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QA: N/A

JUL 06 2001

OVERNIGHT MAIL

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TOTAL SYSTEM PERFORMANCE ASSESSMENT ISSUES IDENTIFIED BY THE U.S. NUCLEAR REGULATORY COMMISSION (NRC)

Reference: Ltr, Reamer to Brocoum, dtd 5/17/01

In a May 4, 2001, conference call with the U.S. Department of Energy (DOE), the NRC identified apparent discrepancies in the *Total System Performance Assessment for Site Recommendation* (TSPA-SR), (TDR-WIS-PA-000001, Revision 00, ICN 1), the *Total System Performance Assessment Model for Site Recommendation* (MDL-WIS-PA-000002, Revision 00), model input files, and related hand computations. These potential discrepancies were discussed further in a conference call on May 9, 2001, and formally documented in the referenced letter. The referenced letter also expressed concerns regarding the programmatic and process implications of the identified discrepancies for the quality and adequacy of the TSPA-SR and its supporting technical documents.

The purpose of this letter is to provide the NRC with responses to the specific discrepancies identified in the subject letter (enclosure 1) and to outline DOE plans for additional evaluation of the potential quality issues that were raised.

Based on the discrepancies identified by the NRC and other potential quality issues identified by DOE, a comprehensive multi-phased management plan was developed and immediately implemented. Enclosure 2 is the Management Plan to address the identified quality issues for TSPA-SR and its supporting technical documents. This plan includes an evaluation of the processes under which the TSPA-SR were developed and additional review of the technical products to determine the extent of potential quality problems. These efforts are underway. This plan also provides the requisite flexibility to alter the approach as the results of the investigation and evaluation mature. This plan was discussed with you and the NRC staff at the Quarterly DOE/NRC Quality Assurance and Management Meetings on June 13, 2001.

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As requested by the NRC during the Quarterly Management Meeting, we will keep you informed of our progress in implementing the Management Plan. We will provide a report on our progress at the technical exchange on the Total System Performance Assessment and Integration (TSPA-I) Key Technical Issue currently scheduled for August 6-10, 2001. In addition, we have begun biweekly briefings to the NRC Onsite Representatives and will provide frequent updates to you and your staff on the status of implementation of the Management Plan. Should any further significant issues arise during our evaluation, we will notify you as soon as we have verified the concern.

Please direct any questions concerning this letter or enclosures to April V. Gil at (702) 794-5578.

Stephan Brocoum
Assistant Manager, Office of
Licensing and Regulatory Compliance

OL&RC:TCG-1358

Enclosures:
1. Response to Potential Discrepancies Identified by NRC in May 17, 2001, Correspondence
2. Management Plan for TSPA-SR and Other Continuing Quality Issues

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ENCLOSURE 1

Response to Specific Questions

in

NRC Letter of May 17, 2001
on TSPA Quality Issues

1. Section 6.3.4.2 In-Package Chemistry

NRC QUESTION: 1.1 Page 265, Table 6-42 (CRWMS, 2000a)

Calculated pH values fell outside the expected range of conditions for which the abstraction was developed. It was observed that the calculated and observed pH ranges fell outside of the calculated pH bound for pH_CDSP during the early time phase, even though DOE had indicated that no abstractions were utilized outside their range on page 559 of the TSPA-SR Model Report.

Given the input parameters and the response surface definitions, the calculated pH bounds (hand calculations) are consistent with an 'Early' time period where the GoldSim produced value and the hand calculation are consistent with a 'Late' time period. Both sets of values (the pH bounds and the pH values) are computationally correct, but they apply to different time periods. The median value problem GoldSim file was consulted and the observed values listed in the table were verified.

The errors in the table led the reviewers to conclude there is a potential error in the TSPA conceptual model abstraction for in-package chemistry. The 'Early' chemistry conditions should apply to all waste packages. As the packages fail over time, all of the packages in a bin will experience the 'Early' chemistry for the first X years (currently 1,000) conditional with their failure time. A package failing at 100,000 years will have 1,000 years of early chemistry conditions just as a package failing at 43,000 years would. The implications are that there won't be the very long unzipping times currently in the model. The peak mean dose at 100,000 years is likely underestimated.

DOE RESPONSE: The values of calculated pH for the times indicated (98,000 and 100,000 years) for the co-disposed spent fuel (CDSP) packages are correct, but are incorrectly labeled as 'Early' time values rather than the 'Late' time values they represent. The "calculated pH" and "observed pH" values are appropriate and consistent for 'Late' time, while the "calculated pH bound" is consistent with an 'Early' time period. The calculated pH bound is applicable for 'Early' time in the noted pH CDSP rows. This is a discrepancy in the documentation. The correct "calculated pH bound" for this 'Late' time should be as follows (with values reported to two significant figures):

Seepage Environment	Calculated pH Bound
Always Drip (t=98,000 years)	8.5 - 9.2
Intermittent Drip (t=100,000 years)	8.5 - 9.2
No Drip (t=98,000 yrs)	8.6 - 9.2

The calculated and observed values are within this range. The subject table will be corrected in the next revision of this document.

The discrepancies in the table are unrelated to the conceptual model of the in-package chemistry evolution. As noted on pages 259-260 of the subject document, a weighted-moving-average of in-package chemistry was selected to assure the in-package chemistry for the different waste package types modeled (CDSP and CSNF), different hydrologic environments (always drip, intermittent drip, never drip), and different infiltration rate bins was representative and reasonable. We believe this approximation is appropriate at times when a small number of waste packages have been degraded and the rate of waste package failure is increasing. We believe these chemistries are most appropriate during the 10,000 year time period of regulatory concern.

After the time period of regulatory concern (i.e., at time approaching 100,000 years) the calculated weighted-moving average pH will be affected by the average chemistry of all packages that would have degraded prior to that time. Although it is possible that the unzipping rate of the cladding may be increased with a different conceptual representation, this is not expected to have a significant effect on the peak mean dose.

The extent of potential non conservatism is expected to be insignificant for the following reasons which relate to the solubility of key radionuclides and the dissolution rate of the commercial spent nuclear fuel (CSNF) and unzipping rate of the Zircaloy cladding on the CSNF. While the lower pH of the packages that fail at any particular time would increase the Np (and other actinide) solubilities in the waste package, the invert pH would remain essentially unchanged. The invert would then be the controlling chemistry as far as actinide releases are concerned. In addition, at lower pH, the dissolution rate may be about a factor of 10 greater, which would have a corresponding change on the rate of unzipping of the cladding (see table 6-49 of subject reference). Such changes in dissolution rate and cladding degradation are insignificant to peak dose, because the peak is dominated by solubility-limited releases rather than the dissolution rate limited release radionuclides. Further discussion of this conceptual model is planned for the Total System Performance Assessment and Integration (TSPAI) Key Technical Issue (KTI) Technical Exchange.

NRC QUESTION: 1.2 Page 266, Table 6-43 (CRWMS, 2000a)

The Total Carbonate Concentrations in Table 6-43 (hand and model produced) are identical but can not be obtained by using the appropriate equation in Table 6-38 and the appropriate input conditions.

The DOE median-value file was reviewed and it was determined that the values listed in Table 6-43 of the document are produced in the model. It was observed that the median-value file, the base-case file for 1,000,000 years, and the hand calculation spreadsheet all used the wrong equation. The equation listed in Table 6-38 is correct based on a review of the input AMR. This error makes all of the TSPA-SR results incorrect; however, the impact to risk is unknown.

