3H Details and Evaluation Results of Seismic Category 1 Structures

The information in this appendix of the reference ABWR DCD, including all subsections, tables, and figures is incorporated by reference with the following departures and supplement.

STD DEP T1 2.15-1

STP DEP T1 5.0-1

STD~~P~~ DEP 1.8-1

STD DEP 3H-1

STP DEP Admin

3H.1 Reactor Building

3H.1.4.2 Site Design Parameters

STP DEP T1 5.0-1

(1) Soil Parameters:

—Minimum static bearing capacity demand: Š718.20 kPa

—In addition for the load combinations involving seismic/dynamic loads, the dynamic bearing capacity demand shall also be met.

—Minimum shear wave velocity: ~~305 m/s~~(See FSAR Subsections 2.5S.4.4 and 2.5S.4.7)

—Poisson's Ratio: 0.30 to 0.38

—Unit Weight: 1.9 to 2.2 t/m^3

(3) ~~Maximum~~ Design Basis *Flood Level*

~~—0.305 m~~ ~~442.0~~182.9 cm ~~*below*~~ above *grade*

(9) Maximum Rainfall

*—Design rainfall is ~~493~~*503 mm/h. *Roof parapets are furnished with scuppers to supplement roof drains, or are designed without parapets so that excessive ponding of water cannot occur. Such roof design meets the provision of ASCE 7-88 Section 8.*

3H.1.4.4.3 Liner Plate

STD DEP 3H-1

- *Liner plate for RCCV in the wetted area shall be stainless steel conforming to ASME SA-240, Type 304L.*
- *Liner plate for the RCCV in the non-wetted area shall be 6.35 mm thick and conform to ASME SA-516 GR. 70.*
- *Liner Anchors: ~~ASTM A-633 GR. C~~* ASME SA-36.
- *Stainless steel cladding to conform to ASME SA-264.*

3H.1.5.2 Foundation Soil Springs

STP DEP T1 5.0-1

The foundation soil is represented by soil springs. The spring constants for rocking and translations are determined based on the following soil parameters:

- *Shear wave velocity ~~305 m/s~~*(See FSAR Subsections 2.5S.4.4 and 2.5S.4.7)
- *Unit weight 1.92 t/m^3*
- *Shear modulus 1.8 x 10^4 t/m^3*
- *Poisson's Ratio 0.38*

3H.1.6 Site Specific Structural Evaluation

The following site specific supplement addresses the structural evaluation of the site specific design parameters for STP 3 & 4.

As documented in Section 3.3 the ABWR Standard Plant Reactor Building (RB) wind loads, and tornado loads bound these site parameters for STP 3 & 4.

As documented in Subsections 2.5S.4.4 and 2.4S.4.7, the shear wave velocity at STP 3&4 site varies both horizontally in a soil stratum and vertically with elevation, and is lower than the 1,000 ft/sec minimum stated in the DCD. A site specific soil-structure interation (SSI) analysis has been~~will be~~ performed using the measured values of shear wave velocity, with appropriate variation to represent the variability at the site, and site specific SSE, to demonstrate that the results of the site-specific SSI are bounded by the standard plant results included in the DCD. This SSI analysis is described in Appendix 3A.~~will be completed and the FSAR will be updated as stated in COM 3A-1.~~

The foundation spring constants for mat design are based on settlement calculations. In the development of settlement estimates, the representative shear wave velocity value for intervals within a soil column is only one input used in the derivation of the elastic modulus for layers within that column. Since this derived elastic modulus value is first adjusted for strain and then weighted with estimated values derived from either SPT tests (for garanular material) or undrained shear strength tests (for cohesive soils) the effect of variability of shear wave velocity upon settlement calculations is significantly attenuated. Based on this, the foundation spring constants are also relatively insensitive to the variation in shear wave velocity.

As documented in Subsection 3.4, the STP 3 & 4 site has a design basis flood elevation that is ~~442.0~~182.9 cm above grade. This results in an increase in the flood level over what was used in the ABWR Standard Plant, however the load due to the revised flood level on the RB is less than the ABWR Standard Plant RB seismic load, hence it doesn't ~~e~~affect the Standard Plant RB structural design.

Therefore the STP 3 & 4 RB utilizing the Standard Plant design is structurally adequate.

3H.2 Control Building

STP DEP T1 5.0-1

3H.2.4.2.1 Soil Parameters

Minimum shear wave velocity:	~~*305 m/s*~~See FSAR Subsections 2.5S4.4 and 2.5S.4.7
Poisson ratio:	*0.3 to 0.38*
Unit weight	*1.9 to 2.2 t/m^3*
Liquefaction potential:	*None*
Minimum Static Soil Bearing Capacity Demand:	*Š 718.20 KPa*

3H.2.4.2.3 Design Basis Flood Level

Design basis *flood level is at ~~0.305m~~* ~~442.0~~182.9 cm ~~*below*~~ above *grade level.*

3H.2.4.2.5 Maximum Rainfall

Design rainfall is ~~493~~ 503 *mm/h. Roof parapets are furnished with scuppers to supplement roof drains, or are designed without parapets so that excessive ponding of water cannot occur. Such roof design meets the provision of ASCE 7-88 Section 8.*

3H.2.4.3.1.4 Lateral Soil Pressures (H and H')

The following parameters are used in the computation of lateral soil pressures:

▪ *Dry unit weight:*	▪ *1.9 to 2.2 t/m^3*
▪ *Shear wave velocity:*	▪ ~~*305 m/s*~~ See FSAR Subsections 2.5S.4.4 and 2.5S.4.7
▪ *Internal friction angle:*	▪ *30° to 40°*

3H.2.6 Site Specific Structural Evaluation

The following site specific supplement addresses the structural evaluation of the site specific design parameters for STP 3 & 4.

As documented in Subsection 3.3, the ABWR Standard Plant Control Building (CB), wind loads, and tornado loads bound these site specific parameters for STP 3 & 4.

As documented in Subsections 2.5S.4.4 and 2.5S.4.7, the shear wave velocity at STP 3&4 site varies both horizontally in a soil stratum and vertically with elevation, and is lower than the 1,000 ft/sec minimum stated in the DCD. A site specific soil-structure interaction (SSI) analysis has been~~will be~~ performed using the measured values of shear wave velocity, with appropriate variation to represent the variability at the site, and site specfic SSE, to demonstrate that the results of the site-specific SSI are bounded by the standard plant results included in the DCD. This SSI analysis is described in Appendix 3A.~~will be completed and the FARA will be updated as stated in COM 3A-1.~~

At-rest lateral earth pressure in non-yielding walls of structures with deep foundations such as the Reactor and Control Buildings will be determined using the method described in Reference 2.5S.4-62. In this method, the at-rest seismic lateral earth pressure computation will utilize site-specific shear wave velocity. The impact of site-specific shear wave velocity on the design of exterior walls of these structures is expected to be insignificant because their designs are controlled by the combination of requirements for in-plane and out-of-plane loads. The at-rest seismic lateral presssure only affects the out-of-plane load. Also, the at-rest pressure includes effect of hydrostatic load, surcharge load etc., in addition to the dynamic pressure caused by the earthquake.~~Shear wave velocity is not used as an input in the calculation of lateral soil pressures. Therefore, change in shear wave velocity has no impact on calculation of the lateral soil pressures.~~

As documented in Subsection 3.4, the STP 3 & 4 site has a basis flood elevation that is ~~442.0~~182.9 cm above grade. This results in an increase in the flood level over what was used in the ABWR Standard Plant, however the load due to the revised flood level on the CB is less than the ABWR Standard Plant seismic load, hence it does not ~~a~~effect the Standard Plant CB structural design.

Therefore the STP 3 & 4 CB utilizing the Standard Plant design is structurally adequate.

3H.3 ~~*Radwaste Building*~~Not Used

STD DEP T1 2.15-1

Due to the re-classification of the Radwaste Building substructure from seismic Category 1 to non-seismic, this subsection of the DCD, including all tables and figures, ~~have~~has been deleted.

3H.5 Structural Analysis Reports

STD DEP T1 2.15-1

3H.5.3 Structural Analysis Report for the Reactor Building~~,~~ and Control Building ~~*and Radwaste Building Substructure (Including Seismic Category 1 Tunnels)*~~ (Including Seismic Category I Tunnels)

3H.5.4 Structural Analysis Report For the Reactor Building~~,~~ and Control Building ~~*and Radwaste Building*~~ Foundation

3H.5.5 Structural Analysis Report For The Radwaste Building (Including Radwaste Tunnels) and TheTurbine Building

STD DEP 1.8-1

STD DEP T1 2.15-1

For material properties and dimensions, assess compliance of the as-built structure with design requirements in the International Building Code (IBC)~~*Uniform Building Code (UBC)*~~ for the Turbine Building and Regulatory Guide 1.143 for the Radwaste Building (including Radwaste Tunnels) *and in the Table 3.2-1 and paragraph 3.7.3.16.*

Construction deviations and design changes will be assessed to determine appropriate disposition.

This disposition will be accepted "as-is," provided the following acceptance criteria are met:

- *The structural design meets the acceptance criteria and load combinations of the* IBC~~*UBC*~~ *code* for the Turbine Building and Regulatory Guide 1.143 for the Radwaste Building (including Radwaste Tunnels)*.*

The RW/B (including Radwaste Tunnels) and *T/B* ~~*is*~~are *not classified as* ~~*a*~~ *Seismic Category 1 structures. However, the buildings* ~~*is*~~are *designed such that damage to safety-related functions does not occur under seismic loads corresponding to the safe shutdown earthquake (SSE) ground acceleration.*

3H.6 Site-Specific Seismic Category I Structures

The following site-specific supplement addresses site specific Seismic Category I structures.

3H.6.1 Objective and Scope

The objective of this appendix is to describe the structural analysis and design of the STP 3 & 4 site-specific seismic Category I structures that are identified below and shown in Figures ~~1.2-32~~1.2-34 through ~~1.2-37~~1.2-36.

(1) Ultimate Heat Sink (UHS) for each unit consists of a water retaining basin with enclosed cooling towers situated above the basin and a Reactor Service Water (RSW) pump house that is integral with the UHS basin.

(2) RSW piping tunnel for each unit.

3H.6.2 Summary

For the ~~conceptual~~ design of the UHS basin and the pump house of each unit, the seismic effects were determined by performing a soil-structure interaction (SSI) analysis, as described in Subsection 3H.6.5. The free-field ground response spectra used in the analysis are described in Subsection 3H.6.5.1.1.1.~~a simplified approach by applying the free-field peak ground motion acceleration of 0.15g in the two horizontal (N-S and E-W) directions and the vertical direction, ignoring the effects of seismic soil-structure interaction (SSI). In addition, a 10% amplification of seismic response was considered for the cooling towers and an acceleration of 0.165g was applied in the three directions.~~ The resulting seismic loads were used in combination with other applicable loads to develop ~~conceptual~~ designs of the structures. Hydrodynamic effects of the water in the basin~~basis~~ were considered. ~~These designs will be used to develop the structural models that will be considered in the final seismic analysis that is described in Subsection 3H.6.5.2. The responses from the final seismic analysis will be combined with responses from other applicable loads.The FSAR will be updated in accordance with 10 CFR 50.71(e) with the first COLA revision to be submitted in 2009, tentatively scheduled for second quarter of 2009. to address the final results identified below. (COM 3H-2)~~The following results are presented in tables and figures, as indicated.

- Natural frequencies (Table 3H.6-3).
- Seismic accelerations (Table 3H.6-4).
- ~~Seismic forces, moments, and torques.~~
- Seismic displacements (Table 3H.6-4).
- Floor response spectra (Figures 3H.6-16 through 3H.6-39).
- Factors of safety against sliding, overturning, and flotation (Table 3H.6-5).
- Combined forces and moments at critical locations in the structures along with ~~corresponding calculated and allowable stresses, and~~ required and provided rebar (Tables 3H.6-7 through 3H.6-9).

The final combined responses are used to evaluate the designs against the following criteria:

- Stresses in concrete and reinforcement are less than the allowable stresses in accordance with the applicable codes listed in Subsection 3H.6.4.1.
- The factors of safety against flotation, sliding, and overturning of the structures under various loading combinations are higher than the required minimum values identified in Subsection 3H.6.4.5.
- The calculated static and dynamic soil bearing pressures/displacements are less than the allowable values.
- The thickness of the roof slabs and exterior walls are more than the minimum required to preclude penetration, perforation, or spalling resulting from impact of design basis tornado missiles. In addition, the passage of tornado missiles through openings in the roof slabs and exterior walls is prevented by the use of missile-proof covers and doors, or the trajectory of missiles through ventilation openings is limited by labyrinth walls configured to prevent safety-related substructures and components from being impacted.

The RSW piping tunnel seismic analysis has been performed using an equivalent static approach, as discussed in Section 3H.6.5.3.

3H.6.3 Structural Descriptions

The site-specific Seismic Category I structures at STP 3 & 4 consist of one set of the following for each unit: UHS basin, enclosed UHS cooling towers located on top of the basin, RSW pump house contiguous with and adjacent to the UHS basin, and buried RSW piping tunnels and access shafts to the tunnels. Each UHS basin and RSW pump house has a 10-ft (3.05-m) thick foundation mat and are connected at a common wall; and the RSW piping tunnels extend from the pump house to the Control Buildings. Each of these structures is described in more detail in the following subsections.

3H.6.3.1 Ultimate Heat Sink Basin

The UHS basin is a rectangular reinforced concrete structure with inner dimensions of 280 ft (85.34 m) by 132 ft (40.23 m) and serves as the reservoir for the RSW system. The walls of the basin are 6 ft (1.83 m) thick and extend from an elevation of 97.~~,~~5 ft (29.72 m) MSL down to an elevation of 14 ft (4.27 m) MSL. The walls are braced by buttresses spaced at a maximum of 50 ft (15.24 m) and are supported on a 312 ft (95.10 m) by 164 ft (49.99 m) by 10 ft (3.05 m) thick mat foundation, poured on a lean concrete mud mat. The mud mat is poured directly on the in-situ soil. Each UHS includes three independent divisions of mechanical cooling towers, with two dedicated cooling towers in each division . The pump house is contiguous with the UHS basin and its walls extend from an elevation of -18~~-22~~ ft (-5.49~~-6.71~~ m) MSL to an elevation of 50 ft (15.24 m) MSL.

As noted in Subsection 9.2.5.5.2, the seepage loss estimated during the 30 days of operation following a design basis accident, with no makeup available, is within the acceptance criteria for standard hydrostatic test HST-025, as defined in ACI 350.1.

3H.6.3.2 Ultimate Heat Sink Cooling Tower Enclosures

The ~~-~~cooling tower enclosure for each unit is a reinforced concrete structure housing the equipment used to cool the water for the RSW system. The enclosure is located above the UHS basin and is supported by reinforced concrete columns anchored to the basin mat foundation. The enclosure is 292 ft (89.0 m) long by 52 ft (15.85 m) wide and extends from the top of the UHS basin walls to elevation 153 ft (46.63 m) MSL. Each enclosure is divided into six compartments or cells, with each compartment housing a fan and associated equipment. Openings are provided at the base of each compartment to allow for the flow of water. Each compartment includes a common basin at the base of the structure, air intake, and substructures and components used to cool the water (fill, drift eliminators, spray system piping and nozzles, and the associated concrete support beams). The air intakes for each compartment~~, which~~ are located at the bottom ~~on only one side~~ of the enclosures~~,~~ and are configured to eliminate ~~limit~~ the trajectory of tornado missiles into the enclosures, thereby preventing damage to safety-related ~~substructures and~~ components. In addition, each compartment includes a reinforced concrete fan deck that supports the fan and the associated motor. Finally, heavy steel grating, which is supported by structural steel beams, is installed at the top of each compartment. This grating allows for the passage of air out of the compartment and prevents the intrusion of tornado wind-borne missiles.

3H.6.3.3 Reactor Service Water Pump Houses

The two RSW pump houses are reinforced concrete structures that are continguous with the UHS basins and house the RSW pumps (six pumps per pump house, with three RSW divisions, and two pumps per division) and their associated auxiliaries. Each set of pumps extracts water for the RSW system from the basin. The operating floor of each pump house is divided into three separate rooms (one per RSW division), each containing two pump drivers and associated equipment, including self-cleaning strainers. There is also an access tunnel through which the RSW system piping is routed to and from the corresponding control building.

The exterior walls of each pump house and the interior walls dividing the pump bay are integral with the UHS basin walls. The pump bay for each pump house measures approximately 44~~42~~ ft (13.41~~12.80~~ m) by 72 ft (21.95 m) in plan with the top of the bay slab being located at elevation -18~~22~~ft (-5.49~~6.71~~ m). The operating floor is at elevation 14 ft (4.27 m) and measures 138 ft (42.06 m) by 72 ft (21.95 m) in plan. Covered ~~O~~openings are provided in the roof of each pump house, which is located at elevation 50 ft (15.24 m), to allow for the removal of ~~access to~~ the six pumps.

