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

ASSOCIATED ATTACHMENTS/ENCLOSURES:

Attachment 02.04.03-8S: Dam Rating Curves, Telico(Attachment E29 Cover Page only. This document available in public domain).

(470 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 090304 002	Calculations (nuclear)	L58 091230 030

Calc Title: Initial Dam Rating Curves, Tellico

CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	CUR REV	NEW REV	REVISION APPLICABILITY
CURRENT	CN	NUC	GEN	CEB	CDQ000020080018	0	1	Entire calc ☒ Selected pages ☐
NEW								

ACTION										No CCRIS Changes ☐ (For calc revision, CCRIS been reviewed and no CCRIS changes required)
	NEW ☐ REVISION ☒		DELETE ☐ RENAME ☐		SUPERSEDE ☐ DUPLICATE ☐		CCRIS UPDATE ONLY ☐ (Verifier Approval Signatures Not 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
wbbondurant	901.755.7166	CEB	See Page 7	☐ Yes ☒ No

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
Bryant Bondurant: Bryant Bondurant	12/23/09	Andrew Murr: Andrew Murr	12/23/2009
VERIFIER SIGNATURE	**DATE**	**APPROVAL SIGNATURE**	**DATE**
Andrew Murr: Andrew Murr	12/23/2009	K.E. Yeates K.E. Yeates	12/28/09

STATEMENT OF PROBLEM/ABSTRACT

12/23/09

Initial dam rating (headwater rating) curves are required as inputs to TVA's SOCH and TRBROUTE models, used in performing flood-routing calculations for the Tennessee River. The initial dam rating curves provide total dam discharge as a function of headwater elevation and are used to define the beginning conditions for the hydraulic analysis. The final dam rating curve is confirmed and documented in the SOCH Probable Maximum Flood model calculation by validating the headwater-tailwater relationship across the modeled dam configuration.

*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
☐ LOAD INTO EDMS AND RETURN CALCULATION TO:

NPG CALCULATION COVERSHEET/CCRIS UPDATE

REV 0 EDMS/RIMS NO.	EDMS TYPE:	EDMS ACCESSION NO (N/A for REV. 0)
L58 090304 002	Calculations (nuclear)	N/A

Calc Title: Dam Rating Curves, Tellico

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	CDQ000020080018	N/A	0	

ACTION									No CCRIS Changes ☐ (For calc revision, CCRIS been reviewed and no CCRIS changes required)
	NEW ☒ REVISION ☐	DELETE ☐ RENAME ☐	SUPERSEDE ☐ DUPLICATE ☐	CCRIS UPDATE ONLY ☐ (Verifier Approval Signatures Not 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
S. Martinez	(865) 632-6448, 220-4346	CEB	Design Review	☐ Yes ☒ No

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
Sara Martinez Sara Martinez	02/03/2009	JANIE B. MAUTER	2/9/09
VERIFIER SIGNATURE	**DATE**	**APPROVAL SIGNATURE**	**DATE**
DAVID H. HUNT for ANDREW C. MURK Russ Williston	2/9/09 2/10/09	K.R. Yates	3/3/09

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 for each dam provide total dam discharge as a function of headwater elevation. This calculation presents dam rating curves for Tellico Dam.

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
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NPG CALCULATION COVERSHEET/CCRIS UPDATE

CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	REV
	CN	NUC	GEN	CEB	CDQ000020080018	1

ALTERNATE CALCULATION IDENTIFICATION

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

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	S	CN	GEN	CEB	CDQ000020080036	

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 CDQ000020080018	
Title	Initial Dam Rating Curves, Tellico
Revision No.	DESCRIPTION OF REVISION
0	Initial issue, 180 total pages Appendix A – 54 pages Appendix B – 24 pages Appendix C – 20 pages Appendix D – 3 pages Appendix E – 10 pages
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 included 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 • Replaced Unverified Assumption 3.2.1 with Assumption 3.1.2 based on Ref. 2.16 and Appendix F • Replaced Unverified Assumption 3.2.2 with Assumption 3.1.3 • Replaced Unverified Assumption 3.2.3 with Assumption 3.1.4 • Replaced Unverified Assumption 3.2.4 with Assumption 3.1.5 • Revised Appendix B – Changed overflow elevations, Added Reference 2.18 • Revised Attachment 7 • Added Appendix F to evaluate the margin of forces on tainter gates Significant changes in Revision 1 are noted with a left margin revision bar. Administrative changes and typos are excluded. Pages Added: 1a, 7, F1, F2, F3 Pages Revised:1-9, 14, 15, 19-59 Total pages of calculation hard copy for Revision 1= 185

NPG CALCULATION TABLE OF CONTENTS

Calculation Identifier: CDQ000020080018 | Revision: 1

TABLE OF CONTENTS

NPG CALCULATION TABLE OF CONTENTS (CONTINUED)

Calculation Identifier: CDQ000020080018 | Revision: 1

TABLE OF CONTENTS

NPG COMPUTER INPUT FILE
STORAGE INFORMATION SHEET

Document CDQ000020080018	Rev. 1	Plant: GEN	

Subject:
Initial Dam Rating Curves, Tellico

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

There are no electronic input or output files associated with this calculation.

☒ 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 E1: TVA drawing no. 10N200, R5 (Ref. 2.1.1)
Attachment E2: TVA drawing no. 10H230, R2 (Ref. 2.1.2)
Attachment E3: TVA drawing no. 10N202, R2 (Ref. 2.1.3)
Attachment E4: TVA drawing no. 22W204, R9 (Ref. 2.1.4)
Attachment E5: TVA drawing no. 10H221, R4 (Ref. 2.1.5)
Attachment E6: TVA drawing no. 10H220, R1 (Ref. 2.1.6)
Attachment E7: TVA drawing no. 23W200, R8 (Ref. 2.1.7)
Attachment E8: TVA drawing no. 23W205-3, R2 (Ref. 2.1.8)
Attachment E9: TVA drawing no. 23W205-4, R1 (Ref. 2.1.9)
Attachment E10: TVA drawing no. 23W210-1, R1 (Ref. 2.1.10)
Attachment E11: TVA drawing no. 23W211-1, R1 (Ref. 2.1.11)
Attachment E12: TVA drawing no. 23W211-2, R1 (Ref. 2.1.12)
Attachment E13: TVA drawing no. 10N254, R0 (Ref. 2.1.13)
Attachment E14: TVA drawing no. 21W856-1, R0 (Ref. 2.1.14)
Attachment E15: TVA drawing no. 10W201, R4 (Ref. 2.1.15)
Attachment E16: TVA drawing no. 23W212-2, R3 (Ref. 2.1.16)
Attachment E17: TVA drawing no. 1101H215, R1 (Ref. 2.1.17)
Attachment E18: TVA drawing no. 1101H102, R1 (Ref. 2.1.18)
Attachment E19: TVA drawing no. 22W205, R9 (Ref. 2.1.19)
Attachment E20: TVA drawing no. 10N206, R6 (Ref. 2.1.20)
Attachment E21: TVA drawing no. 22W202, R7 (Ref. 2.1.21)
Attachment E22: TVA drawing no. 21K10009 (Field Office Drawing) (Ref. 2.1.22)
Attachment E23: TVA drawing no. 21N200, R3 (Ref. 2.1.23)
Attachment E24: TVA drawing no. 51N200, R2 (Ref. 2.1.24)
Attachment E25: TVA drawing no. 51N203, R2 (Ref. 2.1.25 and Ref. A8)
Attachment E26: TVA drawing no. 54N200, R3 (Ref. 2.1.26 and Ref. A7)
Attachment E27: TVA drawing no. 58W200, R5 (Ref. 2.1.27)
Attachment E28: TVA vendor drawing no. 9091-2B, R2, contract no. 74 C57-84047 (Ref. 2.1.28)
Attachment E29: "Design of Small Dams" (Ref. 2.9)
Attachment E30: TVA Calculation, RIMS accession number B66 '88 0811 005 (Ref. 2.8)
Attachment E31: Tellico Model Data (Ref. 2.4 and Ref. A2)
Attachment E32: Discharge Coefficients for Spillways at TVA Dams," Kirkpatrick (Ref. 2.7 and Ref. A3)
Attachment E33: Tellico "Blue Book" (Ref. 2.12)
Attachment E34: Topographic Map (Refs. 2.10 and 2.11)
Attachment E35: Dam Safety Inspection Report (Ref. 2.14)
Attachment E36: Spillway Discharge Tables (Ref. 2.2 and Ref. A1)
Attachment E37: Spreadsheet Calculations

☐ Microfiche/eFiche

NPG CALCULATION VERIFICATION FORM

Calculation Identifier CDQ000020080018 Revision: 1

Method of verification used:

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

Verifier: Andrew Murr Date 12/23/2009

Comments:

This calculation entitled, "Dam Rating Curve, Tellico," 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.

The methodology used to justify the operability of the gates is based solely on the conclusions of the "Watts Bar Dam – Flood and Earthquake Analysis on Radial Spillway Gates." Appendix F uses the same assumptions, methodology, and approach developed in the Watts Bar radial gate analysis to determine the forces on the radial gates in a closed position with the forces on the gates in the maximum open position. This appendix does not assert that a structural analysis has been performed beyond that found in the Watts Bar radial gate 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).

1.0 Purpose

This calculation presents initial dam rating curves for Tellico 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 hydrometeorological 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 Units 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.

Figure 1 is a plan view of Tellico dam (a portion of Reference 2.1.1) and the surrounding area including Ft. Loudoun Dam, the Left Rim Saddle Dams 1, 2 and 3 and the Right Bank Saddle Dam. Figure 2 is a portion of a topographic map (References 2.10 and 2.11) showing the same area. For headwaters in the normal operating range, discharge passes over the spillway crest at El. 773.0 (Ref. 2.1.26). The spillway consists of three spillway bays, each with a radial, or tainter, gate to control discharge. If, as during a probable maximum flood (PMF) event, headwater rises above the normal operating range, discharge may pass over the non-overflow dam sections, the tops of the spillway piers and operating deck as well as the east/right embankment (labeled "earth embankment" in Figure 3). In addition, as visible in Figures 1 and 2, discharge may also pass over the left rim earth dike saddle dams 2 & 3, the emergency spillway at saddle dam 1 (Ref. 2.1.7 and 2.1.8) and the east/right embankment saddle dam (Ref. 2.1.2).

This initial dam rating curve is based on the configuration of Tellico Dam as defined on the current design drawings or recent modifications. The purpose of this calculation does not evaluate the design loading conditions of the dam.

Rating curve Cases 1 and 7 have been updated. Rating curve Cases 1A, 2, 2A, 3, 4, 5, 6, 8, and 9 are no longer valid because the embankments have been raised and these rating curves were not modified to reflect the raised embankment elevations.

1. Pre-failure Condition (Fort Loudoun turbines operating, Fort Loudoun spillway gates fully open): main dam works, embankment and saddle dams intact. This rating curve is used for rising and falling headwaters unless the headwater rises far enough to cause embankment and /or saddle dam failure or the headwater or tailwater rises far enough to inundate the switchyard or powerhouse.

~~1A. Pre-failure Condition (Fort Loudoun turbines not operating, Fort Loudoun spillway gates fully open): main dam works, embankment and saddle dams intact. This rating curve is used for rising and falling headwaters following inundation of the switchyard or powerhouse unless the headwater has risen far enough to cause embankment and /or saddle dam failure.~~

~~2. Pre-failure Condition (Fort Loudoun turbines operating, Fort Loudoun spillway gates closed): main dam works, embankment and saddle dams intact. This rating curve is used for rising and falling headwaters unless the headwater rises far enough to cause embankment and /or saddle dam failure or the headwater or tailwater rises far enough to inundate the switchyard or powerhouse.~~

~~2A. Pre-failure Condition (Fort Loudoun turbines not operating, Fort Loudoun spillway gates closed): main dam works, embankment and saddle dams intact. This rating curve is used for rising and falling headwaters following inundation of the switchyard or powerhouse unless the headwater has risen far enough to cause embankment and /or saddle dam failure.~~

~~3. Pre-Failure Condition at Tellico, Embankment Failure at Fort Loudoun, (Fort Loudoun spillway gates open): main dam works, embankment and saddle dams intact. This rating curve is used for both rising and falling headwaters unless the headwater rises far enough to cause embankment and /or saddle dam failure.~~

~~4. Pre-Failure Condition at Tellico, Embankment Failure at Fort Loudoun, (Fort Loudoun spillway gates closed): main dam works, embankment and saddle dams intact. This rating curve is used for both rising and falling headwaters unless the headwater rises far enough to cause embankment and /or saddle dam failure.~~

~~5. Embankment Failure at Tellico and Fort Loudoun, Tellico and Fort Loudoun Spillway Gates Open: Main dam works intact, embankment and saddle dam failure. This rating curve is used for both rising and falling headwaters.~~

~~6. Embankment Failure at Tellico and Fort Loudoun, Fort Loudoun Spillway Gates Closed: Main dam works intact, embankment and saddle dam failure. This rating curve is used for both rising and falling headwaters.~~

7. Embankment Failure at Tellico, Pre-Failure at Fort Loudoun, (Fort Loudoun spillway gates open): main dam works intact, embankment and saddle dam failure. This rating curve is used for both rising and falling headwaters.

~~8. Embankment Failure at Tellico, Pre-Failure at Fort Loudoun, (Fort Loudoun spillway gates closed): main dam works intact, embankment and saddle dam failure. This rating curve is used for both rising and falling headwaters.~~

~~9. Pre-Failure Condition at Tellico, Seismic Failure at Fort Loudoun: main dam works, embankment and saddle dams intact. This rating curve is used for both rising and falling headwaters unless the headwater rises far enough to cause embankment and / or saddle dam failure.~~

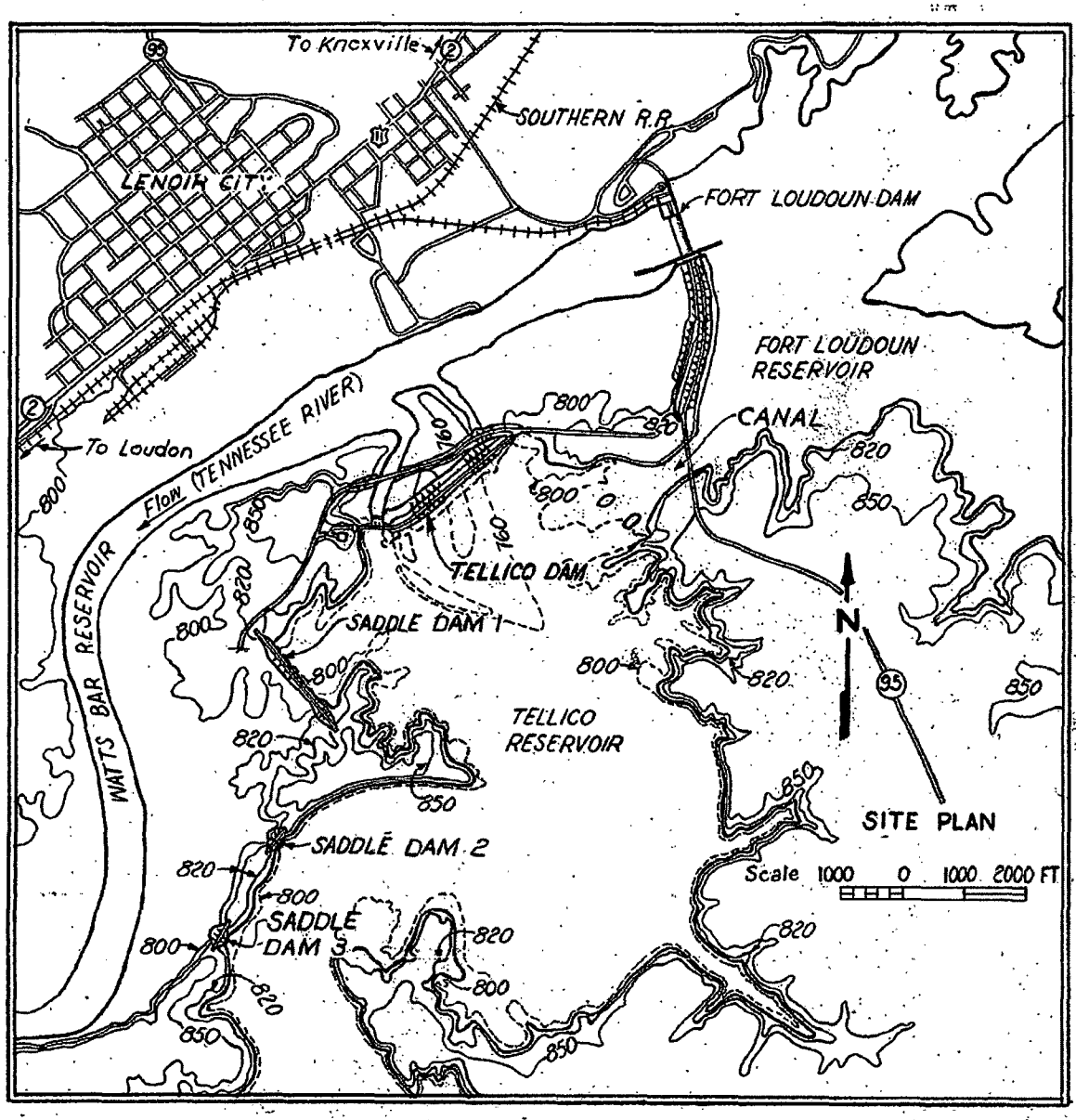


Figure 1 – Tellico Dam, General Plan (Ref. 2.1.1, Att. E1).

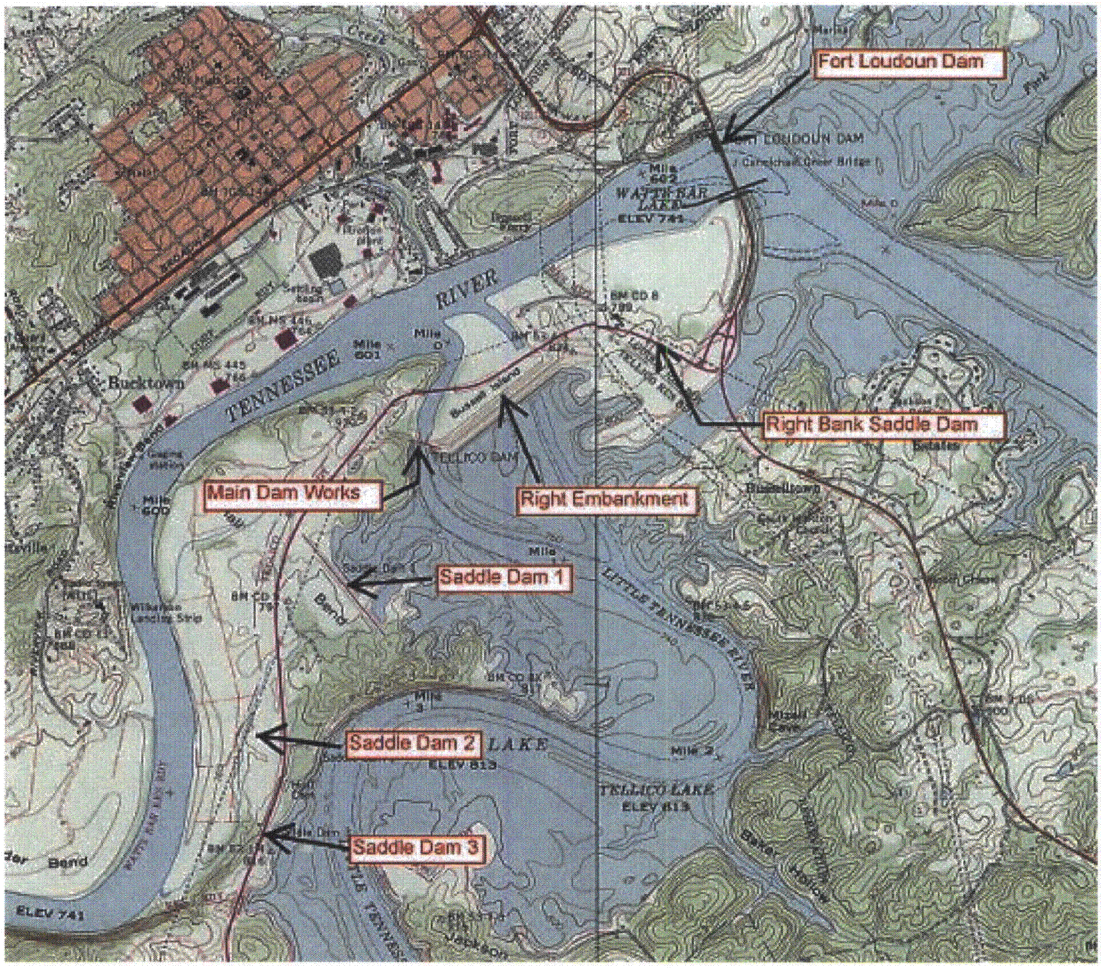


Figure 2 – Topographic Map showing Tellico overflow elements (Ref. 2.10 & 2.11, Att. E34)

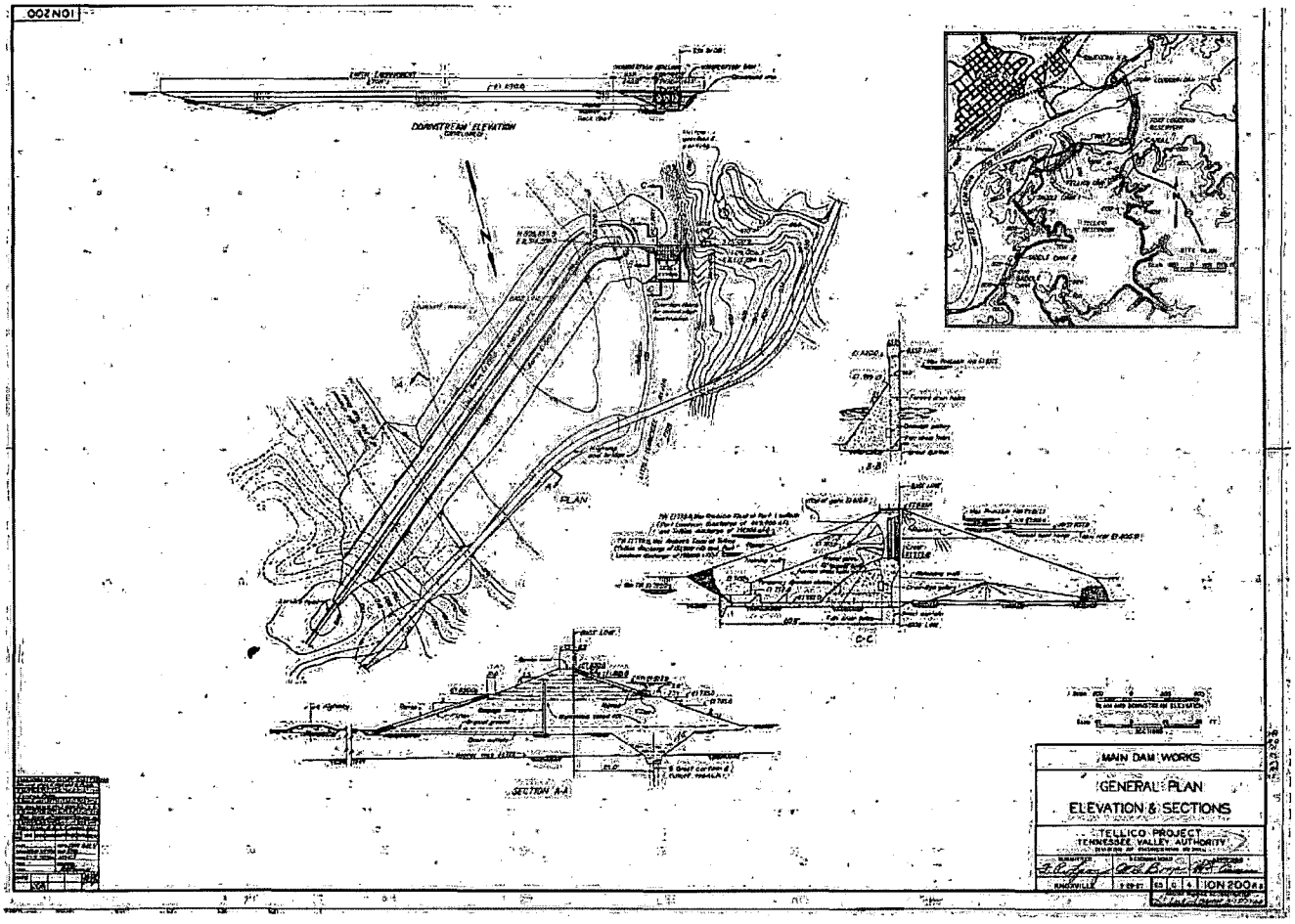


Figure 3 – Tellico Dam Plan and Elevations (Ref. 2.1.1, Att. E1)

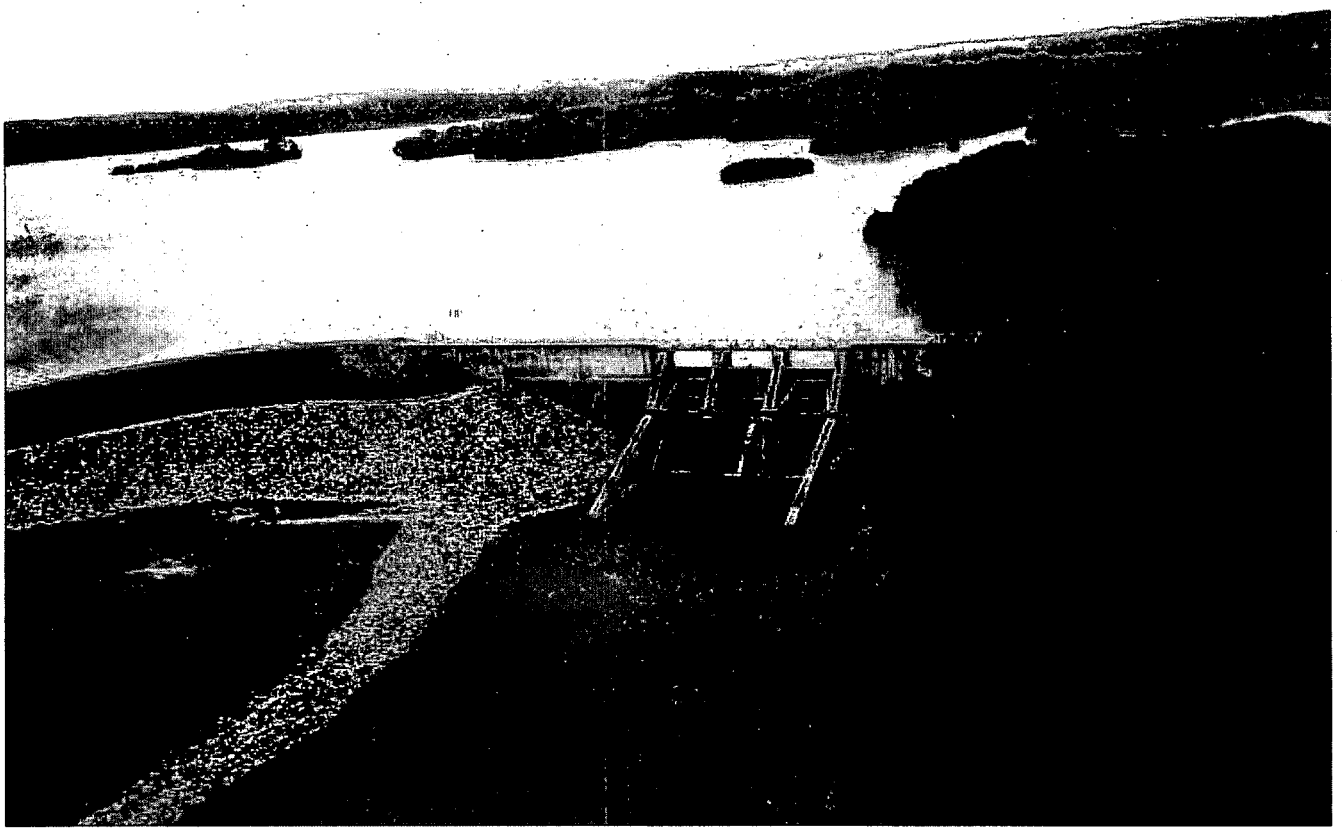


Figure 4—Photograph of Tellico Dam (Ref. 2.12, Att. E33)

2.0 References

2.1 TVA Drawings
- 2.1.1 10N200 Rev. 5 (Att. E1)
- 2.1.2 10H230 Rev. 2 (Att. E2)
- 2.1.3 10N202 Rev. 2 (Att. E3)
- 2.1.4 22W204 Rev. 9 (Att. E4)
- 2.1.5 10H221 Rev. 4 (Att. E5)
- 2.1.6 10H220 Rev. 1 (Att. E6)
- 2.1.7 23W200 Rev. 8 (Att. E7)
- 2.1.8 23W205-3 Rev. 2 (Att. E8)
- 2.1.9 23W205-4 Rev. 1 (Att. E9)
- 2.1.10 23W210-1 Rev. 1 (Att. E10)
- 2.1.11 23W211-1 Rev. 1 (Att. E11)
- 2.1.12 23W211-2 Rev. 1 (Att. E12)
- 2.1.13 10N254 Rev. 0 (Att. E13)
- 2.1.14 21W856-1 Rev. 0 (Att. E14)
- 2.1.15 10W201 Rev. 4 (Att. E15)
- 2.1.16 23W212-2 Rev. 3 (Att. E16)
- 2.1.17 1101H215 Rev. 1 (Att. E17)
- 2.1.18 1101H102 Rev. 1 (Att. E18)
- 2.1.19 22W205 Rev. 9 (Att. E19)
- 2.1.20 10N206 Rev. 6 (Att. E20)
- 2.1.21 22W202 Rev. 7 (Att. E21)
- 2.1.22 21K10009 (Field Office Drawing), (Att. E22)
- 2.1.23 21N200 Rev. 3 (Att. E23)
- 2.1.24 51N200 Rev. 2 (Att. E24)
- 2.1.25 51N203 Rev. 2 (Att. E25)
- 2.1.26 54N200 Rev. 3 (Att. E26)
- 2.1.27 58W200 Rev. 5 (Att. E27)
- 2.1.28 9091-2B, TVA contract no. 74 C57-84047 (Att. E28)

2.2 "Tellico Dam Spillway Discharge Tables", River Operations, Tennessee Valley Authority, 2008, EDMS Accession no. L58 081212 808 (Attachment E36).

2.3 "Hydraulic Design Criteria," USACE (U. S. Army Engineer Waterways Experiment Station), Eighteenth issue, Vicksburg, MS, 1988.

2.4 "Tellico Spillway Rating, 1:72 Model, Books 1 and 2 of 2" June 1969 (relevant pages included as Att. E31)

2.5 Handbook of Hydraulics, E. F. Brater and H. W. King, Sixth Ed., McGraw Hill, 1976.

2.6 Hydraulic Design Chart 711 (HDC 711) from Reference 3 (Attachment 6).

2.7 "Discharge Coefficients for Spillways at TVA Dams," Kenneth W. Kirkpatrick, Paper No. 2855, Transactions of the American Society of Civil Engineers, vol. 22, pp. 190-210, 1957 (Attachment E32)

2.8 TVA Calculation, "Emergency Spillway 1 at Saddle Dam 1", RIMS Accession no. B66 '88 0811 005 (Att. E30)

2.9 *Design of Small Dams*, Third Edition, United States Bureau of Reclamation, 1987 (relevant pages included in Appendix C, document included as Attachment E29)

2.10 USGS - TVA, Topo. Map, Lenoir City Quadrangle, 7.5 minute series, 35084-G3-024, 1986 (Att. E34)

2.11 USGS - TVA, Topo. Map, Concord Quadrangle, 7.5 minute series, 35084-G2-024, 1984 (Att. E34)

2.12 TVA Tellico Dam Water Control Project Manual (Blue Book), 1998 (Attachment E33)

2.13 Open Channel Flow, F. M. Henderson, Macmillan, New York, 1966 (relevant portion included within Appendix A as Attachment A5)

2.14 Dam Safety Inspection Report – Class B Report ID# R02TEHCLB112907, EDMS accession number J22 080110 002 (Att. E35)

2.15 TVA Calculation, "Fort Loudoun Dam Rating Curve", Calc. No. NUCGENCEBCDQ000020080009

2.16 "Basis for Dam Spillway Gate/Outlet Open Configuration for Flood Analysis," Tennessee Valley Authority, May 29, 2009 (EDMS No. L58 090529 800)
2.17"SOCH Model Calibration, Ft. Loudoun - Tellico," CDQ000020080036 (EDMS L58 090814 003)
2.18 "Bellefonte Units 3 and 4 Hydrology Project Request for Information (RFI) Response Information Continuation Sheet," RFI Number: BWSC_75578_209_054 (EDMS L58 091216 801)

3.0 Assumptions & Methodology

The initial dam rating curves developed in these calculations will be used in simulations of probable maximum flood events. Consequently, the rating curves have been calculated well above the normal operating range and several feet above the top of the dam.

3.1 Assumptions

3.1.1 Assumption: The headwater and tailwater at Tellico Dam is affected by Fort Loudoun Dam. Therefore the dam rating curves must be interdependent.
Technical Justification: Reference 2.12, Attachment E33, page iii states, "Tellico is unique among tributary projects because it is connected via an unregulated canal to Fort Loudoun Lake, and thus its annual operating scheme is the same as Fort Loudoun, a main river lake.... Although there are no power generating facilities at Tellico Dam, most of the water is diverted through the canal into Fort Loudoun Lake, and thus the flow regulation provided by Tellico Lake significantly increases hydroelectric production at Fort Loudoun Dam."

3.1.2 Assumption: All three (3) spillway gates will remain operable and will be set to the maximum openings specified in the spillway discharge tables.
Technical Justification: For technical justification, see Reference 2.14, "Basis for Dam Spillway Gate/Outlet Open Configuration for Flood Anaylsis", and Appendix F. The radial gates will remain operable in the maximum opened position based on the findings of the "Watts Bar Dam – Flood and Earthquake Analysis on Radial Spillway Gates" (Reference F1). Appendix F uses the same assumptions, methodology, and approach as the Watts Bar radial gate analysis to compare forces on the gates in a closed position with forces on the gates in the maximum open position to provide technical justification for the gates to remain operable in the maximum open position during a PMF.

3.1.3 Assumption: The tailwater curves included as Attachment 7 are valid for computing the initial dam rating curves.
Technical Justification: The final tailwater curve was verified in the unsteady SOCH Model Calibration, Ft. Loudoun - Tellico (Reference 2.15).

3.1.4 Assumption: The PMF headwaters at Ft. Loudoun and Tellico will the same until the elevation reaches 830.0. For PMF headwaters above 830.0, it is assumed that the PMF headwater at Tellico linearly increases from 830.0 to 834.0 as the PMF headwater at Ft. Loudoun increases from 830.0 to 837.0.
Technical Justification : Development of initial rating curves requires an assumption about the relationship between headwater elevations at Ft. Loudoun and Tellico. The assumed relationship was based on preliminary SOCH analysis. Since this assumption affects only the initial curves and has no effect on ratings determined from future iterative analyses, this assumption is acceptable.

3.1.5Assumption: Steady-state tailwater rating is sufficient for computing submergence effects on the initial dam rating curves.
Technical Justification: The final tailwater curve is validated in the unsteady SOCH PMF calculation (Reference 2.17) by ensuring consistency with the headwater-tailwater relationship across the modeled dam configuration. This calculation provides the initial dam rating curve for the SOCH PMF calculation.

3.2Unverified Assumptions (UVA)
None.

3.3 Methodology -- Discharge Equations

Discharges past the dam are computed as either "free" discharge or "orifice" discharge. Free discharge refers to free surface overflow and is computed using a weir-type equation as follows (Reference 2.3 shows weir flow equations for overflow discharges and Reference 2.7 shows the discharge equation for both free and submerged flow over a spillway crest):

$$Q_f = C_f L H_c^{1.5} \quad (1)$$

in which Q_f = free discharge (cfs)
C_f = free discharge coefficient ($ft^{0.5}/s$ -- varies with H_c)
L = length of overflowing section (ft)
H_c = head on crest (ft) = HW - Z_c
HW = headwater elevation (ft)
Z_c = top, or crest, elevation of overflowing section (ft)

This equation is modified to account for tailwater submergence as follows:

$$Q_{fs} = Q_f S_f \quad (2)$$

in which Q_{fs} = "corrected" free discharge (cfs)
S_f = tailwater submergence factor (dimensionless -- varies between 0 and 1)

S_f varies with d/H_c where d = TW - Z_c (ft) and TW = tailwater elevation (ft).

Flow over the non-overflow section, the tops of the spillway piers and operating deck, the east embankment, and the saddle dams is treated as free discharge. Flow over the spillway crest is treated as free discharge for headwater elevations below $H_c = H_{Lmin}$, the head at which the overflowing nappe first touches the bottoms of the open gates (see Attachment A4). H_{Lmin} varies with gate opening, V, defined as the vertical distance between the bottom of the gate and the spillway crest.

For headwater elevations above $H_c = H_{Lmin}$ flow through the spillway gates is treated as orifice discharge. Orifice discharge refers to flow passing through a contracted opening and is computed using an orifice-type equation as follows (e.g., Reference 2.3, Hydraulic Design Chart 311-1):

$$Q_g = C_g G_n L \sqrt{2g(H_c - H_{mp})} \quad (3)$$

in which Q_g = orifice discharge (cfs)
C_g = orifice discharge coefficient (dimensionless -- varies with gate opening and H_c)
G_n = effective gate opening = minimum distance between the gate lip and the crest (ft)
g = acceleration of gravity (ft/s^2)
H_{mp} = vertical distance between the mid-point of G_n and the crest (ft)

This equation is modified to account for tailwater submergence as follows:

$$Q_{gs} = S_g Q_g \quad (4)$$

in which Q_{gs} = "corrected" orifice discharge (cfs)
S_g = tailwater submergence factor (dimensionless -- varies with d/H_c and gate opening, G_n)

3.4 Methodology -- Spillway Discharge Calculations

The discharge coefficient, C_f, for free discharge over a spillway crest varies with head, H_c (References 2.3 and 2.5 both provide this kind of data). For the Tellico spillway crest, the relationships $H_{Lmin}(V)$, $C_f(H_c)$, and $S_f(d/H_c)$ are available from model test data (Ref. 2.4, Att. E31) and have been compiled in Appendix A. The relationship between orifice discharge coefficient, C_g, and head, H_c, for each gate opening, V, is also available from the model test data. The crest length, L, and crest elevation, Z_c, are shown on TVA drawings (Ref. 2.1.15, for example). The parameters G_n and H_{mp} are determined from geometry (Appendix A). In addition, data is available for submergence effects on orifice spillway discharges within the model data for Tellico Dam (Ref. 2.4, Att. E31). This data is used to estimate $S_g(d/H_c,G_n)$ for Tellico Dam (Appendix A).

The physical model used to measure spillway discharge included three bays and the piers between them. Consequently, pier contraction effects are implicitly included in the discharge coefficients derived from the model test data.

Under the assumption that all spillway gates are fully open, the two end bays (first and last) are the only spillway bays subject to end contraction effects. These effects, which may reduce discharge through these two bays by a few percent, are neglected in this calculation. Neglecting this minor effect has negligible impact on the dam rating curve.

3.5 Methodology – Discharge Coefficients for Emergency Spillway

It is necessary to determine $C_f(H_c)$ for the emergency spillway within Saddle Dam 1. "Design of Small Dams" (Ref. 2.9, Att. E29) contains procedures for the design and analysis of ogee (standard) crests. In order find a relationship between the discharge coefficient and the head on the crest, the emergency spillway crest profile was compared with an ogee crest. This comparison showed that the emergency spillway is very similar to an ogee crest; therefore the "Design of Small Dams" method was used to determine $C_f(H_c)$. This calculation is contained in Appendix C.

The relationship is as follows:

$$C_f = 2.873 + .10187\ H_c - .004286\ H_c^2 + .00009152\ H_c^3 \qquad (5)$$

"Design of Small Dams" (Ref. 2.9, Att. E29) presented a method of design which considered tailwater submergence effects which was considered unacceptable for the purpose of developing a submergence factor/tailwater relationship. However, the USACE Hydraulic Design Criteria (Ref. 2.3) provides an acceptable relationship between submergence and the tailwater elevation above the crest to head on crest ratio. The effects of submergence were calculated using the bottom half of Chart 711 from "Hydraulic Design Criteria" (Ref. 2.6, Att. 6). The "Cornell Crest (Round Crest)" is a good representation of the relationship between headwater and tailwater levels and the effect of submergence on a round crested weir. This relationship is applicable to the emergency spillway crest because the ogee crest is best described by the USACE term "round crest". The determination of S_f is located in Appendix C, pages C-19 and C-20. The factor is represented as follows:

$$S_f = \left(1 - \left(\frac{d}{H_c}\right)^{2.0}\right)^{0.22} \quad for\ 0 < \frac{d}{H_c} \le 0.6$$

and (6)

$$S_f = \left(1 - \left(\frac{d}{H_c}\right)^{2.9}\right)^{0.345} \quad for\ 0.6 < \frac{d}{H_c} \le 1.0$$

3.6 Methodology -- Discharge Coefficients and Submergence Factors for Overflow Sections

Values of the discharge coefficient, C_f, and the submergence factor, S_f, for flows over the non-overflow section, the top of the operating deck, the earthen embankment, and the saddle dams are estimated using Hydraulic Design Chart 711 (Ref. 2.6), which is included as Att. 6. Length, L, and crest elevation, Z_c, in each case is determined from TVA drawings (all relevant drawings are defined as References). Appendix B contains calculations which determine the values of C_f before failure for each section which is expected to overflow. Appendix E contains calculations which determine the overflow parameters for failed sections. Appendix D contains a calculation which has determined that the elevation of the operating deck is above the top of the gates at their largest allowable opening.

The upper plot of HDC 711 (Ref. 2.6) shows that C_f is about 2.65 for very broad crests ($H_1/B < 0.4$ where $H_1 = H_c$ and B = streamwise length of the crest) and gradually increases to 3.1, the maximum value for a "broad-crested" weir, as H_1/B increases to about 1.2. As H_1/B increases above 1.2, C_f continues to increase as the weir transitions from broad-crested to sharp-crested at about $H_1/B = 2.0$. Since the estimation of discharge over the top of various sections of a dam and its embankments is an approximation, small variations in C_f with H_c are not modeled and the effects of end contractions are neglected. A single representative value for C_f within the range of its variation is used for all headwater elevations included in the rating. Neglecting minor variations in C_f values and end contractions has negligible impact on the dam rating curve.

The lower plot of HDC 711 Ref. 2.6 (Att. 6) shows several curves of C_s/C_f (equivalent to S_f) versus H_2/H_1 (equivalent to d/H_c). As illustrated in Attachment 8, the curve labeled "suggested for design (broad crests)" is well-represented by the following polynomial:

$$S_f = 1.0 + 0.023\sigma - 5.0259\sigma^2 + 18.266\sigma^3 - 44.658\sigma^4 \quad \text{for} \quad 0 \le \sigma \le 0.37 \quad \text{broad crest} \qquad (7)$$

in which $\sigma = d/H_c - 0.6$. According to this relationship, submergence affects discharge over a broad-crested weir for $d/H_c > 0.6$.

When $\sigma > 0.37$, the overflow section submergence factor must be interpolated from the following table:

Table 1: Submergence Factors, S_f, for Overflow Sections with $\sigma > 0.37$

d/H_c	$\sigma = d/H_c - 0.6$	S_f (Broad Crest)
0.97	0.37	0.4087
0.98	0.38	0.35
0.99	0.39	0.25
0.995	0.395	0.15
1	0.4	0.0

4.0 Design Input

Sect.	Input Parameter	Source	Symbol	Value
4.1	**Acceleration of gravity**	Common knowledge	g	32.2 ft/sec^2
4.2	**Spillway crest parameters**			
4.2.1	Crest length	3 - 40-foot wide bays (Ref. 2.1.15)	L	120 feet
4.2.2	Crest elevation	(Ref. 2.1.15)	Z_c	773 feet
4.2.3	Free discharge coefficient	Polynomial fit to model data given in Att. A10 and discussed in Appendix A	$C_f(H_c)$	Equation A6
4.2.4	Submergence factor for free discharge	Curve fit to model data given in Att. A11 and discussed in Appendix A	$S_f(d/H_c)$	Equation A7
4.3	**Spillway gate parameters**			
4.3.1	Vertical opening	Field measurements given in Att. A3, data given in Att. A2 and discussed in App. A	V	33 feet
4.3.2	Effective gate opening	Computed in Appendix A	G_n	33.576 feet
4.3.3	Mid-point elevation of opening relative to crest	Computed in Appendix A	H_{mp}	16.354 feet
4.3.4	Headwater elevation at which nappe touches gates	Model data and linear fit given in Att. A9 and estimated in Appendix A	$H_{Lmin} + Z_c$	815.796 feet
4.3.5	Orifice discharge coefficient	Curve developed in Att. A12, given in Table A3 and discussed in Appendix A	$C_g(H_c)$	Interpolate between points in Table A3
4.3.6	Submergence factors for orifice discharge	Family of curves developed from data in Ref. A2, given in Att. A13 and discussed in Appendix A	$S_g(d/H_c, H_c/G_n)$	Interpolate between points in Table A1
4.4	**Main Dam Works Concrete and Embankment Parameters Before Failure**	Includes Earthen Embankment		
4.4.1	Overflow discharge coefficient	Justification in App. B	C_f	2.65, 2.65
4.4.2	Overflow elevation	Justification in App. B	Z_c	830, 834 feet
4.4.3	Overflow length	Justification in App. B	L	447.5, 2700 feet
4.5	**Right Bank Saddle Dam Overflow Parameters Before and After Failure**			
4.5.1	Overflow discharge coefficient	Justification in App. B	C_f	2.65
4.5.2	Overflow elevation before failure	Justification in App. B	Z_c	834 feet
4.5.3	Overflow length	Justification in App. B	L	2000 feet
4.5.4	Overflow elevation after failure	Justification in App. E	Z_c	823 feet
4.6	**Saddle Dam 1-Section 1 Before and After Failure**	Excludes Emergency Spillway Parameters		
4.6.1	Overflow discharge coefficient	Justification in App. B	C_f	3.1
4.6.2	Overflow elevation	Justification in App. B	Z_c	834 feet
4.6.3	Overflow length	Justification in App. B	L	100 feet
4.7	**Saddle Dam 1-Section 2 Before and After Failure**	Excludes Emergency Spillway Parameters		
4.7.1	Overflow discharge coefficient	Justification in App. B	C_f	2.65
4.7.2	Overflow elevation	Justification in App. B	Z_c	834 feet
4.7.3	Overflow length	Justification in App. B	L	62 feet
4.8	**Saddle Dam 2- Before Failure**			
4.8.1	Overflow discharge coefficient	Justification in App. B	C_f	2.65
4.8.2	Overflow elevation	Justification in App. B	Z_c	834 feet

4.8.3	Overflow length	Justification in App. B	L	525 feet
4.9	**Saddle Dam 3-Section 1 Before Failure**			
4.9.1	Overflow discharge coefficient	Justification in App. B	C_f	2.65
4.9.2	Overflow elevation	Justification in App. B	Z_c	834 feet
4.9.3	Overflow length	Justification in App. B	L	62.12 feet
4.10	**Saddle Dam 3-Section 2 Before Failure**			
4.10.1	Overflow discharge coefficient	Justification in App. B	C_f	2.65
4.10.2	Overflow elevation	Justification in App. B	Z_c	834 feet
4.10.3	Overflow length	Justification in App. B	L	253.6 feet
4.11	**Emergency Spillway- Before and After Failure**			
4.11.1	Overflow discharge coefficient	Polynomial developed on page C3 and discussed in Appendix C	C_f	Equation 5
4.11.2	Overflow elevation	Justification in App. C	Z_c	817 feet
4.11.3	Overflow length	Justification in App. C	L	2000 feet
4.11.4	Submergence Factor	Justification in App. C	S_f	Equation 6
4.12	**Main Dam Works Overflow Parameters After Failure**	Excludes Earthen Embankment Dam does not fail, therefore parameters do not change.		
4.12.1	Overflow discharge coefficient	Justification in App. E	C_f	2.65
4.12.2	Overflow elevation	Justification in App. E	Z_c	830 feet
4.12.3	Overflow length	Justification in App. E	L	447.5 feet
4.13	**Earthen Embankment After Failure**			
4.13.1	Overflow discharge coefficient	Justification in App. E	C_f	2.65
4.13.2	Overflow elevation (majority)	Justification in App. E	Z_{c1}	755 feet
4.13.3	Overflow elevation (old river bed)	Justification in App. E	Z_{c2}	722 feet
4.13.4	Overflow length (majority)	Justification in App. E	L_1	2400 feet
4.13.5	Overflow length (old river bed)	Justification in App. E	L_2	300 feet
4.14	**Saddle Dam 2- After Failure**			
4.14.1	Overflow discharge coefficient	Justification in App. E	C_f	2.65
4.14.2	Overflow elevation	Justification in App. E	Z_c	822 feet
4.14.3	Overflow length	Justification in App. E	L	525 feet
4.15	**Saddle Dam 3- After Failure**			
4.15.1	Overflow discharge coefficient	Justification in App. E	C_f	2.65
4.15.2	Overflow elevation	Justification in App. E	Z_c	820 feet
4.15.3	Overflow length	Justification in App. E	L	315.72 feet
4.16	Not used			
4.17	**Submergence Factor for Overflow Sections Both Before and After Failure**	Justification in Attachment 8 and Section 3.6	S_f	Equation 7 or Interpolate between points in Table 1
4.18	**Tailwater Rating Curves**			
4.18.1	TW vs. total discharge, Q	Paragraph 4.21	TW(Q)	Equations 8 & 9
4.19	**Upper limit on headwater elevation for rating**	Paragraph 4.22		834 feet

4.20 Earthen Embankment and Saddle Dam Failure

A value for C_f of 2.65 is used in accordance with the data in Attachment 6 since the crest is broad compared to the depth of water flowing over it.

4.21 Tailwater rating curve

The tailwater at Tellico Dam (between river miles 601 and 602) is greatly affected by conditions at Fort Loudoun Dam (at river mile 602.3), and vice versa. For this reason, a tailwater rating curve which takes into account discharges from both Tellico and Fort Loudoun Dams must be used to develop the initial dam rating curves. Additionally, the Tellico saddle dams extend nearly three miles downstream of Fort Loudoun Dam. It would not be reasonable to assume that the tailwater is the same at all points. For this reason, variations in tailwater across this distance must be accounted for. In order to do this, separate tailwater rating curves for points above and below river mile 600 will be used.

Specific tailwater elevations at river miles 602.3, 600.17 and 598.04 for various steady-state discharges from previously determined tailwater rating curves were entered into the spreadsheets shown in Figures 5 through 15. The tailwater rating curves used to calculate these values are shown in Attachment 7.

The tailwater rating curves were developed under the assumption that all discharge in the tailwater originated at Ft. Loudoun Dam (at mile 602.3). Under this assumption, the tailwater at river mile 600.17 is slightly lower than the tailwater at river mile 602.3. However, for the assumptions used in computing the initial dam rating curves, with all gates at Tellico Dam fully open, a major portion of the tailwater discharge originates from Tellico Dam. Consequently, the difference in tailwater elevation between Ft. Loudoun and Tellico dams is smaller than suggested by the tailwater rating curves and will be neglected. Therefore, the tailwater rating curve for river mile 602.3 is used for all discharges entering the tailwater between river miles 600 and 602.3. The polynomial fit for this rating curve is as follows:

$$TW602.3 = 745.07 + 0.1276Q - 0.9492x10\text{-}4Q2 + 4.350x10\text{-}8Q3 - 0.7392x10\text{-}11Q4 \quad (8)$$

where TW = tailwater elevation in feet and Q = discharge in 1000 cfs

Discharges past Saddle Dams 1, 2, and 3 and the emergency spillway enter the tailwater near river mile 599. The tailwater rating curve for computing submergence effects on these discharges is determined by linear interpolation between the tailwater rating curves for miles 600.17 and 598.04. The polynomial fit for this curve is as follows:

$$TW599.0 = 745.38 + 0.1195Q - 8.5046x10\text{-}5Q2 + 3.8094x10\text{-}8Q3 - 6.3535x10\text{-}12Q4 \quad (9)$$

where TW = tailwater elevation in feet and Q = discharge in 1000 cfs

4.22 Upper Limit on Headwater Elevation Included in Rating Curves

The initial dam rating curves need to include all headwater elevations that may occur during a PMF event. Because the Fort Loudoun dam rating curve is dependant on Tellico tailwater and vice versa, the maximum headwater elevation at Tellico will be taken as 834' while the maximum headwater at Fort Loudoun Dam wii be 837' [4.19], [3.1.4].

5. Special Requirements/Limiting Conditions

N/A

6. Calculations

The calculations consist of computing spillway and overflow discharges (from Equations 1 through 4) for a list of headwater elevations ranging from a varying minimum up to 834 feet [4.19], which is seven feet above the embankment. The embankment is expected to fail soon after being overtopped. The initial dam rating curve for each case is a plot of headwater elevation versus total dam discharge. All tailwater and discharge values consider Tellico and Fort Loudoun Dams to be an interdependent system.

Rating curve Cases 1 and 7 have been updated. Rating curve Cases 1A, 2, 2A, 3, 4, 5, 6, 8, and 9 are no longer valid because the embankments have been raised and these rating curves were not modified to reflect the raised embankment elevations.

6.1 Case 1, Pre-Failure Condition, Fort Loudoun Gates Fully Open, Fort Loudoun turbines operating

This case considers no failure has occurred at either Tellico Dam or Fort Loudoun Dam. The spillway gates at both dams are considered fully open. The turbines at Fort Loudoun are generating electricity.

For the pre-failure condition, discharges are computed for headwaters ranging from 773 feet, the spillway crest elevation, to 837 feet, seven feet above the top of the dam and embankment. Discharge passes through the spillway section of the dam, the emergency spillway in saddle dam 1 and the various overflow sections as headwater rises above the crest elevations in each case. Total discharge, given in "1000 cfs" is the sum of all discharges in cfs past the dam plus discharge in cfs past the embankment and saddle dams divided by 1000.

Figure 5 shows the spreadsheet calculations for the pre-failure dam rating curve (spreadsheet included as Attachment E37). The final result, the rating curve, is defined by the first two columns, HW vs. Total Tellico Discharge (Q_{TEL}). The third and fourth columns contain the Fort Loudoun Discharge (Q_{FTL}) and the total combined discharge (Q_{TOT}). The fifth and sixth columns (TW) give the tailwater associated with the "Total Discharge" at Tellico Dam and the Saddle Dams, respectively. They are represented by the tailwater rating curve polynomial fits [4.18.1]. This is used to check for tailwater submergence effects on the discharge. Tailwater submergence reduces the spillway and emergency spillway discharges for Case 1. Consequently, it is necessary to iterate through different tailwater elevations until the total computed discharge fits the tailwater rating curves [4.18.1]. Figure 5 shows the final results but does not show the iteration steps. The results are readily checked by computing the individual discharges (only the spillway and emergency spillway are affected by tailwater), adding them up to compute total discharge, and then making sure the listed tailwater and total combined discharge agree with the tailwater rating curves.

Spillway discharge in cfs is computed in the next five columns (under the header "Spillway"), H_c, $C_f|C_g$, d/H_c, $S_f|S_g$ and $Q_f|Q_g$. Free discharge occurs for headwater elevations below 815.796 feet [4.3.4] and orifice discharge occurs for headwaters above 815.796 feet. The transition point is indicated by a horizontal line. Above the line, the listed discharge coefficient is C_f [4.2.3] computed from Equation (A6) and below the line the listed discharge coefficient is C_g [4.3.5] computed by interpolation between the points in Table A3. Column $Q_f|Q_g$ is the spillway discharge computed from Equation 2 for free discharge and from Equation 4 for orifice discharge. Column d/H_c verifies that the spillway discharge is not affected by tailwater below elevation 809 feet since $d/H_c < 0.2$ [4.2.4]. Submergence affects discharge for all remaining headwater elevations at which free discharge occurs. Spillway discharge is affected by tailwater at all headwater elevations where orifice discharge occurs because all values of $d/H_c > 0.2$ [4.3.6].

Emergency Spillway discharge is computed in the next four columns (under the header "Emergency Spillway"), H_c, C_f, S_f and Q_f. Free discharge occurs at all heads (H_c) above the spillway crest at elevation 817 feet [4.11.2]. The discharge coefficient is C_f [4.11.1] computed from Equation 5. The submergence factor, S_f [4.11.4], is computed using Equation 6. Column Q_f is the emergency spillway discharge computed from Equation 2 for free discharge with submergence.

The column following the emergency spillway discharge column shows "C_f=", "Z_c=", and "L=" in three rows to indicate the meaning of the values included in those rows in the "Overflow Section Discharges" columns.

The next eight columns are overflow discharges in cfs for the right bank saddle dam, main dam works (including the earthen embankment), three saddle dams and the remaining overflow sections below the maximum headwater elevation. The overflow discharge coefficient C_f ([4.5.1], [4.4.1], [4.6.1], [4.7.1], [4.8.1], [4.9.1], [4.10.1]), elevation Z_c ([4.5.2], [4.4.2], [4.6.2], [4.7.2], [4.8.2], [4.9.2], [4.10.2]) and length L ([4.5.3], [4.4.3], [4.6.3], [4.7.3], [4.8.3], [4.9.3], [4.10.3]) in each case are indicated in the three rows above the computed discharges. Submergence does not affect the discharge for the overflow sections because the tailwater never rises to an elevation which will affect any of the overflow section. All overflow discharges are computed using Equation 1.

Tellico:Pre-Failure Condition, Fort Loudoun Gates Open-Fort Loudoun Turbines Operating

g = 32.2 ft/s^2

Spillway Parameters: L = 120 feet; Z_c = 773 feet; G_n = 33.576 feet; H_{mp} = 16.354 feet; H_{cmin} = 42.796 feet

Emergency Spillway Parameters: L = 2000 feet; Z_c = 817 feet

	Q_{TEL}	Q_{FTL}	Q_{TOT}	Main Dam TRM 602.3	Saddle Dam TRM 599.0	Spillway					Emergency Spillway				Overflow Section Discharges (cfs)							
															Right Bank Saddle Dam	Main Dam Works Concrete	Main Dam Works Embankment	Saddle Dam 1-Section 1	Saddle Dam 1-Section 2	Saddle Dam 2	Saddle Dam 3-Section 1	Saddle Dam 3-Section 2
															C_f = 2.65	2.65	2.65	3.10	2.65	2.65	2.65	2.65
	Total	Total	Total												Z_c = 834	830	834	834	834	834	834	834
HW	Discharge	Discharge	Discharge	TW	TW	H_c	$C_f \mid C_g$	d/H_c	S/S_3	$Q_f \mid Q_g$	H_c	C_f	S_f	Q_f	L = 2000	447.5	2700	100	62	525	62.12	253.60
feet	1000 cfs	1000 cfs	1000 cfs	feet	feet	ft				cfs	ft			cfs	Q_f	Q_f	Q_f	Q_f	Q_f	Q_f	Q_f	Q_f
773	0.00	20.55	20.55	747.65	747.80	0	3.100		1.000	0	0			0	0	0	0	0	0	0	0	0
775	1.06	22.44	23.50	748.02	748.14	2	3.112	-12.492	1.000	1056	0			0	0	0	0	0	0	0	0	0
777	3.01	24.14	27.15	748.46	748.56	4	3.134	-6.134	1.000	3009	0			0	0	0	0	0	0	0	0	0
779	5.58	25.67	31.25	748.97	749.03	6	3.166	-4.006	1.000	5583	0			0	0	0	0	0	0	0	0	0
781	8.70	27.07	35.77	749.51	749.55	8	3.204	-2.936	1.000	8699	0			0	0	0	0	0	0	0	0	0
783	12.32	28.33	40.65	750.10	750.10	10	3.247	-2.290	1.000	12320	0			0	0	0	0	0	0	0	0	0
785	16.42	34.09	50.51	751.28	751.20	12	3.292	-1.810	1.000	16423	0			0	0	0	0	0	0	0	0	0
787	20.99	43.97	64.96	752.97	752.79	14	3.339	-1.431	1.000	20992	0			0	0	0	0	0	0	0	0	0
789	26.01	56.82	82.83	755.01	754.72	16	3.387	-1.124	1.000	26009	0			0	0	0	0	0	0	0	0	0
791	31.46	72.23	103.68	757.33	756.90	18	3.432	-0.871	1.000	31455	0			0	0	0	0	0	0	0	0	0
793	37.31	89.91	127.22	759.86	759.28	20	3.476	-0.657	1.000	37309	0			0	0	0	0	0	0	0	0	0
795	43.54	109.70	153.24	762.55	761.83	22	3.517	-0.475	1.000	43545	0			0	0	0	0	0	0	0	0	0
797	50.13	131.45	181.58	765.36	764.50	24	3.553	-0.318	1.000	50134	0			0	0	0	0	0	0	0	0	0
799	57.05	155.07	212.12	768.27	767.25	26	3.586	-0.182	1.000	57047	0			0	0	0	0	0	0	0	0	0
801	64.25	180.52	244.77	771.23	770.07	28	3.614	-0.063	1.000	64251	0			0	0	0	0	0	0	0	0	0
803	71.72	207.77	279.49	774.22	772.93	30	3.637	0.041	1.000	71715	0			0	0	0	0	0	0	0	0	0
805	79.40	236.82	316.22	777.23	775.81	32	3.656	0.132	1.000	79398	0			0	0	0	0	0	0	0	0	0
807	87.23	267.70	354.92	780.23	778.68	34	3.670	0.213	0.999	87227	0			0	0	0	0	0	0	0	0	0
809	95.13	300.43	395.56	783.20	781.54	36	3.681	0.283	0.997	95129	0			0	0	0	0	0	0	0	0	0
811	103.04	335.05	438.09	786.14	784.38	38	3.688	0.346	0.994	103044	0			0	0	0	0	0	0	0	0	0
813	110.94	371.58	482.51	789.03	787.18	40	3.692	0.401	0.990	110937	0			0	0	0	0	0	0	0	0	0
815	118.80	410.02	528.82	791.86	789.93	42	3.695	0.449	0.984	118798	0			0	0	0	0	0	0	0	0	0
815.80	121.92	425.84	547.76	792.97	791.01	42.8	3.697	0.467	0.982	121920	0			0	0	0	0	0	0	0	0	0
816	120.88	430.08	550.96	793.15	791.19	43	0.743	0.469	0.974	120881	0			0	0	0	0	0	0	0	0	0
817	120.38	450.77	571.15	794.30	792.31	44	0.729	0.484	0.971	120376	0			0	0	0	0	0	0	0	0	0
818	125.41	471.53	596.95	795.73	793.71	45	0.715	0.505	0.965	119471	1	2.971	1.000	5941	0	0	0	0	0	0	0	0
819	135.20	492.46	627.65	797.37	795.31	46	0.701	0.530	0.955	117886	2	3.060	1.000	17312	0	0	0	0	0	0	0	0
820	150.12	513.69	663.80	799.23	797.14	47	0.696	0.558	0.942	117459	3	3.143	1.000	32658	0	0	0	0	0	0	0	0
821	169.55	515.17	684.72	800.28	798.16	48	0.692	0.568	0.937	118063	4	3.218	1.000	51484	0	0	0	0	0	0	0	0
822	192.73	513.62	706.34	801.33	799.20	49	0.692	0.578	0.933	119236	5	3.287	1.000	73492	0	0	0	0	0	0	0	0
823	218.74	512.79	731.52	802.53	800.38	50	0.692	0.591	0.927	120275	6	3.350	1.000	98460	0	0	0	0	0	0	0	0
824	247.01	512.16	759.17	803.81	801.64	51	0.692	0.604	0.917	120795	7	3.407	1.000	126214	0	0	0	0	0	0	0	0
825	277.21	511.18	788.39	805.13	802.94	52	0.692	0.618	0.903	120603	8	3.461	1.000	156605	0	0	0	0	0	0	0	0
826	308.64	520.83	829.47	806.93	804.72	53	0.692	0.640	0.880	119134	9	3.509	1.000	189507	0	0	0	0	0	0	0	0
827	341.15	534.11	875.26	808.87	806.64	54	0.692	0.664	0.847	116336	10	3.555	1.000	224814	0	0	0	0	0	0	0	0
828	375.82	543.85	919.67	810.69	808.44	55	0.692	0.685	0.815	113379	11	3.597	1.000	262442	0	0	0	0	0	0	0	0
829	412.64	552.48	965.12	812.50	810.23	56	0.692	0.705	0.783	110313	12	3.636	1.000	302325	0	0	0	0	0	0	0	0
830	451.56	558.17	1009.73	814.23	811.95	57	0.692	0.723	0.751	107143	13	3.674	1.000	344421	0	0	0	0	0	0	0	0
830.57	474.20	568.86	1043.06	815.51	813.21	57.6	0.692	0.738	0.726	104223	14	3.695	1.000	369461	0	512	0	0	0	0	0	0
831.14	497.58	581.48	1079.05	816.87	814.55	58.1	0.692	0.754	0.698	100911	14	3.715	1.000	395216	0	1449	0	0	0	0	0	0
831.71	521.74	594.01	1115.76	818.24	815.90	58.7	0.692	0.771	0.669	97393	15	3.736	1.000	421689	0	2662	0	0	0	0	0	0
832.29	546.93	605.35	1152.28	819.59	817.24	59.3	0.692	0.786	0.641	93968	15	3.756	1.000	448862	0	4098	0	0	0	0	0	0
832.86	572.16	616.35	1188.51	820.92	818.55	59.9	0.692	0.801	0.614	90622	16	3.776	0.998	475808	0	5727	0	0	0	0	0	0
833.43	596.79	627.10	1223.88	822.22	819.82	60.4	0.692	0.814	0.586	87097	16	3.796	0.993	502161	0	7529	0	0	0	0	0	0
834	621.10	638.13	1259.23	823.51	821.09	61	0.692	0.828	0.560	83673	17	3.816	0.987	527939	0	9487	0	0	0	0	0	0

Figure 5 – Calculations for Case 1, Pre-Failure Condition, Fort Loudoun Gates Fully Open, Fort Loudoun Turbines Operating

6.2 Case 1A, Pre-Failure Condition, Fort Loudoun Gates Fully Open, Fort Loudoun Turbines Not Operating

This case considers no failure has occurred at either Tellico Dam or Fort Loudoun Dam. The spillway gates at both dams are considered fully open. The turbines at Fort Loudoun are not generating electricity.

For the pre-failure condition, discharges are computed for headwaters ranging from 773 feet, the spillway crest elevation, to 837 feet, seven feet above the top of the dam and embankment. Discharge passes through the spillway section of the dam, the emergency spillway in saddle dam 1 and the various overflow sections as headwater rises above the crest elevations in each case. Total discharge, given in "1000 cfs" is the sum of all discharges in cfs past the dam plus discharge in cfs past the embankment and saddle dams divided by 1000.

Figure 6 shows the spreadsheet calculations for the pre-failure dam rating curve (spreadsheet included as Attachment E37). The final result, the rating curve, is defined by the first two columns, HW vs. Total Tellico Discharge (Q_{TEL}). The third and fourth columns contain the Fort Loudoun Discharge (Q_{FTL}) and the total combined discharge (Q_{TOT}). The fifth and sixth columns (TW) give the tailwater associated with the "Total Discharge" at Tellico Dam and the Saddle Dams, respectively. They are represented by the tailwater rating curve polynomial fits [4.18.1]. This is used to check for tailwater submergence effects on the discharge. Tailwater submergence reduces the spillway and emergency spillway discharges for Case 1A. Consequently, it is necessary to iterate through different tailwater elevations until the total computed discharge fits the tailwater rating curve [4.18.1]. Figure 6 shows the final results but does not show the iteration steps. The results are readily checked by computing the individual discharges (only the spillway and emergency spillway are affected by tailwater), adding them up to compute total discharge, and then making sure the listed tailwater and total combined discharge agree with the tailwater rating curves.

Spillway discharge in cfs is computed in the next five columns (under the header "Spillway"), H_c, $C_f|C_g$, d/H_c, $S_f|S_g$ and $Q_f|Q_g$. Free discharge occurs for headwater elevations below 815.796 feet [4.3.4] and orifice discharge occurs for headwaters above 815.796 feet. The transition point is indicated by a horizontal line. Above the line, the listed discharge coefficient is C_f [4.2.3] computed from Equation (A6) and below the line the listed discharge coefficient is C_g [4.3.5] computed by interpolation between the points in Table A3. Column $Q_f|Q_g$ is the spillway discharge computed from Equation 2 for free discharge and from Equation 3 for orifice discharge. Column d/H_c verifies that the spillway discharge is not affected by tailwater below elevation 811 feet since $d/H_c < 0.2$ [4.2.4]. Submergence affects discharge for all remaining headwater elevations at which free discharge occurs. Spillway discharge is affected by tailwater at all headwater elevations where orifice discharge occurs because all values of $d/H_c > 0.2$ [4.3.6].

Emergency Spillway discharge is computed in the next four columns (under the header "Emergency Spillway"), H_c, C_f, S_f and Q_f. Free discharge occurs at all heads (H_c) above the spillway crest at elevation 817 feet [4.11.2]. The discharge coefficient is C_f [4.11.1] computed from Equation 5. The submergence factor, S_f [4.11.4], is computed using Equation 6. Column Q_f is the emergency spillway discharge computed from Equation 2 for free discharge with submergence.

The column following the emergency spillway discharge column shows "C_f=", "Z_c=", and "L=" in three rows to indicate the meaning of the values included in those rows in the "Overflow Section Discharges" columns.

The next eight columns are overflow discharges in cfs for the right bank saddle dam, main dam works (including the earth embankment), three saddle dams and the remaining overflow sections below the maximum headwater elevation. The overflow discharge coefficient C_f ([4.5.1], [4.4.1], [4.6.1], [4.7.1], [4.8.1], [4.9.1], [4.10.1], [4.16.1]), elevation Z_c ([4.5.2], [4.4.2], [4.6.2], [4.7.2], [4.8.2], [4.9.2], [4.10.2], [4.16.2]), and length L ([4.5.3], [4.4.3], [4.6.3], [4.7.3], [4.8.3], [4.9.3], [4.10.3], [4.16.3]) in each case are indicated in the three rows above the computed discharges. Submergence does not affect the discharge for the overflow sections because the tailwater never rises to an elevation which will affect any of the overflow section. All overflow discharges are computed using Equation 1.

Case No Longer Valid

TVA

Calculation No. CDQ000020080018	Rev: 1	Plant: GEN	Page: 26
Subject: Dam Rating Curves, Tellico		Prepped	WBB
		Checked	ACM

Tellico:Pre-Failure Condition, Fort Loudoun Gates Open-Fort Loudoun Turbines Operating

g = 32.2 ft/s²

Spillway Parameters: L = 120 feet; Z_s = 773 feet; G_s = 33.576 feet; H_{req} = 16.354 feet; H_{Limit} = 42.796 feet

Emergency Spillway Parameters: L = 2000 feet; Z_e = 817 feet

HW feet	Q_{TEL} Total Discharge 1000 cfs	Q_{FTL} Total Discharge 1000 cfs	Q_{TOT} Total Discharge 1000 cfs	Main Dam TRM 602.3 TW feet	Saddle Dam TRM 599.0 TW feet	Spillway H_s ft	C_f | C_s	d/H_s	S_f/S_s	Q_f | Q_s cfs	Emergency Spillway H_e ft	C_f	S_f	Q_f cfs
773	0.00	20.55	20.55	747.65	747.60	0	3.100		1.000	0	0			0
775	1.06	22.44	23.50	748.02	748.14	2	3.112	-12.492	1.000	1056	0			0
777	3.01	24.14	27.15	748.46	748.56	4	3.134	-6.134	1.000	3009	0			0
779	5.58	25.67	31.25	748.97	749.03	6	3.166	-4.006	1.000	5563	0			0
781	8.70	27.07	35.77	749.51	749.55	8	3.204	-2.936	1.000	8699	0			0
783	12.32	28.33	40.65	750.10	750.10	10	3.247	-2.290	1.000	12320	0			0
785	16.42	34.09	50.51	751.28	751.20	12	3.292	-1.810	1.000	16423	0			0
787	20.99	43.97	64.96	752.97	752.79	14	3.339	-1.431	1.000	20992	0			0
789	26.01	56.82	82.83	755.01	754.72	16	3.387	-1.124	1.000	26009	0			0
791	31.46	72.23	103.68	757.33	756.90	18	3.432	-0.871	1.000	31455	0			0
793	37.31	89.91	127.22	759.86	759.28	20	3.476	-0.657	1.000	37309	0			0
795	43.54	109.70	153.24	762.55	761.83	22	3.517	-0.475	1.000	43545	0			0
797	50.13	131.45	181.58	765.36	764.50	24	3.553	-0.318	1.000	50134	0			0
799	57.05	155.07	212.12	768.27	767.25	26	3.586	-0.182	1.000	57047	0			0
801	64.25	180.52	244.77	771.23	770.07	28	3.614	-0.063	1.000	64251	0			0
803	71.72	207.77	279.49	774.22	772.93	30	3.637	0.041	1.000	71715	0			0
805	79.40	236.82	316.22	777.23	775.81	32	3.656	0.132	1.000	79398	0			0
807	87.23	267.70	354.92	780.23	778.68	34	3.670	0.213	0.999	87227	0			0
809	95.13	300.43	395.56	783.20	781.54	36	3.681	0.283	0.997	95129	0			0
811	103.04	335.05	438.09	786.14	784.36	38	3.688	0.346	0.994	103044	0			0
813	110.94	371.58	482.51	789.03	787.16	40	3.692	0.401	0.990	110937	0			0
815	116.80	410.02	526.82	791.86	789.93	42	3.695	0.449	0.984	118798	0			0
815.80	121.92	425.84	547.76	792.97	791.01	42.8	3.697	0.467	0.982	121920	0			0
816	120.88	430.08	550.96	793.15	791.19	43	0.743	0.469	0.974	120881	0			0
817	120.38	450.77	571.15	794.30	792.31	44	0.729	0.484	0.971	120376	0			0
818	125.41	471.53	596.95	795.73	793.71	45	0.715	0.505	0.965	119471	1	2.971	1.000	5941
819	135.20	492.46	627.65	797.37	795.31	46	0.701	0.530	0.955	117886	2	3.060	1.000	17312
820	150.12	513.69	663.80	799.23	797.14	47	0.696	0.558	0.942	117459	3	3.143	1.000	32658
821	169.55	515.17	684.72	800.28	798.16	48	0.692	0.568	0.937	118063	4	3.218	1.000	51484
822	192.73	513.62	706.34	801.33	799.20	49	0.692	0.578	0.933	119236	5	3.287	1.000	73492
823	218.74	512.79	731.52	802.53	800.38	50	0.692	0.591	0.927	120275	6	3.350	1.000	98460
824	247.01	512.16	759.17	803.81	801.64	51	0.692	0.604	0.917	120795	7	3.407	1.000	126214
825	277.21	511.18	788.39	805.13	802.94	52	0.692	0.618	0.903	120603	8	3.461	1.000	156605
826	308.64	520.83	829.47	806.93	804.72	53	0.692	0.640	0.880	119134	9	3.509	1.000	189507
827	341.15	534.11	875.26	808.87	806.64	54	0.692	0.664	0.847	116336	10	3.555	1.000	224814
828	375.82	543.85	919.67	810.69	808.44	55	0.692	0.685	0.815	113379	11	3.597	1.000	
829	412.64	552.48	965.12	812.50	810.23	56	0.692	0.705	0.783	110313	12	3.638	1.000	
830	451.56	558.17	1009.73	814.23	811.95	57	0.692	0.723	0.751	107143	13	3.674	1.000	344421
830.57	474.20	568.86	1043.06	815.51	813.21	57.6	0.692	0.738	0.726	104223	14	3.695	1.000	369461
831.14	497.58	581.48	1079.05	816.87	814.55	58.1	0.692	0.754	0.698	100911	14	3.715	1.000	25216
831.71	521.74	594.01	1115.76	818.24	815.90	58.7	0.692	0.771	0.669	97393	15	3.736	1.000	589
832.29	546.93	605.35	1152.28	819.59	817.24	59.3	0.692	0.786	0.641	93968	15		1.000	44
832.86	572.16	616.35	1188.51	820.92	818.55	59.9	0.692	0.801	0.614	90622	16	3.776	0.9	4758
833.43	596.79	627.10	1223.88	822.22	819.82	60.4	0.692	0.814	0.586	87097	16	3.796	0.9	502161
834	621.10	638.13	1259.23	823.51	821.09	61	0.692	0.828	0.560	83673	16	3.816	0.98	527939

HW feet	Overflow Section Discharges (cfs) Right Bank Saddle Dam Q_f	Main Dam Works Concrete Q_f	Main Dam Works Embankment Q_f	Saddle Dam 1-Section 1 Q_f	Saddle Dam 1-Section 2 Q_f	Saddle Dam 2 Q_f	Saddle Dam 3-Section 1 Q_f	Saddle Dam 3-Section 2 Q_f
C_f =	2.65	2.65	2.65	3.10	2.65	2.65	2.65	2.65
Z_e =	834	830	834	834	834	834	834	834
L =	2000	447.5	2700	100	62	525	112	0.60
773	0	0	0	0	0	0	0	0
775	0	0	0	0	0	0	0	0
777	0	0	0	0	0	0	0	0
779	0	0	0	0	0	0	0	0
781	0	0	0	0	0	0	0	0
783	0	0	0	0	0	0	0	0
785	0	0	0	0	0	0	0	0
787	0	0	0	0	0	0	0	0
789	0	0	0	0	0	0	0	0
791	0	0	0	0	0	0	0	0
793	0	0	0	0	0	0	0	0
795	0	0	0	0	0	0	0	0
797	0	0	0	0	0	0	0	0
799	0	0	0	0	0	0	0	0
801	0	0	0	0	0	0	0	0
803	0	0	0	0	0	0	0	0
805	0	0	0	0	0	0	0	0
807	0	0	0	0	0	0	0	0
809	0	0	0	0	0	0	0	0
811	0	0	0	0	0	0	0	0
813	0	0	0	0	0	0	0	0
815	0	0	0	0	0	0	0	0
815.80	0	0	0	0	0	0	0	0
816	0	0	0	0	0	0	0	0
817	0	0	0	0	0	0	0	0
818	0	0	0	0	0	0	0	0
819	0	0	0	0	0	0	0	0
820	0	0	0	0	0	0	0	0
821	0	0	0	0	0	0	0	0
822	0	0	0	0	0	0	0	0
823	0	0	0	0	0	0	0	0
824	0	0	0	0	0	0	0	0
825	0	0	0	0	0	0	0	0
826	0	0	0	0	0	0	0	0
827	0	0	0	0	0	0	0	0
828	0	0	0	0	0	0	0	0
829	0	0	0	0	0	0	0	0
830	0	0	0	0	0	0	0	0
830.57	0	0	512	0	0	0	0	0
831.14	0	1449	0	0	0	0	0	0
831.71	0	2662	0	0	0	0	0	0
832.29	0	4098	0	0	0	0	0	0
832.86	0	5727	0	0	0	0	0	0
833.43	0	7529	0	0	0	0	0	0
834	0	9487	0	0	0	0	0	0

Figure 6 – Calculations for Case 1A, Pre-Failure Condition, Fort Loudoun Gates Fully Open, Fort Loudoun Turbines Not Operating

Case No Longer Valid

6.3 Case 2, Pre-Failure Condition, Fort Loudoun Gates Closed, Fort Loudoun Turbines Operating

This case considers no failure has occurred at Tellico Dam. The spillway gates at Tellico Dam are considered fully open, while a seismic event has caused the bridge over Fort Loudoun Dam to collapse, rendering the gates at Fort Loudoun unable to be opened. No other failure of Fort Loudoun Dam is considered. The turbines at Fort Loudoun are generating electricity.

For the pre-failure condition, discharges are computed for headwaters ranging from 773 feet, the spillway crest elevation, to 837 feet, seven feet above the top of the dam and embankment. Discharge passes through the spillway section of the dam, the emergency spillway in saddle dam 1 and the various overflow sections as headwater rises above the crest elevations in each case. Total discharge, given in "1000 cfs" is the sum of all discharges in cfs past the dam plus discharge in cfs past the embankment and saddle dams divided by 1000.

Figure 7 shows the spreadsheet calculations for the pre-failure dam rating curve (spreadsheet included as Attachment E37). The final result, the rating curve, is defined by the first two columns, HW vs. Total Tellico Discharge (Q_{TEL}). The third and fourth columns contain the Fort Loudoun Discharge (Q_{FTL}) and the total combined discharge (Q_{TOT}). The fifth and sixth columns (TW) give the tailwater associated with the "Total Discharge at Tellico Dam and the Saddle Dams, respectively. They are represented by the tailwater rating curve polynomial fit [4.18.1]. This is used to check for tailwater submergence effects on the discharge. Tailwater submergence can reduce the spillway and emergency spillway discharges for Case 2. Consequently, it is necessary to iterate through different tailwater elevations until the total computed discharge fits the tailwater rating curve [4.18.1]. Figure 7 shows the final results but does not show the iteration steps. The results are readily checked by computing the individual discharges (only the spillway and emergency spillway are affected by tailwater), adding them up to compute total discharge, and then making sure the listed tailwater and total combined discharge agree with the tailwater rating curves.

Spillway discharge in cfs is computed in the next five columns (under the header "Spillway"), H_c, $C_f|C_g$, d/H_c, $S_f|S_g$ and $Q_f|Q_g$. Free discharge occurs for headwater elevations below 815.796 feet [4.3.4] and orifice discharge occurs for headwaters above 815.796 feet. The transition point is indicated by a horizontal line. Above the line, the listed discharge coefficient is C_f [4.2.3] computed from Equation (A6) and below the line the listed discharge coefficient is C_g [4.3.5] computed by interpolation between the points in Table A3. Column $Q_f|Q_g$ is the spillway discharge computed from Equation 1 for free discharge and from Equation 4 for orifice discharge. Column d/H_c verifies that the spillway discharge is not affected by tailwater since $d/H_c < 0.2$ [4.2.4] for all headwater elevations at which free discharge occurs. Spillway discharge is affected by tailwater for all values of $d/H_c > 0.2$ [4.3.6] at all headwater elevations where orifice discharge occurs. For this reason, discharges above elevation 828 feet are affected by submergence.

Emergency Spillway discharge is computed in the next four columns (under the header "Emergency Spillway"), H_c, C_f, S_f and Q_f. Free discharge occurs at all heads (H_c) above the spillway crest at elevation 817 feet [4.11.2]. The discharge coefficient is C_f [4.11.1] computed from Equation 5. The submergence factor, S_f [4.11.4], is computed using Equation 6. Column Q_f is the emergency spillway discharge computed from Equation 2 for free discharge with submergence.

The column following the emergency spillway discharge column shows "C_f=", "Z_c=", and "L=" in three rows to indicate the meaning of the values included in those rows in the "Overflow Section Discharges" columns.

The next eight columns are overflow discharges in cfs for the right bank saddle dam, main dam works (including the earth embankment), three saddle dams and the remaining overflow sections below the maximum headwater elevation. The overflow discharge coefficient C_f ([4.5.1], [4.4.1], [4.6.1], [4.7.1], [4.8.1], [4.9.1], [4.10.1], [4.16.1]), elevation Z_c ([4.5.2], [4.4.2], [4.6.2], [4.7.2], [4.8.2], [4.9.2], [4.10.2], [4.16.2]), and length L ([4.5.3], [4.4.3], [4.6.3], [4.7.3], [4.8.3], [4.9.3], [4.10.3], [4.16.3]) in each case are indicated in the three rows above the computed discharges. Submergence does not affect the discharge for the overflow sections because the tailwater never reaches the overflow elevation of any overflow section. All overflow discharges are computed using Equation 1.

Case No Longer Valid

Pre-Failure-Saddle Dams and Embankment Intact-Ft. Loudoun Gates Closed-Fort Loudoun Turbines Operating

g = 32.2 ft/s²

Spillway Parameters: L = 120 feet; Z_c = 773 feet; G_n = 33.576 feet; H_{mp} = 16.354 feet

Emergency Spillway Parameters: L = 2000 feet; Z_c = 817 feet

						Spillway					Emergency Spillway				Overflow Section Discharges (cfs)							
	Q_{TEL}	Q_{FTL}	Q_{TOT}												Right Bank Saddle Dam	Main Dam Works	Saddle Dam 1-Section 1	Saddle Dam 1-Section 2	Saddle Dam 2	Saddle Dam 3-Section 1	Saddle Dam 3-Section 2	Remaining Overflow Sections
	Total	Total	Total	Main Dam TW	Saddle Dam TW										C_f =	2.65	2.65	3.10	2.65	2.65	2.65	2.65
															Z_c =	830	830	830.5	830.5	830	831.7	
HW	Discharge	Discharge	Discharge			H_c	$C_f \mid C_g$	d/H_c	S_f/S_g	$Q_f \mid Q_g$	H_c	C_f	S_f	Q_f	L =	2000	3147.5	100	62	525		253.6	2500
feet	1000 cfs	1000 cfs	1000 cfs	feet	feet	feet				cfs	feet			cfs		Q_f	Q_f	Q_f	Q_f	Q_f	Q_f	Q_f
773	0.00	0.00	0.00	735.00	735.00	0				0	0			0		0	0	0	0	0	0	0
775	1.06	24.17	25.23	746.43	745.24	2	3.112	-13.284	1.000	1056	0			0		0	0	0	0	0	0	0
777	3.01	25.71	28.72	746.92	745.71	4	3.134	-6.519	1.000	3009	0			0		0	0	0	0	0	0	0
779	5.58	27.10	32.68	747.48	746.23	6	3.166	-4.254	1.000	5583	0			0		0	0	0	0	0	0	0
781	8.70	28.35	37.05	748.08	746.81	8	3.204	-3.115	1.000	8699	0			0		0	0	0	0	0	0	0
783	12.32	29.48	41.80	748.74	747.43	10	3.247	-2.426	1.000	12320	0			0		0	0	0	0	0	0	0
785	16.42	30.49	46.91	749.44	748.09	12	3.292	-1.964	1.000	16423	0			0		0	0	0	0	0	0	0
787	20.99	31.40	52.39	750.18	748.79	14	3.339	-1.630	1.000	20992	0			0		0	0	0	0	0	0	0
789	26.01	32.20	58.21	750.96	749.53	16	3.387	-1.378	1.000	26009	0			0		0	0	0	0	0	0	0
791	31.46	32.20	63.66	751.68	750.21	18	3.432	-1.185	1.000	31455	0			0		0	0	0	0	0	0	0
793	37.31	32.20	69.51	752.45	750.94	20	3.476	-1.028	1.000	37309	0			0		0	0	0	0	0	0	0
795	43.54	32.20	75.74	753.26	751.71	22	3.517	-0.897	1.000	43545	0			0		0	0	0	0	0	0	0
797	50.13	32.20	82.33	754.11	752.52	24	3.553	-0.787	1.000	50134	0			0		0	0	0	0	0	0	0
799	57.05	32.20	89.25	754.98	753.35	26	3.588	-0.693	1.000	57047	0			0		0	0	0	0	0	0	0
801	64.25	32.20	96.45	755.89	754.21	28	3.614	-0.611	1.000	64251	0			0		0	0	0	0	0	0	0
803	71.72	32.20	103.92	756.82	755.09	30	3.637	-0.539	1.000	71716	0			0		0	0	0	0	0	0	0
805	79.41	32.20	111.61	757.76	755.99	32	3.656	-0.476	1.000	79411	0			0		0	0	0	0	0	0	0
807	87.31	32.20	119.51	758.71	756.90	34	3.670	-0.420	1.000	87313	0			0		0	0	0	0	0	0	0
809	95.40	32.20	127.60	759.68	757.81	36	3.681	-0.370	1.000	95399	0			0		0	0	0	0	0	0	0
811	103.66	32.20	135.86	760.65	758.73	38	3.688	-0.325	1.000	103659	0			0		0	0	0	0	0	0	0
813	112.09	32.20	144.29	761.62	759.66	40	3.692	-0.284	1.000	112091	0			0		0	0	0	0	0	0	0
815	120.70	32.20	152.90	762.61	760.60	42	3.695	-0.247	1.000	120704	0			0		0	0	0	0	0	0	0
815.796	124.19	33.19	157.38	763.09	761.05	43	3.697	-0.232	1.000	124188	0			0		0	0	0	0	0	0	0
816	124.01	34.16	158.17	763.21	761.17	43	0.743	-0.228	1.000	124	0			0		0	0	0	0	0	0	0
817	123.94	37.74	161.68	763.60	761.54	44	0.7	-0	1.000	123936	0			0		0	0	0	0	0	0	0
818	129.68	42.38	172.06	764.75	762	45	0	-0.183	1.000	123735	1	2.971	1.000	5941		0	0	0	0	0	0	0
819	140.72	47.91	188.64	766.54	764.35	46	0.6	-0.140	1.000	123411	2	3.060	1.000	17312		0	0	0	0	0	0	0
820	157.24	54.41	211.65	768.95	766.64	47	0.696		1.000	124580	3	3.143	1.000	32658		0	0	0	0	0	0	0
821	177.35	55.59	232.94	771	768	48	0.6	-0.040	1.000	125869	4	3.218	1.000	51484		0	0	0	0	0	0	0
822	201.33	58.62	259.95	773.69	771.16	49	0.692	0.014	1.000	127842	5	3.287	1.000	73492		0	0	0	0	0	0	0
823	228.25	32.34	260.58	773.75	771	50	0.692	0.015	1.000	129785	6	3.350	1.000	98460		0	0	0	0	0	0	0
824	257.91	40.68	298.59	777.21	774.53	51	0.692	0.083	1.000	131700	7	3.407	1.000	126214		0	0	0	0	0	0	0
825	290.19	50.58	340.77	780.80	777.97	52	0.692	0.150	1.000	133587	8	3.461	1.000	156605		0	0	0	0	0	0	0
826	324.84	61.75	386.59	784.68	781.45	53	0.692	0.216	0.999	135332	9	3.509	1.000	189507		0	0	0	0	0	0	0
827	361.54	78.01	439.55	788.85	785.17	54	0.692	0.283	0.996	136730	10	3.555	1.000	224814		0	0	0	0	0	0	0
828	400.46	92.17	492.63	793.26	788.62	55	0.692	0.343	0.992	138023	11	3.597	1.000	262442		0	0	0	0	0	0	0
829	441.39	108	549.70	795.34	791.99	56	0.692	0.399	0.987	139066	12	3.636	1.000	302325		0	0	0	0	0	0	0
830	483.54	125.11	608.64	798.66	795.21	57	0.692	0.450	0.975	139114	13	3.674	1.000	344421		0	0	0	0	0	0	0
831	548.[illegible]	142	691.25	802.90	799.34	58	0.692	0.515	0.949	137057	14	3.710	1.000	388710		5300	8341	110	58	1391	0	672	6625
832	63[illegible]	161.86	792.98	807.57	803.91	59	0.692	0.586	0.902	131867	15	3.746	1.000	435197		14991	23592	570	302	3935	27	1901	18738
833	[illegible].08	181.66	905.73	812.26	808.53	60	0.692	0.654	0.825	122022	16	3.781	1.000	483913		27540	43340	1225	649	7229	244	3492	34425
834	[illegible]	206.56	1032.32	817.14	813.35	61	0.692	0.724	0.726	108529	17	3.816	1.000	534917		42400	66727	2030	1076	11130	574	5376	53000
835	935.08	235.33	1170.41	822.26	818.41	62	0.692	0.795	0.611	92417	18	3.852	0.999	587502		59256	93254	2959	1568	15555	987	7514	74070
836	1037.98	269.51	1307.49	827.31	823.40	63	0.692	0.862	0.490	74881	19	3.889	0.974	627343		77894	122585	3999	2119	20447	1468	9877	97367
	1129.86	303.47	1433.33	832.00	828.03	64	0.692	0.922	0.373	57607	20	3.928	0.923	648844		98157	154475	5137	2723	25766	2009	12446	122697

Case No Longer Valid

Figure 7 – Calculations for Case 2, Pre-Failure Condition, Fort Loudoun Gates Closed, Fort Loudoun Turbines Operating

6.4 Case 2A, Pre-Failure Condition, Fort Loudoun Gates Closed, Fort Loudoun Turbines Not Operating

This case considers no failure has occurred at Tellico Dam. The spillway gates at Tellico Dam are considered fully open, while a seismic event has caused the bridge over Fort Loudoun Dam to collapse, rendering the gates at Fort Loudoun unable to be opened. No other failure of Fort Loudoun Dam is considered. The turbines at Fort Loudoun are not generating electricity.

For the pre-failure condition, discharges are computed for headwaters ranging from 773 feet, the spillway crest elevation, to 837 feet, seven feet above the top of the dam and embankment. Discharge passes through the spillway section of the dam, the emergency spillway in saddle dam 1 and the various overflow sections as headwater rises above the lowest elevations in each case. Total discharge, given in "1000 cfs" is the sum of all discharges in cfs past the dam plus discharge in cfs past the embankment and saddle dams divided by 1000.

Figure 8 shows the spreadsheet calculations for the pre-failure dam rating curve (spreadsheet included as Attachment E37). The final result, the rating curve, is defined by the first two columns, HW vs. Total Tellico Discharge (Q_{TEL}). The third and fourth columns contain the Fort Loudoun Discharge (Q_{FTL}) and the total combined discharge (Q_{TOT}). The fifth and sixth columns (TW) give the tailwater associated with the "Total Discharge at Tellico Dam and the Saddle Dams, respectively. They are represented by the tailwater rating curve polynomial fit [4.18.1]. This is used to check for tailwater submergence effects on the discharge. Tailwater submergence affects the spillway and emergency spillway discharges for Case 2A. Consequently, it is necessary to iterate through different tailwater elevations until the total computed discharge fits the tailwater rating curve [4.18.1]. Figure 8 shows the final results but does not show the iteration steps. The results are readily checked by computing the individual discharges (only the spillway and emergency spillway are affected by tailwater), adding them up to compute total discharge, and then making sure the listed tailwater and total combined discharge agree with the tailwater rating curves.

Spillway discharge in cfs is computed in the next five columns (under the header "Spillway"), H_c, $C_f|C_g$, d/H_c, $S_f|S_g$ and $Q_f|Q_g$. Free discharge occurs for headwater elevations below 815.796 feet [4.3.4] and orifice discharge occurs for headwaters above 815.796 feet. The transition point is indicated by a horizontal line. Above the line, the listed discharge coefficient is C_f [4.2.3] computed from Equation (A6) and below the line the listed discharge coefficient is C_g [4.3.5] computed by interpolation between the points in Table A3. Column $Q_f|Q_g$ is the spillway discharge computed from Equation 1 for free discharge and from Equation 4 for orifice discharge. Column d/H_c verifies that the spillway discharge is not affected by tailwater since $d/H_c < 0.2$ [4.2.4] for all headwater elevations at which free discharge occurs. Spillway discharge is affected by tailwater for all values of $d/H_c > 0.2$ [4.3.6] at all headwater elevations where orifice discharge occurs. For this reason, all discharges above elevation 828 feet are affected by submergence.

Emergency Spillway discharge is computed in the next four columns (under the header "Emergency Spillway"), H_c, C_f, S_f and Q_f. Free discharge occurs at all heads (H_c) above the spillway crest at elevation 817 feet [4.11.2]. The discharge coefficient is C_f [4.11.1] computed from Equation 5. The submergence factor, S_f [4.11.4], is computed using Equation 6. Column Q_f is the emergency spillway discharge computed from Equation 2 for free discharge with submergence.

The column following the emergency spillway discharge column shows "C_f=", "Z_c=", and "L=" in three rows to indicate the meaning of the values included in those rows in the "Overflow Section Discharges" columns.

The next eight columns are overflow discharges in cfs for the right bank saddle dam, main dam works (including the earth embankment), three saddle dams and the remaining overflow sections below the maximum headwater elevation. The overflow discharge coefficient C_f ([4.5.1], [4.4.1], [4.6.1], [4.7.1], [4.8.1], [4.9.1], [4.10.1], [4.16.1]), elevation Z_c ([4.5.2], [4.4.2], [4.6.2], [4.7.2], [4.8.2], [4.9.2], [4.10.2], [4.16.2]), and length L ([4.5.3], [4.4.3], [4.6.3], [4.7.3], [4.8.3], [4.9.3], [4.10.3], [4.16.3]) in each case are indicated in the three rows above the computed discharges. Submergence does not affect the discharge for the overflow sections because the tailwater never reaches the overflow elevation of any overflow section. All overflow discharges are computed using Equation 1.

Case No Longer Valid

Pre-Failure-Saddle Dams and Embankment Intact-Ft. Loudoun Gates Closed-Fort Loudoun Turbines Not Operating

g = 32.2 ft/s²

Spillway Parameters: L = 120 feet; Z_c = 773 feet; C_h = 33.576 feet; H_{mp} = 16.354 feet

Emergency Spillway Parameters: L = 2000 feet; Z_c = 817 feet

						Spillway						Emergency Spillway				Overflow Section Discharges (cfs)							
	Q_{TEL}	Q_{FTL}	Q_{TOT}													Right Bank Saddle Dam	Main Dam Works	Saddle Dam 1-Section 1	Saddle Dam 1-Section 2	Saddle Dam 2	Saddle Dam 3-Section 1	Saddle Dam 3-Section 2	Remaining Overflow Sections
	Total	Total	Total	Main Dam	Saddle Dam											C_f = 2.65	2.65	3.10	2.65	2.65	2.6	2.6	2.6
																Z_c = 830	830	830.5	830.5	830	831.7	830	830
HW	Discharge	Discharge	Discharge	TW	TW	H_c	$C_f \mid C_g$	d/H_c	S_f/S_g	$Q_f \mid Q_g$	H_L	C_f	S_f	Q_f	L =	2000	3147.5	100	62	525	2	2	2500
feet	1000 cfs	1000 cfs	1000 cfs	feet	feet	feet				cfs	feet			cfs		Q_f	Q_f	Q_f	Q_f	Q_f	Q_f	Q_f	Q_f
773	0.00	0.00	0.00	735.00	735.00	0				0	0			0		0	0	0	0	0	0	0	0
775	1.06	0.00	1.06	742.96	741.95	2	3.112	-15.023	1.000	1056	0			0		0	0	0	0	0	0	0	0
777	3.01	0.00	3.01	743.24	742.22	4	3.134	-7.440	1.000	3009	0			0		0	0	0	0	0	0	0	0
779	5.58	0.00	5.58	743.62	742.57	6	3.166	-4.897	1.000	5583	0			0		0	0	0	0	0	0	0	0
781	8.70	0.00	8.70	744.07	743.00	8	3.204	-3.616	1.000	8699	0			0		0	0	0	0	0	0	0	0
783	12.32	0.00	12.32	744.59	743.50	10	3.247	-2.841	1.000	12320	0			0		0	0	0	0	0	0	0	0
785	16.42	0.00	16.42	745.18	744.06	12	3.292	-2.318	1.000	16423	0			0		0	0	0	0	0	0	0	0
787	20.99	0.00	20.99	745.83	744.67	14	3.339	-1.940	1.000	20992	0			0		0	0	0	0	0	0	0	0
789	26.01	0.00	26.01	746.54	745.35	16	3.387	-1.654	1.000	26009	0			0		0	0	0	0	0	0	0	0
791	31.46	0.00	31.46	747.31	746.07	18	3.432	-1.427	1.000	31455	0			0		0	0	0	0	0	0	0	0
793	37.31	0.00	37.31	748.12	746.84	20	3.476	-1.244	1.000	37309	0			0		0	0	0	0	0	0	0	0
795	43.54	0.00	43.54	748.98	747.65	22	3.517	-1.092	1.000	43545	0			0		0	0	0	0	0	0	0	0
797	50.13	0.00	50.13	749.87	748.50	24	3.553	-0.964	1.000	50134	0			0		0	0	0	0	0	0	0	0
799	57.05	0.00	57.05	750.80	749.38	26	3.586	-0.854	1.000	57047	0			0		0	0	0	0	0	0	0	0
801	64.25	0.00	64.25	751.76	750.29	28	3.614	-0.759	1.000	64251	0			0		0	0	0	0	0	0	0	0
803	71.72	0.00	71.72	752.73	751.22	30	3.637	-0.676	1.000	71716	0			0		0	0	0	0	0	0	0	0
805	79.41	0.00	79.41	753.73	752.16	32	3.656	-0.602	1.000	79411	0			0		0	0	0	0	0	0	0	0
807	87.31	0.00	87.31	754.74	753.12	34	3.670	-0.537	1.000	[illegible]	0			0		0	0	0	0	0	0	0	0
809	95.40	0.00	95.40	755.76	754.09	36	3.681	-0.479	1.000	95399	0			0		0	0	0	0	0	0	0	0
811	103.66	0.00	103.66	756.78	755.06	38	3.688	-0.427	1.000	103659	0			0		0	0	0	0	0	0	0	0
813	112.09	0.00	112.09	757.82	756.04	40	3.692	-0.380	1.000	[illegible]	0			0		0	0	0	0	0	0	0	0
815	120.70	0.00	120.70	758.86	757.03	42	3.6[illegible]	-0.337	1.000	120[illegible]	0			0		0	0	0	0	0	0	0	0
815.796	124.19	0.80	124.99	759.36	757.51	42.8	3.697	-[illegible]319	1.000	[illegible]	0			0		0	0	0	0	0	0	0	0
816	124.01	1.96	125.97	759.49	757.63	43	0.743	-0.[illegible]	1.000	124010	0			0		0	0	0	0	0	0	0	0
817	123.94	5.54	129.48	759.90	758.03	44	0.729	-0.298	[illegible]	123936	0			0		0	0	0	0	0	0	0	0
818	129.68	10.18	139.86	761.12	759.18	[illegible]	[illegible]715	-0.264	1.000	123735	1	2.971	1.000	5941		0	0	0	0	0	0	0	0
819	140.72	15.71	156.44	763.01	760.[illegible]	46	0.[illegible]	-0.217	1.000	123411	2	3.060	1.000	17312		0	0	0	0	0	0	0	0
820	157.24	22.21	179.45	764.[illegible]	763.[illegible]	47	0.69[illegible]	-0.158	1.000	124580	3	3.143	1.000	32658		0	0	0	0	0	0	0	0
821	177.35	23.39	200.74	767.82	765.56	[illegible]	[illegible]	-0.108	1.000	125869	4	3.218	1.000	51484		0	0	0	0	0	0	0	0
822	201.33	26.42	[illegible]	770.57	[illegible]	49	0.692	-0.050	1.000	127842	5	3.287	1.000	73492		0	0	0	0	0	0	0	0
823	228.25	32.34	26[illegible]	773.[illegible]	[illegible]	50	0.692	0.015	1.000	129785	6	3.350	1.000	98460		0	0	0	0	0	0	0	0
824	257.91	40.68	298.59	777.21	774.53	51	0.692	0.083	1.000	131700	7	3.407	1.000	126214		0	0	0	0	0	0	0	0
825	290.19	50.58	340.77	[illegible]	777.97	52	0.692	0.150	1.000	133587	8	3.461	1.000	156605		0	0	0	0	0	0	0	0
826	324.84	61.75	386.59	784.4[illegible]	781.45	53	0.692	0.216	0.999	135332	9	3.509	1.000	189507		0	0	0	0	0	0	0	0
827	361.54	[illegible]01	[illegible]39.55	788.29	785.17	54	0.692	0.283	0.996	136730	10	3.555	1.000	224814		0	0	0	0	0	0	0	0
828	400.46	[illegible]92.57	[illegible]03	791.86	788.62	55	0.692	0.343	0.992	138023	11	3.597	1.000	262442		0	0	0	0	0	0	0	0
829	441.39	[illegible]	[illegible]70	795.34	791.99	56	0.692	0.399	0.987	139066	12	3.636	1.000	302325		0	0	0	0	0	0	0	0
830	[illegible]6.54	129.[illegible]	608.64	798.66	795.21	57	0.692	0.450	0.975	139114	13	3.674	1.000	344421		0	0	0	0	0	0	0	0
831	[illegible]48.[illegible]	[illegible]98	691.25	802.90	799.34	58	0.692	0.515	0.949	137057	14	3.710	1.000	388710		5300	8341	110	58	1391	0	672	6625
832	631.12	[illegible]86	792.98	807.57	803.91	59	0.692	0.586	0.902	131867	15	3.746	1.000	435197		14991	23592	570	302	3935	27	1901	18738
833	724.6[illegible]	181.66	905.73	812.26	808.53	60	0.692	0.654	0.825	122022	16	3.781	1.000	483913		27540	43340	1225	649	7229	244	3492	34425
834	[illegible]26.[illegible]	206.56	1032.32	817.14	813.35	61	0.692	0.724	0.726	108529	17	3.816	1.000	534917		42400	66727	2030	1076	11130	574	5376	53000
835	[illegible]35.08	235.33	1170.41	822.26	818.41	62	0.692	0.795	0.611	92417	18	3.852	0.999	587502		59256	93254	2959	1568	15555	987	7514	74070
836	1037.98	269.51	1307.49	827.31	823.40	63	0.692	0.862	0.490	74881	19	3.889	0.974	627343		77894	122585	3999	2119	20447	1468	9877	97367
837	1129.86	303.47	1433.33	832.00	828.03	64	0.692	0.922	0.373	57607	20	3.928	0.923	648844		98157	154475	5137	2723	25766	2009	12446	122697

Case No Longer Valid

Figure 8 – Calculations for Case 2A, Pre-Failure Condition, Fort Loudoun Gates Closed, Fort Loudoun Turbines Not Operating

6.5 Case 3, Pre-Failure Condition at Tellico Dam, Fort Loudoun Embankment Failure, Fort Loudoun Gates Open, Fort Loudoun Turbines Not Operating

This case considers no failure has occurred at Tellico Dam. The south embankment at Fort Loudoun Dam has failed. The spillway gates at both dams are considered fully open. The turbines at Fort Loudoun are not generating electricity.

For the pre-failure condition, discharges are computed for headwaters ranging from 773 feet, the spillway crest elevation, to 837 feet, seven feet above the top of the dam and embankment. Discharge passes through the spillway section of the dam, the emergency spillway in saddle dam 1 and the various overflow sections as headwater rises above the crest elevations in each case. Total discharge, given in "1000 cfs" is the sum of all discharges in cfs past the dam divided by 1000. Tailwater is discharge in cfs past the embankment and saddle dams divided by 1000.

Figure 9 shows the spreadsheet calculations for the pre-failure dam rating curve (spreadsheet included as Attachment E37). The final result, the rating curve, is defined by the first two columns, HW vs. Total Tellico Discharge (Q_{TEL}). The third and fourth columns contain the Fort Loudoun Discharge (Q_{FTL}) and the total combined discharge (Q_{TOT}). The fifth and sixth columns (TW) give the tailwater associated with the "Total Discharge" at Tellico Dam and the Saddle Dams, respectively. They are represented by the tailwater rating curve polynomial fit [4.18.1]. This is used to check for tailwater submergence effects on the discharge. Tailwater submergence reduces the spillway and emergency spillway discharges for Case 3. Consequently, it is necessary to iterate through different tailwater elevations until the total computed discharge fits the tailwater rating curve [4.18.1]. Figure 9 shows the final results but does not show the iteration steps. The results are readily checked by computing the individual discharges, adding them up to compute total discharge and then making sure the listed tailwater and total combined discharge agree with the tailwater rating curves.

Spillway discharge in cfs is computed in the next five columns (under the header "Spillway"), H_c, $C_f|C_g$, d/H_c, $S_f|S_g$ and $Q_f|Q_g$. Free discharge occurs for headwater elevations below 815.796 feet [4.3.4] and orifice discharge occurs for headwaters above 815.796 feet. The transition point is indicated by a horizontal line. Above the line, the listed discharge coefficient is C_f [4.2.3] computed from Equation (A6) and below the line the listed discharge coefficient is C_g [4.3.5] computed by interpolation between the points in Table A3. Column $Q_f|Q_g$ is the spillway discharge computed from Equation 2 for free discharge and from Equation for orifice discharge. Column d/H_c indicates that the spillway discharge is not affected by tailwater for elevations below 777 feet since $d/H_c < 0.2$ [4.2.4], but is affected at all headwater elevations above 777 feet at which free discharge occurs. Spillway discharge is affected by tailwater at all headwater elevations where orifice discharge occurs because $d/H_c > 0.2$ [4.3.6] at all values of d/H_c.

Emergency Spillway discharge is computed in the next four columns (under the header "Emergency Spillway"), H_c, C_f, S_f and Q_f. Free discharge occurs at all heads (H_c) above the spillway crest at elevation 817 feet [4.11.2]. The discharge coefficient is C_f [4.11.1] computed from Equation 5. The submergence factor, S_f [4.11.4], is computed using Equation 6. Column Q_f is the emergency spillway discharge computed from Equation 2 for free discharge with submergence.

The column following the emergency spillway discharge column shows "C_f=", "Z_c=", and "L=" in three rows to indicate the meaning of the values included in those rows in the "Overflow Discharge" columns.

The next eight columns are divided into three sub-columns, each. Contained in the sub-columns are overflow discharges in cfs for the right bank saddle dam, main dam works (including the earthen embankment), the three saddle dams and the remaining sections which are expected to overflow. The overflow discharge coefficient C_f ([4.5.1], [4.4.1], [4.6.1], [4.7.1], [4.8.1], [4.9.1], [4.10.1], [4.16.1]), elevation Z_c ([4.5.2], [4.4.2], [4.6.2], [4.7.2], [4.8.2], [4.9.2], [4.10.2], [4.16.2]), and length L ([4.5.3], [4.4.3], [4.6.3], [4.7.3], [4.8.3], [4.9.3], [4.10.3], [4.16.3]) in each case are indicated in the three rows above the computed discharge sub-columns. The three sub-columns contain calculated values of d/H_c, S_f [4.17] and Q_f, respectively. All overflow discharges are computed using Equation 2. The values of d/H_c and S_f have been truncated in order fit all the columns.

Case No Longer Valid

Tellico Dam Saddle Dams and Embankment Intact, Fort Loudoun Dam Embankment Failure, Fort Loudoun Gates Open, Fort Loudoun Turbines Not Operating

g = 32.2 ft/s²

Spillway Parameters: L = 120 feet; Z_s = 773 feet; G_s = 33.576 feet; H_{vs} = 16.354 feet

Emergency Spillway Parameters: L = 2000 feet; Z_e = 817 feet

HW	Q_{TEL} Total Discharge	Q_{FTL} Total Discharge	Q_{TOT} Total Discharge	Main Dam TW	Saddle Dam TW	Spillway H_s	Spillway $C_f \mid C_s$	Spillway d/H_c	Spillway S_f/S_s	Spillway $Q_f \mid Q_s$	Emergency Spillway H_e	Emergency Spillway C_f	Emergency Spillway S_f	Emergency Spillway Q_f	Overflow Discharge, Q_f in cfs: Right Bank Saddle Dam	Main Dam Works	Saddle Dam 1-Section 1 *	Saddle Dam 1-Section 2	Saddle Dam 2	Saddle Dam 3-Section 1	Saddle Dam 3-Section 2	Remaining Overflow Sections
															C_f = 2.65	2.65	3.1	2.65	2.65	2.65	2.65	
															Z_c = 830	830	830.5	830.5	830	831.7	830	830
															L = 2000	3147.5	100	82	525	62.12	253	200
feet	1000 cfs	1000 cfs	1000 cfs	feet	feet	feet				cfs	feet			cfs	d/H_c S_f Q_f	d/H_c S_f Q_f	d/H_c S_f Q_f	d/H_c S_f Q_f	d/H_c S_f Q	d/H_c S_f Q_f	d/H_c S_f Q_f	d/H_c S_f Q_f
773	0.00	220.86	220.86	769.88	787.52	0				0	0			0		0		0		0		0
775	1.06	246.27	247.33	772.48	770.01	2	3.112	-0.258	1.000	1056	0			0		0		0		0		0
777	2.95	270.29	273.24	774.93	772.35	4	3.134	0.481	0.979	2947	0			0		0		0		0		0
779	5.08	293.40	298.48	777.20	774.52	6	3.166	0.700	0.911	5085	0			0		0		0		0		0
781	7.33	316.49	323.82	779.39	776.62	8	3.204	0.799	0.842	7328	0			0		0		0		0		0
783	9.68	339.90	349.58	781.52	778.66	10	3.247	0.852	0.785	9675	0			0		0		0		0		0
785	12.04	364.50	376.55	783.66	780.71	12	3.292	0.888	0.733	12044	0			0		0		0		0		0
787	14.41	390.32	404.73	785.79	782.76	14	3.339	0.913	0.686	14406	0			0		0		0		0		0
789	16.79	417.19	433.98	787.90	784.79	16	3.387	0.931	0.646	16793	0			0		0		0		0		0
791	19.25	445.04	464.29	789.98	786.80	18	3.432	0.943	0.612	19252	0			0		0		0		0		0
793	21.78	474.07	495.85	792.04	788.79	20	3.476	0.952	0.584	21779	0			0		0		0		0		0
795	24.36	504.48	528.82	794.09	790.78	22	3.517	0.959	0.559	24360	0			0		0		0		0		0
797	27.00	536.34	563.34	796.13	792.76	24	3.553	0.964	0.539	27003	0			0		0		0		0		0
799	29.87	569.35	599.22	798.15	794.71	26	3.586	0.967	0.524	29871	0			0		0		0		0		0
801	32.83	603.99	636.82	800.16	796.67	28	3.614	0.970	0.511	32835	0			0		0		0		0		0
803	35.88	640.44	676.32	802.16	798.62	30	3.637	0.972	0.500	35878	0			0		0		0		0		0
805	38.99	678.75	717.75	804.16	800.58	32	3.656	0.974	0.491	38994	0			0		0		0		0		0
807	42.17	718.97	761.14	806.16	802.53	34	3.670	0.975	0.483	42172	0			0		0		0		0		0
809	45.41	761.06	806.47	808.15	804.49	36	3.681	0.977	0.476	45413	0			0		0		0		0		0
811	48.73	804.97	853.70	810.15	806.45	38	3.688	0.977	0.470	48726	0			0		0		0		0		0
813	52.10	850.56	902.66	812.13	808.40	40	3.692	0.978	0.465	52102	0			0		0		0		0		0
815	55.59	897.49	953.08	814.12	810.36	42	3.695	0.979	0.461	55591	0			0		0		0		0		0
815.796	57.60	915.00	972.60	814.88	811.11	42.8	3.697	0.979	0.464	57602	0			0		0		0		0		0
816	34.98	942.80	977.78	815.07	811.30	43	0.743	0.978	0.282	34981	0			0		0		0		0		0
817	33.96	969.85	1003.81	816.07	812.28	44	0.729	0.979	0.274	33964	0			0		0		0		0		0
818	38.72	991.63	1030.35	817.07	813.27	45	0.715	0.979	0.265	32779	1	2.971	1.000	5941		0		0		0		0
819	48.78	1008.59	1057.36	818.08	814.28	46	0.701	0.980	-0.255	31466	2	3.[illegible]	[illegible]	17312		0		0		0		0
820	63.13	1021.63	1084.75	819.10	815.28	47	0.696	0.981	0.245	30169	3	[illegible]3	1.000	[illegible]58		0		0		0		0
821	82.38	1027.32	1109.69	820.02	816.20	48	0.692	0.980	0.245	30[illegible]	4	[illegible]	1.000	[illegible]04		0		0		0		0
822	103.65	1033.52	1137.17	821.04	817.20	49	0.692	0.980	0.236	30182	[illegible]	3.287	[illegible]	[illegible]466		0		0		0		0
823	126.96	1037.91	1164.87	822.06	818.21	50	0.692	0.98[illegible]	[illegible]	29391	6	[illegible]50	0.991	97571		0		0		0		0
824	152.05	1040.70	1192.75	823.08	819.22	51	0.692	0.982	[illegible]	28745	[illegible]	[illegible]	0.977	123305		0		0		0		0
825	178.62	1042.11	1220.73	824.11	820.24	52	0.692	0.983	0.210	[illegible]8048	8	3.461	0.961	150569		0		0		0		0
826	206.30	1042.56	1248.86	825.14	821.26	53	0.692	0.984	0.200	[illegible]	9	3.509	0.946	179221		0		0		0		0
827	235.11	1041.89	1277.00	826.18	822.28	54	0.692	0.985	0.189	25915	10	3.555	0.931	209190		0		0		0		0
828	264.91	1040.20	1305.11	827.22	823.31	55	0.692	[illegible]	0.176	24538	11	3.597	0.916	240374		0		0		0		0
829	297.84	1035.34	1333.18	828.26	824.34	56	0.692	[illegible]	0.162	22838	12	3.636	0.910	275002		0		0		0		0
830	329.53	1031.21	1360.74	829.28	825.36	57	[illegible]	0.987	0.151	21550	13	3.674	0.894	307975		0		0		0		0
831	384.22	1004.56	1388.78	830.33	[illegible]38	58	0.69[illegible]	[illegible]	0.140	20258	14	3.710	0.878	341463	0.3 1.0 5300	0.3 1.0 8341	-8.2 1.0 110	-8.2 1.0 58	-3.6 1.0 1391		0	-3.6 1.0 672 0.3 1.0 6625
832	456.39	960.74	1417.13	831.39	[illegible]47	59	[illegible]92	0.990	0.128	18713	15	3.746	0.863	375407	0.7 1.0 14524	0.7 1.0 22857	-2.0 1.0 570	-2.0 1.0 302	-1.3 1.0 3935	-14.2 1.0	27	-1.3 1.0 1901 0.7 1.0 18155
833	531.20	913.96	1445.16	[illegible]44	828.47	60	[illegible]92	0.991	0.118	17438	16	3.781	0.848	410248	0.8 0.9 23712	0.8 0.9 37317	-0.8 1.0 1225	-0.8 1.0 649	-0.5 1.0 7229	-2.5 1.0	244	-0.5 1.0 3492 0.8 0.9 29840
834	604.97	868.04	1473[illegible]	833[illegible]	829.50	[illegible]	0.692	0.992	0.109	16243	17	3.816	0.834	445904	0.9 0.8 32073	0.9 0.8 50474	-0.3 1.0 2030	-0.3 1.0 1076	-0.1 1.0 11130	-1.0 1.0	574	-0.1 1.0 5378 0.9 0.8 40091
835	676.27	824.48	150[illegible]	[illegible]64	[illegible]	62	0.692	0.993	0.099	14937	18	3.852	0.820	482446	0.9 0.7 39308	0.9 0.7 61860	0.0 1.0 2959	0.0 1.0 1568	0.1 1.0 15555	-0.4 1.0	987	0.1 1.0 7514 0.9 0.7 49135
836	[illegible]	783.02	1528.35	[illegible]35.58	[illegible]1.57	63	0.692	0.993	0.087	13371	19	3.889	0.807	519937	0.9 0.6 45535	0.9 0.6 71661	0.2 1.0 3999	0.2 1.0 2119	0.3 1.0 20447	0.0 1.0	1468	0.3 1.0 9877 0.9 0.6 56919
837	5.53	740.42	1555.95	[illegible]	832.59	64	0.692	0.994	0.077	11961	20	3.928	0.795	558786	0.9 0.5 51442	0.9 0.5 80957	0.3 1.0 5137	0.3 1.0 2723	0.4 1.0 25766	0.2 1.0	2009	0.4 1.0 12448 0.9 0.5 64303

Case No Longer Valid

Figure 9 – Calculations for Case 3, Pre-Failure Condition at Tellico, Fort Loudoun Embankment Failure, Fort Loudoun Gates Open, Fort Loudoun Turbines Not Operating

6.6 Case 4, Pre-Failure Condition at Tellico Dam, Fort Loudoun Embankment Failure, Fort Loudoun Gates Closed, Fort Loudoun Turbines Not Operating

This case considers no failure has occurred at Tellico Dam. The south embankment at Fort Loudoun Dam has failed. The spillway gates at Tellico Dam are considered fully open, while the gates at Fort Loudoun are considered closed. The turbines at Fort Loudoun are not generating electricity.

For the pre-failure condition, discharges are computed for headwaters ranging from 773 feet, the spillway crest elevation, to 837 feet, seven feet above the top of the dam and embankment. Discharge passes through the spillway section of the dam, the emergency spillway in saddle dam 1 and the various overflow sections as headwater rises above the crest elevations in each case. Total discharge, given in "1000 cfs" is the sum of all discharges in cfs past the dam plus discharge in cfs past the embankment and saddle dams divided by 1000.

Figure 10 shows the spreadsheet calculations for the pre-failure dam rating curve (spreadsheet included as Attachment E37). The final result, the rating curve, is defined by the first two columns, HW vs. Total Tellico Discharge (Q_{TEL}). The third and fourth columns contain the Fort Loudoun Discharge (Q_{FTL}) and the total combined discharge (Q_{TOT}). The fifth and sixth columns (TW) give the tailwater associated with the "Total Discharge at Tellico Dam and the Saddle Dams, respectively. They are represented by the tailwater rating curve polynomial fit [4.18.1]. This is used to check for tailwater submergence effects on the discharge. Tailwater submergence affects the spillway and emergency spillway discharges for Case 4. Consequently, it is necessary to iterate through different tailwater elevations until the total computed discharge fits the tailwater rating curve [4.18.1]. Figure 10 shows the final results but does not show the iteration steps. The results are readily checked by computing the individual discharges, adding them up to compute total discharge, and then making sure the listed tailwater and total combined discharge agree with the tailwater rating curves.

Spillway discharge in cfs is computed in the next five columns (under the header "Spillway"), H_c, $C_f|C_g$, d/H_c, $S_f|S_g$ and $Q_f|Q_g$. Free discharge occurs for headwater elevations below 815.796 feet [4.3.4] and orifice discharge occurs for headwaters above 815.796 feet. The transition point is indicated by a horizontal line. Above the line, the listed discharge coefficient is C_f [4.2.3] computed from Equation (A6) and below the line the listed discharge coefficient is C_g [4.3.5] computed by interpolation between the points in Table A3. Column $Q_f|Q_g$ is the spillway discharge computed from Equation 2 for free discharge and from Equation 4 for orifice discharge. Column d/H_c indicates that the spillway discharge is not affected by tailwater for elevations below 777 feet since $d/H_c < 0.2$ [4.2.4], but is affected at all headwater elevations above 777 feet at which free discharge occurs. Spillway discharge is affected by tailwater at all headwater elevations where orifice discharge occurs because $d/H_c > 0.2$ [4.3.6] at all values of d/H_c.

