Attachment 02.04.03-08B
TVA letter dated February 12, 2010
RAI Response

ASSOCIATED ATTACHMENTS/ENCLOSURES:

Attachment 02.04.03-8B: SOCH Model Calibration, Fort Loudon-Tellico CDQ000020080036

(329 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 090814 003	calculations(nuclear)	L58 091230 008

Calc Title: SOCH Model Calibration, Fort Loudoun-Tellico

CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	CUR REV	NEW REV	REVISION APPLICABILITY
CURRENT	CN	NUC	GEN	CEB	CDQ000020080036	0	1	Entire calc ☒ Selected pages ☐
NEW	CN	NUC						

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

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

DCN,EDC,N/A	APPLICABLE DESIGN DOCUMENT(S)	CLASSIFICATION
EDCN 22404A (SQN), EDCN 54018A (WBN), LATER (BFN)	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
clstokes	615-252-4343	CEB	See Page 6	☐ Yes ☒ No

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
Carrie L. Stokes Carrie L Stokes	12/15/09	L. Yu Lin L. Lin	12/16/09
VERIFIER SIGNATURE	**DATE**	**APPROVAL SIGNATURE**	**DATE**
L. Yu Lin L. Lin	12/16/09	K.R. Spates K.R. Spates	12/23/09

STATEMENT OF PROBLEM/ABSTRACT

OK 12/16/09

TVA's Simulated Open Channel Hydraulics (SOCH) Model has been developed and used for flood routing calculations for the Tennessee River and tributaries. The SOCH Model Calibrations for each reservoir calculate Manning's *n* values so that the SOCH Model will accurately model the river discharges and elevations of known events. The SOCH Model can then reliably predict flood conditions for events of other magnitudes. This calculation presents the SOCH Model Calibration for the Fort Loudoun and Tellico Reservoirs.

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:LP 4D-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 090814 003	calculations(nuclear)	N/A

Calc Title: SOCH Model Calibration, Fort Loudoun-Tellico

CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	CUR REV	NEW REV
CURRENT	CN	NUC					
NEW	CN	NUC	GEN	CEB	CDQ000020080036	N/A	0

REVISION APPLICABILITY: Entire calc ☐ Selected pages ☐

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

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

DCN,EDC,N/A	APPLICABLE DESIGN DOCUMENT(S) N/A	CLASSIFICATION
EDCN 22404A (SQN), EDCN 54018A (WBN), LATER (BLN)		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
ADRIAN WARD	615-252-4329	CEB	Design Review	☐ Yes ☒ No

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
Adrian Ward Adrian Ward	8/13/09	Chris Triplett Chris Triplett	8/13/09

VERIFIER SIGNATURE	DATE	APPROVAL SIGNATURE	DATE
L. Lin L.Yu Lin	8/13/09	K.R. Spates K.R. Spates	8/14/09

STATEMENT OF PROBLEM/ABSTRACT

TVA's Simulated Open Channel Hydraulics (SOCH) Model has been developed and used for flood routing calculations for the Tennessee River and tributaries. The SOCH Model Calibrations for each reservoir calculate Manning's *n* values so that the SOCH Model will accurately model the river discharges and elevations of known events. The SOCH Model can then reliably predict flood conditions for events of other magnitudes. This calculation presents the SOCH Model Calibration for the Fort Loudoun and Tellico Reservoirs.

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:LP 4D-C
☐ LOAD INTO EDMS AND RETURN CALCULATION TO:

NPG CALCULATION COVERSHEET/CCRIS UPDATE

CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	REV
	CN	NUC	GEN	CEB	CDQ000020080036	1

ALTERNATE CALCULATION IDENTIFICATION

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

CATEGORIES

KEY NOUNS (A-add, D-delete)

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

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

ACTION (A/C/D)	XREF CODE	XREF TYPE	XREF PLANT	XREF BRANCH	XREF NUMBER	XREF REV
A	P	CO	GEN	CEB	SOCH Version 1.0	
A	P	CO	GEN	CEB	CONVEY Version 1.0	

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 CDQ000020080036

Title SOCH Model Calibration, Fort Loudoun-Tellico

Revision No.	DESCRIPTION OF REVISION
0	Initial issue (150 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 includes only changes made in this revision as the checking of the calculation was not impacted by PER 203951. The verification is inclusive of work completed prior to this revision. • PER 203872 – Replaced NEDP-2 forms pages 2 through 16 with the forms from the NEDP-2 Revision in effect at the time of calculation issuance. • Updated References 2.10, 2.11, 2.12 and 2.23. Note: Dam rating curves were used in this calculation as a common starting point between two models. Any changes to the dam rating curves will have no impact on the calibration effort and does not require revision of the calibration. Significant changes in Revision 1 are noted with a right margin revision bar. Administrative changes and typos are excluded. Pages Added: 1a & 6a Pages Replaced: 1 -16, 17, 19, 20, 23, 25, 31, 95, 97, 98, and 99 Total pages of calculation hard copy for Revision 1= 152

NPG CALCULATION TABLE OF CONTENTS

Calculation Identifier: CDQ000020080036	Revision:	1

TABLE OF CONTENTS

SECTION	TITLE	PAGE
	Coversheet	1
	CCRIS Update Sheet	2
	Record of Revision	3
	Table of Contents	4
	Verification Form	6
	Computer Input Sheet	7
1	Purpose	17
2	References	19
3	Assumptions and Methodology	21
4	Design Input	31
5	Special Requirements/Limiting Conditions	32
6	Calculations	33
7	Results/Conclusions	146
APPENDIX		
A	Final Manning's *n*, SOCH Geometry, and Calibration Graphs	N/A
B	Unit Hydrograph Modifications	11 pages
C	Cross-Section Modifications	22 pages
D	SOCH Input Files, Steady-State (.dat, .bnd)	N/A
E	SOCH Input Files, March 1973 Flood (.dat, .loc, .bnd)	N/A
F	SOCH Input Files, May 2003 Flood (.dat, .loc, .bnd)	N/A
G	SOCH Output File, Steady-State (.out)	N/A
H	SOCH Output Files, March 1973 (.out, .prt)	N/A
I	SOCH Output Files, May 2003 (.out, .prt)	N/A
J	Calibrated Steady-State HEC-RAS Model	N/A
K	CONVEY Files and SOCH Geometry Files	N/A
L	Flow Distribution for Fort Loudoun-Tellico	NA

NPG CALCULATION TABLE OF CONTENTS

Calculation Identifier: CDQ000020080036	Revision:	1

TABLE OF CONTENTS

ATTACHMENT	TITLE	PAGE
1	Initial Geometry Files	59 pages
2	Tailwater Rating Curves	N/A
3	Headwater Rating Curves	N/A
4	1973 Elevations and Discharges	4 pages
5	2003 Elevations and Discharges	22 pages
6	Local Inflows for Basins 8,16,17,18, and 24	N/A
7	Local Inflows for Little Pigeon River	N/A
8	Flood Insurance Studies	N/A
9	FIS HEC Files	N/A
10	Composite Rating Curve for Fort Loudoun	N/A
11	SOCH Input Preprocessor, Steady-State	N/A
12	SOCH Input Preprocessor, March 1973 Flood	N/A
13	SOCH Input Preprocessor, May 2003 Flood	N/A
14	Macro File for SOCH Input Preprocessor	N/A
15	Macro File for Extraction of SOCH Output	N/A
16	Native Word Calculation File	N/A

NPG CALCULATION VERIFICATION FORM

Calculation Identifier CDQ000020080036 Revision 1

Method of verification used:

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

Verifier L. Yu Lin Date 12/16/09

L. Lin

Comments:

This calculation entitled, SOCH Model Calibration, Ft. Loudoun-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.

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

NPG CALCULATION VERIFICATION FORM

Calculation Identifier CDQ000020080036 Revision 0

Method of verification used:

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

Verifier L. Yu Lin Date 8-13, 2009

L. Lin

Comments:

The purpose of this calculation is to calibrate the Simulated Open Channel Hydraulics Model (SOCH) developed by TVA, so that the SOCH model can be reliably used to predict other magnitudes of flood. The fundamental design view process for this calculation was a design review of the data collection, model simulation, model calibration and model verification. Alternate calculations were conducted to verify this design process as described below:

As discussed on Page 22, steady-state models for the Fort Loudoun-Tellico Reservoir were developed using the U.S. Army Corps of Engineers Center's River Analysis System (HEC-RAS) version 3.1.3. The Manning's values in the HEC-RAS were calibrated to match the high-water marks for the 1973 and 2003 flood events. The Manning values were also verified using V.T. Chow's Open Channel Hydraulics (1959), Roughness Characteristics of Natural Channels: Geological Survey Water-Supply Paper 1849 (1967), Flood Insurance Study, Knox County (Reference 2.15) and Flood Insurance Study, Loudon County (Reference 2.16) as alternate design process. The Manning values from the SOCH and HEC-RAS model were consistent with the values listed in both reference books. It concluded that the Manning values in the SOCH and the HEC-RAS model were properly used for the Fort Loudoun-Tellico Reservoir calculation.

As discussed beginning on Page 33, the flow data of the 1 Percent Annual Chance flood and the 0.2 Percent Annual Chance flood published in Flood Insurance Studies (FIS) for the Tennessee River, Holston River, French Broad River and Little Tennessee River were collected. The 1 Percent and 0.2 Percent Annual Chance floods in the Tennessee River at TRM 652.22 were used to develop the boundary conditions for the Holston River and French Broad River models. The 1 Percent and 0.2 Percent Annual Chance floods in the Little Tennessee River at LTRM 0.3 were used to develop the boundary conditions for the Little Tennessee River model.

Since a difference source was used to verify the input data for the TVA model, compliance with NEDP-2, Section 3.1.J.2 is achieved.

As shown in Appendix J, steady-state HEC-RAS models of the Fort Loudoun Reservoir, Holston River, French Broad River, and Little Tennessee River were developed to demonstrate that given the same inputs as SOCH models, the results showed that HEC-RAS models produce equivalent results as SOCH models.

Since a difference source was used to verify the results of the models, compliance with NEDP-2, Section 3.1.J.2 is achieved.

NPG COMPUTER INPUT FILE
STORAGE INFORMATION SHEET

Document CDQ000020080036	Rev. 1	Plant: GEN	

Subject:
SOCH Model Calibration, Fort Loudoun-Tellico

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

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

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

Appendix A

1. FtLoudoun_FinalManningsn.xls
2. FtLoudoun Rev3.geo
3. Tellico Rev4.geo
4. Holston Rev3.geo
5. FrenchBroad Rev2.geo
6. Canal Rev1.geo
7. FtLoudounHEC_RAS_SteadyState_Profiles.xls
8. FtLoudoun_SOCH_SteadyState_Profiles.xls
9. LittleTNHEC_RAS_SteadyState_Profiles.xls
10. 49XS_LittleTNSOCH_100Kto600K_SteadyState_Profiles.xls
11. HolstonHEC_RAS_SteadyState_Profiles.xls
12. HolstonSOCH_SteadyState_Profiles.xls
13. FrBroadHEC_RAS_SteadyState_Profiles.xls
14. FrBroadSOCH_SteadyState_Profiles.xls
15. Observed vs. SOCH Mar 1973 Hydrographs.xls
16. Remove7_45Observed vs. SOCH May 2003 Hydrographs.xls

Appendix B

17. DistHyd_FBroad1973.bnd
18. DistHyd_FBroad1973.dat

☐ Microfiche/eFiche

NPG COMPUTER INPUT FILE
STORAGE INFORMATION SHEET

Document CDQ000020080036	Rev. 1	Plant: GEN	

Subject:
SOCH Model Calibration, Fort Loudoun-Tellico

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

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

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

Appendix B

19. DistHyd_FBroad1973.loc
20. DistHyd_FBroad1973.out
21. DistHyd_FBroad1973.prt
22. DistHyd_FBroad1973.run
23. DistHyd_FBroad1973.sto
24. DistHyd_Holston_1973.bnd
25. DistHyd_Holston_1973.dat
26. DistHyd_Holston_1973.loc
27. DistHyd_Holston_1973.out
28. DistHyd_Holston_1973.prt
29. DistHyd_Holston_1973.run
30. DistHyd_Holston_1973.sto
31. DistHydDevelopment_Holston_1973_BuildSOCHdata.xls
32. DistLocalHyd_FrenchBroadOnly_1973_BuildSOCHdata.xls
33. Distributed_vs_Point_Local_Graphs.xls
34. DistributedHydrographs.xls
35. DistributedLocalHydrographGraph.xls
36. HolstonFlood_ExtractSelectedSOCHOutputHydrographs.xls
37. PointHyd_FBroad1973.bnd
38. PointHyd_FBroad1973.dat
39. PointHyd_FBroad1973.loc
40. PointHyd_FBroad1973.out

☐ Microfiche/eFiche

NPG COMPUTER INPUT FILE
STORAGE INFORMATION SHEET

Document CDQ000020080036	Rev. 1	Plant: GEN	

Subject:
SOCH Model Calibration, Fort Loudoun-Tellico

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

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

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

Appendix B (cont.)

41. PointHyd_FBroad1973.prt
42. PointHyd_FBroad1973.run
43. PointHyd_FBroad1973.sto
44. PointHyd_Holston_1973.bnd
45. PointHyd_Holston_1973.dat
46. PointHyd_Holston_1973.loc
47. PointHyd_Holston_1973.out
48. PointHyd_Holston_1973.prt
49. PointHyd_Holston_1973.run
50. PointHyd_Holston_1973.sto
51. PointHydDevelopment_Holston_1973_BuildSOCHdata.xls
52. PointLocalHyd_FrenchBroadOnly_1973_BuildSOCHdata.xls
53. PointLocalHydrographGraph.xls

Appendix D

54. 1footslices_FtLoudoun_Calibrate_100Kto1400K-59 Cross-sections.dat
55. 1ftsections_49XS_FrenchBroad_Calibrate_65Kto845K.dat
56. 49XS_LittleTN_Calibrate_100Kto600K.dat

☐ Microfiche/eFiche

NPG COMPUTER INPUT FILE
STORAGE INFORMATION SHEET

Document CDQ000020080036	Rev. 1	Plant: GEN	

Subject:
SOCH Model Calibration, Fort Loudoun-Tellico

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

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

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

Appendix D (cont.)
57. Holston_Calibrate_35Kto490K.dat
58. 1footslices_FB and Holston 100Kto1400K-59 Cross-sections.bnd
59. 1ftsections_49XS_Douglas65Kto845K.bnd
60. 49XS_Chilhowee100Kto600K.bnd
61. Cherokee35Kto490K.bnd

Appendix E
62. FtLoudoun_Holston_FBroad1973.dat
63. FtLoudoun_Holston_FBroad1973.bnd
64. FtLoudoun_Holston_FBroad1973.loc

Appendix F
65. DistLocalRemove7_45_FtLoudoun_EL_LittleT_Q_2003.dat
66. DistLocalRemove7_45_FtLoudoun_EL_LittleT_Q_2003.bnd
67. DistLocalRemove7_45_FtLoudoun_EL_LittleT_Q_2003.loc

Appendix G
68. 1footslices_FtLoudoun_Calibrate_100Kto1400K-59 Cross-sections.out
69. 1ftsections_49XS_FrenchBroad_Calibrate_65Kto845K.out
70. 49XS_LittleTN_Calibrate_100Kto600K.out
71. Holston_Calibrate_35Kto490K.out

☐ Microfiche/eFiche

NPG COMPUTER INPUT FILE
STORAGE INFORMATION SHEET

Document CDQ000020080036	Rev. 1	Plant: GEN	

Subject:
SOCH Model Calibration, Fort Loudoun-Tellico

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

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

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

Appendix H
72. FtLoudoun_Holston_FBroad1973.out
73. FtLoudoun_Holston_FBroad1973.prt

Appendix I
74. DistLocalRemove7_45_FtLoudoun_EL_LittleT_Q_2003.out
75. DistLocalRemove7_45_FtLoudoun_EL_LittleT_Q_2003.prt

Appendix J
76. Fort Loudoun100K.f06
77. Fort Loudoun100K.prj
78. Fort Loudoun100K.p60
79. Fort Loudoun100K.g12
80. Fort Loudoun100K.f08
81. LittleTNRiver.f05
82. LittleTNRiver.g06
83. LittleTNRiver.p22
84. LittleTNRiver.prj
85. LittleTNRiver.f06
86. LittleTNRiver.f04

☐ Microfiche/eFiche

NPG COMPUTER INPUT FILE
STORAGE INFORMATION SHEET

Document CDQ000020080036	Rev. 1	Plant: GEN	

Subject:
SOCH Model Calibration, Fort Loudoun-Tellico

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

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

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

Appendix J (cont.)
87. Holston.g06
88. Holston.f04
89. Holston.prj
90. Holston.p42
91. Holston.f03
92. Holston.f02
93. FrBroadR.f03
94. FrBroadR.g17
95. FrBroadR.p63
96. FrBroadR.prj
97. FrBroadR.f02

Appendix K
98. Tellico Rev4.geo
99. Tellico Merge 20090811.xls
100. Tellico CONVEY20090723.xls
101. Tellico CONVEY20090723.prt
102. Tellico CONVEY20090723.out
103. Tellico CONVEY20090723.dat
104. Tellico20090716.geo

☐ Microfiche/eFiche

NPG COMPUTER INPUT FILE
STORAGE INFORMATION SHEET

Document CDQ000020080036	Rev. 1	Plant: GEN	

Subject:
SOCH Model Calibration, Fort Loudoun-Tellico

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

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

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

Appendix K (cont.)

105. Holston Rev3.geo
106. Holston CONVEY 200900723.xls
107. Holston CONVEY 200900723.prt
108. Holston CONVEY 200900723.out
109. Holston CONVEY 200900723.dat
110. Holston20090720.geo
111. FtLoudoun Rev3.geo
112. FtLoudoun CONVEY 20090803cal B.prt
113. FtLoudoun CONVEY 20090803cal B.out
114. FtLoudoun CONVEY 20090803cal B.dat
115. FtLoudoun CONVEY 20090803cal A.prt
116. FtLoudoun CONVEY 20090803cal A.out
117. FtLoudoun CONVEY 20090803cal A.dat
118. FtLoudoun CONVEY 20090803cal.xls
119. FtLoudoun Combined Merge 20090803cal.xls
120. FtLoudoun20090720.geo
121. French Broad Rev2.geo
122. FrenchBroad20090720.geo
123. French Broad CONVEY20090721cal.xls
124. French Broad CONVEY20090721cal b.prt
125. French Broad CONVEY20090721cal b.out
126. French Broad CONVEY20090721cal b.dat
127. French Broad CONVEY20090721cal a.prt
128. French Broad CONVEY20090721cal a.out

☐ Microfiche/eFiche

NPG COMPUTER INPUT FILE
STORAGE INFORMATION SHEET

Document CDQ000020080036	Rev. 1	Plant: GEN	

Subject:
SOCH Model Calibration, Fort Loudoun-Tellico

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

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

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

Appendix K (cont.)
129. French Broad CONVEY20090721cal a.dat
130. Canal20090713.geo
131. Canal Rev1.geo
132. FrBroadR.g16
133. Fort Loudoun100K.g10
134. Holston Merge 20090811.xls

Appendix L
135. FinalFtLoudoun_FB_Holston_TellicoFlowDist.xls

Attachment 1
136. Canal20090713.geo
137. FrenchBroad20090720.geo
138. FtLoudoun20090720.geo
139. Holston20090720.geo
140. Tellico20090716.geo

Attachment 2
141. Chilhowee DRC.pdf
142. Douglas Dam Rating Curves, Rev 2.xls
143. Cherokee Dam Rating Curves, Rev.1.xls

Attachment 3
144. Fort Loudoun DRC.xls
145. Tellico Dam Rating Curve Rev 0 Attachment.xls

☐ Microfiche/eFiche

NPG COMPUTER INPUT FILE
STORAGE INFORMATION SHEET

Document CDQ000020080036	Rev. 1	Plant: GEN	

Subject:
SOCH Model Calibration, Fort Loudoun-Tellico

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

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

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

Attachment 5
146. All Fort Loudoun Flows and Elevations2003.xls
147. All_Tellico_Flows_&_Elevations_May2003_rev0.xls

Attachment 6
148. 1-1_Fort Loudoun-Tellico (8, 16, 17, 18, & 24) hydrographs.xls

Attachment 7
149. LittlePigeonAtSevierville_rev0.xls
150. 1973 Local Inflow for Little Pigeon River.pdf

Attachment 8
151. Jefferson Co.pdf
152. Knox Co.pdf
153. Loudon Co.pdf
154. Sevier Co.pdf

Attachment 9
155. FrBroadR.f01
156. FrBroadR.g13
157. FrBroadR.p15
158. FrBroadR.prj

☐ Microfiche/eFiche

NPG COMPUTER INPUT FILE
STORAGE INFORMATION SHEET

Document CDQ000020080036	Rev. 1	Plant: GEN	

Subject:
SOCH Model Calibration, Fort Loudoun-Tellico

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

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

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

Attachment 9 (cont.)
159. ltnr97.dat
160. hol2000.dat

Attachment 10
161. Composite Rating Curve for Ft Loudoun.xls

Attachment 11
162. FtLoudoun100Kto1400KBuildSOCHdata59sections.xls
163. 49XS_1ftsections_FrenchBroad65Kto845KBuildSOCHdata1.xls
164. Holston35Kto490KBuildSOCHdata.xls
165. 49XS_LittleTennBuildSOCHdata.xls

Attachment 12
166. FtLoudoun_Holston_FB_1973_BuildSOCHdata.xls

Attachment 13
167. DistLocalsRemove7_45FtLoudoun_EL_Tellico_Q_2003_BuildSOCHdata.xls

Attachment 14
168. SOCH_Macros.xls

Attachment 15
169. Remove7_45Flood_ExtractSelectedSOCHOutputHydrographs.xls

Attachment 16
170. CDQ000020080036_rev_1.doc

☐ Microfiche/eFiche

1. Purpose

TVA's Simulated Open Channel Hydraulics (SOCH) Model has been developed and used for flood routing calculations for the Tennessee River and selected tributaries. The SOCH Model is calibrated for each reservoir so that the model will accurately replicate observed river discharges and elevations for known historic events. The SOCH model can then be used to reliably predict flood elevations and discharges for events of other magnitudes. This calculation presents the SOCH model calibration for Fort Loudoun and Tellico Reservoirs (Figure 1).

History

Tennessee Valley Authority (TVA) developed the method of analysis, procedures and computer programs needed to determine the design basis flood levels for nuclear plant sites in the 1970s. 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 standard computer programs (codes) available that would handle unsteady flow and dam failure analysis. As a result of this early work TVA developed a runoff and stream course modeling procedure for the TVA reservoir system that provided the basis for currently licensed plants (Sequoyah Nuclear Plant, Watts Bar Nuclear Plant and Browns Ferry Nuclear Plant). The Bellefonte Nuclear Plant (BLN) Unit 1 and Unit 2 Final Safety Analysis Report (FSAR) was also based on this process.

The BLN Unit 3 and Unit 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 calculation.

A quality assurance audit conducted by NRC staff in early 2008 raised several documentation questions related to past work regarding design basis flood level determinations because TVA's nuclear organization was not able to readily produce supporting materials for the review. While there is supporting data and analysis available to document the work, it is stored in multiple file books and on microfilm stored in both Knoxville and Chattanooga. This calculation supports and documents the procedure followed to calibrate the Chickamauga Reservoir SOCH model.

The purpose of this calculation is to document the calibration process for Fort Loudoun and Tellico Reservoir portions of the SOCH model so that it can be reliably used to predict flood elevations and discharges for events of varying magnitudes and to validate the unit hydrograph local inflows. The Fort Loudoun-Tellico Reservoir SOCH model includes the Fort Loudoun Reservoir, the Holston River to Cherokee dam, the French Broad River to Douglas dam, the canal between Fort Loudoun and Tellico and Tellico Reservoir. Inputs to this calculation include channel geometry, local inflow hydrographs, dam rating curves and historic flood elevations and discharges. The result of this calculation will be the final Manning's *n* values for the Fort Loudoun-Tellico Reservoir and the SOCH geometry files for the Fort Loudoun-Tellico Reservoir to be used in the SOCH PMF determination for TVA Nuclear Plant sites. In the SOCH PMF determination and other subsequent analyses such as seismic failure evaluations, the Fort Loudoun-Tellico Reservoir model will be run in series with models of the other reservoirs. As a result, additional modification to the SOCH geometry for Fort Loudoun-Tellico Reservoir may be required. However, any required changes will be made during that phase and the calibration will be confirmed for the revised model.

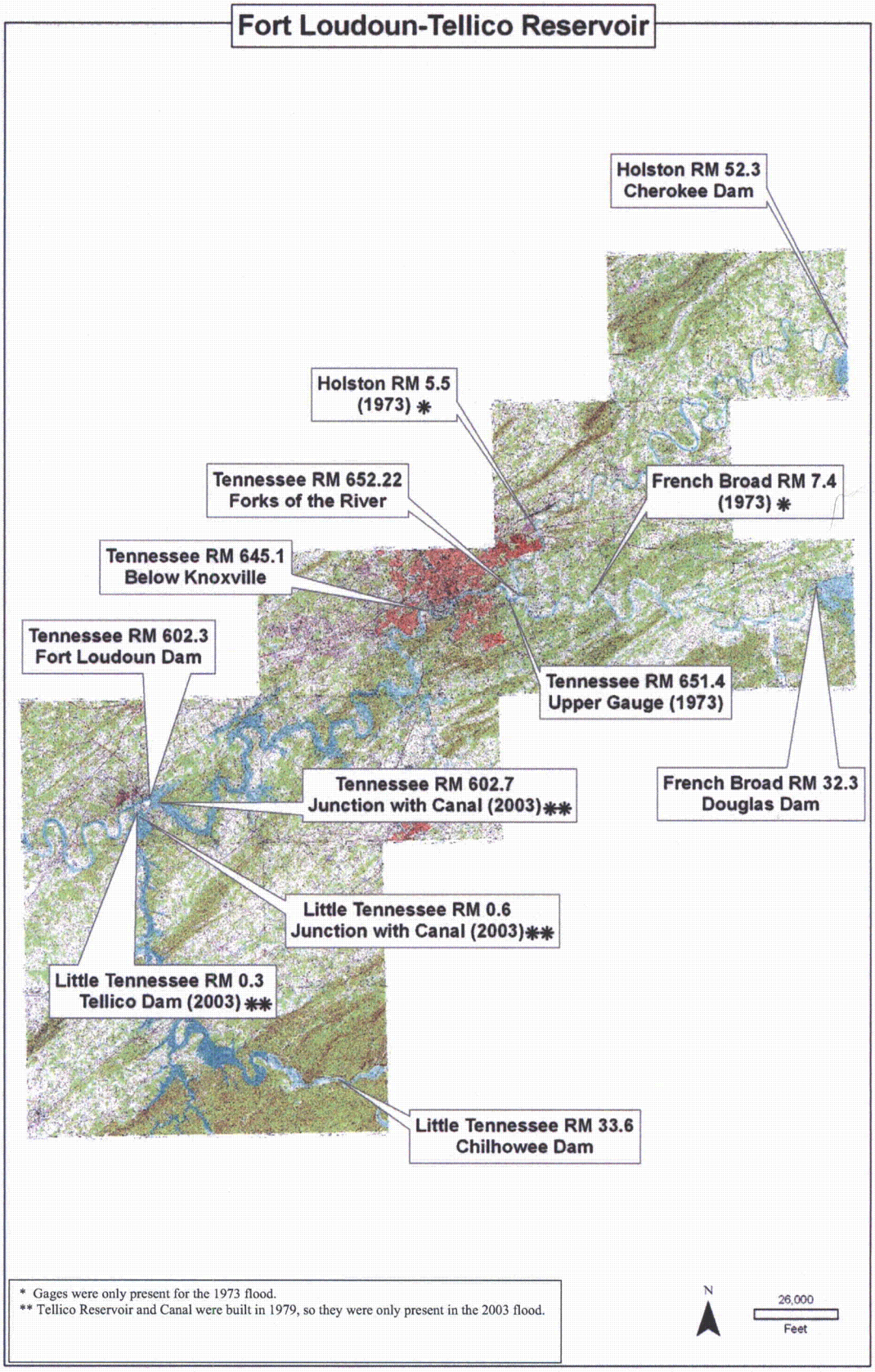

Fort Loudoun-Tellico Reservoir
Holston RM 52.3
Cherokee Dam
Holston RM 5.5
(1973) *
Tennessee RM 652.22
Forks of the River
French Broad RM 7.4
(1973) *
Tennessee RM 645.1
Below Knoxville
Tennessee RM 602.3
Fort Loudoun Dam
Tennessee RM 651.4
Upper Gauge (1973)
Tennessee RM 602.7
Junction with Canal (2003)**
French Broad RM 32.3
Douglas Dam
Little Tennessee RM 0.6
Junction with Canal (2003)**
Little Tennessee RM 0.3
Tellico Dam (2003) **
Little Tennessee RM 33.6
Chilhowee Dam
* Gages were only present for the 1973 flood.
** Tellico Reservoir and Canal were built in 1979, so they were only present in the 2003 flood.
N
26,000
Feet

Figure 1.

2. References

2.1 *Drainage Areas for Streams in Tennessee River Basin*, Report No. 0-5829-R-2, Tennessee Valley Authority, Division of Water Control Planning, Hydraulic Data Branch, Knoxville, TN, March 1970.

