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March 19, 2012

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Subject: Duke Energy Carolinas, LLC
William States Lee III Nuclear Station – Docket Nos. 52-018 and 52-019
AP1000 Combined License Application for the
William States Lee III Nuclear Station Units 1 and 2
Supplemental Partial Response to Request for Additional Information (RAI No. 6182)
Ltr# WLG2012.03-04

References: Letter from Brian Hughes (NRC) to James Thornton (Duke Energy), Request for Additional Information Letter No. 100 Related to SRP 03.07.02 – Seismic System Analysis for the William States Lee III Units 1 and 2 Combined License Application, dated November 9, 2011 (ML11313A170)

Letter from Ronald A. Jones (Duke Energy) to Document Control Desk (NRC), Partial Response to Request for Additional Information (RAI No. 6182), Ltr# WLG2011.12-03, dated December 8, 2011 (ML11343A567)

This letter provides the completion of Duke Energy's response to the Nuclear Regulatory Commission's request for additional information (RAI) included in the referenced letter.

The response to the NRC information request described in the referenced letter is addressed in a separate enclosure, which also identifies associated changes that will be made in a future revision of the Final Safety Analysis Report for the Lee Nuclear Station.

If you have any questions or need any additional information, please contact James R. Thornton, Nuclear Plant Development Licensing Manager (Acting), at (704) 382-2612.

Sincerely,

John W. Pitesa

John W. Pitesa
Senior Vice President
Nuclear Operations

D093
NRO

Enclosure:

1) Lee Nuclear Station Supplemental Partial Response to Request for Additional Information (RAI), Letter No. 100, RAI 03.07.02-001

xc (w/out enclosure):
Charles Casto, Deputy Regional Administrator, Region II

xc (w/ enclosure):
Brian Hughes, Senior Project Manager, DNRL

AFFIDAVIT OF JOHN W. PITESA

John W. Pitesa, being duly sworn, states that he is Senior Vice President, Nuclear Operations, Duke Energy Carolinas, LLC, that he is authorized on the part of said Company to sign and file with the U. S. Nuclear Regulatory Commission this combined license application for the William States Lee III Nuclear Station, and that all the matter and facts set forth herein are true and correct to the best of his knowledge.

John W. Pitesa

John W. Pitesa, Senior Vice President
Nuclear Operations

Subscribed and sworn to me on March 19, 2012

Freda K. Crump

Notary Public

My commission expires: August 17, 2016

SEAL

FREDA K CRUMP
NOTARY
PUBLIC
LINCOLN COUNTY, NC

Lee Nuclear Station Supplemental Partial Response to Request for Additional Information (RAI)

RAI Letter No. 100

NRC Technical Review Branch: Structural Engineering Branch 1 (AP1000/EPR Projects) (SEB1)

Reference NRC RAI Number(s): RAI 03.07.02-001

NRC RAI:

The staff performed a review of WLG-1000-S2R-802, Revision 1, and finds that additional information is required to assess the adequacy of the applicant's seismic analysis for satisfying NRC regulations (Appendix A to 10 CFR Part 50):

(a) WLG-1000-S2R-802 contains a site-specific analysis to demonstrate acceptability of the AP1000 standard design. Staff review of this report finds that there is insufficient detail to assess adequacy of the seismic analysis method used by the applicant. In particular, it is not clear if the applicant's method of seismic analysis is consistent with that of AP1000 DCD Sections 3.7.1 and 3.7.2, which provide acceptable methods for performing seismic analysis. To address this issue, the staff requests the applicant to identify any DCD departures pertaining to these DCD sections, particularly as they relate to critical damping values (3.7.1.3), development of design time-histories (3.7.1.2), three components of earthquake motion (3.7.2.6), and seismic modeling and analysis of Seismic Category II building structures (3.7.2.8.4).

Staff notes that NRC regulation, 10 CFR Part 52.79, "Contents of Applications; Technical Information in Final Safety Analysis Report," requires that the COL applicant's FSAR contain a description and safety assessment of the structures, systems, and components as well as the evaluations required to show that the safety functions will be accomplished. Based on this requirement, staff requests the applicant to include a description of the site-specific seismic analysis (including methods, significant assumptions, and results) in FSAR Section 3.7.

(b) WLG-1000-S2R-802, Section 5.0, describes a parametric study performed to assess the impact of the reduced shear wave velocity below the NW corner of Unit 1. Based on these results (Figures 6-1 though 6-6), the applicant asserts that (a) the effect of the "softer" NW corner on the design is minimal, and that (b) the SSI results from Unit 2 bound the Unit 1 results, thereby constituting a conservative seismic input assumption for the 3-D SSI analysis of Unit 1.

Staff review of the applicant's sensitivity study finds that the assessment of the NW corner effects should include a comparison of vertical responses (Figures 6-1 through 6-6), since a "soft" corner may affect the rocking response of the nuclear island. In addition, staff notes that AP1000 DCD Section 2.5.2 states that, for site-specific analysis of hard-rock sites, the COL applicant should compare in-structure response spectra (ISRS) to the AP1000 HRHF spectra at the locations given in APP-GW-GLR-115, "AP1000 Standard Combined License Technical Report Effect of High Frequency Seismic Content on SSCs." Since Appendix A does not contain such comparisons, the staff requests the applicant to provide comparisons at locations described in APP-GW-GLR-115, Section 5.2. In order to assess the significance of the sensitivity study results on the standard design, the applicant is requested to provide comparisons of the sensitivity study results to the standard plant design spectra (HRHF and CSDRS). If the Unit 1 seismic demands (including vertical response) exceed those of Unit 2, the applicant should justify the use of the Unit 2 profile (centerline) for the 3D SSI analysis of Unit 1.

(c) WLG-1000-S2R-802, Section 3.0, describes site-specific 3-D SSI analysis, which makes use of ground-motion coherency functions (incoherency). Staff review finds that this report section does not provide sufficient detail to assess the acceptability of the incoherency approach used by the applicant. To address this issue, the applicant is requested to summarize the methodology used and describe the consistency with guidance provided in ISG-01, "Interim Staff Guidance on Seismic Issues Associated with High-Frequency Ground Motion in Design Certification and Combined License Applications."

(d) WLG-1000-S2R-802, Section 4, provides time-histories matched to the WLS FIRS. SRP Section 3.7.1 provides acceptance criteria for using a single set of synthetic time histories. Staff review finds that Section 4 does not address the SRP criteria for matching (e.g., design response spectrum enveloping and power spectral density requirements). To address this issue, the applicant is requested to provide the bases for acceptability of the assumed time histories used in SSI analysis.

Duke Energy Response:

In Reference 1, Duke Energy provided a response to item (d) above, and indicated that updated site-specific analyses of the Lee Nuclear Station nuclear islands would soon be completed, replacing WLG-1000-S2R-802, Revision 1 (previously submitted as part of Reference 2) and addressing items (a), (b), and (c). This supplemental response presents the updated site-specific analyses. Reference 4 submits Revision 2 to WLG-1000-S2R-802, which is a Westinghouse Proprietary Class 2 document. Attachment 1 to this Enclosure is Westinghouse Electric Company's report WLG-1000-S2R-803, Revision 0, *William S. Lee Site Specific Seismic Evaluation Report*, which is the public version of the report. These site-specific analyses have been updated to include changes made to the nuclear island analytical model during the AP1000 Design Certification Amendment process, updated properties for granular fill material in the Lee Unit 1 Northwest Corner, and an updated representation of the Lee Unit 1 Foundation Input Response Spectrum (FIRS) and the associated time-histories.

In response to item (a), the report (Attachment 1) confirms consistency with the analyses supporting the AP1000 DCD, and confirms that there are no inconsistencies in the seismic analysis method or departures from the DCD with respect to modeling and analysis of plant structures, including critical damping values used, design time-histories, and the application of three components of earthquake motions.

Consistent with the AP1000 DCD evaluations for hard-rock sites, analyses of the nuclear island conservatively neglect the effects of the backfill material adjacent to the nuclear island. Therefore, Attachment 1 and Reference 4 do not address the modeling and analyses of Seismic Category II building structures that are founded on that backfill material. Duke Energy's response to NRC's Letter 67 (RAI 2350) (Reference 3) addresses the seismic requirements for those adjacent Seismic Category II building structures, and indicates that a site-specific evaluation of the adjacent Seismic Category II building structures will be submitted by June 29, 2012.

Duke Energy will include a summary of the site-specific seismic analyses described in Attachment 1 and Reference 4 (including methods, significant assumptions, and results) in FSAR Section 3.7. Attachments 2 and 3 provide updated content for a new FSAR Subsection 3.7.2.15, Site-Specific Analyses of Nuclear Island Seismic Category I Structures.

In response to item (b), Section 5 of Attachment 1 presents site-specific horizontal and vertical in-structure floor response spectra (FRS) that result from two-dimensional east-west analyses of the nuclear island. Three cases are considered: the Unit 1 centerline founded on a profile of fill concrete over hard rock; the Unit 2 centerline founded on a hard rock profile; and a Unit 1 Northwest corner model that includes a range of granular fill material placed beside the nuclear island and below the level of the nuclear island basemat. In-structure FRS are presented at the six key locations identified in DCD Subsection 3.7.2 and DCD Table 3G.4-1, similar to the locations investigated in Section 5.2 of APP-GW-GLR-115. The resulting 2D east-west horizontal and vertical spectra are compared to the corresponding in-structure FRS from DCD-supporting analyses using the CSDRS and HRHF spectra.

The 2D results confirm that the Unit 1 Northwest corner conditions have only a small effect compared to the Unit 1 centerline, and that the Unit 1 and Unit 2 centerline FRS have only minor differences across the frequency spectrum in both the horizontal and vertical directions. Therefore, the two centerline configurations were selected for more detailed 3D analysis.

For these 3D analyses, Lee Unit 1 and Lee Unit 2 were individually analyzed, with the first analysis using the Unit 1 centerline profile and the second using the Unit 2 centerline profile. Section 7 of Attachment 1 presents the resulting in-structure three-dimensional FRS. These spectra also represent the six key locations specified in the AP1000 DCD, and compare the site-specific FRS to the corresponding results of DCD-supporting analyses of the CSDRS and HRHF. The 3D incoherent SSI analyses also show only minor differences between Unit 1 and Unit 2, and indicate that the site-specific 3D in-structure FRS at the six key nuclear island locations are enveloped by the corresponding AP1000 CSDRS SSI envelope FRS. The results from these analyses are described in Attachment 1, and are summarized in the proposed new FSAR content in Attachments 2 and 3.

In response to item (c), Section 6.2 of WLG-1000-S2R-802, Revision 2 (Reference 4) describes the 3D incoherent SASSI SSI analyses of the Unit 1 and Unit 2 nuclear islands using the 3D AP1000 NI20r analytical model, using the same methodology as was used for the AP1000 DCD, which is consistent with NRC guidance in COL/DC-ISG-01.

In response to item (d), Duke Energy's initial partial response to this RAI (Reference 1) described development of the time-histories representing the Unit 1 FIRS and demonstrated compliance with SRP 3.7.1. Reference 1 also presented updated content for the WLS FSAR reflecting this response. For clarity, that partial response is not repeated here.

Associated revisions to FSAR text and figures will be incorporated into a future revision of the Final Safety Analysis Report.

References:

1. Letter from Ronald A. Jones (Duke Energy) to Document Control Desk, U.S. Nuclear Regulatory Commission, Partial Response to Request for Additional Information (RAI No. 6182), Ltr# WLG2011.12-03, dated December 8, 2011 (ML11343A567)
2. Letter from Bryan J. Dolan (Duke Energy) to Document Control Desk, U.S. Nuclear Regulatory Commission, Response to Request for Additional Information (RAI No. 3644), Ltr# WLG2009.12-10, dated December 18, 2009 (ML093570281)
3. Letter from John W. Pitesa (Duke Energy) to Document Control Desk, U.S. Nuclear Regulatory Commission, Supplemental Response to Request for Additional Information (RAI No. 2350), Ltr# WLG2012.02-03, dated February 28, 2012 (ML12060A377)
4. Letter from John W. Pitesa (Duke Energy) to Document Control Desk, U.S. Nuclear Regulatory Commission, Westinghouse Electric Company Report on William States Lee III Nuclear Station Site-Specific Seismic Analyses, Ltr# WLG2012.03-05

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

1. FSAR Subsection 3.7.1.1.1
2. New FSAR Subsection 3.7.2.15
3. FSAR Subsection 3.7.6
4. New FSAR Figures: 3.7-204a, 3.7-204b, 3.7-204c, 3.7-205a, 3.7-205b, 3.7-205c, 3.7-206a, 3.7-206b, 3.7-206c, 3.7-207a, 3.7-207b, 3.7-207c, 3.7-208a, 3.7-208b, 3.7-208c

Attachments:

1. Attachment 1 to Supplemental Response to Request for Additional Information 03.07.02-001, Westinghouse Electric Company Report WLG-1000-S2R-803, Revision 0, *William S. Lee Site Specific Seismic Evaluation Report*
2. Attachment 2 to Supplemental Response to Request for Additional Information 03.07.02-001, Revisions to FSAR Chapter 3 Text
3. Attachment 3 to Supplemental Response for Request for Additional Information 03.07.02-001, Revisions to FSAR Chapter 3 Figures

Lee Nuclear Station

Attachment 1 to Supplemental Response to

Request for Additional Information 03.07.02-001,

Westinghouse Electric Company Report

WLG-1000-S2R-803, Revision 0

William S. Lee Site Specific Seismic Evaluation Report

Note: This report is the public version of WLG-1000-S2R-802, Revision 2, *William S. Lee Site Specific Seismic Evaluation Report*, a Westinghouse Proprietary Class 2 document, which is separately provided to NRC by Duke Energy Letter WLG2012.03-05, dated March 19, 2012

WLG-1000-S2R-803
Revision 0
March 2012

AP1000
William S. Lee Site Specific Seismic Evaluation Report

Westinghouse Electric Company LLC
Nuclear Power Plants
Post Office Box 355
Pittsburgh, PA 15230-0355

Record of Revisions

Rev	Date	Revision Description
0	See EDMS	Original Issue

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1.0 Introduction and Purpose

Two AP1000 units are to be located at the partially constructed Duke Energy Carolinas, LLC (Duke) William S. Lee (Lee) site of the previously planned Cherokee Nuclear Station (CNS). The Duke Lee site will be developed for placement of the AP1000 units in their standard configurations; however, there are some foundation site characteristics that differ from the generic site conditions for which the AP1000 has been designed. This plant-specific analysis of the Duke Lee site addresses these differences.

As shown in Figure 2.1-1, the proposed locations for the two AP1000 units align the new Duke Lee Unit 1 Nuclear Island with the old CNS Unit 1 centerline, and the Unit 2 NI is aligned with the old CNS Unit 3 centerline. The preferred location of the AP1000 units assumes partial demolition of existing CNS superstructure, and subsequent fill concrete beneath the NI and engineered backfill adjacent to the NI to grade.

Westinghouse Electric Company (WEC) has completed a revised, site-specific Soil Structure Interaction (SSI) analysis of the Duke Lee Units 1 and 2 Seismic Category (SC) I Nuclear Island (NI). This report describes the results of the revised site-specific SSI analyses that have been performed to demonstrate the acceptability of the AP1000 plant at the Duke Lee site.

The purpose of the revised analyses was to address the following:

1. Perform two-dimensional (2D) parametric studies to:
    a. Address the revised FIRS A1 spectrum and associated time history.
    b. Evaluate the extent of subsurface characterization, site response and surface motions;
    c. Analyze the site-specific dynamic profile and foundation medium underlying the Units 1 and 2 NI footprints;
    d. Assess the effect of the Unit 1 northwest (NW) corner site-specific conditions on the seismic response; and
    e. Compare the 2D SSI results of the various site subsurface and foundation conditions, and determine the controlling model(s) to be used in subsequent three-dimensional (3D) SSI analysis.
2. Update the Duke Lee 3D SSI model and analysis incorporating the AP1000 NI20r 3D Model, the results and parameters established in the 2D parametric studies and perform twenty-five (25) 3D SASSI incoherent simulation analyses;
3. Compare the Duke Lee 3D horizontal and vertical in-structure floor response spectra (FRS) to the AP1000 3D Certified Seismic Design Response Spectra (CSDRS) and hard rock high frequency (HRHF) FRS envelops at six (6) key AP1000 NI locations; and
4. Incorporate pertinent NRC Request for Additional Information (RAI) responses associated with RAI No. 6182 Rev. 4 (Reference 15).

The 2D SSI analyses were performed using the computer code SASSI2000 (Reference 4) specifically modules SITE, POINT, HOUSE and ANALYS, and post-processed using ACS SASSI modules COMBIN and MOTION (Reference 5). 3D Incoherent SSI analyses were performed using ACS SASSI. All SASSI SSI analyses performed and described in this report utilized the SASSI Direct Method for computing in-structure FRS.

WEC conducted the site-specific SSI analysis for Duke Lee Units 1 & 2 using the AP1000 NI20r finite element model (FEM) and the Duke Lee site-specific Foundation Input Response Spectra (FIRS) A1 time history inputs provided by Duke in DUK-001-CALC-01 (Reference 3).

The 3D SSI analyses are consistent with those supporting the Design Control Document (DCD) and the results will show that the in-structure FRS of an AP1000 plant at the Duke Lee Units 1 & 2 site is enveloped by the AP1000 CSDRS and HRHF envelop FRS at the six key AP1000 NI locations.

2.0 Duke Lee Site Characteristics

The Duke Lee site characteristics at the location of the two AP1000 units are described in the Foundation Interface Report DUK-010-PR-012 (Reference 1) and Final Safety Analysis Report (FSAR) (Reference 2). The Unit 1 NI basemat is founded predominately on fill concrete at El. 550.5 feet (AP1000 El. 60.5 feet), and the Unit 2 NI basemat is founded on hard rock also at El. 550.5 feet. The final grade level for both units is at EL 590.0 feet (AP1000 El. 100.0 feet). The following sections summarize the subsurface conditions, cross-sections and soil profiles used to develop the 2D embedded and 3D surface models for evaluation of the Duke Lee Units 1 and 2 seismic response.

2.1 Summary of Duke Lee Subsurface Conditions

As shown in Figure 2.1-1, the new AP1000 Duke Lee Unit 1 will utilize portions of the former CNS Unit 1 footprint and it is planned to overlie portions of the CNS existing foundation and native rock. Similarly, the new AP1000 Unit 2 will occupy portions of the former CNS Unit 3 footprint area, and will overlie native rock. Both AP1000 Nuclear Island (NI) Units 1 and 2 structures under this configuration will require some additional minor excavation for the development of the Duke Lee NI and replacement with fill concrete. In the northwest corner of Unit 1 and shown in Figure 2.3-2, the placement and compaction of engineered fill is required to backfill the existing excavations adjacent the NI and develop a plant grade at approximately El. 590.0 feet.

The foundation conditions and geologic profiles vary between the Duke Lee Units 1 and 2, and locally at the northwest corner of Unit 1. A total of three (3) site-specific SSI models were developed with corresponding dynamic soil profiles to represent the varied conditions beneath the Duke Lee Units 1 and 2 NI. The following cross-sections were evaluated including:

1. Unit 1 Centerline Cross-Section B-B (Figure 2.2-1);
2. Unit 2 Centerline Cross-Section B-B (Figure 2.2-1); and
3. Unit 1 Northwest Corner Cross-Sections Y-Y and U-U (Figures 2.3-1 and 2.3-2);

A brief description of the cross-sections and site conditions are summarized below in Sections 2.2 and 2.3.

Three dynamic profiles were provided by Duke representing the site conditions at each plant basemat and are described in Sections 2.4 through 2.6. The Duke Lee dynamic soil profiles are identified as follows (References 1 and 6):

- Unit 1 Centerline – Base Case A1 (Figure 2.4-1);
- Unit 1 Northwest Corner – Base Case B3-1 (Figure 2.5-1); and
- Unit 2 Centerline – Profile C (Figure 2.6-1).

Additionally, and as shown in the Unit 1 NW Corner Cross-Section U-U and Y-Y (Figures 2.3-1 and 2.3-2), up to approximately 30 feet of engineered fill is required adjacent the Unit 1 NI (below El. 550.5), which replaces excavated lower velocity saprolite and weathered rock down to continuous rock at the northwest corner. Strain compatible dynamic soil profiles were provided by Duke (Reference 8) for base case dynamic profiles B3-7, B3-8 and B3-9 located within the Unit 1 NW corner. Dynamic properties were provided for three (3) potential engineered fill material types including Unified Soil Classification System (USCS) well-graded gravel (GW), poorly-graded gravel (GP) and well-graded sand (SW) granular materials (Reference 8). Dynamic properties included median, 16th and 84th percentile profiles for each material and a range of ground water conditions, which are shown in Figures 2.5-2, 2.5-3 and 2.5-4, respectively. A range of average dynamic properties were determined, parametrically evaluated in the 2D SSI analysis of the Unit 1 NW corner, and results enveloped as described in Sections 2.5, 5.0 and Appendixes A through C.

It should be noted that Duke Energy has recently decided to revise the height of the top of the engineered fill material adjacent to the nuclear island from El. 589.5 feet (AP1000 El. 99.6 feet), indicated in the input documents for this report, to El. 589.0 feet (AP1000 El. 99.0 feet). The elevation of the nuclear island is unchanged. This small change in site grading adjacent to the nuclear island will have negligible effect on these evaluations.

2.2 Units 1 and 2 Centerline, Cross-Section B-B

Cross-Section B-B (Figure 2.2-1) represents bedrock conditions along an East-West (EW) centerline of both the Unit 1 and Unit 2 NI. The new Unit 1 NI basemat will be constructed over native rock and an average of about 15 feet of existing fill concrete and structural basemat concrete from the former CNS Unit 1 plant foundation, and the new Annex Building will be constructed on approximately 50 feet of engineered backfill. The Unit 2 NI basemat is founded on native hard rock and the Annex Building is constructed on about 30 feet of engineered fill. The Unit 1 NI Centerline rock shear wave velocity (Vs) ranges from about 7,500 feet per second (fps) (fill concrete) to about 9,600 fps (continuous rock) as shown in the Unit 1 Base Case A1 (Table 2.2-1 and Figure 2.4-1). The Unit 2 Centerline continuous rock Vs ranges from about 8,400 fps to about 9,600 fps as shown in the Unit 2 Profile C (Table 2.6-1 and Figure 2.6-1).

2.3 Unit 1 Northwest Corner, Cross-Sections Y-Y and U-U

Cross-Section U-U and Y-Y (Figures 2.3-1 and 2.3-2) represents bedrock conditions at the northwest corner of the Unit 1 NI. In this area, the NI overlies a localized zone of weathered and fractured rock, extending approximately 15 to 25 feet deep below the Unit 1 basemat elevation (El. 550.5 feet). This localized zone of weathered rock exhibits lower Vs velocities, ranging from approximately 4500 to 6000 fps, than the underlying and adjacent sound rock with Vs of approximately 9200 fps. Excavation of this isolated lower velocity material to continuous rock at the northwest corner of Unit 1 NI will be replaced with fill concrete beneath the basemat.

Engineered backfill will be placed and compacted adjacent the NI (and beneath the Annex Building) approximately 20 to 30 feet below the basemat elevation. The Unit 1 rock shear wave velocity at the Northwest corner ranges from about 5,300 fps to about 9,200 fps as shown in the Unit 1 Base Case B3-1 (Table 2.5-1 and Figure 2.5-1). Cross-section U-U is presented in Figure 2.3.2, which indicates the pertinent borings within the Unit 1 NW corner area where engineered fill strain compatible dynamic properties were derived in DUK010-FSAR-2.5.2-CALC-015 (Reference 8).

2.4 Unit 1 Centerline, Base Case A1

Base Case A1 (Table 2.4-1 and Figure 2.4-1) represents bedrock conditions at the centerline of the Unit 1 NI. The new Unit 1 basemat will be constructed over an average of about 15 feet of existing fill concrete and structural basemat concrete from the former CNS foundation. The rock constituting this profile is considered to be not subject to significant dynamic degradation and therefore the material properties are represented by the low strain and static field and laboratory properties without consideration of shear modulus reduction (Reference 1). Table 2.4-1 presents the Vs, Vp and damping values provided by Duke (References 6 and 7) for the Unit 1 NI Centerline and are graphically presented in Figure 2.4-1. Sections 4.0 and 6.0 presents descriptions of the 2D embedded and 3D surface models, respectively, and Tables 4.3-1 and 6.3-1 present the respective 2D and 3D Unit 1 Centerline SASSI SITE profiles.

Table 2.4-1: Duke Lee Unit 1 Centerline – Base Case A1

Depth (top) (feet below El. 589.5)	Depth (bottom) (feet below El. 589.5)	Thickness (feet)	Unit Weight (kips/ft^3)	S-Wave (ft/sec)	P-Wave (ft/sec)	Damping	Elevation of Layer Base (ft)	Description
39.0	44.5	5.5	0.145	7500.0	14031.2	0.005	545.0	Fill Concrete
44.5	48.5	4.0	0.145	7500.0	14031.2	0.005	541.0	Fill Concrete
48.5	59.5	11.0	0.145	7500.0	14031.2	0.005	530.0	Fill Concrete
59.5	80.5	21.0	0.169	9297.0	17167.7	0.005	509.0	Rock
80.5	262.6	182.1	0.177	9559.1	17167.1	0.005	326.9	Rock

2.5 Unit 1 Northwest Corner, Base Case B3-1

Base Case Dynamic Profiles B3-1 through B3-6 were provided by Duke in Reference 6, which developed dynamic properties in the area including the Unit 1 NW corner. Base Case B3-1 (Table 2.5-1 and Figure 2.5-1) was chosen to represent bedrock conditions at the northwest corner of the Unit 1 NI based on its location and soil profile variation with depth. This area of the Unit 1 NI footprint exhibits locally deeper occurrence of high-velocity bedrock. In this area, the Duke Lee Unit 1 NI overlies a localized zone of weathered and fractured rock, extending approximately 15 to 25 feet, below the Unit 1 basemat elevation. Excavation of this isolated, lower velocity material to continuous rock at the northwest corner of the Unit 1 NI will be replaced with new fill concrete. Engineered granular backfill including USGS GP, GW and/or SW materials represent potential fill sources for the backfill placed adjacent the NI (and beneath the Annex Building). Engineered fill (GP, GW and SW) dynamic soil properties for the 16th, median and 84th percentiles were provided by Duke in Reference 8 and are graphically presented in Figures 2.5-2 through 2.5-4. The weathered rock and engineered backfill conditions were modeled to parametrically evaluate the effect of the NW corner subsurface conditions on the Unit 1 seismic response. Table 2.5-1 presents the Vs, Vp and damping values provided by Duke (References 6, 7 and 8) for the Unit 1 NI Northwest Corner. Section 4.0 presents descriptions of the 2D embedded model and Table 4.3-3 presents the Unit 1 NW Corner SASSI SITE profile.

Table 2.5-1: Duke Lee Unit 1 Northwest Corner – Base Case B3-1

Depth (top) (feet below El. 589.5)	Depth (bottom) (feet below El. 589.5)	Thickness (feet)	Unit Weight (kips/ft^3)	S-Wave (ft/sec)	P-Wave (ft/sec)	Damping	Elevation of Layer Base (ft)	Description
39.0	64.5	25.5	0.145	7500.0	14031.2	0.005	525.0	Fill Concrete
64.5	81.5	17.0	0.167	5348.1	13726.6	0.005	508.0	W. Rock
81.5	88.3	6.8	0.167	7575.3	17154.2	0.005	501.2	W. Rock
88.3	114.6	26.3	0.168	8645.4	17399.3	0.005	474.9	Rock
114.6	155.3	40.7	0.169	9242.3	17840.3	0.005	434.2	Rock

2.6 Unit 2 Centerline, Profile C

Profile C (Table 2.6-1 and Figure 2.6-1) represents bedrock conditions beneath the centerline of the Unit 2 NI. The NI basemat will bear directly on high-velocity, sound rock, or a thin fill concrete leveling pad over the sound rock. The rock shear wave velocity for this profile ranges from about 8,400 fps (upper 6-feet) to about 9,600 fps. This profile represents a hard rock seismic velocity profile, and is intended for comparative evaluation with the Unit 1 Base Case A1. The rock constituting this profile is also considered not subject to significant dynamic degradation and therefore the material properties are represented by the low strain and static field and laboratory properties without consideration of shear modulus reduction. Table 2.6-1 presents the Vs, Vp and damping values provided by Duke (Reference 7) for the Unit 2 NI Centerline and are graphically presented in Figure 2.6-1. Sections 4.0 and 6.0 presents descriptions of the 2D embedded and 3D surface models, respectively, and Tables 4.3-2 and 6.3-2 present the respective Unit 2 NI Centerline SASSI SITE profiles.

Table 2.6-1: Duke Lee Unit 2 Centerline – Profile C

Depth (top) (feet below El. 589.5)	Depth (bottom) (feet below El. 589.5)	Thickness (feet)	Unit Weight (kips/ft^3)	S-Wave (ft/sec)	P-Wave (ft/sec)	Damping	Elevation of Layer Base (ft)	Description
39.4	45.5	6.1	0.177	8391.2	17245.2	0.005	544.0	Rock
45.5	98.5	53.0	0.177	8983.0	18009.0	0.005	491.0	Rock
98.5	155.5	57.0	0.177	9587.0	18703.0	0.005	434.0	Rock

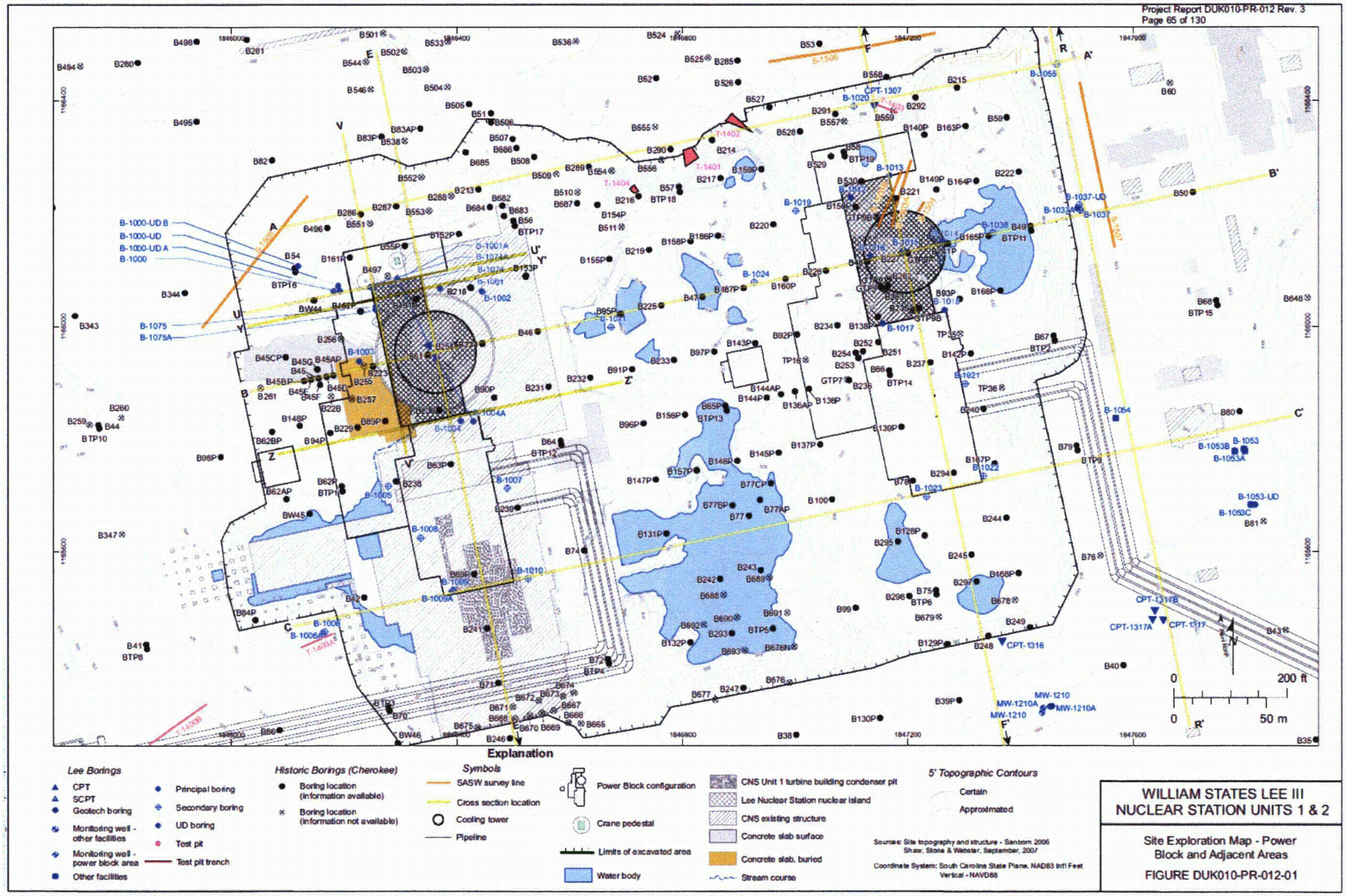

Figure 2.1-1: Duke Lee Site Plan – Units 1 and 2

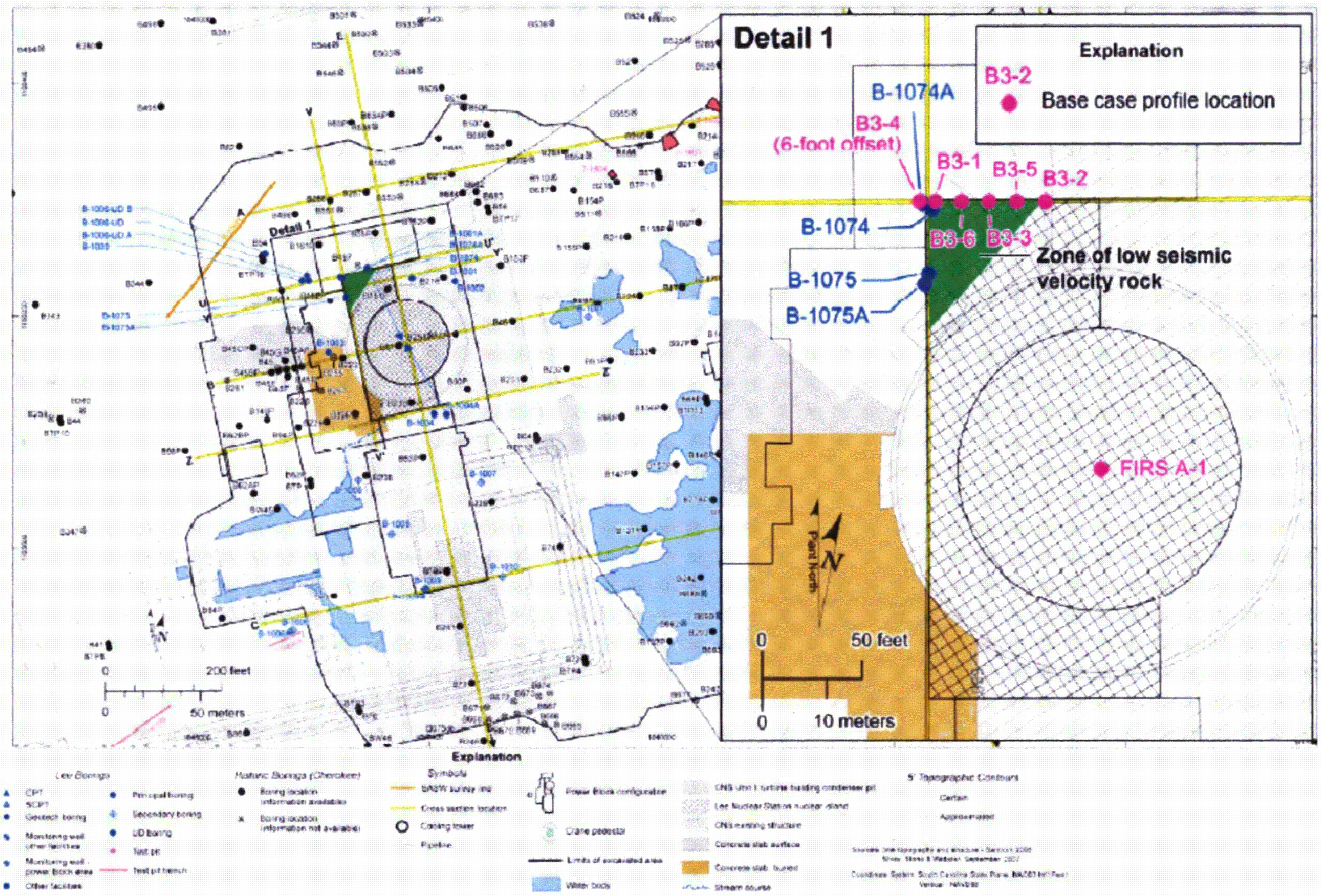

Figure 2.1-2: Duke Lee Site Plan – Unit 1 Northwest Corner

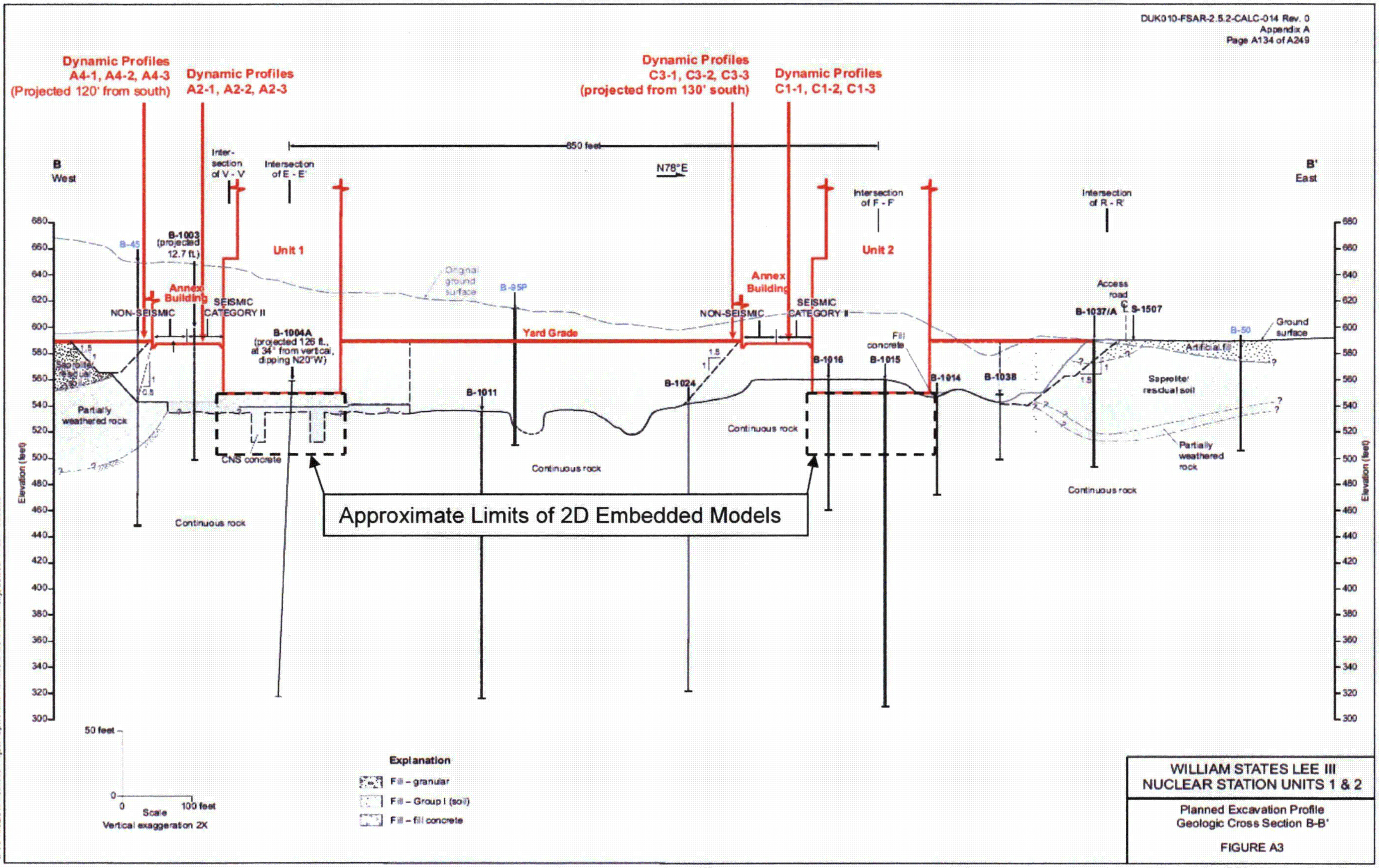

Figure 2.2-1: Cross-Section B-B

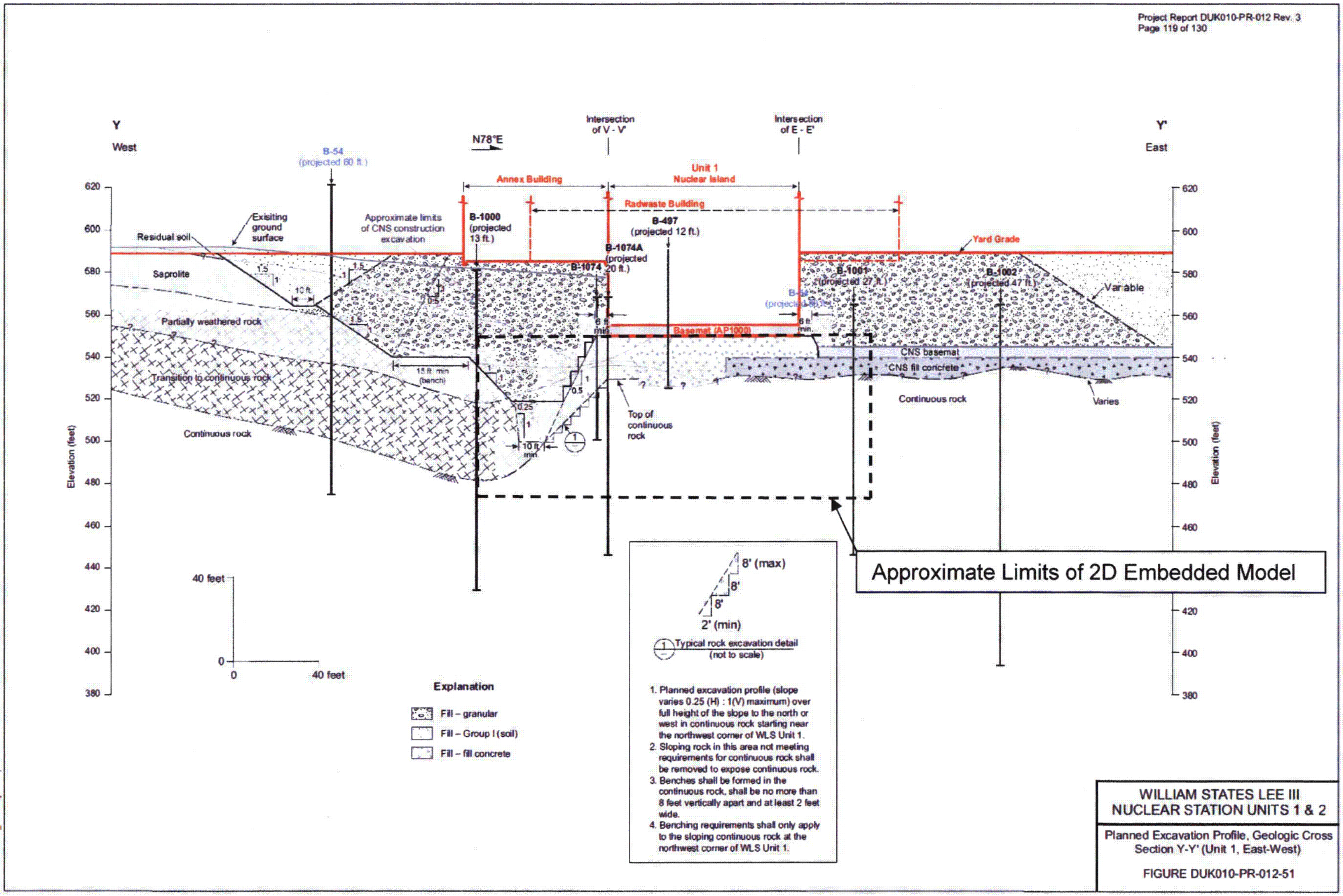

Figure 2.3-1: Cross-Section Y-Y (Unit 1, East-West)

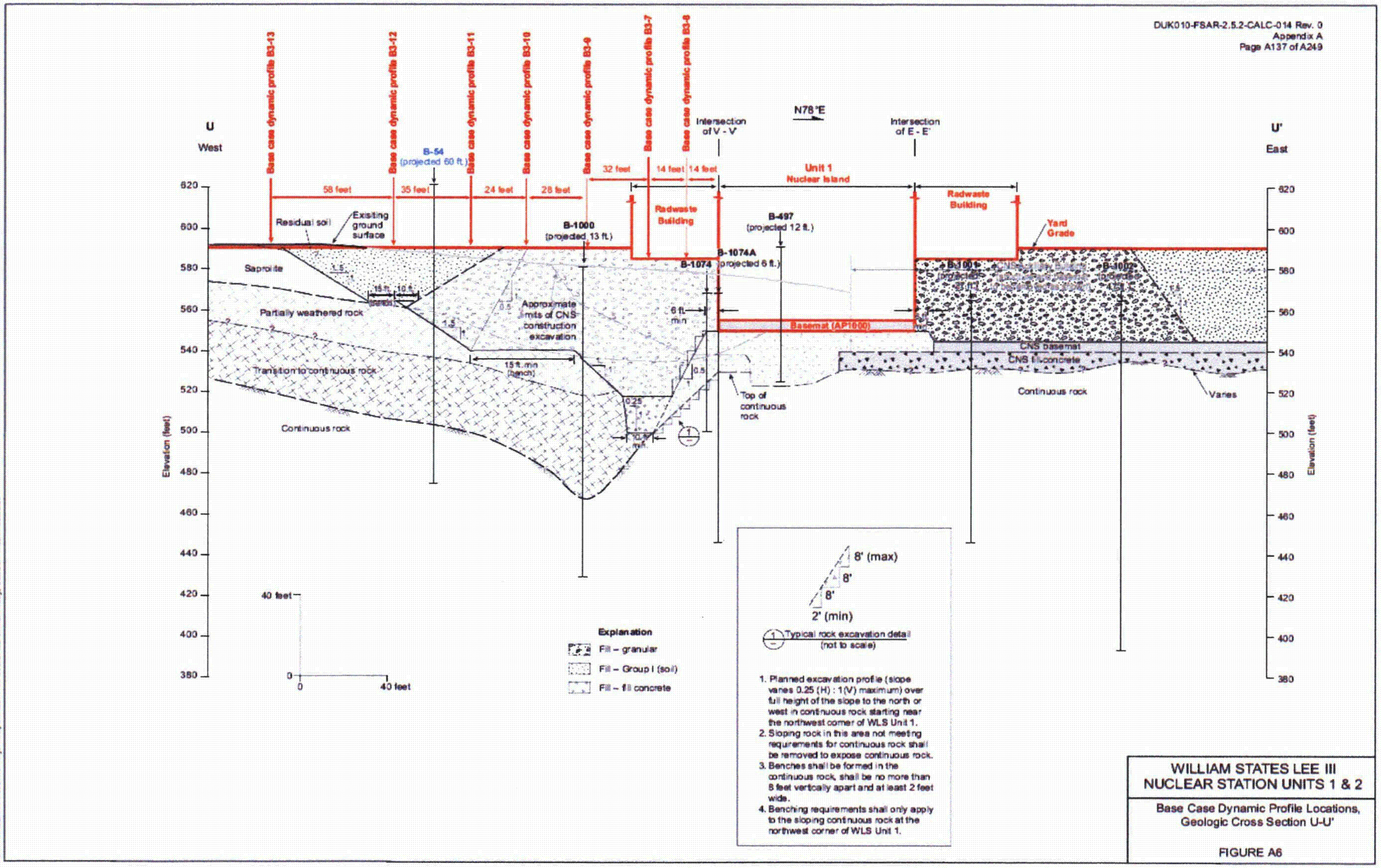

Figure 2.3-2: Cross-Section U-U (Unit 1, East-West)

