Attachment 3

LNG-1000-S2R-808

Revision 0

Levy Nuclear Island and RCC Bridging Mat - 3D SASSI SSI Evaluation Report

[123 pages attached]

F-3.4.1-1 Rev 6

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Plant Applicability: ☐ All AP1000 plants except:
☒ Only the following plants: LN1, LN2

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WESTINGHOUSE NON-PROPRIETARY CLASS 3

LNG-1000-S2R-808
Revision 0

May 2011

AP1000
Levy Nuclear Island and RCC Bridging Mat – 3D SASSI SSI Evaluation Report

Westinghouse Electric Company LLC
Nuclear Power Plants
1000 Westinghouse Drive
Cranberry Township, PA 16066

Record of Revisions

Rev	Date	Revision Description[1]
0	See EDMS	Original Issue

Note (1) Significant changes are briefly described in this table. In the rest of the report, each row that has changed is marked using a revision bar in the margin of the page. This approach satisfies the change identification requirements in WP 4.5 Section 7.4.

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1.0 Purpose

In accordance with Progress Energy Florida, Inc. (Progress) Contract No. 3382, Work Authorization 208 dated June 17, 2010 (Reference 1) and the March 2011 Nuclear Regulatory Commission (NRC) audit, Westinghouse Electric Company (WEC) has completed a revised site specific soil-structure interaction (SSI) analysis of the Levy Nuclear Plant (LNP) Nuclear Island (NI) and Roller Compacted Concrete (RCC) bridging mat.

This revised report was prepared to provide supplemental responses to information requests in NRC Letter 085 RAI 03.07.02-2 (Reference 3) and:

1. Perform a LNP specific SSI analysis as a result of a vertical exceedence of the Certified Seismic Design Response Spectra (CSDRS) in the Performance-Based Surface Response Spectra (PBSRS) (Reference 2) at the 30 to 40 hertz (hz) frequency;
2. Incorporate in the LNP SSI model/analysis site specific conditions including the RCC mat, engineered fill, controlled low strength material (CLSM), and LNP site soil profiles;
3. Address NRC action items identified during the March 2011 audit of the LNP SSI analysis pertaining to justification of the LNP 3D model and analysis results; and
4. Compare the LNP in-structure floor response spectra (FRS) to the AP1000 FRS envelope at six (6) key AP1000 NI locations.

2.0 Background

This section summarizes the free field response analyses and SSI analyses that have been performed for the LNP site to demonstrate that the AP1000 generic seismic response envelops the LNP site specific seismic response. In addition, analyses that have been performed as a result of the March 2011 NRC audit of the LNP SSI analyses are also summarized.

2.1 LNP Free Field Response Analyses

FSAR Figure 2.5.2-296 (Figure 2.1-1 herein) shows the comparison of the horizontal and vertical site-specific ground motion response spectra (GMRS) to the AP1000 CSDRS. The AP1000 CSDRS envelops the LNP GMRS by a significant margin. The GMRS was developed as the Truncated Soil Column Surface Response (TSCSR) on the uppermost in-situ competent material (elevation +36 ft.) as described in FSAR Subsection 2.5.2.6.

Plant design grade will be established at elevation +51 ft. (AP1000 elevation 100 ft.) by placing engineered fill above in-situ material from elevation +36 ft. to elevation +51 ft. Horizontal and vertical PBSRS at the design grade elevation were developed using the same methodology and in-situ soil properties used for developing the GMRS. Engineered fill properties including shear modulus reduction and damping relationships are presented in FSAR Subsection 2.5.2.5.1.4.

The vertical and the horizontal PBSRS were scaled by a factor that is required for the horizontal free-field soil column outcrop response spectra (SCOR) at the LNP foundation elevation +11 ft. (AP1000 elevation 60.5 ft.) to meet the 0.1g zero period acceleration (ZPA) requirement of

10 CFR Part 50 Appendix S. The scaled horizontal and vertical SCOR FIRS at the LNP foundation elevation +11 ft. are shown in FSAR Figure 3.7-205 (Figure 2.1-2 herein). Horizontal and vertical SCOR were also developed at the base of planned excavation beneath the nuclear island (elevation -24 ft.) for the deterministic free field response analysis. FSAR Figure 2.5.2-297 (Figure 2.1-3 herein) presents the comparison of the AP1000 CSDRS with the scaled PBSRS for horizontal and vertical ground motions. The CSDRS envelops the PBSRS for both the horizontal and the vertical ground motions by a significant margin.

In addition to the PBSRS, design grade deterministic surface spectra were developed following Subsection 5.2.1 of the Interim Staff Guidance DC/COL-ISG-017 as described in FSAR Subsection 2.5.2.6. The design grade surface response spectra from the four soil columns, best estimate (BE), lower bound (LB), lower lower bound (LLB), and the upper bound (UB) properties, were developed using the scaled SCOR developed at the base of planned excavation beneath the nuclear island (elevation -24 ft.). The SCOR at elevation -24 ft. was scaled to ensure that the computed SCOR at the AP1000 foundation elevation +11 ft. meets the 0.1g minimum ZPA requirement of 10 CFR Part 50 Appendix S. FSAR Figure 3.7-201 (Figure 2.1-4 herein) presents the comparison of the AP1000 CSDRS with the scaled SCOR at the base of planned excavation beneath the nuclear island (elevation -24 ft.) for horizontal and vertical ground motions.

The in-column time histories at elevation -24 ft. for the BE, LB, UB, and LLB soil profiles were used as input to the SSI analysis. First, consistent time histories matching the scaled SCOR at elevation -24 ft. (FSAR Figure 3.7-205 and Figure 2.1-2 herein) were developed using seed time histories representing a distant recording of a large (M 7.3) earthquake, consistent with the dominant contribution to the LNP site hazard by the Charleston source. Then these time histories are input into the four (BE, UB, LB, and LLB) soil columns as outcropping motions at elevation -24 ft. and then output as in-column motions at elevation at elevation -24 ft for use in the SSI analysis. These in-column time histories at elevation -24 ft. are shown in Figures 3.5-1 through 3.5-12.

The BE, UB, and LB soil property profiles were developed based on the variation in the randomized soil profiles used for developing the PBSRS and complying with SRP 3.7.2.II.4 guidance on soil property variation for SSI analysis, i.e., the coefficient of variation used was the larger of that calculated from the randomized soil profiles or 1.5 as described in FSAR Subsection 2.5.2.6.7. In addition, an LLB soil profile was developed to account for additional degradation of soil properties due to construction activities related to the drilled shaft foundations and diaphragm wall installation as described in the response to NRC letter 087 RAI 03.07.02-2. The soil column profile and soil properties are presented in FSAR Tables 2.5.2-228, 2.5.2-229, and 2.5.2-230 (Tables 2.1-1, 2.1-2 and 2.1-3 herein) for BE, LB, and UB cases respectively. The soil column profile and soil properties for the LLB are presented in Table RAI 03.07.01-02-1 (Table 2.4-1 herein.) The envelope of the deterministic surface response spectra from the UB, LB, and BE envelops the PBSRS as required by DC/COL-ISG-017. FSAR Figures 3.7-202 and 3.7-203 (Figure 2.1-5 and 2.1-6) present the comparison of the AP1000 CSDRS with the deterministic surface response spectra from the UB, BE, and LB soil columns for the horizontal ground motions for the North-South (H1) and the East-West (H2) directions. The CSDRS envelops the H1 and H2 SSI input response spectra from the three soil columns.

For the vertical ground motions, FSAR Figure 3.7-204 (Figure 2.1-7 herein) presents the comparison of the AP1000 CSDRS with the scaled PBSRS and the SSI input response spectra from the three soil columns. The AP1000 CSDRS envelops the scaled vertical PBSRS by a similarly large margin as the horizontal. However, it does not envelop the design grade deterministic surface spectra developed using Subsection 5.2.1 of the Interim Staff Guidance DC/COL-ISG-017 in the high frequency range (greater than approximately 30 Hz). For the vertical direction, the response at the top of the free field soil columns overestimates amplification that will be experienced by the AP1000. This is due to the fact that the AP1000 basemat for LNP is supported vertically on the 35-foot thick RCC mat that rests on rock. Amplification of the vertical motion to the AP1000 basemat will be minimal because of the high shear wave (>3500 ft/sec) velocity through the RCC mat.

Table 2.1-1: LNP Best Estimate Soil Column Profile and Soil Properties (Progress FSAR Table 2.5.2-228)

Table 2.5.2-228: Best Estimate Properties for SSI Analyses of the LNP Site

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
1	2.5	2.5	110	836	1.3	1590	48.5
2	2.5	5	110	824	1.6	1590	46
3	2.5	7.5	110	796	2.0	1590	43.5
4	3.5	11	110	788	2.3	1590	40
5	2	13	110	796	2.4	5000	38
6	2	15	110	786	2.6	5000	36
7	3.5	18.5	120	1503	2.4	5600	32.5
8	2.5	21	120	1500	2.5	5600	30
9	1	22	120	1500	2.5	5600	29
10	3.5	25.5	120	1501	2.0	5600	25.5
11	3.5	29	120	1496	2.1	5600	22
12	6.9	35.9	120	1482	2.1	5600	15.1
13	4.1	40	120	1476	2.1	5600	11
14	2.8	42.8	120	1476	2.1	5600	8.2
15	8.4	51.2	130	2267	2.1	7550	-0.2
16	8.4	59.6	130	2266	2.1	7550	-8.6
17	7.1	66.7	130	2254	2.2	7550	-15.7
18	7.1	73.8	130	2251	2.2	7550	-22.8
19	1.2	75	138	2772	1.4	8700	-24
20	24.6	99.6	138	2772	1.4	8700	-48.6
21	47.4	147	138	2694	1.4	8550	-96
22	61.3	208.3	138	3374	1.4	10600	-157.3
23	17.9	226.2	138	3315	1.4	9450	-175.2
24	24.1	250.3	120	3243	1.9	7250	-199.3
25	24.6	274.9	120	3210	1.9	7250	-223.9
26	40	314.9	120	3539	1.3	7900	-263.9
27	42	356.9	120	3358	1.3	7900	-305.9
28	38.4	395.3	140	4144	0.9	8900	-344.3
29	59.4	454.7	140	3369	0.9	8100	-403.7
30	59.4	514.1	140	3721	0.9	9000	-463.1
31	242.7	756.8	140	4541	0.9	11000	-705.8
32	355.8	1112.6	140	5934	0.9	14400	-1061.6
33	249.4	1362	150	7294	0.7	17850	-1311
34	252.9	1614.9	150	5101	0.7	12350	-1563.9
35	148.3	1763.2	150	7279	0.7	17400	-1712.2
36	106.1	1869.3	150	6259	0.7	14900	-1818.3
37	199	2068.3	150	7168	0.7	17500	-2017.3
38	601.2	2669.5	150	5429	0.8	13000	-2618.5
39	149.2	2818.7	150	5955	0.8	14200	-2767.7
40	192.7	3011.4	150	6200	0.8	14950	-2960.4
41	652.3	3663.7	150	5168	0.8	12600	-3612.7
42	603.7	4267.4	150	5555	0.8	13450	-4216.4
43	96.6	4364	150	4800	0.8	11500	-4313
44	Half Space		169	9396	0.1	16100	

Table 2.1-2: LNP Lower Bound Soil Column Profile and Soil Properties (Progress FSAR Table 2.5.2-229)

Table 2.5.2-229: Lower Bound Properties for SSI Analyses of the LNP Site

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
1	2.5	2.5	110	373	2.6	935	48.5
2	2.5	5	110	342	4.4	935	46
3	2.5	7.5	110	315	5.8	935	43.5
4	3.5	11	110	300	6.8	935	40
5	2	13	110	301	7.3	5000	38
6	2	15	110	294	7.9	5000	36
7	3.5	18.5	120	1123	5.4	5000	32.5
8	2.5	21	120	1115	5.5	5000	30
9	1	22	120	1115	5.5	5000	29
10	3.5	25.5	120	1074	5.3	5000	25.5
11	3.5	29	120	1070	5.5	5000	22
12	6.7	35.7	120	1111	5.6	5000	15.3
13	4.3	40	120	1100	5.9	5000	11
14	2.4	42.4	120	1100	4.8	5000	8.6
15	8.3	50.7	130	1851	4.9	6165	0.3
16	8.3	59	130	1850	5.0	6165	-8
17	7.2	66.2	130	1841	5.1	6165	-15.2
18	7.2	73.4	130	1838	2.4	6165	-22.4
19	1.6	75	138	2264	2.4	7022	-24
20	24.2	99.2	138	2264	2.4	7022	-48.2
21	46.8	146	138	2199	2.4	6532	-95
22	61.5	207.5	138	2755	2.4	7634	-156.5
23	17.9	225.4	138	2707	2.4	6654	-174.4
24	23.9	249.3	120	2145	4.7	5920	-198.3
25	24.6	273.9	120	2148	4.7	5920	-222.9
26	40	313.9	120	2890	1.9	6450	-262.9
27	42.1	356	120	2742	1.9	6450	-305
28	38.3	394.3	140	3384	1.3	7267	-343.3
29	59.8	454.1	140	2750	1.3	6614	-403.1
30	61.1	515.2	140	3038	1.3	7348	-464.2
31	242.7	757.9	140	3708	1.3	8981	-706.9
32	354.8	1112.7	140	4845	1.3	11758	-1061.7
33	246.6	1359.3	150	5956	1.0	14574	-1308.3
34	255.7	1615	150	4165	1.0	10084	-1564
35	150.7	1765.7	150	5943	1.0	14207	-1714.7
36	100.8	1866.5	150	5111	1.0	12166	-1815.5
37	199.6	2066.1	150	5853	1.0	14289	-2015.1
38	600.3	2666.4	150	4432	1.2	10614	-2615.4
39	149.6	2816	150	4863	1.2	11594	-2765
40	199.2	3015.2	150	5062	1.2	12207	-2964.2
41	650.5	3665.7	150	4220	1.2	10288	-3614.7
42	597	4262.7	150	4535	1.2	10982	-4211.7
43	104.1	4366.8	150	3919	1.2	9390	-4315.8
44	Half Space		169	7672	0.1	13146	

Table 2.1-3: LNP Upper Bound Soil Column Profile and Soil Properties (Progress FSAR Table 2.5.2-230)

Table 2.5.2-230: Upper Bound Properties for SSI Analyses of the LNP Site

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
1	2.5	2.5	110	1280	0.9	1948	48.5
2	2.5	5	110	1275	1.1	1948	46
3	2.5	7.5	110	1291	1.2	1948	43.5
4	3.5	11	110	1287	1.3	1948	40
5	2	13	110	1273	1.4	5000	38
6	2	15	110	1266	1.5	5000	36
7	3.5	18.5	120	1982	1.1	7226	32.5
8	2.5	21	120	1980	1.2	7226	30
9	1	22	120	1980	1.2	7226	29
10	3.5	25.5	120	1931	0.6	7226	25.5
11	3.5	29	120	1931	0.6	7226	22
12	7.1	36.1	120	1906	0.6	7226	14.9
13	3.9	40	120	1902	5.9	7226	11
14	3.2	43.2	120	1902	0.6	7226	7.8
15	9	52.2	130	2993	0.5	9737	-1.2
16	9	61.2	130	2991	0.5	9737	-10.2
17	9.2	70.4	130	2887	0.5	9737	-19.4
18	4.6	75	130	2887	0.5	9737	-24
19	4.6	79.6	130	2887	0.5	9737	-28.6
20	20	99.6	138	4731	0.6	10655	-48.6
21	48.8	148.4	138	3984	0.6	10472	-97.4
22	51.9	200.3	138	5157	0.6	12982	-149.3
23	11.9	212.2	138	4356	0.6	11574	-161.2
24	27	239.2	120	3972	0.5	9308	-188.2
25	26.2	265.4	120	3975	0.6	9308	-214.4
26	35.1	300.5	120	4335	0.7	9798	-249.5
27	44.5	345	120	4112	0.7	9798	-294
28	44.7	389.7	140	5075	0.5	11329	-338.7
29	49.8	439.5	140	4126	0.5	10043	-388.5
30	72.6	512.1	140	4620	0.5	11023	-461.1
31	244.3	756.4	140	5562	0.5	13472	-705.4
32	356	1112.4	140	7267	0.5	17636	-1061.4
33	254.7	1367.1	150	8934	0.4	21862	-1316.1
34	244	1611.1	150	6247	0.4	15126	-1560.1
35	153.4	1764.5	150	8915	0.4	21311	-1713.5
36	96.4	1860.9	150	7666	0.4	18249	-1809.9
37	205.2	2066.1	150	8779	0.4	21433	-2015.1
38	601.3	2667.4	150	6649	0.4	15922	-2616.4
39	148	2815.4	150	7294	0.4	17391	-2764.4
40	198.5	3013.9	150	7593	0.4	18310	-2962.9
41	647.8	3661.7	150	6330	0.4	15432	-3610.7
42	602.2	4263.9	150	6803	0.4	16473	-4212.9
43	95.2	4359.1	150	5879	0.4	14085	-4308.1
44	0	4359.1	169	11507	0.1	19718	-4308.1

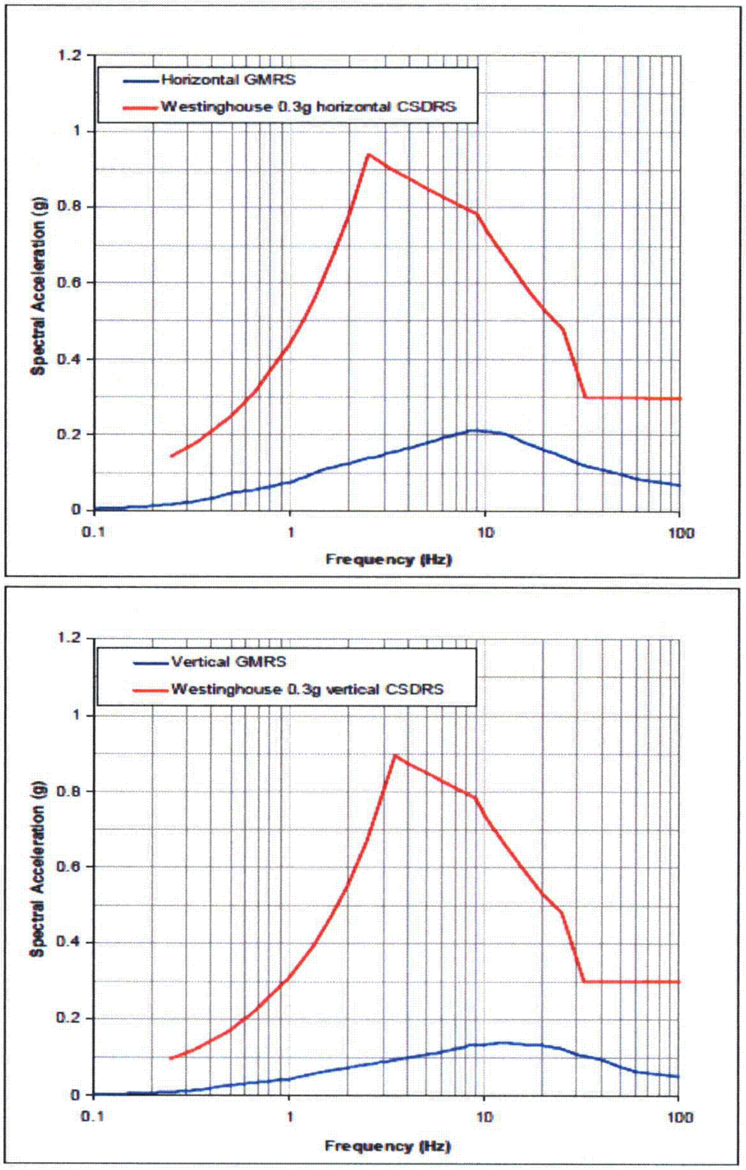
Table 2.1-4: LNP Lower Lower Bound Soil Column Profile and Soil Properties (Progress RAI Table 03.07.02-02-1)

LNP COL 2.5-3 Table RAI 03.07.02-02-1:
Lower Lower Bound Properties for SSI Analyses of the LNP Site

Layer	Thickness (ft.)	Total Depth (ft.)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft.)
1	2.5	2.5	110	373	2.6	935	48.5
2	2.5	5	110	342	4.4	935	46
3	2.5	7.5	110	315	5.8	935	43.5
4	3.5	11	110	300	6.8	935	40
5	2	13	110	301	7.3	5000	38
6	2	15	110	294	7.9	5000	36
7	3.5	18.5	120	1066	5.4	5000	32.5
8	2.5	21	120	1058	5.5	5000	30
9	1	22	120	1058	5.5	5000	29
10	3.5	25.5	120	1019	5.3	5000	25.5
11	3.5	29	120	1015	5.5	5000	22
12	6.7	35.7	120	1054	5.6	5000	15.3
13	4.3	40	120	1043	5.9	5000	11
14	2.4	42.4	120	1043	4.8	5000	8.6
15	8.3	50.7	130	1756	4.9	5848	0.3
16	8.3	59	130	1755	5.0	5848	-8
17	7.2	66.2	130	1746	5.1	5848	-15.2
18	7.2	73.4	130	1744	2.4	5848	-22.4
19	1.6	75	138	2147	2.4	6661	-24
20	24.2	99.2	138	2264	2.4	7022	-48.2
21	46.8	146	138	2199	2.4	6532	-95
22	61.5	207.5	138	2755	2.4	7634	-156.5
23	17.9	225.4	138	2707	2.4	6654	-174.4
24	23.9	249.3	120	2145	4.7	5920	-198.3
25	24.6	273.9	120	2148	4.7	5920	-222.9
26	40	313.9	120	2890	1.9	6450	-262.9
27	42.1	356	120	2742	1.9	6450	-305
28	38.3	394.3	140	3384	1.3	7267	-343.3
29	59.8	454.1	140	2750	1.3	6614	-403.1
30	61.1	515.2	140	3038	1.3	7348	-464.2
31	242.7	757.9	140	3708	1.3	8981	-706.9
32	354.8	1112.7	140	4845	1.3	11758	-1061.7
33	246.6	1359.3	150	5956	1.0	14574	-1308.3
34	255.7	1615	150	4165	1.0	10084	-1564
35	150.7	1765.7	150	5943	1.0	14207	-1714.7
36	100.8	1866.5	150	5111	1.0	12166	-1815.5
37	199.6	2066.1	150	5853	1.0	14289	-2015.1
38	600.3	2666.4	150	4432	1.2	10614	-2615.4
39	149.6	2816	150	4863	1.2	11594	-2765
40	199.2	3015.2	150	5062	1.2	12207	-2964.2
41	650.5	3665.7	150	4220	1.2	10288	-3614.7
42	597	4262.7	150	4535	1.2	10982	-4211.7
43	104.1	4366.8	150	3919	1.2	9390	-4315.8
44	Halfspace		169	7672	0.1	13146	

Notes: % = percent; ft. = feet; ft/sec = feet per second; pcf = pound per cubic foot; SSI = soil structure interaction

LNP COL 2.5-2



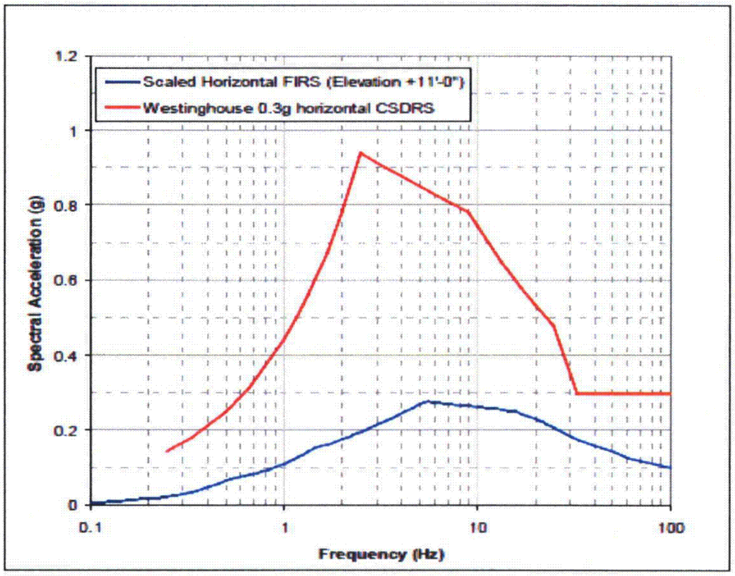
Progress Energy Florida

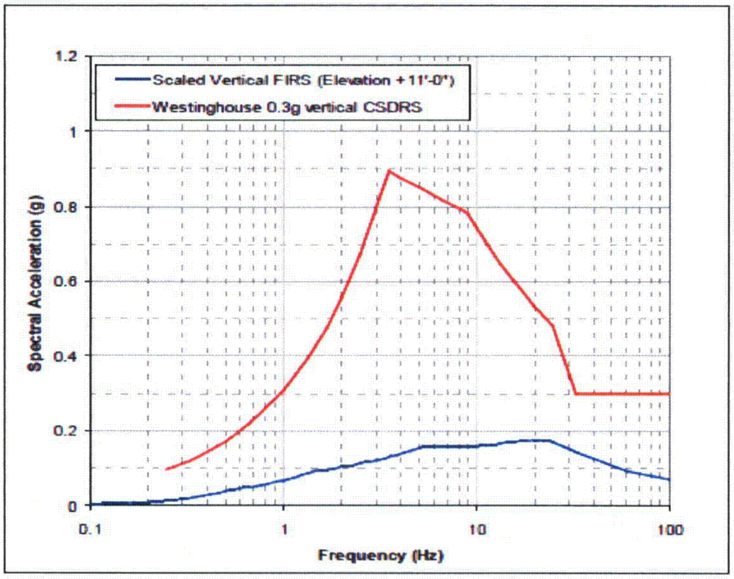
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Horizontal and Vertical
GMRS for the LNP Site