3H.6.3.4 Reactor Service Water Piping Tunnels

The three RSW piping tunnels, one for each RSW division, are reinforced concrete structures configured in a stacked arrangement. The tunnel is 17'-0" (5.18 m)~~11.9~~

~~meters~~ wide and has an overall height of 40'-0" (12.2 m)~~4.42 meters~~ high. They extend from each pump ~~house~~room to the ~~corresponding~~ control building. ~~Each~~The three tunnels ~~is~~are separated~~divided into three sections (one section for each RSW division)~~ by reinforced concrete slabs~~walls~~, which serve to isolate the supply and return lines and associated equipment for each of the three divisions. Access to the tunnels from the surface, for inspections and maintenance activities, is provided by reinforced concrete personnel access shafts~~manholes~~. The interfaces between the tunnels and the pump houses and control buildings are configured to allow relative movement between the tunnels and structures.

3H.6.4 Structural Design Criteria

3H.6.4.1 Design Codes and Standards

- Code Requirements for Nuclear Safety-Related Concrete Structures (ACI 349), as supplemented by RG 1.142
- Code Requirements for Environmental Engineering Concrete Structures (ACI 350)
- American National Standard Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities (ANSI/AISC N690)
- Tightness Testing of Environmental Engineering Concrete Structures (ACI 350.1)
- Minimum Design Loads for Buildings and Other Structures (ASCE/SEI 7)
- Seismic Analysis of Safety-Related Nuclear Structures and Commentary (ASCE 4)
- Structural Welding Code – Steel (AWS D1.1)
- Regulatory Guide 1.76, Design Basis Tornado and Tornado Missiles for Nuclear Power Plants
- Regulatory Guide 1.61 – Damping Values for Seismic Design of Nuclear Power Plants

3H.6.4.2 Site Design Parameters

3H.6.4.2.1 Soil Parameters

- Poisson's ratio (above groundwater): 0.42
- Poisson's ratio (below groundwater): 0.47
- Unit weight (moist): .... 120 pcf (1.92 t/m^3)
- Unit weight (saturated): .... 140 pcf (2.24 t/m^3)
- Liquefaction potential: .... None

- Static Soil Bearing Capacity: .... See FSAR Subsection 2.5S.4.10
- *Dynamic Soil Bearing Capacity:................... Calculated Factor of Safety (LATER)

3H.6.4.2.2 Design Groundwater Level

Design groundwater level is at elevation 28 (8.53 meters) MSL. This elevation bounds the groundwater elevation defined in FSAR Subsection 2.4S.12.

3H.6.4.2.3 Design Flood Level

Design flood basis level is at ~~14.8~~12.2 meters MSL. This elevation is defined in Subsection 2.4S.2.2.

3H.6.4.2.4 Maximum Snow Load

Design snow load is 0 kPa (100-year return snow pack) and 0.263 kPa (5.5 psf) (Maximum ground level snow load) in accordance with Subsection 2.3S.1.3.4.

3H.6.4.2.5 Maximum Rainfall

Design rainfall is 19.8 in/hr (503 mm/hour) in accordance with Subsection 2.3S.1.3.4. The roof of each pump house is designed without parapets so that excessive ponding of water cannot occur. Such roof design meets the provisions of RG 1.102.

3H.6.4.3 Design Loads and Load Combinations

3H.6.4.3.1 Normal Loads

Normal loads are those that are encountered during normal plant startup, operation, and shutdown.

3H.6.4.3.1.1 Dead Loads (D)

Dead loads include the weight of the structure, permanent equipment, and other permanent static loads. An additional 50 psf (2.39 kPa) uniform load is considered to account for dead loads due to piping, raceways, grating, and HVAC duct work.

3H.6.4.3.1.2 Live Loads (L and L_o)

Live loads include floor and roof area loads, movable loads, and laydown loads. The only areas of the site-specific Category I structures requiring consideration of a live load are the operating floor and roof of the pump houses. While a live load of 200 psf (9.6~~58~~ kPa) is defined for the operating floor, a live load of 50 psf (2.4~~39~~ kPa) is defined for the roof.

For the computation of global seismic loads and the definition of load combinations that include seismic loads, the live load is limited to the expected live load present during normal plant operation, L_o. This load has been defined as 25% of the operating floor and roof live loads.

3H.6.4.3.1.3 Snow Loads

Design snow load is 0 kPa (100-year return snow pack) and 0.263 kPa (5.5 psf) (Maximum ground level snow load) in accordance with Subsection 2.3S.1.3.4. ~~No snow load is considered in the evaluation of the site-specific seismic Category I structures.~~

3H.6.4.3.1.4 Lateral Soil Pressures (H ~~and H'~~)

Lateral soil pressures are calculated using the following soil properties.

- Unit weight (moist):...120 pcf (1.92 t/m^3)
- Unit weight (saturated): ....140 pcf (2.24 t/m^3)
- Internal friction angle: ....30°
- Poisson's ratio (above groundwater).. 0.42
- Poisson's ratio (below groundwater) 0.47

3H.6.4.3.1.5 Thermal Loads (T_o)

Internal moments and forces caused by temperature distribution.

3H.6.4.3.1.6 Hydrostatic Loads(F)

The hydrostatic load due to the water inside the UHS basin.

3H.6.4.3.2 Severe Environmental Load

The severe environmental load considered in the design is that generated by wind. The following parameters are used in the computation of the wind loads:

- Basic wind speed (100 year recurrence interval, 3-second gust):............ 134 mph (215 km/h)
- Exposure: C
- Importance factor: 1.15
- Velocity pressure exposure coefficient as per ASCE 7 Table 6-3, but ≥ 0.87
- Topographic factor 1.0
- Wind directionality factor 1.0

Wind loads will be calculated in accordance with the provisions of Chapter 6 of ASCE 7.

3H.6.4.3.3 Extreme Environmental Load

Extreme environmental loads consist of loads generated by the tornado, extreme snow load, flooding and safe shutdown earthquake (SSE).

3H.6.4.3.3.1 Tornado Loads (Wt)

The following tornado load effects are considered in the design:

- Wind speed .... (W_w)
- Differential pressure .... (W_p)
- Missile impact .... (W_m)

Parameters used in computation of tornado loads are as follows (see Tables 1 and 2 of RG 1.76, for Region II):

- Maximum wind speed: .... 200 mph (322 km/h)~~320 km/h~~
- Maximum rotational speed: .... 160 mph (257 km/h)~~259 km/h~~
- Maximum translational speed: .... 40 mph (64 km/h)~~65 km/h~~
- Radius of maximum rotational speed: .... 150 ft (45.7 m)
- Differential pressure: .... 0.9 psi (6.2 kPa)~~06.3 kPa~~
- Pressure differential rate: .... 0.4 psi/s (2.8 kPa/s)~~2.5 kPa/s~~
- Missile spectrum: .... (See Table 2 of RG 1.76)

(1) Tornado Wind Pressure (W_w)

With the exception of the RSW piping tunnel, which does not require the consideration of a tornado wind pressure, tornado wind pressures are computed using the procedure described in Chapter 6 of ASCE 7, in conjunction with the maximum wind speed defined above and the following parameters:

- Importance factor 1.15
- Velocity pressure exposure coefficient 0.87
- Topographic factor 1.0
- Wind directionality factor 1.0

(2) Tornado Differential Pressure (W_p)

The designs of the UHS basin, UHS cooling tower, and the RSW piping tunnel do not require the consideration of a tornado differential pressure. ~~Although the UHS cooling tower enclosures and the~~ RSW pump house~~s~~ and RSW piping tunnel access shafts are ~~partially vented, they are~~ evaluated for the specified differential pressure.

(3) Tornado Missile Impact (W_m)

Buried RSW piping tunnels do not require the consideration of tornado missile impact. All other structures are evaluated for the effects of missile impact.

Tornado missile impact effects on the UHS basin and cooling tower enclosures, ~~and the~~ RSW pump houses, and RSW tunnel access shafts are evaluated for the following two conditions:

(a) Local damage in terms of penetration, perforation, and spalling, which is evaluated using the TM 5-855-1 formula (Reference 3H.6-1).

(b) The global overall damage prediction will be performed during the detailed design phase in accordance with Section 3.5.3.2.

(4) Tornado Load Combinations

Tornado load effects are combined as follows:

$$W_t = W_p$$

$$W_t = W_w + 0.5W_p + W_m$$

3H.6.4.3.3.2 Safe Shutdown Earthquake Loads (E')

The SSE loads are applied in three mutually orthogonal directions— two horizontal directions and the vertical direction. The total structural response is predicted by combining the applicable maximum co-directional responses in accordance with RG 1.92.

The SSE loads are based on seismic analysis using~~free-field peak ground motions consistent with~~ the ground motion response spectra defined in Subsection 3H.6.5.1.1.1~~3H.6.5.1.1~~. The loads consist of vertical forces, horizontal forces, torsional moments, and overturning moments.

The SSE induced loads also include the hydrodynamic effect of the water in the UHS basin. This hydrodynamic effect was calculated based on the methodology included in Section 3.1.6.3 of ASCE 4 and TID 7024, referenced in the commentary section of ASCE 4.

3H.6.4.3.3.3 Lateral Soil Pressures Including the Effects of SSE (H')

This is the total lateral soil pressure, including the dynamic effect of SSE.

3H.6.4.3.3.4 Extreme Environmental Flood (FL)

See Subsection 3H.6.4.2.3.

3H.6.4.3.3.5 Extreme Snow Load (S_E)

Maximum ground level snow load, in accordance with Subsection 2.3S.1.3.4, is 0.263 kPa (5.5 psf).

3H.6.4.3.4 Load Combinations

The load combinations and structural acceptance criteria used to evaluate the site-specific Category I concrete structures are consistent with the provisions of ACI 349, as supplemented by RG 1.142 as well as ACI 350. Loads T_a, R_a, P_a, and E_o, as defined in ACI 349, are not applicable to the evaluation of the site-specific seismic Category I structures and are not included in the load combinations defined below.

3H.6.4.3.4.1 Notation

S	=	Allowable stress for allowable stress design method
U	=	Required strength for strength design method
D	=	Dead load
F	=	Hydrostatic load
L	=	Live load
L_o	=	Live load concurrent with SSE
FL	=	Static and dynamic effects due to extreme environmental flood
S_E	=	Extreme snow load
H	=	Lateral soil pressure and groundwater effects
H'	=	Lateral soil pressure and groundwater effects, including dynamic effects of SSE
W	=	Wind load
Wt	=	Tornado load
E'	=	SSE load, including associated hydrodynamic loads
R_o	=	Piping and equipment reactions

T_o = Internal moments and forces caused by temperature distributions

3H.6.4.3.4.2 Structural Steel Load Combinations

S = D + L + H + F + R_o + T_o

S = D + L + W + R_o + H + F + T_o

1.6S = D + L + Wt + H + R_o + F + T_o

1.6S = D + L + FL + H + R_o + F + T_o

1.6S = D + L_o + E' + H' + R_o + F + T_o

1.6S = D + L + S_E + R_o + H + F + T_o

3H.6.4.3.4.3 Reinforced Concrete Load Combinations

U = 1.4D + 1.4F + 1.7L + 1.7H + 1.7 R_o

U = 1.4D + 1.4F + 1.7L + 1.7H + 1.7W + 1.7 R_o

U = D + F + L + H + T_o + R_o+ W_t

U = D + F + L_o + H'+ T_o + R_o+ E'

U = 1.05D + 1.05F + 1.3L + 1.3H+ ~~1.05~~1.2T_o + 1.3R_o

U = 1.05D + 1.05F + 1.3L + 1.3H + 1.3W + ~~1.05~~1.2T_o + 1.3R_o

U = D + F + L + H + T_o + R_o + FL

U = D + F + L + H + T_o + R_o + S_E

For the UHS basin, the required strength defined by the above load combinations are multiplied by the following Environmental Durability Factors (S) defined in ACI 350:

- Flexural strength... ~~S =~~ 1.3
- Axial tension (including hoop tension)... ~~S =~~ 1.65
- Excess shear strength carried by shear reinforcement............................. ~~S =~~ 1.3

3H.6.4.4 Materials

Structural materials used in the design of the site-specific Category I structures are as follows:

3H.6.4.4.1 Reinforced Concrete

Concrete conforms to the requirements of ACI 349. Its design properties are:

- Compressive strength .... 4.0 ksi (27.6 MPa)
- Modulus of elasticity .... 3,597 ksi (24.8 GPa)
- Shear modulus .... 1,537 ksi (10.6 GPa)
- Poisson's ratio 0.17

3H.6.4.4.2 Reinforcement

Deformed billet steel reinforcing bars are considered in the design. Reinforcement conforms to the requirements of ASTM A615. Its design properties are:

- Yield strength .... 60 ksi (414 MPa)
- Tensile strength .... 90 ksi (621 MPa)

3H.6.4.4.3 Structural Steel

High strength, low-alloy structural steel conforming to ASTM A572, Grade 50 is considered in the design. The steel design properties are:

- Yield strength .... 50 ksi (345 MPa)
- Tensile strength .... 65 ksi (448 MPa)

3H.6.4.4.4 Steel Grating

~~Grating conforming to ASTM A36 is~~Bearing bars conforming to ASTM A1011 are considered in the design. The design ~~properties are~~property is:

- Yield strength .... ~~248 MPa~~30 to 50 ksi (207 to 345 MPa)
- ~~Tensile strength .... 400 MPa~~

3H.6.4.4.5 Anchor Bolts

Material for anchor bolts conforms to the requirements of ASTM F1554, Grade 36. Its design properties are:

- Yield strength .... 36 ksi (248 MPa)
- Tensile strength .... 58 ksi (400 MPa)

3H.6.4.5 Stability Requirements

The following minimum factors of safety are required against overturning, sliding, and flotation:

Load Combination	Overturning	Sliding	Flotation
D + F' ~~[1]~~	–	–	1.1
D + H + W	1.5	1.5	–
D + H + W_t ~~[1]~~	1.1	1.1	–
D + H' + E' ~~[1]~~	1.1	1.1	–

[1] ~~Based on the section of the basin for one unit being empty, while the section for the other unit is filled to a level 1.52 meters (5'-0") below the normal low water level.~~

Loads D, H, H', W, W_t, and E' are defined in Subsection 3H.6.4.3.4.1. F' is the buoyant force corresponding to the flood water level.

3H.6.5 Seismic Analysis

3H.6.5.1 Seismic Design Parameters

3H.6.5.1.1 Design Ground Motion

3H.6.5.1.1.1 Design Response Spectra

Site-specific horizontal and vertical ground motion response spectra (GMRS) for the SSE are developed for the STP 3 & 4 site. The development of these spectra is documented in Subsection 2.5S.2.

For the seismic analysis of the site-specific structures, free field ground surface response spectra (Input Spectra) were developed, in the horizontal and vertical directions, by modifying the 0.13g Regulatory Guide 1.60 response spectra. The Input Spectra are the same as the 0.13g Regulatory Guide 1.60 spectra for frequencies equal to and higher than 2.5 Hz for the horizontal spectrum, and 3.5 Hz for the vertical spectrum. For frequencies lower than 2.5 Hz for the horizontal spectrum, and 3.5 Hz for the vertical spectrum, the Regulatory Guide spectra were increased to envelop the GMRS. These Input Spectra were developed to meet the following requirements:

a. The Input Spectra shall envelop the GMRS. See Figures 3H.6-1 and 3H.6-2 showing that the Input Spectrum envelops the GMRS in the horizontal and vertical directions, respectively.

b. When a deconvolution analysis is performed in the SHAKE program with the Input Spectrum applied at the free field ground surface, the resulting response spectrum at the outcrop of each Seismic Category I foundation will envelop the foundation input response spectrum (FIRS) developed using the same probabilistic approach and model which was used to develop the GMRS. See Figures 3H.6-3 through 3H.6-11 for a comparison of the outcrop response spectra, resulting from the application of the time histories consistent with the Input Spectra at the free field ground surface in SHAKE, and the FIRS for the UHS basin, RSW tunnel, and RSW pump house foundations, in the two horizontal and vertical directions. These figures show that the FIRS are enveloped by the foundation outcrop spectra in all cases.

c. The response spectrum at the SHAKE outcrop of each Seismic Category I foundation envelops a broad band spectrum anchored at 0.1g. This is the minimum requirement as stated in SRP 3.7.1 and Appendix S to 10 CFR 50, "Earthquake Engineering Criteria for Nuclear Power Plants". The broad band spectrum used in our analysis is conservatively defined as the Regulatory Guide 1.60 spectrum anchored at 0.1g. See Figures 3H.6-3 through 3H.6-11, which demonstrate that this requirement is met for the UHS basin, RSW tunnel, and RSW pump house foundations, in the two horizontal and vertical directions.