2.2 "Bellefonte Nuclear Plant, White Paper –Hydrologic Analysis, Revision 1", Tennessee Valley Authority, July 25, 2008. (EDMS No. L58 081219 800) FOR INFORMATION ONLY

2.3 "Dam Rating Curves – Cherokee" CDQ000020080005 Revision 1 (EDMS No. L58 090406 003)

2.4 "Dam Rating Curves – Douglas" CDQ000020080007 Revision 2 (EDMS No. L58 090406 002)

2.5 "Dam Rating Curves – Fort Loudoun" CDQ000020080009 Revision 0 (EDMS No. L58 090304 001)

2.6 "Dam Rating Curves – Tellico" CDQ000020080018 Revision 0 (EDMS No. L58 090304 002)

2.7 "Bellefonte Units 3 and 4 Hydrology Project Request for Information (RFI) Response Information Continuation Sheet," RFI Number BE21108160B021, Rev. 0. (EDMS No. L58 090311 800)

2.8 "Bellefonte Units 3 and 4 Hydrology Project Request for Information (RFI) Response Information Continuation Sheet," RFI Number BE21108160B021, Rev. 1. (EDMS No. L58 090604 800)

2.9 "Bellefonte Units 3 and 4 Hydrology Project Request for Information (RFI) Response Information Continuation Sheet," RFI Number BE21147150B031, Rev. 0. (EDMS No. L58 090604 800)

2.10 "SOCH Geometry Verification for Fort Loudoun Reservoir, French Broad River, and Holston River" CDQ000020080024 Revision 1

2.11 "SOCH Geometry Verification for Tellico Reservoir and Canal" CDQ000020080025 Revision 1

2.12 "Calculation of Initial Flood Flows from the Fort Loudoun-Tellico Watershed (Subbasins 8, 16, 17, 18, and 24) for Use in the SOCH Model Calibration and Unit Hydrograph Validation, CDQ000020080069 Revision 1

2.13 Omitted

2.14 *Flood Insurance Study, Jefferson County, Tennessee, and Incorporated Areas*, Flood Insurance Study Number 47089CV000A, Federal Emergency Management Agency, December 16, 2008.

2.15 *Flood Insurance Study, Knox County, Tennessee, and Incorporated Areas*, Volumes 1-4, Flood Insurance Study Numbers 47093CV001A, 47093CV002A, 47093CV003A, 47093CV004A, Federal Emergency Management Agency, May 2, 2007.

2.16 *Flood Insurance Study, Loudon County, Tennessee, and Incorporated Areas*, Flood Insurance Study Number 47105CV000A, Federal Emergency Management Agency, May 16, 2007.

2.17 *Flood Insurance Study, Sevier County, Tennessee, and Incorporated Areas*, Flood Insurance Study Number 47155CV000A, Federal Emergency Management Agency, May 18, 2009.

2.18 "Software Verification and Validation Report (SVVR) Simulated Open Channel Hydraulics (SOCH) Version 1.0" (EDMS No. L58 090528 004)

2.19 "User's Manual Simulated Open Channel Hydraulics (SOCH) Version 1.0", (EDMS No. L58 090528 002)

2.20 *HEC-RAS, River Analysis System Hydraulic Reference Manual*, Revision 3.1, Report No. CPD-69, U.S. Army Corps of Engineers Hydraulic Engineering Center, November 2002.

2.21 NUREG 0800, Standard Review Plan, Section 2.4.1

2.22 "Weighted Width (WWIDTH) Version 1.0 Conveyance (CONVEY) Version 1.0 User Manual." Revision 0 (EDMS No. L58 090213 001)

2.23 "SOCH Model Calibration, Guntersville" CDQ000020080041 Revision 1

2.24 "Bellefonte Units 3 and 4 Hydrology Project Request for Information (RFI) Response Information Continuation Sheet," RFI Number BE21108160B021, Rev. 2. (EDMS No. L58 090813 800)

3. Assumptions and Methodology

3.1 Assumptions

3.1.1 Assumption: Flow, elevation and date information used in this calculation are acceptable for use in the development of the TVA design basis PMF analysis.
Technical Justification: The flow, elevation and other input data were not obtained via a 10 CFR 50 Appendix B program; however they represent the best and most complete data set available. Based on the Acceptance Criteria Section of NUREG 800 Standard Review Plan (SRP) 2.4.1 (Reference 2.21), these data are expected to meet the requirements of an Appendix B program, excerpt follows:

"Data collected, maintained, and distributed by Federal and State agencies, such as USGS, NOAA, NRCS, USACE, and various State water resources departments, are adequate for safety evaluation of the plant."

TVA is the Federal agency responsible for flood control in watersheds of concern and minimal data are available from the other Federal agencies delineated in the SRP. Historical data from TVA records are used to calibrate the models to the 1973 and 2003 historical floods of record. TVA, NWS, and USGS are responsible for operating the majority of the gages in the Tennessee Valley at the time of these floods.

3.2 Unverified Assumptions - None

3.3 Methodology

The purpose of this calculation is to document the calibration process for the Fort Loudoun-Tellico Reservoir portion of the SOCH model so that it can be reliably used to predict flood elevations and discharges for events of varying magnitudes and to validate one concentrated and four distributed local unit hydrographs. An overview of the calibration process is depicted in Figure 2.

The objective of calibrating a model is to adjust model parameters so that the model will accurately replicate known historic events and published Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) profiles. The model will therefore be considered reliable to predict the outcome of events of other magnitudes. In the case of the SOCH model, the model results must accurately replicate observed elevations and discharges for known historic flood events. Because the model will ultimately be used to predict PMF flood levels, large recorded flood events should be used to calibrate the model. The Fort Loudoun portion of the model is based on replication of the March 1973 and May 2003 (Reference 2.7) flood events. The French Broad and Holston River arms of the model were calibrated to the 1973 and 2003 floods and compared to the published FEMA 100 and 500 yr profiles. The Tellico Reservoir portion was calibrated by replication of the 2003 flood event and the published FEMA 100 and 500 yr frequency profiles. The March 1973 flood is one of the largest recorded flood events.

The following describes the methodology of the calibration process in detail.

3.3.1 HEC-RAS Steady-State Calibration

A steady-state model of the Fort Loudoun-Tellico reservoir was first developed using the U.S. Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS) version 3.1.3. A review performed of subsequent versions of HEC-RAS (up to the most recent version) did not identify any changes that would affect the results and conclusions developed in this calculation (Section 2.12 of Reference 2.18). The Fort Loudoun/Tellico/Canal model was divided into four HEC-RAS steady-state models: the Holston River from the mouth to Cherokee Dam (Holston River Mile 52.30), the French Broad River from the mouth to Douglas Dam (French Broad River Mile 32.30), Fort Loudoun Reservoir on the Tennessee River from the junction of the Holston and French Broad Rivers at River Mile 652.22 to Fort Loudoun Dam at River Mile 602.30, and the Tellico Reservoir from Chilhowee Dam at River Mile 33.60 to Tellico Dam at River Mile 0.30.

Holston River

The Holston River HEC-RAS model was initially set up using elevations from the 1 Percent Annual Chance flood profile and the 0.2 Percent Annual Chance flood profile published in the Knox County and Jefferson County Flood Insurance Studies (FIS) (References 2.14 and 2.15). The flow distribution for the cross sections was then determined from the HEC2 files (Attachment 9) used to produce the flood profiles and interpolated where necessary (Reference 2.9). The downstream water surface elevations input as the starting water surface elevations were the elevations published in the FIS.

Steady-flow data used initially to set-up the 1973 flood was determined by taking the observed flows at the time the observed approximate peak elevations at Fort Loudoun, Cherokee and Douglas Dams occurred. The upstream inflows at Cherokee and Douglas Dams were subtracted from the outflow at Fort Loudoun. The difference between inflow and outflow represents the local inflow. This local inflow was distributed along Fort Loudoun Reservoir and the Holston and French Broad Rivers based on the drainage area (Appendix L). The downstream starting water surface elevation input as the Reach Boundary Condition was then interpolated by using observed elevations from the gages at Holston River Mile 5.50 and Tennessee River Mile 651.40.

The HEC-RAS model was then adjusted by varying the Manning's *n* values, using good engineering judgment, to match the water-surface elevations of the 1 Percent and 0.2 Percent Annual Chance floods and to match the tailwater gage at

The HEC-RAS model was then adjusted by varying the Manning's *n* values, using good engineering judgment, to match the water-surface elevations of the 1 Percent and 0.2 Percent Annual Chance floods and to match the tailwater gage at Holston River Mile 52.30 and the gage at Holston River Mile 5.50 for the 1973 flood. The Manning's *n* values were then adjusted to refine the calibration and more closely match the published elevations.

French Broad River

The French Broad River HEC-RAS model was initially set up using elevations from the 1 Percent Annual Chance flood profile and the 0.2 Percent Annual Chance flood profile published in the Knox County and Sevier County Flood Insurance Studies (References 2.15 and 2.17). The flow distribution for the cross sections was then determined from the HEC2 files (Attachment 9) used to produce the flood profiles and interpolated where necessary (Reference 2.9). The downstream water surface elevations input were the elevations published in the FIS.

Steady-flow data used initially to set-up the 1973 flood was determined by taking the observed flows at the time the observed approximate peak elevations at Fort Loudoun, Cherokee and Douglas Dams occurred. The upstream inflows at Cherokee and Douglas Dams were subtracted from the outflow at Fort Loudoun. The difference between inflow and outflow represents the local inflow. This local inflow was distributed along Fort Loudoun Reservoir and the Holston and French Broad Rivers based on the drainage area (Appendix L). The downstream starting water surface elevation input as the Reach Boundary Condition was then interpolated by using observed elevations from the gages at French Broad River Mile 7.40 and Tennessee River Mile 651.40.

The HEC-RAS model was then adjusted by varying the Manning's *n* values, using good engineering judgment, to match the water-surface elevations of the 1 Percent Annual Chance flood event and the 0.2 Percent Annual Chance flood event and to match the tailwater gage at French Broad River Mile 32.30 and the gage at French Broad River Mile 7.40 for the 1973 flood.

Fort Loudoun Reservoir

The steady-flow data used initially to set-up the HEC-RAS model of Fort Loudoun Reservoir for the 1973 and 2003 historic floods was determined by using the recorded flows at the approximate peak elevations from Fort Loudoun, Cherokee and Douglas Dams (Reference 2.7) for inflows and outflows. The upstream inflows at Cherokee and Douglas Dams were subtracted from the outflow at Fort Loudoun. The difference between inflow and outflow represents the local inflow. This local inflow was distributed along Fort Loudoun Reservoir and the Holston and French Broad Rivers based on the drainage area (Appendix L). The downstream water surface elevations input were the recorded peak elevations (Reference 2.7).

The HEC-RAS model was then adjusted by varying the flow distribution and the Manning's *n* values, using good engineering judgment, to match the 1973 and 2003 flood events at available river gage stations.

Tellico Reservoir

The Tellico Reservoir HEC-RAS model was initially set up using elevations from the 1 Percent Annual Chance flood profile and the 0.2 Percent Annual Chance flood profiles published in the Loudon County Flood Insurance Study (Reference 2.16). The flow distributions for all of the cross sections were determined from the FIS up to Little Tennessee River Mile 18.59 and from HEC2 files (Attachment 9) used to produce the flood profiles for the remainder of the reservoir. The downstream water surface elevations input were the elevations published in the FIS.

Steady-flow data used initially to set up the 2003 flood was determined by using the recorded peak flows from Chilhowee and Tellico Dams (Reference 2.7) for the upstream and downstream flows, respectively. The upstream inflow was subtracted from the downstream outflow. The difference between the two represents the local inflow. This local inflow was distributed along Tellico Reservoir based on the drainage area (Appendix L). The downstream water surface elevations input were the recorded peak elevations at Tellico Dam.

After completion of the HEC-RAS steady-state calibration, the CONVEY program (Reference 2.22) was re-run to compute a new $R^{2/3}$ term and the SOCH geometry was re-built as described in Appendix A of References 2.10 and 2.11. The HEC-RAS steady-state computations were verified by hand calculations as documented in Appendix L of Reference 2.23.

3.3.2 HEC-RAS Steady-State Profiles

Following calibration of the models, HEC-RAS was run with uniform flow to produce steady-state water surface profiles of each model.

Fort Loudoun Reservoir

The Fort Loudoun Reservoir HEC-RAS model was run with uniform flow to produce steady-state water surface profiles ranging from 100,000 cfs to 1,400,000 cfs in 100,000 cfs increments. The 1,400,000 cfs profile is expected to be above the PMF level and was set as the upper bound of the calibration. The downstream boundary conditions were set at 817 ft, to account for surcharge of the reservoir pool until the flow increases to 400,000 cfs. As flow continues to increase up to 1,000,000 cfs, the boundary condition follows a curve developed to account for modeled tailwater and interaction with the Canal (Reference 2.24). For discharges between 1,200,000 and 1,400,000 cfs, Ft. Loudoun must be assumed to have failed; therefore the boundary condition then follows a curve taken from a SOCH model seismic failure run up to 1,400,000 cfs (Reference 2.24 and Attachment 10).

Tellico Reservoir

Steady-state profiles of the Tellico Reservoir (Little Tennessee River from River Miles 0.30 to 33.60) were produced by running HEC-RAS with uniform flow ranging from 100,000 cfs to 600,000 cfs in 100,000 cfs increments. The 600,000 cfs profile is expected to be above the PMF level and was set as the upper bound of the calibration. The downstream boundary conditions were set at the surcharge level, 817 ft (Reference 2.24), of the reservoir for flows up to 400,000 since the headwater elevations at Ft. Loudoun and Tellico are equal up to this flow. After 400,000 cfs flow has been reached, the boundary conditions followed the Tellico dam rating curve.

Holston and French Broad Rivers

Steady-state profiles of the Holston and French Broad Rivers were produced by running HEC-RAS with uniform flow. The Holston and French Broad Rivers meet to form the Tennessee River at Tennessee River Mile 652.22. The downstream boundary conditions for both the Holston River and French Broad River models were set as the water-surface elevation at Tennessee River Mile 652.22 determined by running steady-state profiles of Fort Loudoun Reservoir. To define starting elevations for these profiles, an appropriate split of Holston River 35% of the flow at Tennessee River Mile 652.22 and the French Broad River 65% of the flow. So, the water-surface elevation for a flow of 100,000 cfs at Tennessee River Mile 652.22 was set as the downstream boundary condition for a steady-state profile of 35,000 cfs in the Holston River and for a flow of 65,000 cfs in the French Broad River. Steady-state profiles of the Holston River were produced with flow ranging from 35,000 cfs to 490,000 cfs. Steady-state profiles of the French Broad River were produced with flow ranging from 65,000 cfs to 845,000 cfs.

3.3.3 SOCH Steady-State Calibration

Calibration of the SOCH model is accomplished by adjusting the Manning's *n* value as described in Section 2.4 of Reference 2.19. In SOCH, the Manning's *n* value is based on vertical segments of the cross-sections. Once the geometry file is built for the SOCH model the Manning's *n* value is the parameter adjusted in the calibration phase. However, in this phase other adjustments to the cross sections, cross section spacing, and effective flow areas may be identified. The geometry required to perform the SOCH calibrations has been compiled in Appendix A. To determine the Manning's *n* values, the SOCH model of each piece of Fort Loudoun-Tellico Reservoir was run under steady-state conditions and compared to the steady-state profiles from HEC-RAS.

geometry required to perform the SOCH calibrations has been compiled in Appendix A. To determine the Manning's *n* values, the SOCH model of each piece of Fort Loudoun-Tellico Reservoir was run under steady-state conditions and compared to the steady-state profiles from HEC-RAS.

Fort Loudoun Reservoir

The Fort Loudoun Reservoir SOCH model was run to produce steady-state water surface profiles ranging from 100,000 cfs to 1,400,000 cfs in 100,000 cfs increments. The downstream boundary conditions were set at 817 ft, to account for surcharge of the reservoir pool until the flow increases to 400,000 cfs. As flow continues to increase up to 1,000,000 cfs, the boundary condition follows a curve developed to account for modeled tailwater and interaction with the Canal (Reference 2.24). For discharges between 1,200,000 and 1,400,000 cfs, Ft. Loudoun is assumed to have failed; therefore the boundary condition then follows a curve taken from a SOCH model seismic failure run up to 1,400,000 cfs (Reference 2.24 and Attachment 10). The Manning's *n* values were adjusted so that the SOCH steady-state profiles coincided with the 600,000 cfs HEC-RAS steady-state profile. By calibrating to a flow in the middle of the flow range, this allows the SOCH and HEC-RAS profiles to be closer together over the total range of flows. Several iterations of Manning's *n* value were run to achieve calibration. These iterations are not shown in this calculation; only the final Manning's *n* values are shown. The Manning's *n* values were then used to replicate the historic floods.

A minimum of five sections are required for the SOCH model to run. The presence of the Canal at the lower end of Fort Loudoun Reservoir required an additional section to be used at the Fort Loudoun/Canal Junction (Tennessee River Mile 602.70). The section at River Mile 602.30 was copied and used at River Mile 602.70 because it was representative. The sections at River Miles 602.30 and 602.70 make up two of the five sections needed for the model to run between Fort Loudoun Dam and the Fort Loudoun/Canal Junction to run. The remaining three sections were interpolated internally in the SOCH program, resulting in a total of five sections (Sections 6.3 and 6.4).

Tellico Reservoir

Steady-state profiles of the Tellico Reservoir were produced by running SOCH with uniform flow ranging from 100,000 cfs to 600,000 cfs in 100,000 cfs increments. The downstream boundary conditions, Table 25, were set at the surcharge level, 817 ft (Reference 2.24), of the reservoir for flows up to 400,000 since the headwater elevations at Ft. Loudoun and Tellico are equal up to this flow. After 400,000 cfs flow has been reached, the boundary conditions followed the Tellico dam rating curve. The Manning's *n* values were adjusted so that the SOCH steady-state profiles coincided with the HEC-RAS steady-state profiles with the 200,000 cfs HEC-RAS steady-state profile. By calibrating to a flow in the middle of the flow range, this allows the SOCH and HEC-RAS profiles to be closer together over the total range of flows. Several iterations of Manning's *n* value were run to achieve calibration. These iterations are not shown in this calculation; only the final Manning's *n* values are shown. The Manning's *n* values were then used to replicate the historic floods and the published FIS flood frequency events.

A minimum of five sections are required for the SOCH model to run. The presence of the Canal at the lower end of Tellico Reservoir required an additional section to be used at the Tellico/Canal Junction (Little Tennessee River Mile 0.60). The section at River Mile 0.30 was copied and used at River Mile 0.60 because it was representative. The sections at River Miles 0.30 and 0.60 make up two of the five sections needed for the model to run between Tellico Dam and the Tellico/Canal Junction. The remaining three sections were interpolated internally in the SOCH program, resulting in a total of five sections (Sections 6.3 and 6.4).

Holston River and French Broad River

Steady-state profiles of the Holston and French Broad Rivers were produced by running SOCH with uniform flow. The Holston and French Broad Rivers meet to form the Tennessee River at Tennessee River Mile 652.22. The downstream boundary conditions for both the Holston River and French Broad River models were set as the water-surface elevation at Tennessee River Mile 652.22 determined by running steady-state profiles of Fort Loudoun Reservoir. The Holston River

contributes 35% of the flow at Tennessee River Mile 652.22 while the French Broad River contributes 65% of the flow. So, the water-surface elevation for a flow of 100,000 cfs at TRM 652.22 was set as the downstream boundary condition

calibration. These iterations are not shown in this calculation; only the final Manning's *n* values are shown. The Manning's *n* values were then used to replicate the historic floods and the published FIS flood frequency events.

3.3.4 SOCH Unsteady-State Historic Runs

The SOCH models of Fort Loudoun Reservoir, French Broad River and Holston River, with the revised Manning's *n* values, were combined into a single model, run under unsteady-flow conditions, and used to replicate the 1973 flood event. The Canal and Tellico Dam were not constructed until after this event occurred, so they were not included in the 1973 model (Figure 3a).

The SOCH models of Fort Loudoun-Tellico Reservoir and the French Broad and Holston Rivers, with the revised Manning's *n* values, and the Canal portion were combined into a single model, run under unsteady-flow conditions, and used to replicate the 2003 flood event. The model was configured with 7 channels as depicted in Figure 3b. For the 1973 flood, the boundary conditions were the recorded discharges for Douglas and Cherokee (upstream boundary conditions) (Reference 2.7) and the recorded elevations for Fort Loudoun (downstream boundary condition) (Reference 2.7). For the 2003 flood, the boundary conditions were recorded discharges for Cherokee, Douglas and Chilhowee Dams (upstream boundary conditions) (Reference 2.7), recorded discharges for Tellico Dam (downstream boundary condition) (Reference 2.7), and recorded Fort Loudoun elevations (downstream boundary condition) (Reference 2.7). The local inflow hydrographs (Subbasins 8, 16, 17, 18 and 24) were input to account for local inflows (developed from unit hydrographs, Reference 2.12). The local inflow hydrographs for Subbasin 7 were also input to account for local inflow, but they are estimated observed flows (Reference 2.8).

For the 1973 flood, calculated flood elevations were compared to the observed elevations at six locations (Figures 43-46) and calculated discharge was compared to observed discharges at Fort Loudoun Dam (Figure 47) (Attachment 4). Figure 45 shows the observed versus computed elevations for the gage at Holston River Mile 5.5. The computed peak elevation matches the observed peak elevation, but the observed elevations are higher than the computed elevations in the periods leading up to and after the occurrence of the peak elevation. There was no information available to determine if there was a gage malfunction, so the calibration was based on a match to the published NFIP profiles and the peak at this gage.

For the 2003 flood, calculated flood elevations were compared to the observed elevations at 5 locations (Figures 48-51) and calculated discharge was compared to observed discharge at Fort Loudoun Dam (Figure 52) (Attachment 5). The observed discharge was the prescribed boundary condition at Tellico Dam (Figure 53). This allowed the headwater to be computed at Tellico Dam (Figure 51). Using the observed headwater at Fort Loudoun and observed discharge at Tellico as boundary conditions allows the model to compute the Tellico headwater with very good agreement. This also indicates that flow through the canal is being handled appropriately by the model.

Cherokee and Douglas Dams are tributary projects that are frequently operated for zero discharge during the early portion of flood events in an effort to reduce flows entering the Tennessee River until the peak has passed when possible. When there is zero discharge in the upper end of the reservoir, the SOCH model will not run in a dry channel. To overcome this problem, a baseflow of 5000 cfs was added at French Broad River Mile 32.29 and Holston River Mile 52.29, 0.01 miles below Douglas Dam and Cherokee Dam, respectively. The extra baseflow was removed at Holston River Mile 5.60 and French Broad River Mile 7.50, just upstream of the gage locations. This allows the model to run without affecting the results at the downstream gages. The extra flow does cause the computed elevations to be high at both the Cherokee and Douglas tailwater locations. Aside from the computed tailwater elevations being consistently higher than the observed, both Cherokee and Douglas computed tailwater elevations track along the observed elevations very well.

The model reproduced the historic floods with good agreement at the gage locations for the two historic events so the calibration was considered complete.

After completion of the calibration, the annotation in the SOCH geometry files was updated to include the final Manning's *n* values for the SOCH model. These geometry files were then considered the final SOCH geometry files for Fort Loudoun Reservoir, Holston River, French Broad River, Little Tennesse River and Canal.

3.3.5 Validation of Local Inflows Developed from Unit Hydrographs (Subbasins 8, 16, 17, 18 and 24)

The local inflows to French Broad River from subbasin 8, to Holston River from subbasin 16, to Little River from subbasin 17, to Fort Loudoun Reservoir from subbasin 18, and to Tellico Reservoir from subbasin 24 were combined with the observed data (as described in Section 3.3.4) to replicate the historic flood events. It was at this point that it was determined that subbasins 8 and 16 should be applied as distributed locals over the majority of the river reach, instead of as a point local. This change was needed to improve agreement with the observed data. Unit hydrographs for subbasins 8 and 16 were modified to be applied as distributed local hydrographs (Appendix B) and reproduced the observed elevations at gage locations. As a result, the unit hydrographs developed for subbasins 17, 18, and 24 (Reference 2.12) and the modified unit hydrographs developed for subbasins 8 and 16 (Appendix B) were validated and are adequate for use in developing flood inflows for other events including the PMF.

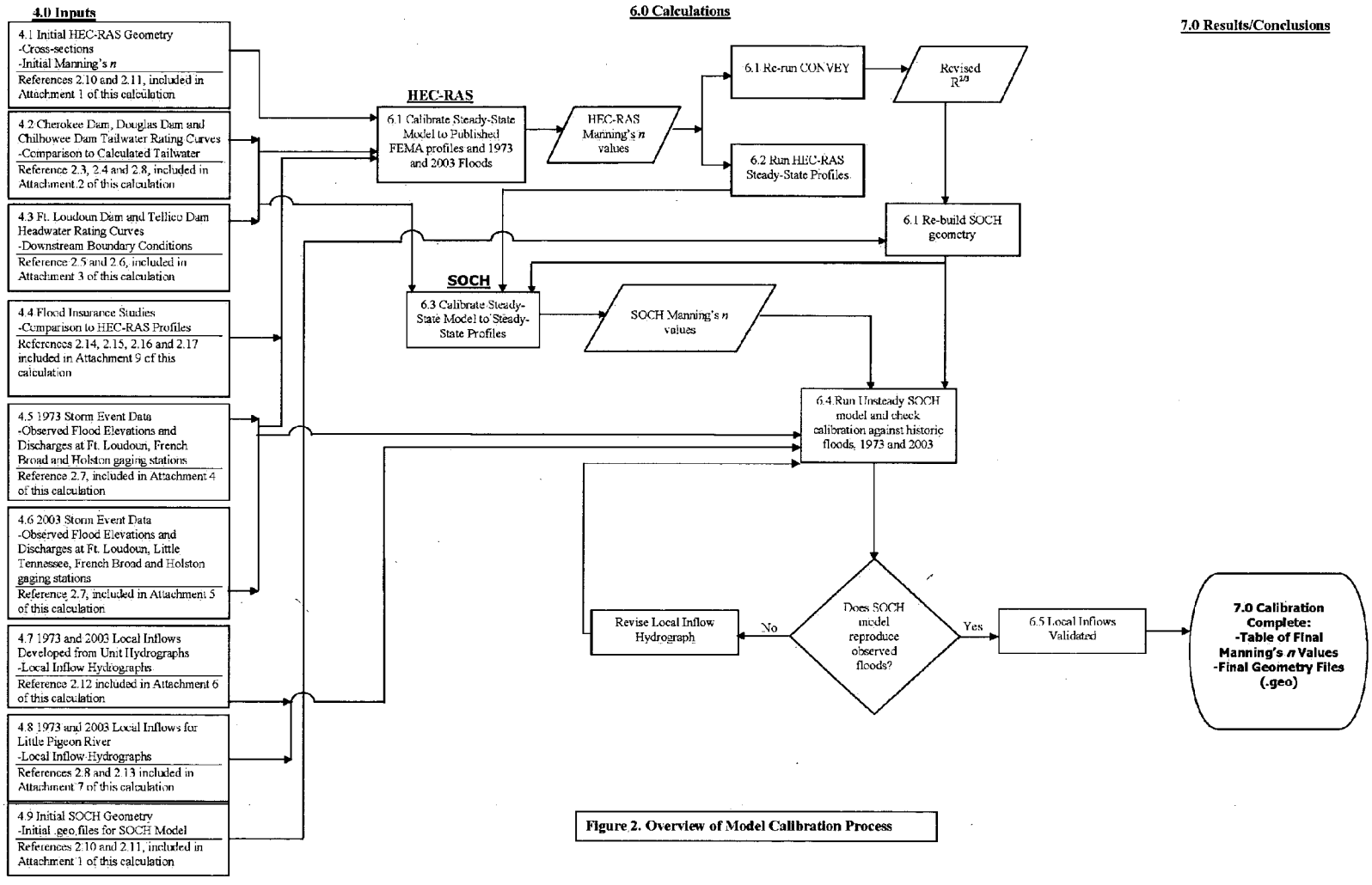


Figure 2. Overview of Model Calibration Process

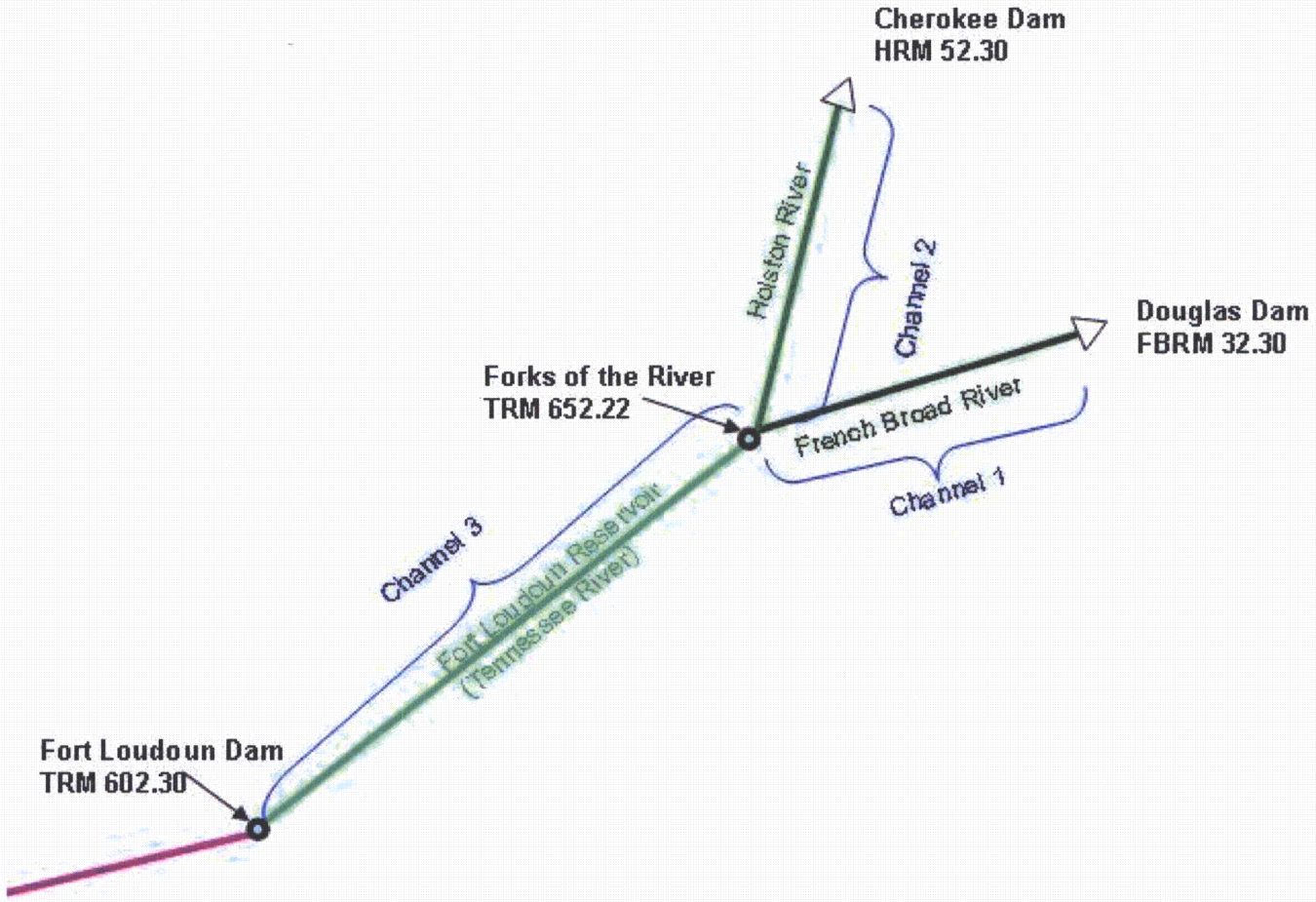


Figure 3a. Fort Loudoun SOCH Configuration (1973)