FIGURE 2.5.2-296 Rev 0

Figure 2.1-1: Horizontal and Vertical GMRS for the LNP Site
(Progress FSAR Figure 2.5.2-296)





	Progress Energy Florida **Levy Nuclear Plant Units 1 and 2 Part 2, Final Safety Analysis Report**
	Scaled Horizontal and Vertical Soil Column Outcrop Response Spectra at AP1000 Foundation Elevation 11'-0" Figure 3.7-205 Rev 2

Figure 2.1-2: Scaled Horizontal and Vertical Soil Column Outcrop Response Spectra at AP1000 Foundation Elevation 11’-0”
(Progress FSAR Figure 3.7-205)

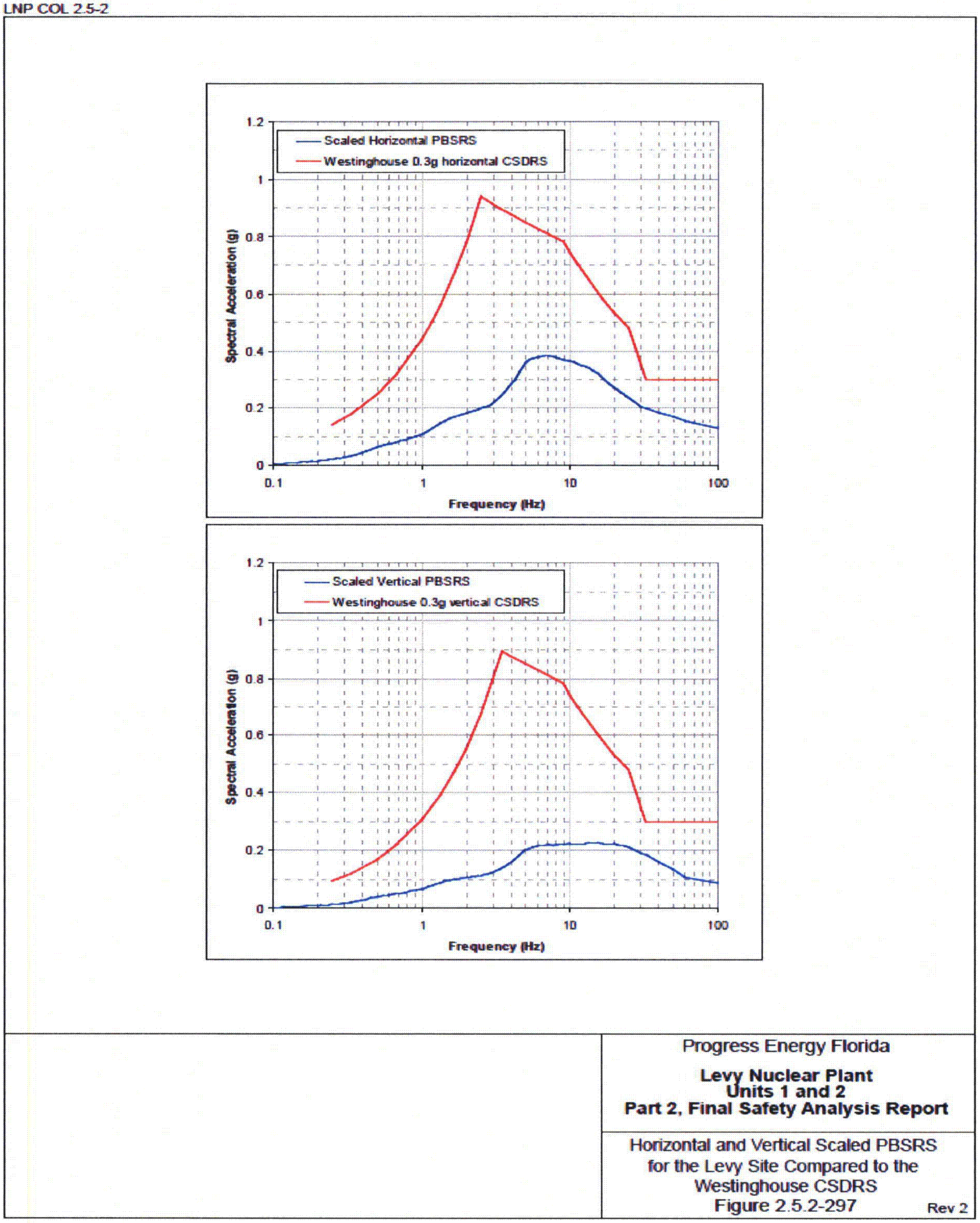
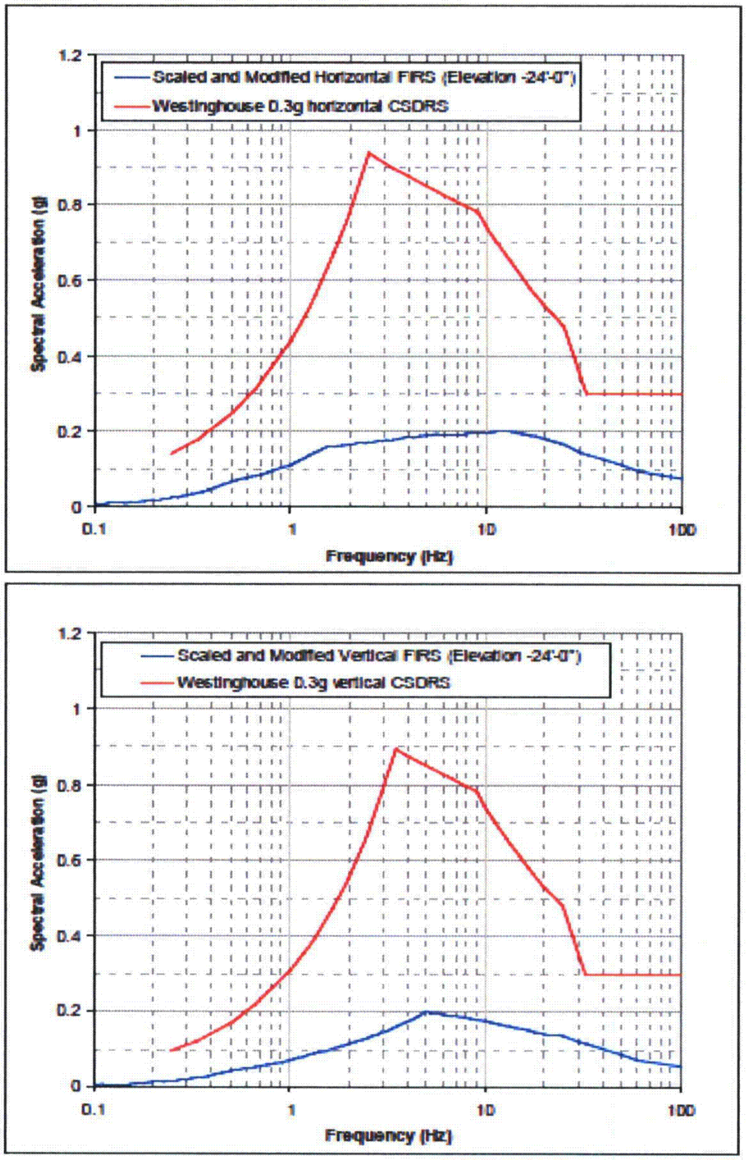


Figure 2.1-3: Horizontal and Vertical Scaled PBSRS for the Levy Site Compared to the Westinghouse CSDRS (Progress FSAR Figure 2.5.2-297)

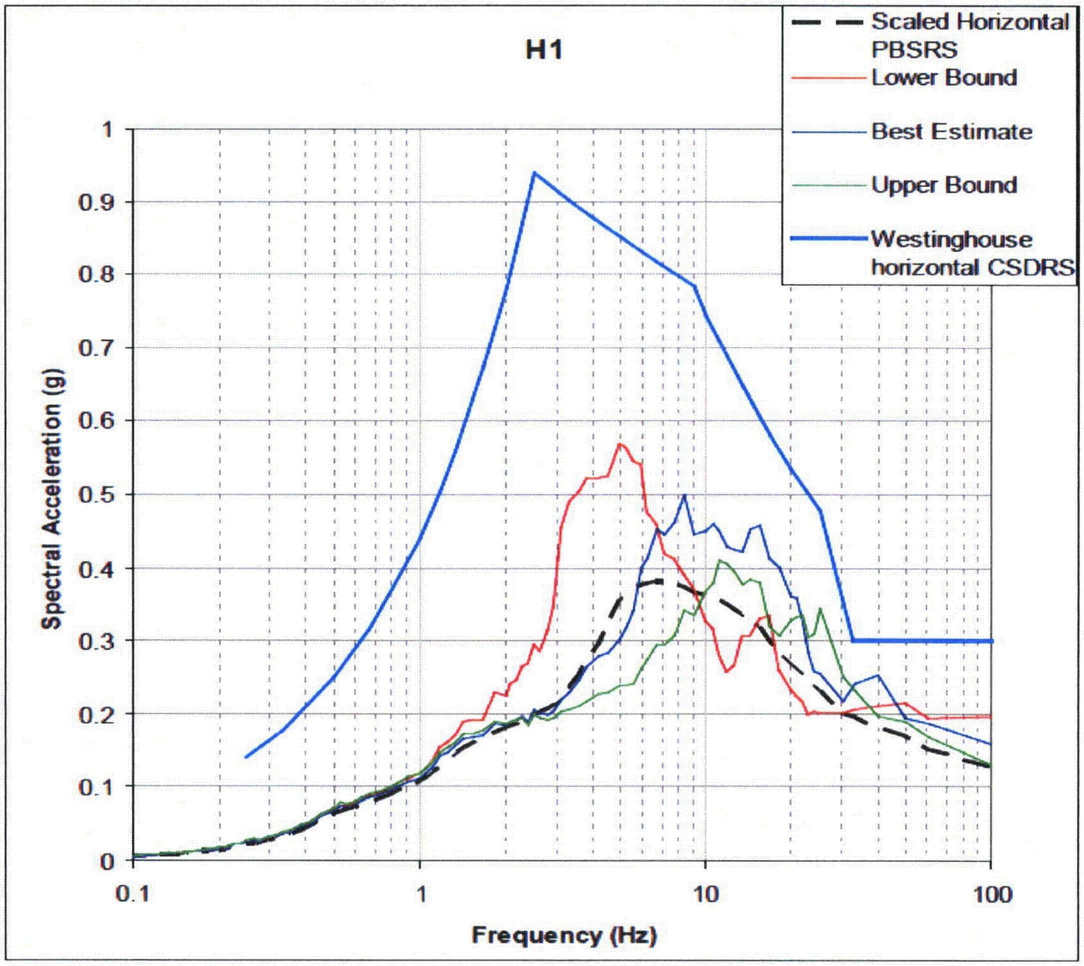
LNP COL 2.5-2



Note: Boring Distance from LNP Site W7543(P350) 25 km (15 mi.) W7534(P358) 18 km (11 mi.) W7538(P353) 11 km (6.8 mi.)	Progress Energy Florida **Levy Nuclear Plant Units 1 and 2 Part 2, Final Safety Analysis Report** Horizontal and Vertical Scaled SCOR FIRS for the Levy Site Compared to the Westinghouse CSDRS Figure 3.7-201 Rev 2

Figure 2.1-4: Horizontal and Vertical Scaled SCOR for the Levy Site Compared to the Westinghouse CSDRS (Progress FSAR Figure 3.7-201)

LNP COL 2.5-2

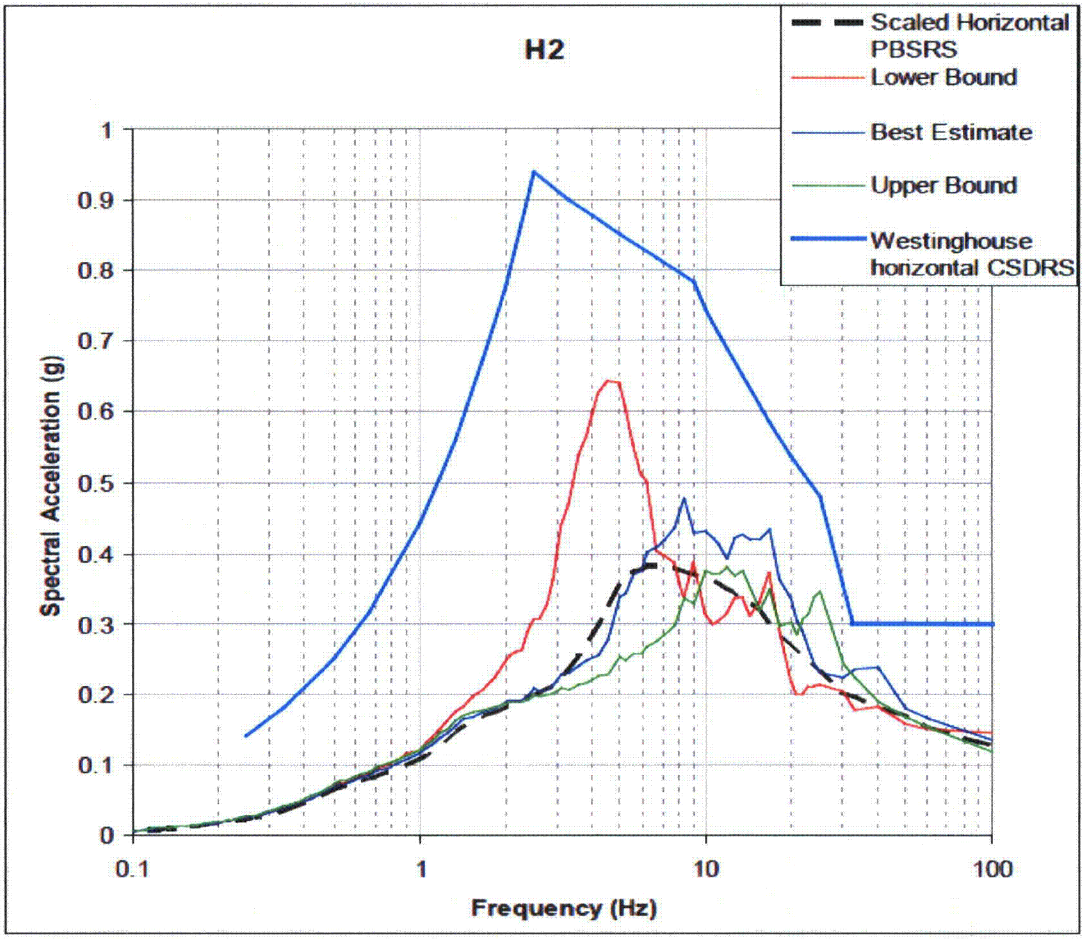


Progress Energy Florida

Levy Nuclear Plant Units 1 and 2 Part 2, Final Safety Analysis Report

Comparison of Spectra of Computed H1 Component Surface Motions for SSI Profiles with Scaled Horizontal PBSRS
Figure 3.7-202 Rev 2

Figure 2.1-5: Comparison of Spectra of Computed H1 Component Surface Motions for SSI Profiles with Scaled Horizontal PBSRS (Progress FSAR Figure 3.7-202)



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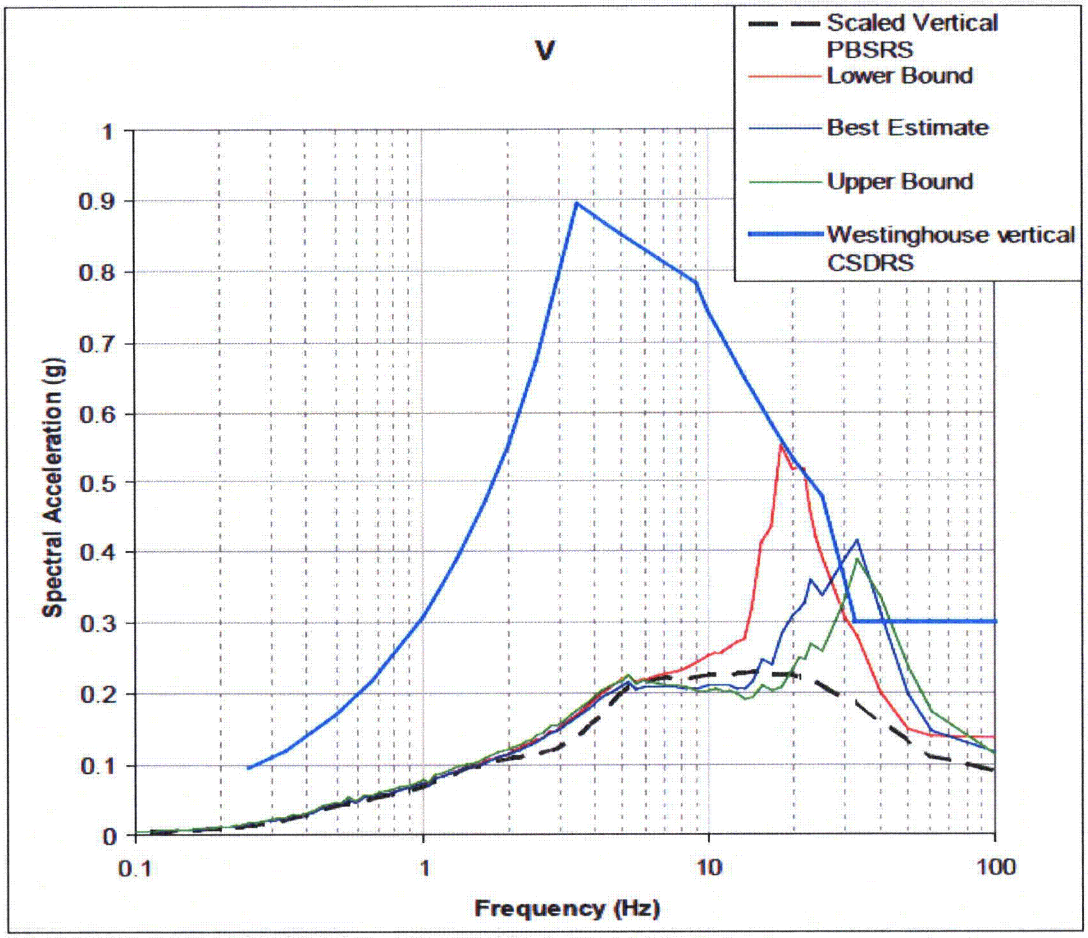
Comparison of Spectra of Computed H2 Component Surface Motions for SSI Profiles with Scaled Horizontal PBSRS
Figure 3.7-203 Rev 2

Figure 2.1-6: Comparison of Spectra of Computed H2 Component Surface Motions for SSI Profiles with Scaled Horizontal PBSRS (Progress FSAR Figure 3.7-203)

LNP COL 2.5-2



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Comparison of Spectra of Computed V Component Surface Motions for SSI Profiles with Scaled Vertical PBSRS
Figure 3.7-204 Rev 2

Figure 2.1-7: Comparison of Spectra of Computed V Component Surface Motions for SSI Profiles with Scaled Vertical PBSRS (Progress FSAR Figure 3.7-204)

2.2 LNP Soil-Structure Interaction (SSI) Analyses

LNP free field response analysis showed that the AP1000 CSDRS for the vertical seismic excitation does not envelop the design grade deterministic surface spectra developed using Subsection 5.2.1 of the Interim Staff Guidance DC/COL-ISG-017 in the high frequency range (greater than approximately 30 Hz). Thus, LNP site specific SSI analysis was performed. This analysis showed that the AP1000 generic FRS envelops the LNP site specific FRS at the six key locations specified in Table 3.4.1. The LNP site specific analysis presented in previous revisions of this report can be summarized as follows:

- The LNP specific SSI analyses utilized three-dimensional (3D) SSI analyses.
- For the LNP 3D SSI analyses, the AP1000 NI20r 3D embedded finite element model (FEM) was modified to incorporate the LNP site conditions including a 35-foot thick RCC bridging mat constructed beneath the NI basemat, and the engineered fill and the controlled low strength material (CLSM) adjacent to the NI.
- The LNP 3D 5-Layer model was used to demonstrate that for the LNP site specific SSI analysis, both the SASSI Subtraction method and the SASSI Direct method yield comparable responses. The LNP 3D 8-Layer model and SASSI Subtraction method was used to develop the LNP site specific FRS.
- The in-column ground motions at the bottom of the excavation (elevation -24 ft.) for the BE, UB, LB, and the LLB soil profiles were the input motions for the SSI models. These in-column input motions were developed as part of the design grade deterministic surface spectra following Subsection 5.2.1 of the Interim Staff Guidance DC/COL-ISG-017.
- The Turbine Building (TB), Annex Building (AB) and Radwaste Building (RB), drilled shafts, and diaphragm wall were not modeled in the LNP SSI analyses. The Seismic Category I/II interaction issues between the adjacent buildings and the NI are addressed in response to NRC Letter 055 RAI 03.08.05-7 for PBSRS and for uniform hazard response spectra (UHRS). In the RAI response it was shown that the gaps provided between the adjacent buildings and the NI are larger than the computed probable maximum relative displacement between the NI and the drilled shaft supported adjacent building foundations. Thus, there is no adverse interaction between the NI and the adjacent buildings.

At the March 2011 NRC audit, the LNP site specific free field site response analysis and the SSI analysis described above were reviewed. Also at the NRC audit, it was agreed to perform additional LNP SSI analysis as follows:

- Supplement the LNP SSI analyses to refine the LNP 3D 5-Layer (Design-Basis) model and SSI analyses, and perform two-dimensional (2D) parametric SSI analyses. The 3D 5-Layer model layer passing frequencies range from about 2 to 67 Hz. Therefore, 2D parametric analyses are performed to demonstrate the adequacy of the 3D mesh size, the soil layer modeling used and passing frequency in the LNP 3D models.
- Create LNP 2D Coarse and Fine models and perform parametric SSI analyses for evaluation of LNP 3D model frequency filtering, model mesh size limitations, and influence of the lower boundary SITE profile depth. The 2D Coarse model layer frequencies range from about 2 to 67 Hz and represent the embedded portion of the LNP 3D model. The Fine model layer frequencies range from about 45 to 121 Hz. The

2D SSI response forms the basis for the Fine-to-Coarse response spectra ratios (Bump Factors) to account for the lower 3D model passing frequencies.

- Use the 2D parametric SSI analysis results to calculate horizontal and vertical frequency-dependent Fine-to-Coarse SSI response spectra ratios (Bump Factors) at each of the six key locations.
- Calculate the factored FRS at the six key locations using the refined LNP 3D Design-Basis model and the revised SASSI Direct method SSI analyses results. Amplify the computed 3D Direct FRS by the Bump Factors and compare the LNP amplified FRS to the AP1000 generic FRS at the six key locations to show that the AP1000 FRS envelops the factored LNP site specific SSI analyses FRS.

The above additional LNP SSI analyses are described in this report.

LNP SSI analyses were performed using the computer codes SASSI2000 (Reference 4), specifically SITE, POINT, HOUSE and ANALYS modules, and ACS SASSI (Reference 5) COMBINE, MOTION and STRESS modules.

3.0 SSI Analysis Design Inputs

The following sections summarize design input information provided by Progress pertaining to the proposed RCC bridging mat and CLSM, LNP site soil profiles, and Base of Excavation [elevation (El.) -24] input time histories. Design inputs also include the WEC generic AP1000 3D FRS envelope, and hard rock high frequency (HRHF) FRS envelope, which the LNP SSI analyses results are compared for the structure (low frequency) and equipment (high frequency) qualification, respectively.

