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May 11, 2007

Gerding/Edlen Development Company, LLC
1120 NW Couch Street, Suite 600
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Attention: Mr. Damin Tarlow

Report of Site-Specific Seismic Evaluation
Providence Office Park
Proposed Providence Offices and Parking Garage
NE 43rd Off-Ramp and NE Halsey Street
Portland, Oregon
GeoDesign Project: Gerding-133-06

INTRODUCTION

GeoDesign, Inc. is pleased to submit this report summarizing our site-specific seismic evaluation for the proposed Providence office and parking structure development located at the Providence Office Park, southeast of the NE 43rd Avenue off-ramp and NE Halsey Street, in Portland, Oregon. We have previously completed a geotechnical engineering report[1] for the proposed development. Our services for this project were conducted in accordance with our proposal dated May 7, 2007. Figure 1 of our previous engineering report[1] shows the site location relative to existing topographic and physical features.

Based on recent concept plans provided by GBD Architects, we understand that a two-phase development is currently being evaluated. Phase I will be initially constructed on the northern half of the property at approximately elevation 171 feet (City of Portland [COP] datum) and will consist of an at-grade seven-story office structure with ground floor retail space along NE Halsey Street and an adjacent six-story parking structure. The parking structure will be located at the center of the site and will extend one level below grade (founded at elevation 161 feet [COP datum]). It is our further understanding that the second phase will be constructed at a later date and will be connected to the Phase I portion. Phase 2 will consist of an at-grade six-story garage structure that will connect to the Phase I garage and a six-story office structure with two lower levels of parking founded at elevation 166 feet (COP datum) to match existing topography.

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[1]GeoDesign, Inc., *Report of Geotechnical Engineering Services, Davis Business Park, Proposed Providence Offices and Parking Garage, NE 43rd Off-Ramp and NE Halsey Street, Portland, Oregon*, dated April 2, 2007

This seismic hazard evaluation was performed in accordance with the requirements in the 2006 International Building Code (IBC). This evaluation is based on Oregon's amendments to the IBC as described in the State of Oregon 2007 Structural Specialty Code Amendments (SOSSCA).

SCOPE OF SERVICES

The specific scope of our additional services that were recently conducted is summarized as follows:

- Reviewed available seismic hazard maps, published dynamic soil properties in the vicinity, and geologic maps and geotechnical reports discussing subsurface conditions.
- Evaluated design-level base rock motions at the site using both probabilistic and deterministic methods.
- Selected and modified existing analogous earthquake records to model expected base rock motions.
- Modeled the soil response at the site using the computer program SHAKE, and conducted sensitivity analyses of model parameters (including soil properties, soil thicknesses, and base rock motions).
- Provided response spectra at the ground surface and primary foundation elevations, as well as peak ground accelerations (PGA).
- Evaluated liquefaction potential and other pertinent and code-identified hazards and their potential effect on the proposed development.
- Provided this report summarizing the results of our analyses and research.

GEOLOGIC SETTING

The site is located within the Portland Basin physiographic province. The basin is bound by the Tualatin Mountains to the west and the Cascade Range to the east. The geologic profile in the vicinity of the site consists of approximately 100 feet of catastrophic flood deposits underlain by the Troutdale Formation that extends to depths between 350 and 450 feet below the ground surface (BGS). The Sandy River Mudstone underlies the Troutdale Formation and extends to depths in excess of 1,200 feet BGS. The Columbia River Basalt is considered the basement material at this site and is present below depths of 1,200 feet BGS (Madin, 1990; Beeson and Tolan, 1991).

The near-surface geologic unit is mapped as Pleistocene age (15,500 to 13,000 years before present) catastrophic flood deposits. These deposits include a channel facies consisting mostly of gravel and cobbles with sand and silt overlain by a fine-grained facies consisting of fine sand, silt, and clay. The catastrophic flood deposits originated from multiple outburst floods from glacial Lake Missoula during the last episode of glaciations (Orr, et al, 1992). Based on our subsurface explorations and a review of available geologic information, the flood deposits are expected to extend up to 100 feet BGS in the site vicinity.

The Pliocene age (5.3 to 1.6 million years before present) Troutdale Formation (Qtg) underlies the catastrophic flood deposits and extends to depths between 350 and 450 feet BGS in the site vicinity (Madin, 1990; Beeson and Tolan, 1991). The Troutdale Formation generally consists of moderately to poorly cemented conglomerate with minor interbeds of sandstone, siltstone, and claystone.

The Sandy River Mudstone (QTs) dating to the late Miocene to Pliocene Age (10 to 5 million years before present) is present below the Troutdale Formation. This unit consists of moderately to poorly cemented siltstone, sandstone, and claystone (Madin, 1990; Beeson and Tolan, 1991). The middle Miocene age (16 to 6 million years before present) Columbia River Basalt Group (CRBG) (Tcr) underlies the Sandy River Mudstone and forms the basement material at this site.

SUBSURFACE CONDITIONS

We explored subsurface conditions at the site by advancing five borings (B-1 through B-5) to depths of 51.5 feet BGS. To further evaluate the extent of fill materials at the site inside the existing warehouse building, an additional three borings (B-6 through B-8) were completed within the western warehouse building to depths of up to 19 feet BGS. The geologic units encountered during our subsurface explorations generally consist of fill overlying silts and sands (flood deposits). A site plan showing the boring locations is presented on Figure 2 of our previous report[1]. A summary of our field exploration program, boring logs, and laboratory testing are provided in the Appendix of our previous report[1] prepared for the site.

HISTORIC SEISMICITY AND POSTULATED EARTHQUAKES

HISTORIC SEISMICITY

Recorded seismicity in the site vicinity is relatively limited, with 11 recorded earthquakes exceeding magnitude M_l=5 or Modified Mercalli intensity equal to or greater than 7 in the Portland Basin. Figure 1 shows the approximate epicenter locations of these events relative to the site (Johnson, et al., 1994). Figure 2 shows the location of faults within a 50-mile radius of the site having hazard potential (Personius, 2002). Studies (Yelin and Patton, 1991) of small earthquakes in the basin indicate that most crustal earthquake activity is occurring at depths of 10 to 20 kilometers (km).

