ENCLOSURE 1

WATTS BAR NUCLEAR PLANT

SEISMIC ANALYSIS

Corrective Action Program Plan

Revision 0

WATTS BAR

TVA NUCLEAR

# WATTS BAR NUCLEAR PLANT

## SEISMIC ANALYSIS
## CORRECTIVE ACTION PROGRAM PLAN

REVISION 0

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SEISMIC ANALYSIS

CORRECTIVE ACTION PROGRAM PLAN

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SEISMIC ANALYSIS

CORRECTIVE ACTION PROGRAM (CAP) PLAN

## 1.0 INTRODUCTION

The seismic design basis for Watts Bar Nuclear Plant (WBN) (Reference 1) is the Modified Newmark design spectrum anchored at 0.18 g horizontal and 0.12 g vertical for the Safe Shutdown Earthquake (SSE). The Operating Basis Earthquake (OBE) is equal to one-half the SSE. The design basis spectrum was confirmed to be an acceptable design basis by comparison with the Site Specific Response Spectra developed in 1979. The seismic design basis was documented in the WBN Final Safety Analysis Report (FSAR) and the NRC review and acceptance was documented in the WBN Safety Evaluation Report (SER).

An independent review of the seismic analysis calculations for Seismic Category I structures was initiated in September 1987 as part of the Civil Calculation Activity of the Design Baseline Verification Program. The Civil Calculation Activity is being performed to ensure that essential civil calculations exist, are retrievable, and are technically adequate. The seismic analysis calculations were selected for an early review to ensure that the analysis and the resulting Amplified Response Spectra (ARS) used for seismic design of structures, systems, and components are technically adequate and satisfy licensing requirements.

Based on this review, certain aspects of the structural seismic analysis were identified as requiring further evaluation and justifications.

An area of seismic analysis methodology was also identified from the WBN Employee Concern Program which required additional evaluation. The concern is related to the time interval of integration used for performing seismic analyses. Also, three CAQRs identified issues related to soil properties used in seismic analyses and consideration of soil and pile interaction effects. The employee concern, CAQRs, and their brief descriptions are provided in Attachment 1. The issues identified from the calculation review, employee concern, and CAQRs are tabulated in Table 1.

To complement the calculation review, a comparison of the seismic criteria used in the analysis of structures with the FSAR commitments and SER provisions was initiated in July 1988. The purpose of this activity was to assure that the criteria used in seismic analysis of structures are technically adequate and consistent with the licensing requirements. The matrix comparing the seismic analysis criteria, FSAR and SER for Seismic Category I structures is shown in Table 2.

A review of Table 2 indicates that the seismic analysis criteria for WBN are consistent with the FSAR and SER. Due to the issues identified in Table 1, an evaluation of several Category I structures is planned to assure that the original seismic analysis of WBN is adequate.

The root cause of the issues identified in this CAP is attributed to the use of engineering judgments in the original seismic analysis without supporting documentation.

## 2.0 OBJECTIVE

The objectives of this CAP are to ensure that the criteria for and the seismic analysis of Category I structures, including the generation of the structural loads and ARS, are technically adequate and meet licensing requirements. Based on the results of the review thus far, some revisions will be necessary to the design criteria and the FSAR. Licensing commitment changes will be proposed only when technically justified.

## 3.0 SCOPE

The scope of this CAP includes:

- Review, revision, and augmentation of the seismic analysis criteria used for Category I structures to assure compliance with the licensing requirements.

- Review, revision, and augmentation of seismic calculations for Category I structures as required to resolve the issues identified in this CAP.

## 4.0 DESCRIPTION OF PROGRAM

This CAP consists of the following activities:

- Review of seismic analysis criteria and licensing requirements for Category I structures.

- Review of seismic analysis calculations for Category I structures and revisions as required, or preparation of new calculations when necessary.

- Disposition of identified issues.

Additionally, recurrence control is addressed and licensing assessment is provided. A flow chart and fragnet for the work are included in Attachments 2 and 3, respectively.

### 4.1 Review of Seismic Analysis Criteria and Licensing Requirements

The seismic analysis criteria have been reviewed for technical adequacy. The criteria have also been compared with the applicable FSAR and SER sections to ensure that the criteria are consistent with the licensing requirements. For the Category I structures, Table 2 shows the comparison between the seismic analysis criteria, FSAR commitments, and SER provisions.

As demonstrated by Table 2, the seismic analysis criteria used at WBN are consistent with the FSAR requirements and SER provisions. In addition, in view of the current industry practice, a study has been initiated to evaluate the effects of floor vertical flexibility on the design of systems and components.

The criteria for seismic analysis of the Additional Diesel Generator Building (ADGB), which was included in Amendment 57 of the FSAR (after the SER was issued), needs further review as discussed in Section 4.3.4.

4.2 Review of Seismic Analysis Calculations

An independent review of the seismic analysis of each Category I structure has recently been performed. The review included the following structures.

- Reactor Building Interior Concrete Structure (ICS).
- Reactor Shield Building (SB).
- Steel Containment Vessel (SCV).
- Auxiliary Control Building (ACB).
- Intake Pumping Station (IPS).
- Diesel Generator Building (DGB).
- Additional Diesel Generator Building (ADGB).
- Refueling Water Storage Tanks (RWST).
- North Steam Valve Room (NSVR).
- Pipe Tunnels
- Waste Packaging Area (WPA).
- Condensate Demineralizer Waste Evaporator Building (CDWE).

The WPA and CDWE contain no safety-related systems or components. They were designed as Category I structures to ensure that they will not impact the adjacent ACB during a seismic event.

Several engineering judgments without supporting documentation were identified during the review of the calculations for the ADGB, DGB, and the CDWE. There are also two CAQRs related to the modeling of the supporting piles in the seismic analysis of the ADGB and CDWE (See Attachment 1). In order to resolve questions related to the engineering judgments and the CAQRs, reanalysis of these structures is being performed as discussed in Section 4.3.2.

The calculation review also identified the need to review the torsional modeling of the ICS, ACB, and NSVR. This issue is being addressed as described in Section 4.3.3.

## 4.3 Disposition of Identified Issues

Issues have been identified through employee concerns, CAQRs, and review of seismic analysis calculations, criteria, and licensing requirements. These issues deal with the following areas:

- Integration time step used to perform time history analysis.
- Soil properties and soil-structure interaction concerns.
- Torsional modeling of structures.
- Seismic analysis criteria for the Additional Diesel Generator Building (ADGB).

The above issues and the approach to resolve them are discussed in the following sections. The effects of these issues on the analysis of Seismic Category I structures are discussed in Section 4.3.5.

### 4.3.1 Integration Time Step Used in Time History Analysis

An integration time step of 0.01 second was used in the original time history analysis of structures to generate the ARS. An engineering judgment was made that 0.01 second was adequate for structural analysis and the earthquake records were digitized at 0.01 second. An employee concern identified that this integration time step might be too large and could result in an underestimation of the response of those modes which have frequencies greater than 20 Hz.

In order to resolve this concern, additional calculations are being performed to evaluate the effect associated with using a 0.01 second integration time step in time history analysis. The preliminary conclusion of the calculations is that the original amplified response spectra (ARS) developed from using a 0.01 second integration time step are adequate due to conservatisms in the design time histories.

### 4.3.2 Soil Properties and Soil-Structure Interaction Concerns

The value of shear modulus for the crushed stone supporting media used in the analysis of the Diesel Generator Building (DGB) and the Waste Packaging Area (WPA) was identified as a concern in a CAQR. The design value originally used was based on the assumption that in situ geophysical measurements made on other similar materials were suitable for the crushed stone. Later, in situ testing of crushed stone and review of technical literature resulted in a lower shear modulus than the one used in the DGB and WPA analysis.

