Attachment 02.04.03-08R
TVA letter dated February 2, 2010
RAI Response

ASSOCIATED ATTACHMENTS/ENCLOSURES:

Attachment 02.04.03-8R: Dam Rating Curves, South Holston

(196 Pages including Cover Sheet)

NPG CALCULATION COVERSHEET/CCRIS UPDATE

REV 0 EDMS/RIMS NO.	EDMS TYPE:	EDMS ACCESSION NO (N/A for REV. 0)
L58 090224 001	Calculations (nuclear)	L58 091230 029

Calc Title: Dam Rating Curves, South Holston

CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	CUR REV	NEW REV	REVISION APPLICABILITY
CURRENT	CN	NUC	GEN	CEB	CDQ000020080017	0	1	Entire calc ☒ Selected pages ☐
NEW								

ACTION	NEW ☐ REVISION ☒	DELETE ☐ RENAME ☐	SUPERSEDE ☐ DUPLICATE ☐	CCRIS UPDATE ONLY ☐ (Verifier Approval Signatures Not Required)	No CCRIS Changes ☐ (For calc revision, CCRIS been reviewed and no CCRIS changes required)

UNITS	SYSTEMS	UNIDS
N/A	N/A	N/A

DCN,EDC,N/A	APPLICABLE DESIGN DOCUMENT(S)	CLASSIFICATION
*See Below	N/A	E

QUALITY RELATED?	SAFETY RELATED? (If yes, QR = yes)	UNVERIFIED ASSUMPTION	SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?	DESIGN OUTPUT ATTACHMENT?	SAR/TS and/or ISFSI SAR/CoC AFFECTED
Yes ☒ No ☐	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒

PREPARER ID	PREPARER PHONE NO	PREPARING ORG (BRANCH)	VERIFICATION METHOD	NEW METHOD OF ANALYSIS
J. B. Mauter	205-298-6074	CEB	Design Review	☐ Yes ☒ No

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
Janie B. Mauter *Janie B. Mauter*	12/7/09	L. Yu Lin *L. Lin*	12/7/09
VERIFIER SIGNATURE	**DATE**	**APPROVAL SIGNATURE**	**DATE**
L. Yu Lin *L. Lin*	12/7/09	K.E. Spates *K.E. Spates*	12-23-09

STATEMENT OF PROBLEM/ABSTRACT

12/8/09

Dam rating curves (headwater rating curves) for 20 dams are required as inputs to TVA's SOCH and TRBROUTE models, which perform flood-routing calculations for the Tennessee River and tributaries. The dam rating curves provide total dam discharge as a function of headwater elevation. This calculation presents dam rating curves for South Holston Dam.

*EDCN 22404A (SQN), EDCN 54018A (WBN), EDCN Later (BFN)

This calculation contains electronic attachments and must be stored in EDMS as an Adobe .pdf file to maintain the ability to retrieve the electronic attachments.

MICROFICHE/EFICHE Yes ☐ No ☒ FICHE NUMBER(S)

☐ LOAD INTO EDMS AND DESTROY
☒ LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION LIBRARY. ADDRESS: LP4D-C
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TVAN CALCULATION COVERSHEET/CCRIS UPDATE

REV 0 EDMS/RIMS NO.	EDMS TYPE:	EDMS ACCESSION NO (N/A for REV. 0)
L 58 090224 001	Calculations (nuclear)	N/A

Calc Title: Dam Rating Curves, South Holston

CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	CUR REV	NEW REV	REVISION APPLICABILITY
CURRENT	CN	NUC						Entire calc ☐ Selected pages ☐
NEW	CN	NUC	GEN	CEB	CDQ000020080017	N/A	0	

ACTION	NEW ☒ REVISION ☐	DELETE ☐ RENAME ☐	SUPERSEDE ☐ DUPLICATE ☐	CCRIS UPDATE ONLY ☐ (Verifier Approval Signatures Not Required)	No CCRIS Changes ☐ (For calc revision, CCRIS been reviewed and no CCRIS changes required)

UNITS	SYSTEMS	UNIDS
N/A	N/A	N/A

DCN,EDC,N/A	APPLICABLE DESIGN DOCUMENT(S)	CLASSIFICATION
N/A	N/A	E

QUALITY RELATED?	SAFETY RELATED? (If yes, QR = yes)	UNVERIFIED ASSUMPTION	SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?	DESIGN OUTPUT ATTACHMENT?	SAR/TS and/or ISFSI SAR/CoC AFFECTED
Yes ☒ No ☐	Yes ☒ No ☐	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒

PREPARER ID	PREPARER PHONE NO	PREPARING ORG (BRANCH)	VERIFICATION METHOD	NEW METHOD OF ANALYSIS
W. H. Roberts	632-6465	CEB	Design Review	☐ Yes ☒ No

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
Wallace H. Roberts	2-6-09	Chris Triplett	02/10/09
VERIFIER SIGNATURE	**DATE**	**APPROVAL SIGNATURE**	**DATE**
Dr. L. Lin	02/10/09	K. R. Spates	2-23-09

STATEMENT OF PROBLEM/ABSTRACT

Dam rating curves (headwater rating curves) for 20 dams are required as inputs to TVA's SOCH and TRBROUTE models, which perform flood-routing calculations for the Tennessee River and tributaries. The dam rating curves provide total dam discharge as a function of headwater elevation. This calculation presents dam rating curves for South Holston Dam.

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MICROFICHE/EFICHE Yes ☐ No ☐ FICHE NUMBER(S)

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☒ LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION LIBRARY. ADDRESS: LP4D-C
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NPG CALCULATION COVERSHEET/CCRIS UPDATE

CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	REV
	CN	NUC	GEN	CEB	CDQ000020080017	1

ALTERNATE CALCULATION IDENTIFICATION

BLDG	ROOM	ELEV	COORD/AZIM	FIRM BWSC	Print Report Yes ☐

CATEGORIES NA

KEY NOUNS (A-add, D-delete)

ACTION (A/D)	KEY NOUN	A/D	KEY NOUN

CROSS-REFERENCES (A-add, C-change, D-delete)

ACTION (A/C/D)	XREF CODE	XREF TYPE	XREF PLANT	XREF BRANCH	XREF NUMBER	XREF REV
A	P	EN	WBN	CEB	54018	
A	P	EN	SQN	CEB	22404	
A	S	CN	GEN	CEB	CDQ000020080053	
D	S	CN	GEN	CEB	CDQ000020080054	

CCRIS ONLY UPDATES:
Following are required only when making keyword/cross reference CCRIS updates and page 1 of form NEDP-2-1 is not included:

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
PREPARER PHONE NO.	EDMS ACCESSION NO.		

NPG CALCULATION RECORD OF REVISION	
CALCULATION IDENTIFIER CDQ000020080017	
Title	Dam Rating Curves, South Holston
Revision No.	DESCRIPTION OF REVISION
0	Initial issue
1	This calculation was revised to address the following: • PER 203951. The verification of the original calculation was completed by personnel who had not completed the required NEDP-7 Job Performance Record (JPR). A verification JPR is now in place for all personnel engaged in verification tasks. Checking includes only changes made in this revision as the checking of the calculation was not impacted by PER 203951. The verification is inclusive of work completed prior to this revision. • PER 203872. Replace NEDP-2 forms on Pages 1 through 6 with the forms from the NEDP-2 Revision in effect at the time of calculations issuance • UVA 3.2.1. Removed and replaced with Assumption 3.1.2 based on Technical Justification. • UVA 3.2.2. Removed based on validation previously included in Section 1 – Purpose. Significant changes to text are marked with a right hand margin revision bar. Administrative changes and typos are excluded. Pages Deleted: None Pages Revised: 1 - 4, 6, 13, 14 New Pages Added: 1a, 5 Total hardcopy pages Revision 1: 105 Additional Comments: • Updated Coversheet and CCRIS form to included EDCN numbers and add/revise calculation references. • Updated page numbers • Added Reference 2.10 to page 13

NPG CALCULATION TABLE OF CONTENTS

Calculation Identifier: CDQ000020080017	Revision: 1	

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C	Flow Through Bent Branch Spillway	15 pages
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1	Selected South Holston Project Drawings (Ref. 2.1.1 thru 2.1.10)	11 pages
2	"South Holston Dam Howell-Bunger Valve Discharge Tables" (Ref. 2.5)	7 pages
3	TVA Report No. 18-10-1, "Advance Report No. 1 South Holston Model Studies" (Ref. 2.3)	22 pages
4	South Holston Tailwater Rating Curve (Ref. 2.4)	4 pages
5	South Holston Rating Curves rev.0A	N/A
6	Bent Branch Spillway	N/A
7	South Holston WCP Manual	51 pages
8	South Holston Model Studies	21 pages
9	Tailwater	3 pages
10	South Holston Howell-Bunger Valve Discharge Tables	6 pages
11	Selected South Holston Project Drawings	10 pages

N/A indicates an electronic file that is not paginated.
See listing of electronic attachments on page 6

NPG CALCULATION VERIFICATION FORM

Calculation Identifier CDQ000020080017 Revision 1

Method of verification used:

1. Design Review ☒
2. Alternate Calculation ☐
3. Qualification Test ☐

Verifier L.Yu Lin Date 12/7/09

L. Lin

Comments:

This calculation entitled, "Dam Rating Curves, South Holston" was verified by independent design review. The process involved a critical review of the calculation to ensure that it is correct and complete, uses appropriate methodologies, and achieves its intended purpose. The inputs were reviewed and determined to be appropriate inputs for this calculation. The results of the calculation were reviewed and were found to be reasonable and consistent with the inputs provided. Backup files and documents were consulted as necessary to verify data and analysis details found in the calculation.

Detailed comments and editorial suggestions for the changes made in this revision were transmitted to the author and reviewer by email along with a marked up copy of the calculation.

(Note: The design verification of this calculation revision is for the total calculation, not just the changes made in the revision. This complete re-verification is performed to disposition PER 203951 as described in the Calculation Revision Log on Page 3.)

NPG COMPUTER INPUT FILE
STORAGE INFORMATION SHEET

Document CDQ000020080017	Rev. 1	Plant: GEN	

Subject:
Dam Rating Curves, South Holston

☐ Electronic storage of the input files for this calculation is not required. Comments:

☒ Input files for this calculation have been stored electronically and sufficient identifying information is provided below for each input file. (Any retrieved file requires re-verification of its contents before use.)

These files are electronically attached to the parent ADOBE.pdf calculation file. All files are therefore stored in an unalterable medium and are retrievable through the EDMS number for this calculation.

Attachment 5: "South Holston Rating Curves rev.0A.xls", Excel spreadsheet for dam rating curve calculations
Attachment 6: "Bent Branch Spillway.xls", Excel spreadsheet
Attachment 7: "South Holston WCP Manual.pdf "TVA Water Control Project Manual (Blue Book) for South Holston Dam, TVA River Operations, September, 1999
Attachment 8: "South Holston Model Studies.pdf "TVA Report No. 18-10-1, "Advance Report No. 1 South Holston Model Studies", June 1944 (Ref. 2.3)
Attachment 9: "Tailwater.pdf", River Scheduling, Tennessee Valley Authority (Ref. 2.4)
Attachment 10: "South Holston Howell-Bunger Valve Discharge Tables.pdf," Tennessee Valley Authority, July 1974 (Ref. 2.5)
Attachment 11: Selected South Holston Project Drawings (Ref. 2.1.1 thru 2.1.10)

☐ Microfiche/eFiche

1. Purpose

Dam rating curves (headwater rating curves) for twenty dams geographically located on the Tennessee River and its tributaries above the existing Bellefonte Nuclear facility are required as inputs to TVA's SOCH and TRBROUTE models, which perform flood-routing calculations. The dam rating curves for each dam provide total dam discharge as a function of headwater elevation. This calculation presents the dam rating curve for South Holston Dam.

TVA developed methods of analysis, procedures, and computer programs for determining design basis flood levels for nuclear plant sites in the 1970's. Determination of maximum flood levels included consideration of the most severe flood conditions that may be reasonably predicted to occur at a site as a result of both severe hydrometerological conditions and seismic activity. This process was followed to meet Nuclear Regulatory Guide 1.59. At that time, there were no computer programs available that would handle unsteady flow and dam failure analysis. As a result of this early work and method development TVA developed a runoff and stream course modeling process for the TVA reservoir system. This process provided a basis for currently licensed plants (Sequoyah Nuclear Plant, Watts Bar Nuclear Plant, and Browns Ferry Nuclear Plant). The Bellefonte Nuclear Plant (BLN) Units 1 & 2 Final Safety Analysis Report (FSAR) was also based on this process.

BLN Unit 3 & 4 Combined Operating License Application (COLA) was submitted using data and analysis that was determined for the original BLN FSAR (Unit 1 and Unit 2) and was documented in a 1998 reassessment. In 1998, the analysis process and documentation was brought under the nuclear quality assurance process for the first time. A quality assurance audit conducted by NRC staff in early 2007 raised several questions related to past work regarding design basis flood level determinations. This calculation supports a portion of the effort to improve the design basis documentation.

Preparation of all calculations supporting nuclear development and licensing are subject to TVA Standard Department Procedure NEDP-2. This standard dictates the process in which calculations are prepared, checked, verified, stored, and cross referenced in a goal to provide the highest quality nuclear design input and output possible.

South Holston is an impervious rolled fill dam with a rock face and a minimum top elevation of 1765'. An impervious rolled fill saddle dam is located approximately 4.5 miles north-east of the main dam. During normal operation discharge is passed through the power conduit to the powerhouse and through a concrete sluiceway tunnel. Flow through the sluiceway is controlled by two Howell-Bunger valves. During flood conditions discharge can pass through a morning-glory spillway with a crest elevation of 1742' located near the main dam and an auxiliary weir spillway with a crest elevation of 1744' located approximately a mile south of the main dam. The auxiliary spillway empties into Bent Branch which flows into the South Fork Holston River about 2.5 miles below the main dam and powerhouse. The sluiceway tunnel merges into the morning-glory spillway tunnel, and the common tunnel empties into a stilling basin just below the dam. Figures 1 through 7 show general arrangement information for the main dam, the main (morning-glory) spillway, the sluiceway, the Bent Branch spillway, the saddle dam and the conduit to the powerhouse. The rating curve is developed in this calculation for headwater elevations up to 1765' which is above the 1764.7' probable maximum flood (PMF) elevation listed on page 15 of the South Holston Blue Book (Ref. 2.2).

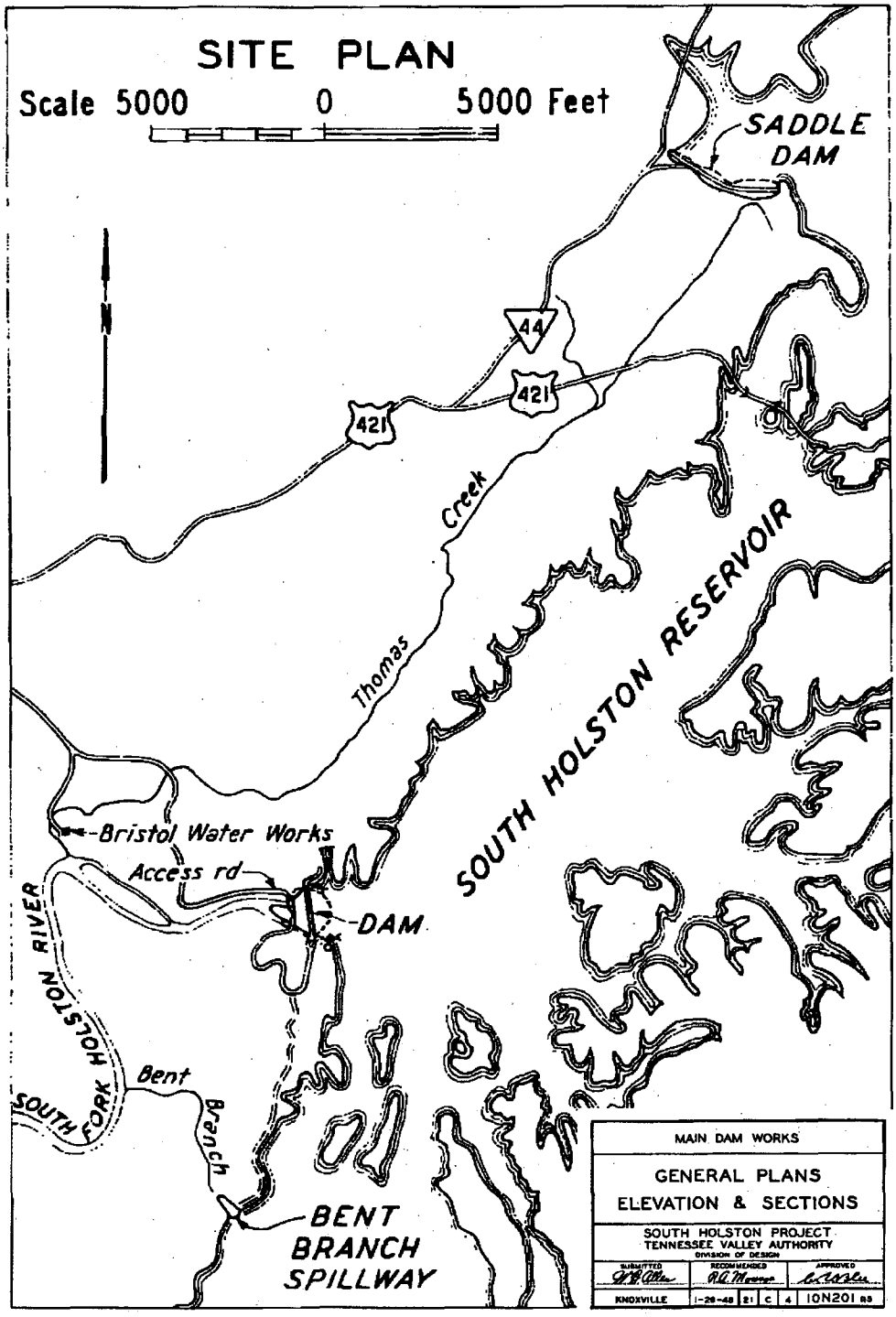


Figure 1 – South Holston Project, General Arrangement (Ref. 2.2).

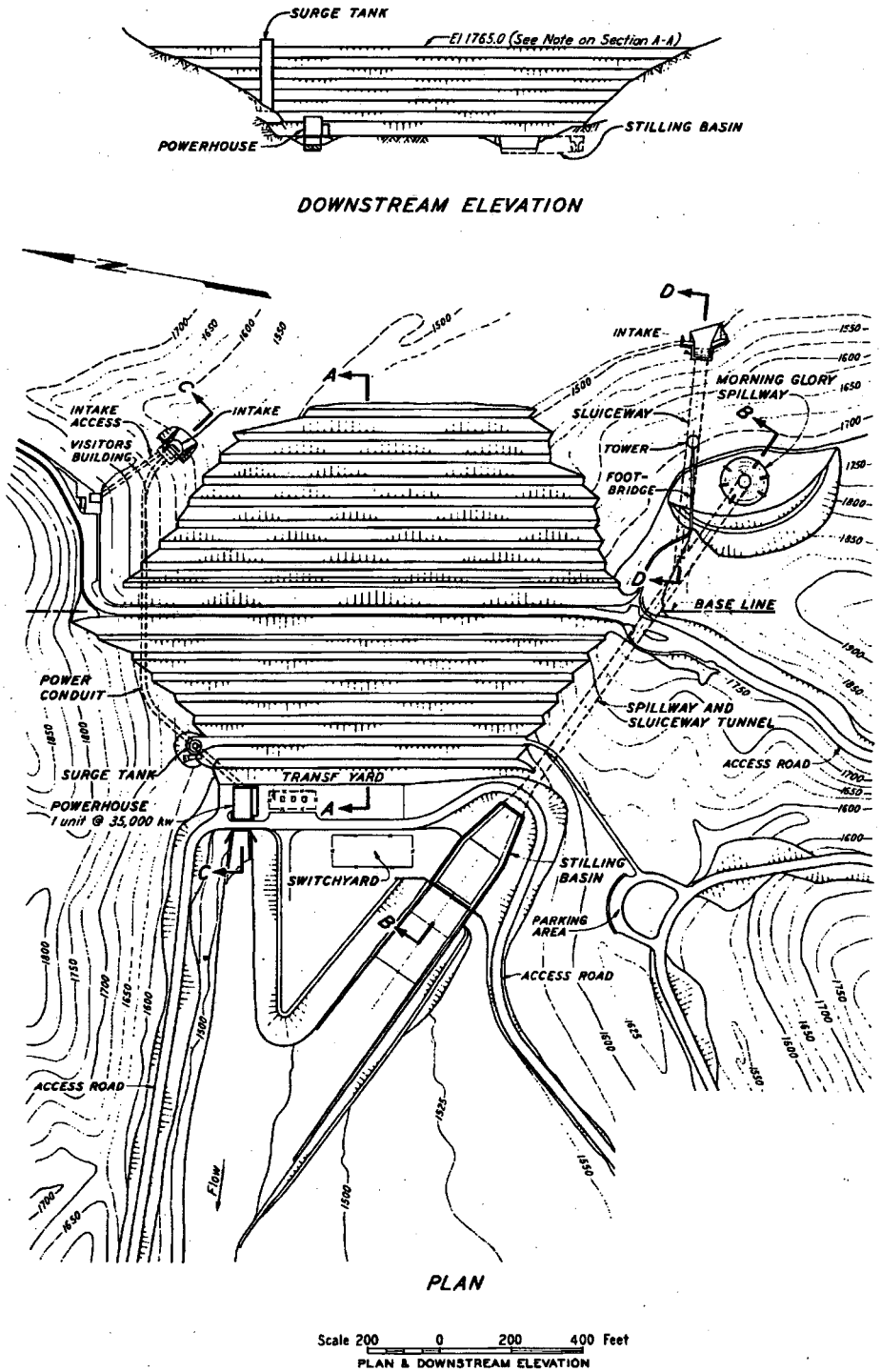


Figure 2 – South Holston Dam, General Plan and Elevation (Ref. 2.2).

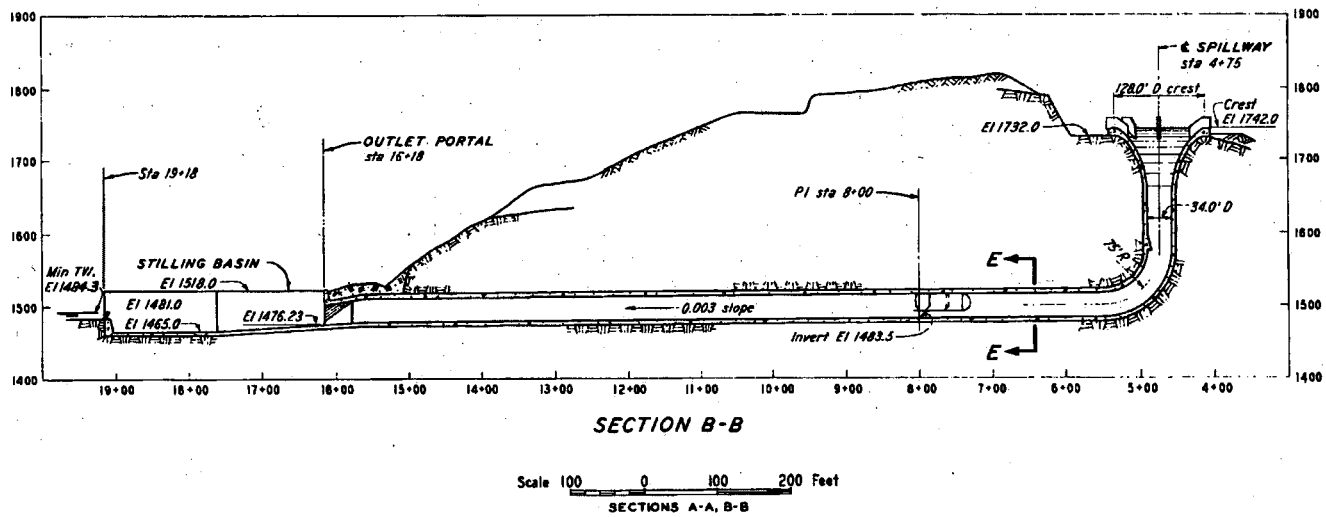


Figure 3 – South Holston Dam, Sections Through Spillway (Ref. 2.2).

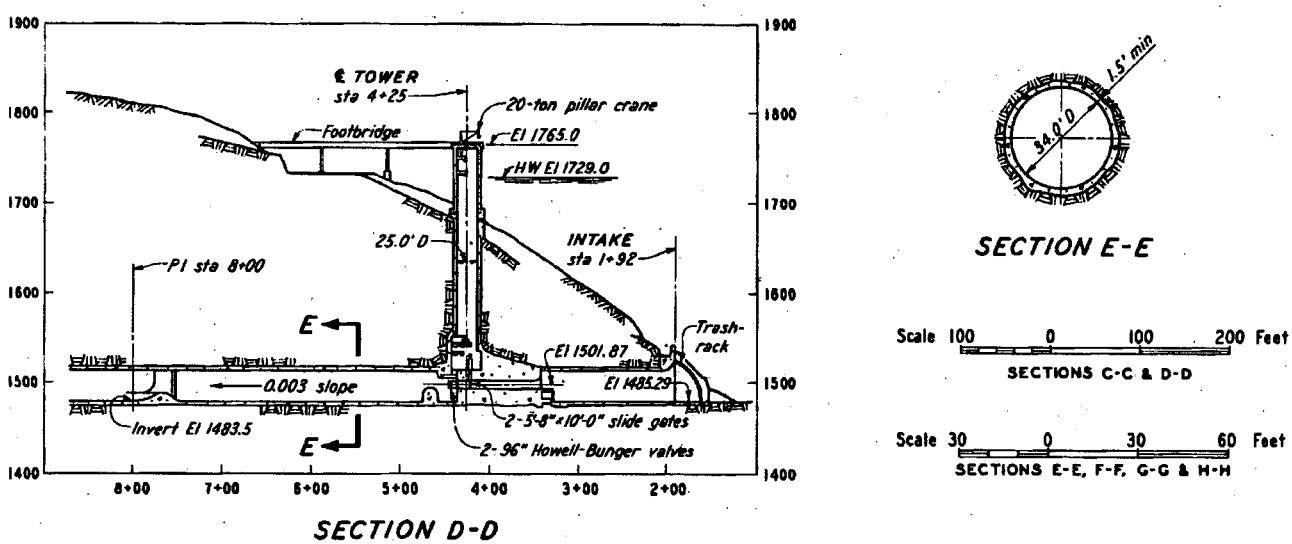


Figure 4 – South Holston Dam, Sections Through Sluiceway (Ref. 2.2).

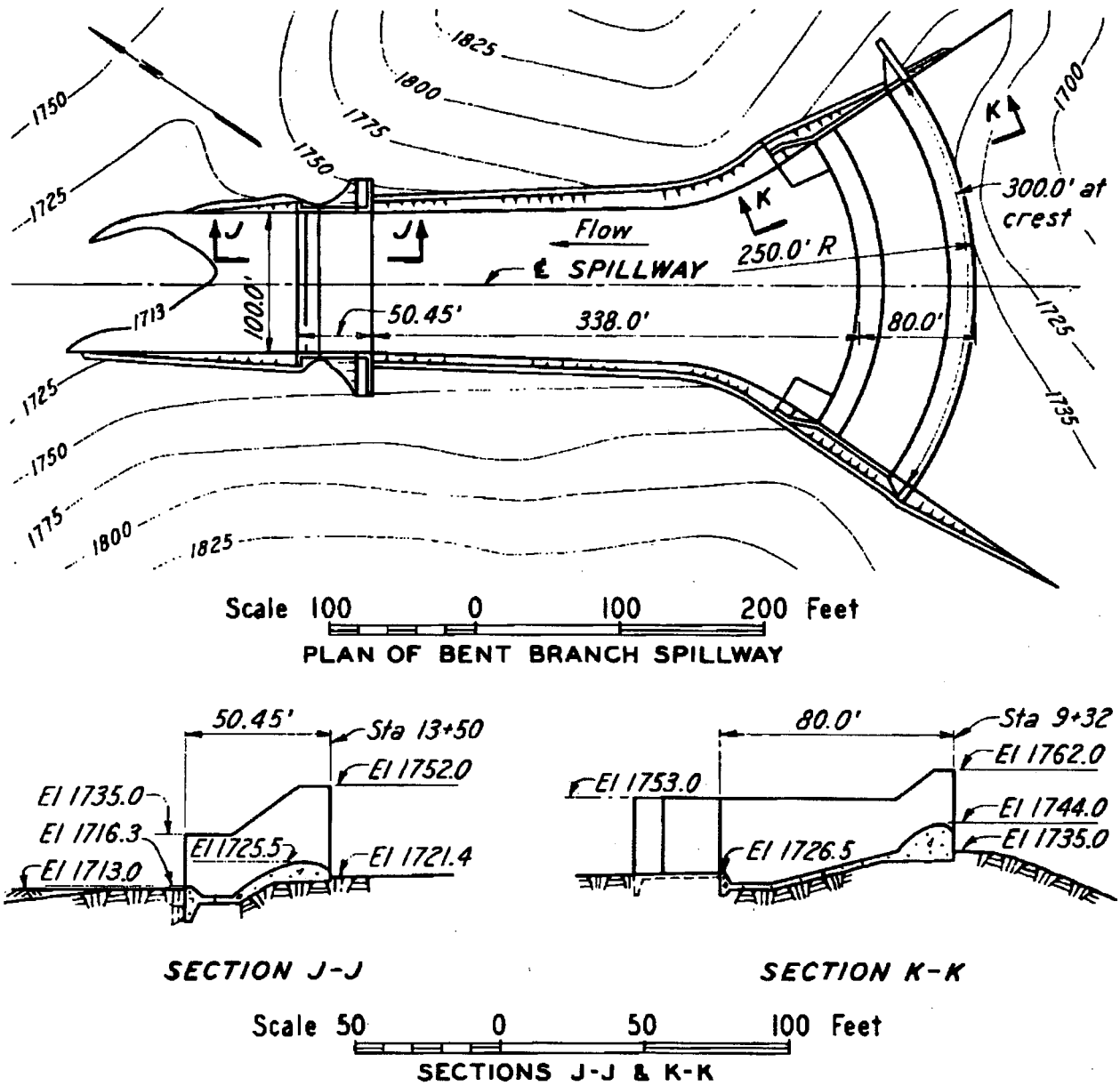


Figure 5 – South Holston Dam, Bent Branch Spillway (Ref. 2.2).

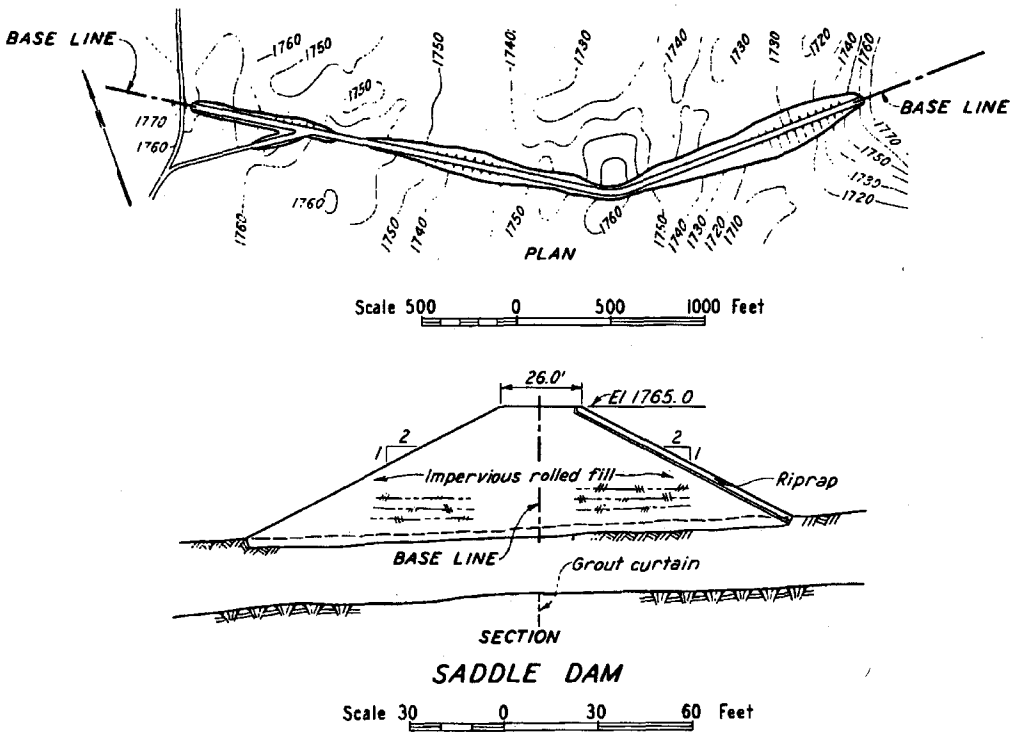


Figure 6 – South Holston Dam, Saddle Dam (Ref. 2.2).

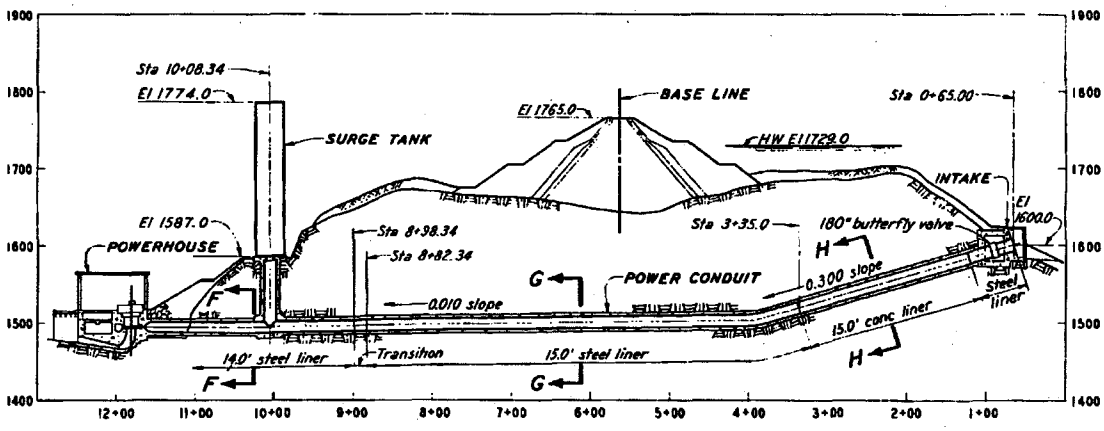


Figure 7 – South Holston Dam, Power Conduit (Ref. 2.2).

2. References

2.1.1. TVA South Holston Project drawing no: 10N201, R5
2.1.2. TVA South Holston Project drawing no: 46N206, R0
2.1.3. TVA South Holston Project drawing no: 51W200, R6
2.1.4. TVA South Holston Project drawing no: 51N203, R2
2.1.5. TVA South Holston Project drawing no: 51N206, R4
2.1.6. TVA South Holston Project drawing no: 51N229, R2
2.1.7. TVA South Holston Project drawing no: 51W250, R4
2.1.8. TVA South Holston Project drawing no: 51N251, R3
2.1.9. TVA South Holston Project drawing no: 51N253, R2
2.1.10. TVA South Holston Project drawing no: 54W220, R3
2.2. TVA Water Control Project Manual (Blue Book) for South Holston Dam, TVA River Operations, September, 1999
2.3. TVA Report No. 18-10-1, "Advance Report No. 1 South Holston Model Studies," June 1944
2.4. "South Holston Tailwater Rating Curve," River Scheduling, Tennessee Valley Authority
2.5. "South Holston Dam Howell-Bunger Valve Discharge Tables," Tennessee Valley Authority, July 1974
2.6. *Applied Hydrology and Sedimentology for Disturbed Areas*, Barfield, Warner and Haan, Oklahoma Technical Press, 1987
2.7. "Hydraulic Design Criteria," USACE (U. S. Army Engineer Waterways Experiment Station), Eighteenth issue, Vicksburg, MS, 1988
2.8. *Design of Small Dams*, Third Edition, United States Bureau of Reclamation, 1987
2.9. *Hydraulic Structures Design Manual 8 Discharge Characteristics*, D. S. Miller, A.A.Balkema Publishers, 1994
2.10. "Basis for Dam Spillway Gate/Outlet Open Configuration for Flood Analyses," Tennessee Valley Authority, May 25, 2009 (EDMS No L58 090529 800).

3. Assumptions & Methodology

The dam rating curve developed in these calculations will be used in simulations of probable maximum flood events. Consequently, the rating curve has been calculated well above the normal operating range.

3.1 Assumptions

3.1.1 Assumption: Power generation will continue until the tailwater elevation reaches 1517'. The turbine will be shut off and the power discharge will be zero when the tailwater reaches elevation 1517' and will remain at zero for the remainder of the flood event.
Technical Justification: The Electrical Bay of the powerhouse will begin to flood when the tailwater reaches 1517' (See Ref. 2.1.2) necessitating that power generation be suspended at that point. Once the turbines are shut off they will not be restarted until a thorough inspection is made.

3.1.2 Assumption: The tailwater elevations obtained from the tailwater rating curve presented in Attachment 4 occur just below the dam and the discharges include flow from the Bent Branch spillway. Also, the curve is sufficient for evaluating submergence effects on the dam rating curve discharges.
Technical Justification: The tailwater rating curve was provided by TVA Flood Risk, which is in the River Operations organization. This tailwater rating curve is used by TVA during actual flood events as input for river management decisions and is the best available source of tailwater data. In addition, evaluations performed in Section 6 of this calculation demonstrate that the dam rating curve discharges for South Holston dam are not sensitive to the accuracy of the tailwater curve.

3.1.3 Assumption: Sluiceway valves are considered fully operable and open to allow maximum flow indicated in the Howell-Bunger Valve Discharge Tables (Reference 2.5).
Technical Justification: For technical justification, see Reference 2.10, "Basis for Dam Spillway Gate/Outlet Open Configuration for Flood Analyses."

3.2 Unverified Assumptions

None.

3.3 Methodology

There are four possible routes for discharging through South Holston Dam: 1) through the power intake tunnel exiting at the powerhouse, 2) through the sluiceway intake exiting at the spillway outlet tunnel outlet portal, 3) through the uncontrolled morning glory spillway exiting at the spillway outlet tunnel outlet portal, and 4) through the Bent Branch spillway. Overtopping the main dam or the saddle dam is not considered a possibility since the tops of both dams are at or above elevation 1765' and the elevation of the maximum probable flood is 1764.7'. This calculation does not consider discharge through the power tunnel as discussed in Assumption 3.1.1.

Headwater rating curves are computed for two separate scenarios as follows:
Case 1 - Headwater Rating Curve with Turbine Flow: This rating curve terminates at a discharge of 82,200 cfs since the tailwater reaches elevation 1517' and the powerhouse begins to flood at that flow. (Q=82,200 cfs results in TW = 1517' is determined by interpolation of values in Table 2.)
Case 2 - Headwater Rating Curve without Turbine Flow: This rating curve is used for both rising and falling headwaters after turbine operation has been suspended.

Discharge through the power tunnel is taken as 3,300 cfs for all headwater elevations. This value is based on the "Reservoir and Power Data" tables listed on pages 35 through 38 of Reference 2.2 (see Attachment 7) which shows a maximum sustainable turbine discharge of 3,300 cfs for all reservoir levels and gross heads.

The calculations consist of computing sluiceway and spillway discharges for headwater elevations ranging from 1742 feet, the morning-glory spillway crest elevation, to 1765 feet, the minimum dam elevation. The dam rating curve is a plot of headwater elevation versus total dam discharge. Total discharge, given in "1000 cfs" is the sum of all discharges in cfs past the dam divided by 1000.

Flow through the sluiceway intake is limited by the discharge capacities of two Howell-Bunger valves located in the sluiceway tunnel before it joins the spillway outlet tunnel. Flow through the valves is determined by the following relationship:

$$Q_{HB} = K*(HW-Z_{HB})^{0.5} \qquad \text{(Eq. 1)}$$

Where:
$K = 294$
Z_{HB} = centerline elevation of the valves = 1501.7'
See Appendix A for justification for this relationship.

Page 408 of Reference 2.8 shows three conditions of flow which can control the flow through a morning glory spillway. Condition 1 is crest control, condition 2 is tube or orifice control, and condition 3 is full pipe flow.

Flow for Condition 1 is determined by the following relationship which is derived by curve fitting data from model studies presented in Ref. 2.3:

$$Q_f = 924.1H_c + 410.8\,H_c^{\,2} - 9.08\,H_c^{\,3} \qquad \text{(Eq. 2)}$$

Where:
H_c = (HW elevation) – (crest elevation)
See Section 6 for derivation of this relationship.

Flow for Condition 2 is determined at two locations: 1) at the transition from the varying diameter morning-glory to the constant diameter conduit, and 2) at the section partially blocked by the deflector.
At the first location the following relationship is used:

$$Q_{thr} = 24.03*(R_{thr})^2(HW - Z_{thr})^{0.5} \qquad \text{(Eq. 3a)}$$

Where:
HW = headwater elevation
R_{th} = radius at throat = 17'
Z_{thr} = elevation of throat
At the second location the following relationship is used:

$$Q_{def} = 7.65*A_{def}*(HW - Z_{def})^{0.5} \quad \text{(Eq. 3b)}$$

Where:

HW = headwater elevation

A_{def} = area of conduit at deflector

Z_{def} = elevation of deflector

See Section 6 for derivation of these relationships.

The flow through the morning-glory spillway, Q_{mg} , is the least of Q_f , Q_{thr} and Q_{def}.

The spillway and sluice tunnels do not flow full for any headwater elevation included in the rating curve; therefore, condition 3 does not control. Condition 3 is investigated at each headwater elevation by assuming the opposite, that the spillway and sluice tunnels are flowing full with sluiceway discharge Q_{HB} from Eq. 1 and spillway discharge Q_{mg} from Eq. 2, 3a, or 3b, depending on which condition controls (which discharge is least). Under the assumption of full-tunnel flow, the energy head at the tunnel exit required to achieve the assumed discharges is computed and compared with the actual energy head at the exit. The actual exit energy head is the tailwater elevation or the centerline elevation of the tunnel outlet, whichever is highest. A computed exit energy head higher than the actual exit energy head means that computed full-tunnel discharge would be higher than the assumed discharge and, therefore, full-tunnel discharge does not control. A computed exit energy head lower than the actual exit energy head means that computed full-tunnel discharge would be lower than the assumed discharge and, therefore, full-tunnel discharge does control.

The energy head of the water exiting the tunnel is calculated starting with an initial head equal to the headwater elevation and deducting losses that would occur for the full-tunnel flows through the spillway and exiting at the outlet portal. The calculated energy head is then compared to the actual exit energy head. The tailwater elevation is determined from the Riverware Rating data provided by the River Scheduling group (see Attachment 4) for a flow equal to $Q_{HB} + Q_{mg} + Q_{BB}$ for the considered headwater elevation. The energy head of the water exiting the tunnel is calculated using the following relationship derived in Appendix B:

$$H' = HW - (Q_{mg}/A)^2/(2*g)*k1-((Q_{mg} + Q_{HB})/A)^2/(2*g)*k3 \quad \text{(Eq. 4)}$$

Where:

H' = energy head of flow exiting the spillway tunnel

Q_{mg} = flow through the morning glory spillway

Q_{HB} = flow through the sluiceway

A = area of tunnel

k1 & k3 = loss coefficients derived in Appendix B

If the energy head calculated using Eq. 4 is greater than the actual exit energy head the actual flows would have to be greater than the assumed flows, and the condition of the conduit flowing full is shown not to control for the assumed Q_{mg} and Q_{HB}.

Flow over the Bent Branch spillway is determined from the standard weir equation:

$$Q_{BB} = C_f L H_c^{1.5} \quad \text{(Eq. 5)}$$

where:

$$C_f = 3.078+0.1201H_c - 0.005556 H_c^2 + 0.0001305H_c^3 \quad \text{(Eq. 6.a)}$$

for $0 <= H_c <= 17.6'$

$$C_f = 3.549+0.03545H_c \quad \text{(Eq. 6.b)}$$

for $H_c > 17.6'$

H_c = HW – (crest elevation)

L = length of crest

See Appendix C for derivation of Equations 6.a and 6.b.

4. Design Input

Sect.	Input Parameter	Symbol	Value	Source
4.1	**Morning Glory Spillway**			
4.1.1	Crest elevation	Z_c	1742 feet	Ref. 2.1.4
4.1.2	Diameter at crest	D_c	128 feet	Ref. 2.1.4
4.1.3	Elevation of transition to constant diameter	Z_{thr}	1652.9 feet	Ref. 2.1.4
4.1.4	Outlet tunnel radius at transition point and below	R_{thr}	17.0 feet	Ref. 2.1.3
4.1.5	Elevation of top of elbow		1576.25'	Ref. 2.1.5
4.1.6	Centerline elevation at bottom of elbow		1501.25'	Ref. 2.1.5
4.1.7	Radius of elbow centerline		75.0'	Ref. 2.1.5
4.1.8	Station at bottom of elbow		5+49.77'	Ref. 2.1.5
4.1.9	Station at intersection with sluiceway centerline		8+00'	Ref. 2.1.3
4.1.10	Station at outlet		16+18'	Ref. 2.1.3
4.1.11	Centerline elevation at outlet	Z_{ex}	1476.23'+24'/2=1488.23'	Ref. 2.1.3
4.1.12	Max projection of deflector into tunnel	p	6.36'	Ref. 2.1.5
4.1.13	Elevation of max. deflector projection	Z_{def}	1576.25'	Ref. 2.1.5
4.1.14	Area of conduit at deflector	A_{def}	790.5 sq.ft.	Appendix B, p.B2
4.1.14	Area of conduit at outlet	A_{ex}	900 sq.ft.	Appendix B, p.B3
4.2	**Sluiceway**			
4.2.1	Tunnel radius	R	17.0'	Ref. 2.1.3
4.2.2	Elevation of valve centerline	Z_{HB}	1501.7'	Ref. 2.1.10
4.3	**Bent Creek Spillway**			
4.3.1	Crest elevation	Z_c	1744 feet	Ref. 2.1.7
4.3.2	Length of crest	L	300 feet	Ref. 2.1.7
4.4	**Main Dam**			
4.4.1	Top elevation		1765'	Ref. 2.1.1
4.5	**Saddle Dam**			
4.5.1	Top elevation		1765'	Ref. 2.1.1

5. Special Requirements/Limiting Conditions

N/A

6. Calculations

6.1 Flow Through Sluiceway

$$Q_{HB} = K*(HW-1501.7)^{0.5} \qquad \text{(Eq. 1)}$$

where: Q_{HB} = discharge through Sluiceway which is controlled by the two Howell-Bunger valves
K = constant derived in Appendix A = 294
HW = headwater elevation

See Appendix A for justification for this relationship.

6.2 Flow Over Morning-Glory Spillway Crest

Values scaled from the Spillway Rating Curve shown on Plate 3 of Ref. 2.3 are listed inTable 1.

Data Scaled from Plate 3 in Ref. 2.3

HW, ft.	H_c, ft.	Q_f, cfs
1742	0	0
1744	2	3300
1745	3	6200
1746	4	9750
1747	5	13800
1748	6	18400
1749	7	23500
1750	8	29000
1751	9	35000
1752	10	41200
1753	11	47750
1754	12	54600
1755	13	61500

Table 1 – Morning-Glory Spillway Model Flow Data

Excel is used to plot the values in Table 1 and determine a third order polynomial curve to fit the values. The equation for the curve is

$$Q_f = 924.1H_c + 410.8\,H_c^{\,2} - 9.08\,H_c^{\,3} \qquad \text{(Eq. 2)}$$

Where:
H_c = (HW elevation) – Z_C
Z_C = crest elevation = 1742'

Figure 8 shows a plot of the values from Table 1 and the derived curve.

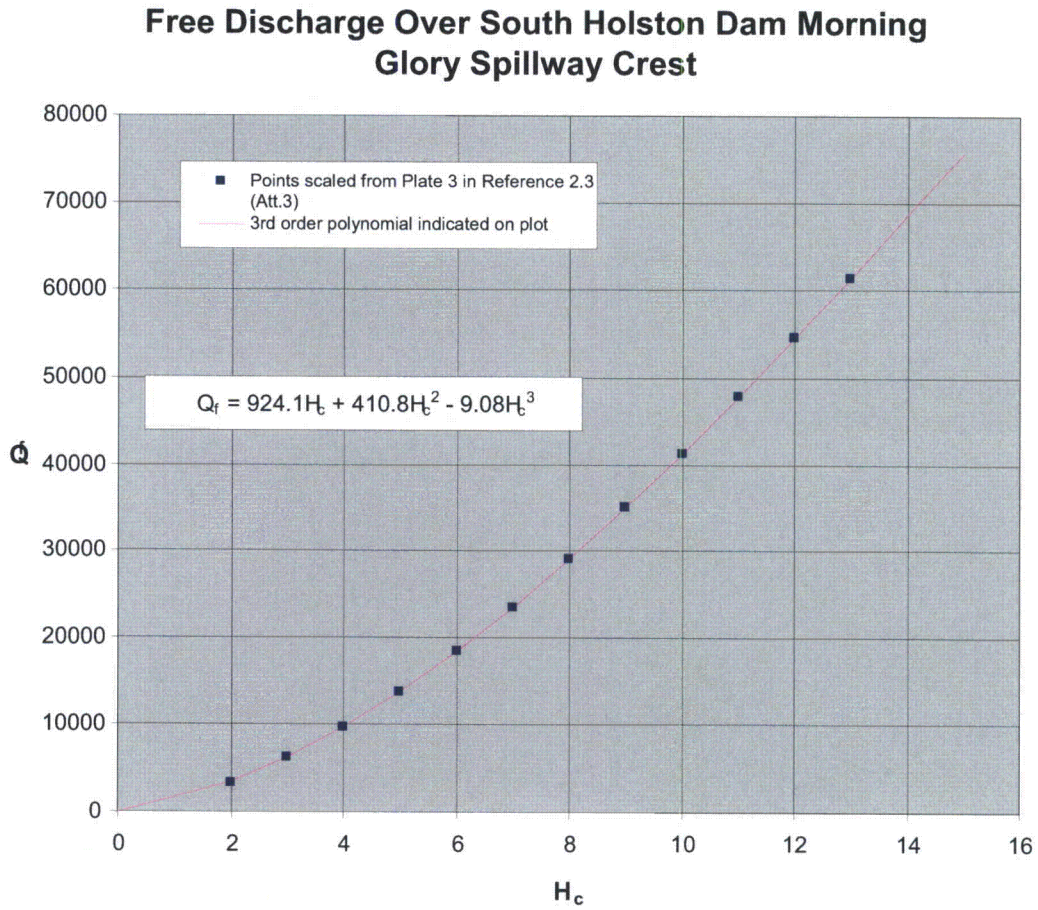


Figure 8 - Morning-Glory Spillway Discharge vs. Head Plot

6.3 Flow Controlled by Spillway Throat

Equation 29 on page 410 of Ref. 2.8 is used as the basis for determining throat controlled flow.

$$R = 0.204*(Q_a\text{^}0.5/ H_a\text{^}0.25)$$

Rearranging and substituting Q_{thr} for Q_a , R_{thr} for R, and $(HW - Z_{thr})$ for H_a gives the equation used to determine throat controlled flow at the transition from the varying diameter morning-glory to the constant diameter conduit:

$$Q_{thr} = (R_{thr}/0.204)\text{^}2*(HW - Z_{thr})\ \text{^}0.5$$
$$= 24.03*(R_{thr})\text{^}2*(HW - Z_{thr})\ \text{^}0.5 \qquad \text{(Eq. 3a)}$$

Where Z_{thr} is the elevation at the start of the constant diameter conduit at the bottom of the morning-glory = 1652.9' and R_{thr} = 17'.

The same relationship can be used to determine the throat controlled flow at the section partially blocked by the deflector by substituting A_{def}/π for R^2 and Z_{def} for Z_{thr} , resulting with:

$$Q_{def} = 7.65*A_{def}*(HW - Z_{def})\ \text{^}0.5 \qquad \text{(Eq. 3b)}$$

Where Z_{def} is the elevation at the maximum reduction of conduit area by the defector = 1576.25' and A_{def} is the conduit area at that location = 790.5 sq.ft. per calculations an sheet B2.

6.4 Total Flow Through Morning-Glory Spillway

The maximum discharge that can flow through the morning-glory spillway at a given headwater elevation, Q_{mg} , is calculated as the minimum controlled by the crest, Q_f , or the throat, Q_{thr} or Q_{def} .

6.5 Spillway Tunnel Flowing Full

The energy head of water exiting the tunnel after flowing through the spillway is determined using the Equation 4 below. The equation is based on the assumptions that the flow through the morning glory = Q_{mg} determined per Section 6.4, flow through the sluiceway = Q_{HB} determined per Section 6.1, and the spillway tunnel is flowing completely full. See Appendix B for derivation of Equation 4.

$$H' = HW - (Q_{mg}/A)^2/(2*g)*k1-((Q_{mg}+Q_{HB})/A)^2/(2*g)*k3 \qquad \text{(Eq. 4)}$$

Where:

Q_{mg} = flow through the morning glory spillway
Q_{HB} = flow through the sluiceway
A = area of 34' diameter tunnel
k1 & k3 = loss coefficients derived in Appendix B

The tailwater elevation is then determined from Table 2 using discharge equal to the combined flow determined per Section 6.8. Table 2 is the Riverware Rating data provided by the River Scheduling group (see Attachment 4) with the straight line portion of the curve extrapolated to a flow of 210 thousand cubic feet per second.

If the assumed flows (Q_{mg} and Q_{HB}) and the assumption that the conduit flowing full are correct, H' must equal TW. If H' calculated from Eq. 4 is greater than TW, the actual flows would have to be greater than the assumed flows, and the condition of the conduit flowing full is shown not to control for the assumed Q_{mg} and Q_{HB} . The margin between the calculated energy head and the actual tailwater is calculated by subtracting (TW from Table 2) from (H' from Eq. 4). If the margin is positive (H' > TW) the conduit flowing full does not control.

Q (cfs*1000)	Elevation (feet)	Q (cfs*1000)	Elevation (feet)
0	1489	42.5	1506.5
2.8	1489	45.0	1507.3
5.0	1491	47.5	1508
7.5	1493	50.0	1508.6
10.0	1494.5	52.5	1509.5
12.5	1496	55.0	1509.8
15.0	1497	57.5	1510.5
17.5	1498	60.0	1510.95
20.0	1499.3	62.5	1511.5
22.5	1500.5	65.0	1512.05
25.0	1501.3	67.5	1512.5
27.5	1502	70	1513.1
30.0	1503	80	1516
32.5	1504	100	1525
35.0	1504.6	150	1530
37.5	1505.5	200	1535
40.0	1506	210	1536

Table 2 – Tailwater Rating Data from River Scheduling Group

6.6 Flow over the Bent Branch Spillway

Flow over the Bent Branch spillway is determined from the standard weir equation:

$Q_{BB} = C_f L H_c^{1.5}$ (Eq. 5)

where:

$C_f = 3.078+0.1201H_c - 0.005556 H_c^2 + 0.0001305H_c^3$ (Eq. 6.a)

for $0 < H_c < 17.6'$

$C_f = 3.549+0.03545H_c$ (Eq. 6.b)

for $H_c > 17.6'$

H_c = HW – (crest elevation)

L = length of crest

See Appendix C for derivation of Equations 6.a and 6.b.

6.7 Flow through Turbines

Case 1: Turbines Generating

Q_T= 3300 cfs (see Section 3.3 for justification)

Case 2: Turbines Generation Suspended

Q_T= 0 cfs

Where: Q_T = flow thru the turbines

6.8 Combining Flows and Calculating Rating Curve

The rating curve for Case 1 is calculated for headwater elevations ranging from 1742' to 1752.25' in one foot (approximate) increments. The Case 1 rating curve is terminated at that point because the calculated total discharge reaches 82,200 cfs causing the tailwater to rise to elevation 1517'. As discussed in Section 3.1.1, if the tailwater rises above elevation 1517', the powerhouse would flood and power generation would have to cease. The rating curve for Case 2 is calculated for headwater elevations ranging from 1742' to 1765' in one foot (approximate) increments. The total flow for any headwater elevation is:

$Q = Q_{HB} + Q_{mg} + Q_{BB} + Q_T$

Where:

Q_{HB} is calculated from Eq. 1

Q_{mg} is the minimum of Q_f calculated from Eq. 2 or Q_{thr} calculated from Eq. 3

Q_{BB} is calculated from Eq. 5 with Cf calculated from Eq. 6.a and 6.b

Q_T = 3300 cfs for Case 1 and 0 cfs for Case 2

The energy head at the spillway tunnel is also calculated from Eq. 4 and is found to be larger than the tailwater elevation in all cases. Therefore, the condition of the tunnel flowing full does not control the spillway flow.

The Excel spreadsheet used to make the calculations described above is shown in Figure 9 and 10.

Calculation of South Holston Dam Rating Curve
Case 1 - Turbine Discharge Included

M-G Spillway and ConduitParameters								Bent Branch Spillway Parameters			Howell-Bunger Valve Parameters		
Z_c =	1742	feet	L1 =	444.5	feet	Ke =	0.05						
Z_{cw} =	1652.9	feet	L3 =	818.0	feet	Kb =	0.135	L =	300	feet	no. of valves =	2	
R_{cw} =	17	feet	A =	908	sq. ft.	Kc =	0.00028	Z_c =	1744	feet	Z_{HB} =	1502	feet
Z_{def} =	1576.25	feet	A_{def} =	790.5	sq. ft.	Ks' =	0.0221				K =	294	$ft^{-1.5}/s$
			A_{ex} =	900	sq. ft.	Ky =	0.15						
			Z_{ex} =	1488.2	feet	Kex =	1.018						
						k1 =	0.333						
						k3 =	1.400						

	Q = Total	Turbine	Sluiceway				Morning Glory Spillway					Bent Branch Spillway		
HW	Discharge	Q_T	Q_{HB}	H_c	Q_f	Q_{cw}	Q_{def}	Q_{mg}	Check for Conduit Running Full (ft)			H_c	C_d	Q_{BB}
feet	1000 cfs	cfs	cfs	feet	cfs	cfs	cfs	cfs	H'	Actual TW	Margin	feet	(Eq. 6.a	cfs
(Note 8)	(Note 1)	(Note 7)	(Eq. 1)	(Note 2)	(Eq. 2)	(Eq. 3a)	(Eq. 3b)	(Note 3)	(Eq. 4)	(Note 4)	(Note 5)	(Note 6)	or Eq 6.b)	(Eq. 5)
1742	**12.4**	3,300	9,115	0	0	65,551	77,840	0	1739.8	1495.9	243.9			
1743	**13.8**	3,300	9,134	1	1,326	65,917	78,074	1,326	1740.1	1496.5	243.6			
1744	**15.9**	3,300	9,153	2	3,419	66,282	78,308	3,419	1739.8	1497.3	242.4	0	3.078	0
1745	**19.7**	3,300	9,172	3	6,224	66,645	78,541	6,224	1738.5	1499.1	239.4	1	3.193	958
1746	**25.0**	3,300	9,190	4	9,688	67,006	78,774	9,688	1736.0	1501.3	234.7	2	3.297	2,798
1747	**31.6**	3,300	9,209	5	13,756	67,365	79,005	13,756	1731.9	1503.6	228.3	3	3.392	5,287
1748	**39.2**	3,300	9,228	6	18,372	67,722	79,236	18,372	1725.8	1505.8	219.9	4	3.478	8,347
1749	**48.0**	3,300	9,247	7	23,483	68,077	79,467	23,483	1717.3	1508.1	209.2	5	3.556	11,927
1750	**57.6**	3,300	9,265	8	29,035	68,430	79,696	29,035	1706.0	1510.5	195.5	6	3.627	15,991
1751	**68.1**	3,300	9,284	9	34,972	68,782	79,925	34,972	1691.7	1512.6	179.0	7	3.691	20,509
1752.25	**82.2**	3,300	9,307	10	42,854	69,218	80,211	42,854	1669.0	1517.0	152.0	8.25	3.764	26,758

Note 1:	$Q = Q_{HB} + Q_{mg} + Q_{BB} + Q_T$
Note 2:	H_c = HW - (Z_c for morning-glory spillway)
Note 3:	Q_{mg} = minimum (Q_f, Q_{cw}, Q_{def})
Note 4:	Actual H' = greater of H_{ex} and TW elevation obtained by interpolation from Table 2 for Q calculated per Note 1
Note 5:	Margin =(Calculated H') - (Actual TW). Since all values are positive, conduit flowing full does not control.
Note 6:	H_c = HW - (Z_c for Bent Branch spillway)
Note 7:	Q_T = 3300 cfs for all HW elevations until total discharge > 82,800 cfs.
Note 8:	For HW > 1752.25 use Case 2 Rating Curve
Eq. 1:	$Q_{HB} = K*(HW-Z_{HB})$^0.5
Eq. 2:	$Q_f = 924.1Hc + 410.8Hc^2 - 9.08Hc^3$
Eq. 3a:	$Q_{cw} = 24.03*(R_{cw})^{2*}(HW - Z_{cw})$^0.5
Eq. 3b:	$Q_{def} = 7.65*A_{def}*(HW - Z_{def})$^0.5
Eq. 4:	$H' = HW - (Q_{mg}/A)$^2/(2*g)*k1-(($Q_{mg} + Q_{HB}$)/A)^2/(2*g)*k3
Eq. 5:	$Q_{BB} = C_d L H_c^{1.5}$
Eq. 6.a:	$C_d = 3.078+0.1201H_c - 0.005556 H_c^2 + 0.0001305H_c^3$ for 0 <= Hc <= 17.6'
Eq. 6.b:	$C_d = 3.549+0.03545H_c$ for 0 Hc > 17.6'

Figure 9 –Spreadsheet Used to Calculate Dam Rating Curve for Case 1 (With Turbine Discharge)

Calculation of South Holston Dam Rating Curve

Case 2 - No Turbine Discharge

		M-G Spillway and Conduit Parameters						Bent Branch					
Z_o =	1742	feet	L1 =	444.5	feet	Ke =	0.05	Spillway Parameters			Howell-Bunger Valve Parameters		
Z_{ib} =	1652.9	feet	L3 =	818.0	feet	Kb =	0.135	L =	300	feet	no. of valves =	2	
R_{ib} =	17	feet	A =	908	sq. ft.	Kc =	0.00028	Z_o =	1744	feet	Z_{HB} =	1501.7	feet
$Z_{d,f}$ =	1576.25	feet	$A_{d,f}$ =	790.5	sq. ft.	Ks' =	0.0221				K =	294	$ft^{2.5}/s$
			$A_{r,s}$ =	900	sq. ft.	Ky =	0.15						
			$Z_{r,s}$ =	1488.23	feet	Kex =	1.018						
						k1 =	0.333						
						k3 =	1.400						

	Q = Total	Sluiceway			Morning Glory Spillway						Bent Branch Spillway		
HW	Discharge	Q_{HB}	H_o	Q_f	Q_{ib}	$Q_{d,f}$	Q_{mg}	Check for Conduit Running Full (ft)			H_o	C_f	Q_{BB}
feet	1000 cfs	cfs	feet	cfs	cfs	cfs	cfs	H'	Actual TW	Margin	feet	(Eq. 6.a	cfs
	(Note 1)	(Eq. 1)	(Note 2)	(Eq. 2)	(Eq. 3a)	(Eq. 3b)	(Note 3)	(Eq. 4)	(Note 4)	(Note 5)	(Note 6)	or Eq 6.b)	(Eq. 5)
1742	**9.1**	9,115	0	0	65,551	77,840	0	1739.8	1494.0	245.8			
1743	**10.5**	9,134	1	1,326	65,917	78,074	1,326	1740.1	1494.8	245.3			
1744	**12.6**	9,153	2	3,419	66,282	78,308	3,419	1739.8	1496.0	243.7	0	3.078	0
1745	**16.4**	9,172	3	6,224	66,645	78,541	6,224	1738.5	1497.5	241.0	1	3.193	958
1746	**21.7**	9,190	4	9,688	67,006	78,774	9,688	1736.0	1500.1	235.9	2	3.297	2,798
1747	**28.3**	9,209	5	13,756	67,365	79,005	13,756	1731.9	1502.3	229.6	3	3.392	5,287
1748	**35.9**	9,228	6	18,372	67,722	79,236	18,372	1725.8	1504.9	220.9	4	3.478	8,347
1749	**44.7**	9,247	7	23,483	68,077	79,467	23,483	1717.3	1507.2	210.1	5	3.556	11,927
1750	**54.3**	9,265	8	29,035	68,430	79,696	29,035	1706.0	1509.7	196.3	6	3.627	15,991
1751	**64.8**	9,284	9	34,972	68,782	79,925	34,972	1691.7	1512.0	179.7	7	3.691	20,509
1752.3	**78.9**	9,307	10	42,854	69,218	80,211	42,854	1669.0	1515.7	153.3	8.25	3.764	26,758
1753	**87.9**	9,321	11	47,786	69,479	80,381	47,786	1652.7	1519.6	133.1	9	3.804	30,812
1754	**100.5**	9,340	12	54,554	69,825	80,608	54,554	1627.7	1525.0	102.6	10	3.854	36,561
1755	**113.5**	9,358	13	61,490	70,170	80,835	61,490	1598.9	1526.4	72.5	11	3.901	42,691
1756	**127.1**	9,377	14	68,539	70,513	81,061	68,539	1566.4	1527.7	38.7	12	3.945	49,193
1757	**136.3**	9,395	15	75,647	70,854	81,286	70,854	1555.6	1528.6	27.0	13	3.987	56,064
1758	**143.9**	9,414	16		71,193	81,510	71,193	1554.8	1529.4	25.4	14	4.029	63,308
1759	**151.9**	9,432	17		71,531	81,734	71,531	1554.0	1530.2	23.8	15	4.070	70,931
1760	**160.3**	9,450	18		71,867	81,958	71,867	1553.2	1531.0	22.2	16	4.112	78,946
1761	**169.0**	9,468	19		72,202	82,180	72,202	1552.4	1531.9	20.5	17	4.155	87,374
1762	**177.9**	9,487	20		72,535	82,402	72,535	1551.5	1532.8	18.7	18	4.187	95,928
1763	**187.3**	9,505	21		72,867	82,624	72,867	1550.7	1533.7	17.0	19	4.223	104,912
1764	**197.0**	9,523	22		73,197	82,845	73,197	1549.9	1534.7	15.2	20	4.258	114,254
1765	**207.0**	9,541	23		73,526	83,065	73,526	1549.1	1535.7	13.4	21	4.293	123,953

Note 1:	$Q = Q_{HB} + Q_{mg} + Q_{BB}$
Note 2:	H_o = HW - (Z_o for morning-glory spillway)
Note 3:	Q_{mg} = minimum (Q_f, Q_{ib}, $Q_{d,f}$)
Note 4:	Actual H' = greater of H_o and TW elevation obtained by interpolation from Table 2 for Q calculated per Note 1
Note 5:	Margin = (Calculated H') - (Actual TW). Since all values are positive, conduit flowing full does not control for HW.
Note 6:	H_o = HW - (Z_o for Bent Branch spillway)
Eq. 1:	$Q_{HB} = K*(HW-Z_{HB})^{0.5}$
Eq. 2:	$Q_f = 924.1Hc + 410.8Hc^2 - 9.08Hc^3$
Eq. 3a:	$Q_{ib} = 24.03*(R_{ib})^2*(HW - Z_{ib})^{0.5}$
Eq. 3b:	$Q_{d,f} = 7.65*A_{d,f}*(HW - Z_{d,f})^{0.5}$
Eq. 4:	$H' = HW - (Q_{mg}/A)^2/(2*g)*k1-((Q_{mg}+Q_{HB})/A)^2/(2*g)*k3$
Eq. 5:	$Q_{BB} = C_f L H_o^{1.5}$
Eq. 6.a:	$C_f = 3.078+0.1201H_o - 0.005556 H_o^2 + 0.0001305H_o^3$ for 0 <= Hc <= 17.6'
Eq. 6.b:	$C_f = 3.549+0.03545H_o$ for 0 Hc > 17.6'

Figure 10 - Spreadsheet Used to Calculate Dam Rating Curve for Case 2 (No Turbine Discharge)

7. Results/Conclusions

For convenience, the dam rating results, separate from the calculation details provided above, are tabulated as total discharge in cfs vs. headwater elevation in feet in Table 3. Case 1 includes turbine discharge and is applicable to rising headwaters until HW exceeds 1752.25'. Case 2 does not include turbine discharge and is applicable to rising headwaters above 1752.25' and to receding headwaters. The dam rating curves for Cases 1 and 2 are plotted in Figure 11.

The dam rating curves developed in this calculation provide South Holston total dam discharge vs. headwater elevation for use in TVA's SOCH and TRBROUTE models for simulation conditions satisfying the assumptions in [3.1]. In particular, the sluiceway Howell-Bunger valves must be fully opened.

	Total Discharge (1000 cfs)	
HW (feet)	Case 1 (with Turbine Discharge)	Case 2 (No Turbine Discharge)
1742	12.4	9.1
1743	13.8	10.5
1744	15.9	12.6
1745	19.7	16.4
1746	25.0	21.7
1747	31.6	28.3
1748	39.2	35.9
1749	48.0	44.7
1750	57.6	54.3
1751	68.1	64.8
1752.25	82.2	78.9
1753	*	87.9
1754	*	100.5
1755	*	113.5
1756	*	127.1
1757	*	136.3
1758	*	143.9
1759	*	151.9
1760	*	160.3
1761	*	169.0
1762	*	177.9
1763	*	187.3
1764	*	197.0
1765	*	207.0

* For HW > 1752.25' use Case 2 discharge values

Table 3 – Dam Rating Results

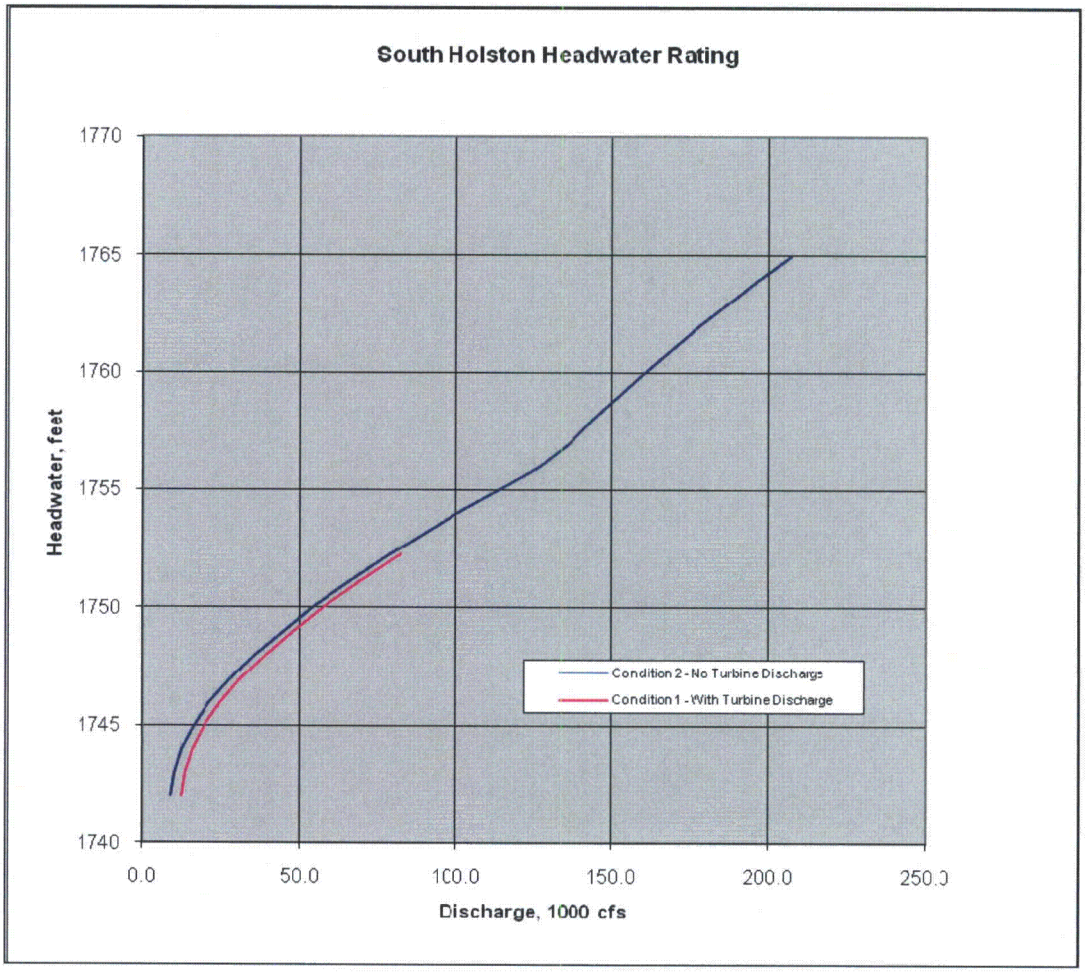


Figure 11 – Dam Rating Curve

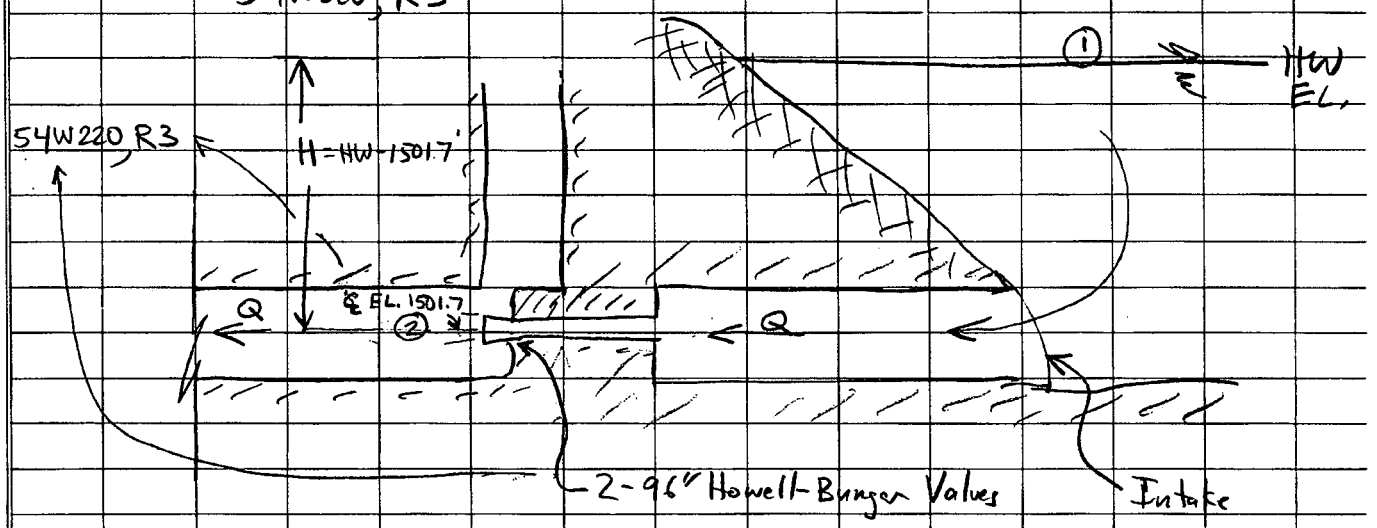
CDQ 00002008 0017

South Holston Sluice Discharge

COMPUTED GAS DATE 10/23/2008

CHECKED JCT DATE 1-29-09

Sketch 51W200, R6
54W220, R3



Energy Equation between ① & ②:

$$H = \frac{V_2^2}{2g} + K\frac{V_2^2}{2g}$$ for flow without downstream submergence effects

where V_2 = Velocity of jet discharging from Howell-Bunger Valves
g = acceleration of gravity = 32.2 ft/sec [4.1]
K = coefficient accounting for all losses from ① to ②

Define discharge, $Q = V_2 A$ where A = a cross-sectional area that need not be specified yet

$$\Rightarrow H = \frac{Q^2}{2gA^2}(1+K) \quad \Rightarrow Q = \frac{A}{\sqrt{1+K}}\sqrt{2gH}$$

or $\underline{Q = K\sqrt{H}}$ with $K = A\sqrt{\frac{2g}{1+K}}$

– see Attachment 2.2

Reference 2.5 indicates openings of 1% to 89% for the Howell-Bunger Valves at South Holston and K varies with % opening. For HW EL. = 1755, this reference gives Q = 4680 cfs for one valve (see Sheet A 4)

$$\Rightarrow K = \frac{Q}{\sqrt{H}} = \frac{4680\text{ cfs}}{\sqrt{1755-1501.7}} = \underline{294 \text{ per valve}}$$ for 89% opening

CDQ 0000 2008 0017

South Holston Sluice Discharge

COMPUTED GAS DATE 10/23/2008
CHECKED JCT DATE 1-29-09

This K-value was determined from field measurements of Q made in the South Holston tailrace by the USGS in 1957 and 1973 (summary included as sheets A7 and A8). As indicated on sheet A7, an average value of 293.3 for K was determined for one valve open to 88% (attachments do not explicitly state that only one valve was operating during the measurements but since Reference 2.5 uses K = 294 to compute discharge for one valve, this must have been the case).

