PMComanchePekNPEm Resource

From: Monarque, Stephen
Sent: Monday, September 14, 2009 3:57 PM
To: ComanchePeakCOL Resource
Subject: FW: Responses to 41 Geotechnical Questions non public for now
Attachments: TXNB-09042 Geo RAI Pkg 3.pdf

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Sent: Thursday, September 10, 2009 6:15 PM
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Subject: Responses to 41 Geotechnical Questions

Luminant has submitted the attached responses to more than 40 geotechnical questions from 6 individual RAIs (listed on page 3 of the letter). Attachments 1-6 contained the responses. Attachment 7 contained all the marked-up FSAR pages resulting from the responses. Attachment 8 contained a list of files that were included on the CD submitted as Attachment 9. These were documents requested by the NRC and digital Appendix D to the Field Reconnaissance Report previously submitted. The attached letter does not include Attachment 7 or 9 (260 Mb).

If there are any questions regarding the responses, please contact me or contact Don Woodlan (254-897-6887, Donald.Woodlan@luminant.com).

Thanks,

John Conly
COLA Project Manager NuBuild
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Email Number: 1039

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Ref. # 10 CFR 52

September 10, 2009

U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555
ATTN: David B. Matthews, Director
Division of New Reactor Licensing

SUBJECT: COMANCHE PEAK NUCLEAR POWER PLANT, UNITS 3 AND 4
DOCKET NUMBERS 52-034 AND 52-035
PARTIAL RESPONSE TO REQUESTS FOR ADDITIONAL INFORMATION
NO. 1889, 2929, 2930, 3015, 3016, AND 3080

Dear Sir:

Luminant Generation Company LLC (Luminant) hereby submits 41 responses to the geotechnical Requests for Additional Information for the Combined License Application for Comanche Peak Nuclear Power Plant Units 3 and 4. The specific questions answered are listed on page 3 of this letter. The FSAR pages affected by these responses have been marked up and are presented in Attachment 7. Additional documents supporting the responses are included on the attached CD.

Additionally, Luminant is submitting digital Appendix D to the Field Reconnaissance Report that was provided on August 12, 2009 (ML092290395). Appendix D contains numerous photographs that may be helpful to the NRC in understanding the conclusions reached during the geotechnical assessment of the Units 3 and 4 site. The photographs are ".jpg" files, which do not meet the requirements for electronic submittal as defined in "Guidance for Electronic Submissions to the NRC, Rev. 5." Some of the other documents provided on the CD are in their native formats for use by the NRC and do not meet the electronic submittal requirements.

Should you have any questions regarding these responses, please contact Don Woodlan (254-897-6887, Donald.Woodlan@luminant.com) or me.

There are no commitments in this letter.

I state under penalty of perjury that the foregoing is true and correct.

Executed on September 10, 2009.

Sincerely,

Luminant Generation Company LLC

Rafael Flores

Rafael Flores

Attachments -
1. Response to Request for Additional Information No. 1889 (CP RAI #11)
2. Response to Request for Additional Information No. 2929 (CP RAI #22)
3. Response to Request for Additional Information No. 2930 (CP RAI #19)
4. Response to Request for Additional Information No. 3015 (CP RAI#21)
5. Response to Request for Additional Information No. 3016 (CP RAI #18)
6. Response to Request for Additional Information No. 3080 (CP RAI #15)
7. Marked-up FSAR Pages
8. List of Files included on CD
9. CD containing documents and photographs

cc – Stephen Monarque w/all Attachments

Electronic Distribution w/Attachments except 7 and 9

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List of Questions Answered in this Letter

RAI #	1889	2929	2930	3015	3016	3080
	02.05.02-2	02.05.04-5	02.05.05-3	02.05.01-4	02.05.03-1	02.05.01-2
	02.05.02-4	02.05.04-6		02.05.01-6	02.05.03-2	
	02.05.02-5	02.05.04-7		02.05.01-8	02.05.03-3	
	02.05.02-6	02.05.04-8		02.05.01-9		
	02.05.02-8	02.05.04-13		02.05.01-11		
	02.05.02-11	02.05.04-15		02.05.01-13		
	02.05.02-12	02.05.04-18		02.05.01-14		
	02.05.02-13	02.05.04-19		02.05.01-15		
	02.05.02-14	02.05.04-20		02.05.01-16		
	02.05.02-15	02.05.04-21		02.05.01-17		
	02.05.02-17			02.05.01-18		
	02.05.02-18			02.05.01-20		
	02.05.02-19					
	02.05.02-20					

Attachment 1

Response to Request for Additional Information No. 1889 (CP RAI #11)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 1889 (CP #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/01/2009

QUESTION NO.: 02.05.02-2

In Tables 2.5.2.-202 through 2.5.2-207 you listed seismic sources that contribute more than 1% of the total hazard at the Comanche Peak site. It is not clear to the staff if these contributing sources are based on the results of the original EPRI PSHA study or they are based on the results of your own assessments conducted using the updated ground motion prediction models and the latest Comanche Peak earthquake catalog. If it is the former, please discuss in details why you concluded that change in ground motion prediction models and/or the updated catalog (e.g., Mmax updates) would not result in higher hazard contributions from these unused seismic sources.

ANSWER:

The list of contributing seismic sources in Tables 2.5.2-202 through 2.5.2-207 were taken from the original EPRI PSHA study, and were confirmed with updated calculations that used the EPRI (2004) ground motion equations (FSAR Reference 2.5-401). Possible effects of the updated Comanche Peak earthquake catalog on earthquake recurrence rates were addressed separately in FSAR Figures 2.5.2-210 and 2.5.2-211, which concentrate on regions that most affect the hazard at the Comanche Peak site.

Impact on R-COLA

FSAR Revision 0 page 2.5-72 has been revised to reflect this RAI response.

See attached changes for page 2.5-72. Because of the text additions and deletions, the page numbers on the mark-up FSAR pages may not be the same as the page numbers in FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 1889 (CP #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/01/2009

QUESTION NO.: 02.05.02-4

In Subsection 2.5.2.1.3.1 you described your interpretation of the tectonic environment that produced the moderate-sized (M=5.8) earthquake of April 14, 1995 in Western Texas. In your PSHA analysis, rather than updating the EPRI M_{max} values of many of the seismic sources, you opted to create a new seismic source to accommodate any potential hazard that may result from an easterly extending Rio Grande Rift model. In your conclusions, you also stated that in your hazard calculations this new source resulted in less than 1% of the total hazard at the site and as a result, you did not incorporate it in your final PSHA calculations. Please provide further scientific evidence including a list of publications and reports that studied the April 14, 1995 earthquake and reached a conclusion that this earthquake is tectonically related to the Rio Grande Rift system. Please also provide further information on how the hazard calculated at the Comanche Peak site would be impacted if you were to update the EPRI source model parameters, such as M_{max} values to accommodate this 5.8 magnitude event, as it is normally done when EPRI source models are used as a starting point to calculate seismic hazard at a COLA site.

ANSWER:

This RAI question raises two issues that can be paraphrased as follows:

1. Provide further evidence the Alpine earthquake is related to the Rio Grande Rift; and
2. Provide further information on how the hazard calculated at the site would be impacted if the EPRI source model parameters were updated to accommodate this 5.8 magnitude event.

Each of these issues is addressed below.

<u>Issue 1</u>

As discussed in the introduction to Subsection 2.5.2 and in detail in Subsection 2.5.2.2, Regulatory Guide (RG) 1.208 (NRC, 2007) was used as the primary guidance in developing the seismic source characterization for CPNPP Units 3 and 4. This guidance states that

> *"… seismic sources and data accepted by the NRC in past licensing decisions may be used as a starting point" for the PSHA (page 14, RG 1.208).*

RG 1.208 also provides guidance stating that site-specific geological, geophysical, and seismological studies should be conducted to determine if these accepted source models adequately describe the seismic hazard for the site of interest given any new data developed since acceptance of the original models. The guidance from RG 1.208 describing this review process includes language such as the following:

> *"The results of these [site-specific] investigations will also be used to assess whether new data and their interpretation are consistent with the information used in recent probabilistic seismic hazard studies accepted by NRC staff" (RG 1.208, page C-1).*

> *". . . determine whether there are any new data or interpretations that are not adequately incorporated into the existing PSHA databases" (RG 1.208, page 11).*

The key issue identified by RG 1.208 guidance is that new data should be evaluated as to whether the accepted, starting point model "adequately" describes, or is "consistent" with, the new data.

If new information or data indicates that the EPRI-SOG model requires updating, RG 1.208 provides the guidance that significant updates to the source characterizations follow the guidance presented in NUREG/CR-6372 (Budnitz et al., 1997). NUREG/CR-6372, prepared by a Senior Seismic Hazard Analysis Committee (SSHAC), provides recommendations on the development of PSHA studies for nuclear facilities. A primary recommendation of the SSHAC is that for a given technical issue (i.e., source zone characterization),

> *"The following should be sought … (1) a representation of the legitimate range of technically supportable interpretations among the entire informed technical community…" (page xv, NUREG/CR-6372).*

For CPNPP Units 3 and 4, the EPRI-SOG (EPRI, 1986-1989) source characterizations are used as the base source models. As guided by RG 1.208, an extensive review of all available information and data developed since the EPRI-SOG study was conducted as part of the CPNPP 3 and 4 COLA effort to determine if the EPRI-SOG source characterizations were inconsistent with or not adequate to describe the newer data. One focus of this review was the April 14, 1995 earthquake near Alpine Texas, and, through following the guidance presented within RG 1.208, it was determined that: (1) the EPRI-SOG model does not adequately described the Alpine earthquake, and (2) it is not a legitimate technical interpretation of the earthquake to account for its occurrence by updating the Mmax values of the contributing EPRI-SOG source zones that contain the earthquake. The data and discussion supporting this decision are presented in Subsections 2.5.1.1.4.3.7.1, 2.5.2.1.3.1, 2.5.2.4.2.2, and 2.5.2.4.2.3.3. The arguments presented in those subsections are expanded upon below.

The Alpine earthquake was a notable earthquake within the south-central US in that it is the second largest known earthquake to have occurred within Texas and the largest well-recorded earthquake in Texas (Frohlich and Davis, 2002). As such, the earthquake has been of considerable interest to the seismological community and data recorded from the event has been used in numerous studies (e.g., Das and Nolet, 1998; Melbourne and Helmberger, 1998; Rodgers and Bhattacharyya, 2001; Xie, 1998). However, there have not been any studies that directly investigated the seismotectonic setting or cause of the earthquake. The conclusion presented within the COLA that the Alpine earthquake is related to the Rio Grande Rift (RGR) is primarily based on two items: (1) the expert opinion of the geologists and geophysicists working on the CPNPP Units 3 and 4 COLA that was reached based on observations that the event was a normal faulting event (Global CMT Project, 2007; Xie, 1998) indicative of the type of tensile stress regime thought to exist throughout the RGR and the Basin and Range tectonic provinces but not central Texas (e.g., Humphreys and Coblentz, 2007a); (2) the expert opinion of a leading US research seismologist with a particular interest in the seismicity of western Texas that the event is related to the RGR (Doser, 2007).

Subsection 2.5.1.1.4.2 describes the regional state of stress around the CPNPP 3 and 4 site in detail and some of the material presented within that subsection is summarized below. Humphreys and Coblentz (2007a), as well as other researchers (e.g., Richardson and Reding, 1991; Zoback and Zoback, 1980; Zoback and Zoback, 1989), have subdivided North America into different stress provinces. The Basin and Range and RGR seismotectonic provinces, including westernmost Texas where the Alpine earthquake occurred, are encompassed within a large tensile stress domain trending roughly north-south from the US-Canada border to southern Mexico that is referred to as the Southern Great Plains Stress province. Tensile stresses within the Southern Great Plains Stress province have been interpreted to arise from positive buoyancy forces associated with the high potential energy of the elevated Cordilleran topography (e.g., the RGR and the Basin and Range) to the west (Humphreys and Coblentz, 2007a). This potential energy gradient is widely recognized as one of the forces driving deformation within the RGR, and the extent of the elevated topography and the extent of the region over which the potential energy gradient impacts the crustal state of stress can be used in defining the full extent of the RGR seismotectonic province (see Subsection 2.5.1.1.4.3.7.1) (Eaton, 1982, 1987; Humphreys and Coblentz, 2007b; Jones et al., 1996, 1998; Keller, 2004; Keller et al., 1990; Olsen et al., 1987; Pazzaglia and Hawley, 2004; Reinecker et al., 2005). As apparent from the material presented within the referenced studies, this region of elevated topography and related tensile stress does not extend as far to the east as central Texas and the CPNPP Units 3 and 4 site. Based on these studies and the observations that (1) the Alpine earthquake occurred within the region considered to be part of the larger, geophysically and dynamically defined RGR, and (2) the Alpine earthquake had a moment tensor solution indicative of normal faulting consistent with a state of stress driven by the RGR, it was concluded that the Alpine earthquake was related to RGR dynamics.

Support for this conclusion was provided by formal communication with Dr. Diane Doser, a leading Texas seismologists from the University of Texas at El Paso. Dr. Doser stated that the Alpine earthquake "… is somehow related to the interaction of the rift with the Great Plains" (Doser, 2007). In previous work, Doser has calculated focal mechanism for earthquakes within the Permian Basin slightly north of the Alpine earthquake that are similar to the Alpine event in that they indicate roughly north-south normal faulting (Doser et al., 1992). Doser (1992) attributes these mechanisms to the presence of a north-northeast oriented minimum compressive stress, and states that "this direction is consistent with regional east-west compression inferred from the recent uplift of the Rio Grande rift located farther west" (page 501) (Doser et al., 1992). Doser (2007) believes that the same factors likely caused the Alpine earthquake. The issue of the Alpine earthquake and its relationship to the RGR was also discussed informally with Dr. Cliff Frohlich, another leading Texas seismologist from the University of Texas at Austin. Dr. Frohlich expressed his opinion that relating the event to the RGR was a valid and defendable interpretation.

Having established that the Alpine earthquake was related to the RGR based on expert opinions from the technical community and all available data, the next step taken was to determine whether the EPRI-SOG source characterizations adequately capture this information. As shown in FSAR Figures 2.5.2-203 through 2.5.2-208 and Tables 2.5.1-206 through 2.5.1-211, the Alpine earthquake occurred within three EPRI-SOG source zones that have Mmax values lower than the magnitude of the earthquake (Emb 5.8): the Law New Mexico – Texas Block, the Rondout Grenville Crust, and the Weston Southwest. All of these zones extend well beyond, and in particular to the east, of the physiographic, lithospheric, and dynamic extent of the RGR province (see Subsection 2.5.1.1.4.3.7.1 and previous discussion in this RAI response). As such, it was readily concluded that: (1) these three EPRI-SOG source zones do not adequately characterize the Alpine earthquake, and (2) simply modifying the Mmax values for these zones to account for the Alpine earthquake would not be a legitimate interpretation of the seismic hazard associated with the Alpine earthquake given that the lithospheric dynamics that likely cased the earthquake are related to the RGR and not the stable continental interior that encompasses central Texas and much of the area represented by the three EPRI-SOG source zones.

Having established that the existing EPRI-SOG source zones did not adequately represent the Alpine earthquake, the guidance of RG 1.208 was followed to determine if revisions to the EPRI-SOG source zones were required. Key guidance provided by RG 1.208 includes the following:

> "If new information identified by the site specific investigations were to result in a significant increase in the hazard estimate for a site, and if this new information were validated by a strong technical basis, the PSHA might have to be modified to incorporate the new technical information" (page C-4, RG 1.208).

This guidance recommends that revisions only be made to the PSHA (e.g., the EPRI-SOG model) if: (1) there is "strong technical basis" for the revisions, and (2) if the new information were to result in a "significant increase in the hazard estimate" for the site. Because of the considerable distance between the location of the Alpine earthquake and the CPNPP Units 3 and 4 site (over 350 miles), a sensitivity study was conducted to determine whether or not including RGR seismic sources, and thus the Alpine earthquake, would result in a significantly increased hazard estimate for the CPNPP Units 3 and 4 site per the second guidance point outlined above. The characterization of the RGR used in this sensitivity study is described in detail in Subsections 2.5.1.1.4.3.7.1, 2.5.2.1.3.1, 2.5.2.4.2.2, and 2.5.2.4.2.3.3, and the results of the sensitivity analysis is discussed in 2.5.2.4.4. As stated in the RAI question, this analysis concluded that the RGR, and thus the Alpine earthquake, does not have a significant impact on the CPNPP Units 3 and 4 hazard. Therefore, it was concluded that the PSHA did not need to be modified to account for the Alpine earthquake or the RGR in the final hazard analysis.

<u>Issue 2</u>

The RAI question asks for additional information on how updating the EPRI-SOG source model parameters (e.g., Mmax) to account for the Alpine earthquake would impact the hazard at the CPNPP Units 3 and 4 site. The question supports this request by stating that such updates are "…normally done when EPRI source models are used as a starting point to calculate seismic hazard at a COLA site."

It is not possible to explicitly discuss what is "normally done" by other COLA applicants because other COLAs are independent of the CPNPP Units 3 and 4 COLA effort and because the CPNPP Units 3 and 4 COLA was explicitly written to follow NRC regulations and regulatory guidance, not the assumed precedent set by other COLAs currently under review. However, the general practice for most COLAs, and the practice followed here, is to follow the guidance of RG 1.208 in developing the seismic hazard assessment for a site. As outlined in response to issue 1, modifications to the EPRI-SOG model, including an update of parameters (e.g., Mmax), should be conducted if needed to ensure the source characterizations are consistent with the latest information and data and only if: (1) there is a "strong technical basis" for the revisions, and (2) if the new information were to result in a "significant increase in the hazard estimate" for the site. As outlined in the response to issue 1, modifying the Mmax values of the existing EPRI-SOG source zones to account for the Alpine earthquake is not a technically supportable or legitimate interpretation of the earthquake, and there is no strong technical basis for making this type of revision. Therefore, from a regulatory and technical point of view, it is not appropriate to conduct sensitivity analyses to determine the impact of such modifications on the site hazard. Because the results of such an analysis are not technically supported and may be misleading, the suggested analysis was not performed.

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<u>Impact on R-COLA</u>

None.

<u>Impact on S-COLA</u>

None.

<u>Impact on DCD</u>

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 1889 (CP #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/01/2009

QUESTION NO.: 02.05.02-5

In Subsection 2.5.2.4.2.3.2.3 you stated that "Epistemic uncertainty in return periods for characteristics earthquakes on the Meers fault is implemented through return period branches on a logic tree." The FSAR does not include this logic tree. Please provide a copy of this logic tree.

ANSWER:

The logic tree (Figure 1 attached) used to represent epistemic uncertainty in the return period and magnitude for characteristic earthquakes on the Meers fault is attached. The details of this logic tree are described in FSAR Subsection 2.5.2.4.2.3.2.3.

Impact on R-COLA

None.

Impact on S-COLA

None.

Impact on DCD

None.

Attachments

Figure 1 - Logic tree of return period and characteristic magnitude for the Meers fault

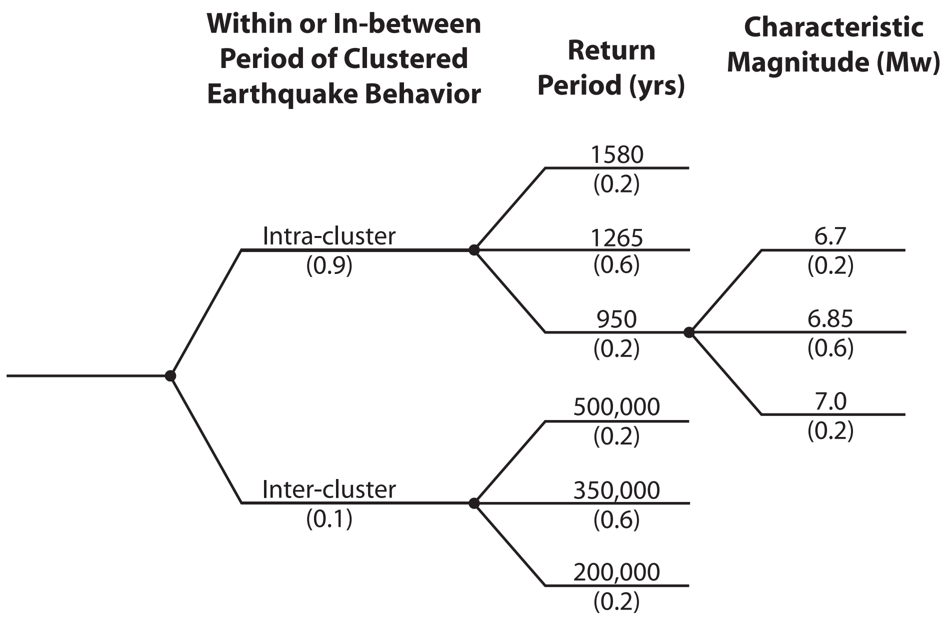

Figure 1: Logic tree of return period and characteristic magnitude for the Meers fault.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 1889 (CP #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/01/2009

QUESTION NO.: 02.05.02-6

In Subsection 2.5.2.4.2.3.3.2 you stated that rather than using areal sources to represent the Rio Grande Rift seismic source, you used a point source because it is more conservative. Please describe why this is a more conservative approach.

ANSWER:

Depending on the characteristics used to define the Rio Grande Rift (RGR) (e.g., physiography, faults, geophysical expression), at its closest extent the RGR is between approximately 300 and 400 miles from the CPNPP Units 3 and 4 site. Following the guidance in RG 1.208, a sensitivity analyses was conducted to determine whether the RGR would have a significant contribution to the seismic hazard at the site. As outlined in Subsection 2.5.2.4.2.3.3, a simplified model of the RGR was used because of the large distance between the site and the RGR.

The statement in Subsection 2.5.2.4.2.3.3 that the point-source model was conservative was meant to refer to the point source being a conservative representation of hazard from potential faults within the RGR that are not included within the USGS source characterization of the RGR (Frankel et al., 2002). The statement was not directed towards comparing a point source and an areal source model. The FSAR text was modified to clarify this point.

The conclusion that the point source model is a conservative representation of the hazard for any individual RGR fault that was not included within the USGS source characterization is based on the fact that: (1) the source-site distance is the shortest possible distance between the RGR (as defined by the lithospheric expression of the RGR) (e.g., Eaton, 1982, 1987; Humphreys and Coblentz, 2007; Keller, 2004; Keller et al., 1990; Olsen et al., 1987; Pazzaglia and Hawley, 2004) and the site, and (2) the point source is further east than any identified, potentially capable faults of the RGR by more than 20 mi (e.g., Collins and Raney, 1994, 1997; Dickerson and Muehlberger, 1994; Muehlberger et al., 1978).

The text of the FSAR was modified to reflect the above.

Impact on R-COLA

FSAR Revision 0 pages 2.5-102 and 2.5-228 were revised to reflect this response.

See attached changes for pages 2.5-101, 2.5-102, 2.5-103, 2.5-244 and 2.5-245. Because of the text additions and deletions, the page numbers on the mark-up FSAR pages may not be the same as the page numbers in FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 1889 (CP #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/01/2009

QUESTION NO.: 02.05.02-8

In FSAR Subsection 2.5.2.5 you stated "Velocity data for the deep profile was limited to only a few wells". The FSAR does not provide the actual number and location of these wells. Please provide additional information on the location and geologic environment of these wells you used in estimating deeper velocities at the site. Also, provide further information on how projections were made to the site given the geology and the well locations relative to the site.

ANSWER:

See revised FSAR Subsection 2.5.4.4.2.2.

A variety of regional information was used to determine the deep stratigraphy for CPNPP 3 and 4. Stratigraphic and velocity data were acquired from published literature and regional oil and gas wells. Final Safety Analysis Report Figure 2.5.1-221 shows the location of the wells used to determine deep stratigraphic units and the two wells that provided velocity data.

The resulting deep stratigraphic profile begins in the lower Pennsylvanian Strawn group, which contains the Mineral Wells formation, the deepest unit defined as part of the shallow profile is discussed in Subsection 2.5.4.4.2.1. The remainder of the Strawn Series is lithologically similar to the Mineral Wells and consists of shales and intebedded sandstones and limestones. Included within the Strawn Series are the Garner and Millsap Lake formations. Below the Strawn is the Atoka Group which includes the Atoka Sand, the Smithwick Shale, and the Big Saline Conglomerate. The top of the Atoka Group, the Atoka sand, is shale interbedded with sands and limestones. The sandstone layers have an average thickness of about 30 feet (Thompson, 1982). To the north and west of the study area, the upper portion of the Atoka Group includes the Caddo Reef, a massive limestone. In Sommervell County, however, located closer to the Ouachita thrust belt, deposition was more likely terrigenous (Thompson, 1982). Beneath the Atoka sand, the Smithwick is primarily a black shale, with a thickness that varies from 300 to 600 feet (Sellards et al., 1932). Below the Smithwick shale, the Big Saline Conglomerate has a variable thickness and pinches out just southeast of the site, so that at CPNPP 3 and 4 it has a projected thickness of about 40 feet. Underlying the Atoka Group is the Marble Falls limestone. The upper portion of this unit is a dark-colored fossiliferous limestone (Sellards et al., 1932). The lower portion of the Marble Falls is interbedded dark limestone and gray-black shale, sometimes referred to as the Comyn Formation (Thompson, 1982), and sometimes considered part of the Barnett Shale, which is stratigraphically below the Marble Falls. The Mississippian Barnett Shale (250 to 1000 ft thick, regionally) represents a gas source and reservoir in the region. The Barnett Shale unconformably overlies the top of the Ellenburger Group throughout most of the Fort Worth Basin, though in the northeastern portion of the basin the Upper Ordovician Viola and Simpson limestones intervene (Montgomery et al., 2005). The Cambrian to Ordovician Ellenburger limestone and a thin underlying clastic sequence rests unconformably on metamorphic basement in the Fort Worth Basin and was deposited in a passive continental margin setting (Montgomery et al., 2005).

The methods for determining stratigraphic elevations of units are listed in order of confidence:

- The top of the Strawn (Mineral Wells formation) was measured in wells at the CPNPP 3 and 4 site location.
- Using GEOMAP-stated elevations of horizons in the three nearest wells, the attitude of each horizon was determined and the elevation projected to the site location.
- The CPNPP 3 and 4 site was projected onto the line of section of GEOMAPS cross section through two nearby wells (Squaw Creek and 1-Davis).
- Horizon elevations determined from GEOMAPS structure contour maps.

For all stratigraphic units, more than one method was available for determining the elevation of a given horizon, and the standard deviation (σ_{top}) of the elevations was used as an estimate of the error. Only a single elevation pick was determined for the top of the Big Saline thus, the average standard deviation in feet for the other stratigraphic units was applied as an estimate of the error.

<u>Impact on R-COLA</u>

FSAR Revision 0 Figure 2.5.1-221 and pages 2.5-109, 2.5-110, 2.5-111 and 2.5-167 were revised to reflect this response.

See attached changes for Figure 2.5.1-221 and pages 2.5-110, 2.5-111, 2.5-114, 2.5-115, 2.5-175, and 2.5-176. Because of the text additions and deletions, the page numbers on the mark-up FSAR pages may not be the same as the page numbers in FSAR Revision 0.

<u>Impact on S-COLA</u>

None.

<u>Impact on DCD</u>

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 1889 (CP #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/01/2009

QUESTION NO.: 02.05.02-11

In FSAR Subsection 2.5.2.1.3.2, you stated that “Other historic events are discussed in the FSAR for CPNPP Units 1 and 2, but intensity observations and isoseismal maps published by Frolich and Davis suggest that these events were not likely to be felt at CPNPP Units 3 and 4.” Please further clarify this statement by describing the number, locations and characteristics of the other historic events, and their maximum modified Mercalli intensity values at or near the CPNPP site.

ANSWER:

Following the guidance of RG 1.208, all new information developed since the EPRI-SOG model,(e.g., Carlson, 1984; Davis et al., 1985), was considered as part of the historic seismic events that may have affected the CNPP 3 and 4 site. FSAR Subsection 2.5.2.1.3 presents part of this review with respect to seismicity within the site region and beyond. Subsection 2.5.2.1.3.1 presents information on notable earthquakes from the updated seismicity catalog (i.e.., new data in the form of new earthquakes) and Subsection 2.5.2.1.3.2 presents information on notable historical earthquakes taken from the existing EPRI-SOG catalog that may have affected the CPNPP Units 3 and 4 site. Subsection 2.5.2.1.3.2 is primarily a review of information that was known during the development of the EPRI-SOG model, however new information developed since the EPRI-SOG model was also considered in evaluating these earthquakes (i.e., Davis et al., 1989; Doser, 1987; Frohlich and Davis, 2002).

The “Other historic events” discussed in the FSAR for CPNPP Units 1 and 2, are not discussed in Subsection 2.5.2.1.3.2 because the earthquake intensities were not detectable at the CPNPP Units 3 and 4 site based on more recent methods of evaluating seismic shaking intensities (e.g., Davis et al., 1989; Frohlich and Davis, 2002). Therefore, the Modified Mercalli intensities of these events near the site would be I and not detectable. These non-detectable earthquakes are as follows:

- The Emb 3.7 potential earthquake on 8 January 1891 near Rusk, Texas;
- The Emb 4.2 earthquake on 19 October 1930 near Donaldsonville, Louisiana;
- The Emb 3.5 earthquake on 9 April 1932 near Mexia, Texas; and
- The Emb 4.1 earthquake on 17 June 1959 near Lawton, OK.

These earthquakes are inconsequential for the CPNPP Units 3 and 4 site because: (1) they were taken into account during development of the EPRI-SOG model, (2) they were of minimal magnitude not causing ground shaking that could be detected at the site, and (3) there has been no new information presented regarding these earthquakes since the EPRI-SOG model.

Since the last sentence in Subsection 2.5.2.1.3.2, has no impact on the CPNPP Units 3 and 4 site so it was deleted.

<u>Impact on R-COLA</u>

FSAR Revision 0 page 2.5-70 was revised to reflect this response.

See attached changes for pages 2.5-69 and 2.5-70. Because of the text additions and deletions, the page numbers on the mark-up FSAR pages may not be the same as the page numbers in FSAR Revision 0.

