EXHIBIT H
GEOLOGY AND SEISMICITY

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Introduction

For this Exhibit the analysis area described in OAR 345-001-0010(2) and the study area described in OAR 345-01-0010(57) refer to the same areas and are defined as the area within the Facility site boundary. OAR 345-021-0010(1)(h) requires that the ASC for the proposed Facility address geological and soil stability and that the Applicant provide sufficient evidence to support EFSC findings under OAR 345-022-0020.
OAR 345-022-0020(1) requires the following:

"Except for facilities described in sections (2) and (3), to issue a site certificate, the Council must find that:

(a) The applicant, through appropriate site-specific study, has adequately characterized the site as to Maximum Considered Earthquake Ground Motion identified at International Building Code (2009 edition) Section 1613 and maximum probable ground motion, taking into account ground failure and amplification for the site specific soil profile under the maximum credible and maximum probable seismic events; and

(b) The applicant can design, engineer, and construct the facility to avoid dangers to human safety presented by seismic hazards affecting the site that are expected to result from maximum probable ground motion events. As used in this rule "seismic hazard" includes ground shaking, ground failure, landslide, liquefaction, lateral spreading, tsunami inundation, fault displacement, and subsidence;

(c) The applicant, through appropriate site-specific study, has adequately characterized the potential geological and soils hazards of the site and its vicinity that could, in the absence of a seismic event, adversely affect, or be aggravated by, the construction and operation of the proposed facility; and

(d) The applicant can design, engineer and construct the facility to avoid dangers to human safety presented by the hazards identified in subsection (c)."

OAR 345-022-0020(2) states *The Council may issue a site certificate for a facility that would produce power from wind, solar or geothermal energy without making the findings described in section (1). However, the Council may apply the requirements of section (1) to impose conditions on a site certificate issued for such a facility*.

This exhibit is intended to demonstrate that based on the Applicant's study and characterization of geologic, soils, and seismic hazards within and surrounding the Facility site the potential hazard risk is low. This finding is supported through study and review of regional and site-specific geological and hydrogeological information and further verified by the performance of a site reconnaissance within and surrounding the proposed Facility site. The Facility will be designed and constructed to standards that effectively protect Facility infrastructure and the public from seismic, geologic, and soils hazards.

H.1 Geologic Report

OAR 345-021-0010(1)(h)(A) *A geologic report meeting the guidance in Oregon Department of Geology and Mineral Industries open file report 00-04 "Guidelines for Engineering Geologic Reports and Site-Specific Seismic Hazard Reports"* (Oregon Board of Geologist Examiners and the Oregon Board of Examiners for Engineering and Land Surveying, 1996).

RESPONSE

Site physical conditions, including topography, geology, and geologic hazards within the Facility boundary and surrounding area were evaluated for preparation of this report. A desktop study was performed using available geologic reports, topographic and geologic maps (DOGAMI, 2009), well logs, soils data and aerial photography. Additionally, field reconnaissance was conducted to verify reported field conditions, assess soil and rock properties, note potential geologic hazards, and potential impacts from project construction and siting of permanent facilities. This report addresses general geologic and seismic conditions; however, a more detailed geotechnical field study will be performed to help determine Facility design parameters and construction methods.

H.1.1 Topographic Setting

The site lies within the Columbia Plateaus Physiographic Province, which consists of a large plateau underlain by a series of basalt flows. Within the Facility area the relief is predominantly level to undulating on the stream dissected terrain. Steeper slopes between 100 and 500 ft occur along major ephemeral creek canyons within the study area and include Rock Creek and Alkali, Eightmile and Cow Canyons. Elevations at the site range from approximately 2,050 ft mean sea level (msl) at the south end to 700 ft-msl at the north end in Alkali Canyon.

Rock Creek, which borders the west boundary side of the Facility site, drains northwesterly to the John Day River, which forms the western boundary of Gilliam County. The other major drainages on the site drain northerly towards the Columbia River.

H.1.2 Geologic Setting

During late Miocene and early Pliocene times (between 17 and 6 million years ago), one of the largest basaltic lava floods ever to appear on the earth's surface engulfed about 77,000 square miles of the Pacific Northwest (Swanson et al., 1979) . Over a period of perhaps 10 to 15 million years repeated lava flows poured out, eventually accumulating to a thickness of more than 6,000 ft. Over 300 high-volume individual lava flows have been identified, along with countless smaller flows. Numerous linear vents, some over 90 miles long, show where lava erupted near the eastern edge of the Columbia River Basalts. Older vents were probably buried by younger flows. As the molten rock came to the surface, the earth's crust gradually sank into the space left by the rising lava. The subsidence of the crust produced a large, slightly depressed lava plain now known as the Columbia Basin (Columbia Plateau). The ancient Columbia River was forced into its present course by the northwesterly advancing lava. Interflow zones - soil and sediment layers - occur between many of the flows. The many flows can be distinguished using subtle variations in appearance, chemical composition, and paleomagnetic direction (Hooper et al., 2002).

Pliocene to Miocene age sedimentary rocks are interbedded between the basalt flows or cover them. Pliocene and Quaternary age loess (fine-grained, wind-blown deposits), as well as Pleistocene and Holocene age glaciofluvial deposits, colluvium talus, and alluvium incompletely cover the Tertiary rocks (Newcomb, 1971).

H.1.3 Site Geologic Setting

H.1.3.1 Site Geology

In general, the project site is underlain by loess and weak sedimentary rock overlying basalt bedrock. Within the vicinity of the site are pockets of glaciofluvial deposits, colluvium, talus, and alluvium. The geologic map prepared by Bela (1982) along with formation descriptions has been used in the following sections, and from site observations made during the site reconnaissance.

Figure H1 shows the geologic units within the Facility site boundary.

Bedrock Geologic Units

Columbia River Basalt flows mapped in the site vicinity are the Grande Ronde, Wanapum, and Saddle Mountains basalt formations (oldest to youngest).