Conclusion: Use K = 294 to compute discharge from

$$Q = K\sqrt{HW - 1501.7}$$

for each valve at its maximum opening position of 89%.

INSTRUCTIONS FOR USE OF TABLES

1. Purpose of Tables

The purpose of these tables is to provide a means of determining the discharge of the Howell-Bunger valves in the sluice tunnel at South Holston Dam. The tables are based on field discharge measurements and pressure measurements taken at several discharges in the sluice upstream from the Howell-Bunger valves. The tables give the discharge in cubic feet per second for one valve when the reservoir elevation and valve opening are known throughout the complete range of normal operating conditions. These tables supersede the tables dated April 1959.

2. Arrangement and Use of Tables

The tables give the discharge in cubic feet per second per valve for each 5-foot interval of headwater between reservoir elevations 1600 and 1755, and for each 1 percent of valve opening between 5 percent and 89 percent valve positions. Discharges are tabulated only to the nearest 10 cubic feet per second because the accuracy of the field measurements does not warrant greater refinement. It is possible to set any discharge within 40 cubic feet per second by using the tabular values. This tolerance has been accepted by the Division of Water Control Planning, and therefore, *it will not be necessary to interpolate* between tabular entries in these tables.

The reservoir elevation values used in the tables are those given by the recorder in the control room. The valve opening used in the tables is that indicated by the pointer on the valve control mechanism.

The arrangement of tables is such that the discharge over the entire range of valve openings for a 100-foot range of reservoir elevation is on two consecutive pages. For example, discharges are given on pages 2 and 3 for reservoir elevations 1600 through 1700. Discharges should be taken from the table for the tabulated values nearest to those observed. For example, if the reservoir is at elevation 1658.76 and the valve number 1 opening is 76.4 percent, the discharge is found on page 3, in the column headed 1660 opposite a valve opening of 76 percent, as 3370 cubic feet per second. If valve number 2 were set at 56.6 percent at the same time when valve number 1 was operating as given above, the discharge for valve number 2 would be found on page 3, in the column headed 1660 opposite a valve opening of 57 percent, as 2720 cubic feet per second. The total discharge would be the sum of the discharges of the two valves or 6090 cubic feet per second.

3. Valve Opening for Maximum and Minimum Discharge

Maximum discharge for the Howell-Bunger valves at South Holston Dam occurs at 89 percent valve opening. At valve openings greater than 89 percent the discharge becomes less. Therefore, the valves should not be operated beyond 89 percent. No tabular data are presented for such operation.

Minimum valve openings should not be less than 5 percent because of cavitation effects. No tabular values are given for such operation.

4. Adjustment of Valve Opening Indicator

At the time the field measurements were made, the valve opening indicator showed an opening of 0 percent when the valve was closed. In case of repairs to or adjustment of the valve and its control mechanism, the pointer should be reset to this position so that the tables will still be applicable.

CDQ00002008001 7
Info Only (From Ref 25)
sh. A3 of 8

SOUTH HOLSTON DAM

HOWELL-BUNGER VALVE DISCHARGE

IN CUBIC FEET PER SECOND

TENNESSEE VALLEY AUTHORITY — ENGINEERING LABORATORY

VALVE OPENING PERCENT	RESERVOIR ELEVATION 1700	1705	1710	1715	1720	1725	1730	1735	1740	1745	1750	1755	VALVE OPENING PERCENT
51	2760	2790	2830	2860	2900	2930	2960	2990	3030	3060	3090	3120	51
52	2800	2840	2870	2910	2940	2970	3010	3040	3070	3100	3140	3170	52
53	2860	2890	2930	2960	3000	3030	3070	3100	3130	3170	3200	3230	53
54	2900	2940	2970	3010	3040	3080	3110	3150	3180	3210	3250	3280	54
55	2940	2980	3020	3050	3090	3120	3160	3190	3230	3260	3290	3330	55
56	2990	3020	3060	3100	3130	3170	3200	3240	3270	3310	3340	3370	56
57	3040	3080	3120	3150	3190	3230	3260	3300	3330	3370	3400	3440	57
58	3080	3120	3160	3200	3240	3270	3310	3350	3380	3420	3450	3490	58
59	3130	3170	3200	3240	3280	3320	3350	3390	3430	3460	3500	3530	59
60	3170	3210	3250	3290	3320	3360	3400	3440	3470	3510	3550	3580	60
61	3210	3250	3290	3330	3370	3410	3440	3480	3520	3560	3590	3630	61
62	3240	3280	3320	3360	3400	3440	3480	3510	3550	3590	3620	3660	62
63	3280	3320	3360	3400	3440	3480	3520	3560	3600	3630	3670	3710	63
64	3320	3360	3410	3450	3490	3530	3570	3600	3640	3680	3720	3760	64
65	3370	3410	3450	3490	3530	3570	3610	3650	3690	3730	3770	3800	65
66	3410	3450	3490	3530	3580	3620	3660	3700	3740	3770	3810	3850	66
67	3440	3480	3520	3560	3610	3650	3690	3730	3770	3810	3840	3880	67
68	3460	3510	3550	3590	3630	3680	3720	3760	3800	3840	3880	3920	68
69	3510	3550	3590	3640	3680	3720	3760	3800	3840	3880	3920	3960	69
70	3550	3590	3640	3680	3720	3770	3810	3850	3890	3930	3970	4010	70
71	3590	3640	3680	3720	3770	3810	3850	3890	3940	3980	4020	4060	71
72	3620	3660	3710	3750	3800	3840	3880	3930	3970	4010	4050	4090	72
73	3660	3710	3750	3800	3840	3890	3930	3970	4010	4060	4100	4140	73
74	3700	3750	3800	3840	3890	3930	3970	4020	4060	4100	4140	4190	74
75	3730	3780	3820	3870	3920	3960	4000	4050	4090	4130	4180	4220	75
76	3770	3820	3870	3910	3960	4000	4050	4090	4140	4180	4220	4270	76
77	3800	3850	3900	3940	3990	4030	4080	4120	4170	4210	4250	4300	77
78	3830	3880	3930	3970	4020	4060	4110	4150	4200	4240	4290	4330	78
79	3870	3910	3960	4010	4060	4100	4150	4190	4240	4280	4330	4370	79
80	3900	3950	4000	4050	4090	4140	4190	4230	4280	4320	4360	4410	80
81	3930	3980	4030	4070	4120	4170	4220	4260	4310	4350	4400	4440	81
82	3960	4010	4060	4100	4150	4200	4250	4290	4340	4380	4430	4470	82
83	4000	4050	4100	4150	4200	4240	4290	4340	4380	4430	4480	4520	83
84	4030	4080	4130	4180	4230	4270	4320	4370	4410	4460	4510	4550	84
85	4060	4110	4160	4210	4260	4300	4350	4400	4450	4490	4540	4580	85
86	4080	4130	4190	4240	4280	4330	4380	4430	4480	4520	4570	4620	86
87	4110	4160	4210	4260	4310	4360	4410	4460	4510	4550	4600	4650	87
88	4130	4180	4230	4280	4330	4380	4430	4480	4520	4570	4620	4660	88
*89	4140	4190	4240	4290	4340	4390	4440	4490	4540	4590	4630	4680	89

JULY 1974

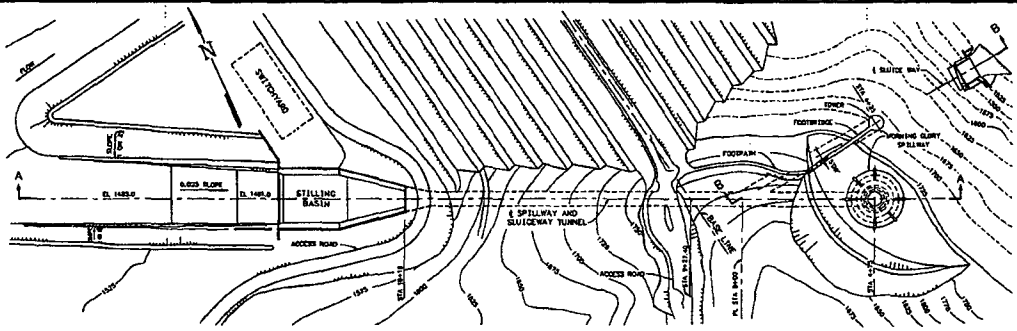
*THE MAXIMUM VALVE OPENING SHOULD NOT EXCEED 89 PERCENT

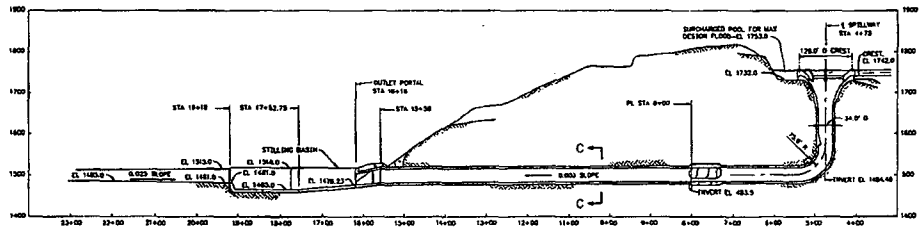
RESERVOIR ELEVATION 1700 TO 1755
VALVE OPENING, PERCENT 51 TO 89

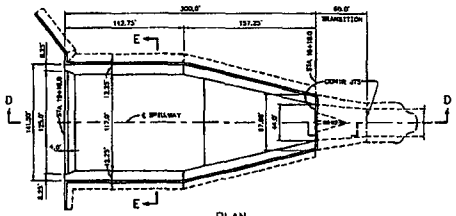
CDQ0000208 0017

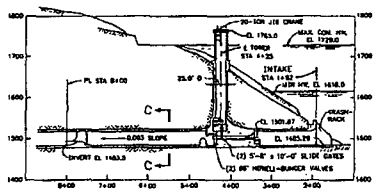
Info Only (From Ref 25)

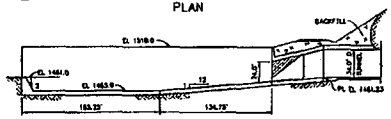
Sh. A4 of 8

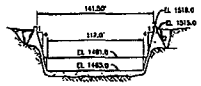




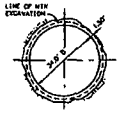








STILLING BASIN
SCALE 1"=50'



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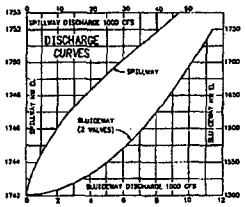
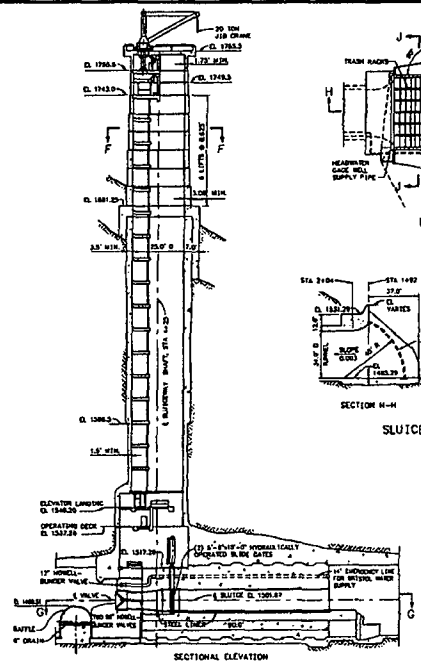
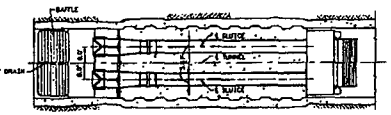






SLUICEWAY GATE PLUG & SHAFT
SCALE: 1"=20'

R 2	12/92	2	NEW	NEW	NEW	NEW	NEW	NEW
ELECTRONICALLY RESTORED PER DCN								
REV. NO.	DATE	DRAWN	CHECKED	DATE	DATE	APPD	MGR	MANAGER ENGINEERING

SCALE: 1"=100' EXCEPT AS NOTED

MAIN SPILLWAY

PLANS AND SECTIONS

DESIGNED BY	DRAWN BY	DRAWN BY	SUPERVISED BY	REVIEWED BY	APPROVED BY	PROJ. ENG.
G. J. J.	D. W. D.	A. C.	A. C.	R. M. R.	J. R.	C. G. M.

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
RIVER SYSTEMS OPERATIONS

AUTOCAD 2002 | 21 | C | 51W200 | R 6

PLOT FACTOR:1200 | C.A.D. DRAWING DO NOT ALTER MANUALLY

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES : 51W200 R5

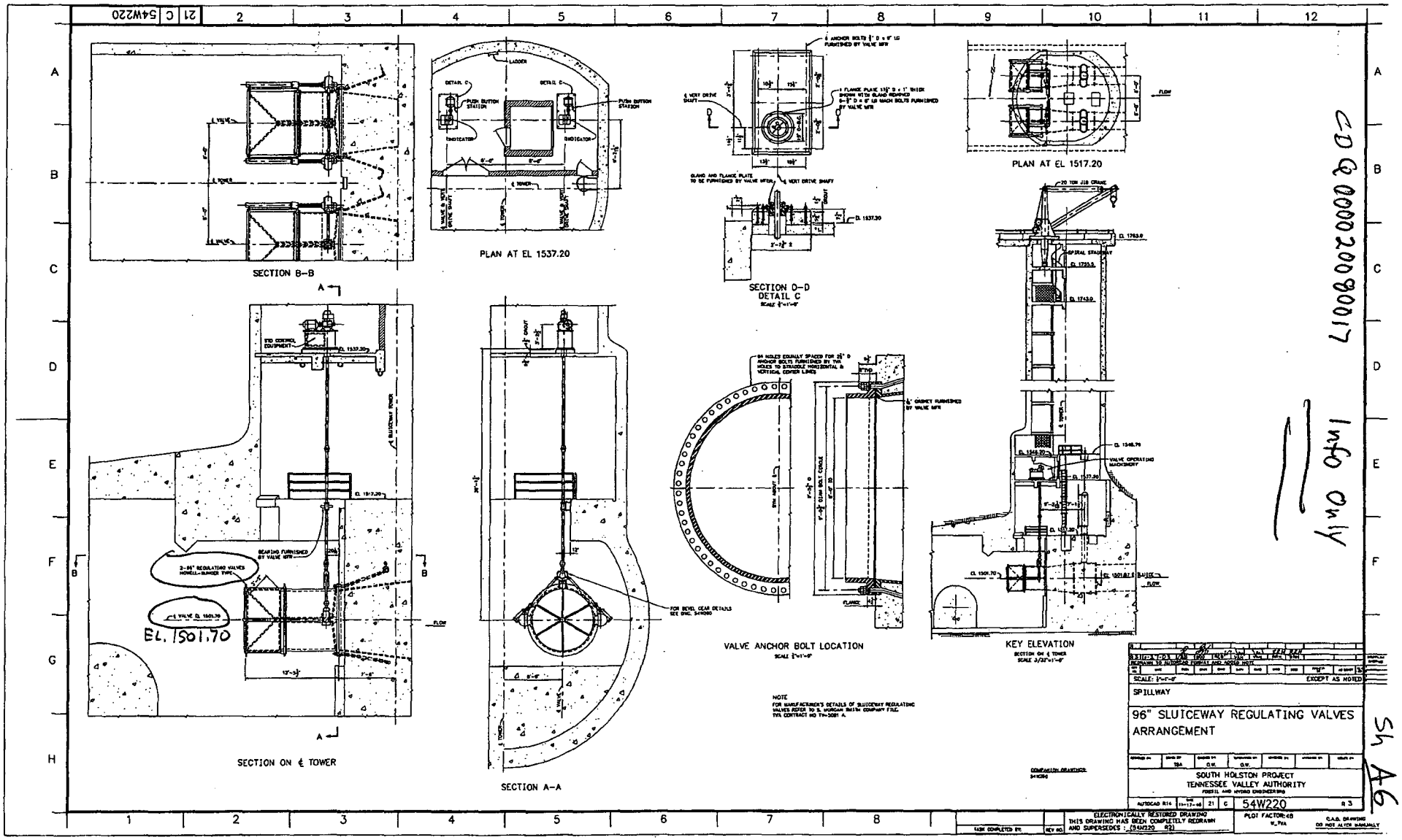
TASK COMPLETED BY: | REV NO.

51W200 | 21 | C

CDQ0000200801 7

Info Only

Sh A5 of 8



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Info Only

Sh A6

of 8

TVA 489 (REV-9 47)

CDQ000020080017 For Comparison Only

Discharge Measurements

USGS

Feb 13, 1957

SHEET Sh A7 OF 8

South Holston

H.B. Valve

COMPUTED KWK DATE 6-26-73

CHECKED DATE

Valve No	Meas No	GO	Time	Total Q	Tard Q	Sluice Q	$\frac{Q}{\sqrt{H}}$	HW	H
1	1	88.0	9:30-10:45	7552	3250	4302	289.8	1722.04	220.34
	2	88.0	10:50-12:05	7634	"	4384	295.4	1721.96	220.26
2	3	88.9	1:35-2:45	7575	3250	4325	291.5	1721.84	220.14
	4	87.9	2:55-4:05	7649	"	4399	296.5	1721.77	220.07

Average = 293.3

Source: File book entitled

South Holston Dam
96" Howell Bunger
Valve Rating

6/19/73 KWK ARS

TVA 489 (REV-9 47)

CUQ0000200800017 For Comparison Only

Discharge Measurements

USGS

6-19-73

SHEET Sh A8 OF 8

South Holston

H.B. Valve

COMPUTED KWK DATE 6-26-73

CHECKED ARS DATE 6-26-73

Meas No	GO	Time	Q	Leak Q	Final Q	$\sqrt{H}$	HW	H
218	5%	8:15A-8:55A	216	8.0	208	13.88	1726.1	224.4
219	"	8:15A-9:00A	217	8.0	209	13.95	"	"
220	10%	11:15A-12:00	520	8.0	512	34.18	1726.1	224.4
221	"	11:15A-11:45	540	8.0	532	35.51	"	"
222	40%	2:15P-3:00P	2410	8.0	2402	160.3	1726.2	224.5
223	"	3:00P-4:00P	2380	8.0	2372	158.3	"	"

Leakage thru unit 8.1 cfs.

Source: File book entitled

South Holston Dam
96" Howell Bunger
Valve Rating
6/19/73 KWK ARS

6.00
5.00
2.00
46

1501.70

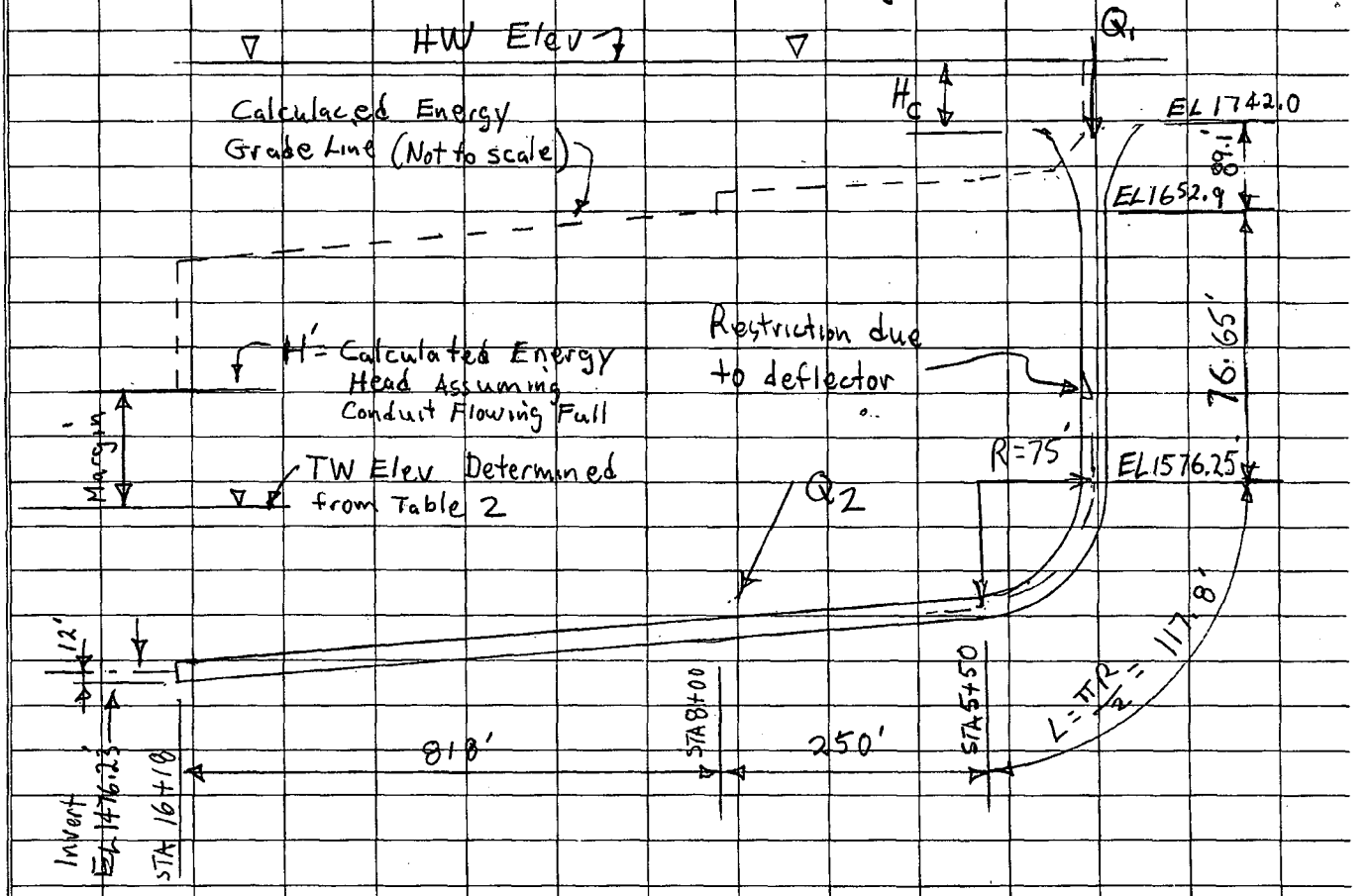
Appendix B — South Holston

CDQ0000200800 17

COMPUTED WHR DATE 11-17-08

CHECKED JCT DATE 1-29-09

Check Condition of Spillway Conduit Flowing Full



Procedure for checking

1) Choose HW Elev to check
2) Assume Q_1 = flow thru spillway controlled by crest or throat (smaller value from crest control or throat control) for H.W. elevation. Assume Q_2 = flow thru sluiceway for the H.W. elevation
3) Calculate energy head after leaving outlet assuming all tunnels are running full = (HW elev) − (Losses thru tunnel) = H'.
4) Determine TW elevation from Table 2 in Section 6.5 using discharge equal to sum of flows thru sluiceway, morning-glory spillway, and Bent Branch spillway calculated for the selected HW.
5) Calculate Margin = (H' determined from step 3) − (TW determined from step 4)
6) If margin is positive (H' > TW) conduit flowing full does not control since a larger flow would be necessary to cause H' to equal TW.

Check Conduit Flowing Full (cont'd)

$$H' = HW - \frac{V_1^2}{2g}\left(K_e + K_b + K_c L_1\right) - \frac{(V_1')^2}{2g}K_s - \frac{V_3^2}{2g}\left(K_y + K_c L_3\right) - \frac{(V_3')^2}{2g}$$

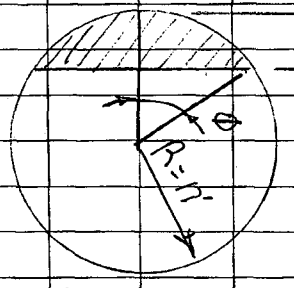
where:

K_e = entry loss coef.
K_b = bend loss coef.
K_c = friction loss coef.
K_s = sudden expansion loss coef.
K_y = coef for loss at Y junction

V_1' = velocity at deflector
V_1 = velocity elsewhere above sluiceway
V_3' = velocity at outlet
V_3 = velocity between sluiceway and outlet
L_1 = conduit length from throat to sluiceway
L_2 = conduit length from sluiceway to outlet

$V_1 = Q_1/A$ where Q_1 = flow thru morning-glory = Q_{mg},
A = conduit area = $\pi(17')^2 = 907.9\ ft^2$

$V_1' = Q_1/A_{def}$ where A_{def} = conduit area at deflector



Conduit @ Deflector

$\rho = 6'\,4\tfrac{3}{8}'' = 6.36'$ per dwg 5 N 206, R4

$\theta = \cos^{-1}\left(\frac{R-\rho}{R}\right) = \cos^{-1}\left(\frac{17-6.36}{17}\right) = 0.8945$ rad

$A_{def} = \pi r^2 - \theta r^2 + (r\sin\theta)(r\cos\theta) = 790.5\ ft^2$

$K_e \simeq 0.05$ per Fig 4.75, p 212 of Ref 2.9 (See sh. B9)

$K_b = 0.135$ per 228-1 of Ref 7 for $r/D = 75/34 = 2.2$ (see sh B11)

$K_c = \frac{5087 n^2}{d_i^{4/3}}$ per p 233 of Ref. 2.6 where n is Mannings Coef. of Roughness (See sh B10)

Conservatively using $n = 0.013$ gives $K_c = \frac{(5087)(0.013)^2}{[(34)(12)]^{1.333}} = 0.000284$ (see sh B7)

$K_y \simeq 0.15$ per Fig 4.40, p. 189 of Ref 2.9, for $\frac{A_1}{A_3} = 1.0$ + $\frac{Q_1}{Q_3} = \frac{9.5}{73.5+9.5} = 0.115$ based on flows for HW = 1765. Calculations will be sufficiently accurate if above value of K_y is used for all flows.

Check Conduit Flowing Full (cont'd)

$K_s = \left[1 - \frac{A_1}{A_2}\right]^2$ per Eq 4.20, p. 199 of Ref 2.9 (see sh. B8)

$= \left[1 - A_{def}/A\right]^2 = \left(1 - \frac{790.5}{907.9}\right)^2 = 0.0167$ when A & A_{def} are substituted

K_s calculated above is to be applied to velocity V_1' at A_{def} in the term $\frac{(V_1')^2}{2g} K_s$

$V_1 = Q_1/A \qquad V_1' = Q_1/A_{def}$

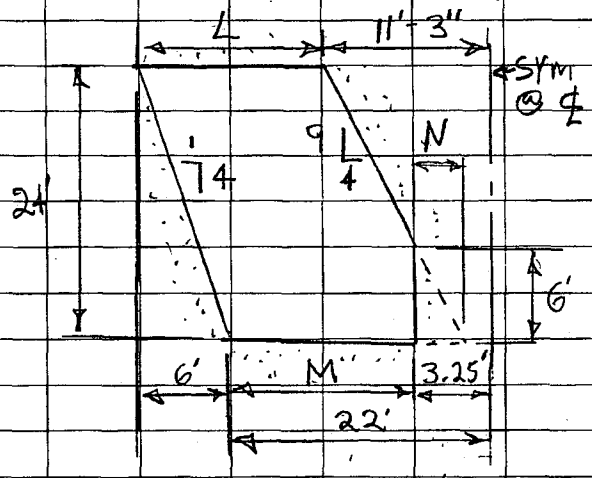
find coef K_s' that gives same result when applied to V_1

let $\frac{V_1^2}{2g} \cdot K_s' = \frac{(V_1')^2}{2g} \cdot K_s$

$K_s' = K_s \frac{(V_1')^2}{V_1^2} = K_s \frac{(Q_1/A_{def})^2}{(Q_1/A)^2} = K_s \frac{A^2}{A_{def}^2} = (0.0167)\left(\frac{907.9}{790.5}\right)^2 = 0.0221$

$V_3 = Q_3/A = \frac{Q_{mg} + Q_{HB}}{A}$

$V_3' = Q_3/A_{ex} = \frac{Q_{mg} + Q_{HB}}{A_{ex}}$ where A_{ex} = area of tunnel at exit



Opening At Outlet

dimensions shown in sketch are from dwg 51N229, R2

$L = 28 - 11.25 = 16.75'$

$M = 22 - 3.25 = 18.75'$

$N = (6)(4/9) = 2.667'$

$A_{ex} = (24)(16.75 + 18.75 + 2.67) - (6)(2.67) = 900\ ft^2$

Exit loss $= \frac{(V_3')^2}{2g} = \frac{(Q_3/A_{ex})^2}{2g} = \frac{V_3^2}{2g} K_{ex} = \frac{(Q_3/A)^2}{2g} K_{ex}$

$\therefore K_{ex} = \left(\frac{A}{A_{ex}}\right)^2 = \left(\frac{907.9}{900}\right)^2 = 1.018$

Check Conduit Flowing Full (Cont'd)

$L_1 = 76.65' + 117.8' + 250' = 444.5'$

$L_2 = 818'$

$$H' = HW - \frac{V_1^2}{2g}(K_e + K_b + K_c L_1) - \frac{(V_1')^2}{2g} K_s - \frac{V_3^2}{2g}(K_y + K_c L_3) - \frac{(V_3')^2}{2g}$$

$$= HW - \frac{(V_1)^2}{2g}(K_e + K_b + K_c L_1 + K_s') - \frac{(V_3)^2}{2g}(K_y + K_c L_3 + 1.018)$$

$$\boxed{H' = HW - \left(\frac{Q_{mg}}{A}\right)^2 \left(\frac{1}{2g}\right) K_1 - \left(\frac{Q_{mg} + Q_{HB}}{A}\right)^2 \left(\frac{1}{2g}\right) K_3} \qquad \text{(Eq 4)}$$

where

$K_1 = K_e + K_b + K_c L_1 + K_s'$

$K_3 = 1.018 + K_y + K_c L_3$

CDQ 0000 20070017 (From Ref 29)

Sh B5 of 11

4.6 DIVIDING AND COMBINING JUNCTIONS

4.6.1 *Introduction*

This section contains loss coefficients given for dividing and combining junctions. The junction geometries included are shown in Figure 4.38. Important geometric parameters are the area ratio, the angle between the legs and the chamfers or radii at the junction of the legs.

The notation used for the junction legs is shown in Figure 4.38. A loss coefficient K_{ij} is defined as the ratio of the total head loss between legs i and j to the mean velocity head in the leg carrying the total flow. The leg carrying the total flow is always referred to as leg 3. In the case of 'T' junctions, leg 1 is the branch and leg 2 is the leg carrying the through flow. Symmetrical 'Y' configurations have only one coefficient since leg 2 can be substituted for leg 1 or vice versa. Loss coefficients are:

Combining flow

$$K_{13} = \frac{\frac{U_1^2}{2g} + h_1 - \frac{U_3^2}{2g} + h_3}{\frac{U_3^2}{2g}} \tag{4.16}$$

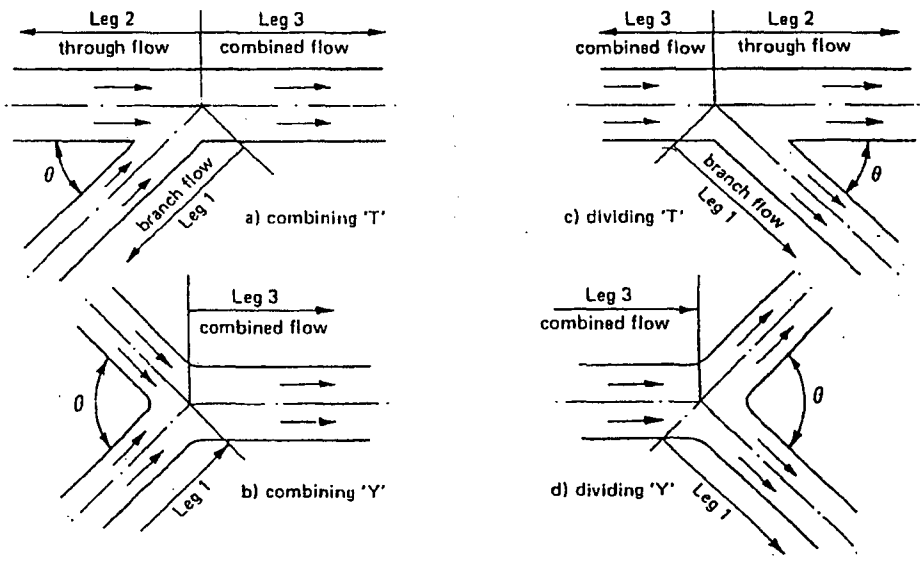


Figure 4.38. Geometric parameters for combining and dividing junctions.

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$$K_{23} = \frac{\frac{U_2^2}{2g} + h_2 - \frac{U_3^2}{2g} + h_3}{\frac{U_3^2}{2g}} \tag{4.17}$$

Dividing flow

$$K_{31} = \frac{\frac{U_3^2}{2g} + h_3 - \frac{U_1^2}{2g} + h_1}{\frac{U_3^2}{2g}} \tag{4.18}$$

$$K_{32} = \frac{\frac{U_3^2}{2g} + h_3 - \frac{U_2^2}{2g} + h_2}{\frac{U_3^2}{2g}} \tag{4.19}$$

The loss coefficients apply to junctions with inlet and outlet legs 30 or more diameters long. Conditions are given under which the loss coefficients can be applied to junctions with short inlet and outlet legs.

Chamfers or radii at junctions can reduce one or both of the junction loss coefficents. Guidance is given on where radii are useful in reducing losses. Because of the marked effect of edge sharpness on 'T' junctions and additional inaccuracies introduced in having to measure flow rates in two legs, scatter in experimental results is often quite high compared to other components. Provided there are no reductions in cross-sectional area below the nominal value, loss coefficients of most practical 'sharp-edged' 'T' junctions are unlikely to exceed the loss coefficients for sharp-edged 'T' junctions given in this section.

Cross-sectional shape

Within limits, cross-sectional shape is not important. Data for circular cross-sections can be applied, without serious error, to junctions with rectangular cross-section legs or to 'T' junctions where the branch, leg 1, has a different cross-section from legs 2 and 3.

4.6.2 *Sharp-edged combining 'T's*

Performance charts showing contours of constant loss coefficients for sharp-edged combining tees with legs 2 and 3 of the same area are given for:

– 45° branch angle, K_{13} in Figure 4.39, K_{23} in Figure 4.40.

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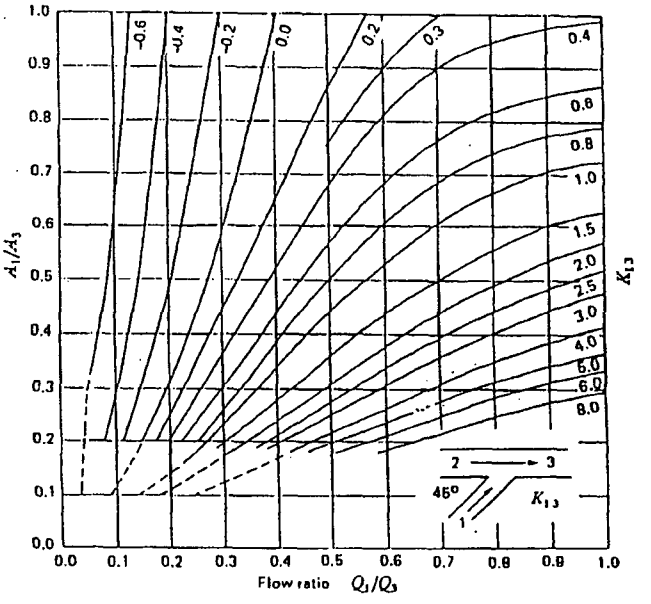

Figure 4.39. Combining flow – branch angle 45° – loss coefficient K_{13}.

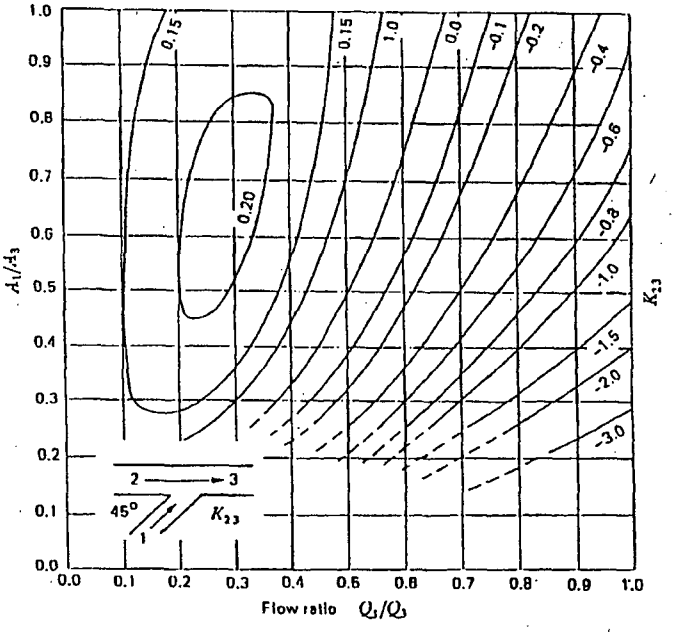

Figure 4.40. Combining flow – branch angle 45° – loss coefficient K_{23}.

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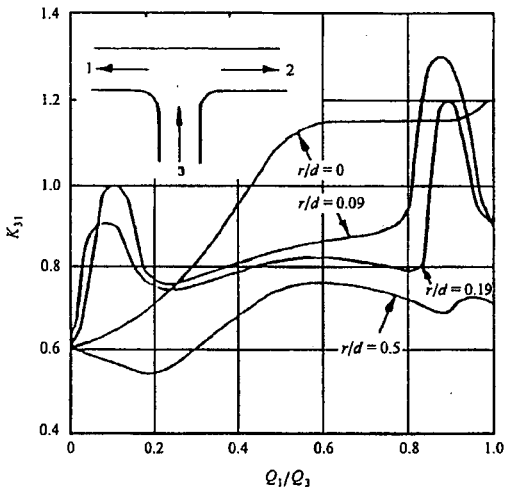

Figure 4.56. Symmetrical dividing 'T' junction with equal area legs.

4.6.8 *Symmetrical dividing junctions*

Loss coefficients, K_{31} , for symmetrically dividing 'T' junctions with the legs of equal area are given in Figure 4.56 for four junction radii.

Performance charts showing contours of constant loss coefficients are given in Figure 4.57 for dividing 'Y' junctions with area $A_1 = A_2$ and $A_1 + A_2 = A_3$ and in Figure 4.58 for dividing 'Y' junctions with $A_1 = A_2 = A_3$.

4.7 VALVES AND GATES

4.7.1 *Introduction*

Valves and gates are used to control the discharge through conduits by dissipating flow energy. This dissipation takes place in a sudden expansion in flow area after the control element. The energy loss due to an abrupt expansion in area can be calculated approximately from the one dimensional continuity, momentum and energy equations in the form:

$$K_s = \left[1 - \left(\frac{A_1}{A_2}\right)\right]^2 \tag{4.20}$$

where A_1 is the minimum flow area which usually occurs after the control element at what is known as the vena contracta; A_2 is the downstream conduit area.

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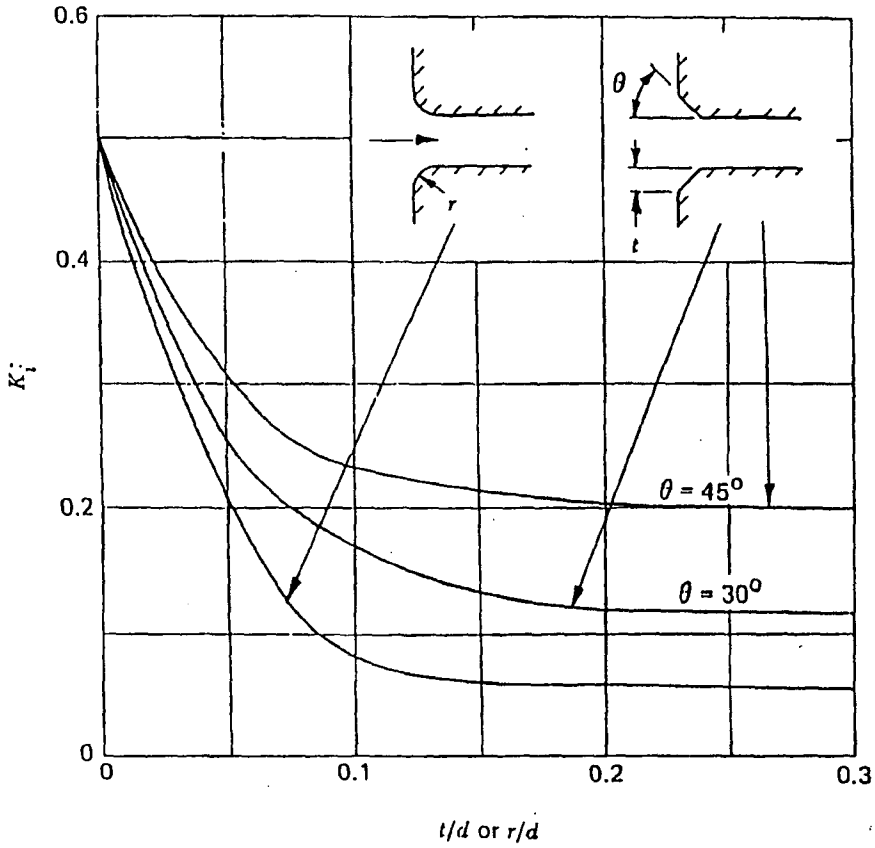

Figure 4.75. Loss coefficients for flush mounted intakes.

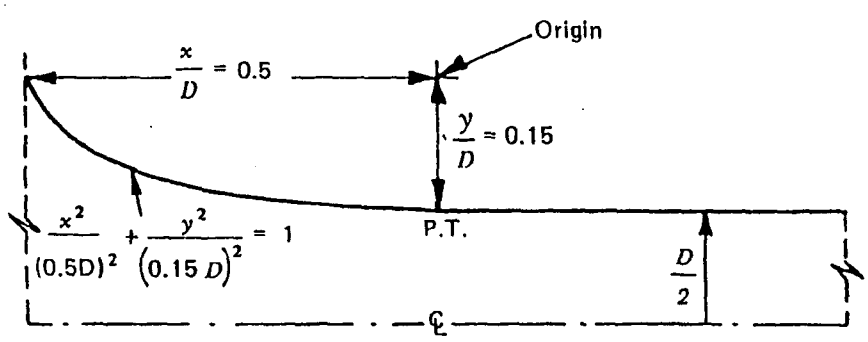

Figure 4.76. Inlet geometry (D = pipe diameter).

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Table 4.1 Head Loss Coefficients for Circular Conduits Flowing Full.

Head Loss Coefficient, K_c, for Circular Pipe Flowing Full $K_c = \frac{5087\ n^2}{d_f^{4/3}}$

Pipe diam. inches	Flow area sq. ft.	Manning's Coefficient of Roughness "n"															
		0.010	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.018	0.019	0.020	0.021	0.022	0.023	0.024	0.025
6	0.196	0.0467	0.0565	0.0672	0.0789	0.0914	0.1050	0.1194	0.1348	0.1510	0.1680	0.1870	0.2060	0.2260	0.2470	0.2690	0.2920
8	0.349	.0318	.0385	.0458	.0537	.0623	.0715	.0814	.0919	.1030	.1148	.1272	.1400	.1540	.1680	.1830	.1990
10	0.545	.0236	.0286	.0340	.0399	.0463	.0531	.0604	.0682	.0765	.0852	.0944	.1041	.1143	.1249	.1360	.1480
12	0.785	.0185	.0224	.0267	.0313	.0363	.0417	.0474	.0535	.0600	.0668	.0741	.0817	.0896	.0980	.1067	.1157
14	1.069	.0151	.0182	.0217	.0255	.0295	.0339	.0386	.0436	.0488	.0544	.0603	.0665	.0730	.0798	.0868	.0942
15	1.230	.0138	.0166	.0198	.0232	.0270	.0309	.0352	.0397	.0446	.0496	.0550	.0606	.0666	.0727	.0792	.0859
16	1.400	.0126	.0153	.0182	.0213	.0247	.0284	.0323	.0365	.0409	.0455	.0505	.0556	.0611	.0667	.0727	.0789
18	1.770	.0178	.0130	.0155	.0182	.0211	.0243	.0276	.0312	.0349	.0389	.0431	.0476	.0522	.0570	.0621	.0674
21	2.410	.00878	.01062	.0126	.0148	.0172	.0198	.0225	.0254	.0284	.0317	.0351	.0387	.0425	.0464	.0506	.0549
24	3.140	.00735	.00889	.01058	.0124	.0144	.0165	.0188	.0212	.0238	.0265	.0294	.0324	.0356	.0389	.0423	.0459
27	3.980	.00628	.00760	.00904	.01061	.0123	.0141	.0161	.0181	.0203	.0227	.0251	.0277	.0304	.0332	.0362	.0393
30	4.910	.00546	.00660	.00786	.00922	.01070	.01228	.0140	.0158	.0177	.0197	.0218	.0241	.0264	.0289	.0314	.0341
36	7.070	.00428	.00518	.00616	.00723	.00839	.00963	.01096	.0124	.0139	.0154	.0171	.0189	.0207	.0226	.0246	.0267
42	9.620	.00348	.00422	.00502	.00589	.00683	.00784	.00892	.01007	.01129	.0126	.0139	.0154	.0169	.0184	.0201	.0218
48	12.570	.00292	.00353	.00420	.00493	.00572	.00656	.00747	.00843	.00945	.01053	.01166	.0129	.0141	.0154	.0168	.0182
54	15.900	.00249	.00302	.00359	.00421	.00488	.00561	.00638	.00720	.00808	.00900	.00997	.01099	.0121	.0132	.0144	.0156
60	19.630	.00217	.00262	.00312	.00366	.00424	.00487	.00554	.00622	.00702	.00782	.00866	.00955	.01048	.0115	.0125	.0135

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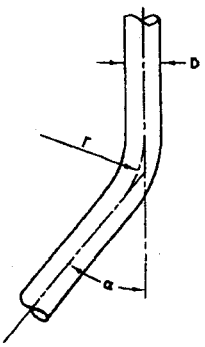
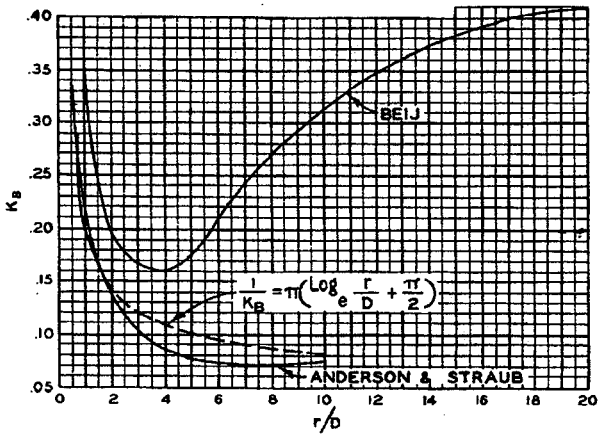
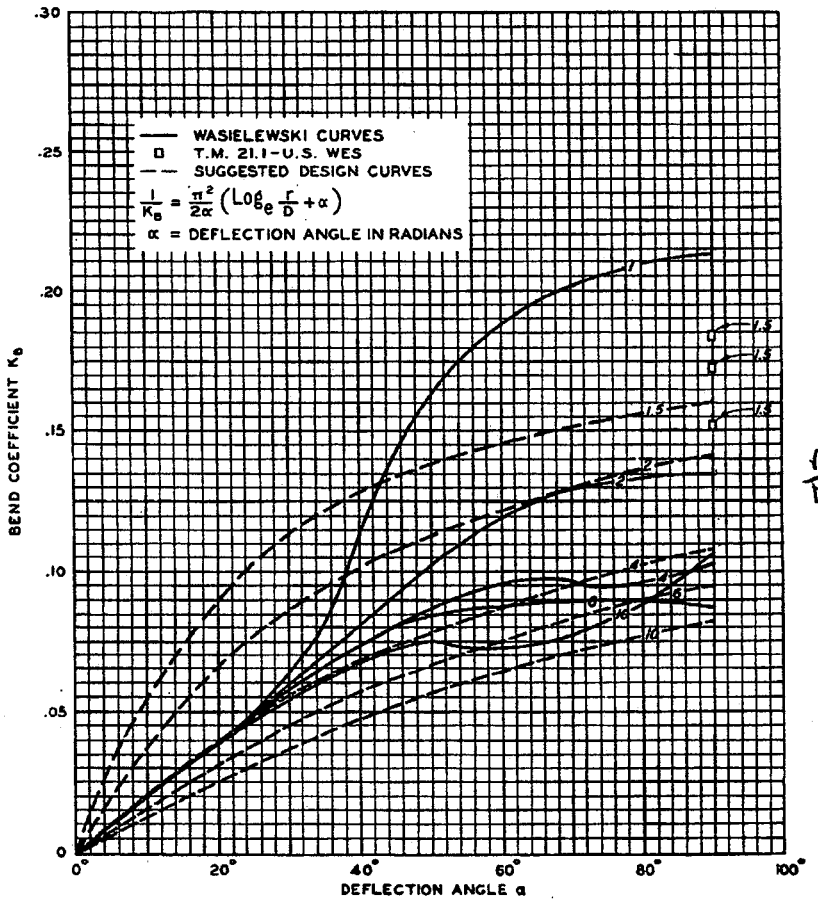




K_B VS r/D FOR 90° BENDS



$\frac{r}{D} = \frac{75}{34} = 2.2$

$K_B \approx 0.135$

BASIC EQUATION = $h_L = K_B V^2/2g$

h_L = HEAD LOSS DUE TO BEND

K_B = BEND LOSS COEFFICIENT

V = VELOCITY IN PIPE

NOTE: FIGURES ON GRAPH INDICATE r/D RATIO.

BEND-LOSS COEFFICIENTS

HYDRAULIC DESIGN CHART 228-1

REVISED 8-58 WES 4-1-52

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South Holston - Bent Branch Spillway

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Purpose: Develop a $C_f(H_c)$ relationship for Bent Branch Spillway where C_f = discharge coefficient and H_c = head above crest.

Approach: Use correlations for Ogee crest given in Design of Small Dams (Ref 2.8).

(1) Select C_o from Fig 9-23 (Sheet C7)

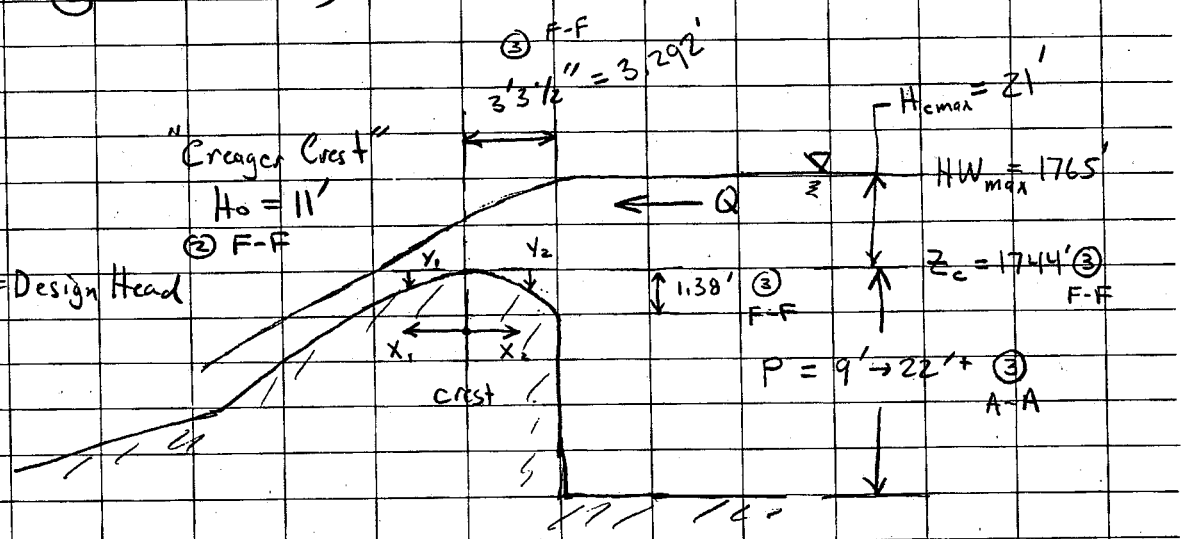
(2) Determine $C_f(H_o)$ using C_o and $\frac{C}{C_o}$ vs. $\frac{H_c}{H_o}$ from Fig 9-24 (Sheet C8)

(3) Show similarity between Bent Branch crest and Ogee crest at same design head, H_o.

Drawings

① 51W250, R4 (See sh C13)
② 51N251, R3
③ 51N253, R2

Sketch



Crest Equations: ③ F-F

$$\begin{cases} Y_1 = 0.07343 X_1^{1.8} \\ Y_2 = 0.0386 X_2^{3} \end{cases}$$

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South Holston - Bent Branch Spillway

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(1) Select C_o from Fig. 9-23

$$\left.\begin{array}{l} H_o = 11' \\ 9' \le P \le 22' \end{array}\right\} \quad 0.82 \le \frac{P}{H_o} \le 2.0 \Rightarrow 3.87 \le C_o \le 3.93$$

on Fig 9-23

Use average value, $\underline{\underline{C_o = 3.90}}$

(2) Determine $C_f(H_c)$ from Fig 9-24

Points scaled from Fig. 9-24 are fit with the following polynomial in the top half of sheet C9

$$\frac{C}{C_o} = 1 + 0.1275\left(\frac{H}{H_o}-1\right) - 0.03876\left(\frac{H}{H_o}-1\right)^2 + 0.04454\left(\frac{H}{H_o}-1\right)^3$$

where $C \equiv C_f$ and $H \equiv H_c$. The dependent variable is $H/H_o - 1$ to ensure that $C = C_o$ at $H = H_o$. Rewrite as

$$\begin{aligned}
\frac{C}{C_o} &= 1 + a_1(h-1) + a_2(h-1)^2 + a_3(h-1)^3 \\
&= 1 + (h-1)\{a_1 + (h-1)[a_2 + (h-1)\cdot a_3]\} \\
&= 1 + (h-1)\{a_1 + (h-1)[a_3 h + (a_2 - a_3)]\} \\
&= 1 + (h-1)[a_1 + a_3 h^2 + (a_2 - a_3)h - a_3 h - (a_2 - a_3)] \\
&= 1 + (h-1)[a_3 h^2 + (a_2 - 2a_3)h + (a_1 - a_2 + a_3)] \\
&= 1 + a_3 h^3 + (a_2 - 2a_3)h^2 + (a_1 - a_2 + a_3)h - a_3 h^2 - (a_2 - 2a_3)h - (a_1 - a_2 + a_3) \\
&= 1 - (a_1 - a_2 + a_3) + (a_1 - 2a_2 + 3a_3)h + (a_2 - 3a_3)h^2 + a_3 h^3
\end{aligned}$$

where
$$\left.\begin{array}{l} a_1 = 0.1275 \\ a_2 = -0.03876 \\ a_3 = 0.04454 \end{array}\right\} \Rightarrow \begin{array}{l} 1 - (a_1 - a_2 + a_3) = 0.7892 \\ a_1 - 2a_2 + 3a_3 = 0.33864 \\ a_2 - 3a_3 = -0.17238 \end{array} \quad \text{and } h = \frac{H}{H_o}$$

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South Holston Bent Branch Spillway

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$$\Rightarrow \frac{C}{C_o} = 0.7892 + 0.33864\frac{H}{H_o} - 0.17238\left(\frac{H}{H_o}\right)^2 + 0.04454\left(\frac{H}{H_o}\right)^3$$

For $C_o = 3.9$ and $H_o = 11'$, this equation becomes

for $0 \le H_c \le 17.6'$

$$\boxed{C_f = 3.078 + 0.1201 \cdot H_c - 0.005556 \cdot H_c^2 + 0.0001305\, H_c^3}$$

with C replaced with C_f and H replaced with H_c. This polynomial is valid for

$\frac{H}{H_o} \le 1.6$, which is the upper limit on Fig 9-24

or $H \le 1.6 \times 11 = \underline{17.6'}$

$C_f(H_c)$ is needed for $0 < H \le 21'$. Use linear extension of C/C_o vs. $H/H_o - 1$ relationship shown on sheet C9 for $H > 17.6'$

slope over largest 3 C/C_o values

$$\frac{C}{C_o} = 1.07 + \left(\frac{1.07-1.05}{0.6-0.4}\right)\left(\frac{H}{H_o} - 1 - 0.6\right)$$

largest $\frac{C}{C_o}$ value from Fig 9-24.

$$\Rightarrow \frac{C}{C_o} = 1.07 + 0.1\left(\frac{H}{H_o} - 1.6\right) = 0.91 + 0.1\frac{H}{H_o}$$

For $C_o = 3.9$ and $H_o = 11'$

$$\boxed{C_f = 3.549 + 0.03545\, H_c \quad \text{for } H_c > 17.6'}$$

The polynomial and linear extension are shown to fit the points scaled from Fig. 9-24 on the bottom half of sheet C9.

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South Holston-Bent Branch Spillway

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(3) Show similarity between Bent Branch crest and Ogee crest at $H_o = 11'$

First compare crest shapes downstream from crest

- Ogee: $\frac{y}{H_o} = -K\left(\frac{x}{H_o}\right)^n$ as shown on Fig 9-21 (sheet C10)

with K and n dependent on $\frac{h_a}{H_o}$ where h_a = velocity head upstream when $H = H_o$

$$h_a = \frac{q^2}{2g(P+h_o)^2}$$

where q = discharge per foot of crest = $C_o H_o^{3/2}$ in cfs/ft, g = acceleration of gravity (32.2 ft/sec^2), and $h_o = H_o - h_a$ (see Fig. 9-21 on sheet C10).

For $C_o = 3.9$ and $H_o = 11$ feet, $q = 3.9 \cdot 11^{3/2} = 142.3$ cfs/ft and

$$h_a = \frac{(142.3)^2}{2(32.2)(P+11-h_a)^2} = \frac{314.4}{(P+11-h_a)^2}$$

P varies from 9' to about 22'. For P = 9', iteration for h_a:

est. $h_a = 0 \longrightarrow h_a = 0.786$

$h_a = .8 \longrightarrow h_a = 0.853$

$h_a = .86 \longrightarrow \underline{h_a = 0.858}$ — close enough

For P = 22'

est. $h_a = 0 \longrightarrow h_a = 0.289$

$h_a = 0.3 \longrightarrow \underline{h_a = 0.294}$ — close enough

$$\Rightarrow \frac{0.3}{11} \le \frac{h_a}{H_o} \le \frac{0.86}{11}$$

$$0.027 \le \frac{h_a}{H_o} \le 0.078$$

For average value of $h_o/H_o = 0.053$

$$\boxed{\begin{aligned} K &= 0.510 \\ n &= 1.847 \end{aligned}}$$

for vertical upstream face (Fig 9-21 of Ref. 2.8) (see p. C10)

CDQ000020080017

South Holston Bent Branch Spillway

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Determine K and n for Bent Branch crest:

$$Y_1 = 0.07343 X_1^{1.8}$$

$$\frac{Y_1}{H_o}\cdot(H_o) = 0.07343\left(\frac{X_1}{H_o}\right)^{1.8}\cdot(H_o)^{1.8}$$

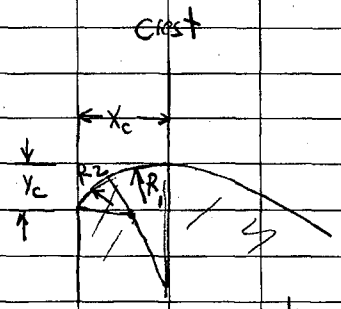
with $H_o = 11'$: $$11\frac{Y_1}{H_o} = 0.07343\left(\frac{X_1}{H_o}\right)^{1.8}\cdot 11^{1.8}$$

$$\Rightarrow \frac{Y_1}{H_o} = 0.50\left(\frac{X_1}{H_o}\right)^{1.8} \Rightarrow \begin{cases} K = 0.50 \\ n = 1.80 \end{cases}$$ for Bent Branch downstream segment of crest

K and n for Bent Branch are 2 → 3% lower than K and n for an Ogee crest.

<u>Upstream from Crest</u>

- Ogee



See Fig 9-21, sheet C10

X_c, Y_c, R_1, R_2 all vary with $\frac{h_a}{H_o}$. From Fig 9-21, sheet C11 for $\frac{h_a}{H_o} = 0.053$ and vertical face:

$$\left.\begin{aligned} X_c/H_o &= 0.256 \\ Y_c/H_o &= 0.104 \\ R_1/H_o &= 0.503 \\ R_2/H_o &= 0.210 \end{aligned}\right\} \xrightarrow{\text{for } H_o = 11'} \left\{\begin{aligned} X_c &= 2.82' \\ Y_c &= 1.14' \\ R_1 &= 5.53' \\ R_2 &= 2.31' \end{aligned}\right.$$

Conclusion

Sheet C12 compares the Bent Branch spillway crest with a Ogee crest for $H_o = 11'$ and $9 \leq P \leq 22'$. Computation of the upstream (negative x-coordinates) segment of an Ogee crest from R_1 and R_2 is somewhat complicated so only the upstream-most coordinate $(-X_c, -Y_c)$ is plotted in sheet 12.

The visual agreement between the Bent Branch and Ogee crest profiles justifies use of the $C_t(H_o)$ relationship determined for an Ogee crest with $H_o = 11'$ and $9 \leq P \leq 22'$.

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stream apron and is independent of any submergence effect from the tailwater. Figure 9-27 shows the effect of downstream apron conditions on the discharge coefficient. It should be noted that this curve plots, in a slightly different form, the same data represented by the vertical dashed lines on figure 9-26. As the downstream apron level nears the crest of the overflow, $(h_d + d)/H_e$ approaches 1.0, and the discharge coefficient is about 77 percent of the coefficient for unretarded flow. On the basis of a coefficient of 4.0 for unretarded flow over a high weir, the coefficient when the weir is submerged will be about 3.08, which is virtually the coefficient for a broad-crested weir.

From figure 9-26, it can be seen that when $(h_d + d)/H_e$ exceeds about 1.7, the downstream floor position has little effect on the coefficient, but there is a decrease in the coefficient caused by tailwater submergence. Figure 9-28 shows the ratio of the discharge coefficient where affected by tailwater conditions to the coefficient for free flow conditions. This curve plots, in a slightly different form, the data represented by the horizontal dashed lines on figure 9-26. Where the dashed lines on figure 9-26 are curved, the decrease in the coefficient is the result of a combination of tailwater effects and downstream apron position.

9.13. ***Examples of Designs of Uncontrolled Ogee Crests.***—The two examples cited below illustrate the methods of designing uncontrolled ogee crests, including the computation of approach channel losses and velocity head, the determination of the total length of the crest, and the correction of the discharge coefficient for various effects.

(a) *Example 1.*—Design an uncontrolled overflow ogee crest for a chute spillway that will discharge 2,000 ft³/s at a 5-foot head, and prepare a discharge-head curve. The upstream face of the

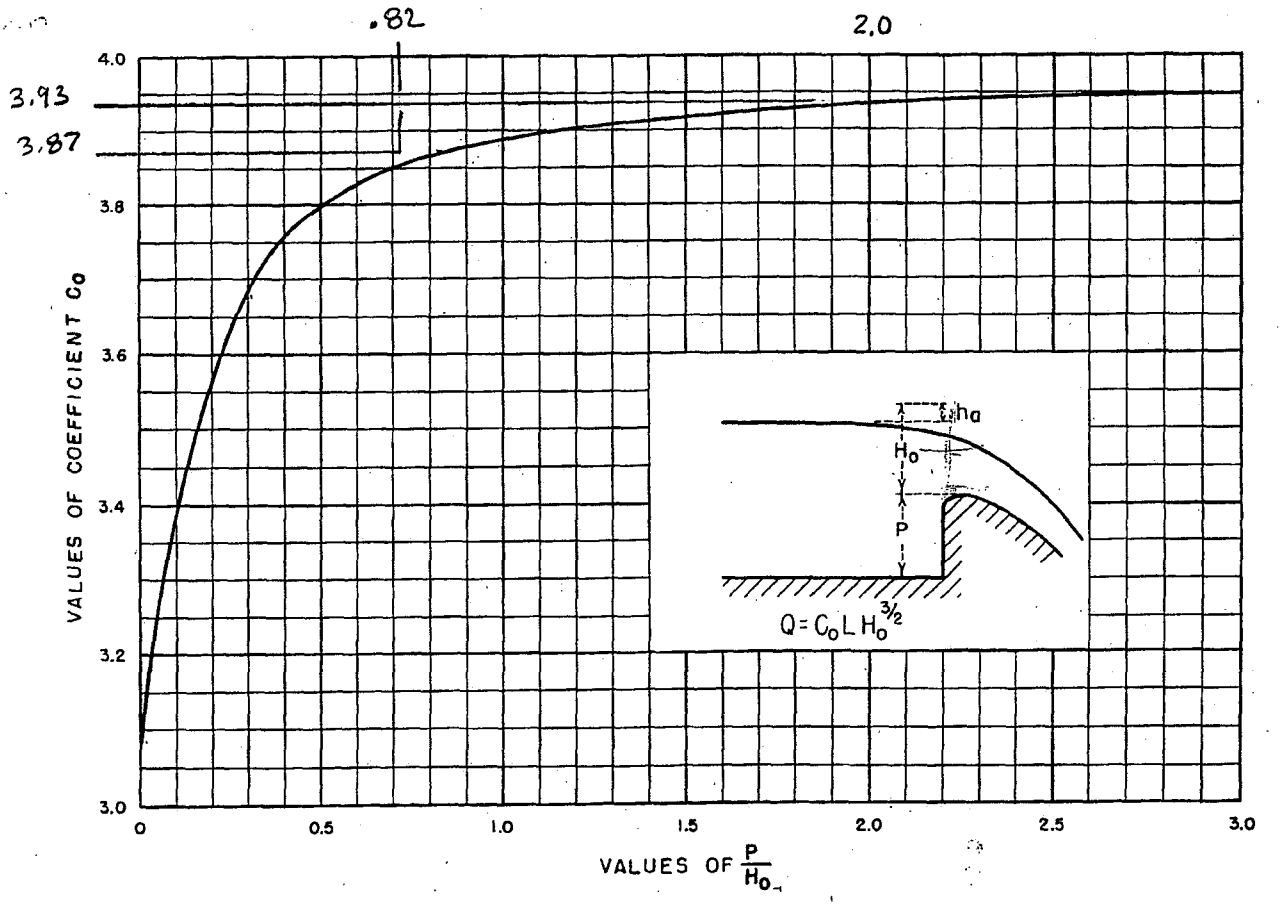

Figure 9-23.—Discharge coefficients for vertical-faced ogee crest. 288-D-2409.

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Info Only

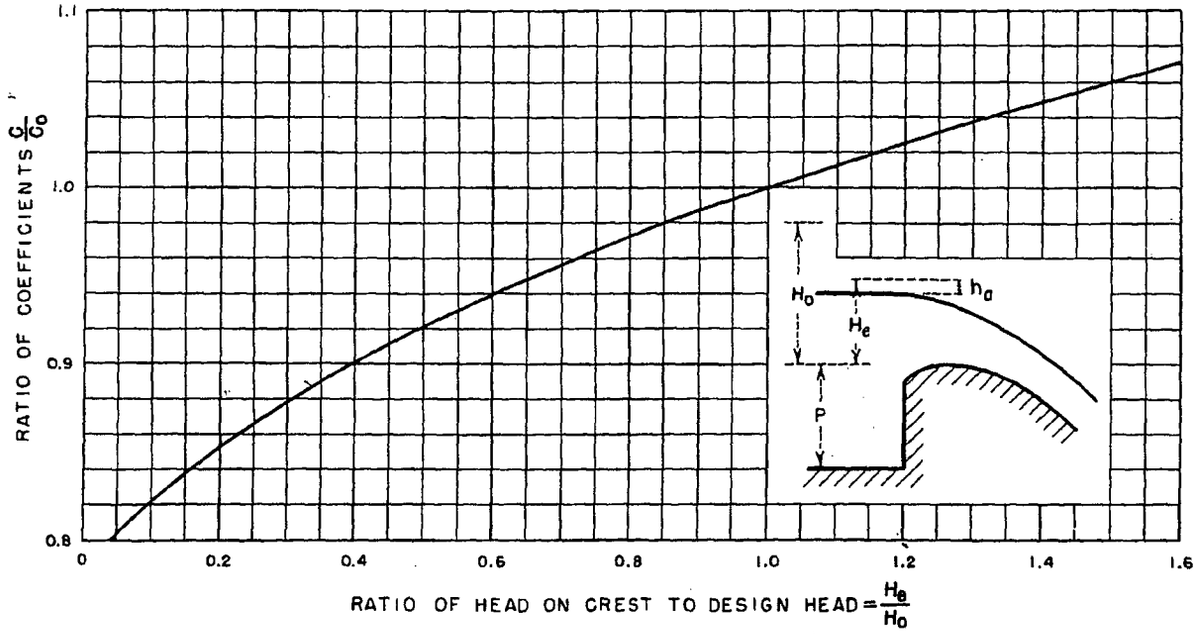

Figure 9-24.—Discharge coefficients for other than the design head. 288-D-2410.

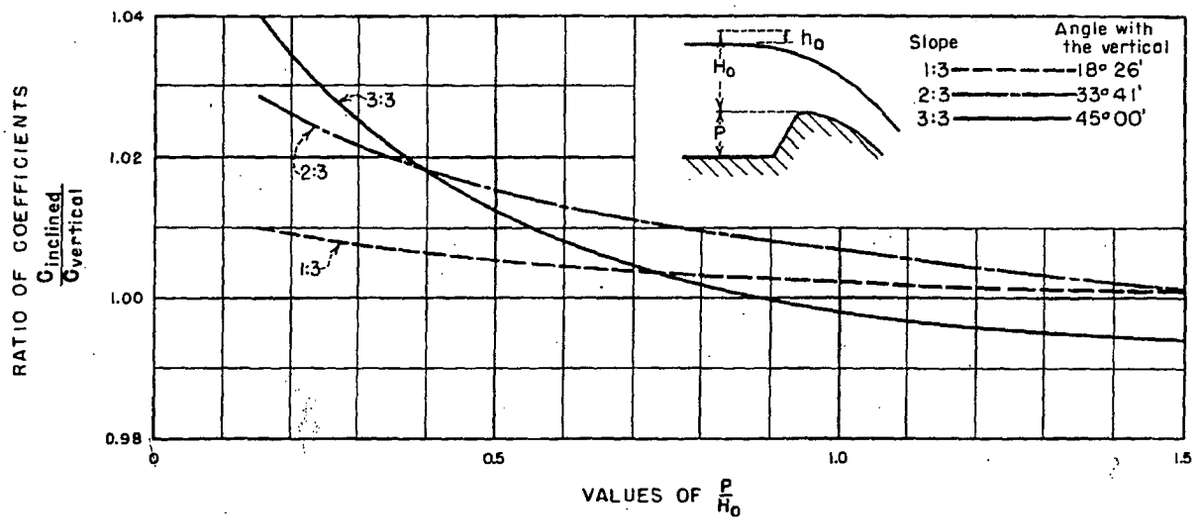

Figure 9-25.—Discharge coefficients for ogee-shaped crest with sloping upstream face. 288-D-2411.

crest is sloped 1:1, and the entrance channel is 100 feet long. A bridge is to span the crest, and 18-inch-wide bridge piers with rounded noses are to be provided. The bridge spans are not to exceed 20 feet. The abutment walls are rounded to a 5-foot radius, and the approach walls are to be placed at 30° with the centerline of the spillway entrance.