<u>Impact on S-COLA</u>

None.

<u>Impact on DCD</u>

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 1889 (CP #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/01/2009

QUESTION NO.: 02.05.02-12

The Oklahoma aulacogen is an identified seismic source within the 200 mi of the CPNPP site and it is included in several of the EPRI/SOG source models as discussed in Subsection 2.5.2.2.1. The majority of these models, however, assign a low Probability of Activity (Pa) for the Oklahoma aulacogen (in the range of 0.08 to 0.6).

a. Please justify that these low probabilities still adequate for this source.

b. Does the recognition of the Meers fault, which marks the southern boundary of the Oklahoma aulocogen, as a Holocene fault with a Pa of 1.0, require a revision of the Pa values assigned for the Oklahoma aulocogen?

c. Does the pronounced seismicity observed within the seismic sources related to the Oklahoma aulocogen require increasing the Pa values and Mmax values for these sources?

ANSWER:

As discussed in the introduction to Subsection 2.5.2, and in detail in Subsection 2.5.2.2, RG 1.208 was used as the primary guidance in developing the seismic source characterization for CPNPP Units 3 and 4. This guidance states that

> *"… seismic sources and data accepted by the NRC in past licensing decisions may be used as a starting point (for the PSHA)"* (page 14, RG 1.208).

RG 1.208 also provides guidance stating that site-specific geological, geophysical, and seismological studies should be conducted to determine if these accepted source models adequately describe the seismic hazard for the site of interest given any new data developed since acceptance of the original models. The guidance from RG 1.208 describing this review process includes language such as the following:

> *“The results of these [site-specific] investigations will also be used to assess whether new data and their interpretation are consistent with the information used in recent probabilistic seismic hazard studies accepted by NRC staff" (RG 1.208, page C-1).*
>
> *". . . determine whether there are any new data or interpretations that are not adequately incorporated into the existing PSHA databases" (RG 1.208, page 11).*

The key issue identified within the RG 1.208 guidance is that new data should be evaluated as to whether the accepted, starting point model “adequately” describes, or is “consistent” with, the new data.

For CPNPP Units 3 and 4, the EPRI-SOG (EPRI, 1986-1989) source characterizations are used as the base source models. As guided by RG 1.208, an extensive review of all available information and data developed since the EPRI-SOG study was conducted as part of the CPNPP 3 and 4 COLA effort to determine if the EPRI-SOG source characterizations were inconsistent with or not adequate to describe the newer data. One focus of this review was the identification of any information or data that would alter the evaluations of the EPRI-SOG teams with respect to the strong earthquake potential of the Oklahoma aulacogen. The new information that was reviewed includes new gravity and magnetic data, refined models for the opening of the aulacogen, the updated earthquake catalog, and revised models of the state of stress within the site region. All of this information is discussed and presented within Subsections 2.5.1 and 2.5.2, and, as stated in those subsections, none of this information requires or motivates a revision to the EPRI-SOG characterization of strong earthquake potential for the Oklahoma aulacogen because none of the new information is inconsistent with or inadequately characterized by the existing EPRI-SOG model.

<u>Issue a</u>

Two of the key topics that were reviewed in evaluating the adequacy of the probability of activities (Pa) assigned to Oklahoma aulacogen sources by EPRI-SOG teams were: (1) the identification of any newly identified potentially capable or capable faults within the aulacogen and, (2) the occurrence of any earthquakes within magnitudes greater than Emb 5.0. The only capable fault within the Oklahoma aulacogen is the Meers fault. As discussed in Subsection 2.5.1.1.4.3.6.1, research post-dating the EPRI-SOG study has shown that fault had two ruptures in the Holocene and at least one additional rupture within the Quaternary. However, the Meers fault was known as a potentially capable fault at the time of the EPRI-SOG study (e.g., EPRI, 1986-1989; Gilbert, 1983a; Gilbert, 1983b), and the more recent research has simply refined the Quaternary history of the fault. It was concluded that the more recent research on the Meers fault does not impact the Pa for the Oklahoma aulacogen because: (1) an updated characterization of the Meers fault was developed for CPNPP 3 and 4, and (2) this newer research is not inconsistent with the EPRI-SOG characterization of the aulacogen when the updated Meers fault characterization is considered. In addition, there are no earthquakes within the Oklahoma aulacogen with magnitudes greater than or equal to Emb 5.0, so there are no new earthquakes to suggest the Pa for the aulacogen needs to be revised.

<u>Issue b</u>

As discussed above, the Meers fault was identified as a potentially capable fault at the time of the EPRI-SOG study, but the detailed history of the fault was not known until after completion of the EPRI-SOG study. Therefore, an updated characterization of the Meers fault was developed for CPNPP 3 and 4 following SSHAC level 2 guidelines (see Subsections 2.5.2.4.2.3.2 and 2.5.1.1.4.3.6.1). This new source characterization takes into account all new data and research on the Meers fault since the EPRI-SOG study, and, as discussed above, none of this information requires modifications to the EPRI-SOG Pa values for the Oklahoma aulacogen. Again, the new information is not inconsistent with the EPRI-SOG characterization of the aulacogen when the updated Meers fault characterization is considered.

Issue c

The correlation of seismicity to seismic sources is discussed in Subsection 2.5.2.3. As discussed in that subsection, the updated seismicity catalog has the same pattern of earthquakes within the Oklahoma aulacogen as shown in the original EPRI-SOG catalog suggesting that there is no need or justification for modifying the aulacogen source characterizations based on seismicity. In particular, the lack of any earthquakes from the updated catalog in the aulacogen with Emb > 5.0 demonstrates there is no basis for updating the Pa of the aulacogen based on seismicity, and the lack of any earthquakes from the updated catalog in the aulacogen with magnitudes greater than the lower-bound Mmax values for EPRI-SOG aulacogen sources demonstrates there is no basis for updating the Mmax of the aulacogen based on seismicity.

References:

EPRI, 1986-1989, Seismic hazard Methodology for the Central and Eastern United States (NP-4726), Vol. 1-3 & 5-10, Electric Power Research Institute (EPRI).

Gilbert, M.C., 1983a, The Meers fault of southwestern Oklahoma: Evidence for possible strong quaternary seismicity in the midcontinent: EOS, Transactions of the American Geophysical Union, v. 64, abstract T21B-13, p. 313.

—, 1983b, The Meers fault: Unusual aspects and possible tectonic consequences: Abstracts with Programs, GSA South Central Section Annual Meeting, v. 15, abstract no. 17428, p. 12,903.

Impact on R-COLA

None.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 1889 (CP #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/01/2009

QUESTION NO.: 02.05.02-13

In FSAR Subsections 2.5.2.4.2.2.1 and 2.5.2.4.2.2.2 you discussed how the Mmax distribution for EPRI source models was updated based on recent earthquake observations. The procedure used raises the lower bound on maximum magnitude to the magnitude of the largest observed earthquake. Please explain why the observed largest magnitude earthquake is suitable for Mmax determinations in seismic sources with limited observations and lower seismicity rates, such as the South Coastal Margin and the NM-Texas block. Please justify your assumption that the maximum observed earthquake magnitude should be used as the Mmax in these sources.

ANSWER:

As discussed in the introduction to Subsection 2.5.2 and in detail in Subsection 2.5.2.2, RG 1.208 was used as the primary guidance in developing the seismic source characterization for CPNPP Units 3 and 4. This guidance states that

> *"… seismic sources and data accepted by the NRC in past licensing decisions may be used as a starting point" for the PSHA (page 14, RG 1.208).*

RG 1.208 also provides guidance stating that site-specific geological, geophysical, and seismological studies should be conducted to determine if these accepted source models adequately describe the seismic hazard for the site of interest given any new data developed since acceptance of the original models. The guidance from RG 1.208 describing this review process includes language such as the following:

> *"The results of these [site-specific] investigations will also be used to assess whether new data and their interpretation are consistent with the information used in recent probabilistic seismic hazard studies accepted by NRC staff" (RG 1.208, page C-1).*
>
> *". . . determine whether there are any new data or interpretations that are not adequately incorporated into the existing PSHA databases" (RG 1.208, page 11).*

The key issue identified within the RG 1.208 guidance is that new data should be evaluated as to whether or not the accepted, starting point model "adequately" describes, or is "consistent" with, the new data.

If new information or data indicates that the EPRI-SOG model requires updating, RG 1.208 provides the guidance that significant updates to the source characterizations follow the guidance presented in NUREG/CR-6372 (Budnitz et al., 1997). NUREG/CR-6372, prepared by a Senior Seismic Hazard Analysis Committee (SSHAC), provides recommendations on the development of PSHA studies for nuclear facilities. A primary recommendation of the SSHAC is that for a given technical issue (i.e., source zone characterization),

> *"The following should be sought … (1) a representation of the legitimate range of technically supportable interpretations among the entire informed technical community…" (page xv, NUREG/CR-6372).*

For CPNPP Units 3 and 4, the EPRI-SOG (EPRI, 1986-1989) source characterizations are used as the base source models. As guided by RG 1.208, an extensive review of all available information and data developed since the EPRI-SOG study was conducted as part of the CPNPP Units 3 and 4 COLA effort to determine if the EPRI-SOG source characterizations were inconsistent with, or not adequate to describe, the newer data. One focus of this review was any new data that may impact the EPRI-SOG ESTs' Mmax evaluations. As discussed in Subsection 2.5.2.4.2.2, the Mmax values of the original EPRI-SOG characterizations adequately describe all new data developed since the EPRI-SOG study with the exception of two source zones in which earthquakes with magnitudes greater than the lower-bound Mmax value occur. These two zones are the Law New Mexico – Texas Block and the Dames & Moore South Coastal Margin.

As presented in Subsection 2.5.2.4.2.2.2, the original Mmax values and weights for the New Mexico – Texas block are mb 4.9 (0.3), 5.5 (0.5), and 5.8 (0.2), and the largest observed earthquake within the zone has a magnitude of Emb 5.0. As presented in Subsection 2.5.2.4.2.2.1, the original Mmax values and weights within the South Coastal Margin are mb 5.3 (0.8) and 7.2 (0.2), and the largest observed earthquake within the zone has a magnitude of Emb 5.5. As is apparent from these Mmax distributions, the two new earthquakes are only greater than the lower-bound magnitude in their respective Mmax distributions. The new data is only inconsistent with the lower bound of the Mmax distribution. Therefore, the observed magnitude is only being used to inform the lower-bound Mmax value, not the entire Mmax distribution.

For the New Mexico – Texas Block the lower-bound Mmax was raised from mb 4.9 to 5.0. As described within the EPRI-SOG documentation, the methodology outlined by the Law EST for assigning Mmax values utilized the historical maximum magnitude earthquake to define the lower bound of the Mmax distribution. The updated used for the CPNPP Units 3 and 4 COLA is justified by the fact that this update simply follows the original methodology of the Law EST. Also, the increase in the lower-bound Mmax of 0.1 magnitude units is exceptionally small and likely has no significant impact on the site hazard.

For the South Coastal Margin the lower-bound Mmax was raised from mb 5.3 to 5.5. The update was adopted from revisions made to the EPRI-SOG Gulf Coast source zones (zones that encompass the Gulf of Mexico and the Gulf coastal plain) as part of the STP Nuclear Operating Company COL application for STP Units 3 and 4 (STPNOC, 2008a). The update developed for the STP Units 3 and 4 is described in detail in Section 2.5.2 of the STP Units 3 and 4 FSAR (STPNOC, 2008a), and in the response to STP Units 3 and 4 RAI 02.05.02-13 from RAI Letter No. 50 (STPNOC, 2008b). In brief, the STP update modifies the Mmax distributions for some of the EPRI-SOG source zones that encompass the Gulf of Mexico and Gulf coastal regions based on the occurrence of two earthquakes within the Gulf of Mexico with magnitudes greater than the lower-bound magnitude values in the respective EPRI-SOG Mmax distributions. The updates were developed following RG 1.208 guidance in that they were developed following SSHAC level 2 guidelines (Budnitz et al., 1997).

This update was thoroughly reviewed as part of the CPNPP Units 3 and 4 COLA effort to determine if the update highlighted any issues that should be addressed for the CPNPP Units 3 and 4 site and if it was appropriate to adopt the update for the site. It was determined that the update was relevant to the CPNPP Units 3 and 4 site because it impacted one of the contributing source zones, the Dames & Moore South Coastal Margin zone. Also, it was determined that the update was appropriate to adopt for the CPNPP Units 3 and 4 site because the update was developed following the guidance of RG 1.208 and the SSHAC methodology for a level 2 study. Therefore, the justification for updating the Mmax values as described within the Subsection 2.5.2.4.2.2.1 is that this update was developed following the pertinent NRC regulatory guidance.

References:

Budnitz, R.J., Apostolakis, G., Boore, D.M., Cluff, L.S., Coppersmith, K.J., Cornell, C.A., and Morris, P.A., 1997, Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts: Washington, D.C., US Nuclear Regulatory Commission, NUREG/CR-6372, p. 278.

EPRI, 1986-1989, Seismic hazard Methodology for the Central and Eastern United States (NP-4726), Vol. 1-3 & 5-10, Electric Power Research Institute (EPRI).

—, 1989, EQHAZARD Primer (NP-6452-D), Electric Power Research Institute (EPRI), prepared by Risk Engineering for Seismicity Owners Group and EPRI.

STPNOC, 2008a, South Texas Project Units 3 & 4 COLA (FSAR), Rev. 2.

—, 2008b, South Texas Project Units 3 & 4, Response to Requests for Additional Information

Impact on R-COLA

None.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 1889 (CP #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/01/2009

QUESTION NO.: 02.05.02-14

In FSAR Subsection 2.5.2.4.2.3.1 you stated that the treatment of the NMSZ in the PSHA calculations is essentially the same as what was done in Bellefonte and Clinton PSHA studies. However, the Bellefonte and Clinton PSHA studies used both time-dependent and time independent source models. FSAR does not mention a time-dependent treatment of the NMSZ.

a. Is the time-dependent treatment of the NMSZ the same as that used in the Bellefonte FSAR? What basic renewal model is applied, Brownian passage time or some other model?

b. Please discuss the important parameters and their uncertainties used for the NMSZ. For example, mean recurrence interval, coefficient of variation, or alpha, time since last main shock cluster to beginning of proposed plant operations, or t0, and exposure time, *Δt*. Please define exposure time, e.g. time from beginning of commercial power generation to plant decommissioning or other appropriate end-time.

ANSWER:

a. The time-dependent treatment of the NMSZ is the same as the treatment used in the Bellefonte FSAR, which used a combination of the Poisson model and a Brownian passage time (BPT) model. The Bellefonte FSAR used a cluster model for earthquake occurrences, and gave Cluster Model A a weight of 1.0 and cluster Model B a weight of 0.0, and this interpretation was followed for the Comanche Peak FSAR.

b. The mean recurrence interval of clusters will have a one-to-one effect on mean annual frequencies of exceedence of ground motion amplitudes. The coefficient of variation on recurrence interval, given the mean interval, will affect the range of hazard curves. The time since the last mainshock cluster *t0* will affect the Poisson model and BPT model in opposite ways; a longer time will decrease the mean recurrence rates for the Poisson model, and will increase the mean rates for the BPT model. Exposure time *Δt* will not affect the Poisson model rates, but for the BPT model, a longer exposure time will increase the average rate of occurrence during the exposure time, given that the time since the last cluster is less than the mean time between clusters. An analysis submitted for the Bellefonte site (Ref. 02.05.02-14A) shows that different assumptions on *t0* and *Δt* will affect mean rates of cluster occurrences by

1.5% percent, and the effect on total hazard will be less than this because the NMSZ is not the only seismic source affecting the site. For the Bellefonte FSAR, Δt was assumed to be 50 years, which accounts for 10 years of licensing and construction and a 40 year plant operation license. This definition is implicit in the calculations done for the Comanche Peak site, since the same input recurrence intervals were used.

Reference:

Bellefonte Combined License Application—Response to Request for Additional Information—Vibratory Ground Motion, Responses to NRC RAI 02.05.02-4 and RAI 02.05.02-5 contained in letter from Sterdis to NRC dated October 20, 2008, (ML082970559).

Impact on R-COLA

FSAR Revision 0 page 2.5-93 was revised to reflect this response.

See attached changes for page 2.5-93. Because of the text additions and deletions, the page numbers on the markup FSAR pages may not be the same as the page numbers in the FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 1889 (CP #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/01/2009

QUESTION NO.: 02.05.02-15

In FSAR Subsection 2.5.2.4.2.3.2.2 you described the data used to determine the maximum magnitude for the Meers fault using source rupture length, source rupture area, and the maximum surface displacement data. The maximum surface displacement data produced an Mmax of 7. The staff is concerned about the lack of multiple displacement data along the Meers fault which makes it uncertain whether or not the two displacement values used are closer to the mean or the maximum displacement.

a. Please justify more fully using the limited surface displacement data available for the Meers fault with the maximum displacement regression equations of Wells and Coppersmith, rather than the average displacement regression equations of Wells and Coppersmith, which would yield a higher maximum magnitude.

b. Please further justify the use of uneven weights (0.2, 0.6, 0.2) for the three magnitude estimates in calculating the Meers fault's impact on the hazard curves.

ANSWER:

Issue a

The development of the Meers fault source characterization is described in detail in FSAR Subsections 2.5.1.1.4.3.6.1 and 2.5.2.4.2.3. As described in that subsection, the source characterization was developed following the guidelines of a SSHAC level 2 study (Budnitz et al., 1997), as is recommended by RG 1.208. As such, the Mmax values used for the Meers fault were developed following these guidelines.

As part of the SSHAC level 2 effort, the Technical Integrators (TIs) decided to investigate a wide range of relationships between observable characteristics of the Meers paleoearthquakes and potential characteristics of future Meers earthquakes and potential magnitudes of those earthquakes. The relationships investigated included those of Wells and Coppersmith (1994) that related surface rupture length, rupture area, and surface displacement to earthquake magnitude (see Subsection 2.5.2.4.2.3.2.2). As indicated in Subsections 2.5.1.1.4.3.6.1 and 2.5.2.4.2.3.2.2, the TIs considered the surface displacement data to be the least robust, and thus likely the least reliable data for estimating earthquake magnitude, because:

- There are very limited estimates of displacement;
- There is only one estimate of net displacement; and
- The estimates of displacement were generally developed from stratigraphic offsets in alluvial and colluvial material as well as from offset paleochannel thalwegs exhumed in trenches. Both of these types of estimates can be difficult to use in developing accurate displacement values as is apparent in the reported displacement uncertainties (Swan et al., 1993).

In addition to the displacement data quality issues, the TIs also noted that the estimated displacements may not be applicable for use with the regressions of Wells and Coppersmith (1994) because:

- The data used to develop the regressions generally came from investigations of modern scarps and ruptures, not trenches and stratigraphic data;
- The data used to the develop the regressions generally came from extensive measurements made for any one earthquake or scarp as opposed to the limited number of trenches examined along the Meers fault; and
- There is only one estimate of net displacement for the Meers fault.

Despite these potential issues, the TIs decided to use the displacement estimates with the Wells and Coppersmith (1994) regressions to, at a minimum, see the resultant magnitudes.

As noted within the question, Wells and Coppersmith (1994) present two relationships relating earthquake magnitude to resultant surface displacement: one for the maximum displacement and one for average displacement. As detailed in their study, Wells and Coppersmith (1994) calculated maximum net displacements for use in their regression calculated from the maximum horizontal and vertical displacements reported at a single location. These values were generally taken from other published studies, and there is no indication of the extent of the scarp these studies investigated to ensure the true maximum was observed. Wells and Coppersmith (1994) describe their calculation of average displacement data as follows:

> Average displacement per event is calculated from multiple measurements of displacement along the rupture zone. For most earthquakes, the largest displacements typically occur along a limited reach of the rupture zone. Thus, simple averaging of a limited number of displacement measurements is unlikely to provide an accurate estimate of the true average surface displacement. The most reliable average displacement values are calculated from net displacement measurements recorded along the entire surface rupture. … [W]e include estimates of average displacement that we calculate from a minimum of 10 displacement measurements distributed along the surface rupture, or were reported from extensive studies of the entire surface rupture (Wells and Coppersmith, 1994), (page 986-987).

An important point included in the description of the calculated average displacements is that the averages used by Wells and Coppersmith (1994) came from a minimum of 10 displacement measurements that were not focused around the region of maximum displacement. The TIs concluded that the Meers displacement estimates were not compatible with the Wells and Coppersmith (1994) regression on average displacement principally because:

- There are significantly less than 10 displacement estimates for the Meers fault;
- There is only one estimate of net displacement;

- All of the estimates came from the same general region of the fault and not near the ends of the scarp where lower displacement estimates would be expected (FSAR Figure 2.5.1-211).

However, the Meers displacement estimates as used to determine the magnitudes in Subsection 2.5.2.4.2.3.2.2 were the maximum observed displacements, albeit from a limited sample. Based on this observation the TIs concluded that it was more appropriate to use the maximum displacement regressions of Wells and Coppersmith (1994). These conclusions regarding the regressions were based on the technical merits of the approaches and were in no way informed by the resulting estimated magnitudes.

Regardless of which displacement relationship was used, the magnitude estimates from the displacement data was given extremely low weight in determining the final Mmax distribution because, as discussed above, the displacement estimates were considered to be the least robust. In brief, the Mmax distribution was primarily based on determining the lower and upper bounds of the distribution and then defining intermediate magnitudes. The lower bound was set at Mw 6.7 because this was the lowest value from the rupture length estimate (considered one of the more robust estimates) and slightly higher than the lowest value from the rupture area estimate (considered a slightly less robust estimate). The lowest magnitude estimate based on the smallest rupture area was not used because it was concluded that such a small rupture area is unlikely for a characteristic Meers earthquake. The largest magnitude estimate from rupture length and rupture area relationships (Mw 6.9) were considered to be the most robust estimate of the upper bound magnitude. However, acknowledging that that surface displacement estimates had higher magnitudes, the TIs decided it was appropriate to raise the upper-bound Mmax above the best estimate of Mw 6.9 to Mw 7.0. As previously stated, this reasoning behind the Mmax distributions demonstrates that the surface displacement estimates were significantly relied upon to develop the Mmax distribution.

<u>Issue b</u>

The symmetrical weights of 0.2, 0.6, and 0.2 used in the magnitude distribution simply reflect the opinion and conclusions of the TIs that the lower-bound and upper-bound Mmax values are less likely than the mean of those two values. This conclusion is based on the observation that these bounding values are from the most extreme rupture scenarios considered (e.g., shortest or longest rupture length, largest or smallest rupture area), and it is more likely that less extreme rupture scenario will occur than the most extreme.

References:

Budnitz, R.J., Apostolakis, G., Boore, D.M., Cluff, L.S., Coppersmith, K.J., Cornell, C.A., and Morris, P.A., 1997, Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts: Washington, D.C., US Nuclear Regulatory Commission, NUREG/CR-6372, p. 278.

Swan, F.H., Wesling, J.R., Hanson, K.A., Kelson, K.I., and Perman, R.C., 1993, Draft Report: Investigation of the Quaternary structural and tectonic character of the Meers fault (southwestern Oklahoma): San Francisco, CA, Geomatrix Consultants, Inc., p. 104 plus appendices.

Wells, D.L., and Coppersmith, K.J., 1994, New empirical relationships among magnitude, rupture length, rupture width, rupture area, and surface displacement: Bulletin of the Seismological Society of America, v. 84, p. 974-1002.

<u>Impact on R-COLA</u>

None.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 1889 (CP #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/01/2009

QUESTION NO.: 02.05.02-17

FSAR Subsection 2.5.2.4.2.3.3.1 states that the fault source characterization for Rio Grande Rift (RGR) faults is based on a simplification of the USGS National Seismic Hazards Maps. Some the RGR faults extend into Mexico near the Big Bend of the Rio Grande River. However, faults south of the USA/Mexico border are not considered in the National Seismic Hazards Maps and faults south of the border are not listed in Tables 2.5.2-214 and 215 of the FSAR.

a. Please explain if any attempt was made to characterize RGR seismic hazard from faults that extend into Mexico.

b. Please explain how you accounted for seismic hazard arising from other potential seismic sources located in Mexico.

ANSWER:

Issue a.

As discussed in the introduction to Section 2.5.2 and in detail in Subsection 2.5.2.2, RG 1.208 was used as the primary guidance in developing the seismic source characterization for CPNPP Units 3 and 4. This guidance states that

> "… seismic sources and data accepted by the NRC in past licensing decisions may be used as a starting point" for the PSHA.

RG 1.208 also provides guidance stating that site-specific geological, geophysical, and seismological studies should be conducted to determine if these accepted source models adequately describe the seismic hazard for the site of interest given any new data developed since acceptance of the original models. The guidance from RG 1.208 describing this review process includes language such as the following:

> “The results of these [site-specific] investigations will also be used to assess whether new data and their interpretation are consistent with the information used in recent probabilistic seismic hazard studies accepted by NRC staff".

> ". . . determine whether there are any new data or interpretations that are not adequately incorporated into the existing PSHA databases".

The key issue identified within the RG 1.208 guidance is that new data should be evaluated as to whether or not the accepted, starting point model “adequately” describes, or is “consistent” with, the new data.

If new information or data indicates that the EPRI-SOG model requires updating, RG 1.208 provides the guidance that significant updates to the source characterizations follow the guidance presented in NUREG/CR-6372 (Budnitz et al., 1997). NUREG/CR-6372, prepared by a Senior Seismic Hazard Analysis Committee (SSHAC), provides recommendations on the development of PSHA studies for nuclear facilities. A primary recommendation of the SSHAC is that for a given technical issue (i.e., source zone characterization),

> “The following should be sought … (1) a representation of the legitimate range of technically supportable interpretations among the entire informed technical community…”.

For CPNPP Units 3 and 4, the EPRI-SOG (EPRI, 1986-1989) source characterizations are used as the base source models. As guided by RG 1.208, an extensive review of all available information and data developed since the EPRI-SOG study was conducted as part of the CPNPP Units 3 and 4 COLA effort to determine if the EPRI-SOG source characterizations were inconsistent with or not adequate to describe the newer data. One focus of this review was the identification of potentially capable faults within the site region and beyond that may contribute to hazard at the site.

The approach used to determine whether a capable fault needed to be included in the hazard analysis or whether a region of potentially capable sources needed to be investigated in further detail was to conduct sensitivity studies of these potential sources to determine their level of contribution to the site hazard. The closest capable faults to the CPNPP Units 3 and 4 site are the Meers fault, the Cheraw fault, and faults of the RGR. As described in FSAR Subsection 2.5.2.5, screening studies were conducted for all of these sources to determine whether they significantly contributed to hazard at the site.

Because of the relatively close proximity of the Meers fault to the site, a robust seismic source characterization of the Meers fault was developed following the SSHAC guidelines for a level 2 study (Budnitz et al., 1997) for this sensitivity analysis. Because of the considerably greater distance from the Cheraw fault and RGR to the site (over 500 and 350 miles, respectively) (FSAR Figure 2.5.2-213), an attempt was made to use existing and relatively robust source characterizations of the faults in the initial sensitivity study with the intent to develop more rigorous source characterizations if the screening study demonstrated that the faults contributed to hazard at the site. As described in FSAR Subsection 2.5.2.4.2.3.4, the Cheraw fault model was based on a conservative simplification of the characterization used within the 2002 USGS National Seismic Hazard Maps (Frankel et al., 2002).

For the RGR, a conservative simplification of the faults used within the 2002 USGS Seismic Hazard Maps (Frankel et al., 2002) was also used in the sensitivity analysis (see FSAR Subsection 2.5.2.4.2.3.3). During the COLA effort it was noted that the USGS fault characterizations only included faults as far south as the Texas-Mexico border in the Big Bend region of west Texas (FSAR Figure 2.5.2-213), but the lithospheric expression of the RGR and potentially capable faults related to the RGR my extend further south into Mexico. Because of this realization, considerable effort was spent attempting to: (1) define the southernmost extent of the RGR, and (2) identify any potentially capable faults associated with the RGR within Mexico that had been studied in enough detail that a preliminary source characterization could be constructed for them. Many of the resources that were reviewed as part of this effort are listed and discussed in FSAR Subsections 2.5.1.1.4.3.7.1 and 2.5.2.4.2.3.3.

Based on these efforts it was determined that the southern termination of the RGR is poorly defined but likely extends no farther south than the Sierra Madre Oriental, a Laramide fold-and-thrust belt with no evidence of extensional faulting (Gray et al., 2001; Murray, 1961). With respect to physiography and geomorphology, the characteristic expression of the RGR (e.g., elevated topography and fault bounded-basins) (e.g., Eaton, 1982, 1987; Olsen et al., 1987; Pazzaglia and Hawley, 2004) extends into northern Mexico, but becomes less distinct as Laramide fold-and-thrust belt structures control the topography (Charleston, 1981; Instituto Nacional de Estadistica Geografia e Informatica (Mexico), 1983; Lawton et al., 2001; McKee et al., 1990). There have been very few geophysical studies of the lithospheric structure in northeast Mexico, and those that have been conducted simply suggest that the lithospheric expression of the RGR extends into Mexico and do not constrain the southernmost extent of the RGR (e.g., Keller, 2004; Keller et al., 1989).

Also based on these efforts, it was determined that there have been very few studies of Quaternary, or potentially Quaternary faults within northeast Mexico (i.e., the Mexican state of Coahuila), and those studies that have been conducted were regional in scale and not in enough detail to either: (1) confirm a fault as capable, or (2) provide detailed enough information to allow development of a preliminary source characterization (e.g., Collins, 1994a, b, 1995a, b; Collins and Raney, 1994, 1997; Dickerson and Muehlberger, 1994; Henry and Price, 1985; Laroche and Viveiros, 1994; Muehlberger et al., 1978). In addition to reviewing available literature, regional experts with familiarity of the Quaternary tectonics of Mexico and the RGR were contacted for guidance on Quaternary faults in northeast Mexico. Individuals contacted include Dr. Luca Ferrari at UNAM (Universidad Nacional Autonoma de Mexico), Dr. Max Suter at UNAM, as well as Lisa Morgan, Michel Machette, Bob Bohannon, and Chris Henry all of the USGS. The general perspective of the state of research of Quaternary faults in northeast Mexico presented by these individuals was the same as that represented within the published literature: there are no detailed studies of Quaternary faults in that region, and the studies that do exist are regional in nature and do not provide the level of information needed to develop source characterizations.

