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

ASSOCIATED ATTACHMENTS/ENCLOSURES:

Attachment 02.04.03-8D: Dam Rating Curve, Boone

(70 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 090128 004 | Calculations (nuclear) | L58 091230 016 |

Calc Title: Dam Rating Curve, Boone

| CALC ID | TYPE | ORG | PLANT | BRANCH | NUMBER | CUR REV | NEW REV | REVISION APPLICABILITY |
|---|---|---|---|---|---|---|---|---|
| CURRENT | CN | NUC | GEN | CEB | CDQ000020080003 | 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 |
|---|---|---|
| *See Below | N/A | E |

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

| PREPARER ID | PREPARER PHONE NO | PREPARING ORG (BRANCH) | VERIFICATION METHOD | NEW METHOD OF ANALYSIS |
|---|---|---|---|---|
| C J Grace | 205.298.6074 | CEB | Design Review | ☐ Yes ☒ No |

| PREPARER SIGNATURE | DATE | CHECKER SIGNATURE | DATE |
|---|---|---|---|
| Chris Grace [signature] | 12/21/2009 | Andrew Murr [signature] | 12/21/2009 |
| **VERIFIER SIGNATURE** | **DATE** | **APPROVAL SIGNATURE** | **DATE** |
| Andrew Murr [signature] | 12/21/2009 | [signature] K.R. Spates | 12/23/09 |

STATEMENT OF PROBLEM/ABSTRACT

NA 12/21/09

Headwater rating curves for 20 dams are required as inputs to TVA's SOCH and TRBROUTE models which perform flood-routing calculations for the Tennessee River and tributaries. The headwater rating curves for each dam provide total dam discharge as a function of headwater elevation. This calculation determines the headwater rating curve for Boone Dam.

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

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

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

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## NPG CALCULATION COVERSHEET/CCRIS UPDATE



| REV 0 EDMS/RIMS NO. | EDMS TYPE: | EDMS ACCESSION NO (N/A for REV. 0) |
|---|---|---|
| L58 090128 004 | Calculations (nuclear) | N/A |

Calc Title: Dam Rating Curve, Boone

| CALC ID | TYPE | ORG | PLANT | BRANCH | NUMBER | CUR REV | NEW REV | REVISION APPLICABILITY |
|---|---|---|---|---|---|---|---|---|
| CURRENT | | | | | | | | Entire calc ☒ Selected pages ☐ |
| NEW | CN | NUC | GEN | CEB | CDQ000020080003 | N/A | 0 | |

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

| UNITS | SYSTEMS | UNIDS |
|---|---|---|
| N/A | N/A | N/A |

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

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

| PREPARER ID | PREPARER PHONE NO | PREPARING ORG (BRANCH) | VERIFICATION METHOD | NEW METHOD OF ANALYSIS |
|---|---|---|---|---|
| jvpeyton | 865-632-3280 | CEB | Design Review | ☐ Yes ☒ No |

| PREPARER SIGNATURE | DATE | CHECKER SIGNATURE | DATE |
|---|---|---|---|
| J.V. Peyton *J V Peyton*<br>G.A. Schohl *G. A. Schohl*<br>C. T. Settler *[signature]* | 01/07/09 | JANIE B. MAUTER<br>*[signature]* | 1/13/09 |

| VERIFIER SIGNATURE | DATE | APPROVAL SIGNATURE | DATE |
|---|---|---|---|
| Russell B. Williston *R.B. Williston*<br>Andrew S. Muir *[signature]* | 1-15-09<br>1-16-09 | *[signature]* *K. R. Spates* 1-21-09 | 1-23-09 |

**STATEMENT OF PROBLEM/ABSTRACT**

Headwater rating curves for 20 dams are required as inputs to TVA's SOCH and TRBROUTE models which perform flood-routing calculations for the Tennessee River and tributaries. The headwater rating curves for each dam provide total dam discharge as a function of headwater elevation. This calculation determines the headwater rating curve for Boone Dam.

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

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

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



| CALC ID | TYPE | ORG | PLANT | BRANCH | NUMBER | REV |
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| | CN | NUC | GEN | CEB | CDQ000020080003 | 1 |

**ALTERNATE CALCULATION IDENTIFICATION**

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

CATEGORIES N/A

**KEY NOUNS (A-add, D-delete)**

| ACTION (A/D) | KEY NOUN | A/D | KEY NOUN |
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**CROSS-REFERENCES (A-add, C-change, D-delete)**

| ACTION (A/C/D) | XREF CODE | XREF TYPE | XREF PLANT | XREF BRANCH | XREF NUMBER | XREF REV |
|---|---|---|---|---|---|---|
| A | P | EN | WBN | CEB | 54018 | |
| A | P | EN | SQN | CEB | 22404 | |
| A | S | CN | GEN | CEB | CDQ000020080053 | |
| D | S | CN | GEN | CEB | CDQ000020080054 | |
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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 | CDQ000020080003 |
| Title | Dam Rating Curve, Boone |
| Revision No. | DESCRIPTION OF REVISION |
| 0 | Initial issue Total pages: 48<br>Attachment 1: 1 page<br>Attachment 2: 9 pages |
| 1 | The revision added Reference 2.25, Page 8, and removes Unverified Assumptions from Section 3.2, Page 9.<br><br>This calculation was also revised to address the following :<br>• 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.<br>• PER 203872- replace NEDP-2 forms on Pages 1 through 6 (excluding Page 1a) with the forms from the NEDP-2 Revision in effect at the time of calculation's issuance.<br>• Removed UVA 3.2.1. Replaced with:<br>o Assumption 3.1.3 on based on Reference 2.25 and,<br>o Assumption 3.1.5 on based on Appendix A.<br>• Removed UVA 3.2.2 – Replaced Assumption 3.1.4 on Page 9 with Technical Justification<br><br>Significant changes in Revision 1 are noted with a right margin revision bar. Administrative changes and typos are excluded.<br><br>Pages deleted: 0<br>Pages revised: 1, 2, 3, 4, 8 and 9<br>New pages added: 1a (Rev 1 NEDP 2-1), 5.1 (NEDP 2-4), A1, A2, A3<br>Total pages for Revision 1: 53<br>Attachment 1: 1 page<br>Attachment 2: 9 pages<br>Appendix A: 3 pages |
| | |

**NPG CALCULATION TABLE OF CONTENTS**

| Calculation Identifier: CDQ000020080003 | Revision: 1 | |
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TABLE OF CONTENTS

**NPG CALCULATION TABLE OF CONTENTS (CONTINUED)**

| Calculation Identifier: CDQ000020080003 | Revision: 1 | |
|---|---|---|

TABLE OF CONTENTS(Continued)

| SECTION | TITLE | PAGE |
|---|---|---|
| Attachments | | |
| 1 | Boone Tailwater Rating Curve | 1 Page |
| 2 | Boone Dam Spillway and Sluice Discharge Tables | 9 Pages |
| 3 | Excel file: BooneTWRatingCurve.xls (Electronic attachment) | N/A |
| 4 | Excel file: Boone Dam Rating Curve.xls (Electronic attachment) | N/A |
| 5 | TVA Boone Project drawing 10N200 R8 (Electronic attachment) | 1 Page |
| 6 | TVA Boone Project drawing 10W201 R8 (Electronic attachment) | 1 Page |
| 7 | TVA Boone Project drawing 10W203 R8 (Electronic attachment) | 1 Page |
| 8 | TVA Boone Project drawing 10N204 R4 (Electronic attachment) | 1 Page |
| 9 | TVA Boone Project drawing 21N207 R2 (Electronic attachment) | 1 Page |
| 10 | TVA Boone Project drawing 21E210 R1 (Electronic attachment) | 1 Page |
| 11 | TVA Boone Project drawing 22E210 R3 (Electronic attachment) | 1 Page |
| 12 | TVA Boone Project drawing 46N401 R2 (Electronic attachment) | 1 Page |
| 13 | TVA Boone Project drawing 46N407 R3 (Electronic attachment) | 1 Page |
| 14 | TVA Boone Project drawing 47K901-1 R0 (Electronic attachment) | 1 Page |
| 15 | TVA Boone Project drawing 47K901-2 R0 (Electronic attachment) | 1 Page |
| 16 | TVA Boone Project drawing 47K901-3 R0 (Electronic attachment) | 1 Page |
| 17 | TVA Boone Project drawing 54W200 R3 (Electronic attachment) | 1 Page |
| 18 | TVA Boone Project drawing 54N201 R1 (Electronic attachment) | 1 Page |
| 19 | TVA Boone Project drawing 54N202 R1 (Electronic attachment) | 1 Page |
| 20 | TVA Boone Project drawing 51N204 R4 (Electronic attachment) | 1 Page |

## NPG CALCULATION VERIFICATION FORM

| | | |
|---|---|---|
| Calculation Identifier CDQ000020080003 | | Revision 1 |
| Method of verification used:<br>1. Design Review ☒<br>2. Alternate Calculation ☐<br>3. Qualification Test ☐ | Verifier Andrew Murr | Date 12/21/2009 |

Comments:

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

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

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

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

**NPG COMPUTER INPUT FILE**
**STORAGE INFORMATION SHEET**

| Document CDQ000020080003 | Rev. 0 | Plant: GEN | |
|---|---|---|---|

Subject:
Dam Rating Curve, Boone

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

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

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

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

Attachment 3: Excel file: "BooneTWRatingCurve.xls"
Attachment 4: Excel file: "Boone Dam Rating Curve.xls"
Attachment 5: TVA Boone Project drawing 10N200 R8
Attachment 6: TVA Boone Project drawing 10W201 R8
Attachment 7: TVA Boone Project drawing 10W203 R8
Attachment 8: TVA Boone Project drawing 10N204 R4
Attachment 9: TVA Boone Project drawing 21N207 R2
Attachment 10: TVA Boone Project drawing 21E210 R1
Attachment 11: TVA Boone Project drawing 22E210 R3
Attachment 12: TVA Boone Project drawing 46N401 R2
Attachment 13: TVA Boone Project drawing 46N407 R3
Attachment 14: TVA Boone Project drawing 47K901-1 R0
Attachment 15: TVA Boone Project drawing 47K901-2 R0
Attachment 16: TVA Boone Project drawing 47K901-3 R0
Attachment 17: TVA Boone Project drawing 54W200 R3
Attachment 18: TVA Boone Project drawing 54N201 R1
Attachment 19: TVA Boone Project drawing 54N202 R1
Attachment 20: TVA Boone Project drawing 51N204 R4

☐ Microfiche/eFiche

## 1.0 Purpose

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

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

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

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

Drawings 10N200 and 10W201 (References 2.1 and 2.2) provide plan and elevation views of Boone Dam. For headwaters in the normal operating range, discharge is passed through the sluice, turbines or the spillway. The spillway consists of five spillway bays, each with a radial (tainter) gate to control discharge. If, as during a probable maximum flood (PMF) event, headwater rises above the normal operating range, discharge may pass also over the dam nonoverflow section, the tops of the open spillway gates and the tops of the spillway piers.

## 2.0 References

2.1 TVA Boone Project drawing 10N200 R8, "General Plan, Elevation & Sections."
2.2 TVA Boone Project drawing 10W201 R8, "General Plan, Elevation & Sections."
2.3 TVA Boone Project drawing 54W200 R3, "Radial Gates Arrangement."
2.4 TVA Boone Project drawing 54N201 R1, "Radial Gates Structural Details – Sheet 1."
2.5 TVA Boone Project drawing 54N202 R1, "Radial Gates Structural Details – Sheet 2."
2.6 "Boone Dam Spillway and Sluice Discharge Tables," River Operations, Tennessee Valley Authority, March 2004, TVA EDMS accession no. L58081211803.
2.7 "Hydraulic Design Criteria," USACE (U. S. Army Engineer Waterways Experiment Station), Eighteenth issue, Vicksburg, MS, 1988.
2.8 Handbook of Hydraulics, E. F. Brater and H. W. King, Sixth Ed., McGraw Hill, 1976.
2.9 "Hydraulic Design Criteria," USACE (U. S. Army Engineer Waterways Experiment Station), Eighteenth issue, Hydraulic Design Chart 711 (HDC 711).
2.10 "Boone Project Hydraulic Model Studies," TVA Division of Water Control Planning, Hydraulic Data Branch, Technical Monograph No. 74, 1954, TVA Research Library call no. 999.6278 T2985b.
2.11 "Rating Curves for Flow over Drum Gates," Joseph N. Bradley, Paper No. 2677, Transactions of the American Society of Civil Engineers, vol. 119, pp. 403-433, 1954.
2.12 Open Channel Flow, Sec. 2.7, F. M. Henderson, Macmillan, New York, 1966.
2.13 Bellefonte Nuclear Plant FSAR, Units 1 and 2, Section 2.4.3.3, page 2.4-16.
2.14 TVA Boone Project drawing 10W203 R8, "Principal Features of Design – Sheet 1."
2.15 TVA Boone Project drawing 10N204 R4, "Principal Features of Design – Sheet 2."
2.16 TVA Boone Project drawing 21N207 R2, "Concrete Blocks 17 & 18 Outline."
2.17 TVA Boone Project drawing 21E210 R1, "Concrete Raising Top of Dam – Blocks 1 Thru 5, Outline and Reinforcement."
2.18 TVA Boone Project drawing 22E210 R3, "Raising Top of Dam Plan, Sections & Details And Misc Conc Details."
2.19 TVA Boone Project drawing 46N401 R2, "Powerhouse, Architectural Elevations."
2.20 TVA Boone Project drawing 46N407 R3, "Powerhouse, Architectural Lobby EL 1302 & Stair 14 Plan & Elevations."
2.21 TVA Boone Project drawing 47K901-1 R0, "Powerhouse Unit 1, Operating Characteristics of 26400 KW Generating Unit."
2.22 TVA Boone Project drawing 47K901-2 R0, "Powerhouse Unit 2, Operating Characteristics of 25000 KW Generating Unit."
2.23 TVA Boone Project drawing 47K901-3 R0, "Powerhouse Unit 3, Operating Characteristics of 25000 KW Generating Unit."
2.24 TVA calculation NUCGENCEBCDQ0000200080010, "Dam Rating Curve, Fort Patrick Henry."
2.25 TVA 2009: "Basis for Dam Spillway Gate/Outlet Open Configuration for Flood Analyses", May 29 2009 (EDMS No. L58 090529 800)

## 3.0 Assumptions & Methodology

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

### 3.1 Assumptions

3.1.1 Assumption: There is no discharge from the sluice.
Technical Justification: TVA standard operation policy requires that the spillway gates at Boone Dam be operated as specified in the Boone Dam Spillway and Sluice Discharge Tables (Attachment 2). Pages 1 and 32 of the instructions include the following statement, "The sluice and spillway must not be operated at the same time." Therefore there is no discharge from the sluice included for the rating curve. As indicated by the sluice discharge table, even with the sluice gate at the maximum opening, the difference in total discharge would be relatively small.

3.1.2 Assumption: The tailwater rating curve provided as Attachment 1 reasonably predicts the tailwater elevation for the range of discharge required for the headwater rating curve.
Technical Justification: The tailwater rating curve was generated by the TVA Flood Risk section. This tailwater rating curve is used by TVA during actual flood events as input for river management decisions and is the best available source of tailwater elevation data. The tailwater elevation for the maximum discharge determined in this calculation (312,690 cfs) is El 1318. This elevation is significantly lower than the elevation of the spillway crest and the other locations of discharge over the dam. The tailwater elevation could be considerably higher and still not affect discharge. (See Sections 6.6 and 6.7, pages 32 and 33.)

3.1.3 Assumption: All spillway gates will be set to the maximum openings specified in the spillway discharge tables.
Technical Justification: See "Basis for Dam Spillway Gate/Outlet Open Configuration for Flood Analyses" (Reference 2.25) for technical justification.

3.1.4 Assumption: The maximum headwater elevation considered in the dam rating curve is 1408.5 feet, the top of the east embankment.
Technical Justification: The maximum headwater considered for the dam rating curve is based on very conservative estimations of the maximum PMF elevation at the dam. Previous simulations have indicated that the dam is not overtopped during a PMF event. A headwater elevation of 1408.5 is a reasonable upper limit for this dam rating curve. If the SOCH/TRBROUTE analysis identifies PMF elevations higher than 1408.5 feet, this issue will be identified by the analyst and a revision of this calculation will be required.

3.1.5 Assumption: All spillway gates will remain operable in the closed position and in the maximum opened position as specified in the spillway discharge tables.
Technical Justification: The radial gates will remain operable in the maximum opened position based on the findings of the "Watts Bar Dam – Flood and Earthquake Analysis on Radial Spillway Gates" (Reference A1). Appendix A uses the same assumptions, methodology, and approach as the Watts Bar radial gate analysis to compare forces on the gates in a closed position with forces on the gates in the maximum open position to provide technical justification for the gates to remain operable in the maximum open position during a PMF.

### 3.2 Unverified Assumptions

None.

### 3.3 Methodology -- Discharge Equations

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

$$Q_f = C_f L H_c^{1.5}$$

in which $Q_f$ = free discharge (cfs), $C_f$ = free discharge coefficient ($ft^{0.5}$/sec -- may vary with HW), L = length of overflowing section (ft), $H_c$ = head on crest (ft) = HW - $Z_c$, HW = headwater elevation (ft), and $Z_c$ = top, or crest, elevation of overflowing section (ft). This equation need not be modified to account for tailwater submergence because the tailwater does not rise high enough to affect the free discharges computed for this headwater rating curve. See Section 6.7.

Flow over the nonoverflow section, the tops of the open spillway gates, and the tops of the spillway piers is treated as free discharge. Flow over the spillway crest is treated as free discharge for headwater elevations below $H_c = H_{Lmin}$, the head at which the overflowing nappe first touches the bottoms of the open gates (Ref. 2.24, Attachment A5). $H_{Lmin}$ varies with gate opening, V, defined as the vertical distance between the spillway crest and the bottom of the gate.

For headwater elevations above $H_c = H_{Lmin}$ flow through the spillway gates is treated as orifice discharge. Orifice discharge refers to flow passing through a contracted opening and is computed using an orifice-type equation as follows (Reference 2.7, Hydraulic Design Chart 311-1):

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

in which $Q_g$ = orifice discharge (cfs), $C_g$ = orifice discharge coefficient (dimensionless -- varies with gate opening and $H_c$), $G_n$ = effective gate opening = minimum distance between the gate lip and the crest (ft), g = acceleration of gravity, and $H_{mp}$ = vertical distance between the mid-point of $G_n$ and the crest. This equation is modified, if required, to account for tailwater submergence as follows:

$$Q_{gs} = S_g Q_g$$

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

The Boone spillway is identical to the Fort Patrick Henry spillway so that the spillway free discharge and spillway orifice discharge coefficients are the same for both dams. See Section 6.3.

### 3.4 Methodology -- Spillway Discharge Calculations

The discharge coefficient, $C_f$, for free discharge over a spillway crest varies with head, $H_c$ (References 2.7 and 2.8 both provide this kind of data). For the Boone spillway crest, the relationships $H_{Lmin}(V)$ and $C_f(H_c)$are available from Fort Patrick Henry model test data (Ref. 2.24, Appendix A). The relationship between orifice discharge coefficient, $C_g$, and head, $H_c$, for each gate opening, V, is also available from the model test data. The crest length, L, and crest elevation, $Z_c$, are shown on TVA drawings (e.g., References 2.1 and 2.2). The parameters $G_n$ and $H_{mp}$ are determined from geometry (Ref. 2.24, Appendix A).

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

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

### 3.5 Methodology -- Discharge Coefficients

Values of the discharge coefficient, $C_f$, for flows over the nonoverflow section, the tops of the open spillway gates, and the tops of the spillway piers, are estimated using Hydraulic Design Chart 711 (Reference 2.9 and page 26). Length, L, and crest elevation, $Z_c$, in each case are determined from TVA drawings (relevant drawings are defined as references).

The upper plot of HDC 711 (Reference 2.9) shows that $C_f$ is about 2.65 for very broad crests ($H_l/B < 0.4$ where $H_l = H_c$ and B = streamwise length of the crest) and gradually increases to 3.1, the maximum value for a "broad-crested" weir, as $H_l/B$ increases to about 1.2. As $H_l/B$ increases above 1.2, $C_f$ continues to increase as the weir transitions from broad-crested to sharp-crested at about $H_l/B = 2.0$. Since the estimation of discharge over the top of various sections of a dam is an approximation, small variations in $C_f$ with $H_c$ and the effects of end contractions are neglected. A single representative value for $C_f$ within the range of its variation is used for all headwater elevations included in the rating. Neglecting minor variations in $C_f$ values and end contractions has negligible impact on the dam rating curve.

## 4.0 Design Input

| Sec | Input Parameter | Source | Symbol | Value |
|---|---|---|---|---|
| **4.1** | **Acceleration of gravity** | | | |
| | | Common knowledge | g | 32.2 ft/sec$^2$ |
| | | | | |
| **4.2** | **Spillway crest parameters** | | | |
| 4.2.1 | Crest length | TVA Boone Project dwg 10W201 R8, Downstream Elevation, 5 bays @ 35' | L | 175 feet |
| 4.2.2 | Crest elevation | TVA Boone Project dwg 10N200 R8, Spillway Section | $Z_c$ | 1350.0 feet |
| 4.2.3 | Free discharge coefficient | TVA calculation NUCGENCEBCDQ0000200080010, Appendix A Section A.6 and Attachment A10 | $C_f(H_c)$ | Equation A3 |
| | | | | |
| **4.3** | **Spillway gate parameters** | | | |
| 4.3.1 | Vertical opening | TVA calculation NUCGENCEBCDQ0000200080010, Appendix A | V | 31.0 feet |
| 4.3.2 | Effective gate opening | TVA calculation NUCGENCEBCDQ0000200080010, Appendix A, page A5 | $G_n$ | 31.54 feet |
| 4.3.3 | Mid-point elevation of opening relative to crest | TVA calculation NUCGENCEBCDQ0000200080010, Appendix A, page A5 | $H_{mp}$ | 15.375 feet |
| 4.3.4 | Headwater elevation at which nappe touches gates | TVA calculation NUCGENCEBCDQ0000200080010, $H_{Lmin}$ estimated in Appendix A and Attachment A9. Boone elevation is 122' higher than Fort Patrick Henry. | $H_{Lmin} + Z_c$ | 1387.49 feet |
| 4.3.5 | Orifice discharge coefficient | TVA calculation NUCGENCEBCDQ0000200080010, Extrapolated curve given in Attachment A12 and Table A2, and discussed in Appendix A | $C_g(H_c)$ | Interpolate between points in Table A2 |
| | | | | |
| **4.4** | **Spillway gate overflow** | | | |
| 4.4.1 | Overflow discharge coeff. | Section 6.2 | $C_o$ | 3.2 |
| 4.4.2 | Overflow elevation | TVA calculation NUCGENCEBCDQ0000200080010, Computed in Appendix A, page A4 for Fort Patrick Henry. Boone elevation is 122' higher than Fort Patrick Henry. | $Z_o$ | 1399 feet |
| 4.4.3 | Overflow length | Same as spillway crest, drawing 10N200 | $L_o$ | 175 feet |
| | | | | |
| **4.5** | **Powerhouse overflow** | | | |
| 4.5.1 | Discharge coefficient | Section 6.1 | $C_f$ | 2.67 |
| 4.5.2 | Overflow elevation | TVA drawing 10W201, D-D | $Z_c$ | 1392 feet |
| 4.5.3 | Overflow length | TVA drawing 10W201, Plan | L | 174 feet |
| | | | | |

## 4.0 Design Input (Continued)

| Sec | Input Parameter | Source | Symbol | Value |
|---|---|---|---|---|
| | | | | |
| **4.6** | **Spillway piers overflow** | | | |
| 4.6.1 | Discharge coefficient | Section 6.1 | $C_f$ | 2.70 |
| 4.6.2 | Overflow elevation | TVA drawing 10W201, E-E | $Z_c$ | 1394.42 feet |
| 4.6.3 | Overflow length | TVA drawing 10W203, Plan | L | 39.0 feet |
| | | | | |
| **4.7** | **Nonoverflow Dam - Part Block 5 and Blocks 6, 7, 16 & 17 (B=12')** | | | |
| 4.7.1 | Discharge coefficient | Section 6.1 | $C_f$ | 2.91 |
| 4.7.2 | Overflow elevation | TVA drawing 10W201, B-B | $Z_c$ | 1392.0 feet |
| 4.7.3 | Overflow length | Section 6.1 | L | 152.5 feet |
| | | | | |
| **4.8** | **Nonoverflow Dam – Part Block 5 (B=12')** | | | |
| 4.8.1 | Discharge coefficient | Section 6.1 | $C_f$ | 2.91 |
| 4.8.2 | Overflow elevation | TVA drawing 21E210 | $Z_c$ | 1392.38 feet |
| 4.8.3 | Overflow length | Section 6.1 | L | 9.96 feet |
| | | | | |
| **4.9** | **Nonoverflow Dam – Blocks 3, 4 and Part Block 5 (B=12')** | | | |
| 4.9.1 | Discharge coefficient | Section 6.1 | $C_f$ | 2.66 or 2.81 |
| 4.9.2 | Overflow elevation | TVA drawing 21E210 | $Z_c$ | Varies 1392.38 to 1400.64 |
| 4.9.3 | Overflow length | Section 6.1 | L | 93.9 feet |
| | | | | |
| **4.10** | **Nonoverflow Dam –Block 18 (B=Varies)** | | | |
| 4.10.1 | Discharge coefficient | Section 6.1 | $C_f$ | 2.66 |
| 4.10.2 | Overflow elevation | TVA drawing 21N207 | $Z_c$ | 1392.0 feet |
| 4.10.3 | Overflow length | Section 6.1 | L | 43.82 feet |
| | | | | |
| **4.11** | **Tailwater Rating Curve** | | | |
| | TW vs. total discharge, Q | Section 6.6, Q = 312,910 cfs | TW(Q) | 1318 feet |
| | | | | |
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## 5.0 Special Requirements/Limiting Conditions

N/A

## 6.0 Calculations

The calculations included in this section are overflow parameters, overflow parameter for the tainter spillway gates, spillway free and orifice discharge coefficients, turbine discharge, tailwater rating curve and tailwater submergence effect on discharge.