3.1 Foundation Concept Description

Two AP1000 units, designated Units 1 and 2 are planned at the Progress LNP site located in Levy County, Florida. Plan and cross-section views of the LNP Unit 1 excavation limits are presented in Figures 3.1-1 and 3.1-2, respectively. Note that the LNP Unit 2 plan and cross-section information are similar, thus only LNP Unit 1 is graphically presented. A detail of the NI excavation, diaphragm wall and RCC bridging mat is presented in Figure 3.1-3.

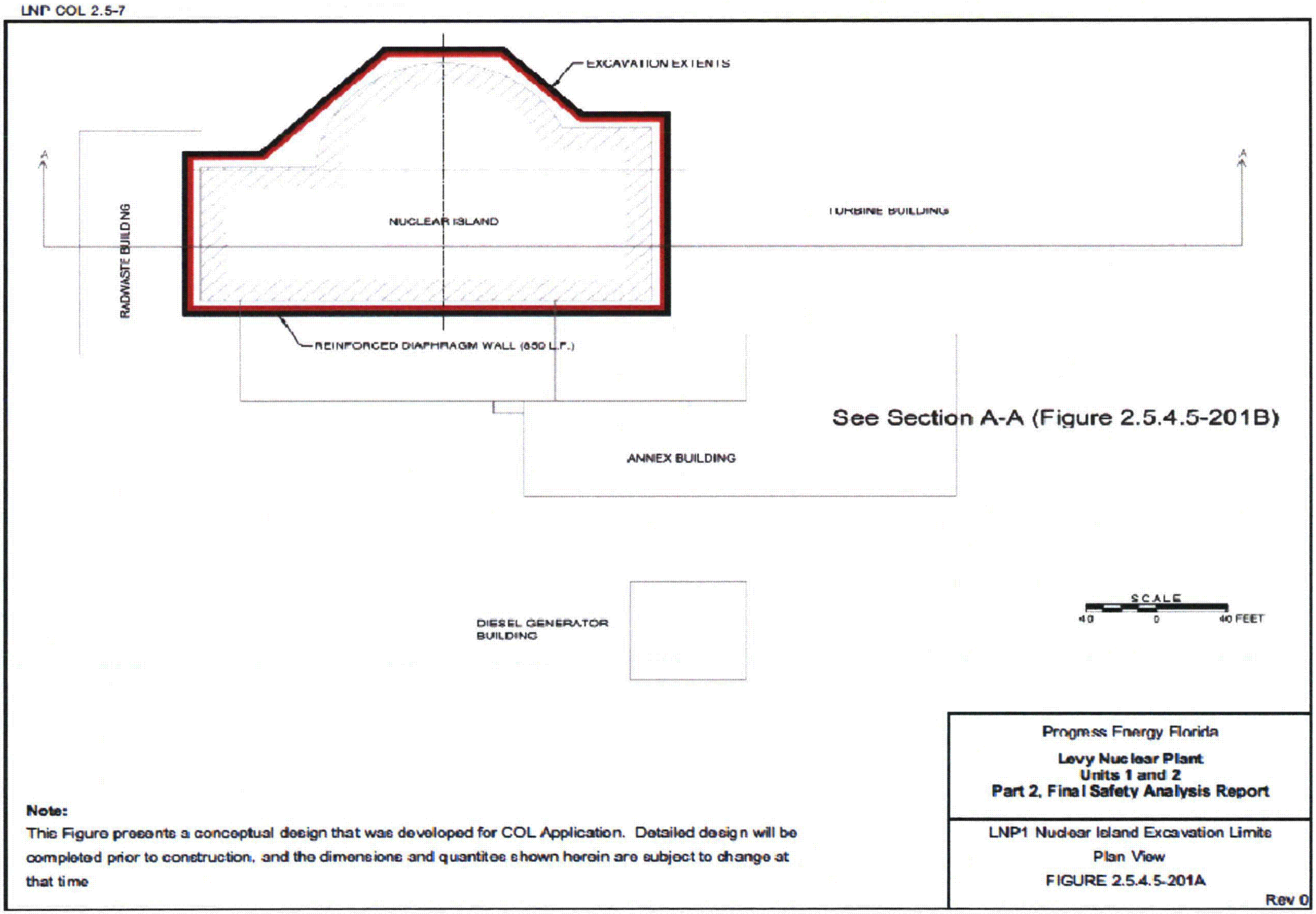

Figure 3.1-1: LNP Unit 1 Excavation Limits Plan View

LNP COL 2.5-7

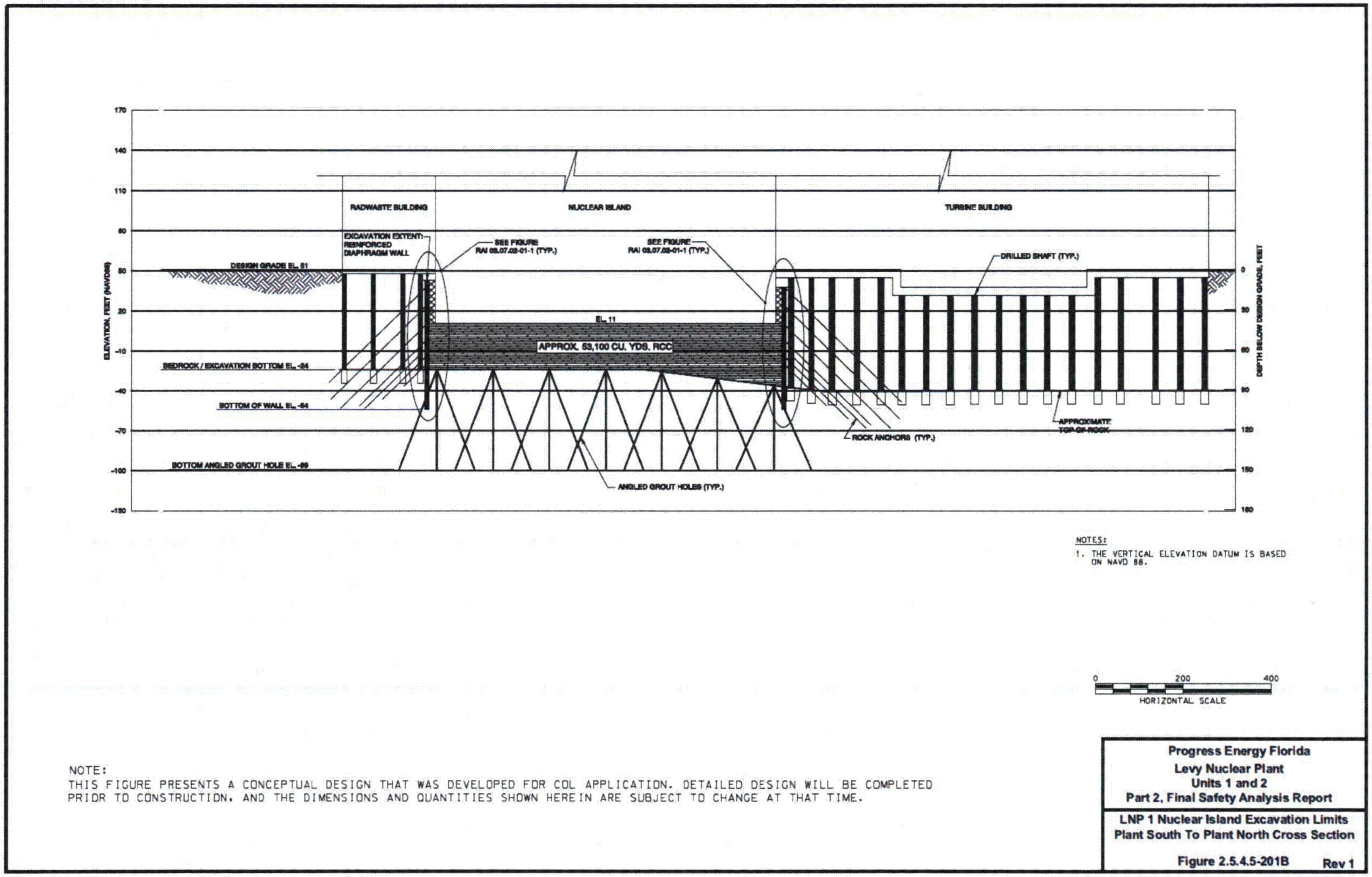

Figure 3.1-2: LNP Unit 1 Excavation Limits Cross-Section

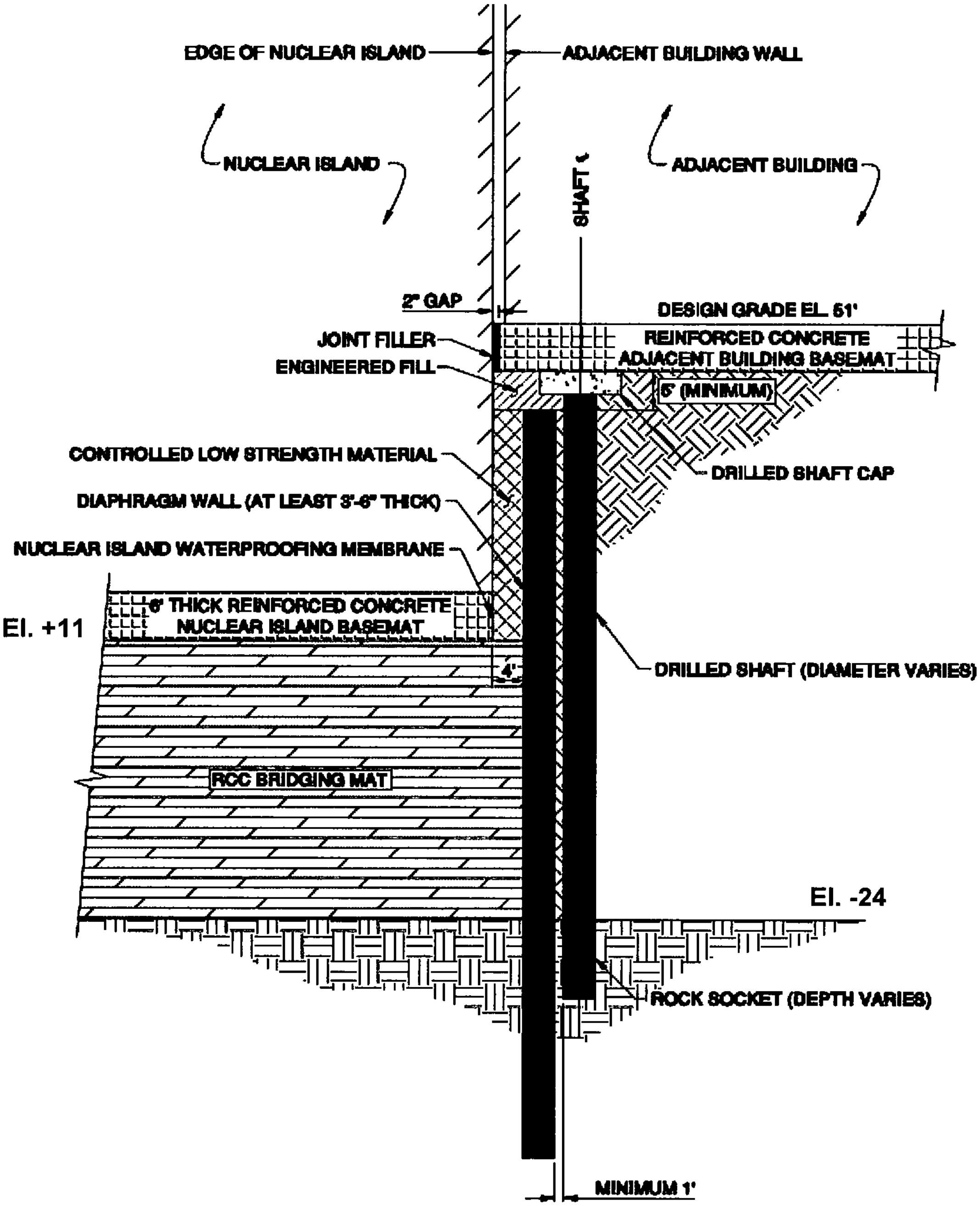

Figure 3.1-3: Conceptual Design Detail – Diaphragm Wall (Progress Figure RAI 03.07.02-01-1)

3.2 LNP Best Estimate, Lower Bound, Upper Bound and Lower Lower Bound Site Soil Profiles

LNP site soil profiles including the BE, UB, LB and LLB soil cases were provided in DIT No. 338884-DIT-041, Rev. 4 (Reference 2 Tables 17 – 20). The layer thickness, unit weight, shear wave velocity (Vs), compression wave velocity (Vp), damping ratio and layer elevation from the ground surface to the simulated halfspace are presented in Tables 3.2-1 to 3.2-4. Figure 3.2-1 graphically presents the LNP Vs profiles within the approximately 4,300-foot LNP site soil profile depth.

Table 3.2-1: LNP Best Estimate (BE) Soil Profile

(Table 17 from DIT No. 338884-DIT-041, Rev. 4)

Best Estimate Properties for SSI Analyses of the LNP Site

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
1	2.5	2.5	110	836	1.3	1590	48.5
2	2.5	5	110	824	1.6	1590	46
3	2.5	7.5	110	796	2.0	1590	43.5
4	3.5	11	110	788	2.3	1590	40
5	2	13	110	796	2.4	5000	38
6	2	15	110	786	2.6	5000	36
7	3.5	18.5	120	1503	2.4	5600	32.5
8	2.5	21	120	1500	2.5	5600	30
9	1	22	120	1500	2.5	5600	29
10	3.5	25.5	120	1501	2.0	5600	25.5
11	3.5	29	120	1496	2.1	5600	22
12	6.9	35.9	120	1482	2.1	5600	15.1
13	4.1	40	120	1476	2.1	5600	11
14	2.8	42.8	120	1476	2.1	5600	8.2
15	8.4	51.2	130	2267	2.1	7550	-0.2
16	8.4	59.6	130	2266	2.1	7550	-8.6
17	7.1	66.7	130	2254	2.2	7550	-15.7
18	7.1	73.8	130	2251	2.2	7550	-22.8
19	1	75	138	2772	1.4	8700	-24
20	24.6	99.6	138	2772	1.4	8700	-48.6
21	47.4	147	138	2694	1.4	8550	-96
22	61.3	208.3	138	3374	1.4	10600	-157.3
23	17.9	226.2	138	3315	1.4	9450	-175.2
24	24.1	250.3	120	3243	1.9	7250	-199.3
25	24.6	274.9	120	3210	1.9	7250	-223.9
26	40	314.9	120	3539	1.3	7900	-263.9
27	42	356.9	120	3358	1.3	7900	-305.9
28	38.4	395.3	140	4144	0.9	8900	-344.3
29	59.4	454.7	140	3369	0.9	8100	-403.7
30	59.4	514.1	140	3721	0.9	9000	-463.1

Table 3.2-1: LNP Best Estimate (BE) Soil Profile (cont'd)

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
Best Estimate Properties for SSI Analyses of the LNP Site							
31	242.7	756.8	140	4541	0.9	11000	-705.8
32	355.8	1112.6	140	5934	0.9	14400	-1061.6
33	249.4	1362	150	7294	0.7	17850	-1311
34	252.9	1614.9	150	5101	0.7	12350	-1563.9
35	148.3	1763.2	150	7279	0.7	17400	-1712.2
36	106.1	1869.3	150	6259	0.7	14900	-1818.3
37	199	2068.3	150	7168	0.7	17500	-2017.3
38	601.2	2669.5	150	5429	0.8	13000	-2618.5
39	149.2	2818.7	150	5955	0.8	14200	-2767.7
40	192.7	3011.4	150	6200	0.8	14950	-2960.4
41	652.3	3663.7	150	5168	0.8	12600	-3612.7
42	603.7	4267.4	150	5555	0.8	13450	-4216.4
43	96.6	4364	150	4800	0.8	11500	-4313
44	Halfspace		169	9396	0.1	16100	

Table 3.2-2: LNP Lower Bound (LB) Soil Profile
(Table 18 from DIT No. 338884-DIT-041, Rev. 4)

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
Lower Bound Properties for SSI Analyses of the LNP Site							
1	2.5	2.5	110	373	2.6	935	48.5
2	2.5	5	110	342	4.4	935	46
3	2.5	7.5	110	315	5.8	935	43.5
4	3.5	11	110	300	6.8	935	40
5	2	13	110	301	7.3	5000	38
6	2	15	110	294	7.9	5000	36
7	3.5	18.5	120	1123	5.4	5000	32.5
8	2.5	21	120	1115	5.5	5000	30
9	1	22	120	1115	5.5	5000	29
10	3.5	25.5	120	1074	5.3	5000	25.5
11	3.5	29	120	1070	5.5	5000	22
12	6.7	35.7	120	1111	5.6	5000	15.3
13	4.3	40	120	1100	5.9	5000	11
14	2.4	42.4	120	1100	4.8	5000	8.6
15	8.3	50.7	130	1851	4.9	6165	0.3

Table 3.2-2: LNP Lower Bound (LB) Soil Profile (cont'd)

Lower Bound Properties for SSI Analyses of the LNP Site

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
16	8.3	59	130	1850	5.0	6165	-8
17	7.2	66.2	130	1841	5.1	6165	-15.2
18	7.2	73.4	130	1838	2.4	6165	-22.4
19	1.6	75	138	2264	2.4	7022	-24
20	24.2	99.2	138	2264	2.4	7022	-48.2
21	46.8	146	138	2199	2.4	6532	-95
22	61.5	207.5	138	2755	2.4	7634	-156.5
23	17.9	225.4	138	2707	2.4	6654	-174.4
24	23.9	249.3	120	2145	4.7	5920	-198.3
25	24.6	273.9	120	2148	4.7	5920	-222.9
26	40	313.9	120	2890	1.9	6450	-262.9
27	42.1	356	120	2742	1.9	6450	-305
28	38.3	394.3	140	3384	1.3	7267	-343.3
29	59.8	454.1	140	2750	1.3	6614	-403.1
30	61.1	515.2	140	3038	1.3	7348	-464.2
31	242.7	757.9	140	3708	1.3	8981	-706.9
32	354.8	1112.7	140	4845	1.3	11758	-1061.7
33	246.6	1359.3	150	5956	1.0	14574	-1308.3
34	255.7	1615	150	4165	1.0	10084	-1564
35	150.7	1765.7	150	5943	1.0	14207	-1714.7
36	100.8	1866.5	150	5111	1.0	12166	-1815.5
37	199.6	2066.1	150	5853	1.0	14289	-2015.1
38	600.3	2666.4	150	4432	1.2	10614	-2615.4
39	149.6	2816	150	4863	1.2	11594	-2765
40	199.2	3015.2	150	5062	1.2	12207	-2964.2
41	650.5	3665.7	150	4220	1.2	10288	-3614.7
42	597	4262.7	150	4535	1.2	10982	-4211.7
43	104.1	4366.8	150	3919	1.2	9390	-4315.8
44	Halfspace		169	7672	0.1	13146	

Table 3.2-3: LNP Upper Bound (UB) Soil Profile
(Table 19 from DIT No. 338884-DIT-041, Rev. 4)

Upper Bound Properties for SSI Analyses of the LNP Site

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
1	2.5	2.5	110	1280	0.9	1948	48.5
2	2.5	5	110	1275	1.1	1948	46
3	2.5	7.5	110	1291	1.2	1948	43.5
4	3.5	11	110	1287	1.3	1948	40
5	2	13	110	1273	1.4	5000	38
6	2	15	110	1266	1.5	5000	36
7	3.5	18.5	120	1982	1.1	7226	32.5
8	2.5	21	120	1980	1.2	7226	30
9	1	22	120	1980	1.2	7226	29
10	3.5	25.5	120	1931	0.6	7226	25.5
11	3.5	29	120	1931	0.6	7226	22
12	7.1	36.1	120	1906	0.6	7226	14.9
13	3.9	40	120	1902	5.9	7226	11
14	3.2	43.2	120	1902	0.6	7226	7.8
15	9	52.2	130	2993	0.5	9737	-1.2
16	9	61.2	130	2991	0.5	9737	-10.2
17	9.2	70.4	130	2887	0.5	9737	-19.4
18	4.6	75	130	2887	0.5	9737	-24
19	4.6	79.6	130	2887	0.5	9737	-28.6
20	20	99.6	138	4731	0.6	10655	-48.6
21	48.8	148.4	138	3984	0.6	10472	-97.4
22	51.9	200.3	138	5157	0.6	12982	-149.3
23	11.9	212.2	138	4356	0.6	11574	-161.2
24	27	239.2	120	3972	0.5	9308	-188.2
25	26.2	265.4	120	3975	0.6	9308	-214.4
26	35.1	300.5	120	4335	0.7	9798	-249.5
27	44.5	345	120	4112	0.7	9798	-294
28	44.7	389.7	140	5075	0.5	11329	-338.7
29	49.8	439.5	140	4126	0.5	10043	-388.5
30	72.6	512.1	140	4620	0.5	11023	-461.1
31	244.3	756.4	140	5562	0.5	13472	-705.4
32	356	1112.4	140	7267	0.5	17636	-1061.4
33	254.7	1367.1	150	8934	0.4	21862	-1316.1
34	244	1611.1	150	6247	0.4	15126	-1560.1
35	153.4	1764.5	150	8915	0.4	21311	-1713.5
36	96.4	1860.9	150	7666	0.4	18249	-1809.9
37	205.2	2066.1	150	8779	0.4	21433	-2015.1
38	601.3	2667.4	150	6649	0.4	15922	-2616.4
39	148	2815.4	150	7294	0.4	17391	-2764.4
40	198.5	3013.9	150	7593	0.4	18310	-2962.9
41	647.8	3661.7	150	6330	0.4	15432	-3610.7
42	602.2	4263.9	150	6803	0.4	16473	-4212.9

Table 3.2-3: LNP Upper Bound (UB) Soil Profile (cont'd)

Upper Bound Properties for SSI Analyses of the LNP Site

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
43	95.2	4359.1	150	5879	0.4	14085	-4308.1
44	Halfspace		169	11507	0.1	19718	

Table 3.2-4: LNP Lower Lower Bound (LLB) Soil Profile
(Table 20 from DIT No. 338884-DIT-041, Rev. 4)

Lower Lower Bound Properties for SSI Analyses of the LNP Site

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
1	2.5	2.5	110	373	2.6	935	48.5
2	2.5	5	110	342	4.4	935	46
3	2.5	7.5	110	315	5.8	935	43.5
4	3.5	11	110	300	6.8	935	40
5	2	13	110	301	7.3	5000	38
6	2	15	110	294	7.9	5000	36
7	3.5	18.5	120	1066	5.4	5000	32.5
8	2.5	21	120	1058	5.5	5000	30
9	1	22	120	1058	5.5	5000	29
10	3.5	25.5	120	1019	5.3	5000	25.5
11	3.5	29	120	1015	5.5	5000	22
12	6.7	35.7	120	1054	5.6	5000	15.3
13	4.3	40	120	1043	5.9	5000	11
14	2.4	42.4	120	1043	4.8	5000	8.6
15	8.3	50.7	130	1756	4.9	5848	0.3
16	8.3	59	130	1755	5.0	5848	-8
17	7.2	66.2	130	1746	5.1	5848	-15.2
18	7.2	73.4	130	1744	2.4	5848	-22.4
19	1.6	75	138	2147	2.4	6661	-24
20	24.2	99.2	138	2264	2.4	7022	-48.2
21	46.8	146	138	2199	2.4	6532	-95
22	61.5	207.5	138	2755	2.4	7634	-156.5
23	17.9	225.4	138	2707	2.4	6654	-174.4
24	23.9	249.3	120	2145	4.7	5920	-198.3
25	24.6	273.9	120	2148	4.7	5920	-222.9
26	40	313.9	120	2890	1.9	6450	-262.9
27	42.1	356	120	2742	1.9	6450	-305

Table 3.2-4: LNP Lower Lower Bound (LLB) Soil Profile (cont'd)

Lower Lower Bound Properties for SSI Analyses of the LNP Site							
Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
28	38.3	394.3	140	3384	1.3	7267	-343.3
29	59.8	454.1	140	2750	1.3	6614	-403.1
30	61.1	515.2	140	3038	1.3	7348	-464.2
31	242.7	757.9	140	3708	1.3	8981	-706.9
32	354.8	1112.7	140	4845	1.3	11758	-1061.7
33	246.6	1359.3	150	5956	1.0	14574	-1308.3
34	255.7	1615	150	4165	1.0	10084	-1564
35	150.7	1765.7	150	5943	1.0	14207	-1714.7
36	100.8	1866.5	150	5111	1.0	12166	-1815.5
37	199.6	2066.1	150	5853	1.0	14289	-2015.1
38	600.3	2666.4	150	4432	1.2	10614	-2615.4
39	149.6	2816	150	4863	1.2	11594	-2765
40	199.2	3015.2	150	5062	1.2	12207	-2964.2
41	650.5	3665.7	150	4220	1.2	10288	-3614.7
42	597	4262.7	150	4535	1.2	10982	-4211.7
43	104.1	4366.8	150	3919	1.2	9390	-4315.8
44	Halfspace		169	7672	0.1	13146	