3H.6.5.1.1.2 Design Time Histories

~~Acceleration time histories consistent with the GMRS defined in Subsection 2.5S.2 are developed for use as input to the seismic analysis. The time histories (two horizontal and one vertical) comply with the response spectra and power spectral density enveloping criteria as well as the cross-correlation criteria specified in RG 1.206.~~

Synthetic acceleration time histories consistent with the Input Spectra defined and discussed in Subsection 3H.6.5.1.1.1 were developed, using the 1952 Taft Earthquake Time Histories as seed, for use as input to the seismic analysis. A single set of time histories (two horizontal and one vertical) was developed satisfying the enveloping requirements of Option 1, Approach 2 of SRP 3.7.1, Section II (Acceptance Criteria), Revision 3. Per paragraph 2(d) of Approach 2, in lieu of the power spectrum density requirement, the requirement that the computed 5% damped response spectrum of the Synthetic time history does not exceed the target response spectrum at any frequency by more than 30% was met. In the time history method of analysis, the two horizontal and the vertical time histories were applied separately (not applied simultaneously) and the maximum responses were combined using the square-root-of-the-sum-of-the-squares (SRSS) or the 100-40-40 percent spatial combination rule. Therefore, per Regulatory Guide 1.92, Revision 2, statistical independence of the three time histories (cross-correlation coefficient requirement) is not required.

Figures 3H.6-12 through 3H.6-14 show the comparison of the response spectrum for the Synthetic time history, the Input Spectrum, and 1.3 times the Input Spectrum, in the two horizontal and vertical directions.

3H.6.5.1.2 Percentage of Critical Damping Values

The percentages of critical damping values considered in the seismic analysis for site-specific seismic Category I structures and associated systems and components are the same as listed in DCD Table 3.7-1. The damping values are the same as in Regulatory Guides 1.61 and 1.84, except for the cable trays and conduits, as explained in DCD Section 3.7.1.3. The SSE damping values were used for the generation of in-structure response spectra (ISRS), since the UHS structure is highly stressed during the SSE event.~~in accordance with the criteria defined in RG 1.61. This includes~~

~~consideration of the calculated stress levels when establishing the appropriate damping values to be used.~~

The strain-compatible, soil-damping values considered in the seismic analysis are ~~defined~~discussed in Subsection ~~2.5S.4.~~3H.6.5.2.4.

3H.6.5.1.3 Supporting Media for Seismic Category I Structures

Soil conditions at the STP 3 & 4 site are described in Subsection 2.5S.4. The soil at the site extends down several thousand feet and consists of alternating layers of clay, silt, and sand. Soil layering characteristics, geophysical shear wave velocity, unit weight, and Poisson's ratio are included in Table 2.5S.4-27. Based on the site groundwater conditions described in Section 2.4S.12, the groundwater elevation of approximately 8 ft below grade was used in computing soil properties for the SSI analysis.

The SASSI2000 soil model, for the UHS basin and RSW pump house, included soil down to a minimum of two times the maximum plan dimension of the building below the basemat. The bottom boundary of the model was considered to have an elastic half space condition.

The characteristic dimensions of the above grade site-specific seismic Category I structures are summarized below:

Structure	Embedment Depth to Bottom of Foundation Mat	Maximum Height[1]	Base Dimensions
UHS Basin	30 ft (9.14 m)	93.5 ft (28.5 m)	312 ft (95.10 m) x 164 ft (49.99 m) x 10 ft (3.05 m) thick foundation
UHS Cooling Towers	[2]	149 ft (45.42 m)	N/A
RSW Pump Houses Pump Bays	~~66 ft (20.12 m)~~62 ft (18.9 m)	~~82 ft (24.99 m)~~78 ft (23.8 m)	94 ft (28.65 m) x 170 ft (51.82 m)
RSW Piping Tunnel	42 ft (12.8 m)	40 ft (12.2 m) [3]	17 ft (5.2 m) wide

[1] As measured from the bottom of the foundation mat.

[2] ~~}~~Located above the basin and supported on columns.

[3] The shaft for the tunnel extends to 64 ft above the bottom of the foundation mat.

3H.6.5.2 Seismic System Analysis

The following Subsections 3H.6.5.2.1 through 3H.6.5.2.14 describe the seismic analysis of the UHS and RSW pump house structures. Subsection 3H.6.5.3 describes the seismic analysis of the RSW piping tunnel.

3H.6.5.2.1 Seismic Analysis Methods

~~The site-specific seismic Category 1 structures at STP 3 & 4 consist of one set of the following for each unit: UHS basin, enclosed UHS cooling towers located on top of the basin's north-south walls, RSW pump house contiguous with and adjacent to the UHS basin, and RSW piping tunnels. Each UHS basin and its cooling towers, share a 10 ft (3.05 m) thick common foundation mat; the RSW pump house is a contiguous structure adjacent to the UHS basin and has 10 ft (3.05 m) thick foundation mat; and the RSW tunnels extend from the pump house to the corresponding control buildingss. For the conceptual design of the UHS basin and the pump house of each unit, the seismic effects were determined by a simplified approach by applying the free-field peak ground motion acceleration of 0.15g in the two horizontal (N-S and E-W) directions and the vertical direction, ignoring the effects of seismic soil-structure interaction (SSI). In addition, a 10% amplification of seismic response was considered for the cooling towers and an acceleration of 0.165g was applied in three directions. The resulting seismic loads were used in combination with other applicable loads to develop conceptual designs of the structures. These will be used to develop the structural models considered in the final seismic analysis that is described in Subsection 3H.6.5.2.3.~~

The ~~final~~ seismic analysis of the ~~site-specific seismic Category I~~UHS basin and RSW pump house structures ~~is~~was performed using a frequency-domain time history analysis. Analyses ~~are~~were performed for three orthogonal (two horizontal and one vertical) directions and account for the translational, rocking, and torsional responses of the structures and foundations.

3H.6.5.2.2 Natural Frequencies and Responses

~~As discussed in Section 3H.6.2, the~~The dominant natural frequencies and the seismic responses of the UHS ~~cooling tower enclosures~~ and RSW pump house~~s will be~~ structures are provided in Tables 3H6-3 and 3H.6-4.~~upon completion of the final seismic analysis.~~

3H.6.5.2.3 Procedures for Analytical Modeling

The seismic analysis of the UHS basin and enclosed cooling tower as well as ~~the~~ RSW pump house for each unit ~~will be~~was performed using a three-dimensional finite element model.~~.~~ The model ~~will~~ consists primarily of plate elements that represent the reinforced concrete walls, buttresses, and foundation as well as the walls and slabs of the basin, cooling towers, and pump house. Beam elements ~~will be~~were used to represent concrete columns and concrete and steel beams in the cooling towers. Finally, ~~brick~~solid elements ~~will be~~were used to represent soil surrounding the basin and pump houses.

The mass of the structures ~~will be~~was represented primarily by the density of the plate, beam, and ~~brick~~solid elements comprising the model. These densities ~~will be~~were appropriately modified to account for applicable live loads. Concentrated masses ~~will be~~were used to represent the weight of equipment in the pump house, and the impulsive water mass that ~~will be~~was calculated using the procedure described in Commentary Subsection C3.5.4 of ASCE 4.

~~The seismic analysis of the RSW piping tunnels will address the effects of seismic waves on the tunnels as well as lateral earth pressures and groundwater effects.~~

3H.6.5.2.4 Soil-Structure Interaction

Soil-structure interaction (SSI) effects ~~are~~ were accounted for by the use of the SASSI2000 computer program in conjunction with time histories described in Subsection 3H.6.5.1.1.2 and the structural model described in Subsection 3H.6.5.2.3 and shown in Figure 3H.6-15. The SASSI2000 analysis addresses the embedment of the structure, groundwater effects, the layering of the soil, and variations of the strain-dependent soil properties.

The strain-compatible soil shear wave velocity and damping values for the SSI analysis were obtained from the same ground response analysis which was used to develop the GMRS, as described in Section 2.5S.2. Three sets of soil properties were used (i.e., mean, upper bound, and lower bound), and the responses from the three analyses were enveloped. The three sets of soil properties are shown in Table 3H.6-1. The soil layer thicknesses used in the SSI model were sufficiently small to transmit frequency up to 33 Hz for mean soil properties.

In order to account for the backfill placed adjacent to the walls, an additional set of SSI analyses was performed by modeling the backfill as the soil horizon above the foundation level in the SASSI2000 model. The responses obtained from this set of SSI analyses and the analyses using in situ soil as the horizon were enveloped.

The following properties were used for the backfill to obtain shear wave and compression wave velocities, and damping ratios used in the SSI analysis:

- Unit Weight:... 120 pcf (1,922 kg/m^3)
- Compression: .... 95% Modified Proctor
- Poisson's Ratio:............................ 0.42 above water table, 0.47 below water table

The strain-compatible shear wave and compression wave velocities, and damping ratios used in the three backfill models (mean, upper bound, and lower bound) are shown in Table 3H.6-2.

3H.6.5.2.5 Development of In-Structure Response Spectra

In-structure response spectra (ISRS), shown in Figures 3H.6-16 through 3H.6-39 ~~are~~were developed as part of the SSI analysis in accordance with RG 1.122. ~~This includes combining the seismic response spectra in all three orthogonal directions~~The

ISRS in a given direction was obtained by combining the three ISRS in that direction (developed from the separate analyses of the three directions of input motion) by the square-root-of-the-sum-of-the-squares (SRSS) method ~~to define the response spectra in a given direction and broadening of the peaks of the resulting spectra~~. The frequency increment for the calculation of ISRS was either smaller than or the same as provided in Table 1 of Regulatory Guide 1.122. The ISRS were broadened by ±15% based on the guidance provided in Regulatory Guide 1.122. See Section 3H.6.5.2.9 for the treatment of the effects due to concrete cracking.

3H.6.5.2.6 Three Components of Earthquake Motion

Separate analyses ~~are~~were performed in three orthogonal (two horizontal and one vertical) directions. Total structural responses (accelerations, displacements, and forces) ~~are~~were calculated by combining the co-directional responses as described in Subsection 3H.6.5.1.1.2.~~in accordance with RG 1.92.~~

3H.6.5.2.7 Combination of Modal Responses

Since a frequency-domain seismic analysis ~~is~~was performed, there ~~will be~~were no modal responses to be combined.

3H.6.5.2.8 Interaction of Non-Category I Structures with Category I SSCs

There are no non-Category I structures near the site-specific seismic Category I structures. Consequently, there is no interaction between non-Category I and the site-specific seismic Category I structures.

3H.6.5.2.9 Effects of Parameter Variations on Floor Responses

The soil property variation ~~referred to~~described in Subsection 3H.6.5.2.4 is accounted for in the generation of the ISRS~~floor response spectra (FRS)~~. In addition, the impact of variations in the input parameters to the seismic analysis is accounted for by broadening the FRS in accordance with RG 1.122. To account for concrete cracking, in addition to other uncertainties, the ISRS are developed with structural properties based on cracked concrete stiffness and the mean soil properties. These spectra are enveloped with the spectra from the uncracked analysis and, then, widened by ±15% to obtain final ISRS for use in design.

3H.6.5.2.10 Use of Equivalent Vertical Static Factors

Since a separate seismic analysis ~~is~~was performed for the vertical direction, equivalent static factors ~~are~~were not used to define the vertical seismic responses.

3H.6.5.2.11 Methods Used to Account for Torsional Effects

The effect of torsion on the seismic responses ~~is~~was accounted for by the use of a three-dimensional model of the structures in the seismic analysis.

The detailed structural analyses ~~are~~ performed using the results from the seismic analysis account for eccentricities of plus and minus 5% in both horizontal directions.

3H.6.5.2.12 Comparison of Responses

Since only a frequency-domain analysis is performed, ~~there will be no~~ comparison of responses is presented.

3H.6.5.2.13 Analysis Procedure for Damping

The SSI analysis accounts for the structural and soil-damping described in Subsection 3H.6.5.1.2.

3H.6.5.2.14 Determination of Seismic Overturning Moments and Sliding Forces for Seismic Category I Structures

The evaluation of seismic overturning moments and sliding accounts for the simultaneous application of seismic forces in three directions.

3H.6.5.2.15 Plant Shutdown Criteria

The plant shutdown criteria described in DCD Section 3.7.4.4 will be used based on the site-specific SSE response spectra shown in Figures 3.7-1a and 3.7-2a.

3H.6.5.3 Seismic Analysis of RSW Piping Tunnels

The RSW piping tunnel seismic analysis has been performed using an equivalent static approach, using the horizontal and vertical Input Spectra defined in Subsection 3H.6.5.1.1.1. The concrete elements of the RSW piping tunnel are sized such that the structure is rigid with a minimum frequency exceeding 33 Hz. The structure is buried inside the soil. Since the minimum structural frequency of the RSW piping tunnel exceeds 33 Hz, in-structure amplification will not take place and, therefore, the Input Spectra can be used as in-structure response spectra. The traveling wave effects during a seismic event that are acting on the structure have been considered per Section 3.5.2.1 of ASCE 4-98. The results of the RSW Tunnel design are summarized in Table 3H.6-6.

3H.6.6 Structural Analysis and Design Summary

3H.6.6.1 Analytical Models

~~The structural analysis of the UHS basin, UHS cooling tower enclosures, and RSW pump houses will be performed using a three-dimensional finite element model of the structures with the solid elements representing the soil surrounding the UHS and pump house. A separate model will be developed for use in the evaluation of the RSW piping tunnels and will be described in the FSAR update discussed in Subsection 3H.6.2.~~

The structural analysis and design of the UHS basin and the RSW pump house was performed using a finite element model (FEM). The FEM model is shown in Figure 3H.6-40. The analysis for the seismic loads was performed using equivalent static loads and the induced forces due to the X, Y, and Z seismic excitations were combined using the SRSS method of combination. For the portions of the UHS basin where liquid-tightness is required (i.e., exterior walls and basemat of the basin), in addition to satisfying ACI 349 strength requirements, the required strength was increased by the environmental durability factors noted in Subsection 3H.6.4.3.4.3 per Section 9.2.8 of ACI 350-01. Detailed stability evaluations were performed for sliding, overturning, and flotation. For sliding and overturning evaluations, the 100%, 40%, 40% rule was used for consideration of the X, Y, and Z seismic excitations. The RSW piping tunnel has been analyzed using an equivalent static approach for the seismic loads, as described in Subsection 3H.6.5.3.

3H.6.6.2 Analytical Approach

3H.6.6.2.1 UHS Basin, UHS Cooling Tower Enclosure, and RSW Pump House

~~A static analysis is performed on the finite element model described in Section 3H.6.5.2.3. This~~The analysis described in Subsection 3H.6.6.1 considers the following loads, combined in accordance with Subsection 3H.6.4.3.4:

- Dead and live loads on the UHS basin, UHS cooling tower enclosures, and RSW pump houses as specified in Subsection 3H.6.4.3.1, plus the weight of the UHS cooling tower fill, equipment and commodities in the RSW pump house.
- Hydrostatic and hydrodynamic (impulsive and convective) loads corresponding to the water in the basin, and on the walls and the piers of the UHS basin. These loads are calculated in accordance with Subsection C3.5.4 of ASCE 4.
- At-rest lateral soil pressure on the walls of the UHS basin and RSW pump houses.
- Hydrostatic pressures on the walls of the UHS basin and RSW pump houses due to groundwater.
- Dynamic lateral soil pressures on the walls of the UHS basin and RSW pump houses due to an SSE, calculated using the methodology defined in Subsection 3.5.3.2.2 of ASCE 4.
- Surcharge pressure of 300 psf (14.4 kPa) applied to the access road to the UHS basin and RSW pump houses.
- SSE forces corresponding to the weight of the structures being acted on by the accelerations established by the SSI analysis.
- Wind loads on the UHS basin, UHS cooling tower enclosures, and RSW pump houses calculated as indicated in Subsection 3H.6.4.3.2.
- Tornado wind and pressure loads on the UHS basin, UHS cooling tower enclosures, and RSW pump houses calculated as specified in Subsection 3H.6.4.3.3.1.
- ~~Overall global effects of applicable tornado missiles on the UHS basin walls and cooling tower enclosure walls.~~The design flood loads on the RSW pump houses and tunnels are as stated in Subsection 3H.6.4.2.3.

3H.6.6.2.2 RSW Piping Tunnels

~~A~~An equivalent static analysis ~~is~~was performed ~~on the finite element model of~~for the RSW piping tunnels (see Subsection 3H.6.5.3). This analysis ~~considers~~considered the loads identified below, combined in accordance with Subsection 3H.6.4.3.4. In addition, SSE forces created in the tunnel walls due to the passage of seismic waves through the soil ~~are~~were considered.

- Dead load of the tunnel walls and the soil above the tunnel.
- Live load of 200 psf (9.6 kPa) applied to the floor of the tunnels.
- At-rest lateral soil pressure on the tunnel walls.
- Hydrostatic pressures on the tunnel walls due to groundwater.
- Dynamic lateral soil pressures on the tunnel walls due to an SSE calculated using the methodology defined in Subsection 3.5.3.2.2 of ASCE 4.
- Surcharge pressure of 500 psf (23.9 kPa) applied to the ground above the tunnels.
- SSE forces corresponding to the weight of the tunnels being acted on by the accelerations established by the SSI analysis.