DOE RESPONSE: The exponent noted was incorrect in the GoldSim file. As noted, the equation used to calculate the in-package carbonate concentration in the GoldSim model input file should be that presented in Table 6-38, i.e.,

$$\text{Total\_CO3 (in mol/kg)} = 10^{-4.47} + 10^{-10.82}/10^{-pH} + 10^{-21.15}/10^{-2pH}$$

rather than the equation used in the GoldSim file and Table 6-43, i.e.,

$$\text{Total\_CO3 (in mol/kg)} = 10^{-4.47} + 10^{-8.1}/10^{-pH} + 10^{-21.15}/10^{-2\,pH}.$$

This discrepancy does not make the TSPA-SR results incorrect. Within the degree of accuracy required of the analyses, the TSPA-SR results are still correct; this discrepancy makes no difference to total system performance. The correct exponent would decrease the total carbonate concentration in the waste package by about 1000. Based on the relationship between carbonate concentration and commercial spent nuclear fuel dissolution rate given in equation 6-2, this would decrease the dissolution rate by approximately 10% (or approximately 0.4 $mg/m^2/day$). This is insignificant and conservative when taken to the total system performance measure of dose to an individual.

The discrepancy in the model will be corrected in subsequent analyses and the documentation will be corrected in a subsequent revision.

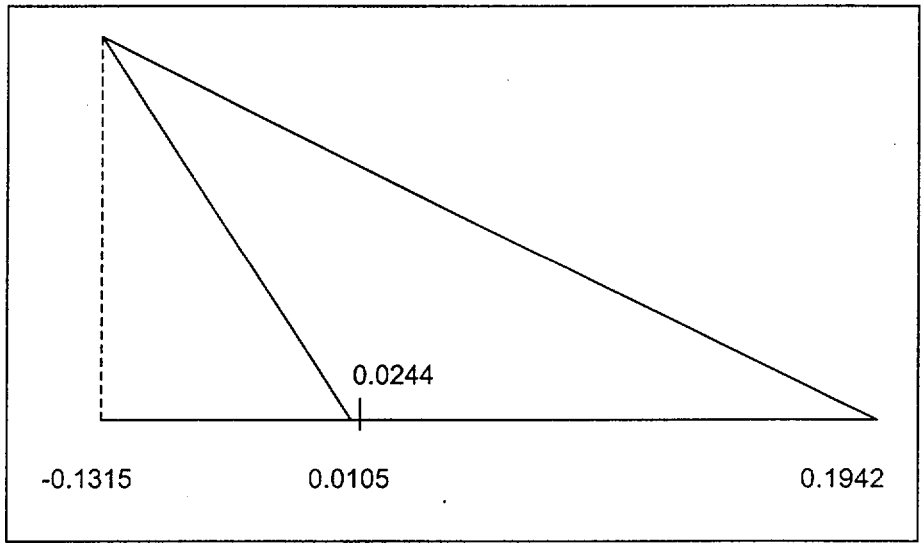
2. Section 6.3.4.3 Cladding Degradation Model (CRWMS, 2000a)

NRC QUESTION: The last paragraph on page 285 states, "Table 6-45 (linearly interpolated between points) is used to define the creep failure distribution (triangular) with the minimum equal to 0.0105, the mean equal to 0.0244, and the maximum equal to 0.1942." However, the triangular distribution in GoldSim uses the minimum value, maximum value, and most likely value, not the mean. It is not clear whether this problem represents a numerical problem, or if there are errors in the documentation and the checking of the documentation.

The information in the TSPA-SR Model Report appears to be incorrect. If the documentation is accurate with the description of the distributions by the minimum value, maximum value, and mean, then there may be a numerical error as discussed below.

If the mean is 0.0244, the peak of the distribution is at -0.1315. As shown in figure 1, the peak lies outside the range represented by the minimum and the maximum values. When parameters are sampled from such a distribution, values outside the range will have two probabilities of occurrence. One value cannot have two different probabilities of occurrence from any distribution function.

Similar arguments can be made to show that the peak for the triangular distribution presented on page 288 (*Unzip_uncert*, is defined as a triangular distribution with a minimum equal to 1, a mean equal to 40, and a maximum of 240) has a peak that lies outside the range (i.e., peak is at -121).



DOE RESPONSE: The document incorrectly uses the term "mean" rather than the correct term "most likely" with respect to the triangular distribution for the fraction of rods perforated from creep (Table 6-45 and page 285) and the unzipping uncertainty multiplier (*Unzip_uncert*, page 288). The input triangular distributions use minimum, most likely, and maximum values. As noted in the text (page 285), the median value for the triangular distribution for the fraction of rods perforated from creep is 0.069 at temperatures less than 177 C. The TSPA-SR model files

(GoldSim files) use the distribution correctly, as intended by the supporting AMR. The documentation will be clarified in a subsequent revision.

The correct distribution for the fraction of rods perforated from creep at peak waste package surface temperatures less than 177 C are illustrated below. Figure 1 is derived directly from the input file used to create the Nominal Scenario Base Case Median Value Simulation (SR00_0037ne6) while Figure 2 is a generic triangular distribution with the same minimum, most likely, and maximum values. [NOTE: Even though the value used for the "most likely" parameter is called 'Creep_Mean', it correctly represents the "most likely" value of the triangular distribution.]

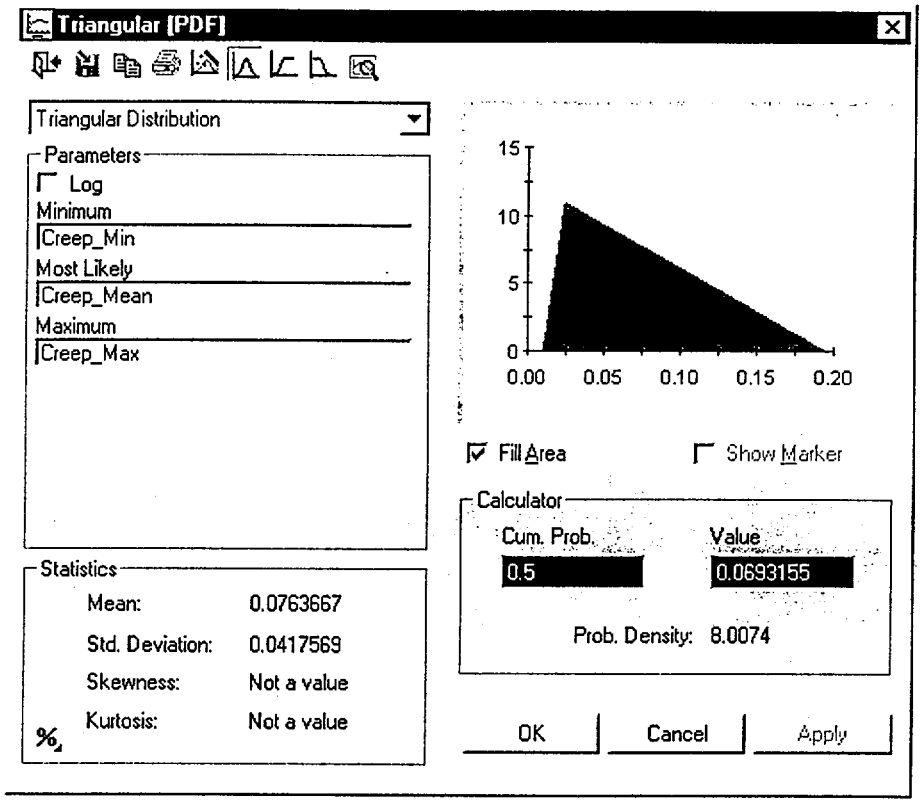


Figure 1. Distribution from SR00_037ne6.gsm file (Creep_Used_BIN4)