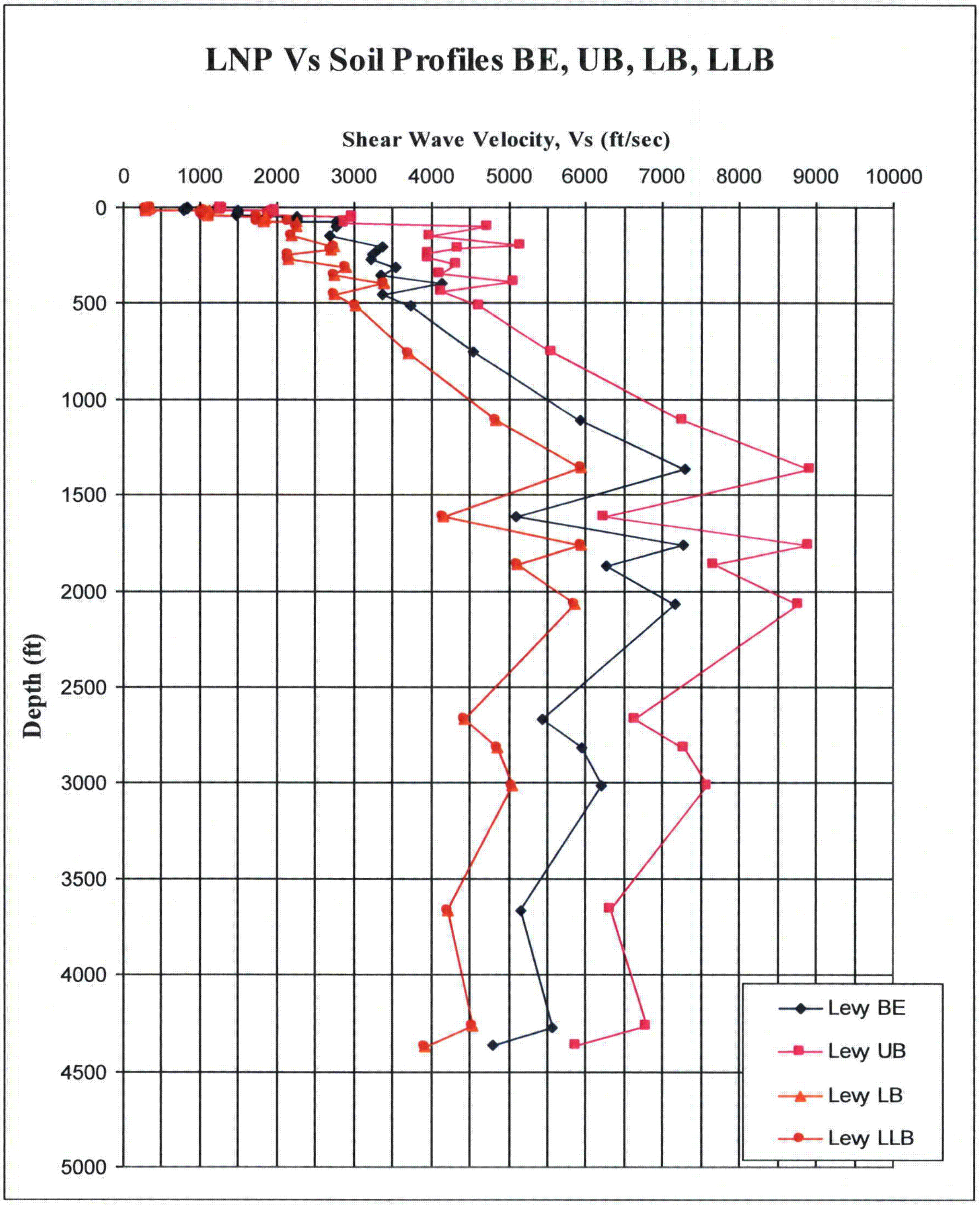

Figure 3.2-1: LNP BE, UB, LB and LLB Vs Profiles – Full Depth

3.3 LNP RCC and CLSM Properties for SSI Analyses

The following Tables 3.3-1 and 3.3-2 present the dynamic material properties for the RCC and CLSM based on the BE, UB and LB elastic modulus (E), unit weight and Poissons ratio data provided by Paul C. Rizzo & Associates, Inc. (Rizzo) (References 8 and 9):

Table 3.3-1: Levy RCC SSI Dynamic Properties

RCC Unit Weight: 147 pcf Poissons Ratio: 0.20											
Elastic Modulus, E (ksi)			Dynamic Modulus, G (ksf)			Shear Wave Velocity, Vs (ft/sec)			Compression Wave Velocity, Vp (ft/sec)		
E-LB	E-BE	E-UB	G-LB	G-BE	G-UB	Vs-LB	Vs-BE	Vs-UB	Vp-LB	Vp-BE	Vp-UB
2956	3422	3935	177360	205320	236100	6233	6706	7191	10175	10950	11740

Table 3.3-2: Levy CLSM SSI Dynamic Properties

CLSM Unit Weight: 115 pcf Poissons Ratio: 0.15											
Elastic Modulus, E (ksi)			Dynamic Modulus, G (ksf)			Shear Wave Velocity, Vs (ft/sec)			Compression Wave Velocity, Vp (ft/sec)		
E-LB	E-BE	E-UB	G-LB	G-BE	G-UB	Vs-LB	Vs-BE	Vs-UB	Vp-LB	Vp-BE	Vp-UB
7050	910	1410	44133	56974	88266	3109	3533	4397	4845	5505	6850

3.4 Key Nodes Selected

The six (6) key nodes selected to obtain floor response spectra (FRS) are shown below in Table 3.4-1.

Table 3.4-1: Key Nodes at Location

LNP/NI20r (3D) Node	LNP (2D) Node	3D-X (feet)	3D-Y (feet)	3D-Z (feet)	Location
1761	4041	1000	1000	100	CIS at Reactor Vessel Support Elevation
2078	4061	1116.5	948.5	116.5	ASB NE Corner at Control Room Floor
2199	4535	1008	1014	134.25	CIS at Operating Deck
2675	4120	929	1000	179.19	ASB Corner of Fuel Building Roof at Shield Building
2788	4412	1000	1000	224	SCV Near Polar Crane
3329	4310	956.5	1000	327.41	ASB Shield Building Roof Area

3.5 LNP Time History Inputs – El. -24 (Base of Excavation)

The LNP input acceleration time histories were provided by Progress in DIT No. 338884-DIT-041, Rev. 4 (Reference 2) and are graphically presented in Figures 3.5-1 through 3.5-12 for the LNP BE, UB, LB and LLB soil cases. The input time histories are used as seismic input in three orthogonal directions at the base of the LNP excavation (El. -24) in the LNP SSI analyses.

Reference 2 provides two horizontal and one vertical Base of Excavation (El. -24) BE, LB, UB and LLB discrete values of acceleration with a time step of 0.005 seconds in files BEBEH1.acc, BEBEH2.acc and BEBEVT.acc, BELBH1.acc, BELBH2.acc and BELBVT.acc, BEUBH1.acc, BEUBH2.acc and BEUBVT.acc, BELLBH1.acc, BELLBH2.acc and BELLBVT.acc. The actual time history is about 55 seconds long with an approximately 27 seconds of silence to capture any trailing response for a total of 81.92 seconds in length. The seismic analysis was executed for each excitation direction separately.

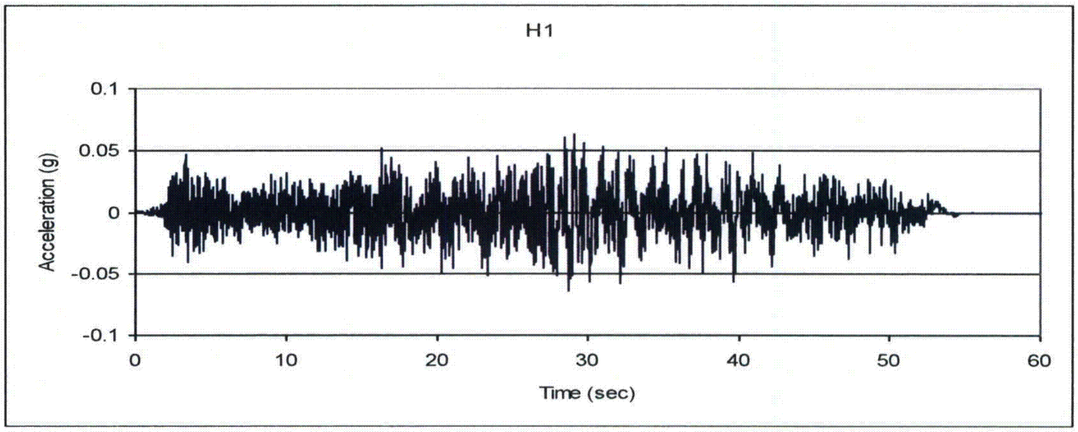

Figure 3.5-1: LNP Scaled BE Seismic Input in X-Direction – El. -24

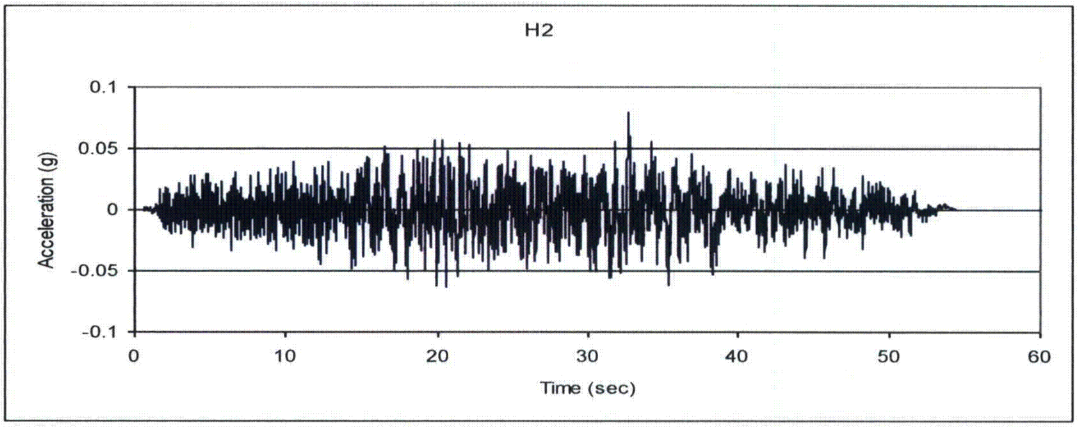

Figure 3.5-2: LNP Scaled BE Seismic Input in Y-Direction – El. -24

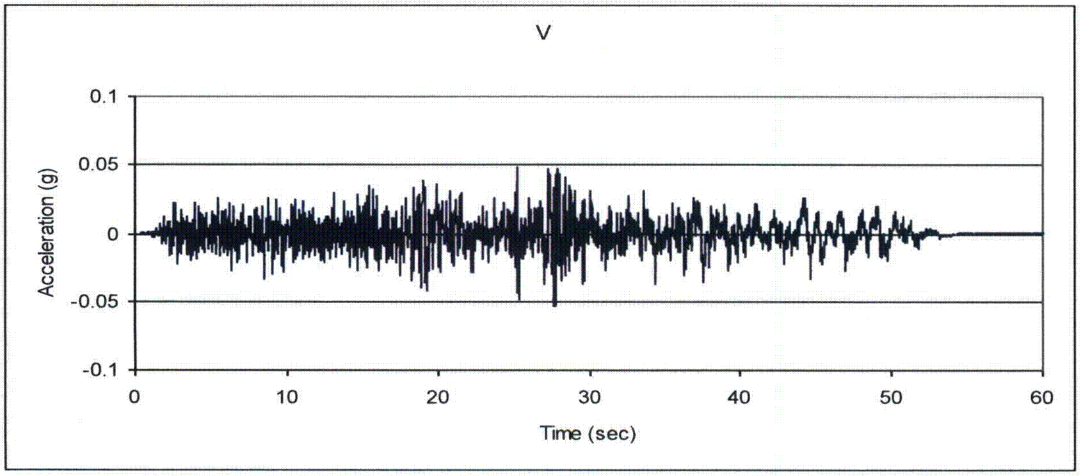

Figure 3.5-3: LNP Scaled BE Seismic Input in Z-Direction – El. -24

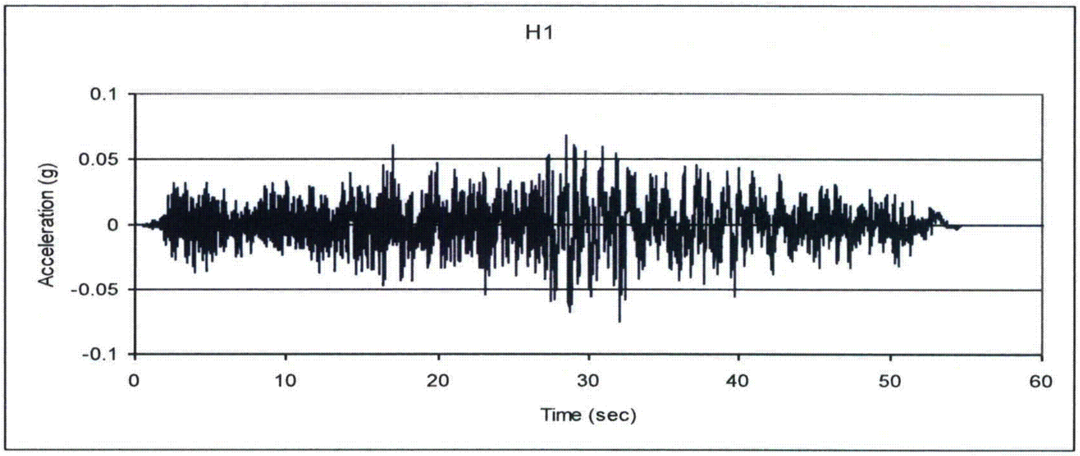

Figure 3.5-4: LNP Scaled UB Seismic Input in X-Direction – El. -24

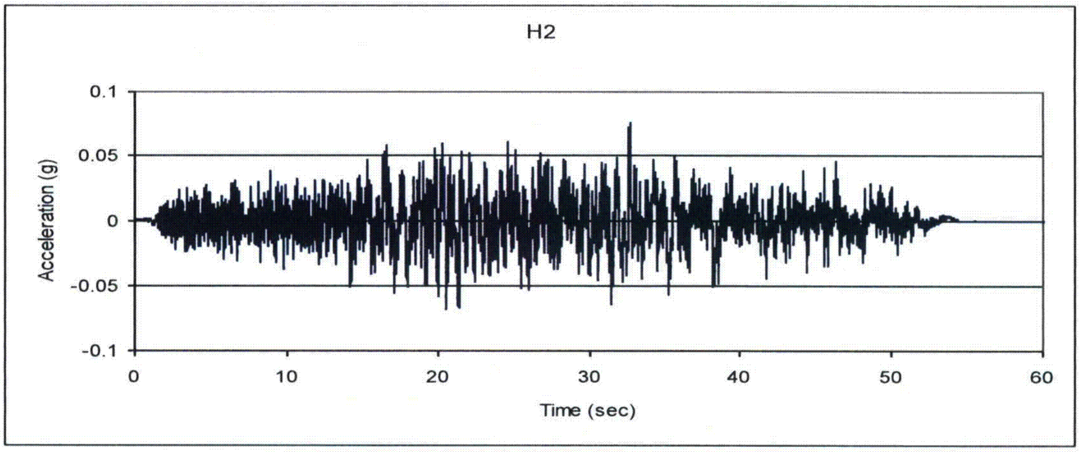

Figure 3.5-5: LNP Scaled UB Seismic Input in Y-Direction – El. -24

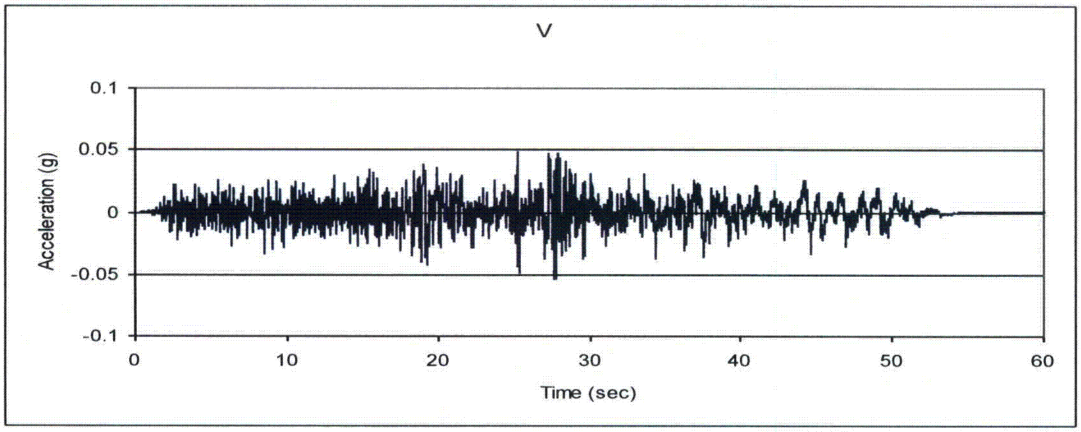

Figure 3.5-6: LNP Scaled UB Seismic Input in Z-Direction – El. -24

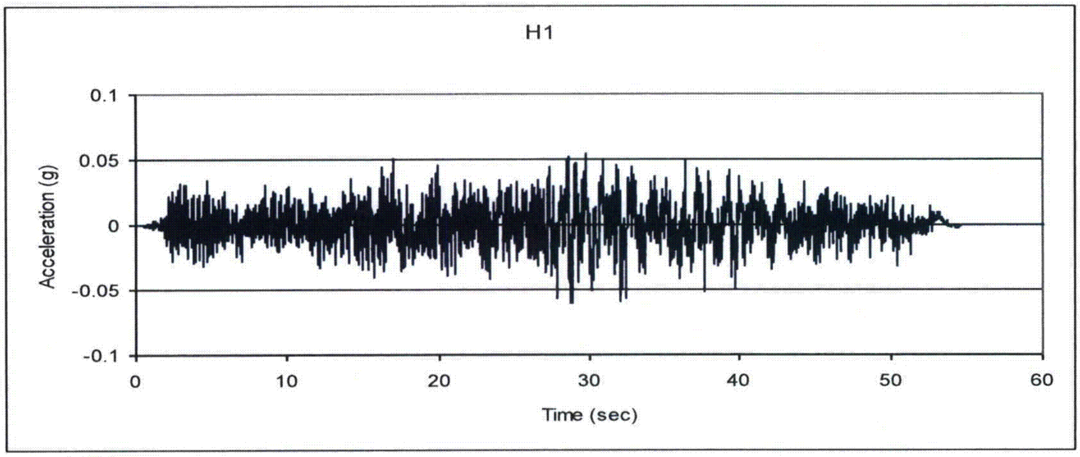

Figure 3.5-7: LNP Scaled LB Seismic Input in X-Direction – El. -24

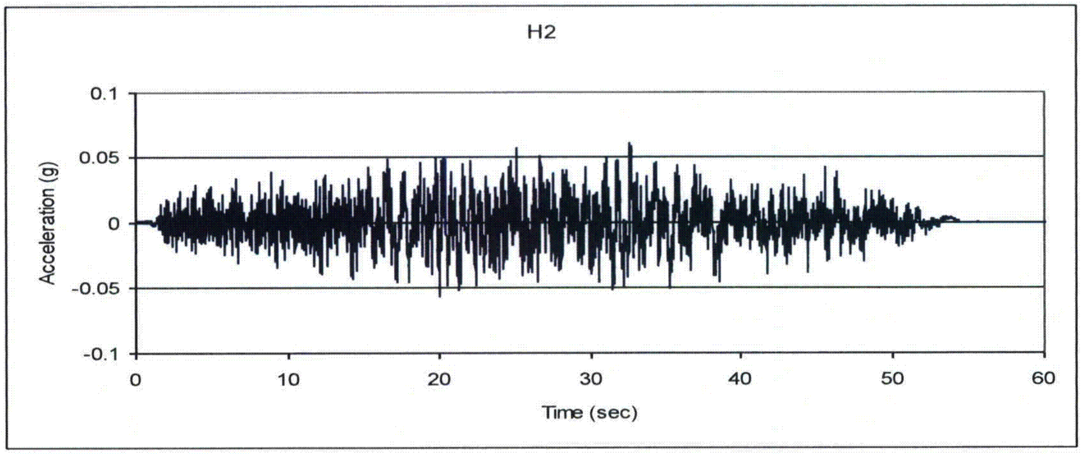

Figure 3.5-8: LNP Scaled LB Seismic Input in Y-Direction – El. -24

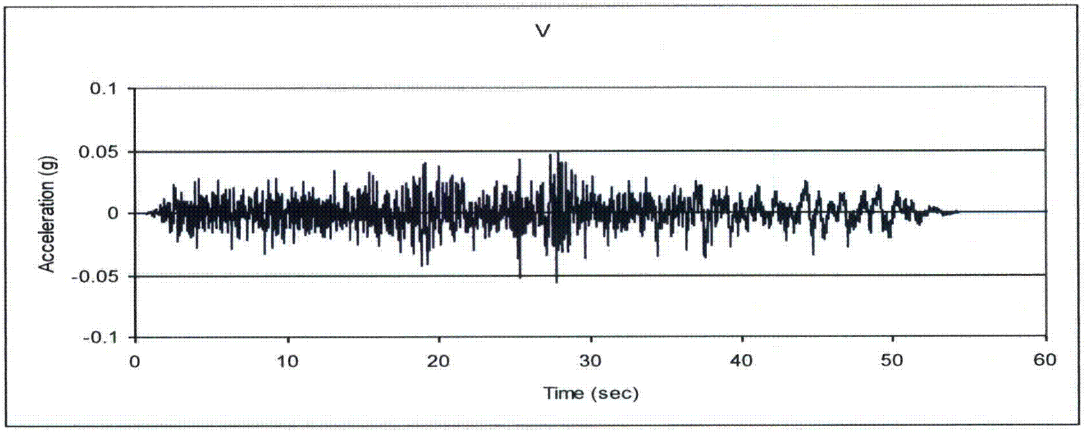

Figure 3.5-9: LNP Scaled LB Seismic Input in Z-Direction – El. -24

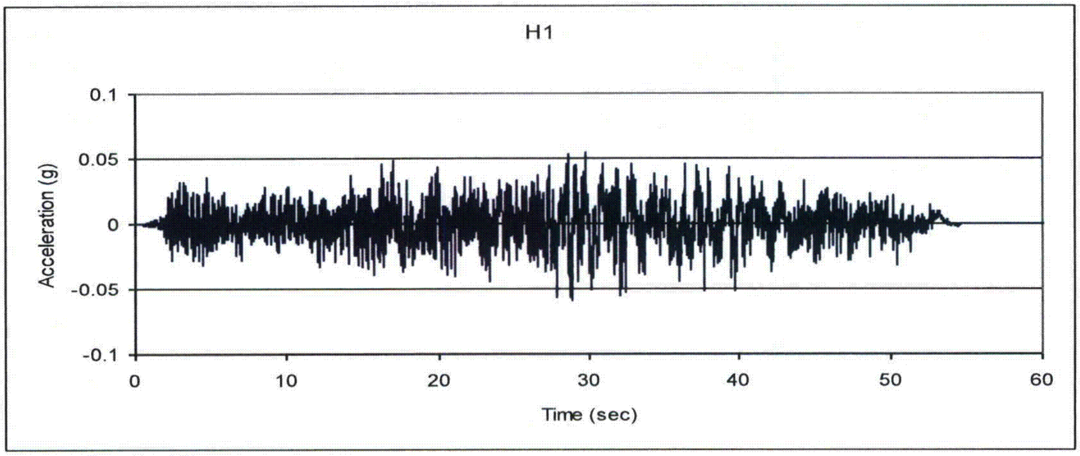

Figure 3.5-10: LNP Scaled LLB Seismic Input in X-Direction – El. -24

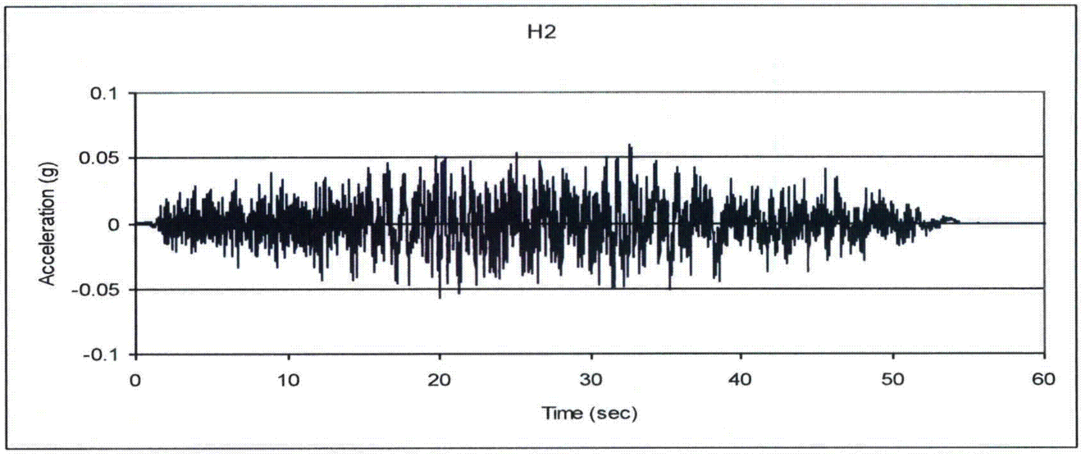

Figure 3.5-11: LNP Scaled LLB Seismic Input in Y-Direction – El. -24

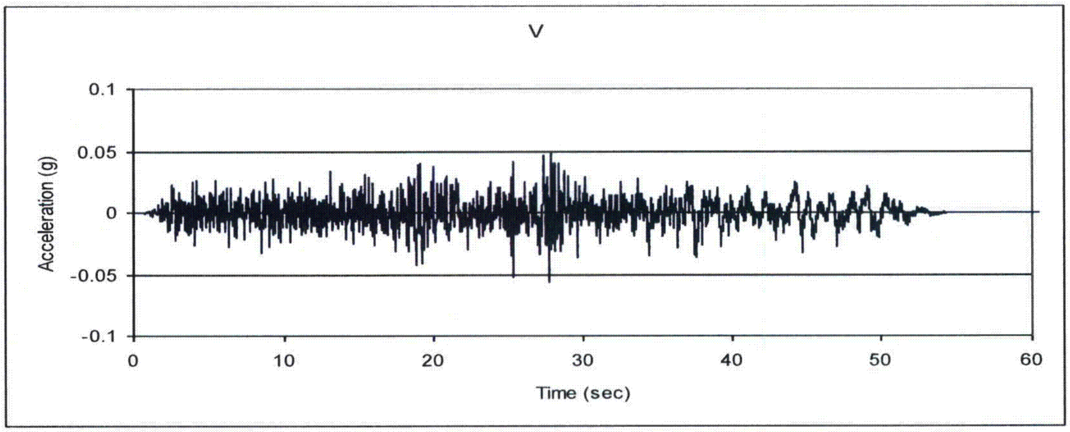

Figure 3.5-12: LNP Scaled LLB Seismic Input in Z-Direction – El. -24

3.6 AP1000 Envelope Response Spectra

The AP1000 3D FRS envelope is provided in Reference 11, and the HRHF FRS envelope (for high frequency equipment qualification) is provided in Reference 12. The LNP 3D SSI FRS are compared to the AP1000 3D and HRHF FRS envelopes at the six key locations identified in Table 3.4-1. Section 6.0 presents the comparison of LNP site specific FRS to the AP1000 and HRHF FRS envelopes.