3H.6.6.3 Structural Design

The strength design criteria defined in ACI 349 as supplemented by RG 1.142 as well as ACI 350, ~~is~~was used to design the reinforced concrete elements making up the UHS basin and cooling tower enclosures as well as the RSW pump houses and piping tunnels. Concrete with a compressive strength of 4.0 ksi (27.6 MPa) and reinforcing steel with a yield strength of 60 ksi (414 MPa) are considered in the design.

3H.6.6.4 Foundations

The foundations for the UHS basin, cooling towers, and pump house consist of a reinforced concrete mat and a lean concrete mud mat supported on undisturbed soil~~- or engineered structural backfill material~~. The RSW piping tunnels, which extend from each pump house to the corresponding control building locations, are provided with flexible connections at the building interfaces that prevent any potential movement of the buildings from creating forces or moments in the tunnels.

The loads and load combinations considered in the design of the common foundation mat are as defined in Subsection 3H.6.4.3. The design is in accordance with the strength design criteria defined in ACI 349 as supplemented by RG 1.142 as well as ACI 350, and ~~will consider~~considered concrete with a compressive strength of 4.0 ksi (27.6 MPa) and reinforcing steel with a yield strength of 60 ksi (414 MPa).

To prevent seepage of groundwater through the common foundation or through the walls of the basin and pump houses, a chemical waterproofing agent is applied to the exposed concrete surface of the mudmat. In addition, a waterproof membrane installed on the walls up to one foot below grade, with a water proof coating being applied from that level up to the flood level. While, as indicated in FSAR Subsection 3.8.6.1, the waterproofing of the mudmat will not reduce the ability of the foundation to transfer horizontal shear forces to the underlying soil, the waterproof membrane will protect the walls from any possible deleterious effects from aggressive groundwater. To prevent seepage of groundwater into the tunnels, a waterproof membrane is used.

3H.6.6.5 Stability Evaluations

~~As discussed in Subsection 3H.6.2, the~~The factors of safety of the combined UHS basin and RSW pump house and RSW Piping tunnel against sliding, overturning, and flotation ~~will be provided in a FSAR update upon completion of the final seismic analysis~~are provided in Table 3H.6-5.

3H.6.6.6 References

3H.6-1 US Department of Army, Fundamentals of Protective Design for Conventional Weapons, TM 5-855-1, November 1986.

Table 3H.6-1 Strain-Compatible Soil Properties Used in SSI Analysis

Soil Layers			Lower Bound			Mean			Upper Bound		
Layer No.	Thickness (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)
1	4.00	0.124	419.1	1128.4	1.6698	548.1	1475.9	1.2224	677.2	1823.4	0.7749
2	5.00	0.124	474.4	1277.4	1.9487	600.1	1615.8	1.4113	735.0	1979.0	0.8738
3	5.00	0.124	470.6	2399.5	2.1614	596.5	3041.5	1.5678	730.5	3725.1	0.9743
4	5.00	0.124	470.0	2396.7	2.3119	599.2	3055.2	1.6698	733.8	3741.9	1.0277
5	5.00	0.124	466.9	2380.6	2.4295	598.3	3050.9	1.7540	732.8	3736.6	1.0785
6	5.00	0.121	578.1	2947.9	2.8987	730.0	3722.5	2.0647	894.1	4559.1	1.2307
7	5.00	0.121	581.3	2964.2	3.0535	733.4	3739.4	2.1657	898.2	4579.8	1.2778
8	5.00	0.122	606.6	3093.0	2.1873	778.2	3968.1	1.4972	953.1	4859.9	0.8072
9	5.00	0.122	602.2	3070.6	2.3098	774.6	3949.6	1.5804	948.7	4837.3	0.8509
10	5.00	0.122	598.1	3049.7	2.4308	771.2	3932.2	1.6566	944.5	4816.0	0.8824
11	5.00	0.122	600.0	3059.2	2.5321	771.9	3935.9	1.7154	945.4	4820.4	0.8986
12	5.00	0.122	719.8	3670.5	2.2554	924.5	4714.1	1.6695	1132.3	5000.0	1.0836
13	5.00	0.122	720.6	3674.4	2.2824	925.0	4716.5	1.6893	1132.9	5000.0	1.0962
14	5.00	0.122	719.8	3670.4	2.3079	924.3	4712.9	1.7112	1132.0	5000.0	1.1145
15	5.00	0.122	719.1	3666.7	2.3275	923.6	4709.5	1.7260	1131.2	5000.0	1.1245
16	5.00	0.123	827.3	4218.4	2.0584	1013.2	5000.0	1.4280	1241.0	5215.9	0.7975
17	5.00	0.123	825.7	4210.5	2.1082	1011.3	5000.0	1.4603	1238.6	5206.1	0.8123
18	5.00	0.123	824.2	4202.7	2.1636	1009.5	5000.0	1.4988	1236.3	5196.6	0.8340
19	5.00	0.123	822.8	4195.2	2.2125	1007.7	5000.0	1.5321	1234.1	5187.3	0.8516
20	5.00	0.125	850.3	4335.6	2.2666	1041.4	5000.0	1.6792	1275.4	5360.8	1.0917
21	5.00	0.125	849.9	4333.5	2.2780	1040.9	5000.0	1.6904	1274.8	5358.3	1.1027
22	5.00	0.125	849.5	4331.5	2.2969	1040.4	5000.0	1.7027	1274.2	5355.8	1.1085
23	5.00	0.125	874.5	4459.3	2.0113	1085.2	5000.0	1.4063	1329.1	5586.6	0.8014
24	5.00	0.125	873.3	4452.8	2.0424	1084.2	5000.0	1.4290	1327.9	5581.2	0.8157
25	5.00	0.125	872.1	4446.7	2.0761	1083.2	5000.0	1.4485	1326.6	5576.1	0.8209
26	7.00	0.125	914.5	4663.0	2.3111	1120.0	5000.0	1.6966	1371.7	5765.6	1.0822
27	7.00	0.125	914.0	4660.8	2.3253	1119.5	5000.0	1.7081	1371.1	5762.9	1.0909
28	7.00	0.125	911.5	4647.8	2.3428	1117.8	5000.0	1.7197	1369.1	5754.5	1.0966

Table 3H.6-1 Strain-Compatible Soil Properties Used in SSI Analysis (Continued)

Soil Layers			Lower Bound			Mean			Upper Bound		
Layer No.	Thickness (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)
29	7.00	0.125	910.9	4644.9	2.3545	1117.4	5000.0	1.7287	1368.5	5751.9	1.1029
30	7.00	0.125	910.4	4642.2	2.3693	1116.9	5000.0	1.7403	1367.9	5749.4	1.1114
31	5.00	0.125	883.7	4506.2	2.2271	1102.4	5000.0	1.5420	1350.1	5674.8	0.8568
32	5.00	0.125	881.5	4494.7	2.2467	1101.0	5000.0	1.5575	1348.4	5667.5	0.8683
33	5.00	0.125	880.6	4490.3	2.2764	1100.2	5000.0	1.5770	1347.4	5663.6	0.8775
34	9.00	0.125	919.6	4689.0	2.3842	1126.3	5000.0	1.7519	1379.4	5797.7	1.1196
35	9.00	0.125	919.1	4686.8	2.3984	1125.7	5000.0	1.7608	1378.7	5795.0	1.1231
36	9.00	0.125	922.5	4703.8	2.4066	1129.8	5000.0	1.7673	1383.7	5816.1	1.1281
37	9.00	0.125	922.8	4705.5	2.4195	1130.2	5000.0	1.7795	1384.2	5818.2	1.1394
38	9.00	0.125	919.2	4687.1	2.4362	1125.8	5000.0	1.7917	1378.8	5795.4	1.1472
39	9.00	0.124	921.5	4698.6	2.4066	1146.4	5000.0	1.7870	1404.0	5901.3	1.1674
40	9.00	0.124	931.4	4749.0	2.4129	1157.6	5000.0	1.7862	1417.8	5959.3	1.1595
41	5.00	0.127	986.2	5000.0	2.2903	1222.6	5138.7	1.5360	1497.4	6293.7	0.7818
42	5.00	0.127	985.7	5000.0	2.2989	1222.1	5136.6	1.5447	1496.7	6291.0	0.7905
43	5.00	0.127	985.1	5000.0	2.3165	1221.6	5134.5	1.5554	1496.1	6288.4	0.7943
44	5.00	0.127	984.6	5000.0	2.3275	1221.1	5132.4	1.5619	1495.5	6285.9	0.7963
45	5.00	0.127	984.0	5000.0	2.3410	1220.6	5130.4	1.5697	1494.9	6283.4	0.7984
46	5.00	0.125	1025.7	5000.0	2.3496	1256.3	5280.3	1.7372	1538.6	6467.1	1.1247
47	15.00	0.127	1010.5	5000.0	2.1171	1237.7	5202.1	1.5316	1515.8	6371.2	0.9461
48	11.80	0.123	1034.4	5000.0	2.3607	1266.9	5324.9	1.7527	1551.6	6521.6	1.1447
49	11.80	0.123	1034.0	5000.0	2.3685	1266.4	5323.0	1.7581	1551.0	6519.3	1.1477
50	11.80	0.123	1033.7	5000.0	2.3815	1266.0	5321.2	1.7665	1550.5	6517.1	1.1516
51	11.80	0.123	1037.2	5000.0	2.3948	1270.3	5339.2	1.7726	1555.8	6539.1	1.1505
52	11.80	0.123	1036.9	5000.0	2.4048	1269.9	5337.6	1.7792	1555.3	6537.2	1.1536
53	17.00	0.128	1252.4	5264.0	1.8381	1575.1	6620.6	1.2897	1929.1	8108.5	0.7413
54	8.00	0.123	1301.7	5471.3	2.1463	1607.2	6755.4	1.6064	1968.4	8273.7	1.0664
55	16.50	0.128	1310.3	5507.2	1.7999	1604.7	6744.9	1.2702	1965.4	8260.8	0.7405
56	16.50	0.128	1309.5	5503.9	1.8246	1603.7	6740.8	1.2855	1964.2	8255.8	0.7465

Table 3H.6-1 Strain-Compatible Soil Properties Used in SSI Analysis (Continued)

Soil Layers			Lower Bound			Mean			Upper Bound		
Layer No.	Thickness (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)
57	8.00	0.123	1290.5	5424.1	2.2004	1580.5	6643.2	1.6357	1935.7	8136.2	1.0711
58	19.00	0.128	1156.1	5000.0	2.0671	1417.2	5956.7	1.4716	1735.7	7295.4	0.8761
59	15.00	0.123	995.4	5000.0	2.5251	1219.2	5124.3	1.8573	1493.2	6276.0	1.1895
60	15.00	0.123	995.2	5000.0	2.5283	1218.9	5123.3	1.8597	1492.8	6274.7	1.1910
61	8.00	0.128	970.0	4946.2	2.6235	1188.1	5000.0	1.8389	1455.1	6115.9	1.0543
62	18.00	0.123	990.9	5000.0	2.5359	1213.6	5101.1	1.8669	1486.4	6247.5	1.1980
63	18.00	0.123	990.6	5000.0	2.5391	1213.3	5099.7	1.8706	1486.0	6245.8	1.2021
64	18.00	0.123	999.5	5000.0	2.5358	1224.1	5145.1	1.8672	1499.2	6301.4	1.1986
65	18.00	0.123	1196.2	5027.7	2.0970	1465.0	6157.6	1.4997	1794.2	7541.5	0.9024
66	14.60	0.123	1172.4	5000.0	2.3353	1435.9	6035.4	1.7343	1758.6	7391.8	1.1332
67	14.60	0.123	1172.2	5000.0	2.3381	1435.6	6034.3	1.7362	1758.3	7390.5	1.1343
68	14.60	0.123	1172.0	5000.0	2.3411	1435.4	6033.3	1.7397	1758.0	7389.2	1.1382
69	14.60	0.123	1171.8	5000.0	2.3468	1435.2	6032.3	1.7427	1757.7	7388.0	1.1386
70	14.60	0.123	1171.7	5000.0	2.3531	1435.0	6031.5	1.7455	1757.5	7387.0	1.1379
71	45.50	0.129	1378.7	5065.8	0.9127	1688.6	6204.3	0.5883	2068.1	7598.6	0.2639
72	45.50	0.129	1378.7	5065.8	0.9127	1688.6	6204.3	0.5883	2068.1	7598.6	0.2639
73	100.00	0.128	1388.7	5102.3	0.9127	1700.8	6249.0	0.5883	2083.0	7653.4	0.2639
74	100.00	0.128	1388.7	5102.3	0.9127	1700.8	6249.0	0.5883	2083.0	7653.4	0.2639
75	100.00	0.130	1533.0	5084.5	0.9127	1877.6	6227.2	0.5883	2299.5	7626.7	0.2639
76	100.00	0.130	1533.0	5084.5	0.9127	1877.6	6227.2	0.5883	2299.5	7626.7	0.2639
77	100.00	0.130	1667.2	5529.4	0.9127	2041.9	6772.1	0.5883	2500.8	8294.1	0.2639
78	100.00	0.130	1667.2	5093.3	0.9127	2041.9	6238.0	0.5883	2500.8	7640.0	0.2639
79	100.00	0.130	1735.4	5301.6	0.9127	2125.4	6493.1	0.5883	2603.0	7952.4	0.2639
80	100.00	0.130	1735.4	5301.6	0.9127	2125.4	6493.1	0.5883	2603.0	7952.4	0.2639
81	100.00	0.130	1870.7	5338.3	0.9127	2291.2	6538.0	0.5883	2806.1	8007.4	0.2639
82	100.00	0.130	1870.7	5338.3	0.9127	2291.2	6538.0	0.5883	2806.1	8007.4	0.2639
83	100.00	0.130	1912.1	5456.3	0.9127	2341.8	6682.6	0.5883	2868.1	8184.4	0.2639
84	100.00	0.130	1912.1	5148.5	0.9127	2341.8	6305.6	0.5883	2868.1	7722.7	0.2639

Table 3H.6-1 Strain-Compatible Soil Properties Used in SSI Analysis (Continued)

Soil Layers			Lower Bound			Mean			Upper Bound		
Layer No.	Thickness (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)
85	100.00	0.135	2042.5	5499.7	0.9127	2501.6	6735.7	0.5883	3063.8	8249.6	0.2639
86	100.00	0.135	2051.1	5522.8	0.9127	2512.1	6764.0	0.5883	3076.7	8284.2	0.2639
87	100.00	0.135	2259.9	5786.1	0.9127	2767.8	7086.5	0.5883	3389.8	8679.2	0.2639
88	100.00	0.135	2259.9	5786.1	0.9127	2767.8	7086.5	0.5883	3389.8	8679.2	0.2639
89	100.00	0.135	2402.8	6152.0	0.9127	2942.8	7534.6	0.5883	3604.1	9228.0	0.2639
90	100.00	0.135	2402.8	5885.6	0.9127	2942.8	7208.3	0.5883	3604.1	8828.3	0.2639
91	100.00	0.140	2402.8	5885.6	0.9127	2942.8	7208.3	0.5883	3604.1	8828.3	0.2639
92	100.00	0.140	2409.5	5902.0	0.9127	2951.0	7228.5	0.5883	3614.3	8853.1	0.2639
93	100.00	0.140	2496.3	5878.5	0.9127	3057.3	7199.6	0.5883	3744.4	8817.7	0.2639
94	100.00	0.140	2496.3	5878.5	0.9127	3057.3	7199.6	0.5883	3744.4	8817.7	0.2639
95	100.00	0.140	2531.9	5962.2	0.9127	3100.9	7302.2	0.5883	3797.8	8943.3	0.2639
96	100.00	0.140	2531.9	5755.0	0.9127	3100.9	7048.4	0.5883	3797.8	8632.5	0.2639
97	100.00	0.140	2789.2	6340.0	0.9127	3416.1	7764.8	0.5883	4183.8	9509.9	0.2639
98	100.00	0.140	2789.2	6340.0	0.9127	3416.1	7764.8	0.5883	4183.8	9509.9	0.2639
99	100.00	0.140	3055.6	6726.6	0.9127	3742.3	8238.4	0.5883	4583.4	10089.9	0.2639
100	100.00	0.140	3055.6	6726.6	0.9127	3742.3	8238.4	0.5883	4583.4	10089.9	0.2639
101	100.00	0.140	3144.4	6922.0	0.9127	3851.0	8477.7	0.5883	4716.5	10383.0	0.2639
102	100.00	0.140	3144.4	6722.9	0.9127	3851.0	8233.9	0.5883	4716.5	10084.4	0.2639
103	100.00	0.140	3245.3	6938.8	0.9127	3974.7	8498.3	0.5883	4868.0	10408.3	0.2639
104	100.00	0.140	3245.3	6938.8	0.9127	3974.7	8498.3	0.5883	4868.0	10408.3	0.2639
105	100.00	0.140	3280.1	6828.1	0.9127	4017.3	8362.7	0.5883	4920.2	10242.1	0.2639
106	100.00	0.140	3280.1	6828.1	0.9127	4017.3	8362.7	0.5883	4920.2	10242.1	0.2639
107	100.00	0.140	3280.1	6828.1	0.9127	4017.3	8362.6	0.5883	4920.1	10242.1	0.2639
108	100.00	0.140	3280.1	6661.9	0.9127	4017.3	8159.1	0.5883	4920.1	9992.8	0.2639
109	100.00	0.140	3337.8	6779.1	0.9127	4088.0	8302.7	0.5883	5006.7	10168.6	0.2639
110	100.00	0.140	3337.8	6779.1	0.9127	4088.0	8302.7	0.5883	5006.7	10168.6	0.2639
111	100.00	0.140	3395.5	6740.9	0.9127	4158.6	8255.9	0.5883	5093.3	10111.3	0.2639
112	100.00	0.140	3395.5	6740.9	0.9127	4158.6	8255.9	0.5883	5093.3	10111.3	0.2639

