

1. Affected Environment – Soils

The purpose of this section is to provide a brief description of the geology and soils that may be impacted by constructing the Willamette River Irrigation Exchange Pipeline option, and to provide information on the seismicity of the project area.

The affected environment for soils includes the pipeline route and construction staging areas. The study methodology for determining the Project affected environment consisted of a review of pertinent literature, including U.S. Geological Survey (USGS) reports and Natural Resource Conservation Service (formally known as the Soil Conservation Services (SCS)) soil maps for the area. As part of the Pacific Northwest Urban Corridor Geologic Mapping and Urban Hazard Project, the US Geological Survey (USGS) is preparing six geologic maps for Gales Creek to Newberg. These maps were unavailable at the time this report was prepared and are expected to be completed, with the exception of Newberg, by the end of 2003 (R. Wells communication, April 2003).

The seismicity of the project area was evaluated by identifying the seismic hazard zone and by determining the overall relative earthquake ground motion-shaking hazard for the pipeline corridor. This information is based on USGS seismic hazard reports and published geologic literature relating to the region.

1.1 Affected Environment – Pipeline Option

1.1.1 Study Area

The Project site is located in the south-central part of Washington County and northeastern part of Yamhill County, in northwestern Oregon. The proposed pipeline route is approximately 18 miles long and extends from Forest Grove south 11 miles then east about 7 miles to Dundee (Intake Alternative #1) or Newberg (Intake Alternative #2).

1.1.2 Geology

The pipeline Project area is located at the boundary between the eastern Coast Range and western Willamette Valley (see Figure 1-1). The proposed pipeline is situated in the lowlands of the Tualatin Valley region of the northern Willamette Valley which includes (from north to south) the Tualatin, Chehalem-Wapato, and Newberg valleys. The adjacent uplands include the moderately steep rolling foothills of the Coast Range and the Red Hills of Dundee to the west, and the Chehalem Mountains to the east. Elevations in the Project area are approximately 170 feet to 200 feet on the valley floor and between 1,000 and 2,000 feet in the uplands.

Structurally, the Coast Range is an uplifted area characterized by thrust faults and high angle normal faults. The adjacent Willamette Valley is a trough with valley-fill sediments. The Coast Range and Willamette Valley were formerly sea floor. Uplift of the Coast Range and downwarping of the valley floor resulted from the subduction of the oceanic plate

beneath the continental plate. The valley floor was further downwarped by the influx of flood basalts and filling of sediments into the basin.

The stratigraphy of the Coast Range in the Project area generally consists of Eocene-age (54.8 to 33.7 million years ago (Ma)) volcanic basement rock overlain by Eocene to Miocene-age (23.8 to 5.3 Ma) volcanics and marine sedimentary rocks and alluvium (see Figure 1-1). In the Project area the submarine basalt volcanics include the Siletz River Volcanics. Marine sedimentary rocks of the Yamhill Formation, Spencer Formation, and undifferentiated Oligocene (33.7 to 23.8 Ma) sedimentary rocks interfinger with and overlie the Siletz River Volcanics. The Yamhill Formation consists of well-indurated (hard) thin-bedded shale and siltstone with occasional interbeds of green basaltic sandstone and poorly-sorted tuffaceous (volcanic rock explosively or aurally ejected from a volcanic vent) sandstone. The Spencer Formation consists of thick-bedded to massive, well-sorted, friable (easily crumbled), fine- to medium-grained feldspathic sandstone (containing 10 to 25 percent feldspar) with occasional thin carbonaceous siltstone and claystone interbeds. The Oligocene marine sediments consist of tuffaceous sandstone and siltstone, basaltic sandstone, and conglomerate (coarse grained rock composed of fragments set in a fine grained matrix of sand or silt) (Schlicker and Deacon, 1967).

The Columbia River Basalt was deposited in a sequence of thick lava flows that cover much of eastern Oregon and Washington. In the vicinity of the Project, the uplands generally consist of Columbia River Basalt of the Miocene age. The Columbia River Basalt underlies the Newberg Valley at an approximate depth of 500 feet (Schlicker and Deacon, 1967).