Due to the lack of information on the capability and potential source characteristics (e.g., characteristic magnitude, recurrence rate) of faults associated with the RGR in Mexico, the simplified model of potentially unidentified RGR faults described in FSAR Subsection 2.5.2.4.2.3.3.2 was developed for use in the sensitivity analysis in place of initiating original research for a seismic source that may not contribute to the site hazard. As described in FSAR Subsection 2.5.2.4.2.3.3.2 and in the response to Question 2.5.2-6, this simplified characterization of any potentially capable, individual RGR fault is considered to be conservative because: (1) it is at the closest distance between the RGR and the site, and (2) there are no confirmed capable faults within the RGR as it extends into Mexico. As discussed in FSAR Subsection 2.5.2.4.4, none of the RGR faults or the simplified RGR model contributed to the hazard at the CPNPP Units 3 and 4 site, so it was determined that no additional effort was needed to develop source characterizations for potential RGR faults within Mexico beyond that described in response to this RAI question.

Issue b.

As described above one focus during the development of the seismic source characterization for the CPNPP Units 3 and 4 site was the search for potentially capable faults beyond the site region that may contribute to hazard at the site. Also as described above Mexico was one region that was investigated in detail because of the potential for the existence of capable faults related to the RGR. During these investigations there were no other potentially capable faults identified within northeast Mexico other than those related to the RGR, so no other potential seismic sources within Mexico besides the RGR were included in the sensitivity study. Given the fact that the RGR faults within the US and Mexico were determined to not contribute to hazard at the CPNPP Units 3 and 4 site, it is not expected that other more distant sources within Mexico will contribute to the site hazard.

References:

Budnitz, R.J., Apostolakis, G., Boore, D.M., Cluff, L.S., Coppersmith, K.J., Cornell, C.A., and Morris, P.A., 1997, Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts: Washington, D.C., US Nuclear Regulatory Commission, NUREG/CR-6372, p. 278.

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<u>Impact on R-COLA</u>

None.

<u>Impact on S-COLA</u>

None.

<u>Impact on DCD</u>

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 1889 (CP #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/01/2009

QUESTION NO.: 02.05.02-18

In FSAR Subsection 2.5.2.4.4 you stated that "Anchoring the LF spectral shape to all frequencies was necessary because otherwise the LF spectral shape exceeded the HF spectral shape at high frequencies. This exceedence results from the contribution of extreme ground motions ($\varepsilon > 1$, see for example Figure 2.5.2-224) at low spectral frequencies, and a resulting UHRS shape that differs for the median shape predicted in NUREG/CR-6728." The staff is not clear on how these adjustments were made. Please describe further details by providing the low-frequency and high-frequency spectral shapes together and whether or not any higher ground motions, mentioned as "extreme ground motions" were disregarded by using the highfrequencies in low-frequency spectral matching.

ANSWER:

The low-frequency (LF) spectrum was anchored to high-frequency (HF) UHRS amplitudes at 100, 25, 10, and 5 Hz because otherwise the spectral shape obtained by extrapolating the LF spectrum from 2.5 Hz to higher amplitudes would not reflect the shape of the UHRS amplitudes. This extrapolation would give higher amplitudes than the HF UHRS, which would not be appropriate because it would overdrive the soil column. There were no "extreme ground motions" that were disregarded in these calculations, all ground motions are included in the calculation of the UHRS at all frequencies. Thus anchoring the LF spectrum to the UHRS values at all frequencies ensures that appropriate ground motions are represented. At low-hazard sites such as Comanche Peak, distant large earthquakes may contribute to seismic hazard with ground motion ε values greater than unity. In these cases, the spectral shapes of NUREG/CR-6728 are not appropriate and the LF spectrum needs to be anchored to the HF UHRS amplitudes.

<u>Impact on R-COLA</u>

FSAR Revision 0 pages 2.5-109 were revised to reflect this response.

See attached changes for pages 2.5-109. Because of the text additions and deletions, the page numbers on the markup FSAR pages may not be the same as the page numbers in the FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 1889 (CP #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/01/2009

QUESTION NO.: 02.05.02-19

FSAR Subsection 2.5.2.6.1.1 states that "Figure 2.5.2-234 shows the horizontal GMRS spectrum taken from Table 2.5.2-228…" However, the GMRS shown on the mentioned figure and the values provided in the table do not match. Please clarify why there is a difference. Please also explain the differences in the GMRS curves shown in Figure 2.5.2-234 of the FSAR and Figure 2.5.2-247 of the supplemental document.

ANSWER:

The GMRS values on Figure 2.5.2-234 were plotted incorrectly. The figure was revised and the corrected version will reflect the values on Table 2.5.2-228 and the GMRS curve will match the one on Figure 2.5.2-247.

Impact on R-COLA

FSAR Revision 0 Figure 2.5.2-234 was revised to reflect this response.

See attached changes for Figure 2.5.2-234.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 1889 (CP #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/01/2009

QUESTION NO.: 02.05.02-20

Please provide the following data in digital format

a. Smooth Rock UHRS values for annual exceedance frequencies of 10-4, 10-5, and 10-6

b. Geographic coordinates of all seismic source geometries used in the Comanche Peak PSHA study

c. Median Amplification Factors used in site response calculations for 10-4, 10-5, and 10-6 annual exceedance frequencies in digital format.

d. The shear wave velocity profile used in site response calculations in digital format.

e. Mean total hazard curves for 0.5, 1, 2.5, 5, 10, 25, and 100 Hz as well as the hazard curves of all individual seismic sources

f. Shear modulus and damping degradation curves shown in FSAR Figure 2.5.2-232

g. Soil UHRS curves electronically for 10-4, 10-5, and 10-6 annual exceedance frequencies

h. Updated earthquake catalog

ANSWER:

The digital files containing the requested material are being provided on CD in their native format.

Impact on R-COLA

None.

Impact on S-COLA

None.

Impact on DCD

None.

Attachments (on CD)

a. Smooth Rock UHRS values for annual exceedance frequencies of 10-4, 10-5, and 10-6

   File Name -ROCK_UHRS

b. Geographic coordinates of all seismic source geometries used in the Comanche Peak PSHA study

   File Name -SOURCE_GEOM

c. Median Amplification Factors used in site response calculations for 10-4, 10-5, and 10-6 annual exceedance frequencies in digital format.

   File Name -SITE_AMPLIF

d. The shear wave velocity profile used in site response calculations in digital format.

   File Name -VS_median_profile

   File Name -FIRS1_randomization_velstat.out

e. Mean total hazard curves for 0.5, 1, 2.5, 5, 10, 25, and 100 Hz as well as the hazard curves of all individual seismic sources

   File Name -MEAN_HAZ_CURVES

f. Shear modulus and damping degradation curves shown in FSAR Figure 2.5.2-232

   File Name -FSAR_figure_252-232

g. Soil UHRS curves electronically for 10-4, 10-5, and 10-6 annual exceedance frequencies

   File Name -SOIL_UHRS

h. Updated earthquake catalog

   File Name -CATALOG_UPDATE

Attachment 2

Response to Request for Additional Information No. 2929 (CP RAI #22)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 2929 (CP #22)

SRP SECTION: 02.05.04 – STABILITY OF SUBSURFACE MATERIALS AND FOUNDATIONS

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/17/2009

QUESTION NO.: 02.05.04-5

Appendix D, ”Spacing and Depth of Subsurface Explorations for Safety-Related Foundations,” to Regulatory Guide 1.132, ”Site Investigations for Foundations of Nuclear Power Plants,” Revision 2 (October 2003), provides guidance for site exploration plans for safety-related foundations. One of the recommendations suggests spacing one principal boring, which is used to explore site soil or rock strata and define the site geology and the properties of the subsurface materials, per 30 m (100 ft) for tunnel or essentially linear structures. Figure 2.5.4-202 of the FSAR illustrates the exploration locations. For the west side Essential Service Water Pipe Tunnel (ESWPT) of both Units 3 and 4, the figure indicates a couple of boring locations on the side east of the structures. However, the proposed borehole is neither within the footprint nor on the side west of the structures. Taking into consideration the complexity of anticipated subsurface conditions, please explain why there is not a boring location within the footprint of west ESWPT for both Units 3 and 4.

ANSWER:

The location of the ESWPT was finalized after the boring activities were completed. The need for additional borings was considered. The recommended spacing and depth of borings provided in RG 1.132 was considered respective to the placement and depth of borings as well as the complexity of subsurface conditions. The Essential Service Water Pipe Tunnel (ESWPT) alignments on the west side of Units 3 and 4 were evaluated respective to the existing boring coverage, distance and depth. The subsurface conditions were determined to be well characterized from the existing borings both in the near proximity as well as more remotely placed borings drilled for monitoring wells. Considering the lateral continuity of bedding (i.e., subsurface conditions) and the relative light net load of the ESWPT’s, additional borings were not required.

<u>Impact on R-COLA</u>

None.

<u>Impact on S-COLA</u>

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 2929 (CP #22)

SRP SECTION: 02.05.04 - STABILITY OF SUBSURFACE MATERIALS AND FOUNDATIONS

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/17/2009

QUESTION NO.: 02.05.04-6

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.4, '"Stability of Subsurface Materials and Foundations," establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

FSAR Section 2.5.4.2.2.2.16 “Laboratory-Based Shear Wave Velocity” mentions that laboratory measurements of shear wave velocity on relatively undisturbed samples of shale, limestone and sandstone were performed. This section indicates that this testing was performed to determine the rock’s degree of disturbance. FSAR Figure 2.5.4-238 provides Laboratory Shear Wave Velocity measurements vs. elevation. Given the large degree of variability in shear wave velocities encountered in the limestone layer, please discuss how this meets the uniformity criteria mentioned in FSAR Section 2.5.4.2.

ANSWER:

Uniformity of subsurface conditions, as described in FSAR Section 2.5.4.2, refers predominantly to the lateral continuity of geologic stratigraphy, which was found to be primarily characterized by nearly horizontal strata of relatively uniform thickness extending laterally across and along the CPNPP Units 3 and 4 project sites, as opposed to a more variable (discontinuous or lenticular) geologic stratigraphy. The site area includes 5 stratigraphic units in the upper 200 ft that consist primarily of limestone beds (engineering Layers A, C, and E_1 through E_3). This laterally continuous stratigraphy is present, not only beneath CPNPP proposed Units 3 and 4, but also beneath existing Units 1 and 2 (FSAR Figures 2.5.4-204, 2.5.4-205, and 2.5.4-209 through 2.5.4-211). The laterally continuous nature of the stratigraphy is also evident in historical photographs of deep excavation during the construction of CPNPP Units 1 and 2.

Shear wave velocity was measured for a number of rock core samples (FSAR Figure 2.5.4-238) as part of the laboratory testing program. Because laboratory tests are performed on relatively small (2.5-inch diameter), intact specimens, the effects of weathering, fissures, and discontinuities of the larger rock mass typically are not reflected in the results. Figure 1 shows results of the laboratory shear wave velocity measurements (FSAR Figure 2.5.4-238) combined with the in situ shear wave velocity data obtained by the downhole suspension P-S logging method (FSAR Figure 2.5.4-239). The mean shear wave velocity based on the suspension P-S logging data and the selected ranges for the lower- and upper-bound suspension-log models are also shown on Figure 1. Generally, laboratory-measured shear wave velocities are higher than those measured in the field because the small lab samples lack the rock-mass discontinuities present in the field, as reflected by the data obtained for this site (Figure 1). For these reasons, it was judged that the results of the laboratory shear wave velocity measurements did not provide a good overall representation of the subsurface mass properties. Consequently they were only used as an indicator of the degree of weathering and soundness of the rock specimens and not used for formulating the site shear wave velocity model.

Impact on R-COLA

None.

Impact on S-COLA

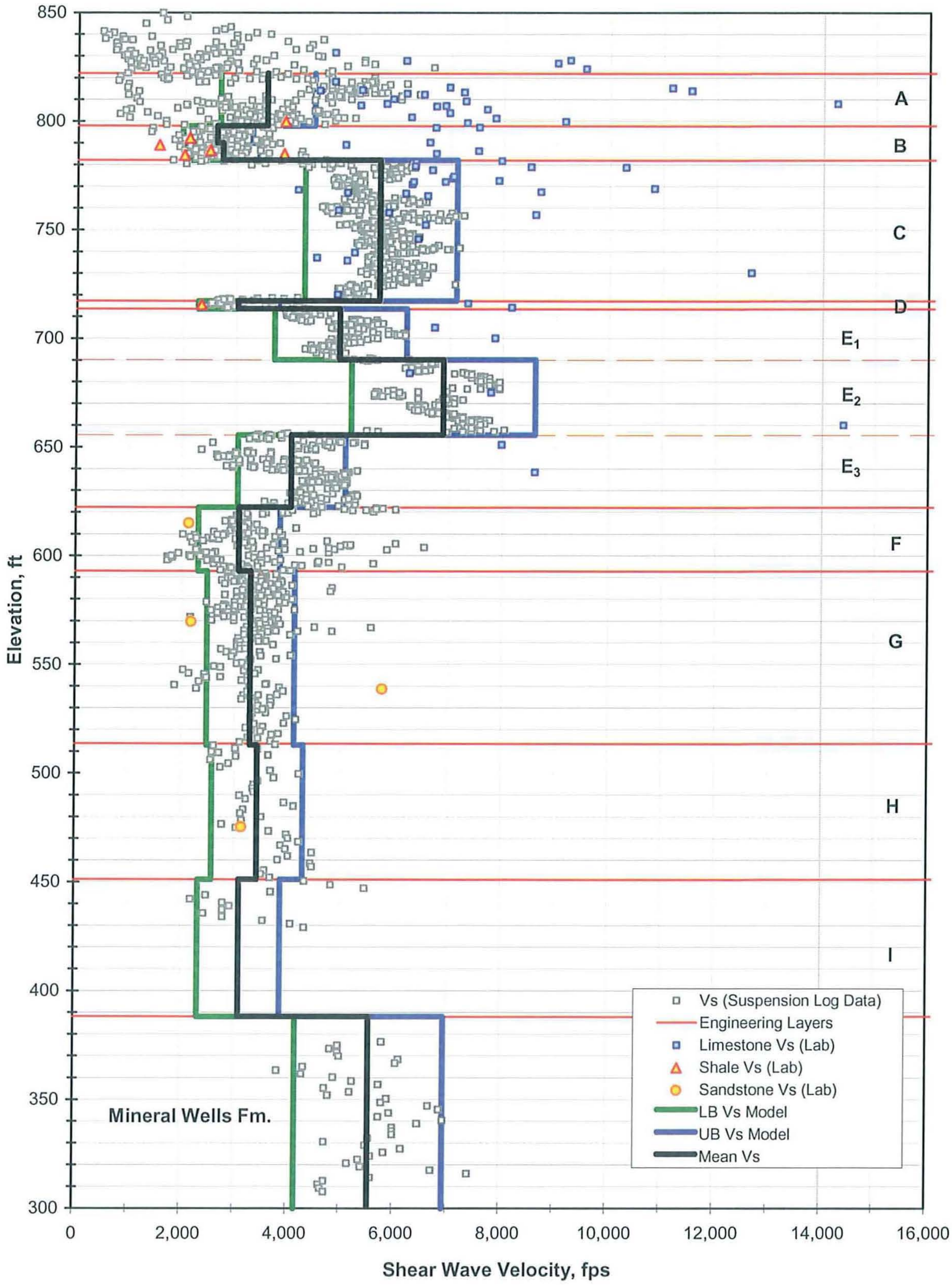
None.

Impact on DCD

None.

Attachments

Figure 1 - Shear Wave Velocity (fps) vs. Elevation (ft)



850
800
750
700
650
600
550
500
450
400
350
300
Elevation, ft
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
Shear Wave Velocity, fps
A
B
C
D
E1
E2
E3
F
G
H
I
Mineral Wells Fm.
Vs (Suspension Log Data)
Engineering Layers
Limestone Vs (Lab)
Shale Vs (Lab)
Sandstone Vs (Lab)
LB Vs Model
UB Vs Model
Mean Vs

FIGURE 1

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 2929 (CP #22)

SRP SECTION: 02.05.04 - STABILITY OF SUBSURFACE MATERIALS AND FOUNDATIONS

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/17/2009

QUESTION NO.: 02.05.04-7

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.4, "Stability of Subsurface Materials and Foundations," establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

FSAR Subsections 2.5.4.2.2.2.5 and 2.5.4.2.3.4.4 state that the organic content of specimens was determined in general and the test results are provided in the Laboratory Test Data Report. Please clarify whether any test results for undocumented fill are included in these test results. In addition, were any tests for chemical properties performed to determine chemical contents of the undocumented fill, such as pH value, chlorides, sulfates, etc.? Please provide information on these chemical contents, and assess the potential impact on the groundwater chemicals due to these chemical contents.

ANSWER:

Undocumented fill materials are quite heterogeneous and variable in composition, including layers and zones of granular soil intermixed with fine-grained soil. In general, undocumented fill consists primarily of material similar to the residual soils, as they were derived from the on-site excavation areas during the construction of CPNPP Units 1 and 2. Index testing consisting of grain-size distribution, hydrometer, moisture content, Atterberg Limits, and organic content tests were performed on residual soil samples obtained from the site. The results of these tests are summarized in the Laboratory Test Data Report (TXUT-001-PR-010).

No geo-chemical analysis was performed on undocumented fill material. Due to the heterogeneous nature of the undocumented fill, any excavated undocumented fill from the site is not anticipated to meet the structural fill requirement and will not be used for backfill within excavated areas around the Units 3 and 4 seismic category I and II structures. Structural fill is discussed in RAI response 2.5.4-13.

As discussed in FSAR Subsections 2.4.12, 2.5.4, and 2.5.5, the permanent groundwater table at the CPNPP Units 3 and 4 site is anticipated to be below an elevation of about 760 ft (about 62 feet below plant yard grade), and below anticipated foundation excavations. The indicated groundwater table elevation of 780 ft is a very conservative estimate that was assumed in order to model the subsurface conditions for geotechnical foundation and stability analyses purposes only and not a true groundwater level. Additionally, because of its tight and impermeable nature, no significant groundwater flow is anticipated within the Glen Rose Formation rock mass. Therefore, the geo-chemistry of the undocumented fill and the residual soils do not have any impact on the groundwater chemistry.

Impact on R-COLA

None.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 2929 (CP #22)

SRP SECTION: 02.05.04 - STABILITY OF SUBSURFACE MATERIALS AND FOUNDATIONS

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/17/2009

QUESTION NO.: 02.05.04-8

TXUT-001-FSAR 2.5-CALC-003 “Shallow Velocity Profile Development-Slope Method,” Page 8, indicates that no velocity measurements were taken from depths 415 ft to 465 ft. In this region, the velocities are inferred from other data.

(1) Please explain why the variability in properties for this region is not increased, since the velocities are not based on measurements.

(2) On the basis of the lack of actual measured data, explain why the apparent larger uncertainty associated with this portion of the profile is or is not reflected in increased variability of the design velocity profile in this section, as opposed to the level of variability one would expect when using the maximum range from the measured data.

(3) In the alternative, demonstrate quantitatively, that there is good correlation between the parameters used to extend the measured velocities and the actual measured velocities.

ANSWER:

Several key data were evaluated to develop the velocity profile through the interval from 415 to 465 feet depth. This missing interval corresponds to the lower-half portion of Engineering Layer I, which is predominately sandstone, as indicated from detailed petrographic analysis (Petrographic report #TZJ for the Comanche Peak COL Project, Samples HS-15, HS-16, and HS-17). The bottom 10 feet of the missing interval corresponds to the Mineral Wells formation, which is predominantly sandstone and silty claystone as indicated from the core boring, corresponding geological signature, and detailed petrographic analysis (Samples HS-18 and HS-19). Velocities were calculated for this interval by first evaluating the condition of the core above, through, and below this interval. It was noted from the recoveries, lithologic consistency, and Rock Quality Designator (RQD) that the missing data interval could be represented by the velocity measurements above, within Layer I, and below, from the Mineral Wells formation. RQD values in the interval above, within Layer I, ranged from 80 to 100% with a mean of 97%, and recoveries ranged from 70 to 100% with a mean of 96%. RQD values in the interval below, within the Mineral Wells formation, ranged from 94 to 100% with a mean of 99%, and recoveries ranged from 96 to 100% with a mean of 99%.

Based on the consistency of the core lithology, RQD, and recoveries as well as geophysical log signature of the resistivity and natural gamma through the missing velocity interval, velocities calculated for Engineering Layer I were extrapolated down to the top of the Mineral Wells formation as picked from the core. The bottom portion of the missing velocity interval was estimated by extrapolating the velocities for Mineral Wells formation up to the top of the Mineral Wells formation.

These key data included a review of the core quality from the missing interval, lithologic variability of the core and variability from other geophysical measurements including electrical resistivity and natural gamma and comparing the missing interval with the intervals both above and below. The RQD and recovery values as well as, close correlation of the rock lithologies and geophysical signature, did not indicate any significant uncertainty, thus the same variability COV of +/-25 percent of the mean was applied to this section as well.

<u>Impact on R-COLA</u>

None.

<u>Impact on S-COLA</u>

None.

<u>Impact on DCD</u>

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 2929 (CP #22)

SRP SECTION: 02.05.04 - STABILITY OF SUBSURFACE MATERIALS AND FOUNDATIONS

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/17/2009

QUESTION NO.: 02.05.04-13

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.4, "Stability of Subsurface Materials and Foundations," establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

Although the backfill material sources have been identified as excavated limestone in FSAR Section 2.5.4.5.4, please discuss the steps that will be taken to avoid inclusion of shale, or other undesirable material, which is unsuitable for structural backfill.

ANSWER:

All seismic category I and II structures, except category I duct banks, are supported on engineering Layer C limestone or on fill concrete placed over engineering Layer C limestone. Backfill materials are only used on the sides of the category I and II structures and beneath category I duct banks. Specifications for fill materials properties are discussed in FSAR Subsection 2.5.4.5.4.1.1. Placement, quality control and testing requirements for fill materials are discussed in Subsections 2.5.4.5.4.2 through 2.5.4.5.4.5. Geotechnical observation and testing will be used to verify that the fill characteristics and properties meet the minimum requirements. As discussed in FSAR Subsection 2.5.4.5.2, geologic observation and mapping is required on a continuous basis during foundation excavations. The general steps that will be followed for handling the excavated materials are:

The materials as excavated from the site will be visually classified by qualified personnel.

Acceptable materials (e.g. limestone and sandstone) will be directed to appropriate, designated areas for storage and stockpiling.

Undesirable materials will be directed to separate storage areas to prevent mixing or contamination with acceptable materials.

Acceptable materials such as limestone and sandstone will be processed by crushing and screening to meet the gradation requirements for acceptable fill, as discussed in FSAR Subsection 2.5.4.5.4.1.1.

Representative samples from the processed materials will be obtained and control tested for verification and conformance of their properties (e.g. grain size, Atterberg Limits, Expansion Index, density, pH, sulfates, chlorides, as appropriate) with the requirement of the fill specification and properties (FSAR Subsection 2.5.4.5.4.1.1). It is acceptable to have shale and other fines within the limestone or sandstone material, as long as the properties of the resulting fill material meet the project specifications.

Where the type or the source of material changes, a new set of control tests like the one indicated above will be performed with the new or changed material.

Impact on R-COLA

FSAR Revision 0 pages 2.5-178 and 2.5-179, have been revised to reflect this response.

See attached changes for pages 2.5-183 and 2.5-184. Because of the text additions and deletions, the page numbers on the mark-up FSAR pages may not be the same as the page numbers in FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 2929 (CP #22)

SRP SECTION: 02.05.04 - STABILITY OF SUBSURFACE MATERIALS AND FOUNDATIONS

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/17/2009

QUESTION NO.: 02.05.04-15

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.4, "Stability of Subsurface Materials and Foundations," establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

FSAR Section 2.5.4.8 states “Thus, the engineered compacted fill does not meet the conditions stated in RG 1.206 or RG 1.198 that would cause suspicion of a potential for liquefaction, and no liquefaction analysis is necessary. Even in the unlikely event that the engineered compacted fill became completely saturated, the soil density is too high and the site PGA range is too low to suspect a potential for liquefaction.” Please provide a quantitative comparison to validate the statement, given that some fill material will be granular. Also, please provide an analysis to verify the effect of potential liquefaction of duct banks and buried safety related piping and tunnels.

ANSWER:

The following provides methodology and a quantitative analysis of the potential for liquefaction of compacted backfill materials. These materials are placed within the excavated areas around the seismic category I and II structures of Units 3 and 4. Duct banks are the only seismic category I structures that are embedded in compacted fill adjacent to the nuclear island.

Two liquefaction analysis methods are considered. The first, referred to as the NCEER Method, is based on Youd et al. (2001) and guidelines provided in RG 1.198. This method is considered to be the standard of practice for liquefaction analysis. The second, referred to as the EERI Method, is based on Idriss and Boulanger (2008). This method is considered to be the state of the art procedure for liquefaction analysis. Both methods involve semi-empirical field-based procedures and are generally analogous.

The assumptions details of the analysis procedures, sample calculations, and figures summarizing the results are presented below.

Assumptions:

- The Peak Ground Acceleration (PGA) is assumed to be 0.1g, based on the results of the ground motion and site response analyses and the US-APWR DCD minimum requirement.
- The Magnitude (M_w) corresponding to this PGA is assumed to be 7.5.
- The permanent groundwater table is well below the foundation or excavation bottoms. However, for the purpose of liquefaction analysis, the groundwater level is conservatively assumed to be at the proposed site yard grade elevation of 822 ft.
- A maximum fill thickness of 45 ft is assumed.
- Finished grade in the areas of engineered compacted fill is level.
- The compacted fill is assumed to have a total unit weight of 125 pcf.
- The fines content of the compacted fill is conservatively assumed to be less than 5 percent.
- The corrected/normalized standard penetration test (SPT) N-Values for compacted fill with relative compaction of 95 percent (ASTM D1557) are expected to be higher than 30 blows/ft. However, for this study a lower value of 25 blows/ft is assumed since granular materials with N-Values of 30 or higher are considered to be too dense to liquefy (Youd et al. ,2001).

NCEER Method:

To compare SPT blowcounts at various depths, it is necessary to normalize them to a standard overburden stress (atmospheric pressure). The overburden normalizing factor is determined from the following relationship:

$$C_N = \frac{2.2}{(1.2 + \sigma'_{vo} / P_a)} \leq 1.7$$

Where:

C_N	=	Overburden normalizing factor
σ'_{vo}	=	Effective Overburden Stress (kPa)
P_a	=	Atmospheric Pressure = 101 kPa

Because subsequent semi-empirical equations in the NCEER Method are based on SI units, effective overburden stress is calculated here in terms of kPa.

Earthquake-induced shear stresses are not uniform throughout the soil column. To account for this variation with depth, a stress reduction coefficient is calculated using the following relationships:

$$r_d = 1.0 - 0.00765z \text{ for } z \leq 9.15m$$

$$r_d = 1.174 - 0.0267z \text{ for } 9.15m < z \leq 23m$$

Where:

r_d = Stress Reduction Coefficient

z = Depth (m)

The relationship for the shear stress reduction coefficient is derived in terms of depth in meters.

The earthquake-induced shear stresses on the soil, or cyclic stress ratio (CSR), is then calculated using the following relationship:

$$CSR = 0.65(a_{\max} / g)(\sigma_{vo} / \sigma'_{vo})r_d$$

Where:

CSR = Cyclic Stress Ratio

$a_{\max}$ = Peak Horizontal Acceleration at the ground surface (g), taken as the PGA

g = Acceleration of Gravity

σ_{vo} = Total Overburden Stress (kPa)

σ'_{vo} = Effective Overburden Stress (kPa)

The ability of the soil to resist earthquake-induced shear stresses, or cyclic resistance ratio (CRR) can be expressed as a function of the penetration resistance and is determined from:

$$CRR_{7.5} = \frac{1}{34-(N_1)_{60,cs}} + \frac{(N_1)_{60,cs}}{135} + \frac{50}{[10\cdot(N_1)_{60,cs}+45]^2} - \frac{1}{200}$$

Where:

$CRR_{7.5}$ = Cyclic Resistance Ratio for magnitude 7.5 earthquakes

$(N_1)_{60,cs}$ = Energy-Corrected, Overburden-Normalized, Clean-Sand SPT Blowcount (blows/ft), equal to $(N_1)_{60,cs}$ for this calculation

The nonlinear relationship between CRR and effective overburden stress is accounted for by estimating an overburden correction factor as follows:

$$K_\sigma = (\sigma'_{vo} / P_a)^{(f-1)}$$

Where:

K_σ = Overburden Correction Factor

f = Exponent to express site conditions, taken as 0.7

Finally, the factor of safety against liquefaction is determined by comparing the ratio of CRR to CSR, and applying appropriate correction factors, as shown in the following relationship:

$$FS = (CRR_{7.5} / CSR) \cdot MSF \cdot K_\sigma \cdot K_\alpha$$

Where:

FS = Factor of Safety against Liquefaction

MSF = Magnitude Scaling Factor, equal to 1.0 for M_w = 7.5

K_α = Static Shear Stress Correction Factor, equal to 1.0 for level ground

Liquefaction calculations are performed at 5-foot depth intervals using the NCEER Method and the results are summarized in Table 1. As shown in Table 1, the estimated results for Factor of Safety against liquefaction for saturated compacted fill with a corrected SPT blowcount value of 25 and a PGA of 0.1g range between 2.5 and 4.0.