The Grande Ronde Basalt (Tcg) is middle and lower Miocene in age. It is exposed in Rock Creek Canyon adjacent to the southern portion of the site. The Grande Ronde Basalt is the oldest formation of the Yakima Basalt Subgroup, the most voluminous and extensive formation in the entire Columbia River Basalt Group, underlying most of the Columbia Plateau. The flows are dark-gray to black, aphyric tholeiitic basalt, including both high- and low-magnesium (Mg) chemical types (Swanson et al., 1979). The contact between the Grande Ronde Basalt and the Wanapum was confirmed along North Rock Creek Road in Rock Creek Canyon during the site reconnaissance. The Grande Ronde Basalt conformably underlies and locally interfingers with the Wanapum Basalt.

The Wanapum Basalt (Tcw) is middle Miocene in age. It is the most extensive formation exposed at the surface of the Columbia Plateau but is much less voluminous than the Grande Ronde Basalt. This unit is described as fine- to coarse-grained basalt with reversed magnetic polarity. It generally exhibits blocky to platy jointing within the site vicinity. Based on subsurface data from Barr (2009), the basalt varies from intact to weathered, with low to high vesicularity, and an unconfined compressive strength that ranges from approximately 3,000 to 20,000 pounds per square inch (psi). The depth to the basalt within the Facility site boundary varies from 0 to 40 ft. The contact between the Wanapum Basalt and the Alkali Canyon Formation of The Dalles Group sedimentary unit was confirmed in a road cut on Baseline Road just east of OR 19. The Wanapum Basalt underlies loess and soil throughout the southern portion of the site following the Willow Creek Monocline, which is shown on Figure H1. It is exposed along the slopes within the southern portion of the site and along portions of Rock Creek.

The Saddle Mountains Basalt (Tcs) is upper and middle Miocene in age. It is exposed in the valley walls along OR 19 in Alkali Canyon and lower Eightmile Canyon. The Saddle Mountains Basalt has been divided into 10 members, each with unique petrographic and paleomagnetic characteristics. It is typically black, aphyric, and dense, with even grain size.

The Selah Member of the Ellensburg Formation is exposed in valleys in the vicinity of the Facility, primarily along OR 19 and along Cedar Springs Lane. This unit was mapped by Bela (1982) but is not shown in Figure H1. Most of the Selah Member is massive and coarsely bedded. The tuff is compact, but lacks cementation or welding of the grains. It has a high porosity, low permeability, and low specific gravity. This unit was deposited as a thick interbed in between basalt flows. In the Facility area, this geologic unit is exposed in slopes along creek valleys, and is mostly overlain on the flat plateaus by the Alkali Canyon Formation.

The Alkali Canyon Formation (Ts) of The Dalles Group underlies most of the northern portion of the Facility site. It is a semiconsolidated to well-consolidated mostly lacustrine tuffaceous sandstone, siltstone, and mudstone. It rests unconformably on top of the Columbia River Basalt group in north-Central Oregon. It consists primarily of basaltic cobble gravel with lesser but variable amounts of fine tuffaceous sediment. The unit is highly variable laterally. Exposures of the Alkali Canyon Formation showed that the material consists of rounded, basaltic, stratified, weakly-cemented, fine gravel to cobbles. Based on subsurface data from Barr (2009).

Pleistocene age Unconsolidated Geologic Units consisting of catastrophic flood deposits are exposed in the lower portion of Alkali Canyon and in Eightmile Canyon. They were mapped by Bela (1982). They consist of coarse, unsorted, poorly bedded basalt gravel and sand.

Flatter plateau areas and uplands throughout the Columbia Plateau are mantled by loess deposits. Loess is an Aeolian sediment formed by the accumulation of wind-blown silt and lesser and variable amounts of sand and clay that is often loosely cemented by calcium carbonate. The loess is typically 15 to 30 ft thick, but it thins to less than 3 ft thick in upland areas (Bela, 1982). Most of the soils in the area are reported to have loess as at least part of their parent rock. Since the geology map for the site is meant to show structural and stratigraphic relationships between formations loess is not typically mapped (Bela, 1982). Based on observations made during the site reconnaissance and by other investigations in the area, loess is thin to absent in the northern portion of the site. In addition, stony (loess-free) soils were observed at the surface of the plateau in several areas. It appears that most of the loess along side slopes has been eroded off. On the south side of the site the steeper slopes have no loess, but on the plateaus there is possibly as much as 15 to 30 ft in some areas along the more easterly and flatter areas. Based on subsurface information from an adjacent project, the loess consists of very loose to very dense, quartzose silt to fine sand and has layers of caliche (Barr, 2009).

Structural Geologic Features

The Facility site is located in the Arlington Basin, which is within the doubly plunging Dalles-Umatilla syncline (Farooqui et al., 1981). This syncline trends predominantly northeasterly and its axis is mapped to the north of the site. The Willow Creek Monocline trends northeasterly through the middle of the site as shown on the Geology Map (see Figure H1). Prominent northwest-trending strike-slip faults and lineaments occur on the Columbia Plateau and, specifically, within the Facility site area there are three features. They include the Turner Butte-Rock Creek lineament, Turner Butte Anticline, and Shutler Lineament.

The Shutler Lineament is a combination of northwest-trending anticlines and normal faults. It has been mapped north of the proposed Facility site. The Turner Butte Anticline is mapped northwest of the site. The Turner Butte-Rock Creek lineament follows the same trend as the Turner Butte Anticline and is mapped as a normal fault, down to the southwest. Rock Creek generally follows the trend of the fault.

No faults are mapped within the Facility site boundary (Bela, 1982). Potentially active faults are discussed in Section H.6.1.

H.1.3.2 Groundwater/Springs

Study of well logs within the project area indicates that groundwater occurs at an average of 300 to 400 ft below ground surface on top of the plateaus or shallower depending on ground surface elevations and formation type. Seasonally, perched groundwater, most likely sourced from precipitation events and/or irrigation, can be expected within the area. .Ephemeral springs flow at creek levels seasonally, as well. Interception of perched groundwater within deep excavations during construction is not anticipated, but is possible.

