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Your ref: Docket No. 52-006
Our ref: DCP/NRC2495

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Subject: AP1000 Response to Request for Additional Information (TR 85)

Westinghouse is submitting a response to the NRC request for additional information (RAI) on Technical Report No. 85. This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in this response is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Enclosure 1 provides the response for the following RAI(s):

RAI-TR85-SEB1-15 R2
RAI-TR85-SEB1-17 R3

Questions or requests for additional information related to the content and preparation of this response should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

Robert Sisk, Manager
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/Enclosure

1. Response to Request for Additional Information on Technical Report No. 85

D063
NRO

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ENCLOSURE 1

Response to Request for Additional Information on Technical Report No. 85

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR85-SEB1-15
Revision: 2

Question:

Section 2.4.3 indicates that the AP1000 site interface requirements for soil to be included in DCD Table 2-1 include an average allowable static bearing capacity greater than or equal to 8.6 ksf and a maximum allowable dynamic bearing capacity for normal plus SSE greater than or equal to 35 ksf at the edge of the NI at its excavation depth. The maximum allowable dynamic bearing capacity is based on the 2D ANSYS nonlinear dynamic analyses. Westinghouse needs to address the following:

a. Since the 2D ANSYS nonlinear model and results (for EW and vertical) are used for the final determination of the maximum allowable bearing capacity needed for the site soil conditions, explain why the effect of the third earthquake direction (NS) is not also considered.

b. Since only EW and vertical SSE earthquake loadings were considered, explain whether the two time histories were input simultaneously or analyzed separately, and how the responses from the two directional earthquake analyses were combined.

c. The site interface criteria of 35 ksf is applicable to “normal” plus SSE; however, the 35 ksf appears to be based on dead load and SSE. Clarify whether the term “normal” is intended to include other normal loads such as live load; fluid loads; weight and pressure of soil, water in the soil, and surcharge loads; and any other applicable normal loads. If so, then the bearing pressure calculation should consider these loads. If normal load was not intended to include all of these loads, then explain why not.

d. Explain why the other load combinations such as those that include live load, accident pressure and accident temperature, or wind instead of earthquake were not considered.

Additional Request (Revision 1):

The staff reviewed the RAI response provided in Westinghouse letter dated 10/19/07. Based on the information provided, Westinghouse is requested to address:

a. As explained by the RAI response, the maximum bearing pressure is close to the EW center liner of the nuclear island so that the contribution of the NS earthquake is expected to be small. Westinghouse is requested to identify the magnitude of the bearing pressure contribution in the NS direction and if it has some contribution, then it should be added.

b. If the EW and vertical SSE earthquake loadings were input simultaneously in the 2D ANSYS time history analysis, then explain why the RAI response indicated that the responses were added algebraically. In a time history analysis, with the EW and vertical input motions simultaneously applied, there is only one analysis performed; therefore, explain the algebraic combination.

c. Explain the loads that are included in the "average allowable static bearing capacity" identified in TR85, Section 2.4.3 - Site Interface for Soil.

d. The RAI response indicates that the other load combinations such as those that include live load, accident pressure and accident temperature, or wind instead of earthquake, is addressed in the response to RAI TR85-SEB1-28. The response to RAI TR85-SEB1-28, however, does not explain why the design pressure which is treated as the accident pressure inside containment (Pa) and accident temperature (Ta) are not considered for calculation of the soil bearing pressure requirement. Westinghouse is requested to explain why the load combinations that include these loads are not considered with and without the SSE, when determining the maximum soil bearing pressure requirements.

Additional Request (Revision 2):
(Follow-up RAIs dated 4/27/09)

In the response for item d of the RAI, Westinghouse indicated that another non-linear analysis was performed with the containment pressure loading. The results showed that the containment pressure had only a small effect on the bearing pressures. The RAI response also indicated that the accidental thermal loading does not occur concurrent with the design pressure and is not included as a design case. Westinghouse is requested to avoid using qualitative terms such as small effect without quantify how small the contribution is. Therefore, quantify the magnitude of the soil bearing pressure contribution from design pressure and accidental pressure, and explain why they are not included in determining the maximum soil bearing pressure demand, unless it is truly a negligible value. In addition, although the RAI response states that the accidental thermal loading does not occur concurrent with the design pressure, accidental thermal loading can occur with accidental pressure, along with the SSE and normal loads. Explain why this loading case was not considered.