In order to resolve this issue for the DGB, a new soil-structure interaction (SSI) analysis using the revised shear modulus will be performed.

As stated previously, the WPA does not house any safety-related systems and components and the original analysis predicted conservative internal structural forces. In the original analysis, a decoupled, two-stage SSI analysis was used to determine the seismic response of the structure and the results were conservative. An analysis using the revised shear modulus is being performed to confirm that the gap between the WPA and adjacent ACB is adequate. Preliminary results confirm that there is sufficient gap between the two structures such that they will not impact each other during a seismic event.

The Condensate Demineralizer Waste Evaporator Building (CDWE) and the Additional Diesel Generator Building (ADGB) analyses included engineering judgments related to the modeling of the supporting piles. The engineering judgments were questioned by a CAQR and involved stiffness consideration of pile groups and an assumption of full contact between the building's mat foundation and the underlying soil. These judgments were made to maximize the structural responses and may not have predicted conservative reactions for the piles.

There are no safety-related systems and components in the CDWE. Calculations are being performed to more accurately consider the stiffness of the pile groups and the postulated gap between the slab and soil. Preliminary results confirm that the gap between the buildings is sufficient for seismic separation and the design of the structure and piles is adequate.

The seismic analysis of the ADGB is addressed in Sections 4.3.4 and 4.3.5.

4.3.3 Torsional Modeling

During the review of the calculations discussed in Section 4.2, two torsional modeling issues identified were the mechanics of modeling eccentric masses and the methodology used in calculating torsional constants for open cross sections.

Modeling of Eccentricities

In the original seismic models, the eccentricity between the center of mass and the center of rigidity was included at each mass point. However, the physical location of the center of rigidity was not incorporated into the model.

The Interior Concrete Structure (ICS) and the Auxiliary Control Building (ACB) are the two structures affected by the issue of modeling of eccentricities. A seismic analysis calculation is being performed to determine the effects of the original eccentricity modeling for the ICS. Preliminary results show that the differences between the two methods of modeling do not significantly affect the structural responses. Since the eccentricities of the ACB are less than those of the ICS, it is concluded from the preliminary results that the ACB dynamic modeling of eccentricities is also adequate.

Torsional Constants

The only two structures with significant open sections, where the issue of the effect of warping on the calculation of the torsional constant becomes important, are the ICS and the North Steam Valve Room (NSVR). In both of these cases the original calculations did not include the warping contribution to torsional stiffnesses and thus the resulting calculated torsional constant was lower. This approach was considered to be conservative since calculated torsional responses would be greater. However, the lower torsional constant can cause shifts in the calculated frequencies of the structure and thus, the shape of the ARS can be affected.

Calculations were performed for the ICS considering the modeling of eccentric masses and the revised torsional constants for open sections. An equivalent stick model was developed from a 3-dimensional finite element model to study the effect of the revised torsional constants. The calculations indicated that further evaluations will be required to justify the adequacy of the original calculations (see Section 4.3.5).

A reanalysis of the NSVR considering torsional constants including the warping contribution will also be performed to evaluate the adequacy of the original calculations.

4.3.4 Seismic Analysis Criteria for the Additional Diesel Generator Building (ADGB)

When the ADGB was added to the WBN design, new criteria for seismic analysis of the ADGB were developed. These criteria were based on the current NRC Standard Review Plans (Revision 1) and Regulatory Guides. These criteria were incorporated in the FSAR by Amendment 57, after the NRC had issued the SER and the supplements. The criteria defined in Amendment 57 will be reviewed to assure consistency with the criteria that will be used to reanalyze other structures. The revised criteria will be used to reanalyze the ADGB as discussed in Section 4.3.5.

4.3.5 Summary of Seismic Analysis Review for Category I Structures

The original analyses of Category I structures were performed consistent with the FSAR requirements and using methodologies that were prevalent at that time. Since then, several issues have been identified, as discussed above, regarding the original analyses. These questions arose as a result of the criteria and calculation review, employee concerns, and CAQR programs.

In order to completely address these issues, some Category I structures are being reanalyzed for the SSE and the adequacy of structures, systems, and components will be evaluated. These reanalyses will use a new artificial time-history record that envelopes the Site-Specific Response Spectra for all applicable damping values. Structural damping values will be based on RG 1.61. This approach meets the requirements of Standard Review Plan 3.7.1. Time-history analysis will be performed using a time step of 0.005 seconds. The SSI analyses will be performed with state-of-the-art techniques using, where applicable, the revised modulus of the crushed stone and revised modeling of the piles.

The Young's and shear moduli of the concrete have been re-evaluated for use in the reanalyses. The evaluation concluded that lower moduli values should be used for the reanalyses of the ICS, ADGB, NSVR, and CDWE. The original moduli used in the analyses of other structures are consistent with the revised lower moduli.

The ICS is being reanalyzed using revised torsional constants and concrete moduli with the actual locations of the center of rigidity. Since the ICS mathematical model also includes the Steel Containment Vessel (SCV) and the Shield Building (SB), spectra will also be developed for these two structures and compared with the original design spectra. The SCV and SB reanalysis results are expected to be enveloped by the original design basis spectra.

The Diesel Generator Building (DGB) is being reanalyzed mainly to address the soil modulus issue. The Additional Diesel Generator Building (ADGB) is being reanalyzed to assure consistency of criteria for seismic Category I structures as well as to incorporate more refined modeling for the piles. DGB and ADGB analysis results will be used for evaluating the adequacy of system and component design.

The North Steam Valve Room is being reanalyzed to address the torsional constant issue and the revised concrete moduli. It is expected that the new spectra will be enveloped by the original spectra, indicating conservatism in the existing design.

Finally, the remaining structures (ACB, IPS, RWST, pipe tunnels) need not be reanalyzed since the original analyses for these structures are technically acceptable and meet licensing requirements. However, the calculations for these structures will be updated to address administrative comments such as providing a list of references.

Based on the reviews performed (see Table 2), it has been demonstrated that the criteria used in original seismic analyses are adequate and meet licensing requirements. The planned additional analyses are intended to address the issues raised and to confirm the adequacy of existing design.

4.3.6 Evaluations for Systems and Components

Systems and components in Category I structures for which reanalysis is being performed, as discussed in Section 4.3.5, will be evaluated to demonstrate the adequacy of their seismic design. In these evaluations, the results from the structural reanalysis, including ARS, will be used in conjunction with the present day criteria. This includes spectral peak broadening of $\pm$ 15 percent and damping values based on RG 1.61, Code Case N411, or actual test data.

The new analysis results may also be used in future designs and for evaluations being performed in other CAPs (Cable Tray, Conduit, HVAC, Instrument Lines, HAAUP, and Equipment Seismic Qualification). Existing analysis results (ARS and seismic motions of record) may continue to be used in future designs and evaluations when the existing ARS envelop the ARS resulting from reanalysis. In the case of structures which are not reanalyzed, the existing ARS will continue to be used. In these cases the damping values based on RG 1.61, Code Case N411, or actual test data may be used. This approach is justified since the existing ARS are based on time-history records which envelop the Site Specific Response Spectra. Since the existing ARS are based on $\pm$ 10 percent peak broadening, revised ARS with 15 percent peak broadening will be obtained for piping analysis in order to satisfy the requirements of RG 1.84.

4.4 Recurrence Control

The root cause identified in this CAP has been addressed through procedural improvement.