Unconsolidated materials overlie marine sedimentary rocks or the Columbia River Basalt. Micaceous sandy silt and clayey silt overlie the Columbia River Basalts in the uplands. The Willamette Silt is present in lowlands and on upland slopes at elevations up to 250 feet. The Willamette Silt consists of fine sand, silt and clay and ranges from a few feet in thickness at the valley margins to 50 feet thick in the valley. Young alluvium consisting of silty clay, clayey silt, and fine sand is present in channels and along the floodplains of rivers within the valley and along upland tributaries. The thickness of the young alluvium ranges from 5 to 15 feet in the upland areas and 20 to 60 feet thick in the valley.

Along the pipeline corridor, the surface material at the valley floor consists of Willamette Silt and recent floodplain deposits. The Willamette silt has moderate plasticity (capable of being deformed permanently without rupture) and is loose to medium dense. Up to 60 feet of organic clay flood deposits are present in Wapato Lake valley (Schlicker and Deacon, 1967).

1.1.3 Soils

The most extensive soils along the proposed pipeline routes and the characteristics of those soils are summarized in Table 1-1. Information was derived from the SCS soil reports for Washington and Yamhill counties.

Soils along the proposed pipeline route along the valley floor include primarily deep silt loam and silty clay loam with relatively gentle slopes (0 to 12 percent). Steeper slopes (12 to 45 percent) are present in the adjacent uplands and in surface drainage channels traversing the lowlands.



TABLE 1-1

Description of Soil Characteristics for Soil Units in Pipeline Project Area

Unit	Soil Type	Occurrence	Parent Material	Depth	Subsoil Texture	Permeability /Drainage	High Water Table	Percent Slope	Erosion Hazard
Am, 2	Amity silt loam	Broad terraces	Stratified glaciolacustrine deposits	Very deep	Silty clay loam	Moderately slow / Somewhat poorly drained	0.5 to 1.5 feet bgs ¹ from November to May	0 – 2	Slight
CaB, CaC	Carlton silt loam	Low terraces and foot slopes	Mixed old alluvium and colluvium		Silty clay loam and silty clay	Moderately slow / Moderately well drained	Perched at 2 to 2.5 feet bgs from December to April	CaB 0 – 7 CaC 0 - 12	Slight Moderate
CeC	Chehalem silty clay loam	Alluvial fans	Alluvium	Very deep	Silty clay and silty clay loam	Slow / Somewhat poorly drained	Perched at 1.5 to 3 feet bgs from December to April	3 - 12	Slight to moderate
19B, 19C, 19D, 19E	Helvetia silt loam	Old terraces	Old alluvium of mixed origin	Very deep	Silty clay, silty clay loam	Moderately slow / Moderately well drained	Perched at 3 to 6 feet bgs from December to March	19B 2 – 7 19C 7 – 12 19D 12 – 20 19E 20 - 30	Slight Moderate Moderate Severe
30	McBee silty clay loam	Flat depressed terraces some distance from large streams; in flat floodplain areas adjacent to small streams.	Alluvium weathered from sedimentary and basic igneous rock	Very deep	Silty clay loam, clay loam	Moderate / Moderately well drained	2 to 3 feet bgs from November to April	0 – 3	Slight. Frequent flooding. High hazard of streambank erosion.
37A, 37B	Quatama loam	Gently sloping low terraces.	Stratified glaciolacustrine deposits.	Deep	Loam, clay loam.	Moderately slow / Moderately well drained	2 to 3 feet bgs from December to April	37A 0 – 3 37B 3 - 7	Slight Slight
Wc	Wapato	Floodplains and	Moderately fine	Very deep	Silty clay	Moderately	1 foot above	0 - 3	Slight

TABLE 1-1
Description of Soil Characteristics for Soil Units in Pipeline Project Area

Unit	Soil Type	Occurrence	Parent Material	Depth	Subsoil Texture	Permeability /Drainage	High Water Table	Percent Slope	Erosion Hazard
	silty clay loam	basin areas. Low-lying areas along streams.	textured recent alluvium.		loam, silty clay	slow / Poorly drained	surface to 1 foot bgs from November to May		Subject to short periods of overflow and ponding.
WeC, WeD, WeE, WeF	Willakenzie silty clay loam	Low hills and foothills.	Colluvium and residuum derived from sandstone and tuffaceous materials.	Moderately deep 20 to 40 inches thick and underlain by sedimentary rock.	Silty clay loam, loam	Moderately slow / Well drained		WeC 2 – 12 WeD 12 – 20 WeE 20 – 30 WeF 30 - 45	Moderate Severe Severe Severe
WkD	Willakenzie silty clay loam	Similar to WeD		Moderately shallow				7 - 20	Severe
44A, WIA, 44B, WIC	Willamette silt loam	Low, broad valley terraces.	Stratified glaciolacustrine deposits. Old alluvium.	Very deep	Sil loam, silty clay loam.	Moderate / Well drained		WIA, 44A 0 – 3 WIC, 44B 3 - 12	Slight Slight to moderate
45A, 45B, WuB, 45C, WuC	Woodburn silt loam	Low, broad valley terraces.	Stratified glaciolacustrine deposits. Old alluvium.	Deep	Sil loam, silty clay loam.	Slow / Moderately well drained	Perched at 2 to 3 feet bgs from December to April	WuB, 45A 0 – 3 WuB, 45B 3 – 7 WuC, 45C 7 - 12	Slight Slight Slight to moderate

