PMBelCOL PEmails

From: Spink, Thomas E [tespink@tva.gov]
Sent: Monday, May 11, 2009 3:13 PM
To: Joseph Sebrosky
Cc: Sterdis, Andrea Lynn; Ryan, William T III; Eddie Grant; Munsey, Jeffrey W
Subject: Courtesy email copy of TVA's Response to RAI Letter 155
Attachments: BLN RAI Response to RAI Letter 155 Final.pdf

Joe,

I have enclosed a PDF copy of our response to RAI Letter 155 with this email as a courtesy. As always, the official submittal has been submitted to the Document Control Desk via paper copy using Federal Express services. The paper copy should arrive on May 12, 2009.

If you have any questions, please do not hesitate to call me.

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From: Spink, Thomas E

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Recipients:
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Tennessee Valley Authority, 1101 Market Street, LP 5A, Chattanooga, Tennessee 37402-2801

May 11, 2009

10 CFR 52.79

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

In the Matter of)
Tennessee Valley Authority)

Docket No. 52-014 and 52-015

BELLEFONTE COMBINED LICENSE APPLICATION – RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION – PSHA CHARLESTON SOURCE

Reference: Letter from Joseph Sebrosky (NRC) to Andrea Sterdis (TVA), Request for Additional Information Letter No. BLN-RAI-LTR-155 related to SRP Section: 02.05.02 for the Bellefonte Units 3 and 4 Combined License Application, dated April 16, 2009.

This letter provides the Tennessee Valley Authority's (TVA) response to the Nuclear Regulatory Commission's (NRC) request for additional information (RAI) items included in the reference letter.

A response to each NRC request in the subject letter is addressed in the enclosure which also identifies any associated changes that will be made in a future revision of the BLN application.

If you should have any questions, please contact Tom Spink at 1101 Market Street, LP5A, Chattanooga, Tennessee 37402-2801, by telephone at (423) 751-7062, or via email at tespink@tva.gov.

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

Executed on this 11th day of May, 2009.

Andrea L. Sterdis
Manager, New Nuclear Licensing and Industry Affairs
Nuclear Generation Development & Construction

Enclosure
cc: See Page 2

cc: (w/ Enclosures)
J. P. Berger, EDF
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A. M. Monroe, SCE&G
C. R. Pierce, SNC
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Enclosure
TVA letter dated May 11, 2009
RAI Responses

Responses to NRC Request for Additional Information letter No. 155 dated April 16, 2009
(5 pages, including this list)

Subject: PSHA Charleston Source in the Final Safety Analysis Report

RAI Number	Date of TVA Response
02.05.02-10	This letter – see following pages

Associated Additional Attachments / Enclosures	Pages Included
Attachment 02.05.02-10A	2
Attachment 02.05.02-10B	2
Attachment 02.05.02-10C	2
Attachment 02.05.02-10D	2

NRC Letter Dated: April 16, 2009

NRC Review of Final Safety Analysis Report

NRC RAI NUMBER: 02.05.02-10

FSAR Section 2.5.2.4 describes the PSHA sensitivity study and update for the BLN site. For the Charleston source, Section 2.5.2.4 indicates that TVA used the TVA Dam Hazard Assessment, developed by Geomatrix (FSAR page 2.5-72). FSAR 2.5.2.4.4, "Updated PSHA," describes the Charleston repeating large magnitude earthquake source, as shown in FSAR Figure 2.5-268. Finally, FSAR Section 2.5.2.4.4.4, "PSHA Results," states that the Charleston source "was simplified to be represented by the Woodstock fault, because this fault is near the center of the alternative geometries and this fault has the highest weight among alternative geometries." Because this Charleston seismic source model has not been previously reviewed by the staff, please provide the following:

a) Clarify whether FSAR Figure 2.5-268 is a representation of the Charleston source as done by Geomatrix for the TVA Dam Study.

b) Clarify whether mean hazard curves (1 and 10 Hz) for the Charleston source shown in FSAR Figures 2.5-272 and 273 are from the full Charleston source model (TVA Dam Study) or from the simplified single fault source (Woodstock fault). Also indicate whether these hazard curves have been through the CAV filter.