H.2 Site-specific Geotechnical Work

OAR 345-021-0010(1)(h)(B) *A description and schedule of site-specific geotechnical work that will be performed before construction for inclusion in the site certificate as conditions.*

RESPONSE:

Site-specific geotechnical work is described in the following sections.

H.2.1 Work Performed to Prepare this Exhibit

A site reconnaissance to observe geological and geotechnical features within the Facility site boundary was performed in September 2010. The field reconnaissance was conducted to verify reported field conditions, determine if other important geologic conditions were present, assess soil and rock properties, note potential geologic hazards, and potential impacts from project construction and site of permanent facilities. The fieldwork included evaluation of existing exposures of soil and rock (in road cuts, quarries, and drainages), classification of soils, and observation of typical slopes in the proposed turbine, overhead collector line, generator lead line, and access road areas.

In preparation for the fieldwork and for the writing of this exhibit, a desktop study was performed using available geologic reports, topographic and geologic maps, well logs, soils data, aerial photography and reports prepared for similar projects within the vicinity of the site. The literature review also included a detailed evaluation of seismic hazards at the site and is presented in Section H.6.

H.2.2 Future Work

A geotechnical study of the site will be conducted prior to final design and construction. Field exploration and laboratory analysis will document existing conditions and possible construction and long-term geotechnical and geologic issues. Exploration activities will be used to assess subsurface soil and geologic physical characteristics for infrastructure (turbine and other structure foundations, installation of cables and overhead collector and generator lead lines) design and to identify geologic/geotechnical hazards that might affect those structures and the public safety.

Once the final turbine locations have been selected, a site-specific geotechnical exploration study will be performed. The exploration activities will include (but not be limited by) the following:

1 – a detailed geologic hazard evaluation will be performed to identify potential slope instability area;

2 – drilling to determine geotechnical parameters at turbine and Facility locations for foundation design;

3 - test pit excavations or geophysical testing to evaluate subsurface conditions;

4 - laboratory testing to determine soil properties and chemical makeup for use as backfill for thermal protection of buried power cable and corrosion potential of steel and concrete.

The information gathered during the detailed site exploration will be used for final design parameters of building and turbine siting and foundation design, grading, utilities, roadway and electrical installation.

H.3 Evidence of Consultation with DOGAMI

OAR 345-021-0010(1)(h)(C) *Evidence of consultation with the Oregon Department of Geology and Mineral Industries regarding the appropriate site-specific geotechnical work that must be performed before submitting the application for the Department to determine that the application is complete.*

RESPONSE

The Applicant consulted with DOGAMI during preparation of this Exhibit (DOGAMI, 2010). The Applicant will consult with DOGAMI before the detailed geotechnical exploration study, after micrositing has occurred.

H.4 Transmission Line

OAR 345-021-0010(1)(h)(D) *For all transmission lines, a description of locations along the proposed route where the applicant proposes to perform site-specific geotechnical work, including but not limited to railroad crossings, major road crossings, river crossings, dead ends, corners, and portions of the proposed route where geologic reconnaissance and other site-specific studies provide evidence of existing landslides or marginally stable slopes that could be made unstable by the planned construction.*

A new overhead 230-kV generator lead line will connect the Facility to BPA's proposed Diamond Butte substation along the Ash-Marion 500-kV line or PGE's proposed Cedar Spring substation. Approximately 22.5 miles of generator lead line will be constructed for interconnection of the Facility with the Diamond Butte substation or Cedar Spring substation. The generator lead line structures will be wood or steel towers. Tower heights may vary from 80 to 135 ft above the ground surface, depending on terrain and type of structure.

A site reconnaissance to observe geological and geotechnical features within the area was performed in September 2010. Based on field reconnaissance, generator lead line tower foundations can be located along the generator lead line route without having an adverse effect on slope stability or long-term erosion. As part of the micrositing process, a geotechnical investigation will be conducted for the final generator lead line route and may include soil borings. This information will be used during the design of the tower foundations.

H.5 Pipelines

OAR 345-021-0010(1)(h)(E) *For all pipelines that would carry explosive, flammable or hazardous materials, a description of locations along the proposed route where the applicant proposes to perform site-specific geotechnical work, including but not limited to railroad crossings, major road crossings, river crossings, and portions of the proposed alignment where geologic reconnaissance and other site-specific studies provide evidence of existing landslides or marginally stable slopes that could be made unstable by the planned construction.*

RESPONSE

OAR 345-021-0010(1)(h)(E) is not applicable as no pipelines are planned.

H.6 Seismic Hazard Assessment

OAR 345-021-0010(1)(h)(F) *An assessment of seismic hazards. For the purposes of this assessment, the maximum probable earthquake (MPE) is the maximum earthquake that could occur under the known tectonic framework with a 10 percent chance of being exceeded in a 50-year period. If seismic sources are not mapped sufficiently to identify the ground motions above, the applicant shall provide a probabilistic seismic hazard analysis to identify the peak ground accelerations expected at the site for a 500-year recurrence interval and a 5000-year recurrence interval. In the assessment, the applicant shall include:*

Identification of the Maximum Considered Earthquake Ground Motion shown at International Building Code (2003 edition) Section 1615 for the site.

RESPONSE

The International Building Code (IBC, 2009) as amended by the Oregon Structural Specialty Code (OSSC, 2010) requires that for new construction, the site should be designed for the maximum considered earthquake. The design event has a 2 percent probability of exceedance in 50 years (or a 2,475-year return period). For this event, the site has a peak ground acceleration (PGA) of 0.19g[1] at bedrock surface – average acceleration at this site for all potential seismic events (crustal, intraplate, or subduction).

Seismic design parameters were developed in accordance with the IBC (2009). Based on gathered and observed soil information and work done on other projects within the area, Site Class D (stiff soil profile) should be used to design the Facility. It is anticipated that after information is obtained from the geotechnical exploration study (shear wave velocity in rock and geotechnical boring findings) some of the Facility could be designed using Site Class C (very dense soil and soft rock) or even Site Class B, competent rock with moderate fracturing and weathering with 10 ft or less of soil overburden. Table H1 summarizes the seismic design parameters based on using Site Class D soil profile.