TVA 489H (EN DES-2-78) **TENNESSEE VALLEY AUTHORITY** SHEET 16 OF

SUBJECT Dam Rating Curve PROJECT Boone

CDQ000020080003

COMPUTED BY JVPeyton DATE 11-14-08 CHECKED BY JB Mauter DATE

## 6.1 Overflow Parameters

### Summary of Parameters

| Item | Width (B) | Elev | Length | $C_f$ (Avg) |
|---|---|---|---|---|
| Block 18 (3 overflow edges) | Varies | 1392.0' | 43.82* | 2.66 |
| Blocks 16 & 17 | 12' | 1392.0' | 52' | 2.91 |
| Powerhouse - Blocks 8, 9 & 10 | 35' | 1392.0 | 174' | 2.67 |
| Blocks 6, 7 & part of 5 | 12' | 1392.0 | 100.5' | 2.91 |
| Part of Block 5 | 12' | 1392.38 ± | 9.96' | 2.91 |
| Blocks 3, 4, & part of 5 | 12' | Varies 1392.38 to 1400.64 | 93.90* | 2.66 or 2.81 |
| Spillway piers | 23' | 1394.42 | 39' | 2.70 |
| | Total | | 513.18' | |

Total length of dam = (Sta 10+27.00) − (Sta 2+45.00) = 782'

Length of spillway = 5 gates × 35'/gate = 175' ✓

Length of wall, top elevation @ 1408.5 = 106' ✓

Length of non-overflow dam = 782' − 175' − 106' = 501'

Length of non-overflow dam @ El 1392 (B = 12) = 52' + 100.5' = 152.5'

Length of Blocks 6, 7, & part of Block 5 @ El 1392.0;
Length = 41.5' (Block 6) + 58.0' (Block 7) + 1.0' (Block 5) = 100.5'

* Lengths increased due to slope or additional length of edge that allows overflow

A 489 (EN DES-11-76)



DAM RATING CURVE - BOONE

BOONE - DAM PROFILE

CDQ 000020080003

COMPUTED CTS DATE 10/21/2008

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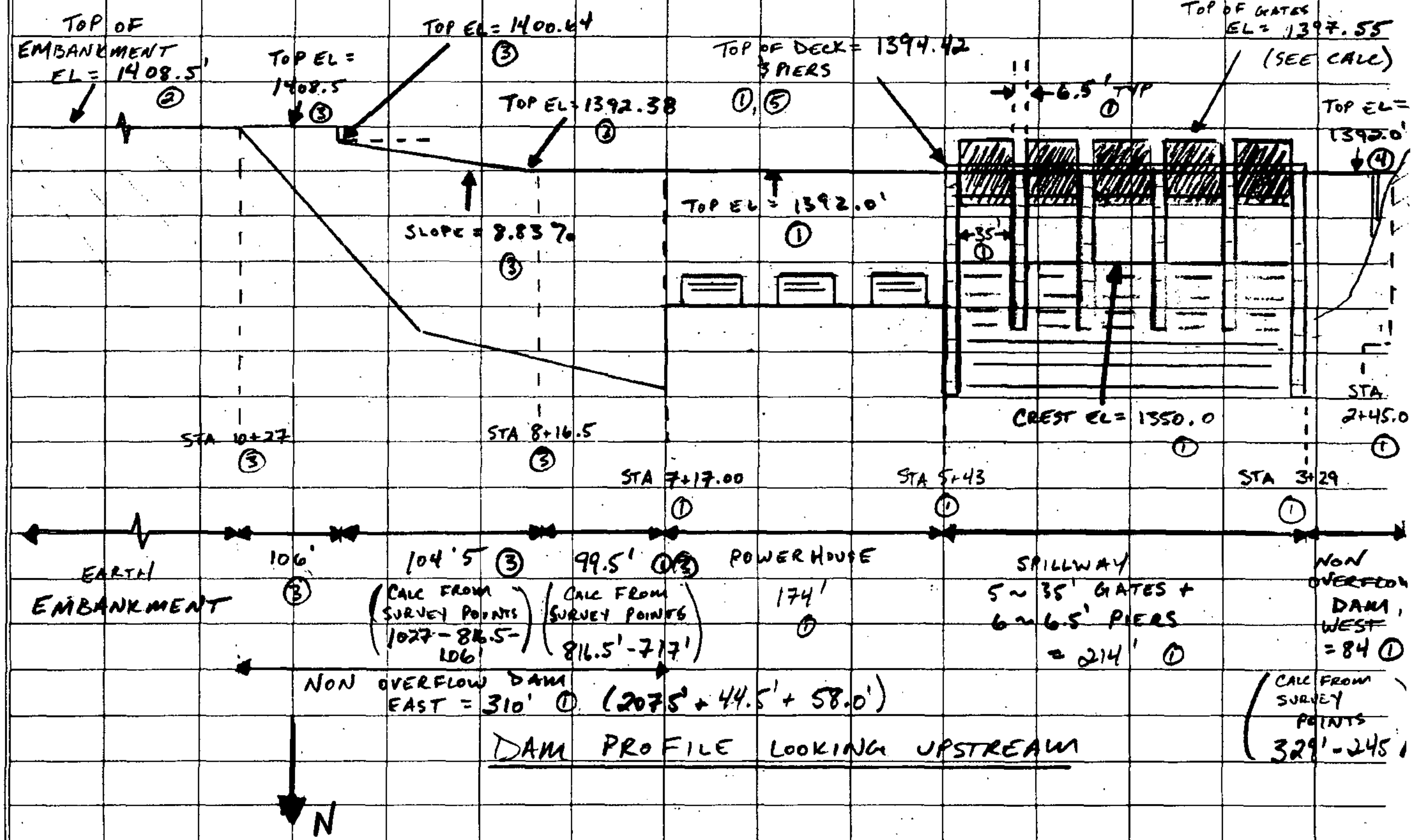
## 6.1 Overflow Parameters (Continued)

DRAWINGS

1. 10W201 R8 (REF 2.2, ATT 6)
2. 22E10 R3 (REF 2.18, ATT 11)
3. 21E210 R1 (REF 2.17, ATT 10)
4. 21N207 R2 (REF 2.16, ATT 9)
5. 10N204 R4 (REF 2.15, ATT 8)
6. 10N200 R8 (REF 2.1, ATT 5)
7. 54W200 R3 (REF 2.3, ATT 17)




DAM PROFILE LOOKING UPSTREAM

NOTE: DRAWING NOT TO SCALE

A 489 (EN DES-11-76)

SHEET 18 OF

DAM RATING CURVE - BOONE

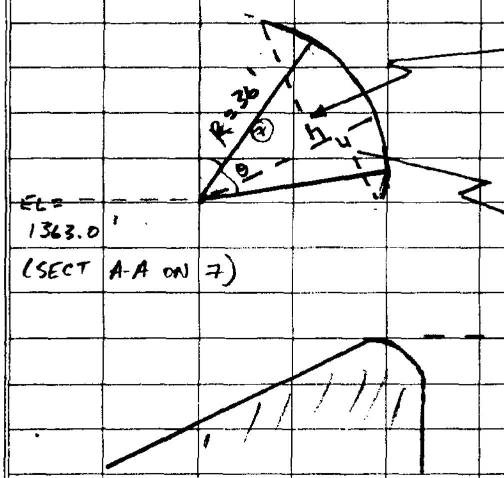
BOONE - MAXIMUM GATE OPENING

CDQ 0000 20080003

COMPUTED CTS DATE 10/23/2008

CHECKED JBM DATE

## 6.1 Overflow Parameters (Continued)




$Z_2 = 22'$ (54N201 SECT A-A)
4'2" + 9'4" + 8'6" = 22'

$Z_1 = 13.61'$ (54N201 SECT A-A)
1'2" + 9'7 5/16" + 2'10" = 13.609375'

EL= 1350.0 (SECT A-A ON 7)

SPILLWAY GATE ARRANGEMENT TABLE (REF 2.6, ATT 2-8) INDICATES MAX V = 31' (SETTING 94)

$$\theta = \sin^{-1}\left(\frac{13.61'}{36'}\right) + \sin^{-1}\left(\frac{22'}{36'}\right) = 59.88^\circ$$

$$\alpha = \tan^{-1}\left[\frac{1363.0' - 1350.0' - 31'}{\sqrt{36^2 - (1363.0' - 1350.0' - 31)^2}}\right] = -30^\circ$$

OVERFLOW ELEVATION $Z_0 = 1363.0' + 36' \times \sin(59.88^\circ - (-30^\circ))$

$Z_0 = 1399'$

NOTE: See TVA calculation NUCGENCEB000020080010, "Dam Rating Curve, Fort Patrick Henry," Appendix A.

DAM RATING CURVE - BOONE

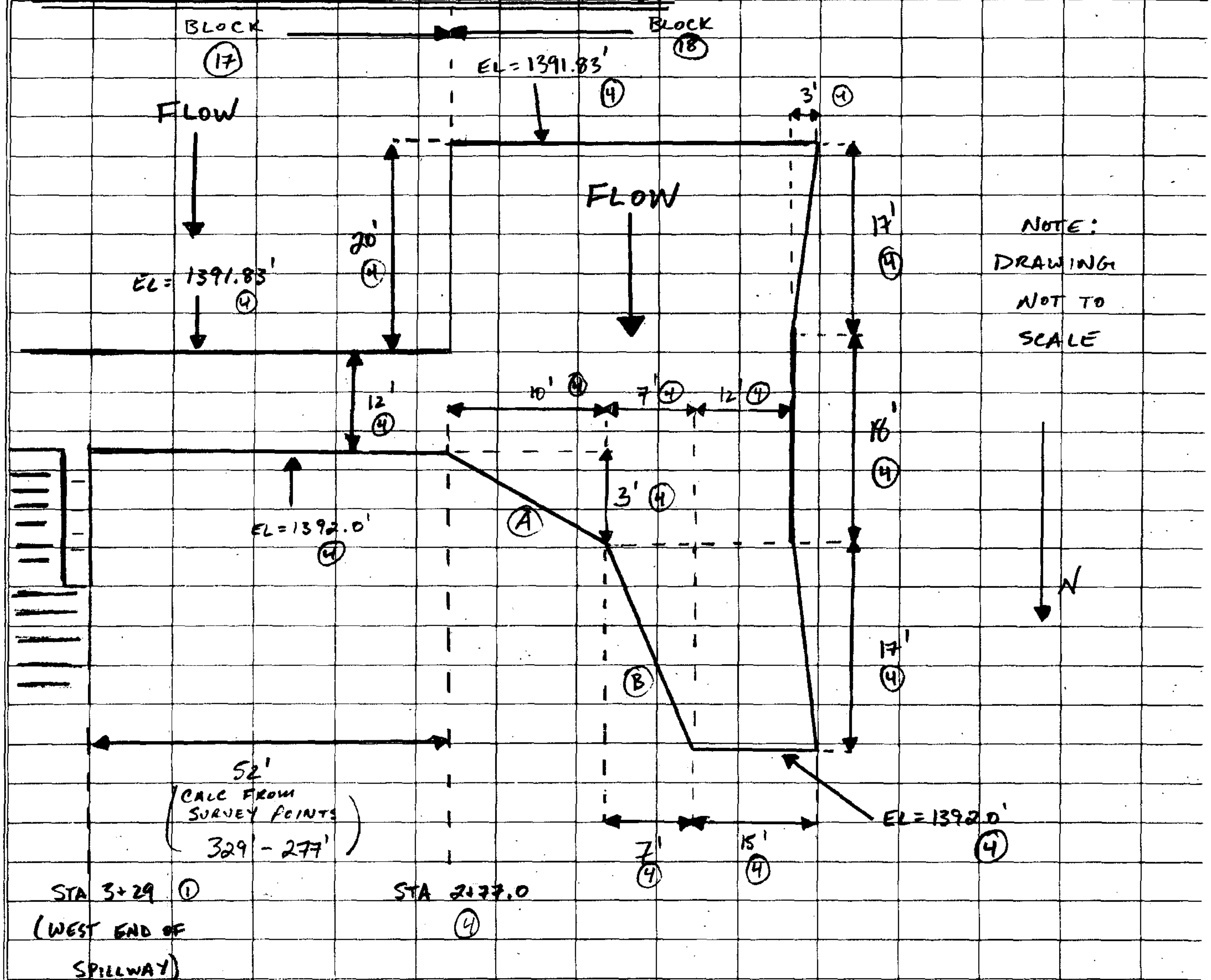
BOONE - WEST NONOVERFLOW AREA PLAN

CDQ 0000 2008 0003

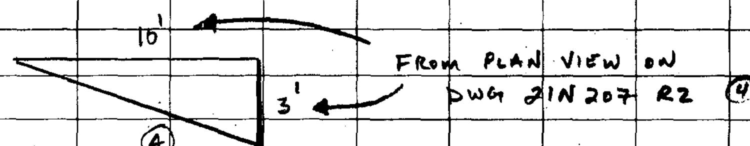
COMPUTED CTS DATE 10/21/2008

CHECKED JBM DATE

## 6.1 Overflow Parameters (Continued)

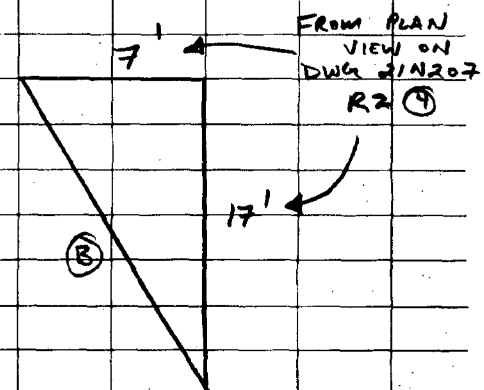



LENGTH OF (A)




$$(A) = \sqrt{(10')^2 + (3')^2} = 10.44'$$

LENGTH OF (B)




$$(B) = \sqrt{(7')^2 + (17')^2} = 18.38'$$

DAM RATING CURVE - BOONE

BOONE - WIER FLOW PARAMETERS

CDQ 0000 2008 0003

COMPUTED CTS DATE 10/21/2008

CHECKED JBM DATE

## 6.1 Overflow Parameters (Continued)

DISCHARGE COEFFICIENTS

REFER TO HCE 711, page 26 (Ref 2.9), FOR VALUES OF FREE FLOW DISCHARGE COEFFICIENT, $C_f$. MAXIMUM HEADWATER ELEVATION USED IN THIS RATING IS 1408.5'.

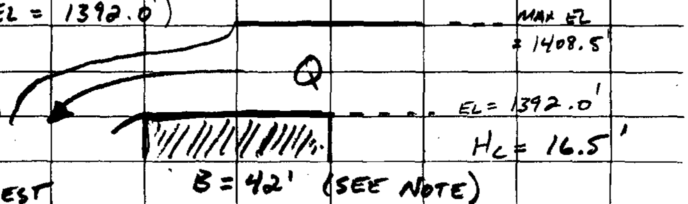
BLOCK 18, WEST NON-OVERFLOW DAM (EL = 1392.0')

- B VALUE VARIES ACROSS BLOCK 18.

MINIMUM B VALUE = 20' + 12' = 32' (EAST END OF BLOCK 18, PLAN VIEW DWG 21N207 R2)

MAXIMUM B VALUE = 17' + 18' + 17' = 52' (WEST END OF BLOCK 18, PLAN VIEW DWG 21N207 R2)

THE AVERAGE VALUE, 42', WILL BE USED




$$0 \le \frac{H_c}{B} = \frac{H_1}{B} \le \frac{16.5'}{42'}$$

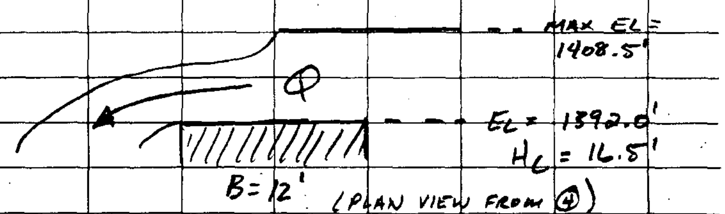
$$0 \le \frac{H_c}{B} \le 0.39$$

$$2.65 \le C_f \le 2.67$$

$L$ = Ⓐ + Ⓑ + 15' = 10.44' + 18.38' + 15' = 43.82' (PLAN VIEW FROM ④)

- THE SLIGHT SLOPING OF BLOCK 18 AND EFFECTS OF HANDRAILS HAVE BEEN NEGLECTED

BLOCK 16 & 17, WEST NON-OVERFLOW DAM (EL = 1392.0')




$$0 \le \frac{H_c}{B} = \frac{H_1}{B} \le \frac{16.5'}{12'}$$

$$0 \le \frac{H_c}{B} \le 1.375$$

$$2.65 \le C_f \le 3.17$$

$L$ = 52' (PLAN VIEW FROM ④, SURVEY POINT STA 2+77.0, WEST END OF BLOCK 17. PLAN VIEW FROM ①, SURVEY POINT STA 3+29.00, WEST END OF SPILLWAY: 329' - 277' = 52')

- THE SLIGHT SLOPING OF BLOCK 17 AND EFFECTS OF HANDRAILS HAVE BEEN NEGLECTED.

DAM RATING CURVE - BOONE

BOONE-WIER FLOW PARAMETERS

CDQ 0000 2008 0003

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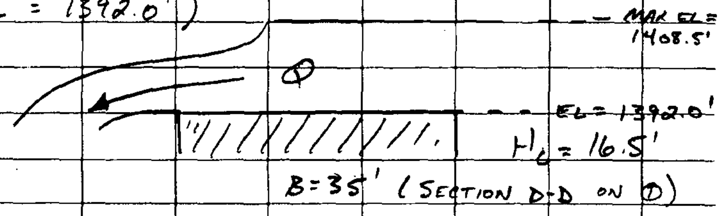
## 6.1 Overflow Parameters (Continued)

TOP OF POWERHOUSE SECTION (EL = 1392.0')




$0 \le \frac{H_c}{B} = \frac{H_1}{B} \le \frac{16.5'}{35'}$

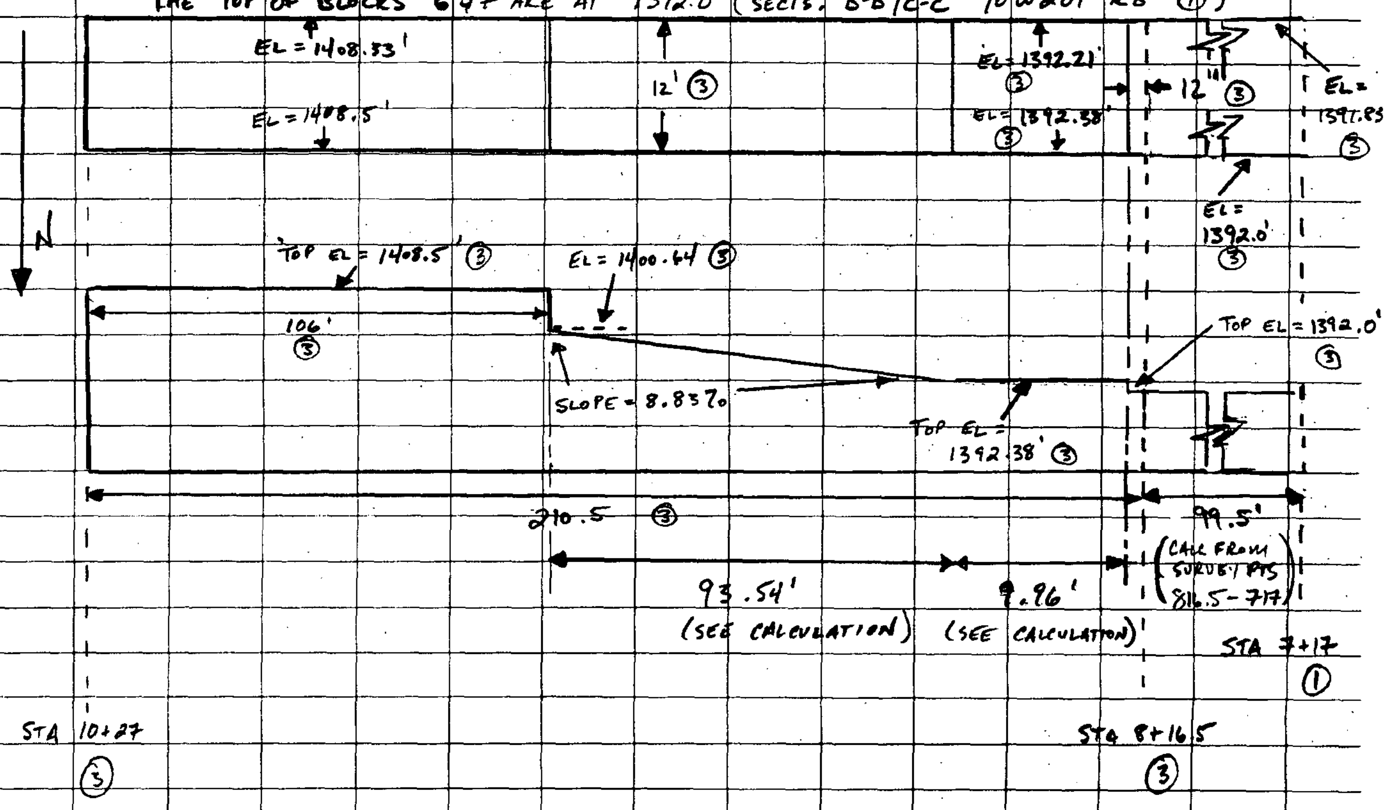
$0 \le \frac{H_c}{B} \le 0.47$

$2.65 \le C_f \le 2.69$

L = 174' (PLAN VIEW ON ①)

EAST NON-OVERFLOW DAM (EL = VARIES)

- THE EAST NON OVERFLOW DAM RISES FROM AN ELEVATION OF 1392.0 (WEST END) TO AN ELEVATION OF 1408.5' (EAST END, AGAINST EARTH EMBANKMENT. SEE PLAN VIEW DWG 21E210 R1 ③.
  THE CHANGE IN ELEVATION OCCURS IN BLOCKS 3-5. THE SLOPE FOR THE ELEVATION CHANGE IS 8.83%. (SECTION A-A ON DWG 21E210 R1 ③)
  THE TOP OF BLOCKS 6 & 7 ARE AT 1392.0 (SECTS. B-B/C-C 10W201 R8 ①)




NOTE: DRAWINGS NOT TO SCALE

DAM RATING CURVE - BOONE

BOONE - WIER FLOW PARAMETERS

CDQ 0000 2008 0003

COMPUTED CTS DATE 10/21/2008

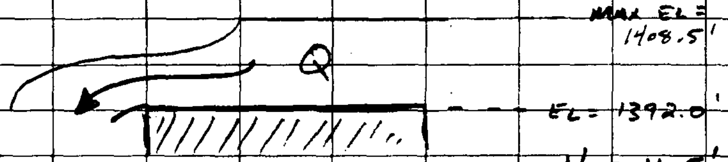
CHECKED JBM DATE

## 6.1 Overflow Parameters (Continued)

EAST NON OVERFLOW DAM. BLOCKS 6, 7 AND 1' PORTION OF 5' (EL = 1392.0')

$0 \le \frac{H_e}{B} \equiv \frac{H_1}{B} \le \frac{16.5'}{12'}$

$0 \le \frac{H_e}{B} \le 1.375$




$2.65 \le C_f \le 3.17$

(FROM SECTS B-B/C-C ON ① AND PLAN VIEW ON ③)

$L = 1' + 41.5' + 58.0' = 100.5'$

PORTION OF BLOCK 5 WITH TOP EL = 1392 (SECTION A-A ON ③)

LENGTH OF BLOCK 6 (PLAN VIEW ON ①)

LENGTH OF BLOCK 7 (SERVICE BAY) (PLAN VIEW ON ①)

- EFFECTS OF HANDRAILS & SLIGHT SLOPING NEGLECTED

NOTE: THIS SECTION CAN BE COMBINED WITH BLOCK 17 OF THE WEST OVERFLOW DAM. THE COMBINED PARAMETERS FOR WIER FLOW ARE AS FOLLOWS

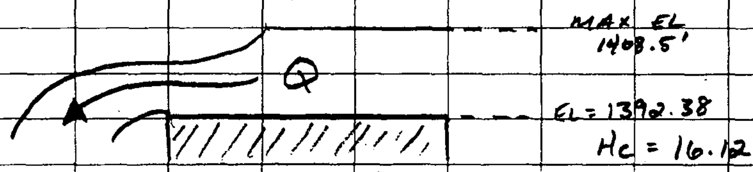
$2.65 \le C_f \le 3.17$

$L = 100.5' + 52' = 152.5'$

EAST NON OVERFLOW DAM, LEVEL SECTION OF BLOCK 5. (EL = 1392.38')

$0 \le \frac{H_e}{B} \equiv \frac{H_1}{B} \le \frac{16.12'}{12'}$

$0 \le \frac{H_e}{B} \le 1.34$

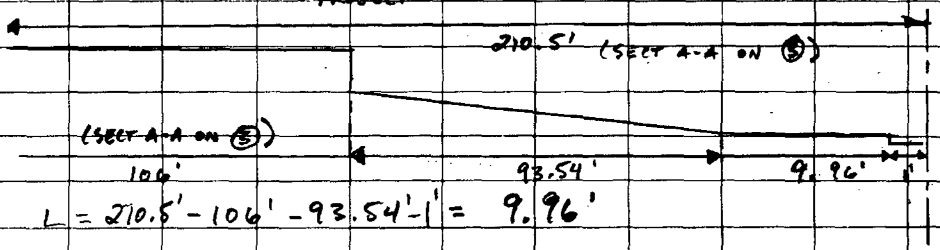



$2.65 \le C_f \le 3.17$

B = 12' (PLAN VIEW ON ③)

IN ORDER TO DETERMINE THE LENGTH OF THIS SECTION, THE PROJECTED LENGTH OF THE SLOPED SECTION MUST BE CALCULATED. FROM SECT A-A ON 21E210 R1

$8.83\% = \frac{(1400.64' - 1392.38')}{L_{PROJECT}} \Rightarrow L_{PROJECT} = \frac{(1400.64' - 1392.38')}{8.83\%} = 93.54'$




$L = 210.5' - 106' - 93.54' - 1' = 9.96'$

A 489 (EN DES-11-76) SHEET 23 OF

DAM RATING CURVE - BOONE

BOONE - WIER FLOW PARAMETERS

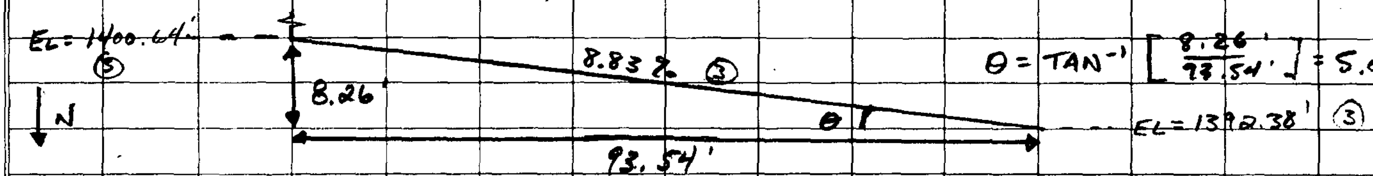
CDQ 0000 2008 0003

COMPUTED CTS DATE 10/21/2008

CHECKED JBM DATE

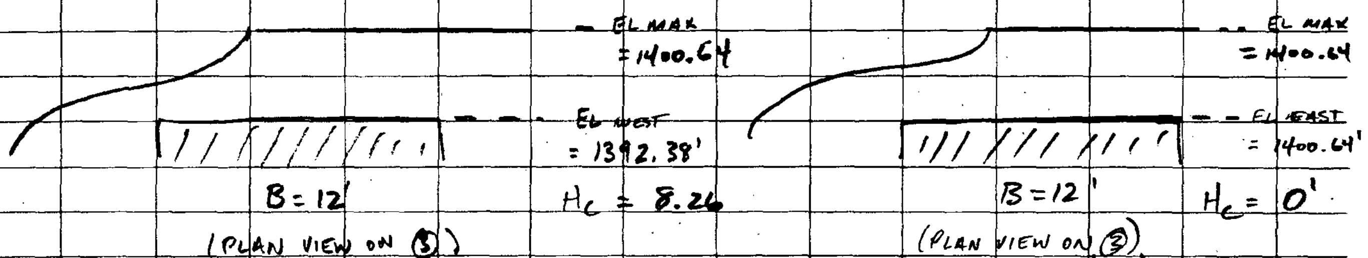
## 6.1 Overflow Parameters (Continued)

EAST NON OVERFLOW DAM, SLOPED SECTION (EL VARIES) 1392.38' ≤ HW ≤ 1400.64




$\theta = \tan^{-1}\left[\frac{8.26'}{93.54'}\right] = 5.05°$

THE LENGTH OF THE WIER AND THE HEAD WILL VARY AS THE DEPTH INCREASES. $H_c$ WILL VARY FROM A MINIMUM VALUE OF ≈ 0 JUST AS EAST END IS OVERTOPPED. WHEN WATER SURFACE REACHES EL 1400.64' Hc WILL VARY ALONG THE LENGTH OF THE SLOPED SURFACE. FOR THIS CASE, THE AVERAGE Hc WILL BE USED




$H_{c\,AVG} = \frac{8.26' + 0'}{2} = 4.13'$

$0 \leq \frac{H_c}{B} = \frac{H_1}{B} \leq \frac{4.13'}{12'}$

$0 \leq \frac{H_1}{B} \leq 0.34$

$2.65 \leq C_f \leq 2.67$ FOR $1392.38' \leq HW \leq 1400.64'$

$L = \frac{(HW - 1392.38')}{\sin 5.05°}$ ⇒ HYPOTENUSE OF TRIANGLE ABOVE AS SHORTER LEG INCREASES IN HEIGHT WITH $1392.38' \leq HW \leq 1400.64'$

A 489 (EN DES-11-76)

SHEET 2A OF

DAM RATING CURVE - BOONE

BOONE - WIER FLOW PARAMETERS

CDQ 000020080003

COMPUTED CTS DATE 10/21/2008

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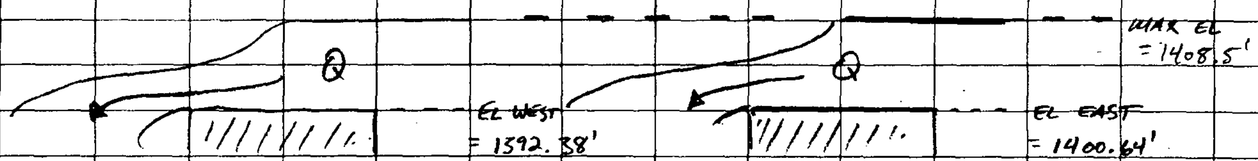
## 6.1 Overflow Parameters (Continued)