A procedure is now in place (NEP 3.1) to ensure that engineering judgments used in the design process will be adequately documented.

4.5 Licensing Assessment

In order to resolve the issues identified in this CAP and to establish the seismic design basis for future work, revisions to the design criteria and FSAR may be necessary. Any changes to the licensing commitments will be proposed only when technically justified.

## 5.0 PROGRAM INTERFACES

The ARS are used in the design of safety-related systems and components. Therefore, the output of this CAP will provide input to other CAPs such as HAAUP, Cable Trays, Conduit, Instrument Lines, HVAC, and Equipment Seismic Qualification.

## 6.0 PROGRAM IMPLEMENTATION

Nuclear Engineering (NE) is the lead organization for implementing and completing the Seismic Analysis CAP. Calculations will be performed in accordance with standard TVA procedures and practices.

## 7.0 PROGRAM DOCUMENTATION

Results of this CAP will be documented in calculations and reports. The FSAR revisions resulting from this CAP will be submitted to the NRC. Affected documents will be revised in accordance with NE procedures. A final report will be prepared documenting the results of evaluations performed to resolve identified issues.

## 8.0 CONCLUSION

The completion of the Seismic Analysis CAP will confirm that the seismic analysis of structures and the ARS generated from the analyses are technically adequate and satisfy licensing requirements. In addition, related employee concern and CAQRs dealing with seismic analysis issues will be resolved.

## 9.0 REFERENCE

1. Dynamic Earthquake Analysis of Category I Structures and EarthEmbankments, WD-DC-20-24, Revision 3, July 1988

TABLE 1

Issues Identified from Review of Seismic Analysis Calculations of Category I Structures, Employee Concerns, and CAQRs.

| Issue | Disposition |
|---|---|
| 1. Integration time step used to perform time history analysis. (ECP-87-KX-009-01) | Calculation is being completed and preliminary evaluation shows the adequacy of existing analyses. |
| 2. Dynamic soil properties and soil-structure interaction concerns (CAQR WBF 870038R1, CAQR WBF 870039R1, and CAQR WBP 870396R0) | |
| ° Waste Packaging Area and Condensate Demineralizer Waste Evaporator Building | ° Calculations are being completed and preliminary eveluation shows the adequacy of existing analyses. |
| ° Diesel Generator Building and Additional Diesel Generator Building | ° Further analyses will be performed to evaluate structures and components. |
| 3. Torsional modeling | |
| ° Reactor Building Interior Concrete Structure. | ° New analyses are being performed to develop ARS which will be used to evaluate structures and components. |
| ° North Steam Valve Room. | ° New analyses will be performed to evaluate structures and components. |
| ° Auxiliary Control Building. | ° Calculation is being completed and preliminary evaluation shows modeling is adequate. |

TABLE 2
COMPARISON OF SEISMIC ANALYSIS CRITERIA, FSAR, AND SER
FOR SEISMIC CATEGORY I STRUCTURES

| ATTRIBUTE | DESIGN CRITERIA (DC) WB-DC-20-24, Rev. 3 | FSAR | SER | DIFFERENCES BETWEEN DC AND FSAR, SER |
|---|---|---|---|---|
| **DYNAMIC ANALYSIS PARAMETERS** | | | | |
| Design Response Spectra (input ground motion spectra) | o Modified Newmark | o Same [1] (2.5.2.6) (2.5.2.7) (3.7.1.1.1) | o Same [2] (2.5.2.1) (3.7.1) | o None - Design basis has been accepted by NRC based on site specific spectra evaluation |
| Max. top-of-rock accelerations SSE: | o 0.18gH, 0.12gV | o Same [3] (2.5) (3.7.1.1.1) | o Same (2.5) (3.7.1) | o None |
| OBE: | o 0.09gH, 0.06gV (3.1) | | | |
| Ratio of vertical to horizontal response spectrum | o 2/3 to 1 (3.1) (3.2.1.2) | o Same (3.7.1.1.1) (3.7.2.4.1) | o Same (3.7.3) | o None |
| Design time histories (input ground motion T-H) | o 4 artificial E/Q's<br>o 2 horizontal comp's the same (3.1) | o Same (3.7.1.2.1) | o Same | o None |
| Frequency (period) interval for generating ground motion input spectra | o Calculated at 55 periods (Table 6) | o Table does not cover period ranges: .03 to .05 sec. 1.0 to 5.0 sec. (Table 3.7.1) | o No explicit statement | o Minor differences - FSAR will be updated |
| Damping values | o FSAR Table 3.7-2A | o Same (Table 3.7-2A) | o Same (3.7.1) | o None |

Notes:

(1) FSAR same as DC.
(2) SER agrees with FSAR.
(3) Due to a typo, the FSAR in Section 3.7.1.1.1 states that the OBE horizontal acceleration is 0.08g, not 0.09g and that the OBE vertical acceleration is 0.6g, not 0.06g.

TABLE 2
WBNP SEISMIC ASSESSMENT PROGRAM
COMPARISON OF SEISMIC ANALYSIS CRITERIA, FSAR, AND SER
FOR SEISMIC CATEGORY I STRUCTURES

| ATTRIBUTE | DESIGN CRITERIA (DC) WB-DC-20-24, Rev. 3 | FSAR | SER | DIFFERENCES BETWEEN DC AND FSAR, SER |
|---|---|---|---|---|
| Supporting media | o Shear wave velocity and embedment and overburden depths are defined | o Same (Table 3.7.3) (3.7.1.4) | o No explicit statement | o None |
| DYNAMIC ANALYSIS METHODS | | | | |
| Analysis method | o Time-history modal analysis using four artificial earthquake records for generation of ARS and Response Spectrum Analysis(RSA) for structural loads (3.1.2) | o Same (3.7.2.1) | o Same (3.7.2) | o None |
| | o Integration time step 0.01 sec | o Same | o Same | o None - However, adequacy of time step is being addressed. |
| Soil-structure interaction | o Rock-Supported Fixed base (allows linear springs which indicate fixed base) | o Same (3.7.2.1) | o Same (3.7.2) | o None |
| | o Soil-Supported Rock motion amplified through soil by linear shear beam w/10% soil damping. Soil modulus varied ±30%. Structures modeled with linear soil springs with 10% damping. | o Same (3.7.2.1) | o Same (3.7.2) | o None - However, dynamic soil properties and SSI for some structures are under review. |
| | o Half-space analysis except for ADGB and RWST which used FLUSH. | o Same (3.7.2.1) | o Same - except ADGB analysis is not addressed in SER. (3.7.2) | o None - However, dynamic soil properties and SSI for some structures are under review. |
| Torsional, rocking, and translational responses | o Rocking and translation considered. Torsional response taken into account where significant. | o Same (3.7.2.1) | o Same (3.7.2) | o None |
| Methods to account for torsional effects | o Lumped-mass models with center of rigidity and center of mass. | o Same (3.7.2.11) | o Torsional effects were considered. (3.7.2) | o None |
| | o Responses calculated at extreme points. | | | |