4.0 LNP SSI Analysis Models Developed

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Table 4.1-1: [ ]a,c a,c

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Figure 4.1-1: [ ][a,c]

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Table 4.2-1: [ ]a,c

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Table 4.2-1: [ ]a,c

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4.3 [ ]^{a,c}

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4.3.1 [ ]^{a,c}

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Figure 4.3-1: [ ]^{a,c}

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Figure 4.3-2: [ ][a,c]

4.3.2 [ ]^{a,c}

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Table 4.3-1: [ ]a,c

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Table 4.3-1: [ ]a,c

Table 4.3-1: [ ]a,c

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Figure 4.3-2: [ ]^{a,c}

4.3.4 [ ]a,c

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Table 4.3-2: [ ]a,c

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Table 4.3-2: [ ]a,c

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4.4 [ ]^{a,c}

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4.4.1 [ ]^{a,c}

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Table 4.4-1: [ ]a,c a,c

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Figure 4.4-1: [ ]a,c

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Table 4.5-1: [ ]a,c

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Table 4.5-1: [ ]a,c

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5.0 LNP Site Specific SSI Analysis Methods

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6.0 LNP Site Specific SSI Analyses Results

6.1 [ ]a,c

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Figure 6.1-1: [ ]a,c

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Figure 6.1-2: [ ]a,c

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Figure 6.1-3: [ ]^a,c

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Figure 6.1-4: [ ]^a,c

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Figure 6.1-5: [ ]a,c

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Figure 6.1-6: [ ]a,c

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Figure 6.1-7: [ ]a,c

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Figure 6.1-8: [ ]a,c

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Figure 6.1-9: [ ]a,c

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Figure 6.1-10: [ ]a,c

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Figure 6.1-11: [ ]a,c

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Figure 6.1-12: [ ]a,c

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Figure 6.1-13: [ ]a,c

a,c

Figure 6.1-14: [ ]a,c

6.2 LNP 3D BE Factored Design-Basis SSI Analysis Results

Time history seismic analyses for the LNP 5-Layer Design-Basis model and the LNP BE case were performed in two horizontal and one vertical direction. The LNP base of excavation (El. -24) input time histories were used in SASSI with the SASSI Direct method of analysis. FRS for 5 percent damping were obtained at the six key NI locations shown in Table 3.4-1. The horizontal and vertical Bump Factors are applied along the frequency spectrum to amplify the LNP 3D BE Design-Basis FRS.

Figures 6.2-1 through 6.2-18 present the horizontal and vertical LNP 3D BE Design-Basis Factored FRS compared to the 3D AP1000 and HRHF (as necessary) FRS envelopes at the six (6) key locations. The HRHF FRS envelope is presented for 3D Nodes 2078, 2199 and 2675 to demonstrate that additional and significant margin exists at these nodes in the high frequency range (20-50 Hz). As shown, the LNP site specific FRS are enveloped by the AP1000 and HRHF FRS envelopes at each of the six key NI locations with sufficient margin to account for variation in the modeling, material properties, and seismic analysis technique.

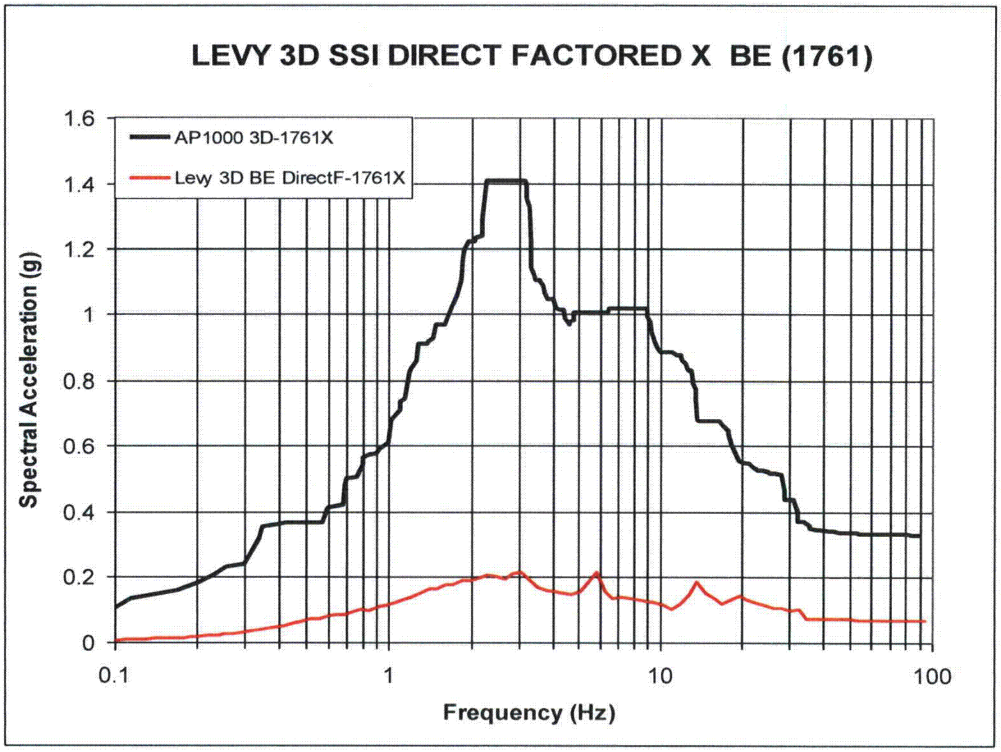

Figure 6.2-1: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in X-Direction – Node 1761

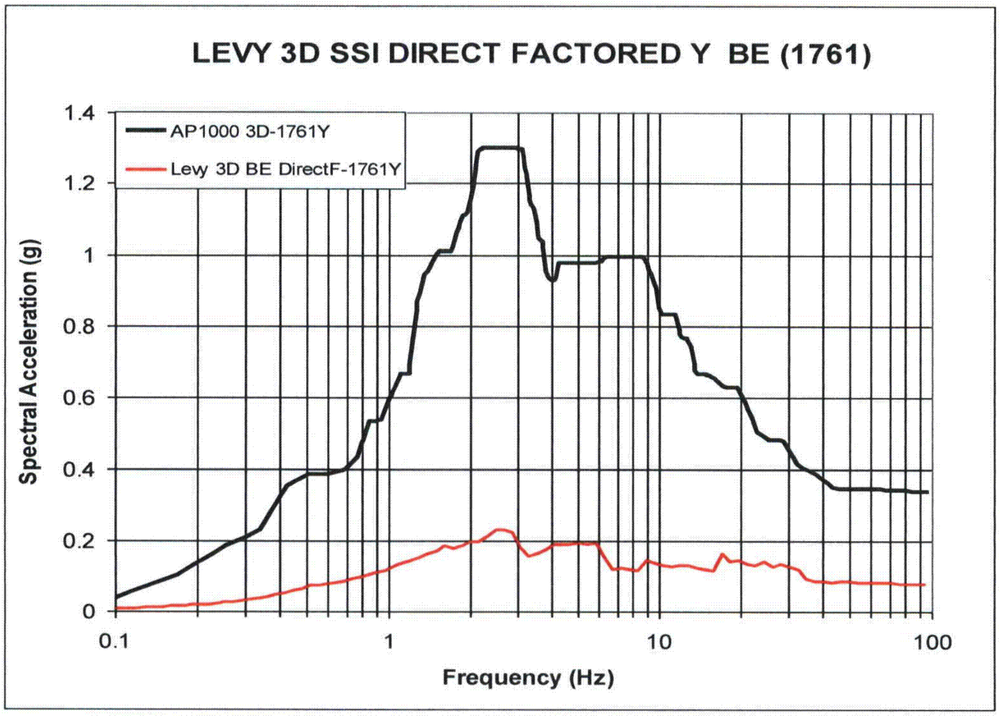

Figure 6.2-2: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in Y-Direction – Node 1761

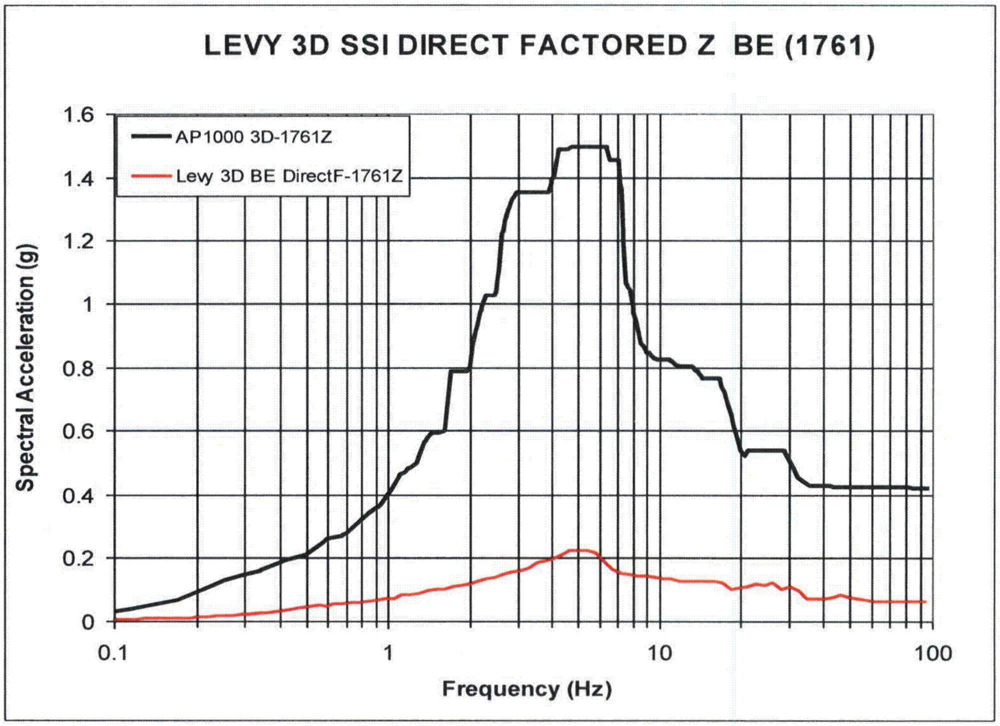

Figure 6.2-3: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in Z-Direction – Node 1761

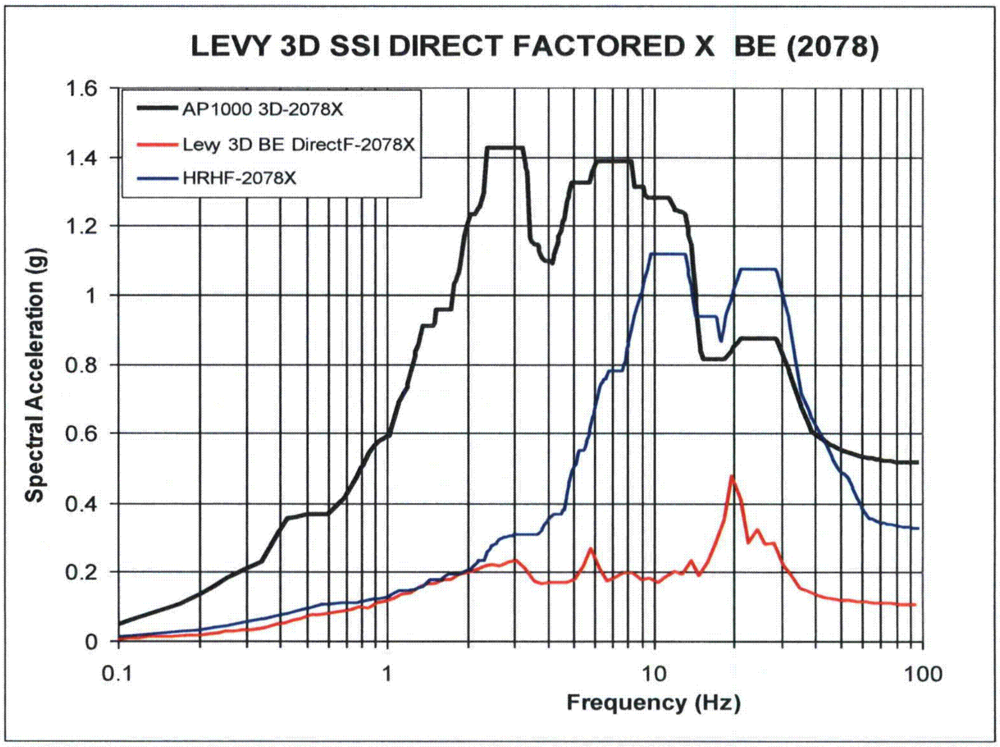

Figure 6.2-4: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in X-Direction – Node 2078

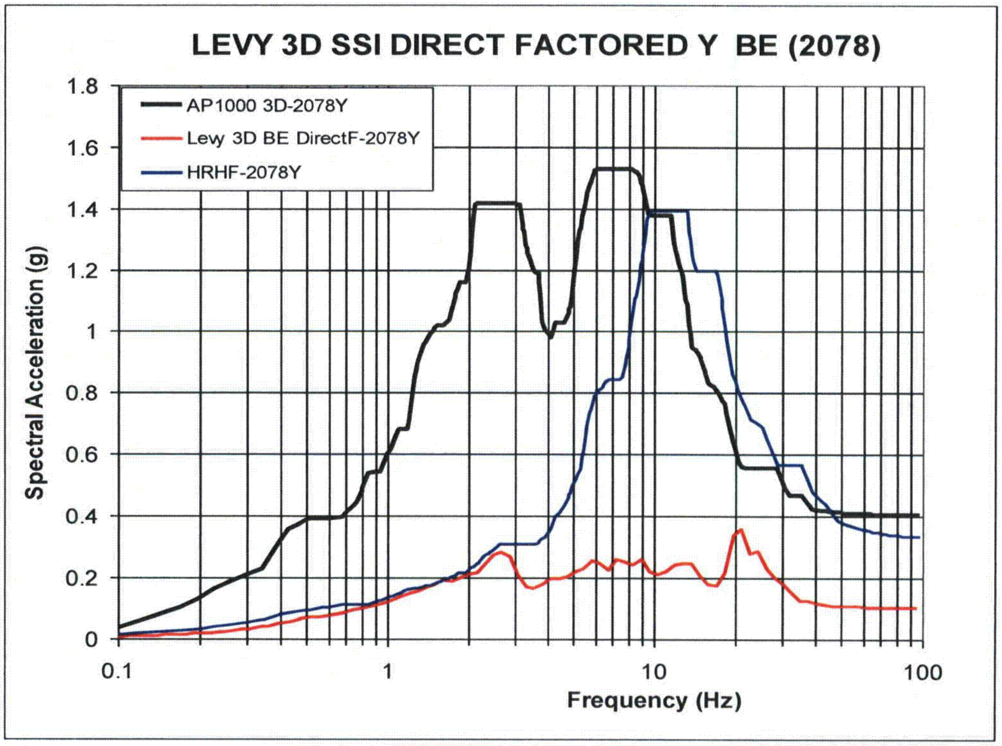

Figure 6.2-5: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in Y-Direction – Node 2078

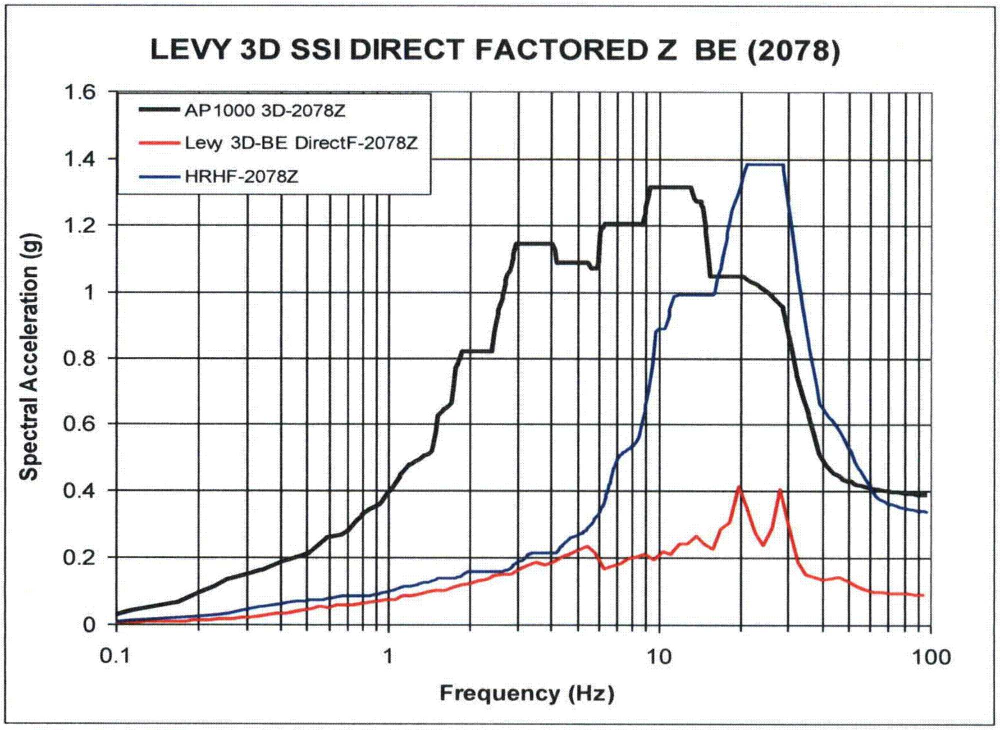

Figure 6.2-6: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in Z-Direction – Node 2078

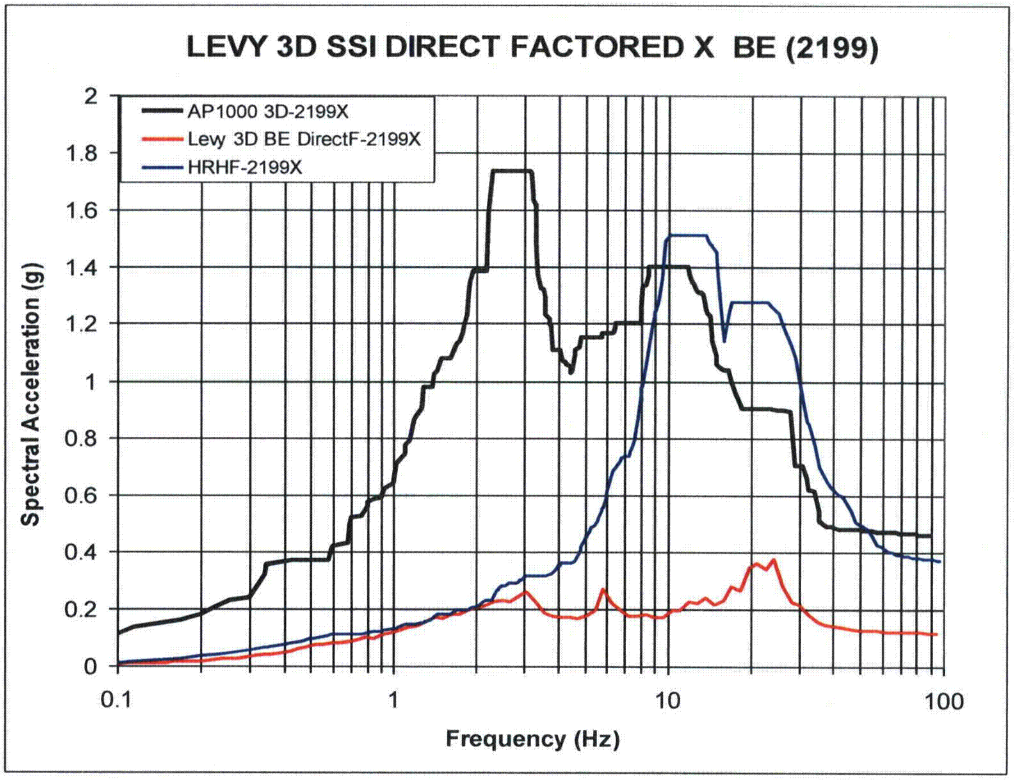

Figure 6.2-7: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in X-Direction – Node 2199

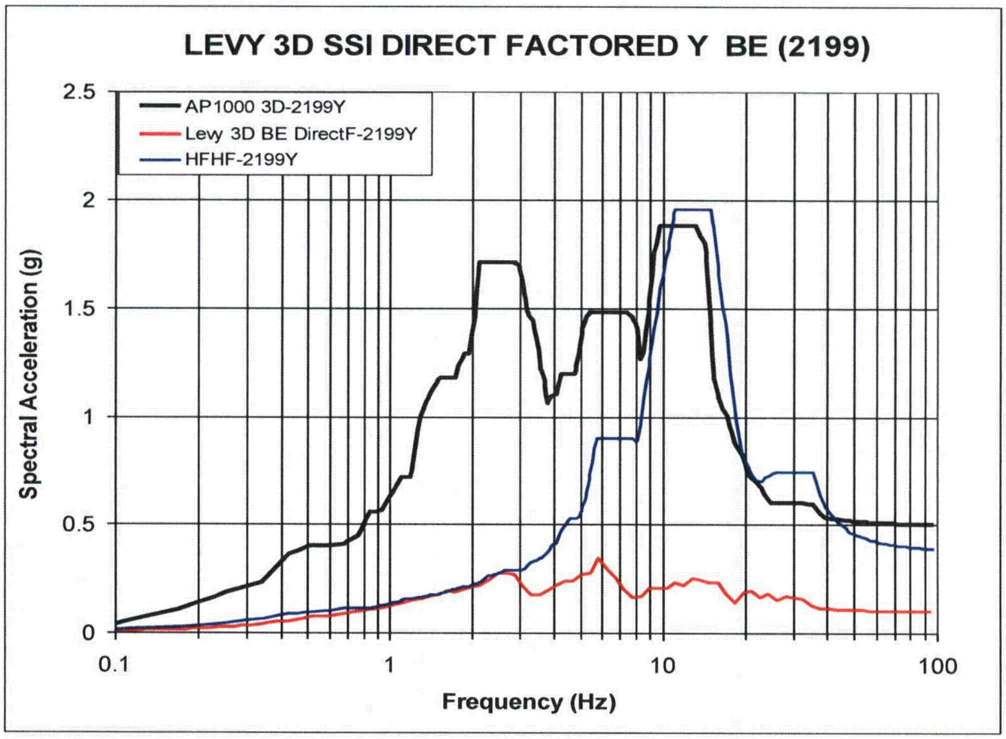

Figure 6.2-8: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in Y-Direction – Node 2199