To solve the problem, either the approach depth and apron position with respect to the crest must be selected and the appropriate coefficient determined, or an arbitrary coefficient must be selected and the appropriate dimensions determined. The

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checked: JCT 1-29-09

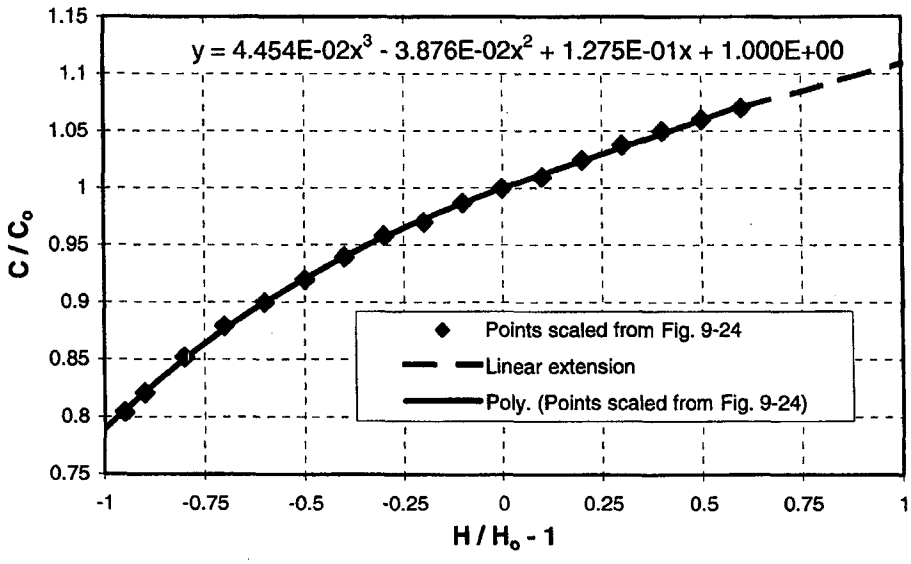
C vs. H

Points scaled from Fig. 9-24 in Design of Small Dams, Bureau of Reclamation, 1987

H/H_o	H/H_o-1	C/C_o
0	-1	
0.05	-0.95	0.804
0.1	-0.9	0.821
0.2	-0.8	0.852
0.3	-0.7	0.879
0.4	-0.6	0.9
0.5	-0.5	0.92
0.6	-0.4	0.94
0.7	-0.3	0.958
0.8	-0.2	0.97
0.9	-0.1	0.987
1	0	1
1.1	0.1	1.01
1.2	0.2	1.025
1.3	0.3	1.038
1.4	0.4	1.05
1.5	0.5	1.06
1.6	0.6	1.07
1.8		
2		

Linear Extrapolation to H/Ho = 2

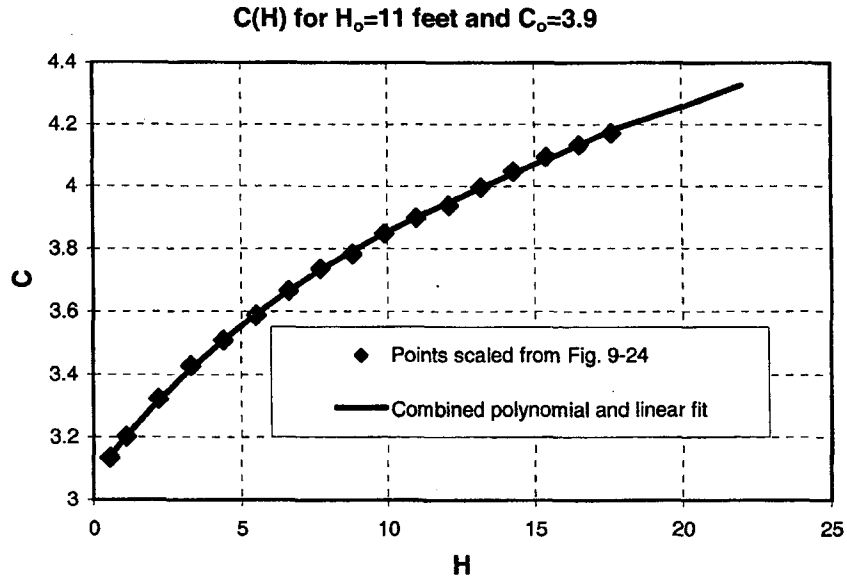
H/H_o	H/H_o-1	C/C_o
1.6	0.6	1.07
1.8	0.8	1.09
2	1	1.11



For H_o = 11 feet
and C_o = 3.9

Poly Fit with Linear Extension

H, feet	C	C
0	0	
0.55	3.1356	3.142
1.1	3.2019	3.204
2.2	3.3228	3.317
3.3	3.4281	3.419
4.4	3.51	3.510
5.5	3.588	3.592
6.6	3.666	3.666
7.7	3.7362	3.733
8.8	3.783	3.794
9.9	3.8493	3.849
11	3.9	3.901
12.1	3.939	3.949
13.2	3.9975	3.995
14.3	4.0482	4.041
15.4	4.095	4.086
16.5	4.134	4.133
17.6	4.173	4.182 poly
19.8		4.251 linear
22		4.329



Curve Fit for C(H):

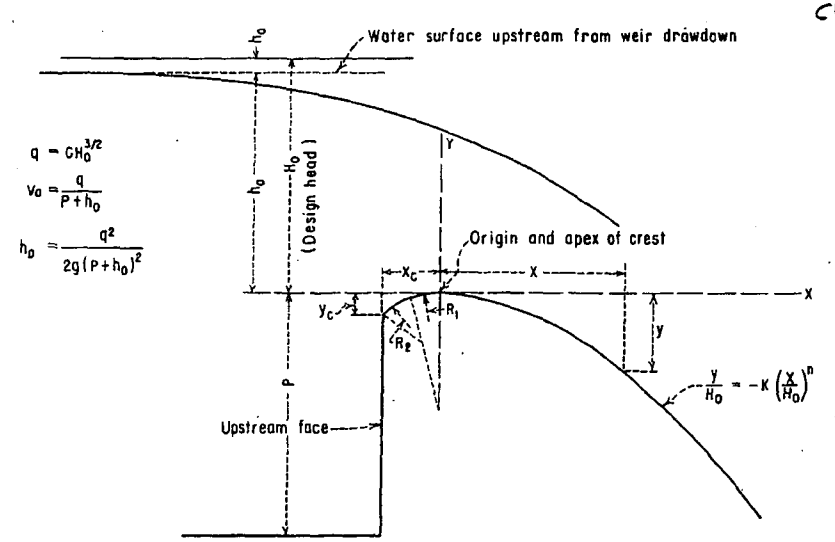
$C = 3.078 + 0.1201H - 0.005556H^2 + 0.0001305H^3$ for 0<=H<=17.6 feet

$C = 3.549 + 0.03545H$ for H>17.6 feet

CDQ 00002008 0017

(From Ref. 2.8)

C10 of 15
prepared: GAS 11/11/08
Checked: JCT 1-29-09



(A) ELEMENTS OF NAPPE-SHAPED CREST PROFILES

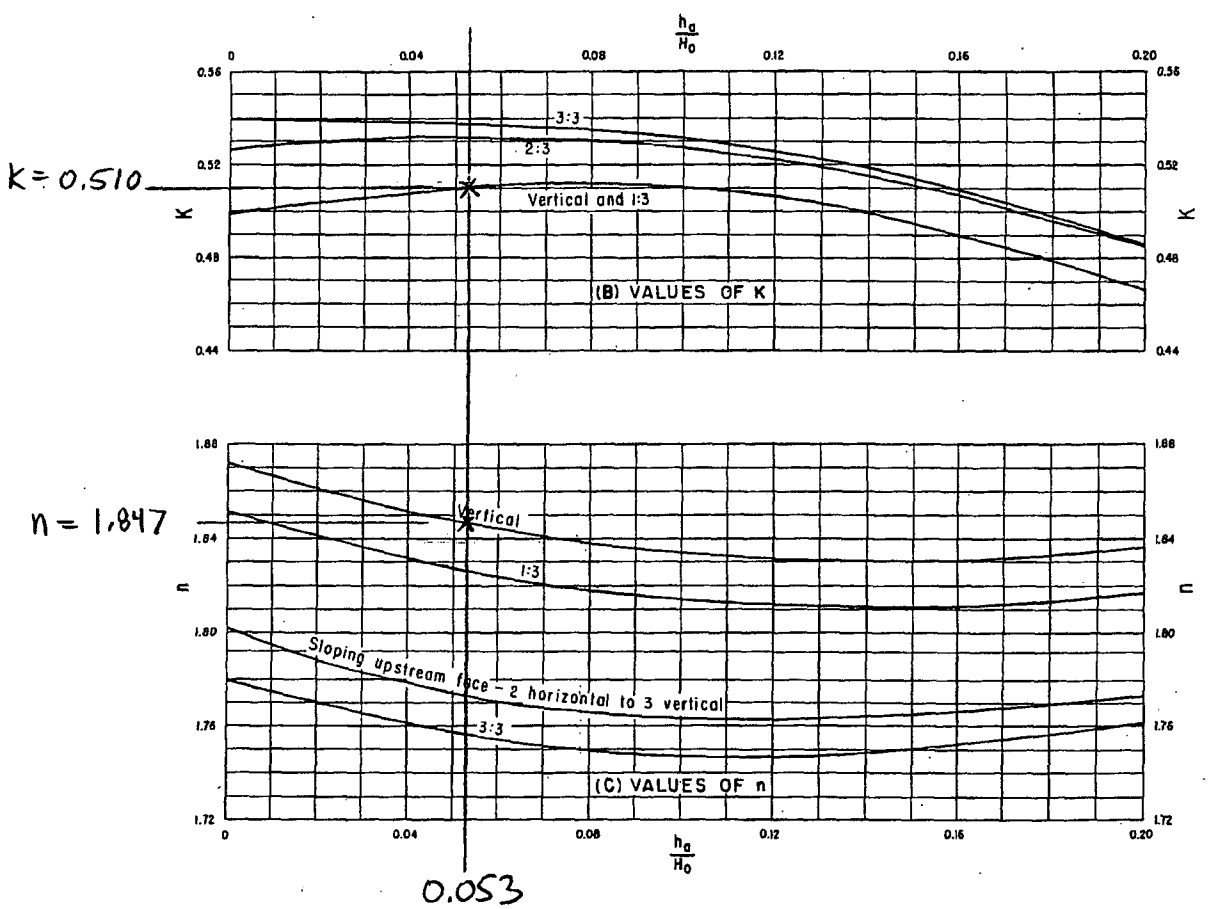


Figure 9-21.—Factors for definition of nappe-shaped crest profiles. 288-D-2406. (Sheet 1 of 2).

CDQ00002008 0017 (From Ref. 2.8)

C11 of 15

367

prepared: GAS 11/11/08
checked: JCT 1-29-09

SPILLWAYS

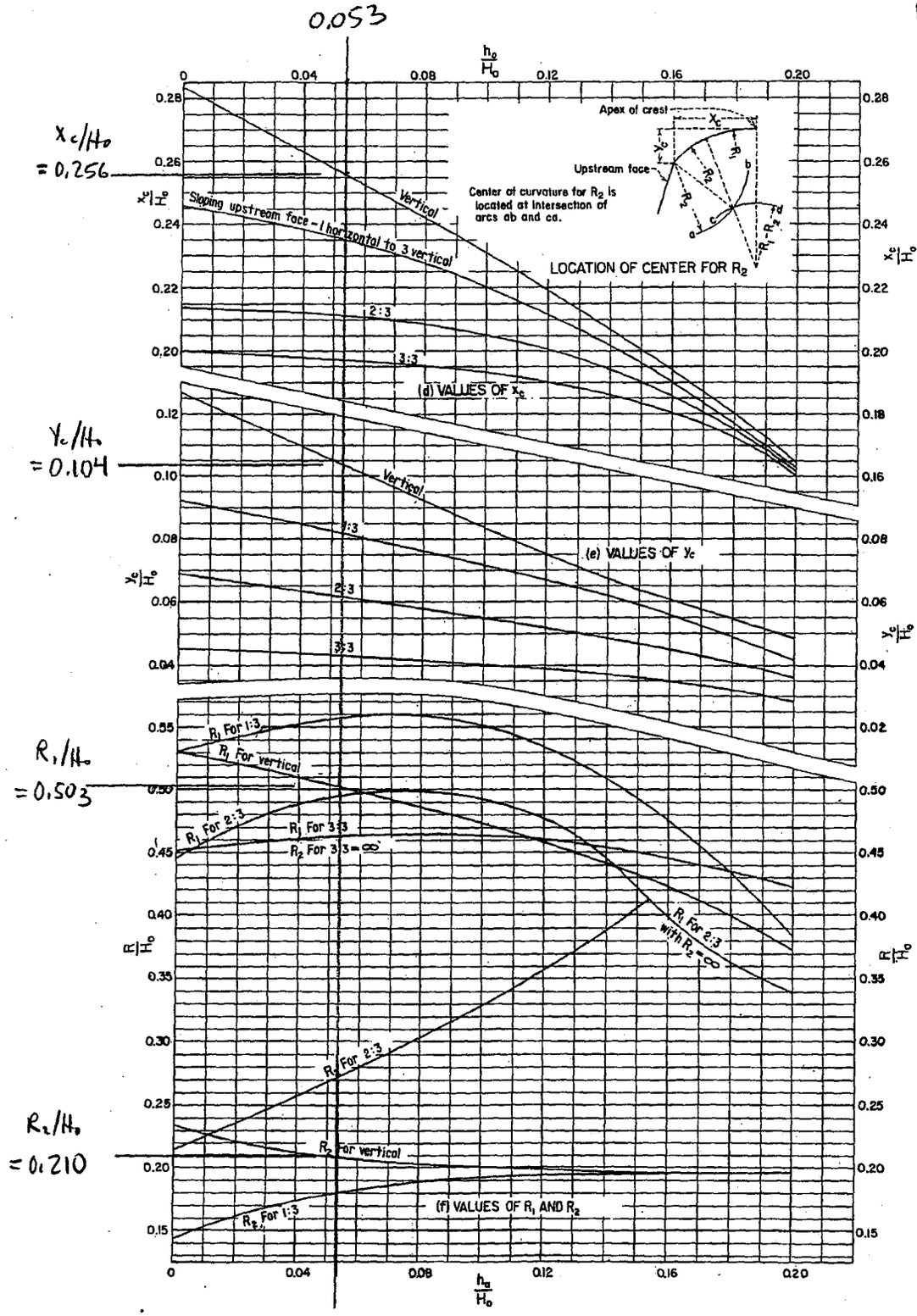
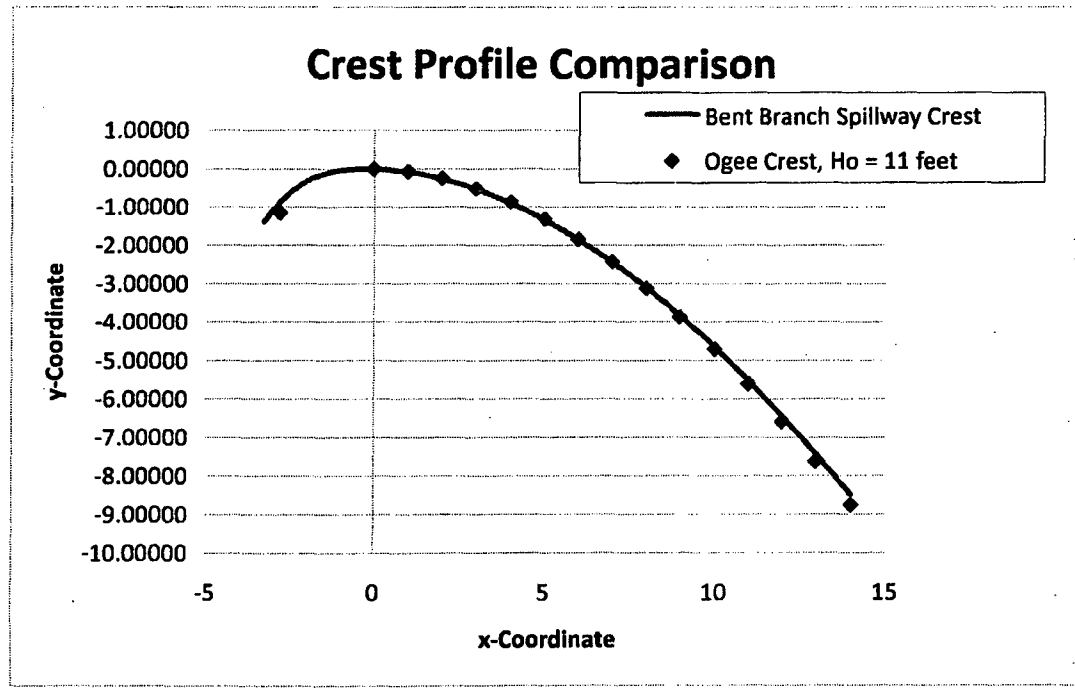


Figure 9-21.—Factors for definition of nappe-shaped crest profiles. 288-D-2407. (Sheet 2 of 2).

	Bent Branch	Ogee Crest		
K	0.500	0.510	Average value for Ogee crest for Ho=11 feet and 9<=P<=22 feet	
n	1.800	1.847	Average value for Ogee crest for Ho=11 feet and 9<=P<=22 feet	

x	y	x	y
-3.292	-1.37710	-2.82000	-1.14000
-3	-1.04220		
-2.6	-0.67843		
-2	-0.30880		
-1.5	-0.13028		
-1	-0.03860		
-0.7	-0.01324		
-0.4	-0.00247		
-0.2	-0.00031		
0	0	0	0
0	0	0	0
1	-0.07343	1	-0.06691
2	-0.25570	2	-0.24072
3	-0.53051	3	-0.50904
4	-0.89039	4	-0.86599
5	-1.33051	5	-1.30770
6	-1.84734	6	-1.83128
7	-2.43809	7	-2.43448
8	-3.10053	8	-3.11543
9	-3.83275	9	-3.87255
10	-4.63312	10	-4.70447
11	-5.50022	11	-5.61000
12	-6.43280	12	-6.58807
13	-7.42970	13	-7.63772
14	-8.48993	14	-8.75808



CD 00002008 0017

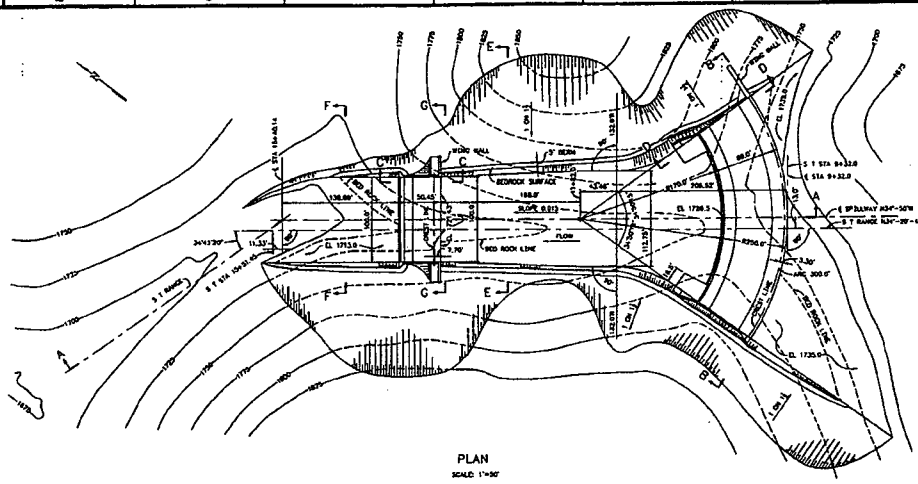
C 12 of 15

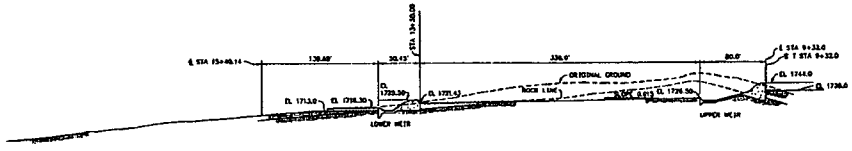
prepared: GAS 11/11/08

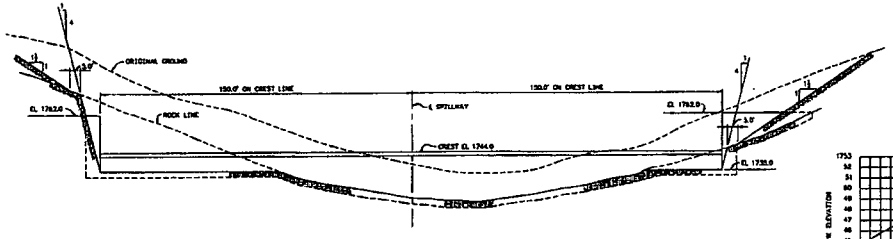
checked: JCT 1-29-09

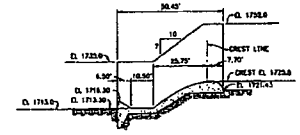
DAM RATING CURVE - SOUTH HOLSTON CU4 0000 2008 0017 C13 of 15

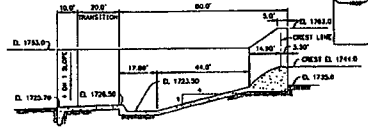
Info Only

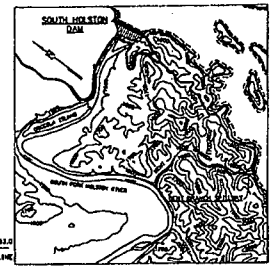


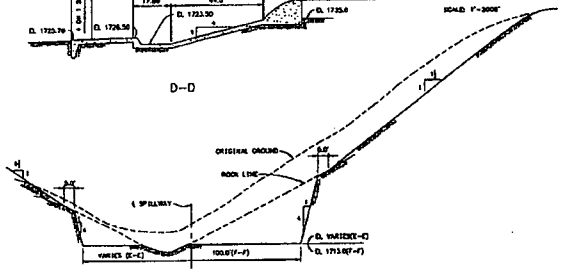


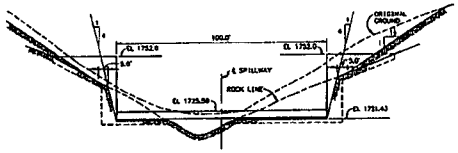




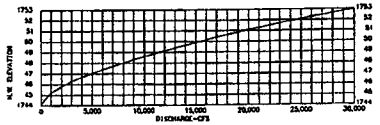








NOTES:
1. SEE FIELD DWGS 51W1241-1248 INCLUSIVE FOR FINAL EXCAVATION.



SCALE: 1"=20' EXCEPT AS NOTED

BENT BRANCH SPILLWAY

PLAN & SECTIONS

DRAWN BY: GAL, REM
CHECKED BY: DFS
DESIGNED BY: RRL

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R14 | 9-2-96 | 21 | C | 51W250 | R 4

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES: (51W250 R3)

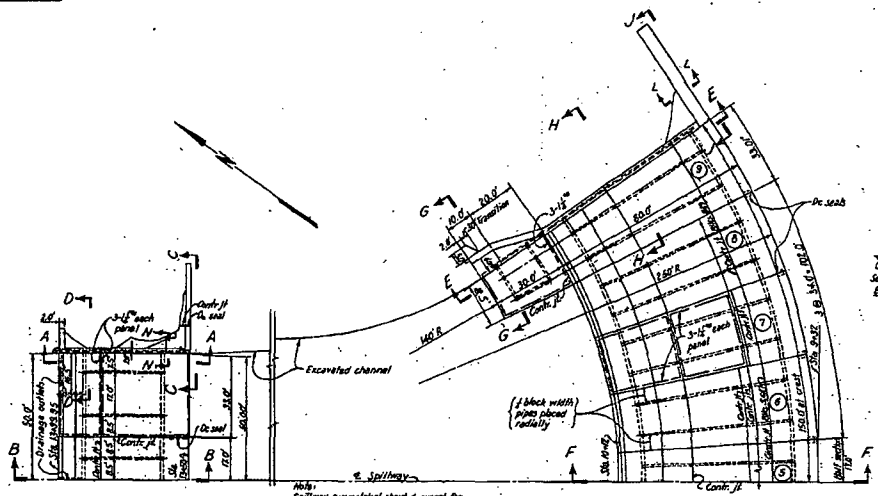
TASK COMPLETED BY: REV NO.

PLOT FACTOR: 240
W_TVA

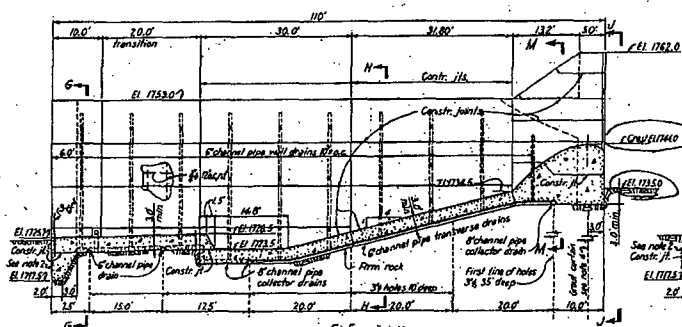
C.A.D. DRAWING
DO NOT ALTER MANUALLY

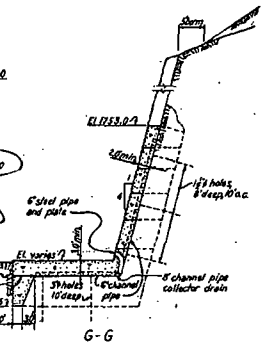
51W250 | 21 | C

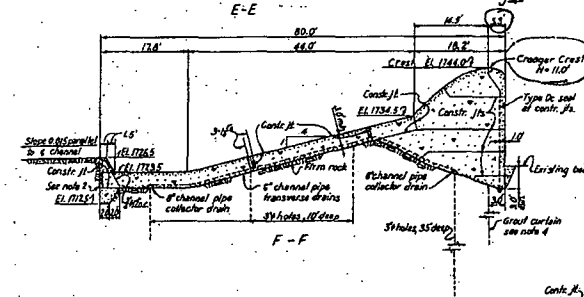
5IN251

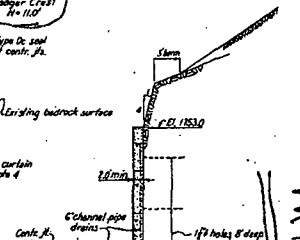


PLAN
Scale 1" = 20'









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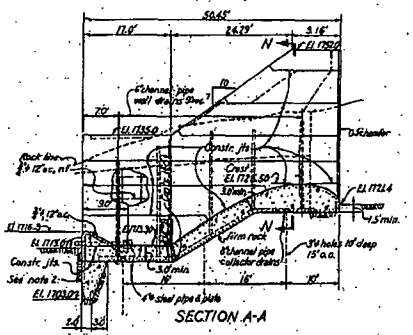
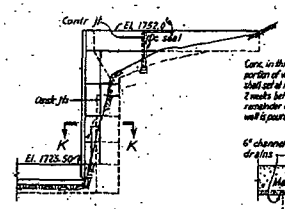
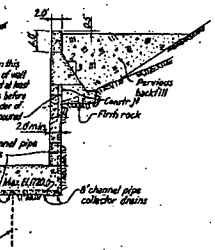
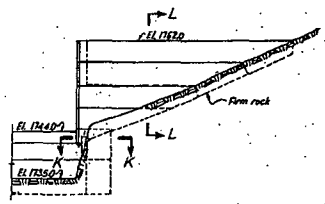
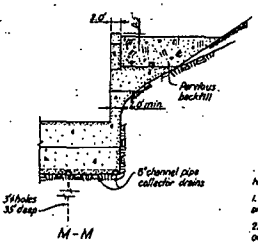
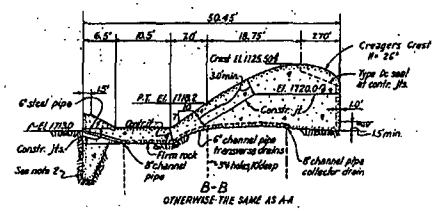


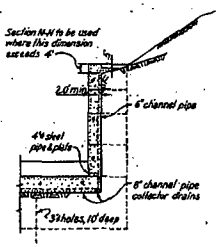


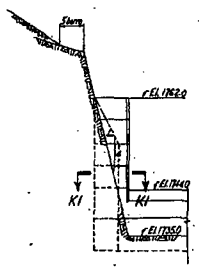


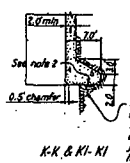


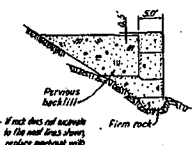












NOTES:

1. Dimensions and details shown are for design purposes only and are not to be used for construction.
2. Line drill and paint vertical rock surface of cut-offs with one heavy coat of asphalt.
3. All contraction joints in aprons shall be provided with keys.
4. In case rock under upstream weir is not water tight, a grout curtain, effectively sealing all seams in the rock to a depth of at least 25' below the base, shall be provided under the weir.
5. See field dwgs 5IN1590-1945 inclusive for final excavation.

Scale 1" = 10' except as noted

BENT BRANCH SPILLWAY

PRINCIPAL FEATURES OF DESIGN

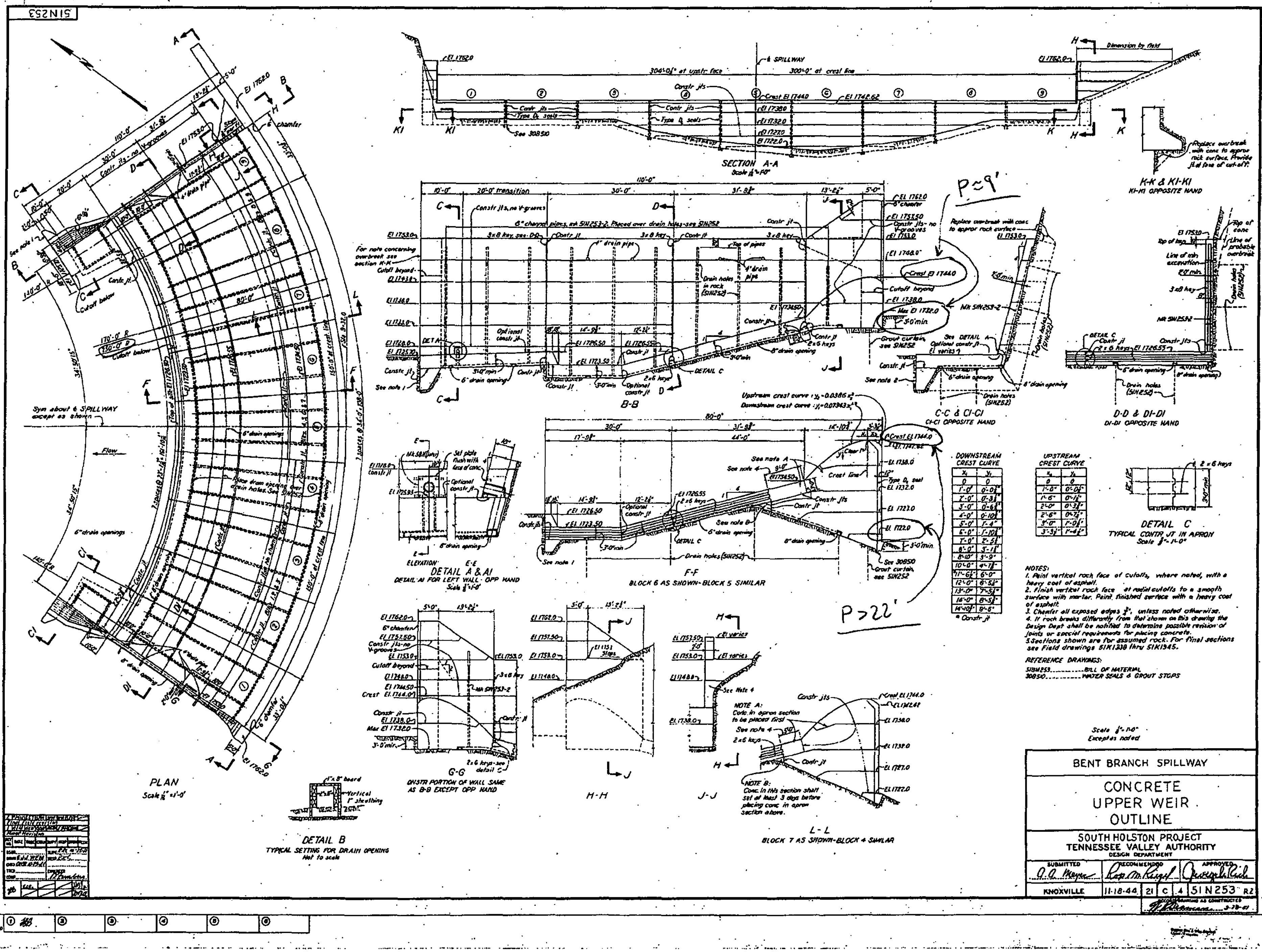
SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DESIGN DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED
O. A. Meyer	Roe M. Krogel	George L. Rich

KNOXVILLE	9-6-44	21	C	4	5IN251	R3

DRAWING AS CONSTRUCTED

DAM RATING CURVE - SOUTH HOLSTON CD00000 200 80017 - C14 of 15



DOWNSTREAM CREST CURVE

x_1	y_1
0	0
1'-0"	0'-0½"
2'-0"	0'-3½"
3'-0"	0'-6½"
4'-0"	0'-10½"
5'-0"	1'-4"
6'-0"	1'-10½"
7'-0"	2'-5½"
8'-0"	3'-1½"
8'-10"	3'-9"
10'-0"	4'-7½"
*11'-6½"	6'-0"
12'-0"	6'-5½"
13'-0"	7'-5½"
14'-0"	8'-5½"
14'-10½"	8'-6"

* Constr jt

UPSTREAM CREST CURVE

x_2	y_2
0	0
1'-0"	0'-0½"
1'-6"	0'-1½"
2'-0"	0'-3½"
2'-6"	0'-7½"
3'-0"	1'-0½"
3'-3½"	1'-4½"

NOTES:
1. Paint vertical rock face of cutoffs, where noted, with a heavy coat of asphalt.
2. Finish vertical rock face at radial cutoffs to a smooth surface with mortar. Paint finished surface with a heavy coat of asphalt.
3. Chamfer all exposed edges ¾", unless noted otherwise.
4. If rock breaks differently from that shown on this drawing the Design Dept shall be notified to determine possible revision of joints or special requirements for placing concrete.
5. Sections shown are for assumed rock. For final sections see Field drawings 51K1338 thru 51K1345.

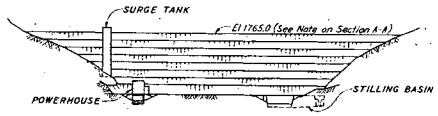
REFERENCE DRAWINGS:
51BM253............BILL OF MATERIAL
30B510............WATER SEALS & GROUT STOPS

ATTACHMENT 1

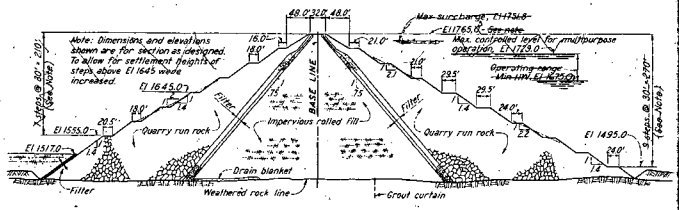
Selected South Holston Project Drawings

(Reference 2.1.1 thru 2.1.10)

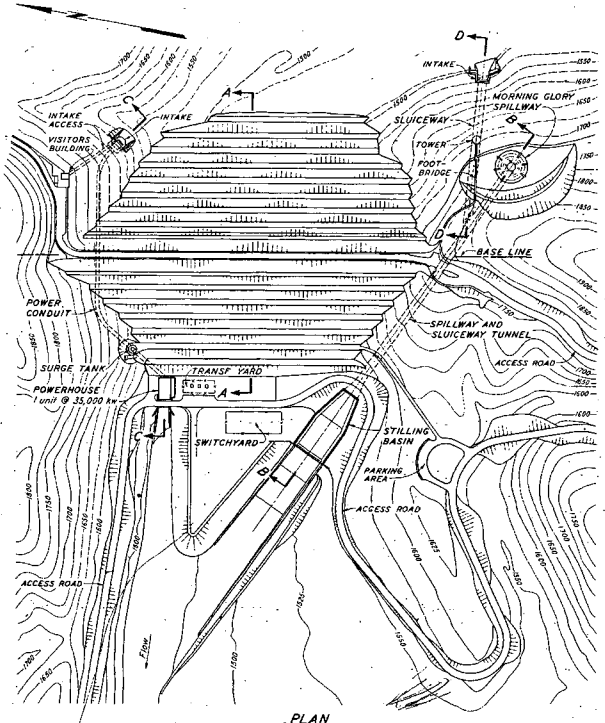
CDQ00002008017



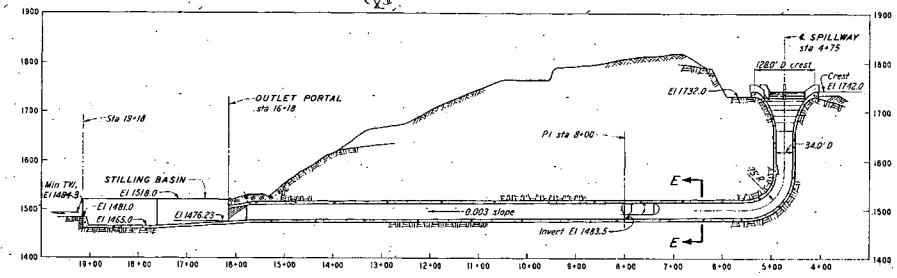
DOWNSTREAM ELEVATION



SECTION A-A



PLAN



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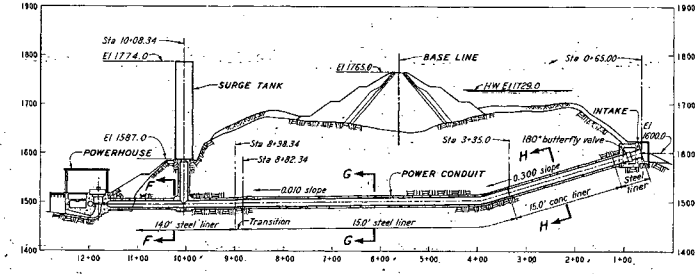

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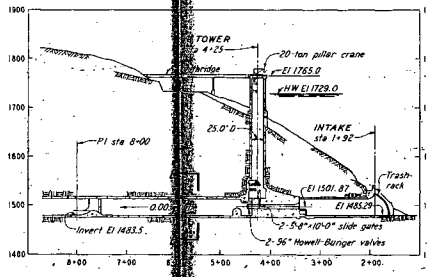
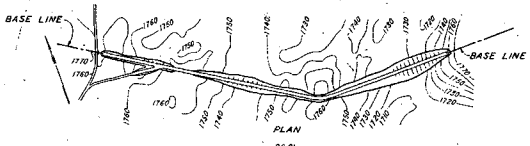


SECTION D-D

SECTION F-F SECTION G-G SECTION H-H



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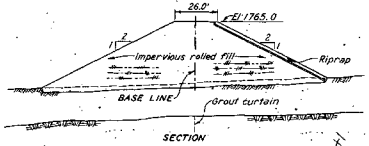
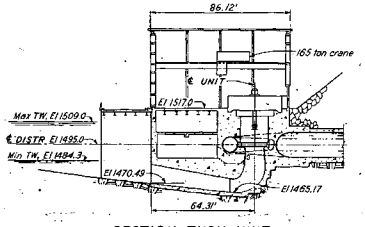


SECTION

SADDLE DAM



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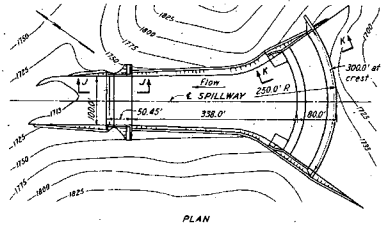

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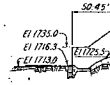
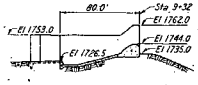


SECTION J-J



SECTION K-K

BENT BRANCH SPILLWAY

SECTION E-E

Scale 500 0 500 1000 Feet
PLAN OF SADDLE DAM

Scale 200 0 200 400 Feet
PLAN & DOWNSTREAM ELEVATION

Scale 100 0 100 200 Feet
PLAN OF BENT BRANCH SPILLWAY
SECTIONS A-A, B-B, C-C & D-D

Scale 50 0 50 100 Feet
SECTIONS J-J & K-K

Scale 30 0 30 60 Feet
SECTS. THRU UNIT & SADDLE DAM
SECTIONS E-E, F-F, G-G & H-H

MAIN DAM WORKS

GENERAL PLANS
ELEVATION & SECTIONS

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

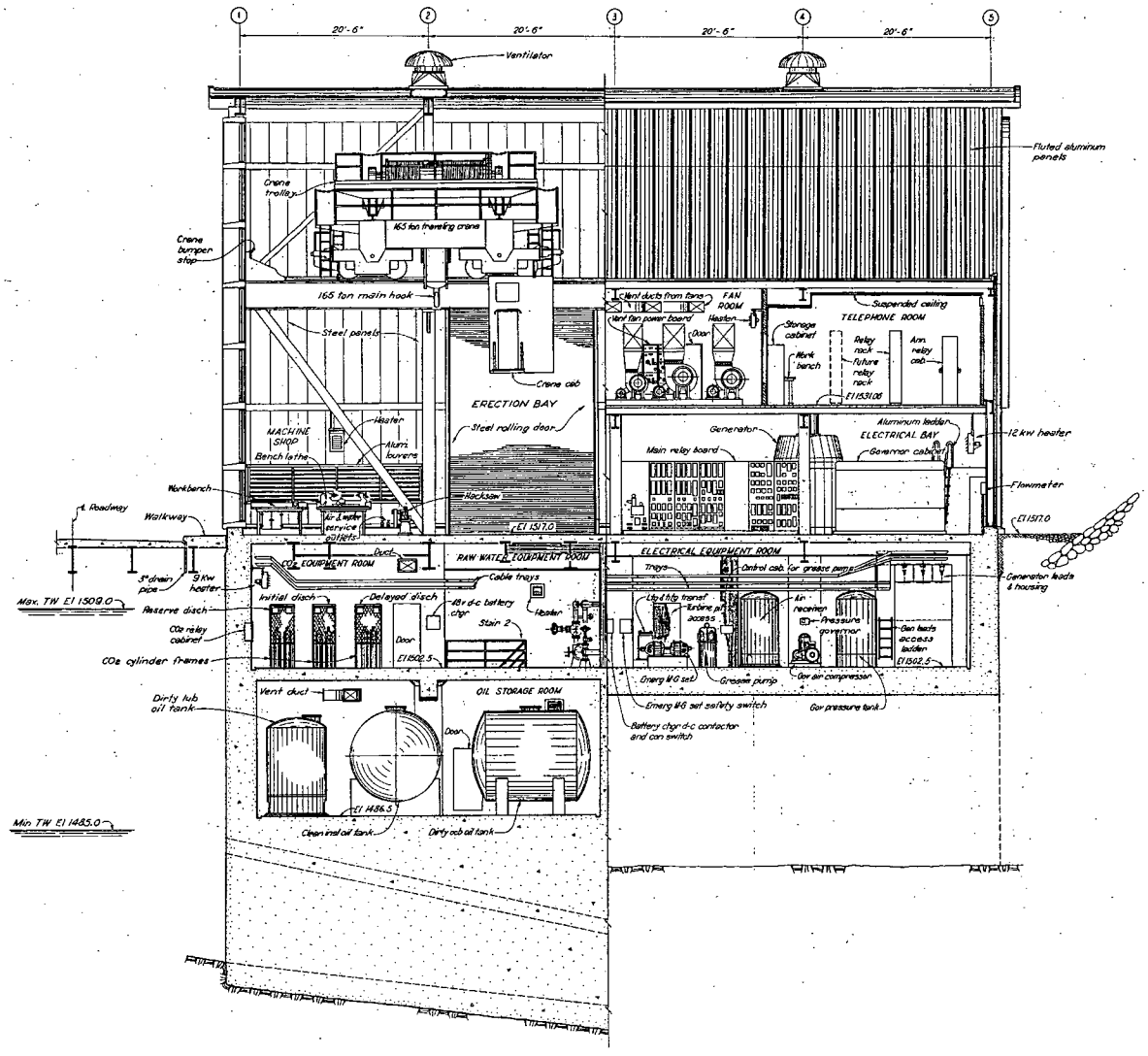
SUBMITTED	RECOMMENDED	APPROVED
	R.D. Morrow	
KNOXVILLE 1-26-48	21 C 4 10N201 R3	

PROJECT MANAGER

DRAWING AS CONSTRUCTED

26 1/8" & 92 1/8"

46N206



Scale 3/8" = 1'-0"
Except as noted

POWERHOUSE

EQUIPMENT
LONGITUDINAL SECTION THRU
ERECTION BAY - ELECTRICAL BAY

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN.

SUBMITTED	RECOMMENDED	APPROVED
H. L. Waterman	Harry R. Jones	A. A. Monroe

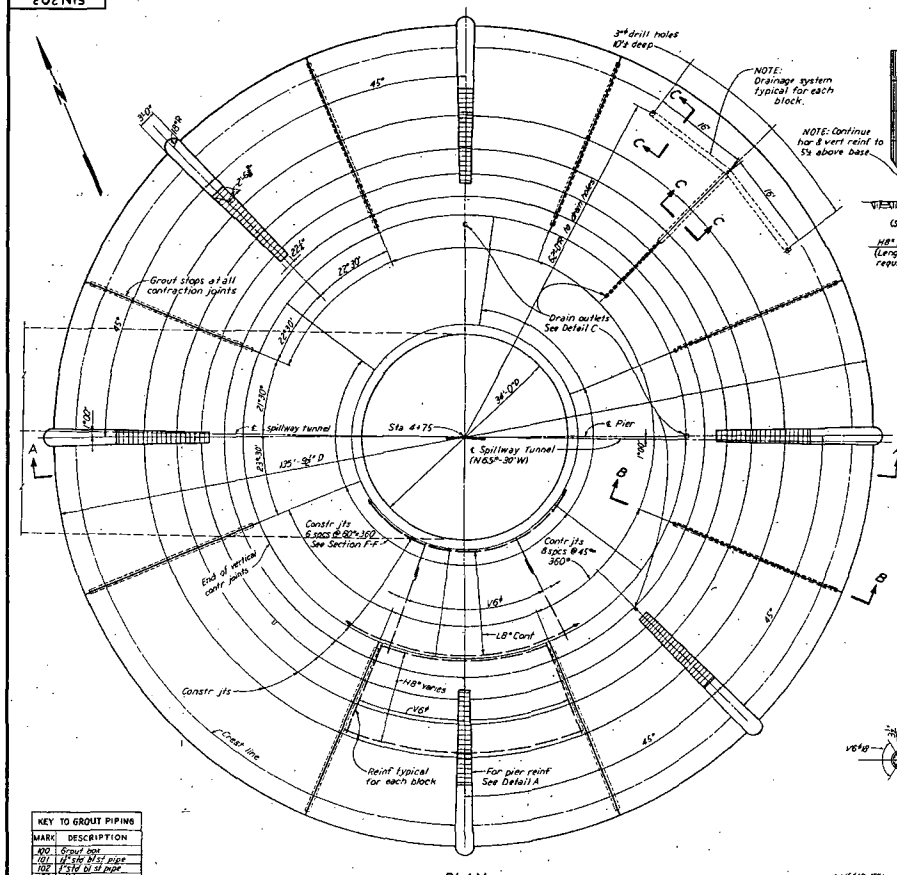
KNOXVILLE	12-22-55	21	A	4	46N206 R0

RECORD DRAWING AS CONSTRUCTED

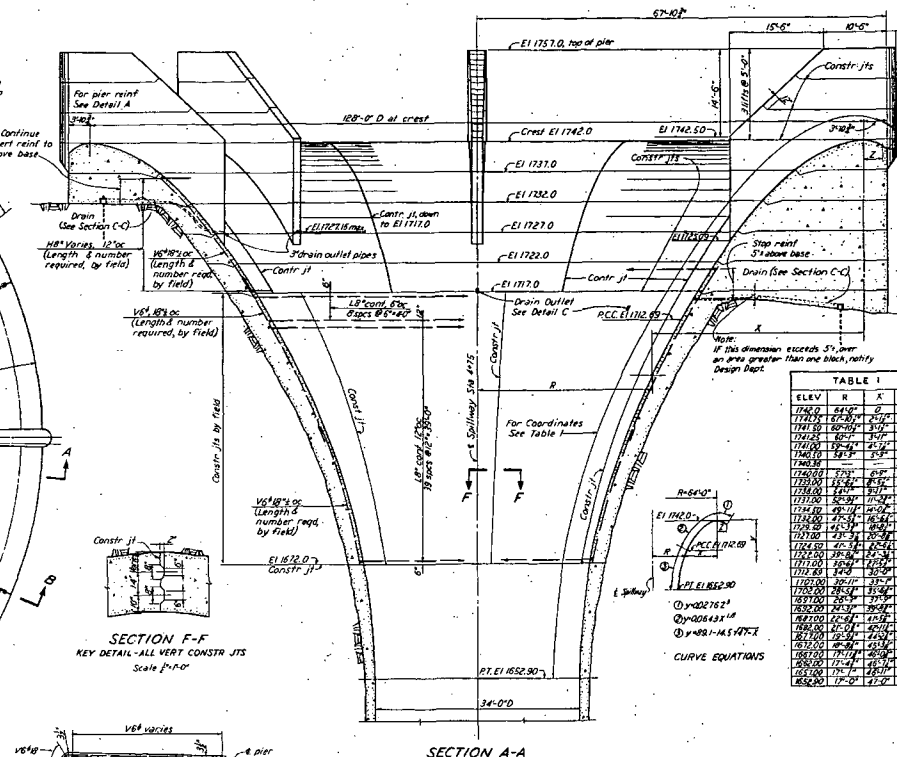
CDQ00002008017

page 1-3 of 11

SIN203



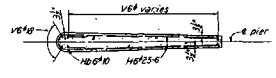
PLAN



SECTION A-A

TABLE I			
ELEV	R	X'	Z
1742.0	64'-0"	0	0
1741.75	67'-10½"	2'-1½"	2'-1"
1741.50	69'-10½"	3'-7½"	2'-7½"
1741.25	69'-7"	3'-5"	3'-0½"
1741.00	69'-4½"	3'-2½"	3'-3"
1740.50	69'-3"	3'-2"	3'-3½"
1740.36	—	—	3'-3½"
1740.00	67'-3½"	0'-8"	—
1739.00	65'-8½"	8'-11½"	—
1738.00	64'-7"	9'-11"	—
1737.00	62'-9½"	11'-10½"	—
1734.00	49'-10½"	16'-0½"	—
1731.00	47'-3½"	16'-8½"	—
1728.00	44'-3½"	18'-8"	—
1727.00	43'-3½"	20'-0½"	—
1724.50	41'-1½"	22'-4½"	—
1722.00	39'-8½"	23'-3½"	—
1717.00	35'-9½"	27'-3½"	—
1712.69	34'-0"	30'-0"	—
1712.00	33'-7"	33'-1"	—
1705.00	33'-5½"	35'-4½"	—
1697.00	33'-5"	37'-5"	—
1682.00	33'-3½"	39'-8½"	—
1672.00	33'-4½"	41'-3½"	—
1662.00	33'-0½"	42'-11½"	—
1652.00	32'-3½"	44'-3½"	—
1642.00	31'-4½"	45'-3½"	—
1632.00	30'-0½"	46'-0½"	—
1622.00	28'-8½"	46'-3½"	—
1612.00	27'-1½"	46'-0½"	—
1602.00	25'-4½"	45'-3½"	—
1592.00	23'-4½"	43'-11½"	—
1582.00	21'-1½"	42'-0½"	—
1572.00	18'-9½"	39'-6½"	—
1562.00	16'-1½"	36'-6½"	—
1552.00	13'-1½"	33'-0½"	—
1552.90	12'-0"	31'-0"	—

SECTION F-F
KEY DETAIL - ALL VERT CONSTR JTS
Scale 1"=1'-0"



SECTION D-D

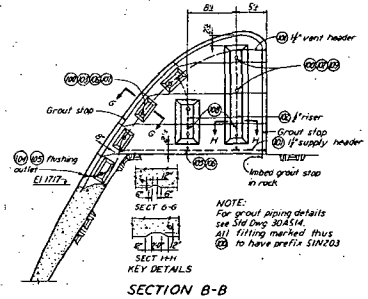
① $y=.00276x^2$
② $y=.00643x^{1.8}$
③ $y=89.1-14.5\sqrt{17-x}$

CURVE EQUATIONS

NOTES:
1. Dimensions from face of concrete to center of reinforcing steel shall be 5" unless noted otherwise.
2. All bar marks on this sheet to have prefix letter "P".
3. All contraction joints to be grouted at a pressure of 10 lbs per sq inch at El 1742, during cold weather in January or February, a minimum of 4 months after completion of concrete placing.

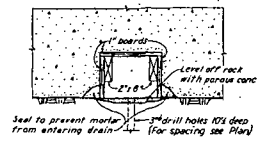
REFERENCE DRAWINGS:
SIN203 BILL OF MATERIAL
SIN203 REINFORCEMENT BAR DETAILS

KEY TO GROUT PIPING	
MARK	DESCRIPTION
100	Grout cap
101	1½"-5#/ft st pipe
102	1"-3.76/ft st pipe
103	1½" tee
104	1½" plug
105	1½" coupling
106	1½"-1" bushing
107	1"-2" nipple
108	1" union
109	1" tee

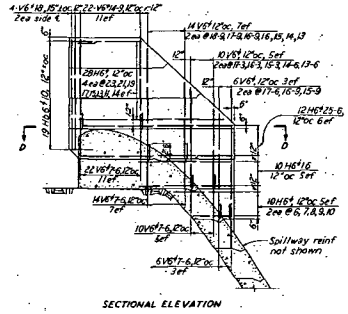


NOTE:
For grout piping details see Std Dwg 30A514.
All fitting marked thus (M) to have prefix SIN203

SECTION B-B
TYPICAL KEYS & GROUT PIPING
Vary to suit actual field conditions

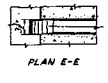


SECTION C-C
Scale 1"=1'-0"

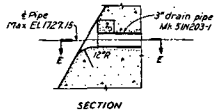


SECTIONAL ELEVATION

DETAIL A
REINF TYPICAL FOR ALL PIERS



PLAN E-E



SECTION

DETAIL C
DRAIN OUTLET
Scale 1"=1'-0"

NOTE: Detail C to be used only for drain outlets located at spillway surface. Cut pipes square & flush with concrete, for outlets located at distrface of piers.

Scale 1/4"=1'-0"
Except as noted

MAIN SPILLWAY

CONCRETE
MORNING GLORY SPILLWAY
OUTLINE & REINFORCEMENT

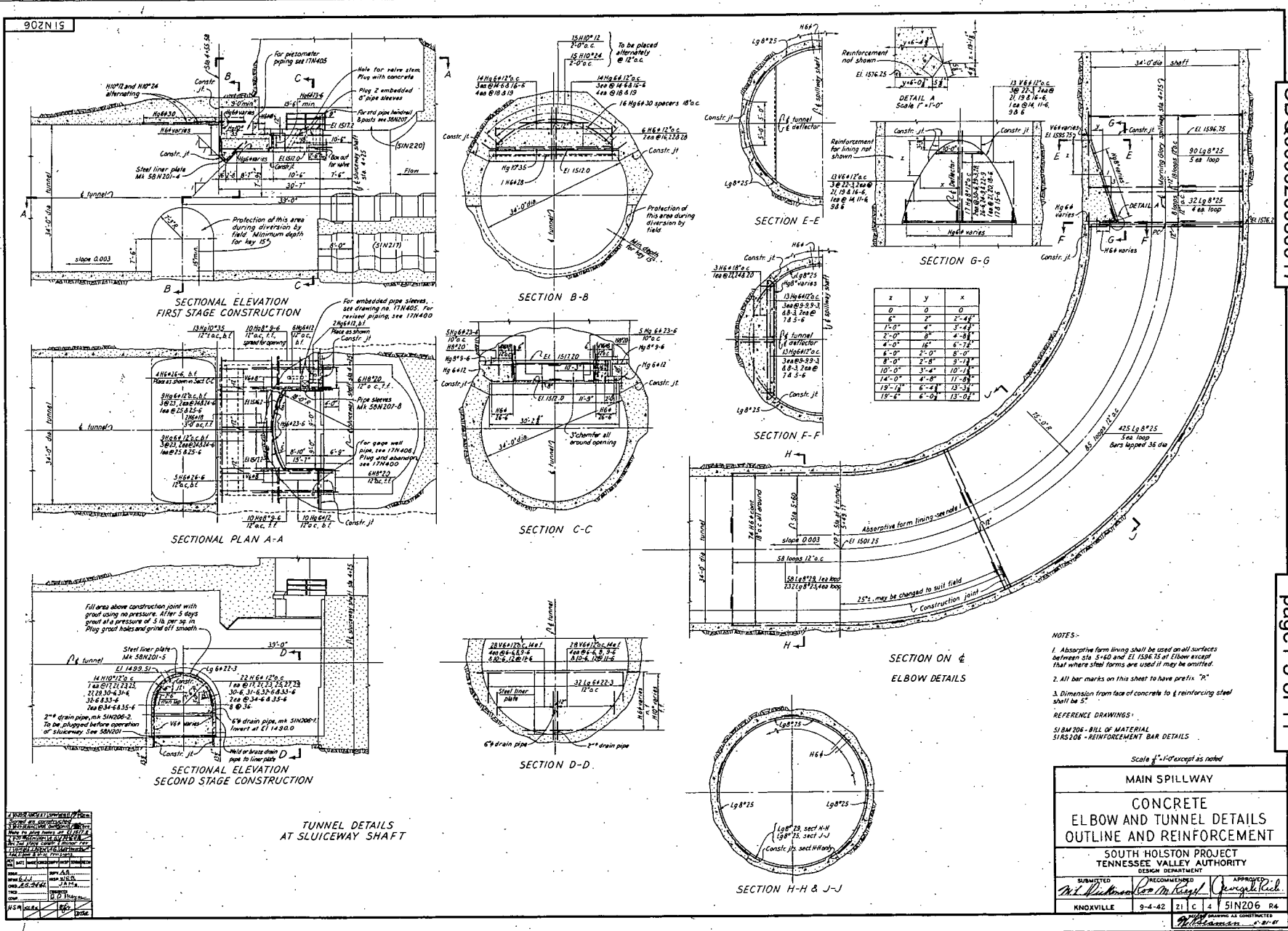
SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DESIGN DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED
M. L. Rechmann	Roy M. Kegel	Quincy Rich

KNOXVILLE	11-3-42	21	C	4	SIN203R2

AS CONSTRUCTED

51N206



z	y	x
0	0	0
6"	2"	2'-4 1/4"
1'-0"	4"	3'-4 1/2"
2'-0"	8"	4'-8 3/4"
4'-0"	16"	6'-7 1/2"
6'-0"	2'-0"	8'-0"
8'-0"	2'-8"	9'-7 1/2"
10'-0"	3'-4"	10'-7 1/2"
14'-0"	4'-8"	11'-6 3/4"
19'-1 1/2"	6'-4 1/2"	13'-3 1/2"
19'-6"	6'-0 1/2"	13'-0 1/2"

NOTES:-

1. Absorptive form lining shall be used on all surfaces between sta. 5+60 and El. 1596.75 of Elbow except that where steel forms are used it may be omitted.
2. All bar marks on this sheet to have prefix "P".
3. Dimension from face of concrete to ℄ reinforcing steel shall be 5".

REFERENCE DRAWINGS:

51BM206 - BILL OF MATERIAL
51RS206 - REINFORCEMENT BAR DETAILS

Scale 1/4" = 1'-0" except as noted

MAIN SPILLWAY

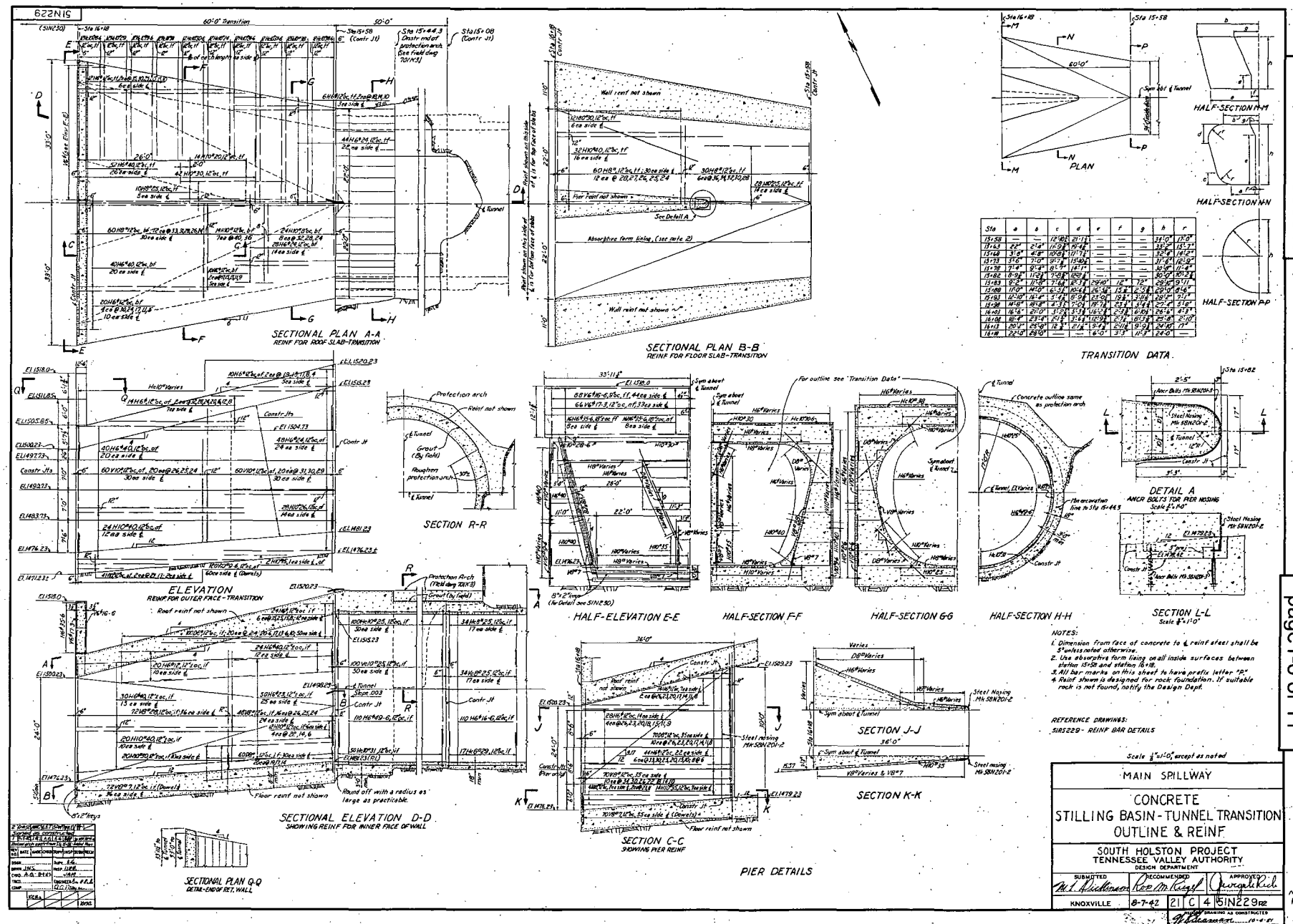
CONCRETE ELBOW AND TUNNEL DETAILS OUTLINE AND REINFORCEMENT

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DESIGN DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED
M. Nickman	Ron McKeigh	George Rich

KNOXVILLE	9-4-42	21	C	4	51N206	R4

REVISED DRAWING AS CONSTRUCTED
M. Nickman 6-21-61



NOTES:

1. Dimension from face of concrete to ℄ reinf steel shall be 5" unless noted otherwise.
2. Use absorptive form lining on all inside surfaces between station 15+58 and station 16+18.
3. All bar marks on this sheet to have prefix letter "R".
4. Reinf shown is designed for rock foundation. If suitable rock is not found, notify the Design Dept.

REFERENCE DRAWINGS:
5IN229 - REINF BAR DETAILS

Scale 1/4"=1'-0" except as noted

MAIN SPILLWAY

CONCRETE
STILLING BASIN - TUNNEL TRANSITION
OUTLINE & REINF.

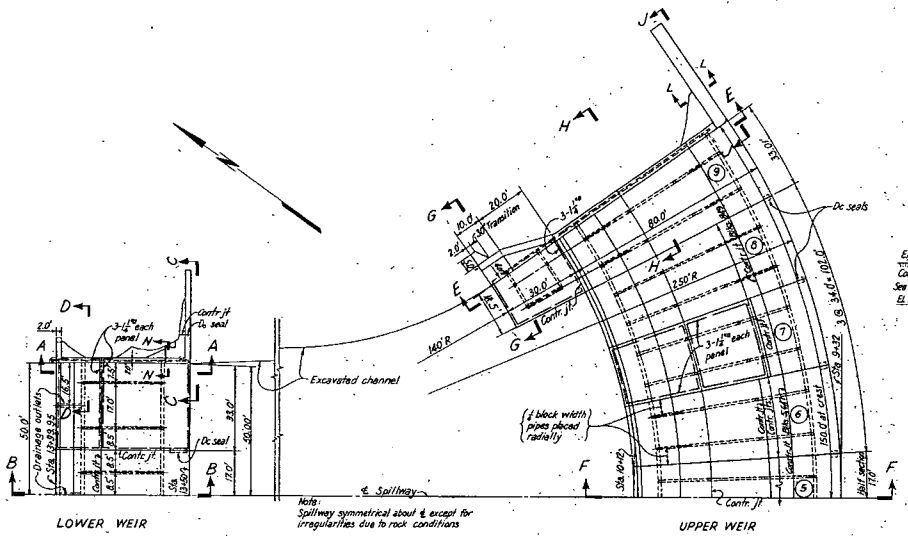
SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DESIGN DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED
M. L. Nicholson	Roy M. Kiesel	Percy H. Rich

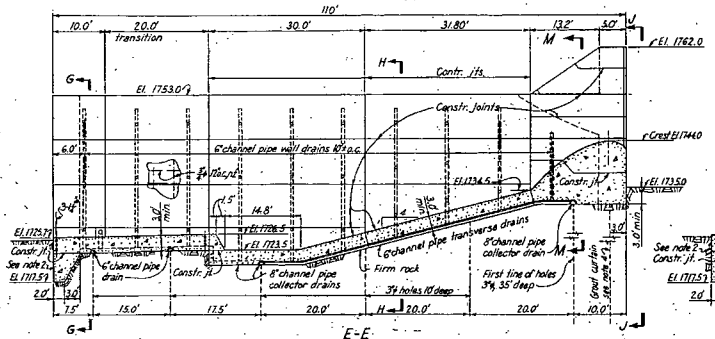
KNOXVILLE | 8-7-42 | 21 | C | 4 | 5IN229 R2

FINAL DRAWING AS CONSTRUCTED
M. L. Nicholson 10-4-51

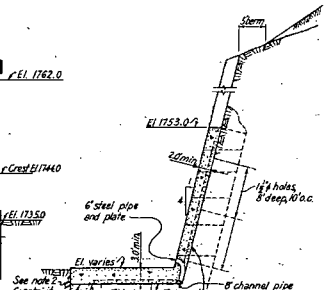
MF R2



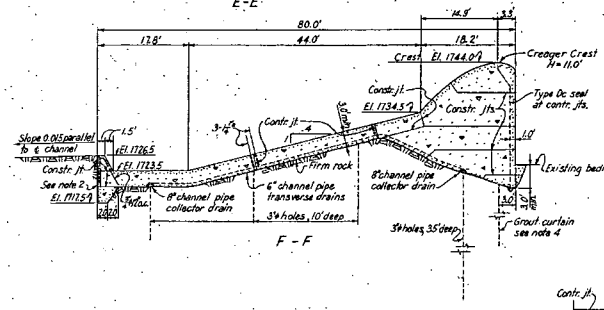
PLAN
Scale 1" = 20'



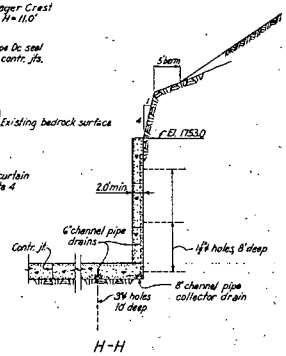
E-E



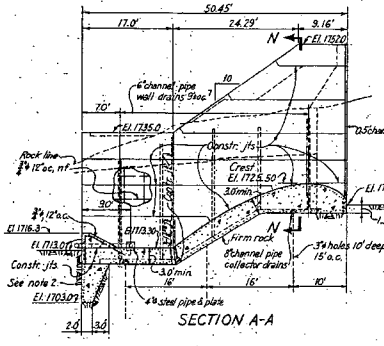
G-G



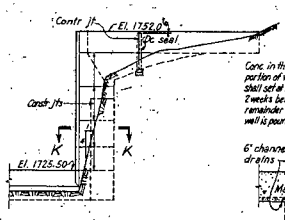
F-F



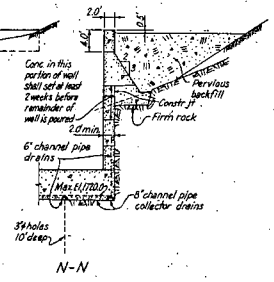
H-H



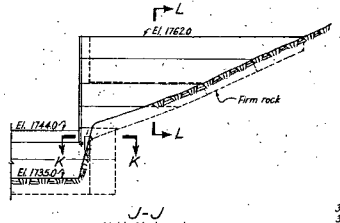
SECTION A-A



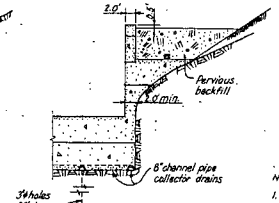
C-C



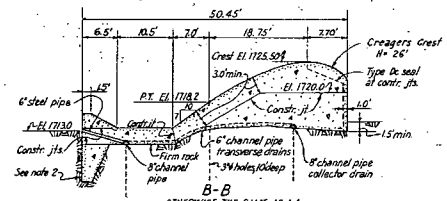
N-N



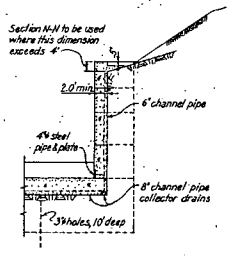
J-J
Right Abutment



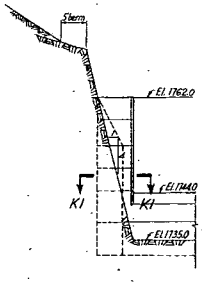
M-M



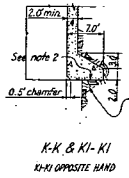
B-B
OTHERWISE THE SAME AS A-A



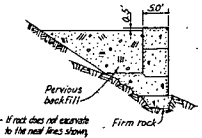
D-D



J1-J1
Left Abutment



K-K & K1-K1
K1-K1 OPPOSITE HAND



L-L

NOTES:

1. Dimensions and details shown are for design purposes only and are not to be used for construction.
2. Line drill and paint vertical rock surface of cut-offs with one heavy coat of asphalt.
3. All contraction joints in aprons shall be provided with keys.
4. In case rock under upstream weir is not water-tight, a grout curtain, effectively sealing all seams in the rock to a depth of at least 25' below the base, shall be provided under the weir.
5. See field dwgs 51K1338-1345 inclusive for final excavation.

Scale 1" = 10' except as noted

3	Weir & Abutments Modified				
2	Brief revision				
1	13-53 Added Weir & Abut. Dimen.				
	Changed Note 4 & minor revisions.				
7	Add at Left Abut. Sheet 7				
	General Revisions				
REV. NO.	DATE	MADE	CHKD	COMPD	TRCD	SUBMD	RECOM

DESIGN ... DUPD Rev. 8-30-41
DRWN E.J.B. 8-30-41 INST. ...
CHKD J.J.H. 12-1-41 ... J.A.H.
TRCD. ... ENGR'D ...
COMP. ... J.A.H.

BENT BRANCH SPILLWAY

PRINCIPAL FEATURES OF DESIGN

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DESIGN DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED
O. A. Meyer	Rex M. Pugh	George D. Reid

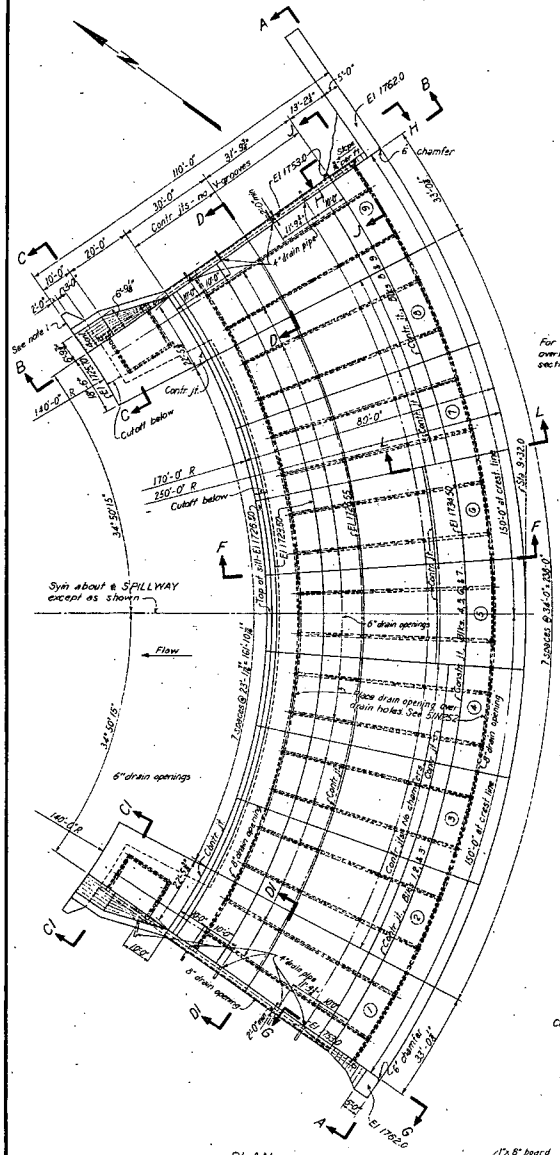
KNOXVILLE	9-6-44	21	C	4	51N251	R3

PRINTED DRAWING AS CONSTRUCTED
G. Rehmann 3-18-41

CDQ000020080017

page 1-7 of 11

5IN253



DOWNSTREAM CREST CURVE	
x_1	y_1
0	0
1'-0"	0'-0 1/4"
2'-0"	0'-3 1/4"
3'-0"	0'-6 1/4"
4'-0"	0'-10 1/4"
5'-0"	1'-4"
6'-0"	1'-10 1/4"
7'-0"	2'-5 1/4"
8'-0"	3'-1 1/4"
8'-10"	3'-9"
10'-0"	4'-7 1/4"
*11'-6 1/4"	5'-0"
12'-0"	6'-5 1/4"
13'-0"	7'-5 1/4"
14'-0"	8'-5 1/4"
14'-10 1/4"	9'-5"

* Constr jt

UPSTREAM CREST CURVE	
x_2	y_2
0	0
1'-0"	0'-0 1/4"
1'-6"	0'-1 1/4"
2'-0"	0'-3 1/4"
2'-6"	0'-5 1/4"
3'-0"	0'-7 1/4"
3'-3 1/4"	1'-4 1/4"

NOTES:
1. Paint vertical rock face of cutoffs, where noted, with a heavy coat of asphalt.
2. Finish vertical rock face at radial cutoffs to a smooth surface with mortar. Paint finished surface with a heavy coat of asphalt.
3. Chamfer all exposed edges 3/4", unless noted otherwise.
4. If rock breaks differently from that shown on this drawing the Design Dept shall be notified to determine possible revision of joints or special requirements for placing concrete.
5. Sections shown are for assumed rock. For final sections see Field drawings 51K1338 thru 51K1345.

REFERENCE DRAWINGS:
5IBM253 ..... BILL OF MATERIAL
308510 ..... WATER SEALS & GROUT STOPS

Scale 1/8" = 1'-0"
Except as noted

2	Mar				Final Field revision
1	12-14				Minor Revision
REV NO.	DATE	MADE	CHKD	SUPV	INSP

DSGN ..... SUPV F.C. 10-22-41
DRWN E.J.J. W.E.M. INSP. 22-C
CHKD. G.D.S. R.Z.K.K.
TYPD ..... CHECKED
COMP ..... D. Tenney

BENT BRANCH SPILLWAY

CONCRETE
UPPER WEIR
OUTLINE

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DESIGN DEPARTMENT

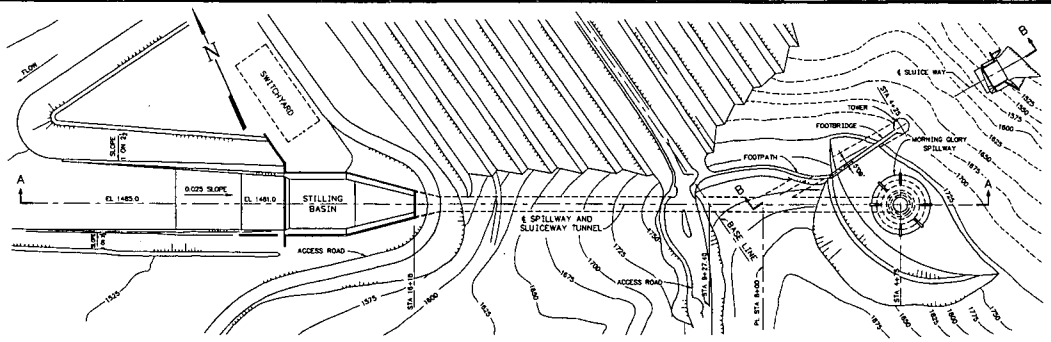
SUBMITTED	RECOMMENDED	APPROVED
A. O. Meyer	Roy M. Kluge	Arvid Grant
KNOXVILLE	11-18-44	21 C 4 5IN253 R2

DRAWING AS CONSTRUCTED
G. Thomson 3-18-51

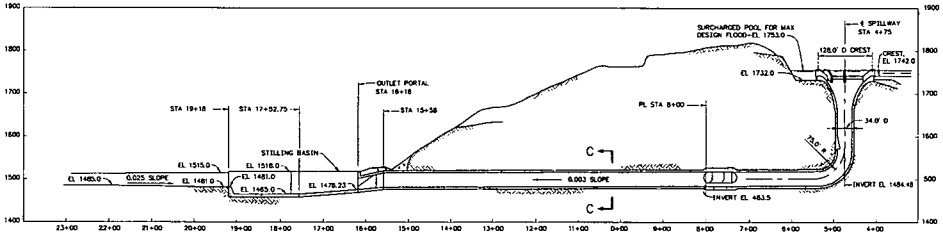
MF R2

CDQ00002008001 7

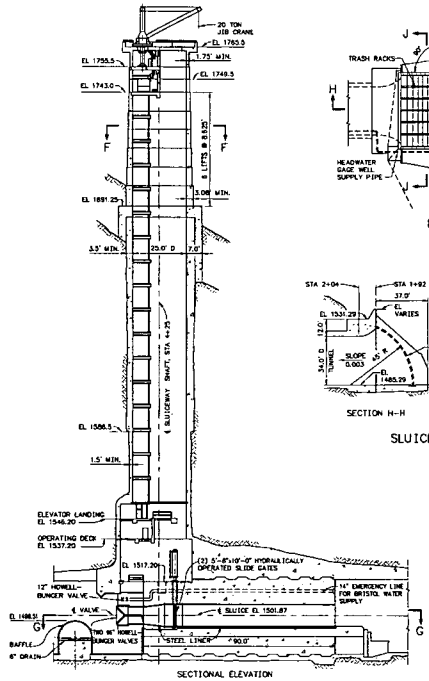
page 1-8 of 11



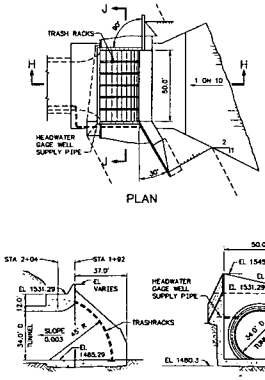
PLAN



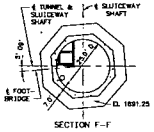
SECTION A–A

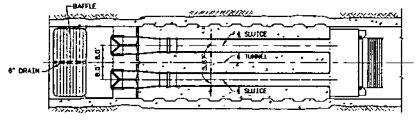


SECTIONAL ELEVATION



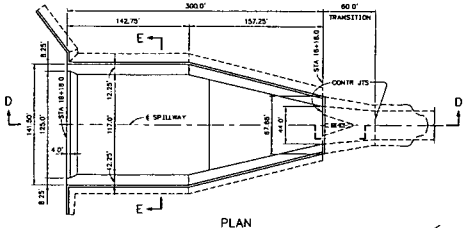
SLUICE WAY INTAKE
SCALE: 1"=30'



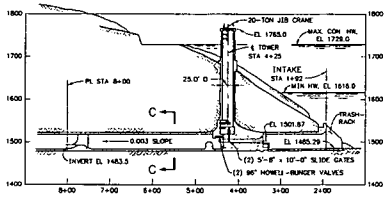


SECTION G–G

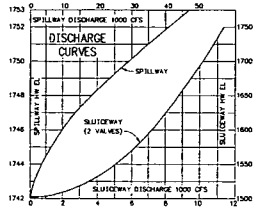
SLUICEWAY GATE PLUG & SHAFT
SCALE: 1"=20'

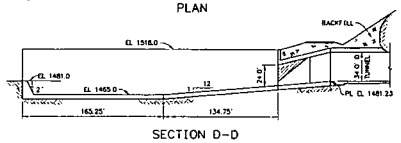


PLAN



SECTION B–B





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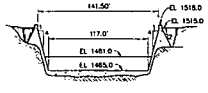
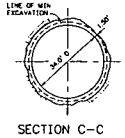


SECTION E–E



SECTION C–C
SCALE: 1"=20'

STILLING BASIN
SCALE 1"=50'

SCALE: 1"=100' EXCEPT AS NOTED

MAIN SPILLWAY

PLANS AND SECTIONS

DESIGNED BY	DRAWN BY	CHECKED BY	SUPERVISED BY	REVIEWED BY	APPROVED BY	ISSUED BY
G. J. J.	D. M. D.	A. C.	A. C.	R. M. R.	J. R.	C. C. M.