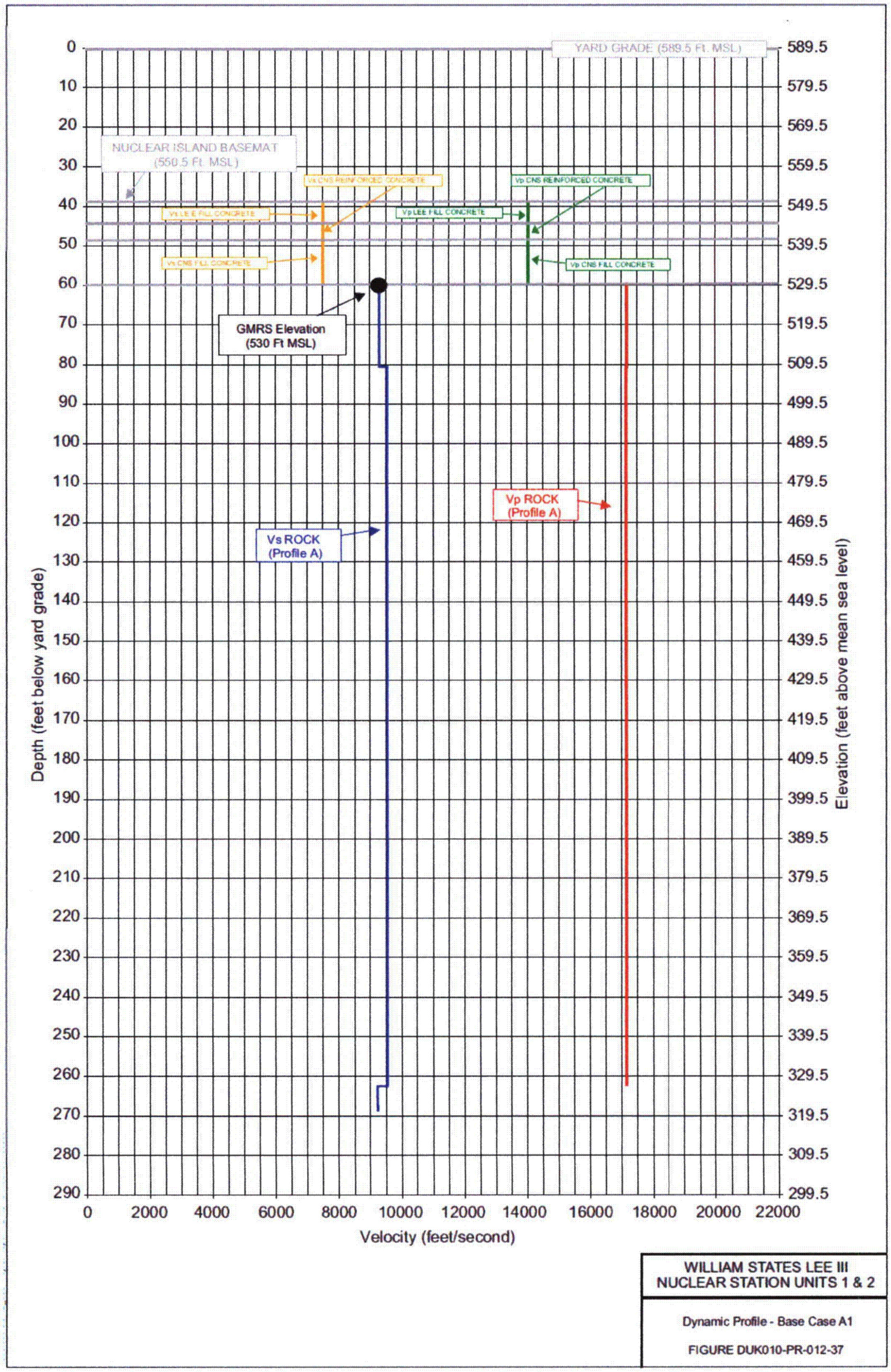

Figure 2.4-1: Base Case A1 Dynamic Profile – Unit 1 NI Centerline

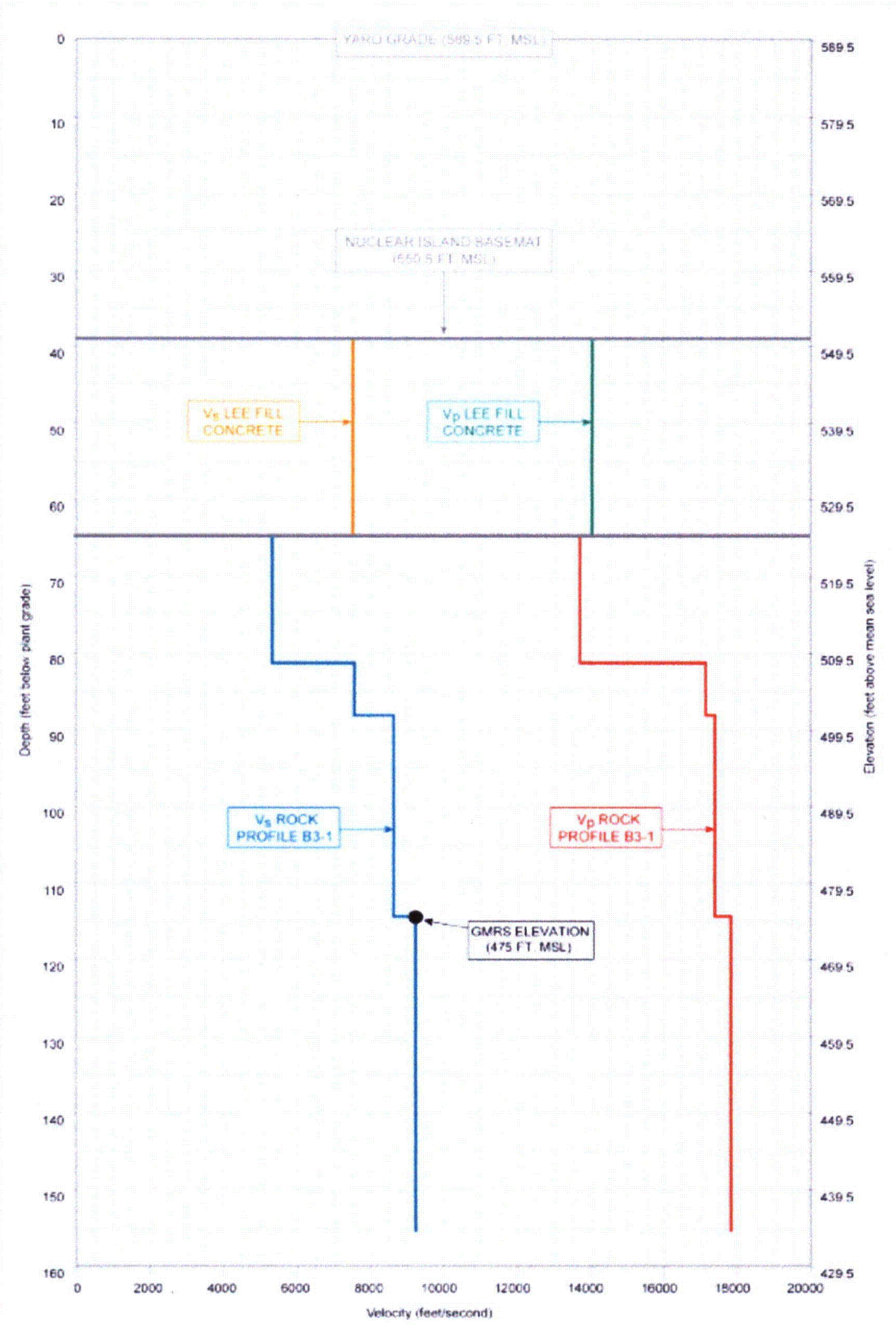

Figure 2.5-1: Base Case B3-1 Dynamic Profile – Unit 1 Northwest Corner

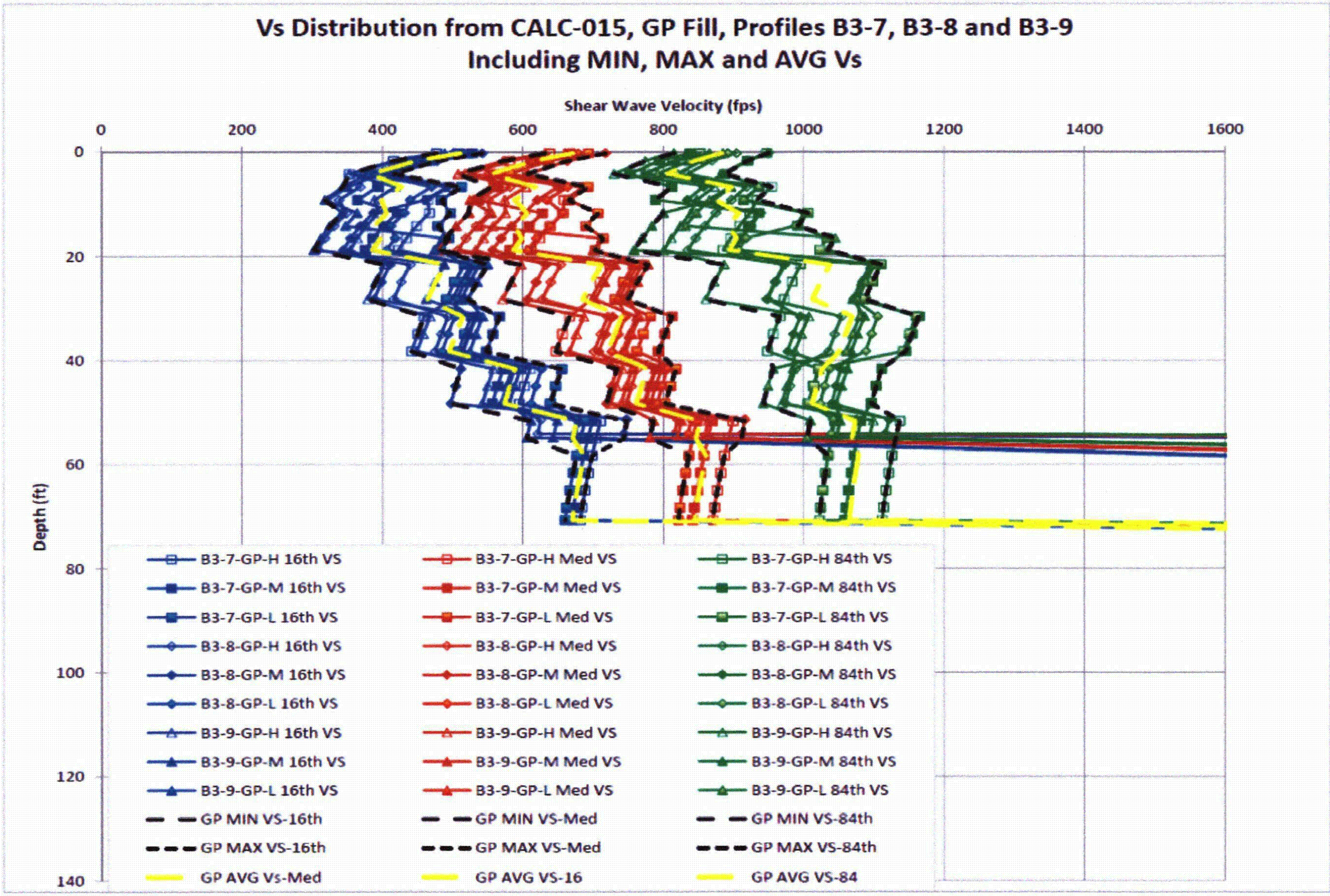

Figure 2.5-2: GP Engineered Fill Dynamic Profile

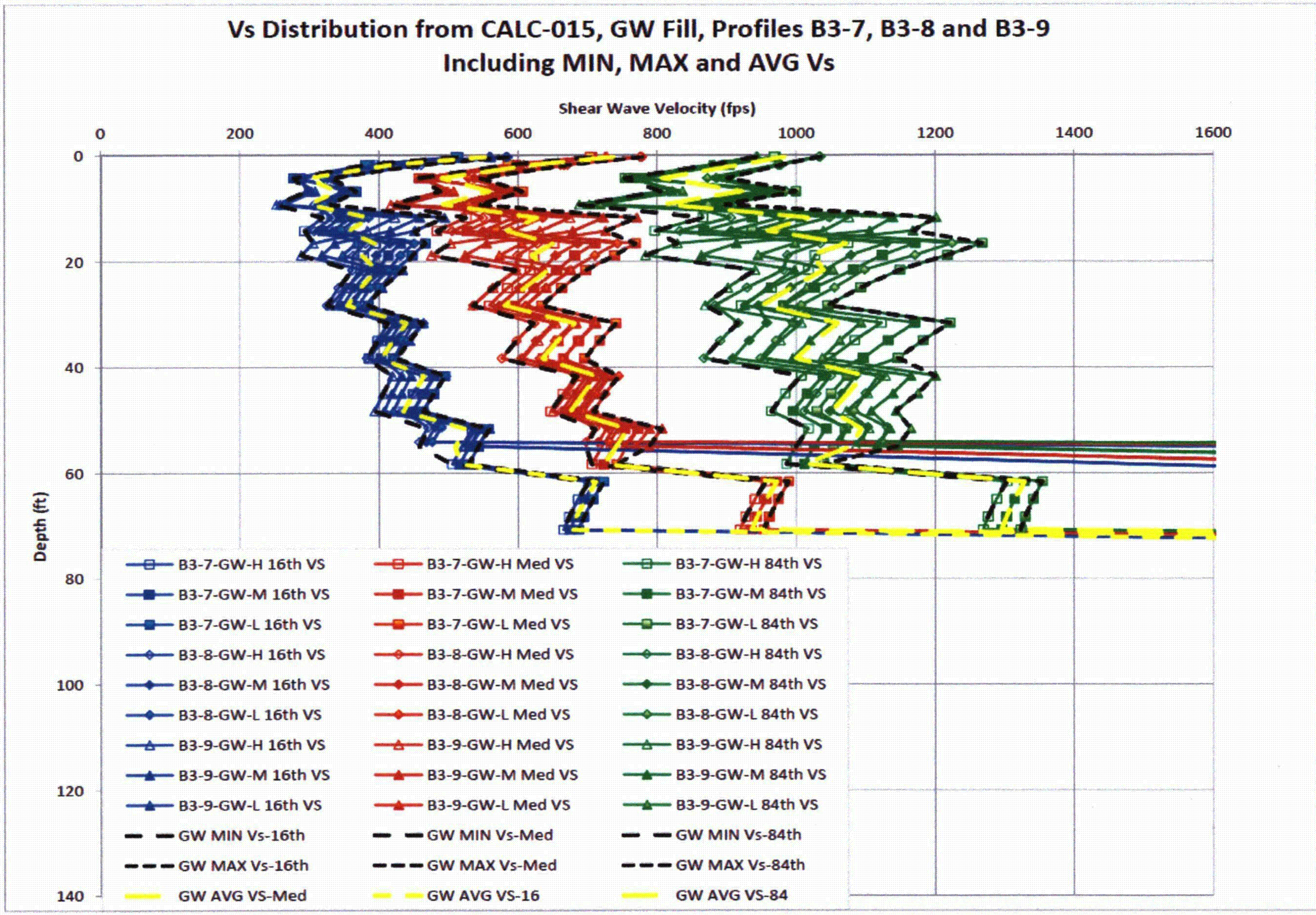

Figure 2.5-3: GW Engineered Fill Dynamic Profile

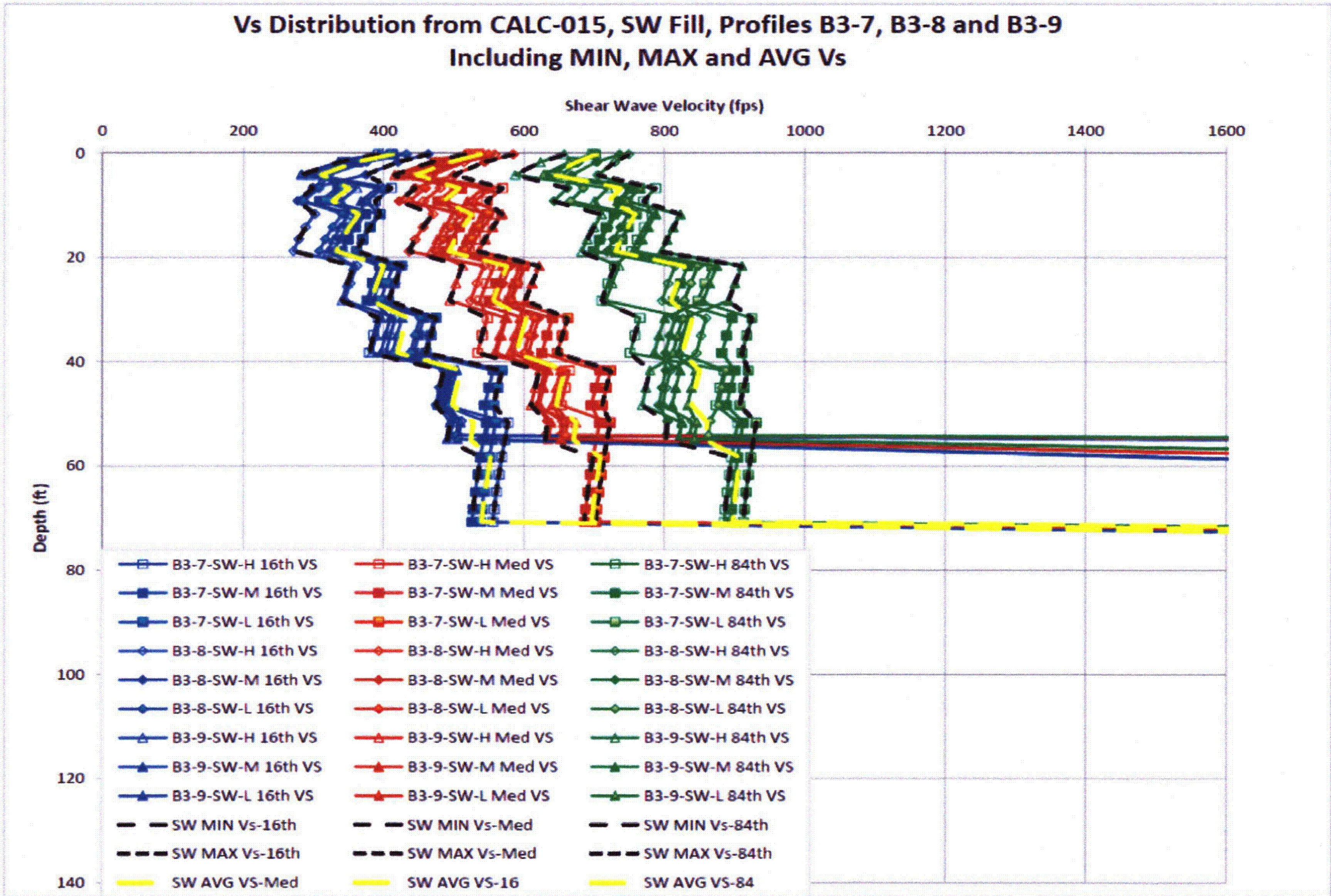

Figure 2.5-4: SW Engineered Fill Dynamic Profile

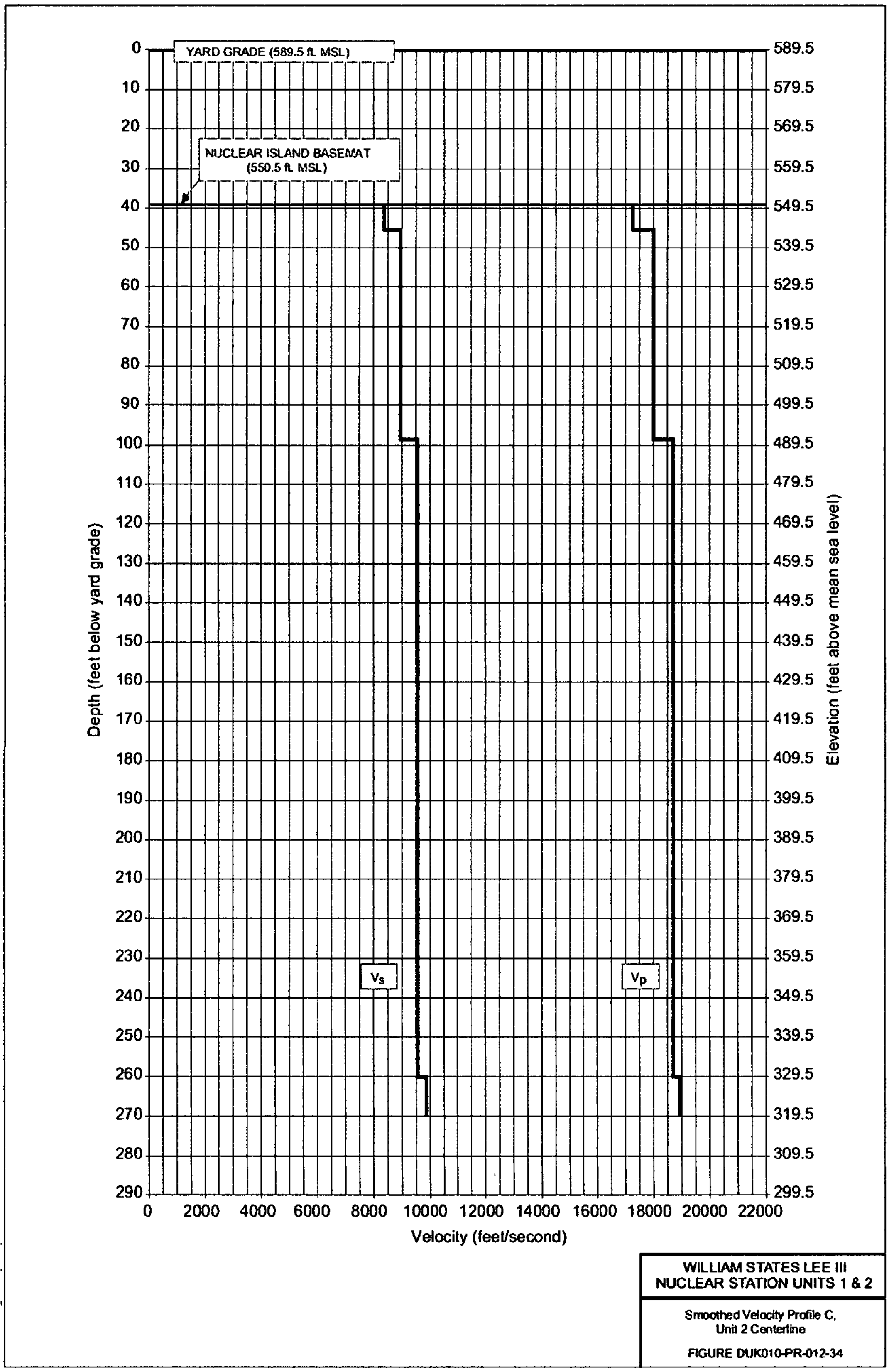

Figure 2.6-1: Profile C Dynamic Profile – Unit 2 NI Centerline

3.0 Duke Lee Units 1 and 2 Seismic Inputs at Basemat El. 550.5 feet

The revised Duke Lee Unit 1 Foundation Input Response Spectra (FIRS) A1 and corresponding two horizontal and one vertical acceleration time histories were provided by Duke in calculation no. DUK-001-CALC-01 (Reference 3).

The Duke Lee FIRS-A1 spectra are graphically presented herein as Figures 3-2 through 3-4. The corresponding input time histories are used as seismic input in three orthogonal directions at the bottom of the foundation mat (Duke El. 550.5 feet; AP1000 El. 60.5 feet) in the Duke Lee SSI analyses, and are presented in Figures 3-5, 3-6 and 3-7.

Reference 3 provides two horizontal and one vertical time history for 9200 discrete values of acceleration with a time step of 0.005 seconds in files DUK_H1.acc, DUK_H2.acc, and DUK_V.acc. Table 3-1 (Table 1 from Reference 3) presents a summary of the characteristics of the artificial ground motions for each time history component. Based on the results and as noted in Reference 3, the FIRS A1 time histories appears to meet the criteria specified in Standard Review Plan (SRP) 3.7.1.

As described in the Duke Lee FSAR (Reference 2) and shown in Figure 3-1, the horizontal FIRS for Duke Lee Unit 2 is the GMRS, which is lower than the Unit 1 FIRS. Therefore, for the purposes of this site-specific analysis, the time histories corresponding to Unit 1 FIRS A1 are conservatively used as the FIRS for both Units 1 and 2.

Table 3-1: Summary of Characteristics of Artificial Ground Motions (Reference 3)

Parameter	Horizontal 1	Horizontal 2	Vertical
File name	DUK-H1.acc	DUK_H2.acc	DUK_V.acc
Duration (5-75%; sec)	12.9	12.4	15.5
PGA (g)	0.23	0.23	0.17
PGV (cm/sec)	8.8	8.7	7.4
PGD (cm)	7.6	7.0	4.9
PGD/PGA (cm/g)	33	30	29
PGV/PGA (cm/sec/g)	38	38	44
$PGA*PGD/PGV^2$	22	21	15
Correlation with Horizontal 1	-	0.074	-0.017
Correlation with Horizontal 2	-	-	-0.091

3.1 AP1000 Envelope Response Spectra

The AP1000 Certified Seismic Design Response Spectra (CSDRS) envelop is provided in Reference 9, and the hard rock high frequency (HRHF) FRS envelop is provided in Reference 10. The Duke Lee 3D SSI in-structure FRS are compared to the AP1000 CSDRS and HRHF envelops at the six key locations identified in Table 4.5-1, which is graphically presented in Section 7.0

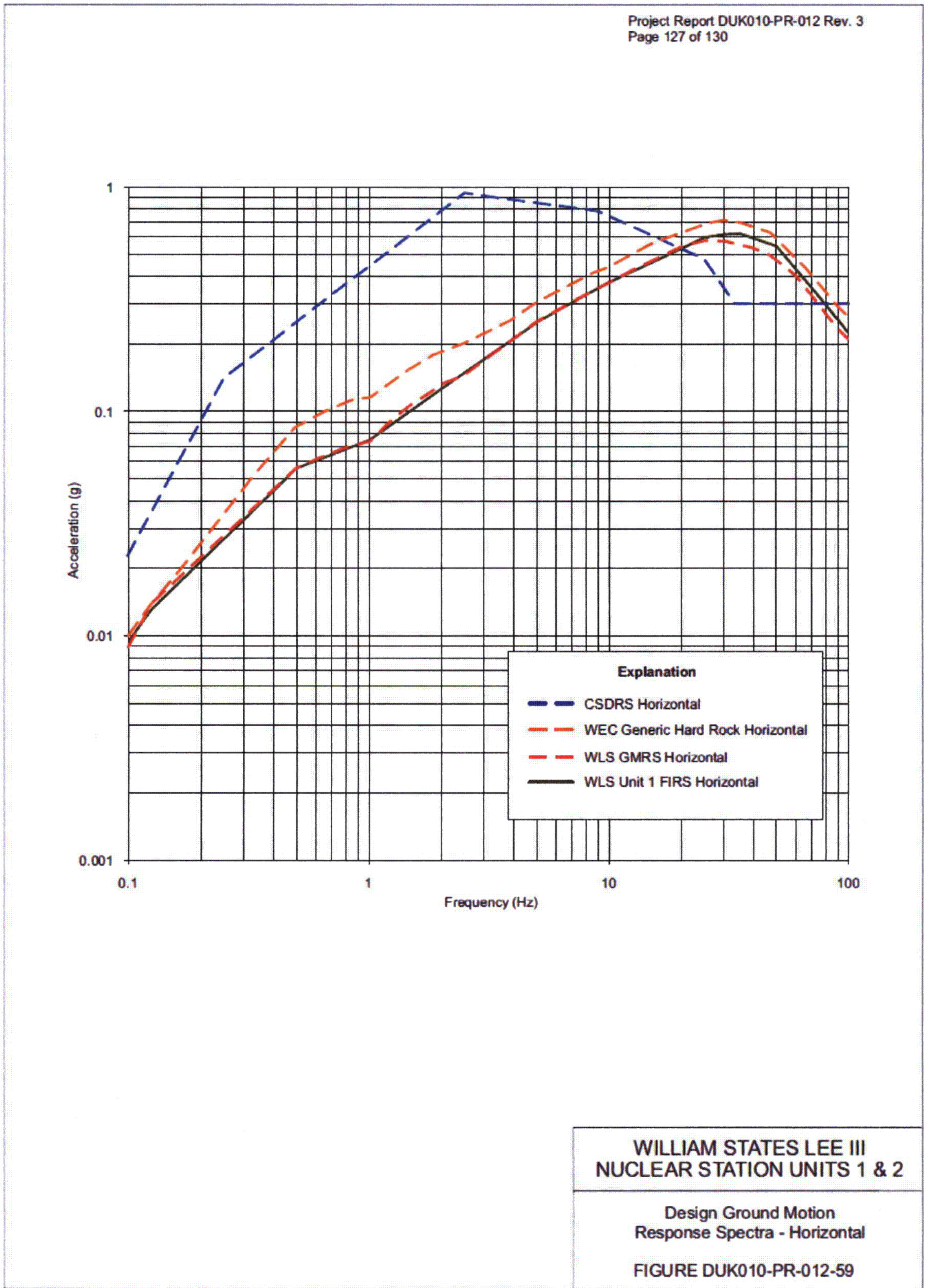

Figure 3-1: Duke Lee Units 1 and 2 Horizontal Ground Motion Response Spectra

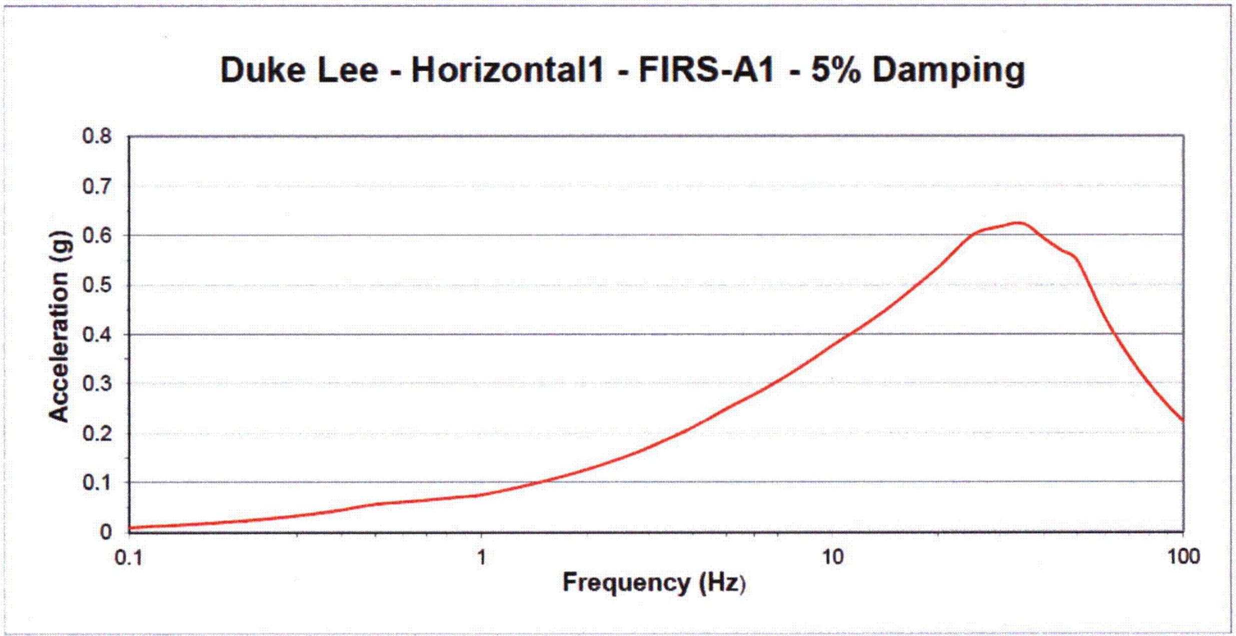

Figure 3-2: Duke Lee North-South Foundation Input Response Spectra at 5% Damping

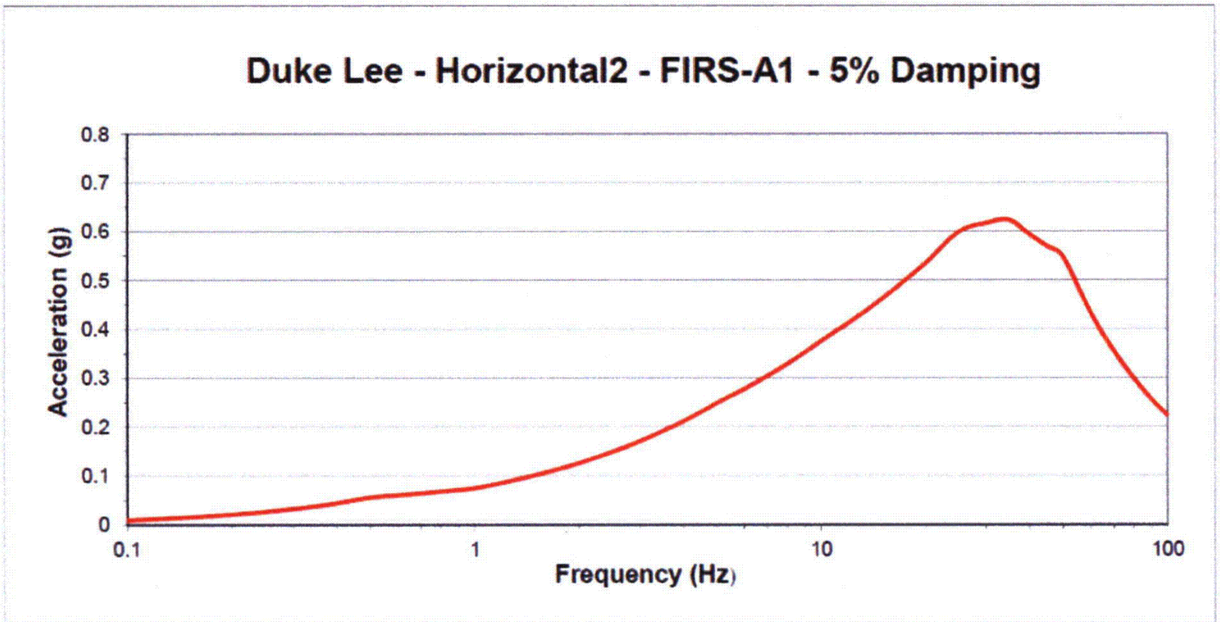

Figure 3-3: Duke Lee East-West Foundation Input Response Spectra at 5% Damping

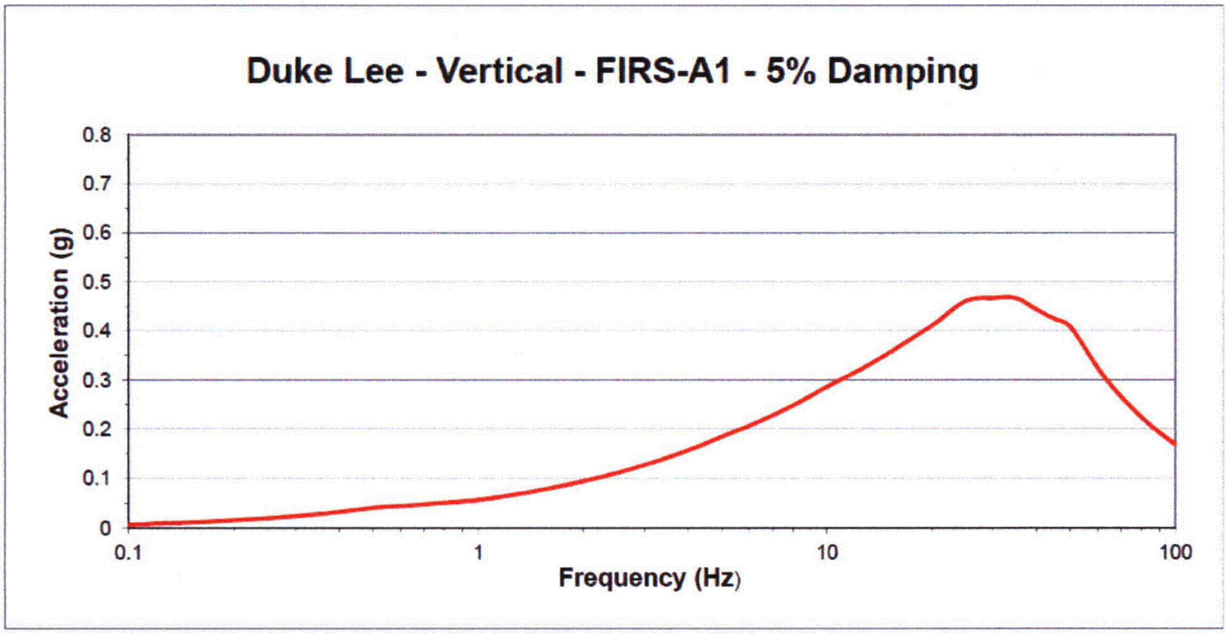

Figure 3-4: Duke Lee Vertical Foundation Input Response Spectra at 5% Damping

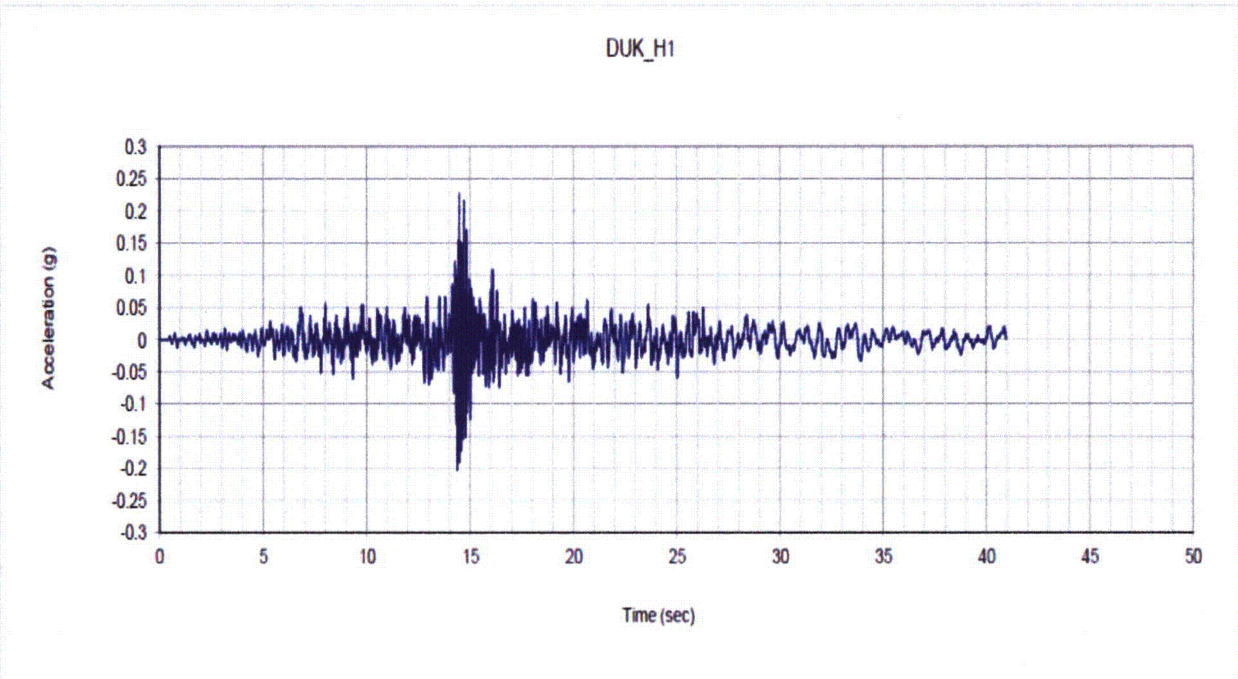

Figure 3-5: Duke Lee North-South Time History H1

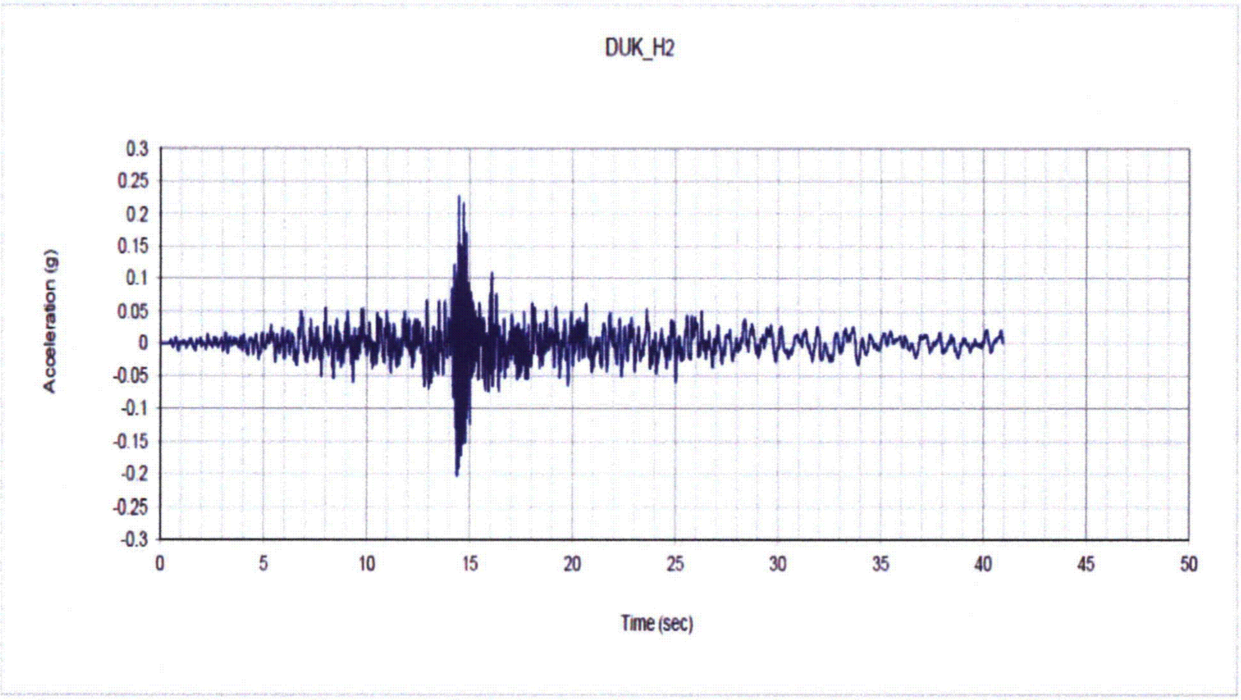

Figure 3-6: Duke Lee East-West Time History H2

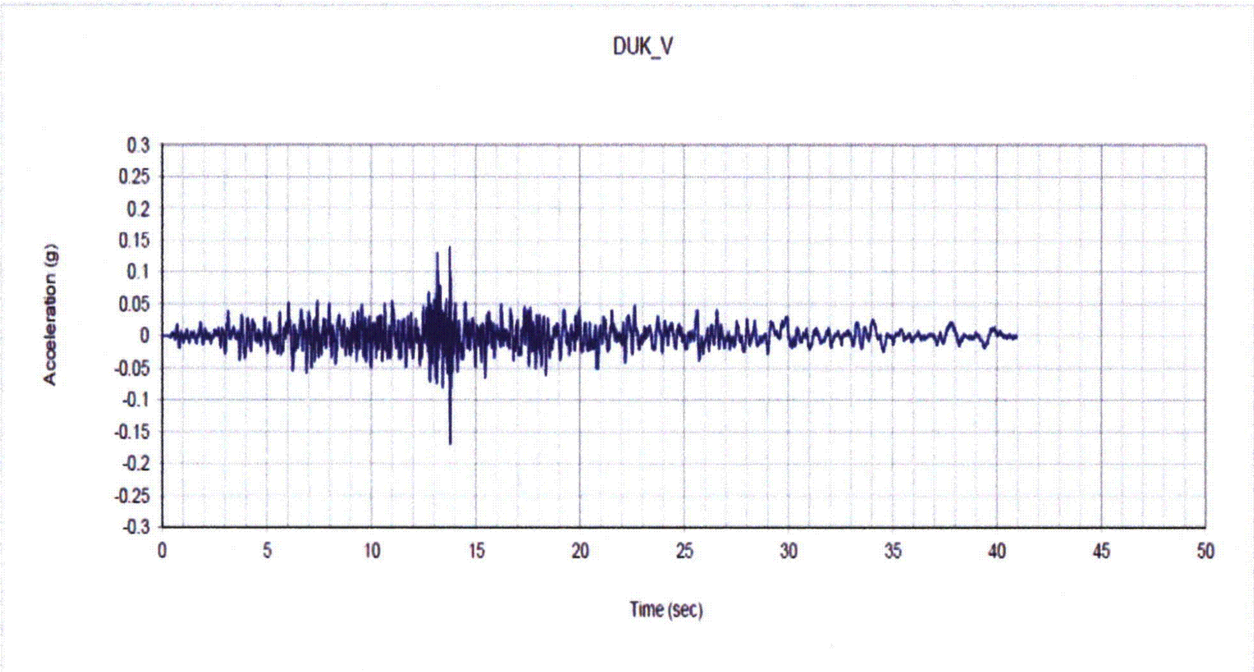

Figure 3-7: Duke Lee Vertical Time History V

4.0 [ ]a,c

[

]a,c

4.1 [ ]a,c

[

]a,c

a,c

Figure 4.1-1: [ ]a,c

4.2 [ ]a,c

[

]a,c

4.2.1 [ ]a,c

[

]a,c

a,c

Figure 4.2-1: [ ]a,c

4.2.2 [ ]^a,c

[

]^a,c

a,c

Figure 4.2-2: [ ]^a,c

4.2.3 [ ]a,c

[

]a,c

a,c

Figure 4.2-3: [ ] a,c

4.3 [ ]a,c

[ ]a,c

4.4 [ ]a,c

[ ]a,c

Table 4.3-1: [ ]a,c

a,c

Table 4.3-2: [ ]a,c

a,c

Table 4.3-3: [ ]^{a,c}

a,c

4.5 [ ]a,c

[

]a,c

Table 4.5-1: [ ]a,c

a,c

5.0 Duke Lee 2D SASSI Parametric SSI Analysis Results

Six locations were selected for comparison as shown in Table 4.5-1. Appendices A, B and C compare the 2D FRS for the Unit 1 and Unit 2 Centerline model/profiles and the Unit 1 NW Corner model with potential GP, GW and SW engineered fill placed adjacent to the NI. Engineered fill dynamic soil properties for the 16^{th}, median and 84^{th} percentiles were provided by Duke in Reference 8 and Figures 2.5-2 through 2.5-4 illustrate the range of strain compatible properties considered in these 2D parameter analyses. The envelopes of the GP, GW and SW FRS are calculated from each of these individual analyses results and the in-structure FRS comparisons of the Unit 1 NI Centerline, Unit 2 NI Centerline, and the Unit 1 NW Corner with the GP, GW and SW engineered backfill envelope from the 16th, median and 84th percentile sensitivity analyses are presented in Figures 5-1 to 5-12. In response to RAI Letter 6182, Item (b) (Reference 15), FRS were also compared to the AP1000 horizontal and vertical CSDRS envelope spectra and the HRHF envelope spectra.

It is important to note that the HRHF broad curve (envelop) is based on SASSI 3D analyses and includes seismic motion incoherency effects; however, the Duke Lee 2D FRS does not include in the SSI analyses coherency functions. As indicated, the purpose of the 2D SSI analyses was to evaluate the various cases for subsequent 3D SSI analyses and assess potential FRS impacts from the NW corner subsurface conditions. Sections 6.0 and 7.0 presents comparisons of the Duke Lee 3D FRS results with incoherency to the AP1000 HRHF envelop (also including incoherency). Based on the 2D SASSI parametric analyses results, the following conclusions are made:

- Consideration of the Unit 1 Northwest Corner configuration and materials results in a relatively small change in the calculated in-structure FRS compared to the Unit 1 Centerline FRS. Likewise, the selection of engineered fill (GP, GW or SW) to be used adjacent to the NI also has a relatively small effect on the calculated in-structure FRS for the NI.

- Only minor spectral acceleration differences were observed between the Unit 1 NI Centerline 2D FRS and the Unit 2 NI Centerline 2D FRS across the entire frequency spectrum in both the horizontal and vertical directions. The slight variation of the dynamic properties of Unit 1 situated on fill concrete versus Unit 2 founded on sound rock do not appear to generate an appreciable difference in each respective model FRS.

- Comparing the Unit 1 and Unit 2 NI Centerline 2D FRS to the AP1000 2D CSDRS and HRHF FRS envelops suggest that above 20 Hz, the Unit 1 and 2 FRS exceed the AP1000 envelop FRS; however, as previously discussed, coherency functions were not applied in the 2D parametric analyses, which will reduce the 3D FRS spectral accelerations response in the higher (>20 Hz) frequency range. Section 7.0 presents comparisons of the Duke Lee 3D FRS results with incoherency to the AP1000 HRHF envelop (also including incoherency).