Westinghouse Response:

a. The maximum bearing pressure occurs below the west side of the shield building. This is shown by the results of the equivalent static non-linear basemat analyses in Table 2.6-2 with the bearing pressures plotted in Figures 2.6-7. It is also shown by the results of the non-linear 2D ANSYS analyses in Figures 2.4-5 where the maximum bearing pressure occurs below the west edge of the shield building. The location of maximum bearing pressure is close to the east-west center line of the nuclear island so the contribution of the north south earthquake is small.

b. The EW and vertical SSE earthquake loadings were input simultaneously and responses were added algebraically.

c. Normal loads are those defined for inclusion as mass in the global seismic analyses of the nuclear island. They include equipment and fluid loads. They also include 25% of the specified floor live loads. The loads do not include the weight and pressure of soil, water in the soil, or surcharge loads.

d. The other load combinations such as those that include live load, accident pressure and accident temperature, or wind instead of earthquake are discussed in the response to RAI-TR85-SEB1-28.

Westinghouse Response (Revision 1):

a. The values obtained using the ANSYS 2D dynamic analyses are consistent with the 3D SASSI bearing pressures obtained from the generic analyses. The bearing pressures from the 3D SASSI analyses have been obtained by combining the time history results from the North-South, East-West, and vertical earthquakes. The maximum bearing pressures obtained from the various soil cases are listed in Table RAI-TR85-SEB1-03-1. Westinghouse will base its 35 ksf limit on the SASSI 3D results given in RAI-TR85-SEB1-3. The ANSYS 2D analyses will be used to support that the 35 ksf limit is a reasonable value.

b. Agreed. Delete "and responses were added algebraically" from response.

c. The loads that are included in the "average allowable static bearing capacity" identified in TR85, Section 2.4.3 - Site Interface for Soil are the normal loads. The average load is the total load divided by the footprint area.

d. The non-linear analyses of the basemat were performed for dead and live load with 16 combinations of seismic loads (1.0, 0.4, 0.4). In addition, for a critical direction combination of seismic inputs, a non-linear analysis was performed with containment pressure. This showed that the containment pressure had only small effect on the bearing pressures. The soil bearing requirement is established from 3D SASSI analyses. The basemat analyses demonstrate that the effect of pressure is small and does not need to be considered in the maximum bearing demand. Accidental thermal does not occur concurrent with the design pressure and is not included as a design case.

Westinghouse Response (Revision 2):

Figure RAI-TR85-SEB1-15-1 shows the soil bearing pressures from a linear analysis of the nuclear island basemat due to containment design pressure. This design pressure exceeds the accident pressure. The containment pressure is applied in the finite element model at the bottom head and a corresponding uplift is applied at the cylindrical shell. The total vertical reaction is zero. The bearing pressures are compressive at the center of the bottom head and tensile at the edge. The maximum bearing pressure of 1.4 ksf is below the center of the containment. The containment design pressure was included in two of the (1.0, 0.4, 0.4) seismic load combinations to confirm that its inclusion did not significantly affect the non-linear response. When the containment pressure was included in the non-linear lift off analyses together with dead load and the equivalent static seismic loads, this study showed a small reduction in the bearing compressive pressure at the edge of the model from that when analyzed without containment pressure. Since the maximum bearing pressures are at the west edge of the nuclear island, the maximum bearing pressure reduces slightly when the containment is pressurized. The nuclear island basemat is designed for load cases both with and without containment pressure.

