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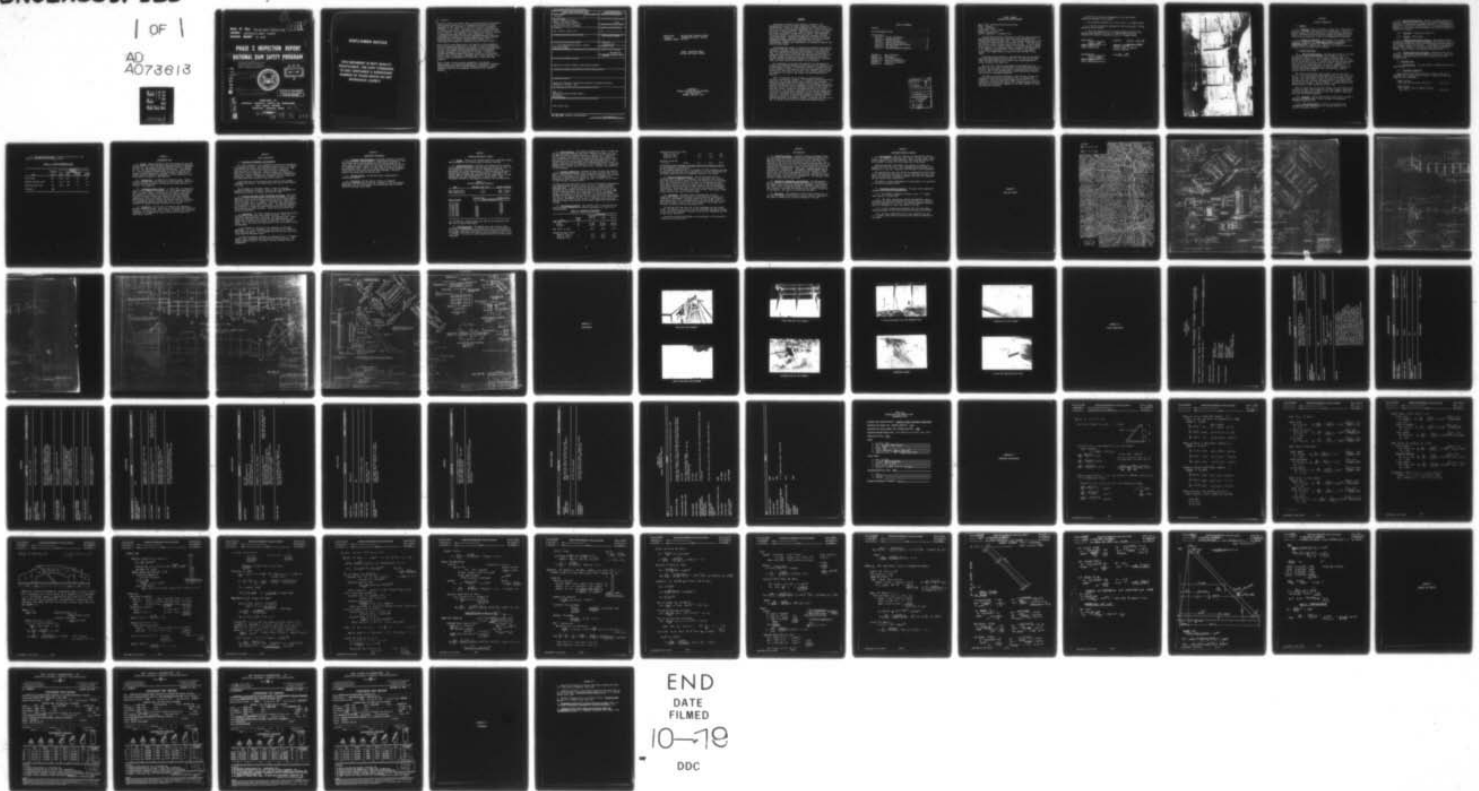
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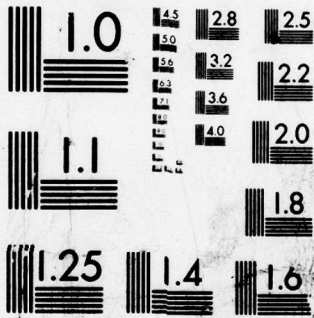
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①
LEVEL II

Name Of Dam: ② FALLING CREEK FILTRATION PLANT

Location: ④ CHESTERFIELD COUNTY, VIRGINIA

③ Inventory Number: VA 04115

⑥ PHASE I INSPECTION REPORT

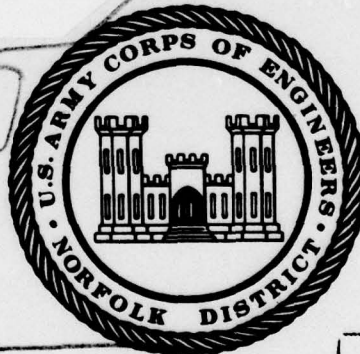
⑥ NATIONAL DAM SAFETY PROGRAM

Falling Creek Filtration Plant.
Inventory Number: VA-04115
Chesterfield County, Virginia.
Phase I Inspection Report.

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⑨ Final report



⑩ James A. Walsh

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PREPARED BY
NORFOLK DISTRICT CORPS OF ENGINEERS
803 FRONT STREET
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20. Abstract

Pursuant to Public Law 92-367, Phase I Inspection Reports are prepared under guidance contained in the recommended guidelines for safety inspection of dams, published by 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 conditions 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.

Based upon the field conditions at the time of the field inspection and all available engineering data, the Phase I report addresses the hydraulic, hydrologic, geologic, geotechnic, and structural aspects of the dam. The engineering techniques employed give a reasonably accurate assessment of the conditions of the dam. It should be realized that certain engineering aspects cannot be fully analyzed during a Phase I inspection. Assessment and remedial measures in the report include the requirements of additional indepth study when necessary.

Phase I reports include project information of the dam and appurtenances, all existing engineering data, operational procedures, hydraulic/hydrologic data of the watershed, dam stability, visual inspection report and an assessment including required remedial measures.

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NAME OF DAM: FALLING CREEK FILTRATION PLANT
LOCATION: CHESTERFIELD COUNTY, VIRGINIA
INVENTORY NUMBER: VA 04115

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
NORFOLK DISTRICT CORPS OF ENGINEERS
803 FRONT STREET
NORFOLK, VIRGINIA 23510

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineer, 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 continued care and inspection can there be any chance that unsafe conditions be detected.

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 (flood discharge, that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region) or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the design flood should not be interpreted as necessarily posing a highly inadequate condition. The design flood provides a measure of relative spillway capacity and serves as an aide 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 REPORT
NATIONAL DAM SAFETY PROGRAM**

Name of Dam: Falling Creek Filtration Plant
State: Virginia
County: Chesterfield
Coordinates: 3718.1 7950.2
Stream: Falling Creek
Date of Inspection: 1 November 1978

Falling Creek Filtration Plant Dam is a 207-foot long and 30-foot high concrete buttressed dam, sited three miles upstream of the Richmond-Petersburg Turnpike (I-95). This dam was constructed in 1952 and raised to elevation 100.0 (top of dam) in 1956. Plans were found for both the initial construction and the additions. A set of design notes, done in 1956, contain a check of the original dam and a design of the addition. An independent Phase I inspection was performed by J. K. Timmons & Associates, Inc., in March 1978, at the owners request. The Timmons Report is used as a basis for much of this report.

During the visual inspection, and additional seep was discovered which the Timmons Report does not refer to. The concrete spillway, slabs, buttress and joints were found to be in same condition as during the March 1978 inspection.

The 1/2 P.M.F., which is considered the appropriate spillway design flood, will reach elevation 106.5, or 6.5 feet above the top of the dam. The spillway is only capable of passing 21% of this flow. Since the dam is an intermediate-size, significant-hazard structure, the spillway is considered inadequate.

The stability analysis performed in 1956 indicates the dam was designed for a water level of elevation 95.0, or, normal flow conditions. Since the appropriate design flow (1/2 P. M. F.) will exceed this elevation by at least 8 feet, further analysis should be performed by a professional engineer at the owners expense to verify the structural stability.

In addition to the above recommendation, the owner should immediately implement the following:

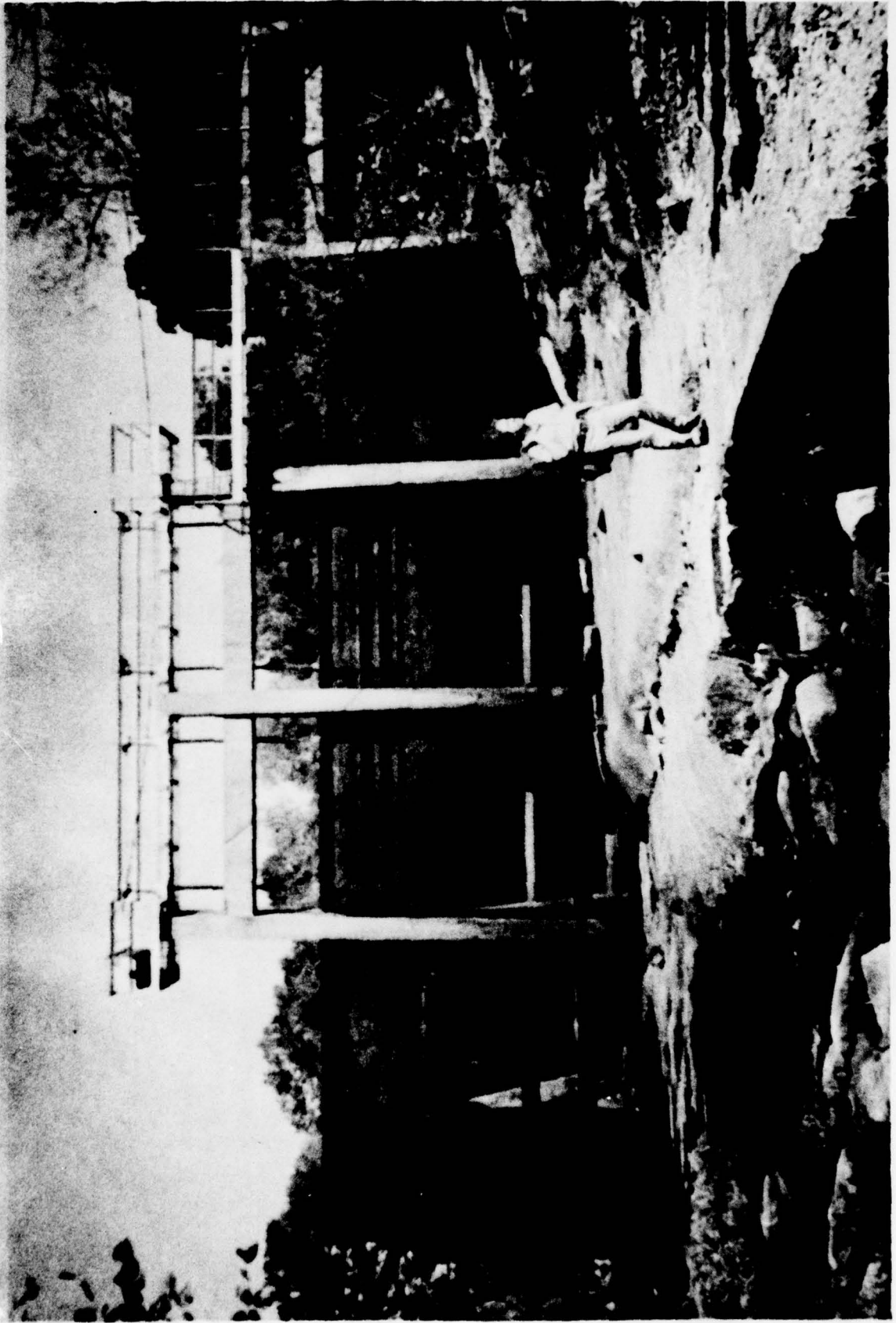
1. The remedial treatment as outlined in the J. K. Timmons Report.
2. A plan of preventive maintenance for the sluice gates, lifting mechanism, and the valves.
3. The seeps identified in the visual inspection of this report and those identified in the J. K. Timmons Report should be monitored and treated as specified in the J. K. Timmons report.

Submitted By:
Original signed by
JAMES A. WALSH
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Chief, Design Branch

Approved: Original signed by
Douglas L. Haller
DOUGLAS L. HALLER
Colonel, Corps of Engineers
District Engineer

Recommended By:
Original signed by
ZANE M. GOODWIN
ZANE M. GOODWIN, P.E.
Chief, Engineering Division

Date: FEB 6 1979



OVERVIEW

SECTION 1

PROJECT INFORMATION

1.1 General:

1.1.1 Authority: Public Law 92-367, 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of safety inspections of dams throughout the United States. The Norfolk District has been assigned the responsibility of supervising the inspection of dams in the Commonwealth of Virginia.

1.1.2 Purpose of Inspection: The purpose is to conduct a Phase I inspection according to the Recommended Guidelines for Safety Inspection of Dams (Appendix VII, Reference 4). The main responsibility is to expeditiously identify those dams which may be a potential hazard to human life or property.

1.2 Project Description:

1.2.1. Dam and Appurtenances: Falling Creek Filtration Plant Dam is a 207-foot long and 30-foot high (from steamed to top of non-overflow section, elev. 100.0) concrete buttressed dam. The buttresses are typically 17 feet 6 inches on centers, taper in cross section and founded on rock. A concrete slab of varying cross section rests on top of the buttresses and is inclined 45 degrees with the high point on the downstream side. (see photos, Appendix II). A concrete retaining wall separates the right abutment, composed of a 37-foot long earthen embankment with a concrete core, from the concrete portion of the dam.

The crest of the 155-foot long spillway is set at elev. 95.0 (m.s.l.). The uncontrolled spillway permits water to fall freely over the dam. Two 7-foot high by 16-foot wide steel sluice gates, top set at elev. 95.0, can be used to lower the reservoir to elevation 88.0. Lifting devices for the gates are supported on a high catwalk at elev. 107.0 over top the gates. The high catwalk is accessed from the left abutment across a lower catwalk set at elev. 100.

Water is drawn from the reservoir through a 16-inch diameter pipe (invert elev. 88.0) which connects to a 14 inch diameter supply pipe. A 24-inch drawdown pipe, designed to drain the reservoir, has never been used and assumed inoperable.

1.2.2 Location: Falling Creek Filtration Plant Dam is located on Falling Creek approximately 3 miles upstream of the Richmond-Petersburg Turnpike (I-95).

1.2.3. Size Classification: The dam is classified as an "intermediate" size structure based on storage potential (1511 acre-ft) and height (30 feet).

1.2.4. Hazard Classification: The dam is located upstream of a Filtration Plant and is given a "significant" hazard classification in accordance with guidelines contained in Section 2.1.2 of Reference 4, Appendix VI. The hazard classifications used to categorize dams are a function of location only and has nothing to do with its stability or probability of failure.

1.2.5. Ownership: Chesterfield County, Va.

1.2.6. Purpose: Water Supply

1.2.7. Design and Construction History: The dam was initially designed and constructed in 1952 to elevation 93.0 (spillway elev. 93.0). The original designer was Perrow and Brockenbrough and the contractor was Thorington Construction Company. A 1956 addition, designed by R. Kenneth Weeks, Engineers, and constructed by English Construction Company, raised the dam to its present elevation of 100.0.

1.2.8. Normal Operational Procedures: Operation of the dam is automatic. The spillway does not require the use of the sluice gates and water rising above the crest of the spillway falls to the streambed below.

1.3 Pertinent Data:

1.3.1 Drainage Areas: The dam controls a drainage area of 53.24 square miles.

1.3.2 Discharge at Dam Site:

Maximum known flood since construction of dam - 5010 cfs in September 1960. Maximum flood of record - 7,270 cfs in July 1945. (gage 400 feet downstream).

Ungated spillway

Pool level at top of dam, elev 100.0 5,571 c.f.s.

Gated spillway

Pool level at crest of ungated spillway,
elev. 95.0 1,919 c.f.s.

1.3.3 Dam and Reservoir Data: Pertinent data on the dam and reservoir are shown in the following table:

Table 1.1 DAM AND RESERVOIR DATA

Item	Elevation feet m.s.l.	Reservoir Capacity			Length miles
		Area acres	Acre feet	Watershed Inches	
Top of dam	100	144.6	1511	.53	3.3
Ungated spillway crest	95	91.8	920	.32	2.7
Gated spillway crest	88	59.6	390	.14	2.0
Streambed	68+	-	-	-	-

SECTION 2

ENGINEERING DATA

2.1 Design: Design drawings on both the original and the 1956 addition are on file with the owner, Chesterfield County, Department of Utilities. The plans include all necessary details to construct the dam. The 1956 drawings are marked "as-builts." (see appendix I). A set of structural design notes, for the 1956 addition, were found in the Engineers files. The notes contain a check of the original dam and a design of the addition. A full discussion of the notes appears in Section 6 - Dam Stability.

2.2. Construction: In addition to "as-built" plans, several concrete cylinder tests were found for the 1956 addition. The tests indicate the concrete used in the dam was well above 3,000 P.S.I. concrete. (See Appendix V)

2.3. Independent Phase I Report: In March 1978, the consulting firms of J. K. Timmons & Associates, Inc. and Schnabel Engineering, Assoc. performed a Phase I inspection at the request of the owner. The inspection, conducted in accordance with Corps of Engineers criteria for Phase I inspections, contains three major concerns regarding the safety of the dam; deterioration of joint sealant, deterioration of concrete buttress shelves and potential overflow on to the embankment during a hundred year storm. The owner plans to implement all remedial measures presented in the report.

2.4. Evaluation: The two sets of existing plans adequately describe the dam in detail. Evaluation of the design notes appears in Section 6. The March 1978, Phase I report is adequate and the general assessment and recommendations appear sufficient to correct the deficiencies reported.