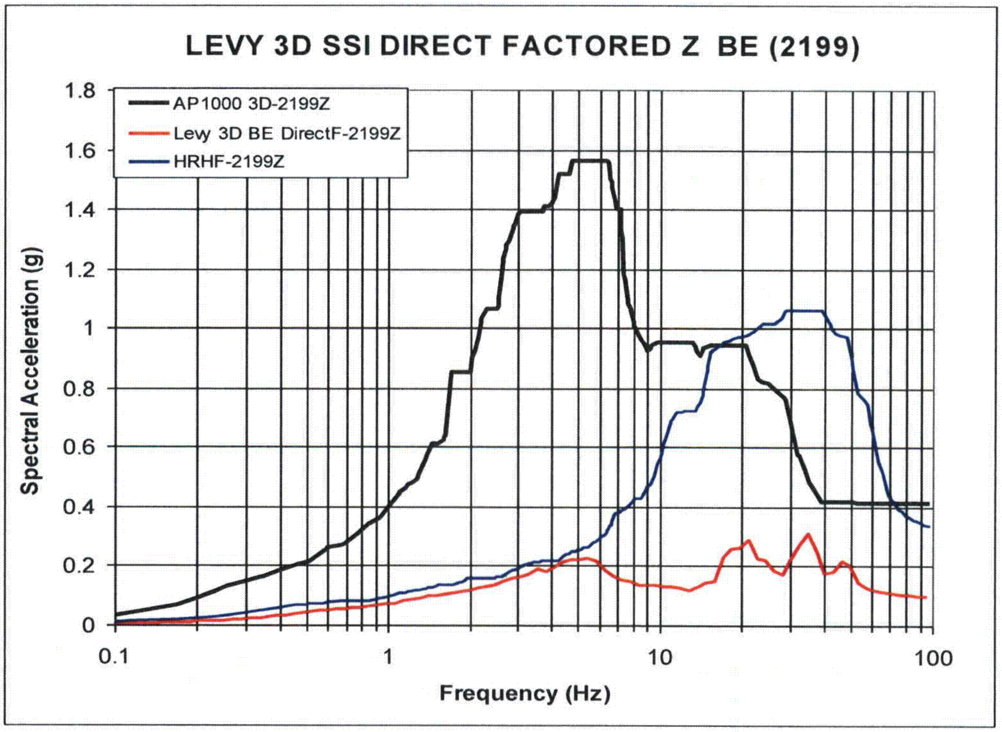

Figure 6.2-9: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in Z-Direction – Node 2199

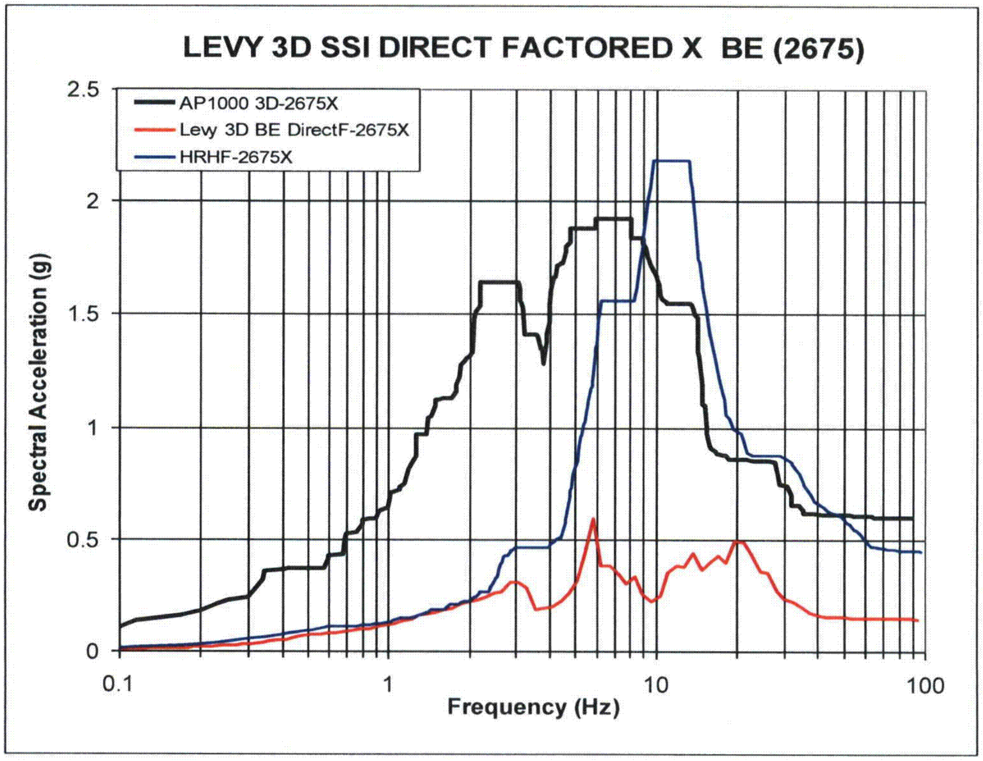

Figure 6.2-10: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in X-Direction – Node 2675

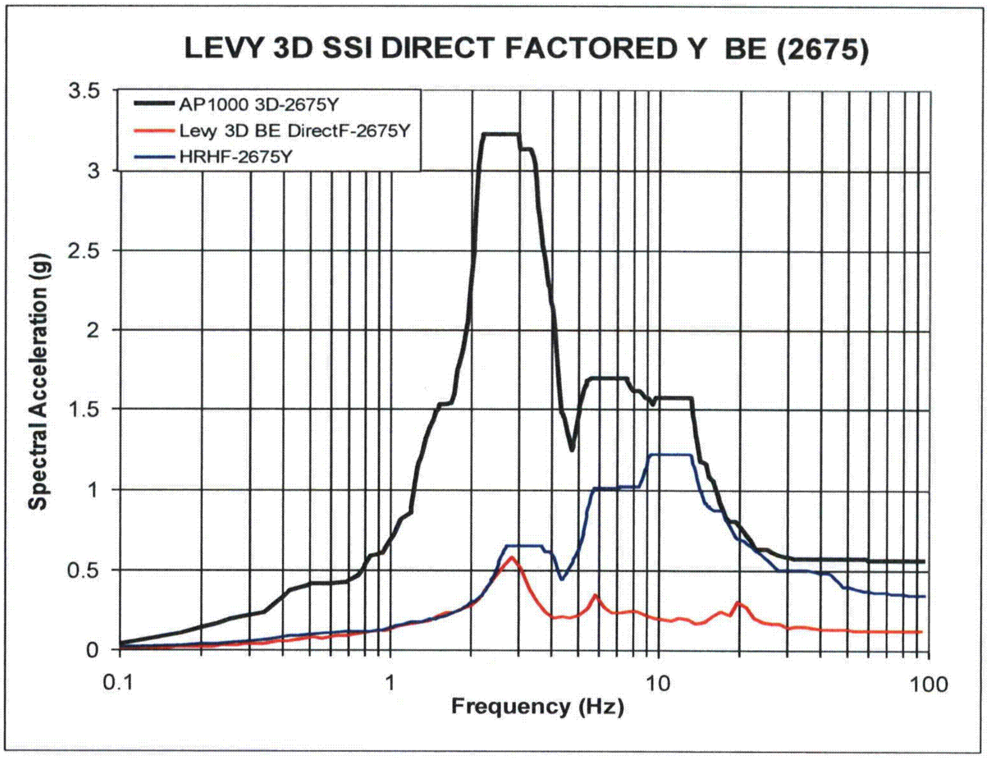

Figure 6.2-11: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in Y-Direction – Node 2675

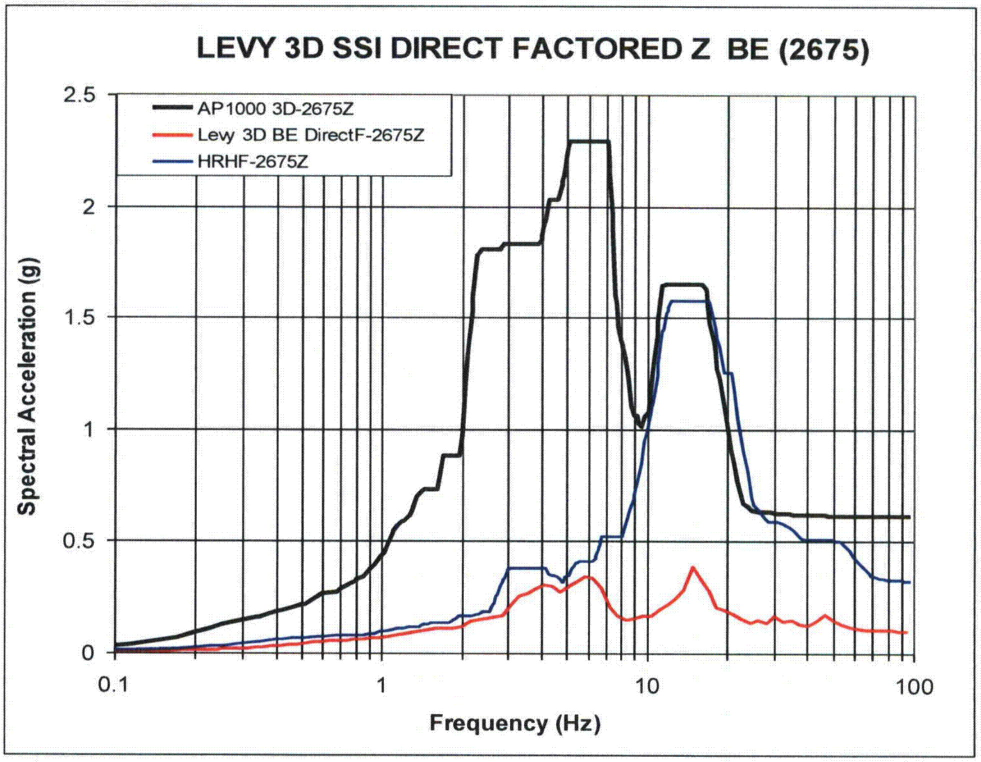

Figure 6.2-12: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in Z-Direction – Node 2675

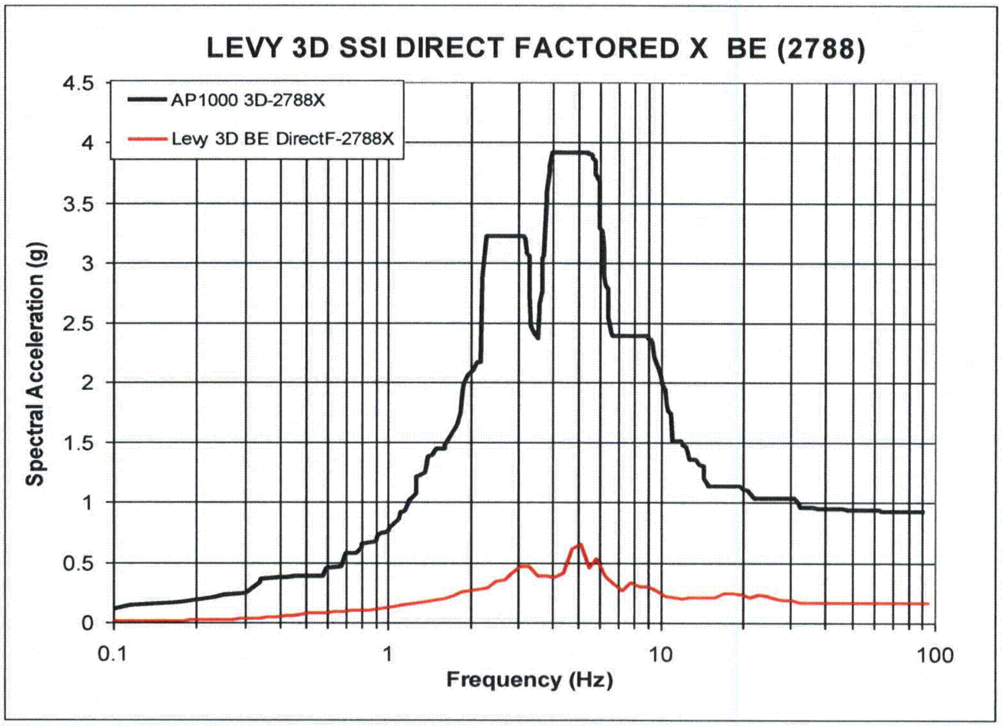

Figure 6.2-13: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in X-Direction – Node 2788

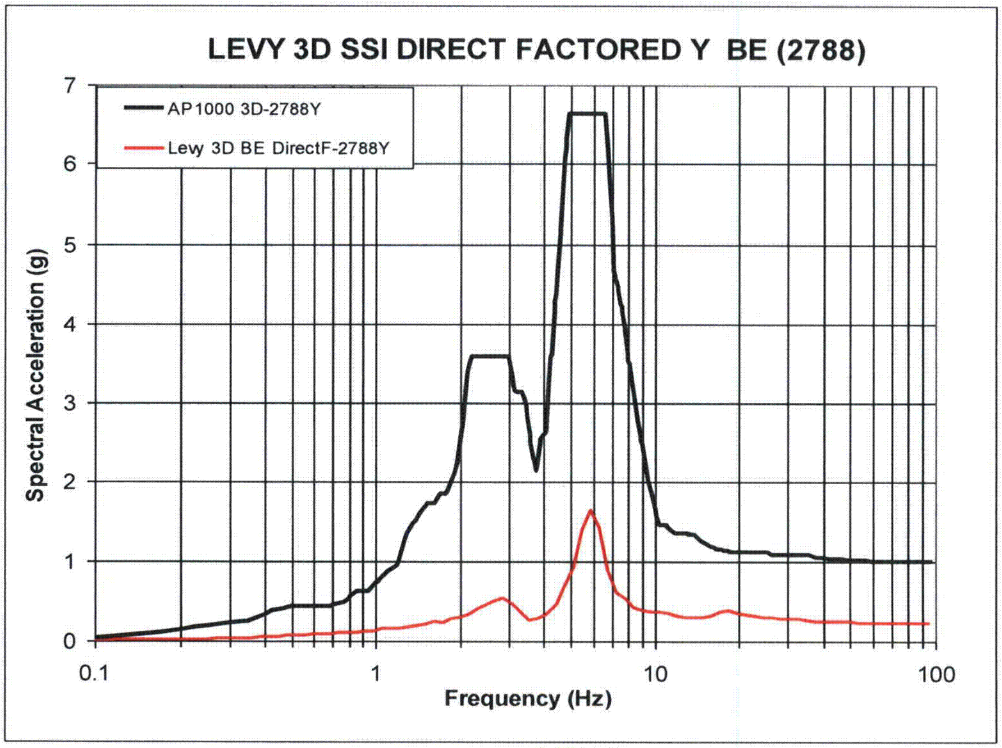

Figure 6.2-14: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in Y-Direction – Node 2788

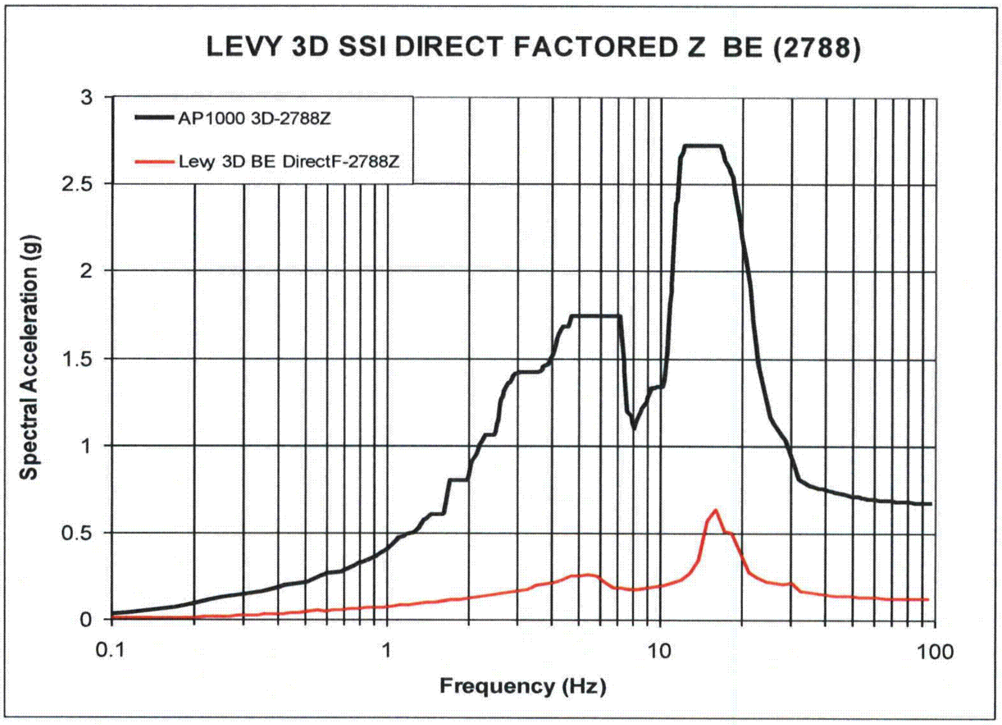

Figure 6.2-15: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in Z-Direction – Node 2788

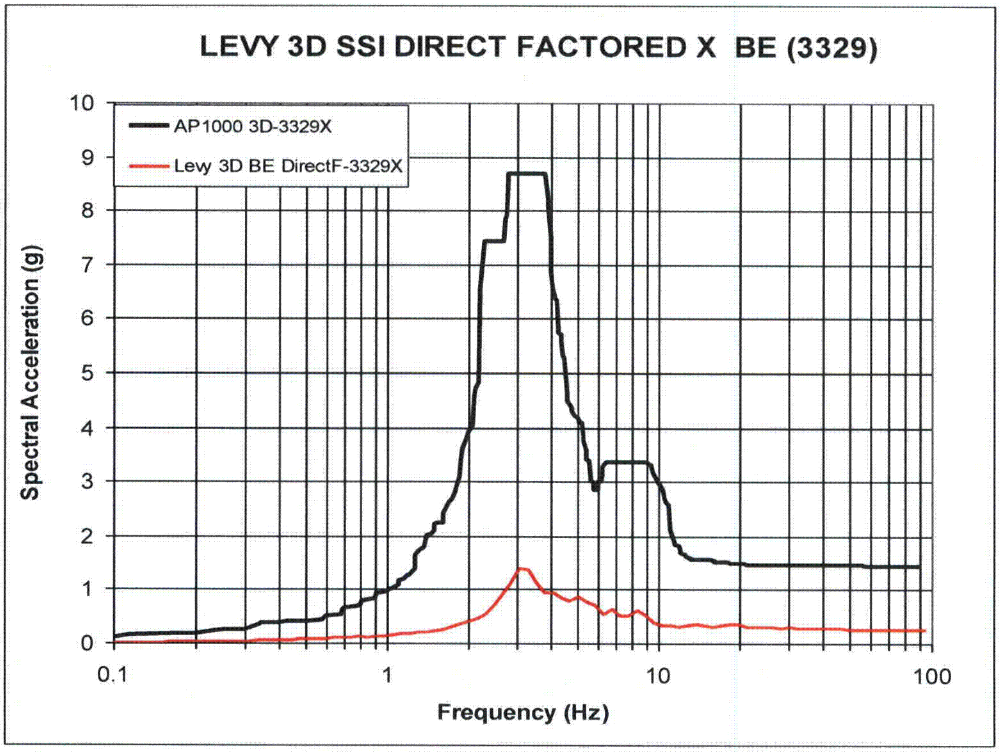

Figure 6.2-16: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in X-Direction – Node 3329

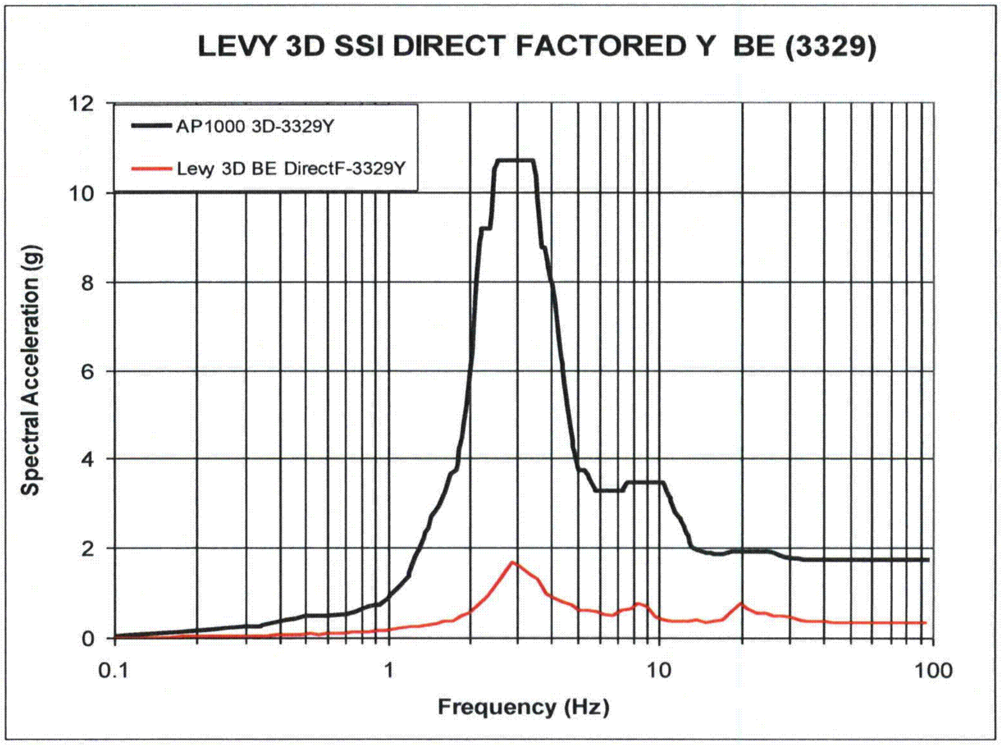

Figure 6.2-17: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope Y-Direction – Node 3329

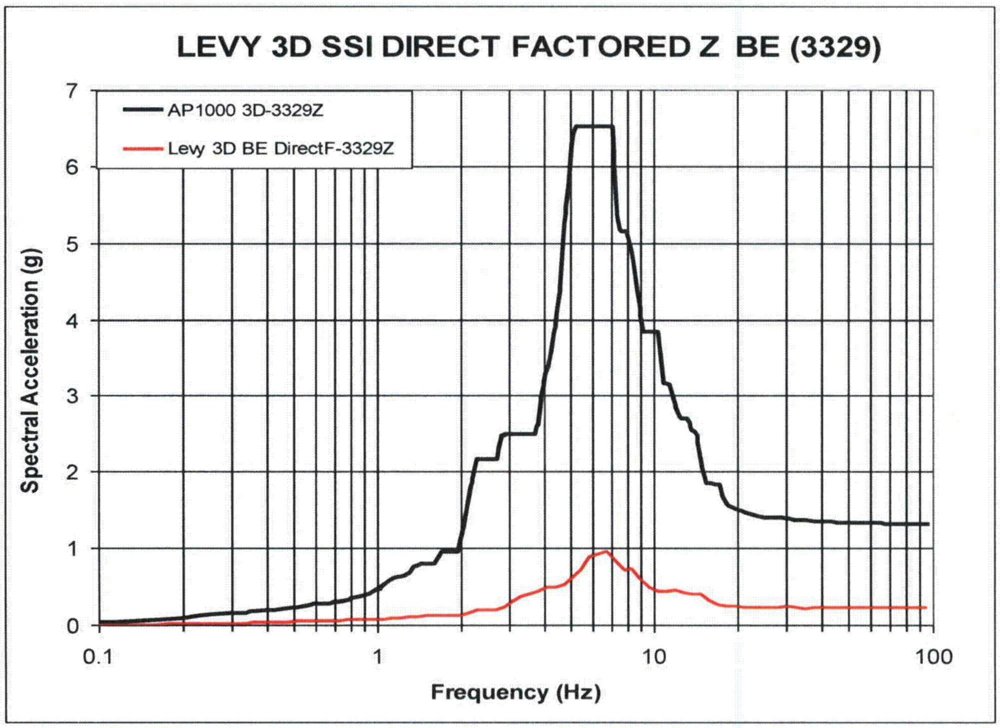

Figure 6.2-18: LNP 3D BE Design-Basis FRS and AP1000 FRS Envelope in Z-Direction – Node 3329

6.3 LNP 3D BE, UB, LB and LLB SSI Sensitivity Analysis Results

LNP Sensitivity SSI analyses were performed to demonstrate the BE soil case is bounding at the high frequency (33 Hz) versus the UB, LB and LLB soil cases, and the results of the these analyses confirm that the BE case is generally the controlling soil case.