EAST NON-OVERFLOW DAM, SLOPED SECTION (EL VARIES), HW > 1400.64

SEE EAST NONOVERFLOW DAM, SLOPED SECTION, 1392.38' ≤ HW ≤ 1400.64 FOR CALCULATION DETAILS AND JUSTIFICATIONS



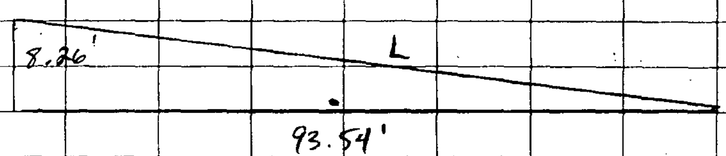

$H_c = 16.12'$ $H_c = 7.86'$

$$H_{c\,AVG} = \frac{16.12' + 7.86'}{2} = 11.99'$$

$$0 \le \frac{H_c}{B} \equiv \frac{H_1}{B} \le \frac{11.99'}{12'}$$

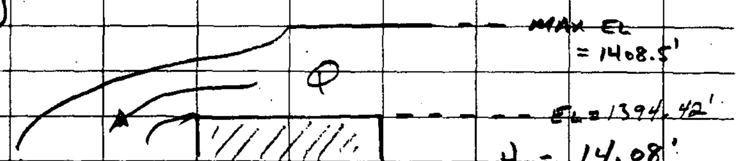
$$0 \le \frac{H_c}{B} \le \sim 1$$

$$2.65 \le C_f \le 2.96$$




$$L = \sqrt{8.26^2 + 93.54'^2} = 93.90'$$

SPILLWAY PIERS (EL 1394.42')




$$0 \le \frac{H_c}{B} \equiv \frac{H_1}{B} \le \frac{14.08'}{23'}$$

$$0 \le \frac{H_c}{B} \le 0.61$$

$H_c = 14.08'$

B = 23'

(SECT E-E ON ①; 35' - 12' = 23')

$$2.65 \le C_f \le 2.74$$

$$L = 6 \times 6.5' = 39'$$

↑ # OF PIERS ↑ WIDTH OF PIERS

SEE PLAN DWG 10W201 R8 ①

DAM RATING CURVE - BOONE

BOONE - WIER FLOW PARAMETERS / SUMMARY

CDQ000020080003

COMPUTED CTS DATE 10/21/2008

CHECKED JBM DATE

## 6.1 Overflow Parameters (Continued)

EAST NON OVERFLOW DAM / EAST EMBANKMENT (EL = 1408.5')

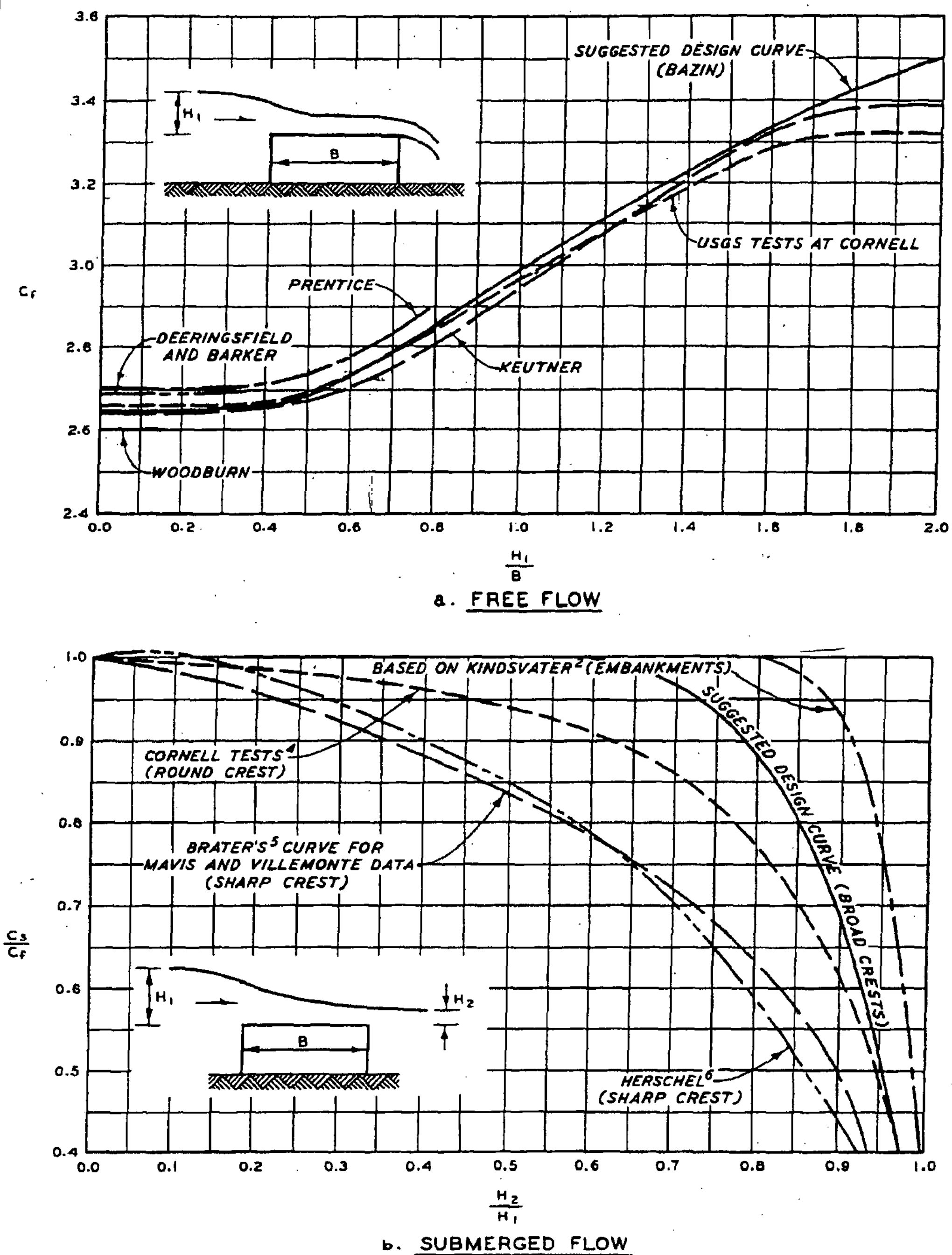
LEVEL SECT BLOCKS 1-3

THESE SECTIONS ARE SUFFICIENTLY HIGH TO PREVENT OVERTOPPING

SUMMARY

| EL | $C_f$ | L | DESC |
|---|---|---|---|
| 1392.0' | $2.65 \le C_f \le 2.67$ | 43.82' | BLOCK 18 |
| 1392.0' | $2.65 \le C_f \le 2.69$ | 174' | TOP OF POWERHOUSE |
| $1392.38 \le HW \le 1400.64$ | $2.65 \le C_f \le 2.67$ | $\frac{(HW - 1392.38')}{\sin 5.05°}$ | SLOPED SECTION - NON OVERFLOW DAM |
| $HW > 1400.64$ | $2.65 \le C_f \le 2.96$ | 93.90' | SLOPED SECTION - NON OVERFLOW DAM |
| 1394.42 | $2.65 \le C_f \le 2.74$ | 39' | SPILLWAY PIERS |

6.1 Overflow Parameters (Continued)




a. FREE FLOW

b. SUBMERGED FLOW

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

LOW-MONOLITH DIVERSION
DISCHARGE COEFFICIENTS
HYDRAULIC DESIGN CHART 711

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

WES 1-86

Reference: "Hydraulic Design Criteria," USACE, U.S. Army Engineer Waterways Experiment Station, 18th Issue, Vicksburg, MS, 1988.

SUBJECT Dam Rating Curve PROJECT Boone

CDQ 000020080003

COMPUTED BY JV Peyton DATE 11-14-08 CHECKED BY JBMauter DATE

## 6.2 Overflow Parameter For Tainter Spillway Gate

Refs:
- "Rating Curves for Flow Over Drum Gates," Joseph N. Bradley, Paper No. 2677, Transactions of the American Society of Civil Engineers, Vol 119, pages 403-433, 1954.
- TVA calculation NUCGENCEBCDQ000020080010, Attachment A6-3.
- TVA Boone Project drawings 54W200 & 54N201.

### Angle $\phi$

$$\phi = \tan^{-1}\left(\frac{x_o}{y_o}\right) \qquad y_o = Z_o - Z_{tr} = 1399' - 1363' = 36'$$

$$x_o = R\cos(\theta - \alpha)$$
$$= 36'\cos[59.856^\circ - (-30^\circ)]$$
$$x_o = 36'\cos(89.856^\circ) = 0.090'$$

$$\phi = \tan^{-1}\left(\frac{0.090'}{36'}\right) = 0.14^\circ \approx 0$$

### Overflow parameter

The overflow parameters for flow depth over the gates, $0 \le H \le 9.5'$ (El 1408.5 - El 1399) are taken from Figure 6 of Ref. 1 (listed above). See the following page.

Minimum flow; $\frac{H}{r} = \frac{0}{36'} = 0 \Rightarrow C_g = 3.00$

Maximum flow; $\frac{H}{r} = \frac{9.5'}{36'} = 0.26 \Rightarrow C_g = 3.50$

Use $C_g = C_o = 3.2$

6.2 Overflow Parameter For Tainter Spillway Gate (Continued)

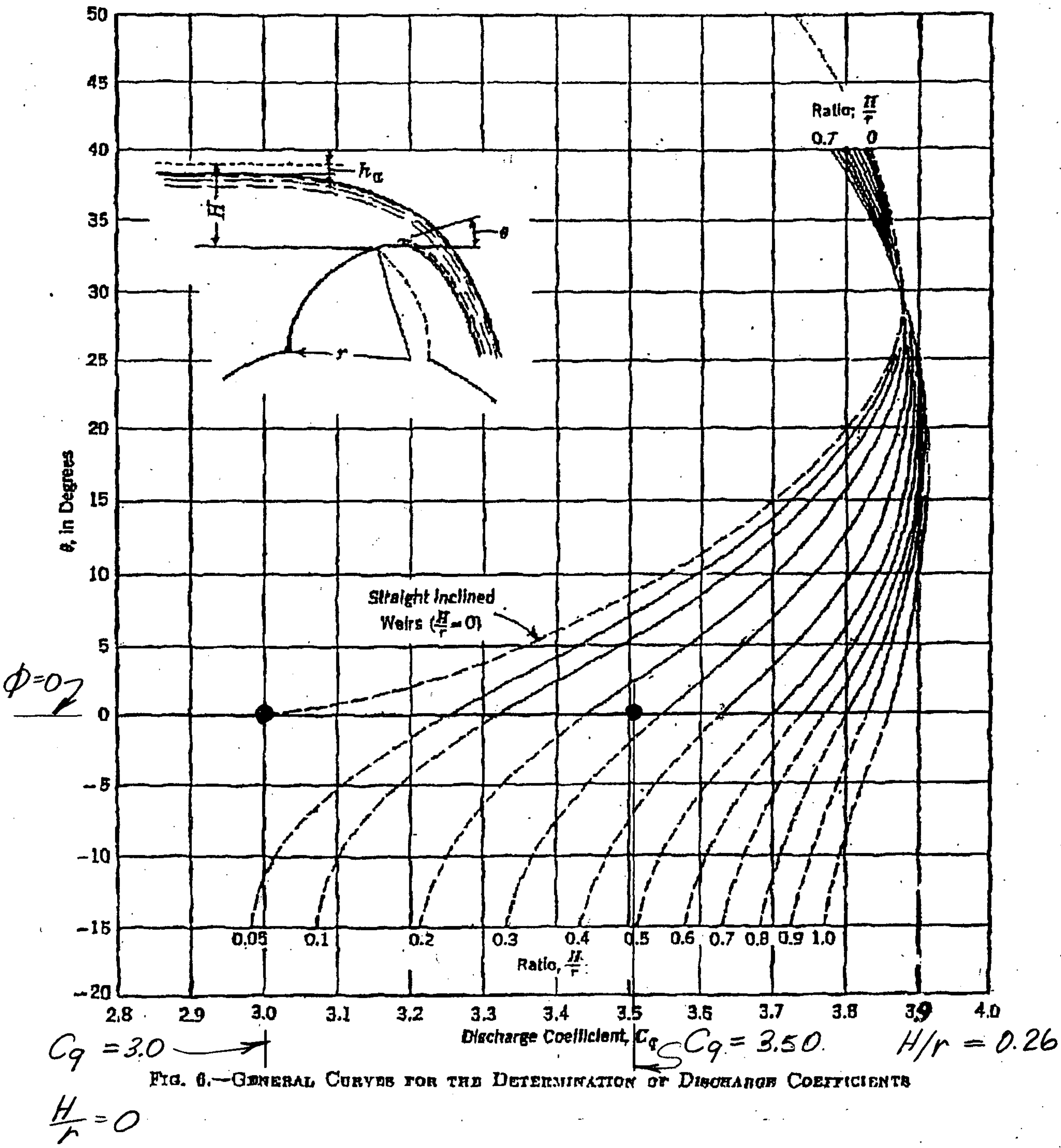



FIG. 6.—GENERAL CURVES FOR THE DETERMINATION OF DISCHARGE COEFFICIENTS

Ref: "Rating Curves for Flow Over Drum Gates," Figure 6

6.3 Spillway Free Discharge and Orifice Discharge Coefficients

Reference: TVA calculation NUCGENCEBCDQ000020080010, Appendix A.

The spillways for Boone Dam and Fort Patrick Henry Dam are identical. Each project has 5 spillways and 5 spillway gates with the same dimensions. The shape of the spillway crests is identical. Therefore the spillway free discharge and orifice discharge coefficients are the same for both projects. The Fort Patrick Henry model testing was done later than the Boone model testing, 1960 compared to 1954. For these reasons the free discharge and orifice discharge coefficients for Fort Patrick Henry Project are used for the Boone Project.

Since the spillway free discharge and orifice discharge coefficients are the same for Boone and Fort Patrick Henry, the spillway discharges ( $Q_f$ and $Q_g$ ) for the 2 projects are the same for the same height of headwater above the crest, Hc.

The following table summaries the data for the spillways:

| Item | Boone Project | Fort Patrick Henry Project |
|---|---|---|
| No. of gates | 5 | 5 |
| Width of each spillway | 35' | 35' |
| Gate radius (outside skin plate) | 36' | 36' |
| Width of piers between gates | 6.5' | 6.5' |
| Crest elevation | 1350.0 | 1228.0 |
| Elevation top of piers | 1394.42 | 1272.42 |
| Elevation of trunnion center | 1363.0 | 1241.0 |
| Elevation top of closed gate | 1385.0 | 1263.0 |
| Coordinates of crest profile x = 0 to x = 5.333 | $y = x^{1.8}/34.378$ | $y = x^{1.8}/34.378$ |
| Coordinates of crest profile x = 5.333 to x = 58.533 | y = 0.592 + (x-5.333)/5 + (x-5.333)/133 | y = 0.592 + (x-5.333)/5 + (x-5.333)/133 |
| Spillway drawing reference | 10W201, Downstream Elev | 10W201,Downstream Elev |
| Spillway gate reference | 54W200 & 54N201 | 54N200 & 54N201 |
| Crest reference | 51N204 | 51N202 |

The free discharge coefficients are given by the following equation:

$$C_f = 2.8 + 0.08548H_c - 0.003963H_c^2 + 1.039x10\text{-}4H_c^3 - 9.875x10\text{-}7H_c^4$$

The orifice discharge coefficients are given by the following equations:

$Cg = 0.764 - ((H_c - 37.49)/(42 - 37.49)) \times (0.764 - 0.720)$ for $37.49 \leq H_c \leq 42$

$Cg = 0.720 - ((H_c - 42)/(48 - 42)) \times (0.720 - 0.712)$ for $42 \leq H_c \leq 48$

$Cg = 0.712 + ((H_c - 48)/(58 - 48)) \times (0.720 - 0.712)$ for $48 \leq H_c \leq 58$

$Cg = 0.720$ for $Hc \geq 58$

SUBJECT Dam Rating Curve PROJECT Boone

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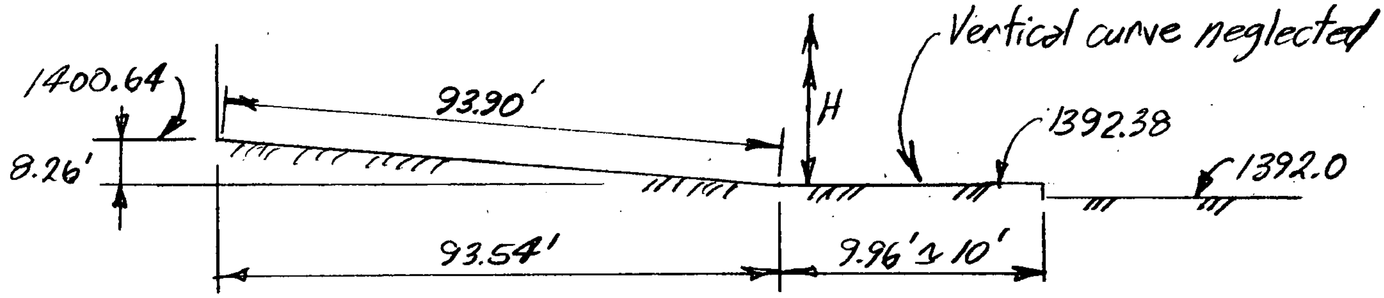
## 6.4 Discharge Equation for Sloping Top of Dam

### Blocks 3, 4 & Part of 5

Ref: TVA Boone Project drawing 21E210 R1

The discharge for overtopping the sloping portion of blocks 3, 4 & part of 5 is as follows:




**1392.38 ≤ HW ≤ 1400.64**

$$C_f = \frac{2.65 + 2.67}{2} = 2.66$$

$$Q_f = C_f L H^{1.5}$$

$$L = 93.90'\left(\frac{H}{8.26'}\right) = 93.90\left(\frac{HW - 1392.38}{8.26}\right)$$

H = Average depth of water above 1392.38

$$H = \left(\frac{HW - 1392.38}{2}\right)$$

$$Q_f = (2.66)(93.90)\left(\frac{HW - 1392.38}{8.26}\right)\left(\frac{HW - 1392.38}{2}\right)^{1.5}$$

**HW > 1400.64**

$$C_f = \frac{2.65 + 2.96}{2} = 2.81$$

$$Q_f = C_f L H^{1.5} \qquad L = 93.90' \qquad H = (HW - 1392.38) - \frac{8.26'}{2}$$

(H = Average depth above 1392.38)

$$Q_f = 2.81(93.90')\left[HW - 1392.38 - \frac{8.26}{2}\right]^{1.5}$$

6.5 Turbine Discharge

The turbine generators are assumed to operate until the tailwater reaches Elevation 1302, the elevation of the doorways to the powerhouse. References 2.21, 2.22 and 2.23 provide the turbine discharge based on the gross head for the dam. The gross head is the difference between the headwater elevation and the tailwater elevation. The following table summaries the iterative steps to determine the turbine discharge for a range of headwater values.

| HW | Spillway Discharge cfs | Estimated Turbine Discharge cfs | Estimated Total Discharge cfs | TW | Gross Head | Turbine Discharge For 87' Gross Head | Total Discharge cfs |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| 1360 | 18553 | 12000 | 30553 | 1275 | 85 | 12600 | 31153 |
| 1370 | 56311 | 12000 | 68311 | 1283 | 87 | 12600 | 68911 |
| 1380 | 109361 | 12000 | 121361 | 1293 | 87 | 12600 | 121961 |
| 1390 | 162546 | 12000 | 174546 | 1302 | 88 | 12600 | 175146 |
| | | | | | | | |

The iteration to determine the turbine discharge is as follows:

1. The spillway discharge for the headwater elevations 1360, 1370, 1380 and 1390 are taken from Table 7.1, page 35.
2. The tailwater elevations for headwater elevations 1360, 1370, 1380 and 1390 are determined from the tailwater rating curve for the Estimated Total Discharge (page 32).
3. The gross head (HW-TW) for the headwater elevations 1360, 1370, 1380 and 1390 are calculated. A gross head of 87' is used to estimate the turbine discharge for all elevations.
4. The turbine discharge for 87' gross head is taken from drawings 47K901-1 R0, 47K901-2 R0 and 47K901-3 R0, references 2.21, 2.22 and 2.23. The turbine discharge listed in the table is the total discharge for all 3 turbines.
5. Finally, the total discharge is the sum of the spillway discharge and the turbine discharge for 87' gross head.

The gross head of 87'for all headwater elevations and the rounding of the turbine discharge doesn't significantly affect the result since the turbine discharge is a small percentage of the total discharge expected.

## 6.6 Tailwater Rating Curve

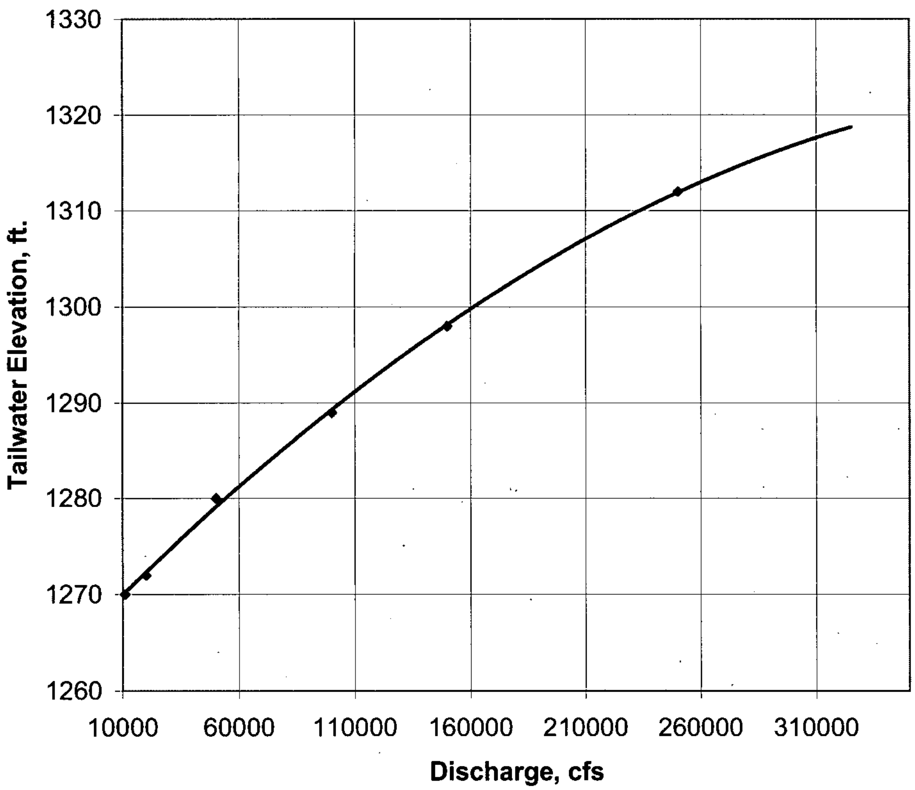
The data plotted below is from the graph "Boone Tailwater Rating," Attachment 1, for Fort Patrick Henry HW EL 1270. Elevation 1270 is the top of the nonoverflow portion of Fort Patrick Dam. The headwater at Fort Patrick for the Bellefonte PMF is not expected to exceed Elevation 1270 so that the curve below is conservative for determining the submergence effect on discharge. The EXCEL best fit second order polynomial equation is extrapolated to the maxmium expected discharge from Boone Dam.

| Boone Discharge cfs | Boone TW Elev ft |
|---|---|
| 11000 | 1270 |
| 20000 | 1272 |
| 50000 | 1280 |
| 100000 | 1289 |
| 150000 | 1298 |
| 250000 | 1312 |

| Extrapolated Values Discharge cfs | TW ft |
|---|---|
| 30553 | 1275 |
| 68311 | 1283 |
| 121361 | 1293 |
| 174546 | 1302 |
| 312910 | 1318 |

**Figure 6.1**
**Boone Tailwater Rating Curve**
**Fort Patrick Henry HW at El 1270**

$$TW = -2.671489E\text{-}10Q^2 + 2.443198E\text{-}04Q + 1.267539E{+}03$$



6.7 Tailwater Submergence Effect on Discharge

The effect of the tailwater submergence on the discharge is evaluated using Figure 6.1, "Boone Tailwater Rating Curve, Fort Patrick Henry Headwater at El 1270," page 32. The maximum Boone headwater elevation considered in this calculation is El 1408.5. The discharge calculated for headwater El 1408.5 is 312,690 cfs, Table 7.1 and Figure 7.1.

From Figure 6.1, the tailwater elevation for the maximum discharge (312,690 cfs) is El 1318. El 1318 is determined using the fit equation, $TW = -2.671489E\text{-}10Q^2 + 0.0002443198Q + 1267.539$, where Q, the discharge, is 312,690 cfs.

Elevation 1318 is considerably lower than the elevation of the top of the nonoverflow sections of the dam (El 1392 minimum), the elevation of the tops of the spillway piers (El 1394.42), the elevation of the top of the spillway gates when fully open (El 1399), the elevation of the top of the dam at the powerhouse (El 1392) and the spillway crest (El 1350). Therefore free discharge and orifice discharge are not affected by the tailwater at El 1318.