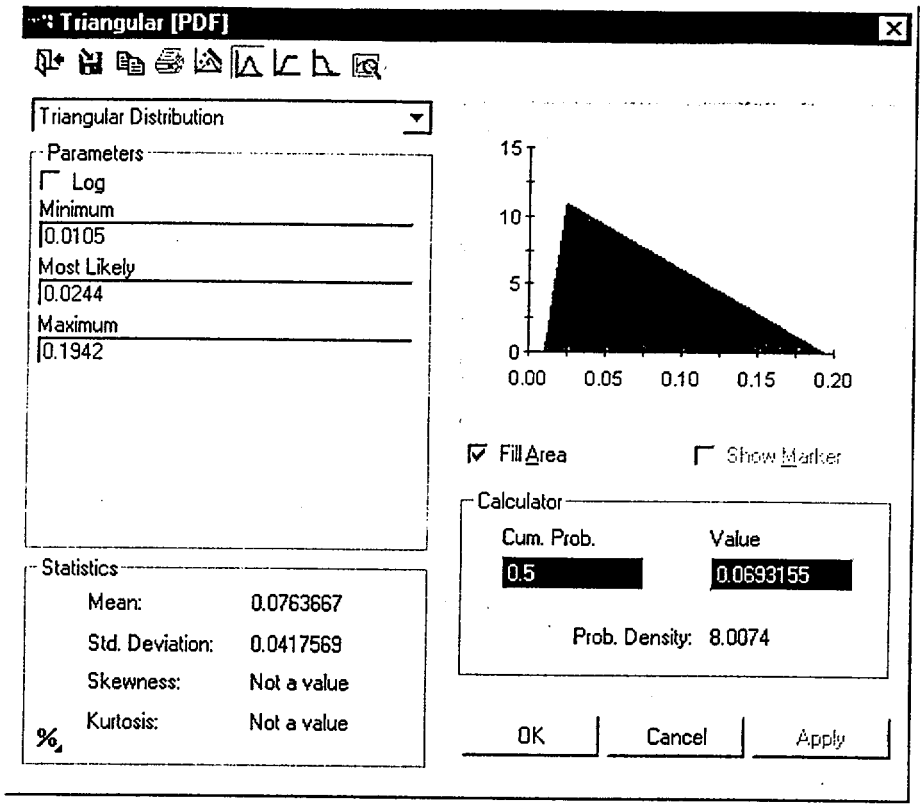


Figure 2. Distribution from a Generic GoldSim File

3. Section 6.3.4.4 Dissolution Rate Model

NRC Question: Page 301, Table 6-54 (CRWMS, 2000a)

The calculated values for High-Level Waste glass dissolution rate were not identical to the observed values. Differences in the precision of the values in the document are explained by DOE as being attributable to round-off error. In order to check the calculation, the staff put the appropriate values and equations into a spreadsheet; however, the differences could not be explained with round-off error. Similar problems are possible for the solubility limits calculations presented in Table 6-60 on page 316.

DOE RESPONSE: The difference is due to the fact that the Universal Gas Constant (R) used in the hand computation was 8.314×10^{-3} kJ/(mol K), while the R value in GoldSim is 8.31451×10^{-3} kJ/(mol K). When using the R value to 6 significant figures in Eq. 6-3, the table is correct to at least 5 significant figures and the difference is insignificant. Using Eq. 6-3 (page 296)

$$DR = S_{im}\, k_{eff}\, 10^{\eta\, pH} \exp(-E_a/RT)$$

and the following values described in the text, Table 6-54 (as well as in the the GoldSim model input file), as follows:

$S_{im} = 5.63 \times 10^{-5}$ m^2/g
$k_{eff} = 10^{6.9}$ g/m^{2}d
$\eta = 0.4$
pH = 8.8573
$E_a = 80$ kJ/mol
$R = 8.31451 \times 10^{-3}$ kJ/(mol K)
T = 295.461 K

as well as the conversion factor of 365.25 days per year, yields the correct (to five significant figures) calculated value for the glass dissolution rate (Glass_Deg_Rate_high) of 4.1035×10^{-6} yr^{-1}.

Similar explanations may be possible for the insignificant differences identified in Table 6-60. However, as described below, we believe these discrepancies at the fifth significant figure (for example, 2.4630 vs 2.4634 for Uranium solubility in Table 6-60), are within the round-off error that would be expected by the implementation of the equations presented in Table 6-55.

4. Section 6.3.4.5 Dissolved Concentration Limit (CRWMS, 2000a)

NRC QUESTION: 4.1: The calculated values for dissolved concentration limits were not identical to the observed values. The hand calculations were requested and reviewed. The hand calculations provided by DOE had different inputs (i.e., environmental conditions) than those provided in the document. The reason that the provided hand calculations differ from the documented verification calculations is uncertain. The source of the imprecision in the calculations — the reason that the calculations were examined in greater detail — could not be determined. The degree of precision that is required by DOE QA procedures during model component verification calculations is unknown to the NRC.

DOE RESPONSE: The discrepancy exists in the fifth significant figure. Precision at the fifth significant figure is not required for verification. The purpose of these calculations and comparisons was to confirm that the model as implemented in GoldSim was successfully reproducing the analytical expressions contained in the supporting AMRs and that the information was being correctly passed from component to component. Similarity at the fifth significant figure is not required for this purpose.

There may be several explanations for this slight imprecision. These include the number of significant figures the hand computation used for some of the input parameters like temperature or pH or fCO2. These parameters where taken from the median value GoldSim file, but the analyst may have used only five significant figures from the GoldSim tables. It is also possible that the order of the hand calculation could be slightly different than the order the computer used, therefore yielding these slight imprecisions. Given that many of the input parameters affecting solubility are themselves uncertain and/or spatially variable, the degree of precision of any one calculation representing the median value should be compared to the full range of possible outputs.

A clarification of degree of precision believed acceptable by the analyst will be incorporated in a subsequent revision of the document.

The "hand calculations" referenced in the NRC Question were comprised of an Excel spreadsheet that was sent electronically to the NRC. This informally transmitted spreadsheet does not represent the controlled calculations contained within the Model Document. The informal Excel computation uses different water chemistries than that used as a basis for the controlled calculation provided in Table 6-60. The basis of record is Table 6-60, not the informally transmitted Excel file.

NRC QUESTION: 4.2 Page 316, Table 6-60 (CRWMS , 2000a)

Hand calculations for the TSPA-SR Model Solubility Limit Calculations for U, Am, and Np could not be verified.

The text indicates that the time (t=100,000 years) was randomly selected. Figure 6-99 shows that the pH of the CSNF waste package in bin 4 is approximately 6.75 (or equal to the pH listed in Table 6-60). The following discussion applies to the hand calculations for uranium solubility within the bin where the environment is always dripping. The hand calculation uses a pH of 3.4454, which is quite different than what is listed in Table 6-60; the pH for the CDSP is different than what is listed in Table 6-60, but is close. The temperatures for the hand calculations of both the CSNF and CDSP are different than what is shown in Table 6-60. The pH used in the hand calculation for the CSNF is outside of the abstracted solubility relationship for U on page 314; 3.4454 was used in the hand calculation, but the stated range of the relationship was between 5 and 9 (see page 314). The calculated solubility in the hand calculation is 8894 mg/L for CSNF, compared to 2.4630 mg/L in Table 6-60. The hand calculated value for CSNF is approximately 2 orders of magnitude larger than the largest solubility limit for uranium displayed for the median value calculation.