POSTULATED EARTHQUAKES

Two of the possible earthquake sources are associated with the Cascadia Subduction Zone (CSZ), and the third event is a shallow local crustal earthquake that could occur in the North American plate. The three earthquake scenarios are discussed in the following sections.

Regional Events

The CSZ is the region where the Juan de Fuca Plate is being subducted beneath the North American plate. This subduction is occurring in the coastal region between Vancouver Island and northern California. Two types of subduction zone earthquakes are possible: (1) an earthquake on the seismogenic part of the interface between the Juan de Fuca plate and the North American plate on the CSZ and (2) a deep earthquake on the seismogenic part of the subducting Juan de Fuca plate.

CSZ

The CSZ megathrust represents the boundary between the subducting Juan de Fuca and the overriding North American plates. The CSZ interface earthquake occurs at a recurrence interval of approximately 400 years. Geologic evidence suggests that the most recent CSZ interface earthquake occurred in January 1700, probably ruptured much of the length of CSZ, and was estimated at M_w=9. The magnitudes for such earthquakes are estimated to range from approximately M_w=7.0 to 9.0.

Crustal Earthquakes and Faults

A significant earthquake could occur on a local fault near the site within the design life of the structure. Such an event would cause ground shaking at the site that could be more intense locally than the CSZ events, though the duration would be shorter. Recorded seismicity due to crustal sources in the site vicinity is relatively limited, with only a few recorded earthquakes exceeding magnitude M_w=5 in the Portland Basin. Studies (Yelin and Patton, 1991) of small earthquakes in the basin indicate that most crustal earthquake activity occurs at depths of 10 to 20 km.

Based on our research, the three most critical faults in the site vicinity are the East Bank Fault, the Portland Hills Fault, and the Oatfield Fault. The locations of these faults relative to the site are shown on Figure 2. The nearest potentially active, and therefore most significant, fault is the Portland Hills Fault inferred at a distance of less than 3 miles west of the site.

Portland Hills Fault

The Portland Hills Fault is mapped trending from northwest to southeast approximately 3 miles west of the site (Figure 2). The Portland Hills Fault has been previously mapped as an inferred-buried fault that has not been directly observed. The location of the fault is based on offsets of the Pliocene to Pleistocene age (5 to 1.5 million years before present) Troutdale Formation and the Miocene age (20 to 10 million years before present) CRGB as determined from water well boring logs and geophysical methods (Beeson, et al., 1991; Madin, 1990).

Recent investigations (Liberty, et al., 2003; Pratt, et al., 2001; Roddy, 2001) indicate fault displacement within the late Pleistocene age (15,500 to 13,000 years before present) Missoula flood deposits. A high resolution geophysical survey across the inferred fault trace shows offset of the Columbia River Basalt and the overlying Troutdale Formation. The survey does not conclude that the Missoula flood deposits were offset due to lack of subsurface information (Liberty, et al., 2003). A trench excavation located approximately 10 miles south of the site was examined at Rowe Middle School in Milwaukie, Oregon. The excavation showed anticlinal bowing of the Missoula flood deposits, but no fault displacement or previous surface rupture. In our opinion, the data is not a definitive indicator of late Pleistocene fault displacement of the Portland Hills Fault.

The seismic history of the Portland area indicates the potential that the Portland Hills Fault and/or other faults in the Portland region are seismogenic. The largest historical seismic event is the 1962 Portland Earthquake; the epicenter of this earthquake was originally mapped in north Portland (6 miles east of the Portland Hills Fault) and later mapped near the fault trend near

Scappoose, Oregon. Focal depth of the earthquake is estimated to be 15 to 20 km (Dehlinger, et al., 1962 and 1963). In recent years, numerous micro earthquakes have been recorded in the Portland area.

The Portland Hills Fault may be the most significant seismic source, although it has no definite evidence for being seismogenic. We have considered this fault active for the purpose of this study. Literature suggests that this fault is capable of generating M_w=6.7 or larger earthquakes, although no such event has occurred in the historical record. Based on a review of literature, the depth of earthquake on the Portland Hills Fault will be approximately 10 to 20 km.

Other Local Faults

The Mount Angel Fault is mapped trending from northwest to southeast approximately 35 miles south of the site (Figure 2). The approximate 9-mile-long fault is the only local fault that has been associated with a historical earthquake. The Mount Angel Fault generated earthquake swarms near Woodburn, Oregon, in 1990 and a ML 5.6 earthquake near Scotts Mills, Oregon, in May 1993. Based on reported shaking from the 1993 earthquake (Black, 1996), the site vicinity received earthquake motions in the range of seismic intensity Modified Mercalli=5 (earthquake widely felt with no structural damage).

Table 1 shows the relative distance, displacement, and estimated age of the crustal faults that contribute to the probabilistic site hazard within a 20-mile radius of the site.