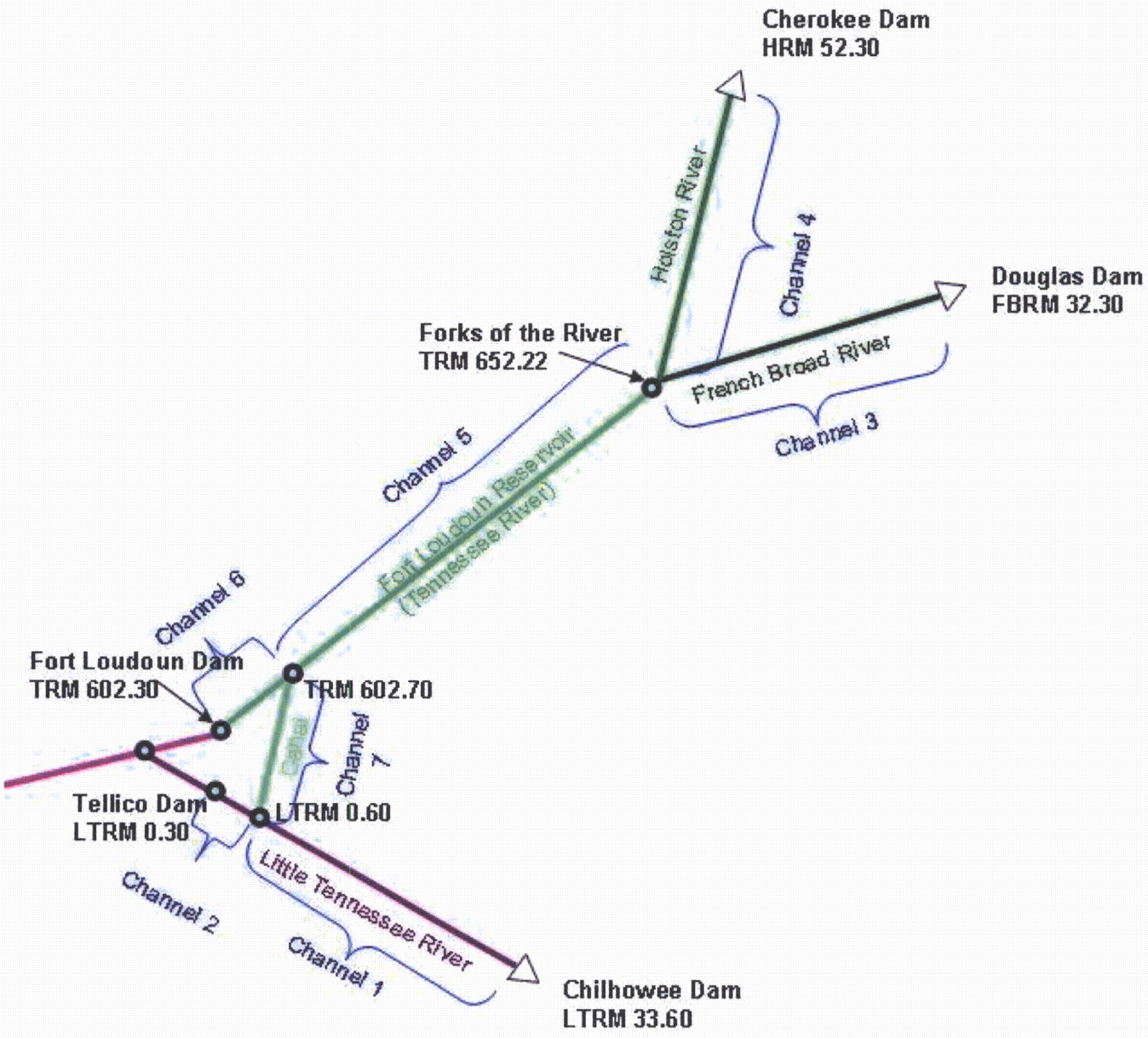


Figure 3b. Fort Loudoun-Tellico SOCH Configuration (2003)

4. Design Input

4.0 Input data included in appendices, attachments and references.

Sect.	Input Parameter	Source	Location	Description
4.1	Initial HEC-RAS Geometry	References 2.10 and 2.11	Attachment 1 of this calculation	Initial HEC-RAS geometry was provided in the "SOCH Geometry Verification for Fort Loudoun-Tellico Reservoir" calculation and used in the HEC-RAS steady-state model.
4.2	Tailwater Rating Curves, Cherokee Dam, Douglas Dam and Chilhowee Dam	References 2.3, 2.4 and 2.7	Attachment 2 of this calculation	The tailwater rating curves were provided in the "Dam Rating Curves – Cherokee" calculation and the "Dam Rating Curves – Douglas" calculation and were used to compare results of the HEC-RAS and SOCH steady-state models. Chilhowee Dam Rating Curve was provided in Reference 2.7 and was used to compare results of the HEC-RAS and SOCH steady-state models.
4.3	Headwater Rating Curves, Fort Loudoun Dam and Tellico Dam	References 2.5 and 2.6	Attachment 3 of this calculation	The dam rating curves were provided in the "Dam Rating Curves-Fort Loudoun" calculation and the "Dam Rating Curves – Tellico" calculation. They were used to establish boundary conditions in the HEC-RAS and SOCH steady-state models.
4.4	Flood Insurance Studies, Jefferson County, Knox County, Loudon County, and Sevier County	References 2.14, 2.15, 2.16, and 2.17	Attachment 8 of this calculation	The Flood Insurance Studies were published by FEMA and were used to calibrate the HEC-RAS steady-state models.
4.5	1973 Elevations and Discharges at Gaging Stations in Fort Loudoun-Tellico Reservoir	Reference 2.7	Attachment 4 of this calculation	The 1973 flood observed elevations and discharges for Fort Loudoun Reservoir, Holston River, and French Broad River were used as boundary conditions in the HEC-RAS and SOCH models and used to compare the SOCH model results.
4.6	2003 Elevations and Discharges at Gaging Stations in Fort Loudoun-Tellico Reservoir	Reference 2.7	Attachment 5 of this calculation	The 2003 flood observed elevations and discharges for Fort Loudoun Reservoir, Holston River, French Broad River, and Tellico Reservoir were used as boundary conditions in the HEC-RAS and SOCH models and used to compare the SOCH model results.
4.7	1973 and 2003 Local Inflows Developed from Unit Hydrographs	Reference 2.12	Attachment 6 of this calculation	The local inflows for subbasins 8, 16, 17, 18, and 24 were provided as part of the "Calculation of Initial Flood Flows from the Fort Loudoun-Tellico Watershed (subbasins 8, 16, 17, 18, and 24) for Use in the SOCH Model Calibration and Unit Hydrograph Validation" calculation and were used as local inflow in the SOCH model and to validate the unit hydrographs.

Sect.	Input Parameter	Source	Location	Description
4.8	1973 and 2003 Local Inflows for Little Pigeon River	Reference 2.8	Attachment 7 of this calculation	The 1973 and 2003 inflows for subbasin 7, Little Pigeon River, were provided as part "Bellefonte Units 3 and 4 Hydrology Project Request for Information (RFI) Response Information Continuation Sheet," RFI Number BE21108160B021, Rev. 1 and are estimated observed flows and were used as local inflow in the SOCH model.
4.9	Initial SOCH Geometry	References 2.10 and 2.11	Attachment 1 of this calculation	The initial SOCH geometry files for Fort Loudoun Reservoir, Holston River, French Broad River, Tellico Reservoir and Canal were provided in the "SOCH Geometry Verification for Fort Loudoun Reservoir, French Broad River, and Holston River" and "SOCH Geometry Verification for Tellico Reservoir and Canal" calculations and used in the SOCH model.

5. Special Requirements/Limiting Conditions

N/A

6. Calculations

6.1 HEC-RAS Steady-State Calibration

The Fort Loudoun-Tellico Reservoir was divided into four HEC-RAS steady-state models: the Holston River from Cherokee Dam at River Mile 52.30 to the junction with the Tennessee River, the French Broad River from Douglas Dam at River Mile 32.30 to the junction with the Tennessee River, the Fort Loudoun Reservoir on the Tennessee River from the junction of the Holston and French Broad Rivers at River Mile 652.22 to Fort Loudoun Dam at River Mile 602.30, and the Tellico Reservoir from Chilhowee Dam at River Mile 33.60 to Tellico Dam at River Mile 0.30.

Holston River

A steady-state HEC-RAS model was set-up for the Holston River using the initial HEC-RAS geometry and the initial Manning's *n* values provided in Attachment 18 of Reference 2.10. Two changes were made to the initial geometry file. The section at River Mile 52.22 was moved to River Mile 52.30 which is the location of the tailwater gage and the section at River Mile 0.08 was moved to River Mile 0.00 so it could serve as a junction section in later calibration steps. A limited amount of observed historic flood data was available for the Holston River, so the 1 Percent Annual Chance flood and the 0.2 Percent Annual Chance flood profiles published in the FIS (Attachment 8) were used. The flows used in the HEC-RAS model for each flood were determined from the HEC2 files (Attachment 9) used to produce the flood profiles. The downstream starting elevations were set as the elevations published in the FIS (Table 1).

Steady-flow data used initially to set-up the 1973 flood was determined by taking the observed flows at the time the observed approximate peak elevations at Fort Loudoun, Cherokee and Douglas Dams occurred. The upstream inflows at Cherokee and Douglas Dams were subtracted from the outflow at Fort Loudoun. The difference between inflow and outflow represents the local inflow. This local inflow was distributed along Fort Loudoun Reservoir and the Holston and French Broad Rivers based on the drainage area (Appendix L). The local inflow occurring at a particular section was added to the inflow from the upstream dam, which gave an approximate total flow at each cross-section for the 1973 event. The downstream water-surface elevation input as the Reach Boundary Condition was then interpolated from the recorded elevations from gages at Holston River Mile 5.50 and Tennessee River Mile 651.40 (Attachment 4).

The HEC-RAS model was then calibrated by varying Manning's *n* values beginning from the downstream cross-section and working upstream to match the water-surface elevations of the 1 Percent Annual Chance flood and the 0.2 Percent Annual Chance flood event profiles. The model was used to match the available high-water marks for the 1973 flood. Several iterations of adjusting Manning's *n* values were run to achieve calibration. Iterations are not shown in this calculation; only the last iteration is shown. The last iteration of Manning's *n* values is shown in Table 2 and the flow distribution is shown in Table 3.

Table 1. Holston River Reach Boundary Conditions at Forks of the River, TRM 652.22, for the 1 Percent and 0.2 Percent Annual Chance Floods and the 1973 Flood in HEC-RAS Steady-State Model

Boundary	1 Percent Annual Chance Flood Event	0.2 Percent Annual Chance Flood Event	1973 Flood Event
Flow (cfs)	43,700	63,900	27,041
Water Surface Elevation (ft)	825.00	831.00	821.60

Table 2. Holston River Initial Manning's *n* Values and Calibrated Manning's *n* Values in HEC-RAS Steady-State Model

Holston River Mile	Initial Manning's *n* Reference 2.10	Calibrated Manning's *n*
52.30	0.055	0.050
50.34	0.027	0.045
48.31	0.034	0.045
46.33	0.028	0.033
44.30	0.038	0.033
42.64	0.030	0.033
40.27	0.030	0.033
39.27	0.035	0.033
35.58	0.034	0.033
33.92	0.043	0.039
32.54	0.032	0.039
30.22	0.045	0.035
28.48	0.032	0.035
26.54	0.032	0.035
24.15	0.030	0.030

Holston River Mile	Initial Manning's *n* Reference 2.10	Calibrated Manning's *n*
22.14	0.026	0.028
20.14	0.024	0.028
18.12	0.026	0.028
17.02	0.022	0.028
16.10	0.034	0.028
13.91	0.035	0.028
12.06	0.030	0.028
10.06	0.038	0.028
8.04	0.034	0.028
6.03	0.035	0.028
5.56	0.030	0.028
4.02	0.032	0.036
2.02	0.050	0.036
0.00	0.040	0.036

Table 3. Holston River Flow Distribution for the 1 Percent and 0.2 Percent Annual Chance Floods and 1973 Flood in HEC-RAS Steady-State Model

Holston River Mile	1 Percent Annual Chance Flood Event	0.2 Percent Annual Chance Flood Event	1973 Flood Event
	Flow (cfs)	Flow (cfs)	Flow (cfs)
52.30	36,000	54,000	12,800
50.34	36,140	54,180	13,005
48.31	36,315	54,395	13,250
46.33	36,485	54,610	13,782
44.30	36,655	54,830	14,273
42.64	36,830	55,050	14,355
40.27	37,000	55,260	14,682
39.27	37,170	55,475	14,887
35.58	37,340	55,695	15,501
33.92	37,515	55,915	15,787
32.54	37,680	56,125	16,033
30.22	37,855	56,345	16,606
28.48	37,900	56,400	17,752
26.54	39,540	58,640	18,652
24.15	39,650	58,750	19,757
22.14	39,775	58,895	20,289
20.14	39,930	59,095	20,535
18.12	40,085	59,295	20,780
17.02	40,170	59,405	20,903
16.10	40,240	59,495	21,312
13.91	40,395	59,695	22,253
12.06	42,310	62,155	23,031
10.06	42,520	62,415	23,890
8.04	42,730	62,675	24,750
6.03	42,945	62,930	25,609
5.56	43,000	63,000	25,814
4.02	43,240	63,325	26,264
2.02	43,570	63,760	26,837
0.00	43,700	63,900	27,041

French Broad River

A steady-state HEC-RAS model was set-up for the French Broad River using the initial HEC-RAS geometry and the initial Manning's *n* values provided in Attachment 17 of Reference 2.10. Several changes were made to the initial geometry file. The sections at French Broad River Miles 0.99, 7.45, 29.34, 30.01, 31.12 and 31.75 were removed from the geometry file because of oscillations in the model caused by the variation between cross-sections. Removal of these sections preserves the most restrictive sections, eliminates oscillations, and results in conservatively high water-surface elevations. The section at River Mile 0.17 was moved to River Mile 0.00 so it could serve as a junction section in later calibration steps. The section at River Mile 32.23 was moved to River Mile 32.30 in order to correspond with the Douglas Dam tailwater location. The section at River Mile 22.38 was examined and it was found that the section underestimated flow area in the channel and overestimated flow area in the left overbank for the reach. It was determined that a section taken from River Mile 22.48 was more representative of the reach and this section was used at River Mile 22.38.

Nine French Broad River cross-sections were modified from the original cross-sections as shown in Appendix C. Cross-sections were modified to either eliminate ineffective flow areas or to extend the elevation of the cross-sections. Removal of ineffective flow area will result in a more restrictive cross-section and therefore conservatively high water-surface elevations. Cross-sections were extended to elevations above the potential PMF levels. The modifications are described in Appendix C.

A limited amount of observed historic flood data was available for the French Broad River, so the 1 Percent Annual Chance flood and the 0.2 Percent Annual Chance flood profiles published in the FIS (Attachment 8) were used. The flows used in the HEC-RAS model for each flood were determined from the HEC2 files (Attachment 9) used to produce the flood profiles and were interpolated where necessary. The downstream starting elevations were set as the elevations published in the FIS (Table 4).

Steady-flow data used initially to set-up the 1973 flood was determined by taking the observed flows at the time the observed approximate peak elevations at Fort Loudoun, Cherokee and Douglas Dams occurred. The upstream inflows at Cherokee and Douglas Dams were subtracted from the outflow at Fort Loudoun. The difference between inflow and outflow represents the local inflow. This local inflow was distributed along Fort Loudoun Reservoir and the Holston and French Broad Rivers based on the drainage area (Appendix L). The downstream water surface elevation input as the Reach Boundary Condition was then interpolated from the recorded elevations from gages at French Broad River Mile 7.40 and Tennessee River Mile 651.40 (Attachment 4)

The HEC-RAS model was then calibrated by varying Manning's *n* values beginning from the downstream cross-section and working upstream to match the water-surface elevations of the 1 Percent Annual Chance flood and the 0.2 Percent Annual Chance flood event profiles. The model was then used to match available high-water marks for the 1973 flood. Several iterations of adjusting the Manning's *n* values were run to achieve calibration. These iterations are not shown in this calculation; only the last iteration is shown. The last iteration of Manning's *n* values is shown in Table 5 and the last iteration of the flow distribution is shown in Table 6.

Table 4. French Broad Reach Boundary Conditions at Forks of the River, TRM 652.22, for the 1 Percent and 0.2 Percent Annual Chance Floods and the 1973 Flood in HEC-RAS Steady-State Model

Boundary	1 Percent Annual Chance Flood Event	0.2 Percent Annual Chance Flood Event	1973 Flood Event
Flow (cfs)	82,000	140,000	37,358
Water Surface Elevation (ft)	825.40	832.00	821.60

Table 5. French Broad River Initial Manning's *n* Values and Calibrated Manning's *n* Values in HEC-RAS Steady-State Model

French Broad River Mile	Initial Manning's *n* Reference 2.10	Calibrated Manning's *n*	French Broad River Mile	Initial Manning's *n* Reference 2.10	Calibrated Manning's *n*
32.30	0.030	0.039	15.76	0.040	0.029
30.75	0.030	0.039	14.97	0.040	0.029
28.85	0.030	0.039	14.26	0.010	0.029
28.23	0.035	0.038	13.63	0.030	0.029
26.84	0.030	0.038	11.42	0.030	0.034
26.30	0.030	0.038	10.07	0.030	0.039
25.65	0.030	0.038	8.40	0.040	0.034
24.78	0.045	0.038	6.06	0.030	0.034
23.50	0.035	0.038	3.90	0.030	0.031
22.38	0.040	0.042	2.02	0.030	0.031
21.56	0.035	0.042	0.00	0.030	0.034
19.70	0.030	0.042			
18.18	0.030	0.034			
17.35	0.030	0.029			

Table 6. French Broad River Flow Distribution for the 1 Percent and 0.2 Percent Annual Chance Floods and 1973 Flood in HEC-RAS Steady-State Model

French Broad River Mile	1 Percent Annual Chance Flood Event Flow (cfs)	0.2 Percent Annual Chance Flood Event Flow (cfs)	1973 Flood Event Flow (cfs)
32.30	57,000	114,000	13,500
30.75	57,000	114,000	13,664
28.85	57,000	114,000	13,909
26.30	74,000	132,000	29,665
25.65	74,000	132,000	30,074
23.50	76,000	134,000	31,424
21.56	76,000	134,000	32,652
19.70	78,000	136,000	33,798
17.35	78,000	136,000	34,085
14.97	78,000	136,000	34,739
14.26	79,000	137,000	35,230
13.63	79,000	137,000	35,599
11.42	79,000	137,000	35,885
10.07	79,000	137,000	36,049
8.40	79,000	137,000	36,294
6.06	82,000	140,000	36,663
3.90	82,000	140,000	36,990
2.02	82,000	140,000	37,154
0.00	82,000	140,000	37,358

Fort Loudoun Reservoir

A steady-state HEC-RAS model was set-up for the Fort Loudoun Reservoir using the initial HEC-RAS geometry and the initial Manning's *n* values provided in Attachment 16 of Reference 2.10. Several changes were made to the initial geometry file. The sections at Tennessee River Miles 645.89, 647.44, 647.68, and 648.68 were removed from the geometry file because of oscillations in the model caused by the variation between cross-sections. Removal of these sections preserves the most restrictive sections, eliminates oscillations, and results in conservatively high water-surface elevations. The section at River Mile 652.04 was moved to River Mile 652.22 in order to correspond with the actual location of the junction point with the Holston and French Broad Rivers.

Sixteen Fort Loudoun Reservoir cross-sections were modified from the original cross-sections as shown in Appendix C. Cross-sections were modified to either eliminate ineffective flow areas or to extend the elevation of the cross-sections. Removal of ineffective flow area will result in a more restrictive cross-section and therefore conservatively high water-surface elevations. Cross-sections were extended up in elevation to be above the potential PMF elevation. The modifications are described in Appendix C.

The two historic floods, 1973 and 2003, were initially set up with the recorded peak flow from Fort Loudoun Dam (Attachments 4 and 5) for the downstream flow. The upstream inflows at Cherokee and Douglas Dams were subtracted from the outflow at Fort Loudoun. The difference between inflow and outflow represents the local inflow. This local inflow was distributed along Fort Loudoun Reservoir and the Holston and French Broad Rivers based on the drainage area (Appendix L). The percent of total flow occurring at a cross-section corresponded directly to the percent of reservoir drainage area draining at that cross section. The downstream water surface elevations input as the Reach Boundary Conditions were the recorded peak elevations at Fort Loudoun Dam (Attachments 4 and 5) (Table 7).

The HEC-RAS model was then calibrated by adjusting the flow distribution and varying Manning's *n* values beginning from the downstream cross-section and working upstream to match the high-water marks for the 1973 and 2003 flood events at available river gage stations. Several iterations of adjusting Manning's *n* values were run to achieve calibration. These iterations are not shown in this calculation; only the last iteration is shown. The last iteration of Manning's *n* values is shown in Table 8 and the flow distribution is shown in Table 9.

Table 7. Fort Loudoun Reservoir Reach Boundary Conditions at Fort Loudoun Dam for Historic Floods in HEC-RAS Steady-State Model

Boundary	1973 Flood Event	2003 Flood Event
Flow (cfs)	91,000	64,201
Water Surface Elevation (ft)	813.90	815.87

Table 8. Fort Loudoun Reservoir Initial Manning's *n* Values and Calibrated Manning's *n* Values in HEC-RAS Steady-State Model

Tennessee River Mile	Initial Manning's *n* Reference 2.10	Calibrated Manning's *n*
652.22	0.041	0.031
650.14	0.026	0.031
648.73	0.035	0.031
647.29	0.025	0.029
646.55	0.021	0.029
645.09	0.021	0.029
643.89	0.022	0.029
641.77	0.024	0.020
639.50	0.024	0.020
637.52	0.025	0.020
635.59	0.025	0.020
634.60	0.025	0.020
633.50	0.025	0.020
631.41	0.030	0.020
630.12	0.035	0.023

Tennessee River Mile	Initial Manning's *n* Reference 2.10	Calibrated Manning's *n*
629.31	0.035	0.023
627.15	0.038	0.023
625.28	0.045	0.023
623.10	0.042	0.023
621.02	0.035	0.035
618.94	0.040	0.035
616.27	0.040	0.035
614.68	0.040	0.035
612.68	0.040	0.035
610.63	0.035	0.035
608.54	0.035	0.031
606.43	0.035	0.031
602.30	0.030	0.031

Table 9. Fort Loudoun Reservoir Flow Distribution for Historic Floods in HEC-RAS Steady-State Model

Tennessee River Mile	1973 Flood Event	2003 Flood Event
	Flow (cfs)	Flow (cfs)
652.22	64,400	57,663
650.14	64,645	57,724
648.73	64,850	57,774
647.29	65,996	58,055
646.55	66,323	58,136
645.09	66,978	58,297
643.89	67,142	58,337
641.77	67,387	58,397
639.50	67,674	58,468
637.52	67,919	58,528
635.59	68,165	58,589
634.60	83,797	62,431
633.50	83,879	62,451
631.41	84,002	62,481
630.12	84,125	62,511
629.31	84,289	62,551
627.15	84,821	62,682
625.28	85,230	62,783
623.10	85,925	62,954
621.02	86,621	63,125
618.94	87,317	63,296
616.27	88,176	63,507
614.68	88,586	63,608
612.68	89,036	63,718
610.63	89,486	63,829
608.54	89,731	63,889
606.43	90,509	64,080
602.30	91,000	64,201

Tellico Reservoir

A steady-state HEC-RAS model was set-up for the Tellico Reservoir using the initial HEC-RAS geometry and the initial Manning's *n* values provided in Attachment 11 of Reference 2.11. Section at River Mile 33.57 was moved to River Mile 33.60, which is the Chilhowee Dam tailwater location. The section at River Mile 0.35 was moved to River Mile 0.30, which is the location of Tellico Dam. This section was also extended in order to match the height of the section just upstream (Appendix C).

A limited amount of observed historic flood data was available for the Tellico Reservoir, so the 1 Percent Annual Chance flood profile and the 0.2 Percent Annual Chance flood profile published in the FIS (Reference 2.17) were used. The flows used in the HEC-RAS model for each flood were determined from the FIS up to Little Tennessee River Mile 18.59 and from HEC2 files (Attachment 9) used to produce the flood profiles for the remainder of the reservoir. The downstream starting elevations were set as the elevations published in the FIS (Table 10).

The 2003 flood was initially set up with the flow at the observed peak elevation from Chilhowee and Tellico Dams (Reference 2.7) for the upstream and downstream flows, respectively. The upstream inflow was subtracted from the downstream outflow. The difference between the two represents the local inflow. This local inflow was distributed

along Tellico Reservoir based on the drainage area (Appendix L). The downstream water surface elevations input as the Reach Boundary Conditions were the recorded peak elevations at Tellico Dam (Table 10).

The HEC-RAS model was then calibrated by varying Manning's *n* values beginning from the downstream cross-section and working upstream to match the water-surface elevations of the 1 Percent Annual Chance flood and the 0.2 Percent Annual Chance flood events. The model was then used to match available high-water marks for the 2003 flood. Several iterations of adjusting the Manning's *n* values were run to achieve calibration. These iterations are not shown in this calculation; only the last iteration is shown. The last iteration of Manning's *n* values is shown in Table 11 and the flow distribution is shown in Table 12.

Table 10. Tellico Reservoir Reach Boundary Conditions at Tellico Dam for the 1 Percent and 0.2 Percent Annual Chance Floods and the 2003 Flood in HEC-RAS Steady-State Model

Boundary	1 Percent Annual Chance Flood Event	0.2 Percent Annual Chance Flood Event	2003 Flood Event
Flow (cfs)	71,000	123,000	44,420
Water Surface Elevation (ft)	814.70	814.70	815.97

Table 11. Tellico Reservoir Initial Manning's *n* Values and Calibrated Manning's *n* Values in HEC-RAS Steady-State Model

Tellico Reservoir Mile	Initial Manning's *n* Reference 2.11	Calibrated Manning's *n*	Tellico Reservoir Mile	Initial Manning's *n* Reference 2.11	Calibrated Manning's *n*
33.60	0.040	0.038	19.87	0.030	0.030
32.34	0.040	0.038	19.11	0.030	0.030
31.55	0.035	0.038	18.59	0.030	0.030
29.68	0.030	0.038	16.64	0.030	0.030
27.62	0.030	0.030	16.05	0.030	0.030
26.73	0.036	0.030	13.31	0.030	0.030
25.74	0.030	0.030	9.66	0.030	0.030
24.41	0.036	0.030	8.43	0.030	0.030
23.73	0.030	0.030	6.33	0.030	0.030
22.54	0.030	0.030	3.68	0.030	0.030
21.17	0.030	0.030	0.30	0.030	0.030
20.10	0.030	0.030			

Table 12. Tellico Reservoir Flow Distribution for the 1 Percent and 0.2 Percent Annual Chance Floods and 2003 Flood in HEC-RAS Steady-State Model

Tellico Reservoir Mile	1 Percent Annual Chance Flood Event	0.2 Percent Annual Chance Flood Event	2003 Flood Event
	Flow (cfs)	Flow (cfs)	Flow (cfs)
33.60	60,020	90,055	40,510
32.34	60,290	90,800	40,570
31.55	60,475	91,300	40,582
29.68	60,905	92,490	40,817
27.62	61,380	93,795	41,069
26.73	61,585	94,360	41,106
25.74	61,815	94,990	41,118
24.41	62,120	95,835	41,154
23.73	62,280	96,265	41,214
22.54	62,555	97,020	41,316
21.17	62,870	97,890	41,430
20.10	63,115	98,570	41,521
19.87	63,170	98,715	41,539
19.11	69,555	116,275	43,319
18.59	71,000	123,000	43,361
16.64	71,000	123,000	43,512
16.05	71,000	123,000	43,560
13.31	71,000	123,000	43,770
9.66	71,000	123,000	44,053
8.43	71,000	123,000	44,149
6.33	71,000	123,000	44,312
3.68	71,000	123,000	44,390
0.30	71,000	123,000	44,420

After the steady-state HEC-RAS model was calibrated, the CONVEY Version 1.0 program was re-run to compute revised $R^{2/3}$ values for Holston River and Tellico Reservoir and the SOCH geometry files were re-built as described in Appendix A of Reference 2.10 and Appendix A of Reference 2.11. The Fort Loudoun Reservoir was calibrated in HEC-RAS without the cross-section at River Mile 604.36 in the HEC-RAS geometry file. The French Broad River was calibrated in HEC-RAS without the cross-section at River Mile 0.73 in the HEC-RAS geometry file. This was done because both of these sections are "even node" sections in the SOCH model. In order to get a point to point comparison between sections, these sections were left out of the HEC-RAS calibrations. Because these are documented sections in Reference 2.10, it is important to have them in the SOCH model. To allow this, a duplicate of the calibrated HEC-RAS geometry file was created for Fort Loudoun with the cross-section at River Mile 604.36 inserted in. Also, a duplicate of the calibrated HEC-RAS geometry file for the French Broad River was created with the cross-section at River Mile 0.73 inserted. During preliminary simulations, it was determined that more definition of the river channels would be needed in the Fort Loudoun Reservoir and French Broad River SOCH geometry files. To achieve this, a maximum of one foot elevation intervals were used from the channel bottom to the approximate bank locations. Based on the cross-section depth, it was determined that 105 elevation entries would be used for Fort Loudoun Reservoir and 63 elevation entries would be used for French Broad River. To achieve 105 elevation entries in each section on Fort Loudoun Reservoir, it was necessary to use some 0.5 foot elevation intervals. After the elevation entries were adjusted, the CONVEY Version 1.0 program was re-run to compute revised area and $R^{2/3}$ values for Fort Loudoun Reservoir and French Broad River at each whole foot elevation. Values at 0.5 foot elevations were then computed by linear interpolation and the SOCH geometry files were re-built as described in Appendix A of Reference 2.10.