## 7.0 Results/Conclusions

The headwater rating results are tabulated as total discharge in cubic feet per second (cfs) vs. headwater elevation in feet in Table 7.1. The headwater rating curve is plotted in Figure 7.1

**Table 7.1**

**Dam Rating Curve**

For $0 \le Hc \le 37.49$: $C_f = 2.8+0.08548Hc-0.003963Hc^2+0.0001039Hc^3-0.0000009857Hc^4$

For $38 \le Hc \le 58.5$: For $C_g$ see Section 6.3 of this calculation.

g = 32.2 ft/s$^2$

Spillway Parameters

$L$ = 175 feet

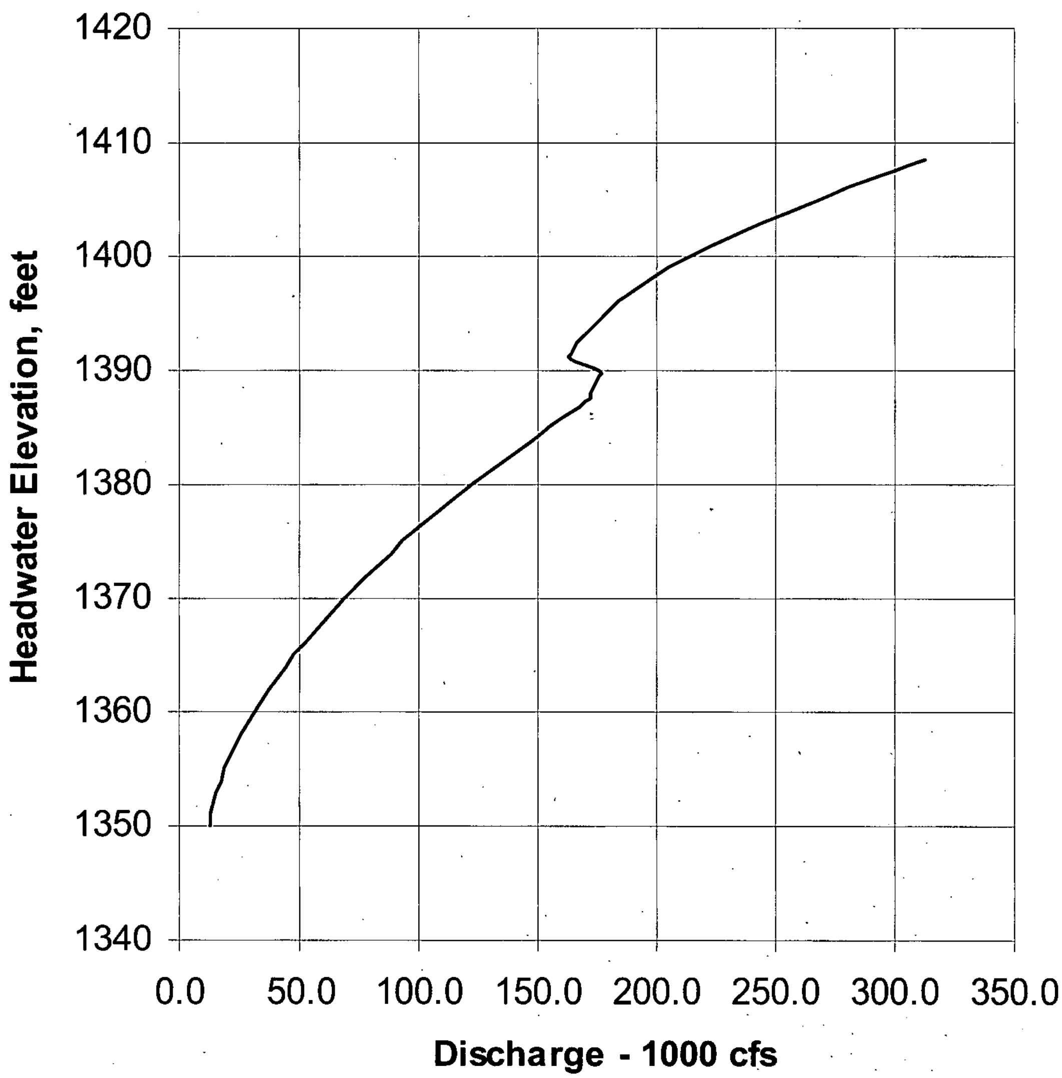
$Z_c$ = 1350 feet

$G_n$ = 31.540 feet

$H_{mp}$ = 15.375 feet

| | Total Discharge,Q | | | Spillway | | | Overtopping Flows, cfs | | | | | | | Turbine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Including | Without | | | | | Spillway | | Nonover | Nonover | Nonover | Nonover | Spillway | Discharge |
| HW | Turbine Discharge | Turbine Discharge | feet | | cfs | | Gates | P-house | B=Varies | B=12 | B=12 | B=12 | Piers | cfs |
| feet | 1000 cfs | 1000 cfs | $H_c$ | $C_f \mid C_g$ | $Q_f \mid Q_g$ | $C_f$ = | | | | | 2.66 | | | |
| | | | | | | $C_f$ = | 3.20 | 2.67 | 2.66 | 2.91 | 2.81 | 2.91 | 2.70 | |
| | | | | | | $Z_c$ = | 1399 | 1392 | 1392 | 1392 | Varies | 1392.38 | 1394.42 | |
| | | | | | | L = | 175.0 | 174.0 | 43.82 | 152.5 | 93.9 | 10.0 | 39.0 | |
| **1350** | **12.60** | **0.00** | 0 | 2.800 | 0 | | | | | | | | | 12600 |
| **1352** | **14.06** | **1.46** | 2 | 2.956 | 1463 | | | | | | | | | 12600 |
| **1354** | **16.92** | **4.32** | 4 | 3.085 | 4319 | | | | | | | | | 12600 |
| **1356** | **20.81** | **8.21** | 6 | 3.191 | 8208 | | | | | | | | | 12600 |
| **1358** | **25.59** | **12.99** | 8 | 3.279 | 12986 | | | | | | | | | 12600 |
| **1360** | **31.15** | **18.55** | 10 | 3.353 | 18553 | | | | | | | | | 12600 |
| **1362** | **37.44** | **24.84** | 12 | 3.414 | 24837 | | | | | | | | | 12600 |
| **1364** | **44.38** | **31.78** | 14 | 3.467 | 31783 | | | | | | | | | 12600 |
| **1366** | **51.96** | **39.36** | 16 | 3.514 | 39357 | | | | | | | | | 12600 |
| **1368** | **60.14** | **47.54** | 18 | 3.557 | 47536 | | | | | | | | | 12600 |
| **1370** | **68.91** | **56.31** | 20 | 3.598 | 56311 | | | | | | | | | 12600 |
| **1372** | **78.29** | **65.69** | 22 | 3.637 | 65686 | | | | | | | | | 12600 |
| **1374** | **88.27** | **75.67** | 24 | 3.678 | 75668 | | | | | | | | | 12600 |
| **1376** | **98.87** | **86.27** | 26 | 3.718 | 86268 | | | | | | | | | 12600 |
| **1378** | **110.10** | **97.50** | 28 | 3.760 | 97498 | | | | | | | | | 12600 |
| **1380** | **121.96** | **109.36** | 30 | 3.803 | 109361 | | | | | | | | | 12600 |
| **1382** | **134.45** | **121.85** | 32 | 3.846 | 121847 | | | | | | | | | 12600 |
| **1384** | **147.53** | **134.93** | 34 | 3.889 | 134931 | | | | | | | | | 12600 |
| **1386** | **161.16** | **148.56** | 36 | 3.930 | 148560 | | | | | | | | | 12600 |
| **1387.49** | **171.62** | **159.02** | 37.49 | 3.959 | 159022 | | | | | | | | | 12600 |
| **1388** | **172.52** | **159.92** | 38 | 0.759 | 159916 | | | | | | | | | 12600 |
| **1389** | **173.91** | **161.31** | 39 | 0.749 | 161312 | | | | | | | | | 12600 |
| **1390** | **175.15** | **162.55** | 40 | 0.740 | 162546 | | | | | | | | | 12600 |
| **1391** | **163.63** | **163.63** | 41 | 0.730 | 163626 | | | | | | | | | |
| **1392** | **164.56** | **164.56** | 42 | 0.720 | 164558 | | | 0 | 0 | 0 | | | | |
| **1393** | **168.35** | **168.35** | 43 | 0.719 | 167310 | | | 465 | 117 | 444 | 3 | 14 | | |
| **1394** | **172.99** | **172.99** | 44 | 0.717 | 169995 | | | 1314 | 330 | 1255 | 36 | 60 | | |
| **1395** | **178.23** | **178.23** | 45 | 0.716 | 172618 | | | 2414 | 606 | 2306 | 119 | 123 | 47 | |
| **1396** | **184.05** | **184.05** | 46 | 0.715 | 175180 | | | 3717 | 932 | 3550 | 267 | 200 | 209 | |
| **1397** | **190.36** | **190.36** | 47 | 0.713 | 177685 | | | 5194 | 1303 | 4962 | 490 | 288 | 436 | |
| **1398** | **197.10** | **197.10** | 48 | 0.712 | 180135 | | | 6828 | 1713 | 6522 | 801 | 386 | 713 | |
| **1399** | **204.79** | **204.79** | 49 | 0.713 | 183080 | | 0 | 8604 | 2159 | 8219 | 1205 | 494 | 1032 | |
| **1400** | **213.45** | **213.45** | 50 | 0.714 | 185991 | | 560 | 10512.2 | 2637 | 10041 | 1714 | 610 | 1388 | |
| **1401** | **223.15** | **223.15** | 51 | 0.714 | 188869 | | 1584 | 12543.7 | 3147 | 11982 | 2510 | 734 | 1777 | |
| **1402** | **233.49** | **233.49** | 52 | 0.715 | 191716 | | 2910 | 14691.3 | 3686 | 14033 | 3394 | 865 | 2198 | |
| **1403** | **244.42** | **244.42** | 53 | 0.716 | 194533 | | 4480 | 16949.2 | 4252 | 16190 | 4363 | 1003 | 2646 | |
| **1404** | **255.87** | **255.87** | 54 | 0.717 | 197322 | | 6261 | 19312.2 | 4845 | 18447 | 5409 | 1148 | 3122 | |
| **1405** | **267.80** | **267.80** | 55 | 0.718 | 200083 | | 8230 | 21775.9 | 5463 | 20801 | 6527 | 1299 | 3624 | |
| **1406** | **280.20** | **280.20** | 56 | 0.718 | 202818 | | 10371 | 24336.2 | 6106 | 23246 | 7714 | 1457 | 4149 | |
| **1407** | **293.02** | **293.02** | 57 | 0.719 | 205527 | | 12671 | 26989.7 | 6772 | 25781 | 8965 | 1620 | 4698 | |
| **1408** | **306.26** | **306.26** | 58 | 0.720 | 208213 | | 15120 | 29733.1 | 7460 | 28402 | 10277 | 1789 | 5270 | |
| **1408.5** | **312.91** | **312.91** | 58.5 | 0.720 | 209430 | | 16397 | 31137.7 | 7812 | 29743 | 10955 | 1876 | 5563 | |

**Figure 7.1**
**Boone Rating Curve**
**Including Turbine Discharge**



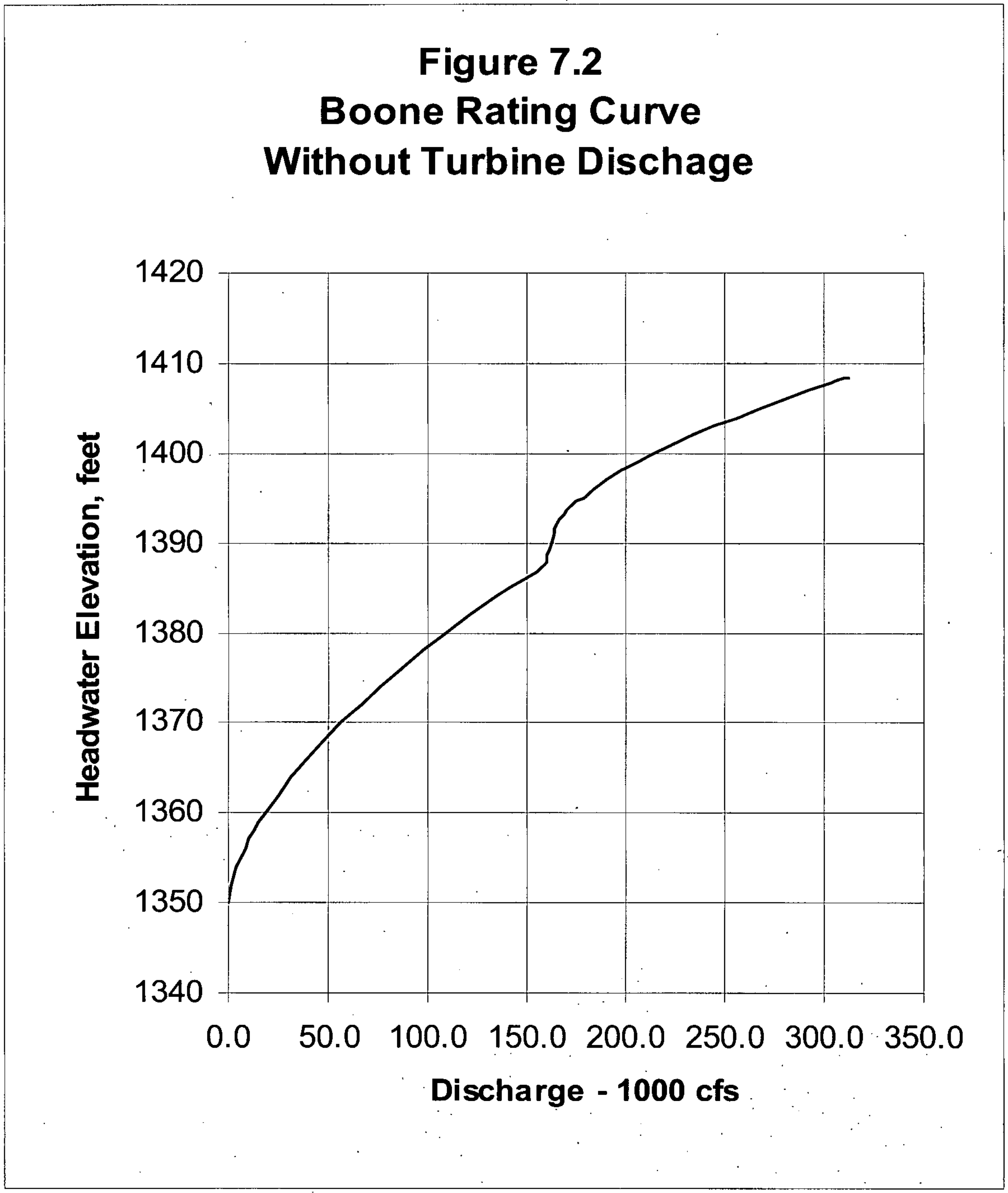


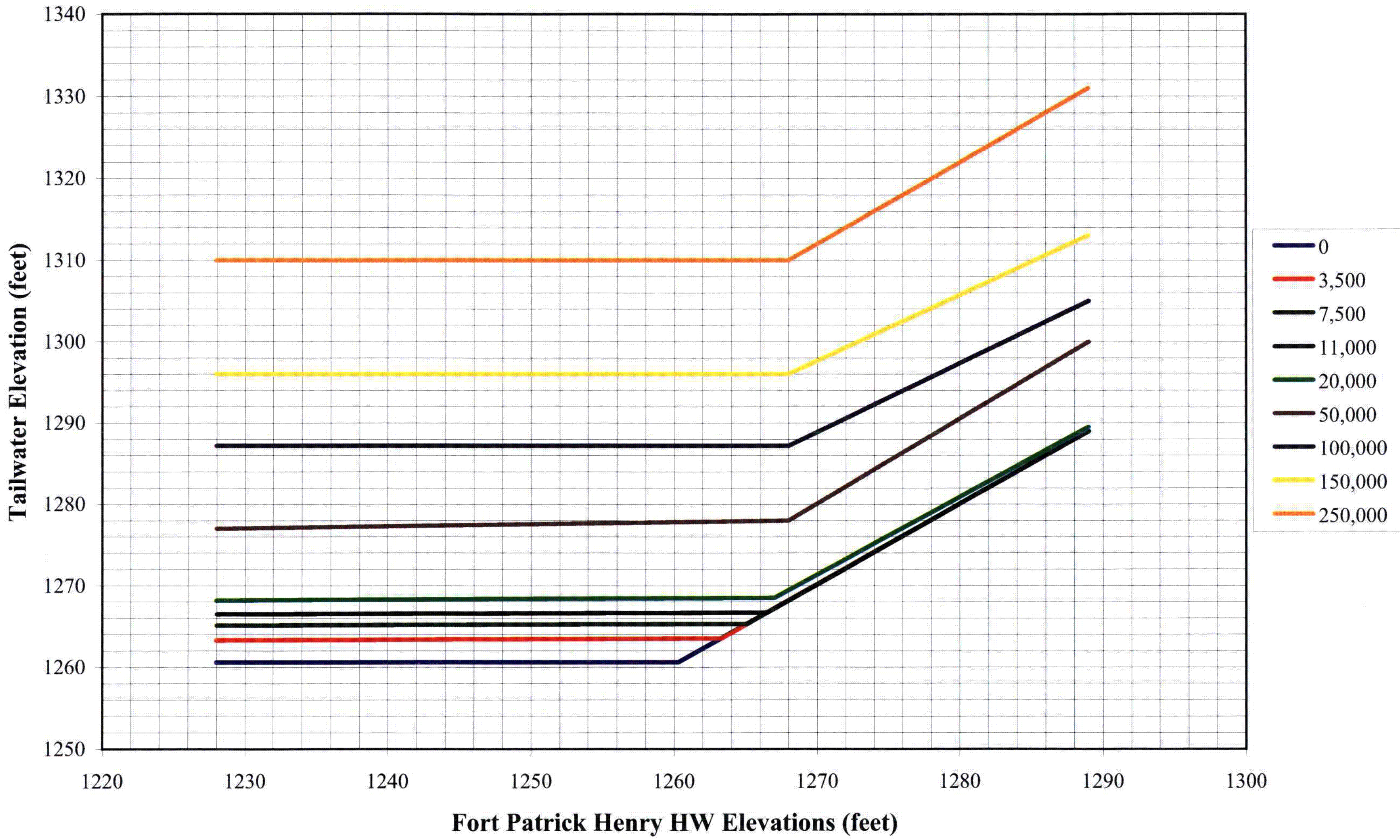
Figure 7.2
Boone Rating Curve
Without Turbine Dischage
1420
1410
1400
1390
1380
1370
1360
1350
1340
Headwater Elevation, feet
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
Discharge - 1000 cfs

# Attachments

Attachment 1

Page 38
Calculation No. CDQ00002008003

## Boone Tailwater Rating




Source: TVA River Operations
Flood Risk Section

TENNESSEE VALLEY AUTHORITY
RIVER SYSTEM OPERATIONS & ENVIRONMENT
RIVER OPERATIONS



# BOONE DAM

# SPILLWAY AND SLUICE DISCHARGE TABLES

MARCH 2004

# CONTENTS

## PART 1. SPILLWAY DISCHARGE TABLES



## PART 2. SLUICE DISCHARGE TABLES

**PART 1**

# SPILLWAY DISCHARGE TABLES

**MARCH 2004**

## INSTRUCTIONS FOR USE OF TABLES

The sluice should be used to pass all flows up to its maximum capacity. The sluice and spillway must not be operated at the same time. When the required spill discharge exceeds the sluice capacity, the sluice must be shut down and the required discharge passed over the spillway.

**1. Tables Update**

These tables supersede the tables dated October 1957. The tables were revised to increase the maximum headwater elevation covered in the tables from 1386 feet to 1390 feet. The computer code SPILLQ generated the tabulated discharges.

The accuracy of these tables depends on properly set zero indicator positions for each of the spillway gates. The tabulated discharges are based on known gate openings for each indicator position. The known gate openings and, therefore, the tabulated discharges are accurate only when the zero indicator settings are properly set.

The indicators should read zero when the gates are closed with the slack removed from the cables. The zero indicator settings should be verified whenever the gates are inspected.

**2. Purpose of Tables**

These tables provide a means for setting required spillway discharges and for determining the discharge when a specific arrangement of gates is in use. The tabulated discharges are based on test results from scale models.

The specific gate arrangements in the tables were determined by considering erosion data obtained from spillway model studies together with incremental discharge values required for satisfactory spillway operation.

**3. Range of Tables**

The tables cover a discharge range from approximately 4,000 cubic feet per second to 164,300 cubic feet per second. Headwater elevations range from 1357 feet to 1390 feet. Smaller discharges and smaller headwater elevations are not included because the performance of the spillway apron is unsatisfactory at small spillway discharges. Consequently, <u>the spillway must not be used for headwater elevations below 1357 feet.</u>

As noted above, the spillway and sluice must not be used at the same time. Therefore, <u>the sluice should be used to pass all flows up to its maximum capacity</u>, which is 3,330 cubic feet per second at headwater elevation 1357 feet and 3,830 cubic feet per second at headwater elevation 1385 feet (top elevation of closed spillway gates). When the required discharge to be passed exceeds the sluice capacity or the headwater elevation exceeds 1385 feet, the sluice must be shut down and the required discharge passed over the spillway.

**4. Arrangement of Tables**

The discharge tables show spillway discharges in cubic feet per second. Headwater elevations for each 0.1 foot of headwater elevation are shown at the top of each column. The headwater range is shown at the bottom of each page.

The discharge is tabulated under the headwater elevations for specific arrangements of gate openings, which are indicated by number in the left and right columns of each page. The numbered arrangements are defined in the table of Spillway Gate Arrangements on page 5. Reference to this table and to the drawing showing the location of the gates on page 4 will determine the gate opening to which each gate is to be set for any particular discharge given in the tables.

The tables have been arranged for the spillway to pass approximately 2,000 cubic feet per second per gate during the initial opening of the five spillway gates, which is required to obtain satisfactory operation of the spillway apron. For all headwater elevations, gates 5 and 4 are always opened first to give a discharge of approximately 4,000 cubic feet per second. Because the required openings for gates 5 and 4 to pass 4,000 cubic feet per second vary with headwater elevation, six sets of four gate arrangements each are provided so that proper spillway apron operation will occur at all headwater elevations. For discharges between approximately 4,000 and 10,000 cubic feet per second, it is necessary to change the gate openings whenever the headwater elevation rises above or falls below elevation 1359.2 feet, 1361.0 feet, 1363.5 feet, 1367.5 feet, or 1374.5 feet.

**5. Discharge Intervals**

The tables have been prepared so that the incremental discharge between the tabulated values for consecutive gate arrangements is generally less than 5 percent of the tabulated discharge. The incremental discharge between tabulated values of consecutive headwater elevations is generally less than 1 percent. The 5 percent increment is exceeded during the initial opening of the five spillway gates, where a discharge of approximately 2,000 cubic feet per second per gate is required to give satisfactory operation of the spillway apron. Except during the initial opening of the five spillway gates, it is possible to set any required discharge within 2-1/2 percent and to know the actual discharge for any given set of conditions within 1 percent. These tolerances are considered to be acceptable and therefore it will not be necessary to interpolate between values given in these tables.

When the exact headwater elevation does not appear in the tables, the discharge for the headwater elevation closest to it is used. For example, the column headed 1362.2 is used for actual headwater elevations between 1362.15 feet and 1362.24 feet inclusive. When the actual headwater elevation is exactly halfway between tabular values, the larger value is used.

**6. Gate Opening Sequence**

The spillway gates are to be opened in the sequential order of gates 5, 4, 3, 2, and 1, and closed in the reverse order. The two spillway gate arrangement tables on page 5 have been prepared for using the prescribed order of opening and closing the gates.

When the spillway gates are changed from one gate arrangement to another within Table 1, or between Table 1 and Table 2, the gate changes should be made by going directly from one gate arrangement to the other, operating the gates in the prescribed opening or closing sequence stated above.

When the spillway gates are being changed from one gate arrangement to another within Table 2, each consecutive intermediate gate arrangement should be set. This automatically gives the correct gate opening or closing sequence.

**7. Rate of Opening Sequence**

A 5-minute interval should be allowed between each gate arrangement change during opening of the spillway gates. This limitation allows time for the tailwater elevation to stabilize and thus eliminates the possibility of producing excessive erosion in the riverbed below the spillway because of insufficient tailwater depth. During the initial opening of gates 5 and 4, this restriction does not apply. Gate 4 must be opened immediately after gate 5 is brought to its initial position.

The 5-minute interval between gate changes applies only to opening gates. Gates may be closed as quickly as desired.

**8. Raising and Lowering Gates**

The operating mechanism for raising and lowering the spillway gates is located on the deck of the dam. The gates are raised individually by operating an electrical switch attached to the operating mechanism. As the gate is raised or lowered, the gate opening is indicated on a dial that is visible from the control switch. The gates may be stopped at any opening, but only the openings shown in the spillway gate arrangement table on page 5 may be used. Care should be taken to set each required position accurately.

**9. Special Instruction – Preventing Flow Over Top of Spillway Gates When Headwater Elevation is Above 1385 feet**

If the headwater elevation exceeds 1385 feet (actually, 1384.8 feet to provide a 0.2-foot margin of safety) the spillway gates must be set to one of the gate arrangements listed in the tables to prevent flow over the tops of the gates. The minimum gate openings are those corresponding to the lowest numbered gate arrangement for which a discharge value is provided in the tables.

**10. Use of Tables**

The tables can be used in two ways: (1) to determine the arrangement of gates needed to pass a required discharge at a given headwater elevation, and (2) to determine the discharge for a given arrangement of gates and headwater elevation.

Example 1: -- What gate arrangement is necessary to pass a discharge of 1,800 cubic feet per second with the headwater at elevation 1367.43 feet? Because the required discharge is within the capacity of the sluice, the sluice must be used instead of the spillway. See Part 2.

Example 2 – Suppose the headwater elevation remains at elevation 1367.43 feet, but the required spill discharge is increased to 4,000 cubic feet per second. Reference to Part 2 (page 38, headwater column 1367, 10-foot opening) shows that the sluice capacity has been exceeded. The sluice should therefore be shut down and the required discharge passed over the spillway. The first step is to find the table in which the headwater elevation appears. Referring to the contents page, we find that headwater elevations between 1367 feet and 1369 feet are found on page 11. The headwater elevation closest to 1367.43 feet is 1367.4 feet. In the column headed 1367.4 the discharge nearest to the required 4,000 cubic feet per second is 4,300 cubic feet per second located at the top of the page. By tracing the horizontal line in which 4,300 cubic feet per second appears, to either side of the page, we find that gate arrangement 9 is the one for producing the discharge closest to 4,000 cubic feet per second at headwater elevation 1367.43 feet. Referring to page 5 it is found that gates 4 and 5 both should be opened to gate opening indicator reading 2.5. Because the gates are opened in the order 5, 4, 3, 2, and 1, gate 5 should first be opened to indicator reading 2.5 and then immediately gate 4 should be opened to indicator reading 2.5. This initial opening of gates 5 and 4 is the only circumstance in which one gate is operated immediately after another without a 5-minute delay.

Example 3 – It may now be necessary to increase the discharge to 10,000 cubic feet per second with the headwater elevation remaining at 1367.43 feet. In the column headed 1367.4 on page 11, the discharge nearest to 10,000 cubic feet per second is 10,740 cubic feet per second for gate arrangement 12. Referring to page 5 it is found that gate arrangement 12 specifies that all five gates should be opened to indicator reading 2.5. Because gate arrangement 9, the current arrangement, and gate arrangement 12, the required arrangement, are both within gate arrangement Table 1, we may go directly from the one gate arrangement to the other following the prescribed order of opening the gates and using the prescribed 5-minute interval between gate changes. With gates 4 and 5 already open to indicator reading 2.5, the remaining gates should be opened as follows: gates 3, 2, and 1, in that order, from closed to indicator reading 2.5 with 5 minutes elapsing between each gate change.

Example 4 – With gate arrangement 12 set the headwater elevation may rise from 1367.43 feet to 1367.60 feet. In the column headed 1367.6 on page 11 there is no value of discharge for gate arrangement 12. This constitutes one of the five breaks in the spillway discharge tables where the gates must be shifted from one basic type of gate arrangement to another to obtain, or maintain, the desired discharge. In the column headed 1367.6 on page 11 the discharge closest to 10,000 cubic feet per second is 10,160 cubic feet per second for gate arrangement 32. Because, as shown on page 5, gate arrangement 12 is in Table 1 and gate arrangement 32 is in Table 2, we may go directly from the one gate arrangement to the other following the prescribed order of opening or closing the gates. Page 5 shows that gates 1 and 2 should be closed from indicator reading 2.5 to indicator reading 2. Because the 5-minute interval between gate changes applies only to opening gates, gates 1 and 2 may be closed as quickly as desired. In accordance with the prescribed closing sequence the gates should be closed in the order 1 and 2.

Example 5 -- It may now be necessary to increase the discharge from 10,000 cubic feet per second to 11,000 cubic feet per second with the headwater elevation remaining at 1367.60 feet. In the column headed 1367.6 on page 11, the discharge nearest to 11,000 cubic feet per second is 11,120 cubic feet per second for gate arrangement 35. Referring to page 5 it is found that gate arrangement 32, the current arrangement, and gate arrangement 35, the required arrangement, are both within gate arrangement Table 2. According to the instructions, each consecutive gate arrangement step should be set when changing from one gate arrangement to another within Table 2. To change from gate arrangement 32 to gate arrangement 35, arrangements 33, 34, and 35, in that order, should be set. This automatically gives the correct gate opening procedure. The gates would be opened as follows: gate 2 from indicator 2 to indicator 2.5; five minutes later, gate 1 from indicator 2 to indicator 2.5; and five minutes later, gate 5 from indicator 2.5 to indicator 3.