TABLE 2
WBNP SEISMIC ASSESSMENT PROGRAM
COMPARISON OF SEISMIC ANALYSIS CRITERIA, FSAR, AND SER
FOR SEISMIC CATEGORY I STRUCTURES

| ATTRIBUTE | DESIGN CRITERIA (DC) WB-DC-20-24, Rev. 3 | FSAR | SER | DIFFERENCES BETWEEN DC AND FSAR, SER |
|---|---|---|---|---|
| Adequate number of masses | o Based on judgement. Mass points were located at floor slabs, change to geometry, and at intermediate points. | o Same (3.7.2.1) | Same (3.7.2) | o None |
| Adequate number of modes to assure participation of significant modes | o Response to be calculated using all significant modes (3.2.1) | o Modes considered are shown in tables | o No explicit statement | o None |
| Maximum relative displacements between structures | o Maximum relative displacement calculated (4.0) | o Same (3.7.3.8.4) | o No explicit statement | o None |
| Equivalent static load method | o Not explicity addressed | o No explicit statement | o Dynamic analysis was employed for all structural amplification in vertical analysis. (3.7.2) | o None |
| Acceleration time history or response spectra | o Response spectra generated at ground level, at all major floors, and at other points where input is needed for further analysis | o Same (3.7.2.12) | o Same | o None |
| ANALYTICAL MODELING | | | | |
| Decoupling criteria for subsystems | o Provides criteria for decoupling subsystems. (5.3.1.1) | o No explicit statement | o No explicit statement | o None |

TABLE 2
WBNP SEISMIC ASSESSMENT PROGRAM
COMPARISON OF SEISMIC ANALYSIS CRITERIA, FSAR, AND SER
FOR SEISMIC CATEGORY I STRUCTURES

| ATTRIBUTE | DESIGN CRITERIA (DC) WB-DC-20-24, Rev. 3 | FSAR | SER | DIFFERENCES BETWEEN DC AND FSAR, SER |
|---|---|---|---|---|
| Modeling for three components of input motion | o Three components of input motion were considered. However, no coupling of horizontal and vertical analyses (3.2.1) | o Same (3.7.2.1) | o Same (3.7.2) | o None |
| DEVELOPMENT OF FLOOR RESPONSE SPECTRA | o Fixed and variable (N411) Damping (2)<br>o Spectra broadened by ± 10%<br>o Optional use of ASME Code Case N-397 for peak shifting (2)<br>o Torsion calc at extreme edges<br>o Spectra was computed for 55 periods given in Table 6 and at significant periods of the structure and at structural periods shifted by fine interval.<br>o Vertical spectra generated using wall stiffnesses and vertical input motion only.(1) (3.2.2) | o Same (3.7.2.9)<br>o Table does not cover period ranges: .03 to .05 sec 1.0 to 5.0 sec | o Development of floor response spectra was reviewed (3.7.2) | o None |
| THREE COMPONENTS OF EARTHQUAKE MOTION | o Critical horizontal responses combined with vertical by ABSUM | o Same (3.7.2.10.1.1) | o Same (3.7.3) | o None |
| COMBINATION OF MODAL RESPONSES | o Modes combined by SRSS. Closely spaced modes by the grouping method in R.G.1.92 | o Same (3.7.2.7.1.1) | o Same (3.7.2) | o None |
| INTERACTION OF NON-CAT I WITH CAT I STRUCTURES | o Need to consider interaction of non-Cat I with Cat I structures. | o Same (3.7.2.8) | o Same (3.7.2) | o None |

Note:

(1) A study is being performed to evaluate the effects of floor vertical flexibility on systems and components.
(2) Added after SER

TABLE 2
WBNP SEISMIC ASSESSMENT PROGRAM
COMPARISON OF SEISMIC ANALYSIS CRITERIA, FSAR, AND SER
FOR SEISMIC CATEGORY I STRUCTURES

| ATTRIBUTE | DESIGN CRITERIA (DC) WB-DC-20-24, Rev. 3 | FSAR | SER | DIFFERENCES BETWEEN DC AND FSAR, SER |
|---|---|---|---|---|
| USE OF EQUIVALENT STATIC FACTORS | o Vertical ARS were developed considering structural amplification | o Same (3.7.2.10.1.1) | o Same (3.7.2) | o None |
| COMPARISON OF RESPONSES | o Results for response spectrum and time history analysis of ICS provided in FSAR Figure 3.7-38. | o Same | o No explicit statement | o None |
| COMPOSITE MODAL DAMPING | o For rock-supported structures, no need to consider composite modal damping.<br>o For soil-supported structures, composite modal damping was considered (limited to 10% damping) | o Same (3.7.2.15) | o No explicit statement | o None |
| STRUCTURE OVERTURNING MOMENTS | o Structure overturning moments were calculated for critical horizontal response combined with vertical. | o Same (3.7.2.14.1) | o Same - Stability against overturning was considered (3.7.2) | o None |