DOE RESPONSE: The hand calculations referred to in this question are not related to the controlled calculations presented in Table 6-60. They instead relate to some informally transmitted "hand computations" in the form of an Excel spreadsheet that was provided by DOE to NRC staff during their review of the TSPA-SR Model Document. The "computations" contained in the Excel spreadsheet that were sent electronically to the NRC were not the controlled calculations contained within the Model Document. The informally-transmitted "hand computations" used different environmental conditions than those used to create Table 6-60. Further examination conducted during the project review verified the values in Table 6-60 as being correct to within the required degree of precision. The basis of record is Table 6-60, not the informally transmitted Excel file.

There are short periods of time, when the pH may extend to values lower than the lower bound indicated on page 314. An example of this is illustrated in Figure 6-99. At about 44,000 years, the pH is slightly less than 3.5 (approximately the value given in the informal "hand computation" described in the NRC question), which would correspond to a Uranium solubility of about 9000 mg/L. While this is outside the bounds of the relationship provided on page 314, this conservatism was noted on pages 314 and 315. Discussions between PA analysts and supporting AMR analysts confirmed that the predicted U solubilities outside the prescribed pH range were not unreasonable based on the observed trend of the abstraction model, and they erred on the conservative side. The effects of this conservatism were noted on page 315. Here the reader was informed that the effects of the conservatively high in-package solubilities are mitigated by the solubilities in the invert which, although using the same geochemical correlations, are more stable due to the relative stability of the invert pH and fCO_2 as compared to the in-package pH and fCO_2.

5. Section 6.3.9.1 Volcanic Release

NRC QUESTION: Page 472, Table 6-133 (CRWMS, 2000a)

Hand calculations relating to Table 6-133 "Dose from Direct Volcanic Release at 500 Years" (probability weighted) could not be verified.

The hand calculations appeared correct, but differ from Table 6-133 by five orders of magnitude. In the electronic mail message from DOE providing the hand calculations, this difference was attributed to a known 'bug' in GoldSim 6.04, which was purported to have a five order-of-magnitude difference between numbers displayed in table form (wrong values) and chart form. Don Kalinich, DOE, surmised that during one of the draft revisions of the report, the GoldSim table values were put into both columns of Table 6-133. The values in Table 6-133 are inconsistent with the values expected, given the values in Table 6-132 (not probability weighted), which shows dose values approximately 12 orders-of-magnitude different than those in Table 6-133 (probability weighted for a volcanic event with a probability of 8.80×10^{-9}). Tim McCartin, NRC, raised the error in Table 6-133 to Peter Swift, DOE, in January 2001. The request for a copy of the hand calculations was made on April 4, 2001. The statistics on the Excel spreadsheet indicate that the file was created on April 10, 2001.

DOE RESPONSE: Table 6-133 is incorrect. It is a remnant of a previous version of the table that was not discovered in the checking process as the document was revised. Analyses conducted for the Total System Performance Assessment – Site Recommendation correctly weight the risk of volcanic release by the probability of occurrence. Figure 6-193, which contains the probability-weighted doses, correctly shows the probability-weighted dose from the unweighted doses illustrated in Figure 6-192. Table 6-133 will be revised in a subsequent revision of the TSPA-SR Model Document.

6. GoldSim Error Messages

NRC QUESTION: The GoldSim Run Log file contains a list of numerous error messages create during execution of the median-value calculation that need to be addressed for potential significance. It is believed that error messages are likely produced in the execution of stochastic GoldSim calculations, based on their presence in the median-value calculation GoldSim Run Log file. The error messages do not appear to be addressed in the TSPA-SR documentation. It is unclear whether the error messages were addressed during verification efforts necessary to determine that the TSPA-SR model is producing expected results. The significance of the error messages with respect to the calculated result is unclear.

DOE RESPONSE: Run log error messages were known and examined by analysts. Some of the errors relate to slight numerical non-convergence that was evaluated by analysts and determined to be insignificant. The nonconvergence errors generally introduce mass and thus, although small, conservatively increase dose. Other run log error messages inform the analyst that a particular model or parameter distribution may be exceeding the expected maximum or minimum values for that model or parameter and that the model will utilize either an extrapolated value or the user-defined "not-to-exceed" value. Examples of several run log error messages from the Nominal Scenario Base Case Median Value Simulation GoldSim file SR00_0037ne6 (DTN: MO0012MWDMED01.032), and their interpretation, are given below:

- \TSPA_Model\Engineered_Barrier_System\CSNF_Packages\Infiltration_Bin_3\Intermittent_Drip\In_Drift_Chemistry\Ionic_Strength_Invert\I_drip_case3c, Column Variable = 360.852800 > defined range. GoldSim will not extrapolate beyond data range. This message will not be repeated.

  This is a warning to inform the user that GoldSim will not extrapolate beyond the defined data range in a table. Thus if the value of the independent variable becomes less than the minimum (or greater than the maximum) value defined by the referenced table then GoldSim will use the minimum (or maximum) value to get the output for the dependent variable. All 1-D tables in the TSPA model were set by the TSPA analysts to not extrapolate beyond their upper and lower bounds, consistent with the tabular data abstractions provided in the supporting AMRs.

- \TSPA_Model\Engineered_Barrier_System\CSNF_Packages\Infiltration_Bin_3\Intermittent_Drip\In_Drift_Chemistry\pH\pH_drip_case3c (error 12968): Error in lookup-table

  This message occurs when an independent parameter of a 2-D table is outside its upper or lower bound. If this occurs, GoldSim will use the minimum (or maximum) value to get the output for the dependent variable. This treatment is consistent with the tabular data abstractions provided in the supporting AMRs. It is similar to the 1-D table message described above, only it is for 2-D tables.

- \TSPA_Model\Saturated_Zone_Transport\SZ_1DModel_Parameters\Alluvium_Properties\SZ_Alluvium (error 9389): The properties for input "SZ_Alluvium.Partition Coefficients" in Solid element "SZ_Alluvium" were not identical for species "Th229" (0.0255) and "Th232" (0). Since the species are isotopes, they should have the same values. The value specified for species "Th229" will be used for all isotopes of element "Th".

  GoldSim warns the user that all isotopes of a species should have the same partition coefficients. GoldSim then correctly sets the partition coefficient for Th232 equal to that for Th229.

- \TSPA_Model\Engineered_Barrier_System\EBS_Results\EBS_Bin3_Out (error 9419): Pathway inflow (0.0348569 m3/sec) exceeds outflow (0.0190129 m3/sec)

  This is a warning sent by GoldSim to inform the user that mass balance is not being maintained for the transport medium (water). When this occurs, GoldSim removes a quantity of "clean" medium (carrying no species mass) from the cell to maintain transport medium mass balance. This has no impact on the TSPA calculation. The cells that generate this warning have very small volumes (1E-6 m3) and very large inflows and outflows (1E+5 m3/yr), hence the residence time of species mass in these cells is still effectively zero regardless of the difference between the inflow and outflow rates.

- The external pathway has discharged mass during a zero-duration time step (due to an event occurring). This mass will be ignored!