1 Below ground surface (bgs).

Minor soils along the pipeline route include Aloha silt loam, Briedwell silt loam, Cascade silt loam, Cornelius and Kinton silt loams, Cove silty clay loam, Hazelair silty clay loam, Huberly silt loam, Laurelwood silt loam, Melbourne silty clay loam, Newberg silt loam, Saum silt loam, and Terrace escarpments.

1.2 Seismicity for Pipeline Alternative

This section provides information on the seismicity of the project area by identifying the seismic hazard zone and by determining the overall relative earthquake ground motion-shaking hazard for the pipeline corridor. This information is based on USGS seismic hazard reports and published geologic literature relating to regional seismic hazards.

1.2.1 Regional Seismic Hazards

The seismic hazards in the Project area result from three seismic sources: interplate events, intraslab events, and crustal events (Geomatrix, 1995). Each of these events has different causes, and therefore, produces earthquakes with different characteristics (peak ground accelerations, response spectra, and duration of strong shaking).

Two of the potential seismic sources, interplate and intraslab events, are related to the subduction of the Juan De Fuca plate beneath the North American plate. Interplate events occur as a result of movement at the interface of these two tectonic plates. Intraslab events originate in the subducting tectonic plate, away from its edges, when built-up stresses in the subducting plate are released. These source mechanisms are referred to as the Cascadia Subduction Zone (CSZ) source mechanism. The CSZ originates off the coast of Oregon and Washington and subducts beneath both states. The two source mechanisms associated with the CSZ are currently thought to be capable of producing moment magnitudes of approximately 9.0 and 7.5, respectively (Geomatrix, 1995).

Geologic evidence suggests interplate earthquakes have occurred at the CSZ in the past, with the most recent event a magnitude 9 (M9) earthquake occurring about 300 years ago (Yamaguchi and others, 1997). These earthquakes occur on average every 500 to 540 years with a recurrence interval ranging from 100 to 1,000 years Atwater and others (1997). The largest recent intraslab earthquakes in the Pacific Northwest occurred in the Puget Sound area in 2001 (M6.8), 1965 (M6.5), and in 1949 (M7.1).

Earthquakes caused by movements along crustal faults, generally in the upper 25 kilometers, result in the third source mechanism. These faults may or may not be visible at the surface. In Oregon, movements occur on the crust of the North America tectonic plate when built-up stresses near the surface are released. This source is capable of producing moment magnitudes of approximately 7 but occur infrequently. Historically, earthquakes in the northern Willamette Valley have been along crustal faults (Wong and Bott, 1995), such as the Scotts Mills M5.6 earthquake that occurred in 1993.

1.2.2 Historical Seismicity

To provide background on the magnitude and location of earthquakes in the vicinity of the Project site, three earthquake databases managed by the United States Geological Survey (USGS) National Earthquake Information Center were searched to identify historical seismic events that have occurred within 100 kilometers (62 miles) of the proposed pipeline route.

The search was performed using approximate coordinates at midpoint of the proposed pipeline (latitude 45.382N, longitude 123.905W). The databases searched were "USGS/NEIC 1973-Present," "Significant US Earthquakes (1568-1989)," and "Mountain States of US, 1534-1986." These searches identified 273 seismic events of all magnitudes and intensities that occurred between 1846 and 2003. Table 1-2 identifies only those seismic events that meet the following criteria:

- Magnitude and/or intensity data are available
- If magnitude data are available, the magnitude of the event is 3.0 or higher
- If only intensity data are available, the intensity using the Modified Mercali (MM) Intensity Scale of the event is III or higher, or the event was actually "felt." For reference, and intensity of MM III is associated with shaking that is "felt indoors by several... Sometimes not recognized to be an earthquake at first" (USGS, 2003). In comparison, an event with an intensity of MM VII would produce the following effects, "Damage negligible in buildings of good design and construction, slight to moderate in well-built ordinary buildings, considerable in poorly built or badly designed buildings (USGS, 2003)."
- The seismic event was not an aftershock associated with a larger quake at the same location.