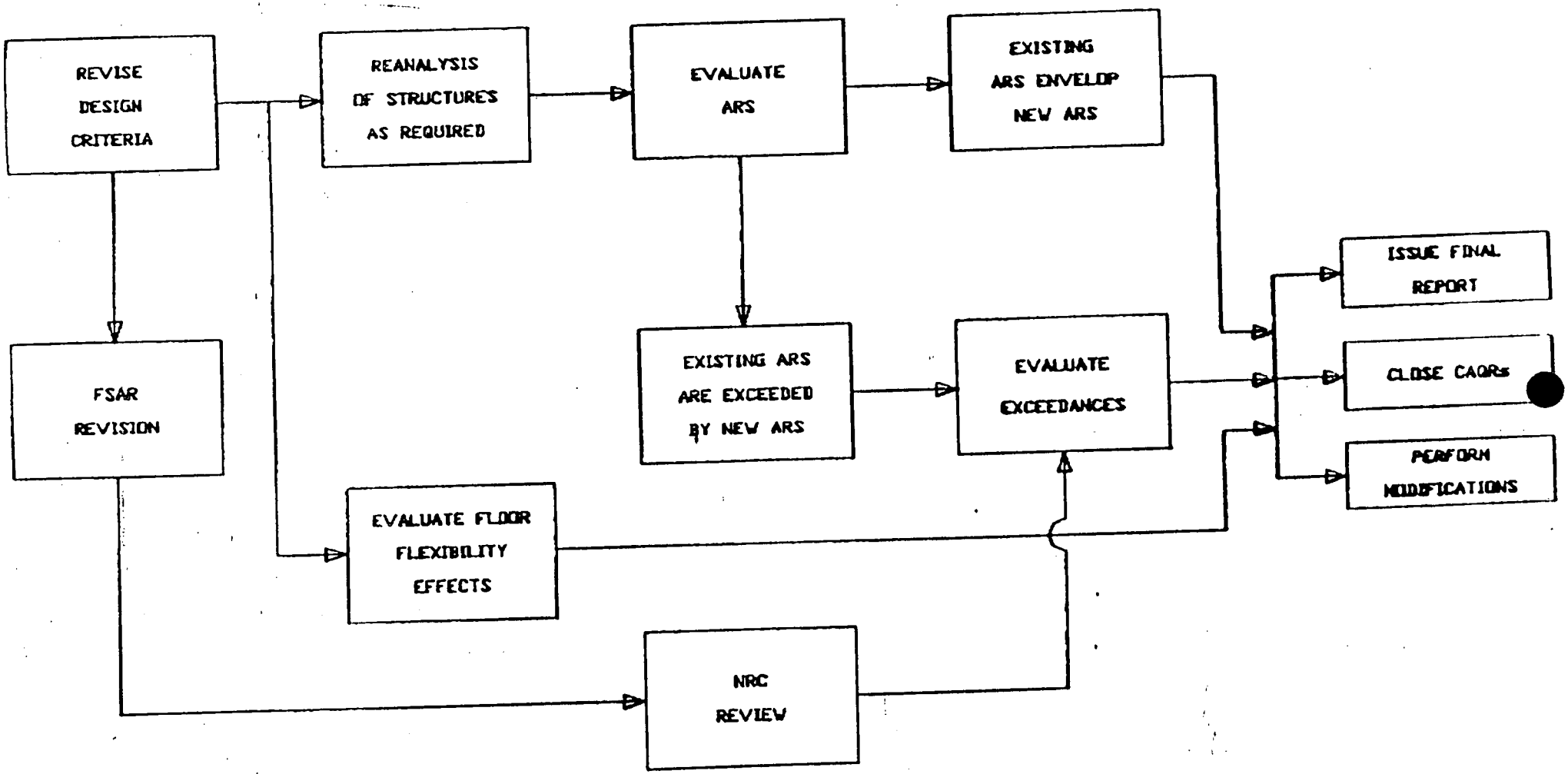
ATTACHMENT 1

LIST OF EMPLOYEE CONCERN AND CAQRs

| Item | Document | Description |
|---|---|---|
| 1 | ECP-87-KX-009-01 (L77 870608 804) | Concern with integration time step used to perform the time-history analysis. The time step used may be too large to calculate high frequency response adequately. |
| 2 | CAQR WBF 870038R1 (B05 870706 300) | Concern with soil structure interaction (SSI) analysis for the design of the pile foundation for Condensate Demineralizer Waste Evaporator Building. The analysis may not reflect the maximum loading condition for the piles and the soil spring constants used in analysis may not be realistic. |
| 3 | CAQR WBF 870039R1 (B05 870729 306) | Concern with SSI analyses for the design of the pile foundation for the Additional Diesel Generator Building. The concern is similar to that of Condensate Demineralizer Waste Evaporator Building analysis. |
| 4 | CAQR WBP 870396R0 (T42 870528 975) | Concern regarding the soil modulus for crushed stone for Diesel Generator Building and Waste Packaging Area. |

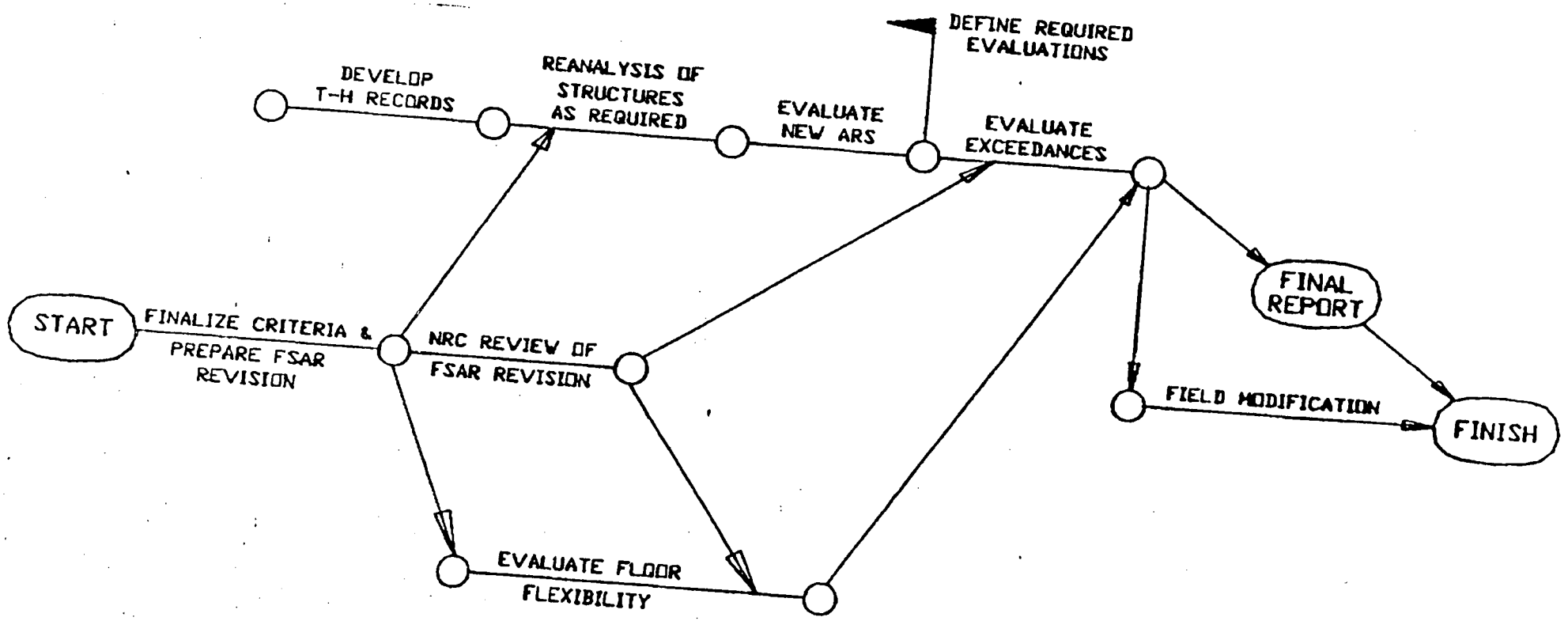
ATTACHMENT 2

# WATTS BAR NUCLEAR PLANT
# SEISMIC ANALYSIS CAP FLOWCHART



ATTACHMENT 3

# WATTS BAR NUCLEAR PLANT
# SEISMIC ANALYSIS CAP FRAGNET



ENCLOSURE 2

For the Watts Bar Nuclear Plant, TVA commits to:

1. Review of seismic analysis calculations for category I structures and revisions as required or preparation of new calculations when necessary.

2. In order to resolve the issues identified in this CAP and to establish the seismic design basis for future work, revisions to the design criteria and FSAR may be necessary. Any changes to the licensing commitments will be proposed only when technically justified.

3. Disposition issues identified through employee concerns, CAQRs, and review of seismic analysis calculations, criteria, and licensing requirements.

TENNESSEE VALLEY AUTHORITY
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NOV 15 1988

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Gentlemen:

In the Matter of the Application of ) Docket Nos. 50-390
Tennessee Valley Authority ) 50-391

WATTS BAR NUCLEAR PLANT (WBN) - VERTICAL SLICE REVIEW (VSR) PLAN

S. D. Richardson's letter to S. A. White dated August 31, 1988, provided the results of the NRC staff's review of the WBN VSR plan. The letter stated that the NRC staff has reviewed the proposed plan and considers the proposed methodology for VSR to be reasonable. In addition, the letter provided 16 comments on the VSR plan.

The purpose of this letter is to respond to those comments. The responses are numbered in enclosure 1 to correspond with the comments in your letter. The responses related to the VSR scope have been reviewed and concurred to by Sargent & Lundy.

A summary of the commitments contained in this submittal is provided in enclosure 2.

We believe that these responses address your comments related to the VSR plan. If there are any questions, please call John F. Cox, Watts Bar Program Team licensing member, at 615-365-3307.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

R. Gridley, Manager
Nuclear Licensing and
Regulatory Affairs

Enclosures
cc: See page 2



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U.S. Nuclear Regulatory Commission

NOV 15 1988

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ENCLOSURE 1

COMMENT 1

The staff understands that as proposed by TVA, the elements and/or attributes associated with five well-defined corrective action programs (CAPs) will be excluded from the VSR. These programs are Hanger and Analysis Update, Concrete Quality, Equipment Qualification, Control Room Design Review, and Welding. The VSR team should consider these areas to make a determination if portions of these programs should be included in the VSR program for completeness of the review. The NRC staff has not reviewed any of these five areas either programmatically or technically. Exclusion of the elements and/or attributes associated with these programs places an additional burden on the VSR team for one to assume that the exclusion does not invalidate the intent of the VSR program.