Emergency Spillway discharge is computed in the next four columns (under the header "Emergency Spillway"), H_c, C_f, S_f and Q_f. Free discharge occurs at all heads (H_c) above the spillway crest at elevation 817 feet [4.11.2]. The discharge coefficient is C_f [4.11.3] computed from Equation 5. The submergence factor, S_f [4.11.4], is computed using Equation 6. Column Q_f is the emergency spillway discharge computed from Equation 2 for free discharge with submergence.

The column following the emergency spillway discharge column shows "C_f=", "Z_c=", and "L=" in three rows to indicate the meaning of the values included in those rows in the "Overflow Discharge" columns.

The next eight columns are divided into three sub-columns, each. Contained in the sub-columns are overflow discharges in cfs for the right bank saddle dam, main dam works (including the earthen embankment), the three saddle dams and the remaining sections which are expected to overflow. The overflow discharge coefficient C_f ([4.5.1], [4.4.1], [4.6.1], [4.7.1], [4.8.1], [4.9.1], [4.10.1], [4.16.1]), elevation Z_c ([4.5.2], [4.4.2], [4.6.2], [4.7.2], [4.8.2], [4.9.2], [4.10.2], [4.16.2]), and length L ([4.5.3], [4.4.3], [4.6.3], [4.7.3], [4.8.3], [4.9.3], [4.10.3], [4.16.3]) in each case are indicated in the three rows above the computed discharge sub-columns. The three sub-columns contain calculated values of d/H_c, S_f [4.17] and Q_f, respectively. All overflow discharges are computed using Equation 2. The values of d/H_c and S_f have been truncated in order fit all the columns.

Case No Longer Valid

Tellico Dam Saddle Dams and Embankment Intact, Fort Loudoun Dam Embankment Failure, Fort Loudoun Gates Closed, Fort Loudoun Turbines Not Operating

g = 32.2 ft/s2

Spillway Parameters: L = 120 feet; Zc = 773 feet; Gn = 33.576 feet; Hmp = 16.354 feet

Emergency Spillway Parameters: L = 2000 feet; Zc = 817 feet

HW	Q_{TEL} Total Discharge	Q_{FTL} Total Discharge	Q_{TOT} Total Discharge	Main Dam TW	Saddle Dam TW	Spillway Hc	Spillway Cf | Cg	Spillway d/Hc	Spillway Sf/Sg	Spillway Qf | Qg	Emergency Spillway Hc	Emergency Spillway Cf	Emergency Spillway Sf	Emergency Spillway Qf
feet	1000 cfs	1000 cfs	1000 cfs	feet	feet	feet				cfs	feet			cfs
773	0.00	220.86	220.86	769.88	767.52	0				0	0			0
775	1.06	246.27	247.33	772.48	770.01	2	3.112	-0.258	1.000	1056	0			0
777	2.95	270.29	273.24	774.93	772.35	4	3.134	0.481	0.979	2947	0			0
779	5.08	293.40	298.48	777.20	774.52	6	3.168	0.700	0.911	5085	0			0
781	7.33	316.49	323.82	779.39	776.62	8	3.204	0.799	0.842	7328	0			0
783	9.68	339.90	349.58	781.52	778.66	10	3.247	0.852	0.785	9675	0			0
785	12.13	363.91	376.04	783.62	780.67	12	3.292	0.885	0.739	12133	0			0
787	14.71	388.70	403.40	785.69	782.67	14	3.339	0.906	0.701	14706	0			0
789	17.39	414.41	431.81	787.74	784.64	16	3.387	0.921	0.669	17394	0			0
791	20.20	441.19	461.39	789.78	786.61	18	3.432	0.932	0.642	20197	0			0
793	23.12	469.15	492.27	791.81	788.57	20	3.476	0.941	0.620	23115	0			0
795	26.16	498.33	524.50	793.83	790.52	22	3.517	0.947	0.601	26165	0			0
797	29.33	528.92	558.25	795.84	792.47	24	3.553	0.952	0.585	29331	0			0
799	32.60	561.03	593.63	797.84	794.41	26	3.586	0.956	0.571	32601	0			0
801	35.98	594.77	630.75	799.84	796.36	28	3.614	0.959	0.560	35984	0			0
803	39.46	630.21	669.67	801.83	798.30	30	3.637	0.961	0.550	39463	0			0
805	43.05	667.41	710.46	803.82	800.24	32	3.656	0.963	0.542	43048	0			0
807	46.74	706.41	753.15	805.80	802.18	34	3.670	0.965	0.535	46743	0			0
809	50.53	747.18	797.71	807.78	804.12	36	3.681	0.966	0.530	50530	0			0
811	54.41	789.68	844.10	809.75	806.05	38	3.688	0.967	0.525	54413	0			0
813	58.40	833.78	892.18	811.72	807.99	40	3.692	0.968	0.521	58400	0			0
815	62.51	879.27	941.78	813.68	809.93	42	3.695	0.969	0.518	62507	0			0
815.796	64.93	895.00	959.93	814.40	810.64	42.8	3.697	0.967	0.523	64929	0			0
816	40.33	924.80	965.13	814.59	810.82	43	0.743	0.967	0.325	40333	0			0
817	39.63	951.45	991.08	815.58	811.81	44	0.729	0.968	0.320	39630	0			[illegible]
818	44.60	973.37	1017.96	816.60	812.81	45	0.715	0.969	0.312	38654	1	2.971	1.000	5941
819	54.67	990.97	1045.65	817.64	813.84	46	0.701	0.970	0.303	[illegible]	2	[illegible]	1.000	17312
820	68.94	1004.86	1073.79	818.69	814.88	47	0.696	[illegible]	0.291	[illegible]	3	3.143	[illegible]	32658
821	86.91	1014.16	1101.06	819.70	815.88	48	0.692	0.973	[illegible]	[illegible]	4	3.218	[illegible]	51484
822	107.70	1021.49	1129.19	820.74	816.91	49	0.692	0.974	[illegible]	[illegible]	[illegible]	[illegible]	1.000	73492
823	130.78	1026.93	1157.70	821.79	817.95	[illegible]	[illegible]	[illegible]	0.253	[illegible]	6	3.350	0.994	97918
824	155.56	1030.94	1186.50	822.85	818.99	51	[illegible]	0.977	[illegible]	[illegible]	7	3.407	0.982	123891
825	181.93	1033.47	1215.40	823.91	820.04	52	0.692	[illegible]	0.229	30617	8	3.461	0.966	151312
826	209.66	1034.13	1244.00	824.97	821.08	53	0.692	[illegible]	[illegible]	29721	9	3.509	0.951	180144
827	239.09	1033.49	1272.58	826.02	822.12	54	0.692	0.982	0.210	28837	10	3.555	0.935	210251
828	269.03	1032.07	1301.11	[illegible]	823.16	[illegible]	0.692	0.983	0.198	27473	11	3.597	0.920	241559
829	302.22	1027.44	1329.66	[illegible]	[illegible]	56	[illegible]	0.984	0.183	25732	12	3.636	0.915	276486
830	333.29	1024.70	1357.98	[illegible]	[illegible]	57	[illegible]	0.986	0.167	23893	13	3.674	0.898	309394
831	386.99	999.87	[illegible]	830.26	[illegible]	[illegible]	0.692	0.987	0.151	21863	14	3.710	0.881	342629
832	459.47	956.20	[illegible]	[illegible]	827.37	59	0.692	0.989	0.136	19916	15	3.746	0.865	376439
833	534.41	[illegible]	[illegible]	832.40	828.43	60	0.692	0.990	0.123	18224	16	3.781	0.849	411035
834	608.84	[illegible]	[illegible]	[illegible]	829.47	61	0.692	0.991	0.113	16842	17	3.816	0.835	446596
835	680.62	[illegible]	[illegible]	834.52	830.51	62	0.692	0.992	0.103	15527	18	3.852	0.821	483054
[illegible]	749.78	[illegible]	[illegible]	835.57	831.55	63	0.692	0.993	0.091	13941	19	3.889	0.808	520489
837	819.05	[illegible]	1555.63	836.61	832.58	64	0.692	0.994	0.080	12339	20	3.928	0.796	559192

Overflow Discharge, Qf in cfs

	Right Bank Saddle Dam			Main Dam Works			Saddle Dam 1- Section 1			Saddle Dam 1- Section 2			Saddle Dam 2			Saddle Dam 3- Section 1			Sadd[illegible]am 3- Sec[illegible] 2			R[illegible]ining Overflow Sections		
Cf =	2.65			2.65			3.1			2.65			2.65			2.65			[illegible]			2.65		
Zc =	830			830			830.5			830.5			830			831.7			[illegible]			[illegible]		
L =	2000			3147.5			100			62			525			62.12			[illegible]			2500		
HW	d/Hc	Sf	Qf	d/Hc	Sf	Qf	d/Hc	Sf	Qf	d/Hc	Sf	Q	d/Hc	Sf	Qf	d/Hc	Sf	Qf	d/Hc	Sf	Qf	d/Hc	Sf	Qf
773			0			0			0			0			0			0			0			0
775			0			0			0			0			0			0			0			0
777			0			0			0			0			0			0			0			0
779			0			0			0			0			0			0			0			0
781			0			0			0			0			0			0			0			0
783			0			0			0			0			0			0			0			0
785			0			0			0			0			0			0			0			0
787			0			0			0			0			0			0			0			0
789			0			0			0			0			0			0			0			0
791			0			0			0			0			0			0			0			0
793			0			0			0			0			0			0			0			0
795			0			0			0			0			0			0			0			0
797			0			0			0			0			0			0			0			0
799			0			0			0			0			0			0			0			0
801			0			0			0			0			0			0			0			0
803			0			0			0			0			0			0			0			0
805			0			0			0			0			0			0			0			0
807			0			0			0			0			0			0			0			0
809			0			0			0			0			0			0			0			0
811			0			0			0			0			0			0			0			0
813			0			0			0			0			0			0			0			0
815			0			0			0			0			0			0			0			0
815.796			0			0			0			0			0			0			0			0
816			0			0			0			0			0			0			0			0
817			0			0			0			0			0			0			0			0
818			0			0			0			0			0			0			0			0
819			0			0			0			0			0			0			0			0
820			0			0			0			0			0			0			0			0
821			0			0			0			0			0			0			0			0
822			0			0			0			0			0			0			0			0
823			0			0			0			0			0			0			0			0
824			0			0			0			0			0			0			0			0
825			0			0			0			0			0			0			0			0
826			0			0			0			0			0			0			0			0
827			0			0			0			0			0			0			0			0
828			0			0			0			0			0			0			0			0
829			0			0			0			0			0			0			0			0
830			0			0			0			0			0			0			0			0
831	0.3	1.0	5300	0.3	1.0	8341	-8.4	1.0	110	-8.4	1.0	58	-3.7	1.0	1391			0	-3.7	1.0	672	0.3	1.0	6625
832	0.7	1.0	14744	0.7	1.0	23204	-2.1	1.0	570	-2.1	1.0	302	-1.3	1.0	3935	-14.4	1.0	27	-1.3	1.0	1901	0.7	1.0	18431
833	0.8	0.9	24141	0.8	0.9	37992	-0.8	1.0	1225	-0.8	1.0	649	-0.5	1.0	7229	-2.5	1.0	244	-0.5	1.0	3492	0.8	0.9	30176
834	0.9	0.8	32746	0.9	0.8	51534	-0.3	1.0	2030	-0.3	1.0	1076	-0.1	1.0	11130	-1.0	1.0	574	-0.1	1.0	5376	0.9	0.8	40933
835	0.9	0.7	40131	0.9	0.7	63157	0.0	1.0	2959	0.0	1.0	1568	0.1	1.0	15555	-0.4	1.0	987	0.1	1.0	7514	0.9	0.7	50164
[illegible]	0.9	0.6	46404	0.9	0.6	73029	0.2	1.0	3999	0.2	1.0	2119	0.3	1.0	20447	0.0	1.0	1468	0.3	1.0	9877	0.9	0.6	58006
837	0.9	0.5	52158	0.9	0.5	82083	0.3	1.0	5137	0.3	1.0	2723	0.4	1.0	25766	0.2	1.0	2009	0.4	1.0	12446	0.9	0.5	65197

Figu[illegible] 10 – Calculations for Case 4, Pre-Failure Condition at Tellico, Fort Loudoun Embankment Failure, Fort Loudoun Gates Closed, Fort Loudoun Turbines Not Operating

Case No Longer Valid

6.7 Case 5, Embankment Failure at Tellico Dam, Fort Loudoun Embankment Failure, Fort Loudoun Gates Open, Fort Loudoun Turbines Not Operating

This case considers failure of embankment and saddle dams has occurred at Tellico Dam. The south embankment at Fort Loudoun Dam has failed. The spillway gates at Tellico Dam and Fort Loudoun are considered fully open. The turbines at Fort Loudoun are not generating electricity.

For the embankment failure condition, discharges are computed for headwaters ranging from 750 feet to 837 feet, seven feet above the top of the dam. Discharge passes through the spillway section of the dam, the emergency spillway in saddle dam 1 and the various overflow sections as headwater rises above the crest elevations in each case. Total discharge, given in "1000 cfs" is the sum of all discharges in cfs past the dam plus discharge in cfs past the embankment and saddle dams divided by 1000.

Figure 11 shows the spreadsheet calculations for the embankment failure dam rating curve (spreadsheet included as Attachment E37). The final result, the rating curve, is defined by the first two columns, HW vs. Total Tellico Discharge (Q_{TEL}). The third and fourth columns contain the Fort Loudoun Discharge (Q_{FTL}) and the total combined discharge (Q_{TOT}). The fifth and sixth columns (TW) give the tailwater associated with the "Total Discharge" at Tellico Dam and the Saddle Dams, respectively. They are represented by the tailwater rating curve polynomial fits [4.18.1]. This is used to check for tailwater submergence effects on the discharge. Tailwater submergence reduces the spillway and emergency spillway discharges for Case 5. Consequently, it is necessary to iterate through different tailwater elevations until the total computed discharge fits the tailwater rating curve [4.18.1]. Figure 11 shows the final results but does not show the iteration steps. The results are readily checked by computing the individual discharges, adding them up to compute total discharge, and then making sure the listed tailwater and total combined discharge agree with the tailwater rating curves.

Spillway discharge in cfs is computed in the next five columns (under the header "Spillway"), H_c, $C_f|C_g$, d/H_c, $S_f|S_g$ and $Q_f|Q_g$. Free discharge occurs for headwater elevations below 815.796 feet [4.3.4] and orifice discharge occurs for headwaters above 815.796 feet. The transition point is indicated by a horizontal line. Above the line, the listed discharge coefficient is C_f [4.2.3] computed from Equation (7.0) and below the line the listed discharge coefficient is C_g [4.3.5] computed by interpolation between the points in Table 4. Column $Q_f|Q_g$ is the spillway discharge computed from Equation 2 for free discharge and from Equation 4 for orifice discharge. Column d/H_c verifies that the spillway discharge is affected by tailwater since $d/H_c > 0.2$ [4.2.4] for all headwater elevations at which free discharge occurs. Spillway discharge is also affected by tailwater at all headwater elevations where orifice discharge occurs because $d/H_c > 0.2$ [4.3.6] at all elevations.

Emergency Spillway discharge is computed in the next four columns (under the header "Emergency Spillway"), H_c, C_f, S_f and Q_f. Free discharge occurs at all heads (H_c) above the spillway crest at elevation 817 feet [4.11.2]. The discharge coefficient is C_f [4.11.3] computed from Equation 5. The submergence factor, S_f [4.11.4], is computed using Equation 6. Column Q_f is the emergency spillway discharge computed from Equation 2 for free discharge with submergence.

The column following the emergency spillway discharge column shows "C_f=", "Z_c=", and "L=" in three rows to indicate the meaning of the values included in those rows in the "Overflow Discharge" columns.

The next nine columns are divided into three sub-columns, each. Contained in the sub-columns overflow parameters and discharges in cfs for the right bank saddle dam, main dam works, the earthen embankment, the three saddle dams and the remaining sections which are expected to overflow. The overflow discharge coefficient C_f ([4.5.1], [4.12.1], [4.6.1], [4.7.1], [4.14.1], [4.15.1], [4.13.1], [4.16.1]), elevation Z_c ([4.5.4], [4.12.2], [4.6.2], [4.7.2], [4.14.2], [4.15.2], [4.13.2], [4.13.3], [4.16.2]), and length L ([4.5.3], [4.12.3], [4.6.3], [4.7.3], [4.14.3], [4.15.3], [4.13.4], [4.13.5], [4.16.3]) in each case are indicated in the three rows above the computed discharge sub-columns. The three sub-columns contain calculated values of d/H_c, S_f [4.17] and Q_f, respectively. All overflow discharges are computed using Equation 2. The values of d/H_c, S_f have been truncated in order fit all the columns.

Case No Longer Valid

TVA

Calculation No. CDQ000020080018	Rev: 1	Plant: GEN	Page: 36
Subject: Dam Rating Curves, Tellico		Prepped	WBB
		Checked	ACM

Case No Longer Valid

Tellico Dam Embankment Failure, Fort Loudoun Dam Embankment Failure, Fort Loudoun Gates Open, Fort Loudoun Turbines Not Operating

g = 32.2 ft/s²

Spillway Parameters: L = 120 feet; Z_c = 773 feet; G_h = 33.576 feet; H_{mp} = 16.354 feet

Emergency Spillway Parameters: L = 2000 feet; Z_c = 817 feet

HW (feet)	Q_{TEL} Total Discharge (1000 cfs)	Q_{FTL} Total Discharge (1000 cfs)	Q_{TOT} Total Discharge (1000 cfs)	Main Dam TW (feet)	Saddle Dam TW (feet)	Spillway H_c (ft)	Spillway C_f | C_g	Spillway d/H_c	Spillway S_f/S_g	Spillway Q_f | Q_g (cfs)	Emergency Spillway H_e (ft)	Emergency Spillway C_f	Emergency Spillway S_f	Emergency Spillway Q_f (cfs)
750	45.65	0.00	45.65	749.26	747.92	0				0	0			0
755	74.22	3.00	77.21	753.45	751.89	0				0	0			0
760	99.04	27.31	126.34	759.52	757.67	0				0	0			0
765	127.83	43.76	171.59	764.69	762.58	0				0	0			0
770	160.26	59.47	219.73	769.74	767.40	0				0	0			0
773	173.65	76.61	250.26	772.77	770.29	0				0	0			0
775	183.66	88.20	271.86	774.79	772.21	2	3.112	0.894	0.724	765	0			0
777	195.50	98.69	294.19	776.79	774.13	4	3.134	0.948	0.597	1797	0			0
779	206.62	110.35	316.97	778.79	776.05	6	3.166	0.966	0.532	2969	0			0
781	218.60	122.27	340.86	780.79	777.97	8	3.204	0.974	0.490	4258	0			0
783	231.52	133.97	365.50	782.79	779.88	10	3.247	0.979	0.459	5660	0			0
785	242.80	148.73	391.53	784.79	781.81	12	3.292	0.983	0.435	7144	0			0
787	254.12	164.46	418.58	786.79	783.73	14	3.339	0.985	0.415	8714	0			0
789	266.43	180.81	447.24	788.79	785.66	16	3.387	0.987	0.399	10381	0			0
791	278.84	197.46	476.31	790.79	787.59	18	3.432	0.989	0.385	12126	0			0
793	294.37	213.51	507.88	792.79	789.52	20	3.476	0.990	0.375	14001	0			0
795	310.15	230.24	540.40	794.79	791.45	22	3.517	0.990	0.366	15954	0			0
797	327.23	247.72	574.95	796.78	793.39	24	3.553	0.991	0.359	18000	0			0
799	345.67	265.51	611.18	798.78	795.32	26	3.586	0.992	0.353	20138	0			0
801	364.24	284.82	649.06	800.77	797.27	28	3.614	0.992	0.348	22365	0			0
803	382.66	305.17	687.83	802.77	799.21	30	3.637	0.992	0.344	24648	0			0
805	404.56	326.48	731.04	804.76	801.16	32	3.656	0.992	0.341	27044	0			0
807	425.20	348.79	774.00	806.75	803.11	34	3.670	0.993	0.337	29454	0			0
809	447.82	372.10	819.92	808.74	805.07	36	3.681	0.993	0.335	31940	0			0
811	472.50	398.37	868.87	810.74	807.03	38	3.688	0.993	0.333	34505	0			0
813	495.88	421.56	917.43	812.73	808.99	40	3.692	0.993	0.331	37073	0			0
815	521.36	447.55	968.92	814.72	810.95	42	3.695	0.993	0.329	39728	0			0
815.796	535.81	453.00	988.81	815.51	811.73	43	3.697	0.993	0.329	40901	0			0
816	524.68	470.47	995.16	815.71	811.93	43	0.743	0.993	0.164	20299	0			0
817	534.51	486.06	1020.58	816.70	812.91	44	0.729	0.993	0.155	19268	0			0
818	548.52	499.30	1047.83	817.70	813.90	45	0.715	0.993	[illegible]	18147	[illegible]	2.971	1.000	[illegible]
819	564.43	510.42	1074.86	818.70	814.89	46	0.701	0.993	0.137	[illegible]	2	[illegible]	1.000	[illegible]
820	580.93	519.99	1100.93	819.70	815.88	47	0.696	0.994	0.128	[illegible]	3	[illegible]	[illegible]	[illegible]
821	629.10	498.30	1127.41	820.69	816.85	48	0.692	[illegible]	0.124	[illegible]	[illegible]	3.218	1.000	51484
822	655.32	499.98	1155.30	821.69	817.84	49	0.692	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.994	73029
823	681.46	501.24	1182.70	822.69	818.83	50	0.692	[illegible]	[illegible]	13679	6	3.350	0.979	96363
824	710.67	499.38	1210.05	823.69	819.83	51	0.692	0.994	[illegible]	13013	7	3.407	0.962	121370
825	740.46	496.42	1236.88	824.70	820.82	52	0.692	0.994	[illegible]	[illegible]	8	3.461	0.945	147933
826	770.28	493.19	1263.47	825.71	821.82	[illegible]	0.692	0.994	0.087	11755	9	3.509	0.928	175945
827	801.73	489.19	1290.92	826.72	[illegible]	54	[illegible]	0.995	0.081	11114	10	3.555	0.913	205317
828	836.63	482.20	1318.83	827.72	[illegible]	[illegible]	0.692	0.995	0.075	10485	11	3.597	0.906	237773
829	870.70	475.49	1346.19	828.73	[illegible]	[illegible]	0.692	0.995	0.070	9885	12	3.636	0.890	268991
830	904.12	468.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.995	0.065	9294	13	3.674	0.874	301109
831	942.18	457.38	[illegible]	[illegible]	[illegible]	58	0.692	0.996	0.060	8729	14	3.710	0.859	334074
832	981.09	445.39	[illegible]	[illegible]	[illegible]	59	0.692	0.996	0.056	8161	15	3.746	0.845	367917
833	1020.51	[illegible]	1453.44	832.78	[illegible]	60	0.692	0.996	0.051	7608	16	3.781	0.832	402638
834	1059.86	[illegible]	[illegible]	[illegible]	829.79	61	0.692	0.997	0.047	7078	17	3.816	0.819	438328
835	1100.44	[illegible]	[illegible]	834.80	830.79	62	0.692	0.997	0.043	6573	18	3.852	0.808	475058
[illegible]	[illegible]	[illegible]	[illegible]	835.81	831.79	63	0.692	0.997	0.040	6088	19	3.889	0.796	512890
[illegible]	1182.07	[illegible]	[illegible]	836.82	832.79	64	0.692	0.997	0.036	5616	20	3.928	0.785	551694

Overflow Discharge, Q_f in cfs

	Right Bank Saddle Dam			Main Dam Works			Saddle Dam 1- Section 1			Saddle Dam 1- Section 2			Saddle Dam 2			Saddle Dam 3			Main Embankment- Section 1			M[illegible]bankment- Section 1			[illegible]emaining Overflo[illegible] Sections		
C_f =	2.65			2.65			3.1			2.65			2.65			2.65			2.65			[illegible]			2.65		
Z_c =	823			830			830.5			830.5			822			820			755			[illegible]			830		
L =	2000			447.5			100			62			525			315.72			[illegible]			300			2500		
HW (feet)	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f
750			0			0			0			0			0			[illegible]	[illegible]	[illegible]	[illegible]	1.0	[illegible]	45646			0
755			0			0			0			0			0			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.5	74215			0
760			0			0			0			0			0			0	[illegible]	0.7	47776	1.0	0.3	51261			0
765			0			0			0			0			0			0	[illegible]	0.4	83776	1.0	0.2	44051			0
770			0			0			0			0			0			[illegible]	[illegible]	[illegible]	118727	1.0	0.2	41530			0
773			0			0			0			0			0			0	1.0	0.3	134646	1.0	0.1	39004			0
775			0			0			0			0			0			0	1.0	0.3	145911	1.0	0.1	38983			0
777			0			0			0			0			0			0	1.0	0.2	156911	1.0	0.1	36790			0
779			0			0			0			0			0			0	1.0	0.2	166381	1.0	0.1	37273			0
781			0			0			0			0			[illegible]			0	1.0	0.2	176418	1.0	0.1	37921			0
783			0			0			0			0			[illegible]			0	1.0	0.2	187116	1.0	0.1	38745			0
785			0			0			0			0			0			0	1.0	0.2	196470	1.0	0.1	39186			0
787			0			0			0			0			0			0	1.0	0.2	205792	1.0	0.1	39611			0
789			0			0			0			0			0			0	1.0	0.2	215834	1.0	0.1	40215			0
791			0			0			0			0			[illegible]			0	1.0	0.2	225907	1.0	0.1	40611			0
793			0			0			0			[illegible]			0			0	1.0	0.2	238370	1.0	0.1	42001			0
795			0			0			0			0			0			0	1.0	0.2	250999	1.0	0.1	43200			0
797			0			0			0			[illegible]			0			0	1.0	0.2	264616	1.0	0.1	44614			0
799			0			0			0			0			0			0	1.0	0.2	279281	1.0	0.1	46252			0
801			0			0			0			[illegible]			0			0	1.0	0.1	293754	1.0	0.1	48120			0
803			0			[illegible]			0			[illegible]			0			0	1.0	0.1	308003	1.0	0.1	50013			0
805			0			0			0			[illegible]			0			0	1.0	0.1	325147	1.0	0.1	52365			0
807			0			0			0			0			0			0	1.0	0.1	341218	1.0	0.1	54532			0
809			0			0			0			0			0			0	1.0	0.1	358935	1.0	0.1	56949			0
811			0			[illegible]			0			0			0			0	1.0	0.1	378371	1.0	0.1	59625			0
813			0			0			0			0			0			0	1.0	0.1	398693	1.0	0.1	62111			0
815			0			0			0			0			0			0	1.0	0.1	416776	1.0	0.1	64880			0
815.796			[illegible]			0			0			0			0			0	1.0	0.1	428399	1.0	0.1	66514			0
816			0			0			0			0			0			0	1.0	0.1	436627	1.0	0.1	67752			0
817			0			0			0			0			0			0	1.0	0.1	446201	1.0	0.1	69041			0
818			0			0			0			0			0			0	1.0	0.1	454328	1.0	0.1	70104			0
819			0			0			0			0			0			0	1.0	0.1	459446	1.0	0.1	70703			0
820			0			0			0			0			0			0	1.0	0.1	461484	1.0	0.1	70831			0
821			0			0			0			0			0	-3.1	1.0	837	1.0	0.1	486721	1.0	0.1	74514			0
822			0			0			0			0			0	-1.1	1.0	2366	1.0	0.1	490394	1.0	0.1	74889			0
823			0			0			0			0	-3.2	1.0	1391	-0.4	1.0	4347	1.0	0.1	490894	1.0	0.1	74783			0
824	0.7	1.0	5141			0			0			0	-1.1	1.0	3935	0.0	1.0	6693	1.0	0.1	486565	1.0	0.1	73948			0
825	0.9	0.8	12031			0			0			0	-0.4	1.0	7229	0.2	1.0	9354	1.0	0.1	478904	1.0	0.1	72615			0
826	0.9	0.7	18678			0			0			0	0.0	1.0	11130	0.3	1.0	12296	1.0	0.1	469451	1.0	0.1	71021			0
827	0.9	0.6	25051			0			0			0	0.2	1.0	15555	0.4	1.0	15495	1.0	0.1	459794	1.0	0.1	69407			0
828	0.9	0.5	31286			0			0			0	0.3	1.0	20447	0.5	1.0	18931	1.0	0.1	449934	1.0	0.1	67772			0
829	1.0	0.5	37479			0			0			0	0.4	1.0	25766	0.5	1.0	22590	1.0	0.1	439875	1.0	0.1	66117			0
830	1.0	0.4	43620			0			0			0	0.5	1.0	31480	0.6	1.0	26457	1.0	0.1	427966	1.0	0.1	64195			0
831	1.0	0.4	49643	0.8	0.9	1100	-7.4	1.0	110	-7.4	1.0	58	0.5	1.0	37564	0.6	1.0	30489	1.0	0.1	412512	1.0	0.1	61752	0.8	0.9	6146
832	1.0	0.4	55312	0.9	0.7	2462	-1.8	1.0	570	-1.8	1.0	302	0.6	1.0	43995	0.8	1.0	34455	1.0	0.1	395126	1.0	0.1	59033	0.9	0.7	13754
833	1.0	0.4	61021	0.9	0.6	3723	-0.7	1.0	1225	-0.7	1.0	649	0.6	1.0	50702	0.7	1.0	38390	1.0	0.1	377462	1.0	0.1	56286	0.9	0.6	20800
834	1.0	0.3	66269	0.9	0.5	4919	-0.2	1.0	2030	-0.2	1.0	1076	0.6	1.0	57299	0.7	1.0	42341	1.0	0.1	359524	1.0	0.1	53510	0.9	0.5	27483
835	1.0	0.3	69951	1.0	0.5	6099	0.1	1.0	2959	0.1	1.0	1568	0.7	1.0	63850	0.7	1.0	46326	1.0	0.1	343020	1.0	0.1	50959	1.0	0.5	34074
[illegible]	1.0	0.3	73571	1.0	0.4	7275	0.2	1.0	3999	0.2	1.0	2119	0.7	1.0	70427	0.7	0.9	50347	1.0	0.1	326268	1.0	0.1	48383	1.0	0.4	40642
[illegible]	1.0	0.3	76943	1.0	0.4	8387	0.4	1.0	5137	0.4	1.0	2723	0.7	1.0	77053	0.8	0.9	54397	1.0	0.1	307543	1.0	0.0	45526	1.0	0.4	46854

Figu[illegible] 11 – Calculations for Case 5, Embankment Failure Condition at Tellico, Fort Loudoun Embankment Failure, Fort Loudoun Gates Open, Fort Loudoun Turbines Not Operating

6.8 Case 6, Embankment Failure at Tellico Dam, Fort Loudoun Embankment Failure, Fort Loudoun Gates Closed, Fort Loudoun Turbines Not Operating

This case considers failure of embankment and saddle dams has occurred at Tellico Dam. The south embankment at Fort Loudoun Dam has failed. The spillway gates at Tellico Dam are considered fully open. The spillway gates at Fort Loudoun Dam are closed. The turbines at Fort Loudoun are not generating electricity.

For the embankment failure condition, discharges are computed for headwaters ranging from 750 feet to 837 feet, seven feet above the top of the dam. Discharge passes through the spillway section of the dam, the emergency spillway, saddle dam 1 and the various overflow sections as headwater rises above the crest elevations in each case. Total discharge, given in "1000 cfs" is the sum of all discharges in cfs past the dam plus discharge in cfs past the embankment and saddle dams divided by 1000.

Figure 12 shows the spreadsheet calculations for the embankment failure dam rating curve (spreadsheet included as Attachment E37). The final result, the rating curve, is defined by the first two columns, TW vs. Total Tellico Discharge (Q_{TEL}). The third and fourth columns contain the Fort Loudoun Discharge (Q_{FTL}) and the total combined discharge (Q_{TOT}). The fifth and sixth columns (TW) give the tailwater associated with the "Total Discharge" at Tellico Dam and the Saddle Dams, respectively. They are represented by the tailwater rating curve polynomials [4.18.1]. This is used to check for tailwater submergence effects on the discharge. Tailwater submergence reduces the spillway and emergency spillway discharges for Case 6. Consequently, it is necessary to iterate through different tailwater elevations until the total computed discharge fits the tailwater rating curve [4.18.1]. Figure 12 shows the final result but does not show the iteration steps. The results are readily checked by computing the individual discharges, adding them up to compute total discharge, and then making sure the listed tailwater and total combined discharge agree with the tailwater rating curves.

Spillway discharge in cfs is computed in the next five columns (under the header "Spillway"), H_c, $C_f|C_g$, d/H_c, $S_f|S_g$ and $Q_f|Q_g$. Free discharge occurs for headwater elevations below 815.796 feet [4.3.4] and orifice discharge occurs for headwaters above 815.796 feet. The transition point is indicated by a horizontal line. Above the line, the listed discharge coefficient is C_f [4.2.3] computed from Equation (A6) and below the line the listed discharge coefficient is C_g [4.3.5] computed by interpolation between the points in Table A6. Column $Q_f|Q_g$ is the spillway discharge computed from Equation 2 for free discharge and from Equation 4 for orifice discharge. Column d/H_c verifies that the spillway discharge is affected by tailwater since $d/H_c > 0.2$ [4.2.4] for all headwater elevations at which free discharge occurs. Spillway discharge is also affected by tailwater for all values of $d/H_c > 0.2$ [4.3.6] at all headwater elevations where orifice discharge occurs.

Emergency Spillway discharge is computed in the next four columns (under the header "Emergency Spillway"), H_c, C_f, S_f and Q_f. Free discharge occurs at all heads (H_c) above the spillway crest at elevation 817 feet [4.11.2]. The discharge coefficient is C_f [4.11.1] computed from Equation 5. The submergence factor, S_f [4.11.4], is computed using Equation 6. Column Q_f is the emergency spillway discharge computed from Equation 2 for free discharge with submergence.

The column following the emergency spillway discharge column shows "C_f=", "Z_c=", and "L=" in three rows to indicate the meaning of the values included in those rows in the "Overflow Discharge" columns.

The next nine columns are divided into three sub-columns, each. Contained in the sub-columns overflow parameters and discharges in cfs for the right bank saddle dam, main dam works, the earthen embankment, the three saddle dams and the remaining sections which are expected to overflow. The overflow discharge coefficient C_f ([4.5.1], [4.12.1], [4.6.1], [4.7.1], [4.14.1], [4.15.1], [4.13.1], [4.16.1]), elevation Z_c ([4.5.4], [4.12.2], [4.6.2], [4.7.2], [4.14.2], [4.15.2], [4.13.2], [4.13.3], [4.16.2]) and length L ([4.5.3], [4.12.3], [4.6.3], [4.7.3], [4.14.3], [4.15.3], [4.13.4], [4.13.5], [4.16.3]) in each case are indicated in the three rows above the computed discharge sub-columns. The three sub-columns contain calculated values of d/H_c, S_f [4.17] and Q_f, respectively. All overflow discharges are computed using Equation 2. The values of d/H_c, S_f have been truncated in order fit all the columns.

Case No Longer Valid

Tellico Dam Embankment Failure, Fort Loudoun Dam Embankment Failure, Fort Loudoun Gates Closed, Fort Loudoun Turbines Not Operating

g = 32.2 ft/s²

Spillway Parameters: L = 120 feet; Z_s = 773 feet; G_s = 33.576 feet; H_{eq} = 16.354 feet

Emergency Spillway Parameters: L = 2000 feet; Z_e = 817 feet

Overflow Discharge, Q_t in cfs

							Spillway				Emergency Spillway				Right Bank Saddle Dam			Main Dam Works			Saddle Dam 1-Section 1			Saddle Dam 1-Section 2			Saddle Dam 2			Saddle Dam 3			Main Embankment-Section 1			Main Embankment-Remaining Sections		
															C_t =	2.65			2.65			3.1			2.65			2.65			2.65			2.65			2.65		
															Z_t =	823			830			830.5			830.5			822			820			755			722		
HW	Q_{TEA} Total Discharge	Q_{TTL} Total Discharge	Q_{TOT} Total Discharge	Main Dam TW	Saddle Dam TW	H_s	$C_t \mid C_d$	d/H_s	S_t/S_s	$Q_t \mid Q_s$	H_e	C_t	S_t	Q_t	L =	2000			447.5			100			62			525			315.72			2400			2500		
																d/H_e	S_t	Q_t	d/H_e	S_t	Q_t	d/H_e	S_t	Q_t	d/H_e	S_t	Q_t	d/H_e	S_t	Q_t	d/H_e	S_t	Q_t	d/H_e	S_t	Q_t	d/H_e	S_t	Q_t
feet	1000 cfs	1000 cfs	1000 cfs	feet	feet	ft				cfs	ft			cfs																								
750	45.65	0.00	45.65	749.26	747.92	0				0	0			0			0			0			0			0			0			0			0.4		0
755	74.22	3.00	77.21	753.45	751.89	0				0	0			0			0			0			0			0			0			0			1.0		74215
760	99.04	27.31	126.34	759.52	757.67	0				0	0			0			0			0			0			0			0			0.9	0.7	76	1.0	0.3	51261
765	127.83	43.76	171.59	764.69	762.58	0				0	0			0			0			0			0			0			0			1.0	0.4	76	1.0	0.2	44051
770	160.26	59.47	219.73	769.74	767.40	0				0	0			0			0			0			0			0			0			1.0	0.3	116	1.0	0.2	41530
773	173.65	76.61	250.26	772.77	770.29	0				0	0			0			0			0			0			0			0			1.0	0.3	134646	1.0	0.1	39004
775	183.66	88.20	271.86	774.79	772.21	2	3.112	0.894	0.724	765	0			0			0			0			0			0			0			1.0	0.3	145911	1.0	0.1	36983
777	195.50	98.69	294.19	776.79	774.13	4	3.134	0.948	0.597	1797	0			0			0			0			0			0			0			1.0	0.2	156911	1.0	0.1	36790
779	206.62	110.35	316.97	778.79	776.05	6	3.166	0.966	0.532	2969	0			0			0			0			0			0			0			1.0	0.2	166381	1.0	0.1	37273
781	218.60	122.27	340.86	780.79	777.97	8	3.204	0.974	0.490	4258	0			0			0			0			0			0			0			1.0	0.2	176418	1.0	0.1	37821
783	231.52	133.97	365.50	782.79	779.88	10	3.247	0.979	0.459	5660	0			0			0			0			0			0			0			1.0	0.2	187116	1.0	0.1	38745
785	245.49	146.18	391.67	784.79	781.80	12	3.292	0.982	0.437	7174	0			0			0			0			0			0			0			1.0	0.2	198560	1.0	0.1	39754
787	259.86	158.92	418.58	786.79	783.72	14	3.339	0.985	0.419	8788	0			0			0			0			0			0			0			1.0	0.2	210109	1.0	0.1	40784
789	274.99	172.22	447.21	788.79	785.65	16	3.387	0.987	0.404	10513	0			0			0			0			0			0			0			1.0	0.2	222509	1.0	0.1	41972
791	290.58	186.11	476.69	790.78	787.58	18	3.432	0.988	0.392	12330	0			0			0			0			0			0			0			1.0	0.2	235066	1.0	0.1	43189
793	307.43	199.89	507.32	792.78	789.50	20	3.476	0.989	0.382	14253	0			0			0			0			0			0			0			1.0	0.2	248564	1.0	0.1	44614
795	326.63	213.63	540.26	794.77	791.43	22	3.517	0.990	0.374	16301	0			0			0			0			0			0			0			1.0	0.2	263871	1.0	0.1	46461
797	346.22	228.03	574.25	796.77	793.37	24	3.553	0.990	0.368	18432	0			0			0			0			0			0			0			1.0	0.2	279455	1.0	0.1	48332
799	367.26	243.14	610.40	798.76	795.30	26	3.586	0.991	0.362	20662	0			0			0			0			0			0			0			1.0	0.2	296156	1.0	0.1	50437
801	389.80	259.01	648.81	800.75	797.24	28	3.614	0.991	0.358	22987	0			0			0			0			0			0			0			1.0	0.2	314027	1.0	0.1	52784
803	412.78	275.68	688.45	802.74	799.19	30	3.637	0.991	0.354	25375	0			0			0			0			0			0			0			1.0	0.2	332238	1.0	0.1	55165
805	437.33	293.17	730.50	804.73	801.13	32	3.656	0.992	0.351	27848	0			0			0			0			0			0			0			1.0	0.2	351681	1.0	0.1	57798
807	462.33	311.51	773.84	806.73	803.09	34	3.670	0.992	0.348	30372	0			0			0			0			0			0			0			1.0	0.2	371487	1.0	0.1	60469
809	488.96	330.68	819.64	808.72	805.04	36	3.681	0.992	0.346	32974	0			0			0			0			0			0			0			1.0	0.2	392585	1.0	0.1	63401
811	516.06	350.65	866.71	810.71	807.00	38	3.688	0.992	0.344	35622	0			0			0			0			0			0			0			1.0	0.2	414067	1.0	0.1	66375
813	544.87	371.36	916.22	812.69	808.96	40	3.692	0.992	0.342	38351	0			0			0			0			0			0			0			1.0	0.2	436896	1.0	0.1	69619
815	575.43	392.70	968.13	814.68	810.92	42	3.695	0.992	0.341	41172	0			0			0			0			0			0			0			1.0	0.2	461114	1.0	0.1	73140
815.796	594.28	394.00	988.28	815.47	811.69	43	3.697	0.992	0.342	42512	0			0			0			0			0			0			0			1.0	0.2	476015	1.0	0.1	75753
815	579.25	413.92	993.17	815.67	811.89	43	0.743	0.992	0.180	22369	0			0			0			0			0			0			0			1.0	0.2	480340	1.0	0.1	76539
817	591.09	428.80	1019.88	816.66	812.88	44	0.729	0.992	0.171	21207	0			0			0			0			0			0			0			1.0	0.2	491773	1.0	0.1	78107
818	605.11	441.40	1046.51	817.66	813.86	45	0.715	0.992	0.161	19921	1	2.971	1.000	5941			0			0			0			0			0			1.0	0.2	500266	1.0	0.1	78984
819	620.77	451.90	1072.68	818.66	814.85	46	0.701	0.993	0.150	18554	2	3.060	1.000				0			0			0			0			0			1.0	0.2	509747	1.0	0.1	79160
820	639.32	460.85	1100.18	819.67	815.84	47	0.696	0.993	0.139	17374	3	3.143	1.000	3263			0			0			0			0			0			1.0	0.2	510196	1.0	0.1	79094
821	664.83	462.80	1127.62	820.67	816.83	48	0.692	0.993	0.130	16322	4	3.218	1.000	51484			0			0			0			0			0	-3.2	1.0	837	1.0	0.2	516689	1.0	0.1	79497
822	685.38	466.61	1154.99	821.67	817.82	49	0.692	0.993	0.119	15277	5	3.287	0.994	73049			0			0			0			0			0	-1.1	1.0	2366	1.0	0.1	518506	1.0	0.1	79182
823	709.21	471.79	1181.00	822.67	818.82	50	0.692	0.993	0.109	14	6	3.3	0.979	96401			0			0			0			0			0	-3.2	1.0	1391	-0.4	1.0	4347	1.0	0.1	514494	1.0	0.1	78378
824	734.93	474.21	1209.13	823.68	819.81	51	0.692	0.994	0.102	13	7	3.407	0.957	121421	0.7	1.0	5179			0			0			0			0	-1.1	1.0	3935	0.0	1.0	6693	1.0	0.1	507169	1.0	0.1	77079
825	761.38	474.71	1236.06	824.69	820.81	52	0.692	0.994	0.096	12	8	3.461	0.935	147989	0.8	0.8	12181			0			0			0			0	-0.4	1.0	7229	0.2	1.0	9354	1.0	0.1	496464	1.0	0.1	75278
826	789.51	474.25	1263.76	825.70	821.81	53	0.692	0.994	0.091	12	9	3.509	0.914	176009	0.9	0.7	18946			0			0			0			0	0.0	1.0	11130	0.3	1.0	12296	1.0	0.1	485528	1.0	0.1	73453
827	817.33	473.05	1290.38	826.71	822.81	54	0.692	0.995	0.086	11434	10	3.559	0.914	205380	0.9	0.6	25363			0			0			0			0	0.2	1.0	15555	0.4	1.0	15495	1.0	0.1	472746	1.0	0.1	71362
828	848.49	469.48	1317.97	827.72	823.80	55	0.692	0.995	0.077	10	11	3.597	0.906	237842	0.9	0.5	31587			0			0			0			0	0.3	1.0	20447	0.5	1.0	18931	1.0	0.1	459715	1.0	0.1	69245
829	880.70	465.10	1345.80	828.73	824.80	56	0.692	0.995	0.072	9	12	3.636	0.890	269060	1.0	0.5	37780			0			0			0			0	0.4	1.0	25766	0.5	1.0	22690	1.0	0.1	448081	1.0	0.1	67351
830	912.21	459.71	1371.92	829.74	825.80	57	0.692	0.995	0.066	9439	13	3.674	0.874	301174	1.0	0.4	43897			0			0			0			0	0.5	1.0	31480	0.6	1.0	26457	1.0	0.1	434575	1.0	0.1	65186
831	950.36	450.25	1400.61	830.75	826.80	58	0.692	0.995	0.061	8849	14	3.710	0.860	334149	1.0	0.4	49954	0.7	0.9	1104	-7.4	1.0	110	-7.4	1.0	58	0.5	1.0	37564	0.6	1.0	30491	1.0	0.1	419166	1.0	0.1	62748	0.7	0.9	6169
832	987.39	439.18	1426.57	831.76	827.79	59	0.692	0.995	0.057	8262	15	3.746	0.846	367981	1.0	0.4	55592	0.9	0.7	2474	-1.8	1.0	570	-1.8	1.0	302	0.6	1.0	43995	0.6	1.0	34458	1.0	0.1	400149	1.0	0.1	59784	0.9	0.7	13823
833	1026.92	427.72	1454.63	832.77	828.79	60	0.692	0.995	0.052	7689	16	3.781	0.832	402710	1.0	0.4	61317	0.9	0.6	3745	-0.7	1.0	1225	-0.7	1.0	649	0.6	1.0	50704	0.7	1.0	38395	1.0	0.1	382518	1.0	0.1	57040	0.9	0.6	20923
834	1064.37	415.43	1479.79	833	829	61	0.692	0.996	0.048	7144	17	3.816	0.820	438381	1.0	0.3	66621	0.9	0.5	4940	-0.2	1.0	2030	-0.2	1.0	1076	0.6	1.0	57303	0.7	1.0	42345	1.0	0.1	362916	1.0	0.1	54015	0.9	0.5	27597
835	1104.98	403.28	1508.26	834	830	62	0.692	0.997	0.044	6630	18	3.852	0.808	475088	1.0	0.3	70318	1.0	0.5	6125	0.1	1.0	2959	0.1	1.0	1568	0.7	1.0	63853	0.7	1.0	46329	1.0	0.1	346433	1.0	0.1	51466	1.0	0.5	34216
836	1144.36	389.78	1534.14	835	831	63	0.692	0.997	0.040	6136	19	3.889	0.796	512922	1.0	0.3	73762	1.0	0.4	7290	0.2	1.0	3999	0.2	1.0	2119	0.7	1.0	70430	0.7	0.9	50349	1.0	0.1	327985	1.0	0.1	48638	1.0	0.4	40726
837	1184.50	375.49	1559.99	836	832.78	64	0.692	0.997	0.037	5657	20	3.928	0.786	551965	1.0	0.3	77142	1.0	0.4	8405	0.4	1.0	5137	0.4	1.0	2723	0.7	1.0	77061	0.8	0.9	54403	1.0	0.1	309270	1.0	0.0	45782	1.0	0.4	46957

Case No Longer Valid

Figure 12 – Calculations for Case 6, Embankment Failure Condition at Tellico, Fort Loudoun Embankment Failure, Fort Loudoun Gates Closed, Fort Loudoun Turbines Not Operating

6.9 Case 7, Embankment Failure at Tellico Dam, Pre-Failure Condition at Fort Loudoun Dam, Fort Loudoun Gates Open, Fort Loudoun Turbines Not Operating

This case considers failure of embankment and saddle dams has occurred at Tellico Dam. No failure at Fort Loudoun Dam is considered. The spillway gates at Tellico and Fort Loudoun Dams are considered fully open. The turbines at Fort Loudoun are not generating electricity.

For the embankment failure condition, discharges are computed for headwaters ranging from 750 to 834 feet, seven feet above the top of the dam. Discharge passes through the spillway section of the dam, the emergency spillway in saddle dam 1 and the various overflow sections as headwater rises above the crest elevations in each case. Total discharge, given in "1000 cfs" is the sum of all discharges in cfs past the dam plus discharge in cfs past the embankment and saddle dams divided by 1000.

Figure 13 shows the spreadsheet calculations for the embankment failure dam rating curve (spreadsheet included as Attachment E37). The final result, the rating curve, is defined by the first two columns, HW vs. Total Tellico Discharge (Q_{TEL}). The third and fourth columns contain the Fort Loudoun Discharge (Q_{FTL}) and the total combined discharge (Q_{TOT}). The fifth and sixth columns (TW) give the tailwater associated with the "Total Discharge" at Tellico Dam and the Saddle Dams, respectively. They are represented by the tailwater rating curve polynomial fits [4.18.1]. This is used to check for tailwater submergence effects on the discharge. Tailwater submergence reduces the spillway and emergency spillway discharges for Case 7. Consequently, it is necessary to iterate through different tailwater elevations until the total computed discharge fits the tailwater rating curve [4.18.1]. Figure 13 shows the final results but does not show the iteration steps. The results are readily checked by computing the individual discharges, adding them up to compute total discharge, and then making sure the listed tailwater and total combined discharge agree with the tailwater rating curves.

Spillway discharge in cfs is computed in the next five columns (under the header "Spillway"), H_c, $C_f|C_g$, d/H_c, $S_f|S_g$ and $Q_f|Q_g$. Free discharge occurs for headwater elevations below 815.796 feet [4.3.4] and orifice discharge occurs for headwaters above 815.796 feet. The transition point is indicated by a horizontal line. Above the line, the listed discharge coefficient is C_f [4.2.3] computed from Equation (A6) and below the line the listed discharge coefficient is C_g [4.3.5] computed by interpolation between the points in Table A3. Column $Q_f|Q_g$ is the spillway discharge computed from Equation 2 for free discharge and from Equation 4 for orifice discharge. Column d/H_c verifies that the spillway discharge is affected by tailwater since $d/H_c > 0.20$ [4.2.4] for all headwater elevations at which free discharge occurs. Spillway discharge is also affected by tailwater for all values of $d/H_c > 0.2$ [4.3.6] at all headwater elevations where orifice discharge occurs.

Emergency Spillway discharge is computed in the next four columns (under the header "Emergency Spillway"), H_c, C_f, S_f and Q_f. Free discharge occurs at all heads (H_c) above the spillway crest at elevation 817 feet [4.11.2]. The discharge coefficient is C_f [4.11.1] computed from Equation 5. The submergence factor, S_f [4.11.4], is computed using Equation 6. Column Q_f is the emergency spillway discharge computed from Equation 2 for free discharge with submergence.

The column following the emergency spillway discharge column shows "C_f=", "Z_c=", and "L=" in three rows to indicate the meaning of the values included in those rows in the "Overflow Discharge" columns.

The next nine columns are divided into three sub-columns, each. Contained in the sub-columns overflow parameters and discharges in cfs for the right bank saddle dam, main dam works, the earthen embankment, the three saddle dams and the remaining sections which are expected to overflow. The overflow discharge coefficient C_f ([4.5.1], [4.12.1], [4.6.1], [4.7.1], [4.14.1], [4.15.1], [4.13.1]), elevation Z_c ([4.5.4], [4.12.2], [4.6.2], [4.7.2], [4.14.2], [4.15.2], [4.13.2], [4.13.3]), and length L ([4.5.3], [4.12.3], [4.6.3], [4.7.3], [4.14.3], [4.15.3], [4.13.4], [4.13.5]) in each case are indicated in the three rows above the computed discharge sub-columns. The three sub-columns contain calculated values of d/H_c, S_f [4.17] and Q_f, respectively. All overflow discharges are computed using Equation 2. The values of d/H_c, S_f have been truncated in order fit all the columns.

TVA

Calculation No. CDQ000020080018	Rev: 1	Plant: GEN	Page: 40
Subject: Dam Rating Curves, Tellico		Prepped	WBB
		Checked	ACM

Tellico: Embankment and Main Dam Works Failure, Fort Loudoun Gates Open, Fort Loudoun Turbines Not Operating

g = 32.2 ft/s²

Spillway Parameters: L = 120 feet; Z_c = 773 feet; G_e = 33.576 feet; H_{max} = 16.354 feet; H_{Lmin} = 42.796 feet

Emergency Spillway Parameters: L = 2000 feet; Z_c = 817 feet

HW	Q_{TEL} Total Discharge 1000 cfs	Q_{TTL} Total Discharge 1000 cfs	Q_{TOT} Total Discharge 1000 cfs	Main Dam TRM 802.3 TW feet	Saddle Dam TRM 599.0 TW feet	Spillway H_c ft	$C_f \mid C_o$	d/H_c	S_f/S_o	$Q_f \mid Q_o$ cfs	Emergency Spillway H_c ft	C_f	S_f	Q_f cfs	Right Bank Saddle Dam C_f = 2.65	Main Dam Works 2.65			Saddle Dam 1-Section 1 3.10	Saddle Dam 1-Section 2 2.65	Saddle Dam 2 2.65	Saddle Dam 3 2.65	Main Embankment-Section 1 2.65			Main Embankment-Section 2 2.65		
															Z_c = 834	830			834	834	834	834	755			722		
															L = 2000	447.5			100	62	525	315.72	2400			300		
															Q_f	d/H_c	S_f	Q_f	Q_f	Q_f	Q_f	Q_f	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f
750	36.15	0.00	36.15	749.56	749.59	-23	4.725			0	-67			0	0			0	0	0	0	0			0	0.984	0.307	36149
755	70.57	0.00	70.57	753.62	753.40	-18	3.966			0	-62			0	0			0	0	0	0	0			0	0.958	0.458	70567
760	121.54	0.00	121.54	759.25	758.71	-13	3.484			0	-57			0	0			0	0	0	0	0	0.851	0.802	56993	0.980	0.347	64547
765	171.99	0.00	171.99	764.42	763.61	-8	3.217			0	-52			0	0			0	0	0	0	0	0.942	0.538	108293	0.987	0.284	83699
770	225.48	0.00	225.48	769.50	768.42	-3	3.109			0	-47			0	0			0	0	0	0	0	0.968	0.428	158011	0.989	0.255	67470
773	259.47	0.00	259.47	772.51	771.30	0	3.100			0	-44			0	0			0	0	0	0	0	0.973	0.391	189869	0.990	0.240	69603
775	283.08	0.00	283.08	774.52	773.22	2	3.112	0.762	0.872	921	-42			0	0			0	0	0	0	0	0.976	0.372	211751	0.991	0.230	70411
777	307.55	0.00	307.55	776.53	775.14	4	3.134	0.884	0.741	2228	-40			0	0			0	0	0	0	0	0.979	0.357	234195	0.992	0.219	71125
779	332.82	0.00	332.82	778.54	777.06	6	3.166	0.923	0.665	3714	-38			0	0			0	0	0	0	0	0.981	0.343	256425	0.992	0.212	72685
781	358.96	0.00	358.96	780.53	778.97	8	3.204	0.941	0.617	5368	-36			0	0			0	0	0	0	0	0.982	0.330	278370	0.992	0.206	75217
783	386.10	0.00	386.10	782.53	780.89	10	3.247	0.953	0.582	7171	-34			0	0			0	0	0	0	0	0.983	0.319	301054	0.992	0.206	77870
785	409.40	5.05	414.45	784.53	782.82	12	3.292	0.961	0.552	9062	-32			0	0			0	0	0	0	0	0.984	0.307	320971	0.993	0.200	79368
787	429.42	14.68	444.10	786.54	784.77	14	3.339	0.967	0.525	11014	-30			0	0			0	0	0	0	0	0.986	0.294	338497	0.993	0.192	79908
789	447.50	27.57	475.07	788.55	786.72	16	3.387	0.972	0.500	13010	-28			0	0			0	0	0	0	0	0.987	0.281	354614	0.993	0.183	79874
791	464.20	43.24	507.43	790.57	788.68	18	3.432	0.976	0.478	15034	-26			0	0			0	0	0	0	0	0.988	0.269	369732	0.994	0.174	79430
793	479.89	61.37	541.26	792.59	790.64	20	3.476	0.980	0.457	17066	-24			0	0			0	0	0	0	0	0.989	0.258	384142	0.994	0.165	78886
795	494.80	81.76	576.56	794.61	792.61	22	3.517	0.982	0.440	19149	-22			0	0			0	0	0	0	0	0.990	0.247	397350	0.995	0.158	78306
797	509.00	104.24	613.24	796.61	794.57	24	3.553	0.984	0.427	21428	-20			0	0			0	0	0	0	0	0.991	0.236	408050	0.995	0.154	79520
799	522.87	128.72	651.59	798.61	796.53	26	3.586	0.985	0.416	23743	-18			0	0			0	0	0	0	0	0.991	0.225	418423	0.995	0.150	80701
801	536.53	155.11	691.64	800.62	798.50	28	3.614	0.986	0.406	26099	-16			0	0			0	0	0	0	0	0.992	0.216	429315	0.995	0.145	81112
803	550.08	183.38	733.46	802.62	800.47	30	3.637	0.987	0.397	28475	-14			0	0			0	0	0	0	0	0.992	0.208	440153	0.995	0.141	81450
805	563.56	213.51	777.07	804.62	802.44	32	3.656	0.988	0.389	30860	-12			0	0			0	0	0	0	0	0.992	0.201	450927	0.995	0.136	81773
807	576.97	245.49	822.46	806.63	804.42	34	3.670	0.989	0.381	33249	-10			0	0			0	0	0	0	0	0.993	0.194	461638	0.995	0.132	82080
809	590.24	279.35	869.59	808.63	806.40	36	3.681	0.990	0.374	35632	-8			0	0			0	0	0	0	0	0.993	0.187	472245	0.996	0.128	82359
811	603.49	310.61	914.11	810.46	808.21	38	3.688	0.986	0.411	42579	-6			0	0			0	0	0	0	0	0.990	0.243	646640	0.994	0.171	114275
813	642.51	121.29	963.80	812.45	810.18	40	3.692	0.986	0.408	45735	-4			0	0			0	0	0	0	0	0.990	0.241	678691	0.994	0.172	118684
815	682.43	132.38	1014.81	814.43	812.14	42	3.695	0.986	0.406	48853	-2			0	0			0	0	0	0	0	0.990	0.240	710289	0.994	0.173	123188
815.796	698.53	136.91	1035.44	815.22	812.92	42.8	3.697	0.987	0.405	50252	-1			0	0			0	0	0	0	0	0.991	0.240	723278	0.994	0.173	125002
816	900.30	140.03	1040.33	815.41	813.10	43	0.743	0.986	0.241	29840	-1			0	0			0	0	0	0	0	0.990	0.245	742527	0.994	0.177	127936
817	920.36	146.11	1066.47	816.40	814.08	44	0.729	0.986	0.232	28810	0			0	0			0	0	0	0	0	0.990	0.245	761016	0.994	0.177	130538
818	941.24	151.73	1092.96	817.39	815.07	45	0.715	0.986	0.224	27672	1	2.971	1.000	5841	0			0	0	0	0	0	0.990	0.244	775160	0.994	0.177	132462
819	962.84	156.92	1119.76	818.39	816.05	46	0.701	0.987	0.214	26384	2	3.060	1.000	17312	0			0	0	0	0	0	0.990	0.241	785383	0.994	0.176	133777
820	984.87	161.94	1146.81	819.39	817.04	47	0.696	0.987	0.203	25308	3	3.143	1.000	32857	0			0	0	0	0	0	0.991	0.238	792313	0.994	0.175	134594
821	1057.93	114.99	1172.92	820.35	817.99	48	0.692	0.988	0.198	24941	4	3.218	0.988	50777	0			0	0	0	0	0	0.990	0.246	840489	0.993	0.181	141725
822	1085.93	114.27	1200.20	821.35	818.97	49	0.692	0.987	0.187	23958	5	3.287	0.963	70806	0			0	0	0	0	0	0.990	0.243	848477	0.994	0.179	142690
823	1112.45	115.20	1227.65	822.36	819.96	50	0.692	0.987	0.178	22868	6	3.350	0.940	92601	0			0	0	0	0	0	0.991	0.239	853738	0.994	0.178	143242
824	1137.98	117.25	1255.22	823.36	820.95	51	0.692	0.987	0.168	22121	7	3.407	0.919	116016	0			0	0	0	0	0	0.991	0.235	856430	0.994	0.175	143408
825	1165.91	116.94	1282.85	824.37	821.94	52	0.692	0.988	0.162	21608	8	3.461	0.907	142034	0			0	0	0	0	0	0.991	0.231	858744	0.994	0.173	143523
826	1193.66	116.83	1310.49	825.37	822.92	53	0.692	0.988	0.156	21084	9	3.509	0.885	167799	0			0	0	0	0	0	0.991	0.226	861126	0.994	0.170	143653
827	1219.78	118.40	1338.19	826.38	823.91	54	0.692	0.989	0.149	20504	10	3.555	0.865	194548	0			0	0	0	0	0	0.991	0.222	861277	0.994	0.168	143453
828	1247.60	118.26	1365.85	827.39	824.90	55	0.692	0.989	0.143	19925	11	3.597	0.847	222255	0			0	0	0	0	0	0.992	0.217	862062	0.994	0.165	143355
829	1275.76	117.75	1393.51	828.40	825.88	56	0.692	0.989	0.137	19326	12	3.636	0.830	250867	0			0	0	0	0	0	0.992	0.213	862372	0.994	0.163	143191
830	1304.04	117.10	1421.14	829.40	826.87	57	0.692	0.990	0.131	18704	13	3.674	0.814	280361	0			0	0	0	0	0	0.992	0.209	862036	0.994	0.160	142938
830.57	1275.31	162.55	1437.88	830.02	827.46	57.6	0.692	0.990	0.122	17587	14	3.695	0.803	296764	0	0.027	1.000	512	0	0	0	0	0.993	0.197	823426	0.995	0.152	137039
831.14	1257.77	196.54	1454.30	830.62	828.05	58.1	0.692	0.991	0.114	16491	14	3.715	0.793	313588	0	0.540	1.000	1449	0	0	0	0	0.993	0.188	785187	0.995	0.145	131072
831.71	1239.66	231.06	1470.72	831.22	828.63	58.7	0.692	0.992	0.106	15440	15	3.736	0.784	330623	0	0.710	0.959	2553	0	0	0	0	0.994	0.179	766978	0.995	0.136	124088
832.29	1221.03	266.10	1487.13	831.82	829.22	59.3	0.692	0.992	0.098	14395	15	3.756	0.775	347858	0	0.796	0.883	3620	0	0	0	0	0.994	0.171	738206	0.996	0.127	116951
832.86	1201.13	302.42	1503.55	832.42	829.81	59.9	0.692	0.993	0.090	13342	16	3.776	0.766	365280	0	0.847	0.808	4625	0	0	0	0	0.994	0.162	708290	0.996	0.118	109592
833.43	1184.52	335.37	1519.89	833.02	830.39	60.4	0.692	0.993	0.083	12377	16	3.796	0.758	383000	0	0.881	0.737	5546	0	0	0	0	0.995	0.154	680806	0.996	0.110	102792
834	1167.46	368.64	1536.10	833.62	830.97	61	0.692	0.994	0.077	11547	17	3.816	0.750	401100	0	0.904	0.674	6398	0	0	0	0	0.995	0.146	651457	0.997	0.103	98960

Figure 13 – Calculations for Case 7, Embankment Failure Condition at Tellico, Pre-Failure Condition at Fort Loudoun, Fort Loudoun Gates Open, Fort Loudoun Turbines Not Operating

6.10 Case 8, Embankment Failure at Tellico Dam, Pre-Failure Condition at Fort Loudoun, Fort Loudoun Gates Closed, Fort Loudoun Turbines Not Operating

This case considers failure of embankment and saddle dams has occurred at Tellico Dam. No failure at Fort Loudoun Dam is considered. The spillway gates at Tellico Dam are considered fully open. The spillway gates at Fort Loudoun Dam are closed. The turbines at Fort Loudoun are not generating electricity.

For the embankment failure condition, discharges are computed for headwaters ranging from 750 feet to 837 feet, seven feet above the top of the dam. Discharge passes through the spillway section of the dam, the emergency spillway, saddle dam 1 and the various overflow sections as headwater rises above the crest elevations in each case. Total discharge, given in "1000 cfs" is the sum of all discharges in cfs past the dam plus discharge in cfs past the embankment and saddle dams divided by 1000.

Figure 14 shows the spreadsheet calculations for the embankment failure dam rating curve (spreadsheet included as Attachment E37). The final result, the rating curve, is defined by the first two columns, TW vs. Total Tellico Discharge (Q_{TEL}). The third and fourth columns contain the Fort Loudoun Discharge (Q_{FTL}) and the total combined discharge (Q_{TOT}). The fifth and sixth columns (TW) give the tailwater associated with the "Total Discharge" at Tellico Dam and the Saddle Dams, respectively. They are represented by the tailwater rating curve polynomials [4.18.1]. This is used to check for tailwater submergence effects on the discharge. Tailwater submergence reduces the spillway and emergency spillway discharges for Case 8. Consequently, it is necessary to iterate through different tailwater elevations until the total computed discharge fits the tailwater rating curve [4.18.1]. Figure 14 shows the final result but does not show the iteration steps. The results are readily checked by computing the individual discharges, adding them up to compute total discharge, and then making sure the listed tailwater and total combined discharge agree with the tailwater rating curves.

Spillway discharge in cfs is computed in the next five columns (under the header "Spillway"), H_c, $C_f|C_g$, d/H_c, $S_f|S_g$ and $Q_f|Q_g$. Free discharge occurs for headwater elevations below 815.796 feet [4.3.4] and orifice discharge occurs for headwaters above 815.796 feet. The transition point is indicated by a horizontal line. Above the line, the listed discharge coefficient is C_f [4.2.3] computed from Equation (A6), and below the line the listed discharge coefficient is C_g [4.3.5] computed by interpolation between the points in Table A3. Column $Q_f|Q_g$ is the spillway discharge computed from Equation 2 for free discharge and from Equation 4 for orifice discharge. Column d/H_c verifies that the spillway discharge is affected by tailwater since $d/H_c > 0.2$ [4.2.4] for all headwater elevations at which free discharge occurs. Spillway discharge is also affected by tailwater for all values of $d/H_c > 0.2$ [4.3.6] at all headwater elevations where orifice discharge occurs.

Emergency Spillway discharge is computed in the next four columns (under the header "Emergency Spillway"), H_c, C_f, S_f and Q_f. Free discharge occurs at all heads (H_c) above the spillway crest at elevation 817 feet [4.11.2]. The discharge coefficient is C_f [4.11.1] computed from Equation 5. The submergence factor, S_f [4.11.4], is computed using Equation 6. Column Q_f is the emergency spillway discharge computed from Equation 2 for free discharge with submergence.

The column following the emergency spillway discharge column shows "C_f=", "Z_c=", and "L=" in three rows to indicate the meaning of the values included in those rows in the "Overflow Discharge" columns.

The next nine columns are divided into three sub-columns, each. Contained in the sub-columns overflow parameters and discharges in cfs for the right bank saddle dam, main dam works, the earthen embankment, the three saddle dams and the remaining sections which are expected to overflow. The overflow discharge coefficient C_f ([4.5.1], [4.12.1], [4.6.1], [4.7.1], [4.14.1], [4.15.1], [4.13.1], [4.16.1]), elevation Z_c ([4.5.4], [4.12.2], [4.6.2], [4.7.2], [4.14.2], [4.15.2], [4.13.2], [4.13.3]), and length L ([4.5.3], [4.12.3], [4.6.3], [4.7.3], [4.14.3], [4.15.3], [4.13.4], [4.13.5]) in each case are indicated in the three rows above the computed discharge sub-columns. The three sub-columns contain calculated values of d/H_c, S_f [4.17] and Q_f, respectively. All overflow discharges are computed using Equation 2. The values of d/H_c, S_f have been truncated in order fit all the columns.

Case No Longer Valid

Tellico Dam Embankment Failure, Fort Loudoun Dam Pre-Failure, Fort Loudoun Gates Closed, Fort Loudoun Turbines Not Operating

g = 32.2 ft/s²

Spillway Parameters: L = 120 feet; Z_c = 773 feet; G_n = 33.576 feet; H_{eg} = 16.354 feet

Emergency Spillway Parameters: L = 2000 feet; Z_c = 817 feet

HW	Q_{TEL} Total Discharge	Q_{FTL} Total Discharge	Q_{TOT} Total Discharge	Main Dam TW	Saddle Dam TW	Spillway H_c	Spillway C_f | C_g	Spillway d/H_c	Spillway S_f/S_g	Spillway Q_f | Q_g	Emergency Spillway H_c	Emergency Spillway C_f	Emergency Spillway S_f	Emergency Spillway Q_f
feet	1000 cfs	1000 cfs	1000 cfs	feet	feet	ft				cfs	ft			cfs
750	45.65	0.00	45.65	749.26	747.92	0				0	0			0
755	76.39	0.00	76.39	753.34	751.79	0				0	0			0
760	123.76	0.00	123.76	759.22	757.38	0				0	0			0
765	169.28	0.00	169.28	764.44	762.35	0				0	0			0
770	217.39	0.00	217.39	769.54	767.20	0				0	0			0
773	248.19	0.00	248.19	772.56	770.08	0				0	0			0
775	269.56	0.00	269.56	774.57	772.01	2	3.112	0.786	0.853	901	0			0
777	291.64	0.00	291.64	776.58	773.93	4	3.134	0.895	0.721	2170	0			0
779	314.17	0.00	314.17	778.58	775.84	6	3.166	0.930	0.648	3618	0			0
781	338.10	0.00	338.10	780.58	777.76	8	3.204	0.947	0.600	5215	0			0
783	362.58	0.00	362.58	782.58	779.68	10	3.247	0.958	0.564	6947	0			0
785	388.56	0.00	388.56	784.57	781.59	12	3.292	0.964	0.537	8817	0			0
787	415.63	0.00	415.63	786.57	783.51	14	3.339	0.969	0.515	10818	0			0
789	443.31	0.00	443.31	788.56	785.43	16	3.387	0.973	0.498	12941	0			0
791	473.15	0.00	473.15	790.55	787.36	18	3.432	0.975	0.483	15206	0			0
793	503.65	0.00	503.65	792.55	789.28	20	3.476	0.977	0.471	17582	0			0
795	535.90	0.00	535.90	794.54	791.21	22	3.517	0.979	0.461	20087	0			0
797	569.94	0.00	569.94	796.52	793.13	24	3.553	0.980	0.453	22715	0			0
799	605.84	0.00	605.84	798.51	795.06	26	3.586	0.981	0.446	25465	0			0
801	643.06	0.00	643.06	800.50	796.99	28	3.614	0.982	0.441	28314	0			0
803	682.82	0.00	682.82	802.48	798.93	30	3.637	0.983	0.436	31291	0			0
805	723.96	0.00	723.96	804.46	800.86	32	3.656	0.983	0.433	34357	0			0
807	767.14	0.00	767.14	806.44	802.80	34	3.670	0.983	0.430	37526	0			0
809	812.40	0.00	812.40	808.41	804.74	36	3.681	0.984	0.428	40796	0			0
811	859.78	0.00	859.78	810.39	806.69	38	3.688	0.984	0.426	44169	0			0
813	908.69	0.00	908.69	812.36	808.63	40	3.692	0.984	0.425	47626	0			0
815	958.47	0.00	958.47	814.34	810.58	42	3.695	0.984	0.424	51154	0			0
815.796	996.31	0.00	996.31	815.10	811.33	43	3.697	0.984	0.428	53178	0			0
816	981.88	1.96	983.84	815.29	811.52	43	0.743	0.984	0.250	30866	0			0
817	1004.27	5.51	1009.78	816.28	812.50	44	0.729	0.984	0.244	30239	0			0
818	1026.67	9.38	1036.05	817.28	813.48	45	0.715	0.984	0.237	29348	1	2.971	1.000	5941
819	1049.15	13.49	1062.64	818.28	814.48	46	0.701	0.984	0.230	28331	2	3.060	[illegible]	[illegible]
820	1071.89	17.84	1089.72	819.29	815.48	47	0.696	0.985	0.221	27591	3	3.143	[illegible]	[illegible]
821	1106.52	10.47	1116.99	820.29	816.46	48	0.692	0.985	0.215	[illegible]	4	[illegible]	[illegible]	51484
822	1133.32	10.98	1144.30	821.31	817.47	49	0.692	0.986	0.207	[illegible]	[illegible]	3.287	[illegible]	73349
823	1157.83	14.56	1172.40	822.33	818.48	50	0.692	0.987	0.195	25271	[illegible]	[illegible]	[illegible]	[illegible]
824	1179.22	20.53	1199.75	823.35	819.48	51	0.692	[illegible]	[illegible]	23944	7	[illegible]	0.971	122532
825	1200.67	26.65	1227.33	824.37	820.50	52	0.692	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	149471
826	1223.14	32.61	1255.75	825.40	821.51	53	0.692	0.989	[illegible]	21181	9	3.509	[illegible]	177826
827	1245.85	38.31	1284.16	826.42	822.52	54	0.692	0.989	0.145	[illegible]	10	3.555	0.823	207510
828	1266.98	43.99	1310.97	827.45	823.54	55	0.692	0.990	0.134	[illegible]	[illegible]	3.597	0.808	238438
829	1289.53	49.36	1338.89	828.48	824.56	56	0.692	0.991	0.124	17503	[illegible]	3.636	0.801	272321
830	1311.61	54.51	1366.12	829.51	825.57	[illegible]	[illegible]	[illegible]	0.116	16489	13	3.674	0.885	304771
831	1335.14	59.17	1394.31	830.54	826.59	[illegible]	0.692	[illegible]	0.108	15632	14	3.710	0.869	337954
832	1359.09	63.36	1422.45	831.57	827.61	[illegible]	[illegible]	[illegible]	[illegible]	14665	15	3.746	0.854	371871
833	1382.45	67.24	1449.69	832.60	[illegible]	[illegible]	[illegible]	[illegible]	0.091	13427	16	3.781	0.840	406609
834	1400.86	76.11	1476.97	[illegible]	829.64	61	[illegible]	[illegible]	0.082	12288	17	3.816	0.827	442394
835	1412.62	91.95	1504.56	[illegible]	[illegible]	[illegible]	0.692	0.995	0.074	11144	18	3.852	0.814	479069
836	1423.58	107.01	1530.59	[illegible]	[illegible]	[illegible]	0.692	0.995	0.066	10057	19	3.889	0.802	516761
837	1439.05	120.02	[illegible]	836.71	[illegible]	[illegible]	0.692	0.996	0.058	9033	20	3.928	0.791	555641

Overflow Discharge, Q_f in cfs

HW	Right Bank Saddle Dam			Main Dam Works			Saddle Dam 1-Section 1			Saddle Dam 1-Section 2			Saddle Dam 2			Saddle Dam 3			Main Embankment-Section 1			Main Embankment-Section 1			Remaining Overflow Sections		
C_f =	2.65			2.65			3.1			2.65			2.65			2.65			2.65			2.65			[illegible]		
Z_c =	823			830			830.5			830.5			822			820			755			[illegible]			830		
L =	2000			447.5			100			62			525			315.72			2400			300			2500		
feet	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f	d/H_c	S_f	Q_f
750			0			0			0			0			0			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			0
755			0			0			0			0			0			[illegible]	[illegible]	[illegible]	[illegible]	0.9	[illegible]	76388			0
760			0			0			0			0			0			0	[illegible]	0.8	[illegible]	[illegible]	[illegible]	65841			0
765			0			0			0			0			0			0	[illegible]	0.5	106614	1.0	0.3	62662			0
770			0			0			0			0			0			0	1.0	[illegible]	152947	1.0	0.2	64443			0
773			0			0			0			0			0			[illegible]	[illegible]	[illegible]	183299	1.0	0.2	64893			0
775			0			0			0			0			0			0	1.0	[illegible]	203774	1.0	0.2	64880			0
777			0			0			0			0			0			0	1.0	0.3	223733	1.0	0.2	65739			0
779			0			0			0			0			0			0	1.0	0.3	243029	1.0	0.2	67524			0
781			0			0			0			0			0			0	1.0	0.3	263330	1.0	0.2	69553			0
783			0			0			0			0			0			0	1.0	0.3	284039	1.0	0.2	71591			0
785			0			0			0			0			0			0	1.0	0.3	305853	1.0	0.2	73891			0
787			0			0			0			0			0			0	1.0	0.3	328475	1.0	0.2	76337			0
789			0			0			0			0			0			0	1.0	0.3	351564	1.0	0.2	78804			0
791			0			0			0			0			0			0	1.0	0.3	376258	1.0	0.2	81689			0
793			0			0			[illegible]			0			0			0	1.0	0.3	401466	1.0	0.2	84606			0
795			0			0			0			[illegible]			0			0	1.0	0.3	427985	1.0	0.2	87827			0
797			0			0			[illegible]			0			0			0	1.0	0.3	455866	1.0	0.2	91363			0
799			0			0			[illegible]			0			0			0	1.0	0.3	485156	1.0	0.2	95224			0
801			0			0			0			0			0			0	1.0	0.3	515471	1.0	0.2	99279			0
803			0			0			[illegible]			0			0			0	1.0	0.3	547708	1.0	0.2	103819			0
805			0			0			0			0			0			0	1.0	0.3	581038	1.0	0.2	108569			0
807			0			0			0			0			0			0	1.0	0.3	615935	1.0	0.2	113681			0
809			[illegible]			[illegible]			0			0			0			0	1.0	0.3	652438	1.0	0.2	119163			0
811			[illegible]			[illegible]			0			0			0			0	1.0	0.3	690587	1.0	0.2	125025			0
813			0			[illegible]			0			0			0			0	1.0	0.3	729935	1.0	0.2	131124			0
815			0			0			0			0			0			0	1.0	0.3	770002	1.0	0.2	137311			0
815.796			0			0			0			0			0			0	1.0	0.3	799263	1.0	0.2	143870			0
816			0			0			0			0			0			0	1.0	0.3	805699	1.0	0.2	145215			0
817			0			0			0			0			0			0	1.0	0.3	825798	1.0	0.2	148233			0
818			[illegible]			0			0			0			0			0	1.0	0.3	841517	1.0	0.2	149868			0
819			0			0			0			0			0			0	1.0	0.3	853258	1.0	0.2	150255			0
820			0			0			0			0			0			0	1.0	0.3	861949	1.0	0.2	149689			0
821			0			0			0			0			0	-3.5	1.0	837	1.0	0.3	876304	1.0	0.2	150847			0
822			0			0			0			0			0	-1.3	1.0	2366	1.0	0.3	881877	1.0	0.2	149301			0
823			0			0			0			0	-3.5	1.0	1391	-0.5	1.0	4347	1.0	0.2	882140	1.0	0.2	147569			0
824	0.3	1.0	5300			0			0			0	-1.3	1.0	3935	-0.1	1.0	6693	1.0	0.2	871169	1.0	0.2	145848			0
825	0.7	1.0	14601			0			0			0	-0.5	1.0	7229	0.1	1.0	9354	1.0	0.2	854576	1.0	0.2	142691			0
826	0.8	0.9	24220			0			0			0	-0.1	1.0	11130	0.3	1.0	12298	1.0	0.2	836545	1.0	0.2	139934			0
827	0.9	0.8	33566			0			0			0	0.1	1.0	15555	0.4	1.0	15495	1.0	0.2	817051	1.0	0.2	136777			0
828	0.9	0.7	42255			0			0			0	0.3	1.0	20447	0.4	1.0	18931	1.0	0.2	794992	1.0	0.2	133252			0
829	0.9	0.6	50301			0			0			0	0.4	1.0	25766	0.5	1.0	22590	1.0	0.2	772516	1.0	0.1	128534			0
830	0.9	0.6	57889			0			0			0	0.4	1.0	31480	0.6	1.0	26457	1.0	0.2	751831	1.0	0.1	122689			0
831	0.9	0.5	64729	0.5	1.0	1186	-7.8	1.0	110	-7.8	1.0	58	0.5	1.0	37564	0.6	1.0	30524	1.0	0.2	725223	1.0	0.1	115537	0.5	1.0	6625
832	1.0	0.5	70895	0.8	0.9	3004	-1.9	1.0	570	-1.9	1.0	302	0.6	1.0	43995	0.6	1.0	34628	1.0	0.2	694819	1.0	0.1	107561	0.8	0.9	16782
833	1.0	0.5	76614	0.9	0.8	4723	-0.7	1.0	1225	-0.7	1.0	649	0.6	1.0	50758	0.7	1.0	38631	1.0	0.2	663929	1.0	0.1	98505	0.9	0.8	26383
834	1.0	0.4	82574	0.9	0.7	6289	-0.2	1.0	2030	-0.2	1.0	1076	0.6	1.0	57540	0.7	1.0	42626	1.0	0.1	625775	1.0	0.1	83137	0.9	0.7	35133
835	1.0	0.4	87996	0.9	0.6	7694	0.0	1.0	2959	0.0	1.0	1568	0.7	1.0	64181	0.7	1.0	46630	1.0	0.1	581938	1.0	0.1	86453	0.9	0.6	42982
836	1.0	0.4	92893	0.9	0.5	8974	0.2	1.0	3999	0.2	1.0	2119	0.7	1.0	70798	0.7	0.9	50657	1.0	0.1	537484	1.0	0.1	79705	0.9	0.5	50136
837	1.0	0.4	97986	1.0	0.5	10188	0.3	1.0	5137	0.3	1.0	2723	0.7	1.0	77447	0.7	0.9	54710	1.0	0.1	495869	1.0	0.1	73404	1.0	0.5	56915

Figure 14 – Calculations for Case 8, Embankment Failure Condition at Tellico, Fort Loudoun Embankment Failure, Fort Loudoun Gates Closed, Fort Loudoun Turbines Not Operating

Case No Longer Valid

6.11 Case 9, Pre-Failure Condition at Tellico Dam, Fort Loudoun Seismic Failure, Fort Loudoun Turbines Not Operating

This case considers no failure has occurred at Tellico Dam. The embankment and much of the main dam works at Fort Loudoun Dam has failed. The spillway gates at Tellico Dam are considered fully open. The spillway at Fort Loudoun is gone. The turbines at Fort Loudoun are not generating electricity.

For the pre-failure condition, discharges are computed for headwaters ranging from 773 feet, the spillway crest elevation, to 837 feet, seven feet above the top of the dam and embankment. Discharge passes through the spillway section of the dam, the emergency spillway in saddle dam 1 and the various overflow sections as headwater rises above the crest elevations in each case. Total discharge, given in "1000 cfs" is the sum of all discharges in cfs past the dam plus discharge in cfs past the embankment and saddle dams divided by 1000.

Figure 15 shows the spreadsheet calculations for the pre-failure initial dam rating curve (spreadsheet included as Attachment E37). The final result, the rating curve, is defined by the first two columns, HW vs. Total Tellico Discharge (Q_{TEL}). The third and fourth columns contain the Fort Loudoun Discharge (Q_{FTL}) and the total combined discharge (Q_{TOT}). The fifth and sixth columns (TW) give the tailwater associated with the "Total Discharge" at Tellico Dam and the Saddle Dams, respectively. They are represented by the tailwater rating curve polynomial fits [4.18.1]. TW is used to check for tailwater submergence effects on the discharge. Tailwater submergence reduces the spillway and emergency spillway discharges for Case 9. Consequently, it is necessary to iterate through different tailwater elevations until the total computed discharge fits the tailwater rating curve [4.18.1]. Figure 15 shows the final results but does not show the iteration steps. The results are readily checked by computing the individual discharges, adding them up to compute total discharge, and then making sure the listed tailwater and total combined discharge agree with the tailwater rating curves.

Spillway discharge in cfs is computed in the next five columns (under the header "Spillway"), H_c, $C_f|C_g$, d/H_c, $S_f|S_g$ and $Q_f|Q_g$. Free discharge occurs for headwater elevations below 815.796 feet [4.3.4] and orifice discharge occurs for headwaters above 815.796 feet. The transition point is indicated by a horizontal line. Above the line, the listed discharge coefficient is C_f [4.2.3] computed from Equation (1.6) and below the line the listed discharge coefficient is C_g [4.3.5] computed by interpolation between the points in Table A3. Column $Q_f|Q_g$ is the spillway discharge computed from Equation 2 for free discharge and from Equation 4 for orifice discharge. Column d/H_c verifies that the spillway discharge is affected by tailwater since $d/H_c > 0.2$ [4.2.4] for all headwater elevations at which free discharge occurs. Spillway discharge is also affected by tailwater for all values of $d/H_c < 0.2$ [4.3.6] at all headwater elevations where orifice discharge occurs.

Emergency Spillway discharge is computed in the next four columns (under the header "Emergency Spillway"), H_c, C_f, S_f and Q_f. Free discharge occurs when (H_c) above the spillway crest at elevation 817 feet [4.11.2]. The discharge coefficient is C_f [4.11.1] computed from Equation 5. The submergence factor, S_f [4.11.4], is computed using Equation 6. Column Q_f is the emergency spillway discharge computed from Equation 2 for free discharge with submergence.

The column following the emergency spillway discharge column shows "C_f=", "Z_c=", and "L=" in three rows to indicate the meaning of the values included in those rows in the "Overflow Discharge" columns.

The next eight columns are divided into three sub-columns, each. Contained in the sub-columns are overflow discharges in cfs for the right bank saddle dam, main dam works (including the earthen embankment), the three saddle dams and the remaining sections which are expected to overflow. The overflow discharge coefficient C_f ([4.5.1], [4.4.1], [4.6.1], [4.7.1], [4.8.1], [4.9.1], [4.10.1], [4.16.1]), elevation Z_c ([4.5.2], [4.4.2], [4.6.2], [4.7.2], [4.8.2], [4.9.2], [4.10.2], [4.16.2]), and length L ([4.5.3], [4.4.3], [4.6.3], [4.7.3], [4.8.3], [4.9.3], [4.10.3], [4.16.3]) in each case are indicated in the three rows above the computed discharge sub-columns. The three sub-columns contain calculated values of d/H_c, S_f [4.17] and Q_f, respectively. All overflow discharges are computed using Equation 2. The values of d/H_c and S_f have been truncated in order fit all the columns.

Case No Longer Valid

Tellico Dam Saddle Dams and Embankment Intact, Fort Loudoun Dam Seismic Failure, Fort Loudoun Turbines Not Operating

g = 32.2 ft/s2

Spillway Parameters: L = 120 feet; Zc = 773 feet; Gn = 33.576 feet; Hmp = 16.354 feet

Emergency Spillway Parameters: L = 2000 feet; Zc = 817 feet

Overflow Discharge, Qf in cfs

							Spillway					Emergency Spillway				Right Bank Saddle Dam			Main Dam Works			Saddle Dam 1-Section 1			Saddle Dam 1-Section 2			Saddle Dam 2			Saddle Dam 3-Section 1			Saddle Dam 3-Section 2			Remaining Overflow Sections		
	Q_{TEL}	Q_{FTL}	Q_{TOT}		Saddle											Cf =	2.65			2.65			3.1			2.65			2.65			2.65			2.65					
	Total	Total	Total	Main Dam	Dam											Zc =	830			830			830.5			830.5			830			831.7						830		
HW	Discharge	Discharge	Discharge	TW	TW	Hc	Cf | Cg	d/Hc	Sf/Sg	Qf | Qg	Hc	Cf	Sf	Qf	L =	2000			3147.5			100			62			525			62.12			253.6			2500		
feet	1000 cfs	1000 cfs	1000 cfs	feet	feet	feet				cfs	feet			cfs		d/Hc	Sf	Qf	d/Hc	Sf	Qf	d/Hc	Sf	Qf	d/Hc	Sf	Q	d/Hc	Sf	Qf	d/Hc	Sf	Qf	d/Hc	Sf	Qf	d/Hc	Sf	Qf
773	0.00	247.04	247.04	772.46	769.99	0				0	0			0				0			0			0			0			0			0			0		
775	0.94	267.48	268.42	774.48	771.92	2	3.112	0.740	0.888	937	0			0				0			0			0			0			0			0			0		
777	2.28	288.14	290.42	776.49	773.84	4	3.134	0.871	0.759	2284	0			0				0			0			0			0			0			0			0		
779	3.83	309.35	313.17	778.48	775.75	6	3.166	0.914	0.685	3825	0			0				0			0			0			0			0			0			0		
781	5.53	331.30	336.83	780.48	777.66	8	3.204	0.935	0.636	5530	0			0				0			0			0			0			0			0			0		
783	7.38	354.07	361.45	782.47	779.58	10	3.247	0.947	0.599	7384	0			0				0			0			0			0			0			0			0		
785	9.39	377.73	387.12	784.47	781.49	12	3.292	0.956	0.572	9388	0			0				0			0			0			0			0			0			0		
787	11.46	402.60	414.06	786.47	783.42	14	3.339	0.962	0.546	11462	0			0				0			0			0			0			0			0			0		
789	13.64	428.62	442.26	788.47	785.35	16	3.387	0.967	0.524	13641	0			0				0			0			0			0			0			0			0		
791	15.93	455.83	471.76	790.48	787.28	18	3.432	0.971	0.506	15931	0			0				0			0			0			0			0			0			0		
793	18.35	484.33	502.67	792.47	789.21	20	3.476	0.974	0.492	18349	0			0				0			0			0			0			0			0			0		
795	20.87	514.21	535.08	794.47	791.14	22	3.517	0.976	0.479	20867	0			0				0			0			0			0			0			0			0		
797	23.49	545.61	569.10	796.47	793.08	24	3.553	0.978	0.469	23469	0			0				0			0			0			0			0			0			0		
799	26.23	578.61	604.84	798.46	795.01	26	3.586	0.979	0.460	26226	0			0				0			0			0			0			0			0			0		
801	29.08	613.32	642.40	800.45	796.95	28	3.614	0.980	0.453	29078	0			0				0			0			0			0			0			0			0		
803	32.01	649.82	681.83	802.44	798.89	30	3.637	0.981	0.446	32006	0			0				0			0			0			0			0			0			0		
805	35.05	688.16	723.20	804.42	800.83	32	3.656	0.982	0.441	35046	0			0				0			0			0			0			0			0			0		
807	38.18	728.36	766.53	806.40	802.77	34	3.670	0.982	0.437	38176	0			0				0			0			0			0			0			0			0		
809	41.42	770.40	811.82	808.38	804.71	36	3.681	0.983	0.434	41417	0			0				0			0			0			0			0			0			0		
811	44.73	814.22	858.95	810.36	806.66	38	3.688	0.983	0.432	44732	0			0				0			0			0			0			0			0			0		
813	48.15	859.66	907.81	812.34	808.61	40	3.692	0.983	0.430	48146	0			0				0			0			0			0			0			0			0		
815	51.62	906.54	958.16	814.32	810.56	42	3.695	0.984	0.428	51624	0			0				0			0			0			0			0			0			0		
815.796	53.62	924.00	977.62	815.08	811.30	42.8	3.697	0.983	0.432	53619	0			0				0			0			0			0			0			0			0		
816	31.48	951.35	982.83	815.27	811.49	43	0.743	0.983	0.254	31475	0			0				0			0			0			0			0			0			0		
817	30.79	977.87	1008.66	816.25	812.47	44	0.729	0.983	0.248	30794	0			0				0			0			0			0			0			0			0		
818	35.86	999.15	1035.01	817.24	813.45	45	0.715	0.983	0.242	29922	1	2.971	[illegible]	5941				0			0			0			0			0			0			0		
819	46.21	1015.60	1061.81	818.25	814.44	46	0.701	0.984	0.234	28900	2	3.060	1.000	[illegible]				0			0			0			0			0			0			0		
820	60.80	1028.19	1088.99	819.26	815.44	47	0.696	0.984	0.226	[illegible]	3	3.143	1.000	[illegible]				0			0			0			0			0			0			0		
821	78.83	1037.63	1116.46	820.27	816.44	48	0.692	0.985	[illegible]	[illegible]	3	3.218	1.000	51484				0			0			0			0			0			0			0		
822	106.12	1043.86	1149.98	821.29	817.45	49	[illegible]	0.985	[illegible]	26755	[illegible]	[illegible]	0.998	73362				0			0			0			0			0			0			0		
823	123.41	1047.98	1171.40	822.30	818.44	50	0.692	[illegible]	[illegible]	26237	[illegible]	[illegible]	0.997	97178				0			0			0			0			0			0			0		
824	147.92	1050.97	1198.89	823.31	819.44	51	0.692	[illegible]	0.192	[illegible]	[illegible]	3.407	0.972	122659				0			0			0			0			0			0			0		
825	173.67	1052.54	1226.41	824.32	[illegible]	[illegible]	[illegible]	0.987	[illegible]	24168	8	3.461	0.956	149704				0			0			0			0			0			0			0		
826	201.30	1052.63	1253.93	825.33	821.44	[illegible]	0.692	[illegible]	[illegible]	23091	9	3.509	0.940	178206				0			0			0			0			0			0			0		
827	230.11	1051.32	1281.43	826.34	822.45	[illegible]	[illegible]	0.988	0.161	22039	10	3.555	0.926	206070				0			0			0			0			0			0			0		
828	260.23	1048.67	1308.90	827.36	823.45	55	[illegible]	0.988	0.151	21009	11	3.597	0.912	239217				0			0			0			0			0			0			0		
829	293.56	1042.79	1336.36	828.38	824.45	56	0.692	[illegible]	0.142	19975	12	3.636	0.905	273568				0			0			0			0			0			0			0		
830	325.44	1038.24	1363.69	[illegible]	[illegible]	57	0.692	0.989	0.133	19037	13	3.674	0.890	306408				0			0			0			0			0			0			0		
831	360.38	1011.07	1391.45	830.41	[illegible]	58	0.692	0.990	0.125	18049	14	3.710	0.874	339812	0.4	1.0	5300	0.4	1.0	8341	-8.0	1.0	110	-8.0	1.0	58	-3.5	1.0	1391			0	-3.5	1.0	672	0.4	1.0	6625
832	451.24	968.17	1419.41	[illegible]	827.[illegible]	59	0.692	0.991	0.115	16856	15	3.746	0.859	373770	0.7	0.9	14092	0.7	0.9	22177	-2.0	1.0	570	-2.0	1.0	302	-1.2	1.0	3935	-14.0	1.0	27	-1.2	1.0	1901	0.7	0.9	17615
833	523.34	923.[illegible]	1447.31	[illegible]	[illegible]	60	0.692	0.992	0.106	15700	16	3.781	0.844	408471	0.8	0.8	22577	0.8	0.8	35531	-0.8	1.0	1225	-0.8	1.0	649	-0.5	1.0	7229	-2.4	1.0	244	-0.5	1.0	3492	0.8	0.8	28221
834	594.15	[illegible]	[illegible]	833.56	829.57	61	0.692	0.993	0.097	14489	17	3.816	0.830	444102	0.9	0.7	30173	0.9	0.7	47485	-0.3	1.0	2030	-0.3	1.0	1076	-0.1	1.0	11130	-0.9	1.0	574	-0.1	1.0	5376	0.9	0.7	37717
835	664.40	[illegible]	[illegible]	[illegible]	830.59	62	0.692	0.993	0.087	13219	18	3.852	0.817	480827	0.9	0.6	37077	0.9	0.6	58350	0.0	1.0	2959	0.0	1.0	1568	0.1	1.0	15555	-0.3	1.0	987	0.1	1.0	7514	0.9	0.6	48348
836	794.40	[illegible]	[illegible]	835.62	831.61	63	0.692	0.994	0.079	12073	19	3.889	0.805	516701	0.9	0.6	43522	0.9	0.6	68492	0.2	1.0	3999	0.2	1.0	2119	0.3	1.0	20447	0.0	1.0	1468	0.3	1.0	9877	0.9	0.6	54402
837	805.00	[illegible]	[illegible]	836.65	832.62	64	0.692	0.995	0.071	10975	20	3.928	0.794	557734	1.0	0.5	49482	1.0	0.5	77873	0.3	1.0	5137	0.3	1.0	2723	0.4	1.0	25766	0.2	1.0	2009	0.4	1.0	12446	1.0	0.5	61853

Case No Longer Valid

Figure 15 — [illegible]culations for Case 9, Pre-Failure Condition at Tellico, Fort Loudoun Seismic Failure, Fort Loudoun Turbines Not Operating

7. Results/Conclusions

For convenience, the headwater rating results, separate from the calculation details provided above, are tabulated as headwater elevation (HW) in feet vs. total discharge (Q_{TEL}) in cfs and tailwater elevation (TW) in feet in Figures 16, 21 and 26. The total discharge for both Tellico Dam and Fort Loudoun Dam, combined, are also given (Q_{TOT}). The initial dam rating curves for cases 1 and 1A are plotted in Figure 17. The initial dam rating curves for cases 2 and 2A are plotted in Figure 18. The initial dam rating curve for case 3 is plotted in Figure 19. The initial dam rating curve for case 4 is plotted in Figure 20. The initial dam rating curve for case 5 is plotted in Figure 22. The for case 6 is plotted in Figure 23. The initial dam rating curve for case 7 is plotted in Figure 24. The initial dam rating curve for case 8 is plotted in Figure 25. The initial dam rating curve for case 9 is plotted in Figure 27. Initial dam rating curves which consider the interaction between Tellico Dam and Fort Loudoun Dam for all cases are included as figures 28 and 29.

The initial dam rating curves developed in this calculation provide Tellico 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 Tellico Dam spillway gates must all be fully raised and the interaction between Tellico Dam and Fort Loudoun Dam must be accounted for.

Rating curve Cases 1 and 7 have been updated. Rating curve Cases 1A, 2, 2A, 3, 4, 5, 6, 8, and 9 are no longer valid because the embankments have been raised and these rating curves were not modified to reflect the raised embankment elevations.

Case 1 (pre-failure) curves are used for both rising and falling headwaters until the earthen embankment and saddle dams are judged to fail, sometime after the headwater rises above its overflow elevation of 834 feet. Case 1 includes Fort Loudoun turbine flow, and considers Fort Loudoun spillway gates to be fully open.

~~Case 1A is the same as Case 1 except Fort Loudoun turbine flow is not included.~~

~~The Case 2 and 2A (pre-failure) curve is used for both rising and falling headwaters until the earthen embankment and saddle dams are judged to fail, sometime after the headwater rises above its overflow elevation of 830 feet. Case 2 considers Fort Loudoun turbine flow and Case 2A does not. Both Cases 2 and 2A consider Fort Loudoun spillway gates to be closed.~~

~~The Case 3 (pre-failure) curve is used for rising and falling headwaters until the earthen embankment and saddle dams are judged to fail, sometime after the headwater rises above its overflow elevation of 830 feet. Case 3 considers the Fort Loudoun spillway gates to be fully open. In addition, the south embankment at Fort Loudoun Dam is considered to have failed.~~

~~The Case 4 (pre-failure) curve is used for rising and falling headwaters until the earthen embankment and saddle dams are judged to fail, sometime after the headwater rises above its overflow elevation of 830 feet. Case 4 considers the Fort Loudoun spillway gates to be closed. In addition, the south embankment at Fort Loudoun Dam is considered to have failed.~~

~~The Case 5 (embankment failure) curve is used for rising and falling headwaters. Case 5 considers the Fort Loudoun spillway gates to be fully open. In addition, the south embankment at Fort Loudoun Dam is considered to have failed.~~

~~The Case 6 (embankment failure) curve is used for rising and falling headwaters. Case 6 considers the Fort Loudoun spillway gates to be closed. In addition, the south embankment at Fort Loudoun Dam is considered to have failed.~~

The Case 7 (embankment failure) curve is used for rising and falling headwaters. Case 7 considers the Fort Loudoun spillway gates to be open. In addition, no failure is considered at Fort Loudoun Dam.

~~The Case 8 (embankment failure) curve is used for rising and falling headwaters. Case 8 considers the Fort Loudoun spillway gates to be closed. In addition, no failure is considered at Fort Loudoun Dam.~~

~~The Case 9 (pre-failure) curve is used for rising and falling headwaters until the earthen embankment and saddle dams are judged to fail, sometime after the headwater rises above its overflow elevation of 830 feet. Case 9 considers the Fort Loudoun Dam has seismically failed.~~

The final two curves combine the Tellico and Fort Loudoun Dam Rating Curves.

Cases 1, 1A, 2, 2A, 3 and 4
Pre-Failure at Tellico

		No Failure at Fort Loudoun			~~No Failure at Fort Loudoun~~						~~Embankment Failure at Fort Loudoun~~					
		Fort Loudoun Gates Fully Open			~~Fort Loudoun Gates Closed~~						~~Fort Loudoun Gates Open~~			~~Fort Loudoun Gates Closed~~		
		Rising Headwater			~~Falling Headwater~~			~~Rising Headwater~~			~~Falling Headwater~~			~~Rising and Falling Headwater~~		
HW_1 (ft)	~~HW_{1A-4} (ft)~~	TW (ft)	Q_{Tot} (cfs)	Q_{tot} (cfs)	~~TW (ft)~~	~~Q_{Tot} (cfs)~~	~~Q_{tot} (cfs)~~	~~TW (ft)~~	~~Q_{Tot} (cfs)~~	~~Q_{tot} (cfs)~~	~~TW (ft)~~	~~Q_{Tot} (cfs)~~	~~Q_{tot} (cfs)~~	~~TW (ft)~~	~~Q_{Tot} (cfs)~~	~~Q_{tot} (cfs)~~
773	~~773~~	747.65	0.00	20.55	~~735.00~~	~~0.00~~	~~0.00~~	~~735.00~~	~~0.00~~	~~0.00~~	~~735.00~~	~~0.00~~	~~0.00~~	~~769.88~~	~~0.00~~	~~220.86~~	~~769.88~~	~~0.00~~	~~220.86~~
775	~~775~~	748.02	1.06	23.50	~~742.96~~	~~1.06~~	~~1.06~~	~~746.43~~	~~1.06~~	~~25.23~~	~~742.96~~	~~1.06~~	~~1.06~~	~~772.48~~	~~1.06~~	~~247.33~~	~~772.48~~	~~1.06~~	~~247.33~~
777	~~777~~	748.46	3.01	27.15	~~743.24~~	~~3.01~~	~~3.01~~	~~746.82~~	~~3.01~~	~~28.72~~	~~743.24~~	~~3.01~~	~~3.01~~	~~774.93~~	~~2.95~~	~~273.24~~	~~774.93~~	~~2.95~~	~~273.24~~
779	~~779~~	748.97	5.58	31.25	~~743.62~~	~~5.58~~	~~5.58~~	~~747.48~~	~~5.58~~	~~32.68~~	~~743.62~~	~~5.58~~	~~5.58~~	~~777.20~~	~~5.08~~	~~298.48~~	~~777.20~~	~~5.08~~	~~298.48~~
781	~~781~~	749.51	8.70	35.77	~~744.07~~	~~8.70~~	~~8.70~~	~~748.08~~	~~8.70~~	~~37.05~~	~~744.07~~	~~8.70~~	~~8.70~~	~~779.39~~	~~7.33~~	~~323.82~~	~~779.39~~	~~7.33~~	~~323.82~~
783	~~783~~	750.10	12.32	40.65	~~744.59~~	~~12.32~~	~~12.32~~	~~748.74~~	~~12.32~~	~~41.80~~	~~744.59~~	~~12.32~~	~~12.32~~	~~781.52~~	~~9.68~~	~~349.58~~	~~781.52~~	~~9.68~~	~~349.58~~
785	~~785~~	751.28	16.42	50.51	~~745.90~~	~~16.42~~	~~21.48~~	~~749.44~~	~~16.42~~	~~46.01~~	~~745.18~~	~~16.42~~	~~16.42~~	~~783.66~~	~~12.04~~	~~376.55~~	~~783.62~~	~~12.13~~	~~376.04~~
787	~~787~~	752.97	20.99	64.96	~~747.89~~	~~20.99~~	~~35.67~~	~~750.18~~	~~20.99~~	~~52.39~~	~~745.83~~	~~20.99~~	~~20.99~~	~~785.79~~	~~14.41~~	~~404.73~~	~~785.69~~	~~14.71~~	~~403.40~~
789	~~789~~	755.01	26.01	82.83	~~750.34~~	~~26.01~~	~~53.58~~	~~750.96~~	~~26.01~~	~~58.21~~	~~746.54~~	~~26.01~~	~~26.01~~	~~787.90~~	~~16.79~~	~~433.98~~	~~787.74~~	~~17.39~~	~~431.81~~
791	~~791~~	757.33	31.46	103.68	~~753.12~~	~~31.46~~	~~74.69~~	~~751.68~~	~~31.46~~	~~63.66~~	~~747.31~~	~~31.46~~	~~31.46~~	~~789.98~~	~~19.25~~	~~464.28~~	~~789.78~~	~~20.20~~	~~461.39~~
793	~~793~~	759.86	37.31	127.22	~~756.17~~	~~37.31~~	~~98.68~~	~~752.45~~	~~37.31~~	~~69.51~~	~~748.12~~	~~37.31~~	~~37.31~~	~~792.04~~	~~21.78~~	~~495.85~~	~~791.81~~	~~23.12~~	~~492.27~~
795	~~795~~	762.55	43.54	153.24	~~759.40~~	~~43.54~~	~~125.30~~	~~753.26~~	~~43.54~~	~~75.74~~	~~748.98~~	~~43.54~~	~~43.54~~	~~794.09~~	~~24.36~~	~~528.82~~	~~793.83~~	~~26.16~~	~~524.50~~
797	~~797~~	765.36	50.13	181.58	~~762.77~~	~~50.13~~	~~154.38~~	~~754.11~~	~~50.13~~	~~82.33~~	~~749.87~~	~~50.13~~	~~50.13~~	~~796.13~~	~~27.00~~	~~563.34~~	~~795.84~~	~~29.33~~	~~558.25~~
799	~~799~~	768.27	57.05	212.12	~~766.23~~	~~57.05~~	~~185.76~~	~~754.98~~	~~57.05~~	~~89.25~~	~~750.80~~	~~57.05~~	~~57.05~~	~~798.15~~	~~29.87~~	~~599.22~~	~~797.84~~	~~32.60~~	~~593.63~~
801	~~801~~	771.23	64.25	244.77	~~769.72~~	~~64.25~~	~~219.36~~	~~755.89~~	~~64.25~~	~~96.45~~	~~751.76~~	~~64.25~~	~~64.25~~	~~800.16~~	~~32.83~~	~~636.82~~	~~799.84~~	~~35.98~~	~~630.75~~
803	~~803~~	774.22	71.72	279.49	~~773.23~~	~~71.72~~	~~255.09~~	~~756.82~~	~~71.72~~	~~103.82~~	~~752.73~~	~~71.72~~	~~71.72~~	~~802.16~~	~~35.88~~	~~676.32~~	~~801.83~~	~~39.46~~	~~669.67~~
805	~~805~~	777.23	79.40	316.22	~~776.71~~	~~79.40~~	~~292.91~~	~~757.76~~	~~79.41~~	~~111.61~~	~~753.73~~	~~79.41~~	~~79.41~~	~~804.16~~	~~38.99~~	~~717.75~~	~~803.82~~	~~43.05~~	~~710.46~~
807	~~807~~	780.23	87.23	354.92	~~780.14~~	~~87.23~~	~~332.72~~	~~758.71~~	~~87.31~~	~~119.51~~	~~754.74~~	~~87.31~~	~~87.31~~	~~806.16~~	~~42.17~~	~~761.14~~	~~805.80~~	~~46.74~~	~~753.15~~
809	~~809~~	783.20	95.13	395.56	~~783.49~~	~~95.10~~	~~374.45~~	~~759.68~~	~~95.40~~	~~127.60~~	~~755.76~~	~~95.40~~	~~95.40~~	~~808.15~~	~~45.41~~	~~806.47~~	~~807.78~~	~~50.53~~	~~797.71~~
811	~~811~~	786.14	103.04	438.09	~~786.76~~	~~102.93~~	~~418.02~~	~~760.65~~	~~103.66~~	~~135.86~~	~~756.78~~	~~103.66~~	~~103.66~~	~~810.16~~	~~48.73~~	~~853.70~~	~~809.76~~	~~54.41~~	~~844.10~~
813	~~813~~	789.03	110.94	482.51	~~789.93~~	~~110.68~~	~~463.39~~	~~761.62~~	~~112.09~~	~~144.29~~	~~757.82~~	~~112.09~~	~~112.09~~	~~812.13~~	~~52.10~~	~~902.66~~	~~811.72~~	~~58.40~~	~~892.18~~
815	~~815~~	791.86	118.80	528.82	~~792.97~~	~~118.34~~	~~510.55~~	~~762.61~~	~~120.70~~	~~152.90~~	~~758.86~~	~~120.70~~	~~120.70~~	~~814.12~~	~~55.59~~	~~953.08~~	~~813.68~~	~~62.51~~	~~941.78~~
815.80	~~815.796~~	792.97	121.92	547.76	~~794.05~~	~~121.42~~	~~528.42~~	~~763.09~~	~~124.19~~	~~157.38~~	~~759.36~~	~~124.19~~	~~124.09~~	~~814.88~~	~~57.60~~	~~972.60~~	~~814.40~~	~~64.93~~	~~959.83~~
816	~~816~~	793.15	120.88	550.96	~~794.33~~	~~120.07~~	~~532.73~~	~~763.21~~	~~124.01~~	~~158.17~~	~~759.49~~	~~124.01~~	~~125.97~~	~~815.07~~	~~34.98~~	~~977.78~~	~~814.59~~	~~40.33~~	~~965.13~~
817	~~817~~	794.30	120.38	571.15	~~795.54~~	~~119.50~~	~~553.05~~	~~763.60~~	~~123.94~~	~~161.68~~	~~759.90~~	~~123.94~~	~~139.48~~	~~816.07~~	~~33.86~~	~~1003.81~~	~~815.58~~	~~39.63~~	~~991.08~~
818	~~818~~	795.73	125.41	596.95	~~797.02~~	~~123.99~~	~~578.74~~	~~764.75~~	~~129.68~~	~~172.06~~	~~761.12~~	~~129.68~~	~~139.86~~	~~817.07~~	~~38.72~~	~~1030.35~~	~~816.60~~	~~44.60~~	~~1017.96~~
819	~~819~~	797.37	135.20	627.65	~~798.74~~	~~133.52~~	~~609.92~~	~~766.54~~	~~140.72~~	~~188.64~~	~~763.01~~	~~140.72~~	~~156.44~~	~~818.08~~	~~48.78~~	~~1057.36~~	~~817.64~~	~~54.67~~	~~1045.65~~
820	~~820~~	799.23	150.12	663.80	~~800.67~~	~~148.22~~	~~646.70~~	~~768.95~~	~~157.24~~	~~211.65~~	~~765.56~~	~~157.24~~	~~179.45~~	~~819.10~~	~~63.13~~	~~1084.75~~	~~818.69~~	~~68.94~~	~~1073.79~~
821	~~821~~	800.28	169.55	684.72	~~802.27~~	~~166.97~~	~~678.44~~	~~771.09~~	~~177.35~~	~~232.94~~	~~767.82~~	~~177.35~~	~~200.74~~	~~820.02~~	~~82.38~~	~~1109.69~~	~~819.70~~	~~86.91~~	~~1101.06~~
822	~~822~~	801.33	192.73	706.34	~~803.29~~	~~190.12~~	~~699.42~~	~~773.69~~	~~201.33~~	~~259.85~~	~~770.57~~	~~201.33~~	~~227.75~~	~~821.04~~	~~103.65~~	~~1137.17~~	~~820.74~~	~~107.70~~	~~1129.19~~
823	~~823~~	802.53	218.74	731.52	~~804.43~~	~~215.69~~	~~723.45~~	~~773.75~~	~~228.25~~	~~260.58~~	~~773.75~~	~~228.25~~	~~260.58~~	~~822.06~~	~~126.86~~	~~1164.87~~	~~821.79~~	~~130.78~~	~~1157.70~~
824	~~824~~	803.81	247.01	759.17	~~805.66~~	~~243.44~~	~~750.13~~	~~777.21~~	~~257.01~~	~~298.59~~	~~777.21~~	~~257.01~~	~~298.59~~	~~823.08~~	~~152.05~~	~~1192.75~~	~~822.85~~	~~155.56~~	~~1186.50~~
825	~~825~~	805.13	277.21	788.39	~~806.95~~	~~273.29~~	~~778.89~~	~~780.80~~	~~290.19~~	~~340.77~~	~~780.80~~	~~290.19~~	~~340.77~~	~~824.11~~	~~178.62~~	~~1220.73~~	~~823.91~~	~~181.93~~	~~1216.40~~
826	~~826~~	806.93	308.64	829.47	~~808.69~~	~~303.83~~	~~818.93~~	~~784.43~~	~~324.84~~	~~386.59~~	~~784.43~~	~~324.84~~	~~386.59~~	~~825.14~~	~~206.30~~	~~1248.86~~	~~824.97~~	~~209.86~~	~~1244.00~~
827	~~827~~	808.87	341.15	875.26	~~810.49~~	~~335.95~~	~~862.14~~	~~788.29~~	~~361.54~~	~~439.55~~	~~788.29~~	~~361.54~~	~~439.55~~	~~826.18~~	~~235.11~~	~~1277.00~~	~~826.02~~	~~239.09~~	~~1272.58~~
828	~~828~~	810.69	375.82	919.67	~~812.25~~	~~370.38~~	~~905.56~~	~~791.86~~	~~400.46~~	~~493.03~~	~~791.86~~	~~400.46~~	~~493.03~~	~~827.22~~	~~264.91~~	~~1305.11~~	~~827.07~~	~~269.03~~	~~1301.11~~
829	~~829~~	812.50	412.64	965.12	~~813.91~~	~~407.42~~	~~947.65~~	~~795.34~~	~~441.39~~	~~549.70~~	~~795.34~~	~~441.39~~	~~549.70~~	~~828.26~~	~~297.84~~	~~1333.18~~	~~828.13~~	~~302.22~~	~~1329.66~~
830	~~830~~	814.23	451.56	1009.73	~~815.59~~	~~446.58~~	~~991.23~~	~~798.66~~	~~483.54~~	~~608.64~~	~~798.66~~	~~483.54~~	~~608.64~~	~~829.28~~	~~329.53~~	~~1360.74~~	~~829.18~~	~~333.29~~	~~1357.08~~
830.57	~~831~~	815.51	474.20	1043.06	~~817.80~~	~~508.17~~	~~1049.59~~	~~802.90~~	~~548.26~~	~~691.25~~	~~802.90~~	~~548.26~~	~~691.25~~	~~830.33~~	~~384.22~~	~~1388.78~~	~~830.26~~	~~386.89~~	~~1386.86~~
831.14	~~832~~	816.87	497.58	1079.05	~~820.35~~	~~589.26~~	~~1118.47~~	~~807.67~~	~~631.12~~	~~792.98~~	~~807.67~~	~~631.12~~	~~792.98~~	~~831.39~~	~~456.39~~	~~1417.13~~	~~831.33~~	~~459.47~~	~~1416.67~~
831.71	~~833~~	818.24	521.74	1115.76	~~822.94~~	~~682.62~~	~~1189.00~~	~~812.26~~	~~724.08~~	~~905.73~~	~~812.26~~	~~724.08~~	~~905.73~~	~~832.44~~	~~531.20~~	~~1445.16~~	~~832.40~~	~~534.41~~	~~1444.14~~
832.29	~~834~~	819.59	546.93	1152.28	~~825.66~~	~~781.77~~	~~1262.97~~	~~817.14~~	~~825.76~~	~~1032.32~~	~~817.14~~	~~825.76~~	~~1032.32~~	~~833.49~~	~~604.97~~	~~1473.01~~	~~833.46~~	~~608.84~~	~~1472.28~~
832.86	~~835~~	820.92	572.16	1188.51	~~828.62~~	~~882.64~~	~~1342.96~~	~~822.26~~	~~936.08~~	~~1170.41~~	~~822.26~~	~~936.08~~	~~1170.41~~	~~834.54~~	~~676.27~~	~~1500.74~~	~~834.52~~	~~680.62~~	~~1500.22~~
833.43	~~836~~	822.22	596.79	1223.88	~~831.57~~	~~983.89~~	~~1421.86~~	~~827.31~~	~~1037.98~~	~~1307.49~~	~~827.31~~	~~1037.98~~	~~1307.49~~	~~835.58~~	~~745.33~~	~~1528.35~~	~~835.57~~	~~749.78~~	~~1527.94~~
834	~~837~~	823.51	621.10	1259.23	~~834.26~~	~~1088.43~~	~~1493.51~~	~~832.00~~	~~1129.86~~	~~1433.33~~	~~832.00~~	~~1129.86~~	~~1433.33~~	~~836.62~~	~~815.53~~	~~1555.95~~	~~836.61~~	~~819.05~~	~~1555.63~~

Figure 16 –Initial Dam Rating Results for Cases 1, 1A, 2, 2A, 3 and 4
Cases 1A, 2, 2A, 3, and 4 are no longer valid