6.1.1 HEC-RAS Steady-State Holston River for 1 Percent Annual Chance Flood

The HEC-RAS profile of the Holston River for the 1 Percent Annual Chance Flood was calibrated to the published FEMA profile. The HEC-RAS profile and the published FEMA profile are shown in Figure 4 and tabulated in Table 13.

6.1.2 HEC-RAS Steady-State Holston River for 0.2 Percent Annual Chance Flood

The HEC-RAS profile of the Holston River for the 0.2 Percent Annual Chance Flood was calibrated to the published FEMA profile. The HEC-RAS profile and points taken from the published FEMA profile are shown in Figure 5 and tabulated in Table 14.

6.1.3 HEC-RAS Steady-State Holston River for 1973 Storm

The HEC-RAS profile of the Holston River for the 1973 flood was compared to the maximum observed elevation at a gage at River Mile 5.50 and the approximate maximum observed elevation at River Mile 52.30 for the March 1973 flood event. The maximum elevation at River Mile 52.30 was not used because it occurred after the storm had passed and when the reservoir was being drawn down. The HEC-RAS profile and observed flood marks are shown in Figure 6 and tabulated in Table 15.

6.1.4 HEC-RAS Steady-State French Broad River for 1 Percent Annual Chance Flood

The HEC-RAS profile of the French Broad River for the 1 Percent Annual Chance Flood was calibrated to the published FEMA profile. The HEC-RAS profile and the published FEMA profile are shown in Figure 7 and tabulated in Table 16.

6.1.5 HEC-RAS Steady-State French Broad River for 0.2 Percent Annual Chance Flood

The HEC-RAS profile of the French Broad River for the 0.2 Percent Annual Chance Flood was calibrated to the published FEMA profile. The HEC-RAS profile and the published FEMA profile are shown in Figure 8 and tabulated in Table 17.

6.1.6 HEC-RAS Steady-State French Broad River for 1973 Storm

The HEC-RAS profile of the French Broad River for the 1973 flood was compared to the maximum observed elevations at River Miles 7.40 and 32.30 for the March 1973 flood event. The HEC-RAS profile and observed flood marks are shown in Figure 9 and tabulated in Table 18.

6.1.7 HEC-RAS Steady-State Fort Loudoun Reservoir for 1973 Storm

The HEC-RAS profile of the Fort Loudoun Reservoir for the 1973 flood was compared to the maximum observed elevations at gages at River Miles 602.30, 645.10 and 651.40 for the March 1973 flood event. The HEC-RAS profile and observed flood marks are shown in Figure 10 and tabulated in Table 19.

6.1.8 HEC-RAS Steady-State Fort Loudoun Reservoir for 2003 Storm

The HEC-RAS profile of the Fort Loudoun Reservoir for the 2003 flood was compared to the maximum observed elevations at gages at River Miles 602.30 and 645.10 for the May 2003 flood event. The HEC-RAS profile and observed flood marks are shown in Figure 11 and tabulated in Table 20.

6.1.9 HEC-RAS Steady-State Tellico Reservoir for 1 Percent Annual Chance Flood

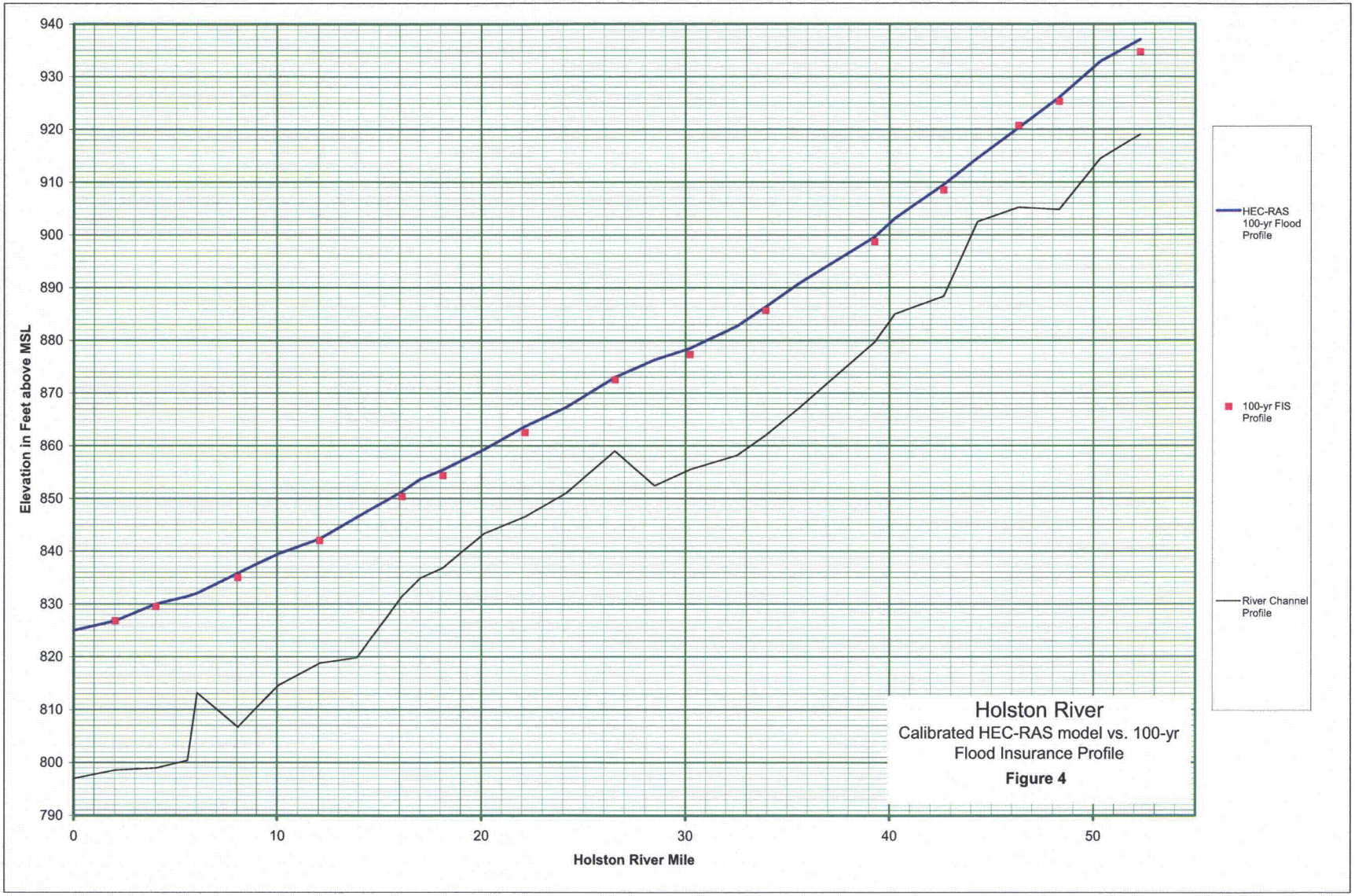
The HEC-RAS profile of the Tellico Reservoir for the 1 Percent Annual Chance Flood was calibrated to the published FEMA profile up to River Mile 18.40. Data was not available for River Miles 18.40 to 33.60. The HEC-RAS profile and points taken from the published FEMA profile are shown in Figure 12 and tabulated in Table 21.

6.1.10 HEC-RAS Steady-State Tellico Reservoir for 0.2 Percent Annual Chance Flood

The HEC-RAS profile of the Tellico Reservoir for the 0.2 Percent Annual Chance Flood was calibrated to the published FEMA profile up to River Mile 18.40. Data was not available for River Miles 18.40 to 33.60. The HEC-RAS profile and points taken from the published FEMA profile are shown in Figure 13 and tabulated in Table 22.

6.1.11 HEC-RAS Steady-State Tellico Reservoir for 2003 Storm

The HEC-RAS profile of the Tellico Reservoir for the 2003 flood was compared to the maximum observed elevation at the gage at River Miles 33.60 for the May 2003 flood event. The HEC-RAS profile and observed flood marks are shown in Figure 14 and tabulated in Table 23.

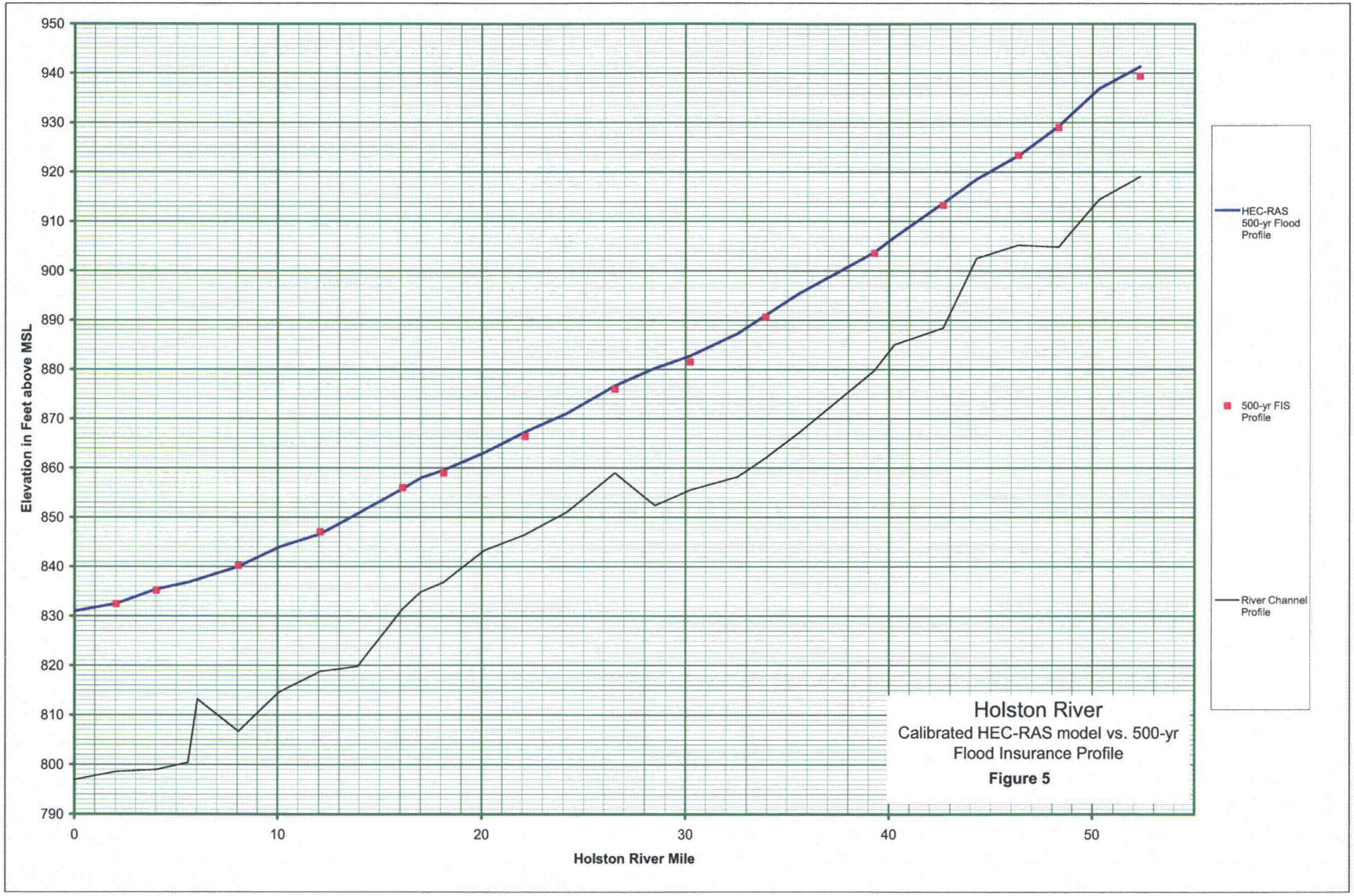


Holston River
Calibrated HEC-RAS model vs. 100-yr Flood Insurance Profile
Figure 4

Table 13. Holston River, Calibrated HEC-RAS Model vs. 1 Percent Annual Chance Flood Marks

Holston River Mile	HEC-RAS 1 Percent Annual Chance Flood Profile	1 Percent Annual Chance Flood Profile[1]	River Bottom Elevation	Manning's *n*
	Elevation (ft)	Elevation (ft)	Elevation (ft)	
52.30	937.06	934.70	919.10	0.050
50.34	932.91		914.50	0.045
48.31	926.09	925.30	904.80	0.045
46.33	920.32	920.70	905.20	0.033
44.30	914.56		902.50	0.033
42.64	909.55	908.50	888.37	0.033
40.27	903.12		885.00	0.033
39.27	899.66	898.70	879.72	0.033
35.58	890.87		867.15	0.033
33.92	886.38	885.70	862.00	0.039
32.54	882.70		858.16	0.039
30.22	878.48	877.30	855.50	0.035
28.48	876.33		852.40	0.035
26.54	873.01	872.50	859.00	0.035
24.15	867.33		851.00	0.035
22.14	863.65	862.50	846.50	0.028
20.14	859.32		843.30	0.028
18.12	855.41	854.30	836.80	0.028
17.021	853.66		834.90	0.028
16.10	851.28	850.30	831.40	0.028
13.91	846.42		819.81	0.028
12.06	842.33	842.00	818.80	0.028
10.06	839.49		814.60	0.028
8.04	835.82	835.00	806.70	0.028
6.03	832.03		813.20	0.028
5.56	831.44		800.44	0.028
4.02	830.00	829.50	799.00	0.036
2.02	826.80	826.80	798.60	0.036
0.00	825.00		797.00	0.036

1. Flood frequency profile from Attachment 8

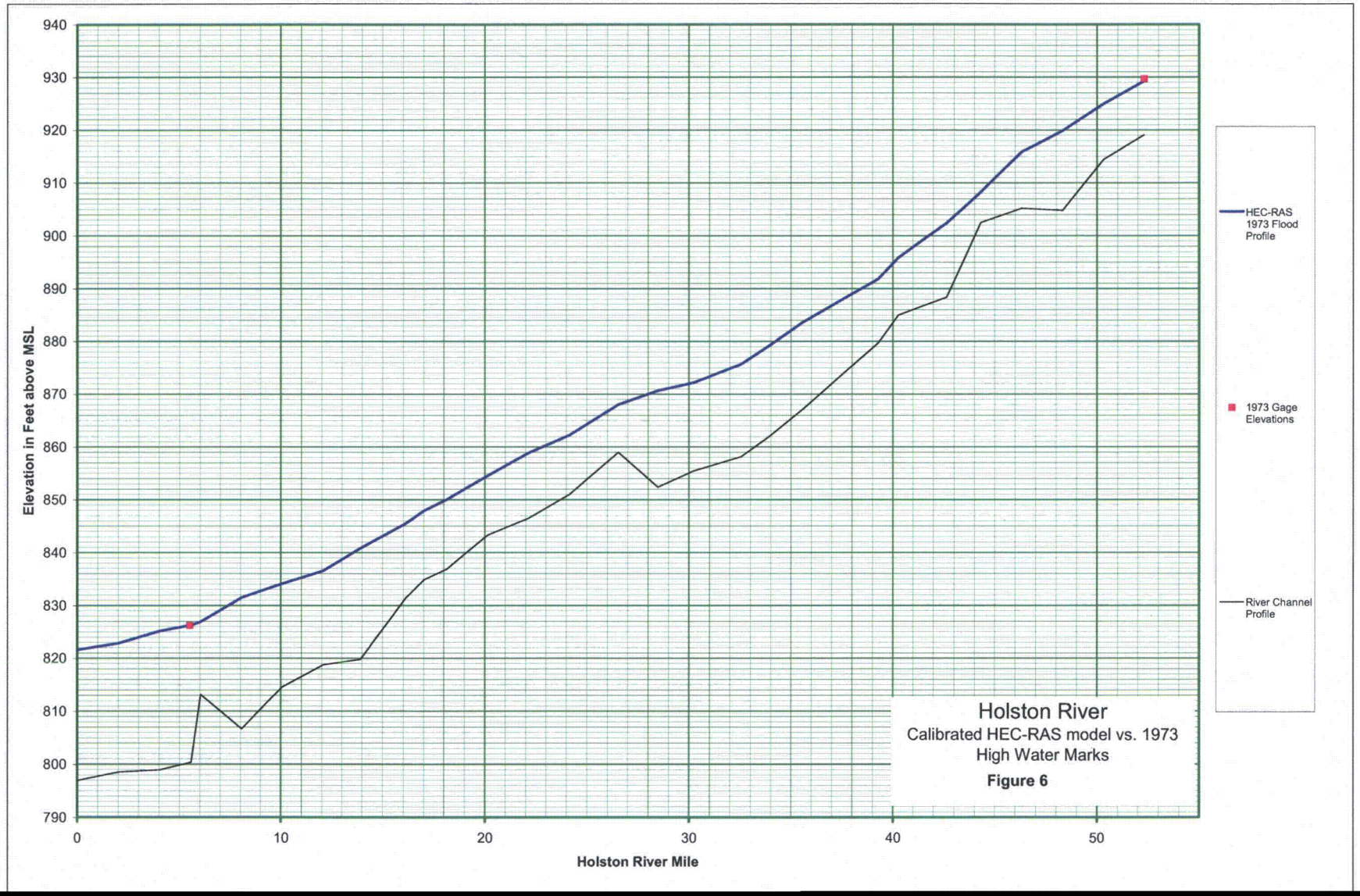


Holston River
Calibrated HEC-RAS model vs. 500-yr Flood Insurance Profile
Figure 5

Table 14. Holston River, Calibrated HEC-RAS Model vs. 0.2 Percent Annual Chance Flood Marks

Holston River Mile	HEC-RAS 0.2 Percent Annual Chance Flood Profile	0.2 Percent Annual Chance Flood Profile[1]	River Bottom Elevation	Manning's *n*
	Elevation (ft)	Elevation (ft)	Elevation (ft)	
52.30	941.34	939.40	919.10	0.050
50.34	936.90		914.50	0.045
48.31	929.27	929.00	904.80	0.045
46.33	923.29	923.40	905.20	0.033
44.30	918.54		902.50	0.033
42.64	913.70	913.30	888.37	0.033
40.27	906.82		885.00	0.033
39.27	903.74	903.50	879.72	0.033
35.58	895.39		867.15	0.033
33.92	890.96	890.60	862.00	0.039
32.54	887.23		858.16	0.039
30.22	882.73	881.50	855.50	0.035
28.48	880.25		852.40	0.035
26.54	876.65	876.00	859.00	0.035
24.15	871.03		851.00	0.035
22.14	867.28	866.40	846.50	0.028
20.14	863.14		843.30	0.028
18.12	859.53	859.00	836.80	0.028
17.02	858.00		834.90	0.028
16.10	855.76	856.00	831.40	0.028
13.91	850.72		819.81	0.028
12.06	846.62	847.00	818.80	0.028
10.06	843.92		814.60	0.028
8.04	840.00	840.20	806.70	0.028
6.03	837.40		813.20	0.028
5.56	836.82		800.44	0.028
4.02	835.43	835.20	799.00	0.036
2.02	832.52	832.50	798.60	0.036
0.00	831.00		797.00	0.036

1. Flood frequency profile from Attachment 8



TVA

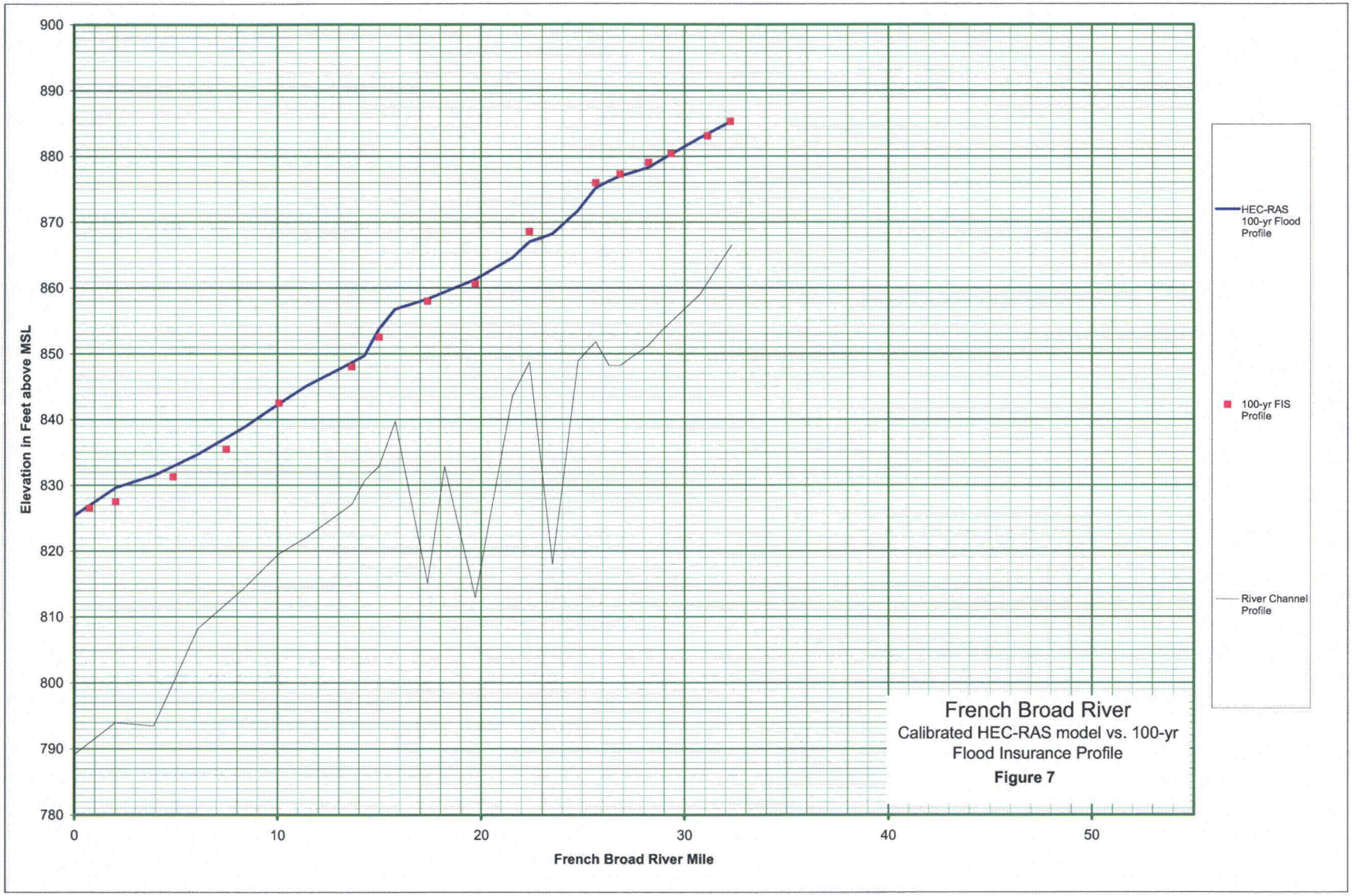
Calculation No. CDQ000020080036 | Rev: 0 | Plant: GEN | Page: 49

Subject: SOCH Model Calibration, Fort Loudoun-Tellico | Prepped JAW | Checked JCT

Table 15. Holston River, Calibrated HEC-RAS Model vs. 1973 Gage Elevations

Holston River Mile	HEC-RAS 1973 Flood Profile	1973 Gage Elevations[1]	River Bottom Elevation	Manning's *n*
	Elevation (ft)	Elevation (ft)	Elevation (ft)	
52.30	929.26	929.68	919.10	0.050
50.34	925.01		914.50	0.045
48.31	919.89		904.80	0.045
46.33	915.91		905.20	0.033
44.30	908.27		902.50	0.033
42.64	902.40		888.37	0.033
40.27	895.85		885.00	0.033
39.27	891.83		879.72	0.033
35.58	883.65		867.15	0.033
33.92	879.17		862.00	0.039
32.54	875.68		858.16	0.039
30.22	872.20		855.50	0.035
28.48	870.69		852.40	0.035
26.54	868.04		859.00	0.035
24.15	862.25		851.00	0.035
22.14	858.88		846.50	0.028
20.14	854.57		843.30	0.028
18.12	849.99		836.80	0.028
17.021	847.95		834.90	0.028
16.10	845.48		831.40	0.028
13.91	840.78		819.81	0.028
12.06	836.54		818.80	0.028
10.06	834.09		814.60	0.028
8.04	831.47		806.70	0.028
6.03	826.90		813.20	0.028
5.56	826.28		800.44	0.028
5.50		826.24		
4.02	825.17		799.00	0.036
2.02	822.88		798.60	0.036
0.00	821.60		797.00	0.036

1. Gage elevations determined from Attachment 4



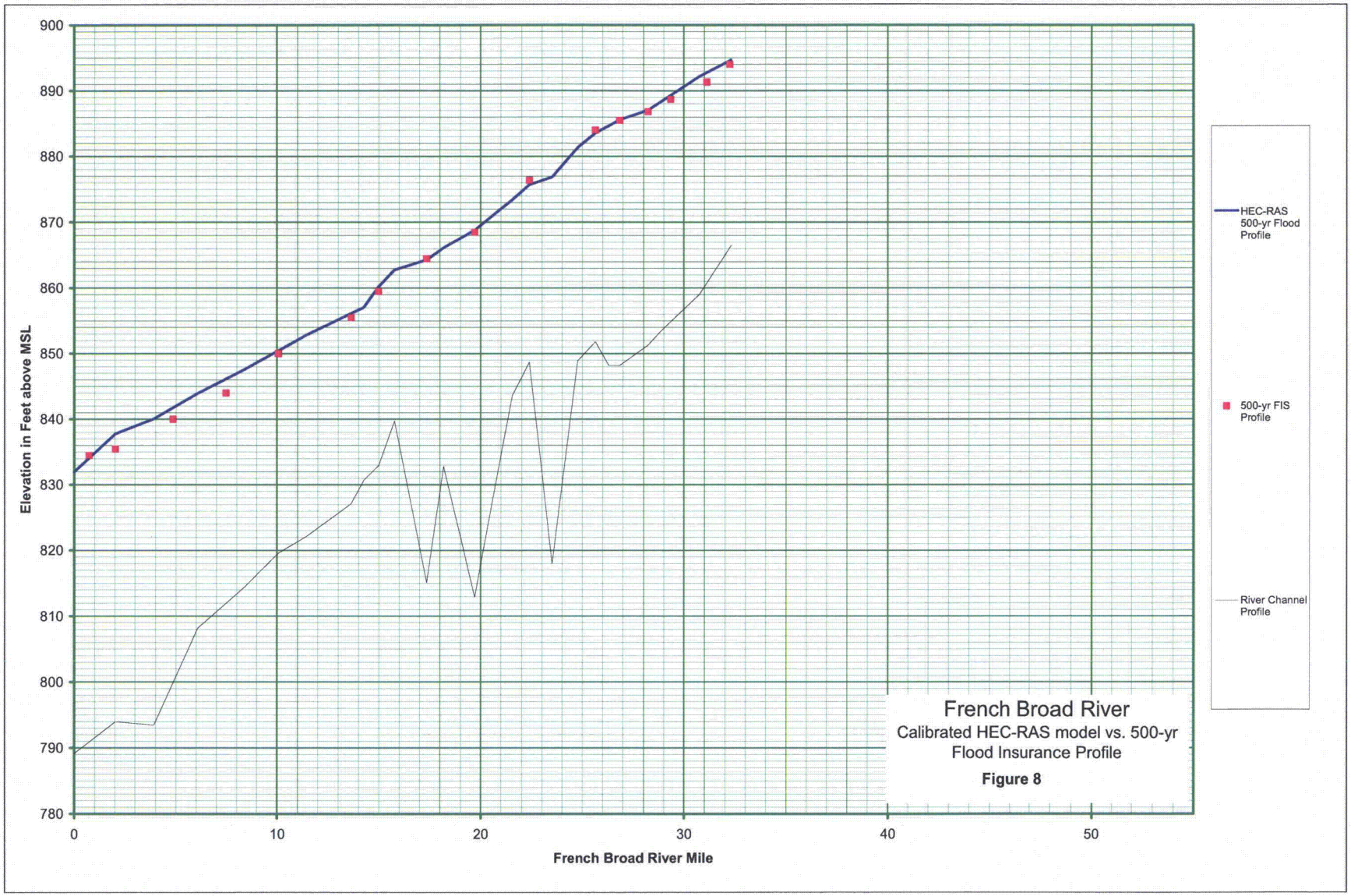
TVA

Calculation No. CDQ000020080036	Rev: 0	Plant: GEN	Page: 51
Subject: SOCH Model Calibration, Fort Loudoun-Tellico		Prepped	JAW
		Checked	JCT