Response

The Vertical Slice Review Team (VSRT) has concluded that the exclusion of the five identified programs will not invalidate the intent of the VSR program because the design interfaces with the exclusion programs are being reviewed, where applicable, by the VSRT. In addition, the five exclusion programs are well defined and will be reviewed by the Watts Bar Program Team (WBPT) to ensure conformance with licensing requirements. The Nuclear Regulatory Commission (NRC), in its letter dated June 27, 1988, from S. D. Richardson to S. A. White, has agreed that sufficient basis exists for exclusion of the five identified programs.

COMMENT 2

Page II-3 - If design and construction activities are not homogeneous (i.e., similar activities performed by different contractors to different acceptance standards) then the VSR should be expanded horizontally to sample non-homogeneous activities.

Response

It is recognized that the design and construction activities in the plant may not be homogeneous. The VSRT has selected elements based on the application of industry experience and engineering judgement. The selection process was biased toward those areas of the selected systems which have greater potential for discrepancies and those areas which are more critical to the proper performance of plant safety functions. These elements are then reviewed for acceptance by using the TVA licensing requirements and other documents imposing safety-related requirements, such as design criteria. Therefore, the design and construction activities are reviewed, based on a uniform acceptance standard, and no horizontal expansion is considered necessary.

COMMENT 3

Page II-8 - The design process review should include an evaluation of Field Change Requests (FCRs) and Nonconformance Reports (NCRs) for appropriate disposition, especially important are those NCRs that have been dispositioned "Use-As-Is."

Response

A review of the design change process is included in the VSR. In the review of both design and construction activities, engineering change notices (ECNs), FCRs, and NCRs related to the systems and components reviewed by the VSRT are included in the review process. In addition, a select list of NCRs dispositioned as "use as-is" is also included in the review. Typical VSR checklists, which demonstrate that this type of review is performed, are MEV-1401 on containment isolation valves, MEV-1201 on small bore piping, and MEV-501 on ducts and plenums. These and other VSR checklists are available for NRC's review at WBN.

COMMENT 4

Page II-9 - Sargent & Lundy intends to review TVA performed design reviews for technical adequacy. The Sargent & Lundy review should also evaluate the adequacy of TVA's plant-specific corrective actions.

Response

The term "TVA-performed design reviews" as used on page II-9 of the VSR plan refers to an independent, overall review of system design performed by engineers other than those responsible for original design. Since the two systems reviewed by the VSRT did not have such a review performed by TVA, no specific assessment of TVA-performed design reviews could be performed by the VSRT. For the same reason, no review of the plant-specific corrective actions was performed. It should be noted that an assessment of the normal design process, including the regular checking and review conducted by the original design reviewers, was performed as part of the VSR. Also, the VSRT will review any corrective actions proposed by TVA line organizations to resolve the discrepancy reports written by the VSRT.

COMMENT 5

Page II-9 - The review of selected design documents should include the following attributes: (1) proper application of barriers at safety-related fluid system interface and (2) transmittal and utilization of interdisciplinary information, i.e., adequacy of discipline interfaces.

Response

The VSR includes a review of the application of barriers at safety-related fluid system interfaces, as demonstrated by VSR checklists MEV-801 on instrument lines, MEV-1001 on large bore piping, and MEV-1402 on general application valves. The adequacy of discipline interfaces is covered, for example, in checklists MEV-1401 (containment isolation valves) and EEV-1515

(valve motor operators) for mechanical and electrical interfaces on motor operated valves. Similarly, checklists MEV-1511 (pumps), EEV-405 (motors and generators), and SEV-1702 (equipment foundations and supports) cover the transmittal and utilization of interdisciplinary information on pump, motor, and foundation designs.

COMMENT 6

Page II-10 - In as much as the cut-off date for the vertical slice review documentation was April 22, 1988, some mechanism should have been in place to capture those attributes/elements not included or which were included but were incomplete as of April 22.

Response

April 22, 1988, was identified as the cutoff date for VSR documentation to ensure the objectivity of the VSR review, i.e., that the plant conditions existing at the start of VSR be objectively reviewed without considering any remedial changes that could have been made after the start of VSR. The April 22, 1988 cutoff date ensures that the elements and attributes of the originally completed plant are being reviewed by VSR because the original design and construction of WBN were completed substantially by 1984.

COMMENT 7

Page II-11 - It is stated that the Mechanical Systems review will include "process design." This terminology is very broad and sweeping but obviously implies different things to different people. The design attributes reviewed need to be clearly defined for all design disciplines.

Response

The term "process design" as used on page II-10 of the VSR plan means fluid process design that includes fluid capacities, pressures, temperatures, etc., for piping, valves, and equipment. The detailed attributes for this review are included in the VSR checklists, e.g., MEV-801 (instrument lines), MEV-1001 (large bore piping), and MEV-1402 (general application valves).

COMMENT 8

Page II-11 - The scope of Civil/Structural review is very vague. This review should include a review of the design attributes that are included in safety-related structures, e.g., design of reinforced concrete walls and slabs, design of masonry walls, development of building seismic models and the generation of the amplified response spectra at various building elevations, cable tray and conduit supports, auxiliary steel, etc.

Response

The scope of the civil and structural review includes a review of the design attributes for elements such as reinforced concrete walls and slabs, masonry

walls, building seismic models and generation of the amplified response spectra, cable tray and conduit supports, auxiliary steel, etc., in addition to many other structural items. These items are specifically identified on the VSR checklists used for the review, e.g., SEV-1601 (concrete structures), SEV-1901 (masonry walls), SEV-2199 (seismic analysis), SEV-301 and 302 (cable tray and conduit supports), and SEV-901 (pipe and instrument support and supplementary steel).

COMMENT 9

Page II-11 - The Electrical Systems review should include the DC system as well as the AC system. The design attributes to be reviewed are not specified.

Response

In addition to the AC Shutdown Power System, portions of the electrical DC system are being reviewed in the VSR, as noted in the VSR checklists prepared for the electrical review activities, i.e., checklist number EEV-0409 for vital and backup DC power, EEV-0404 for vital battery charger, and EEV-0401 for vital battery. The design attributes to be reviewed are included in these checklists.

COMMENT 10

Page II-11 - Design for "common requirements" such as seismic II/I, HELB/MELB, internal flooding, etc., should be verified by a field walkdown conducted by the Sargent & Lundy VSR team.

Response

Design for common requirements, which include fire protection and high energy line break (HELB), are being verified by field walkdown conducted by the VSRT, as demonstrated by checklists MEV-2105 (fire protection) and MEV-2106 (HELB). The WBPT is evaluating the addition of the seismic II/I activities to the VSR scope and will advise NRC of its plans within 60 days. The moderate energy line break (MELB) and associated internal flooding have not been included in the VSR because these evaluations for these areas were performed, including a field walkdown, for WBN during 1986-87. The program adequacy for these areas will be reviewed by the WBPT for acceptance.

COMMENT 11

Page II-14 - We agree that certain items embedded in concrete are inaccessible, however, pull tests on anchor bolts can be performed and anchor bolt depth can be measured by ultrasonics. These tests are not difficult to perform and should be included in the Construction Verification Review (CVR).

Response

The WBPT is evaluating the addition of either a pull test on anchor bolts or anchor bolt depth measurements to the VSR and will advise NRC of its plans within 60 days.

COMMENT 12

Page II-14 - The examples of what is anticipated to be reviewed in the CVR inspections are quite general. The purpose of the CVR and the specific attributes reviewed need to be clearly stated.

Response

The areas and the specific attributes to be reviewed under CV are identified in the VSR checklists and associated checklist instructions developed for construction review, e.g., ECV-101 (cables), MCV-1511 (pumps), and SCV-1806 (steel structures).