SECTION 3

VISUAL INSPECTION

3.1 Foundation, Embankment, and Abutments:

The visual inspection of the foundation conditions was obscured by local ponding and debris. The findings outlined in the J. K. Timmons & Associates, Inc. March 1978 report were used as a guideline. The Corps was unable to locate the 4 seeps outlined in Section B, Geotechnical, Field Inspection. Possible reasons for missing the seeps are outlined in Appendix III, Field Observations, Concrete Dam, Foundations. However, an additional foundation seep was located at the downstream base of Buttress 6 and noted on Plate 3.

Large quantities of iron bacteria were found in local ponding underneath the spillway. The significance and origin of the bacteria is unclear.

The embankment and abutments showed no signs of cracking, movements, sloughing, or erosion. However, the right embankment was vegetated with several coniferous and deciduous trees.

3.2 Concrete Spillway, Slabs, Buttresses and Joints: The visual inspection of the concrete portion of the dam was hindered by dense vegetation along the non-overflow sections and water flowing down the face of the dam. The J. K. Timmons & Associates, Inc., March 1978 report was again used as a guideline. Very few cracks were observed in the underside of the slabs or buttresses. The concrete appeared in good condition. Seepage and deterioration around the slab seats on the buttresses were very noticeable. Joints and joint sealant were almost non observable.

3.3 Evaluation: The visual inspection of the foundation revealed two significant conditions that warrant attention. First, the previously identified seeps, and second, the additional seep. These seeps should be marked in the field for easy identification. They should also be monitored and treated as specified in the Timmons report. Also, the origin and significance of the iron bacteria should be determined.

A less significant condition is the vegetation on the right embankment. It is not recommended that the trees be cut because of their extensive growth. It is suspected that killing the trees would cause decay and encourage piping.

The visual inspection confirmed the findings of the J. K. Timmons Phase I report concerning concrete portions of the structure. The remedial measures given in the report for these findings should be implemented.

SECTION 4

OPERATIONAL PROCEDURES

4.1. Procedures and Maintenance: Operating procedures are handled as the need arises. Debris removal is accomplished irregularly. The sluice gates and lifting mechanism have only been operated two or three times, the latest operation of the gates being in March 1978 for the independent Phase I report. At that time, only one of the gates was raised and closed. The 16-inch water supply and 24-inch drawdown valves remain in one position and are never operated. The valve operator is missing from the 24-inch valve.

4.2. Warning Systems: No warning system is maintained by Chesterfield County.

4.3. Evaluation: The dam does not require an elaborate operational and maintenance procedure. However, a plan of preventive maintenance for the sluice gates, lifting mechanism, and the valves should be developed and followed.

SECTION 5

HYDRAULIC/HYDROLOGIC DESIGN

5.1 Design: There are no original hydraulic or hydrologic design data available for the Falling Creek Filtration Plant Dam.

5.2 Hydrologic Records: Reservoir pool elevations are recorded once a month by personnel from the Falling Creek Filtration Plant, but not maintained at the plant. The U.S. Geological Survey has maintained flow records approximately 5 miles upstream of the dam on Falling Creek (drainage area 32.8 square miles) since August 1955. Another gage was located approximately 400 feet downstream of the dam between 1943 and 1964 (drainage area 54 square miles). Peak discharges recorded at these gages are shown in the following table:

TABLE 5.1
FALLING CREEK FLOOD RECORD 1/

GAGE	DRAINAGE AREA SQ.MI.	PERIOD OF RECORD
Near Chesterfield	32.8	1955 - Present
Near Drewrys Bluff	54.0	1942 - 1964

Date of Flood	Chesterfield	Drewrys Bluff
	Peak Discharges c.f.s.	
18 Jul 1945	—	7270
13 Aug 1955	—	3100
18 Aug 1955	2000	4700
12 Sep 1960	2500	5010
21 Oct 1961	1500	2780
6 Jan 1962	1450	2800
23 Jul 1969	1200	—
14 Jul 1975	1600	—

1/ Includes all recorded floods over 1000 cfs at Chesterfield and 2000 cfs at Drewrys Bluff gages.

5.3 Flood Experience: The maximum pool level sited by plant personnel was approximately at elevation 96.5+ or 3.5 feet below the top of dam. Calculations indicated the peak discharge of 5010 cfs of 12 September 1960 would have caused a rise to within one foot of the top of dam. No records or visual sightings show that the dam has been overtopped.

5.4 Flood Potential: The Probable Maximum Flood (PMF), 1/2 PMF, and 100-year flood were developed and routed through the reservoir by use of the HEC-1DB computer program (Reference 1, Appendix VI) and appropriate unit hydrograph, precipitation, and storage-outflow data. Clark's T_c and R coefficients for the local drainage area were estimated from basin characteristics and actual rainfall and flood hydrograph records. The rainfall applied to the developed unit hydrograph was obtained from U. S. Weather Bureau Publications (Reference 2 and 3, Appendix VI). Losses were estimated at an initial loss of 0.80 inch and a constant loss thereafter of 0.05 inch/hour.

5.5 Reservoir Regulation: Releases through a 14-inch pipe supplies water to the Falling Creek Filtration Plant, which provides water to the County of Chesterfield. Under normal streamflow conditions, the reservoir pool level is approximately elevation 95. Excess streamflows are automatically passed over the ungated spillway. Two gates can be raised to lower the pool to elevation 88.0.

A storage curve was developed for the reservoir from known storage values, then extended above the top of dam by use of U. S. Geological Survey Quadrangle Maps. A rating curve with the gated spillway closed was developed for the ungated spillway and non-overflow section of the dam. For pool elevations above top of dam (elevation 100.0), the gates, when lifted, allow less flow to pass downstream. In routing hydrographs through the reservoir, it was assumed that the initial pool level was at the crest of the ungated spillway. Flow through the 14-inch water supply pipe was not considered in the routing. A tailwater rating curve was developed using a cross section of the channel immediately downstream of the dam.

5.6 Overtopping Potential: The probable rise of the reservoir and other pertinent information on reservoir performance is shown in the following table:

Table 5.2 RESERVOIR PERFORMANCE

Item	Normal Flow	Hydrograph		
		One Per-Cent 1/	1/2 PMF	PMF 2/
Peak flow, c.f.s.				
Inflow	53	14,189	26,252	52,517
Outflow	53	14,354	26,205	52,286
Max. elev., ft. msl	-	103.1	106.5	112.1
Ungated Spillway (El 95)				
Depth of flow, ft.	-	8.1	11.5	17.1
Duration, hours	-	65	108	111
Velocity, f.p.s.	-	9.4	11.2	13.6

Non-overflow section (El 100)

Depth of flow, ft.	-	3.1	6.5	12.1
Duration, hours	-	15	21	30
Velocity, f.p.s.	-	4.7	6.8	9.2
Tailwater elevation, ft m.s.l.	68.5 ₊	91	96.5	107.5

1/ The one percent exceedence frequency flood has one chance in 100 of being exceeded in any given year.

2/ The Probable Maximum Flood is an estimate of flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

5.7 Reservoir Emptying Potential: The 24-inch gated outlet at elevation 70.0, if operable, is available for dewatering the reservoir. The gated spillway may be opened to lower the reservoir pool to elevation 88.0. With the reservoir pool at the crest of the ungated spillway, it would take 13 hours to lower the reservoir pool to the gated spillway crest (gates opened) and 8 days to lower reservoir pool to approximately elevation 82. An average flow of 53 cfs into the reservoir is assumed from 53 square miles of drainage area above the dam. Equilibrium, inflow equals outflow, will occur at elevation 80₊.

5.8 Evaluation: This dam is given "intermediate" size and "significant" hazard classifications in which guidelines (appendix Vii, reference 4) recommended a spillway design flood of 1/2 pmf to pmf as being appropriate. It is considered that a spillway design flood of 1/2 pmf is more clearly related to the risk involved in this project and is therefore selected as the spillway design flood.

The spillway will pass only 21% of the recommended spillway design flood. The reservoir will rise 3.1 and 6.5 feet above the top of the dam in the one percent exceedence frequency flood and the recommended spillway design flood, respectfully.

The effect of future development on the hydrology is not reflected in conclusions presented herein.

SECTION 6

DAM STABILITY

6.1 Stability Analysis: A stability analysis performed during the time of the 1956 addition indicates the concrete portions of the dam are designed for a water level of elev. 95.0, spillway crest. Hydrology calculations give the 100-year flood at elev. 103+. The tailwater at the time of the 100-year flood has been calculated by the Corps of Engineers to be elev. 91. The left non-overflow section was designed for a maximum depth of water six feet below the top of dam (see sheet IV-1, Appendix IV). This gives a maximum design head at elevation 91.0 of three feet. The 100-year storm produces a design head at this elevation of approximately 12 feet. Similarly, the design notes use a seven-foot head to design the spillway slabs under the sluice gates (see sheet IV-13, Appendix IV). The 100-year storm produces a design head of twelve feet.

6.2 Foundation, Embankment, and Abutments: The Geotechnical section prepared by Schnabel Engineering Associates and presented in the Timmons report covers the foundation, embankment, and abutments. The report covers the regional geology, review of available design data, results of the March 1978 inspection and potential erosion due to overtopping. The report is on file with the owner.

6.3 Evaluation: The examples of rather large discrepancies in the concrete design indicate further analysis should be performed by the owner to determine the structural integrity of the dam.

SECTION 7

ASSESSMENT/REMEDIAL MEASURE

7.1 Dam Assesment: With the exception of deficiencies outlined in the J. K. Timmons & Associates, Inc. report, the dam, from a visual aspect, appears to be in good condition. The structural design notes do not appear to account for flood conditions in the design.

Based on hydrology calculations, the spillway is capable of passing 21% of the 1/2 P.M.F., the recommended spillway design flood appropriate to this dam. Therefore, the spillway is rated inadequate.

The spillway will pass only 21% of the recommended spillway design flood. The reservoir will rise 3.1 and 6.5 feet above the top of the dam in the one percent exceedence frequency flood and the recommended spillway design flood, respectfully.

The effect of future development on the hydrology is not reflected in conclusions presented herein.

7.2 Recommended Remedial Measures: The owner should immediately implement the following recommendations:

7.2.1 The remedial treatment as outline in the J. K. Timmons report should be accomplished.

7.2.2. The owner, through his professional Engineers, should investigate the structural stability of the dam under all conditions up to and including the 1/2 P.M.F. Any resulting remedial measures should be undertaken to insure the safety of the dam.

7.2.3 A plan of preventive maintenance for the sluice gates, lifting mechanism, and the valves should be developed and followed.

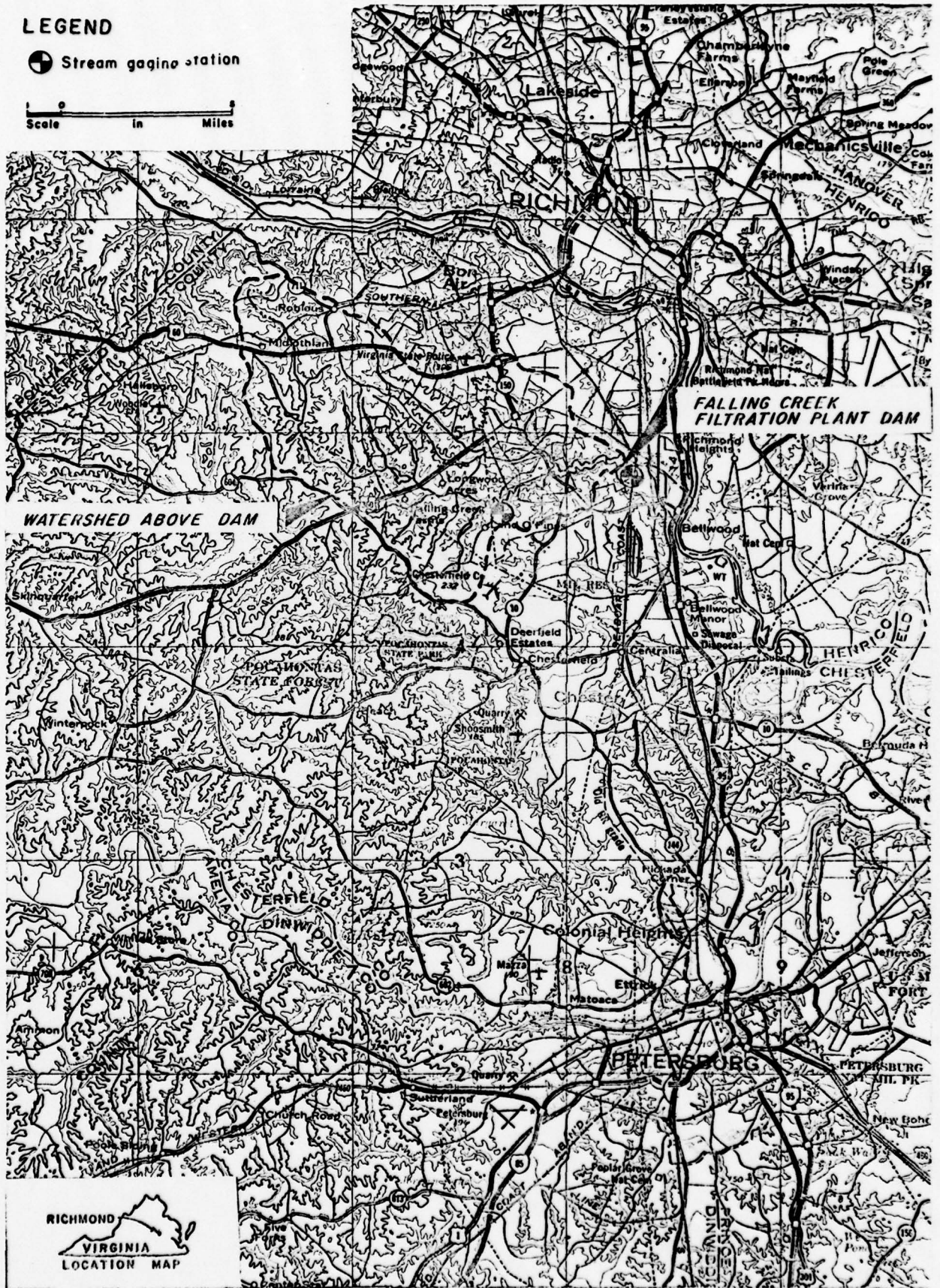
7.2.4 The seeps identified in the visual inspection and the J. K. Timmons report should be monitored and treated as specified in the report.

APPENDIX I
MAPS AND PLATES

LEGEND

 Stream gaging station

Scale 0 1 2 Miles
In Miles



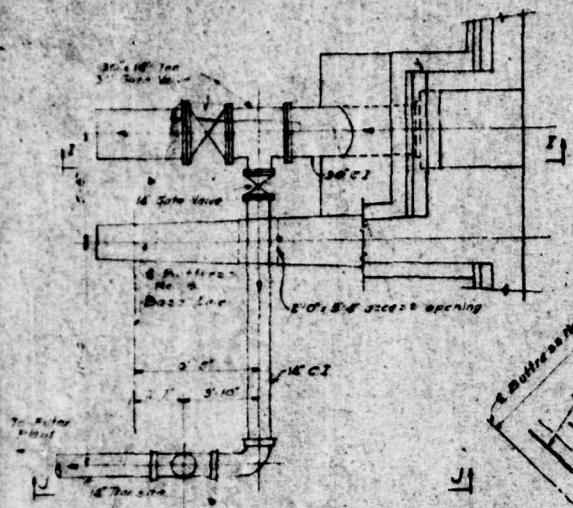
WATERSHED ABOVE DAM

FALLING CREEK
FILTRATION PLANT DAM

RICHMOND
VIRGINIA
LOCATION MAP

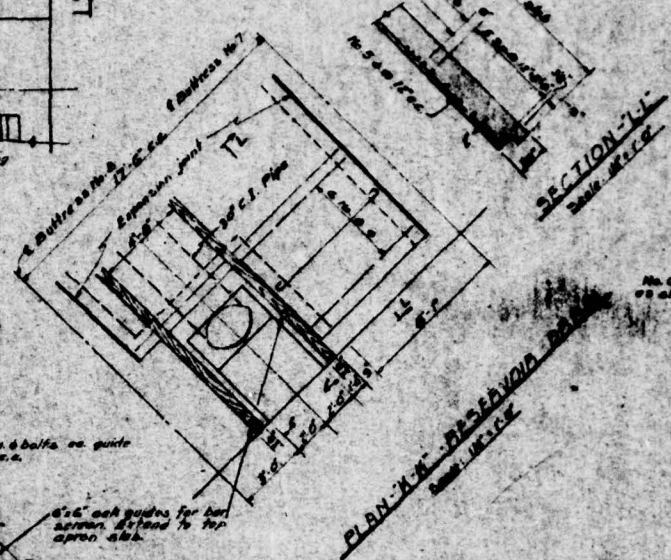
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Hooked ends

1/2" V
No 5 @ 4" c/c
10" x 10"

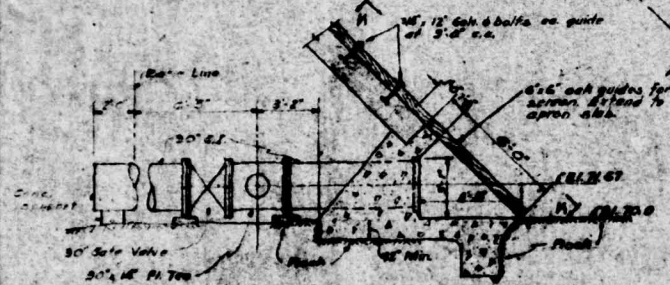


PLAN-WATER INTAKE & DRAIN
Scale 1/4" = 1'-0"

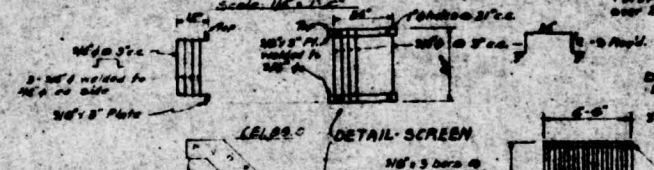
Place reinforcing bars as shown in Sect. P-P to this point.