Table 1. Faults Within the Site Vicinity

Fault Name	Proximity to Site (surface projection in miles)	Estimated Displacement Description	Estimated Age
Portland Hills	3	Potential offset of Missoula flood deposits by means of geophysical techniques and trench excavation.	Late Quaternary (< 15,000 years before present)
East Bank	1.2	Probable offset of unconformities and paleochannels associated with the Missoula flood deposits.	Late Quaternary (< 15,000 years before present)
Oatfield	5	Offsets Columbia River Basalt flows and overlying fluvial and lacustrine deposits. Does not offset Missoula flood deposits.	Quaternary (< 1.6 million years before present)
Damascus-Tickle Creek	5	Offsets Plio-Pleistocene deposits and Boring Lava. Does not offset Missoula flood deposits.	Middle to late Quaternary (< 750,000 years before present)

Table 1. Faults Within the Site Vicinity (continued)

Fault Name	Proximity to Site (surface projection in miles)	Estimated Displacement Description	Estimated Age
Beaverton Fault Zone	9	Offsets Columbia River Basalt flows and overlying fluvial and lacustrine deposits. Does not offset Missoula flood deposits.	Middle to late Quaternary (< 750,000 years before present)
Bolton	6	Offsets Columbia River Basalt flows and overlying fluvial and lacustrine deposits. Does not offset Missoula flood deposits.	Quaternary (< 1.6 million years before present)
Canby-Molalla	11	Probable offset of Missoula flood deposits.	Late Quaternary (< 15,000 years before present)
Helvetia	14	Offsets Columbia River Basalt flows and overlying fluvial and lacustrine deposits. Does not offset Missoula flood deposits.	Quaternary (< 1.6 million years before present)
Lacamas Lake	11	Offsets Plio-Pleistocene deposits and Boring Lava. Does not offset Missoula flood deposits.	Middle to late Quaternary (< 750,000 years before present)

SEISMIC RESPONSE ANALYSIS

We determined acceleration response spectra for the three postulated events discussed above by performing an equivalent linear seismic response analysis. The site-specific design response spectrum was determined by amplifying the probabilistic bedrock response spectra reported by the U.S. Geological Survey (USGS) Seismic Mapping Project for the site through the soil column that overlies the bedrock unit. The bedrock spectrum is based on a 2 percent probability of exceedance in 50 years. Figure 3 shows the probabilistic bedrock response spectrum reported by USGS for the site. The following sections provide a description of our analyses.

GROUND MOTION SELECTION

USGS report that events on the Portland Hills Fault and the CSZ interface provide the highest contribution to probabilistic seismic site hazard. Consequently, we selected three acceleration time histories for each of these events as input for the seismic response analysis. The recorded ground motions were selected to represent the local seismic setting based on the faulting mechanism and distance to recording station. The records were scaled to match the spectral accelerations at periods of 0.2 second and between 1.0 and 2.0 seconds. Table 2 shows between the acceleration time histories selected for this study.

Table 2. Input Ground Motions

Ground Motion/Recording Station	Measured PHGA[1] (g's)
Crustal Event	
Whittier Narrows/Mt. Wilson	0.17
Kiholo Bay/Kailua-Kona Fire Station	0.27
Imperial Valley/Superstition Mountain	0.19
CSZ Interplate Event	
Miyagi-oki	0.20
Michoacan/La Union	0.17
Michoacan/Zihuatanejo	0.16

1. Measured on bedrock
PHGA: peak horizontal ground acceleration

SOIL MODEL

The input subsurface soil profile used in our analysis is based on the findings of our subsurface exploration program and review of available geologic information in the project area. A detailed description of site subsurface conditions is provided in our previous report[1]. Shear wave velocities for various soil layers were based on standard penetration testing, published shear wave velocity data for the region (Mabey and Madin, 1995), and our experience with measured shear wave velocities in similar soils. Table 3 provides a summary of the soil model used in our analysis.

Table 3. Summary of Geologic Input Profile

<table>
<tr><th>Profile Depth (feet BGS)</th><th>Subsurface Unit</th><th>Modulus Reduction Curve</th><th>Damping Curve</th><th>Geologic Unit</th><th>Shear Wave Velocity (feet per second)</th></tr>
<tr><td>0 to 70</td><td>Loose to Very Dense Sand</td><td>Sand (Seed and Idriss/Average)</td><td>Sand (Seed and Idriss/Average)</td><td>Catastrophic flood deposits (Qfc) - fine</td><td>500 to 950</td></tr>
<tr><td rowspan="2">70 to 100</td><td rowspan="2">Very Dense Sand and Gravel</td><td>Sand (Seed and Idriss/Average)</td><td>Sand (Seed and Idriss/Average)</td><td rowspan="2">Catastrophic flood deposits (Qfc) - coarse</td><td rowspan="2">1,000 to 1,500</td></tr>
<tr><td>Gravel (Seed, et. al.)</td><td>Gravel (Seed, et. al.)</td></tr>
<tr><td>100 to 450</td><td>Lower Alluvial Dense to Very Dense Gravels</td><td>Gravel (Seed, et al.)</td><td>Gravel (Seed, et al.)</td><td>Troutdale Formation (QTg)</td><td>1,600 to 2,500</td></tr>
</table>

Table 3. Summary of Geologic Input Profile (continued)

Profile Depth (feet BGS)	Subsurface Unit	Modulus Reduction Curve	Damping Curve	Geologic Unit	Shear Wave Velocity (feet per second)
450 to 1,200	Very Stiff to Hard Clay and Rock	Clay PI 40 to 80 (Sun, et al.)	Clay-Upper Bound (Sun, et al.)	Sandy River Mudstone (Tsr)	2,000 to 2,250
		Rock	Rock		
> 1,200	Bedrock/ Columbia River Basalt	Rock (Idriss)	Rock (Idriss)	Columbia River Basalt (Tcr)	2,500

DESIGN RESPONSE SPECTRA

The design response spectra for the site were determined by modifying the bedrock spectra for the site available from the USGS Seismic Hazard Mapping Project. The site bedrock response spectrum is presented on Figure 3. The following procedure was used to amplify the bedrock response spectra:

- The input bedrock ground motions were scaled by adjusting their PGA so the spectral accelerations matched the probabilistic USGS bedrock ground motions near the 0.2 second and between 1.0 and 2.0 seconds ranges.
- An equivalent linear seismic response analysis using the "Proshake" software package (version 1.1) was completed using the scaled bedrock motions.
- Amplification factors were computed between the bedrock and depth of interest in the soils column.
- The average amplification factors for each mechanism were applied to the maximum credible earthquake (MCE) bedrock spectrum obtained from USGS. The greater of the crustal and CSZ amplification factors were used.