  This is a warning sent by GoldSim when a zero-duration time step occurs resulting from an event (e.g., seismic event). The mass is ignored.

- Cell Waste_Form: Smallest substep failed. Species U (unsat -> sat)

  This message indicates there was an unacceptable (>5%) "overshoot" across the solubility limit from below due to non-convergence at the smallest substep modeled. This may result in a one timestep "spike" in which the solubility limit is exceeded for the specified element. This generally has a conservative impact on dose as more dissolved mass may become available for transport.

- Cell Waste_Form: Smallest substep failed. Species U (sat -> unsat)

  This message indicates there was an unacceptable (>5%) "overshoot" across the solubility limit from above due to non-convergence at the smallest substep modeled. This is unlikely to have a significant impact on results since it simply implies that an element was held at the solubility limit for a fraction of timestep longer than it should have been.

- Cell Waste_Form: Smallest substep failed. Species Pu240 (neg. inventory)

  The negative inventory message is an extreme case of "sat->unsat" error and indicates that more mass was discharged from the cell than it contained. In GoldSim the tolerance limit is 1 μg of mass created. GoldSim subsequently resets this negative mass to zero in the next time step. This increase in mass is conservative in TSPA calculations.

The TSPA analysts have reviewed these run log messages as part of the development and testing of the TSPA model. However, the evaluation of these messages has not been documented. Appropriate processes to document the review and analysis of run log messages are being investigated.

7. Use of Conditions Outside of Intended Ranges (CRWMS, 2000a)

NRC QUESTION: The staff were able to identify several instances in which the DOE model was applying abstracted models when the physico-chemical conditions were outside the range of conditions under which the abstractions were developed (see 4.2, above). However, DOE indicates that no abstractions were utilized outside of the intended range on page 559 of the TSPA-SR Model Report.

DOE RESPONSE: Instances of a particular model or parameter being run outside of the range of the intended use were noted in the text. These issues were discussed with the analysis and model report authors to assure the appropriateness of the abstraction, even if not documented in the analysis and model report.

The actual quote from page 559 is: "The integrated TSPA-SR model has not been utilized such that the assumptions are overridden, or such that the key components and subsystem models are used out of the range of their intended use." This is true. DOE believes that there is no key component or subsystem where the model has been used outside of its intended range. Where it was run outside of its range it was either insignificant or believed to be appropriate for the intended use.

This issue will be further evaluated as part of the response to a deficiency report on this condition (Deficiency Report BSC-01-D-078). In addition, as appropriate, the supporting analysis and model reports will be updated in subsequent revisions to extend their range of applicability.

8. Incorporating Intrusive Event Probability

NRC QUESTION: Pages 4-18 - 4-20 (Section 4.2.1) in TSPA-SR Technical Document (CRWMS, 2000b)

This section of TSPA-SR discusses how event probability is used to calculate the expected annual dose from igneous events, both extrusive and intrusive. The intrusive calculation uses the cumulative probability of an event occurring over the time period of interest to weight the results of the calculation. The TSPA-SR calculations are performed over a 50,000 year time period of interest, so the cumulative probability is calculated as the mean annual probability of occurrence, 1.6×10^{-8}/yr, times the 50,000 years. However, the result of this multiplication is reported in TSPA-SR as 8×10^{-3}, not the correct result of 8×10^{-4}. It is not clear whether this is simply a typographical error, or if this probability was actually used to calculate the results for the intrusive scenario. The 8×10^{-3} value is, however, repeated later in the section. Questions were raised about the intrusive volcanism calculation during the June, 2000, TSPA Technical Exchange.

DOE RESPONSE: This is a typographical error in the documentation. The correct values were used in the analysis and in all figures generated as a result of the analysis. The correct value in the text will be included in a subsequent revision of the technical report. A review has been performed to determine if the incorrect value has been used in other documents. It has not been cited elsewhere.

The approach, methodology, key assumptions and parameter distributions were presented to NRC staff in the noted June, 2000 TSPA Technical Exchange as well as subsequent Technical Exchanges on Igneous Activity and the TSPA-SR results.

REFERENCES:

CRWMS 2000a. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV. 00. Las Vegas, Nevada.

CRWMS 2000b. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV. 00 ICN 01. Las Vegas, Nevada.

ENCLOSURE 2

to
Response to NRC Letter of May 17, 2001
on
TSPA Issues

Management Plan
Revision 2

The attached management plan delineates the approach to identifying and resolving the issues presented during the DOE/NRC Quarterly Management and Quality Assurance Meetings on June 13, 2001. DOE will keep the NRC informed of the status of the investigations and reviews and findings on an ongoing basis. To the extent that dates and durations are included in this description, the dates are planned dates and should not be interpreted as commitments.

Management Plan
for
TSPA-SR
and
Other Identified Issues
Revision 2

Prepared by:

Gordon Pedersen, Project Manager

July 6, 2001
Date

Approved:

Nancy Williams, BSC Manager of Projects

July 6, 2001
Date

Management Plan for TSPA-SR and Other Identified Issues

Table of Contents

Background/Introduction

This document is the Management Plan that is intended to address several document integrity and other issues. The planned actions include a horizontal review of key documents, vertical reviews of several key documents, and conduct of several root cause analyses.

1. In the May 18, 2001 BSC board meeting, the BSC management team identified the need for:
   - A team to perform a cross-cut review of the key technical documents that will form the basis for a possible site recommendation
   - Assistance in providing resources for the performance of root cause analysis in response to Corrective Action Requests (CARs) on software verification and model validation (BSC management had already determined that an independent team was appropriate and had begun efforts to mobilize the team.)
   - An external review of processes, schedules, and management resources and organization improvements to improve the overall level of project performance for continuing phases of the work.
2. The BSC management team's request resulted from the correlation of three issues that indicated a quality problem in the preparation of technical products:
   - Total System Performance Assessment (TSPA): On May 17, 2001 the NRC asked the DOE to determine the scope of errors and/or inconsistencies between the TSPA, the underlying analysis and modeling reports, the associated GoldSim computer code results, and associated hand calculations. The TSPA was issued in early January 2001 and forms a key scientific basis for the project. The project is

currently preparing a Supplemental Science & Performance Analysis (SSPA) to provide the Nuclear Waste Technical Review Board (NWTRB) with additional analyses for a wider range of repository operating temperatures.

- A model validation CAR raises implementation concerns related to one of the "super CARs" that was issued in 1998.
- A pending CAR on software qualification (subsequently issued June 12, 2001).

3. The BSC management team wanted to ensure that the committed program schedule that calls for Presidential approval of the Site Recommendation in December is not jeopardized by these conditions.

Bechtel finalized the formation of a management review team on May 25, 2001. That team arrived on site on May 29, 2001 and began working with the BSC management team, under the guidance of BSC's President and General Manager, on the technical, quality, and Project issues associated with the CARs and NRC issues.

An early fallout of this review was a recommendation, on May 31, 2001, to expand the scope of the reviews already begun in response to the NRC's May 17, 2001 letter. The TSPA review was expanded to include both volumes of the SSPA and a separate review was initiated to review the key documents that support site recommendation. These include the Supplement to the Draft Environmental Impact Statement (DEIS), Science and Engineering Report, TSPA, and the SSPA. These reviews were to be conducted by 4 separate review teams and were intended to identify and, as needed, correct errors and/or inconsistencies in the key documents.