TABLE 1-2
Historical Seismic Events That Have Occurred Within 100 Kilometers of the Project Site¹

Year	Month	Day	Latitude	Longitude	Magnitude ²	Intensity ³	Depth (km)	Distance from Project Site (km)
1869	6	27	46.2	-123.6		F		99
1877	10	12	45.5	-122.7		VII		33
1877	10	12	45.7	-121.9		F		99
1877	10	12	45.75	-122.5		VIII		61
1877	11	30	45.5	-122.7		III		33
1879			45.5	-122.7		IV		33
1882	5	1	45.5	-122.7		III		33
1882	5	1	45.5	-122.7		IV		33
1883	9	29	45.5	-122.7		IV		33
1884	1	4	45.5	-122.7		III		33
1885	10	10	45.5	-122.7		III		33
1891	9	17	44.9	-123		IV		54
1892	2	4	45.5	-122.7	5	VF		33
1892	3		46	-122.8		F		72
1892	11		45.4	-122.6		F		38
1896	4	2	45.2	-123.2	5	VF		21
1897	12	7	45.5	-123.2		III		15

TABLE 1-2

Historical Seismic Events That Have Occurred Within 100 Kilometers of the Project Site¹

Year	Month	Day	Latitude	Longitude	Magnitude ²	Intensity ³	Depth (km)	Distance from Project Site (km)
1898	2	22	45.5	-122.7		III		33
1898	2	22	45.5	-122.7		IV		33
1900	9	28	45.9	-122.8		F		61
1902	12	18	44.8	-122.5		III		79
1904	6	16	45.5	-122.7		F		33
1904	6	16	45.5	-122.7		IV		33
1907	5	27	45.5	-122.6		III		40
1909	12	31	45.5	-122.7		IV		33
1910	2	8	45.5	-122.7		F		33
1910	2	16	45.5	-122.7		IV		33
1914	3	22	45.5	-122.7		IV		33
1914	9	5	45.5	-122.7		III		33
1915	5	19	45.5	-122.7		V		33
1915	11	18	45.8	-122.7		IV		55
1918	2	13	45.5	-122.7		III		33
1919	12	26	45.5	-122.2		IV		71
1920	11	9	45.5	-122.7		IV		33
1921	3	4	45.5	-122.7		IV		33
1921	9	22	45.5	-122.7		IV		33
1922	3	27	45.5	-122.7		IV		33
1922	5	15	45.5	-122.7		IV		33
1922	7	5	45.8	-122		III		97
1930	7	8	45	-123.2		III		43
1930	7	19	45	-123.2		V		43
1930	7	19	45	-123.2		VIF		43
1932	1	14	45.5	-122.7		IV		33
1933	11	23	45.5	-122.7		III		33
1937	12	14	44.9	-123.4		IV		58
1938	1	3	46	-122.6		F		78
1939	2	14	45.5	-123.8		IV		56
1939	4	13	45.5	-122.7		III		33
1939	11	15	45.5	-122.7		III		33
1941	7	26	45.4	-122.8		IV		23
1941	12	29	45.5	-122.7		VIF		33
1941	12	29	45.6	-122.7		VI		39
1942	5	13	44.6	-123.3		V		88
1942	11	1	45.5	-122.7		V		33
1944	3	5	44.9	-123.3		III		55
1944	3	5	44.9	-123.3		V		55
1948	3	1	45.7	-123.2		IV		36
1951	3	25	45.5	-122.7		II		33
1953	12	16	45.5	-122.7	5	VIF		33
1954	4	23	45.5	-122.7		IV		33
1956	5	18	45	-124	3.7	....		82
1956	12	15	46.1	-122.8		IV		83
1957	11	16	45.3	-123.8	5	....		56
1957	11	17	45.3	-123.8	4	VIF		56
1957	11	17	45.8	-124.2	3.6	....		97
1957	11	29	45.5	-122.7		III		33