Based on the results of the Duke Lee 2D parametric SSI analyses, subsequent 3D incoherent SSI analyses are performed using both the Unit 1 and Unit 2 NI Centerline cross-section models and corresponding Base Case A1 and Profile C soil profiles, respectively. FRS from 3D incoherent SSI analyses is subsequently compared to the AP1000 and HRHF 3D envelope spectra. The 3D SASSI SSI models and analyses results are discussed in Sections 6.0 and 7.0 respectively.

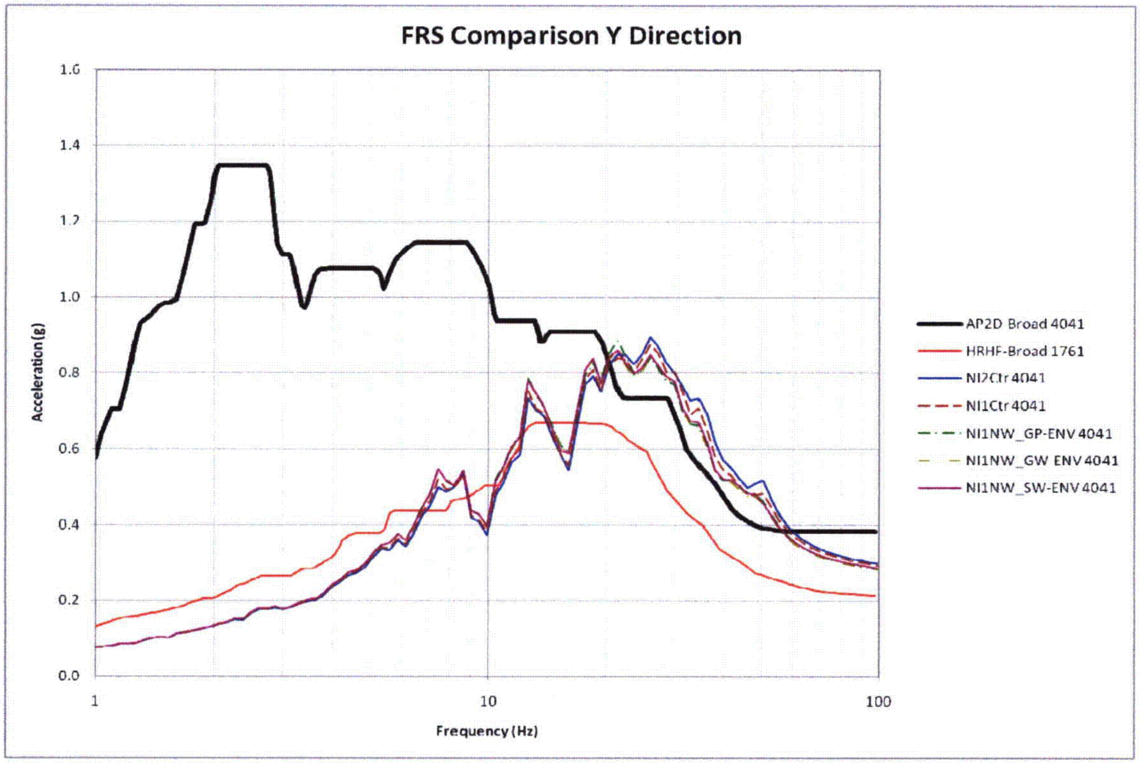

Figure 5-1: 2D Parametric FRS Comparison of Node 4041 in Y-Direction

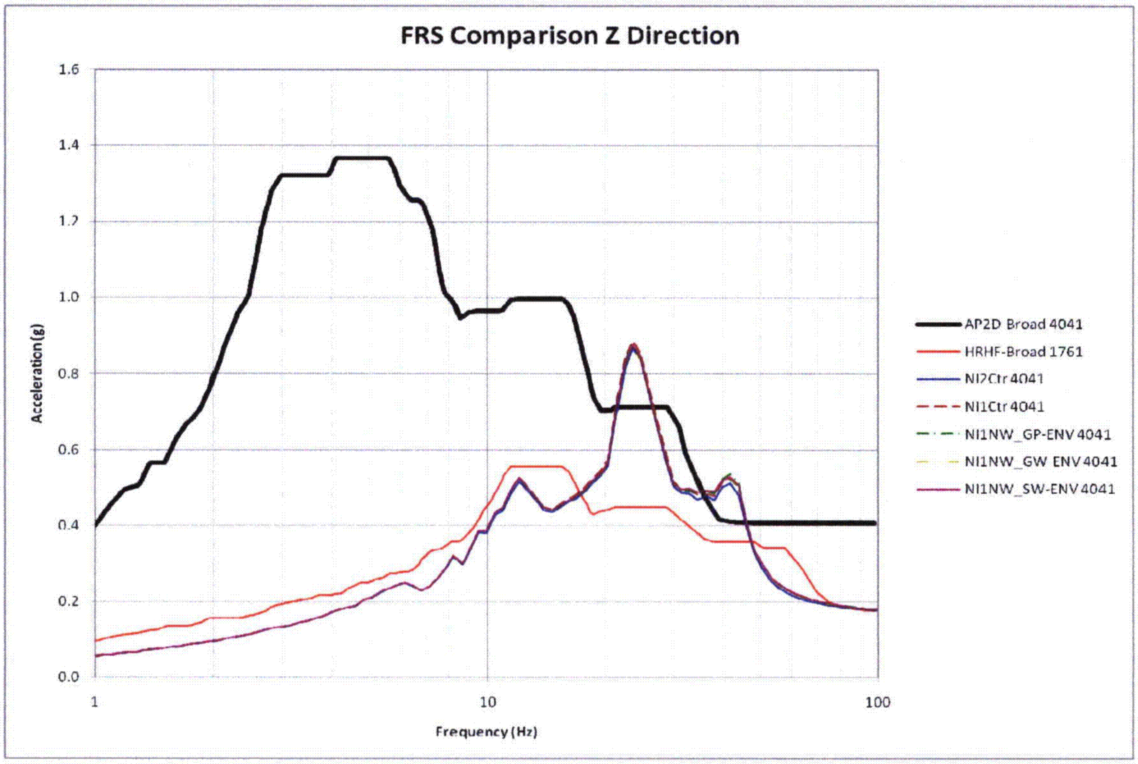

Figure 5-2: 2D Parametric FRS Comparison of Node 4041 in Z-Direction

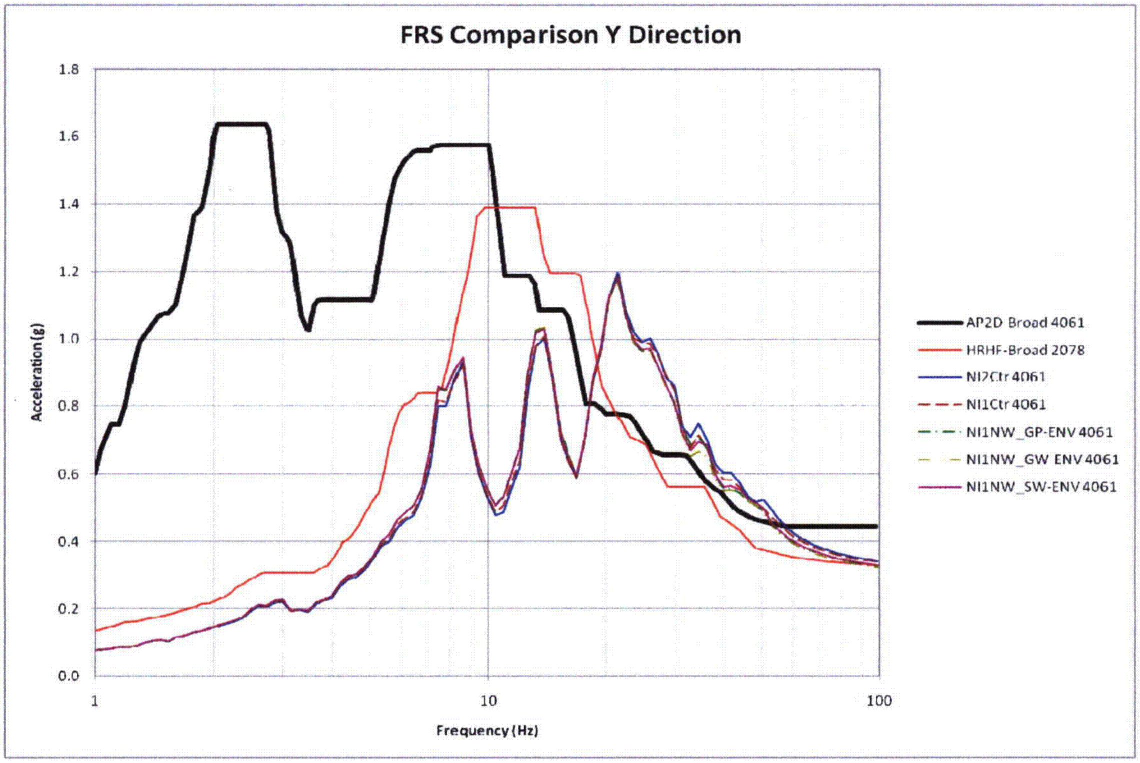

Figure 5-3: 2D Parametric FRS Comparison of Node 4061 in Y-Direction

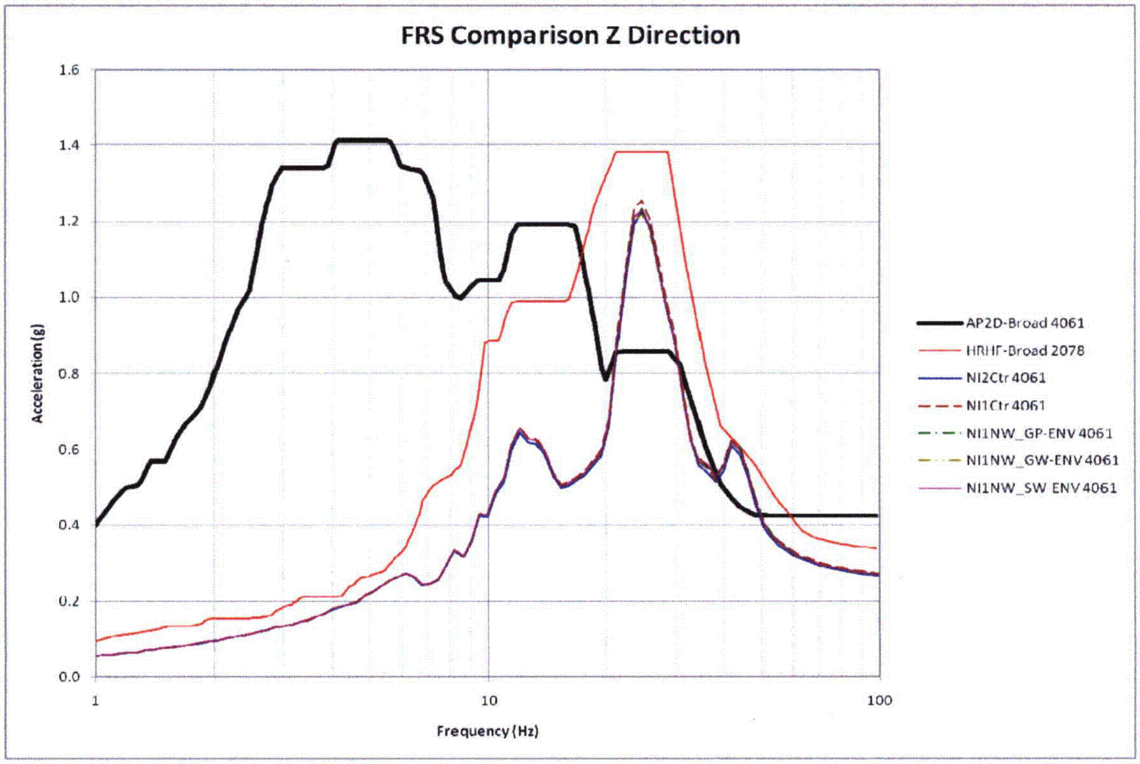

Figure 5-4: 2D Parametric FRS Comparison of Node 4061 in Z-Direction

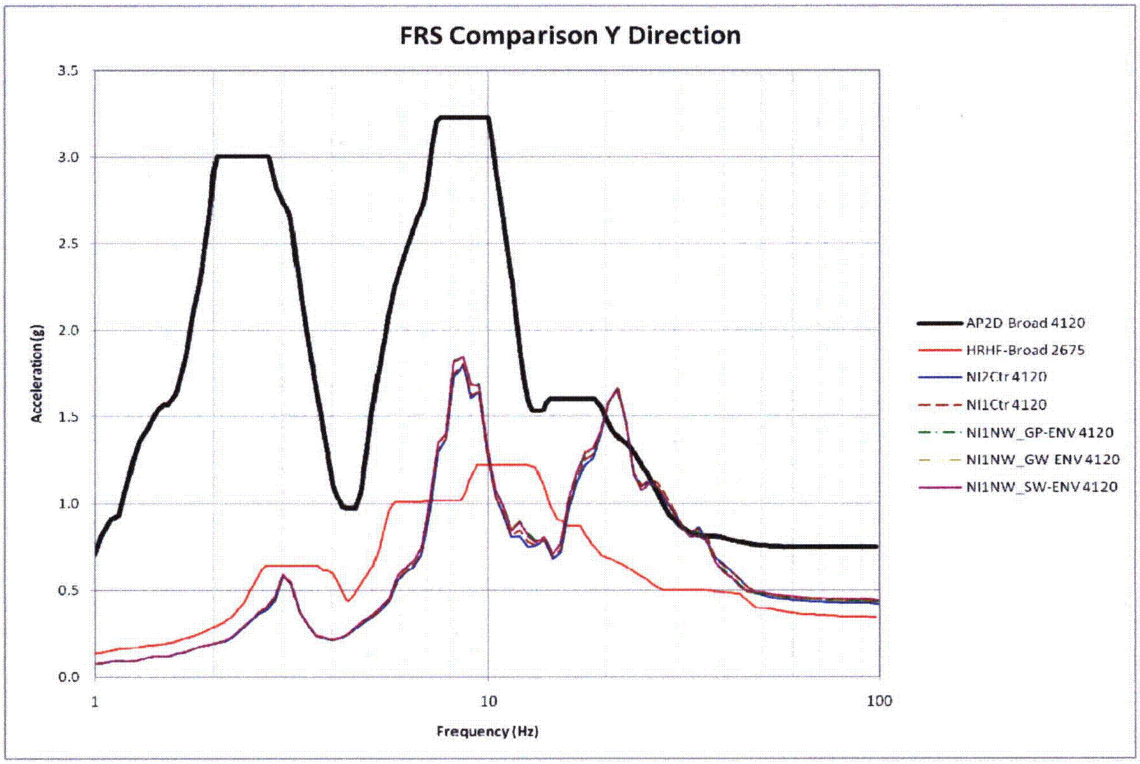

Figure 5-5: 2D Parametric FRS Comparison of Node 4120 in Y-Direction

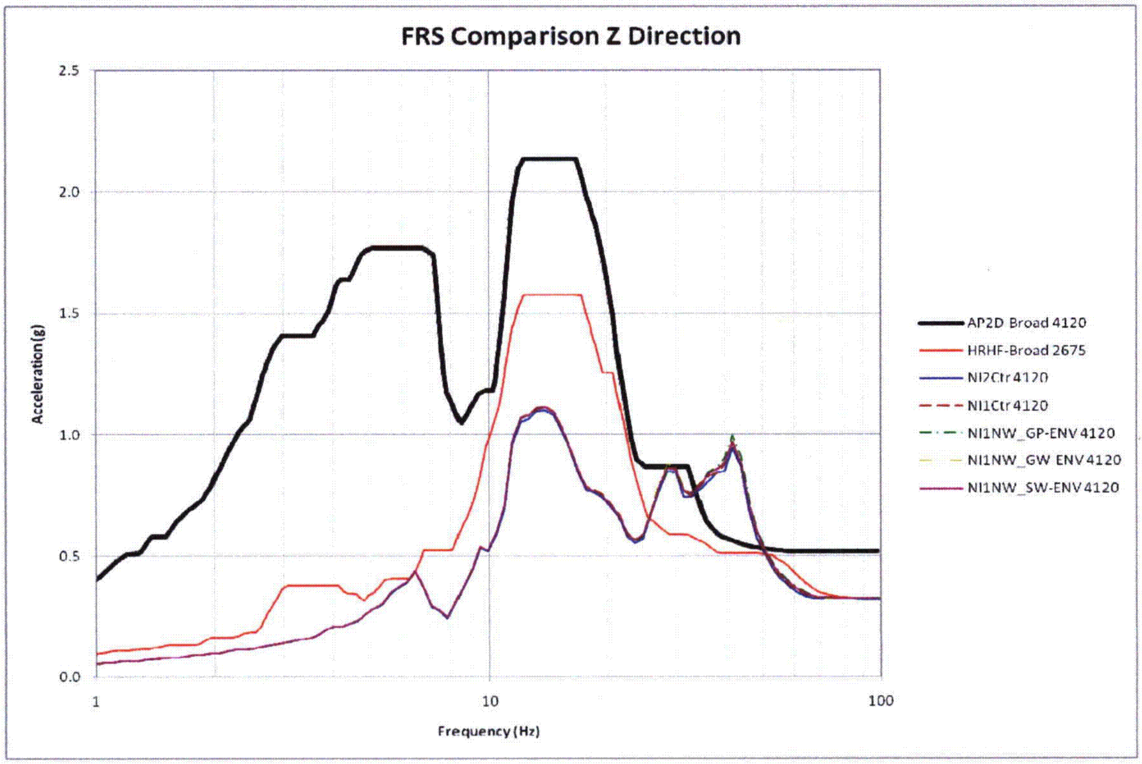

Figure 5-6: 2D Parametric FRS Comparison of Node 4120 in Z-Direction

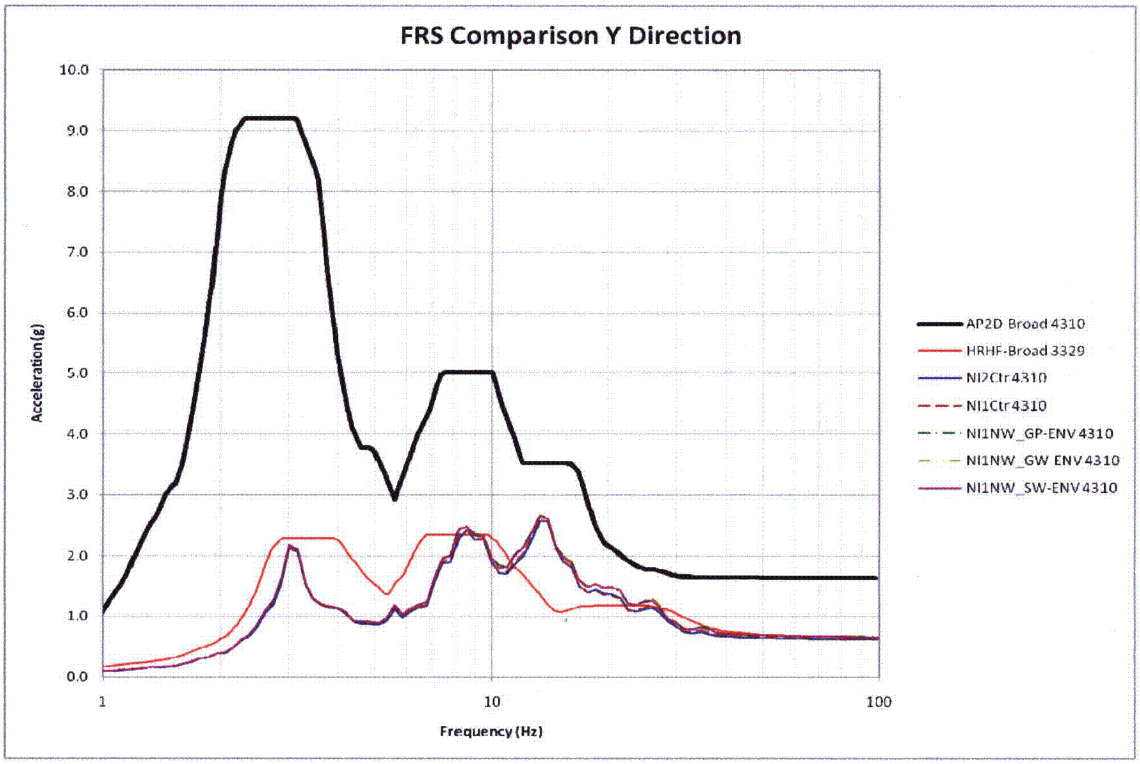

Figure 5-7: 2D Parametric FRS Comparison of Node 4310 in Y-Direction

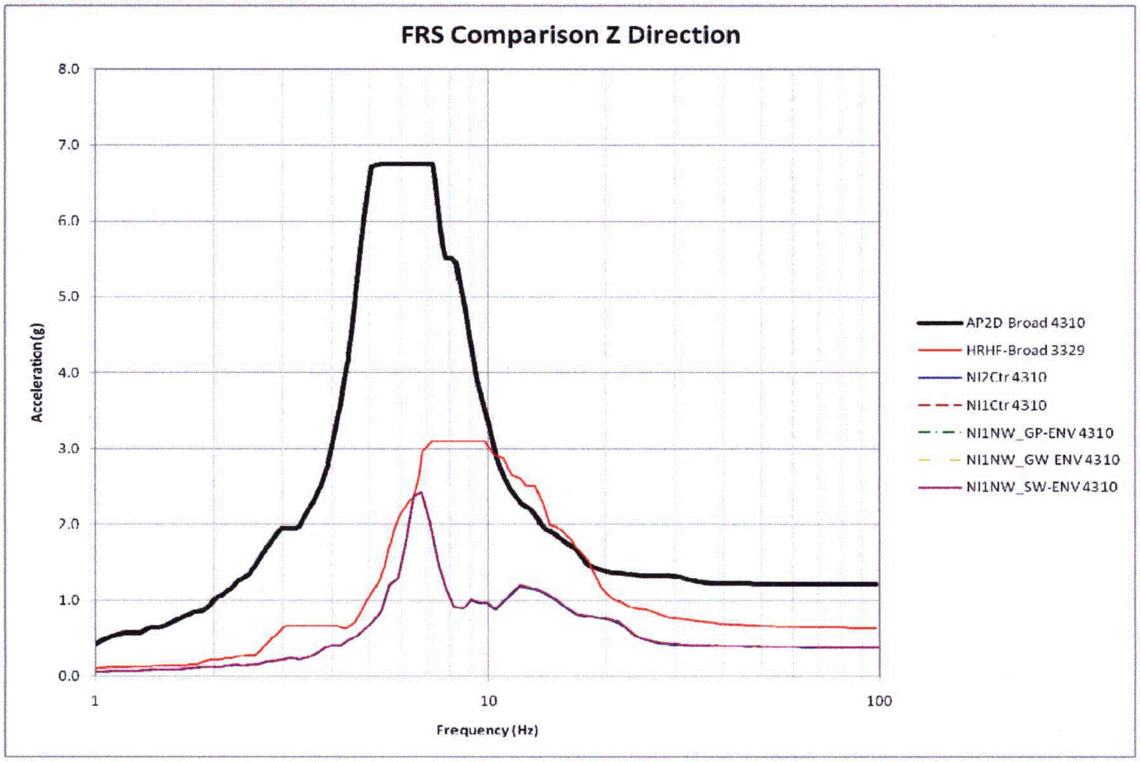

Figure 5-8: 2D Parametric FRS Comparison of Node 4310 in Z-Direction

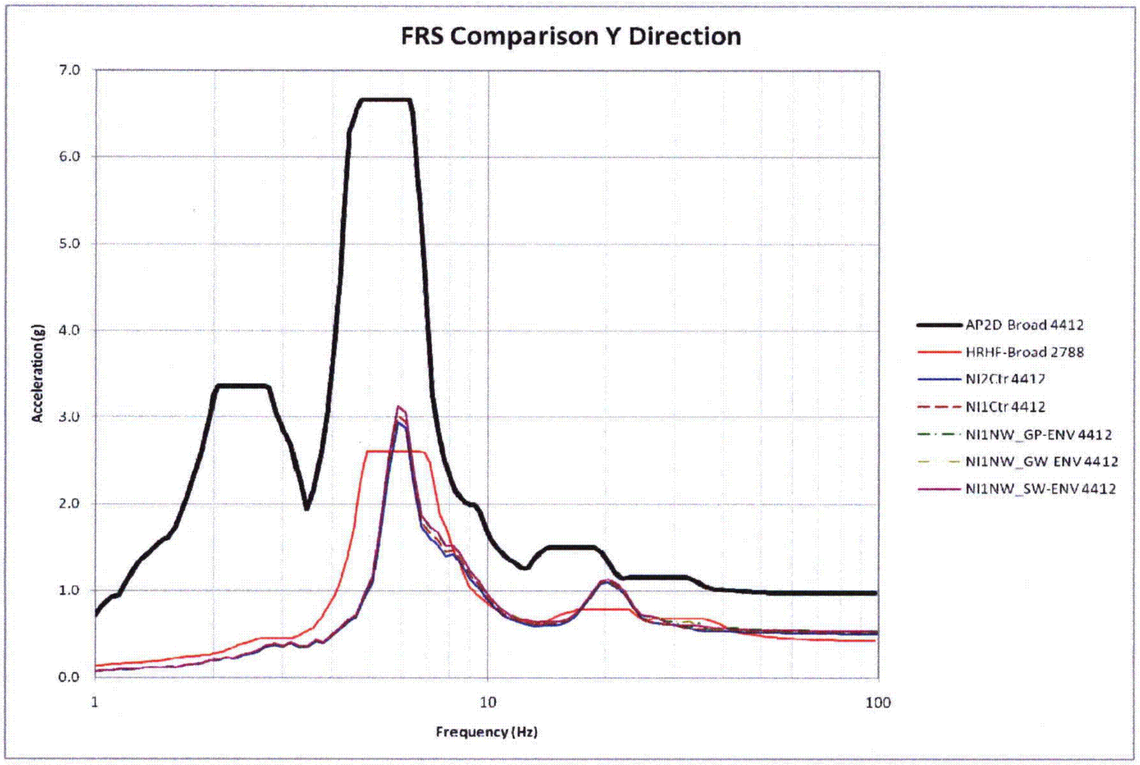

Figure 5-9: 2D Parametric FRS Comparison of Node 4412 in Y-Direction

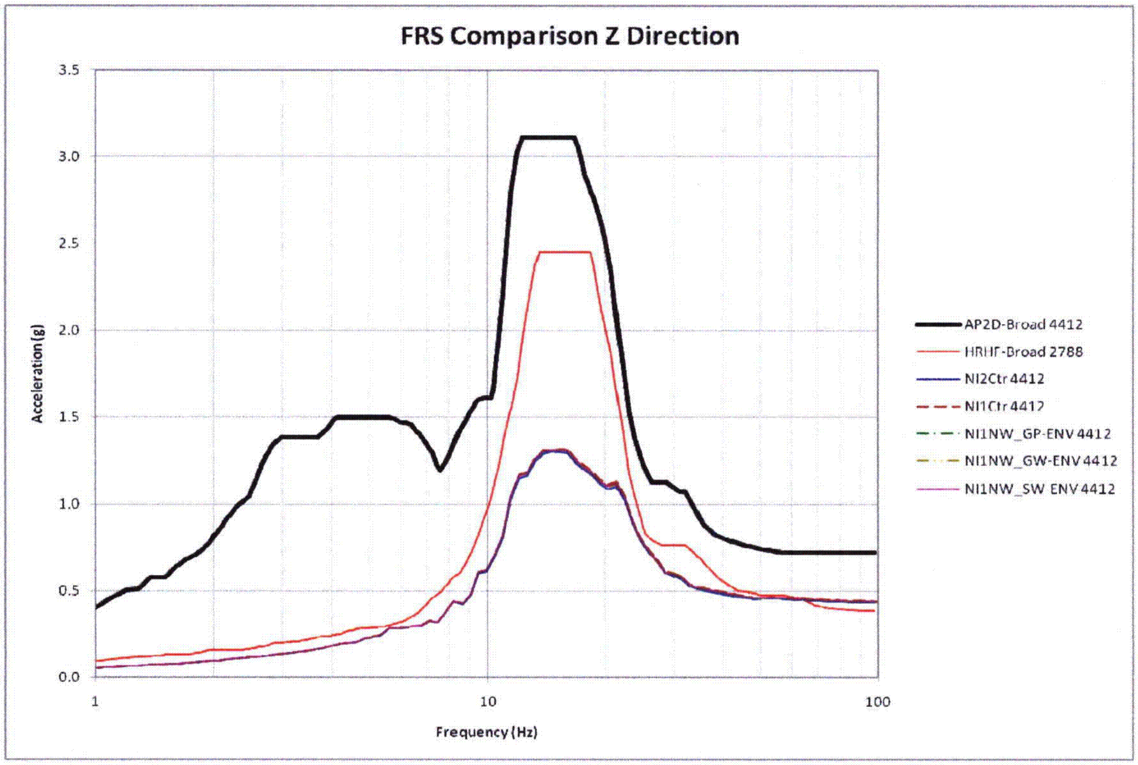

Figure 5-10: 2D Parametric FRS Comparison of Node 4412 in Z-Direction

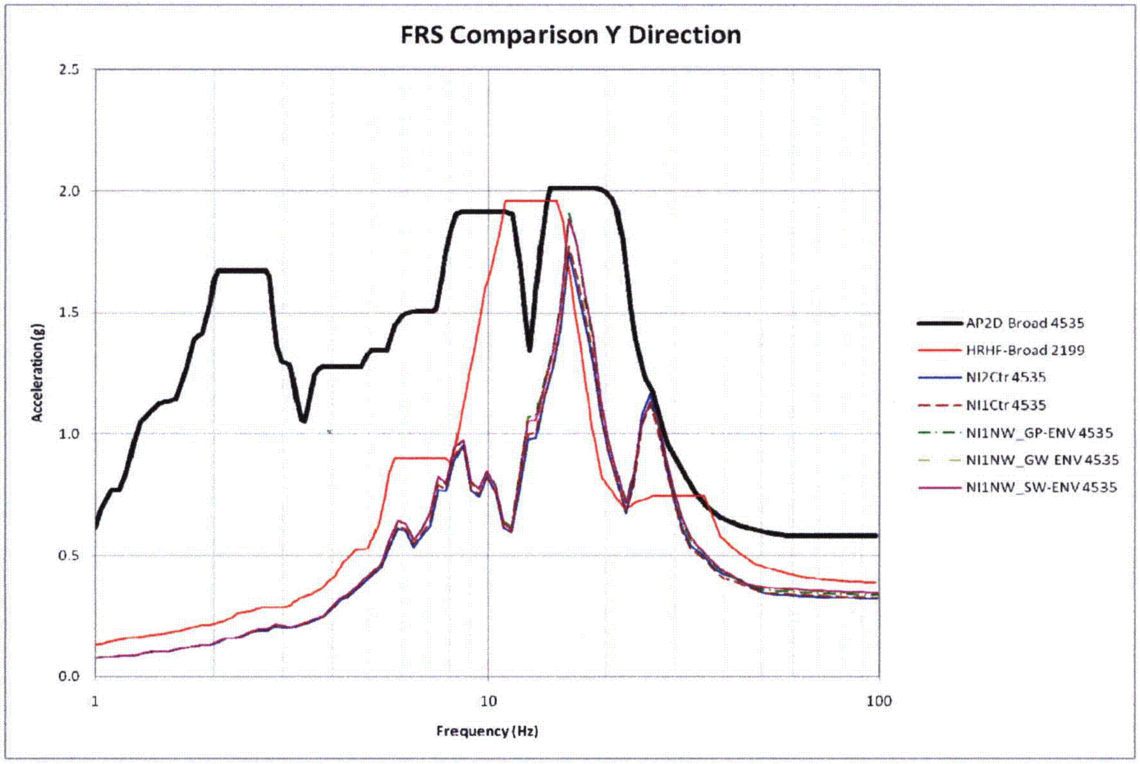

Figure 5-11: 2D Parametric FRS Comparison of Node 4535 in Y-Direction

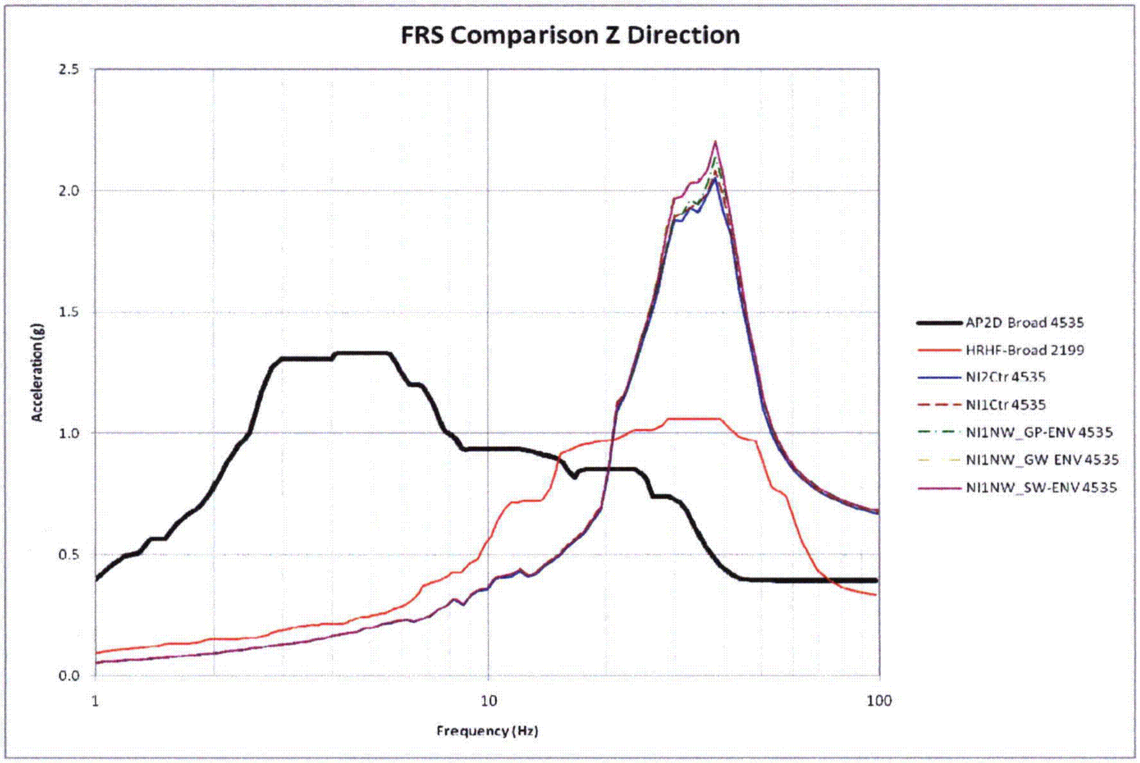

Figure 5-12: 2D Parametric FRS Comparison of Node 4535 in Z-Direction

6.0 [ ]a,c

[

]a,c

a,c

Figure 6-1: [ ]a,c

6.1 [ ]^{a,c}

[

]^{a,c}

Table 6.1-1: [ ]^{a,c} a,c

Table 6.1-2: [ ]^{a,c} a,c

6.2 [ ]^a,c^

[

]^a,c^

6.3 [ ]^a,c^

[

]^a,c^

Table 6.3-1: [ ]^{a,c} a,c

Table 6.3-2: [ ]^{a,c} a,c

7.0 Duke Lee 3D SASSI Analysis Results

The Duke Lee Units 1 and 2 NI 3D SASSI results are shown in Figures 7-1 through 7-18. The Duke Lee Units 1 and 2 NI20r surface models were run through 25 simulations of incoherent 3D analysis using the three predefined direction-based time histories shown in Figures 3-5, 3-6 and 3-7. The Duke Lee site is classified as a hard rock high frequency site, and therefore analyzed at a high frequency range. The analysis results presented in Figures 7-1 through 7-18 indicate that the Units 1 and 2 Nuclear Island 5 percent damping FRS of an AP1000 at the Duke Lee site at the six key locations are enveloped by the AP1000 3D CSDRS and HRHF SSI envelops.