Table H1: Summary of Seismic Design Parameters – Site Class D Soil Profile

Earthquake Magnitude	Peak Horizontal Ground Acceleration on Bedrock	Soil Amplification Factor, F_a	Peak Horizontal Ground Acceleration at Ground Surface
6.0	0.18g	1.442	0.24g

[1] g=acceleration from gravity

A short period (0.2-second) spectral response acceleration, S_{MS} = 0.60g for Site Class $S_{D,}$ and a 1-second period spectral response acceleration, S_{M1} = 0.30g for Site Class S_D can be used for structural design for the Maximum Considered Earthquake (MCE).

The design spectral response accelerations, S_{DS}, for both short period and 1-second period can be determined by multiplying the MCE spectral response accelerations (S_{MS} and S_{M1}) by a factor of 2/3.

H.6.1 Earthquake Sources

(ii) Identification and characterization of all earthquake sources capable of generating median peak ground accelerations greater than 0.05g on rock at the site. For each earthquake source, the applicant shall assess the magnitude and minimum epicentral distance of the maximum credible earthquake (MCE).

RESPONSE

There are three seismic sources that could impact the Facility area potentially triggering seismic hazards. These sources are the Cascadia Subduction Zone (CSZ) interplate events, CSZ intraslab events, and crustal events (Geomatrix, 1995).

The Juan de Fuca plate is being subducted beneath the North American plate along the west coast from Northern California to Canada. Interplate events occur at the plate boundaries. Intraslab events originate within the plate being subducted – (Juan de Fuca), and can be associated with normal faulting. The combination of these factors is often referred to as the CSZ source mechanism. The interplate event is potentially capable of producing a maximum earthquake with a moment magnitude of 9.0. The intraslab event is potentially capable of producing a maximum earthquake with a moment magnitude of 7.5 (Geomatrix, 1995; U.S. Geological Survey [USGS], 2009a and 2009b and Madin et. al., 1996).

The third source mechanism is earthquakes caused by crustal fault movements. These are generally in the upper 10 to 15 miles of the earth's surface. Crustal faults occur when built-up stresses near the surface are released through fault rupture. Faults within the site area are shown in Figure H1.

The primary potentially active crustal faults are within the Wallula Fault system with late Quaternary age displacement on at least one structure in the system.

Using the USGS National Seismic Hazard Mapping Database (USGS, 2009a and 2009b) the PGA at the Facility resulting from a seismic event from one of the seismic sources was calculated. PGA is estimated at a theoretical soft rock/stiff soil interface for different probabilities of exceedance. The USGS database also provides the seismic deaggregation information for the seismic hazard, including estimates of the mean earthquake moment magnitude and mean epicentral distance associated with given probability of exceedance at a given location.

An earthquake that has a 10 percent probability of exceedance in 50 years (a nominal 500-year recurrence interval) is the MPE. An earthquake with a nominal 2,500-year recurrence interval (a 2 percent probability of exceedance in 50 years) is the MCE. To provide an estimate of magnitudes for seismic events with epicentral distances ranging from 0 to 60 miles and from 60 to 100 miles, the PGA and a Spectral Acceleration (SA) at a period of 2.0 seconds were estimated using the USGS seismic hazard database (USGS, 2009a and 2009b). These estimates of magnitude, epicentral distance, and PGA are provided in Table H2.

Table H2: MPE and MCE Source Characterization Parameters

Earthquake Event	Mean Moment Magnitude	Epicentral Distance (miles)	Peak Ground Acceleration (PGA)
MPE Events	5.2 (crustal) 9.0 (subduction)	9 (crustal) 175 (subduction)	0.09g
MCE Events	6.2 (mean)	39 (mean)	0.18g

Note: The parameters for both events are for a frequency that corresponds to the PGA.
g = acceleration from gravity.

See Figure H2 for the MPE and Figure H3 for the MCE.

H.6.2 Recorded Earthquakes

(iii) *A description of any recorded earthquakes within 50 miles of the site and of recorded earthquakes greater than 50 miles from the site that caused ground shaking at the site more intense than the Modified Mercalli III intensity. The applicant shall include the date of occurrence and a description of the earthquake that includes its magnitude and highest intensity and its epicenter location or region of highest intensity.*

RESPONSE

Table H3 provides the date of occurrence, location, and reported magnitude and intensity at the epicenter (unless otherwise noted) of earthquakes causing Modified Mercalli (MM) III shaking intensity or greater at the Facility. A magnitude 5.89 Milton-Freewater earthquake in 1936 was the largest recorded earthquake in the region, which caused shaking intensity of MM VII at its epicenter. The largest recorded earthquake magnitude within 50 miles (80 kilometers) of the Facility was 4.8.

The information in Table H3 was developed for the Montague Wind Power Facility, which is adjacent to the Facility site and, therefore, is a similar distance from the recorded earthquake events. The information was developed by screening DOGAMI (Madin, 1994) and the USGS Earthquake Information Center (USGS, 2009a) earthquake databases. For earthquakes that were reported in terms of magnitude, a relationship between PGA and MM intensity (Kramer, 1996) was used to define a PGA associated with an MM III event. A distance-attenuation relationship was then used to determine the combination of earthquake magnitude and distance producing an intensity of MM III at the Facility. A mean Joyner and Boore attenuation relationship was used to develop the magnitude-distance information (Joyner and Boore, 1988). The most distant event affecting the site was a magnitude 3.9 earthquake occurring on July 13, 1971, and located more than 84 miles from the site.