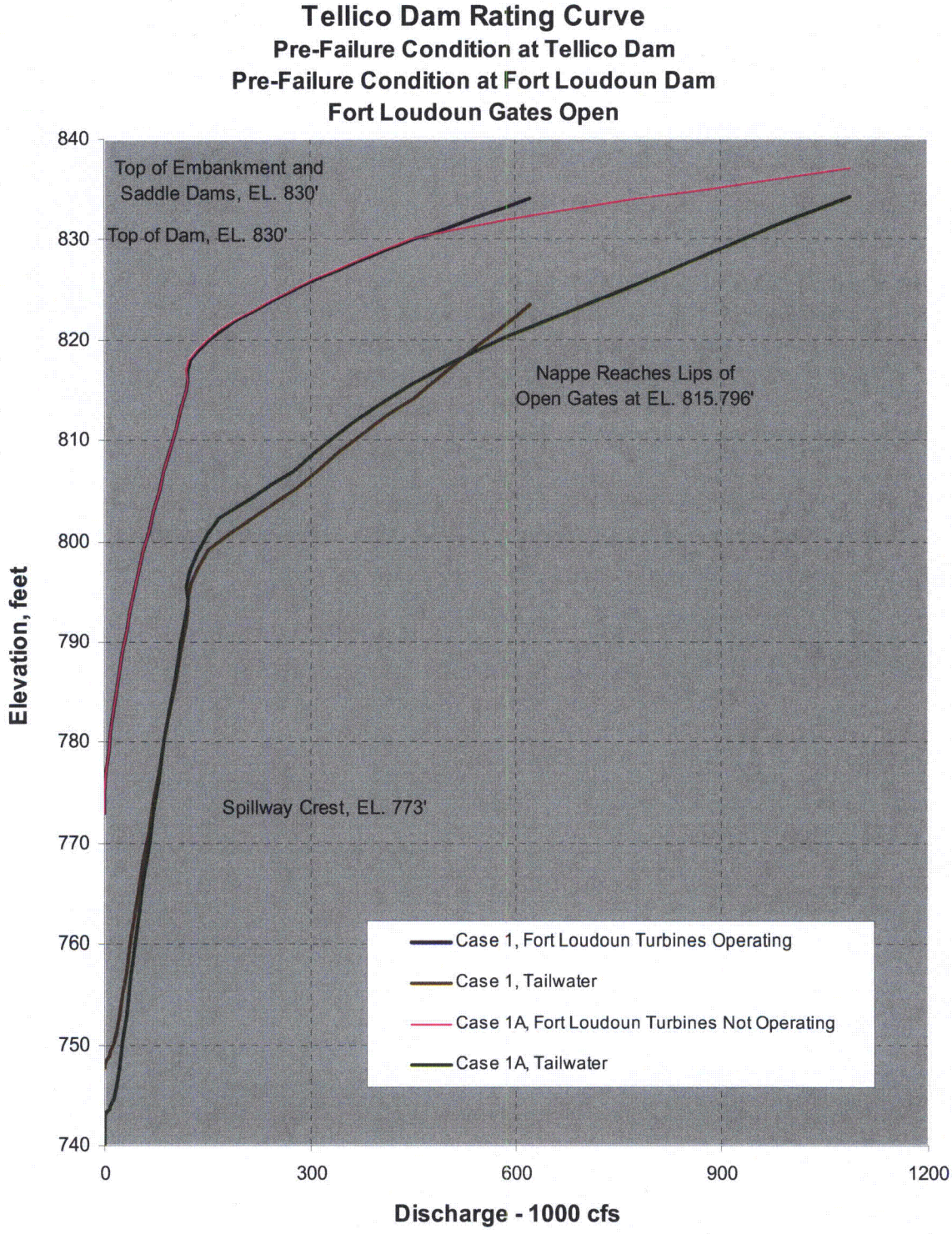
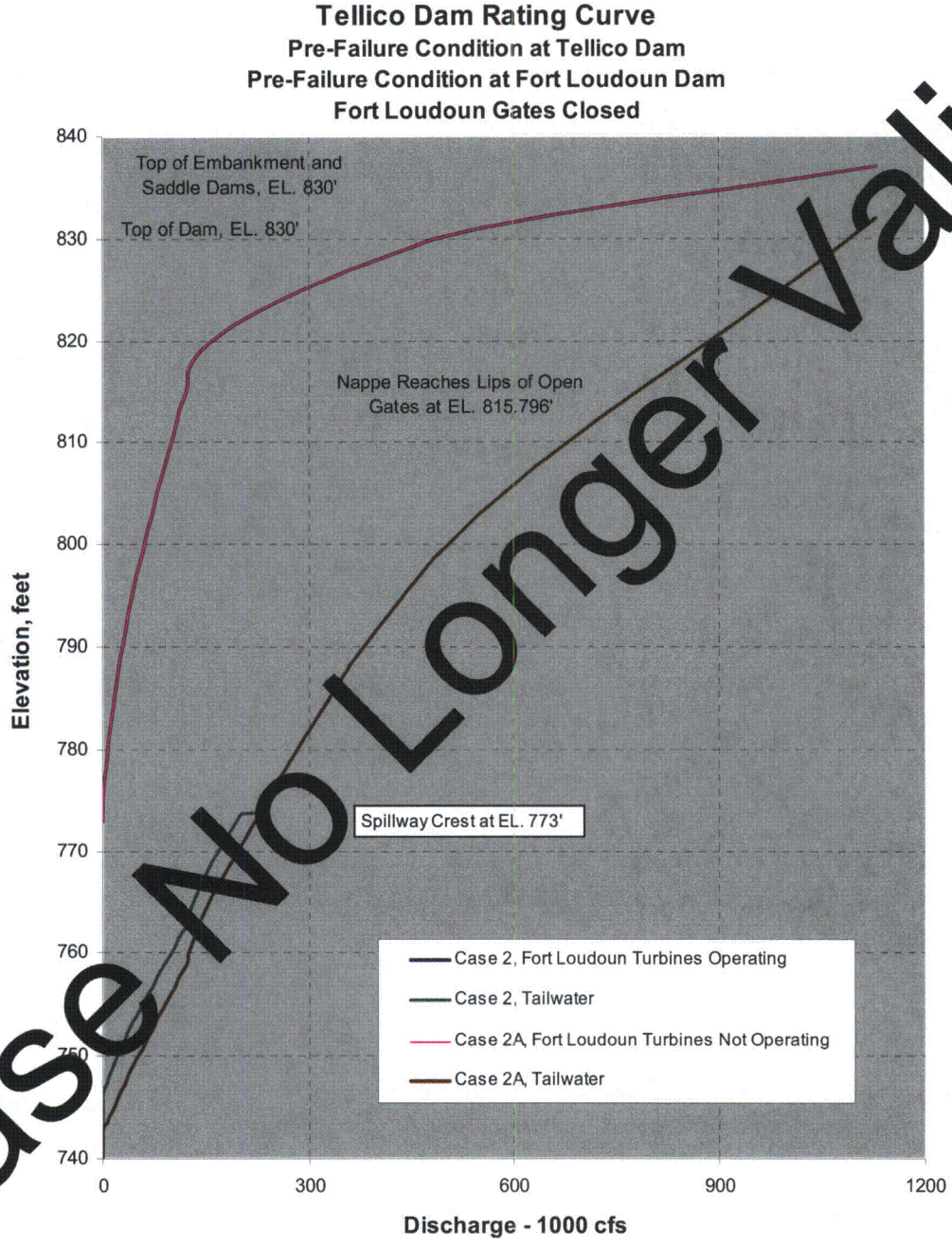
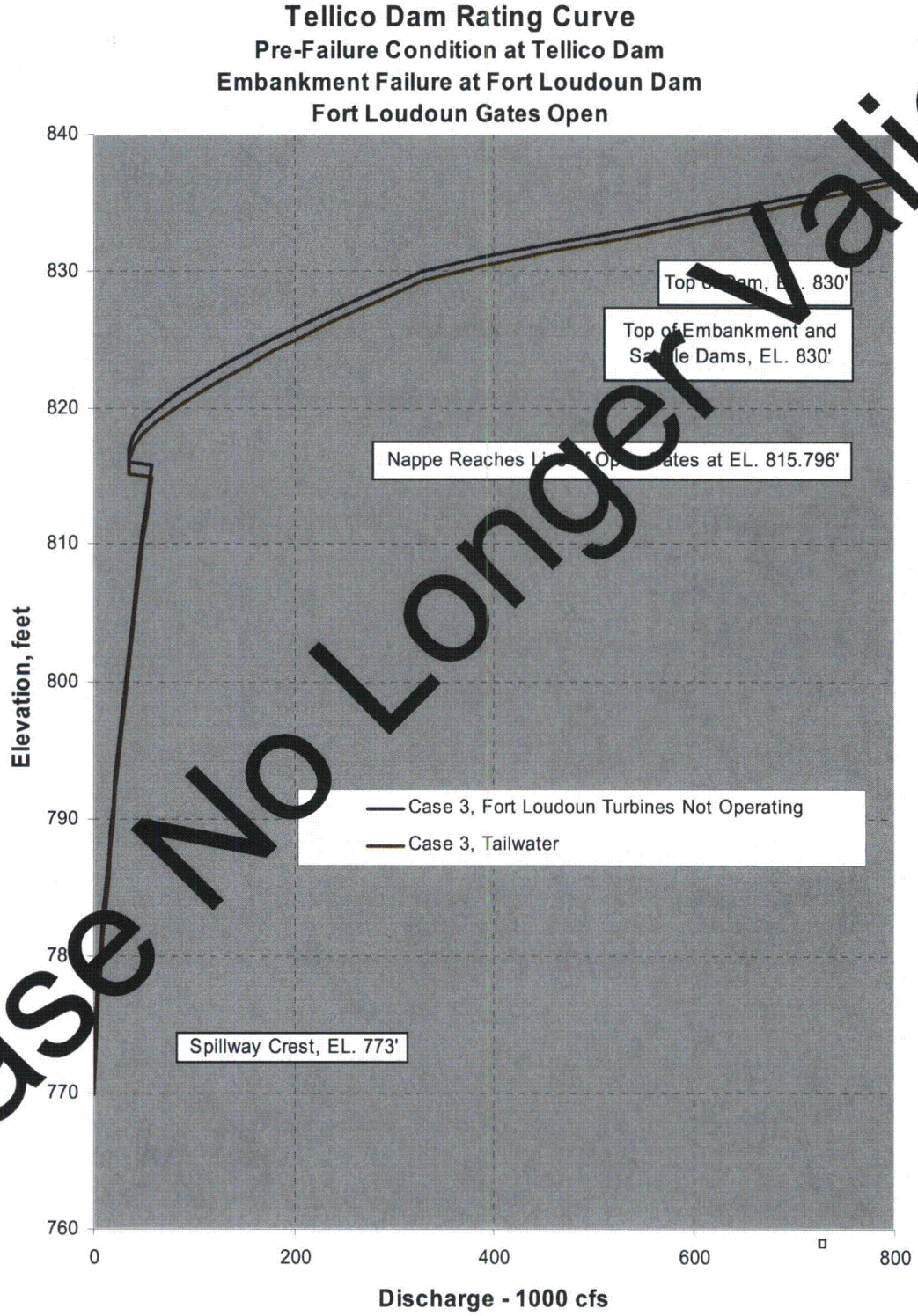


Figure 17 – Initial Dam Rating curves for Cases 1 and 1A
Case 1A is no longer valid



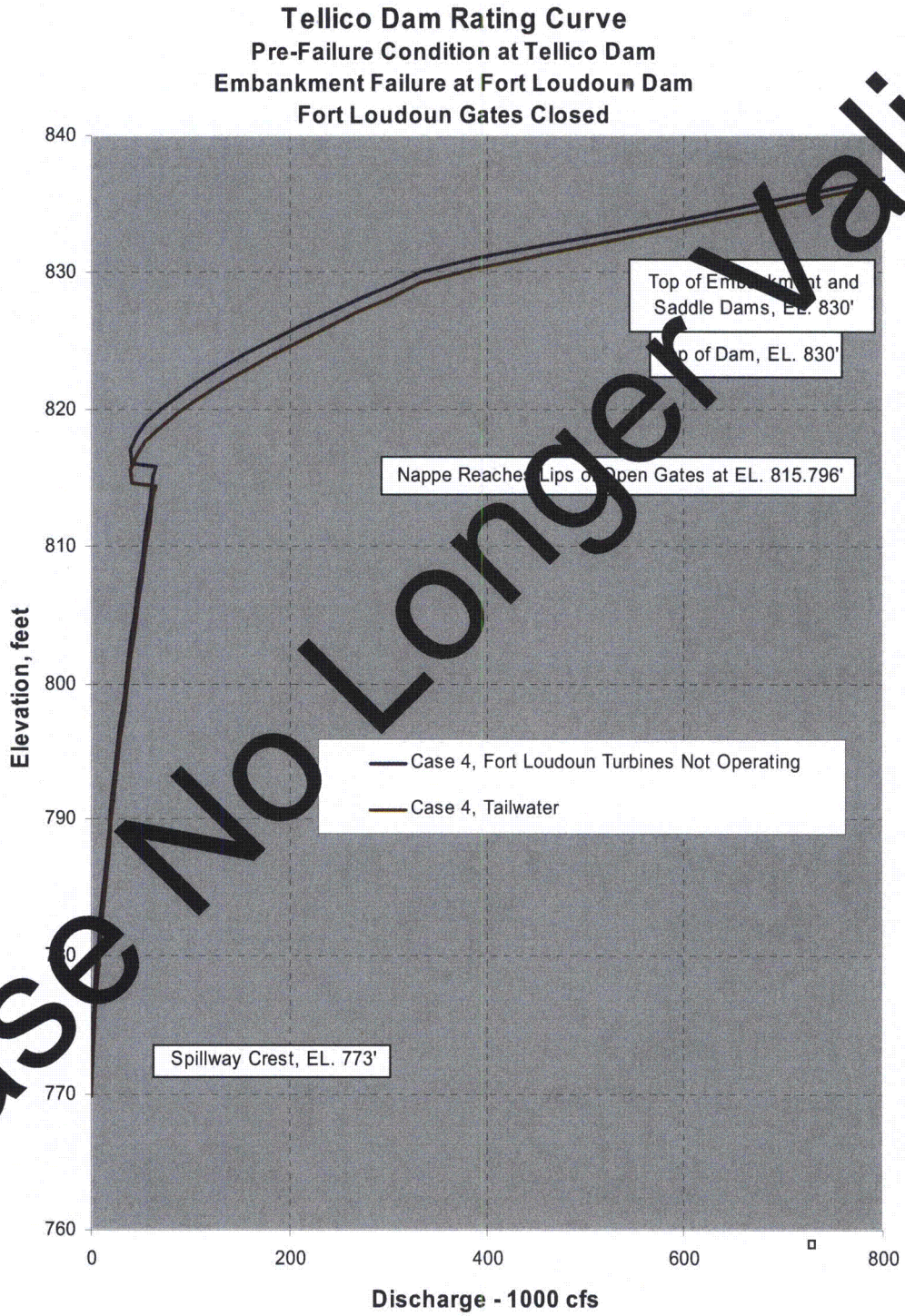
Case No Longer Valid

Figure 18 –Initial Dam Rating Curves for Cases 2 and 2A



Case No Longer Valid

Figure 19 – Initial Dam Rating Curve for Case 3



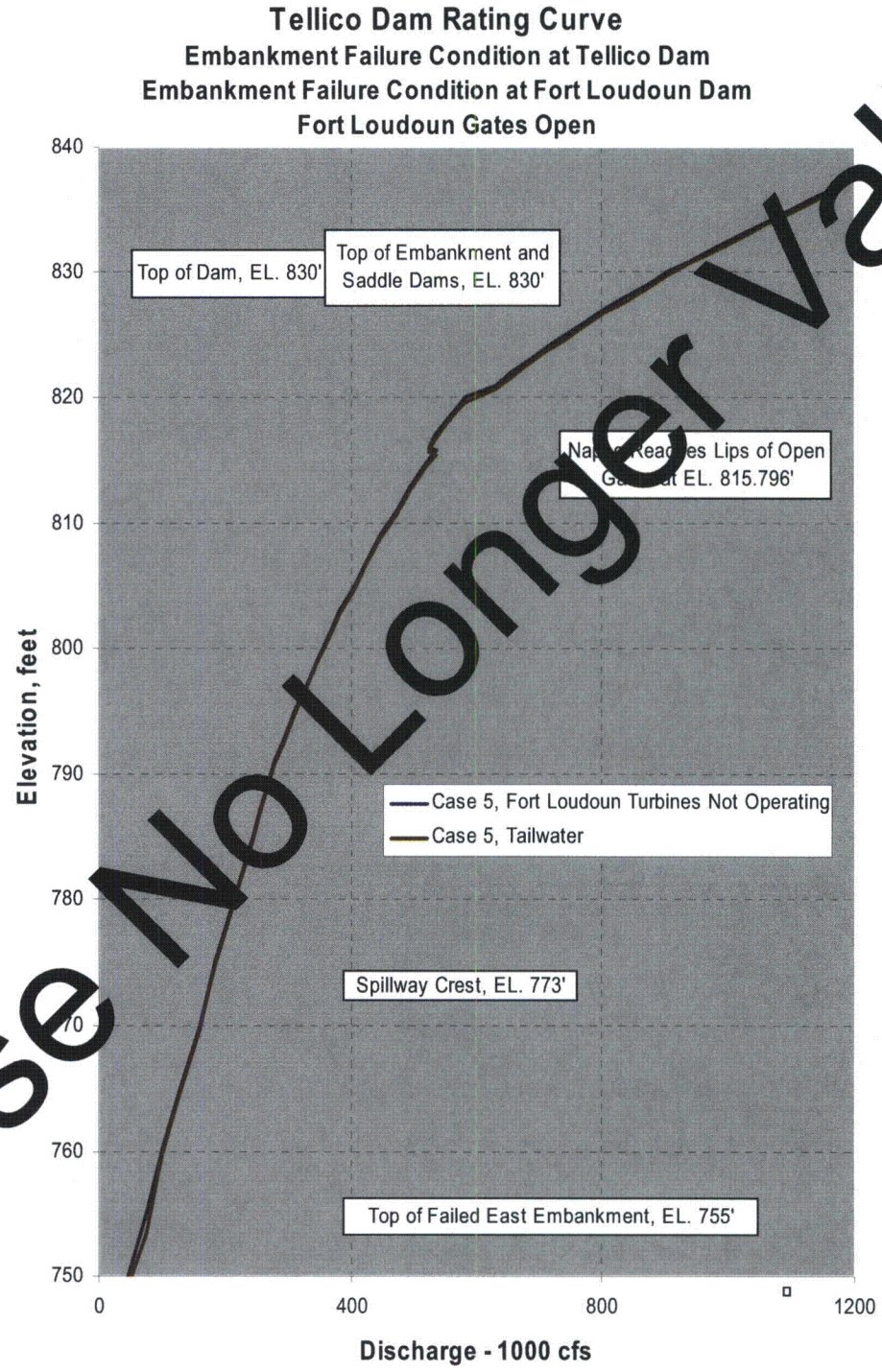
Case No Longer Valid

Figure 20 – –Initial Dam Rating Curve for Case 4

Cases 5, 6, 7 and 8
Embankment Failure at Tellico

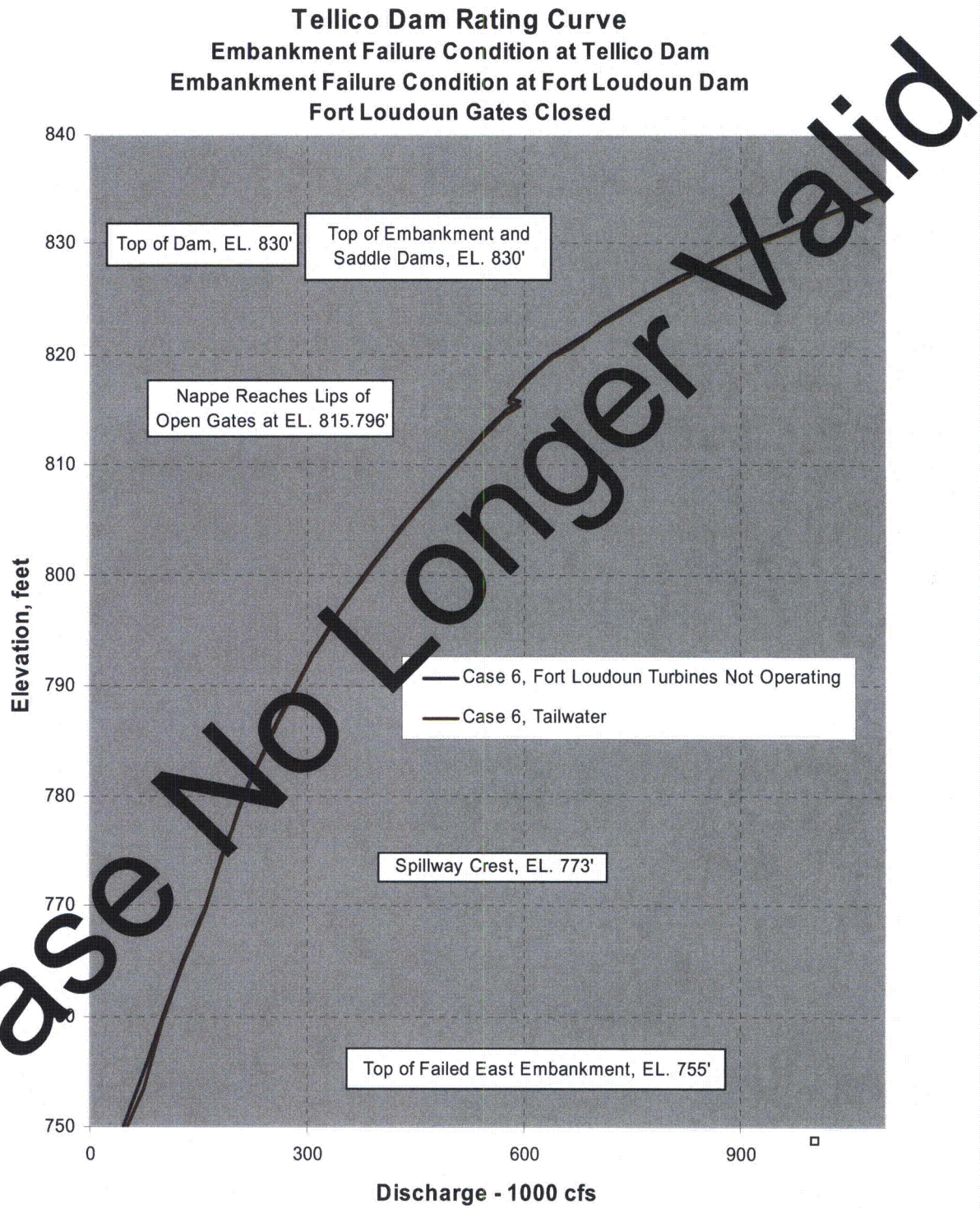
		~~Embankment Failure at Fort Loudoun~~						No Failure at Fort Loudoun					
		~~Fort Loudoun Gates Open~~			~~Fort Loudoun Gates Closed~~			Fort Loudoun Gates Open			~~Fort Loudoun Gates Closed~~		
		~~Rising and Falling Headwater~~						Rising and Falling Headwater					
HW_7 (ft)	~~$HW_{5,6,8}$ (ft)~~	~~TW (ft)~~	~~Q_{Tel} (cfs)~~	~~Q_{tot} (cfs)~~	~~TW (ft)~~	~~Q_{Tel} (cfs)~~	~~Q_{tot} (cfs)~~	TW (ft)	Q_{Tel} (cfs)	Q_{tot} (cfs)	~~TW (ft)~~	~~Q_{Tel} (cfs)~~	~~Q_{tot} (cfs)~~
750	~~750~~	~~749.26~~	~~45.65~~	~~45.65~~	~~749.26~~	~~45.65~~	~~45.65~~	749.56	36.15	36.15	~~749.26~~	~~45.65~~	~~45.65~~
755	~~755~~	~~753.45~~	~~74.22~~	~~77.21~~	~~753.45~~	~~74.22~~	~~77.21~~	753.62	70.57	70.57	~~753.34~~	~~76.39~~	~~76.39~~
760	~~760~~	~~759.52~~	~~99.04~~	~~126.34~~	~~759.52~~	~~99.04~~	~~126.34~~	759.25	121.54	121.54	~~759.22~~	~~123.76~~	~~123.76~~
765	~~765~~	~~764.69~~	~~127.83~~	~~171.59~~	~~764.69~~	~~127.83~~	~~171.59~~	764.42	171.99	171.99	~~764.44~~	~~169.28~~	~~169.28~~
770	~~770~~	~~769.74~~	~~160.26~~	~~219.73~~	~~769.74~~	~~160.26~~	~~219.73~~	769.50	225.48	225.48	~~769.54~~	~~217.39~~	~~217.39~~
773	~~773~~	~~772.77~~	~~173.65~~	~~250.26~~	~~772.77~~	~~173.65~~	~~250.26~~	772.51	259.47	259.47	~~772.56~~	~~248.19~~	~~248.19~~
775	~~775~~	~~774.79~~	~~183.66~~	~~271.86~~	~~774.79~~	~~183.66~~	~~271.86~~	774.52	283.08	283.08	~~774.57~~	~~269.56~~	~~269.56~~
777	~~777~~	~~776.79~~	~~195.50~~	~~294.19~~	~~776.79~~	~~195.50~~	~~294.19~~	776.53	307.55	307.55	~~776.58~~	~~291.64~~	~~291.64~~
779	~~779~~	~~778.79~~	~~206.62~~	~~316.97~~	~~778.79~~	~~206.62~~	~~316.97~~	778.54	332.82	332.82	~~778.58~~	~~314.17~~	~~314.17~~
781	~~781~~	~~780.79~~	~~218.60~~	~~340.86~~	~~780.79~~	~~218.60~~	~~340.86~~	780.53	358.96	358.96	~~780.58~~	~~338.10~~	~~338.10~~
783	~~783~~	~~782.79~~	~~231.52~~	~~365.50~~	~~782.79~~	~~231.52~~	~~365.50~~	782.53	386.10	386.10	~~782.58~~	~~362.58~~	~~362.58~~
785	~~785~~	~~784.79~~	~~242.80~~	~~391.53~~	~~784.79~~	~~245.49~~	~~391.67~~	784.53	409.40	414.46	~~784.57~~	~~388.56~~	~~388.56~~
787	~~787~~	~~786.79~~	~~254.12~~	~~418.58~~	~~786.79~~	~~259.66~~	~~418.58~~	786.54	429.42	444.10	~~786.57~~	~~415.63~~	~~415.63~~
789	~~789~~	~~788.79~~	~~266.43~~	~~447.24~~	~~788.79~~	~~274.99~~	~~447.21~~	788.55	447.50	475.07	~~788.56~~	~~443.31~~	~~443.31~~
791	~~791~~	~~790.79~~	~~278.84~~	~~476.31~~	~~790.78~~	~~290.58~~	~~476.69~~	790.57	464.20	507.43	~~790.55~~	~~473.15~~	~~473.15~~
793	~~793~~	~~792.79~~	~~294.37~~	~~507.88~~	~~792.78~~	~~307.43~~	~~507.32~~	792.59	479.89	541.26	~~792.55~~	~~503.65~~	~~503.65~~
795	~~795~~	~~794.79~~	~~310.15~~	~~540.40~~	~~794.77~~	~~326.63~~	~~540.26~~	794.61	494.80	576.56	~~794.54~~	~~535.90~~	~~535.90~~
797	~~797~~	~~796.78~~	~~327.23~~	~~574.95~~	~~796.77~~	~~346.22~~	~~574.25~~	796.61	509.00	613.24	~~796.52~~	~~569.94~~	~~569.94~~
799	~~799~~	~~798.78~~	~~345.67~~	~~611.18~~	~~798.76~~	~~367.26~~	~~610.40~~	798.61	522.87	651.59	~~798.51~~	~~605.84~~	~~605.84~~
801	~~801~~	~~800.77~~	~~364.24~~	~~649.06~~	~~800.75~~	~~389.80~~	~~648.81~~	800.62	536.53	691.64	~~800.50~~	~~643.06~~	~~643.06~~
803	~~803~~	~~802.77~~	~~382.66~~	~~687.83~~	~~802.74~~	~~412.78~~	~~688.45~~	802.62	550.08	733.46	~~802.48~~	~~682.82~~	~~682.82~~
805	~~805~~	~~804.76~~	~~404.56~~	~~731.04~~	~~804.73~~	~~437.33~~	~~730.50~~	804.62	563.56	777.07	~~804.46~~	~~723.96~~	~~723.96~~
807	~~807~~	~~806.75~~	~~425.20~~	~~774.00~~	~~806.73~~	~~462.33~~	~~773.84~~	806.63	576.97	822.46	~~806.44~~	~~767.14~~	~~767.14~~
809	~~809~~	~~808.74~~	~~447.82~~	~~819.92~~	~~808.72~~	~~488.96~~	~~819.64~~	808.63	590.24	869.59	~~808.41~~	~~812.40~~	~~812.40~~
811	~~811~~	~~810.74~~	~~472.50~~	~~868.87~~	~~810.71~~	~~516.06~~	~~866.71~~	810.46	803.49	914.11	~~810.39~~	~~859.78~~	~~859.78~~
813	~~813~~	~~812.73~~	~~495.88~~	~~917.43~~	~~812.69~~	~~544.87~~	~~916.22~~	812.45	842.51	963.80	~~812.36~~	~~908.69~~	~~908.69~~
815	~~815~~	~~814.72~~	~~521.36~~	~~968.92~~	~~814.68~~	~~575.43~~	~~968.13~~	814.43	882.43	1014.81	~~814.34~~	~~958.47~~	~~958.47~~
815.796	~~815.796~~	~~815.51~~	~~535.81~~	~~988.81~~	~~815.47~~	~~594.28~~	~~988.28~~	815.22	898.53	1035.44	~~815.10~~	~~996.31~~	~~996.31~~
816	~~816~~	~~815.71~~	~~524.68~~	~~995.16~~	~~815.67~~	~~579.25~~	~~993.17~~	815.41	900.30	1040.33	~~815.29~~	~~981.88~~	~~983.84~~
817	~~817~~	~~816.7~~	~~534.52~~	~~1020.58~~	~~816.66~~	~~591.09~~	~~1019.88~~	816.40	920.36	1066.47	~~816.28~~	~~1004.27~~	~~1009.78~~
818	~~818~~	~~817.7~~	~~548.53~~	~~1047.83~~	~~817.66~~	~~605.11~~	~~1046.51~~	817.39	941.24	1092.96	~~817.28~~	~~1026.67~~	~~1036.05~~
819	~~819~~	~~818.7~~	~~564.44~~	~~1074.86~~	~~818.66~~	~~620.77~~	~~1072.68~~	818.39	962.84	1119.76	~~818.28~~	~~1049.15~~	~~1062.64~~
820	~~820~~	~~819.7~~	~~580.94~~	~~1100.93~~	~~819.67~~	~~639.32~~	~~1100.18~~	819.39	984.87	1146.81	~~819.29~~	~~1071.89~~	~~1089.72~~
821	~~821~~	~~820.69~~	~~629.11~~	~~1127.41~~	~~820.67~~	~~664.83~~	~~1127.62~~	820.35	1057.93	1172.92	~~820.29~~	~~1106.52~~	~~1116.99~~
822	~~822~~	~~821.69~~	~~655.32~~	~~1155.30~~	~~821.67~~	~~688.38~~	~~1154.99~~	821.35	1085.93	1200.20	~~821.31~~	~~1133.32~~	~~1144.30~~
823	~~823~~	~~822.69~~	~~681.46~~	~~1182.70~~	~~822.67~~	~~709.21~~	~~1181.00~~	822.36	1112.45	1227.65	~~822.33~~	~~1157.83~~	~~1172.40~~
824	~~824~~	~~823.69~~	~~710.67~~	~~1210.05~~	~~823.68~~	~~734.03~~	~~1209.13~~	823.36	1137.98	1255.22	~~823.35~~	~~1179.22~~	~~1199.75~~
825	~~825~~	~~824.7~~	~~740.46~~	~~1236.88~~	~~824.69~~	~~761.36~~	~~1236.06~~	824.37	1165.91	1282.85	~~824.37~~	~~1200.67~~	~~1227.33~~
826	~~826~~	~~825.71~~	~~770.28~~	~~1263.47~~	~~825.70~~	~~789.51~~	~~1263.76~~	825.37	1193.66	1310.49	~~825.40~~	~~1223.14~~	~~1255.75~~
827	~~827~~	~~826.72~~	~~801.73~~	~~1290.92~~	~~826.71~~	~~817.33~~	~~1290.38~~	826.38	1219.78	1338.19	~~826.42~~	~~1245.85~~	~~1284.16~~
828	~~828~~	~~827.72~~	~~836.63~~	~~1318.83~~	~~827.72~~	~~848.49~~	~~1317.97~~	827.39	1247.60	1365.85	~~827.45~~	~~1266.98~~	~~1310.97~~
829	~~829~~	~~828.73~~	~~870.70~~	~~1346.19~~	~~828.73~~	~~880.70~~	~~1345.80~~	828.40	1275.76	1393.51	~~828.48~~	~~1289.53~~	~~1338.89~~
830	~~830~~	~~829.74~~	~~904.12~~	~~1373.13~~	~~829.74~~	~~912.21~~	~~1371.92~~	829.40	1304.04	1421.14	~~829.51~~	~~1311.61~~	~~1366.12~~
830.57	~~831~~	~~830.75~~	~~942.18~~	~~1399.56~~	~~830.75~~	~~950.36~~	~~1400.61~~	830.02	1275.31	1437.86	~~830.54~~	~~1335.14~~	~~1394.31~~
831.14	~~832~~	~~831.76~~	~~981.09~~	~~1426.48~~	~~831.76~~	~~987.39~~	~~1426.57~~	830.62	1257.77	1454.30	~~831.57~~	~~1359.09~~	~~1422.45~~
831.71	~~833~~	~~832.78~~	~~1020.51~~	~~1453.44~~	~~832.77~~	~~1026.92~~	~~1454.63~~	831.22	1239.66	1470.72	~~832.60~~	~~1382.45~~	~~1449.69~~
832.29	~~834~~	~~833.79~~	~~1059.86~~	~~1479.83~~	~~833.79~~	~~1064.37~~	~~1479.79~~	831.82	1221.03	1487.13	~~833.63~~	~~1400.86~~	~~1476.97~~
832.86	~~835~~	~~834.8~~	~~1100.44~~	~~1507.73~~	~~834.80~~	~~1104.98~~	~~1508.26~~	832.42	1201.13	1503.55	~~834.66~~	~~1412.62~~	~~1504.56~~
833.43	~~836~~	~~835.81~~	~~1142.01~~	~~1535.32~~	~~835.81~~	~~1144.36~~	~~1534.14~~	833.02	1184.52	1519.89	~~835.69~~	~~1423.58~~	~~1530.59~~
834	~~837~~	~~836.82~~	~~1182.07~~	~~1560.65~~	~~836.82~~	~~1184.50~~	~~1559.99~~	833.62	1167.46	1536.10	~~836.71~~	~~1439.05~~	~~1559.07~~

Figure 21 – Initial Dam Rating Results for Cases 5, 6, 7 and 8
Cases 5, 6, and 8 are no longer valid



Case No Longer Valid

Figure 22 – Initial Dam Rating Curve for Case 5



Case No Longer Valid

Figure 23 – Initial Dam Rating Curve for Case 6

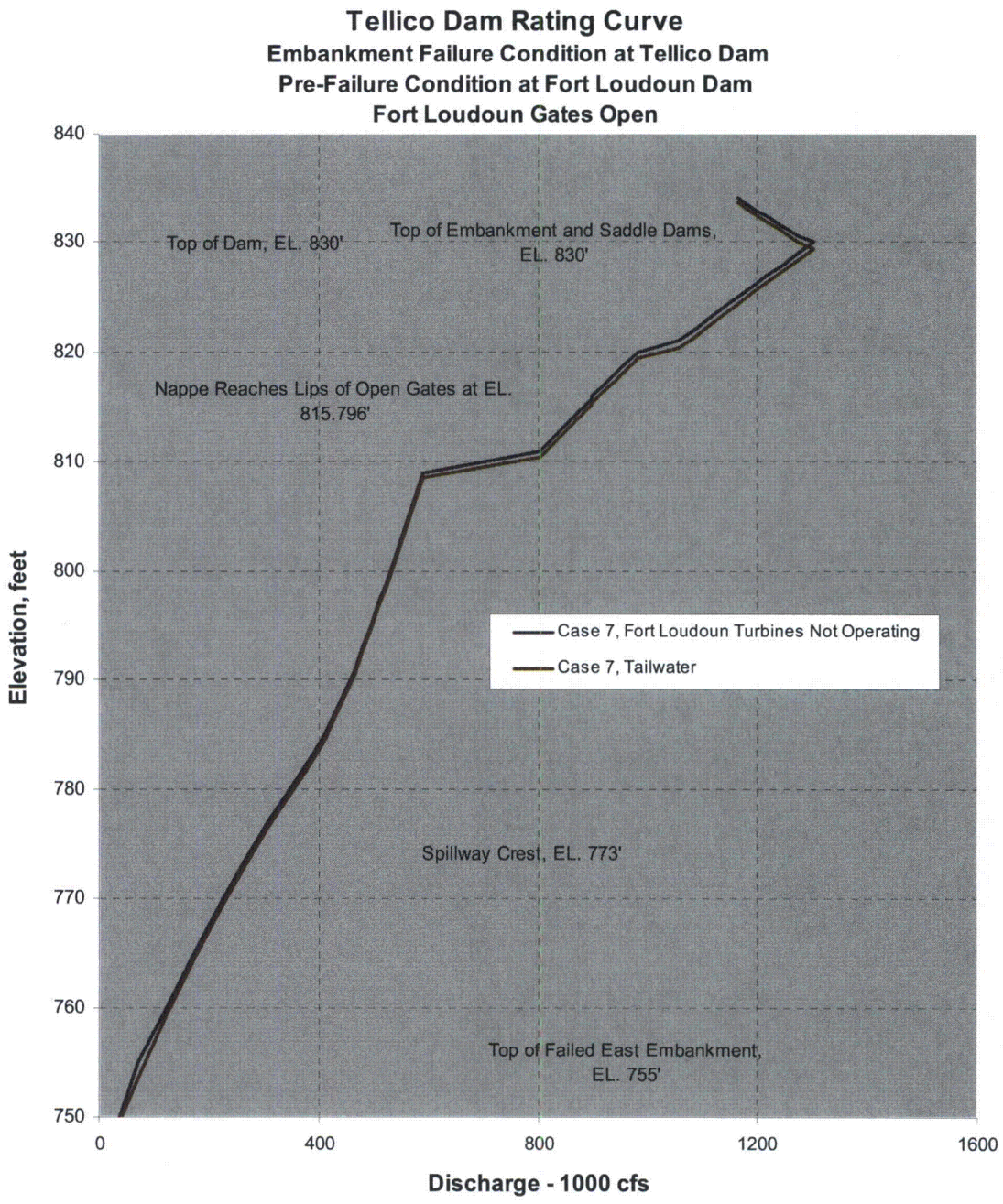
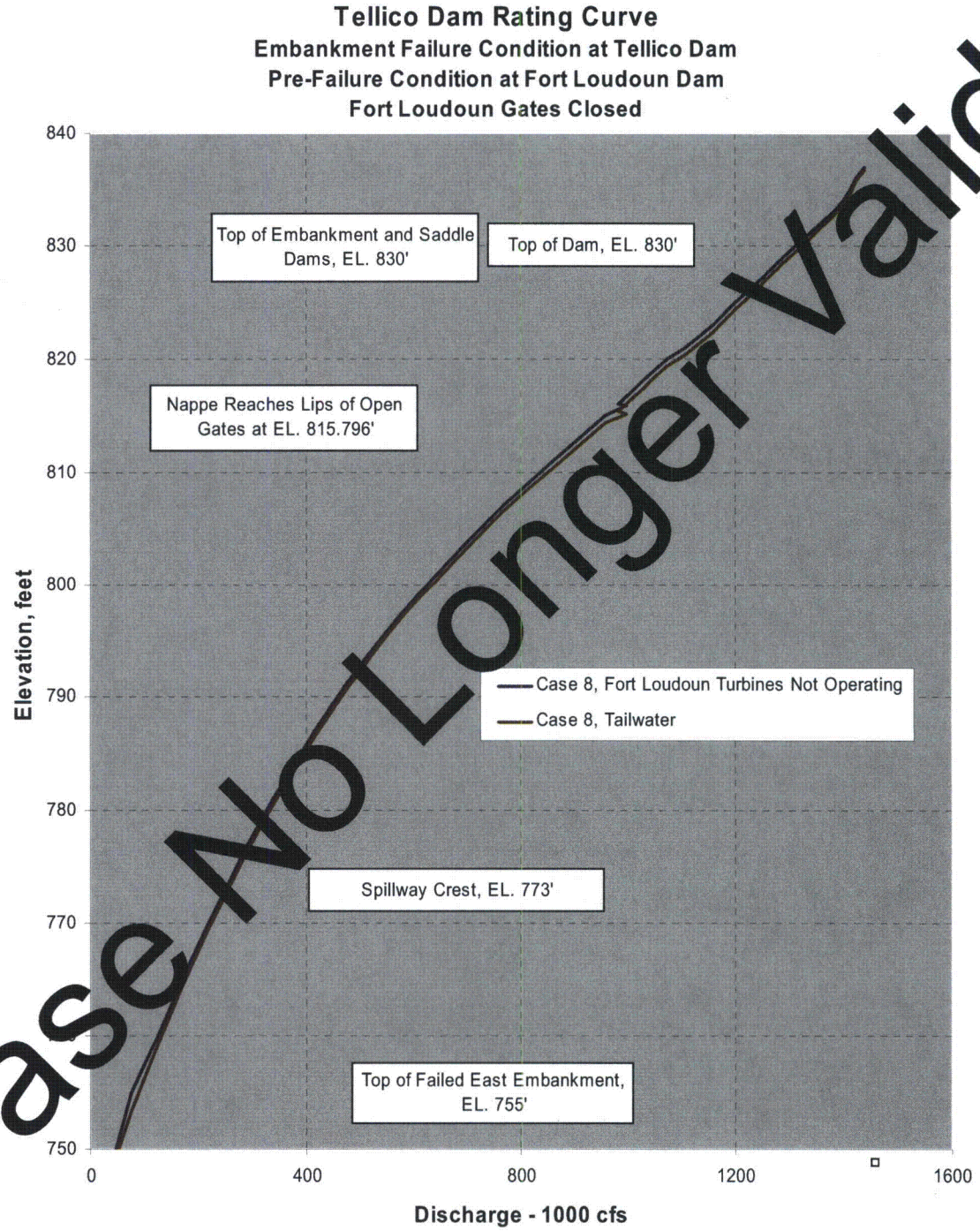


Figure 24 – Initial Dam Rating Curve for Case 7



Case No Longer Valid

Figure 25 – Initial Dam Rating Curve for Case 8

Case 9

Pre-failure at Tellico Dam

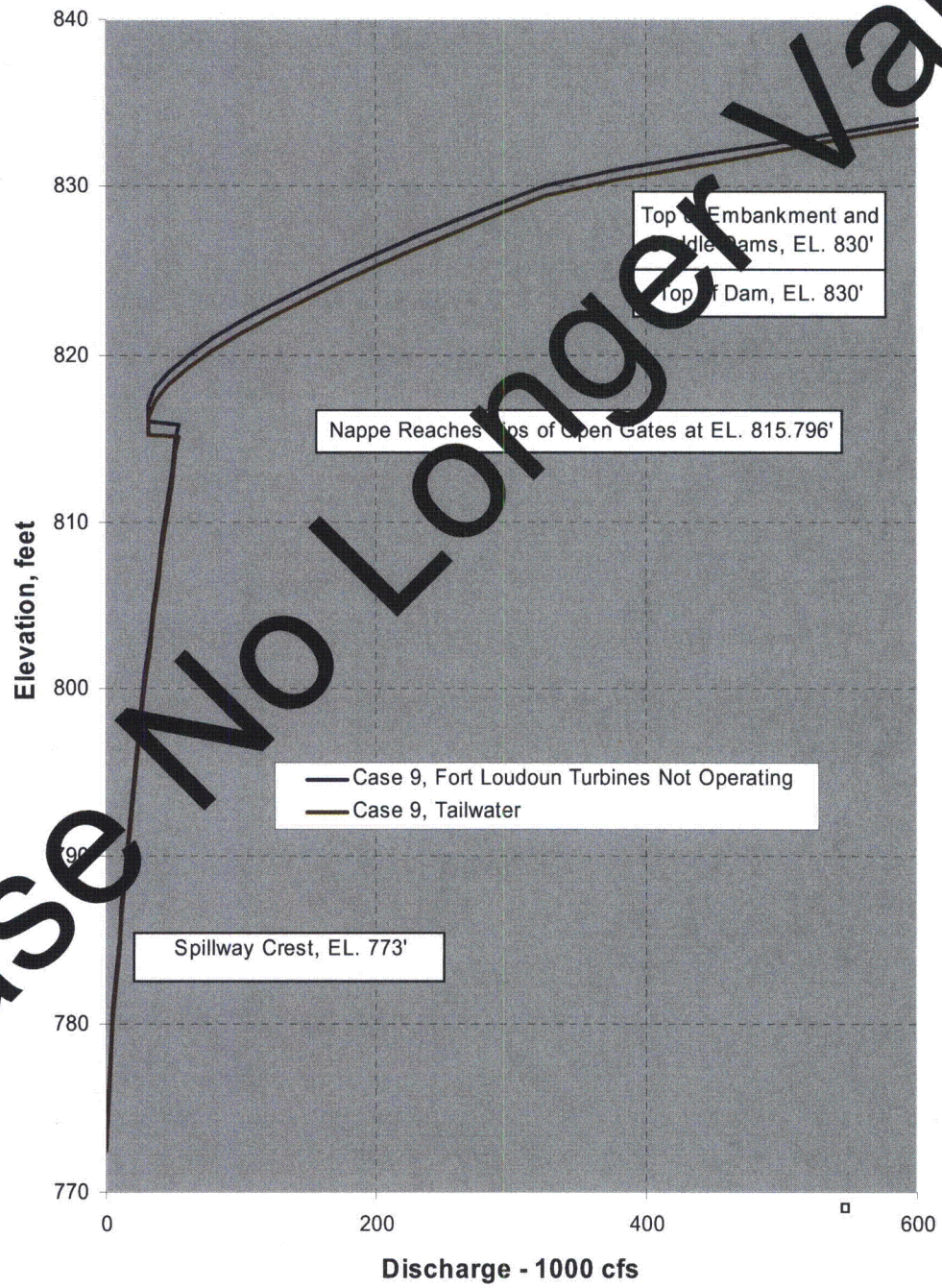
Seismic Failure at Fort Loudoun

Fort Loudoun Turbines Not Operating

HW (ft)	TW (ft)	Q_{TEL} (cfs)	Q_{TOT} (cfs)
773	772.46	0.00	247.04
775	774.48	0.94	268.42
777	776.49	2.28	290.42
779	778.48	3.83	313.17
781	780.48	5.53	336.83
783	782.47	7.38	361.45
785	784.47	9.39	387.12
787	786.47	11.46	414.06
789	788.47	13.64	44[illegible].26
791	790.48	15.93	47[illegible]
793	792.47	18.35	502.[illegible]
795	794.47	20.87	5[illegible].08
797	796.47	23.49	56[illegible]
799	798.46	[illegible]	[illegible].8
801	800.45	[illegible].08	6[illegible].40
803	802.44	3[illegible].1	681.83
805	804.42	[illegible].03	723.20
807	806.40	3[illegible].18	766.53
809	808.38	[illegible].42	811.82
811	810.36	44.73	858.95
813	[illegible].34	48.15	907.81
815	814[illegible]	51.62	958.16
815[illegible]	815.08	53.62	977.62
[illegible]16	815.27	31.48	982.83
[illegible]17	816.25	30.79	1008.66
[illegible]818	817.24	35.86	1035.01
[illegible]9	818.25	46.21	1061.81
820	819.26	60.80	1088.99
821	820.27	78.83	1116.46
822	821.29	100.12	1143.98
823	822.30	123.41	1171.40
824	823.31	147.92	1198.89
825	824.32	173.87	1226.41
826	825.33	201.30	1253.93
827	826.34	230.11	1281.43
828	827.36	260.23	1308.90
829	828.38	293.56	1336.36
830	829.39	325.44	1363.69
831	830.43	380.36	1391.43
832	831.47	451.24	1419.41
833	832.52	523.34	1447.31
834	833.56	594.15	1474.90
835	834.60	664.40	1502.29
836	835.62	735.10	1529.50
837	836.65	806.00	1556.60

Case No Longer Valid

Figure 26 – Initial Dam Rating Results for Case 9



Case No Longer Valid

Figure 27 – Initial Dam Rating Curve for Case 9

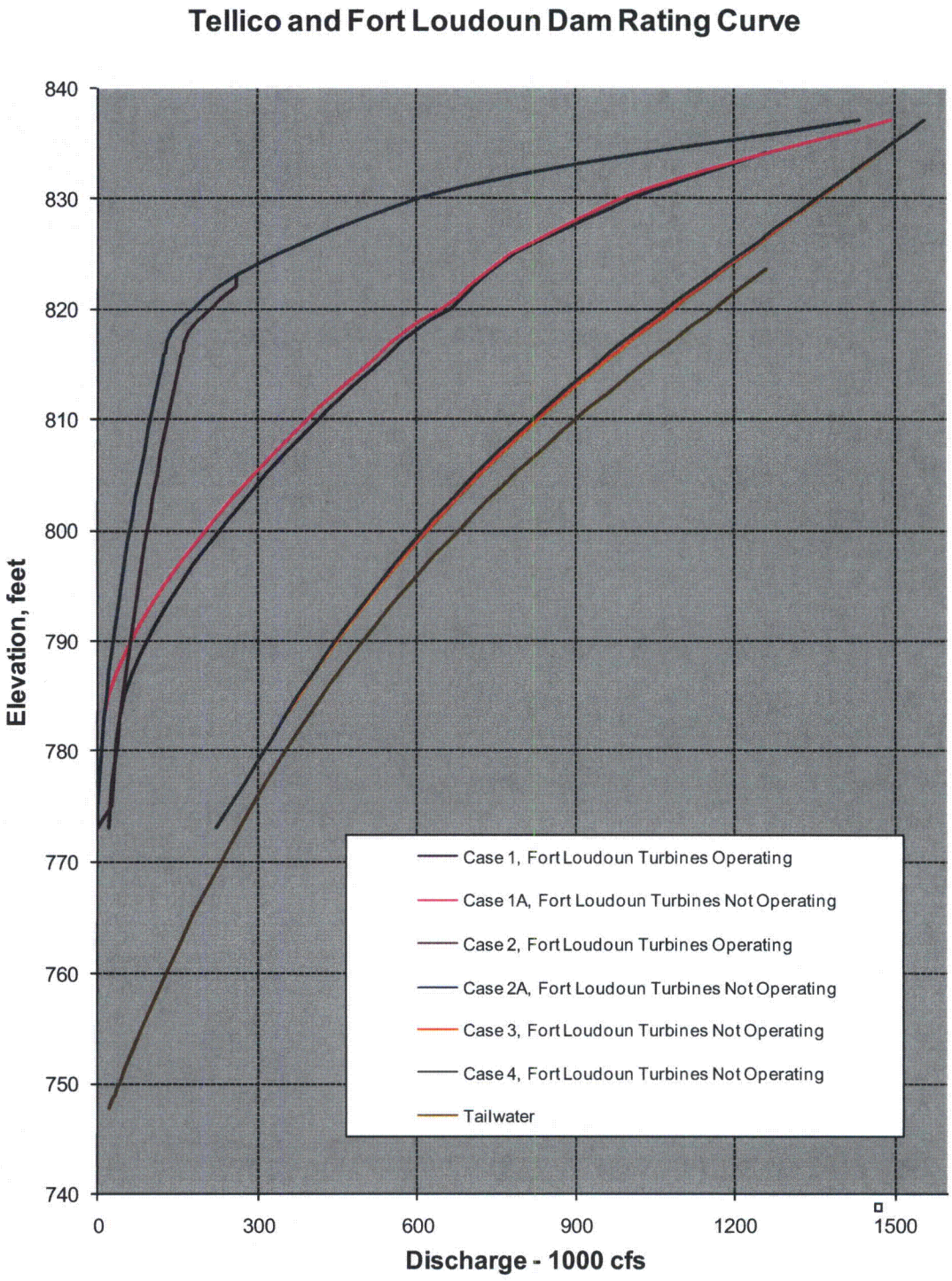


Figure 28 – Initial Dam Rating Curves for Tellico and Fort Loudoun, Combined, for Cases 1 - 4
Cases 1A, 2, 2A, 3, and 4 are no longer valid

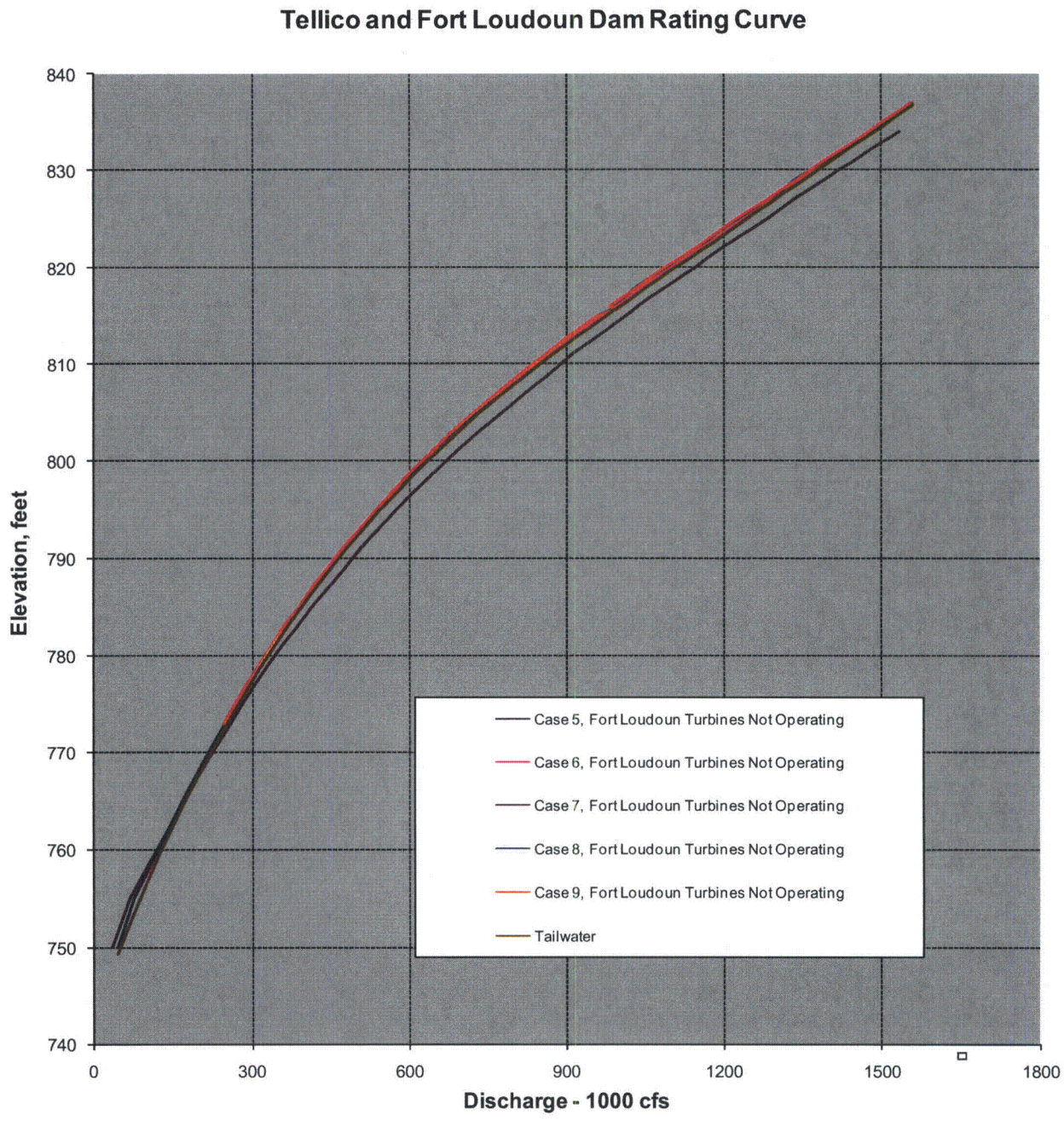
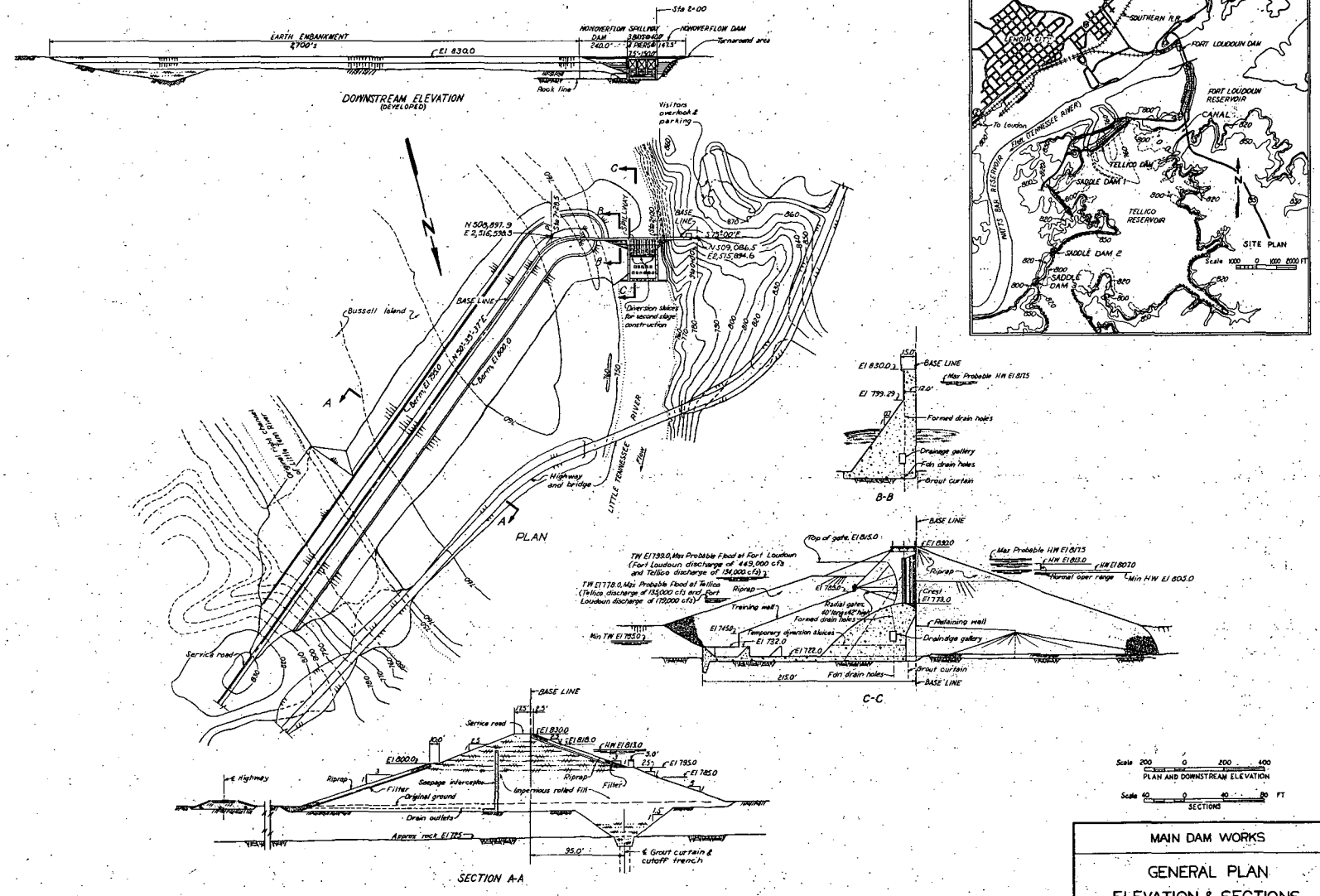


Figure 29 – Initial Dam Rating Curves for Tellico and Fort Loudoun, Combined, for Cases 5 – 9
Cases 5, 6, 8, and 9 are no longer valid

Calculation No: CDQ000020080018

Attachment 1
Ref. 2.1.1
1 page



MAIN DAM WORKS

GENERAL PLAN
ELEVATION & SECTIONS

TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

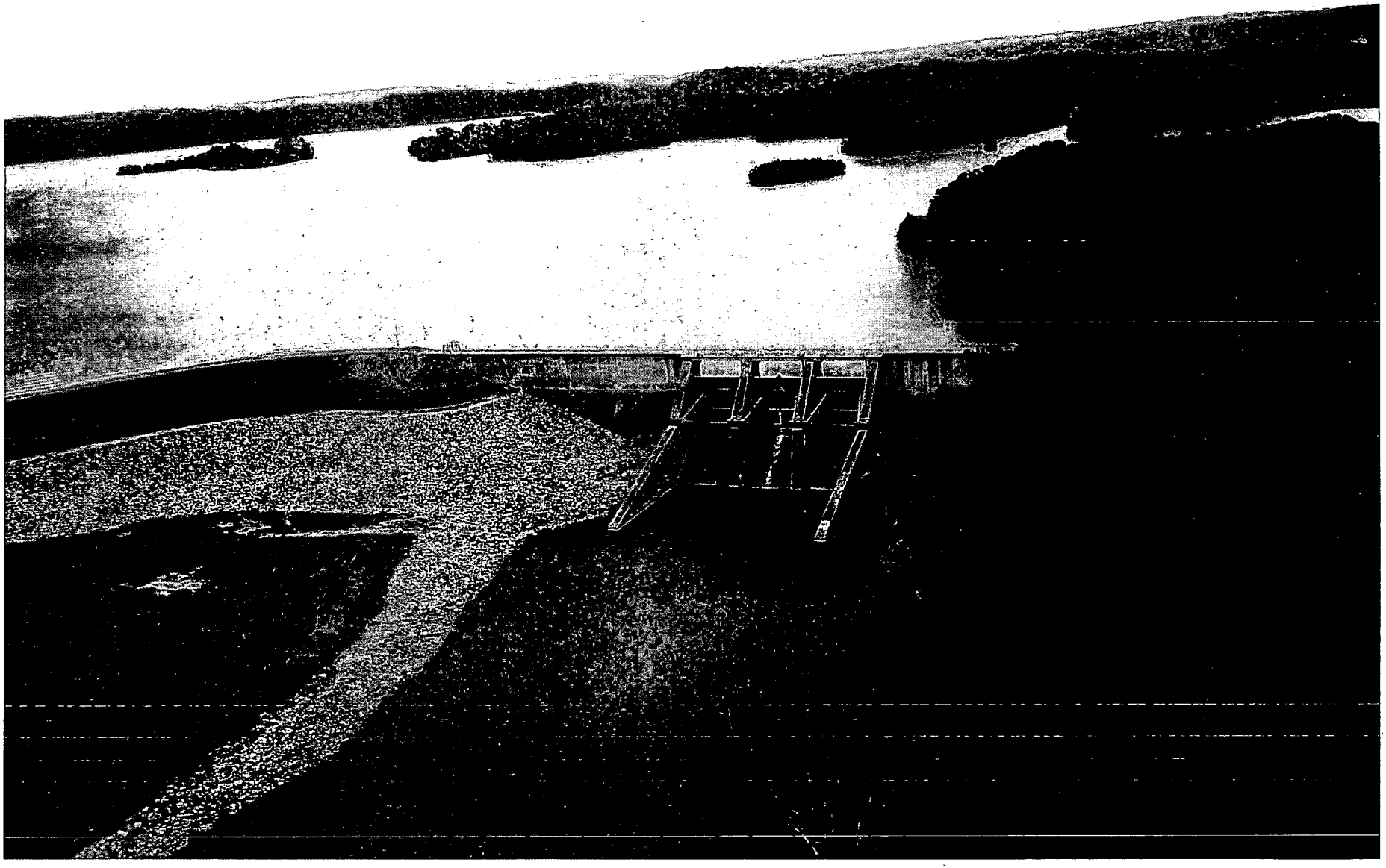
SUBMITTED	RECOMMENDED	APPROVED
KNOXVILLE	5-29-47	65 C 4 1ON200 R5

1ON200

Calculation No: CDQ000020080018

Attachment 2
from Ref. 2.12
1 page

TELLICO DAM



July 1998

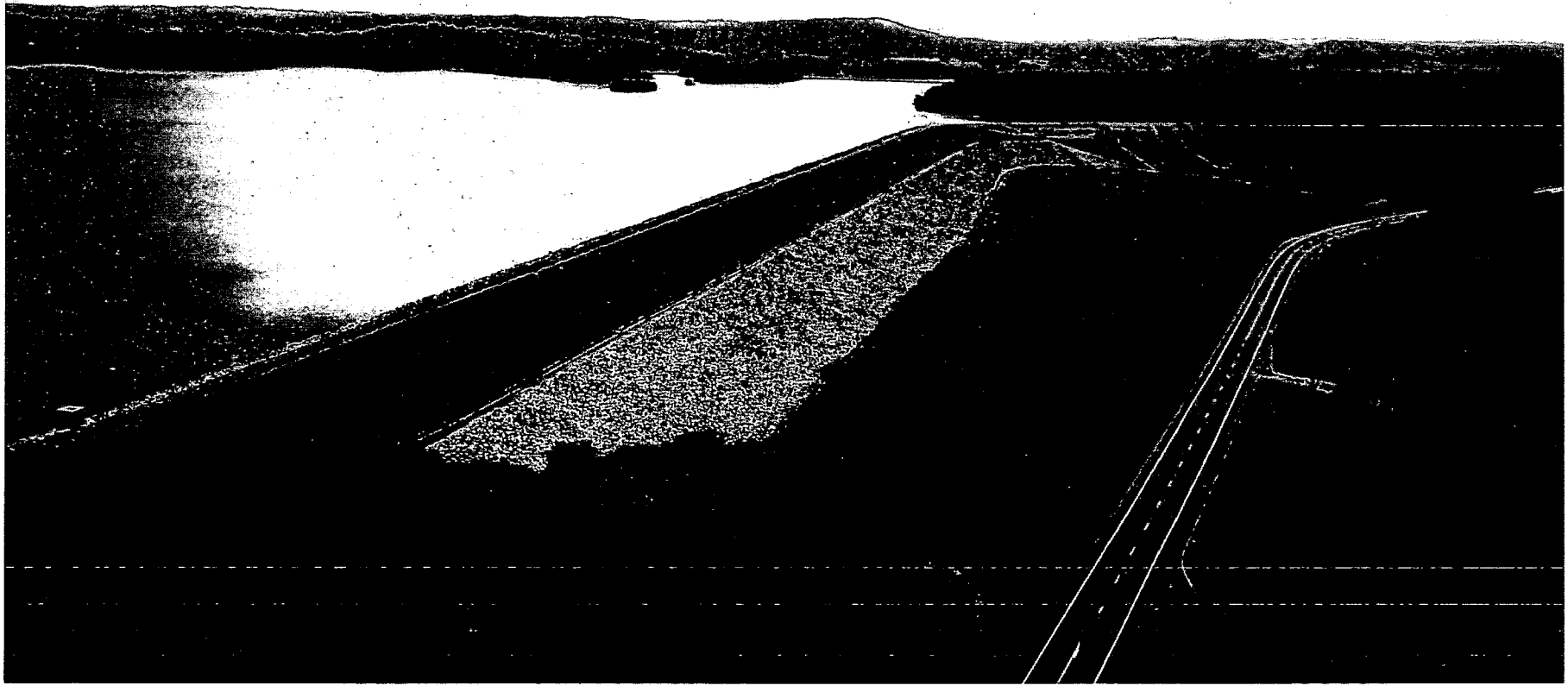
Calculation No: CDQ000020080018

Attachment 3
from Ref. 2.12
1 page

April 1999

Tellico ii

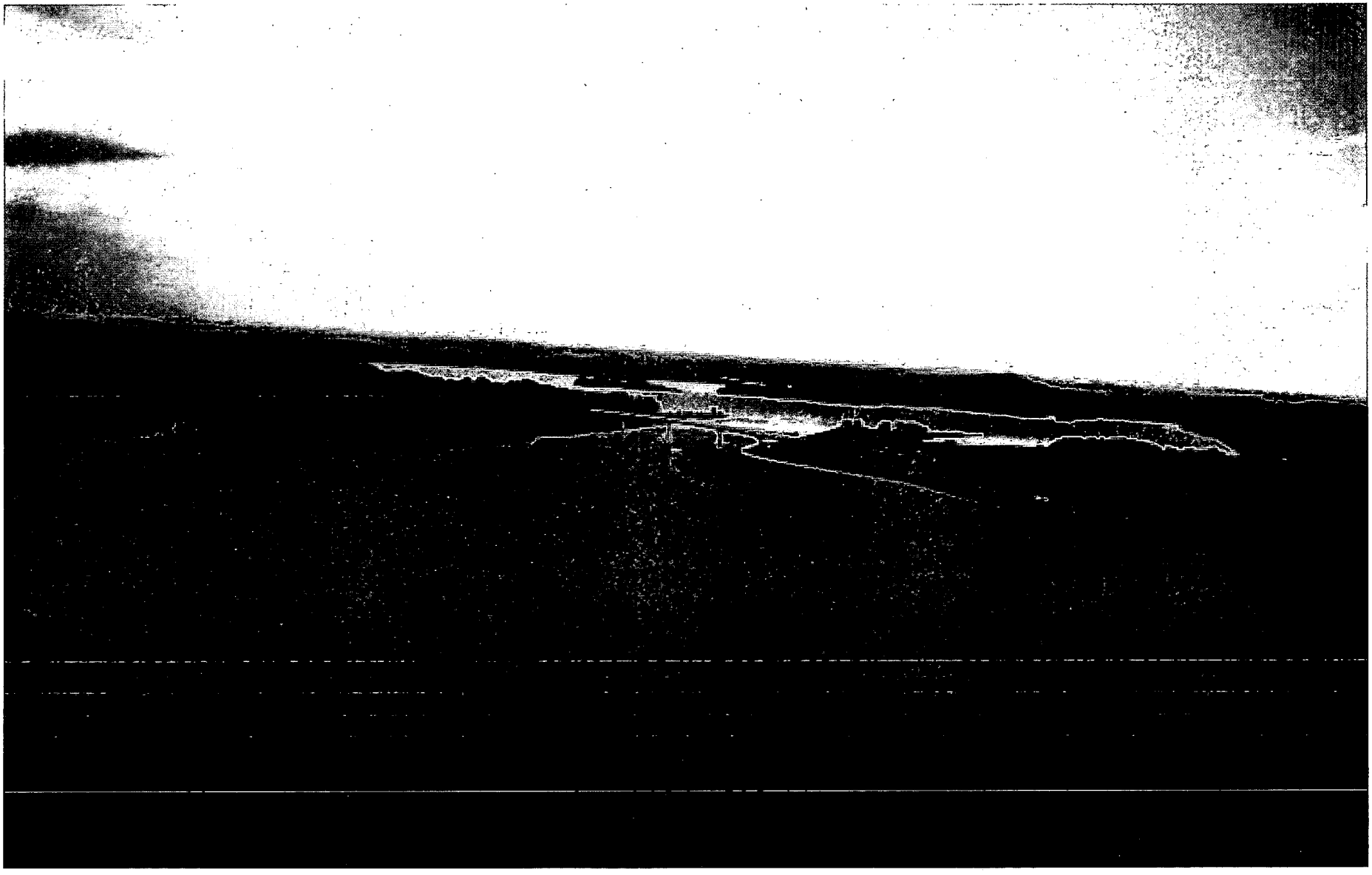
EMBANKMENT PORTION OF MAIN DAM



July 1998

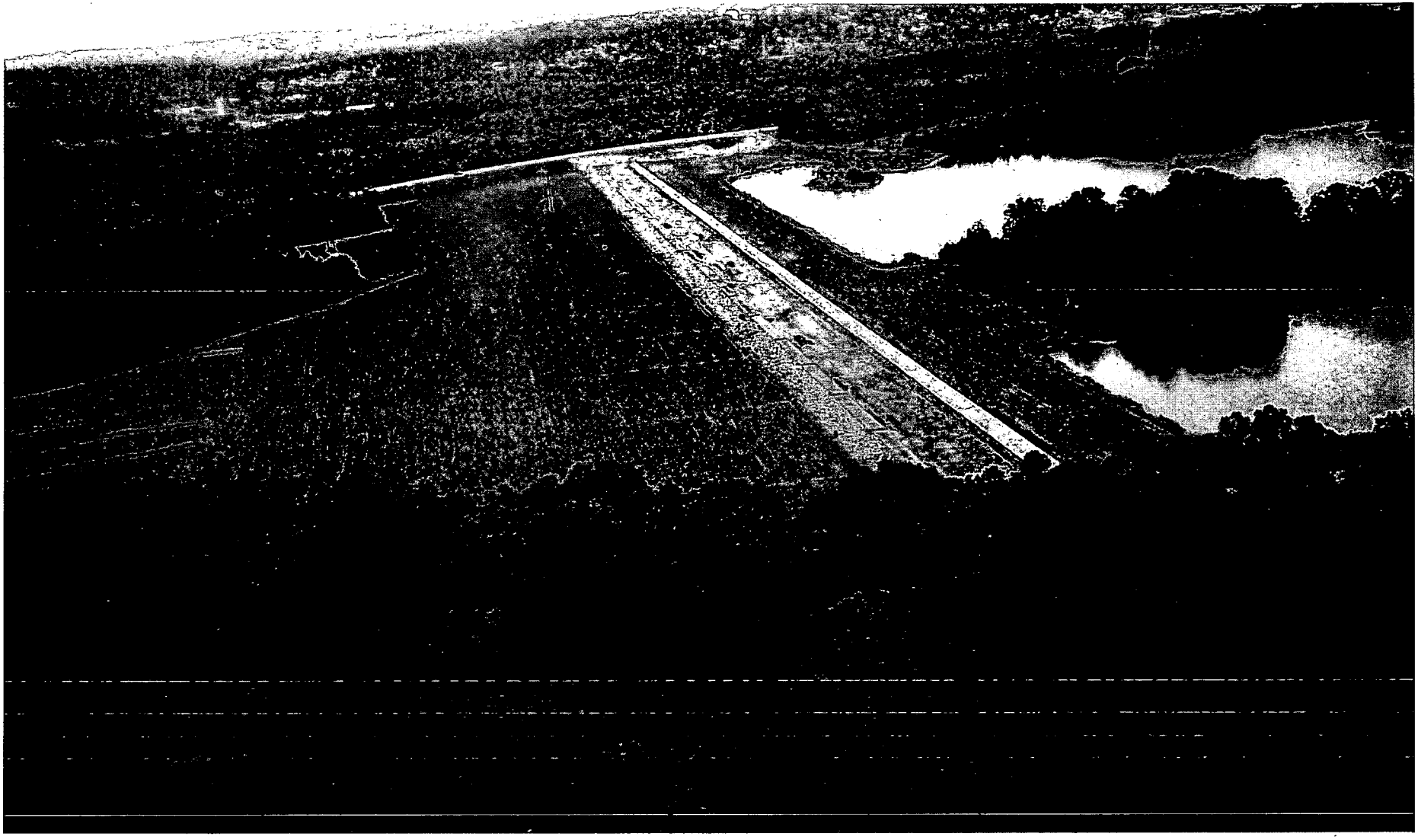
Canal between Ft.Loudoun and Tellico Lakes

Figure 6



SAFETY MODICATIONS FOR PROBABLE MAXIMUM FLOOD

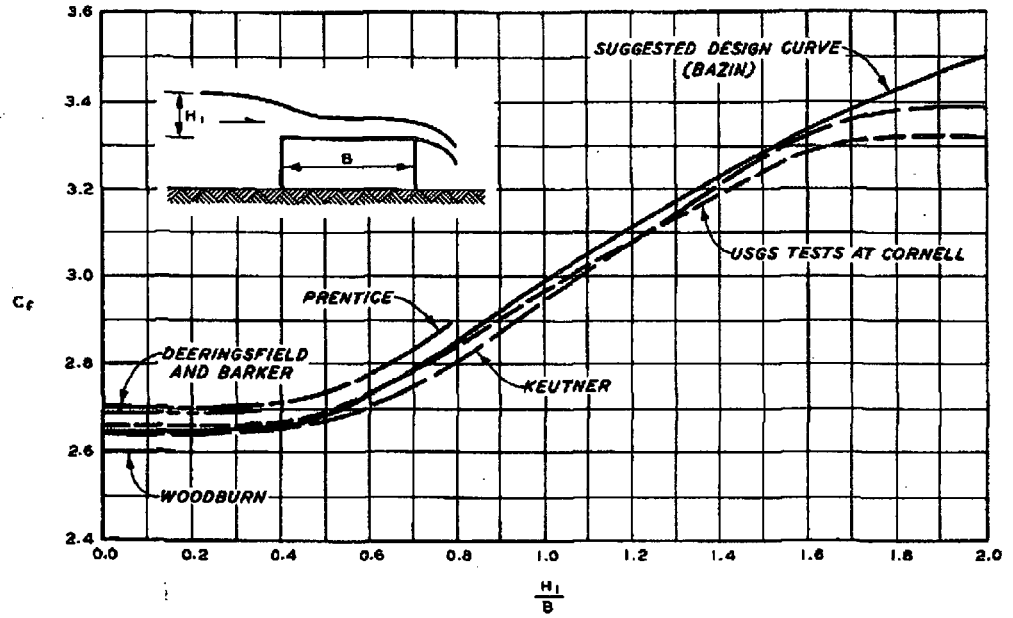
Figure 7



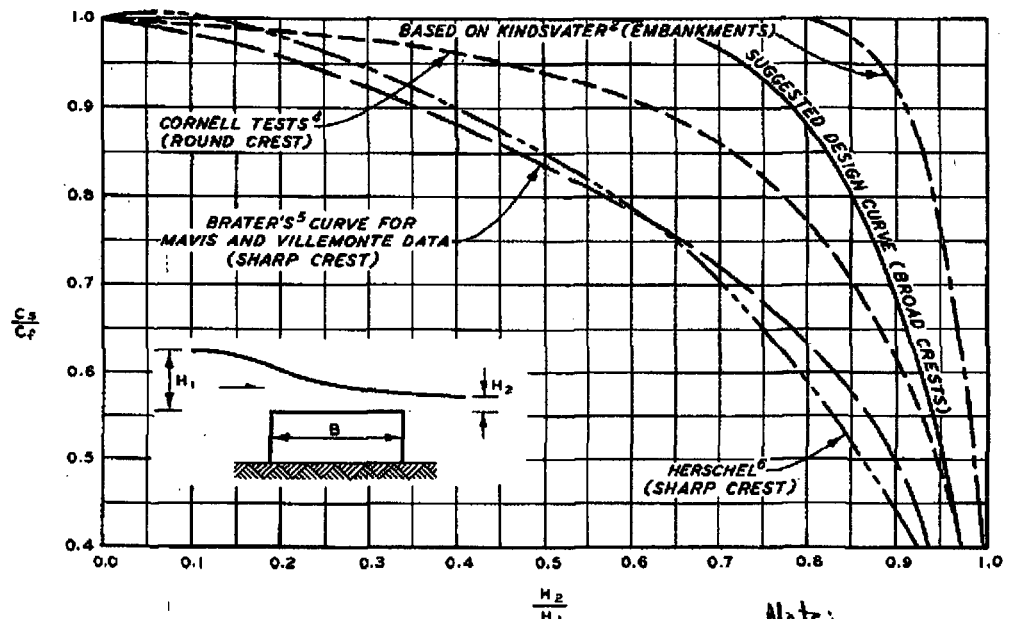
July 1998

Attachment 6
Ref. 2.6
1 page

Calculation No: CDQ000020080018



a. FREE FLOW



b. SUBMERGED FLOW

Note:
$\frac{H_1}{} \equiv H_c$
$H_2 \equiv d$
$\frac{C_s}{C_f} \equiv S_f$

NOTE: C_f = FREE-FLOW COEFFICIENT
C_s = SUBMERGED-FLOW COEFFICIENT
NEGLIGIBLE VELOCITY OF APPROACH
RAISED NUMBERS ON SUBMERGED FLOW CHART ARE REFERENCE NUMBERS FROM TEXT.

LOW-MONOLITH DIVERSION
DISCHARGE COEFFICIENTS

HYDRAULIC DESIGN CHART 711

PREPARED BY U. S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION, VICKSBURG, MISSISSIPPI

WES 1-66

Calculation No: CDQ000020080018

Attachment 7
1 page

Fort Loudoun Dam Tailwater Values And Polynomial Fit

	TRM 602.3		
	Discharge (1000 cfs)	TW (ft)	TW Polynomial
	100	756.57	756.92
	200	767.51	767.13
	300	776.20	775.92
	400	783.48	783.52
	600	795.51	795.90
	800	805.49	805.65
	1000	813.98	813.86
	1100	817.80	817.65
	1200	821.42	821.35
**	1400	828.66	828.63
**	1600	835.90	835.97
**	1800	843.14	843.30
**	2000	850.38	850.32

	TRM 599.0		
	Discharge (1000 cfs	TW (ft)	TW Polynomial
	100	756.13	756.52
	200	766.58	766.17
	300	774.87	774.55
	400	781.82	781.85
	600	793.3	793.87
	800	803.36	803.45
	1000	811.71	811.57
	1100	815.44	815.33
	1200	818.98	818.97
**	1400	826.06	826.11
**	1600	833.14	833.26
**	1800	840.22	840.40
**	2000	847.30	847.29

* = Points from preliminary HEC-RAS Runs
** = Linearly Extrapolated Points

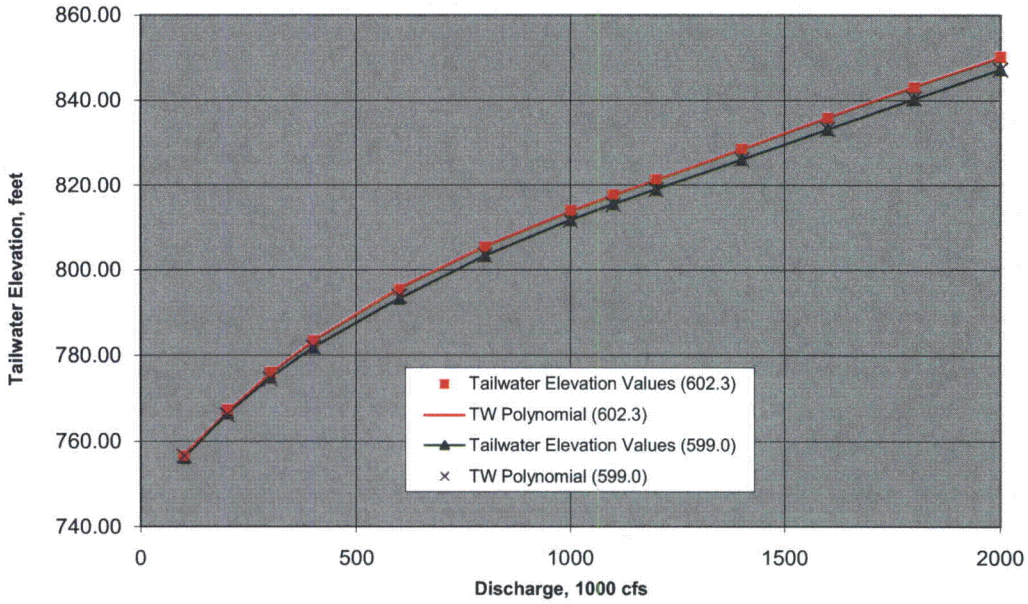
Polynomial Curve Fit: $TW_{602.3} = 745.07 + 0.1276Q - 0.9492x10^{-4}Q^2 + 4.350x10^{-8}Q^3 - 0.7392x10^{-11}Q^4$

where TW = tailwater elevation in feet and Q = discharge in 1000 cfs

Polynomial Curve Fit: $TW_{599.0} = 745.38 + 0.1195Q - 8.5046x10^{-5}Q^2 + 3.8094x10^{-8}Q^3 - 6.3535x10^{-12}Q^4$

where TW = tailwater elevation in feet and Q = discharge in 1000 cfs

Tailwater Curves



Calculation No: CDQ000020080018

Attachment 8-1
2 total pages

Submergence Factor for Overflow Sections

Prepared by: S.E.M.
Checked by: J.B.M.

Hyd. Design Criteria, Hydraulic Design Chart 711
Suggested Design Curve (Broad Crests)

d/H_c	S_f	$(d/H_c)^{1.5}$	d/H_c	S_f	
0	1	0	0.000	1	
0.6	1	0.05	0.136	0.98	
0.65	0.985	0.1	0.215	0.965	0.987
0.7	0.97	0.2	0.342	0.915	0.965
0.75	0.93	0.3	0.448	0.87	0.927
0.8	0.88	0.4	0.543	0.82	0.885
0.85	0.8	0.5	0.630	0.765	0.84
0.9	0.68	0.6	0.711	0.7	0.785
0.95	0.52	0.7	0.788	0.63	0.725
0.97	0.4	0.8	0.862	0.535	0.635
		0.9	0.932	0.38	0.5

These points have been scaled from the bottom section of the USACE Hydraulic Design Criteria, Chart 711 (Reference 2.6. Attachment 6).

alpha = 1.5
beta = 0.385

d/H_c	σ $d/H_c - 0.6$	Broad Crest S_f	Sharp Crest S_f
0		1	1.000
0.05		1	0.996
0.1		1	0.988
0.15		1	0.977
0.2		1	0.965
0.25		1	0.950
0.3		1	0.933
0.35		1	0.915
0.4		1	0.894
0.45		1	0.871
0.5		1	0.845
0.55		1	0.817
0.6	0	1.000	0.786
0.65	0.05	0.991	0.751
0.7	0.1	0.966	0.712
0.75	0.15	0.929	0.668
0.8	0.2	0.878	0.616
0.85	0.25	0.803	0.555
0.9	0.3	0.686	0.477
0.95	0.35	0.505	0.367
0.97	0.37	0.409	0.302
0.98	0.38	0.350	0.259
0.99	0.39	0.250	0.198
0.995	0.395	0.150	0.152
1	0.4	0.000	0.000

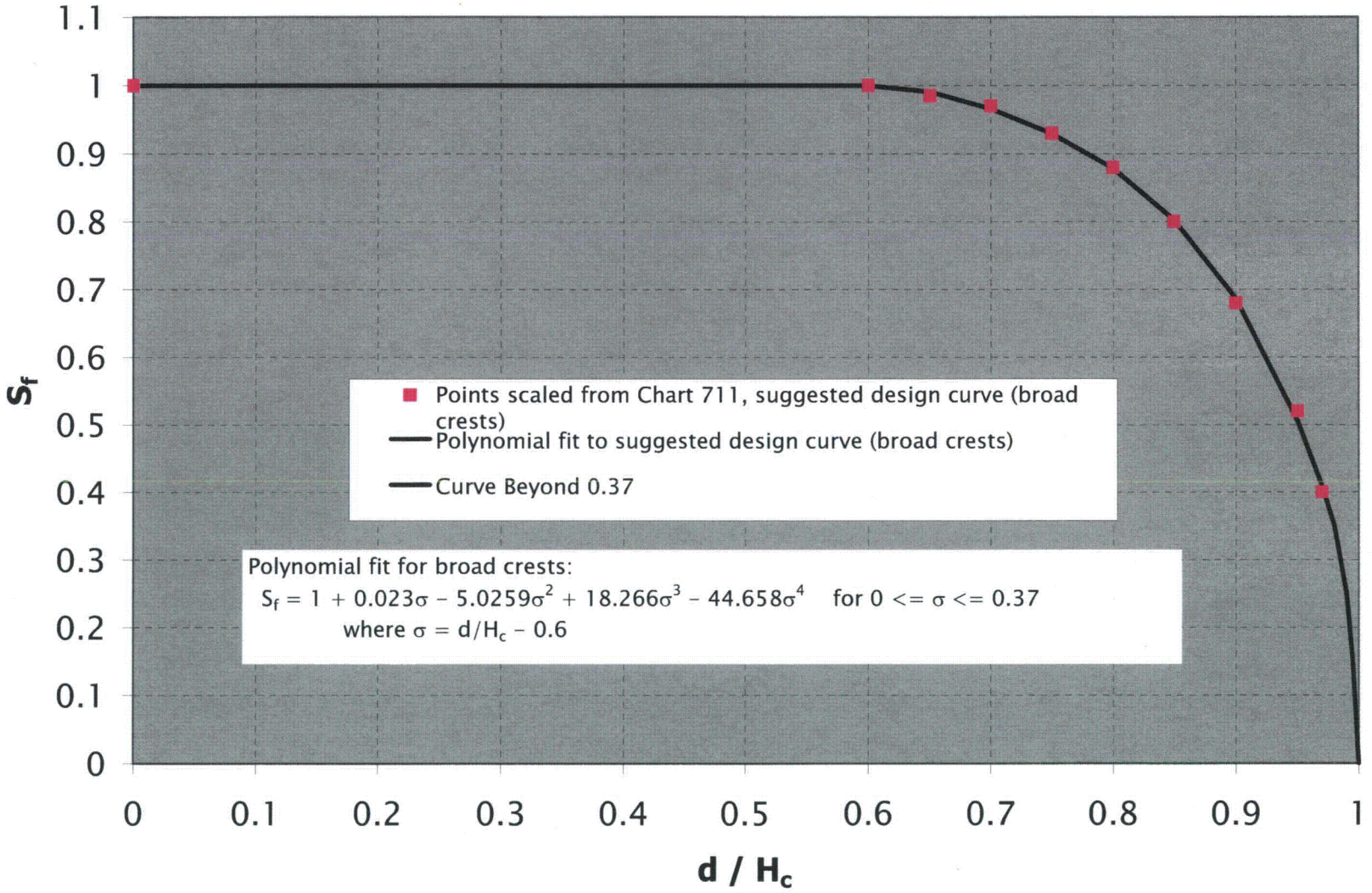
When $\sigma > 0.37$, S_f for broad crests must be interpolated.

Calculation No: CDQ000020080018

Attachment 8-2
2 total pages

Prepared by: S.E.M.
Checked by: J.B.M.

Submergence Factors for Weirs from Chart 711 in Hydraulic Design Criteria



April 1999

Calculation No: CDQ000020080018

SAFETY MODIFICATIONS FOR PROBABLE MAXIMUM FLOOD

Attachment 9
from Reference 2.12
1 page

Chronology

Safety analysis studies for Tellico Dam to evaluate the dam safety hydrologic deficiencies caused by a Probable Maximum Flood (PMF) were essentially completed in fiscal year (FY) 1986. The recommended proposal to provide additional ungated spillway capacity at Tellico Saddle Dam No.1 was programmed in the FY 1988 Operating Plan and approved by the TVA Board of Directors.

Cost of Modifications

Engineering and design costs for the capital safety modifications to Tellico Dam were approximately $230,600. The construction costs were approximately $2,733,900. The total project cost was approximately $2.96 million. Construction at the site was completed in September 1989. Figure 7 is a photograph of the completed emergency spillway.

Controlling Features

Modifications for the PMF consisted of a 2000 foot long ungated ogee crested spillway located 40 feet downstream of the centerline of Tellico Saddle Dam No.1 (See Figure 8). The spillway crest was set at elevation 817 which is the approximate level of the Maximum Probable Flood (MPF.) The width of the ogee section is 18.5 feet and the overall height of the crest is 13.5 feet from the bottom of the shear key. A horizontal apron energy dissipater extends 61.52 feet downstream of the ogee section. The 2000 foot long apron is about 18 inches thick. A 2 feet 3 inch high by 14 feet wide endsill at the downstream end of the apron provides additional energy dissipation. The ogee crest is flanked by a retaining wall that connects to the left abutment. The maximum height of the retaining wall is 24.5 feet above the footing.

Modifications for PMF (Tellico Emergency Spillway)

Quantities

Earth excavation	250,000 cu yd
Concrete	4,300 cu yd
Roller Compacted Concrete	19,600 cu yd
Rolled earthfill	186,000 cu yd
Crushed stone	9,400 tons
Riprap (new)	3,500 tons
Riprap (relocated)	3,600 tons

Appendix A: Spillway Discharge Coefficients and Submergence Factors for Tellico Dam from 1:72 Scale Model Test Data

TVA has model test data describing the relationships between discharge, headwater, tailwater, and gate opening for most of its spillways. These data, which are the basis for the spillway discharge tables developed for each dam, are used in the dam rating curve calculations. Use of reference book discharge coefficients for standard crests would result in inferior results because TVA's spillway crests are not standard.

Tellico dam has three spillway bays, each controlled by a radial (tainter) gate as illustrated in Attachment A1. For dam rating curve calculations the gates are assumed to be open to their maximum opening position as specified in the Spillway Gate Arrangements table in Reference A1 and included as Attachment A2. As shown in this table, the maximum opening corresponds to reading of 35.75 on the gate position indicators for the spillway. Field measurements of V, the vertical distance between the bottom lip of a raised spillway gate and the spillway crest, are summarized in Attachment A3-1. For gate position indicator reading of 35.75 the value of V for the three gates is 33.0 feet.

Test data from a 1:72 scale model (circa 1969) are available for free discharge conditions and for orifice discharge conditions for ten different gate openings varying from V = 1 foot to V = 35 feet (Reference A2). Orifice discharge data were not collected for the specific gate opening of V = 33.0 feet. However, because data exists for openings both less than and greater than 33', the data for gate openings V = 1, 3, 5, 7, 10, 15, 20, 25, 30 and 35 feet are used here to estimate orifice flow discharge characteristics for V = 33.0 feet.

A.1 References

A1. "Tellico Dam Spillway Discharge Tables," River Operations, Tennessee Valley Authority, 2008, EDMS Accession no. L58 081212 808 (Att. E36)
A2. "Tellico Spillway Rating, 1:72 Model, Books 1 and 2 of 2" June 1969 (relevant pages included as Att. E31)
A3. "Discharge Coefficients for Spillways at TVA Dams," Kenneth W. Kirkpatrick, Paper No. 2855, Transactions of the American Society of Civil Engineers, vol. 22, pp. 190-210, 1957 (Attachment E32)
A5. "Hydraulic Design Criteria," USACE (U. S. Army Engineer Waterways Experiment Station), Eighteenth issue, Vicksburg, MS, 1988
A6. Open Channel Flow, F. M. Henderson, Macmillan, New York, 1966.
A7. TVA drawing no: 54N200, R3 (Attachments A7 and E26)
A8. TVA drawing no: 51N203, R2 (Attachments A8 and E25)

A.2 Design Input

Sect.	Input Parameter	Source	Symbol	Value
A2.1	**Acceleration of gravity**	Common knowledge	g	32.2 ft/sec^2
A2.2	**Spillway gate parameters**			
A2.2.1	Crest elevation	Ref. A7 or Ref. A8	Z_c	773 feet
A2.2.2	Trunnion centerline elevation	Ref. A7 or Ref. A8	Z_{tr}	788 feet
A2.2.3	Gate lip elevation (fully closed)	Ref. A7	Z_{lip}	772.12 feet
A2.2.4	Gate top elevation (fully closed)	Ref. A7	Z_{top}	815 feet
A2.2.5	Gate radius	Ref. A7	R	41 feet

A.3 Discharge Equations

Attachment A4 is a definition sketch for flow over the Tellico Dam spillway. Free discharge occurs for headwater elevations below the elevation at which the overflowing nappe first touches the bottom lip of the gate, or $H_c \leq H_{Lmin}$, and is computed using a weir equation (e.g., Reference A5):

$$Q_f = C_f L H_c^{1.5} \quad \text{(A1)}$$

in which
Q_f = free discharge (cfs)
C_f = free discharge coefficient ($ft^{0.5}/s$ -- may vary with HW)
L = length of overflowing section (ft)
H_c = head on crest (ft) = HW - Z_c
HW = headwater elevation (ft)
Z_c = top, or crest, elevation of overflowing section (ft).

This equation is modified to account for tailwater submergence as follows:

$$Q_{fs} = Q_f S_f \quad \text{(A2)}$$

in which
Q_{fs} = "corrected" free discharge (cfs)
S_f = tailwater submergence factor (dimensionless -- varies with d / H_c)
d = height of tailwater above crest (ft) = TW - Z_c
TW = tailwater elevation (ft).

For headwater elevations above the elevation at which the nappe touches the gate lip, or $H_c > H_{Lmin}$, orifice flow occurs and is computed from (e.g., Reference A5)

$$Q_g = C_g G_n L \sqrt{2g(H_c - H_{mp})} \quad \text{(A3)}$$

in which
Q_g = orifice discharge (cfs)
C_g = orifice discharge coefficient (dimensionless -- varies with gate opening and H_c)
G_n = effective gate opening = minimum distance between the gate lip and the crest (ft)
g = acceleration of gravity [A2.1]
H_{mp} = vertical distance between the mid-point of G_n and the crest.

This equation is modified to account for tailwater submergence as follows:

$$Q_{gs} = S_g Q_g \quad \text{(A4)}$$

in which
Q_{gs} = "corrected" orifice discharge (cfs)
S_g = tailwater submergence factor (dimensionless -- varies with d / H_c and gate opening, V).

A.4 Model Test Data

The 1:72 scale Tellico model test data (Reference A2) are used to determine

- $C_f(H_c)$ and $S_f(d/H_c)$
- H_{Lmin} and $C_g(H_c)$ for V = 33.00 ft.
- $S_g(d/H_c)$ for V = 33.00 ft

Submergence effects on orifice discharge were included in the Tellico model study data. These data are used to estimate submergence effects on orifice discharges in Attachment A13 from page A13-3 to A13-11. The curve fits for $S_g(d/H_c)$ are included in Attachment A13 on page A13-1. The coordinates defining the curve fits are given in Table A1 and Attachment A13 on page A13-2.

The Tellico model test results published in Reference A2 have been used to calculate $C_f(H_c)$ [Att. A10] and $S_f(H_c)$ [Att. A11]. The model test data for both orifice and free discharge are tabulated following the results in Attachments A10, A12 and A13 and these data are used below to estimate H_{Lmin} [Att. A9] and $C_g(H_c)$ [Att. A12] for V = 33.00 feet, to establish a curve fit for $C_f(H_c)$ [Att. A10]. Attachment E31 provides the pages from Reference A2 that are relevant to the calculation of $C_f(H_c)$, $S_f(d/H_c)$, $C_g(H_c)$ and $S_g(d/H_c)$.

Table A1: Points Defining Curves Through Tellico S_g data (Ref. A2, Att. A13).

Curve Fit, H_c/G_n = 1.35		Curve Fit, H_c/G_n = 1.5		Curve Fit, H_c/G_n = 1.7		Curve Fit, H_c/G_n = 2.0		Curve Fit, H_c/G_n = 2.3	
d/H_c	S_g	d/H_c	S_g	d/H_c	S_g	d/H_c	S_g	d/H_c	S_g
0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000
0.200	1.000	0.200	1.000	0.200	1.000	0.200	1.000	0.200	1.000
0.280	0.997	0.280	0.997	0.303	0.997	0.390	0.986	0.290	0.990
0.424	0.984	0.424	0.984	0.392	0.989	0.431	0.980	0.375	0.981
0.469	0.975	0.469	0.975	0.451	0.975	0.501	0.947	0.448	0.961
0.513	0.964	0.513	0.964	0.530	0.945	0.540	0.917	0.485	0.930
0.615	0.915	0.615	0.915	0.614	0.895	0.611	0.834	0.630	0.769
0.665	0.872	0.665	0.872	0.696	0.791	0.699	0.725	0.700	0.685
0.720	0.800	0.776	0.709	0.785	0.660	0.757	0.637	0.862	0.458
0.755	0.750	0.830	0.603	0.850	0.540	0.853	0.488	0.901	0.383
0.825	0.636	0.880	0.500	0.868	0.502	0.905	0.400	0.946	0.300
0.870	0.545	0.927	0.400	0.918	0.400	0.953	0.300	0.974	0.200
0.915	0.450	0.966	0.300	0.959	0.300	0.979	0.200	0.991	0.100
0.935	0.400	0.986	0.200	0.982	0.200	0.992	0.100	1.000	0.000
0.973	0.300	0.994	0.100	0.993	0.100	1.000	0.000		
0.990	0.200	1.000	0.000	1.000	0.000				
0.996	0.100								
1.000	0.000								

Model data are scaled to prototype values using the following scale ratios from Attachment A5 (Reference A6):

- V_p/V_m and $H_p/H_m = 72$
- $Q_p/Q_m = (72)^{2.5} \approx 43987.7$

in which H is "head" in feet and represents any water level difference (d of H_c, for example), the p-subscript denotes prototype, and the m-subscript denotes model.

A.5 Geometry

Parameters G_n, H_{mp}, Z_o (gate overflow elevation), and β (angle plotted against discharge coefficient in Reference A5) are computed from crest and gate geometry as described in Attachment A6. Table A2 gives the values of these parameters for V = 1.0, 3.0, 5.0, 7.0, 10.0, 15.0, 20.0, 25.0, 30.0, 33.0 and 35.0 feet.

Table A2: Geometrical Parameters for Relevant Gate Openings

V, feet	G_n, feet	H_{mp}, feet	Z_o, feet	β, deg.
1.0	1.696	0.167	816.49	59.23
3.0	3.549	1.249	817.96	63.47
5.0	5.439	2.310	819.34	67.46
7.0	7.358	3.352	820.62	71.23
10.0	10.277	4.894	822.37	76.51
15.0	15.218	7.426	824.84	84.47
20.0	20.225	9.931	826.76	91.66
25.0	25.291	12.418	828.12	98.33
30.0	30.436	14.885	828.87	104.74
33.0	33.576	16.354	829.00	108.58
35.0	35.699	17.326	828.94	111.11

As an example, the procedure for computing the geometrical parameters for V = 33 feet is given here. Using the first three parameters below, from Attachments A7 and A8 (References A7 and A8, respectively) and given in Section A.2, and the geometrical relationships given in Attachment A6, page A6-2:

- R = 41 feet
- Z_c = 773 feet
- Z_{tr} = 788 feet
- $z_1 = Z_{tr} - Z_{lip} =$ 788 – 772.12 = 15.88 feet
- $z_2 = Z_{top} - Z_{tr} =$ 815 - 788 = 27.0 feet

where the relationships are defined in Attachment A6-2. Referring to Attachment A6:

Angle θ: $$\theta = \sin^{-1}\left(\frac{15.88}{41}\right) + \sin^{-1}\left(\frac{27.0}{41}\right) = 63.976°$$

Angle α: $$\alpha = \tan^{-1}\left(\frac{788 - 773 - 33.00}{\sqrt{41^2 - (788 - 773 - 33.00)^2}}\right) = -26.042°$$

Overflow elevation Z_o: $$Z_o = 788 + 41\sin[63.976 - (-26.042)] = 829.00 \ \textit{feet}$$

Gate lip y-coordinate: $$y_\ell = 788 - 773 - 33.00 = -18.00 \ \textit{feet}$$

Gate lip x-coordinate: $$x_\ell = \sqrt{41^2 - (-18.00)^2} = 36.837 \ \textit{feet}$$

From Attachment A8 (Reference A8):

The spillway crest curve is divided into three sections with different equations for each. The three sections and their formulas are detailed below. During the design of the spillway crest, the crest, itself, was the origin for the curves (y^*_s and x^*_s). The crest equations have been normalized below, using the trunnion centerline as the origin (y_s and x_s). The three sections are as follows: 1) Upstream from the crest, 2) From the crest to the top of the sill beam, and 3) Downstream of the sill beam.

1) For the portion of the crest from the outer edge to the crest centerline:

$$y^*_s = f(x^*_s) = \frac{(x^*_s)^3}{424} \quad for\ x^*_s \le 0'$$

in which $y^*_s = y_s - 15.00$ *and* $x^*_s = x_s - 45.219$.

In terms of y_s and x_s:

$$y_s = f(x_s) = -203.07 + 4.949x_s - 0.3199x_s^2 + 0.002358x_s^3 \quad for \quad 45.219\,feet \le x_s \le 58.552\,feet$$

and $\frac{dy_s}{dx_s} = 4.949 - 0.6398\,x_s + .007074\,x_s^2$

2) For the portion of the crest from the centerline to the top of the sill beam:

$$y^*_s = f(x^*_s) = \frac{(x^*_s)^{1.8}}{42} \quad for\ 0' \le x^*_s \le 7.417'$$

in which $y^*_s = y_s - 15.0$ *and* $x^*_s = 45.219 - x_s$.

In terms of y_s and x_s:

$$y_s = f(x_s) = 15 + \frac{(45.219 - x_s)^{1.8}}{42} \quad for \quad 37.802\,feet \le x_s \le 45.219\,feet$$

and $\frac{dy_s}{dx_s} = -\frac{(1.8)(45.219 - x_s)^{0.8}}{42}$

3) For the portion of the crest beyond the top of the sill beam:

$$y^*_s = f(x^*_s) = 0.877 + \frac{x^*_s - 7.417}{4.7} + \frac{(x^*_s - 7.417)^2}{160} \quad for\ x^*_s \ge 7.417'$$

in which $y^*_s = y_s - 15.88$ *and* $x^*_s = 37.802 - x_s$.

In terms of y_s and x_s:

$$y_s = f(x_s) = 28.1152 - 94.8126\left(\frac{x_s}{160}\right) + 160\left(\frac{x_s}{160}\right)^2 \quad for \quad x_s \le 37.802 \; feet$$

and

$$\frac{dy_s}{dx_s} = -0.5926 + \frac{x_s}{80}$$

Because the coordinates of x_{sn} and y_{sn} could be located on either of the curves defined by the second and third sets of equations, the coordinate values have been calculated using both normalized formulas. The more reasonable values should be considered accurate.

To get effective gate opening, G_n, solve the following equations for x_{sn} for the x coordinate of the lip at 36.837':

❖ $$x_{sn} - 36.837 + \left[28.1152 - 94.8126\left(\frac{x_{sn}}{160}\right) + 160\left(\frac{x_{sn}}{160}\right)^2 - (-18.00)\right]\left[-0.5926 + \frac{x_{sn}}{80}\right] = 0$$

Solution:

- x_{sn} = 33.034 feet (by iteration)
- $y_{sn} = 28.1152 - 94.8126(33.034/160) + 160(33.034/160)^2 = 15.36$ feet

❖ $$x_{sn} - 36.837 + \left[15 + \frac{(45.219 - x_{sn})^{1.8}}{42} - (-18.00)\right]\left[\frac{-(1.8)(45.219 - x_{sn})^{0.8}}{42}\right] = 0$$

Solution:

- x_{sn} = 41.2 feet (by iteration)
- $$y_{sn} = 15 + \frac{(45.219 - 41.2)^{1.8}}{42} = 15.291 \; feet$$

The values found from the second formula are more reasonable. The coordinate of x_{sn} should be greater than that of x_l due to the geometry and distance from the trunnion centerline (see Att. 6-5). Therefore the values derived from the second set of equations will be used to determine G_n, H_{mp} and β.

Therefore:

- $$G_n = \sqrt{(41.2 - 36.837)^2 + (15.291 - (-18.00))^2} = 33.576 \; feet$$
- H_{mp} = 33.0-[15.291 - (-18.0)]/2 = 16.354 feet
- $$\beta = \frac{\pi}{2} - \tan^{-1}\left(\frac{-18.00}{36.837}\right) - \tan^{-1}\left(\frac{41.2 - 36.837}{15.291 - (-18.00)}\right) = 90 - (-26.042) - (7.466) = 108.576°$$

A.6 Determination of $H_{Lmin}(V)$

In order to determine the relationship between H_{Lmin} and V, the model data from Reference A2 (Att. E31) was again used. It is known that at the point where the nappe just touches the bottom lip of the gate (H_{Lmin}), flow transitions from free to orifice. In addition, the relationship between discharge and head is known to change at the transition point. By plotting the discharge v/s head from the model data, the transition point can easily be seen and the values of H_{Lmin} determined. This plot is located in Att. 9-2.

Attachment A9-1 relates the H_{Lmin} values at the transition point to the values of V. The relationship is established by using a polynomial fit. The following formula is used to calculate H_{Lmin} for varying values of V for this dam rating curve calculation:

$$H_{Lmin} = 1.2668\ V + 0.992 \qquad \text{(A5)}$$

The linear relationship is the best fit to the data. From this formula, the following value is used for the Tellico dam rating curve calculations: H_{Lmin} = 42.796 feet for V = 33.0 feet. Therefore, the elevation at which the headwater nappe touches the gate is 773 feet + 42.796 feet = 815.796 feet.

A.7 Determination of $C_f(H_c)$ and $S_f(d/H_c)$

Attachment A10 shows the model test data for free discharge (pages A10-2 to A10-4) and a polynomial curve fit to the data (page A10-1). The polynomial indicated in Attachment A10, page A10-1 is used for the dam rating curve calculations:

$$C_f = 3.10 + .0026062\ H_c + 0.0016954\ H_c^2 - 5.3795\text{x}10^{-5}\ H_c^3 + 4.759\text{x}10^{-7}\ H_c^4 \qquad \text{(A6)}$$

A plot of S_f vs. d/H_c from the Tellico Dam model data (Ref. A2, Att. E31) is provided in Attachment A11. The points listed were taken from the model data found in Attachment A10, pages A10-2 to A10-4 and, as shown on the plot of S_f vs. d / H_c (Att. A11), the following equation was fit to the scaled points:

$$S_f = \left[1 - \left(\frac{d}{H_c}\right)^{3.7}\right]^{0.3} \quad for\ \frac{d}{H_c} > 0.2, \quad and\ S_f = 1.0 \quad for\ \frac{d}{H_c} \le 0.2 \qquad \text{(A7)}$$

This equation is used for the dam rating calculations.

A.8 Determination of $C_g(H_c)$ for V = 33.00 feet

Attachment A12 shows the calculations and results for determining $C_g(H_c)$ for V = 33.00 feet based on the model data for other gate openings. The first column in Attachment A12-1 indicates the data for which $H_c = H_{Lmin}$, at which H_c is just high enough to touch the bottom of the gate. The second column lists the gate opening, V, for openings 3, 5, 7, 10, 15, 20, 25, 30 and 35 feet from the model data as listed in Attachment E31, as well as V = 33' (maximum gate opening). The third column lists the prototype head on crest. The fourth column gives the calculated gated discharge, Q_g, calculated from the free discharge formula (based on the fact that at the point where the flow changes from free to orifice, the discharges are equal). The fifth and sixth columns contain the parameters G_n and H_{mp}, which are used to calculate the gated discharge coefficient. The seventh column shows the values of C_g. The first row for each gate opening contains the value calculated using the gated discharge formula. The remaining values for each gate opening have either been taken directly from the model data or have been extrapolated (noted with "*"). The last numerical column lists the maximum values of d/H_c for each gate opening in the model data. It can be seen that the maximum value for each is 0.2.

Attachment A12-2 shows C_g plotted against H_c for all gate openings. The curves include extrapolated segments based on the fact that the values should level off after a certain point. The estimated curve for V = 33.00 feet starts with the value for $H_c = H_{Lmin}$ and runs approximately parallel to the curve for V = 30 feet. Given the absence of data specific to a 33' gate opening, this line segment fit for $C_g(H_c)$ at V = 33.00 feet is used for the dam rating calculations. Table A3 lists the points describing the relationship developed in Att A12.

Table A3: Points Defining Extrapolated Curve for $C_g(H_c)$ at V = 33.00 feet.

H_c, feet	C_g
42.80	0.746
46.10	0.700
48.10	0.692
50.00	0.692
60.00	0.692

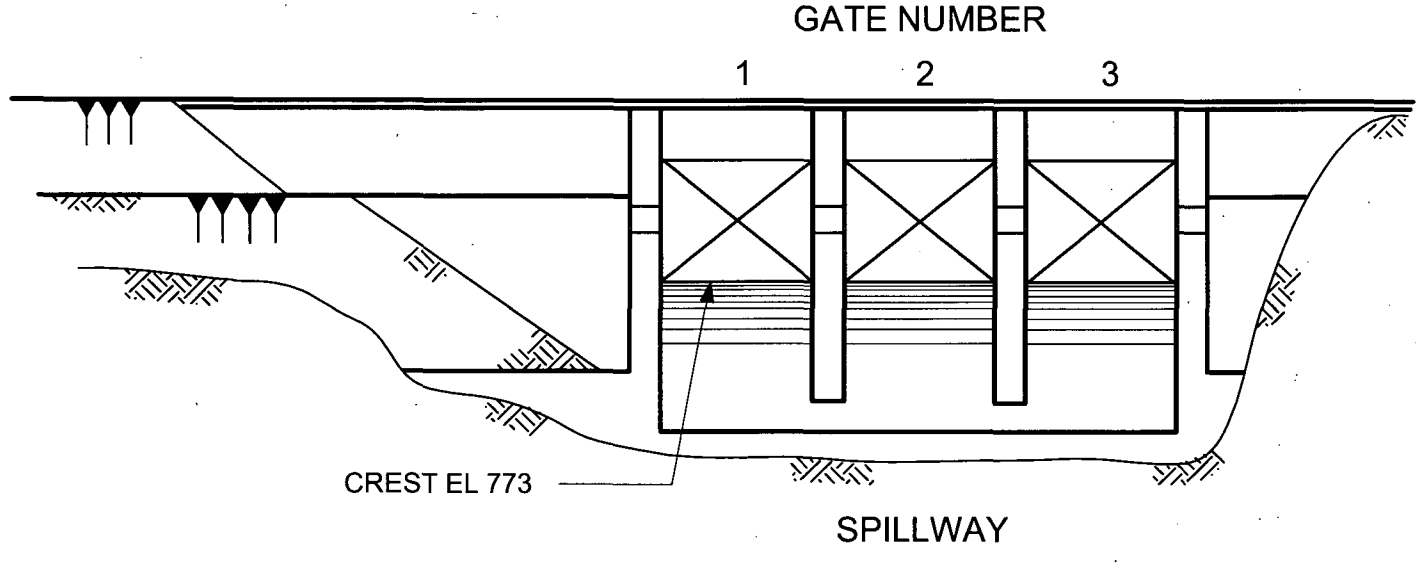
As further justification for the extrapolation, Attachment A12-3 shows the Tellico C_g values at large H_c values plotted against the angle β on Hydraulic Design Chart 311-1 (Reference A5) showing U.S. Army Corps of Engineers data for tainter gates on standard crests. Presumably because TVA's spillway crests are not standard, TVA data always lie to the left of the suggested design curves on this chart. Note that $C_g = 0.692$ at $H_c = 60$ feet and V = 33.0 feet (β = 108.58 degrees) is a very reasonable extrapolation of the Tellico data curve and appears reasonable compared with the suggested design curves on the chart.

Calculation No: CDQ000020080018

TELLICO DAM

LOCATION OF SPILLWAY GATES

Attachment A1
from Ref. A1
1 page



DOWNSTREAM ELEVATION

Calculation No: CDQ000020080018

Attachment A2
Ref. A1
1 page

TELLICO DAM

SPILLWAY GATE ARRANGEMENTS

Arrangement Number	Gate Number		
	1	2	3
1	1.19	1.19	1.19
2	2.25	2.25	2.25
3	3.36	3.36	3.36
4	4.43	4.43	4.43
5	5.51	5.51	5.51
6	6.58	6.58	6.58
7	7.63	7.63	7.63
8	8.69	8.69	8.69
9	9.74	9.74	9.74
10	10.79	10.79	10.79
11	11.82	11.82	11.82
12	12.87	12.87	12.87
13	13.91	13.91	13.91
14	14.94	14.94	14.94
15	15.97	15.97	15.97
16	17.00	17.00	17.00
17	17.00	22.19	17.00
18	22.19	22.19	17.00
19	22.19	22.19	22.19
20	22.19	27.40	22.19
21	27.40	27.40	22.19
22	27.40	27.40	27.40
23	27.40	32.63	27.40
24	32.63	32.63	27.40
25	32.63	32.63	32.63
26	32.63	35.75	32.63
27	35.75	35.75	32.63
28	35.75	35.75	35.75

Figures in columns under each gate number refer to gate opening indicator reading
Gate closed at 0 indicator reading

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.

SHEET ____ OF ____

Attachment A3-1
from Reference A2
5 total pages

Tellico Dam
Gates 1, 2 & 3

COMPUTED RS DATE 6/27/77

CHECKED ____ DATE ____ corrected

	Indicator Reading	Gate Opening	Ind rdg. Δ	adjusted Indicator rdg.	add 0.16'	used ↓	Gate No.
	~~99.84~~ ~~99.10~~	seal		0			
	98.81	crest	~~1.03~~ ~~0.27~~	1.03	0.16	1.19	.8 0.5
	97.75	1.00	1.06	2.09		2.25	
	96.64	2.015	1.11	3.20		3.38	2
	95.57	3.00	1.07	4.27		4.43	3
	94.49	4.005	1.08	5.35		5.51	4
	93.42	5.01	1.07	6.42		6.58	5
	92.37	6.00	1.05	7.47		7.63	6
	91.31	7.00	1.06	8.53		8.69	7
	90.26	8.005	1.05	9.58		9.74	8
	89.21	9.00	1.05	10.63		10.79	9
	88.18	10.00	1.03	11.66		11.82	10
	87.13	11.05	1.05	12.71		12.87	11
	86.09	12.005	1.04	13.75		13.91	12
	85.06	13.00	1.03	14.78		14.94	13
	84.03	14.01	1.03	15.81		15.97	14
	83.00	15.005	1.03	16.84		17.00	15
	81.96	16.005	1.04	17.88		2	
	79.90	18.005	2.06	19.94			
	77.81	20.01	2.09	22.03		22.19	20
	75.73	22.01	2.08	24.11			
	73.63	24.02	2.10	26.21			
	72.60	25.005	1.03	27.24		27.40	25
	71.54	26.015	1.06	28.30			
	69.45	28.01	2.09	30.39			
	67.37	30.015	2.08	32.47		32.63	30
	65.30	32.00	2.07	34.54			
	~~64.25~~	~~Relocated gate stop~~	~~10-16-79~~			~~35.25 gate stop~~	35
3/18/80	63.27	34. ~~35.00~~	2.03	36.57			
	62.27	35. 36.00	1.00	37.57			
	61.32	36. 37.00	0.95	38.52		38.68	
Gate 1	61.18	36. ~~37~~ 37.13	upper	Limit switch			
Gate 2	61.08	36. 37.282	"	"			
Gate 3	61.22	36. 37.14	"	"			

This is the indicator rating at the measured maximum gate opening of 33'.

Attachment A3-2
from Reference A2
5 total pages

Calculation No: CDQ000020080018

SHEET ____ OF ____

Gate No 1
Measured Gate Openings

Tellico Dam
RS

COMPUTED KWK DATE 11-17-20

CHECKED ____ DATE ____

	Ind Read	Left Tape	Right Tape	Avg	Gate Opening
	0.00				
Seal	99.84				
Crest	98.81	or 2.00	or 2.00	2.00	0
1	97.75	3.00	3.00	3.00	1.00
2	96.64	4.01	4.00	4.005	2.005
3	95.57	5.00	4.98	4.99	2.99
4	94.49	6.00	5.98	5.99	3.99
5	93.42	7.00	6.98	6.99	4.99 ✓
6	92.37	7.99	7.98	7.985	5.985
7	91.31	9.00	8.98	8.99	6.99
8	90.26	10.00	9.98	9.99	7.99
9	89.21	11.00	10.99	10.995	8.995
10	88.18	12.00	11.98	11.99	9.99
11	87.13	13.01	12.99	13.00	11.00
12	86.09	14.02	13.99	14.005	12.005
13	85.06	15.02	14.99	15.005	13.005
14	84.03	16.02	15.99	16.005	14.005
15	83.00	17.01	16.99	16.995	14.995
16	81.96	18.02	17.99	18.005	16.005
18	79.90	20.01	19.99	20.00	18.00
20	77.81	22.02	22.00	22.01	20.01
22	75.73	24.01	24.00	24.005	22.005
24	73.63	26.02	26.00	26.01	24.01
25	72.60	27.01	26.99	27.00	25.00
26	71.54	28.02	28.01	28.015	26.015
28	69.45	30.02	30.00	30.01	28.01
30	67.37	32.00	32.00	32.00	30.00
32	65.30				

Calculation No: CDQ000020080018

SHEET _____ OF _____

Gate No 3 — Tellico Dam

Measured gate openings

COMPUTED KWH DATE 11-18-76 (RS)

CHECKED _____ DATE _____

Attachment A3-3
from Reference A2
5 total pages

	Ind Read		Left Tape		Right Tape		Gate Opening
Seal	99.10						
Crest	98.81		2.00 .02		2.00 .03	High	gate
1	97.75		3.00		3.00		1.00
2	96.64		4.01	?	4.02	?	2.015
3	95.57		5.00		5.00		3.00
4	94.49		6.00		6.01		4.005
5	93.42		7.01		7.01		5.01
6	92.37		8.00		8.00		6.00
7	91.31		9.00		9.00		7.00
8	90.26		10.00		10.01		8.005
9	89.21		11.00		11.00		9.00
10	88.18		12.00		12.00		10.00
11	87.13		13.01		13.00		11.005
12	86.09		14.01		14.00		12.005
13	85.06		15.00		15.00		13.000
14	84.03		16.01		16.01		14.01
15	83.00		17.00	Good	17.01		15.005
16	81.96		18.00		18.01		16.005
18	79.90		20.00		20.01		18.005
20	77.81		22.01		22.01		20.01
22	75.73		24.01		24.01		22.01
24	73.63		26.01		26.03		24.02
25	72.60		27.00		27.01		25.005
26	71.54		28.01		28.02		26.015
28	69.45		30.00		30.02		28.01
30	67.37		32.01		32.02		30.015

Gate No C

SHEET ____ OF ____

Measured gate Openings — Tellico Dam

Attachment A3-4
from Reference A2
5 total pages

Calculation No: CDQ000020080018

COMPUTED KWK DATE 11-16-76

CHECKED ____ DATE ____

		Ind. Read		Left Tape			Right Tape		Ave	Gate Opening
	Seal	99.84								
	Crest	98.81	ok	2.00		ok	2.00			
	1	97.75		2.98	.98		3.00	1.00		0.99
	2	96.64		3.98	1.98		4.01	2.00		1.99
	3	95.57		4.97	2.98		5.00	3.00		2.99
	4	94.49		5.99	3.99		6.00	4.00		3.995
	5	93.42		6.99	4.99		7.01	5.01		5.00
	6	92.37		7.99	5.99		8.00	6.00		5.995
	7	91.31		8.99	6.99		9.00	7.00		6.995
	8	90.26		9.99	7.99		10.00	8.00		7.995
	9	89.21		10.99	8.99		10.99	8.99		8.990
	10	88.18		11.99	9.99		12.01	10.01		10.00
	11	87.13		13.00	11.00	Good	13.02	11.02		11.01
	12	86.09		14.00	12.00	"	14.02	12.02		12.01
	13	85.06		15.00	13.00		15.02	13.02		13.01
	14	84.03		16.00	14.00		16.02	14.02		14.01
	15	83.00		17.00	15.00		17.01	15.01		15.01
	16	81.96		18.00	16.00		18.02	16.02		16.01
	18	79.90		20.00	18.00		20.02	18.02		18.01
	20	77.81		22.00	20.00		22.02	20.02		20.01
	22	75.73		24.00	22.00		24.02	22.02		22.01
	24	73.63		26.00	24.00		26.02	24.02		24.01
	25	72.60		27.00	25.00		27.02	25.02		25.01
	26	71.54		28.00	26.00		28.02	26.02		26.01
	28	69.45		30.00	28.00		30.02	28.02		28.01
	30	67.37	✓	32.00	30.00		32.02	30.02		30.01
	32	65.30		34.00	32.00		34.02	32.00		32.00
		64.25	✓	35.03			35.05			

Newt Harris
Paul Martin

Dam Safety Inspection Report - Class B
Tellico Dam

Dates of Inspection: 11/29/2007
File Number: 91-02
Work Order #: 07-136406-000
Report ID: R02TEHCLB112907
EDMS #: J22 080110 002
Headwater: 11/29/07 – 810.61-ft. Tailwater: 11/29/07 – 739.90-ft.

Inspection Participants:
Dam Safety Maintenance: Isaac Allen, D. Webb Patten, Mike Richardson, Travis Simpson
Fort Loudoun Hydro: Jeremy Ellison

This report covers the inspection of the spillway gates.

Maintenance History:

The spillway gate chains were greased using Mobil EAL 102 grease in October 2007.

Spillway Gates:

Tellico Dam has three (3) radial type spillway gates measuring 39'-6" high and 39' wide. The skin plate is stiffened by both horizontal girders and vertical purlins. A supporting truss frame transfers the load from the girders and purlins to the main struts. The load is then carried through the main struts to the trunnions, which are anchored into the spillway piers.

The spillway gates were inspected using Rope Access techniques. Structurally, the gates were in satisfactory condition with various areas of rust, corrosion, and coating loss. Areas of coating loss and mild corrosion were found in the corners of the gates. The gate stops have been moved in the past, allowing the gate to travel open further. However, the effected areas were never properly coated and have heavy surface rust (see Figure 1). Most of the underside 3/8" weld where the strut arms connect to the horizontal girders were not properly coated and have heavy surface rust. A similar condition exists where the second purlin from either side connects to the horizontal girders (see Figure 3). The majority of the areas around the downstream seal nuts had coating loss and mild to moderate rust along the length of the gate (see Figure 4). The lower sections of the gates are in worse condition, coating wise, than the upper two-thirds of the gate. This is especially true on gate 2, where the siphon keeps moisture in the area. The gates should be maintenance coated. The siphon should be extended away from the gate more.

The trunnions were in good condition with the anchor rods in fair-to-good condition. The trunnion blocks had areas of bad surface preparation causing the coating to be in poor condition. The trunnion block's coating condition on gate 2 is in especially poor condition with considerable coating loss, mild-to-moderate rust, corrosion in the corners, pack rust, and moderate-to-heavy pitting in areas (see Figure 5).