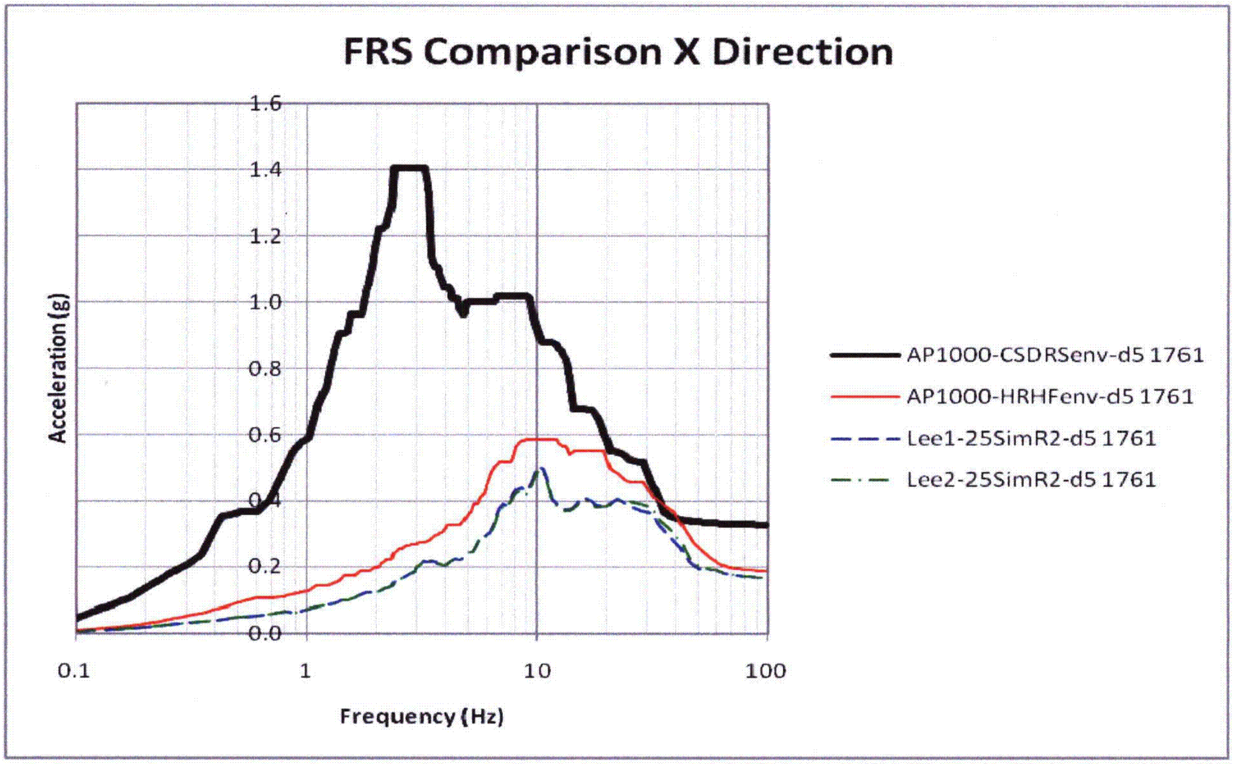

Figure 7-1: 3D FRS and AP1000 Envelope Comparison of Node 1761 in X-Direction

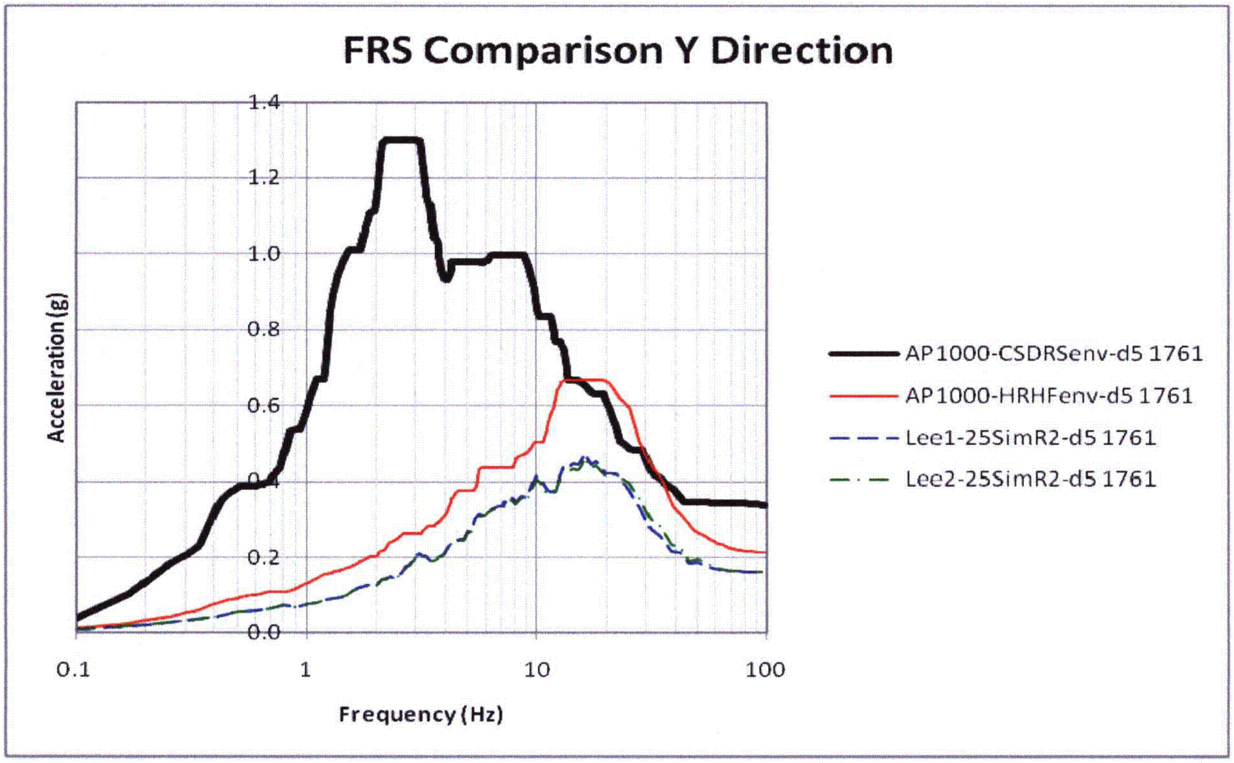

Figure 7-2: 3D FRS and AP1000 Envelope Comparison of Node 1761 in Y-Direction

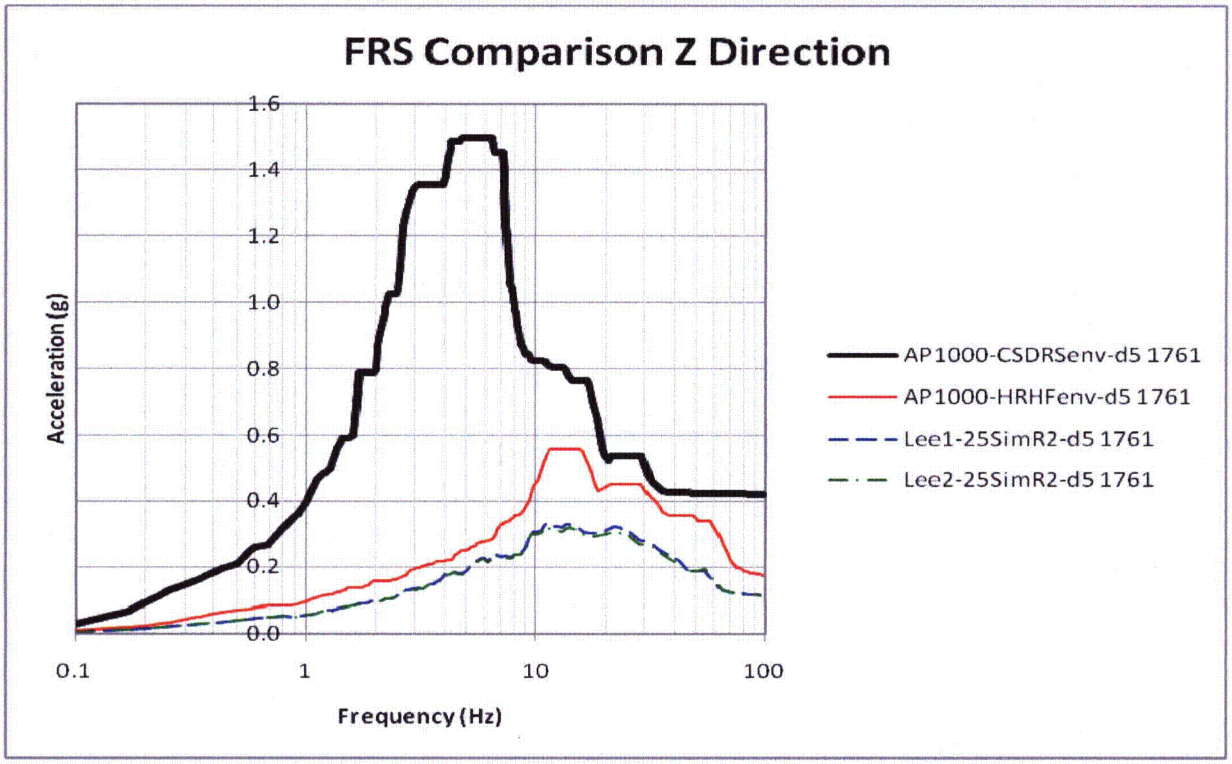

Figure 7-3: 3D FRS and AP1000 Envelope Comparison of Node 1761 in Z-Direction

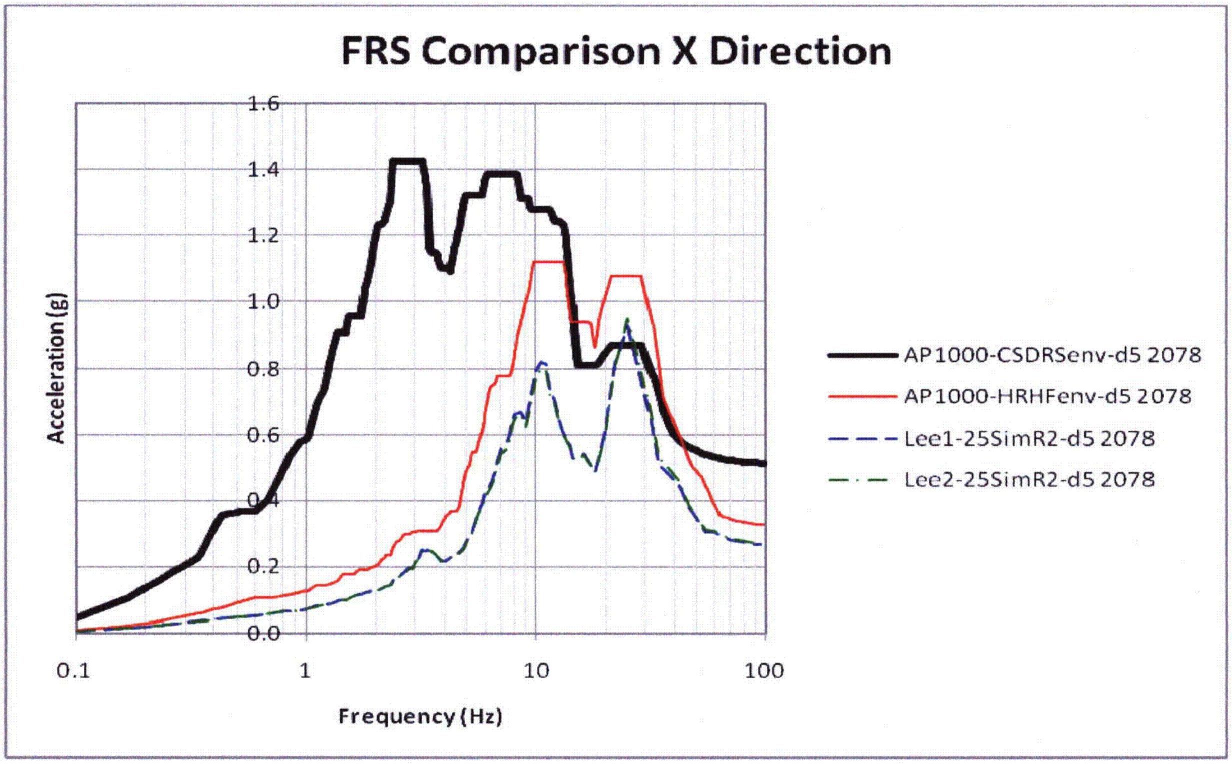

Figure 7-4: 3D FRS and AP1000 Envelope Comparison of Node 2078 in X-Direction

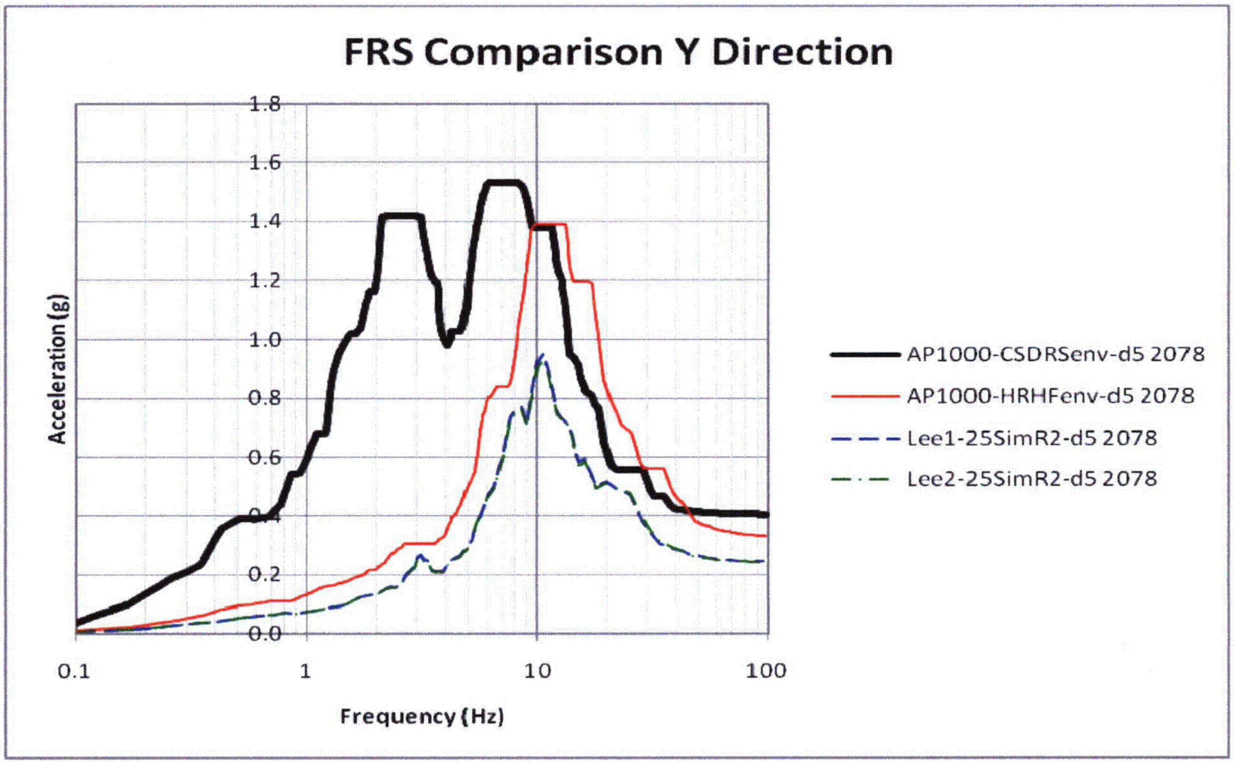

Figure 7-5: 3D FRS and AP1000 Envelope Comparison of Node 2078 in Y-Direction

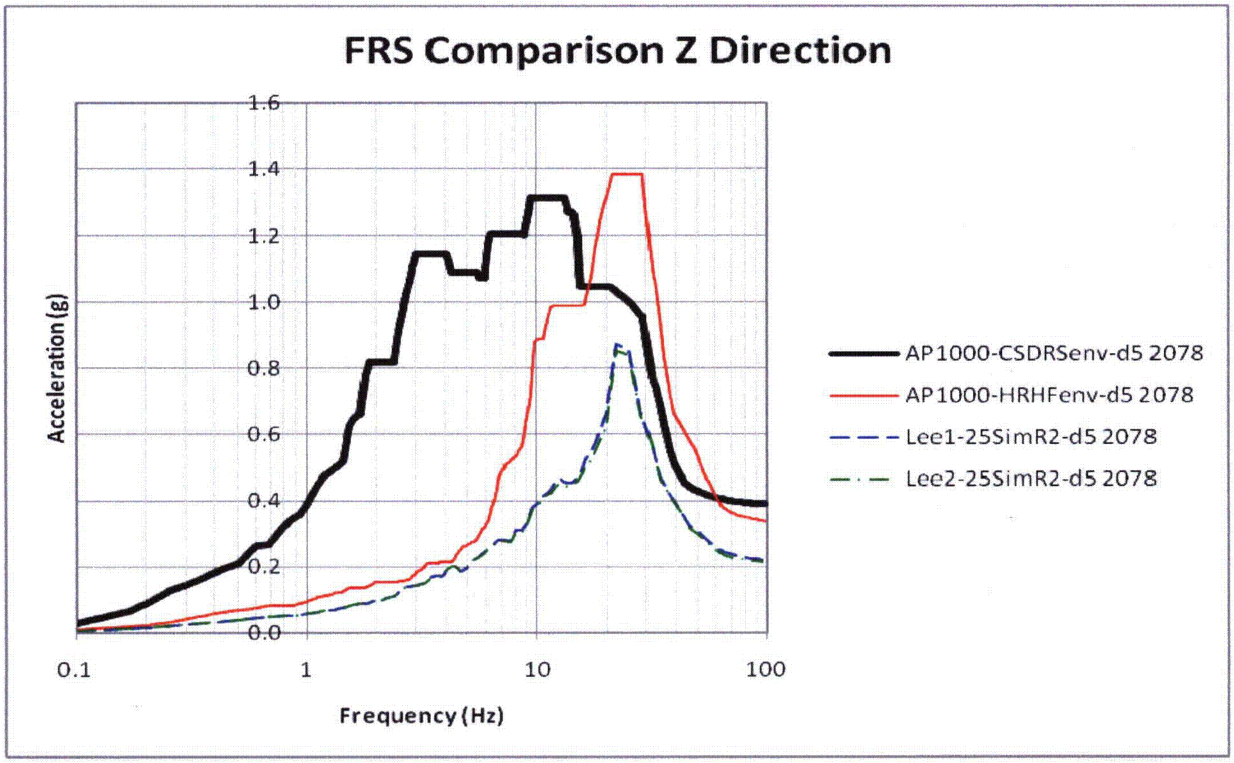

Figure 7-6: 3D FRS and AP1000 Envelope Comparison of Node 2078 in Z-Direction

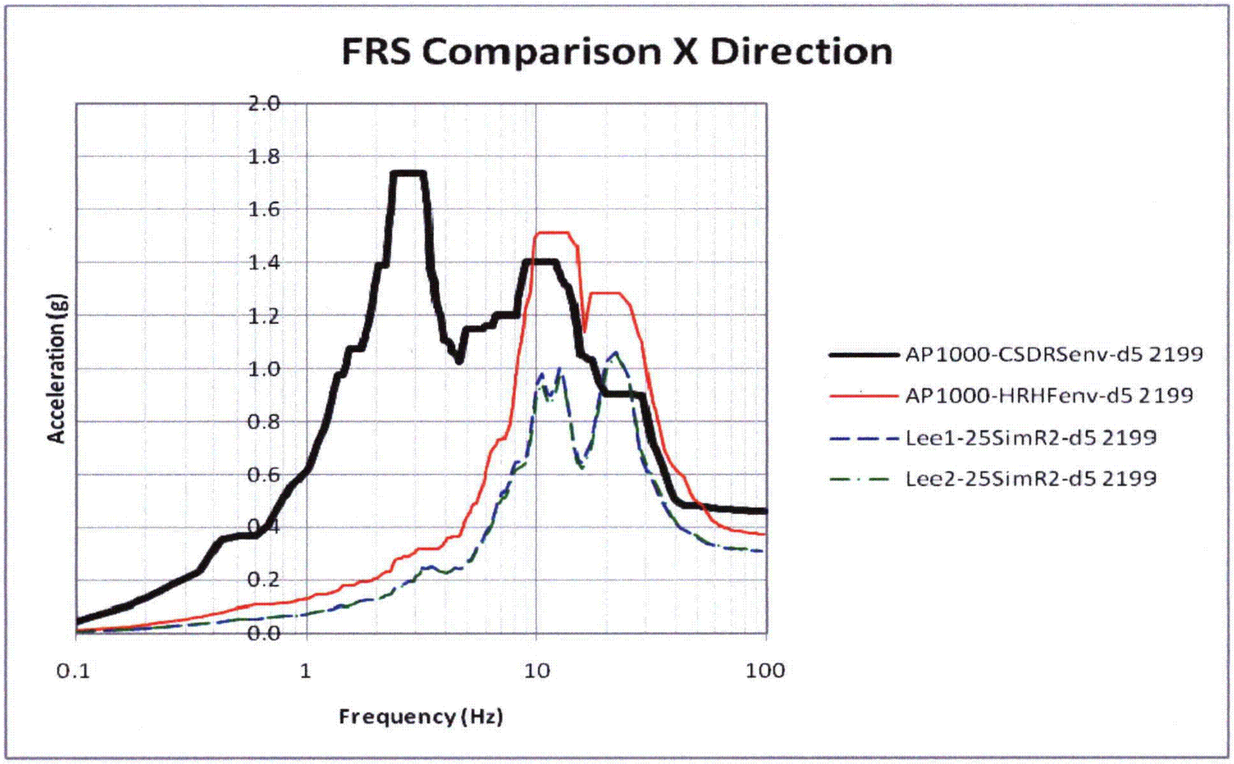

Figure 7-7: 3D FRS and AP1000 Envelope Comparison of Node 2199 in X-Direction

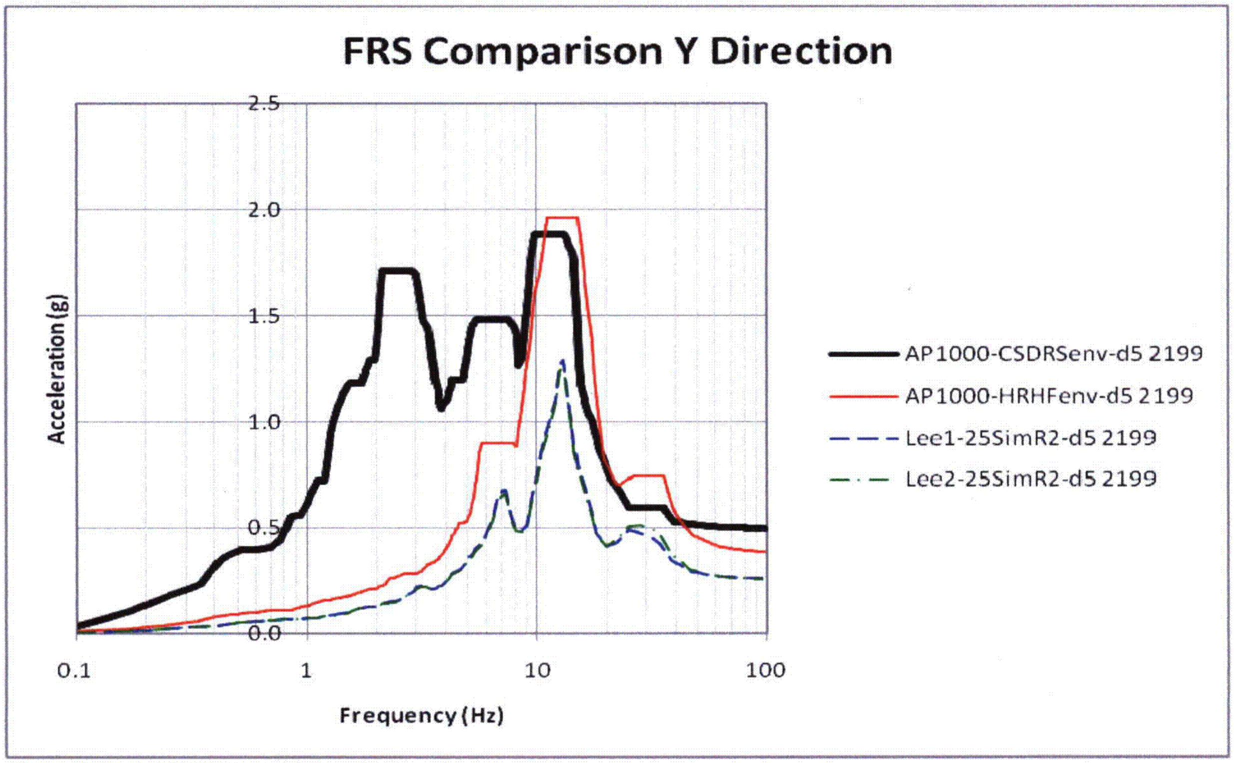

Figure 7-8: 3D FRS and AP1000 Envelope Comparison of Node 2199 in Y-Direction

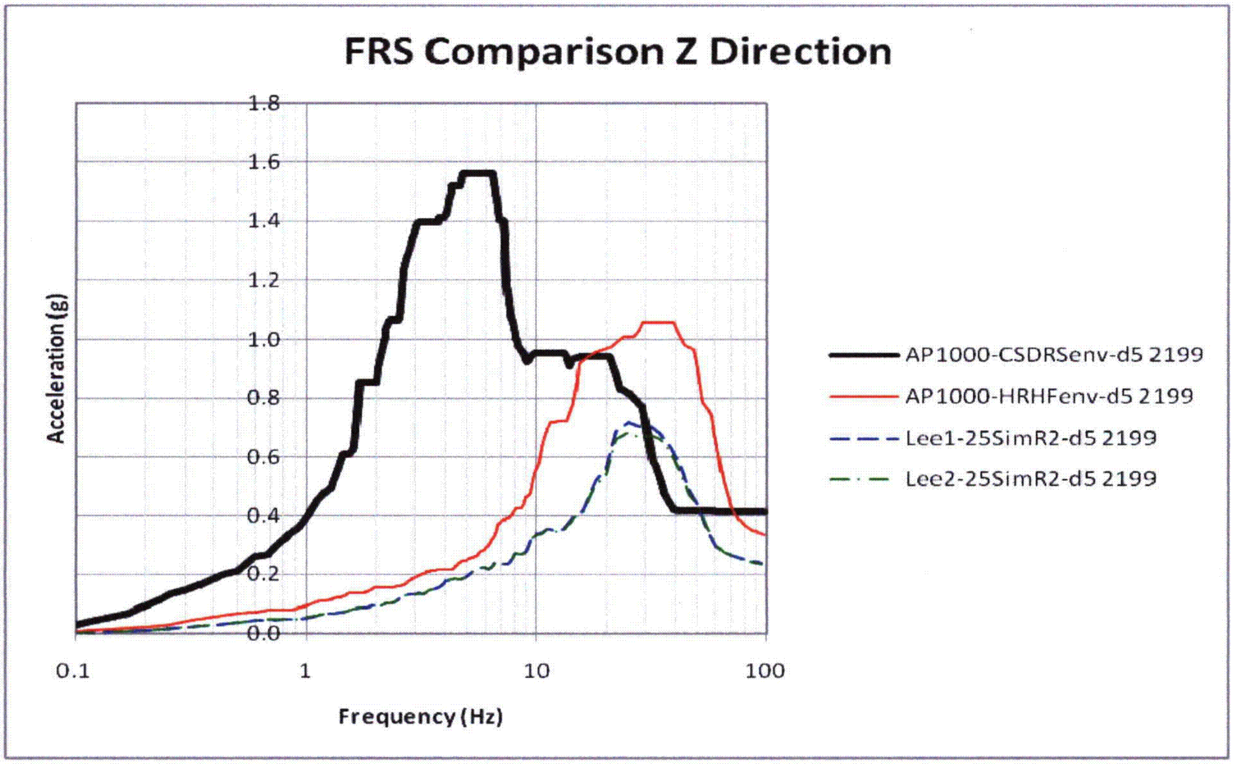

Figure 7-9: 3D FRS and AP1000 Envelope Comparison of Node 2199 in Z-Direction

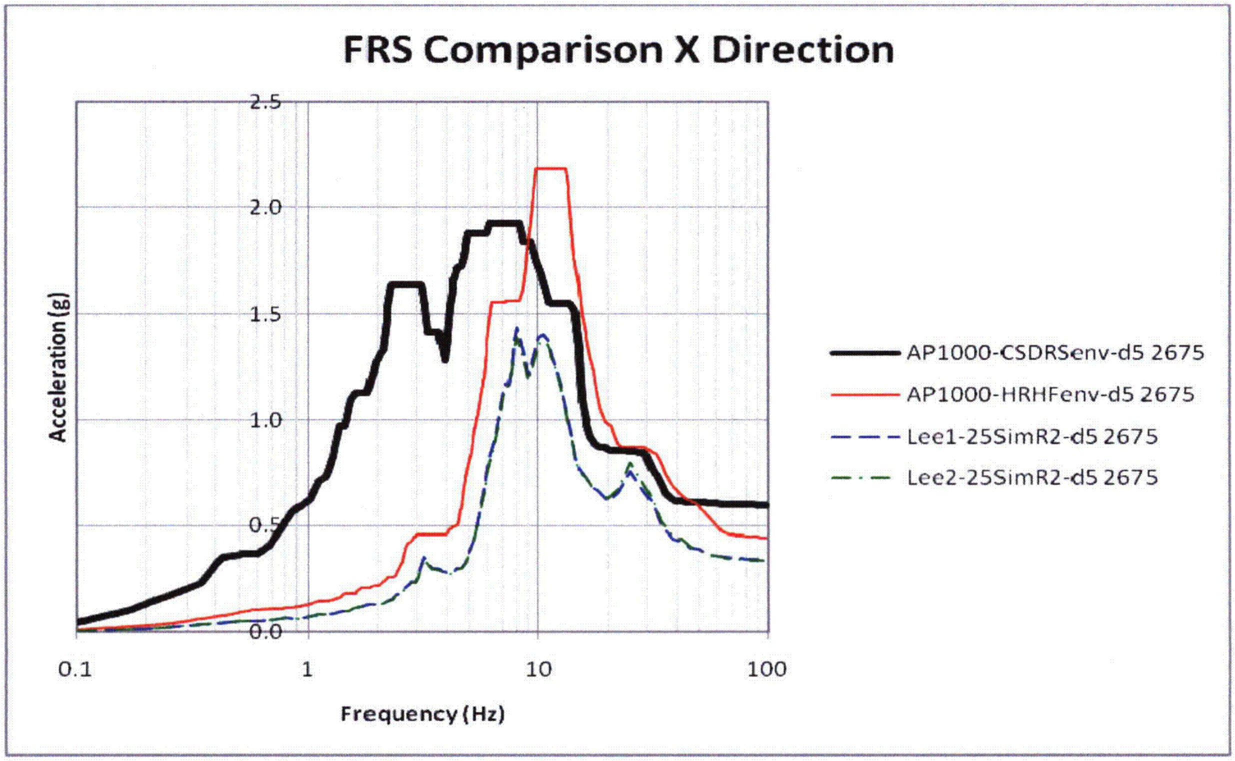

Figure 7-10: 3D FRS and AP1000 Envelope Comparison of Node 2675 in X-Direction

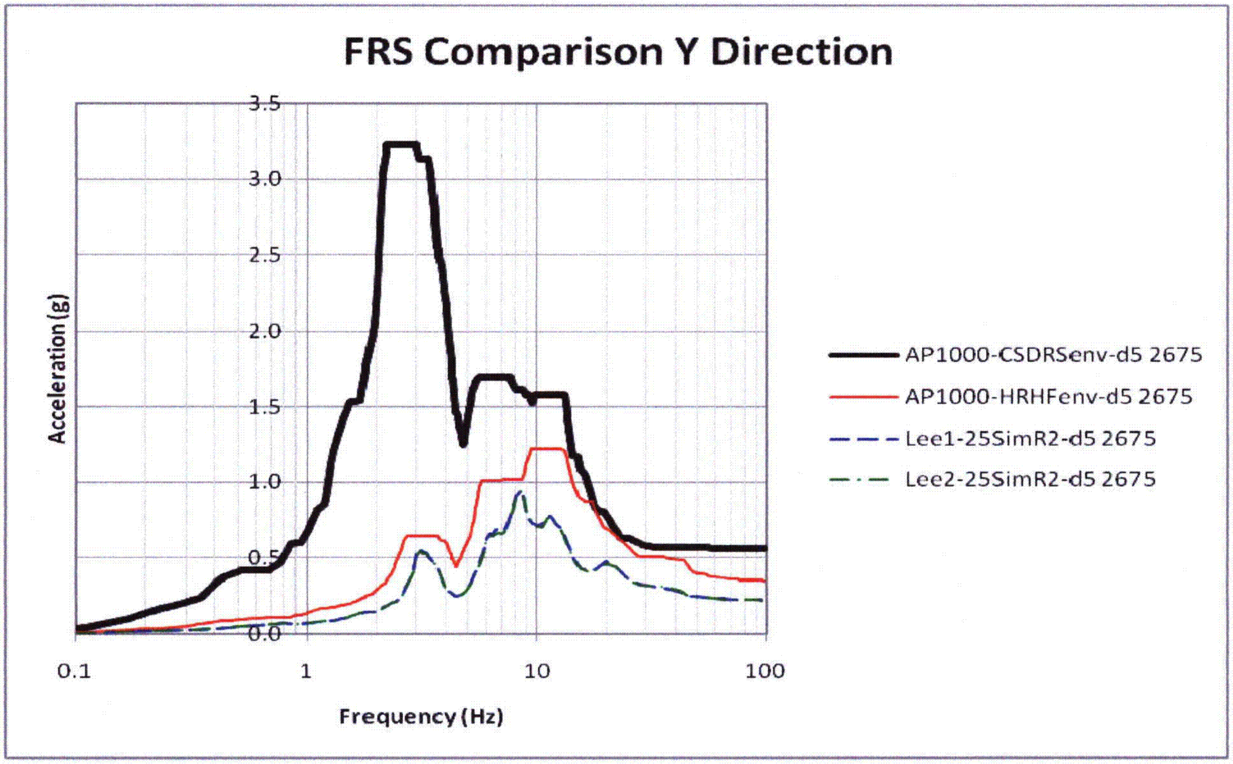

Figure 7-11: 3D FRS and AP1000 Envelope Comparison of Node 2675 in Y-Direction

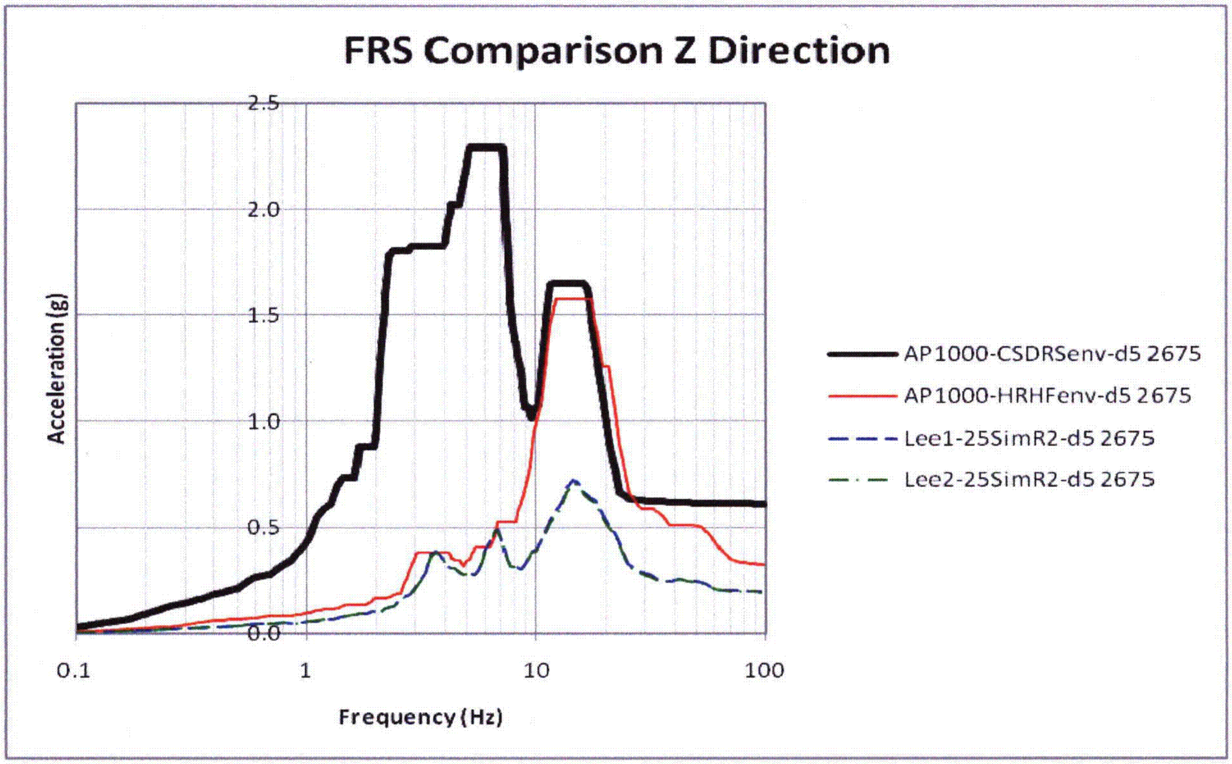

Figure 7-12: 3D FRS and AP1000 Envelope Comparison of Node 2675 in Z-Direction

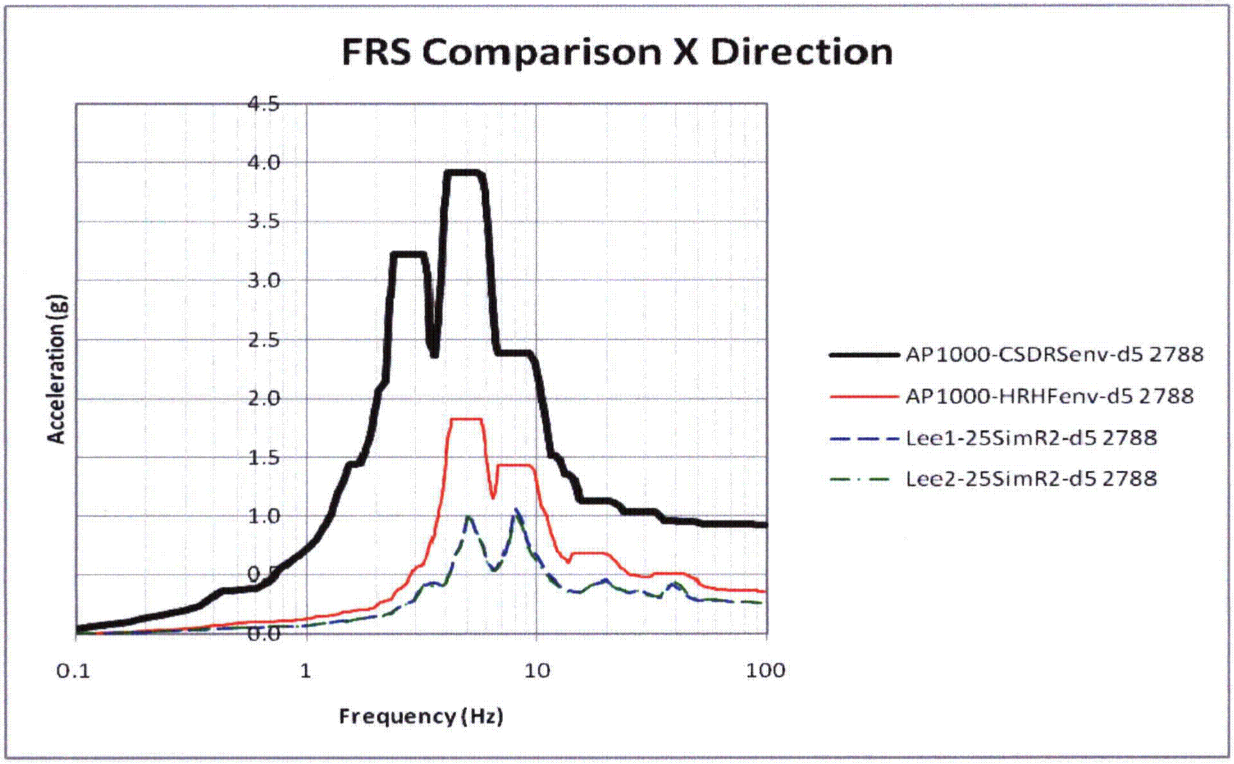

Figure 7-13: 3D FRS and AP1000 Envelope Comparison of Node 2788 in X-Direction

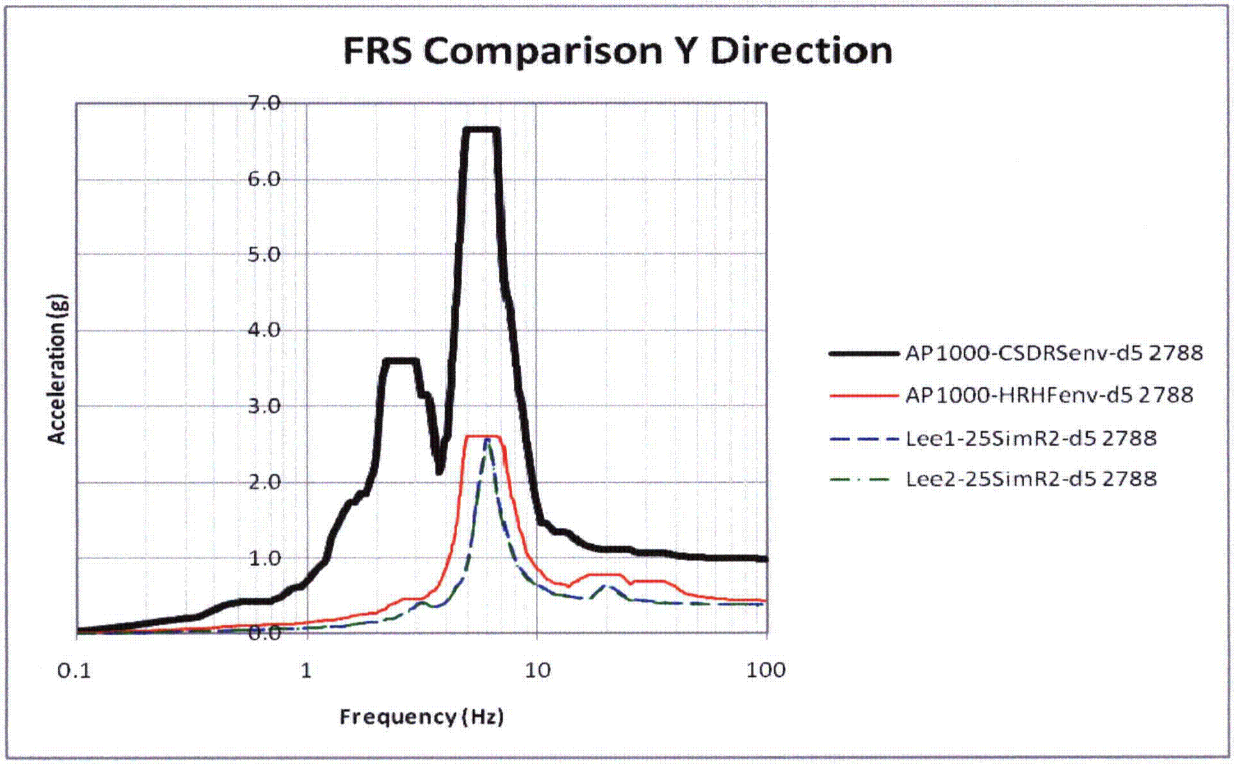

Figure 7-14: 3D FRS and AP1000 Envelope Comparison of Node 2788 in Y-Direction

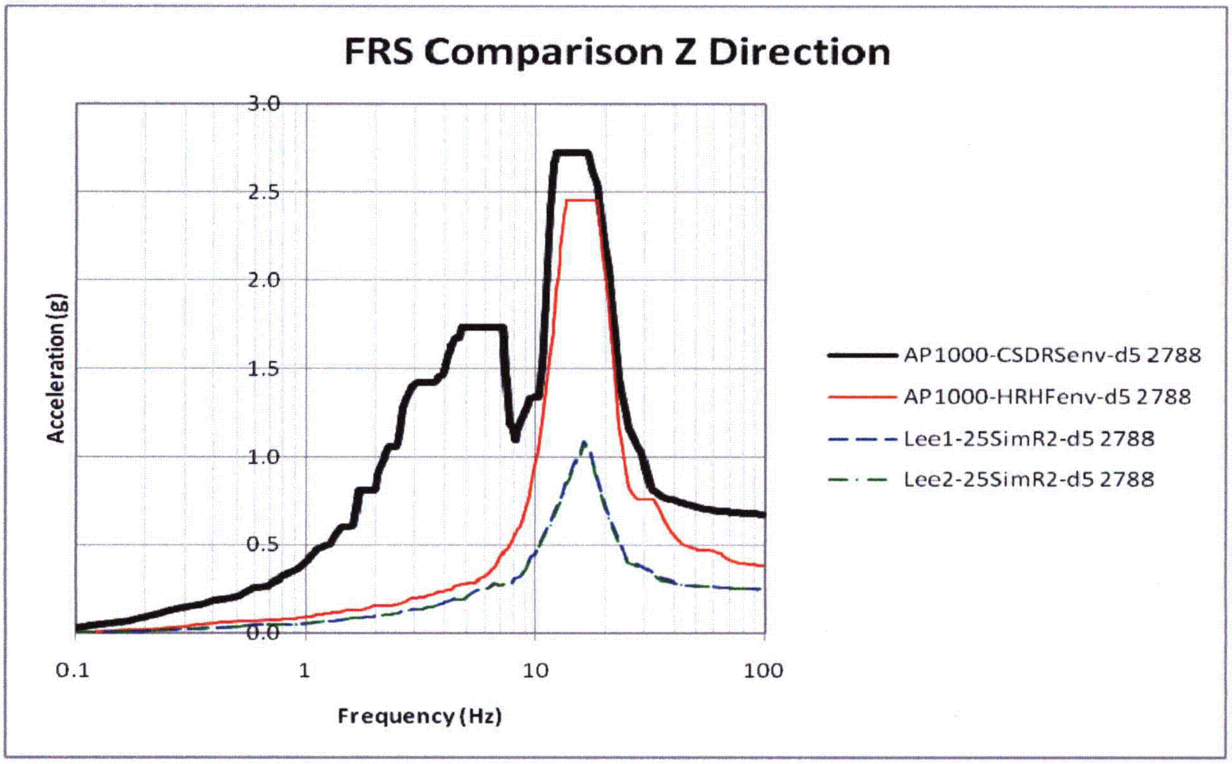

Figure 7-15: 3D FRS and AP1000 Envelope Comparison of Node 2788 in Z-Direction

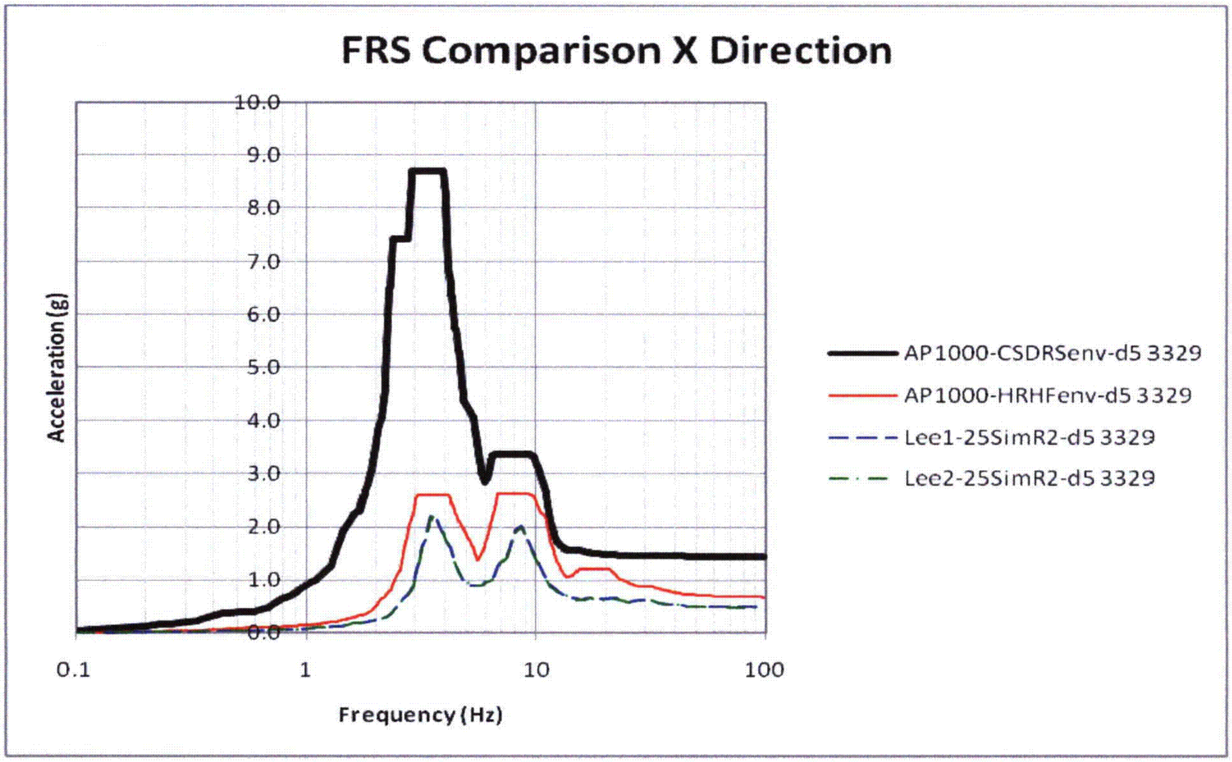

Figure 7-16: 3D FRS and AP1000 Envelope Comparison of Node 3329 in X-Direction

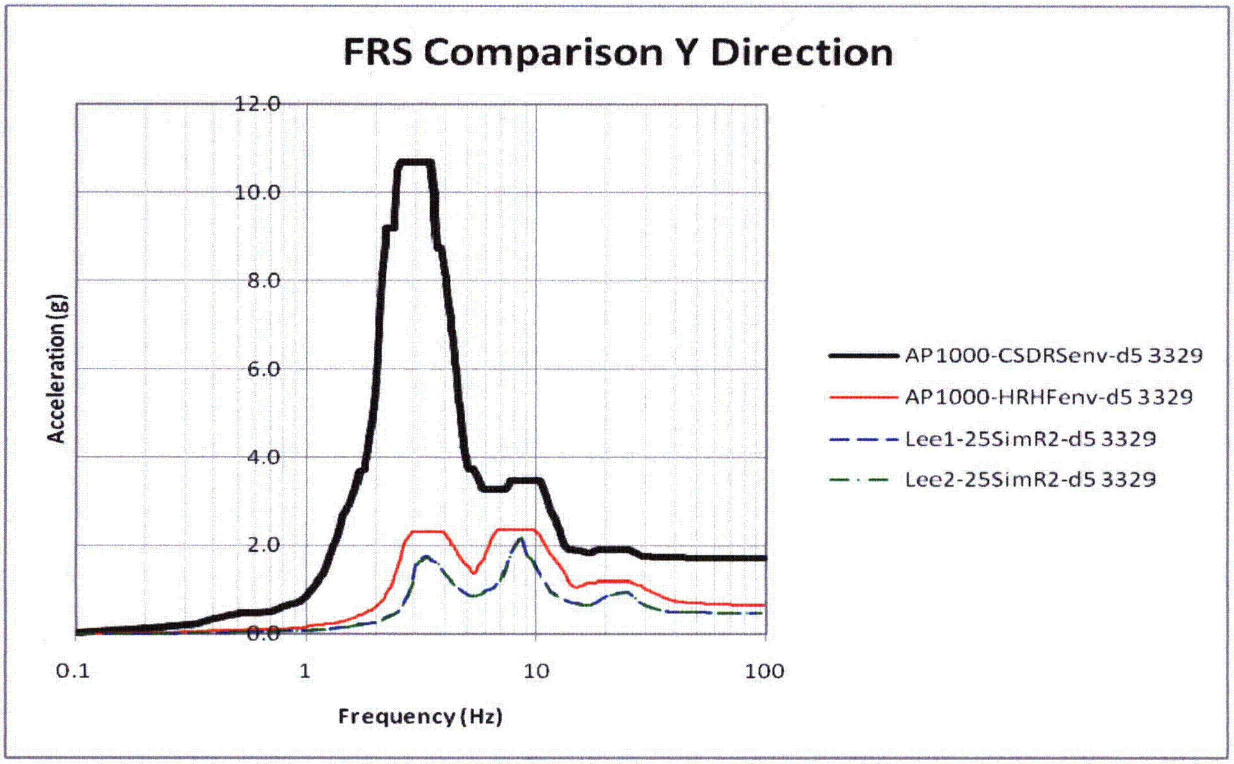

Figure 7-17: 3D FRS and AP1000 Envelope Comparison of Node 3329 in Y-Direction

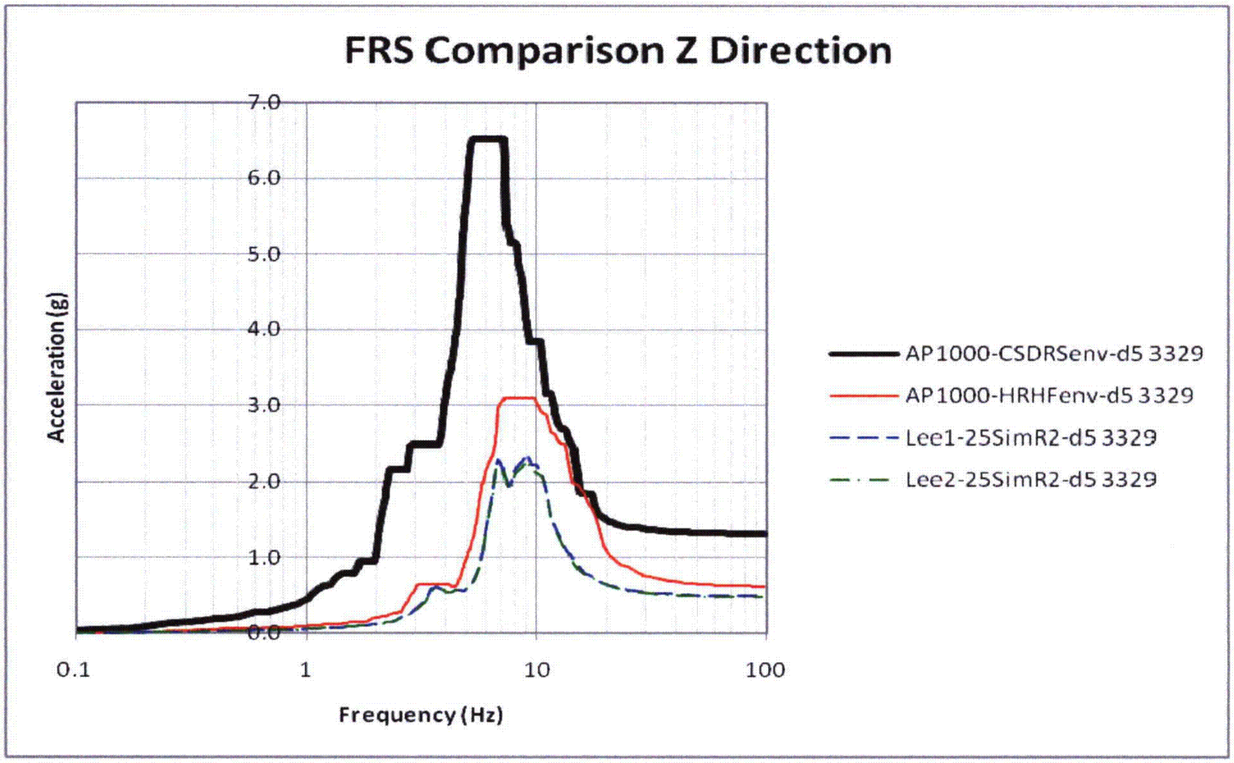

Figure 7-18: 3D FRS and AP1000 Envelope Comparison of Node 3329 in Z-Direction

8.0 Conclusions

Based on the information presented in this report, the following conclusions are presented:

- Consideration of the Unit 1 Northwest Corner configuration and materials results in a relatively small change in the calculated in-structure FRS compared to the Unit 1 Centerline FRS. Likewise, the selection of engineered fill (GP, GW or SW) to be used adjacent to the NI also has a relatively small effect on the calculated in-structure FRS for the NI.

- Only minor differences exist between the Unit 1 NI Centerline FRS and the Unit 2 NI Centerline 2D FRS across the frequency spectrum in both the horizontal and vertical directions;

- Based on the Duke Lee 2D parametric SSI analyses results, subsequent 3D incoherent SSI analyses are performed using the both Unit 1 and Unit 2 NI Centerline cross-section models and corresponding Base Case A1 and Profile C soil profiles, respectively.

- The revised Duke Lee 3D incoherent SSI analyses results, which incorporate the AP1000 NI20r 3D model and revised FIRS A1 time history indicate that the Duke Lee Units 1 and 2 FRS at six key NI locations are enveloped by the AP1000 CSDRS and HRHF SSI envelops.

9.0 References

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Appendix A: Duke Lee 2D FRS – UNIT 1 NW CORNER GP MODEL

This Appendix compares the 2D FRS for the Unit 1 and Unit 2 Centerline models/profiles and the Unit 1 NW Corner model with potential GP engineered fill placed adjacent the NI as shown in Figure 4.2-3. GP dynamic soil properties for the 16th, median and 84th percentiles were provided by Duke in Reference 8. Figure 2.5-2 illustrates the range of strain-compatible properties considered, and the selection of representative properties for use in analyses. Figures A-1 to A-12 present the FRS comparison at 5 percent damping. The envelope of the GP FRS response is calculated from these individual analyses results, and the in-structure FRS comparisons of the Unit 1 NI Centerline, Unit 2 NI Centerline, and the Unit 1 NW Corner with the GP engineered backfill envelope are presented in Figures 5-1 to 5-12.