Table 3H.6-1 Strain-Compatible Soil Properties Used in SSI Analysis (Continued)

Soil Layers			Lower Bound			Mean			Upper Bound		
Layer No.	Thickness (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)
113	100.00	0.140	3425.0	6799.4	0.9127	4194.7	8327.6	0.5883	5137.5	10199.1	0.2639
114	100.00	0.140	3425.0	6657.0	0.9127	4194.7	8153.1	0.5883	5137.5	9985.5	0.2639
115	100.00	0.140	3609.5	7015.6	0.9127	4420.7	8592.3	0.5883	5414.2	10523.4	0.2639
116	100.00	0.140	3609.5	7015.6	0.9127	4420.7	8592.3	0.5883	5414.2	10523.4	0.2639
117	100.00	0.140	3815.4	7271.0	0.9127	4672.9	8905.1	0.5883	5723.2	10906.5	0.2639
118	100.00	0.140	3815.4	7271.0	0.9127	4672.9	8905.1	0.5883	5723.2	10906.5	0.2639
119	100.00	0.140	3828.5	7295.9	0.9127	4689.0	8935.6	0.5883	5742.8	10943.9	0.2639
120	100.00	0.140	3828.5	7162.5	0.9127	4689.0	8772.3	0.5883	5742.8	10743.8	0.2639
121	100.00	0.140	3995.3	7474.4	0.9127	4893.2	9154.3	0.5883	5992.9	11211.7	0.2639
122	100.00	0.140	3995.3	7474.4	0.9127	4893.2	9154.3	0.5883	5992.9	11211.7	0.2639
123	100.00	0.140	4042.3	7562.4	0.9127	4950.8	9262.1	0.5883	6063.4	11343.7	0.2639
124	100.00	0.140	4042.3	7562.4	0.9127	4950.8	9262.1	0.5883	6063.4	11343.7	0.2639
125	100.00	0.140	4057.2	7590.4	0.9127	4969.1	9296.2	0.5883	6085.8	11385.5	0.2639
126	100.00	0.140	4057.2	7590.4	0.9127	4969.1	9296.2	0.5883	6085.8	11385.5	0.2639
127	100.00	0.140	4064.5	7604.1	0.9127	4978.0	9313.0	0.5883	6096.8	11406.1	0.2639
128	100.00	0.140	4064.5	7604.1	0.9127	4978.0	9313.0	0.5883	6096.8	11406.1	0.2639
129	100.00	0.140	3997.4	7478.4	0.9127	4895.8	9159.2	0.5883	5996.1	11217.7	0.2639
130	100.00	0.140	3997.4	7478.4	0.9127	4895.8	9159.2	0.5883	5996.1	11217.7	0.2639
131	100.00	0.140	3779.9	7071.5	0.9127	4629.4	8660.8	0.5883	5669.8	10607.3	0.2639
132	100.00	0.140	3779.9	7071.5	0.9127	4629.4	8660.8	0.5883	5669.8	10607.3	0.2639
133	100.00	0.140	3164.0	5919.4	0.9127	3875.1	7249.7	0.5883	4746.1	8879.1	0.2639
134	100.00	0.140	3164.0	5919.4	0.9127	3875.1	7249.7	0.5883	4746.1	8879.1	0.2639
135	100.00	0.140	2974.8	5565.3	0.9127	3643.3	6816.0	0.5883	4462.1	8347.9	0.2639
136	100.00	0.140	2974.8	5565.3	0.9127	3643.3	6816.0	0.5883	4462.1	8347.9	0.2639
137	100.00	0.140	2942.9	5505.7	0.9127	3604.3	6743.0	0.5883	4414.4	8258.5	0.2639
138	100.00	0.140	2942.9	5505.7	0.9127	3604.3	6743.0	0.5883	4414.4	8258.5	0.2639
139	100.00	0.140	2914.5	5452.5	0.9127	3569.5	6677.9	0.5883	4371.7	8178.7	0.2639
140	100.00	0.140	2914.5	5452.5	0.9127	3569.5	6677.9	0.5883	4371.7	8178.7	0.2639

Table 3H.6-1 Strain-Compatible Soil Properties Used in SSI Analysis (Continued)

Soil Layers			Lower Bound			Mean			Upper Bound		
Layer No.	Thickness (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)
141	100.00	0.140	2914.5	5452.5	0.9127	3569.5	6677.9	0.5883	4371.7	8178.7	0.2639
142	100.00	0.140	2914.5	5452.5	0.9127	3569.5	6677.9	0.5883	4371.7	8178.7	0.2639
143	100.00	0.140	2875.7	5379.9	0.9127	3522.0	6589.1	0.5883	4313.6	8069.9	0.2639
144	100.00	0.140	2875.7	5379.9	0.9127	3522.0	6589.1	0.5883	4313.6	8069.9	0.2639
145	100.00	0.140	2875.9	5380.4	0.9127	3522.3	6589.6	0.5883	4313.9	8070.6	0.2639
146	100.00	0.140	2875.9	5380.4	0.9127	3522.3	6589.6	0.5883	4313.9	8070.6	0.2639

Table 3H.6-2 Strain-Compatible Backfill Properties Used in SSI Analysis

Soil Depth (ft)	Lower Bound Soil			Mean Value Soil			Upper Bound Soil		
	Vs (ft/sec)	Vp (ft/sec)	D (%)	Vs (ft/sec)	Vp (ft/sec)	D (%)	Vs (ft/sec)	Vp (ft/sec)	D (%)
0 to 32	592.6	2491.0	3.0	725.8	3051.0	2.0	952.1	4002.0	1.0
32 to 64	735.2	3090.0	3.0	900.4	3785.0	2.0	1253.0	5267.0	1.0

Table 3H.6-3 Dominant UHS and Pump House Natural Frequencies

[LATER]

Table 3H.6-4 Seismic Accelerations and Displacements for UHS and Pump House

[LATER]

Table 3H.6-5 Factors of Safety Against Sliding, Overturning, and Flotation for UHS Basin and RSW Pump House

[LATER]

Table 3H.6-6 Results of RSW Piping Tunnel Design

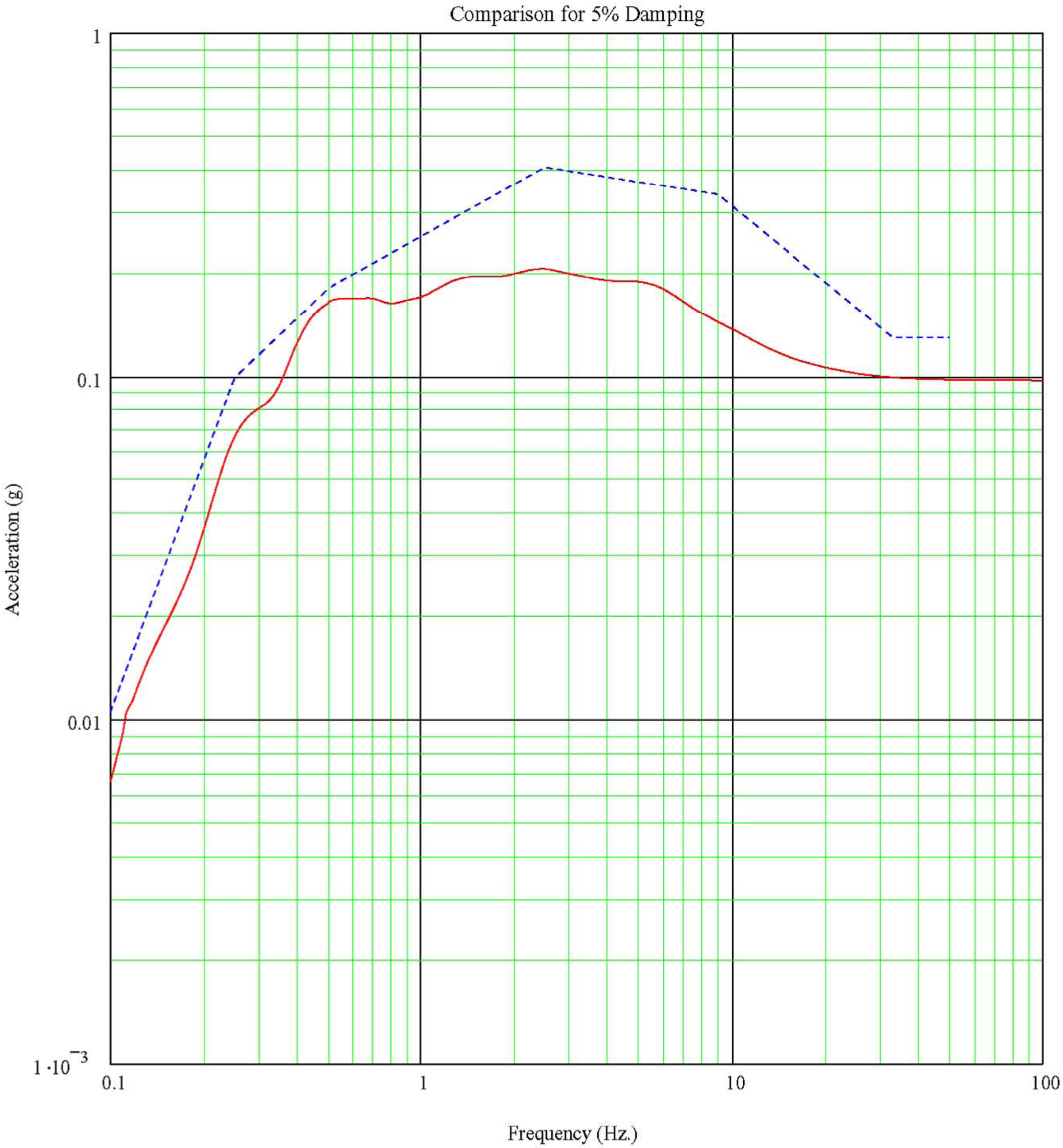
[LATER]

Table 3H.6-7 Results of UHS/RSW Pump House Concrete Wall Design

[LATER]

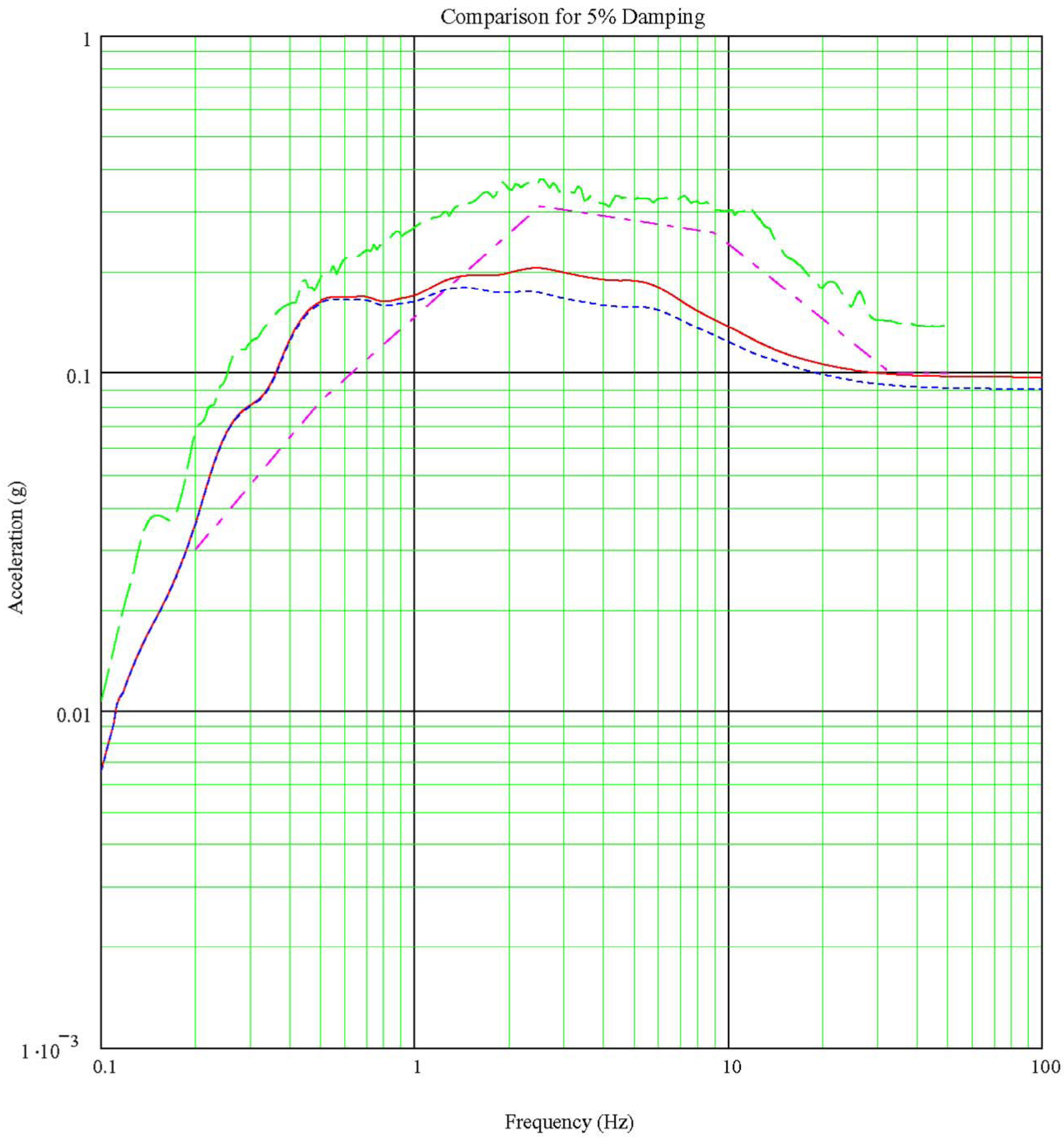
Table 3H.6-8 Results of UHS/RSW Pump House Concrete Slab Design

[LATER]



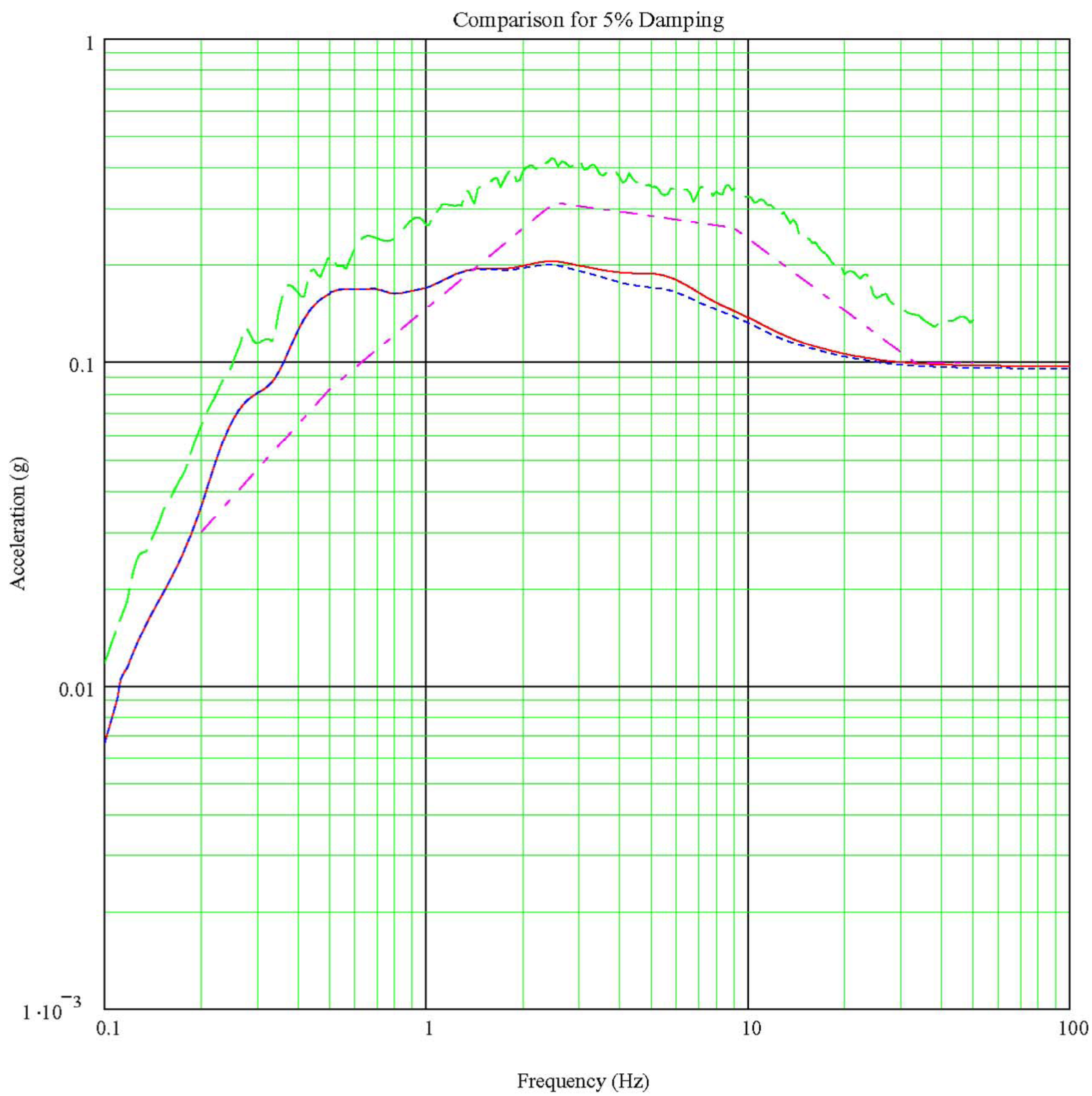
___ (Red): GMRS in the horizontal direction
...... (Blue): Input Spectrum in the horizontal direction