Table 1: Summary of Liquefaction Analysis – NCEER Method (Factor of Safety against Liquefaction)

Depth (ft/m)	$(N_1)_{60,cs}$ (blows/ft)	σ_{vo} (psf/kPa)	σ'_{vo} (psf/kPa)	C_N	r_d	PGA (g)	CSR	$CRR_{7.5}$	K_σ	FS
5/1.5	25	625/29.9	313/15.0	1.63	0.99	0.1	0.13	0.29	1.77	**4.0**
10/3.0	25	1250/59.9	626/30.0	1.47	0.98	0.1	0.13	0.29	1.44	**3.3**
15/4.6	25	1875/89.8	939/45.0	1.34	0.97	0.1	0.13	0.29	1.27	**3.0**
20/6.1	25	2500/119.7	1252/59.9	1.23	0.95	0.1	0.12	0.29	1.17	**2.8**
25/7.6	25	3125/149.6	1565/74.9	1.13	0.94	0.1	0.12	0.29	1.09	**2.6**
30/9.1	25	3750/179.6	1878/89.9	1.05	0.93	0.1	0.12	0.29	1.04	**2.5**
35/10.7	25	4375/209.5	2191/7104.9	0.98	0.89	0.1	0.12	0.29	0.99	**2.5**
40/12.2	25	5000/239.4	2504/119.9	0.92	0.85	0.1	0.11	0.29	0.95	**2.5**
45/13.7	25	5625/269.3	2817/134.9	0.87	0.81	0.1	0.10	0.29	0.92	**2.6**

For comparison purposes, the above liquefaction analysis is also repeated to estimate the SPT blowcount and PGA values needed to trigger liquefaction (FS=1). Results of these parametric studies are shown in Tables 2 and 3. As shown in Table 2, the estimated maximum SPT blowcount values needed to trigger Liquefaction range between 5.0 and 10.4, which is significantly lower that the expected minimum SPT blowcount value for compacted fill (25). The estimated minimum PGA values needed to trigger liquefaction are shown in Table 3 and range between 0.25g and 0.40g. These values are significantly higher than the design PGA value of 0.1g for the CPNPP site.

Table 2: Summary of Liquefaction Analysis – NCEER Method (SPT Blowcount Needed to Trigger Liquefaction)

Depth (ft/m)	PGA (g)	FS (Assumed)	$(N_1)_{60,cs}$ Needed to Trigger Liquefaction (blows/ft)	$(N_1)_{60,cs}$ Compacted Fill (blows/ft)
5/1.5	0.1	1.0	**5.0**	25
10/3.0	0.1	1.0	**7.1**	25
15/4.6	0.1	1.0	**8.3**	25
20/6.1	0.1	1.0	**9.2**	25
25/7.6	0.1	1.0	**9.8**	25
30/9.1	0.1	1.0	**10.4**	25
35/10.7	0.1	1.0	**10.4**	25
40/12.2	0.1	1.0	**10.3**	25
45/13.7	0.1	1.0	**10.1**	25

Table 3: Summary of Liquefaction Analysis – NCEER Method (PGA Values Needed to Trigger Liquefaction)

Depth (ft/m)	$(N_1)_{60,cs}$ Compacted Fill (blows/ft)	FS (Assumed)	PGA Needed to Trigger Liquefaction (g)	PGA (g)
5/1.5	25	1.0	**0.403**	0.1
10/3.0	25	1.0	**0.331**	0.1
15/4.6	25	1.0	**0.297**	0.1
20/6.1	25	1.0	**0.276**	0.1
25/7.6	25	1.0	**0.261**	0.1
30/9.1	25	1.0	**0.250**	0.1
35/10.7	25	1.0	**0.250**	0.1
40/12.2	25	1.0	**0.252**	0.1
45/13.7	25	1.0	**0.255**	0.1

EERI Method:

The overburden normalizing factor used in the EERI Method is a function of SPT blowcount, and therefore requires iteration. The factor can be calculated using the following:

$$C_N = \left(\frac{P_a}{\sigma'_{vo}}\right)^{0.784-0.0768\sqrt{(N_1)_{60}}} \leq 1.7$$

Where:

C_N = Overburden Normalizing Factor

P_a = Atmospheric Pressure = 101 kPa

σ'_{vo} = Effective Overburden Stress (kPa)

$(N_1)_{60}$ = Energy Corrected, Overburden Normalized SPT Blowcount (blows/ft), equal to $(N_1)_{60,cs}$ for this calculation

The shear stress reduction coefficient in the EERI Method is a function of depth and earthquake magnitude and can be determined from the following relationships:

$$r_d = \exp(\alpha(z) + \beta(z)M) \quad \text{for } z \leq 34m$$

Where:

r_d = Shear Stress Reduction Coefficient

$$a(z) = -1.012 - 1.126\sin\left(\frac{z}{11.73} + 5.133\right)$$

$$\beta(z) = 0.106 + 0.118\sin\left(\frac{z}{11.28} + 5.142\right)$$

z = Depth (m)

M = Earthquake Magnitude

Cyclic stress ratio in the EERI Method is calculated similarly to the NCEER Method, as seen in the following:

$$CSR_{M,\sigma'_{vo}} = 0.65(a_{max}/g)(\sigma_{vo}/\sigma'_{vo})r_d$$

Where:

$CSR_{M,\sigma'_{vo}}$ = Cyclic Stress Ratio under a specific magnitude and overburden stress

a_{max} = Peak Horizontal Acceleration at the ground surface (g), taken as the PGA

g = Acceleration of Gravity

σ_{vo} = Total Overburden Stress (kPa)

Overburden correction factor by the EERI Method is determined using effective overburden stress and SPT blowcount, as shown in following relationship:

$$K_\sigma = 1 - C_\sigma \ln\left(\frac{\sigma'_{vo}}{P_a}\right) \leq 1.1$$

Where:

K_σ = Overburden Correction Factor

C_σ = $\dfrac{1}{18.9 - 2.55\sqrt{(N_1)_{60}}} \leq 0.3$

The earthquake-induced CSR is also adjusted to the equivalent CSR for the reference values of M=7.5 and σ'_{vo} =1 atm, according to the following relationship:

$$CSR_{M=7.5,\sigma'_{vo}=1} = CSR_{M,\sigma'_{vo}} \frac{1}{MSF}\frac{1}{K_\sigma}$$

Where:

MSF = Magnitude Scaling Factor, equal to 1.0 for M_w = 7.5

The EERI-Method cyclic resistance ratio can be calculated using the following relationship:

$$CRR_{M=7.5,\sigma'_{vo}=1} = \exp\left(\frac{(N_1)_{60,cs}}{14.1} + \left(\frac{(N_1)_{60,cs}}{126}\right)^2 - \left(\frac{(N_1)_{60,cs}}{23.6}\right)^3 + \left(\frac{(N_1)_{60,cs}}{25.4}\right)^4 - 2.8\right)$$

Where:

$CRR_{M=7.5,\sigma'_{vo}=1}$ = Cyclic Resistance Ratio under magnitude 7.5 earthquake and 1 atmosphere overburden stress

$(N_1)_{60,cs}$ = Energy Corrected, Overburden Normalized SPT Blowcount (blows/ft)

Finally, the factor of safety against liquefaction is determined by comparing the ratio of CRR to CSR as follows:

$$FS = \frac{CRR_{M=7.5,\sigma'_{vo}=1}}{CSR_{M=7.5,\sigma'_{vo}=1}}$$

Where:

FS = Factor of Safety against Liquefaction

Liquefaction calculations using the EERI Method are again performed at 5-foot depth intervals, and the results are summarized in Table 4. As shown in Table 4, the estimated result for Factor of Safety against liquefaction for saturated compacted fill with a corrected SPT blowcount value of 25 and a PGA of 0.1g range between 2.4 and 2.6.

Table 4: Summary of Liquefaction Analysis – EERI Method (Factor of Safety against Liquefaction)

Depth (ft/m)	$(N_1)_{60,cs}$ blows/ft	σ_{vo} (psf/kPa)	σ'_{vo} (psf/kPa)	C_N	r_d	K_σ	CSR $M_{7.5},\sigma'_{vo=1}$	CRR $M_{7.5},\sigma'_{vo=1}$	FS
5/1.5	25	625/29.9	313/15.0	1.70	1.00	1.10	0.12	0.29	2.5
10/3.0	25	1250/59.9	626/30.0	1.63	0.98	1.07	0.12	0.29	2.4
15/4.6	25	1875/89.8	939/45.0	1.38	0.97	1.05	0.12	0.29	2.4
20/6.1	25	2500/119.7	1252/59.9	1.23	0.95	1.03	0.12	0.29	2.4
25/7.6	25	3125/149.6	1565/74.9	1.13	0.93	1.02	0.12	0.29	2.5
30/9.1	25	3750/179.6	1878/89.9	1.05	0.91	1.01	0.12	0.29	2.5
35/10.7	25	4375/209.5	2191/7104.9	0.98	0.89	1.00	0.12	0.29	2.5
40/12.2	25	5000/239.4	2504/119.9	0.93	0.86	0.99	0.11	0.29	2.6
45/13.7	25	5625/269.3	2817/134.9	0.89	0.84	0.98	0.11	0.29	2.6

For comparison purposes, the above liquefaction analysis is also repeated to estimate the SPT blowcount and PGA values needed to trigger liquefaction (FS=1). Results of these parametric studies using the EERI Method are shown in Tables 5 and 6. As shown in Table 5, the estimated maximum SPT blowcount values needed to trigger liquefaction range between 8.9 and 10.2, which is significantly lower than the expected minimum SPT blowcount value for compacted fill (25). The estimated minimum PGA values needed to trigger liquefaction are shown in Table 6 and range between 0.24g and 0.26g. These values are significantly higher than the design PGA value of 0.1g for the CPNPP site.

Table 5: Summary of Liquefaction Analysis – EERI Method
(SPT Blowcount Needed to Trigger Liquefaction)

Depth (ft/m)	PGA (g)	FS (Assumed)	$(N_1)_{60,cs}$ Needed to Trigger Liquefaction (blows/ft)	$(N_1)_{60,cs}$ Compacted Fill (blows/ft)
5/1.5	0.1	1.0	**9.9**	25
10/3.0	0.1	1.0	**10.2**	25
15/4.6	0.1	1.0	**10.2**	25
20/6.1	0.1	1.0	**10.2**	25
25/7.6	0.1	1.0	**10.0**	25
30/9.1	0.1	1.0	**9.8**	25
35/10.7	0.1	1.0	**9.6**	25
40/12.2	0.1	1.0	**9.3**	25
45/13.7	0.1	1.0	**8.9**	25

Table 6: Summary of Liquefaction Analysis – EERI Method
(PGA Values Needed to Trigger Liquefaction)

Depth (ft/m)	$(N_1)_{60,cs}$ Compacted Fill (blows/ft)	FS (Assumed)	PGA Needed to Trigger Liquefaction (g)	PGA (g)
5/1.5	25	1.0	**0.248**	0.1
10/3.0	25	1.0	**0.245**	0.1
15/4.6	25	1.0	**0.242**	0.1
20/6.1	25	1.0	**0.243**	0.1
25/7.6	25	1.0	**0.245**	0.1
30/9.1	25	1.0	**0.248**	0.1
35/10.7	25	1.0	**0.251**	0.1
40/12.2	25	1.0	**0.256**	0.1
45/13.7	25	1.0	**0.262**	0.1

The results of both analyses are also presented on Figure 1, Blowcount vs. Depth. This figure demonstrates that for a given depth, the minimum SPT blowcount design criteria for compacted fill is significantly greater than the maximum SPT blowcounts required to trigger liquefaction, as determined by both analysis methods.

Figure 2, PGA vs. Depth, also shows that the potential for liquefaction is unlikely. The data on Figure 2 are generated by back-calculating the minimum PGA values required to trigger liquefaction in compacted fill with a minimum SPT blowcount value of 25 blows/ft. This figure also demonstrates that for a given depth, the minimum PGA required to trigger liquefaction is significantly greater than the CPNPP site design PGA value of 0.1g.

In summary, the results of liquefaction analyses using the methods described above indicate that liquefaction of the compacted fill is not likely.

References:

Youd, T.L. et al., (2001), Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, Journal of Geotechnical and Geoenvironmental Engineering, ASCE 127(10), pages 817-833.

Idriss, I.M. and Boulanger, R.W., (2008), Soil Liquefaction during Earthquakes, Earthquake Engineering Research Institute Monograph MNO-12.

<u>Impact on R-COLA</u>

None.

Impact on S-COLA

None.

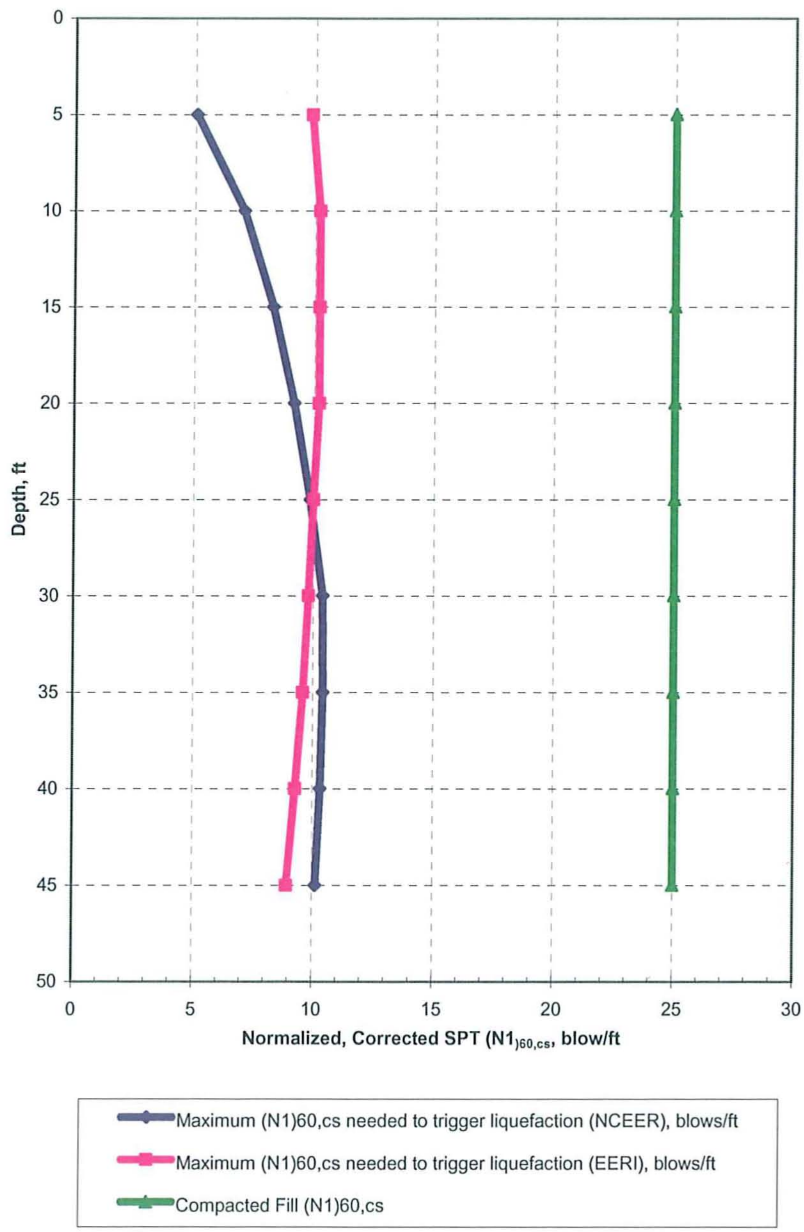
Impact on DCD

None.

Attachments

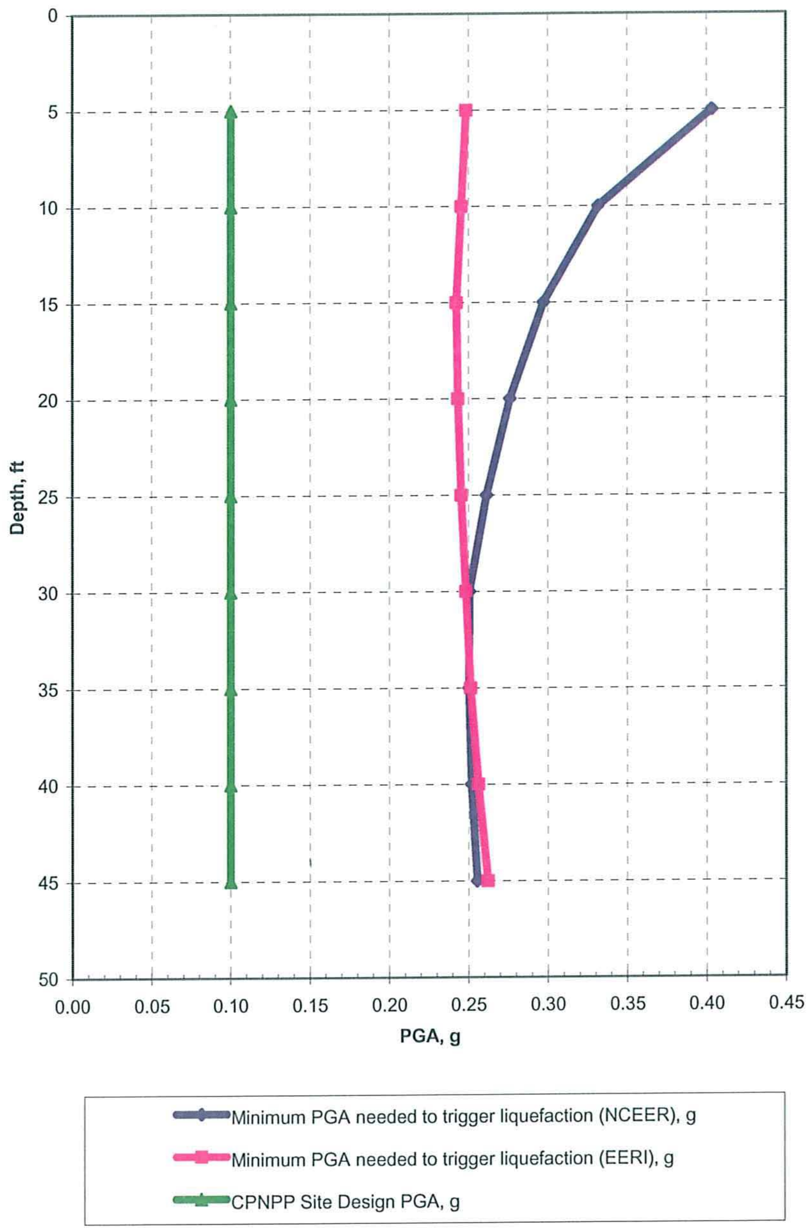
Figure 1 – Liquefaction Assessment SPT Blowcount vs. Depth

Figure 2 – Liquefaction Assessment PGA vs. Depth



Liquefaction Assessment
SPT Blowcount vs. Depth

FIGURE 1



Liquefaction Assessment
PGA vs. Depth

FIGURE 2

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 2929 (CP #22)

SRP SECTION: 02.05.04 - STABILITY OF SUBSURFACE MATERIALS AND FOUNDATIONS

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/17/2009

QUESTION NO.: 02.05.04-18

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.4, "Stability of Subsurface Materials and Foundations," establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

Section 2.5.4.10.5 of the FSAR indicates that resistance to lateral loads can be achieved by both passive soil pressure as well as friction below the base. Please provide information on how safety against sliding was computed incorporating consistent displacement estimates for both friction under the basemat and passive pressure estimates. Please provide information on how ultimate friction coefficients were computed between basemat and fill materials potentially located under the basemat.

ANSWER:

Resistance to lateral loads is achieved by friction between the foundation basemat and by shear keys if and where needed. Passive soil resistance is not relied upon to resist lateral loads. Further, friction resistance acting on the side walls of embedded structures is not relied upon to resist lateral loads. Shear keys transfer lateral loads by lateral bearing on limestone and/or lateral bearing on fill concrete. Because there is no reliance on passive soil pressure, no specific displacement estimates have been made with respect to development of passive resistance of the soil. Resistance to lateral loads for site-specific structures is described further in the general discussions in FSAR Subsections 3.8.4.4.3.1, 3.8.4.4.3.2, and 3.8.4.4.3.3 for the ESWPT, UHSRS, and PSFSVs, respectively.

An “ultimate” coefficient of friction is not applied in the stability design. The coefficient of friction considered is a static coefficient of friction since the structures are designed to preclude sliding. Therefore, a factor of safety is not applied to the coefficient of friction. Instead, a minimum factor of safety for sliding is applied that is consistent with the requirements of Table 3.8.5-1 of the US-APWR DCD, which is incorporated by reference in the FSAR. Table 3.8.5-1 is based on the safety factor requirements contained in SRP 3.8.5 regarding stability against sliding, overturning and buoyancy. The factor of safety varies depending on each load combination shown in Table 3.8.5-1. Note that the strength design of site-specific concrete structures (as opposed to stability requirements) is in accordance with the loads and load combination given in Table 3.8.4-3 of the US-APWR DCD, which is incorporated by reference in the FSAR. Thus, the pertinent loads and load combinations of Table 3.8.4-3 are also applied to the strength design for the individual elements of structures, such as the mat foundations, below-grade walls, and shear keys (if and where needed).

The value of 0.6 cited for the coefficient of friction as discussed in FSAR Subsection 2.5.4.10.5 was conservatively selected based on an interface friction angle of 31 degrees (NAVFAC Design Manual 7.02, 1986). This value is valid for the foundation concrete/limestone interface and for foundation concrete/fill concrete interfaces. The dampproofing used on the exterior surfaces of below-grade walls does not extend below the structure basemats and is therefore not present between the foundation and limestone, nor between fill concrete and limestone. Also, as stated above, no credit is taken for sliding resistance provided by friction acting along the side walls of structures. Therefore, this coefficient of friction is not affected by the dampproofing used at CPNPP.

Based on the above discussion, FSAR Subsection 2.5.4.10.5 has been revised to delete and add the portions of the discussion which state that passive soil pressure and friction on side walls are relied upon. The reference to an ultimate coefficient of friction has been deleted from this subsection.

Reference:

Naval Facilities Engineering Command (NAVFAC) (1986), Foundations & Earth Structures, Design Manual 7.02, dated September 1986.

Impact on R-COLA

FSAR Revision 0 page 2.5-192 has been revised to reflect this response.

See attached changes for page 2.5-207. Because of the text additions and deletions, the page number on the mark-up FSAR page may not be the same as the page number in FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 2929 (CP #22)

SRP SECTION: 02.05.04 - STABILITY OF SUBSURFACE MATERIALS AND FOUNDATIONS

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/17/2009

QUESTION NO.: 02.05.04-19

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.4, "Stability of Subsurface Materials and Foundations," establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

FSAR Section 2.5.4.10.4 “Lateral Earth Pressure” reference FSAR Figure 2.5.4-242-2.5.4.-243 which provides calculation of the lateral active and at-rest pressures for selected granular backfill. Please provide sample calculations considering effects of the seismic lateral earth pressure on the retaining structures.

ANSWER:

The following provides sample calculations of active and at-rest lateral earth pressures (including the seismic component) on below-grade retaining structures. Seismic lateral load calculations for walls capable of yielding (flexible walls or those free to displace or rotate at the top) are based on the Mononabe-Okabe method (Kramer, 1996; Seed and Whitman, 1970). Calculations for walls not capable of yielding (rigid and restrained from displacement or rotation) are based on a procedure developed by Wood (Kramer, 1996; Wood, 1973). Detailed procedures for calculating lateral earth pressures are presented in the Lateral Earth Pressures Calculation Package (TXUT-001-FSAR-2.5-CALC-010).

The assumptions made for this sample calculation are provided below. Sample calculations for yielding and unyielding walls are shown on revised FSAR Figures 2.5.4-242 and 2.5.4-243, respectively.

Assumptions:

The following is a list of assumptions that are made to prepare these sample calculations:

- The Peak Ground Acceleration (PGA) is assumed to be 0.1g based on the results of the ground motion and site response analyses.
- The effective horizontal ground acceleration coefficient (kh) is assumed to be 85% of the PGA.

- The dimensionless thrust factor (f) is assumed equal to one.
- Backfill behind all walls is assumed to be horizontal.
- The angle of wall friction is assumed to be zero.
- The slope of the back of all walls is assumed to be vertical.
- Compacted backfill properties are shown on revised Figure 2.5.4-242 and 2.5.4-243 (attached).

References:

Kramer, S.L. (1996), Geotechnical Earthquake Engineering, Prentice-Hall, New Jersey.

Seed, H.B. and Whitman, R.V. (1970), Design of Earth Retaining Structures for Dynamic Loads, ASCE Specialty Conference on Lateral Stresses in the Ground and Design of Earth Retaining Structures, Ithaca, New York.

Wood, J.H. (1973), Earthquake Induced Soil Pressures on Structures, Doctoral Dissertation, EERL 73-05, California Institute of Technology, Pasadena, CA.

Impact on R-COLA

FSAR Revision 0 Figures 2.5.4-242 and 2.5.4-243 were revised to reflect this response.

See attached changes for Figures 2.5.4-242 and 2.5.4-243.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 2929 (CP #22)

SRP SECTION: 02.05.04 - STABILITY OF SUBSURFACE MATERIALS AND FOUNDATIONS

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/17/2009

QUESTION NO.: 02.05.04-20

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.4, "Stability of Subsurface Materials and Foundations," establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

Calculation No. TXUT-001-FSAR-2.5-CALC-009, "Settlement and Bearing Capacity," indicates that the 50th percentile ultimate strength of the shale material is approximately 10 to 15 tsf, while the dynamic demand under the reactor building (static plus seismic loads) is over 30 tsf. The dynamic demands under the other facilities are also high, relative to this ultimate material strength. Please provide information to indicate that the shale material, as well as other such low-strength materials, will not be found under the power block facilities, and the program that will be used for confirmation.

ANSWER:

Evaluation of the effect on bearing capacity as a result of the scattered, discontinuous shale lenses and interbeds within engineering Layer C limestone requires consideration of several parameters, including:

- shale location, amount, thickness, and distribution,
- confining pressure acting on shale layers; and
- shale orientation with respect to applied loads.

A brief discussion of those parameters follows below:

Distribution of Shale Interbeds - Refined geologic assessment of Layer C:

This engineering Layer C was described as a massive limestone layer within the near surface stratigraphic model at CPNPP. That is because the shale materials within that unit form a relatively minor percentage of the unit. In response to this question, a more detailed analysis of the stratigraphy of Layer C was undertaken to identify the distribution of lithologies, differing from limestone, as summarized below.

Information from boring logs from was used to determine the top and bottom elevations of engineering Layer C as well as to indicate areas of shale throughout Layer C. Additionally, RQD and recovery data, photo logs, televiewer logs, and lithologic descriptions were also evaluated. Only boring logs whose depth reached or exceeded the depth of Layer C limestone were examined.

Using these sources, data for the elevation, thickness, and percentage of shale within engineering Layer C were collected and summarized to evaluate the spatial distribution of the shale observed in each boring under CPNPP Units 3 and 4, within the full elevation range of Layer C, or to the elevation in which each boring terminated (Figures 1 and 2). The stick plots shown on Figures 1 and 2 show the borings sequentially with each shale layer thickness plotted against elevation. These figures allow for the identification of laterally persistent shale beds as well as their vertical distribution and the following observations can be made:

Distribution of shale interbeds within Layer C is predominantly variable. The minimum thickness of individual shale layers is typically 0.2 ft (except in borings where no shale is present) and the maximum thickness is about 3.2 feet.

Figures 1 and 2 show semi-continuous relatively thin layers of shale (about 0.2 to nearly 3 ft thick) ranging from approximately 783 to 778 ft in elevation. These layers are expected to be removed during the construction as part of the site excavation and subgrade preparation.

The shale beds within Layer C appear to be somewhat more common in the western portion of the site.

Percentages of accumulated shale thickness in each boring range from a minimum of zero to a maximum of about16. Only one out of 58 borings under Unit 3 area and one out of 54 borings under Unit 4 area, contains an accumulated thickness of shale lenses or layers of more than 10 percent of the total thickness of Layer C.

Further, 50 out of 58 borings (or about 86% of borings) under Unit 3 area and 32 out 54 borings under Unit 4 area (or about 59% of borings), contain an accumulated thickness of shale lenses or layers of less than 2% of the total thickness of Layer C (or about 1.2 ft).

Although most shales identified within Layer C are monolithic, several layers of shale identified contain considerable amounts of interbedded limestone, as determined after a thorough examination of boring logs, photographic logs, and televiewer logs. In some cases, limestone rip-up clasts were in-filled with shale making it difficult to determine the exact ratio of limestone to shale. Thus, thickness of shale as shown in Figures 1 and 2 is a combination of uninterrupted units of shale and units of shale with some limestone.

The combined thickness of interbedded shale lenses or layers within the 60-foot-thick engineering Layer C is at most locations less than 1.2 ft, or about 2 percent of the total thickness. This is the case for 59% and 86% of the borings drilled under proposed CPNPP Units 4 and 3 areas, respectively. The remaining thickness of Layer C (more than 98% of Layer C thickness at most locations) consists of competent, massive limestone bedrock. The individual thickness of each interbedded shale layers or lens is often only few inches, and in some locations they occur in groups/clusters of interbedded shale and limestone that commonly add up to less than 2 feet combined.

One case of a nearly 3-foot-thick shale lens or layer was found at about elevation 782 ft. That shale layer, however, will be removed during construction as part of the site excavation and subgrade preparation. Two other apparent occurrences, as suggested by Figures 1 and 2, are within approximate elevation ranges 765±3 and 745±3 ft, and under Unit 4 area. Our evaluation of corehole borings under Units 3 and 4 indicate that the lateral continuity of these thin layers is limited.

In summary, this refined evaluation of engineering Layer C indicates that limestone is the dominant lithology. Shale units have variable thicknesses throughout engineering Layer C limestone, but are very uncommon and not laterally or vertically extensive. The majority of borings within Layer C contain little to no shale.

Seismic category I and II foundations will be installed at approximate elevation of 782 ft. Therefore, the thickness of the overburden after grading to finish grade elevation of 822 ft will be about 40 ft, with an average thickness of about 48 ft based on existing site grade elevations. Therefore, the anticipated net foundation loads at the elevation of 782 ft would be approximately 3 tsf less than the total foundation loads. As shown on FSAR Figure 2.5.4-235, the shale design strength parameters for across-bedding condition is about 25 degrees for internal friction angle 3,000 psf for cohesion. Using these strength parameters and the more applicable General Shear Failure Model, the ultimate bearing capacity of the shale at an embedment depth of about 40 feet, is still significant (>50 tsf). Considering that the Compressive Failure Model that was used for estimating the bearing capacity of 73 tsf for Layer C is very conservative, the presence of the localized shale interbeds do not appear to have any adverse effect on the overall bearing capacity of engineering Layer C.