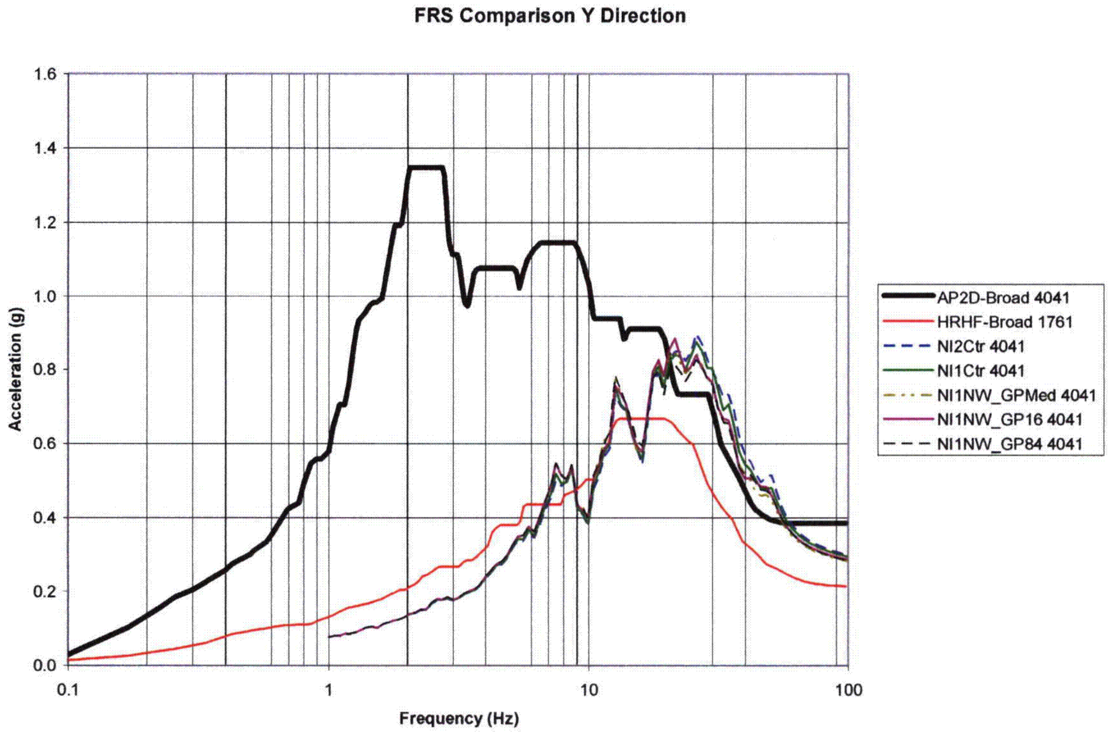

Figure A-1: 2D GP Backfill Parametric FRS Comparison of Node 4041 in Y-Direction

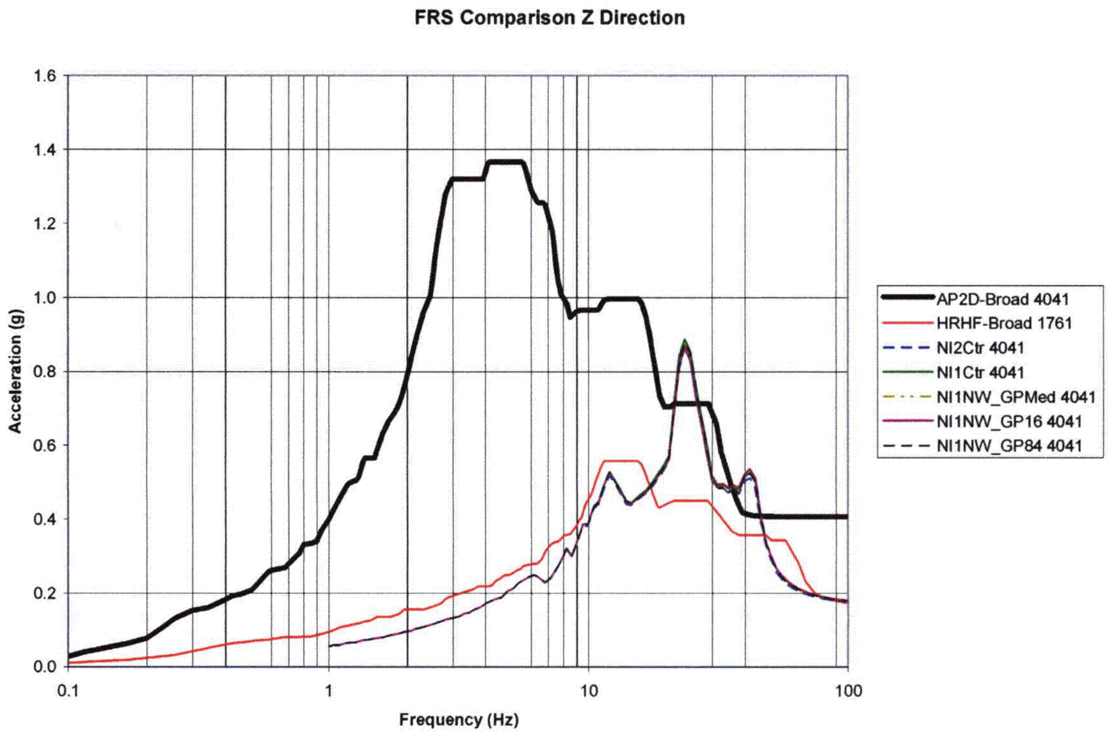

Figure A-2: 2D GP Backfill Parametric FRS Comparison of Node 4041 in Z-Direction

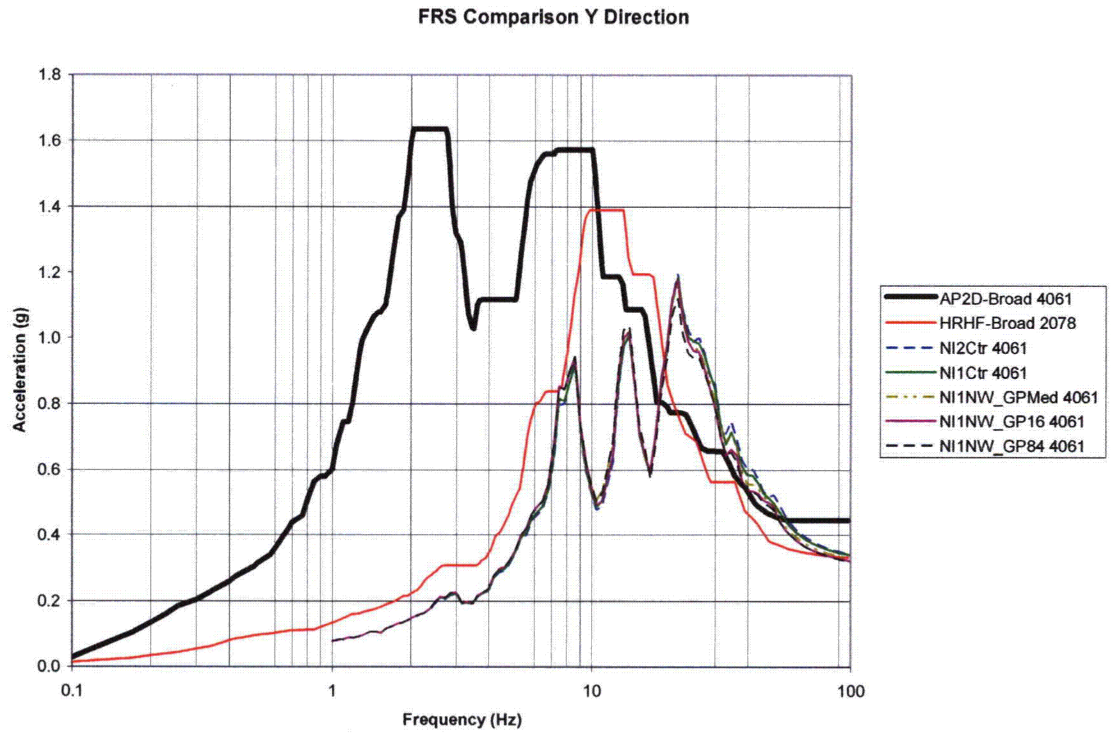

Figure A-3: 2D GP Backfill Parametric FRS Comparison of Node 4061 in Y-Direction

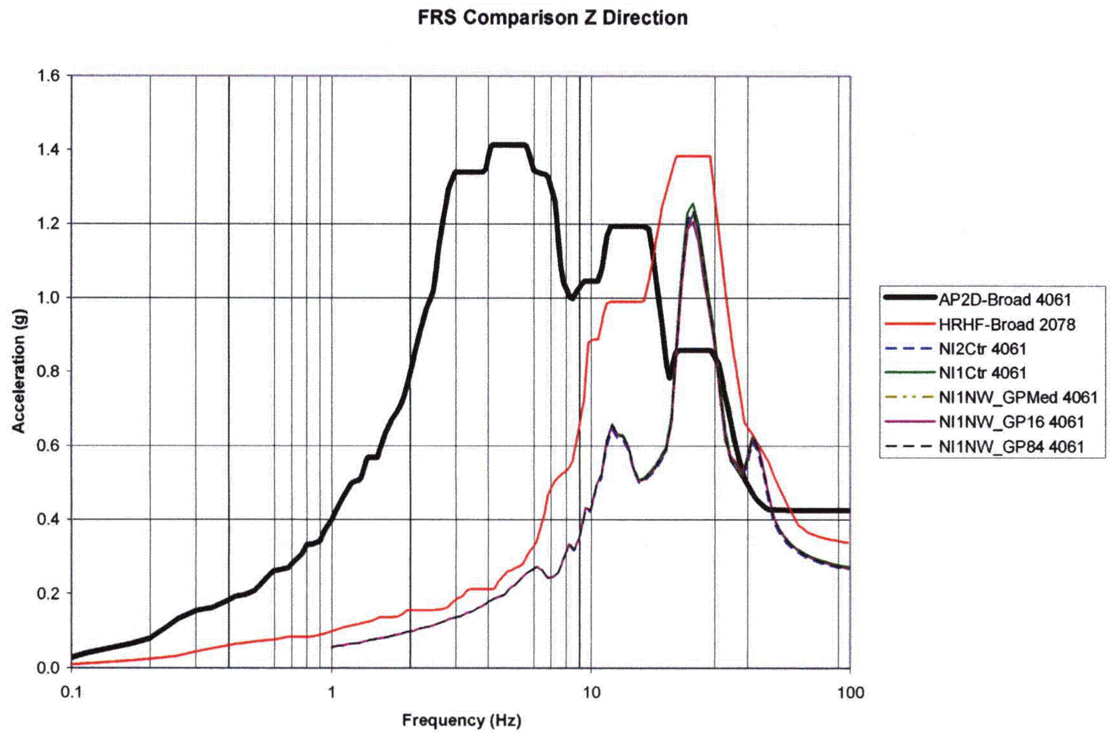

Figure A-4: 2D GP Backfill Parametric FRS Comparison of Node 4061 in Z-Direction

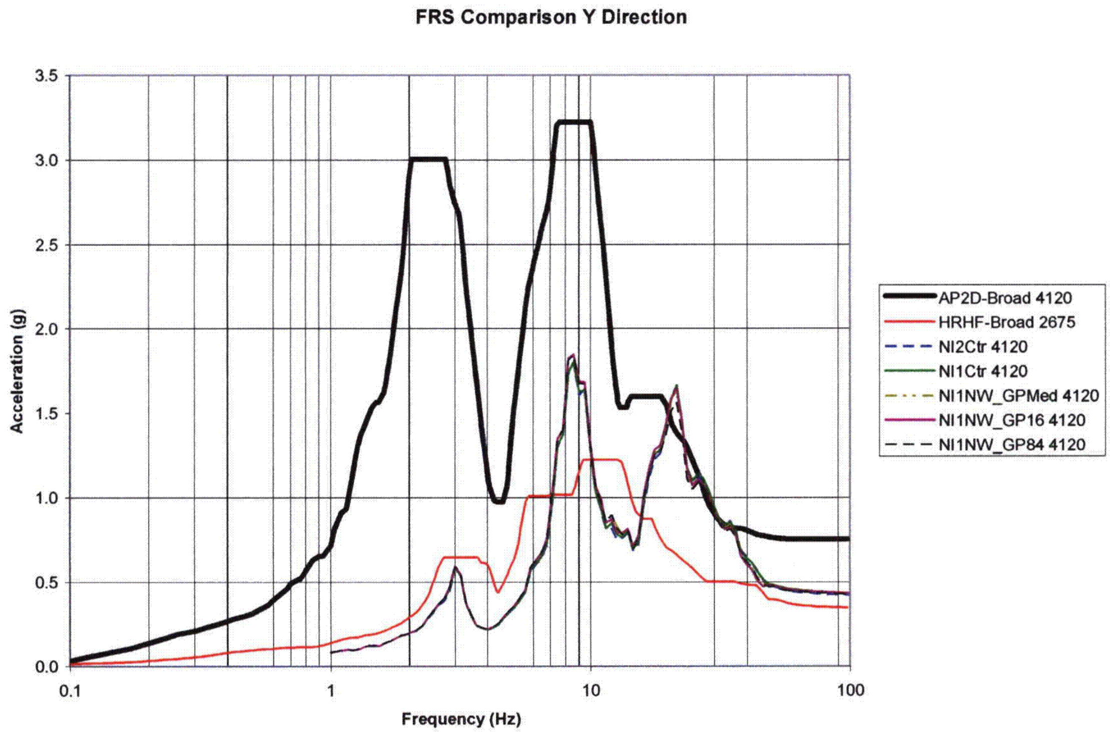

Figure A-5: 2D GP Backfill Parametric FRS Comparison of Node 4120 in Y-Direction

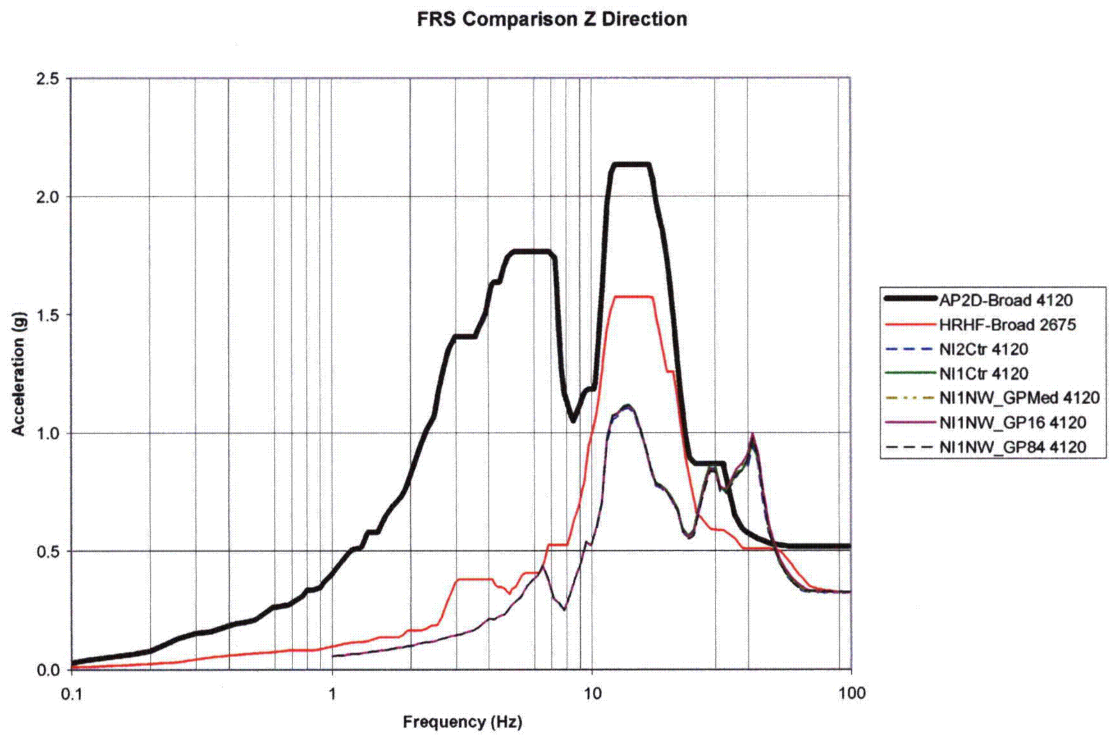

Figure A-6: 2D GP Backfill Parametric FRS Comparison of Node 4120 in Z-Direction

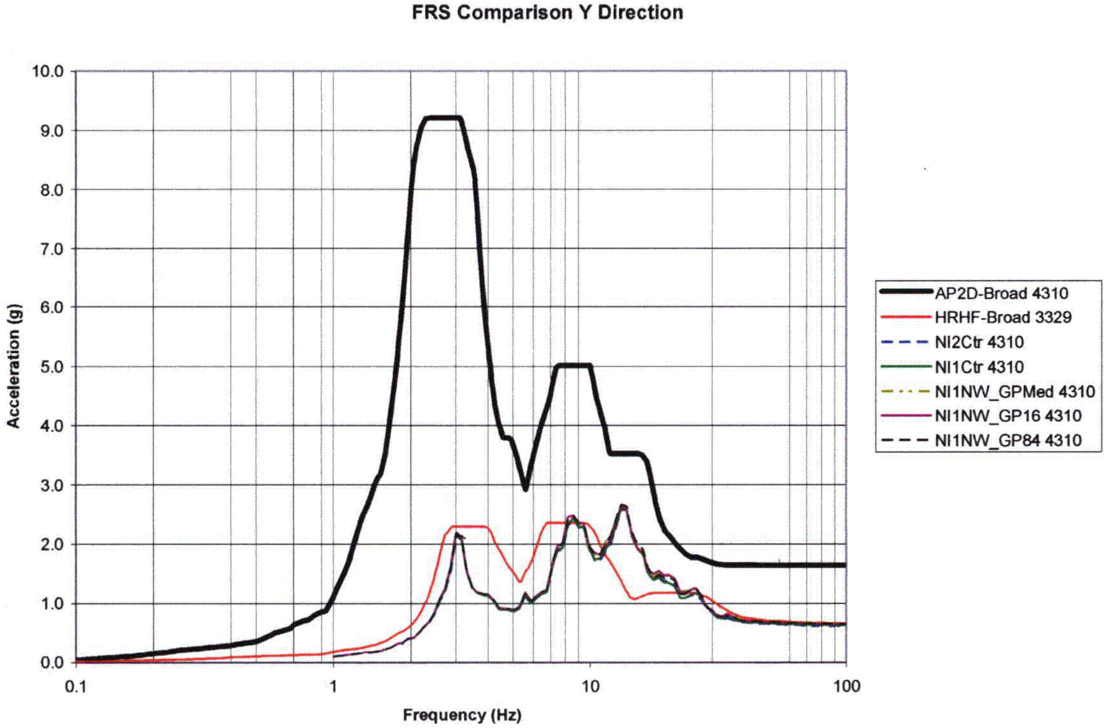

Figure A-7: 2D GP Backfill Parametric FRS Comparison of Node 4310 in Y-Direction

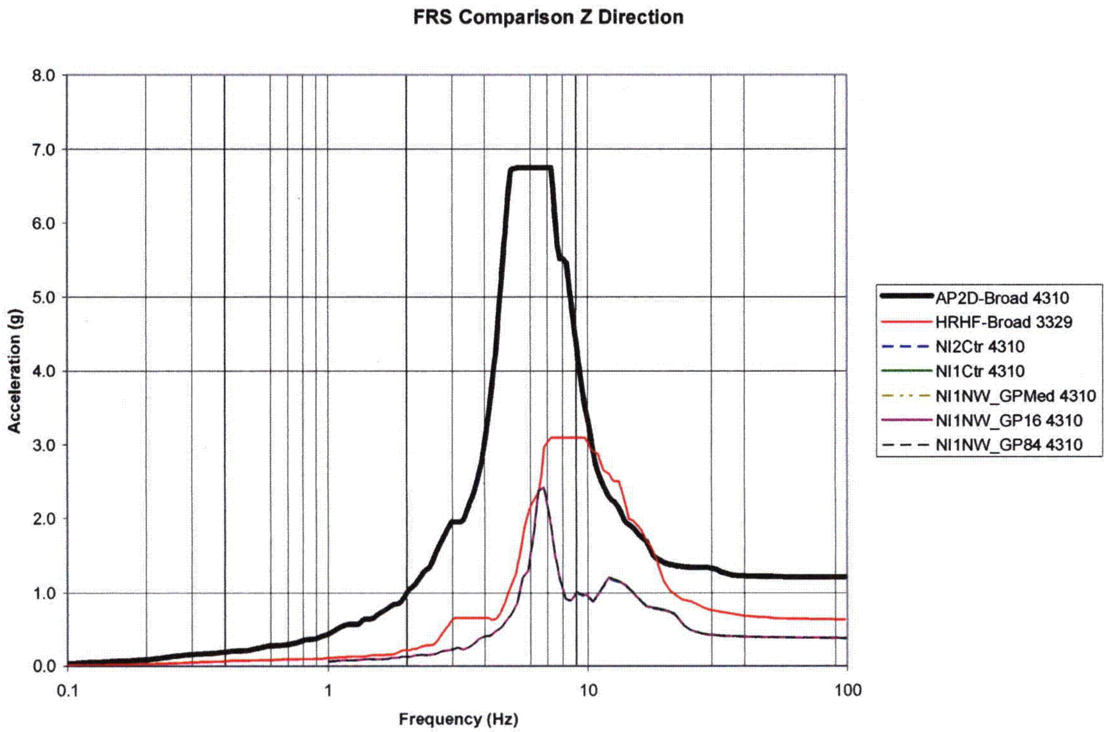

Figure A-8: 2D GP Backfill Parametric FRS Comparison of Node 4310 in Z-Direction

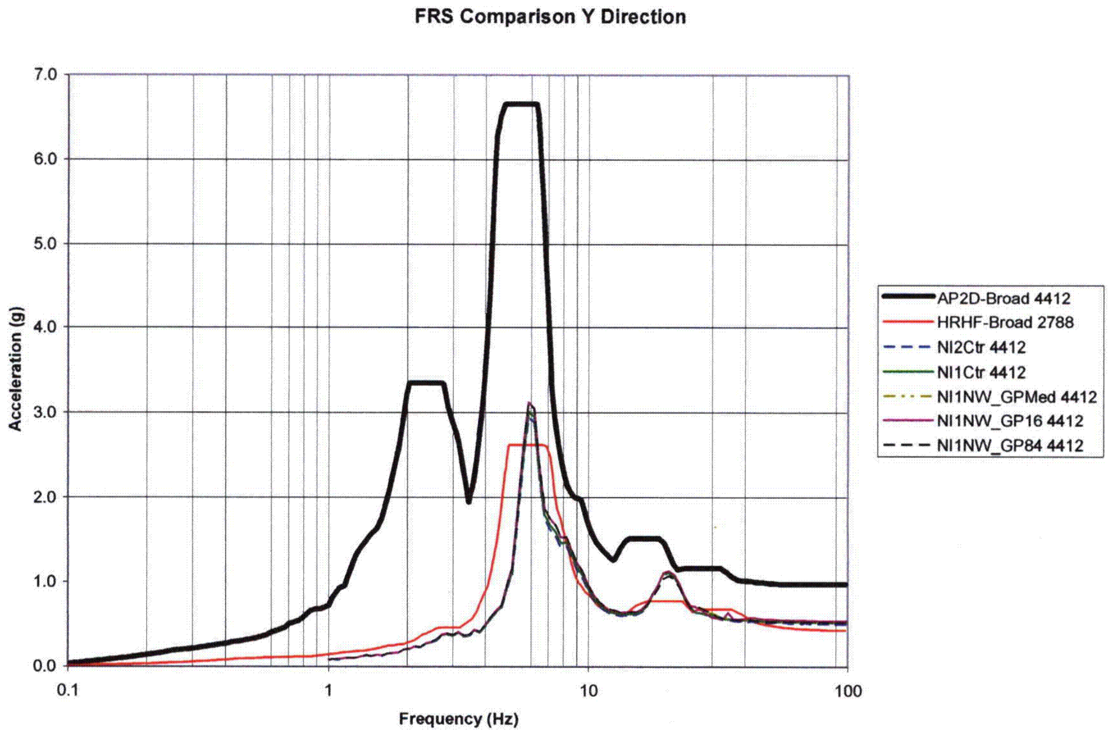

Figure A-9: 2D GP Backfill Parametric FRS Comparison of Node 4412 in Y-Direction

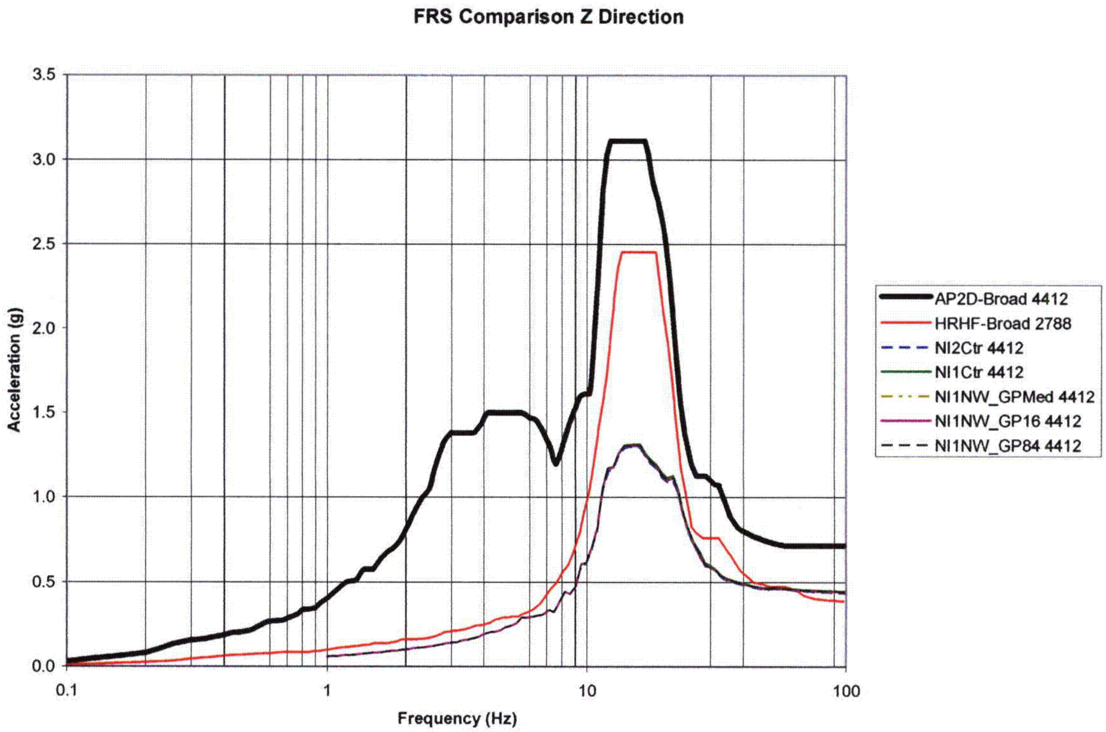

Figure A-10: 2D GP Backfill Parametric FRS Comparison of Node 4412 in Z-Direction

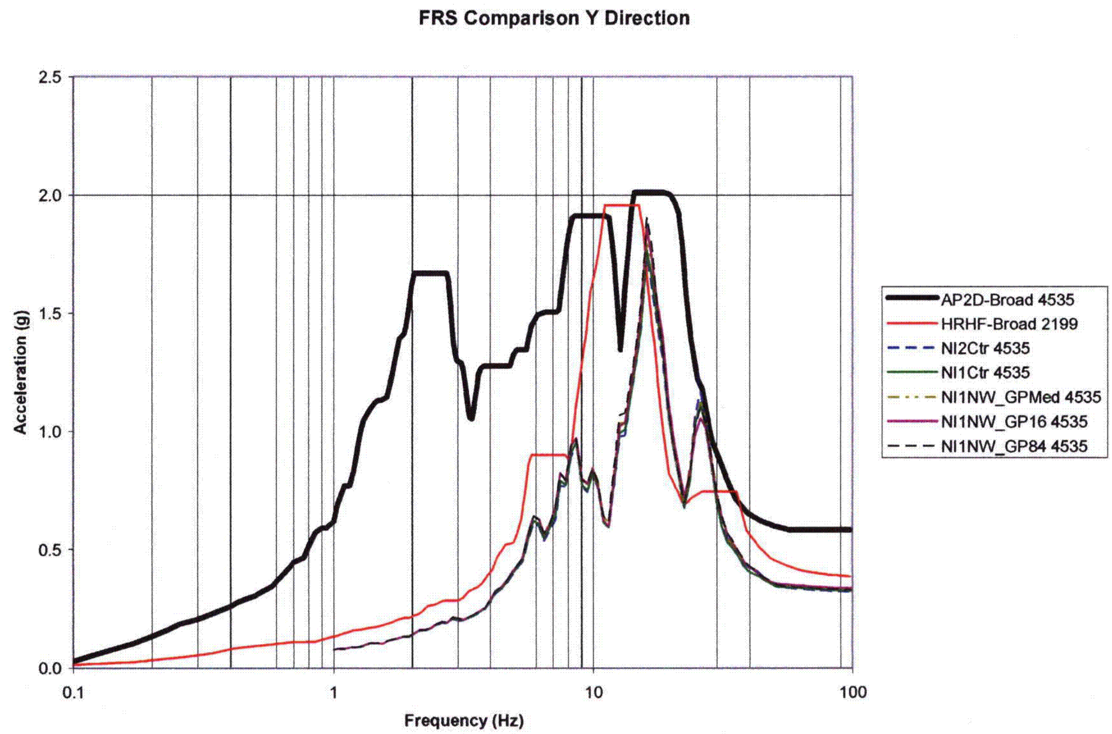

Figure A-11: 2D GP Backfill Parametric FRS Comparison of Node 4535 in Y-Direction

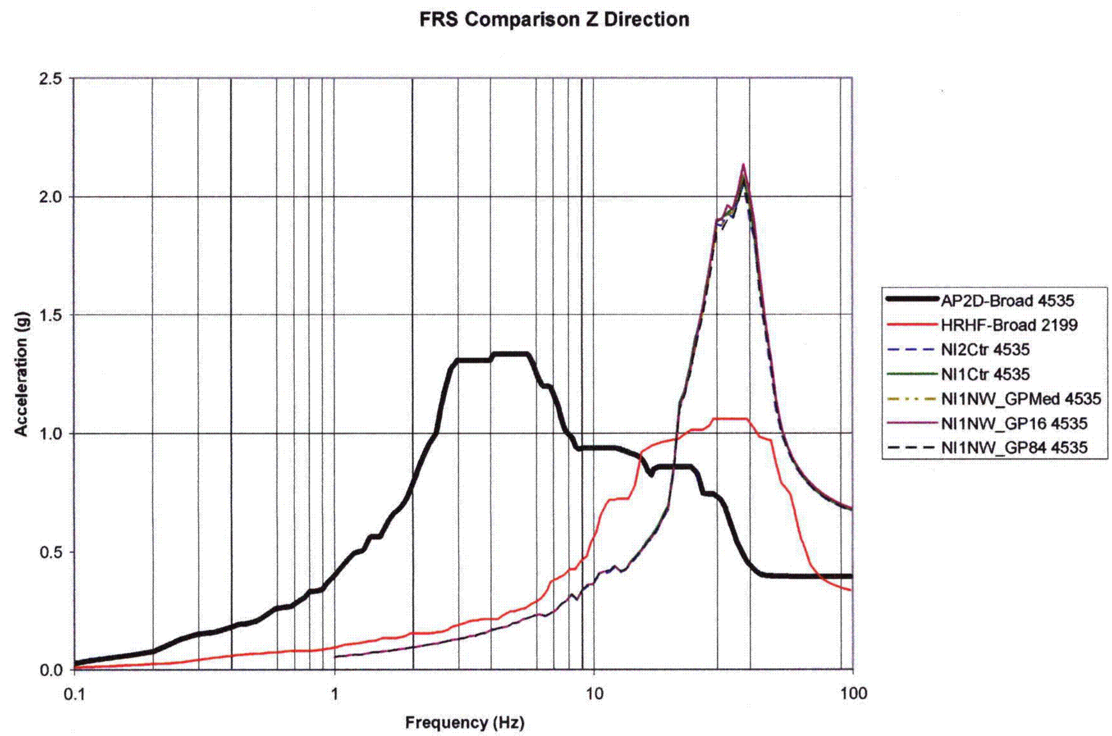

Figure A-12: 2D GP Backfill Parametric FRS Comparison of Node 4535 in Z-Direction

Appendix B: Duke Lee 2D FRS – UNIT 1 NW CORNER GW MODEL

This Appendix compares the 2D FRS for the Unit 1 and Unit 2 Centerline models/profiles and the Unit 1 NW Corner model with potential GW engineered fill placed adjacent the NI as shown in Figure 4.2-3. GW dynamic soil properties for the 16th, median and 84th percentiles were provided by Duke in Reference 8. Figure 2.5-3 illustrates the range of strain-compatible properties considered, and the selection of representative properties for use in analyses. Figures B-1 to B-12 present the FRS comparison at 5 percent damping. The envelope of the GW FRS response is calculated from these individual analyses results, and the in-structure FRS comparisons of the Unit 1 NI Centerline, Unit 2 NI Centerline, and the Unit 1 NW Corner with the GW engineered backfill envelope are presented in Figures 5-1 to 5-12.