Table H3: Significant Historical Earthquakes Within 50 Miles of the Facility

Year	Month	Day	Latitude	Longitude	Magnitude	Intensity
1893	3	7	45.90	119.40	--	VII
1918	11	1	46.70	119.50	--	VI
1921	9	14	46.07	118.33	--	VI

Table H3: Significant Historical Earthquakes Within 50 Miles of the Facility

Year	Month	Day	Latitude	Longitude	Magnitude	Intensity
1922	10	16	45.83	119.23	--	III
1922	12	12	45.67	118.75	--	III
1924	1	6	46.07	118.33	--	IV
1924	1	6	45.83	118.33	--	V
1924	5	27	46.07	118.33	--	IV
1926	4	11	46.07	118.33	--	III
1926	4	23	46.07	118.33	--	IV
1936	7	16	45.83	118.67	--	III
1936	7	16	45.75	118.50	--	III
1936	7	18	45.92	118.30	--	III
1936	7	18	46.00	118.30	--	V
1936	7	30	46.07	118.33	--	IV
1936	7	30	45.93	118.32	--	IV
1936	7	30	45.93	118.30	--	IV
1936	8	4	45.92	118.78	--	V
1936	8	24	45.93	118.28	--	III
1936	8	24	45.93	118.27	--	III
1936	8	28	45.95	118.32	--	V
1936	11	17	46.07	118.33	--	III
1936	11	17	46.07	118.33	--	III
1936	11	17	46.07	118.33	--	III
1937	2	8	46.07	118.33	--	III
1937	2	9	46.07	118.33	--	IV
1937	6	4	46.07	118.33	--	IV
1938	8	11	45.95	118.30	--	IV
1938	10	27	45.95	118.28	--	IV
1939	1	26	45.67	118.67	--	IV
1939	1	26	45.67	118.67	--	IV
1944	9	2	46.07	118.33	--	IV
1944	9	2	46.07	118.33	--	IV
1945	9	23	46.07	118.33	--	IV
1951	1	7	45.92	119.23	--	V
1959	1	21	46.07	118.33	--	IV
1965	8	19	44.60	118.40	4.4	--
1966	7	23	47.20	119.50	4.3	--
1969	4	19	45.78	119.70	3.2	--
1969	9	27	46.63	118.08	3.1	--
1969	11	5	47.13	118.15	3.5	--
1969	11	21	46.62	118.88	3.6	--
1970	1	1	46.27	118.35	3.0	--
1970	1	30	46.85	118.22	3.1	--

Table H3: Significant Historical Earthquakes Within 50 Miles of the Facility

Year	Month	Day	Latitude	Longitude	Magnitude	Intensity
1971	1	4	46.22	119.35	3.1	--
1971	3	17	46.68	118.87	3.0	--
1971	7	13	44.98	117.95	3.8	--
1971	7	13	44.82	117.88	3.9	--
1971	10	25	46.70	119.55	3.7	--
1974	12	13	45.26	-121.6	4	--
1976	4	8	44.97	-120.8	--	--
1976	4	13	45.22	-120.77	4.8	--
1976	4	17	45.08	-120.8	4.2	--
1980	7	7	45.22	-121.69	3.3	--
1981	6	14	45.95	-120.49	3.1	--
1987	9	8	45.18	-120.08	3.1	--
1987	9	29	45.19	-120.11	2.7	--
1988	7	11	45.25	-120.13	2.9	--
1988	9	29	45.85	-120.26	3.5	--
1989	3	27	45.82	-120.26	3.1	--
1989	9	15	45.37	-121.71	3.5	--
1990	10	19	45.34	-121.69	3.5	--
1991	4	20	45.35	-120.14	2.8	--
1993	12	16	45.2	-120.09	3	--
1993	12	18	45.25	-120.11	3.1	--
1994	4	13	45.14	-120.85	2.8	--
1994	4	16	45.14	-120.84	2.6	--
1994	9	22	45.69	-120.16	2.9	--
1994	11	17	45.7	-120.18	2.7	--
1996	4	7	45.37	-121.72	3	--
1997	4	17	45.19	-120.08	3.2	--
1997	8	17	45.65	-120.19	2.8	--
1997	9	10	45.65	-120.2	2.7	--
1997	11	11	45.85	-120.57	2.8	--
1998	2	3	45.81	-120.2	3.1	--
1998	4	28	45.26	-120.28	2.7	--
1998	10	31	45.1	-120.82	2.7	--
1998	11	1	45.1	-120.83	2.9	--
1999	1	11	45.32	-121.65	2.9	--
1999	1	11	45.32	-121.65	3.2	--
1999	1	14	45.33	-121.66	3.2	--
1999	1	14	45.33	-121.67	3	--
1999	2	15	45.32	-121.66	2.6	--
1999	8	31	45.19	-120.09	3.2	--
2000	1	30	45.2	-120.12	4.1	--

Table H3: Significant Historical Earthquakes Within 50 Miles of the Facility

Year	Month	Day	Latitude	Longitude	Magnitude	Intensity
2000	1	30	45.19	-120.1	3.4	--
2000	1	30	45.18	-120.11	2.8	--
2000	2	1	45.19	-120.11	3.6	--
2000	2	1	45.19	-120.12	2.8	--
2000	7	25	45.34	-121.68	2.8	--
2000	7	28	45.17	-120.14	2.6	--
2000	8	3	45.21	-120.07	2.8	--
2000	8	17	45.31	-120.04	3.2	--
2001	9	14	45.31	-121.73	2.9	--
2002	1	31	45.69	-120.17	2.7	--
2002	5	6	45.33	-121.69	2.8	--
2002	6	29	45.33	-121.69	4.5	--
2002	6	29	45.33	-121.68	3.2	--
2002	6	29	45.34	-121.68	3.8	--
2002	6	30	45.34	-121.68	2.7	--
2002	7	2	45.34	-121.68	2.8	--
2002	10	25	45.19	-120.09	2.7	--
2002	12	12	45.36	-121.7	2.7	--
2003	6	1	45.19	-120.11	2.8	--
2003	7	7	45.33	-121.69	3.3	--
2005	4	6	45.37	-121.71	2.8	--
2006	12	30	45.12	-120.94	2.6	--
2007	1	1	45.12	-120.93	2.5	--
2007	1	4	45.12	-120.94	3	--
2007	1	20	45.12	-120.94	3	--
2007	2	13	45.12	-120.94	2.9	--
2007	2	13	45.12	-120.93	2.7	--
2007	3	1	45.12	-120.93	3.6	--
2007	4	1	45.13	-120.95	2.6	--
2007	4	8	45.13	-120.94	3.1	--
2007	5	2	45.13	-120.94	3.3	--
2007	6	3	45.13	-120.96	2.7	--
2007	6	14	45.13	-120.94	3.9	--
2007	7	16	45.12	-120.94	2.5	--
2007	7	19	45.12	-120.95	2.6	--
2007	8	20	45.13	-120.95	2.9	--
2007	11	21	45.13	-120.94	3.3	--
2008	1	3	45.13	-120.95	2.7	--
2008	2	4	45.13	-120.94	3.3	--
2008	3	20	45.13	-120.93	3.1	--
2008	4	5	45.13	-120.94	3.6	--