Table 16. French Broad River, Calibrated HEC-RAS Model vs. 1 Percent Annual Chance Flood Marks

French Broad River Mile	HEC-RAS 1 Percent Annual Chance Flood Profile	1 Percent Annual Chance Flood Profile[1]	River Bottom Elevation	Manning's *n*
	Elevation (ft)	Elevation (ft)	Elevation (ft)	
32.30	885.33	885.30	866.50	0.039
31.12		883.10		
30.75	882.81		865.10	0.039
29.34		880.40		
28.85	879.48		859.00	0.039
28.23	878.33	879.10	865.60	0.038
26.84	877.02	877.30	857.00	0.038
26.30	876.28		853.40	0.038
25.65	875.20	876.00	851.30	0.038
24.78	871.79		848.20	0.038
23.50	868.25		848.20	0.038
22.38	867.03	868.60	851.80	0.042
21.56	864.59		848.90	0.042
19.70	861.29	860.60	818.00	0.042
18.18	859.37		848.70	0.034
17.35	858.31	858.00	843.60	0.029
15.76	856.78		812.90	0.029
14.97	853.73	852.50	832.80	0.029
14.26	849.70		815.10	0.029
13.63	848.64	848.00	839.70	0.029
11.42	845.09		832.90	0.034
10.07	842.40	842.50	830.70	0.039
8.40	838.89		827.10	0.034
7.46		835.50		
6.06	834.70		819.60	0.034
4.85		831.30		
3.90	831.48		811.00	0.031
2.02	829.61	827.50	808.20	0.031
0.73		826.50		
0.00	825.40		793.50	0.034

1. Flood frequency profile from Attachment 8



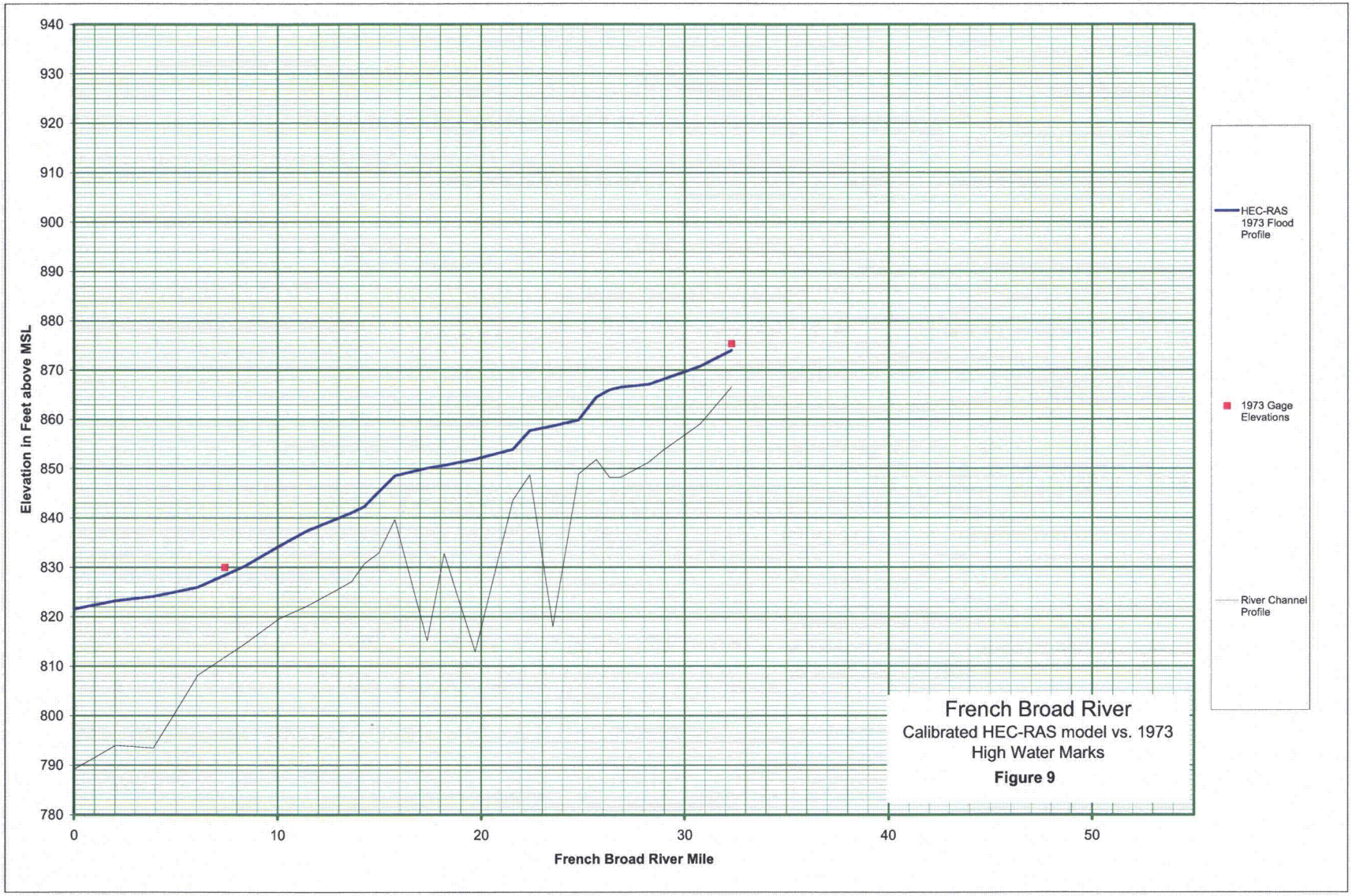
French Broad River
Calibrated HEC-RAS model vs. 500-yr Flood Insurance Profile

Figure 8

Table 17. French Broad River, Calibrated HEC-RAS Model vs. 0.2 Percent Annual Chance Flood Marks

French Broad River Mile	HEC-RAS 0.2 Percent Annual Chance Flood Profile	0.2 Percent Annual Chance Flood Profile[1]	River Bottom Elevation	Manning's *n*
	Elevation (ft)	Elevation (ft)	Elevation (ft)	
32.30	894.68	894.00	866.50	0.039
31.12		891.30		
30.75	892.18		865.10	0.039
29.34		888.70		
28.85	888.32		859.00	0.039
28.23	887.06	886.80	865.60	0.038
26.84	885.59	885.50	857.00	0.038
26.30	884.67		853.40	0.038
25.65	883.57	884.00	851.30	0.038
24.78	881.35		848.20	0.038
23.50	876.88		848.20	0.038
22.38	875.73	876.40	851.80	0.042
21.56	873.43		848.90	0.042
19.70	868.79	868.50	818.00	0.042
18.18	866.15		848.70	0.034
17.35	864.30	864.50	843.60	0.029
15.76	862.79		812.90	0.029
14.97	860.20	859.50	832.80	0.029
14.26	857.05		815.10	0.029
13.63	856.12	855.50	839.70	0.029
11.42	852.80		832.90	0.034
10.07	850.42	850.00	830.70	0.039
8.40	847.62		827.10	0.034
7.46		844.00		
6.06	843.91		819.60	0.034
3.90	840.04		811.00	0.031
4.85		840.00		
2.02	837.77	835.50	808.20	0.031
0.73		834.50		
0.00	832.00		793.50	0.034

1. Flood frequency profile determined from Attachment 8



TVA

Calculation No. CDQ0000020080036	Rev: 0	Plant: GEN	Page: 55
Subject: SOCH Model Calibration, Fort Loudoun-Tellico		Prepped	JAW
		Checked	JCT

Table 18. French Broad River, Calibrated HEC-RAS Model vs. 1973 Gage Elevations

French Broad River Mile	HEC-RAS 1973 Flood Profile	1973 Gage Elevations[1]	River Bottom Elevation	Manning's *n*
	Elevation (ft)	Elevation (ft)	Elevation (ft)	
32.30	873.97	875.30	866.50	0.039
30.75	870.75		859.00	0.039
28.85	867.98		853.40	0.039
28.23	867.10		851.30	0.038
26.84	866.49		848.20	0.038
26.30	865.96		848.20	0.038
25.65	864.47		851.80	0.038
24.78	859.84		848.90	0.038
23.50	858.64		818.00	0.038
22.38	857.69		848.70	0.042
21.56	853.90		843.60	0.042
19.70	851.92		812.90	0.042
18.18	850.67		832.80	0.034
17.35	850.11		815.10	0.029
15.76	848.55		839.70	0.029
14.97	845.30		832.90	0.029
14.26	842.29		830.70	0.029
13.63	841.02		827.10	0.029
11.42	837.32		822.10	0.034
10.07	834.30		819.60	0.039
8.40	830.26		814.50	0.034
7.40		830.00		
6.06	825.99		808.20	0.034
3.90	824.12		793.50	0.031
2.02	823.24		794.00	0.031
0.00	821.60		789.20	0.034

1. Gage elevations determined from Attachment 4

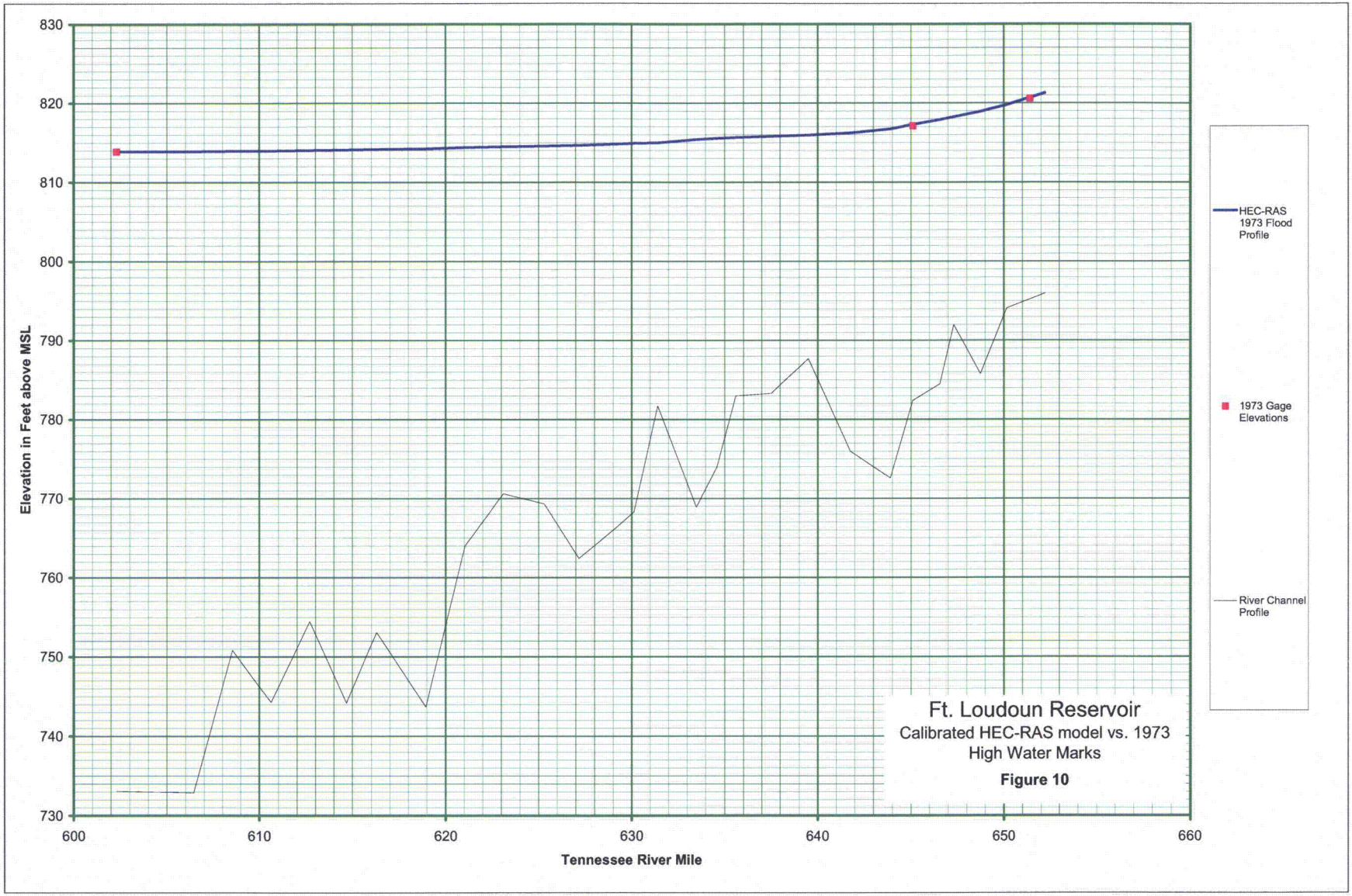

Elevation in Feet above MSL
830
820
810
800
790
780
770
760
750
740
730
600
610
620
630
640
650
660
Tennessee River Mile
HEC-RAS 1973 Flood Profile
1973 Gage Elevations
River Channel Profile
Ft. Loudoun Reservoir
Calibrated HEC-RAS model vs. 1973 High Water Marks
Figure 10

Table 19. Fort Loudoun Reservoir, Calibrated HEC-RAS Model vs. 1973 Gage Elevations

Tennessee River Mile	HEC-RAS 1973 Flood Profile	1973 Gage Elevations[1]	River Bottom Elevation	Manning's *n*
	Elevation (ft)	Elevation (ft)	Elevation (ft)	
652.22	821.29		796.00	0.031
651.40		820.63		
650.14	819.78		794.10	0.031
648.73	818.92		785.80	0.031
647.29	818.26		792.00	0.029
646.55	817.90		784.50	0.029
645.10		817.13		
645.09	817.28		782.40	0.029
643.89	816.71		772.60	0.029
641.77	816.22		776.00	0.020
639.50	815.96		787.70	0.020
637.52	815.79		783.30	0.020
635.59	815.66		783.00	0.020
634.60	815.54		774.00	0.020
633.50	815.40		768.90	0.020
631.41	814.98		781.70	0.020
630.12	814.93		768.30	0.023
629.31	814.84		766.60	0.023
627.15	814.67		762.40	0.023
625.28	814.58		769.30	0.023
623.10	814.49		770.60	0.023
621.02	814.40		764.00	0.035
618.94	814.24		743.70	0.035
616.27	814.16		753.10	0.035
614.68	814.10		744.20	0.035
612.68	814.04		754.50	0.035
610.63	813.97		744.30	0.035
608.54	813.95		750.90	0.031
606.43	813.91		732.90	0.031
602.30	813.90	813.90	733.10	0.031

1. Gage elevations determined from Attachment 4

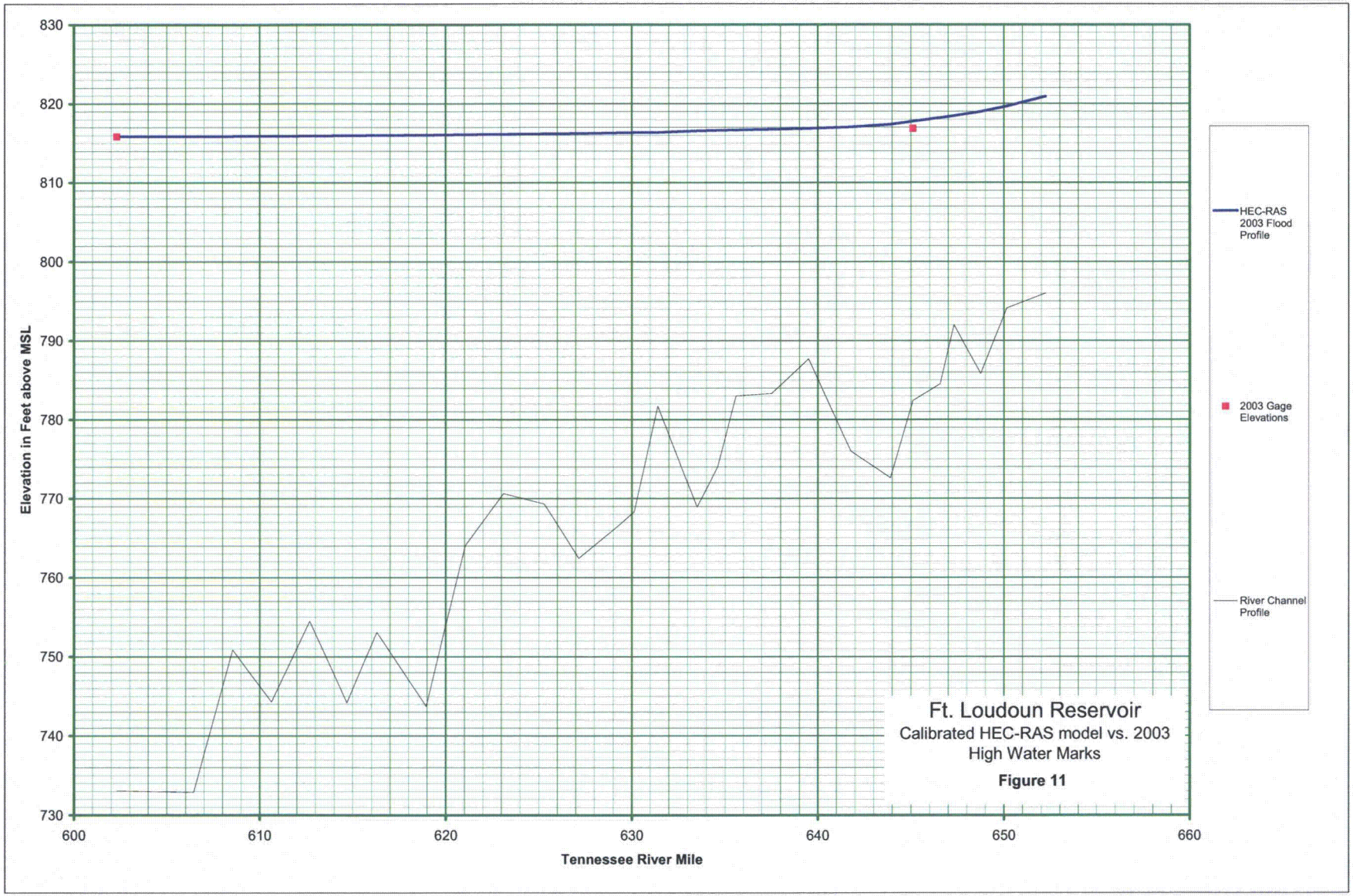

Ft. Loudoun Reservoir
Calibrated HEC-RAS model vs. 2003
High Water Marks
Figure 11
Elevation in Feet above MSL
Tennessee River Mile
830
820
810
800
790
780
770
760
750
740
730
600
610
620
630
640
650
660
HEC-RAS 2003 Flood Profile
2003 Gage Elevations
River Channel Profile

Table 20. Fort Loudoun Reservoir, Calibrated HEC-RAS Model vs. 2003 Gage Elevations

Tennessee River Mile	HEC-RAS 2003 Flood Profile	2003 Gage Elevations[1]	River Bottom Elevation	Manning's *n*
	Elevation (ft)	Elevation (ft)	Elevation (ft)	
652.22	820.89		796.00	0.031
650.14	819.65		794.10	0.031
648.73	818.96		785.80	0.031
647.29	818.46		792.00	0.029
646.55	818.20		784.50	0.029
645.10		816.84		
645.09	817.75		782.40	0.029
643.89	817.35		772.60	0.029
641.77	817.02		776.00	0.020
639.50	816.85		787.70	0.020
637.52	816.74		783.30	0.020
635.59	816.67		783.00	0.020
634.60	816.61		774.00	0.020
633.50	816.54		768.90	0.020
631.41	816.35		781.70	0.020
630.12	816.33		768.30	0.023
629.31	816.29		766.60	0.023
627.15	816.21		762.40	0.023
625.28	816.17		769.30	0.023
623.10	816.13		770.60	0.023
621.02	816.09		764.00	0.035
618.94	816.02		743.70	0.035
616.27	815.99		753.10	0.035
614.68	815.96		744.20	0.035
612.68	815.93		754.50	0.035
610.63	815.90		744.30	0.035
608.54	815.89		750.90	0.031
606.43	815.87		732.90	0.031
602.30	815.87	815.87	733.10	0.031

1. Gage elevations determined from Attachment 5

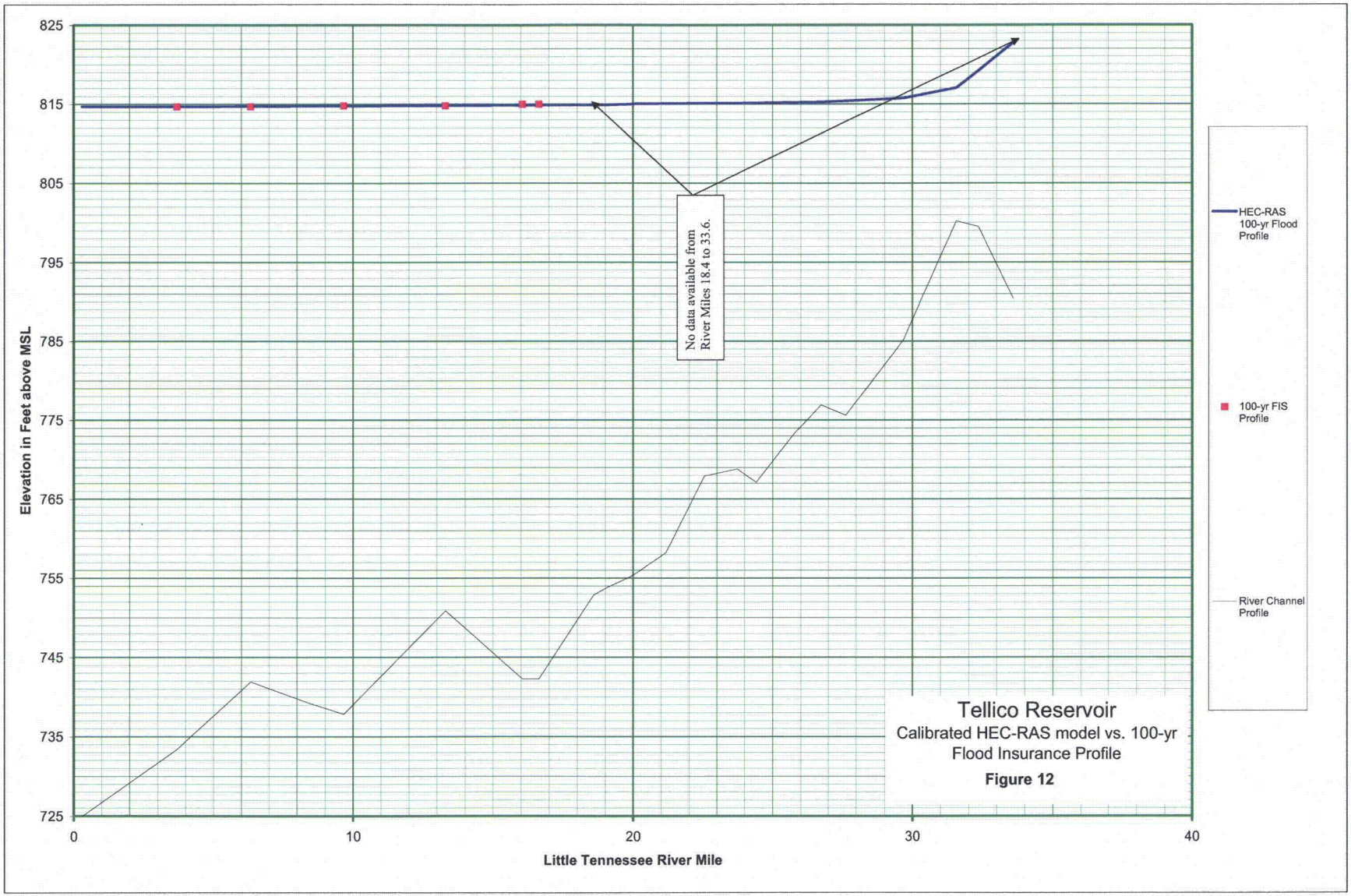

825
815
805
795
785
775
765
755
745
735
725
Elevation in Feet above MSL
0
10
20
30
40
Little Tennessee River Mile
No data available from River Miles 18.4 to 33.6.
HEC-RAS 100-yr Flood Profile
100-yr FIS Profile
River Channel Profile
Tellico Reservoir
Calibrated HEC-RAS model vs. 100-yr Flood Insurance Profile
Figure 12

Table 21. Tellico Reservoir, Calibrated HEC-RAS Model vs. 1 Percent Annual Chance Flood Marks

Tellico Reservoir Mile	HEC-RAS 1 Percent Annual Chance Flood Profile	1 Percent Annual Chance Flood Profile[1]	River Bottom Elevation	Manning's *n*
	Elevation (ft)	Elevation (ft)	Elevation (ft)	
33.60	822.79	[2]	790.40	0.038
32.34	819.24	[2]	799.50	0.038
31.55	817.05	[2]	800.20	0.038
29.68	815.74	[2]	785.20	0.038
27.62	815.40	[2]	775.60	0.030
26.73	815.27	[2]	776.90	0.030
25.74	815.22	[2]	773.20	0.030
24.41	815.14	[2]	767.10	0.030
23.73	815.13	[2]	768.80	0.030
22.54	815.13	[2]	767.90	0.030
21.17	815.08	[2]	758.20	0.030
20.10	815.04	[2]	755.60	0.030
19.87	814.99	[2]	755.120	0.030
19.11	814.90	[2]	753.90	0.030
18.59	814.89	[2]	752.90	0.030
16.64	814.88	815.00	742.30	0.030
16.05	814.86	815.00	742.30	0.030
13.31	814.81	814.80	750.90	0.030
9.66	814.76	814.80	737.80	0.030
8.43	814.75		739.20	0.030
6.33	814.72	814.70	741.90	0.030
3.68	814.70	814.70	733.40	0.030
0.30	814.70		725.00	0.030

1. Flood frequency profile from Attachment 8 2. No data available.

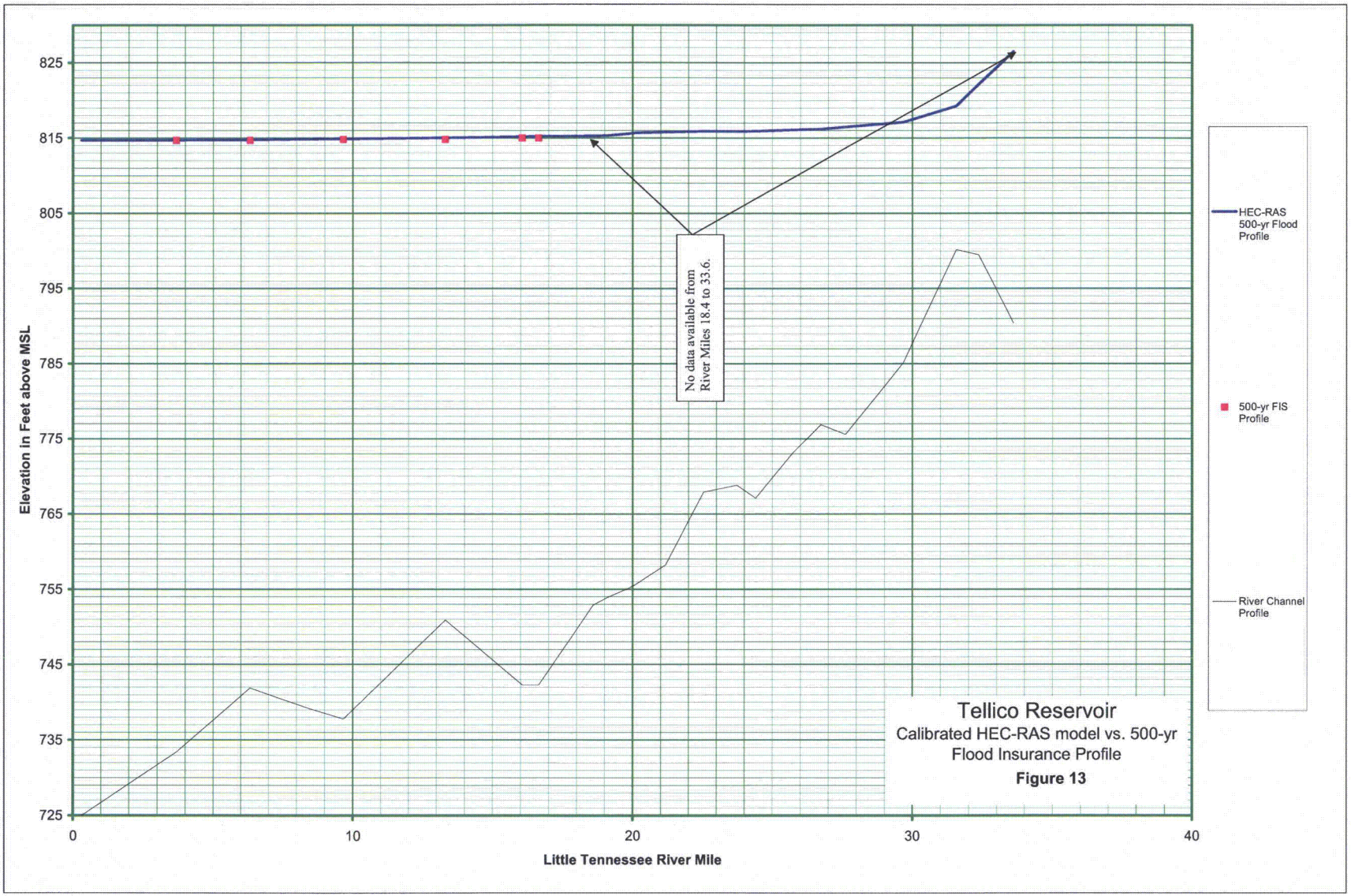
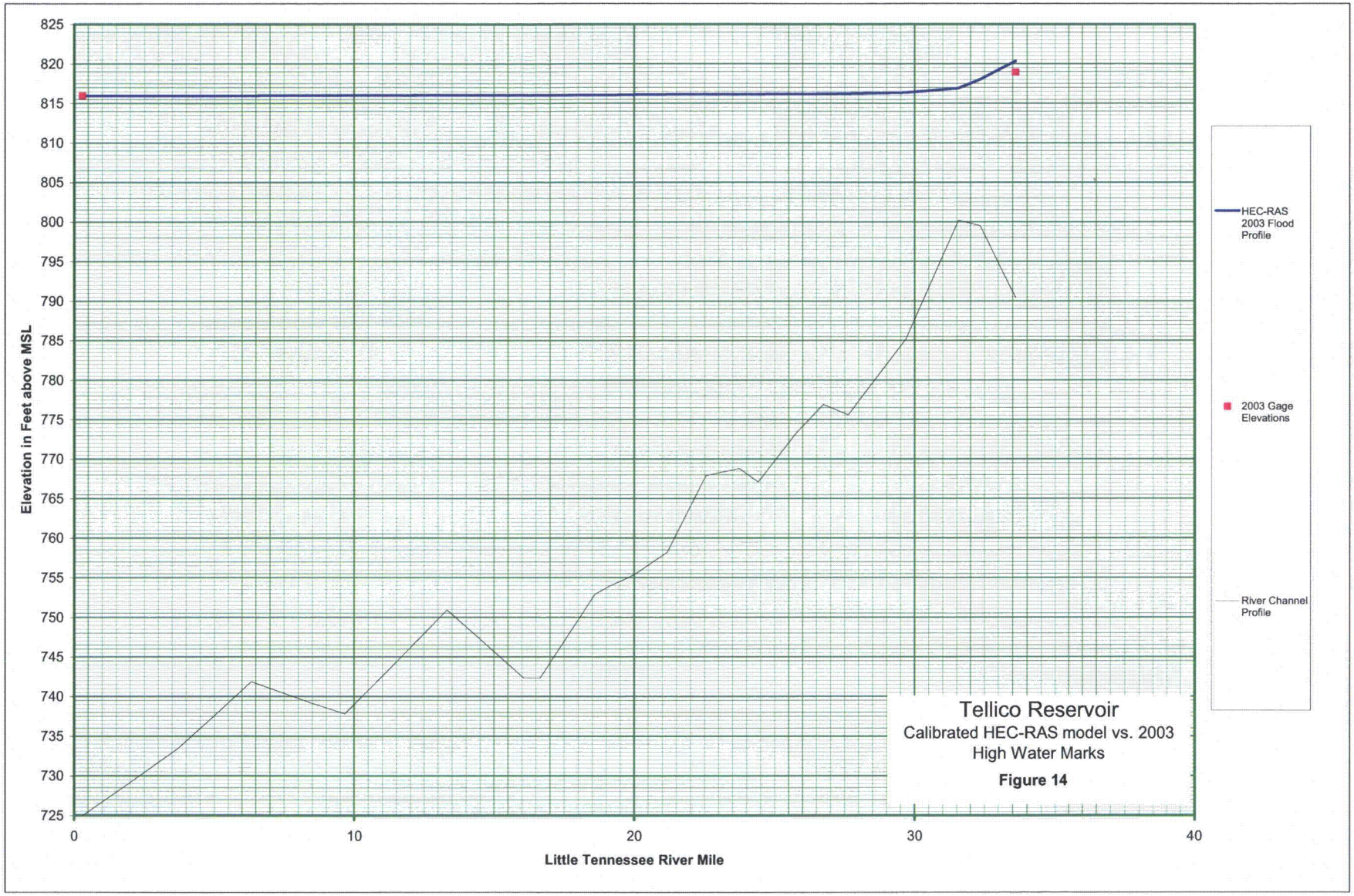