BSC management had determined that the root cause-analyses team should include independent members. The BSC board concurred and supported the associated resource needs.

The model validation, software and technical document issues appear to share common causal factors. In recognition of the need to provide an integrated review and corrective action plan, the team will investigate the results of the key document review findings to determine which institutional processes may have been root or contributory causes to the document errors and inconsistencies. Since the individual document discrepancies and performance issues identified appear to indicate a systemic failure of project processes, the overall review will endeavor to determine how procedure and process controls, human performance, and the effectiveness of problem identification measures contributed to the problems and recommend appropriate response actions. This investigation will be included in the root cause determination of the TSPA-SR discrepancies that occurred during preparation, checking and review of the TSPA-SR.

Finally, the management team identified a number of issues that should be addressed. These include:

- Procedure Revision/Enhancements - science and design processes (both of which are ongoing at Yucca Mountain) have different characteristics. These processes can be controlled in a more appropriate manner if the processes reflect the nature of each type of activity. Consequently, there is a need to implement separate processes for

these activities. In addition, this will allow the implementation of a more standard design and engineering approach for the design and engineering activities.

- Baseline Management - better control of project scope and schedule using industry accepted scheduling methods that are:
  - fully integrated
  - resource-loaded
  - logic-tied schedules

  thus assuring that scoped activities can be accomplished as scheduled and to assure that appropriate schedule adjustments are made when scope is changed. This also enhances the project ability to properly include commitments in the scoped and scheduled work and to satisfy commitments.
- Organization Responsibility/Accountability - it is anticipated that the root cause determinations could find that improved responsibility and accountability are needed for project related work. Consequently, the BSC management team is prepared to enhance the responsibility and accountability on the project.

Review Teams & Organization

Role	Assigned Individual	Description
Project Manager	Gordon Pedersen	
Staff Assistant	Sherron Bell	
Team 1 Lead	Jim Whitcraft	Perform horizontal reviews of key documents to ensure consistency of technical inputs and conclusions across key documents.
Team 2 Lead	John Peters	SSPA Vol. 1 vertical review team.
Team 3 Lead	Tom Doering	TSPA vertical review team.
Team 4 Lead	Darren Jolley	SSPA Vol. 2 vertical review team.
Root Cause Lead	Steve Metta	Perform formal root cause evaluation of CARs and TSPA-SR preparation, communicate corrective action plans, and assess root cause results for additional actions.

Review Description

Five reviews are planned: four technical reviews and a root cause analysis in response to these issues. The root cause team will conduct root cause determinations on both of the CARs and on the TSPA-SR problems. It is expected that the root cause determination on the TSPA-SR problems will be done in a fashion that is aware of the results of the horizontal and vertical reviews and will identify potential organizational and process corrections that need to be addressed. Identified items will be statistically evaluated for process concerns. Appropriate deficiency reports will be initiated following validation that the review findings represent conditions adverse to quality.

In general for vertical reviews, the teams need to confirm that results from analyses, calculations, and models are traceable to their origin and that the document is consistent

internally. The TSPA-SR review will also focus on identifying any technical discrepancies or inadequacies. In addition, and to a reasonable extent, the teams are to read the text for obvious issues with the writing/presentation.

Results (output) from analyses, calculations, and models are represented in the various reports in three principal ways:

1. Text description of results
2. Figures displaying data values
3. Tables presenting data values

The reviewers will check that:

- for all three of the methods used to represent results from analyses, calculations, and modeling, reference citations are provided unless all work is shown in the report text
- the references available from the document control system contain a description of the analysis, input parameters and data, assumptions (if used or appropriate), and output

The general items to be considered as the review is conducted include:

1. Is the technical description clear and logical
2. Is the discussion adequately supported
3. Does the discussion reflect the scope and objectives
4. Are assumptions clearly identified
5. Has adequate rationale for assumptions been provided
6. Are the references traceable
7. Is the cross-referencing between sections and topics accurate
8. Identify editing, typographic errors

The following additional attributes should be sampled:

1. Inventory sources of information used to support data in tables, figures, text
2. Verify the units on figures, tables, figure captions, table headers, etc.
3. Between text, tables and figures, verify data are consistent within and between sections.
4. Verify the output data presented are correctly cited from source
5. Within computer files, verify the input data are correct (i.e., the same as cited in text or tables that describe the inputs)

Horizontal Review of Key Documents (Team 1)

The project is producing a number of documents that relate to and build on each other. Therefore, they should be consistent with respect to similar subject matter addressed in each report. These include the Supplement to the DEIS, the Science and Engineering Report (S&ER), TSPA, SSPA and the Preliminary Site Suitability Evaluation (PSSE).

The Draft Environmental Impact Statement (DEIS) was produced and issued for public comment in 1999. A Supplemental EIS was issued in May, 2001 to address evolution of the design. Also in May, 2001, S&ER was issued which contains a summary of the current design basis. It includes both the results of scientific investigations and conceptual engineering designs for the required facilities. The Total System Performance Assessment (TSPA) documents the results of probabilistic assessments of both natural and engineered barriers within the repository. The SSPA consists of two volumes and addresses a number of issues raised by the Nuclear Waste Technical Review Board (NWTRB). These include identification and quantification of uncertainties and analyses that characterize the performance of a design that is capable of operating at a cooler operating temperature. The PSSE describes information presently available to support a preliminary evaluation of the suitability of the Yucca Mountain site for the location of a monitored geologic repository based on the proposed site suitability guidelines of 10CFR963.

The TSPA was issued in late 2000 as a technical reference for the Site Recommendation Consideration Report (SRCR) (including the TSPA model report). The SRCR was completed but never issued. The work embodied in the SRCR served as the basis document for the S&ER, however text was rewritten to include the flexible operating strategy that would allow a decision on operating temperature to be delayed until later in the program.

SSPA expands the analysis in TSPA to provide discussion that: quantifies uncertainties in TSPA and evaluates the performance of a cooler repository. The PSSE uses the contents of the S&ER to show how applicable regulations are met by the current design as a basis for the site recommendation.

The horizontal review of draft documents (SSPA and PSSE) and issued documents (TSPA, S&ER, DEIS) will be conducted for consistency of technical inputs, text, and conclusions across these key documents. Since the DEIS Supplement and the S&ER documents have already been released for public comment, they are the pace setting documents with which future work must be aligned. The volume of text involved in the review is substantial (a total of approximately 4700 pages).

The horizontal reviews will be conducted by subject matter, with each reviewer first collecting the same subject matter from each document. The consistency reviews are then to be conducted across documents to verify:

- the continuity and transparency of the presentation
- if inputs and references were cited correctly and contained the inputs the information cited
- if the information was correctly translated into the document
- if internal referencing was consistent
- mathematical accuracy of internal calculations
- that the conclusions are adequately supported

Comments on the draft SSPA and PSSE will be forwarded to the document authors as they occur. Comments on the S&ER, TSPA, and DEIS will be tabulated. These will then go through a validation review with the technical authors. Validated comments will be resolved by the author organization, and if appropriate, closed by the reviewing team.

A team consisting of 11 professionals (including personnel from national laboratories and independent outside personnel) has been assigned to the review.

Vertical Reviews

Vertical reviews are being conducted on both volumes of the SSPA and the TSPA-SR and its associated Model Document to assure consistency and traceability. In addition, the TSPA-SR review will identify whether the linkage to supporting models is clear and adequate and will attempt to identify errors.