COMMENT 13

Page II-16 - It is not clear to the staff how the Construction Support Records review will determine to what extent maintenance activities have been done on elements and how the elements have been changed materially as a result of these maintenance activities.

Response

The VSR construction support records review is intended to demonstrate that the records adequately reflect the installed plant hardware. There are several CAPs which will address the effects of maintenance activities on the plant equipment and components. The quality assurance list (Q-List) program will verify the proper use of quality assurance (QA) program application to the maintenance activity on systems and components. The piece parts program will review the adequacy of the parts replaced through maintenance activity on safety-related equipment. The Design Baseline and Verification Program will provide the preoperational test scoping documents which will be used by the Prestart Test Program to determine whether the components and systems can function as designed. This process will detect any adverse effects of maintenance activity on the equipment and components.

COMMENT 14

General - TVA should have a program that determines the adequacy of its as-built reconciliation programs for piping, electrical cable routing and pull lengths, common hazards, (e.g., HELB target evaluation,) etc.

Response

The systematic evaluation being performed under the Watts Bar Program Plan will provide reasonable assurance that WBN design and construction meet licensing requirements; this includes verification of the as-built conditions of the plant. The WBPT is reviewing the adequacy of as-built reconciliation programs, such as the Hanger and Analysis Update Program (HAAUP), which will verify the adequacy of as-built piping and supports. As-built verification of cable routing by the VSRT using signal tracing is being evaluated by the WBPT, and the WBPT will advise NRC of its plans within 60 days. As noted in response to comment 10, field walkdowns will be performed by the VSRT for common hazards, e.g., HELB and fire protection.

COMMENT 15

Section V - Who does the Head, Quality Assurance Division report to as described in the Quality Assurance Program for the VSR?

Response

The head of Sargent & Lundy (S&L) Quality Assurance (QA) Division reports to S&L's director of services for QA activities in accordance with the S&L QA manual, as shown on the attached Figure 01.01-1, "Sargent & Lundy Organization Chart," from S&L Topical Report SL-TR-1A, revision 7.

COMMENT 16

Section V - The Quality Assurance Coordinator reports to the Senior Quality Assurance Coordinator as described in Section 2.2.4. However, the Senior Coordinator does not appear on the organization chart (Exhibit IV-1). Where does the Senior QA Coordinator fit in the organization?

Response

The QA coordinator in the VSRT reports to the project manager for project activities, as shown in the attached Exhibit IV-1. It should be noted that this exhibit, when originally submitted with the VSR plan to NRC, had an error in that it showed the QA coordinator reporting to the project director instead of project manager. Also, D. C. Haan (Internal Review Committee member) and J. P Wittenauer (Electrical Project Engineer) have replaced R. L. Givan and T. M. McCauley, respectively, due to availability reasons. The exhibit does not show a senior QA coordinator because there is no senior QA coordinator on the project team. The QA coordinator reports to the senior QA coordinator for his non-VSR activities, e.g., administrative and technical direction, and the senior QA coordinator reports to the Head, QA Division, as shown on the attached Figure 01.02-1, "Quality Assurance Division Organization Chart," from S&L Topical Report S1-TR-1A, revision 7.

ENCLOSURE 2

For the Watts Bar Nuclear Plant (WBN), TVA commits to:

1. The Watts Bar Program Team (WBPT) will review the five exclusion programs to ensure conformance with licensing requirements.

2. The Vertical Slice Review Team (VSRT) will review any corrective actions proposed by TVA to resolve the discrepancy reports written by the VSRT.

3. The WBPT is evaluating the addition of seismic II/I activities to the vertical slice review (VSR) scope and will advise NRC of its plan within 60 days.

4. The WBPT will review the program adequacy of the evaluations for moderate energy line break (MELB) and internal flooding.

5. The WBPT is evaluating the addition of either a pull test on anchor bolts or anchor bolt depth measurements to the VSR scope and will advise NRC of its plans within 60 days.

6. The WBPT is reviewing the adequacy of as-built reconciliation programs, such as the Hanger Analysis and Update Program, which will verify the adequacy of as-built piping and supports.

7. As-built verification of cable routing by the VSRT using signal tracing is being evaluated by the WBPT, and the WBPT will advise NRC of its plans within 60 days.