TVA 489 (EN DES-11-76)

Attachment A-4
1 page

SHEET _____ OF _____

Attachment A4

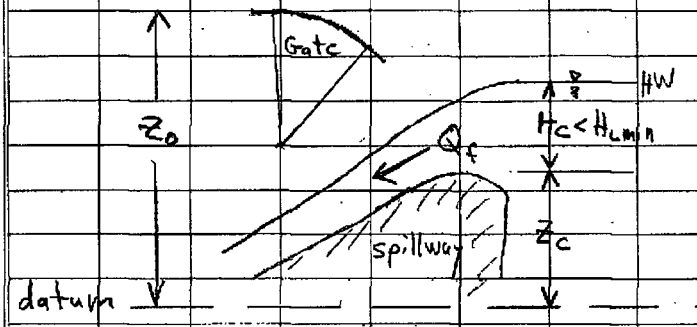
Calculation No: CDQ000020080018

Definition Sketch for Spillway Discharge

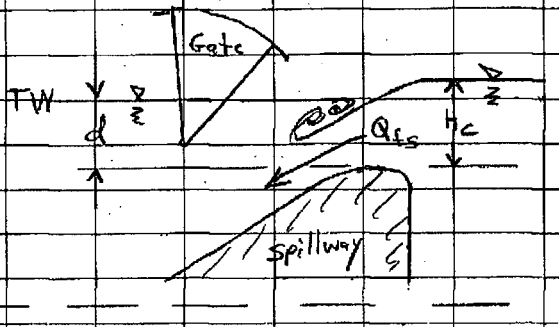
COMPUTED GAS DATE 8/12/2011B

CHECKED J.B.M. DATE 2/3/2009

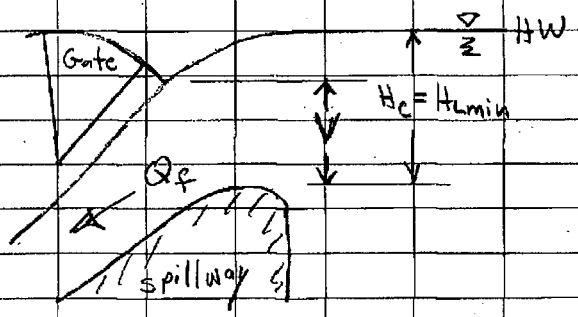
Free Discharge - No Tailwater effect



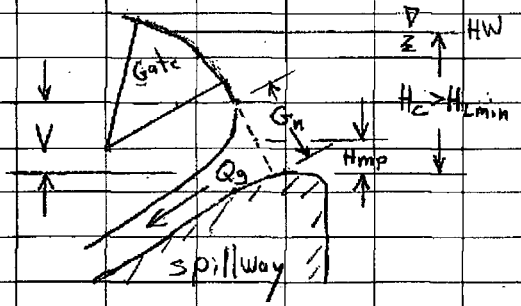
Free Discharge affected by Tailwater



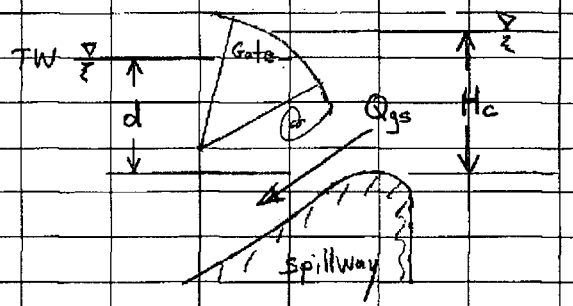
Nappe Touches Gate



Orifice Discharge - No Tailwater Effect



Orifice Discharge affected by Tailwater



Attachment A5
from Ref. A6
1 page

Calculation No: CDQ000020080018

The state of kinematic similarity can be maintained if, and only if, the corresponding force ratios remain constant. That is, if F_a and F_b are the net forces exerted on the fluid elements at A and B,

$$\frac{(F_a)_p}{(F_a)_m} = \frac{(F_b)_p}{(F_b)_m} \tag{11–3}$$

Each of these net forces may be thought of as an inertia force, mass × acceleration. It is made up of a number of different forces (those due to gravity,

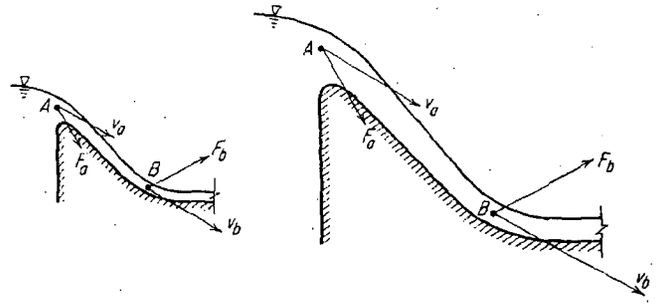


Figure 11-1. *Basic Model-Prototype Relationships*

viscosity, etc.), all of which vary in different ways with v, L, ρ, etc. If each of the ratios in Eq. (11–3) is to be kept constant at all points in the field of flow, then the various components of force must bear a constant ratio to one another. Now it can be shown (Prob. 11.1) that the Froude number is the ratio of inertia force to gravitational force, expressed in general dimensional form; similarly that the Reynolds, Weber, and Cauchy numbers are the ratios of the inertia force to viscous, capillary, and compression forces respectively. The final conclusion is the same as that already drawn from Eq. (11–1): that if a certain type of force is effective in a certain flow situation, the appropriate dimensionless number must be given the same value in the model as in the prototype.

Secondary Scale Ratios

The detailed interpretation of model measurements requires that scale ratios be available for translating model values of various quantities, e.g., velocity, discharge, etc., into the corresponding prototype values. Scales can be deduced for all physical quantities if scales are known for mass, length, time, and the physical properties of prototype and model fluids. It is convenient to introduce here the subscript r to indicate the ratio of prototype : model quantity, e.g., if model lengths are one-tenth those of the protoype, then $L_p/L_m = L_r = 10$, the subscripts p and m indicating prototype and model as before. Now it is always true that the mass ratio $M_r = \rho_r L_r^3$, so we have

scale ratios for mass and length. The time scale T_r is deduced indirectly from the relationship between velocity scale and length scale dictated by the fact that the appropriate dimensionless number, e.g., the Froude number, must be kept constant.

In open channel flow the presence of a free surface means that the Froude number Fr is always significant, indeed dominant. The secondary scale ratios based on the constancy of Fr and its corollary

$$v_r = L_r^{1/2} \tag{11–4}$$

will therefore be applicable, although they may be modified in some case by the action of influences other than gravity. A complete list of scale ratios is therefore as follows

$\frac{V_p}{V_m}$ & $\frac{H_p}{H_m}$ →

Mass	M_r	$= \rho_r L_r^3$
Length	L_r	$= L_r$
Velocity	v_r	$= L_r^{1/2}$
Time	$T_r = L_r v_r^{-1}$	$= L_r^{1/2}$

$\frac{Q_p}{Q_m}$ →

Discharge	$Q_r = v_r L_r^2$	$= L_r^{2\frac{1}{2}}$
Force	$F_r = M_r L_r T_r^{-2}$	$= \rho_r L_r^3$
Pressure	$p_r = F_r L_r^{-2}$	$= \rho_r L_r$

(11–5)

as the reader can verify (Prob. 11.2).

The Influence of Forces Other Than Gravity

Compressibility effects are never significant in open channel flow models. Surface tension effects are appreciable only when radii of curvature of the liquid surface, and the distances from solid boundaries, are very small. They will therefore be negligible in all real prototype situations, and care must be taken to keep them negligible in model situations. This is accomplished by keeping model water depths no less than an inch or two, and similarly for channel widths. Beyond the taking of this precaution, capillary effects do not warrant any further attention.

Viscosity is much more important, and exerts its influence in many different situations. The term *scale effect* can be introduced here; it is the name given to the slight distortions introduced by forces—for example, viscosity—other than the dominant one, such as gravity. Such effects are often slight without being altogether negligible. For example, the flow over a spillway will encounter some slight viscous resistance down the face of the spillway, although resistance will be negligible at the crest itself, where the discharge-head relation is determined.

The only perfect way of dealing with the effect of viscosity is to keep both

Attachment A6-1
5 total pages

SHEET 1 OF 5

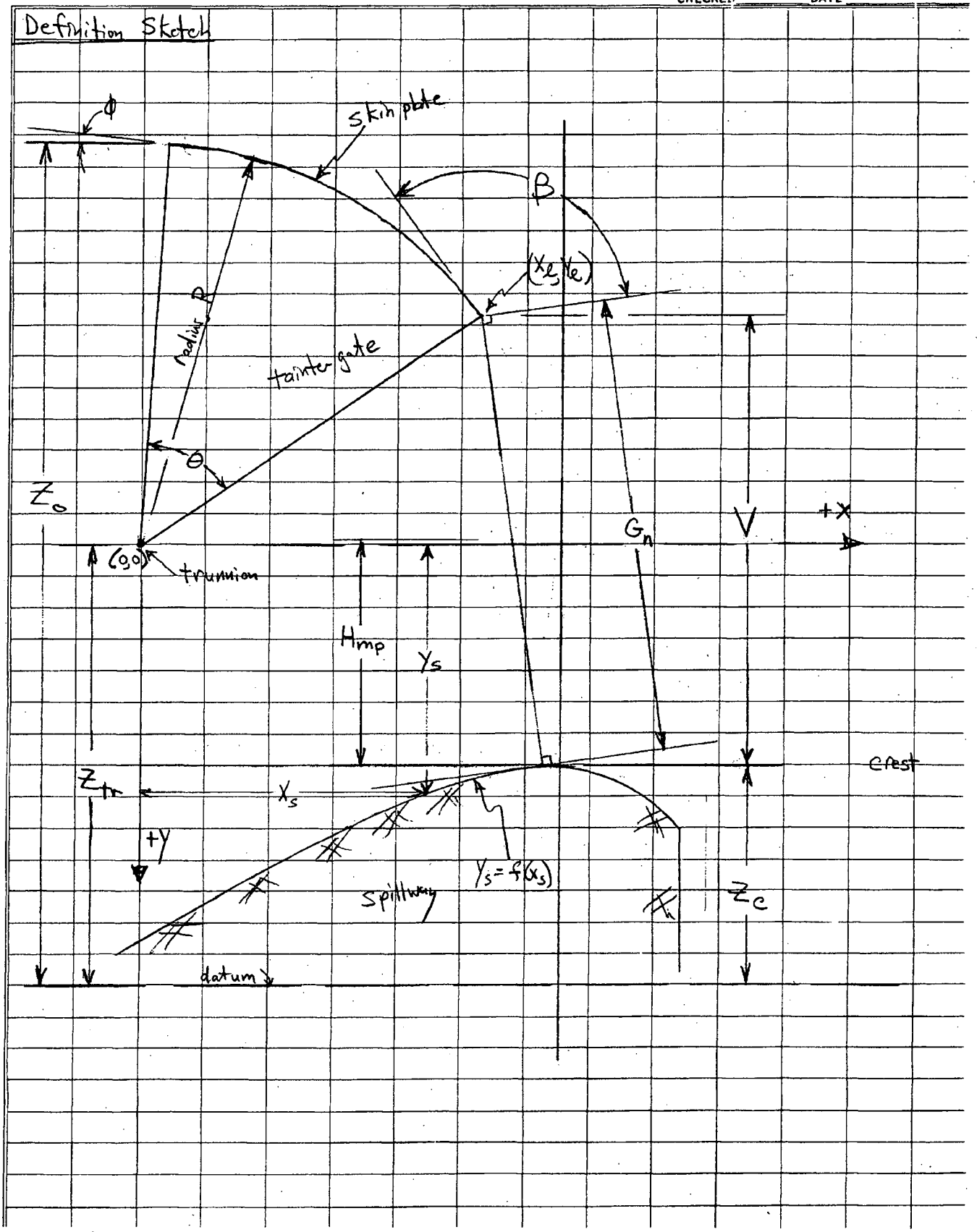
Spillway Discharge Calculations
Geometry for Flow Under an Open Tainter Gate

Calculation No: CDQ000020080018

COMPUTED CAS DATE 8/11/2008

CHECKED J.B.M. DATE 2/3/2009

Definition Sketch



Calculation No: CDQ000020080018

Spillway Gate Geometry

COMPUTED GAS DATE 8/11/2008

CHECKED J.B.M. DATE 2/3/2009

Variables

V = Vertical distance between the bottom of the open gate and the crest

Z_c = crest elevation

Z_{tr} = trunnion elevation

Z_o = overflow elevation

R = radius of the tainter gate

G_n = minimum distance between the gate lip and the crest

H_{mp} = vertical distance between the mid-point of G_n and the crest

β = angle formed by the tangent to the gate lip and the tangent to the crest curve at the nearest point of the crest curve

Θ = angle of the sector of a circle formed by two lines connecting the trunnion axis to the bottom and top of the radial gate.

X, Y = Coordinates relative to trunnion axis (Y positive downward)

X_s, Y_s = Coordinates of spillway surface defined by $Y_s = f(X_s)$

X_ℓ, Y_ℓ = coordinates of the gate lip relative to trunnion axis

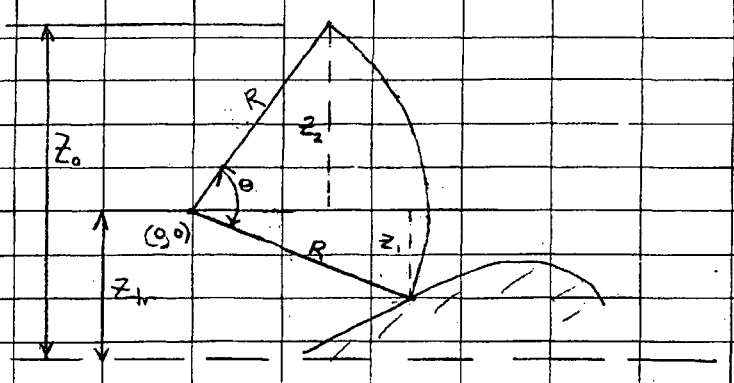
notes: Y positive downward for all coordinates
all coordinates relative to trunnion axis

ϕ = angle formed by the tangent to the gate top and horizontal

Angle, Θ

$$\Theta = \sin^{-1}\left(\frac{Z_2}{R}\right) + \sin^{-1}\left(\frac{Z_1}{R}\right)$$

Z_1 & Z_2 are determined from drawings



Closed Gate

Spillway Gate Geometry

Calculation No: CDQ000020080018

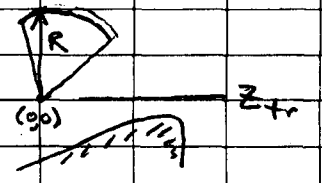
COMPUTED GAS DATE 8/11/2008

CHECKED J.B.M. DATE 2/3/2009

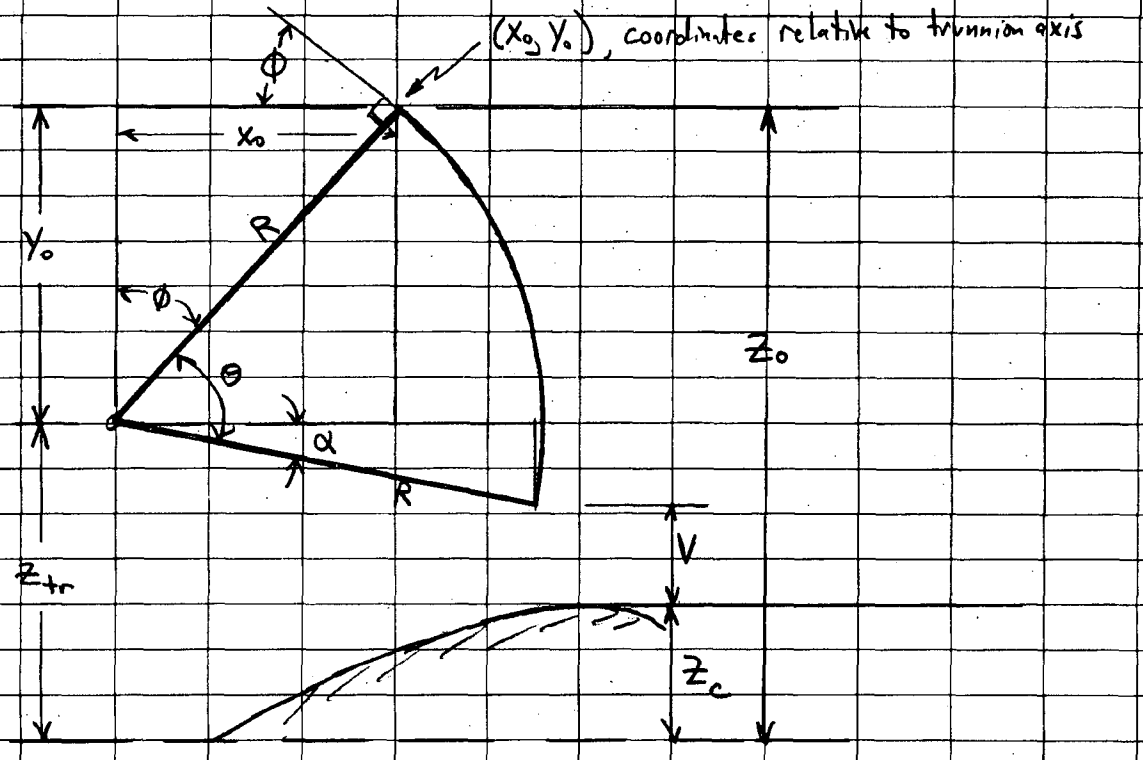
Overflow Elevation, Z_o and Angle, Φ

For a gate opened so far that its upper edge is downstream of the trunnion:

$$Z_o = Z_{tr} + R$$



For a gate opened less:



$$\alpha = \tan^{-1}\left(\frac{Z_{tr} - (Z_{cr} + V)}{\sqrt{R^2 - (Z_{tr} - Z_{cr} - V)^2}}\right)$$

V given

$$\boxed{Z_o = Z_{tr} + R\sin(\theta - \alpha)}$$

and $$\boxed{\Phi = \tan^{-1}\left(\frac{X_o}{Y_o}\right)}$$ with $$\begin{cases} Y_o = Z_o - Z_{tr} \\ X_o = R\cos(\theta - \alpha) \end{cases}$$

Calculation No: CDQ000020080018

Spillway Gate Geometry

COMPUTED GAS DATE 8/11/2008

CHECKED J.B.M. DATE 2/3/2009

Gate Opening, G_n

Gate lip coordinates: $\begin{cases} Y_\ell = Z_{tr} - Z_{cr} - V \\ X_\ell = \sqrt{R^2 - Y_\ell^2} \end{cases}$

Distance between gate lip and any point on spillway surface is

$$\ell = \sqrt{(X_s - X_\ell)^2 + (Y_s - Y_\ell)^2} \equiv \sqrt{(X_s - X_\ell)^2 + [f(X_s) - Y_\ell]^2}$$

G_n is the minimum distance. ℓ is minimum when $\frac{d\ell}{dX_s} = 0$

$$\frac{d\ell}{dX_s} = \frac{1}{2}\left\{(X_{sn} - X_\ell)^2 + [f(X_{sn}) - Y_\ell]^2\right\}^{-1/2} \cdot \left\{2(X_{sn} - X_\ell) + 2[f(X_{sn}) - Y_\ell]\frac{df(X_{sn})}{dX_s}\right\} = 0$$

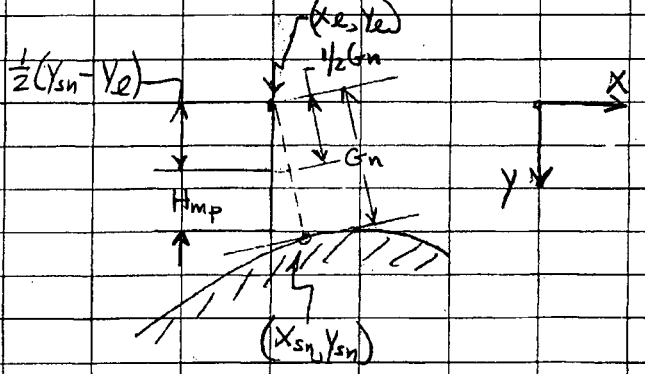
$$\Rightarrow 0 = \frac{(X_{sn} - X_\ell) + [f(X_{sn}) - Y_\ell]\frac{df(X_{sn})}{dX_s}}{\ell_{minimum}}$$

where $X_{sn} = X_s$ for minimum ℓ, $\ell_{minimum} \equiv G_n$.

Solve: $X_{sn} - X_\ell + [f(X_{sn}) - Y_\ell]\frac{df(X_{sn})}{dX_s} = 0$ for X_{sn}

Then: $Y_{sn} = f(X_{sn})$ and $\boxed{G_n = \sqrt{(X_{sn} - X_\ell)^2 + (Y_{sn} - Y_\ell)^2}}$

Mid-Point Head, H_{mp}



$H_{mp} = Z_{tr} - Z_c - Y_\ell - \frac{1}{2}(Y_{sn} - Y_\ell)$

$\Rightarrow \boxed{H_{mp} = V - \frac{1}{2}(Y_{sn} - Y_\ell)}$

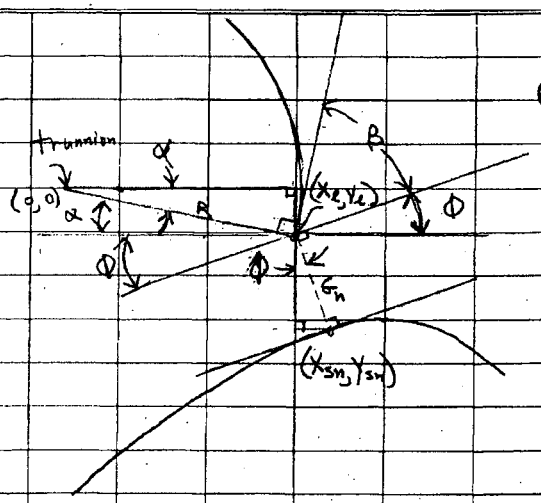
Calculation No: CDQ000020080018

Spillway Gate Geometry

COMPUTED GAS DATE

CHECKED J.B.M. DATE 2/3/2009

Angle, B



$$\beta + \frac{\pi}{2} + \alpha + \Phi = \pi$$

$$\beta + \Phi = \frac{\pi}{2} - \alpha$$

$$\beta = \frac{\pi}{2} - \alpha - \Phi$$

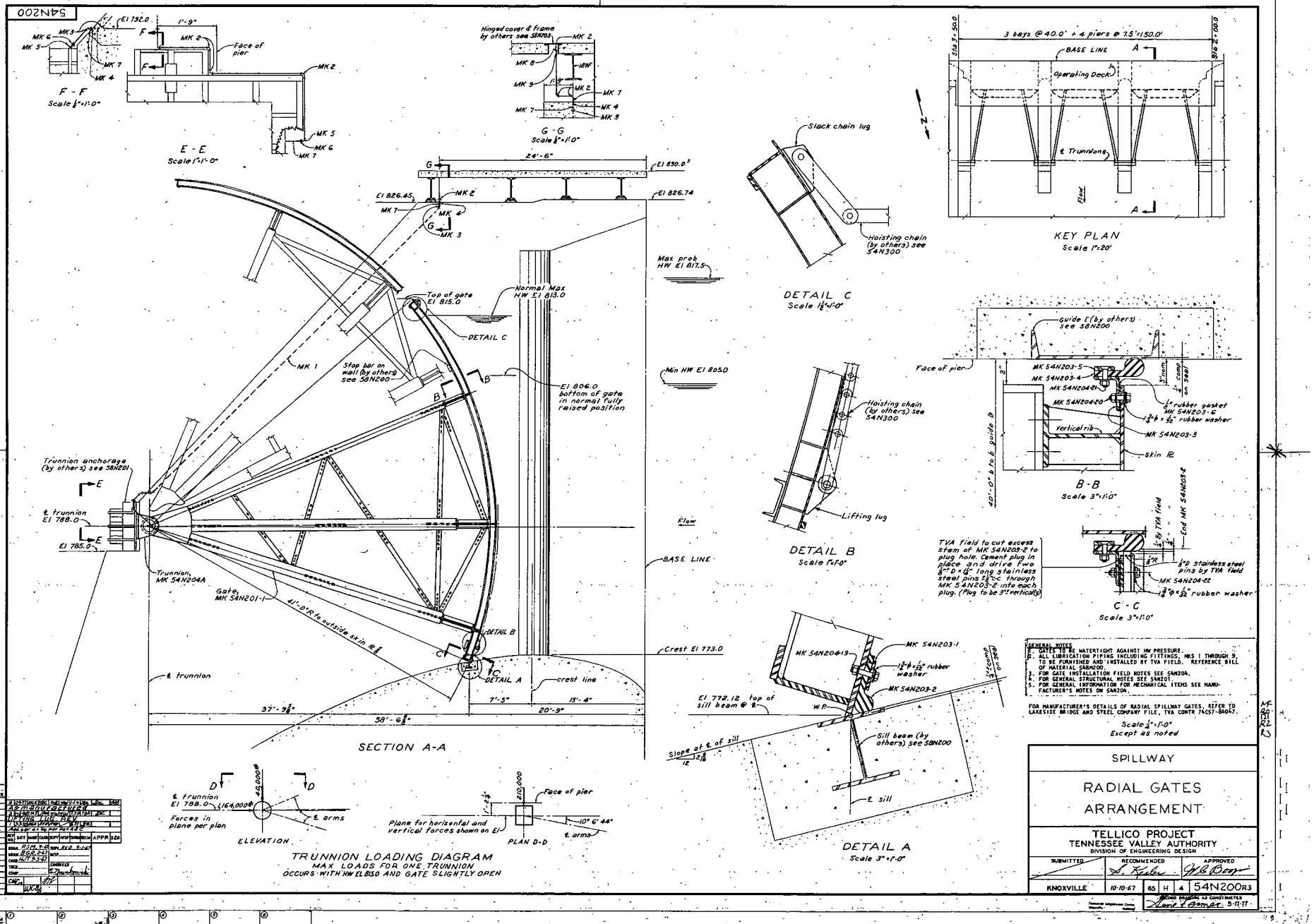
$$\alpha = \tan^{-1}\left(\frac{Y_e}{X_e}\right)$$

$$\Phi = \tan^{-1}\left(\frac{X_{sn} - X_e}{Y_{sn} - Y_e}\right)$$

$$\beta = \frac{\pi}{2} - \tan^{-1}\left(\frac{Y_e}{X_e}\right) - \tan^{-1}\left(\frac{X_{sn} - X_e}{Y_{sn} - Y_e}\right)$$

Calculation No: CDQ000020080018

Attachment A7
Reference A7
1 page



GENERAL NOTES

1. GATES TO BE WATERTIGHT AGAINST HW PRESSURE.
2. ALL LUBRICATION PIPING INCLUDING FITTINGS, MKS 1 THROUGH 9, TO BE FURNISHED AND INSTALLED BY TVA FIELD. REFERENCE BILL OF MATERIAL 54N200.
3. FOR GATE INSTALLATION FIELD NOTES SEE 54N204.
4. FOR GENERAL STRUCTURAL NOTES SEE 54N201.
5. FOR GENERAL INFORMATION FOR MECHANICAL ITEMS SEE MANUFACTURER'S NOTES ON 54N204.

FOR MANUFACTURER'S DETAILS OF RADIAL SPILLWAY GATES, REFER TO LAKESIDE BRIDGE AND STEEL COMPANY FILE, TVA CONTR 74C57-84047.

Scale ½"=1'-0"
Except as noted

TVA field to cut excess stem of MK 54N203-2 to plug hole. Cement plug in place and drive Two ⅜" D x 1¼" long stainless steel pins ⅔ c to c through MK 54N203-2 into each plug. (Plug to be 3" vertical)

SPILLWAY

RADIAL GATES
ARRANGEMENT

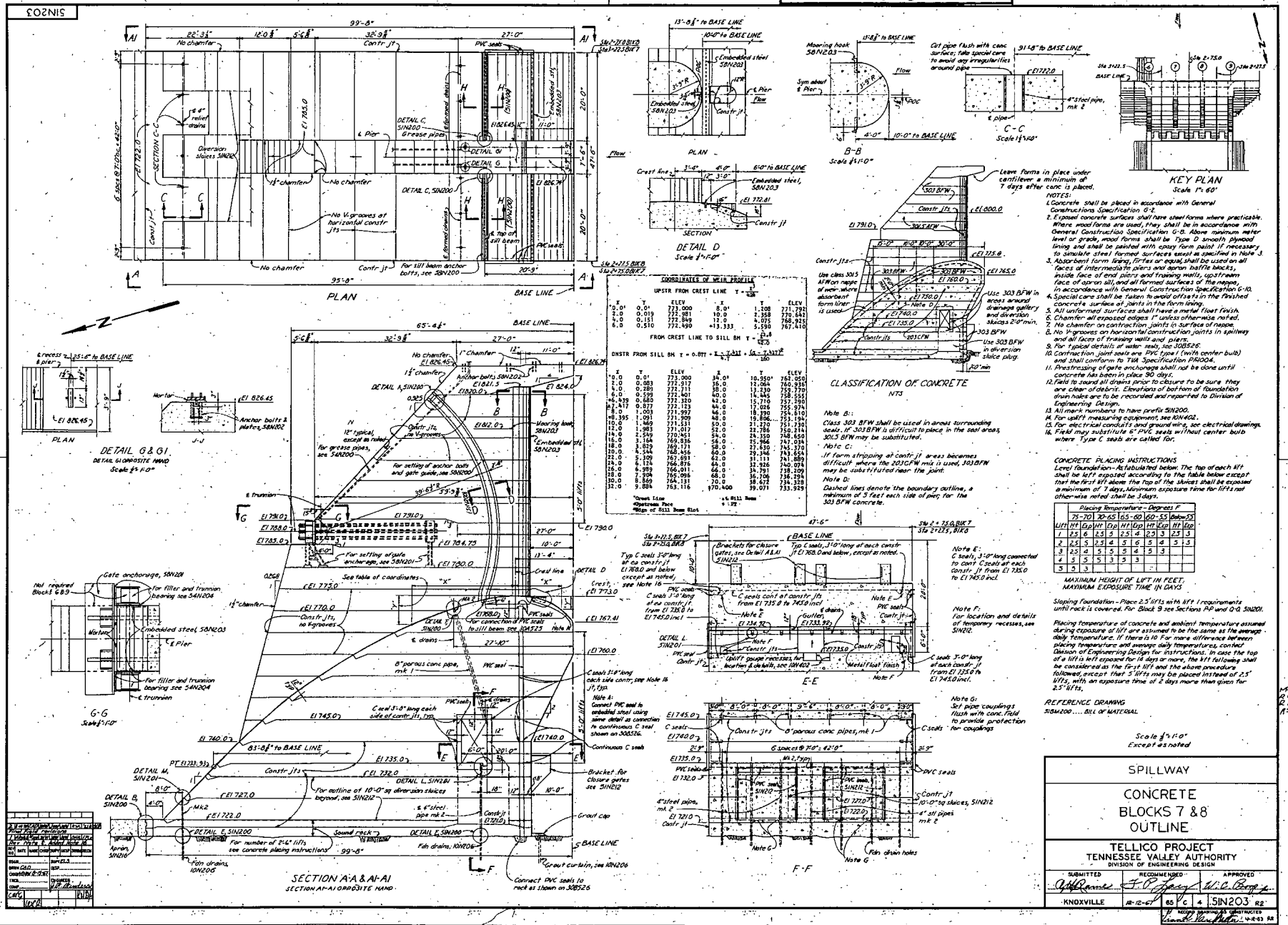
TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED
	L Kuhn	G B Dorr
KNOXVILLE	10-10-67	65 H 4 54N200R3

ISSUED DRAWING AS CONSTRUCTED
Lent L Bonar 5-11-77

Calculation No: CDQ000020080018

Attachment A8
Reference A8
1 page



Attachment A9-1
2 total pages

Calculation No: CDQ000020080018

$H_{L,min}$ vs. V

Prepared by: S.E.M.
Checked by: J.B.M.

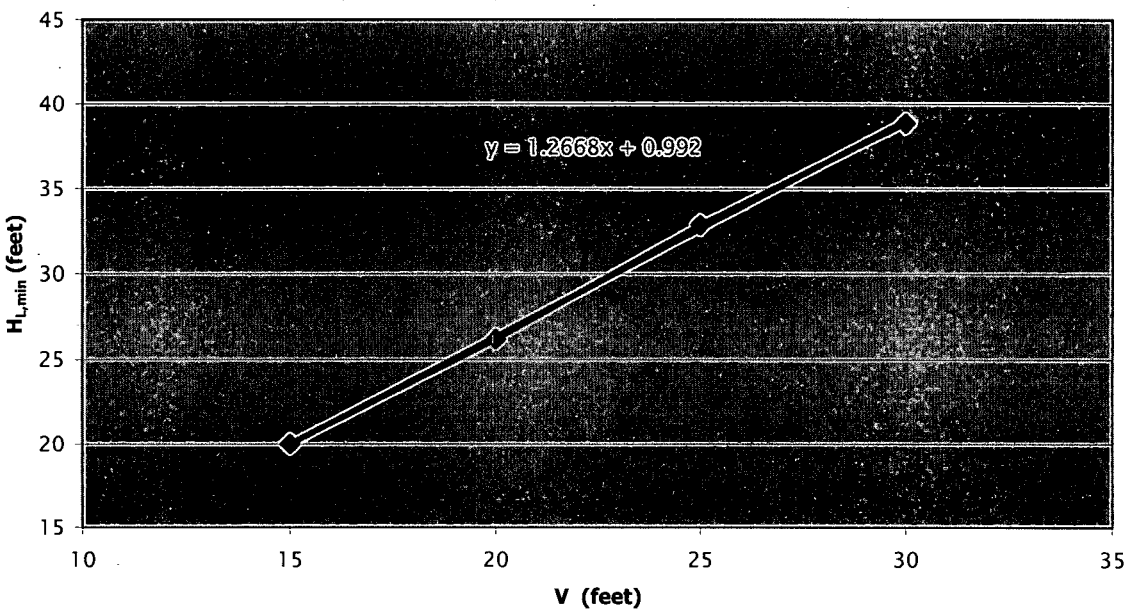
V is the vertical gate opening.

The values of H_{L1} are determined from the chart in the "Model Data Unaffected by Submergence Compared with Free Discharge" chart.

The values of $H_{L,min}$ have been calculated from the linear curve fit to the H_{L1} values.

$H_{L,min}$ is measured from the crest to the point where the nappe first touches the lip of the open gate.

	V	H	$H_{L,min}$	
17.00	15	20.00	19.994	1.33
22.19	20	26.20	26.328	1.31
27.40	25	32.90	32.662	1.32
32.63	30	38.88	38.996	1.30
35.75	**33**		**42.796**	$H_{L,min}$ from extrapolation

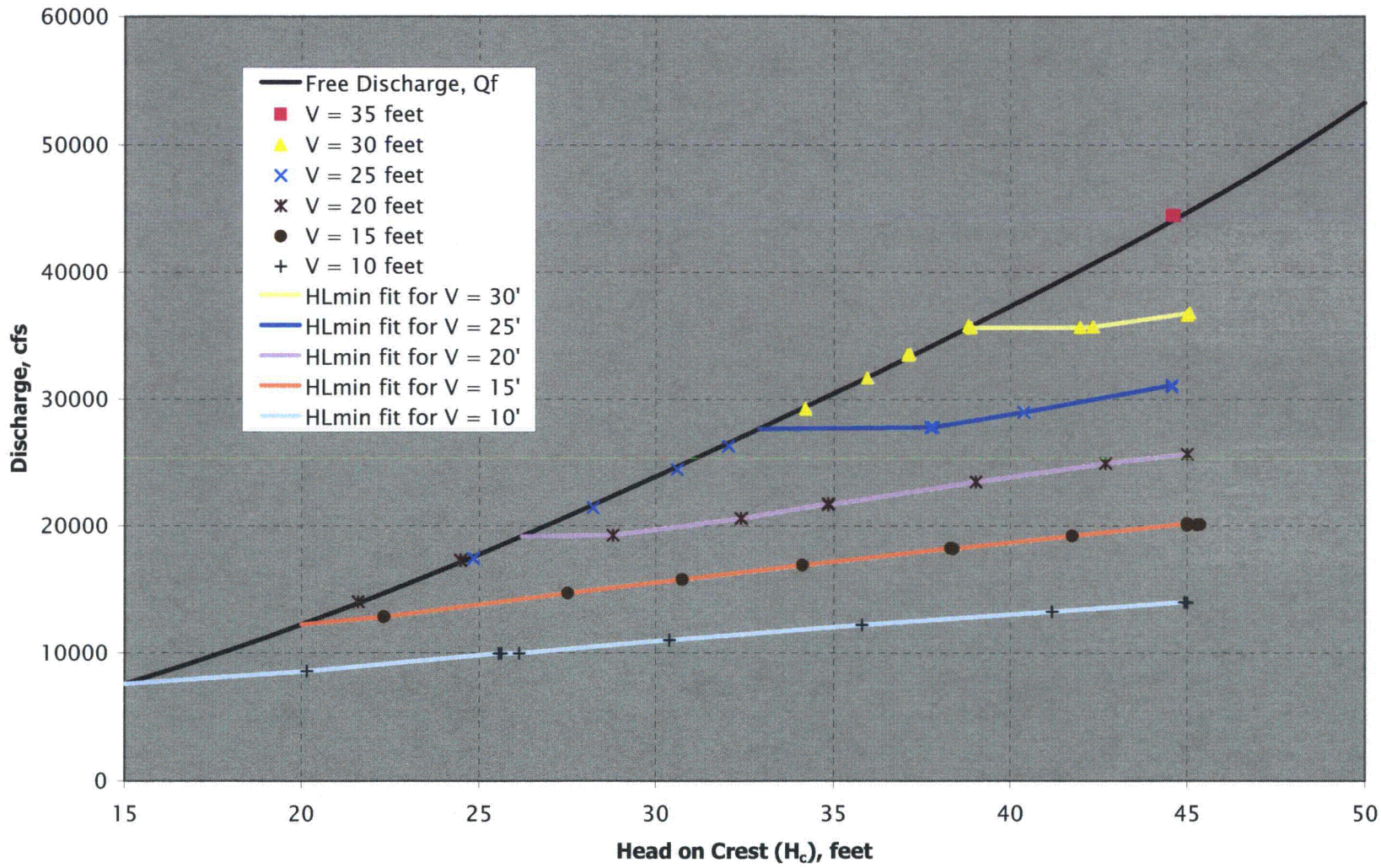


Calculation No: CDQ000020080018

Attachment A9-2
2 total pages

Prepared by: S.E.M.
Checked by: J.B.M.

Model Data Unaffected by Submergence Compared with Free Discharge



Attachment A10-1
4 total pages

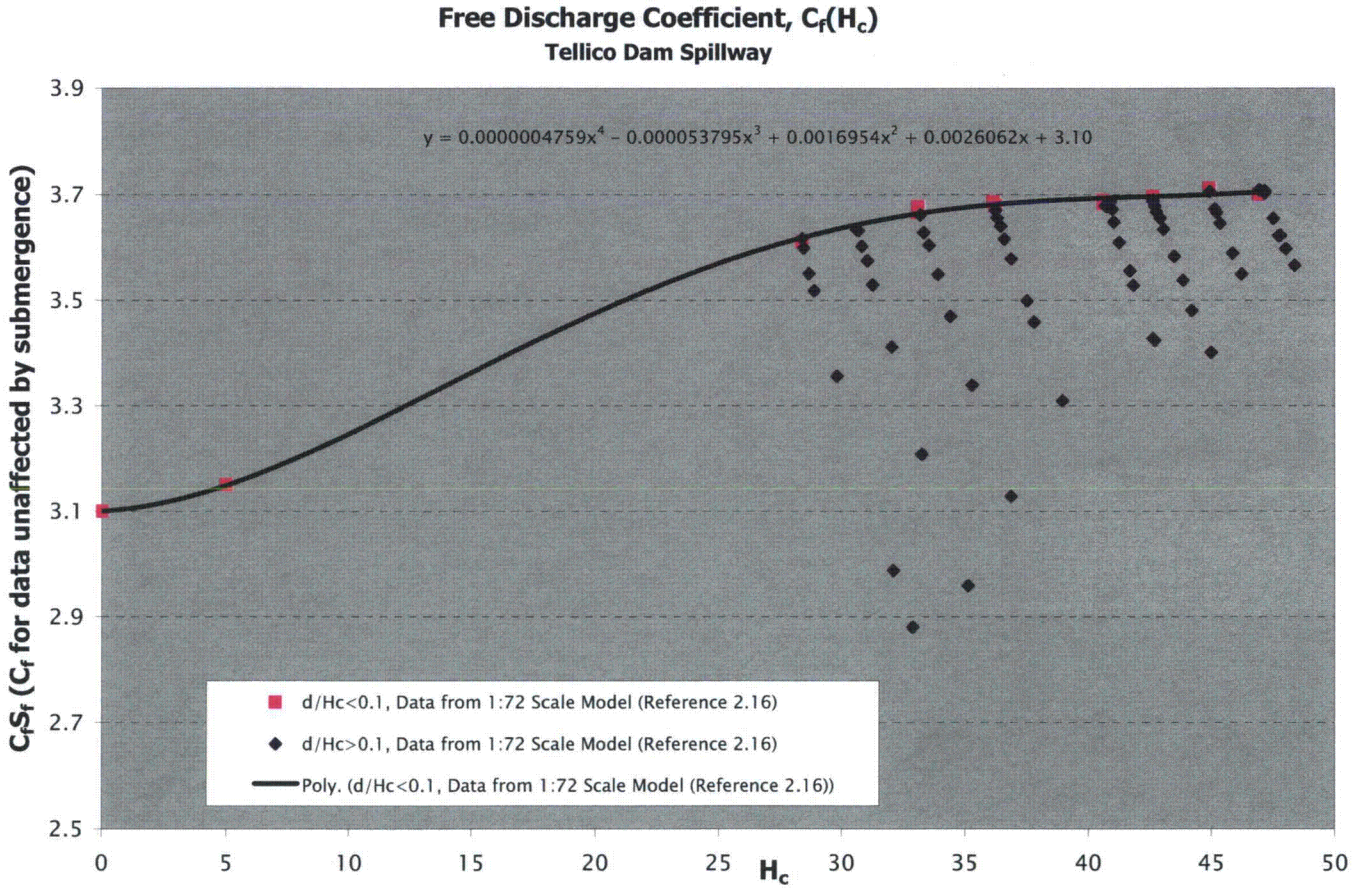
Determination of Free Flow Coefficient, C_f

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.

ft. 4th-order curve fit to points for which $d/H_c < 0.6$ (see plot for equation)

H_c	C_f
0	3.100
0.5	3.102
1	3.104
2	3.112
4	3.134
6	3.166
8	3.204
10	3.247
12	3.292
15	3.363
18	3.432
21	3.497
25	3.570
30	3.637
34	3.670
37	3.684
40	3.692
42	3.695
44	3.698
46	3.702
48	3.708
50	3.719



Attachment A10-2
Data from Reference A2
4 total pages

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.

Free Discharge Model Data

Tellico Project
Tainter Gates Raised Above the Water Surface
Tellico Spillway Rating, 1:72 Model, Book 2 of 2, 1969
under tab: "Open Gate" (Ref. A3)

Model scale, S = 72
L_p = 40 ft
g = 32.2 ft/s^2
Z_c = 773 ft

Submergence Effects

	Model Data			Prototype Values											
	ft	ft	cfs (3 bays)	ft			ft		cfs (3 bays)	cfs (1 bay)					
Test No.	$H_{c,m}$	d_m	$Q_{f,m}$	$H_{c,p}$ (1)	HW elev (ft)	d_p (2)	TW elev. (ft	$Q_{f,p}$ (3)	$Q_{fs,p}$	d/H_c (4)	C_fS_f (5)	Cf (6)	Sf (7)	
56	0.46	-0.18	1.912	33.120	806.120	-12.96	760.040	84104	28035	-0.391	3.677	3.664	1.003	
45	0.502	-0.124	2.185	36.144	809.144	-8.93	764.072	96113	32038	-0.247	3.686	3.681	1.001	
32	0.564	-0.132	2.604	40.608	813.608	-9.50	763.496	114544	38181	-0.234	3.689	3.693	0.999	
57	0.46	-0.094	1.906	33.120	806.120	-6.77	766.232	83841	27947	-0.204	3.666	3.664	1.000	
21	0.592	-0.086	2.806	42.624	815.624	-6.19	766.808	123429	41143	-0.145	3.696	3.696	1.000	
75	0.394	-0.041	1.488	28.368	801.368	-2.95	770.048	65454	21818	-0.104	3.610	3.618	0.998	
46	0.503	-0.046	2.187	36.216	809.216	-3.31	769.688	96201	32067	-0.091	3.678	3.681	0.999	
11	0.624	-0.015	3.049	44.928	817.928	-1.08	771.920	134118	44706	-0.024	3.711	3.700	1.003	
33	0.564	-0.004	2.6	40.608	813.608	-0.29	772.712	114368	38123	-0.007	3.683	3.693	0.997	
10	0.652	-0.004	3.247	46.944	819.944	-0.29	772.712	142828	47609	-0.006	3.701	3.705	0.999	
66	0.425	0.006	1.682	30.600	803.600	0.43	773.432	73987	24662	0.014	3.642	3.643	1.000	
47	0.503	0.025	2.187	36.216	809.216	1.80	774.800	96201	32067	0.050	3.678	3.681	0.999	
1	0.654	0.036	3.284	47.088	820.088	2.59	775.592	144456	48152	0.055	3.726	3.705	1.006	
34	0.565	0.036	2.606	40.680	813.680	2.59	775.592	114632	38211	0.064	3.682	3.693	0.997	
58	0.46	0.03	1.907	33.120	806.120	2.16	775.160	83885	27962	0.065	3.667	3.664	1.001	
19	0.592	0.041	2.799	42.624	815.624	2.95	775.952	123122	41041	0.069	3.687	3.696	0.997	
12	0.624	0.058	3.049	44.928	817.928	4.18	777.176	134118	44706	0.093	3.711	3.700	1.003	
48	0.503	0.063	2.182	36.216	809.216	4.54	777.536	95981	31994	0.125	3.670	3.681	0.997	
76	0.394	0.054	1.491	28.368	801.368	3.89	776.888	65586	21862	0.137	3.617	3.618	1.000	
67	0.425	0.059	1.678	30.600	803.600	4.25	777.248	73811	24604	0.139	3.634	3.643	0.997	
35	0.565	0.087	2.604	40.680	813.680	6.26	779.264	114544	38181	0.154	3.679	3.693	0.996	
20	0.592	0.092	2.801	42.624	815.624	6.62	779.624	123210	41070	0.155	3.690	3.696	0.998	
14	0.624	0.11	3.044	44.928	817.928	7.92	780.920	133899	44633	0.176	3.705	3.700	1.001	
2	0.655	0.123	3.271	47.160	820.160	8.86	781.856	143884	47961	0.188	3.702	3.705	0.999	
9	0.652	0.132	3.254	46.944	819.944	9.50	782.504	143136	47712	0.202	3.708	3.705	1.001	
31	0.593	0.123	2.8	42.696	815.696	8.86	781.856	123166	41055	0.207	3.679	3.696	0.995	
49	0.504	0.113	2.18	36.288	809.288	8.14	781.136	95893	31964	0.224	3.656	3.682	0.993	
59	0.461	0.107	1.91	33.192	806.192	7.70	780.704	84017	28006	0.232	3.661	3.665	0.999	
23	0.593	0.14	2.799	42.696	815.696	10.08	783.080	123122	41041	0.236	3.678	3.696	0.995	
43	0.568	0.136	2.63	40.896	813.896	9.79	782.792	115688	38563	0.239	3.686	3.694	0.998	
30	0.594	0.152	2.798	42.768	815.768	10.94	783.944	123078	41026	0.256	3.667	3.696	0.992	
13	0.627	0.161	3.039	45.144	818.144	11.59	784.592	133679	44560	0.257	3.673	3.700	0.993	
68	0.426	0.116	1.683	30.672	803.672	8.35	781.352	74031	24677	0.272	3.632	3.644	0.997	
22	0.592	0.162	2.799	42.624	815.624	11.66	784.664	123122	41041	0.274	3.687	3.696	0.997	
36	0.566	0.156	2.61	40.752	813.752	11.23	784.232	114808	38269	0.276	3.678	3.694	0.996	
3	0.655	0.182	3.275	47.160	820.160	13.10	786.104	144060	48020	0.278	3.707	3.705	1.000	
18	0.628	0.198	3.041	45.216	818.216	14.26	787.256	133767	44589	0.315	3.666	3.700	0.991	
42	0.569	0.18	2.627	40.968	813.968	12.96	785.960	115556	38519	0.316	3.672	3.694	0.994	

Calculation No: CDQ000020080018

Attachment A10-3
Data from Reference A2
4 total pages

Prepared by: S.E.M.
Checked by: J.B.M.

Submerged Free Discharge

25	0.596	0.194	2.803	42.912	815.912	13.97	786.968	123298	41099	0.326	3.655	3.697	0.989
50	0.506	0.165	2.184	36.432	809.432	11.88	784.880	96069	32023	0.326	3.641	3.682	0.989
77	0.395	0.13	1.489	28.440	801.440	9.36	782.360	65498	21833	0.329	3.599	3.619	0.994
37	0.57	0.199	2.616	41.040	814.040	14.33	787.328	115072	38357	0.349	3.647	3.694	0.987
60	0.463	0.163	1.905	33.336	806.336	11.74	784.736	83797	27932	0.352	3.628	3.666	0.990
4	0.66	0.25	3.266	47.520	820.520	18.00	791.000	143664	47888	0.379	3.655	3.706	0.986
16	0.63	0.242	3.038	45.360	818.360	17.42	790.424	133635	44545	0.384	3.645	3.701	0.985
69	0.428	0.17	1.681	30.816	803.816	12.24	785.240	73943	24648	0.397	3.602	3.645	0.988
24	0.598	0.244	2.801	43.056	816.056	17.57	790.568	123210	41070	0.408	3.634	3.697	0.983
51	0.508	0.218	2.182	36.576	809.576	15.70	788.696	95981	31994	0.429	3.616	3.683	0.982
5	0.664	0.297	3.267	47.808	820.808	21.38	794.384	143708	47903	0.447	3.623	3.708	0.977
8	0.663	0.301	3.259	47.736	820.736	21.67	794.672	143356	47785	0.454	3.622	3.707	0.977
61	0.466	0.212	1.911	33.552	806.552	15.26	788.264	84060	28020	0.455	3.604	3.667	0.983
38	0.573	0.261	2.609	41.256	814.256	18.79	791.792	114764	38255	0.455	3.609	3.694	0.977
78	0.398	0.19	1.486	28.656	801.656	13.68	786.680	65366	21789	0.477	3.551	3.622	0.980
44	0.579	0.277	2.611	41.688	814.688	19.94	792.944	114852	38284	0.478	3.556	3.695	0.962
15	0.637	0.309	3.041	45.864	818.864	22.25	795.248	133767	44589	0.485	3.589	3.702	0.970
70	0.431	0.214	1.686	31.032	804.032	15.41	788.408	74163	24721	0.497	3.575	3.647	0.980
26	0.604	0.3	2.803	43.488	816.488	21.60	794.600	123298	41099	0.497	3.583	3.697	0.969
6	0.667	0.342	3.266	48.024	821.024	24.62	797.624	143664	47888	0.513	3.597	3.708	0.970
52	0.512	0.266	2.185	36.864	809.864	19.15	792.152	96113	32038	0.520	3.578	3.684	0.971
62	0.471	0.256	1.912	33.912	806.912	18.43	791.432	84104	28035	0.544	3.549	3.670	0.967
7	0.672	0.368	3.274	48.384	821.384	26.50	799.496	144016	48005	0.548	3.566	3.710	0.961
17	0.642	0.363	3.043	46.224	819.224	26.14	799.136	133855	44618	0.565	3.549	3.703	0.959
79	0.401	0.227	1.489	28.872	801.872	16.34	789.344	65498	21833	0.566	3.518	3.625	0.971
27	0.609	0.346	2.802	43.848	816.848	24.91	797.912	123254	41085	0.568	3.537	3.698	0.957
39	0.581	0.334	2.604	41.832	814.832	24.05	797.048	114544	38181	0.575	3.528	3.695	0.955
71	0.434	0.253	1.682	31.248	804.248	18.22	791.216	73987	24662	0.583	3.530	3.649	0.967
53	0.521	0.312	2.193	37.512	810.512	22.46	795.464	96465	32155	0.599	3.499	3.686	0.949
28	0.614	0.374	2.791	44.208	817.208	26.93	799.928	122770	40923	0.609	3.481	3.699	0.941
63	0.478	0.302	1.911	34.416	807.416	21.74	794.744	84060	28020	0.632	3.470	3.673	0.945
54	0.525	0.336	2.193	37.800	810.800	24.19	797.192	96465	32155	0.640	3.459	3.687	0.938
41	0.592	0.394	2.602	42.624	815.624	28.37	801.368	114456	38152	0.666	3.427	3.696	0.927
40	0.593	0.395	2.606	42.696	815.696	28.44	801.440	114632	38211	0.666	3.424	3.696	0.926
72	0.445	0.303	1.688	32.040	805.040	21.82	794.816	74251	24750	0.681	3.412	3.656	0.933
29	0.625	0.427	2.801	45.000	818.000	30.74	803.744	123210	41070	0.683	3.401	3.700	0.919
80	0.414	0.296	1.49	29.808	802.808	21.31	794.312	65542	21847	0.715	3.356	3.635	0.923
64	0.49	0.355	1.909	35.280	808.280	25.56	798.560	83973	27991	0.724	3.339	3.677	0.908
55	0.541	0.399	2.195	38.952	811.952	28.73	801.728	96553	32184	0.738	3.310	3.690	0.897
73	0.462	0.359	1.679	33.264	806.264	25.85	798.848	73855	24618	0.777	3.208	3.665	0.875
65	0.512	0.406	1.91	36.864	809.864	29.23	802.232	84017	28006	0.793	3.128	3.684	0.849
82	0.446	0.365	1.483	32.112	805.112	26.28	799.280	65234	21745	0.818	2.987	3.657	0.817
74	0.488	0.405	1.681	35.136	808.136	29.16	802.160	73943	24648	0.830	2.959	3.676	0.805
81	0.457	0.387	1.483	32.904	805.904	27.86	800.864	65234	21745	0.847	2.880	3.663	0.786

Calculation No: CDQ000020080018

Attachment A10-4
Data from Reference A2
4 total pages

Prepared by: S.E.M.
Checked by: J.B.M.

Formulas:

(1) $H_{c,p} = S * H_{c,m}$

(2) HW elev = $Z_c + H_{c,p}$

(2) $d_p = Sd_m$

(3) TW elev = $Z_c + d_p$

(3) $Q_{f,p} = S^{2.5}Q_{f,m}$

(4) $d/H_c = d_p/H_{c,p}$

(5) $C_fS_f = Q_{fs,p}/(L_pH_{c,p}^{1.5})$

(6) $C_f = 1.1582x10^{-6}H_{cp}^4 + 1.2994x10^{-4}H_{cp}^3 - .0044938H_{cp}^2 + .031271H_{cp} + 3.1$

(7) $S_f = C_fS_f/C_f$

Note: No small values of H_{cp} were tested because H_{cp}=35 feet at minimum operating headwater

Attachment A11
Data from Reference A2
1 page

Calculation No: CDQ000020080018

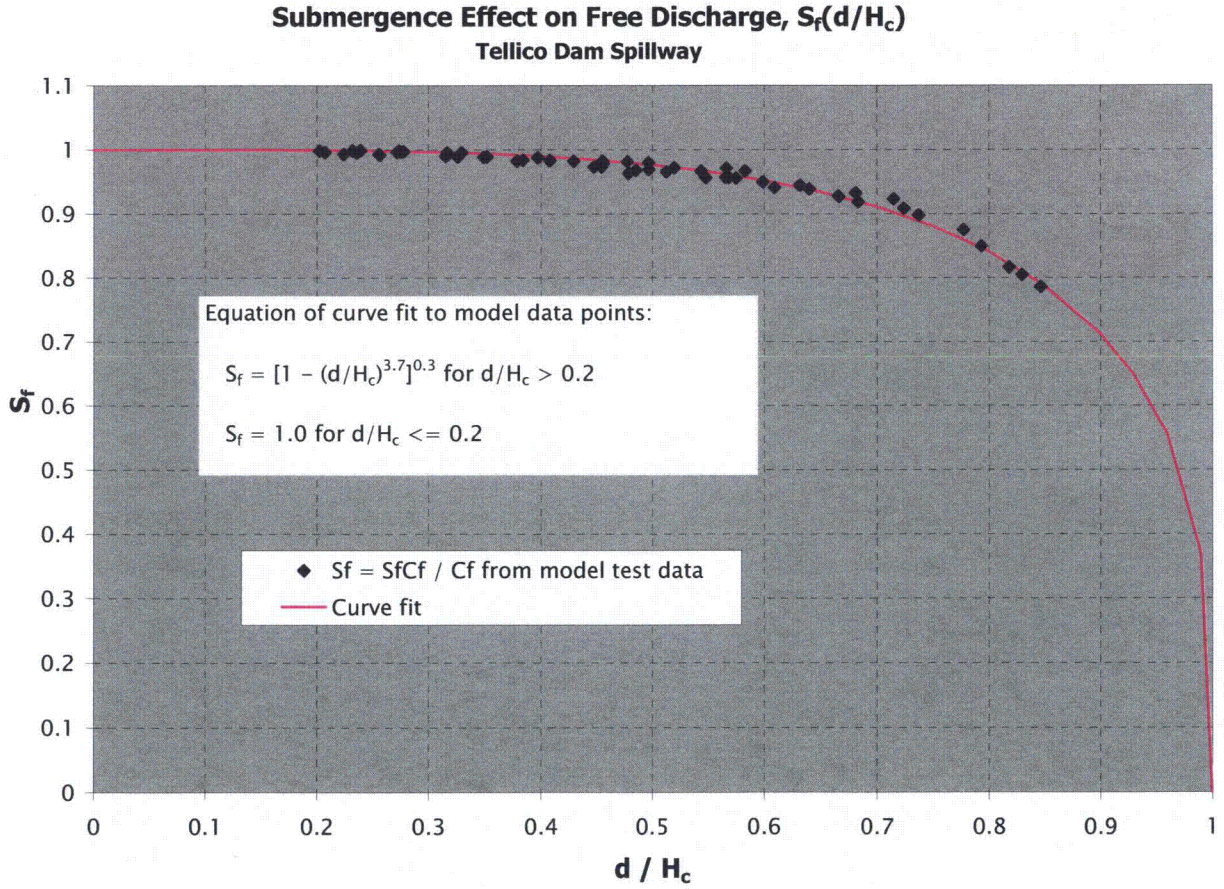
Prepared by: S.E.M.
Checked by: J.B.M.

Determination of Free Flow Submergence Factor, S_f

0.2

d / H_c	Curve fit to S_f
0	1.000
0.1	1.000
0.15	1.000
0.2	0.999
0.25	0.998
0.3	0.996
0.35	0.994
0.4	0.990
0.45	0.984
0.5	0.976
0.55	0.966
0.6	0.952
0.65	0.934
0.7	0.911
0.75	0.881
0.8	0.841
0.85	0.788
0.9	0.712
0.93	0.648
0.96	0.555
0.99	0.370
1	0.000

exponents (see chart)
3.7
0.3



Calculation No: CDQ000020080018

Attachment A12-1
Data from Reference A2
13 total pages

Determination of C_g from 1:72 Model Data

Prepared by: S.E.M.
Checked by: J.B.M.

Line segment curve fits to data for C_g unaffected by tailwater submergence

	ft V_p	ft H_{cp}	cfs Q_g	ft G_{np}	ft H_{mp}	C_g	$(d/H_c)_{max}$ [1]	
	3	4.79	3827	3.549	1.249	0.460	0.2	&
		44.27				0.455		
		60				0.455	*	
	5	7.33	7292	5.439	2.31	0.390	0.2	&
		32.26				0.376		
		60				0.376	*	
	7	9.86	11572	7.358	3.352	0.669	0.2	&
		33.48				0.674		
		39.6				0.675		
		46.37				0.675		
		60				0.675	*	
$H_c=H_{L,min}$	10	13.66	19511	10.277	4.894	0.666	0.2	&
		25.56				0.665		
		35.78				0.666		
		41.18				0.666		
		60				0.666	*	
$H_c=H_{L,min}$	15	19.99	36666	15.218	7.426	0.706	0.2	&
		22.32				0.681		
		27.5				0.672		
		30.74				0.669		
		45.29				0.668		
		60				0.668	*	
$H_c=H_{L,min}$	20	26.33	57983	20.225	9.931	0.735	0.2	&
		28.8				0.682		
		32.4				0.669		
		45				0.671		
		60				0.671	*	
$H_c=H_{L,min}$	25	32.7	82054	25.291	12.418	0.749	0.2	&
		37.73				0.679		
		40.39				0.675		
		44.57				0.673		
		60				0.673	*	
$H_c=H_{L,min}$	30	39.00	107742	30.436	14.885	0.749	0.2	&
		41.98				0.701		
		42.38				0.697		
		45				0.683	*	
		60				0.683	*	
$H_c=H_{L,min}$	33	42.80	124050	33.58	16.35	0.746		
		46.10				0.700	*	
		48.10				0.692	*	
		50.00				0.692	*	
		60.00				0.692	*	
$H_c=H_{L,min}$	35	45.3	135631	35.699	17.326	0.746	0.2	&
		48				0.705	*	
		50				0.697	*	
		60				0.697	*	

(&) For data points included in curve fit, this is the highest value of d/H_c (no submergence effects for lower values of d/H_c)
(*) These values have been extroplated from existing data under the assumption that the values of C_g level out at a point beyond the existing data.

Free Discharge
$Q_f = C_f L H_c^{3/2}$

Gated Discharge
$Q_g = C_g G_n L\{[2g(H_c - H_{mp})]0.5\}$

$g = 32.2\ ft/s^2$

$L = 120$ ft

The discharge, Q_g, was determined using the formula for Q_f. This is based on the principle that at $H_c = H_{lmin}$, the flow transitions from free to orifice flow. At this point, $Q_f = Q_g$. Then, the value of C_g was calculated using the Q_g formula.

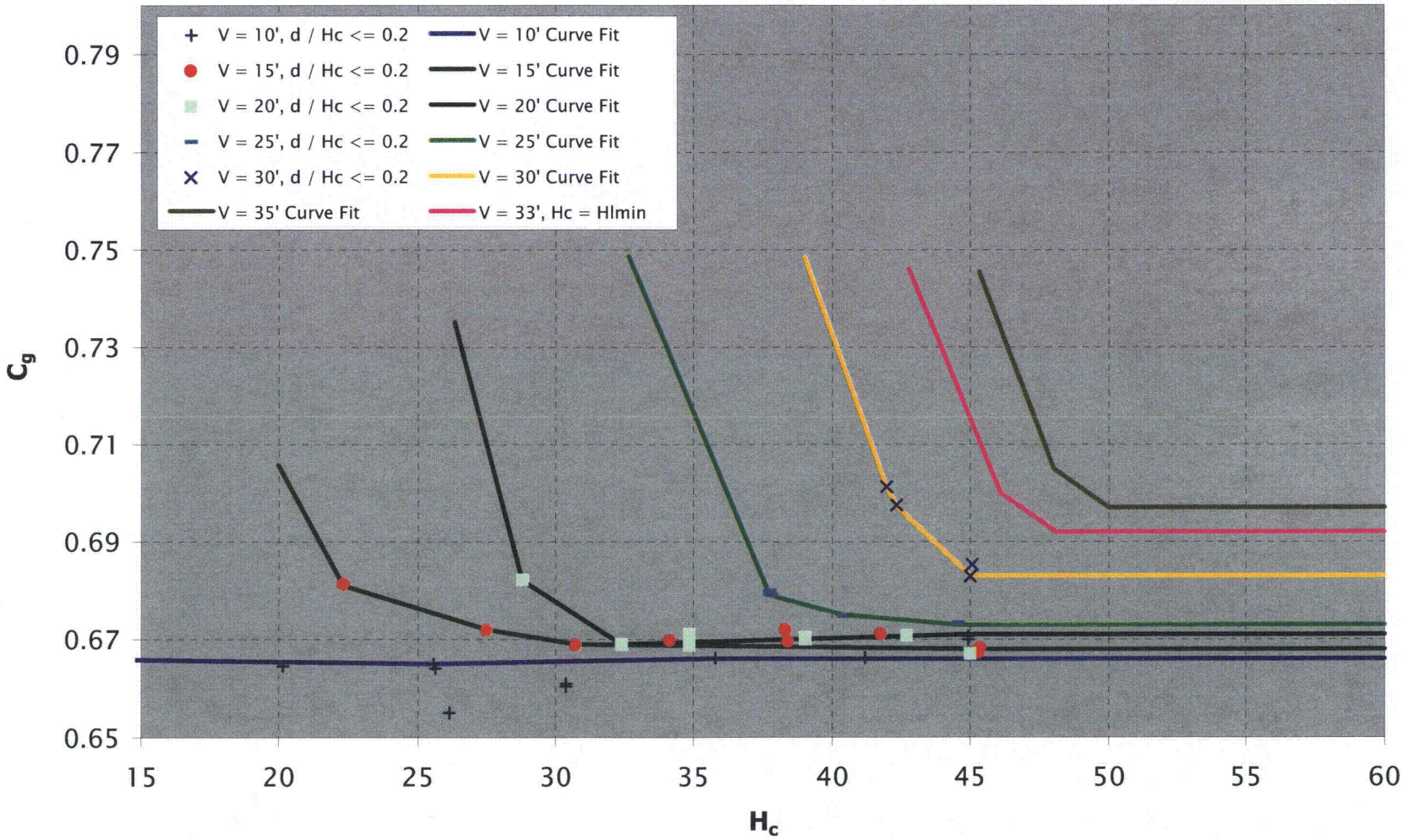
Because no model test data is available for the maximum gate opening, V, this data has been developed from the existing data.

Attachment A12-2
13 total pages

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.

Unsubmerged Cg
Tellico Dam 1:72 scale model data

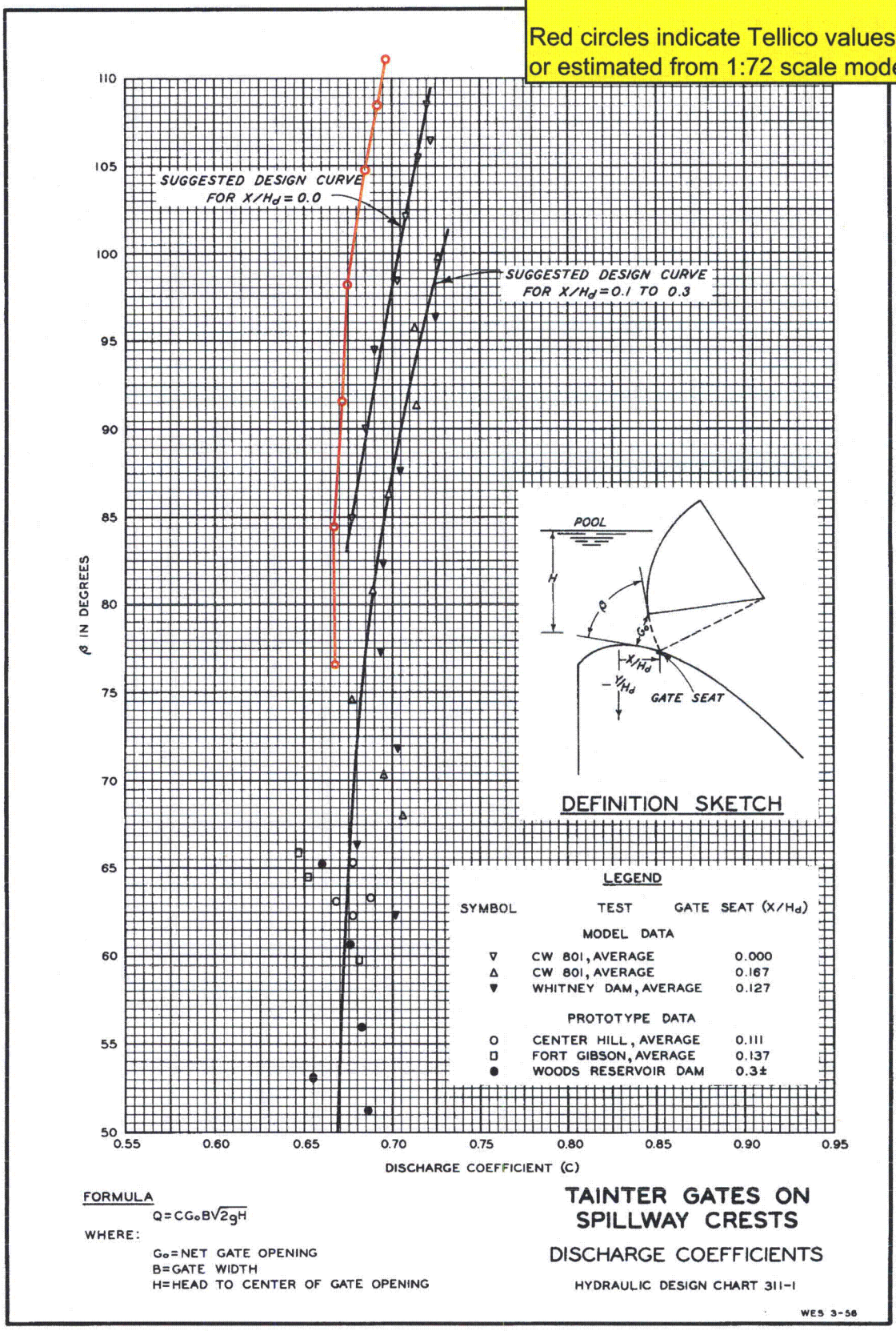


Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A12-3
Chart 311-1 from Reference A5
13 total pages

Red circles indicate Tellico values determined or estimated from 1:72 scale model data



Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A12-4
Data from Reference A2
13 total pages

Model Data to Determine Orifice Discharge Coefficients

Tellico Project
Tainter Gates Raised Above the Water Surface
Tellico Spillway Rating, 1:72 Model, Books 1 and 2 of 2, 1969
under tabs: "X' Gate Opening" (Ref. 2.4)

Model scale, S = 72

Z_{cp} = 773 ft
L_p = 40 ft
g = 32.2 f/s^2

	Model Data					Prototype Geometry			Prototype Values									
Order No.	Test No.	ft V_m	ft H_{1m}	ft d_m	cfs (3 bays) Q_m	ft V_p	ft G_{np}	ft H_{mpp}	ft H_{cp} (1)	ft HW elev.	ft d_p (2)	ft TW elev.	cfs (3 bays) $Q_{g,p}$	cfs (1 bay) Q_{gsp} (3)	H_{cp}/G_{np}	d/H_c (4)	C_gS_g (5)	C_g (6)	S_g (7)
7	494	0.013889	0.388		0.1353	1	1.696	0.167	27.94	800.94			5952	1984	16.47	0.000	0.692	0.692	*
4	491	0.013889	0.401		0.1413	1	1.696	0.167	28.87	801.87			6215	2072	17.02	0.000	0.710	0.710	*
5	492	0.013889	0.43		0.1426	1	1.696	0.167	30.96	803.96			6273	2091	18.25	0.000	0.692	0.692	*
3	490	0.013889	0.484		0.1549	1	1.696	0.167	34.85	807.85			6814	2271	20.55	0.000	0.708	0.708	*
8	495	0.013889	0.507		0.1535	1	1.696	0.167	36.50	809.50			6752	2251	21.52	0.000	0.686	0.686	*
2	489	0.013889	0.557		0.1662	1	1.696	0.167	40.10	813.10			7311	2437	23.65	0.000	0.708	0.708	*
6	493	0.013889	0.569		0.1628	1	1.696	0.167	40.97	813.97			7161	2387	24.16	0.000	0.686	0.686	*
1	488	0.013889	0.61		0.1738	1	1.696	0.167	43.92	816.92			7645	2548	25.90	0.000	0.708	0.708	*
13	384	0.041667	0.384	-0.094	0.275	3	3.549	1.249	27.65	800.65	-6.770	766.23	12085	4032	7.79	-0.245	0.689	0.457	1.507
30	401	0.041667	0.565	-0.093	0.337	3	3.549	1.249	40.68	813.68	-6.700	766.30	14793	4941	11.46	-0.165	0.691	0.455	1.517
1	372	0.041667	0.303	-0.023	0.242	3	3.549	1.249	21.82	794.82	-1.660	771.34	10651	3548	6.15	-0.076	0.687	0.458	1.500
14	385	0.041667	0.384	-0.026	0.275	3	3.549	1.249	27.65	800.65	-1.870	771.13	12085	4032	7.79	-0.068	0.689	0.457	1.507
36	407	0.041667	0.619	-0.026	0.337	3	3.549	1.249	44.57	817.57	-1.870	771.13	15511	4941	12.56	-0.042	0.659	0.455	1.448
21	392	0.041667	0.472	-0.019	0.307	3	3.549	1.249	33.98	806.98	-1.370	771.63	13469	4501	9.57	-0.040	0.691	0.456	1.514
31	402	0.041667	0.565	0.012	0.337	3	3.549	1.249	40.68	813.68	0.860	773.86	14793	4941	11.46	0.021	0.691	0.455	1.517
28	399	0.041667	0.467	0.013	0.307	3	3.549	1.249	33.60	806.60	0.940	773.94	13390	4501	9.47	0.028	0.695	0.456	1.522
37	408	0.041667	0.619	0.020	0.337	3	3.549	1.249	44.57	817.57	1.440	774.44	15511	4941	12.56	0.032	0.659	0.455	1.448
22	393	0.041667	0.472	0.027	0.307	3	3.549	1.249	33.98	806.98	1.940	774.94	13469	4501	9.57	0.057	0.691	0.456	1.514
15	386	0.041667	0.385	0.038	0.275	3	3.549	1.249	27.72	800.72	2.740	775.74	12101	4032	7.81	0.099	0.688	0.457	1.505
33	404	0.041667	0.567	0.060	0.337	3	3.549	1.249	40.82	813.82	4.320	777.32	14820	4941	11.50	0.106	0.690	0.455	1.514
38	409	0.041667	0.620	0.066	0.337	3	3.549	1.249	44.64	817.64	4.760	777.76	15523	4941	12.58	0.107	0.658	0.455	1.447
27	398	0.041667	0.468	0.054	0.307	3	3.549	1.249	33.70	806.70	3.890	776.89	13411	4501	9.50	0.115	0.694	0.456	1.520
39	410	0.041667	0.621	0.072	0.337	3	3.549	1.249	44.71	817.71	5.180	778.18	15536	4941	12.60	0.116	0.658	0.455	1.446
32	403	0.041667	0.581	0.085	0.337	3	3.549	1.249	41.83	814.83	6.120	779.12	15009	4941	11.79	0.146	0.681	0.455	1.495
17	388	0.041667	0.391	0.059	0.275	3	3.549	1.249	28.18	801.18	4.250	777.25	12195	4032	7.94	0.151	0.682	0.457	1.492
23	394	0.041667	0.484	0.074	0.307	3	3.549	1.249	34.85	807.85	5.330	778.33	13648	4501	9.82	0.153	0.682	0.456	1.494

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A12-5
Data from Reference A2
13 total pages

34	405	0.041667	0.609	0.098	0.337	3	3.549	1.249	43.85	816.85	7.060	780.06	15381	4941	12.36	0.161	0.665	0.455	1.460
35	406	0.041667	0.615	0.102	0.337	3	3.549	1.249	44.27	817.27	7.340	780.34	15451	4941	12.47	0.166	0.661	0.455	1.453
2	373	0.041667	0.305	0.052	0.242	3	3.549	1.249	21.96	794.96	3.740	776.74	10689	3548	6.19	0.170	0.684	0.458	1.495
26	397	0.041667	0.543	0.106	0.307	3	3.549	1.249	39.10	812.10	7.630	780.63	14492	4501	11.02	0.195	0.642	0.456	1.409
24	395	0.041667	0.572	0.130	0.307	3	3.549	1.249	41.18	814.18	9.360	782.36	14888	4501	11.60	0.227	0.625	0.455	1.373
16	387	0.041667	0.465	0.109	0.275	3	3.549	1.249	33.48	806.48	7.850	780.85	13365	4032	9.43	0.234	0.623	0.456	1.366
25	396	0.041667	0.575	0.138	0.307	3	3.549	1.249	41.40	814.40	9.940	782.94	14929	4501	11.67	0.240	0.624	0.455	1.369
4	375	0.041667	0.368	0.091	0.242	3	3.549	1.249	26.50	799.50	6.550	779.55	11816	3548	7.47	0.247	0.620	0.457	1.356
29	400	0.041667	0.619	0.175	0.307	3	3.549	1.249	44.57	817.57	12.600	785.60	15511	4501	12.56	0.283	0.600	0.455	1.319
3	374	0.041667	0.412	0.133	0.242	3	3.549	1.249	29.66	802.66	9.580	782.58	12541	3548	8.36	0.323	0.584	0.457	1.279
18	389	0.041667	0.547	0.185	0.275	3	3.549	1.249	39.38	812.38	13.320	786.32	14546	4032	11.10	0.338	0.573	0.456	1.258
19	390	0.041667	0.582	0.220	0.275	3	3.549	1.249	41.90	814.90	15.840	788.84	15022	4032	11.81	0.378	0.555	0.455	1.219
5	376	0.041667	0.462	0.182	0.242	3	3.549	1.249	33.26	806.26	13.100	786.10	13318	3548	9.37	0.394	0.551	0.456	1.206
20	391	0.041667	0.620	0.259	0.275	3	3.549	1.249	44.64	817.64	18.650	791.65	15523	4032	12.58	0.418	0.537	0.455	1.181
6	377	0.041667	0.528	0.246	0.242	3	3.549	1.249	38.02	811.02	17.710	790.71	14283	3548	10.71	0.466	0.514	0.456	1.127
7	378	0.041667	0.607	0.324	0.242	3	3.549	1.249	43.70	816.70	23.330	796.33	15353	3548	12.31	0.534	0.478	0.455	1.050
8	379	0.041667	0.622	0.340	0.242	3	3.549	1.249	44.78	817.78	24.480	797.48	15548	3548	12.62	0.547	0.472	0.455	1.038
9	380	0.041667	0.219	0.122	0.014	3	3.549	1.249	15.77	788.77	8.780	781.78	8924	205	4.44	0.557	0.047	0.459	0.103
10	381	0.041667	0.280	0.183	0.014	3	3.549	1.249	20.16	793.16	13.180	786.18	10207	205	5.68	0.654	0.041	0.458	0.090
11	382	0.041667	0.364	0.264	0.014	3	3.549	1.249	26.21	799.21	19.010	792.01	11749	205	7.39	0.725	0.036	0.457	0.079
12	383	0.041667	0.467	0.368	0.014	3	3.549	1.249	33.62	806.62	26.500	799.50	13395	205	9.47	0.788	0.032	0.456	0.069
37	358	0.069444	0.271	-0.046	0.3352	5	5.439	2.31	19.51	792.51	-3.312	769.69	14745	4915	3.59	-0.170	0.679	0.383	1.771
31	352	0.069444	0.339	-0.049	0.3791	5	5.439	2.31	24.41	797.41	-3.528	769.47	16676	5559	4.49	-0.145	0.677	0.380	1.780
16	336	0.069444	0.636	-0.091	0.5357	5	5.439	2.31	45.79	818.79	-6.552	766.45	23564	7855	8.42	-0.143	0.682	0.376	1.815
10	330	0.069444	0.54	-0.074	0.4875	5	5.439	2.31	38.88	811.88	-5.328	767.67	21444	7148	7.15	-0.137	0.677	0.376	1.801
6	326	0.069444	0.619	-0.074	0.5252	5	5.439	2.31	44.57	817.57	-5.328	767.67	23102	7701	8.19	-0.120	0.679	0.376	1.805
26	346	0.069444	0.392	-0.002	0.4117	5	5.439	2.31	28.22	801.22	-0.144	772.86	18110	6037	5.19	-0.005	0.679	0.378	1.796
17	337	0.069444	0.637	-0.001	0.5362	5	5.439	2.31	45.86	818.86	-0.072	772.93	23586	7862	8.43	-0.002	0.682	0.376	1.815
11	331	0.069444	0.54	0.022	0.4876	5	5.439	2.31	38.88	811.88	1.584	774.58	21448	7149	7.15	0.041	0.677	0.376	1.801
18	338	0.069444	0.637	0.041	0.5377	5	5.439	2.31	45.86	818.86	2.952	775.95	23652	7884	8.43	0.064	0.684	0.376	1.820
7	327	0.069444	0.619	0.04	0.5254	5	5.439	2.31	44.57	817.57	2.880	775.88	23111	7704	8.19	0.065	0.679	0.376	1.805
21	341	0.069444	0.448	0.029	0.4423	5	5.439	2.31	32.26	805.26	2.088	775.09	19456	6485	5.93	0.065	0.679	0.376	1.805
13	333	0.069444	0.541	0.053	0.4879	5	5.439	2.31	38.95	811.95	3.816	776.82	21462	7154	7.16	0.098	0.677	0.376	1.800
9	329	0.069444	0.622	0.085	0.5259	5	5.439	2.31	44.78	817.78	6.120	779.12	23133	7711	8.23	0.137	0.678	0.376	1.802
19	339	0.069444	0.638	0.088	0.5385	5	5.439	2.31	45.94	818.94	6.336	779.34	23687	7896	8.45	0.138	0.685	0.376	1.821
30	351	0.069444	0.34	0.051	0.3799	5	5.439	2.31	24.48	797.48	3.672	776.67	16711	5570	4.50	0.150	0.678	0.380	1.781
27	347	0.069444	0.392	0.062	0.4116	5	5.439	2.31	28.22	801.22	4.464	777.46	18105	6035	5.19	0.158	0.679	0.378	1.795

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A12-6
Data from Reference A2
13 total pages

20	340	0.069444	0.641	0.102	0.5367	5	5.439	2.31	46.15	819.15	7.344	780.34	23608	7869	8.49	0.159	0.681	0.376	1.810
22	342	0.069444	0.45	0.084	0.4423	5	5.439	2.31	32.40	805.40	6.048	779.05	19456	6485	5.96	0.187	0.677	0.376	1.801
8	328	0.069444	0.643	0.121	0.5252	5	5.439	2.31	46.30	819.30	8.712	781.71	23102	7701	8.51	0.188	0.665	0.376	1.769
12	332	0.069444	0.557	0.113	0.4882	5	5.439	2.31	40.10	813.10	8.136	781.14	21475	7158	7.37	0.203	0.667	0.376	1.774
15	335	0.069444	0.599	0.138	0.4859	5	5.439	2.31	43.13	816.13	9.936	782.94	21374	7125	7.93	0.230	0.639	0.376	1.699
28	348	0.069444	0.415	0.106	0.412	5	5.439	2.31	29.88	802.88	7.632	780.63	18123	6041	5.49	0.255	0.659	0.377	1.746
38	359	0.069444	0.273	0.071	0.3352	5	5.439	2.31	19.66	792.66	5.112	778.11	14745	4915	3.61	0.260	0.676	0.383	1.764
14	334	0.069444	0.65	0.171	0.4865	5	5.439	2.31	46.80	819.80	12.312	785.31	21400	7133	8.60	0.263	0.613	0.376	1.629
32	353	0.069444	0.364	0.098	0.3873	5	5.439	2.31	26.21	799.21	7.056	780.06	17036	5679	4.82	0.269	0.665	0.379	1.754
23	343	0.069444	0.534	0.145	0.4415	5	5.439	2.31	38.45	811.45	10.440	783.44	19421	6474	7.07	0.272	0.617	0.376	1.640
4	324	0.069444	0.487	0.15	0.4244	5	5.439	2.31	35.06	808.06	10.800	783.80	18668	6223	6.45	0.308	0.623	0.376	1.656
29	349	0.069444	0.503	0.165	0.4112	5	5.439	2.31	36.22	809.22	11.880	784.88	18088	6029	6.66	0.328	0.593	0.376	1.577
33	354	0.069444	0.455	0.154	0.3883	5	5.439	2.31	32.76	805.76	11.088	784.09	17080	5693	6.02	0.338	0.591	0.376	1.572
39	360	0.069444	0.321	0.11	0.3393	5	5.439	2.31	23.11	796.11	7.920	780.92	14925	4975	4.25	0.343	0.625	0.381	1.639
24	344	0.069444	0.603	0.207	0.4417	5	5.439	2.31	43.42	816.42	14.904	787.90	19429	6476	7.98	0.343	0.579	0.376	1.539
25	345	0.069444	0.619	0.223	0.4404	5	5.439	2.31	44.57	817.57	16.056	789.06	19372	6457	8.19	0.360	0.569	0.376	1.513
5	325	0.069444	0.389	0.149	0.4244	5	5.439	2.31	28.01	801.01	10.728	783.73	18668	6223	5.15	0.383	0.703	0.378	1.858
3	323	0.069444	0.552	0.213	0.4244	5	5.439	2.31	39.74	812.74	15.336	788.34	18668	6223	7.31	0.386	0.583	0.376	1.549
34	355	0.069444	0.52	0.216	0.3873	5	5.439	2.31	37.44	810.44	15.552	788.55	17036	5679	6.88	0.415	0.549	0.376	1.460
2	322	0.069444	0.605	0.263	0.4235	5	5.439	2.31	43.56	816.56	18.936	791.94	18629	6210	8.01	0.435	0.554	0.376	1.473
40	361	0.069444	0.445	0.208	0.3422	5	5.439	2.31	32.04	805.04	14.976	787.98	15053	5018	5.89	0.467	0.527	0.376	1.401
35	356	0.069444	0.575	0.27	0.3867	5	5.439	2.31	41.40	814.40	19.440	792.44	17010	5670	7.61	0.470	0.519	0.376	1.381
1	321	0.069444	0.648	0.308	0.4235	5	5.439	2.31	46.66	819.66	22.176	795.18	18629	6210	8.58	0.475	0.534	0.376	1.420
43	364	0.069444	0.295	0.146	0.273	5	5.439	2.31	21.24	794.24	10.512	783.51	12009	4003	3.91	0.495	0.527	0.382	1.379
36	357	0.069444	0.643	0.338	0.3866	5	5.439	2.31	46.30	819.30	24.336	797.34	17006	5669	8.51	0.526	0.490	0.376	1.302
41	362	0.069444	0.558	0.319	0.3387	5	5.439	2.31	40.18	813.18	22.968	795.97	14899	4966	7.39	0.572	0.462	0.376	1.229
44	365	0.069444	0.369	0.218	0.2723	5	5.439	2.31	26.57	799.57	15.696	788.70	11978	3993	4.88	0.591	0.464	0.379	1.224
42	363	0.069444	0.634	0.396	0.3389	5	5.439	2.31	45.65	818.65	28.512	801.51	14907	4969	8.39	0.625	0.432	0.376	1.150
45	366	0.069444	0.418	0.262	0.2753	5	5.439	2.31	30.10	803.10	18.864	791.86	12110	4037	5.53	0.627	0.439	0.377	1.163
46	367	0.069444	0.495	0.339	0.275	5	5.439	2.31	35.64	808.64	24.408	797.41	12097	4032	6.55	0.685	0.400	0.376	1.064
47	368	0.069444	0.539	0.382	0.2748	5	5.439	2.31	38.81	811.81	27.504	800.50	12088	4029	7.14	0.709	0.382	0.376	1.016
49	370	0.069444	0.366	0.329	0.1309	5	5.439	2.31	26.35	799.35	23.688	796.69	5758	1919	4.85	0.899	0.224	0.379	0.591
50	371	0.069444	0.457	0.42	0.1309	5	5.439	2.31	32.90	805.90	30.240	803.24	5758	1919	6.05	0.919	0.199	0.376	0.529
48	369	0.069444	0.277	0.263	0.1281	5	5.439	2.31	19.94	792.94	18.936	791.94	5635	1878	3.67	0.949	0.256	0.383	0.669
35	446	0.097222	0.293	-0.172	0.4529	7	7.358	3.352	21.10	794.10	-12.384	760.62	19922	6641	2.87	-0.587	0.667	0.671	0.994
24	435	0.097222	0.386	-0.086	0.5341	7	7.358	3.352	27.79	800.79	-6.192	766.81	23494	7831	3.78	-0.223	0.671	0.673	0.997
1	412	0.097222	0.642	-0.058	0.7153	7	7.358	3.352	46.22	819.22	-4.176	768.82	31464	10488	6.28	-0.090	0.678	0.675	1.005

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A12-7
Data from Reference A2
13 total pages

36	447	0.097222	0.293	-0.022	0.4542	7	7.358	3.352	21.10	794.10	-1.584	771.42	19979	6660	2.87	-0.075	0.669	0.671	0.997
14	425	0.097222	0.465	-0.02	0.595	7	7.358	3.352	33.48	806.48	-1.440	771.56	26173	8724	4.55	-0.043	0.673	0.674	0.998
6	417	0.097222	0.551	0.024	0.6535	7	7.358	3.352	39.67	812.67	1.728	774.73	28746	9582	5.39	0.044	0.673	0.675	0.997
25	436	0.097222	0.386	0.028	0.5341	7	7.358	3.352	27.79	800.79	2.016	775.02	23494	7831	3.78	0.073	0.671	0.673	0.997
2	413	0.097222	0.642	0.051	0.7119	7	7.358	3.352	46.22	819.22	3.672	776.67	31315	10438	6.28	0.079	0.675	0.675	1.000
15	426	0.097222	0.465	0.042	0.5963	7	7.358	3.352	33.48	806.48	3.024	776.02	26230	8743	4.55	0.090	0.674	0.674	1.001
7	418	0.097222	0.55	0.059	0.6528	7	7.358	3.352	39.60	812.60	4.248	777.25	28715	9572	5.38	0.107	0.673	0.675	0.997
8	419	0.097222	0.55	0.085	0.6542	7	7.358	3.352	39.60	812.60	6.120	779.12	28777	9592	5.38	0.155	0.675	0.675	0.999
3	414	0.097222	0.644	0.113	0.7132	7	7.358	3.352	46.37	819.37	8.136	781.14	31372	10457	6.30	0.175	0.675	0.675	1.000
5	416	0.097222	0.647	0.12	0.7149	7	7.358	3.352	46.58	819.58	8.640	781.64	31447	10482	6.33	0.185	0.675	0.675	1.000
4	415	0.097222	0.654	0.141	0.7142	7	7.358	3.352	47.09	820.09	10.152	783.15	31416	10472	6.40	0.216	0.670	0.675	0.993
9	420	0.097222	0.554	0.121	0.6565	7	7.358	3.352	39.89	812.89	8.712	781.71	28878	9626	5.42	0.218	0.674	0.675	0.999
16	427	0.097222	0.469	0.105	0.5952	7	7.358	3.352	33.77	806.77	7.560	780.56	26181	8727	4.59	0.224	0.670	0.674	0.994
38	449	0.097222	0.293	0.074	0.4559	7	7.358	3.352	21.10	794.10	5.328	778.33	20054	6685	2.87	0.253	0.672	0.671	1.001
11	422	0.097222	0.57	0.144	0.6537	7	7.358	3.352	41.04	814.04	10.368	783.37	28755	9585	5.58	0.253	0.661	0.675	0.979
18	429	0.097222	0.473	0.122	0.5966	7	7.358	3.352	34.06	807.06	8.784	781.78	26243	8748	4.63	0.258	0.668	0.674	0.992
26	437	0.097222	0.391	0.104	0.535	7	7.358	3.352	28.15	801.15	7.488	780.49	23533	7844	3.83	0.266	0.667	0.673	0.991
10	421	0.097222	0.593	0.16	0.6539	7	7.358	3.352	42.70	815.70	11.520	784.52	28764	9588	5.80	0.270	0.647	0.675	0.959
13	424	0.097222	0.613	0.17	0.6526	7	7.358	3.352	44.14	817.14	12.240	785.24	28706	9569	6.00	0.277	0.634	0.675	0.940
19	430	0.097222	0.499	0.147	0.5946	7	7.358	3.352	35.93	808.93	10.584	783.58	26155	8718	4.88	0.295	0.647	0.674	0.959
12	423	0.097222	0.659	0.199	0.6533	7	7.358	3.352	47.45	820.45	14.328	787.33	28737	9579	6.45	0.302	0.611	0.675	0.905
17	428	0.097222	0.523	0.16	0.5946	7	7.358	3.352	37.66	810.66	11.520	784.52	26155	8718	5.12	0.306	0.630	0.675	0.934
21	432	0.097222	0.543	0.169	0.5945	7	7.358	3.352	39.10	812.10	12.168	785.17	26151	8717	5.31	0.311	0.617	0.675	0.915
28	439	0.097222	0.418	0.139	0.5346	7	7.358	3.352	30.10	803.10	10.008	783.01	23516	7839	4.09	0.333	0.642	0.673	0.953
20	431	0.097222	0.583	0.2	0.594	7	7.358	3.352	41.98	814.98	14.400	787.40	26129	8710	5.70	0.343	0.593	0.675	0.879
27	438	0.097222	0.445	0.153	0.5342	7	7.358	3.352	32.04	805.04	11.016	784.02	23498	7833	4.35	0.344	0.619	0.674	0.919
30	441	0.097222	0.466	0.164	0.5352	7	7.358	3.352	33.55	806.55	11.808	784.81	23542	7847	4.56	0.352	0.605	0.674	0.897
37	448	0.097222	0.303	0.112	0.4552	7	7.358	3.352	21.82	794.82	8.064	781.06	20023	6674	2.96	0.370	0.658	0.672	0.979
22	433	0.097222	0.617	0.231	0.5936	7	7.358	3.352	44.42	817.42	16.632	789.63	26111	8704	6.04	0.374	0.575	0.675	0.852
23	434	0.097222	0.64	0.251	0.5928	7	7.358	3.352	46.08	819.08	18.072	791.07	26076	8692	6.26	0.392	0.563	0.675	0.834
29	440	0.097222	0.502	0.203	0.5332	7	7.358	3.352	36.14	809.14	14.616	787.62	23454	7818	4.91	0.404	0.578	0.674	0.857
31	442	0.097222	0.525	0.215	0.5321	7	7.358	3.352	37.80	810.80	15.480	788.48	23406	7802	5.14	0.410	0.563	0.675	0.834
39	450	0.097222	0.349	0.143	0.4533	7	7.358	3.352	25.13	798.13	10.296	783.30	19940	6647	3.42	0.410	0.603	0.672	0.897
44	455	0.097222	0.399	0.174	0.3446	7	7.358	3.352	28.73	801.73	12.528	785.53	15158	5053	3.90	0.436	0.425	0.673	0.631
32	443	0.097222	0.563	0.249	0.5317	7	7.358	3.352	40.54	813.54	17.928	790.93	23388	7796	5.51	0.442	0.541	0.675	0.802
40	451	0.097222	0.417	0.197	0.4509	7	7.358	3.352	30.02	803.02	14.184	787.18	19834	6611	4.08	0.472	0.542	0.673	0.805
33	444	0.097222	0.601	0.286	0.5325	7	7.358	3.352	43.27	816.27	20.592	793.59	23423	7808	5.88	0.476	0.523	0.675	0.775
34	445	0.097222	0.654	0.338	0.5321	7	7.358	3.352	47.09	820.09	24.336	797.34	23406	7802	6.40	0.517	0.499	0.675	0.740
41	452	0.097222	0.481	0.257	0.4536	7	7.358	3.352	34.63	807.63	18.504	791.50	19953	6651	4.71	0.534	0.503	0.674	0.747

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A12-8
Data from Reference A2
13 total pages

42	453	0.097222	0.565	0.339	0.4501	7	7.358	3.352	40.68	813.68	24.408	797.41	19799	6600	5.53	0.600	0.457	0.675	0.678
45	456	0.097222	0.365	0.237	0.3442	7	7.358	3.352	26.28	799.28	17.064	790.06	15141	5047	3.57	0.649	0.446	0.672	0.664
43	454	0.097222	0.66	0.433	0.4486	7	7.358	3.352	47.52	820.52	31.176	804.18	19733	6578	6.46	0.656	0.419	0.675	0.621
46	457	0.097222	0.414	0.284	0.344	7	7.358	3.352	29.81	802.81	20.448	793.45	15132	5044	4.05	0.686	0.415	0.673	0.617
47	458	0.097222	0.47	0.338	0.3435	7	7.358	3.352	33.84	806.84	24.336	797.34	15110	5037	4.60	0.719	0.386	0.674	0.573
48	459	0.097222	0.518	0.387	0.3425	7	7.358	3.352	37.30	810.30	27.864	800.86	15066	5022	5.07	0.747	0.365	0.675	0.541
49	460	0.097222	0.296	0.264	0.1714	7	7.358	3.352	21.31	794.31	19.008	792.01	7539	2513	2.90	0.892	0.251	0.671	0.374
50	461	0.097222	0.343	0.311	0.1714	7	7.358	3.352	24.70	797.70	22.392	795.39	7539	2513	3.36	0.907	0.230	0.672	0.343
51	462	0.097222	0.405	0.373	0.1707	7	7.358	3.352	29.16	802.16	26.856	799.86	7509	2503	3.96	0.921	0.209	0.673	0.310
52	463	0.097222	0.445	0.412	0.1701	7	7.358	3.352	32.04	805.04	29.664	802.66	7482	2494	4.35	0.926	0.197	0.674	0.293
20	296	0.138889	0.28	-0.041	0.5842	10	10.277	4.894	20.16	793.16	-2.952	770.05	25698	8566	1.96	-0.146	0.665	0.665	0.999
35	311	0.138889	0.422	-0.059	0.7508	10	10.277	4.894	30.38	803.38	-4.248	768.75	33026	11009	2.96	-0.140	0.661	0.665	0.993
6	282	0.138889	0.497	-0.046	0.833	10	10.277	4.894	35.78	808.78	-3.312	769.69	36642	12214	3.48	-0.093	0.666	0.666	1.000
43	471	0.138889	0.624	0	0.9547	10	10.277	4.894	44.93	817.93	0.000	773.00	41995	13998	4.37	0.000	0.671	0.666	1.007
12	288	0.138889	0.355	0.002	0.6801	10	10.277	4.894	25.56	798.56	0.144	773.14	29916	9972	2.49	0.006	0.665	0.665	1.000
5	281	0.138889	0.572	0.022	0.903	10	10.277	4.894	41.18	814.18	1.584	774.58	39721	13240	4.01	0.038	0.666	0.666	1.000
44	472	0.138889	0.624	0.04	0.9537	10	10.277	4.894	44.93	817.93	2.880	775.88	41951	13984	4.37	0.064	0.670	0.666	1.006
13	289	0.138889	0.363	0.029	0.6792	10	10.277	4.894	26.14	799.14	2.088	775.09	29876	9959	2.54	0.080	0.655	0.665	0.985
14	290	0.138889	0.356	0.03	0.6804	10	10.277	4.894	25.63	798.63	2.160	775.16	29929	9976	2.49	0.084	0.664	0.665	0.999
36	312	0.138889	0.422	0.043	0.7502	10	10.277	4.894	30.38	803.38	3.096	776.10	33000	11000	2.96	0.102	0.660	0.665	0.992
45	473	0.138889	0.625	0.117	0.9507	10	10.277	4.894	45.00	818.00	8.424	781.42	41819	13940	4.38	0.187	0.667	0.666	1.002
21	297	0.138889	0.281	0.066	0.5841	10	10.277	4.894	20.23	793.23	4.752	777.75	25693	8564	1.97	0.235	0.663	0.665	0.996
1	277	0.138889	0.58	0.145	0.905	10	10.277	4.894	41.76	814.76	10.440	783.44	39809	13270	4.06	0.250	0.662	0.666	0.995
7	283	0.138889	0.5	0.132	0.83	10	10.277	4.894	36.00	809.00	9.504	782.50	36510	12170	3.50	0.264	0.661	0.666	0.993
46	474	0.138889	0.636	0.174	0.9546	10	10.277	4.894	45.79	818.79	12.528	785.53	41991	13997	4.46	0.274	0.663	0.666	0.996
37	313	0.138889	0.424	0.121	0.7507	10	10.277	4.894	30.53	803.53	8.712	781.71	33022	11007	2.97	0.285	0.659	0.665	0.990
9	285	0.138889	0.504	0.148	0.83	10	10.277	4.894	36.29	809.29	10.656	783.66	36510	12170	3.53	0.294	0.658	0.666	0.989
47	475	0.138889	0.671	0.207	0.9513	10	10.277	4.894	48.31	821.31	14.904	787.90	41845	13948	4.70	0.308	0.642	0.666	0.963
3	279	0.138889	0.609	0.193	0.903	10	10.277	4.894	43.85	816.85	13.896	786.90	39721	13240	4.27	0.317	0.643	0.666	0.966
4	280	0.138889	0.661	0.222	0.903	10	10.277	4.894	47.59	820.59	15.984	788.98	39721	13240	4.63	0.336	0.614	0.666	0.922
2	278	0.138889	0.681	0.234	0.9	10	10.277	4.894	49.03	822.03	16.848	789.85	39589	13196	4.77	0.344	0.602	0.666	0.904
10	286	0.138889	0.536	0.187	0.83	10	10.277	4.894	38.59	811.59	13.464	786.46	36510	12170	3.76	0.349	0.636	0.666	0.954
8	284	0.138889	0.569	0.206	0.828	10	10.277	4.894	40.97	813.97	14.832	787.83	36422	12141	3.99	0.362	0.613	0.666	0.920
38	314	0.138889	0.459	0.18	0.7488	10	10.277	4.894	33.05	806.05	12.960	785.96	32938	10979	3.22	0.392	0.627	0.666	0.942
40	316	0.138889	0.509	0.208	0.7516	10	10.277	4.894	36.65	809.65	14.976	787.98	33061	11020	3.57	0.409	0.593	0.666	0.890
11	287	0.138889	0.672	0.286	0.828	10	10.277	4.894	48.38	821.38	20.592	793.59	36422	12141	4.71	0.426	0.558	0.666	0.838
22	298	0.138889	0.288	0.124	0.5839	10	10.277	4.894	20.74	793.74	8.928	781.93	25684	8561	2.02	0.431	0.652	0.665	0.980
16	292	0.138889	0.411	0.182	0.6791	10	10.277	4.894	29.59	802.59	13.104	786.10	29872	9957	2.88	0.443	0.607	0.665	0.913
39	315	0.138889	0.559	0.249	0.7476	10	10.277	4.894	40.25	813.25	17.928	790.93	32885	10962	3.92	0.445	0.559	0.666	0.839

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A12-9
Data from Reference A2
13 total pages

15	291	0.138889	0.467	0.22	0.6772	10	10.277	4.894	33.62	806.62	15.840	788.84	29788	9929	3.27	0.471	0.562	0.666	0.843
41	317	0.138889	0.611	0.295	0.747	10	10.277	4.894	43.99	816.99	21.240	794.24	32859	10953	4.28	0.483	0.531	0.666	0.797
24	300	0.138889	0.307	0.153	0.5835	10	10.277	4.894	22.10	795.10	11.016	784.02	25667	8556	2.15	0.498	0.625	0.665	0.940
17	293	0.138889	0.523	0.271	0.6772	10	10.277	4.894	37.66	810.66	19.512	792.51	29788	9929	3.66	0.518	0.526	0.666	0.790
23	299	0.138889	0.381	0.203	0.5821	10	10.277	4.894	27.43	800.43	14.616	787.62	25605	8535	2.67	0.533	0.545	0.665	0.819
42	318	0.138889	0.701	0.389	0.7459	10	10.277	4.894	50.47	823.47	28.008	801.01	32810	10937	4.91	0.555	0.491	0.666	0.737
18	294	0.138889	0.6	0.343	0.6746	10	10.277	4.894	43.20	816.20	24.696	797.70	29674	9891	4.20	0.572	0.484	0.666	0.727
25	301	0.138889	0.451	0.268	0.5817	10	10.277	4.894	32.47	805.47	19.296	792.30	25588	8529	3.16	0.594	0.492	0.666	0.740
19	295	0.138889	0.668	0.409	0.6742	10	10.277	4.894	48.10	821.10	29.448	802.45	29657	9886	4.68	0.612	0.456	0.666	0.685
26	302	0.138889	0.528	0.339	0.5802	10	10.277	4.894	38.02	811.02	24.408	797.41	25522	8507	3.70	0.642	0.448	0.666	0.673
27	303	0.138889	0.597	0.406	0.5795	10	10.277	4.894	42.98	815.98	29.232	802.23	25491	8497	4.18	0.680	0.417	0.666	0.627
29	305	0.138889	0.347	0.272	0.3766	10	10.277	4.894	24.98	797.98	19.584	792.58	16566	5522	2.43	0.784	0.373	0.665	0.562
30	306	0.138889	0.407	0.329	0.375	10	10.277	4.894	29.30	802.30	23.688	796.69	16495	5498	2.85	0.808	0.337	0.665	0.507
31	307	0.138889	0.462	0.383	0.3755	10	10.277	4.894	33.26	806.26	27.576	800.58	16517	5506	3.24	0.829	0.313	0.666	0.471
28	304	0.138889	0.284	0.251	0.376	10	10.277	4.894	20.45	793.45	18.072	791.07	16539	5513	1.99	0.884	0.424	0.665	0.637
32	308	0.138889	0.322	0.29	0.2451	10	10.277	4.894	23.18	796.18	20.880	793.88	10781	3594	2.26	0.901	0.255	0.665	0.383
33	309	0.138889	0.387	0.353	0.2453	10	10.277	4.894	27.86	800.86	25.416	798.42	10790	3597	2.71	0.912	0.227	0.665	0.342
34	310	0.138889	0.427	0.392	0.2492	10	10.277	4.894	30.74	803.74	28.224	801.22	10962	3654	2.99	0.918	0.218	0.666	0.327
1	227	0.20833	0.382	-0.182	1.003	15	15.218	7.426	27.50	800.50	-13.104	759.90	44120	14707	1.81	-0.476	0.672	0.668	1.006
18	244	0.20833	0.474	-0.103	1.153	15	15.218	7.426	34.13	807.13	-7.416	765.58	50718	16906	2.24	-0.217	0.670	0.668	1.003
2	228	0.20833	0.382	-0.063	1.003	15	15.218	7.426	27.50	800.50	-4.536	768.46	44120	14707	1.81	-0.165	0.672	0.668	1.006
51	464	0.20833	0.63	-0.082	1.371	15	15.218	7.426	45.36	818.36	-5.904	767.10	60307	20102	2.98	-0.130	0.668	0.668	1.000
10	236	0.20833	0.427	-0.037	1.076	15	15.218	7.426	30.74	803.74	-2.664	770.34	47331	15777	2.02	-0.087	0.669	0.668	1.001
52	465	0.20833	0.629	0.011	1.369	15	15.218	7.426	45.29	818.29	0.792	773.79	60219	20073	2.98	0.017	0.668	0.668	1.000
25	251	0.20833	0.532	0.013	1.244	15	15.218	7.426	38.30	811.30	0.936	773.94	54721	18240	2.52	0.024	0.672	0.668	1.006
32	258	0.20833	0.58	0.033	1.31	15	15.218	7.426	41.76	814.76	2.376	775.38	57624	19208	2.74	0.057	0.671	0.668	1.005
19	245	0.20833	0.474	0.035	1.153	15	15.218	7.426	34.13	807.13	2.520	775.52	50718	16906	2.24	0.074	0.670	0.668	1.003
37	263	0.20833	0.31	0.029	0.876	15	15.218	7.426	22.32	795.32	2.088	775.09	38533	12844	1.47	0.094	0.681	0.681	1.000
11	237	0.20833	0.427	0.042	1.076	15	15.218	7.426	30.74	803.74	3.024	776.02	47331	15777	2.02	0.098	0.669	0.668	1.001
53	466	0.20833	0.625	0.071	0.1376	15	15.218	7.426	45.00	818.00	5.112	778.11	6053	2018	2.96	0.114	0.067	0.668	0.101
26	252	0.20833	0.533	0.065	1.241	15	15.218	7.426	38.38	811.38	4.680	777.68	54589	18196	2.52	0.122	0.670	0.668	1.002
54	467	0.20833	0.625	0.121	0.1366	15	15.218	7.426	45.00	818.00	8.712	781.71	6009	2003	2.96	0.194	0.067	0.668	0.100
55	468	0.20833	0.629	0.122	1.368	15	15.218	7.426	45.29	818.29	8.784	781.78	60175	20058	2.98	0.194	0.667	0.668	0.999
3	229	0.20833	0.382	0.077	1.003	15	15.218	7.426	27.50	800.50	5.544	778.54	44120	14707	1.81	0.202	0.672	0.668	1.006
33	259	0.20833	0.58	0.124	1.309	15	15.218	7.426	41.76	814.76	8.928	781.93	57580	19193	2.74	0.214	0.671	0.668	1.004
27	253	0.20833	0.534	0.13	1.245	15	15.218	7.426	38.45	811.45	9.360	782.36	54765	18255	2.53	0.243	0.671	0.668	1.004
20	246	0.20833	0.477	0.133	1.151	15	15.218	7.426	34.34	807.34	9.576	782.58	50630	16877	2.26	0.279	0.666	0.668	0.997
12	238	0.20833	0.428	0.121	1.074	15	15.218	7.426	30.82	803.82	8.712	781.71	47243	15748	2.02	0.283	0.667	0.668	0.998

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A12-10
Data from Reference A2
13 total pages

56	469	0.20833	0.635	0.196	1.373	15	15.218	7.426	45.72	818.72	14.112	787.11	60395	20132	3.00	0.309	0.666	0.668	0.997
34	260	0.20833	0.584	0.181	1.308	15	15.218	7.426	42.05	815.05	13.032	786.03	57536	19179	2.76	0.310	0.667	0.668	0.999
5	231	0.20833	0.386	0.13	1.002	15	15.218	7.426	27.79	800.79	9.360	782.36	44076	14692	1.83	0.337	0.666	0.668	0.998
28	254	0.20833	0.54	0.187	1.246	15	15.218	7.426	38.88	811.88	13.464	786.46	54809	18270	2.55	0.346	0.667	0.668	0.998
57	470	0.20833	0.656	0.242	1.369	15	15.218	7.426	47.23	820.23	17.424	790.42	60219	20073	3.10	0.369	0.651	0.668	0.975
35	261	0.20833	0.605	0.235	1.308	15	15.218	7.426	43.56	816.56	16.920	789.92	57536	19179	2.86	0.388	0.653	0.668	0.978
13	239	0.20833	0.435	0.178	1.076	15	15.218	7.426	31.32	804.32	12.816	785.82	47331	15777	2.06	0.409	0.661	0.668	0.989
21	247	0.20833	0.488	0.2	1.155	15	15.218	7.426	35.14	808.14	14.400	787.40	50806	16935	2.31	0.410	0.659	0.668	0.986
36	262	0.20833	0.667	0.279	1.308	15	15.218	7.426	48.02	821.02	20.088	793.09	57536	19179	3.16	0.418	0.616	0.668	0.922
30	256	0.20833	0.567	0.239	1.241	15	15.218	7.426	40.82	813.82	17.208	790.21	54589	18196	2.68	0.422	0.645	0.668	0.965
29	255	0.20833	0.609	0.268	1.244	15	15.218	7.426	43.85	816.85	19.296	792.30	54721	18240	2.88	0.440	0.619	0.668	0.926
38	264	0.20833	0.318	0.141	0.876	15	15.218	7.426	22.90	795.90	10.152	783.15	38533	12844	1.50	0.443	0.669	0.680	0.983
31	257	0.20833	0.682	0.315	1.24	15	15.218	7.426	49.10	822.10	22.680	795.68	54545	18182	3.23	0.462	0.577	0.668	0.863
22	248	0.20833	0.547	0.26	1.152	15	15.218	7.426	39.38	812.38	18.720	791.72	50674	16891	2.59	0.475	0.612	0.668	0.916
14	240	0.20833	0.452	0.218	1.072	15	15.218	7.426	32.54	805.54	15.696	788.70	47155	15718	2.14	0.482	0.642	0.668	0.961
4	230	0.20833	0.398	0.192	1.004	15	15.218	7.426	28.66	801.66	13.824	786.82	44164	14721	1.88	0.482	0.654	0.668	0.979
23	249	0.20833	0.609	0.301	1.153	15	15.218	7.426	43.85	816.85	21.672	794.67	50718	16906	2.88	0.494	0.573	0.668	0.858
15	241	0.20833	0.507	0.258	1.072	15	15.218	7.426	36.50	809.50	18.576	791.58	47155	15718	2.40	0.509	0.597	0.668	0.893
24	250	0.20833	0.684	0.363	1.149	15	15.218	7.426	49.25	822.25	26.136	799.14	50542	16847	3.24	0.531	0.533	0.668	0.798
6	232	0.20833	0.437	0.236	1.001	15	15.218	7.426	31.46	804.46	16.992	789.99	44032	14677	2.07	0.540	0.613	0.668	0.917
16	242	0.20833	0.587	0.318	1.070	15	15.218	7.426	42.26	815.26	22.896	795.90	47067	15689	2.78	0.542	0.544	0.668	0.815
8	234	0.20833	0.534	0.303	0.998	15	15.218	7.426	38.45	811.45	21.816	794.82	43900	14633	2.53	0.567	0.538	0.668	0.805
39	265	0.20833	0.343	0.203	0.877	15	15.218	7.426	24.70	797.70	14.616	787.62	38577	12859	1.62	0.592	0.633	0.677	0.936
9	235	0.20833	0.592	0.356	0.998	15	15.218	7.426	42.62	815.62	25.632	798.63	43900	14633	2.80	0.601	0.505	0.668	0.756
40	266	0.20833	0.414	0.253	0.878	15	15.218	7.426	29.81	802.81	18.216	791.22	38621	12874	1.96	0.611	0.557	0.668	0.834
41	267	0.20833	0.467	0.294	0.876	15	15.218	7.426	33.62	806.62	21.168	794.17	38533	12844	2.21	0.630	0.514	0.668	0.769
42	268	0.20833	0.51	0.331	0.876	15	15.218	7.426	36.72	809.72	23.832	796.83	38533	12844	2.41	0.649	0.486	0.668	0.727
17	243	0.20833	0.54	0.366	1.068	15	15.218	7.426	38.88	811.88	26.352	799.35	46979	15660	2.55	0.678	0.572	0.668	0.856
44	270	0.20833	0.349	0.253	0.709	15	15.218	7.426	25.13	798.13	18.216	791.22	31187	10396	1.65	0.725	0.506	0.676	0.748
45	271	0.20833	0.43	0.315	0.718	15	15.218	7.426	30.96	803.96	22.680	795.68	31583	10528	2.03	0.733	0.444	0.668	0.665
7	233	0.20833	0.502	0.382	1.001	15	15.218	7.426	36.14	809.14	27.504	800.50	44032	14677	2.38	0.761	0.561	0.668	0.839
46	272	0.20833	0.519	0.396	0.717	15	15.218	7.426	37.37	810.37	28.512	801.51	31539	10513	2.46	0.763	0.393	0.668	0.589
50	276	0.20833	0.306	0.259	0.525	15	15.218	7.426	22.03	795.03	18.648	791.65	23094	7698	1.45	0.846	0.412	0.684	0.603
49	275	0.20833	0.378	0.32	0.53	15	15.218	7.426	27.22	800.22	23.040	796.04	23313	7771	1.79	0.847	0.358	0.672	0.532
48	274	0.20833	0.435	0.371	0.531	15	15.218	7.426	31.32	804.32	26.712	799.71	23357	7786	2.06	0.853	0.326	0.668	0.488
47	273	0.20833	0.479	0.413	0.53	15	15.218	7.426	34.49	807.49	29.736	802.74	23313	7771	2.27	0.862	0.306	0.668	0.458
54	476	0.27778	0.625	0.012	1.749	20	20.225	9.931	45.00	818.00	0.864	773.86	76934	25645	2.22	0.019	0.667	0.671	0.994

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A12-11
Data from Reference A2
13 total pages

1	83	0.27778	0.4	0.012	1.312	20	20.225	9.931	28.80	801.80	0.864	773.86	57712	19237	1.42	0.030	0.682	0.682	1.000
16	98	0.27778	0.542	0.024	1.601	20	20.225	9.931	39.02	812.02	1.728	774.73	70424	23475	1.93	0.044	0.670	0.670	1.000
21	103	0.27778	0.484	0.028	1.478	20	20.225	9.931	34.85	807.85	2.016	775.02	65014	21671	1.72	0.058	0.669	0.669	0.999
9	91	0.27778	0.593	0.064	1.7	20	20.225	9.931	42.70	815.70	4.608	777.61	74779	24926	2.11	0.108	0.671	0.671	1.000
29	112	0.27778	0.45	0.063	1.404	20	20.225	9.931	32.40	805.40	4.536	777.54	61759	20586	1.60	0.140	0.669	0.669	1.000
22	104	0.27778	0.484	0.087	1.483	20	20.225	9.931	34.85	807.85	6.264	779.26	65234	21745	1.72	0.180	0.671	0.669	1.002
14	96	0.27778	0.542	0.098	1.6	20	20.225	9.931	39.02	812.02	7.056	780.06	70380	23460	1.93	0.181	0.670	0.670	1.000
2	84	0.27778	0.401	0.082	1.313	20	20.225	9.931	28.87	801.87	5.904	778.90	57756	19252	1.43	0.204	0.681	0.682	0.999
55	477	0.27778	0.625	0.128	1.746	20	20.225	9.931	45.00	818.00	9.216	782.22	76803	25601	2.22	0.205	0.666	0.671	0.992
8	90	0.27778	0.593	0.132	1.704	20	20.225	9.931	42.70	815.70	9.504	782.50	74955	24985	2.11	0.223	0.672	0.671	1.003
28	111	0.27778	0.45	0.104	1.404	20	20.225	9.931	32.40	805.40	7.488	780.49	61759	20586	1.60	0.231	0.669	0.669	1.000
15	97	0.27778	0.543	0.13	1.601	20	20.225	9.931	39.10	812.10	9.360	782.36	70424	23475	1.93	0.239	0.670	0.670	0.999
10	92	0.27778	0.595	0.166	1.7	20	20.225	9.931	42.84	815.84	11.952	784.95	74779	24926	2.12	0.279	0.669	0.671	0.998
56	478	0.27778	0.627	0.182	1.746	20	20.225	9.931	45.14	818.14	13.104	786.10	76803	25601	2.23	0.290	0.665	0.671	0.990
17	99	0.27778	0.544	0.159	1.6	20	20.225	9.931	39.17	812.17	11.448	784.45	70380	23460	1.94	0.292	0.668	0.670	0.997
23	105	0.27778	0.489	0.154	1.486	20	20.225	9.931	35.21	808.21	11.088	784.09	65366	21789	1.74	0.315	0.668	0.669	0.997
30	113	0.27778	0.452	0.147	1.406	20	20.225	9.931	32.54	805.54	10.584	783.58	61847	20616	1.61	0.325	0.668	0.669	0.998
3	85	0.27778	0.404	0.137	1.311	20	20.225	9.931	29.09	802.09	9.864	782.86	57668	19223	1.44	0.339	0.676	0.681	0.993
57	479	0.27778	0.635	0.238	1.744	20	20.225	9.931	45.72	818.72	17.136	790.14	76715	25572	2.26	0.375	0.658	0.671	0.981
11	93	0.27778	0.605	0.236	1.698	20	20.225	9.931	43.56	816.56	16.992	789.99	74691	24897	2.15	0.390	0.661	0.671	0.986
18	100	0.27778	0.553	0.224	1.603	20	20.225	9.931	39.82	812.82	16.128	789.13	70512	23504	1.97	0.405	0.662	0.670	0.988
24	106	0.27778	0.495	0.209	1.482	20	20.225	9.931	35.64	808.64	15.048	788.05	65190	21730	1.76	0.422	0.660	0.670	0.986
58	480	0.27778	0.656	0.294	1.747	20	20.225	9.931	47.23	820.23	21.168	794.17	76847	25616	2.34	0.448	0.646	0.671	0.963
13	95	0.27778	0.623	0.281	1.7	20	20.225	9.931	44.86	817.86	20.232	793.23	74779	24926	2.22	0.451	0.650	0.671	0.968
31	114	0.27778	0.46	0.211	1.406	20	20.225	9.931	33.12	806.12	15.192	788.19	61847	20616	1.64	0.459	0.659	0.669	0.986
12	94	0.27778	0.663	0.319	1.699	20	20.225	9.931	47.74	820.74	22.968	795.97	74735	24912	2.36	0.481	0.624	0.671	0.930
19	101	0.27778	0.581	0.287	1.597	20	20.225	9.931	41.83	814.83	20.664	793.66	70248	23416	2.07	0.494	0.639	0.670	0.952
25	107	0.27778	0.513	0.262	1.484	20	20.225	9.931	36.94	809.94	18.864	791.86	65278	21759	1.83	0.511	0.645	0.670	0.963
4	86	0.27778	0.422	0.217	1.316	20	20.225	9.931	30.38	803.38	15.624	788.62	57888	19296	1.50	0.514	0.657	0.676	0.972
20	102	0.27778	0.642	0.331	1.598	20	20.225	9.931	46.22	819.22	23.832	796.83	70292	23431	2.29	0.516	0.599	0.671	0.893
26	108	0.27778	0.556	0.306	1.483	20	20.225	9.931	40.03	813.03	22.032	795.03	65234	21745	1.98	0.550	0.610	0.670	0.911
32	115	0.27778	0.509	0.293	1.407	20	20.225	9.931	36.65	809.65	21.096	794.10	61891	20630	1.81	0.576	0.615	0.670	0.918
27	109	0.27778	0.659	0.38	1.477	20	20.225	9.931	47.45	820.45	27.360	800.36	64970	21657	2.35	0.577	0.545	0.671	0.812
33	116	0.27778	0.576	0.339	1.4	20	20.225	9.931	41.47	814.47	24.408	797.41	61583	20528	2.05	0.589	0.563	0.670	0.840
5	87	0.27778	0.46	0.28	1.31	20	20.225	9.931	33.12	806.12	20.160	793.16	57624	19208	1.64	0.609	0.614	0.669	0.918
34	117	0.27778	0.654	0.402	1.401	20	20.225	9.931	47.09	820.09	28.944	801.94	61627	20542	2.33	0.615	0.519	0.671	0.774
6	88	0.27778	0.523	0.326	1.309	20	20.225	9.931	37.66	810.66	23.472	796.47	57580	19193	1.86	0.623	0.561	0.670	0.838
7	89	0.27778	0.606	0.392	1.302	20	20.225	9.931	43.63	816.63	28.224	801.22	57272	19091	2.16	0.647	0.507	0.671	0.755
40	123	0.27778	0.406	0.276	1.179	20	20.225	9.931	29.23	802.23	19.872	792.87	51861	17287	1.45	0.680	0.606	0.680	0.891

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A12-12
Data from Reference A2
13 total pages

41	124	0.27778	0.484	0.337	1.17	20	20.225	9.931	34.85	807.85	24.264	797.26	51466	17155	1.72	0.696	0.529	0.669	0.791
42	125	0.27778	0.565	0.395	0.956	20	20.225	9.931	40.68	813.68	28.440	801.44	42052	14017	2.01	0.699	0.389	0.670	0.581
48	131	0.27778	0.424	0.329	0.962	20	20.225	9.931	30.53	803.53	23.688	796.69	42316	14105	1.51	0.776	0.479	0.676	0.708
49	132	0.27778	0.513	0.4	0.718	20	20.225	9.931	36.94	809.94	28.800	801.80	31583	10528	1.83	0.780	0.312	0.670	0.466
50	133	0.27778	0.424	0.368	0.719	20	20.225	9.931	30.53	803.53	26.496	799.50	31627	10542	1.51	0.868	0.358	0.676	0.529
51	134	0.27778	0.462	0.401	0.717	20	20.225	9.931	33.26	806.26	28.872	801.87	31539	10513	1.64	0.868	0.335	0.669	0.501
53	136	0.27778	0.387	0.336	1.750	20	20.225	9.931	27.86	800.86	24.192	797.19	76978	25659	1.38	0.868	0.933	0.702	1.329
1	137	0.347222	0.524	-0.011	1.894	25	25.291	12.418	37.73	810.73	-0.792	772.21	83313	27771	1.49	-0.021	0.680	0.679	1.001
45	481	0.347222	0.561	0.029	1.976	25	25.291	12.418	40.39	813.39	2.088	775.09	86920	28973	1.60	0.052	0.675	0.675	1.000
3	139	0.347222	0.524	0.038	1.892	25	25.291	12.418	37.73	810.73	2.736	775.74	83225	27742	1.49	0.073	0.679	0.679	1.000
8	144	0.347222	0.619	0.049	2.114	25	25.291	12.418	44.57	817.57	3.528	776.53	92990	30997	1.76	0.079	0.673	0.673	1.001
2	138	0.347222	0.525	0.084	1.894	25	25.291	12.418	37.80	810.80	6.048	779.05	83313	27771	1.49	0.160	0.679	0.679	1.000
9	145	0.347222	0.619	0.124	2.122	25	25.291	12.418	44.57	817.57	8.928	781.93	93342	31114	1.76	0.200	0.676	0.673	1.004
46	482	0.347222	0.561	0.134	1.975	25	25.291	12.418	40.39	813.39	9.648	782.65	86876	28959	1.60	0.239	0.674	0.675	0.999
4	140	0.347222	0.527	0.148	1.893	25	25.291	12.418	37.94	810.94	10.656	783.66	83269	27756	1.50	0.281	0.677	0.679	0.997
10	146	0.347222	0.624	0.189	2.118	25	25.291	12.418	44.93	817.93	13.608	786.61	93166	31055	1.78	0.303	0.671	0.673	0.997
48	484	0.347222	0.565	0.187	1.980	25	25.291	12.418	40.68	813.68	13.464	786.46	87096	29032	1.61	0.331	0.673	0.675	0.997
47	483	0.347222	0.569	0.223	1.974	25	25.291	12.418	40.97	813.97	16.056	789.06	86832	28944	1.62	0.392	0.667	0.675	0.989
11	147	0.347222	0.633	0.254	2.115	25	25.291	12.418	45.58	818.58	18.288	791.29	93034	31011	1.80	0.401	0.663	0.673	0.986
5	141	0.347222	0.536	0.227	1.893	25	25.291	12.418	38.59	811.59	16.344	789.34	83269	27756	1.53	0.424	0.668	0.678	0.986
49	485	0.347222	0.575	0.258	1.981	25	25.291	12.418	41.40	814.40	18.576	791.58	87140	29047	1.64	0.449	0.665	0.675	0.985
31	167	0.347222	0.49	0.237	1.787	25	25.291	12.418	35.28	808.28	17.064	790.06	78606	26202	1.39	0.484	0.675	0.713	0.947
12	148	0.347222	0.67	0.336	2.113	25	25.291	12.418	48.24	821.24	24.192	797.19	92946	30982	1.91	0.501	0.638	0.673	0.947
6	142	0.347222	0.55	0.29	1.893	25	25.291	12.418	39.60	812.60	20.880	793.88	83269	27756	1.57	0.527	0.656	0.676	0.970
50	486	0.347222	0.609	0.323	1.976	25	25.291	12.418	43.85	816.85	23.256	796.26	86920	28973	1.73	0.530	0.637	0.673	0.945
32	168	0.347222	0.515	0.281	1.786	25	25.291	12.418	37.08	810.08	20.232	793.23	78562	26187	1.47	0.546	0.650	0.688	0.944
51	487	0.347222	0.654	0.368	1.971	25	25.291	12.418	47.09	820.09	26.496	799.50	86700	28900	1.86	0.563	0.605	0.673	0.898
7	143	0.347222	0.644	0.382	1.889	25	25.291	12.418	46.37	819.37	27.504	800.50	83093	27698	1.83	0.593	0.586	0.673	0.870
33	169	0.347222	0.568	0.349	1.784	25	25.291	12.418	40.90	813.90	25.128	798.13	78474	26158	1.62	0.614	0.604	0.675	0.895
34	170	0.347222	0.634	0.397	1.785	25	25.291	12.418	45.65	818.65	28.584	801.58	78518	26173	1.80	0.626	0.559	0.673	0.831
58	502	0.347222	0.471	0.3	1.662	25	25.291	12.418	33.91	806.91	21.600	794.60	73108	24369	1.34	0.637	0.647	0.732	0.885
59	503	0.347222	0.497	0.324	1.662	25	25.291	12.418	35.78	808.78	23.328	796.33	73108	24369	1.41	0.652	0.621	0.706	0.880
60	504	0.347222	0.528	0.352	1.661	25	25.291	12.418	38.02	811.02	25.344	798.34	73064	24355	1.50	0.667	0.593	0.679	0.874
61	505	0.347222	0.582	0.388	1.661	25	25.291	12.418	41.90	814.90	27.936	800.94	73064	24355	1.66	0.667	0.552	0.674	0.819
44	180	0.347222	0.529	0.386	1.454	25	25.291	12.418	38.09	811.09	27.792	800.79	63958	21319	1.51	0.730	0.518	0.678	0.764
43	179	0.347222	0.553	0.404	1.453	25	25.291	12.418	39.82	812.82	29.088	802.09	63914	21305	1.57	0.731	0.501	0.676	0.742
42	178	0.347222	0.494	0.363	1.454	25	25.291	12.418	35.57	808.57	26.136	799.14	63958	21319	1.41	0.735	0.546	0.709	0.770
21	157	0.347222	0.493	0.401	1.185	25	25.291	12.418	35.50	808.50	28.872	801.87	52125	17375	1.40	0.813	0.446	0.710	0.628
20	156	0.347222	0.455	0.378	1.188	25	25.291	12.418	32.76	805.76	27.216	800.22	52257	17419	1.30	0.831	0.476	0.747	0.636

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A12-13
Data from Reference A2
13 total pages

25	205	0.41667	0.583	0.007	2.432	30	30.436	14.885	41.98	814.98	0.504	773.50	106978	35659	1.38	0.012	0.701	0.701	1.000
24	204	0.41667	0.583	0.05	2.432	30	30.436	14.885	41.98	814.98	3.600	776.60	106978	35659	1.38	0.086	0.701	0.701	1.000
17	197	0.41667	0.625	0.06	2.497	30	30.436	14.885	45.00	818.00	4.320	777.32	109837	36612	1.48	0.096	0.683	0.683	1.000
26	206	0.41667	0.588	0.109	2.435	30	30.436	14.885	42.34	815.34	7.848	780.85	107110	35703	1.39	0.185	0.697	0.697	1.000
19	199	0.41667	0.626	0.124	2.509	30	30.436	14.885	45.07	818.07	8.928	781.93	110365	36788	1.48	0.198	0.685	0.683	1.003
32	212	0.41667	0.595	0.146	2.434	30	30.436	14.885	42.84	815.84	10.512	783.51	107066	35689	1.41	0.245	0.691	0.695	0.995
18	198	0.41667	0.629	0.165	2.502	30	30.436	14.885	45.29	818.29	11.880	784.88	110057	36686	1.49	0.262	0.681	0.683	0.997
23	203	0.41667	0.594	0.157	2.422	30	30.436	14.885	42.77	815.77	11.304	784.30	106538	35513	1.41	0.264	0.688	0.695	0.991
27	207	0.41667	0.601	0.198	2.436	30	30.436	14.885	43.27	816.27	14.256	787.26	107154	35718	1.42	0.329	0.686	0.692	0.991
33	213	0.41667	0.607	0.219	2.434	30	30.436	14.885	43.70	816.70	15.768	788.77	107066	35689	1.44	0.361	0.680	0.690	0.986
20	200	0.41667	0.638	0.24	2.503	30	30.436	14.885	45.94	818.94	17.280	790.28	110101	36700	1.51	0.376	0.674	0.683	0.987
28	208	0.41667	0.611	0.254	2.426	30	30.436	14.885	43.99	816.99	18.288	791.29	106714	35571	1.45	0.416	0.675	0.688	0.980
30	210	0.41667	0.619	0.276	2.426	30	30.436	14.885	44.57	817.57	19.872	792.87	106714	35571	1.46	0.446	0.668	0.685	0.975
21	201	0.41667	0.659	0.31	2.507	30	30.436	14.885	47.45	820.45	22.320	795.32	110277	36759	1.56	0.470	0.659	0.683	0.965
29	209	0.41667	0.637	0.326	2.423	30	30.436	14.885	45.86	818.86	23.472	796.47	106582	35527	1.51	0.512	0.653	0.683	0.957
38	218	0.41667	0.57	0.315	2.280	30	30.436	14.885	41.04	814.04	22.680	795.68	100292	33431	1.35	0.553	0.669	0.716	0.934
39	219	0.41667	0.595	0.343	2.284	30	30.436	14.885	42.84	815.84	24.696	797.70	100468	33489	1.41	0.576	0.648	0.695	0.933
40	220	0.41667	0.621	0.382	2.280	30	30.436	14.885	44.71	817.71	27.504	800.50	100292	33431	1.47	0.615	0.627	0.685	0.915
15	195	0.41667	0.577	0.375	2.153	30	30.436	14.885	41.54	814.54	27.000	800.00	94706	31569	1.36	0.650	0.626	0.708	0.884
16	196	0.41667	0.622	0.414	2.156	30	30.436	14.885	44.78	817.78	29.808	802.81	94837	31612	1.47	0.666	0.592	0.684	0.865
[redacted]	226	0.486111	0.699	0.296	3.025	35	35.699	17.326	50.33	823.33	21.312	794.31	133063	44354	1.41	[redacted]	0.674	0.697	0.967

Formulas:

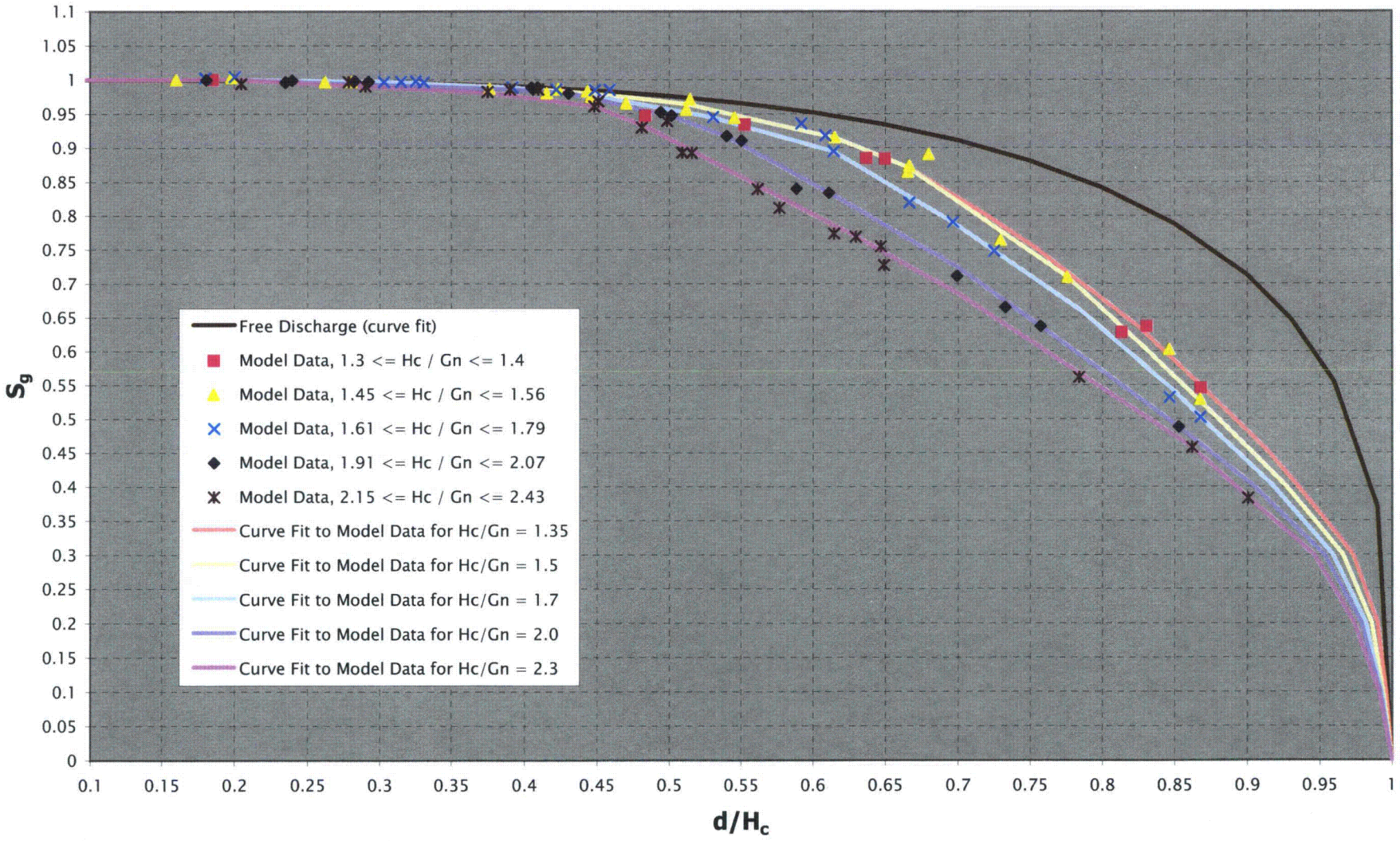
(1) $H_{cp} = S\{H_{1m}\}$
(2) $V_p = S\{V_m\}$
(3) $d_p = S\{d_m\}$
(4) $Q_{gsp} = S^{2.5}Q_m/3$
(5) $d/H_c = d_p/H_{cp}$
(6) $C_gS_g = Q_{gsp}/\{G_{np}L_p[2g(H_{cp} - H_{,mpp})]^{0.5}\}$
(7) C_g by interpolation between points on worksheet "C_g" defining $C_g(H_c)$ for no tailwater submergence effects
(8) $S_g = C_gS_g/C_g$
(9) * Indicates unsubmerged values, meaning $S_f = 1.0$

Calculation No: CDQ000020080018

Attachment A13-1
Data from Reference A2
11 total pages

Submergence Factors for Radial Gates on Spillway Crests
Tellico Dam 1:72 scale model data

Prepared by: S.E.M.
Checked by: J.B.M.