Figures 4 and 5 present computed design acceleration response spectra appropriate for the site for buildings constructed near existing grade and one story below grade, respectively. These spectra are scaled to two-thirds of the MCE as prescribed by the IBC.

SEISMIC HAZARDS

In addition to ground shaking, site-specific geologic conditions can influence the potential for earthquake damage. The following sections address other seismic hazards as required by the 2006 IBC, including site amplification, liquefaction, lateral spreading, earthquake-induced slope stability, fault rupture, and tsunami inundation.

FAULT SURFACE RUPTURE

The nearest mapped Quaternary fault is the East Bank Fault, located approximately 1.2 miles east of the site (Personius, 2002; Burns, et al., 1997; Schlicker and Deacon, 1967). No faults are mapped as crossing the site; therefore, the potential for site fault surface rupture is low.

LIQUEFACTION ANALYSIS

Liquefaction can be defined as the sudden loss of shear strength in a soil due to an excessive buildup of pore water pressure.

We performed our liquefaction analysis based on our subsurface explorations at the site and the widely accepted method of evaluating soil liquefaction potential as recommended by National Center for Earthquake Engineering Research (Youd, et al., 2001). The method is based on cyclic stress ratio (CSR) measurements in clean, saturated sand of varying relative density. This method compares the anticipated CSR developed in the soil during the design event at given depths to the cyclic resistance ratio available in the soil at corresponding depths. The potential for liquefaction of silt was evaluated. The potential for liquefaction or cyclic failure of silts was evaluated using recent updates to the simplified method (Boulanger and Idriss, 2004). Input soil parameters were based on the results of our explorations. The upper 50 feet of soil generally consists of soft to medium stiff silt and clay and loose to very dense sand or silty sand. The static groundwater level was encountered at depths between approximately 45 and 46 feet BGS in our borings.

Based on liquefaction analysis and laboratory testing, and the absence of static groundwater within the upper 40 feet at the site, we consider the risk of liquefaction at the site to be low.

Clean, loose, uniform or silty, fine-grained, saturated sands are particularly susceptible to liquefaction. Lateral spreading is a liquefaction-related seismic hazard. Areas subject to lateral spreading are typically gently sloping or flat sites underlain by liquefiable sediments adjacent to an open face (such as riverbanks). Liquefied soils adjacent to open faces may "flow" in that direction, resulting in lateral displacement and surface cracking. Relative earthquake hazard mapping completed in the site vicinity indicates the area soils have a low to moderate liquefaction hazard (Mabey, et al., 1995).

LATERAL SPREAD

Lateral spread is a liquefaction-related seismic hazard. Development areas subject to lateral spreading are typically gently sloping or flat sites underlain by liquefiable sediments adjacent to an open face (such as riverbanks). Liquefied soils adjacent to open faces may flow in that direction, resulting in lateral displacement towards the open face (i.e., riverbank). The magnitude of lateral spread decreases with distance from the open face. Lateral spreading is frequently evaluated using procedures first developed by Bartlett and Youd and published in 1992 to identify the potential for lateral spreading. Based on the low susceptibility of liquefaction at the site vicinity, lateral spreading is expected to be negligible at this site.

GROUND MOTION AMPLIFICATION

Soils capable of significantly amplifying ground motions beyond the levels determined by our site-specific seismic response analysis were not encountered during our subsurface investigation program. We conclude the level of amplification determined by our response analysis is appropriate for use in design of the facility.

NEAR-SOURCE EFFECTS

We evaluated the effects of directivity at the site due to a seismic event on the East Bank Fault using the method developed by Somerville, et al. (1997). For the purpose of this study, we have considered the fault to be a strike slip fault. Somerville concludes that the effects of directivity are: (1) dependent on the angle between the direction of propagation and direction of the wave traveling toward the site and (2) the fraction of the fault rupture surface that lies between the hypocenter and the site. USGS (2002) reports that the 18-mile-long fault is approximately 1 mile west of the site.

We have assumed that the site is located near the center of the mapped fault and the distance to the epicenter would be less than one-half of the fault length. We consider the fault to have low probability of a design level seismic event and low probability that the hypocenter will be located at the end of the fault. Based on these reasonable assumptions and the methods proposed by Somerville, et al. (1997) to evaluate the effects of directivity, we conclude that the effects of directivity at the site will be small to negligible.

LANDSLIDE

Earthquake-induced landsliding generally occurs in steeper slopes comprised of relatively weak soil deposits. The site contains relatively gently sloping terrain in the vicinity of the proposed building area; therefore, landslides do not present a risk within the proposed development areas of the site.

SUBSIDENCE/UPLIFT

Subduction zone earthquakes can cause vertical tectonic movements. The movements reflect coseismic strain release accumulation associated with interplate coupling in the subduction zone. An interplate event would occur at a distance in excess of 100 km of the site. Consequently, we do not anticipate that subsidence or uplift is a significant design concern.

LURCHING

Lurching is a phenomenon generally associated with very high levels of ground shaking, which causes localized failures and distortion of the soil. The anticipated site ground accelerations shown are below the threshold required to induce lurching of the site soils.

SEICHE AND TSUNAMI

The site is inland and elevated away from tsunami inundation zones and away from large bodies of water that may develop seiches. Seiche and tsunamis are not considered a hazard in the site vicinity.

LIMITATIONS

We have prepared this seismic hazard study for use by the design and construction team for the proposed Providence Office Park project. The conclusions presented in this report are based on the data available at the time this report was written.

Our seismic hazard study report, conclusions, and interpretations should not be construed as a warranty of subsurface conditions and earthquake ground motions. We have interpreted subsurface conditions based on our exploration and review of available geologic information. The design earthquakes and base rock accelerations referred to are based on review of available data, literature, and our previous experience.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with the generally accepted practices in this area at the time the report was prepared. No warranty or other conditions, expressed or implied, should be understood.