PLAN-WATER RESERVOIR
Scale 1/4" = 1'-0"



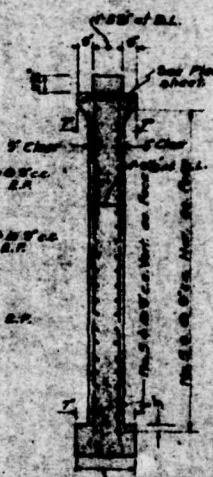
SECTION-T-T
Scale 1/4" = 1'-0"



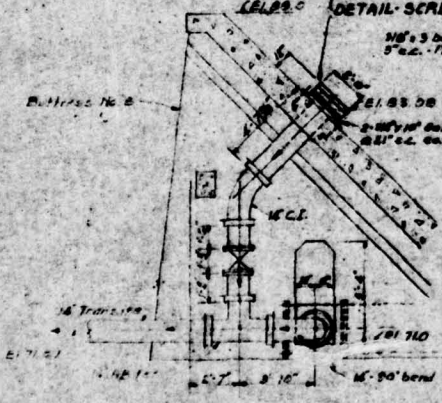
FOR SCREEN-CONC
Scale 1/4" = 1'-0"

Turn down No. 5 @ 12" c/c as shown to allow for future extension. Not over 1' away on stream.

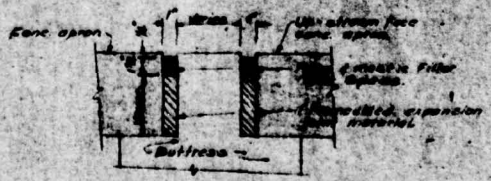
DETAIL-B
Not to Scale



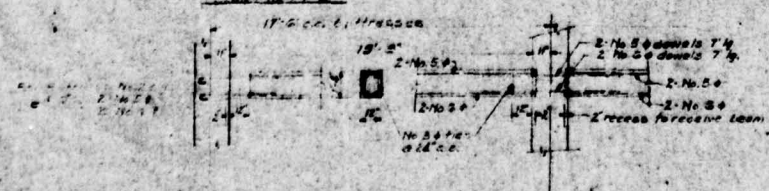
SECTION-G-G
Scale 1/4" = 1'-0"



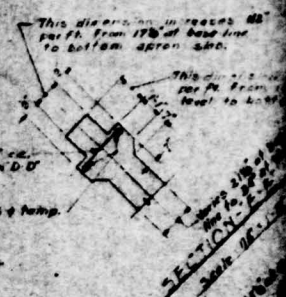
SECTION-U-U
Scale 1/4" = 1'-0"



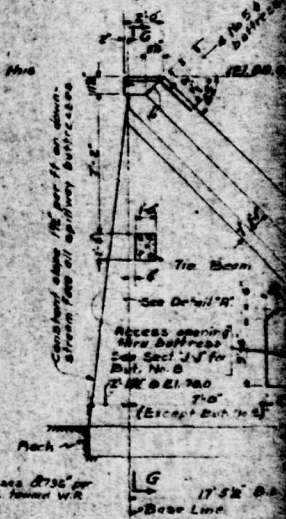
DETAIL-EXPANSION JOINT
Det. to scale



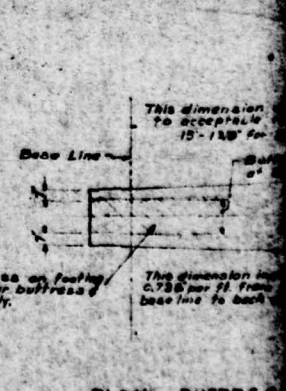
ELEVATION-BUTTRESS TO BEAM
Scale 1/4" = 1'-0"



SECTION-V-V
Scale 1/4" = 1'-0"

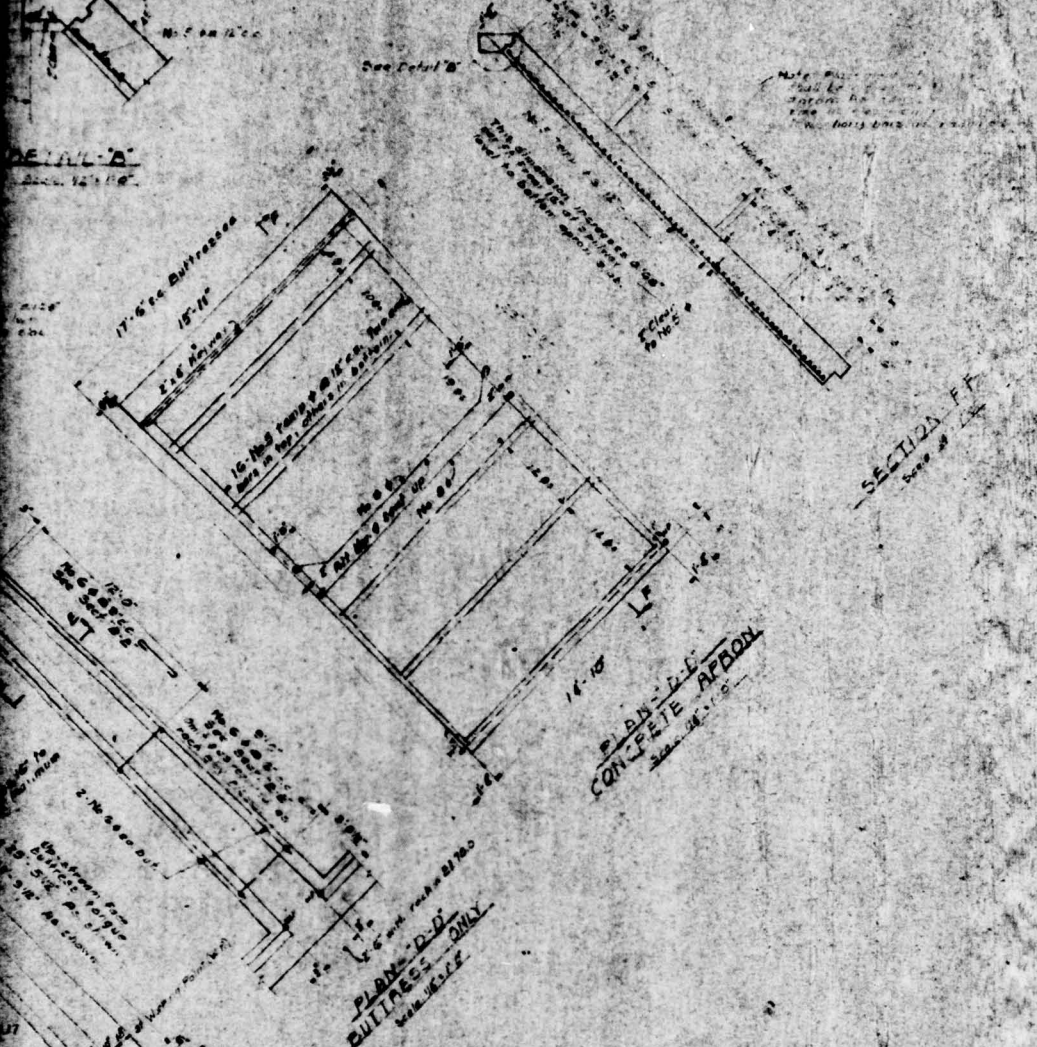


ELEVATION-1
Scale 1/4" = 1'-0"

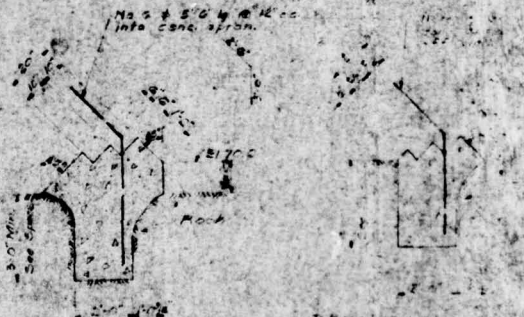
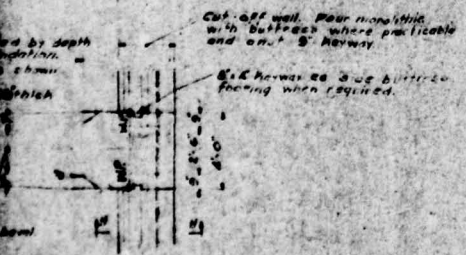


PLAN-BUTTRESS
Scale 1/4" = 1'-0"

This to be removed from base also with spillway base is to be



SPILLWAY BUTTRESS
14' x 10'



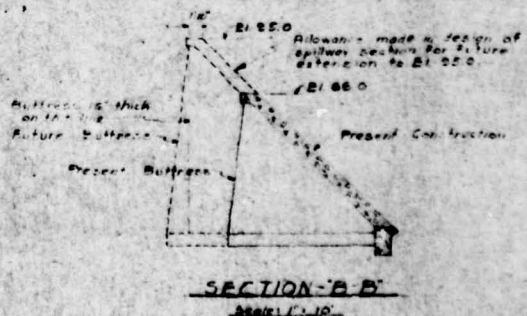
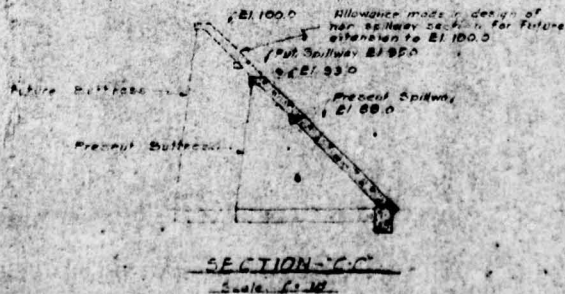
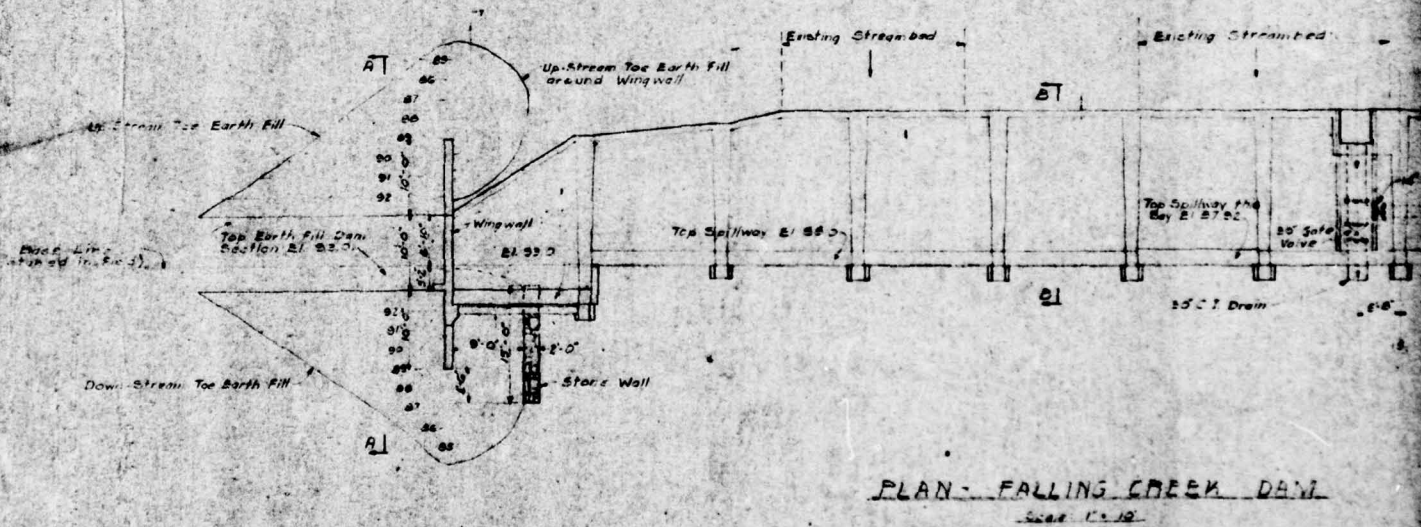
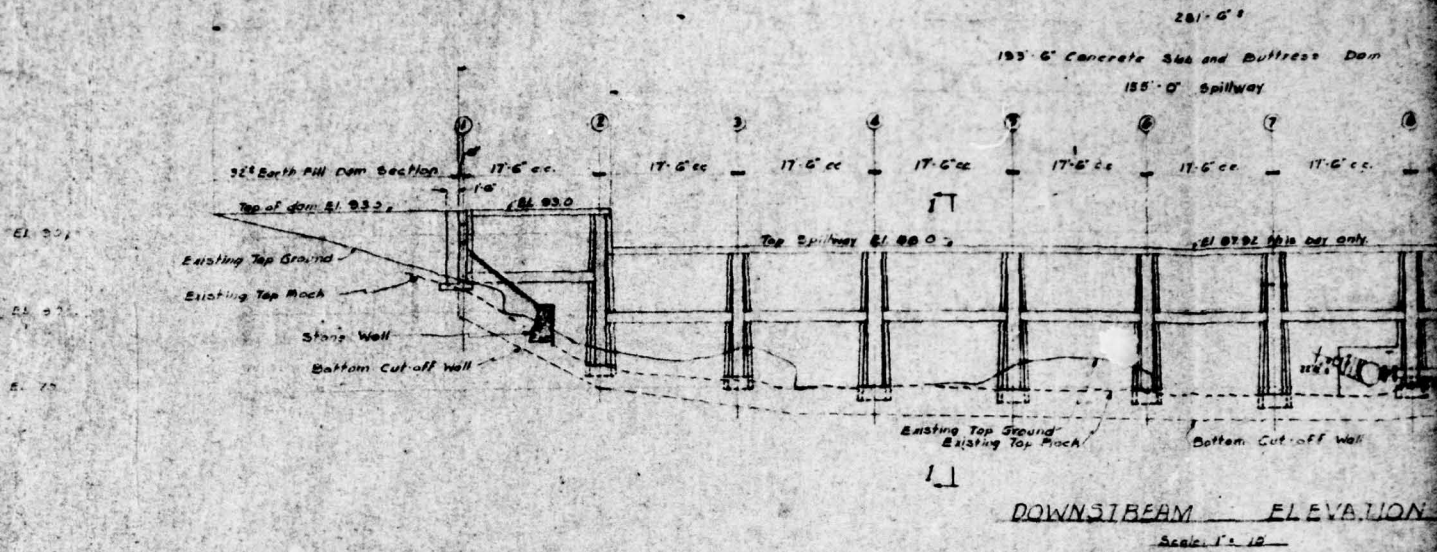
SECTION H-H - CUT-OFF WALL
Scale 1/4" = 1'-0"

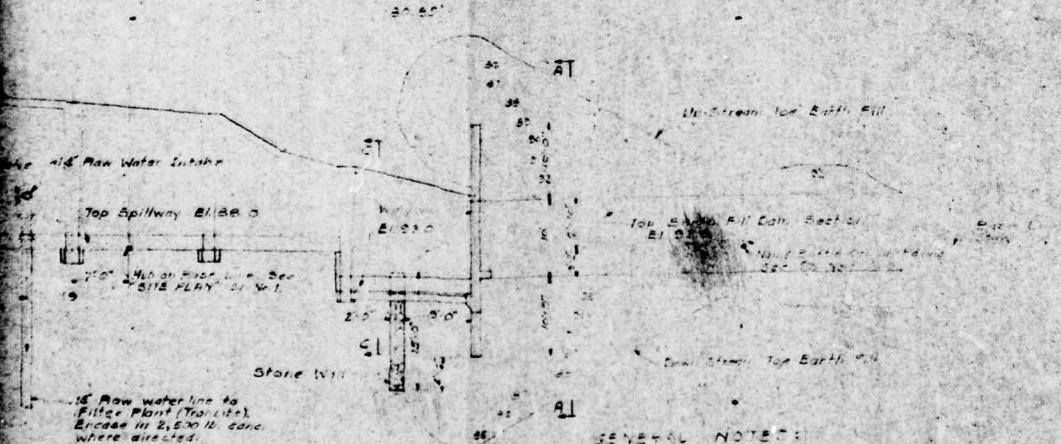
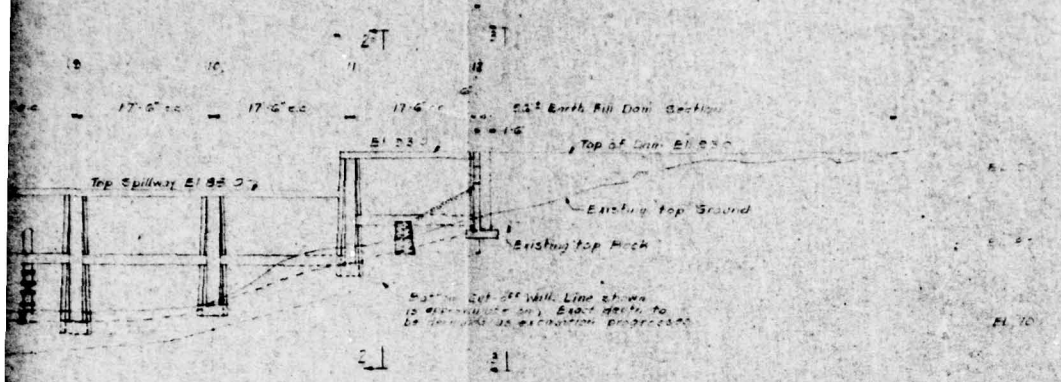
PLATE 1

PERROW & BROCKENBACH
CONSULTING ENGINEERS, PUGH AND

WRITTEN BY: [Name]
DESIGNED BY: [Name]
DRAWN BY: [Name]
CHECKED BY: [Name]

ORTING
10'





GENERAL NOTES:

1. All concrete to be water tight. Buried pipes to be cut off with a saw. Windows shall be 2" x 2" and 4" x 4" and shall be grouted.
2. Rock line shown is approximate. Actual depth to be determined as excavation progresses and shown on the drawings if different.