The design basis accident results in pressures and atmospheric temperatures inside containment. The safety systems are designed such that the accident pressure reduces below one half of the design pressure within 24 hours. Due to the large thickness of the containment internal concrete basemat and of the nuclear island basemat, thermal conditions are slow to develop across the basemat and are not concurrent with the containment design pressure. In addition, the SSE and design basis accident are independent events that are conservatively assumed to be concurrent based on past precedent. Accident thermal conditions are therefore not considered concurrent with the design pressure and the SSE.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None

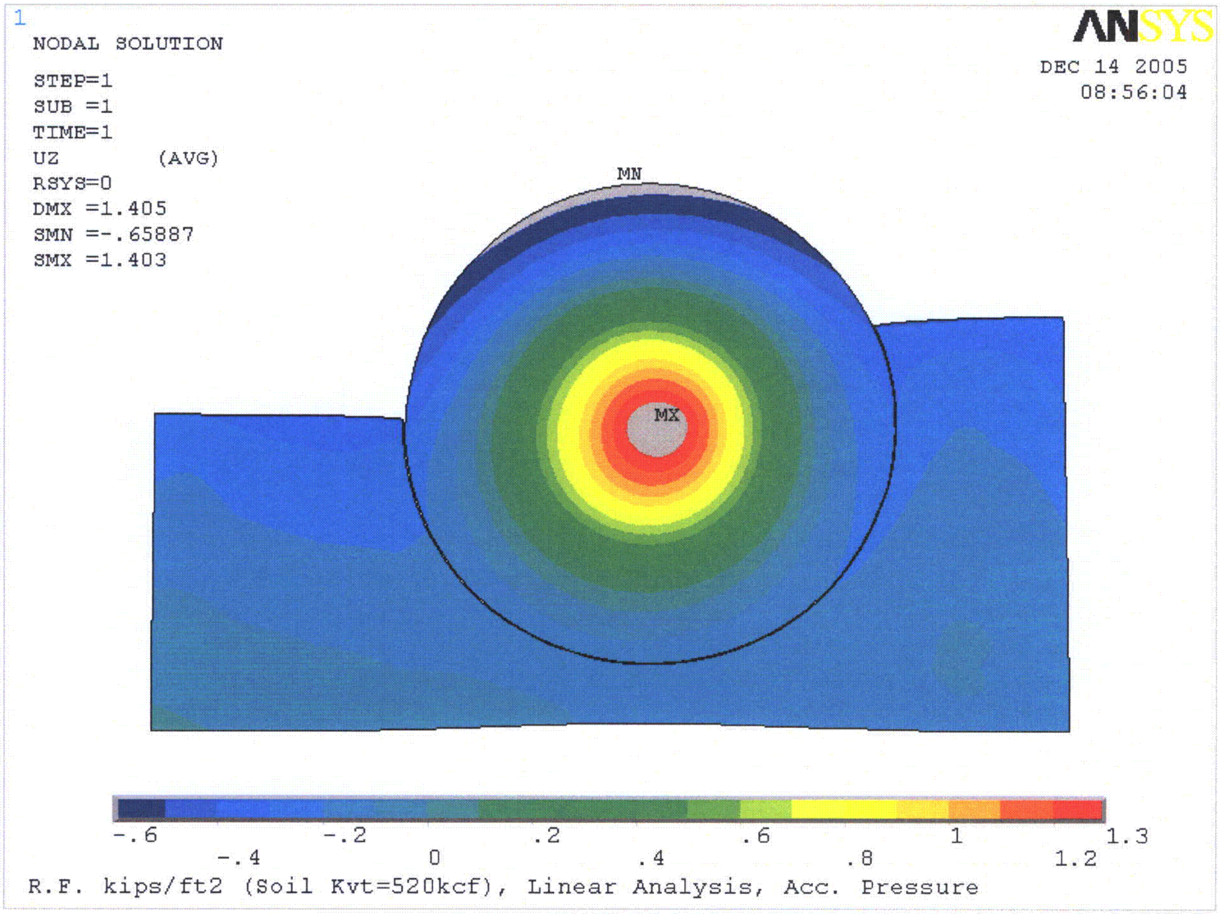

Figure RAI-TR85-SEB1-15-1
Bearing pressures in linear analysis due to containment design pressure

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR85-SEB1-17
Revision: 3

Question:

In Section 2.5, the first paragraph (Page 19 of 83) states that in the expected basemat construction sequence, concrete for the mat is placed in a single placement. The last sentence of the same paragraph states that once the shield building and auxiliary building walls are completed to Elevation 82'-6", the load path changes and loads are resisted by the basemat stiffened by the shear walls. The staff identified the following issues:

a. Since the size of the basemat is 256 feet by 161 feet, provide a detailed description of how the single placement is to be placed (e.g., by layers or by areas, time period between pouring of layers or areas, if by areas - type of joint detail to ensure proper connection, etc.).

b. Explain how the “single placement” can be completed and considered as a “single placement,” if any unexpected incidents (such as malfunction of concrete mixer, etc.) occur.

c. Provide the basis of how the residual stress at the junction between the shear walls and the shield building is calculated (detailed calculation procedure needs to be provided) and designed for, if the auxiliary building shear walls are to be constructed up to Elevation 82'-6" first and then construction of the shield building.

d. Describe what construction techniques and design provisions are needed to address issues related to the use of a single massive concrete pour of the entire basemat. The response should also address concerns related to the effects of heat generation, restraint, and volume changes associated with a large single massive pour, and how the cracking of the concrete basemat will be avoided.

e. Where in the DCD is the requirement for the COL applicant to follow the construction sequences considered by Westinghouse in the design of the NI structures? If the COL applicant proposes to use a construction sequence that is substantially different than that studied by Westinghouse, the COL applicant should be required to demonstrate that their proposed sequence does not cause a problem.

Additional Request (Revision 1):

The RAI response states that the acceptability of the construction sequence used by the COL applicant is addressed by an ITAAC. However, the ITAAC could not be located; therefore, Westinghouse is requested to identify the ITAAC to be included in DCD Tier 1.

Additional Request (Revision 2):

The staff reviewed the RAI response provided in Westinghouse letter dated 12/2/08. The staff concurs that DCD Rev. 17 Section 3.8.5.4.2 has been revised to update the information for the three construction sequences that were evaluated to demonstrate construction flexibility within certain limits. However, a statement in the RAI response indicates that the acceptability of the construction sequence used by the COL applicant is addressed by the settlement analyses described in DCD subsection 2.5.6.4 which provides guidance to the Combined License applicant on predictions of absolute and differential settlement that are acceptable without further evaluation. Since DCD subsection 2.5.6.4 does not exist, explain what subsection this should refer to. If the intent was to refer to DCD subsection 2.5.4.3 - Settlement, then the information contained in this subsection does not explain how this settlement criteria ensures that the construction sequences evaluated and described in DCD Section 3.8.5.4.2 will be satisfied. To facilitate the resolution of this issue, it would be appropriate to include in the DCD the construction sequence limitations that were assumed in the set of construction sequence analyses described in the RAI response.

Additional Request (Revision 3):
(Follow-up RAIs dated 4/27/09 [note: this was based on review of the Rev 1 response])

The staff concurs (note: this was based on review of Rev 1) that DCD Rev. 17, Section 3.8.5.4.2, has been revised to update the information for the three construction sequences that were evaluated to demonstrate construction flexibility within certain limits. However, a statement in the RAI response indicates that the acceptability of the construction sequence used by the COL applicant is addressed by the settlement analyses described in DCD subsection 2.5.6.4 which provides guidance to the Combined License applicant on predictions of absolute and differential settlement that are acceptable without further evaluation. Since DCD subsection 2.5.6.4 does not exist, explain what subsection this should refer to. If the intent was to refer to DCD subsection 2.5.4.3 - Settlement, then the information contained in this subsection does not explain how these settlement criteria ensure that the construction sequences evaluated and described in DCD Section 3.8.5.4.2 will be satisfied. To facilitate the resolution of this issue, it would be more appropriate to include in the DCD the construction sequence limitations that were assumed in the set of construction sequence analyses described in the RAI response.