SARGENT & LUNDY ENGINEERS

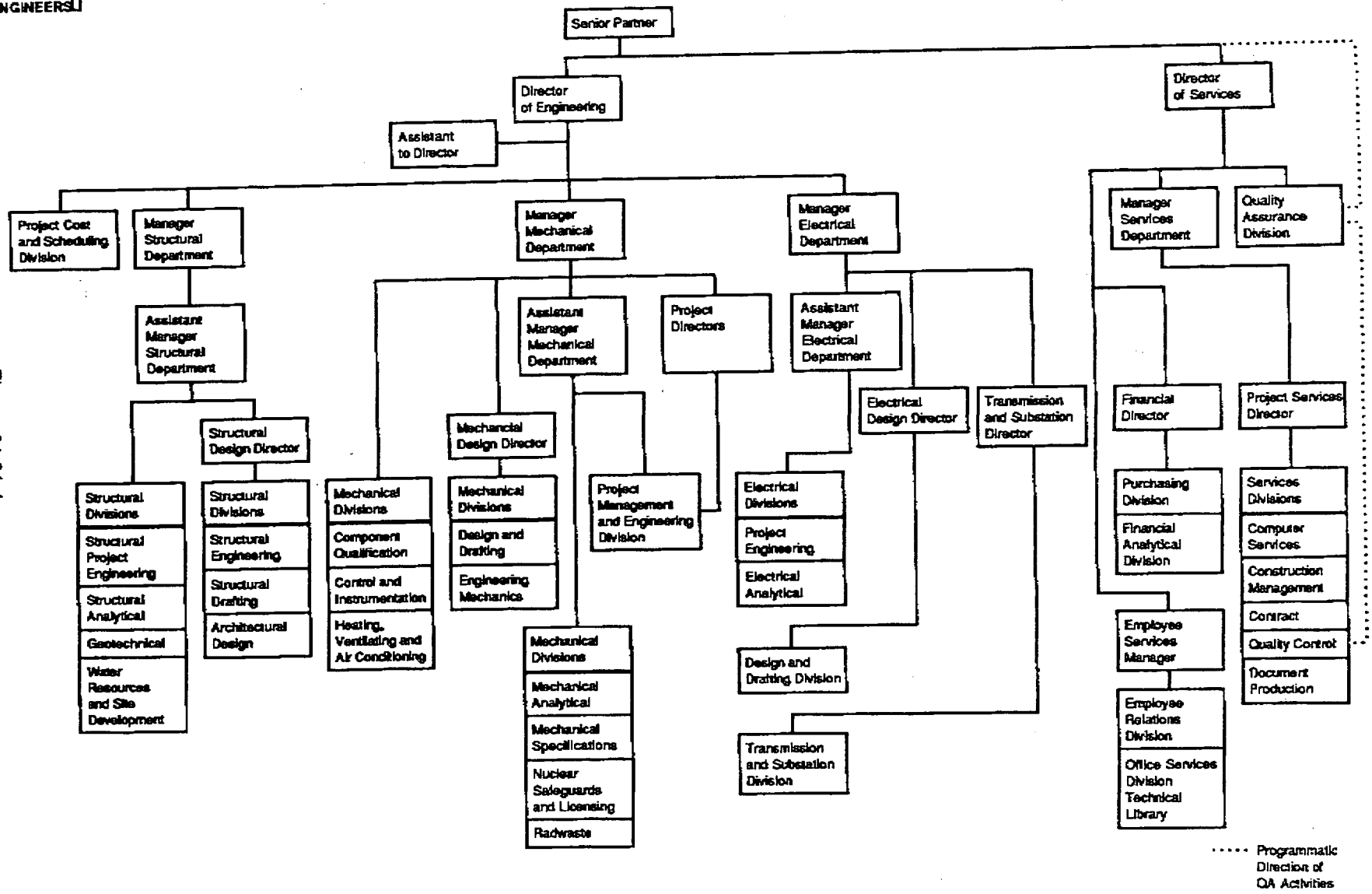


Figure 01.01-1
Sargent & Lundy Organization Chart
01-2

Figure Revised 7

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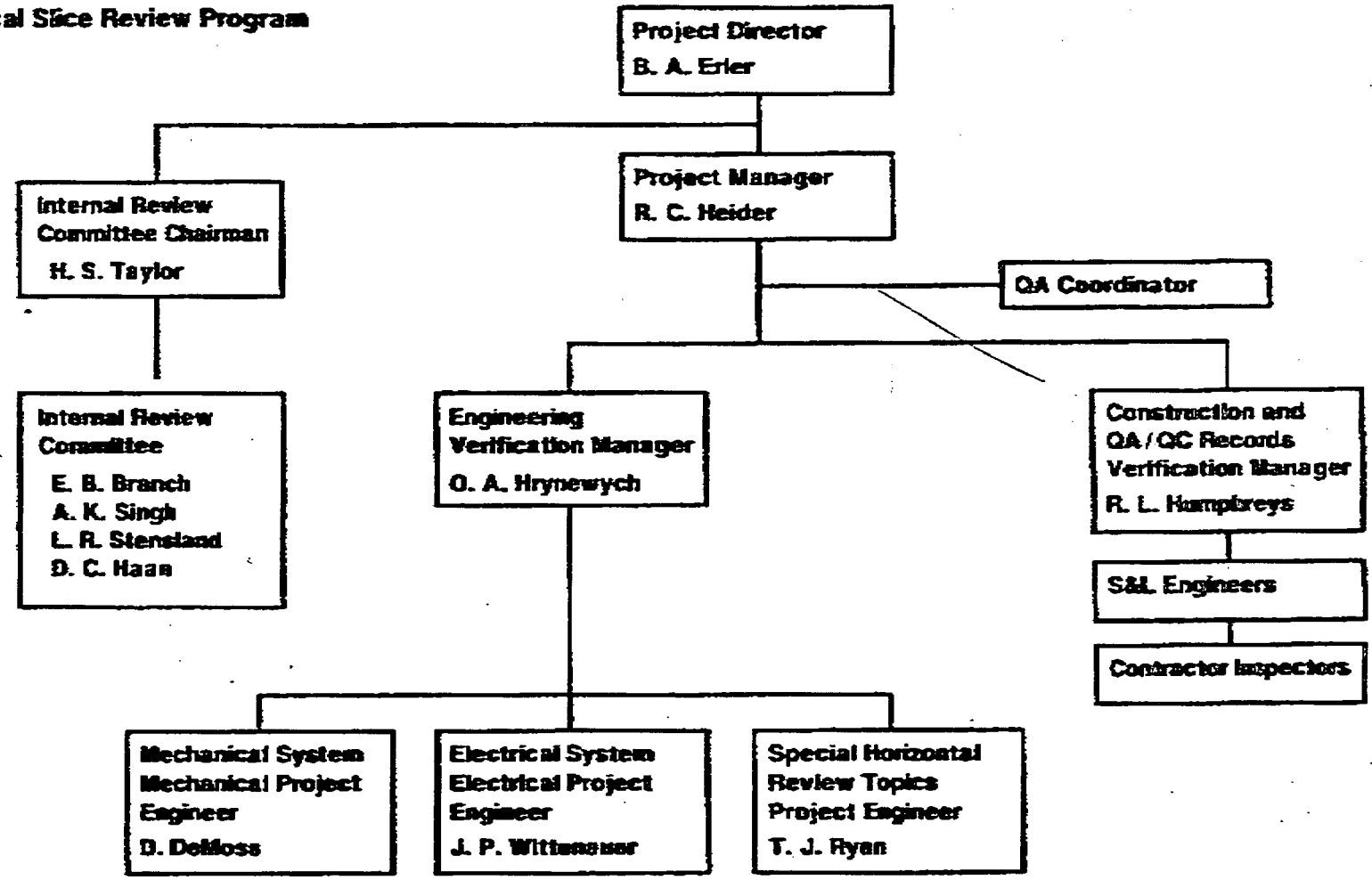
**TVA Watts Bar Nuclear Plant**
**Vertical Slice Review Program**

**Exhibit IV-1**



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## Quality Assurance Division

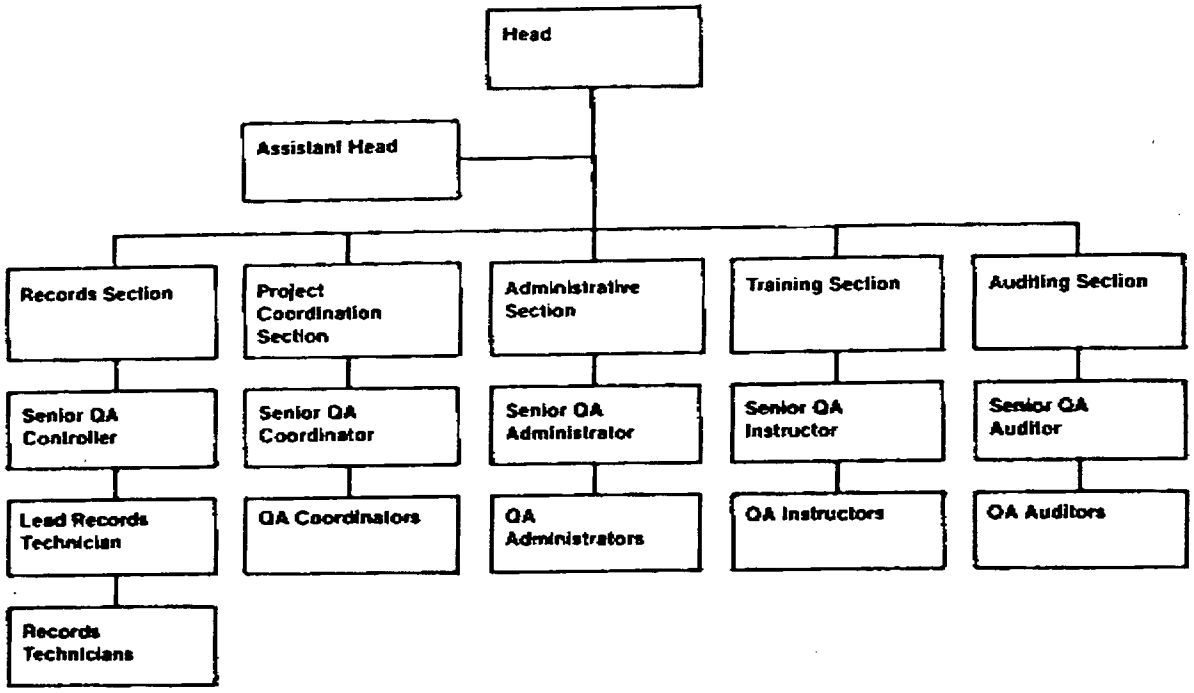


Figure 01.02-1
Quality Assurance Division
01-7

Figure Revised | 7