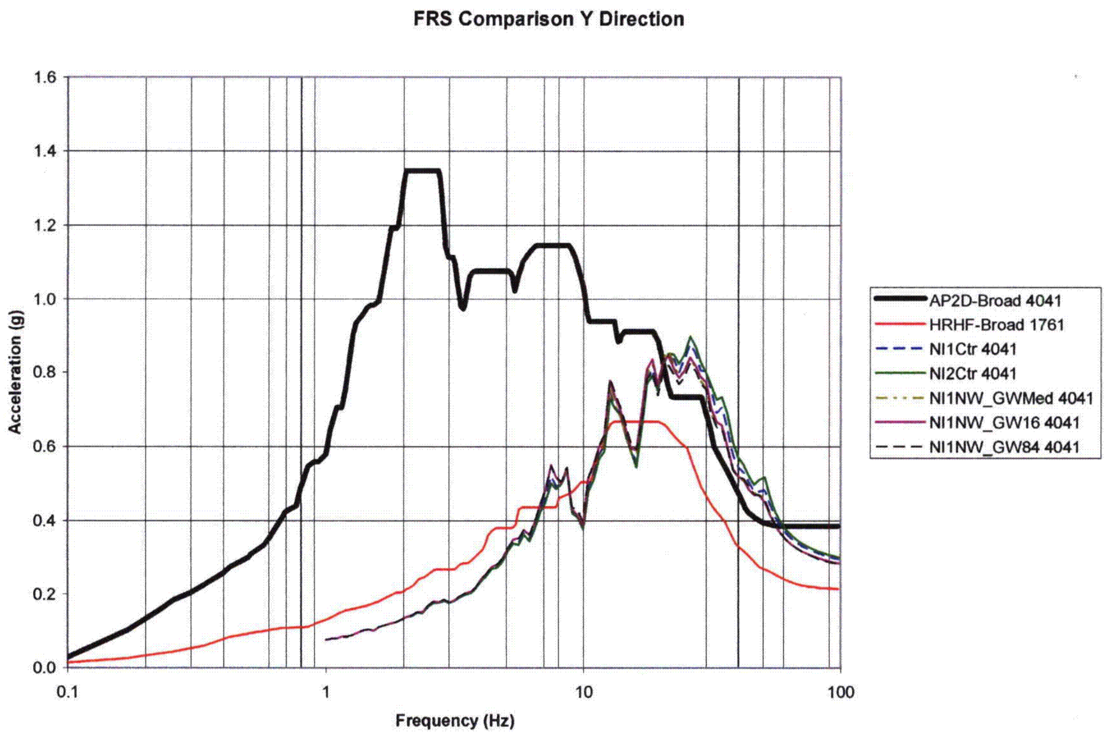

Figure B-1: 2D GW Backfill Parametric FRS Comparison of Node 4041 in Y-Direction

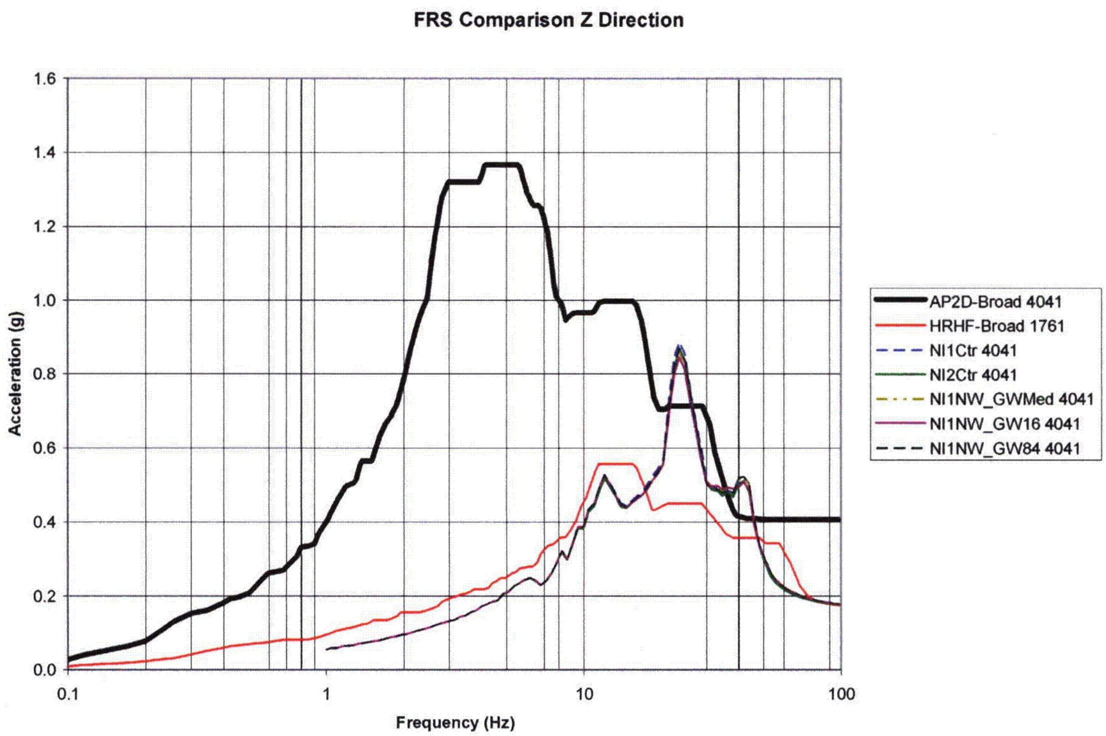

Figure B-2: 2D GW Backfill Parametric FRS Comparison of Node 4041 in Z-Direction

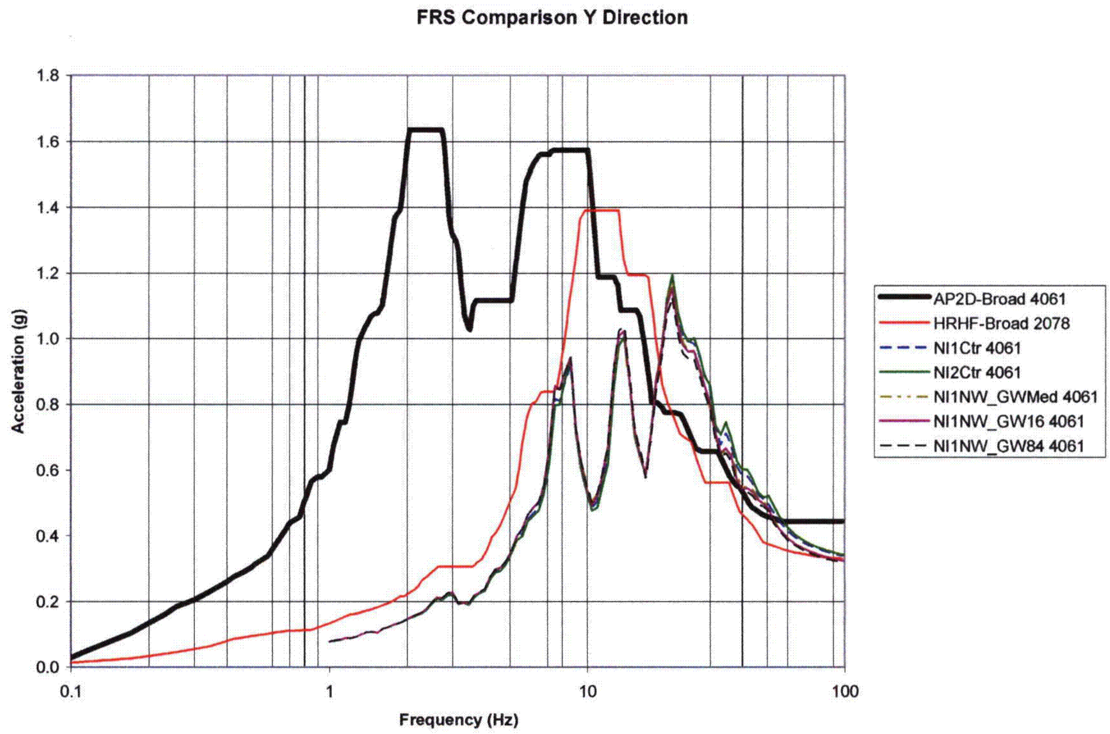

Figure B-3: 2D GW Backfill Parametric FRS Comparison of Node 4061 in Y-Direction

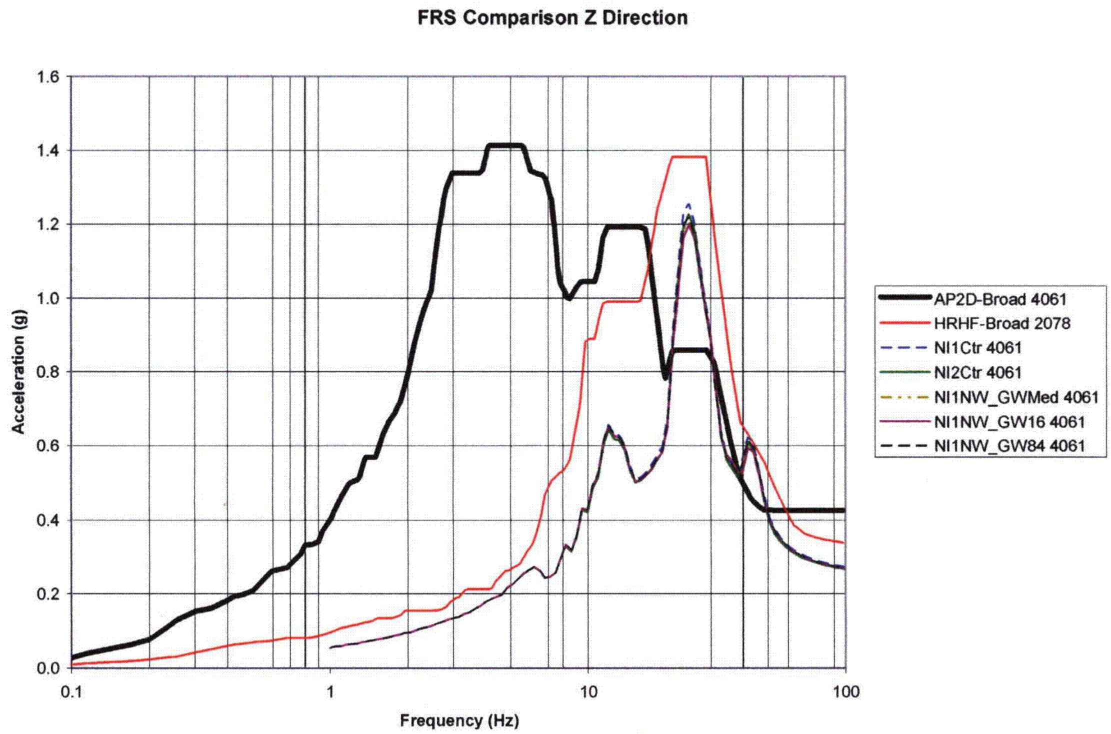

Figure B-4: 2D GW Backfill Parametric FRS Comparison of Node 4061 in Z-Direction

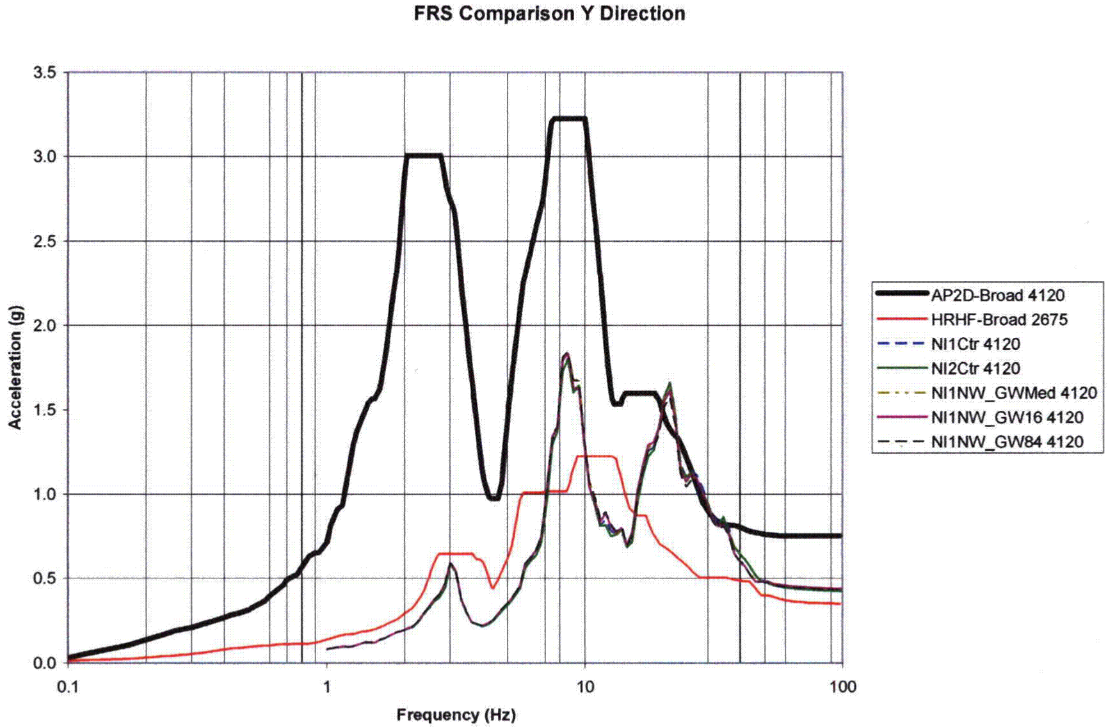

Figure B-5: 2D GW Backfill Parametric FRS Comparison of Node 4120 in Y-Direction

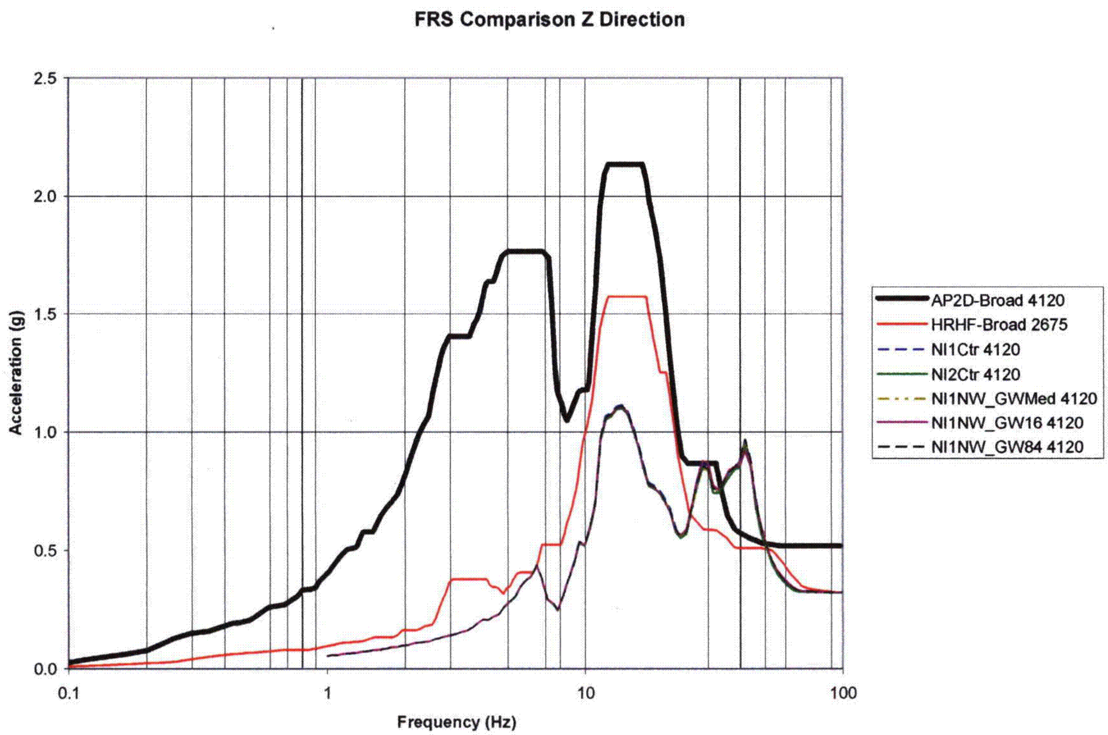

Figure B-6: 2D GW Backfill Parametric FRS Comparison of Node 4120 in Z-Direction

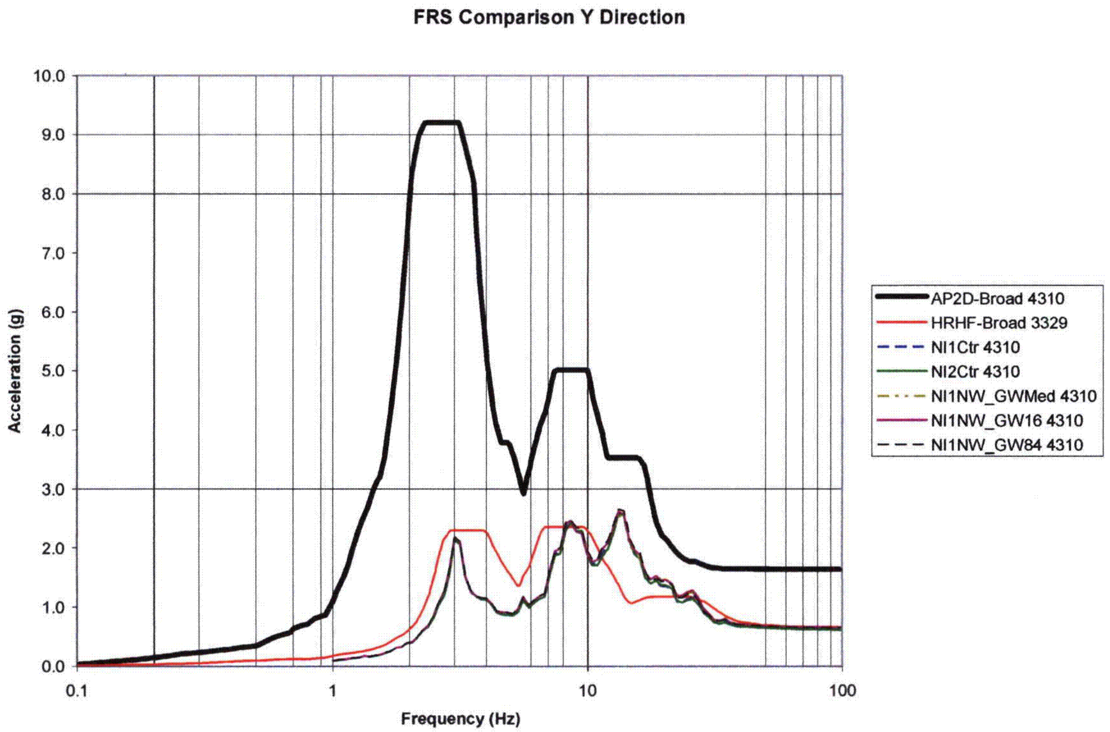

Figure B-7: 2D GW Backfill Parametric FRS Comparison of Node 4310 in Y-Direction

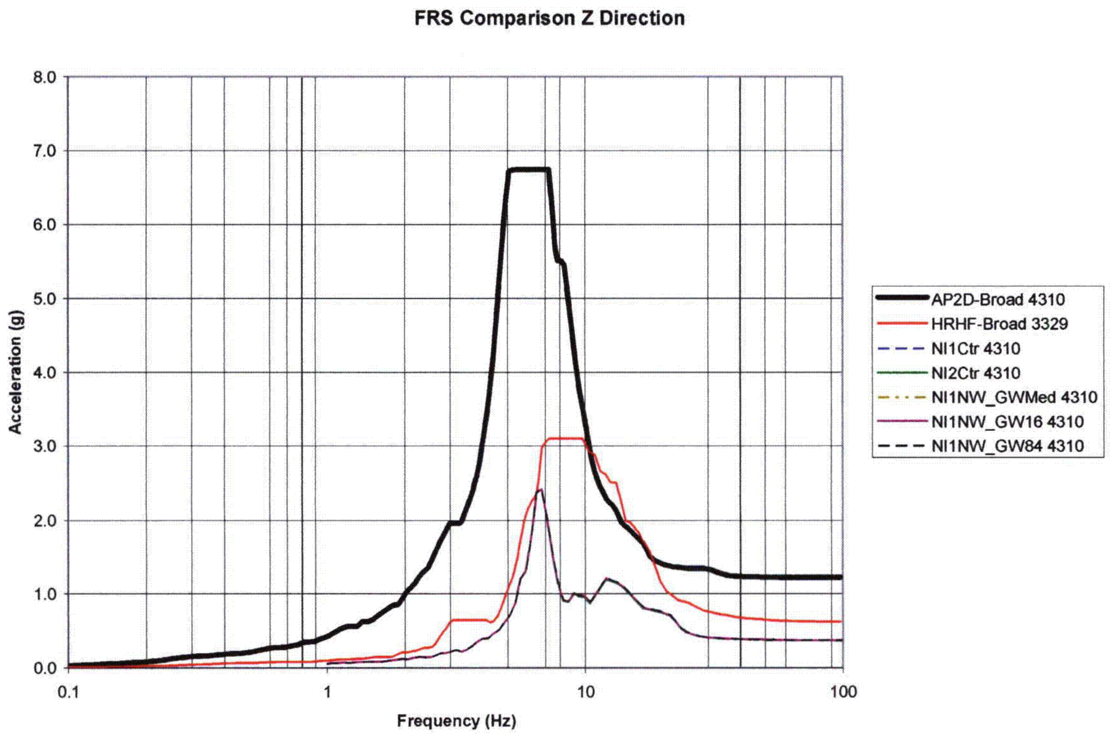

Figure B-8: 2D GW Backfill Parametric FRS Comparison of Node 4310 in Z-Direction

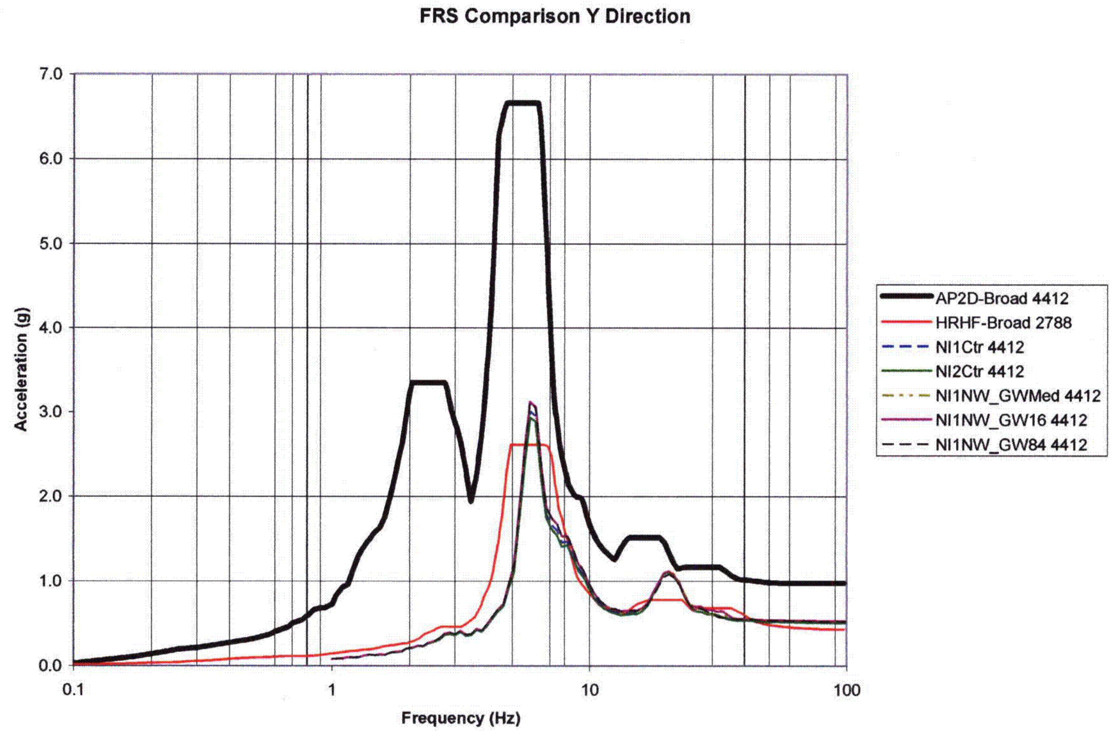

Figure B-9: 2D GW Backfill Parametric FRS Comparison of Node 4412 in Y-Direction

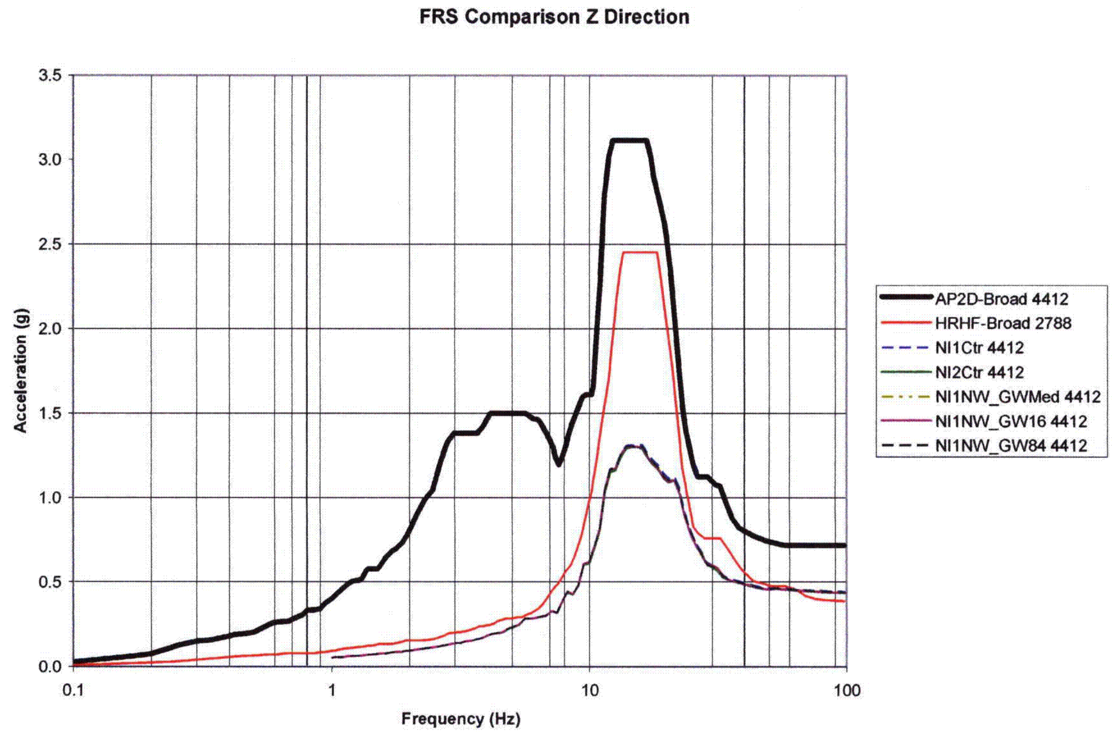

Figure B-10: 2D GW Backfill Parametric FRS Comparison of Node 4412 in Z-Direction

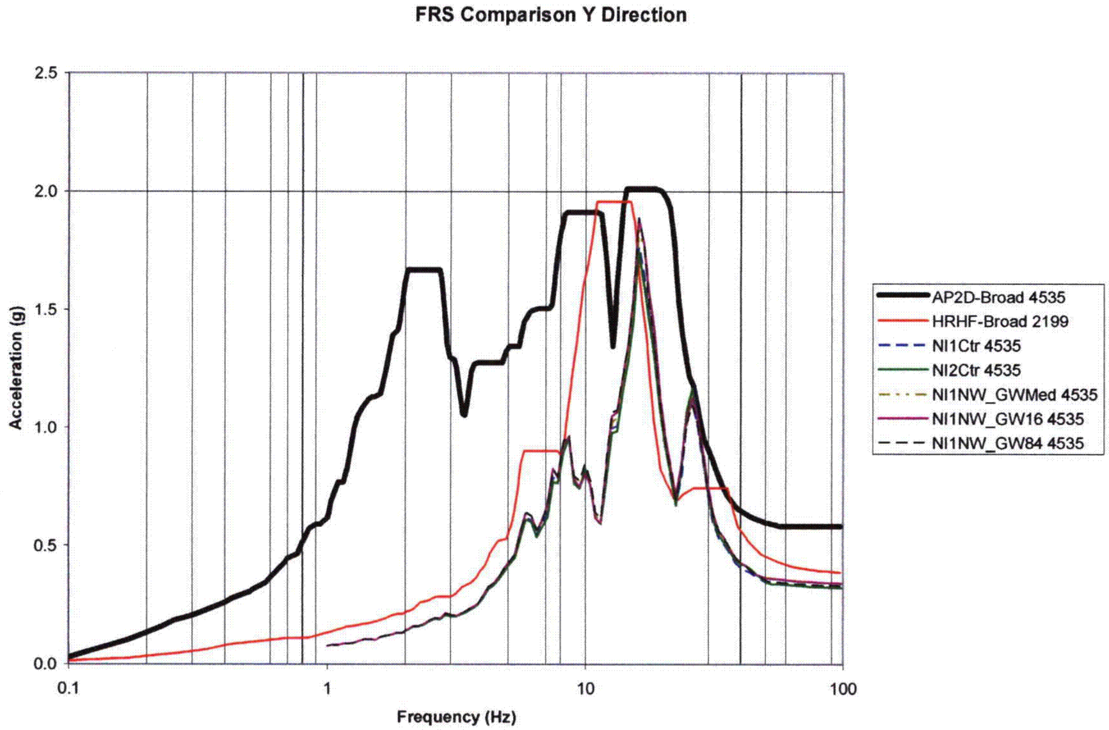

Figure B-11: 2D GW Backfill Parametric FRS Comparison of Node 4535 in Y-Direction

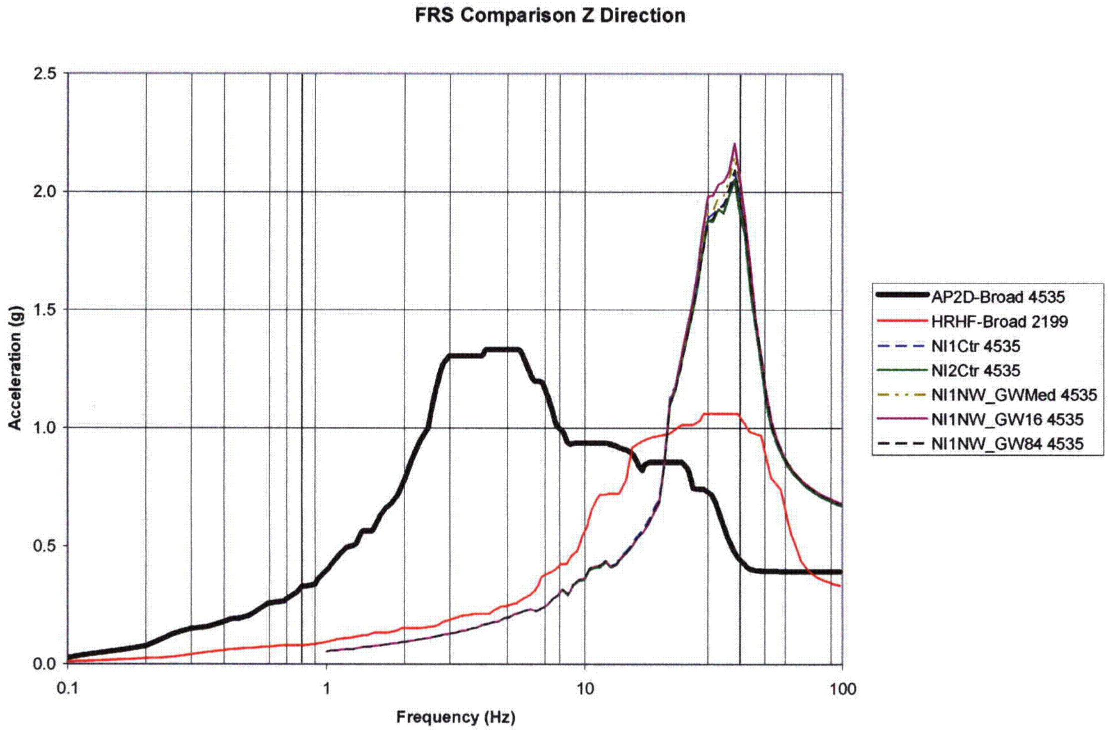

Figure B-12: 2D GW Backfill Parametric FRS Comparison of Node 40535 in Z-Direction

Appendix C: Duke Lee 2D FRS – UNIT 1 NW CORNER SW MODEL

This Appendix compares the 2D FRS for the Unit 1 and Unit 2 Centerline models/profiles and the Unit 1 NW Corner model with potential SW engineered fill placed adjacent the NI as shown in Figure 4.2-3. SW dynamic soil properties for the 16th, median and 84th percentiles were provided by Duke in Reference 8. Figure 2.5-4 illustrates the range of strain-compatible properties considered, and the selection of representative properties for use in analyses. Figures C-1 to C-12 present the FRS comparison at 5 percent damping. The envelope of the SW FRS response is calculated from these individual analyses results, and the in-structure FRS comparisons of the Unit 1 NI Centerline, Unit 2 NI Centerline, and the Unit 1 NW Corner with the SW engineered backfill envelope are presented in Figures 5-1 to 5-12.

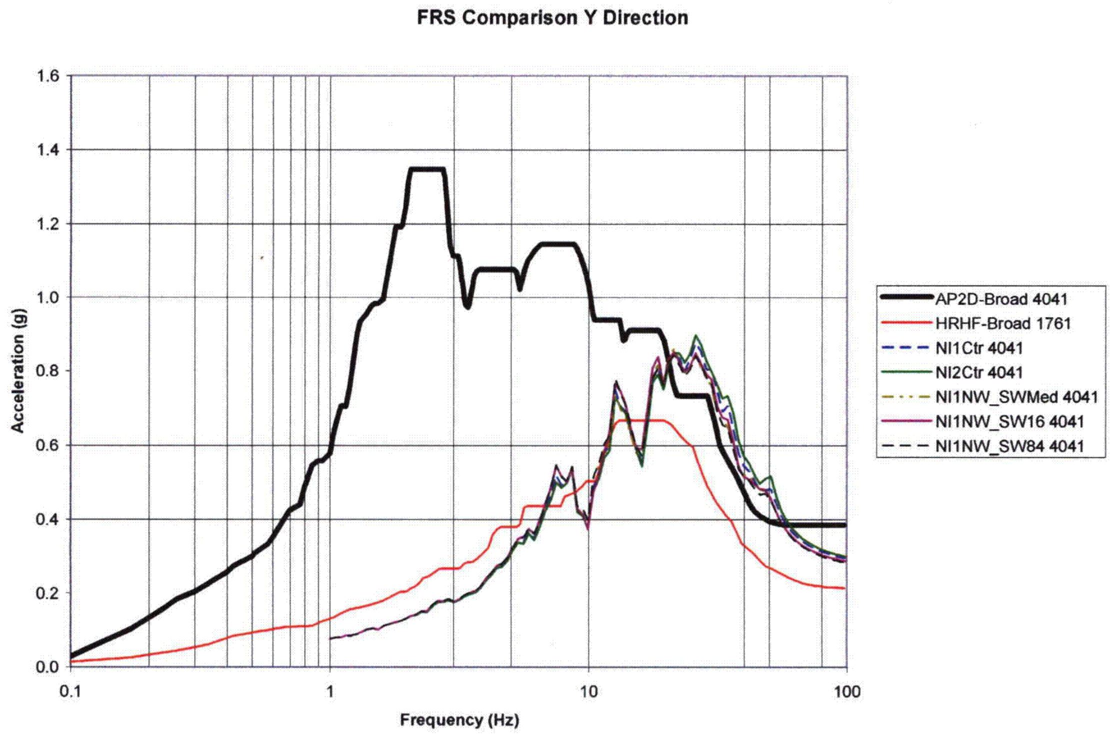

Figure C-1: 2D SW Backfill Parametric FRS Comparison of Node 4041 in Y-Direction

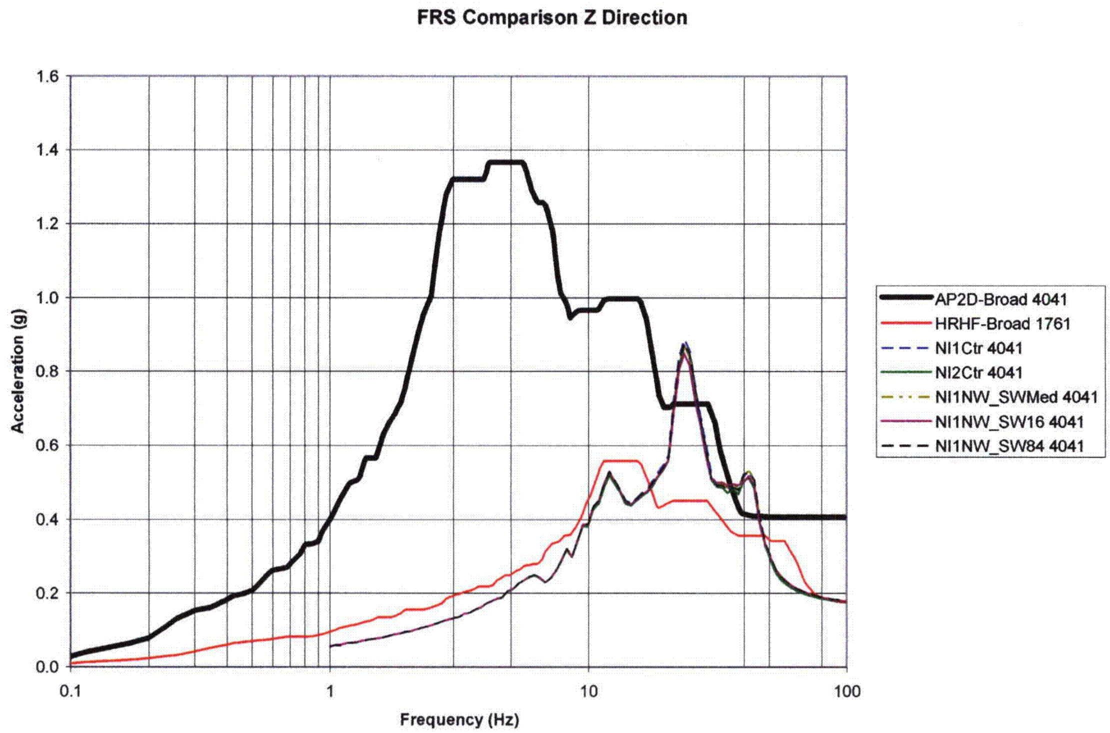

Figure C-2: 2D SW Backfill Parametric FRS Comparison of Node 4041 in Z-Direction

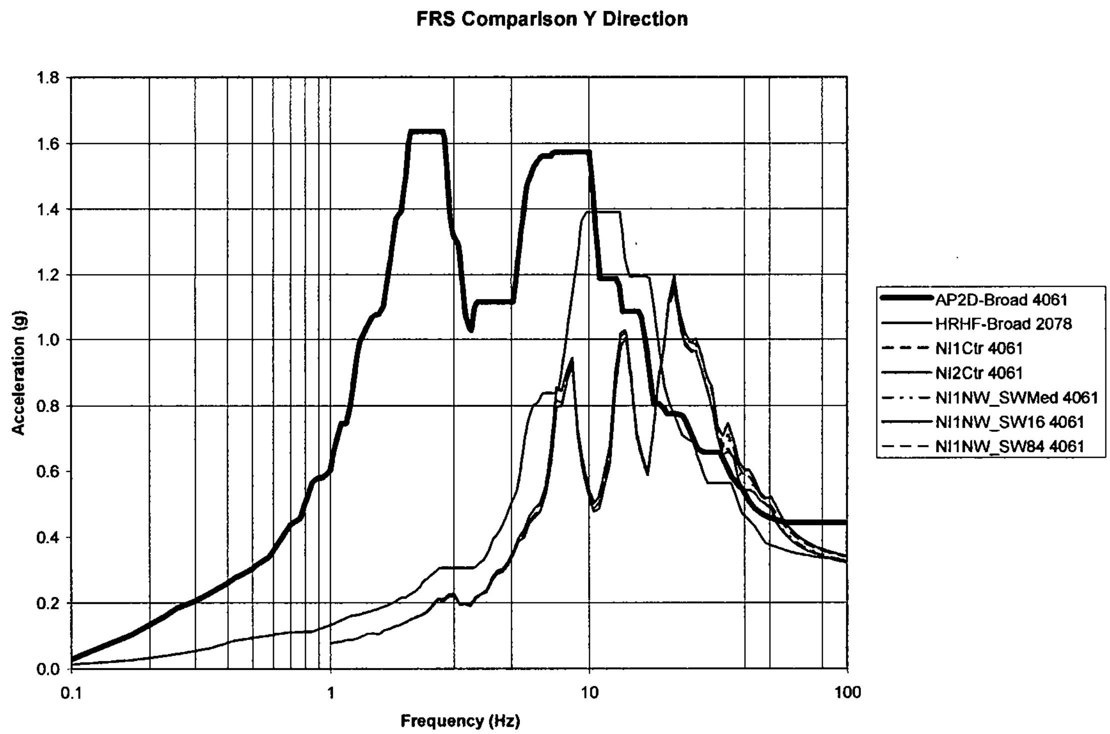

Figure C-3: 2D SW Backfill Parametric FRS Comparison of Node 4061 in Y-Direction

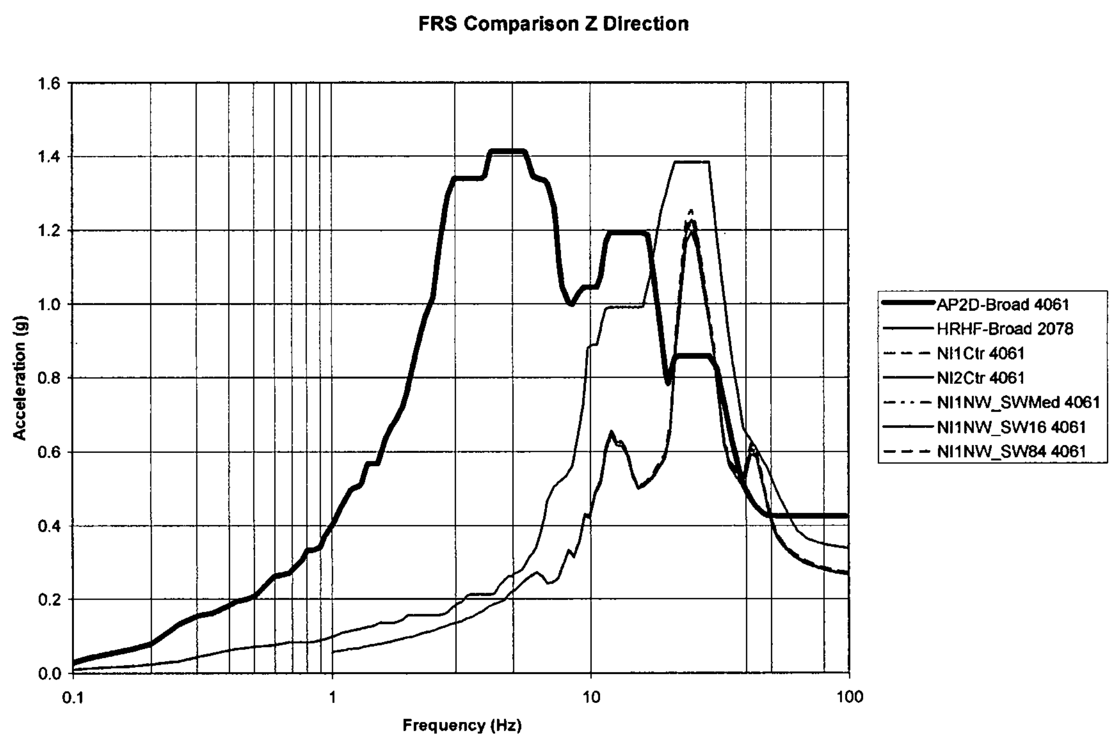

Figure C-4: 2D SW Backfill Parametric FRS Comparison of Node 4061 in Z-Direction

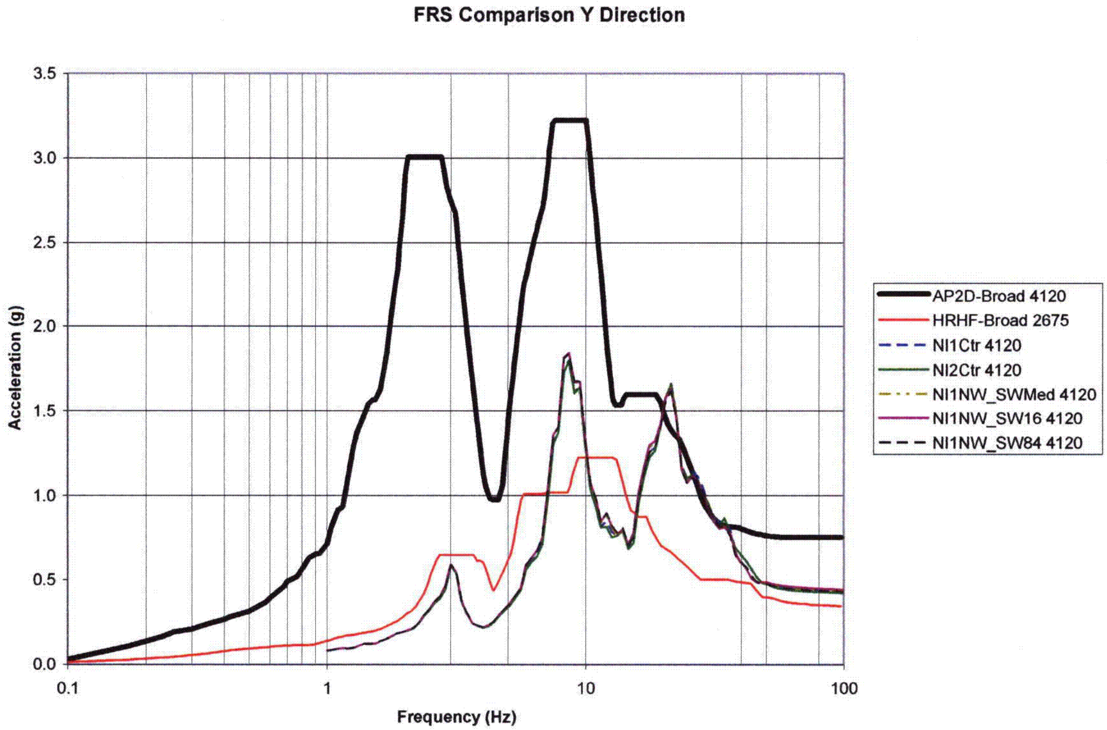

Figure C-5: 2D SW Backfill Parametric FRS Comparison of Node 4120 in Y-Direction

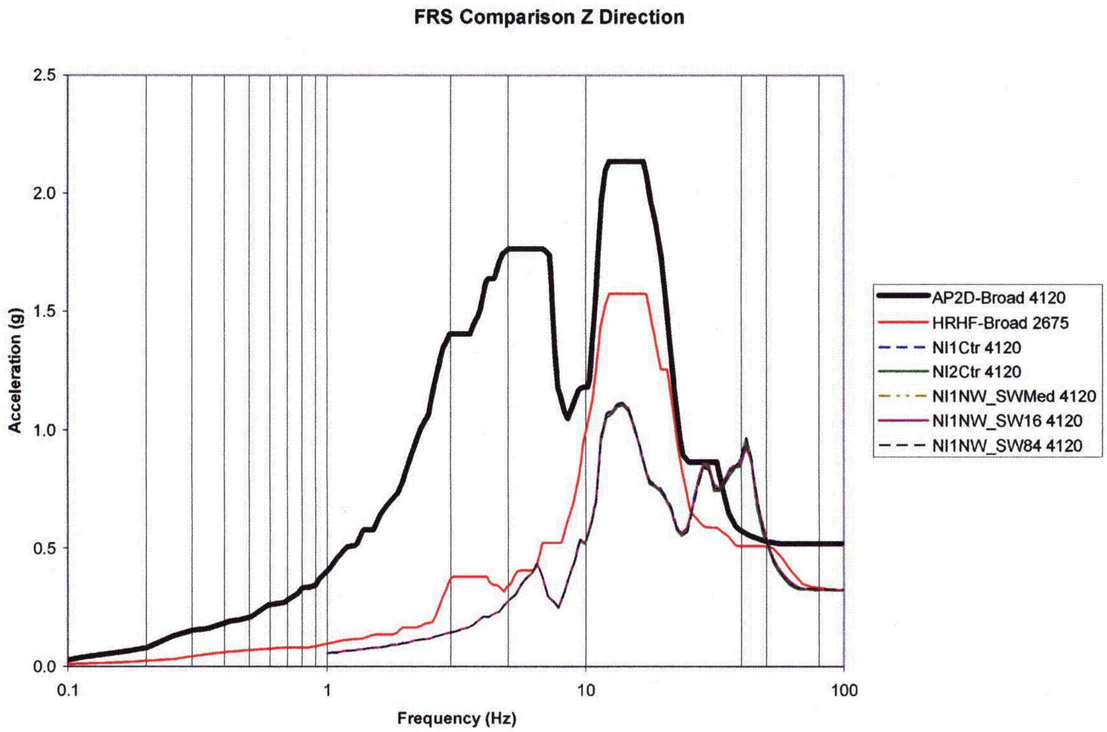

Figure C-6: 2D SW Backfill Parametric FRS Comparison of Node 4120 in Z-Direction

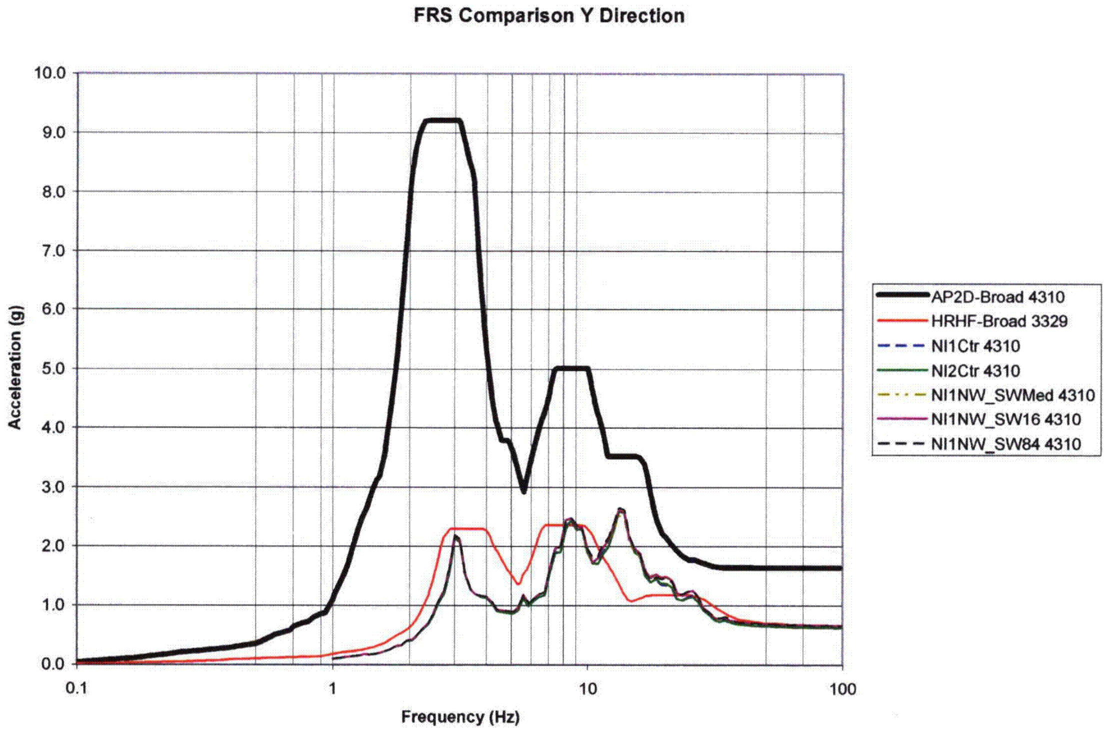

Figure C-7: 2D SW Backfill Parametric FRS Comparison of Node 4310 in Y-Direction

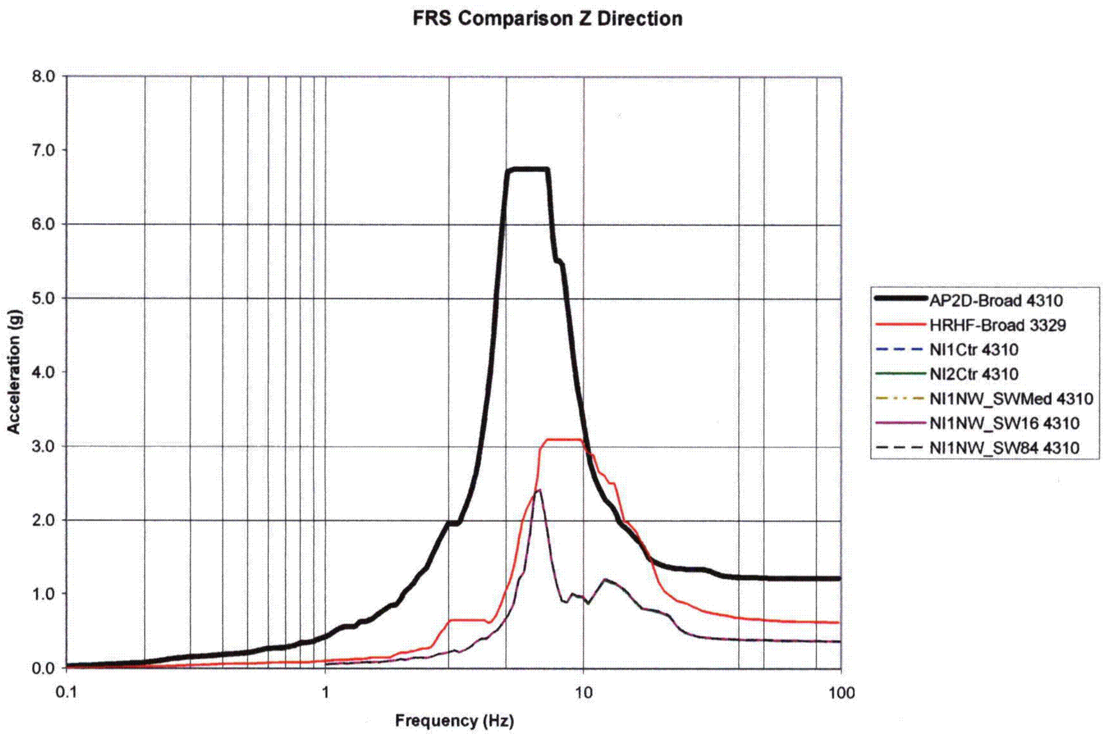

Figure C-8: 2D SW Backfill Parametric FRS Comparison of Node 4310 in Z-Direction

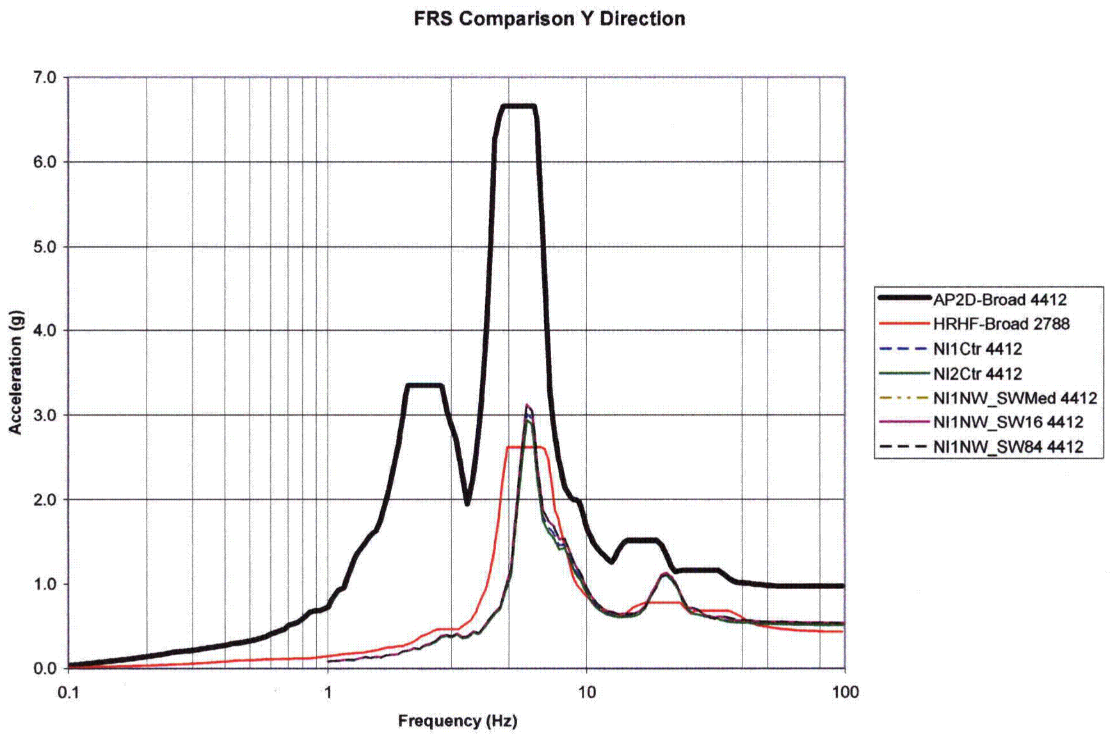

Figure C-9: 2D SW Backfill Parametric FRS Comparison of Node 4412 in Y-Direction

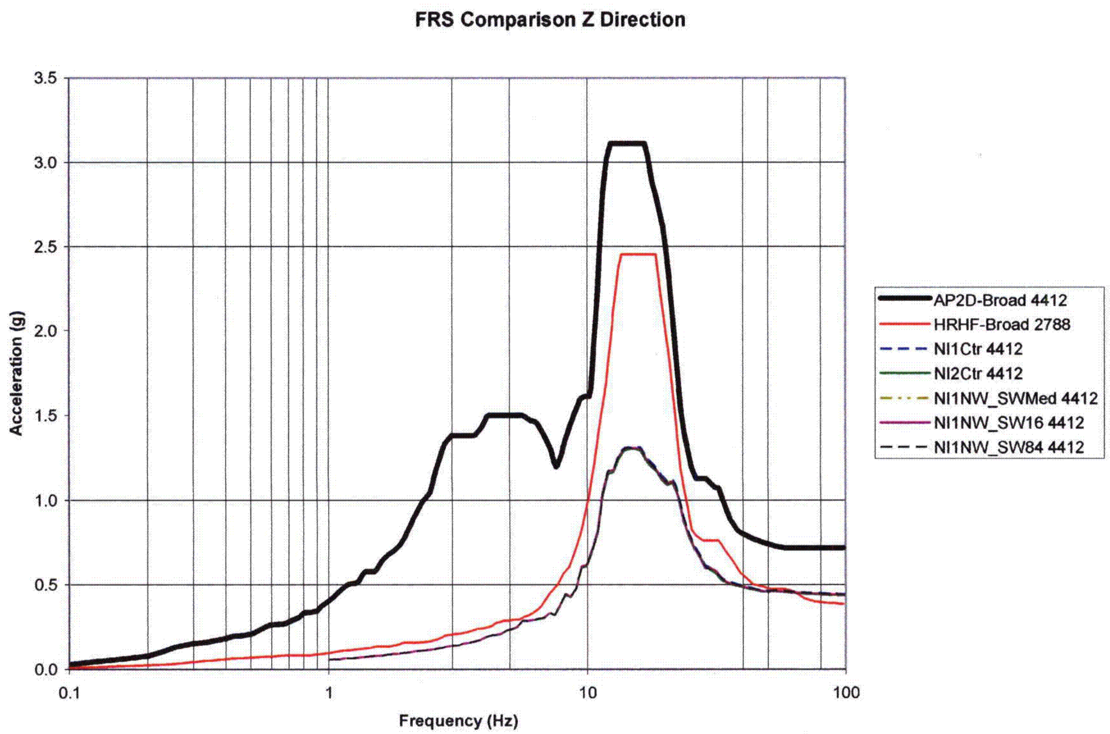

Figure C-10: 2D SW Backfill Parametric FRS Comparison of Node 4412 in Z-Direction

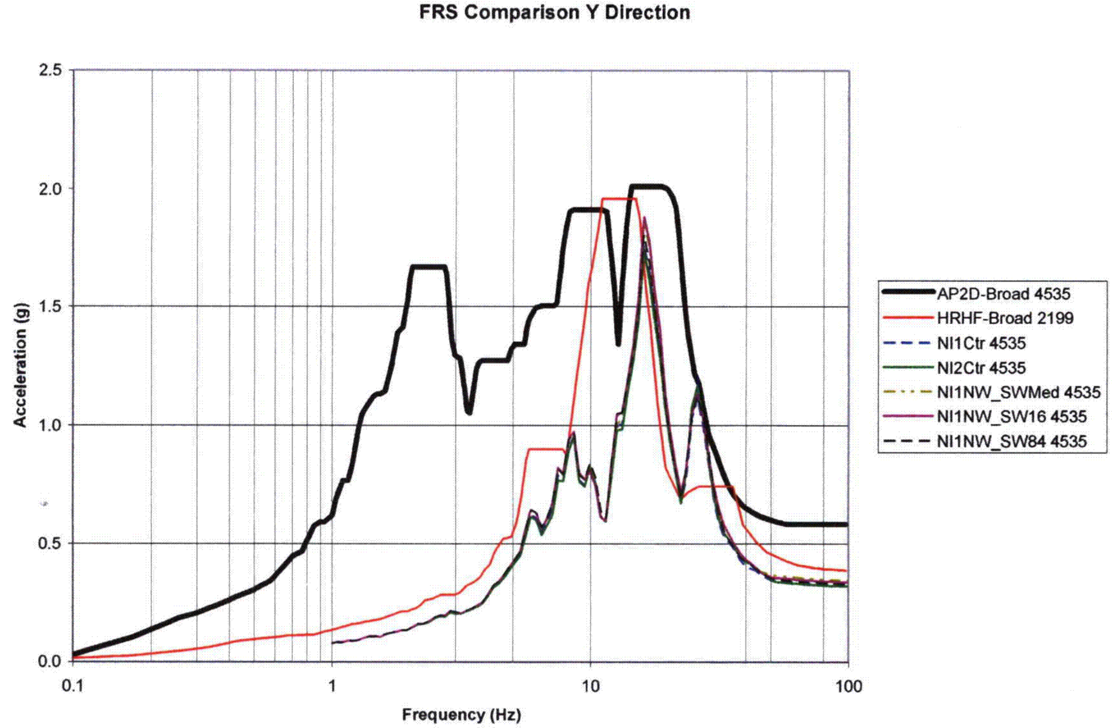

Figure C-11: 2D SW Backfill Parametric FRS Comparison of Node 4535 in Y-Direction

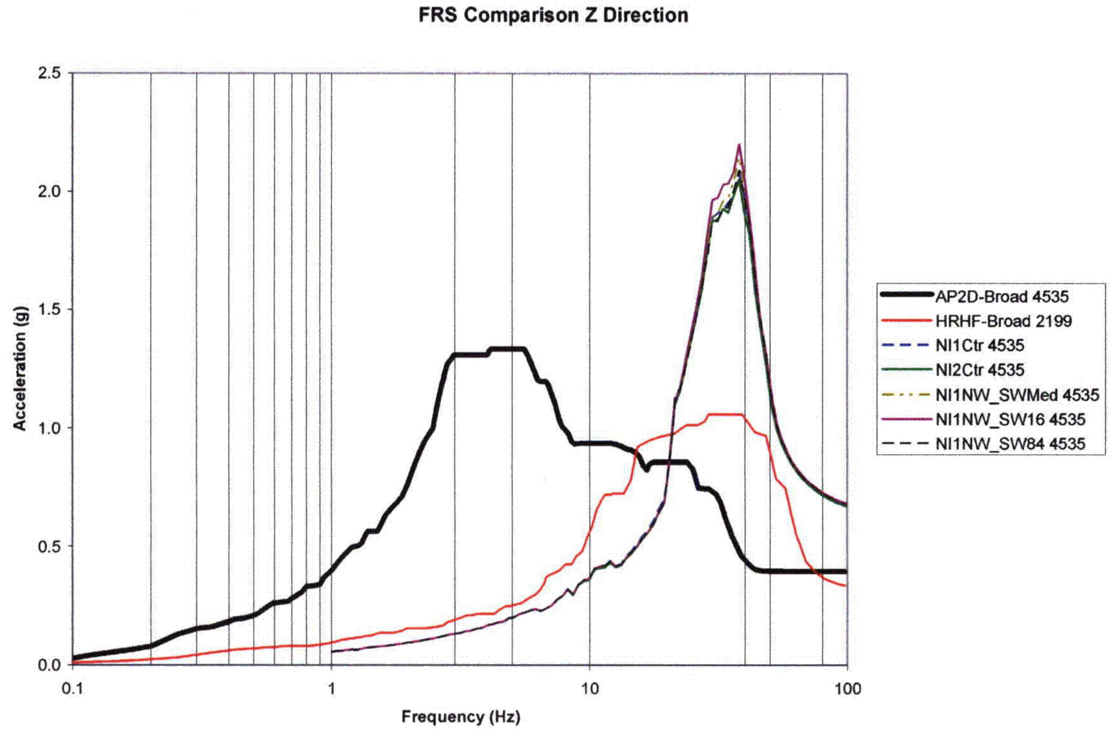

Figure C-12: 2D SW Backfill Parametric FRS Comparison of Node 4535 in Z-Direction

Lee Nuclear Station

Attachment 2 to Supplemental Response to

Request for Additional Information 03.07.02-001,

Revisions to FSAR Chapter 3 Text:

FSAR Subsection 3.7.1.1.1

New FSAR Subsection 3.7.2.15

FSAR Subsection 3.7.6

COLA Part 2, FSAR, Chapter 3, Subsection 3.7.1.1.1, is revised as follows:

3.7.1.1.1 Design Ground Motion Response Spectra

Revise the final paragraph of COLA Part 2, FSAR, Chapter 3, Subsection 3.7.1.1.1 to read:

Subsection 2.5.4.7.4.1, including Figures 2.5.4-245, 2.5.4-246, and 2.5.4-264, describe and illustrate a localized area of non-uniform foundation conditions associated with the Unit 1 Northwest Corner, and the area adjacent to and outside the nuclear island foundation footprint. Westinghouse has evaluated (Reference 201) the potential effect of this condition on the dynamic response of the nuclear island, and has concluded that its effect on in-structure response spectra is small. At the six key nuclear island locations described in AP1000 DCD Appendix 3G, significant margin exists between the site-specific in-structure response spectra and that resulting from the AP1000 CSDRS. Subsection 3.7.2.15 describes the site-specific analyses of the nuclear island to demonstrate compliance with the AP1000 DCD.