Westinghouse Response (Revision 1):

The reference to the ITAAC has been replaced in the response to item (e) by a reference to the Combined License applicant's information on settlement.

a. Site specific placement plans will be developed to address the placement of concrete for the NI basemat. Those plans will address the conditions outlined below:

The concrete for the NI basemat will be placed in a single continuous placement operation. It is expected that the batch plant equipment and materials on site (site dependent) for this operation will consist of the following equipment or equal in order to support this placement:

- 12 cubic yard central mix batch plant (main plant)
- 10 or 12 cubic yard backup/auxiliary batch plant
- All coarse and fine aggregates stockpiled on-site to support the placement
- All admixtures (water reducer, plasticizer, air entraining agent, etc.) on-site to support the placement.
- All cement and fly ash stored on-site (batch plant silos and supplemental storage blimps) or reliability of re-supply during the placement verified.
- If ice is required, adequate supplies will be stored on-site or reliability of re-supply during the placement verified.
- Adequate concrete trucks including back-up trucks on-site to support the placement.
- Adequate personnel and truck drivers assigned to the batch plants to support multiple shift operations.

For the main batch plant, sustained maximum production is expected to reach 250 cubic yards per hour and average production is expected to exceed 200 cubic yards per hour allowing for decreased production periods at the beginning and at the end of the concrete placement. The placement plan shall be based on the use of one plant being able to successfully complete the placement, however the back-up plant may be used during the placement. Initial plans indicate that the placement will take approximately 36 hours.

Concrete will be placed by conventional placement equipment (i.e., pumps, conveyors, buckets, etc.) suitable for the site conditions. Telebelts (conveyors mounted on hydraulic cranes) or conventional conveyors may be used in concert with concrete pumps dependent on the site. Back-up equipment will be provided. Concrete will be placed in a "stair-step" pattern to minimize the exposed working face. Multiple concrete placing crews will be used to balance the concrete placement with the expected rate of concrete supply.

b. In theory a single placement could be interrupted for any one of several reasons. Possible causes of placement interruption based on experience at other projects are listed below together with the associated preventative or mitigating action being planned in each case for the AP1000 NI basemat.

Reason for Interruption	Preventative or Mitigating Action
Bad Weather	Placement to be made only after comprehensive site specific favorable weather forecast. Contingency plans will be in place

	for unexpected weather conditions.
Breakdown of Batch Plant	Back-up Batch Plant capacity on or nearby the site that satisfies Quality Control and Quality Assurance requirements of the Project. Critical system such as power supply to the batch plant will also have backup.
Breakdown of Concrete Trucks	Backup trucks will be provided.
Breakdown of Concrete Placement Equipment	Backup equipment will be provided.
Inadequate Quantities of Batch Constituents	Sufficient materials will be stored on site to provide for the required concrete quantity plus allowances for extra concrete that may be required for rejected concrete, waste and spillage and low estimated quantities.
Power Failure – unable to operate batch plant	Redundant source of power on site such as a portable diesel generator
Failure of Formwork	Field Engineers will check the formwork prior to the placement. Carpenters will be assigned to monitor the formwork during the placement.
Construction Accident	Enhanced Safety training and briefing of all supervisors and craft labor prior to the placement

In the unlikely event that a major interruption occurs in spite of the above cited Preventative or Mitigating Actions, the duration and cause of the delay and the associated effect on the integrity of the NI basemat will be evaluated. Depending on the level of the impact on the integrity, remediation actions could range from (a) removal, cleaning and green cutting of a new mating surface to (b) complete removal and subsequent placement of a portion of the placement and insertion of a new unplanned construction joint to be designed at the time of the occurrence.

c. The "residual stresses" are evaluated as "locked-in" stresses considering the immediate and long term settlements, the loading history consistent with the construction sequence, and the increasing foundation mat and superstructure stiffness as construction elements are placed and integrated into the structure.

The response to RAI-TR85-SEB1-19 presents details of the computational process and how the resulting forces and moments are considered in the design. The generic analysis includes the effects of three construction sequences, namely, a base case, a delayed Auxiliary building case and a delayed Shield building case.