Calculation No: CDQ000020080018

Attachment A13-2
11 total pages

Prepared by: S.E.M.
Checked by: J.B.M.

Curve Fits through S_g Data

Curve Fit, H_c/G_n = 1.35

d/H_c	S_g
0.000	1.000
0.200	1.000
0.280	0.997
0.424	0.984
0.469	0.975
0.513	0.964
0.615	0.915
0.665	0.872
0.720	0.800
0.755	0.750
0.825	0.636
0.870	0.545
0.915	0.450
0.935	0.400
0.973	0.300
0.990	0.200
0.996	0.100
1.000	0.000

Curve Fit, H_c/G_n = 1.5

d/H_c	S_g
0.000	1.000
0.200	1.000
0.280	0.997
0.424	0.984
0.469	0.975
0.513	0.964
0.615	0.915
0.665	0.872
0.776	0.709
0.830	0.603
0.880	0.500
0.927	0.400
0.966	0.300
0.986	0.200
0.994	0.100
1.000	0.000

Curve Fit, H_c/G_n = 1.7

d/H_c	S_g
0.000	1.000
0.200	1.000
0.303	0.997
0.392	0.989
0.451	0.975
0.530	0.945
0.614	0.895
0.696	0.791
0.785	0.660
0.850	0.540
0.868	0.502
0.918	0.400
0.959	0.300
0.982	0.200
0.993	0.100
1.000	0.000

Curve Fit, H_c/G_n = 2.0

d/H_c	S_g
0.000	1.000
0.200	1.000
0.390	0.986
0.431	0.980
0.501	0.947
0.540	0.917
0.611	0.834
0.699	0.725
0.757	0.637
0.853	0.488
0.905	0.400
0.953	0.300
0.979	0.200
0.992	0.100
1.000	0.000

Curve Fit, H_c/G_n = 2.3

d/H_c	S_g
0.000	1.000
0.200	1.000
0.290	0.990
0.375	0.981
0.448	0.961
0.485	0.930
0.630	0.769
0.700	0.685
0.862	0.458
0.901	0.383
0.946	0.300
0.974	0.200
0.991	0.100
1.000	0.000

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A13-3
Data from Reference A2
11 total pages

Model Data to Determine Orifice Discharge Submergence Factor

Tellico Project
Tainter Gates Raised Above the Water Surface
Tellico Spillway Rating, 1:72 Model, Books 1 & 2, 1969
under tabs: "X' Gate Opening" (Ref. 2.4)

Model scale, S = 72

Z_{cp} = 773 ft
L_p = 40 ft
g = 32.2 f/s^2
L_m = 1.667 ft (3 bays)

	Model Data					Prototype Geometry			Prototype Values									
Order No.	Test No.	ft V_m	ft H_{1m}	ft d_m	cfs (3 bays) Q_m	ft V_p	ft G_{np}	ft H_{mpp}	ft H_{cp} (1)	ft HW elev.	ft d_p (2)	ft TW elev.	cfs (3 bays) $Q_{g,p}$	cfs (1 bay) Q_{gsp} (3)	H_{cp}/G_{np}	d/H_c (4)	C_gS_g (5)	C_g (6)	S_g (7)
20	156	0.347222	0.455	0.378	1.188	25	25.291	12.418	32.76	805.76	27.216	800.22	52257	17419	1.30	0.831	0.476	0.747	0.636
58	502	0.347222	0.471	0.3	1.662	25	25.291	12.418	33.91	806.91	21.600	794.60	73108	24369	1.34	0.637	0.647	0.732	0.885
38	218	0.41667	0.57	0.315	2.280	30	30.436	14.885	41.04	814.04	22.680	795.68	100292	33431	1.35	0.553	0.669	0.716	0.934
15	195	0.41667	0.577	0.375	2.153	30	30.436	14.885	41.54	814.54	27.000	800.00	94706	31569	1.36	0.650	0.626	0.708	0.884
53	136	0.27778	0.387	0.336	0.718	20	20.225	9.931	27.86	800.86	24.192	797.19	31583	10528	1.38	0.868	0.383	0.702	0.545
24	204	0.41667	0.583	0.05	2.432	30	30.436	14.885	41.98	814.98	3.600	776.60	106978	35659	1.38	0.086	0.701	0.701	1.000
25	205	0.41667	0.583	0.007	2.432	30	30.436	14.885	41.98	814.98	0.504	773.50	106978	35659	1.38	0.012	0.701	0.701	1.000
26	206	0.41667	0.588	0.109	2.435	30	30.436	14.885	42.34	815.34	7.848	780.85	107110	35703	1.39	0.185	0.697	0.697	1.000
31	167	0.347222	0.49	0.237	1.787	25	25.291	12.418	35.28	808.28	17.064	790.06	78606	26202	1.39	0.484	0.675	0.713	0.947
21	157	0.347222	0.493	0.401	1.185	25	25.291	12.418	35.50	808.50	28.872	801.87	52125	17375	1.40	0.813	0.446	0.710	0.628
23	203	0.41667	0.594	0.157	2.422	30	30.436	14.885	42.77	815.77	11.304	784.30	106538	35513	1.41	0.264	0.688	0.695	0.991
42	178	0.347222	0.494	0.363	1.454	25	25.291	12.418	35.57	808.57	26.136	799.14	63958	21319	1.41	0.735	0.546	0.709	0.770
32	212	0.41667	0.595	0.146	2.434	30	30.436	14.885	42.84	815.84	10.512	783.51	107066	35689	1.41	0.245	0.691	0.695	0.995
39	219	0.41667	0.595	0.343	2.284	30	30.436	14.885	42.84	815.84	24.696	797.70	100468	33489	1.41	0.576	0.648	0.695	0.933
5	226	0.486111	0.699	0.296	3.025	35	35.699	17.326	50.33	823.33	21.312	794.31	133063	44354	1.41	0.423	0.674	0.697	0.967
59	503	0.347222	0.497	0.324	1.662	25	25.291	12.418	35.78	808.78	23.328	796.33	73108	24369	1.41	0.652	0.621	0.706	0.880
27	207	0.41667	0.601	0.198	2.436	30	30.436	14.885	43.27	816.27	14.256	787.26	107154	35718	1.42	0.329	0.686	0.692	0.991
1	83	0.27778	0.4	0.012	1.312	20	20.225	9.931	28.80	801.80	0.864	773.86	57712	19237	1.42	0.030	0.682	0.682	1.000
2	84	0.27778	0.401	0.082	1.313	20	20.225	9.931	28.87	801.87	5.904	778.90	57756	19252	1.43	0.204	0.681	0.682	0.999
33	213	0.41667	0.607	0.219	2.434	30	30.436	14.885	43.70	816.70	15.768	788.77	107066	35689	1.44	0.361	0.680	0.690	0.986
3	85	0.27778	0.404	0.137	1.311	20	20.225	9.931	29.09	802.09	9.864	782.86	57668	19223	1.44	0.339	0.676	0.681	0.993
40	123	0.27778	0.406	0.276	1.179	20	20.225	9.931	29.23	802.23	19.872	792.87	51861	17287	1.45	0.680	0.606	0.680	0.891
28	208	0.41667	0.611	0.254	2.426	30	30.436	14.885	43.99	816.99	18.288	791.29	106714	35571	1.45	0.416	0.675	0.688	0.980
50	276	0.20833	0.306	0.259	0.525	15	15.218	7.426	22.03	795.03	18.648	791.65	23094	7698	1.45	0.846	0.412	0.684	0.603
30	210	0.41667	0.619	0.276	2.426	30	30.436	14.885	44.57	817.57	19.872	792.87	106714	35571	1.46	0.446	0.668	0.685	0.975
32	168	0.347222	0.515	0.281	1.786	25	25.291	12.418	37.08	810.08	20.232	793.23	78562	26187	1.47	0.546	0.650	0.688	0.944
37	263	0.20833	0.31	0.029	0.876	15	15.218	7.426	22.32	795.32	2.088	775.09	38533	12844	1.47	0.094	0.681	0.681	1.000
40	220	0.41667	0.621	0.382	2.280	30	30.436	14.885	44.71	817.71	27.504	800.50	100292	33431	1.47	0.615	0.627	0.685	0.915
16	196	0.41667	0.622	0.414	2.156	30	30.436	14.885	44.78	817.78	29.808	802.81	94837	31612	1.47	0.666	0.592	0.684	0.865

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A13-4
Data from Reference A2
11 total pages

17	197	0.41667	0.625	0.06	2.497	30	30.436	14.885	45.00	818.00	4.320	777.32	109837	36612	1.48	0.096	0.683	0.683	1.000
19	199	0.41667	0.626	0.124	2.509	30	30.436	14.885	45.07	818.07	8.928	781.93	110365	36788	1.48	0.198	0.685	0.683	1.003
18	198	0.41667	0.629	0.165	2.502	30	30.436	14.885	45.29	818.29	11.880	784.88	110057	36686	1.49	0.262	0.681	0.683	0.997
1	137	0.347222	0.524	-0.011	1.894	25	25.291	12.418	37.73	810.73	-0.792	772.21	83313	27771	1.49	-0.021	0.680	0.679	1.001
3	139	0.347222	0.524	0.038	1.892	25	25.291	12.418	37.73	810.73	2.736	775.74	83225	27742	1.49	0.073	0.679	0.679	1.000
2	138	0.347222	0.525	0.084	1.894	25	25.291	12.418	37.80	810.80	6.048	779.05	83313	27771	1.49	0.160	0.679	0.679	1.000
4	140	0.347222	0.527	0.148	1.893	25	25.291	12.418	37.94	810.94	10.656	783.66	83269	27756	1.50	0.281	0.677	0.679	0.997
4	86	0.27778	0.422	0.217	1.316	20	20.225	9.931	30.38	803.38	15.624	788.62	57888	19296	1.50	0.514	0.657	0.676	0.972
60	504	0.347222	0.528	0.352	1.661	25	25.291	12.418	38.02	811.02	25.344	798.34	73064	24355	1.50	0.667	0.593	0.679	0.874
38	264	0.20833	0.318	0.141	0.876	15	15.218	7.426	22.90	795.90	10.152	783.15	38533	12844	1.50	0.443	0.669	0.680	0.983
44	180	0.347222	0.529	0.386	1.454	25	25.291	12.418	38.09	811.09	27.792	800.79	63958	21319	1.51	0.730	0.518	0.678	0.764
29	209	0.41667	0.637	0.326	2.423	30	30.436	14.885	45.86	818.86	23.472	796.47	106582	35527	1.51	0.512	0.653	0.683	0.957
20	200	0.41667	0.638	0.24	2.503	30	30.436	14.885	45.94	818.94	17.280	790.28	110101	36700	1.51	0.376	0.674	0.683	0.987
48	131	0.27778	0.424	0.329	0.963	20	20.225	9.931	30.53	803.53	23.688	796.69	42360	14120	1.51	0.776	0.479	0.676	0.709
50	133	0.27778	0.424	0.368	0.719	20	20.225	9.931	30.53	803.53	26.496	799.50	31627	10542	1.51	0.868	0.358	0.676	0.529
5	141	0.347222	0.536	0.227	1.893	25	25.291	12.418	38.59	811.59	16.344	789.34	83269	27756	1.53	0.424	0.668	0.678	0.986
21	201	0.41667	0.659	0.31	2.507	30	30.436	14.885	47.45	820.45	22.320	795.32	110277	36759	1.56	0.470	0.659	0.683	0.965
6	142	0.347222	0.55	0.29	1.893	25	25.291	12.418	39.60	812.60	20.880	793.88	83269	27756	1.57	0.527	0.656	0.676	0.970
43	179	0.347222	0.553	0.404	1.453	25	25.291	12.418	39.82	812.82	29.088	802.09	63914	21305	1.57	0.731	0.501	0.676	0.742
45	481	0.347222	0.561	0.029	1.976	25	25.291	12.418	40.39	813.39	2.088	775.09	86920	28973	1.60	0.052	0.675	0.675	1.000
46	482	0.347222	0.561	0.134	1.975	25	25.291	12.418	40.39	813.39	9.648	782.65	86876	28959	1.60	0.239	0.674	0.675	0.999
28	111	0.27778	0.45	0.104	1.404	20	20.225	9.931	32.40	805.40	7.488	780.49	61759	20586	1.60	0.231	0.669	0.669	1.000
29	112	0.27778	0.45	0.063	1.404	20	20.225	9.931	32.40	805.40	4.536	777.54	61759	20586	1.60	0.140	0.669	0.669	1.000
48	484	0.347222	0.565	0.187	1.980	25	25.291	12.418	40.68	813.68	13.464	786.46	87096	29032	1.61	0.331	0.673	0.675	0.997
30	113	0.27778	0.452	0.147	1.406	20	20.225	9.931	32.54	805.54	10.584	783.58	61847	20616	1.61	0.325	0.668	0.669	0.998
33	169	0.347222	0.568	0.349	1.784	25	25.291	12.418	40.90	813.90	25.128	798.13	78474	26158	1.62	0.614	0.604	0.675	0.895
47	483	0.347222	0.569	0.223	1.974	25	25.291	12.418	40.97	813.97	16.056	789.06	86832	28944	1.62	0.392	0.667	0.675	0.989
39	265	0.20833	0.343	0.203	0.877	15	15.218	7.426	24.70	797.70	14.616	787.62	38577	12859	1.62	0.592	0.633	0.677	0.936
49	485	0.347222	0.575	0.258	1.981	25	25.291	12.418	41.40	814.40	18.576	791.58	87140	29047	1.64	0.449	0.665	0.675	0.985
5	87	0.27778	0.46	0.28	1.31	20	20.225	9.931	33.12	806.12	20.160	793.16	57624	19208	1.64	0.609	0.614	0.669	0.918
31	114	0.27778	0.46	0.211	1.406	20	20.225	9.931	33.12	806.12	15.192	788.19	61847	20616	1.64	0.459	0.659	0.669	0.986
51	134	0.27778	0.462	0.401	0.717	20	20.225	9.931	33.26	806.26	28.872	801.87	31539	10513	1.64	0.868	0.335	0.669	0.501
44	270	0.20833	0.349	0.253	0.709	15	15.218	7.426	25.13	798.13	18.216	791.22	31187	10396	1.65	0.725	0.506	0.676	0.748
61	505	0.347222	0.582	0.388	1.661	25	25.291	12.418	41.90	814.90	27.936	800.94	73064	24355	1.66	0.667	0.552	0.674	0.819
21	103	0.27778	0.484	0.028	1.478	20	20.225	9.931	34.85	807.85	2.016	775.02	65014	21671	1.72	0.058	0.669	0.669	0.999
22	104	0.27778	0.484	0.087	1.483	20	20.225	9.931	34.85	807.85	6.264	779.26	65234	21745	1.72	0.180	0.671	0.669	1.002
41	124	0.27778	0.484	0.337	1.17	20	20.225	9.931	34.85	807.85	24.264	797.26	51466	17155	1.72	0.696	0.529	0.669	0.791
50	486	0.347222	0.609	0.323	1.976	25	25.291	12.418	43.85	816.85	23.256	796.26	86920	28973	1.73	0.530	0.637	0.673	0.945
23	105	0.27778	0.489	0.154	1.486	20	20.225	9.931	35.21	808.21	11.088	784.09	65366	21789	1.74	0.315	0.668	0.669	0.997
24	106	0.27778	0.495	0.209	1.482	20	20.225	9.931	35.64	808.64	15.048	788.05	65190	21730	1.76	0.422	0.660	0.670	0.986
8	144	0.347222	0.619	0.049	2.114	25	25.291	12.418	44.57	817.57	3.528	776.53	92990	30997	1.76	0.079	0.673	0.673	1.001

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A13-5
Data from Reference A2
11 total pages

9	145	0.347222	0.619	0.124	2.122	25	25.291	12.418	44.57	817.57	8.928	781.93	93342	31114	1.76	0.200	0.676	0.673	1.004
10	146	0.347222	0.624	0.189	2.118	25	25.291	12.418	44.93	817.93	13.608	786.61	93166	31055	1.78	0.303	0.671	0.673	0.997
49	275	0.20833	0.378	0.32	0.53	15	15.218	7.426	27.22	800.22	23.040	796.04	23313	7771	1.79	0.847	0.358	0.672	0.532
11	147	0.347222	0.633	0.254	2.115	25	25.291	12.418	45.58	818.58	18.288	791.29	93034	31011	1.80	0.401	0.663	0.673	0.986
34	170	0.347222	0.634	0.397	1.785	25	25.291	12.418	45.65	818.65	28.584	801.58	78518	26173	1.80	0.626	0.559	0.673	0.831
1	227	0.20833	0.382	-0.182	1.003	15	15.218	7.426	27.50	800.50	-13.104	759.90	44120	14707	1.81	-0.476	0.672	0.668	1.006
2	228	0.20833	0.382	-0.063	1.003	15	15.218	7.426	27.50	800.50	-4.536	768.46	44120	14707	1.81	-0.165	0.672	0.668	1.006
3	229	0.20833	0.382	0.077	1.003	15	15.218	7.426	27.50	800.50	5.544	778.54	44120	14707	1.81	0.202	0.672	0.668	1.006
32	115	0.27778	0.509	0.293	1.407	20	20.225	9.931	36.65	809.65	21.096	794.10	61891	20630	1.81	0.576	0.615	0.670	0.918
25	107	0.27778	0.513	0.262	1.484	20	20.225	9.931	36.94	809.94	18.864	791.86	65278	21759	1.83	0.511	0.645	0.670	0.963
49	132	0.27778	0.513	0.4	0.962	20	20.225	9.931	36.94	809.94	28.800	801.80	42316	14105	1.83	0.780	0.418	0.670	0.624
5	231	0.20833	0.386	0.13	1.002	15	15.218	7.426	27.79	800.79	9.360	782.36	44076	14692	1.83	0.337	0.666	0.668	0.998
7	143	0.347222	0.644	0.382	1.889	25	25.291	12.418	46.37	819.37	27.504	800.50	83093	27698	1.83	0.593	0.586	0.673	0.870
51	487	0.347222	0.654	0.368	1.971	25	25.291	12.418	47.09	820.09	26.496	799.50	86700	28900	1.86	0.563	0.605	0.673	0.898
6	88	0.27778	0.523	0.326	1.309	20	20.225	9.931	37.66	810.66	23.472	796.47	57580	19193	1.86	0.623	0.561	0.670	0.838
4	230	0.20833	0.398	0.192	1.004	15	15.218	7.426	28.66	801.66	13.824	786.82	44164	14721	1.88	0.482	0.654	0.668	0.979
12	148	0.347222	0.67	0.336	2.113	25	25.291	12.418	48.24	821.24	24.192	797.19	92946	30982	1.91	0.501	0.638	0.673	0.947
14	96	0.27778	0.542	0.098	1.6	20	20.225	9.931	39.02	812.02	7.056	780.06	70380	23460	1.93	0.181	0.670	0.670	1.000
16	98	0.27778	0.542	0.024	1.601	20	20.225	9.931	39.02	812.02	1.728	774.73	70424	23475	1.93	0.044	0.670	0.670	1.000
15	97	0.27778	0.543	0.13	1.601	20	20.225	9.931	39.10	812.10	9.360	782.36	70424	23475	1.93	0.239	0.670	0.670	0.999
17	99	0.27778	0.544	0.159	1.6	20	20.225	9.931	39.17	812.17	11.448	784.45	70380	23460	1.94	0.292	0.668	0.670	0.997
40	266	0.20833	0.414	0.253	0.878	15	15.218	7.426	29.81	802.81	18.216	791.22	38621	12874	1.96	0.611	0.557	0.668	0.834
20	296	0.138889	0.28	-0.041	0.5842	10	10.277	4.894	20.16	793.16	-2.952	770.05	25698	8566	1.96	-0.146	0.665	0.665	0.999
18	100	0.27778	0.553	0.224	1.603	20	20.225	9.931	39.82	812.82	16.128	789.13	70512	23504	1.97	0.405	0.662	0.670	0.988
21	297	0.138889	0.281	0.066	0.5841	10	10.277	4.894	20.23	793.23	4.752	777.75	25693	8564	1.97	0.235	0.663	0.665	0.996
26	108	0.27778	0.556	0.306	1.483	20	20.225	9.931	40.03	813.03	22.032	795.03	65234	21745	1.98	0.550	0.610	0.670	0.911
28	304	0.138889	0.284	0.215	0.376	10	10.277	4.894	20.45	793.45	15.480	788.48	16539	5513	1.99	0.757	0.424	0.665	0.637
42	125	0.27778	0.565	0.395	1.17	20	20.225	9.931	40.68	813.68	28.440	801.44	51466	17155	2.01	0.699	0.477	0.670	0.711
22	298	0.138889	0.288	0.124	0.5839	10	10.277	4.894	20.74	793.74	8.928	781.93	25684	8561	2.02	0.431	0.652	0.665	0.980
10	236	0.20833	0.427	-0.037	1.076	15	15.218	7.426	30.74	803.74	-2.664	770.34	47331	15777	2.02	-0.087	0.669	0.668	1.001
11	237	0.20833	0.427	0.042	1.076	15	15.218	7.426	30.74	803.74	3.024	776.02	47331	15777	2.02	0.098	0.669	0.668	1.001
12	238	0.20833	0.428	0.121	1.074	15	15.218	7.426	30.82	803.82	8.712	781.71	47243	15748	2.02	0.283	0.667	0.668	0.998
45	271	0.20833	0.43	0.315	0.718	15	15.218	7.426	30.96	803.96	22.680	795.68	31583	10528	2.03	0.733	0.444	0.668	0.665
33	116	0.27778	0.576	0.339	1.4	20	20.225	9.931	41.47	814.47	24.408	797.41	61583	20528	2.05	0.589	0.563	0.670	0.840
13	239	0.20833	0.435	0.178	1.076	15	15.218	7.426	31.32	804.32	12.816	785.82	47331	15777	2.06	0.409	0.661	0.668	0.989
48	274	0.20833	0.435	0.371	0.531	15	15.218	7.426	31.32	804.32	26.712	799.71	23357	7786	2.06	0.853	0.326	0.668	0.488
6	232	0.20833	0.437	0.236	1.001	15	15.218	7.426	31.46	804.46	16.992	789.99	44032	14677	2.07	0.540	0.613	0.668	0.917
19	101	0.27778	0.581	0.287	1.597	20	20.225	9.931	41.83	814.83	20.664	793.66	70248	23416	2.07	0.494	0.639	0.670	0.952
8	90	0.27778	0.593	0.132	1.704	20	20.225	9.931	42.70	815.70	9.504	782.50	74955	24985	2.11	0.223	0.672	0.671	1.003
9	91	0.27778	0.593	0.064	1.7	20	20.225	9.931	42.70	815.70	4.608	777.61	74779	24926	2.11	0.108	0.671	0.671	1.000
10	92	0.27778	0.595	0.166	1.7	20	20.225	9.931	42.84	815.84	11.952	784.95	74779	24926	2.12	0.279	0.669	0.671	0.998
14	240	0.20833	0.452	0.218	1.072	15	15.218	7.426	32.54	805.54	15.696	788.70	47155	15718	2.14	0.482	0.642	0.668	0.961
24	300	0.138889	0.307	0.153	0.5835	10	10.277	4.894	22.10	795.10	11.016	784.02	25667	8556	2.15	0.498	0.625	0.665	0.940

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A13-6
Data from Reference A2
11 total pages

11	93	0.27778	0.605	0.236	1.698	20	20.225	9.931	43.56	816.56	16.992	789.99	74691	24897	2.15	0.390	0.661	0.671	0.986
7	89	0.27778	0.606	0.392	1.302	20	20.225	9.931	43.63	816.63	28.224	801.22	57272	19091	2.16	0.647	0.507	0.671	0.755
41	267	0.20833	0.467	0.294	0.876	15	15.218	7.426	33.62	806.62	21.168	794.17	38533	12844	2.21	0.630	0.514	0.668	0.769
13	95	0.27778	0.623	0.281	1.7	20	20.225	9.931	44.86	817.86	20.232	793.23	74779	24926	2.22	0.451	0.650	0.671	0.968
54	476	0.27778	0.625	0.012	1.750	20	20.225	9.931	45.00	818.00	0.864	773.86	76978	25659	2.22	0.019	0.667	0.671	0.995
55	477	0.27778	0.625	0.128	1.749	20	20.225	9.931	45.00	818.00	9.216	782.22	76934	25645	2.22	0.205	0.667	0.671	0.994
56	478	0.27778	0.627	0.182	1.746	20	20.225	9.931	45.14	818.14	13.104	786.10	76803	25601	2.23	0.290	0.665	0.671	0.990
18	244	0.20833	0.474	-0.103	1.153	15	15.218	7.426	34.13	807.13	-7.416	765.58	50718	16906	2.24	-0.217	0.670	0.668	1.003
19	245	0.20833	0.474	0.035	1.153	15	15.218	7.426	34.13	807.13	2.520	775.52	50718	16906	2.24	0.074	0.670	0.668	1.003
32	308	0.138889	0.322	0.29	0.2451	10	10.277	4.894	23.18	796.18	20.880	793.88	10781	3594	2.26	0.901	0.255	0.665	0.383
20	246	0.20833	0.477	0.133	1.151	15	15.218	7.426	34.34	807.34	9.576	782.58	50630	16877	2.26	0.279	0.666	0.668	0.997
57	479	0.27778	0.635	0.238	1.746	20	20.225	9.931	45.72	818.72	17.136	790.14	76803	25601	2.26	0.375	0.659	0.671	0.982
47	273	0.20833	0.479	0.413	0.53	15	15.218	7.426	34.49	807.49	29.736	802.74	23313	7771	2.27	0.862	0.306	0.668	0.458
20	102	0.27778	0.642	0.331	1.598	20	20.225	9.931	46.22	819.22	23.832	796.83	70292	23431	2.29	0.516	0.599	0.671	0.893
21	247	0.20833	0.488	0.2	1.155	15	15.218	7.426	35.14	808.14	14.400	787.40	50806	16935	2.31	0.410	0.659	0.668	0.986
34	117	0.27778	0.654	0.402	1.401	20	20.225	9.931	47.09	820.09	28.944	801.94	61627	20542	2.33	0.615	0.519	0.671	0.774
58	480	0.27778	0.656	0.294	1.744	20	20.225	9.931	47.23	820.23	21.168	794.17	76715	25572	2.34	0.448	0.645	0.671	0.961
27	109	0.27778	0.659	0.38	1.477	20	20.225	9.931	47.45	820.45	27.360	800.36	64970	21657	2.35	0.577	0.545	0.671	0.812
12	94	0.27778	0.663	0.319	1.699	20	20.225	9.931	47.74	820.74	22.968	795.97	74735	24912	2.36	0.481	0.624	0.671	0.930
7	233	0.20833	0.502	0.282	1.001	15	15.218	7.426	36.14	809.14	20.304	793.30	44032	14677	2.38	0.562	0.561	0.668	0.839
15	241	0.20833	0.507	0.258	1.072	15	15.218	7.426	36.50	809.50	18.576	791.58	47155	15718	2.40	0.509	0.597	0.668	0.893
42	268	0.20833	0.51	0.331	0.876	15	15.218	7.426	36.72	809.72	23.832	796.83	38533	12844	2.41	0.649	0.486	0.668	0.727
29	305	0.138889	0.347	0.272	0.3766	10	10.277	4.894	24.98	797.98	19.584	792.58	16566	5522	2.43	0.784	0.373	0.665	0.562
46	272	0.20833	0.519	0.396	0.717	15	15.218	7.426	37.37	810.37	28.512	801.51	31539	10513	2.46	0.763	0.393	0.668	0.589
12	288	0.138889	0.355	0.002	0.6801	10	10.277	4.894	25.56	798.56	0.144	773.14	29916	9972	2.49	0.006	0.665	0.665	1.000
14	290	0.138889	0.356	0.03	0.6804	10	10.277	4.894	25.63	798.63	2.160	775.16	29929	9976	2.49	0.084	0.664	0.665	0.999
25	251	0.20833	0.532	0.013	1.244	15	15.218	7.426	38.30	811.30	0.936	773.94	54721	18240	2.52	0.024	0.672	0.668	1.006
26	252	0.20833	0.533	0.065	1.241	15	15.218	7.426	38.38	811.38	4.680	777.68	54589	18196	2.52	0.122	0.670	0.668	1.002
8	234	0.20833	0.534	0.303	0.998	15	15.218	7.426	38.45	811.45	21.816	794.82	43900	14633	2.53	0.567	0.538	0.668	0.805
27	253	0.20833	0.534	0.13	1.245	15	15.218	7.426	38.45	811.45	9.360	782.36	54765	18255	2.53	0.243	0.671	0.668	1.004
13	289	0.138889	0.363	0.029	0.6792	10	10.277	4.894	26.14	799.14	2.088	775.09	29876	9959	2.54	0.080	0.655	0.665	0.985
17	243	0.20833	0.54	0.366	1.068	15	15.218	7.426	38.88	811.88	26.352	799.35	46979	15660	2.55	0.678	0.572	0.668	0.856
28	254	0.20833	0.54	0.187	1.246	15	15.218	7.426	38.88	811.88	13.464	786.46	54809	18270	2.55	0.346	0.667	0.668	0.998
22	248	0.20833	0.547	0.26	1.152	15	15.218	7.426	39.38	812.38	18.720	791.72	50674	16891	2.59	0.475	0.612	0.668	0.916
23	299	0.138889	0.381	0.203	0.5821	10	10.277	4.894	27.43	800.43	14.616	787.62	25605	8535	2.67	0.533	0.545	0.665	0.819
30	256	0.20833	0.567	0.239	1.241	15	15.218	7.426	40.82	813.82	17.208	790.21	54589	18196	2.68	0.422	0.645	0.668	0.965
33	309	0.138889	0.387	0.353	0.2453	10	10.277	4.894	27.86	800.86	25.416	798.42	10790	3597	2.71	0.912	0.227	0.665	0.342
32	258	0.20833	0.58	0.033	1.31	15	15.218	7.426	41.76	814.76	2.376	775.38	57624	19208	2.74	0.057	0.671	0.668	1.005
33	259	0.20833	0.58	0.124	1.309	15	15.218	7.426	41.76	814.76	8.928	781.93	57580	19193	2.74	0.214	0.671	0.668	1.004
34	260	0.20833	0.584	0.181	1.308	15	15.218	7.426	42.05	815.05	13.032	786.03	57536	19179	2.76	0.310	0.667	0.668	0.999
16	242	0.20833	0.587	0.318	1.070	15	15.218	7.426	42.26	815.26	22.896	795.90	47067	15689	2.78	0.542	0.544	0.668	0.815
9	235	0.20833	0.592	0.356	0.998	15	15.218	7.426	42.62	815.62	25.632	798.63	43900	14633	2.80	0.601	0.505	0.668	0.756
30	306	0.138889	0.407	0.329	0.375	10	10.277	4.894	29.30	802.30	23.688	796.69	16495	5498	2.85	0.808	0.337	0.665	0.507

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A13-7
Data from Reference A2
11 total pages

35	261	0.20833	0.605	0.235	1.308	15	15.218	7.426	43.56	816.56	16.920	789.92	57536	19179	2.86	0.388	0.653	0.668	0.978
35	446	0.097222	0.293	-0.172	0.4529	7	7.358	3.352	21.10	794.10	-12.384	760.62	-7566	-2522	2.87	-0.587	-0.253	0.671	-0.378
36	447	0.097222	0.293	-0.022	0.4542	7	7.358	3.352	21.10	794.10	-1.584	771.42	-968	-323	2.87	-0.075	-0.032	0.671	-0.048
38	449	0.097222	0.293	0.074	0.4559	7	7.358	3.352	21.10	794.10	5.328	778.33	3255	1085	2.87	0.253	0.109	0.671	0.162
16	292	0.138889	0.411	0.182	0.6791	10	10.277	4.894	29.59	802.59	13.104	786.10	29872	9957	2.88	0.443	0.607	0.665	0.913
23	249	0.20833	0.609	0.301	1.153	15	15.218	7.426	43.85	816.85	21.672	794.67	50718	16906	2.88	0.494	0.573	0.668	0.858
29	255	0.20833	0.609	0.268	1.244	15	15.218	7.426	43.85	816.85	19.296	792.30	54721	18240	2.88	0.440	0.619	0.668	0.926
49	460	0.097222	0.296	0.264	0.1714	7	7.358	3.352	21.31	794.31	19.008	792.01	11613	3871	2.90	0.892	0.387	0.671	0.576
35	311	0.138889	0.422	-0.059	0.7508	10	10.277	4.894	30.38	803.38	-4.248	768.75	33026	11009	2.96	-0.140	0.661	0.665	0.993
36	312	0.138889	0.422	0.043	0.7502	10	10.277	4.894	30.38	803.38	3.096	776.10	33000	11000	2.96	0.102	0.660	0.665	0.992
53	466	0.20833	0.625	0.071	0.1376	15	15.218	7.426	45.00	818.00	5.112	778.11	6053	2018	2.96	0.114	0.067	0.668	0.101
54	467	0.20833	0.625	0.121	0.1366	15	15.218	7.426	45.00	818.00	8.712	781.71	6009	2003	2.96	0.194	0.067	0.668	0.100
37	448	0.097222	0.303	0.112	0.4552	7	7.358	3.352	21.82	794.82	8.064	781.06	4927	1642	2.96	0.370	0.162	0.672	0.241
37	313	0.138889	0.424	0.121	0.7507	10	10.277	4.894	30.53	803.53	8.712	781.71	33022	11007	2.97	0.285	0.659	0.665	0.990
52	465	0.20833	0.629	0.011	1.369	15	15.218	7.426	45.29	818.29	0.792	773.79	60219	20073	2.98	0.017	0.668	0.668	1.000
55	468	0.20833	0.629	0.122	1.368	15	15.218	7.426	45.29	818.29	8.784	781.78	60175	20058	2.98	0.194	0.667	0.668	0.999
51	464	0.20833	0.63	-0.082	1.371	15	15.218	7.426	45.36	818.36	-5.904	767.10	60307	20102	2.98	-0.130	0.668	0.668	1.000
34	310	0.138889	0.427	0.392	0.2492	10	10.277	4.894	30.74	803.74	28.224	801.22	10962	3654	2.99	0.918	0.218	0.666	0.327
56	469	0.20833	0.635	0.196	1.373	15	15.218	7.426	45.72	818.72	14.112	787.11	60395	20132	3.00	0.309	0.666	0.668	0.997
57	470	0.20833	0.656	0.242	1.369	15	15.218	7.426	47.23	820.23	17.424	790.42	60219	20073	3.10	0.369	0.651	0.668	0.975
36	262	0.20833	0.667	0.279	1.308	15	15.218	7.426	48.02	821.02	20.088	793.09	57536	19179	3.16	0.418	0.616	0.668	0.922
25	301	0.138889	0.451	0.268	0.5817	10	10.277	4.894	32.47	805.47	19.296	792.30	25588	8529	3.16	0.594	0.492	0.666	0.740
38	314	0.138889	0.459	0.18	0.7488	10	10.277	4.894	33.05	806.05	12.960	785.96	32938	10979	3.22	0.392	0.627	0.666	0.942
31	257	0.20833	0.682	0.315	1.24	15	15.218	7.426	49.10	822.10	22.680	795.68	54545	18182	3.23	0.462	0.577	0.668	0.863
24	250	0.20833	0.684	0.363	1.149	15	15.218	7.426	49.25	822.25	26.136	799.14	50542	16847	3.24	0.531	0.533	0.668	0.798
31	307	0.138889	0.462	0.383	0.3755	10	10.277	4.894	33.26	806.26	27.576	800.58	16517	5506	3.24	0.829	0.313	0.666	0.471
15	291	0.138889	0.467	0.22	0.6772	10	10.277	4.894	33.62	806.62	15.840	788.84	29788	9929	3.27	0.471	0.562	0.666	0.843
50	461	0.097222	0.343	0.311	0.1714	7	7.358	3.352	24.70	797.70	22.392	795.39	13680	4560	3.36	0.907	0.418	0.672	0.622
39	450	0.097222	0.349	0.143	0.4533	7	7.358	3.352	25.13	798.13	10.296	783.30	6290	2097	3.42	0.410	0.190	0.672	0.283
6	282	0.138889	0.497	-0.046	0.833	10	10.277	4.894	35.78	808.78	-3.312	769.69	36642	12214	3.48	-0.093	0.666	0.666	1.000
7	283	0.138889	0.5	0.132	0.83	10	10.277	4.894	36.00	809.00	9.504	782.50	36510	12170	3.50	0.264	0.661	0.666	0.993
9	285	0.138889	0.504	0.148	0.83	10	10.277	4.894	36.29	809.29	10.656	783.66	36510	12170	3.53	0.294	0.658	0.666	0.989
40	316	0.138889	0.509	0.208	0.7516	10	10.277	4.894	36.65	809.65	14.976	787.98	33061	11020	3.57	0.409	0.593	0.666	0.890
45	456	0.097222	0.365	0.237	0.3442	7	7.358	3.352	26.28	799.28	17.064	790.06	10425	3475	3.57	0.649	0.307	0.672	0.457
37	358	0.069444	0.271	-0.046	0.3352	5	5.439	2.31	19.51	792.51	-3.312	769.69	14745	4915	3.59	-0.170	0.679	0.383	1.771
38	359	0.069444	0.273	0.071	0.3352	5	5.439	2.31	19.66	792.66	5.112	778.11	14745	4915	3.61	0.260	0.676	0.383	1.764
17	293	0.138889	0.523	0.271	0.6772	10	10.277	4.894	37.66	810.66	19.512	792.51	29788	9929	3.66	0.518	0.526	0.666	0.790
48	369	0.069444	0.277	0.263	0.1281	5	5.439	2.31	19.94	792.94	18.936	791.94	5635	1878	3.67	0.949	0.256	0.383	0.669
26	302	0.138889	0.528	0.339	0.5802	10	10.277	4.894	38.02	811.02	24.408	797.41	25522	8507	3.70	0.642	0.448	0.666	0.673
10	286	0.138889	0.536	0.187	0.83	10	10.277	4.894	38.59	811.59	13.464	786.46	36510	12170	3.76	0.349	0.636	0.666	0.954
24	435	0.097222	0.386	-0.086	0.5341	7	7.358	3.352	27.79	800.79	-6.192	766.81	-3783	-1261	3.78	-0.223	-0.108	0.673	-0.161
25	436	0.097222	0.386	0.028	0.5341	7	7.358	3.352	27.79	800.79	2.016	775.02	1232	411	3.78	0.073	0.035	0.673	0.052
26	437	0.097222	0.391	0.104	0.535	7	7.358	3.352	28.15	801.15	7.488	780.49	4575	1525	3.83	0.266	0.130	0.673	0.193

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A13-8
Data from Reference A2
11 total pages

44	455	0.097222	0.399	0.174	0.3446	7	7.358	3.352	28.73	801.73	12.528	785.53	7654	2551	3.90	0.436	0.214	0.673	0.319
43	364	0.069444	0.295	0.146	0.273	5	5.439	2.31	21.24	794.24	10.512	783.51	12009	4003	3.91	0.495	0.527	0.382	1.379
39	315	0.138889	0.559	0.249	0.7476	10	10.277	4.894	40.25	813.25	17.928	790.93	32885	10962	3.92	0.445	0.559	0.666	0.839
51	462	0.097222	0.405	0.373	0.1707	7	7.358	3.352	29.16	802.16	26.856	799.86	16407	5469	3.96	0.921	0.456	0.673	0.677
8	284	0.138889	0.569	0.206	0.828	10	10.277	4.894	40.97	813.97	14.832	787.83	36422	12141	3.99	0.362	0.613	0.666	0.920
5	281	0.138889	0.572	0.022	0.903	10	10.277	4.894	41.18	814.18	1.584	774.58	39721	13240	4.01	0.038	0.666	0.666	1.000
46	457	0.097222	0.414	0.284	0.344	7	7.358	3.352	29.81	802.81	20.448	793.45	12493	4164	4.05	0.686	0.343	0.673	0.509
1	277	0.138889	0.58	0.145	0.905	10	10.277	4.894	41.76	814.76	10.440	783.44	39809	13270	4.06	0.250	0.662	0.666	0.995
40	451	0.097222	0.417	0.197	0.4509	7	7.358	3.352	30.02	803.02	14.184	787.18	8666	2889	4.08	0.472	0.237	0.673	0.352
28	439	0.097222	0.418	0.139	0.5346	7	7.358	3.352	30.10	803.10	10.008	783.01	6114	2038	4.09	0.333	0.167	0.673	0.248
27	303	0.138889	0.597	0.406	0.5795	10	10.277	4.894	42.98	815.98	29.232	802.23	25491	8497	4.18	0.680	0.417	0.666	0.627
18	294	0.138889	0.6	0.343	0.6746	10	10.277	4.894	43.20	816.20	24.696	797.70	29674	9891	4.20	0.572	0.484	0.666	0.727
39	360	0.069444	0.321	0.11	0.3393	5	5.439	2.31	23.11	796.11	7.920	780.92	14925	4975	4.25	0.343	0.625	0.381	1.639
3	279	0.138889	0.609	0.193	0.903	10	10.277	4.894	43.85	816.85	13.896	786.90	39721	13240	4.27	0.317	0.643	0.666	0.966
41	317	0.138889	0.611	0.295	0.747	10	10.277	4.894	43.99	816.99	21.240	794.24	32859	10953	4.28	0.483	0.531	0.666	0.797
27	438	0.097222	0.445	0.153	0.5342	7	7.358	3.352	32.04	805.04	11.016	784.02	6730	2243	4.35	0.344	0.177	0.674	0.263
52	463	0.097222	0.445	0.412	0.1701	7	7.358	3.352	32.04	805.04	29.664	802.66	18123	6041	4.35	0.926	0.478	0.674	0.709
43	471	0.138889	0.624	0	0.9547	10	10.277	4.894	44.93	817.93	0.000	773.00	41995	13998	4.37	0.000	0.671	0.666	1.007
44	472	0.138889	0.624	0.04	0.9537	10	10.277	4.894	44.93	817.93	2.880	775.88	41951	13984	4.37	0.064	0.670	0.666	1.006
45	473	0.138889	0.625	0.117	0.9507	10	10.277	4.894	45.00	818.00	8.424	781.42	41819	13940	4.38	0.187	0.667	0.666	1.002
9	380	0.041667	0.219	0.122	0.014	3	3.549	1.249	15.77	788.77	8.780	781.78	6280	205	4.44	0.557	0.047	0.4586	0.103
46	474	0.138889	0.636	0.174	0.9546	10	10.277	4.894	45.79	818.79	12.528	785.53	41991	13997	4.46	0.274	0.663	0.666	0.996
31	352	0.069444	0.339	-0.049	0.3791	5	5.439	2.31	24.41	797.41	-3.528	769.47	16676	5559	4.49	-0.145	0.677	0.380	1.780
30	351	0.069444	0.34	0.051	0.3799	5	5.439	2.31	24.48	797.48	3.672	776.67	16711	5570	4.50	0.150	0.678	0.380	1.781
14	425	0.097222	0.465	-0.02	0.595	7	7.358	3.352	33.48	806.48	-1.440	771.56	-880	-293	4.55	-0.043	-0.023	0.674	-0.034
15	426	0.097222	0.465	0.042	0.5963	7	7.358	3.352	33.48	806.48	3.024	776.02	1847	616	4.55	0.090	0.048	0.674	0.070
30	441	0.097222	0.466	0.164	0.5352	7	7.358	3.352	33.55	806.55	11.808	784.81	7214	2405	4.56	0.352	0.185	0.674	0.275
16	427	0.097222	0.469	0.105	0.5952	7	7.358	3.352	33.77	806.77	7.560	780.56	4619	1540	4.59	0.224	0.118	0.674	0.175
47	458	0.097222	0.47	0.338	0.3435	7	7.358	3.352	33.84	806.84	24.336	797.34	14868	4956	4.60	0.719	0.380	0.674	0.564
18	429	0.097222	0.473	0.122	0.5966	7	7.358	3.352	34.06	807.06	8.784	781.78	5366	1789	4.63	0.258	0.137	0.674	0.203
4	280	0.138889	0.661	0.222	0.903	10	10.277	4.894	47.59	820.59	15.984	788.98	39721	13240	4.63	0.336	0.614	0.666	0.922
19	295	0.138889	0.668	0.409	0.6742	10	10.277	4.894	48.10	821.10	29.448	802.45	29657	9886	4.68	0.612	0.456	0.666	0.685
47	475	0.138889	0.671	0.207	0.9513	10	10.277	4.894	48.31	821.31	14.904	787.90	41845	13948	4.70	0.308	0.642	0.666	0.963
41	452	0.097222	0.481	0.257	0.4536	7	7.358	3.352	34.63	807.63	18.504	791.50	11305	3768	4.71	0.534	0.285	0.674	0.423
11	287	0.138889	0.672	0.286	0.828	10	10.277	4.894	48.38	821.38	20.592	793.59	36422	12141	4.71	0.426	0.558	0.666	0.838
2	278	0.138889	0.681	0.234	0.9	10	10.277	4.894	49.03	822.03	16.848	789.85	39589	13196	4.77	0.344	0.602	0.666	0.904
32	353	0.069444	0.364	0.098	0.3873	5	5.439	2.31	26.21	799.21	7.056	780.06	17036	5679	4.82	0.269	0.665	0.379	1.754
49	370	0.069444	0.366	0.329	0.1309	5	5.439	2.31	26.35	799.35	23.688	796.69	5758	1919	4.85	0.899	0.224	0.379	0.591
19	430	0.097222	0.499	0.147	0.5946	7	7.358	3.352	35.93	808.93	10.584	783.58	6466	2155	4.88	0.295	0.160	0.674	0.237
44	365	0.069444	0.369	0.218	0.2723	5	5.439	2.31	26.57	799.57	15.696	788.70	11978	3993	4.88	0.591	0.464	0.379	1.224
42	318	0.138889	0.701	0.389	0.7459	10	10.277	4.894	50.47	823.47	28.008	801.01	32810	10937	4.91	0.555	0.491	0.666	0.737
29	440	0.097222	0.502	0.203	0.5332	7	7.358	3.352	36.14	809.14	14.616	787.62	8930	2977	4.91	0.404	0.220	0.674	0.326
48	459	0.097222	0.518	0.387	0.3425	7	7.358	3.352	37.30	810.30	27.864	800.86	17023	5674	5.07	0.747	0.412	0.675	0.611

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A13-9
Data from Reference A2
11 total pages

17	428	0.097222	0.523	0.16	0.5946	7	7.358	3.352	37.66	810.66	11.520	784.52	7038	2346	5.12	0.306	0.170	0.675	0.251
31	442	0.097222	0.525	0.215	0.5321	7	7.358	3.352	37.80	810.80	15.480	788.48	9457	3152	5.14	0.410	0.227	0.675	0.337
5	325	0.069444	0.389	0.149	0.4244	5	5.439	2.31	28.01	801.01	10.728	783.73	18668	6223	5.15	0.383	0.703	0.378	1.858
26	346	0.069444	0.392	-0.002	0.4117	5	5.439	2.31	28.22	801.22	-0.144	772.86	18110	6037	5.19	-0.005	0.679	0.378	1.796
27	347	0.069444	0.392	0.062	0.4116	5	5.439	2.31	28.22	801.22	4.464	777.46	18105	6035	5.19	0.158	0.679	0.378	1.795
21	432	0.097222	0.543	0.169	0.5945	7	7.358	3.352	39.10	812.10	12.168	785.17	7434	2478	5.31	0.311	0.175	0.675	0.260
7	418	0.097222	0.55	0.059	0.6528	7	7.358	3.352	39.60	812.60	4.248	777.25	2595	865	5.38	0.107	0.061	0.675	0.090
8	419	0.097222	0.55	0.085	0.6542	7	7.358	3.352	39.60	812.60	6.120	779.12	3739	1246	5.38	0.155	0.088	0.675	0.130
6	417	0.097222	0.551	0.024	0.6535	7	7.358	3.352	39.67	812.67	1.728	774.73	1056	352	5.39	0.044	0.025	0.675	0.037
9	420	0.097222	0.554	0.121	0.6562	7	7.358	3.352	39.89	812.89	8.712	781.71	5323	1774	5.42	0.218	0.124	0.675	0.184
28	348	0.069444	0.415	0.106	0.412	5	5.439	2.31	29.88	802.88	7.632	780.63	18123	6041	5.49	0.255	0.659	0.377	1.746
32	443	0.097222	0.563	0.249	0.5317	7	7.358	3.352	40.54	813.54	17.928	790.93	10953	3651	5.51	0.442	0.253	0.675	0.376
42	453	0.097222	0.565	0.339	0.4501	7	7.358	3.352	40.68	813.68	24.408	797.41	14912	4971	5.53	0.600	0.344	0.675	0.510
45	366	0.069444	0.418	0.262	0.2753	5	5.439	2.31	30.10	803.10	18.864	791.86	12110	4037	5.53	0.627	0.439	0.377	1.163
11	422	0.097222	0.57	0.144	0.6537	7	7.358	3.352	41.04	814.04	10.368	783.37	6334	2111	5.58	0.253	0.146	0.675	0.216
10	381	0.041667	0.280	0.183	0.014	3	3.549	1.249	20.16	793.16	13.180	786.18	6280	205	5.68	0.654	0.041	0.4581	0.090
20	431	0.097222	0.583	0.2	0.594	7	7.358	3.352	41.98	814.98	14.400	787.40	8798	2933	5.70	0.343	0.200	0.675	0.296
10	421	0.097222	0.593	0.16	0.6539	7	7.358	3.352	42.70	815.70	11.520	784.52	7038	2346	5.80	0.270	0.158	0.675	0.235
33	444	0.097222	0.601	0.286	0.5325	7	7.358	3.352	43.27	816.27	20.592	793.59	12580	4193	5.88	0.476	0.281	0.675	0.416
40	361	0.069444	0.445	0.208	0.3422	5	5.439	2.31	32.04	805.04	14.976	787.98	15053	5018	5.89	0.467	0.527	0.376	1.401
21	341	0.069444	0.448	0.029	0.4423	5	5.439	2.31	32.26	805.26	2.088	775.09	19456	6485	5.93	0.065	0.679	0.376	1.805
22	342	0.069444	0.45	0.084	0.4423	5	5.439	2.31	32.40	805.40	6.048	779.05	19456	6485	5.96	0.187	0.677	0.376	1.801
13	424	0.097222	0.613	0.17	0.6526	7	7.358	3.352	44.14	817.14	12.240	785.24	7478	2493	6.00	0.277	0.165	0.675	0.245
33	354	0.069444	0.455	0.154	0.3883	5	5.439	2.31	32.76	805.76	11.088	784.09	17080	5693	6.02	0.338	0.591	0.376	1.572
22	433	0.097222	0.617	0.231	0.5936	7	7.358	3.352	44.42	817.42	16.632	789.63	10161	3387	6.04	0.374	0.224	0.675	0.331
50	371	0.069444	0.457	0.42	0.1309	5	5.439	2.31	32.90	805.90	30.240	803.24	5758	1919	6.05	0.919	0.199	0.376	0.529
1	372	0.041667	0.303	-0.023	0.242	3	3.549	1.249	21.82	794.82	-1.660	771.34	10636	3548	6.15	-0.076	0.687	0.4578	1.500
2	373	0.041667	0.305	0.052	0.242	3	3.549	1.249	21.96	794.96	3.740	776.74	10636	3548	6.19	0.170	0.684	0.4578	1.495
23	434	0.097222	0.64	0.251	0.5928	7	7.358	3.352	46.08	819.08	18.072	791.07	11041	3680	6.26	0.392	0.238	0.675	0.353
1	412	0.097222	0.642	-0.058	0.7153	7	7.358	3.352	46.22	819.22	-4.176	768.82	-2551	-850	6.28	-0.090	-0.055	0.675	-0.081
2	413	0.097222	0.642	0.051	0.7119	7	7.358	3.352	46.22	819.22	3.672	776.67	2243	748	6.28	0.079	0.048	0.675	0.072
3	414	0.097222	0.644	0.113	0.7132	7	7.358	3.352	46.37	819.37	8.136	781.14	4971	1657	6.30	0.175	0.107	0.675	0.158
5	416	0.097222	0.647	0.12	0.7149	7	7.358	3.352	46.58	819.58	8.640	781.64	5279	1760	6.33	0.185	0.113	0.675	0.168
4	415	0.097222	0.654	0.141	0.7142	7	7.358	3.352	47.09	820.09	10.152	783.15	6202	2067	6.40	0.216	0.132	0.675	0.196
34	445	0.097222	0.654	0.338	0.5321	7	7.358	3.352	47.09	820.09	24.336	797.34	14868	4956	6.40	0.517	0.317	0.675	0.470
4	324	0.069444	0.487	0.15	0.4244	5	5.439	2.31	35.06	808.06	10.800	783.80	18668	6223	6.45	0.308	0.623	0.376	1.656
12	423	0.097222	0.659	0.199	0.6533	7	7.358	3.352	47.45	820.45	14.328	787.33	8754	2918	6.45	0.302	0.186	0.675	0.276
43	454	0.097222	0.66	0.433	0.4486	7	7.358	3.352	47.52	820.52	31.176	804.18	19047	6349	6.46	0.656	0.404	0.675	0.599
46	367	0.069444	0.495	0.339	0.275	5	5.439	2.31	35.64	808.64	24.408	797.41	12097	4032	6.55	0.685	0.400	0.376	1.064
29	349	0.069444	0.503	0.165	0.4112	5	5.439	2.31	36.22	809.22	11.880	784.88	18088	6029	6.66	0.328	0.593	0.376	1.577
34	355	0.069444	0.52	0.216	0.3873	5	5.439	2.31	37.44	810.44	15.552	788.55	17036	5679	6.88	0.415	0.549	0.376	1.460
23	343	0.069444	0.534	0.145	0.4415	5	5.439	2.31	38.45	811.45	10.440	783.44	19421	6474	7.07	0.272	0.617	0.376	1.640
47	368	0.069444	0.539	0.382	0.2748	5	5.439	2.31	38.81	811.81	27.504	800.50	12088	4029	7.14	0.709	0.382	0.376	1.016

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A13-10
Data from Reference A2
11 total pages

10	330	0.069444	0.54	-0.074	0.4875	5	5.439	2.31	38.88	811.88	-5.328	767.67	21444	7148	7.15	-0.137	0.677	0.376	1.801
11	331	0.069444	0.54	0.022	0.4876	5	5.439	2.31	38.88	811.88	1.584	774.58	21448	7149	7.15	0.041	0.677	0.376	1.801
13	333	0.069444	0.541	0.053	0.4879	5	5.439	2.31	38.95	811.95	3.816	776.82	21462	7154	7.16	0.098	0.677	0.376	1.800
3	323	0.069444	0.552	0.213	0.4244	5	5.439	2.31	39.74	812.74	15.336	788.34	18668	6223	7.31	0.386	0.583	0.376	1.549
12	332	0.069444	0.557	0.113	0.4882	5	5.439	2.31	40.10	813.10	8.136	781.14	21475	7158	7.37	0.203	0.667	0.376	1.774
11	382	0.041667	0.364	0.264	0.014	3	3.549	1.249	26.21	799.21	19.010	792.01	6280	205	7.39	0.725	0.036	0.4573	0.079
41	362	0.069444	0.558	0.319	0.3387	5	5.439	2.31	40.18	813.18	22.968	795.97	14899	4966	7.39	0.572	0.462	0.376	1.229
4	375	0.041667	0.368	0.091	0.242	3	3.549	1.249	26.50	799.50	6.550	779.55	10636	3548	7.47	0.247	0.620	0.4573	1.356
35	356	0.069444	0.575	0.27	0.3867	5	5.439	2.31	41.40	814.40	19.440	792.44	17010	5670	7.61	0.470	0.519	0.376	1.381
13	384	0.041667	0.384	-0.094	0.275	3	3.549	1.249	27.65	800.65	-6.770	766.23	12110	4032	7.79	-0.245	0.689	0.4571	1.507
14	385	0.041667	0.384	-0.026	0.275	3	3.549	1.249	27.65	800.65	-1.870	771.13	12110	4032	7.79	-0.068	0.689	0.4571	1.507
15	386	0.041667	0.385	0.038	0.275	3	3.549	1.249	27.72	800.72	2.740	775.74	12110	4032	7.81	0.099	0.688	0.4571	1.505
15	335	0.069444	0.599	0.138	0.4859	5	5.439	2.31	43.13	816.13	9.936	782.94	21374	7125	7.93	0.230	0.639	0.376	1.699
17	388	0.041667	0.391	0.059	0.275	3	3.549	1.249	28.18	801.18	4.250	777.25	12110	4032	7.94	0.151	0.682	0.457	1.492
24	344	0.069444	0.603	0.207	0.4417	5	5.439	2.31	43.42	816.42	14.904	787.90	19429	6476	7.98	0.343	0.579	0.376	1.539
2	322	0.069444	0.605	0.263	0.4235	5	5.439	2.31	43.56	816.56	18.936	791.94	18629	6210	8.01	0.435	0.554	0.376	1.473
6	326	0.069444	0.619	-0.074	0.5252	5	5.439	2.31	44.57	817.57	-5.328	767.67	23102	7701	8.19	-0.120	0.679	0.376	1.805
7	327	0.069444	0.619	0.04	0.5254	5	5.439	2.31	44.57	817.57	2.880	775.88	23111	7704	8.19	0.065	0.679	0.376	1.805
25	345	0.069444	0.619	0.223	0.4404	5	5.439	2.31	44.57	817.57	16.056	789.06	19372	6457	8.19	0.360	0.569	0.376	1.513
9	329	0.069444	0.622	0.085	0.5259	5	5.439	2.31	44.78	817.78	6.120	779.12	23133	7711	8.23	0.137	0.678	0.376	1.802
3	374	0.041667	0.412	0.133	0.242	3	3.549	1.249	29.66	802.66	9.580	782.58	10636	3548	8.36	0.323	0.584	0.4569	1.279
42	363	0.069444	0.634	0.396	0.3389	5	5.439	2.31	45.65	818.65	28.512	801.51	14907	4969	8.39	0.625	0.432	0.376	1.150
16	336	0.069444	0.636	-0.091	0.5357	5	5.439	2.31	45.79	818.79	-6.552	766.45	23564	7855	8.42	-0.143	0.682	0.376	1.815
17	337	0.069444	0.637	-0.001	0.5362	5	5.439	2.31	45.86	818.86	-0.072	772.93	23586	7862	8.43	-0.002	0.682	0.376	1.815
18	338	0.069444	0.637	0.041	0.5377	5	5.439	2.31	45.86	818.86	2.952	775.95	23652	7884	8.43	0.064	0.684	0.376	1.820
19	339	0.069444	0.638	0.088	0.5385	5	5.439	2.31	45.94	818.94	6.336	779.34	23687	7896	8.45	0.138	0.685	0.376	1.821
20	340	0.069444	0.641	0.102	0.5367	5	5.439	2.31	46.15	819.15	7.344	780.34	23608	7869	8.49	0.159	0.681	0.376	1.810
8	328	0.069444	0.643	0.121	0.5252	5	5.439	2.31	46.30	819.30	8.712	781.71	23102	7701	8.51	0.188	0.665	0.376	1.769
36	357	0.069444	0.643	0.338	0.3866	5	5.439	2.31	46.30	819.30	24.336	797.34	17006	5669	8.51	0.526	0.490	0.376	1.302
1	321	0.069444	0.648	0.308	0.4235	5	5.439	2.31	46.66	819.66	22.176	795.18	18629	6210	8.58	0.475	0.534	0.376	1.420
14	334	0.069444	0.65	0.171	0.4865	5	5.439	2.31	46.80	819.80	12.312	785.31	21400	7133	8.60	0.263	0.613	0.376	1.629
5	376	0.041667	0.462	0.182	0.242	3	3.549	1.249	33.26	806.26	13.100	786.10	10636	3548	9.37	0.394	0.551	0.4564	1.206
16	387	0.041667	0.465	0.109	0.275	3	3.549	1.249	33.48	806.48	7.850	780.85	12110	4032	9.43	0.234	0.623	0.4564	1.366
28	399	0.041667	0.467	0.013	0.307	3	3.549	1.249	33.60	806.60	0.940	773.94	13491	4501	9.47	0.028	0.695	0.4564	1.522
12	383	0.041667	0.467	0.368	0.014	3	3.549	1.249	33.62	806.62	26.500	799.50	6280	205	9.47	0.788	0.032	0.4563	0.069
27	398	0.041667	0.468	0.054	0.307	3	3.549	1.249	33.70	806.70	3.890	776.89	13491	4501	9.50	0.115	0.694	0.4563	1.520
21	392	0.041667	0.472	-0.019	0.307	3	3.549	1.249	33.98	806.98	-1.370	771.63	13491	4501	9.57	-0.040	0.691	0.4563	1.514
22	393	0.041667	0.472	0.027	0.307	3	3.549	1.249	33.98	806.98	1.940	774.94	13491	4501	9.57	0.057	0.691	0.4563	1.514
23	394	0.041667	0.484	0.074	0.307	3	3.549	1.249	34.85	807.85	5.330	778.33	13491	4501	9.82	0.153	0.682	0.4562	1.494
6	377	0.041667	0.528	0.246	0.242	3	3.549	1.249	38.02	811.02	17.710	790.71	10636	3548	10.71	0.466	0.514	0.4558	1.127
26	397	0.041667	0.543	0.106	0.307	3	3.549	1.249	39.10	812.10	7.630	780.63	13491	4501	11.02	0.195	0.642	0.4557	1.409
18	389	0.041667	0.547	0.185	0.275	3	3.549	1.249	39.38	812.38	13.320	786.32	12110	4032	11.10	0.338	0.573	0.4556	1.258
30	401	0.041667	0.565	-0.093	0.337	3	3.549	1.249	40.68	813.68	-6.700	766.30	14815	4941	11.46	-0.165	0.691	0.4555	1.517

Prepared by: S.E.M.
Checked by: J.B.M.

Calculation No: CDQ000020080018

Attachment A13-11
Data from Reference A2
11 total pages

31	402	0.041667	0.565	0.012	0.337	3	3.549	1.249	40.68	813.68	0.860	773.86	14815	4941	11.46	0.021	0.691	0.4555	1.517
33	404	0.041667	0.567	0.060	0.337	3	3.549	1.249	40.82	813.82	4.320	777.32	14815	4941	11.50	0.106	0.690	0.4554	1.514
24	395	0.041667	0.572	0.130	0.307	3	3.549	1.249	41.18	814.18	9.360	782.36	13491	4501	11.60	0.227	0.625	0.4554	1.373
25	396	0.041667	0.575	0.138	0.307	3	3.549	1.249	41.40	814.40	9.940	782.94	13491	4501	11.67	0.240	0.624	0.4554	1.369
32	403	0.041667	0.581	0.085	0.337	3	3.549	1.249	41.83	814.83	6.120	779.12	14815	4941	11.79	0.146	0.681	0.4553	1.495
19	390	0.041667	0.582	0.220	0.275	3	3.549	1.249	41.90	814.90	15.840	788.84	12110	4032	11.81	0.378	0.555	0.4553	1.219
7	378	0.041667	0.607	0.324	0.242	3	3.549	1.249	43.70	816.70	23.330	796.33	10636	3548	12.31	0.534	0.478	0.4551	1.050
34	405	0.041667	0.609	0.098	0.337	3	3.549	1.249	43.85	816.85	7.060	780.06	14815	4941	12.36	0.161	0.665	0.4551	1.460
35	406	0.041667	0.615	0.102	0.337	3	3.549	1.249	44.27	817.27	7.340	780.34	14815	4941	12.47	0.166	0.661	0.455	1.453
29	400	0.041667	0.619	0.175	0.307	3	3.549	1.249	44.57	817.57	12.600	785.60	13491	4501	12.56	0.283	0.600	0.455	1.319
36	407	0.041667	0.619	-0.026	0.337	3	3.549	1.249	44.57	817.57	-1.870	771.13	15523	4941	12.56	-0.042	0.659	0.455	1.448
37	408	0.041667	0.619	0.020	0.337	3	3.549	1.249	44.57	817.57	1.440	774.44	15523	4941	12.56	0.032	0.659	0.455	1.448
20	391	0.041667	0.620	0.259	0.275	3	3.549	1.249	44.64	817.64	18.650	791.65	12110	4032	12.58	0.418	0.537	0.455	1.181
38	409	0.041667	0.620	0.066	0.337	3	3.549	1.249	44.64	817.64	4.760	777.76	15523	4941	12.58	0.107	0.658	0.455	1.447
39	410	0.041667	0.621	0.072	0.337	3	3.549	1.249	44.71	817.71	5.180	778.18	15523	4941	12.60	0.116	0.658	0.455	1.446
8	379	0.041667	0.622	0.340	0.242	3	3.549	1.249	44.78	817.78	24.480	797.48	10636	3548	12.62	0.547	0.472	0.455	1.038
7	494	0.013889	0.388		0.1353	1	1.696	0.167	27.94	800.94			5952	1984	16.47	0.000	0.692	0.692	1
4	491	0.013889	0.401		0.1413	1	1.696	0.167	28.87	801.87			6215	2072	17.02	0.000	0.710	0.710	1
5	492	0.013889	0.43		0.1426	1	1.696	0.167	30.96	803.96			6273	2091	18.25	0.000	0.692	0.692	1
3	490	0.013889	0.484		0.1549	1	1.696	0.167	34.85	807.85			6814	2271	20.55	0.000	0.708	0.708	1
8	495	0.013889	0.507		0.1535	1	1.696	0.167	36.50	809.50			6752	2251	21.52	0.000	0.686	0.686	1
2	489	0.013889	0.557		0.1662	1	1.696	0.167	40.10	813.10			7311	2437	23.65	0.000	0.708	0.708	1
6	493	0.013889	0.569		0.1628	1	1.696	0.167	40.97	813.97			7161	2387	24.16	0.000	0.686	0.686	1
1	488	0.013889	0.61		0.1738	1	1.696	0.167	43.92	816.92			7645	2548	25.90	0.000	0.708	0.708	1

Formulas:

(1) $H_{cp} = S\{H_{1m}\}$

(2) $V_p = S\{V_m\}$

(3) $d_p = S\{d_m\}$

(4) $Q_{gsp} = S^{2.5}Q_m/3$

(5) $d/H_c = d_p/H_{cp}$

(6) $C_gS_g = Q_{gsp}/\{G_{np}L_p[2g(H_{cp} - H_{,mpp})]^{0.5}\}$

(7) C_g by interpolation between points defining $C_g(H_c)$ for no tailwater submergence effects

(8) $S_g = C_gS_g/C_g$

Overflow Parameters

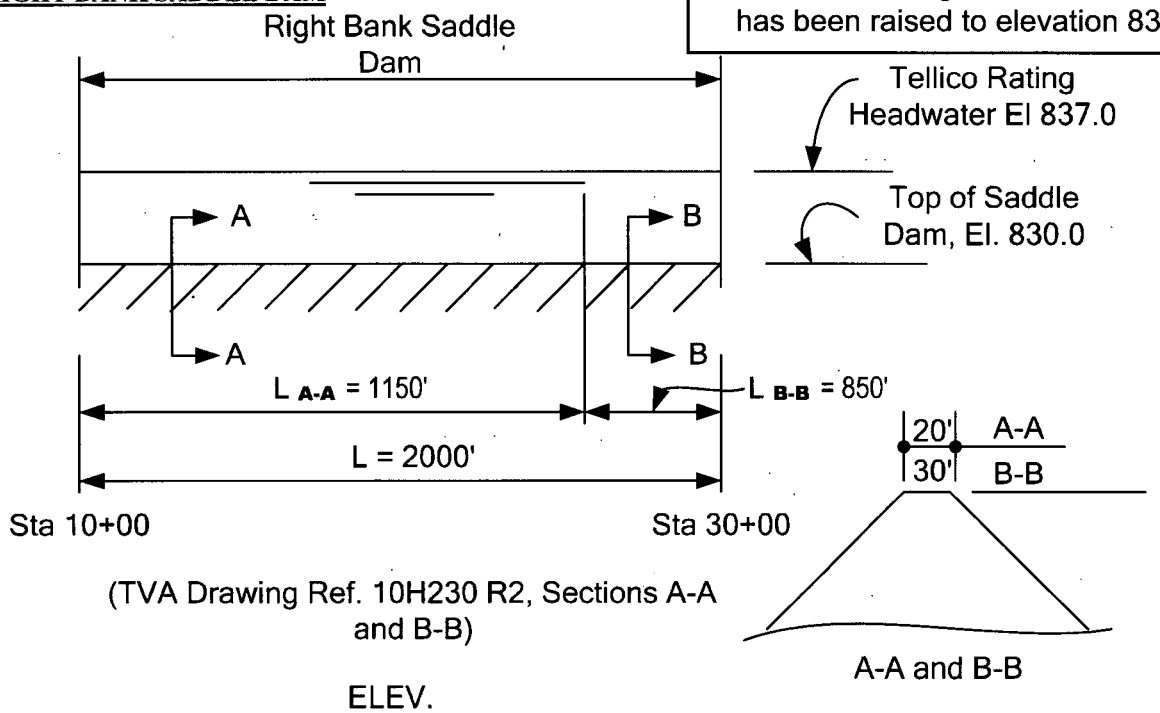
In order to determine the discharge coefficient when the dam is overtopped, the following overflow parameters have been developed. All flow over the top of the dam, embankments and saddle dams is considered free flow. The free flow discharge coefficient, C_f, is determined using USACE Hydraulic Design Criteria Chart 711 (Reference 2.6, Attachment 6).

Each section of the dam has been divided and analyzed in the following pages. Attached to the Appendix are the TVA drawings which were used to determine the overflow parameters. Each drawing has had the applicable dimensions called out. They are numbered as follows:

(1) TVA drawing no. 10N200, R5 (Ref. 2.1.1, Att. E1)
(2) TVA drawing no. 10W201, R4 (Ref. 2.1.15, Att. E15)
(3) TVA drawing no. 10N202, R2 (Ref. 2.1.3, Att. E3)
(4) TVA drawing no. 22W204, R9 (Ref. 2.1.4, Att. E4)
(5) TVA drawing no. 22W205, R9 (Ref. 2.1.19, Att. E19)
(6) TVA drawing no. 10H230, R2 (Ref. 2.1.2, Att. E2)
(7) TVA drawing no. 10H220, R1 (Ref. 2.1.6, Att. E6)
(8) TVA drawing no. 10H221, R4 (Ref. 2.1.5, Att. E5)
(9) TVA drawing no. 23W200, R8 (Ref. 2.1.7, Att. E7)
(10) TVA drawing no. 10N254, R0 (Ref. 2.1.13, Att. E13)
(11) TVA drawing no. 21W856-1, R0 (Ref. 2.1.14, Att. E14)
(12) TVA drawing no. 1101H215, R1 (Ref. 2.1.17, Att. E17)
(13) TVA drawing no. 1101H102, R1 (Ref. 2.1.18, Att. E18)
(14) A portion of TVA drawing no. 23W205-3, R2 (Ref. 2.1.8, Att. E8)
(15) TVA drawing no. 23W210-1, R2 (Ref. 2.1.10, Att. E10)

RIGHT BANK SADDLE DAM

Based on TVA modifications the top elevation of the Right Bank Saddle Dam has been raised to elevation 834'.



(TVA Drawing Ref. 10H230 R2, Sections A-A and B-B)

ELEV.

At Section A-A

$Z_c = 830'$, $L_{A-A} = 1150'$, $B = 20'$

$0 \leq H_c \leq (HW_{max} - Z_c)$

$0 \leq H_c / B \leq (837' - 830') / 20' = .35$

From Ref. 2.6, Att. 6:

$2.65 \leq C_f \leq 2.67$

$C_f = 2.65$

At Section B-B

$Z_c = 830'$, $L_{B-B} = 850'$, $B = 30'$

$0 \leq H_c \leq (HW_{max} - Z_c)$

$0 \leq H_c / B \leq (837' - 830') / 30' = .23$

From Ref. 2.6, Att. 6:

$2.65 \leq C_f \leq 2.65$

$C_f = 2.65$

Because C_f is the same for both widths, the entire length of the right bank saddle dam will be combined.

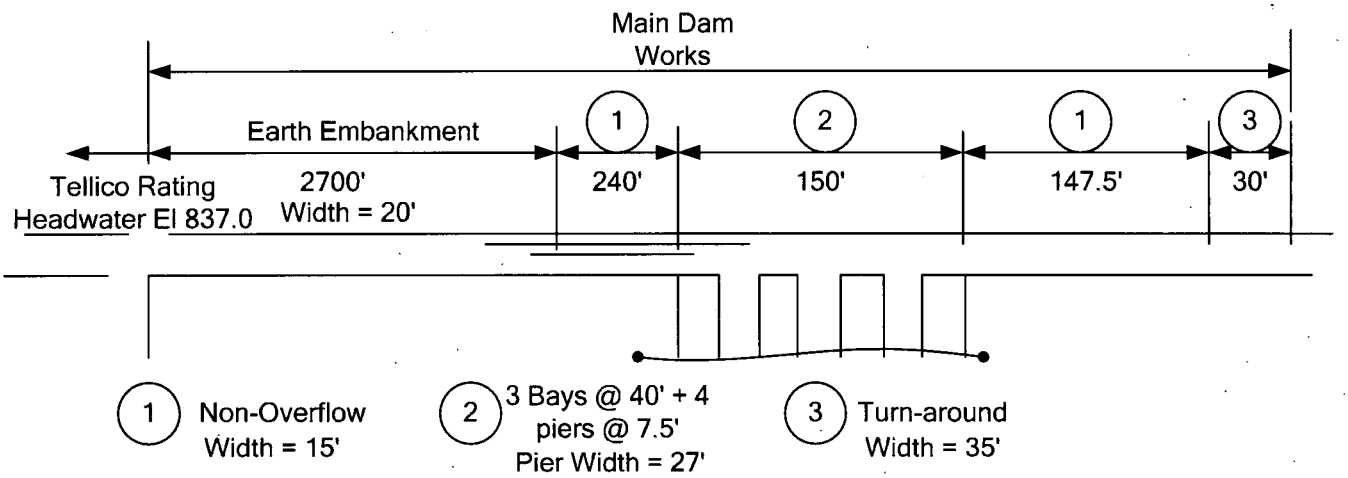
Based on TVA modifications the top elevation of the Right Bank Saddle Dam has been raised to elevation 834'.

TVA

Calculation No. CDQ000020080018 Appendix B	Rev: 0	Plant: GEN	Page: B3
Subject: Dam Rating Curves, Tellico		Prepped	J.W.M./S.E.M.
		Checked	J.B.M.

MAIN DAM WORKS

Feature	L (ft)	Width (ft)	Z_c (ft)
Earth Emb.	**2700'**	20'	830
1	240'+147.5' = **387.5'**	15'	830
2	4(7.5') = **30'**	27'	830
3	**30'**	35'	830



(TVA Drawing References: 10N200, R5; 10W201, R4; 10N202, R2; 22W204, R9; 22W205, R9)

ELEV

At the Earth Embankment

$Z_c = 830'$, $L = 2700'$, $B = 20'$

$0 \le H_c \le (HW_{max} - Z_c)$

$0 \le H_c / B \le (837' - 830') / 20' = .35$

From Ref. 2.6, Att. 6:

$2.65 \le C_f \le 2.67$

$C_f = 2.65$

Based on TVA modifications the top elevation of the Earth Embankment has been raised to elevation 834'.

At Section 1 (Non Overflow Dam)

$Z_c = 830'$, $L_1 = 387.5'$, $B = 15'$

$0 \leq H_c \leq (HW_{max} - Z_c)$

$0 \leq H_c / B \leq (837' - 830') / 15' = .47$

From Ref. 2.6, Att. 6:

$2.65 \leq C_f \leq 2.7$

$C_f = 2.65$

At Section 2 (Spillway Piers)

$Z_c = 830'$, $L_2 = 30'$, $B = 27'$

$0 \leq H_c \leq (HW_{max} - Z_c)$

$0 \leq H_c / B \leq (837' - 830') / 27' = .26$

From Ref. 2.6, Att. 6:

$2.65 \leq C_f \leq 2.65$

$C_f = 2.65$

Based on TVA modifications the top elevation of the Earth Embankment has been raised to elevation 834'.

At Section 3 (Turnaround)

$Z_c = 830'$, $L_3 = 30'$, $B = 35'$

$0 \leq H_c \leq (HW_{max} - Z_c)$

$0 \leq H_c / B \leq (837' - 830') / 35' = .2$

From Ref. 2.6, Att. 6:

$2.65 \leq C_f \leq 2.65$

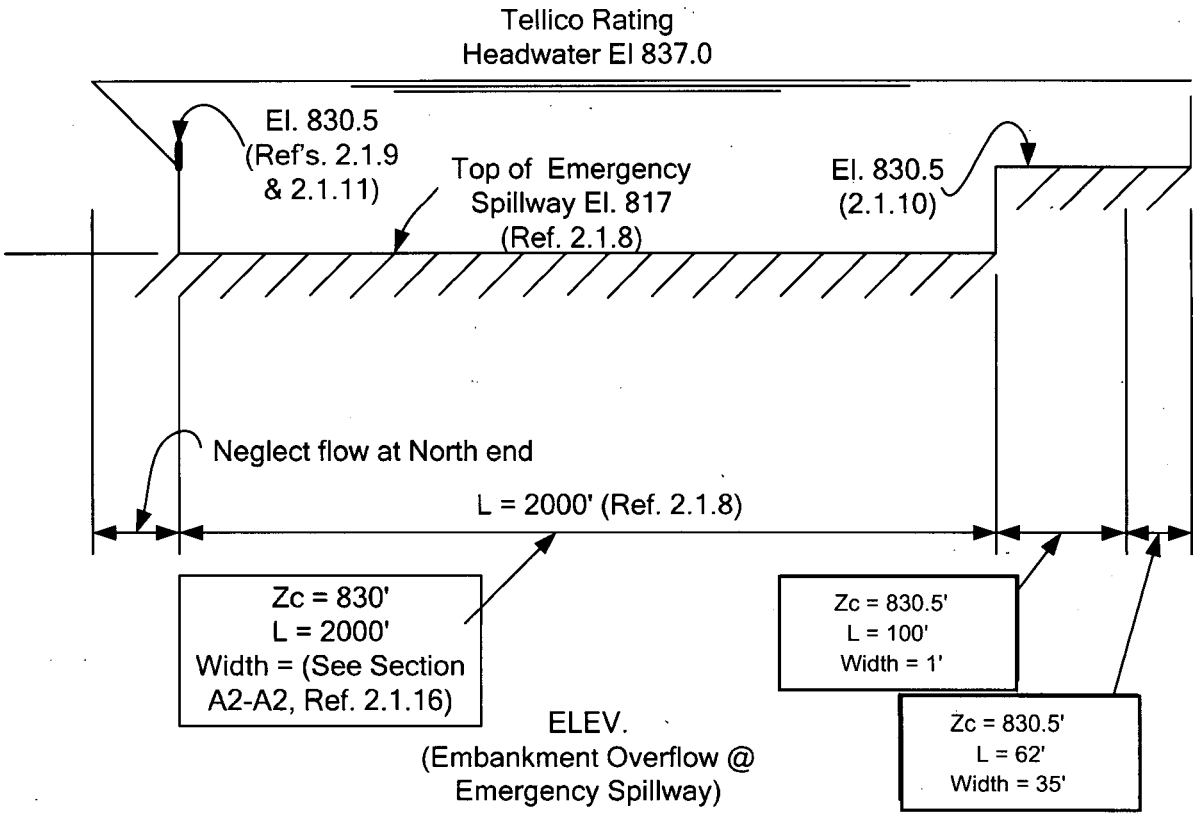
$C_f = 2.65$

Because the elevation and discharge coefficients are the same for the whole length of the main dam works, the lengths will be combined.

EAST END OF RIGHT BANK TO DIVERSION CANAL

The East end of the Right Embankment is approximately 200' from the toe of riprap at the diversion canal. This value is estimated from TVA drawings 10H220R1, 10H221, R1 (Ref's. 2.1.5, 2.1.6, respectively). Since the length is so short in relation to the other considered lengths, and because topographic parameters are difficult to determine in this area for HW > 832, neglect any additional overflow that may occur here. This length essentially covers the bank of the canal. During a PMF event, the length of bank perpendicular to the canal would most likely be flooded anyway, leading to another justification for its exclusion from the overflow parameters for Tellico Dam.

SADDLE DAM 1 - LEFT RIM EMBANKMENT



The Overflow Parameters for the Emergency Spillway have been calculated in Appendix C.

$L = 2000'$
$Z_c = 817'$
$C_f = 2.873 + .10187\ H_c - .004286\ H_c^2 + .00009152\ H_c^3$ when $0 \leq H_c \leq 19.36'$

Parameters for the Section to the left of the emergency spillway in the above diagram have been divided into sections. The first is the 100' wall section with the ≈62' section from the wall to the point where the elevation of the finished grade reaches the maximum headwater elevation:

Section 1:

$Z_c = 830.5'$, $L_1 = 100'$, $B = 1'$

$0 \leq H_c \leq (HW_{max} - Z_c)$

$0 \leq H_c / B \leq (837' - 830.5') / 1' = 6.5$

From Ref. 2.6, Att. 6:

$2.65 \leq C_f \leq 3.1$

$C_f = 3.1$

Section 2 (assuming the bank is eroded horizontally at the elevation of the top of the wall):

$Z_c = 830.5'$, $L_2 = 62'$, $B = 35'$

$0 \leq H_c \leq (HW_{max} - Z_c)$

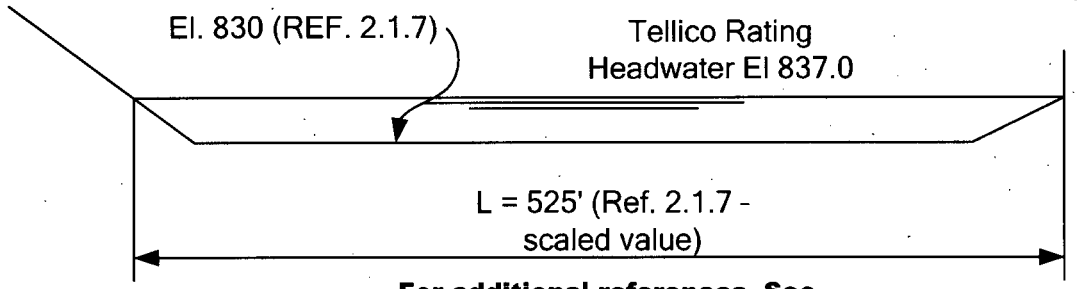
$0 \leq H_c / B \leq (837' - 830.5') / 35' = .19$

From Ref. 2.6, Att. 6:

$2.65 \leq C_f \leq 2.65$

$C_f = 2.65$

SADDLE DAM 2 – LEFT RIM EMBANKMENT



For additional references, See Ref's. 2.1.13 and 2.1.14)

Zc = 830
L = 525'
Width = 14'
(Ref. 2.1.7)

Elev. at Saddle Dam 2

$Z_c = 830'$, $L = 525'$, $B = 14'$

$0 \le H_c \le (HW_{max} - Z_c)$

$0 \le H_c / B \le (837' - 830') / 14' = .5$

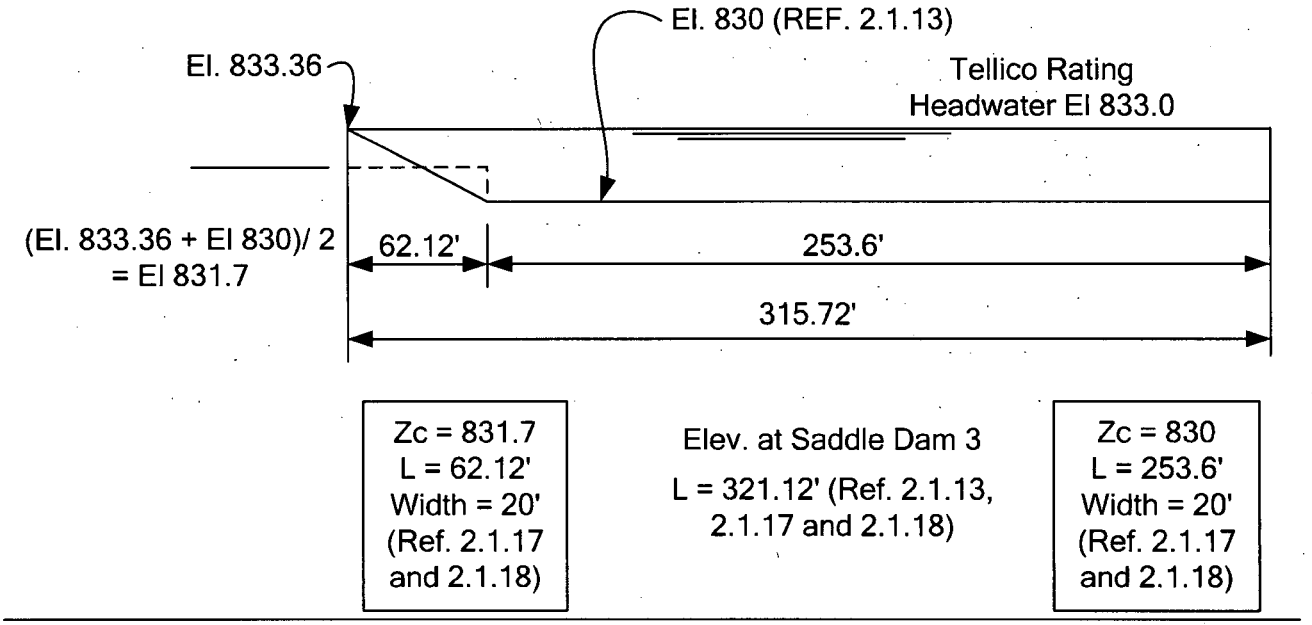
From Ref. 2.6, Att. 6:

$2.65 \le C_f \le 2.69$

$C_f = 2.65$

Based on TVA modifications the top elevation of Saddle Dam 2 has been raised to elevation 834'.

SADDLE DAM 3 – LEFT RIM EMBANKMENT



Section 1 (left most section):

$Z_c = 831.7'$, $L_1 = 62.12'$, $B = 20'$

$0 \le H_c \le (HW_{max} - Z_c)$

$0 \le H_c / B \le (837' - 831.7') / 20' = .27$

From Ref. 2.6, Att. 6:

$2.65 \le C_f \le 2.65$

$C_f = 2.65$

Based on TVA modifications the top elevation of Saddle Dam 3 has been raised to elevation 834'.

Section 2 (Main saddle dam section):

$Z_c = 830'$, $L_2 = 253.6'$, $B = 20'$

$0 \le H_c \le (HW_{max} - Z_c)$

$0 \le H_c / B \le (837' - 830') / 20' = .35$

From Ref. 2.6, Att. 6:

$2.65 \le C_f \le 2.67$

$C_f = 2.65$

REMAINING OVERFLOW SECTIONS:

The Remaining Overflow Sections component will no longer be used in this calculation.

Due to the maximum headwater elevation of 837', terrain between the main dam works and the saddle dams will be inundated. The highest elevation in this area is approximately 832'. For this reason, an average elevation of 830' with a length of 2500' (scaled length from App. E) has been assigned to this section. Because the relative width is broad compared to the elevation difference, a discharge coefficient of 2.65 will be used.

SUMMARY OF OVERFLOW PARAMETERS:

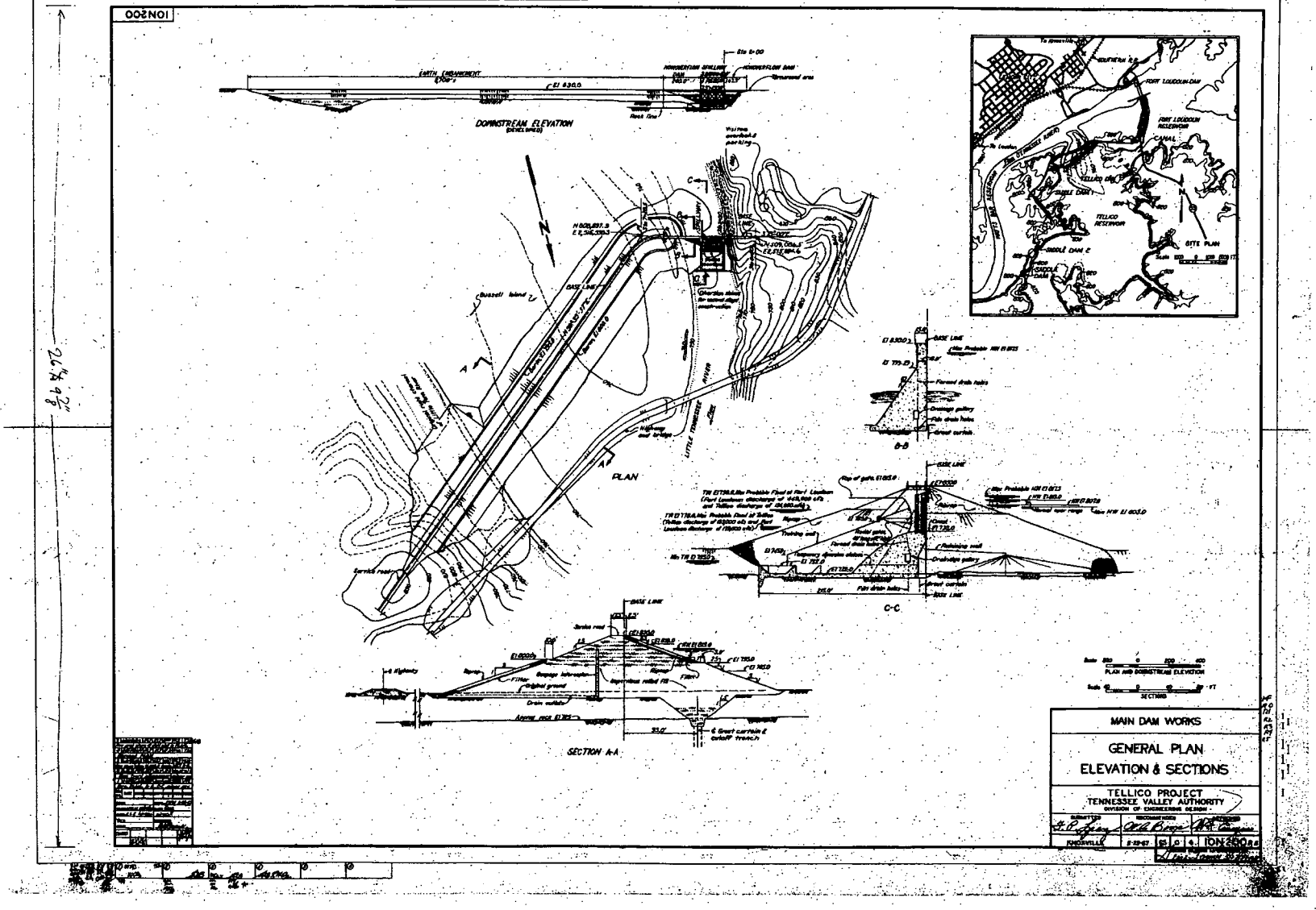
Overflow Parameters

	Z_c (ft)	L (ft)	C_f
Right Bank Saddle Dam	830	2000	2.65
Main Dam Works	830	3147.5	2.65
Saddle Dam 1 (excludes spillway parameters)	830.5	100	3.1
	830.5	62	2.65
Saddle Dam 2	830	525	2.65
Saddle Dam 3	831.7	62.12	2.65
	830	253.6	2.65
Remaining Overflow Sections	830	2500	2.65

Based on TVA modifications the top elevation of the Right Bank Saddle Dam, 2000' of the Main Dam Works Embankment, Saddle Dam 2, and Saddle Dam 3 have all been raised to elevation 834'. The Remaining Overflow Sections component will no longer be used in this calculation.

Appendix B-10
from Ref. 2.1.1
24 total pages

Calculation No: CDQ000020080018



DAM RATING CURVES - TELLICO
OVERFLOW PARAMETERS
CDQ 0000 2.00 80018

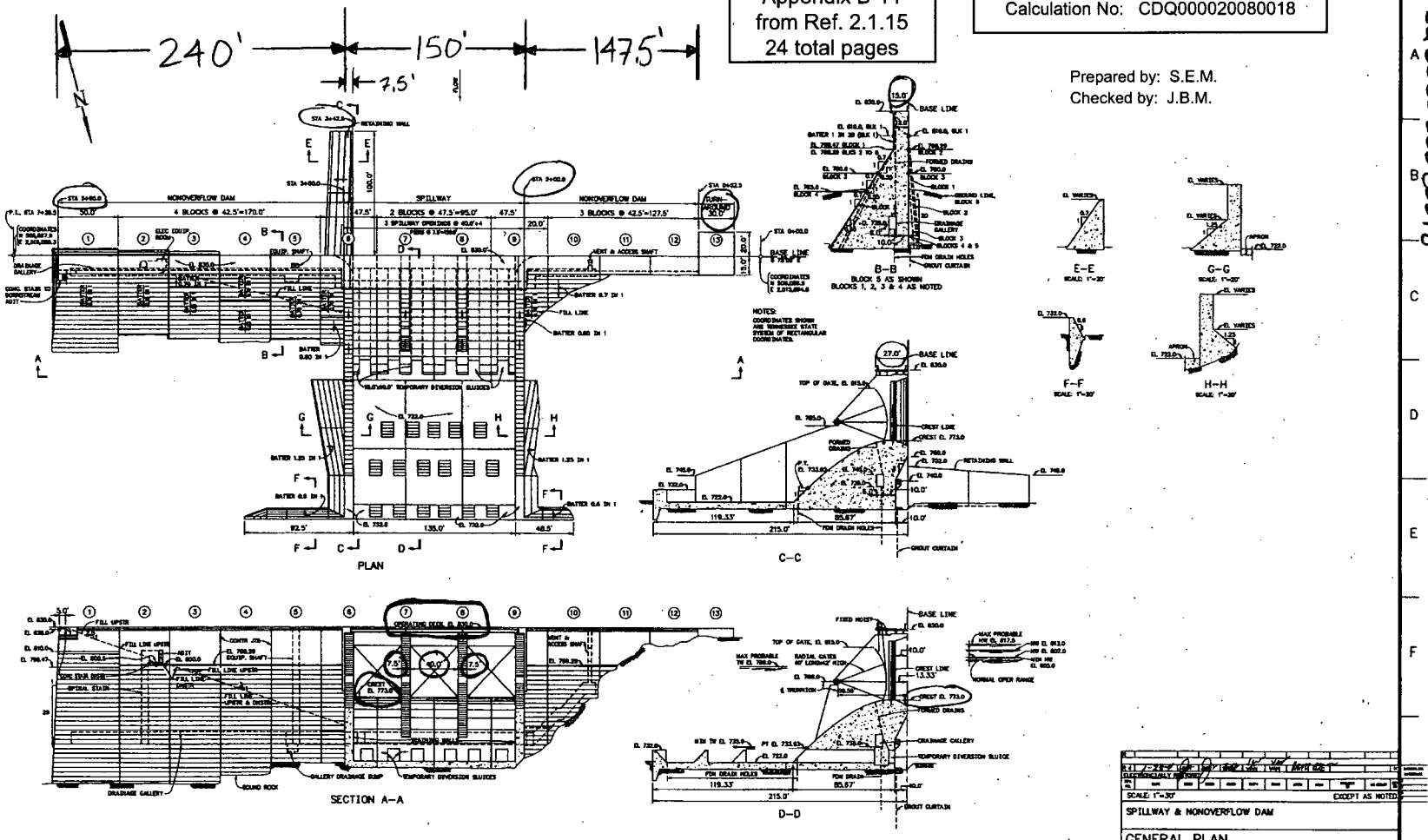
(1)

Appendix B-11
from Ref. 2.1.15
24 total pages

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.

DAM RATING CURVES - TELLICO - OVERFLOW PARAMETERS
CDQ0000200800 18



SCALE: 1"=30' EXCEPT AS NOTED

SPILLWAY & MONOVERFLOW DAM

GENERAL PLAN
ELEVATION & SECTIONS

TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
CIVIL AND HYDRO ENGINEERING

AUTOCAD R14 | 6-19-97 | 65 | C | 10W201 | R 4

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES: (10W201 R3)

PLOT FACTOR: 380

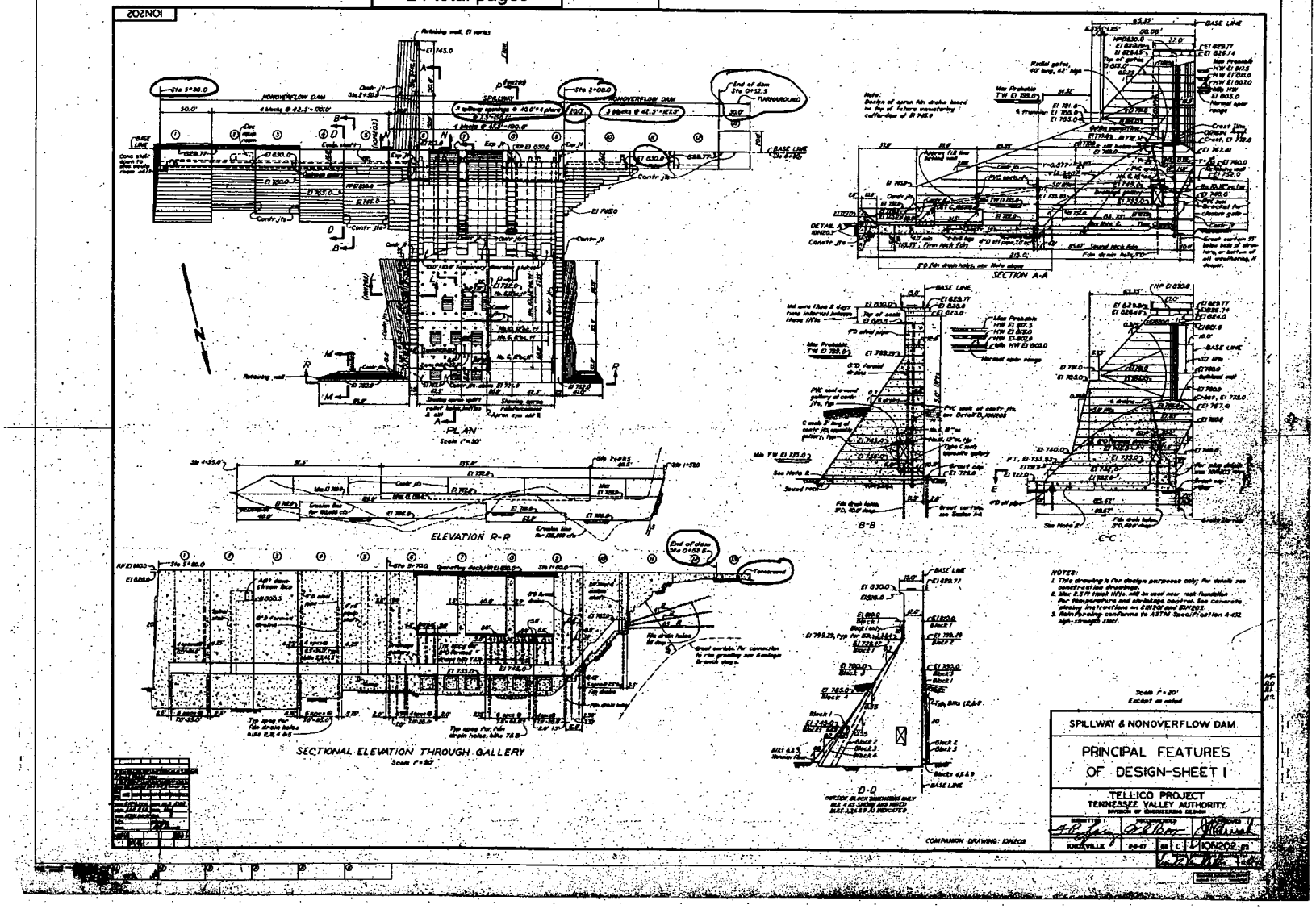
C.A.D. DRAWING DO NOT ALTER MANUALLY

(2)

Appendix B-12
from Ref. 2.1.3
24 total pages

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.



DAM RATING CURVES- TELLICO
OVERFLOW PARAMETERS
CDQ000020080018

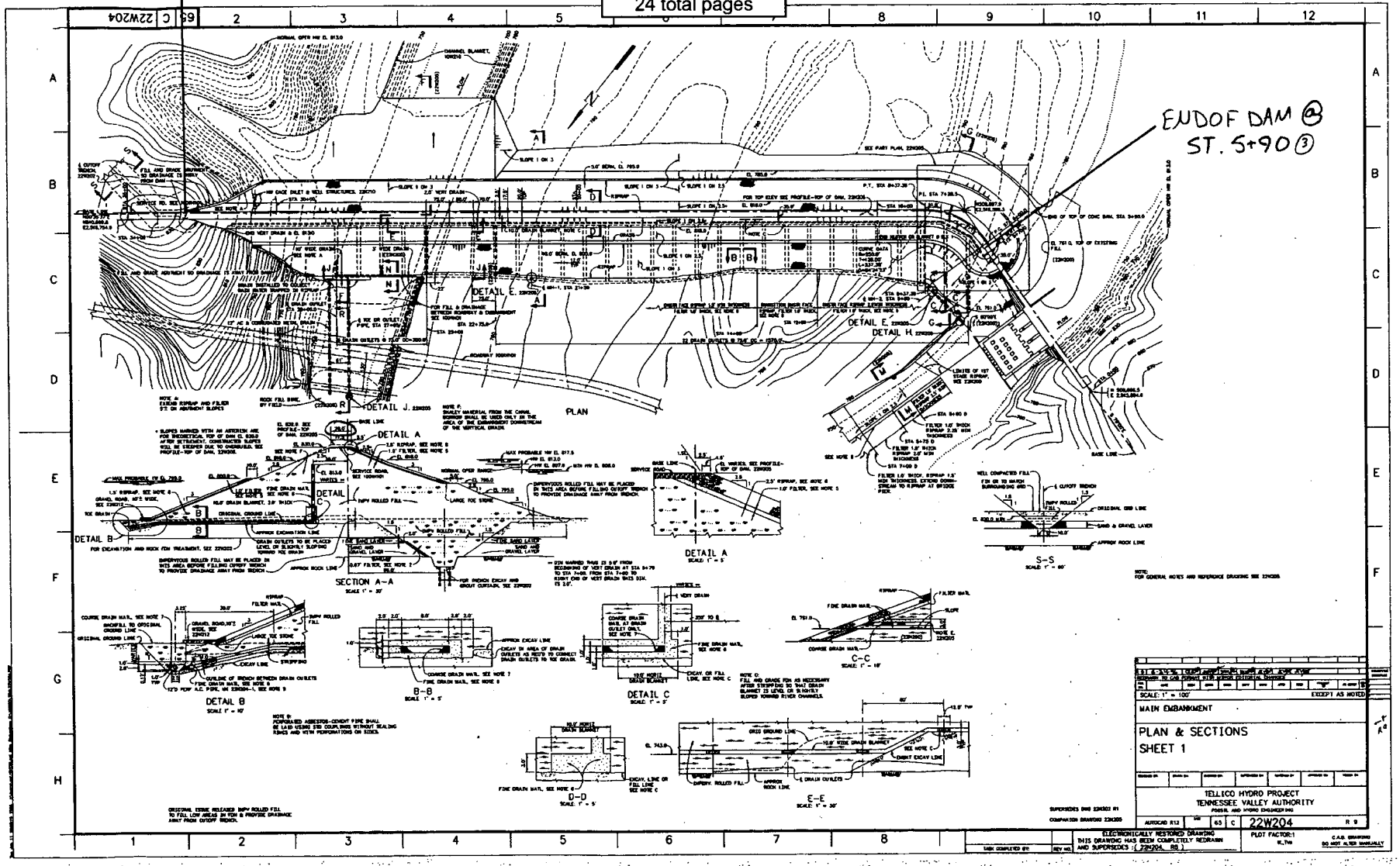
(3)

END OF EMBANKMENT
≈ ST. 32+90

Appendix B-13
from Ref. 2.1.4
24 total pages

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.



DAM RATING CURVES - TELLICO
OVERFLOW PARAMETERS

CDQ 0000200800 18

(4)

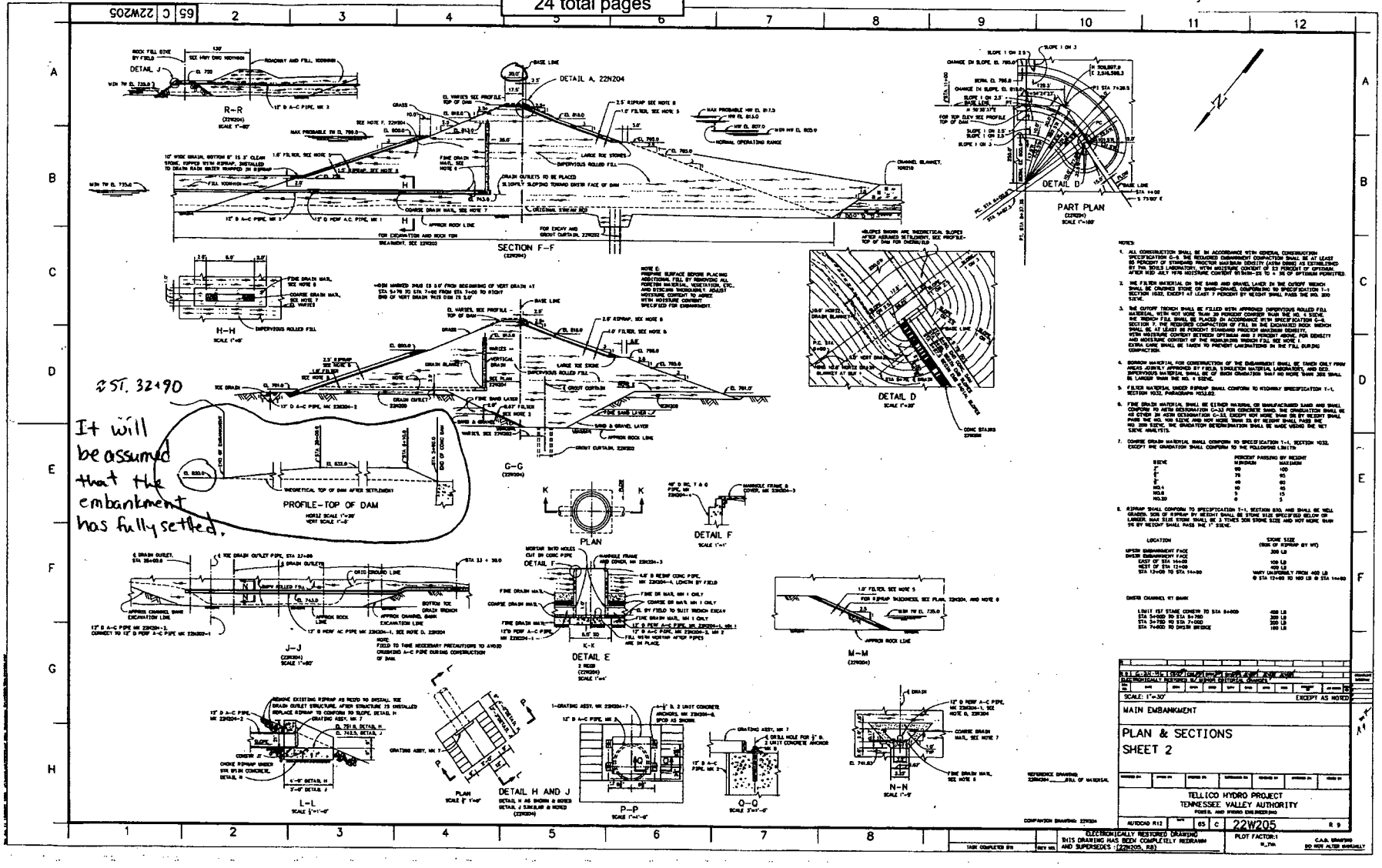
Appendix B-14
from Ref. 2.1.19
24 total pages

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.

DAM RATING CURVES - TELLICO
OVERFLOW PARAMETERS

CDQ 0000200 80018 (5)



ST. 32490

It will be assumed that the embankment has fully settled.