As discussed in FSAR Subsections 2.5.4.5.2, 2.5.4.5.4.6.1, and 2.5.4.5.4.6.3 engineering geologic observation and mapping supplemented with photographs, and topographic survey is required on a continuous basis during foundation excavations in order to ensure that all shale and unsuitable materials are removed and competent rock materials are exposed at the bottom.

Impact on R-COLA

FSAR Revision 0 pages 2.5-176 and 2.5-181 were revised to reflect this response.

See attached changes for pages 2.5-182 and 2.5-190. Because of the text additions and deletions, the page numbers on the markup FSAR pages may not be the same as the page numbers in the FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

Attachments

Figure 1 - Stick Plot of Shale Interbeds within Layer C below Unit 4

Figure 2 - Stick Plot of Shale Interbeds within Layer C below Unit 3

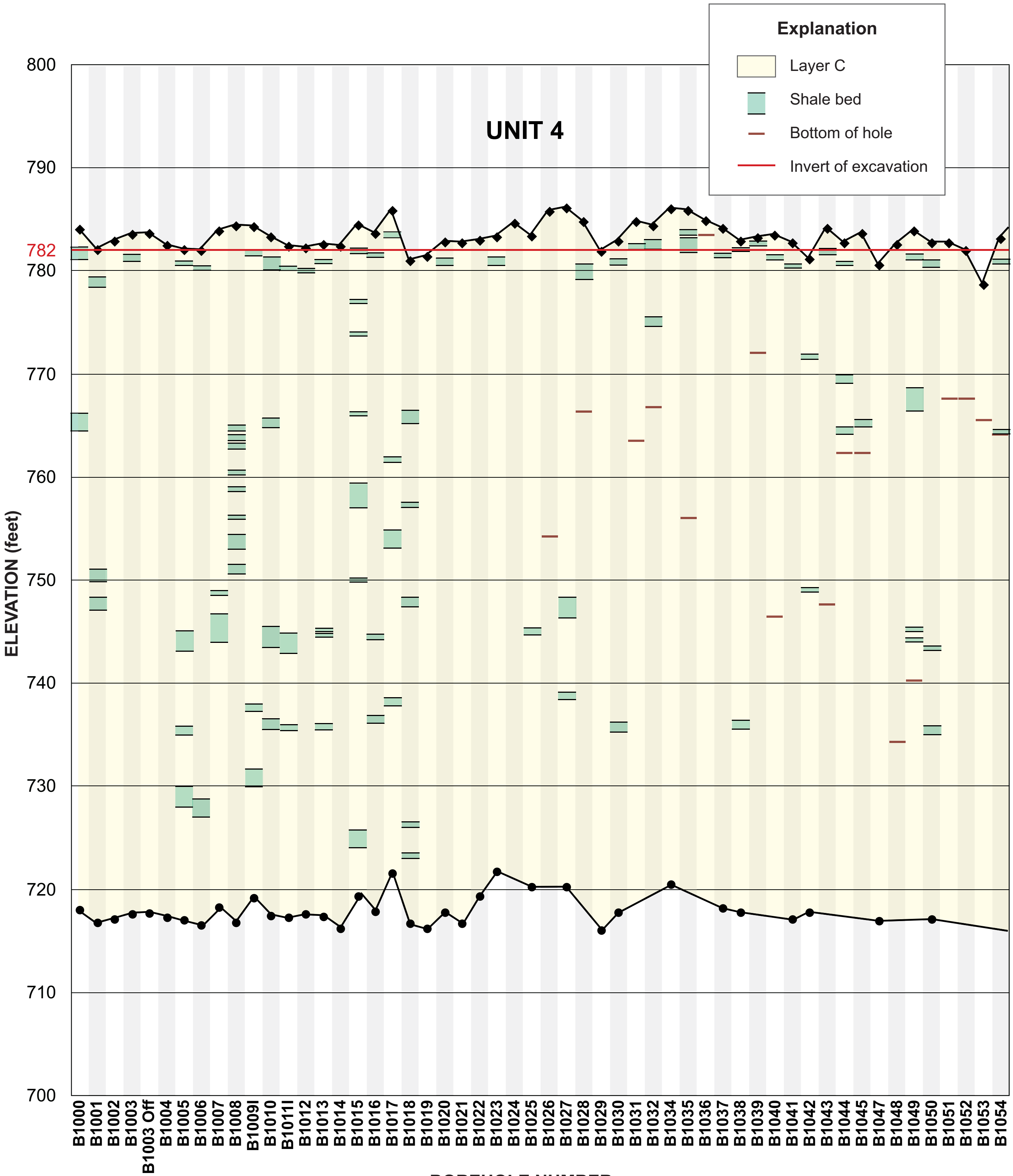


Figure 1. Stick Plot of Shale Interbeds within Layer C below Unit 4 - RAI 2.5.4-20

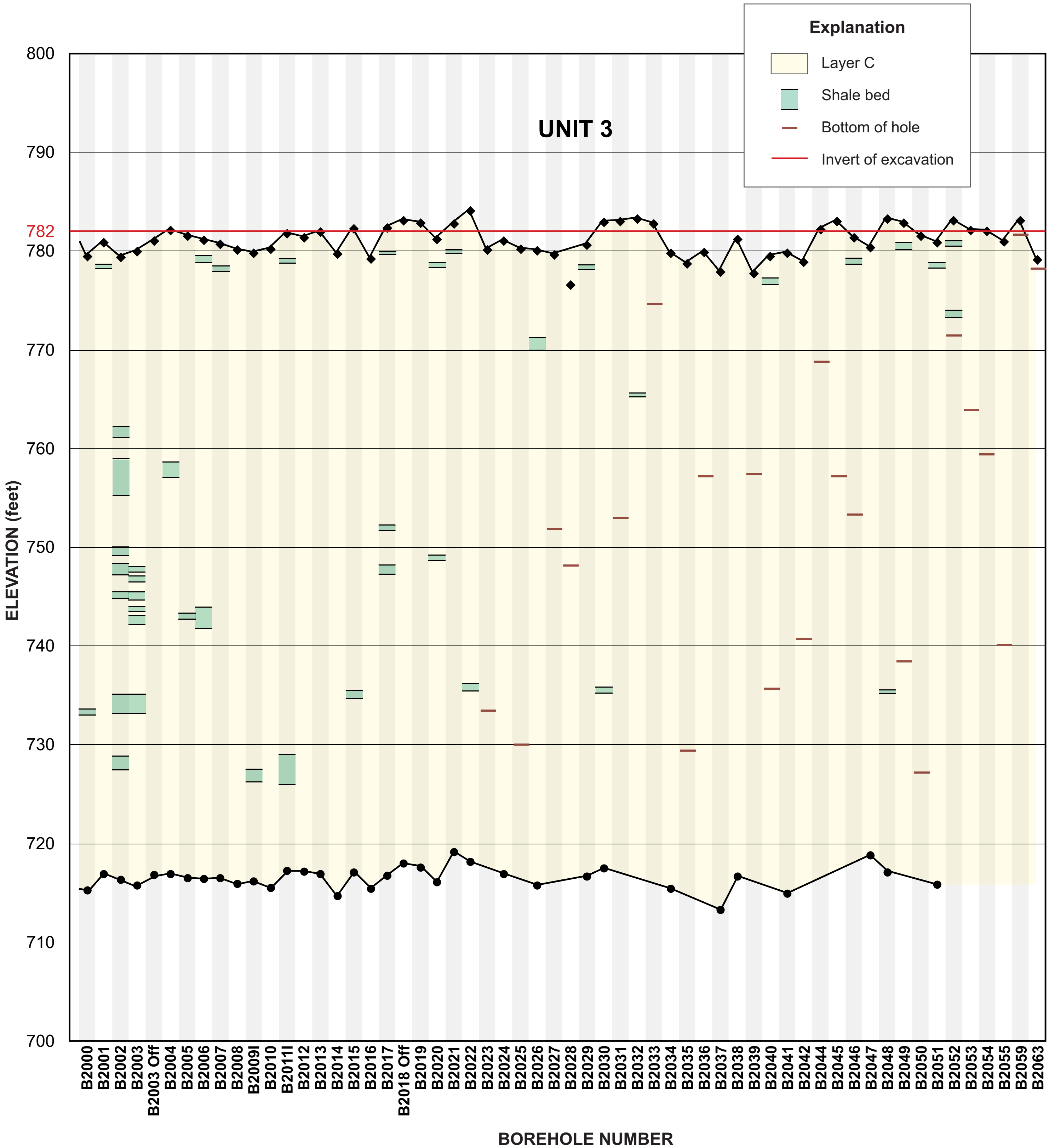


Figure 2. Stick Plot of Shale Interbeds within Layer C below Unit 3 - RAI 2.5.4-20

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 2929 (CP #22)

SRP SECTION: 02.05.04 - STABILITY OF SUBSURFACE MATERIALS AND FOUNDATIONS

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/17/2009

QUESTION NO.: 02.05.04-21

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.4, "Stability of Subsurface Materials and Foundations," establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

FSAR section 2.5.4.10.2, "Settlement," states that "settlement estimates are based on interpreted compressibility characteristics and elastic modulus properties of Glen Rose Formation limestone and shale materials, as discussed in Subsection 2.5.4.2." Please provide the settlement monitoring program that will be used during and after construction.

ANSWER:

As discussed in FSAR Subsections 2.5.4.10.2 and 2.5.4.10.3, all seismic category I and II structure foundations are supported on competent rock materials consisting of Glen Rose, Twin Mountain, and Mineral Wells Formations. Considering the properties and nature of these underlying rock formations, the settlement behavior of the foundations will be elastic in nature. The rebound deformation due to removal of about 40 ft of overburden rock is estimated to be less than 1/8 in. The total settlements for all seismic category I and II structures are anticipated to be less than 1/2 in. These estimated deformation values are very comparable to those for CPNPP Units 1 and 2, which are supported on similar materials. Data from actual measurements collected from Units 1 and 2 suggest that these deformation estimates are conservative (e.g. removal of about 30-60 ft of overburden material resulted in a rebound measured by extensometers of about 0.02 in).

Because the magnitudes of the anticipated settlements and rebound deformations are only a fraction of the acceptable tolerance levels of the structures (i.e., about 2 in), monitoring the rebound or settlements may not be very critical. However, as indicated in FSAR Subsection 2.5.4.5.4.6.3, extensometers will be used during the excavation for Units 3 and 4 to monitor the rebound deformations. A minimum of two extensometers (1 per unit) will be installed before the start of the excavation process at Units

3 and 4 to monitor the rebound behavior of the excavation bottoms. Details with respect to the number, locations, installation, and monitoring procedures will be developed at a later date before the start of construction.

During construction and the initial stages of foundation installation, a number of settlement plates or points will be established in order to measure and monitor the settlement of the structures as loads are applied through the completion of construction. Details with respect to the number, locations, installation, and monitoring procedures for the settlement points will be developed at a later date before the start of construction.

CPNPP Units 1 and 2 have an ongoing Maintenance Effectiveness Monitoring Program in place that details the quality control and monitoring program for all aspects of the plant, including the settlement and performance of the structures. After the completion of Units 3 and 4 construction, a number of settlement points or plates will be established on selected parts of the structures for settlement monitoring purposes during the life of the plant. The existing Maintenance Effectiveness Monitoring Program for Units 1 and 2 will also be adopted to carry on the monitoring program for Units 3 and 4.

Impact on R-COLA

FSAR Revision 0 page 2.5-191 was revised to reflect this response.

See attached changes for page 2.5-205. Because of the text additions and deletions, the page numbers on the markup FSAR pages may not be the same as the page numbers in the FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

Attachment (on CD)

CPNPP Maintenance Effectiveness Monitoring Program, Procedure No. STA-744 (See section 8H).

Attachment 3

Response to Request for Additional Information No. 2930 (CP RAI #19)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 2930 (CP #19)

SRP SECTION: 02.05.05 – STABILITY OF SLOPES

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/14/2009

QUESTION NO.: 02.05.05-3

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.5, 'Stability of Slopes,' establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

FSAR Subsections 2.5.4.1.5 and 2.5.5.1.2 indicate that localized surficial erosion and raveling have occurred in undocumented fill and/or native colluvial soils on the reservoir slopes, and conclude that this is a surficial condition that does not present a significant slope stability hazard to the CPNPP Units 3 and 4 plant sites. Please provide information including (1) to what extent the "localized surficial erosion and raveling" has happened, (2) the technical basis of the applicant's conclusion that there is no significant slope stability hazard, and (3) what, if anything, the applicant intends to do to ensure the maintenance and protection the slope for CPNPP Units 3 and 4. In addition, please explain whether this local erosion and raveling is considered as a factor in the slope stability analyses presented in Subsection 2.5.5.3.

ANSWER:

Part (1)

Raveling typically refers to stress-relief and erosion-induced particle-by-particle removal of rock fragments and soil from the surface of natural and cut/fill slopes. When raveling occurs on steep slopes, the loosened material rolls, creeps, or washes downslope to collect at the base of the slope in a colluvial talus debris fan that is commonly inclined at the angle of repose of the material. This is a long-term, progressive process that is usually self-limiting because, in the absence of erosion, the debris fan eventually accumulates to a point at which the toe of the slope is pushed outward, and the debris builds upward against the slope and acts as a buttress against the slope face. When raveling occurs on gently inclined slopes, the result is typically a slope of similar inclination that is mantled by a surficial layer of residual colluvium.

Competent, sound bedrock slopes, such as natural or cut slopes in massive Glen Rose Limestone Layer C, typically are relatively resistant to raveling because the cementation and paucity of jointing or discontinuities tends to keep the slopes intact and lessen the generation of abundant loosened fragments. Raveling of these slopes, therefore, typically consists of minor stress-relief loosening of small rock fragments that fall from the slope and form a small debris fan at the base of the slope. For example, the relatively high cut-slope above the existing Units 1 and 2 circulating water outfall structure and the low cut- and-natural slopes along the reservoir margin and in-road cuts or drainage ditches are Glen Rose Limestone slopes that exhibit this behavior. Stress relief relaxation in these slopes is observed to be restricted to the outermost 2 to 5 feet of the slope, as evidenced by the distance of dilation-induced loosening or opening of joints/discontinuities extending back from the top of the slopes. Raveling of shale beds of Glen Rose Formation bedrock is generally developed to a greater degree than in the limestone beds. The softer shale beds produce a greater amount of small, loosened fragments, such that the debris fan formed at the base of the slope is typically somewhat larger and extends higher up the slope face, in comparison to the debris fans on limestone slopes.

The gently inclined areas of outcropping or shallow bedrock in the Squaw Creek Reservoir slopes are relatively resistant to significant raveling and are typically mantled by a surficial covering of residual soil/colluvium that is only a few feet thick. On the surfaces of those natural slopes, a few shallow erosion gullies have developed as a result of the sheet-flow of water across their surfaces.

Raveling on fill slopes tends to develop more pervasively and to a greater degree than on the bedrock slopes. The raveling in the fill soil slopes includes general surficial loosening of small to large incorporated rock fragments, erosion and sloughing of finer-grained soil matrix, and creep of loosened rock and soil debris. The depth of raveling in the fill materials is typically limited to the outermost few to 5 feet or so of material in the slope face.

Along the margin of Squaw Creek Reservoir, surficial erosion has formed gullies or swales in the slopes that drain downward into the reservoir. Some of the drainage swales have developed on natural slopes and are incised through the colluvium and slightly into the underlying weathered Glen Rose formation bedrock. In these instances, surficial erosion primarily affects the thin colluvial soils and does not significantly affect the underlying bedrock. The areas of greatest development of surficial erosion and raveling that are referenced in FSAR Subsections 2.5.4.1.5 and 2.5.5.1.2 are in areas of undocumented fill and thicker colluvial soil deposits on and adjacent to the reservoir slopes, where erosional channels/swales have incised into the soil. Where most developed, erosion of the finer-grained fill soil matrix has isolated and left cobble and boulder-sized limestone blocks within the channel bottoms. The cobble and boulder-size lag-gravel materials form an erosion-resistant layer in the channel bottom that generally restricts future incision and lateral expansion of the individual drainage channels. Therefore, the erosion/raveling becomes somewhat self-limiting and restricted in depth and lateral extent.

The surficial erosion and raveling discussed above occurs to some extent on most of the slopes veneered or formed in undocumented fill. These processes are potentially most influential on gross slope performance relative to plant stability in areas where plant facilities encroach closest to the reservoir slopes, modeled in FSAR geologic Cross Sections D-D' and E-E' (Figures 2.5.5.202 and 2.5.5.203, respectively). For these areas, the presence and properties of the undocumented fill and/or colluvial soil are specifically modeled in the deep-seated slope stability analyses discussed in FSAR Subsections 2.5.5.2.4 through 2.5.5.2.7. However, surficial erosion and raveling only occur in the outermost few to 5 feet of slope materials, and that type of shallow slope process is not typically modeled in the gross slope stability analyses, which focuses on potential deeper-seated stability/failure modes that are of greater potential engineering and safety consequence. The reservoir slopes in these areas have an overall maximum inclination ranging from about 3:1 to 5:1 (horizontal to vertical; or about 11 to 18 degrees). Although some localized areas may have slightly steeper inclinations, these overall slope gradients are gentle and less than the angle of repose of even the finer-grained soil matrix in the undocumented fill and colluvium.

Surficial erosion and raveling do not represent a potential gross stability concern for planned plant structures because they are restricted in depth and lateral extent to surficial soils that are not planned for support of any plant structures (which instead bear upon stable bedrock below fill or soil) and are located a sufficient distance from plant structures to provide a large buffer zone to protect against potential future progressive development of erosion and raveling.

Part (2)

Our basis is observation in the field during the geologic reconnaissance and subsequent field exploration, performance of the slopes since site development over the period of operation of the present CPNPP Units 1 and 2, and our geologic engineering experience and professional judgment with similar site materials and local slope performance. Technical descriptions of the erosion and raveling process developed from these bases are described in the answer to Question 1.

Part (3)

As discussed above, the severity and extent of erosion and raveling do not present a safety concern for the planned plant facilities, and are considered to be a typical slope maintenance issue common with any hillside development or grading project. No special design provisions are required to address the erosion and raveling. Typical grading and slope design and maintenance measures, such as stable cut/fill slope inclinations (based on slope stability analyses), incorporation of standard drainage/debris benches, possible short-term stabilization or support of freshly cut/fill slopes until vegetation is established, and control of surface runoff, will be suitable. Typical long term maintenance approaches that are applicable and suitable include periodic maintenance review, cleaning of drainage ditches and debris accumulated at the base of slopes or benches, and refilling of significant erosion gullies with compacted fill materials as they develop.

Part (4)

As discussed in the answer to Question 1, erosion and raveling are not typically addressed by or incorporated in gross slope stability analyses. These surficial erosive processes are typically restricted at the site to the outermost several to about 5 feet of slope materials, whereas gross slope stability analyses are focused on rotational or translational failure modes and deeper failure planes that are of greater engineering/stability consequence and control safe design of facilities on or above the analyzed slopes. FSAR Subsections Subsection 2.5.5.2.4 through 2.5.5.2.7 describe the slope stability analyses performed for the most-critical cross sections where plant facilities encroach closest to the reservoir slopes. The material properties for the undocumented fill and colluvial soil are incorporated into slope stability modeling, and therefore appropriately model the influence of these materials with respect to deep-seated slope stability. Surficial erosion and raveling of the fill and colluvial soil do not affect the results of the deep-seated slope stability analyses.

Impact on R-COLA

None.

Impact on S-COLA

None.

Impact on DCD

None.

Attachment 4

Response to Request for Additional Information No. 3015 (CP RAI#21)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3015 (CP #21)

SRP SECTION: 02.05.01 – BASIC GEOLOGIC AND SEISMIC INFORMATION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 07/15/2009

QUESTION NO.: 02.05.01-4

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.1, 'Basic Geologic and Seismic Information,' establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

FSAR Section 2.5.1.1.2, and other sections, reference figures such as FSAR Figures 2.5.1-202 and 2.5.1-205, which show that the thick crust underlying the CPNPP site transitions to much thinner crust less than 100 km to the east, and to rocks of the southern Oklahoma aulacogen a similar distance to the northeast. Thus, the geologic setting and tectonic history of the eastern and northeastern parts of the site region are similar to other extended margins where large historic earthquakes have occurred, such as the 1886 Charleston and the 1811-1812 New Madrid earthquakes. Please provide a complete discussion (with additional figures, if needed) of the potential for large earthquakes on known or unknown structures within thick and thin transitional crust (i.e., extended margin) in the site region. Please explain how conclusions provided by Schulte and Mooney (2005) may influence your assessment of the CPNPP site.

References:

“An updated global earthquake catalogue for stable continental regions; reassessing the correlation with ancient rifts,” Geophysical Journal International, v. 161, p. 707-721, Schulte, S.M., and Mooney, W.D., 2005.

ANSWER:

This RAI question raises two issues, each of which is addressed below:

1. Please provide a complete discussion (with additional figures, if needed) of the potential for large earthquakes on known or unknown structures within thick and thin transitional crust (i.e., extended margin) in the site region; and
2. Please explain how conclusions provided by Schulte and Mooney (2005) may influence your assessment of the CPNPP site.

Issue 1

As outlined in Subsection 2.5.2, the Electric Power Research Institute Seismicity Owners Group (EPRI-SOG) source model (EPRI, 1986-1989) comprises the base characterization of strong earthquake potential within the site region. A comprehensive review of available information and data developed since the EPRI-SOG study was conducted as part of the CPNPP Units 3 and 4 COLA effort. One focus of this review was the identification of information or data that would alter the evaluations of the EPRI-SOG teams with respect to the strong earthquake potential of the site region, including the thick- and thin-transitional crust beneath the site region. New information developed since the EPRI-SOG study includes new gravity and magnetic data, refined kinematic models for the opening of the Gulf of Mexico, earthquakes that occurred since the EPRI-SOG study, and revised models of the state of stress within the site region. This information is discussed and presented in Subsections 2.5.1 and 2.5.2 and, as stated in those sections, none of this information requires or motivates a revision to the EPRI-SOG characterization of strong earthquake potential for the site region with the exception of modifications to the maximum magnitude (Mmax) distribution for some Gulf Coastal Source Zones, the development of a new Meers fault source characterization, the development of a Rio Grande Rift source characterization, and the development of a Cheraw fault characterization (see FSAR Subsection 2.5.2.4.2.3).

Particular to this RAI question, no new information developed since the EPRI-SOG study presents or hypothesizes the specific locations, orientations, and dimensions of potentially capable faults within the transitional crust or the Oklahoma aulacogen within the site region. Given the lack of specific information about discrete faults that may be potential seismic sources, the contribution to ground shaking hazard at the CPNPP site from the Gulf coastal region and the Oklahoma aulacogen is modeled by areal source zones, as defined and characterized in the EPRI-SOG study. Therefore, from the perspective of the strong ground motion characterization used for the CPNPP Units 3 and 4 site, the documentation of the EPRI-SOG source characterizations (EPRI, 1986-1989) is the most comprehensive evaluation for the site region. These characterizations are summarized in Subsection 2.5.2.2 and described in detail in the EPRI-SOG documentation (EPRI, 1986-1989). This position is further supported below.

As outlined in the introduction to FSAR Subsection 2.5.2, the potential for strong ground motion at the CPNPP 3 and 4 site, including areas underlain by thick- and thin-transitional crust, is characterized by the seismic source model used in the probabilistic seismic hazard analysis (PSHA) described in Subsection 2.5.2. The basis for this source model and PSHA is guidance provided by the NRC in Regulatory Guide (RG) 1.208. This guidance states that the PSHA should be:

> "…conducted with up-to-date interpretations of earthquake sources, earthquake recurrence, and strong ground motion estimation" (page 3).

RG 1.208 also states that

> "… seismic sources and data accepted by the NRC in past licensing decisions may be used as a starting point" for the PSHA.

According to RG 1.208, the EPRI-SOG study (EPRI, 1986-1989, 1989a, b) is an acceptable starting-point source zone characterization. Therefore, the EPRI-SOG model was adopted as the starting model for CPNPP Units 3 and 4.

The EPRI-SOG study provided a comprehensive assessment of seismic hazards for the central and eastern US (CEUS) that was developed using an expert elicitation process involving six independent earth science teams (ESTs) comprised of scientists recognized as experts in the fields of seismology, geology, and geophysics. Through the expert elicitation process, this study incorporated the range of uncertainty about the occurrence of future earthquakes and seismic sources within the CEUS. An explicit motivation for the EPRI-SOG study as stated within the preface to the source characterizations reports (EPRI, 1986) was to assess the possibility for an earthquake similar to that which occurred near Charleston throughout the CEUS. Therefore, the resulting seismic source model for the CEUS can be viewed as representing the state of knowledge of the informed expert community at the time of the study with respect to the seismogenic potential of the CEUS crust, including the crust throughout the CPNPP site region.

However, RG 1.208 also states that site-specific geological, geophysical, and seismological studies should be conducted to determine if the EPRI-SOG source model adequately describes the seismic hazard for the site of interest given new data developed since acceptance of the original model. The regulatory guidance explicitly states that:

> "The results of these investigations will also be used to assess whether new data and their interpretation are consistent with the information used in recent probabilistic seismic hazard studies accepted by NRC staff. If new data, such as new seismic sources and new ground motion attenuation relationships, are consistent with the existing earth science database, updating or modification of the information used in the site-specific hazard analysis is not required. It will be necessary to update seismic sources and ground motion attenuation relationships for sites where there is significant new information provided by the site investigation".

As outlined in Subsections 2.5.1 and 2.5.2, a comprehensive review was conducted to determine whether any new data or information exists that would require updating the EPRI-SOG source model for the CPNPP Units 3 and 4 site, and all of the updates made to the EPRI-SOG model are described in Subsection 2.5.2.4. With these modifications to the original EPRI-SOG source characterizations (EPRI, 1986-1989), the source model used for the CPNPP Units 3 and 4 PSHA fully represents the potential for strong earthquake ground motions from sources within the site region, including the transitional crust and Oklahoma aulacogen, is consistent with the characterization provided by the EPRI-SOG teams, and is consistent with the guidelines of RG 1.208.

As stated in the RAI question, the CPNPP Units 3 and 4 site region includes both thick- and thin-transitional crust developed during Mesozoic extension and rifting that resulted in the opening of the Gulf of Mexico. The potential exists for basement faults associated with this Mesozoic extension and rifting to extend into or occur within the site region. To date, however, no geological or geophysical information has been published that documents the locations, dimensions, or orientations of any such faults partly because basement structures cannot be adequately imaged through the thick accumulations of salt and sediments within the Texas coastal plain and Gulf of Mexico. The ESTs that participated in the EPRI-SOG study were aware of these basic crustal divisions (e.g., thick- and thin-transitional crust) and potential structures (e.g., block-bounding basement faults), and the source model used in the CPNPP Units 3 and 4 PSHA represents the EPRI-SOG evaluation of the earthquake potential for these poorly resolved structures. Since the EPRI-SOG study, no studies have effectively identified any of these potential basement structures or positively associated seismicity with any of the potential structures. Specifically, there is no new information about the locations, dimensions and orientations of basement faults with which to evaluate their potential for generating strong earthquakes and associated vibratory ground motion in the site region, beyond the information that was available to the ESTs during the EPRI-SOG study. Therefore, with the exception of the updates made to the EPRI-SOG source model described above, the EPRI-SOG source zones summarized in Subsection 2.5.2.2 and fully presented within the EPRI-SOG documentation (EPRI, 1986-1989), characterize the strong earthquake potential for thick- and thin-transitional crustal structures beneath the site region, given the current state of knowledge.

Issue 2

In preparing the CPNPP Units 3 and 4 FSAR, the Schulte and Mooney (2005) study was evaluated to determine whether it constituted new information that should motivate revisions to EPRI-SOG seismic source characterizations (EPRI, 1986) per the guidance provided in RG 1.208. This evaluation resulted in the determination that there was no new information or data within the Schulte and Mooney (2005) study that requires updating of the EPRI-SOG source characterizations. The basis for this conclusion is that the main conclusions of the Schulte and Mooney (2005) study relevant to the seismic source characterization of the CPNPP site region are essentially confirmations of the results of the Johnston et al. (1994) study that were taken into account in the development of the EPRI-SOG source characterizations. In particular, EPRI-SOG ESTs were aware of the primary conclusion of the Johnston et al. (1994) study that there was a correlation between Mesozoic and Cenozoic extended crust and large stable continental region (SCR) earthquakes and thus considered and accounted for that observation in their seismic source characterizations. The Schulte and Mooney (2005) study reassessed this correlation between earthquakes and extended and non-extended SCRs using an updated SCR earthquake catalog. Based on their analysis, Schulte and Mooney (2005) made numerous observations and conclusions that largely support the conclusions of Johnston et al. (1994). In particular, Schulte and Mooney (2005) conclude that:

1. Extended SCR crust only has slightly more earthquakes then non-extended SCR crust, and

2. The largest SCR earthquakes (Mw > 7.0) occur predominately within extended crust.

Schulte and Mooney (2005) state that these conclusions are essentially the same as those of the Johnston et al. (1994) study, and thus the relevance of the Schulte and Mooney (2005) study is that it supports the results of the Johnston et al. (1994) study that were accounted for in the EPRI-SOG source characterizations. Therefore, Schulte and Mooney (2005) do not present any new information with respect to the seismic potential of rifted SCRs that requires specific updates to the EPRI-SOG source characterizations used for the CPNPP site.

The basis for these conclusions is presented below in additional detail.

Johnston et al. (1994) Study

The Johnston et al. (1994) study was conducted from the mid-1980s to the early 1990s under the direction of EPRI with the goal of developing an earthquake database for SCRs worldwide and exploring the possibility of using this database to help constrain characterizations of the potential for large earthquakes within SCRs. To accomplish this goal, the Johnston et al. (1994) study:

(1) Defined SCRs worldwide, subdivided these regions into tectonic domains, and defined descriptor variables for these domains (e.g., crust type, tectonic age, stress regime) (see Chapter 2 of Johnston et al. (1994)).