Table H3: Significant Historical Earthquakes Within 50 Miles of the Facility

Year	Month	Day	Latitude	Longitude	Magnitude	Intensity
2008	4	16	45.13	-120.95	2.9	--
2008	4	28	45.13	-120.96	3.1	--
2008	6	1	45.13	-120.95	3.4	--
2008	6	5	45.14	-120.95	2.6	--
2008	6	20	45.13	-120.94	3.2	--
2008	7	14	45.13	-120.95	4.2	--
2008	9	16	45.13	-120.95	2.7	--
2008	11	16	45.13	-120.95	3.4	--
2008	12	27	45.13	-120.95	3.6	--
2009	3	20	45.13	-120.96	3	--
2009	4	20	45.13	-120.96	3.6	--
2009	4	20	45.13	-120.95	2.5	--
2009	6	6	45.12	-120.94	2.6	--

Sources: Madi, 1994; USGS, 2009a; Iberdrola Renewables, Inc., 2010.

H.6.3 Median Ground Response Spectrum

(iv) Assessment of the median ground response spectrum from the MCE and the MPE and identification of the spectral accelerations greater than the design spectrum provided in the Oregon Structural Specialty Code (2004 edition). The applicant shall include a description of the probable behavior of the subsurface materials and amplification by subsurface materials and any topographic or subsurface conditions that could result in expected ground motions greater than those characteristic of the Maximum Considered Earthquake Ground Motion identified above.

RESPONSE

Surface soils within the Facility boundary were identified using the Natural Resources Conservation Service (NRCS) Soil Survey of Gilliam County, Oregon (NRCS, 2009). Additionally, during the field reconnaissance, soil types were confirmed in readily accessible areas like road cuts and quarries. Presently, it is recommended that Site Class D (S_D) be used for Facility design. However, due to the varying nature of the soils at the site, along with depth to competent bedrock, much of the site may be designed using Site Class B (S_B) or Site Class C (S_C). Figure H4 is a comparison of the design response spectrum using the 2003 IBC with the OSSC. MCE and MPE response spectra are used. For the MCE, separate response spectra modified by the amplification factors for S_D and also S_B are provided.

H.6.4 Seismic Hazards Expected to Result from Seismic Events

(v) An assessment of seismic hazards expected to result from reasonably probable seismic events. As used in this rule "seismic hazard" includes ground shaking, ground failure, landslide, lateral spreading, liquefaction, tsunami inundation, fault displacement and subsidence.

RESPONSE

The MCE is a very low probability event with a 2,500-year recurrence interval, which must be considered in design of the project (OSSC, 2010). The facilities will be designed to current IBC and OSSC guidelines for S_D (or S_B). Facilities will be designed for no permanent structural damage either from the vibrational response of the structure or from secondary hazards. The secondary hazards are associated with ground movement or failure, such as landslides, lateral spreading, liquefaction, fault displacement, or subsidence. The risk to human safety will be minimal assuming that structural damage can be prevented through design.

Anticipated to be low, potential seismic hazards associated with a design seismic event include fault displacement, instability from landslides or subsurface movement, and adverse effects from groundwater or surface water. Specific conditions and the potential of hazards at the Facility are discussed below:

- **Fault Displacement Potential**. No potentially active faults that could cause ground surface rupture have been mapped within the Facility site boundary.

- **Subsurface Material Behavior**. There is a low potential for seismically induced landslides within the Facility site boundary and the potential is limited to canyon slopes. Turbine structures will be well away from these slopes, and constructed on relatively flat ground. Areas where large, prehistoric landslides (primarily along the slopes of Alkali Canyon) may have oversteepened slopes could be prone to slightly reduced shear strength. Potential reactivation of the slides by a change in land use, flooding, or loading near the crest of existing slopes exists.

  Limited extent rockfall hazards may exist along outcrops, or overly steep excavated slopes, but these will tend to be of limited extent and are not expected to affect the operation of the Facility. These areas are limited and facilities will be located away from potential hazards.

  Soil slippage is not expected to be a design consideration for the turbine structures because they will be located on relatively flat ground, and the geometry of the slope movement is not anticipated to be great enough to encompass the turbine locations. Other facilities, such as roads, may exist below slopes steeper than 21 to 30 degrees in some locations. Soil movement could affect these facilities if the slopes were to fail. However, because these roads will be used infrequently, the risk associated with slope movement is very low.

- **Adverse Effects from Groundwater or Surface Water**. The hazard potential associated with landslides, liquefaction, lateral spreading, and subsidence is very low. Due to the level or gently sloping terrain on which the towers will be constructed, depth to groundwater, and the competent nature of the shallow bedrock, the hazard potential associated with landslides, liquefaction, lateral spreading, and subsidence is very low. Flooding is not a risk because the site is several hundred feet above the Columbia River. Additionally, there is no risk from a tsunami because the site is well over one hundred miles from the Pacific Ocean.

- **Mitigation measures to address the hazards listed** above in the siting, design, and construction of the Facility are not necessary, because the potential of the occurrence of these hazards is very low. The design of the turbine tower can readily accommodate the level of seismic energy described in Section H.6.3, Median Ground Response Spectrum.