TABLE 1-2

Historical Seismic Events That Have Occurred Within 100 Kilometers of the Project Site¹

Year	Month	Day	Latitude	Longitude	Magnitude ²	Intensity ³	Depth (km)	Distance from Project Site (km)
1958	3	13	45.5	-122.7		II		33
1958	5	7	45.1	-122	3.4	....		91
1958	5	7	45.1	-122		III		91
1958	11	18	45.5	-122.4		III		55
1959	8	4	45.6	-122.6		V		45
1959	8	4	45.68	-122.27	4.7	VF		72
1959	8	4	45.7	-122.3		V		71
1960	3	5	45.63	-122.67	3.5	....		43
1961	1	4	45.8	-122.9		IV		48
1961	1	4	46	-122.2		IV		97
1961	1	6	46	-122.2		F		97
1961	8	19	44.7	-122.5	4.5	VIF	33	89
1961	9	16	46	-122.2	4.3	....		97
1961	9	16	46	-122.2		F		97
1961	9	16	46	-122.2		V		97
1961	9	16	46	-122.2		VI		97
1961	9	17	46	-122.2	5	....		97
1961	9	17	46	-122.2		F		97
1961	9	17	46	-122.2		VI		97
1961	11	7	45.5	-122.7		V		33
1961	11	7	45.6	-122.6		VI	33	45
1961	11	7	45.7	-122.9	5	....		38
1961	11	7	45.7	-122.4	4.9	....	33	64
1961	11	7	45.7	-122.4	4.5	VIF	33	64
1961	11	29	45.5	-122.7		IV		33
1961	12	15	45.8	-122.9		III		48
1961	12	16	45.6	-122.6		F		45
1962	11	6	45.6	-122.7		F		39
1962	11	6	45.6	-122.7		VI		39
1962	11	6	45.64	-122.59	5.2	VIIIF	16	49
1962	11	6	45.8	-122.5	4.75	VI	44	65
1962	11	6	45.9	-122.7		F		65
1963	3	2	45.6	-122.6		IV		45
1963	3	7	44.88	-122.74	4.6	VF		62
1963	3	7	44.9	-123.5		III	33	62
1963	3	7	44.9	-123.5	4.6	V	33	62
1963	12	27	45.7	-123.4	4.5	VIF	33	42
1964	1	26	46.01	-122.4		V	33	88
1964	1	26	46.1	-122.4	4.3	....		96
1964	1	26	46.1	-122.4		V		96
1964	10	1	45.7	-122.8	5.3	V	33	42
1964	10	1	45.8	-122.7	3.5	....	39	55
1964	10	12	45.7	-122.8	4.3	....		42
1968	1	27	45.7	-122.8		IV	37	42
1968	1	27	45.72	-122.7	3.5	....	37	48
1969	3	5	45.7	-122.8	3.5	....		42
1972	11	17	45.87	-122.63	3.08	....		65
1974	7	29	45.9	-122.6	3.6	....		69
1974	7	29	45.9	-122.6	3	IV		69

TABLE 1-2

Historical Seismic Events That Have Occurred Within 100 Kilometers of the Project Site¹