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We appreciate the opportunity to be of continued service to you. Please call if you have questions concerning this report or if we can provide additional services.

Sincerely,

GeoDesign, Inc.

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Project Engineer

Scott V. Mills, P.E., G.E.
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Mr. Ron Huld, GBD Architects (via email only)

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Attachments
One copy submitted (via email only)
Document ID: Gerding-133-06-051107-geolr-seismic_hazard.doc

REFERENCES

Black, Gerald L., 1996, "Earthquake Intensity Maps for the March 25, 1993, Scotts Mills, Oregon, Earthquake," Oregon Geology, Volume 58, Number 2, March 1996.

Blakely, R.J., Wells, R.E., Tolan, T.L., Beeson, M.H., Trehu, A.M., and Liberty, L.M., 2000, New aeromagnetic data reveal large strike-slip (?) faults in the northern Willamette Valley, Oregon. Geological Society of America Bulletin, v.112, n.8, pp.1225-1233.

Boore, D.M., et al., 1993, Estimation of Response Spectra and peak accelerations from western North America Earthquakes: An interim report, Open-File-Report 93-509.

Bott, D.J. and Wong I.G.,1993, "Historical Earthquakes in and Around Portland, Oregon," Oregon Geology, Volume 55, Number 5, September 1993.

Boulanger, R.W., and Idriss, I.M. 2004, "Evaluating The Potential For Liquefaction Or Cyclic Failure of Silts and Clays," Center For Geotechnical Modeling, University of California at Davis, Report No. UCD/CGM-04/01.

Darienzo M.E., and Peterson, C.D., 1995, Magnitude and Frequency of Subduction-zone Earthquakes along the Northern Oregon Coast in the past 3,000 years: Oregon Geology, Volume 57, Number 1, p. 3-12.

Dehlinger, Peter, and Berg, Joseph W., Jr., 1962, The Portland earthquake of Nov. 5, 1962: The OreBin, vol. 24, no. 11, Nov. 1962, p. 185-188.

Dehlinger, Peter, Bowen, R.G., Chiburis, E.F., and Westphal, W.H., 1963, Investigations of the earthquake of Nov. 5, 1962, north of Portland: The Ore Bin, vol. 25, no. 4, April 1963, p. 53-68.

DOGAMI, 2003, Overview of the Kelly Point Park Earthquake, Portland, Oregon. Oregon Geology, Geologic Notes, v.65, n.1, p.25.

Gannett, Marshall W., and Caldwell, Rodney R., 1998, Geologic Framework of the Willamette Lowland Aquifer System, Oregon and Washington: U. S. Geological Survey Professional Paper 1424-A, 32p, 8 plates.

Geomatrix, 1995, "Seismic Design Mapping, State of Oregon," prepared for Oregon Department of Transportation.

Johnson, A.J., Schofield, D.H., and Madin, I.P., 1994, Earthquake Database for Oregon, 1833-October 25, 1993, Oregon Department of Geology and Mineral Industries, Open-File Report O-94-04.

Mabey, Matthew A., Madin, Ian P., 1995, Downhole and Seismic Cone Penetrometer Shear-Wave Velocity Measurements for the Portland Metropolitan Area, 1993 and 1994, Oregon Department of Geology and Mineral Industries, Open-File Report O-95-7.

Mabey, M. A., et al., 1993, Earthquake Hazard Maps of the Portland Quadrangle, Multnomah and Washington Counties, Oregon, and Clark County, Washington, Oregon Department of Geology and Mineral Industries, GMS-79, scale 1:24,000.

Madin, Ian P., 1990, Earthquake-Hazard Geology Maps of the Portland Metropolitan Area, Oregon: Text and Map Explanation, Oregon Department of Geology and Mineral Industries, Open-File Report O-90-2, 21p., 8 plates, scale 1:24,000.

Orr, E.L. and Orr, W.N., 1999, Geology of Oregon. Kendall/Hunt Publishing Company, Iowa: 254 p.

Personius, S.F., compiler, 2002, Quaternary fault and fold database of the United States, ver. 1.0: U.S. Geological Survey Open-File Report 03-417, http://qfaults.cr.usgs.gov.

Pratt, T.L., et al., 2001, Late Pleistocene and Holocene Tectonics of the Portland Basin, Oregon and Washington, from High-Resolution Seismic Profiling, Bulletin of the Seismological Society of America, 91, pp. 637-650.

Somerville, Smith, Graves and Abrahamson, 1997, Modification of Empirical Strong Ground Motion Attenuation Relations to Included the Amplitude and Duration Effects of Rupture Directivity.