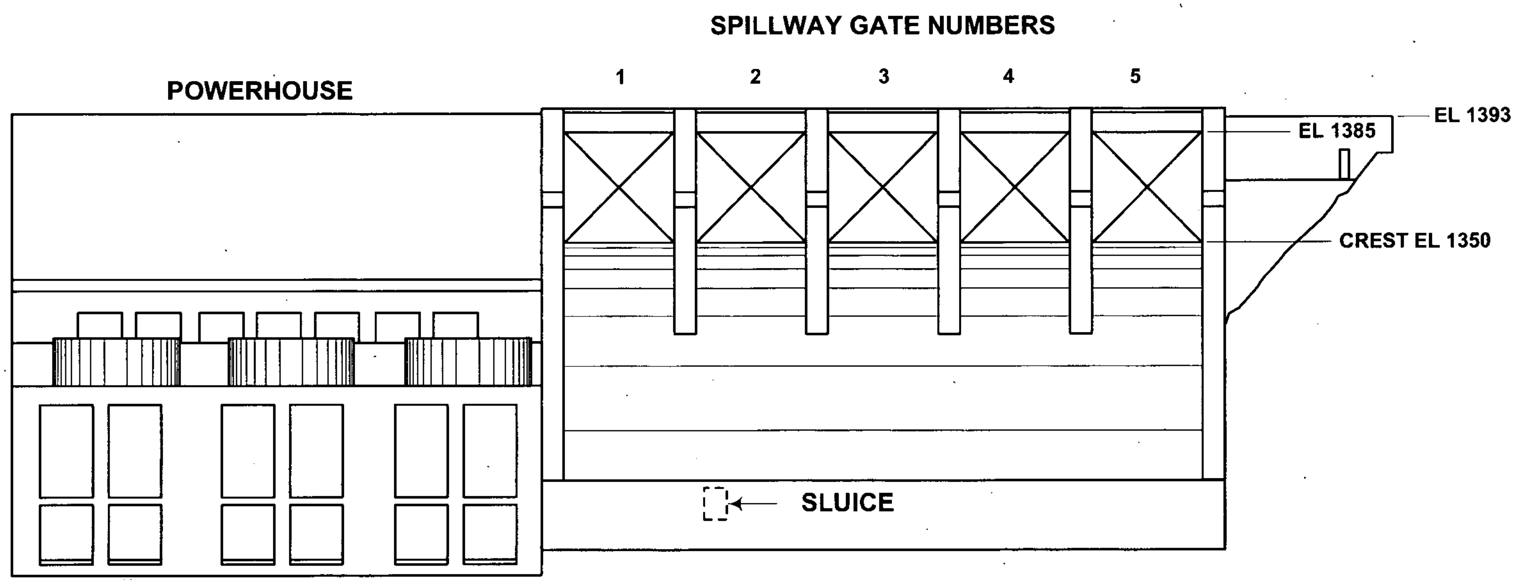
Example 6 -- Suppose the operating records show that the headwater is at elevation 1371.15 feet and gate arrangement 58 is in use. The headwater is found on page 13, which is marked "Headwater 1371 to 1373." The elevation given is exactly halfway between elevation 1371.1 feet and 1371.2 feet. The larger value, 1371.2 feet, should be used. In the column headed 1371.2 opposite gate arrangement 58, the discharge is found to be 25,110 cubic feet per second.

Attachment 2-7



BOONE DAM

# LOCATION OF SPILLWAY GATES AND SLUICE GATE




DOWNSTREAM ELEVATION

BOONE DAM

# SPILLWAY GATE ARRANGEMENTS

## TABLE 1

| Arrangement Number | Gate Number 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | - | - | - | 1.5 | 1.5 |
| 2 | - | - | 1.5 | 1.5 | 1.5 |
| 3 | - | 1.5 | 1.5 | 1.5 | 1.5 |
| 4 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| 5 | - | - | - | 2 | 2 |
| 6 | - | - | 2 | 2 | 2 |
| 7 | - | 2 | 2 | 2 | 2 |
| 8 | 2 | 2 | 2 | 2 | 2 |
| 9 | - | - | - | 2.5 | 2.5 |
| 10 | - | - | 2.5 | 2.5 | 2.5 |
| 11 | - | 2.5 | 2.5 | 2.5 | 2.5 |
| 12 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| 13 | - | - | - | 3 | 3 |
| 14 | - | - | 3 | 3 | 3 |
| 15 | - | 3 | 3 | 3 | 3 |
| 16 | 3 | 3 | 3 | 3 | 3 |
| 17 | - | - | - | 3.5 | 3.5 |
| 18 | - | - | 3.5 | 3.5 | 3.5 |
| 19 | - | 3.5 | 3.5 | 3.5 | 3.5 |
| 20 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| 21 | - | - | - | 4 | 4 |
| 22 | - | - | 4 | 4 | 4 |
| 23 | - | 4 | 4 | 4 | 4 |
| 24 | 4 | 4 | 4 | 4 | 4 |

## TABLE 2

| Arrangement Number | Gate Number 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 25 | 1.5 | 1.5 | 1.5 | 1.5 | 2 |
| 26 | 1.5 | 1.5 | 1.5 | 2 | 2 |
| 27 | 1.5 | 1.5 | 2 | 2 | 2 |
| 28 | 1.5 | 2 | 2 | 2 | 2 |
| 29 | 2 | 2 | 2 | 2 | 2 |
| 30 | 2 | 2 | 2 | 2 | 2.5 |
| 31 | 2 | 2 | 2 | 2.5 | 2.5 |
| 32 | 2 | 2 | 2.5 | 2.5 | 2.5 |
| 33 | 2 | 2.5 | 2.5 | 2.5 | 2.5 |
| 34 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| 35 | 2.5 | 2.5 | 2.5 | 2.5 | 3 |
| 36 | 2.5 | 2.5 | 2.5 | 3 | 3 |
| 37 | 2.5 | 2.5 | 3 | 3 | 3 |
| 38 | 2.5 | 3 | 3 | 3 | 3 |
| 39 | 3 | 3 | 3 | 3 | 3 |
| 40 | 3 | 3 | 3 | 3 | 3.5 |
| 41 | 3 | 3 | 3 | 3.5 | 3.5 |
| 42 | 3 | 3 | 3.5 | 3.5 | 3.5 |
| 43 | 3 | 3.5 | 3.5 | 3.5 | 3.5 |
| 44 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| 45 | 3.5 | 3.5 | 3.5 | 3.5 | 4 |
| 46 | 3.5 | 3.5 | 3.5 | 4 | 4 |
| 47 | 3.5 | 3.5 | 4 | 4 | 4 |
| 48 | 3.5 | 4 | 4 | 4 | 4 |
| 49 | 4 | 4 | 4 | 4 | 4 |
| 50 | 4 | 4 | 4 | 4 | 5 |
| 51 | 4 | 4 | 4 | 5 | 5 |
| 52 | 4 | 4 | 5 | 5 | 5 |
| 53 | 4 | 5 | 5 | 5 | 5 |
| 54 | 5 | 5 | 5 | 5 | 5 |
| 55 | 5 | 5 | 5 | 5 | 6.5 |
| 56 | 5 | 5 | 5 | 6.5 | 6.5 |
| 57 | 5 | 5 | 6.5 | 6.5 | 6.5 |
| 58 | 5 | 6.5 | 6.5 | 6.5 | 6.5 |
| 59 | 6.5 | 6.5 | 6.5 | 6.5 | 6.5 |

| Arrangement Number | Gate Number 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 60 | 6.5 | 6.5 | 6.5 | 6.5 | 8 |
| 61 | 6.5 | 6.5 | 6.5 | 8 | 8 |
| 62 | 6.5 | 6.5 | 8 | 8 | 8 |
| 63 | 6.5 | 8 | 8 | 8 | 8 |
| 64 | 8 | 8 | 8 | 8 | 8 |
| 65 | 8 | 8 | 8 | 8 | 10 |
| 66 | 8 | 8 | 8 | 10 | 10 |
| 67 | 8 | 8 | 10 | 10 | 10 |
| 68 | 8 | 10 | 10 | 10 | 10 |
| 69 | 10 | 10 | 10 | 10 | 10 |
| 70 | 10 | 10 | 10 | 10 | 13 |
| 71 | 10 | 10 | 10 | 13 | 13 |
| 72 | 10 | 10 | 13 | 13 | 13 |
| 73 | 10 | 13 | 13 | 13 | 13 |
| 74 | 13 | 13 | 13 | 13 | 13 |
| 75 | 13 | 13 | 13 | 13 | 17 |
| 76 | 13 | 13 | 13 | 17 | 17 |
| 77 | 13 | 13 | 17 | 17 | 17 |
| 78 | 13 | 17 | 17 | 17 | 17 |
| 79 | 17 | 17 | 17 | 17 | 17 |
| 80 | 17 | 17 | 17 | 17 | 21 |
| 81 | 17 | 17 | 17 | 21 | 21 |
| 82 | 17 | 17 | 21 | 21 | 21 |
| 83 | 17 | 21 | 21 | 21 | 21 |
| 84 | 21 | 21 | 21 | 21 | 21 |
| 85 | 21 | 21 | 21 | 21 | 25 |
| 86 | 21 | 21 | 21 | 25 | 25 |
| 87 | 21 | 21 | 25 | 25 | 25 |
| 88 | 21 | 25 | 25 | 25 | 25 |
| 89 | 25 | 25 | 25 | 25 | 25 |
| 90 | 25 | 25 | 25 | 25 | 31 |
| 91 | 25 | 25 | 25 | 31 | 31 |
| 92 | 25 | 25 | 31 | 31 | 31 |
| 93 | 25 | 31 | 31 | 31 | 31 |
| 94 | 31 | 31 | 31 | 31 | 31 |

GATE OPENINGS

Figures in columns under each gate number refer to gate opening indicator reading
dash (-) indicates closed gate

# INSTRUCTIONS FOR USE OF TABLES

The sluice should be used to pass all flows up to its maximum capacity. The sluice and spillway must not be operated at the same time. When the required spill discharge exceeds the sluice capacity, the sluice must be shut down and the required discharge passed over the spillway.

**1. Tables Update**

These tables supersede the tables dated February 1953 in the October 1957 issue of the Sluice and Spillway Discharge Tables. The tables were revised to reflect the discharge values obtained from SPILLQ, which is a computer code used in TVA software for monitoring spill discharges and determining gate arrangements.

**2. Purpose of Tables**

These tables provide a means of setting up or determining the discharge through the sluice in Boone Dam. They give the discharge in cubic feet per second when the headwater elevation and sluice gate opening are known. The discharges are based on discharge measurements taken at the bridge downstream from the dam, and on pressure measurements taken from the upstream sluice gate bypass line for each one-half foot of gate opening.

**3. Range of Tables**

The tables cover a discharge range from 0 to 3,830 cubic feet per second. Headwater elevations range from 1325 feet to 1385 feet. Sluice gate openings range from 0.2 feet to the maximum opening of 10 feet.

**4. Arrangement of Tables**

The sluice discharge tables show discharges in cubic feet per second for each foot of headwater elevation. The headwater range is shown at the bottom of each page. Gate opening positions ranging from 0.2 feet to 10 feet in 0.1-foot increments are listed in the left and right columns.

Discharges are recorded to the nearest 5 cubic feet per second for discharges less than 100 cubic feet per second and to the nearest 10 cubic feet per second for discharges greater than 100 cubic feet per second. Because the accuracy of the field measurements does not warrant greater refinement, <u>there should be no interpolation between values given in these tables</u>.

**5. Gate Opening Indicator**

A pointer and scale attached to the gate lifting mechanism indicates the gate opening. The indicator must read zero when the gate is closed for these tables to be accurate.

**6. Use of Tables**

Discharges should be taken from the tables for the tabulated values nearest to those observed. For example, if the headwater elevation is 1343.76 feet and the gate is open 8.4 feet, the discharge is found on page 34 in the column headed 1344 opposite the gate opening of 8.4 feet, or 2720 cubic feet per second.

When the actual headwater elevation is exactly halfway between tabular values, the larger value should be used in determining the discharge.

**Appendix A: Hydrostatic Loads on the Spillway Tainter Gates**

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

**A1 References**

A1. "Watts Bar Dam – Flood and Earthquake Analysis on Radial Spillway Gates, pages 76-100" Tennessee Valley Authority, HEPE3WBHSQN-WBNBLNBFN.

**A2. Calculations**

Reference B1 evaluates the structural capacity of the radial spillway gates at Watts Bar Dam. This reference was used as a basis for evaluating the margin between the forces on the closed gates ($FR_{closed}$) when the headwater elevation is at the top of the gate (1385 feet) and when the gates are completely open ($FR_{open}$) and the headwater elevation is at 1408.5 feet at Boone Dam. The margin is defined as the ration of $FR_{open}$ to $FR_{closed}$. The calculation of these forces and the results of this comparison are shown in Figure A1.

Comparison of forces when gates are closed and HW is at 1385 feet (top of gate) vs. when gates are fully open and HW at an elevation of 1408.50 feet.

| Attribute | Symbol | Value |
|---|---|---|
| top elev | Zo | 1385 |
| trun elev | Ztr | 1363 |
| sill elev | Zsill | 1349.41 |
| radius | R | 36 |
| length | L | 35 |
| angle up | α2 | 37.67 |
| angle lwr | α | 22.18 |
| angle tot | θ | 59.85 |
| area of lower slice | Aslice1 | 676.88 |
| proj area | AProjected | 1245.65 |
| Desgn LdH | FRx | 1383179.73 |
| Result elv | Z1 | 1361.27 |
| Result ang deg | | 2.75 |
| Result ang rad | | 0.05 |
| Result Dsgn | Horiz | 1381587.84 |
| Area slice upper | Aslice2 | 426.04 |
| Area triangle | Atriangle | 313.45 |
| project vert | x1 | 7.50 |
| vert weight water | FRy | 114685.91 |
| Resultant load - Gates Closed | $FR_{closed}$ | **1387926.15** |
| | | |
| vert open fm calc | calc App A | 31.54 |
| max hw | calc | 1408.50 |
| lwr lip elev | Z2 | 1380.95 |
| bot angle | α3 | 29.91 |
| top elev | Zo | 1399.00 |
| project area for h ld | AProjected | 631.74 |
| Flood LdH | FRx | 730271.01 |
| Height over gate | y1 | 9.50 |
| Height ratio to orig | | 1.66 |
| project vert | x2 | 31.05 |
| Flood LdV1 | | 644310.00 |
| Flood ILdV2 | | 357525.12 |
| Total Flood LdV | FRy | 1001835.12 |
| Resultant load - Gates Fully Open | $FR_{open}$ | **1239745.68** |
| | | |
| Margin | $FR_{open}/FR_{closed}$ | **0.89** |

Figure A1: Boone Spillway Gate Margin Evaluation

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

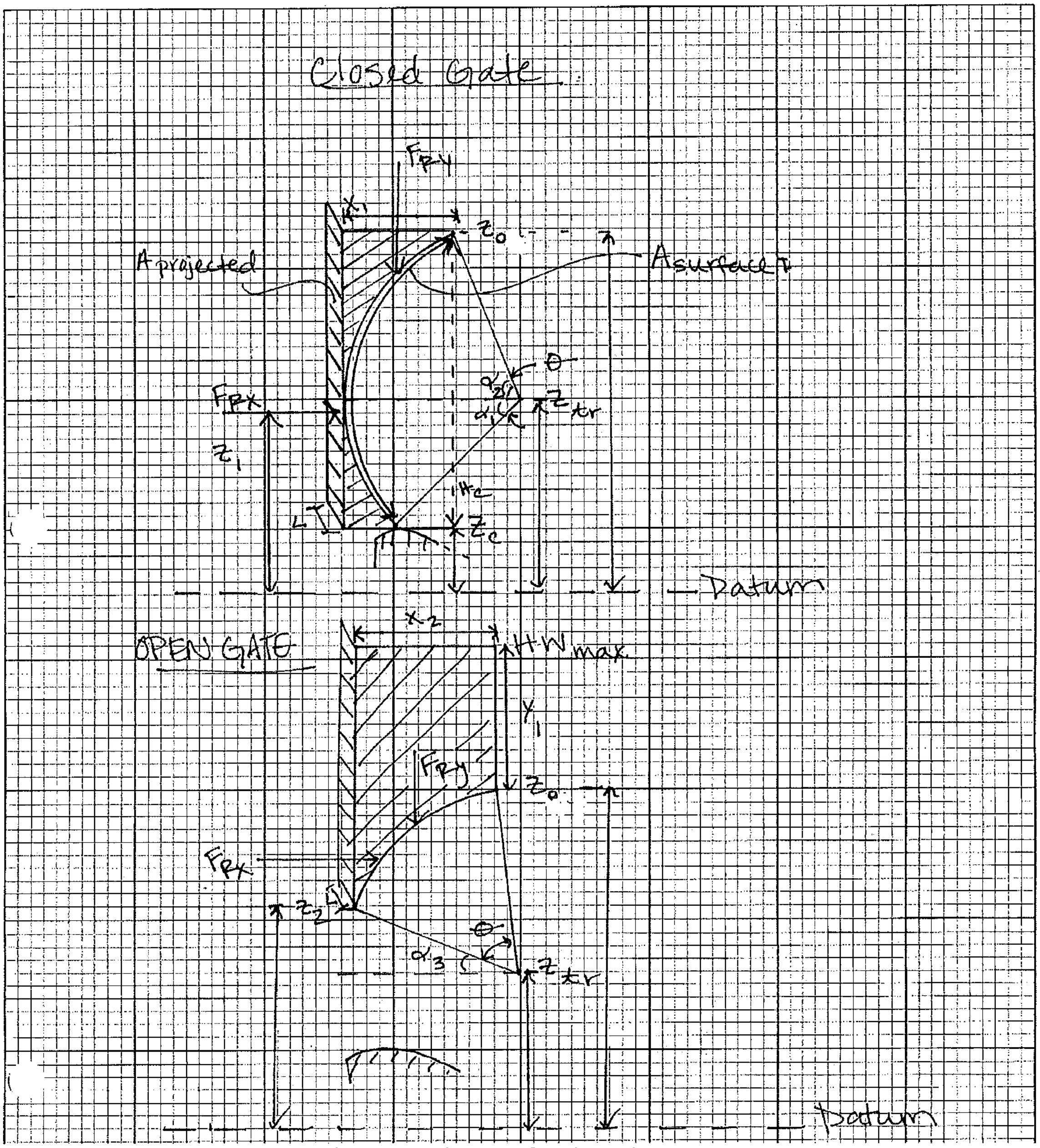
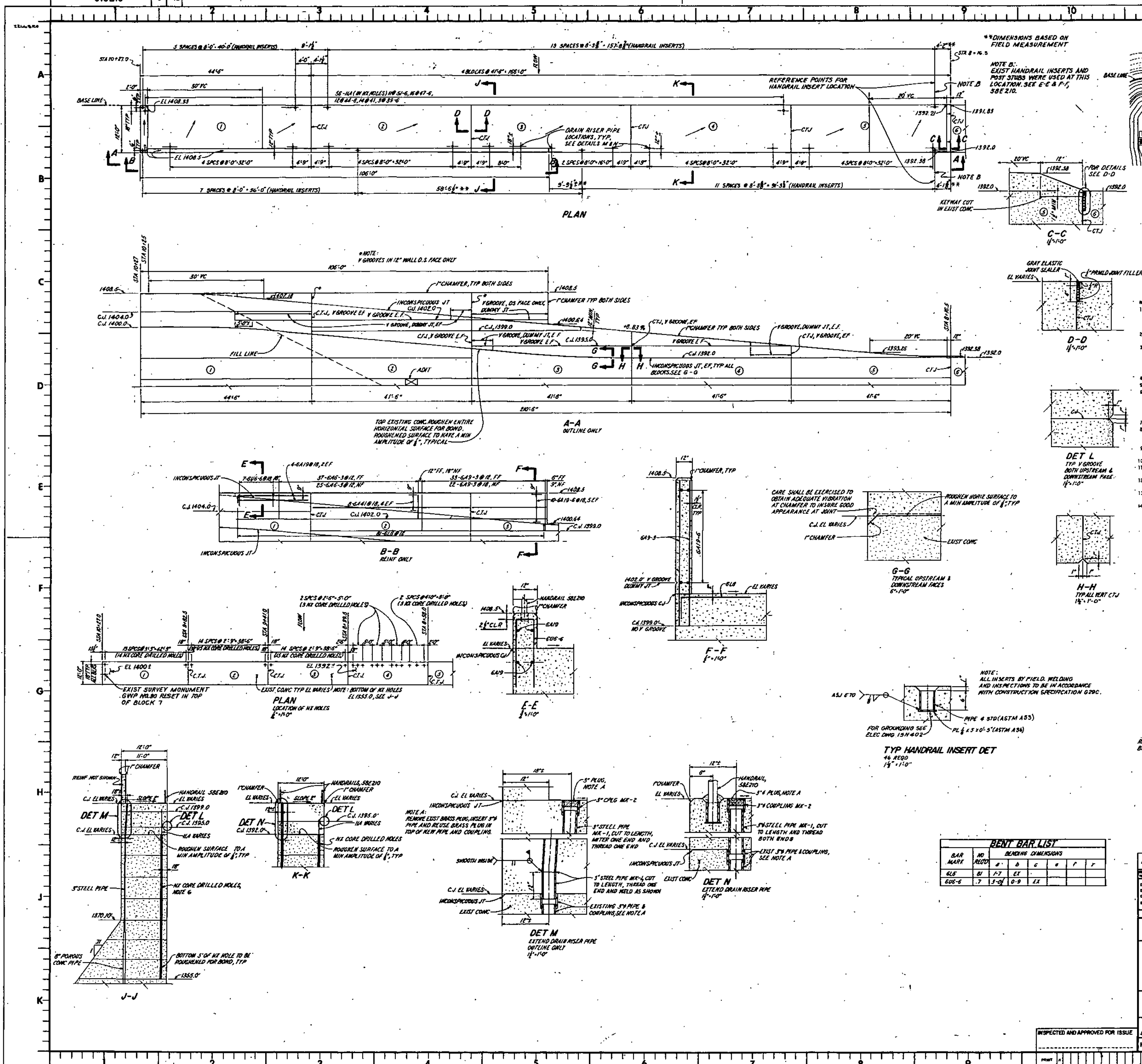



Figure A2: Diagram of Hydrostatic Forces




NOTES:

1. CONCRETE SHALL BE PLACED IN ACCORDANCE WITH GENERAL CONSTRUCTION SPECIFICATION G-2. CONCRETE SHALL BE CLASS 300.5 AFM EXCEPT CLASS 300.75 AFM SHALL BE USED IN THE 12-INCH WALL ON BLOCKS 1, 2 AND 3. THE MAXIMUM PLACING TEMPERATURE OF CONCRETE SHALL BE 75°F.
2. MINIMUM EXPOSURE TIME BEFORE PLACING ONE LIFT UPON ANOTHER OR ONE POUR ADJACENT TO ANOTHER SHALL BE 3 DAYS.
3. FORMWORK SHALL BE IN ACCORDANCE WITH GENERAL CONSTRUCTION SPECIFICATION G-8. ALL EXPOSED CONCRETE SURFACES SHALL HAVE A SMOOTH FORM FINISH. ALL OTHER SURFACES MAY HAVE A ROUGH FORM FINISH. PRACTICAL MEASURES SHALL BE TAKEN IN FINISHING EXPOSED SURFACES TO MATCH THE EXISTING CONCRETE FINISH.
4. A METAL FLOAT AND BROOM FINISH SHALL BE USED ON EXPOSED TOP SURFACES.
5. CHAMFER ALL EXPOSED EDGES 1" UNLESS OTHERWISE NOTED.
6. HOLES FOR DOWELS ARE TO BE CLEAN AND FREE OF WATER BEFORE FILLING WITH SAND-CEMENT GROUT. THE DOWEL IS TO BE FORCED INTO GROUT TO BOTTOM OF HOLE AND SHAKEN AND WORKED TO INSURE GOOD BOND BETWEEN GROUT AND BAR AND BETWEEN GROUT AND CONCRETE. SAND-CEMENT GROUT SHALL CONFORM TO GENERAL CONSTRUCTION SPECIFICATION G-32, SECT. 2.5.
7. ALL MARK NUMBERS ON THIS DRAWING TO HAVE PREFIX 21E210.
8. EXISTING HANDRAILING IS TO BE REMOVED AND NEW HANDRAILING INSTALLED. THE EXISTING FENCE BARRIER IS TO BE REMOVED AND REINSTALLED AFTER CONCRETE WORK IS FINISHED.
9. ALL DRAIN RISER PIPE EXTENSIONS SHOULD BE SOUNDED AFTER INSTALLATION TO BE SURE THEY ARE CLEAR OF DEBRIS.
10. FOR EMBEDDED CONDUITS AND GROUNDING SEE ELECTRICAL DRAWINGS.
11. ALL REINFORCING STEEL SHALL CONFORM TO ASTM SPECIFICATION A-615, GRADE 60.
12. COVER DIMENSIONS SHOWN ARE TO BE CLEAR COVER. ALL OTHER DIMENSIONS ARE TO CENTERLINE OF REINFORCEMENT.
13. WELDING OF OR TO HIGH-STRENGTH REINFORCING BARS WITHOUT APPROVAL OF HYDRO DESIGN PROJECTS IS PROHIBITED.
14. FOR DESIGN COMPUTATIONS FOR RAISING TOP OF NONOVERFLOW DAM, SEE RIMS ACCESSION NUMBER B66 '861001002 (RAISING EMBANKMENT & RIGHT NONOVERFLOW FOR PMF, SERVICE BAY & EMBANKMENT SLOPE PROTECTION SLABS).