SSPA Volumes 1 & 2

Volume 1 of the SSPA is a collection of evaluations and studies that are documented within the SSPA itself. The purpose of the document is to provide the NWTRB (Nuclear Waste Technical Review Board), an appointed oversight board for Yucca Mountain (YMP), other interested parties, and the public with additional information. Specifically the SSPA Volume 1 work is an extension of the work previously completed for a higher temperature design. It contains sensitivity analyses that then characterize the performance of a design that is capable of operating at a cooler operating temperature. This work was performed under the procedure for technical reports, AP.3.11Q, and, commensurate with its intended use, does not require the more rigorous controls such as those associated with analyses or models.

Based on the size of the document (approximately 1200 pages) and its aggressive production schedule (10 weeks), BSC management has directed that the review focus on and consider the overall integrity of the document and its traceability to support site suitability determinations. More rigorous analysis and documentation will follow as part of the license application.

Volume 2 of the SSPA is the results of TSPA analyses for a range of repository operating temperatures. The purpose of SSPA Volume 2 work is to document the results from two TSPA analyses: one for the higher operating temperature and one for the lower operating temperature. The results of these analyses and some of the comparisons are documented in Volume 2. It is important to note that the information contained in SSPA Volume 1 is an input to SSPA Volume 2. These analyses were done for study purposes only and do not replace TSPA Rev. 0, ICN 1. This work was performed under the procedure for technical reports, AP 3.11Q, and, commensurate with its intended use, does not require the more rigorous controls such as those associated with analyses or models.

Volume 2 of the SSPA uses the results from Volume 1 of the SSPA and was prepared in parallel to Volume 1. Based on the size of the document (approximately 200 pages) and its aggressive production schedule (10 weeks) conducted in parallel to the preparations of Volume 1, BSC management has directed the review to focus on and consider the overall integrity of the document and its traceability. This is intended to support site suitability determinations. The more rigorous analysis and documentation will follow as part of the license application.

The two reviews are being conducted in the manner of an engineering check; i.e. each reviewer will use yellow highlighter to mark the material they reviewed and comment entered on the documents in red ink. The review, although exhaustive, will not be a total review. Approximately one third (4 sections) will be given a detailed review; the remaining sections will be checked for reference traceability and input accuracy. A third portion of the group will review calculations which were submitted as Input Transmittals (governed by procedure AP-3.14Q) and inter-office correspondence and not prepared, reviewed and approved through the procedural processes. It should be noted that the review is not intended to judge scientific adequacy of the analyses but rather to confirm the integrity of the documentation of the analyses. Consequently, the reviewers are not subject matter experts but are experienced scientists and engineers implementing a document review. These reviews will consist of reviewing the section to determine:

- the continuity and transparency of the presentation
- if inputs and references were cited correctly and contained the inputs the information cited
- if the information was correctly translated into the document
- if internal referencing was consistent
- mathematical accuracy of internal calculations

The comments will be marked up on the documents and returned to the authors for resolution and incorporation, along with comments from other procedural and management reviews. The annotated review copies will be collected for record of the exact scope of the review.

SSPA Vol 1 and 2 comments will be collected in the following bins. Specific comments will be shown on marked-up documents.

1. Content of the reference does not appear to be correct (input leading to output)
2. Results from data reduction are not reasonable compared to inputs
3. Computations are not sufficiently described to permit independent repetition
4. Reference does not exist
5. Reference citation points to the incorrect reference
6. Reference citation does not include table, figure or page numbers for specific statements or information in text
7. Reference does not contain the requisite information; such as, description, assumptions, input, and output
8. Figure improperly labeled (title, legend, notes, labels)
9. Figure inaccurately represents the referenced output

10. Table not properly labeled (title, column headings, notes)
11. Table inaccurately presents the referenced output
12. Text description does not provides sufficient detail of the analysis, table, or figure
13. Other comments (typographic errors, etc.) that affect the overall quality of the document.

Following the check, the organization responsible for issuing the SSPA will complete the review of those areas not covered by Teams 2 & 4. Specifically, following procedures AP-3.11Q, AP-2.14Q, and AP-6.28Q, the following items will be addressed:

- Ensuring the technical section authors complete the review for the sections not reviewed by the teams as well as verifying the data where references were incorrect or missing.
- Checking document changes that have occurred in drafts (e.g., Vol. 1 Rev. F) since the time of the review.

A team consisting of 11 professionals (including personnel from one of the national laboratories) has been assigned to the review.

TSPA (Team 3)

This task involves the review of two completed documents: (1) the model document *Total System Performance Assessment (TSPA) Model for Site Recommendation* (MDL-WIS-PA-000002 REV 00) and (2) the technical report *Total System Performance Assessment for the Site Recommendation* (TDR-WIS-PA-000001 REV 00 ICN 01). In addition to these primary documents, supporting documents such as analysis and model reports will be investigated. The purpose of the model document is to describe the integration into one comprehensive model of information that represents different aspects of the repository.

The vertical review of the TSPA-SR will include the review of the NRC comments received as of the date the document review. The comments provided by the NRC will be used as the starting point to the self-assessment of the TSPA documents.

The TSPA-SR assesses the post-closure dose to a defined critical group for the regulatory period of 10,000 years as well as extending the assessment for periods longer than the regulatory period for trending purposes. The vertical review specifically reviews the TSPA-SR to identify that the underlying purpose is satisfied, that appropriate analysis inputs are used, that methodology is documented and correct and that the calculations and analysis done in the TSPA-SR are correct. Finally, the reviewers will consider whether the outputs are reasonable from a technical perspective.

In regard to this review and in addition to the other stated review requirements noted in other sections of this document, the review team was charged with verifying that the noted values in the associated documents were properly generated. To this end, the team

of engineers is charged with verifying questionable values through out the documents. Therefore unlike the other vertical and horizontal teams dealing with the other documents, the TSPA review team will perform independent hand calculations to verify the values in tables and figures as needed, as well as performing consistency review of the words. The team is made up of engineers and scientists drawn from the Project and external resources as needed. The Lead for the review team has been involved in other industry performance assessments.

The following categories will be used to identify findings from the TSPA review:

1. Significant item (Category 1) – could affect a major calculation in support of the TSPA. May or may not impact TSPA supporting results. Items identified will be reviewed for validity.
2. Important item (Category 2) – could affect a supporting calculation but does not change the conclusions of the TSPA. Items identified to date are currently under review for validity.
3. Weak basis/assumptions/reference (Category 3) – Question requires the review or input of the technical author or checker to resolve. These items include incomplete references or text that is not clear.
4. Minor errors (Category 4) – These are editorial items that are not quantified or tracked for resolution.

The TSPA review team will confirm that results from analyses, calculations, and models are traceable to their origin, that the document is consistent internally, and that values in the associated documents were properly generated. This will include independent hand calculations to verify the values in tables and figures as needed. TSPA review comments will be summarized on a spreadsheet and categorized (1-4). These "potential" comments will then be checked for validity and reviewed with the technical authors.

At the conclusion of the review, the review team will produce a self assessment report consistent with the Project self assessment procedure AP-2.20Q. This report will include an assessment of any impact on the TSPA Rev. 0, ICN 1 conclusions. If there is an instance where there is a significant impact in the period of regulatory concern appropriate corrective action will be taken. .