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
RIVER SYSTEMS OPERATIONS

AUTOCAD 2002 | 21 | C | 51W200 | R 6

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN
AND SUPERSEDES : (51N200 R5)

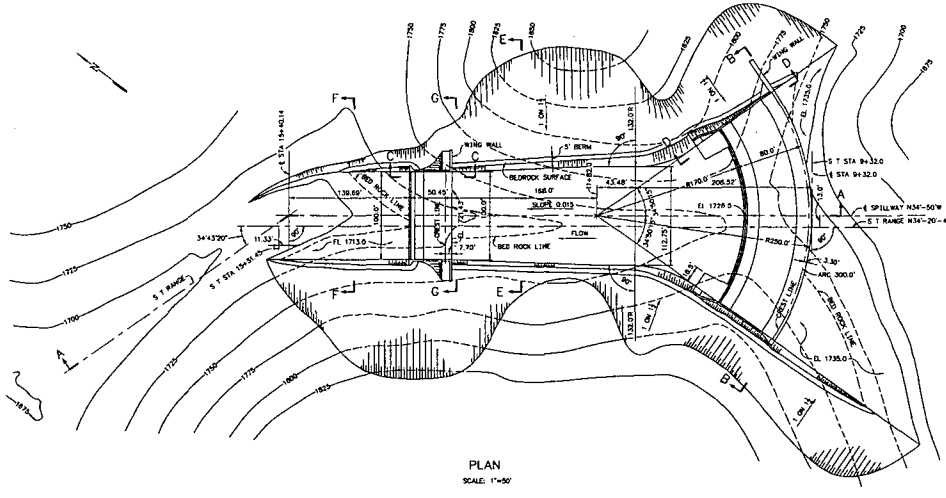
TASK COMPLETED BY: | REV NO

PLOT FACTOR:1200
W_TVA

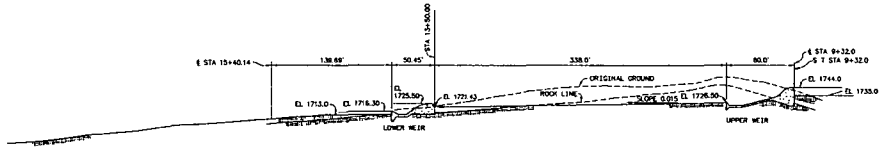
C.A.D. DRAWING
DO NOT ALTER MANUALLY

CDQ00002008001 7

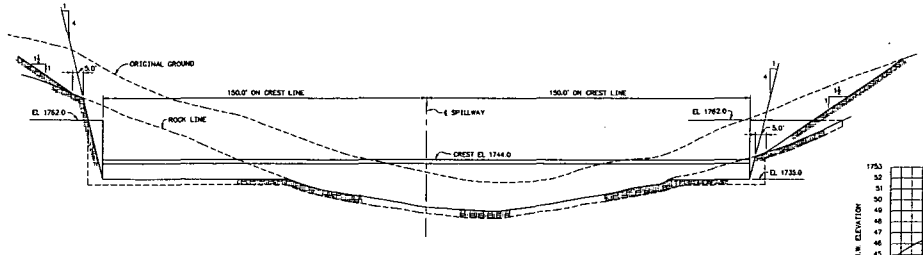
page1-9 of 11



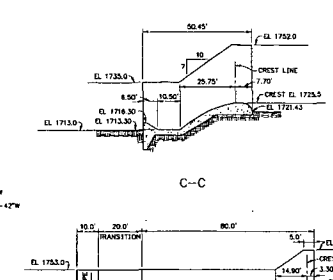
PLAN
SCALE: 1"=50'



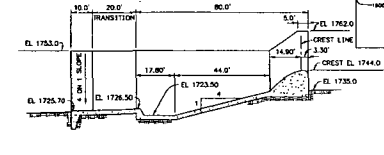
SECTION A-A
SCALE: 1"=50'



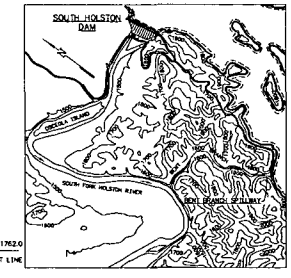
B-B



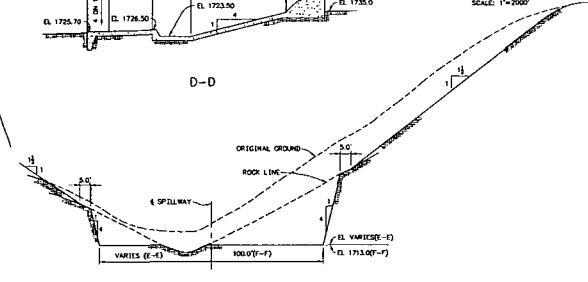
C-C



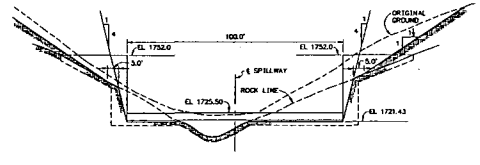
D-D



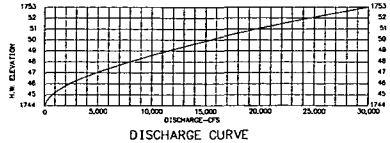
LOCATION MAP
SCALE: 1"=2000'



E-E & F-F
AS SHOWN AND NOTED



G-G



DISCHARGE CURVE

NOTES:
1. SEE FIELD DWGS 51K1241-1248 INCLUSIVE FOR FINAL EXCAVATION.

SCALE: 1"=20' EXCEPT AS NOTED

BENT BRANCH SPILLWAY

PLAN & SECTIONS

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

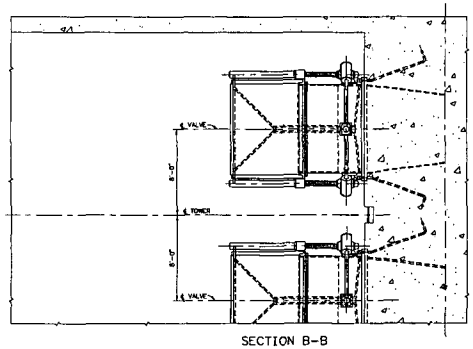
AUTOCAD R14 | 21 | C | 51W250 | R 4

PLOT FACTOR:240
W_TVA

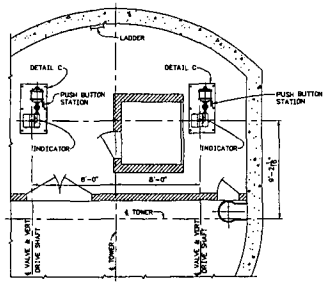
C.A.D. DRAWING
DO NOT ALTER MANUALLY

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES : (51N250 R3)

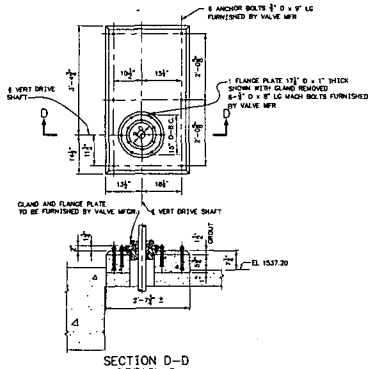
TASK COMPLETED BY: | REV NO.



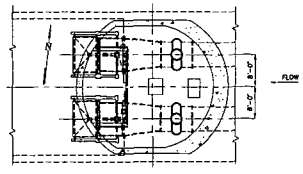
SECTION B-B



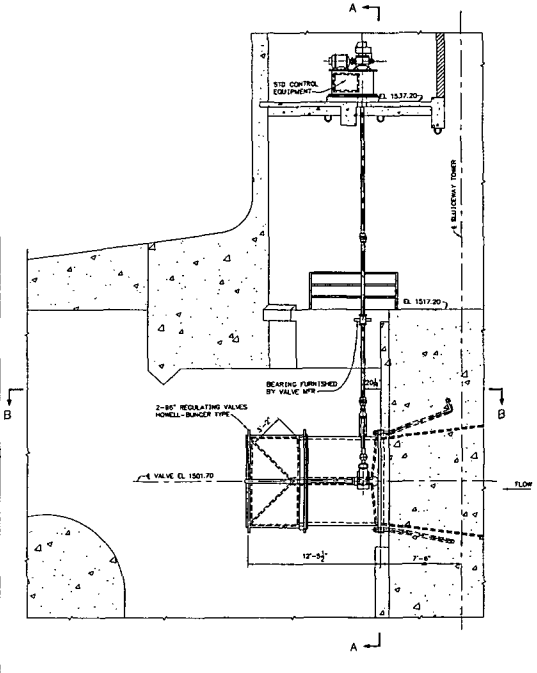
PLAN AT EL 1537.20



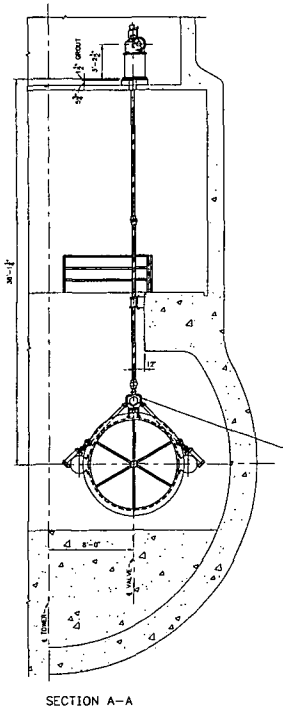
SECTION D-D
DETAIL C
SCALE 1/4"=1'-0"



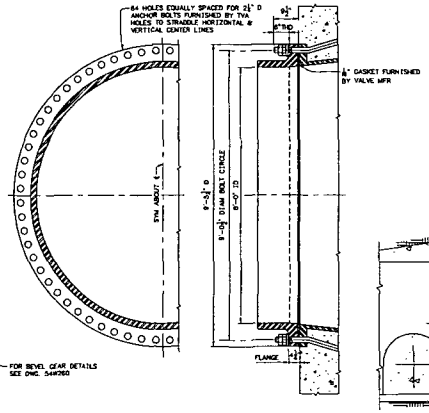
PLAN AT EL 1517.20



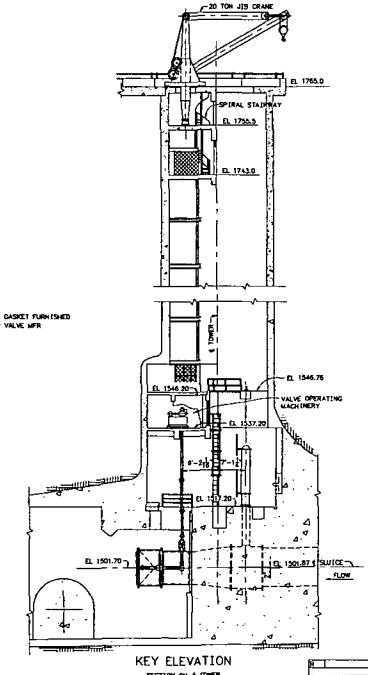
SECTION ON ℄ TOWER



SECTION A-A



VALVE ANCHOR BOLT LOCATION
SCALE 1/4"=1'-0"



KEY ELEVATION
SECTION ON ℄ TOWER
SCALE 3/32"=1'-0"

NOTE
FOR MANUFACTURER'S DETAILS OF SLUICEWAY REGULATING VALVES REFER TO S. MORGAN SMITH COMPANY FILE, TVA CONTRACT NO TV-5081 A.

COMPANION DRAWINGS:
54W260

REV NO.	DATE	DRAWN	DESIGN	CHECK	SUPV	APPR	CORR	PROJECT ENG	AE CONT	REV. CODE
3	11-3-97	JAE	TBO	RED	VAN	VRH	RRH	RBH		

REDRAWN TO AUTOCAD FORMAT AND ADDED NOTE

SCALE: 1/4"=1'-0" EXCEPT AS NOTED

SPILLWAY

96" SLUICEWAY REGULATING VALVES ARRANGEMENT

DESIGNED BY	DRAWN BY	CHECKED BY	SUPERVISED BY	REVIEWED BY	APPROVED BY	ISSUED BY
	TBA	D.W.	D.W.			

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R14 | REV 11-17-48 | 21 | C | 54W220 | R 3

TASF COMPLETED BY: | REV NO.

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES - (54N220 R2)

PLOT FACTOR:48
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

CDQ000020080017

page11-1 of 11

21 C 54W220

ATTACHMENT 2

South Holston Dam Howell-Bunger Valve Discharge Tables

(Reference 2.5)

CDQ00002008001 7

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
ENGINEERING LABORATORY

SOUTH HOLSTON DAM

HOWELL-BUNGER VALVE DISCHARGE TABLES

JULY 1974

CDQ00002008001 7

INSTRUCTIONS FOR USE OF TABLES

1. Purpose of Tables

The purpose of these tables is to provide a means of determining the discharge of the Howell-Bunger valves in the sluice tunnel at South Holston Dam. The tables are based on field discharge measurements and pressure measurements taken at several discharges in the sluice upstream from the Howell-Bunger valves. The tables give the discharge in cubic feet per second for one valve when the reservoir elevation and valve opening are known throughout the complete range of normal operating conditions. These tables supersede the tables dated April 1959.

2. Arrangement and Use of Tables

The tables give the discharge in cubic feet per second per valve for each 5-foot interval of headwater between reservoir elevations 1600 and 1755, and for each 1 percent of valve opening between 5 percent and 89 percent valve positions. Discharges are tabulated only to the nearest 10 cubic feet per second because the accuracy of the field measurements does not warrant greater refinement. It is possible to set any discharge within 40 cubic feet per second by using the tabular values. This tolerance has been accepted by the Division of Water Control Planning, and therefore, *it will not be necessary to interpolate* between tabular entries in these tables.

The reservoir elevation values used in the tables are those given by the recorder in the control room. The valve opening used in the tables is that indicated by the pointer on the valve control mechanism.

The arrangement of tables is such that the discharge over the entire range of valve openings for a 100-foot range of reservoir elevation is on two consecutive pages. For example, discharges are given on pages 2 and 3 for reservoir elevations 1600 through 1700. Discharges should be taken from the table for the tabulated values nearest to those observed. For example, if the reservoir is at elevation 1658.76 and the valve number 1 opening is 76.4 percent, the discharge is found on page 3, in the column headed 1660 opposite a valve opening of 76 percent, as 3370 cubic feet per second. If valve number 2 were set at 56.6 percent at the same time when valve number 1 was operating as given above, the discharge for valve number 2 would be found on page 3, in the column headed 1660 opposite a valve opening of 57 percent, as 2720 cubic feet per second. The total discharge would be the sum of the discharges of the two valves or 6090 cubic feet per second.

3. Valve Opening for Maximum and Minimum Discharge

Maximum discharge for the Howell-Bunger valves at South Holston Dam occurs at 89 percent valve opening. At valve openings greater than 89 percent the discharge becomes less. Therefore, the valves should not be operated beyond 89 percent. No tabular data are presented for such operation.

Minimum valve openings should not be less than 5 percent because of cavitation effects. No tabular values are given for such operation.

4. Adjustment of Valve Opening Indicator

At the time the field measurements were made, the valve opening indicator showed an opening of 0 percent when the valve was closed. In case of repairs to or adjustment of the valve and its control mechanism, the pointer should be reset to this position so that the tables will still be applicable.

SOUTH HOLSTON DAM

HOWELL-BUNGER VALVE DISCHARGE

IN CUBIC FEET PER SECOND

TENNESSEE VALLEY AUTHORITY

ENGINEERING LABORATORY

VALVE OPENING PERCENT	RESERVOIR ELEVATION																					VALVE OPENING PERCENT
	1600	1605	1610	1615	1620	1625	1630	1635	1640	1645	1650	1655	1660	1665	1670	1675	1680	1685	1690	1695	1700	
1																						1
2																						2
3																						3
4																						4
* 5	140	140	140	150	150	150	160	160	160	170	170	170	170	180	180	180	180	190	190	190	190	5
6	180	180	190	190	200	200	200	210	210	220	220	220	230	230	230	240	240	240	250	250	250	6
7	230	240	240	250	250	260	260	270	270	280	280	290	290	300	300	310	310	310	320	320	330	7
8	270	280	290	290	300	300	310	320	320	330	330	340	340	350	360	360	370	370	380	380	390	8
9	310	320	330	340	340	350	360	360	370	380	380	390	400	400	410	420	420	430	430	440	440	9
10	350	360	370	380	390	400	400	410	420	430	430	440	450	450	460	470	480	480	490	490	500	10
11	400	410	420	430	440	440	450	460	470	480	490	500	500	510	520	530	530	540	550	560	560	11
12	440	450	460	470	490	500	510	510	520	530	540	550	560	570	580	590	600	600	610	620	630	12
13	490	500	520	530	540	550	560	570	580	590	600	610	620	630	640	650	660	670	680	690	700	13
14	540	550	560	580	590	600	610	630	640	650	660	670	680	690	700	710	720	730	740	750	760	14
15	590	600	620	630	640	660	670	680	700	710	720	730	750	760	770	780	790	800	810	820	840	15
16	640	650	670	680	700	710	730	740	750	770	780	790	810	820	830	850	860	870	880	890	900	16
17	680	700	710	730	750	760	780	790	810	820	840	850	860	880	890	900	920	930	940	950	970	17
18	720	740	760	780	790	810	830	840	860	870	890	900	920	930	950	960	970	990	1000	1010	1030	18
19	770	790	800	820	840	860	880	890	910	930	940	960	970	990	1000	1020	1030	1050	1060	1070	1090	19
20	810	830	850	870	890	900	920	940	960	980	990	1010	1030	1040	1060	1070	1090	1100	1120	1130	1150	20
21	840	870	890	910	930	950	970	980	1000	1020	1040	1050	1070	1090	1110	1120	1140	1150	1170	1180	1200	21
22	880	900	930	950	970	990	1010	1030	1050	1070	1080	1100	1120	1140	1150	1170	1190	1200	1220	1240	1250	22
23	920	940	970	990	1010	1030	1050	1070	1090	1110	1130	1150	1170	1190	1210	1220	1240	1260	1270	1290	1310	23
24	960	980	1000	1030	1050	1070	1090	1110	1130	1160	1180	1190	1210	1230	1250	1270	1290	1310	1320	1340	1360	24
25	990	1020	1040	1060	1090	1110	1130	1150	1180	1200	1220	1240	1260	1280	1300	1320	1340	1350	1370	1390	1410	25
26	1030	1060	1080	1110	1130	1150	1180	1200	1220	1240	1270	1290	1310	1330	1350	1370	1390	1410	1430	1450	1460	26
27	1070	1100	1120	1150	1170	1200	1220	1250	1270	1290	1320	1340	1360	1380	1400	1420	1440	1460	1480	1500	1520	27
28	1120	1140	1170	1200	1220	1250	1270	1300	1320	1350	1370	1390	1420	1440	1460	1480	1500	1520	1540	1560	1580	28
29	1160	1180	1210	1240	1270	1290	1320	1350	1370	1390	1420	1440	1470	1490	1510	1530	1560	1580	1600	1620	1640	29
30	1190	1220	1250	1280	1310	1330	1360	1390	1410	1440	1460	1490	1510	1530	1560	1580	1600	1620	1650	1670	1690	30
31	1230	1260	1290	1320	1350	1380	1400	1430	1460	1480	1510	1540	1560	1580	1610	1630	1660	1680	1700	1720	1750	31
32	1270	1300	1330	1360	1390	1420	1450	1480	1510	1530	1560	1580	1610	1640	1660	1690	1710	1730	1760	1780	1800	32
33	1310	1340	1370	1410	1440	1470	1500	1520	1550	1580	1610	1630	1660	1690	1710	1740	1760	1790	1810	1840	1860	33
34	1350	1380	1420	1450	1480	1510	1540	1570	1600	1630	1660	1680	1710	1740	1760	1790	1820	1840	1870	1890	1920	34
35	1390	1420	1460	1490	1520	1550	1590	1620	1650	1680	1700	1730	1760	1790	1820	1840	1870	1900	1920	1950	1970	35
36	1430	1460	1500	1530	1570	1600	1630	1660	1690	1720	1750	1780	1810	1840	1870	1900	1920	1950	1980	2000	2030	36
37	1470	1500	1540	1580	1610	1640	1680	1710	1740	1770	1800	1830	1860	1890	1920	1950	1980	2000	2030	2060	2080	37
38	1510	1540	1580	1620	1650	1690	1720	1750	1790	1820	1850	1880	1910	1940	1970	2000	2030	2060	2090	2110	2140	38
39	1540	1580	1610	1650	1690	1720	1760	1790	1820	1860	1890	1920	1950	1980	2010	2040	2070	2100	2130	2160	2180	39
40	1570	1610	1650	1690	1720	1760	1800	1830	1860	1900	1930	1960	1990	2030	2060	2090	2120	2150	2170	2200	2230	40
41	1610	1650	1690	1730	1770	1800	1840	1880	1910	1950	1980	2010	2040	2080	2110	2140	2170	2200	2230	2260	2290	41
42	1650	1690	1730	1770	1810	1840	1880	1920	1950	1990	2020	2060	2090	2120	2150	2190	2220	2250	2280	2310	2340	42
43	1680	1720	1760	1800	1840	1880	1920	1960	1990	2030	2060	2100	2130	2170	2200	2230	2260	2290	2330	2360	2390	43
44	1720	1760	1800	1840	1880	1920	1960	2000	2030	2070	2110	2140	2180	2210	2240	2280	2310	2340	2370	2410	2440	44
45	1740	1790	1830	1870	1910	1950	1990	2030	2070	2110	2140	2180	2210	2250	2280	2320	2350	2380	2420	2450	2480	45
46	1780	1820	1870	1910	1950	1990	2030	2070	2110	2150	2190	2220	2260	2290	2330	2360	2400	2430	2460	2500	2530	46
47	1810	1860	1900	1950	1990	2030	2070	2110	2150	2190	2230	2270	2300	2340	2370	2410	2440	2480	2510	2540	2580	47
48	1840	1890	1940	1980	2020	2070	2110	2150	2190	2230	2270	2300	2340	2380	2410	2450	2480	2520	2550	2590	2620	48
49	1870	1920	1970	2010	2060	2100	2140	2180	2220	2260	2300	2340	2380	2420	2450	2490	2520	2560	2590	2630	2660	49
50	1910	1960	2010	2050	2100	2140	2190	2230	2270	2310	2350	2390	2430	2470	2500	2540	2580	2610	2650	2680	2720	50

JULY 1974

* THE MINIMUM ALLOWABLE VALVE OPENING IS 5 PERCENT

RESERVOIR ELEVATION 1600 TO 1700
VALVE OPENING, PERCENT 5 TO 50

CDQ00002008001 7

SOUTH HOLSTON DAM

HOWELL-BUNGER VALVE DISCHARGE

IN CUBIC FEET PER SECOND

TENNESSEE VALLEY AUTHORITY

ENGINEERING LABORATORY

VALVE OPENING PERCENT	RESERVOIR ELEVATION																					VALVE OPENING PERCENT
	1600	1605	1610	1615	1620	1625	1630	1635	1640	1645	1650	1655	1660	1665	1670	1675	1680	1685	1690	1695	1700	
51	1940	1990	2040	2090	2130	2180	2220	2260	2300	2350	2390	2430	2470	2500	2540	2580	2620	2650	2690	2730	2760	51
52	1970	2020	2070	2120	2160	2210	2250	2300	2340	2380	2420	2460	2500	2540	2580	2620	2660	2690	2730	2770	2800	52
53	2010	2060	2110	2160	2210	2250	2300	2340	2390	2430	2470	2510	2550	2590	2630	2670	2710	2750	2790	2820	2860	53
54	2040	2090	2140	2190	2240	2290	2330	2380	2420	2470	2510	2550	2590	2630	2670	2710	2750	2790	2830	2860	2900	54
55	2070	2120	2180	2220	2270	2320	2370	2410	2460	2500	2550	2590	2630	2670	2710	2750	2790	2830	2870	2910	2940	55
56	2100	2150	2210	2260	2310	2350	2400	2450	2490	2540	2580	2620	2670	2710	2750	2790	2830	2870	2910	2950	2990	56
57	2140	2200	2250	2300	2350	2400	2450	2490	2540	2590	2630	2670	2720	2760	2800	2840	2880	2920	2960	3000	3040	57
58	2170	2230	2280	2330	2380	2430	2480	2530	2580	2620	2670	2710	2760	2800	2840	2880	2920	2970	3010	3040	3080	58
59	2200	2260	2310	2360	2410	2470	2510	2560	2610	2660	2700	2750	2790	2840	2880	2920	2960	3010	3050	3090	3130	59
60	2230	2290	2340	2390	2450	2500	2550	2600	2650	2690	2740	2790	2830	2880	2920	2960	3000	3050	3090	3130	3170	60
61	2260	2320	2370	2430	2480	2530	2580	2630	2680	2730	2780	2820	2870	2910	2960	3000	3040	3090	3130	3170	3210	61
62	2280	2340	2390	2450	2500	2550	2610	2660	2700	2750	2800	2850	2890	2940	2980	3030	3070	3110	3160	3200	3240	62
63	2310	2370	2420	2480	2530	2590	2640	2690	2740	2790	2840	2880	2930	2980	3020	3070	3110	3150	3200	3240	3280	63
64	2340	2400	2460	2510	2570	2620	2670	2720	2780	2830	2870	2920	2970	3020	3060	3110	3150	3200	3240	3280	3320	64
65	2370	2430	2490	2540	2600	2650	2710	2760	2810	2860	2910	2960	3010	3050	3100	3150	3190	3240	3280	3320	3370	65
66	2400	2460	2520	2580	2630	2690	2740	2790	2850	2900	2950	3000	3040	3090	3140	3190	3230	3280	3320	3360	3410	66
67	2420	2480	2540	2600	2650	2710	2760	2820	2870	2920	2970	3020	3070	3120	3170	3210	3260	3300	3350	3390	3440	67
68	2440	2500	2560	2620	2680	2730	2790	2840	2890	2940	3000	3050	3100	3140	3190	3240	3280	3330	3380	3420	3460	68
69	2470	2530	2590	2650	2710	2760	2820	2870	2930	2980	3030	3080	3130	3180	3230	3280	3320	3370	3420	3460	3510	69
70	2500	2560	2620	2680	2740	2800	2850	2910	2960	3020	3070	3120	3170	3220	3270	3320	3360	3410	3460	3500	3550	70
71	2530	2590	2650	2710	2770	2830	2890	2940	3000	3050	3110	3160	3210	3260	3310	3360	3400	3450	3500	3550	3590	71
72	2550	2610	2670	2740	2800	2850	2910	2970	3020	3080	3130	3180	3230	3280	3330	3380	3430	3480	3530	3570	3620	72
73	2580	2640	2710	2770	2830	2890	2950	3000	3060	3110	3170	3220	3270	3320	3370	3420	3470	3520	3570	3610	3660	73
74	2610	2670	2740	2800	2860	2920	2980	3040	3090	3150	3200	3260	3310	3360	3410	3460	3510	3560	3610	3660	3700	74
75	2630	2690	2760	2820	2880	2940	3000	3060	3120	3170	3230	3280	3330	3390	3440	3490	3540	3590	3640	3680	3730	75
76	2660	2720	2790	2850	2910	2980	3040	3090	3150	3210	3260	3320	3370	3420	3480	3530	3580	3630	3680	3730	3770	76
77	2680	2740	2810	2870	2940	3000	3060	3120	3180	3230	3290	3340	3400	3450	3500	3550	3610	3660	3710	3750	3800	77
78	2700	2760	2830	2900	2960	3020	3080	3140	3200	3260	3310	3370	3420	3480	3530	3580	3630	3680	3730	3780	3830	78
79	2720	2790	2860	2920	2990	3050	3110	3170	3230	3290	3340	3400	3450	3510	3560	3610	3670	3720	3770	3820	3870	79
80	2750	2820	2880	2950	3010	3080	3140	3200	3260	3320	3370	3430	3490	3540	3590	3650	3700	3750	3800	3850	3900	80
81	2770	2840	2900	2970	3030	3100	3160	3220	3280	3340	3400	3450	3510	3570	3620	3670	3730	3780	3830	3880	3930	81
82	2790	2860	2920	2990	3060	3120	3180	3240	3300	3360	3420	3480	3540	3590	3650	3700	3750	3800	3860	3910	3960	82
83	2820	2890	2960	3020	3090	3150	3220	3280	3340	3400	3460	3520	3570	3630	3680	3740	3790	3850	3900	3950	4000	83
84	2840	2910	2980	3040	3110	3180	3240	3300	3360	3420	3480	3540	3600	3650	3710	3770	3820	3870	3920	3980	4030	84
85	2860	2930	3000	3070	3130	3200	3260	3330	3390	3450	3510	3570	3620	3680	3740	3790	3850	3900	3950	4000	4060	85
86	2880	2950	3020	3090	3150	3220	3280	3350	3410	3470	3530	3590	3650	3710	3760	3820	3870	3930	3980	4030	4080	86
87	2900	2970	3040	3110	3180	3240	3310	3370	3430	3500	3560	3620	3670	3730	3790	3840	3900	3950	4010	4060	4110	87
88	2900	2980	3050	3120	3190	3250	3320	3380	3450	3510	3570	3630	3690	3740	3800	3860	3910	3970	4020	4070	4130	88
*89	2910	2990	3060	3130	3200	3260	3330	3390	3460	3520	3580	3640	3700	3760	3810	3870	3930	3980	4030	4090	4140	89

JULY 1974

* THE MAXIMUM VALVE OPENING SHOULD NOT EXCEED 89 PERCENT

RESERVOIR ELEVATION 1600 TO 1700
VALVE OPENING, PERCENT 51 TO 89

CDQ00002008001 7

SOUTH HOLSTON DAM

HOWELL-BUNGER VALVE DISCHARGE

IN CUBIC FEET PER SECOND

TENNESSEE VALLEY AUTHORITY

ENGINEERING LABORATORY

VALVE OPENING PERCENT	RESERVOIR ELEVATION																					VALVE OPENING PERCENT
	1700	1705	1710	1715	1720	1725	1730	1735	1740	1745	1750	1755										
1																						1
2																						2
3																						3
4																						4
*5	190	200	200	200	200	210	210	210	210	220	220	220										5
6	250	260	260	260	270	270	270	270	280	280	280	290										6
7	330	330	330	340	340	350	350	350	360	360	370	370										7
8	390	390	400	400	400	410	410	420	420	430	430	440										8
9	440	450	460	460	470	470	480	480	490	490	500	500										9
10	500	510	510	520	530	530	540	540	550	560	560	570										10
11	560	570	580	580	590	600	600	610	620	620	630	640										11
12	630	640	640	650	660	670	670	680	690	700	700	710										12
13	700	710	710	720	730	740	750	760	760	770	780	790										13
14	760	770	780	790	800	810	820	830	840	850	850	860										14
15	840	850	860	870	880	890	900	910	920	920	930	940										15
16	900	920	930	940	950	960	970	980	990	1000	1010	1020										16
17	970	980	990	1000	1010	1030	1040	1050	1060	1070	1080	1090										17
18	1030	1040	1050	1060	1080	1090	1100	1110	1130	1140	1150	1160										18
19	1090	1100	1120	1130	1140	1160	1170	1180	1190	1210	1220	1230										19
20	1150	1160	1180	1190	1200	1220	1230	1240	1260	1270	1280	1300										20
21	1200	1210	1230	1240	1260	1270	1290	1300	1320	1330	1340	1360										21
22	1250	1270	1280	1300	1310	1330	1340	1360	1370	1390	1400	1420										22
23	1310	1320	1340	1360	1370	1390	1400	1420	1430	1450	1460	1480										23
24	1360	1380	1390	1410	1430	1440	1460	1470	1490	1510	1520	1540										24
25	1410	1430	1440	1460	1480	1490	1510	1530	1540	1560	1580	1590										25
26	1460	1480	1500	1520	1540	1550	1570	1590	1610	1620	1640	1660										26
27	1520	1540	1560	1580	1600	1610	1630	1650	1670	1680	1700	1720										27
28	1580	1600	1620	1640	1660	1680	1700	1720	1740	1750	1770	1790										28
29	1640	1660	1680	1700	1720	1740	1760	1780	1800	1820	1840	1850										29
30	1690	1710	1730	1750	1770	1790	1810	1830	1850	1870	1890	1910										30
31	1750	1770	1790	1810	1830	1850	1870	1890	1910	1930	1950	1970										31
32	1800	1830	1850	1870	1890	1910	1930	1960	1980	2000	2020	2040										32
33	1860	1880	1910	1930	1950	1970	1990	2020	2040	2060	2080	2100										33
34	1920	1940	1960	1990	2010	2030	2050	2080	2100	2120	2140	2160										34
35	1970	2000	2020	2040	2070	2090	2120	2140	2160	2180	2210	2230										35
36	2030	2050	2080	2100	2130	2150	2180	2200	2220	2250	2270	2290										36
37	2080	2110	2140	2160	2190	2210	2240	2260	2280	2310	2330	2360										37
38	2140	2170	2190	2220	2250	2270	2300	2320	2350	2370	2400	2420										38
39	2180	2210	2240	2260	2290	2320	2340	2370	2390	2420	2440	2470										39
40	2230	2260	2290	2310	2340	2370	2390	2420	2450	2470	2500	2520										40
41	2290	2320	2350	2370	2400	2430	2460	2480	2510	2530	2560	2590										41
42	2340	2370	2400	2420	2450	2480	2510	2540	2560	2590	2620	2640										42
43	2390	2420	2450	2480	2500	2530	2560	2590	2620	2640	2670	2700										43
44	2440	2470	2500	2530	2560	2590	2610	2640	2670	2700	2730	2750										44
45	2480	2510	2540	2570	2600	2630	2660	2690	2720	2750	2770	2800										45
46	2530	2560	2590	2620	2650	2680	2710	2740	2770	2800	2830	2860										46
47	2580	2610	2640	2670	2700	2730	2770	2800	2820	2850	2880	2910										47
48	2620	2650	2680	2720	2750	2780	2810	2840	2870	2900	2930	2960										48
49	2660	2690	2730	2760	2790	2820	2860	2890	2920	2950	2980	3010										49
50	2720	2750	2790	2820	2850	2880	2920	2950	2980	3010	3040	3070										50

JULY 1974

* THE MINIMUM ALLOWABLE VALVE OPENING IS 5 PERCENT

RESERVOIR ELEVATION 1700 TO 1755
VALVE OPENING, PERCENT 5 TO 50

CDQ00002008017

SOUTH HOLSTON DAM

HOWELL-BUNGER VALVE DISCHARGE

IN CUBIC FEET PER SECOND

TENNESSEE VALLEY AUTHORITY

ENGINEERING LABORATORY

VALVE OPENING PERCENT	RESERVOIR ELEVATION												VALVE OPENING PERCENT
	1700	1705	1710	1715	1720	1725	1730	1735	1740	1745	1750	1755	
51	2760	2790	2830	2860	2900	2930	2960	2990	3030	3060	3090	3120	51
52	2800	2840	2870	2910	2940	2970	3010	3040	3070	3100	3140	3170	52
53	2860	2890	2930	2960	3000	3030	3070	3100	3130	3170	3200	3230	53
54	2900	2940	2970	3010	3040	3080	3110	3150	3180	3210	3250	3280	54
55	2940	2980	3020	3050	3090	3120	3160	3190	3230	3260	3290	3330	55
56	2990	3020	3060	3100	3130	3170	3200	3240	3270	3310	3340	3370	56
57	3040	3080	3120	3150	3190	3230	3260	3300	3330	3370	3400	3440	57
58	3080	3120	3160	3200	3240	3270	3310	3350	3380	3420	3450	3490	58
59	3130	3170	3200	3240	3280	3320	3350	3390	3430	3460	3500	3530	59
60	3170	3210	3250	3290	3320	3360	3400	3440	3470	3510	3550	3580	60
61	3210	3250	3290	3330	3370	3410	3440	3480	3520	3560	3590	3630	61
62	3240	3280	3320	3360	3400	3440	3480	3510	3550	3590	3620	3660	62
63	3280	3320	3360	3400	3440	3480	3520	3560	3600	3630	3670	3710	63
64	3320	3360	3410	3450	3490	3530	3570	3600	3640	3680	3720	3760	64
65	3370	3410	3450	3490	3530	3570	3610	3650	3690	3730	3770	3800	65
66	3410	3450	3490	3530	3580	3620	3660	3700	3740	3770	3810	3850	66
67	3440	3480	3520	3560	3610	3650	3690	3730	3770	3810	3840	3880	67
68	3460	3510	3550	3590	3630	3680	3720	3760	3800	3840	3880	3920	68
69	3510	3550	3590	3640	3680	3720	3760	3800	3840	3880	3920	3960	69
70	3550	3590	3640	3680	3720	3770	3810	3850	3890	3930	3970	4010	70
71	3590	3640	3680	3720	3770	3810	3850	3890	3940	3980	4020	4060	71
72	3620	3660	3710	3750	3800	3840	3880	3930	3970	4010	4050	4090	72
73	3660	3710	3750	3800	3840	3890	3930	3970	4010	4060	4100	4140	73
74	3700	3750	3800	3840	3890	3930	3970	4020	4060	4100	4140	4190	74
75	3730	3780	3820	3870	3920	3960	4000	4050	4090	4130	4180	4220	75
76	3770	3820	3870	3910	3960	4000	4050	4090	4140	4180	4220	4270	76
77	3800	3850	3900	3940	3990	4030	4080	4120	4170	4210	4250	4300	77
78	3830	3880	3930	3970	4020	4060	4110	4150	4200	4240	4290	4330	78
79	3870	3910	3960	4010	4060	4100	4150	4190	4240	4280	4330	4370	79
80	3900	3950	4000	4050	4090	4140	4190	4230	4280	4320	4360	4410	80
81	3930	3980	4030	4070	4120	4170	4220	4260	4310	4350	4400	4440	81
82	3960	4010	4060	4100	4150	4200	4250	4290	4340	4380	4430	4470	82
83	4000	4050	4100	4150	4200	4240	4290	4340	4380	4430	4480	4520	83
84	4030	4080	4130	4180	4230	4270	4320	4370	4410	4460	4510	4550	84
85	4060	4110	4160	4210	4260	4300	4350	4400	4450	4490	4540	4580	85
86	4080	4130	4190	4240	4280	4330	4380	4430	4480	4520	4570	4620	86
87	4110	4160	4210	4260	4310	4360	4410	4460	4510	4550	4600	4650	87
88	4130	4180	4230	4280	4330	4380	4430	4480	4520	4570	4620	4660	88
*89	4140	4190	4240	4290	4340	4390	4440	4490	4540	4590	4630	4680	89

JULY 1974

* THE MAXIMUM VALVE OPENING SHOULD NOT EXCEED 89 PERCENT

RESERVOIR ELEVATION 1700 TO 1755
VALVE OPENING, PERCENT 51 TO 89

CDQ00002008001 7

ATTACHMENT 3

TVA Report No. 18-10-1, "Advance Report No. 1 South Holston Model Studies"

(Reference 2.3)

CDQ000020080017

Tennessee Valley Authority
Division of Water Control Planning
Hydraulic Data Branch

Report No. 18-10-1

Advance Report No. 1

SOUTH HOLSTON MODEL STUDIES

Knoxville, Tennessee
June 1944

ADVANCE REPORT NO. 1

SOUTH HOLSTON MODEL STUDIES

SUMMARY

This report presents the results of tests made on models of the spillway, Howell-Bunger valve structures, and stilling basin for the South Holston project. Entrainment of air in the prototype during both spillway and Howell-Bunger valve operation will probably modify the results to some extent. The effect and amount of the change is unknown. The results of the model tests can be summarized as follows:

Flow in the vertical shaft was regular and free from surging when the spillway crest was provided with six piers as shown on Plate 1.

No negative pressures of any consequence were found to exist on the face of the spillway.

A bend of 75-foot radius between vertical shaft and tunnel gave the best flow conditions in the tunnel.

Flow in the tunnel was further improved by placing a deflector immediately above the tunnel at the foot of the vertical shaft.

The revised spillway has sufficient capacity to pass the required maximum discharge at the desired head.

Structures in the branch tunnel below the Howell-Bunger valve were found to be necessary to produce smooth flow in the main tunnel. These structures consisted of a massive weir and a horizontal deflector immediately below the Howell-Bunger valves and a low weir with two vertical piers at the end of the branch tunnel immediately above the Y junction.

Stilling basins V and Z, shown on Plate 2, provided satisfactory dissipation of energy at the tunnel outlet. Wave heights and erosion were somewhat less for scheme Z.

DESCRIPTION OF PROJECT

The outlet works for the South Holston Project are located some distance from the dam and consist of a morning glory type spillway, 128 feet in diameter on the crest line, discharging into a vertical shaft 34 feet in diameter. At the base of the shaft is a 90-degree

bend connecting with a horizontal tunnel, also 34 feet in diameter, that extends some 1100 feet to a stilling basin which discharges into the river just below the dam. The reservoir is controlled, for headwater elevations below the crest of the spillway, by two 96-inch Howell-Bunger valves located side by side in a branch tunnel 34 feet in diameter that intersects the main tunnel at an angle of 29 degrees some 300 feet below the morning glory spillway. The valves are located 375 feet upstream from this intersection. The general layout is shown on Plate 1.

For normal operation of the system the tunnels will be only partially full. Either tunnel may operate alone or both may operate together.

DESCRIPTION OF TESTS

General

It was believed desirable for the flow in the tunnels to be as smooth and uniform as possible in order to prevent the tunnel from filling momentarily and causing surges and vibrations that might damage the structure. Further, it was found necessary for the flow at the tunnel portal to be smooth and uniform in order to ensure proper operation of the stilling basin. Most of the tests described in this report were made to ensure smooth uniform flow throughout the structure. They were made on models at three difference scales, 1:100, 1:51, and 1:34. The detailed description indicates the scale used for any particular test.

Morning Glory Spillway

The spillway was constructed as shown on Plate 1 to a scale of 1:51 except that the diameter of the spillway on the crest line was 110 feet. It was found impossible to pass the required discharge with this spillway at the design head. Consequently, it was necessary to increase the diameter of the spillway on the crest line to 128 feet. However, the enlarged spillway was constructed to a scale of 1:100 and calibrated with more topography surrounding it. The relationship between reservoir elevation and discharge is shown on Plate 3.

Flow in Spillway and Vertical Shaft

The spillway was originally built without piers. Its operation at the maximum discharge of 60,000 cfs was not satisfactory. The vertical shaft was filled with water which surged up and down and back and forth across the spillway mouth, creating considerable disturbance. Figure 1 shows one phase of this condition. One cause of the difficulty

appeared to be the large fin which formed on the side of the spillway next to the hillside. This fin closed the shaft at the top, causing unstable conditions. A remedy was found in radial piers on the crest, as shown on Plate 1. Various numbers of piers from 2 to 8 were tried and it was found thay 6 gave very satisfactory results. Figure 2 illustrates the same discharge with 6 piers. An attempt was made to improve the flow still further by adding curved fins ahead of the piers. This arrangement is shown in Figure 3. Comparison with Figure 2 shows that no particular improvement was realized.

Attempts were made to reduce the size of the fin still further by changing the size of the excavated area around the rim of the spillway. The distance from spillway rim to toe of slope was varied from zero to several hundred feet. A distance of 30 feet seemed to give the best results although the fin was not eliminated. A smaller distance increased the size and roughness of the fin and a greater distance did not give enough improvement to warrant the increased excavation cost.

Flow in Tunnel

It was desired that flow in the horizontal tunnel be smooth and have a minimum of disturbance and wave action. The radius of the bend connecting the shaft with the tunnel was found to have a marked effect upon the flow in the tunnel. Elbows having radii of 38.2, 50, and 75 feet were tested. With the short-radius elbow the flow in the vertical shaft tended to pass around the elbow with a spiral motion that caused the flow in the tunnel to sway from side to side, resulting in unsymmetrical flow in the stilling basin. Conditions were made smoother with the longer radius elbows. The best results were obtained with the 75-foot radius.

For all elbows some disturbance was caused by the water which came down the shaft on the side above the tunnel. As the shaft wall curved away from the vertical at the bend, this portion of the flow was left without a guiding wall. Consequently its direction of flow was subject to the influence of minor irregularities and was highly uncertain. Several schemes were proposed in an effort to remedy this condition. Two of them are shown on Plate 1 as schemes Q and AB. Scheme Q simply blocked off that portion of the spillway crest above the tunnel. Scheme AB blocked off a portion of the spillway shaft as well as the crest. Neither of these was suitable because of the increased head necessary to produce the required discharge. Scheme AB also caused the vertical shaft to fill.

The disadvantages of blocking off the crest were eliminated by placing a deflecting block at the base of the vertical shaft. It was found that a deflector of the proper size and in the right location could be depended upon to produce stable and desirable flow conditions in the tunnel. The action of the deflector was to force the water to the outside of the bend and prevent spiral flow in the tunnel. Deflectors projecting 5, 6.5, 8, and 10 feet into the vertical shaft were tried. These all had a slope of three vertical on one horizontal. For higher discharges the 10-foot deflector caused the shaft to flow full while the 5-foot one was

not effective. Either of the other two was satisfactory. The 6.5-foot deflector was adopted for further testing, and it was found that best flow conditions in the tunnel were obtained when this deflector was placed in line with it. Moving the deflector to either side caused an uneven water surface and standing waves in the tunnel. The first tests on these deflectors were made on the 1:51 scale model. A final model check was made on the 1:100 scale model in which more topography surrounding the spillway could be reproduced. Figures 4 and 5 show the improvement in tunnel flow caused by the 6.5-foot deflector.

Observations of flow in the tunnel indicated that prototype flow would be considerably aerated with a corresponding increase in the area of flow. The effect of this aeration upon flow in the tunnel is quite uncertain. The model tests indicated that the tunnel did not flow full except when spillway and sluices were operating together at maximum discharge. It is certain that aeration of the model is much less than in the prototype and the effect of this aeration upon the prototype performance is uncertain.

Pressures in Vertical Shaft

Pressures in the shaft of the South Holston spillway were not measured with the corresponding South Holston topography. However, observations of pressure at a number of piezometers in the morning glory were made on the Watauga spillway which is identical in design with the South Holston spillway. The locations of the piezometers are shown on Plate 2 of Advance Report No. 1, Watauga Model Studies, and the pressures at these piezometers are given in Table 1 of that report. These pressures were measured with the Watauga topography around the spillway but it is believed that they are essentially the same for the South Holston spillway.

Water Surface Profile

The height of the radial piers in the spillway crest was governed by the water surface profile for the maximum discharge. Plate 1 shows the water surface adjacent to the pier face for a discharge of 60,000 cfs.

HOWELL-BUNGER VALVE OPERATION

Operation of the Howell-Bunger valves in the branch tunnel showed that auxiliary structures were necessary to reduce the velocity of the flow in the branch tunnel before it entered the main tunnel. Figure 6 shows a discharge of 10,000 cfs entering the main tunnel from the branch tunnel with no energy-dissipating structures below the valves. The high-velocity flow along the bottom loops completely around the main tunnel just below the Y. This is a very undesirable condition, and a

number of tests were made for the purpose of producing smooth flow in the main tunnel. Preliminary studies of suitable structures below the valves were made on a 1:34 scale model. The design was refined and developed to completion on a 1:51 scale model made of transparent material so that the performance could be observed.

Plate 1 shows a number of the various structures that were tried. The ring shown as scheme BL worked fairly well when both valves were discharging but was unsatisfactory for only one valve. Piezometers in the ring showed the existence of pressures as low as 20 feet below atmosphere and the possibility of damage by cavitation. The tests soon showed that two sets of structures were necessary. A deflector and weir were required immediately below the Howell-Bunger valves to reduce the velocity in the branch tunnel and a weir was needed at the end of the branch to ensure that the velocity remained low as it entered the Y. These two structures were complementary as one aided the operation of the other.

The weir and deflector shown as scheme BR gave satisfactory flow conditions in the tunnel, but piezometers placed as shown on Plate 1 indicated that the pressures were apt to be low enough to induce cavitation. Pressures varied with the distance of the sill from the end of the valve. Table 1 gives the results of pressure measurements. It may be seen that pressures 20 feet below atmosphere were obtained.

TABLE 1

PRESSURES ON WEIR

SCHEME BR

Both Valves Open

Test Number	Distance Below Valve in Feet	Pressure in Feet of Water		
		a	b	c
220	15.5	+52.5	-20.0	-9.0
221	35.5	+36.5	-12.0	0
222	47.5	+38.0	- 1.0	+2.5

The arrangment that gave the best operation is shown as scheme CD on Plate 1. Immediately below the valve was a heavy sill 15 feet high and 15 feet thick, which operated in conjunction with a horizontal deflector near the roof. Table 2 shows that the pressures on this weir were much more favorable than for the other structures. It will be seen

that the location 11.5 feet below the valve gave the best results with respect to negative pressures. Flow conditions downstream were also best with the weir at this location. Figure 7 shows the flow conditions in the tunnel below the structures for the best weir position with both valves operating. There was considerable turbulence below the weir which was soon smoothed out into quiet flow down the tunnel. Figure 8 shows the performance of the same structures with the weir placed closer to the valve. Here high-velocity flow persisted for a considerable distance downstream. Figure 9 illustrates the performance for discharge through one valve only.

Operation of the Howell-Bunger valves required that a considerable amount of air be supplied to the tunnel. The location of the air vent is shown on the drawing.

The structure of the Y consisted of a sill 7.36 feet high and two vertical piers 5 feet thick, reaching from bottom to top of the branch tunnel. Both sill and piers were so shaped that they formed a continuation of the main tunnel wall as high as the horizontal diameter. For moderate spillway discharges, therefore, the walls of the main tunnel were continuous. The effect of the sill was to maintain a considerable depth of water in the branch tunnel thus reducing the velocity. The streamlined piers served to introduce the flow quietly into the main tunnel. Figure 10 shows flow from the branch into the main tunnel with no spillway discharge.

The structures immediately below the Howell-Bunger valve, shown as scheme CD, gave fairly satisfactory operation. The design was not refined further because of lack of time. Subsequent tests on the low-level outlet for the Fontana spillway indicated that better results may be obtained with simpler structures.

STILLING BASIN OPERATION

Conditions at the end of the tunnel made it necessary to provide a stilling basin to protect the outlet structures. The design of the stilling basin was carried out on the 1:51 scale model. The principal problem encountered was that of spreading the discharge as it left the tunnel so that the flow would be uniformly distributed across the stilling basin and the velocities at the end would be low. It was desired that the length of the stilling basin be kept to a minimum. Plate 2 shows several schemes tested in an attempt to spread the jet issuing from the tunnel toward the sides of the stilling basin. Stilling basins A, B, and C used an elevated floor in the center of the channel to accomplish this. The results were not satisfactory. Figure 11 shows basin A operating at a discharge of 10,000 cfs. Eddies occurred over the sill at the end of the structure. Figure 12 shows stilling basin C operating at a discharge of

TABLE 2

PRESSURES ON WEIR

SCHEME CD

Test Number	Distance Below Valve in Feet	Pressure in Feet of Water				
		a	b	c	d	e
		Both Valves Open				
239	7.5	+13	-3.0	-9.0	-3.0	+1.5
241	9.5	+38	0	-7.0	-2.0	+3.0
242	10.5	+52	+0.5	-6.0	-2.0	+3.0
236	11.5	+55	-1.0	-5.0	-2.0	+3.0
243	12.5	+56	-2.0	-6.0	-2.0	+3.0
240	13.5	+53	-4.0	-6.0	-3.0	+3.0
235	15.5	+57	-6.0	-6.0	-2.5	+2.0
237	19.5	+53	-9.0	-6.0	-2.0	+3.5
238	23.5	+48	-11.0	-5.0	-0.5	+5.5
		One Valve Open				
244	11.5	+26	+2.0	-1.0	-1.0	+1.5

20,000 cfs. The eddy illustrated here shows that there was no flow down the right side of the basin. Some improvement of flow distribution was obtained by placing a tapered pier in the transition between tunnel and stilling basin, as shown for stilling basin N, Plate 2. Still further improvement was made by placing triangular deflecting blocks in the upper inside corners of the tunnel outlets, as shown for stilling basin V. This design gave much more satisfactory operation, as illustrated by Figure 13, which shows a discharge of 40,000 cfs.

The performance was improved by increasing the length of the basin 50 feet, as for basin Z. Velocities at the end were reduced and there was less erosion and lower wave heights. Table 3 is a comparison of erosion depths and wave heights for basins V and Z.

The operation of stilling basin Z for small discharges was somewhat unsymmetrical as illustrated by Figure 15, which shows a discharge of 10,000 cubic feet per second. For such small discharges, however, velocities at the end of the structure were very low and there seemed to be no danger of erosion.

The height of the end sill was fixed at 6 feet. Four different upstream slopes were tested; 1 on 2, 1 on 1, 2 on 1, and 4 on 1. The best results were obtained with the 2 on 1 slope. Wave heights downstream were increased with a steeper slope, while a slight slope allowed the hydraulic jump to move nearer the end of the basin.

ACKNOWLEDGMENTS

This investigation was conducted by the Hydraulic Data Branch under the direction of Albert S. Fry, Chief of Branch. The tests were made and the report prepared in the Hydraulic Laboratory at Norris under the supervision of G. H. Hickox, Head, Hydraulic Laboratory Section. A. J. Peterka and B. R. Blackwell were in charge of the testing. They were assisted by the entire laboratory staff. The report was prepared by B. R. Blackwell.

TABLE 3

EROSION DEPTHS AND WAVE HEIGHTS

STILLING BASINS V AND Z

Discharge		Stilling Basin V				Stilling Basin Z			
			Maximum Erosion at Sill in Feet	Wave Heights			Maximum Erosion at Sill in Feet	Wave Heights	
Spillway cfs	Sluices cfs	Test Number		100* Feet	400* Feet	Test Number		100* Feet	350* Feet
0	10,000	169	0	-	-	198	0	-	-
10,000	0	170	8	-	-	199	1	-	-
10,000	10,000					200	2	1	1
20,000	0	171	6	3	1	196	3	1	1
20,000	10,000					202	3	3	2
30,000	0					201	3	3	2
30,000	10,000					204	4	3	2
40,000	0	172	5	6	4	203	3	3	3
40,000	10,000					206	10	4	4
50,000	0					205	6	5	4
50,000	10,000					197	12	8	5
60,000	0	173	9	15	10	194	8	8	5
60,000	10,000	174	16	15-20	10-12	195	15	7-10	5

* Distance downstream from sill.

Length of stilling basin V = 300 feet.
Length of stilling basin Z = 350 feet.

Figure 1.--Morning glory spillway without piers. Toe of bank 30 feet from spillway. Discharge 60,000 cubic feet per second.

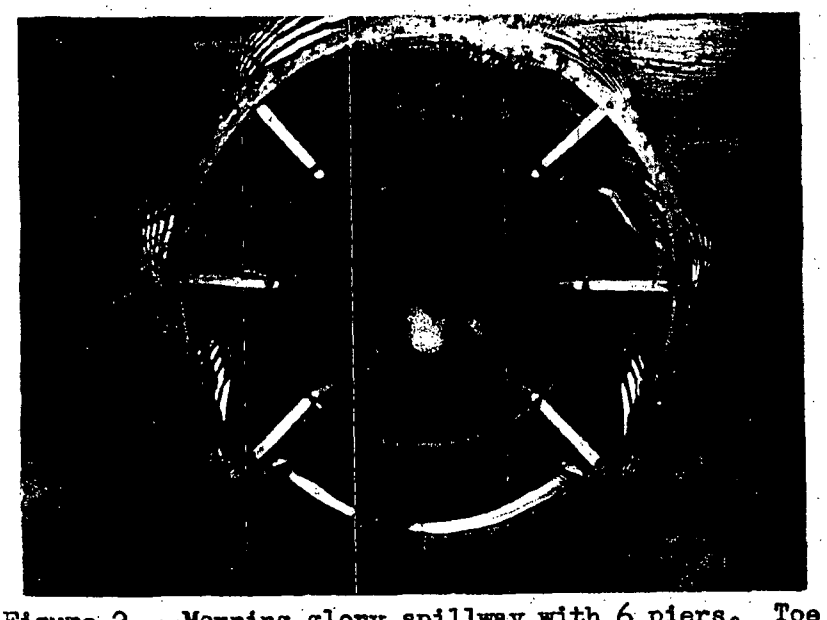


Figure 2.--Morning glory spillway with 6 piers. Toe of bank 30 feet from spillway. Discharge, 60,000 cubic feet per second.

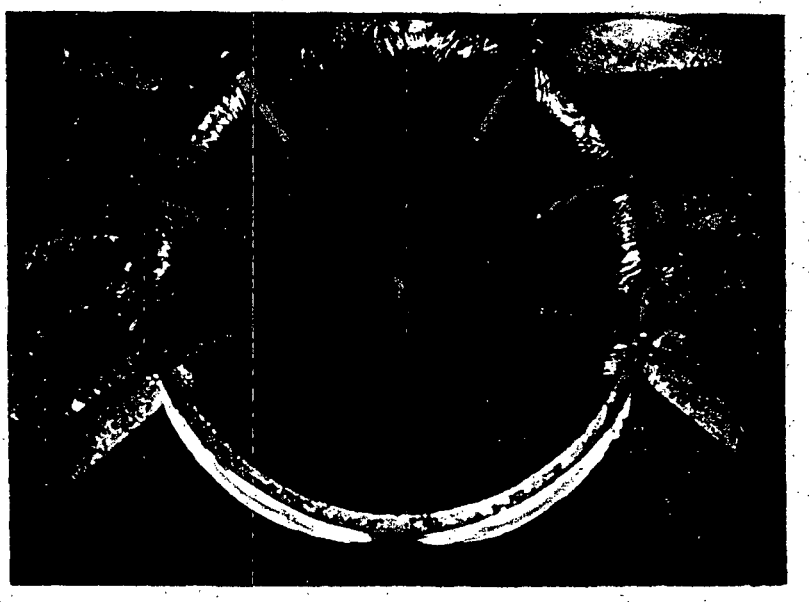


Figure 3.--Morning glory spillway with 6 piers and curved fins. Toe of bank 30 feet from spillway. Discharge, 60,000 cubic feet per second.

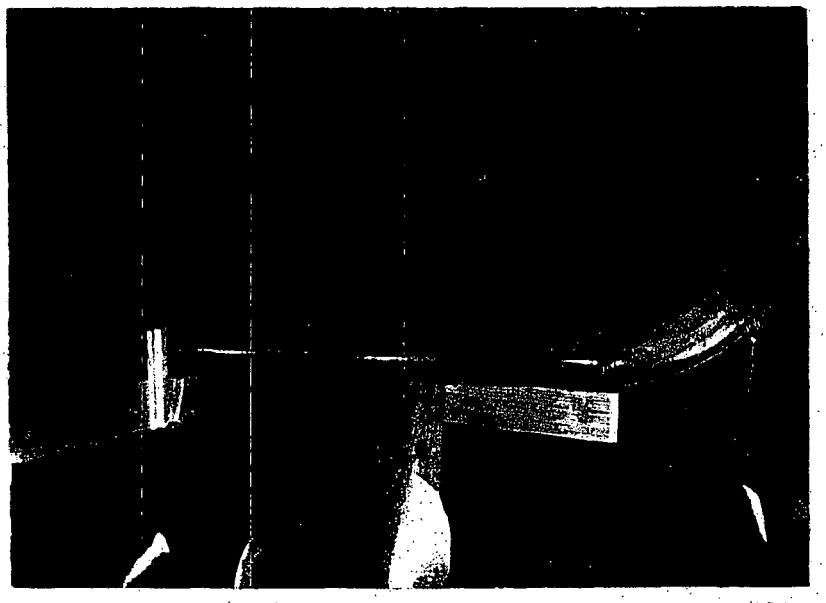


Figure 4.--Spiral flow in elbow and tunnel with no deflector in the spillway shaft. Discharge, 60,000 cubic feet per second.

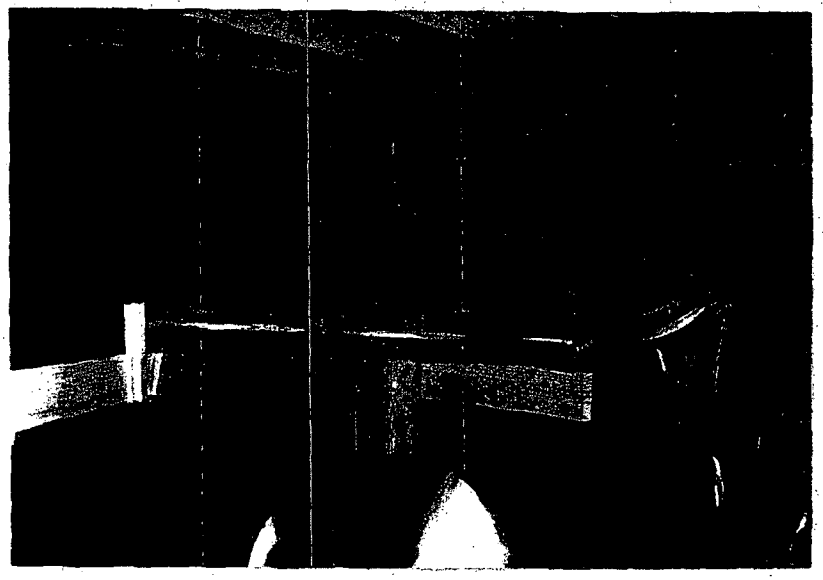


Figure 5.--Smooth uniform flow in elbow and tunnel with the 6.5-foot deflector in the spillway shaft. Discharge, 60,000 cubic feet per second.

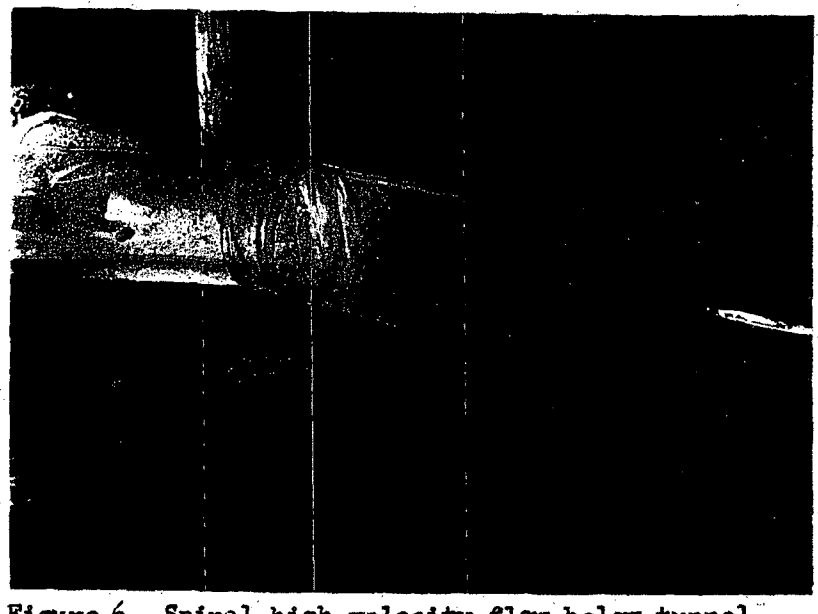


Figure 6.--Spiral high-velocity flow below tunnel intersection with no energy-dissipating structures in the tunnel. Valve discharge, 10,000 cubic feet per second.

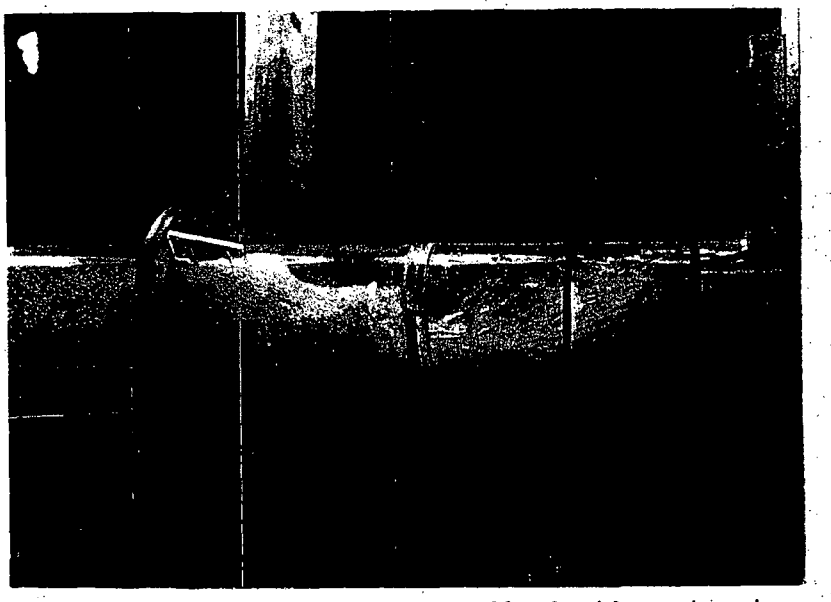


Figure 7.--Operation of energy-dissipating structures, scheme CD, 11.5 feet below the valves. The flow does not fill the tunnel at any place. Discharge, 10,000 cubic feet per second.

Figure 8.--Operation of energy-dissipating structures, scheme CD, with the weir too close to the valves. Water splashes on the tunnel roof at the weir and high-velocity flow persists in the tunnel. Discharge, 10,000 cubic feet per second.

Figure 9.--Operation of energy-dissipating structures, scheme CD, 11.5 feet below the valves. One valve discharging 5,000 cubic feet per second.

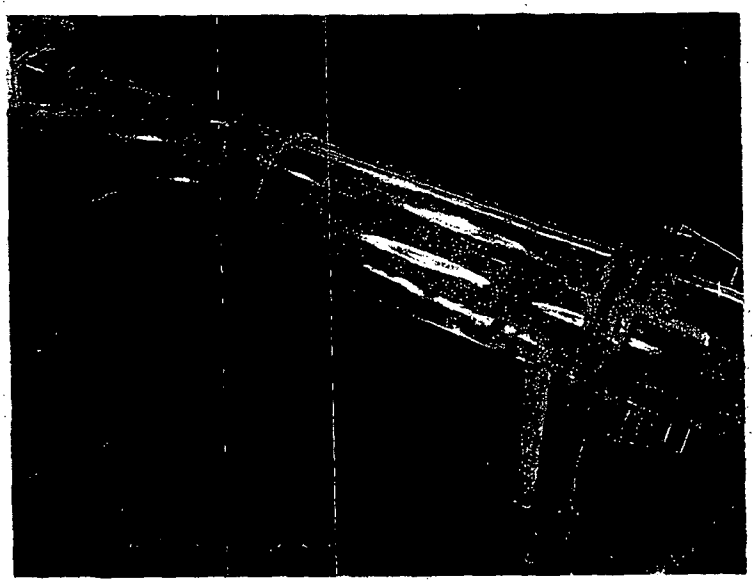


Figure 10.--Smooth low-velocity flow below tunnel intersection, with valve and wye energy-dissipating structures in place. Valve discharge, 10,000 cubic feet per second. Compare with Figure 6.

Figure 11.--Operation with stilling basin A. Discharge, 20,000 cubic feet per second.

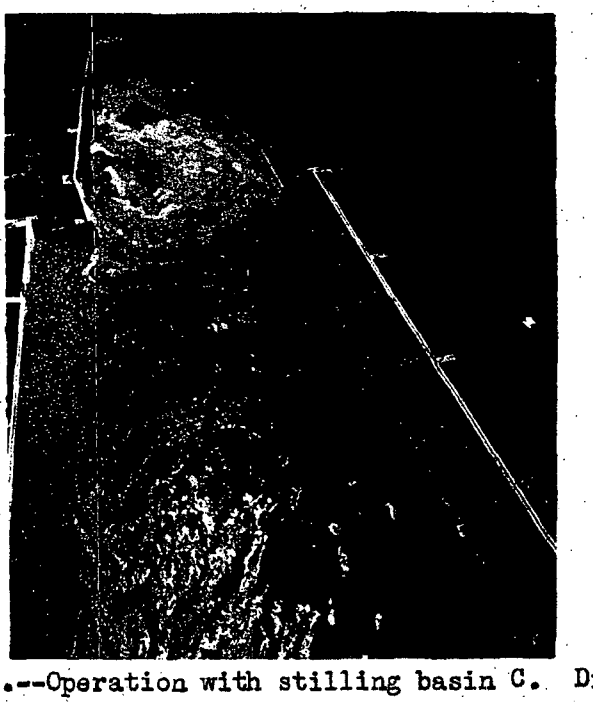


Figure 12.--Operation with stilling basin C. Discharge, 20,000 cubic feet per second.

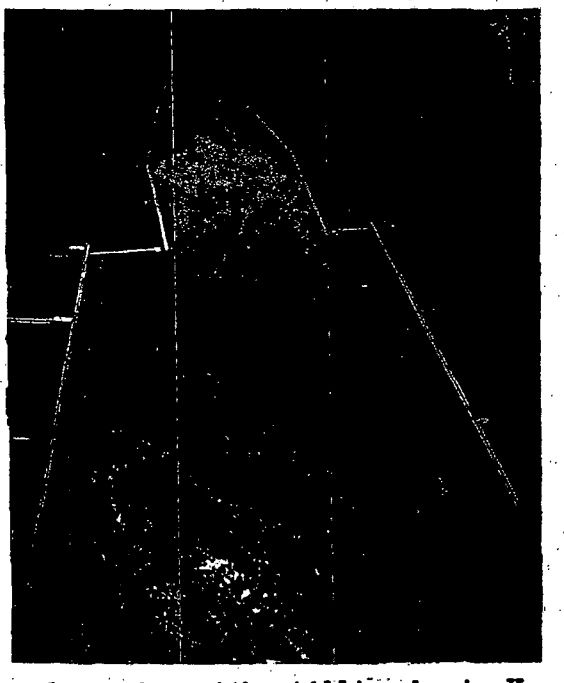


Figure 13.--Operation with stilling basin V. Discharge, 40,000 cubic feet per second.

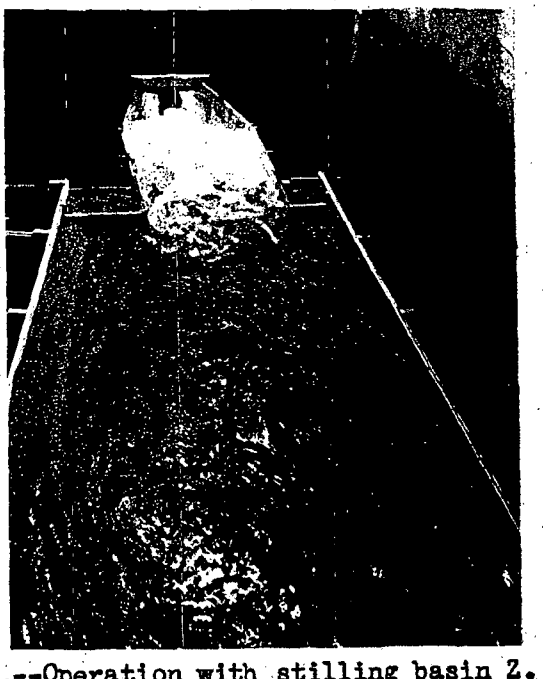


Figure 14.--Operation with stilling basin Z. Discharge, 40,000 cubic feet per second.

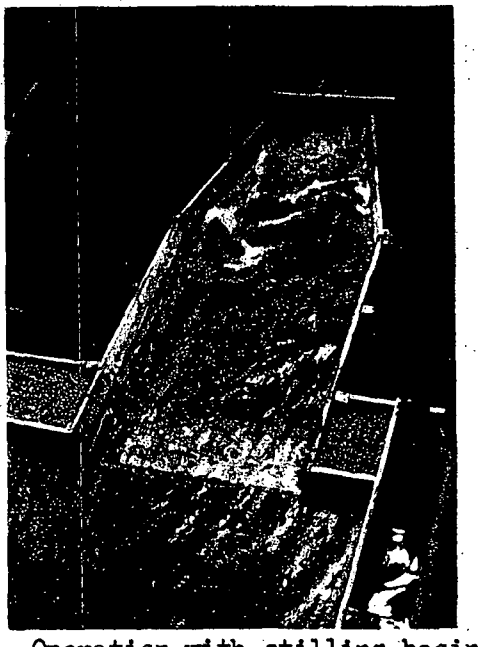
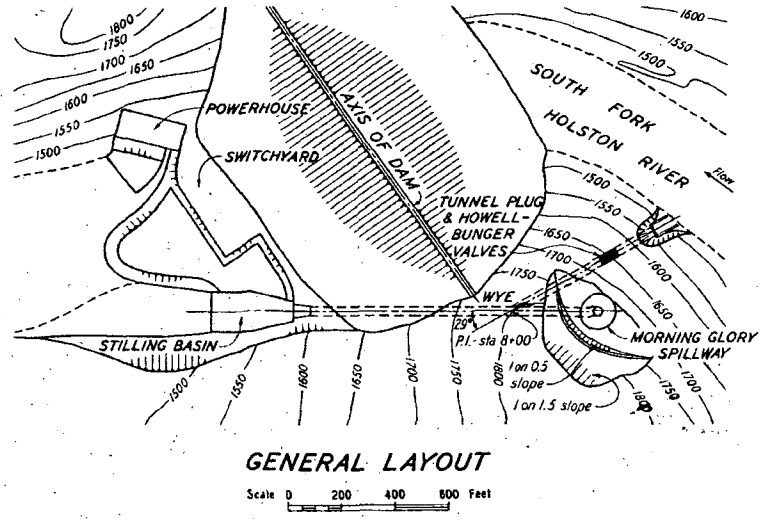
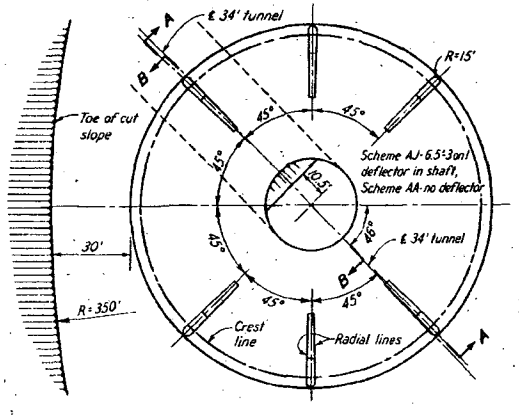


Figure 15.--Operation with stilling basin Z. Discharge, 10,000 cubic feet per second.