**BENT BAR LIST**

| BAR MARK | NO REQD | BENDING DIMENSIONS a | b | c | e | f | r |
|---|---|---|---|---|---|---|---|
| 6L6 | 81 | 1-7 | EX | | | | |
| 6U6-6 | 7 | 3-0 | 0-9 | EX | | | |

1 FINAL FIELD REVISIONS 10-7-86

DRAWN M.E. NOEL
TRACED J.A. TALLEY
CHECKED E.L. TODD 12-7-83
SUPV E.L. TODD
ENGINEER Russell D. Myers

SCALE: 1/8" = 1'-0" EXCEPT AS NOTED

NONOVERFLOW DAM

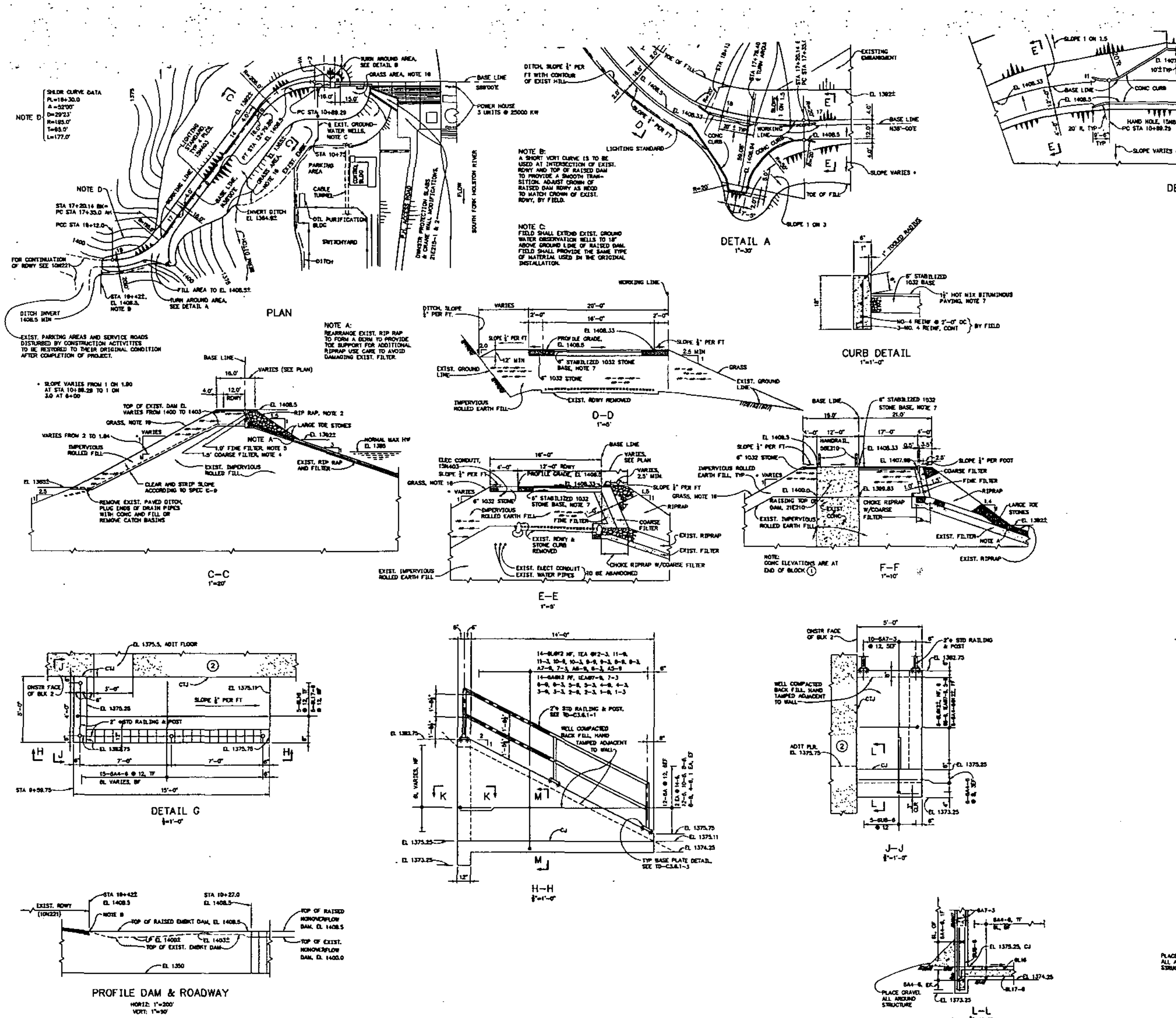
# CONCRETE
# RAISING TOP OF DAM-BLKS 1 THRU 5
# OUTLINE AND REINFORCEMENT

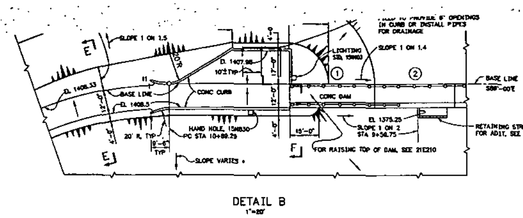
BOONE PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED Russell D. Myers | RECOMMENDED | APPROVED

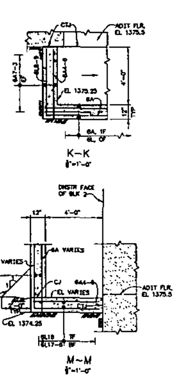
INSPECTED AND APPROVED FOR ISSUE

KNOXVILLE 12-6-83 31 C 21E210 R1




| BENT BAR LIST | | | | | | | |
|---|---|---|---|---|---|---|---|
| BAR MARK | NO. REQD | BENDING DIMENSIONS | | | | | |
| | | A | B | C | E | F | R |
| 6L17-6 | 6 | 14-7½ | EX | | | | |
| 6L16 | 6 | 14-7½ | EX | | | | |
| 6L12-3 | 1 | 7-10 | EX | | | | |
| 6L11-9 | 1 | 7-4 | EX | | | | |
| 6L11-3 | 1 | 6-10 | EX | | | | |
| 6L10-9 | 1 | 6-4 | EX | | | | |
| 6L10-3 | 1 | 5-10 | EX | | | | |
| 6L9-9 | 1 | 5-4 | EX | | | | |
| 6L9-3 | 1 | 4-10 | EX | | | | |
| 6L8-9 | 1 | 4-4 | EX | | | | |
| 6L8-3 | 1 | 3-10 | EX | | | | |
| 6L7-9 | 1 | 4-6¾ | EX | | | | |
| 6LA7-9 | 1 | 3-4 | EX | | | | |
| 6L7-3 | 1 | 2-10 | EX | | | | |
| 6L6-9 | 6 | 4-6¾ | EX | | | | |
| 6LA6-9 | 1 | 2-4 | EX | | | | |
| 6L6-3 | 1 | 1-10 | EX | | | | |
| 6L5-9 | 1 | 4-6¾ | EX | | | | |
| 6LA5-9 | 1 | 1-4 | EX | | | | |
| 6U8-6 | 6 | 4-0 | 0-9 | EX | | | |
| | | | | | | | |




NOTES:

1. ALL EARTHWORK CONSTRUCTION SHALL BE IN ACCORDANCE WITH TVA CONSTRUCTION SPECIFICATION G-9.
2. RIPRAP SHALL CONFORM TO HIGHWAY SPECIFICATION T-1 SECTION 575 AND SHALL BE WELL GRADED WITH 50% OF RIPRAP BY WEIGHT 250-LB STONES OR LARGER. MAXIMUM SIZE STONE SHALL BE 750-LB AND NORE THAN 5% BY WEIGHT SHALL PASS THE 1" SIEVE. THE COLOR OF THE NEW RIPRAP SHALL MATCH THE COLOR OF EXISTING RIPRAP.
3. IMPERVIOUS ROLLED EARTH FILL SHALL BE APPROVED MATERIAL UNIFORMLY COMPACTED TO AT LEAST 95% OF MAXIMUM DRY DENSITY AS DETERMINED BY ASTM D-698 PROCEDURES (STANDARD PROCTOR), DETERMINED BY TVA SOILS LABORATORY, WITH MOISTURE CONTENT OF ± 2% OF OPTIMUM. ROUTINE SAMPLING AND LABORATORY TESTING OF PLACED FILL SHALL BE AS FOLLOWS:

   TWO SAMPLES IN THE FIRST FIVE-FOOT OF FILL PLACED ON THE BERM AND ONE SAMPLE FOR EACH ADDITIONAL FIVE-FOOT OF HEIGHT.

   TEST RESULTS SHALL BE SUBMITTED ON AN INDIVIDUAL BASIS AS SOON AS POSSIBLE.

4. MATERIAL FOR THE COARSE FILTER SHALL BE SOUND AND DURABLE AND SHALL CONFORM TO SPECIFICATION T-1, SECTION 1032, EXCEPT GRADATION SHALL CONFORM TO THE FOLLOWING LIMITS:

PERCENT PASSING BY WEIGHT

| SIEVE SIZE | MINIMUM | MAXIMUM |
|---|---|---|
| 6" | 100 | --- |
| 4" | 90 | 100 |
| 2" | 70 | 90 |
| 1" | 35 | 70 |
| ½" | 20 | 40 |
| NO. 4 | 10 | 25 |
| NO. 8 | 5 | 15 |
| NO. 20 | 0 | 5 |

5. MATERIAL FOR FINE FILTER SHALL BE NATURAL OR MANUFACTURED CONCRETE SAND CONFORMING TO ASTM DESIGN. C-33. GRADATION SHALL CONFORM TO THE FOLLOWING LIMITS:

PERCENT PASSING BY WEIGHT

| SIEVE SIZE | MINIMUM | MAXIMUM |
|---|---|---|
| ⅜" | 100 | --- |
| NO. 4 | 85 | 100 |
| NO. 8 | 80 | 100 |
| NO. 16 | 50 | 85 |
| NO. 30 | 25 | 60 |
| NO. 50 | 10 | 30 |
| NO. 100 | 2 | 10 |

6. PRIOR TO RAISING TOP OF DAM, REMOVE APPURTENANCES OR UTILITIES AS NECESSARY AND FILL ANY TRENCHES OR HOLES WITH WELL COMPACTED FILL.
7. SURFACING OF ROADWAY ON DAM AND TURN AROUND AREAS IS TO CONSIST OF A-6" STABILIZED BASE, A 1½" HOT MIX BITUMINOUS SURFACE COARSE IN ACCORDANCE WITH SECTIONS 225 AND 345 OF THE T-1 HIGHWAY SPECIFICATIONS.
8. CONCRETE CONSTRUCTION SHALL BE IN ACCORDANCE WITH GENERAL CONSTRUCTION SPECIFICATION G-2. CONCRETE CLASS SHALL BE 301.5 AFW. THE MAX PLACING TEMPERATURE SHALL BE 75° F.
9. CHAMFER ALL EXPOSED EDGES ¾ INCH UNLESS OTHERWISE NOTED.
10. FORM WORK SHALL BE IN ACCORDANCE WITH GENERAL CONSTRUCTION SPECIFICATION G-8. ALL EXPOSED CONCRETE SURFACES SHALL HAVE A SMOOTH FORM FINISH. ALL FORM JOINTS TO BE WATERTIGHT.
11. ALL REINFORCING ON THIS DRAWING SHALL CONFORM TO ASTM SPECIFICATION A615, GRADE 60.
12. CLEAR COVER BETWEEN FACE OF CONCRETE AND NEAREST REINFORCING STEEL SHALL BE AS FOLLOWS:

    WALLS - 1-½ INCHES

    SLAB

    TOP FACE - 1-½ INCHES
    BOTTOM FACE - 3 INCHES
    ALL OTHER DIMENSIONS ARE TO CENTERLINE OF REINFORCEMENT.

13. WELDING OF OR TO HIGH STRENGTH REINFORCING BARS WITHOUT APPROVAL OF CIVIL ENGINEERING SUPPORT BRANCH IS PROHIBITED.
14. FOR HANDRAIL NOTES SEE 58E210.
15. EXCAVATION AND RESTORATION OF ALL BORROW AREAS SHALL BE IN ACCORDANCE WITH GENERAL CONSTRUCTION SPECIFICATIONS G-9 AND T-1. AREAS TO BE SEEDED AND GRASSED WITH TYPE 8, MIXTURE 8.
16. THE DAM SLOPE SHALL BE SOLID SODDED WITH EMERALD ZOYSIA. THE SLOPE SHALL HAVE A MINIMUM OF 2 INCHES OF CLEAN TOPSOIL UNIFORMLY PLACED ON THE SLOPE. ALL GROUND PREPARATION AND PLANTING SHALL CONFORM TO T-1 SPECIFICATION (SECTION 561-2 THROUGH 561-11). SODDING SHALL BE DONE IN THE SPRING WHEN WEATHER AND SOIL CONDITIONS ARE FAVORABLE IF POSSIBLE. SOD IS TO BE WATERED WHEN NECESSARY DURING THE FIRST SUMMER MONTHS.
17. FOR DESIGN COMPUTATIONS FOR RAISING TOP OF EMBANKMENT DAM SEE RIMS ACCESSION NUMBER B 68 '86 1001 002 (RAISING EMBANKMENT & RIGHT NONOVERFLOW FOR PMF, SERVICE BAY & EMBANKMENT SLOPE PROTECTION SLABS).

REVISION HISTORY

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| R 2 | 10-3-88 | DEW | ELT | ELT | RDM | DLS | GLB |
| FINAL FIELD REVISIONS | | | | | | | |
| R 3 | | SRH/25 | YAN | YAN | YAN | CDW | CDW |
| ELECTRONICALLY RESTORED | | | | | | | |
| R 1 | 4-5-84 | ALM | ELT | ELT | RDM | DLS | GLB |
| ADDED NOTE 16 & REVISION PLAN | | | | | | | |

SCALE: 1"=100' EXCEPT AS NOTED

EMBANKMENT

# RAISING TOP OF DAM
# PLAN, SECTIONS & DETAILS
# AND MISC CONC DETAILS

A.L.M. | J.H.B. | E.L.T. | E.L.T.

BOONE PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

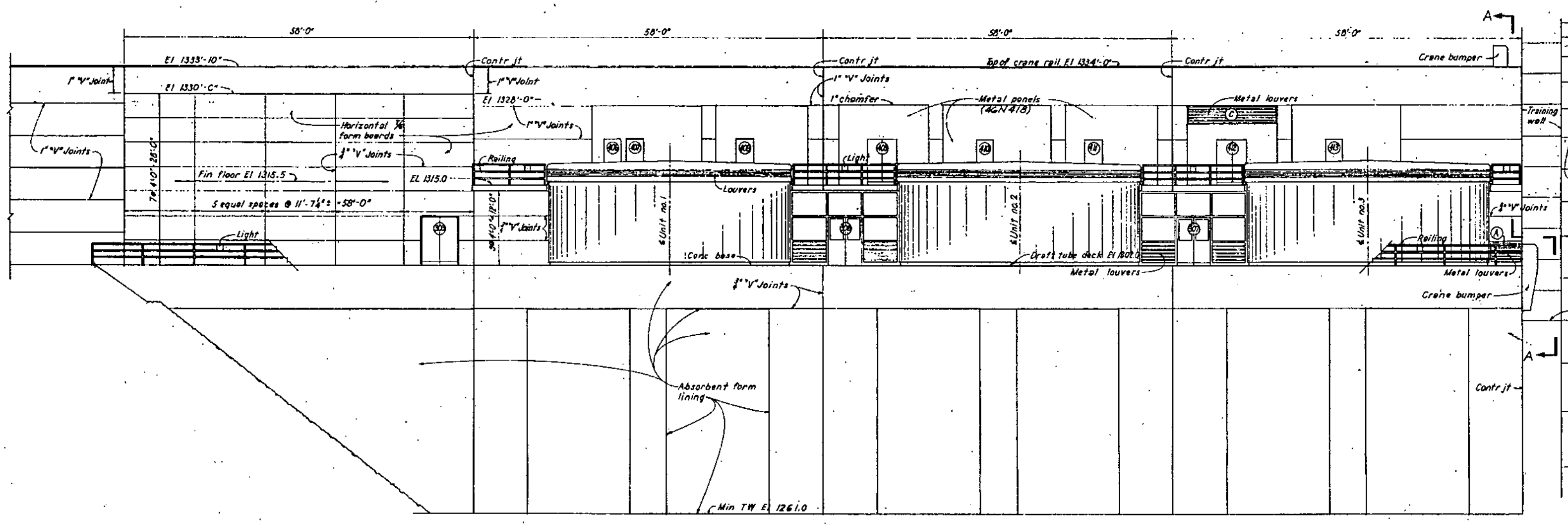
AUTOCAD R00 | 31 | DS | 22E210 | R 3

TASK COMPLETED BY: | REV NO.

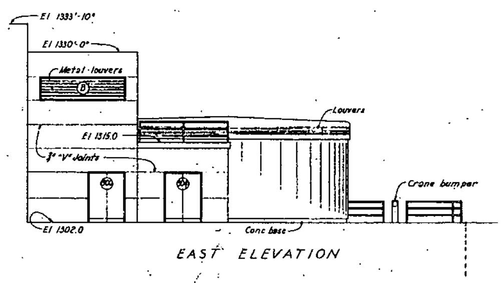
ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES :(22E210 R2)

PLOT FACTOR:1200
W_TVA

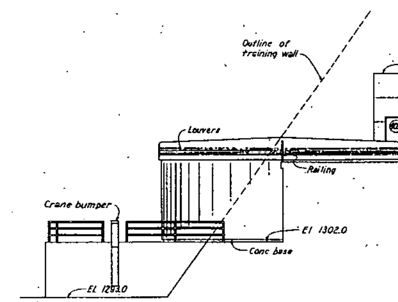
C.A.D. DRAWING
DO NOT ALTER MANUALLY




NORTH ELEVATION




EAST ELEVATION




WEST ELEVATION
(AT SECTION A-A)

NOTE:
Absorbent form lining boards are to run in a vertical direction without horizontal joints between lifts.

Scale 1/8" = 1'-0"

POWERHOUSE

ARCHITECTURAL ELEVATIONS

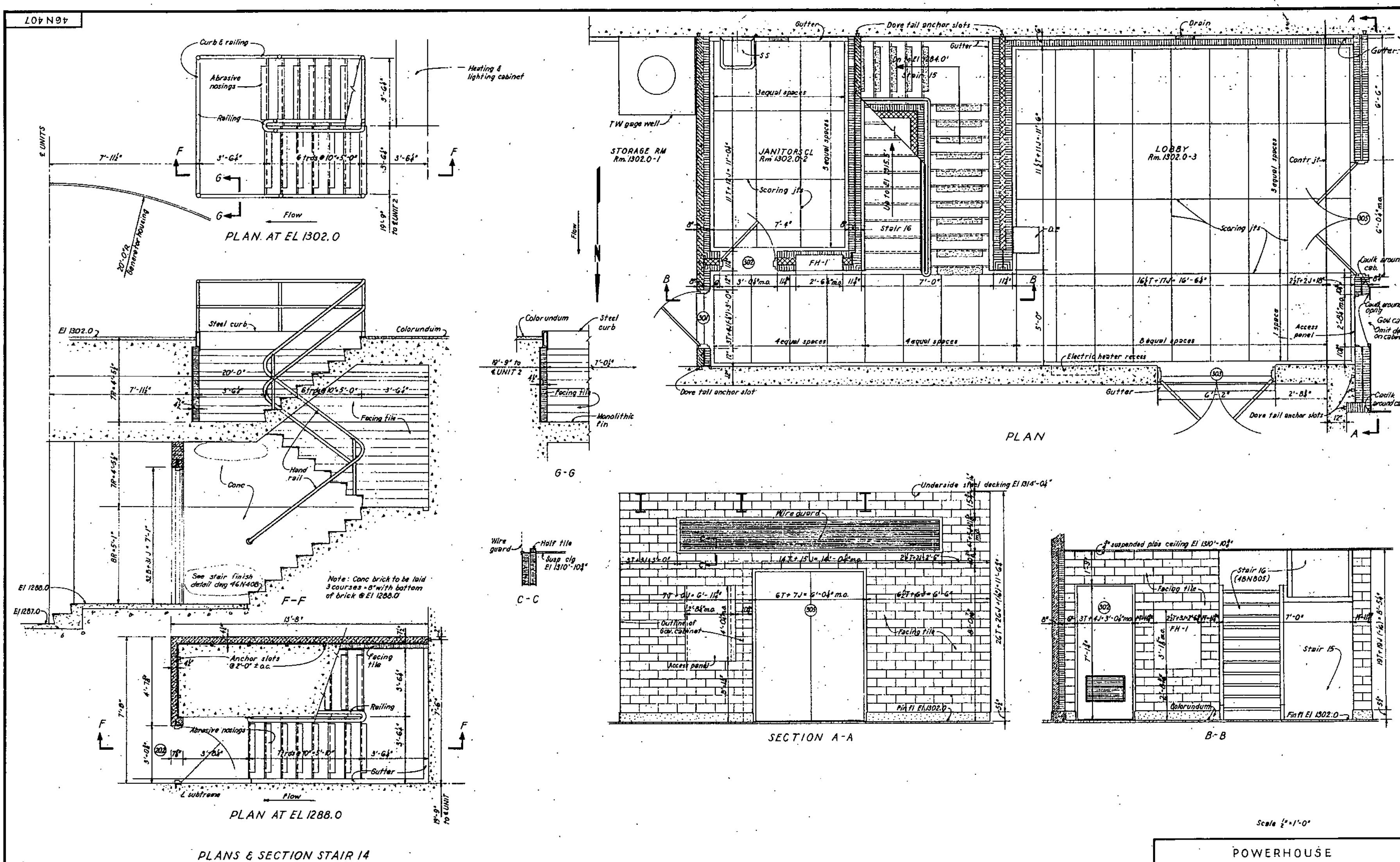
BOONE PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

| SUBMITTED | RECOMMENDED | APPROVED |
|---|---|---|
| [signature] | Harry B. [signature] | R.A. Monroe |

KNOXVILLE | 1-24-52 | 31 | A | 4 | 46N401R2

DRAWING AS CONSTRUCTED 3-2-54

As constructed
Release entire sheet




POWERHOUSE

ARCHITECTURAL
LOBBY EL 1302.0 & STAIR 14
PLAN & ELEVATIONS

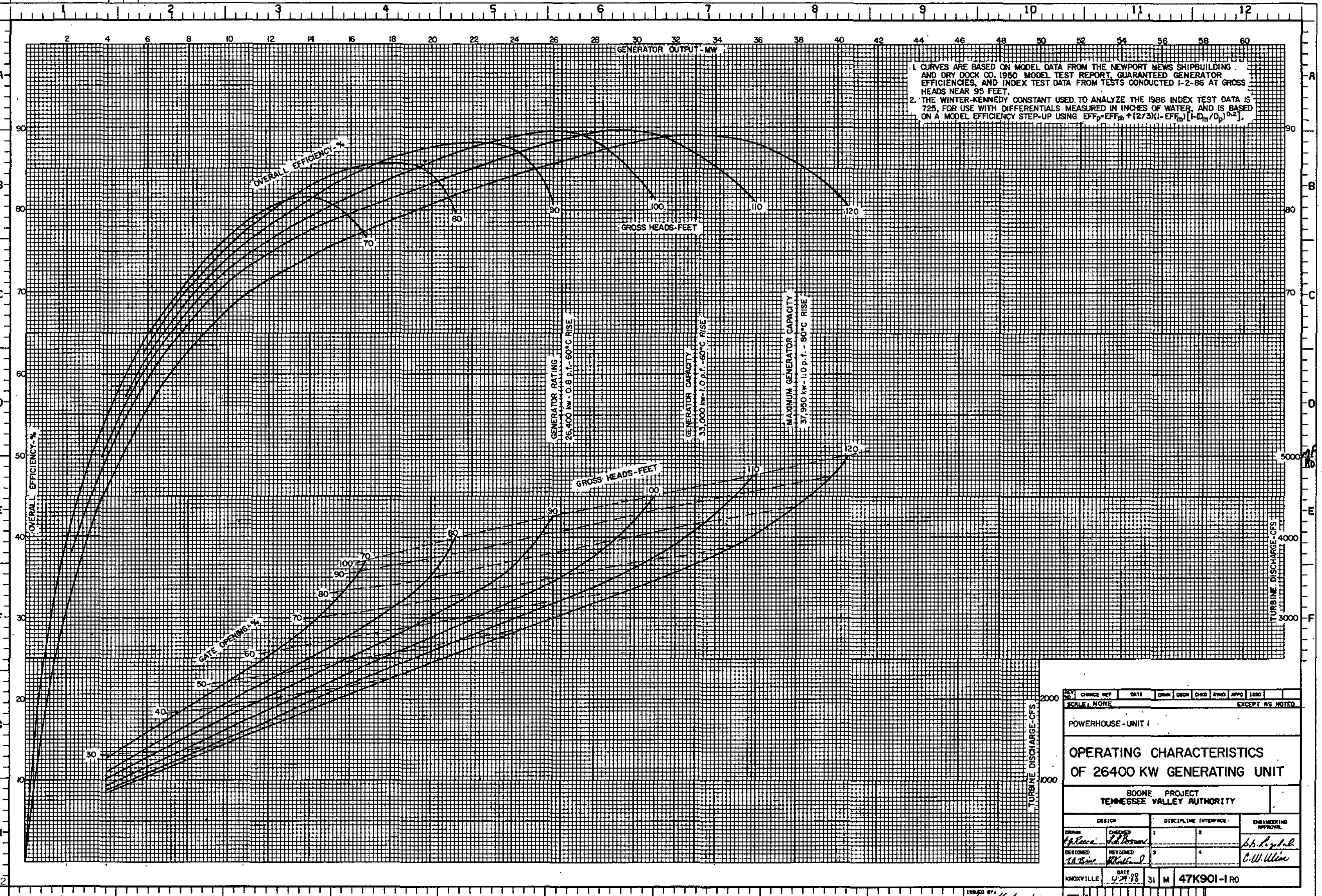
BOONE PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

| SUBMITTED | RECOMMENDED | APPROVED |
|---|---|---|
| [signature] | [signature] | R.A. Monroe |

KNOXVILLE | 1-24-52 | 31 | A | 4 | 46N407 R3

DRAWING AS CONSTRUCTED 3-8-54

Revisions: 3 Final field revisions; 2 Revised per C&B; 1 Added stair 14 details




1. CURVES ARE BASED ON MODEL DATA FROM THE NEWPORT NEWS SHIPBUILDING AND DRY DOCK CO. 1950 MODEL TEST REPORT, GUARANTEED GENERATOR EFFICIENCIES, AND INDEX TEST DATA FROM TESTS CONDUCTED 1-2-86 AT GROSS HEADS NEAR 95 FEET.
2. THE WINTER-KENNEDY CONSTANT USED TO ANALYZE THE 1986 INDEX TEST DATA IS 725, FOR USE WITH DIFFERENTIALS MEASURED IN INCHES OF WATER, AND IS BASED ON A MODEL EFFICIENCY STEP-UP USING $EFF_p = EFF_m + (2/3)(1-EFF_m)[1-(D_m/D_p)^{0.2}]$.

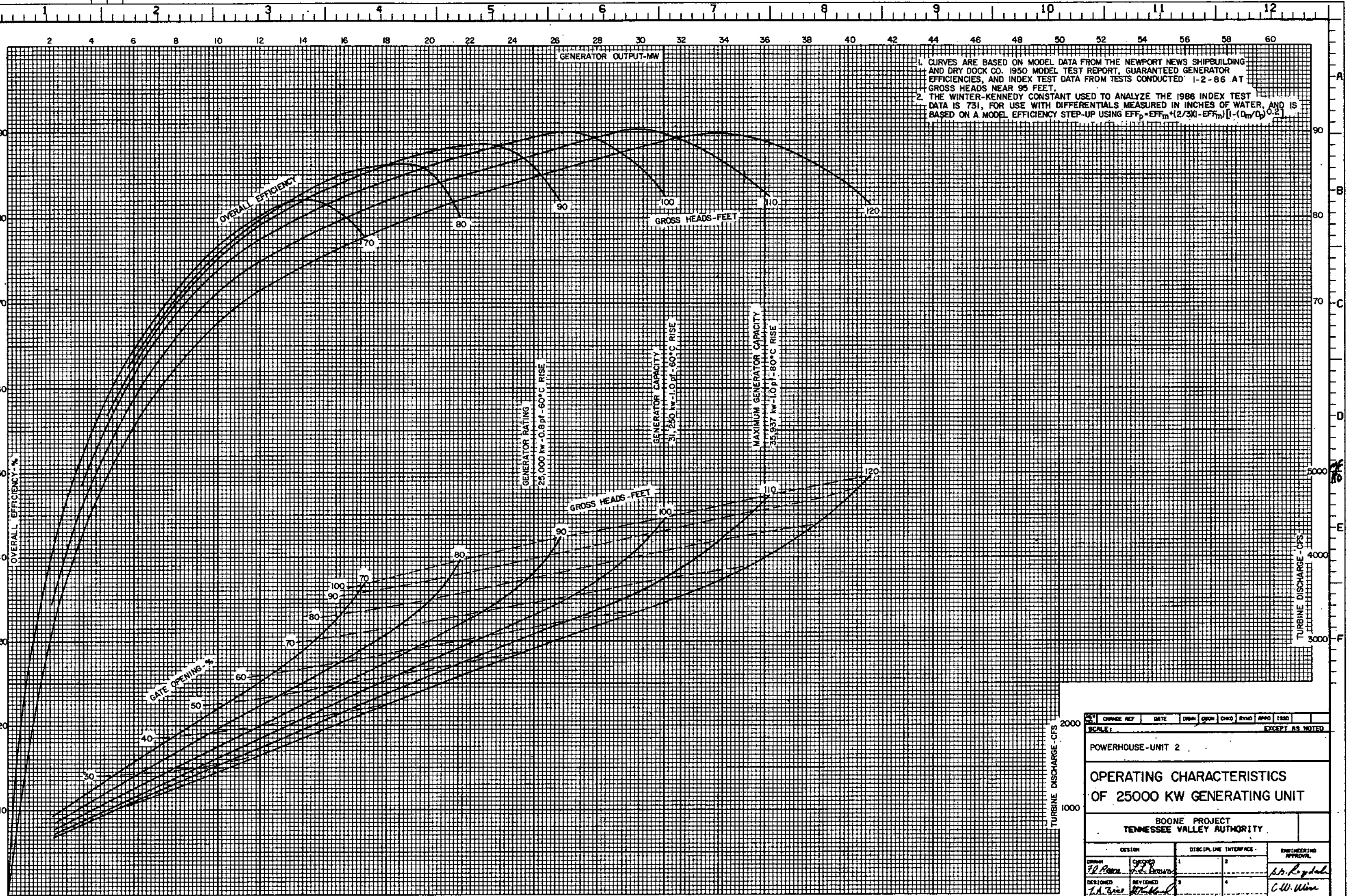
SCALE: NONE EXCEPT AS NOTED

POWERHOUSE - UNIT 1

# OPERATING CHARACTERISTICS OF 26400 KW GENERATING UNIT

BOONE PROJECT
TENNESSEE VALLEY AUTHORITY

KNOXVILLE DATE 4-29-88 31 M 47K901-1 R0




POWERHOUSE-UNIT 2

# OPERATING CHARACTERISTICS OF 25000 KW GENERATING UNIT

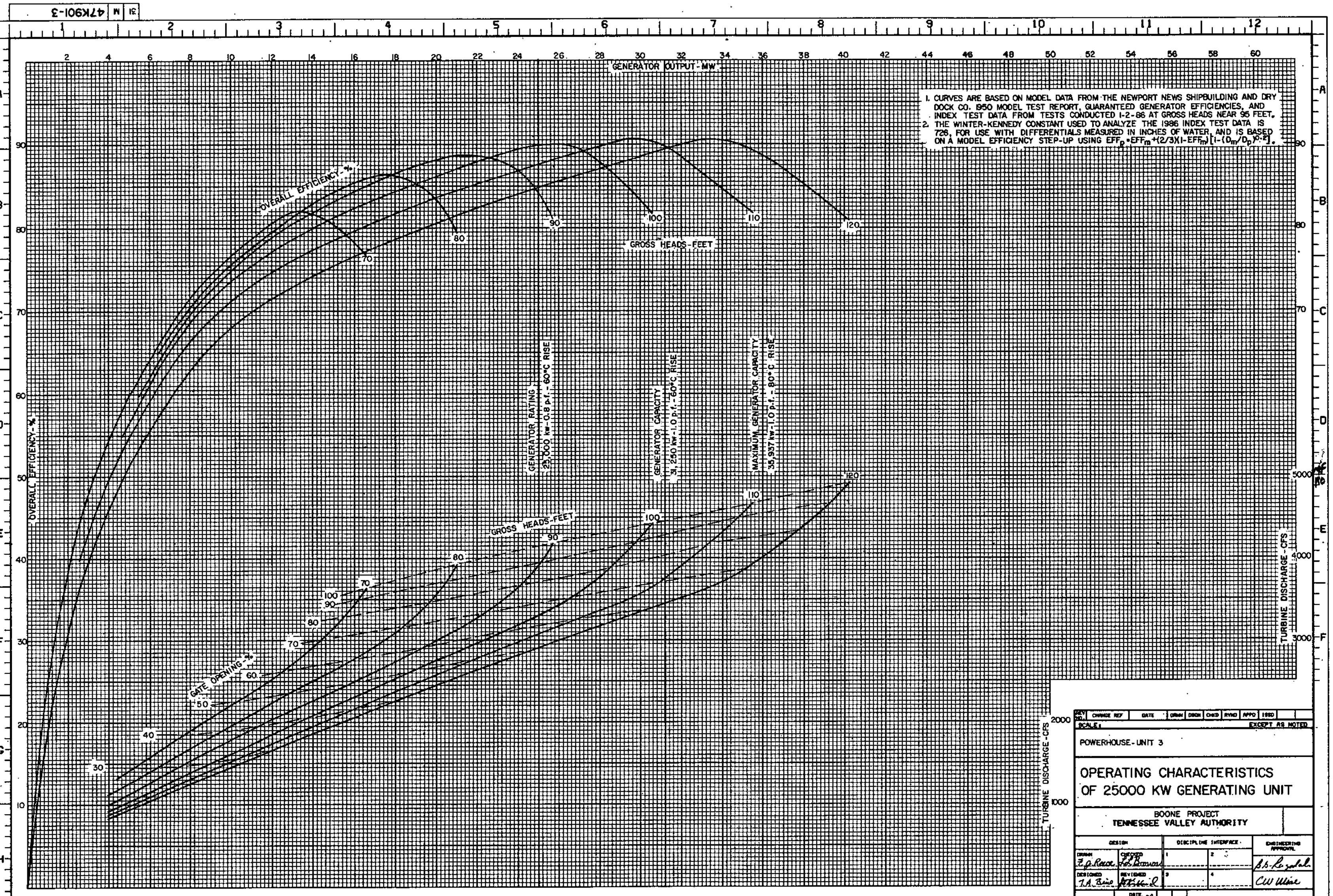
BOONE PROJECT
TENNESSEE VALLEY AUTHORITY

SCALE: EXCEPT AS NOTED

| DESIGN | | DISCIPLINE INTERFACE | | ENGINEERING APPROVAL |
|---|---|---|---|---|
| DRAWN [illegible] | CHECKED [illegible] | 1 | 2 | [illegible] |
| DESIGNED [illegible] | REVIEWED [illegible] | 3 | 4 | C.W. [illegible] |

KNOXVILLE | DATE [illegible] | 31 | M | 47K901-2 R0

MIK052




1. CURVES ARE BASED ON MODEL DATA FROM THE NEWPORT NEWS SHIPBUILDING AND DRY DOCK CO. 1950 MODEL TEST REPORT, GUARANTEED GENERATOR EFFICIENCIES, AND INDEX TEST DATA FROM TESTS CONDUCTED 1-2-86 AT GROSS HEADS NEAR 95 FEET.
2. THE WINTER-KENNEDY CONSTANT USED TO ANALYZE THE 1986 INDEX TEST DATA IS 726, FOR USE WITH DIFFERENTIALS MEASURED IN INCHES OF WATER, AND IS BASED ON A MODEL EFFICIENCY STEP-UP USING $EFF_p = EFF_m + (2/3)(1-EFF_m)[1-(D_m/D_p)^{0.2}]$.