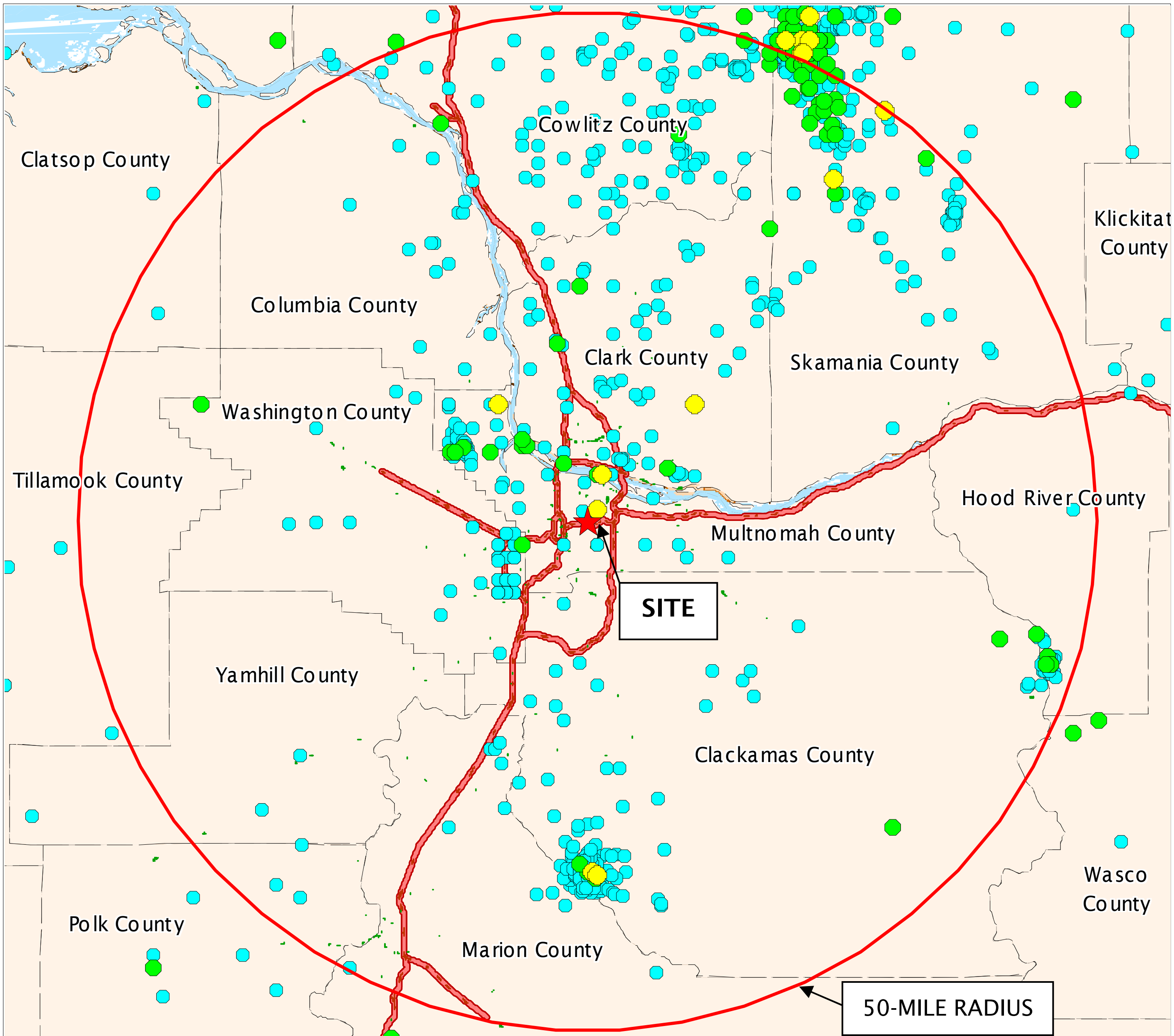
Wong, Silva I., et al., 2000, Earthquake Scenario and Probabilistic Ground Shaking Maps for the Portland, Oregon, Metropolitan Area, Department of Geology and Mineral Industries, IMS-16, Scale 1:62,500.

Yelin, T.S., and Patton, H.J., 1991, Seismotectonics of the Portland, Oregon, region: Seismological Society of America Bulletin, v. 81, p. 109-130.

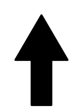
Youd, T. L., et al. (2001). "Liquefaction resistance of soils: Summary report from the 1996 NCEER and 1998 NCEER/NSF workshops on evaluation of liquefaction resistance of soils" *J. Geotech.and Geoenvir. Engrg.*, ASCE, 127(10), 817-833

Youngs, R.R., et al., 1988, "Near field ground motions on rock for Large Subduction Earthquakes," Proceedings, Earthquake Engineering and Soil Dynamics II: Recent Advances in Ground Motion Evaluation, Geotechnical Special Publication 20, ASCE, New York, pp. 445-462.

FIGURES



MAP PROVIDED BY MAPINFO.



EARTHQUAKES BY MAGNITUDE

- 7 +
- 5 to 6.9
- 3 to 4.9
- 0 to 2.9

HISTORICAL EARTHQUAKE INFORMATION PROVIDED BY JOHNSON, ET AL. (1994) AND USGS (2006).

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GERDING-133-06	**HISTORICAL SEISMICITY MAP**	
MAY 2007	PROVIDENCE OFFICE PARK PORTLAND, OR	**FIGURE 1**

File Name: Gerding-133-06-F1-HSM.doc Print Date: 5/11/07

MAP PROVIDED BY MAPINFO.