(2) Compiled a global catalog of earthquakes within SCRs (see Chapter 3 of Johnston et al. (1994)).

(3) Tested for significant statistical correlations between the SCRs subdivided at different levels and the maximum observed earthquake magnitude with these subdivisions to determine if a robust estimator of Mmax values could be developed (see Chapter 5 of Johnston et al. (1994)).

Two of the fundamental assumptions of the Johnston et al. (1994) study are: (1) that for similar tectonic domains within SCRs worldwide (e.g., extended Mesozoic crust), space can be traded for time to allow development of a composite earthquake catalog for that particular style of tectonic domain that is larger than the catalog of earthquakes within just a single occurrence of that domain (e.g., extended Mesozoic crust in North America); and (2) these grouped, similar tectonic domains (e.g., all extended Mesozoic crust worldwide) have the same fundamental seismicity characteristics (i.e., maximum magnitudes (Mmax)).

EPRI's primary motivation for initiating the Johnston et al. (1994) study was twofold: (1) to provide the EPRI-SOG ESTs with guidance on estimating Mmax values for source zones within the central and eastern US (CEUS); and (2) to determine if there is a robust method of estimating Mmax based on historical seismicity. The Johnston et al. (1994) study was conducted in two phases to meet these goals. As part of the first phase, Johnston et al. (1994) developed an initial division of SCRs based on tectonic features and a global catalog of earthquakes within SCRs. These materials were then used to develop first-order conclusions to aid the ESTs in their development of source characterizations for the CEUS. The main conclusion presented to the ESTs was that there is an association between rifts and passive margins of Mesozoic and younger age, where age is defined as the time of the last penetrative deformation (page 2-4) (Johnston et al., 1994), and the largest observed earthquakes in SCR regions (see chapter 1, page 1-2 of Johnston et al. (1994)).

The second phase of the Johnston et al. (1994) study attempted to expand upon this conclusion and determine if there was a robust method for estimating Mmax based on historical earthquakes by following three steps: (1) defining tectonic domains; (2) developing a SCR seismicity catalog; and (3) testing for statistical correlation between the tectonic domains and seismicity. As part of this effort Johnston et al. (1994) refined their subdivision of tectonic domains and their defining characteristics (see Chapter 2 of Johnston et al. (1994)). The broadest subdivision used by Johnston et al. (1994) to classify SCRs was that between extended and non-extended crust. Extended crust includes regions of rifting, distributed continental extension, and passive margins; non-extended crust includes the remainder of SCR crust. In addition to this subdivision, Johnston et al. (1994) further defined 24 different categories of non-extended crust and 720 categories of extended crust based on what they refer to as descriptor variables characterizing the crust (e.g., stress regime, crustal type, crustal age) (see Chapter 2 and 5 of Johnston et al. (1994)).

These subdivisions, representing different sets of descriptor variables, were examined to determine if there was a statistically significant correlation between the subdivisions and the maximum observed earthquakes in the subdivisions. The conclusion reached by Johnston et al. (1994) from analyzing all of the different subdivisions and descriptor variables was that there is only a slight statistical difference between the mean maximum observed earthquake magnitude in extended crust and the mean maximum observed magnitude in non-extended crust. Additionally, no other descriptor variable was found to have a statistically significant correlation. Johnston et al. (1994) qualify the impact of these conclusions by stating, "we find that there is no strong evidence that any typical extended crust domain has a larger maximum magnitude than a typical non-extended crust domain," (page 5-17) (1994). Johnston et al. (1994) essentially concluded that a robust estimator of Mmax cannot be found using the assumption of space-time equivalence for seismicity and the tectonic descriptions of SCRs defined by Johnston et al. (1994).

Despite the lack of a robust estimator for Mmax, the main conclusion from the first phase of the Johnston et al. (1994) study persisted through the end of the second phase and was refined to say that the maximum observed earthquake in extended SCRs worldwide is greater than the maximum observed earthquake in non-extended SCRs (see Chapter 4 and 5 of Johnston et al. (1994)). As summarized above and outlined in Chapter 1 of Johnston et al. (1994), this main conclusion of the study was presented to the EPRI-SOG ESTs during their evaluations of seismic sources. The information contained within this conclusion was evaluated by the EPRI-SOG ESTs, and thus the information is not new information that requires updating of the EPRI-SOG source characterizations.

Schulte and Mooney (2005) Study

Largely due to the results of the Johnston et al. (1994) study, many in the seismic hazards community have held the opinion that there is a difference in seismicity between extended and non-extended SCRs. The stated purpose of the Schulte and Mooney (2005) study was to reevaluate this hypothesis using an updated earthquake catalog. Unlike the Johnston et al. (1994) study, the goal of the Schulte and Mooney (2005) study was not to investigate SCR Mmax values.

Besides the difference in study motivation, there are three main methodological differences between the Johnston et al. (1994) and Schulte and Mooney (2005) studies:

1. Schulte and Mooney (2005) used an updated seismicity catalog with approximately 58% more earthquakes than in the Johnston et al. (1994) catalog;
2. Schulte and Mooney (2005) divided SCRs into five different classifications of tectonic domains (interior rifts, rifted margins, non-rifted crust, possible interior rifts, and possible rifted margins) as opposed to the hundreds used by Johnston et al. (1994); and
3. Instead of performing statistically robust regressions between domain classifications and earthquakes within the domains, Schulte and Mooney (2005) simply calculated the proportions of SCR earthquakes and seismic moment occurring within the domains for various subsets of the catalog based on earthquake magnitudes, completeness, and measurement type (i.e., historical vs. instrumental) (see Figure 3 of Schulte and Mooney (2005)).

Based on their analysis of the updated seismicity catalog, Schulte and Mooney (2005) present nine specific conclusions (see page 719 of Schulte and Mooney (2005)). Each of these conclusions is discussed below with respect to its relevance for potentially updating the EPRI-SOG source characterizations used for CPNPP Units 3 and 4.

Conclusions 1-3:

- 27% of earthquakes occur within interior rifts, 25% within rifted margins, 36% occur within non-rifted crust, and 12% have an uncertain setting;
- These percentages imply that within interior regions there are slightly more earthquakes within non-rifted crust (36%) than within rifts (25%); and
- These results are relatively stable if only instrumental earthquakes are considered.

Schulte and Mooney (2005) state that these results are similar to the results of Johnston et al. (1994), and thus Schulte and Mooney (2005) provide support to the conclusion that their study presents no new information or data that motivates revisions to the EPRI-SOG source characterizations used for CPNPP Units 3 and 4.

Conclusion 4:

- The above results are relatively stable if only Mw > 6.0 earthquakes are considered, but Mw > 7.0 earthquakes overwhelmingly occur within rifted crust.

This conclusion is essentially the same as that of the Johnston et al. (1994) that noted the maximum observed earthquakes in extended SCRs worldwide is greater than the maximum observed earthquakes in non-extended SCRs. Therefore, this conclusion is not considered new information that requires updating the EPRI-SOG source characterizations.

Conclusions 5-6:

- Seismicity is spatially inhomogeneous between different interior rifts; and
- Mw > 6.0 earthquakes occur within non-rifted crust.

Both of these conclusions are trivial observations that are also apparent within the earthquake catalog of Johnston et al. (1994). They do not motivate any revisions to the EPRI-SOG source characterizations.

Conclusion 7:

- The most seismically active rifts are the Kutch, East China, St. Lawrence, and Reelfoot rifts, and these rifts, with the exception of the Reelfoot, may have additional factors influencing their seismicity.

These regions were also identified as very seismically active within the Johnston et al. (1994) study, and thus this basic observation is not considered new information. The opinion that seismicity within the Kutch and East China rifts may be due to plate boundary process and that seismicity within the St. Lawrence rift may be influenced by the existence of a terrane suture and meteorite impact implies that these regions may be better classified as not SCRs. If these regions are not SCRs, earthquakes within them should not be considered in the analysis of Schulte and Mooney (2005) and Johnston et al. (1994), and the reported relationship between large earthquakes and rifted crust is likely even less robust than presented by Schulte and Mooney (2005) and Johnston et al. (1994). Such a paradigm shift would suggest that there is little significance to the presence of rifted crust surrounding the CPNPP Units 3 and 4 site and thus does not motivate modifying the EPRI-SOG source characterization.

Conclusion 8:

- The majority of historically active regions have instrumental records of seismicity that show hardly any greater seismic activity then surrounding regions when only the instrumental record is considered (i.e., many regions with large historical earthquakes have few if any large instrumentally recorded earthquakes).

This conclusion is based on observations of the historical and instrumental seismicity catalog that were also apparent at the time of the EPRI-SOG (EPRI, 1986) and Johnston et al. (1994) studies. As such, this conclusion does not motivate any revisions to the EPRI-SOG source characterizations.

Conclusion 9:

- There are few large earthquakes observed within Europe, a region with extensive rifted crust.

While not explicitly stated within the Johnston et al. (1994) study, this observation was apparent in the seismicity catalog used by Johnston et al. (1994) and was therefore accounted for in their domain-earthquake regressions. The impact of the extended SCRs with low levels of seismicity and very few large earthquakes is summarized by Johnston et al. (1994) where they state that "…there is no strong evidence that any typical extended crust domain has a larger maximum magnitude than a typical non-extended crust domain," (page 5-17) (Johnston et al., 1994).

Without referencing any particular studies, Schulte and Mooney (2005) summarize their study by suggesting that "the correlation of seismicity within SCRs and ancient rifts has been overestimated in the past." Again, this conclusion supports the Johnston et al. (1994) observation of only minor differences between the seismicity observed in extended and non-extended SCRs.

Summary

The main conclusions of the Johnston et al. (1994) study with respect to source characterizations are that: (1) there is little statistical difference in the observed seismicity of extended and non-extended SCRs, but (2) the largest magnitude earthquakes tend to occur in extended SCRs. These conclusions were known and evaluated by the EPRI-SOG ESTs during the development of their source characterizations and are thus accounted for in the EPRI-SOG model used for CPNPP Units 3 and 4 (EPRI, 1986). The relevance of the Schulte and Mooney (2005) study to the CPNPP site is that their conclusions largely support the conclusions of Johnston et al. (1994). As reviewed above, several Schulte and Mooney (2005) conclusions directly support the conclusions of Johnston et al. (1994), and none of the Schulte and Mooney (2005) conclusions contradict those of Johnston et al. (1994) or provide new information that motivates revisions of the EPRI-SOG source characterizations used for CPNPP.

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Impact on R-COLA

None.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3015 (CP #21)

SRP SECTION: 02.05.01 – BASIC GEOLOGIC AND SEISMIC INFORMATION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 07/15/2009

QUESTION NO.: 02.05.01-6

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.1, 'Basic Geologic and Seismic Information,' establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

FSAR Subsection 2.5.1.1.4.1.2 describes the regional tectonic history up to the Late Oligocene and Early Miocene periods. Please describe the regional tectonic history from the Early Miocene period to the present.

ANSWER:

As discussed in FSAR Subsection 2.5.1.1.4.1.2, Miocene regional uplift of the western United States led to limited uplift and unroofing in central Texas, along with flexure and minor faulting within the site region. Since those Miocene processes, the CPNPP site region has been tectonically quiescent. The main Gulf of Mexico depocenters had migrated outside of the CPNPP site region by the Miocene, along with any associated growth faulting (Ewing, 1991). Since the end of the Miocene, the CPNPP site region has dominately been undergoing local erosion and deposition along drainages, as sediments shed from the north have been transported by rivers through the site region and deposited south of it in the Gulf of Mexico (Galloway et al., 1991).

References:

Ewing, T.E., 1991a, Structural framework, in Salvador, A., ed., The Geology of North America: the Gulf of Mexico Basin, Volume J: Boulder, CO, Geological Society of America, p. 31-52.

Galloway, W. E., Bebout, D. G., Fisher, W. L., Dunlap, J. B., Jr., Cabrera-Castro, R., Lugo-Rivera, J. E., and Scott, T. M., 1991, Cenozoic, in Salvador, A., ed., The Gulf of Mexico Basin: Boulder, Colorado, Geological Society of America, The Geology of North America, v. J.

<u>Impact on R-COLA</u>

FSAR Revision 0 page 2.5-14 was revised to reflect this response.

See attached changes for page 2.5-16. Because of the text additions and deletions, the page numbers on the mark-up FSAR pages may not be the same as the page numbers in FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3015 (CP #21)

SRP SECTION: 02.05.01 – BASIC GEOLOGIC AND SEISMIC INFORMATION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 07/15/2009

QUESTION NO.: 02.05.01-8

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.1, 'Basic Geologic and Seismic Information,' establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

FSAR Sub-section 2.5.1.1.4.3.4.2 describes the normal faults of the Mount Enterprise-Elkhart Graben (MEEG) system. Both pre-1986 and post-1986 publications suggest, as the FSAR points out, that there is evidence for Quaternary deformation associated with the MEEG. Please provide additional evidence, explanation and discussion to support your conclusion that “there is no new information bearing on the Quaternary activity of the MEEG fault system requiring a revision of the [Electric Power Research Institute] EPRI seismic source characterization of this region.” Specifically,

(1) Please provide a detailed figure that shows the locations of the geographic and structural features mentioned in FSAR Section 2.5.1.1.4.3.4.2, including the locations of the published evidence for displacement on the MEEG.

(2) Please provide a more detailed summary of the data (including deposits, landform morphology, and age estimation) for late Quaternary faulting on the MEEG. Please also explain the evidence that supports the “estimated age of 37 thousand years for the late Quaternary gravels” stated in the FSAR.

(3) The FSAR states “Presumably, this was the evaluation of the EPRI Earth Science Teams (ESTs),” regarding the MEEG fault system. Please provide the evidence and any relevant sources that support the assumption that the MEEG is not a source of tectonic deformation.

(4) The FSAR states that Ewing (FSAR reference 2.5-228) suggested that seismicity associated with the MEEG may indicate “continuing deformation.” Please explain the origin of the seismicity and why this seismicity is or is not an indicator of displacement on the MEEG faults.

(5) The FSAR points out that Crone and Wheeler (FSAR Reference 2.5-271), a compilation of data, did not identify or discuss the MEEG as a potential tectonic fault. Please address whether Crone and Wheeler evaluated all potential tectonic features in the CEUS (central and eastern United States). If not, please explain specifically how this information supports the FSAR conclusion that the MEEG is not a capable tectonic structure.

(6) FSAR Section 2.5.1.1.4.3.4.2 states that [William Lettis & Associates] WLA “conducted a field reconnaissance study” of the MEEG. Please describe this study in greater detail, including the locations investigated, the types of outcrops, surfaces and sediments examined, and the descriptions of evidence, or lack of evidence, found at each location. Please justify the applicant’s conclusion, based on these investigations that no evidence was found “to support post-Eocene tectonic activity on the MEEG.”

(7) Several references listed in FSAR Section 2.5.1.1.4.3.4.2 indicate recent movement on the faults of the MEEG. Please justify your conclusion, based on these publications, that this is not a capable tectonic feature.

(8) Provide a more detailed discussion of whether or not salt movement at depth could produce modern slip of 4 mm/yr on overlying normal faults, and whether stratigraphic relations of the displaced gravel favor sudden surface displacement of tens of centimeters or gradual creep. Please cite examples of other places in the Gulf Coast region, or other similar regions, where salt movement has caused similar rates of surface deformation.

ANSWER:

<u>Issue 1</u>

The faults and pertinent locations of the MEEG system are shown on Figure 1 (attached). These faults and locations are discussed further in the remainder of this response.

<u>Issue 2</u>

Collins et al. (1980) have proposed Quaternary slip on faults within the MEEG. In particular, Collins et al (1980) cite three observations (folded Quaternary gravel in outcrop, presumed folded Quaternary gravel in an auger profile, and leveling data) as the basis for their conclusion of Quaternary activity. Each of these observations is outlined below.

Collins et al. (1980) noted the existence of a folded Quaternary gravel unit above faulted Eocene strata in a cut-bank deposit along the Trinity River. This cut-bank is at the southern end of a horseshoe bend in the river (Figure 1, “Folded Quaternary Deposits”). Collins et al. (1980) provide an interpreted outcrop map that shows sand and shale units of the Eocene Claiborne group unconformably overlain by a thin (10-40 cm thick) Quaternary sand and gravel deposit, which in turn is overlain by a several-foot-thick sand unit. Collins et al. (1980) identify three discrete normal faults (two consistent with down-to-the-south slip, and one with down-to-the-north slip) within the Eocene strata, and Collins et al. (1980) measured a maximum offset of 118 cm along these faults. These distinct faults continue upsection but cannot be traced into the overlying Quaternary gravel. Instead, Collins et al. (1980) notes that above the faults there is relatively broad (wavelengths on the order of several feet) folding of the thin Quaternary sand and gravel and that the faults in the Eocene units become “closely spaced, multiple shear surfaces” within this deposit. Collins et al. (1980) describe these folds as having cumulative offsets of 22 cm, 53 cm and 66 cm. Collins et al. (1980) estimate the age of the sand and gravel deposit by correlating the deposit to the middle terrace level of the Trinity River. Collins et al. (1980) notes that this middle terrace level has been determined to be 37,000 years old further north in the Trinity basin, and, as such, attributes this same age to the folded deposits. Collins et al. (1980) do not describe any faulting or folding within the overlying sand unit.

Collins et al. (1980) also excavated a backhoe trench and measured an auger profile approximately 115 m to the east of the cut-bank exposure. No details are given as to the results of the trench excavation, but Collins et al. (1980) report that 6 auger holes intersect the Quaternary sand and gravel identified in the outcrop. Collins et al. (1980) cite a 46 to 60 cm apparent offset in the top of the gravel between two auger holes 9 feet apart as evidence that the Quaternary faulting in the outcrop extends further east.

The final observation that Collins et al. (1980) use to support the conclusion of Quaternary faulting in the MEEG is an anomalous elevation change observed across the MEEG in a National Geodetic Survey leveling line originally surveyed in 1920 and then remeasured between 1947 and 1952. This leveling survey is approximately 40 miles to the northeast of the Trinity River outcrop described above and extends south from Tyler passing through Jacksonville and terminating approximately 20 km south of the MEEG (Figure 1). The releveling survey shows a down-to-the-south change in land surface elevation of 13.0 cm between two stations located approximately 5 miles apart. No information is given as to the accuracy of, or uncertainty in, the leveling survey, and the actual survey data were not published. Collins et al. (1980) further report that no geologic or geomorphic field evidence of this change in elevation was observed along the leveling line.

Issue 3

The statement quoted in question presumes that the EPRI-SOG teams concluded that the MEEG is not accommodating tectonic deformation and is not an independent source of earthquakes because none of the teams identified the MEEG as a unique seismic source. Instead of having slip that reflects tectonic strain accumulation in the crust, the MEEG system is a series of growth faults, similar to those observed within the Gulf of Mexico region. In particular, the MEEG is comprised of shallow crustal, listric normal faults that root into the Jurassic Louann salt and do not penetrate into the underlying crystalline basement (Jackson, 1982; Lee, 2005). Faults of this style, and in particular the MEEG, are generally characterized as, and observed to be, aseismic (Jackson, 1982; Frohlich 1982; EPRI, 1986; Frankel et al., 1996; Wheeler, 1999; Frankel et al., 2002, Peterson et al., 2008; NRC, 1997; Crone and Wheeler, 2000; Wheeler and Crone, 2001; Wheeler, 2005; Dokka et al., 2006). The basis for this evaluation is the observation that: (1) there have been no earthquakes positively associated with growth faults (Davis et al., 1985; Davis et al., 1989; Frohlich and Davis, 2002), and (2) the shallow faults do not penetrate competent basement rocks but occur in poorly consolidated, relatively weak, sedimentary basin deposits that have little capacity to accumulate elastic strain energy or stress. Instead of seismogenic rupture, these faults are observed to slip aseismically in response to non-tectonic processes that occur within the sedimentary section at shallow to moderate depths (e.g., salt movement, fluid withdrawal, large-scale slumping of the Gulf of Mexico sediments) (Kreilter, 1978; Jackson et al., 1994; Angell et al., 2003; Morton et al, 2006). This same style of aseismic slip appears to be occurring at the MEEG as evident in the 13 cm of elevation change that accumulated aseismically across the MEEG between 1920 and 1952 (Collins et al., 1980; Davis et al., 1985; Davis et al., 1989; Frohlich and Davis, 2002).

Issue 4

The FSAR statement that is the topic of this question cites Reference 2.5-228, which refers to Ewing (1991b). However, Reference 2.5-228 should refer to Ewing (1991a), not Ewing (1991b). The FSAR was revised so that Reference 2.5-228 refers to Ewing (1991a).

Ewing (1991a) provides a very brief, three sentence description of the Mount Enterprise – Elkhart Graben (MEEG) system that states, in part, “Major movement occurred in the Late Jurassic and Early Cretaceous, but surface strata are displaced and seismicity suggests continuing deformation” (page 35-37). Ewing (1991a) does not provide any further information supporting these statements, and does not provide any citations supporting the statements. However, the only published information documenting reportedly “displaced” surface strata is the study of Collins et al. (1980) discussed elsewhere in this response.

The study of Collins et al. (1980) also notes that there is a “concentration of seismicity” in the area of the MEEG system. We presume that Ewing (1991a) based his seismicity comment on the Collins et al.

(1980) study. The earthquakes described as surrounding the MEEG system are briefly discussed in FSAR Subsection 2.5.1.1.4.3.4.2. These earthquakes include:

- The January 8, 1891 Emb 3.7 (see Subsection 2.5.2.1) Rusk earthquake, which some believe was not a real earthquake, but a tornado or strong thunderstorm (Frohlich and Davis, 2002). The location and magnitude of the earthquake are based on felt reports, and there are no known studies that investigated potential geologic causes for the earthquake. The earthquake is located approximately 12 miles south of the MEEG (Figure 1).

- The March 19, 1957 Emb 4.2 (see Subsection 2.5.2.1) Gladewater earthquake, and its three aftershocks of Emb 1.9. While the mainshock was instrumentally recorded and located, the aftershock locations are based on felt reports. There are no known studies that investigated potential geologic causes for these earthquakes. The mainshock is located approximately 40 miles north of the MEEG (Figure 1).

- The June 9, 1981 Emb 3.2 (see Subsection 2.5.2.1) Center earthquake. There are no known studies that investigated potential geologic causes for the earthquake. The earthquake is located at the eastern end of the MEEG (Figure 1).

- The November 6, 1981 Emb 3.2 (see Subsection 2.5.2.1) Jacksonville earthquake. There are no known studies that investigated potential geologic causes for the earthquake. The earthquake is located immediately north of the MEEG system (Figure 1).

As illustrated in Figure 1 and discussed above, the spatial association of seismicity with the MEEG is weak with only two earthquakes occurring proximal to the MEEG; the other earthquakes described by Collins et al. (1980) as being concentrated near the MEEG are actually at considerable distances from the MEEG. Because of the lack of studies exploring the cause of the earthquakes and the weak spatial association with the MEEG, it was concluded that the earthquakes do not provide any information constraining potential activity in the MEEG system.

Issue 5

Information contained in FSAR 2.5.1 was developed in accordance with RG 1.208. As such, the information summarized in the FSAR is the result of a thorough literature search, interviews with experts, and review of relevant maps and data (including geologic, geomorphologic, geophysical, seismological sources, etc). Data sources include the United States Geological Survey (USGS), state and local organizations, literature published in international journals by academic and industry workers, and a variety of regional and local publications and field trip guidebooks. The compilation studies of Crone and Wheeler (2000; Wheeler, 2005) aimed to be comprehensive and evaluate all geologic evidence of Quaternary tectonic faulting or deformation. However, this study is just one piece of a broad investigation that led to the conclusion that the MEEG is not a capable tectonic fault.

Issue 6

The field reconnaissance study WLA conducted regarding the MEEG consisted of two parts. The first, was an aerial reconnaissance along the fault system looking for locations of geomorphic or geologic disruption requiring further investigation. This reconnaissance was conducted from an overhead wing Cessna 182 on October 12, 2007. The flight was conducted in the early morning when low-angle sunlight conditions would allow for the easiest identification of potentially anomalous geomorphic features (e.g., scarps, linear surface features). The aerial reconnaissance focused on the western end of the MEEG system because this region is closest to the CPNPP site and is the region where Collins et al. (1980) noted potential Quaternary deformation (Figure 1). This aerial reconnaissance did not identify any anomalous features that could be related to Quaternary faulting along faults of the MEEG system.

The second phase of the MEEG study was a field reconnaissance to the locations of the faulted outcrop and auger profile from Collins et al. (1980) (Location 1 on photograph A of Figure 2). WLA geologists obtained access to land on either side of the Trinity river where Collins et al. (1980) observed folding of Quaternary units (photograph A of Figure 2). As shown in the view to the east in photograph B of Figure 2, on the east river bank several east-striking, listric, normal faults were observed in Eocene units as described earlier (Collins et al. 1980) (photograph B of Figure 2). However, WLA field investigations revealed that east of this outcrop, a near-vertical west-facing landslide scarp of variable height (1-6 ft) is exposed. This landslide scarp can be seen in the right side of photograph C of Figure 2 as a short, shadowed scarp. The landslide scarp can be traced extending from the river, into the vegetation east of the Eocene fault outcrop, and back down to the river bank north of the outcrop. Hence, the Eocene fault outcrop and overlying potentially folded Quaternary units are located within a larger slump block (photographs C and D of Figure 2). On the west side of the river, no faults were identified (Location 2 in photograph A of Figure 2 and outcrop photograph E of Figure 2). The land surface is flat and undisrupted except for slumping immediately adjacent to the river bank. As a result of these investigations, WLA concluded that the proposed faults folding the Quaternary gravels were restricted to erosional landslide blocks, and thus, the faults likely did not reflect Quaternary tectonic deformation.

Issue 7

In FSAR Subsection 2.5.1.1.4.3.4.2, Collins et al. (1980) is the only reference that presents data to support the hypothesis that the MEEG fault is active. As described in response to issue 4, the reference of Ewing (1991a) only briefly restates this hypothesis presumably based on the work of Collins et al. (1980). The study of Collins et al. (1980) is discussed in detail in response to the preceding issues.

The conclusion that the MEEG is not a capable fault that needs to be considered for the CPNPP site is primarily based on four observations:

- There has not been any new information developed since the EPRI-SOG study suggesting that the MEEG fault is a capable tectonic feature;
- The observations of Collins et al. (1980) that suggest Quaternary faulting (e.g., folding gravels in cut-bank deposits above small faults offsetting Eocene deposits) occur within a large slump block along the banks of the Trinity river, and the observed folding is likely due to the slump;
- The MEEG is a system of growth faults rooted into shallow salt deposits and/or salt welds (Ewing, 1991a; Jackson, 1982; Lee, 2005), and growth faults are considered aseismic structures (Crone and Wheeler, 2000; Dokka et al., 2006; EPRI, 1986; Frankel et al., 1996; Frankel et al., 2002; Frohlich, 1982; Jackson, 1982; NRC, 2007; Petersen et al., 2008; Wheeler, 1999, 2005; Wheeler and Crone, 2001); and
- Deformation across the MEEG systems appears to accumulate aseismically as evident in the 13 cm of elevation change that accumulated between 1920 and 1952 without any correlated seismicity (Collins et al., 1980; Davis et al., 1985; Davis et al., 1989; Frohlich and Davis, 2002).

Issue 8

Quaternary separation rates across the MEEG can be estimated from the folding observed in the Quaternary sand and gravel in the cut-bank exposure, the inferred folding observed in the auger profile, and the change in elevation observed in the leveling line. The highest separation rate comes from the releveling profile, which indicates a separation rate of ~4 mm/yr. As mentioned above, Collins et al.

(1980) does not discuss the uncertainty or accuracy of the leveling surveys. Therefore, it is difficult to judge the robustness of the 4 mm/yr separation rate estimate. However, both fault slip and surface displacement rates of 4 mm/yr are not uncommon in geologic settings where deformation is related to salt movement. For example, Angell et al. (2003) studied extensional faults which form part of the Sigsbee Escarpment and disrupt the seafloor in the Gulf of Mexico. These faults formed above an allochthonous mass of the Louann salt and have slip rates between 2 and 10 mm/yr (Angell et al., 2003). In Louisiana, faulting rooted in low-strength salt has caused surface subsidence of 5 mm/yr (Dokka et al., 2006). Also in Louisiana, surface subsidence rates of 5-9 mm/yr have been attributed to the reactivation of faults by salt movement at depth (Morton et al., 2002).

References:

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Impact on R-COLA

FSAR Revision 0 page 2.5-210 was revised to reflect this response.