c) Indicate how the 6000-yr completeness event scenarios are incorporated into the Charleston source model as FSAR Figure 2.5-268 shows only one set of three scenarios for the 2000-yr completeness record. Have you considered 2 sigma confidence range in your evaluation of recurrence times for paleoliquefaction events? Also indicate how different Mmax values are incorporated into the logic tree. As currently shown, FSAR Figure 2.5-268 appears to be missing several branches.

d) Describe the development of the Charleston source model in terms of the process used to incorporate epistemic uncertainty. Did the TVA Dam Study by Geomatrix use the SSHAC process to elicit expert opinion?

e) For the simplified single fault model used for the updated PSHA, provide the range of maximum magnitudes along with their corresponding weights as well as the logic tree for the single fault source model.

f) In order for the staff to perform a sensitivity study of the Charleston source for the BLN site, please provide 1 and 10 Hz mean seismic hazard curves for the Charleston source for both the simplified single fault model (used for the actual PSHA) and the full source model (TVA Dam Study). Provide the actual numerical values of each hazard curve in text format. Please also provide these sets of hazard curves both with and without the CAV filter. In addition, provide the coordinates of the two endpoints for the Woodstock fault (lat, lon) used for the simplified single fault source model.

BLN RAI ID: 3314

BLN RESPONSE:

a. BLN FSAR Figure 2.5-268 is a representation of the Charleston source as done by Geomatrix for the TVA Dam Study (Reference 269). This figure is a reproduction without modification of Figure 2-34 of the TVA Dam Study, which was provided in a previous letter (ML0810704703). This figure will become FSAR Figure 2.5-268A as shown in Attachment 02.05.02-10A in a future revision of the BLN COLA.

.

b. The mean hazard curves (1 and 10 Hz) for the Charleston source shown in FSAR Figures 2.5-272 and 2.5-273 are from the simplified model using the Woodstock fault. These curves were calculated with the CAV filter.

c. The Charleston source characterization logic tree, FSAR Figure 2.5-268 and new Figure 2.5-268A, is simplified and does not include all possible branches. Missing are branches for maximum earthquake magnitudes, mean repeat times, and the two different durations (completeness intervals) of the paleoliquefaction record. These three branches are discussed in FSAR Subsection 2.5.2.4.4.2.3 and data for the branches presented in FSAR Tables 2.5-215, 2.5-216, and 2.5-217. FSAR Subsection 2.5.2.4.4.2 will be modified to reflect this information as indicated below in the COL Application Revision Section of this response. The 6,000-yr completeness event scenarios are not incorporated into the analysis of hazard as they were not considered to have a significant effect on the results. The exclusive use of the 2,000 year completeness interval will produce a slightly greater hazard because the mean repeat times for this interval are shorter relative to the 6,000 year interval. Both the 2,000 year completeness records for scenarios 1, 2 and 3 and the 6,000 (actually 5,800) year completeness records for scenarios 4, 5 and 6 are provided in FSAR Table 2.5-215.

Uncertainties in maximum magnitude values are included in the hazard analysis and are depicted on the simplified Woodstock fault logic tree (New FSAR Figure 2.5-268B shown in Attachment 02.05.02-10B). The data that supports the magnitudes shown in the logic tree are found in FSAR Table 2.5-216. As a simplification, the magnitude and weight data shown on branch (4) of logic tree are a combination of the magnitude and weight data from two references listed in FSAR Table 2.5-216- Martin and Clough (1994) (FSAR Section 2.5 Reference 298) and Johnston (1996) (FSAR Section 2.5 Reference 297). As a further simplification, a uniform uncertainty of ± 0.25 is assigned to the magnitude on each branch (1) through (4) as defined in the characteristic magnitude distribution developed by Youngs and Coppersmith (FSAR Section 2.5 Reference 357). FSAR Subsection 2.5.2.4.4.4 will be revised to include discussion of revised Figure 2.5-268A and B as indicated in the COL Application Revisions Section of this response.

Both 2-sigma and 1-sigma confidence ranges were considered in developing recurrence times from the paleoliquefaction age data. However, as described in Subsection 2.5.2.4.4.2.3, considering higher confidence levels in the ages of paleoliquefaction events (e.g., 2-sigma age ranges) can result in fewer interpreted earthquake events. By using the 1-sigma confidence ranges, the maximum number of events is interpreted, resulting in recurrence times that are at least as conservative as would result from using the 2-sigma ranges.

The identified FSAR changes will be implemented in a future revision of the BLN COLA.

d. The Charleston seismic source model was developed using a Senior Seismic Hazard Analysis Committee (SSHAC) level 2 process. This process addresses epistemic uncertainty, as described in an excerpt from the TVA dam study (FSAR Section 2.5 Reference 269), page 3 [FSAR References added].

> "The scope of the present study [TVA dam study, FSAR Reference 269] would be characterized by SSHAC (1997) [FSAR Reference 235] as Level II. The epistemic uncertainties in the PSHA model have been quantified by the project team based on review of the literature and discussion with active researchers. However, it is important to note that these assessments are based in part on the results of three studies focused on quantification of epistemic uncertainty in seismic hazards in the CEUS using expert elicitation. The first is the EPRI-SOG study completed in the late 1980's (EPRI-SOG, 1988 [FSAR Reference 203]).
>
> This study involved quantification of the uncertainty in seismic source characterization in the CEUS by formal elicitation of six expert teams. The EPRI-SOG study can be considered the prototype of a SSHAC Level IV analysis. The second study conducted by Lawrence Livermore National Laboratory (LLNL) (Savy et al., 1998 [FSAR Reference 234]) was a trial

> implementation project (TIP) of the SSHAC guidance for a Level IV analysis. Although focused primarily on process, the LLNL TIP study provided assessments for some of the seismic sources significant to the TVA region. The third study addressed characterization of earthquake ground motions in the CEUS. The EPRI (2003) [FSAR Reference 350] study was a SSHAC Level III analysis that used a panel of ground motion experts to guide the work of a project team in characterizing the uncertainty in CEUS ground motions. In addition, the USGS's National Seismic Hazard Mapping Program (Frankel et al., 1996, 2002) [FSAR References 349, 348] involves gathering input from many researchers through regional workshops. Although the USGS program does not use formal expert elicitation and full uncertainty quantification, the resulting seismic hazard model provides information on the current understanding of the seismic potential of the region and the catalog of recorded earthquakes."

In characterizing the Charleston seismic source, a number of active researchers were consulted during the course of the TVA dam study (Reference 269). Dr. Pradeep Talwani of the University of South Carolina, Dr. Dave Amick of Ebasco Services and Dr. R. Wheeler provided insight on the paleoliquefaction evidence. Dr. Arch Johnston of University of Memphis, and Dr. Gil Bollinger of Virginia Tech (retired) were consulted regarding maximum magnitude estimates.

e. The simplified single fault model logic tree is described below and presented graphically in Attachment 02.05.02-10B. For the Woodstock fault, maximum magnitude values and weights (in parentheses) were as follows (with magnitudes given as moment magnitudes): 6.8 (0.2), 6.9 (0.35), 7.0 (0.1), 7.3 (0.35). These magnitude values represent characteristic magnitudes with a range that is $\pm$0.25 magnitude units of the indicated value. The data and references from which these magnitudes are derived are provided in FSAR Table 2.5-216. The distribution of annual rates of occurrence was represented with a discrete distribution with the following values and weights (in parentheses): 1.50E-7 (0.083), 2.51E-5 (0.167), 1.31E-3 (0.5), 3.23E-3 (0.167), and 5.65E-3 (0.083). The logic tree for the single fault (Woodstock) source had two nodes: one for maximum magnitude (with 4 branches and weights, as indicated above) and one for annual rate (with 5 branches and weights, as indicated above). The two nodes (maximum magnitude and annual rate) have values that are independent. The simplified Woodstock fault logic tree will be added to the FSAR as Figure 2.5-268B (as shown in Attachment 02.05.02-10B) in a future revision of the BLN COLA.

f. Seismic hazard curves for 10 Hz and 1 Hz are archived in tables attached to this response (Attachments 02.05.02-10C and 02.05.02-10D). Results labeled "Charleston complete" were calculated with the complete TVA Charleston model, and results labeled "Woodstock only" were calculated with only the Woodstock fault. Results were calculated both with and without the CAV filter, and were calculated using the revised sigmas from EPRI (2006) [FSAR Reference 362]. End points (lon, lat) for the Woodstock fault are as follows: (80.080, 33.222) (80.324, 32.744).

This response is PLANT-SPECIFIC.

ASSOCIATED BLN COL APPLICATION REVISIONS:

1. COLA, part 2, Chapter 2, Subsection 2.5.2.4.4.2, will be revised from:

An updated source characterization logic tree for repeating large magnitude Charleston earthquakes based on these new data is presented in Figure 2.5-268, and the basis for the alternative characterizations is described as follows.

To read:

An updated source characterization logic tree for repeating large magnitude Charleston earthquakes based on these new data is presented in Figure 2.5-268A. The logic tree is simplified and does not include all possible branches. Missing are branches for maximum earthquake magnitudes, mean repeat times, and the two different durations of the paleoliquefaction record, or "completeness intervals. Data for the three branches are presented in Tables 2.5-215, 2.5-216, and 2.5-217, and the basis for the alternative characterizations is described as follows.

2. COLA, part 2, Chapter 2, Subsection 2.5.2.4.4.4, will be revised from:

The Charleston source was simplified to be represented by the Woodstock fault (see Figure 2.5-262), because this fault is near the center of the alternative geometries and this fault has the highest weight among alternative geometries (see Figure 2.5-268). Further, the Charleston source contributes only a small percentage of the hazard at BLN, as is discussed below. This simplification does not affect hazard results in a significant way.

To read:

The Charleston source was simplified to be represented by the Woodstock fault (see Figure 2.5-262), because this fault is near the center of the alternative geometries and this fault has the highest weight among alternative geometries (see Figure 2.5-268A). Further, the Charleston source contributes only a small percentage of the hazard at BLN, as is discussed below. This simplification does not affect hazard results in a significant way. A simplified logic tree for the Woodstock source is presented in Figure 2.5-268B. The hazard analysis is based on Scenarios 1, 2, and 3 and does not account for events in the 6,000-yr interval of the paleoliquefaction record.

3. COLA Part 2, Chapter 2, Figure 2.5-268 will be renumbered to Figure 2.5-268A.

4. COLA Part 2, Chapter 2, will be revised to add new Figure 2.5-268B.

ASSOCIATED ATTACHMENTS/ENCLOSURES:

Attachment 02.05.02-10A	Charleston source logic tree, new FSAR Figure 2.5-268A
Attachment 02.05.02-10B	Simplified Woodstock fault logic tree, new FSAR Figure 2.5-268B
Attachment 02.05.02-10C	10 Hz Hazard at Bellefonte from Charleston source
Attachment 02.05.02-10D	1 Hz Hazard at Bellefonte from Charleston source

Attachment 02.05.02-10A

New Figure 2.5-268A
(from current FSAR Figure 2.5-268)

Source Characterization Logic Tree for

Repeating Large Magnitude Charleston Earthquakes

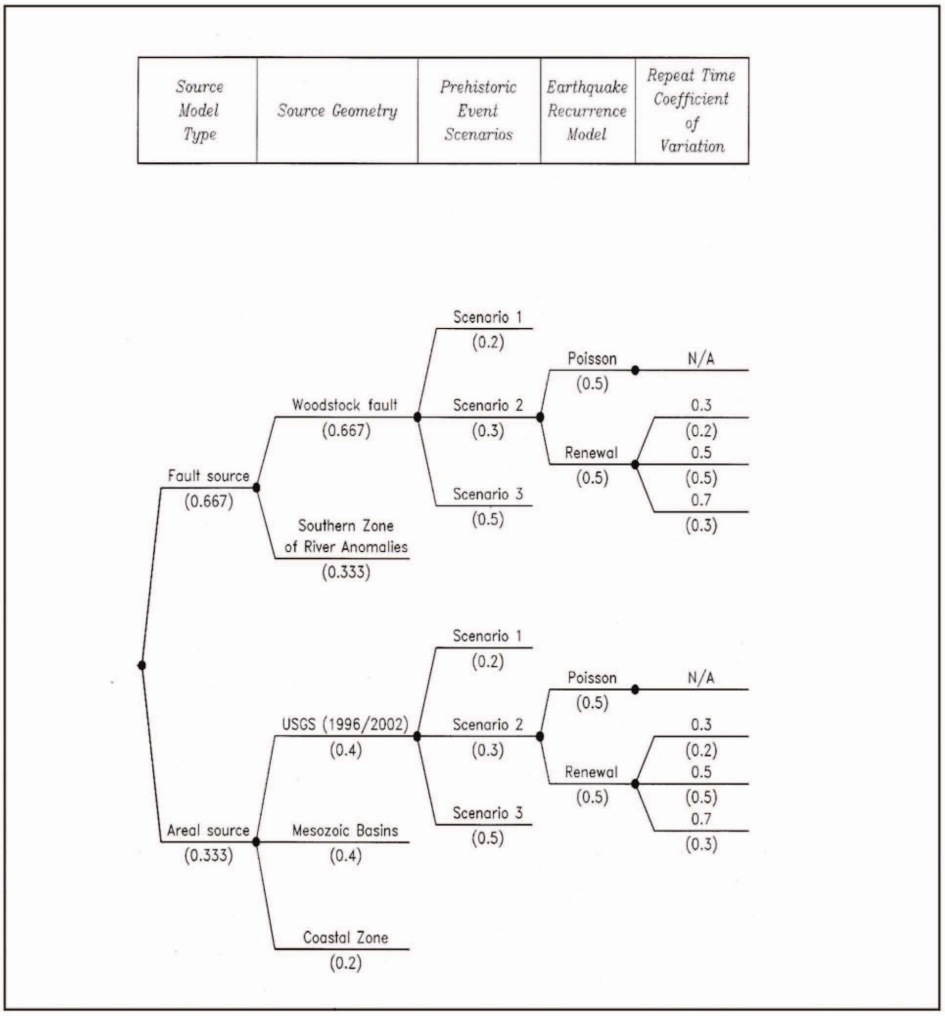
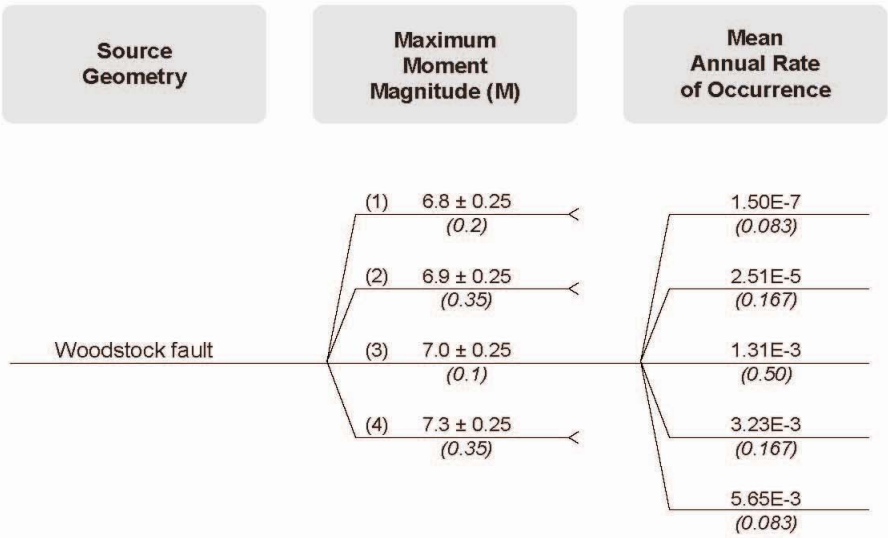


FIGURE 2.5-268A
Source Characterization Logic Tree for Repeating Large Magnitude Charleston Earthquakes

Attachment 02.05.02-10B

New FSAR Figure 2.5-268B

Simplified Woodstock Fault Logic Tree



Explanation

Sub-branches not shown but are the same as for branch (3)

(0.35) Weight

Note: Magnitudes are derived from data in Table 2.5-216.

FIGURE 2.5-268B
Simplified Woodstock Fault Logic Tree

Attachment 02.05.02-10C

10 Hz Hazard at Bellefonte from Charleston source representations

10 Hz Hazard at Bellefonte from Charleston source representations

	Woodstock only	Charleston Complete	Woodstock only	Charleston Complete
10 Hz ampl.	Non-CAV	Non-CAV	CAV	CAV
1.00E-03	1.64E-03	1.64E-03	7.47E-06	6.22E-06
1.50E-03	1.61E-03	1.61E-03	7.47E-06	6.22E-06
2.00E-03	1.58E-03	1.57E-03	7.47E-06	6.22E-06
3.00E-03	1.50E-03	1.47E-03	7.47E-06	6.22E-06
5.00E-03	1.30E-03	1.25E-03	7.47E-06	6.22E-06
7.00E-03	1.11E-03	1.05E-03	7.47E-06	6.22E-06
1.00E-02	8.58E-04	7.98E-04	7.47E-06	6.22E-06
1.50E-02	5.71E-04	5.21E-04	7.47E-06	6.22E-06
2.00E-02	3.93E-04	3.55E-04	7.47E-06	6.22E-06
3.00E-02	2.08E-04	1.86E-04	7.46E-06	6.22E-06
5.00E-02	8.00E-05	7.09E-05	7.34E-06	6.12E-06
7.00E-02	3.97E-05	3.50E-05	6.91E-06	5.76E-06
1.00E-01	1.78E-05	1.55E-05	5.69E-06	4.74E-06
1.50E-01	6.35E-06	5.44E-06	3.44E-06	2.86E-06
2.00E-01	2.76E-06	2.33E-06	1.92E-06	1.59E-06
3.00E-01	7.06E-07	5.88E-07	6.06E-07	4.99E-07
5.00E-01	8.88E-08	7.24E-08	8.50E-08	6.92E-08
7.00E-01	1.79E-08	1.44E-08	1.76E-08	1.42E-08
1.00E+00	2.63E-09	2.10E-09	2.61E-09	2.09E-09
1.50E+00	2.25E-10	1.79E-10	2.25E-10	1.78E-10
2.00E+00	3.29E-11	2.60E-11	3.29E-11	2.59E-11
3.00E+00	1.61E-12	1.27E-12	1.63E-12	1.27E-12
5.00E+00	3.87E-24	6.48E-16	7.14E-16	1.30E-15
7.00E+00	1.67E-33	5.29E-30	1.23E-26	9.65E-20
1.00E+01	1.67E-33	4.34E-30	1.67E-33	4.34E-30

Attachment 02.05.02-10D

1 Hz Hazard at Bellefonte from Charleston source representations

1 Hz Hazard at Bellefonte from Charleston source representations

	Woodstock only	Charleston Complete	Woodstock only	Charleston Complete
1 Hz ampl.	Non-CAV	Non-CAV	CAV	CAV
5.00E-04	1.64E-03	1.64E-03	7.47E-06	6.22E-06
7.00E-04	1.62E-03	1.61E-03	7.47E-06	6.22E-06
1.00E-03	1.57E-03	1.55E-03	7.47E-06	6.22E-06
1.50E-03	1.49E-03	1.45E-03	7.47E-06	6.22E-06
2.00E-03	1.39E-03	1.34E-03	7.47E-06	6.22E-06
3.00E-03	1.20E-03	1.14E-03	7.47E-06	6.22E-06
5.00E-03	8.94E-04	8.31E-04	7.46E-06	6.22E-06
7.00E-03	6.75E-04	6.18E-04	7.45E-06	6.21E-06
1.00E-02	4.61E-04	4.16E-04	7.40E-06	6.16E-06
1.50E-02	2.67E-04	2.37E-04	7.21E-06	6.00E-06
2.00E-02	1.68E-04	1.48E-04	6.88E-06	5.71E-06
3.00E-02	7.91E-05	6.84E-05	5.95E-06	4.91E-06
5.00E-02	2.54E-05	2.16E-05	3.98E-06	3.25E-06
7.00E-02	1.07E-05	8.93E-06	2.54E-06	2.06E-06
1.00E-01	3.79E-06	3.12E-06	1.31E-06	1.05E-06
1.50E-01	9.84E-07	7.96E-07	4.73E-07	3.76E-07
2.00E-01	3.34E-07	2.68E-07	1.93E-07	1.52E-07
3.00E-01	6.04E-08	4.76E-08	4.22E-08	3.28E-08
5.00E-01	4.95E-09	3.82E-09	4.04E-09	3.11E-09
7.00E-01	7.60E-10	5.81E-10	6.65E-10	5.06E-10
1.00E+00	8.52E-11	6.45E-11	7.83E-11	5.91E-11
1.50E+00	5.42E-12	4.05E-12	5.16E-12	3.86E-12
2.00E+00	6.34E-13	4.70E-13	6.14E-13	4.54E-13
3.00E+00	2.56E-24	1.75E-16	1.47E-14	1.04E-14
5.00E+00	1.67E-33	4.34E-30	4.96E-26	8.96E-20