825
815
805
795
785
775
765
755
745
735
725
Elevation in Feet above MSL
0
10
20
30
40
Little Tennessee River Mile
No data available from River Miles 18.4 to 33.6.
HEC-RAS 500-yr Flood Profile
500-yr FIS Profile
River Channel Profile
Tellico Reservoir
Calibrated HEC-RAS model vs. 500-yr Flood Insurance Profile
Figure 13

Table 22. Tellico Reservoir, Calibrated HEC-RAS Model vs. 0.2 Percent Annual Chance Flood Marks

Tellico Reservoir Mile	HEC-RAS 0.2 Percent Annual Chance Flood Profile	0.2 Percent Annual Chance Flood Profile[1]	River Bottom Elevation	Manning's *n*
	Elevation (ft)	Elevation (ft)	Elevation (ft)	
33.60	826.51	[2]	790.40	0.038
32.34	822.15	[2]	799.50	0.038
31.55	819.27	[2]	800.20	0.038
29.68	817.11	[2]	785.20	0.038
27.62	816.47	[2]	775.60	0.030
26.73	816.19	[2]	776.90	0.030
25.74	816.09	[2]	773.20	0.030
24.41	815.91	[2]	767.10	0.030
23.73	815.89	[2]	768.80	0.030
22.54	815.88	[2]	767.90	0.030
21.17	815.78	[2]	758.20	0.030
20.10	815.68	[2]	755.60	0.030
19.87	815.57	[2]	755.12	0.030
19.11	815.31	[2]	753.90	0.030
18.59	815.27	[2]	752.90	0.030
16.64	815.23	815.00	742.30	0.030
16.05	815.18	815.00	742.30	0.030
13.31	815.02	814.80	750.90	0.030
9.66	814.87	814.80	737.80	0.030
8.43	814.84		739.20	0.030
6.33	814.76	814.70	741.90	0.030
3.68	814.71	814.70	733.40	0.030
0.30	814.70		725.00	0.030

1. Flood frequency profile from Attachment 8 2. No available data.



Tellico Reservoir
Calibrated HEC-RAS model vs. 2003 High Water Marks

Figure 14

Table 23. Tellico Reservoir, Calibrated HEC-RAS Model vs. 2003 Gage Elevations

Tellico Reservoir Mile	HEC-RAS 2003 Flood Profile	2003 Gage Elevations[1]	River Bottom Elevation	Manning's *n*
	Elevation (ft)	Elevation (ft)	Elevation (ft)	
33.60	820.33	818.93	790.40	0.038
32.34	818.01		799.50	0.038
31.55	816.90		800.20	0.038
29.68	816.36		785.20	0.038
27.62	816.23		775.60	0.030
26.73	816.18		776.90	0.030
25.74	816.16		773.20	0.030
24.41	816.13		767.10	0.030
23.73	816.13		768.80	0.030
22.54	816.12		767.90	0.030
21.17	816.11		758.20	0.030
20.10	816.09		755.60	0.030
19.87	816.07		755.12	0.030
19.11	816.04		753.90	0.030
18.59	816.04		752.90	0.030
16.64	816.03		742.30	0.030
16.05	816.03		742.30	0.030
13.31	816.01		750.90	0.030
9.66	815.99		737.80	0.030
8.43	815.99		739.20	0.030
6.33	815.98		741.90	0.030
3.68	815.97		733.40	0.030
0.30	815.97	815.97	725.00	0.030

1. Gage Elevations determined from Attachment 5

6.2 HEC-RAS Steady-State Profiles

Fort Loudoun Reservoir

The calibrated HEC-RAS model of the Fort Loudoun Reservoir was then run to produce steady-state water surface profiles ranging from 100,000 cfs to 1,400,000 cfs. The 1,400,000 cfs profile is expected to be above the PMF level and was set as the upper bound of the calibration. Uniform, steady-flow was specified in 100,000 cfs or 200,000 cfs increments so no local inflows were used. The downstream boundary conditions, Table 24, were set at 817 ft, to account for surcharge of the reservoir pool until the flow increases to spillway capacity. As flow continues to increase up to 1,000,000 cfs, the boundary condition follows the dam rating curve developed to account for modeled tailwater and interaction with the Canal (Reference 2.24). The highest discharges (greater than 100,000,000 cfs) would only occur after Fort Loudoun dam is assumed to have failed from overtopping following upstream dam failure events. For the higher discharges, the boundary conditions were extracted from a previous SOCH model of seismic failures where Fort Loudoun Dam had already failed from overtopping (Reference 2.24 and Attachment 10). This is the reason for the high flow versus the low headwater elevations.

Table 24. Reach Boundary Conditions at Fort Loudoun Dam for Steady-State Profiles

Flow (cfs)	Elevation (ft)
100,000	817.00
200,000	817.00
300,000	817.00
400,000	817.00
500,000	819.00
600,000	821.00
700,000	824.50
800,000	828.00
900,000	830.25
1,000,000	832.50
1,200,000	806.00
1,300,000	817.00
1,400,000	828.00

Tellico Reservoir

Steady-state profiles of the Tellico Reservoir were produced by running HEC-RAS with uniform flow ranging from 100,000 cfs to 600,000 cfs in 100,000 cfs increments. The 600,000 cfs profile is expected to be above the PMF level and was set as the upper bound of the calibration. Uniform, steady-flow was specified in 100,000 cfs increments so no local inflows were used. The downstream boundary conditions, Table 25, were set at the surcharge level, 817 ft (Reference 2.24), of the reservoir for flows up to 400,000 with the headwater elevations at Ft. Loudoun and Tellico assumed to be equal up to this flow. After 400,000 cfs flow has been reached, the boundary conditions followed the Tellico dam rating curve.

Table 25. Reach Boundary Conditions at Tellico Reservoir for Steady-State Profiles

Flow (cfs)	Elevation (ft)
100,000	817.00
200,000	817.00
300,000	817.00
400,000	817.00
500,000	830.90
600,000	832.10

Holston and French Broad Rivers

Steady-state profiles of the Holston and French Broad Rivers were produced by running HEC-RAS with uniform flow. The two rivers meet at the Forks of the Rivers, TRM 652.22. Uniform steady-flow was specified so no local inflows were used. The downstream boundary conditions for both the Holston River and French Broad River models were set as the water-surface elevation at TRM 652.22 determined by running steady-state profiles of Fort Loudoun Reservoir. The Holston River contributes 35% of the flow at TRM 652.22 while the French Broad River contributes 65% of the flow. The ratio was determined by comparing the flow from each river during the 1 Percent Annual Chance Flood (Table 26). So, the water-surface elevation for a flow of 100,000 cfs at TRM 652.22 was set as the downstream boundary condition for a steady-state profile of 35,000 cfs in the Holston River and for a flow of 65,000 cfs in the French Broad River. Steady-state profiles of the Holston River were produced with flow ranging from 35,000 cfs to 490,000 cfs (Table 27). Steady-state profiles of the French Broad River were produced with flow ranging from 65,000 cfs to 845,000 cfs (Table 27).

Table 26. Comparison of 1 Percent Annual Chance Flows in Holston River and French Broad River

1 Percent Annual Chance Flood Event		
River	Flow (cfs)	Ratio
Holston River	29,682	35%
French Broad River	55,124	65%
Total	84,806	100%

Table 27. Reach Boundary Conditions Holston River and French Broad Rivers for Steady-State Profiles

Holston River Flow	French Broad River Flow (cfs)	Elevation (ft)
35,000	65,000	826.14
70,000	130,000	835.85
105,000	195,000	843.70
140,000	260,000	850.46
175,000	325,000	856.63
210,000	390,000	862.26
245,000	455,000	867.55
280,000	520,000	872.59
315,000	585,000	877.30
350,000	650,000	881.68
420,000	780,000	889.31
455,000	845,000	893.39
490,000	-	897.35

6.2.1 HEC-RAS Steady-State Profiles of Fort Loudoun Reservoir

The calibrated HEC-RAS model of Fort Loudoun Reservoir was run from 100,000 cfs to 1,400,000 cfs. The 1,400,000 cfs profile is expected to be above the PMF level and was set as the upper bound of the calibration. The steady-state profiles are shown in Figures 15 through 18 and tabulated in Tables 28 - 29. No tailwater curve is provided for Fort Loudoun since there is no dam at the upstream boundary.

6.2.2 HEC-RAS Steady-State Profiles of the Tellico Reservoir

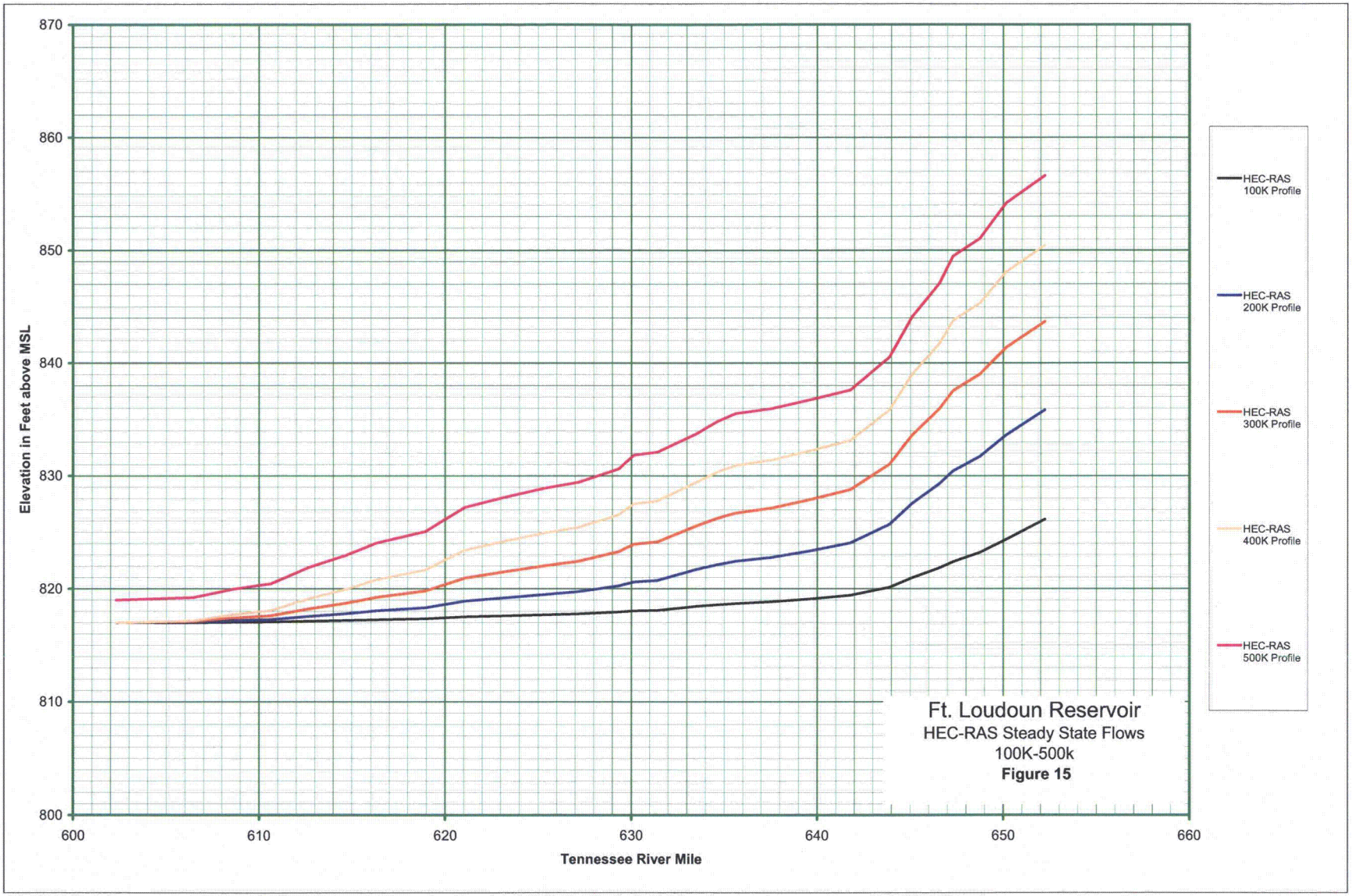
The calibrated HEC-RAS model of the Tellico Reservoir was run in flow increments of 100,000 cfs up to 600,000 cfs. The 600,000 cfs profile is expected to be above the PMF level and was set as the upper bound of the calibration. The steady-state profiles are shown in Figure 19 and tabulated in Table 30. Figure 20 and Table 31 show the elevations from the HEC-RAS steady-state profiles at Chilhowee Dam, LTRM 33.60, compared to the tailwater rating curve for Chilhowee Dam (Attachment 2).

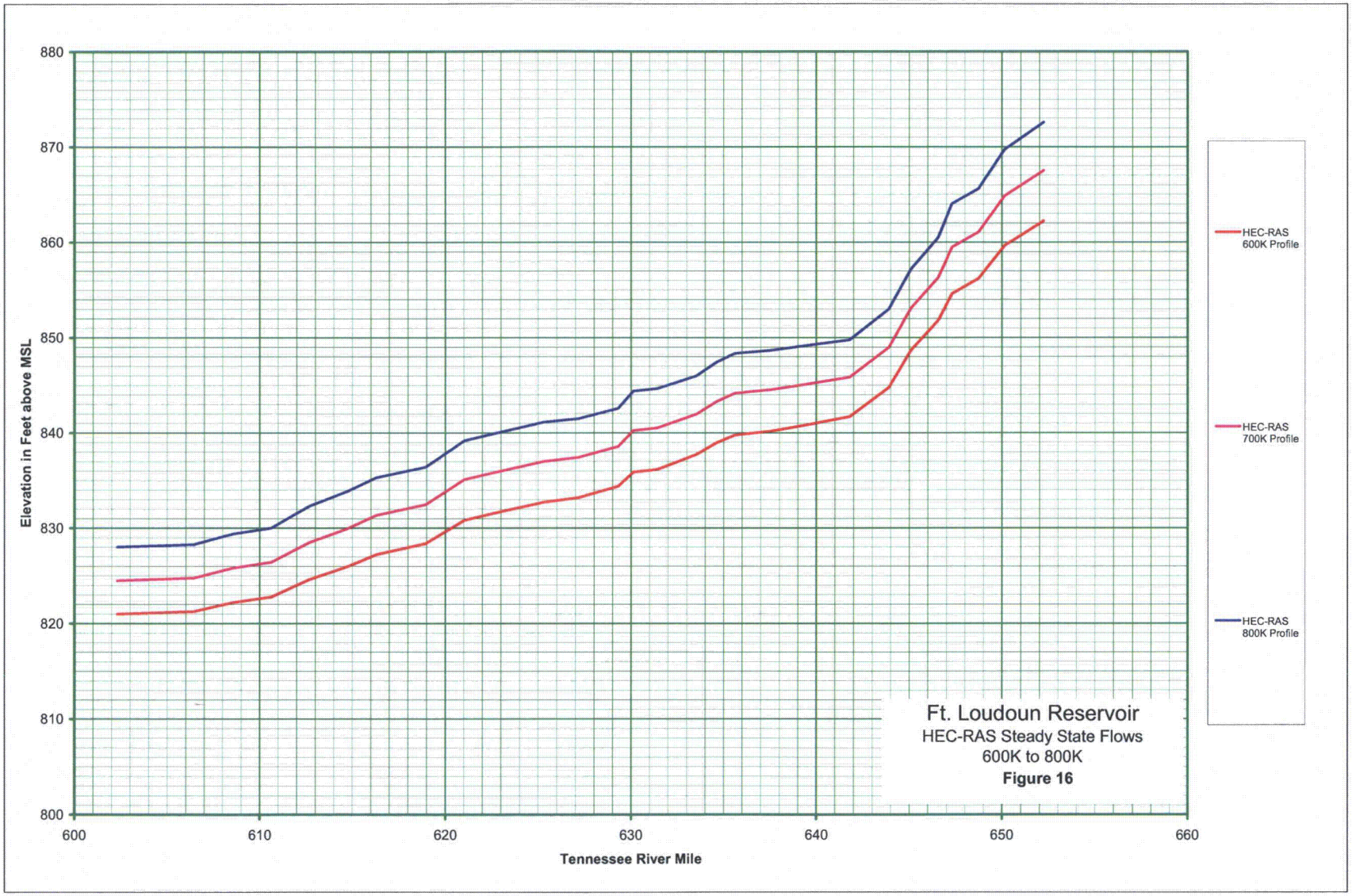
6.2.3 HEC-RAS Steady-State Profiles of the Holston River

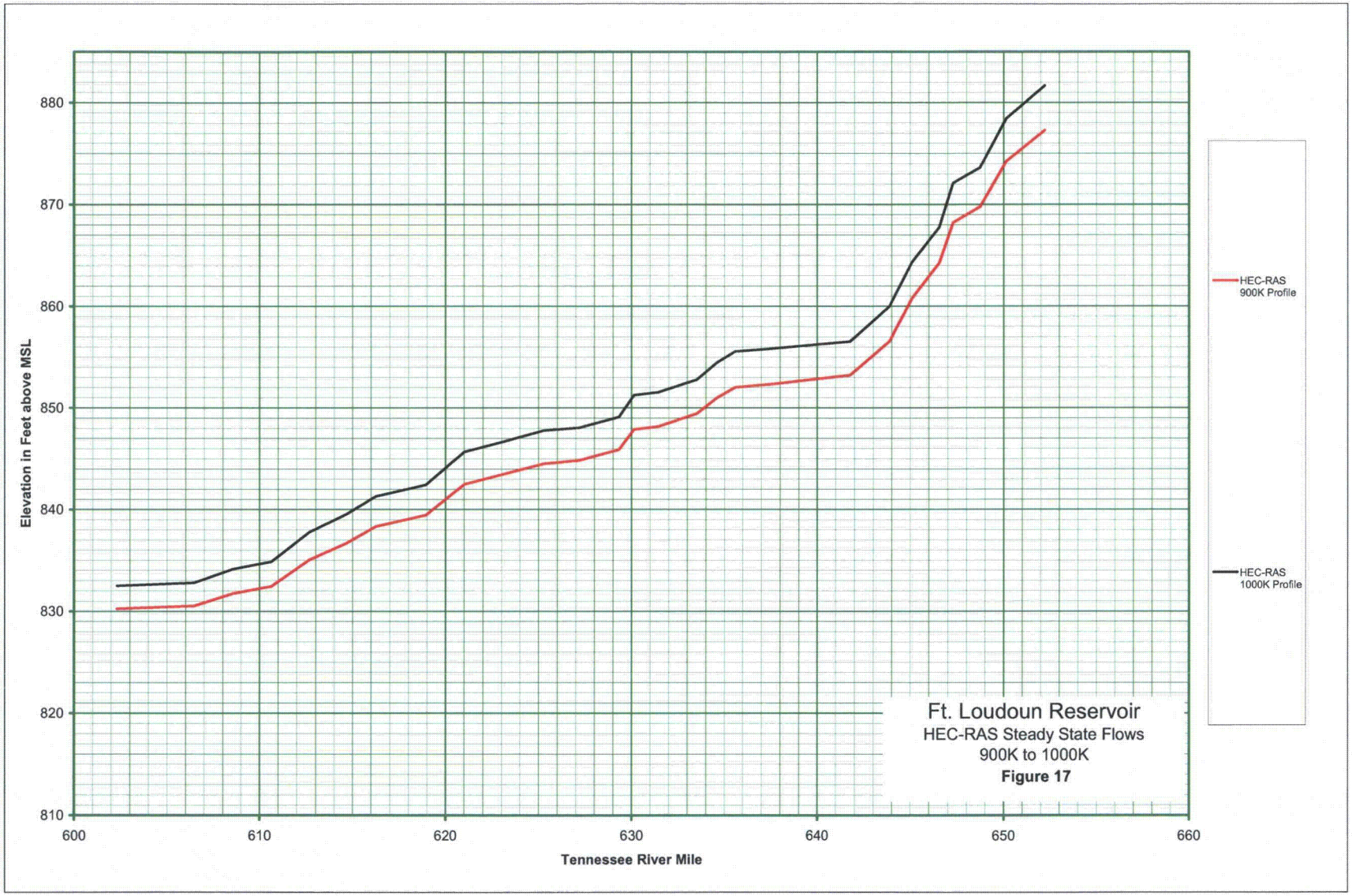
The HEC-RAS model of the Holston River was run from 35,000 cfs up to 490,000 cfs. The steady-state profiles are shown in Figures 21 through 23 and tabulated in Tables 32 and 33. Figure 24 and Table 34 show the elevations from the HEC-RAS steady-state profiles at Cherokee Dam, Holston River Mile 52.30, compared to the tailwater rating curve for Cherokee Dam (Attachment 2).

6.2.4 HEC-RAS Steady-State Profiles of the French Broad River

The HEC-RAS model of the French Broad River was run in flow increments of 65,000 cfs up to 845,000 cfs. The steady-state profiles are shown in Figures 25 through 27 and tabulated in Tables 35 and 36. Figure 28 and Table 37 show the elevations from the HEC-RAS steady-state profiles at Douglas Dam, FBRM 32.30, compared to the tailwater rating curve for Douglas Dam (Attachment 2).


Ft. Loudoun Reservoir
HEC-RAS Steady State Flows
100K-500k
Figure 15
Elevation in Feet above MSL
Tennessee River Mile
870
860
850
840
830
820
810
800
600
610
620
630
640
650
660
HEC-RAS 100K Profile
HEC-RAS 200K Profile
HEC-RAS 300K Profile
HEC-RAS 400K Profile
HEC-RAS 500K Profile


880
870
860
850
840
830
820
810
800
Elevation in Feet above MSL
600
610
620
630
640
650
660
Tennessee River Mile
HEC-RAS 600K Profile
HEC-RAS 700K Profile
HEC-RAS 800K Profile
Ft. Loudoun Reservoir
HEC-RAS Steady State Flows
600K to 800K
Figure 16


Elevation in Feet above MSL
880
870
860
850
840
830
820
810
600
610
620
630
640
650
660
Tennessee River Mile
HEC-RAS 900K Profile
HEC-RAS 1000K Profile
Ft. Loudoun Reservoir
HEC-RAS Steady State Flows
900K to 1000K
Figure 17

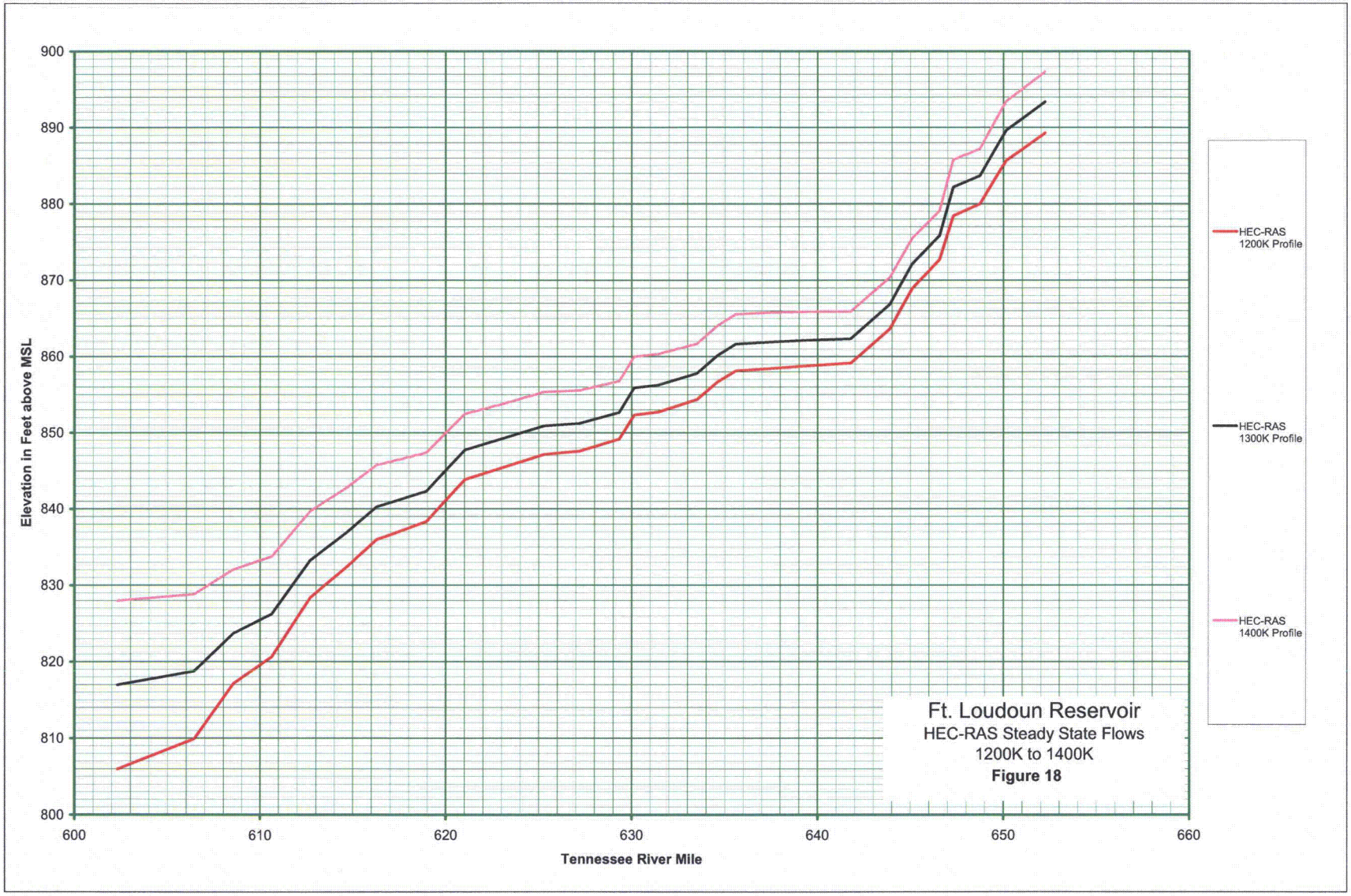

Ft. Loudoun Reservoir
HEC-RAS Steady State Flows
1200K to 1400K
Figure 18
Elevation in Feet above MSL
Tennessee River Mile
900
890
880
870
860
850
840
830
820
810
800
600
610
620
630
640
650
660
HEC-RAS 1200K Profile
HEC-RAS 1300K Profile
HEC-RAS 1400K Profile