d. While the quantity of concrete in the NI basemat is relatively large when compared to walls and floor slabs throughout the Nuclear Island, it is not large by normal modern construction practices. The American Concrete Institute (ACI) Code, including ACI 207.1R-05, "Guide to Mass Concrete" and ACI 207.2R-95 (reapproved 2002) "Effect of Restraint, Volume Change and Reinforcement on Cracking of Mass Concrete," has been considered in the design and planning of the NI basemat placement. The most significant issue is the heat of hydration associated with large placement which, in theory, could lead to deleterious cracking if not addressed in the design and construction operation. Depending on the site location and conditions, the concrete temperature will be monitored and the concrete mix will be designed to minimize the heat of hydration, associated temperature rise and subsequent drop and the related tendency for cracking. Measures available for dealing with the heat of hydration, to be worked out on a site by site basis depending on the time of the year and location of the site, include the following:

Aggregate Size and cement fineness
Overall placement procedure
Use of chilled water and/or ice
Enhanced quantity of flyash (pozzolanic)
Use of chilled aggregate
Immediate commencement of curing after finishing
Use of misting equipment
Additives such as water reducers & retarders
Evaporative cooling (water spray) of aggregates

e. DCD 3.8.5.4.2 describes three construction sequences that were evaluated for a soft soil site to demonstrate construction flexibility within broad limits. The acceptability of the construction sequence used by the COL applicant is addressed by the settlement analyses described in DCD subsections 2.5.4.3 and 2.5.4.6.11 which provides guidance to the Combined License applicant on predictions of absolute and differential settlement that are acceptable without further evaluation. When the predicted settlement exceeds these values, the Combined License applicant will describe any special construction provisions to accommodate the predicted settlement.

- A base construction sequence which assumes no unscheduled delays.
- A delayed shield building case which assumes a delay in the placement of concrete in the shield building while construction continues in the auxiliary building.
- A delayed auxiliary building case which assumes a delay in the construction of the auxiliary building while concrete placement for the shield building continues.

The analyses of alternate construction scenarios show that member forces in the basemat are acceptable subject to the following limits imposed for soft soil sites on the relative level of construction of the buildings prior to completion of both buildings at elevation 82′ -6″:

- Concrete may not be placed above elevation 84′ -0″ for the shield building or containment internal structure.
- Concrete may not be placed above elevation 117′ -6″ in the auxiliary building, except in the CA20 structural module where it may be placed to elevation 135' - 3".

Westinghouse Response (Revision 2):

The response has been revised to correct the reference to DCD subsection 2.5.4.6.11 instead of 2.5.6.4. This subsection states: "Special construction requirements will be described, if required, to accommodate settlement predicted to exceed the values shown in Table 2.5-1." The construction sequence limitations assumed in the analyses are already described in DCD Rev 17 subsection 3.8.5.4.2.

The majority of sites will satisfy the values of Table 2.5-1. The special construction requirements will only apply at unusual very soft sites. Any additional discussion of this should be in the Combined License applications for such sites.

Westinghouse Response (Revision 3):

A reference to DCD subsection 2.5.4.3 has been added in the response to Item (e) above.

A revision is shown to the DCD subsection 2.5.4.6.11 referencing the construction sequence limitations that were assumed in the set of analyses described in the RAI response and described in DCD Section 3.8.5.4.2.

References:

ACI 207.1R-05, "Guide to Mass Concrete"
ACI 207.2R-95 (Re-approved 2002), "Effect of Restraint, Volume Change and Reinforcement on Cracking of Mass Concrete"

Design Control Document (DCD) Revision:

The revisions described in Revision 0 of this response are incorporated in DCD Rev 17. The followingNo additional changes are required.

2.5.4.6.11 Settlement of Nuclear Island – Data will be provided on short-term (elastic) and long-term (heave and consolidation) settlement for soil sites for the history of loads imposed on the nuclear island foundation and adjacent buildings consistent with the construction sequence. The resulting time-history of settlements includes construction activities such as dewatering, excavation, bearing surface preparation, placement of the basemat, and construction of the superstructure (see subsection 3.8.5.4.2 for analyses of settlement during construction and the required limitations on construction sequence by the Combined License applicant). Special construction requirements will be described, if required, to accommodate settlement predicted to exceed the values shown in Table 2.5-1.

PRA Revision:

None

Technical Report (TR) Revision:

Section 5, DCD markup is being revised to include all changes from DCD Rev 17 identified in TR85 RAI responses at the time of issue ofNo changes to Revision 1 of the Technical Report.