LEGEND

2002 USGS FAULT DATA LINE

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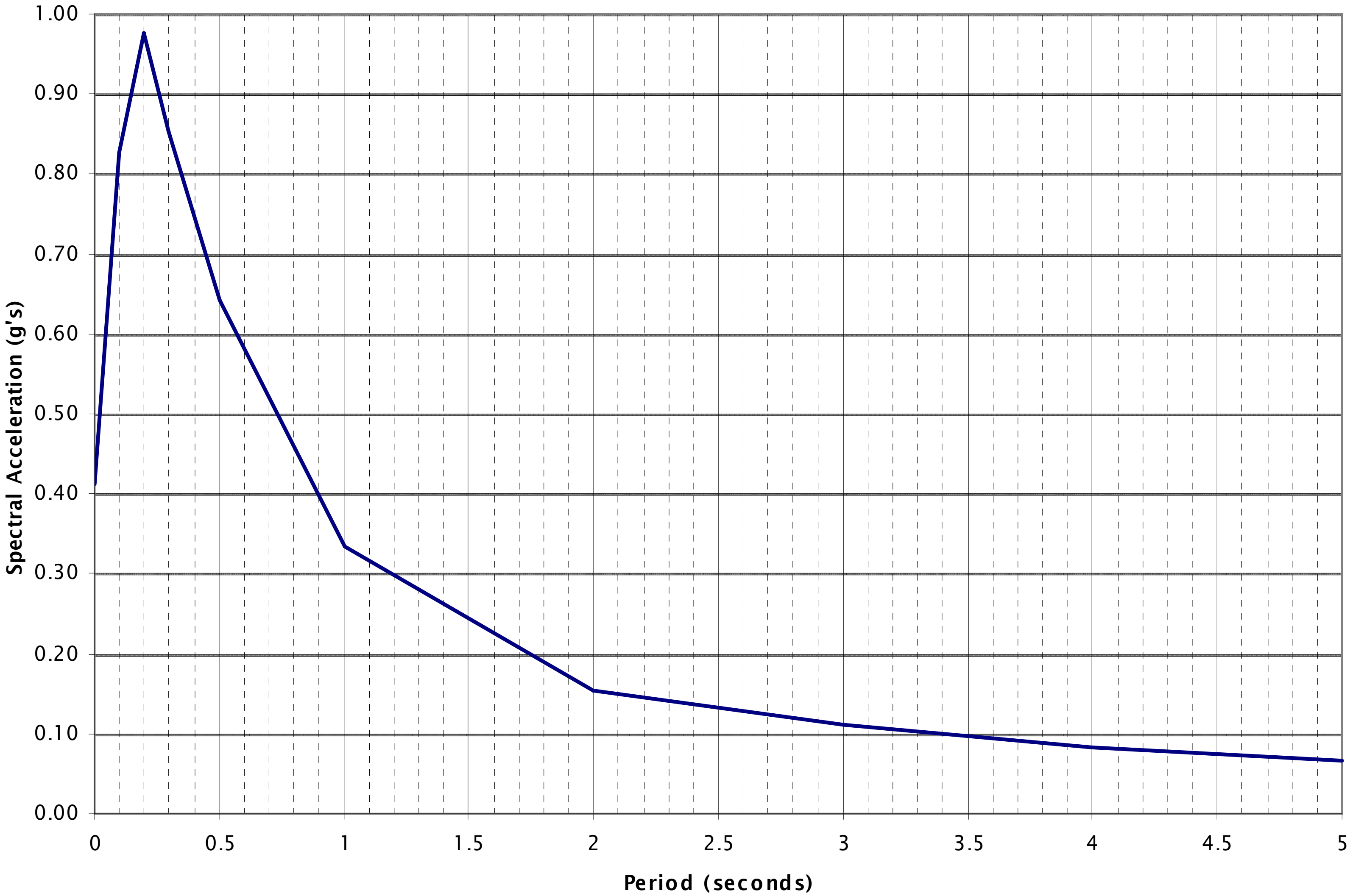
FAULT INFORMATION PROVIDED BY PERSONIUS, S.F. (2002).

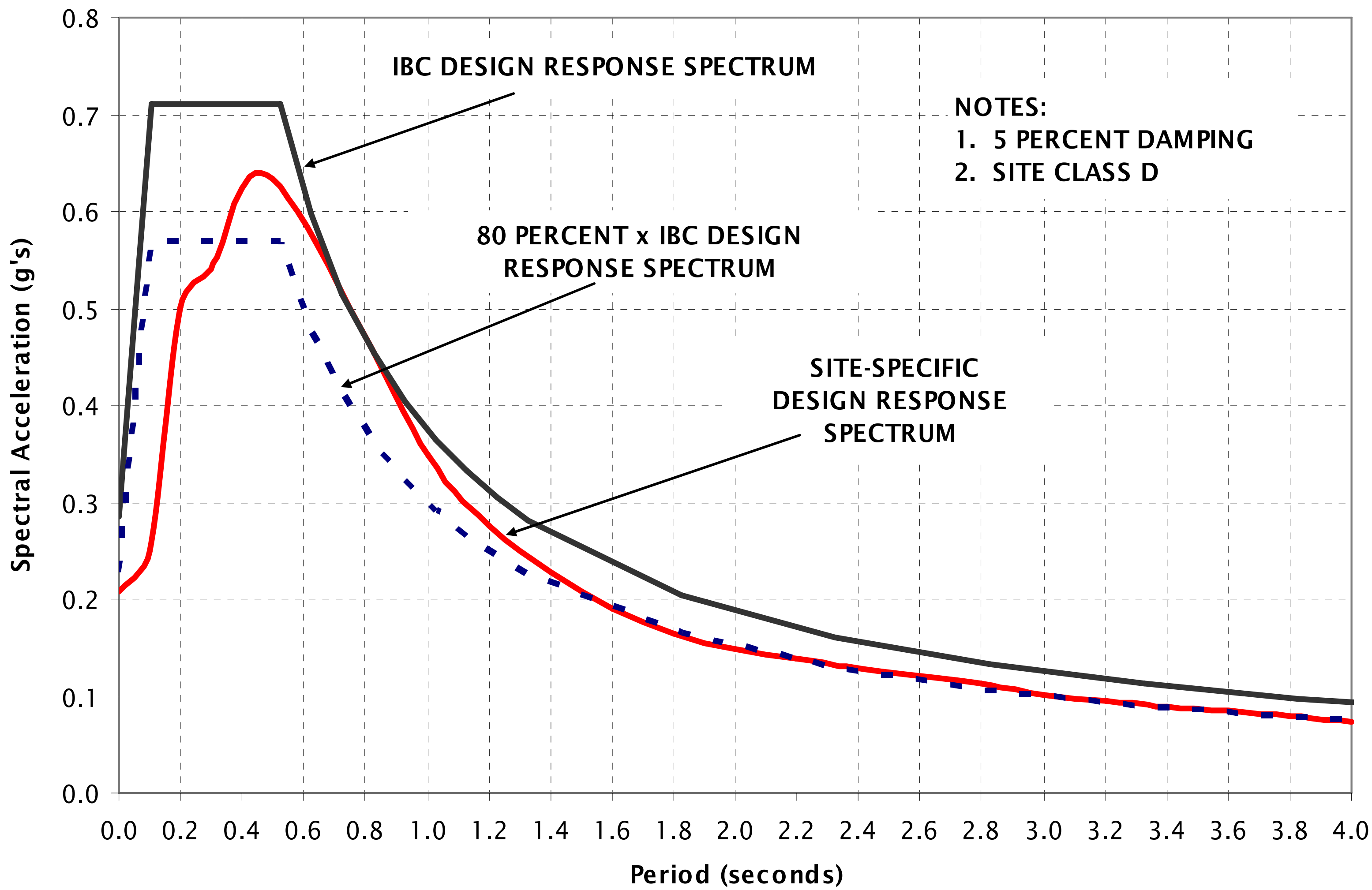
GEODESIGN INC 15575 SW Sequoia Parkway - Suite 100 Portland OR 97224 Off 503.968.8787 Fax 503.968.3068	GERDING-133-06	QUATERNARY FAULT MAP	
	MAY 2007	PROVIDENCE OFFICE PARK PORTLAND, OR	FIGURE 2