SCALE: EXCEPT AS NOTED

POWERHOUSE-UNIT 3

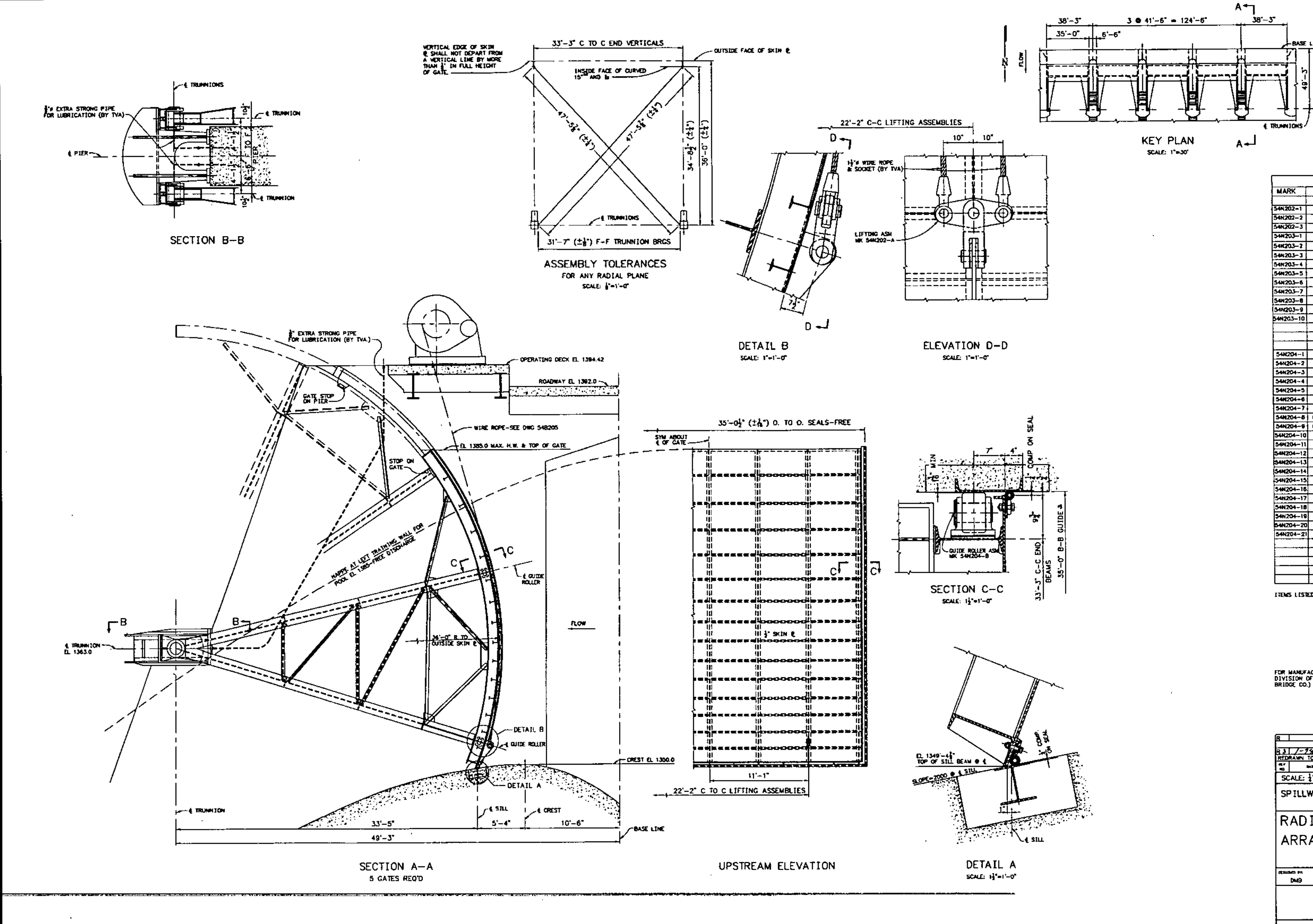
# OPERATING CHARACTERISTICS OF 25000 KW GENERATING UNIT

BOONE PROJECT
TENNESSEE VALLEY AUTHORITY

DRAWN: F. J. Reece CHECKED: [signature]
DESIGNED: T.A. Bire REVIEWED: [signature]
ENGINEERING APPROVAL: [signature] CW Wise

KNOXVILLE DATE 4-27-88 31 M 47K901-3 R0

MIK052




| BILL OF MATERIAL | | | |
|---|---|---|---|
| MARK | DESCRIPTION | NO. REQD | MATERIAL |
| | GATE STRUCTURE | 5 | STR STEEL |
| 54N202-1 | LIFTING BAR | 10 | STEEL FORGING |
| 54N202-2 | CLEVIS | 10 | STEEL FORGING |
| 54N202-3 | PIN & COTTER | 20 | STEEL FORGING |
| 54N203-1 | BOTTOM RUBBER SEAL | 5 | RUBBER |
| 54N203-2 | CORNER RUBBER SEAL | 10 | RUBBER |
| 54N203-3 | SIDE RUBBER SEAL | 5 | RUBBER |
| 54N203-4 | SIDE RUBBER SEAL | 5 | RUBBER |
| 54N203-5 | SEAL BAR | 5 | STEEL |
| 54N203-6 | SEAL BAR | 5 | STEEL |
| 54N203-7 | BOTTOM SEAL BAR | 5 | STEEL |
| 54N203-8 | SEAL BOLT | 1150 | BOLT STEEL |
| 54N203-9 | SEAL BOLT | 550 | BOLT STEEL |
| 54N203-10 | BEVEL WASHER | 550 | STEEL |
| | | | |
| | | | |
| | | | |
| 54N204-1 | GATE TRUNNION BEARING | 10 | STEEL CASTING |
| 54N204-2 | TRUNNION BEARING BUSHING | 10 | BRONZE |
| 54N204-3 | FINISHED BOLTS | 240 | BOLT STEEL |
| 54N204-4 | FIXED TRUNNION BEARING | 10 | STEEL CASTING |
| 54N204-5 | TRUNNION PIN | 10 | STEEL FORGING |
| 54N204-6 | LOCK ℄ | 20 | STEEL |
| 54N204-7 | HEX HD CAP SCRS 1"φx2 1/2" LG | 40 | BRONZE |
| 54N204-8 | FLAT POINT SET SCRS 3/4"φx1 1/4" LG | 40 | BOLT STEEL |
| 54N204-9 | FLAT POINT SET SCRS 3/4"x2 1/4" LG | 60 | BOLT STEEL |
| 54N204-10 | GUIDE ROLLER | 20 | STEEL FORGING |
| 54N204-11 | GUIDE ROLLER BEARING | 20 | STEEL CASTING |
| 54N204-12 | GUIDE ROLLER PIN | 20 | STEEL FORGING |
| 54N204-13 | GUIDE ROLLER BUSHING | 20 | BRONZE & GRAPHITE |
| 54N204-14 | LOCK PLATE | 20 | STEEL |
| 54N204-15 | SHIMS | 20 | STEEL |
| 54N204-16 | FINISHED BOLTS | 80 | STEEL |
| 54N204-17 | DOWEL PINS 1/2"φx3/4" | 120 | STEEL |
| 54N204-18 | DOWEL PIN 1/2"φx1" | 80 | STEEL |
| 54N204-19 | HEX HD CAP SCREW 1/2"φx2 1/2" | 40 | BRONZE |
| 54N204-20 | HEX HD CAP SCREW 1/2"φx1 1/2" | 40 | BRONZE |
| 54N204-21 | MACHINE BOLTS | 120 | BOLT STEEL |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

ITEMS LISTED ABOVE ARE FOR 5 GATES. 5 GATES REQD.

FOR MANUFACTURER'S DETAILS OF RADIAL GATES REFER TO AMERICAN BRIDGE DIVISION OF UNITED STATES STEEL CORPORATION (FORMERLY VIRGINIA BRIDGE CO.) FILE, TVA CONTRACT NO. C-52-13968.

R 3 1-7-99 REDRAWN TO AUTOCAD FORMAT

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

SPILLWAY

# RADIAL GATES ARRANGEMENT

DESIGNED BY: DMB · DRAWN BY: AAL · CHECKED BY: DMB

BOONE PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

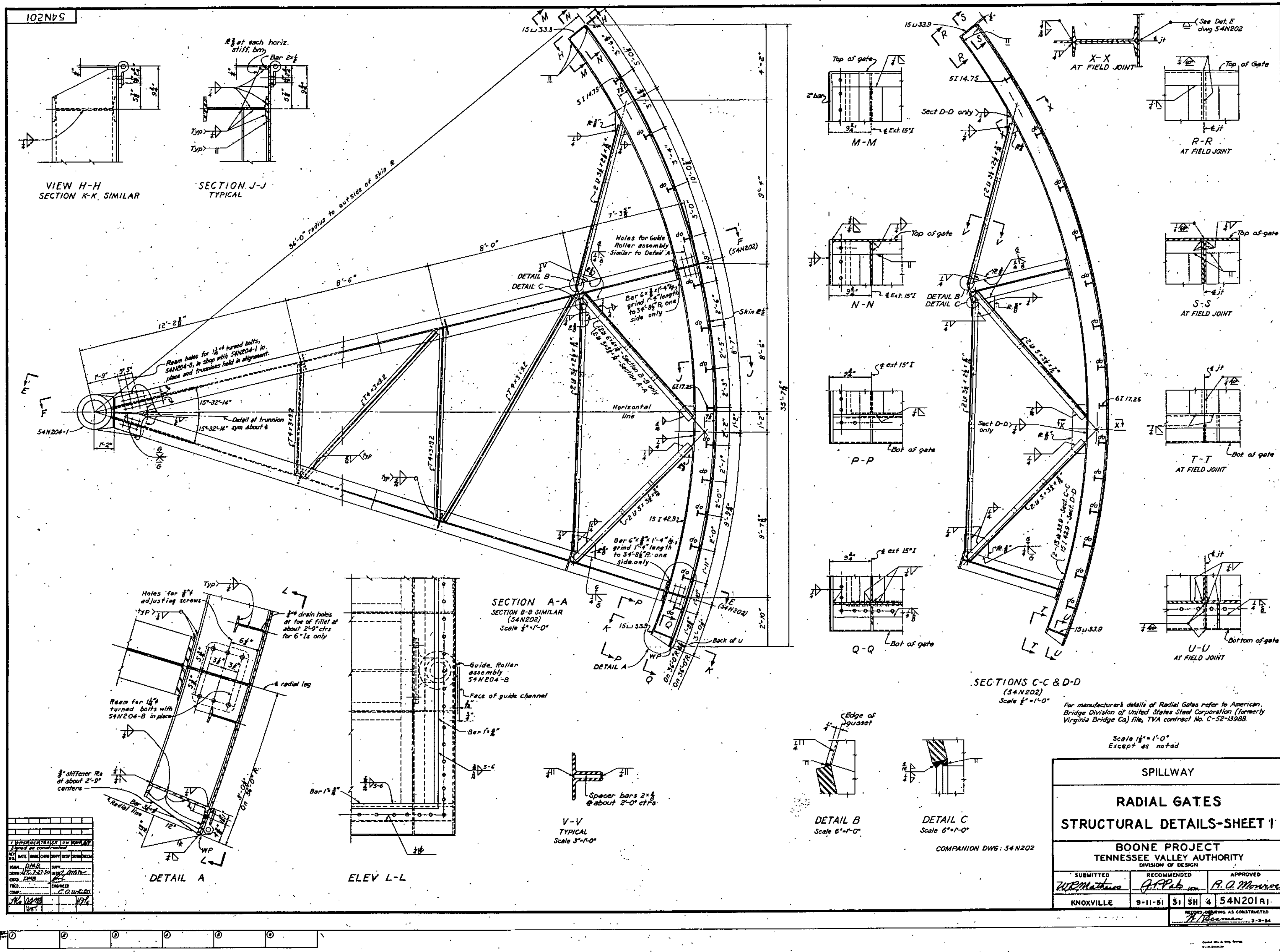
AUTOCAD R14 · DATE 9-11-51 · 31 SH 54W200 · R 3

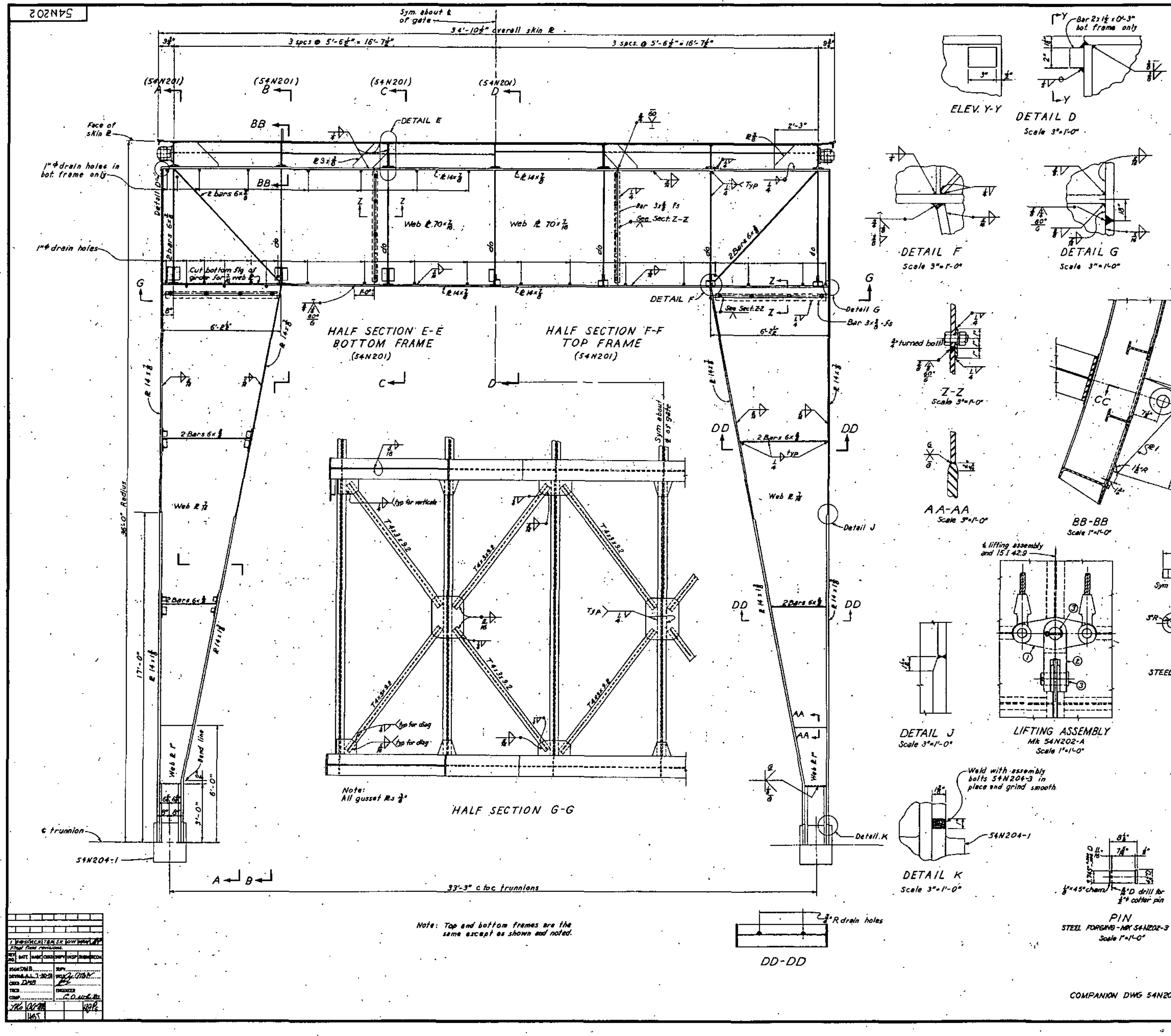
ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES :(54N200 R2)

TASK COMPLETED BY: · REV NO.

PLOT FACTOR:48
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY


54N201
VIEW H-H
SECTION K-K SIMILAR
SECTION J-J
TYPICAL
36'-0" radius to outside of skin R
Holes for Guide Roller assembly Similar to Detail A
DETAIL B
DETAIL C
Horizontal line
Detail at trunnion sym about ℄
SECTION A-A
SECTION B-B SIMILAR
(54N202)
Scale ¼"=1'-0"
DETAIL A
ELEV L-L
Guide Roller assembly 54N204-B
Face of guide channel
V-V
TYPICAL
Scale 3"=1'-0"
Spacer bars 2×⅜ @about 2'-0" ctrs
M-M
N-N
P-P
Q-Q
Top of gate
Bot of gate
X-X
AT FIELD JOINT
See Det. E dwg 54N202
R-R
AT FIELD JOINT
S-S
AT FIELD JOINT
T-T
AT FIELD JOINT
U-U
AT FIELD JOINT
SECTIONS C-C & D-D
(54N202)
Scale ¼"=1'-0"
For manufacturer's details of Radial Gates refer to American Bridge Division of United States Steel Corporation (formerly Virginia Bridge Co.) file, TVA contract No. C-52-13988.
Scale 1½"=1'-0"
Except as noted
Edge of gusset
DETAIL B
Scale 6"=1'-0"
DETAIL C
Scale 6"=1'-0"
COMPANION DWG: 54N202
SPILLWAY
RADIAL GATES
STRUCTURAL DETAILS-SHEET 1
BOONE PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
9-11-51
54N201 R1
RECORD DRAWING AS CONSTRUCTED




For manufacturer's details of Radial Gates refer to American Bridge Division of United States Steel Corporation (formerly Virginia Bridge Co.) file, TVA contract No. C-52-13988.

Scale ⅛"=1'-0"
Except as Noted

SPILLWAY

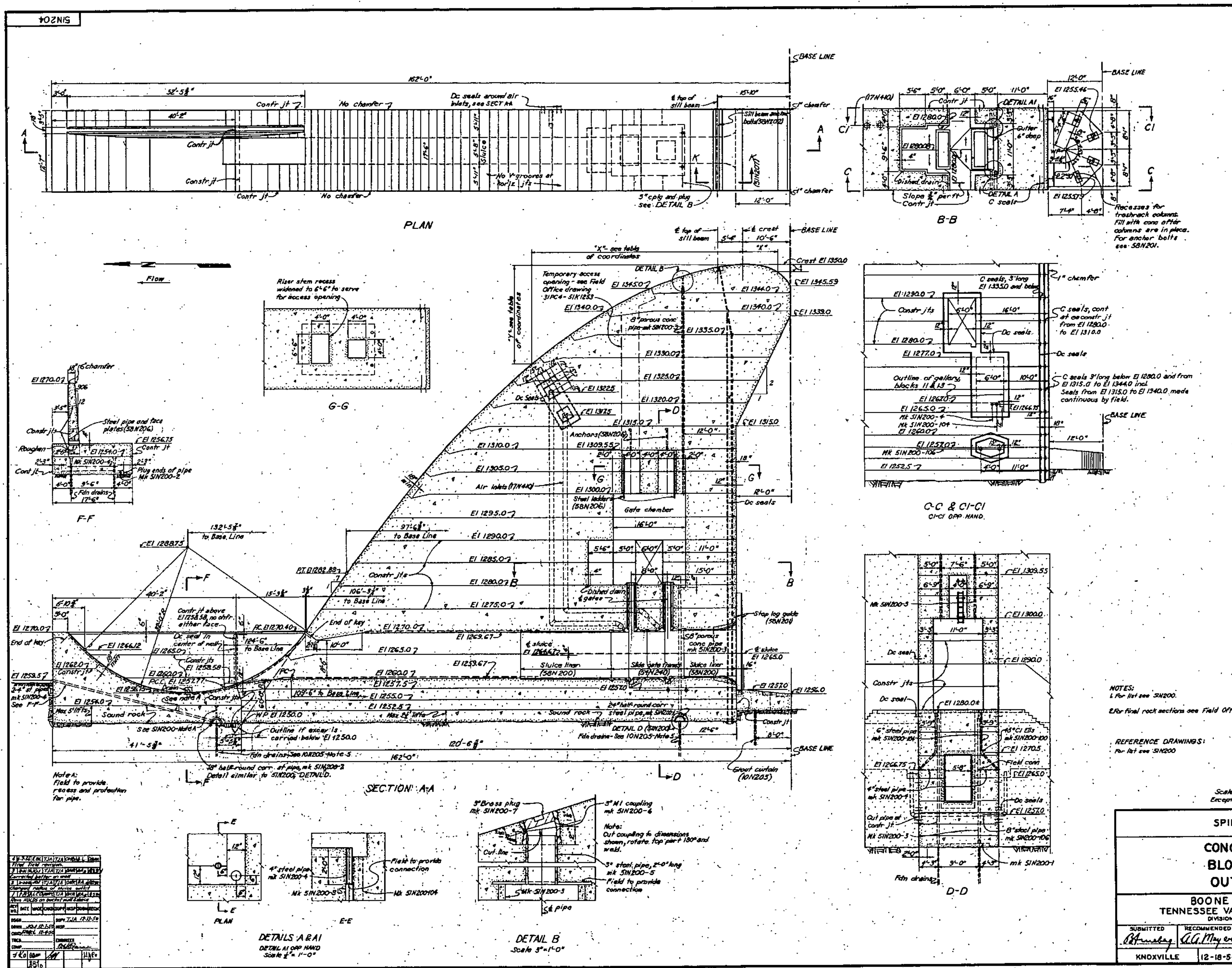
# RADIAL GATES
## STRUCTURAL DETAILS-SHEET 2

BOONE PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

| SUBMITTED | RECOMMENDED | APPROVED |
|---|---|---|
| W.R. Mathews | G.P. Palo | R.A. Monroe |

KNOXVILLE | 9-11-51 | 31 | SH 4 | 54N202 R1

RECORD DRAWING AS CONSTRUCTED



**COORDINATES OF WEIR PROFILE**

**DNSTR FROM ℄ CREST**

$Y = \frac{X^{1.8}}{34.378}$ from X=0 to X=5.333

$Y = 0.592 + \frac{X-5.333}{5} + \frac{(X-5.333)^2}{133}$ from X=5.333 to X=87.033

| X | Y | EL |
|---|---|---|
| +0.0' | 0.0' | 1350.000 |
| 2.00 | 0.101 | 1349.899 |
| 4.00 | 0.353 | 1349.647 |
| ▲4.352 | 0.411 | 1349.589 |
| 6.00 | 0.729 | 1349.271 |
| ▲6.314 | 0.795 | 1349.205 |
| 8.00 | 1.179 | 1348.821 |
| 10.00 | 1.689 | 1348.311 |
| 12.00 | 2.260 | 1347.740 |
| 14.00 | 2.890 | 1347.110 |
| 16.00 | 3.581 | 1346.419 |
| 18.00 | 4.332 | 1345.668 |
| 20.00 | 5.143 | 1344.857 |
| 22.00 | 6.014 | 1343.986 |
| 24.00 | 6.945 | 1343.055 |
| 26.00 | 7.937 | 1342.063 |
| 28.00 | 8.989 | 1341.011 |
| 30.00 | 10.100 | 1339.900 |
| 32.00 | 11.272 | 1338.728 |
| 34.00 | 12.504 | 1337.496 |
| 36.00 | 13.797 | 1336.203 |
| 38.00 | 15.149 | 1334.851 |
| 40.00 | 16.562 | 1333.438 |
| 42.00 | 18.034 | 1331.966 |
| 44.00 | 19.567 | 1330.433 |
| 46.00 | 21.160 | 1328.840 |
| 48.00 | 22.813 | 1327.187 |
| 50.00 | 24.527 | 1325.473 |
| 52.00 | 26.300 | 1323.700 |
| 54.00 | 28.134 | 1321.866 |
| 56.00 | 30.027 | 1319.973 |
| 58.00 | 31.981 | 1318.019 |
| 60.00 | 33.995 | 1316.005 |
| 62.00 | 36.069 | 1313.931 |
| 64.00 | 38.204 | 1311.796 |
| 66.00 | 40.398 | 1309.602 |
| 68.00 | 42.653 | 1307.347 |
| 70.00 | 44.968 | 1305.032 |
| 72.00 | 47.343 | 1302.657 |
| 74.00 | 49.778 | 1300.222 |
| 76.00 | 52.273 | 1297.727 |
| 78.00 | 54.828 | 1295.172 |
| 80.00 | 57.444 | 1292.556 |
| 82.00 | 60.119 | 1289.881 |
| 84.00 | 62.855 | 1287.145 |
| *87.033 | 67.119 | 1282.881 |

**UPSTR FROM ℄ CREST**

$Y = \frac{X^3}{262.5}$

| X | Y | EL |
|---|---|---|
| +0.0' | 0.0' | 1350.000 |
| 2.00 | 0.030 | 1349.970 |
| 4.00 | 0.244 | 1349.756 |
| 6.00 | 0.823 | 1349.177 |
| 8.00 | 1.950 | 1348.050 |
| 10.00 | 3.810 | 1346.190 |
| ♦10.50 | 4.410 | 1345.590 |

+ ℄ Crest.
▲ Edge of sill beam slot
* P.T.
♦ Upstr face

NOTES:
1. For list see 51N200.
2. For final rock sections see Field Office dwg 31PC4-51K1502.