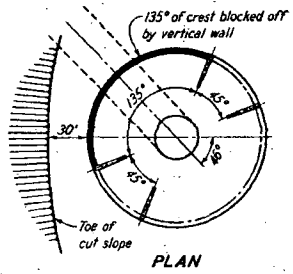


GENERAL LAYOUT

Scale 0 200 400 800 Feet

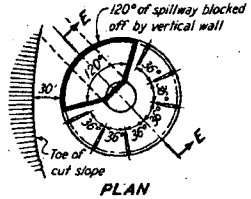


PLAN

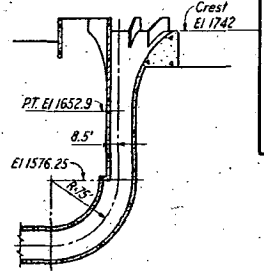


PLAN

SCHEME Q

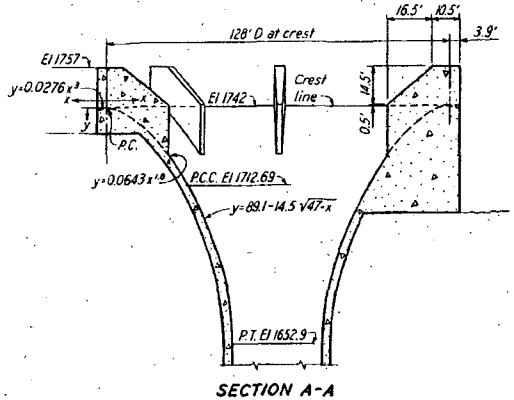


PLAN



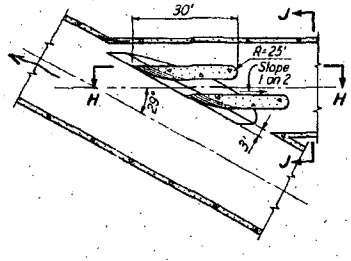
SECTION E-E

SCHEME AB

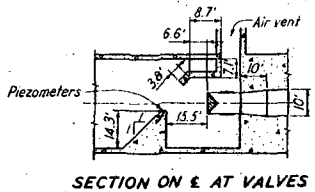


SECTION A-A

SCHEMES AA & AJ

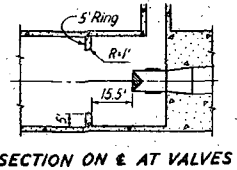


SECTIONAL PLAN AT WYE



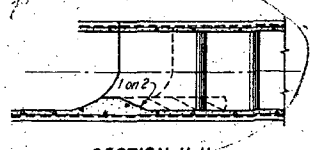
SECTION ON ℄ AT VALVES

SCHEME BR

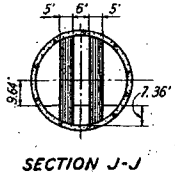


SECTION ON ℄ AT VALVES

SCHEME BL

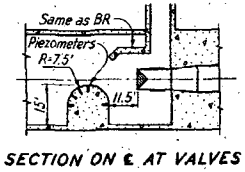


SECTION H-H



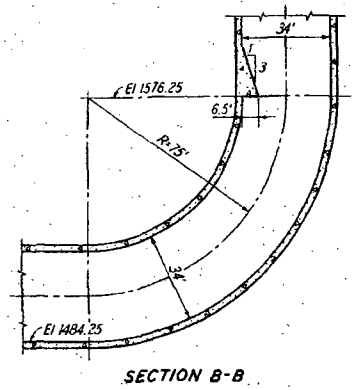
SECTION J-J

SCHEMES BR, BL, CD



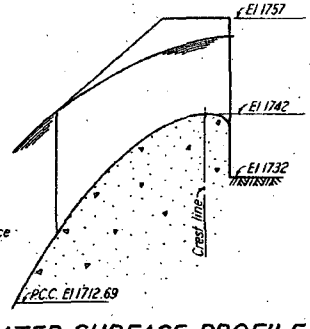
SECTION ON ℄ AT VALVES

SCHEME CD



SECTION B-B

SCHEME AJ



The profile was taken 2 feet from the pier face

MAXIMUM WATER SURFACE PROFILE

DISCHARGE 60,000 C.F.S.

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

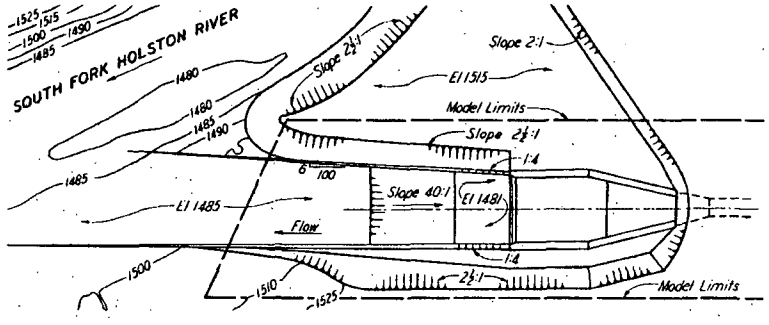
SOUTH HOLSTON PROJECT HYDRAULIC MODEL STUDIES
SPILLWAY AND TUNNEL

MODEL LAYOUT AND DETAILS

MODEL SCALES 1:34, 1:51, AND 1:100

PLATE 1

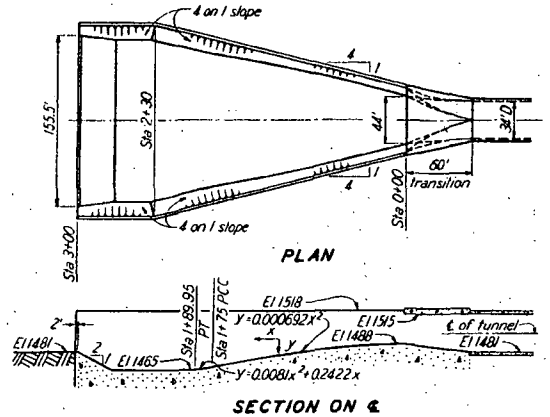
CDQ00002008001 7



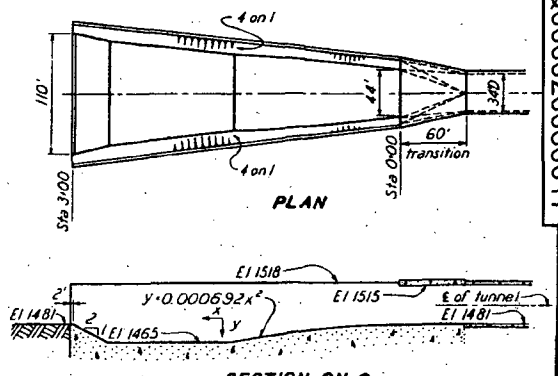
GENERAL LAYOUT

STILLING BASIN V IN PLACE

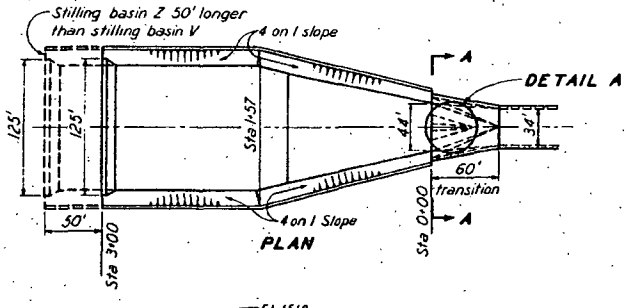
Scale 0 100 200 300 Feet

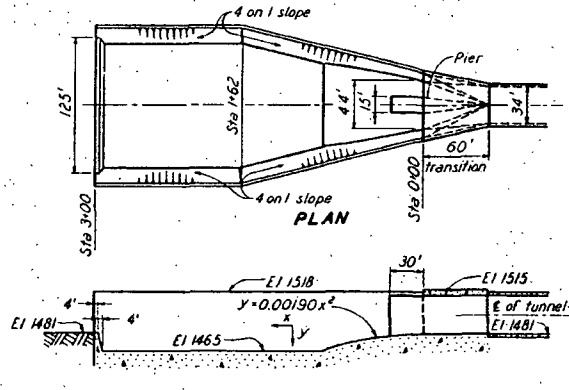


STILLING BASIN A

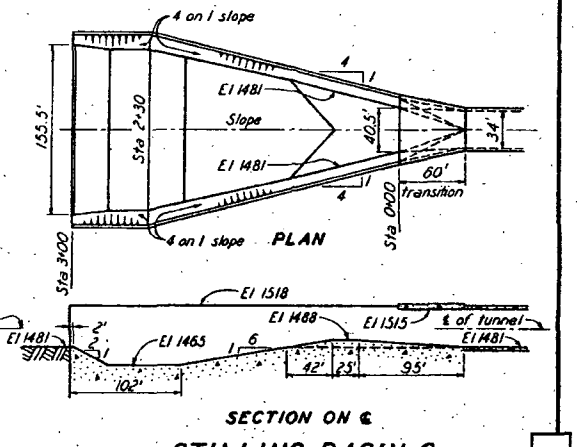


STILLING BASIN B

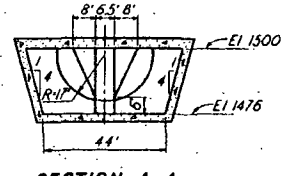




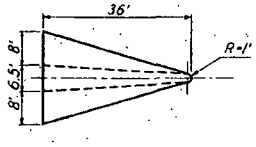
STILLING BASIN N



STILLING BASIN C



SECTION A-A



DETAIL A

STILLING BASINS V & Z

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

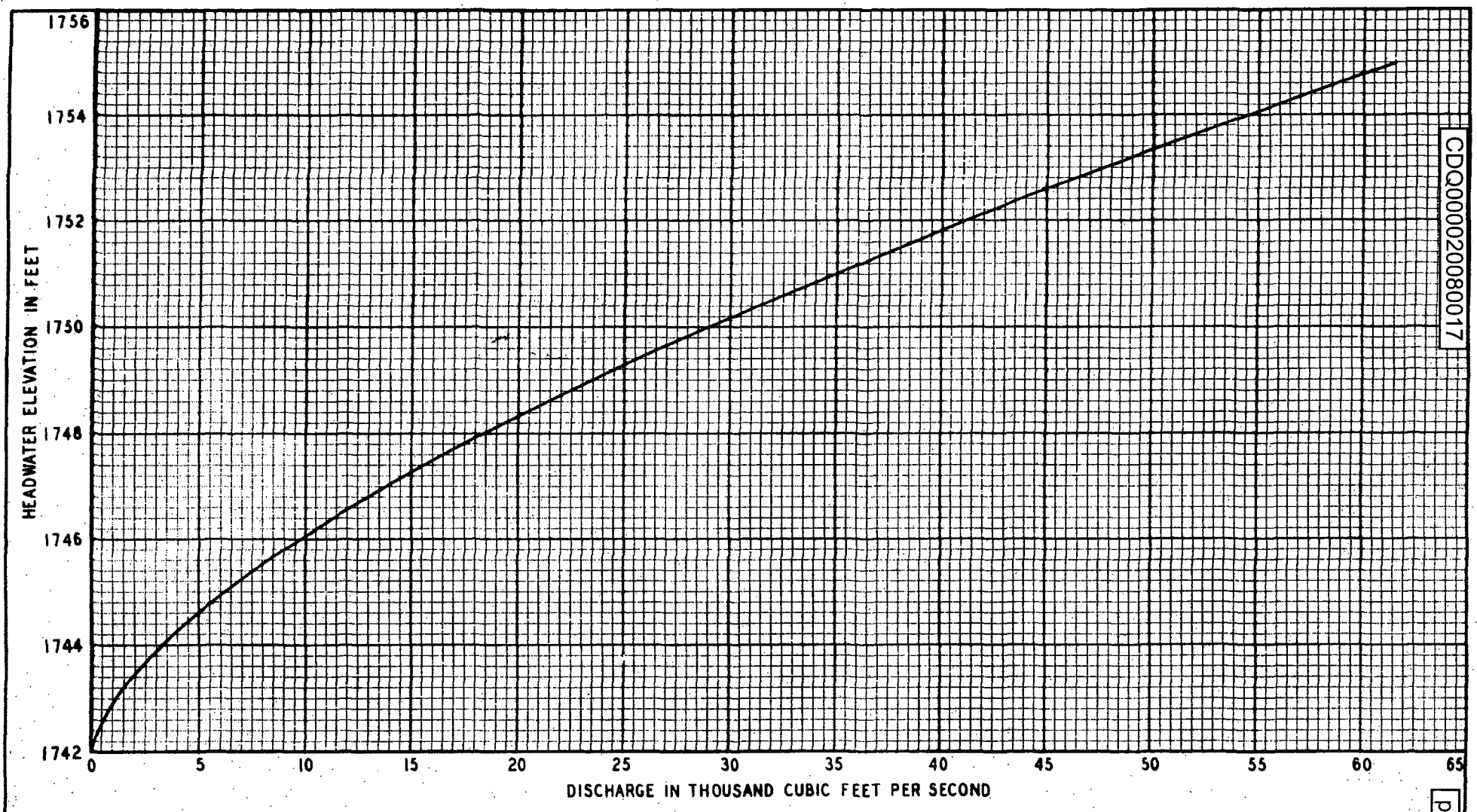
SOUTH HOLSTON PROJECT HYDRAULIC MODEL STUDIES

STILLING BASIN

MODEL LAYOUT AND DETAILS

MODEL SCALE 1:51

CDQ00002008001 7



TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

SOUTH HOLSTON PROJECT HYDRAULIC MODEL STUDIES
MORNING-GLORY SPILLWAY
SPILLWAY RATING CURVE

CDQ00002008001 7

PLATE 3

ATTACHMENT 4

South Holston Tailwater Rating Curve

(Reference 2.4)

South Holston Tailwater Rating

Riverware Rating

Q*1000	Q	Elevation
0	0	1489
2.8	2,800	1489
5	5,000	1491
7.5	7,500	1493
10	10,000	1494.5
12.5	12,500	1496
15	15,000	1497
17.5	17,500	1498
20	20,000	1499.3
22.5	22,500	1500.5
25	25,000	1501.3
27.5	27,500	1502
30	30,000	1503
32.5	32,500	1504
35	35,000	1504.6
37.5	37,500	1505.5
40	40,000	1506
42.5	42,500	1506.5
45	45,000	1507.3
47.5	47,500	1508
50	50,000	1508.6
52.5	52,500	1509.5
55	55,000	1509.8
57.5	57,500	1510.5
60	60,000	1510.95
62.5	62,500	1511.5
65	65,000	1512.05
67.5	67,500	1512.5
70	70,000	1513.1
80	80,000	1516
100	100,000	1525
150	150,000	1530
200	200,000	1535

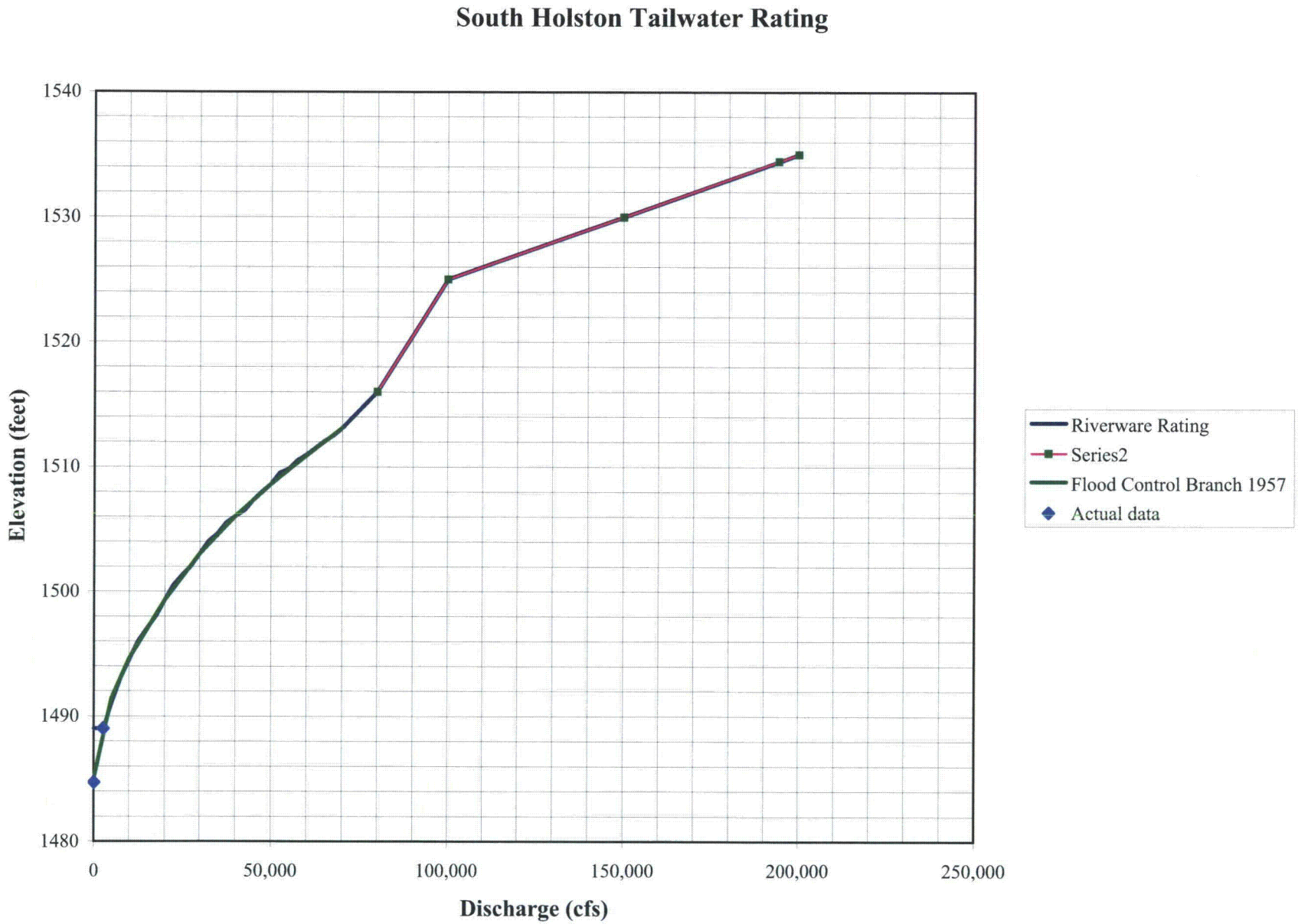
Flood Control Branch 1957

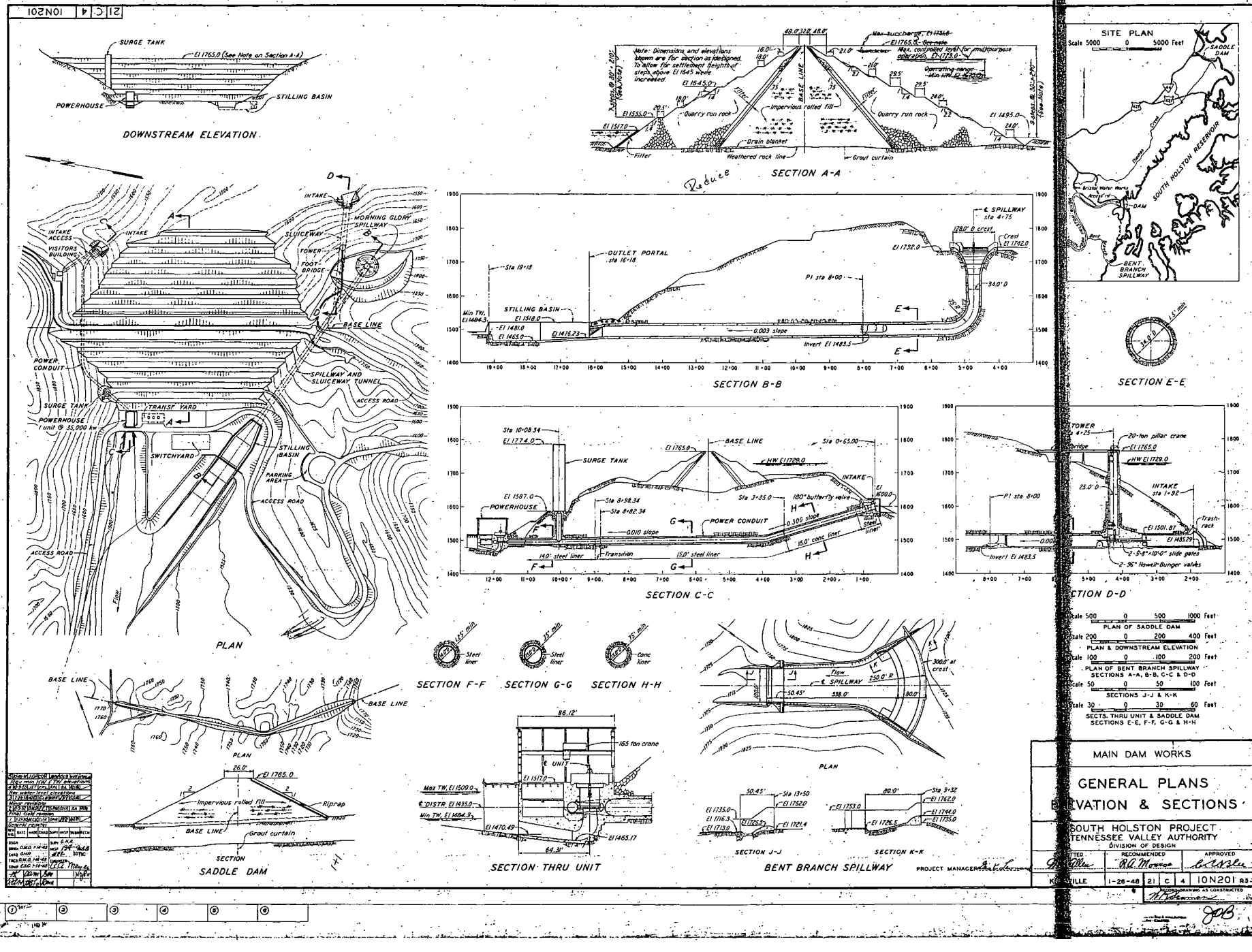
Discharge	Elevation	
0	1485.0	
5,000	1491.4	
10,000	1494.6	
20,000	1499.3	
30,000	1503.0	
40,000	1506.0	
50,000	1508.6	
60,000	1510.9	
70,000	1513.1	
80,000	1516	
100,000	1525	
150,000	1530	
194,200	1534.45	**PMF**
200,000	1535	

Actual data

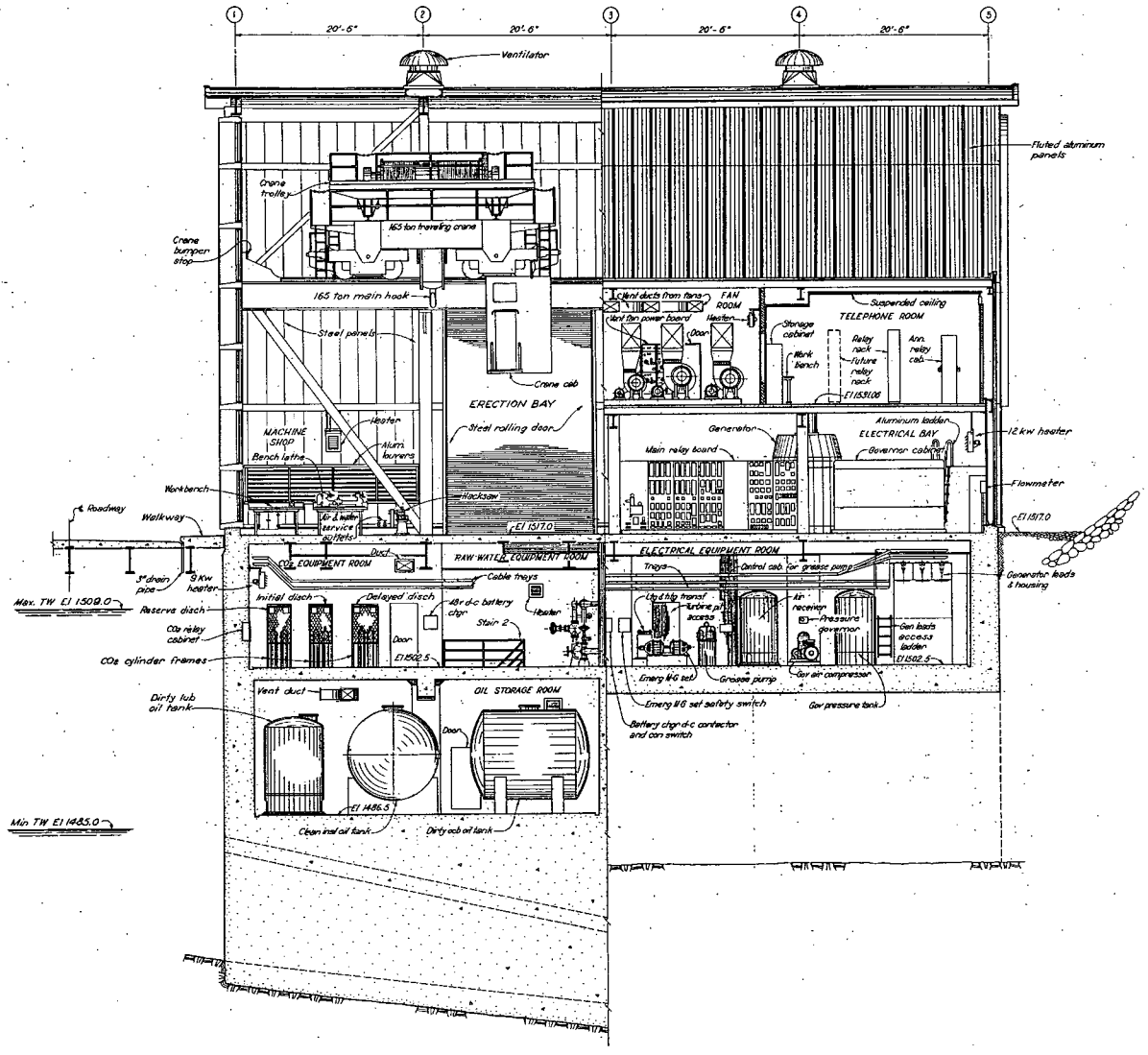
0	1484.7
2630	1489

CDQ00002008001 7




DOWNSTREAM ELEVATION
SURGE TANK
El 1765.0 (See Note on Section A-A)
POWERHOUSE
STILLING BASIN
SECTION A-A
Note: Dimensions and elevations shown are for section as designed. To allow for settlement heights of steps above El 1645 were increased.
Max. succharge El 1751.8
El 1765.0 - See note
Max. controlled level for multipurpose operation El 1775.0
Operating range Min WL El 1694.0
Impervious rolled fill
Quarry run rock
Drain blanket
Weathered rock line
Grout curtain
Filter
BASE LINE
El 1555.0
El 1517.0
El 1645.0
El 1495.0
Reduce
SECTION B-B
OUTLET PORTAL sta 16+18
Sta 19+18
STILLING BASIN
El 1518.0
El 1481.0
El 1465.0
El 1476.23
0.003 slope
Invert El 1483.5
Min TW, El 1494.3
PI sta 8+00
El 1732.0
℄ SPILLWAY sta 4+75
128.0' D crest
Crest El 1742.0
34.0' D
SECTION C-C
Sta 10+08.34
El 1774.0
SURGE TANK
El 1765.0
BASE LINE
Sta 0+65.00
HW El 1729.0
INTAKE
El 1600.0
El 1587.0
POWERHOUSE
Sta 8+98.34
Sta 8+82.34
0.010 slope
POWER CONDUIT
Sta 3+35.0
180" butterfly valve
0.300 slope
Steel liner
14.0' steel liner
Transition
150' steel liner
15.0' conc liner
SECTION D-D
TOWER 4+25
20-ton pillar crane
Bridge
El 1765.0
HW El 1729.0
25.0' D
INTAKE sta 1+92
PI sta 8+00
Trash-rack
El 1501.87
El 1485.29
0.003
Invert El 1483.5
2-5'-8"x10'-0" slide gates
2-96" Howell-Bunger valves
SECTION E-E
1.5 min
SITE PLAN
Scale 5000 0 5000 Feet
SADDLE DAM
SOUTH HOLSTON RESERVOIR
Bristol Water Works
DAM
BENT BRANCH SPILLWAY
PLAN
INTAKE
INTAKE ACCESS
VISITORS BUILDING
SLUICEWAY
TOWER
FOOT BRIDGE
MORNING GLORY SPILLWAY
BASE LINE
POWER CONDUIT
SPILLWAY AND SLUICEWAY TUNNEL
ACCESS ROAD
SURGE TANK
POWERHOUSE 1 unit @ 35,000 kw
TRANSF YARD
SWITCHYARD
STILLING BASIN
PARKING AREA
Flow
SECTION F-F
SECTION G-G
SECTION H-H
Steel liner
Conc liner
15' min
PLAN
BASE LINE
SECTION
26.0'
El 1765.0
Impervious rolled fill
Riprap
Grout curtain
SADDLE DAM
86.12'
165 ton crane
℄ UNIT
El 1517.0
Max TW, El 1509.0
℄ DISTR. El 1495.0
Min TW, El 1484.3
El 1470.49
El 1465.17
64.31'
SECTION THRU UNIT
Flow
℄ SPILLWAY
250.0' R
50.45'
338.0'
90.0'
300.0' at crest
PLAN
50.45'
Sta 13+50
El 1752.0
El 1735.0
El 1716.3
El 1713.0
El 1725.5
El 1721.4
SECTION J-J
80.0'
Sta 9+32
El 1753.0
El 1762.0
El 1744.0
El 1735.0
El 1726.5
SECTION K-K
Scale 500 0 500 1000 Feet
PLAN OF SADDLE DAM
Scale 200 0 200 400 Feet
PLAN & DOWNSTREAM ELEVATION
Scale 100 0 100 200 Feet
PLAN OF BENT BRANCH SPILLWAY
SECTIONS A-A, B-B, C-C & D-D
Scale 50 0 50 100 Feet
SECTIONS J-J & K-K
Scale 30 0 30 60 Feet
SECTS. THRU UNIT & SADDLE DAM
SECTIONS E-E, F-F, G-G & H-H
MAIN DAM WORKS
GENERAL PLANS
ELEVATION & SECTIONS
SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
1-26-48
21 C 4 10N201 R3
PROJECT MANAGER
DRAWING AS CONSTRUCTED

46N206



Scale 3/8"-1'-0"
Except as noted

POWERHOUSE

EQUIPMENT
LONGITUDINAL SECTION THRU
ERECTION BAY-ELECTRICAL BAY

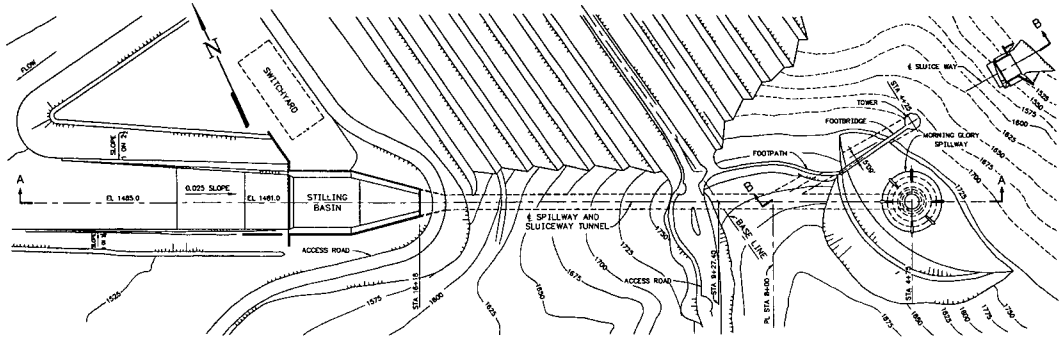
SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN.

SUBMITTED	RECOMMENDED	APPROVED
H. Hildebrandt	Harry B. Sims	R.D. Monroe

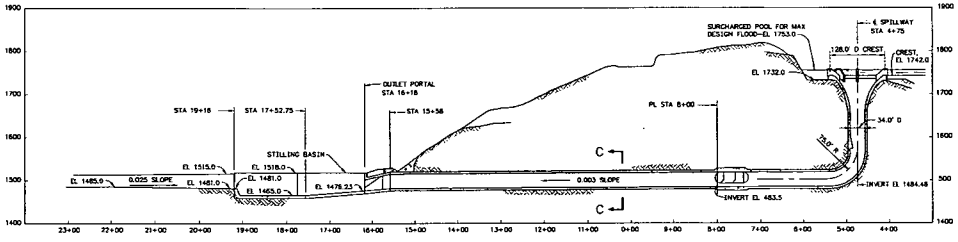
KNOXVILLE	12-22-55	21	A	4	46N206 R0

RECORD DRAWING AS CONSTRUCTED

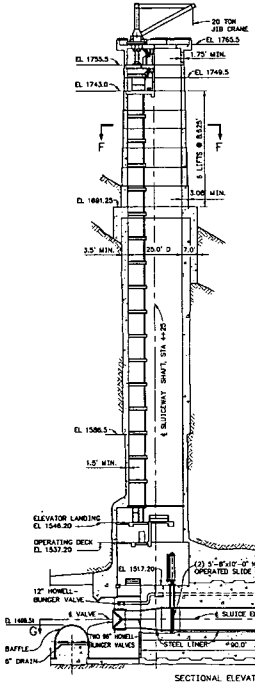
REV. NO.	DATE	MADE	CHKD	SUPV	INSP	SUBM	RECD
DRAN.							
DESIGN.							
CHKD.							
TRCD.							
CHKD.							



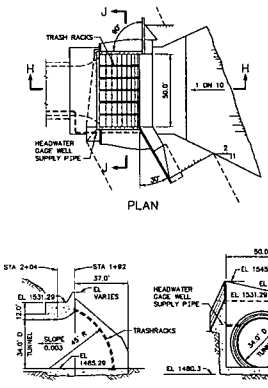
PLAN



SECTION A–A



SECTIONAL ELEVATION



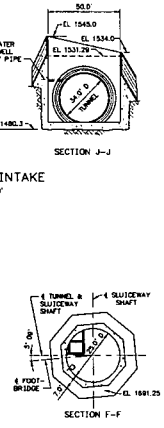
PLAN

SECTION H–H

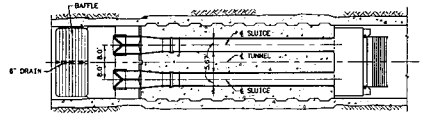
SECTION J–J

SLUICE WAY INTAKE

SCALE: 1"=30'



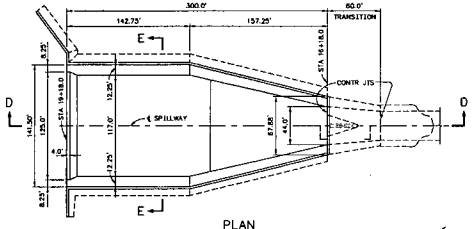
SECTION F–F



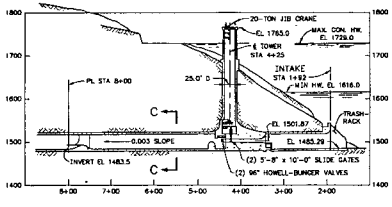
SECTION G–G

SLUICEWAY GATE PLUG & SHAFT

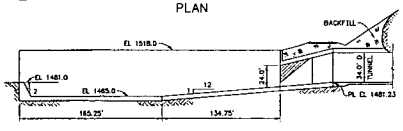
SCALE: 1"=20'



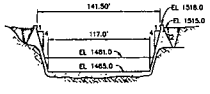
PLAN



SECTION B–B



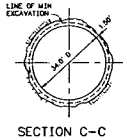
SECTION D–D



SECTION E–E

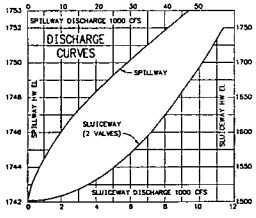
STILLING BASIN

SCALE: 1"=50'



SECTION C–C

SCALE: 1"=20'



R													
R 5	INC. 1 & 2002			KGK	KGK	KGK	RAS	CONTROL	TEAM				5
				KGK	KGK	RAS	RWT	R RWT	MAC				
ELECTRONICALLY RESTORED PER DCN #SHH-03-01													
NO.	DATE	BY	DWN	CHKD	SUPV	APPD	CHKD	PROJ ENGR	HD CONTROL				

SCALE: 1"=100' EXCEPT AS NOTED

MAIN SPILLWAY

PLANS AND SECTIONS

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
G. J. J.	D. M. D.	A. G.	A. G.	R. M. R.	J. R.	C. G. M.

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
RIVER SYSTEMS OPERATIONS

AUTOCAD 2002 | DATE 5-21-42 | 21 | C | 51W200 | R 6

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES : (51W200 R5)

TASK COMPLETED BY: | REV NO.

PLOT FACTOR:1200
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

21 | C | 51W200

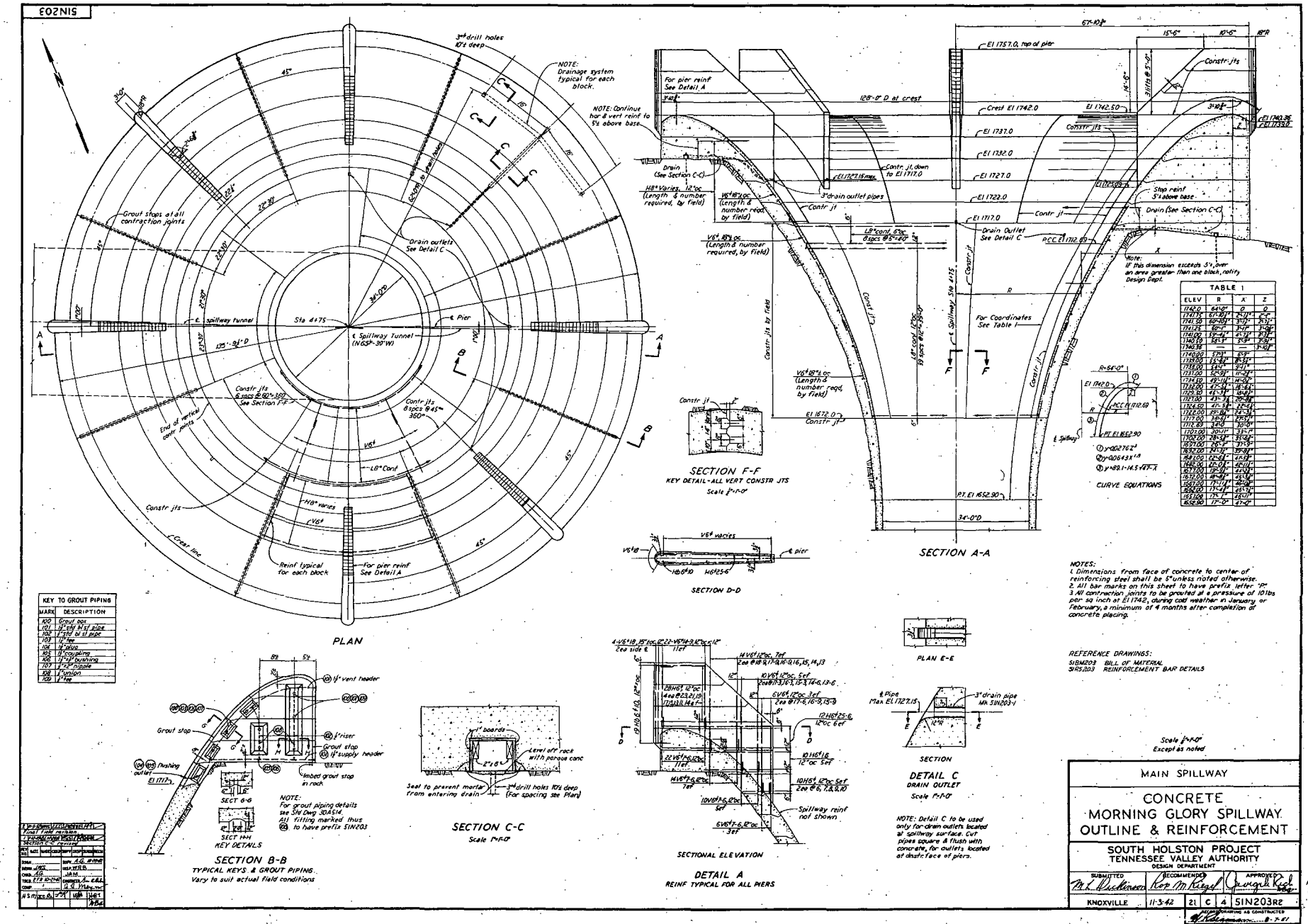


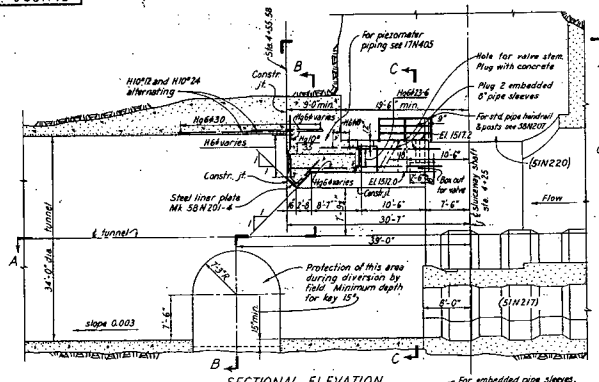
TABLE 1			
ELEV	R	X	Z
1742.0	64'-0"	0	0
1741.75	61'-10"	2'-11"	2'-6"
1741.50	60'-10"	3'-7"	3'-7"
1741.25	60'-7"	3'-9"	3'-9"
1741.00	59'-4"	4'-7"	4'-7"
1740.50	57'-3"	5'-9"	5'-9"
1740.38	—	—	3'-10"
1740.00	53'-3"	6'-9"	
1739.00	45'-8"	8'-5"	
1738.00	38'-4"	9'-11"	
1737.00	32'-0"	11'-3"	
1734.00	19'-11"	14'-0"	
1732.00	12'-5"	15'-8"	
1729.50	4'-3"	16'-9"	
1727.50	0'-3"	20'-8"	
1724.50	0'-3"	22'-4"	
1722.00	0'-8"	24'-3"	
1717.00	3'-0"	27'-7"	
1712.83	3'-0"	30'-0"	
1703.00	30'-11"	33'-1"	
1702.00	28'-0"	35'-0"	
1697.00	26'-3"	37'-9"	
1692.00	24'-3"	39'-8"	
1687.00	22'-8"	41'-8"	
1682.00	20'-8"	42'-11"	
1677.00	19'-0"	44'-0"	
1672.00	17'-8"	45'-3"	
1667.00	17'-1"	46'-0"	
1662.00	17'-4"	46'-7"	
1657.00	17'-7"	46'-7"	
1652.90	17'-0"	47'-0"	

NOTES:
1. Dimensions from face of concrete to center of reinforcing steel shall be 5" unless noted otherwise.
2. All bar marks on this sheet to have prefix letter "P".
3. All contraction joints to be grouted at a pressure of 10 lbs per sq inch at El 1742, during cold weather in January or February, a minimum of 4 months after completion of concrete placing.

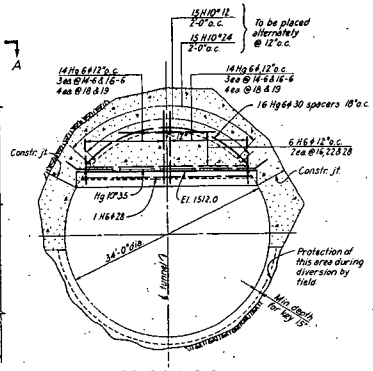
REFERENCE DRAWINGS:
51BM203 BILL OF MATERIAL
51RS203 REINFORCEMENT BAR DETAILS

Scale 1"=1'-0" Except as noted

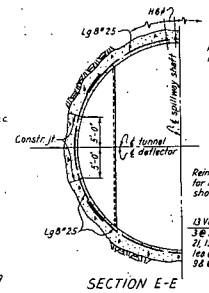
51N206



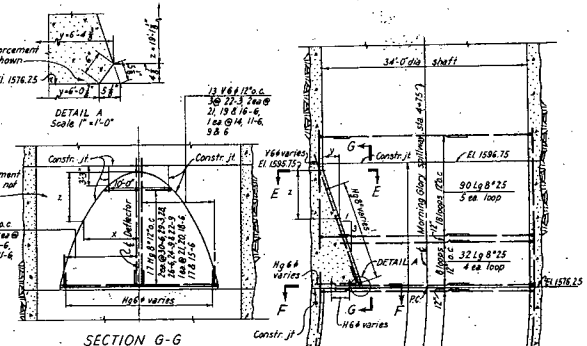
SECTIONAL ELEVATION
FIRST STAGE CONSTRUCTION



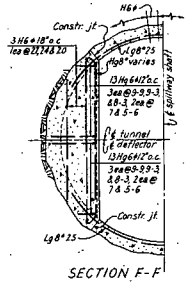
SECTION B-B



SECTION E-E

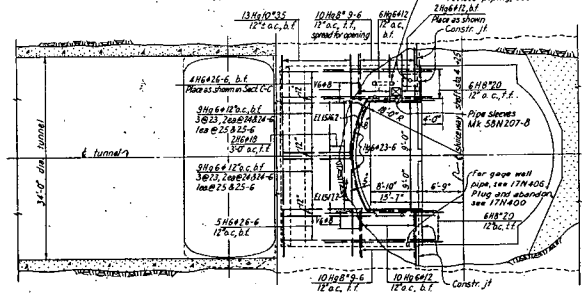


SECTION G-G

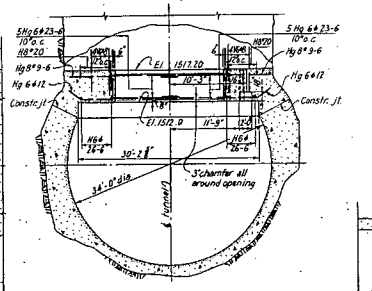


SECTION F-F

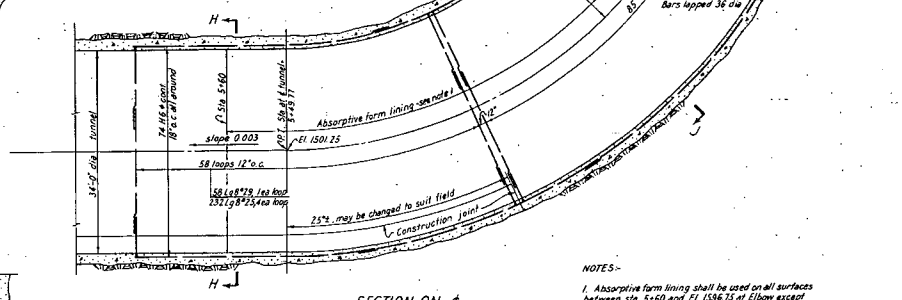
z	y	x
0	0	0
6"	2"	2'-4½"
1'-0"	4"	3'-4½"
2'-0"	8"	4'-8½"
4'-0"	16"	6'-7½"
6'-0"	2'-0"	8'-0"
8'-0"	2'-8"	9'-7½"
10'-0"	3'-4"	10'-7½"
14'-0"	4'-8"	11'-8½"
19'-7½"	6'-4½"	13'-3½"
19'-6"	6'-0½"	13'-0½"



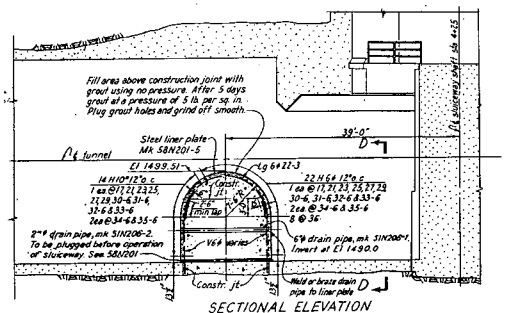
SECTIONAL PLAN A-A



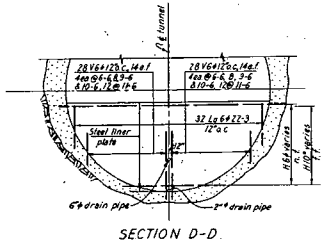
SECTION C-C



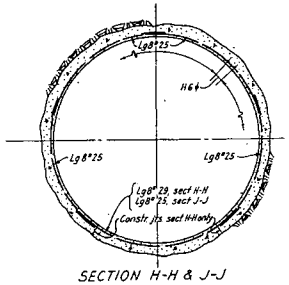
SECTION ON ℄
ELBOW DETAILS



SECTIONAL ELEVATION
SECOND STAGE CONSTRUCTION



SECTION D-D



SECTION H-H & J-J

TUNNEL DETAILS
AT SLUICEWAY SHAFT

NOTES:-

1. Absorptive form lining shall be used on all surfaces between sta. 5+60 and EL 1596.75 at Elbow except that where steel forms are used it may be omitted.

2. All bar marks on this sheet to have prefix "P."

3. Dimension from face of concrete to ℄ reinforcing steel shall be 5".

REFERENCE DRAWINGS:

51 BM 206 - BILL OF MATERIAL
51 RS 206 - REINFORCEMENT BAR DETAILS

Scale 1/8" = 1'-0" except as noted

MAIN SPILLWAY

CONCRETE ELBOW AND TUNNEL DETAILS OUTLINE AND REINFORCEMENT

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DESIGN DEPARTMENT

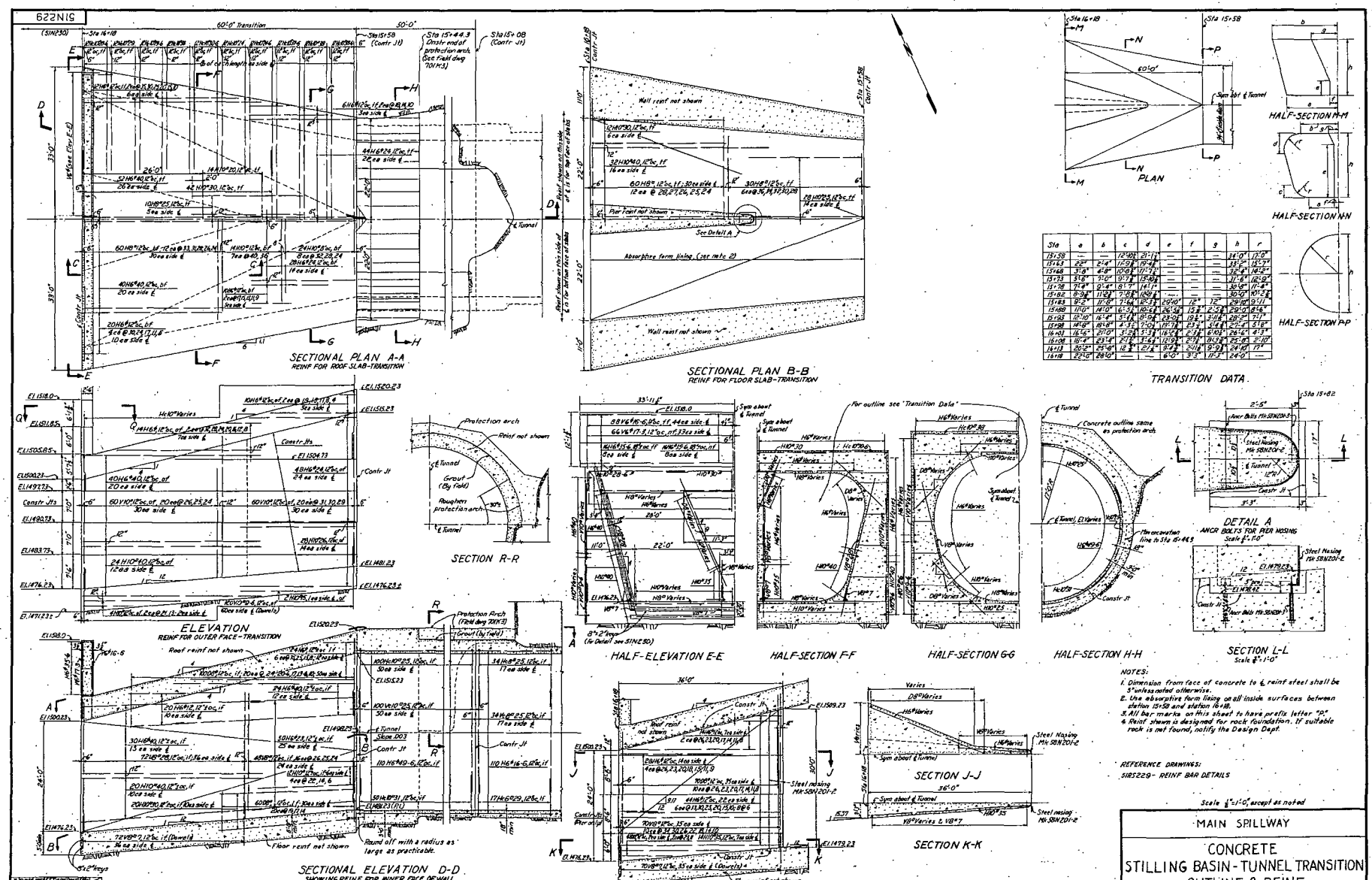
SUBMITTED: M. L. Nielsen — RECOMMENDED: Roy M. Kiesel — APPROVED: George Reich

KNOXVILLE | 9-4-42 | 21 | C | 4 | 51N206 | R4

DRAWING AS CONSTRUCTED

REV.	DATE	MADE	CHECKED	DRAFT	SUPERV.	DESIGN
4	10-29-41	Added 8" construction joint				
3	9-29-41	Revised per construction				
2	8-29-41	Revised per construction				
1	7-29-41	Revised per construction				
0	6-30-41	Note to show holes at El 1517.0				
0	6-30-41	Revised per construction				
0	6-30-41	Revised per construction				
0	6-30-41	Add stone comm. & minor rev.				
0	6-30-41	Revised per field construction				
0	6-30-41	Add line & dim. requires				

SCALE: 1/8" = 1'-0" | DATE: 6-30-41



NOTES:

1. Dimension from face of concrete to ℄ reinf steel shall be 3" unless noted otherwise.
2. Use absorptive form lining on all inside surfaces between station 15+58 and station 16+18.
3. All bar marks on this sheet to have prefix letter "D".
4. Reinf shown is designed for rock foundation. If suitable rock is not found, notify the Design Dept.

REFERENCE DRAWINGS:

- 51R5229 - REINF BAR DETAILS

Scale $\frac{1}{8}$"=1'-0" except as noted

MAIN SPILLWAY

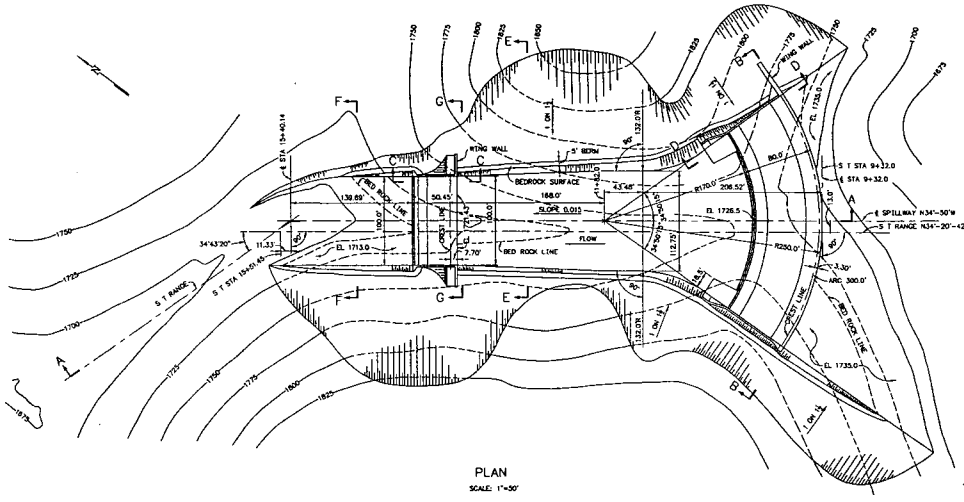
CONCRETE
STILLING BASIN - TUNNEL TRANSITION
OUTLINE & REINF

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DESIGN DEPARTMENT

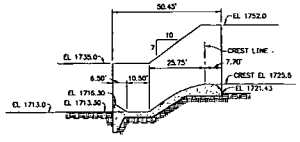
SUBMITTED	RECOMMENDED	APPROVED
M. I. Hiddleson	Roe McLeod	George Rich

KNOXVILLE 8-7-42 | 21 | C | 4 | 51N229 R2

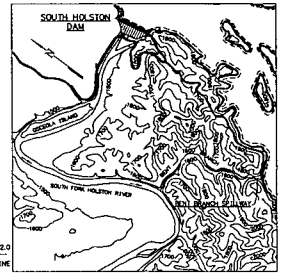
REVISED DRAWING AS CONSTRUCTED
M. I. Hiddleson 10-6-51



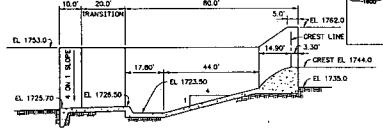
PLAN
SCALE: 1"=50'



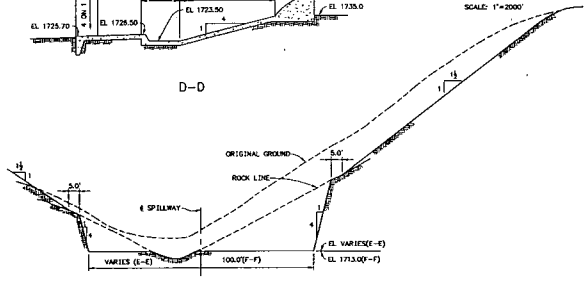
C–C



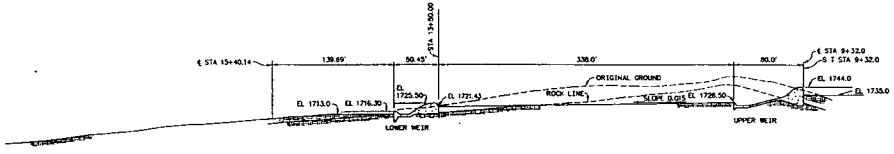
LOCATION MAP
SCALE: 1"=2000'



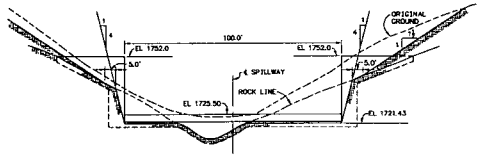
D–D



E–E & F–F
AS SHOWN AND NOTED

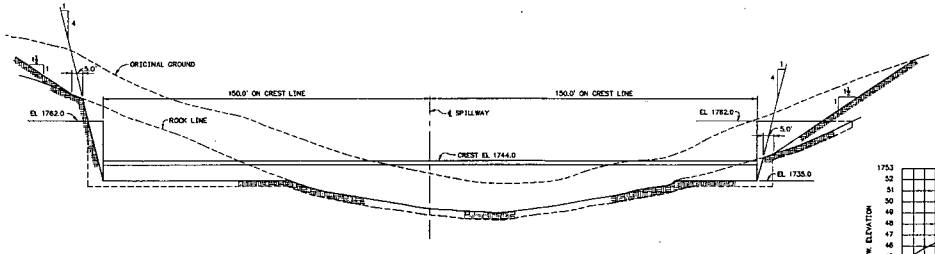


SECTION A–A
SCALE: 1"=50'

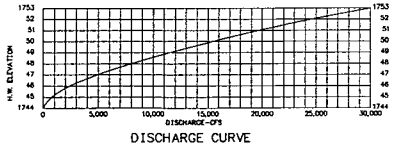


G–G

NOTES:
1. SEE FIELD DWGS 51K1241-1248 INCLUSIVE FOR FINAL EXCAVATION.



B–B



DISCHARGE CURVE

R 4 JUN 29 2007 ELECTRONICALLY RESTORED

SCALE: 1"=20' EXCEPT AS NOTED

BENT BRANCH SPILLWAY

PLAN & SECTIONS

DRAWN BY C.A.I., WEM | CHECKED BY CWS | SUPERVISED BY RRL | REVIEWED BY | APPROVED BY | ISSUED BY

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R14 | DATE 9-6-94 | 21 | C | 51W250 | R 4

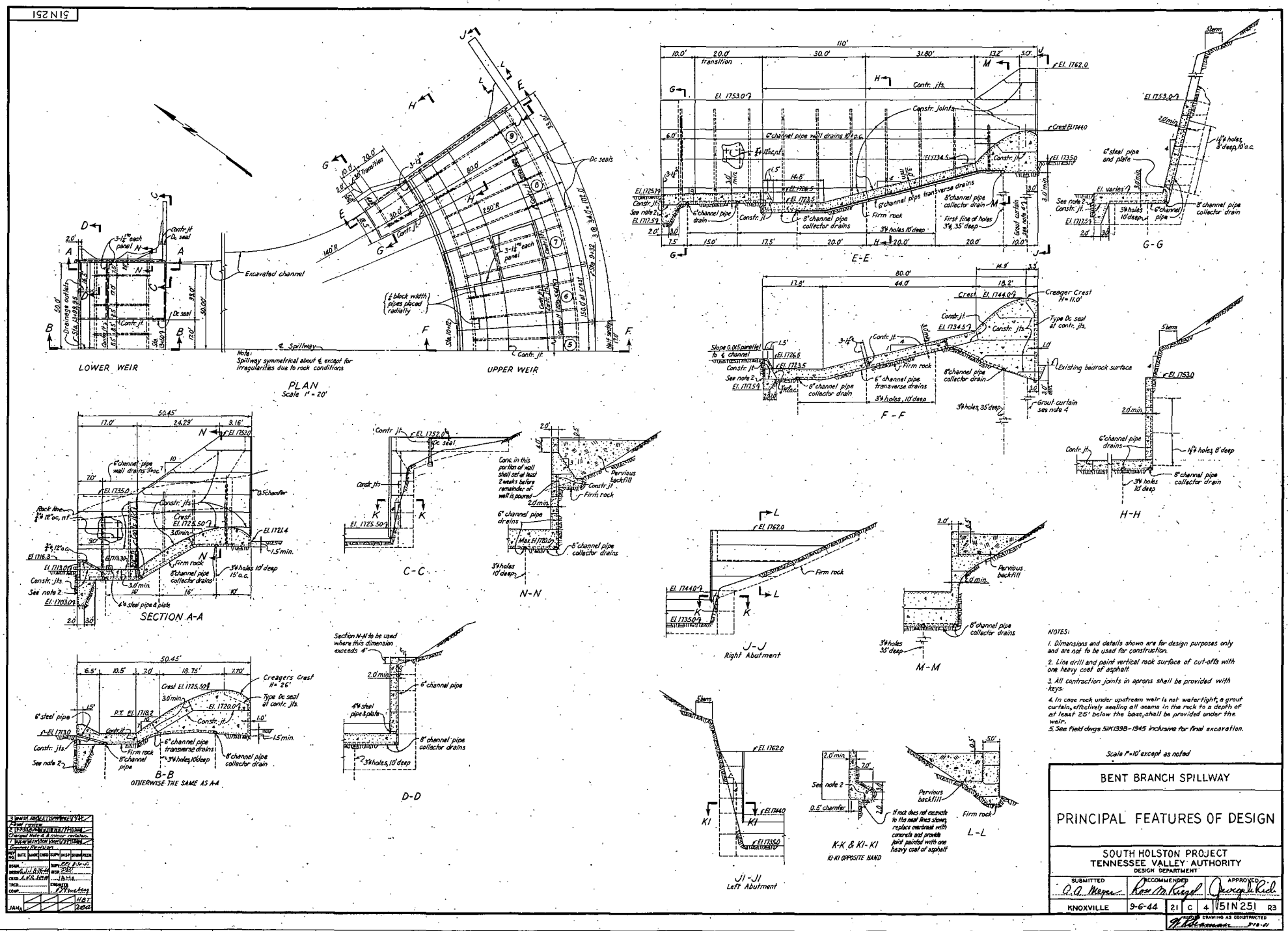
ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES : (51N250 R3)

TASK COMPLETED BY: | REV NO

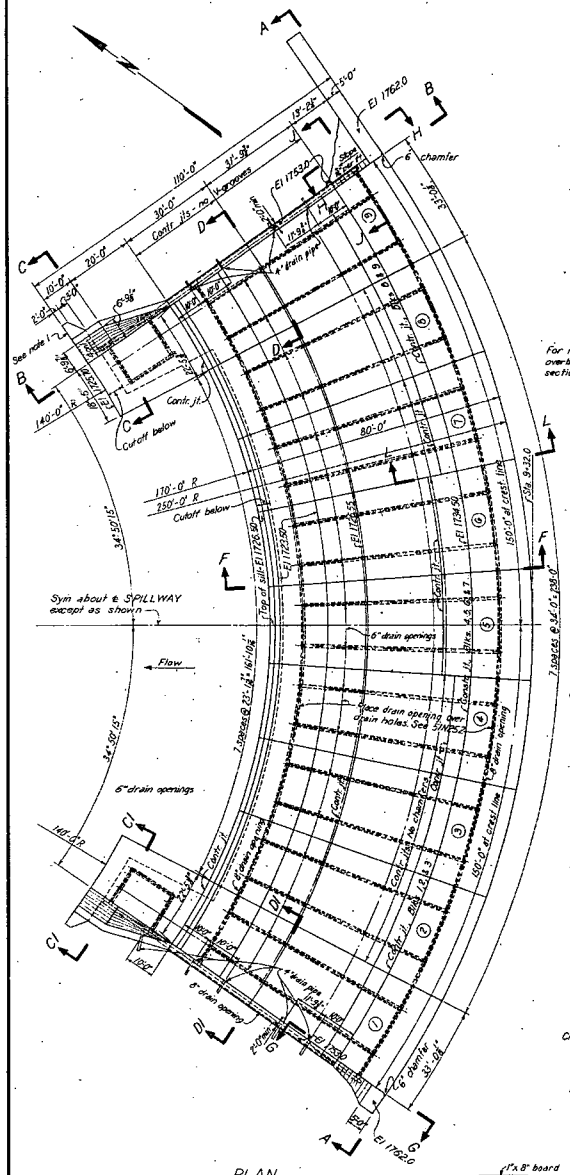
PLOT FACTOR:240
W_TVA

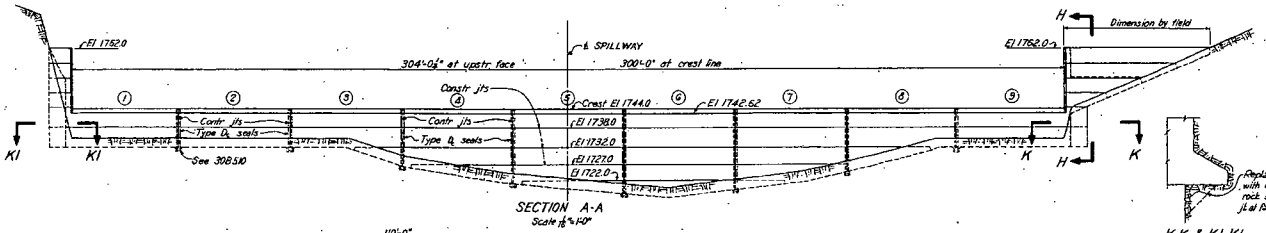
C.A.D. DRAWING
DO NOT ALTER MANUALLY

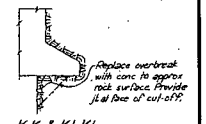
21 C 51W250


LOWER WEIR
UPPER WEIR
PLAN
Scale 1" = 20'
Note: Spillway symmetrical about ℄ except for irregularities due to rock conditions
Excavated channel
℄ Spillway
Drainage outlets
Dc seal
Contr. jt.
3-1¼" each panel
℄ block width pipes placed radially
Dc seals
140' R
250' R
SECTION A-A
B-B
OTHERWISE THE SAME AS A-A
C-C
D-D
N-N
E-E
F-F
G-G
H-H
J-J
Right Abutment
J1-J1
Left Abutment
K-K & K1-K1
K1-K1 OPPOSITE HAND
L-L
M-M
Firm rock
Pervious backfill
Creager Crest H=11.0'
Existing bedrock surface
Grout curtain see note 4
6" channel pipe wall drains 10' o.c.
8" channel pipe collector drains
6" channel pipe transverse drains
3¾ holes, 10' deep
3¾ holes, 35' deep
1¼" holes, 8' deep, 10' o.c.
6" steel pipe and plate
4¾ steel pipe & plate
Section N-N to be used where this dimension exceeds 4'
If rock does not coincide to the neat lines shown, replace overbreak with concrete and provide joint painted with one heavy coat of asphalt
NOTES:
1. Dimensions and details shown are for design purposes only and are not to be used for construction.
2. Line drill and paint vertical rock surface of cut-offs with one heavy coat of asphalt.
3. All contraction joints in aprons shall be provided with keys.
4. In case rock under upstream weir is not watertight, a grout curtain, effectively sealing all seams in the rock to a depth of at least 25' below the base, shall be provided under the weir.
5. See field dwgs. 51K1398-1345 inclusive for final excavation.
Scale 1" = 10' except as noted
BENT BRANCH SPILLWAY
PRINCIPAL FEATURES OF DESIGN
SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DESIGN DEPARTMENT
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
9-6-44
21
C
4
51N251
R3
AS CONSTRUCTED

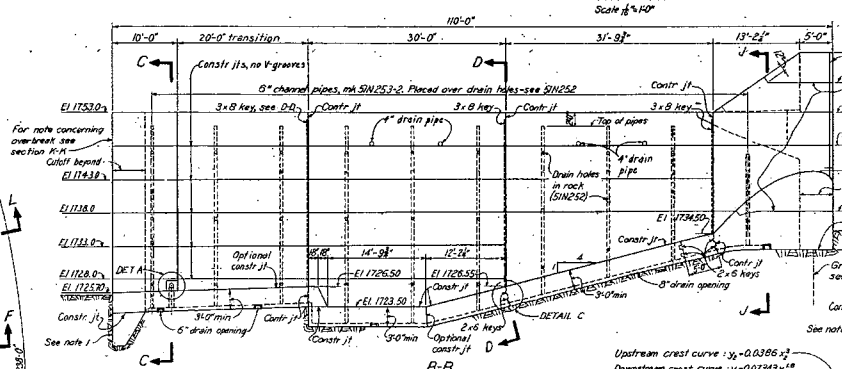
5IN253

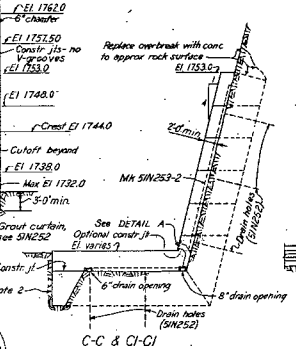


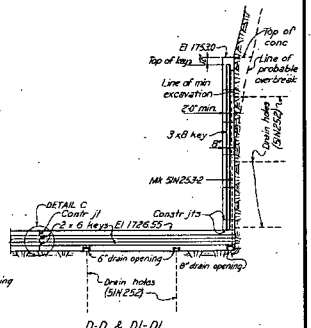


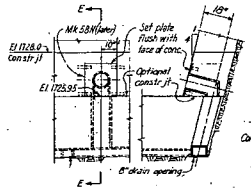


K-K & K1-K1
K1-K1 OPPOSITE HAND

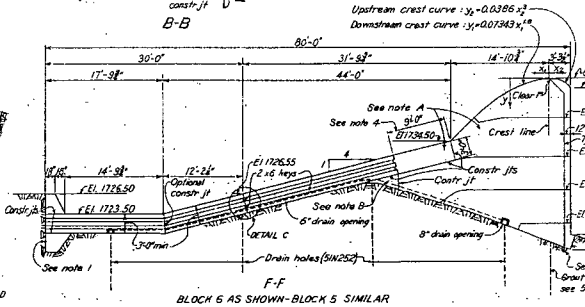








DETAIL A & A1
DETAIL A1 FOR LEFT WALL OPP HAND
Scale 3/8" = 1'-0"



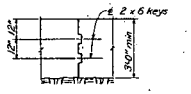
DOWNSTREAM CREST CURVE

x_d	y_d
0	0
1'-0"	0'-0 3/8"
2'-0"	0'-3 1/8"
3'-0"	0'-6 3/8"
4'-0"	0'-10 3/8"
5'-0"	1'-4"
6'-0"	1'-10 3/8"
7'-0"	2'-5 1/8"
8'-0"	3'-1 1/8"
8'-10"	3'-9"
10'-0"	4'-7 3/8"
11'-6 1/2"	6'-0"
12'-0"	6'-5 1/2"
13'-0"	7'-5 3/8"
14'-0"	8'-5 3/8"
14'-10 3/8"	9'-6"

* Constr jt

UPSTREAM CREST CURVE

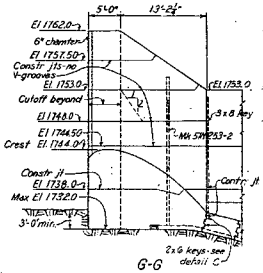
x_u	y_u
0	0
1'-0"	0'-0 1/2"
1'-6"	0'-1 1/2"
2'-0"	0'-3 1/2"
2'-6"	0'-7 1/2"
3'-0"	1'-0 1/2"
3'-3 1/2"	1'-4 1/2"

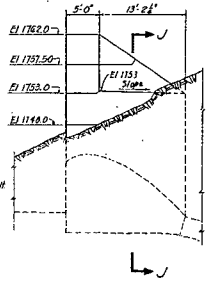


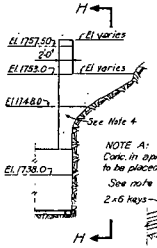
DETAIL C
TYPICAL CONTR. JT. IN APRON
Scale 3/8" = 1'-0"

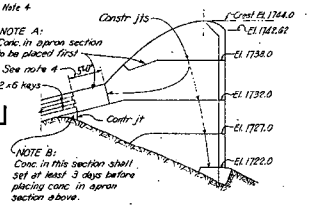
NOTES:
1. Paint vertical rock face of cutoffs, where noted, with a heavy coat of asphalt.
2. Finish vertical rock face at radial cutoffs to a smooth surface with mortar. Paint finished surface with a heavy coat of asphalt.
3. Chamfer all exposed edges 3/4", unless noted otherwise.
4. If rock breaks differently from that shown on this drawing the Design Dept shall be notified to determine possible revision of joints or special requirements for placing concrete.
5. Sections shown are for assumed rock. For Final sections see Field drawings 5IK1338 thru 5IK1345.