File Name: Gerding-133-06-F2-QFM.doc Print Date: 5/11/07



GEODESIGN INC 15575 SW Sequoia Parkway - Suite 100 Portland OR 97224 Off 503.968.8787 Fax 503.968.3068	GERDING-133-06	**USGS BEDROCK RESPONSE SPECTRUM**
	MAY 2007	PROVIDENCE OFFICE PARK PORTLAND, OR — **FIGURE 3**

Gerding-133-06-F3_5-SRS.doc Print Date: 5/11/07



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ACCELERATION RESPONSE SPECTRA – GRADE LEVEL STRUCTURE

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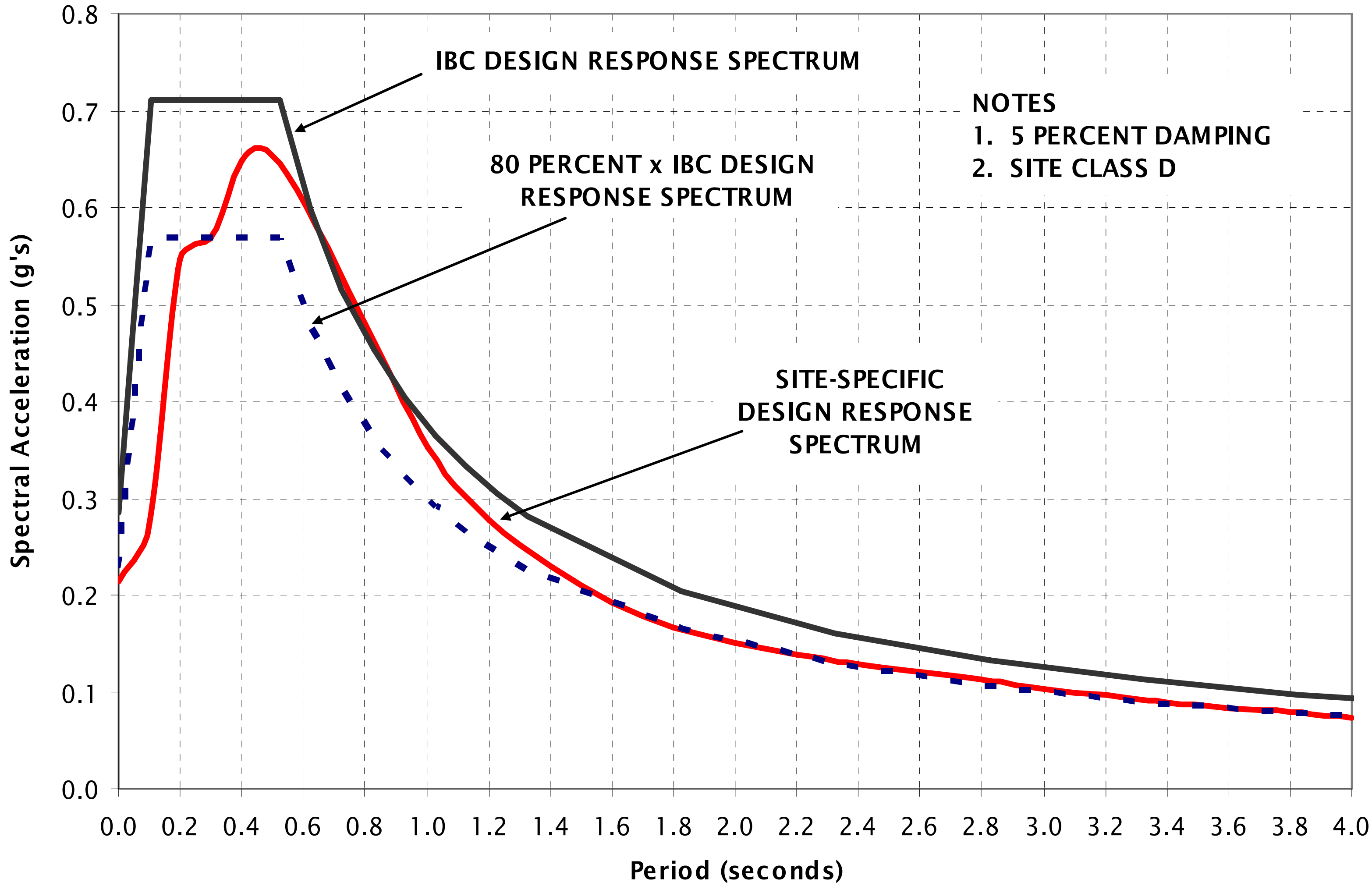
FIGURE 4



GEODESIGN INC	GERDING-133-06	ACCELERATION RESPONSE SPECTRA – GARAGE LEVEL STRUCTURE
15575 SW Sequoia Parkway - Suite 100 Portland OR 97224 Off 503.968.8787 Fax 503.968.3068	MAY 2007	PROVIDENCE OFFICE PARK PORTLAND, OR — FIGURE 5