REFERENCE DRAWINGS:
For list see 51N200

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

SPILLWAY

**CONCRETE BLOCK 12 OUTLINE**

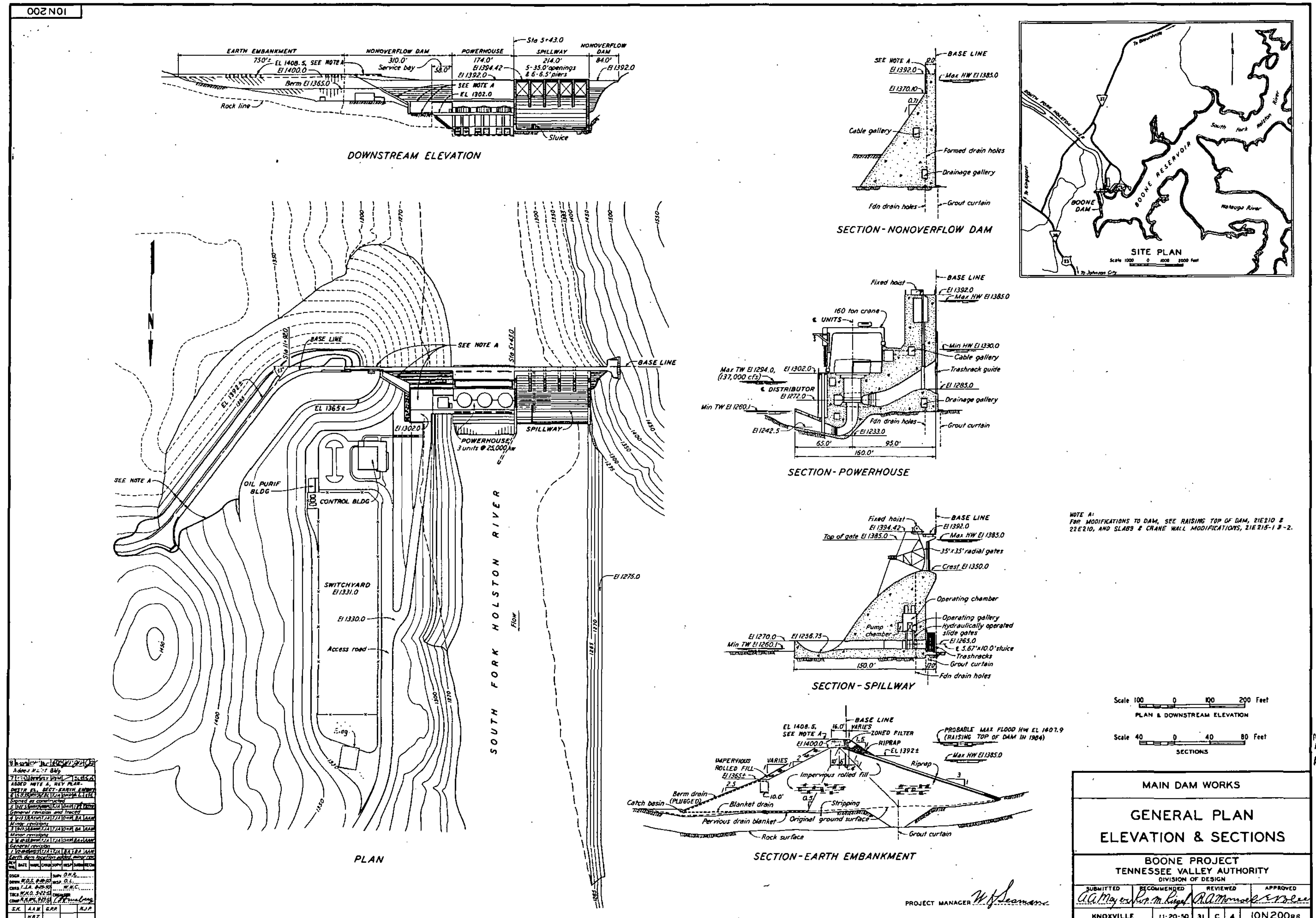
BOONE PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

| SUBMITTED | RECOMMENDED | REVIEWED | APPROVED |
|---|---|---|---|
| | | | |

KNOXVILLE | 12-18-50 | 31 | C | 4 | 51N204 R4

DRAWING AS CONSTRUCTED

MAY 23 1955




MAIN DAM WORKS

# GENERAL PLAN
# ELEVATION & SECTIONS

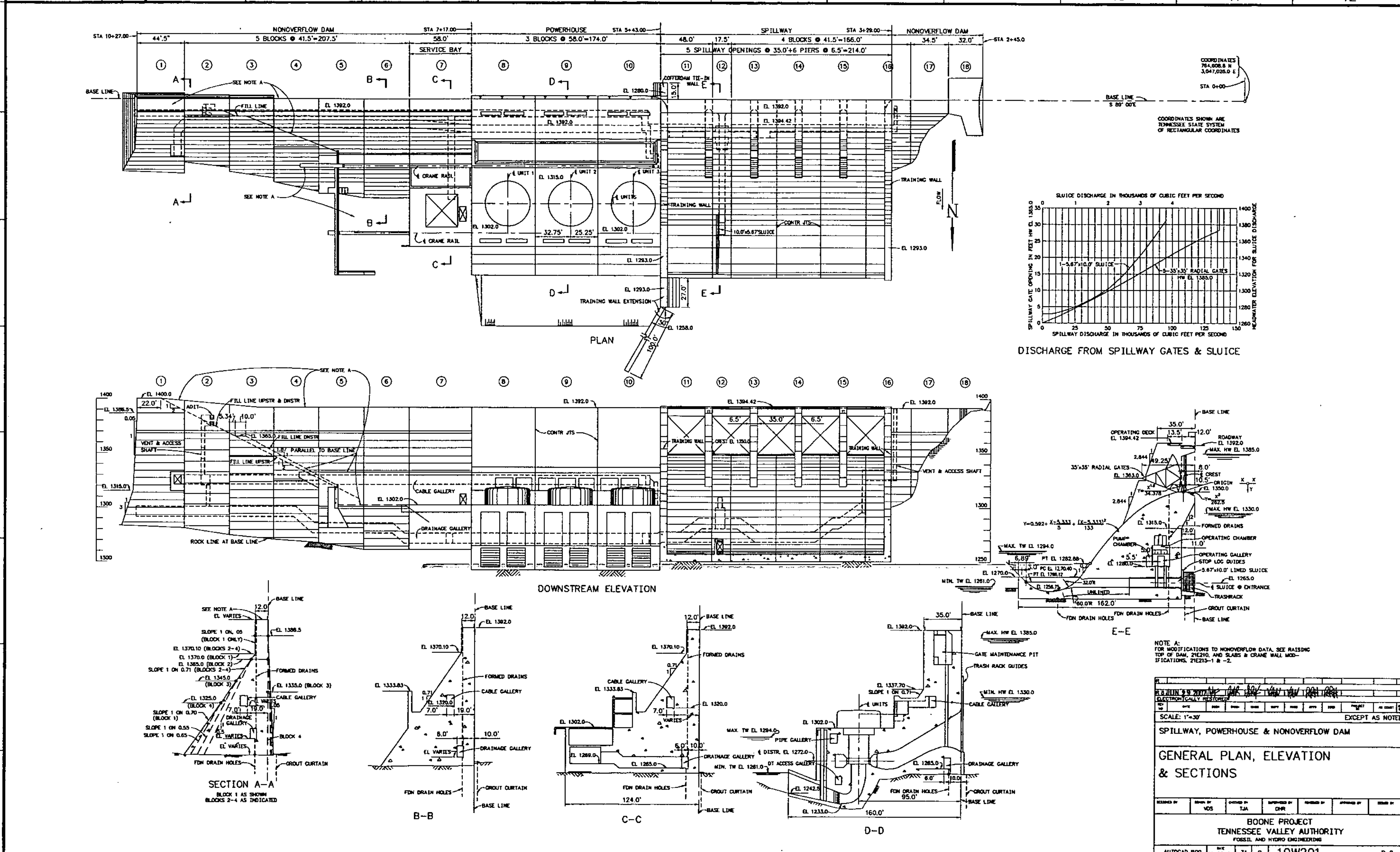
BOONE PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

| SUBMITTED | RECOMMENDED | REVIEWED | APPROVED |
|---|---|---|---|
| A.A. Meyer | R.M. Riegel | R.A. Monroe | [illegible] |

KNOXVILLE 11-20-50 31 C 4 10N200R8

PROJECT MANAGER W. F. Seaman

DRAWING AS CONSTRUCTED




SCALE: 1"=30' EXCEPT AS NOTED

SPILLWAY, POWERHOUSE & NONOVERFLOW DAM

# GENERAL PLAN, ELEVATION & SECTIONS

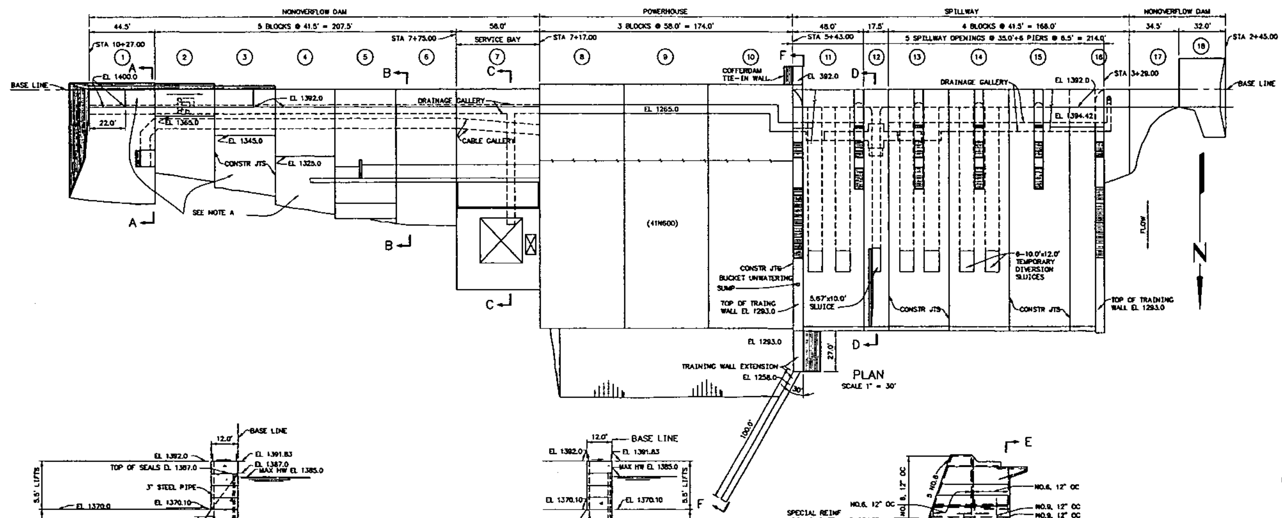
BOONE PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R00 | 11-22-50 | 31 | C | 10W201 | R 8

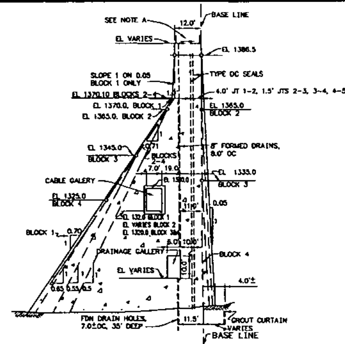
ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES : (10W201 R7)

PLOT FACTOR:360

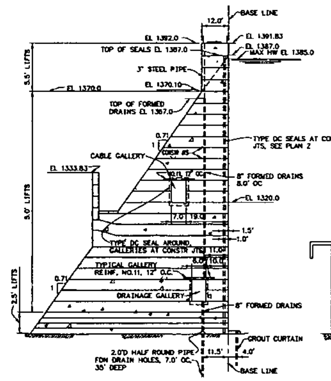
C.A.D. DRAWING
DO NOT ALTER MANUALLY



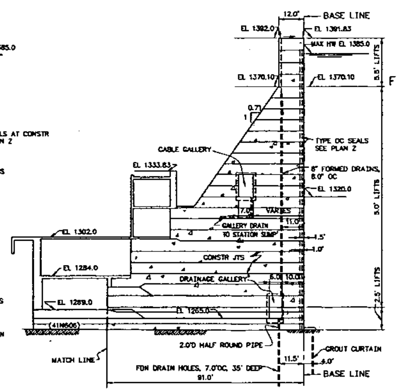

PLAN
SCALE 1" = 30'



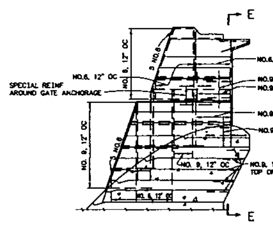
SECTION A-A
BLOCK 1 AS SHOWN
BLOCKS 2,3,4 AS INDICATED
FOR CONSTR JTS SEE SECTION B-B



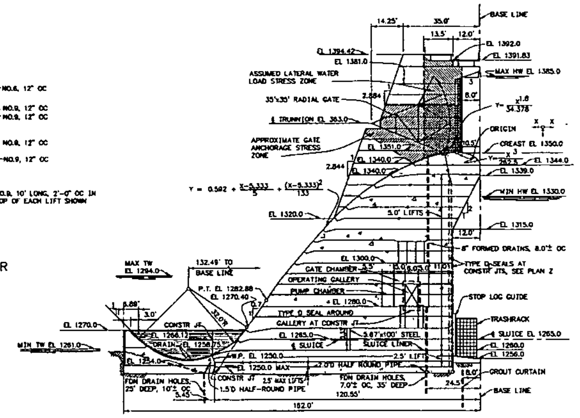
SECTION B-B
BLOCKS 5 & 6



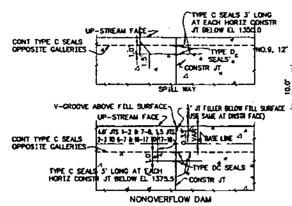
SECTION C-C



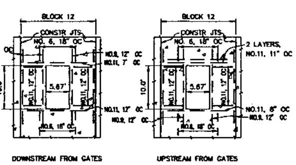
ELEVATION OF SPILLWAY PIER
SHOWING MAIN REINFORCEMENT IN PIER FACE & WEIR



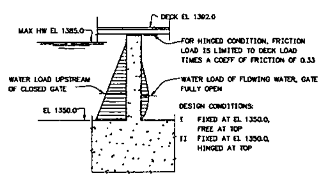
SECTION D-D



NONOVERFLOW DAM
PLAN Z
SHOWING ARRGT OF SEALS AT UPSTREAM FACE
SCALE 1"=5'



SLUICE SECTIONS
SHOWING TYPICAL REINFORCEMENT
SCALE 1"=10'



SECTION E-E
SHOWING CONDITIONS OF LOADING FOR PIER REINF DESIGN

CONCRETE PLACING INSTRUCTIONS
HEIGHT OF LIFTS AND RATE OF PLACING SHALL BE AS FOLLOWS:

SPILLWAY
BELOW EL 1255:
BLOCKS 11 THROUGH 16: 2½-FT LIFTS, EACH EXPOSED 3 DAYS.
ABOVE EL 1255:
BLOCKS 11,13 & 14: THREE 4-FT LIFTS, EACH EXPOSED 3 DAYS; THEN 5-FT LIFTS,EACH EXPOSED 3 DAYS.
BLOCK 12: TWO 2½-FT LIFTS, EACH EXPOSED 3 DAYS; THEN 5-FT LIFTS,EACH EXPOSED 3 DAYS.
BLOCKS 15 & 16: TWO 2½-FT LIFTS, EACH EXPOSED 3 DAYS; THEN ONE 5-FT LIFT, EXPOSED 5 DAYS; THEN 5-FT LIFTS; EACH EXPOSED 3 DAYS. ALL 5-FT LIFTS IN CONTACT WITH ROCK ARE TO HAVE EMBEDDED PIPING FOR COOLING WITH RIVER WATER AS SHOWN ON 10N500.

NONOVERFLOW DAM
BLOCK 17 &18: 5-FT LIFTS, EACH EXPOSED 3 DAYS. ALL LIFTS BELOW EL 1355 ARE TO HAVE EMBEDDED PIPING FOR COOLING WITH RIVER WATER AS SHOWN ON 10N500.

BLOCKS 1 TO 7 INCL: TWO 2½-FT LIFTS, EACH EXPOSED 5 DAYS; THEN 2½-FT LIFTS UNTIL ROCK IS COVERED, EACH LIFT EXPOSED 3 DAYS, WITH A MINIMUM OF TWO SUCH LIFTS; THEN TWO 5-FT LIFTS, EACH EXPOSED 5 DAYS; THEN 5-FT LIFTS, EACH EXPOSED 3 DAYS.

NOTE A:
FOR MODIFICATION TO NONOVERFLOW DAM, SEE RAISING TOP OF DAM, 21E210, AND SLABS & CRANE WALL MODIFICATIONS, 21E215-1 & -2.

R6 JUN 29 2007 ELECTRONICALLY RESTORED

SCALE: 1"=20'-0" EXCEPT AS NOTED

SPILLWAY & NONOVERFLOW DAM

# PRINCIPAL FEATURES OF DESIGN – SHEET 1

APPROVED BY R.A. MONROE

BOONE PROJECT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

COMPANION DRAWING: 10N204

AUTOCAD R2000 | 12-15-50 | 31 | C | 10W203 | R 6

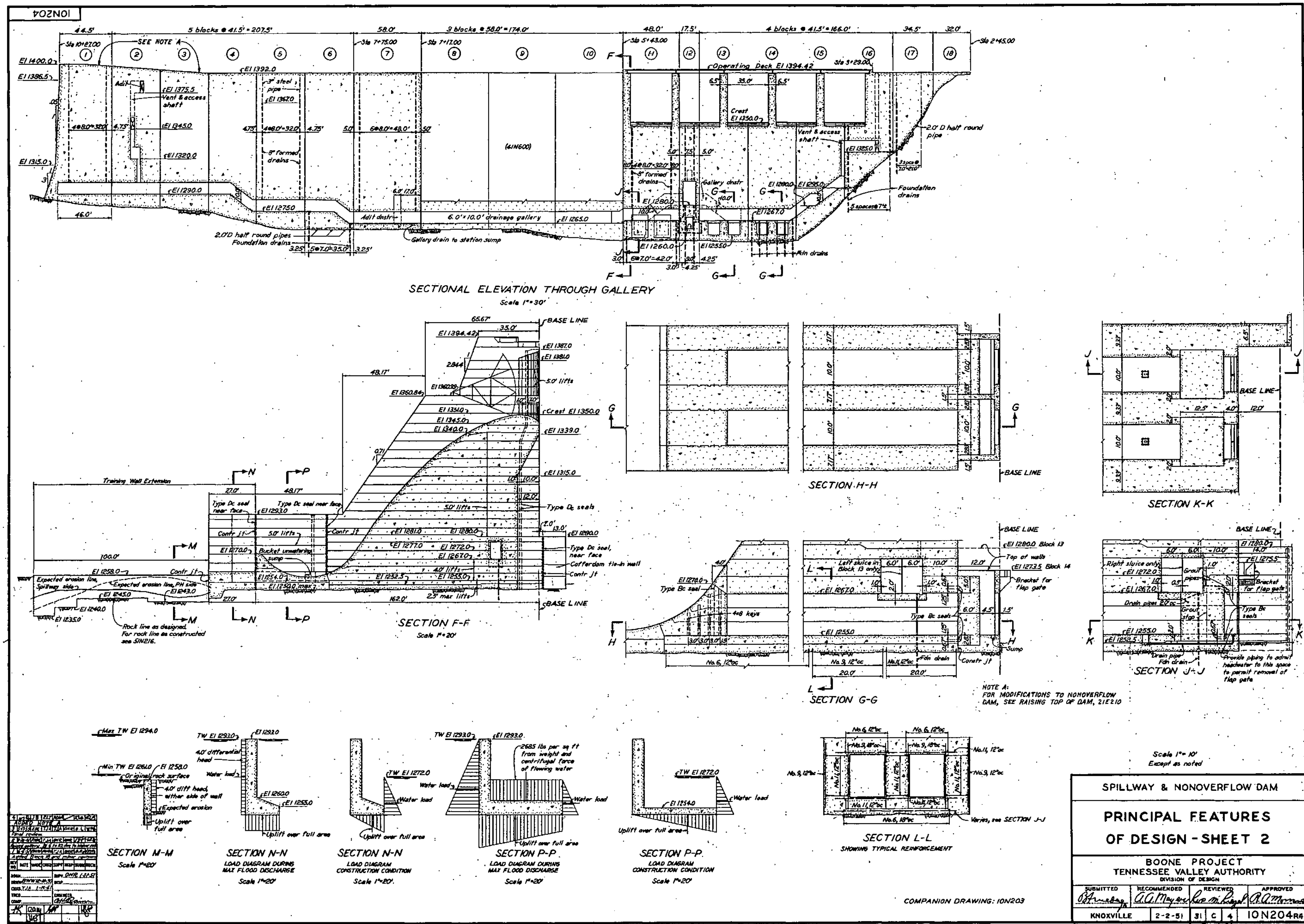
ELECTRONICALLY RESTORED DRAWING
THIS DRAWING HAS BEEN COMPLETELY REDRAWN AND SUPERSEDES :(10N203 R7)

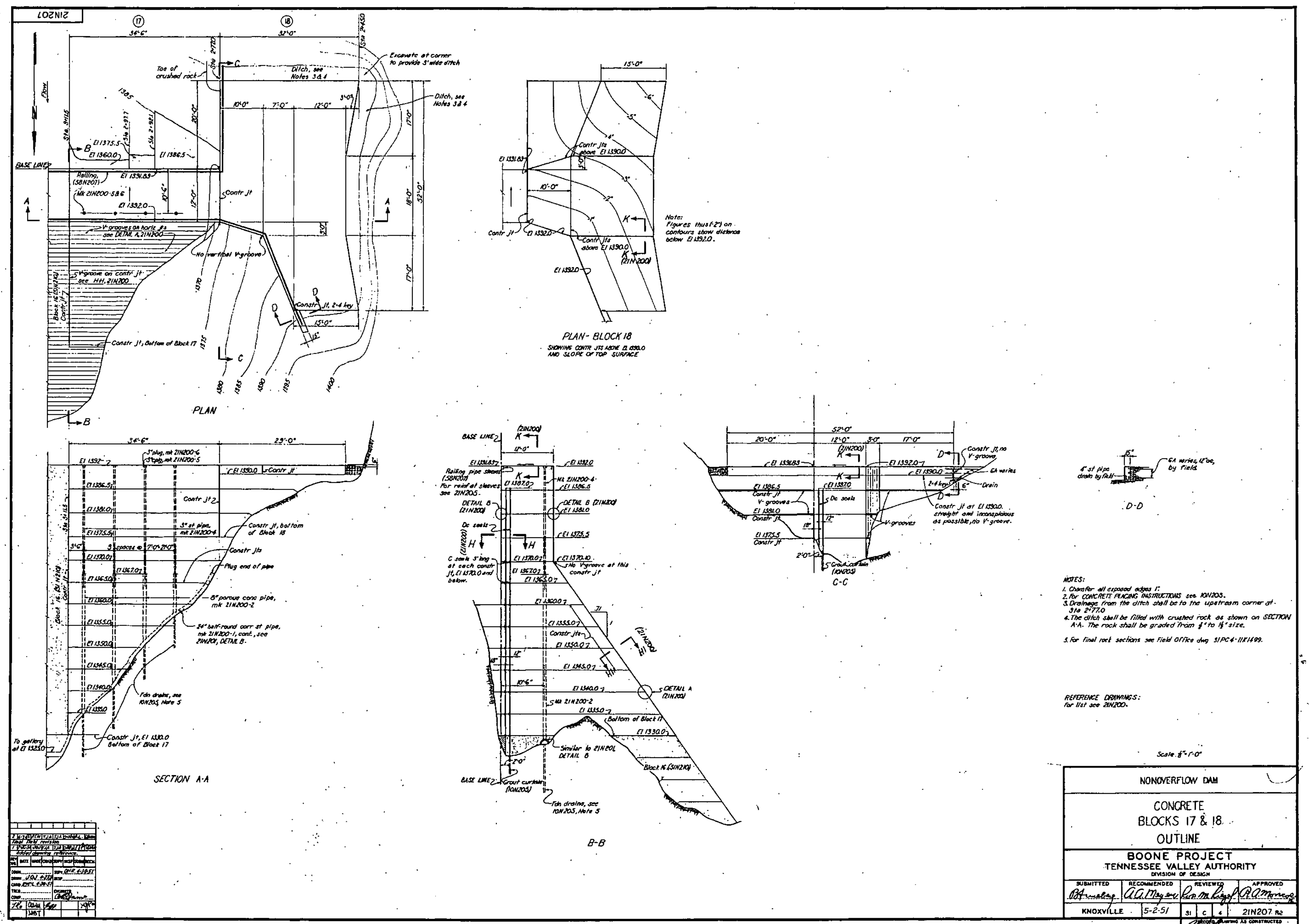
TASK COMPLETED BY. REV NO.

PLOT FACTOR:240
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

31 C 10W203


10N204
SECTIONAL ELEVATION THROUGH GALLERY
Scale 1" = 30'
SECTION F-F
Scale 1" = 20'
SECTION H-H
SECTION K-K
SECTION G-G
SECTION J-J
NOTE A:
FOR MODIFICATIONS TO NONOVERFLOW DAM, SEE RAISING TOP OF DAM, 21E210
SECTION M-M
Scale 1" = 20'
SECTION N-N
LOAD DIAGRAM DURING MAX FLOOD DISCHARGE
Scale 1" = 20'
SECTION N-N
LOAD DIAGRAM CONSTRUCTION CONDITION
Scale 1" = 20'
SECTION P-P
LOAD DIAGRAM DURING MAX FLOOD DISCHARGE
Scale 1" = 20'
SECTION P-P
LOAD DIAGRAM CONSTRUCTION CONDITION
Scale 1" = 20'
SECTION L-L
SHOWING TYPICAL REINFORCEMENT
Scale 1" = 10'
Except as noted
COMPANION DRAWING: 10N203
SPILLWAY & NONOVERFLOW DAM
PRINCIPAL FEATURES OF DESIGN - SHEET 2
BOONE PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
REVIEWED
APPROVED
KNOXVILLE
2-2-51
31
C
4
10N204R4
MAY 23 1955



21N207
PLAN
PLAN- BLOCK 18
SHOWING CONTR JTS ABOVE El 1390.0 AND SLOPE OF TOP SURFACE
Note: Figures thus(-2') on contours show distance below El 1392.0.
SECTION A-A
B-B
C-C
D-D
NOTES:
1. Chamfer all exposed edges 1".
2. For CONCRETE PLACING INSTRUCTIONS see 10N203.
3. Drainage from the ditch shall be to the upstream corner at Sta 2+77.0
4. The ditch shall be filled with crushed rock as shown on SECTION A-A. The rock shall be graded from ¾" to 1½" size.
5. For final rock sections see Field Office dwg 31PC4-11K1499.
REFERENCE DRAWINGS:
for list see 21N200.
Scale ⅛"=1'-0"
NONOVERFLOW DAM
CONCRETE
BLOCKS 17 & 18
OUTLINE
BOONE PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
REVIEWED
APPROVED
KNOXVILLE
5-2-51
31
C
4
21N207 R2
RECORD DRAWING AS CONSTRUCTED
MAY 23 1955