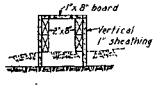
REFERENCE DRAWINGS:
5IBN253 ..... BILL OF MATERIAL
30B510 ..... WATER SEALS & GROUT STOPS











DETAIL B
TYPICAL SETTING FOR DRAIN OPENING
Not to scale

Scale 1/8" = 1'-0"
Except as noted

BENT BRANCH SPILLWAY

CONCRETE UPPER WEIR OUTLINE

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DESIGN DEPARTMENT

SUBMITTED	RECOMMENDED	APPROVED
G. O. Mayer	Rep. M. Kiegel	Joseph Rich

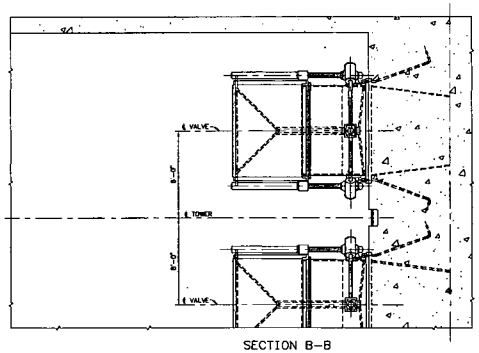
KNOXVILLE	11-18-44	21	C	4	51N253 R2

RECORD DRAWING AS CONSTRUCTED 3-18-81

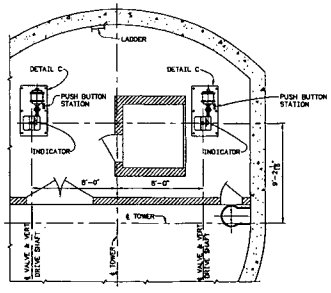
Final Field (rev 5/81)
Design Revisions

NO.	DATE	DRAWN	CHKD	SUPV	DESIGN	SUPV	DESIGN	CHECK

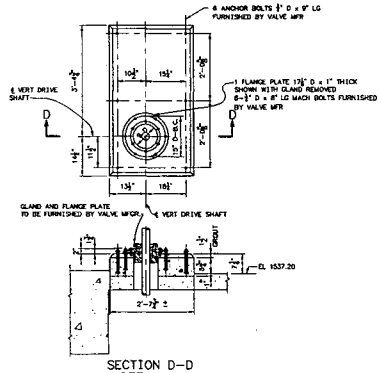
DRAWN B.J.J. WEM SUPV. E.E. 10-25-60
DESIGN B.J.J. WEM DESIGN
CHKD. 10-18-60 AK
TRCD. DRAWING
CHKD. C.F. Bentley
NO. DATE BY



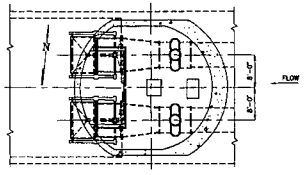
SECTION B–B



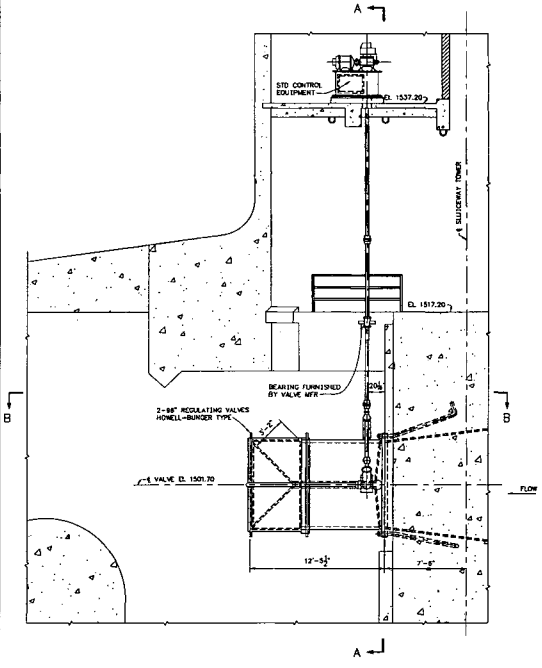
PLAN AT EL 1537.20



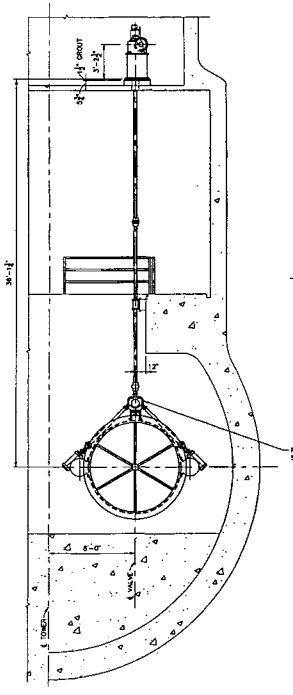
SECTION D–D
DETAIL C
SCALE 1½"=1'-0"



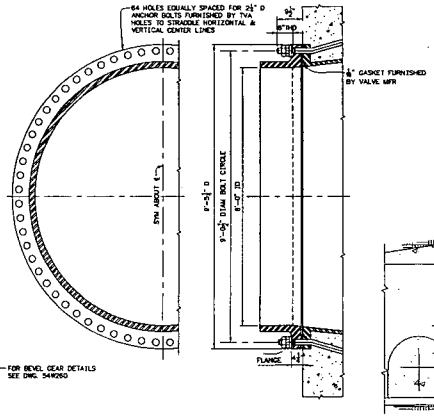
PLAN AT EL 1517.20



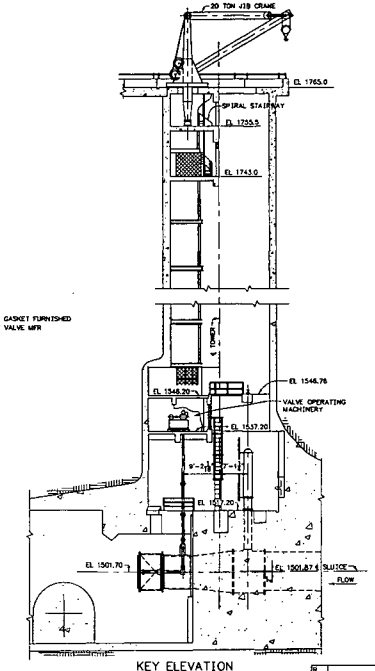
SECTION ON ℄ TOWER



SECTION A–A



VALVE ANCHOR BOLT LOCATION
SCALE 3"=1'-0"



KEY ELEVATION
SECTION ON ℄ TOWER
SCALE 3/32"=1'-0"

NOTE
FOR MANUFACTURER'S DETAILS OF SLUICEWAY REGULATING VALVES REFER TO S. MORGAN SMITH COMPANY FILE, TVA CONTRACT NO TV-5081 A.

COMPANION DRAWINGS:
54W260

REV. NO.	DATE	REDRAWN	DRAWN	CHECKED	SUPV.	APPR.	DESIGN	DESCRIPTION OF REVISION
3	8-15-03	JLB	JBO	REB	LVW	VMH	RMH	MRH

REDRAWN TO AUTOCAD FORMAT AND ADDED NOTE

SCALE: 1"=1'-0" EXCEPT AS NOTED

SPILLWAY

96" SLUICEWAY REGULATING VALVES ARRANGEMENT

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	TRACED BY:
	TBA	O.W.	O.W.			

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R14	DATE 11-17-48	21	C	54W220	R 3

TASK COMPLETED BY: | REV NO.

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES : (54N220 R2)

PLOT FACTOR:48
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

21 | C | 54W220

TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
ENGINEERING LABORATORY

SOUTH HOLSTON DAM

HOWELL-BUNGER VALVE DISCHARGE TABLES

JULY 1974

INSTRUCTIONS FOR USE OF TABLES

1. Purpose of Tables

The purpose of these tables is to provide a means of determining the discharge of the Howell-Bunger valves in the sluice tunnel at South Holston Dam. The tables are based on field discharge measurements and pressure measurements taken at several discharges in the sluice upstream from the Howell-Bunger valves. The tables give the discharge in cubic feet per second for one valve when the reservoir elevation and valve opening are known throughout the complete range of normal operating conditions. These tables supersede the tables dated April 1959.

2. Arrangement and Use of Tables

The tables give the discharge in cubic feet per second per valve for each 5-foot interval of headwater between reservoir elevations 1600 and 1755, and for each 1 percent of valve opening between 5 percent and 89 percent valve positions. Discharges are tabulated only to the nearest 10 cubic feet per second because the accuracy of the field measurements does not warrant greater refinement. It is possible to set any discharge within 40 cubic feet per second by using the tabular values. This tolerance has been accepted by the Division of Water Control Planning, and therefore, *it will not be necessary to interpolate* between tabular entries in these tables.

The reservoir elevation values used in the tables are those given by the recorder in the control room. The valve opening used in the tables is that indicated by the pointer on the valve control mechanism.

The arrangement of tables is such that the discharge over the entire range of valve openings for a 100-foot range of reservoir elevation is on two consecutive pages. For example, discharges are given on pages 2 and 3 for reservoir elevations 1600 through 1700. Discharges should be taken from the table for the tabulated values nearest to those observed. For example, if the reservoir is at elevation 1658.76 and the valve number 1 opening is 76.4 percent, the discharge is found on page 3, in the column headed 1660 opposite a valve opening of 76 percent, as 3370 cubic feet per second. If valve number 2 were set at 56.6 percent at the same time when valve number 1 was operating as given above, the discharge for valve number 2 would be found on page 3, in the column headed 1660 opposite a valve opening of 57 percent, as 2720 cubic feet per second. The total discharge would be the sum of the discharges of the two valves or 6090 cubic feet per second.

3. Valve Opening for Maximum and Minimum Discharge

Maximum discharge for the Howell-Bunger valves at South Holston Dam occurs at 89 percent valve opening. At valve openings greater than 89 percent the discharge becomes less. Therefore, the valves should not be operated beyond 89 percent. No tabular data are presented for such operation.

Minimum valve openings should not be less than 5 percent because of cavitation effects. No tabular values are given for such operation.

4. Adjustment of Valve Opening Indicator

At the time the field measurements were made, the valve opening indicator showed an opening of 0 percent when the valve was closed. In case of repairs to or adjustment of the valve and its control mechanism, the pointer should be reset to this position so that the tables will still be applicable.

SOUTH HOLSTON DAM

HOWELL-BUNGER VALVE DISCHARGE

IN CUBIC FEET PER SECOND

TENNESSEE VALLEY AUTHORITY

ENGINEERING LABORATORY

VALVE OPENING PERCENT	RESERVOIR ELEVATION																					VALVE OPENING PERCENT
	1600	1605	1610	1615	1620	1625	1630	1635	1640	1645	1650	1655	1660	1665	1670	1675	1680	1685	1690	1695	1700	
1																						1
2																						2
3																						3
4																						4
* 5	140	140	140	150	150	150	160	160	160	170	170	170	170	180	180	180	180	190	190	190	190	5
6	180	180	190	190	200	200	200	210	210	220	220	220	230	230	230	240	240	240	250	250	250	6
7	230	240	240	250	250	260	260	270	270	280	280	290	290	300	300	310	310	310	320	320	330	7
8	270	280	290	290	300	300	310	320	320	330	330	340	340	350	360	360	370	370	380	380	390	8
9	310	320	330	340	340	350	360	360	370	380	380	390	400	400	410	420	420	430	430	440	440	9
10	350	360	370	380	390	400	400	410	420	430	430	440	450	450	460	470	480	480	490	490	500	10
11	400	410	420	430	440	440	450	460	470	480	490	500	500	510	520	530	530	540	550	560	560	11
12	440	450	460	470	490	500	510	510	520	530	540	550	560	570	580	590	600	600	610	620	630	12
13	490	500	520	530	540	550	560	570	580	590	600	610	620	630	640	650	660	670	680	690	700	13
14	540	550	560	580	590	600	610	630	640	650	660	670	680	690	700	710	720	730	740	750	760	14
15	590	600	620	630	640	660	670	680	700	710	720	730	750	760	770	780	790	800	810	820	840	15
16	640	650	670	680	700	710	730	740	750	770	780	790	810	820	830	850	860	870	880	890	900	16
17	680	700	710	730	750	760	780	790	810	820	840	850	860	880	890	900	920	930	940	950	970	17
18	720	740	760	780	790	810	830	840	860	870	890	900	920	930	950	960	970	990	1000	1010	1030	18
19	770	790	800	820	840	860	880	890	910	930	940	960	970	990	1000	1020	1030	1050	1060	1070	1090	19
20	810	830	850	870	890	900	920	940	960	980	990	1010	1030	1040	1060	1070	1090	1100	1120	1130	1150	20
21	840	870	890	910	930	950	970	980	1000	1020	1040	1050	1070	1090	1110	1120	1140	1150	1170	1180	1200	21
22	880	900	930	950	970	990	1010	1030	1050	1070	1080	1100	1120	1140	1150	1170	1190	1200	1220	1240	1250	22
23	920	940	970	990	1010	1030	1050	1070	1090	1110	1130	1150	1170	1190	1210	1220	1240	1260	1270	1290	1310	23
24	960	980	1000	1030	1050	1070	1090	1110	1130	1160	1180	1190	1210	1230	1250	1270	1290	1310	1320	1340	1360	24
25	990	1020	1040	1060	1090	1110	1130	1150	1180	1200	1220	1240	1260	1280	1300	1320	1340	1350	1370	1390	1410	25
26	1030	1060	1080	1110	1130	1150	1180	1200	1220	1240	1270	1290	1310	1330	1350	1370	1390	1410	1430	1450	1460	26
27	1070	1100	1120	1150	1170	1200	1220	1250	1270	1290	1320	1340	1360	1380	1400	1420	1440	1460	1480	1500	1520	27
28	1120	1140	1170	1200	1220	1250	1270	1300	1320	1350	1370	1390	1420	1440	1460	1480	1500	1520	1540	1560	1580	28
29	1160	1180	1210	1240	1270	1290	1320	1350	1370	1390	1420	1440	1470	1490	1510	1530	1560	1580	1600	1620	1640	29
30	1190	1220	1250	1280	1310	1330	1360	1390	1410	1440	1460	1490	1510	1530	1560	1580	1600	1620	1650	1670	1690	30
31	1230	1260	1290	1320	1350	1380	1400	1430	1460	1480	1510	1540	1560	1580	1610	1630	1660	1680	1700	1720	1750	31
32	1270	1300	1330	1360	1390	1420	1450	1480	1510	1530	1560	1580	1610	1640	1660	1690	1710	1730	1760	1780	1800	32
33	1310	1340	1370	1410	1440	1470	1500	1520	1550	1580	1610	1630	1660	1690	1710	1740	1760	1790	1810	1840	1860	33
34	1350	1380	1420	1450	1480	1510	1540	1570	1600	1630	1660	1680	1710	1740	1760	1790	1820	1840	1870	1890	1920	34
35	1390	1420	1460	1490	1520	1550	1590	1620	1650	1680	1700	1730	1760	1790	1820	1840	1870	1900	1920	1950	1970	35
36	1430	1460	1500	1530	1570	1600	1630	1660	1690	1720	1750	1780	1810	1840	1870	1900	1920	1950	1980	2000	2030	36
37	1470	1500	1540	1580	1610	1640	1680	1710	1740	1770	1800	1830	1860	1890	1920	1950	1980	2000	2030	2060	2080	37
38	1510	1540	1580	1620	1650	1690	1720	1750	1790	1820	1850	1880	1910	1940	1970	2000	2030	2060	2090	2110	2140	38
39	1540	1580	1610	1650	1690	1720	1760	1790	1820	1860	1890	1920	1950	1980	2010	2040	2070	2100	2130	2160	2180	39
40	1570	1610	1650	1690	1720	1760	1800	1830	1860	1900	1930	1960	1990	2030	2060	2090	2120	2150	2170	2200	2230	40
41	1610	1650	1690	1730	1770	1800	1840	1880	1910	1950	1980	2010	2040	2080	2110	2140	2170	2200	2230	2260	2290	41
42	1650	1690	1730	1770	1810	1840	1880	1920	1950	1990	2020	2060	2090	2120	2150	2190	2220	2250	2280	2310	2340	42
43	1680	1720	1760	1800	1840	1880	1920	1960	1990	2030	2060	2100	2130	2170	2200	2230	2260	2290	2330	2360	2390	43
44	1720	1760	1800	1840	1880	1920	1960	2000	2030	2070	2110	2140	2180	2210	2240	2280	2310	2340	2370	2410	2440	44
45	1740	1790	1830	1870	1910	1950	1990	2030	2070	2110	2140	2180	2210	2250	2280	2320	2350	2380	2420	2450	2480	45
46	1780	1820	1870	1910	1950	1990	2030	2070	2110	2150	2190	2220	2260	2290	2330	2360	2400	2430	2460	2500	2530	46
47	1810	1860	1900	1950	1990	2030	2070	2110	2150	2190	2230	2270	2300	2340	2370	2410	2440	2480	2510	2540	2580	47
48	1840	1890	1940	1980	2020	2070	2110	2150	2190	2230	2270	2300	2340	2380	2410	2450	2480	2520	2550	2590	2620	48
49	1870	1920	1970	2010	2060	2100	2140	2180	2220	2260	2300	2340	2380	2420	2450	2490	2520	2560	2590	2630	2660	49
50	1910	1960	2010	2050	2100	2140	2190	2230	2270	2310	2350	2390	2430	2470	2500	2540	2580	2610	2650	2680	2720	50

JULY 1974

* THE MINIMUM ALLOWABLE VALVE OPENING IS 5 PERCENT

RESERVOIR ELEVATION 1600 TO 1700
VALVE OPENING, PERCENT 5 TO 50

SOUTH HOLSTON DAM

HOWELL-BUNGER VALVE DISCHARGE

IN CUBIC FEET PER SECOND

TENNESSEE VALLEY AUTHORITY

ENGINEERING LABORATORY

VALVE OPENING PERCENT	RESERVOIR ELEVATION																					VALVE OPENING PERCENT
	1600	1605	1610	1615	1620	1625	1630	1635	1640	1645	1650	1655	1660	1665	1670	1675	1680	1685	1690	1695	1700	
51	1940	1990	2040	2090	2130	2180	2220	2260	2300	2350	2390	2430	2470	2500	2540	2580	2620	2650	2690	2730	2760	51
52	1970	2020	2070	2120	2160	2210	2250	2300	2340	2380	2420	2460	2500	2540	2580	2620	2660	2690	2730	2770	2800	52
53	2010	2060	2110	2160	2210	2250	2300	2340	2390	2430	2470	2510	2550	2590	2630	2670	2710	2750	2790	2820	2860	53
54	2040	2090	2140	2190	2240	2290	2330	2380	2420	2470	2510	2550	2590	2630	2670	2710	2750	2790	2830	2860	2900	54
55	2070	2120	2180	2220	2270	2320	2370	2410	2460	2500	2550	2590	2630	2670	2710	2750	2790	2830	2870	2910	2940	55
56	2100	2150	2210	2260	2310	2350	2400	2450	2490	2540	2580	2620	2670	2710	2750	2790	2830	2870	2910	2950	2990	56
57	2140	2200	2250	2300	2350	2400	2450	2490	2540	2590	2630	2670	2720	2760	2800	2840	2880	2920	2960	3000	3040	57
58	2170	2230	2280	2330	2380	2430	2480	2530	2580	2620	2670	2710	2760	2800	2840	2880	2920	2970	3010	3040	3080	58
59	2200	2260	2310	2360	2410	2470	2510	2560	2610	2660	2700	2750	2790	2840	2880	2920	2960	3010	3050	3090	3130	59
60	2230	2290	2340	2390	2450	2500	2550	2600	2650	2690	2740	2790	2830	2880	2920	2960	3000	3050	3090	3130	3170	60
61	2260	2320	2370	2430	2480	2530	2580	2630	2680	2730	2780	2820	2870	2910	2960	3000	3040	3090	3130	3170	3210	61
62	2280	2340	2390	2450	2500	2550	2610	2660	2700	2750	2800	2850	2890	2940	2980	3030	3070	3110	3160	3200	3240	62
63	2310	2370	2420	2480	2530	2590	2640	2690	2740	2790	2840	2880	2930	2980	3020	3070	3110	3150	3200	3240	3280	63
64	2340	2400	2460	2510	2570	2620	2670	2720	2780	2830	2870	2920	2970	3020	3060	3110	3150	3200	3240	3280	3320	64
65	2370	2430	2490	2540	2600	2650	2710	2760	2810	2860	2910	2960	3010	3050	3100	3150	3190	3240	3280	3320	3370	65
66	2400	2460	2520	2580	2630	2690	2740	2790	2850	2900	2950	3000	3040	3090	3140	3190	3230	3280	3320	3360	3410	66
67	2420	2480	2540	2600	2650	2710	2760	2820	2870	2920	2970	3020	3070	3120	3170	3210	3260	3300	3350	3390	3440	67
68	2440	2500	2560	2620	2680	2730	2790	2840	2890	2940	3000	3050	3100	3140	3190	3240	3280	3330	3380	3420	3460	68
69	2470	2530	2590	2650	2710	2760	2820	2870	2930	2980	3030	3080	3130	3180	3230	3280	3320	3370	3420	3460	3510	69
70	2500	2560	2620	2680	2740	2800	2850	2910	2960	3020	3070	3120	3170	3220	3270	3320	3360	3410	3460	3500	3550	70
71	2530	2590	2650	2710	2770	2830	2890	2940	3000	3050	3110	3160	3210	3260	3310	3360	3400	3450	3500	3550	3590	71
72	2550	2610	2670	2740	2800	2850	2910	2970	3020	3080	3130	3180	3230	3280	3330	3380	3430	3480	3530	3570	3620	72
73	2580	2640	2710	2770	2830	2890	2950	3000	3060	3110	3170	3220	3270	3320	3370	3420	3470	3520	3570	3610	3660	73
74	2610	2670	2740	2800	2860	2920	2980	3040	3090	3150	3200	3260	3310	3360	3410	3460	3510	3560	3610	3660	3700	74
75	2630	2690	2760	2820	2880	2940	3000	3060	3120	3170	3230	3280	3330	3390	3440	3490	3540	3590	3640	3680	3730	75
76	2660	2720	2790	2850	2910	2980	3040	3090	3150	3210	3260	3320	3370	3420	3480	3530	3580	3630	3680	3730	3770	76
77	2680	2740	2810	2870	2940	3000	3060	3120	3180	3230	3290	3340	3400	3450	3500	3550	3610	3660	3710	3750	3800	77
78	2700	2760	2830	2900	2960	3020	3080	3140	3200	3260	3310	3370	3420	3480	3530	3580	3630	3680	3730	3780	3830	78
79	2720	2790	2860	2920	2990	3050	3110	3170	3230	3290	3340	3400	3450	3510	3560	3610	3670	3720	3770	3820	3870	79
80	2750	2820	2880	2950	3010	3080	3140	3200	3260	3320	3370	3430	3490	3540	3590	3650	3700	3750	3800	3850	3900	80
81	2770	2840	2900	2970	3030	3100	3160	3220	3280	3340	3400	3450	3510	3570	3620	3670	3730	3780	3830	3880	3930	81
82	2790	2860	2920	2990	3060	3120	3180	3240	3300	3360	3420	3480	3540	3590	3650	3700	3750	3800	3860	3910	3960	82
83	2820	2890	2960	3020	3090	3150	3220	3280	3340	3400	3460	3520	3570	3630	3680	3740	3790	3850	3900	3950	4000	83
84	2840	2910	2980	3040	3110	3180	3240	3300	3360	3420	3480	3540	3600	3650	3710	3770	3820	3870	3920	3980	4030	84
85	2860	2930	3000	3070	3130	3200	3260	3330	3390	3450	3510	3570	3620	3680	3740	3790	3850	3900	3950	4000	4060	85
86	2880	2950	3020	3090	3150	3220	3280	3350	3410	3470	3530	3590	3650	3710	3760	3820	3870	3930	3980	4030	4080	86
87	2900	2970	3040	3110	3180	3240	3310	3370	3430	3500	3560	3620	3670	3730	3790	3840	3900	3950	4010	4060	4110	87
88	2900	2980	3050	3120	3190	3250	3320	3380	3450	3510	3570	3630	3690	3740	3800	3860	3910	3970	4020	4070	4130	88
*89	2910	2990	3060	3130	3200	3260	3330	3390	3460	3520	3580	3640	3700	3760	3810	3870	3930	3980	4030	4090	4140	89

JULY 1974

* THE MAXIMUM VALVE OPENING SHOULD NOT EXCEED 89 PERCENT

RESERVOIR ELEVATION 1600 TO 1700
VALVE OPENING, PERCENT 51 TO 89

SOUTH HOLSTON DAM

HOWELL-BUNGER VALVE DISCHARGE

IN CUBIC FEET PER SECOND

TENNESSEE VALLEY AUTHORITY

ENGINEERING LABORATORY

VALVE OPENING PERCENT	RESERVOIR ELEVATION												VALVE OPENING PERCENT
	1700	1705	1710	1715	1720	1725	1730	1735	1740	1745	1750	1755	
1													1
2													2
3													3
4													4
*5	190	200	200	200	200	210	210	210	210	220	220	220	5
6	250	260	260	260	270	270	270	270	280	280	280	290	6
7	330	330	330	340	340	350	350	350	360	360	370	370	7
8	390	390	400	400	400	410	410	420	420	430	430	440	8
9	440	450	460	460	470	470	480	480	490	490	500	500	9
10	500	510	510	520	530	530	540	540	550	560	560	570	10
11	560	570	580	580	590	600	600	610	620	620	630	640	11
12	630	640	640	650	660	670	670	680	690	700	700	710	12
13	700	710	710	720	730	740	750	760	760	770	780	790	13
14	760	770	780	790	800	810	820	830	840	850	850	860	14
15	840	850	860	870	880	890	900	910	920	920	930	940	15
16	900	920	930	940	950	960	970	980	990	1000	1010	1020	16
17	970	980	990	1000	1010	1030	1040	1050	1060	1070	1080	1090	17
18	1030	1040	1050	1060	1080	1090	1100	1110	1130	1140	1150	1160	18
19	1090	1100	1120	1130	1140	1160	1170	1180	1190	1210	1220	1230	19
20	1150	1160	1180	1190	1200	1220	1230	1240	1260	1270	1280	1300	20
21	1200	1210	1230	1240	1260	1270	1290	1300	1320	1330	1340	1360	21
22	1250	1270	1280	1300	1310	1330	1340	1360	1370	1390	1400	1420	22
23	1310	1320	1340	1360	1370	1390	1400	1420	1430	1450	1460	1480	23
24	1360	1380	1390	1410	1430	1440	1460	1470	1490	1510	1520	1540	24
25	1410	1430	1440	1460	1480	1490	1510	1530	1540	1560	1580	1590	25
26	1460	1480	1500	1520	1540	1550	1570	1590	1610	1620	1640	1660	26
27	1520	1540	1560	1580	1600	1610	1630	1650	1670	1680	1700	1720	27
28	1580	1600	1620	1640	1660	1680	1700	1720	1740	1750	1770	1790	28
29	1640	1660	1680	1700	1720	1740	1760	1780	1800	1820	1840	1850	29
30	1690	1710	1730	1750	1770	1790	1810	1830	1850	1870	1890	1910	30
31	1750	1770	1790	1810	1830	1850	1870	1890	1910	1930	1950	1970	31
32	1800	1830	1850	1870	1890	1910	1930	1960	1980	2000	2020	2040	32
33	1860	1880	1910	1930	1950	1970	1990	2020	2040	2060	2080	2100	33
34	1920	1940	1960	1990	2010	2030	2050	2080	2100	2120	2140	2160	34
35	1970	2000	2020	2040	2070	2090	2120	2140	2160	2180	2210	2230	35
36	2030	2050	2080	2100	2130	2150	2180	2200	2220	2250	2270	2290	36
37	2080	2110	2140	2160	2190	2210	2240	2260	2280	2310	2330	2360	37
38	2140	2170	2190	2220	2250	2270	2300	2320	2350	2370	2400	2420	38
39	2180	2210	2240	2260	2290	2320	2340	2370	2390	2420	2440	2470	39
40	2230	2260	2290	2310	2340	2370	2390	2420	2450	2470	2500	2520	40
41	2290	2320	2350	2370	2400	2430	2460	2480	2510	2530	2560	2590	41
42	2340	2370	2400	2420	2450	2480	2510	2540	2560	2590	2620	2640	42
43	2390	2420	2450	2480	2500	2530	2560	2590	2620	2640	2670	2700	43
44	2440	2470	2500	2530	2560	2590	2610	2640	2670	2700	2730	2750	44
45	2480	2510	2540	2570	2600	2630	2660	2690	2720	2750	2770	2800	45
46	2530	2560	2590	2620	2650	2680	2710	2740	2770	2800	2830	2860	46
47	2580	2610	2640	2670	2700	2730	2770	2800	2820	2850	2880	2910	47
48	2620	2650	2680	2720	2750	2780	2810	2840	2870	2900	2930	2960	48
49	2660	2690	2730	2760	2790	2820	2860	2890	2920	2950	2980	3010	49
50	2720	2750	2790	2820	2850	2880	2920	2950	2980	3010	3040	3070	50

JULY 1974

* THE MINIMUM ALLOWABLE VALVE OPENING IS 5 PERCENT

RESERVOIR ELEVATION 1700 TO 1755
VALVE OPENING, PERCENT 5 TO 50

SOUTH HOLSTON DAM

HOWELL-BUNGER VALVE DISCHARGE

IN CUBIC FEET PER SECOND

TENNESSEE VALLEY AUTHORITY

ENGINEERING LABORATORY

VALVE OPENING PERCENT	RESERVOIR ELEVATION												VALVE OPENING PERCENT
	1700	1705	1710	1715	1720	1725	1730	1735	1740	1745	1750	1755	
51	2760	2790	2830	2860	2900	2930	2960	2990	3030	3060	3090	3120	51
52	2800	2840	2870	2910	2940	2970	3010	3040	3070	3100	3140	3170	52
53	2860	2890	2930	2960	3000	3030	3070	3100	3130	3170	3200	3230	53
54	2900	2940	2970	3010	3040	3080	3110	3150	3180	3210	3250	3280	54
55	2940	2980	3020	3050	3090	3120	3160	3190	3230	3260	3290	3330	55
56	2990	3020	3060	3100	3130	3170	3200	3240	3270	3310	3340	3370	56
57	3040	3080	3120	3150	3190	3230	3260	3300	3330	3370	3400	3440	57
58	3080	3120	3160	3200	3240	3270	3310	3350	3380	3420	3450	3490	58
59	3130	3170	3200	3240	3280	3320	3350	3390	3430	3460	3500	3530	59
60	3170	3210	3250	3290	3320	3360	3400	3440	3470	3510	3550	3580	60
61	3210	3250	3290	3330	3370	3410	3440	3480	3520	3560	3590	3630	61
62	3240	3280	3320	3360	3400	3440	3480	3510	3550	3590	3620	3660	62
63	3280	3320	3360	3400	3440	3480	3520	3560	3600	3630	3670	3710	63
64	3320	3360	3410	3450	3490	3530	3570	3600	3640	3680	3720	3760	64
65	3370	3410	3450	3490	3530	3570	3610	3650	3690	3730	3770	3800	65
66	3410	3450	3490	3530	3580	3620	3660	3700	3740	3770	3810	3850	66
67	3440	3480	3520	3560	3610	3650	3690	3730	3770	3810	3840	3880	67
68	3460	3510	3550	3590	3630	3680	3720	3760	3800	3840	3880	3920	68
69	3510	3550	3590	3640	3680	3720	3760	3800	3840	3880	3920	3960	69
70	3550	3590	3640	3680	3720	3770	3810	3850	3890	3930	3970	4010	70
71	3590	3640	3680	3720	3770	3810	3850	3890	3940	3980	4020	4060	71
72	3620	3660	3710	3750	3800	3840	3880	3930	3970	4010	4050	4090	72
73	3660	3710	3750	3800	3840	3890	3930	3970	4010	4060	4100	4140	73
74	3700	3750	3800	3840	3890	3930	3970	4020	4060	4100	4140	4190	74
75	3730	3780	3820	3870	3920	3960	4000	4050	4090	4130	4180	4220	75
76	3770	3820	3870	3910	3960	4000	4050	4090	4140	4180	4220	4270	76
77	3800	3850	3900	3940	3990	4030	4080	4120	4170	4210	4250	4300	77
78	3830	3880	3930	3970	4020	4060	4110	4150	4200	4240	4290	4330	78
79	3870	3910	3960	4010	4060	4100	4150	4190	4240	4280	4330	4370	79
80	3900	3950	4000	4050	4090	4140	4190	4230	4280	4320	4360	4410	80
81	3930	3980	4030	4070	4120	4170	4220	4260	4310	4350	4400	4440	81
82	3960	4010	4060	4100	4150	4200	4250	4290	4340	4380	4430	4470	82
83	4000	4050	4100	4150	4200	4240	4290	4340	4380	4430	4480	4520	83
84	4030	4080	4130	4180	4230	4270	4320	4370	4410	4460	4510	4550	84
85	4060	4110	4160	4210	4260	4300	4350	4400	4450	4490	4540	4580	85
86	4080	4130	4190	4240	4280	4330	4380	4430	4480	4520	4570	4620	86
87	4110	4160	4210	4260	4310	4360	4410	4460	4510	4550	4600	4650	87
88	4130	4180	4230	4280	4330	4380	4430	4480	4520	4570	4620	4660	88
*89	4140	4190	4240	4290	4340	4390	4440	4490	4540	4590	4630	4680	89

JULY 1974

*THE MAXIMUM VALVE OPENING SHOULD NOT EXCEED 89 PERCENT

RESERVOIR ELEVATION 1700 TO 1755
VALVE OPENING, PERCENT 51 TO 89

Tennessee Valley Authority
Division of Water Control Planning
Hydraulic Data Branch

Report No. 18-10-1

Advance Report No. 1

SOUTH HOLSTON MODEL STUDIES

Knoxville, Tennessee
June 1944

ADVANCE REPORT NO. 1

SOUTH HOLSTON MODEL STUDIES

SUMMARY

This report presents the results of tests made on models of the spillway, Howell-Bunger valve structures, and stilling basin for the South Holston project. Entrainment of air in the prototype during both spillway and Howell-Bunger valve operation will probably modify the results to some extent. The effect and amount of the change is unknown. The results of the model tests can be summarized as follows:

Flow in the vertical shaft was regular and free from surging when the spillway crest was provided with six piers as shown on Plate 1.

No negative pressures of any consequence were found to exist on the face of the spillway.

A bend of 75-foot radius between vertical shaft and tunnel gave the best flow conditions in the tunnel.

Flow in the tunnel was further improved by placing a deflector immediately above the tunnel at the foot of the vertical shaft.

The revised spillway has sufficient capacity to pass the required maximum discharge at the desired head.

Structures in the branch tunnel below the Howell-Bunger valve were found to be necessary to produce smooth flow in the main tunnel. These structures consisted of a massive weir and a horizontal deflector immediately below the Howell-Bunger valves and a low weir with two vertical piers at the end of the branch tunnel immediately above the Y junction.

Stilling basins V and Z, shown on Plate 2, provided satisfactory dissipation of energy at the tunnel outlet. Wave heights and erosion were somewhat less for scheme Z.

DESCRIPTION OF PROJECT

The outlet works for the South Holston Project are located some distance from the dam and consist of a morning glory type spillway, 128 feet in diameter on the crest line, discharging into a vertical shaft 34 feet in diameter. At the base of the shaft is a 90-degree

bend connecting with a horizontal tunnel, also 34 feet in diameter, that extends some 1100 feet to a stilling basin which discharges into the river just below the dam. The reservoir is controlled, for head-water elevations below the crest of the spillway, by two 96-inch Howell-Bunger valves located side by side in a branch tunnel 34 feet in diameter that intersects the main tunnel at an angle of 29 degrees some 300 feet below the morning glory spillway. The valves are located 375 feet upstream from this intersection. The general layout is shown on Plate 1.

For normal operation of the system the tunnels will be only partially full. Either tunnel may operate alone or both may operate together.

DESCRIPTION OF TESTS

General

It was believed desirable for the flow in the tunnels to be as smooth and uniform as possible in order to prevent the tunnel from filling momentarily and causing surges and vibrations that might damage the structure. Further, it was found necessary for the flow at the tunnel portal to be smooth and uniform in order to ensure proper operation of the stilling basin. Most of the tests described in this report were made to ensure smooth uniform flow throughout the structure. They were made on models at three difference scales, 1:100, 1:51, and 1:34. The detailed description indicates the scale used for any particular test.

Morning Glory Spillway

The spillway was constructed as shown on Plate 1 to a scale of 1:51 except that the diameter of the spillway on the crest line was 110 feet. It was found impossible to pass the required discharge with this spillway at the design head. Consequently, it was necessary to increase the diameter of the spillway on the crest line to 128 feet. However, the enlarged spillway was constructed to a scale of 1:100 and calibrated with more topography surrounding it. The relationship between reservoir elevation and discharge is shown on Plate 3.

Flow in Spillway and Vertical Shaft

The spillway was originally built without piers. Its operation at the maximum discharge of 60,000 cfs was not satisfactory. The vertical shaft was filled with water which surged up and down and back and forth across the spillway mouth, creating considerable disturbance. Figure 1 shows one phase of this condition. One cause of the difficulty

appeared to be the large fin which formed on the side of the spillway next to the hillside. This fin closed the shaft at the top, causing unstable conditions. A remedy was found in radial piers on the crest, as shown on Plate 1. Various numbers of piers from 2 to 8 were tried and it was found thay 6 gave very satisfactory results. Figure 2 illustrates the same discharge with 6 piers. An attempt was made to improve the flow still further by adding curved fins ahead of the piers. This arrangement is shown in Figure 3. Comparison with Figure 2 shows that no particular improvement was realized.

Attempts were made to reduce the size of the fin still further by changing the size of the excavated area around the rim of the spillway. The distance from spillway rim to toe of slope was varied from zero to several hundred feet. A distance of 30 feet seemed to give the best results although the fin was not eliminated. A smaller distance increased the size and roughness of the fin and a greater distance did not give enough improvement to warrant the increased excavation cost.

Flow in Tunnel

It was desired that flow in the horizontal tunnel be smooth and have a minimum of disturbance and wave action. The radius of the bend connecting the shaft with the tunnel was found to have a marked effect upon the flow in the tunnel. Elbows having radii of 38.2, 50, and 75 feet were tested. With the short-radius elbow the flow in the vertical shaft tended to pass around the elbow with a spiral motion that caused the flow in the tunnel to sway from side to side, resulting in unsymmetrical flow in the stilling basin. Conditions were made smoother with the longer radius elbows. The best results were obtained with the 75-foot radius.

For all elbows some disturbance was caused by the water which came down the shaft on the side above the tunnel. As the shaft wall curved away from the vertical at the bend, this portion of the flow was left without a guiding wall. Consequently its direction of flow was subject to the influence of minor irregularities and was highly uncertain. Several schemes were proposed in an effort to remedy this condition. Two of them are shown on Plate 1 as schemes Q and AB. Scheme Q simply blocked off that portion of the spillway crest above the tunnel. Scheme AB blocked off a portion of the spillway shaft as well as the crest. Neither of these was suitable because of the increased head necessary to produce the required discharge. Scheme AB also caused the vertical shaft to fill.

The disadvantages of blocking off the crest were eliminated by placing a deflecting block at the base of the vertical shaft. It was found that a deflector of the proper size and in the right location could be depended upon to produce stable and desirable flow conditions in the tunnel. The action of the deflector was to force the water to the outside of the bend and prevent spiral flow in the tunnel. Deflectors projecting 5, 6.5, 8, and 10 feet into the vertical shaft were tried. These all had a slope of three vertical on one horizontal. For higher discharges the 10-foot deflector caused the shaft to flow full while the 5-foot one was

not effective. Either of the other two was satisfactory. The 6.5-foot deflector was adopted for further testing, and it was found that best flow conditions in the tunnel were obtained when this deflector was placed in line with it. Moving the deflector to either side caused an uneven water surface and standing waves in the tunnel. The first tests on these deflectors were made on the 1:51 scale model. A final model check was made on the 1:100 scale model in which more topography surrounding the spillway could be reproduced. Figures 4 and 5 show the improvement in tunnel flow caused by the 6.5-foot deflector.

Observations of flow in the tunnel indicated that prototype flow would be considerably aerated with a corresponding increase in the area of flow. The effect of this aeration upon flow in the tunnel is quite uncertain. The model tests indicated that the tunnel did not flow full except when spillway and sluices were operating together at maximum discharge. It is certain that aeration of the model is much less than in the prototype and the effect of this aeration upon the prototype performance is uncertain.

Pressures in Vertical Shaft

Pressures in the shaft of the South Holston spillway were not measured with the corresponding South Holston topography. However, observations of pressure at a number of piezometers in the morning glory were made on the Watauga spillway which is identical in design with the South Holston spillway. The locations of the piezometers are shown on Plate 2 of Advance Report No. 1, Watauga Model Studies, and the pressures at these piezometers are given in Table 1 of that report. These pressures were measured with the Watauga topography around the spillway but it is believed that they are essentially the same for the South Holston spillway.

Water Surface Profile

The height of the radial piers in the spillway crest was governed by the water surface profile for the maximum discharge. Plate 1 shows the water surface adjacent to the pier face for a discharge of 60,000 cfs.

HOWELL-BUNGER VALVE OPERATION

Operation of the Howell-Bunger valves in the branch tunnel showed that auxiliary structures were necessary to reduce the velocity of the flow in the branch tunnel before it entered the main tunnel. Figure 6 shows a discharge of 10,000 cfs entering the main tunnel from the branch tunnel with no energy-dissipating structures below the valves. The high-velocity flow along the bottom loops completely around the main tunnel just below the Y. This is a very undesirable condition, and a

number of tests were made for the purpose of producing smooth flow in the main tunnel. Preliminary studies of suitable structures below the valves were made on a 1:34 scale model. The design was refined and developed to completion on a 1:51 scale model made of transparent material so that the performance could be observed.

Plate 1 shows a number of the various structures that were tried. The ring shown as scheme BL worked fairly well when both valves were discharging but was unsatisfactory for only one valve. Piezometers in the ring showed the existence of pressures as low as 20 feet below atmosphere and the possibility of damage by cavitation. The tests soon showed that two sets of structures were necessary. A deflector and weir were required immediately below the Howell-Bunger valves to reduce the velocity in the branch tunnel and a weir was needed at the end of the branch to ensure that the velocity remained low as it entered the Y. These two structures were complementary as one aided the operation of the other.

The weir and deflector shown as scheme BR gave satisfactory flow conditions in the tunnel, but piezometers placed as shown on Plate 1 indicated that the pressures were apt to be low enough to induce cavitation. Pressures varied with the distance of the sill from the end of the valve. Table 1 gives the results of pressure measurements. It may be seen that pressures 20 feet below atmosphere were obtained.

TABLE 1

PRESSURES ON WEIR

SCHEME BR

Both Valves Open

Test Number	Distance Below Valve in Feet	Pressure in Feet of Water		
		a	b	c
220	15.5	+52.5	-20.0	-9.0
221	35.5	+36.5	-12.0	0
222	47.5	+38.0	- 1.0	+2.5

The arrangment that gave the best operation is shown as scheme CD on Plate 1. Immediately below the valve was a heavy sill 15 feet high and 15 feet thick, which operated in conjunction with a horizontal deflector near the roof. Table 2 shows that the pressures on this weir were much more favorable than for the other structures. It will be seen

that the location 11.5 feet below the valve gave the best results with respect to negative pressures. Flow conditions downstream were also best with the weir at this location. Figure 7 shows the flow conditions in the tunnel below the structures for the best weir position with both valves operating. There was considerable turbulence below the weir which was soon smoothed out into quiet flow down the tunnel. Figure 8 shows the performance of the same structures with the weir placed closer to the valve. Here high-velocity flow persisted for a considerable distance downstream. Figure 9 illustrates the performance for discharge through one valve only.

Operation of the Howell-Bunger valves required that a considerable amount of air be supplied to the tunnel. The location of the air vent is shown on the drawing.

The structure of the Y consisted of a sill 7.36 feet high and two vertical piers 5 feet thick, reaching from bottom to top of the branch tunnel. Both sill and piers were so shaped that they formed a continuation of the main tunnel wall as high as the horizontal diameter. For moderate spillway discharges, therefore, the walls of the main tunnel were continuous. The effect of the sill was to maintain a considerable depth of water in the branch tunnel thus reducing the velocity. The streamlined piers served to introduce the flow quietly into the main tunnel. Figure 10 shows flow from the branch into the main tunnel with no spillway discharge.

The structures immediately below the Howell-Bunger valve, shown as scheme CD, gave fairly satisfactory operation. The design was not refined further because of lack of time. Subsequent tests on the low-level outlet for the Fontana spillway indicated that better results may be obtained with simpler structures.

STILLING BASIN OPERATION

Conditions at the end of the tunnel made it necessary to provide a stilling basin to protect the outlet structures. The design of the stilling basin was carried out on the 1:51 scale model. The principal problem encountered was that of spreading the discharge as it left the tunnel so that the flow would be uniformly distributed across the stilling basin and the velocities at the end would be low. It was desired that the length of the stilling basin be kept to a minimum. Plate 2 shows several schemes tested in an attempt to spread the jet issuing from the tunnel toward the sides of the stilling basin. Stilling basins A, B, and C used an elevated floor in the center of the channel to accomplish this. The results were not satisfactory. Figure 11 shows basin A operating at a discharge of 10,000 cfs. Eddies occurred over the sill at the end of the structure. Figure 12 shows stilling basin C operating at a discharge of

TABLE 2

PRESSURES ON WEIR

SCHEME CD

Test Number	Distance Below Valve in Feet	Pressure in Feet of Water				
		a	b	c	d	e
		Both Valves Open				
239	7.5	+13	-3.0	-9.0	-3.0	+1.5
241	9.5	+38	0	-7.0	-2.0	+3.0
242	10.5	+52	+0.5	-6.0	-2.0	+3.0
236	11.5	+55	-1.0	-5.0	-2.0	+3.0
243	12.5	+56	-2.0	-6.0	-2.0	+3.0
240	13.5	+53	-4.0	-6.0	-3.0	+3.0
235	15.5	+57	-6.0	-6.0	-2.5	+2.0
237	19.5	+53	-9.0	-6.0	-2.0	+3.5
238	23.5	+48	-11.0	-5.0	-0.5	+5.5
		One Valve Open				
244	11.5	+26	+2.0	-1.0	-1.0	+1.5

20,000 cfs. The eddy illustrated here shows that there was no flow down the right side of the basin. Some improvement of flow distribution was obtained by placing a tapered pier in the transition between tunnel and stilling basin, as shown for stilling basin N, Plate 2. Still further improvement was made by placing triangular deflecting blocks in the upper inside corners of the tunnel outlets, as shown for stilling basin V. This design gave much more satisfactory operation, as illustrated by Figure 13, which shows a discharge of 40,000 cfs.

The performance was improved by increasing the length of the basin 50 feet, as for basin Z. Velocities at the end were reduced and there was less erosion and lower wave heights. Table 3 is a comparison of erosion depths and wave heights for basins V and Z.

The operation of stilling basin Z for small discharges was somewhat unsymmetrical as illustrated by Figure 15, which shows a discharge of 10,000 cubic feet per second. For such small discharges, however, velocities at the end of the structure were very low and there seemed to be no danger of erosion.

The height of the end sill was fixed at 6 feet. Four different upstream slopes were tested; 1 on 2, 1 on 1, 2 on 1, and 4 on 1. The best results were obtained with the 2 on 1 slope. Wave heights downstream were increased with a steeper slope, while a slight slope allowed the hydraulic jump to move nearer the end of the basin.

ACKNOWLEDGMENTS

This investigation was conducted by the Hydraulic Data Branch under the direction of Albert S. Fry, Chief of Branch. The tests were made and the report prepared in the Hydraulic Laboratory at Norris under the supervision of G. H. Hickox, Head, Hydraulic Laboratory Section. A. J. Peterka and B. R. Blackwell were in charge of the testing. They were assisted by the entire laboratory staff. The report was prepared by B. R. Blackwell.

TABLE 3

EROSION DEPTHS AND WAVE HEIGHTS

STILLING BASINS V AND Z

Discharge		Stilling Basin V				Stilling Basin Z			
				Wave Heights				Wave Heights	
Spillway cfs	Sluices cfs	Test Number	Maximum Erosion at Sill in Feet	100* Feet	400* Feet	Test Number	Maximum Erosion at Sill in Feet	100* Feet	350* Feet
0	10,000	169	0	-	-	198	0	-	-
10,000	0	170	8	-	-	199	1	-	-
10,000	10,000					200	2	1	1
20,000	0	171	6	3	1	196	3	1	1
20,000	10,000					202	3	3	2
30,000	0					201	3	3	2
30,000	10,000					204	4	3	2
40,000	0	172	5	6	4	203	3	3	3
40,000	10,000					206	10	4	4
50,000	0					205	6	5	4
50,000	10,000					197	12	8	5
60,000	0	173	9	15	10	194	8	8	5
60,000	10,000	174	16	15-20	10-12	195	15	7-10	5

* Distance downstream from sill.

Length of stilling basin V = 300 feet.
Length of stilling basin Z = 350 feet.

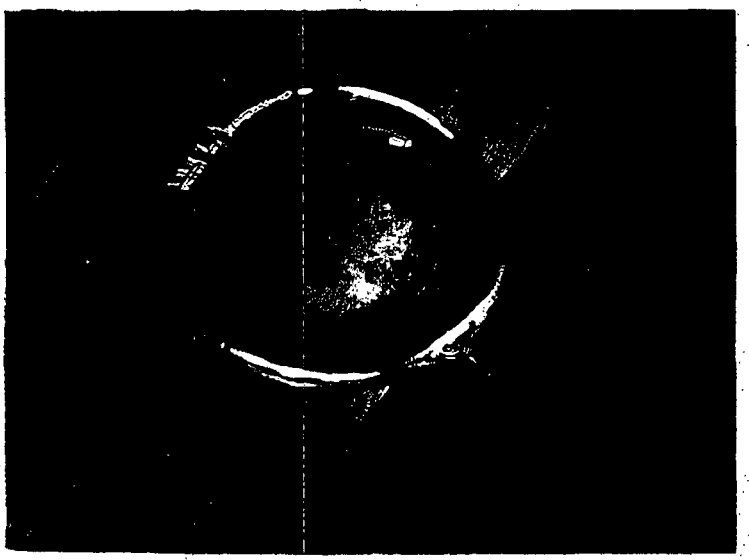


Figure 1.--Morning glory spillway without piers. Toe of bank 30 feet from spillway. Discharge 60,000 cubic feet per second.

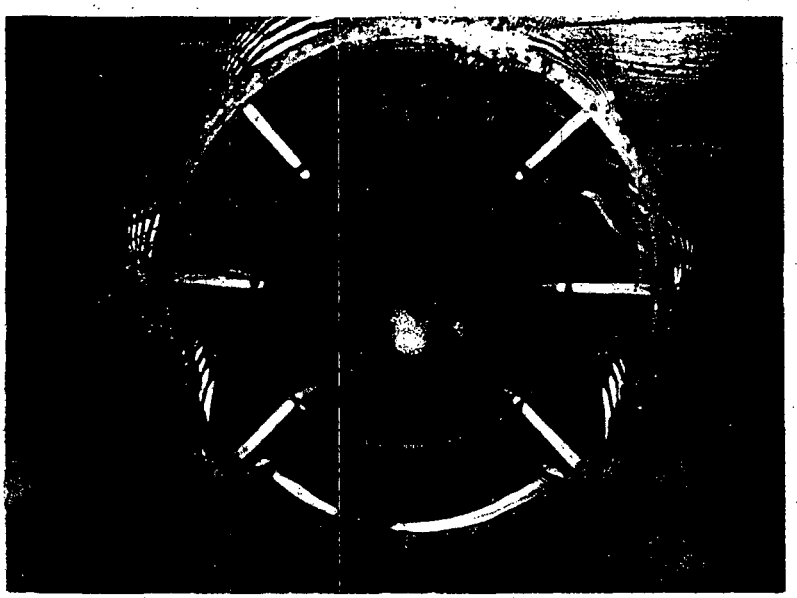


Figure 2.--Morning glory spillway with 6 piers. Toe of bank 30 feet from spillway. Discharge, 60,000 cubic feet per second.

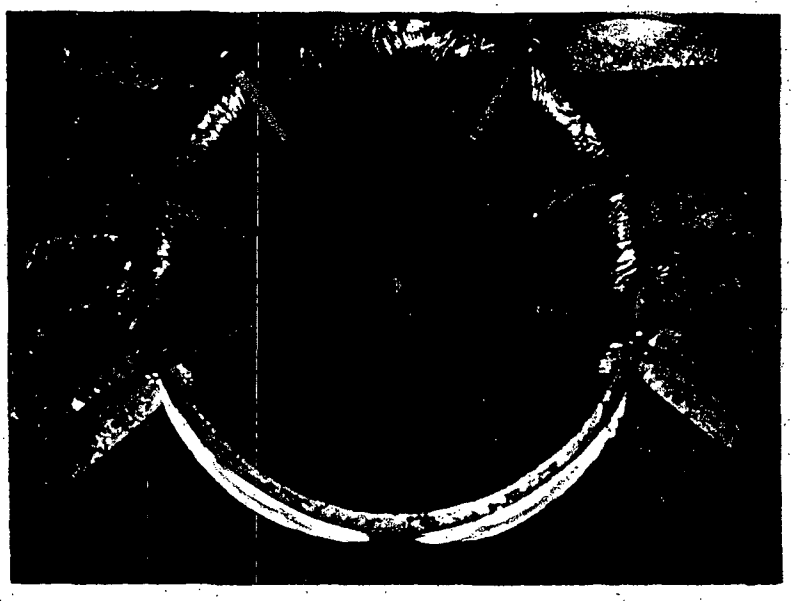


Figure 3.--Morning glory spillway with 6 piers and curved fins. Toe of bank 30 feet from spillway. Discharge, 60,000 cubic feet per second.

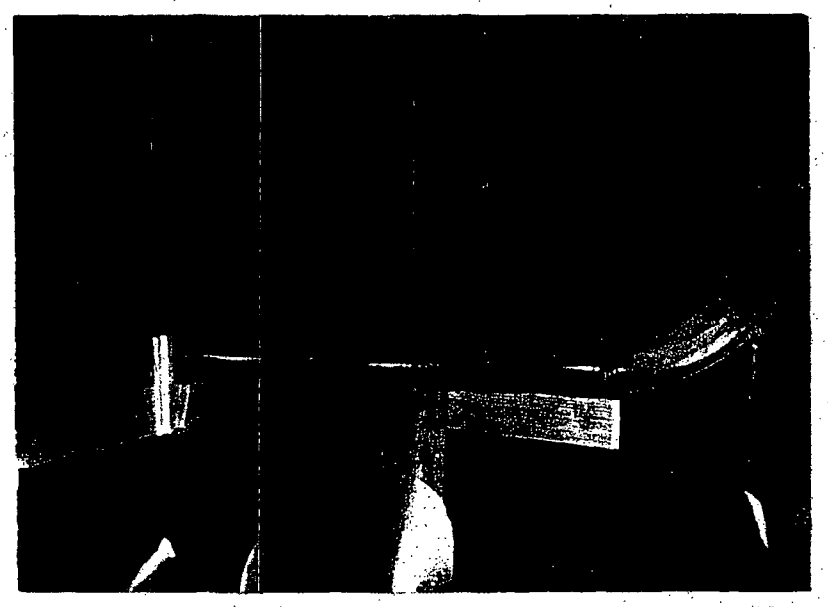


Figure 4.--Spiral flow in elbow and tunnel with no deflector in the spillway shaft. Discharge, 60,000 cubic feet per second.

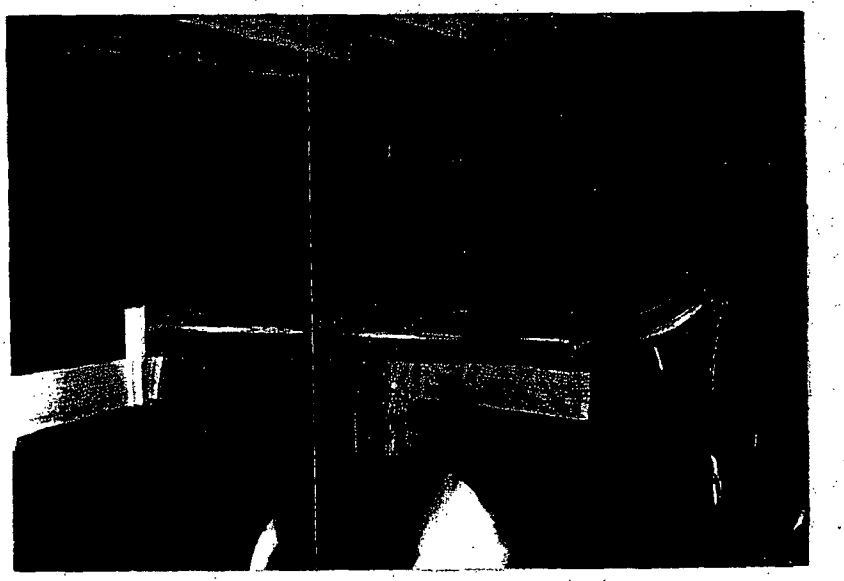


Figure 5.--Smooth uniform flow in elbow and tunnel with the 6.5-foot deflector in the spillway shaft. Discharge, 60,000 cubic feet per second.

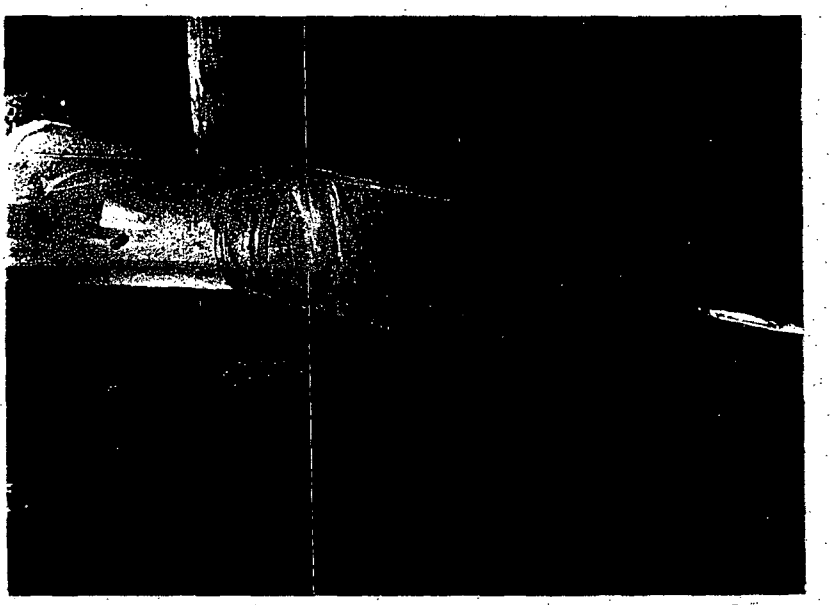


Figure 6.--Spiral high-velocity flow below tunnel intersection with no energy-dissipating structures in the tunnel. Valve discharge, 10,000 cubic feet per second.

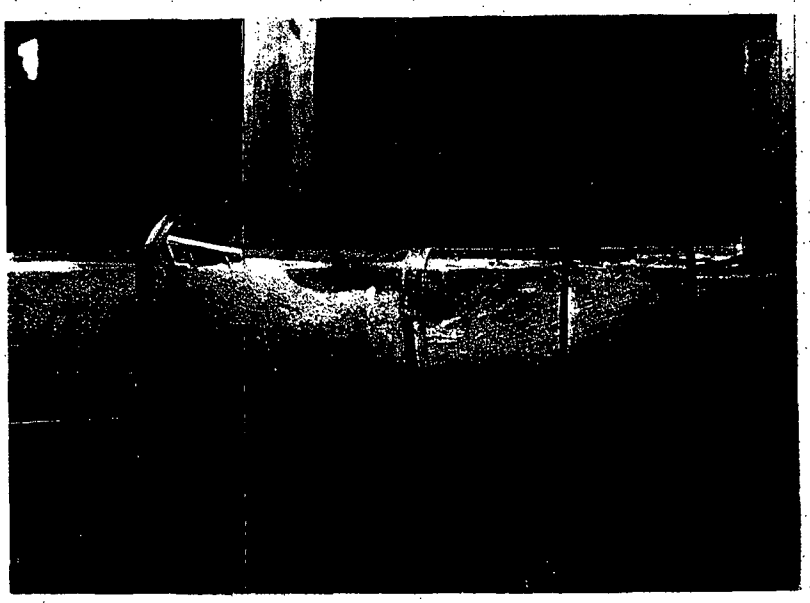


Figure 7.--Operation of energy-dissipating structures, scheme CD, 11.5 feet below the valves. The flow does not fill the tunnel at any place. Discharge, 10,000 cubic feet per second.

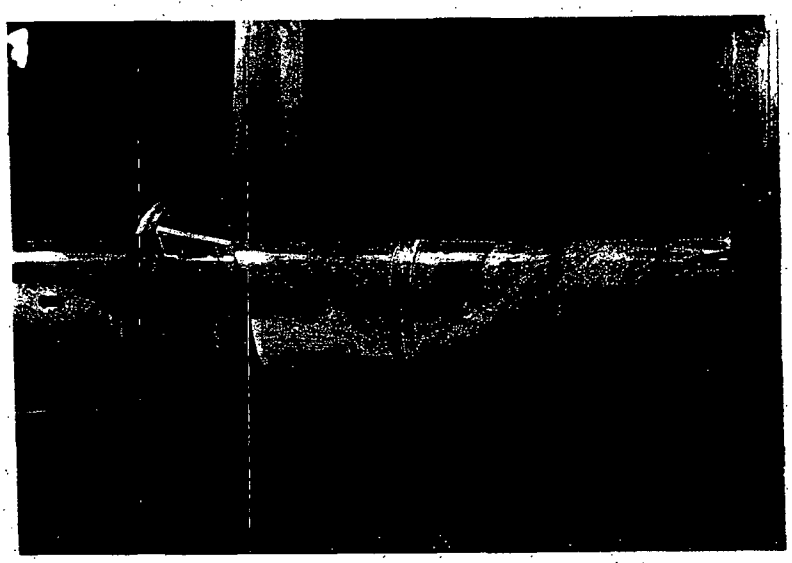


Figure 8.--Operation of energy-dissipating structures, scheme CD, with the weir too close to the valves. Water splashes on the tunnel roof at the weir and high-velocity flow persists in the tunnel. Discharge, 10,000 cubic feet per second.

Figure 9.--Operation of energy-dissipating structures, scheme CD, 11.5 feet below the valves. One valve discharging 5,000 cubic feet per second.

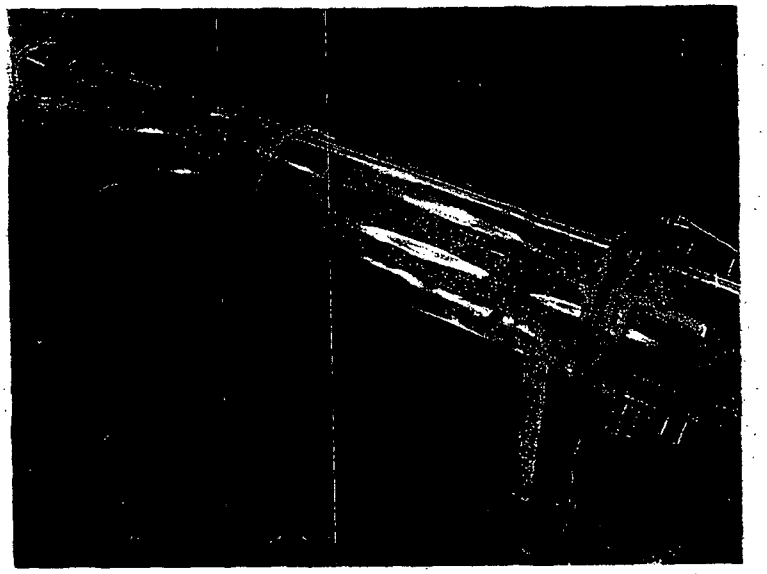


Figure 10.--Smooth low-velocity flow below tunnel intersection, with valve and wye energy-dissipating structures in place. Valve discharge, 10,000 cubic feet per second. Compare with Figure 6.

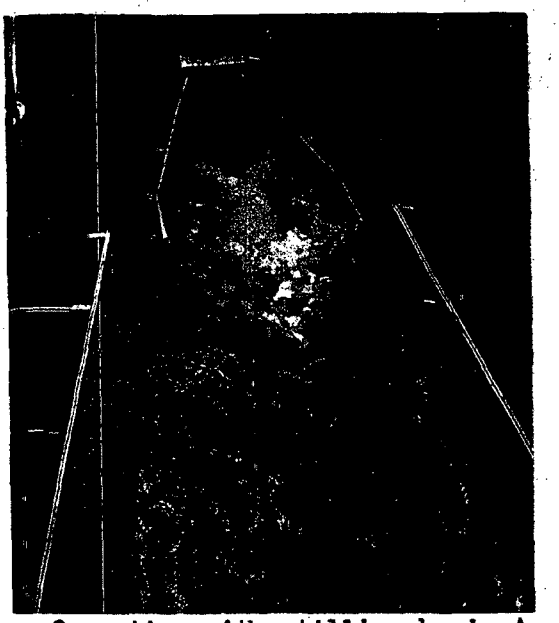


Figure 11.--Operation with stilling basin A. Discharge, 20,000 cubic feet per second.

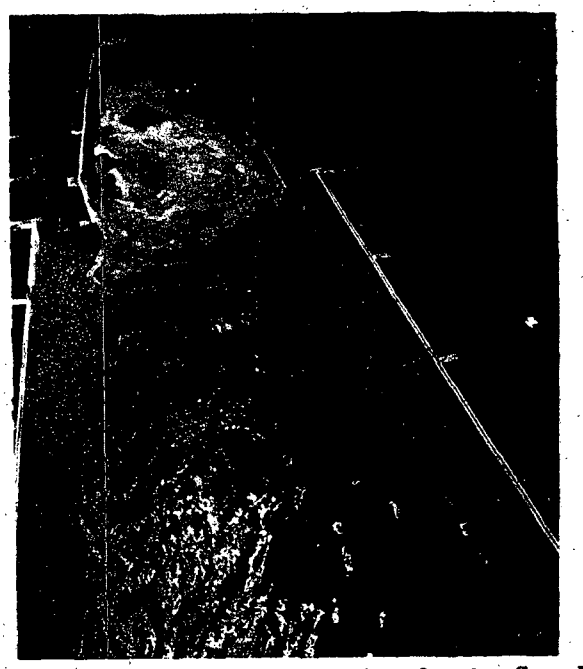


Figure 12.--Operation with stilling basin C. Discharge, 20,000 cubic feet per second.

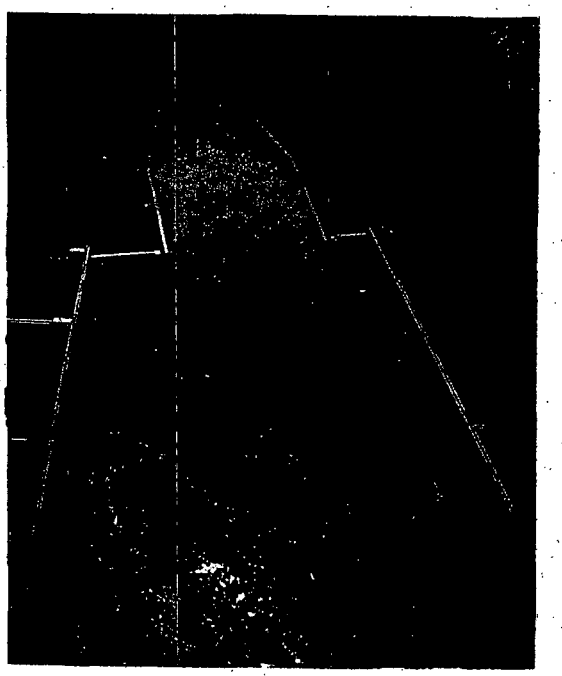


Figure 13.--Operation with stilling basin V. Discharge, 40,000 cubic feet per second.

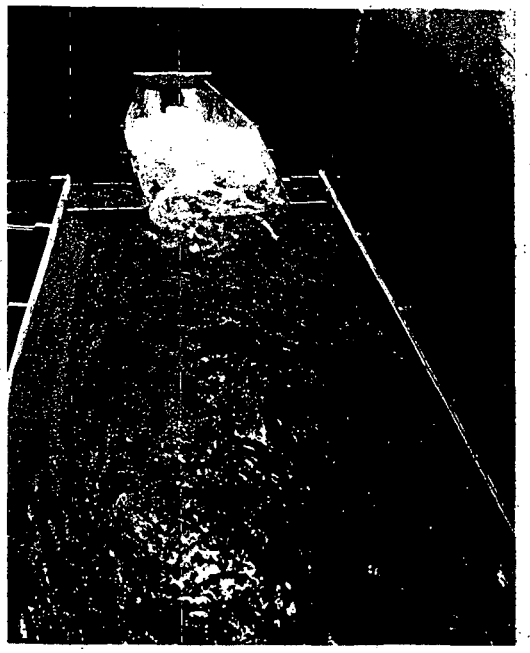


Figure 14.--Operation with stilling basin Z. Discharge, 40,000 cubic feet per second.

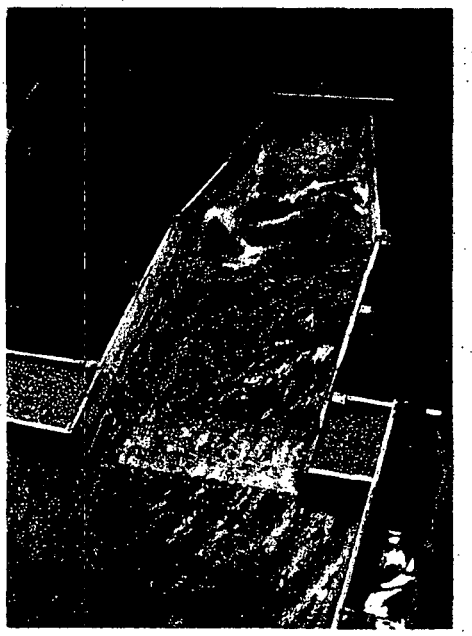
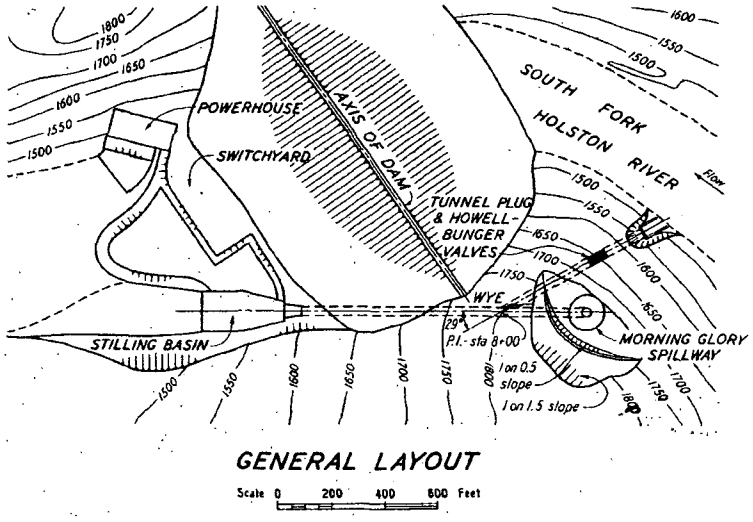
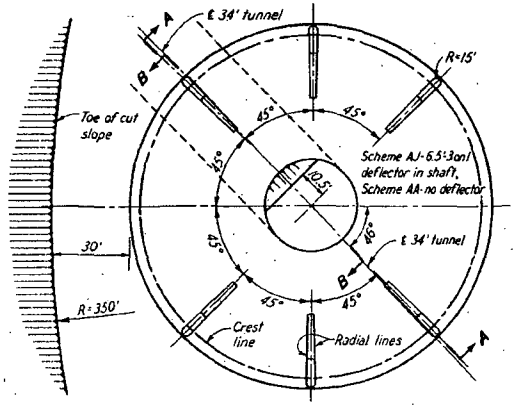


Figure 15.--Operation with stilling basin Z. Discharge, 10,000 cubic feet per second.

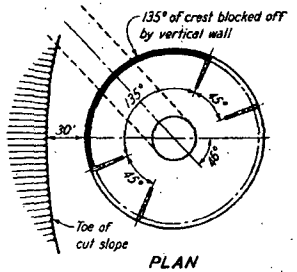


GENERAL LAYOUT

Scale 0 200 400 600 Feet

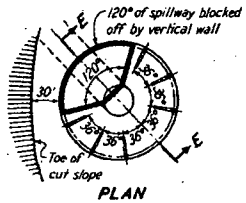


PLAN

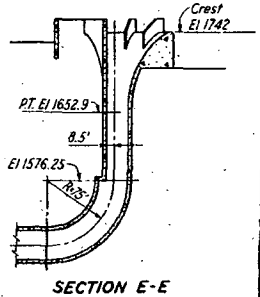


PLAN

SCHEME Q

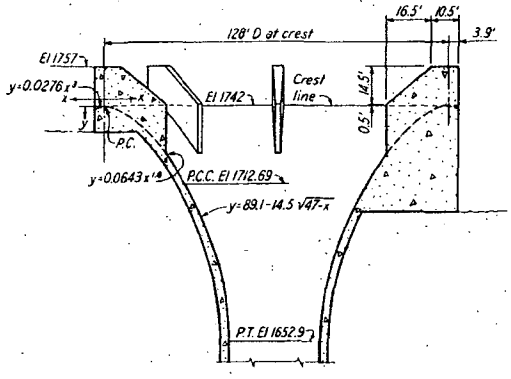


PLAN



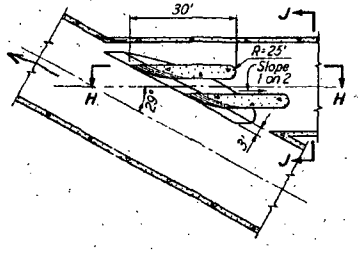
SECTION E-E

SCHEME AB

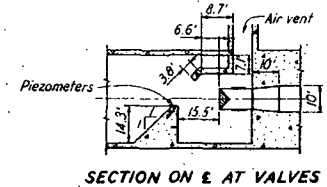


SECTION A-A

SCHEMES AA & AJ

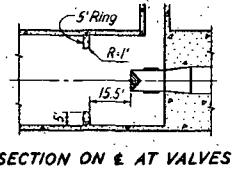


SECTIONAL PLAN AT WYE



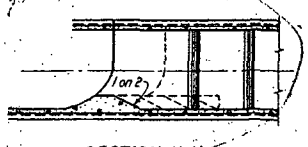
SECTION ON ℄ AT VALVES

SCHEME BR

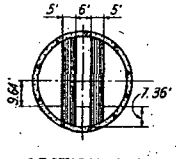


SECTION ON ℄ AT VALVES

SCHEME BL

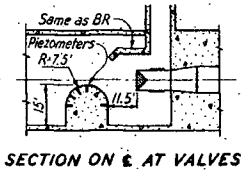


SECTION H-H



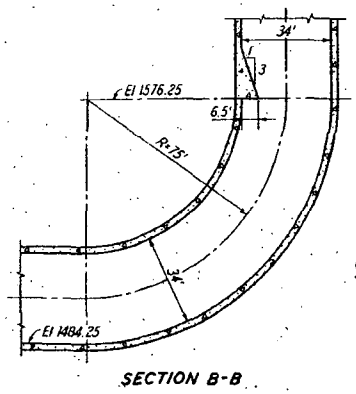
SECTION J-J

SCHEMES BR, BL, CD



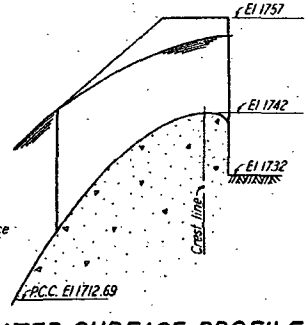
SECTION ON ℄ AT VALVES

SCHEME CD



SECTION B-B

SCHEME AJ



The profile was taken 2 feet from the pier face

MAXIMUM WATER SURFACE PROFILE

DISCHARGE 60,000 C.F.S.

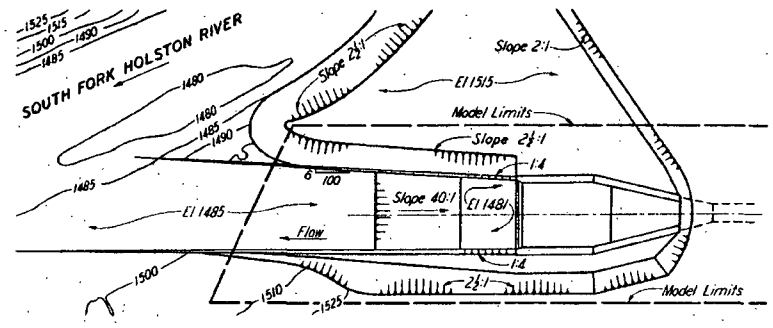
TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

SOUTH HOLSTON PROJECT HYDRAULIC MODEL STUDIES
SPILLWAY AND TUNNEL

MODEL LAYOUT AND DETAILS

MODEL SCALES 1:34, 1:51, AND 1:100

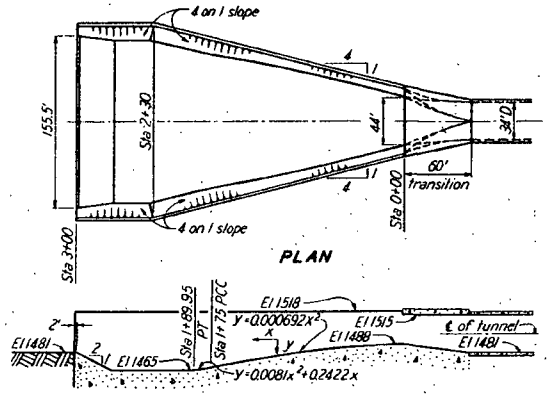
PLATE 1



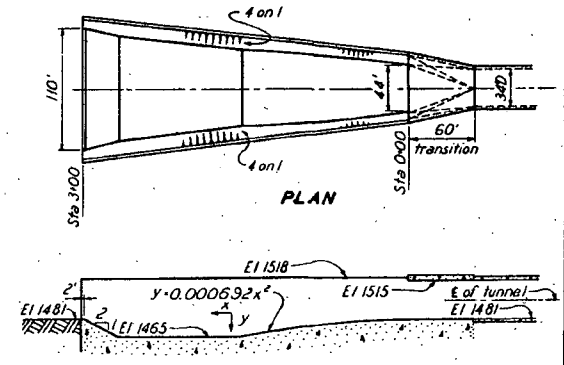
GENERAL LAYOUT

STILLING BASIN V IN PLACE

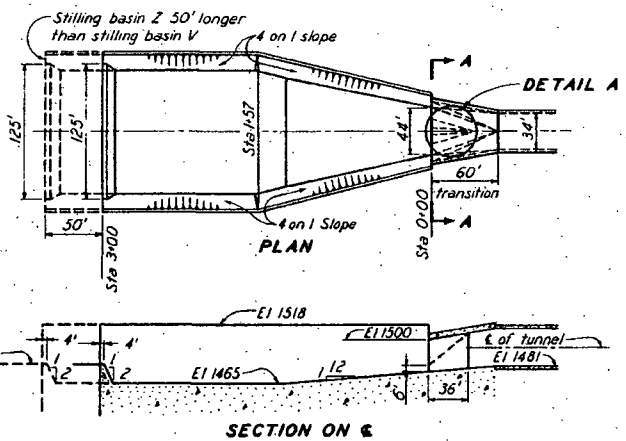
Scale 0 100 200 300 Feet

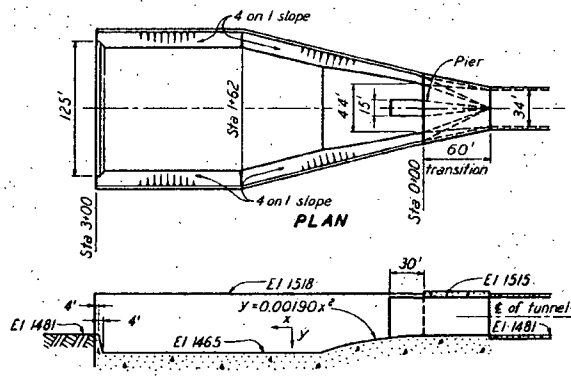


STILLING BASIN A

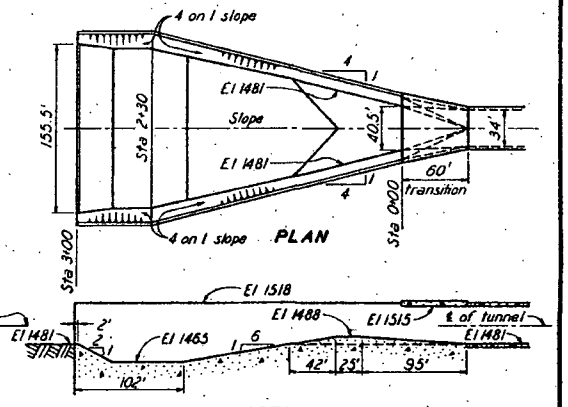


STILLING BASIN B

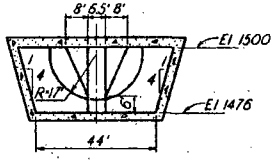




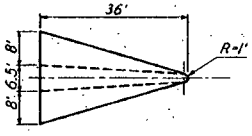
STILLING BASIN N



STILLING BASIN C



SECTION A-A



DETAIL A

STILLING BASINS V & Z

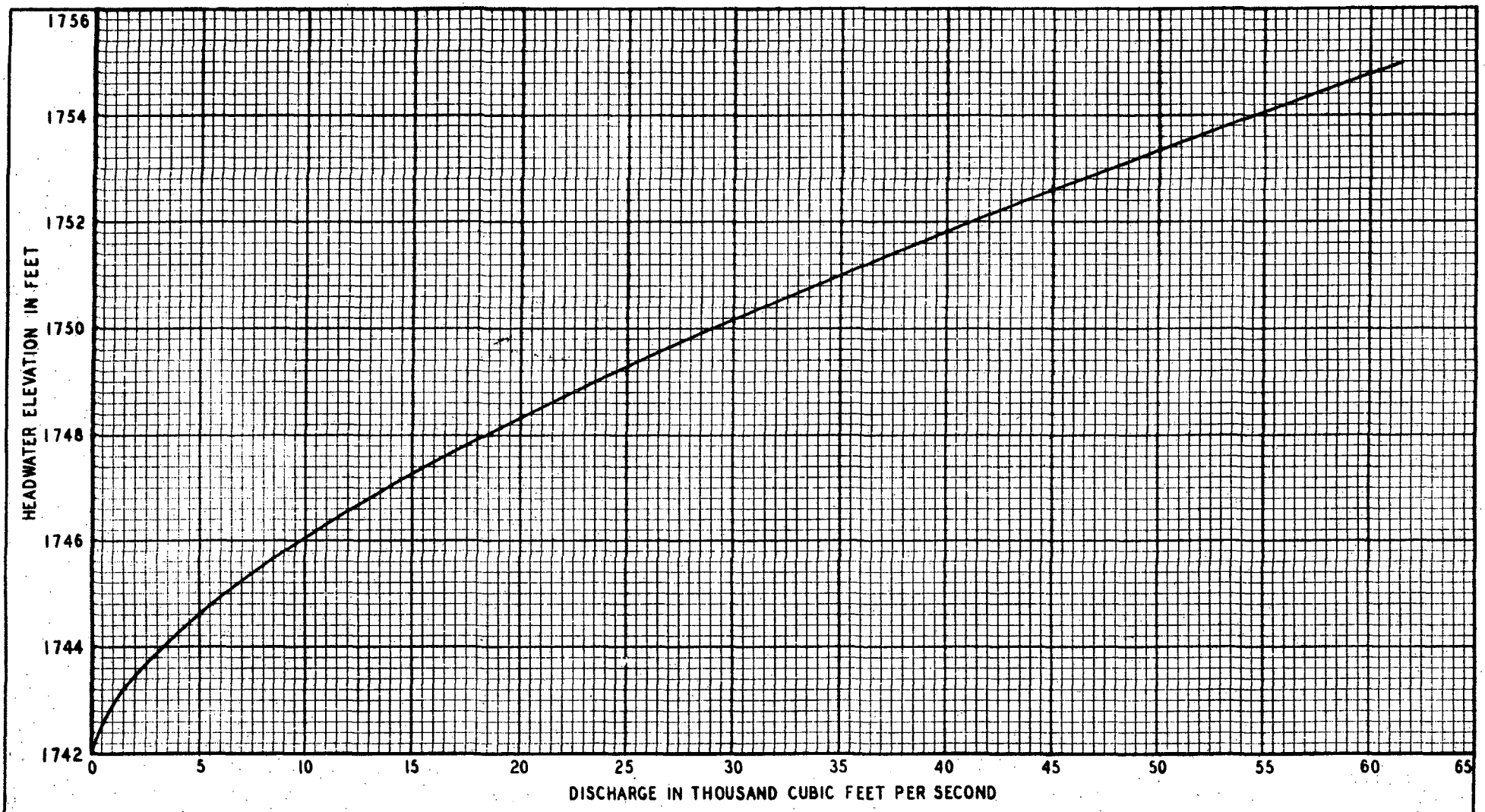
TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

SOUTH HOLSTON PROJECT HYDRAULIC MODEL STUDIES

STILLING BASIN

MODEL LAYOUT AND DETAILS

MODEL SCALE 1:51



TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
HYDRAULIC DATA BRANCH

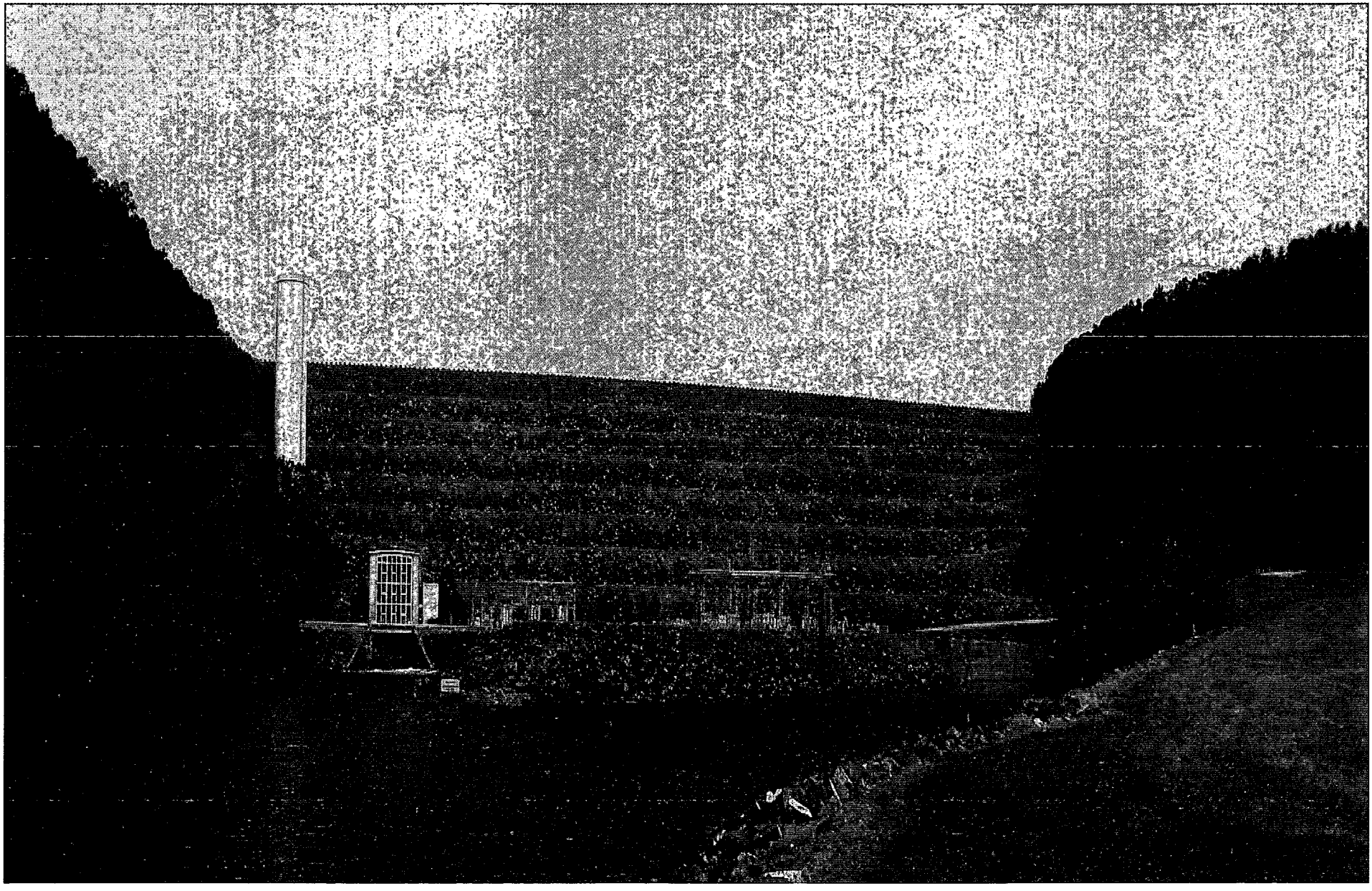
SOUTH HOLSTON PROJECT HYDRAULIC MODEL STUDIES

MORNING-GLORY SPILLWAY

SPILLWAY RATING CURVE

PLATE 3

SOUTH HOLSTON DAM



September 1999

RESERVOIR OPERATION OVERVIEW

South Holston is a multipurpose tributary project located on the South Fork of the Holston River in northeastern Tennessee. South Holston is operated for many purposes, including flood control, augmentation of flows for navigation and water supply, hydropower production, water quality, recreation, and aquatic ecology. It is an earth and rockfill dam with 1 hydroelectric unit installed. Construction originally began in early 1942, but was curtailed after about a year in favor of other war time construction efforts. Construction resumed in 1947, the dam was closed in 1950, and the hydroelectric unit began operation in 1951.

South Holston Reservoir has an annual pool variation of about 35 feet during normal years. This fluctuation is necessary to provide for seasonal flood storage and for economical augmentation of flows during the drier seasons of the year. In 1991, construction was completed on a reregulating weir immediately downstream of the dam to help provide minimum flows and increased dissolved oxygen content in the river. The tailwaters now support a thriving cold water fishery.

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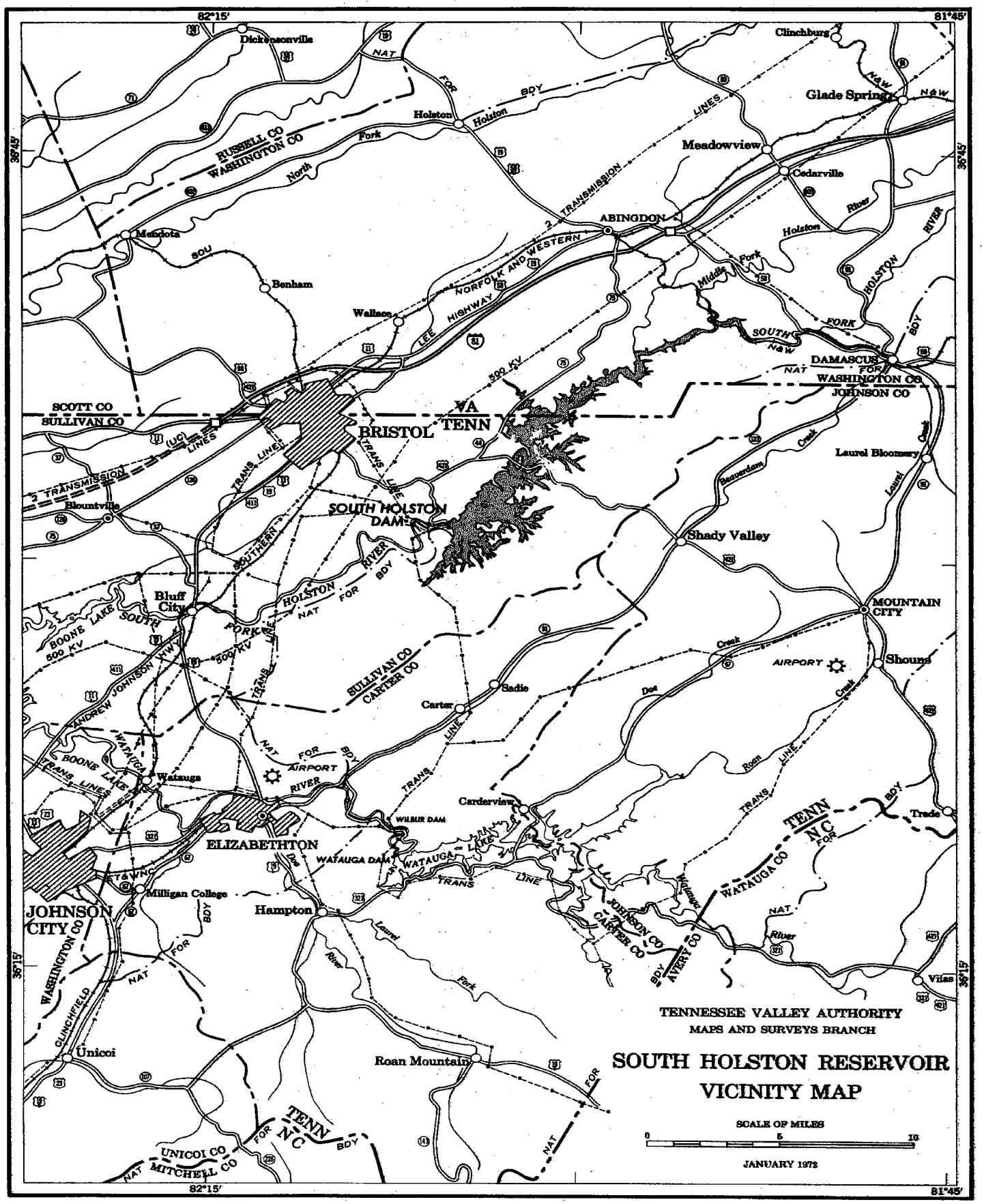

TENNESSEE VALLEY AUTHORITY
MAPS AND SURVEYS BRANCH
SOUTH HOLSTON RESERVOIR
VICINITY MAP
SCALE OF MILES
0 5 10
JANUARY 1972
82°15'
81°45'
36°45'
36°15'
Dickensonville
Clinchburg
Glade Spring
Holston
Meadowview
Cedarville
ABINGDON
Mendota
Benham
Wallace
DAMASCUS
WASHINGTON CO
JOHNSON CO
SCOTT CO
SULLIVAN CO
VA
TENN
BRISTOL
Laurel Bloomery
Bluff City
SOUTH HOLSTON DAM
Shady Valley
MOUNTAIN CITY
Shouns
AIRPORT
SULLIVAN CO
CARTER CO
Sadie
Carter
Watauga
Carderview
WILBUR DAM
ELIZABETHTON
WATAUGA DAM
WATAUGA LAKE
Milligan College
Hampton
JOHNSON CITY
Trade
TENN
NC
WATAUGA CO
JOHNSON CO
CARTER CO
AVERY CO
Vilas
Unicoi
Roan Mountain
UNICOI CO
MITCHELL CO
WASHINGTON CO

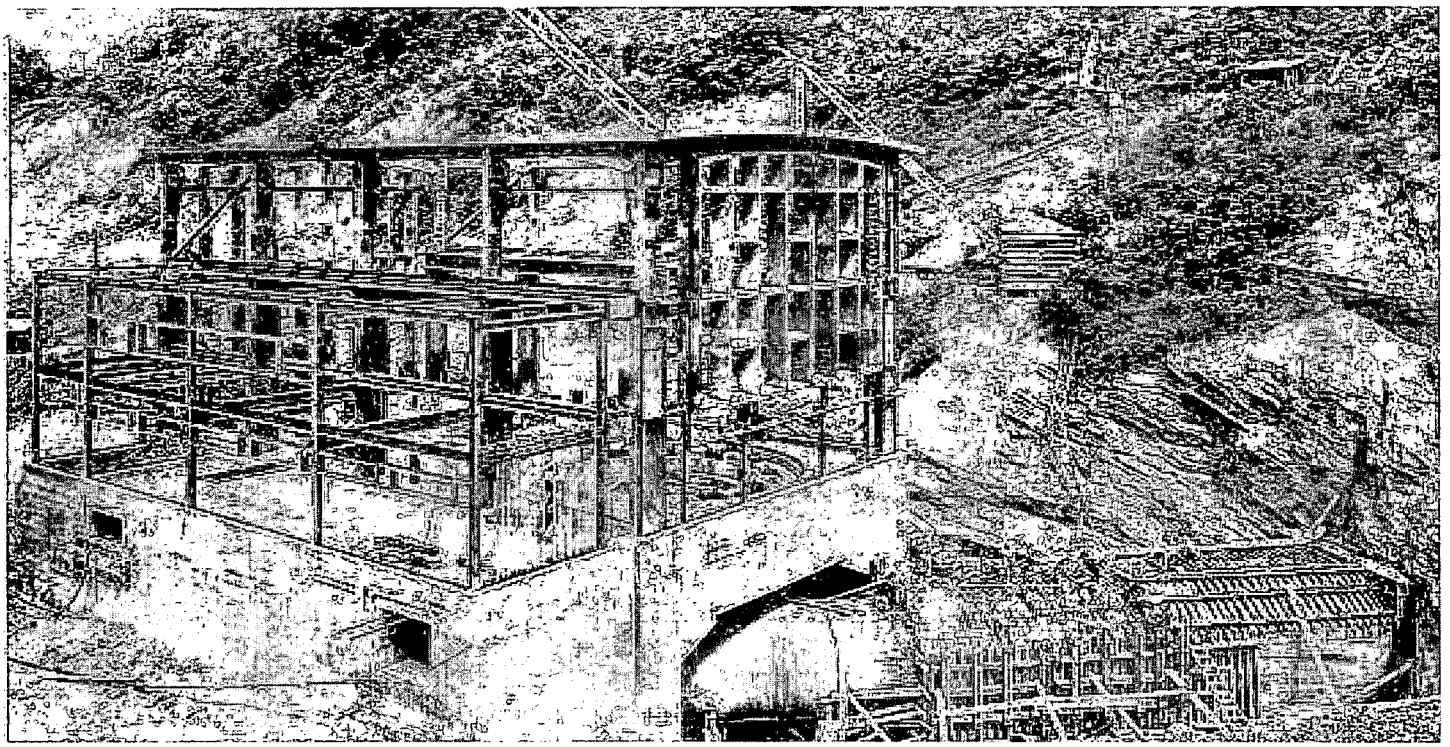


FIGURE 1 - Powerhouse Construction, 1947

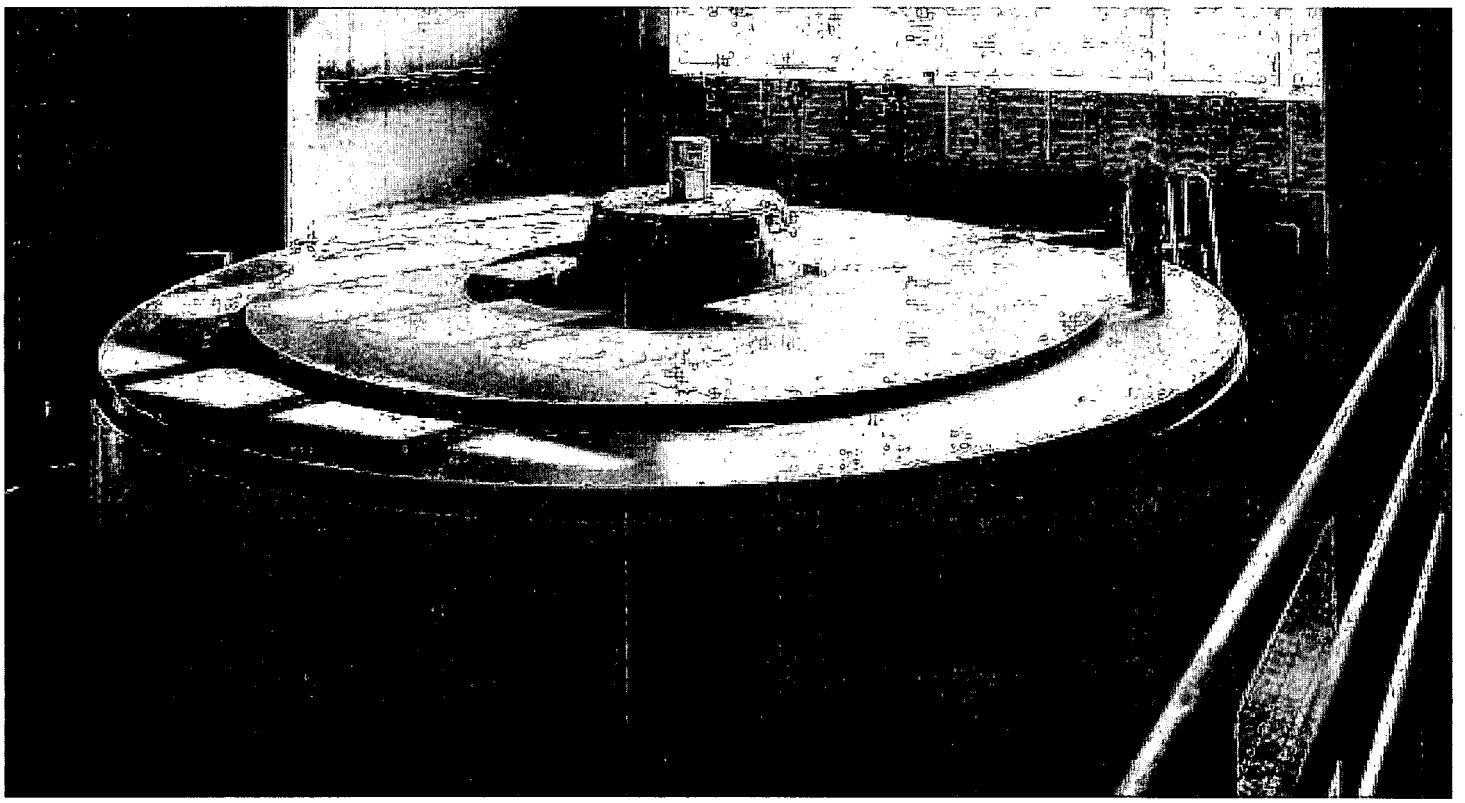


FIGURE 2 - Generating Unit, 1950

FIGURE 3

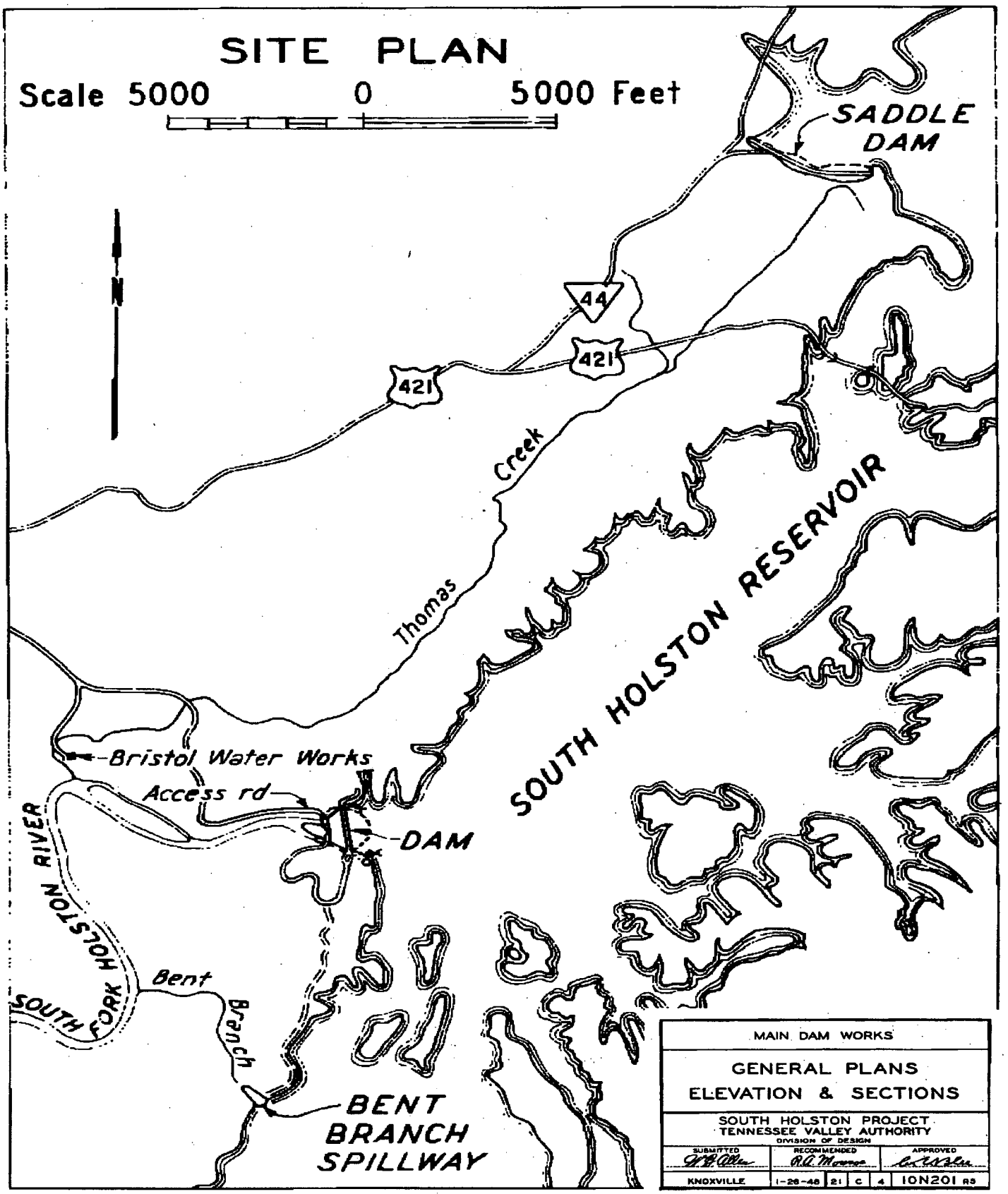

SITE PLAN
Scale 5000 0 5000 Feet
N
SADDLE DAM
44
421
421
Thomas Creek
SOUTH HOLSTON RESERVOIR
Bristol Water Works
Access rd
DAM
SOUTH FORK HOLSTON RIVER
Bent Branch
BENT BRANCH SPILLWAY
MAIN DAM WORKS
GENERAL PLANS
ELEVATION & SECTIONS
SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
1-26-48
21
C
4
10N201 R5

FIGURE 4

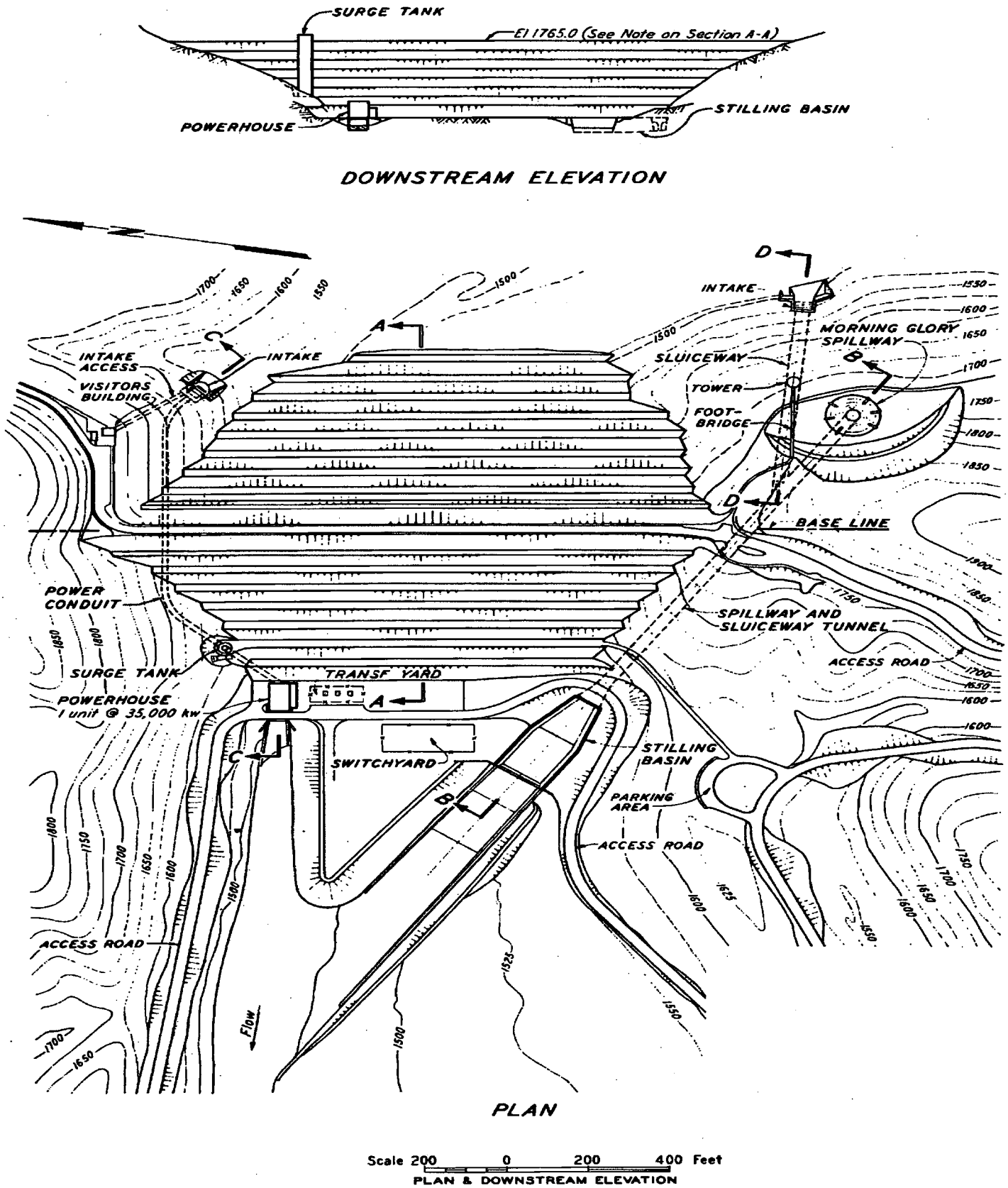
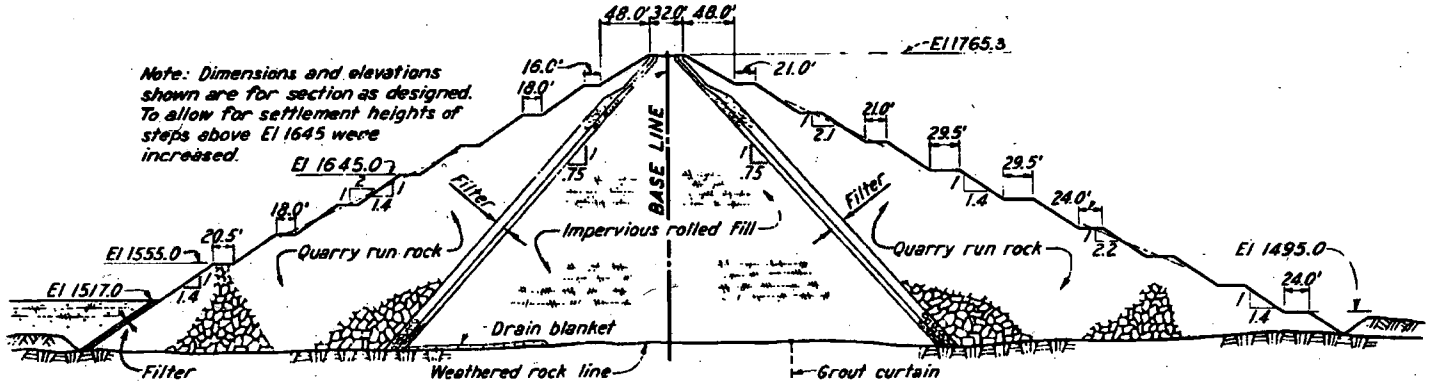
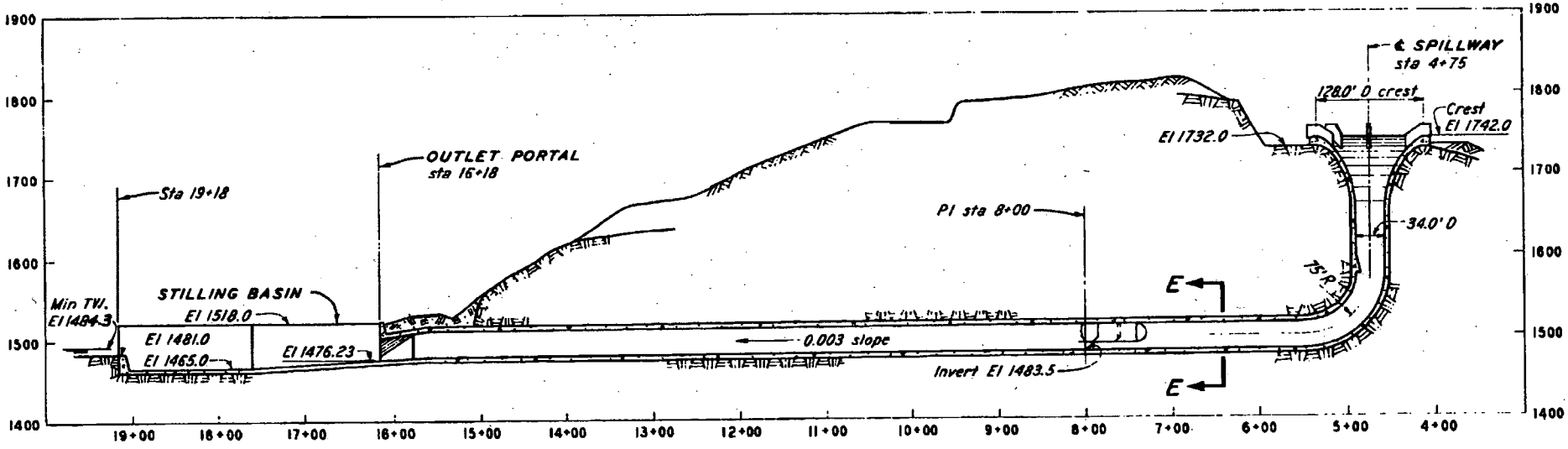

SURGE TANK
El 1765.0 (See Note on Section A-A)
POWERHOUSE
STILLING BASIN
DOWNSTREAM ELEVATION
INTAKE
MORNING GLORY SPILLWAY
SLUICEWAY
TOWER
FOOT-BRIDGE
INTAKE ACCESS
VISITORS BUILDING
INTAKE
BASE LINE
POWER CONDUIT
SPILLWAY AND SLUICEWAY TUNNEL
ACCESS ROAD
SURGE TANK
TRANSF YARD
POWERHOUSE
1 unit @ 35,000 kw
SWITCHYARD
STILLING BASIN
PARKING AREA
ACCESS ROAD
ACCESS ROAD
Flow
PLAN
Scale 200 0 200 400 Feet
PLAN & DOWNSTREAM ELEVATION

FIGURE 5



SECTION A-A

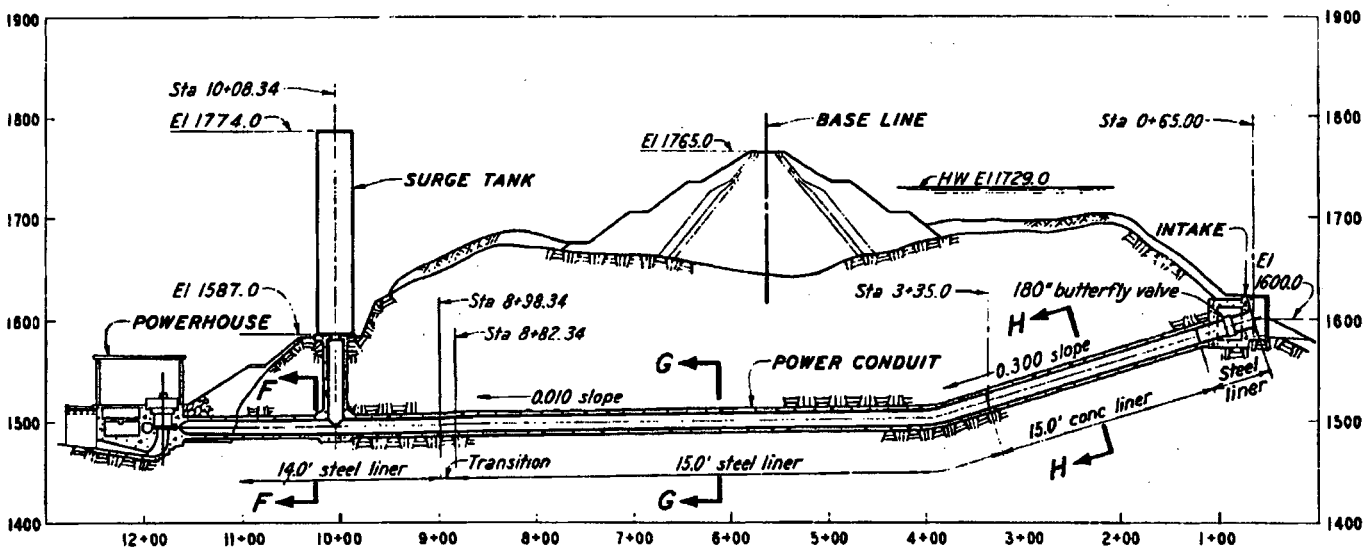


SECTION B-B

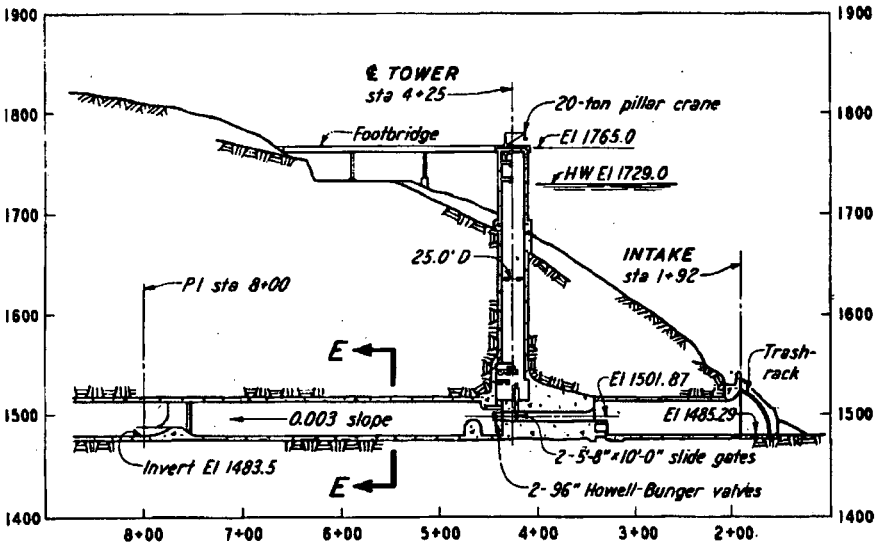
Scale 100 0 100 200 Feet

SECTIONS A-A, B-B

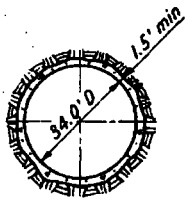
FIGURE 6



SECTION C-C



SECTION D-D



SECTION E-E

Scale 100 0 100 200 Feet

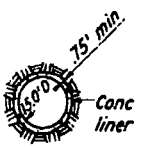
SECTIONS C-C & D-D

Scale 30 0 30 60 Feet

SECTIONS E-E, F-F, G-G & H-H

SECTION F-F

SECTION G-G



SECTION H-H

FIGURE 7

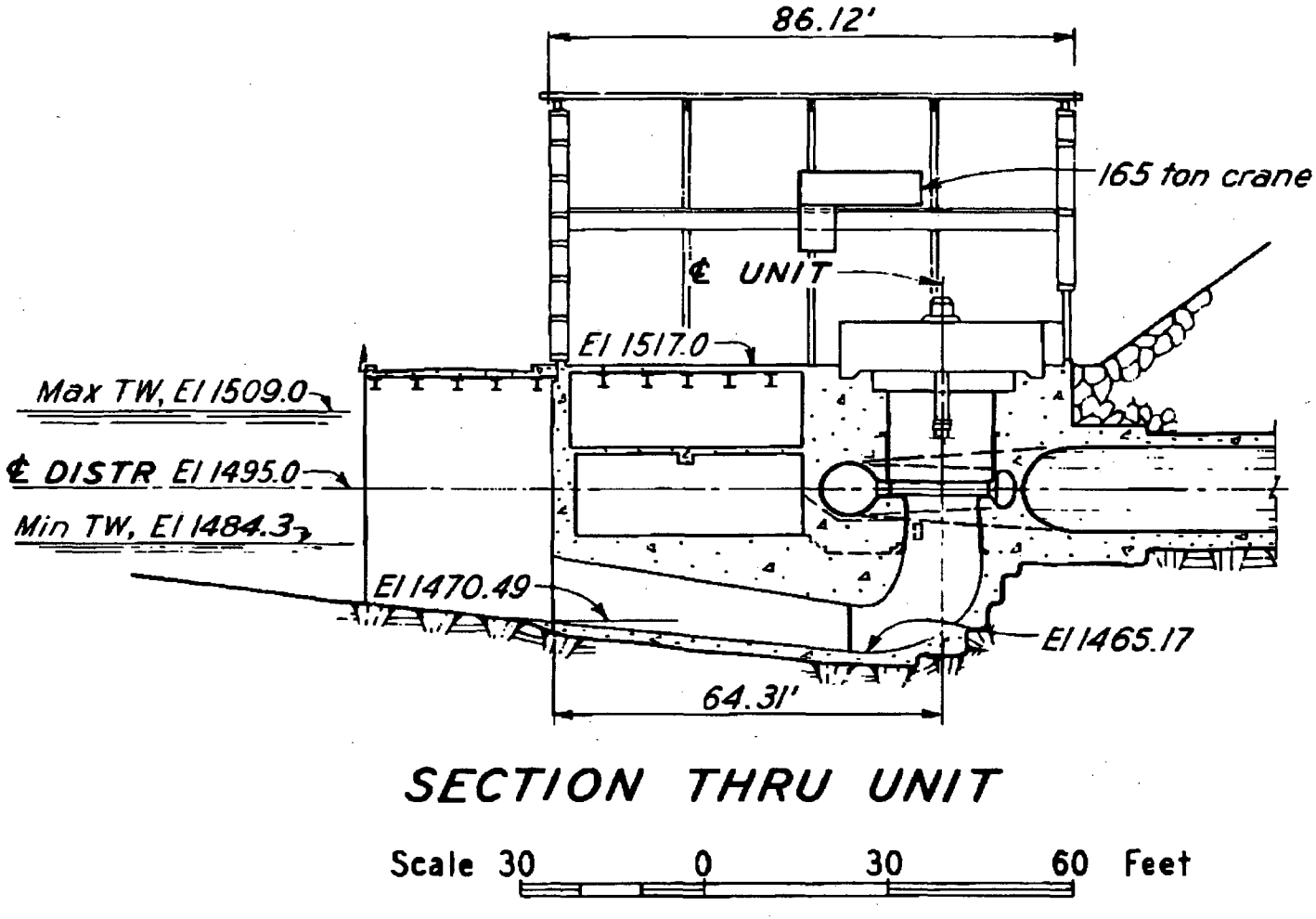

86.12'
165 ton crane
℄ UNIT
El 1517.0
Max TW, El 1509.0
℄ DISTR El 1495.0
Min TW, El 1484.3
El 1470.49
El 1465.17
64.31'
SECTION THRU UNIT
Scale 30 0 30 60 Feet

FIGURE 8 - Saddle Dam is on the right rim, 4.5 miles from the main dam

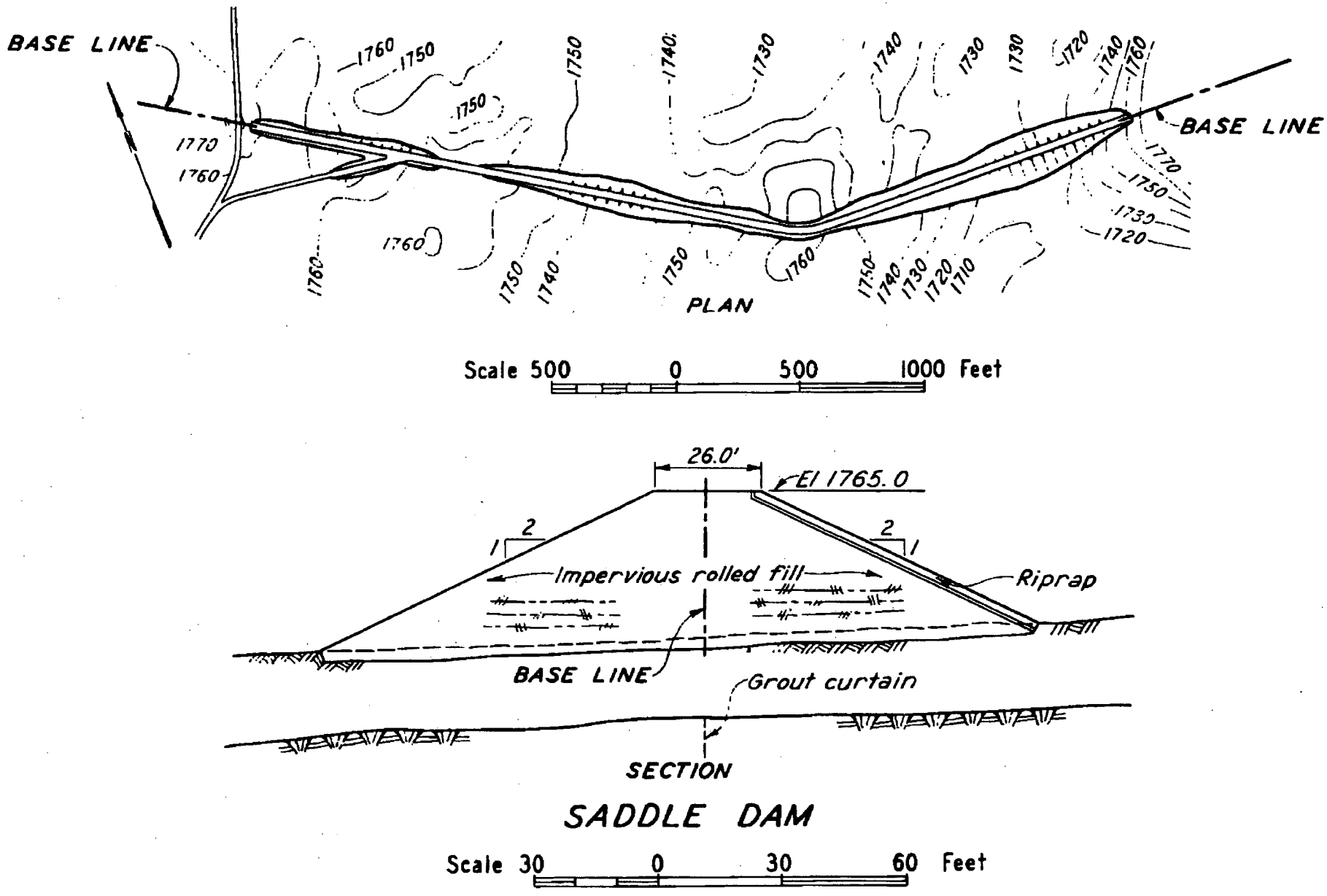
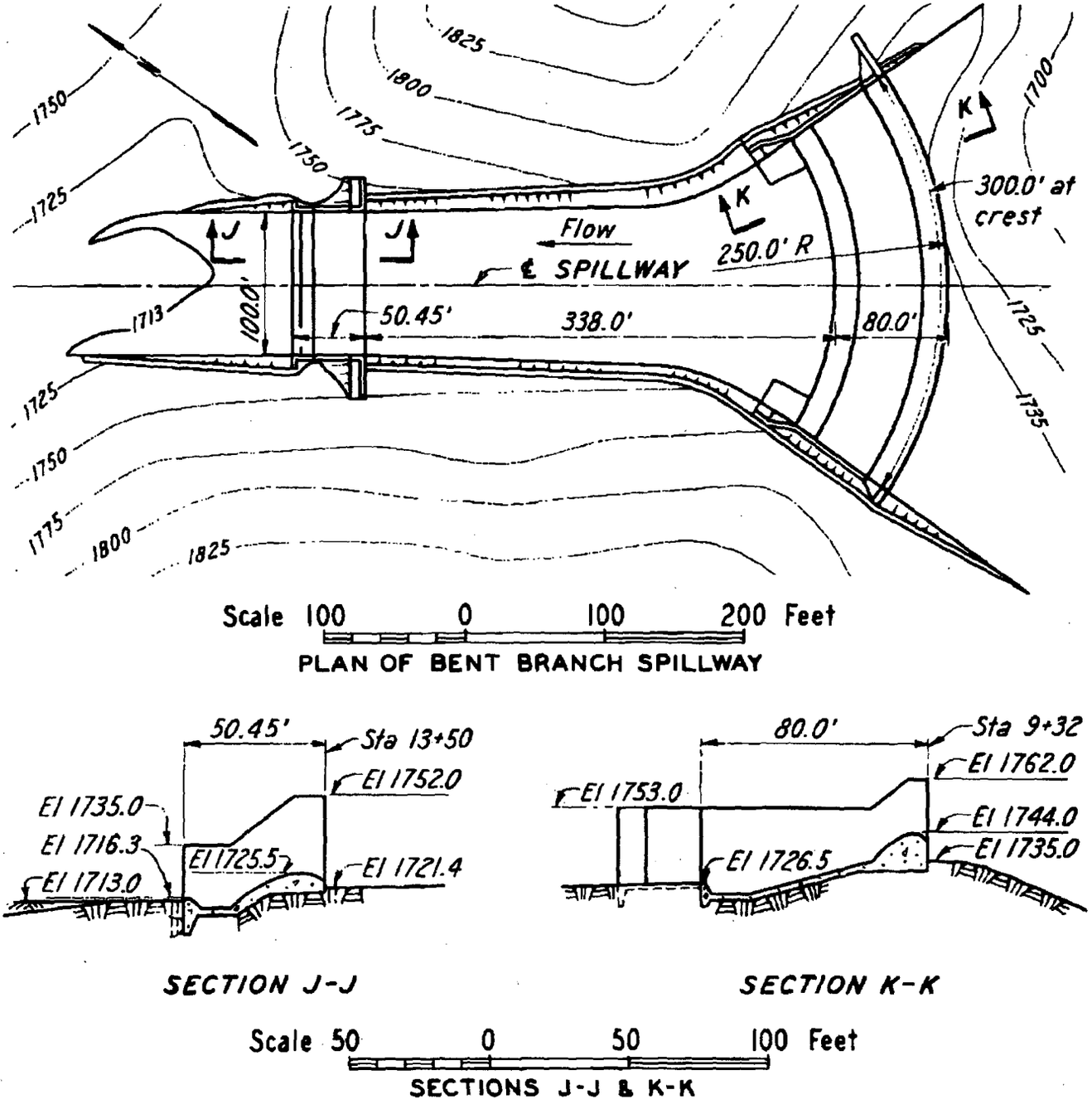


FIGURE 9


1825
1800
1775
1750
1725
1713
1700
1735
J
K
Flow
℄ SPILLWAY
250.0' R
300.0' at crest
100.0'
50.45'
338.0'
80.0'
Scale 100 0 100 200 Feet
PLAN OF BENT BRANCH SPILLWAY
50.45'
Sta 13+50
El 1752.0
El 1735.0
El 1716.3
El 1725.5
El 1721.4
El 1713.0
SECTION J-J
80.0'
Sta 9+32
El 1762.0
El 1753.0
El 1744.0
El 1735.0
El 1726.5
SECTION K-K
Scale 50 0 50 100 Feet
SECTIONS J-J & K-K

SOUTH HOLSTON PROJECT

SUMMARY OF PRINCIPAL FEATURES

NOTE:
Elevations are based on the U.S.C. & G.S. 1936 Supplementary Adjustment.

LOCATION

On South Fork Holston River at river mile 49.8; in Sullivan County, Tennessee; 7 miles southeast of Bristol, Tennessee/Virginia; 110 air miles northeast of Knoxville, Tennessee.

CHRONOLOGY

Initial appropriation by Congress	December 17, 1941
Authorized by TVA Board of Directors	January 15, 1942
Construction started	February 16, 1942
Construction deferred	April 15, 1943
Construction resumed	August 4, 1947
Dam closure	November 20, 1950
Power unit in commercial operation	February 13, 1951
Reservoir Release Improvements - completed	December 30, 1991

PROJECT COST

Initial project, including one unit and switchyard	$31,242,224
Reservoir Release Improvements	$2,400,000
Total including switchyard	$33,642,224

STREAMFLOW

Drainage area at dam	703 sq. miles
Gaging station discharge records :	
At Bluff City, Tennessee, July 1900 to May 1953; drainage area	813 sq. miles
Below South Holston Dam, July 1951 to date; drainage area	703 sq. miles
Maximum known flood at dam site:	
Natural (1867)	45,000 cfs
Regulated	10,000 cfs
Average unregulated flow at dam site, estimated (1900-1969)	980 cfs
Minimum daily natural flow at dam site (1925), approx	100 cfs

RESERVOIR

Counties affected:	
State of Tennessee	Sullivan
State of Virginia	Washington
Reservoir land at May 1996:	
Fee simple	8,178 ac.
Easements	1,858 ac.
Total	10,036 ac.
Transferred	3,834 ac.
Operating levels at dam:	
Probable maximum flood elevation	el. 1764.7
500 Year flood elevation	el. 1742.0
100 Year flood elevation	el. 1738.0
Maximum used for design (133,000 cfs)	el. 1755.0
Spillway crest (area 9,010 ac.)	el. 1742.0
Summer maximum pool (area 7,580 ac.)	el. 1729.0
Winter minimum pool (area 4,860 ac.)	el. 1675.0
Backwater, length at normal maximum pool level	23.7 miles
Shoreline, length at normal maximum pool level:	
Main shore	160 miles
Islands	8 miles
Total	168 miles
Original river area (to el. 1742 crossing)	
Storage (flat pool assumption):	
Total volume:	
At spillway crest (el. 1742)	764,000 ac.-ft
At normal maximum pool (el. 1729)	657,500 ac.-ft
At normal minimum pool (el. 1675)	326,000 ac.-ft
Reservation for flood control on:	
January 1 (el. 1742-1702)	290,200 ac.-ft
March 15 (el. 1742-1713)	220,000 ac.-ft
Useful controlled storage (el. 1742-1675)	438,000 ac.-ft

TAILWATER

Maximum used for design (71,000 cfs)	el.1513.0
Full plant operation (1 unit)	el.1489.1
Unit operating at best efficiency	el.1489.1
Minimum level	el.1484.3

Tailwater Weirs (See Figure 10)

FIGURE 10 - Tailwater Weirs, September 1999

HEAD (Gross)

Maximum static (el. 1742-1484.3)	257.7 ft
Normal maximum operating (el. 1729-1489)	245.0 ft
Average operating	225.0 ft
Minimum operating (el. 1616-1490)	170.0 ft

RESERVOIR ADJUSTMENTS

Clearing	4,378 ac.
Highways:	
Access	4.5 miles
State	8.6 miles
County and Tertiary	17.4 miles
Total	30.5 miles
Railroads (protection)	0.3 miles
Bridges (highway 5; railroad 1)	6
Families affected	342
Graves	559
Utilities adjusted or constructed, approx.	44 miles

DAMS

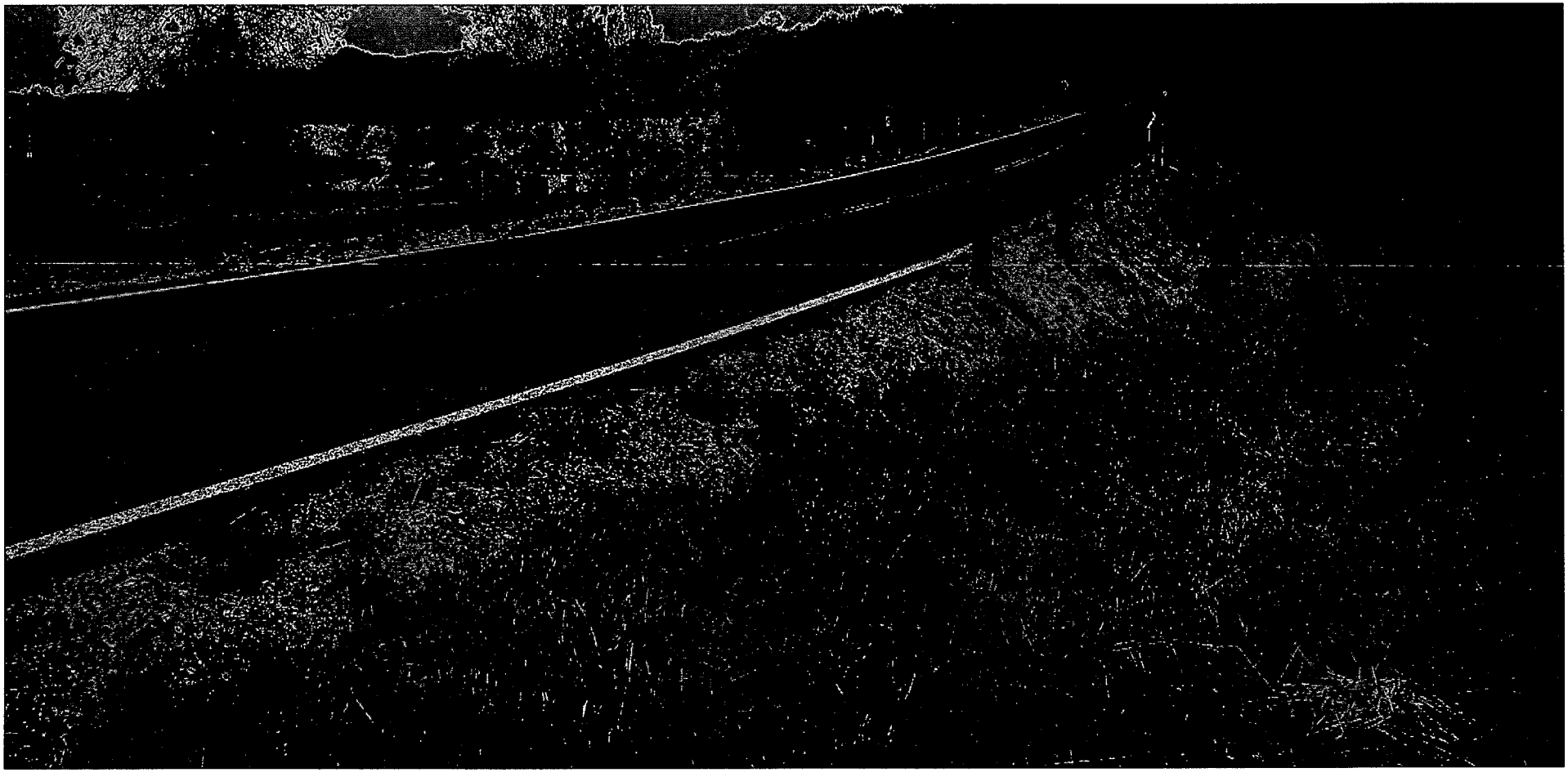
MAIN DAM

Material and type	Rockfill and impervious rolled earthfill embankment
Length	1,600 ft
Maximum height	285 ft
Maximum width at base	1,175 ft
Top of embankment	el. 1765.0
Top width	32 ft
Foundation	Tellico sandstone

SADDLE DAM (See Figure 11)

Location	Right rim, 4.5 miles from main dam
Material and type	Impervious rolled earthfill embankment
Length	3,700 ft
Maximum height	40 ft
Maximum width at base	186 ft
Top of embankment	el. 1765.0
Top width	26 ft
Foundation	Earth

FIGURE 11 - Saddle Dam



OUTLET WORKS

SPILLWAY (See Figure 12)

Location	Left abutment
Material and type	Concrete, uncontrolled morning-glory spillway with concrete-lined shaft and discharge tunnel; concrete stilling basin at tunnel outlet
Crest diameter	128 ft
Crest length, clear	385 ft
Crest level	el. 1742.0
Shaft and tunnel diameter	34 ft
Length:	
Shaft and elbow	283 ft
Tunnel	1,068 ft
Invert of tunnel outlet	el. 1476.2
Stilling basin:	
Length	300 ft
Width at bottom	117 ft
Height of walls	53 ft
Discharge capacity, HW el. 1755	62,000 cfs

FIGURE 12 - Morning-glory Spillway Intake Structure, September 1999

OUTLET WORKS (CONT.)

SLUICEWAY (See Figure 13)

Location ..... Left abutment
Material and type ..... Concrete-lined tunnel with concrete access tower to regulating valves in tunnel plug; discharges into spillway tunnel
Tunnel:
- Diameter ..... 34 ft
- Length ..... 608 ft

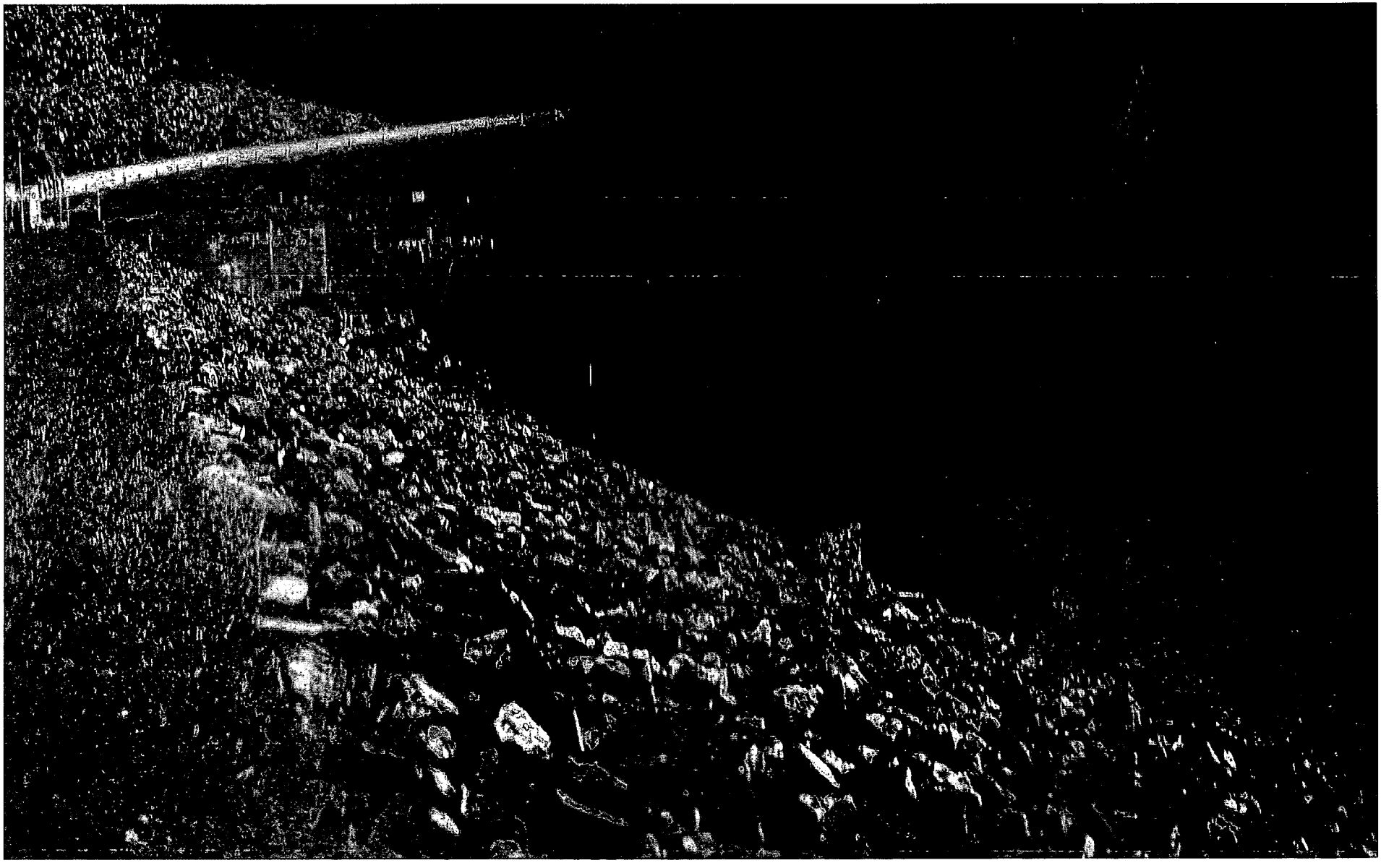
Tower:
- Inside diameter ..... 25 ft
- Height ..... 248 ft

Trashracks ..... Bars spaced approx. 12-in. center to center
Regulating valves ..... Two 96-in. Howell-Bunger valves
Emergency gates ..... Two 5-ft-8-in. by 10-ft hydraulically operated slide gates
Centerline of valves ..... el. 1501.7
Service crane on tower ..... One 20-ton pillar crane
Discharge capacity:
- HW el. 1755 (maximum design level) ..... 11,000 cfs
- HW el. 1742 (spillway crest) ..... 10,700 cfs
- HW el. 1729 (normal maximum) ..... 10,400 cfs

Spill and Sluiceway Discharge Stilling Basin (See Figure 14)

FIGURE 13 - Sluiceway Access Tower, September 1999

FIGURE 14 - Spill and Sluiceway Discharge Stilling Basin on Right Side of Dam Looking Upstream, September 1999



OUTLET WORKS (CONT.)

AUXILIARY SPILLWAY (See Figure 15)

Location ..... In saddle, 1.5 miles south of main dam
Material and type ..... Chute-type spillway; curved concrete overflow weir, uncontrolled; sloping apron with converging side walls end sill; rock-cut channel through saddle, unlined; concrete control weir with ski-jump sill at end of channel

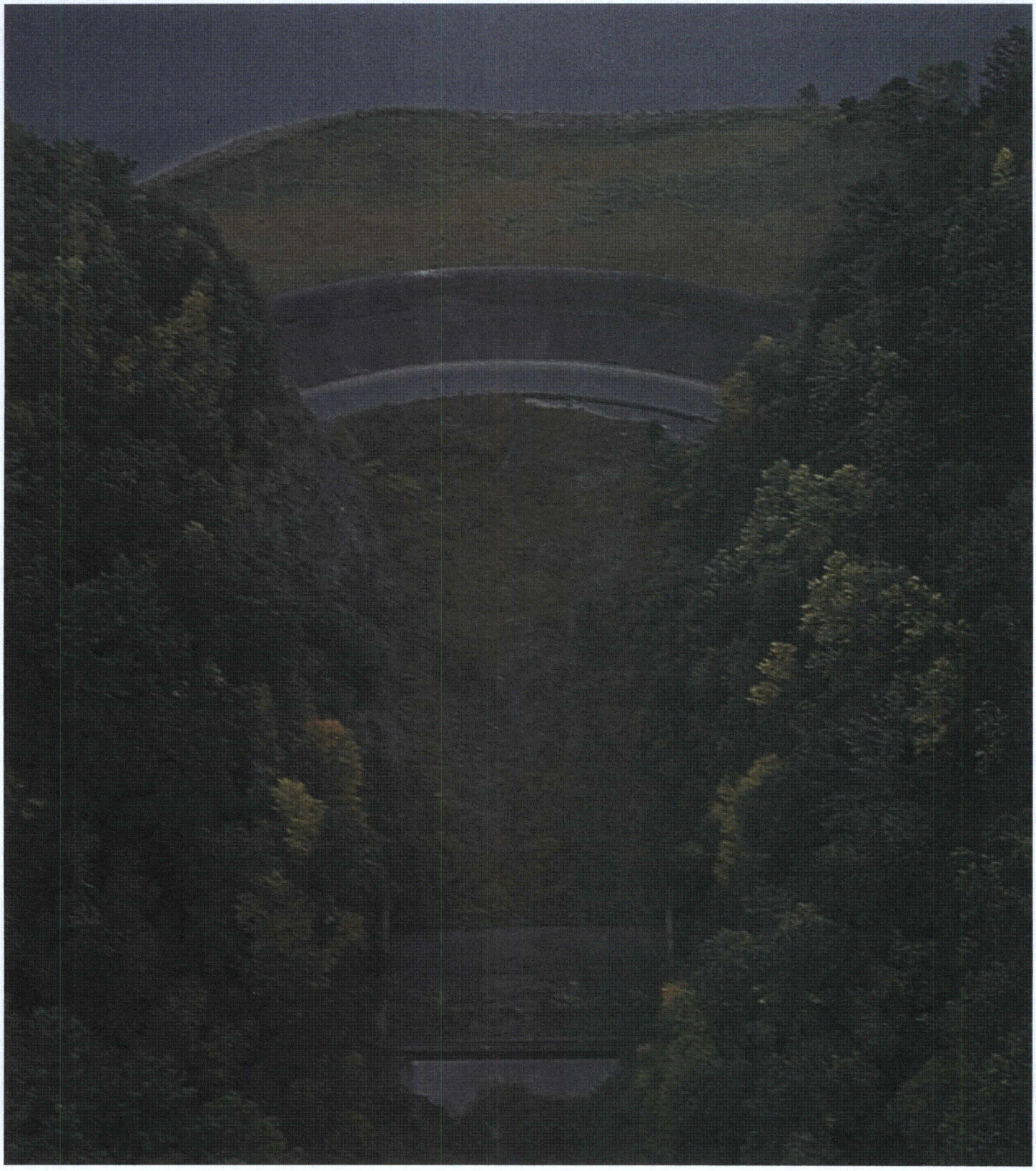
Overflow weir:
- Crest level ..... el. 1744.0
- Crest length ..... 300 ft
- Width, including apron ..... 80 ft

Channel:
- Length ..... 338 ft
- Width ..... Varies from 206 to 100 ft

Control weir:
- Crest level ..... el. 1725.5
- Crest length ..... 100 ft
- Width, including sill ..... 50 ft

Discharge capacity, HW el. 1755 (design level) ..... 43,000 cfs
Foundation ..... Tellico sandstone

FIGURE 15 - Bent Branch Auxiliary Spillway



POWER FACILITIES

INTAKE

Type ..... Submerged concrete chamber with access shaft from visitors' building
Size (outside dimensions) .... 43-ft long by 43-ft wide by 46-ft high
Trashracks ..... Steel bars spaced on 4-in. centers
Gross area of racks ..... 1,170 sq. ft
Valve ..... One 15-ft-dia. butterfly valve

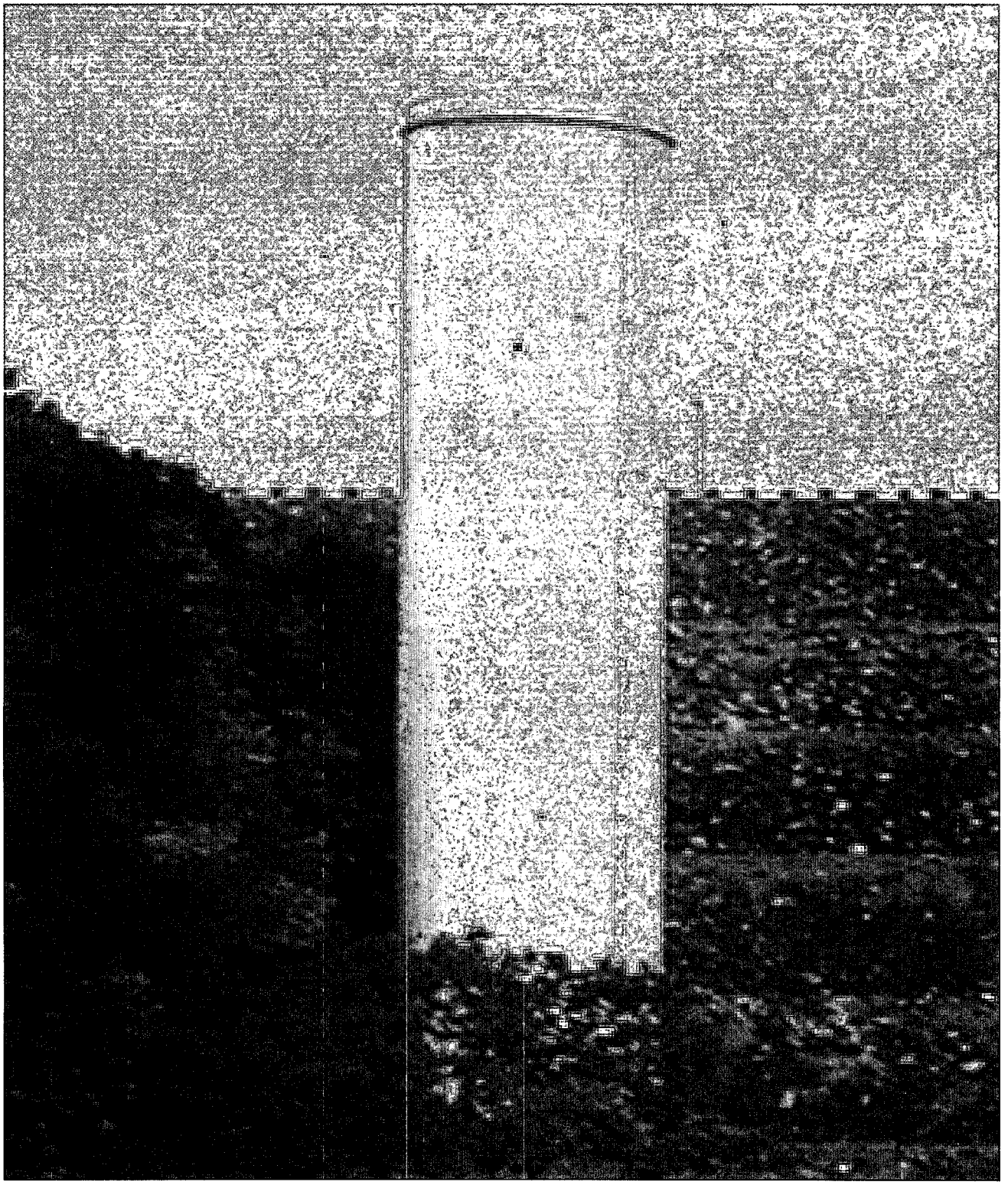
CONDUIT

Type ..... Concrete-lined and steel-lined tunnel
Size and lengths:
Concrete section, 15-ft dia ..... 240 lin ft
Steel sections, 15-ft dia ..... 590 lin ft
Steel section, 14-ft dia ..... 310 lin ft
Total length ..... 1,140 lin ft

SURGE TANK (See Figure 16)

Location ..... On right bank approx. 185-ft upstream from powerhouse
Type ..... Restricted orifice, steel-plate cylindrical tank
Height ..... 200 ft
Diameter:
Tank ..... 36 ft
Riser to tank ..... 14 ft

FIGURE 16 - Surge Tank, Right Downstream Side of Dam, September 1999



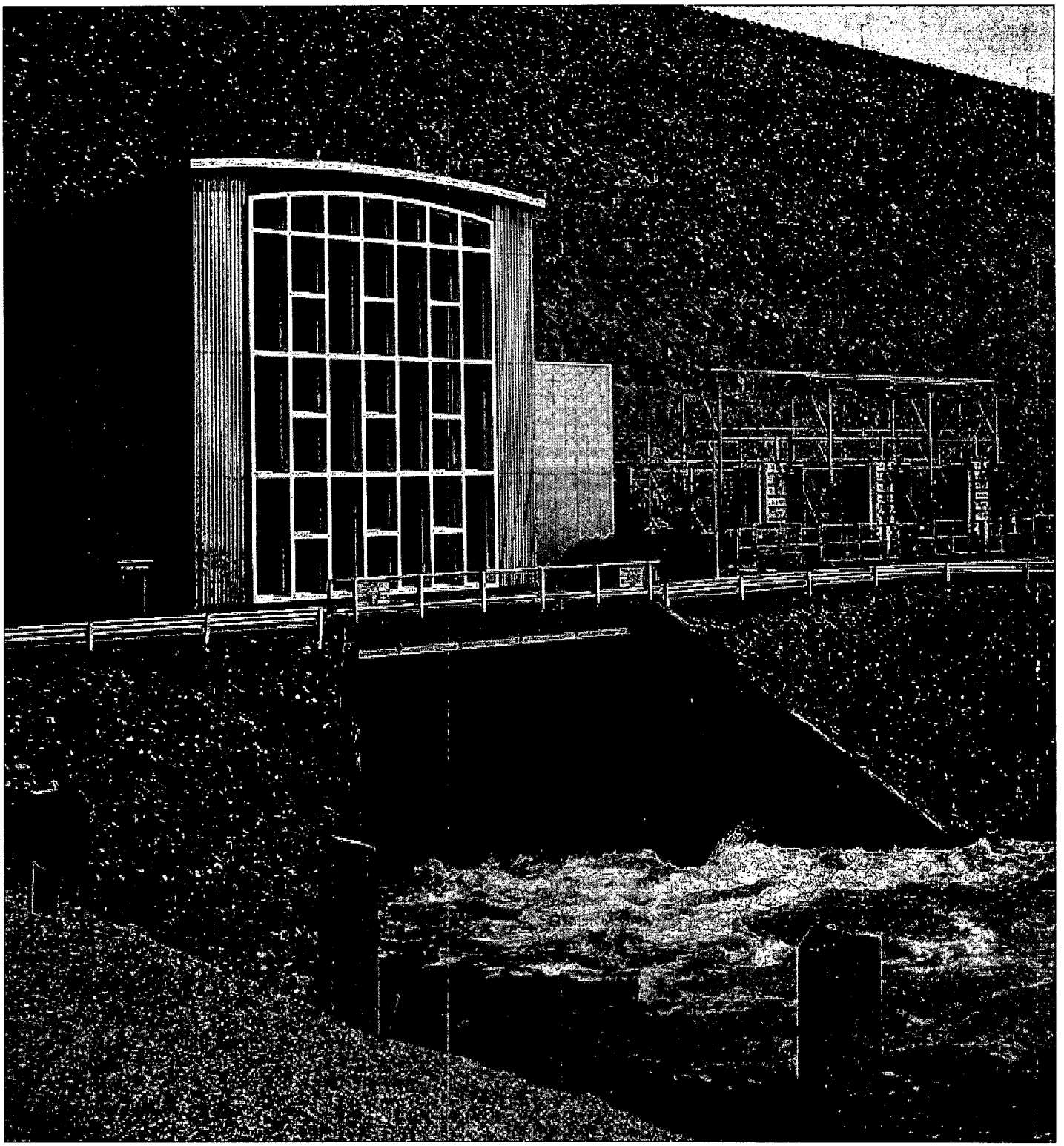
POWER FACILITIES (CONT.)

POWERHOUSE (See Figure 17)

Generating capacity, 1 unit ..... 38,500 kW
Type of construction ..... Enclosed, reinforced concrete, structural steel frame with insulated aluminum panel walls
Principal outside dimensions . 86-ft long by 50-ft wide by 100-ft high
Draft tube:
- Horizontal length (centerline of turbine to downstream face) ..... 64.31 ft
- Vertical distance from distributor centerline to draft tube floor ..... 29.83 ft
- Net area at outlet opening ..... 468 sq. ft

Erecting crane ..... 1 overhead, traveling crane; main hook 165-ton capacity, auxiliary hook 25-ton capacity

FIGURE 17 - Powerhouse and Discharge Structure, September 1999



POWER FACILITIES (CONT.)

HYDRAULIC TURBINES

Number 1
Manufacturer ..... S. Morgan Smith Co.
Type ..... Vertical Francis
Rated capacity ..... (each) 48,500 hp at 180-ft net head
Rated speed ..... 144 rpm
Maximum runaway speed ..... 267 rpm
Specific speed at rating 48
Value of sigma at rating 0.163
Diameter of runner, intake ..... 142 in.
Diameter of runner, discharge ..... 141 in.
Centerline to bottom of runner ..... 36.875 in.
Centerline to top of runner ..... 14.938 in.
Diameter of guide vane circle ..... 173 in.
Diameter of lower pit ..... 16.75 ft
Draft tube (see Powerhouse) ..... Elbow type
Governors ..... Woodward, cabinet actuator type
Heaviest assembly to be lifted by crane ..... 96,600 lb

GENERATORS

Number 1
Manufacturer ..... Westinghouse Electric Corp
Type ..... Enclosed, water-cooled, vertical-shaft
Original Rating ..... 38,888 Kva, 35,000 Kw, 1627 A, 60 degrees C rise, 0.9 pf, 13.8 Kv, 3 ph, 60 Hz
Capacity ..... 44,721 Kva, 40,250 Kw, 1871 A, 80 degrees C rise
Note: Unit 1 rewound and rerated in June 1985:
Rating: ..... 42,777 Kva, 38,500 Kw, 1,790a, 60 degrees C rise, 0.9 pf, 13.8 kV, 3 phase, 60 Hz
Efficiency (guaranteed):
At rated Kva, 1.0 pf ..... 97.75 percent
At 75% kVA, 0.9 pf ..... 97.20 percent
Flywheel effect 25,000,000 lb-ft2
Thrust bearing ..... Kingsbury type, dia. 68 in., Max. load 440 tons
Neutral reactor ..... 0.75 ohm, 5000 A, 1 min
Exciters:
Main ..... 200 kW, 250 V
Pilot ..... 8 kW, 250 V

POWER FACILITIES (CONT.)

GENERATORS (CONT.)

Weight of heaviest crane lift, rotor ..... 165 tons
Diameter over air housing, less trim ..... 410 in.
Diameter of stator bore ..... 258 in.
Top of pilot exciter:
    Above stator soleplates ..... 142.5 in.
    Above generator floor ..... 131 in.

GENERATOR AND TURBINE MODERNIZATION

South Holston Unit 1 is scheduled to be modernized starting in March 2009 and completing in July 2009. The project scope, including components to be replaced and rehabilitated, is yet to be determined.

SINGLE LINE DIAGRAM OF MAIN CONNECTIONS

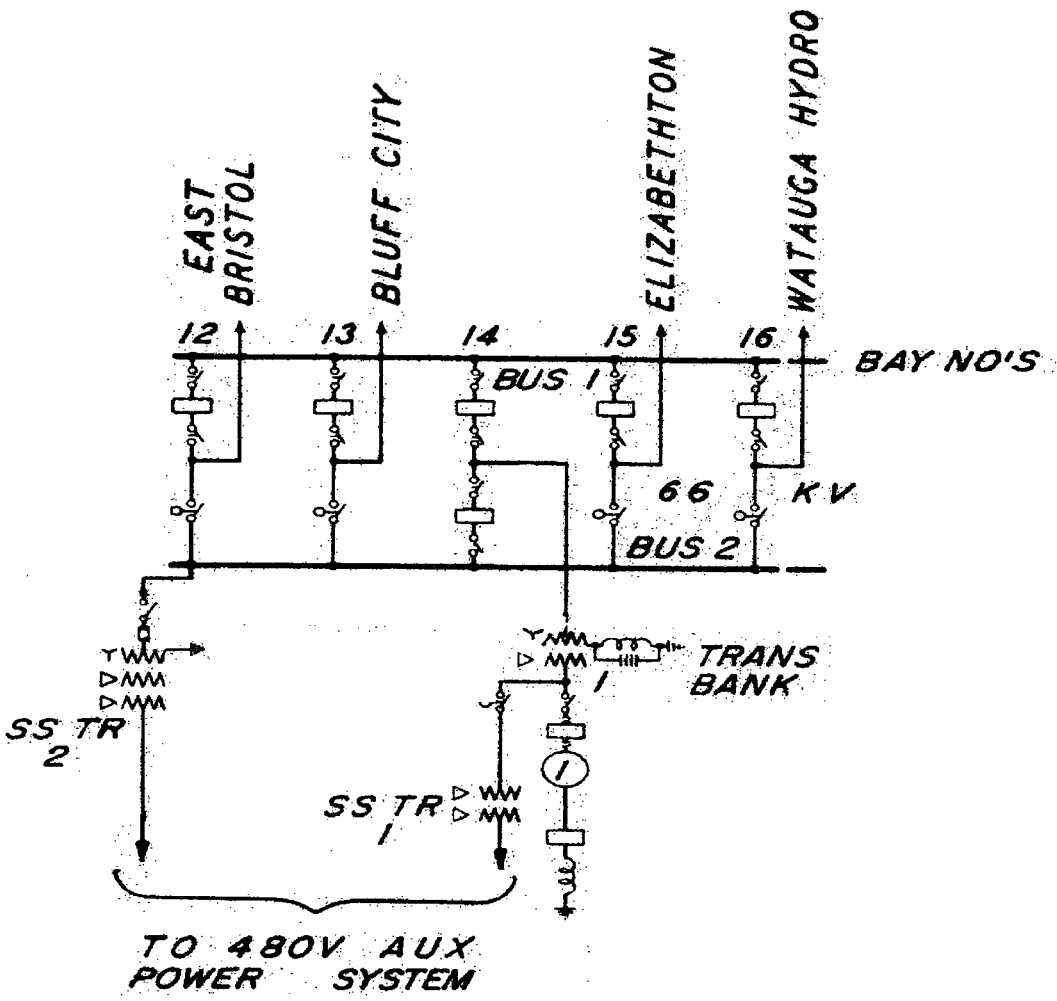
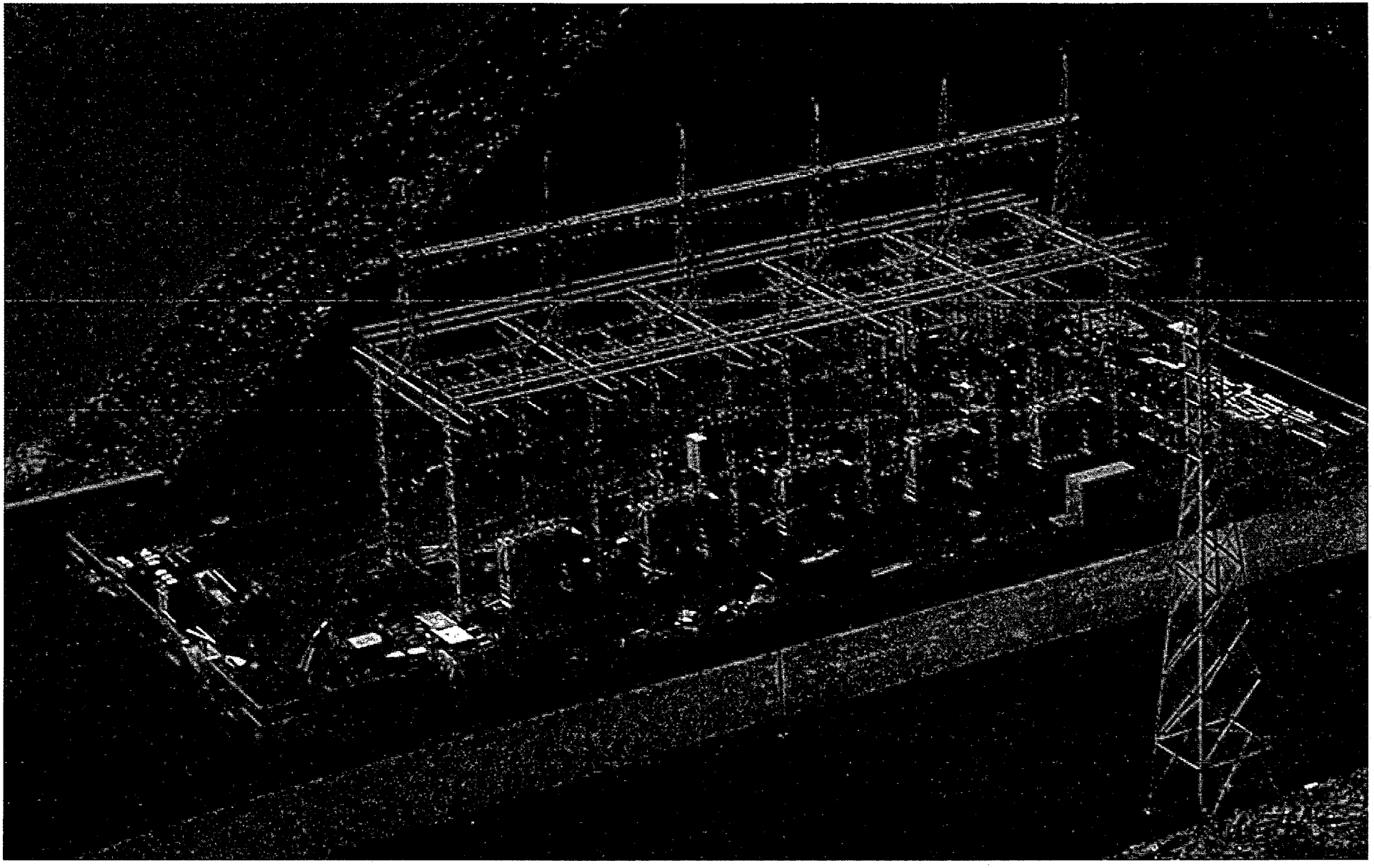


FIGURE 18 - Switchyard, September 1999



POWER FACILITIES (CONT.)

ELECTRIC CONTROLS

From Watauga, by power-line-carrier relay channel. Local controls for initial operation and maintenance.

TRANSMISSION PLANT

Step-up transformers:
1 bank of 3 single-phase, 2-winding transformers, bank 1; bank rated 13.2-69 kV, 33,750 kVA self-cooled, 45,000 kVA forced-air-cooled; Wagner

69-kV circuit breakers:
6 ..... 600-A, 1,000,000-kVA, 5/20-Hz, pneu, Westinghouse

Structures:
5 ..... 69-kV switchyard bays, 26 ft wide
1 ..... transformer structure

TRANSMISSION PLANT DATA

Plant	Location	Phase	Serial Number	MVA Rating		Voltage kV	Cooling	Tap Changer	Oil Preservation System	Oil Volume Gal.	Configuration	Impedance %			Contract Number	Manuf	Yr of Manuf
				55 deg	65 deg							H-X	H-Y	X-Y			
South Holston	Bank 1	A	G9D1045	11.25/15	N/A	69/13.2	OA/FA	DETC	Gas-Blanketed	2530	Wye/Delta	7.63	N/A	N/A	TV-2714A	Wagner	1950
South Holston	Bank 1	B	G9D1044	11.25/15	N/A	69/13.2	OA/FA	DETC	Gas-Blanketed	2530	Wye/Delta	7.66	N/A	N/A	TV-2714A	Wagner	1950
South Holston	Bank 1	C	G9D1046	11.25/15	N/A	69/13.2	OA/FA	DETC	Gas-Blanketed	2530	Wye/Delta	7.65	N/A	N/A	TV-2714A	Wagner	1950

Note: H=High voltage winding
Y=Tertiary winding
X=Low voltage winding

RESERVOIR AND POWER DATA

South Holston

Elevation (feet)	Area (acre*1000)	Volume (ac-ft*1000)	Gross Head (feet)	Best Efficiency Plant Output (mW)	Best Efficiency Turbine Discharge (cfs)	Best Efficiency kW/CFS	Maximum Sustainable Plant Output (mW)	Maximum Sustainable Turbine Discharge (cfs)	Maximum Sustainable kW/CFS
1742	8.94	764.0	252.9	53.3	2,840	18.94	56.6	3,300	17.13
1741	8.79	755.2	251.9	53.1	2,850	18.87	56.4	3,300	17.07
1740	8.65	746.4	250.9	52.9	2,850	18.80	56.2	3,300	17.01
1739	8.51	737.9	249.9	52.8	2,850	18.72	56.0	3,300	16.95
1738	8.39	729.4	248.9	52.6	2,860	18.65	55.8	3,300	16.89
1737	8.27	721.1	247.9	52.4	2,860	18.58	55.6	3,300	16.83
1736	8.16	712.9	246.9	52.2	2,860	18.51	55.4	3,300	16.77
1735	8.05	704.8	245.9	52.0	2,860	18.44	55.2	3,300	16.70
1734	7.96	696.8	244.9	51.9	2,870	18.36	55.0	3,300	16.64
1733	7.87	688.9	243.9	51.7	2,870	18.29	54.8	3,300	16.58
1732	7.79	681.0	242.9	51.5	2,870	18.22	54.6	3,300	16.52
1731	7.72	673.3	241.9	51.3	2,880	18.15	54.4	3,300	16.46
1730	7.66	665.6	240.9	51.1	2,880	18.08	54.2	3,300	16.40
1729	7.60	658.0	239.9	51.0	2,880	18.01	54.0	3,300	16.34
1728	7.54	650.4	238.9	50.8	2,880	17.93	53.8	3,300	16.28
1727	7.48	642.9	237.9	50.6	2,890	17.86	53.6	3,300	16.22
1726	7.42	635.4	236.9	50.4	2,890	17.79	53.4	3,300	16.16
1725	7.36	628.0	235.9	50.2	2,890	17.72	53.2	3,300	16.10
1724	7.30	620.7	234.9	50.1	2,900	17.65	53.0	3,300	16.04
1723	7.24	613.4	233.9	49.9	2,900	17.58	52.8	3,300	15.98
1722	7.18	606.2	232.9	49.7	2,900	17.50	52.6	3,300	15.92
1721	7.12	599.1	231.9	49.5	2,900	17.43	52.4	3,300	15.86
1720	7.07	592.0	230.9	49.3	2,910	17.36	52.2	3,300	15.79
1719	7.01	584.9	229.9	49.2	2,910	17.29	52.0	3,300	15.73
1718	6.95	578.0	228.9	49.0	2,910	17.22	51.8	3,300	15.67
1717	6.89	571.0	227.9	48.8	2,910	17.14	51.6	3,300	15.61
1716	6.83	564.2	226.9	48.6	2,920	17.07	51.4	3,300	15.55
1715	6.78	557.4	225.9	48.4	2,920	17.00	51.2	3,300	15.49
1714	6.72	550.6	224.9	48.3	2,920	16.93	51.0	3,300	15.43
1713	6.67	543.9	223.9	48.1	2,930	16.86	50.8	3,300	15.37
1712	6.61	537.3	222.9	47.9	2,930	16.79	50.6	3,300	15.31
1711	6.56	530.7	221.9	47.7	2,930	16.71	50.4	3,300	15.25

NOTE: Energy in storage values not included in this data

RESERVOIR AND POWER DATA

South Holston

				Best Efficiency			Maximum Sustainable		
Elevation (feet)	Area (acre*1000)	Volume (ac-ft*1000)	Gross Head (feet)	Plant Output (mW)	Turbine Discharge (cfs)	kW/CFS	Plant Output (mW)	Turbine Discharge (cfs)	kW/CFS
1710	6.50	524.2	220.9	47.5	2,930	16.64	50.2	3,300	15.19
1709	6.45	517.7	219.9	47.4	2,940	16.57	50.0	3,300	15.13
1708	6.40	511.3	218.9	47.2	2,940	16.50	49.7	3,300	15.07
1707	6.35	504.9	217.9	47.0	2,940	16.43	49.5	3,300	15.01
1706	6.30	498.6	216.9	46.8	2,950	16.36	49.3	3,300	14.95
1705	6.25	492.3	215.9	46.6	2,950	16.28	49.1	3,300	14.89
1704	6.20	486.1	214.9	46.4	2,950	16.21	48.9	3,300	14.82
1703	6.15	479.9	213.9	46.3	2,950	16.14	48.7	3,300	14.76
1702	6.10	473.8	212.9	46.1	2,960	16.07	48.5	3,300	14.70
1701	6.05	467.7	211.9	45.9	2,960	16.00	48.3	3,300	14.64
1700	6.00	461.7	210.9	45.7	2,960	15.93	48.1	3,300	14.58
1699	5.96	455.7	209.9	45.5	2,960	15.85	47.9	3,300	14.52
1698	5.91	449.8	208.9	45.4	2,970	15.78	47.7	3,300	14.46
1697	5.87	443.9	207.9	45.2	2,970	15.71	47.5	3,300	14.40
1696	5.82	438.0	206.9	45.0	2,970	15.64	47.3	3,300	14.34
1695	5.78	432.2	205.9	44.8	2,980	15.57	47.1	3,300	14.28
1694	5.73	426.5	204.9	44.6	2,980	15.49	46.9	3,300	14.22
1693	5.69	420.8	203.9	44.5	2,980	15.42	46.7	3,300	14.16
1692	5.64	415.1	202.9	44.3	2,980	15.35	46.5	3,300	14.10
1691	5.60	409.5	201.9	44.1	2,990	15.28	46.3	3,300	14.04
1690	5.56	403.9	200.9	43.9	2,990	15.21	46.1	3,300	13.98
1689	5.51	398.4	199.9	43.7	2,990	15.14	45.9	3,300	13.91
1688	5.47	392.9	198.9	43.6	3,000	15.06	45.7	3,300	13.85
1687	5.43	387.4	197.9	43.4	3,000	14.99	45.5	3,300	13.79
1686	5.38	382.0	196.9	43.2	3,000	14.92	45.3	3,300	13.73
1685	5.34	376.7	195.9	43.0	3,000	14.85	45.1	3,300	13.67
1684	5.29	371.3	194.9	42.8	3,010	14.78	44.9	3,300	13.61
1683	5.25	366.1	193.9	42.7	3,010	14.71	44.7	3,300	13.55
1682	5.20	360.9	192.9	42.5	3,010	14.63	44.5	3,300	13.49
1681	5.15	355.7	191.9	42.3	3,020	14.56	44.3	3,300	13.43
1680	5.10	350.6	190.9	42.1	3,020	14.49	44.1	3,300	13.37
1679	5.06	345.5	189.9	41.9	3,020	14.42	43.9	3,300	13.31

NOTE: Energy in storage values not included in this data

RESERVOIR AND POWER DATA

South Holston

				Best Efficiency			Maximum Sustainable		
Elevation (feet)	Area (acre*1000)	Volume (ac-ft*1000)	Gross Head (feet)	Plant Output (mW)	Turbine Discharge (cfs)	kW/CFS	Plant Output (mW)	Turbine Discharge (cfs)	kW/CFS
1678	5.01	340.4	188.9	41.8	3,020	14.35	43.7	3,300	13.25
1677	4.96	335.5	187.9	41.6	3,030	14.27	43.5	3,300	13.19
1676	4.91	330.5	186.9	41.4	3,030	14.20	43.3	3,300	13.13
1675	4.86	325.6	185.9	41.2	3,030	14.13	43.1	3,300	13.07
1674	4.81	320.8	184.9	41.0	3,030	14.06	42.9	3,300	13.00
1673	4.75	316.0	183.9	40.9	3,040	13.99	42.7	3,300	12.94
1672	4.70	311.3	182.9	40.7	3,040	13.92	42.5	3,300	12.88
1671	4.65	306.6	181.9	40.5	3,040	13.84	42.3	3,300	12.82
1670	4.59	302.0	180.9	40.3	3,050	13.77	42.1	3,300	12.76
1669	4.54	297.4	179.9	40.1	3,050	13.70	41.9	3,300	12.70
1668	4.49	292.9	178.9	39.9	3,050	13.63	41.7	3,300	12.64
1667	4.43	288.5	177.9	39.8	3,050	13.56	41.5	3,300	12.58
1666	4.38	284.1	176.9	39.6	3,060	13.49	41.3	3,300	12.52
1665	4.33	279.7	175.9	39.4	3,060	13.41	41.1	3,300	12.46
1664	4.28	275.4	174.9	39.2	3,060	13.34	40.9	3,300	12.40
1663	4.22	271.2	173.9	39.0	3,070	13.27	40.7	3,300	12.34
1662	4.17	267.0	172.9	38.9	3,070	13.20	40.5	3,300	12.28
1661	4.12	262.8	171.9	38.7	3,070	13.13	40.3	3,300	12.22
1660	4.07	258.7	170.9	38.5	3,070	13.05	40.1	3,300	12.16
1659	4.02	254.7	169.9	38.3	3,080	12.98	39.9	3,300	12.10
1658	3.97	250.7	168.9	38.1	3,080	12.91	39.7	3,300	12.03
1657	3.92	246.7	167.9	38.0	3,080	12.84	39.5	3,300	11.97
1656	3.87	242.8	166.9	37.8	3,090	12.77	39.3	3,300	11.91
1655	3.82	239.0	165.9	37.6	3,090	12.70	39.1	3,300	11.85
1654	3.77	235.2	164.9	37.4	3,090	12.62	38.9	3,300	11.79
1653	3.72	231.5	163.9	37.2	3,090	12.55	38.7	3,300	11.73
1652	3.67	227.8	162.9	37.1	3,100	12.48	38.5	3,300	11.67
1651	3.62	224.1	161.9	36.9	3,100	12.41	38.3	3,300	11.61
1650	3.57	220.5	160.9	36.7	3,100	12.34	38.1	3,300	11.55
1649	3.52	217.0	159.9	36.5	3,100	12.27	37.9	3,300	11.49
1648	3.47	213.5	158.9	36.3	3,110	12.19	37.7	3,300	11.43
1647	3.42	210.1	157.9	36.2	3,110	12.12	37.5	3,300	11.37

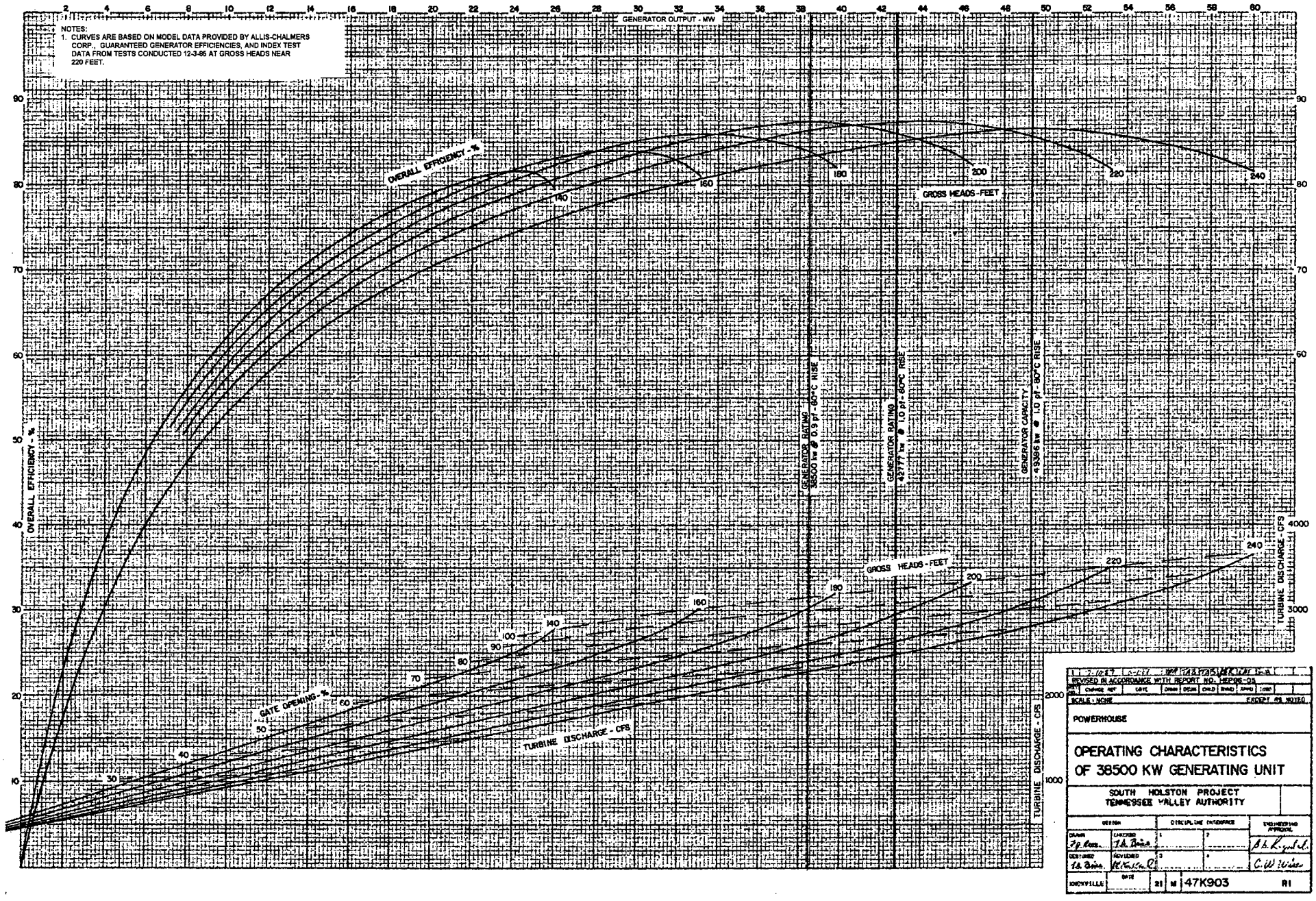
NOTE: Energy in storage values not included in this data

RESERVOIR AND POWER DATA

South Holston

				Best Efficiency			Maximum Sustainable		
Elevation (feet)	Area (acre*1000)	Volume (ac-ft*1000)	Gross Head (feet)	Plant Output (mW)	Turbine Discharge (cfs)	kW/CFS	Plant Output (mW)	Turbine Discharge (cfs)	kW/CFS
1646	3.38	206.6	156.9	36.0	3,110	12.05	37.3	3,300	11.31
1645	3.34	203.3	155.9	35.8	3,120	11.98	37.1	3,300	11.25
1644	3.29	200.0	154.9	35.6	3,120	11.91	36.9	3,300	11.19
1643	3.25	196.7	153.9	35.4	3,120	11.83	36.7	3,300	11.12
1642	3.21	193.5	152.9	35.3	3,120	11.76	36.5	3,300	11.06
1641	3.17	190.3	151.9	35.1	3,130	11.69	36.3	3,300	11.00
1640	3.14	187.1	150.9	34.9	3,130	11.62	36.1	3,300	10.94
1639	3.10	184.0	149.9	34.7	3,130	11.55	35.9	3,300	10.88
1638	3.06	180.9	148.9	34.5	3,140	11.48	35.7	3,300	10.82
1637	3.03	177.9	147.9	34.4	3,140	11.40	35.5	3,300	10.76
1636	2.99	174.9	146.9	34.2	3,140	11.33	35.3	3,300	10.70
1635	2.96	171.9	145.9	34.0	3,140	11.26	35.1	3,300	10.64
1634	2.93	169.0	144.9	33.8	3,150	11.19	34.9	3,300	10.58
1633	2.89	166.0	143.9	33.6	3,150	11.12	34.7	3,300	10.52
1632	2.86	163.2	142.9	33.4	3,150	11.05	34.5	3,300	10.46
1631	2.83	160.3	141.9	33.3	3,150	10.97	34.3	3,300	10.40
1630	2.80	157.5	140.9	33.1	3,160	10.90	34.1	3,300	10.34
1629	2.77	154.7	139.9	32.9	3,160	10.83	33.9	3,300	10.28
1628	2.74	152.0	138.9	32.7	3,160	10.76	33.7	3,300	10.22
1627	2.71	149.2	137.9	32.5	3,170	10.69	33.5	3,300	10.15
1626	2.69	146.5	136.9	32.4	3,170	10.61	33.3	3,300	10.09
1625	2.66	143.8	135.9	32.2	3,170	10.54	33.1	3,300	10.03
1624	2.63	141.2	134.9	32.0	3,170	10.47	32.9	3,300	9.97
1623	2.60	138.6	133.9	31.8	3,180	10.40	32.7	3,300	9.91
1622	2.57	136.0	132.9	31.6	3,180	10.33	32.5	3,300	9.85
1621	2.54	133.5	131.9	31.5	3,180	10.26	32.3	3,300	9.79
1620	2.51	130.9	130.9	31.3	3,190	10.18	32.1	3,300	9.73
1619	2.48	128.4	129.9	31.1	3,190	10.11	31.9	3,300	9.67
1618	2.46	126.0	128.9	30.9	3,190	10.04	31.7	3,300	9.61
1617	2.43	123.5	127.9	30.7	3,190	9.97	31.5	3,300	9.55
1616	2.40	121.1	126.9	30.6	3,200	9.90	31.3	3,300	9.49

NOTE: Energy in storage values not included in this data


NOTES:
1. CURVES ARE BASED ON MODEL DATA PROVIDED BY ALLIS-CHALMERS CORP., GUARANTEED GENERATOR EFFICIENCIES, AND INDEX TEST DATA FROM TESTS CONDUCTED 12-3-85 AT GROSS HEADS NEAR 220 FEET.
GENERATOR OUTPUT - MW
OVERALL EFFICIENCY - %
GROSS HEADS - FEET
GATE OPENING - %
TURBINE DISCHARGE - CFS
GENERATOR RATING 38500 kw @ 0.9 pf - 60°C RISE
GENERATOR RATING 42777 kw @ 1.0 pf - 60°C RISE
GENERATOR CAPACITY 43396 kw @ 1.0 pf - 80°C RISE
REVISED IN ACCORDANCE WITH REPORT NO. HEPRS-05
SCALE - NONE
POWERHOUSE
OPERATING CHARACTERISTICS OF 38500 KW GENERATING UNIT
SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
KNOXVILLE
47K903
R1

South Holston Spill Compilation

Tennessee Valley Authority
River System Operations

Volumes are average daily in day-second-feet. except as shown.
Maximum spill, date of maximum, and number of days of spill in each spill period, in this order. "Total Days" is for calendar year and does not always equal the sum of the days in periods because of extension of periods into adjacent years.
Water may be spilled through the spillway and/or Howell-Bunger valves. All unmarked spill was through valves.
Maximum hourly average discharge to date was 8945 cfs at 11 p.m. on 2/11/57.
*Spillway

YEAR	MAXIMUM AVERAGE DAILY DISCHARGE (TURBINE + SPILL)	DATE	NUMBER OF PERIODS	TOTAL DAYS	
1950	2	2/9	1	42	2---11/20-12/31---42
1951	1736	11/26	2	2	8---5/25---1; 116---6/26---1
1952	2882	10/3	0	0	
1953	2500	5/9	0	0	
1954	2623	1/2	0	0	
1955	3139	9/2	0	0	
1956	2887	11/28	0	0	
1957	8300	2/12	1	10	5000---2/12-13---10
1958	3008	11/27	0	0	
1959	2818	1/5	0	0	
1960	3028	9/22	0	0	
1961	2794	6/30	0	0	
1962	2697	11/2	0	0	
1963	2736	9/16	0	0	
1964	2313	11/20	0	0	
1965	2925	12/20	0	0	
1966	2663	2/3	0	0	
1967	2975	12/28	2	14	7---3/28---5; 9---4/3---9 (through two 4-inch hoses as a special operation)
1968	3005	1/7	0	0	
1969	2910	11/15	1	4	12---4/29---4 (through small hose line to supply Bristol)
1970	2761	8/6	0	0	
1971	2522	8/3	0	0	
1972	3187	12/30	0	0	

South Holston Spill Compilation

Volumes are average daily in day-second-feet. except as shown.
Maximum spill, date of maximum, and number of days of spill in each spill period, in this order. "Total Days" is for calendar year and does not always equal the sum of the days in periods because of extension of periods into adjacent years.
Water may be spilled through the spillway and/or Howell-Bunger valves. All unmarked spill was through valves.
Maximum hourly average discharge to date was 8945 cfs at 11 p.m. on 2/11/57.
*Spillway

YEAR	MAXIMUM AVERAGE DAILY DISCHARGE (TURBINE + SPILL)	DATE	NUMBER OF PERIODS	TOTAL DAYS	
1973	3214	1/10	3	17	93---4/14---2; 93---5/26---2; 645---6/19---13
1974	3137	1/27	0	0	
1975	3028	1/31	2	16	2510---4/2---5; 209---5/23---11
1976	2673	9/8	0	0	
1977	3400	12/14	3	31	530---11/20---2; 330---12/13-16---26; 200---12/30---3
1978	2813	1/1	1	9	1259---1/10---9
1979	2827	3/9	4	10	272---4/8---3; 267---4/16---1; 124---4/18---3; 1175---11/27---3
1980	2469	7/8	2	5	848---7/9---3; 604---10/16---2
1981	2052	2/13	1	19	769---6/9---19
1982	2425	1/11	1	5	340---7/27-29---5
1983	2559	12/26	2	16	230---4/17---14;430---11/6---2
1984	4457	5/13	2	13	939---1/23---4; 2140---5/13-17---9
1985	2731	1/21	4	64	431---2/4---3; 128---4/26---1; 451---6/12---58; 8---9/24---2
1986	2252	1/1	0	0	
1987	4345	4/19	2	32	14---3/31---13; 1183---5/4---19
1988	991	6/22	2	6	14---5/7---5; 2---11/13---1
1989	3044	5/12	2	21	14---3/28---18; 148---6/24---3
1990	3352	2/26	0	0	
1991	3388	4/6	3	51	600---4/4---2; 125---4/11---46, 8---12/29---3
1992	3020	12/27-31	1	235	3020---12/27-31---235
1993	3020	1/1-7	2	227	3020---1/1-7---226; 50---8/21---1
1994	4497	2/28	5	33	2173---2/18---8; 1770---2/26-28---5; 540---4/1,2, & 4---6; 530---4/8 & 9---4; 210---6/24-30---10
1995	2493	2/23	3	6	113---4/11-13---4; 48---8/9---1; 19---9/3---1

South Holston Spill Compilation

Tennessee Valley Authority
River System Operations

Volumes are average daily in day-second-feet. except as shown.
Maximum spill, date of maximum, and number of days of spill in each spill period, in this order. "Total Days" is for calendar year and does not always equal the sum of the days in periods because of extension of periods into adjacent years.
Water may be spilled through the spillway and/or Howell-Bunger valves. All unmarked spill was through valves.
Maximum hourly average discharge to date was 8945 cfs at 11 p.m. on 2/11/57.
*Spillway

YEAR	MAXIMUM AVERAGE DAILY DISCHARGE (TURBINE + SPILL)	DATE	NUMBER OF PERIODS	TOTAL DAYS	
1996	2769	2/9	1	23	200---4/16-5/6---23
1997	2924	6/2	3	10	588---10/31---3; 125---11/3---1; 251---11/18,20---6
1998	3100	5/26	3	26	400---2/20-22,27---10; 270---5/19-22---6; 125---11/10-19---10
1999	1928	3/14	2	11	42---10/1---1; 125---10/4-12---10

ANNUAL MAXIMUM AND MINIMUM ELEVATIONS, IN ORDER OF MAGNITUDE

RIVER SCHEDULING
TVA OPERATED RESERVOIR SYSTEM
FROM DATE OF RESERVOIR CLOSURE THROUGH 1999

SOUTH HOLSTON

MAXIMUM					MINIMUM				
ORDER	ELEVATION	YEAR	MONTH	DAY	ORDER	ELEVATION	YEAR	MONTH	DAY
1	1736.92	1987	APR.	27	1	1488.80 *	1950	NOV.	20
2	1736.86	1984	MAY	10	2	1595.30 #	1951	JAN.	1
3	1732.82	1975	APR.	3	3	1614.15	1956	JAN.	13
4	1732.35	1972	MAY	25	4	1615.47	1954	DEC.	24
5	1732.34	1989	JUNE	22	5	1616.68	1955	FEB.	4
6	1732.29	1998	APR.	22	6	1617.42	1978	JAN.	3
7	1730.92	1996	JUNE	1	7	1619.92	1977	DEC.	31
8	1730.80	1992	JUNE	7	8	1632.51	1959	JAN.	17
9	1730.76	1997	MAY	27	9	1642.66	1958	DEC.	27
10	1730.68	1990	MAY	7	10	1643.97	1953	DEC.	31
11	1729.87	1973	APR.	29	11	1648.96	1966	FEB.	9
12	1729.63	1983	MAY	25	12	1656.81	1960	DEC.	30
13	1729.51	1991	JUNE	13	13	1657.04	1961	JAN.	1
14	1729.38	1993	MAY	17	14	1658.94	1970	DEC.	18
15	1729.26	1979	JUNE	25	15	1662.75	1963	DEC.	31
16	1729.25	1968	JUNE	4	16	1662.76	1964	JAN.	1
17	1729.04	1994	MAY	30	17	1663.00	1971	JAN.	1
18	1728.96	1971	JUNE	2	18	1667.97	1962	NOV.	16
19	1728.88	1995	JULY	3	19	1669.74	1952	NOV.	15
20	1727.42	1958	MAY	19	20	1669.90	1957	NOV.	15
21	1727.41	1980	MAY	5	21	1674.22	1981	FEB.	13
22	1727.04	1974	MAY	14	22	1674.54	1965	DEC.	31
23	1727.03	1967	JUNE	5	23	1675.52	1969	DEC.	29
24	1726.99	1965	APR.	18	24	1681.10	1980	DEC.	26
25	1726.15	1999	MAY	31	25	1681.73	1987	DEC.	24
26	1725.10	1981	JUNE	29	26	1682.00	1975	DEC.	21
27	1725.07	1957	APR.	15	27	1683.25	1988	OCT.	23
28	1724.75	1969	MAY	5	28	1683.93	1976	JAN.	1
29	1723.89	1960	APR.	25	29	1686.56	1968	DEC.	23
30	1723.21	1962	APR.	17	30	1688.37	1989	JAN.	1
31	1723.19	1986	JUNE	16	31	1688.41	1984	DEC.	8
32	1723.06	1963	APR.	2	32	1689.14	1979	JAN.	1
33	1722.96	1982	JUNE	23	33	1689.29	1997	DEC.	24
34	1721.40	1952	APR.	14	34	1689.40	1998	JAN.	2
35	1720.97	1977	APR.	18	35	1690.17	1985	JAN.	1
36	1719.80	1953	MAY	23	36	1690.99	1982	JAN.	1
37	1719.45	1961	JUNE	22	37	1691.00	1974	DEC.	6
38	1718.66	1985	JUNE	18	38	1691.55	1986	DEC.	9
39	1717.12	1964	JUNE	5	39	1693.65	1999	JAN.	6
40	1716.51	1976	JUNE	25	40	1693.85	1995	JAN.	6
41	1713.61	1956	MAY	21	41	1694.34	1996	DEC.	27
42	1712.62	1978	JUNE	12	42	1695.40	1994	DEC.	31
43	1711.94	1970	MAY	20	43	1696.45	1993	NOV.	26
44	1709.51	1955	APR.	26	44	1697.99	1990	JAN.	1
45	1704.66	1966	DEC.	19	45	1698.25	1983	FEB.	1
46	1704.08	1951	JULY	2	46	1698.65	1972	JAN.	1
47	1702.54	1988	MAY	25	47	1698.95	1991	NOV.	8
48	1696.42	1959	MAY	23	48	1701.71	1967	JAN.	7
49	1692.44	1954	MAY	31	49	1702.39 %	1973	DEC.	21
50	1595.30 #	1950	DEC.	31	50	1703.06	1992	DEC.	16

*** CLOSURE**
% MIDNIGHT ELEVATION
 # ESTIMATED
TOP-OF-GATES ELEVATION 1742

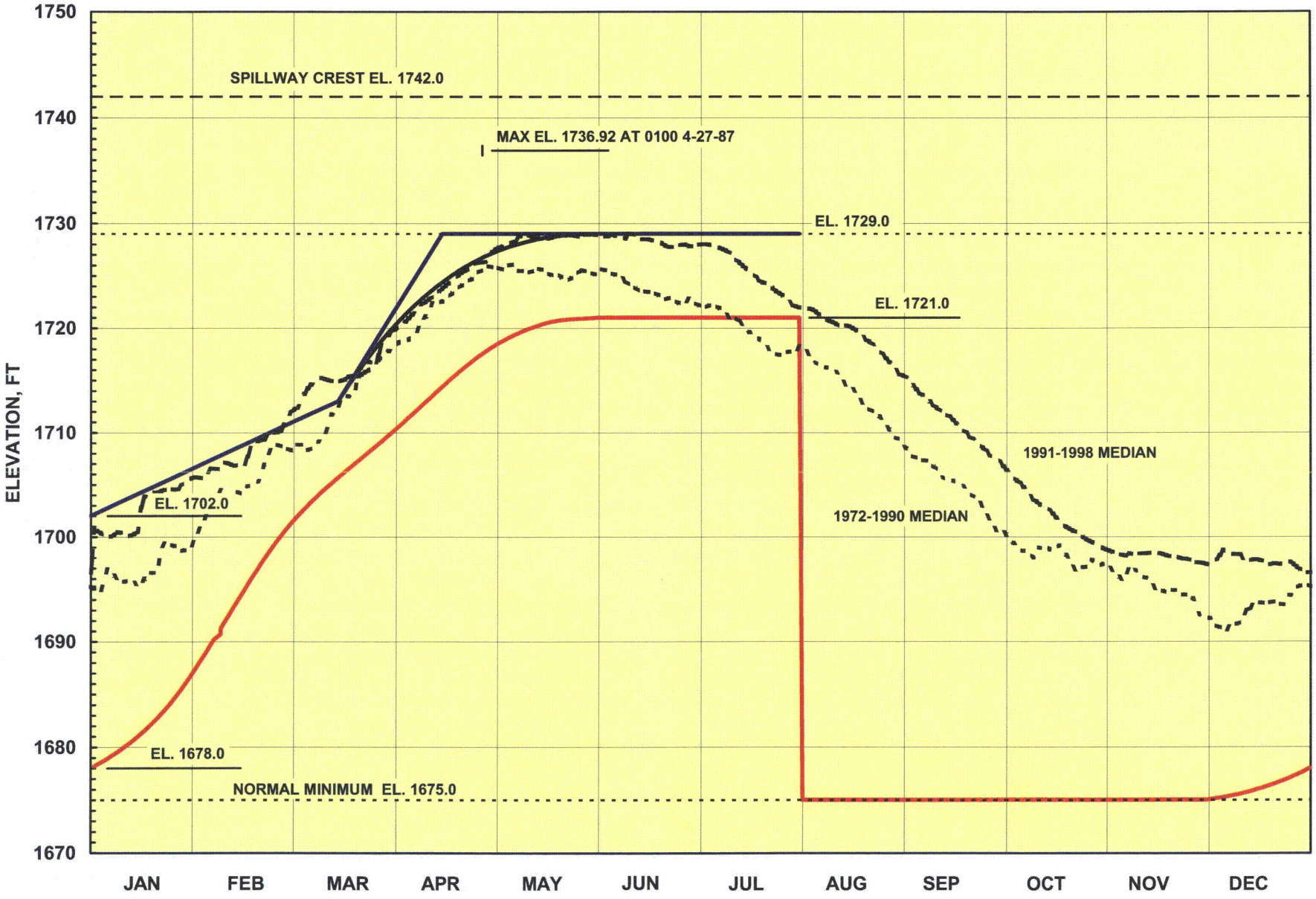
AVERAGE WEEKLY CFS

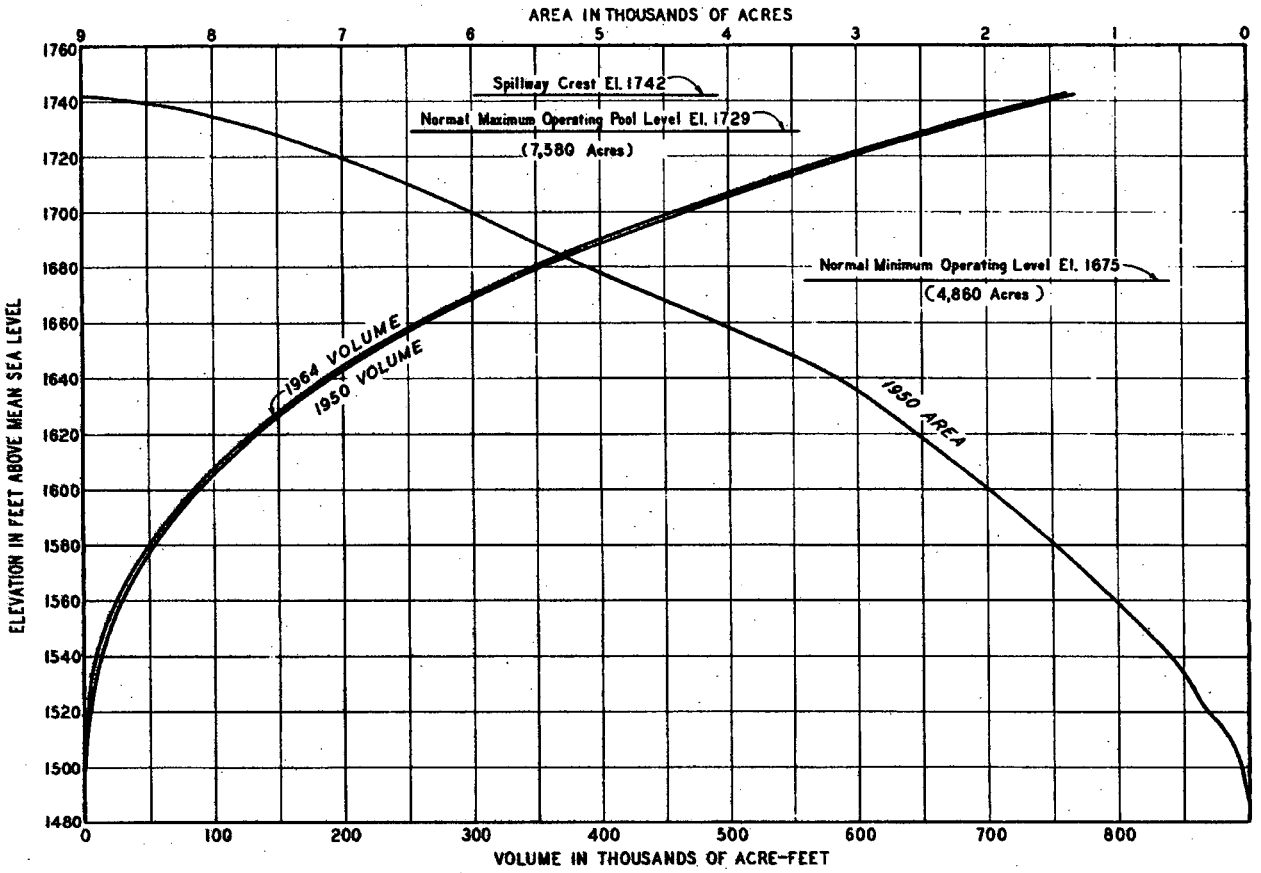
MAXIMUM, MINIMIUM, MEDIAN, AND MEAN
Adjusted Flow by Weeks
South Holston
Years = 1926-1999

WEEK ENDING	WEEK NO.	MAXIMUM	YR	MINIMUM	YR	MEDIAN	MEAN
JAN 7	1	5,400	1974	138	1940	996	1,240
JAN 14	2	4,780	1946	152	1942	963	1,210
JAN 21	3	6,390	1947	230	1981	1,010	1,330
JAN 28	4	4,240	1954	142	1940	1,180	1,500
FEB 4	5	13,100	1957	149	1940	1,380	1,690
FEB 11	6	8,900	1957	187	1934	1,370	1,810
FEB 18	7	4,750	1948	191	1934	1,530	1,820
FEB 25	8	6,450	1927	216	1934	1,580	1,760
MAR 4	9	4,540	1929	316	1941	1,380	1,660
MAR 11	10	4,910	1963	360	1931	1,560	1,720
MAR 18	11	7,340	1963	371	1931	1,370	1,820
MAR 25	12	5,520	1955	390	1931	1,630	1,890
APR 1	13	6,850	1994	435	1966	1,470	1,860
APR 8	14	8,850	1977	391	1966	1,360	1,660
APR 15	15	4,240	1987	417	1986	1,260	1,530
APR 22	16	6,900	1987	358	1942	1,160	1,370
APR 29	17	4,980	1987	271	1942	1,140	1,310
MAY 6	18	3,700	1958	233	1942	956	1,160
MAY 13	19	7,240	1984	268	1942	959	1,290
MAY 20	20	3,180	1950	284	1941	915	1,100
MAY 27	21	2,980	1942	239	1941	838	1,050
JUN 3	22	3,890	1981	196	1941	700	993
JUN 10	23	3,260	1981	221	1988	646	783
JUN 17	24	2,830	1998	182	1999	571	747
JUN 24	25	3,530	1972	182	1988	569	702
JUL 1	26	2,900	1929	83	1988	481	593
JUL 8	27	2,480	1929	91	1988	525	579
JUL 15	28	2,410	1949	133	1993	497	571
JUL 22	29	2,750	1938	176	1988	420	544
JUL 29	30	3,100	1938	146	1986	449	544
AUG 5	31	2,820	1940	36	1993	405	582
AUG 12	32	3,460	1942	115	1988	395	500
AUG 19	33	5,490	1940	58	1988	361	542
AUG 26	34	1,590	1940	84	1987	355	467
SEP 2	35	1,150	1928	43	1988	290	370
SEP 9	36	2,870	1928	108	1995	277	399
SEP 16	37	802	1928	76	1985	291	316
SEP 23	38	2,170	1989	90	1999	266	339
SEP 30	39	1,930	1989	-72	1998	257	354
OCT 7	40	3,770	1977	74	1987	266	445
OCT 14	41	3,260	1976	68	1988	250	363
OCT 21	42	2,230	1964	93	1998	252	393
OCT 28	43	2,680	1937	25	1927	260	428
NOV 4	44	2,200	1937	91	1991	292	419
NOV 11	45	6,670	1977	124	1953	337	509
NOV 18	46	1,740	1977	137	1941	398	482
NOV 25	47	1,610	1957	137	1998	444	524
DEC 2	48	2,500	1982	109	1998	496	688
DEC 9	49	2,830	1950	151	1939	477	775
DEC 16	50	6,470	1972	156	1939	684	939
DEC 23	51	4,190	1961	176	1941	653	941
DEC 31	52	5,530	1926	217	1939	957	1,170

AVERAGE FLOW: 1926 - 1999 = 957 CFS **RIVER SYSTEM OPERATIONS**

ANNUAL OPERATING CYCLE





ELEVATION FT	1950 AREA AC	VOLUME AC-FT		
		1950	1958	1964
1742	9,010	767,970	768,640	764,040
1730	7,660	669,520	668,190	665,590
1720	7,060	595,920	594,600	591,980
1710	6,500	528,140	526,850	524,180
1700	6,000	465,670	464,450	461,690
1690	5,550	407,900	406,720	403,910
1680	5,120	354,510	353,380	350,560
1670	4,630	305,770	304,750	302,020
1660	4,100	262,150	261,240	258,720
1650	3,590	223,720	222,880	220,540
1640	3,160	190,010	189,350	187,130
1630	2,820	160,150	159,660	157,500
1620	2,540	133,380	132,990	130,930
1610	2,260	109,410	109,130	107,190
1600	1,990	88,170	87,970	86,120
1590	1,730	69,580	69,430	67,740
1580	1,470	53,570	53,460	51,900
1570	1,250	39,990	39,860	38,430
1560	1,020	28,660	28,520	27,140
1550	800	19,580	19,470	18,290
1540	600	12,610	12,500	11,450
1530	450	7,450	7,390	6,430
1520	310	3,670	3,600	2,710
1510	140	1,390	1,340	974
1500	60	390	390	180
1490	10	30	30	0
1485	0	0	0	0

NOTES:

Reservoir areas were measured on TVA land maps, scale 1" = 500', at elevations 1640, 1730, & 1742, and on TVA topographic maps, scale 1"=2,000', at elevations 1500, 1520, 1540, & 1560. The TVA maps were prepared by the Maps & Surveys Branch. Contours were made to conform to elevations on TVA sediment range cross sections which are at one-half to two mile intervals within the reservoir.

Elevations are referred to the 1936 Supplementary Adjustment of the USC & GS.

Area of the original river within reservoir = 710 acres.

Drainage area above dam = 703 square miles.

The 1958 and subsequent volumes were determined by the constant factor method for computing sediment.

Dam closure November 20, 1950.

S.F. HOLSTON RIVER MILE 49.8

RESERVOIR AREAS AND VOLUMES

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING

SUBMITTED	RECOMMENDED	APPROVED

KNOXVILLE	12-28-62	21	DA	1	321N799R

THIS DRAWING SUPERSEDES 21-DA-1 321 G 670+0

RESERVOIR RELEASE IMPROVEMENTS

A minimum flow improvement system has been implemented at South Holston by installing a reregulation weir. This weir has a tongue-and-groove timbers fitted together and supported as independent wall sections in a stoplog arrangement using slotted concrete piers as wall support. The minimum flow improvement target at South Holston is 90 cfs.

An areation system has also been developed to increase the dissolved oxygen in tailwaters. This has resulted in a dissolved oxygen improvement of approximately 7 mg/L. This improvement was accomplished by installing an extended-crest labyrinth weir (See Figure 9) and utilizing turbine venting. Turbine venting utilizes the vacuum breaker ports on the turbine casing to induce air into the water flowing through the turbine. This technique provides vacuum breaker system by-pass piping for aeration.

Both the aeration and minimum flow system at South Holston have resulted in an overall improvement in the quality of the tailwaters and aquatic habitat downsteam of the dam. Also as a result of these improvements, visits to the South Holston tailwaters have essentially doubled. Further, an increase in diversity of aquatic insects and small fish such as rollers, darters, and shiners has been observed in the South Holston tailwaters.

CONSTRUCTION DATA

HOUSING FACILITIES

Houses ..... 55 semipermanent houses remaining in place from construction of Watauga

Dormitories built:
Men (238 total capacity) 4
Demountable houses (4 duplex, 2 single) 6

Public buildings constructed included a cafeteria (180 seats), first-aid building (1 bed), 2 recreation buildings, Public Safety Service building including post office and fire station, and an observation building.

PERSONNEL

	Dam and Reservoir Construction	Dam Construction Only
Peak employed	1,350	1,100*
Total man-hours	7,842,134	6,009,003
Number of injuries	49	42
Days lost	28,999	28,494
Fatalities	3	3
Accident frequency	6.2	7.0
Accident severity	3,698	4,742

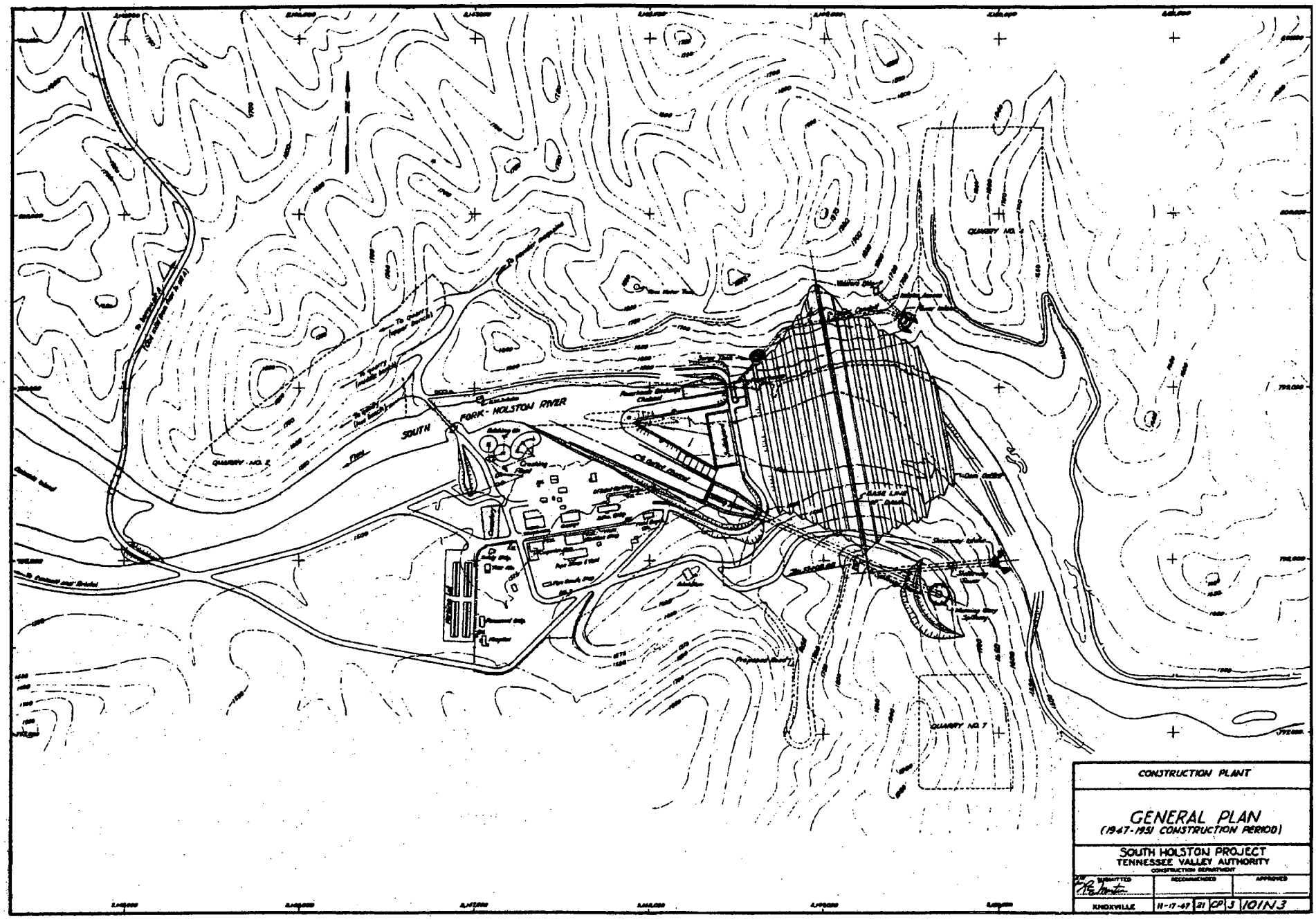
*Estimated

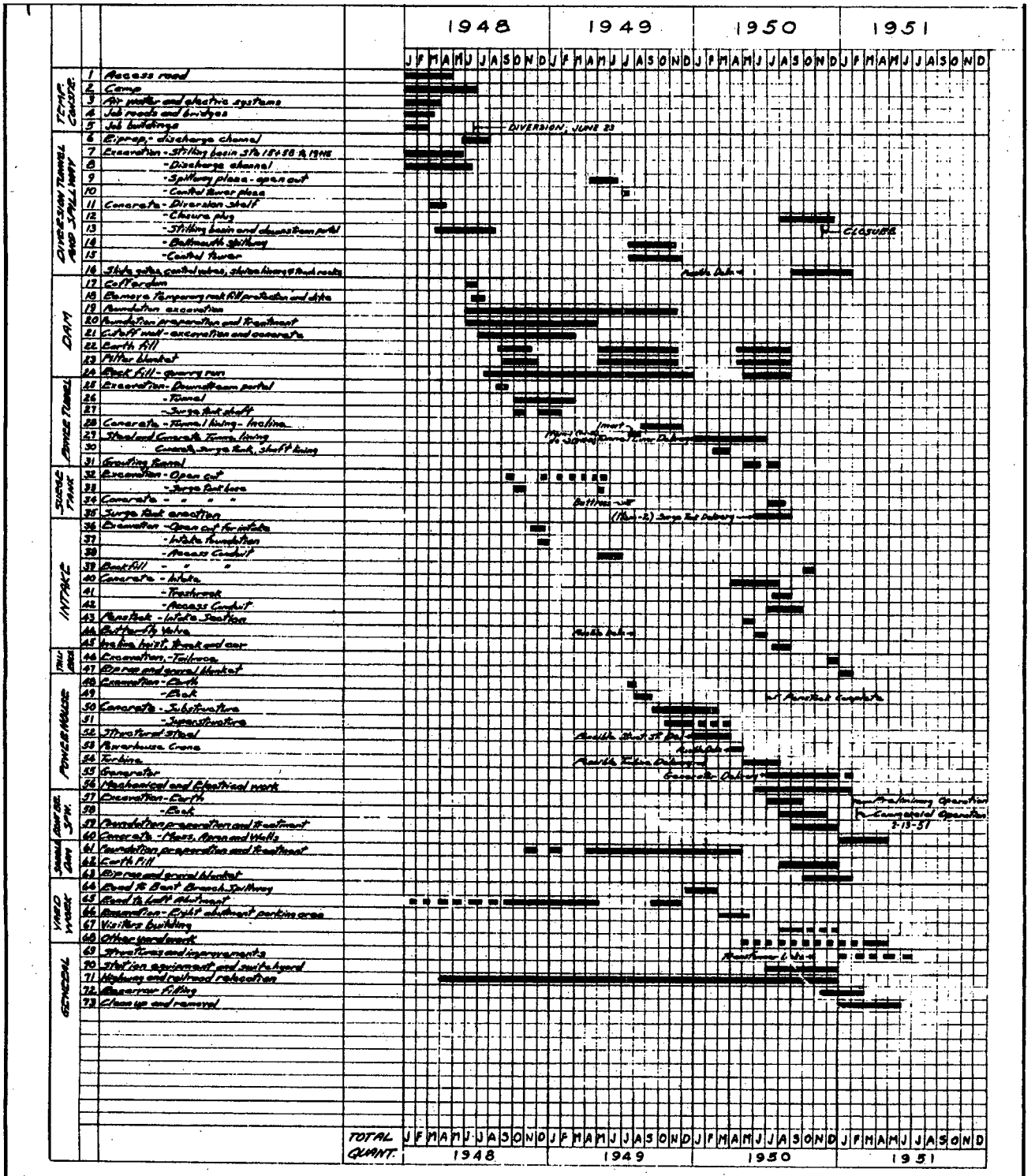
CONSTRUCTION DATA (CONT.)

QUANTITIES

	Dam and Power Plant	Saddle Dam
Dam and power facilities:		
Rock excavation	123,500 cu. Yd	
Unclassified excavation	1,022,800 cu. yd	
Rolled earthfill	2,089,000 cu. Yd	89,300 cu. yd
Rockfill-quarry run	3,383,700 cu. yd	
Filter blanket	412,100 cu. yd*	5,119 cu. yd**
Riprap	12,640 cu. yd	10,882 cu. yd
Reinforcing steel	550 tons	
Structural steel (including conduit liners, trashracks, and surge tank)	1,660 tons	
Formwork	112,600 sq. ft	
Grouting	33,760 cu. ft	1,687,830 cu. ft
Concrete	97,500 cu. yd	
Highway and railroad:		
Excavation	1,600,000 cu. yd	

*Crushed rock
**Gravel


SOUTH FORK - HOLSTON RIVER
QUARRY NO. 2
QUARRY NO. 4
QUARRY NO. 7
CONSTRUCTION PLANT
GENERAL PLAN
(1947-1951 CONSTRUCTION PERIOD)
SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
CONSTRUCTION DEPARTMENT
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
11-17-47
21
CP
3
101N3



GENERAL

CONSTRUCTION SCHEDULE
2-25-49

SOUTH HOLSTON PROJECT
TENNESSEE VALLEY AUTHORITY
CONSTRUCTION DEPARTMENT

FIELD OFFICE | 2-25-49 | 2 | C-3 | 10K 11/41 F2

South Holston Tailwater Rating

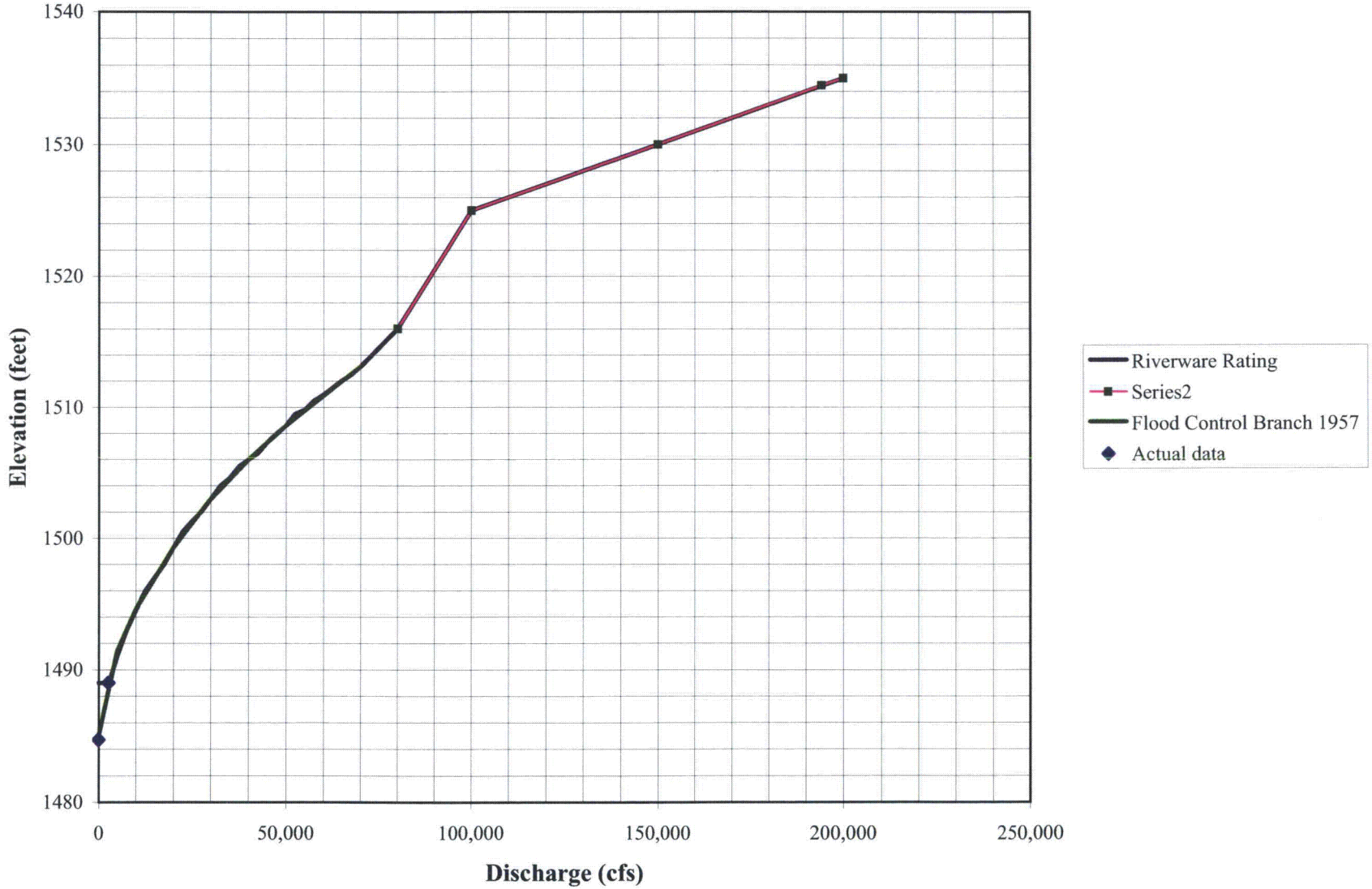
Riverware Rating

Q*1000	Q	Elevation
0	0	1489
2.8	2,800	1489
5	5,000	1491
7.5	7,500	1493
10	10,000	1494.5
12.5	12,500	1496
15	15,000	1497
17.5	17,500	1498
20	20,000	1499.3
22.5	22,500	1500.5
25	25,000	1501.3
27.5	27,500	1502
30	30,000	1503
32.5	32,500	1504
35	35,000	1504.6
37.5	37,500	1505.5
40	40,000	1506
42.5	42,500	1506.5
45	45,000	1507.3
47.5	47,500	1508
50	50,000	1508.6
52.5	52,500	1509.5
55	55,000	1509.8
57.5	57,500	1510.5
60	60,000	1510.95
62.5	62,500	1511.5
65	65,000	1512.05
67.5	67,500	1512.5
70	70,000	1513.1
80	80,000	1516
100	100,000	1525
150	150,000	1530
200	200,000	1535

Flood Control Branch 1957

Discharge	Elevation	
0	1485.0	
5,000	1491.4	
10,000	1494.6	
20,000	1499.3	
30,000	1503.0	
40,000	1506.0	
50,000	1508.6	
60,000	1510.9	
70,000	1513.1	
80,000	1516	
100,000	1525	
150,000	1530	
194,200	1534.45	**PMF**
200,000	1535	

Actual data

0	1484.7
2630	1489

South Holston Tailwater Rating