SECTION "A-A"
Scale: 1/2" = 10'

PLATE 2

PEARSON & BROCKENBACH
CONSULTING ENGINEERS

W. 25 S. 12 E. 1/2 Sec. 36, T. 12 N., R. 10 E., S. 100'

GEN. ENG. PLAN

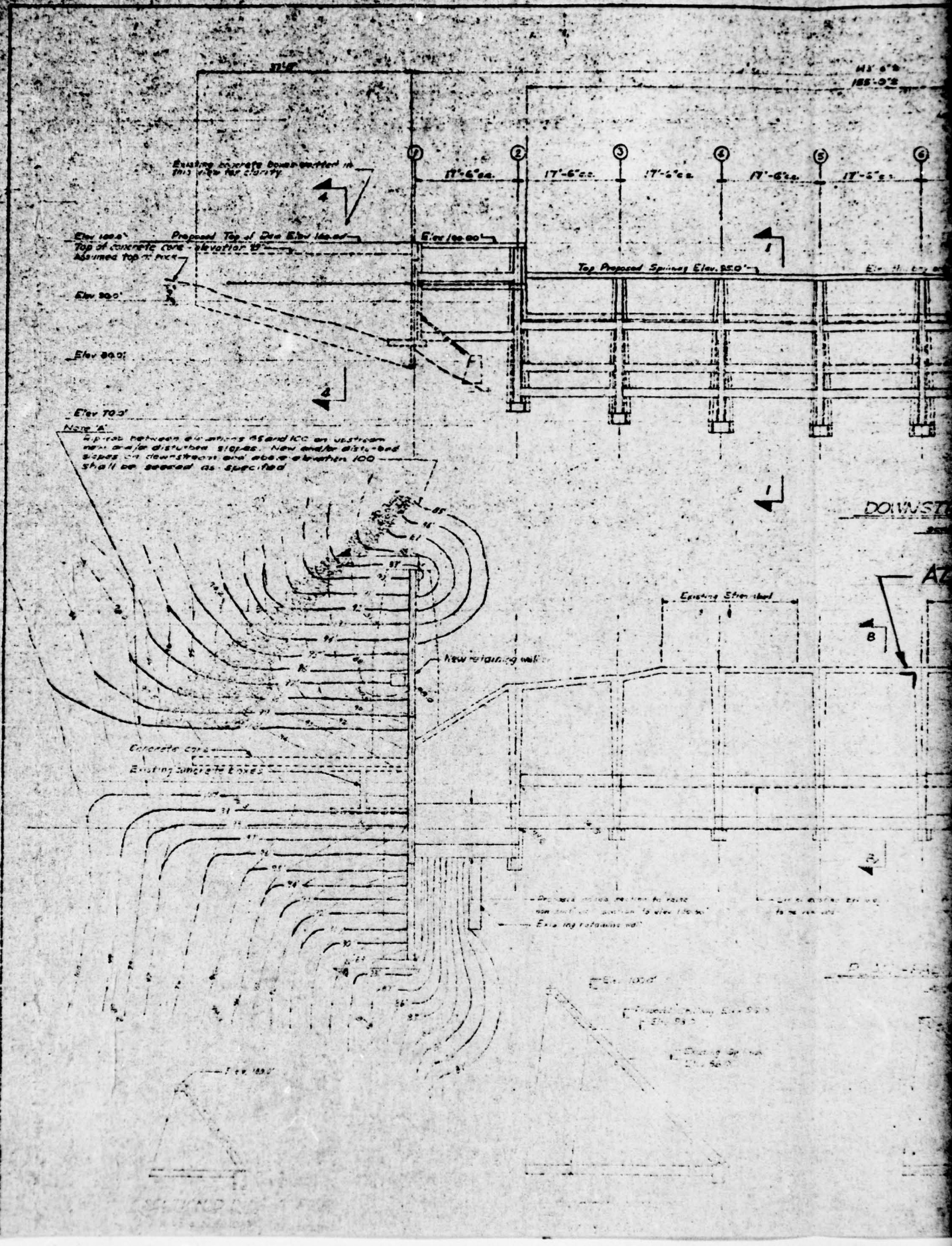
DATE: 12-15-1918

Designed by: [Signature]

Drawn by: [Signature]

Checked by: [Signature]

2



Existing concrete down-sloped in this view for clarity

Proposed Top of Dam Elev. 100.00
 Top of concrete core - elevation 97
 Assumed Top of rock

Elev. 90.0

Elev. 80.0

Elev. 70.0

Note: A

Repair between elevations 85 and 100 on upstream face and/or disturbed slope. New and/or dist. bed slopes on downstream and above elevation 100 shall be as specified

Top Proposed Spillway Elev. 95.00

DOWNSTREAM

New retaining wall

Concrete core

Existing concrete cores

Existing Spillway

Discharge into the river in rock now and/or position to view 100.00
 Existing retaining wall

Elev. 100.00

Proposed Spillway Elev. 95.00
 Elev. 95.00

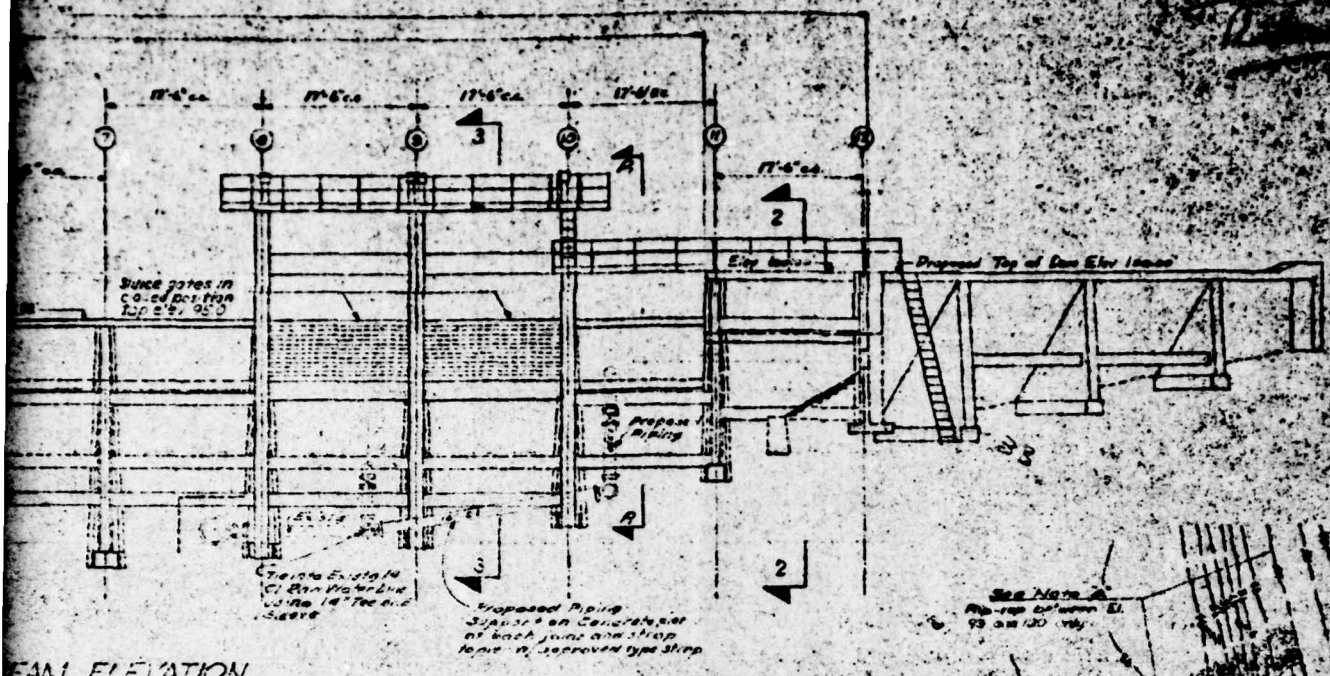
Existing Spillway Elev. 95.00

AZ

B

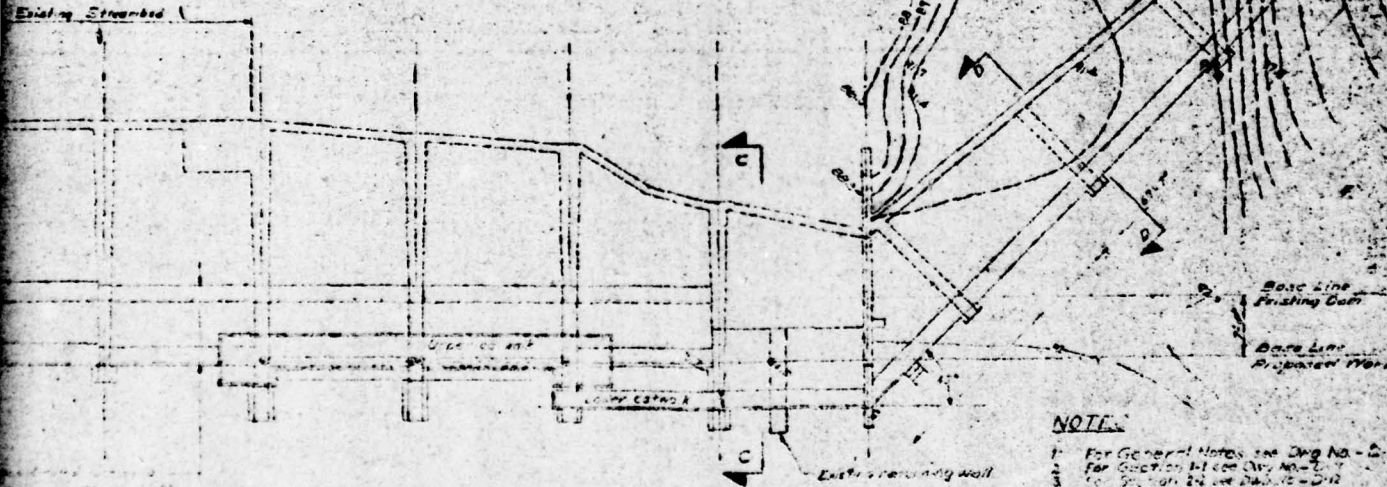
3

1



SEAM ELEVATION

ADDITIONAL SEEP NOTED



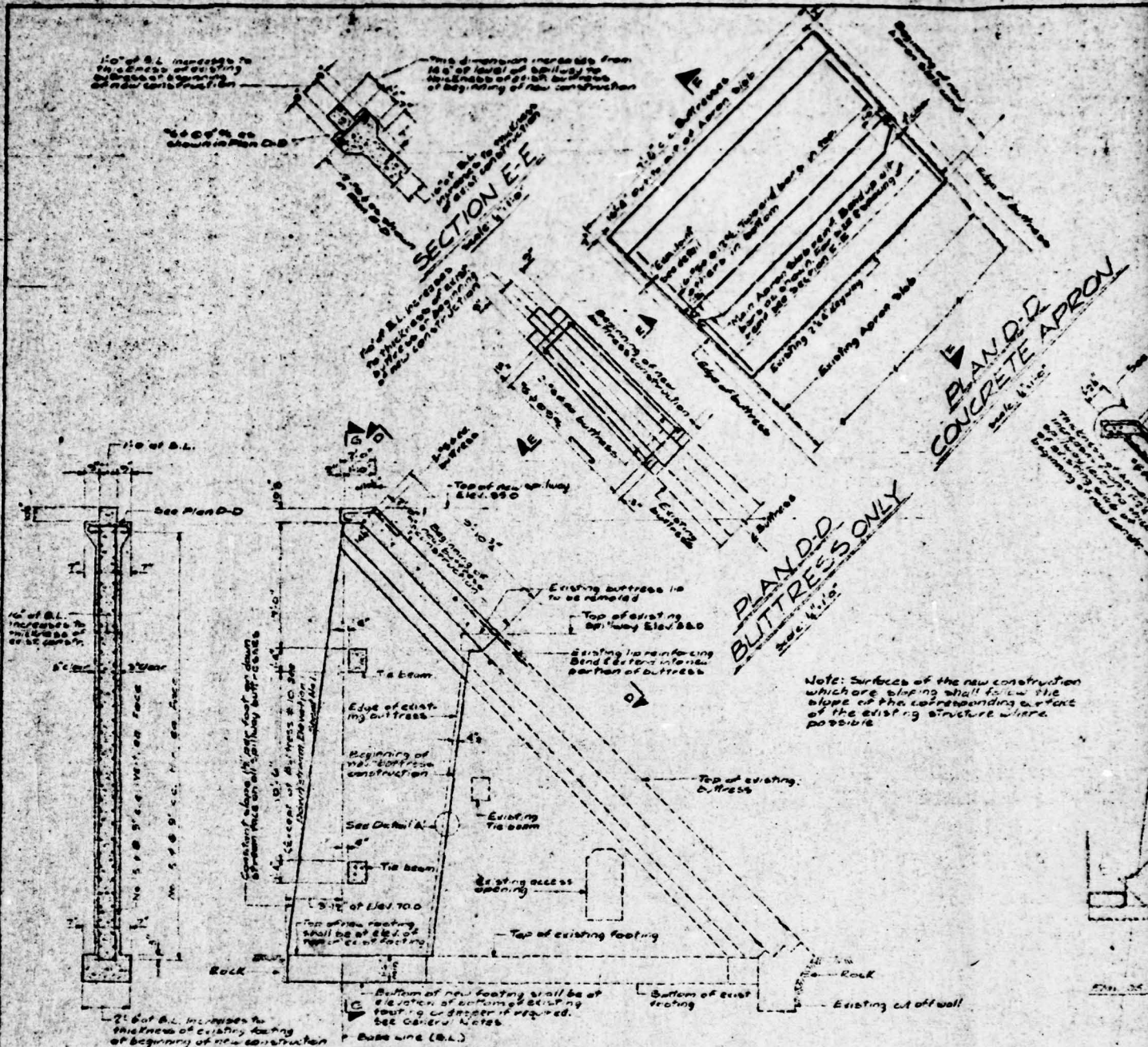
- NOTES**
1. For General Notes see Dwg No. - 2-12
 2. For Section 11 see Dwg No. - 2-17
 3. For Section 12 see Dwg No. - 2-18
 4. For Section 13 see Dwg No. - 2-19
 5. For Section 14 see Dwg No. - 2-20
- LEGEND**
- Rs Existing Elevation
 - 10 New Contour Elevation
 - 10 Existing Contour Elevation

PLATE 3

AS-BUILTS

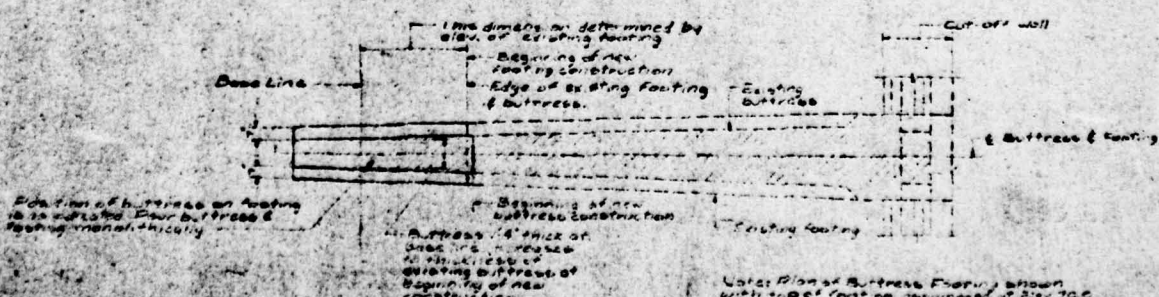
WATER CONTROL DISTRICT OF CALIFORNIA		
DIVISION OF FILTRATION WORKS		
GENERAL LAYOUT AND ELEVATION		
DESIGNED BY	KENNETH WING	SCALE
DRAWN BY	PAUL J. ...	AS-BUILTS
CHECKED BY		D-10

2



SECTION G-G
SCALE 1/4" = 1'-0"

SECTION E-E (SPILLWAY BUTTRESS)
SCALE 1/4" = 1'-0"



PLAN-BUTTRESS FOOTING
SCALE 1/4" = 1'-0"

Note: Surfaces of the new construction which are sloping shall follow the slope of the corresponding surface of the existing structure where possible.

BLAND D. D. CONCRETE APRON
Scale 1/4" = 1'-0"

BLAND D. D. BUTTRESS ONLY
Scale 1/4" = 1'-0"

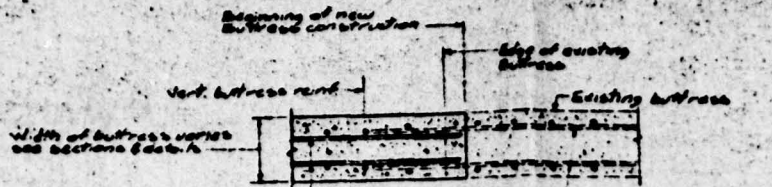
16" of B.L. increases to thickness of existing spillway buttress at beginning of new construction

16" of B.L. increases to thickness of existing spillway buttress at beginning of new construction

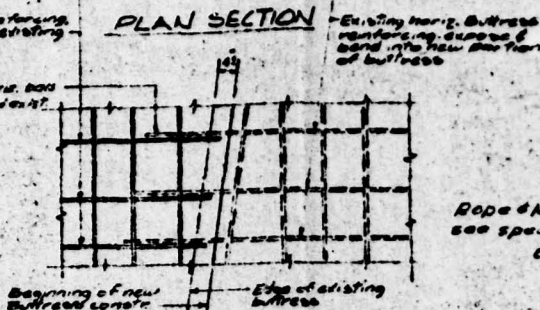
16" of B.L. increases to thickness of existing footing at beginning of new construction

Bottom of new footing wall to be at elevation of existing footing top or deeper if required. See General Notes.