COLA Part 2, FSAR, Chapter 3, Subsection 3.7.2.15, is added as follows:

3.7.2.15 Site-Specific Analyses of Nuclear Island Seismic Category I Structures

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Add the following information to the end of DCD Subsection 3.7.2:

3.7.2.15 Site-Specific Analyses of Nuclear Island Seismic Category I Structures

WLS COL 2.5-3 To fully document the acceptability of the WLS site, Westinghouse has performed site-specific analyses of the nuclear island Seismic Category I structures. These analyses were initially documented in Revision 1 of Reference 201, and were subsequently updated in Revision 2 of Reference 201 to address AP1000 modeling updates during the Design Certification Amendment, revisions to the WLS Unit 1 Foundation Input Response Spectrum (FIRS) and the associated time-histories, and the decision to use granular fill material adjacent to the WLS nuclear island structures.

The site-specific analyses included a combination of two-dimensional (2D) and three-dimensional (3D) analyses. The 2D analyses were conducted to:

- Address the revised Unit 1 FIRS and associated time-history;
- Evaluate the extent of subsurface characterization, site response and surface motions;
- Analyze the site-specific dynamic profile and foundation medium underlying the Units 1 and 2 NI footprints;
- Assess the effect of the Unit 1 Northwest corner site-specific conditions on the seismic response; and
- Compare the 2D SSI results of the various site subsurface and foundation conditions, and determine the controlling conditions to be used in subsequent three-dimensional (3D) SSI analyses.

The 3D analyses updated the WLS 3D SSI model and analysis to include the AP1000 NI20r 3D Model, incorporated the results and parameters established in the 2D parametric studies and performed twenty-five (25) 3D SASSI incoherent simulation analyses.

The WLS 3D horizontal and vertical in-structure floor response spectra (FRS) were compared to the AP1000 3D Certified Seismic Design Response Spectra (CSDRS) and Hard Rock High Frequency (HRHF) FRS envelopes at six (6) key AP1000 NI locations.

The 2D SSI analyses were performed using the computer code SASSI2000 and post-processed using ACS SASSI. 3D Incoherent SSI analyses were performed using ACS SASSI. All SASSI SSI analyses performed used the SASSI Direct method for computing in-structure FRS.

Site-specific SSI analyses were performed using the AP1000 NI20r finite element model and the site-specific Foundation Input Response Spectra (FIRS) A1 time history inputs described in Subsection 3.7.2.1.2.

As described below, the 3D SSI analyses results show that the in-structure FRS of an AP1000 plant at the WLS Unit 1 & 2 sites are enveloped by the FRS from AP1000 CSDRS and HRHF analyses at the six key AP1000 NI locations described in DCD Subsection 3.7.2 and DCD Table 3G.4-1.

3.7.2.15.1 Site Characteristics

Foundation conditions for the two (2) WLS units are described in Subsection 2.5.4.7.4. The Unit 1 NI basemat is founded at El. 550.5 ft. msl (AP1000 El. 60.5 ft.), predominately on fill concrete over hard rock, and the Unit 2 NI basemat is founded at El. 550.5 ft. msl. on hard rock. The final grade level for both units is at El 590.0 ft. msl (AP1000 El. 100.0 ft.).

Unit 1 will overlie portions of the former Cherokee Nuclear Station fill concrete and legacy structural slabs and native rock. Similarly, Lee Unit 2 will occupy portions of the former Cherokee Unit 3 area, and will overlie native rock. Both nuclear island (NI) structures will require some additional minor excavation and replacement with fill concrete. In the Northwest corner of Unit 1, engineered fill will be placed adjacent to the fill concrete which will extend below the elevation of the AP1000 basemat.

The foundation conditions and geologic profiles vary between Units 1 and 2, and locally at the Northwest corner of Unit 1. A total of three (3) site-specific SSI models were developed with corresponding site dynamic profiles to represent the varied conditions and backfill beneath the Units 1 and Unit 2 NIs. Three cross-sections were modeled:

- Unit 1 Centerline Cross-Section B-B' (Figure 2.5.4-260);
- Unit 2 Centerline Cross-Section B-B' (Figure 2.5.4-260); and
- Unit 1 Northwest Corner Cross-Sections Y-Y' and U-U' (Figures 2.5.4-264 and 2.5.4-245).

Three dynamic profiles were developed to represent the conditions at each plant basemat, corresponding to:

- Unit 1 Centerline – Base Case A1 (Figure 2.5.4-252);
- Unit 2 Centerline – Profile C (Figure 2.5.4-250); and
- Unit 1 Northwest Corner – Profile B (Figure 2.5.4-249).

As shown in the Unit 1 Northwest Corner Cross-Sections U-U' (Figure 2.5.4-245) and Y-Y' (Figure 2.5.4-260), up to approximately 30 feet of engineered fill is required adjacent to the fill concrete beneath the NI (below El. 550.5), which replaces excavated lower shear wave velocity weathered rock down to continuous rock at the Northwest corner. Strain compatible dynamic soil properties were calculated for granular fill materials in three (3) representative profiles located within the Unit 1 Northwest corner. Calculation of these properties considered the three candidate engineered fill material types (GP, GW, and SW) described in Subsection 2.5.4, and a range of ground water conditions. The calculation results included 16th, median, and 84th percentile values for the dynamic soil properties. A range of average dynamic properties was determined, parametrically evaluated in the 2D SSI analysis of the Unit 1 Northwest corner, and the results (in-structure FRS) were enveloped.

Cross-Section B-B' (Figure 2.5.4-260) shows bedrock conditions on an East-West centerline of Unit 1 and Unit 2. The new Unit 1 NI basemat will be constructed over approximately five (5) feet of new fill concrete overlying an average of about 15 feet of existing fill concrete, structural basemat concrete and native rock from the former Cherokee foundation. The Unit 2 NI basemat is founded on native hard rock. The Unit 1 NI centerline rock shear wave velocity (Vs) ranges from about 7,500 feet per second (fps) (fill concrete) to about 9,600 fps (continuous rock) as shown in the Unit 1 Base Case A1 (Figure 2.5.4-252). The Unit 2 Centerline continuous rock Vs ranges from about 8,400 fps to about 9,600 fps as shown in the Unit 2 Profile C (Figure 2.5.4-250).

Cross-Sections Y-Y' and U-U' (Figures 2.5.4-264 and 2.5.4-245) represents bedrock conditions at the Northwest corner of the Unit 1 NI. In this area, the NI overlies a localized zone of weathered and fractured rock, extending approximately 15 to 25 feet deep below the Unit 1 basemat elevation (El. 550.5 ft.). This localized zone of weathered rock exhibits lower Vs velocities, ranging from approximately 4500 to 6000 fps, than the underlying and adjacent sound rock with Vs of approximately 9200 fps. Excavation of this isolated lower velocity material to continuous rock at the Northwest corner of Unit 1 NI will be replaced with fill concrete beneath the basemat. Engineered backfill will be placed and compacted adjacent to the fill concrete beneath the NI (and beneath the northern end of the Annex Building) approximately 20 to 30 feet below the NI basemat elevation. The Unit 1 rock shear wave velocity at the Northwest corner ranges from about 5,300 fps to about 9,200.

Because the rock and fill concrete materials were found to behave linearly in the development of site response spectra, a material damping value of 0.005 was used for rock and for fill concrete in all profiles. For the granular fill materials adjacent to the Northwest corner, damping values were determined as one of the strain-compatible material properties, and varied between approximately 0.05 and 0.10, depending on material type and depth.

3.7.2.15.2 Seismic Inputs

The horizontal and vertical site GMRS and Unit 1 Foundation Input Response Spectra (FIRS) are described in Subsection 3.7.1.1.1. Subsection 3.7.2.1.2 describes the development of artificial time histories to represent the Unit 1 FIRS, consistent with the guidance in Standard Review Plan 3.7.1. Since the Unit 1 FIRS bounds the site GMRS, which is the Unit 2 base motion, the Unit 1 FIRS time histories are conservatively used for the analysis of both Unit 1 and Unit 2.

Analysis of the AP1000 for the Certified Seismic Design Response Spectra (CSDRS) envelope is provided in Reference 202, and for the hard rock high frequency (HRHF) FRS envelope in

Reference 203. The WLS 3D SSI in-structure FRS are compared to the AP1000 CSDRS and HRHF envelopes at the six key locations identified in DCD Subsection 3.7.2 and DCD Table 3G.4-1.

3.7.2.15.3 Two-Dimensional SASSI Parametric Studies

Two-dimensional (2D) parametric SSI analyses were performed using SASSI to compare the 2D SSI results of the various site subsurface and foundation conditions, and determine the controlling conditions to be evaluated in greater detail in subsequent 3D SSI analyses. The 2D East-West (EW) model typically yields a higher response than the north-south model as described in Section 6.2 of Westinghouse Technical Report TR03 (APP-GW-S2R-010, "Extension of Nuclear Island Seismic Analysis to Soil Site", Reference 202). Therefore, the 2D EW model is used for these parametric studies.

The models consist of a 2D SASSI stick model of the AP1000 nuclear island that is used with three site-specific 2D SASSI finite element models representing three (3) cross-sections of interest for Units 1 and 2. The AP1000 Nuclear Island model includes three stick models representing the the Auxiliary Shield Building (ASB), the Steel Containment Vessel (SCV), and the Containment Internal Structure (CIS). The three (3) east-west cross-sections modeled are the Unit 1 NI centerline, the Unit 2 NI centerline, and the Unit 1 nuclear island Northwest corner. The SASSI Direct method is used to compute in-structure FRS. From the analyses using the 2D models, the important modes of the structure and seismic interaction between the NI structures and supporting media are obtained to evaluate the response of the three cross-sections.

The Unit 1 centerline east-west 2D SASSI finite element model includes the supporting medium up to the bottom of the basemat of the nuclear island. Consistent with DCD analyses of hard-rock conditions, the model does not include backfill material adjacent to the nuclear island above that level. The 2D model of the supporting medium has properties assigned to represent areas of continuous rock, legacy fill concrete and structural concrete remaining from the Cherokee construction, and new fill concrete to be used to bring the site to the level of the bottom of the nuclear island basemat. The Unit 2 centerline east-west 2D SASSI finite element model is constructed similarly, but the finite element properties are selected to represent the continuous hard rock supporting the Unit 2 nuclear island.

The Unit 1 Northwest corner east-west 2D SASSI model is constructed similarly, but is extended laterally so that the SASSI finite elements can represent not only the material types in the Unit 1 centerline model, but also materials and configurations that are unique to the Northwest corner. These include areas of continuous rock with lower shear wave velocity, thicker fill concrete layers, the irregular surface of the continuous rock, and the presence of weathered rock and granular fill outside the support zone of the nuclear island, but adjacent to the nuclear island and below the level of the bottom of the basemat.

The configuration of each of the site-specific models is selected with the objective that each material layer should have a passing frequency of approximately 50 Hz based on the material properties. The 2D SASSI analysis uses a 50 Hz cut-off frequency. Time-history seismic analyses of the three (3) east-west 2D SASSI models were performed considering simultaneous occurrences of one horizontal and one vertical component. The Unit 1 FIRS time history was input at the basemat bottom elevation. The 2D in-structure FRS results were combined algebraically using each directional analysis FRS to produce site-specific in-structure 5% damped horizontal and vertical spectra at each of the six (6) key locations identified in DCD

Subsection 3.7.2 and DCD Table 3G.4-1. These six (6) locations are shown below. (Note that Lee North corresponds to AP1000 South.)

- 2D Node 4041, CIS at Reactor Vessel Support Elevation
- 2D Node 4061, ASB SW Corner at Control Room Floor
- 2D Node 4535, CIS at Operating Deck
- 2D Node 4120, ASB Corner of Fuel Building Roof at Shield Building
- 2D Node 4412, SCV Near Polar Crane
- 2D Node 4310, ASB Shield Building Roof Area

For the Northwest corner 2D SASSI analyses, individual analyses were conducted for the three (3) candidate granular fill materials (GP, GW, and SW), for a range of groundwater levels, and for the 16th, median and 84th percentile values of the strain-compatible dynamic properties, and the results enveloped for each granular fill type. The resulting site-specific in-structure FRS are shown in Figures 3.7-204a through 3.7-205c for these six (6) key locations.

It is important to note that the HRHF broad curve (envelope) is based on SASSI 3D analyses and includes seismic motion incoherency effects. The WLS 2D FRS does not include in the SSI analyses coherency functions. The purpose of the 2D SSI analyses was to evaluate the various cases for subsequent 3D SSI analyses and to assess potential FRS impacts from the NW corner subsurface conditions. Subsequent 3D analyses compare the WLS 3D FRS results with incoherency to the AP1000 HRHF envelope, also including incoherency. The following observations can be made from the 2D SASSI parametric analyses results:

- Consideration of the Unit 1 Northwest Corner configuration and materials results in a relatively small change in the calculated in-structure FRS compared to the Unit 1 Centerline model. Likewise, the selection of engineered fill (GP, GW or SW) to be used adjacent to the nuclear island also has a relatively small effect on the calculated in-structure FRS for the nuclear island.
- Only minor spectral acceleration differences are observed between the Unit 1 NI Centerline 2D FRS and the Unit 2 NI Centerline 2D FRS across the entire frequency spectrum in both the horizontal and vertical directions. The slight variation of the dynamic properties of Unit 1 situated on fill concrete versus Unit 2 founded on sound rock do not result in a appreciable difference in each respective model FRS; and
- Comparing the Unit 1 and Unit 2 NI Centerline 2D FRS to the AP1000 2D CSDRS and HRHF FRS envelopes suggests that above 20 Hz, the Unit 1 and 2 in-structure FRS exceed the AP1000 envelope FRS. As previously discussed, coherency functions were not applied to the WLS 2D parametric analyses. As demonstrated in the 3D analyses below, consideration of incoherency effects reduces the calculated in-structure FRS above 20 Hz.

Based on the results of the 2D parametric SSI analyses, subsequent 3D incoherent SSI analyses were performed using both the Unit 1 and Unit 2 NI Centerline cross-section models and the corresponding Base Case A1 and Profile C site dynamic profiles, respectively. In-structure FRS from 3D incoherent SSI analyses are compared to the AP1000 and HRHF 3D envelope spectra.

3.7.2.15.4 Three-Dimensional SASSI SSI Analyses

3D SASSI analyses were performed to demonstrate that the in-structure FRS of an AP1000 plant at the WLS site is enveloped by the AP1000 CSDRS and HRHF 3D envelopes at the six (6) NI key locations shown below. (Note that Lee North corresponds to AP1000 South.)

- 3D Node 1761, CIS at Reactor Vessel Support Elevation
- 3D Node 2078, ASB SW Corner at Control Room Floor
- 3D Node 2199, CIS at Operating Deck
- 3D Node 2675, ASB Corner of Fuel Building Roof at Shield Building
- 3D Node 2788, SCV Near Polar Crane
- 3D Node 3329, ASB Shield Building Roof Area

Since WLS is a hard-rock site, the Unit 1 FIRS spectra shown in Figures 3.7-201 and 3.7-202 exhibit a shape similar to the HRHF response spectra documented in Westinghouse Technical Report TR115 (Reference 203). Therefore, the same incoherent analysis methodology was used in the WLS site-specific 3D SASSI SSI analyses.

The 3D SASSI incoherent analyses were performed with the Unit 1 and Unit 2 NI Centerline soil profiles and the corresponding Unit 1 FIRS time history. The 3D SASSI model used is the AP1000 NI20r surface model that is described in Westinghouse Technical Report TR03 (APP-GW-S2R-010, Rev. 5, Reference 202). Consistent with AP1000 DCD analyses, reinforced concrete elements are assigned 7% damping, structural steel elements are assigned 4% damping, and concrete-filled steel plate (SC) structures are assigned 5% damping. The benchmarking of AP1000 NI10 and NI20r was documented in Westinghouse Technical Report TR03 Appendix C – Comparison of NI10 and NI20r Responses. Structural damping of 7% is used in the development of HRHF in-structure response spectra (ISRS).

The 3D incoherent analyses include performing 25 simulations of the Unit 1 and Unit 2 NI20r surface models with outcrop input time history. The coherency functions employed and the methods of analysis are consistent with COL/DC-ISG-1 (Reference 204) and are also consistent with those used in DCD-supporting analyses. The 3D incoherent analyses includes 25 simulations using the NI20r surface model, and were performed using the Unit 1 and Unit 2 NI Centerline Base Case A1 and C site dynamic profiles, respectively, Unit 1 FIRS time history input at AP1000 El. 60.5 ft., and SASSI Direct method.

Similar to the 2D SASSI analyses, the configuration of each 3D SASSI layer was selected considering the SASSI wavelength criteria for 50 Hz. Since the Unit 1 and Unit 2 centerline profiles are comprised of fill concrete and hard rock, with Vs>7500 fps, this criteria is easily met. The 3D SASSI analyses use a 50 Hz cut-off frequency, and are consistent with the guidance in COL/DC-ISG-1.

The site-specific NI 3D SASSI results are shown in Figures 3.7-206a through 3.7-208c. The WLS Units 1 and 2 NI20r surface models were run through 25 simulations of incoherent 3D analysis using the three predefined direction-based Unit 1 FIRS time histories. The calculated 5% damping in-structure FRS at the six (6) key locations are enveloped by the AP1000 3D CSDRS and HRHF SSI envelopes with significant margin.

3.7.2.15.5 Site-Specific Analyses Conclusions

The site-specific analyses of the WLS nuclear islands led to the following conclusions:

- Consideration of the Unit 1 Northwest Corner configuration and materials results in a relatively small change in the calculated in-structure FRS compared to the Unit 1 Centerline model. Likewise, the selection of engineered fill (GP, GW or SW) to be used adjacent to the nuclear island also has a relatively small effect on the calculated in-structure FRS for the nuclear island.
- Only minor differences exist between the Unit 1 NI Centerline 2D FRS and the Unit 2 NI Centerline 2D FRS across the frequency spectrum in both the horizontal and vertical directions;
- The site-specific WLS 3D incoherent SSI analyses results for Unit 1 and Unit 2, which incorporate the AP1000 NI20r 3D model and revised Unit 1 FIRS time history, indicate that the 5% damping in-structure FRS at six (6) key NI locations are enveloped by the AP1000 CSDRS and HRHF SSI envelopes.

COLA Part 2, FSAR, Chapter 3, Subsection 3.7.6, is revised as follows:

3.7.6 REFERENCES

Revise the COLA Part 2, FSAR, Chapter 3, Subsection 3.7.6 to add the following references:

201. Westinghouse Electric Company Report WLG-1000-S2R-802, Revision ~~1~~2, William S. Lee Site Specific Seismic Evaluation Report, ~~December 15, 2009~~March 15, 2012.

202. Westinghouse Electric Company Report APP-GW-S2R-010, TR03 "Extension of Nuclear Island Seismic Analyses to Soil Sites," Rev. 5, February 2011.

203. Westinghouse Electric Company Report APP-GW-GLR-115, TR115 "Effect of High Frequency Seismic Content on SSCs," Rev.3, January 2011.

204. COL/DC-ISG-1, "Interim Staff Guidance on Seismic Issues Associated with High Frequency Ground Motion in Design Certification and Combined License Applications," May 2008.

Lee Nuclear Station

Attachment 3 to Supplemental Response to

Request for Additional Information 03.07.02-001,

Revisions to FSAR Chapter 3 Figures:

New FSAR Figure 3.7-204a

New FSAR Figure 3.7-204b

New FSAR Figure 3.7-204c

New FSAR Figure 3.7-205a

New FSAR Figure 3.7-205b

New FSAR Figure 3.7-205c

New FSAR Figure 3.7-206a

New FSAR Figure 3.7-206b

New FSAR Figure 3.7-206c

New FSAR Figure 3.7-207a

New FSAR Figure 3.7-207b

New FSAR Figure 3.7-207c

New FSAR Figure 3.7-208a

New FSAR Figure 3.7-208b

New FSAR Figure 3.7-208c

COLA Part 2, FSAR Figure 3.7-204a is added as follows:

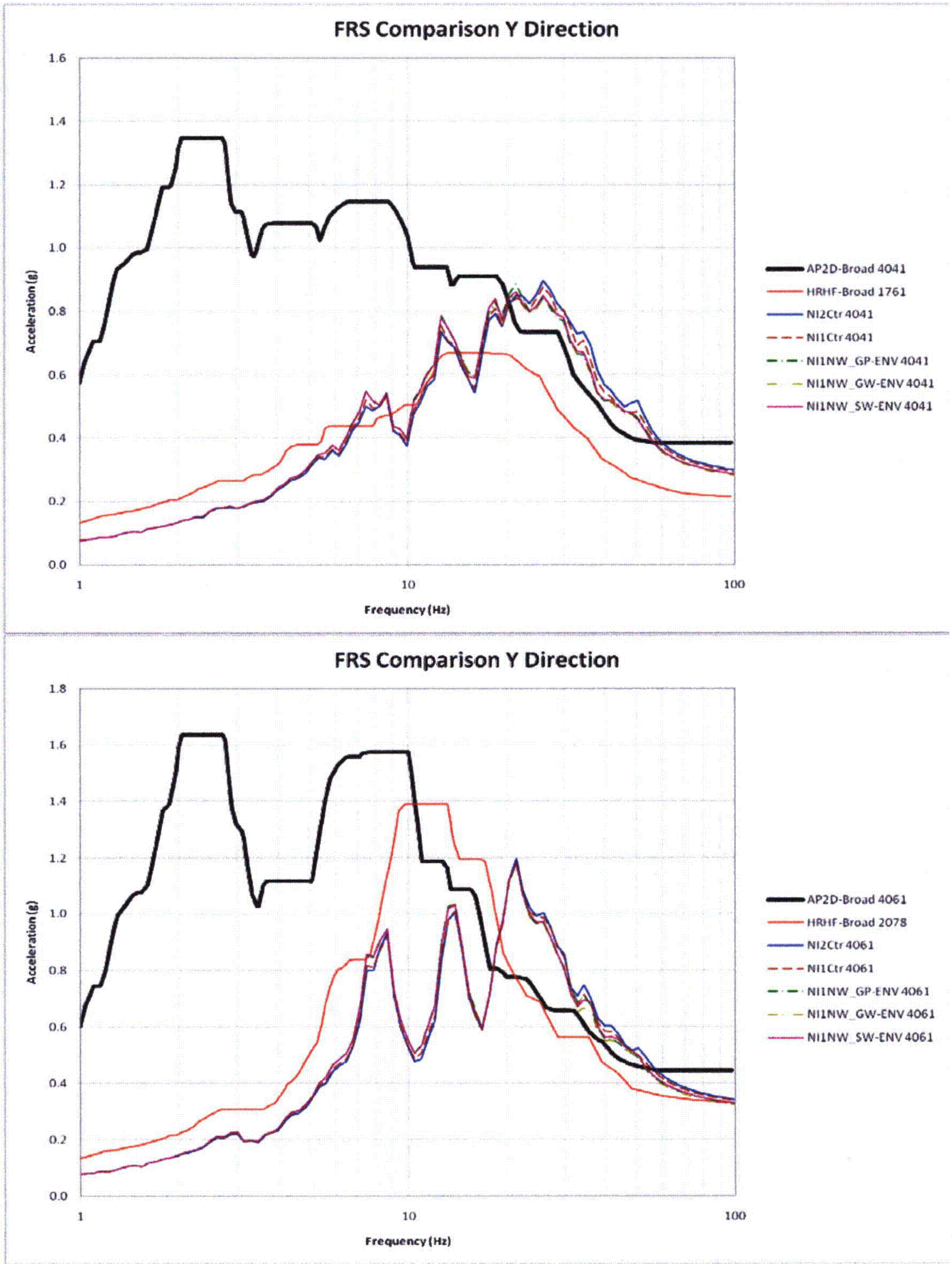


Figure 3.7-204a Comparison of 2D FRS and AP1000 Envelope (Y-Direction, Nodes 4041 and 4061)

COLA Part 2, FSAR Figure 3.7-204b is added as follows:

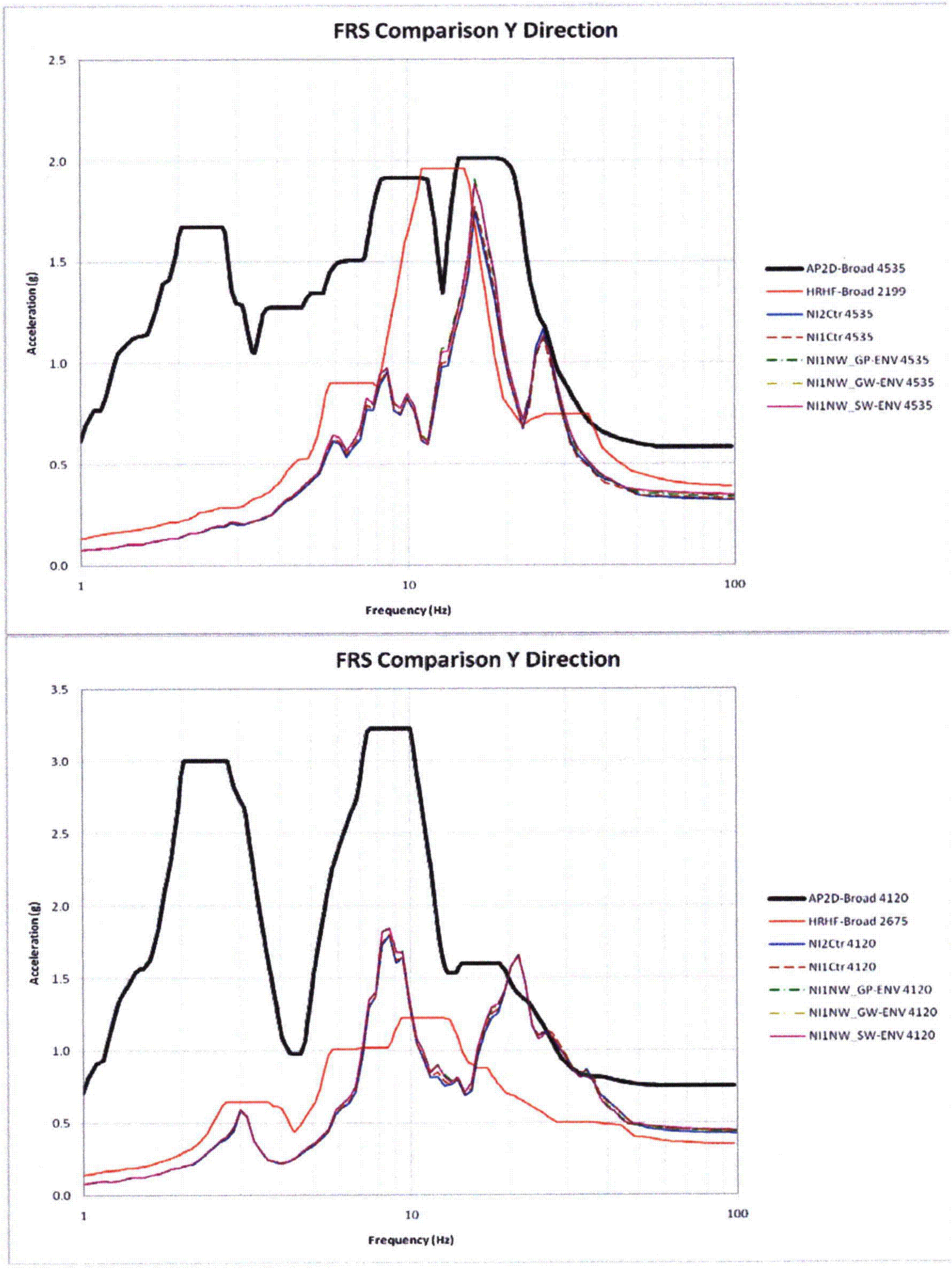


Figure 3.7-204b Comparison of 2D FRS and AP1000 Envelope (Y-Direction, Nodes 4535 and 4120)

COLA Part 2, FSAR Figure 3.7-204c is added as follows:

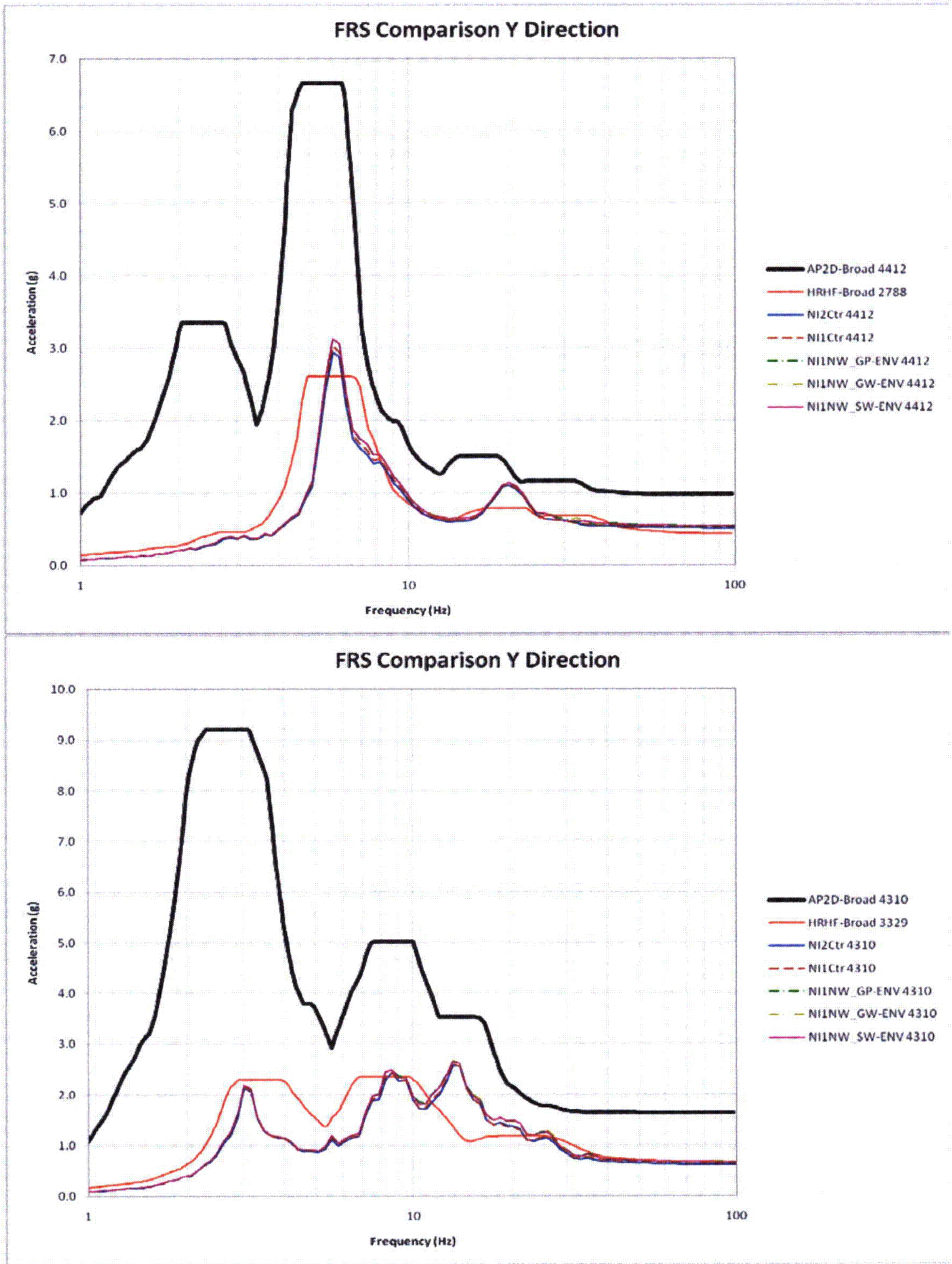


Figure 3.7-204c Comparison of 2D FRS and AP1000 Envelope (Y-Direction, Nodes 4412 and 4310)

COLA Part 2, FSAR Figure 3.7-205a is added as follows:

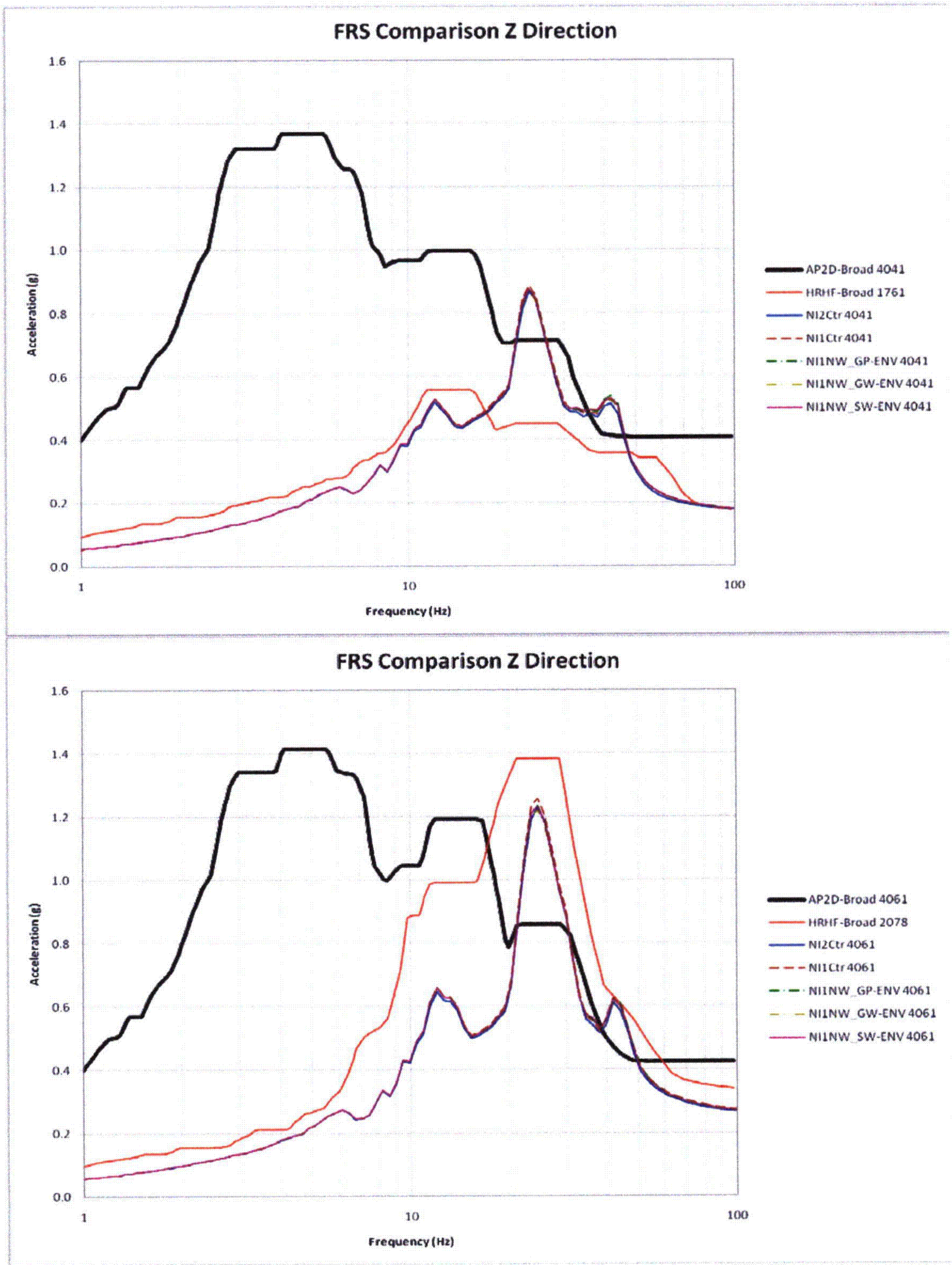


Figure 3.7-205a Comparison of 2D FRS and AP1000 Envelope (Z-Direction, Nodes 4041 and 4061)

COLA Part 2, FSAR Figure 3.7-205b is added as follows:

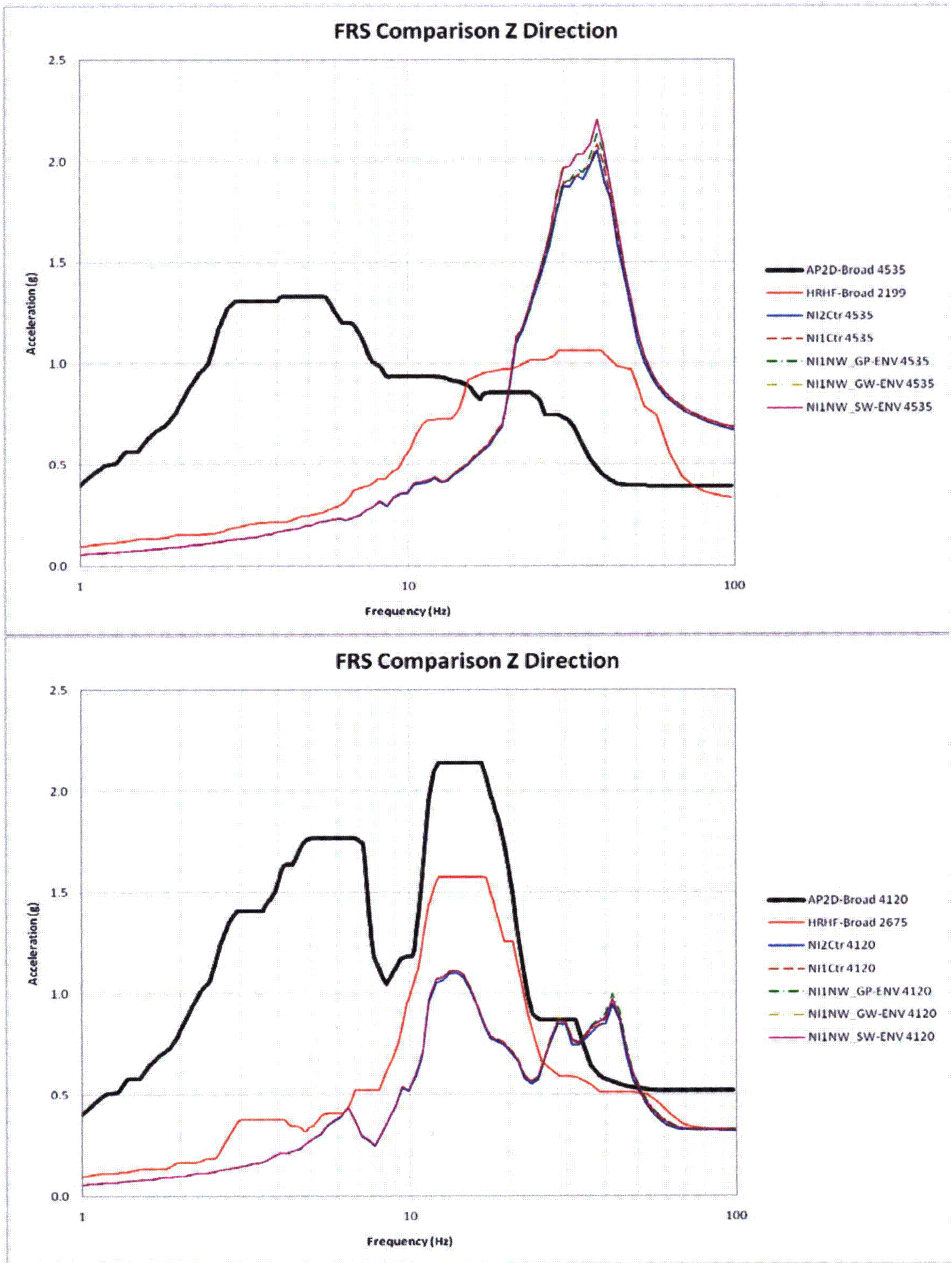


Figure 3.7-205b Comparison of 2D FRS and AP1000 Envelope (Z-Direction, Nodes 4535 and 4120)

COLA Part 2, FSAR Figure 3.7-205c is added as follows:

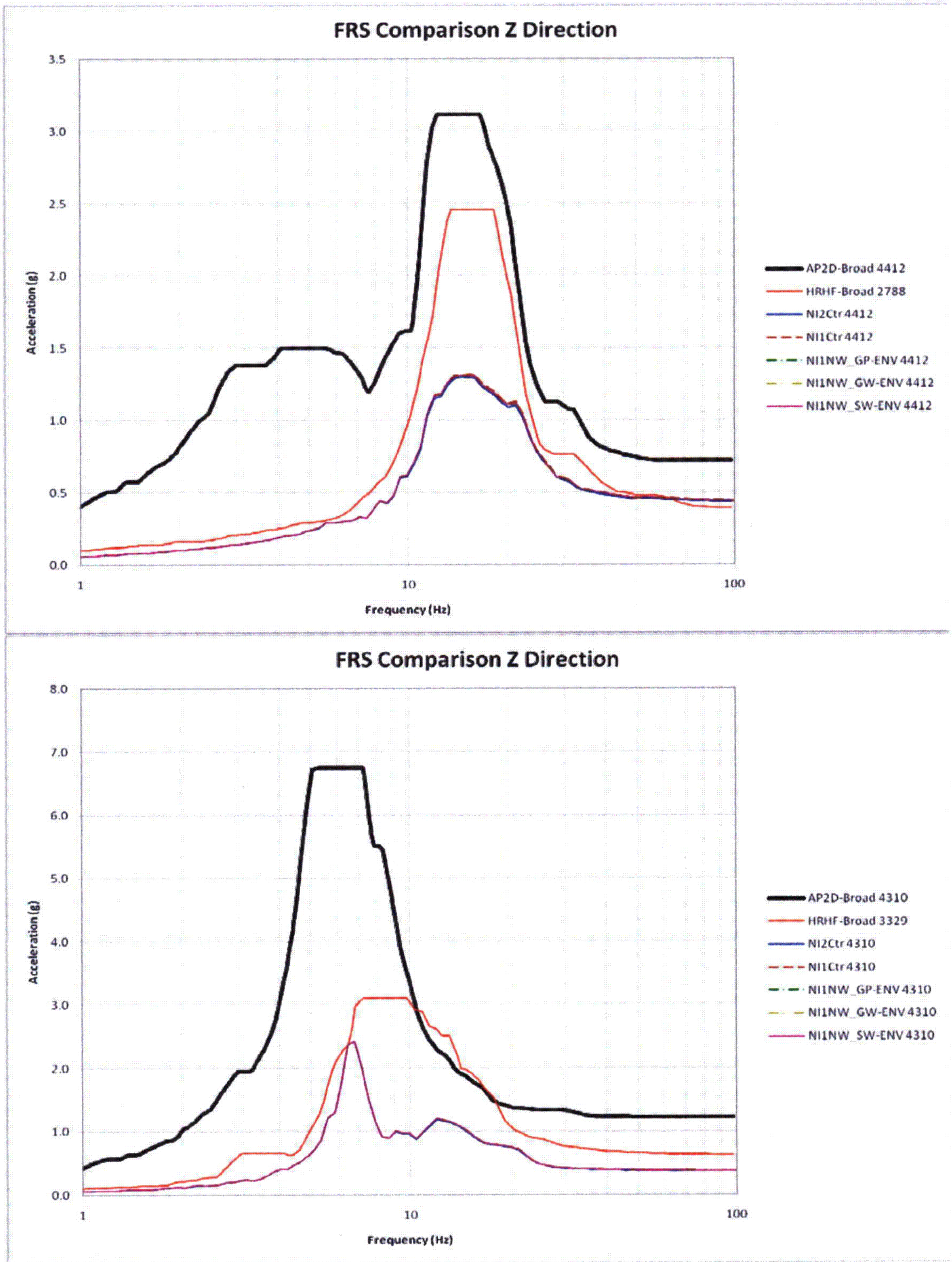
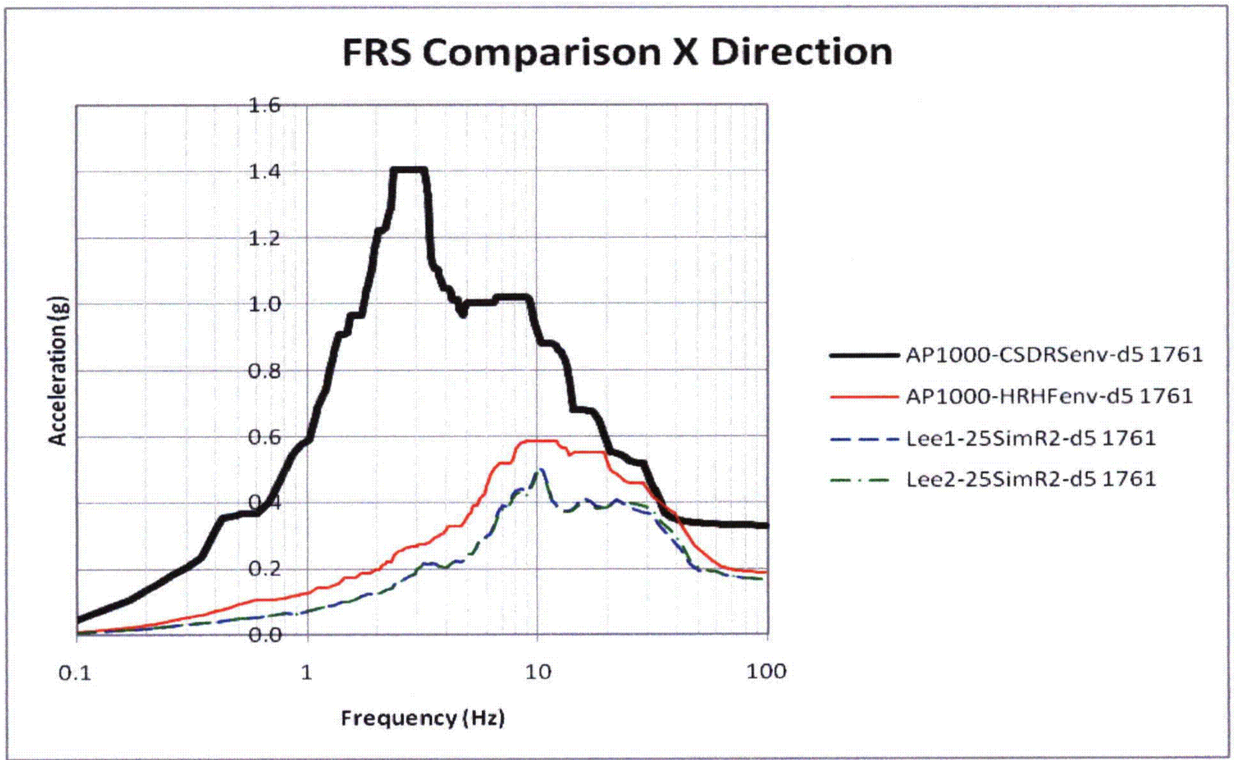


Figure 3.7-205c Comparison of 2D FRS and AP1000 Envelope (Z-Direction, Nodes 4412 and 4310)

COLA Part 2, FSAR Figure 3.7-206a is added as follows:



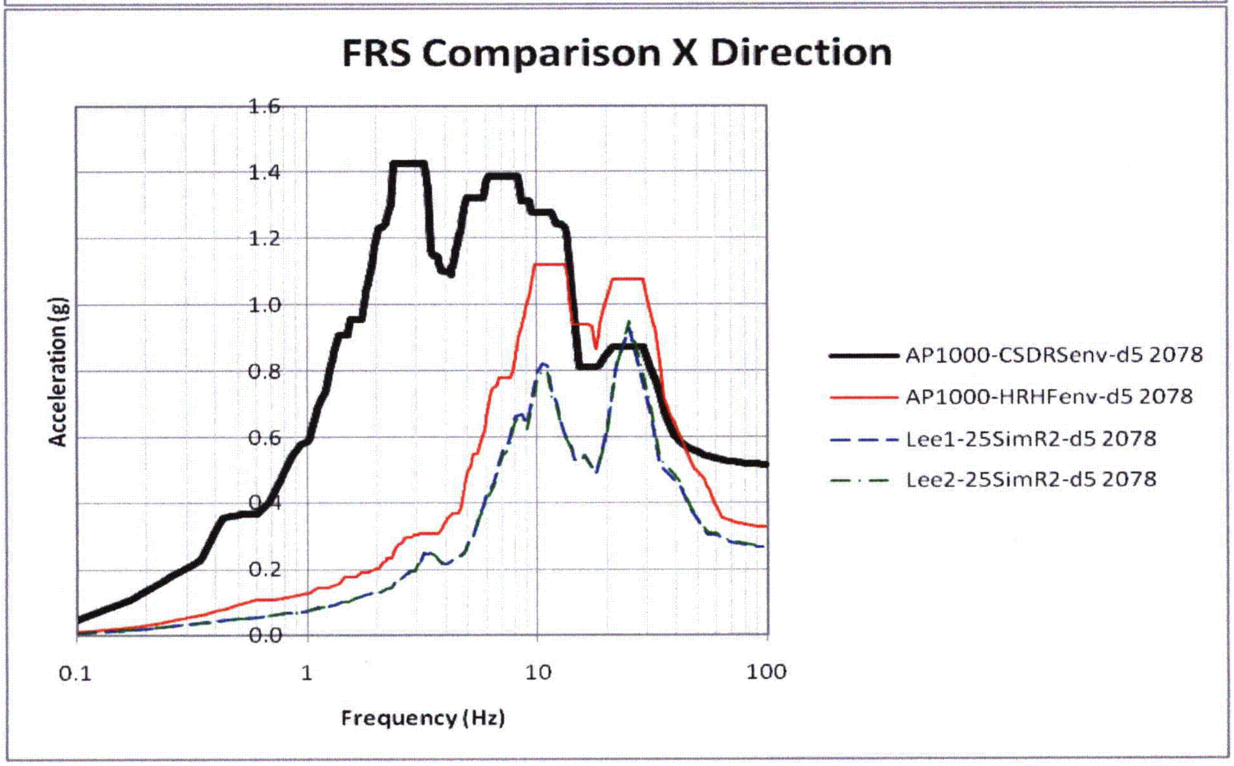
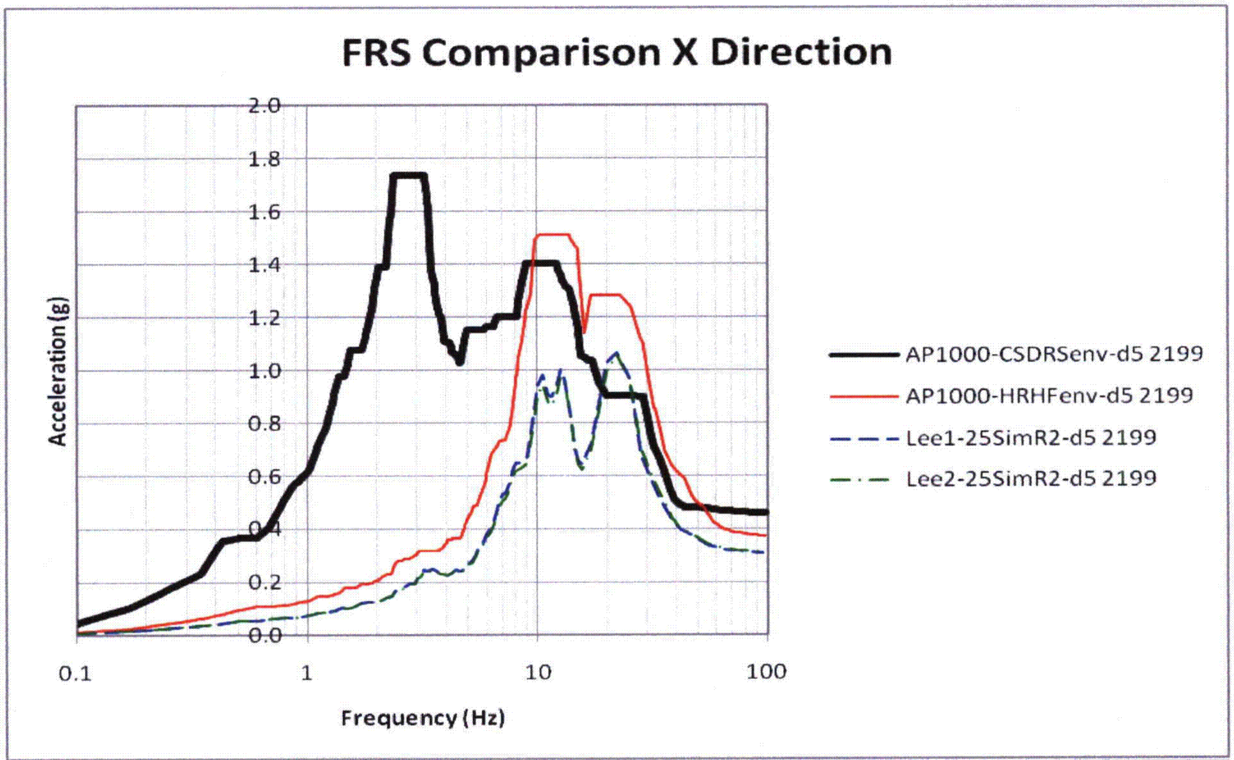


Figure 3.7-206a Comparison of 3D FRS and AP1000 Envelope (X-Direction, Nodes 1761 and 2078)

COLA Part 2, FSAR Figure 3.7-206b is added as follows:



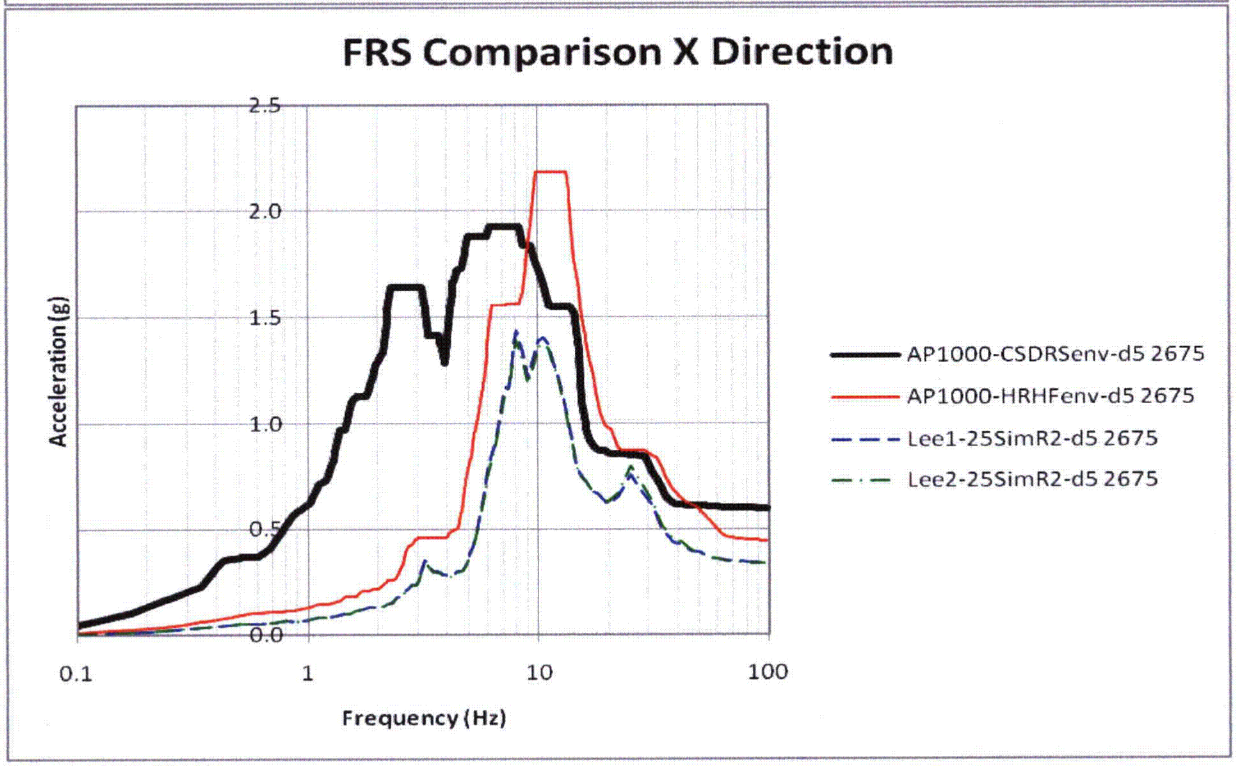
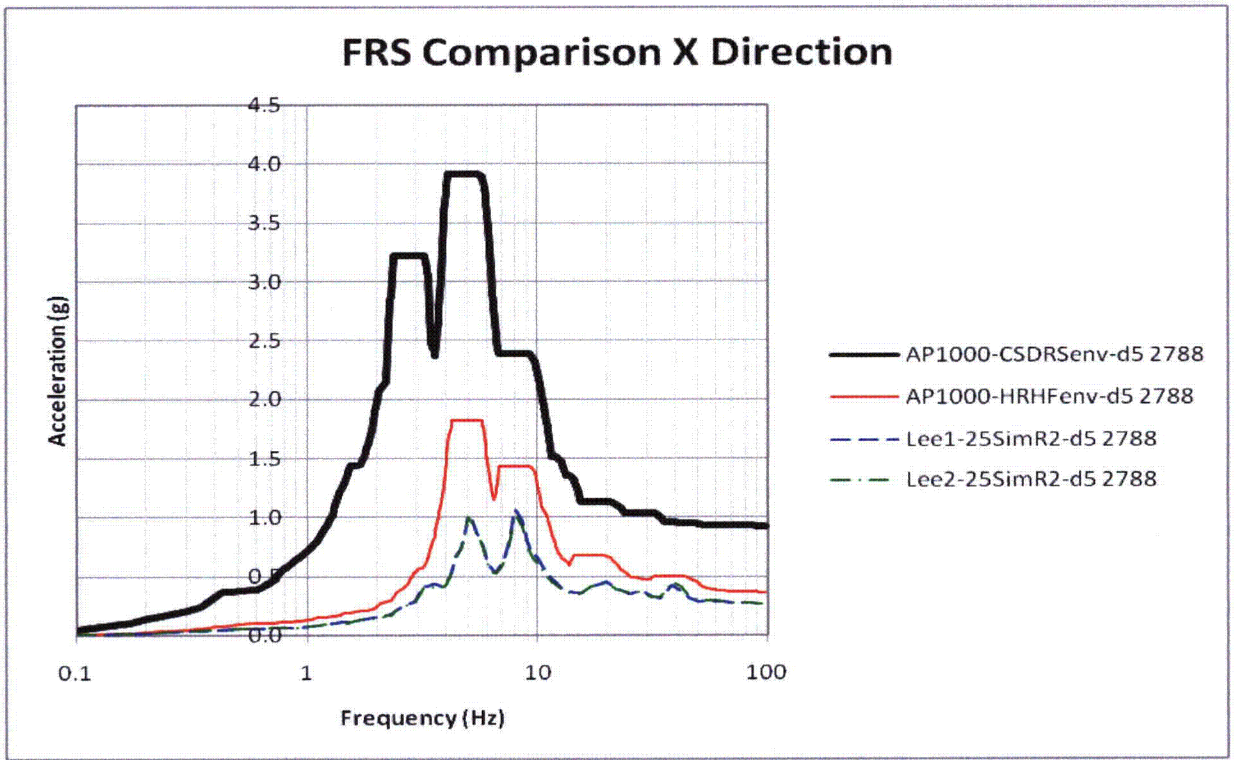


Figure 3.7-206b Comparison of 3D FRS and AP1000 Envelope (X-Direction, Nodes 2199 and 2675)

COLA Part 2, FSAR Figure 3.7-206c is added as follows:



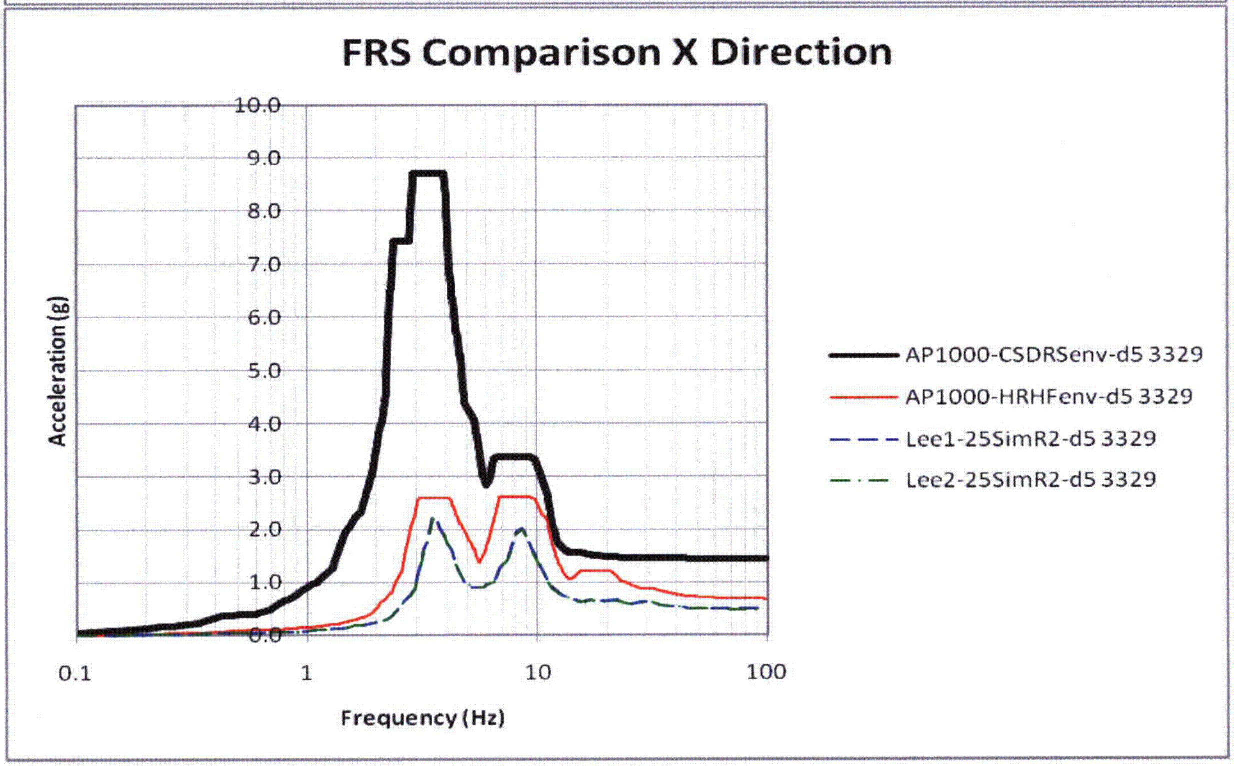
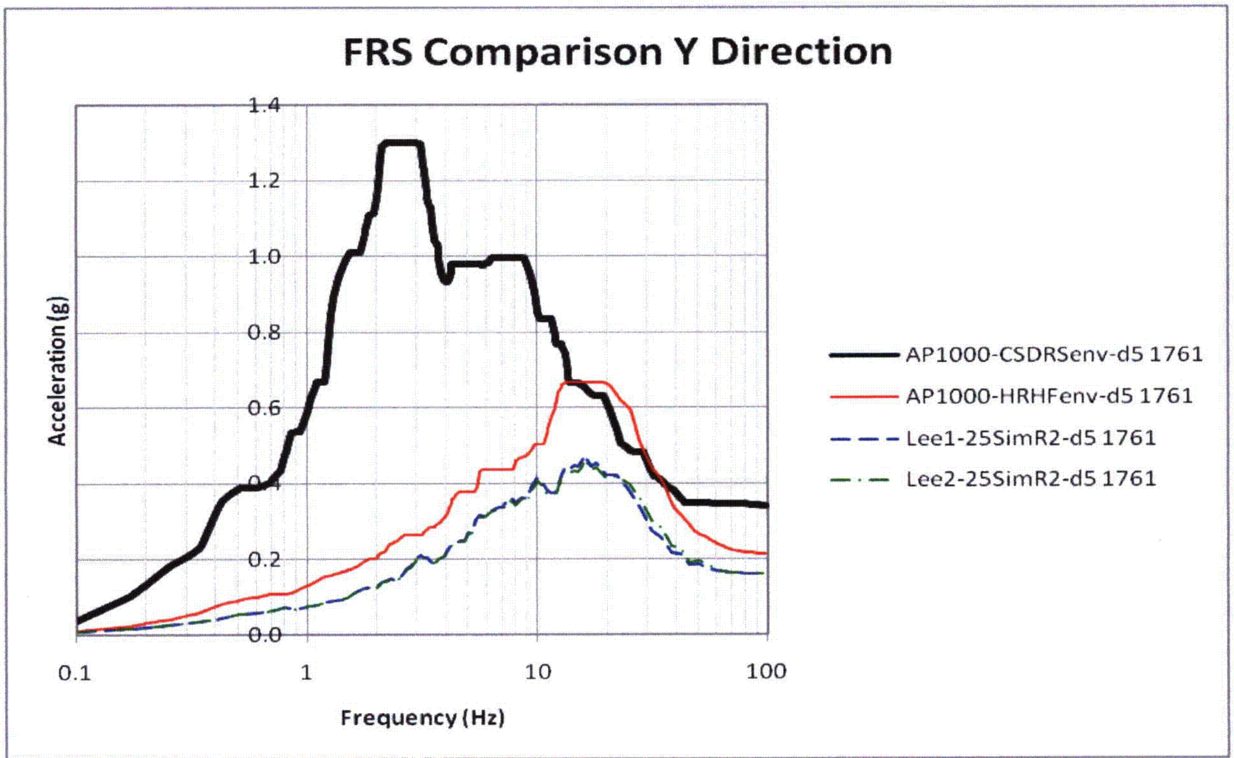


Figure 3.7-206c Comparison of 3D FRS and AP1000 Envelope (X-Direction, Nodes 2788 and 3329)

COLA Part 2, FSAR Figure 3.7-207a is added as follows:



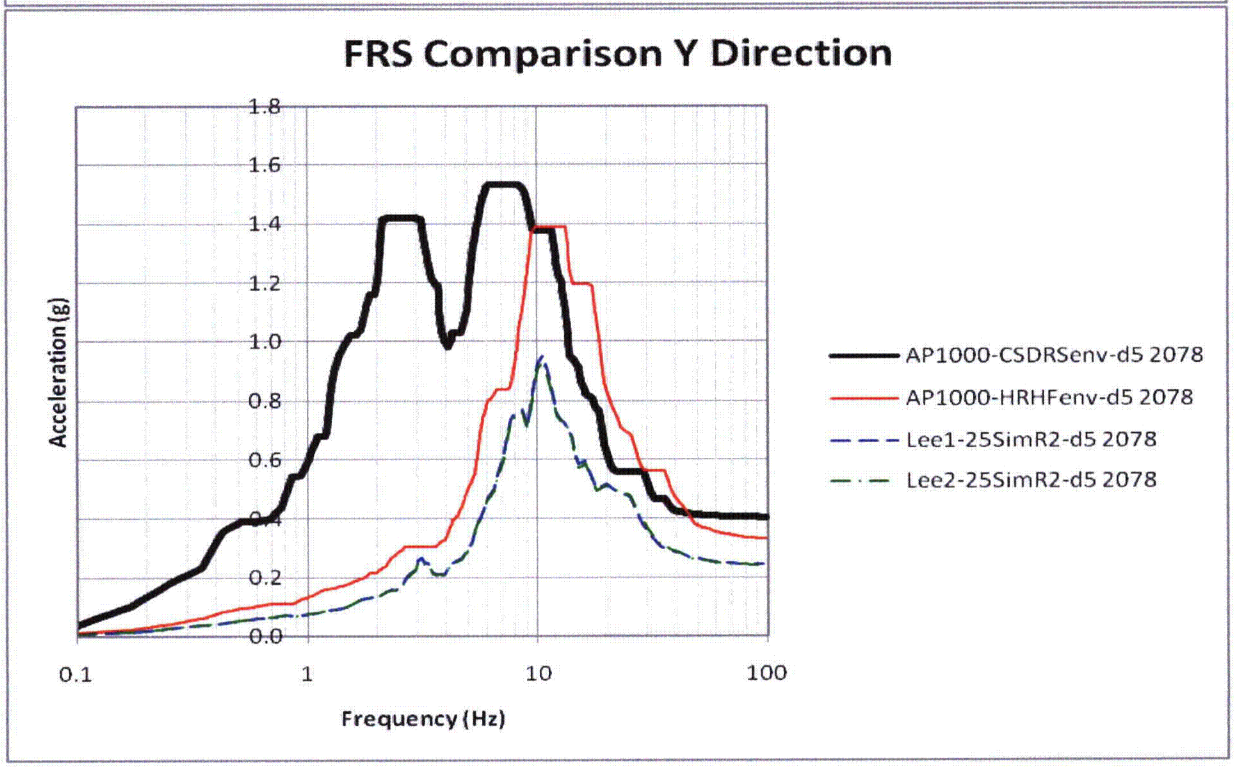
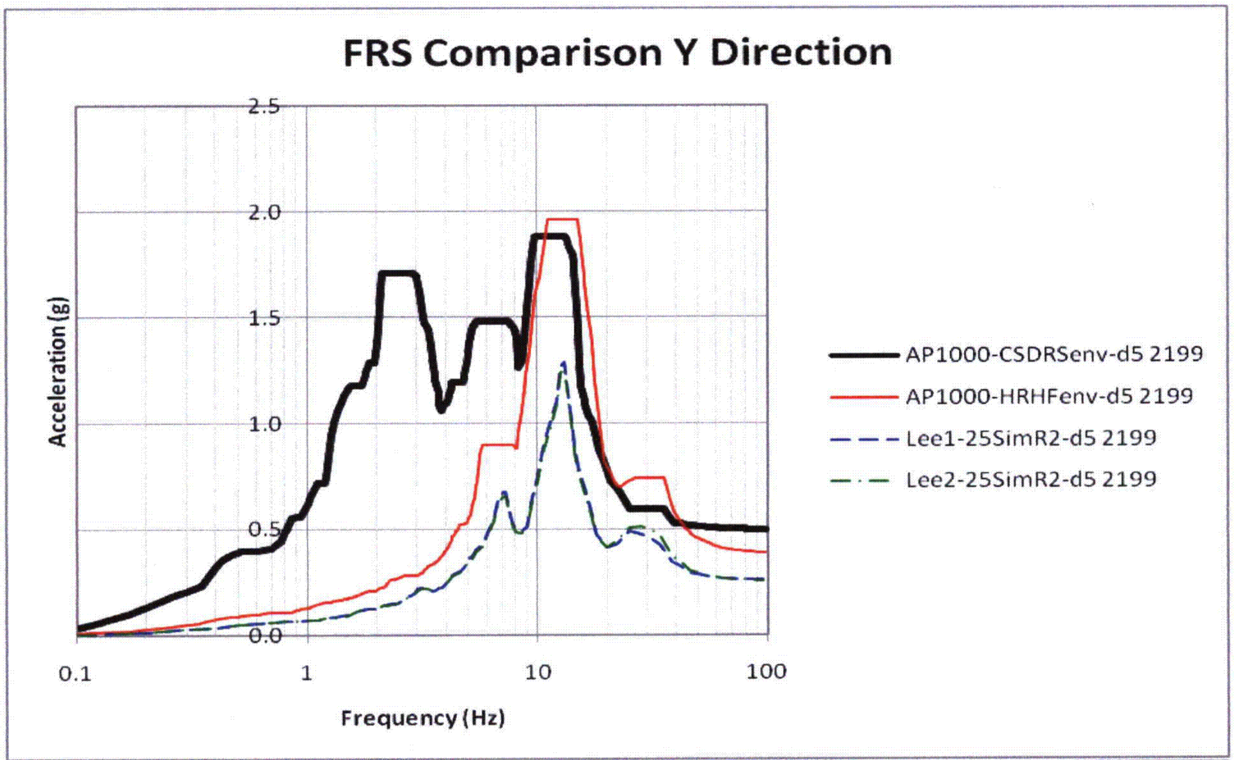


Figure 3.7-207a Comparison of 3D FRS and AP1000 Envelope (Y-Direction, Nodes 1761 and 2078)

COLA Part 2, FSAR Figure 3.7-207b is added as follows:



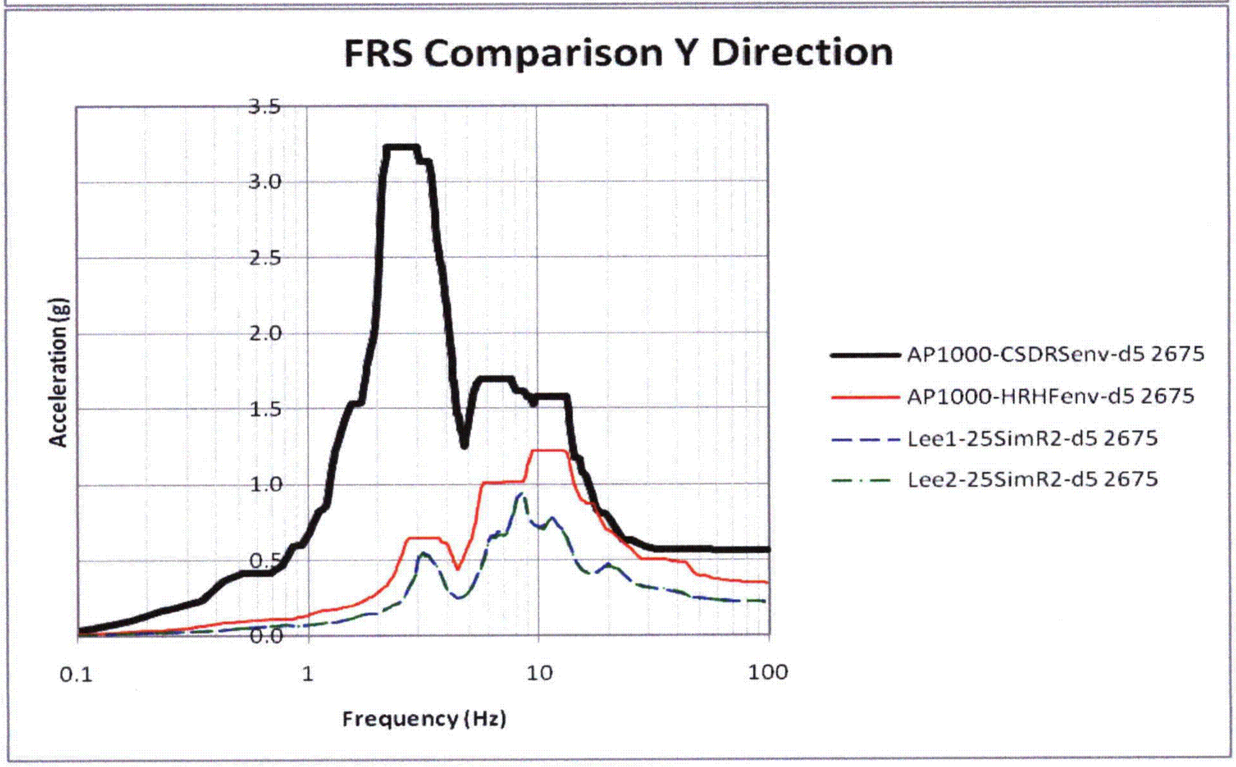
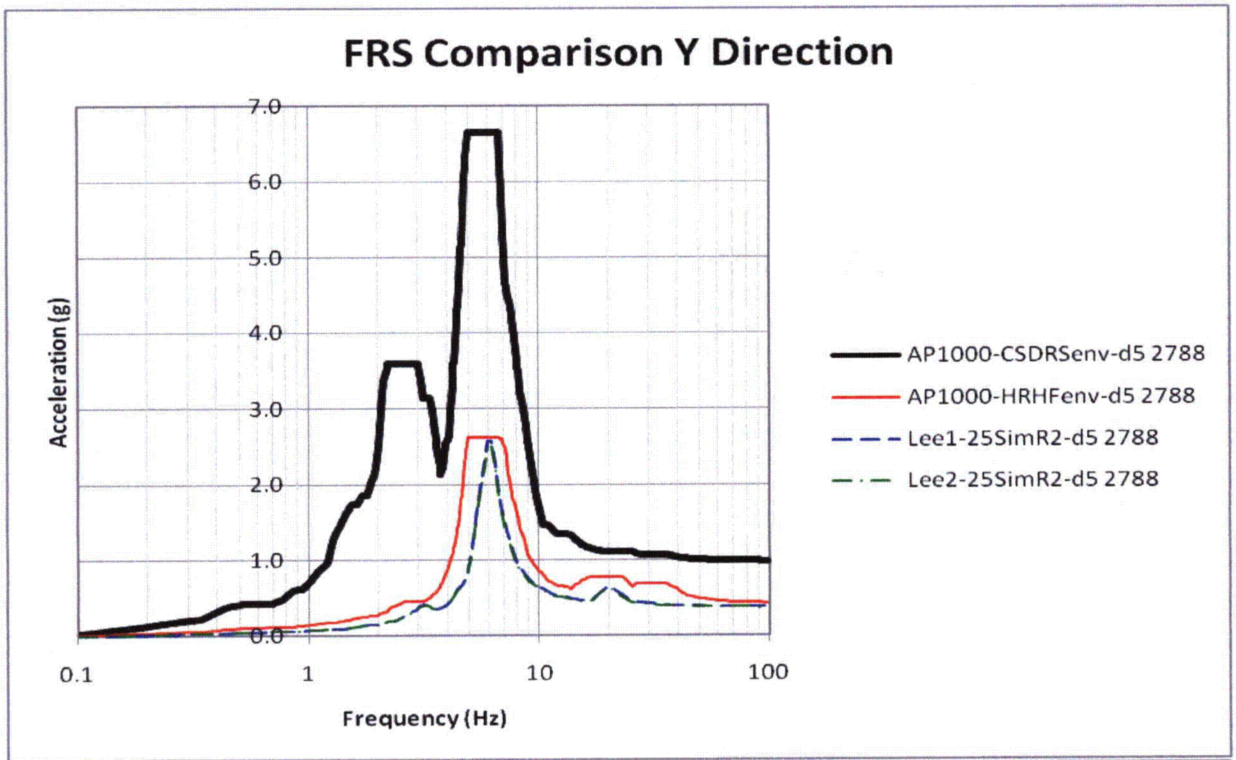


Figure 3.7-207b Comparison of 3D FRS and AP1000 Envelope (Y-Direction, Nodes 2199 and 2675)

COLA Part 2, FSAR Figure 3.7-207c is added as follows:



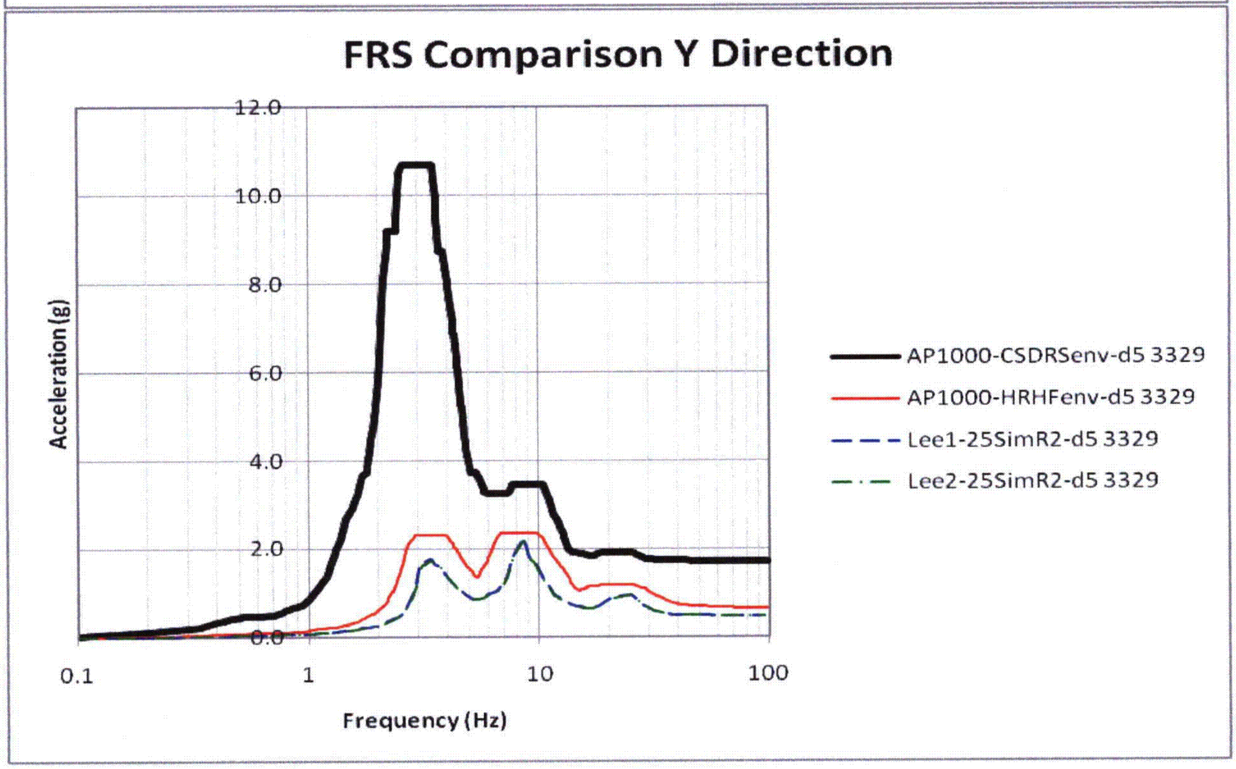
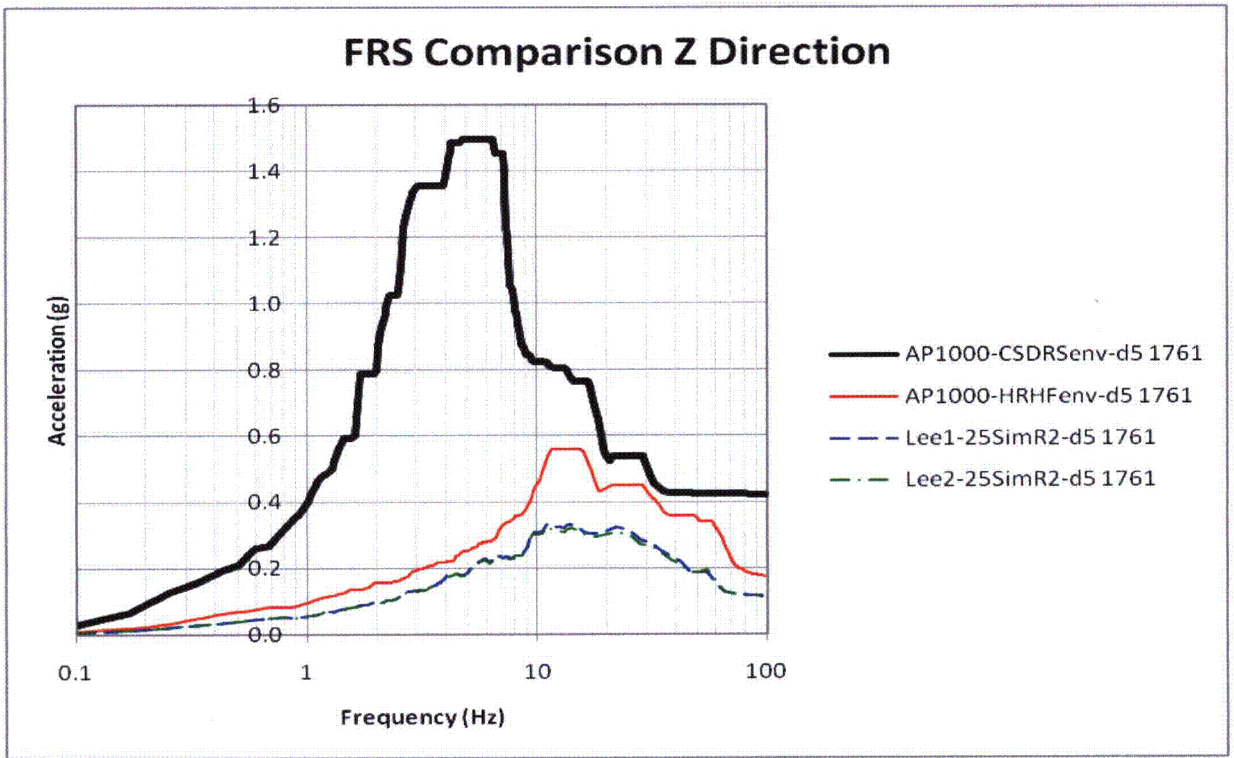


Figure 3.7-207c Comparison of 3D FRS and AP1000 Envelope (Y-Direction, Nodes 2788 and 3329)

COLA Part 2, FSAR Figure 3.7-208a is added as follows:



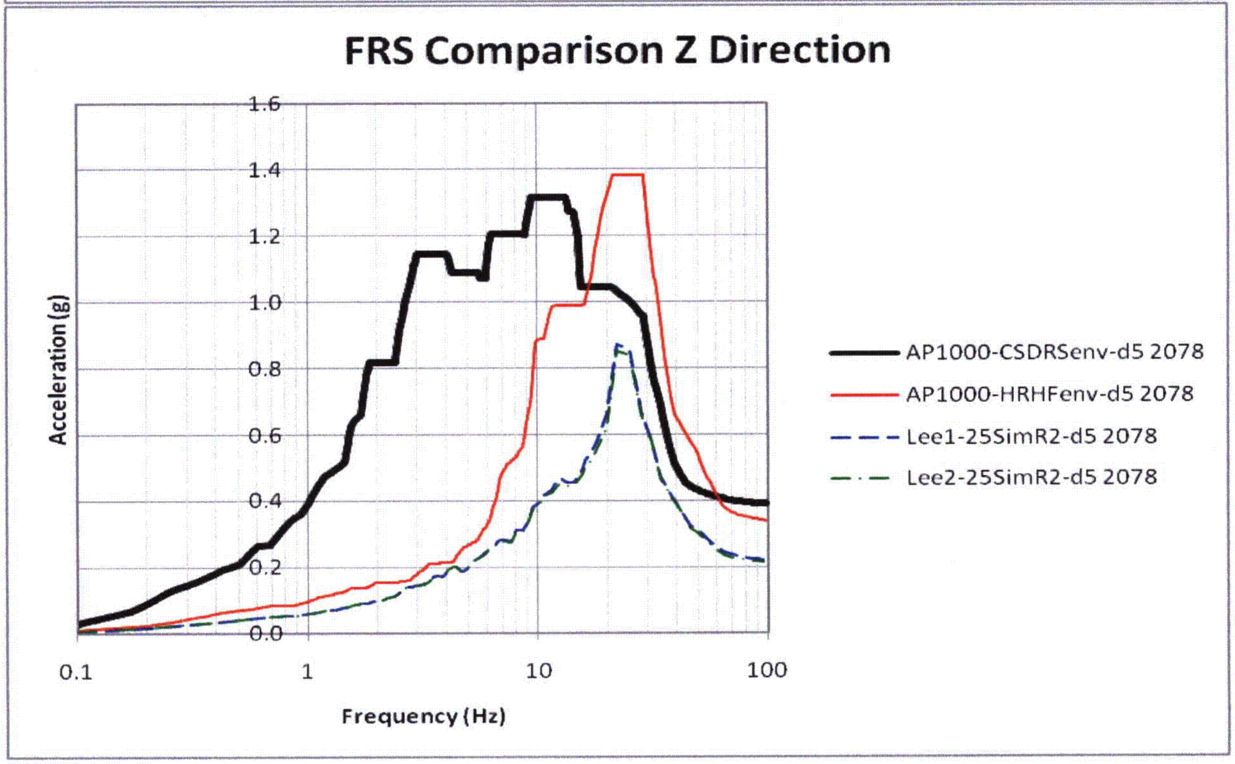


Figure 3.7-208a Comparison of 3D FRS and AP1000 Envelope (Z-Direction, Nodes 1761 and 2078)

COLA Part 2, FSAR Figure 3.7-208b is added as follows:

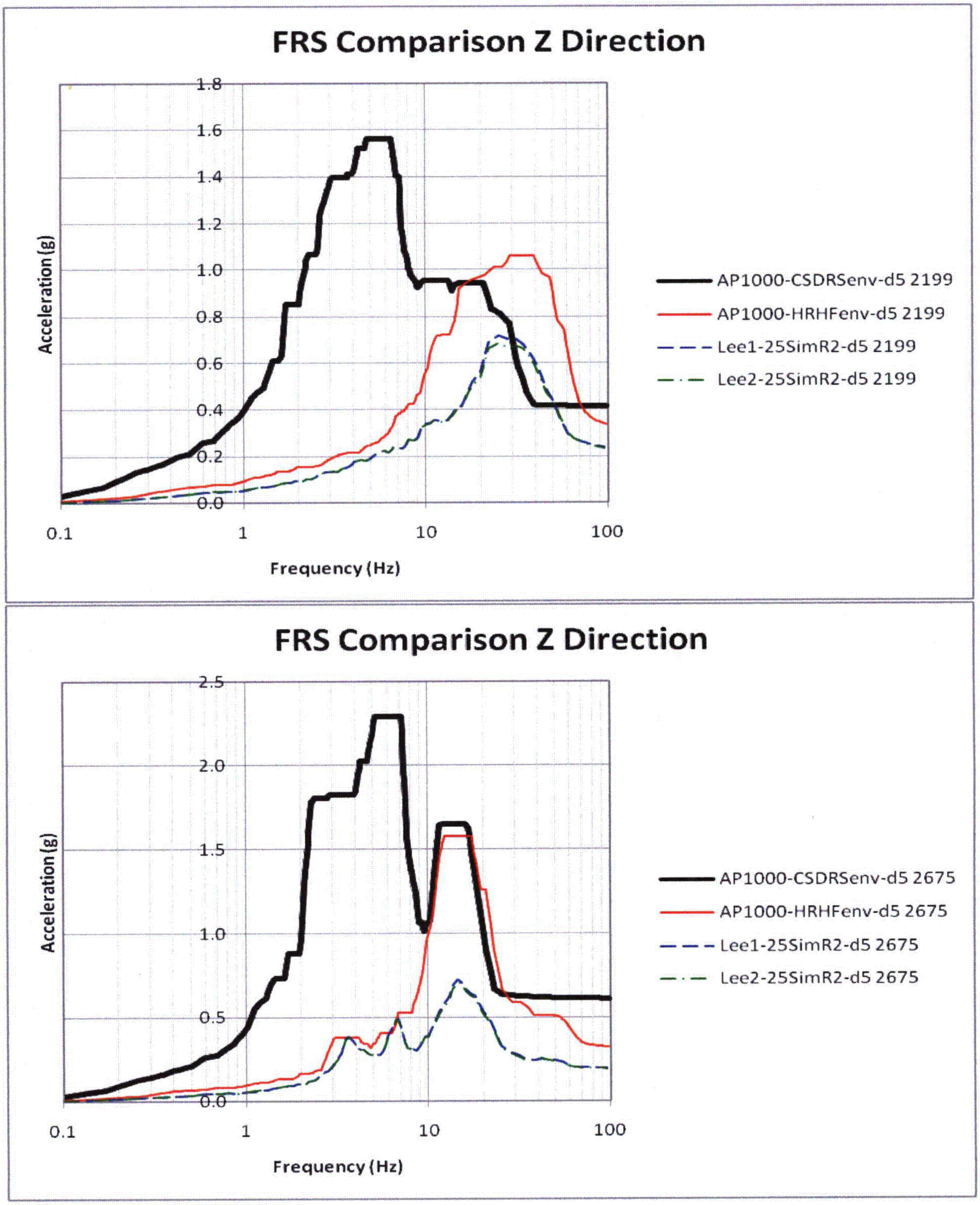


Figure 3.7-208b Comparison of 3D FRS and AP1000 Envelope (Z-Direction, Nodes 2199 and 2675)

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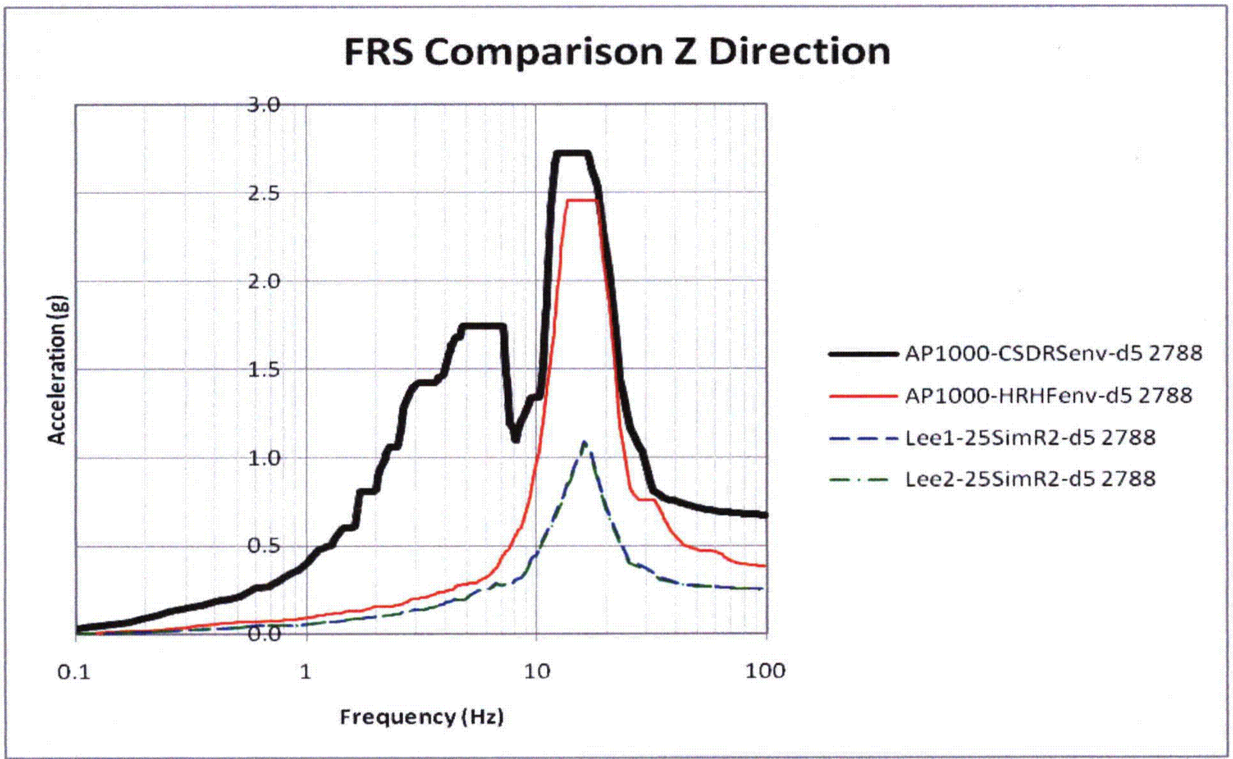

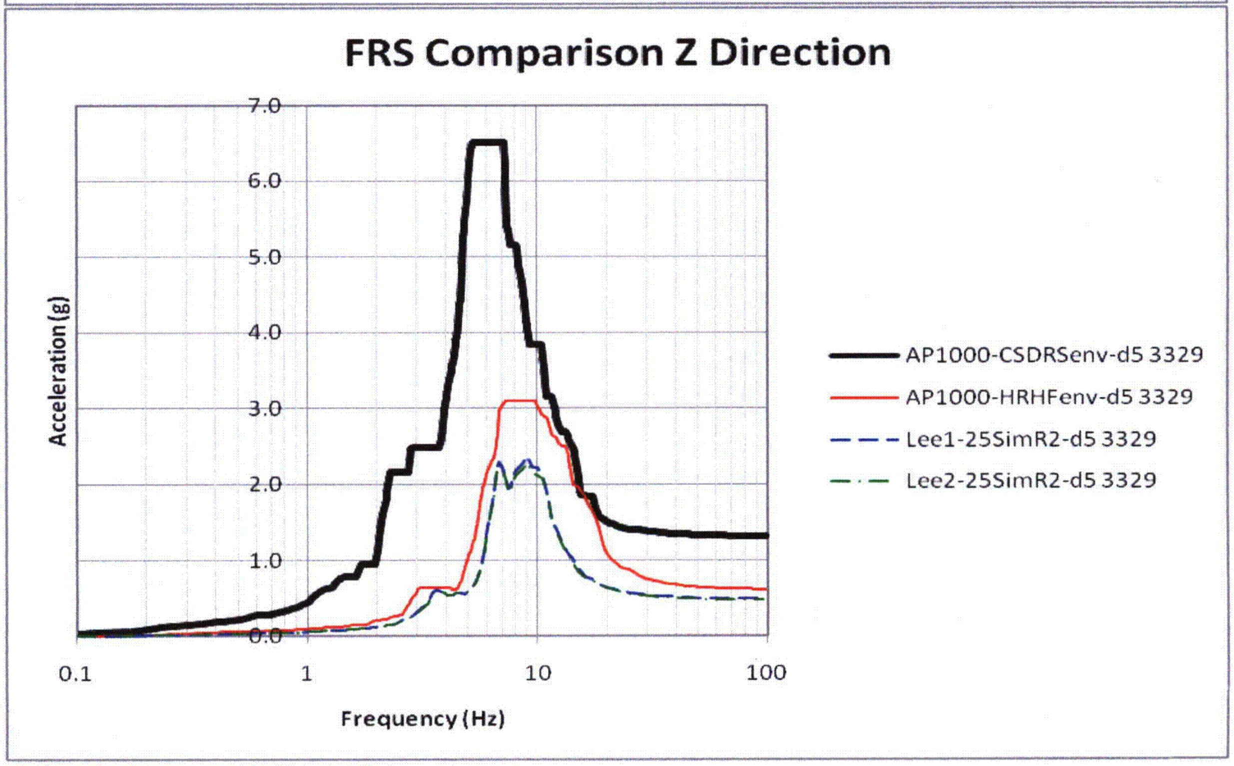

Figure 3.7-208c Comparison of 3D FRS and AP1000 Envelope (Z-Direction, Nodes 2788 and 3329)