Time history seismic analyses using the LNP 8-Layer Sensitivity model and the LNP BE, UB, LB and LLB cases were performed in two horizontal and one vertical direction. The LNP base of excavation (El. -24) input time histories were used in SASSI in conjunction with the Subtraction method. FRS for 5 percent damping were obtained at the six key NI locations shown in Table 3.4-1.

Figures 6.3-1 through 6.3-18 present the horizontal and vertical LNP FRS envelopes and the individual FRS for the LNP BE, UB, LB and LLB soil cases compared to the AP1000 FRS envelope at the six (6) key locations. As shown, the AP1000 FRS envelops the LNP site specific FRS and broadened LNP FRS at each of the six key NI nodes. Also, the LNP BE FRS is generally the bounding case of the LNP BE, UB, LB and LLB soil cases evaluated, and for nodes where the BE case is not the bounding case, there exists significant margin when compared to the AP1000 FRS envelope.

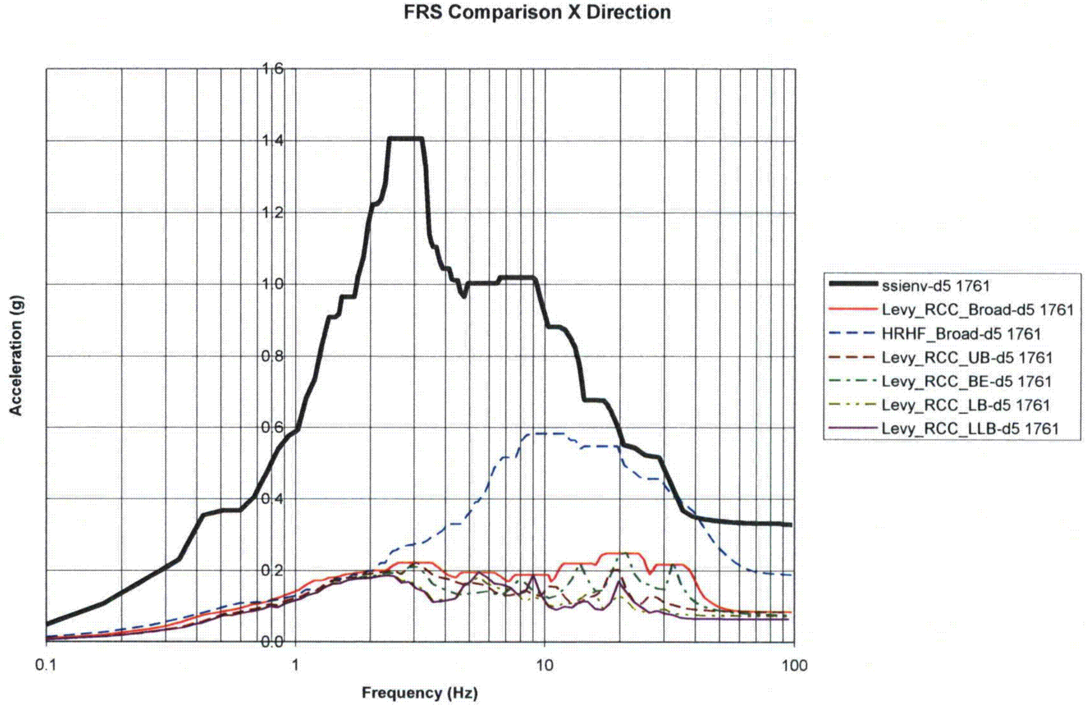

Figure 6.3-1: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in X-Direction – Node 1761

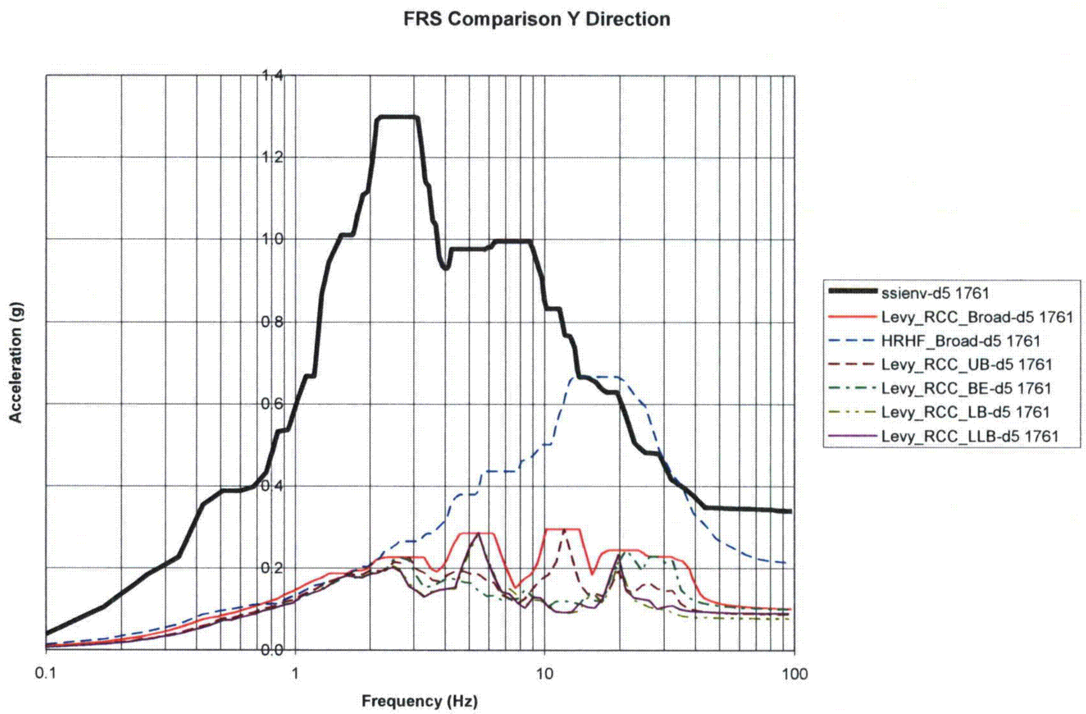

Figure 6.3-2: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in Y-Direction – Node 1761

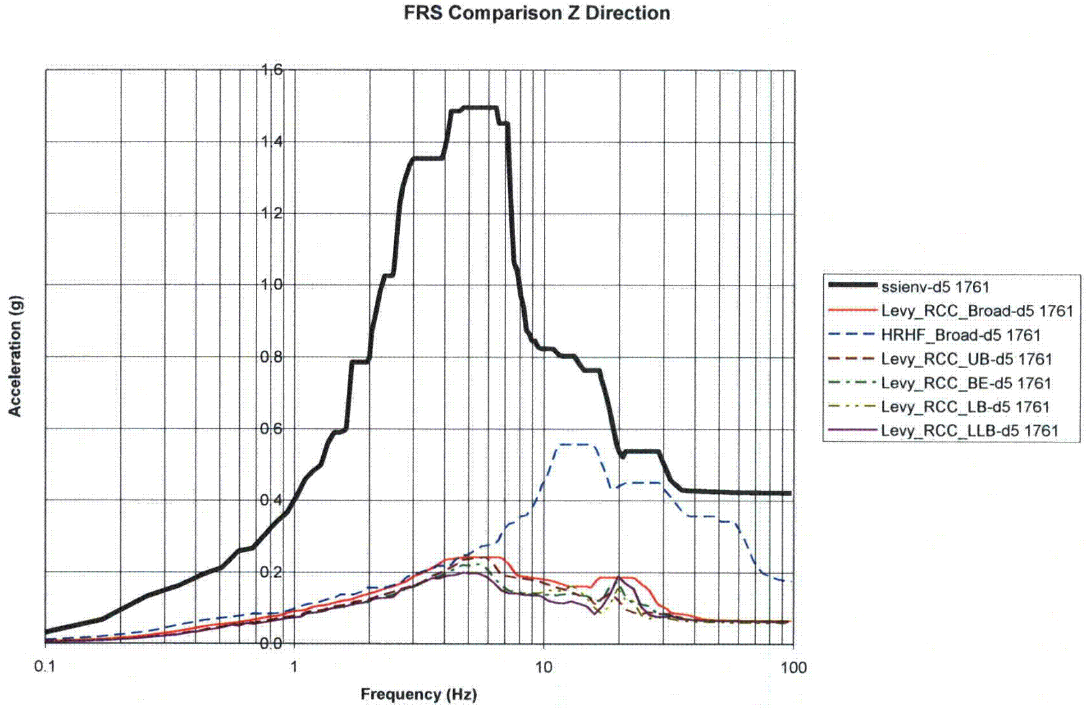

Figure 6.3-3: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in Z-Direction – Node 1761

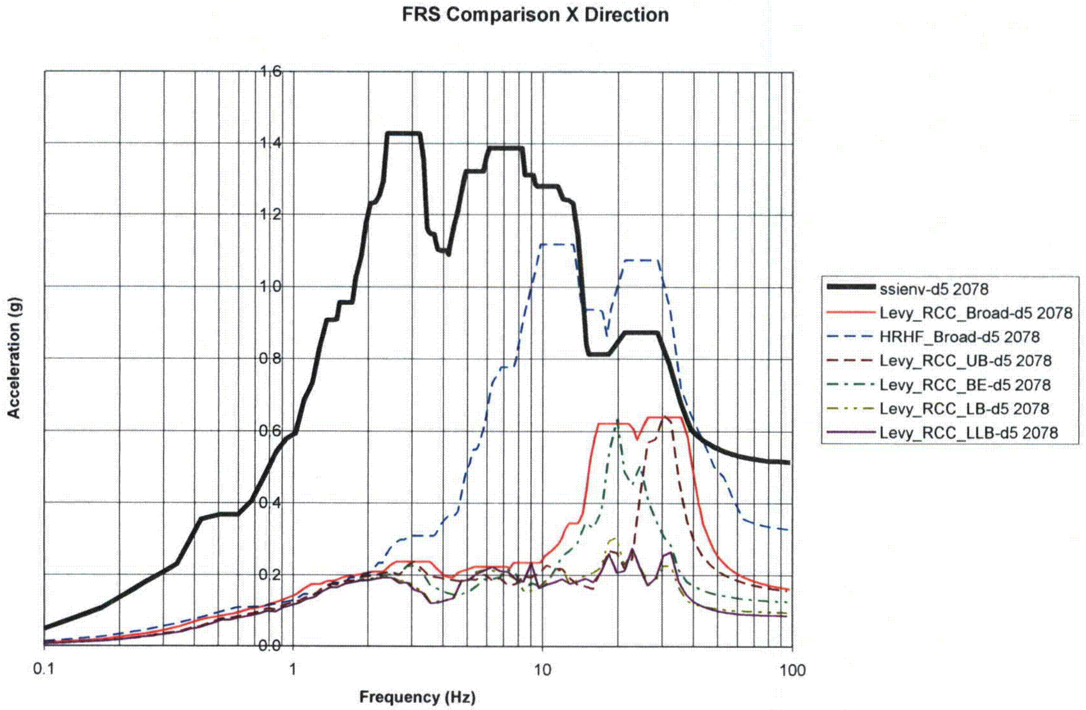

Figure 6.3-4: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in X-Direction – Node 2078

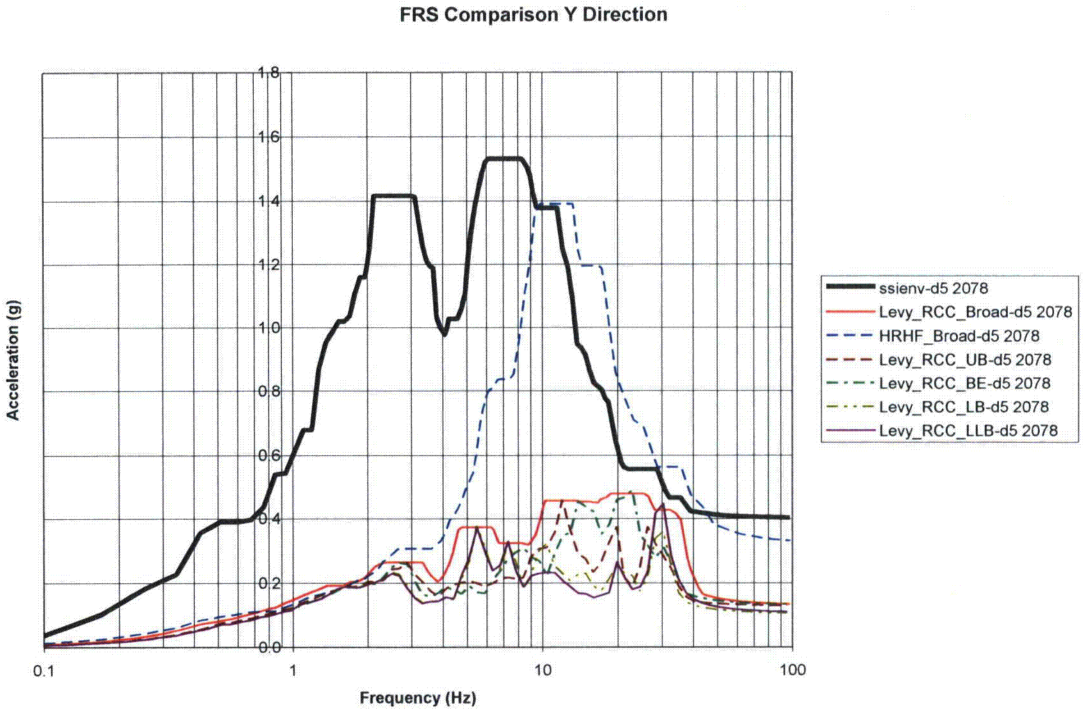

Figure 6.3-5: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in Y-Direction – Node 2078

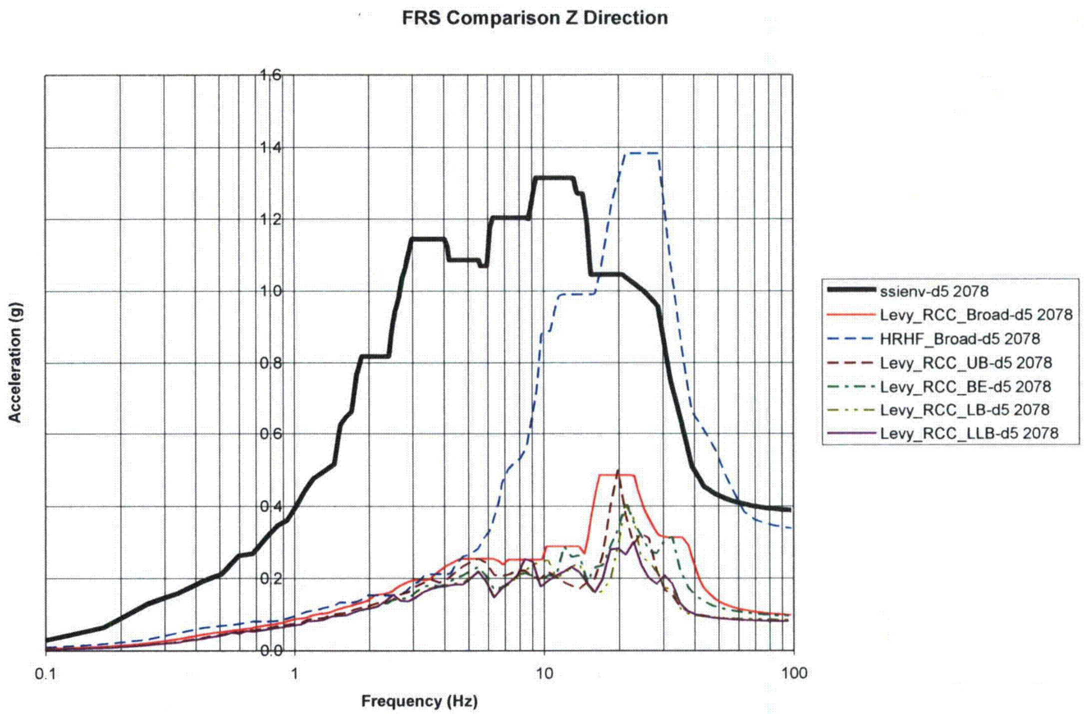

Figure 6.3-6: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in Z-Direction – Node 2078

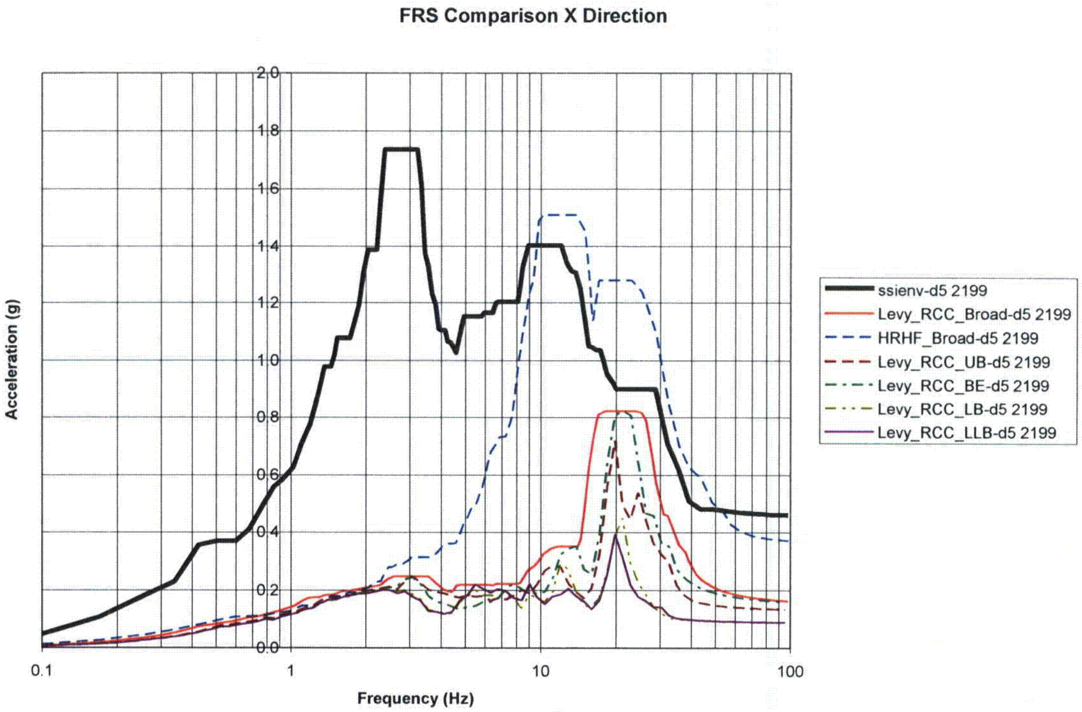

Figure 6.3-7: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in X-Direction – Node 2199

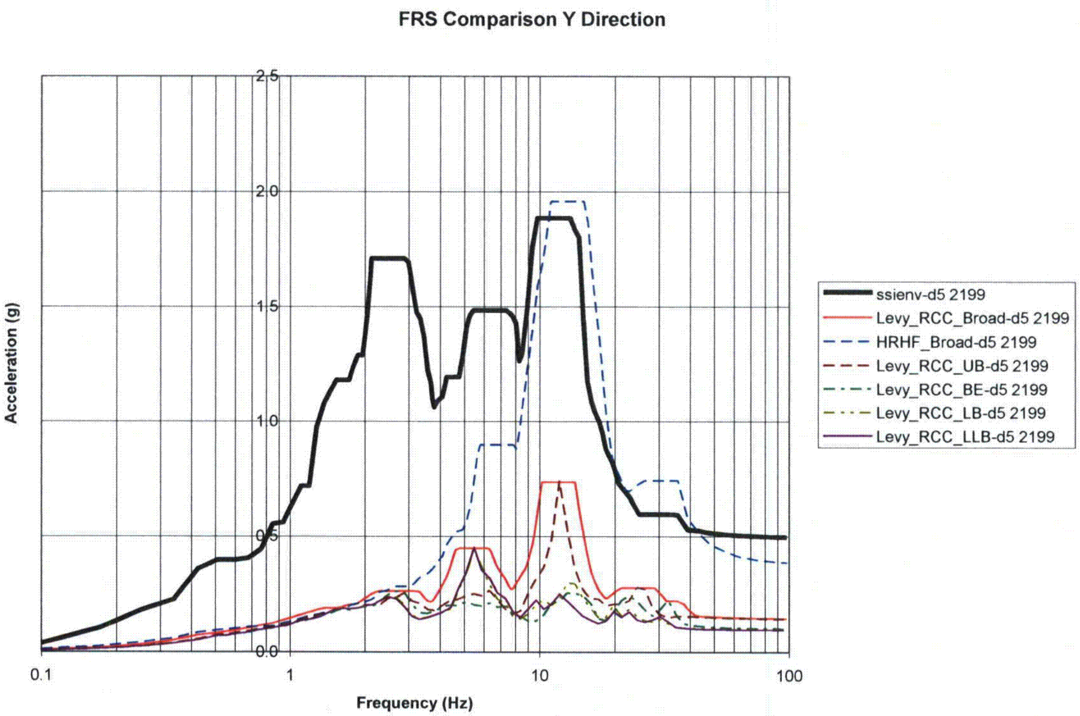

Figure 6.3-8: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in Y-Direction – Node 2199

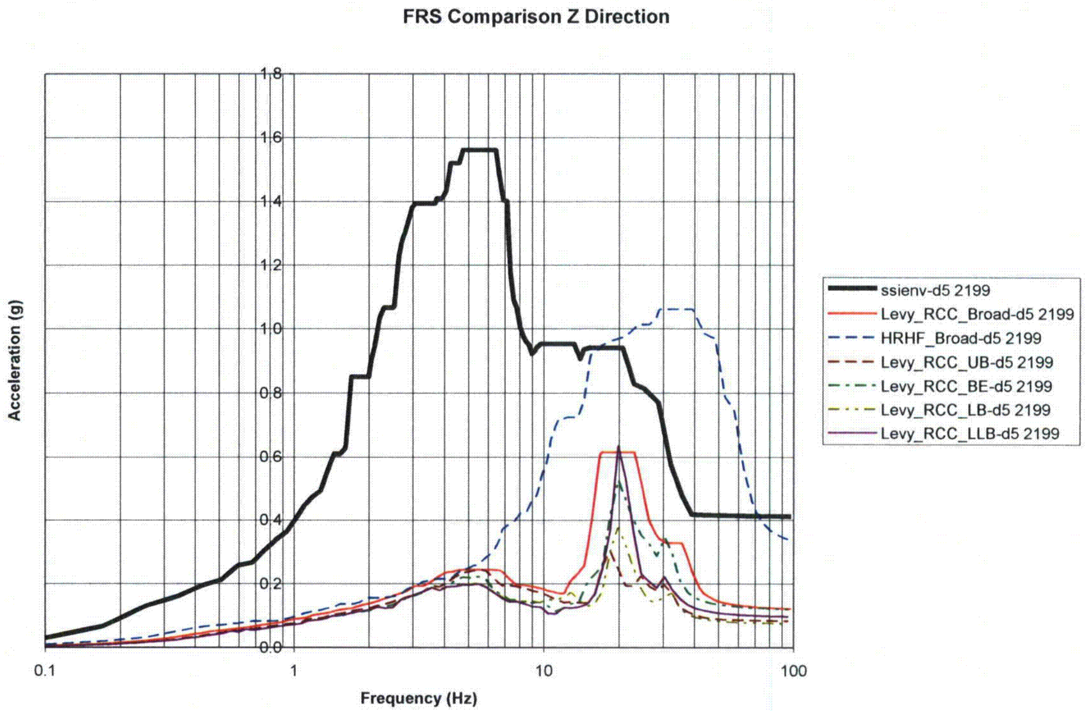

Figure 6.3-9: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in Z-Direction – Node 2199