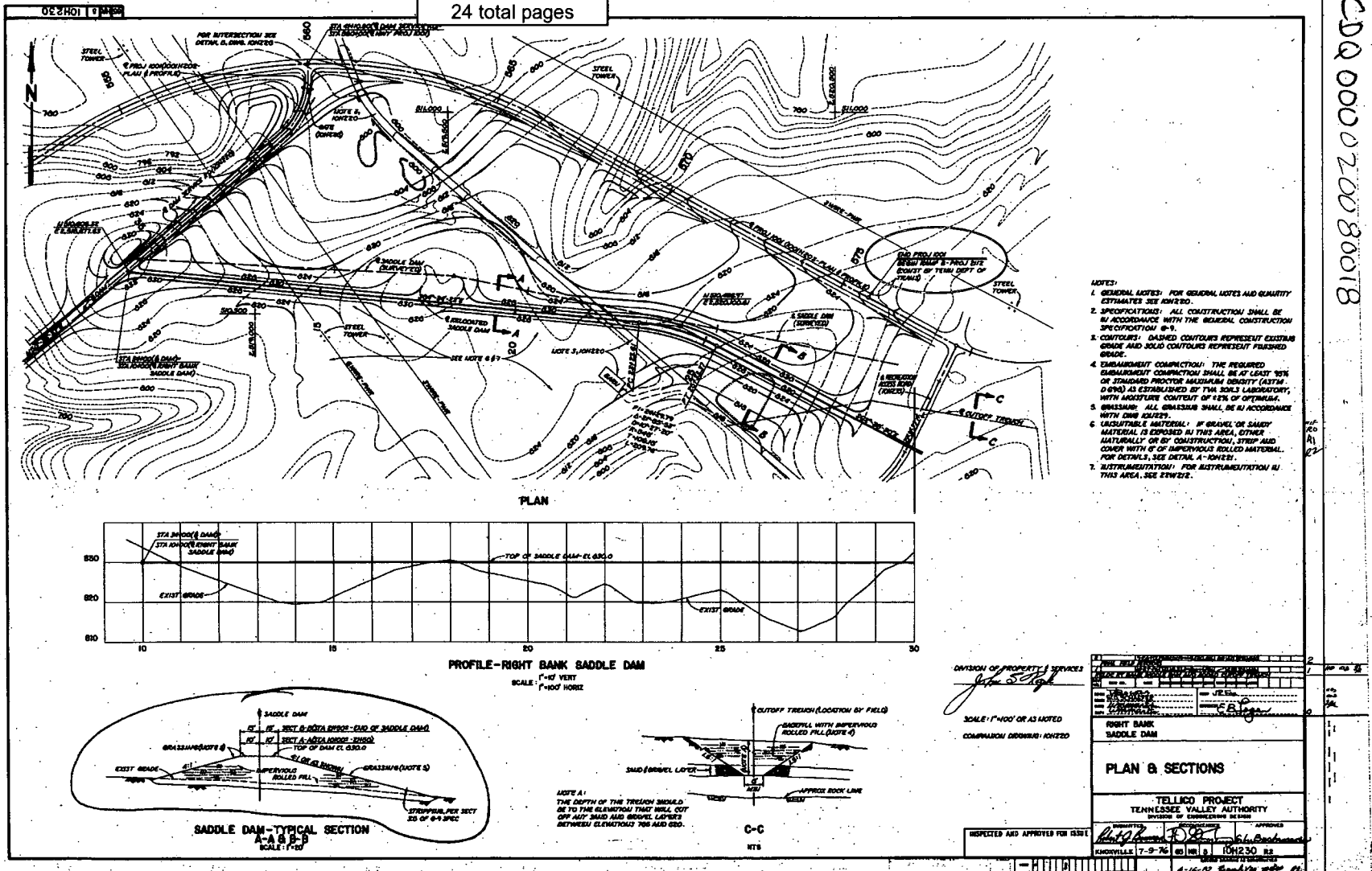
Appendix B-15
from Ref. 2.1.2
24 total pages

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.

DAM RATING CURVES - TELLICO
OVERFLOW PARAMETERS
CDQ0000200800 18

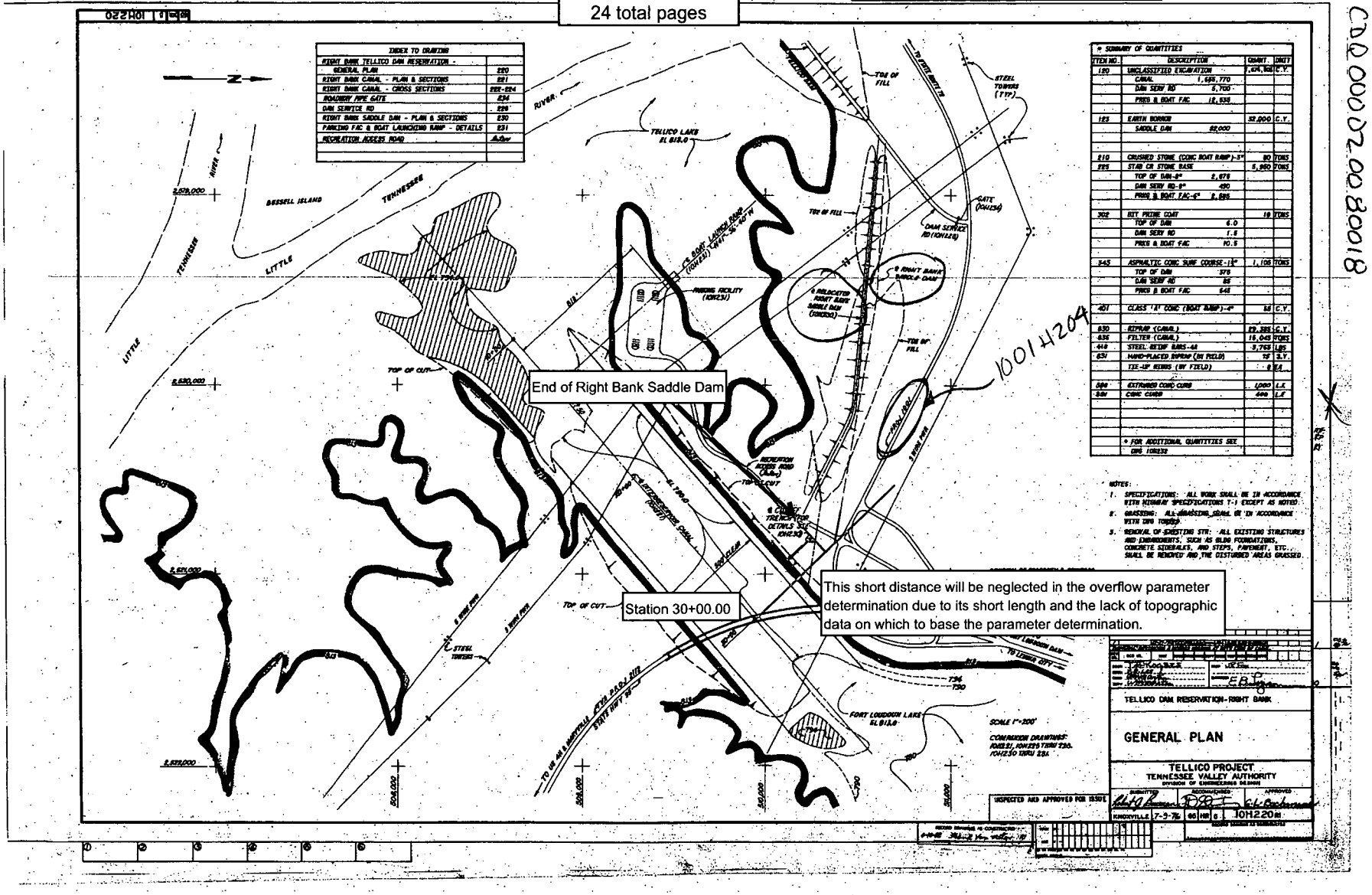
6



Appendix B-16
from Ref. 2.1.6
24 total pages

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.



DAM RATING CURVES - TELLICO
OVERFLOW PARAMETERS
CDQ0000200800 18

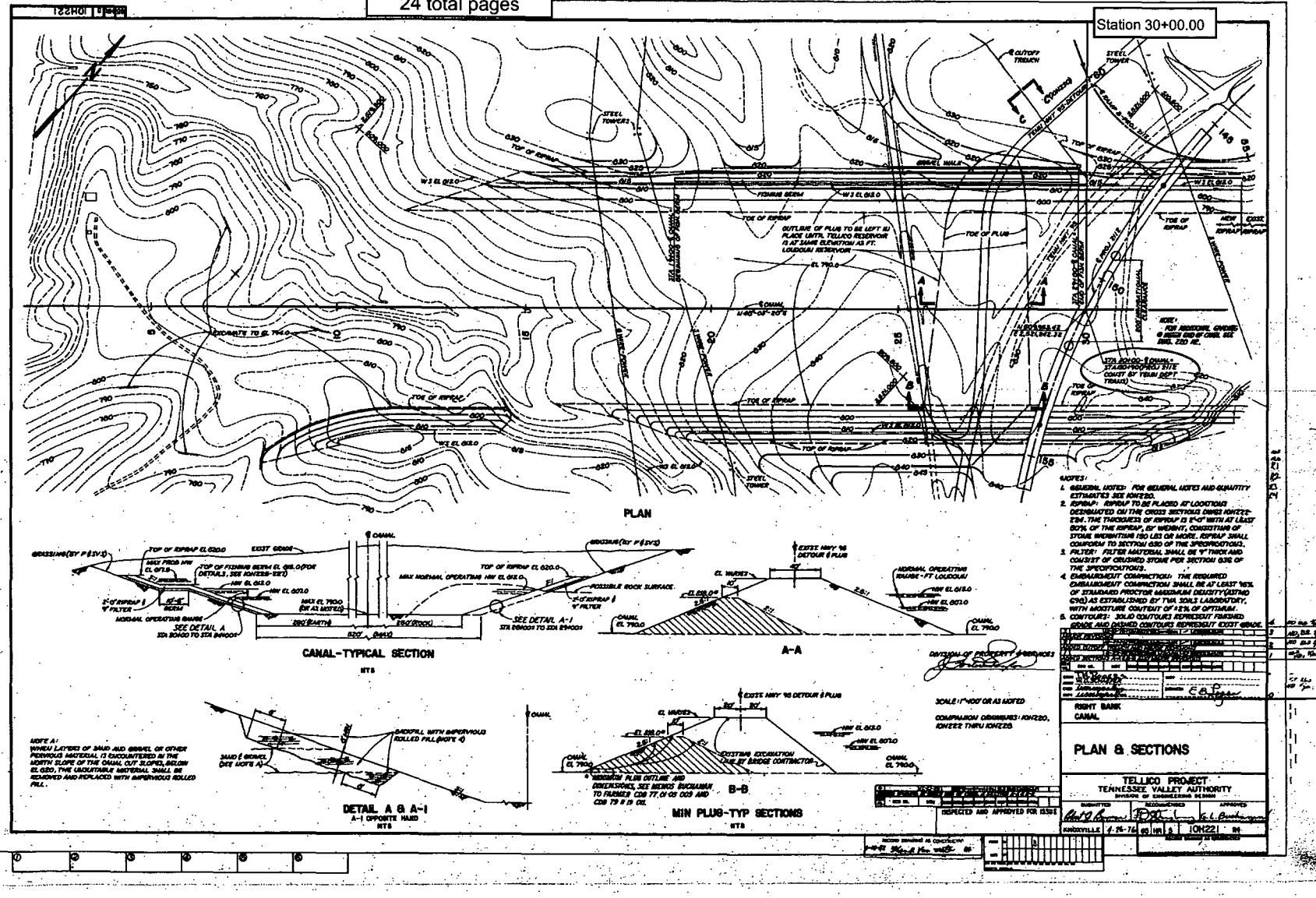
(7)

Appendix B-17
from Ref. 2.1.5
24 total pages

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.

DAM RATING CURVES - TELLICO
OVERFLOW PARAMETERS
CDQ0000200800 18



(8)

Appendix B-18
from Ref. 2.1.7
24 total pages

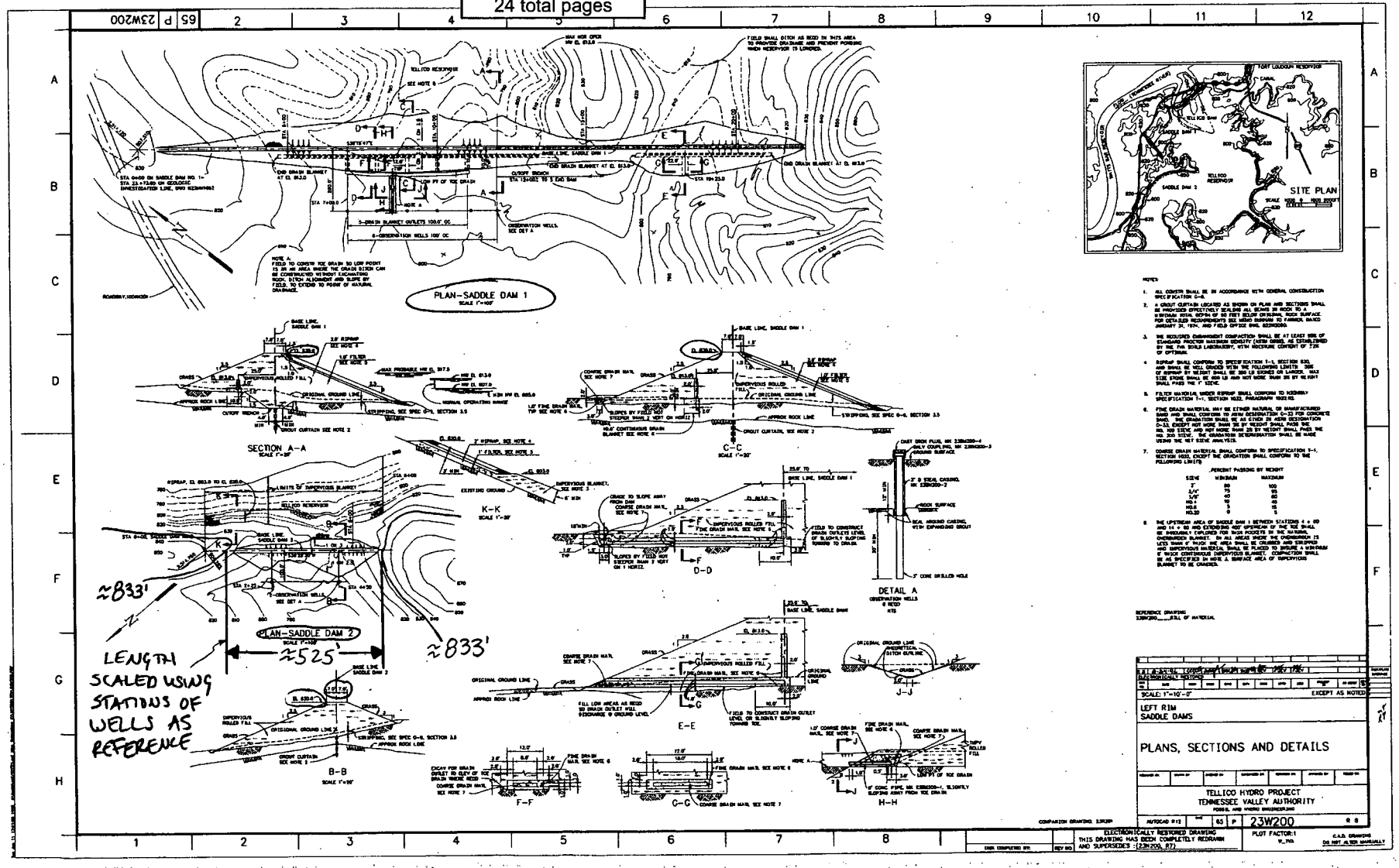
Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.

DAM RATING CURVES - TELLICO
OVERFLOW PARAMETERS

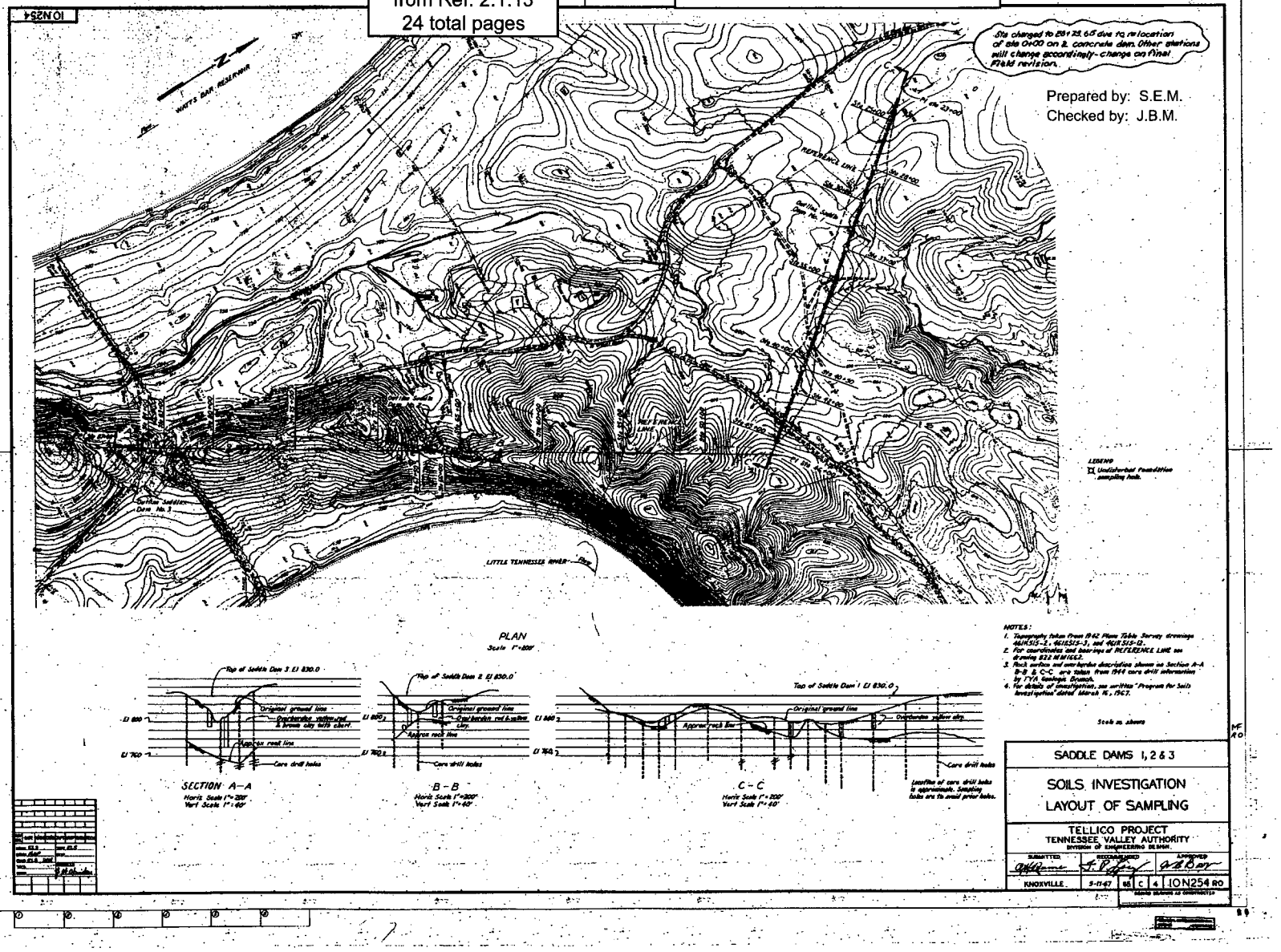
CDQ000020080018

9



Appendix B-19
from Ref. 2.1.13
24 total pages

Calculation No: CDQ000020080018



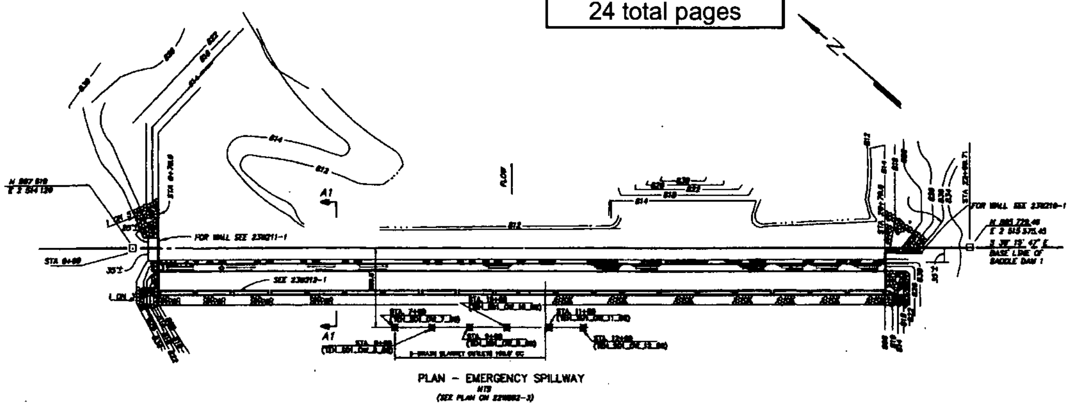
DAM RATING CURVES - TELLICO
OVERFLOW PARAMETERS
CDQ0000200 80018

(10)

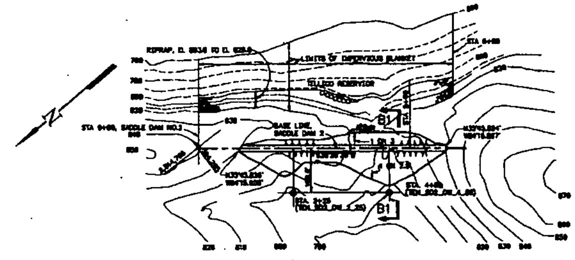
Appendix B-20
from Ref. 2.1.14
24 total pages

Calculation No: CDQ000020080018

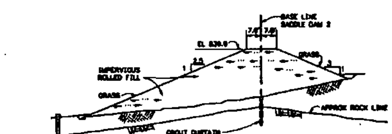
DAM RATING CURVES - TELLICO
OVERFLOW PARAMETERS
CDQ000020080018



PLAN - EMERGENCY SPILLWAY
NTS

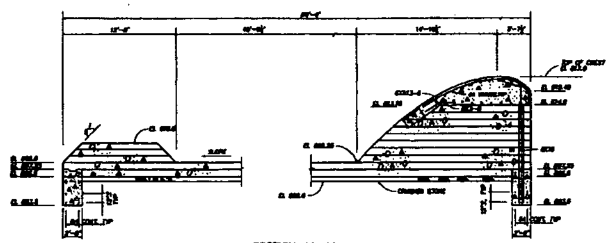


PLAN-SADDLE DAM 2
SCALE 1"=100'



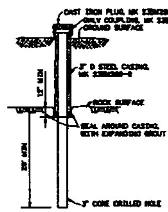
B1-B1
SCALE 1"=20'

NOTE:
THERE IS ONE SETTLEMENT MONUMENT ON SADDLE DAM NO.2 SD2-2A (TEH_SS_SD_2_2A) THE EXACT LOCATION IS NOT KNOWN AT THIS TIME.



SECTION A1-A1
SCALE 1/4" = 1'-0"
(SECTION A3-A3, 22W882-3)

TABLE 1							
SADDLE DAM #1 OBSERVATION WELLS							
INSTRUMENT ID	DATABASE NAME	STATION	GROUND ELEVATION (FT)	BOTTOM OF HOLE (FT)	DEPTH (FT)	LATITUDE	LONGITUDE
STA.7+00	TEH_SD1_OW_7_00	7+00	[illegible]	764.6	44.2	N35 46.320	W84 13.8[illegible]
STA.8+00	TEH_SD1_OW_8_00	8+00	803.2	754.0	49.2	N35 46.305	W84 13.838
STA.9+00	TEH_SD1_OW_9_00	9+00	804.7	758.40	46.3	N35 46.283	W84 13.824
STA.10+00	TEH_SD1_OW_10_00	10+00	807.8	767.40	40.4	N35 46.280	W84 13.812
STA.11+00	TEH_SD1_OW_11_00	11+00	808.6	769.96	38.7	N35 46.267	W84 13.800
STA.12+00	TEH_SD1_OW_12_00	12+00	807.0	767.70	39.2	N35 46.234	W84 13.807

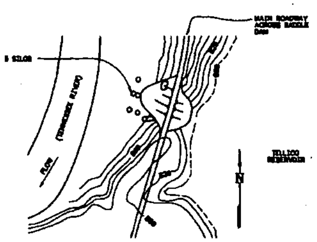


DETAIL C1
OBSERVATION WELLS
NTS

TABLE 2							
SADDLE DAM #2 OBSERVATION WELLS							
INSTRUMENT ID	DATABASE NAME	STATION	GROUND ELEVATION (FT)	BOTTOM OF HOLE (FT)	DEPTH (FT)	LATITUDE	LONGITUDE
STA.2+25	TEH_SD2_OW_2_25	2+25	798.4	755.80	43.0	N35 45.870	W84 13.870
STA.4+00	TEH_SD2_OW_4_00	4+00	798.1	762.80	36.3	N35 46.040	W84 13.866

NOTE:
FOR KEY PLAN, SEE 10W805-1

KEY
OW- OBSERVATION/GROUNDWATER WELL
SS- SURVEY/SETTLEMENT MARKER
ABANDONED OBSERVATION/GROUNDWATER WELL



PLAN-SADDLE DAM 3
NTS

MAY 09 2008

SCALE: 1"=10'-0" EXCEPT AS NOTED

LEFT RIM
SADDLE DAMS

INSTRUMENTATION
OBSERVATION WELLS & SETTLEMENT MARKERS
PLAN & SECTIONS, SH.1

TELLICO HYDRO PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R00 | 65 | DS | 21W856-1 | R 0

PLOT FACTOR:1

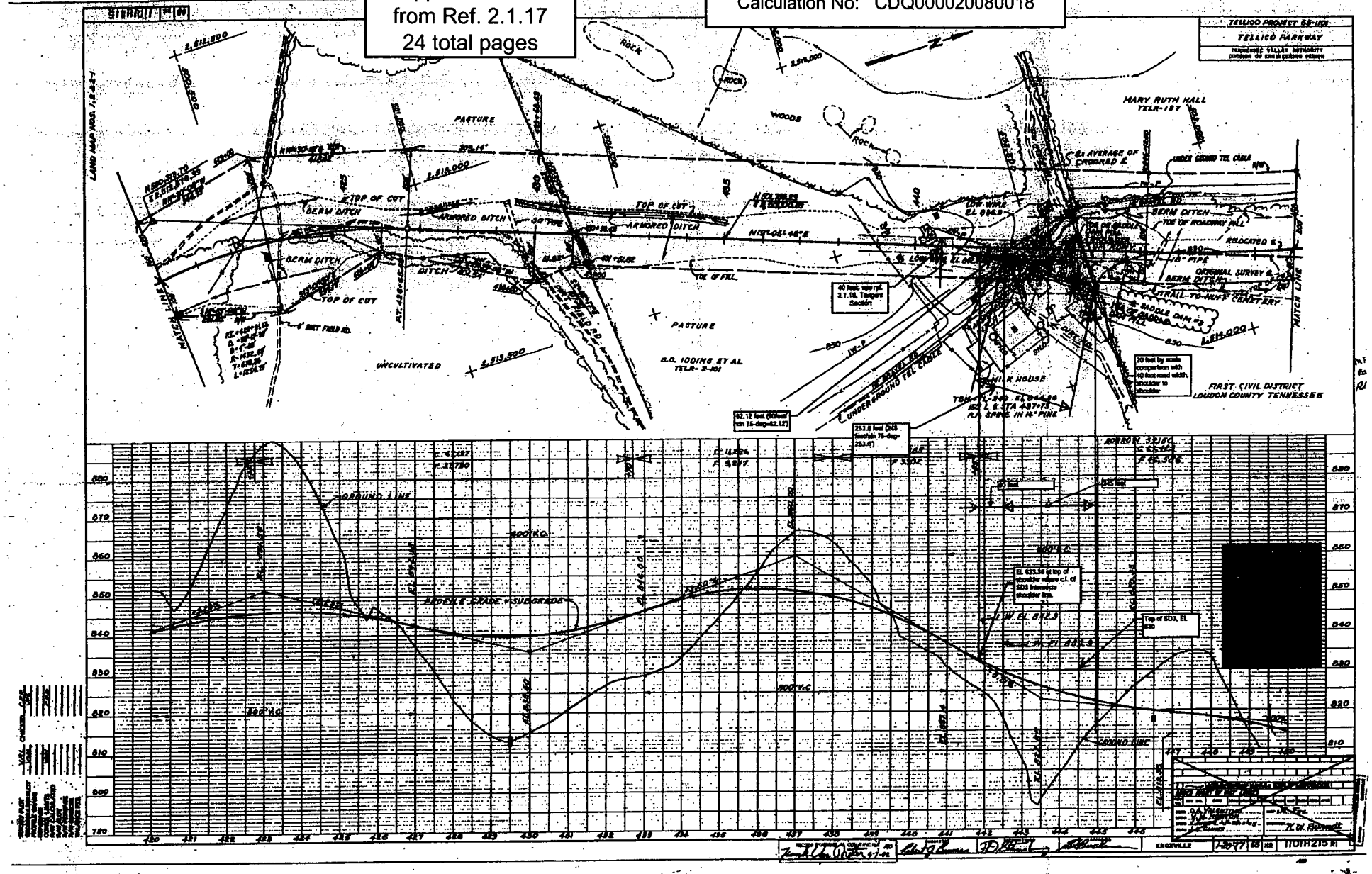
C.A.D. DRAWING
DO NOT ALTER MANUALLY

65 DS 21W856-1

(11)

Appendix B-21
from Ref. 2.1.17
24 total pages

Calculation No: CDQ000020080018



DAM RATING CURVES - TELLICO

CDQ000020080018

OVERFLOW PARAMETERS

Prepared by: S.E.M.
Checked by: J.B.M.

12

Prepared by: S.E.M.
Checked by: J.B.M.

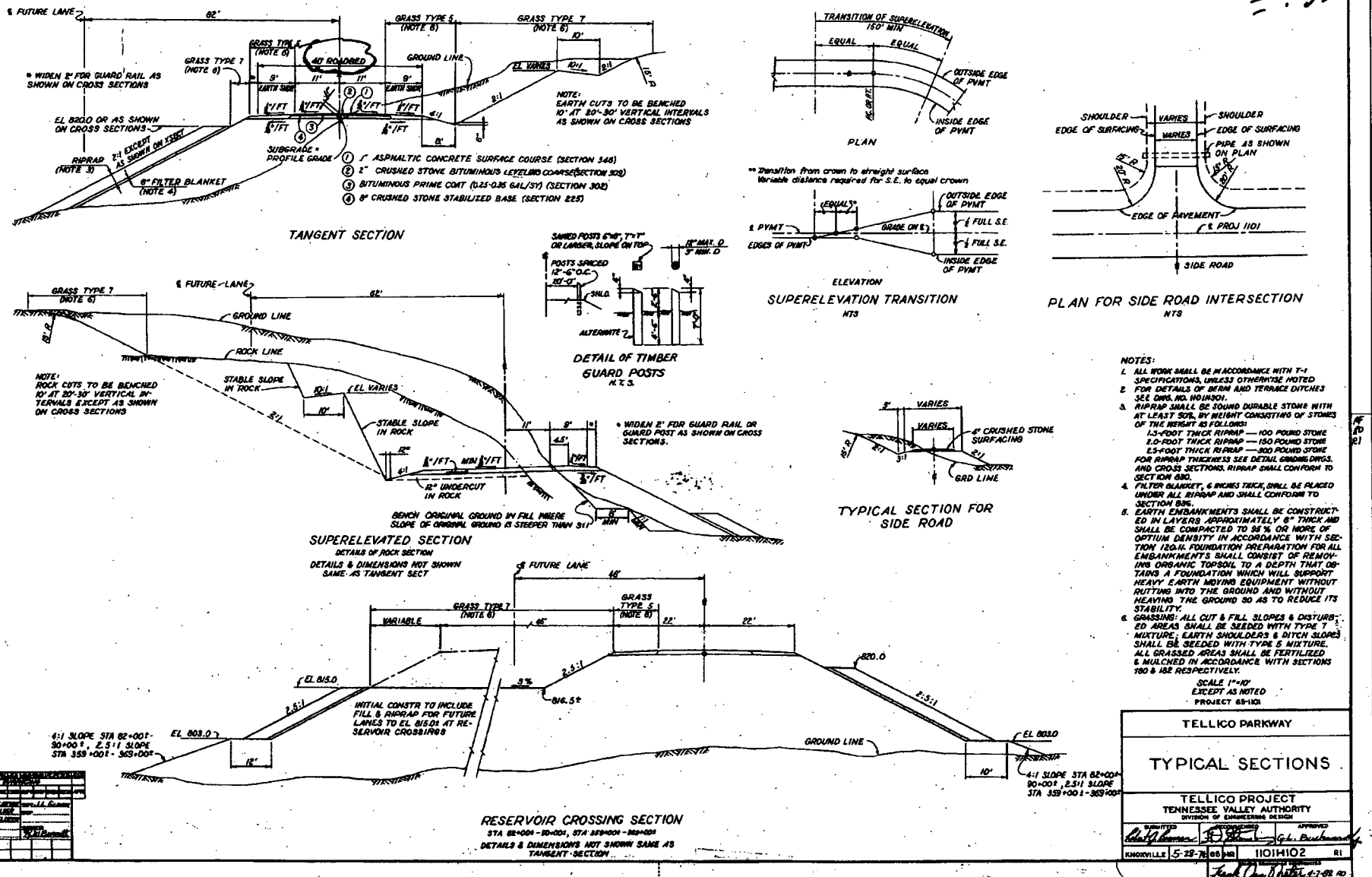
DAM RATING CURVES - TELLICO
OVERFLOW PARAMETERS
CDQ0000200 80018

Appendix B-22
from Ref. 2.1.18
24 total pages

Calculation No: CDQ000020080018

(13)

66" 9x1 = 4.5"
6.56"
= .55'



824.5'
+ 1 1/2 = 96'

DAM RATING CURVES - TELLICO

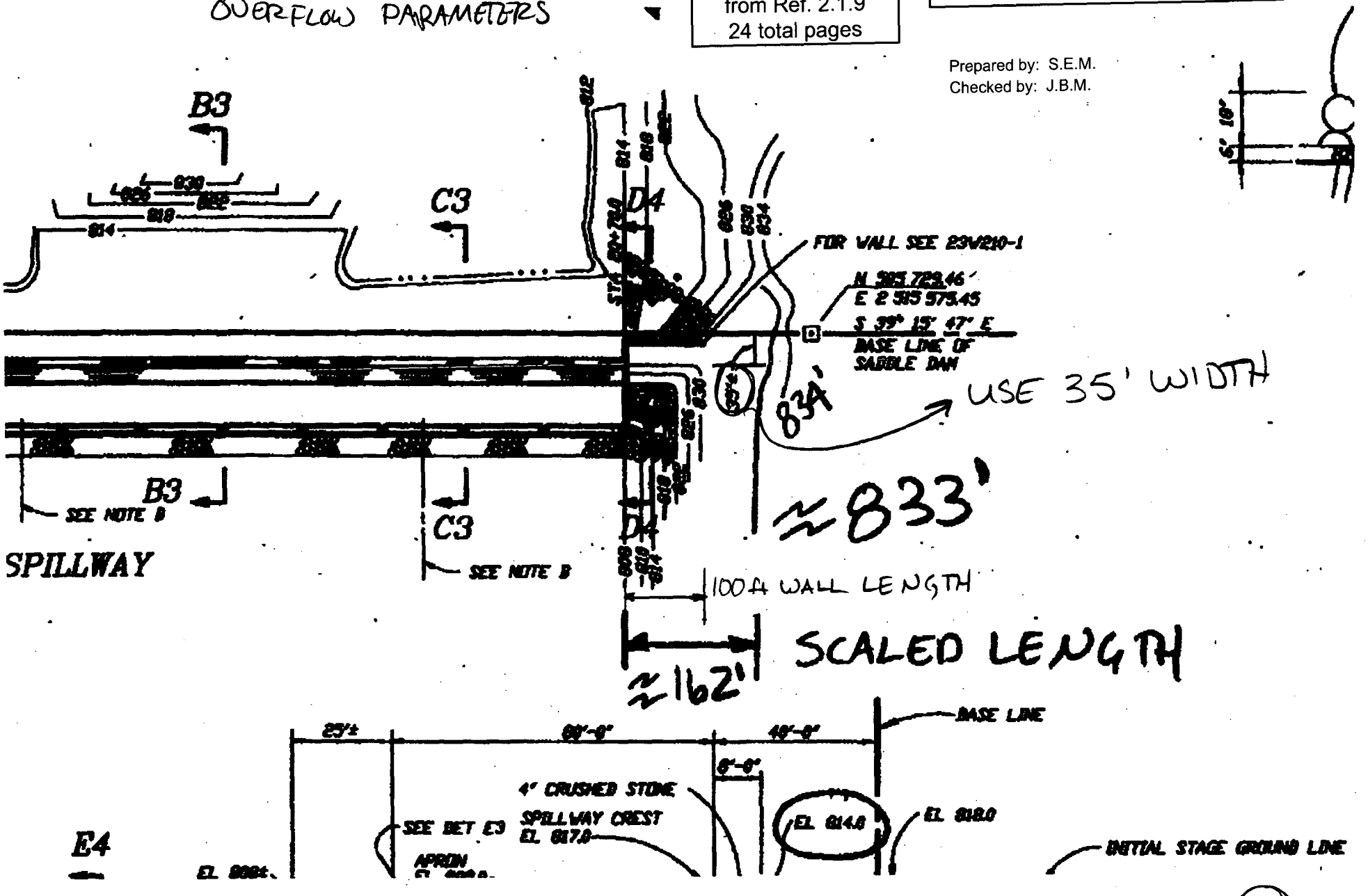
CDQ0000200 80018

OVERFLOW PARAMETERS

Appendix B-23
from Ref. 2.1.9
24 total pages

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.



from: 23W205-3, R2

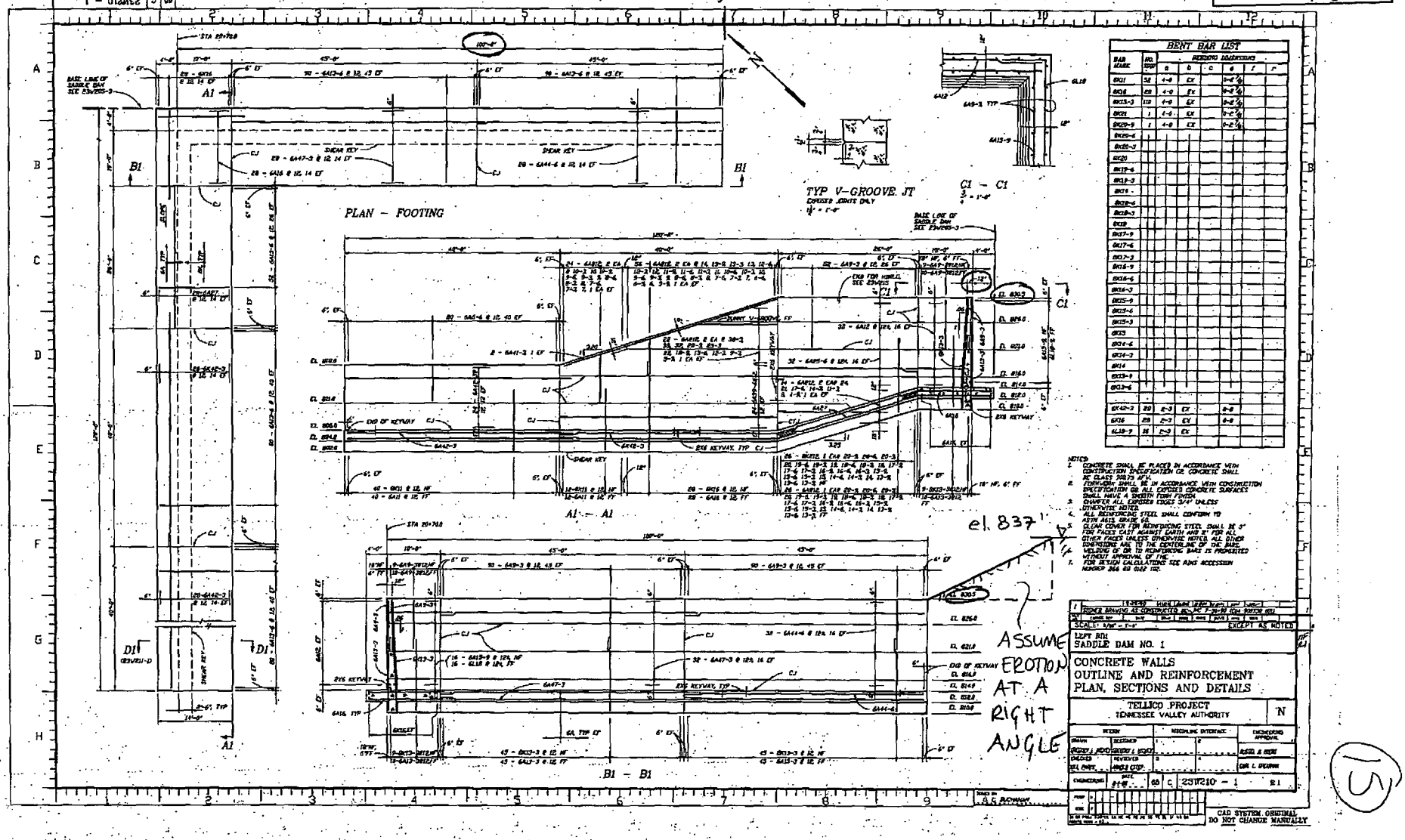
(14)

Prepared by: S.E.M.
Checked by: J.B.M.

ST.21+70

Calculation No: CDQ000020080018

Appendix B-24
from Ref. 2.1.10
24 total pages



(5)

DAM RATING CURVES - TELLICO

SUBJECT TELLICO SADDLE DAM 1, EMERGENCY SPILLWAY PRO

Calculation No: CDQ000020080018

SEM 12-3-08 J.B.M. 2/3/2009

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Appendix C-1
20 Total Pages

PURPOSE: DEVELOP A $C_f(H_c)$ RELATIONSHIP FOR THE EMERGENCY SPILLWAY ON SADDLE DAM 1 OF THE TELLICO PROJECT, C_f IS THE FREE FLOW DISCHARGE COEFFICIENT AND H_c IS THE HEAD ABOVE THE CREST IN FEET.

APPROACH: USE THE CORRELATION BETWEEN OGEE CRESTS GIVEN IN DESIGN OF SMALL DAMS (REFERENCE 2.9) AND THE EMERGENCY SPILLWAY CREST.

(1) SELECT C_o FROM FIGURE 9-23 (SHEET 8)

(2) DETERMINE $C_f(H_c)$ USING C_o AND $\frac{C}{C_o}$ v/s $\frac{H_c}{H_o}$ FROM FIGURE 9-24 (SHEET 9)

(3) SHOW THE SIMILARITY BETWEEN THE EMERGENCY SPILLWAY AND OGEE CRESTS AT THE SAME DESIGN HEAD, H_o.

DRAWINGS AND REFERENCES:

① 23 W 212-2, R3 (Ref 2.1.16, Att. E16)
② 23 W 210-1, R1 (Ref. 2.1.10, Att. E10)
③ 23 W 205-3, R2 (Ref. 2.1.8, Att. E8)
④ TVA CALCULATION, "EMERGENCY SPILLWAY AT SADDLE DAM 2" RIMS ACCESSION NO. B66 88 0811 005 (REF 2.8, Att. E30)

DAM RATING CURVES - TELLICO

SUBJECT TELLICO SADDLE DAM 1 - EMERGENCY SPILLWAY PRC

Calculation No: CDQ000020080018

SEM 12-3-08 J.B.M. 2/3/2009

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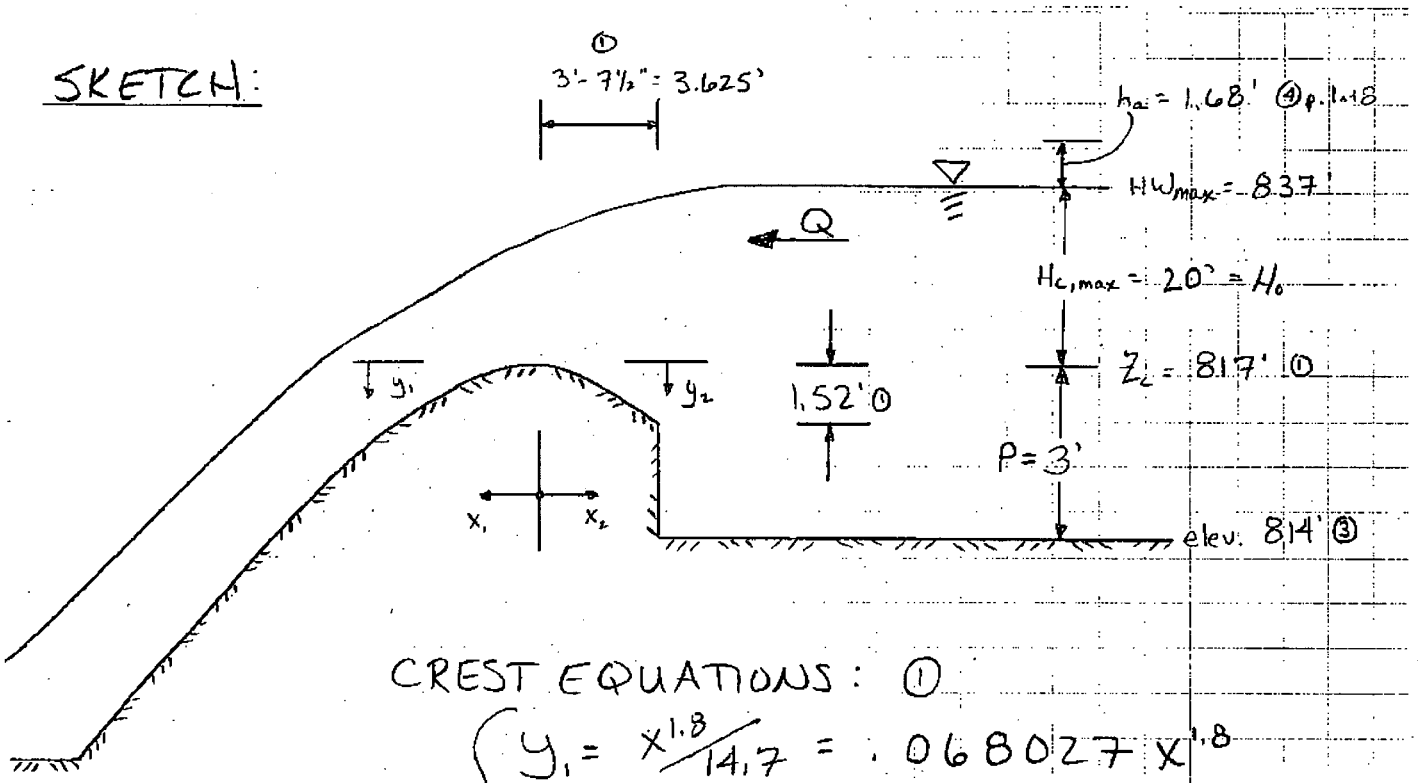
Appendix C-2
20 Total Pages

SKETCH:



CREST EQUATIONS: ①

$$\begin{cases} y_1 = x^{1.8}/14.7 = .068027\,x^{1.8} \\ y_2 = x^3/31.4 = .031847\,x^2 \end{cases}$$

FROM FIG 9-24 (SHEET 9), H_o = DESIGN HEAD = 12.1' FROM ④ p. 5 of 8

$H_e = H_{c,max} + h_a = 20' + 1.68' = 21.68'$

$H_e/H_o = 21.68'/12.1' = 1.79$

(1) SELECT C_o FROM FIG 9-23 (SHEET 8)

$H_o = 12.1'$, $P = 3'$ ⇒ $P/H_o = 3/12.1' = .248$ ⇒ $C_o = 3.64$

↳ THE DESIGN HEAD IS USED HERE WITH THIS NOTATION

(2) DETERMINE $C_f(H_c)$ FROM FIG 9-24 (SHEET 9)

POINTS SCALED FROM FIG 9-24 ARE FIT TO THE FOLLOWING POLYNOMIAL ON THE TOP HALF OF SHEET 10.

$$\frac{C}{C_o} = 1 + .1275\left(\frac{H}{H_o}-1\right) - .03876\left(\frac{H}{H_o}-1\right)^2 + .04454\left(\frac{H}{H_o}-1\right)^3$$

DAM RATING CURVES - TELLICO

SUBJECT TELLICO SADDLE DAM 1 - EMERGENCY SPILLWAY

Calculation No: CDQ000020080018

SEM 12-3-08 COMPUTED BY DATE

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Appendix C-3
20 Total Pages

where $C = C_f$ AND $H = H_c$. THE DEPENDENT VARIABLE IS $H/H_0 - 1$ TO ENSURE THAT $C = C_0$ AT $H = H_0$.

REWRITE AS:

$$\frac{C}{C_0} = 1 + a_1(h-1) + a_2(h-1)^2 + a_3(h-1)^3$$

$$= 1 + (h-1)\{a_1 + (h-1)[a_2 + a_3(h-1)]\}$$

$$= 1 + (h-1)\{a_1 + (h-1)[a_3 h + (a_2 - a_3)]\}$$

$$= 1 + (h-1)[a_1 + a_3 h^2 + (a_2 - a_3)h - a_3 h - (a_2 - a_3)]$$

$$= 1 + (h-1)[a_3 h^2 + (a_2 - 2a_3)h + (a_1 - a_2 + a_3)]$$

$$= 1 + a_3 h^3 + (a_2 - 2a_3)h^2 + (a_1 - a_2 + a_3)h - a_3 h^2 - (a_2 - 2a_3)h - (a_1 - a_2 + a_3)$$

$$= 1 - (a_1 - a_2 + a_3) + (a_1 - 2a_2 + 3a_3)h + (a_2 - 3a_3)h^2 + a_3 h^3$$

where $a_1 = .1275$, $a_2 = -.03876$, $a_3 = .04454$

$\Rightarrow 1 - (a_1 - a_2 + a_3) = .7892$

$a_1 - 2a_2 + 3a_3 = .33864$

$a_2 - 3a_3 = -.17238$

and $h = \frac{H}{H_0}$

$$\Rightarrow \frac{C}{C_0} = .7892 + .33864\left(\frac{H}{H_0}\right) - .17238\left(\frac{H}{H_0}\right)^2 + .04454\left(\frac{H}{H_0}\right)^3$$

FOR $C_0 = 3.64$ AND $H_0 = 12.1'$, THIS EQUATION BECOMES:

$$C_f = 2.873 + .10187 H_c - .004286 H_c^2 + .00009152 H_c^3$$

for $0 \le H_c \le 19.36'$ (Eq. C-1)

DAM RATING CURVES - TELLICO

SUBJECT SADDLE DAM 1 - EMERGENCY SPILLWAY PR Calculation No: CDQ000020080018

SEM 12-3-08 J.B.M. 2/3/2009

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Appendix C-4
20 Total Pages

WITH C REPLACED WITH C_f AND H REPLACED WITH H_c, THIS POLYNOMIAL IS VALID FOR

$H/H_0 \leq 1.6$ (UPPER LIMIT ON FIG 9-24, SHEET 9)

OR $H \leq 1.6 \times 12.1' = 19.36'$

C_f IS NEEDED FOR $0 < H \leq 20$, BECAUSE THE MAXIMUM HEAD ON THE EMERGENCY SPILLWAY CREST IS JUST SLIGHTLY HIGHER THAN THE LIMIT FROM FIGURE 9-24, THE POLYNOMIAL OF EQUATION C-1 IS DEEMED ADEQUATE TO $HW_{max} = 837'$.

(3) SHOW SIMILARITY BETWEEN EMERGENCY SPILLWAY AND OGEE CREST AT THE SAME DESIGN HEAD.

FIRST COMPARE CREST SHAPES DOWNSTREAM FROM CREST

OGEE : $\frac{y}{H_0} = -K\left(\frac{x}{H_0}\right)^n$ AS SHOWN ON FIG 9-21(1), SHEET 11

WITH K AND n DEPENDANT ON $\frac{h_a}{H_0}$ WHERE

h_a = VELOCITY HEAD UPSTREAM WHEN $H = H_0$

$$h_a = \frac{q^2}{2g(P+h_0)^2}$$

WHERE q = DISCHARGE PER FT OF CREST = $C H_0^{3/2}$ (cfs per ft)

g = ACCELERATION OF GRAVITY (32.2 ft/s²)

$h_a = H_0 - h_a$ (SEE FIG 9-21(1), SHEET 11)

DAM RATING CURVE - TELLICO

SUBJECT SADDLE DAM 1 - EMERGENCY SPILLWAY PR

Calculation No: CDQ000020080018

S.E.M. 12/3/2008 J.B.M. 2/3/2009

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Appendix C-5
20 Total Pages

FOR $C_o = 3.64$ AND $H_o = 12.1'$,

$$q = 3.64\,(12.1)^{3/2} = 153.21 \text{ cfs/ft}$$

and $$h_a = \frac{(153.21 \text{ cfs/ft})^2}{2(32.2 \text{ ft/s}^2)(3' + 12.1' - 1.68')^2} = 2.024'$$

$$\Rightarrow \frac{h_a}{H_o} = \frac{2.024'}{12.1'} = .16727$$

THEREFORE, CONSIDERING THE ABOVE VALUE OF h_a/H_o AND THE VERTICAL UPSTREAM FACE OF THE CREST, FIG 9-216), SHEET 11 SHOWS:

$K = .486$

$n = 1.831$

EMERGENCY SPILLWAY CREST K : n :

$$y_1 = .068027\,x^{1.8} \quad \text{(DOWNSTREAM)} \quad \text{(SEE ①)}$$

$$\frac{y_1}{H_o}(H_o) = .068027\left(\frac{x_1}{H_o}\right)^{1.8}(H_o)^{1.8}$$

WITH $H_o = 12.1'$: $$12.1\left(\frac{y_1}{H_o}\right) = .068027\left(\frac{x_1}{H_o}\right)^{1.8}(12.1)^{1.8}$$

$$\Rightarrow \frac{y_1}{H_o} = .4999\left(\frac{x_1}{H_o}\right)^{1.8}$$

$\Rightarrow K = .4999$, $n = 1.8$ FOR DOWNSTREAM SEGMENT OF EMERGENCY SPILLWAY CREST.

DAM RATING CURVES - TELLICO

SUBJECT SADDLE DAM 1 - EMERGENCY SPILLWAY PR

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SEM 12-3-08 J.B.M. 2/3/2009

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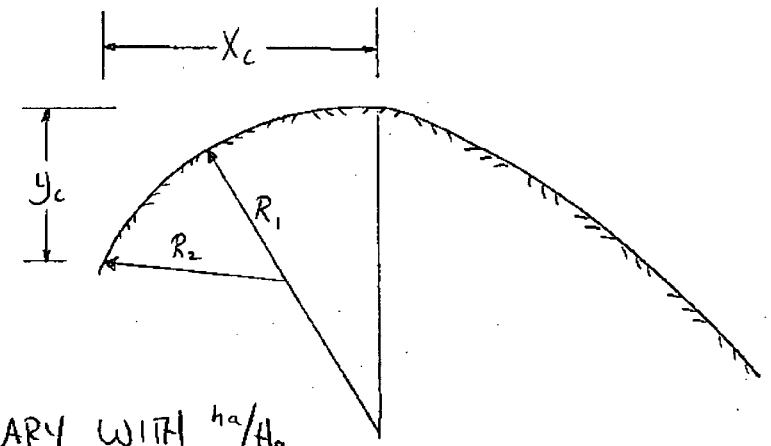
Appendix C-6
20 Total Pages

- K FOR THE EMERGENCY SPILLWAY IS LESS THAN 3% GREATER THAN THE OGEE CREST K, WHILE THE VALUE OF n IS LESS THAN 2% LESS THAN THE OGEE CREST VALUE, DOWNSTREAM.

UPSTREAM FROM CREST:

UPSTREAM CREST PROFILE FROM FIG 9-21(2), SHEET 12.



X_c, y_c, R_1 & R_2 ALL VARY WITH h_a/H_o

FROM FIG 9-21(2), SHEET 12 FOR $h_a/H_o = .16727$ AND A VERTICAL UPSTREAM FACE:

$X_c/H_o = .189$

$y_c/H_o = .058$

$R_1/H_o = .415$

$R_2/H_o = .196$

For $H_o = 12.1'$ ⟹

$X_c = 2.29'$

$y_c = 0.70'$

$R_1 = 5.02'$

$R_2 = 2.37'$

- SUBMERGENCE EFFECTS HAVE BEEN DETERMINED ON SHEET 19.

DAM RATING CURVES - TELLICO

SUBJECT SADDLE DAM 1 - EMERGENCY SPILLWAY PL

Calculation No: CDQ000020080018

SEM 12-3-08 J.B.M. 2/3/2009

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Appendix C-7
20 Total Pages

CONCLUSION

SHEET 13 COMPARES THE EMERGENCY SPILLWAY CREST WITH AN OGEE CREST FOR $H_o = 12.1'$ AND $P = 3'$. COMPUTATION OF THE UPSTREAM (NEGATIVE X-COORDINATES) SEGMENT OF AN OGEE CREST FROM R_1 & R_2 IS SOMEWHAT COMPLICATED SO ONLY THE UPSTREAM-MOST COORDINATE $(-X_c, -Y_c)$ IS PLOTTED ON SHEET 13.

THE USUAL AGREEMENT BETWEEN THE EMERGENCY AND OGEE CREST PROFILES JUSTIFIES THE USE OF THE $C_f(H_c)$ RELATIONSHIP DETERMINED FOR AN OGEE CREST WITH $H_o = 12.1'$ AND $P = 3'$.

$$C_f = 2.873 + .10187\,H_c - .004286\,H_c^2 + .00009152\,H_c^3$$

for $0 \le H_c \le 19.36'$

$Z_c = 817'$, $L = 2000'$

$$S_f = \begin{cases} \left(1 - \left(d/H_c\right)^{2.0}\right)^{.22} & \text{for } 0 < d/H_c \le 0.6 \\ \left(1 - \left(d/H_c\right)^{2.9}\right)^{.345} & \text{for } 0.6 < d/H_c \le 1.0 \end{cases}$$

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 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 ft^3/s at a 5-foot head, and prepare a discharge-head curve. The upstream face of the

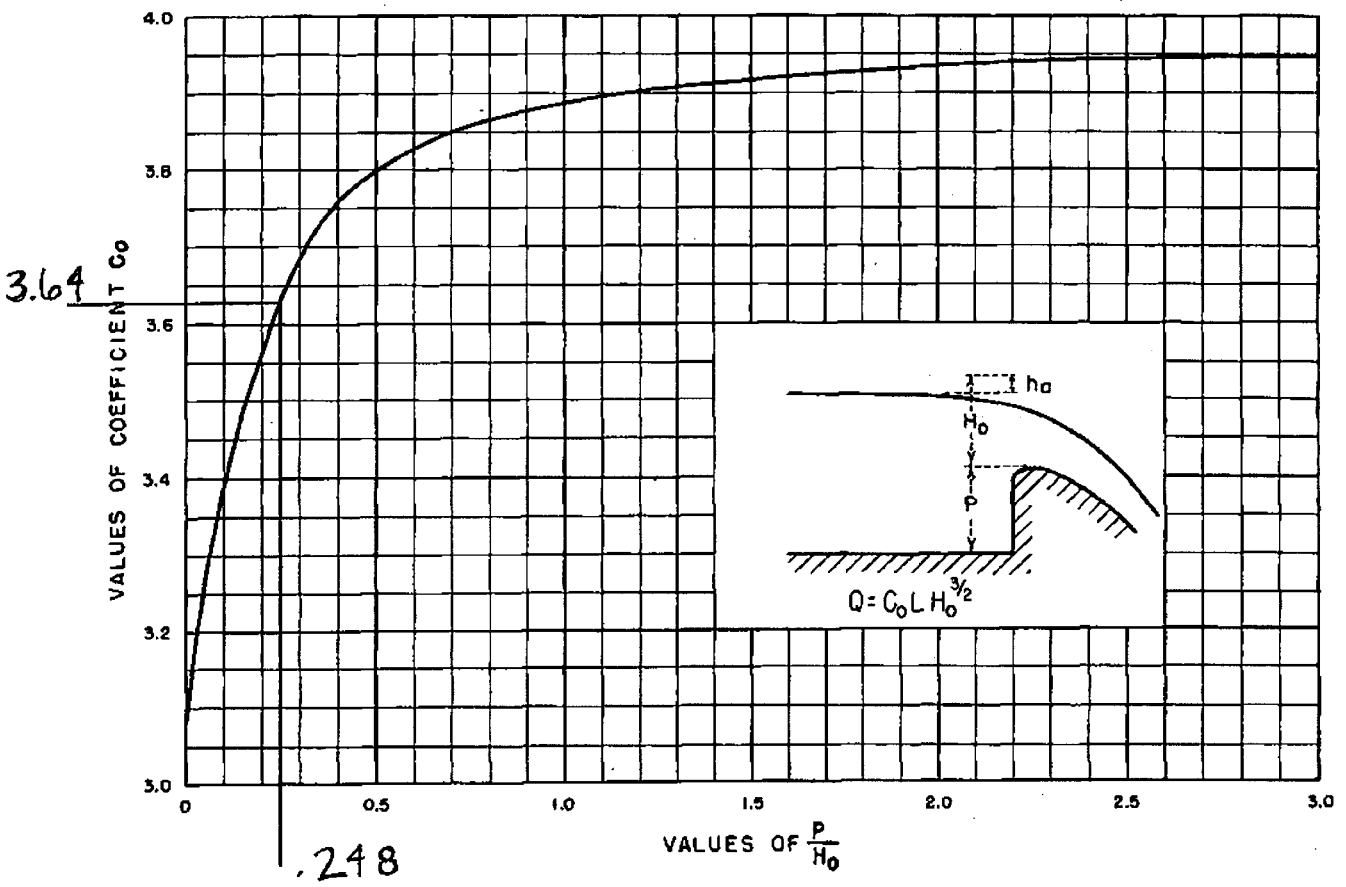


Figure 9-23.—Discharge coefficients for vertical-faced ogee crest. 288-D-2409.

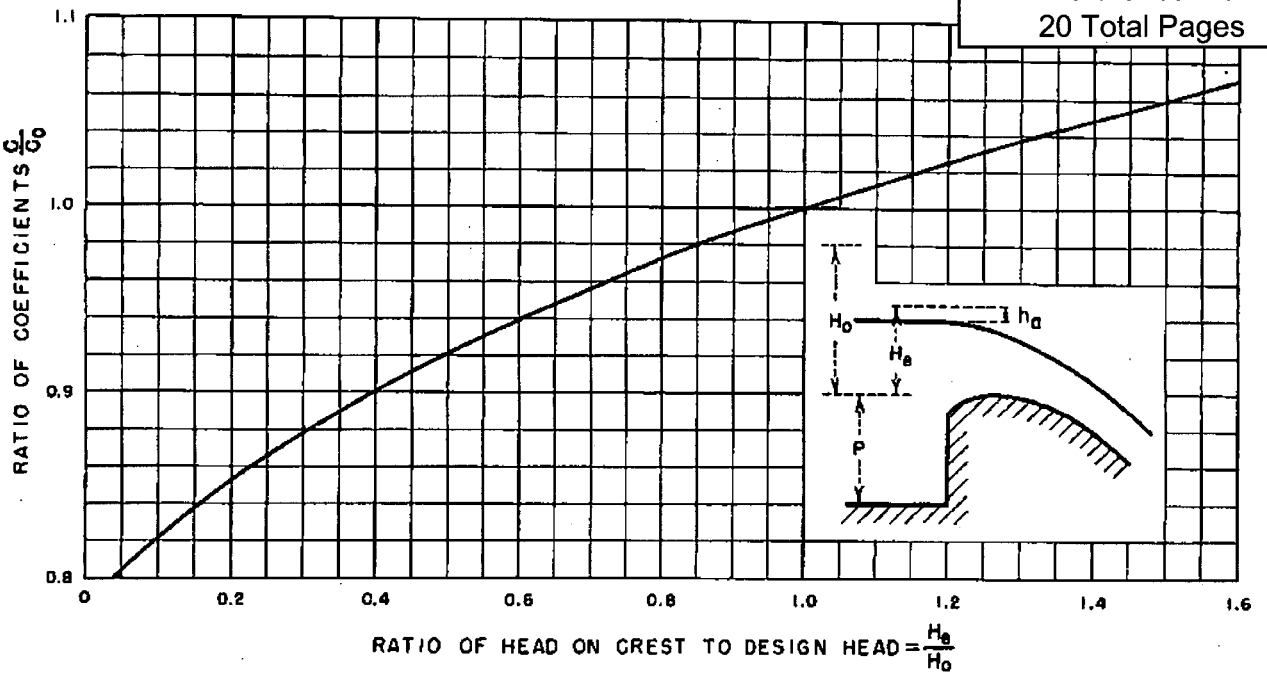


Figure 9-24.—Discharge coefficients for other than the design head. 288-D-2410.

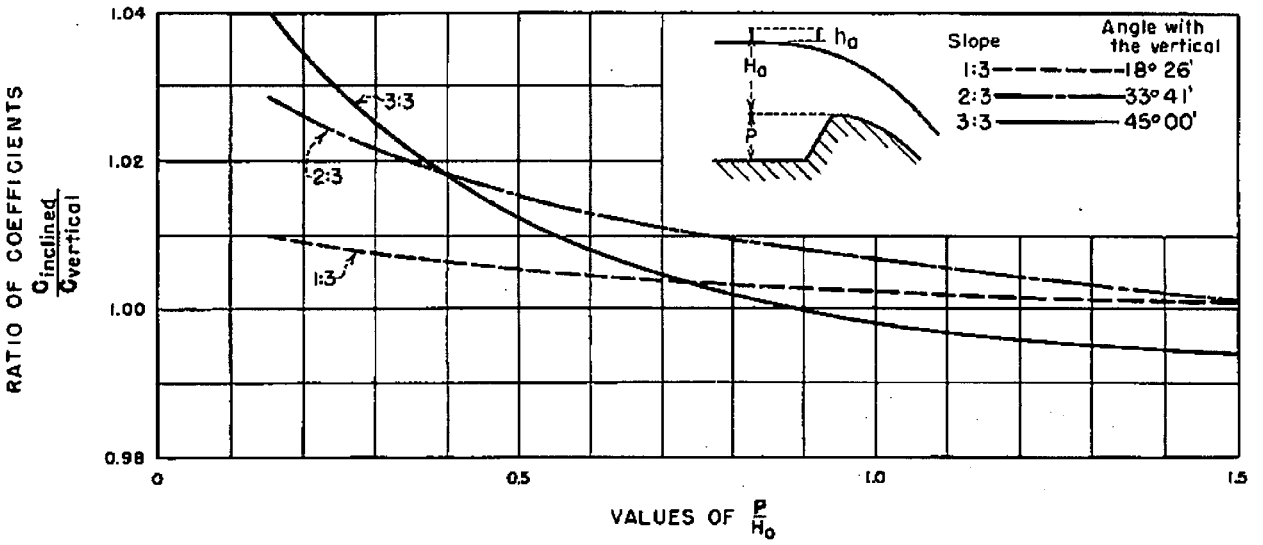


Figure 9-25.—Discharge coefficients for ogee-shaped crest with sloping upstream face. 288-D-2411.

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

Calculation No: CDQ000020080018

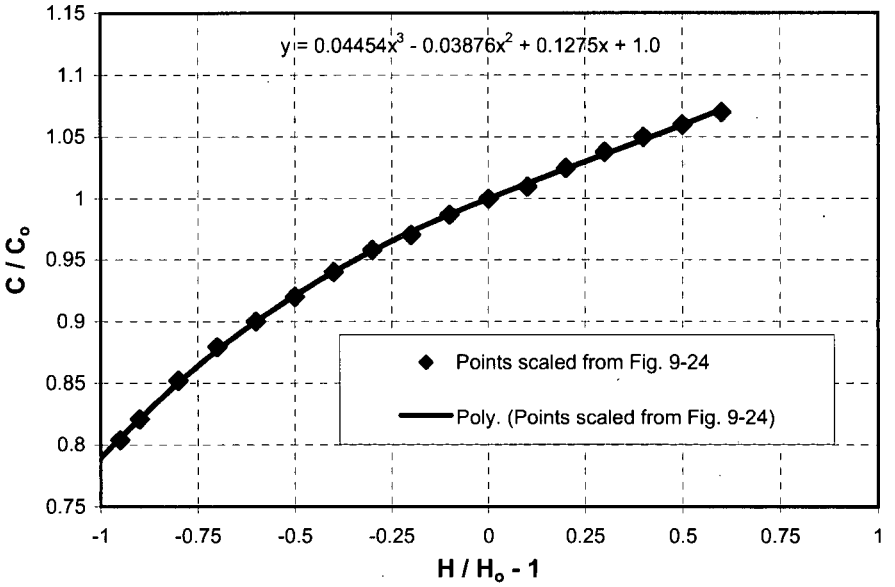
Appendix C-10
20 Total Pages

Determination of C/C_o Fit and Development of C_f (H_c) Relationship

Prepared by: S.E.M.
Checked by: J.B.M.

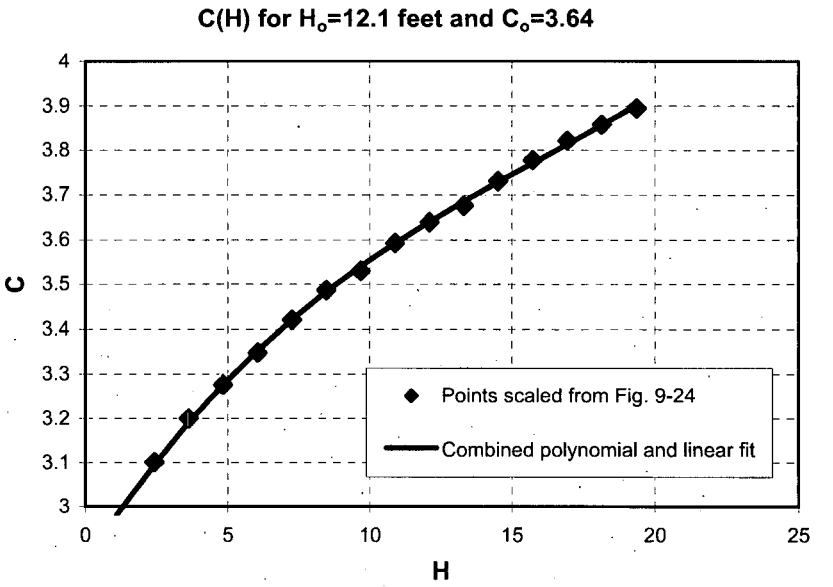
Points scaled from Fig. 9-24 in Design of Small Dams, Bureau of Reclamation, 1987

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



For H_o = 12.1 feet
and C_o = 3.64

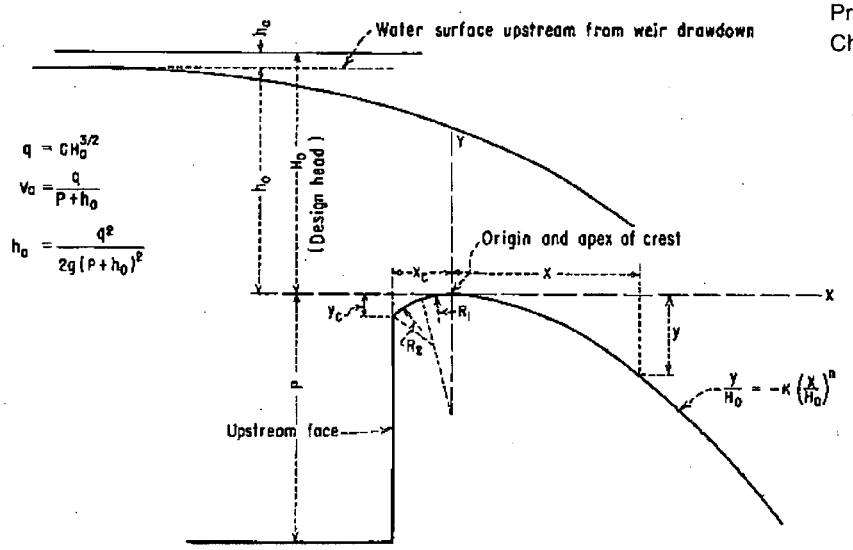
H, feet	C	C
0	0	
0.605	2.92656	2.933
1.21	2.98844	2.990
2.42	3.10128	3.096
3.63	3.19956	3.191
4.84	3.276	3.276
6.05	3.3488	3.353
7.26	3.4216	3.422
8.47	3.48712	3.484
9.68	3.5308	3.541
10.89	3.59268	3.592
12.1	3.64	3.640
13.31	3.6764	3.685
14.52	3.731	3.729
15.73	3.77832	3.771
16.94	3.822	3.814
18.15	3.8584	3.857
19.36	3.8948	3.903



Curve Fit for $C_f(H_c)$:

$C_f = 2.873 + 0.10187H_c - 0.004286H_c^2 + 0.00009152H_c^3$ for $0 \le H_c \le 19.36$ feet

Prepared by: S.E.M.
Checked by: J.B.M.



(A) ELEMENTS OF NAPPE-SHAPED CREST PROFILES

0.16727

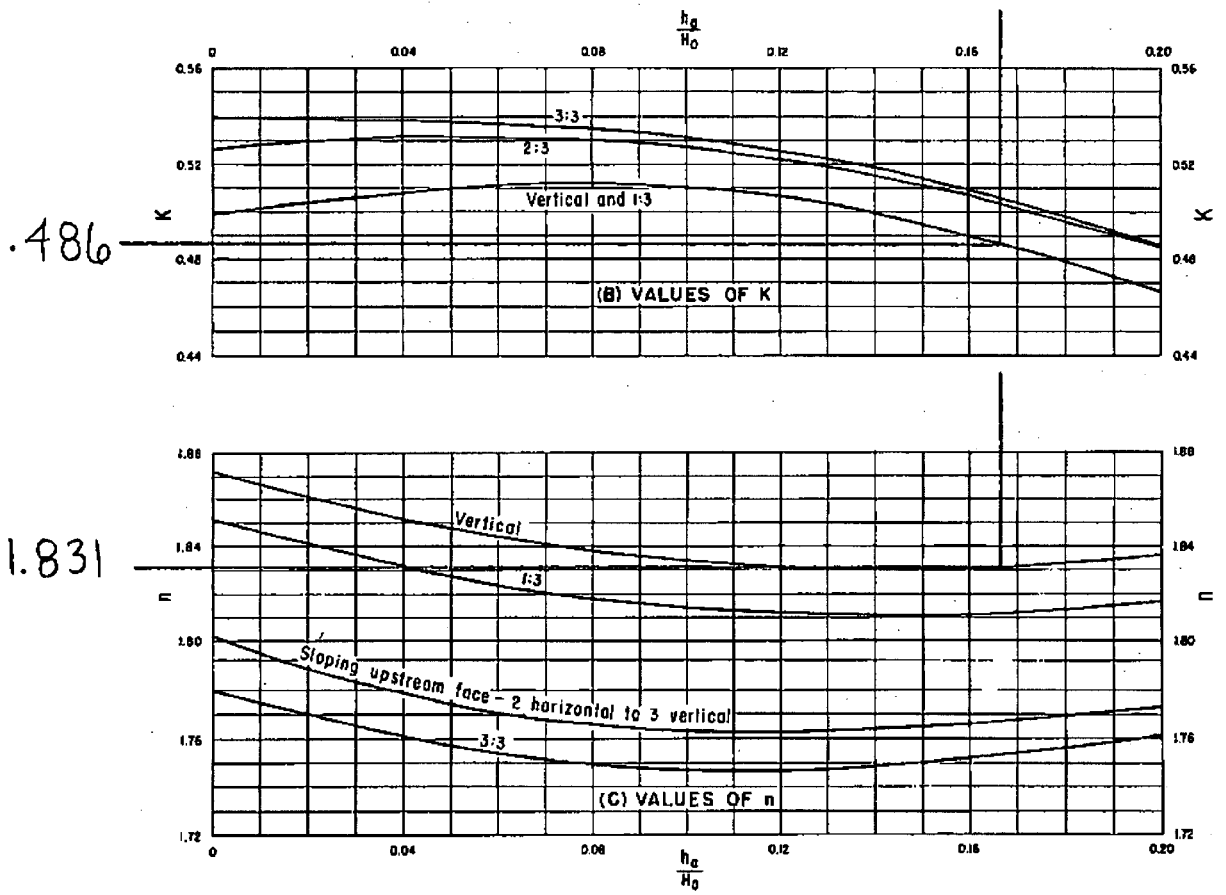
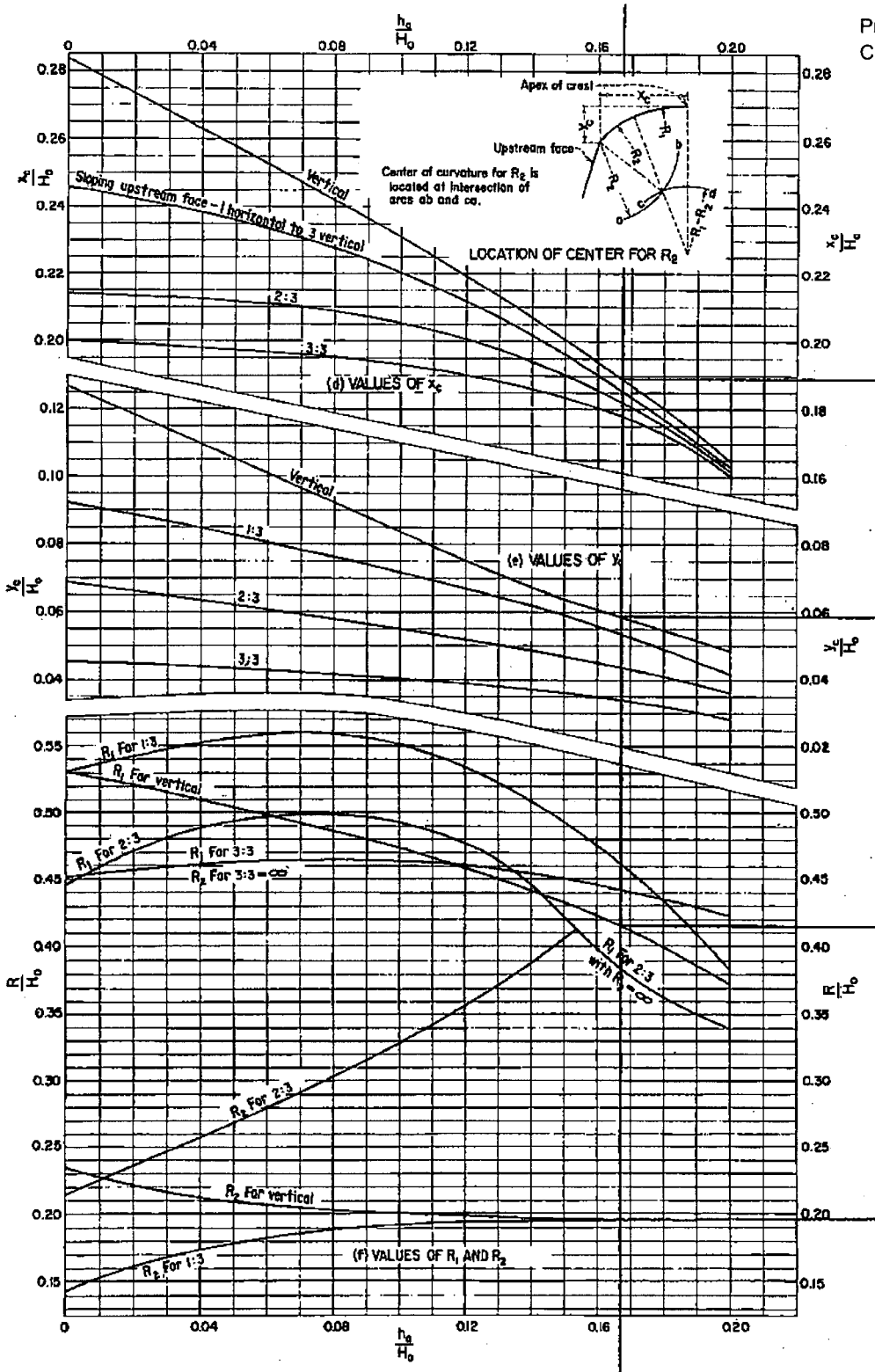


Figure 9-21.—Factors for definition of nappe-shaped crest profiles. 288-D-2406. (Sheet 1 of 2).

0.16727

Prepared by: S.E.M.
Checked by: J.B.M.



$.189 = \frac{X_c}{H_o}$

$.058 = \frac{y_c}{H_o}$

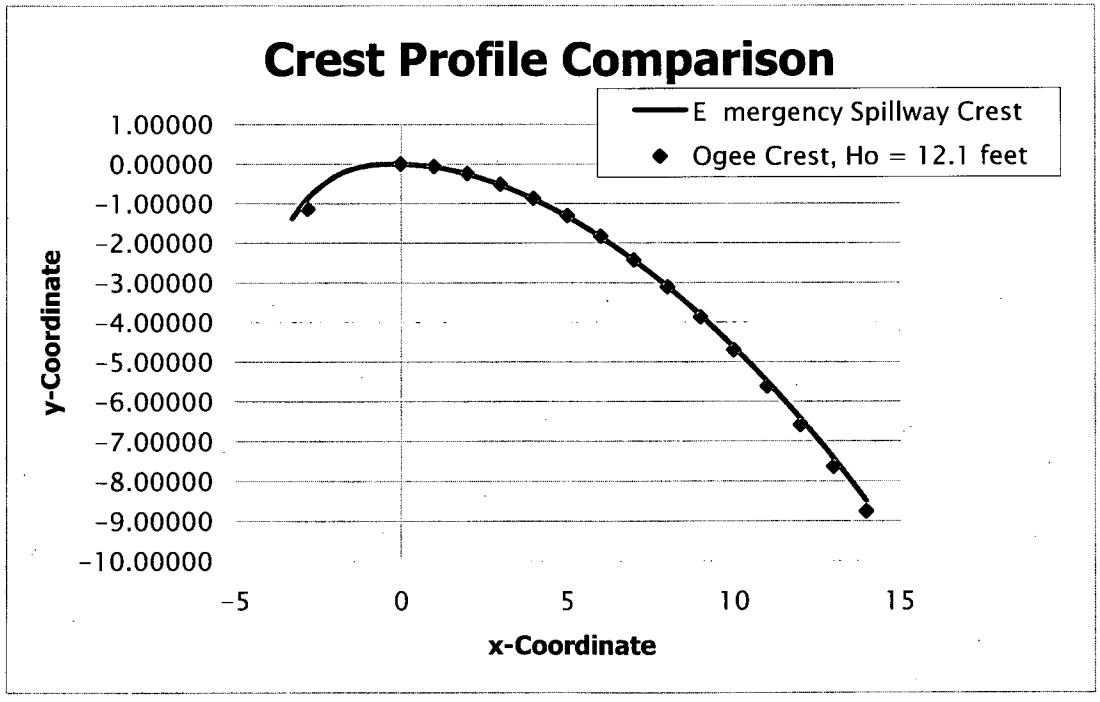
$.415 = \frac{R_1}{H_o}$

$.196 = \frac{R_2}{H_o}$

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

	E mergency Spillway	Ogee Crest	
K	0.540	0.510	Value for Ogee crest for Ho=12.1 feet and P=3 feet
n	1.800	1.847	Value for Ogee crest for Ho=12.1 feet and P=3 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



Calculation No: CDQ000020080018

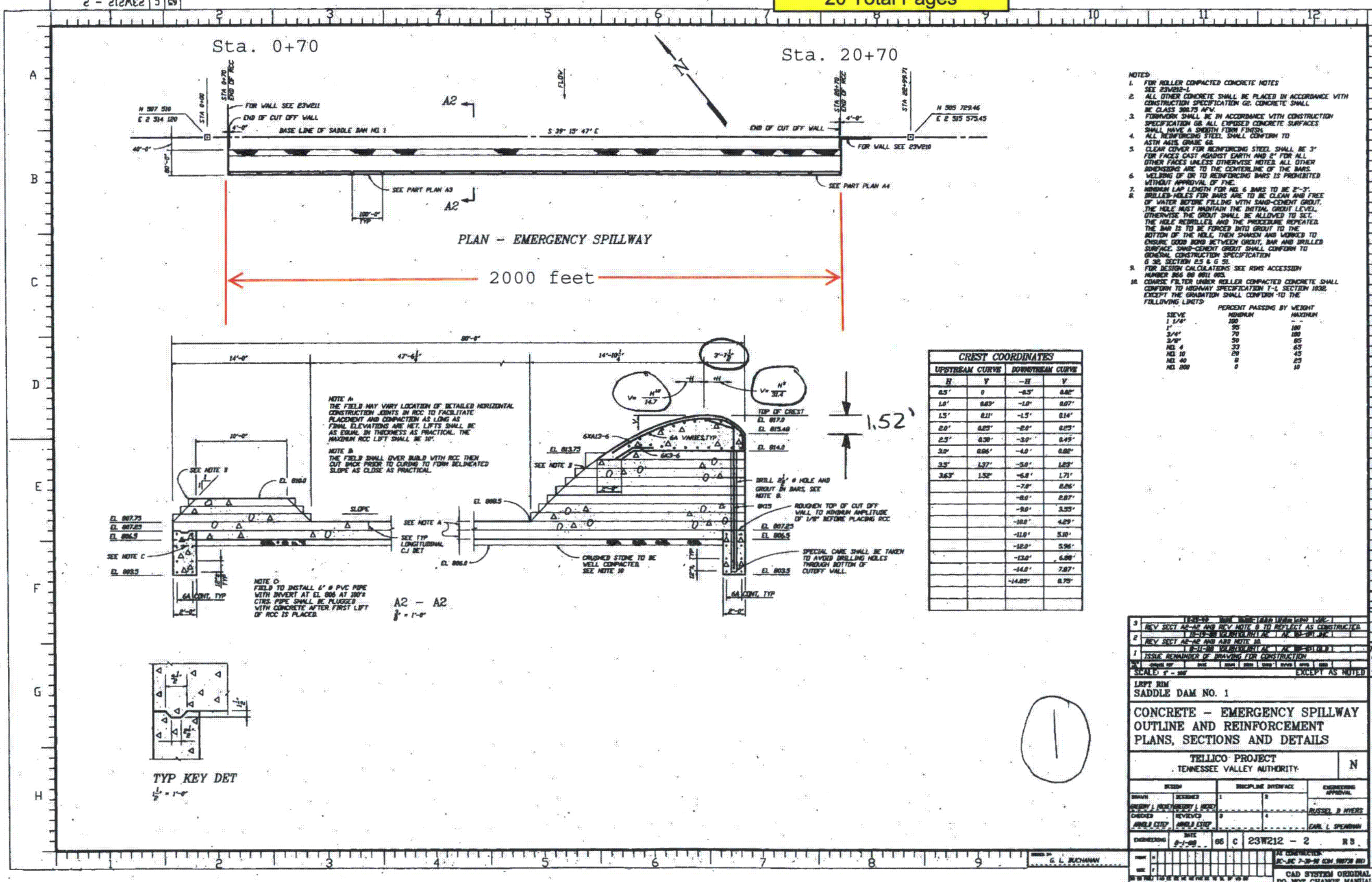
Appendix C-14
Reference 2.1.16
20 Total Pages

Prepared by: S.E.M.
Checked by: J.B.M.

DAM RATING CURVES - TELLICO
SADDLE DAM 1 - EMERGENCY SPILLWAY

CDQ000020080018

14 of 18



CREST COORDINATES			
UPSTREAM CURVE		DOWNSTREAM CURVE	
H	Y	-H	Y
0.5'	0	-0.5'	0.02'
1.0'	0.03'	-1.0'	0.07'
1.5'	0.11'	-1.5'	0.14'
2.0'	0.25'	-2.0'	0.25'
2.5'	0.38'	-3.0'	0.49'
3.0'	0.66'	-4.0'	0.82'
3.5'	1.37'	-5.0'	1.23'
3.63'	1.52'	-6.0'	1.71'
		-7.0'	2.26'
		-8.0'	2.87'
		-9.0'	3.55'
		-10.0'	4.29'
		-11.0'	5.10'
		-12.0'	5.96'
		-13.0'	6.88'
		-14.0'	7.87'
		-14.85'	8.75'

LEFT RIM
SADDLE DAM NO. 1

CONCRETE - EMERGENCY SPILLWAY
OUTLINE AND REINFORCEMENT
PLANS, SECTIONS AND DETAILS

TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY

23W212 - 2 R3

CAD SYSTEM ORIGINAL
DO NOT CHANGE MANUALLY

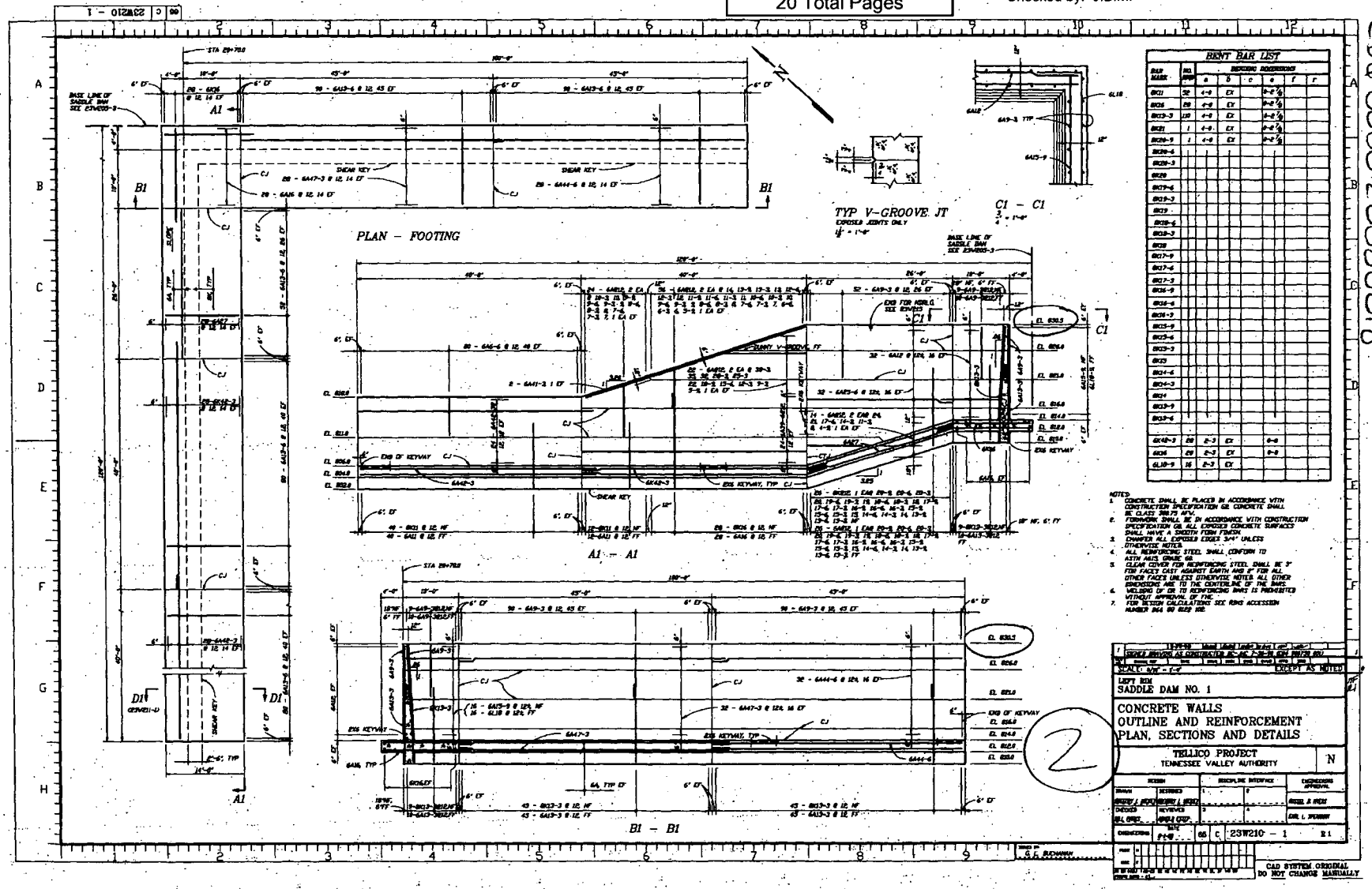
Calculation No: CDQ0000200800018

Appendix C-15
Reference 2.1.10
20 Total Pages

Prepared by: S.E.M.
Checked by: J.B.M.

DAM RATING CURVES - TELLICO
SADDLE DAM 1 - EMERGENCY SPILLWAY
CDQ0000200800018

15 of 18



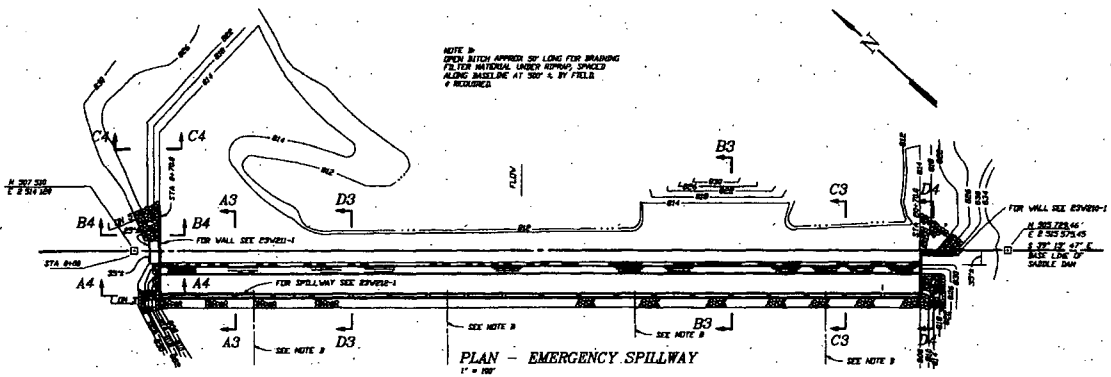
Calculation No: CDQ000020080018

Appendix C-16
Reference 2.1.8
20 Total Pages

Prepared by: S.E.M.
Checked by: J.B.M.

DAM RATING CURVES - TELLICO
SADDLE DAM 1 - EMERGENCY SPILLWAY
CDQ0000200 80018

16 of 18



$P = Z_c - Z_{\text{ground line}} = 817' - 814' = 3'$

3

TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY

LEFT ABUT
SADDLE DAM NO.1

EMERGENCY SPILLWAY
FINAL EXCAV, DRAINAGE & GRADING
PLAN, SECTIONS AND DETAILS

23W205 - 3 R2

CAD SYSTEM ORIGINAL
DO NOT CHANGE MANUALLY

DAM RATING CURVES - TELLICO

SADDLE DAM 1 - EMERGENCY SPILLWAY

17 of 20

Calculation No: CDQ000020080018

Prepared by: S.E.M.

Checked by: J.B.M.

FROM (A)

Appendix C-17
Reference 2.8
20 Total Pages

TVA 489 (EN DES-11-76)

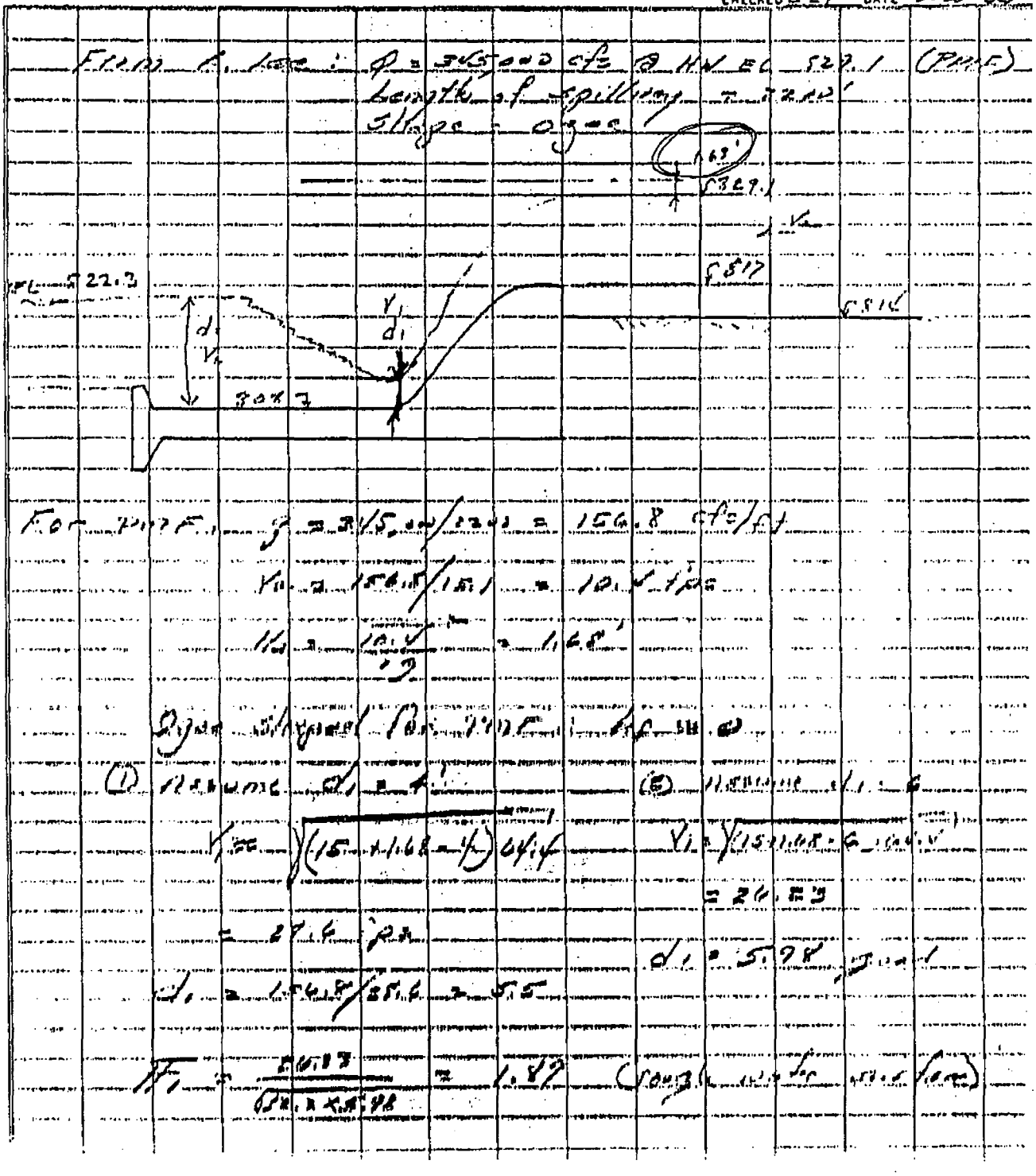
SHEET 1 OF 8

Spillway Apron

Tellico

COMPUTED HD DATE 3-20-86

CHECKED ELT DATE 3-20-86



DAM RATING CURVES - TELLICO

SADDLE DAM 1 - EMERGENCY SPILLWAY 18 of 20

FROM (4)

Calculation No: CDQ000020080018

Prepared by: S.E.M.

Checked by: J.B.M.

Appendix C-18
Reference 2.8
20 Total Pages

SHEET 5 OF 8

EMERGENCY SPILLWAY FOR SADDLE DAM #1

TELLICO PROJECT

COMPUTED CDW DATE 2-6-86

CHECKED ELT DATE 3-3-86

DESIGN DATA:

HEADWATER EL 829.1
SPILLWAY CREST EL 817.0
APRON EL 808.0

USING CREAGER'S EQUATION FOR OGEE SPILLWAY

a.) UPSTREAM OF CREST CURVE

$Y = \frac{14 \cdot X^{1.8}}{2 \cdot H_e^{0.8}}$

Typical approach losses

$H_e = 829.1 - 817.0 = 12.1$

DESIGN HEAD

or $Y = \frac{14 \cdot X^{1.8}}{2 \cdot (12.1)^{0.8}} = \frac{X^{1.8}}{21.14}$

Distance from upstream face to crest line = $0.2 H$
$= 3.63'$

b) DOWNSTREAM OF CREST CURVE

$Y = \frac{0.5 \cdot X^{1.8}}{H^{0.8}}$

or $Y = \frac{0.5 \cdot X^{1.8}}{(12.1)^{0.8}} = \frac{X^{1.8}}{14.14}$

Calculation No: CDQ000020080018

Appendix C-19
20 Total Pages

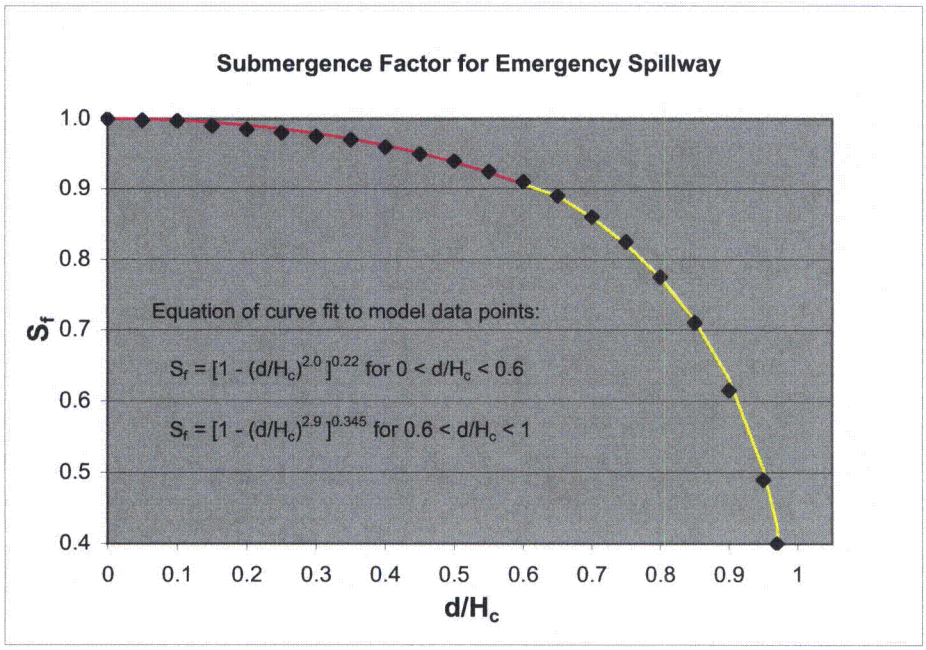
Determination of Submergence Factor, S_f, for the Emergency Spillway

Prepared by: S.E.M.
Checked by: J.B.M.

Data from "Hydraulic Design Criteria", Figure 7-11,b, Reference 2.6 (Cornell Tests, Round Crest)

Data from curve fit 2 0.22 2.9 0.345

C_s / C_o	h_d / H_e	S_f	d / H_c	% difference
1.000	0	1.000	0	0.00
0.998	0.05	0.999	0.05	0.14
0.997	0.1	0.998	0.1	0.08
0.990	0.15	0.995	0.15	0.50
0.985	0.2	0.991	0.2	0.61
0.980	0.25	0.986	0.25	0.59
0.975	0.3	0.979	0.3	0.45
0.970	0.35	0.972	0.35	0.17
0.960	0.4	0.962	0.4	0.24
0.950	0.45	0.951	0.45	0.14
0.940	0.5	0.939	0.5	0.13
0.925	0.55	0.924	0.55	0.12
0.910	0.6	0.906	0.6	0.35
0.890	0.65	0.890	0.65	0.00
0.860	0.7	0.859	0.7	0.06
0.825	0.75	0.822	0.75	0.34
0.775	0.8	0.774	0.8	0.07
0.710	0.85	0.713	0.85	0.35
0.615	0.9	0.631	0.9	1.60
0.490	0.95	0.505	0.95	1.52
0.4	0.97	0.426	0.97	2.64
0.000	1	0.000	1	0.00

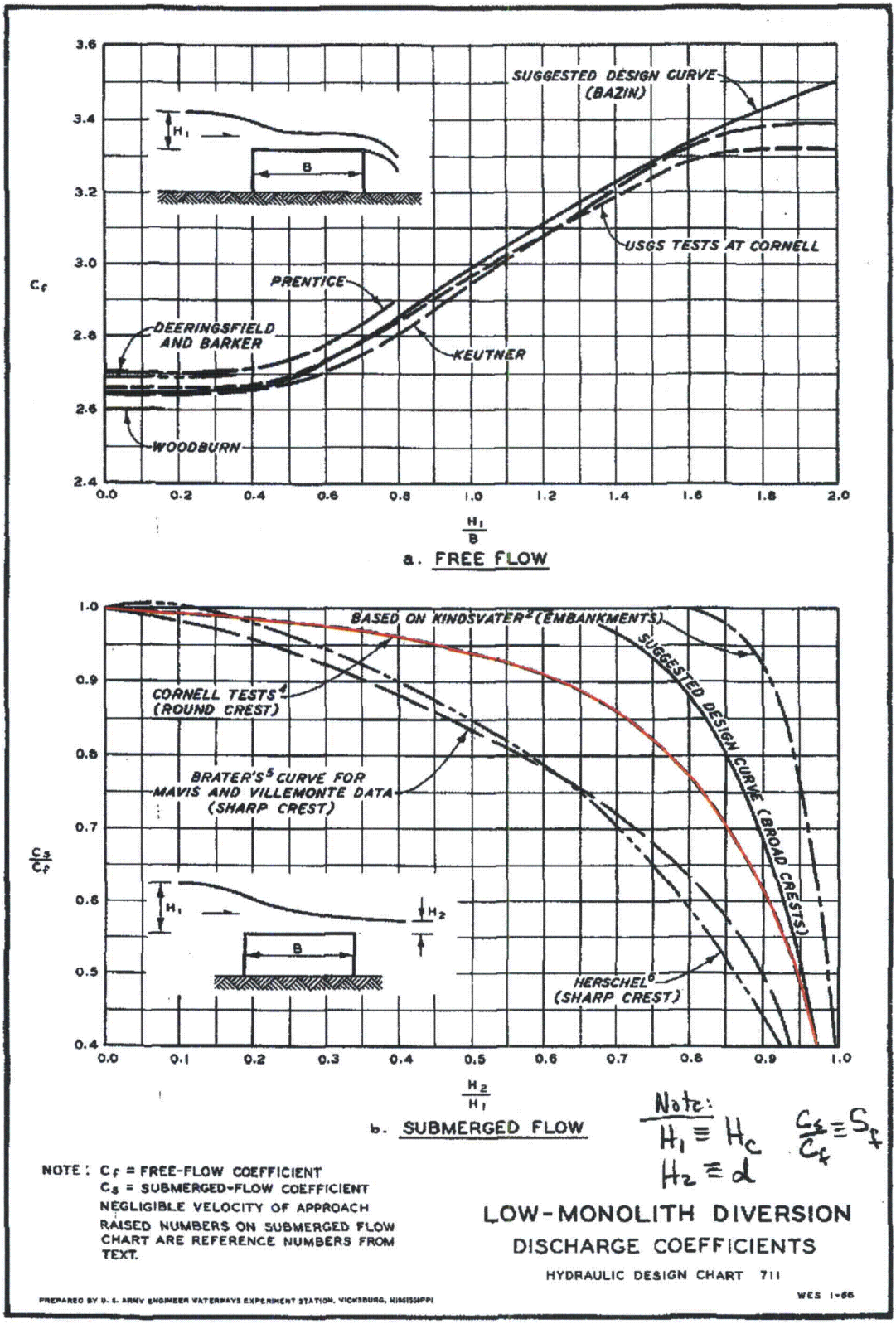


The equations developed above will be considered Equation (6) in the main document [4.11.4].

Calculation No: CDQ000020080018

Appendix C-20
Reference 2.6
20 Total Pages

Prepared by: S.E.M.
Checked by: J.B.M.



TENNESSEE VALLEY AUTHORITY

Appendix D-1
3 total pages

Calculation No: CDQ000020080018

TELLICO DAM RATING CURVE

SUBJECT FLOW OVER TOPS OF WIDE OPEN TAINTER GATES PL

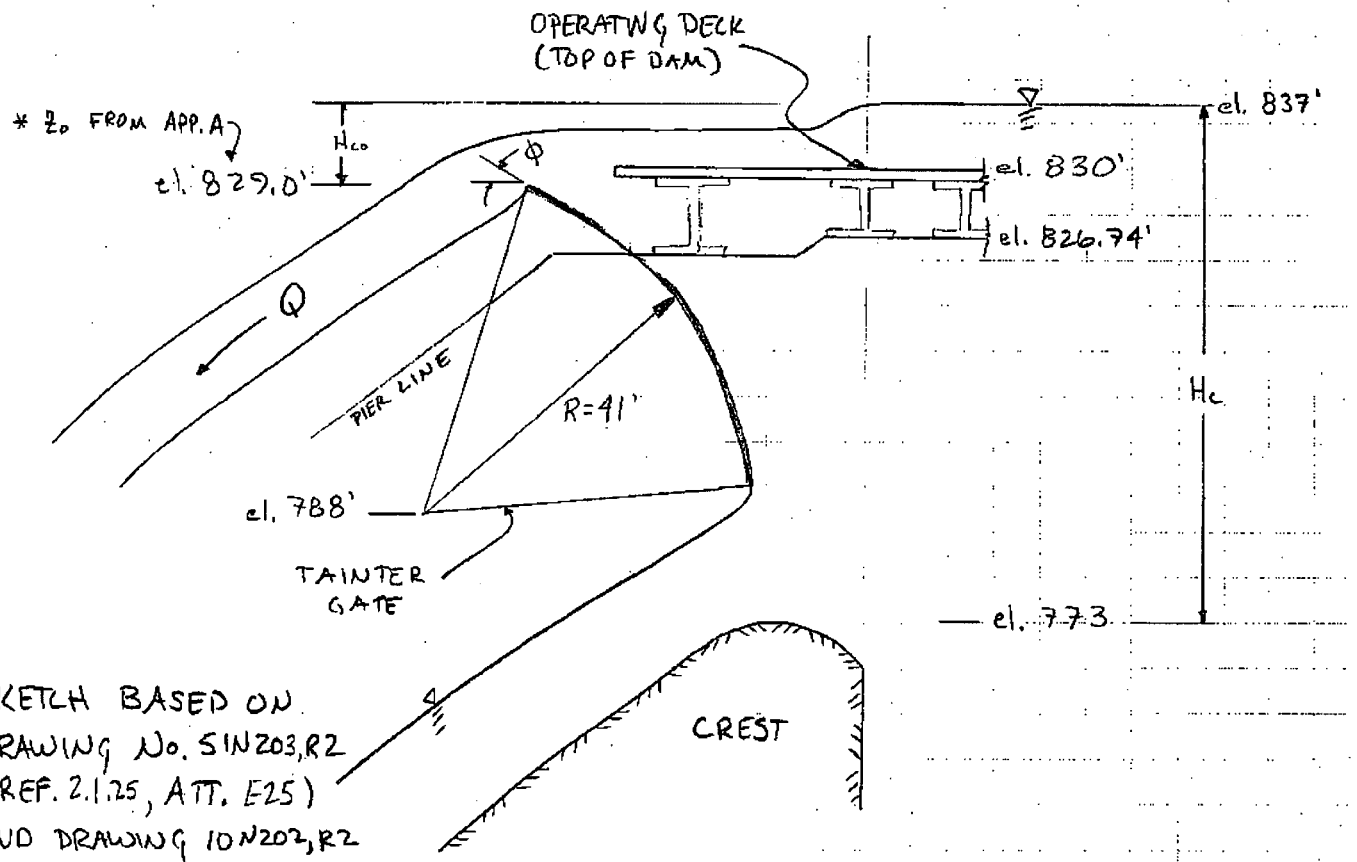
SEM | 12-15-08 | J.B.M. | 2/3/2009

COMPUTED BY | DATE | CHECKED BY | DATE

WITH REFERENCE TO THE SKETCH BELOW, DISCHARGE OVER THE TOPS OF THE WIDE OPEN TAINTER GATES IS COMPUTED AS:

$$Q_o = C_o \, L_o \, H_{co}^{3/2}$$

WHERE L_o = TOTAL LENGTH OF OVERFLOWING GATES = TOTAL LENGTH OF SPILLWAY



SKETCH BASED ON DRAWING No. 51N203, R2 (REF. 2.1.25, ATT. E25) AND DRAWING 10N202, R2 (REF. 2.1.3, ATT. E3)

BECAUSE THE ELEVATION OF THE TOP OF OPERATING DECK (830') IS PROVEN HIGHER THAN THE MAXIMUM ELEVATION OF THE TOP OF THE OPEN TAINTER GATE (829') FLOW OVER THE DECK CONTROLS FLOW OVER THE DAM.

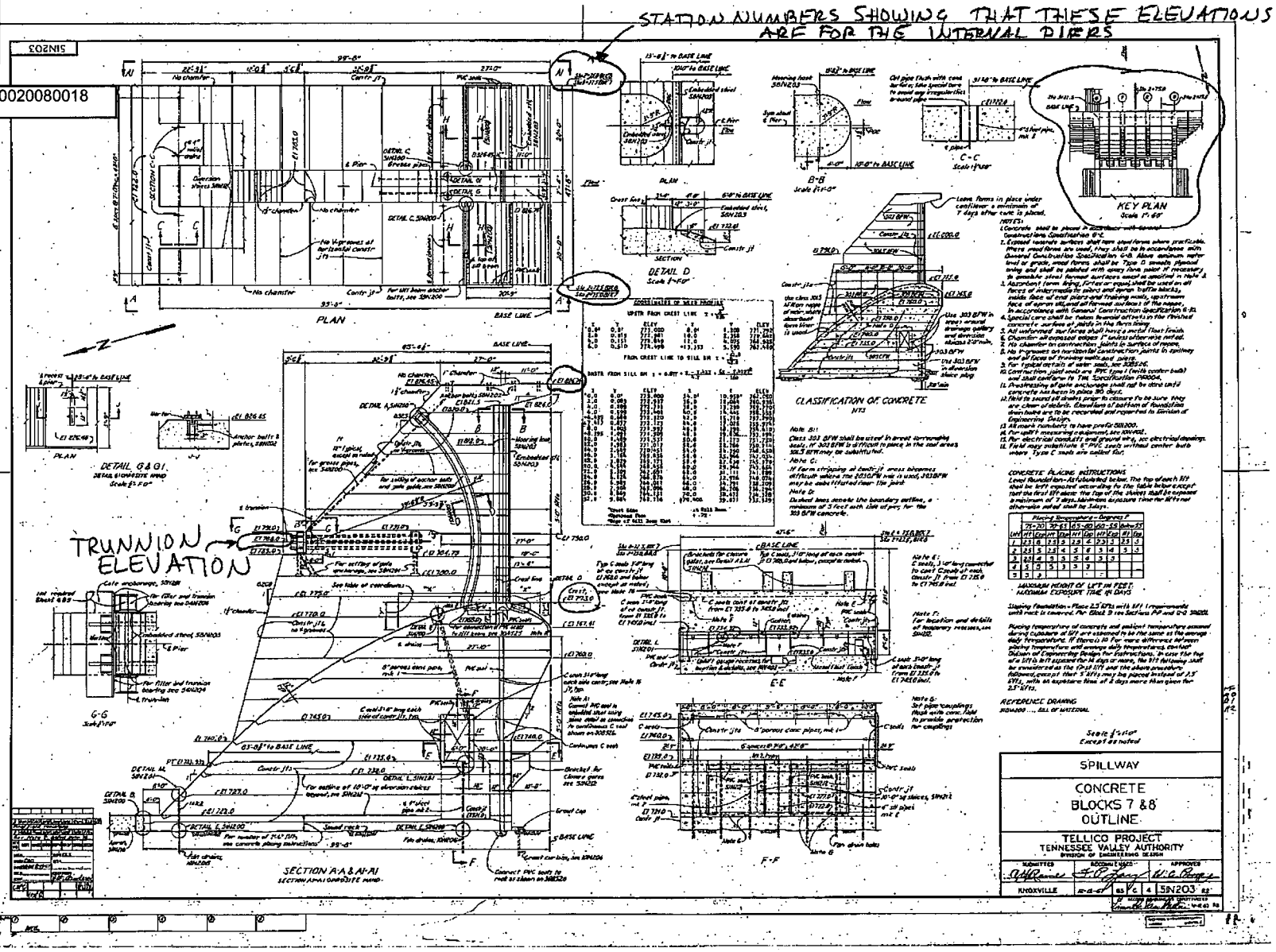
FOR THIS REASON, THE WIDTH OF THE DECK (27') LEADS TO A DISCHARGE COEFFICIENT OF 2.65 (SEE APP. B, page B4 for SPILLWAY PIER OVERFLOW). THE LENGTH OF THE SPILLWAY APPLIES ((3)(40) + (4)(7.5) = 150')

Appendix D-2
from Ref. 2.1.25
3 total pages

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.

STATION NUMBERS SHOWING THAT THESE ELEVATIONS ARE FOR THE INTERNAL PIERS



DAM RATING CURVES - TELLICO
FLOW OVERTOPS OF OPEN GATES
CDQ000020080018

2 of 3

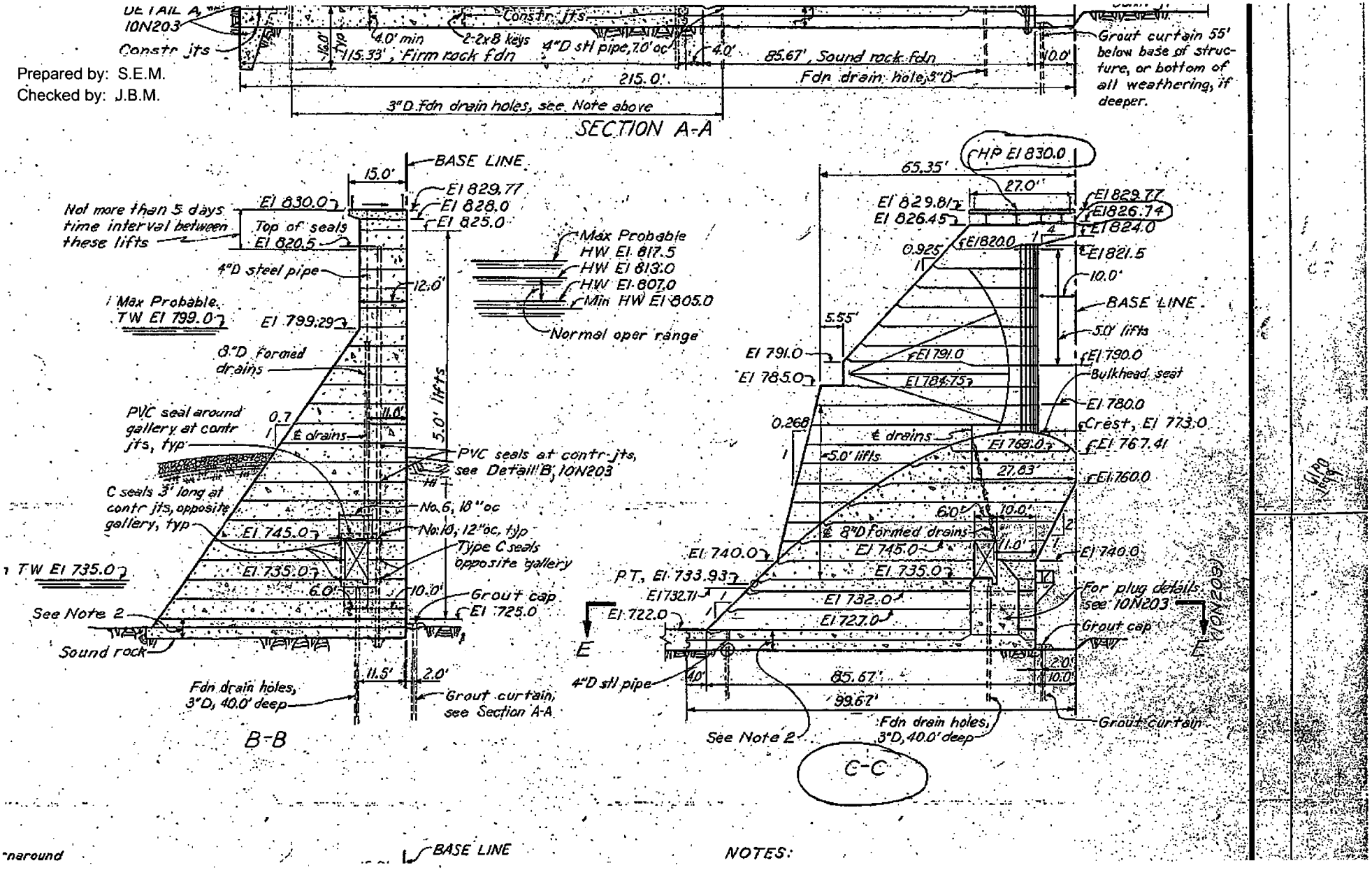
Appendix D-3
from Ref. 2.1.3
3 total pages

DAM RATING CURVES - TELLICO
FLOW OVER TOPS OF OPEN GATES
CDQ 0000200 80018

Calculation No: CDQ000020080018

3 of 3

Prepared by: S.E.M.
Checked by: J.B.M.



SECTION C-C OF TVA DWG NO. 10N202, R2 (Ref. 2.1.3)
(ATT. E3)

DAM RATING CURVES - TELLICO

SUBJECT OVERFLOW PARAMETERS AFTER FAILURE

Calculation No: CDQ000020080018

SEM 12-16-08 COMPUTED BY DATE

J.B.M. 2/3/2009 CHECKED BY

Appendix E-1
10 total pages

THE TELLICO DAM RATING CURVE WILL BE CALCULATED TO A MAXIMUM HEADWATER ELEVATION OF 837! THIS IS SEVERAL FEET ABOVE THE TOPS OF THE EMBANKMENTS AND SADDLE DAMS. SUSTAINED FLOW IS EXPECTED TO QUICKLY ERODE THESE SECTIONS. IN ORDER TO DETERMINE THE EXTENT OF EROSION, THE FOLLOWING DRAWINGS HAVE BEEN REFERENCED:

① 10N200, R5 (REF. 2.1.1, ATT. E1)
② 22W202, R7 (REF. 2.1.21, ATT. E21)
③ & ④ 23W200, R8 (REF. 2.1.7, ATT. E7)
⑤ 10N254, R0 (REF. 2.1.13, ATT. E13)
⑥ 10H230, R2 (REF. 2.1.2, ATT. E2)
⑦ 23W205-3, R2 (REF. 2.1.8, ATT. E8)

THE EMBANKMENT AND SADDLE DAMS WILL BE PRESUMED TO FAIL TO THE ORIGINAL SURFACE GRADE QUICKLY FOLLOWING OVERTOPPING. AT THIS POINT, AN AVERAGE LENGTH WILL BE USED.