Root Cause Investigation

Investigate and analyze the events that resulted in CAR BSC-01-C-001 on Modeling and YMSCO-01-C-002 on Software Control. Determine the causal factors (root and contributing) in accordance with AP-16.4Q, *Root Cause Determination*, for each CAR and submit the results of this investigation in a report to include recommended corrective actions addressing the causes. The root cause determinations will use procedurally prescribed TapRoot® process.

The root cause team will also conduct a root cause determination on the TSPA-SR errors which management has directed will include investigating the preparation, checking, review, and approval process. In recognition of the need to provide an integrated review and corrective action plan, the team will investigate the results of the horizontal and vertical review findings to determine which institutional processes may have been root or contributory causes to the document errors and inconsistencies

The root cause determinations will include recommended corrective actions based on its findings of root and contributing causes. The responsible BSC manager for BSC-01-C-001 and the appropriate software project manager responsible for Bechtel/BSC aspects of YMSCO-01-C-002 confer regularly with the root cause team. During the conduct of the TSPA-SR discrepancy root cause investigation, the responsible manager in the Performance Assessment group will also confer regularly with the root cause team. This communication will enhance the continuity of management efforts to implement the appropriate corrective actions resulting from these root cause investigations.

Staffing

BSC management initiated an independent root cause team to perform a root cause evaluation for both CARs. The fifteen-person team is made up of three consultants with commercial nuclear power troubled plant turn-around and root cause experience and twelve Bechtel personnel from other Bechtel projects. The Bechtel personnel have project management, quality assurance, root cause and software and modeling expertise.

Schedule, Procedures and Reporting

Preliminary Schedule:

Team	Review	Comment Resolution
1. Jim Whitcraft - Horizontal review	6/4/01-6/22/02	6/25/01-6/29/01
2. John Peters –SSPA Vol. 1	6/4/01-6/15/01	6/18/01-6/22/01
3. Tom Doering –TSPA	6/11/01-7/6/01	7/9/01-7/20/01
4. Darren Jolley –SSPA Vol. 2	6/11/01-6/22/01	6/25/01-6/29/01
5. Steve Metta –Root Cause Team	6/10/01-8/31/01	
Root Cause Final Report	9/17/01	

A summary Gantt chart is included.

Procedures:

Management Plan work will be done in accordance with written plans. Where appropriate specific procedures will be used. In particular:

- The key document review will be conducted in accordance with AP-2.20Q, Self-Assessments.
- The root cause determination will be conducted in accordance with procedure AP-16.4Q.

Reporting:

Teams 1-4 will issue reports M-W-F, beginning June 8th. The root cause team will report weekly.

Ongoing and Longer Term Actions

Various additional remedial actions are underway regarding the two CARs in accordance with project procedures. These actions are not explicitly part of the management plan; however, the same management team responsible for conducting the management plan reviews and investigations are in regular contact with and monitoring progress on the remedial actions. These actions have begun prior to completion of the root cause analysis. As appropriate, these actions will be completed, extended or modified (upon completion of the root cause determinations) to assure effective implementation of corrective actions.

One specific remedial action that has been implemented as part of the management plan is a management directed stand-down to control the further processing of software development. Exceptions to the stand-down can only be granted by the BSC General Manager or Manager of Projects. Criteria are under development to determine what actions must be completed prior to ending the stand-down.

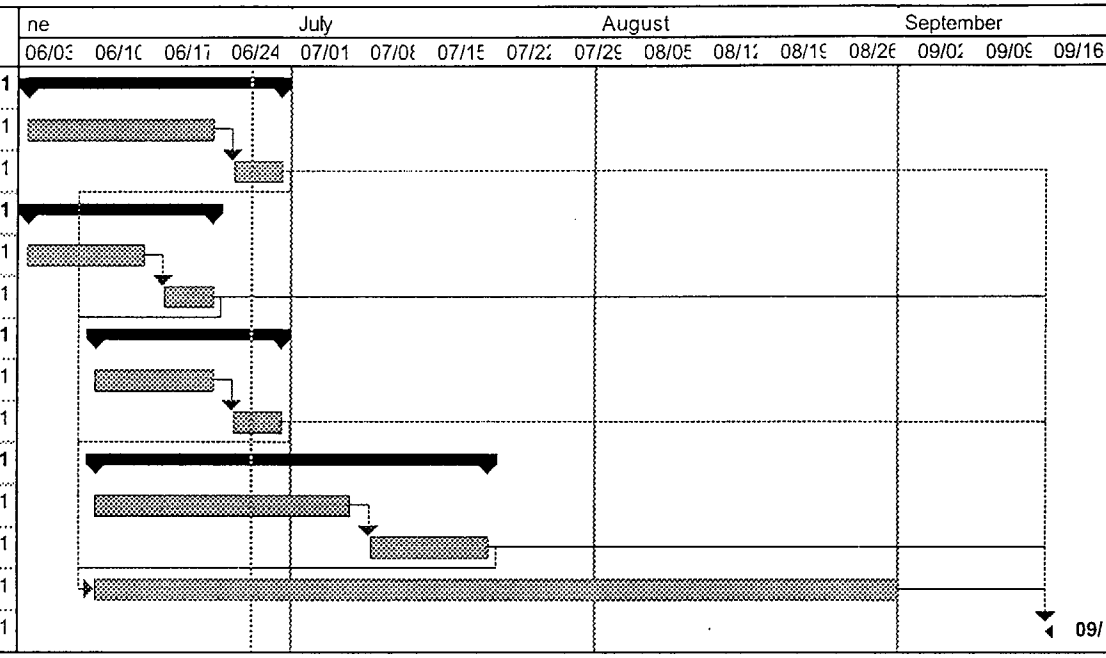
Further, execution of this plan will result in identification of specific discrepancies and deficiencies which will require remediation and root and contributory causes which will require actions to prevent recurrence. The review team will identify these conditions and causes and recommend appropriate actions to the BSC management team. These recommendations will include recommendations developed for all aspects of the management plan.

Conclusion

BSC (backed by Bechtel and SAIC corporate management) is strongly committed to identifying and implementing complete and effective corrective actions. This corporate commitment is reflected by the personal commitments of the executive sponsor (the BSC Manager of Projects) of the management plan and the BSC General Manager to identify the root causes and prevent recurrence.

Management Plan Summary Schedule

ID	Task Name	Start	Finish
1	**Key Document Horizontal Review**	**Mon 06/04/01**	**Fri 06/29/01**
2	Conduct of Review	Mon 06/04/01	Fri 06/22/01
3	Resolve Comments	Mon 06/25/01	Fri 06/29/01
4	**Vertical Review - SSPA Vol. 1**	**Mon 06/04/01**	**Fri 06/22/01**
5	Conduct of Review	Mon 06/04/01	Fri 06/15/01
6	Resolve Comments	Mon 06/18/01	Fri 06/22/01
7	**Vertical Review - SSPA Vol. 2**	**Mon 06/11/01**	**Fri 06/29/01**
8	Conduct of Review	Mon 06/11/01	Fri 06/22/01
9	Resolve Comments	Mon 06/25/01	Fri 06/29/01
10	**Vertical Review - TSPA**	**Mon 06/11/01**	**Fri 07/20/01**
11	Conduct of Review	Mon 06/11/01	Fri 07/06/01
12	Resolve Comments	Mon 07/09/01	Fri 07/20/01
13	Root Cause Determination	Mon 06/11/01	Fri 08/31/01
14	Root Cause Final Report	Mon 09/17/01	Mon 09/17/01



Task
Split
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Split
Rolled Up Milestone
Rolled Up Progress
External Tasks
Project Summary