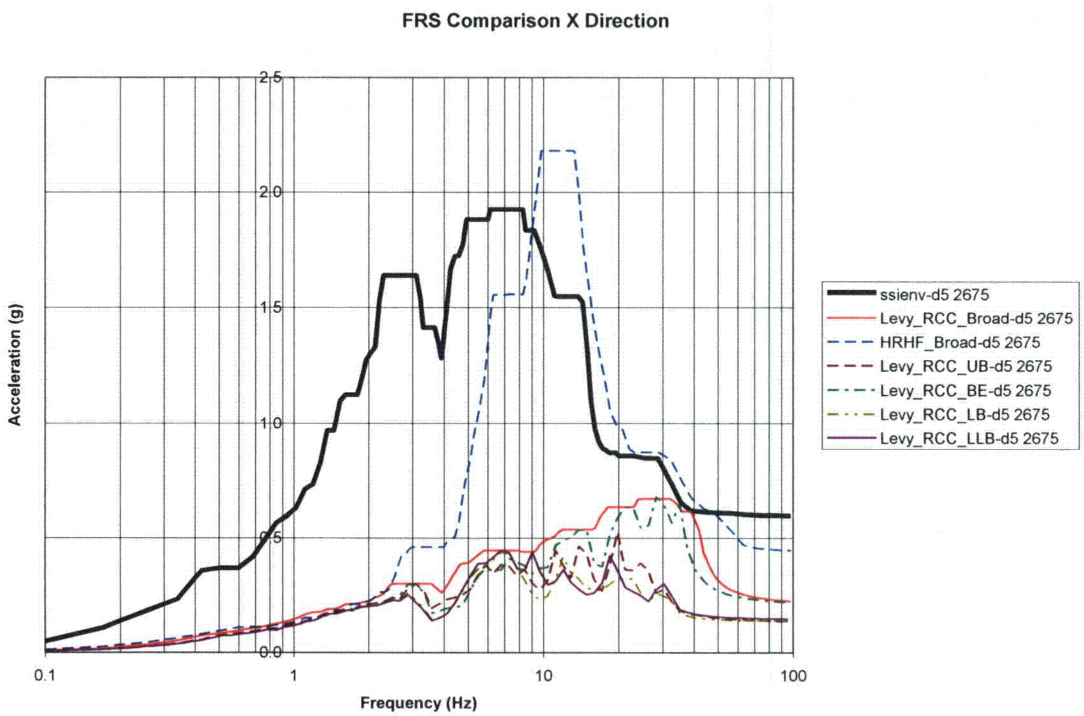

Figure 6.3-10: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in X-Direction – Node 2675

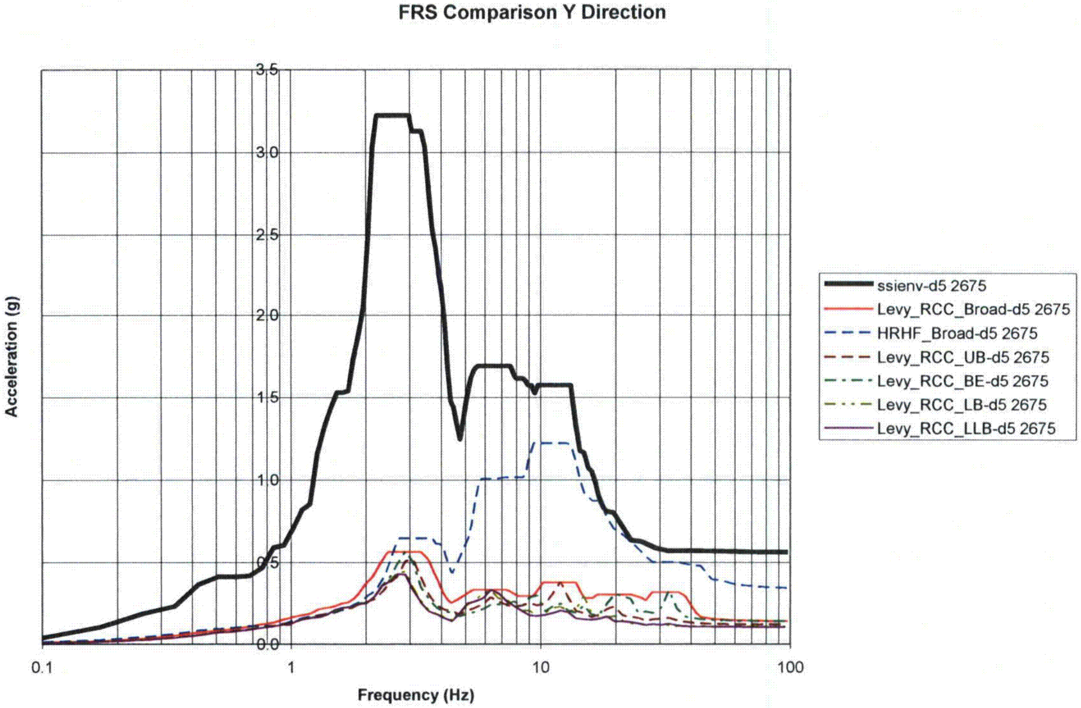

Figure 6.3-11: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in Y-Direction – Node 2675

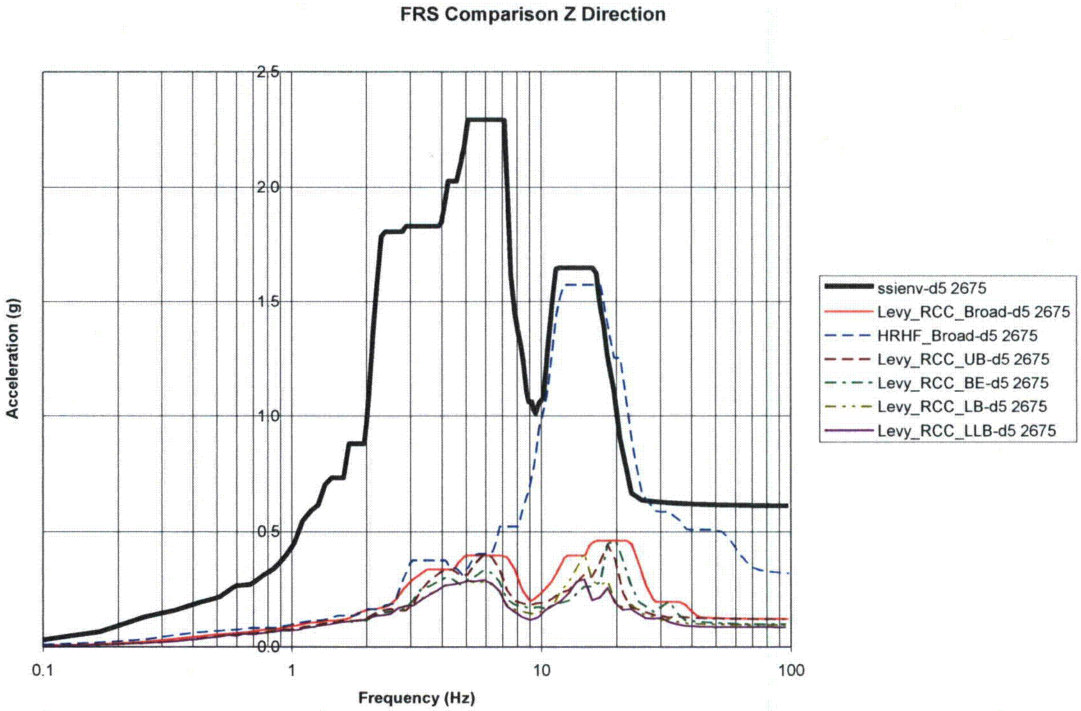

Figure 6.3-12: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in Z-Direction – Node 2675

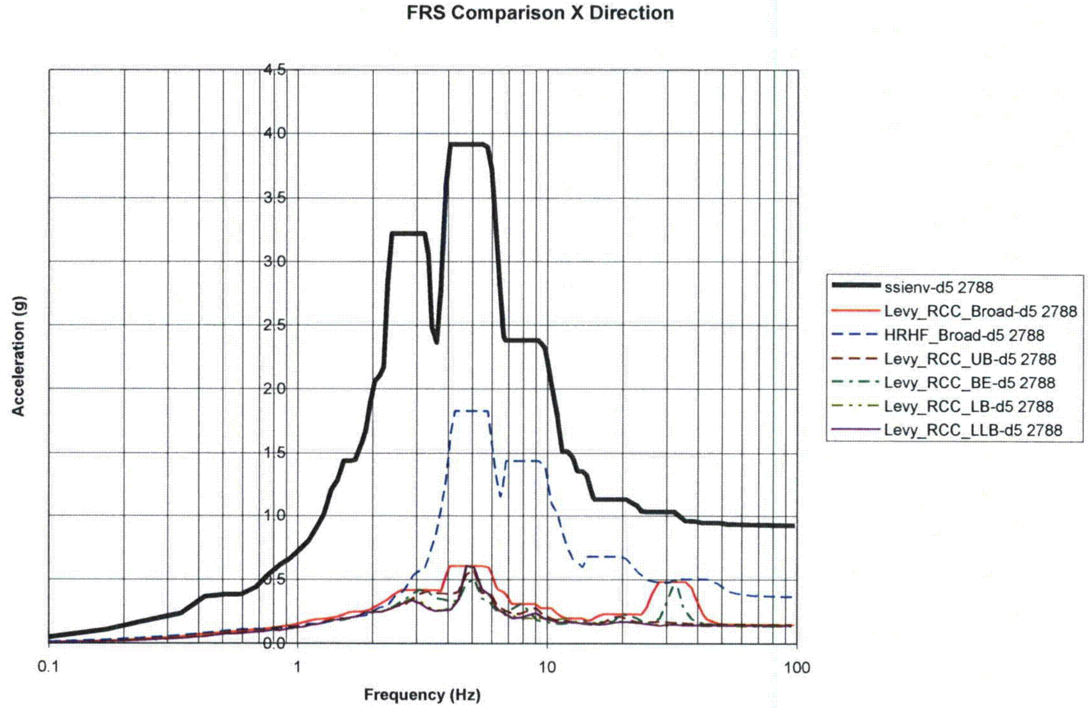

Figure 6.3-13: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in X-Direction – Node 2788

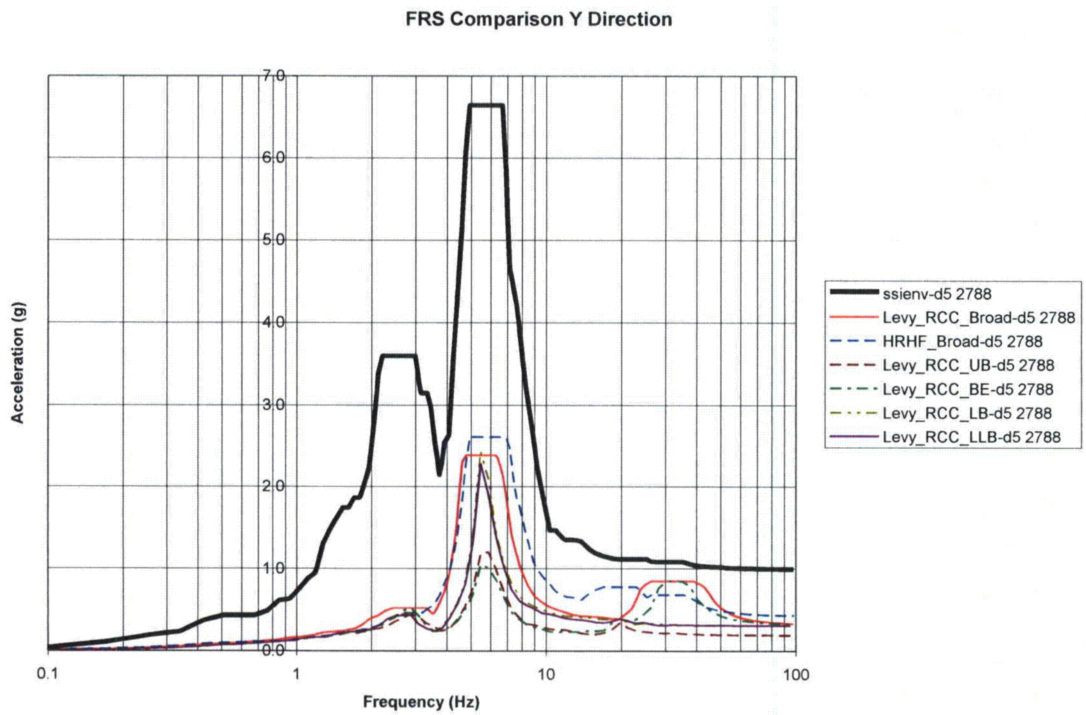

Figure 6.3-14: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in Y-Direction – Node 2788

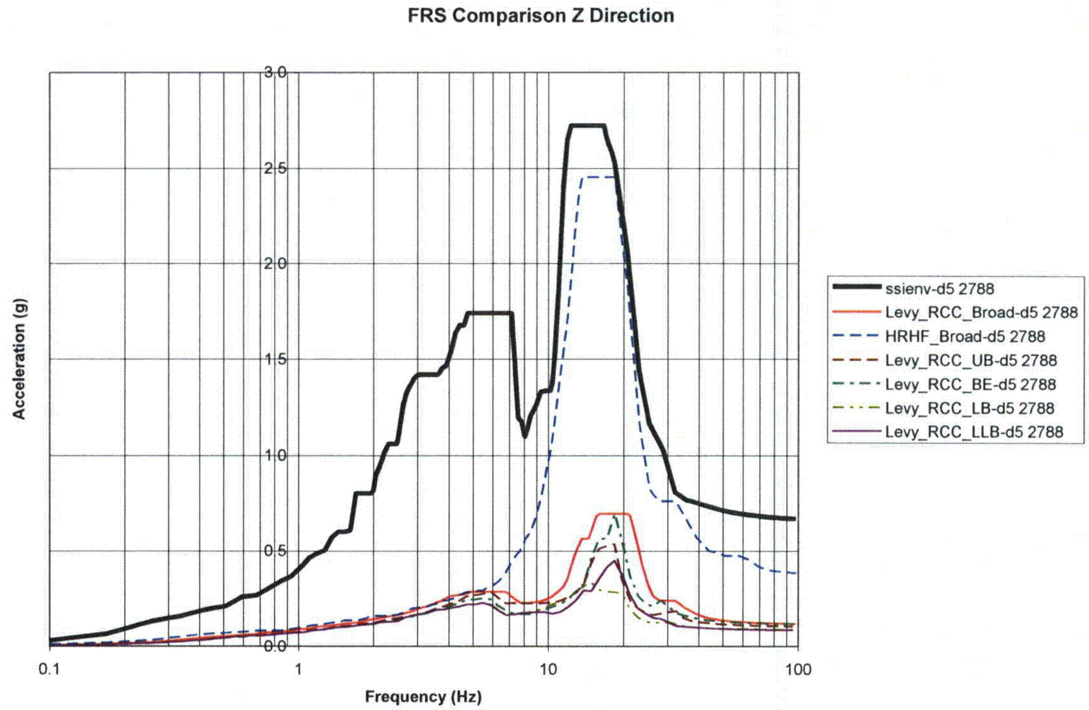

Figure 6.3-15: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in Z-Direction – Node 2788

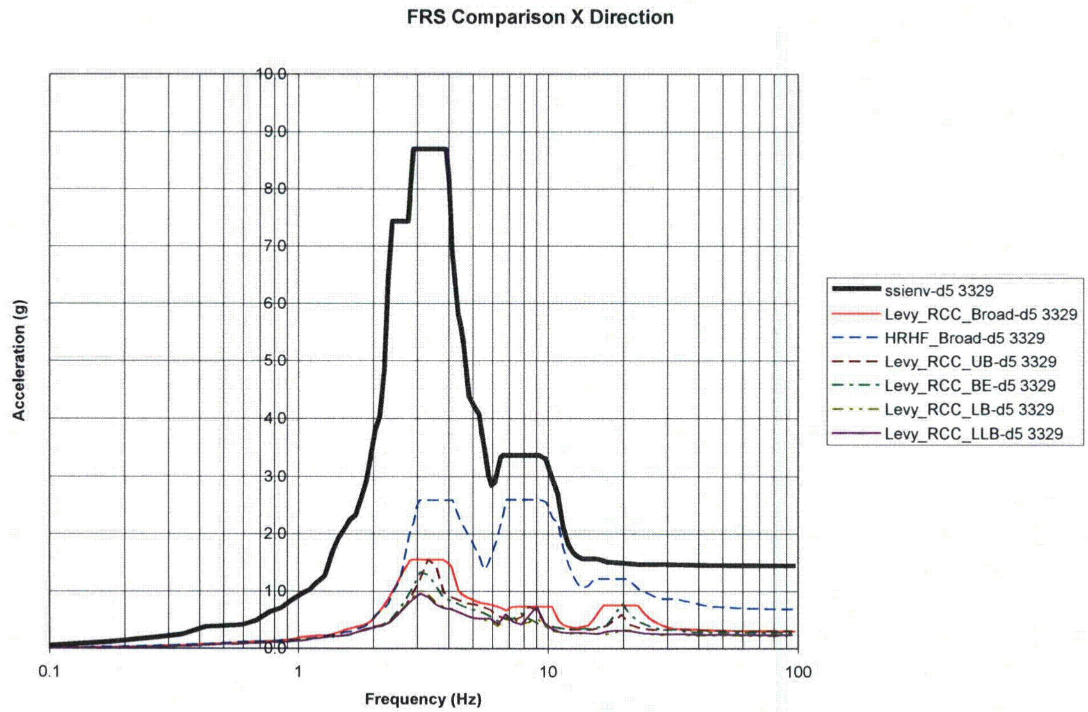

Figure 6.3-16: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in X-Direction – Node 3329

FRS Comparison Y Direction

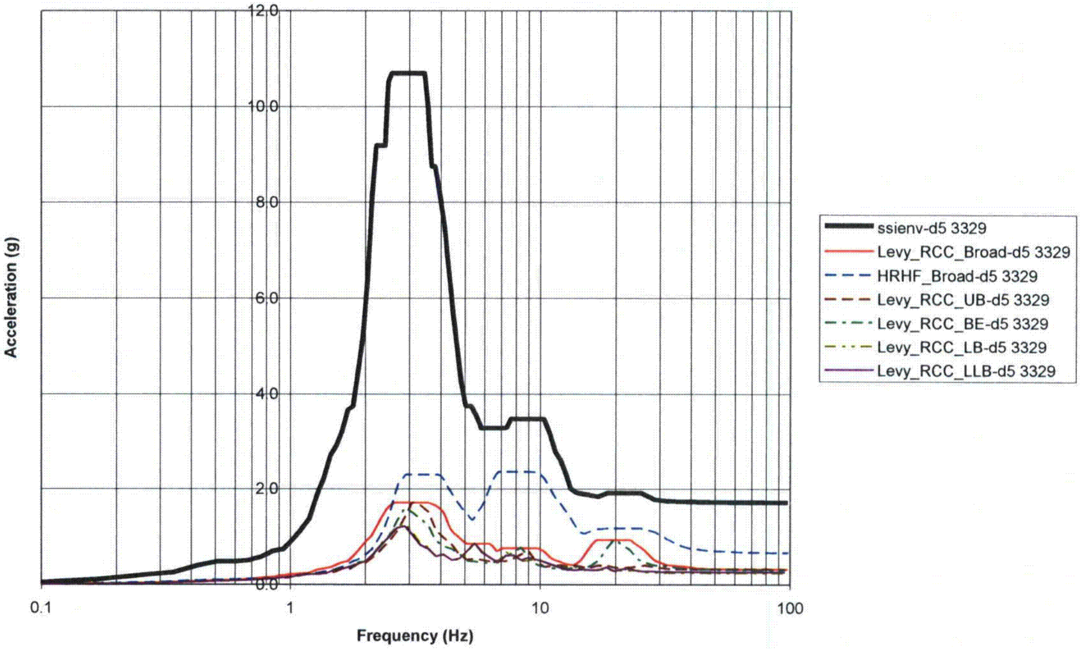

Figure 6.3-17: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope Y-Direction – Node 3329

FRS Comparison Z Direction

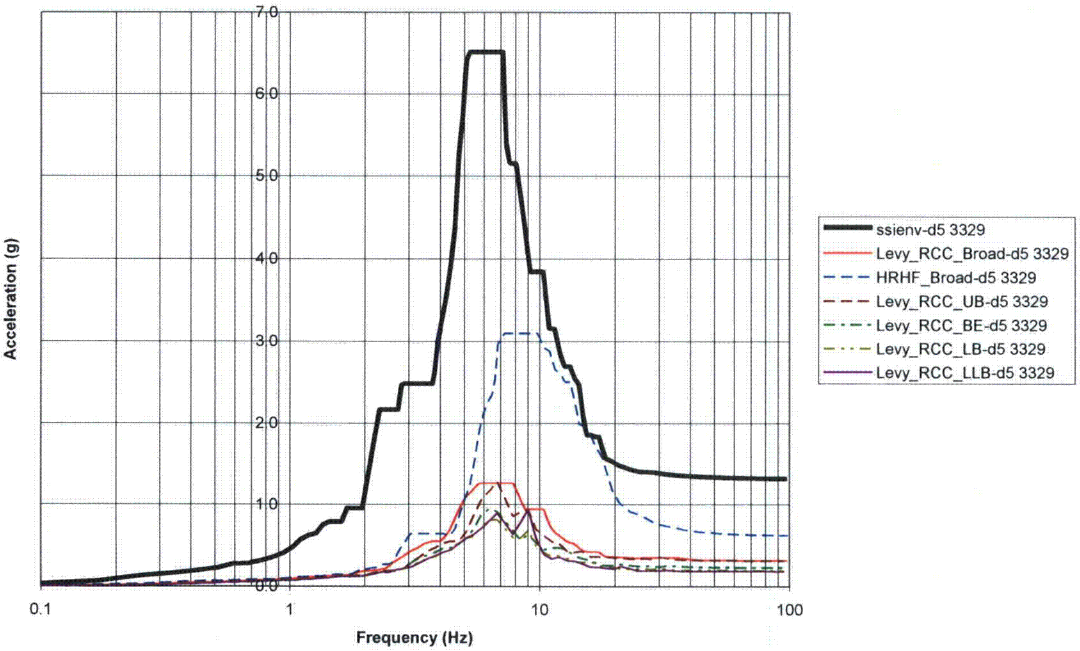

Figure 6.3-18: LNP BE, UB, LB and LLB FRS and AP1000 FRS Envelope in Z-Direction – Node 3329

6.4 [ ]a,c

[

]a,c

6.5 [ ]a,c

[

]a,c

Table 6.5-1: [ ]a,c

a,c

6.6 [ ]^{a,c}

[

]^{a,c}

7.0 Conclusions

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

- The LNP 3D BE Factored Design-Basis FRS are enveloped by the AP1000 3D and HRHF (high frequency) FRS envelope with sufficient margin;
- The LNP BE maximum bearing pressure of 20.07 ksf is less than the AP1000 bearing pressure of 35 ksf; and
- The LNP BE τ/σ ratio of 0.17 is less than the 0.55 τ/σ allowable based on the maximum base shear force of 110.5 thousand kips, maximum bearing pressure of 20.07 ksf and 32,480 square-foot basemat area.

8.0 [ ]a,c

[

]a,c

Appendix A: [ ]a,c

[

]a,c

a,c

Figure A-1: [ ]a,c

a,c

Figure A-2: [ ]a,c

a,c

Figure A-3: [ ][a,c]

a,c

Figure A-4: [ ][a,c]

a,c

Figure A-5: [ ]a,c

a,c

Figure A-6: [ ]a,c

a,c

Figure A-7: [ ]a,c

a,c

Figure A-8: [ ]a,c

a,c

Figure A-9: [ ]a,c

a,c

Figure A-10: [ ]a,c

a,c

Figure A-11: [ ][a,c]

a,c

Figure A-12: [ ][a,c]

a,c

Figure A-13: [ ]^{a,c}

a,c

Figure A-14: [ ]^{a,c}

a,c

Figure A-15: [ ]a,c

a,c

Figure A-16: [ ]a,c

a,c

Figure A-17: [ ]a,c

a,c

Figure A-18: [ ]a,c

Appendix B: [ ]a,c

[

]a,c

a,c

Figure B-1: [ ]a,c

a,c

Figure B-2: [ ]a,c

a,c

Figure B-3: [ ]a,c

a,c

Figure B-4: [ ]^{a,c}

a,c

Figure B-5: [ ]a,c

Appendix C: [ ]^a,c

[

]^a,c

a,c

Figure C-1: [ ]a,c

a,c

Figure C-2: [ ]a,c

a,c

Figure C-3: [ ]a,c

a,c

Figure C-4: [ ][a,c]