H.7 Nonseismic Geological Hazards

OAR 345-021-0010(1)(h)(G) *An assessment of soil-related hazards such as landslides, flooding and erosion which could, in the absence of a seismic event, adversely affect or be aggravated by the construction or operation of the facility.*

RESPONSE

Nonseismic geologic hazards potential risks at the site include slope instability, soil erosion by wind and water, collapse potential of loess, and volcanic eruptions. Each of these hazards is discussed briefly below. Mitigation measures that could be used to address potential nonseismic geologic hazards are discussed in Section H.9.

H.7.1 Slope Instability

No landslides are shown on the Statewide Landslide Information Database of Oregon (SLIDO) within the Facility site boundary. The nearest landslides are mapped at the lower end of Eightmile Canyon where it intersects Oregon State Highway 74 (OR 74), approximately 4 miles northeast of the Facility site boundary.

During the site reconnaissance of the area, areas of prehistoric landslides were observed along Alkali Canyon. These areas were also observed during site visits for the Montague Wind Power Facility (Iberdrola Renewables, Inc., 2010). The Alkali Canyon Formation is shown on the Geology Map (see Figure I1). The landslides occur along the oversteepened slopes of Alkali Canyon and do not underlie proposed infrastructure locations. Other prehistoric landslides near the intersection of OR 19 and Montague Lane were also mapped for the Montague Wind Power Facility. The interpretation was that these landslides were formed in lacustrine sediments and the weakly cemented Selah Interbed. It was interpreted that these landslides were triggered by saturation of sediments and subsequent rapid drawdown resulting from periodic and repeated inundation during catastrophic flooding that occurred between 12,000 and 15,000 years ago (Allen et al., 1986). Since unsaturated conditions exist today, these landslides are not considered active.

Although these landslides are not anticipated to be active, soil strength and slope stability can be reduced in areas where landslides have occurred. Slope instability will be identified during siting of turbines to avoid potential impacts to roads.

H.7.1.1 Erosion Potential

The erosion factor K is a soil erodibility factor that represents both susceptibility of soil to erosion and the rate of runoff. It is one of the six factors used in the Universal Soil Loss Equation and Revised Universal Soil Loss Equation (RUSLE). In general, soils high in clay have low K values because they are resistant to detachment. Coarse textured soils, such as sandy soils, have low K values because of low runoff even though these soils are easily detached. Medium textured soils, such as silt loams, have moderate K values, because they are moderately susceptible to detachment and produce moderate runoff. Soils having high silt content are most erodible of all soils. They are easily detached, tend to crust, and produce high rates of runoff. K Values for these soils tend to be greatest. RUSLE is used to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates include the type of soil as mentioned above, and also amount of organic matter and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water. Data from the NRCS Web Soil Survey (NRCS, 2006) indicate that the silt loam soils on the site have an erodibility (K) that ranges from 0.43 to 0.64. Given the range of K for the Facility, the soils could be considered moderately to highly erodible and subject to sheet erosion and rill erosion by water.

Erosion will be minimized by adherence to the erosion control plan and NPDES 1200-C construction permit. Areas of vegetation removal will be reclaimed through reseeding of native vegetation or crops.

Exhibit I describes soil properties within the Facility site boundary along with mitigation measures to minimize erosion. The Applicant will provide the NPDES permit application.

H.7.1.2 Collapse Potential of Loess

Collapsible soil is defined as soil that is susceptible to a large and sudden reduction in volume upon wetting. Collapsible soil deposits, like loess, share two main features: they are loose, cemented deposits and they are naturally quite dry. Collapsible soil can withstand a large applied vertical pressure with small compression, but then show much larger settlement upon wetting, with no increase in vertical stress. Surface soils may become saturated during heavy precipitation events or snowmelt; however, since the depth to groundwater is as much as 300 ft below ground surface, the likelihood of long-term saturation that could lead to collapse is very low to none.

Saturation of loess at the Facility during or after construction is not anticipated. Loess soils used for embankments are not expected to retain a high void ratio structure that is subject to collapse or swell after excavation, placement, and compaction. The collapse or swell potential is anticipated to be minimal. As part of the site design phase, loess soils can be assessed and tested for collapse and swell potential to ensure an adequate margin of safety against collapse or swelling.

H.7.1.3 Volcanic Eruption

The Cascade Range consists of numerous active volcanoes. Eruptions will continue to occur in the region. The closest volcanoes to the site are Mount Hood, Mount Adams, and Mount Saint Helens. They are approximately 75, 75, and 100 miles to the west and northwest of the site, respectively. Mount St. Helens and Mount Hood have both erupted in the last 200 years.

Direct impacts from volcanoes include the effects of lava flows, blast, ash fallout, and avalanches of volcanic products. Indirect effects include ash fall, mudflows, flooding, and sedimentation. Ash fall will be the expected hazard at the site during new eruptions and the degree of impact will depend on the size and type of eruption and wind direction.

H.8 Seismic Hazard Mitigation

OAR 345-021-0010(1)(h)(H) *An explanation of how the applicant will design, engineer and construct the facility to avoid dangers to human safety from the seismic hazards identified in paragraph (F). The applicant shall include proposed design and engineering features, applicable construction codes, and any monitoring for seismic hazards.*

RESPONSE

The Facility design will meet or exceed the minimum standards required by design codes within the 2009 IBC, used by the State of Oregon, with current amendments of the OSSC and local agencies. The design codes are in IBC Chapter 16, Section 1613, with some modification by the State of Oregon current amendments and local agencies. These codes relate to geology, seismicity, and near surface soil. Section 1613 presents criteria for the design and construction of buildings and non-building structures subject to earthquake ground motion.

There are prehistoric landslides in the site area. Catastrophic flooding during the late Pleistocene most likely triggered them. These conditions are not present today and so the risk of landslides is low. The final design for the Facility will utilize information collected during the geotechnical exploration. The main purpose is the mitigation of potential hazards that could be created during a seismic event. Surficial rupture along a fault trace is low based on information gathered to prepare this exhibit. Therefore, there is a low probability that a fault rupture will actually displace the ground surface at the location of one of the wind turbines or the underground cables between turbines.