Figure 3H.6-1 Comparison of GMRS with the Input Spectrum (Horizontal)



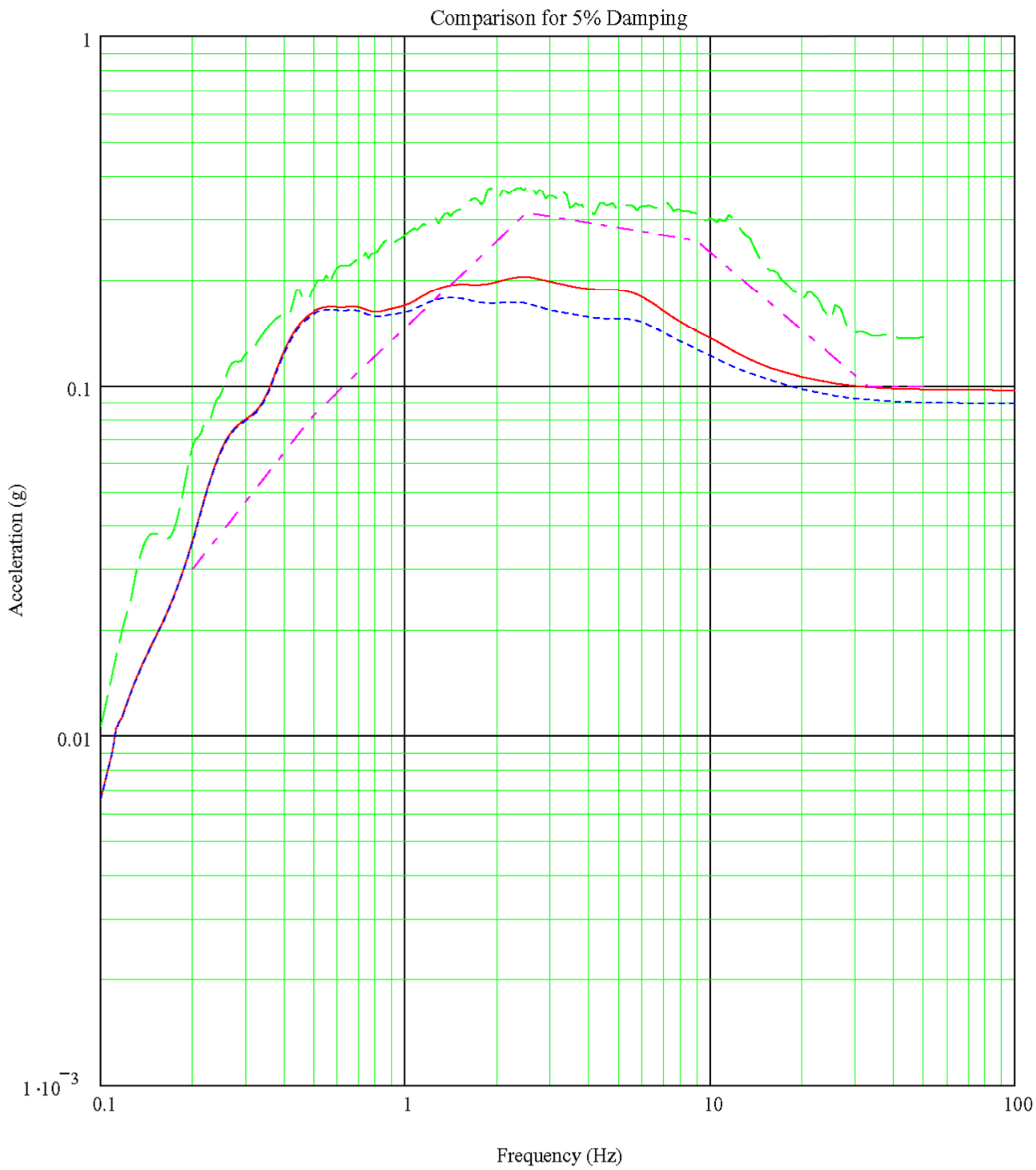
___ (Red): GMRS
...... (Blue): FIRS at foundation 68 ft below ground surface
___ (Green): Outcrop spectrum at 68 ft below ground surface from artificial time history
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-2 Comparison of GMRS with the Input Spectrum (Vertical)



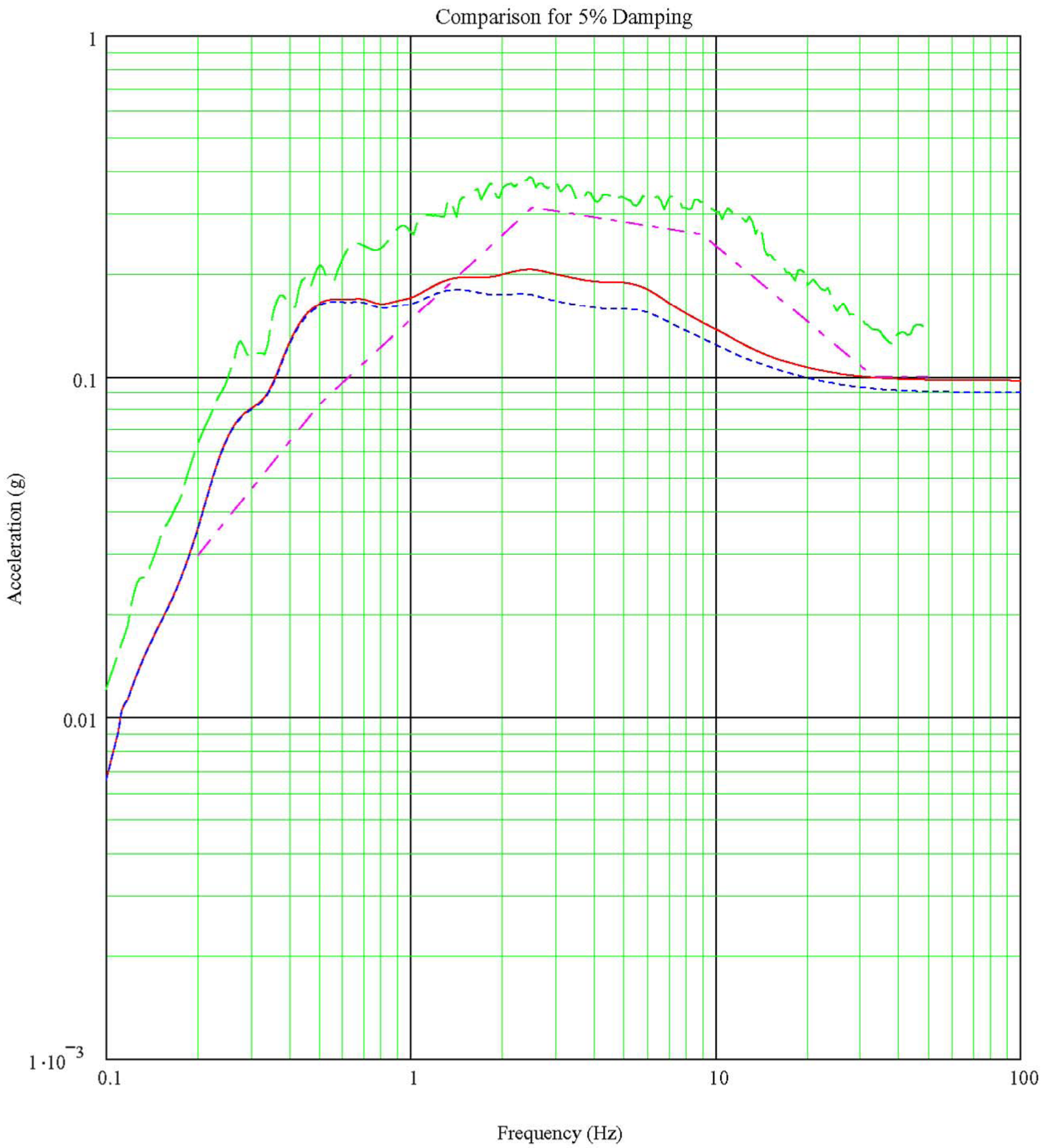
___ (Red): GMRS
...... (Blue): FIRS at foundation 32 ft below ground surface
___ (Green): Outcrop spectrum at 32 ft below ground surface from artificial time history
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-3 Comparison of Spectra at Foundation of UHS Basin (E-W (X) Direction)



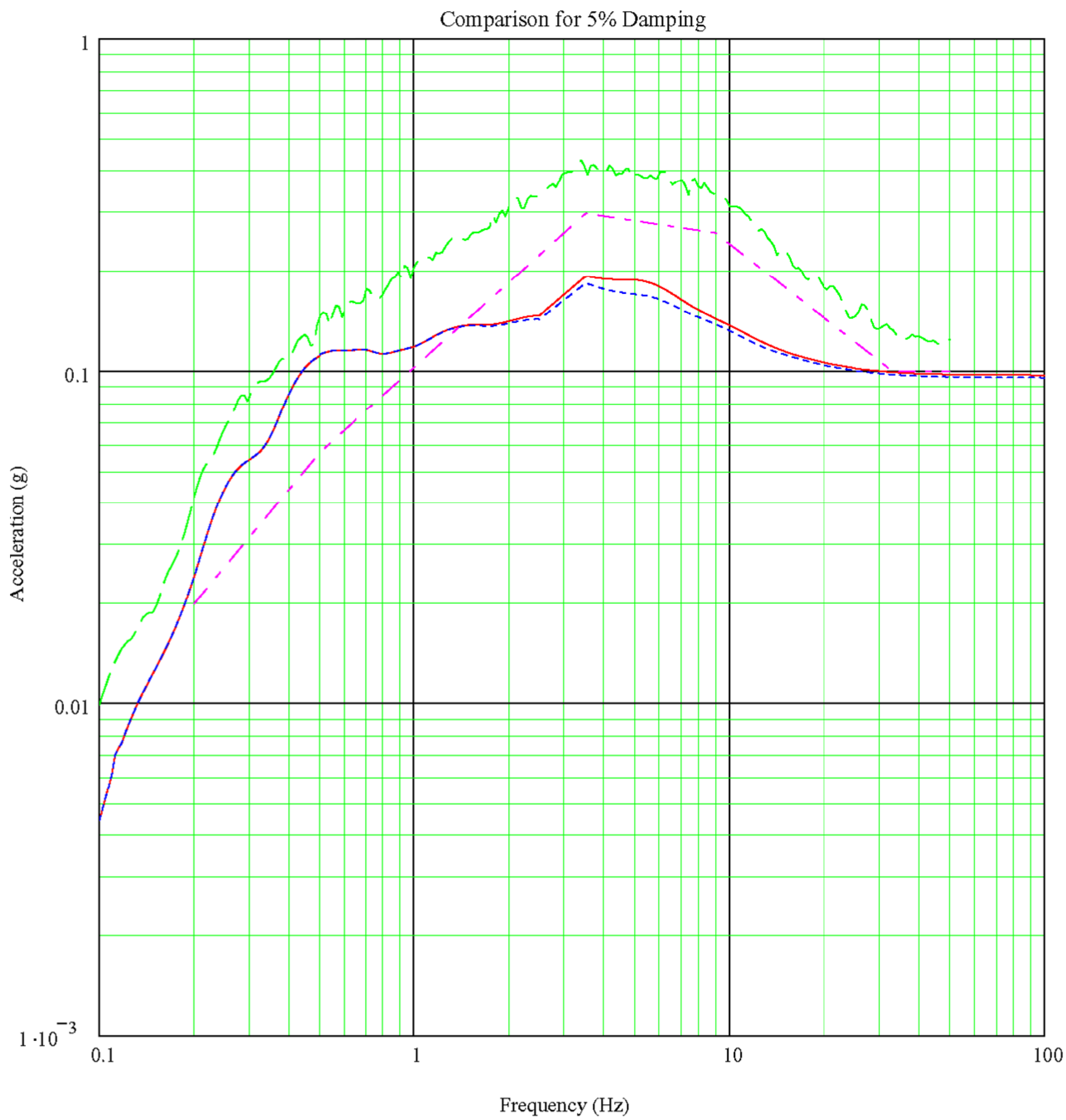
___ (Red): GMRS
...... (Blue): FIRS at foundation 57 ft below ground surface
___ (Green): Outcrop spectrum at 57 ft below ground surface from artificial time history
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-4 Comparison of Spectra at Foundation of RSW Tunnel (E-W (X) Direction)



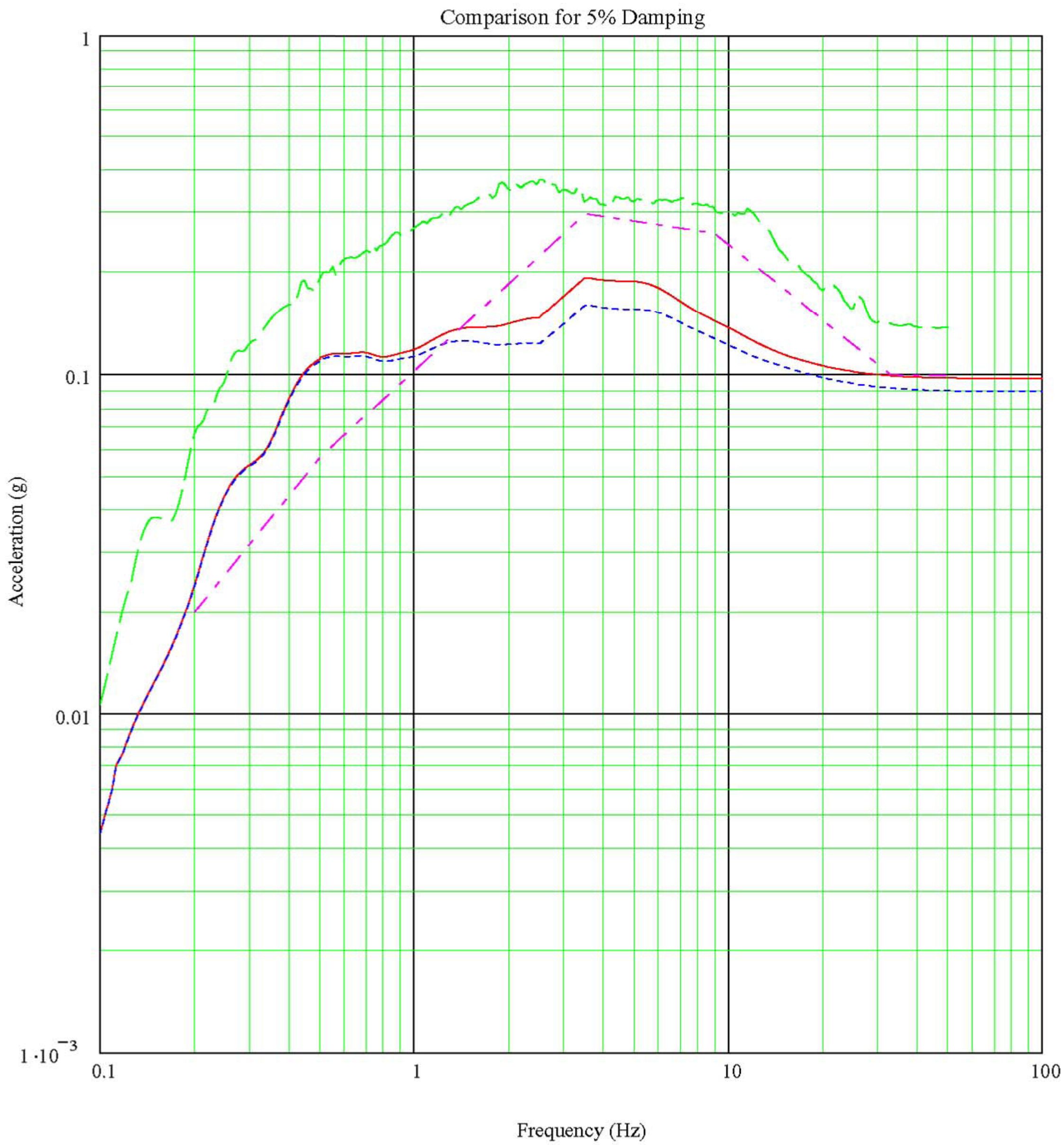
___ (Red): GMRS
...... (Blue): FIRS at foundation 68 ft below ground surface
___ (Green): Outcrop spectrum at 68 ft below ground surface from artificial time history
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-5 Comparison of Spectra at Foundation of RSW Pump House (E-W (X) Direction)