See attached changes for page 2.5-225. Because of the text additions and deletions, the page numbers on the mark-up FSAR pages may not be the same as the page numbers in FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

Attachments

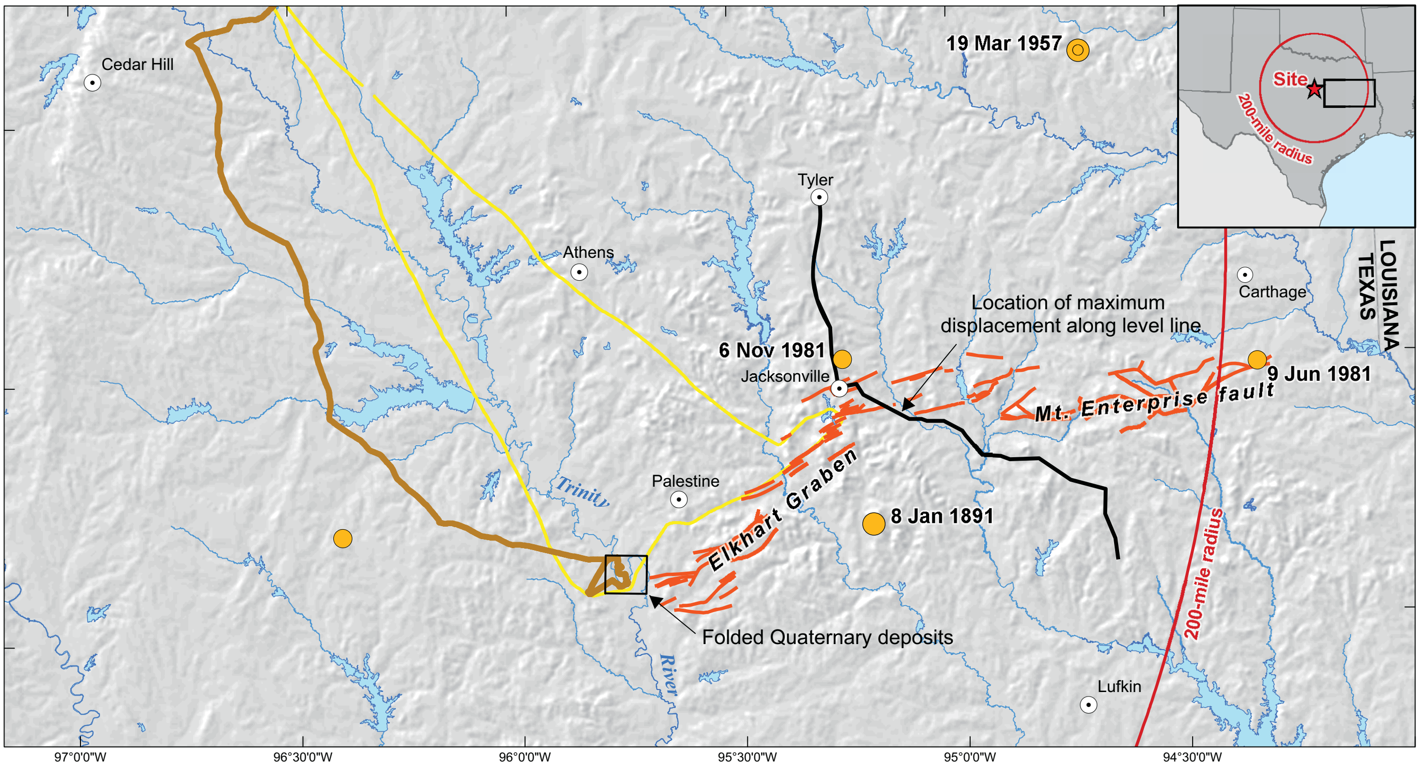
Figure 1 - Mt. Enterprise – Elkhart Graben Figure RAI 2.5.1-8

Figure 2 - MEEG Field Observations Figure RAI 2.5.1-8

Mt. Enterprise – Elkhart Graben
FIGURE RAI 2.5.1-8, FIGURE 1

Rev 0

COMANCHE PEAK NUCLEAR POWER PLANT
UNITS 3 AND 4



Explanation

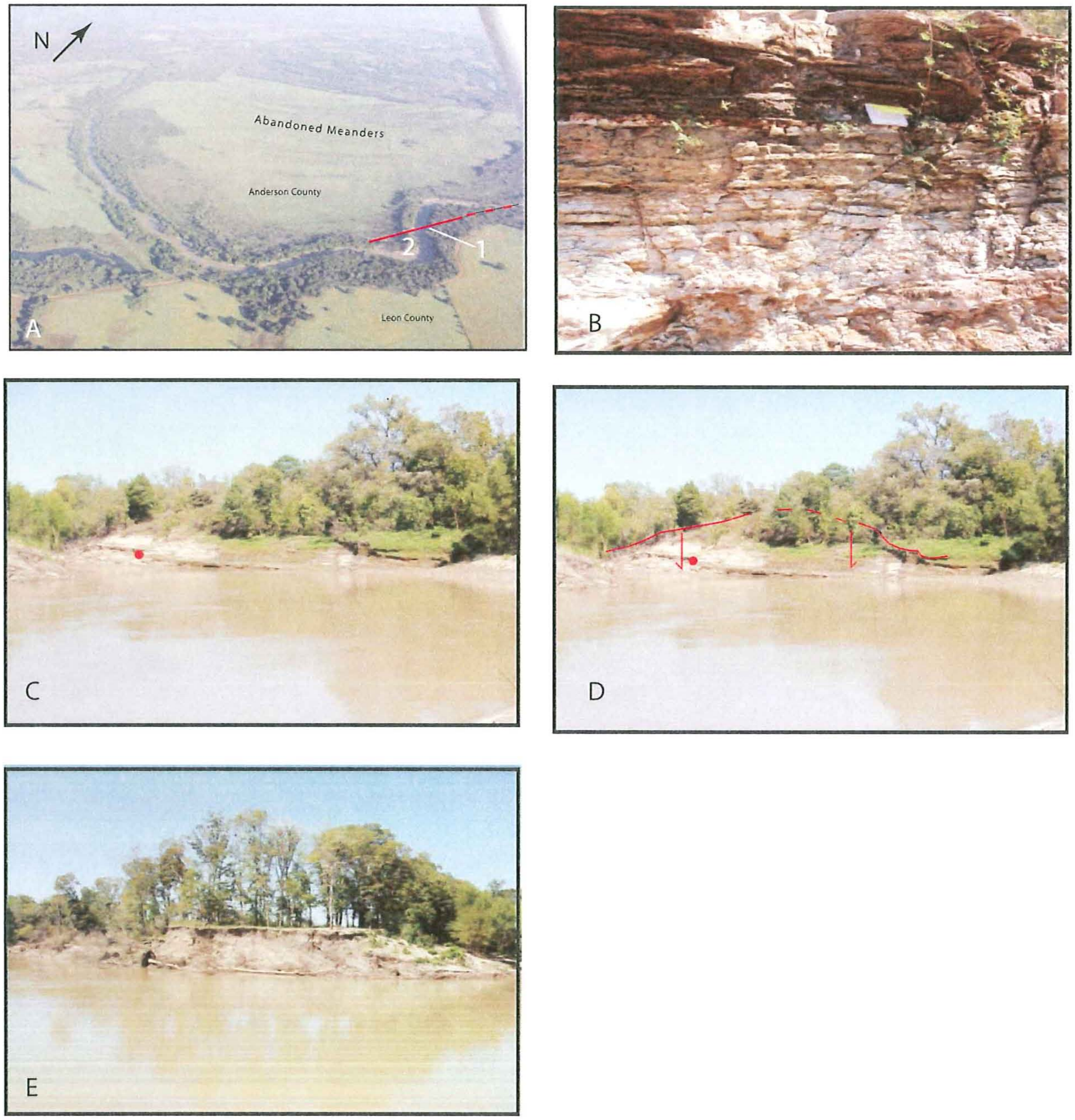
- Survey level line (from Collins et al., 1980)
- Faults
- WLA ground reconnaissance
- WLA aerial reconnaissance

Earthquake Epicenters (by estimated body wave magnitude Emb)
EPRI 1986 Seismicity Catalog (1627-1985)

- 1.68 - 2.50
- 2.51 - 3.00
- 3.01 - 3.50
- 3.51 - 4.20

N

0 10 mi
0 20 km



Photographs of WLA field observations along the MEEG. A. Aerial view to northwest of horseshoe bend in the Trinity river where Collins et al (1980) identified folding in Quatneray units and Eocene faulting. the numeral 1 marks the location of the "folded Quaternary units" outcrop and location of Figure 2b. B. View to east of east-west striking normal faults in Eocene units along river. Field notebook for scale. C. View to east of location 1, taken from west bank of Trinity river (location 2 in Figure 2a). Red dot marks the location of outcrop in Figure 2b. D. Same view as in C, but interpreted to show location of headscarp marking the eastern extent of the landslide block found by WLA. E. View to west of west bank of Trinity river (location 2 in Figure 2a). Note flat, undisrupted topography to west and slumping along river banks.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3015 (CP #21)

SRP SECTION: 02.05.01 – BASIC GEOLOGIC AND SEISMIC INFORMATION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 07/15/2009

QUESTION NO.: 02.05.01-9

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.1, 'Basic Geologic and Seismic Information,' establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

FSAR Section 2.5.1.1.4.3.5, discusses the Tertiary-age Balcones fault zone, and states that there is some evidence (FSAR References 2.5-266 and 2.5-274) for post-Eocene movement on the Balcones faults. Please provide a detailed description of the Balcones fault zone and address the capability of this fault zone, including any seismicity, or lack of seismicity, that may be associated with this fault zone, and the potential for these geologic structures to be reactivated in the current stress regime.

ANSWER:

Two publications describe and have indicate the possibility of post-Eocene movement on the Balcones fault zone, a down-to-the-gulf normal fault system. The Weeks (1945) paper hypothesized that faulting occurred on the Balcones in Oligocene or Miocene time based on the presence of Cretaceous age limestone cobbles and shell fragments within Oligocene and Miocene age units. Weeks (1945) interpreted the presence of these cobbles and shells as evidence of uplift and erosion of Cretaceous units along the Balcones faults. More recent research has shown that this Miocene uplift reflects regional Western United States tectonics during that time period, and has no implication for Quaternary activity on the Balcones (Ewing, 1991a; 1991b).

Collins et al. (1990) also interpreted post-Eocene activity on the Balcones. This study notes “wedge shaped” fractures at one location along the Balcones fault zone that are filled with reddish clay, silt, and sand that Collins et al. (1990) suggest “may be terra rossa” deposits, an old soil interpreted to be between 0.73 and 2.0 million years old. Collins et al. (1990) speculate that these wedge-shaped fractures “likely opened during rupture or slip of the fault, and it is possible that the sediments filled the fractures during or soon after fault movement.” Based on the assumption that the fracture-filling sediments are Quaternary terra rossa deposits, Collins et al. (1990) concludes that “this fault may have moved during the early Pleistocene" and that "it may be premature to conclude that this fault zone is extinct." However, Collins et al. (1990) also note that "poorly dated Pleistocene (?) high terrace deposits are apparently not offset by the fault" providing positive and direct evidence that the Balcones fault zone has not had Pleistocene activity.

For the CPNPP Units 3 and 4 COLA, the above information was evaluated to determine whether it was evidence that the Balcones is a capable fault. It was concluded that the fracture filling deposits cited as potential evidence for Quaternary activity by Collins et al. (1990) is contradictory and does not provide positive evidence that the fault zone is a capable tectonic feature. The observation of unfaulted Pleistocene deposits overlying the fault is positive evidence for non-activity. The presence of colluvial deposits within fractures can be explained by non-tectonic processes, and thus is ambiguous evidence for tectonic activity. Also, the Collins et al. (1990) study, when considered in the context of other more recent peer-reviewed studies (e.g., Crone and Wheeler, 2000; Frankel et al., 1996; Frankel et al., 2002; Savy et al., 1998; Wheeler, 2005, 2006, 2008; Wheeler and Crone, 2001), does not reflect a change in the state of knowledge of the seismic potential of the Balcones fault zone that is robust enough to justify modifying the seismic source characterizations of the EPRI-SOG model. This conclusion is based on the following observations:

- The field trip guidebook within which Collins et al. (1990) make their observations has not been peer reviewed, and thus there is no implicit acceptance of its scientific validity by the broader technically informed community.
- There is uncertainty in whether or not the reddish deposits in the fractures, which are the basis for the conclusion that the fault may have had Quaternary activity, are terra rossa.
- If the deposits are terra rossa, there is considerable uncertainty in the age of the terra rossa, and at its oldest the terra rossa may be Late Pliocene (i.e., pre-Quaternary implying the fault zone is not capable).
- It is unknown whether the fractures opened during a seismogenic event, and if so when this event occurred (i.e., the reddish brown deposits may not have filled the fractures till well after the fractures formed). Thus the fractures provide only indirect and ambiguous evidence of fault activity.
- Deposits mapped as Pleistocene (Garner and Young, 1976) deposits are not offset by the fault, which is direct and unambiguous evidence for nonactivity.
- Expert compilations of the known evidence for potentially and positively Quaternary active features do not include the Balcones fault zone (e.g., Crone and Wheeler, 2000; Wheeler, 2005, 2006, 2008; Wheeler and Crone, 2001).

Eddie Collins, lead author of the Collins et al. (1990) report, was interviewed regarding his opinion of the evidence for activity of the Balcones fault zone. In his response he replied that, "I don't know of any field evidence that would verify Pleistocene or Holocene slip on any of the fault strands that compose the Balcones Fault Zone" (Collins, 2008). Collin's current opinion of the Balcones fault zone agrees with the interpretation of the Collins et al. (1990) work summarized here that there is no evidence to support the interpretation of the Balcones fault zone as a capable feature.

There is also no correlation between seismicity and the Balcones fault zone that would suggest the fault is a potentially capable structure. Seismicity surrounding the fault is extremely sparse. Davis et al. (1989) identified two earthquakes (the October 9, 1902 Creedmoor and the May 1, 1873 Manor earthquakes) near Austin that they hypothesize occurred along faults within the system. However, Davis et al.'s (1989) attribution of the earthquakes to the Balcones was based solely on the proximity of the earthquakes to the Balcones. Both earthquakes were relatively small with maximum felt modified

Mercalli intensities of III to V, and both locations have significant uncertainties due to their locations having been derived from sparse felt reports (Davis et al., 1989; Frohlich and Davis, 2002). Also, there is no evidence that either of these earthquakes were responsible for geologic failure or rupture of any faults of the Balcones fault zone (see FSAR Subsection 2.5.2.1).

Most data indicate that the state of stress within the CPNPP site region is characterized by north-northeast to east-northeast oriented maximum compressive horizontal stresses (Zoback and Zoback, 1989; Heidbach et al. 2008). Given the orientation of the maximum compressive horizontal stress and the orientation of the Balcones fault, the expected motion on the fault if it were to slip in response to the modern state of stress would be strike-slip to oblique thrusting. This relationship is consistent with the analysis of Humphreys and Coblentz (2007) that suggests the region surrounding the Balcones is a strike-slip domain. Given that the sense of slip of Quaternary slip proposed by Collins et al. (1990) is normal, there is no expectation that the Balcones fault would be reactivated in the current stress regime.

References:

Collins, E.W., Laubach, S.E., Vendeville, B.C., and Muehlberger, W.R., 1990, Faults and fractures of the Balcones fault zone, Austin region, central Texas: Guidebook 13: Austin, TX, Austin Geological Society, 34 p.

Crone, A.J., and Wheeler, R.L., 2000, Data for Quaternary faults, liquefaction features, and possible tectonic features in the Central and Eastern United States, east of the Rocky Mountain front, U.S. Geological Survey Open-File Report 00-260, p. 342.

Davis, S.D., Pennington, W.D., and Carlson, S.M., 1989, A compendium of earthquake activity in Texas, University of Texas at Austin, Bureau of Economic Geology, Geological Circular 89-3.

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Garner, L.E., and Young, K.P., 1976, Environmental Geology of the Austin Area: An Aid to Urban Planning, University of Texas at Austin Bureau of Economic Geology: Report of Investigations No. 86, p. 39, 7 plates.

Heidbach, O., Tingay, M., Barth, A., Reinecker, J., Kurfess, D., Mueller, B., 2008, The World Stress Map database release 2008, doi:10.1594/GFZ.WSM.Rel2008.

Humphreys, E. D., Coblentz, D. D., 2007, North American Dynamics and Western U. S. Tectonics: Reviews in Geophysics: v. 45, RG3001, doi:10.1029/2005RG000181.

Weeks, A.W., *Balcones, Luling, and Mexia fault zones in Texas.* Bull. Seismo. Soc. Am., 1945. 29(12): p. 1733–1737.

Wheeler, R.L., 2005, Known or Suggested Quaternary Tectonic Faulting, Central and Eastern United States—New and Updated Assessments for 2005, U.S. Geological Survey Open-File Report 2005-1336, p. 40.

Zoback, M.L. and M.D. Zoback, Tectonic stress field of the continental United States, in Geophysical Framework of the Continental United States, L.C. Pakiser and W.D. Mooney, Editors. 1989, Geological Society of America: Boulder, Colorado. p. 523–539.

Impact on R-COLA

None.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3015 (CP #21)

SRP SECTION: 02.05.01 – BASIC GEOLOGIC AND SEISMIC INFORMATION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 07/15/2009

QUESTION NO.: 02.05.01-11

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.1, 'Basic Geologic and Seismic Information,' establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

FSAR Section 2.5.1.1.4.3.6 states that “Only one fault within the site region has been identified as demonstrating possible evidence for Quaternary activity: the Meers fault in Oklahoma.” Please explain, in light of the FSAR’s sixteen pages documenting evidence for very late Quaternary faulting on the Meers fault, the FSAR’s conclusion that Quaternary activity on the Meers is “possible.”

ANSWER:

The FSAR statement that is the subject of this question was meant to indicate that excluding the Meers fault, there were no other features within the site region that have evidence of possible Quaternary, seismogenic rupture. However, as indicated by the question, the wording within the FSAR seems to imply that the Meers fault only has evidence of “possible” Quaternary activity. This implication is not correct because there is conclusive evidence that the Meers fault has had seismogenic rupture within the Quaternary. Subsection 2.5.1.1.4.3.6 was modified to clarify this issue.

Impact on R-COLA

FSAR Revision 0 page 2.5-26 was revised to reflect this response.

See attached changes for page 2.5-26. Because of the text additions and deletions, the page numbers on the mark-up FSAR pages may not be the same as the page numbers in FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3015 (CP #21)

SRP SECTION: 02.05.01 – BASIC GEOLOGIC AND SEISMIC INFORMATION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 07/15/2009

QUESTION NO.: 02.05.01-13

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.1, 'Basic Geologic and Seismic Information,' establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

FSAR Section 2.5.1.1.4.3.7.2, describing the Cheraw fault, notes that Crone et al. (1997) (FSAR Reference 2.5-323) found evidence for three surface-rupturing events in the past 25,000 years. Please explain whether the Cheraw fault is a capable fault, and whether it is included as a seismic source in the FSAR.

ANSWER:

As stated in the first paragraph of FSAR Subsection 2.5.1.1.4.3.7.2, the Cheraw fault is a capable fault. This conclusion is based on the observations of Crone et al. (1997) of three surface rupturing events on the Cheraw fault within the past 25,000 years. As described in FSAR Subsection 2.5.2.4.2.3.4, the Cheraw fault was analyzed to determine whether the fault was a significant contributor to seismic hazard at the CPNPP Units 3 and 4 site. The source characterization used for the Cheraw fault is presented in Subsection 2.5.2.4.2.3.4 and the results of the screening study are described in Subsection 2.5.2.4.4.

References:

Crone, A.J., Machette, N.M., Bradley, L.-A., and Mahan, S.A., 1997, Late Quaternary surface faulting on the Cheraw Fault, southeastern Colorado: Denver, CO, US Geological Survey Investigations Map, IMAP-2591.

<u>Impact on R-COLA</u>

None.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3015 (CP #21)

SRP SECTION: 02.05.01 – BASIC GEOLOGIC AND SEISMIC INFORMATION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 07/15/2009

QUESTION NO.: 02.05.01-14

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.1, 'Basic Geologic and Seismic Information,' establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

Despite its distance from the CPNPP site, FSAR Section 2.5.1.1.4.3.7.3 discusses the current understanding of the New Madrid seismic zone (NMSZ) as a seismic source because it is one of the closest sources to the CPNPP site. The updated NMSZ source model does not include new paleoseismic results related to the southern end of the Reelfoot Rift system.

(1) Please explain whether the southern end of the Reelfoot Rift system, which is closer than the NMSZ (approximately 580 km from the CPNPP site), is also capable of M>7 earthquakes. Please discuss the applicability of studies by Tuttle, et al., (2006), and Cox, et al., (2007), and explain how the extended NMSZ source impacts the seismic hazard at the CPNPP site.

(2) Please discuss if and to what extent paleoliquefaction features in southeastern Arkansas and northeastern Louisiana indicate that previously unrecognized seismogenic sources may exist in those areas. Please discuss studies by Al-Shukri, et. al. (2005); Cox, et al, (2004); and Tuttle, et al., (2006), and explain how these other seismogenic sources, which are closer to CPNPP than the NMSZ, impact the seismic hazard at the CPNPP site.

Additional References:

“Spatial and temporal characteristics of paleoseismic features in the southern terminus of the New Madrid Seismic Zone in eastern Arkansas,” Seismological Research Letters, Volume 76, pp. 502-511, Al-Shukri, H. J., Lemmer, R. E., Mahdi, H. H., Connelly, J. B., 2005.

“Preliminary assessment of sand blows in the southern Mississippi Embayment,” Bulletin of the Seismological Society of America, Volume 94, pp.1125-1142, Cox, R. T., Larsen, D., Forman, S. L., Woods, J., Morat, J., and Galluzzi, J., 2004.

“Very large earthquakes centered southwest of the New Madrid seismic zone 5,000-7,000 years ago,” Seismological Research Letters, Volume 77, pp.755-770, Tuttle, M. P., Al-Shukri, H., Mahdi, H., 2006.

"Seismotectonic implications of sand blows in the southern Mississippi embayment," Engineering Geology, volume 89, pp. 278-299, Cox, R. T., Hill, A. A., Larsen, D., Holzer, T., Forman, S. L., Noce, T., Gardner, C., and Morat, J., 2007.

ANSWER:

The papers referenced within the question describe liquefaction features discovered in eastern Arkansas. Specifically, the papers of Cox et al. (2007; 2004) describe a series of sand blow fields in southern Arkansas, and the papers of Al-Shukri et al. (2005) and Tuttle et al. (2006) describe two series of sand blows near Marianna and Parkin in central Arkansas, approximately 80 km south of the southwestern end of the New Madrid Seismic Zone (NMSZ) as defined by microseismicity. In the following discussion each of these sets of studies is briefly summarized and the implication of these studies for the CPNPP seismic source model is reviewed.

Studies of Cox et al. (2007)

Through the analyses of historical aerial photographs, the studies of Cox et al. (2007; 2004) identified large numbers (greater than 100) of sand blow or potential sand blow clusters along the Arkansas-Mississippi river valley in southern Arkansas. From this distribution of sand blows Cox et al. (2007; 2004) identified three relatively distinct sand blow fields with higher concentrations of sand blow clusters, which they refer to, from north to south, as the Lincoln/Jefferson county field, the Desha county field, and the Ashley county field. The closest approach of these fields to the CPNPP site is approximately 600 km. Within the two southern fields Cox et al. (2007; 2004) excavated trenches at five sites and, based on stratigraphic relationships and radiocarbon dating, interpreted the observed stratigraphic relations as presenting evidence of multiple sand venting episodes (e.g., earthquakes). Objectively, the total number of unique events and the event timing observed within the trenches has considerable uncertainty because the stratigraphy and radiocarbon dating conducted by Cox et al. (2007; 2004) in many cases provides relatively weak constraints. However, Cox et al. (2007) concluded that their observations provide evidence that the Ashley and Desha county fields each experienced at least three earthquakes within the last 7000 years.

Based on the clustering of sand blows in distinct fields, Cox et al. (2007) also concluded that a local source of earthquakes proximal to the sand blows is the most earthquake source, as opposes to the NMSZ. However, Cox et al. (2007) also acknowledged that some of the sand blow events do correlate with the NMSZ earthquake chronology and may be related to NMSZ seismicity. Cox et al. (2007) estimated the earthquake magnitudes causing the liquefaction to be approximately Mw 6.0 based on the width of the liquefaction fields. In their summary Cox et al. (2007) also make the misleading statement that “CPT indicate possible stronger events of about M[w]7” (page 296). This statement is based on analysis of CPT data collected by Cox et al. (2007) at the Ashley and Desha county fields that related peak ground acceleration (PGA) to magnitude expected to cause sand blows. However, this analysis only presents a continuous relationship between PGA, earthquake magnitude, and the potential for sand blows. The analysis is incapable of identifying a preferred or expected magnitude (e.g., Mw 7 as suggested by Cox et al., 2007) for the earthquakes that caused the observed sand blows.

Studies of Al-Shukri et al. (2005) and Tuttle et al. (2006)

Through analysis of aerial photography and field surveys, Al-Shukri et al. (2005) identified sand blows near Mariana and Parkin, Arkansas. Al-Shukri et al. (2005) trenched 3 sites (two near Marianna, one near Parkin), approximately 80 km south of the present-day seismicity of the NMSZ and approximately 700 km from the CPNPP site. The trenching revealed the presence of a sand blow unit varying in thickness from 22 to 130 cm. Three radiocarbon dates on underlying clay units range between 4800 and 5660 B.P. and were interpreted to represent a liquefaction event at ~5500 B.P. Al-Shukri et al. (2005) suggested that this event could be the result of: (1) a New Madrid seismic event, (2) a local source that might not be related to NMSZ seismicity, or (3) aftershocks near the study area from a local source triggered by mainshocks within the NMSZ. Al-Shukri et al. (2005) did not identify a preferred hypothesis for the causative earthquake source and did not attempt to estimate magnitude for the causative earthquakes.

Building upon the initial results of Al-Shukri et al. (2005), Tuttle et al. (2006) further investigated the sand blows near Mariana, Arkansas. Tuttle et al. (2006) used multiple trenches, a cut-bank exposure, and ground-penetrating radar surveys were used to identify several large sand-blow deposits. Radiocarbon and optically-stimulated luminescence dates they collected indicate these sand blows were likely caused by two earthquakes, one approximately 5500 years ago (recorded at their Daytona site) and one approximately 6800 years ago (recorded at their St. Francis site). Tuttle et al. (2006) noted that the age of the Daytona event broadly correlates in time to liquefaction features observed within the southern NMSZ and to some of the features observed by Cox et al. (2004). Tuttle et al. (2006) also noted that the age of the St. Francis event does not appear to correlate with any other liquefaction features within the NMSZ or those presented by Cox et al. (2004). Based on these observations Tuttle et al. (2006) hypothesized that: (1) the liquefaction observed near Mariana is due to a local source, and (2) if the other correlated liquefaction features are from the same source, the causative earthquakes could be very large (Mw > 7.2). However, the correlation between the Cox et al. (2007; 2004) sand blows and the Tuttle et al. (2006) sand blows is weak in part because most of the sand blow events observed by Cox et al. (2007; 2004) further south do not correlate to those of Tuttle et al. (2006) suggesting that the different sets of sand blows are not caused by the same source. Tuttle et al. (2006) acknowledges this uncertainty in the cause of the sand blows and states that “The ages of Middle Holocene liquefaction features in all three areas, however, would need to be better constrained and the intervening areas searched for similar age features in order to correlate them with confidence” (page 768). Therefore, the estimate of a causative earthquake of approximately Mw 7 can also not be implied with confidence.

Implication for CPNPP

The wording of the question implies that the studies of Cox et al. (2007; 2004), Al-Shukri et al. (2005), and Tuttle et al. (2006) present: (1) information supporting the extension of the NMSZ source zone south of the current extent of the NMSZ as defined by seismicity, and (2) information supporting the creating of new seismic sources in southern Arkansas. However, as reviewed above, these studies present numerous hypotheses for what seismic source is causing the liquefaction features. Source scenarios presented within these studies include: (1) the hypothesis that all of the liquefaction is caused by large earthquakes from the NMSZ source, (2) the hypothesis that all of the liquefaction is caused by large earthquakes from a source near Mariana, (3) the hypothesis that all of the liquefaction events are caused by moderate earthquakes proximal to the observed liquefaction, and (4) the hypothesis that there is some combination of these sources. With the exception of the study of Cox et al. (2007), these studies do not present any strongly supportable opinion as to which of these scenarios is most likely.

The information contained in the studies of Cox et al. (2007; 2004) was used in developing a new seismic source characterization for the region surrounding the Cox et al. (2007; 2004) liquefaction features for the Grand Gulf Early Site Permit Application (SER, 2005) that was granted in April 2007. This source zone is referred to as the Saline River source zone (SRSZ). This source characterization was developed following SSHAC level 2 guidelines (Budnitz et al., 1997) and captures the data presented within the papers of Cox et al. (2007; 2004). It was concluded that the SRSZ would likely not have a significant impact on the site hazard due to the large distance between this source zone and the site (approximately 450 km), the characteristic earthquake magnitudes for the source zone (mean Mw 6.4), and the recurrence period for characteristic earthquakes with the zone (mean approximately 4000 years). Therefore, the SRSZ was not included in any analyses for CPNPP Units 3 and 4.

The papers of Al-Shukri et al. (2005) and Tuttle et al. (2006) were also evaluated as part of the CPNPP Units 3 and 4 COLA effort, and, as with the Cox et al. (2007; 2004) papers, it was determined that this work did not contain any new information that required updating of the EPRI-SOG source characterizations. This decision was based on the observations that:

- No new seismic sources have been directly linked to the liquefaction features;
- External reviews of this research concluded that the NMSZ was a likely source for these liquefaction features (Wheeler, 2005); and
- The potential for the liquefaction to have been caused by the NMSZ is captured by the NMSZ model used in the PSHA for CPNPP Units 3 and 4.

In summary, the papers of Cox et al. (2007; 2004), Al-Shukri et al. (2005) and Tuttle et al. (2006) do not present any new information or data that justifies modifying the EPRI-SOG source characterizations for the CPNPP Units 3 and 4 site.

References:

Al-Shukri, H., Lemmer, R.E., Mahdi, H., and Connelly, J.B., 2005, Spatial and Temporal Characteristics of Paleoseismic Features in the Southern Terminus of the New Madrid Seismic Zone in Eastern Arkansas: Seismological Res. Lett., v. 76, p. 502-511.

Budnitz, R.J., Apostolakis, G., Boore, D.M., Cluff, L.S., Coppersmith, K.J., Cornell, C.A., and Morris, P.A., 1997, Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts: Washington, D.C., US Nuclear Regulatory Commission, NUREG/CR-6372, p. 278.

Cox, R.T., Hill, A.A., Larsen, D., Holzer, T., Forman, S.L., Noce, T., Gardner, C., and Morat, J., 2007, Seismotectonic implications of sand blows in the southern Mississippi Embayment: Engineering Geology, v. 89, p. 278-299.

Cox, R.T., Larsen, D., Forman, S.L., Woods, J., Morat, J., and Galluzzi, J., 2004, Preliminary Assessment of Sand Blows in the Southern Mississippi Embayment: Bulletin of the Seismological Society of America, v. 94, p. 1125-1142.

SER, 2005, System Energy Resources Inc. (SER) Application for the ESP at the Grand Gulf Site, Rev. 2, NRC ADAMS Accession Number ML052780449.

Tuttle, M.P., Al-Shukri, H., and Mahdi, H., 2006, Very Large Earthquakes Centered Southwest of the New Madrid Seismic Zone 5,000–7,000 Years Ago: Seismological Res. Lett., v. 77, p. 755-770.