Overall, rock formations in the site area are competent and so large-scale landslides are not expected. Facility towers and appurtenances/infrastructure will be constructed away from the canyon slopes on which sliding occurred. Additionally, because of the arid conditions in the project area, hazards related to saturated soil conditions are not expected. For these reasons, the Applicant has demonstrated that the Facility meets OAR 345-022-0020(1)(b).

H.9 Nonseismic Hazard Mitigation

OAR 345-021-0010(1)(h)(I) *An explanation of how the applicant will design, engineer and construct the facility to adequately avoid dangers to human safety presented by the hazards identified in paragraph (G).*

RESPONSE

Nonseismic geologic hazards might include soil erosion, collapsing soils, landslides, and volcanic eruptions. Mitigation for these hazards might include avoidance of potential hazards by creating a detailed geologic hazard map of the site to plan the location of facilities, through geotechnical exploration of subsurface soils, determine soil strength and foundation conditions, and planning ahead for potential hazard events.

- **Soil Erosion**. To reduce the potential for soil erosion, an erosion control plan and NPDES 1200-C construction permit will be developed and compliance expected during the construction of roads and turbine foundations.

- **Collapsing Soils/Piping**. During the final design geotechnical exploration, potentially collapsible soils (such as loess) will be identified, and the collapse potential will be evaluated by laboratory testing. If collapsible soils are found within construction areas, mitigation measures implemented as part of foundation design and construction including overexcavating, wetting, and compacting may be recommended during subgrade preparation.

- **Landslides**. Identification of potential slope instability/failure areas will be mapped during the geotechnical exploration process. The turbines will be located safe distances from steep slopes so that if slope failure should occur, the turbines and their associated foundation structures will not be affected. Facility infrastructure will be located away from unstable slopes and landslide prone areas to the extent possible.
- **Volcanic Eruptions**. If there is an eruption during construction, a temporary shutdown will probably be required to protect human health and equipment. During Facility operations, if there is a volcanic eruption that could damage or affect Facility components, those components will be shut down until safe operating conditions return.

Erosion control measures will meet local, county, and state erosion control measures, including procedures described in Exhibit V. Some of the activities that will disturb soil and vegetation will include preparation of turbine pads and the grading and re-graveling of existing roads, and construction of new roads for site access. Specific erosion control measures are listed in Exhibits I and V.

A geotechnical exploratory program will be completed prior to final design and construction. The exploration will assess subsurface soil and geologic conditions. Soil samples will be tested in a soils laboratory and assessed as necessary. The purpose of this program will be to identify geologic hazards and inform design of turbine foundations and foundations of other related and supporting facilities. This information will also be used for planning subsurface cable installation and overhead collector and generator lead lines.

H.10 Proposed Site Certificate Conditions

Similar to the conditions proposed by previously-approved wind energy facilities in the vicinity of the Facility, the Applicant proposes the following conditions:

<u>Condition 39</u>
Before beginning construction, the certificate holder shall conduct a site-specific geotechnical investigation and shall report its findings to the Oregon Department of Geology & Mineral Industries (DOGAMI) and the Department. The certificate holder shall conduct the geotechnical investigation after consultation with DOGAMI and in general accordance with DOGAMI open file report 00-04 "Guidelines for Engineering Geologic Reports and Site-Specific Seismic Hazard Reports."

<u>Condition 40</u>
The certificate holder shall design and construct the Facility in accordance with requirements of the Oregon Structural Specialty Code (OSSC, 2007) and the 2009 International Building Code (IBC, 2009).

<u>Condition 41</u>
The certificate holder shall design, engineer, and construct the Facility to avoid dangers to human safety presented by non-seismic hazards. As used in this condition, "non-seismic hazards" include settlement, landslides, flooding and erosion.

H.11 Conclusion

Based on the research and field reconnaissance studies for the Facility, the risks of geologic and seismic hazards to human safety are low. The Applicant has adequately characterized the site in accordance with OAR 345-022-0020(1)(a) and considered seismic events and amplification for the Facility's specific soil profile. Facility plans include improved access roads, wind turbine towers, and underground collector cables. The area is sparsely populated and used primarily for animal grazing and crops. Various setbacks have been established between turbines and other facilities, as discussed in Exhibit K; such setbacks protect the public in the event of serious Facility damage resulting from seismic events. There will be no continually staffed facilities other than the Facility O&M building, which will be occupied during normal business hours.

The Applicant has demonstrated that the Facility can, and will, be designed, engineered, and constructed to avoid dangers to human safety in case of a design seismic event by adhering to IBC requirements to comply with OAR 345-022-0020(1)(b). Under design earthquake standards, it is required that the factors of safety exceed certain values. A factor of safety of at least 1.1 will be used to determine seismic stability. In the event that factors of safety for slope stability are not met, the Facility components will either be relocated or else remedial measures to improve slope stability will be implemented. The Applicant has provided appropriate site-specific information and demonstrated in accordance with OAR 345-022-0020(1)(c) that the construction and operation of the proposed Facility, in the absence of a seismic event, will not adversely affect or aggravate the geological or soil conditions of the Facility site or vicinity. The risks posed by nonseismic geologic hazards are generally considered to be low because the Facility components will be located on relatively flat plateaus and stable uplands. The primary landslide hazard is on slopes, upon which no structures will be placed.

As previously mentioned, a geotechnical study of the site will be conducted prior to final design and construction. Field exploration and laboratory analysis will document existing soil and geologic conditions that will be used to determine site specific criteria for foundation and structural design to meet applicable building safety standards.

An erosion control plan will be implemented to minimize soil erosion hazards resulting from water and wind action. Pursuant to OAR 345-022-0020(1)(d) the Facility can be designed, engineered, and constructed to avoid dangers to human safety resulting from the geological and soil hazards of the site. Accordingly, given the relatively small risk these hazards pose to human safety, standard methods of practice—including implementation of the current IBC—will be adequate for the design and construction of the Facility.

H.12 References

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