THE DISCHARGE COEFFICIENT OF 2.65 WILL BE USED ACCORDING TO HYDRAULIC DESIGN GUIDE CHART 711 (REF. 2.6, ATT 6). THIS IS DEEMED ADEQUATE BECAUSE THE CREST IN QUESTION IS BROAD IN COMPARISON TO THE DEPTH OF WATER FLOWING OVER IT.

THE EMERGENCY SPILLWAY IN SADDLE DAM 1 IS ASSUMED TO REMAIN INTACT AS WELL AS THE BANKS ON EACH SIDE.

THE PORTIONS OF LAND WITH ELEVATIONS BELOW THE PMF LEVEL WILL ALSO BE APPROXIMATED. THEY WILL NOT BE ASSUMED TO FAIL.

DAM RATING CURVES- TELLICO

SUBJECT OVERFLOW PARAMETERS AFTER FAILURE

Calculation No: CDQ000020080018

SEM 12-16-08 J.B.M. 2/3/2009

COMPUTED BY DATE CHECKED BY

Appendix E-2
10 total pages

SUMMARY OF FAILURE OVERFLOW PARAMETERS

	FAILURE ELEVATION	OVERTOPPING ELEVATION (ft)	LENGTH (ft)	C_f
MAIN EMBANKMENT	755' (MAJORITY) 722' (OLD RIVER BED)	830'	2400' 300'	2.65
MAIN DAM WORKS	N/A	830'	447.5'	2.65
SADDLE DAM 2	822' (AVERAGE)	830'	525'	2.65
SADDLE DAM 3	820' (AVERAGE)	830'	315.72'	2.65
RIGHT BANK SADDLE DAM	823' (AVERAGE)	830'	2000'	2.65
REMAINING PORTIONS OF LAND BELOW PMF ELEVATION	N/A	830'	2500'	2.65

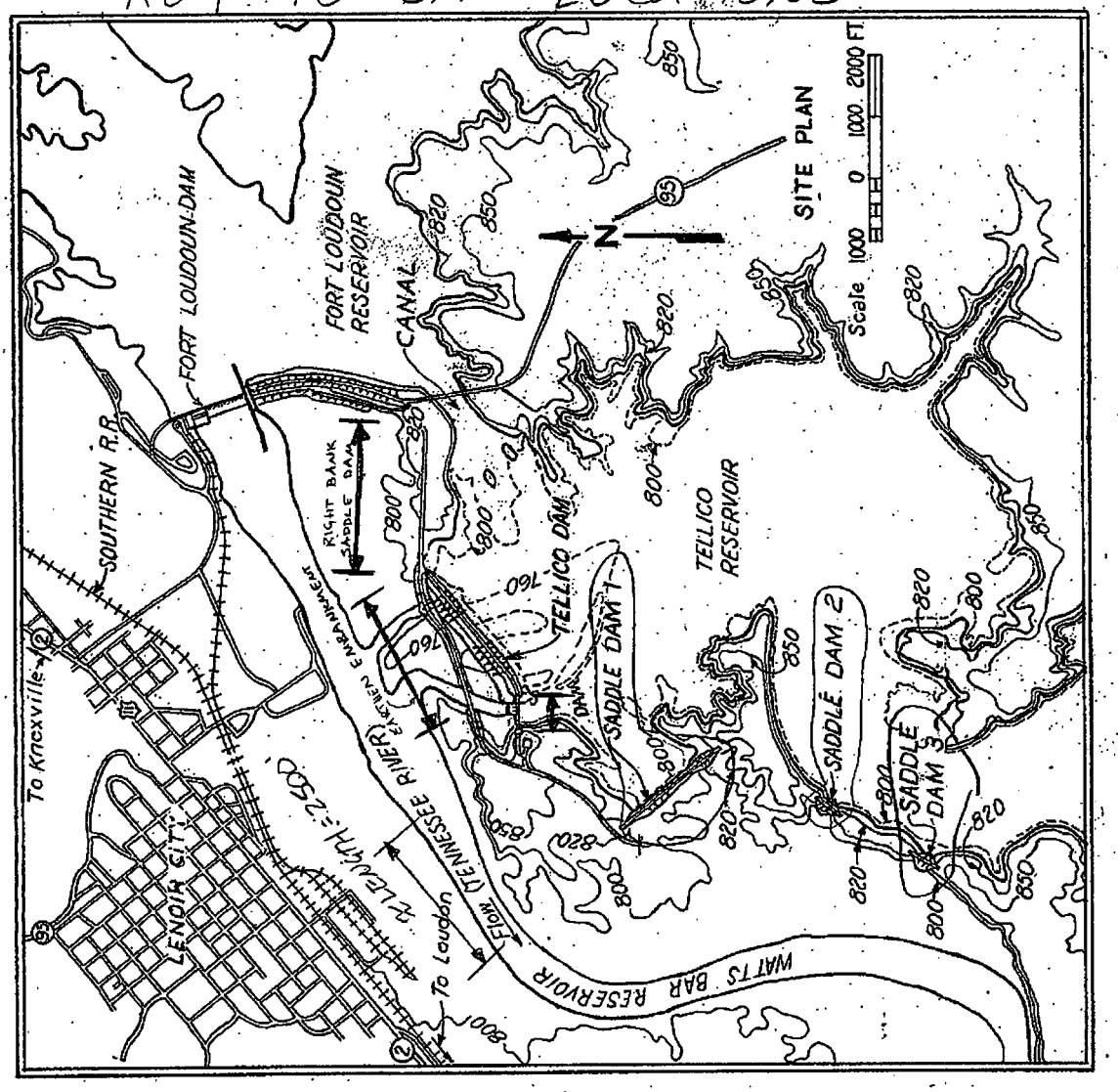
DAM RATING CURVES - TELLICO

OVERFLOW PARAMETERS AFTER FAILURE

CDQ 0000200.80018

(1)

KEY TO DAM LOCATIONS



FROM: TVA DWG. NO. 10N200, R5
(REF. 2.1.1, ATT. 'E1')

Calculation No: CDQ0000020080018

Appendix E-3
from Ref. 2.1.1
10 total pages

Prepared by: S.E.M.
Checked by: J.B.M.

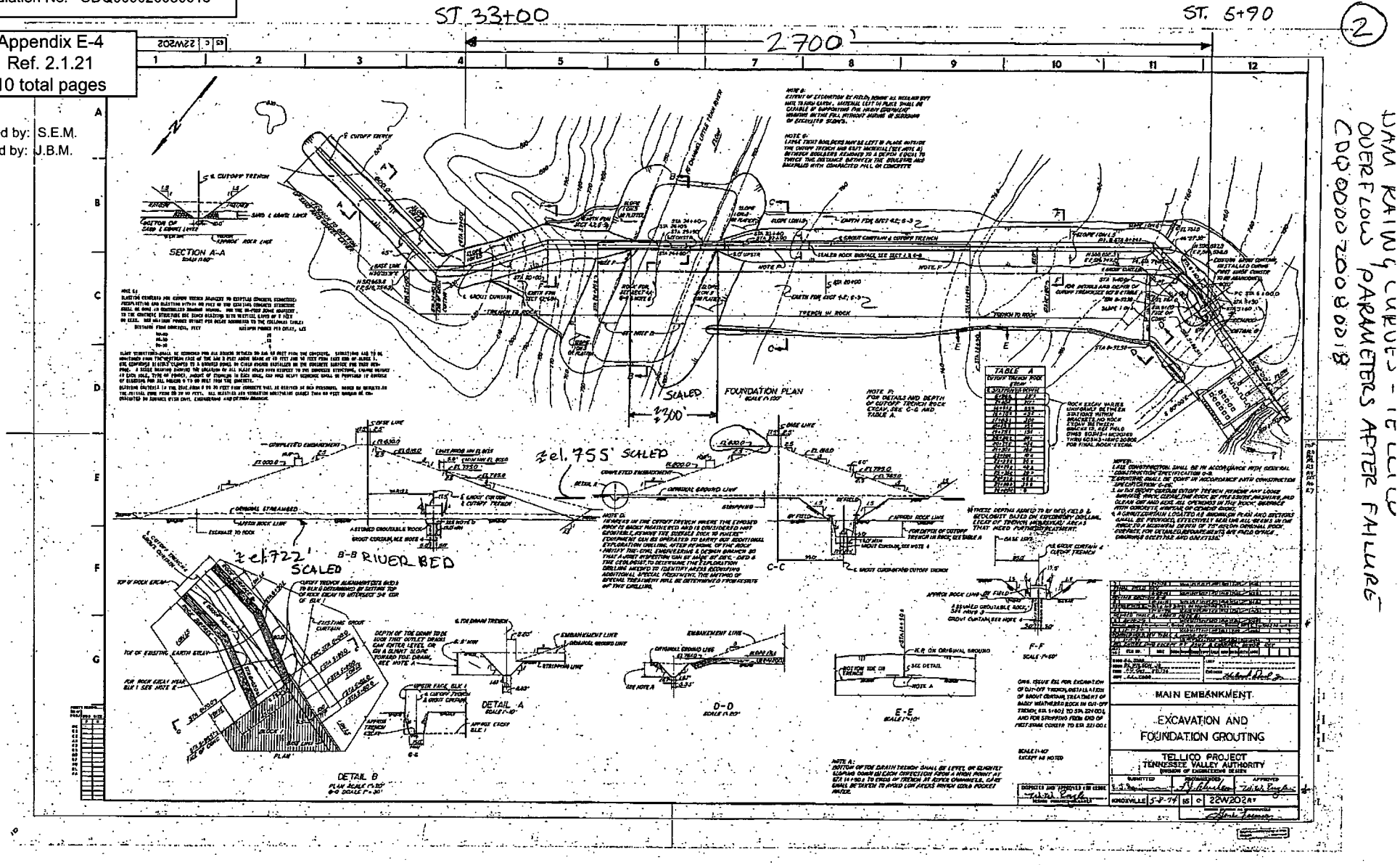
Calculation No: CDQ000020080018

Appendix E-4
Ref. 2.1.21
10 total pages

Prepared by: S.E.M.
Checked by: J.B.M.

(2)

JAM RAIN & CURVES - TO ILLUS OVERFLOW PARAMETERS AFTER FAILURE
CDQ 000 200 800 18



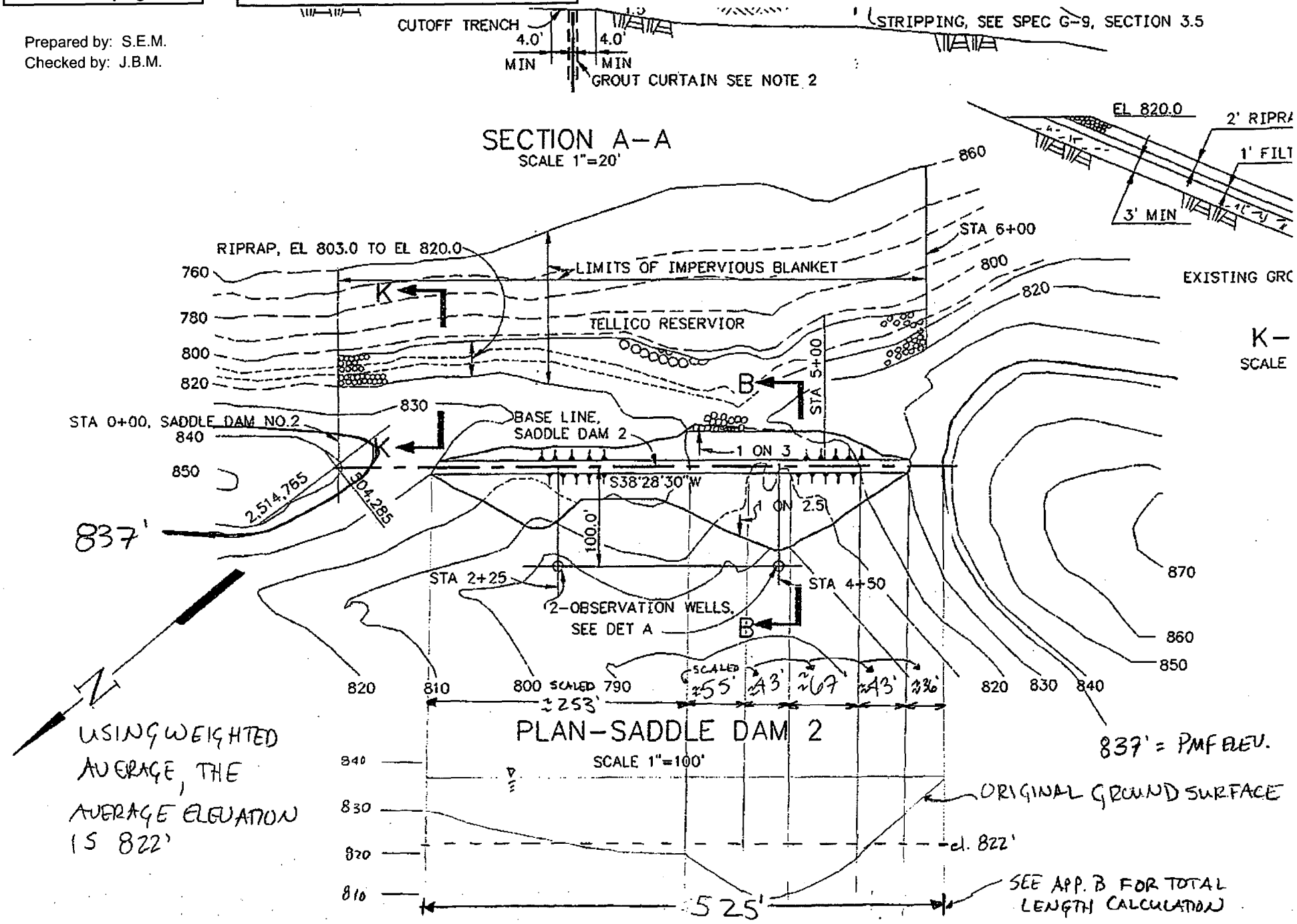
Appendix E-5
from Ref. 2.1.7
10 total pages

Prepared by: S.E.M.
Checked by: J.B.M.

DAM RATING CURVES - TELLICO
OVERFLOW PARAMETERS AFTER FAILURE

Calculation No: CDQ000020080018

(3)



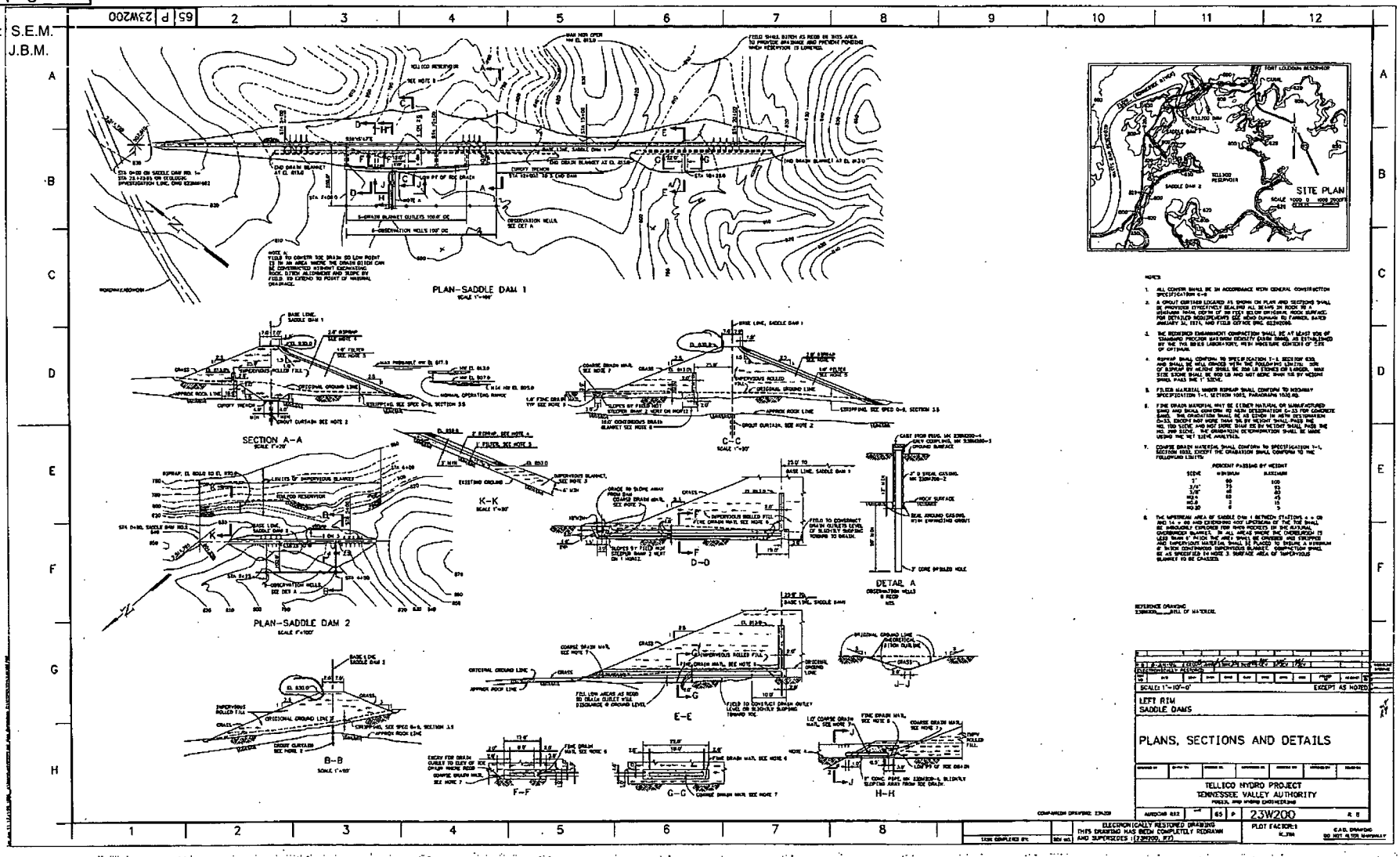
USING WEIGHTED AVERAGE, THE AVERAGE ELEVATION IS 822'

Appendix E-6
Ref. 2.1.7
10 total pages

Calculation No: CDQ000020080018

3a

Prepared by: S.E.M.
Checked by: J.B.M.

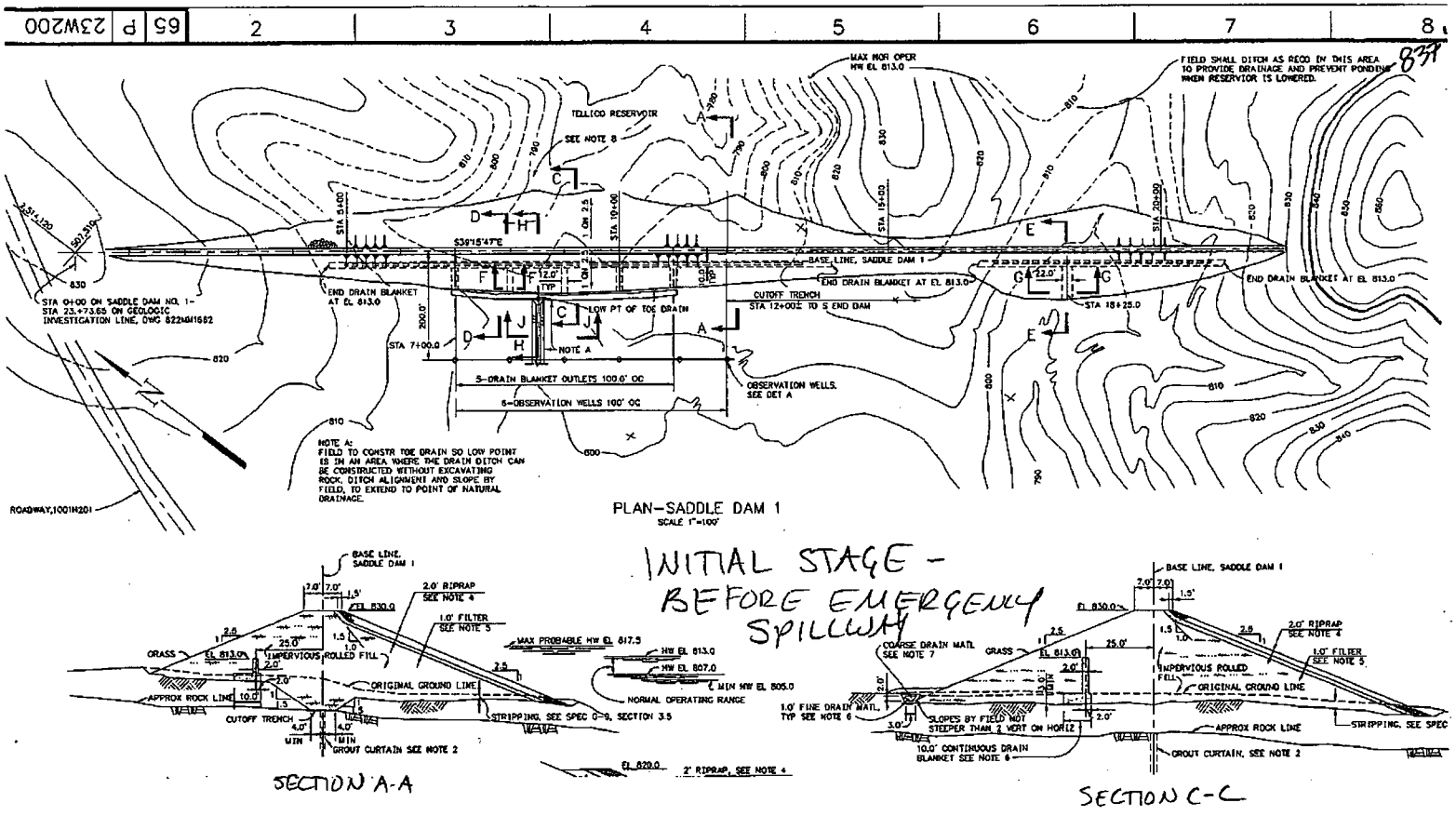


Appendix E-7
from Ref. 2.1.7
10 total pages

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.

4

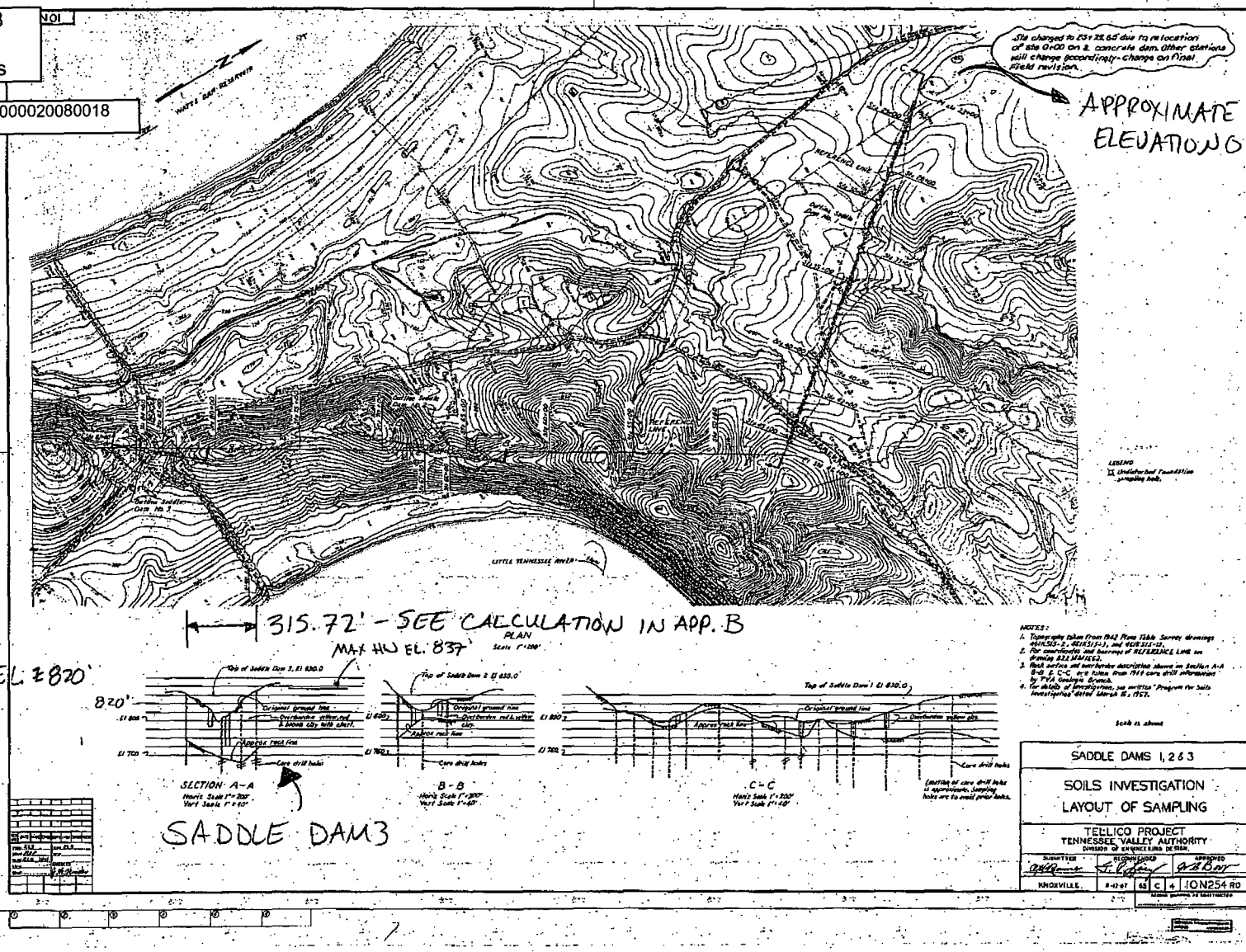


Appendix E-8
Ref. 2.1.13
10 total pages

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.

(5)

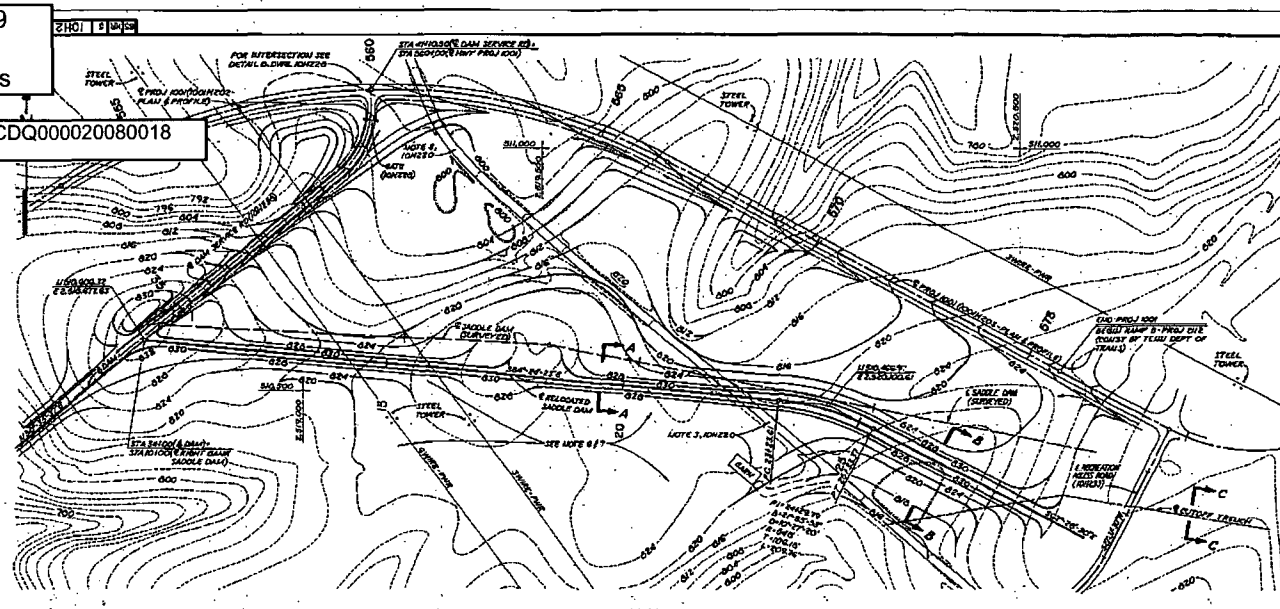


Appendix E-9
Ref. 2.1.2
10 total pages

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.

(6)



WEIGHTED AVERAGE ELEVATION = 823'

NOTES:
1. GENERAL NOTES: FOR GENERAL NOTES AND QUANTITY ESTIMATES SEE 10H230.
2. SPECIFICATIONS: ALL CONSTRUCTION SHALL BE IN ACCORDANCE WITH THE GENERAL CONSTRUCTION SPECIFICATION G-9.
3. CONTOURS: DASHED CONTOURS REPRESENT EXISTING GRADE AND SOLID CONTOURS REPRESENT FINISHED GRADE.
4. EMBANKMENT COMPACTION: THE REQUIRED EMBANKMENT COMPACTION SHALL BE AT LEAST 95% OF STANDARD PROCTOR MAXIMUM DENSITY (ASTM D 698) AS ESTABLISHED BY TVA SOILS LABORATORY, WITH MOISTURE CONTENT OF +2% OF OPTIMUM.
5. GRASSING: ALL GRASSING SHALL BE IN ACCORDANCE WITH DWG 10U229.
6. UNSUITABLE MATERIAL: IF GRAVEL OR SANDY MATERIAL IS EXPOSED IN THIS AREA, EITHER MATERIALLY OR BY CONSTRUCTION, STRIP AND COVER WITH 6' OF IMPERVIOUS ROLLED MATERIAL. FOR DETAILS, SEE DETAIL A-10H231.
7. INSTRUMENTATION: FOR INSTRUMENTATION IN THIS AREA, SEE 28W212.

DIVISION OF PROPERTY & SERVICES
SCALE: 1"=100' OR AS NOTED
COMPANION DRAWING: 10H230

RIGHT BANK
SADDLE DAM

PLAN & SECTIONS

TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED | RECOMMENDED | APPROVED
KNOXVILLE 7-9-76 | 55 | HR | 5 | 10H230 R2

INSPECTED AND APPROVED FOR ISSUE

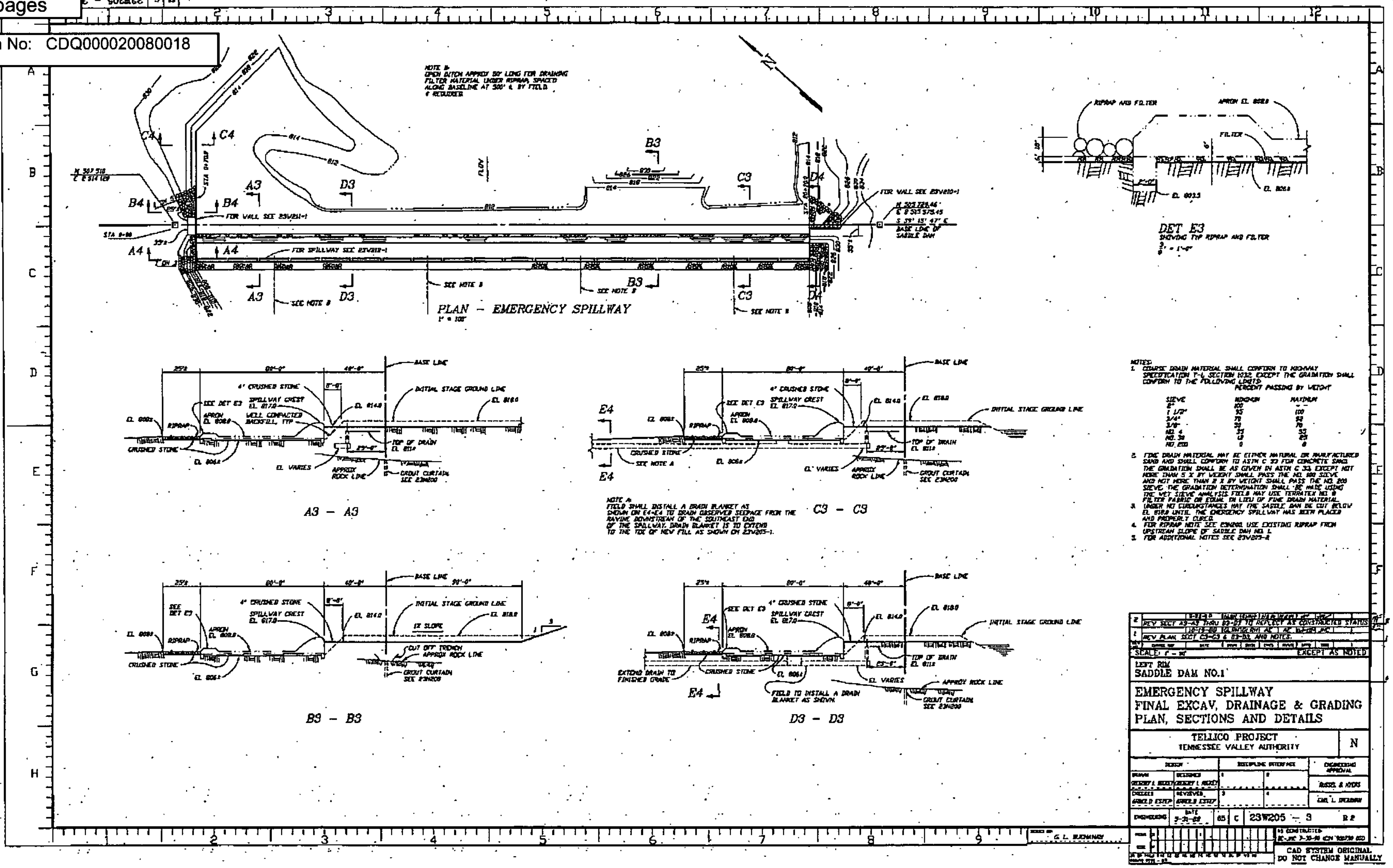
4-16-02

Appendix E-10
Ref. 2.1.8
10 total pages

Calculation No: CDQ000020080018

Prepared by: S.E.M.
Checked by: J.B.M.

7



Appendix F: Hydrostatic Loads on the Spillway Tainter Gates

The Hydrostatic loads on the spillway tainter gates for Tellico Dam can be found in the following calculations.

F1 References

F1. "Watts Bar Dam – Flood and Earthquake Analysis on Radial Spillway Gates, pages 76-100" Tennessee Valley Authority, HEPE3WBHSQN-WBNBLNBFN.

F2 Calculations

Reference F1 evaluates the structural capacity of the radial spillway gates at Watts Bar Dam. This reference was used as a basis for evaluating the margin between the forces on the closed gates (FR_{closed}) when the headwater elevation is at the top of the gate (815.00 feet) and when the gates are completely open (FR_{open}) and the headwater elevation is at 834.00 feet. The margin is defined at the ratio of FR_{open} to FR_{closed}. The calculation of these forces and the results of this comparison are shown in Figure F1.

Tellico Hydrostatic Forces on Gates

Comparison of forces when gates are closed and HW is at 815.00 feet (top of gate) vs. when gates are fully open and HW at an elevation of 834.00 feet.

Attribute	Symbol	Value	Unit
top elev	Zo	815.00	ft
trun elev	Ztr	788.00	ft
sill elev	Zsill	772.12	ft
radius	R	41.00	ft
length	L	40.00	ft
angle up	α2	41.19	deg
angle lwr	α	22.79	deg
angle tot	θ	63.98	deg
area of lower slice	Aslice1	938.50	ft^2
proj area	AProjected	1715.20	ft^2
Desgn LdH	FRx	2294690.61	lbs
Result elv	Z1	786.41	ft
Result ang deg		2.22	deg
Result ang rad		0.04	rad
Result Dsgn	Horiz	2292971.67	lbs
Area slice upper	Aslice2	604.21	ft^2
Area triangle	Atriangle	416.54	ft^2
project vert	x1	10.15	ft
vert weight water	FRy	215284.89	lbs
Resultant load - Gates Closed	FR_{closed}	**2304767.36**	lbs
vert open fm calc	calc App A	33.00	ft
max hw	calc	834.00	ft
lwr lip elev	Z2	805.12	ft
bot angle	α3	24.68	deg
top elev	Zo	828.99	ft
project area for h ld	AProjected	954.75	ft^2
Flood LdH	FRx	1009559.12	lbs
Height over gate	y1	5.01	ft
Height ratio to orig		1.44	(ratio)
project vert	x2	36.29	ft
Flood LdV1		453963.10	lbs
Flood lLdV2		623814.88	lbs
Total Flood LdV	FRy	1077777.98	lbs
Resultant load - Gates Fully Open	FR_{open}	**1476758.27**	lbs
Margin	FR_{open}/FR_{closed}	**0.64**	(ratio)

Figure F1: Tellico Spillway Gate Margin Evaluation

BWSC BARGE WAGGONER SUMNER & CANNON, INC.

Project: Hydrostatic Force on Gate
Description: Diagram
Project No. _____ Sheet No. _____ of _____
Designer: _____ Date: _____
Checker: _____ Date: _____

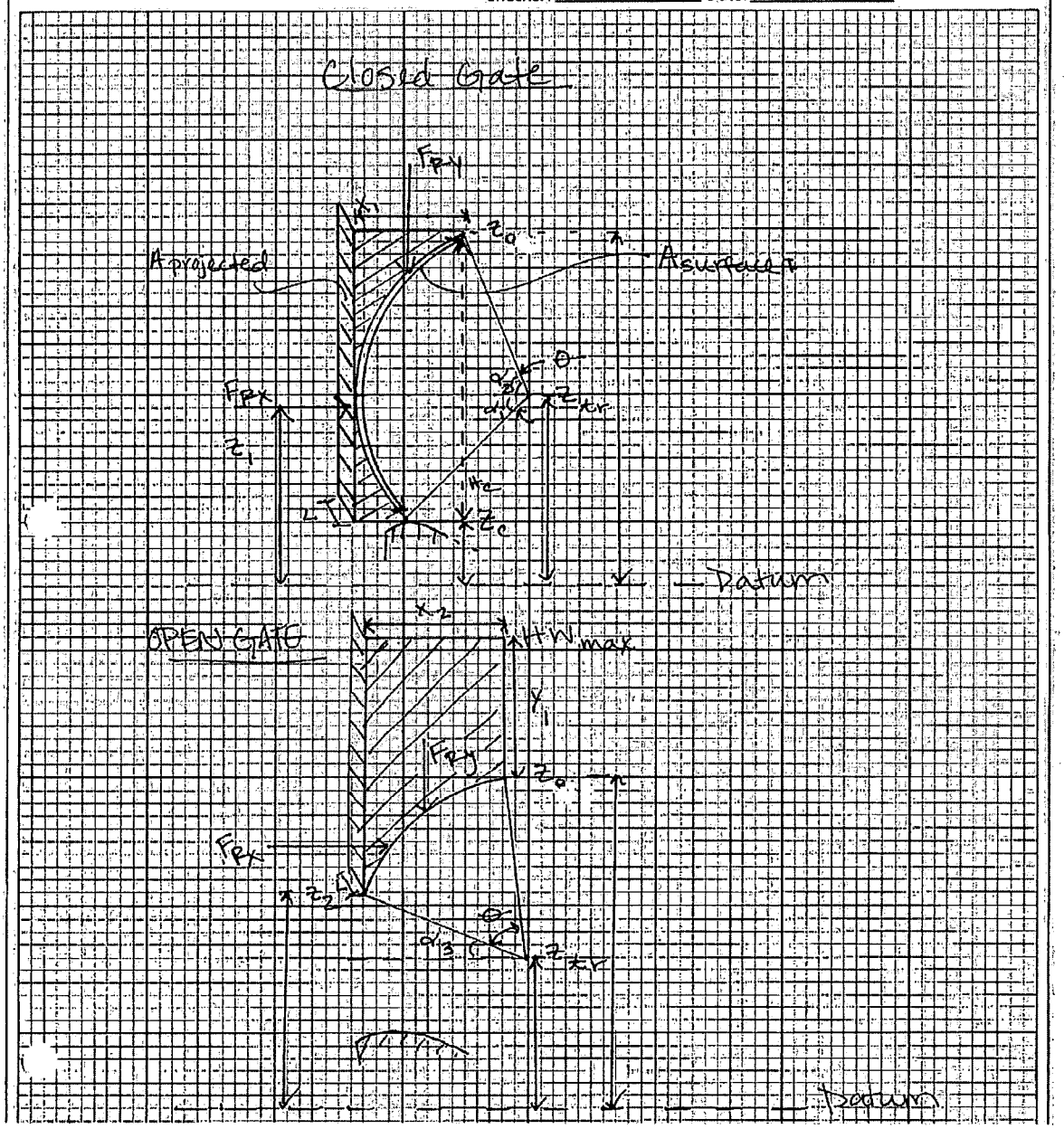
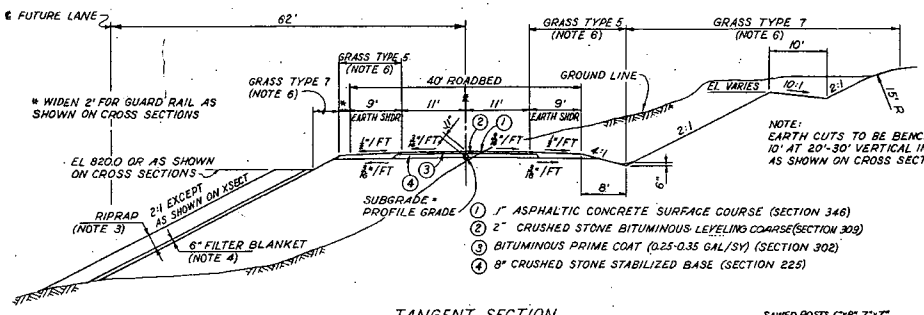
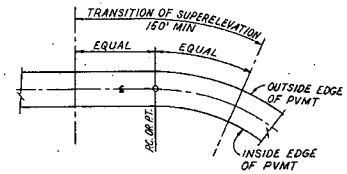


Figure F2: Diagram of Hydrostatic Forces

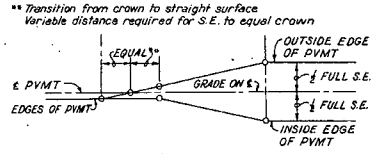
65 HR 1101H102



TANGENT SECTION



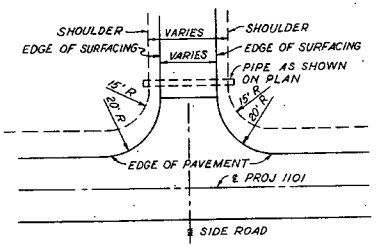
PLAN



ELEVATION

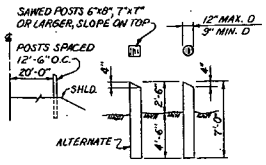
SUPERELEVATION TRANSITION

NTS



PLAN FOR SIDE ROAD INTERSECTION

NTS



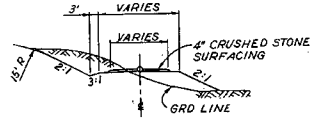
DETAIL OF TIMBER GUARD POSTS

N.T.S.

SUPERELEVATED SECTION

DETAILS OF ROCK SECTION

DETAILS & DIMENSIONS NOT SHOWN SAME AS TANGENT SECT

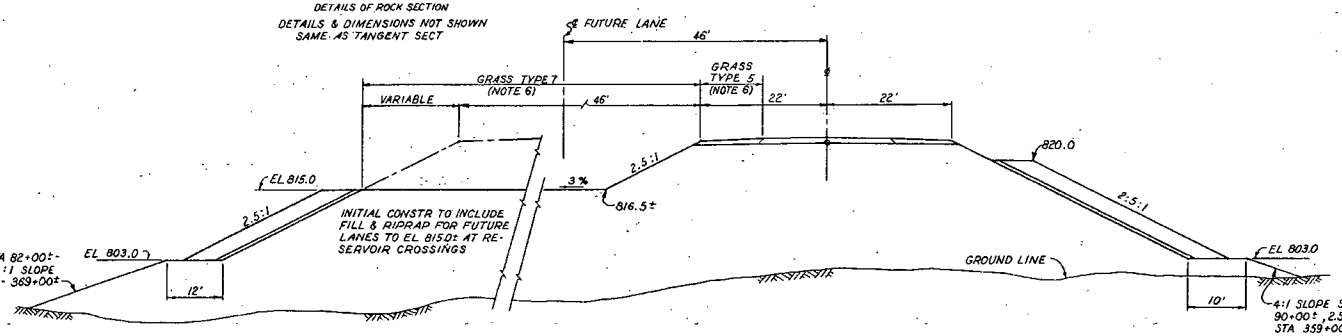


TYPICAL SECTION FOR SIDE ROAD

NOTES:

1. ALL WORK SHALL BE IN ACCORDANCE WITH T-1 SPECIFICATIONS, UNLESS OTHERWISE NOTED
2. FOR DETAILS OF BERM AND TERRACE DITCHES SEE DWG. NO. 1101H301.
3. RIPRAP SHALL BE SOUND DURABLE STONE WITH AT LEAST 50%, BY WEIGHT CONSISTING OF STONES OF THE WEIGHT AS FOLLOWS:
   1.5-FOOT THICK RIPRAP — 100 POUND STONE
   2.0-FOOT THICK RIPRAP — 150 POUND STONE
   2.5-FOOT THICK RIPRAP — 300 POUND STONE
   FOR RIPRAP THICKNESS SEE DETAIL GRADING DWGS. AND CROSS SECTIONS. RIPRAP SHALL CONFORM TO SECTION 830.
4. FILTER BLANKET, 6 INCHES THICK, SHALL BE PLACED UNDER ALL RIPRAP AND SHALL CONFORM TO SECTION 836.
5. EARTH EMBANKMENTS SHALL BE CONSTRUCTED IN LAYERS APPROXIMATELY 6" THICK AND SHALL BE COMPACTED TO 95% OR MORE OF OPTIUM DENSITY IN ACCORDANCE WITH SECTION 120.11. FOUNDATION PREPARATION FOR ALL EMBANKMENTS SHALL CONSIST OF REMOVING ORGANIC TOPSOIL TO A DEPTH THAT OBTAINS A FOUNDATION WHICH WILL SUPPORT HEAVY EARTH MOVING EQUIPMENT WITHOUT RUTTING INTO THE GROUND AND WITHOUT HEAVING THE GROUND SO AS TO REDUCE ITS STABILITY.
6. GRASSING: ALL CUT & FILL SLOPES & DISTURBED AREAS SHALL BE SEEDED WITH TYPE 7 MIXTURE; EARTH SHOULDERS & DITCH SLOPES SHALL BE SEEDED WITH TYPE 5 MIXTURE. ALL GRASSED AREAS SHALL BE FERTILIZED & MULCHED IN ACCORDANCE WITH SECTIONS 180 & 182 RESPECTIVELY.

SCALE 1"=10'
EXCEPT AS NOTED
PROJECT 65-1101



RESERVOIR CROSSING SECTION

STA 82+00± - 90+00±, STA 359+00± - 369+00±

DETAILS & DIMENSIONS NOT SHOWN SAME AS TANGENT SECTION.

NO.	DATE	MADE	CKED	SUPV	IN SP	SUBM	RECM	APPD
1	8-11-80	V.P.L.	W.J.A.	V.P.E.				

REVISED SURFACING

DSGN R.A. VALENTINE SUPV. J.L. GLOVER
DRWN V.P. ELDER IN SP.
CKD J.L. GLOVER
TRCD CHECKED R.W. Everett
COMP

TELLICO PARKWAY

TYPICAL SECTIONS

TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

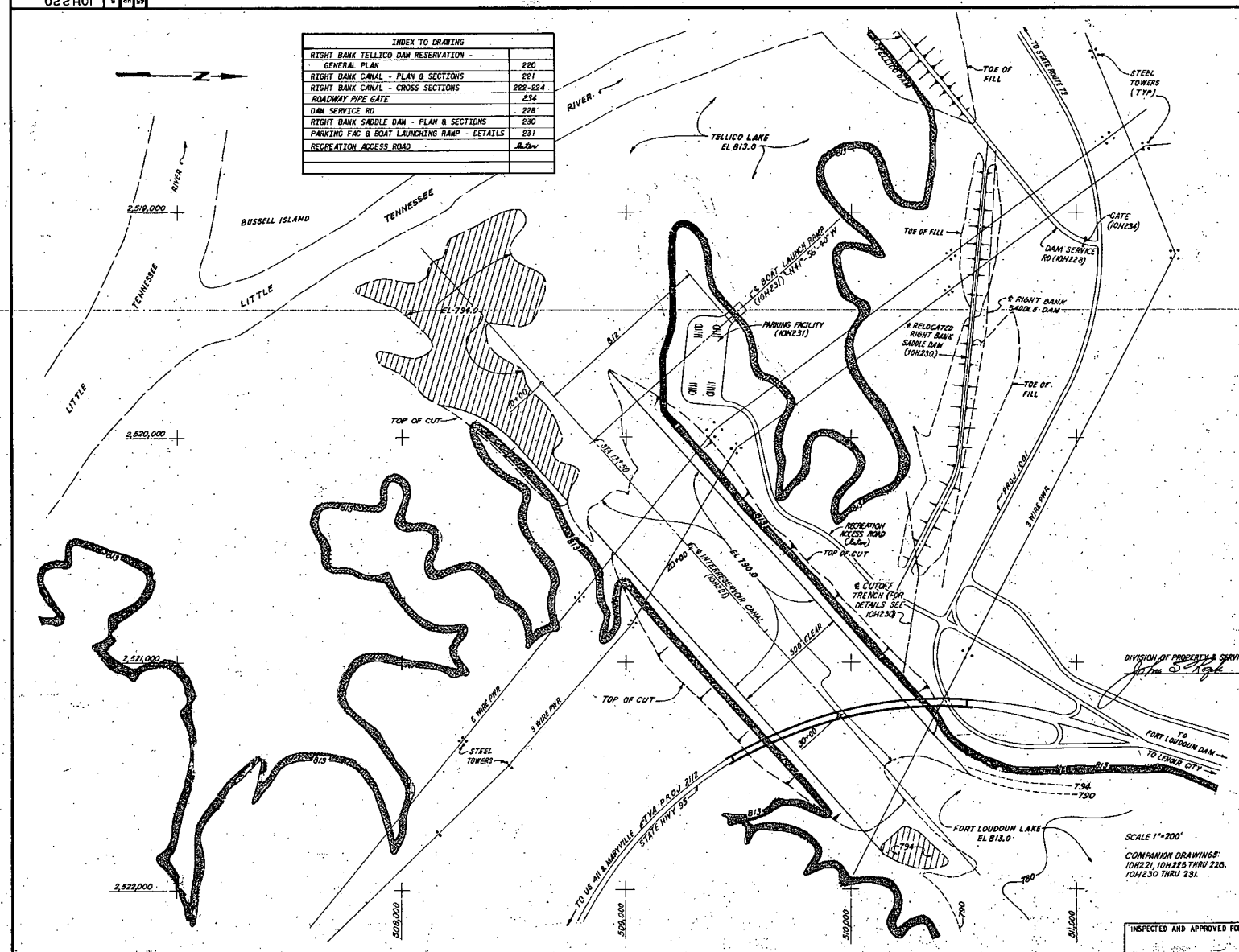
SUBMITTED	RECOMMENDED	APPROVED
Robert J. Freeman	[illegible]	G. L. Buchanan Jr.

KNOXVILLE | 5-29-76 | 65 HR | 1101H102 | R1

RECORD DRAWING AS CONSTRUCTED
Frank Ann Dexter 4-7-82 RD

TECHNICAL INFORMATION CENTER RECEIVED

AF 10 81



INDEX TO DRAWING	
RIGHT BANK TELLICO DAM RESERVATION - GENERAL PLAN	220
RIGHT BANK CANAL - PLAN & SECTIONS	221
RIGHT BANK CANAL - CROSS SECTIONS	222-224
ROADWAY PIPE GATE	234
DAM SERVICE RD	228
RIGHT BANK SADDLE DAM - PLAN & SECTIONS	230
PARKING FAC & BOAT LAUNCHING RAMP - DETAILS	231
RECREATION ACCESS ROAD	Below

* SUMMARY OF QUANTITIES

ITEM NO.	DESCRIPTION		QUANT.	UNIT
120	UNCLASSIFIED EXCAVATION		1,676,006	C.Y.
	CANAL	1,655,770		
	DAM SERV RD	5,700		
	PRKG & BOAT FAC	12,535		
123	EARTH BORROW		32,000	C.Y.
	SADDLE DAM	32,000		
210	CRUSHED STONE (CONC BOAT RAMP)-3"		80	TONS
225	STAB GR STONE BASE		5,950	TONS
	TOP OF DAM-8"	2,875		
	DAM SERV RD-8"	490		
	PRKG & BOAT FAC-6"	2,585		
302	BIT PRIME COAT		18	TONS
	TOP OF DAM	6.0		
	DAM SERV RD	1.5		
	PRKG & BOAT FAC	10.5		
345	ASPHALTIC CONC SURF COURSE-1½"		1,105	TONS
	TOP OF DAM	375		
	DAM SERV RD	85		
	PRKG & BOAT FAC	645		
401	CLASS 'A' CONC (BOAT RAMP)-4"		55	C.Y.
830	RIPRAP (CANAL)		29,385	C.Y.
836	FILTER (CANAL)		15,045	TONS
418	STEEL REINF BARS-4A		3,765	LBS
831	HAND-PLACED RIPRAP (BY FIELD)		75	S.Y.
	TIE-UP RINGS (BY FIELD)		8	EA
386	EXTRUDED CONC CURB		1,080	L.F.
331	CONC CURB		400	L.F.
	* FOR ADDITIONAL QUANTITIES SEE DWG 10H232			

NOTES:

1. SPECIFICATIONS: ALL WORK SHALL BE IN ACCORDANCE WITH HIGHWAY SPECIFICATIONS T-1 EXCEPT AS NOTED:
2. GRASSING: ALL GRASSING SHALL BE IN ACCORDANCE WITH DWG 10H229.
3. REMOVAL OF EXISTING STR: ALL EXISTING STRUCTURES AND EMBANKMENTS, SUCH AS BLDG FOUNDATIONS, CONCRETE SIDEWALKS, AND STEPS, PAVEMENT, ETC., SHALL BE REMOVED AND THE DISTURBED AREAS GRASSED.

SCALE 1"=200'

COMPANION DRAWINGS: 10H221, 10H225 THRU 225, 10H230 THRU 231.

INSPECTED AND APPROVED FOR ISSUE

RECORD DRAWING AS CONSTRUCTED 6-16-82

GENERAL REVISIONS & REVISED GRADING AT BOTH ENDS OF CANAL.

TELLICO DAM RESERVATION-RIGHT BANK

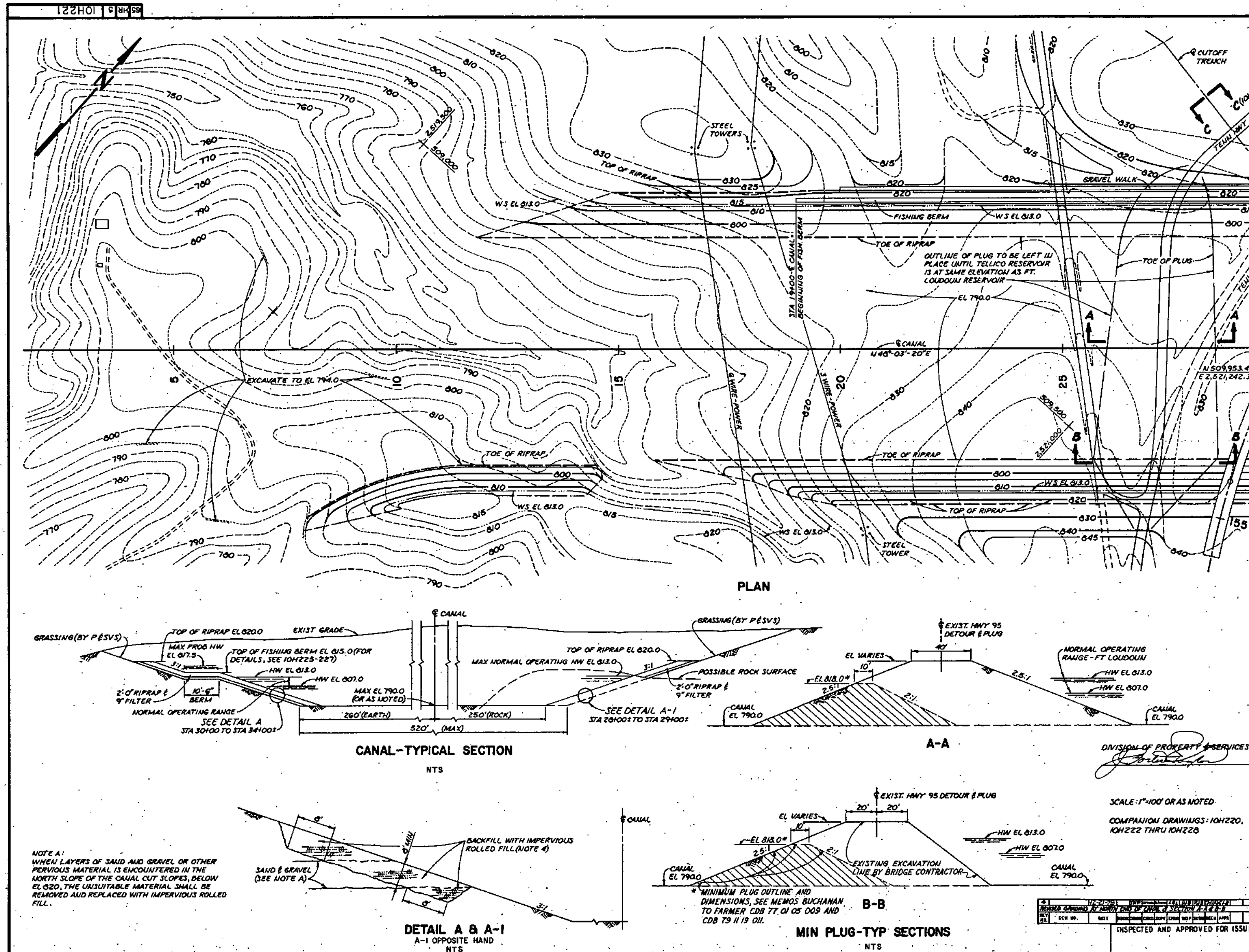
GENERAL PLAN

TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED
Robert J. Bauman	D.R.	G.L. Buchanan

KNOXVILLE | 7-9-76 | 65 | MR | 5 | 10H220RI

RECORD DRAWING AS CONSTRUCTED



NOTE A:
WHEN LAYERS OF SAND AND GRAVEL OR OTHER PERVIOUS MATERIAL IS ENCOUNTERED IN THE NORTH SLOPE OF THE CANAL CUT SLOPES, BELOW EL 820, THE UNSUITABLE MATERIAL SHALL BE REMOVED AND REPLACED WITH IMPERVIOUS ROLLED FILL.

NOTES:
1. GENERAL NOTES: FOR GENERAL NOTES AND QUANTITY ESTIMATES SEE 10H220.
2. RIPRAP: RIPRAP TO BE PLACED AT LOCATIONS DESIGNATED ON THE CROSS SECTIONS DWGS 10H222-224. THE THICKNESS OF RIPRAP IS 2'-0" WITH AT LEAST 50% OF THE RIPRAP, BY WEIGHT, CONSISTING OF STONE WEIGHTING 150 LBS OR MORE. RIPRAP SHALL CONFORM TO SECTION 630 OF THE SPECIFICATIONS.
3. FILTER: FILTER MATERIAL SHALL BE 9" THICK AND CONSIST OF CRUSHED STONE PER SECTION 636 OF THE SPECIFICATIONS.
4. EMBANKMENT COMPACTION: THE REQUIRED EMBANKMENT COMPACTION SHALL BE AT LEAST 95% OF STANDARD PROCTOR MAXIMUM DENSITY (ASTM D 698) AS ESTABLISHED BY TVA SOILS LABORATORY, WITH MOISTURE CONTENT OF ±2% OF OPTIMUM.
5. CONTOURS: SOLID CONTOURS REPRESENT FINISHED GRADE AND DASHED CONTOURS REPRESENT EXIST GRADE.

SCALE: 1"=100' OR AS NOTED

COMPANION DRAWINGS: 10H220, 10H222 THRU 10H228

DIVISION OF PROPERTY & SERVICES

REV NO.	DATE	DESCRIPTION
3	12-10-76	MINOR REVISIONS
2	10-27-76	ADDED CUTOFF TRENCH AND MINOR REVISIONS
1	6-22-76	ADDED SECTIONS A-A & B-B AND MINOR REVISIONS

REVISED GRADING AT NORTH END OF CANAL & SECTION A-A & B-B

INSPECTED AND APPROVED FOR ISSUE

DSGN T.H. Rogers
DRWN W.D. Schaefer
ENGINEER E.B. Logan

RIGHT BANK CANAL

PLAN & SECTIONS

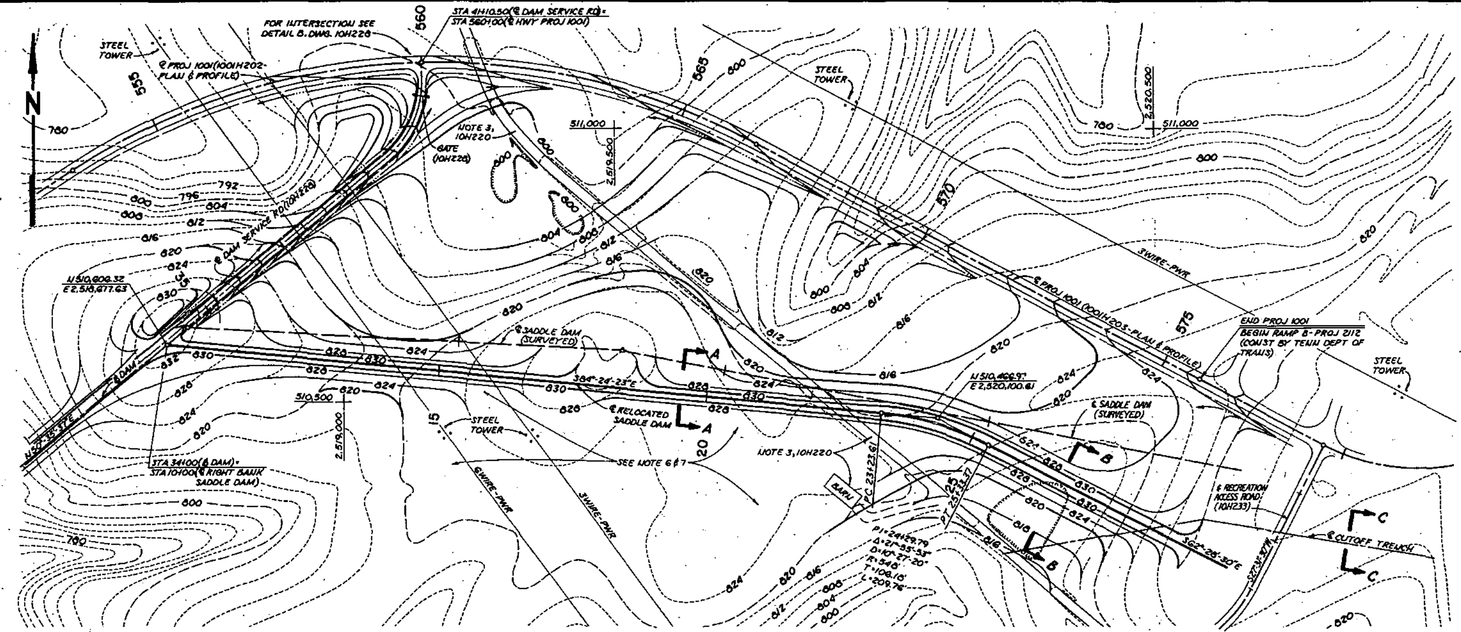
TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED
Robert J. Bowman	[signature]	G.L. Buchanan

KNOXVILLE 4-26-76 65 HR 5 10H221 R4

RECORD DRAWING AS CONSTRUCTED
4-16-82 Frank Van Metre R4

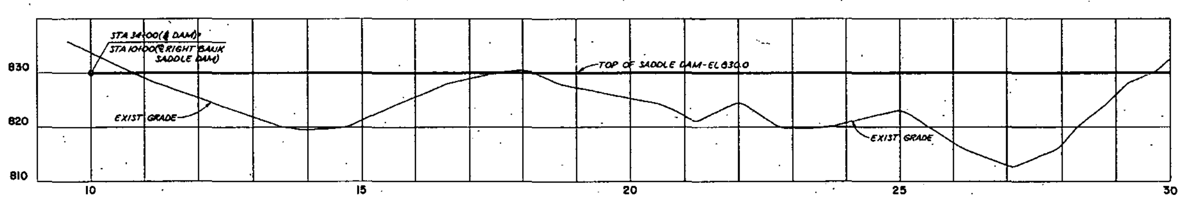
65 HR 5 10H221



PLAN

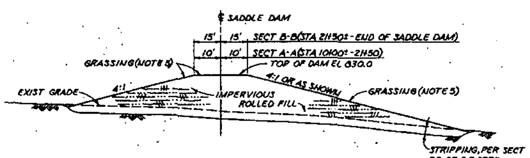
NOTES:

1. GENERAL NOTES: FOR GENERAL NOTES AND QUANTITY ESTIMATES SEE 10H220.
2. SPECIFICATIONS: ALL CONSTRUCTION SHALL BE IN ACCORDANCE WITH THE GENERAL CONSTRUCTION SPECIFICATION G-9.
3. CONTOURS: DASHED CONTOURS REPRESENT EXISTING GRADE AND SOLID CONTOURS REPRESENT FINISHED GRADE.
4. EMBANKMENT COMPACTION: THE REQUIRED EMBANKMENT COMPACTION SHALL BE AT LEAST 95% OR STANDARD PROCTOR MAXIMUM DENSITY (ASTM. D698) AS ESTABLISHED BY TVA SOILS LABORATORY, WITH MOISTURE CONTENT OF ±2% OF OPTIMUM.
5. GRASSING: ALL GRASSING SHALL BE IN ACCORDANCE WITH DWG 10H229.
6. UNSUITABLE MATERIAL: IF GRAVEL OR SANDY MATERIAL IS EXPOSED IN THIS AREA, EITHER NATURALLY OR BY CONSTRUCTION, STRIP AND COVER WITH 6" OF IMPERVIOUS ROLLED MATERIAL. FOR DETAILS, SEE DETAIL A-10H221.
7. INSTRUMENTATION: FOR INSTRUMENTATION IN THIS AREA, SEE 22W212.



PROFILE-RIGHT BANK SADDLE DAM

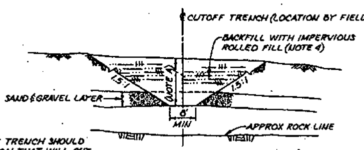
SCALE: 1"=10' VERT, 1"=100' HORIZ



SADDLE DAM-TYPICAL SECTION A-A & B-B

SCALE: 1"=20'

NOTE A:
THE DEPTH OF THE TRENCH SHOULD BE TO THE ELEVATION THAT WILL CUT OFF ANY SAND AND GRAVEL LAYERS BETWEEN ELEVATIONS 785 AND 820.



C-C

NTS

DIVISION OF PROPERTY & SERVICES

SCALE: 1"=100' OR AS NOTED

COMPANION DRAWING: 10H220

INSPECTED AND APPROVED FOR ISSUE

2 FINAL FIELD REVISIONS
1 RELOC RT BANK SADDLE DAM AND ADDED CUTOFF TRENCH

DSGN W.G. SCHAEFFER
INSP J.R. FOX

RIGHT BANK SADDLE DAM

PLAN & SECTIONS

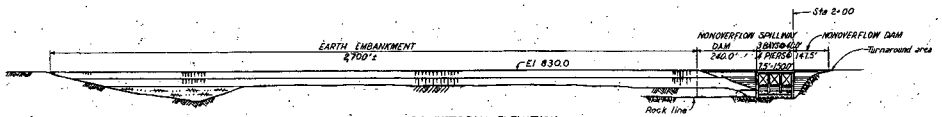
TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED | RECOMMENDED | APPROVED

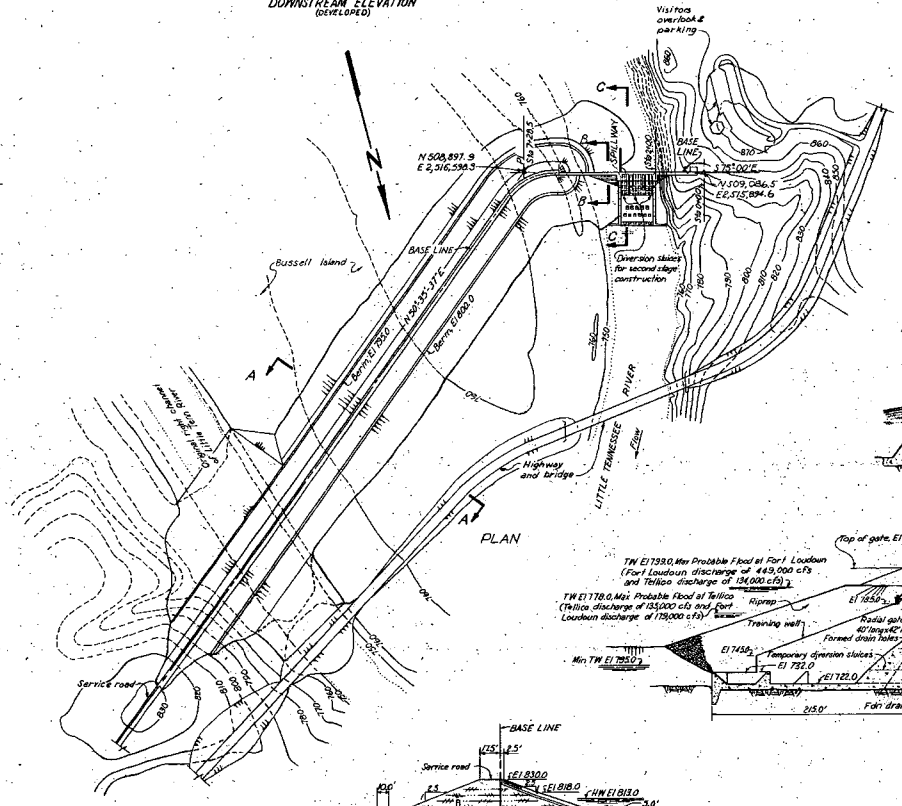
KNOXVILLE 7-9-76 65 HR 5 10H230 R2

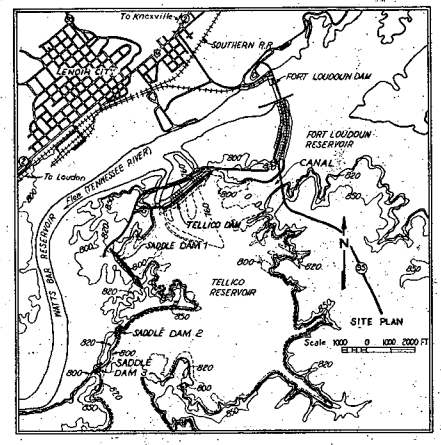
RECORD DRAWING AS CONSTRUCTED 4-16-82 R2

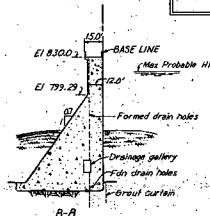
10N200



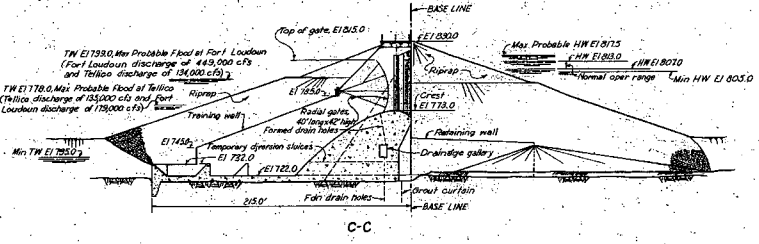
DOWNSTREAM ELEVATION
(DEVELOPED)



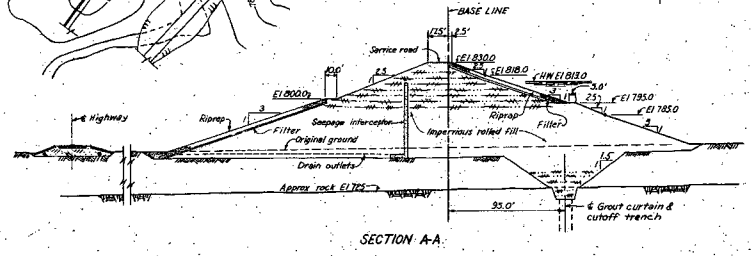




B-B



C-C



SECTION A-A

Scale 200 0 200 400
PLAN AND DOWNSTREAM ELEVATION

Scale 40 0 40 80 FT
SECTIONS

MAIN DAM WORKS

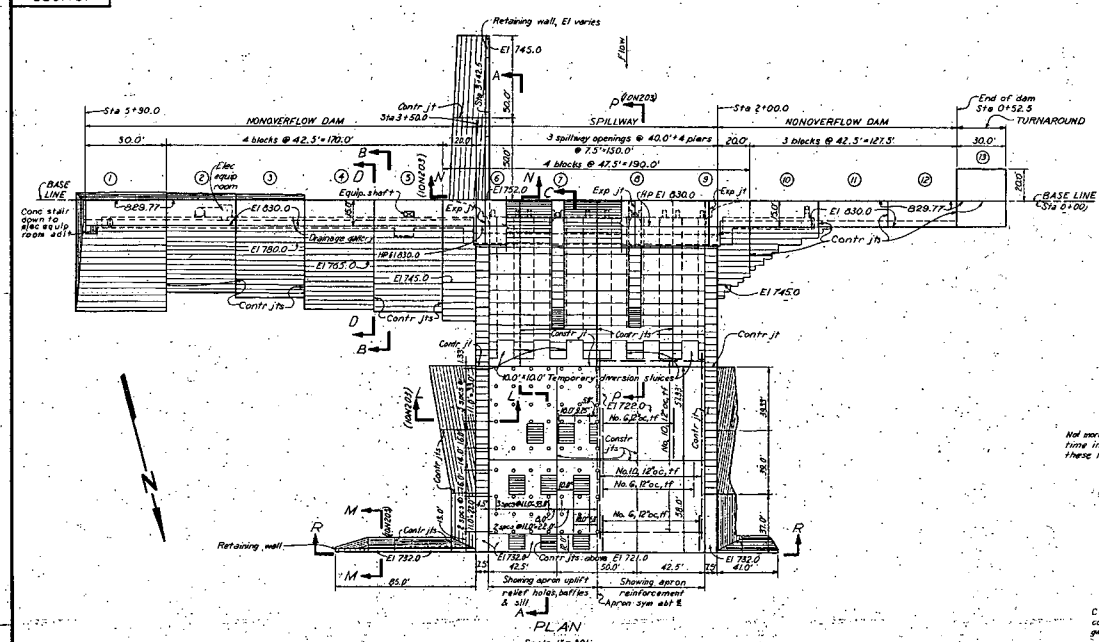
GENERAL PLAN ELEVATION & SECTIONS

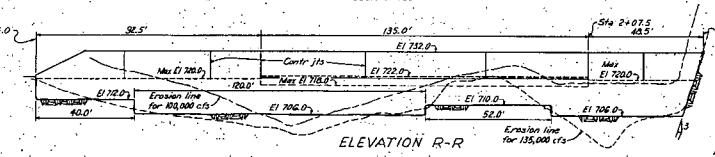
TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

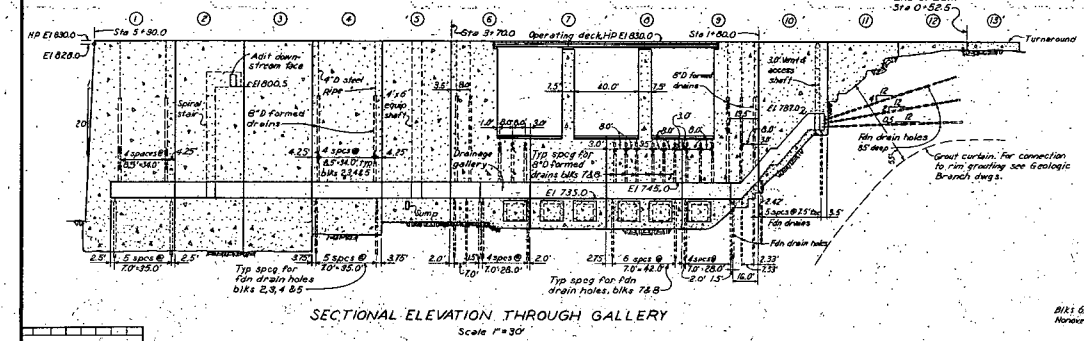
SUBMITTED	RECOMMENDED	APPROVED
KNOXVILLE	5-29-67	65 C 4

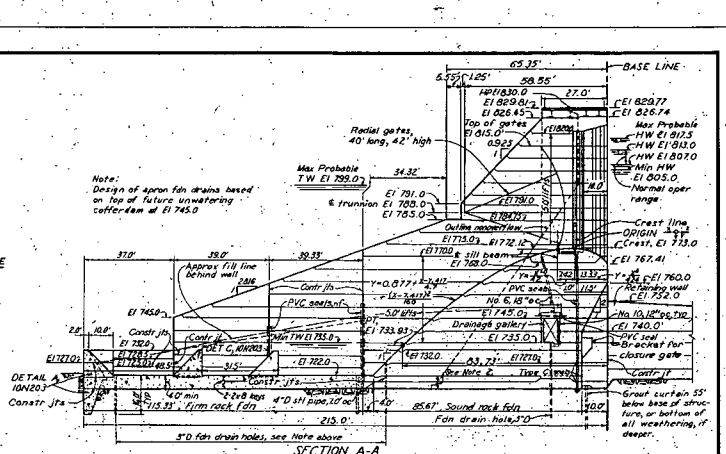
10N200R5

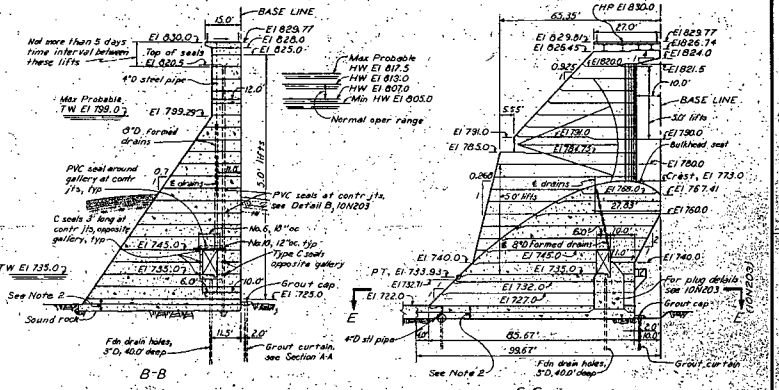
ISSUED FOR INFORMATION & CONSTRUCTION

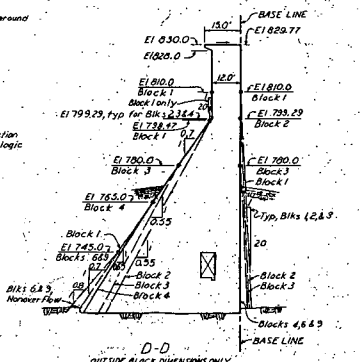












NOTES:
1. This drawing is for design purposes only; for details see construction drawings.
2. Max 2.5ft thick lifts will be used near rock foundation for temperature and shrinkage control. See concrete placing instructions on EIN 201 and EIN 203.
3. Reinforcing conforms to ASTM Specification A-432 high-strength steel.

Scale 1"=20' Except as noted

COMPANION DRAWING: 10N203

SPILLWAY & NONOVERFLOW DAM

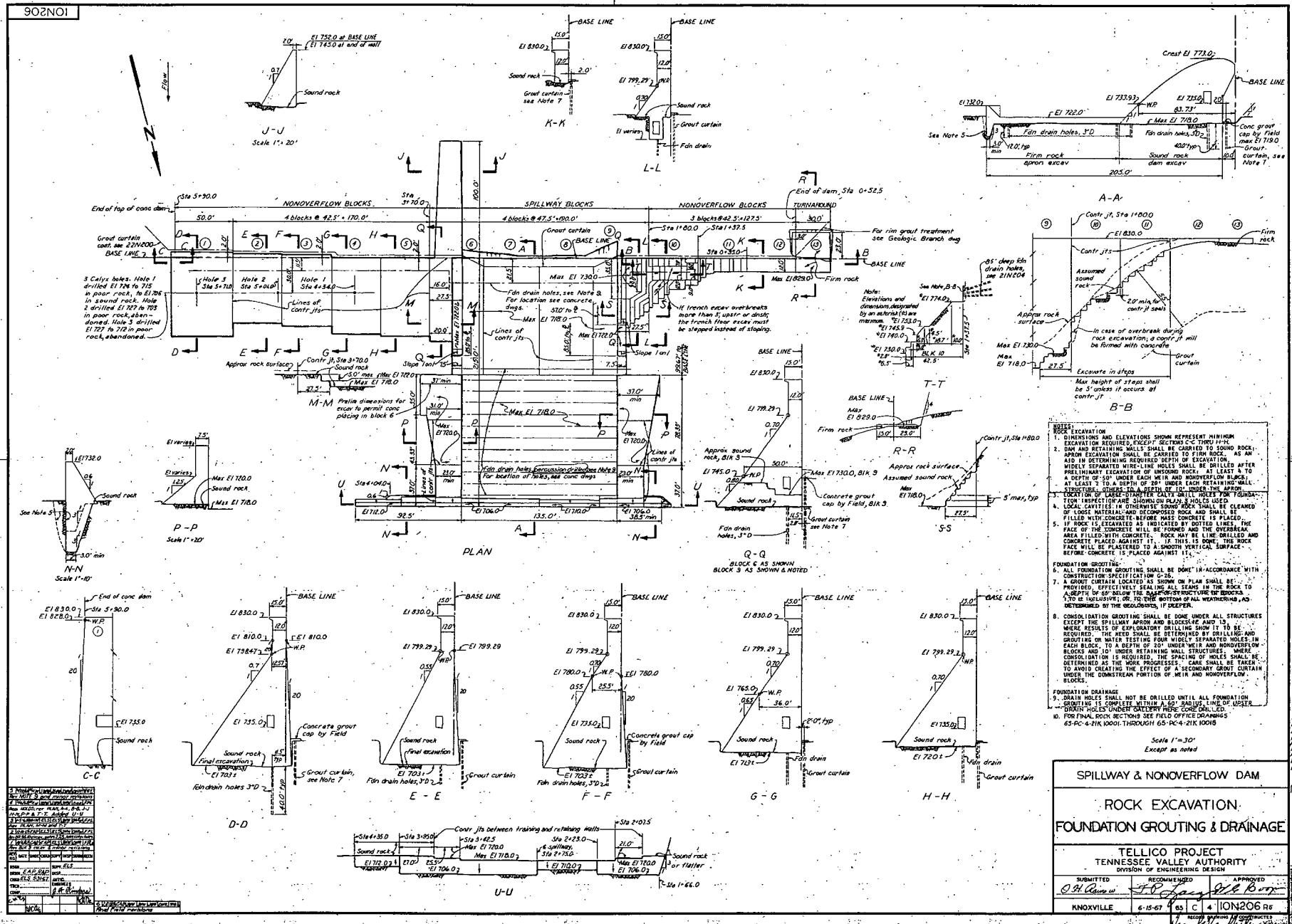
PRINCIPAL FEATURES OF DESIGN-SHEET I

TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED
KNOXVILLE	11-3-67	65 C

10N202-R2

10N206



NOTES:
ROCK EXCAVATION
1. DIMENSIONS AND ELEVATIONS SHOWN REPRESENT MINIMUM EXCAVATION REQUIRED, EXCEPT SECTIONS C-C THRU H-H.
2. DAM AND RETAINING WALLS SHALL BE CARRIED TO SOUND ROCK; APRON EXCAVATION SHALL BE CARRIED TO FIRM ROCK. AS AN AID IN DETERMINING REQUIRED DEPTH OF EXCAVATION, WIDELY SEPARATED WIRE-LINE HOLES SHALL BE DRILLED AFTER PRELIMINARY EXCAVATION OF UNSOUND ROCK. AT LEAST 6 TO A DEPTH OF 50' UNDER EACH WEIR AND NONOVERFLOW BLOCK; AT LEAST 3 TO A DEPTH OF 20' UNDER EACH RETAINING WALL STRUCTURE; OTHERS TO A DEPTH OF 10' UNDER THE APRON.
3. LOCATION OF LARGE-DIAMETER CALYX DRILL HOLES FOR FOUNDATION INSPECTION ARE SHOWN ON PLAN. 3 HOLES USED.
4. LOCAL CAVITIES IN OTHERWISE SOUND ROCK SHALL BE CLEANED OF LOOSE MATERIAL AND DECOMPOSED ROCK AND SHALL BE FILLED WITH CONCRETE BEFORE MASS CONCRETE IS PLACED.
5. IF ROCK IS EXCAVATED AS INDICATED BY DOTTED LINES, THE FACE OF THE CONCRETE WILL BE FORMED AND THE OVERBREAK AREA FILLED WITH CONCRETE. ROCK MAY BE LINE DRILLED AND CONCRETE PLACED AGAINST IT. IF THIS IS DONE, THE ROCK FACE WILL BE PLASTERED TO A SMOOTH VERTICAL SURFACE BEFORE CONCRETE IS PLACED AGAINST IT.

FOUNDATION GROUTING
6. ALL FOUNDATION GROUTING SHALL BE DONE IN ACCORDANCE WITH CONSTRUCTION SPECIFICATION G-26.
7. A GROUT CURTAIN LOCATED AS SHOWN ON PLAN SHALL BE PROVIDED, EFFECTIVELY SEALING ALL SEAMS IN THE ROCK TO A DEPTH OF 65' BELOW THE BASE OF STRUCTURE OR BLOCK 3, TO BE INCLUSIVE; OR TO THE BOTTOM OF ALL WEATHERING, AS DETERMINED BY THE GEOLOGISTS, IF DEEPER.
8. CONSOLIDATION GROUTING SHALL BE DONE UNDER ALL STRUCTURES EXCEPT THE SPILLWAY APRON AND BLOCKS 4 AND 13, WHERE RESULTS OF EXPLORATORY DRILLING SHOW IT TO BE REQUIRED. THE NEED SHALL BE DETERMINED BY DRILLING AND GROUTING OR WATER TESTING FOUR WIDELY SEPARATED HOLES IN EACH BLOCK, TO A DEPTH OF 20' UNDER WEIR AND NONOVERFLOW BLOCKS AND 10' UNDER RETAINING WALL STRUCTURES. WHERE CONSOLIDATION IS REQUIRED, THE SPACING OF HOLES SHALL BE DETERMINED AS THE WORK PROGRESSES. CARE SHALL BE TAKEN TO AVOID CREATING THE EFFECT OF A SECONDARY GROUT CURTAIN UNDER THE DOWNSTREAM PORTION OF WEIR AND NONOVERFLOW BLOCKS.

FOUNDATION DRAINAGE
9. DRAIN HOLES SHALL NOT BE DRILLED UNTIL ALL FOUNDATION GROUTING IS COMPLETE WITHIN A 50' RADIUS LINE OF UPSTR CURTAIN HOLES UNDER GALLERY WERE CORE DRILLED.
10. FOR FINAL ROCK SECTIONS SEE FIELD OFFICE DRAWINGS 65-PC-4-21K 10001 THROUGH 65-PC-4-21K 10015

SPILLWAY & NONOVERFLOW DAM

ROCK EXCAVATION
FOUNDATION GROUTING & DRAINAGE

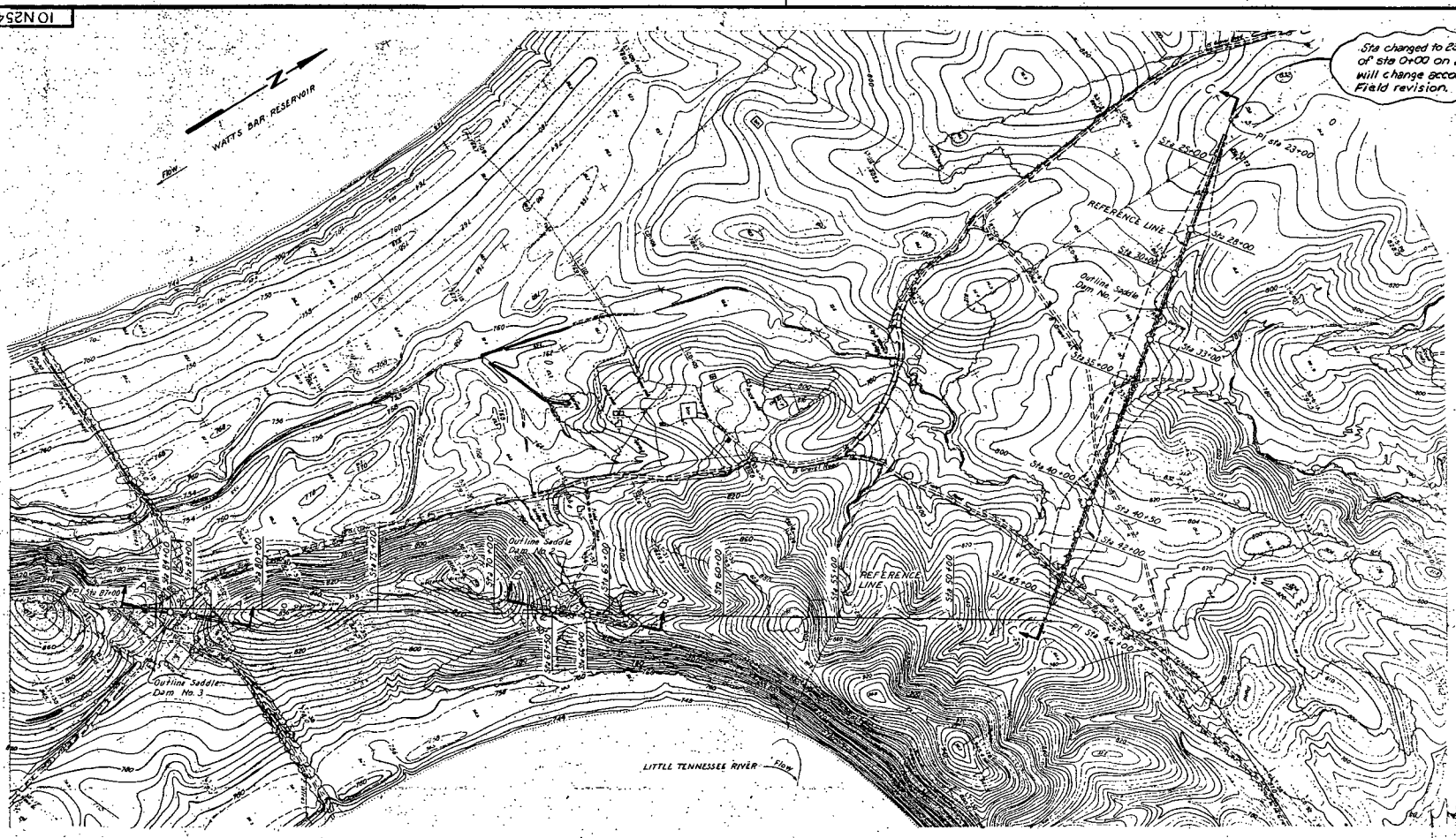
TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED
O.H. Laurence	F.J. Lang	W.A. Burr
KNOXVILLE	6-15-67	65 C 4 10N206 R5

RECORD DRAWING AS CONSTRUCTED

10N254

Sta changed to 23+23.65 due to relocation of Sta 0+00 on ℄ concrete dam. Other stations will change accordingly - change on final. Field revision.

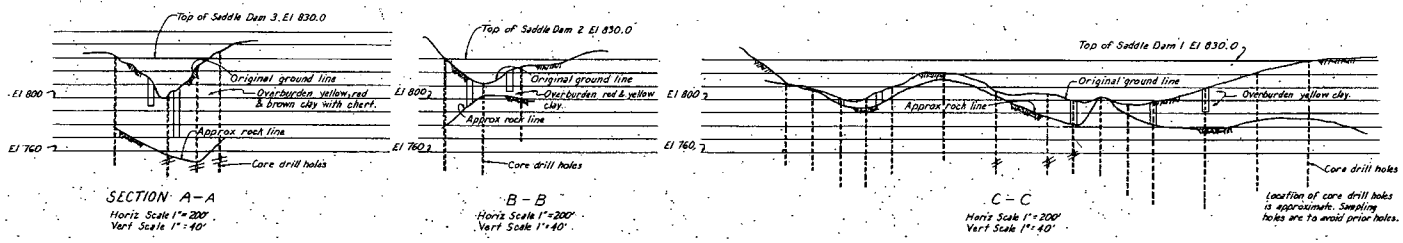


LEGEND

⊠ Undisturbed foundation sampling hole.

PLAN

Scale 1"=200'



SECTION A-A
Horiz Scale 1"=200'
Vert Scale 1"=40'

B-B
Horiz Scale 1"=200'
Vert Scale 1"=40'

C-C
Horiz Scale 1"=200'
Vert Scale 1"=40'

NOTES:

1. Topography taken from 1942 Plane Table Survey drawings 46IK515-2, 46IK515-3, and 46IK515-12.
2. For coordinates and bearings of REFERENCE LINE see drawing 822 NM1662.
3. Rock surface and overburden description shown on Section A-A B-B & C-C are taken from 1944 core drill information by TVA Geologic Branch.
4. For details of investigation, see written "Program for Soils Investigation" dated March 16, 1967.

Scale as shown

MF RO

SADDLE DAMS 1, 2 & 3

SOILS INVESTIGATION

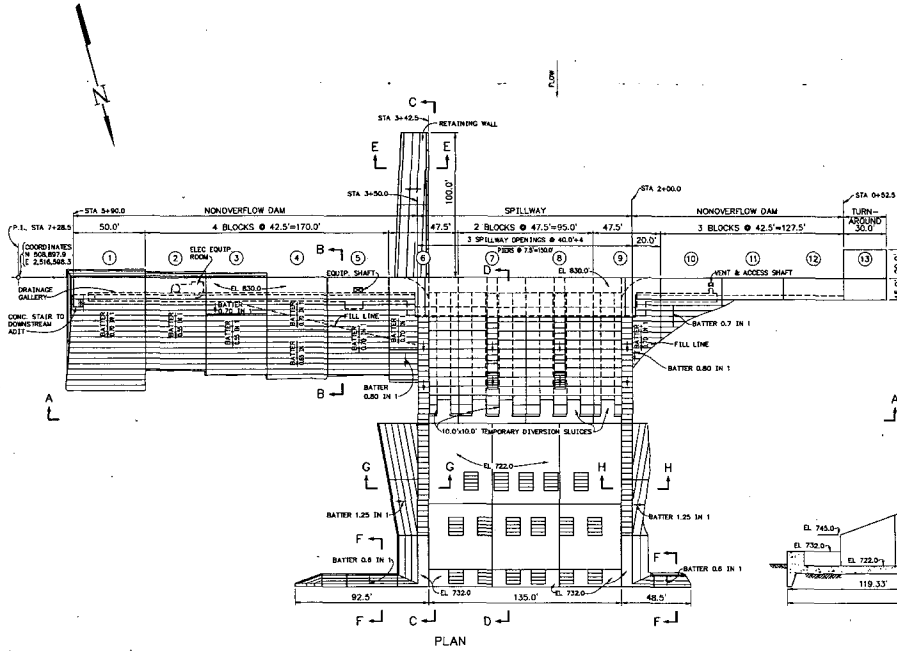
LAYOUT OF SAMPLING

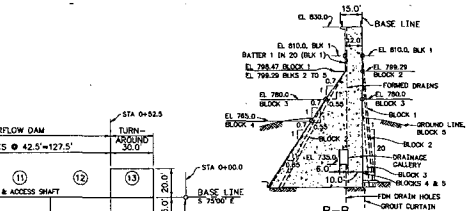
TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

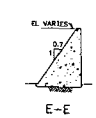
SUBMITTED	RECOMMENDED	APPROVED
[signature]	[signature]	[signature]
KNOXVILLE	3-17-67	65 C 4 10N254 RO

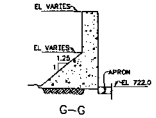
RECORD DRAWING AS CONSTRUCTED

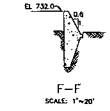
NO.	DATE	SUBM'D	CHK'D	SUPV	ENGR	SUBM'D
DSGN.	SLS			SUPV.	ELS	
DRWN.	RAP			INSP.		
CHKD.	ELS	INIT.		CHECKED		
TRCD.				J. A. Sheridan		
COMP.						

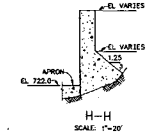




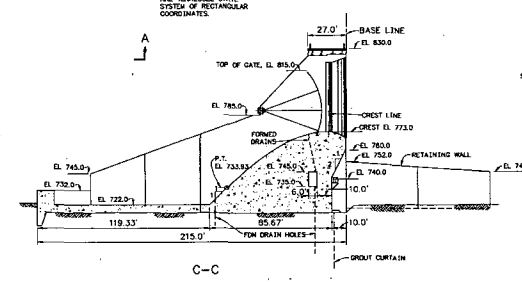


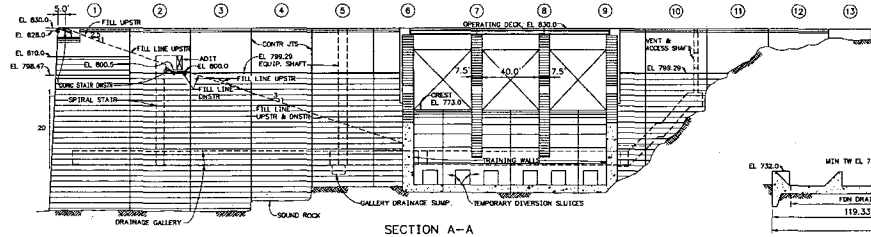


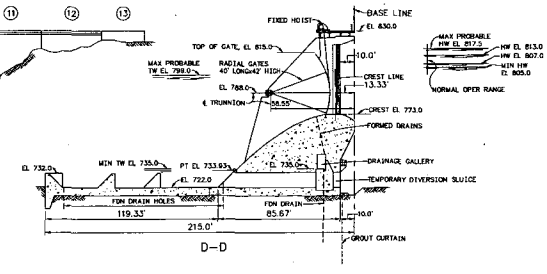




NOTES:
COORDINATES SHOWN ARE TENNESSEE STATE SYSTEM OF RECTANGULAR COORDINATES.







ELECTRONICALLY RESTORED

SCALE: 1"=30' EXCEPT AS NOTED

SPILLWAY & NONOVERFLOW DAM

GENERAL PLAN
ELEVATION & SECTIONS

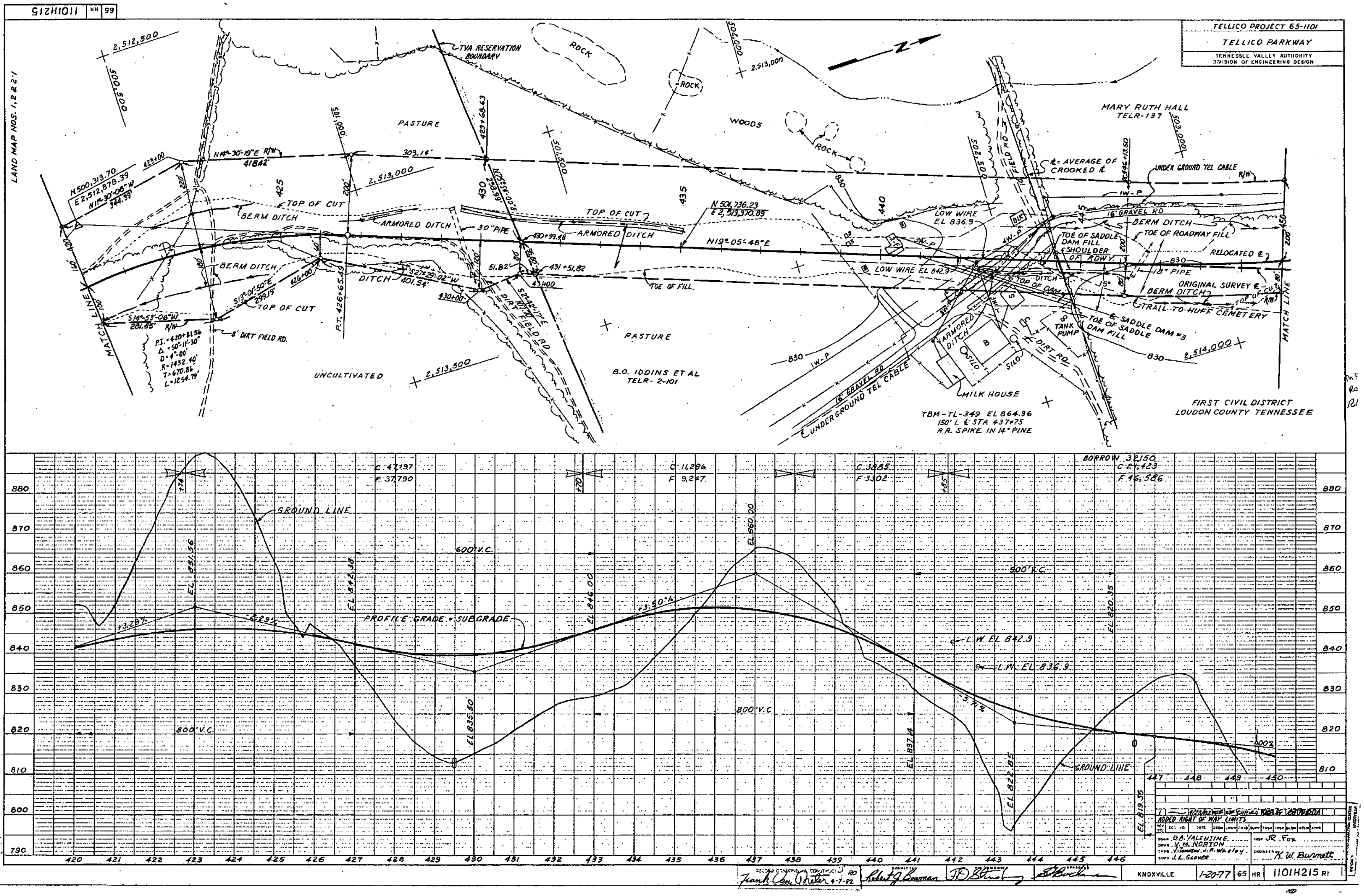
TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

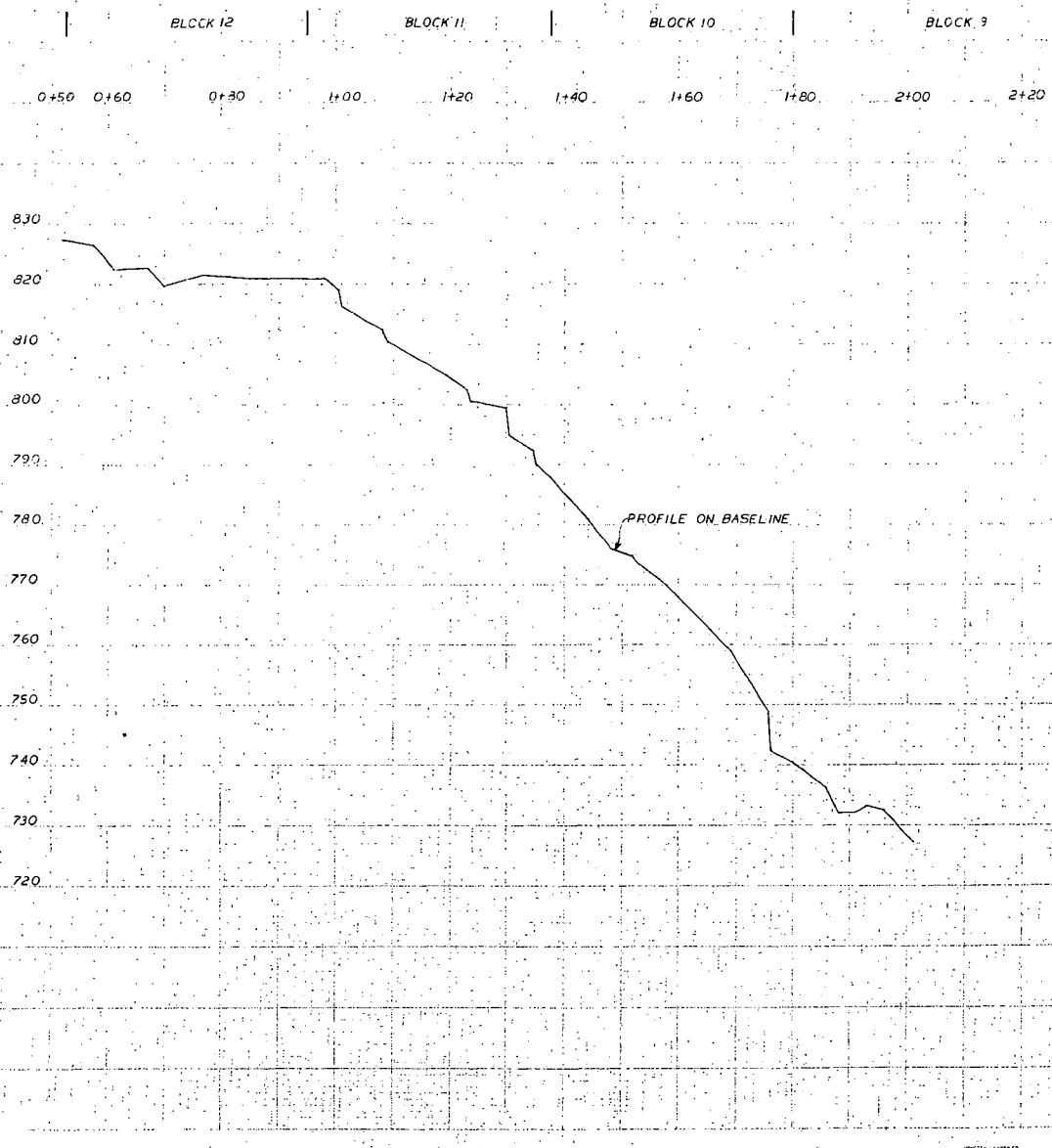
AUTOCAD R14 | 6-16-87 | 65 | C | 10W201 | R 4

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES :(10N201 R3)

PLOT FACTOR:360
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY


TELLICO PROJECT 65-1101
TELLICO PARKWAY
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN
LAND MAP NOS. 1, 2 & 2-1
MATCH LINE
PASTURE
WOODS
ROCK
TVA RESERVATION BOUNDARY
MARY RUTH HALL
TELR-197
TOP OF CUT
BERM DITCH
ARMORED DITCH
30" PIPE
N19°-05'-48"E
TOE OF FILL.
8' DIRT FIELD RD.
UNCULTIVATED
B.O. IDDINS ET AL
TELR-2-101
LOW WIRE EL 836.9
LOW WIRE EL 842.9
16' GRAVEL RD
UNDERGROUND TEL CABLE
MILK HOUSE
SILO
TANK PUMP
DIRT RD.
TOE OF SADDLE DAM FILL
TOE OF ROADWAY FILL
SHOULDER OF RDWY.
RELOCATED ℄
ORIGINAL SURVEY ℄
18" PIPE
TRAIL TO HUFF CEMETERY
℄ SADDLE DAM #3
TOE OF SADDLE DAM FILL
℄ = AVERAGE OF CROOKED ℄
TBM-TL-349 EL 864.96
150' L ℄ STA 437+75
R.R. SPIKE IN 14" PINE
FIRST CIVIL DISTRICT
LOUDON COUNTY TENNESSEE
P.I. = 420+81.54
Δ = 50°-11'-30"
D = 4°-00'
R = 1432.40'
T = 670.86
L = 1254.79'
GROUND LINE
PROFILE GRADE = SUBGRADE
600' V.C.
800' V.C.
800' V.C.
500' V.C.
C 47,197
F 37,790
C 11,286
F 9,247
C 3885
F 3302
BORROW 32,150
C 27,423
F 46,586
L.W. EL 842.9
L.W. EL 836.9
DSGN D.A. VALENTINE
DRWN V. M. NORTON
CHKD J.R. Wholey
SUPV J. L. GLOVER
INSP JR. Fox
ENGINEER K. W. Burnett
ADDED RIGHT OF WAY LIMITS
KNOXVILLE
1-20-77
65 HR
1101H215 R1

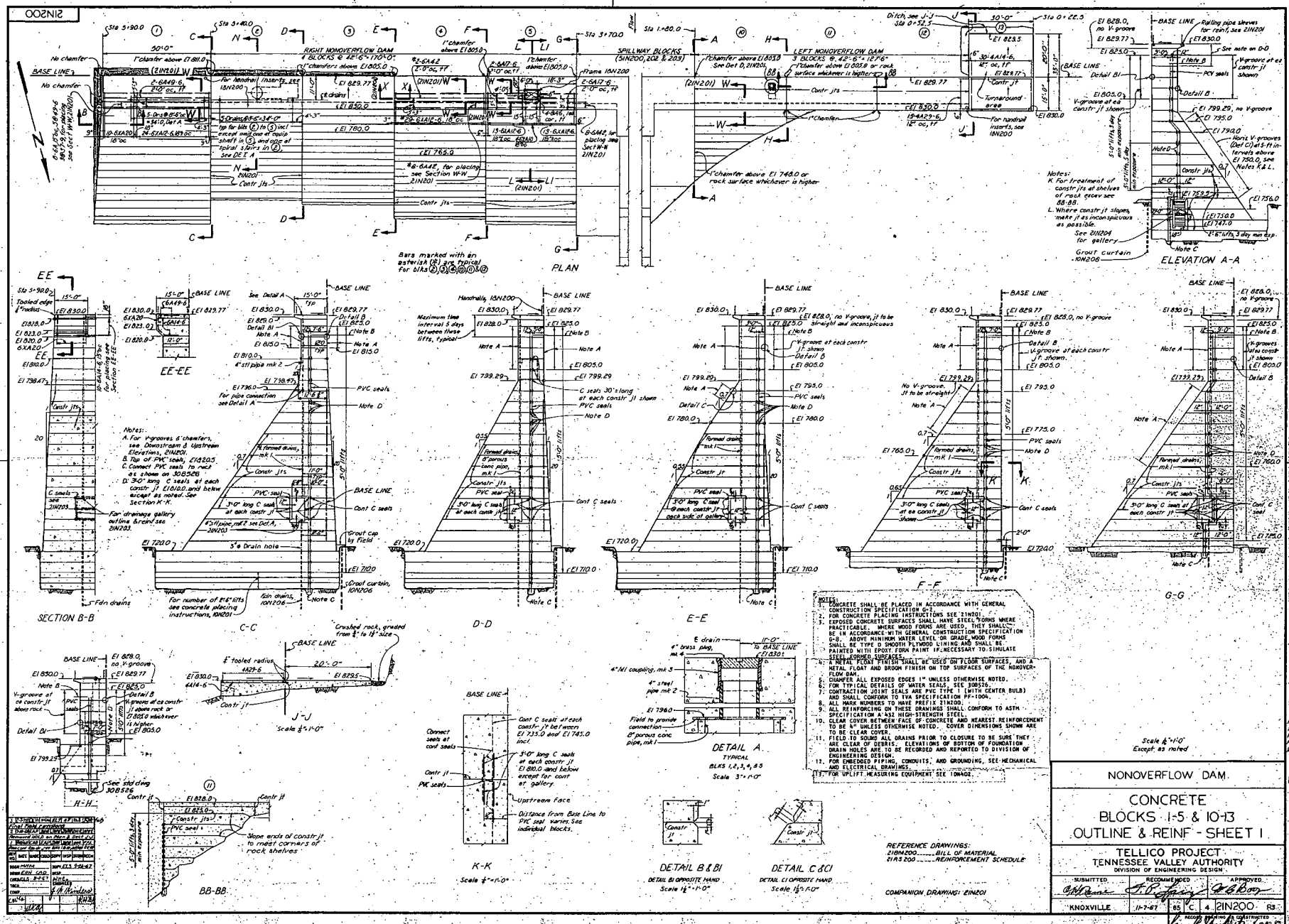


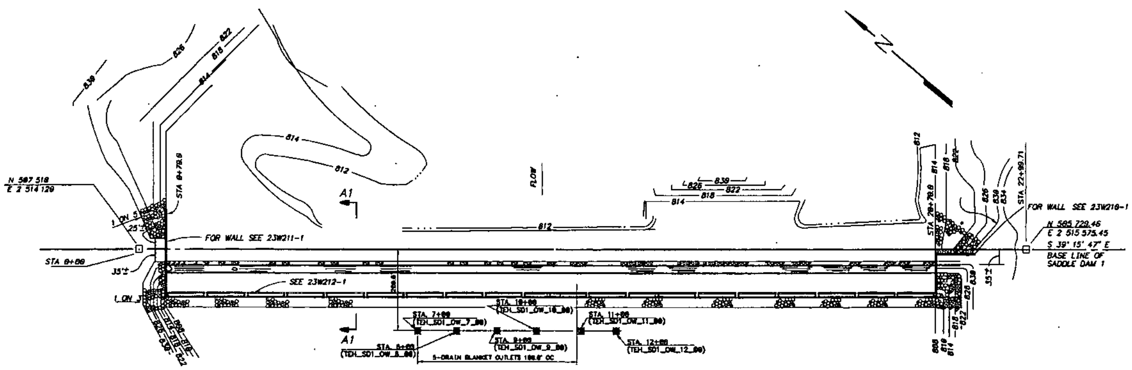
NONOVERFLOW DAM & SPILLWAY

FINAL ROCK SECTIONS BLOCKS 9 THRU 12 STA. 0+52 TO STA. 2+01 - ON B/L

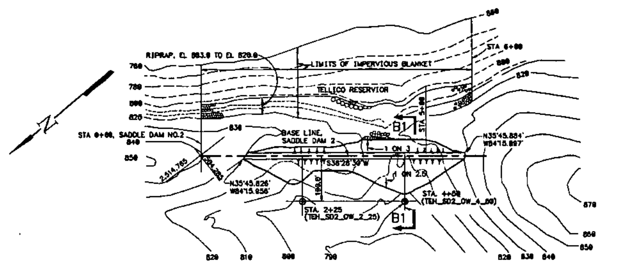
TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF CONSTRUCTION

SUBMITTED	RECOMMENDED	APPROVED
FIELD OFFICE	65 PC 4 21 K 10009	

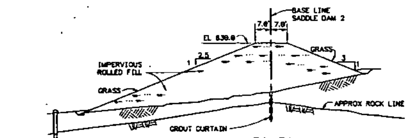

PLAN
ELEVATION A-A
SECTION B-B
EE-EE
C-C
D-D
E-E
F-F
G-G
H-H
J-J
K-K
BB-BB
DETAIL A
DETAIL B & BI
DETAIL C & CI
RIGHT NONOVERFLOW DAM
LEFT NONOVERFLOW DAM
SPILLWAY BLOCKS (2IN200, 202 & 203)
Bars marked with an asterisk (*) are typical for blks (2) (3) (4) (10) (11) (12)
Maximum time interval 5 days between these lifts, typical
Scale 1/4"=1'-0"
Except as noted
NOTES:
1. CONCRETE SHALL BE PLACED IN ACCORDANCE WITH GENERAL CONSTRUCTION SPECIFICATION G-2.
2. FOR CONCRETE PLACING INSTRUCTIONS SEE 2IN201.
3. EXPOSED CONCRETE SURFACES SHALL HAVE STEEL FORMS WHERE PRACTICABLE. WHERE WOOD FORMS ARE USED, THEY SHALL BE IN ACCORDANCE WITH GENERAL CONSTRUCTION SPECIFICATION G-8. ABOVE MINIMUM WATER LEVEL OR GRADE, WOOD FORMS SHALL BE TYPE D SMOOTH PLYWOOD LINING AND SHALL BE PAINTED WITH EPOXY FORM PAINT IF NECESSARY TO SIMULATE STEEL FORMED SURFACES.
4. A METAL FLOAT FINISH SHALL BE USED ON FLOOR SURFACES, AND A METAL FLOAT AND BROOM FINISH ON TOP SURFACES OF THE NONOVERFLOW DAM.
5. CHAMFER ALL EXPOSED EDGES 1" UNLESS OTHERWISE NOTED.
6. FOR TYPICAL DETAILS OF WATER SEALS, SEE 30B526.
7. CONTRACTION JOINT SEALS ARE PVC TYPE 1 (WITH CENTER BULB) AND SHALL CONFORM TO TVA SPECIFICATION PF-1004.
8. ALL MARK NUMBERS TO HAVE PREFIX 2IN200.
9. ALL REINFORCING ON THESE DRAWINGS SHALL CONFORM TO ASTM SPECIFICATION A 432 HIGH-STRENGTH STEEL.
10. CLEAR COVER BETWEEN FACE OF CONCRETE AND NEAREST REINFORCEMENT TO BE 4" UNLESS OTHERWISE NOTED. COVER DIMENSIONS SHOWN ARE TO BE CLEAR COVER.
11. FIELD TO SOUND ALL DRAINS PRIOR TO CLOSURE TO BE SURE THEY ARE CLEAR OF DEBRIS. ELEVATIONS OF BOTTOM OF FOUNDATION DRAIN HOLES ARE TO BE RECORDED AND REPORTED TO DIVISION OF ENGINEERING DESIGN.
12. FOR EMBEDDED PIPING, CONDUITS, AND GROUNDING, SEE MECHANICAL AND ELECTRICAL DRAWINGS.
13. FOR UPLIFT MEASURING EQUIPMENT SEE 10NA08.
REFERENCE DRAWINGS:
2IBM200 ..... BILL OF MATERIAL
2IRS200 ..... REINFORCEMENT SCHEDULE
COMPANION DRAWING: 2IN201
NONOVERFLOW DAM
CONCRETE
BLOCKS 1-5 & 10-13
OUTLINE & REINF - SHEET 1
TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
11-7-67
65 C 4 2IN200 83
RECORD DRAWING AS CONSTRUCTED
6-8-72



PLAN - EMERGENCY SPILLWAY
NTS
(SEE PLAN ON 22W882-3)

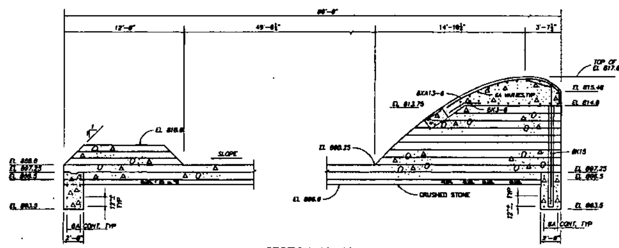


PLAN-SADDLE DAM 2
SCALE 1"=100'



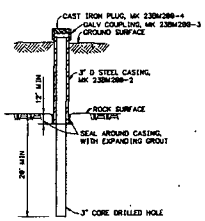
B1-B1
SCALE 1"=20'

NOTE:
THERE IS ONE SETTLEMENT MONUMENT ON SADDLE DOM NO.2 SD2-2A (TEH.SS_SD_2_2A) THE EXACT LOCATION IS NOT KNOWN AT THIS TIME.