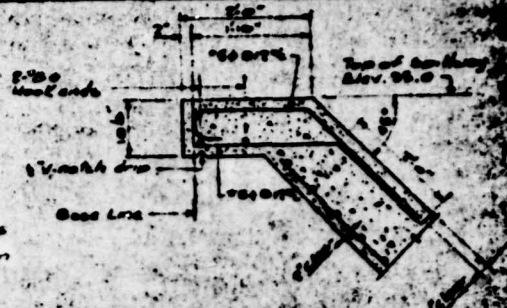
Notes: Plan of Buttress Footing shown with top of footing assumed at Elev. 70.0



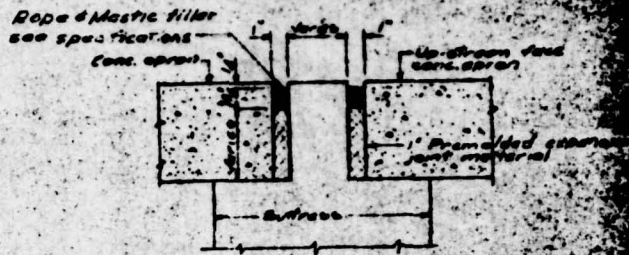
Note:
If extent of exist. horiz. bar is less than 16" add 4" horiz. bar.



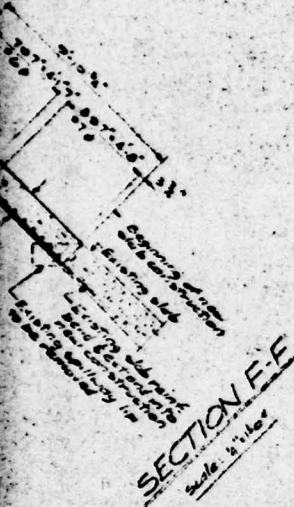
ELEVATION
DETAIL 'A'
No scale



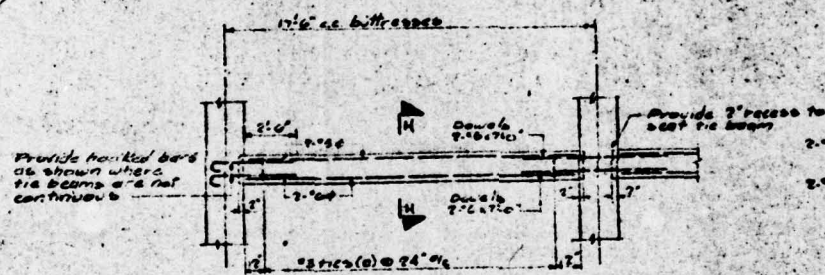
DETAIL 'B'
No scale



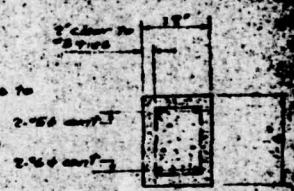
EXPANSION JOINT
DETAIL
No scale



SECTION F-F
Scale 1/4" = 1'-0"



ELEVATION-BUTTRESS
TIE BEAM
Scale 1/4" = 1'-0"



SECTION H-H
Scale 1/4" = 1'-0"

Note: For General Notes see DWS No. D-12

20' dia. manhole to 10' dia. 4' dia. manhole
Elev. 100.0

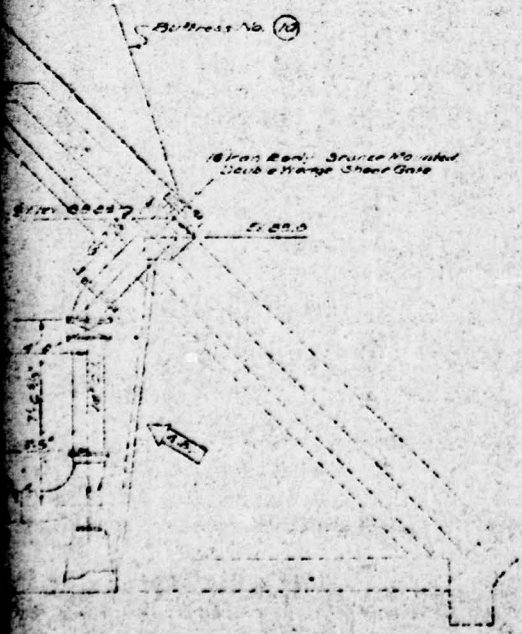


PLATE 4

AS-BUILT

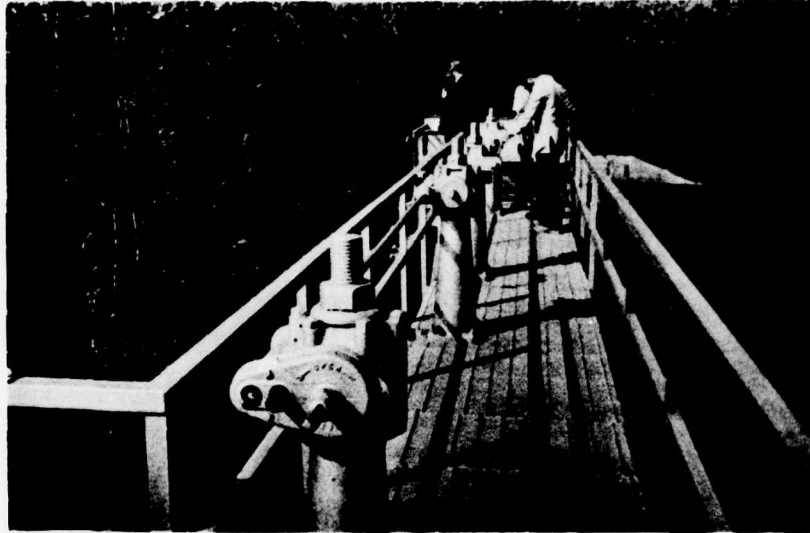
WATER SUPPLY FILTRATION STORAGE AND DISTRIBUTION CONTRACT NO. 1077-1-10-11-12		
ADDITION TO FILTRATION WORKS SPILLWAY BUTTRESS AND APRON		
REV. 1	R. KENNETH WEENS ENGINEER	SCALE: AS SHOWN
REV. 2	NO. 1077-1-10-11-12	DWS NO. 0411
REV. 3	CONTRACT NO. 1077-1-10-11-12	

No.	REVISION	DATE
49	As BUILT	12-25-55

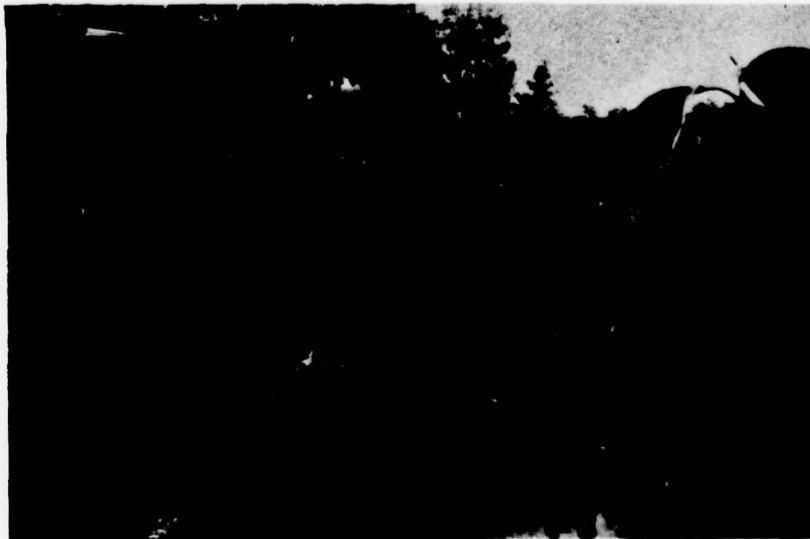
2

APPENDIX II

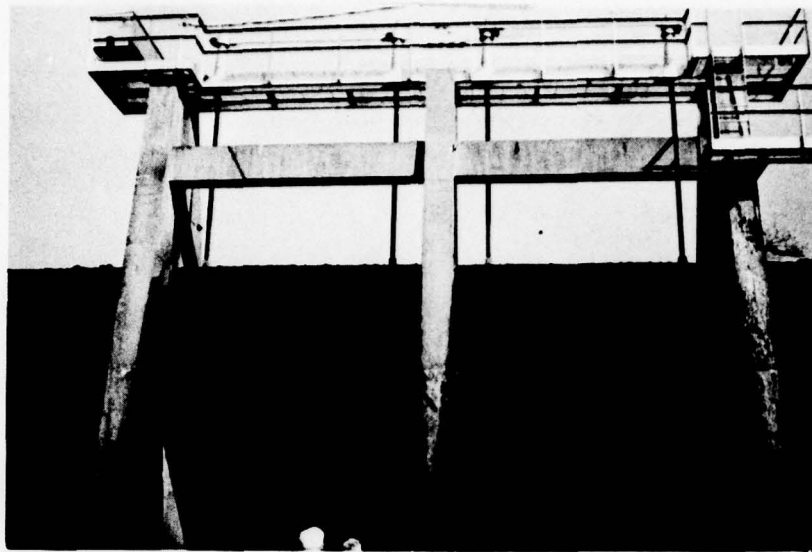
PHOTOGRAPHS



STEEL GATE LIFT ASSEMBLY



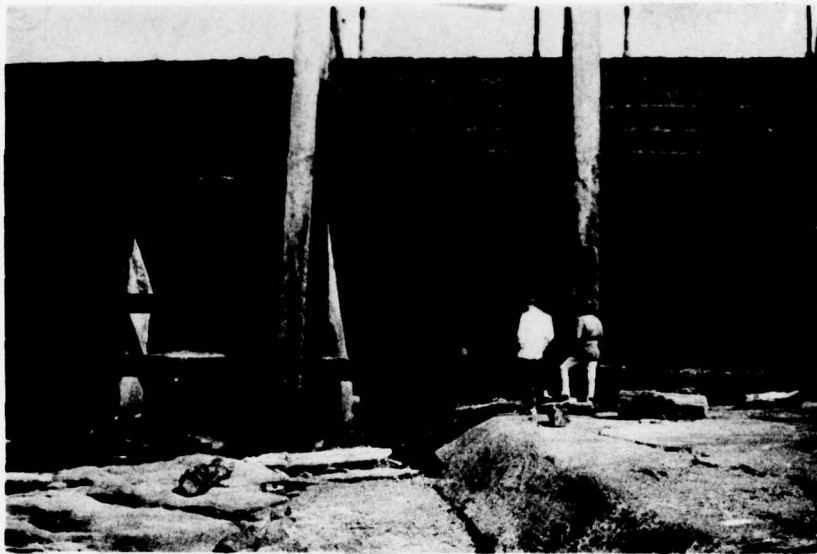
VIEW OF DAM FROM RIGHT ABUTMENT



STEEL GATES AND LIFT ASSEMBLY



UPSTREAM VIEW OF LIFT ASSEMBLY



14 INCH WATER SUPPLY PIPE AND CONCRETE APRON



DOWNSTREAM CHANNEL



UNDERSIDE OF SLAB AT GATES



24 INCH CAST IRON DRAIN AND VALVE

APPENDIX III
FIELD OBSERVATIONS

Check List
Visual Inspection
Phase 1

Name Dam Falling Creek Filtration Plant County Chesterfield State Virginia Coordinates Latitude 3718.1
Longitude 7950.2

Date(s) Inspection 1 Nov 1978 Weather Fair Temperature 70°

Pool Elevation at Time of Inspection 95' m.s.l.

Tailwater at Time of Inspection (Steambed + .5') 68.5 m.s.l.

Inspection Personnel:

State Water Control Board: Jack Hyden
Chenchaya Bathala

Chesterfield County: Robert A. Painter
Craig S. Bryant
Donald E. Addison

Corps of Engineers: David A. Pezza
David Dougan
Jim Robinson
William A. Sorrentino
Jeffery C. Irving (Recorder)

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF

OBSERVATIONS

REMARKS OR RECOMMENDATIONS

SEEPAGE OR LEAKAGE

Seepage is apparent along the top of several buttresses. Water flowing over the spillway hinders a true evaluation of the seeps.

This condition is written up in J. K. Timmons Phase I Report and remedial measures are prescribed.

STRUCTURE TO
ABUTMENT/EMBANKMENT
FUNCTIONS

Very Vegetated. Could not tell very much.

DRAINS

NONE

WATER PASSAGES

2 1-24" At base which empties dam
(closed)
1-16" Thru dam for water supply
(open),
The valves are not operated

Preventive maintenance should be provided for all valves.

FOUNDATION

Reference Timmons & Assoc.'s Report, Section B, Geotechnical, Drawing No. 4. The inspector is unable to locate the four seeps identified on Drawing No. 4. The inspection of Seeps 1 & 2 is hampered by local ponding clouded with iron bacteria and debris. The exact location of Seep 3 is not clear, but no seepage in the general area is apparent. It is suspected that Seep 4 is submerged. An additional seep is apparent at the base of the right (West) downstream junction of the spillway and Buttress No. 6. The flow is easily observable and appears to come from beneath the dam. The amount and rate are difficult to estimate and local ponding is clouded with iron bacteria.

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Minimal	See J. K. Timmons Report
STRUCTURAL CRACKING	Minimal	See J. K. Timmons Report
VERTICAL AND HORIZONTAL ALIGNMENT	N/A	
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS	NONE OBSERVED	See J. K. Timmons Report

EMBANKMENT

VISUAL EXAMINATION OF OBSERVATIONS REMARKS OR RECOMMENDATIONS

SURFACE CRACKS

There are no signs of cracks.

UNUSUAL MOVEMENT OR
CRACKING AT OR BEYOND
THE TOE

There are no signs of movement or cracking.

SLOUCHING OR EROSION

There are no signs of sloughing or erosion. The right embankment is vegetated with several coniferous and deciduous trees several inches in diameter. There are rock outcrops on the left abutment.

VERTICAL AND HORIZONTAL
ALIGNMENT OF THE CREST

There are no apparent deviations from available drawings.

RIPRAP FAILURES

Portions of the downstream area and the area at the toe of the embankment appear to be riprapped. The riprap in the downstream area is disheveled. The riprap at the toe of the embankment appears to be intact

JUNCTION OF EMBANKMENT
AND ABUTMENT, SPILLWAY
AND DAM

There are no signs of deterioration of any nature

STAFF GAGE AND RECORDER

Staff gage located on left non-flow section.

DRAINS

Available drawings do not show drains. No drains are apparent in the field.

OUTLETS WORKS

VISUAL EXAMINATION OF OBSERVATIONS REMARKS OR RECOMMENDATIONS

CRACKING AND SPALLING OF
CONCRETE SURFACES IN
OUTLET CONDUIT

N/A

INTAKE STRUCTURE

Submerged unable to check (16" water supply
reduces to 14" on d/s face)

OUTLET STRUCTURE

14" water supply pipe to filtration plant
buried beyond toe of dam.

Note: Wheel is available if
needed at another location

OUTLET CHANNEL

Large rocks along streambed 20-30 ft. wide
with 30-35° slopes. Trees and shrubs
Road Bridge approx. 100 yds. d/s

EMERGENCY GATE

2 gates 7'x16' closed-opened twice in 15 years
only for maintenance and Timmons Phase I
24" drawdown pipe (no wheel). Never been used.

UNGATED SPILLWAY

VISUAL EXAMINATION OF OBSERVATIONS REMARKS OR RECOMMENDATIONS

CONCRETE WEIR

155' wide
Vertical downstream face
2' wide crest
Great slope upstream 70°
large tree extends over right side of spillway

APPROACH CHANNEL

RESERVOIR 2.7 miles long (narrow)

DISCHARGE CHANNEL

Vertical drop to a pool formed by large rocks and boulders some concrete work noted in left portion (apron) of d/s channel at toe of dam. It slopes to stream center, protects water supply line against erosion (channel)

Remove dead tree limbs that have passed over the spillway.

BRIDGE AND PIERS

Gate lift assembly (steel) catwalk and motors appear in good shape. Hand rail noted along top of dam.

GATED SPILLWAY

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Unobserved	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	Vertical discharge to stream.	
BRIDGE AND PIERS	Rises above top of dam. Previous page	
GATES AND OPERATION EQUIPMENT		Forms ungated spillway when gate is closed operated only twice. Unlikely to be operated during storm.

RESERVOIR

VISUAL EXAMINATION OF

OBSERVATIONS

REMARKS OR RECOMMENDATIONS

SLOPES

1' to 8' vertical from water line to elevation where road borders reservoir. Trees and shrubs line shore. Some small docks for fishing visible.

SEDIMENTATION

None observed but 2 trees appeared to rest vertically near dam face so that the top branches can be seen.

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF

OBSERVATIONS

REMARKS OR RECOMMENDATIONS

**CONDITION
(OBSTRUCTIONS,
DEBRIS, ETC.)**

Some dead tree limbs just below toe of dam
Bridge located 100 yds. d/s will cause backwater
effect

SLOPES

30°-40° slopes (wooded)

**APPROXIMATE NO.
OF HOMES AND
POPULATION**

Filtration Plant 2-6 people. Moderately traveled
road along reservoir and bridge below dam

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

REMARKS

ITEM	REMARKS
PLAN OF DAM	Two sets of plans, original done in 1952 and addition done in 1956.
CONSTRUCTION HISTORY	Original dam designed in 1952 to spillway elevation of 88.0 by Perrow & Brockenbrough. Addition designed in 1956 by R. Kenneth Weeks, Engineer.
TYPICAL SECTIONS OF DAM	See Plans
HYDROLOGIC/HYDROLIC DATA	None exists from either design. J. K. Timmons did Phase I Report in 1977 and worked-up Hydrology
DESIGN REPORTS	Not Found
GEOLOGY REPORTS	Not Found
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	A set of structural design notes gives check of existing structure and design of addition.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Only some concrete test cylinder results remain from the addition.
POST-CONSTRUCTION SURVEYS OF DAM	NONE
BORROW SOURCES	NOT KNOWN
SPILLWAY PLAN	See Plans
OPERATING EQUIPMENT PLANS & DETAILS	NONE UNKNOWN

ITEM	REMARKS
MONITORING SYSTEMS	NONE
MODIFICATIONS	N/A
HIGH POOL RECORDS	NONE
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	J. K. Timmons Phase I Report - March 1978
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	NONE
MAINTENANCE OPERATION RECORDS	NONE

**CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA**

DRAINAGE AREA CHARACTERISTICS: Slightly sloped, vegetated, undeveloped

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 95.0

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): NONE

ELEVATION MAXIMUM DESIGN POOL: 95.0 (Should be 1/2 P.M.F. elev. 106.5)

ELEVATION TOP DAM: 100.0

CREST:

- a. Elevation 95.0
- b. Type Concrete - Sharp Crested
- c. Width 1'-0"
- d. Length 155'
- e. Location Spillover Approx. Center Dam
- f. Number and Type of Gates 2 Steel Sluice Gates

OUTLET WORKS:

- a. Type 16" pipe
- b. Location Near Left Abutment
- c. Entrance inverts 88.0
- d. Exist inverts 88.0
- e. Emergency draindown facilities 24" pipe

HYDROMETEOROLOGICAL GAGES: NONE

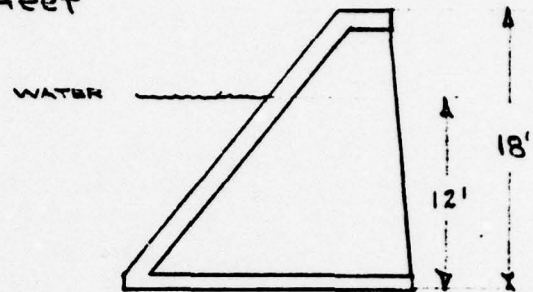
- a. Type _____
- b. Location _____
- c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE: EL. 97.+ -

APPENDIX IV
STRUCTURAL CALCULATIONS

Design of inclined slab

Maximum depth of water is 12 feet



First examine a one foot strip along the bottom
Water pressure

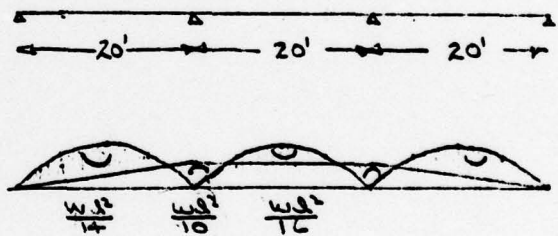
$$12 \times .0624 = .748 \text{ K/ft}^2$$

$$\frac{wL^2}{14} = \frac{.748 \times 20 \times 20}{14} = 21.4 \text{ f-k}$$

$$\frac{wL^2}{10} = \frac{.748 \times 20 \times 20}{10} = 29.9 \text{ f-k}$$

$$\frac{wL^2}{16} = \frac{.748 \times 20 \times 20}{16} = 18.7 \text{ f-k}$$

uniform load .748 K/ft



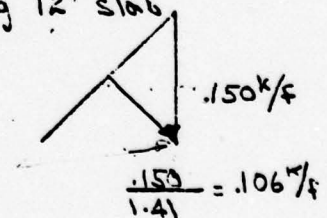
Note — weight of concrete can be ignored in bottom strip since it is resting on rock.

Moment due to weight of concrete — assuming 12" slab

$$\frac{wL^2}{14} = \frac{.106 \times 20 \times 20}{14} = 3.03 \text{ f-k}$$

$$\frac{wL^2}{10} = \frac{.106 \times 20 \times 20}{10} = 4.24 \text{ f-k}$$

$$\frac{wL^2}{16} = \frac{.106 \times 20 \times 20}{16} = 2.65 \text{ f-k}$$



fs _____ Archt _____

Date _____

fc _____ Project _____ Subject _____

Des. By EDR

Examine strip 3 feet from bottom 85
 Moments due to water are proportional to depth
 Depth is 9 feet

$$\frac{9}{12} \times 21.4 = 16.1, \quad \text{Water + Concrete} \quad 16.1 + 3.03 = 19.1 \text{ f-k}$$

$$\frac{9}{12} \times 29.9 = 22.4, \quad 22.4 + 4.24 = 26.6 \text{ f-k}$$

$$\frac{9}{12} \times 18.7 = 14.1, \quad 14.1 + 2.65 = 16.8 \text{ f-k}$$

Examine strip 6 feet from bottom 88
 Depth is 6 feet

$$\frac{6}{12} \times 21.4 = 10.7, \quad 10.7 + 3.03 = 13.7 \text{ f-k}$$

$$\frac{6}{12} \times 29.9 = 14.9, \quad 14.9 + 4.24 = 19.1 \text{ f-k}$$

$$\frac{6}{12} \times 18.7 = 9.3, \quad 9.3 + 2.65 = 12.0 \text{ f-k}$$

Examine strip 9 feet from bottom 91
 Depth is 3 feet

$$\frac{3}{12} \times 21.4 = 5.35, \quad 5.35 + 3.03 = 8.38 \text{ f-k}$$

$$\frac{3}{12} \times 29.9 = 7.48, \quad 7.48 + 4.24 = 11.7 \text{ f-k}$$

$$\frac{3}{12} \times 18.7 = 4.67, \quad 4.67 + 2.65 = 7.32 \text{ f-k}$$

Examine strip at surface of water
 Only moment is from weight of concrete

$$3.03 \text{ f-k}$$

$$4.24 \text{ f-k}$$

$$2.65 \text{ f-k}$$

fs _____ Archt. _____

Date _____

fc _____ Project _____ Subject _____

Des. By EDC

Steel design at bottom

Outer panel

$$M = 21.4 \text{ f-k}$$

$$a = 1.44$$

$$A_s \cdot \frac{M}{\phi d} = \frac{21.4}{1.44 \times 12} = 1.24 \text{ in}^2$$

bottom steel
#8@7 $\frac{1}{2}$ " = 1.26 in²

In front of buttress

$$M = 29.9 \text{ f-k}$$

$$a = 1.44$$

$$A_s \cdot \frac{M}{\phi d} = \frac{29.9}{1.44 \times 12} = 1.73 \text{ in}^2$$

top steel
#10@8" = 1.91 in²

Inner panel

$$M = 18.7 \text{ f-k}$$

$$A_s \cdot \frac{M}{\phi d} = \frac{18.7}{1.44 \times 12} = 1.08 \text{ in}^2$$

bottom steel
#8@8" = 1.19 in²

Steel design 3' from bottom

Outer panel

$$M = 19.1 \text{ f-k}$$

$$a = 1.44$$

$$A_s \cdot \frac{M}{\phi d} = \frac{19.1}{1.44 \times 12} = 1.1 \text{ in}^2$$

bottom steel
#8@8" = 1.19 in²

Front of buttress

$$M = 26.6 \text{ f-k}$$

$$a = 1.44$$

$$A_s \cdot \frac{M}{\phi d} = \frac{26.6}{1.44 \times 12} = 1.54 \text{ in}^2$$

top steel
#10@9" = 1.69 in²

Inner panel

$$M = 16.8 \text{ f-k}$$

$$a = 1.44$$

$$A_s \cdot \frac{M}{\phi d} = \frac{16.8}{1.44 \times 12} = 0.97 \text{ in}^2$$

bottom steel
#8@9" = 1.05 in²

Steel design 6' from bottom

Outer panel

$$M = 13.7 \text{ f-k}$$

$$a = 1.44$$

$$A_s \cdot \frac{M}{\phi d} = \frac{13.7}{1.44 \times 12} = 0.79 \text{ in}^2$$

bottom steel
#7@9" = 0.80 in²

Front of buttress

$$M = 19.1 \text{ f-k}$$

$$a = 1.44$$

$$A_s \cdot \frac{M}{\phi d} = \frac{19.1}{1.44 \times 12} = 1.1 \text{ in}^2$$

top steel
#8@8" = 1.19 in²

Inner panel

$$M = 12.0 \text{ f-k}$$

$$a = 1.44$$

$$A_s \cdot \frac{M}{\phi d} = \frac{12}{1.44 \times 12} = 0.69 \text{ in}^2$$

bottom steel
#7@10" = 0.72 in²

fs _____ Archt _____

Date _____

fc _____ Project _____ Subject _____

Des. By FCP

Steel design 9 feet from bottom

Outer panel

$$M = 8.38 \text{ FK} \quad A_s = \frac{M}{\sigma d} = \frac{8.38}{1.44 \times 12} = 0.49 \text{ in}^2$$

bottom steel
#6 @ 10" = 0.53 in²

$$d = 1.44$$

Front of buttress

$$M = 11.7 \text{ F-K} \quad A_s = \frac{M}{\sigma d} = \frac{11.7}{1.44 \times 12} = 0.68 \text{ in}^2$$

top steel
#7 @ 10" = 0.72 in²

$$d = 1.44$$

Inner panel

$$M = 7.32 \text{ FK} \quad A_s = \frac{M}{\sigma d} = \frac{7.32}{1.44 \times 12} = 0.42 \text{ in}^2$$

bottom steel
#6 @ 12" = 0.44 in²

$$d = 1.44$$

steel design at surface of water

Outer panel

$$M = 3.03 \text{ F-K} \quad A_s = \frac{M}{\sigma d} = \frac{3.03}{1.44 \times 12} = 0.18 \text{ in}^2$$

bottom steel
#6 @ 12" = 0.31 in²

$$d = 1.44$$

Front of Buttress

$$M = 4.24 \text{ F-K} \quad A_s = \frac{M}{\sigma d} = \frac{4.24}{1.44 \times 12} = 0.25 \text{ in}^2$$

top steel
#5 @ 12" = 0.31 in²

$$d = 1.44$$

Inner panel

$$M = 2.65 \text{ F-K} \quad A_s = \frac{M}{\sigma d} = \frac{2.65}{1.44 \times 12} = 0.15 \text{ in}^2$$

bottom steel
#5 @ 12" = 0.31 in²

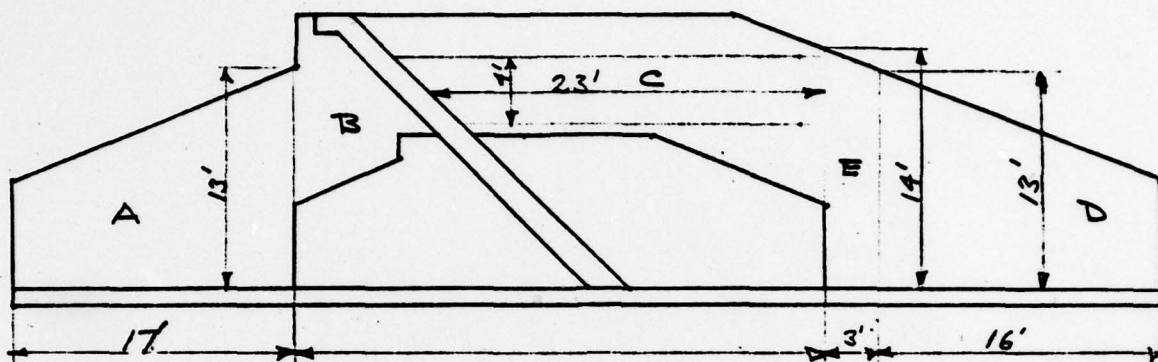
$$d = 1.44$$

Temperature steel - (minimum A_s allowed)

$$.002 \times 12 \times 13 = 0.312 \text{ in}^2/\text{ft of width}$$

$$\text{use } \#5 @ 12" \text{ o.c.} - A_s = 0.31 \text{ in}^2/\text{ft}$$

Design of retaining wall

Thickness of existing wall
is 14"

Sections A & D are designed as conventional retaining walls. Section B is reinforced as a continuation of A. Section C is designed as a horizontal beam supported by the end of the dam slab and section E. Section E is designed as a retaining wall carrying the earth behind it and the reaction from the end of section C.

Section 'C'

Span = 23'

Pressure at top = 0

bottom = $7 \times 30 = 210$ psf

Load per linear foot

$$\frac{210 + 0}{2} \times 7 = 735 \text{ lb}$$

Assume this load is carried

by a 4' band of reinforcing

$$\frac{735}{4} = 184 \text{ lb/ft} = .184 \text{ K}$$

$$M = \frac{wL^2}{8} = \frac{.184 \times 23^2}{8} = 12.2 \text{ F-K}$$

$$A_s = \frac{M}{f_s d} = \frac{12.2 \times 1000 \times 12}{20,000 \times .87 \times 12} = .79 \text{ in}^2/\text{ft}$$

2.8" in 4' band

use 9 #5 bars $A_s = 2.71 \text{ in}^2$

Section E

Reaction from end of section 'C'

$$735 \times \frac{23}{2} = 8,450^{\#}$$

distributed over a 3' band width $\frac{8450^{\#}}{3} = 2,850^{\#}$
per foot of width

Earth force per foot of width

maximum pressure

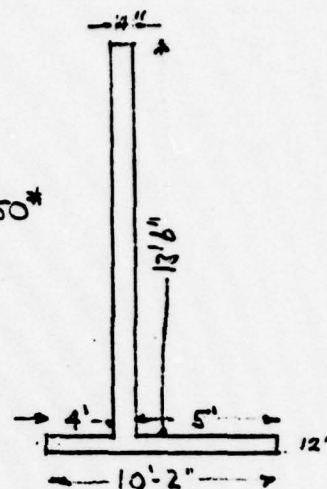
$$13.5 \times 30 = 405 \text{ psf}$$

total load

$$\frac{405 + 0}{2} \times 13.5 = 2,730^{\#}$$

point of action

$$\frac{13.5}{3} = 4.4' = 4'-5" \text{ up from base - add } 1'-0" \text{ for base} = 5'-5"$$



Stability

Resisting moments

Footing - $10.13 \times 1 \times 150 = 1,520^{\#} \times 5.08 = 7,720^{\#}$

stem - $13.5 \times 1.13 \times 150 = 2,290^{\#} \times 4.58 = 10,500^{\#}$

Earth - $13.5 \times 5 \times 100 = 6,750^{\#} \times 7.66 = 51,700^{\#}$

Overturning moments

Earth $2,730^{\#} \times 5.4 = 14,700^{\#}$

Reaction from 'C' $2,850^{\#} \times 12.0 = 34,200^{\#}$

$69,920^{\#}$
 $48,900^{\#}$

Safety factor = $\frac{69,920}{48,900} = 1.43$

Extend heel to 6' long

Added resisting moments

Earth $13.5 \times 1 \times 150 = 2,020^{\#} \times 10.66 = 21,400^{\#}$

Concrete $1 \times 1 \times 150 = 150 \times 10.66 = 1,600^{\#}$

$23,000^{\#}$

Total resisting moment

$69,920$
 $23,000$
 $92,920^{\#}$

added wt. $2,020$
 150
 $2,170$

Safety factor

$\frac{92,920}{48,900} = 1.9 - \text{O.K.}$

Location of resultant

$$\begin{array}{r} 72,720 \\ 48,900 \\ \hline 44,020 \end{array}$$

$$\begin{array}{r} \text{Total weight} \\ 10,560 \\ 2,170 \\ \hline 12,730 \end{array}$$

$$\frac{44,020}{12,730} = 3.46' \text{ from tip of toe}$$

Pressure on soil

$$\frac{11.16}{2} - 3.46 = 2.12 > \frac{11.16}{6} = 1.86 \text{ hence force lies outside of middle third}$$

$$P = \frac{P}{A} = \frac{Mc}{I} = \frac{P}{bh} = \frac{6Pe}{bh^2} = \frac{12,730}{1 \times 11.16} = \frac{6 \cdot 12,730 \cdot 2.12}{1 \times 11.16 \cdot 11.16}$$

$$P = 1,140 \pm 1,300$$

$$P = 2,440 \text{ psf or } \underline{-160 \text{ psf}} \text{ at end of heel}$$

Reinforcing at base of stem

$$M = 2730 \times 4.4' = 12,000' \#$$

$$2,850 \times 11.0 = \underline{31,400' \#}$$

$$43,400' \# = 43.4 \text{ F-K.}$$

$$A_s = \frac{M}{f_s d} = \frac{43,400 \times 12}{20,000 \times 37 \times 12}$$

$$A_s = 2.5 \text{ sq. in./ft} - \text{too much}$$

change the layout of the retaining wall so that the supporting band E is 2' wide and put a 3' buttress behind it. Effective depth is 48" Total load from band 'c' is now spread over 2' - hence reaction is

$$\frac{8450}{2} = 4225' \text{ moment from reaction is } 4225 \times 11 = 46,500' \#$$

$$\text{Total moment is } 46,500 + 12,000 = 58,500' \#$$

$$A_s = \frac{M}{f_s d} = \frac{58,500 \times 12}{20,000 \times 37 \times 48} = 0.84 \text{ sq. in./ft or } 1.68 \text{ sq. in. total}$$

for buttress - use 6 # 5 bars $A_s = 1.86 \text{ sq. in.}$

Location of cut off for 2 bars

A_s for 4 bars is 1.24⁵" or 0.62⁵" for 1 bar width

$$0.62 = \frac{M}{20,000 \cdot 87 \cdot 48}, \quad M = 0.62 = 20,000 \cdot 87 \cdot 48$$

$$m = 516,000 \text{ in}^2 = 43,000 \text{ ft}^2$$

Bond

$$v = \frac{V}{2.14} = \frac{6955}{5.9 \cdot 87 \cdot 48}$$

$$v = 283 \text{ psi} - \text{o.k.}$$

Try 4' above top of footing
Moment due to reaction from 'c'

$$4225 \times 7 = 29,600 \text{ ft}^2$$

Moment due to earth

$$\frac{9.5 \times 30}{2} \times 9.5 \times 3.2 = 4,330 \text{ ft}^2$$

$$\text{Total moment is } 4,330 + 29,600 = 33,930 \text{ ft}^2 < 43,000 \text{ ft}^2$$

Try 3' above top of footing

Moment due to reaction from 'c'

$$4225 \times 8 = 33,800 \text{ ft}^2$$

Moment due to earth

$$\frac{10.5 \times 30}{2} \times 10.5 \times 3.5 = 5,800 \text{ ft}^2$$

$$\text{Total moment is } 5,800 + 33,800 = 39,600 \text{ ft}^2 < 43,000 \text{ ft}^2$$

Try 2.5' above top of footing.

Moment due to reaction from 'c'

$$4225 \times 8.5 = 35,900 \text{ ft}^2$$

Moment due to earth

$$\frac{11 \times 30}{2} \times 11 \times 3.67 = 6,650 \text{ ft}^2$$

$$\text{Total moment} = 35,900 + 6,650 = 42,550 \text{ ft}^2$$

$$\text{Add 24 bar diameters} - 24 \times \frac{5}{8} = 15"$$

$$15" + 30" + 45"$$

Hence stop 2 of the bars 3'-9" from top of footing.

Shear at base of section

horizontal thrust due to earth

$$V = \frac{13.5 \times 30}{2} \times 13.5 = 2,730$$

horizontal thrust from c

$$+2225 \text{ ft}^2$$

Total 2730

$$4225$$

$$6,955 \text{ ft}^2$$

check shear

$$v = \frac{V}{b \cdot d} = \frac{6955}{12 \times .87 \times 48} = 13.9 \text{ psi} - \text{O.K.}$$

Toe of Footing
Loads

Concrete

$$1'-0" \times 150 = 150 \text{ psf}$$

$$\text{at toe } 2440 - 150 = 1990 \text{ psf}$$

under face of stem

$$1990 - (4 \times 233) = 1058 \text{ psf}$$

Shear

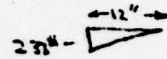
$$V = 4 \times \frac{1990 + 1058}{2} = 6,100^*$$

$$v = \frac{V}{b \cdot d} = \frac{6,100}{12 \times .87 \times 10} = 585 \text{ psi} - \text{O.K.}$$

Soil pressure change

$$2440 - (-16) = 2600$$

$$\frac{2600}{11.0} = 233^*/ft$$



Bond

$$u = \frac{V}{\Sigma o \cdot d} = \frac{6100}{5.9 \times .87 \times 10}$$

$$v = 119 \text{ psi} - \text{O.K.}$$

Moment about face of stem

$$M = 1058 \times 4 \times 2 = 8460' \#$$

$$= \frac{933}{2} \times 4 \times 2.67 = 4,970' \#$$

$$13,430' \#$$

$$A_s = \frac{M}{f_s \cdot d} = \frac{13,430 \times 12}{20,000 \times .87 \times 10} = 926^*/ft = 1.85^{\#}/ft \text{ under buttress}$$

use 6 # 5 bars $A_s = 1.86^{\#}$

Heel of footing

$$6 \times 13.5 \times 100 = 8100^*$$

$$1 \times 6 \times 150 = 900$$

$$\frac{900}{9,000}$$

Moment about back of stem

$$9000 \times 3 = 27,000' \#$$

$$\frac{160}{2} \times .68 \times 5.65 = 307' \#$$

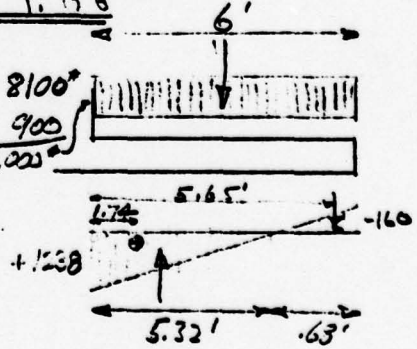
$$27,307' \#$$

$$+ 27,307' \#$$

$$\frac{1238}{2} \times 5.32 \times 1.74 = -5720' \#$$

$$- 5,720' \#$$

$$+ 21,587' \#$$



$$A_s = \frac{M}{f_s \cdot d} = \frac{21,587 \times 12}{20,000 \times .87 \times 10} = 149^{\#}/ft = 2.98^{\#} \text{ in the buttress band}$$

use 5 # 7 $A_s = 3.00^{\#}$

check shear

$$V = 9000 + \left(\frac{160}{2} \times 68\right) - \left(\frac{1238}{2} \times 5.32\right) = 9000 + 58.5 - 3290 = 5768$$

$$v = \frac{V}{b \cdot d} = \frac{5768}{12 \times 87 \times 10} = 55.2 \text{ psi} - \text{o.k.}$$

$$\text{bond } v = \frac{V}{\Sigma o \cdot d} = \frac{5768}{6.6 \times 37 \times 10}$$

$$v = 100 \text{ psi} - \text{o.k.}$$

Design of sections A & D - both will have the same steel and will be designed for a height of 13'.

stability

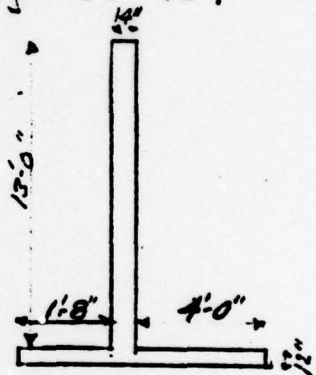
Resisting moment

$$\text{Footing} - 6.83 \times 1 \times 150 = 1025' \times 3.41 = 3049'$$

$$\text{Stem} - 13 \times 1.16 \times 150 = 2268' \times 2.3 = 5200'$$

$$\text{Earth} - 4 \times 13 \times 100 = 5200' \times 4.83 = 25,100'$$

$$W = 8485' \quad M = 33,344'$$



Overturning moment

$$\frac{13 \times 30}{2} \times 13 \times 4.33 = 11,000'$$

Location of resultant

$$\frac{33,349}{11,000} = 3.03$$

$$\frac{22,349}{8,485} = 2.64' \text{ from toe}$$

Factor of safety

$$\frac{33,349}{11,000} = 3.03 - \text{o.k.}$$

Soil pressure

Eccentricity of resultant

$$\frac{6.83}{2} - 2.64 = 0.77 < \frac{6.83}{6} \text{ hence resultant lies in middle third.}$$

$$P = \frac{P}{A} \pm \frac{M_c}{I} = \frac{P}{bh} \pm \frac{6Pe}{bh^2} = \frac{3485}{1 \times 6.83} \pm \frac{6 \times 8435 \times 0.77}{1 \times 6.83^2 \times 6.83} = 1240 \pm 840$$

$$\text{Toe pressure} = 1240 + 840 = 2080 \text{ psf}$$

$$\text{heel pressure} = 1240 - 840 = 400 \text{ psf}$$

Shear at base of stem

$$V = \frac{13 \times 30}{2} \times 13 = 2540 \#$$

$$v = \frac{V}{b \times d} = \frac{2540}{12 \times .87 \times 12} = 20.3 \text{ psi} - \text{O.K.}$$

Moment at base of stem

$$M = \frac{2540 \times 13}{3} = 11,000 \#'$$

$$A_s = \frac{M}{f_s \times d} = \frac{11,000 \times 12}{20,000 \times .87 \times 12} = .632 \text{ in}^2/\text{ft} - \text{use } 5 @ 6 \frac{1}{2} \text{ in}, A_s = .62 \text{ in}^2/\text{ft}$$

Location of cut-off point for half of bars

$$A_s = .31 \text{ in}^2/\text{ft}$$

$$.31 = \frac{M}{20,000 \times .87 \times 12} = 64,900 \#'$$

$$M = 5,400 \#'$$

Try 2' up from top of footing

$$M = \frac{11 \times 30}{2} \times 11 \times 3.67 = 6,650 \#' - \text{too big}$$

Try 2½' up from top of footing

$$M = \frac{10.5 \times 30}{2} \times 10.5 \times 3.5 = 5,790 \#' - \text{too big}$$

Try 3' up from top of footing

$$M = \frac{10 \times 30}{2} \times 10 \times 3.2 = 4,950 \#' - \text{O.K.}$$

$$\text{add } 24 \text{ bar diameters } 24 \times \frac{5}{8} = 15" = 1'-3"$$

$$\text{Cut off } \frac{1}{2} \text{ of steel } 4'-3" \text{ from top of footing } \frac{+3}{4'-3"}$$

bond on steel

$$u = \frac{V}{200d} = \frac{2540}{3.9 \times .87 \times 12} = 62.3 \text{ psi} - \text{O.K.}$$

Toe

Loads - concrete $1 \times 150 = 150$ psf
 at toe $2080 - 150 = 1930$ psf
 face of stem $1930 - (1.67 \times 246) = 1520$ psf

slope of pressure
 diagram

$$\frac{2080}{400} = 5.2$$

shear
 $V = 1.67 \times \left(\frac{1930 + 1520}{2} \right) = 2880$

$$\frac{1680}{6.83} = 246 \text{ psf/ft}$$

$$v = \frac{V}{b \cdot d} = \frac{2880}{12 \times .87 \times 10} = 27.5 \text{ psi} - \text{O.K.}$$

moment about face of stem

$$M_1 = 1520 \times 1.67 \times .83 = 2100' \text{ ft}$$

$$M_2 = 410 \times \frac{1.67 \times 1}{2} = 340' \text{ ft}$$

$$2440' \text{ ft}$$

$$A_s = \frac{M}{f_s \cdot d} = \frac{2440 \cdot 12}{20,000 \cdot .87 \times 10} = .1685 \text{ in}^2/\text{ft} - \text{use } 3\#8 \text{ @ } 12", A_s = .17 \text{ in}^2/\text{ft}$$

bond
 $u = \frac{V}{\sum A_s \cdot d} = \frac{2880}{1.8 \times .87 \times 10} = 184 \text{ psi} - \text{O.K.}$

Heel

shear

$$d = 1450 \times 4 = 5800$$

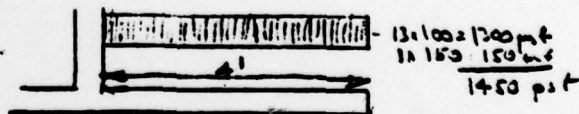
$$l = 400 \times 4 = 1600$$

$$1 = 984 \times 4 \times \frac{1}{2} = 1968$$

1600
1968
3568

$$V = \frac{5800 - 3568}{2232} = 1.0$$

$$v = \frac{V}{b \cdot d} = \frac{2232}{12 \times .87 \times 10} = 21.5 \text{ psi} - \text{O.K.}$$



Moment about face of stem

$$M_1 = 1450 \times 4 \times 2 = 11,600' \text{ ft}$$

$$M_2 = 400 \times 4 \times 2 = 3,200' \text{ ft}$$

$$M_3 = 984 \times \frac{4}{2} \times 1.67 = 3,290' \text{ ft}$$

3200
3290
6490

$$M = 11,600 - 6490 = 5,110' \text{ ft}$$

$$A_s = \frac{M}{f_s \cdot s \cdot d} = \frac{5110 \times 12}{20,000 \times .87 \times 10} = .352 \text{ }^{\text{D}}/\text{ft} \quad \text{use } \#4 @ 5" \text{ } \approx .4\%$$

$$v = \frac{V}{s \cdot d} = \frac{2232}{3.1 \times .87 \times 10} = 82.7 \text{ psi} - \text{o.k.}$$

Design of spillway slab & supporting beam

span of slab = 8'

thickness = $11\frac{1}{2}"$

depth of water = 7'

Use 1 foot thick strip

$$\text{Water load} = 7 \times 62.4 = 436.8$$

$$\text{D.l. equal } \frac{11.5}{12} \times 150 = \underline{143.7}$$

$$580.5 \text{ lb/ft}$$

$$M = \frac{wL^2}{8} = \frac{580.5 \times 8^2}{8} = 4644'$$

$$A_s = \frac{M}{f_s \cdot s \cdot d} = \frac{4644 \times 12}{20,000 \times .87 \times 10} = .32'$$

USE #3 @ 4" % $A_s = .33\%$

Span of beam = 17'-6"

load per foot coming in from slab

$$\text{Water} - 5' \times 7' \times 62.4 = 2190'$$

$$\text{Slab} - 4 \times \frac{11.5}{12} \times 150 = 575'$$

$$\text{beam} - 2.25' \times 1.5' \times 150 = \underline{506'}$$

$$3271' / \text{ft of beam}$$

$$M = \frac{1}{8} wL^2 = \frac{1}{8} \cdot 3271 \times 17.5^2 = 125,000'$$

$$A_s = \frac{M}{f_s \cdot s \cdot d} = \frac{125,000 \times 12}{20,000 \times .87 \times 24} = 36'' \text{ use } 3 \text{ } \#10 - A_s = 3.8\%$$

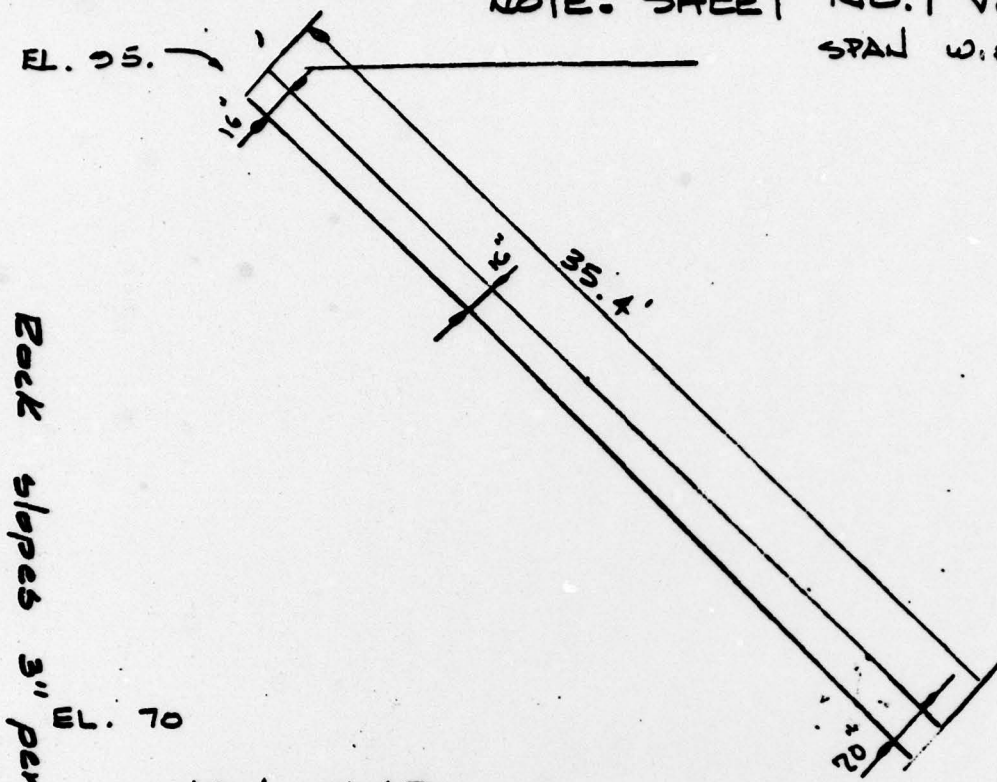
check for shear

$$V = 3271 \times \frac{17.5}{2} = 28,600'$$

$$v = \frac{V}{b \cdot d} = \frac{28,600}{19 \times .87 \times 24} = 722 \text{ psi} < 75 \text{ psi} - \text{o.k.}$$

NOTE: SHEET NO. 1 VOIDED

SPAN WIDTH = 15.92'



Rock slopes 3" per ft.

CHECK SLAB
AT BASE

$$P = .0624(25) = 1.56$$

$$SLAB = \frac{1.67(15)}{1.414} = \frac{.18}{1.74}$$

$$M = 1.74(15.92)^2/8 = 55.2 \text{ k/ft}$$

$$A_s = \frac{55.2}{1.44(17)} = 2.28 \leftarrow \text{AS FURNISHED} = 2.37$$

AT BEV. 74.0

$$P = .0624(24) = 1.31$$

$$SLAB = \frac{.18}{1.49}$$

$$M = 1.49(15.92)^2/8 = 47.5$$

$$A_s = \frac{47.5}{1.44(16)} = 2.07 \leftarrow A_s \text{ furn} = 2.11$$

AT ELEV. 77.0

$$P = .0624(18) = 1.12$$

$$SLAB = \frac{1.58(15)}{1.414} = \frac{.17}{1.29}$$

$$M = 1.29(15.92)^2/8 = 41.5$$

$$A_s = \frac{41.5}{1.44(15)} = 1.86 \leftarrow A_s \text{ furn} = 1.90$$

AT ELEV. 83.0

$$P = .0624(12) = .75$$

$$SLAB = \frac{.17}{1.92}$$

$$M = .72(15.92)^2/8 = 29.5$$

$$A_s = \frac{29.5}{1.44(14)} = 1.47 \leftarrow A_s \text{ furn} = 1.72$$

AT ELEV. 86.5
 $P = 8.5(0.624) = .53$
 $SLAB = \frac{1.33(15)}{1.414} = \frac{.14}{.67}$

$M = .67(15.92)^2/8 = 21.5$
 $A_s = 21.5/1.44(13) = 1.15$
 $A_{s\text{ FURN}} = 1.46$

AT ELEV. 88.0
 $P = 7.0(0.624) = .44$
 $SLAB = \frac{.14}{.58}$

$M = 18.6$
 $A_s = 1.0$ - USE #7@7"

AT ELEV. 91.5
 $P = 3.5(0.624) = .22$
 $SLAB = \frac{.14}{.36}$

$M = 11.3$
 $A_s = .71$ USE - #6@7"

SHEAR ON BUTRESS LIP SUPPORTING SLAB

$R = 14 \text{ K/1}$
 $A = 20(12) = 144$
 $v = 14000/144 = 97 \text{ PSI/1}$ - WP HAS #6 BARS - O.K.

BEARING ON LIP

$R = 14 \text{ K/1}$
 $A = 9(12) = 108$
 $f_c = 14000/108 = 130 \text{ PSI}$ - OK

Comm. No. 1447
369
 fs _____
 fo _____

FRAIOLI-BLUM-YESSELMAN, CONSULTING ENGINEERS

Arch. CAUSEY & WEEKS

Project FALL GR. DAM

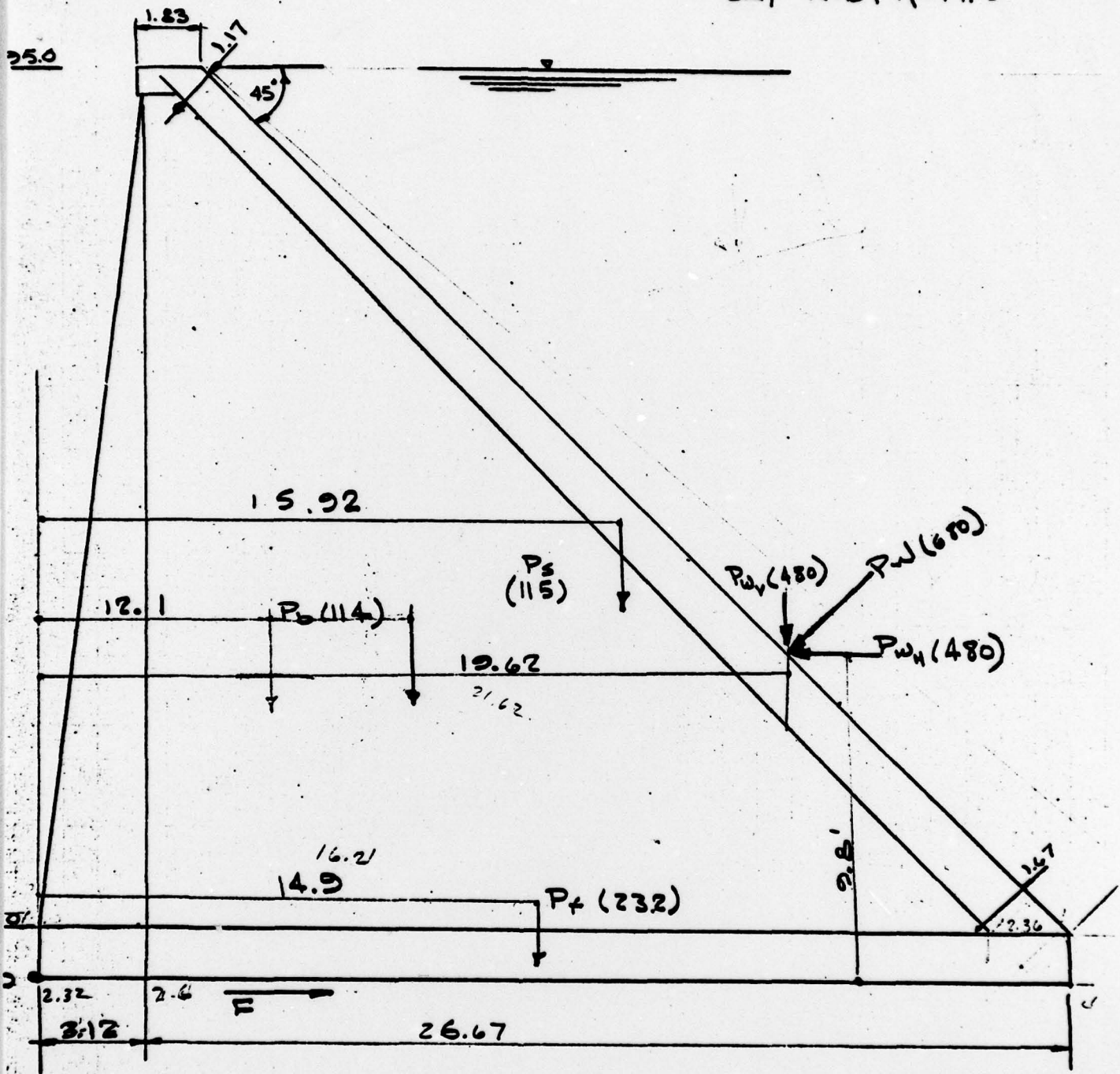
Subject STABILITY

Sheet No. 4

Date 28 AUG 56

Des. By PLG

BAY WIDTH = 17.5'



SLAB - Ps
 $15.33(1.42)(1.5)(35.3) = 115 \text{ K}$

$P_w = .0624(17.5)(35.3)(35.3/2) = 680 \text{ K}$

$P_f = 1.5(1 \times 5)(29.8)(3.46) = 232 \text{ K}$

Pb

$$\frac{250(6.5)(25.67)(2.13)}{2} = 103K$$

$$25/2(1.15)(1.76)(3.12) = \frac{11K}{P_b = 114K}$$

EMo

$$(P_b) 12.1(114) = 1380$$

$$480(9.8) = 4700$$

$$(P_f) 14.9(23.2) = 345$$

$$(P_s) 15.92(115) = 1830$$

$$(P_{wr}) 17.62(480) = 8420$$

$$12,975$$

$$W/R = \frac{8,275}{832} = 9.95 \text{ "3}$$

$$F = \frac{732}{832}(65) = 540$$

$$\text{SLIDING S.F.} = \underline{1.13}$$

$$\text{O.T. S.F.} = \frac{12,975}{4700} = \underline{2.7}$$

SOIL PRESSURE

$$f = \frac{832}{3.46} = 240'$$

$$P_{act} \frac{zf}{l} = \frac{480}{29.75} = \underline{16 \text{ k.s.f.}} = \underline{370 \text{ lb}} \text{ } \rightarrow \text{ft}$$

APPENDIX V
CONCRETE TEST REPORTS

FRC FLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

SINCE  1881

BRANCH LABORATORIES
NORFOLK, CHARLOTTE, RALEIGH
WASHINGTON, BALTIMORE

MAIN OFFICE & LABORATORIES
814 WEST CARY STREET
RICHMOND, VIRGINIA

No. E-4784-10

November 20, 1957

CONCRETE TEST REPORT

Project Addition to Filtration Works, Contract C-1, Chesterfield County, Virginia

Location Sampled Apron slab, Buttress Nos. 2 and 3 Dam

Designed Compressive Strength 3000 lbs. per sq. in. at 28 days. Date moulded 10/22/57

MATERIALS USED — PER CUBIC YARD OF CONCRETE

Cement 5.70 Sacks Brand Lone Star Mfd. at Norfolk, Va.
 Fine Aggregate 1166 Pounds Source _____ Size 100 to #4
 Coarse Aggregate 1950 Pounds Source _____ Size #4 to 1"
 Water 32.8 Gallons, including moisture in aggregates. Gals. water per sack 5.8
 Admixture Pozzolith 3% Solution Amount 5.7 Water-Cement Ratio _____ Slump 2-1/2"
 Made for English Construction Company, Altavista, Virginia
 Received 10/27/57 Condition: _____
 Marked D17, 18, 19, 20

Curing: Field: _____ to _____ F° Damp Sand, _____ to _____ F° Moist Room, 73 F°
 Period: _____ Period: _____ Period: 2 days
23 days

COMPRESSIVE STRENGTH
TYPE OF BREAK



No.	Size Inches	Breaking Load Pounds	Pounds per Sq. In.	Weight Lbs. Per Cu. Ft.	Age at Test	Type of Break	Per Cent Aggregate Broken through Line of Fracture
17	6 x 12	60,500	2140	148.2	7 days	2	1
18	6 x 12	116,000	4103	147.7	28 days	1	6
19	6 x 12	114,000	4032	148.2	28 days	1	5
20	6 x 12	112,000	3961	147.7	28 days	2	5

Conclusions:

- 1 cc English Construction Co., Altavista, Va.
- 1 cc English Construction Co., Rt. 10, Box 144A, Richmond, Va.
- 1 cc R. Kenneth Weeks, Engineers, 6165 E. Sewell Point Rd, Norfolk, Va.
- 1 cc Robert Painter, Engineer, Engineers Office, Chesterfield Courthouse, Chesterfield Co., Va.
- 1 cc Edgar L. White, Res. Eng., 24 E. Belt Boulevard, Richmond, Va.

FROEHLING & ROBERTSON, INC.

Form CT-57

MEMBER: American Society for Testing Materials • American Concrete Institute • American Council of Commercial Laboratories • Virginia Academy of Science
 American Road Builders Association • Southern Association of Science & Industry • Society for Nondestructive Testing
 REPRESENTED IN: American Wood Preservers Association • Association of Asphalt Paving Technologists • American Water Works Association • American Chemical
 Society • American Public Health Association • Technical Association Pulp & Paper Industry

NOV 20 1957
CHESTERFIELD
COUNTY, VA.
ENGINEER'S
OFFICE

FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

SINCE  1881

BRANCH LABORATORIES
NORFOLK, CHARLOTTE, RALEIGH
WASHINGTON, BALTIMORE

MAIN OFFICE & LABORATORIES
814 WEST CARY STREET
RICHMOND, VIRGINIA

No. E-4784-11

November 25, 1957

CONCRETE TEST REPORT

Project Addition to Filtration Works, Contract C-1, Chesterfield County, Virginia

Location Sampled Settling basins, Wall # 4, Also Dam-Beams Buttress Nos. 8 & 9 - 9 & 10

Designed Compressive Strength 3000 lbs. per sq. in. at 28 days. Date moulded 10/26/57

MATERIALS USED — PER CUBIC YARD OF CONCRETE

Cement 5.70 Sacks. Brand Lone Star Mfd. at Norfolk, Va.

Fine Aggregate 1166 Pounds. Source _____ Size 100 to #4

Coarse Aggregate 1950 Pounds. Source _____ Size #4 to 1"

Water 32.8 Gallons, including moisture in aggregates. Gals. water per sack 5.8

Admixture Pozzolith 3% Solution Amount 5.7 quarts. Water-Cement Ratio _____ Slump 2-1/2"

Made for English Construction Company, Altavista, Virginia

Received 10/31/57

Condition: _____

Marked SB Nos. 17, 18, 19, 20

Curing: Field: _____ to _____ F°
Period: _____

Damp Sand, _____ to _____ F°
Period: _____

Moist Room, 73 F°

Period: 2 days
23 days

COMPRESSIVE STRENGTH TYPE OF BREAK

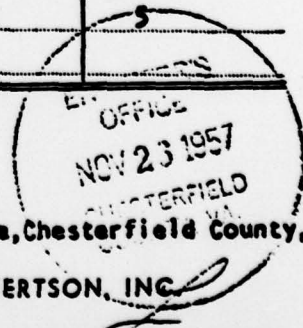


No.	Size Inches	Breaking Load Pounds	Pounds per Sq. In.	Weight Lbs. Per Cu. Ft.	Age at Test	Type of Break	Per Cent Aggregate Broken through Line of Fracture
17	6 x 12	61,000	2157	147.1	7 days	2	3
18	6 x 12	103,000	3643	147.1	28 days	1	5
19	6 x 12	104,500	3696	146.8	28 days	2	7
20	6 x 12	106,000	3749	146.8	28 days	2	5

Conclusions:

- 1 cc English Construction Co. Inc., Altavista, Va.
- 1 cc English Construction Co. Inc., Rt. 10, Box 144A, Richmond, Va.
- 1 cc R. Kenneth Weeks, Engineers, 6165 E. Sewalls Point Rd, Norfolk, Va.
- 1 cc Robert Painter, Engineer, Engineers Office, Chesterfield Courthouse, Chesterfield County, Va.
- 1 cc Edgar L. White, Res. Eng., 24 E. Belt Boulevard, Richmond, Va.

FROEHLING & ROBERTSON, INC.



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American Road Builders Association • Southern Association of Science & Industry • Society for Nondestructive Testing
REPRESENTED IN: American Wood Preservers Association • Association of Asphalt Paving Technologists • American Water Works Association • American Chemical Society • American Public Health Association • Technical Association Pulp & Paper Industry

FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

SINCE  1881

BRANCH LABORATORIES
NORFOLK, CHARLOTTE, RALEIGH
WASHINGTON, BALTIMORE

MAIN OFFICE & LABORATORIES
814 WEST CARY STREET
RICHMOND, VIRGINIA

No. E-4734-10

November 7, 1957

CONCRETE TEST REPORT

Project Addition to Filtration Works, Contract C-1, Chesterfield County, Virginia

Location Sampled Dam-Buttress Nos. 8-9-10 to Elev. 83.0'

Designed Compressive Strength 3000 lbs. per sq. in. at 28 days. Date moulded 10/10/57

MATERIALS USED — PER CUBIC YARD OF CONCRETE

Cement 5.70 Sacks Brand Lone Star Mfd. at Norfolk, Va.

Fine Aggregate 1166 Pounds Source _____ Size 100 to #4

Coarse Aggregate 1950 Pounds Source _____ Size #4 to 1"

Water 32.8 Gallons, including moisture in aggregates. Gals. water per sack 5.8

Admixture pozzolith 3% solution Amount 5.7 qts. Water-Cement Ratio _____ Slump 3"

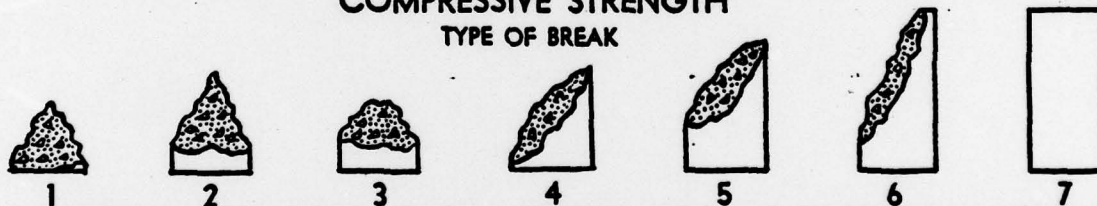
Made for English Construction Company, Altavista, Virginia

Received 10/15/57 Condition: _____

Marked D-13-14-15-16

Curing: Field: _____ to _____ F° | Damp Sand, _____ to _____ F° | Moist Room, 73 F°
Period: _____ | Period: _____ | Period: 2 days
23 days

COMPRESSIVE STRENGTH TYPE OF BREAK



No.	Size Inches	Breaking Load Pounds	Pounds per Sq. In.	Weight Lbs. Per Cu. Ft.	Age at Test	Type of Break	Per Cent Aggregate Broken through Line of Fracture
D-13	6 x 12	71,000	2511	147.7	7 days	1	2
D-14	6 x 12	127,500	4510	148.3	28 days	1	8
D-15	6 x 12	124,500	4404	147.7	23 days	1	6
D-16	6 x 12	120,000	4244	147.7	28 days	2	8

Conclusions:

- 1 cc English Construction Co., Altavista, Va.
- 1 cc English Construction Co., Rt. 10, Box. 144A, Richmond, Va.
- 1 cc R. Kenneth Weeks, Engineers, 6165 E. Sewalls Point Ed., Norfolk, Va.
- 1 cc Robert Painter, Engineer, Engineers Office, Chesterfield Courthouse,
Chesterfield County, Va.
- 1 cc Edgar L. White, Res. Eng., 24 East Belt Boulevard, Richmond, Va.

FROEHLING & ROBERTSON, INC.

Form CT-87

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American Road Builders Association • Southern Association of Science & Industry • Society for Nondestructive Testing
REPRESENTED IN: American Wood Preservers Association • Association of Asphalt Paving Technologists • American Water Works Association • American Chemical

FRC FROHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

SINCE  1881

BRANCH LABORATORIES
NORFOLK, CHARLOTTE, RALEIGH
WASHINGTON, BALTIMORE

MAIN OFFICE & LABORATORIES
814 WEST CARY STREET
RICHMOND, VIRGINIA

No. E-4784-9

September 27, 1957

CONCRETE TEST REPORT

Project Addition to Filtration Works, Contract C-1

Location Sampled Dam Buttrass Pour - Buttrass No. 6

Designed Compressive Strength 3000 lbs. per sq. in. at 28 days. Date moulded 8/30/57

MATERIALS USED — PER CUBIC YARD OF CONCRETE

Cement 5.70 Sacks. Brand Lone Star Mfd. at Norfolk, Va.

Fine Aggregate 1166 Pounds. Source Size 100 to #4

Coarse Aggregate 1950 Pounds. Source Size #4 to 1"

Water 32.8 Gallons, including moisture in aggregates. Gals. water per sack 5.8

Admixture Pozzolith 3% solution Amount 5.70 quarts Water-Cement Ratio Slump 3"

Made for English Construction Company, Inc., Altavista, Virginia

Received 9/3/57

Condition:

Marked D-9, 10, 11 and 12.

Curing: Field: _____ to _____ F°
Period: _____

Damp Sand, _____ to _____ F°
Period: _____

Moist Room, 73 F°
Period: 3 days
24 days

COMPRESSIVE STRENGTH
TYPE OF BREAK



No.	Size inches	Breaking Load Pounds	Pounds per Sq. In.	Weight Lbs. Per Cu. Ft.	Age at Test	Type of Break	Per Cent Aggregate Broken through Line of Fracture
D-9	6 x 12	101,000	3572	147.7	7 days	1	6
D-10	6 x 12	140,100	4952	146.2	28 days	2	10
D-11	6 x 12	152,000	5376	146.7	28 days	1	14
D-12	6 x 12	137,000	4845	147.1	28 days	1	10

Conclusions:

- 1 cc English Construction Company, Altavista, Va.
- 1 cc English Construction Company, Rt. 10, Box 144A, Richmond, Va.
- 1 cc R. Kenneth Weeks, Engineers, 6165 E. Sewells Point Rd, Norfolk, Va.
- 1 cc Robert Painter, Engineer, Engineers Office, Chesterfield Court House, Chesterfield Co., Va.
- 1 cc Edgar L. White, Res. Eng., Rt. 7, Box 458, Richmond, Va.

ENGINEER'S
SEP 30 1957
CHESTERFIELD
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APPENDIX VI

REFERENCES

APPENDIX VI

1. HEC-1DB Flood Hydrograph Package, (Hydrologic Engineering Center, U. S. Army Corps of Engineers, July 1978).
2. "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian," Hydrometeorological Report No. 33, (U. S. Weather Bureau, April 1956).
3. "Rainfall Frequency Atlas of the United States," Technical Paper No. 40, (U. S. Weather Bureau, May 1961).
4. Recommended Guidelines for Safety Inspection of Dams, Office of the Chief of Engineers, Department of the Army, Washington, D. C.
5. INSPECTION REPORT SWIFT CREEK DAM AND FALLING CREEK DAM, CHESTERFIELD CO., VA., J. K. Timmons & Associates, Inc., March, 1978.