Table 28. Fort Loudoun Reservoir, HEC-RAS Steady-State Flows 100K-700K

Tennessee River Mile	HEC-RAS 100K Profile	HEC-RAS 200K Profile	HEC-RAS 300K Profile	HEC-RAS 400K Profile	HEC-RAS 500K Profile	HEC-RAS 600K Profile	HEC-RAS 700K Profile
	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)
652.22	826.14	835.85	843.70	850.46	856.63	862.26	867.55
650.14	824.36	833.61	841.39	848.10	854.19	859.70	864.89
648.73	823.21	831.71	839.02	845.32	851.06	856.24	861.10
647.29	822.37	830.42	837.55	843.77	849.48	854.64	859.51
646.55	821.83	829.29	835.94	841.73	847.05	851.83	856.33
645.09	820.96	827.54	833.61	839.01	844.10	848.72	853.14
643.89	820.12	825.69	831.03	835.84	840.52	844.79	849.00
641.77	819.41	824.05	828.77	833.15	837.61	841.71	845.84
639.50	819.06	823.31	827.84	832.16	836.69	840.86	845.13
637.52	818.83	822.76	827.12	831.39	835.95	840.18	844.54
635.59	818.67	822.42	826.69	830.92	835.51	839.77	844.17
634.60	818.56	822.11	826.22	830.31	834.80	838.97	843.30
633.50	818.42	821.71	825.55	829.41	833.73	837.74	841.96
631.41	818.06	820.73	824.14	827.77	832.10	836.17	840.52
630.12	818.01	820.59	823.93	827.50	831.83	835.89	840.24
629.31	817.91	820.24	823.27	826.53	830.60	834.41	838.59
627.15	817.75	819.73	822.43	825.43	829.43	833.20	837.43
625.28	817.67	819.48	822.01	824.91	828.90	832.71	837.00
623.10	817.58	819.18	821.47	824.16	828.05	831.77	836.05
621.02	817.50	818.89	820.94	823.40	827.19	830.83	835.10
618.94	817.34	818.31	819.80	821.67	825.07	828.37	832.46
616.27	817.26	818.03	819.24	820.79	824.04	827.22	831.33
614.68	817.20	817.79	818.72	819.96	822.96	825.93	829.92
612.68	817.14	817.55	818.22	819.13	821.89	824.63	828.51
610.63	817.07	817.27	817.61	818.07	820.44	822.79	826.42
608.54	817.04	817.18	817.40	817.70	819.95	822.20	825.80
606.43	817.01	817.04	817.09	817.17	819.22	821.27	824.77
602.30	817.00	817.00	817.00	817.00	819.00	821.00	824.50

Table 29. Fort Loudoun Reservoir, HEC-RAS Steady-State Flows 800K-1400K

Tennessee River Mile	HEC-RAS 800K Profile	HEC-RAS 900K Profile	HEC-RAS 1000K Profile	HEC-RAS 1200K Profile	HEC-RAS 1300K Profile	HEC-RAS 1400K Profile
	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)
652.22	872.59	877.30	881.68	889.31	893.39	897.35
650.14	869.73	874.24	878.46	885.70	889.66	893.49
648.73	865.61	869.78	873.63	880.02	883.68	887.21
647.29	864.04	868.22	872.10	878.47	882.19	885.80
646.55	860.50	864.28	867.75	872.71	875.85	879.10
645.09	857.21	860.79	864.31	868.95	872.16	875.50
643.89	853.00	856.59	860.00	863.64	866.87	870.38
641.77	849.77	853.22	856.51	859.13	862.32	865.90
639.50	849.19	852.75	856.15	858.79	862.14	865.88
637.52	848.67	852.32	855.80	858.44	861.91	865.79
635.59	848.35	852.02	855.53	858.12	861.63	865.56
634.60	847.42	851.01	854.44	856.67	860.13	864.04
633.50	845.98	849.44	852.76	854.37	857.77	861.68
631.41	844.65	848.16	851.52	852.71	856.24	860.32
630.12	844.39	847.89	851.24	852.33	855.87	859.97
629.31	842.58	845.90	849.09	849.17	852.64	856.77
627.15	841.49	844.83	848.04	847.58	851.19	855.53
625.28	841.12	844.51	847.77	847.16	850.88	855.35
623.10	840.14	843.48	846.69	845.49	849.26	853.82
621.02	839.19	842.49	845.68	843.88	847.75	852.47
618.94	836.40	839.46	842.44	838.35	842.34	847.40
616.27	835.30	838.34	841.31	835.99	840.30	845.78
614.68	833.81	836.71	839.55	832.43	836.95	842.81
612.68	832.32	835.08	837.79	828.39	833.28	839.69
610.63	830.00	832.45	834.86	820.62	826.25	833.74
608.54	829.37	831.76	834.14	817.17	823.73	832.09
606.43	828.27	830.53	832.79	809.93	818.80	828.84
602.30	828.00	830.25	832.50	806.00	817.00	828.00

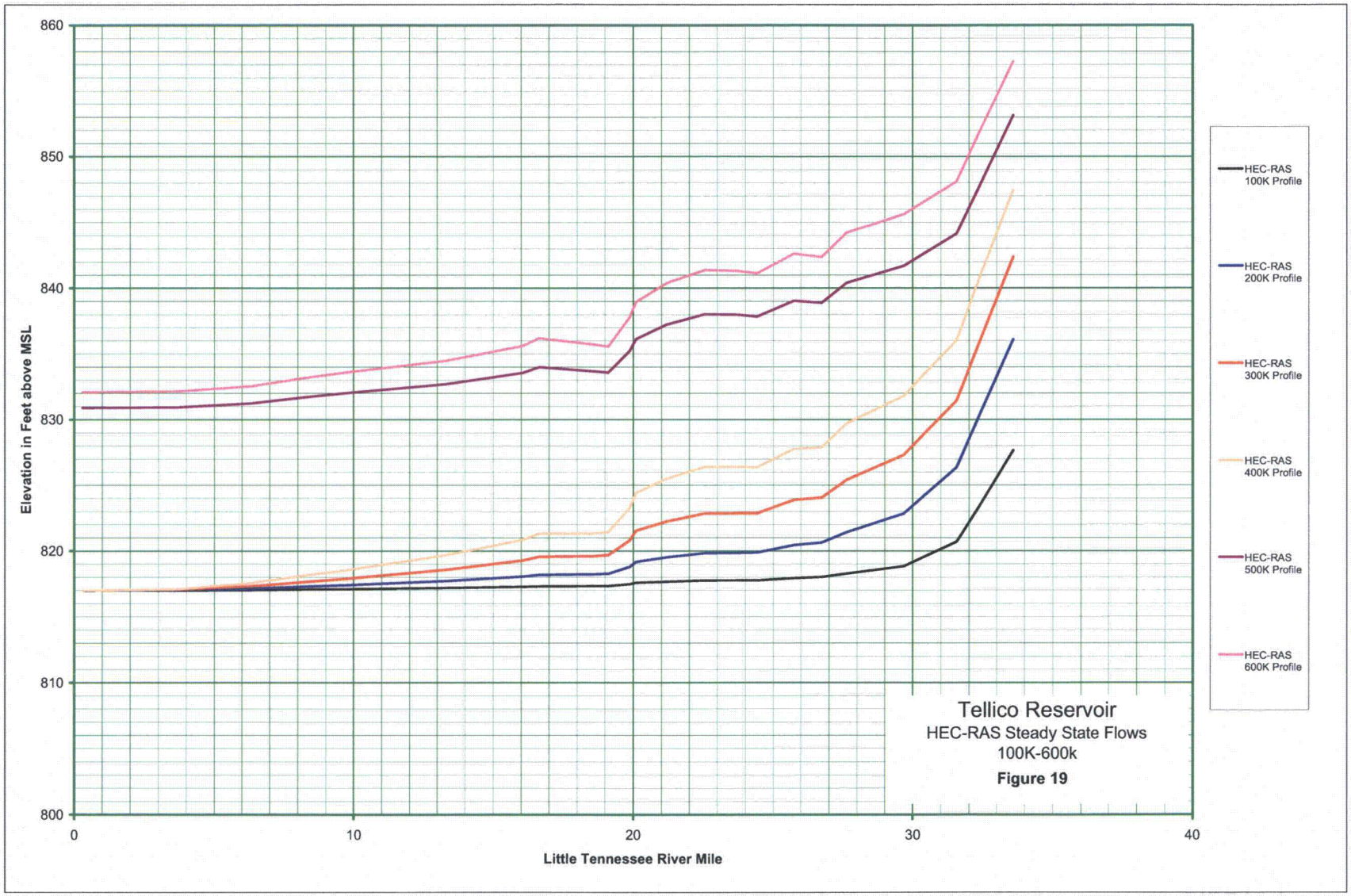

Tellico Reservoir
HEC-RAS Steady State Flows
100K-600k
Figure 19
Elevation in Feet above MSL
Little Tennessee River Mile
860
850
840
830
820
810
800
0
10
20
30
40
HEC-RAS 100K Profile
HEC-RAS 200K Profile
HEC-RAS 300K Profile
HEC-RAS 400K Profile
HEC-RAS 500K Profile
HEC-RAS 600K Profile

Table 30. Tellico Reservoir, HEC-RAS Steady-State Flows 100K-600K

Tellico Reservoir Mile	HEC-RAS 100K Profile	HEC-RAS 200K Profile	HEC-RAS 300K Profile	HEC-RAS 400K Profile	HEC-RAS 500K Profile	HEC-RAS 600K Profile
	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)
33.60	827.67	836.10	842.40	847.48	853.16	857.27
32.34	823.34	830.22	835.79	840.67	847.65	851.79
31.55	820.70	826.36	831.45	836.05	844.16	848.11
29.68	818.83	822.83	827.31	831.81	841.70	845.61
27.62	818.27	821.42	825.42	829.71	840.41	844.21
26.73	818.02	820.62	824.06	827.88	838.89	842.37
25.74	817.94	820.44	823.88	827.77	839.05	842.63
24.41	817.77	819.88	822.87	826.37	837.85	841.13
23.73	817.76	819.85	822.86	826.40	837.98	841.32
22.54	817.75	819.83	822.84	826.39	838.02	841.38
21.17	817.66	819.51	822.23	825.49	837.22	840.37
20.10	817.57	819.17	821.54	824.42	836.14	838.95
19.87	817.47	818.79	820.79	823.26	835.21	837.77
19.11	817.33	818.26	819.68	821.42	833.58	835.55
18.59	817.32	818.22	819.60	821.32	833.67	835.71
16.64	817.30	818.18	819.55	821.31	833.99	836.19
16.05	817.27	818.05	819.27	820.85	833.55	835.61
13.31	817.18	817.71	818.56	819.68	832.69	834.48
9.66	817.10	817.39	817.87	818.52	832.00	833.58
8.43	817.08	817.31	817.68	818.20	831.75	833.24
6.33	817.04	817.14	817.32	817.57	831.24	832.55
3.68	817.01	817.03	817.06	817.11	830.94	832.15
0.30	817.00	817.00	817.00	817.00	830.90	832.10

TVA

Calculation No. CDQ000020080036	Rev: 0	Plant: GEN	Page: 78
Subject: SOCH Model Calibration, Fort Loudoun-Tellico		Prepped	JAW
		Checked	JCT

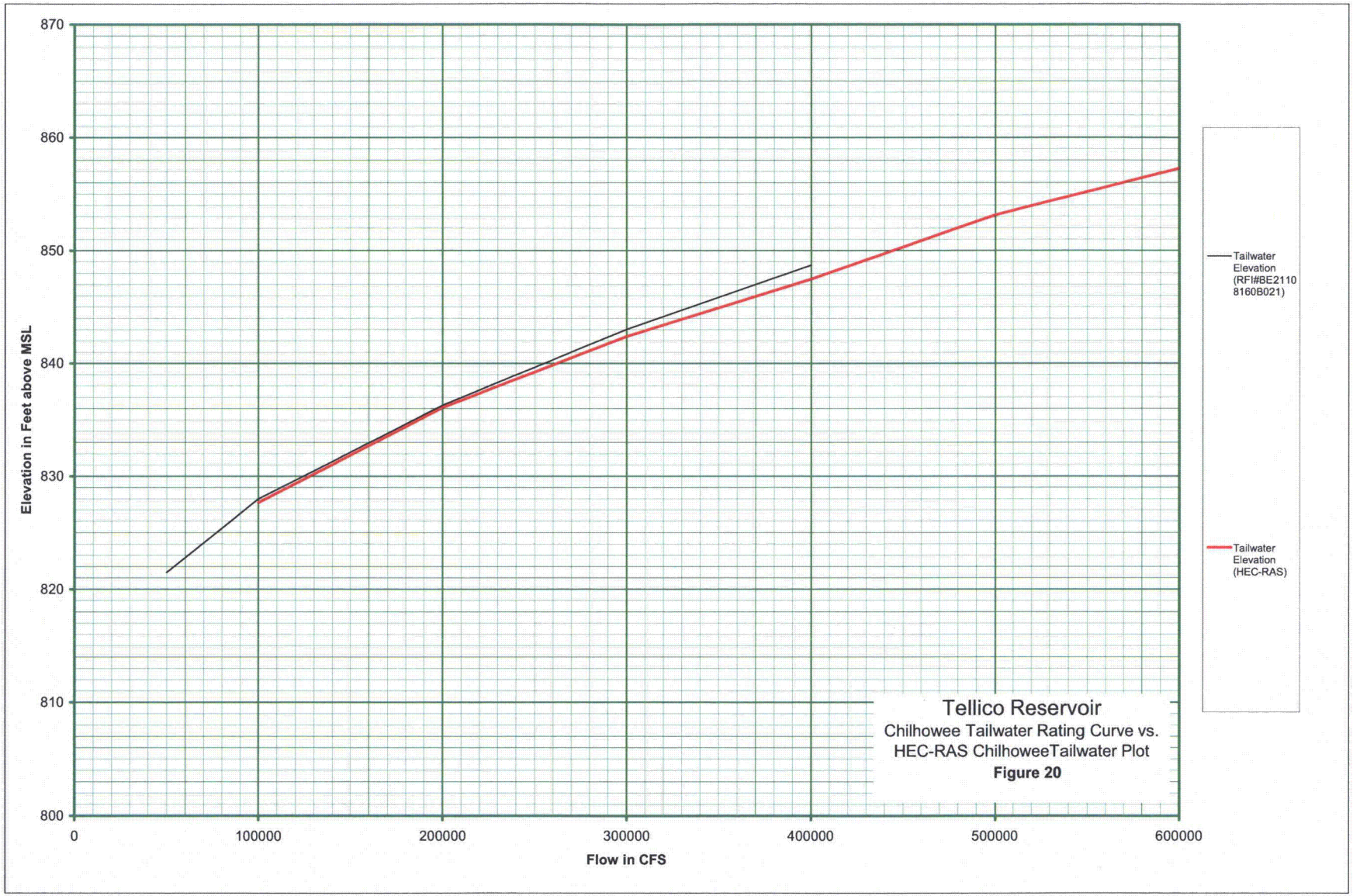
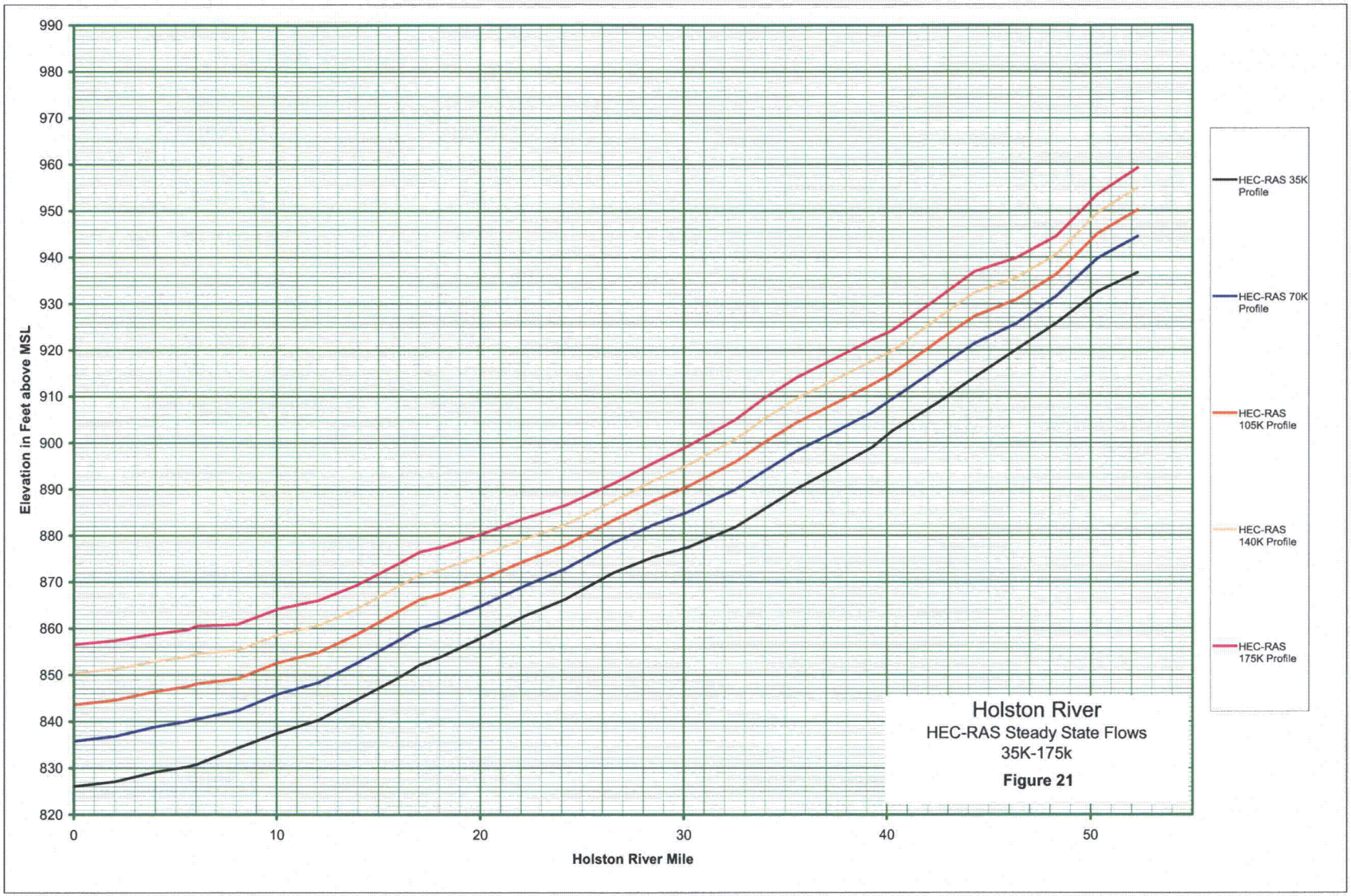
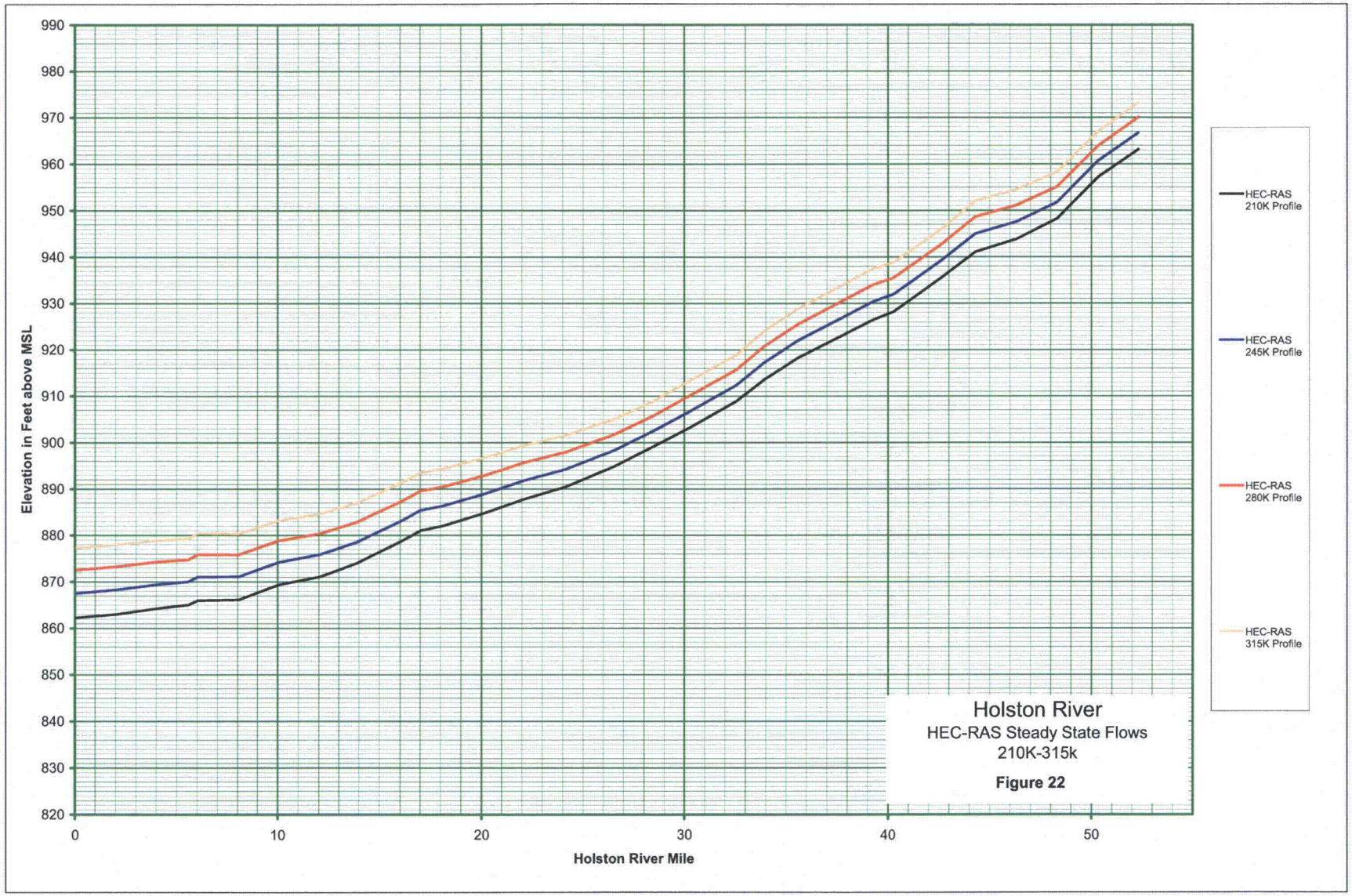


Table 31. Tellico Reservoir, HEC-RAS Chilhowee Tailwater vs. Chilhowee Tailwater Rating Curve (Attachment 2)

Discharge (Dam Rating Curve)	Tailwater Profile (Dam Rating Curve)	Discharge- (HEC-RAS)	Tailwater Profile (HEC-RAS)
1000 cfs	Elevation (ft)	1000 cfs	Elevation (ft)
50	821.50		
100	828.00	100	827.67
200	836.30	200	836.10
300	843.00	300	842.40
400	848.70	400	847.48
		500	853.16
		600	857.27


Elevation in Feet above MSL
990
980
970
960
950
940
930
920
910
900
890
880
870
860
850
840
830
820
0
10
20
30
40
50
Holston River Mile
HEC-RAS 35K Profile
HEC-RAS 70K Profile
HEC-RAS 105K Profile
HEC-RAS 140K Profile
HEC-RAS 175K Profile
Holston River
HEC-RAS Steady State Flows
35K-175k
Figure 21



TVA

Calculation No. CDQ000020080036	Rev: 0	Plant: GEN	Page: 81
Subject: SOCH Model Calibration, Fort Loudoun-Tellico		Prepped	JAW
		Checked	JCT

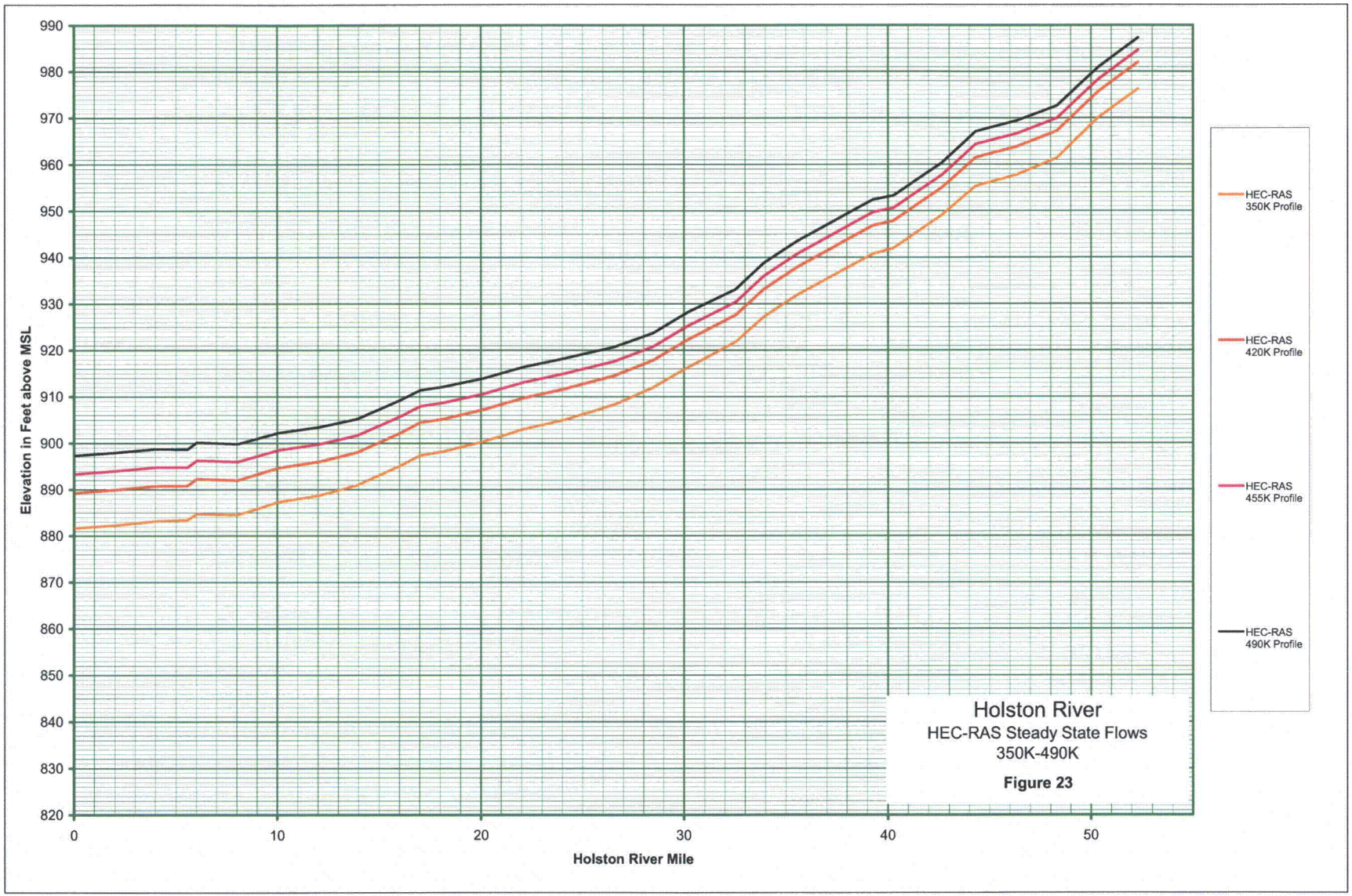

Elevation in Feet above MSL
990
980
970
960
950
940
930
920
910
900
890
880
870
860
850
840
830
820
0
10
20
30
40
50
Holston River Mile
HEC-RAS 350K Profile
HEC-RAS 420K Profile
HEC-RAS 455K Profile
HEC-RAS 490K Profile
Holston River
HEC-RAS Steady State Flows
350K-490K
Figure 23

Table 32. Holston River, HEC-RAS Steady-State Flows 35K-245K

Holston River Mile	HEC-RAS 35K Profile	HEC-RAS 70K Profile	HEC-RAS 105K Profile	HEC-RAS 140K Profile	HEC-RAS 175K Profile	HEC-RAS 210K Profile	HEC-RAS 245K Profile
	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)
52.30	936.75	944.48	950.21	955.01	959.26	963.13	966.71
50.34	932.59	939.80	945.12	949.60	953.61	957.29	960.73
48.31	925.81	931.63	936.35	940.61	944.56	948.27	951.78
46.33	920.06	925.69	930.86	935.56	939.87	943.87	947.62
44.30	914.12	921.43	927.33	932.42	936.97	941.12	944.99
42.64	909.04	916.58	922.39	927.31	931.65	935.60	939.27
40.27	902.56	909.40	914.97	919.84	924.21	928.21	931.96
39.27	899.02	906.53	912.53	917.70	922.30	926.48	930.39
35.58	890.14	898.26	904.41	909.60	914.13	918.22	921.99
33.92	885.59	893.80	899.96	905.08	909.53	913.56	917.28
32.54	881.83	889.93	895.88	900.77	905.03	908.84	912.36
30.22	877.51	885.08	890.62	895.23	899.32	903.10	906.65
28.48	875.32	882.27	887.40	891.73	895.59	899.17	902.57
26.54	871.99	878.44	883.27	887.44	891.23	894.85	898.34
24.15	866.24	872.78	877.80	882.29	886.46	890.44	894.26
22.14	862.59	869.07	874.39	879.18	883.63	887.84	891.86
20.14	858.16	865.04	870.74	875.77	880.41	884.79	888.93
18.12	853.98	861.48	867.47	872.70	877.52	882.05	886.35
17.02	852.13	860.00	866.19	871.54	876.45	881.06	885.42
16.10	849.68	857.73	863.97	869.33	874.25	878.87	883.23
13.91	844.63	852.44	858.68	864.19	869.28	874.08	878.59
12.06	840.31	848.37	854.86	860.68	866.06	871.12	875.86
10.06	837.51	845.86	852.64	858.66	864.20	869.39	874.23
8.04	834.30	842.29	849.18	855.29	860.92	866.15	871.09
6.03	830.81	840.50	848.14	854.66	860.56	865.99	871.05
5.56	830.31	839.99	847.52	853.92	859.70	865.04	870.01
4.02	829.22	838.89	846.48	852.97	858.85	864.28	869.40
2.02	827.14	836.84	844.63	851.33	857.44	863.02	868.28
0.00	826.14	835.85	843.70	850.46	856.63	862.26	867.55