SECTION A1-A1
SCALE ½" = 1'-0"
(SECTION A3-A3, 22W882-3)

TABLE 1							
SADDLE DAM #1 OBSERVATION WELLS							
INSTRUMENT ID	DATABASE NAME	STATION	GROUND ELEVATION (FT)	BOTTOM OF HOLE (FT)	DEPTH (FT)	LATITUDE	LONGITUDE
STA.7+00	TEH_SD1_OW_7_00	7+00	808.8	764.6	44.2	N35 46.320	W84 15.951
STA.8+00	TEH_SD1_OW_8_00	8+00	803.2	754.0	49.2	N35 46.306	W84 15.936
STA.9+00	TEH_SD1_OW_9_00	9+00	804.7	759.40	45.3	N35 46.293	W84 15.924
STA.10+00	TEH_SD1)_OW_10_00	10+00	807.8	767.40	40.4	N35 46.280	W84 15.912
STA.11+00	TEH_SD1_OW_11_00	11+00	806.6	780.90	25.7	N35 46.267	W84 15.899
STA.12+00	TEH_SD1_OW_12_00	12+00	807.9	757.70	50.2	N35 46.254	W84 15.887

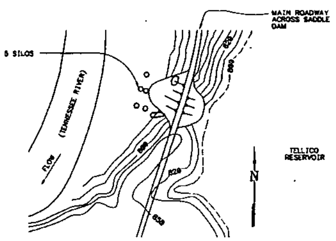


DETAIL C1
OBSERVATION WELLS
6 REQD
NTS

TABLE 2							
SADDLE DAM #2 OBSERVATION WELLS							
INSTRUMENT ID	DATABASE NAME	STATION	GROUND ELEVATION (FT)	BOTTOM OF HOLE (FT)	DEPTH (FT)	LATITUDE	LONGITUDE
STA.2+25	TEH_SD2_OW_2_25	2+25	799.4	755.00	43.8	N35 45.870	W84 15.970
STA.4+50	TEH_SD2_OW_4_50	4+50	799.1	762.00	36.3	N35 45.848	W84 15.988

NOTE:
FOR KEY PLAN, SEE 10W855-1

KEY
⊙ OW= OBSERVATION/GROUNDWATER WELL
▨ SS= SURVEY/SETTLEMENT MARKER
⊠ ABANDONED OBSERVATION/GROUNDWATER WELL



PLAN-SADDLE DAM 3
NTS

COMPANION DWGS: 21W855-1

MAY 0 2 2008

R 0	3-31-2008	BWH	TR	JAG	SRH	DJH	RWT	DWM		0
INITIAL ISSUE										
REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST

SCALE: 1"=10'-0" EXCEPT AS NOTED

LEFT RIM
SADDLE DAMS

INSTRUMENTATION
OBSERVATION WELLS & SETTLEMENT MARKERS
PLAN & SECTIONS, SH.1

B.W. HALL | R.R. SMITH | J.A. GRAVES | S.R. KRAMER | D.J. HELTON | R.W. TOMPKINS | D.W. MAULDIN

TELLICO HYDRO PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

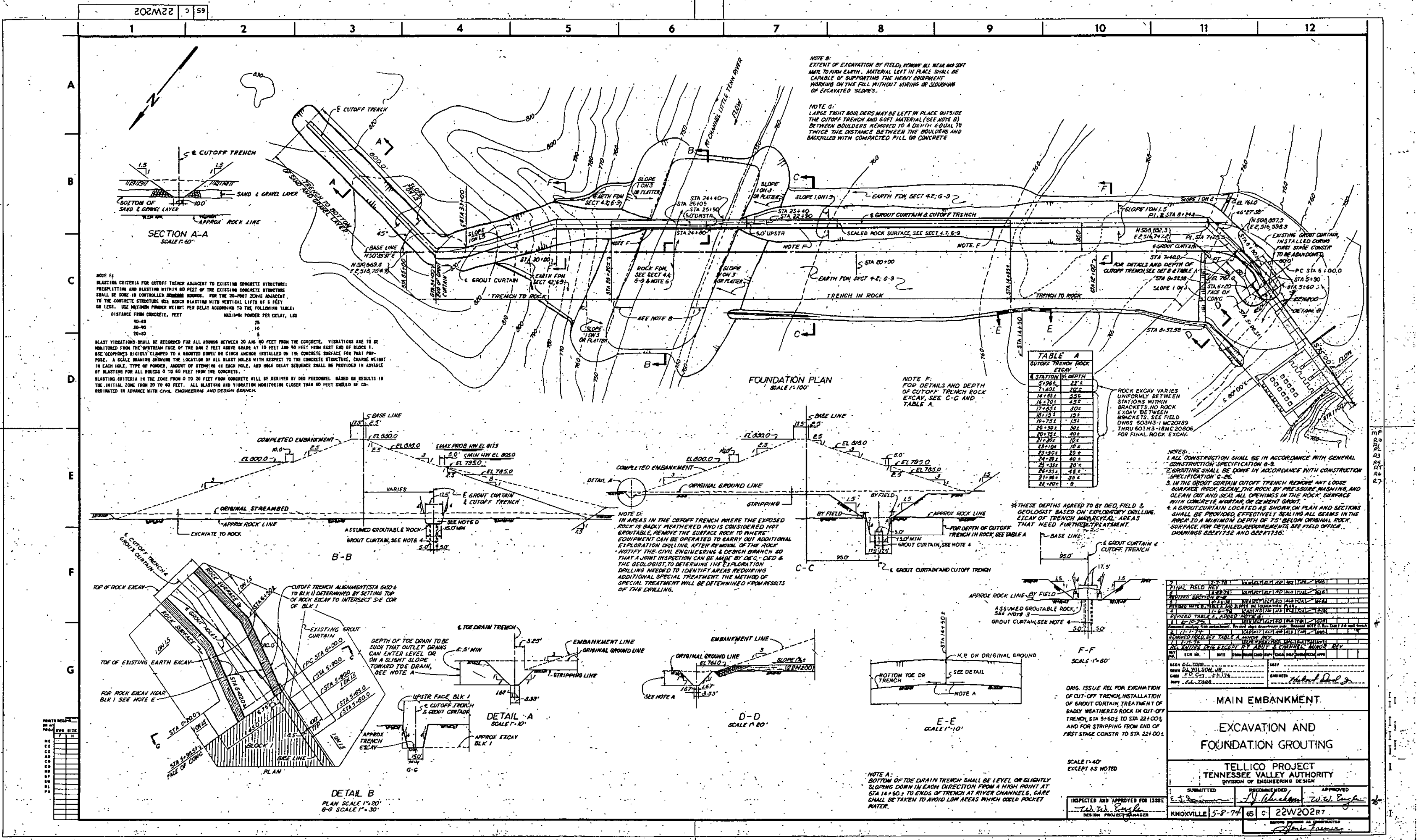
AUTOCAD R00 | 65 | OS | 21W856-1 | R 0

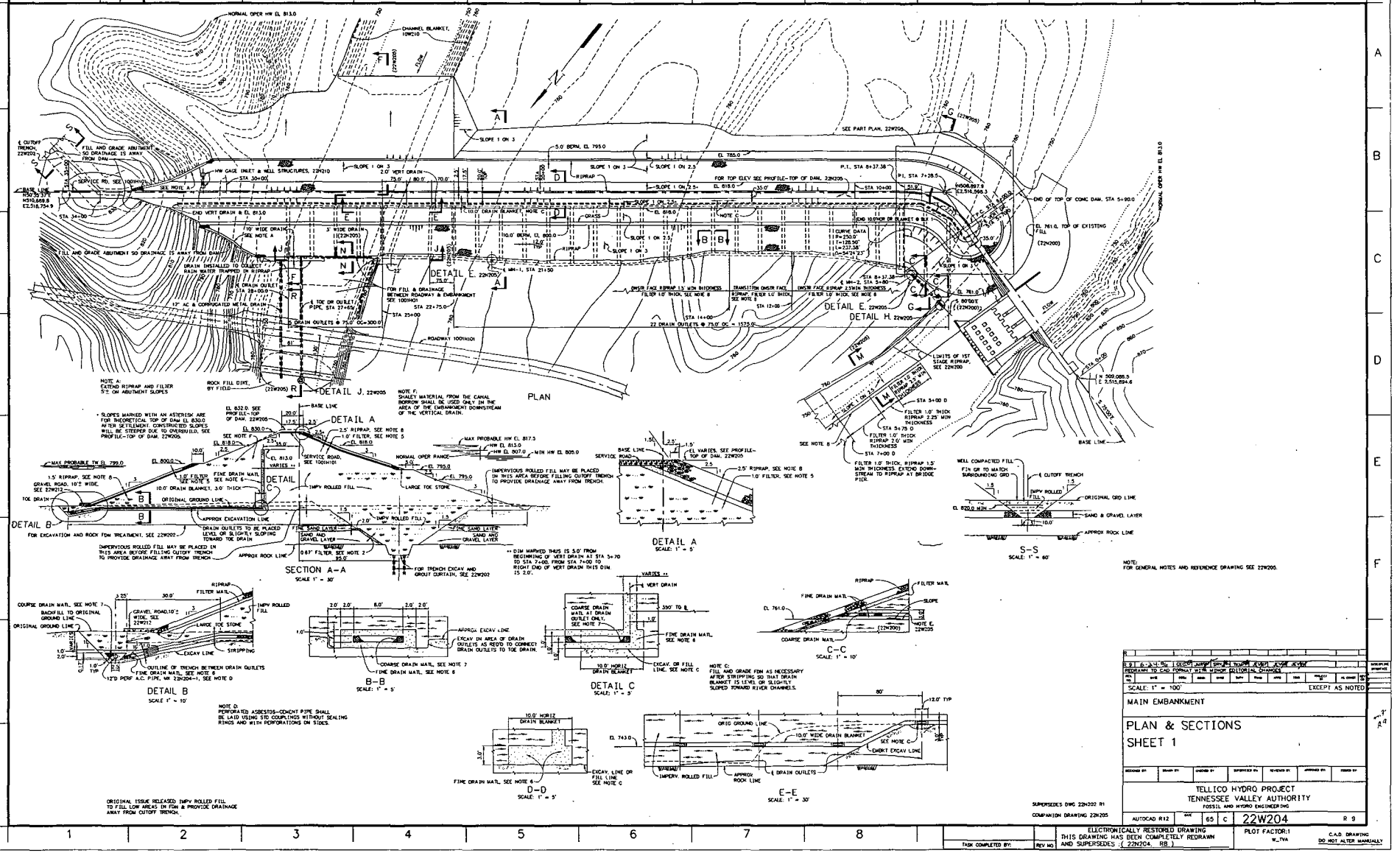
PLOT FACTOR:1
W_TVA

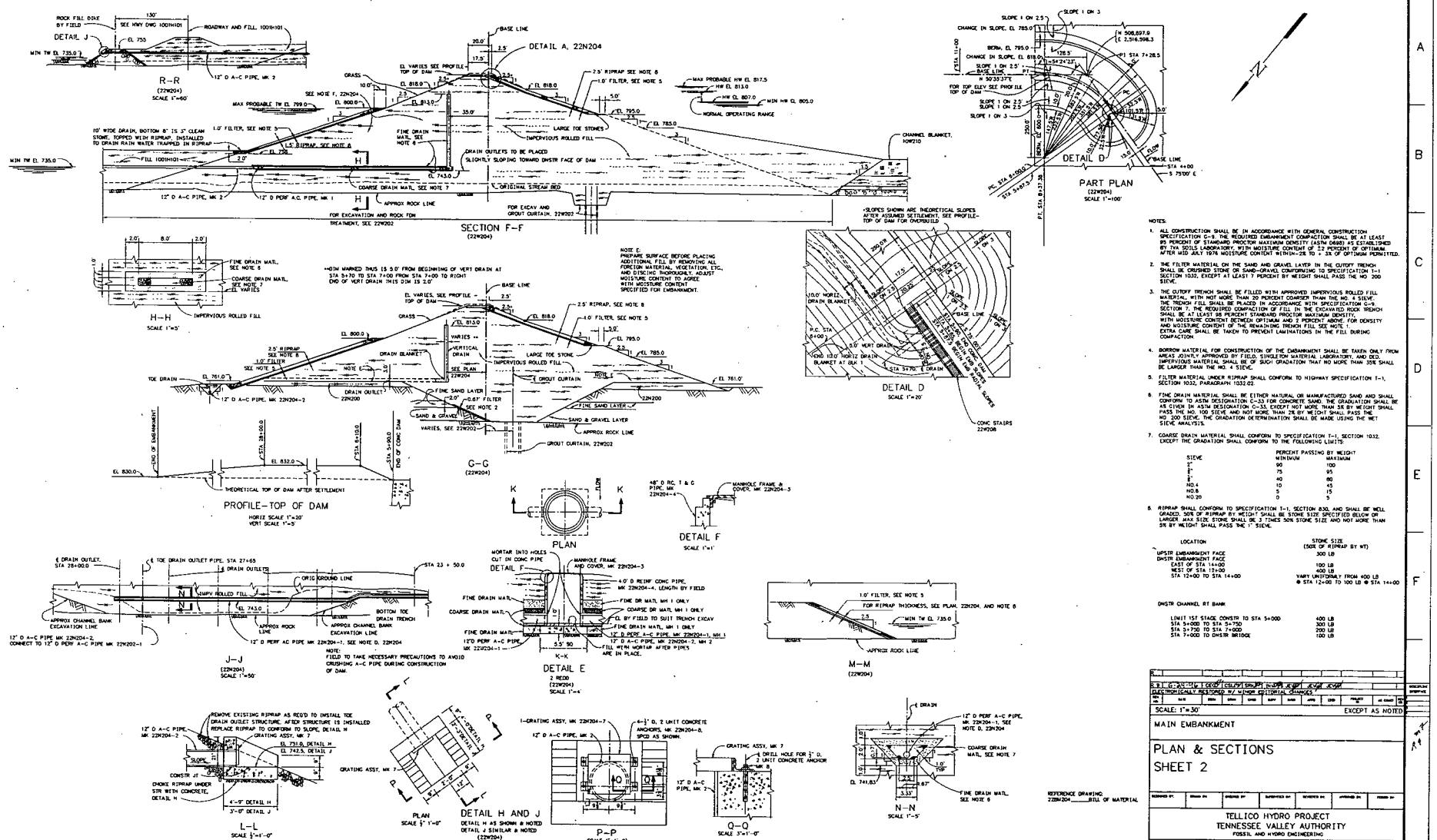
C.A.D. DRAWING
DO NOT ALTER MANUALLY

TASK COMPLETED BY: | REV NO.

65 OS 21W856-1


FOUNDATION PLAN
SCALE 1"=100'
SECTION A-A
SCALE 1"=60'
B-B
C-C
DETAIL A
SCALE 1"=10'
D-D
SCALE 1"=20'
E-E
SCALE 1"=10'
F-F
SCALE 1"=60'
DETAIL B
PLAN SCALE 1"=20'
G-G SCALE 1"=30'
NOTE B:
EXTENT OF EXCAVATION BY FIELD; REMOVE ALL WEAK AND SOFT MATL TO FIRM EARTH. MATERIAL LEFT IN PLACE SHALL BE CAPABLE OF SUPPORTING THE HEAVY EQUIPMENT WORKING ON THE FILL WITHOUT MIRING OR SLOUGHING OF EXCAVATED SLOPES.
NOTE G:
LARGE TIGHT BOULDERS MAY BE LEFT IN PLACE OUTSIDE THE CUTOFF TRENCH AND SOFT MATERIAL (SEE NOTE B) BETWEEN BOULDERS REMOVED TO A DEPTH EQUAL TO TWICE THE DISTANCE BETWEEN THE BOULDERS AND BACKFILLED WITH COMPACTED FILL OR CONCRETE
NOTE D:
IN AREAS IN THE CUTOFF TRENCH WHERE THE EXPOSED ROCK IS BADLY WEATHERED AND IS CONSIDERED NOT GROUTABLE, REMOVE THE SURFACE ROCK TO WHERE EQUIPMENT CAN BE OPERATED TO CARRY OUT ADDITIONAL EXPLORATION DRILLING. AFTER REMOVAL OF THE ROCK NOTIFY THE CIVIL ENGINEERING & DESIGN BRANCH SO THAT A JOINT INSPECTION CAN BE MADE BY DEC, DED & THE GEOLOGIST, TO DETERMINE THE EXPLORATION DRILLING NEEDED TO IDENTIFY AREAS REQUIRING ADDITIONAL SPECIAL TREATMENT. THE METHOD OF SPECIAL TREATMENT WILL BE DETERMINED FROM RESULTS OF THE DRILLING.
NOTE F:
FOR DETAILS AND DEPTH OF CUTOFF TRENCH ROCK EXCAV, SEE C-C AND TABLE A.
TABLE A
CUTOFF TRENCH ROCK EXCAV
℄ STATION | ※ DEPTH
5+96± | 23'±
7+40± | 20'±
14+65± | 55±
16+70± | 45±
17+85± | 30±
18+15± | 15±
19+75± | 15±
20+50± | 50±
20+75± | 40±
21+30± | 10±
23+10± | 10±
23+30± | 20±
24+20± | 40±
25+35± | 20±
26+35± | 45±
27+90± | 35±
28+10± | 0
ROCK EXCAV VARIES UNIFORMLY BETWEEN STATIONS WITHIN BRACKETS. NO ROCK EXCAV BETWEEN BRACKETS. SEE FIELD DWGS 603H3-1 MC20789 THRU 603H3-18MC20806 FOR FINAL ROCK EXCAV.
※THESE DEPTHS AGREED TO BY DED, FIELD & GEOLOGIST BASED ON EXPLORATORY DRILLING. EXCAV OF TRENCH MAY REVEAL AREAS THAT NEED FURTHER TREATMENT.
NOTES:
1. ALL CONSTRUCTION SHALL BE IN ACCORDANCE WITH GENERAL CONSTRUCTION SPECIFICATION G-9.
2. GROUTING SHALL BE DONE IN ACCORDANCE WITH CONSTRUCTION SPECIFICATION G-26.
3. IN THE GROUT CURTAIN CUTOFF TRENCH REMOVE ANY LOOSE SURFACE ROCK, CLEAN THE ROCK BY PRESSURE WASHING, AND CLEAN OUT AND SEAL ALL OPENINGS IN THE ROCK SURFACE WITH CONCRETE MORTAR OR CEMENT GROUT.
4. A GROUT CURTAIN LOCATED AS SHOWN ON PLAN AND SECTIONS SHALL BE PROVIDED, EFFECTIVELY SEALING ALL SEAMS IN THE ROCK TO A MINIMUM DEPTH OF 75' BELOW ORIGINAL ROCK SURFACE. FOR DETAILED REQUIREMENTS SEE FIELD OFFICE DRAWINGS 622K1732 AND 622K1736.
NOTE A:
BOTTOM OF TOE DRAIN TRENCH SHALL BE LEVEL OR SLIGHTLY SLOPING DOWN IN EACH DIRECTION FROM A HIGH POINT AT STA 14+50± TO ENDS OF TRENCH AT RIVER CHANNELS. CARE SHALL BE TAKEN TO AVOID LOW AREAS WHICH COULD POCKET WATER.
ORIG. ISSUE REL FOR EXCAVATION OF CUT-OFF TRENCH, INSTALLATION OF GROUT CURTAIN, TREATMENT OF BADLY WEATHERED ROCK IN CUT-OFF TRENCH, STA 5+60± TO STA 22+00±, AND FOR STRIPPING FROM END OF FIRST STAGE CONSTR TO STA 22+00±
SCALE 1"=40'
EXCEPT AS NOTED
7 2-7-78 FINAL FIELD REV
6 6-29-76 REVISED SECTION B-B
5 4-26-76 REVISED NOTE B, TABLE A AND SLOPES ON FOUNDATION PLAN.
4 1-6-76 REVISED TABLE A, ADDED NOTE G
3 6-10-75
2 11-1-74 REMOVED HOLD, REV TABLE A, MINOR REV.
1 7-11-74 REL ENTIRE DWG EXCEPT RT ABUT & CHANNEL. MINOR REV
DSGN E.L. TODD
DRWN D.L. WILSON, JR.
SUPV E.L. TODD
MAIN EMBANKMENT
EXCAVATION AND FOUNDATION GROUTING
TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN
SUBMITTED
RECOMMENDED
APPROVED
INSPECTED AND APPROVED FOR ISSUE
DESIGN PROJECT MANAGER
KNOXVILLE 5-8-74 65 C 22W202 R7


PLAN
SECTION A–A
SCALE 1" = 30'
DETAIL A
SCALE: 1" = 5'
S–S
SCALE: 1" = 60'
DETAIL B
SCALE 1" = 10'
B–B
SCALE: 1" = 5'
DETAIL C
SCALE: 1" = 5'
C–C
SCALE: 1" = 10'
D–D
SCALE: 1" = 5'
E–E
SCALE: 1" = 30'
NOTE A: EXTEND RIPRAP AND FILTER 5'± ON ABUTMENT SLOPES
NOTE F: SHALEY MATERIAL FROM THE CANAL BORROW SHALL BE USED ONLY IN THE AREA OF THE EMBANKMENT DOWNSTREAM OF THE VERTICAL DRAIN.
NOTE D: PERFORATED ASBESTOS-CEMENT PIPE SHALL BE LAID USING STD COUPLINGS WITHOUT SEALING RINGS AND WITH PERFORATIONS ON SIDES.
NOTE C: FILL AND GRADE FDN AS NECESSARY AFTER STRIPPING SO THAT DRAIN BLANKET IS LEVEL OR SLIGHTLY SLOPED TOWARD RIVER CHANNELS.
NOTE: FOR GENERAL NOTES AND REFERENCE DRAWING SEE 22W205.
ORIGINAL ISSUE RELEASED. IMPV ROLLED FILL TO FILL LOW AREAS IN FDN & PROVIDE DRAINAGE AWAY FROM CUTOFF TRENCH.
SUPERSEDES DWG 22N202 R1
COMPANION DRAWING 22N205
SCALE: 1" = 100'
EXCEPT AS NOTED
MAIN EMBANKMENT
PLAN & SECTIONS
SHEET 1
TELLICO HYDRO PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING
AUTOCAD R12
65 C 22W204 R 9
ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES: (22N204, R8)
PLOT FACTOR:1
W_TVA
C.A.D. DRAWING
DO NOT ALTER MANUALLY



NOTES:

1. ALL CONSTRUCTION SHALL BE IN ACCORDANCE WITH GENERAL CONSTRUCTION SPECIFICATION G-9. THE REQUIRED EMBANKMENT COMPACTION SHALL BE AT LEAST 95 PERCENT OF STANDARD PROCTOR MAXIMUM DENSITY (ASTM D698) AS ESTABLISHED BY TVA SOILS LABORATORY, WITH MOISTURE CONTENT OF 1-2 PERCENT OF OPTIMUM, AFTER MID JULY 1976 MOISTURE CONTENT WITHIN -2% TO + 3% OF OPTIMUM PERMITTED.
2. THE FILTER MATERIAL ON THE SAND AND GRAVEL LAYER IN THE CUTOFF TRENCH SHALL BE CRUSHED STONE OR SAND-GRAVEL CONFORMING TO SPECIFICATION 1-1 SECTION 1032, EXCEPT AT LEAST 7 PERCENT BY WEIGHT SHALL PASS THE NO. 200 SIEVE.
3. THE CUTOFF TRENCH SHALL BE FILLED WITH APPROVED IMPERVIOUS ROLLED FILL MATERIAL, WITH NOT MORE THAN 20 PERCENT COARSER THAN THE NO. 4 SIEVE. THE TRENCH FILL SHALL BE PLACED IN ACCORDANCE WITH SPECIFICATION G-9 SECTION 7. THE REQUIRED COMPACTION OF FILL IN THE EXCAVATED ROCK TRENCH SHALL BE AT LEAST 98 PERCENT STANDARD PROCTOR MAXIMUM DENSITY WITH MOISTURE CONTENT BETWEEN OPTIMUM AND 2 PERCENT ABOVE FOR DENSITY AND MOISTURE CONTENT OF THE REMAINING TRENCH FILL SEE NOTE 1. EXTRA CARE SHALL BE TAKEN TO PREVENT LAMINATIONS IN THE FILL DURING COMPACTION.
4. BORROW MATERIAL FOR CONSTRUCTION OF THE EMBANKMENT SHALL BE TAKEN ONLY FROM AREAS JOINTLY APPROVED BY FIELD, SINGLETON MATERIAL LABORATORY, AND DED. IMPERVIOUS MATERIAL SHALL BE OF SUCH GRADATION THAT NO MORE THAN 35% SHALL BE LARGER THAN THE NO. 4 SIEVE.
5. FILTER MATERIAL UNDER RIPRAP SHALL CONFORM TO HIGHWAY SPECIFICATION T-1, SECTION 1032, PARAGRAPH 1032.02.
6. FINE DRAIN MATERIAL SHALL BE EITHER NATURAL OR MANUFACTURED SAND AND SHALL CONFORM TO ASTM DESIGNATION C-33 FOR CONCRETE SAND. THE GRADATION SHALL BE AS GIVEN IN ASTM DESIGNATION C-33, EXCEPT NOT MORE THAN 5% BY WEIGHT SHALL PASS THE NO. 100 SIEVE, AND NOT MORE THAN 2% BY WEIGHT SHALL PASS THE NO. 200 SIEVE. THE GRADATION DETERMINATION SHALL BE MADE USING THE WET SIEVE ANALYSIS.
7. COARSE DRAIN MATERIAL SHALL CONFORM TO SPECIFICATION T-1, SECTION 1032, EXCEPT THE GRADATION SHALL CONFORM TO THE FOLLOWING LIMITS:

SIEVE	PERCENT PASSING BY WEIGHT MINIMUM	MAXIMUM
2"	90	100
1"	75	95
⅜"	40	80
NO.4	10	45
NO.8	5	15
NO.20	0	5

8. RIPRAP SHALL CONFORM TO SPECIFICATION T-1, SECTION 830, AND SHALL BE WELL GRADED, 50% OF RIPRAP BY WEIGHT SHALL BE STONE SIZE SPECIFIED BELOW OR LARGER. MAX SIZE STONE SHALL BE 3 TIMES 50% STONE SIZE AND NOT MORE THAN 5% BY WEIGHT SHALL PASS THE 1" SIEVE.

LOCATION	STONE SIZE (50% OF RIPRAP BY WT)
UPSTR EMBANKMENT FACE	300 LB
DWSTR EMBANKMENT FACE	
EAST OF STA 14+00	100 LB
WEST OF STA 12+00	400 LB
STA 12+00 TO STA 14+00	VARY UNIFORMLY FROM 400 LB @ STA 12+00 TO 100 LB @ STA 14+00

DWSTR CHANNEL RT BANK

LIMIT 1ST STAGE CONSTR TO STA 5+000	400 LB
STA 5+000 TO STA 5+750	300 LB
STA 5+750 TO STA 7+000	200 LB
STA 7+000 TO DWSTR BRIDGE	100 LB

NOTE E: PREPARE SURFACE BEFORE PLACING ADDITIONAL FILL BY REMOVING ALL FOREIGN MATERIAL, VEGETATION, ETC., AND DISCING THOROUGHLY. ADJUST MOISTURE CONTENT TO AGREE WITH MOISTURE CONTENT SPECIFIED FOR EMBANKMENT.

*SLOPES SHOWN ARE THEORETICAL SLOPES AFTER ASSUMED SETTLEMENT, SEE PROFILE-TOP OF DAM FOR OVERBUILD

*DIM MARKED THUS IS 5.0' FROM BEGINNING OF VERT DRAIN AT STA 5+70 TO STA 7+00 FROM STA 7+00 TO RIGHT END OF VERT DRAIN THIS DIM IS 2.0'

REFERENCE DRAWING 22W204 ____ BILL OF MATERIAL

COMPANION DRAWING: 22W204

SCALE: 1"=30' EXCEPT AS NOTED

MAIN EMBANKMENT

PLAN & SECTIONS
SHEET 2

TELLICO HYDRO PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

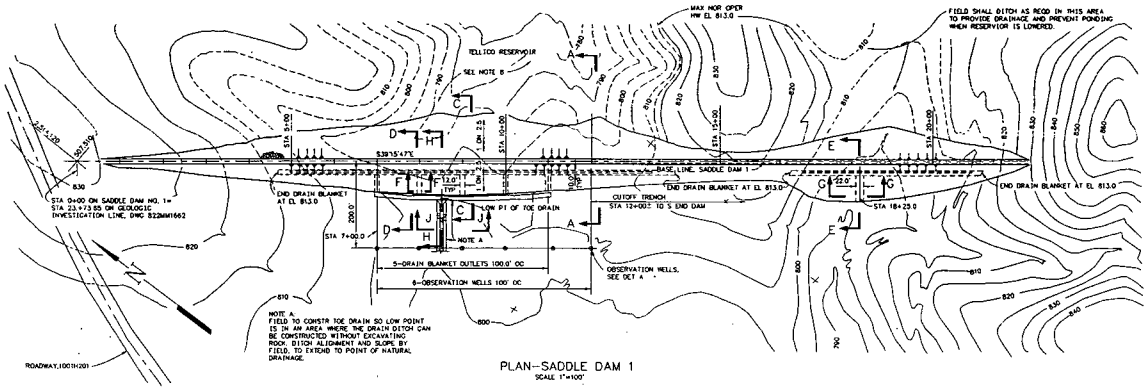
AUTOCAD R12 | DATE | 65 | C | 22W205 | R 9

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES :(22N205, R8)

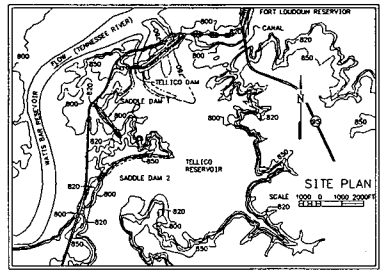
TASK COMPLETED BY: | REV NO.:

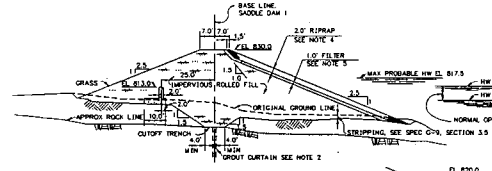
PLOT FACTOR:1
W_TVA

C.A.D. DRAWING DO NOT ALTER MANUALLY

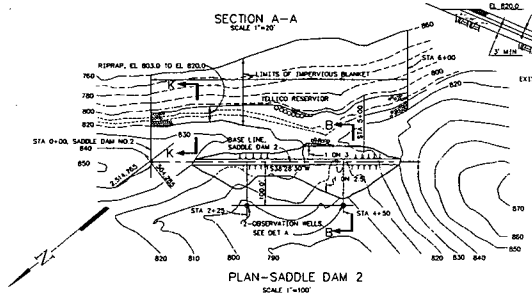


PLAN–SADDLE DAM 1
SCALE 1"=100'

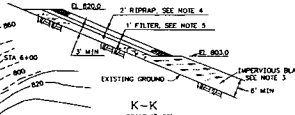




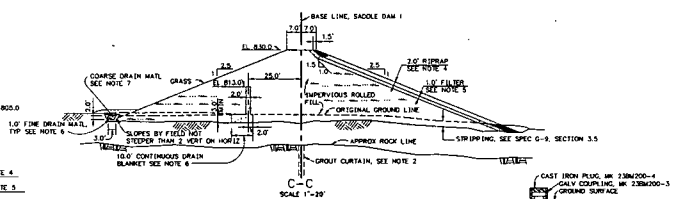
SECTION A–A
SCALE 1"=20'



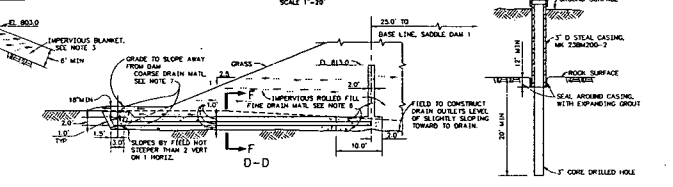
PLAN–SADDLE DAM 2
SCALE 1"=100'



K–K
SCALE 1"=20'

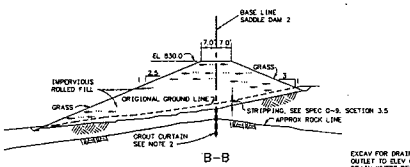


C–C
SCALE 1"=20'

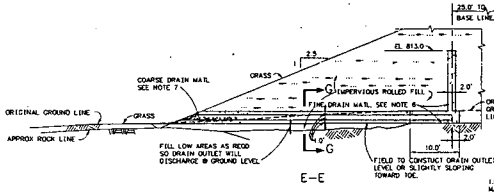


D–D

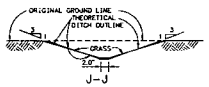
DETAIL A
OBSERVATION WELLS
6 REQD
NTS



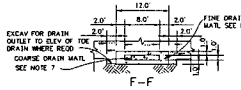
B–B
SCALE 1"=20'



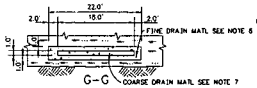
E–E



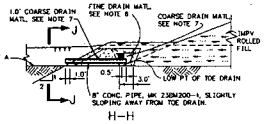
J–J



F–F



G–G



H–H

NOTES

1. ALL CONSTR SHALL BE IN ACCORDANCE WITH GENERAL CONSTRUCTION SPECIFICATION G-8.
2. A GROUT CURTAIN LOCATED AS SHOWN ON PLAN AND SECTIONS SHALL BE PROVIDED EFFECTIVELY SEALING ALL SEAMS IN ROCK TO A MINIMUM TOTAL DEPTH OF 50 FEET BELOW ORIGINAL ROCK SURFACE. FOR DETAILED REQUIREMENTS SEE MEMO DUNHAM TO FARMER, DATED JANUARY 31, 1974, AND FIELD OFFICE DWG. 822W2060
3. THE REQUIRED EMBANKMENT COMPACTION SHALL BE AT LEAST 95% OF STANDARD PROCTOR MAXIMUM DENSITY (ASTM D698), AS ESTABLISHED BY THE TVA SOILS LABORATORY, WITH MOISTURE CONTENT OF 22% OF OPTIMUM.
4. RIPRAP SHALL CONFORM TO SPECIFICATION T-1, SECTION 830, AND SHALL BE WELL GRADED WITH THE FOLLOWING LIMITS: 50% OF RIPRAP BY WEIGHT SHALL BE 200 LB STONES OR LARGER. MAX SIZE STONE SHALL BE 600 LB AND NOT MORE THAN 5% BY WEIGHT SHALL PASS THE 1" SIEVE.
5. FILTER MATERIAL UNDER RIPRAP SHALL CONFORM TO HIGHWAY SPECIFICATION T-1, SECTION 1032, PARAGRAPH 1032.07
6. FINE DRAIN MATERIAL MAY BE EITHER NATURAL OR MANUFACTURED SAND AND SHALL CONFORM TO ASTM DESIGNATION C-33 FOR CONCRETE SAND. THE GRADATION SHALL BE AS GIVEN IN ASTM DESIGNATION C-33, EXCEPT NOT MORE THAN 5% BY WEIGHT SHALL PASS THE NO. 100 SIEVE AND NOT MORE THAN 2% BY WEIGHT SHALL PASS THE NO. 200 SIEVE. THE GRADATION DETERMINATION SHALL BE MADE USING THE WET SIEVE ANALYSIS.
7. COARSE DRAIN MATERIAL SHALL CONFORM TO SPECIFICATION T-1, SECTION 1032, EXCEPT THE GRADATION SHALL CONFORM TO THE FOLLOWING LIMITS:

SIEVE	PERCENT PASSING BY WEIGHT MINIMUM	MAXIMUM
2"	90	100
3/4"	75	95
3/8"	40	80
NO 4	10	45
NO 8	5	15
NO 20	0	5

8. THE UPSTREAM AREA OF SADDLE DAM 1 BETWEEN STATIONS 4 + 00 AND 14 + 00 AND EXTENDING 400' UPSTREAM OF THE TOE SHALL BE THOROUGHLY EXPLORED FOR THIN POCKETS IN THE NATURAL OVERBURDEN BLANKET. IN ALL AREAS WHERE THE OVERBURDEN IS LESS THAN 5' THICK THE AREA SHALL BE CRUBBED AND STRIPPED AND IMPERVIOUS MATERIAL SHALL BE PLACED TO INSURE A MINIMUM 5' THICK CONTINUOUS IMPERVIOUS BLANKET. COMPACTION SHALL BE AS SPECIFIED IN NOTE 3. SURFACE AREA OF IMPERVIOUS BLANKET TO BE GRASSED.

REFERENCE DRAWING
23BM200 BILL OF MATERIAL

COMPANION DRAWING: 23W201

ELECTRONICALLY RESTORED
SCALE: 1"=10'-0" EXCEPT AS NOTED

LEFT RIM
SADDLE DAMS

PLANS, SECTIONS AND DETAILS

TELLICO HYDRO PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

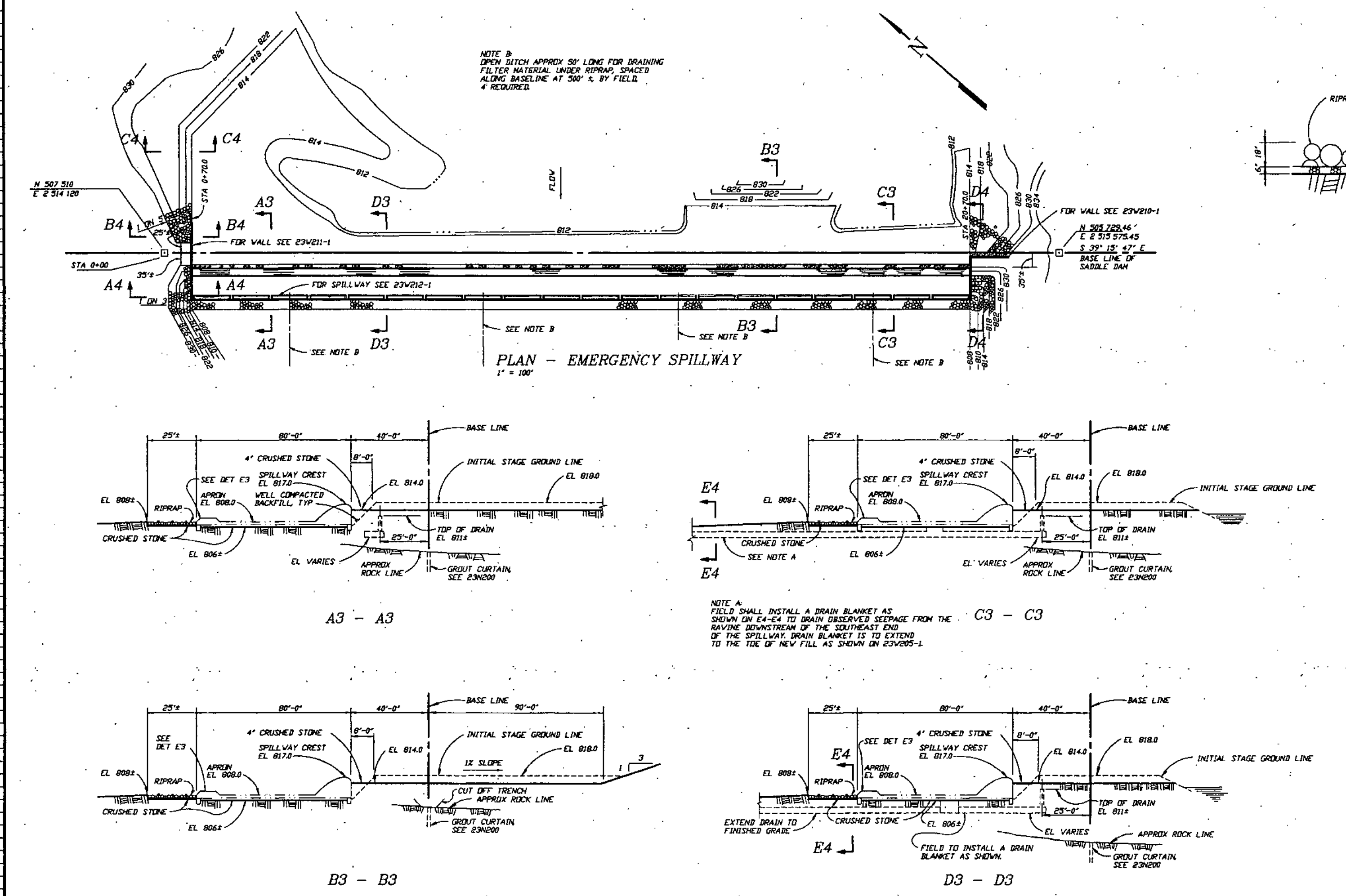
AUTOCAD R12 | 65 | P | 23W200 | R 8

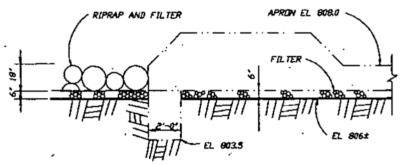
PLOT FACTOR:1
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

TASK COMPLETED BY: | REV NO.

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES :[23W200, R7]





DET E3
SHOWING TYP RIPRAP AND FILTER
3/8" = 1'-0"

NOTES:

1. COARSE DRAIN MATERIAL SHALL CONFORM TO HIGHWAY SPECIFICATION T-1, SECTION 1032, EXCEPT THE GRADATION SHALL CONFORM TO THE FOLLOWING LIMITS:

SIEVE	PERCENT PASSING BY WEIGHT MINIMUM	MAXIMUM
2"	100	- -
1 1/2"	95	100
3/4"	70	92
3/8"	50	70
NO. 4	35	55
NO. 30	12	25
NO. 200	0	8

2. FINE DRAIN MATERIAL MAY BE EITHER NATURAL OR MANUFACTURED SAND AND SHALL CONFORM TO ASTM C 33 FOR CONCRETE SAND. THE GRADATION SHALL BE AS GIVEN IN ASTM C 33, EXCEPT NOT MORE THAN 5 % BY WEIGHT SHALL PASS THE NO. 100 SIEVE AND NOT MORE THAN 2 % BY WEIGHT SHALL PASS THE NO. 200 SIEVE. THE GRADATION DETERMINATION SHALL BE MADE USING THE WET SIEVE ANALYSIS. FIELD MAY USE TERRATEX NO. 8 FILTER FABRIC OR EQUAL IN LIEU OF FINE DRAIN MATERIAL.
3. UNDER NO CIRCUMSTANCES MAY THE SADDLE DAM BE CUT BELOW EL 818.0 UNTIL THE EMERGENCY SPILLWAY HAS BEEN PLACED AND PROPERLY CURED.
4. FOR RIPRAP NOTE SEE 23N200. USE EXISTING RIPRAP FROM UPSTREAM SLOPE OF SADDLE DAM NO. 1.
5. FOR ADDITIONAL NOTES SEE 23W205-2

REV NO.	CHANGE REF	DATE	DRWN	DSGN	CHKD	RVWD	APPD	ISSD
2	REV SECT A3-A3 THRU D3-D3 TO REFLECT AS CONSTRUCTED STATUS	8-28-90	GARH	GARH	HAM	HAM		
1	REV PLAN, SECT C3-C3 & D3-D3, AND NOTES.	10-19-88	GLRH	GLRH	AE	AE		JHC

SCALE: 1" = 20' EXCEPT AS NOTED

LEFT RIM
SADDLE DAM NO.1

EMERGENCY SPILLWAY FINAL EXCAV, DRAINAGE & GRADING PLAN, SECTIONS AND DETAILS

TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
N

DESIGN		DISCIPLINE INTERFACE		ENGINEERING APPROVAL
DRAWN: GREGORY L HICKEY	DESIGNED: GREGORY L HICKEY	1	2	RUSSEL B MYERS
CHECKED: ARNOLD ESTEP	REVIEWED: ARNOLD ESTEP	3	4	CARL L. SPEARMAN

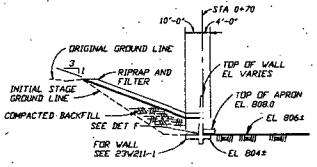
ENGINEERING DATE 5-31-88 | 65 | C | 23W205 - 3 | R 2

ISSUED BY: G. L. BUCHANAN

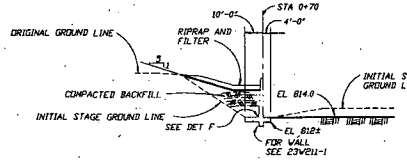
AS CONSTRUCTED: DC-JHC 7-30-90 (C04 900730 001)

CAD SYSTEM ORIGINAL
DO NOT CHANGE MANUALLY

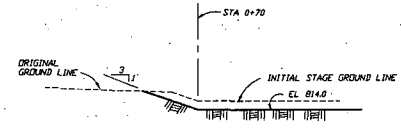
65 C 23W205 - 3



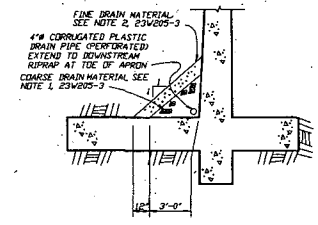
A4 – A4



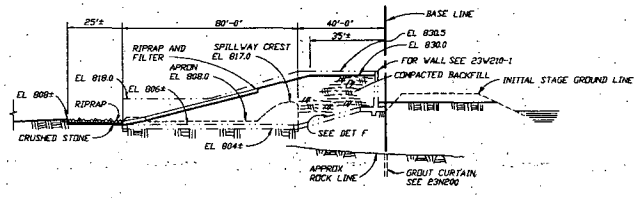
B4 – B4



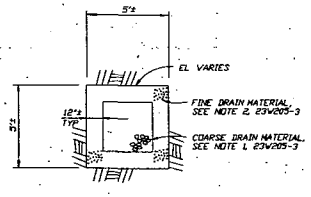
C4 – C4



DETAIL F
3/8" = 1'-0"



D4 – D4



E4 – E4
3/8" = 1'-0"

NOTES:
1. FOR LIST SEE 23W205-3.

1	8-28-90	[illegible]						
SIGNED DRAWING AS CONSTRUCTED DC-MC 7-30-90 (CO4 900730 001)								
REV	CHANGE NO	DATE	DRAW	DESIGN	CHK'D	APV'D	ISSD	

SCALE 1" = 20' EXCEPT AS NOTED

LEFT RIM
SADDLE DAM NO. 1

EMERGENCY SPILLWAY FINAL EXCAV, DRAINAGE & GRADING SECTIONS AND DETAILS

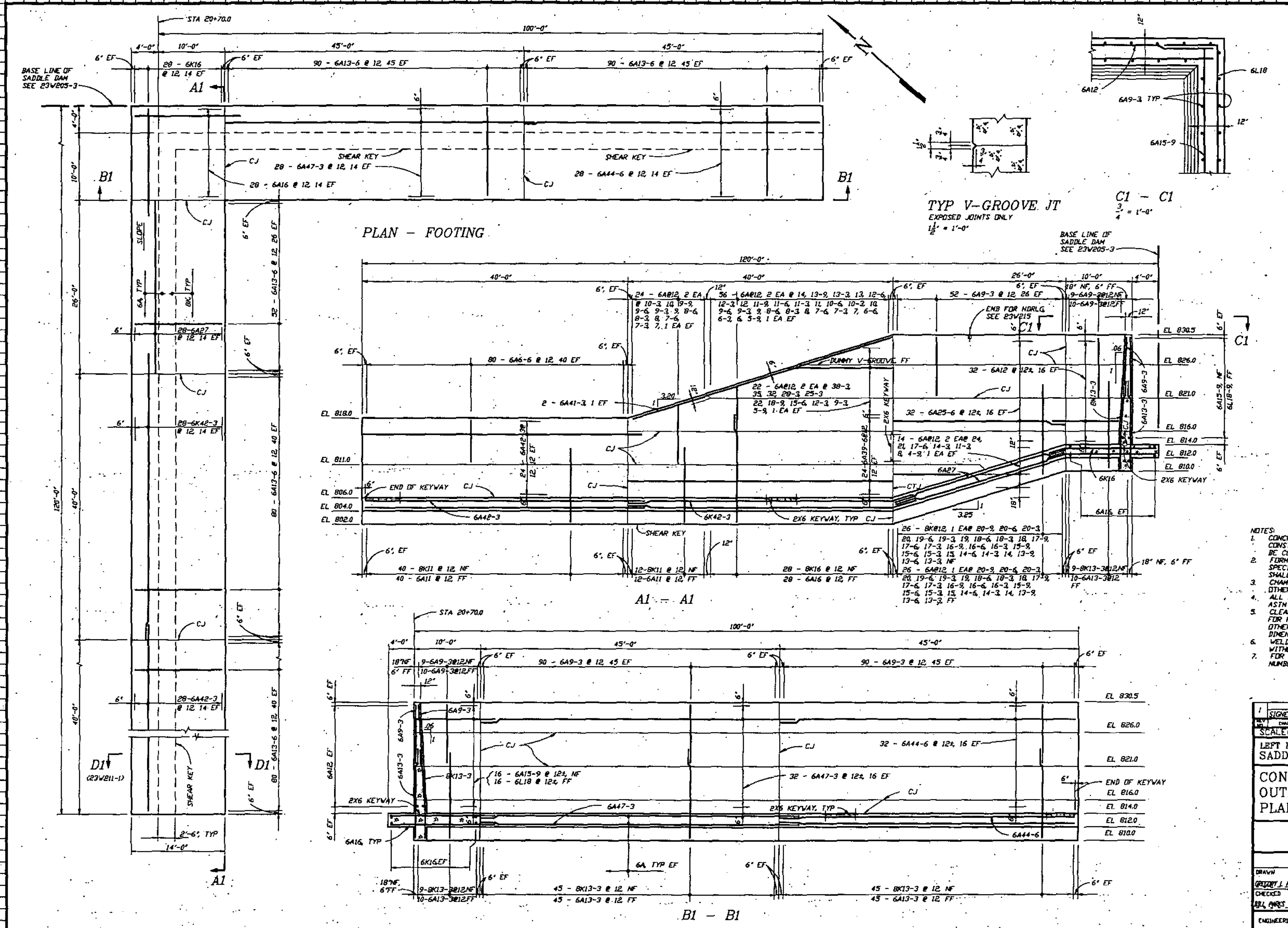
TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY

N

DESIGN		DISCIPLINE INTERFACE		ENGINEERING APPROVAL
DRAWN	DESIGNED	1	2	
GREGORY L HICKEY	GREGORY L HICKEY			RUSSELL B MYERS
CHECKED	REVIEWED	3	4	
ARNOLD ESTEP	ARNOLD ESTEP			EARL L SHEARMAN
ENGINEERING	DATE	65 C	23W205 - 4	R1
	5-31-89			

ISSUED BY: G. L. BUCHANAN

CAD SYSTEM ORIGINAL
DO NOT CHANGE MANUALLY



BENT BAR LIST

BAR MARK	NO. REQD	BENDING DIMENSIONS a	b	c	e	f	r
8K11	52	4-0	EX		0-2 7/8		
8K16	28	4-0	EX		0-2 7/8		
8K13-3	110	4-0	EX		0-2 7/8		
8K21	1	4-0	EX		0-2 7/8		
8K20-9	1	4-0	EX		0-2 7/8		
8K20-6							
8K20-3							
8K20							
8K19-6							
8K19-3							
8K19							
8K18-6							
8K18-3							
8K18							
8K17-9							
8K17-6							
8K17-3							
8K16-9							
8K16-6							
8K16-3							
8K15-9							
8K15-6							
8K15-3							
8K15							
8K14-6							
8K14-3							
8K14							
8K13-9							
8K13-6							
6K42-3	28	2-3	EX		0-8		
6K16	28	2-3	EX		0-8		
6L18-9	16	2-3	EX				

NOTES:
1. CONCRETE SHALL BE PLACED IN ACCORDANCE WITH CONSTRUCTION SPECIFICATION G2. CONCRETE SHALL BE CLASS 300.75 AFW.
2. FORMWORK SHALL BE IN ACCORDANCE WITH CONSTRUCTION SPECIFICATION G8. ALL EXPOSED CONCRETE SURFACES SHALL HAVE A SMOOTH FORM FINISH.
3. CHAMFER ALL EXPOSED EDGES 3/4" UNLESS OTHERWISE NOTED.
4. ALL REINFORCING STEEL SHALL CONFORM TO ASTM A615, GRADE 60.
5. CLEAR COVER FOR REINFORCING STEEL SHALL BE 3" FOR FACES CAST AGAINST EARTH AND 2" FOR ALL OTHER FACES UNLESS OTHERWISE NOTED. ALL OTHER DIMENSIONS ARE TO THE CENTERLINE OF THE BARS.
6. WELDING OF OR TO REINFORCING BARS IS PROHIBITED WITHOUT APPROVAL OF FHE.
7. FOR DESIGN CALCULATIONS SEE RIMS ACCESSION NUMBER B66 88 0122 102.

REV NO	CHANGE REF	DATE	DRWN	DSGN	CHKD	RVWD	APPD	ISSD
1	SIGNED DRAWING AS CONSTRUCTED, DC-JHC 7-30-90 (C04 900730 001)	8-28-90						

SCALE: 3/16" = 1'-0" EXCEPT AS NOTED

LEFT RIM
SADDLE DAM NO. 1

CONCRETE WALLS OUTLINE AND REINFORCEMENT PLAN, SECTIONS AND DETAILS

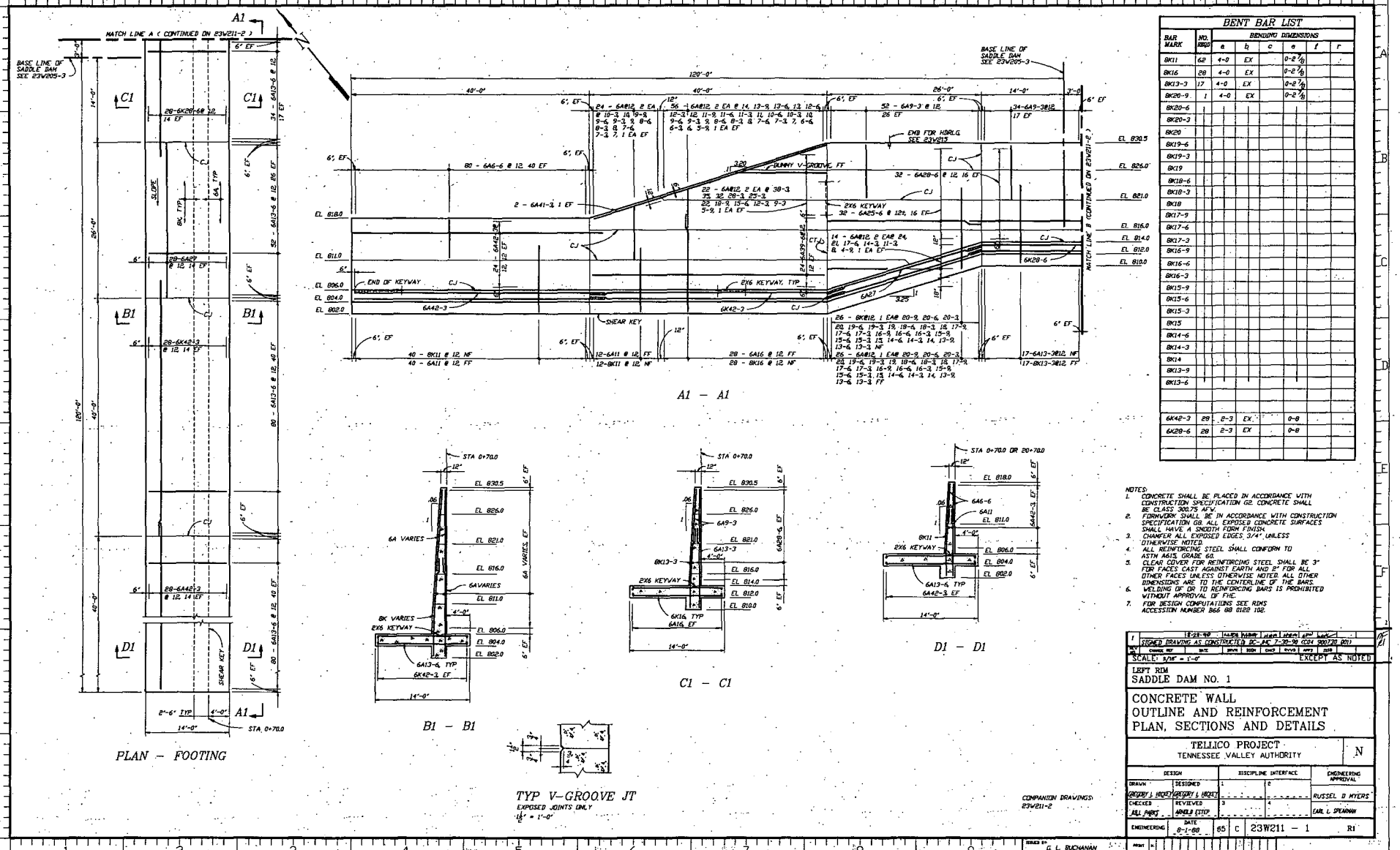
TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY

N

DESIGN		DISCIPLINE INTERFACE		ENGINEERING APPROVAL
DRAWN: GREGORY L. HICKEY	DESIGNED: GREGORY L. HICKEY	1	2	RUSSEL R. MYERS
CHECKED: BILL PARKS	REVIEWED: ARNOLD ESTEP	3	4	EARL L. SPEARMAN
ENGINEERING	DATE 8-1-88	65	C	23W210 - 1 R1

ISSUED BY: G. E. BUCHANAN

CAD SYSTEM ORIGINAL
DO NOT CHANGE MANUALLY



BENT BAR LIST

BAR MARK	NO. REQD	BENDING DIMENSIONS a	b	c	e	f	r
8K11	62	4-0	EX		0-2 7/8		
8K16	28	4-0	EX		0-2 7/8		
8K13-3	17	4-0	EX		0-2 7/8		
8K20-9	1	4-0	EX		0-2 7/8		
8K20-6							
8K20-3							
8K20							
8K19-6							
8K19-3							
8K19							
8K18-6							
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8K15-3							
8K15							
8K14-6							
8K14-3							
8K14							
8K13-9							
8K13-6							
6K42-3	29	2-3	EX		0-8		
6K28-6	28	2-3	EX		0-8		

NOTES:
1. CONCRETE SHALL BE PLACED IN ACCORDANCE WITH CONSTRUCTION SPECIFICATION G2. CONCRETE SHALL BE CLASS 3000.75 AFV.
2. FORMWORK SHALL BE IN ACCORDANCE WITH CONSTRUCTION SPECIFICATION G8. ALL EXPOSED CONCRETE SURFACES SHALL HAVE A SMOOTH FORM FINISH.
3. CHAMFER ALL EXPOSED EDGES 3/4" UNLESS OTHERWISE NOTED.
4. ALL REINFORCING STEEL SHALL CONFORM TO ASTM A615, GRADE 60.
5. CLEAR COVER FOR REINFORCING STEEL SHALL BE 3" FOR FACES CAST AGAINST EARTH AND 2" FOR ALL OTHER FACES UNLESS OTHERWISE NOTED. ALL OTHER DIMENSIONS ARE TO THE CENTERLINE OF THE BARS.
6. WELDING OF OR TO REINFORCING BARS IS PROHIBITED WITHOUT APPROVAL OF TVA.
7. FOR DESIGN COMPUTATIONS SEE RIMS ACCESSION NUMBER 866 88 0128 102.

1 | 12-28-98 | SIGNED DRAWING AS CONSTRUCTED DC-AK 7-20-98 (CO4 980720 011)

SCALE: 3/16" = 1'-0" EXCEPT AS NOTED

LEFT RDM
SADDLE DAM NO. 1

CONCRETE WALL OUTLINE AND REINFORCEMENT PLAN, SECTIONS AND DETAILS

TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY

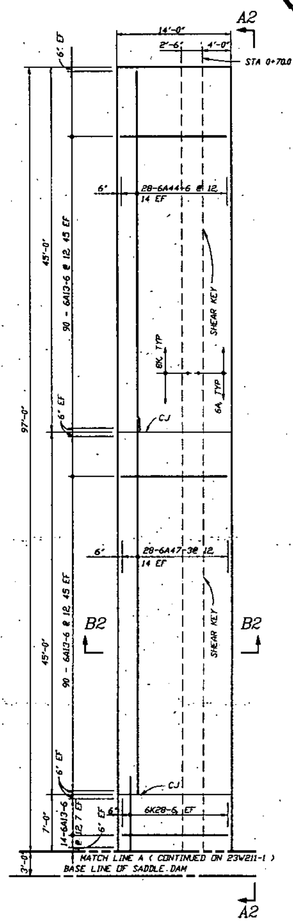
N

DESIGN		DISCIPLINE INTERFACE		ENGINEERING APPROVAL
DRAWN: GREGORY J. HICKEY	DESIGNED: GREGORY J. HICKEY	1	2	RUSSEL D. MYERS
CHECKED: ALL PARTS	REVIEWED: ARNOLD STEP	3	4	EARL L. SPEARMAN
ENGINEERING	DATE: 8-1-88	65 C 23W211 – 1 R1		

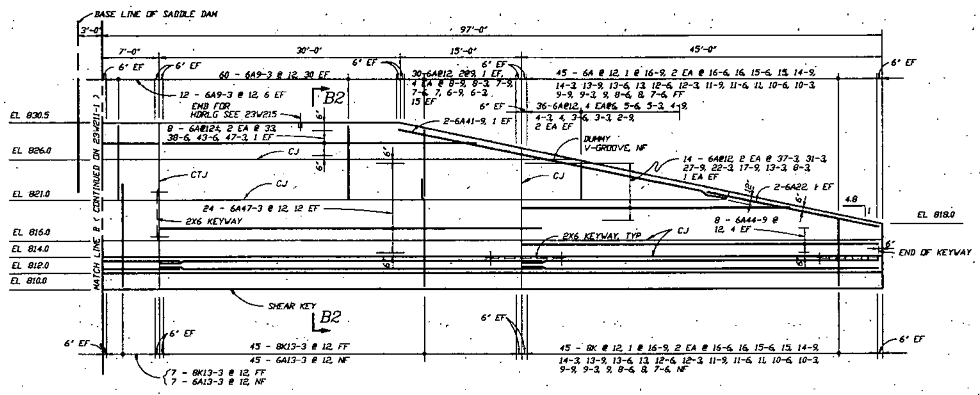
ISSUED BY: G. L. BUCHANAN

COMPANION DRAWINGS: 23W211-2

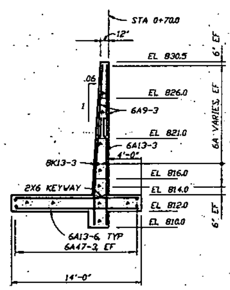
CAD SYSTEM ORIGINAL
DO NOT CHANGE MANUALLY



PLAN – FOOTING



A2 – A2



B2 – B2

BENT BAR LIST							
BAR MARK	NO. REQD	BENDING DIMENSIONS					
		a	b	c	e	f	r
8K16-9	1	4-0	EX		0-2 7/8		
8K16-6	2						
8K16							
8K15-6							
8K15							
8K14-9							
8K14-3							
8K13-9							
8K13-6							
8K13-3	52						
8K13	2						
8K12-6							
8K12-3							
8K11-9							
8K11-6							
8K11							
8K10-6							
8K10-3							
8K9-9							
8K9-3							
8K9							
8K8-6							
8K8							
8K7-6							

NOTES:
1. FOR LIST SEE 23W211-1.

1 SIGNED DRAWING AS CONSTRUCTED DC-JHC 7-30-90 (C04 900730 001)

SCALE: 3/16" = 1'-0" EXCEPT AS NOTED

LEFT RIM
SADDLE DAM NO. 1

CONCRETE WALL
OUTLINE AND REINFORCEMENT
PLAN, SECTIONS AND DETAILS

TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY

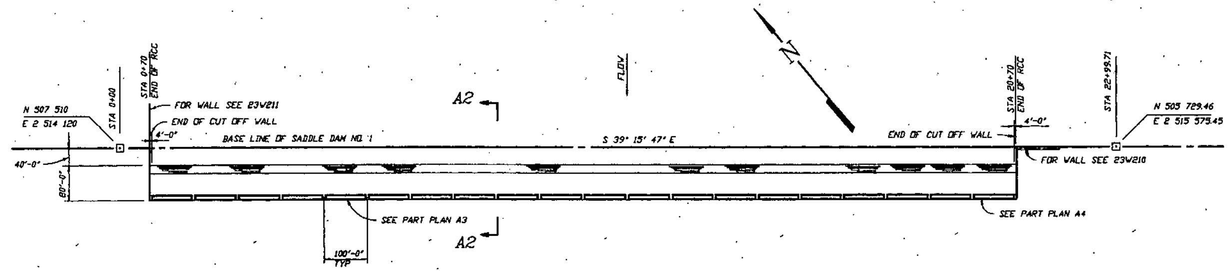
N

DESIGN		DISCIPLINE INTERFACE		ENGINEERING APPROVAL
DRAWN GREGORY L HICKEY	DESIGNED GREGORY L HICKEY	1	2	RUSSEL D MYERS
CHECKED BILL PARKS	REVIEWED ARNOLD ESTEP	3	4	EARL L SPEARMAN

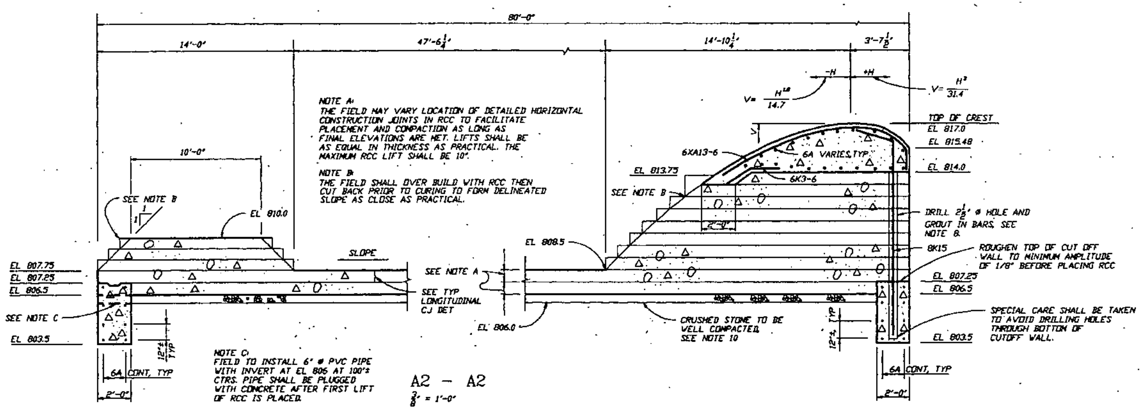
ENGINEERING DATE 8-1-89 | 65 | C | 23W211 – 2 | R1

G. L. BUCHANAN

CAD SYSTEM ORIGINAL
DO NOT CHANGE MANUALLY



PLAN – EMERGENCY SPILLWAY



NOTE A:
THE FIELD MAY VARY LOCATION OF DETAILED HORIZONTAL CONSTRUCTION JOINTS IN RCC TO FACILITATE PLACEMENT AND COMPACTION AS LONG AS FINAL ELEVATIONS ARE MET. LIFTS SHALL BE AS EQUAL IN THICKNESS AS PRACTICAL. THE MAXIMUM RCC LIFT SHALL BE 10".

NOTE B:
THE FIELD SHALL OVER BUILD WITH RCC THEN CUT BACK PRIOR TO CURING TO FORM DELINEATED SLOPE AS CLOSE AS PRACTICAL.

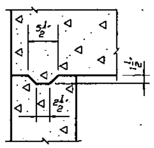
NOTE C:
FIELD TO INSTALL 6" ø PVC PIPE WITH INVERT AT EL 806 AT 100'± CTRS. PIPE SHALL BE PLUGGED WITH CONCRETE AFTER FIRST LIFT OF RCC IS PLACED.

A2 – A2
⅜" = 1'-0"

CREST COORDINATES			
UPSTREAM CURVE		DOWNSTREAM CURVE	
H	V	−H	V
0.5'	0	-0.5'	0.02'
1.0'	0.03'	-1.0'	0.07'
1.5'	0.11'	-1.5'	0.14'
2.0'	0.25'	-2.0'	0.25'
2.5'	0.50'	-3.0'	0.49'
3.0'	0.86'	-4.0'	0.82'
3.5'	1.37'	-5.0'	1.23'
3.63'	1.52'	-6.0'	1.71'
		-7.0'	2.26'
		-8.0'	2.87'
		-9.0'	3.55'
		-10.0'	4.29'
		-11.0'	5.10'
		-12.0'	5.96'
		-13.0'	6.88'
		-14.0'	7.87'
		-14.85'	8.75'

NOTES:
1. FOR ROLLER COMPACTED CONCRETE NOTES SEE 23W212-1.
2. ALL OTHER CONCRETE SHALL BE PLACED IN ACCORDANCE WITH CONSTRUCTION SPECIFICATION G2. CONCRETE SHALL BE CLASS 300.75 AFW.
3. FORMWORK SHALL BE IN ACCORDANCE WITH CONSTRUCTION SPECIFICATION G8. ALL EXPOSED CONCRETE SURFACES SHALL HAVE A SMOOTH FORM FINISH.
4. ALL REINFORCING STEEL SHALL CONFORM TO ASTM A615, GRADE 60.
5. CLEAR COVER FOR REINFORCING STEEL SHALL BE 3" FOR FACES CAST AGAINST EARTH AND 2" FOR ALL OTHER FACES UNLESS OTHERWISE NOTED. ALL OTHER DIMENSIONS ARE TO THE CENTERLINE OF THE BARS.
6. WELDING OF OR TO REINFORCING BARS IS PROHIBITED WITHOUT APPROVAL OF FHE.
7. MINIMUM LAP LENGTH FOR NO. 6 BARS TO BE 2'-3".
8. DRILLED HOLES FOR BARS ARE TO BE CLEAN AND FREE OF WATER BEFORE FILLING WITH SAND-CEMENT GROUT. THE HOLE MUST MAINTAIN THE INITIAL GROUT LEVEL. OTHERWISE THE GROUT SHALL BE ALLOWED TO SET, THE HOLE REDRILLED, AND THE PROCEDURE REPEATED. THE BAR IS TO BE FORCED INTO GROUT TO THE BOTTOM OF THE HOLE, THEN SHAKEN AND WORKED TO ENSURE GOOD BOND BETWEEN GROUT, BAR AND DRILLED SURFACE. SAND-CEMENT GROUT SHALL CONFORM TO GENERAL CONSTRUCTION SPECIFICATION G 32, SECTION 2.5 & G 51.
9. FOR DESIGN CALCULATIONS SEE RIMS ACCESSION NUMBER B66 88 0811 005.
10. COARSE FILTER UNDER ROLLER COMPACTED CONCRETE SHALL CONFORM TO HIGHWAY SPECIFICATION T-1, SECTION 1032, EXCEPT THE GRADATION SHALL CONFORM TO THE FOLLOWING LIMITS:

SIEVE	PERCENT PASSING BY WEIGHT MINIMUM	MAXIMUM
1 1/4"	100	- -
1"	95	100
3/4"	70	100
3/8"	50	85
NO. 4	33	65
NO. 10	20	45
NO. 40	8	25
NO. 200	0	10



TYP KEY DET
1½" = 1'-0"

REV NO.	CHANGE REF	DATE	DRWN	DSGN	CHKD	RVWD	APPD	CSCD
3	REV SECT A2-A2 AND REV NOTE 8 TO REFLECT AS CONSTRUCTED.	8-28-90						
2	REV SECT A2-A2 AND ADD NOTE 10.	10-19-88	GLRH	GLRH	AE	AE		JHC
1	ISSUE REMAINDER OF DRAWING FOR CONSTRUCTION	8-11-88	GLRH	GLRH	AE	AE		GLB

SCALE: 1" = 100' EXCEPT AS NOTED

LEFT RIM
SADDLE DAM NO. 1

CONCRETE – EMERGENCY SPILLWAY
OUTLINE AND REINFORCEMENT
PLANS, SECTIONS AND DETAILS

TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
N

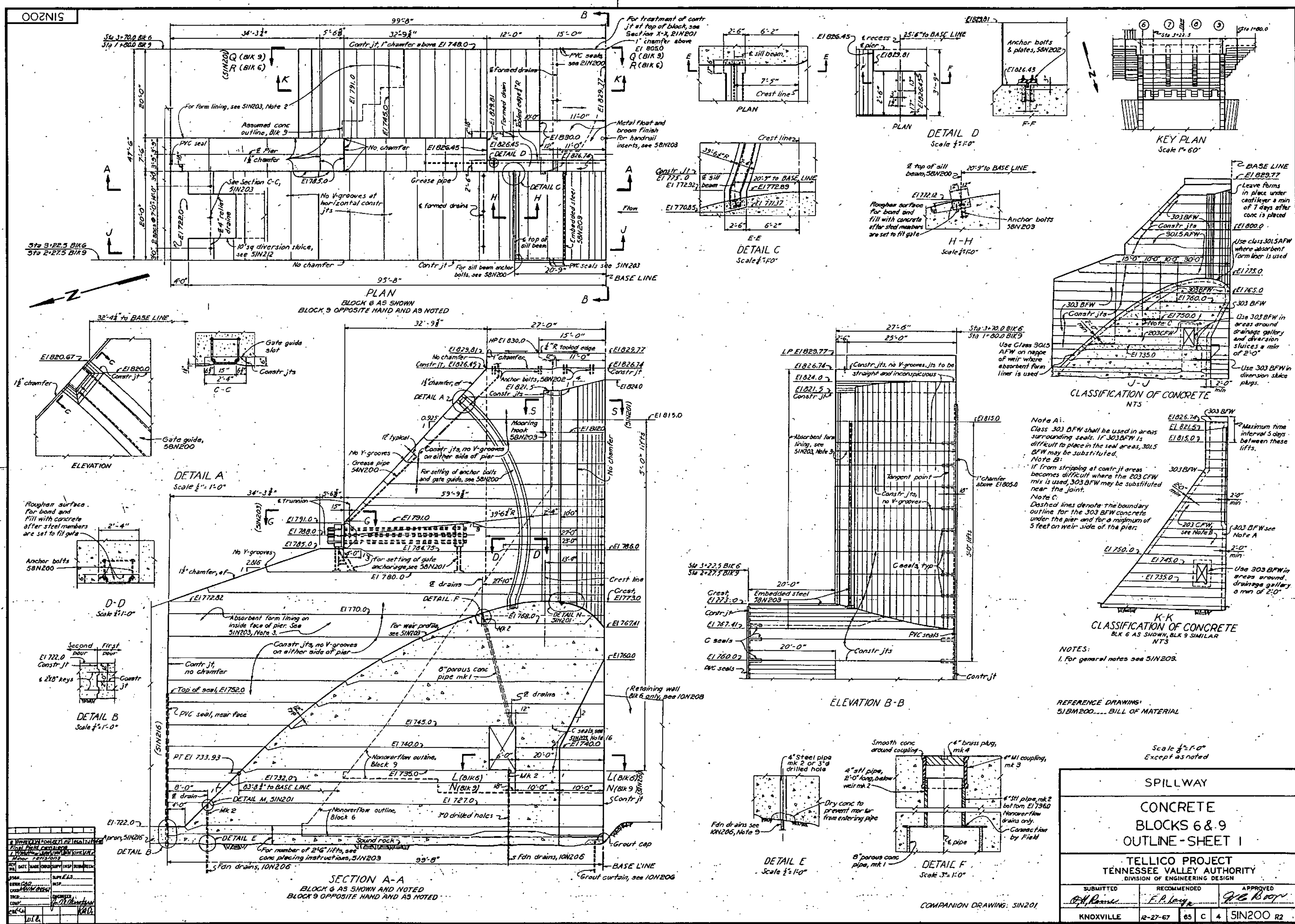
DESIGN		DISCIPLINE INTERFACE		ENGINEERING APPROVAL
DRAWN: GREGORY L HICKEY	DESIGNED: GREGORY L HICKEY	1	2	RUSSEL D MYERS
CHECKED: ARNOLD ESTEP	REVIEWED: ARNOLD ESTEP	3	4	EARL L SPEARMAN

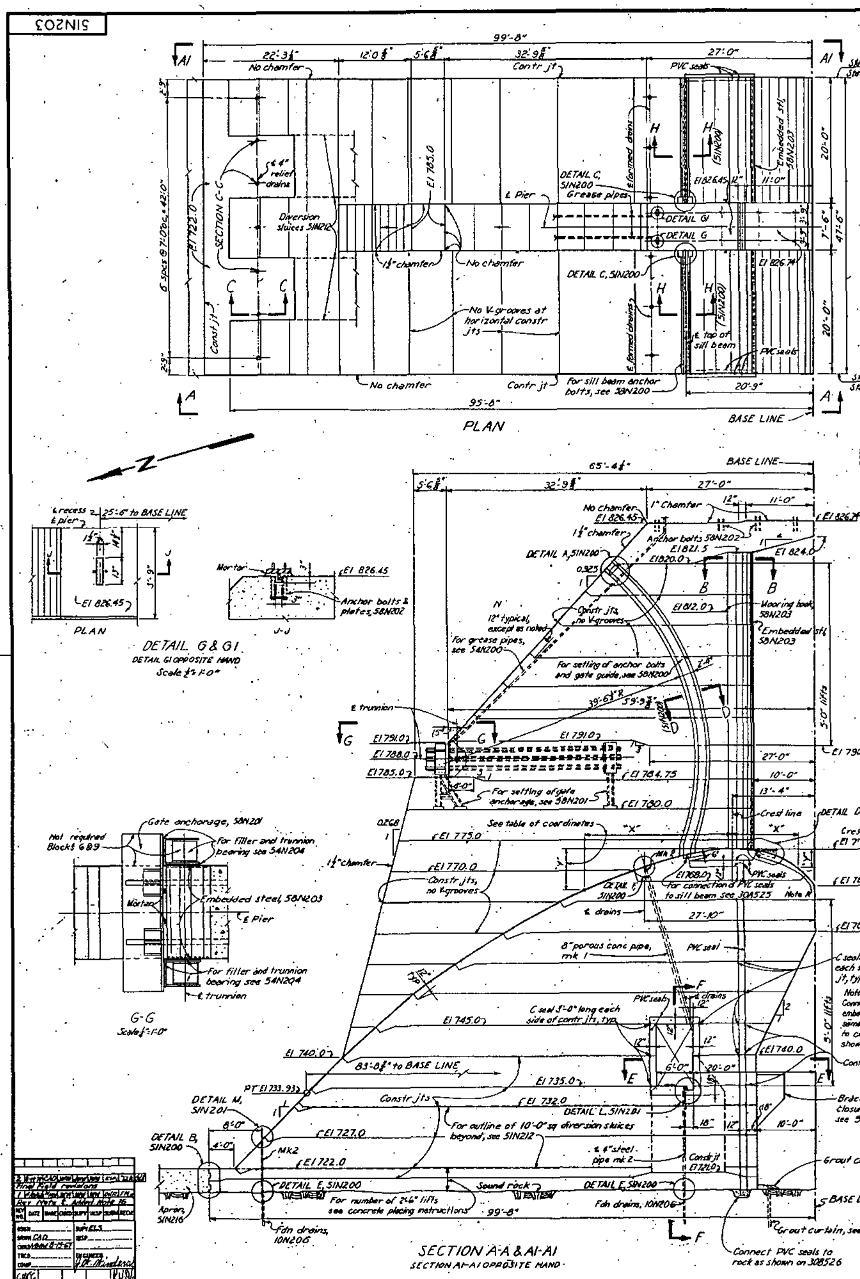
ENGINEERING DATE 8-1-88 | 65 | C | 23W212 – 2 | R3

ISSUED BY: G. L. BUCHANAN

AS CONSTRUCTED: BC-JHC 7-30-90 (C04 900730 801)

CAD SYSTEM ORIGINAL
DO NOT CHANGE MANUALLY


5IN200
PLAN
BLOCK 6 AS SHOWN
BLOCK 9 OPPOSITE HAND AND AS NOTED
SECTION A-A
BLOCK 6 AS SHOWN AND NOTED
BLOCK 9 OPPOSITE HAND AND AS NOTED
DETAIL A
Scale ½"=1'-0"
DETAIL B
D-D
C-C
DETAIL C
DETAIL D
H-H
E-E
F-F
KEY PLAN
Scale 1"=60'
ELEVATION B-B
DETAIL E
DETAIL F
J-J
CLASSIFICATION OF CONCRETE
NTS
K-K
CLASSIFICATION OF CONCRETE
BLK 6 AS SHOWN, BLK 9 SIMILAR
NTS
Note A:
Class 303 BFW shall be used in areas surrounding seals. If 303BFW is difficult to place in the seal areas, 301.5 BFW may be substituted.
Note B:
If from stripping at contr jt areas becomes difficult where the 203 CFW mix is used, 303 BFW may be substituted near the joint.
Note C:
Dashed lines denote the boundary outline for the 303 BFW concrete under the pier and for a minimum of 5 feet on weir side of the pier.
NOTES:
1. For general notes see 5IN209.
REFERENCE DRAWING:
5IBM200 .... BILL OF MATERIAL
COMPANION DRAWING: 5IN201
Scale ⅛"=1'-0"
Except as noted
SPILLWAY
CONCRETE
BLOCKS 6 & 9
OUTLINE - SHEET 1
TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
12-27-67
5IN200 R2

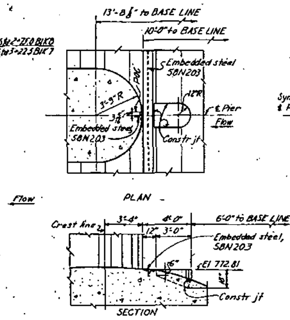


PLAN

DETAIL G & G1
DETAIL G1 OPPOSITE HAND
Scale 1/2"=1'-0"

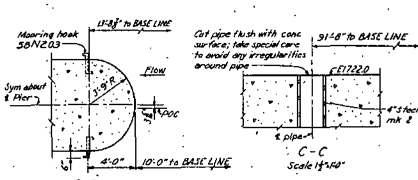
G-G
Scale 1/2"=1'-0"

SECTION A-A & A1-A1
SECTION A1-A1 OPPOSITE HAND



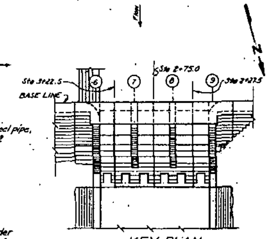
PLAN

DETAIL D
Scale 1/4"=1'-0"



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

C-C
Scale 1 1/2"=1'-0"



KEY PLAN
Scale 1"=60'

COORDINATES OF WEIR PROFILE

UPSTR FROM CREST LINE $Y = \frac{X^3}{424}$

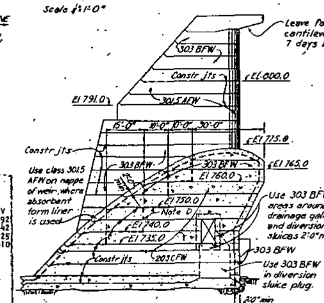
X	Y	ELEV	X	Y	ELEV
*0.0'	0.0'	773.000	8.0'	1.208	771.792
2.0	0.019	772.981	10.0	2.358	770.642
4.0	0.151	772.849	12.0	4.075	768.925
6.0	0.510	772.490	+13.333	5.590	767.410

FROM CREST LINE TO SILL BM $Y = \frac{X^{1.8}}{42.0}$

DNSTR FROM SILL BM $Y = 0.877 + \frac{X - 7.417}{4.7} + \frac{(X - 7.417)^2}{160}$

X	Y	ELEV	X	Y	ELEV
*0.0	0.0'	773.000	34.0'	10.950'	762.050
2.0	0.083	772.917	36.0	12.064	760.936
4.0	0.289	772.711	38.0	13.230	759.770
6.0	0.599	772.401	40.0	14.445	758.555
+6.439	0.680	772.320	42.0	15.710	757.290
▲7.417	0.877	772.123	44.0	17.026	755.974
8.0	1.003	771.997	46.0	18.390	754.610
*8.395	1.091	771.909	48.0	19.806	753.194
10.0	1.469	771.531	50.0	21.270	751.730
12.0	1.983	771.017	52.0	22.786	750.214
14.0	2.549	770.451	54.0	24.350	748.650
16.0	3.164	769.836	56.0	25.966	747.034
18.0	3.829	769.171	58.0	27.630	745.370
20.0	4.544	768.456	60.0	29.346	743.654
22.0	5.309	767.691	62.0	31.111	741.889
24.0	6.124	766.876	64.0	32.926	740.074
26.0	6.989	766.011	66.0	34.791	738.209
28.0	7.904	765.096	68.0	36.706	736.294
30.0	8.869	764.131	70.0	38.672	734.328
32.0	9.884	763.116	‡70.400	39.071	733.929

*Crest Line ▲℄ Sill Beam
+Upstream Face ‡ PT
*Edge of Sill Beam Slot

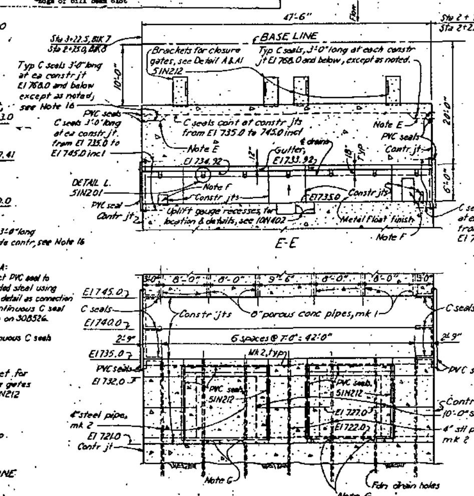


CLASSIFICATION OF CONCRETE
NTS

Note B:
Class 303 BFW shall be used in areas surrounding seals. If 303 BFW is difficult to place in the seal areas, 301.5 BFW may be substituted.

Note C:
If form stripping at contr jt areas becomes difficult where the 203CFW mix is used, 303BFW may be substituted near the joint.

Note D:
Dashed lines denote the boundary outline, a minimum of 5 feet each side of pier, for the 303 BFW concrete.



E-E

F-F

Note E:
C seals, 3'-0" long connected to cont C seals at each constr jt from El 735.0 to El 745.0 incl.

Note F:
For location and details of temporary recesses, see 5IN212.

Note G:
Set pipe couplings flush with conc. Field to provide protection for couplings

NOTES:
1. Concrete shall be placed in accordance with General Constructions Specification G-2.
2. Exposed concrete surfaces shall have steel forms where practicable. Where wood forms are used, they shall be in accordance with General Construction Specification G-8. Above minimum water level or grade, wood forms shall be Type D smooth plywood lining and shall be painted with epoxy form paint if necessary to simulate steel formed surfaces except as specified in Note 3.
3. Absorbent form lining, Firtex or equal, shall be used on all faces of intermediate piers and apron baffle blocks, inside face of end piers and training walls, upstream face of apron sill, and all formed surfaces of the nappe, in accordance with General Construction Specification G-10.
4. Special care shall be taken to avoid offsets in the finished concrete surface at joints in the form lining.
5. All unformed surfaces shall have a metal float finish.
6. Chamfer all exposed edges 1" unless otherwise noted.
7. No chamfer on contraction joints in surface of nappe.
8. No V-grooves on horizontal construction joints in spillway and all faces of training walls and piers.
9. For typical details of water seals, see 30B526.
10. Contraction joint seals are PVC type I (with center bulb) and shall conform to TVA Specification PR1004.
11. Prestressing of gate anchorage shall not be done until concrete has been in place 90 days.
12. Field to sound all drains prior to closure to be sure they are clear of debris. Elevations of bottom of foundation drain holes are to be recorded and reported to Division of Engineering Design.
13. All mark numbers to have prefix 5IN200.
14. For uplift measuring equipment, see 10N402.
15. For electrical conduits and ground wire, see electrical drawings.
16. Field may substitute 6" PVC seals without center bulb where Type C seals are called for.

CONCRETE PLACING INSTRUCTIONS
Level foundation - As tabulated below. The top of each lift shall be left exposed according to the table below except that the first lift above the top of the sluices shall be exposed a minimum of 7 days. Minimum exposure time for lifts not otherwise noted shall be 3 days.

	Placing Temperature - Degrees F									
	75-70		70-65		65-60		60-55		Below 55	
Lift	Ht	Exp	Ht	Exp	Ht	Exp	Ht	Exp	Ht	Exp
1	2.5	6	2.5	5	2.5	4	2.5	3	2.5	3
2	2.5	5	2.5	4	5	6	5	4	5	3
3	2.5	4	5	5	5	4	5	3		
4	5	5	5	3	5	3				
5	5	3								

MAXIMUM HEIGHT OF LIFT IN FEET.
MAXIMUM EXPOSURE TIME IN DAYS

Sloping Foundation - Place 2.5' lifts with lift 1 requirements until rock is covered. For Block 9 see Sections P-P and Q-Q 5IN201.

Placing temperature of concrete and ambient temperature assumed during exposure of lift are assumed to be the same as the average daily temperature. If there is 10 F or more difference between placing temperature and average daily temperatures, contact Division of Engineering Design for instructions. In case the top of a lift is left exposed for 14 days or more, the lift following shall be considered as the first lift and the above procedure followed, except that 5' lifts may be placed instead of 2.5' lifts, with an exposure time of 2 days more than given for 2.5' lifts.

REFERENCE DRAWING
51BM200 .... BILL OF MATERIAL

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

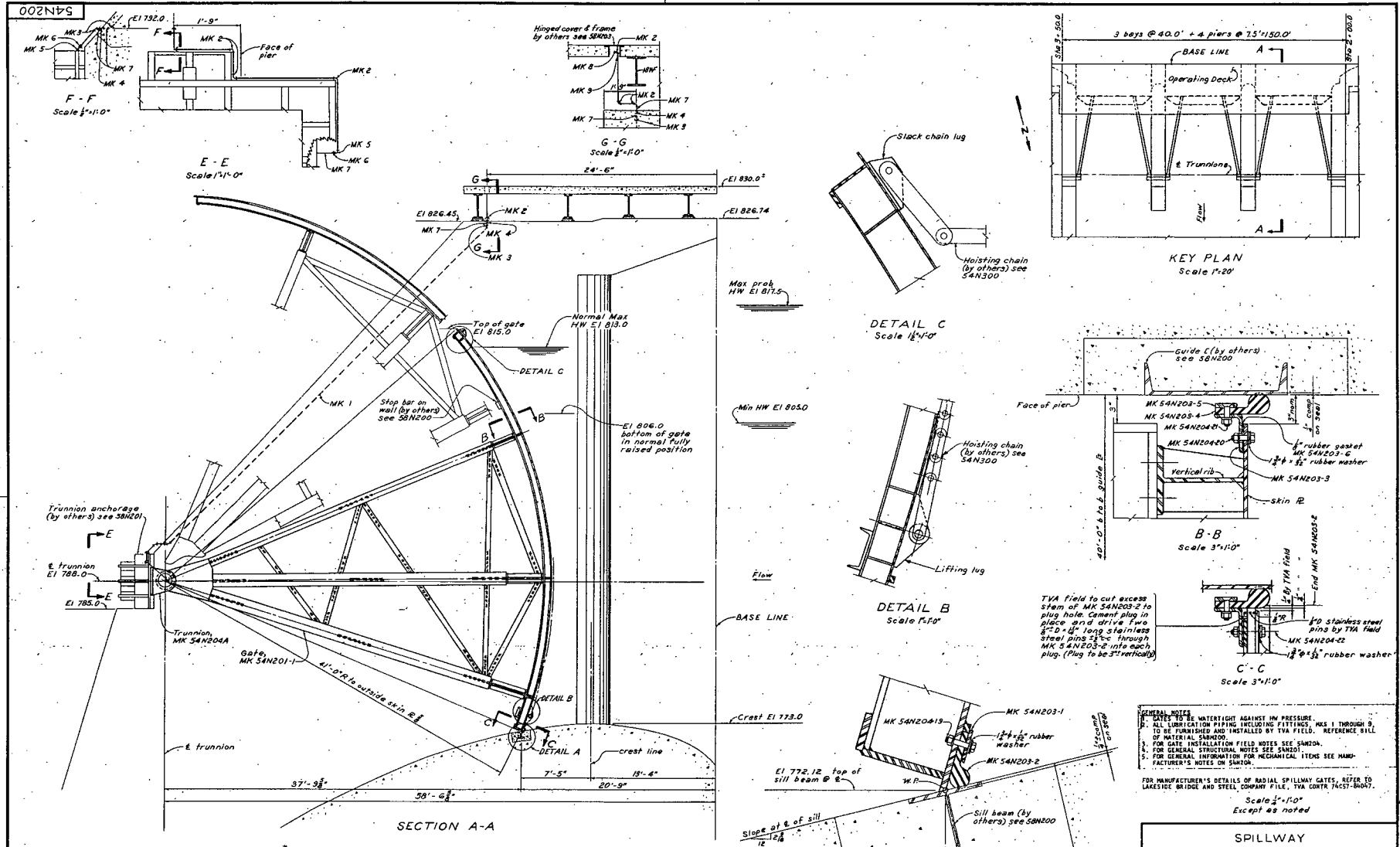
SPILLWAY
CONCRETE
BLOCKS 7 & 8
OUTLINE

TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED
[signature]	[signature]	[signature]

KNOXVILLE 12-12-67 65 C 4 5IN203 R2

54N200



SPILLWAY

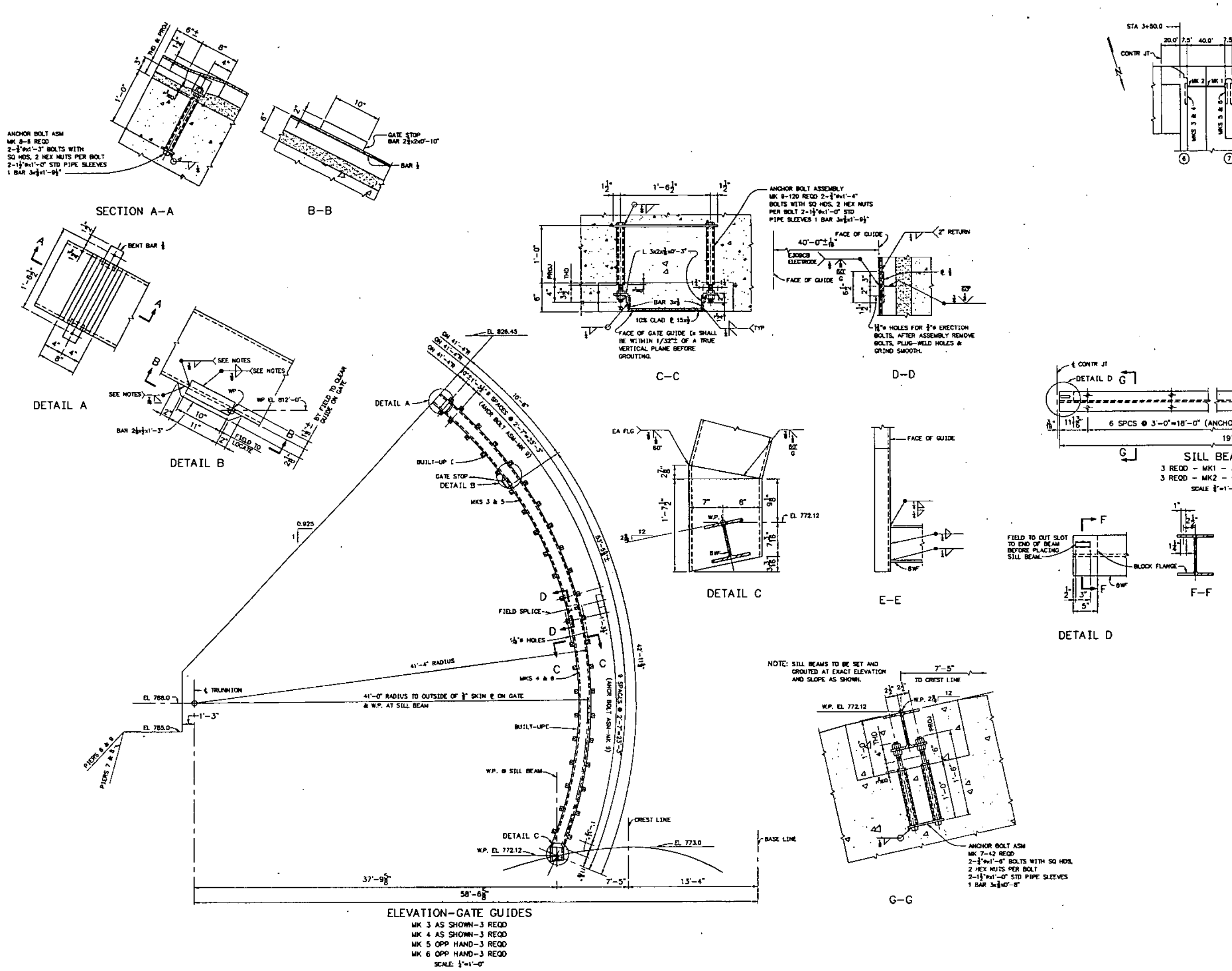
RADIAL GATES ARRANGEMENT

TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED

KNOXVILLE	10-10-67	85	H	4	54N200R3

RECORD DRAWING AS CONSTRUCTED 5-11-77



NOTES:

ALL MARKS TO HAVE PREFIX 58N200.
ENDS OF SILL BEAM TO BE SAW-CUT, SQUARE WITH FLANGES.
ALL ANCHOR BOLT ASSEMBLIES BY TVA FIELD.
PLATES AND SHAPES SHALL BE ASTM A-36 MATERIAL EXCEPT CLAD ℄ SHALL BE AS ROLLED LUKENS MH-3 CLAD STEEL WITH A36 BACKING STEEL, OR EQUIVALENT. CLADDING THICKNESS SHALL BE 10% OF ½" TOTAL GAGE ℄.

WELDING ELECTRODES:

CARBON STEEL TO STAINLESS STEEL-AWS A5.4, E309 CLASSIFICATION.
CARBON STEEL TO CARBON STEEL-AWS A5.1, E70 CLASSIFICATION.

R 5 1-28-97 ELECTRONICALLY RESTORED

SCALE: 1½"=1'-0" EXCEPT AS NOTED

SPILLWAY

STRUCTURAL STEEL
GATE GUIDES & SILL BEAMS

DRAWN BY: DLG | CHECKED BY: CWH | SUPERVISED BY: CWH

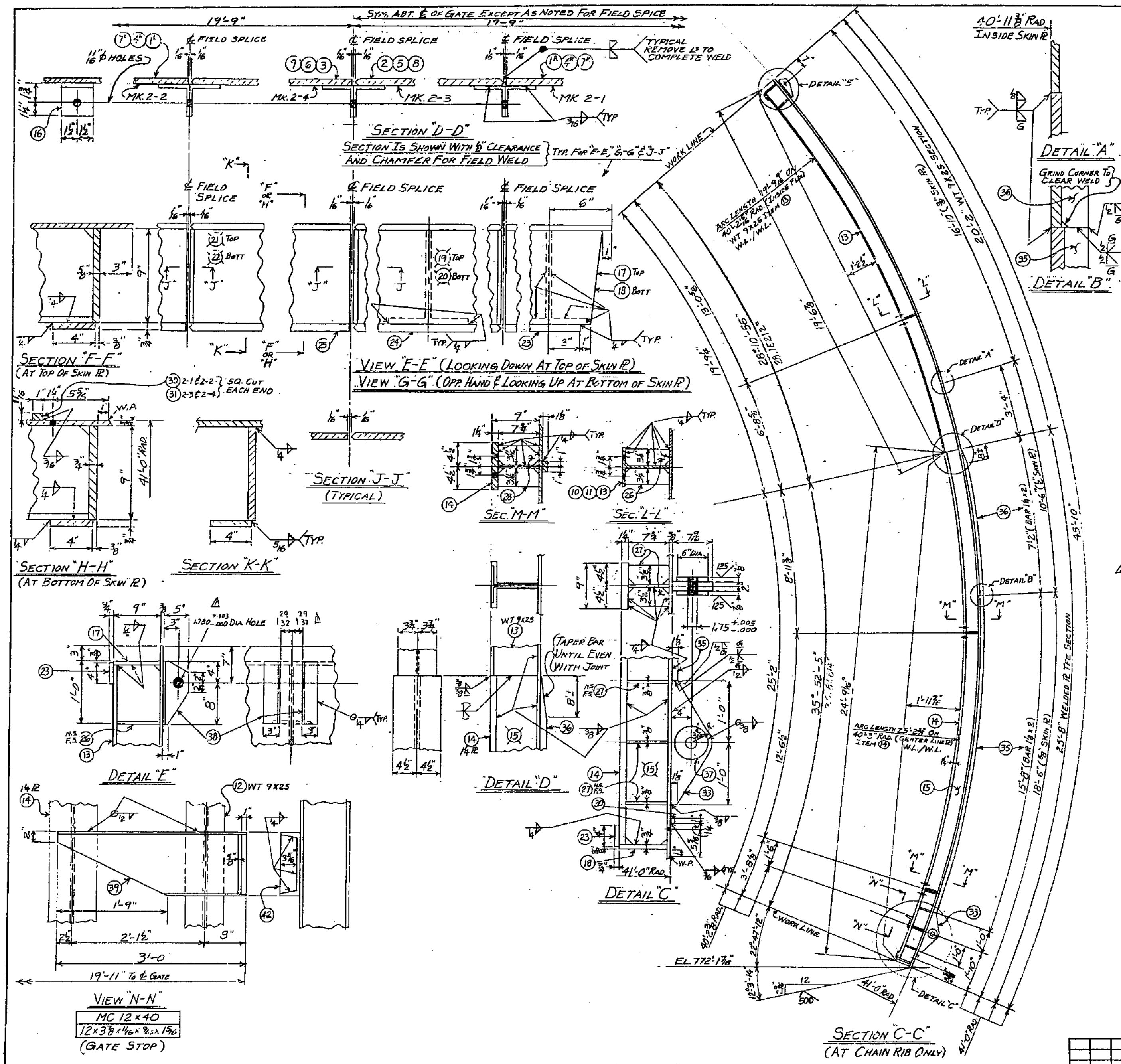
TELLICO PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R14 | DATE 6-10-67 | 65 | S | 58W200 | R 5

ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES :(58N200 R4)

PLOT FACTOR:8
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY



Piece Mark Sht.	Piece Mark Sct.	Item	This Number	On Mark	Quan.	Description (All material to be A-441 unless noted)	Width	Length	Weight	Spec. Code	P. Bill No.
2	1				3	SKIN PLATE AS SHOWN					
2	2				3	SKIN PLATE OPP HAND					
		1			6	PL 5/8	11844	18 3			215
		4			6	PL 1/2	11844	10 594			214
		7			6	PL 3/8	11844	16 994			2 6
		10			12	WT 9X25		46 988			2 4
		11			6	WT 9X25		46 988			2 4
		12			6	WT 9X25		46 788			2 4
		13			6	WT 9X25		21 756			2 5
		14			6	PL 1 1/4	4	28 33			3 5
		15			1	PL 5/8 1 CUTS 2	75	25 8			218
		16			96	L 3x3x1/4		3		36	
		17			6	PL 5/8	9	9 944			212
		18			6	PL 3/4	9	9 944			221
		23			12	PL 3/4	4	9 744			217
		26			150	BAR 3/8	325	844			3 5
		27			36	BAR 3/8	350	775			3 6
		28			24	BAR 3/8	367	775			3 6
		29			18	BAR 3/8	525	844			3 5
		30			6	BAR 11/16	1	9 1044			314
		33			3	PL 2	756	2			5 6
		35			6	BAR 1 1/8	2	16			3 6
		36			6	BAR 1 1/4	2	7 6			3 7
		37			12	BAR 1 1/8	6	6			316
		38			12	L 5x3x1/2		1			114
		39			6	MC 12X40		3		912	115
		40			18	BAR 9/16	425	6			312
		41			12	BAR 1/2	4	1 10		912	310
		42			6	BAR 5/8	231	10 75			313
		43			24	PL 1	350	12		36	
2	3				3	SKIN PLATE AS SHOWN & NOTED					
2	4				3	SKIN PLATE OPP HAND & NOTED					
		2		2-3	3	PL 5/8	11838	18 8			215
		5		2-3	3	PL 1/2	11838	10 594			214
		8		2-3	3	PL 3/8	11838	16 994			2 6
		3		2-4	3	PL 5/8	11838	18 8			215
		6		2-4	3	PL 1/2	11838	10 594			214
		9		2-4	3	PL 3/8	11838	16 994			2 6
		10			3	WT 9X25		46 988			2 4
		16			192	L 3x3x1/4		3		36	
		19		2-3	3	PL 5/8	9	9 1036			216
		20		2-3	3	PL 3/4	9	9 1036			221
		21		2-4	3	PL 5/8	9	9 1036			216
		22		2-4	3	PL 3/4	9	9 1038			221
		23		2-3	6	PL 3/4	4	9 1038			217
		25		2-4	6	PL 3/4	4	9 1036			217
		26			180	BAR 3/8	325	844			3 5
		31			6	BAR 11/16	1	9 1075			314
		43			24	PL 1	350	12		36	
Δ	2					ASTM A572 GR 50				912	

T.V.A. CONTRACT No. 74C57-84047

DESIGN DRWG. REF. 54N200-R2, 54N201-R2, 54N202-R2, 54N203-R1

OPEN HOLES AS NOTED UNLESS NOTED
SHOP PAINT SEE SHT. 901

LAKESIDE BRIDGE & STEEL CO.
MILWAUKEE, WISCONSIN 53209

CUSTOMER TENNESSEE VALLEY AUTHORITY
LOCATION OF WORK TELLICO DAM
DESCRIPTION RADIAL SPILLWAY GATES
TITLE SKIN PLATE

DRAWN BY E.L.T	DATE 8-22-74	DRAWING NUMBER 9091-2B
CHECKED BY R. DE NEVE	OCT 14-1974	
APPROVED BY FK	10-14-74	SYMBOL C — UNIT 1
INSP. BY T.V.A.		

REV.	ZONE	DESCRIPTION	BY	DATE
		SEE DWG. 9091-2AB		

9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1

Dam Safety Inspection Report - Class B
Tellico Dam

Dates of Inspection: 11/29/2007
File Number: 91-02
Work Order #: 07-136406-000
Report ID: R02TEHCLB112907
EDMS #: J22 080110 002
Headwater: 11/29/07 – 810.61-ft. Tailwater: 11/29/07 – 739.90-ft.

Inspection Participants:
Dam Safety Maintenance: Isaac Allen, D. Webb Patten, Mike Richardson, Travis Simpson
Fort Loudoun Hydro: Jeremy Ellison

This report covers the inspection of the spillway gates.

Maintenance History:

The spillway gate chains were greased using Mobil EAL 102 grease in October 2007.

Spillway Gates:

Tellico Dam has three (3) radial type spillway gates measuring 39'-6" high and 39' wide. The skin plate is stiffened by both horizontal girders and vertical purlins. A supporting truss frame transfers the load from the girders and purlins to the main struts. The load is then carried through the main struts to the trunnions, which are anchored into the spillway piers.

The spillway gates were inspected using Rope Access techniques. Structurally, the gates were in satisfactory condition with various areas of rust, corrosion, and coating loss. Areas of coating loss and mild corrosion were found in the corners of the gates. The gate stops have been moved in the past, allowing the gate to travel open further. However, the effected areas were never properly coated and have heavy surface rust (see Figure 1). Most of the underside 3/8" weld where the strut arms connect to the horizontal girders were not properly coated and have heavy surface rust. A similar condition exists where the second purlin from either side connects to the horizontal girders (see Figure 3). The majority of the areas around the downstream seal nuts had coating loss and mild to moderate rust along the length of the gate (see Figure 4). The lower sections of the gates are in worse condition, coating wise, than the upper two-thirds of the gate. This is especially true on gate 2, where the siphon keeps moisture in the area. The gates should be maintenance coated. The siphon should be extended away from the gate more.

The trunnions were in good condition with the anchor rods in fair-to-good condition. The trunnion blocks had areas of bad surface preparation causing the coating to be in poor condition. The trunnion block's coating condition on gate 2 is in especially poor condition with considerable coating loss, mild-to-moderate rust, corrosion in the corners, pack rust, and moderate-to-heavy pitting in areas (see Figure 5).

Drain holes should be added to the middle gate struts as they are holding water. All of the drain holes in the areas on the lower strut arm nearest the connection to the lower horizontal girders had to be unclogged to drain standing water. The majority of these areas had various degrees of coating loss and rust.

Many of the bracing connections, and some of the areas on the main support beams, have bolt holes that have not been plug welded (see Figure 6). These areas do not require repairs.

Drain holes need to be added to the bracing on the strut arm connection to the horizontal girders on gate 1 as seen on TVA drawing 54W201, Detail B. Drain holes should be added to the upstream side of the middle horizontal girder on gate 1 to alleviate the standing water issue. The left side seal bar is not tight near the upper horizontal girder on gate 1, which is causing a leak of about 10 gpm (see Figure 7). The seal bar nuts should be tightened in this area.

The lower third of gate 2 has major coating delamination with rust that is starting to deteriorate the weld condition on the purlins, lower horizontal girder, and brace support for the gate stop. The 10th purlin from the left has a cracked welded that is approximately 2.5-inches long starting from about 2-feet up from the bottom horizontal girder (see Figure 8). This cracked weld should be repaired. Another weld section directly above this one is starting to show signs of a crack and should be examined closer. There is a suspect weld on the first purlin on the left side that should also be examined closer. The inner lock plate bolt holes on each of the trunnions on gate 2 have been slotted.

Please refer to the "Tellico Spillway Gate Inspection" checklist for more detailed information on each gate. For detailed photographs from each gate, refer to the share drive Maintenance Unit Photo folder "TEH Spillway Gate RA FY2007."

Coating Information:

For information concerning the coating condition of the items discussed in the report please refer to the 'TEH Coatings Condition' sheets.

Original signed by
Travis Simpson
Mechanical Inspector

Original signed by
Ronald E. Branam, P.E.
Lead Maintenance Engineer

Original signed by
Rusty Tompkins, P.E.
Manager, Civil Engineering

Distribution: Dam Safety Manager, Regional Manager, Chattanooga Dam Safety Files (original), BSL-Diana Miles, Terry Nash

Maintenance and Repair Items:

1. CM, Spillway Gates – Add drain holes to the middle gate struts on all of the gates, to the bracing on the strut arm connection to the horizontal girder on gate 1, and to the upstream side of the middle horizontal girder on gate 1.
   Responsible Organization: Power Service Shop
   Estimated Cost: $2,000
   Priority Code: C
   Estimated Completion Date: 03/07/2011
   Work Request: 08-001603

2. CM, Spillway Gate 1 – Tighten the left side seal bar nuts near the upper horizontal girder.
   Responsible Organization: Power Service Shop
   Estimated Cost: $750
   Priority Code: C
   Estimated Completion Date: 03/07/2011
   Work Request: 08-001604

Pending Projects:

1. Spillway Gates – Maintenance coat each of the spillway gates and trunnion blocks.
   Responsible Organization: Base O&M Coatings
   Estimated Cost: $10,000
   Recommended Fiscal Year: 2009

2. Spillway Gate 2 – Repair the cracked weld on the 10th purlin from the left. Inspect and repair if required the weld directly above the cracked one and the suspect weld on the first purlin from the left.
   Responsible Organization: Power Service Shop
   Estimated Cost: $20,000
   Recommended Fiscal Year: 2009
   Project No.: TEHZ06

3. Spillway Gates – Extend the siphon away from the gate.
   Responsible Organization: Power Service Shop
   Estimated Cost: $7,000
   Recommended Fiscal Year: 2009
   Project No.: TEHZ07

Follow-up Tasks:

1. Determine the cause of the cracked weld on the spillway gate 2.
   Responsible Organization: Civil Engineering
   Recommended Fiscal Year: 2008

Figure 1:

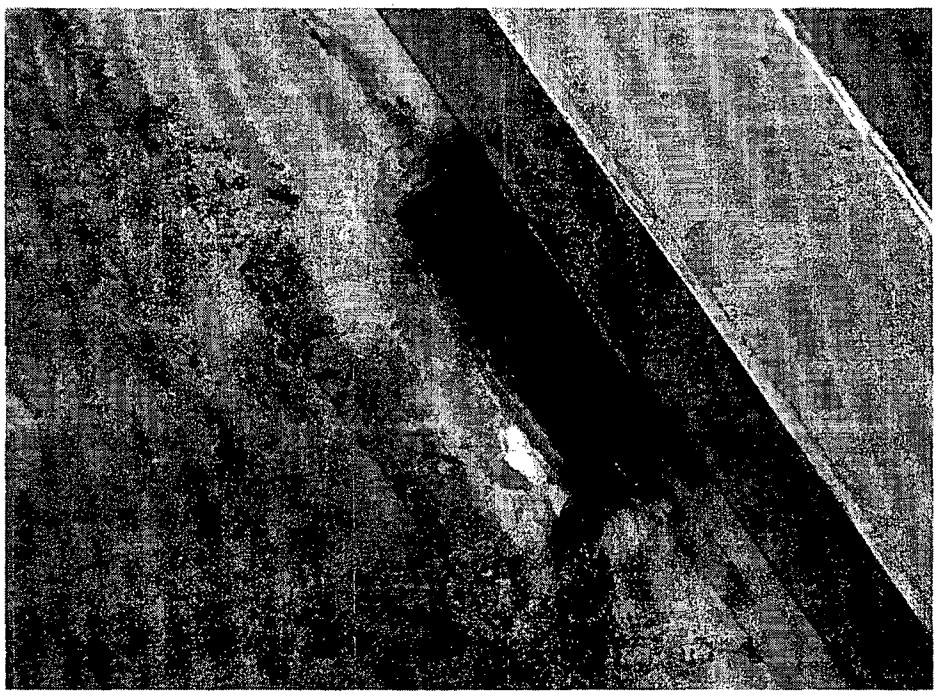
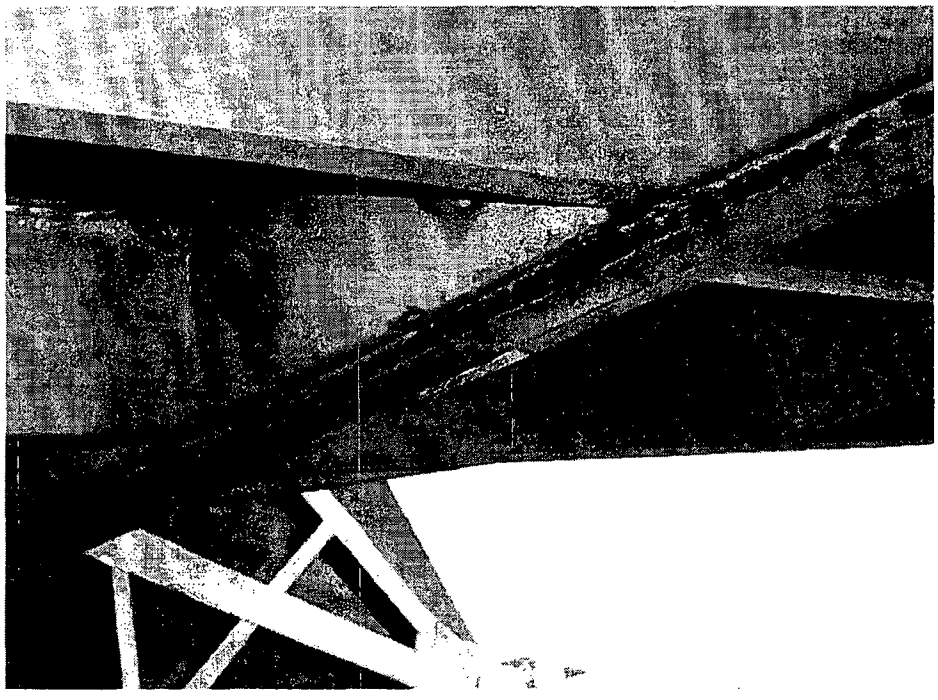


Figure 2:



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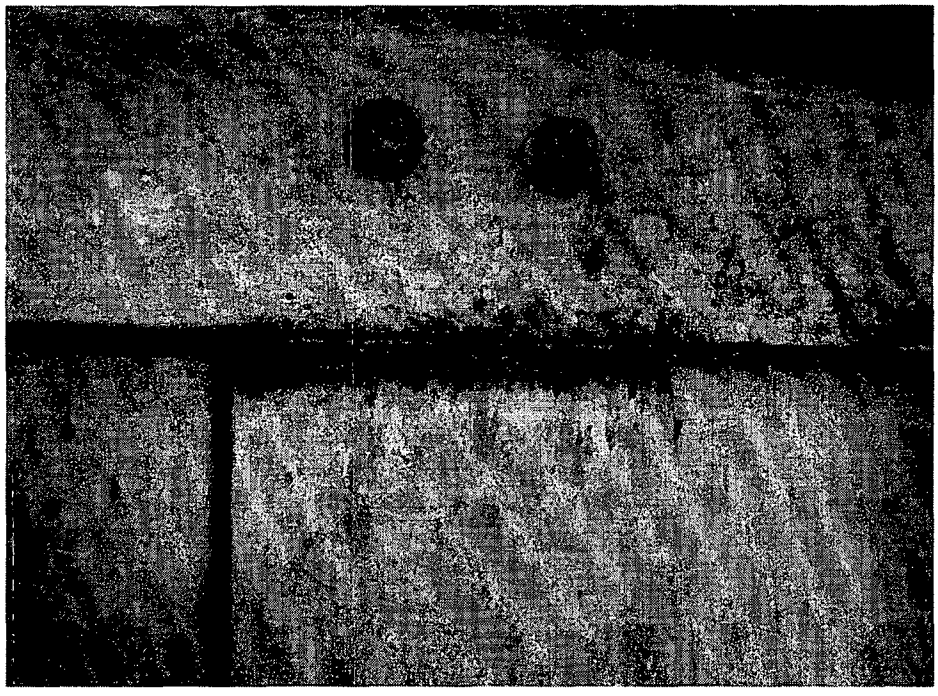
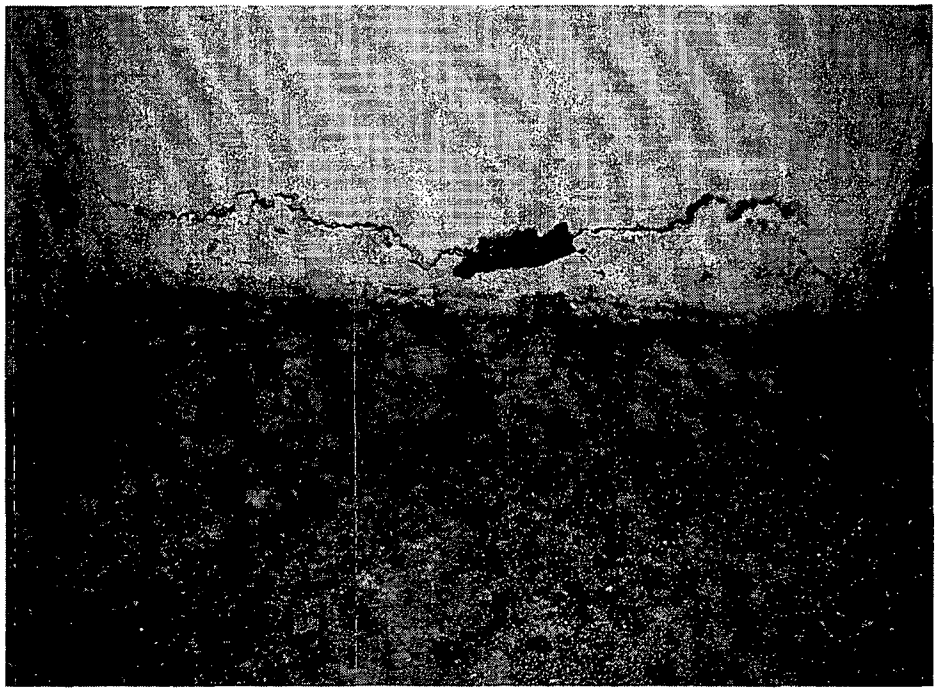


Figure 4:

Figure 5:



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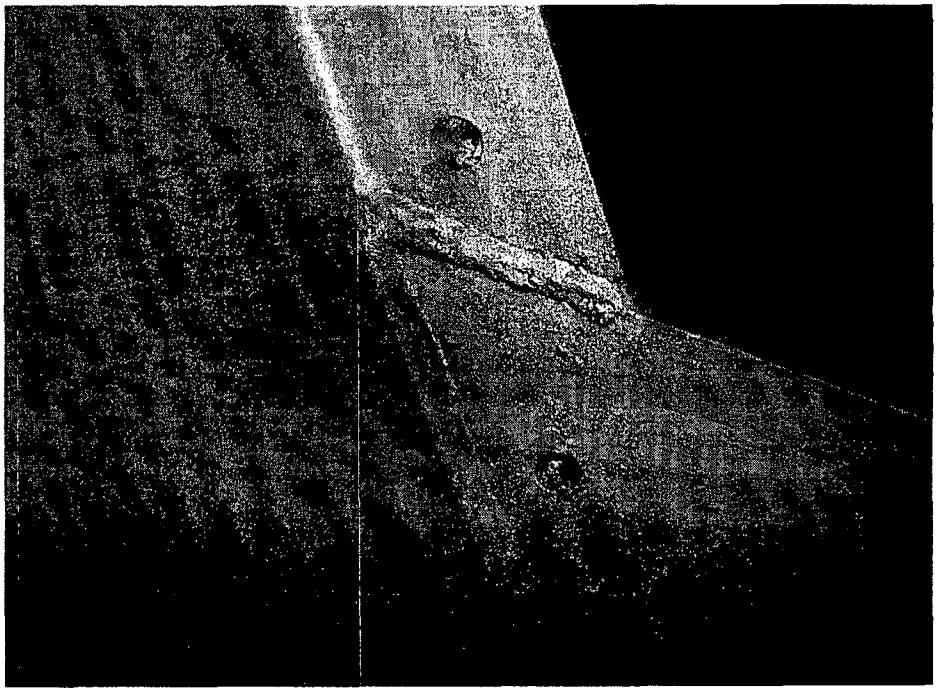

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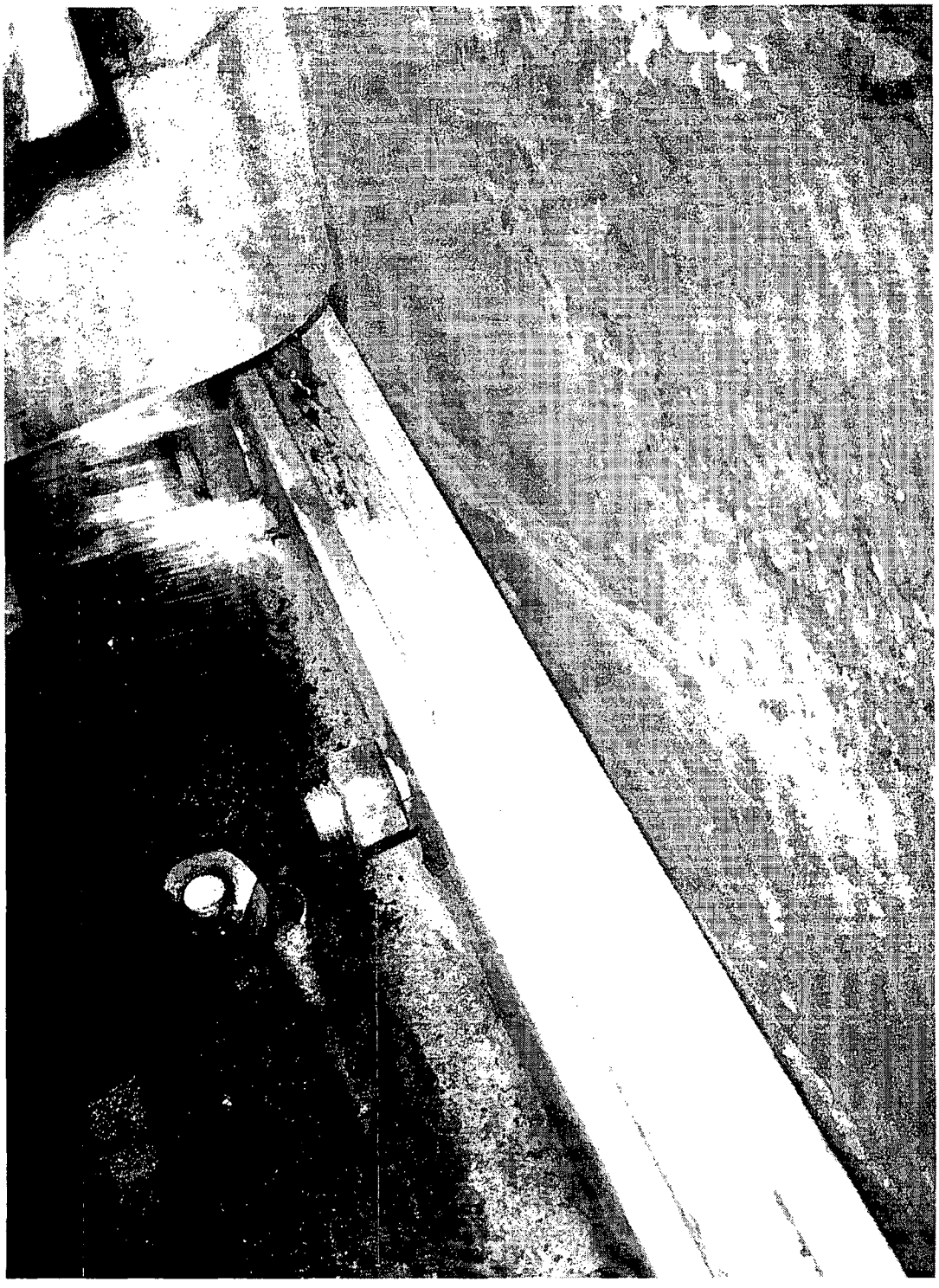

Figure 8: