Schaperow, Jason

From: Schaperow, Jason
Sent: Wednesday, January 05, 2011 5:35 PM
To: 'Bixler, Nathan E'; Tinkler, Charles
Cc: Chang, Richard
Subject: RE: mark up
Attachments: Siting Study ComparisonRev5.doc

On my PC, all of the changes in the attached document are in blue. I am thinking I need to learn how to manipulate the reviews' colors. I did find a drop down menu under "show markup" that listed 2 reviewers: nbixler and CGT. Next to nbixler was a red box, and next to CGT was a blue box.

From: Bixler, Nathan E [mailto:nbixler@sandia.gov]
Sent: Wednesday, January 05, 2011 5:28 PM
To: Tinkler, Charles; Schaperow, Jason
Subject: RE: mark up

Unfortunately, the x's I inserted this time are the same red as before, so they blend in.

Nate

From: Tinkler, Charles [mailto:Charles.Tinkler@nrc.gov]
Sent: Wednesday, January 05, 2011 3:14 PM
To: Bixler, Nathan E
Subject: mark up

Attached are my minor markups to the version you sent me.

Charles Tinkler
Charles.Tinkler@nrc.gov

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~~7.3.6~~1.1.1 Comparison with the Siting Study

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This subsection discusses the results of a comparison of scenario-specific risk between xxx SOARCA and the 1982 Siting Study analysis for~~best-effort attempt to reproduce the Sandia Siting Study results for Peach Bottom using~~ the SST1 source term. Since the 1982 Siting Study does not provide latent cancer results at distances that are meaningful xxx and comparable to those in provided in the SOARCA study or to the NRC safety goal, an effort was made to reproduce the Sandia Siting Study results for Peach Bottom using the SST1 source term in order to produce results that are directly comparable to the SOARCA results. An exact reproduction of those results ~~is~~ was not ~~possible~~ feasible because the CRAC2 code is no longer available and some of the models and modeling choices used in the Siting Study cannot be readily reconstructed~~are difficult or impossible to reconstruct~~. The current successor to the CRAC2 code, MACCS2, shares a number of models with its ancestor, but other models have been improved and therefore produce different results. However, those model parameters that were known or presumed to have been used in the 1982 Siting Study were used to in an effort to reproduce the results of that study. The results presented in this appendix were all computed with MACCS2 version 2.5.

~~Part of t~~The motivation for this ~~study work~~ calculation is to establish ~~a~~ another point of comparison between the ~~Sandia~~ 1982 Siting Study and ~~this current work~~SOARCA. The previous subsection (**Error! Reference source not found.**) provides a comparison of scenario-specific risk focusing solely on source terms, using the oft-cited SST1 source term from the 1982 Siting Study. This additional comparison seeks to ~~explore~~ examine ~~a~~ scenario-specific risk using all aspects of the 1982 Siting Study, as best as can be reproduced. ~~to the extent they can be understood and recreated~~. Key aspects of the modeling ~~choices~~ are discussed in the following subsection. **Error! Reference source not found.**.
~~Such a comparison is not straightforward because SOARCA results are presented as average individual risks for acute and latent cancer fatalities at distances up to 50 miles from the plant; the Siting Study results were presented as mean early fatalities, mean early injuries, and mean latent cancer fatalities within a large distance of the site. The distance is difficult to determine, but population data are presented out to 200 miles, so that may be the outer distance considered in the study. Later studies, like NUREG-1150, chose 1000 miles as the outer radius, so that distance could have been used in the Siting Study as well. Fortunately, the predictions are not very sensitive to the choice of outer radius when it is in the range of 200 to 1000 miles. Acute fatalities and injuries do not occur at all as such large distances; predicted latent cancer fatalities using the LNT dose-response model only vary by about 20% over this range of distances. Other uncertainties in the reconstruction of the Siting Study results create much larger differences, as discussed in the subsequent paragraphs.~~

Table 32 compares the release fractions from the Peach Bottom unmitigated STSBO ~~sequence~~ scenario and the SST1 source term. The unmitigated STSBO sequence was chosen for this comparison because it is the largest of the source terms for Peach Bottom that were evaluated as part of the SOARCA investigation. Its frequency is only 3×10^{-7}/yr compared with the frequency assigned to the SST1 source term of 10^{-5}/yr.

Table 1 ~~Table 32~~ Total Release Fractions by Chemical Group Comparison between the SST1 and the SOARCA Unmitigated STSBO Peach Bottom Sequences

	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SOARCA	0.970	0.015	0.025	0.062	0.063	0.000	0.003	0.001	0.000
SST1	1.000	0.670	0.070	0.450	0.640	0.050	0.050	0.009	0.009

The last subsection, **Error! Reference source not found.**, compares the results and shows that predicted risk has diminished markedly between the time of the 1982 Siting Study and the current SOARCA study. Some of the comparisons are based on the linear, no-threshold dose-response model, the only one used at the time of the 1982 Siting Study. Comparisons are also provided for two levels of dose truncation.~~Another part of the motivation for this appendix is to lay out the important changes in modeling approaches between the time of the Sandia Siting Study (1982) and this current SOARCA study, which is done in the next section. The last subsection compares the results. Comparisons are based on the linear, no-threshold dose-response model, which was the only one used at the time of the Sandia Siting Study.~~

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~~7.3.6.1~~1.1.1.1 Comparison of Modeling ~~Choices~~

Table 33 compares key modeling choices and parameters used in the ~~Sandia~~ 1982 Siting Study with those used in SOARCA for Peach Bottom. This table ~~is~~ ~~not comprehensive~~ reflects our understanding of the differences in key modeling aspects between these 2 studies. ~~undoubtedly incomplete; it does, however, represent the set of modeling choices that were discovered or suspected to be different~~. Some of the modeling choices listed in the table could be established with a reasonable degree of certainty from the ~~Sandia~~ 1982 Siting Study documentation; others represent best ~~guesses~~ judgments as to how consequence analyses were performed at the time of the Siting Study. Generally, those judgments were based on NUREG-1150 or WASH-1400 modeling practices. Best ~~guesses~~ judgments or approximations are denoted with an asterisk in the table. Each of the modeling choices shown in the table are discussed below.

Weather Sampling The exact strategy that was used in the Siting Study is unknown. The Siting Study does show a binned representation of each of the weather files used in the study, so it is highly likely that weather binning was used. Also, the exact weather data that were used in the study are unknown. (what do we know? We know they used site specific wind rose data) Weather sampling used in this reconstruction uses the current Peach Bottom weather file and the NUREG-1150 choices for weather bin structure and samples per bin.

Habitability Criterion The habitability criterion used in the Siting Study was 25 rem over 30 years. This criterion leads to higher long-term doses than the one used in SOARCA, which is 500 mrem over 1 year.

Emergency Response Emergency response was treated simplistically and conservatively in the Sandia Siting Study; the SOARCA treatment of emergency response is more complex and realistic. For example, 30% of the population began to evacuate by 2 hours after accident initiation in the Siting Study; whereas, almost 93% of the population have begun to evacuate by 2 hours in the STSBO scenario. Also, SOARCA uses the more realistic network evacuation model to represent traffic on designated emergency routes. This model was not developed until

after the Siting Study. The evacuation speed, 10 MPH, used in the Siting Study leads to faster evacuation than in the SOARCA representation of Peach Bottom once evacuation begins.

Table 2 ~~Table 33~~ Comparison of Modeling Choices and Parameters Used to Reconstruct Sandia Siting Study Results with the Peach Bottom Unmitigated STSBO from SOARCA

Modeling Choice or Parameter	Siting Study	SOARCA
Weather Sampling	142 Trials*	984 Trials
Habitability Criterion	25 rem in 30 yr	0.5 rem in 1 yr
Emergency Response	3 Cohorts	6 Cohorts
	30% Evacuate at 2 hr	37.2% Evacuate at 1.0 hr
	40% Evacuate at 4 hr	55.5% Evacuate at 2.0 hr
	30% Evacuate at 6 hr	6.8% Evacuate at 5.25 hr
		0.5% Do Not Evacuate
KI Ingestion	No One Takes KI	50% Take KI with 70% Efficacy
Number of Sectors	16	64
Fission Product Inventory	Low Burnup	Mid-Cycle High Burnup
Deposition Velocity	1 cm/s	0.05 to 1.7 cm/s
Mixing Height	Annual Ave.	Day & Night Seasonal Ave.
Risk Factors for Cancers	BEIR III*	BEIR V
Population Basis Year	~~1970~~1980	2005
Groundshine Weathering	WASH-1400*	MACCS2
Relocation Criteria		
Normal	25 rem / 24 hr*	1 rem / 24 hr
Hot Spot	50 rem / 12 hr*	5 rem / 12 hr
Plume Meander Model	MACCS2*	None
Dose Conversion Factors	ICRP-26, -30*	FGR-13
Food Ingestion Model	COMIDA2*	None

* Best judgment or approximation

~~**Weather Sampling** The exact strategy that was used in the Siting Study is unknown. The Siting Study does show a binned representation of each of the weather files used in the study, so it is highly likely that weather binning was used. Also, the exact weather data that were used in the study are unknown. Weather sampling used in this reconstruction uses the current Peach Bottom weather file and the NUREG-1150 choices for weather bin structure and samples per bin.~~

~~**Habitability Criterion** The habitability criterion used in the Siting Study was 25 rem over 30 years. This criterion leads to higher long-term doses than the one used in SOARCA, which is 500 mrem over 1 year.~~

~~**Emergency Response** Emergency response was treated simplistically and conservatively in the Sandia Siting Study; the SOARCA treatment of emergency response is more complex and realistic. For example, 30% of the population began to evacuate by 2 hours after accident~~

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~~initiation in the Siting Study; whereas, almost 93% of the population have begun to evacuate by 2 hours in the STSBO scenario. Also, SOARCA uses the more realistic network evacuation model to represent traffic on designated emergency routes. This model was not developed until after the Siting Study. The evacuation speed, 10 MPH, used in the Siting Study leads to faster evacuation than in the SOARCA representation of Peach Bottom once evacuation begins.~~

KI Ingestion KI was not distributed at the time of the Siting Study. Because it was not distributed, no model for the effect of KI ingesting had been developed. Distribution of KI is relatively common now and is realistically accounted for in the SOARCA study.

Number of Sectors The only option available at the time of the Sandia Siting Study was to model wind directions using 16 compass sectors. That capability has been extended, and SOARCA takes advantage of the full 64-sector capability in the current version of MACCS2.

Fission Product Inventory ~~Burnups at the time of the Siting Study were much lower than today.~~ The Siting Study report provides the fission product inventory used in that study. The inventory used for the SOARCA evaluation of Peach Bottom was based on current fuel cycle practices -at Peach Bottom and assumes that the accident occurs mid-cycle~~. The values are~~ and is laid out in Appendix A.1. Why not simply explicitly compare cesium-137 inventories?

Deposition Velocity

Dry deposition of aerosol particles is represented through a set of aerosol size bins. Each size bin represents a range of aerosol sizes, usually characterized by a mass median diameter. Each aerosol bin is assigned a dry deposition velocity. The set of dry deposition velocities are used by MACCS2, along with airborne aerosol concentrations that are calculated using the Gaussian plume approximation, to determine the ground concentrations.

Common practice from the time of the Siting Study through NUREG-1150 was to treat a single aerosol bin using a representative deposition velocity of 1 cm/s. The current practice, used in SOARCA, uses all of the aerosol data from MELCOR. These data are for 10 aerosol bins, each representing a range of aerosol sizes. The representative deposition velocities for the 10 bins range from 0.05 for the smaller particles to 1.7 cm/s for the larger ones. This still does not give a sense of the dominant size for offsite health effects.

Mixing Height The Siting Study report shows mean annual daytime mixing heights for each site location. Apparently, a single mixing height was used to represent the entire year. In SOARCA, seasonal average daytime and nighttime mixing heights are used.

Risk Factors for Cancer Cancer risk factors used in the ~~Sandia~~ 1982 Siting Study are presumed to have come from the BEIR III report, which would have been the latest available at the time. Cancer risk factors in the SOARCA study are based on BEIR V even though the BEIR VII study had been published before SOARCA started. BEIR V was chosen because the treatment of tissues is consistent with the FGR-13 dose conversion factors. The BEIR V risk factors are about a factor of 2.7 higher than those from BEIR III, so this single change in modeling parameters significantly affects the predicted cancer risks.

Population Basis Year To simplify recreation of the Siting Study results for Peach Bottom, the NUREG-1150 site file, which is for 1980, was used. Data provided in the Siting Study report give population densities at low resolution and would have been difficult to convert into a site file. This NUREG-1150 site file is based on the year 1980 rather than basis year for the Siting Study, which is believed to be 1970. ~~Fortunately~~However, individual risks only depend on the relative locations of the population, not on the total population. From that standpoint, the 1980 population data used to reconstruct the Siting Study should have a minor effect on the comparison presented below.

Groundshine Weathering The Siting Study report did not document the parameters used in the groundshine weathering model. It was judged that the model might have been the same as the one used in WASH-1400, which predated the Siting Study. The SOARCA model for groundshine weathering is the same as the one used in NUREG-1150. The specific model used turns out to play a small role for a large, early release like the SST1 source term because most of the doses are during the emergency phase. Weathering occurs during the long-term phase.

Relocation Criteria The values used for normal and hot-spot relocation were not described in the Siting Study report, so the values were assumed to be the same as those used in NUREG-1150. The SOACA dose values to trigger relocation were much smaller, but the relocation times were the same.

Plume Meander Model The plume meander model used in the Siting Study was assumed to be the same as the one used in NUREG-1150. Plume meander was not treated in SOARCA. We should either justify why not and/or state the effect

Dose Conversion Factors The original version of MACCS2 was distributed with a set of dose conversion factors (DCFs) using tissue weighting factors from ICRP-26 and organ-specific DCFs from ICRP-30. These publications predated the Siting Study, so it is reasonable to expect that they were also used in the Siting Study. These DCFs were used in the reconstruction of the Siting Study SST1 results.

Food Ingestion Model No details of the ingestion pathway are provided in the Siting Study report, but it does mention that ingestion of contaminated food and milk were treated. The food ingestion model that would have been used certainly predates the implementation of the COMIDA2 food model, which first became available in MACCS2. Since the food model used in the Siting Study would be difficult or impossible to reconstruct, the COMIDA2 model was used as a stand in. For comparison, the food pathway was not treated in the SOARCA analyses.

Making all of the changes listed above plus replacing the Peach Bottom unmitigated STSBO source term with the SST1 source term resulted in a best-effort attempt to reproduce the Siting Study results. However, this effort over-predicted the Siting Study latent cancer results using the SST1 source term for Peach Bottom by ~~almost~~ about a factor of 2 at long distance (e.g. 500 miles).. ~~Clearly~~Thus, there are other changes in the models and parameter choices that were not captured in the attempt to ~~recreate~~reproduce this result. Nonetheless, even with this imprecision in recreating the 1982 study and a residual factor-of-2 bias in the results, this characterization of

the 1982 study at shorter, more meaningful distances that can be compared directly with the SOARCA results provides a useful comparison.~~Consequently, the comparisons presented below should not be viewed as accurately reflecting the difference between the Siting Study and the SOARCA predictions; rather, the comparison should be viewed as being uncertain within about a factor of two, with a bias toward the high end of the uncertainty range.~~

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~~7.3.6.2~~1.1.1.2 **Comparison of Results**

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Table 3 ~~Table 34~~ below compares the best-estimate Sandia Siting Study conditional probabilities of an excess, individual latent cancer fatality using the SST1 source term with those for the unmitigated STSBO scenario evaluated in SOARCA. The comparison shows that the conditional probabilities within 10 miles of the plant are higher by about a factor of ~~514~~950. Accounting for a potential factor-of-2 bias, the ratio is about 25 within a 10-mile radius. Therefore, at the distance associated with the NRC Safety Goal for latent cancers, the risk predicted for SOARCA is substantially smaller than that predicted in the 1982 study. This ratio diminishes with increasing radius, becoming about a factor of 6 within a 50-mile radius. Again, accounting for a potential bias, the ratio may be more like a factor of 3. The decrease in the ratio from 25 to 3 occurs because relocation of the population beyond the 10-mile EPZ limits exposures during the emergency phase and the habitability criterion limits exposures during the long-term phase. However, implementing the habitability requirement results in significantly greater need for decontamination or condemnation of land in the case of the 1982 study than for SOARCA.

If these comparisons were made on the basis of unconditional risk, the factors would be much larger since the frequency of the Unmitigated STSBO is about a factor of 30 lower than the frequency estimated for the SST1 source term. The ratios on the basis of risk (1/reactor year) are therefore about 800 for residents living within 10 miles of the plant and about 100 for residents living within 50 miles of the plant.

Table 3 ~~Table 34~~ Conditional, i.e., Assuming the Accident Occurs, Mean, Latent-Cancer Fatality Probabilities (dimensionless) Using a LNT Dose-Response Model for Residents within the Specified Radii of the Peach Bottom Site. Probabilities Are for the Recreation of the Sandia Siting Study Using the SST1 Source Term at Peach Bottom and for the Unmitigated STSBO Calculated for SOARCA. Core Damage Frequencies Were Estimated to Be 10^{-5}/yr and $3 \cdot 10^{-7}$/yr for the SST1 and STSBO Source Terms, Respectively.

Radius of Circular Area (mi)	SST1	PB STSBO	Ratio SST1 to STSBO
10	7.6E-03	1.5E-04	51
20	2.1E-03	1.8E-04	12
30	9.2E-04	1.3E-04	7
40	5.3E-04	8.3E-05	6
50	4.2E-04	6.9E-05	6

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