Table 33. Holston River, HEC-RAS Steady-State Flows 280K-490K

Holston River Mile	HEC-RAS 280K Profile	HEC-RAS 315K Profile	HEC-RAS 350K Profile	HEC-RAS 420K Profile	HEC-RAS 455K Profile	HEC-RAS 490K Profile
	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)
52.30	970.07	973.25	976.29	982.01	984.70	987.30
50.34	963.98	967.08	970.06	975.68	978.33	980.90
48.31	955.13	958.33	961.42	967.26	970.03	972.70
46.33	951.17	954.53	957.76	963.84	966.69	969.43
44.30	948.63	952.06	955.35	961.49	964.37	967.13
42.64	942.73	945.99	949.12	954.98	957.72	960.34
40.27	935.49	938.81	941.97	947.87	950.65	953.30
39.27	934.05	937.49	940.76	946.85	949.71	952.44
35.58	925.52	928.84	932.01	937.98	940.84	943.62
33.92	920.77	924.06	927.21	933.17	936.03	938.83
32.54	915.67	918.82	921.85	927.61	930.41	933.17
30.22	910.03	913.26	916.39	922.40	925.36	928.28
28.48	905.82	908.95	912.00	917.88	920.82	923.72
26.54	901.75	905.05	908.28	914.52	917.63	920.71
24.15	897.98	901.57	905.07	911.72	915.03	918.27
22.14	895.73	899.46	903.05	909.78	913.13	916.41
20.14	892.91	896.73	900.39	907.23	910.63	913.96
18.12	890.46	894.40	898.18	905.18	908.68	912.09
17.02	889.59	893.56	897.38	904.43	907.96	911.40
16.10	887.42	891.43	895.28	902.31	905.89	909.41
13.91	882.90	887.02	890.93	897.99	901.63	905.20
12.06	880.38	884.67	888.73	896.01	899.78	903.47
10.06	878.84	883.21	887.32	894.67	898.50	902.24
8.04	875.83	880.32	884.53	892.00	895.97	899.85
6.03	875.89	880.45	884.73	892.28	896.28	900.18
5.56	874.77	879.25	883.46	890.85	894.80	898.65
4.02	874.31	878.91	883.22	890.78	894.81	898.74
2.02	873.28	877.97	882.33	889.95	894.02	897.97
0.00	872.59	877.30	881.68	889.31	893.39	897.35

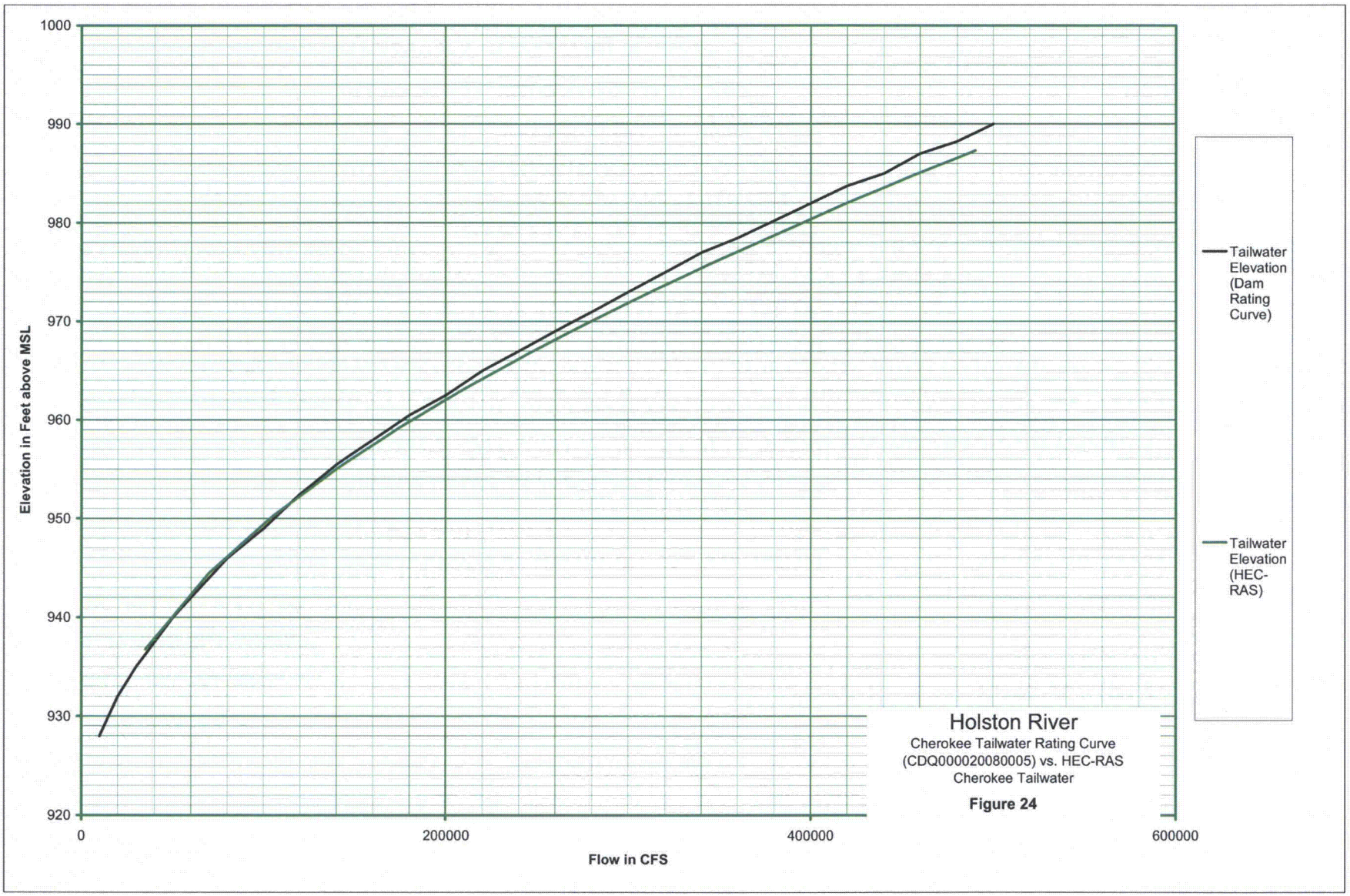
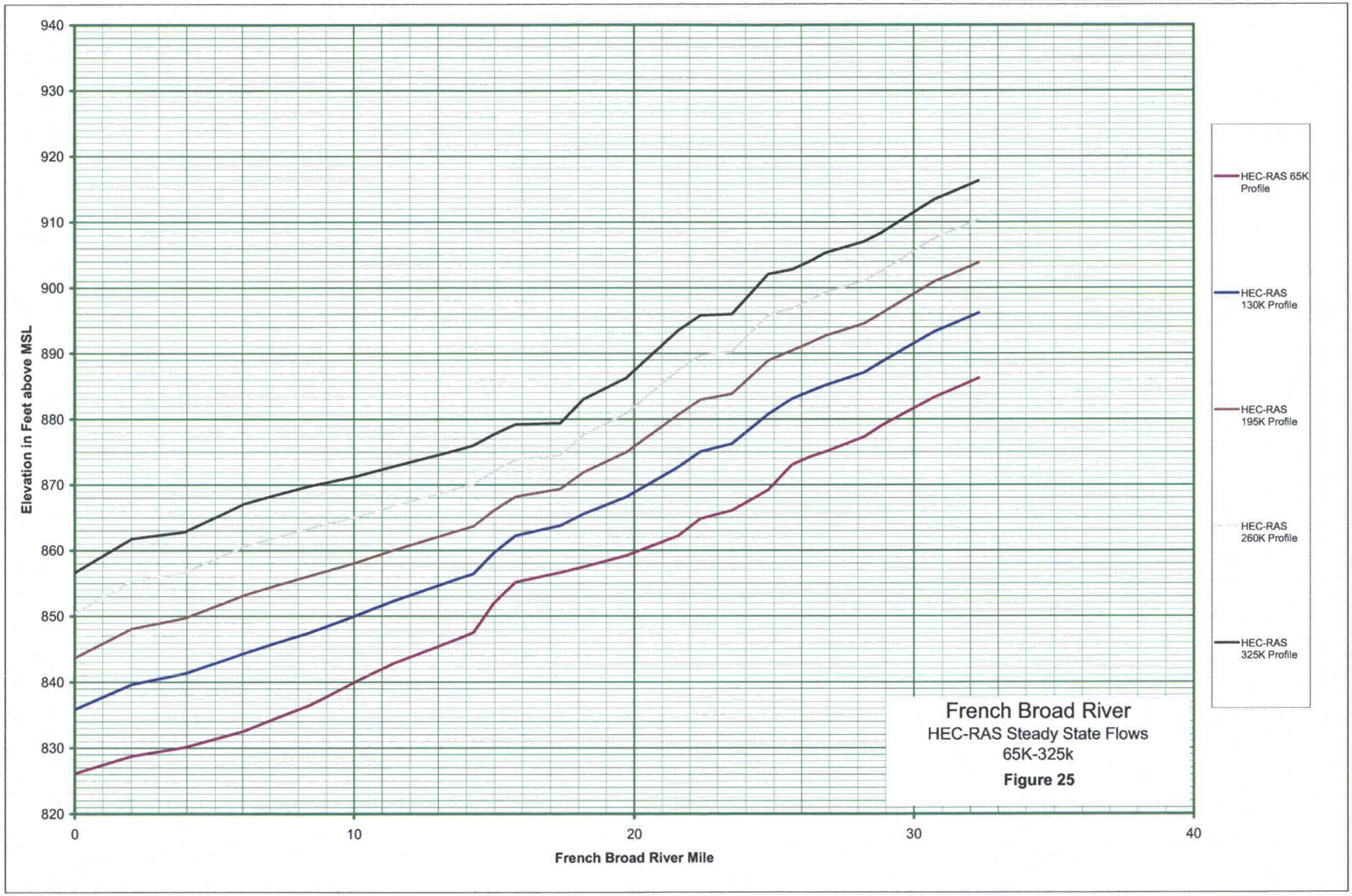
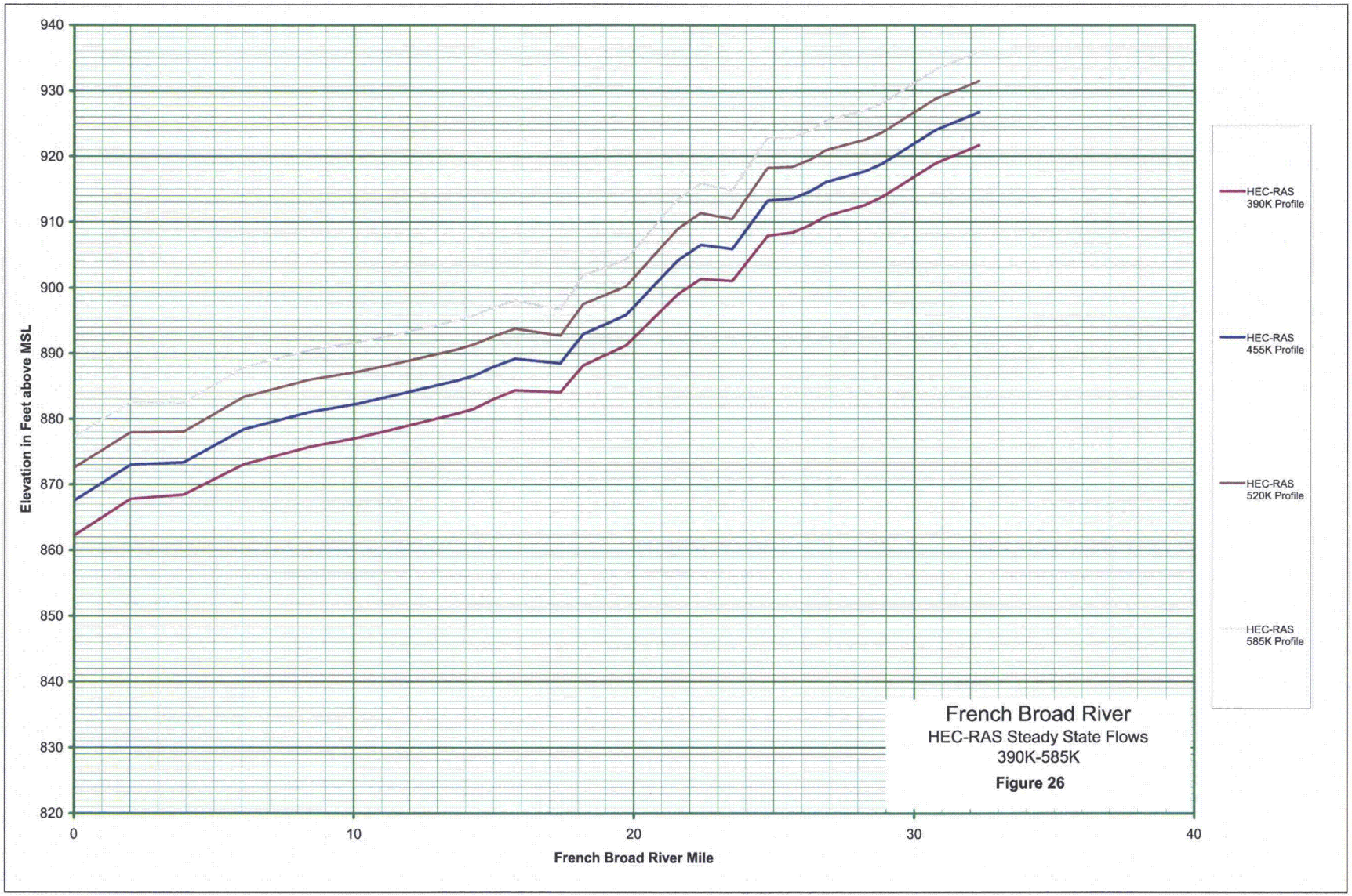

1000
990
980
970
960
950
940
930
920
Elevation in Feet above MSL
0
200000
400000
600000
Flow in CFS
Tailwater Elevation (Dam Rating Curve)
Tailwater Elevation (HEC-RAS)
Holston River
Cherokee Tailwater Rating Curve
(CDQ000020080005) vs. HEC-RAS
Cherokee Tailwater

Figure 24

Table 34. Holston River, HEC-RAS Cherokee Dam Tailwater vs. Cherokee Dam Tailwater Rating Curve (Attachment 2- CDQ000020080005)

Discharge (Dam Rating Curve)	Tailwater Profile (Dam Rating Curve)	Discharge- (HEC-RAS)	Tailwater Profile (HEC-RAS)
1000 cfs	Elevation (ft)	1000 cfs	Elevation (ft)
10	928.00		
20	932.00		
30	935.00		
		35	936.75
40	937.50		
50	940.00		
60	942.00		
		70	944.48
80	946.00		
100	949.00		
		105	950.21
120	952.50		
140	955.50	140	955.01
160	958.00		
		175	959.26
180	960.50		
200	962.50		
		210	963.13
220	965.00		
240	967.00		
		245	966.71
260	969.00		
280	971.00	280	970.07
300	973.00		
		315	973.25
320	975.00		
340	977.00		
		350	976.29
360	978.50		
380	980.25		
400	982.00		
420	983.75	420	982.01
440	985.00		
		455	984.70
460	987.00		
480	988.25		
		490	987.30
500	990.00		


Elevation in Feet above MSL
940
930
920
910
900
890
880
870
860
850
840
830
820
0
10
20
30
40
French Broad River Mile
HEC-RAS 65K Profile
HEC-RAS 130K Profile
HEC-RAS 195K Profile
HEC-RAS 260K Profile
HEC-RAS 325K Profile
French Broad River
HEC-RAS Steady State Flows
65K-325k
Figure 25


Elevation in Feet above MSL
940
930
920
910
900
890
880
870
860
850
840
830
820
0
10
20
30
40
French Broad River Mile
HEC-RAS 390K Profile
HEC-RAS 455K Profile
HEC-RAS 520K Profile
HEC-RAS 585K Profile
French Broad River
HEC-RAS Steady State Flows
390K-585K
Figure 26

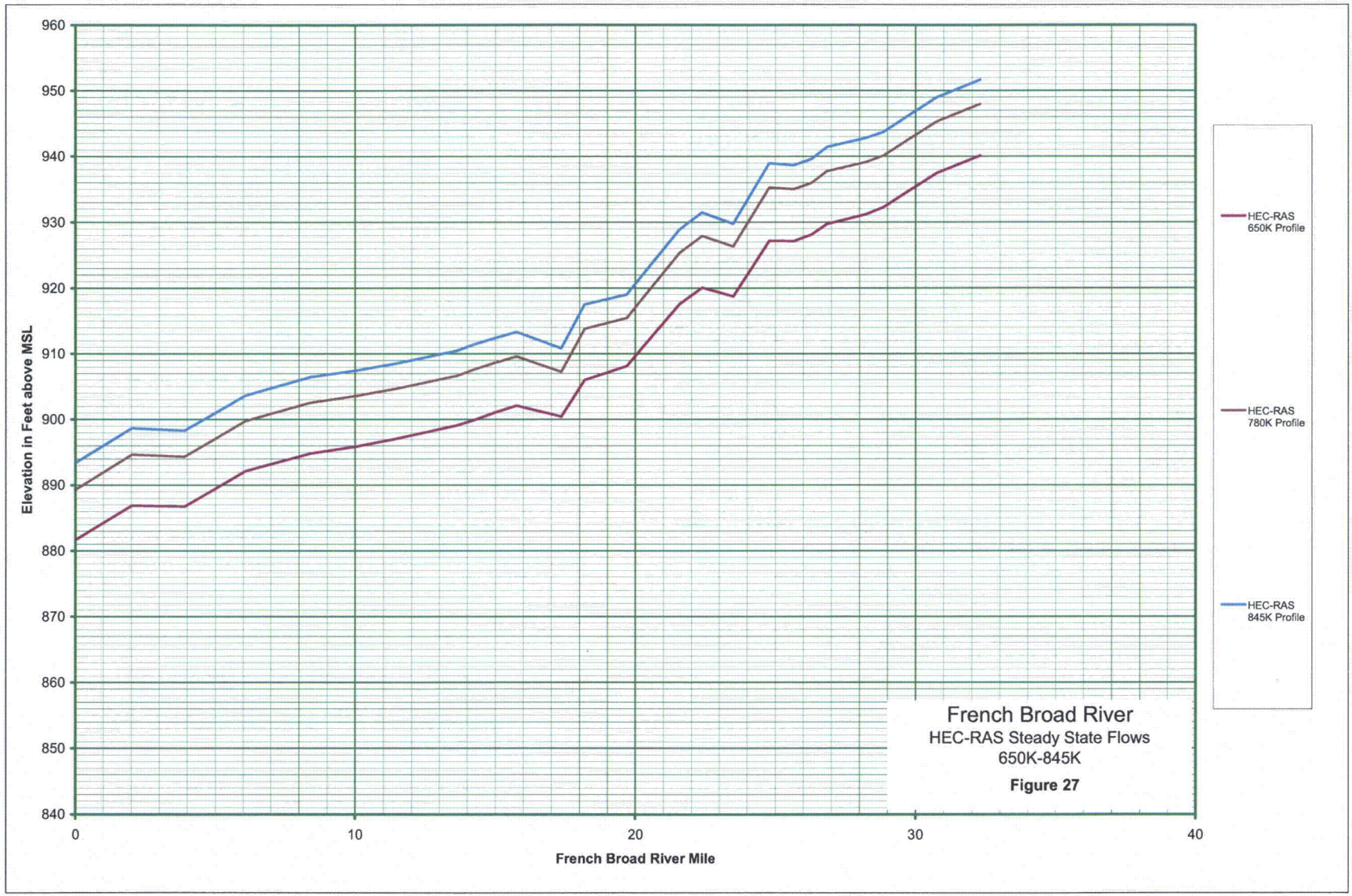

Elevation in Feet above MSL
960
950
940
930
920
910
900
890
880
870
860
850
840
0
10
20
30
40
French Broad River Mile
HEC-RAS 650K Profile
HEC-RAS 780K Profile
HEC-RAS 845K Profile
French Broad River
HEC-RAS Steady State Flows
650K-845K
Figure 27

Table 35. French Broad River, HEC-RAS Steady-State Flows 65K-455K

French Broad River Mile	HEC-RAS 65K Profile	HEC-RAS 130K Profile	HEC-RAS 195K Profile	HEC-RAS 260K Profile	HEC-RAS 325K Profile	HEC-RAS 390K Profile	HEC-RAS 455K Profile
	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)
32.30	886.24	896.15	903.80	910.35	916.24	921.69	926.72
30.75	883.36	893.36	900.98	907.53	913.44	918.93	924.00
28.85	879.04	888.73	896.10	902.51	908.34	913.82	918.87
28.23	877.30	887.12	894.55	901.05	906.99	912.56	917.69
26.84	875.02	885.13	892.66	899.25	905.25	910.90	916.09
26.30	874.24	884.22	891.59	898.06	903.98	909.57	914.69
25.65	873.05	883.09	890.43	896.85	902.75	908.39	913.56
24.78	869.18	880.73	888.87	895.78	902.02	907.91	913.26
23.50	866.05	876.22	883.81	890.24	895.95	901.05	905.88
22.38	864.82	875.03	882.92	889.69	895.77	901.35	906.52
21.56	862.18	872.66	880.63	887.40	893.46	899.01	904.14
19.70	859.19	868.11	874.92	880.82	886.21	891.22	895.83
18.18	857.50	865.54	871.90	877.68	883.06	888.17	892.95
17.35	856.61	863.77	869.35	874.49	879.38	884.09	888.50
15.76	855.17	862.24	868.18	873.83	879.21	884.37	889.18
14.97	851.99	859.61	866.07	872.06	877.68	883.01	887.93
14.26	847.54	856.45	863.68	870.11	875.99	881.51	886.56
13.63	846.44	855.55	862.87	869.33	875.23	880.76	885.79
11.42	842.87	852.33	860.05	866.76	872.80	878.45	883.57
10.07	840.10	850.08	858.13	865.07	871.27	877.06	882.26
8.40	836.47	847.50	856.12	863.37	869.78	875.72	881.02
6.06	832.56	844.34	853.20	860.55	867.08	873.11	878.42
3.90	830.09	841.27	849.69	856.64	862.78	868.46	873.39
2.02	828.77	839.62	848.11	855.31	861.77	867.82	873.05
0.00	826.14	835.85	843.70	850.46	856.63	862.26	867.55

Table 36. French Broad River, HEC-RAS Steady-State Flows 520K-845K

French Broad River Mile	HEC-RAS 520K Profile	HEC-RAS 585K Profile	HEC-RAS 650K Profile	HEC-RAS 780K Profile	HEC-RAS 845K Profile
	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)
32.30	931.46	935.91	940.13	948.01	951.67
30.75	928.77	933.24	937.47	945.32	948.97
28.85	923.62	928.07	932.28	940.11	943.70
28.23	922.49	926.97	931.22	939.13	942.79
26.84	920.94	925.47	929.75	937.74	941.42
26.30	919.48	923.93	928.15	935.98	939.59
25.65	918.39	922.89	927.13	935.03	938.66
24.78	918.23	922.85	927.19	935.26	938.96
23.50	910.42	914.70	918.75	926.31	929.76
22.38	911.35	915.84	920.07	927.91	931.48
21.56	908.93	913.38	917.57	925.36	928.89
19.70	900.19	904.28	908.15	915.46	919.02
18.18	897.54	901.88	906.02	913.80	917.48
17.35	892.70	896.66	900.44	907.26	910.83
15.76	893.75	898.04	902.11	909.60	913.31
14.97	892.58	896.94	901.06	908.63	912.37
14.26	891.31	895.75	899.93	907.63	911.44
13.63	890.53	894.94	899.10	906.67	910.44
11.42	888.37	892.84	897.04	904.68	908.50
10.07	887.14	891.66	895.91	903.61	907.46
8.40	885.97	890.54	894.82	902.55	906.44
6.06	883.36	887.90	892.13	899.74	903.59
3.90	878.06	882.50	886.75	894.35	898.30
2.02	877.97	882.58	886.92	894.66	898.67
0.00	872.59	877.30	881.68	889.31	893.39

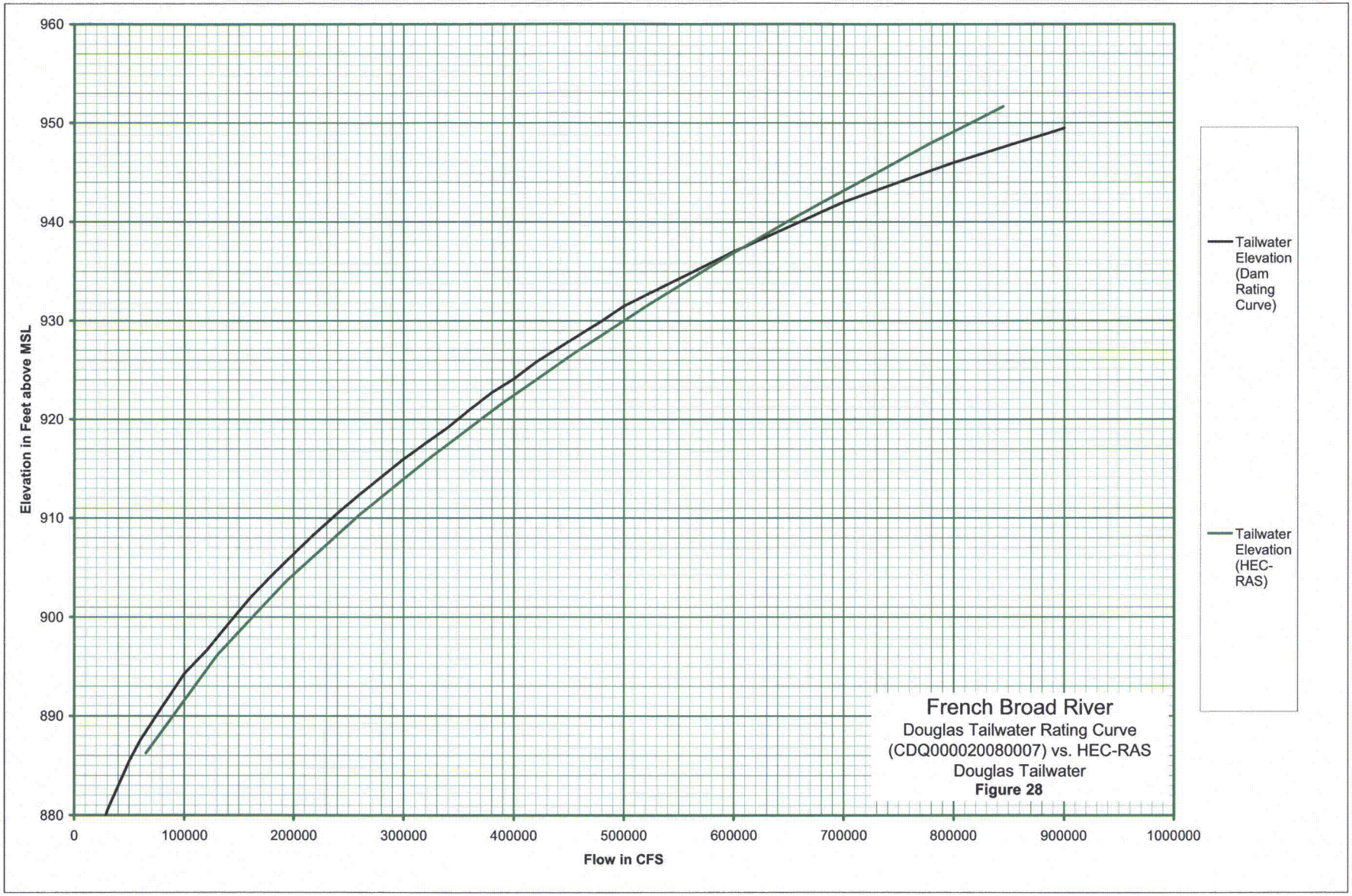

Elevation in Feet above MSL
960
950
940
930
920
910
900
890
880
0
100000
200000
300000
400000
500000
600000
700000
800000
900000
1000000
Flow in CFS
Tailwater Elevation (Dam Rating Curve)
Tailwater Elevation (HEC-RAS)
French Broad River
Douglas Tailwater Rating Curve
(CDQ000020080007) vs. HEC-RAS
Douglas Tailwater
Figure 28

Table 37. French Broad River, HEC-RAS Douglas Dam Tailwater vs. Douglas Dam Tailwater Rating Curve (Attachment 2-CDQ000020080007)

Discharge (Dam Rating Curve)	Tailwater Profile (Dam Rating Curve)	Discharge- (HEC-RAS)	Tailwater Profile (HEC-RAS)
1000 cfs	Elevation (ft)	1000 cfs	Elevation (ft)
16.4	875.50		
30	880.50		
40	883.00		
50	885.50		
60	887.60		
		65	886.24
80	891.00		
100	894.30		
120	896.60		
		130	896.15
140	899.30		
160	901.90		
180	904.20		
		195	903.80
200	906.40		
220	908.50		
240	910.50		
260	912.40	260	910.35
280	914.20		
300	916.00		
320	917.60		
		325	916.24
340	919.20		
360	921.00		
380	922.70		
		390	921.69
400	924.10		
420	925.80		
440	927.20		
		455	926.72
460	928.60		
480	930.00		
500	931.50		
		520	931.46
		585	935.91
600	937.00		
		650	940.13
700	942.00		
		780	948.01
800	946.00		
		845	951.67
900	949.50		