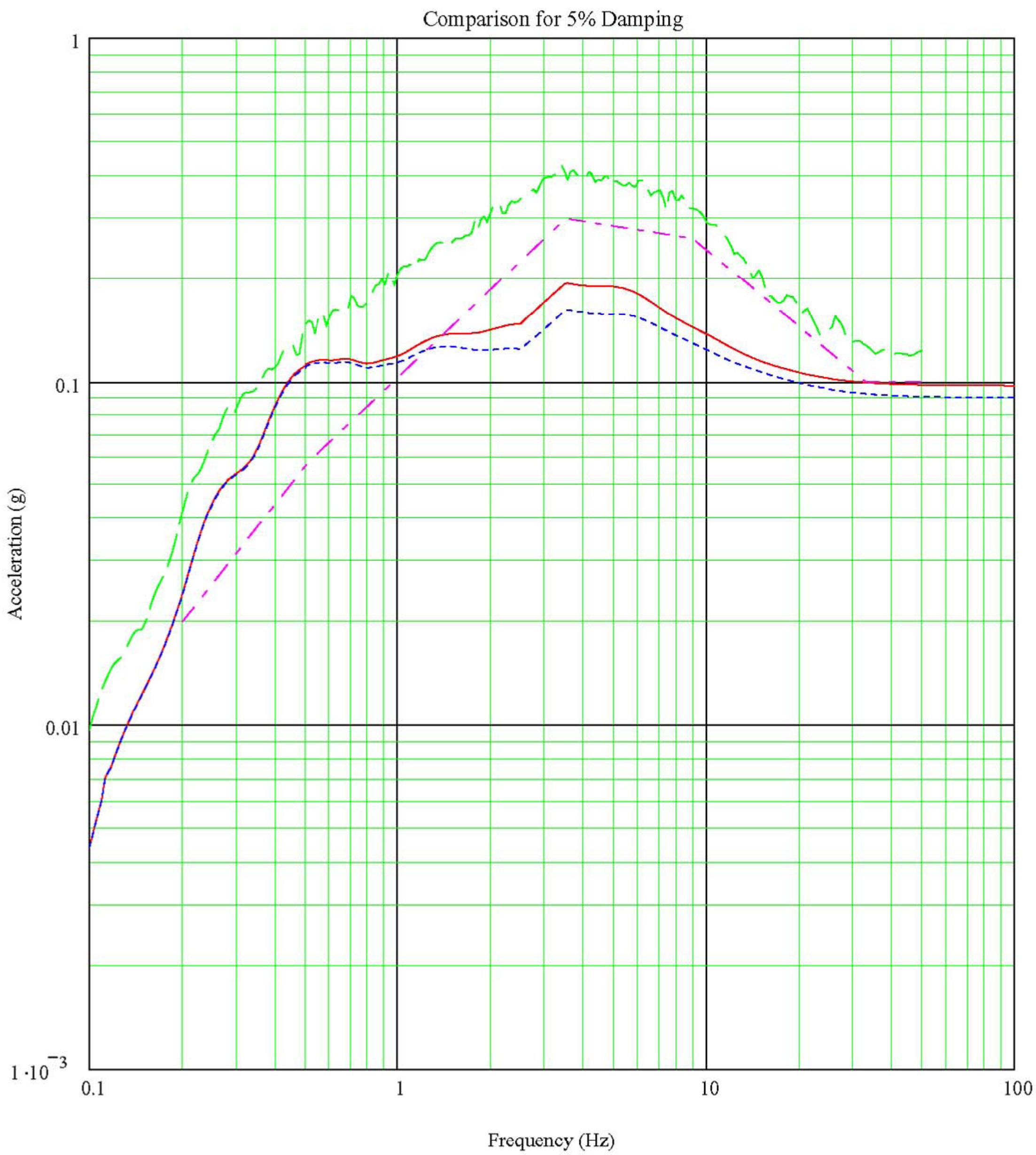
___ (Red): GMRS
...... (Blue): FIRS at foundation 32 ft below ground surface
___ (Green): Outcrop spectrum at 32 ft below ground surface from artificial time history
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-6 Comparison of Spectra at foundation of UHS Basin (N-S (Y) Direction)



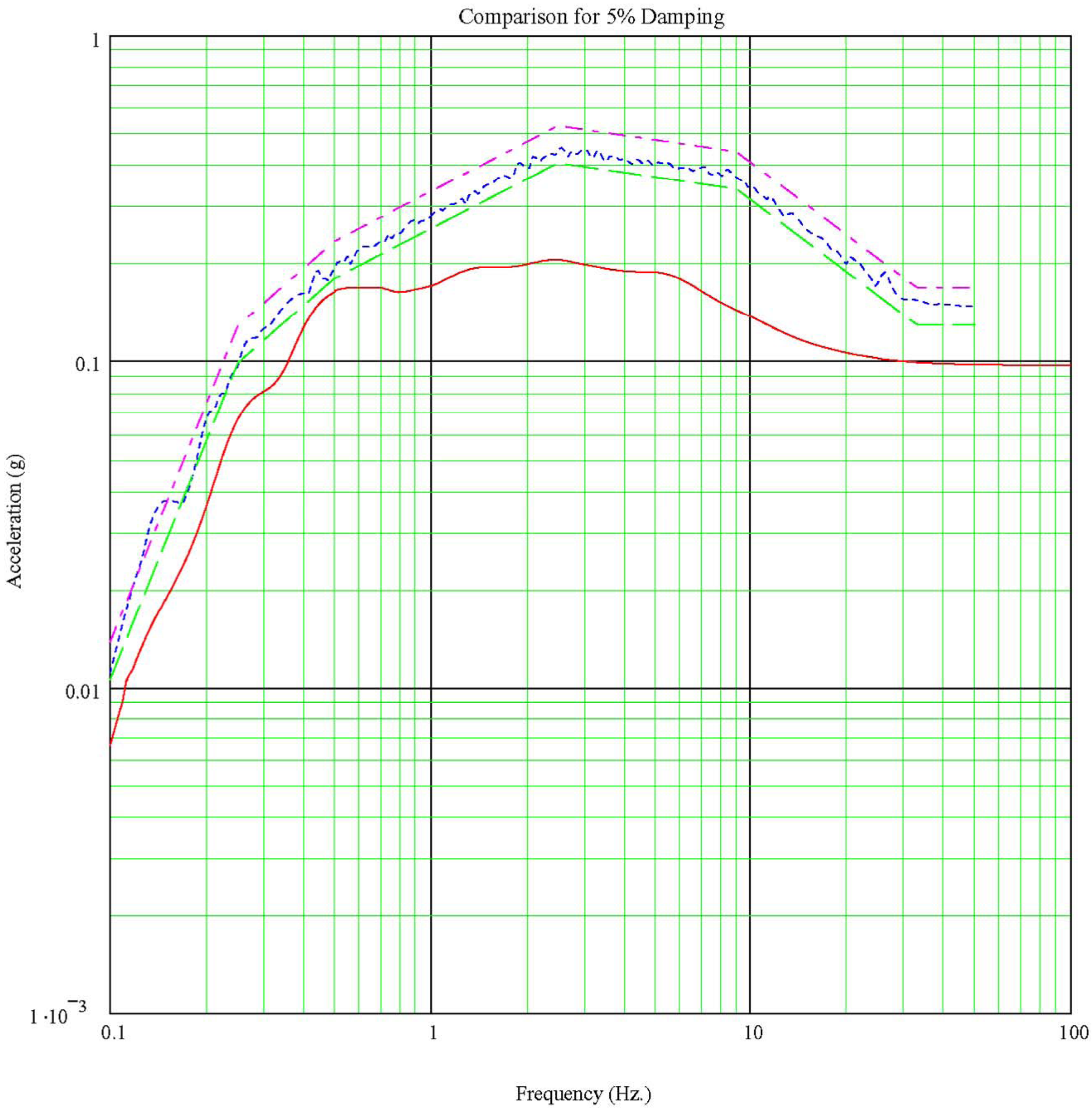
___ (Red): GMRS
...... (Blue): FIRS at foundation 57 ft below ground surface
___ (Green): Outcrop spectrum at 57 ft below ground surface from artificial time history
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-7 Comparison of Spectra at Foundation of RSW Tunnel (N-S (Y) Direction)



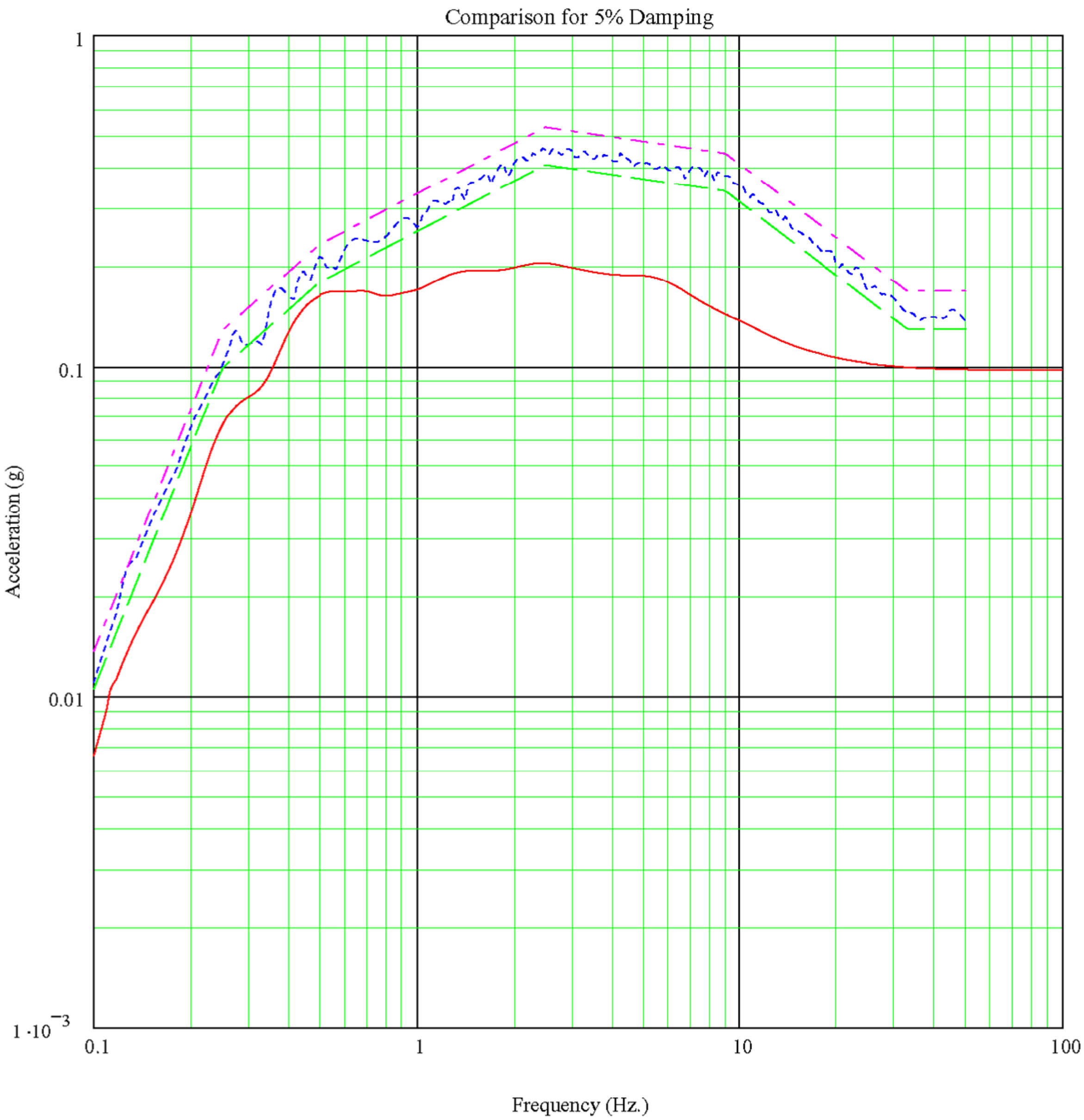
___ (Red): GMRS
...... (Blue): FIRS at foundation 68 ft below ground surface
___ (Green): Outcrop spectrum at 68 ft below ground surface from artificial time history
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-8 Comparison of Spectra at Foundation of RSW Pump House (N-S (Y) Direction)



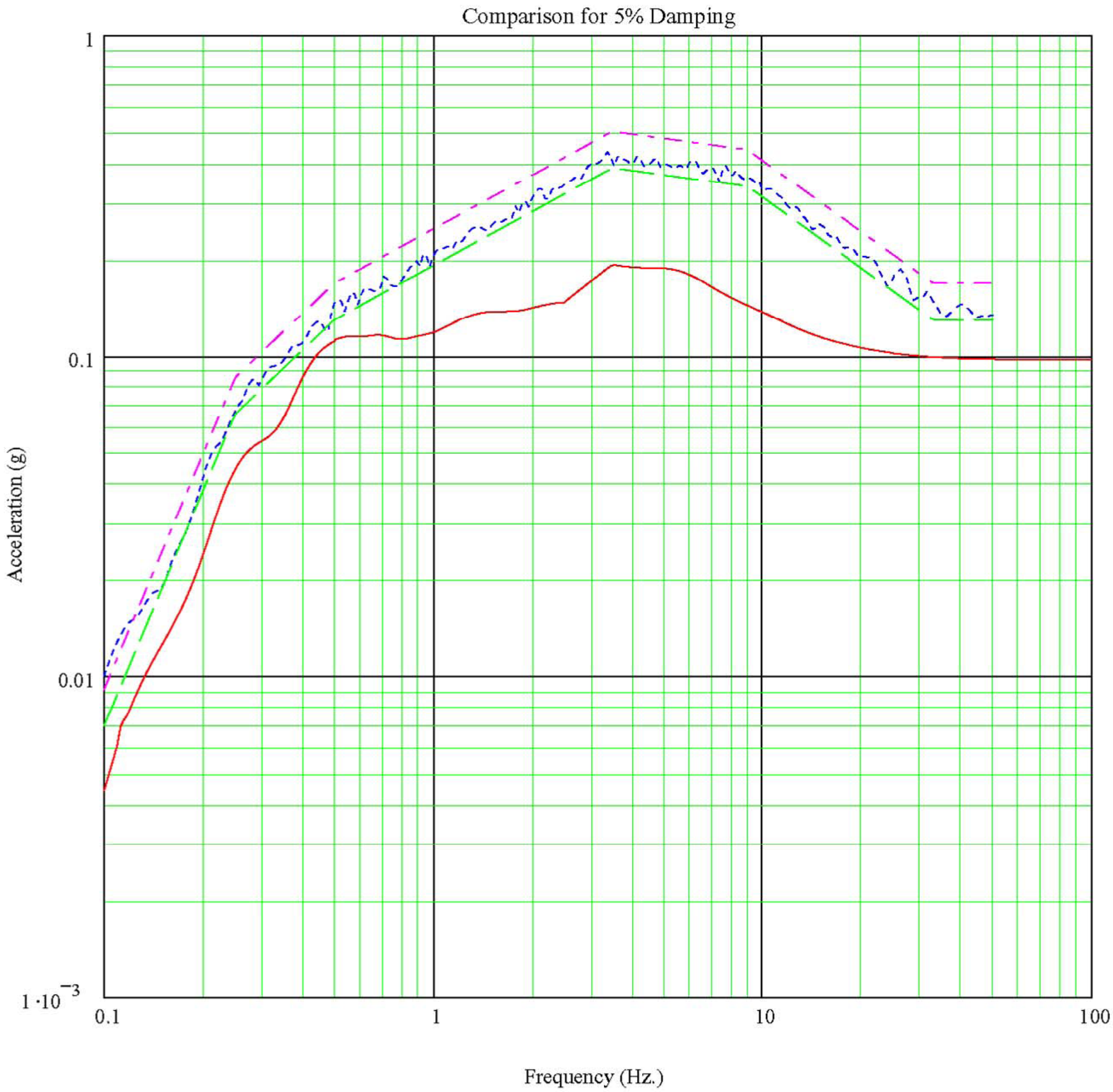
___ (Red): GMRS
...... (Blue): Response spectrum from artificial time history
___ (Green): Input response spectrum
_._. (Magenta): 130% of input response spectrum