Wheeler, R.L., 2005, Known or Suggested Quaternary Tectonic Faulting, Central and Eastern United States—New and Updated Assessments for 2005, U.S. Geological Survey Open-File Report 2005-1336, p. 40.

<u>Impact on R-COLA</u>

None.

<u>Impact on S-COLA</u>

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3015 (CP #21)

SRP SECTION: 02.05.01 – BASIC GEOLOGIC AND SEISMIC INFORMATION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 07/15/2009

QUESTION NO.: 02.05.01-15

FSAR Subsection 2.5.1.2.4.1 describes two basement faults beneath the Cretaceous rocks within a 25-mi radius of the CPNPP site. However, the location of these basement faults is not shown in FSAR Figure 2.5.1-216, a geologic map of the site vicinity. Please provide a description of where the basement faults were mapped in the 25-mi radius or illustrate the location of these faults on the appropriate figure.

ANSWER:

The basement faults discussed in FSAR Subsection 2.5.1.2.4.1 are offsets in the top of the Mississippian Marble Falls unit identified at depth with seismic and well log data. They are buried beneath at least 3500 ft of younger strata, and hence not exposed at the surface. They are not mapped on FSAR Figure 2.5.1-216, but for illustrative purposes, their projections are shown on FSAR Figure 2.5.1-220.

FSAR Figure 2.5.1-220 is revised. For clarification, the text of FSAR Subsection 2.5.1.2.4 is also revised.

Impact on R-COLA

FSAR Revision 0 Figure 2.5.1-220 and pages 2.5-47 and 2.5-48 was revised to reflect this response.

See attached changes for Figure 2.5.1-220 and pages 2.5-47 and 2.5-48. Because of the text additions and deletions, the page numbers on the mark-up FSAR pages may not be the same as the page numbers in FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3015 (CP #21)

SRP SECTION: 02.05.01 – BASIC GEOLOGIC AND SEISMIC INFORMATION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 07/15/2009

QUESTION NO.: 02.05.01-16

FSAR Subsection 2.5.1.2.4.2 states that “no tectonic structures (such as faults, folds, or shear zones) were found within 5 mi. of the CPNPP Units 3 and 4 site” but does describe two disruptions within the site area. FSAR Figure 2.5.1-217 labels these two disruptions as “Fold in Paluxy” and “Fold near Dam”. Please clarify if these map features are folds or the disruptions described in the FSAR.

ANSWER:

The structures discussed in FSAR Subsection 2.5.1.2.4.2 and referred to as “disruptions” and the structures referred to in FSAR Figure 2.5.1-217 as “folds” are the same. In outcrop these structures appear to be gentle folds. However, it is unclear if they have a well defined fold axis or if they are domal features. To clarify this point, FSAR Figure 2.5.1-217 was modified to refer to these features as “gentle folds” and clarifying text was added to FSAR Subsection 2.5.1.2.4.2 and the term “disruptions” removed.

Impact on R-COLA

FSAR Revision 0 Figure 2.5.1-217 and page 2.5-48 was revised to reflect this response.

See attached changes for Figure 2.5.1-217 and page 2.5-48. Because of the text additions and deletions, the page numbers on the mark-up FSAR pages may not be the same as the page numbers in FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3015 (CP #21)

SRP SECTION: 02.05.01 – BASIC GEOLOGIC AND SEISMIC INFORMATION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 07/15/2009

QUESTION NO.: 02.05.01-17

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.1, 'Basic Geologic and Seismic Information,' establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

Section 2.5.1.2.5.1 mentions a "Field reconnaissance of the region and immediate site area…," including surveys of "…Quaternary deposits within nearby river and stream valleys…" to evaluate 1) the "…presence of liquefaction features…", 2) "…signs of deformation…", and 3) a "…lineament analysis followed by field confirmation surveys."

(1) Please describe separately, in detail, each part of the overall field investigation that addressed each of the three types of investigations numbered above (liquefaction features, signs of deformation, and lineament analysis), including:

(a) the locations investigated,

(b) the types of outcrops, surfaces and sediments examined,

(c) the origins of features, and

(d) any other evidence found during the surveys that may bear on the Quaternary seismic and deformation history of the site region and site vicinity.

Please fully explain the extent to which each type of investigation indicates "no evidence of seismic activity, either recent or historic."

(2) Explain what the phrase "…signs of deformation…" means and provide complete details on possible deformation features that were found and the evidence used in their interpretation.

(3) For the "…lineament analysis followed by field confirmation surveys.", please provide a complete description of the surveys and analysis of features with appropriate figures, including details of methods and imagery used, aerial extent, identification criteria, identified lineaments, and conclusions regarding the origin of each identified lineament in the site vicinity.

ANSWER:

Field reconnaissance for the CPNPP Units 3 and 4 investigation, other than that conducted on the site location, consisted of visiting publicly accessible locations in the site area, site vicinity and site region. Generally, all publicly accessible locations in and around the site area were visited in order to verify the accuracy of the site area map, to search for signs of deformation in bedrock and surficial outcrops, and to search for paleoliquefaction features. The Glen Rose Formation that underlies the site regionally is a uniformly relatively flat lying formation. Therefore "signs of deformation" would consist of either flexure of bedding indicating folding or offset of stratigraphic markers indicating faulting.

A GPS track log of areas covered during the site area reconnaissance overlain on both the site area and site vicinity geologic map is provided as part of this response. Locations visited for the site region as part of the field reconnaissance were selected in order to visit type sections for geologic formations or to obtain first hand information on specific structures reported in the site region so that their characteristics could be compared to those observed for the site area. The specific numbered requests in the RAI above are addressed in corresponding numbered sequence below.

1. Details from the overall field investigation that addressed liquefaction features, signs of deformation, lineament analysis.

    Liquefaction features:

    (a) Locations investigated – The only geologic units potentially susceptible to liquefaction are the Quaternary Alluvium and Quaternary terrace deposits that primarily occur in the Brazos and Paluxy River Valleys as well as Squaw Creek. Significant aerial extents of these deposits occur in the southern parts of the site area. These localities were investigated both by examining aerial photographs as part of the lineament analysis and by inspection during the field reconnaissance.

    (b) Types of outcrops and sediments examined - The Quaternary deposits form a thick rich soil and flat lying surfaces with essentially no relief. Therefore they consist of flat vegetated surfaces, that are not readily visible from the ground and do not form outcrops. The most likely signs of liquefaction in these deposits would be the existence of sand blows or fissures on the surface. Very little information on these deposits was available from the reconnaissance phase of the investigation for the reasons stated above.

    (c) Origins of features - No features were identified.

    (d) Additional evidence on Quaternary deformation - All evidence previously reported.

    Signs of deformation:

    (a) Locations investigated – As stated above all publicly accessible areas in the site area and immediately surrounding vicinity were visited.

    (b) These locations consisted primarily of the Glen Rose and Paluxy Formations. Although in northern parts of the site area some outcrops of Walnut Clay and Comanche Peak Limestone are present.

    (c) Only two features were identified that exhibited signs of deformation. These two features were a gentle fold in the Glen Rose Formation below the Squaw Creek Dam and a gentle fold in Paluxy Formation near Hill City in a road cut on Highway

56. Both of these features are interpreted to have resulted from differential compaction or instratal dissolution.

(d) Additional evidence on Quaternary deformation – All evidence previously reported.

Lineament Analysis:

Specifics of the lineament analysis are provided in response to Question 02.05.03-2.

2. The term "signs of deformation" would include folding or faulting. The details of the deformation features that were found and the evidence used are included in the revised FSAR Subsection 2.5.1.2.5.1.

3. FSAR Subsection 2.5.3.2.1 that addresses this issue is provided in the response to Question 02.05.03-2.

Impact on R-COLA

FSAR Revision 0 pages 2xlvii and 2.5-51 were revised and Figures 2.5.1-231 and 2.5.1-232 were added to reflect this response.

See attached Figures 2.5.1-231 and 2.5.1-232 and changes for pages 2xlvii and 2.5-51. Because of the text additions and deletions, the page numbers on the mark-up FSAR pages may not be the same as the page numbers in FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3015 (CP #21)

SRP SECTION: 02.05.01 – BASIC GEOLOGIC AND SEISMIC INFORMATION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 07/15/2009

QUESTION NO.: 02.05.01-18

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.1, 'Basic Geologic and Seismic Information,' establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

As discussed in FSAR Sections 2.5.1.1.2 and 2.5.1.1.4, faults that were active during Mesozoic rifting and that are now buried by Mesozoic and Cenozoic deposits are likely to occur below the site region. Direct study of these buried faults in outcrop is not possible. Elsewhere in the Central and Eastern US (CEUS) where similar geologic conditions exist, researchers use liquefaction features induced by large earthquakes to estimate timing, source areas, magnitudes, and recurrence intervals of large prehistoric earthquakes. Partly as a result of such studies, in the last 15 years there is wider recognition that seismicity migrates within crustal zones over periods of thousands to tens of thousands of years (e.g., Nelson et al., 1999; Schweig and Ellis, 1994; Coppersmith, 1999; Tuttle et al., 2006; Cox et al., 2007). Holocene and late Pleistocene deposits (e.g., fluvial, alluvial deposits) that are likely to be susceptible to liquefaction during large earthquakes occur in the CPNPP site region, for example, along the Brazos River and its tributaries. In the context of the search for liquefaction features mentioned in Section 2.5.1.2.5.1, please explain how the wider recognition that crustal seismicity migrates applies to the CPNPP site region.

ANSWER:

The probability that a depositional sequence will liquefy as a result of a nearby earthquake of sufficient magnitude (greater than about 5.5 to 6.0; Obermeier, 1996) depends on the composition and age of the deposits and the condition that they be saturated at the time of the earthquake event. The most susceptible deposits are Holocene and Pleistocene in age although the liquefaction susceptibility decreases with increasing age (Kramer, 1996). The stratification of the deposit requires a relatively clean sand interval overlain by a relatively impermeable cap (Obermeier, 1996 Figure 7.5) to allow pore pressure confinement during the liquefaction event. As pointed out in the Question above, the fluvial and alluvial deposits that constitute the fluvial terraces and flood plains of the Brazos River and its tributaries in the site region meet these criteria. The depositional processes that result in floodplain development sort sediments into uniform grain size strata and deposit them into unconsolidated states typically in a fining upward sequence that results in a clay cap of over bank and flood stage material. The widespread occurrence of these types of sediments throughout the Brazos River drainage and consequently the site region means that sediments of the right age, composition and stratigraphic order, although sparsely distributed, are present over large areal portions of the site region.

In addition to the age, compositional and stratigraphic characteristics discussed above, the requirement that the deposits be saturated means that liquefaction susceptibility decreases with depth to groundwater and that changing groundwater levels result in changes of liquefaction potential (Kramer, 1996). Thus deposits that form the floodplain at the time of an earthquake event are more likely to experience liquefaction than deposits that occur in terraces that have been elevated significantly above the level of the river and therefore have deeper ground water. However, this simple statement is complicated by the fact that climate change through the Pleistocene and Holocene has resulted in prolonged wet periods in the site region (Sylvia and Galloway, 2006). Prolonged wet periods make elevated groundwater and perched water conditions more likely and therefore could result in enhanced liquefaction susceptibility in larger portions of flood plain and terrace deposits. Therefore, the areal extent of Pleistocene and younger deposits that have the potential to liquefy probably fluxuate in time and are possibly correlated to periods of wetter climate. This effect on the spatial extent of the paleoliquefaction record is probably enhanced by the fact that during dry periods the most likely deposits susceptible to liquefaction are in the floodplain only, and these deposits are the most susceptible to subsequent erosion and destruction.

The relevance of the above discussion to the migration of crustal seismicity throughout the site region can be understood by reference to Figure 9.4 in Kramer (1996) that illustrates the epicentral distance of liquefaction effects and moment magnitude for shallow earthquakes. Earthquakes with moment magnitudes of 7.5 or greater should produce liquefaction in liquefiable deposits over significant portions the site region. However, the spatial extent and preservation of this record would depend on which phase of the climactic cycle the earthquake occurred. As the magnitude of the earthquake becomes smaller the epicentral liquefaction limits become progressively smaller. The consequence of this, is that the likelihood for smaller earthquakes to produce a widespread paleoliquefaction record for any particular location is enhanced if the locus of seismicity coincides temporally with a climatic wet period at that location. For any particular area in the site region, the probability that the locus of seismicity would leave a widespread paleoliquefaction record as it migrated through that area would be greatly enhanced if it coincided with wet conditions. Based on the discussion above, no evidence was found that crustal seismicity applies to the CPNPP Units 3 and 4 region, but the migration may not have left a detectable record.

To summarize, deposits of the proper age and composition to be susceptible to liquefaction are sparsely, but relatively uniformly spatially distributed throughout the site region. However, the requirement for saturation and consequent dependence on the depth to groundwater means that the spatial areal coverage of liquefiable deposits is probably not temporally uniform but fluxuates with wet periods in the climatic cycle. Therefore the probability for the paleoliquefaction record to be preserved and recognized as the locus of seismicity migrated through a particular location would be enhanced if the timing of increased seismic rate and magnitude occurred in phase with a wet climactic episode at that location.

References

Kramer, S. L. (1996) Geotechnical Earthquake Engineering. Prentice-Hall International Series in Civil Engineering and Engineering Mechanics, Prentice Hall, 653p.

Obermeier, S. F. (1996) "Using liquefaction-induced features for paleoseismic analysis". In Paleoseismology, McCalpin, P. P. ed., p.331-396.

Silva, D. A., Galloway, W. E. (2006) “Morphology and stratigraphy of the late Quaternary lower Brazos valley: Implications for paleo-climate, discharge and sediment delivery”, Sedimentary Geology, v.190, p.159-175.

Impact on R-COLA

None.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3015 (CP #21)

SRP SECTION: 02.05.01 – BASIC GEOLOGIC AND SEISMIC INFORMATION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 07/15/2009

QUESTION NO.: 02.05.01-20

Please provide the following text and figural corrections:

a) Please label all features on all figures, including but not limited to all structures mentioned in the text of the FSAR, in Sections 2.5.1.1.4.3.3 (p. 2.5-21) through 2.5.1.1.4.3.4.2 (p 2.5-23)..

b) For Figure 2.5.1-202b, please clarify whether “King and Beikman, 1974” should be included in the reference list, and provide reference numbers for “Nichols and Waddell.”

c) Please provide the reference number for “Nichols and Waddell” on Figure 2.5.1-204, provide the citation for the cross section line, and enhance or enlarge the text in the small inset and the key.

d) Please clarify whether “Walper” should be listed as a reference for Figure 2.5.1-208.

e) Please provide the CPNPP site location on FSAR Figure 2.5.1-208

f) For Figure 2.5.1-229, please clarify whether “Pollastro 2007” references the “Pollastro et. al 2007” study.

g) Please provide the correct referenced publication listed as “Reference 2.5-266.”

ANSWER:

a. Figure 2.5.1-207 has been revised to label structures. Subsection 2.5.1.1.4.3.3 has been revised to clarify important strctures that should be labeled on the affected figures.

b. A reference to King and Beikman has been added to the reference list.

c. Figure 2.5.1-204 has been revised to add the Reference number 2.5-212 for Nichols and Waddell, 1989 and the text insert enlarged.

d. Figure 2.5.1-208 has been revised to add Reference 2.5-203 to Walper 1977.

e. Figure 2.5.1-208 has been revised to show the Site Location.

f. Figure 2.5.1-229 has been revised to correctly reference Pollastro et. al 2007 (Reference 2.5-347).

g. Reference document 2.5-266 is attached.

Impact on R-COLA

FSAR Revision 0 Figures 2.5.1-204, 2.5.1-207, 2.5.1-208, and 2.5.1-229 and page 2.5-228 were revised to reflect this response.

See attached changes for Figures 2.5.1-204, 2.5.1-207, 2.5.1-208, and 2.5.1-229; and page 2.5-245. Because of the text additions and deletions, the page numbers on the mark-up FSAR pages may not be the same as the page numbers in FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

Attachment 5

Response to Request for Additional Information No. 3016 (CP RAI #18)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3016 (CP #18)

SRP SECTION: 02.05.03 – SURFACE FAULTING

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 07/14/2009

QUESTION NO.: 02.05.03-1

FSAR Section 2.5.3.1.2 states that "The [United States Geological Survey] USGS has compiled information related to all known Quaternary faults, liquefaction features, and possible tectonic features in the [central and eastern United States] CEUS." Please clarify whether or not this is a complete compilation or evaluation of all known Quaternary faults, liquefaction features, and all possible tectonic features and what are its limitations for the purposes of concluding that a feature is, or is not, a capable tectonic structure.

ANSWER:

Information contained within FSAR Subsection 2.5.1 was developed in accordance with RG 1.208. As such, the information summarized in the FSAR is the result of a thorough literature search, interviews with experts, and review of relevant maps and data (including geologic, geomorphologic, geophysical, seismological resources, etc). Data sources include the USGS, state and local organizations, literature published in international journals by academic and industry workers, and a variety of regional and local publications and field trip guidebooks. The list of tectonic features presented in FSAR Subsection 2.5.1 is determined through an evaluation of all these data, particularly focused on newer information presented since the EPRI (1986) studies.

The compilation studies of Crone and Wheeler (2000; Wheeler, 2005) aimed to be comprehensive and evaluate all geologic evidence of Quaternary tectonic faulting or deformation. As such, these studies were reviewed as part of the CPNPP Units 3 and 4 COLA effort. However, these studies were a single component used in evaluating potentially capable tectonic features, and conclusions about a given tectonic feature presented in the FSAR were made based on a thorough review of all publications and datasets that bear on that feature, and if potentially applicable, new field and aerial reconnaissance, interviews with experts, and analysis of aerial imagery and other data. These evaluations are discussed in detail in FSAR Subsection 2.5.1.

References:

Crone, A.J., and Wheeler, R.L., 2000, Data for Quaternary faults, liquefaction features, and possible tectonic features in the Central and Eastern United States, east of the Rocky Mountain front, U.S. Geological Survey Open-File Report 00-260, p. 342.

EPRI, 1986, Seismic hazard Methodology for the Central and Eastern United States (NP-4726), Vol. 5-10, Electric Power Research Institute (EPRI).

Wheeler, R.L., 2005, Known or Suggested Quaternary Tectonic Faulting, Central and Eastern United States—New and Updated Assessments for 2005, U.S. Geological Survey Open-File Report 2005-1336, p. 40.

Impact on R-COLA

None.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3016 (CP #18)

SRP SECTION: 02.05.03 – SURFACE FAULTING

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 7/14/2009

QUESTION NO.: 02.05.03-2

NUREG-0800. Standard Review Plan (SRP). Chapter 2.5.3 "Surface Faulting" establishes criteria that the NRC Staff intends to use to evaluate whether an applicant meets the NRC's regulation.

In Section 2.5.3.2 the FSAR briefly mentions a lineament analysis using 1940's air photos. Please describe the analysis in much greater detail, preferably in Section 2.5.1 where tectonic features in the site vicinity are discussed. Please include the following:

a) What other types of imagery were used in the lineament analysis;

b) Are the lineaments numbered on figure 2.5.3-201;

c) Please explain the "lineament report (WLA, 2007)" referenced on figure 2.5.3-201 and whether or not it is referenced and described in the FSAR;

d) Please explain the origin of each lineament, or group of lineaments, and state the evidence for their inferred origin.

ANSWER:

New Subsection 2.5.3.2.1 discusses the lineament analysis methodology and results. Also the FSAR text has been modified to provide reference to this new subsection in 2.5.1.

Concerning Figure 2.5.3-201, the lineaments are numbered on the figure. The "lineament report" is more formally known as the "Field Reconnaissance Report," which was recently provided to the NRC (ML092290395).

<u>Impact on R-COLA</u>

FSAR Revision 0 pages 2.5-48 and 2.5-118 were revised to reflect this response.

See attached changes for pages 2.5-48, 2.5-123 and 2.5-124. Because of the text additions and deletions, the page numbers on the mark-up FSAR pages may not be the same as the page numbers in FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3016 (CP #18)

SRP SECTION: 02.05.03 – SURFACE FAULTING

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 7/14/2009

QUESTION NO.: 02.05.03-3

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.3, 'Surface Faulting,' establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

In FSAR Section 2.5.3.8.2, you state, "It has been concluded that anthropogenic activities occurring near the site do not pose a hazard for surface deformation." Please explain in detail the basis for this conclusion, and what parts of the FSAR explain the evidence and analysis fully justifying this conclusion.

ANSWER:

The basis for this conclusion is discussed in Subsections 2.5.3.8.2.2 and 2.5.1.2.5.

The potential hazard of surface deformation resulting from man-induced activities was evaluated by first summarizing what activities could pose such hazards. Two primary activities identified included surface and subsurface mining and petroleum production. Mining activities were summarized from a review of the Texas Mining and Reclamation Association and the Texas Bureau of Economic Geology as well as screening the 2006 satellite imagery of the site vicinity of any evidence of mining activities. No subsurface mining activities were identified and only one surface aggregate (sand and gravel) mine was identified within the 5-mile radius of the site. The surface mining activities are open excavation, strip mining of Paluxy sand.

Activities related to petroleum production are not deemed to present hazards associated with surface deformation. These activities in the site vicinity respective to the geologic conditions are discussed in Subsection 2.5.1.2.5.10. These activities include primarily gas extraction from the Barnett Shale and injection of waste water into the Ellenberger Limestone.

<u>Impact on R-COLA</u>

FSAR Revision 0 page 2.5-120 was revised to reflect this response.

See attached changes for pages 2.5-126 and 2.5-127. Because of the text additions and deletions, the page numbers on the markup FSAR pages may not be the same as the page numbers in the FSAR Revision 0.

Impact on S-COLA

None.

Impact on DCD

None.

Attachment 6

Response to Request for Additional Information No. 3080 (CP RAI #15)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak Unit 3/4

Luminant Generation Company LLC

Docket No. 52-034 and 52-035

RAI NO.: 3080 (CP #15)

SRP SECTION: 02.05.01 – BASIC GEOLOGIC AND SEISMIC INFORMATION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 07/13/2009

QUESTION NO.: 02.05.01-2

NUREG-0800, Standard Review Plan (SRP), Chapter 2.5.1, 'Basic Geologic and Seismic Information,' establishes criteria that the NRC staff intends to use to evaluate whether an applicant meets the NRC's regulations.

In your discussion of regional Quaternary tectonic structures in FSAR Sub-Section 2.5.1.1.4.3.6, you do not include a discussion of the Washita Valley Fault. Given that Quaternary-age displacement has been suggested along this fault, please explain why you did not include a discussion of this feature.

ANSWER:

The Washita Valley fault (WVF) was not discussed in the FSAR because there is no credible evidence to suggest that the fault is a capable tectonic feature (Cox and Van Arsdale, 1988), and there is significant credible evidence to suggest there has been no slip on the fault in Quaternary times (Van Arsdale et al., 1989). Unlike the Criner fault, which has a history of being considered a potentially capable fault before being conclusively demonstrated to not have Quaternary activity (see FSAR Subsection 2.5.1.1.4.3.6.2), the WVF has not been a controversial fault with respect to its Quaternary activity. For example, the researchers who originally hypothesized that the WVF has geomorphic evidence suggestive of Quaternary activity (Cox and Van Arsdale, 1988) one year later demonstrated that Holocene and Pleistocene deposits across the fault are not faulted (Van Arsdale et al., 1989). In addition, modern evaluations of research on the fault have concluded that there is no evidence of Quaternary activity (Crone and Wheeler, 2000). The results of the original studies of the WVF are briefly summarized below.

Cox and Van Arsdale (1988) originally hypothesized that the WVF has had Quaternary slip based on observations of several geomorphic features at one location along the western extent of the fault. The main observations were:

- Constricted river valleys upstream and broader river valleys downstream of the fault that Cox and Van Arsdale (1988) hypothesized demonstrate displacement along the fault with downward motion of the block containing the broader river valleys;

- Bends in two creeks across the fault that Cox and Van Arsdale (1988) hypothesized demonstrate left-lateral offset across the fault; and
- Apparent thickening alluvial deposits adjacent to the fault that Cox and Van Arsdale (1988) hypothesized demonstrate ponding of sediments against a fault scarp.

Taken alone, these observations of Cox and Van Arsdale (1988) do not provide robust evidence of Quaternary activity along the WVF. To further investigate the potential activity of the WVF, Van Arsdale et al. (1989) conducted a more detailed study of the fault that included an analysis of stream valleys along the WVF, trenching studies across the fault trace, and field reconnaissance for geomorphic and geologic features that would indicate young fault activity. From their analysis of the stream valleys along much of the WVF trace, Van Arsdale et al. (1989) concluded that there is no evidence of systematic stream offsets across the WVF indicative of Quaternary activity. Van Arsdale et al.'s (1989) other efforts focused on identifying faulted and unfaulted datable deposits that could provide evidence for or against Quaternary activity. At the five sites investigated by Cox and Van Arsdale (1988), all within an approximately 50-mile stretch of the WVF, they were able to identify and date, primarily through radiocarbon dating, unfaulted deposits ranging in age from approximately 2000 years to 20,000 years. While the ages of these deposits do not extended significantly into the Pleistocene, at all of the locations investigated by Van Arsdale et al. (1989), there was also no evidence of any offset Quaternary deposits. Taken in light of the original Cox and Van Arsdale (1988), the study of Van Arsdale et al. (1989) demonstrated that there is no evidence of Quaternary activity along the Washita fault.

References:

Cox, R.T., and Van Arsdale, R.B., 1988, Structure and chronology of the Washita Valley Fault, southern Oklahoma Aulacogen: Shale Shaker, v. 39, p. 222-233.

Crone, A.J., and Wheeler, R.L., 2000, Data for Quaternary faults, liquefaction features, and possible tectonic features in the Central and Eastern United States, east of the Rocky Mountain front, U.S. Geological Survey Open-File Report 00-260, p. 342.

Van Arsdale, R., Ward, C., and Cox, R.T., 1989, Post-Pennsylvania Reactivation Along the Washita Valley Fault, Southern Oklahoma: Washington, D.C., US Nuclear Regulatory Commission, NUREG/CR-5375, p. 48.

Impact on R-COLA

None.

Impact on S-COLA

None.

Impact on DCD

None.

Attachment 7

Marked-up FSAR Pages

Attachment 8

List of Files Included on CD

List of Files on the CD

NRC Question No.	File Name	Name of Document(s) or Description	Document Date	Type of Document
2.5.2-20	Attachment a: ROCK_UHRS.txt	0737-ACR-051-Rev1 - Smooth Rock UHRS values for annual exceedance frequencies of 10-4, 10-5, and 10-6	None	Input/Output files
	Attachment b: SOURCE_GEOM.txt	0737-ACR-051-Rev1 - Geographic coordinates of all seismic source geometries used in the Comanche Peak PSHA study	None	Input/Output files
	Attachment c: SITE_AMPLIF.txt	Attachment c: 0737-ACR-051-Rev1 - Median Amplification Factors used in site response calculations for 10-4, 10-5, and 10-6 annual exceedance frequencies in digital format	None	Input/Output files
	Attachment d: VS_median_profile.txt	0737-ACR-051-Rev1 - The shear wave velocity profile used in site response calculations in digital format	None	Input/Output files
		0737-ACR-051-Rev1 - FIRS1_randomization_velstat.out	None	Input/Output files
	Attachment e: MEAN_HAZ_CURVES.txt	0737-ACR-051-Rev1 - Mean total hazard curves for 0.5, 1, 2.5, 5, 10, 25, and 100 Hz as well as the hazard curves of all individual seismic sources	None	Input/Output files
	Attachment f: FSAR_figure_252-232.txt	0737-ACR-051-Rev1 - Shear modulus and damping degradation curves shown in FSAR Figure 2.5.2-232	None	Input/Output files
	Attachment g: SOIL_UHRS.txt	0737-ACR-051-Rev1 - Soil UHRS curves electronically for 10-4, 10-5, and 10-6 annual exceedance frequencies	None	Input/Output files
	Attachment h: CATALOG_UPDATE.out	0737-ACR-051-Rev1 - Updated earthquake catalog	None	Input/Output files
2.5.4-21	STA-744-R4-P0.pdf	CPNPP Maintenance Effectiveness Monitoring Program, Procedure No. STA-744 (See section 8H).	February 18, 2009	Procedure
Digital Appendix D	Recon-1 Photos: P5160006.jpg to P51600016.jpg P5170021.jpg P5170030.jpg P5170040.jpg P5190049.jpg P5190059.jpg	TXUT-001-PR-013 Rev.0 Digital Appendix D	None	Photos
	Recon-2 Photos: P5P6200090.jpg to P6200097.jpg P6210100.jpg to P6210101.jpg P6210105jpg	TXUT-001-PR-013 Rev.0 Digital Appendix D	None	Photos
	Appendix D Recon-3 Photos: P8280114.jpg to P8280121..jpg P8280128.jpg	TXUT-001-PR-013 Rev.0 Digital Appendix D	None	Photos

List of Files on the CD

NRC Question No.	File Name	Name of Document(s) or Description	Document Date	Type of Document
	Recon-4 Photos: CO0B5D~1 CO0B5F~1 CO0D3B~1 CO0D3D~1 CO0D4B~1 CO0D4D~1 CO0D37~1 CO1B3B~1 CO1B5B~1 CO014B~1 CO014D~1 CO015B~1 CO015D~1 CO053B~1 CO053D~1 CO054B~1 CO054D~1 CO055B~1 CO055D~1 CO073D~1 CO093B~1 CO093D~1 CO093D~2 CO094B~1 CO094D~1 CO095B~1 CO095D~1 CO095D~2 CO095F~1 CO193B~1 CO195B~1 CO0533~1 CO0537~1 CO0555~1 CO0557~1 CO0733~1 CO0753~1 CO0755~1 CO0757~1 CO0937~1 CO0953~1 CO0957~1 COF051~1 COF451~1 COF841~1 COF851~1 COFA51~1 COFC41~1 COFC51~1 COMANC~1 COMANC~2 COMANC~3 COMANC~4	TXUT-001-PR-013 Rev.0 Digital Appendix D	None	Photos