Figure 3H.6-9 Comparison of Spectra at foundation of UHS Basin (Vertical (Z) Direction)



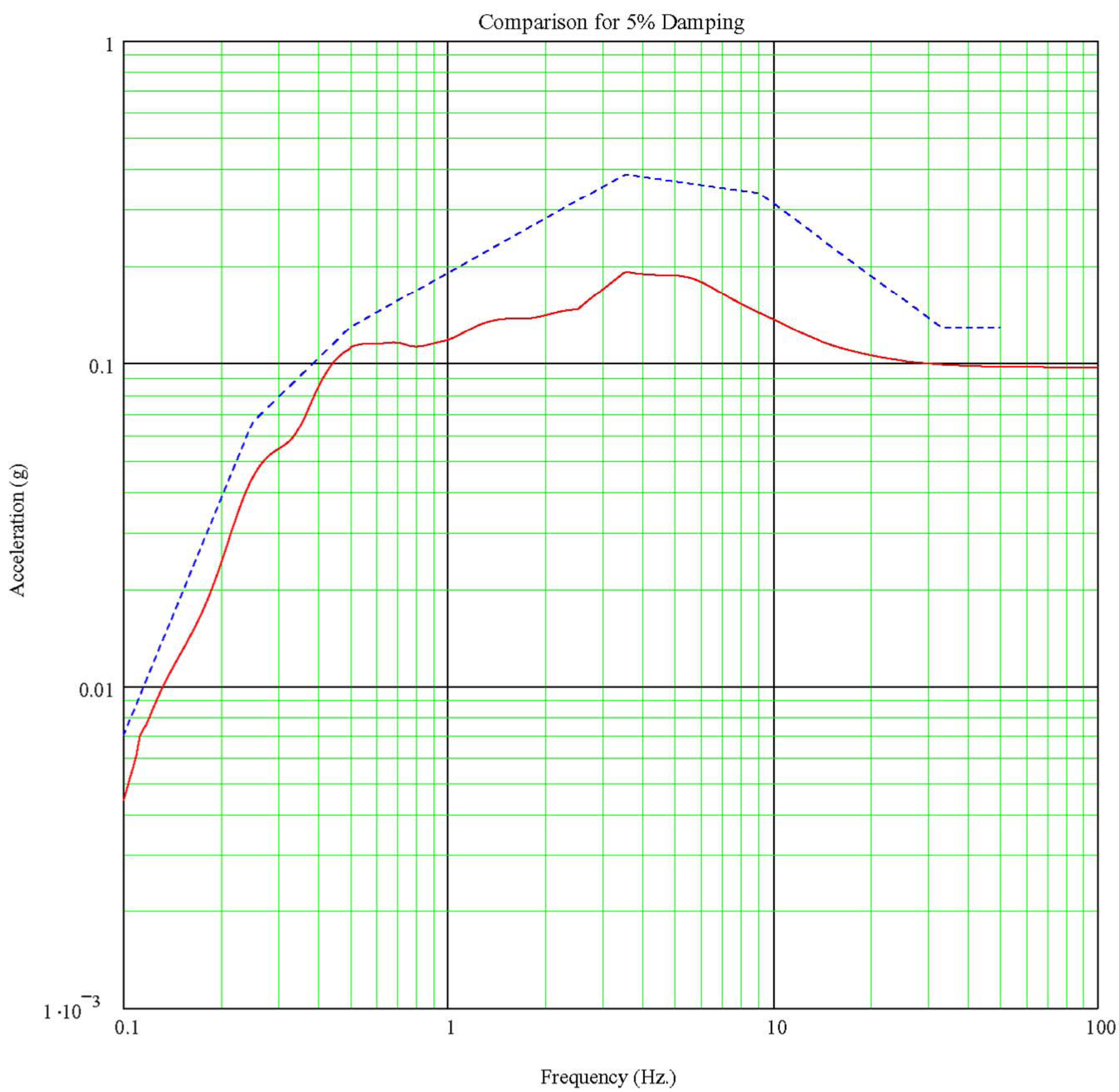
____ (Red): GMRS
...... (Blue): Response spectrum from artificial time history
____ (Green): Input response spectrum
_._. (Magenta): 130% of input response spectrum

Figure 3H.6-10 Comparison of Spectra at foundation of UHS Basin (Vertical (Z) Direction)



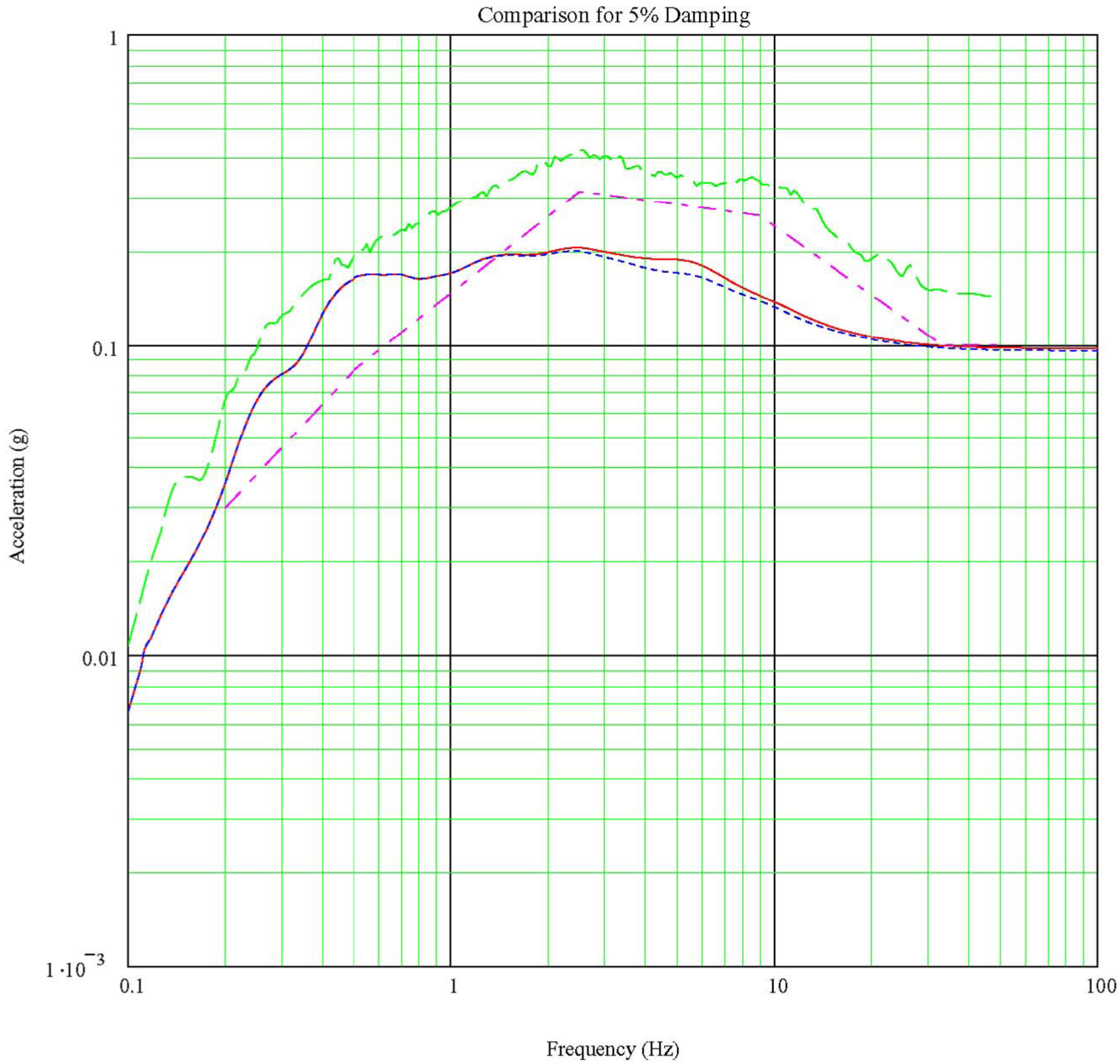
___ (Red): GMRS
...... (Blue): Response Spectrum from artificial time history
___ (Green): Input response spectrum
_._. (Magenta): 130% input response spectrum

Figure 3H.6-11 Comparison of Spectra at Foundation of RSW Pump House (Vertical (Z) Direction)



___ (Red): GMRS in the vertical direction
...... (Blue): Input Spectrum in the vertical direction

Figure 3H.6-12 Comparison of Spectrum from Artificial Time History, Input Spectrum, 130% of Input Spectrum, and GMRS (E-W (X) Direction)



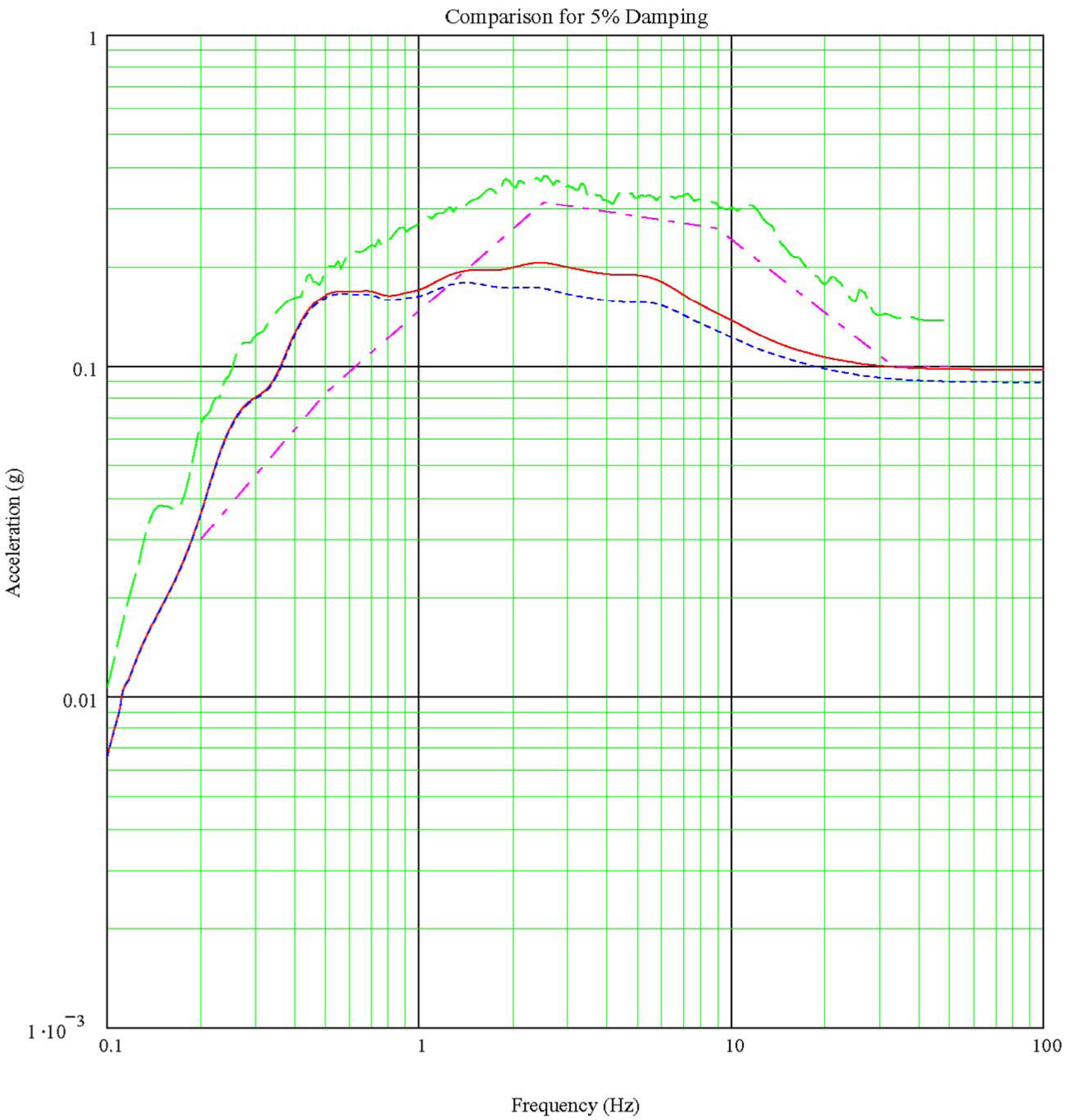
___ (Red): GMRS

...... (Blue): FIRS at foundation 32 ft below ground surface

___ (Green): Outcrop spectrum at 32 ft below ground surface from artificial time history

_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-13 Comparison of Spectrum from Artificial Time History, Input Spectrum, 130% of Input Spectrum, and GMRS (N-S (Y) Direction)



___ (Red): GMRS
...... (Blue): FIRS at foundation 57 ft below ground surface
___ (Green): Outcrop spectrum at 57 ft below ground surface from artificial time history
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-14 Comparison of Spectrum from Artificial Time History, Input Spectrum, 130% of Input Spectrum, and GMRS (Vertical (Z) Direction)

[LATER]

Figure 3H.6-15 SASSI Model for UHS and RSW Pumphouse

[LATER]

Figure 3H.6-16 Broadened FRS in E-W (X) Direction at the Top of Pump House Mat (Elevation -18 ft MSL)

[LATER]

Figure 3H.6-17 Broadened FRS in N-S (Y) Direction at the Top of Pump House Mat (Elevation -18 ft MSL)

[LATER]

Figure 3H.6-18 Broadened FRS in Vertical (Z) Direction at the Top of Pump House Mat (Elevation -18 ft MSL)

[LATER]

Figure 3H.6-19 Broadened FRS in E-W (X) Direction at the Pump House Operating Floor (Elevation 14 ft MSL)

[LATER]

Figure 3H.6-20 Broadened FRS in N-S (Y) Direction at the Pump House Operating Floor (Elevation 14 ft MSL)

[LATER]

Figure 3H.6-21 Broadened FRS in Vertical (Z) Direction at the Pump House Operating Floor (Elevation 14 ft MSL)

[LATER]

Figure 3H.6-22 Broadened FRS in E-W (X) Direction for the Pump House Walls at Operating Floor (Elevation 14 ft MSL)

[LATER]

Figure 3H.6-23 Broadened FRS in N-S (Y) Direction for the Pump House Walls at Operating Floor (Elevation 14 ft MSL)

[LATER]

Figure 3H.6-24 Broadened FRS in Vertical (Z) Direction for the Pump House Walls at Operating Floor (Elevation 14 ft MSL)

[LATER]

Figure 3H.6-25 Broadened FRS in E-W (X) Direction at the Pump House Roof (Elevation 50 ft MSL)

[LATER]

Figure 3H.6-26 Broadened FRS in N-S (Y) Direction at the Pump House Roof (Elevation 50 ft MSL)

[LATER]

Figure 3H.6-27 Broadened FRS in Vertical (Z) Direction at the Pump House Roof (Elevation 50 ft MSL)

[LATER]

Figure 3H.6-28 Broadened FRS in E-W (X) Direction at the Top UHS Basin Mat (Elevation 14 ft MSL)

[LATER]

Figure 3H.6-29 Broadened FRS in N-S (Y) Direction at the Top UHS Basin Mat (Elevation 14 ft MSL)

[LATER]

Figure 3H.6-30 Broadened FRS in Vertical (Z) Direction at the Top UHS Basin Mat (Elevation 14 ft MSL)

[LATER]

Figure 3H.6-31 Broadened FRS in E-W (X) Direction at Bottom of Cooling Towers/Cell A (Elevation 97.5 ft MSL)

[LATER]

Figure 3H.6-32 Broadened FRS in N-S (Y) Direction at Bottom of Cooling Towers/Cell A (Elevation 97.5 ft MSL)

[LATER]

Figure 3H.6-33 Broadened FRS in Vertical (Z) Direction at Bottom of Cooling Towers/Cell A (Elevation 97.5 ft MSL)

[LATER]

Figure 3H.6-34 Broadened FRS in E-W (X) Direction at Mid-Level of Cooling Towers/Cell A (Elev. 125.25 ft MSL)

[LATER]

Figure 3H.6-35 Broadened FRS in N-S (Y) Direction at Mid-Level of Cooling Towers/Cell A (Elev. 125.25 ft MSL)

[LATER]

Figure 3H.6-36 Broadened FRS in Vertical (Z) Direction at Mid-Level of Cooling Towers/Cell A (Elev. 125.25 ft MSL)

[LATER]

Figure 3H.6-37 Broadened FRS in E-W (X) Direction at Top of Cooling Towers/Cell A (Elev. 153 ft MSL)

[LATER]

Figure 3H.6-38 Broadened FRS in N-S (Y) Direction at Top of Cooling Towers/Cell A (Elev. 153 ft MSL)

[LATER]

Figure 3H.6-39 Broadened FRS in Vertical (Z) Direction at Top of Cooling Towers/Cell A (Elev. 153 ft MSL)

[LATER]

Figure 3H.6-40 SAP Finite Element Model for UHS and RSW Pumphouse