Year	Month	Day	Latitude	Longitude	Magnitude ²	Intensity ³	Depth (km)	Distance from Project Site (km)
1977	10	7	45.95	-122.25	4.11	....		90
1979	7	31	46.21	-122.77	3.65	....		95
1980	3	25	46.16	-122.46	4.2	....	4	99
1980	4	12	46.27	-122.96	3.8	....	1	98
1980	4	16	45.79	-122.89	4	....	4	48
1980	4	29	45.83	-122.12	4.1	....	2	90
1980	5	1	46.17	-122.92	4.2	....	3	88
1980	5	5	46.02	-122.35	4.4	....	1	91
1980	5	11	46.08	-123.03	4	....	12	77
1980	5	18	46.15	-122.75	4.3	....	0	89
1981	11	8	45.6	-122.49	2.4	F	7	53
1982	11	21	45.9	-122.89	2.5	F	22	59
1982	11	21	45.9	-122.89	2.5	F	22	60
1983	5	11	45.65	-122.83	2.6	F	0	36
1984	6	4	46.21	-123	3.5	F	51	92
1984	6	4	46.21	-123.06	3.7	IV	53	92
1984	12	11	45.47	-122.83	2.5	F	22	22
1985	11	22	45.12	-122.6	3	....	23	48
1986	3	11	45.94	-122.41	3.1	V	15	81
1986	3	11	45.94	-122.42	3.1	VF	15	81
1987	10	2	45.63	-122.65	3	IVF	5	43
1989	8	1	45.61	-122.46	3.9	VF	14	55
1990	4	6	45.47	-123.55	3.2	IIIF	43	36
1990	6	18	45.99	-123.59	3	....	20	77
1991	3	5	45.79	-122.68	3.1	IVF	20	55
1991	7	22	45.64	-122.87	2.2	F	17	33
1991	7	22	45.64	-122.87	3.5	IVF	19	33
1991	10	18	45.63	-122.9	3.1	F	20	31
1991	10	18	45.63	-122.86	2.8	F	18	33
1991	10	21	45.63	-122.89	3	IIIF	20	32
1992	3	15	46.22	-123.25	3.1	IIIF	28	93
1993	3	25	45.03	-122.6	3	F	19	55
1993	3	25	45.03	-122.61	3.2	IVF	14	54
1993	3	25	45.03	-122.61	5.7	VIIC.G S	20	54
1993	3	26	45.04	-122.62	3	....	14	53
1993	3	26	45.05	-122.63	3.1	IVF	21	51
1993	4	6	45.06	-122.65	2.2	F	4	49
1993	6	2	45.04	-122.61	2.8	IIIF	11	53
1993	6	8	45.03	-122.6	3.7	IVF	20	55
1993	7	15	45.1	-122.5	2.7	IIIF	20	56
1993	8	28	45.05	-122.63	2.9	IVF	15	51
1994	4	30	45.04	-122.61	2.8	IVF	22	53
1995	2	8	45.13	-122.71	3.7	VF	31	41
1995	2	13	45.56	-122.88	2.2	F	22	25
1995	3	13	44.63	-122.77	2.7	IIIF	21	86
1995	4	2	45.92	-122.98	2.6	F	24	60
1995	6	13	45.92	-122.98	3	IVF	25	60
1995	6	29	45.03	-122.6	2.4	IVF	17	54
2003	4	24	45.64	-122.76	3.9	IVF	16	38

TABLE 1-2

Historical Seismic Events That Have Occurred Within 100 Kilometers of the Project Site¹

Year	Month	Day	Latitude	Longitude	Magnitude ²	Intensity ³	Depth (km)	Distance from Project Site (km)
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Source: <http://neic.usgs.gov/neis/epic/epic.html>

¹The approximate center of the project site (pipeline) is located at latitude 45.382N, longitude 123.905W.

²Magnitude values calculated by the US Geological Survey.

³Maximum intensity on the Modified Mercalli Intensity Scale of 1931. F = "felt."

1.2.3 Project Area Seismic Hazards

Several northwest-trending faults are present along the flanks of the Coast Range in the creek valleys (Gales Creek, Carpenter Creek, and Scoggins Creek) and across the Tualatin Valley west of Gaston (Schlicker and others, 1967). There are three substantial northwest-trending faults in the project vicinity: the Gales Creek fault, the Newberg fault, and the Mount Angel fault. Fault locations are shown in Figure 1-2. These high angle (70°) faults extend in series from the town of Gales Creek northwest of the project area, southeast across the project area through the city of Newberg, and southeast of the project area to Mount Angel. Two alternative models appear in the literature that consider the faults to be either three separate faults or one interconnected fault zone. The distinction is relevant regarding the seismic hazard potential for the project area because the Mount Angel fault has been associated with recent seismic activity – the 1993 Scotts Mills M5.6 earthquake.

Recent investigations by the USGS support the model that the faults comprise a 90-km-long structural zone (the Gales Creek-Mount Angel fault zone). As part of the Pacific Northwest Urban Corridor Geologic Mapping and Urban Hazard Project, the US Geological Survey (USGS) conducted a series of aeromagnetic surveys in the Willamette Valley region. The data suggest that a left-stepping compressive bend near Newberg may kinematically link the Gales Creek and Mount Angel faults (Blakely and others, 2000). According to the USGS, the Scotts Mills earthquake occurred on a restraining bend in the Mount Angel-Gales Creek fault zone and may not be typical of faults that could occur along the zone (USGS, 2000). However, they also indicate that no geologic evidence presently exists to conclude the fault has or could slip across its entire length. According to the USGS, unequivocal evidence of Quaternary activity on the Gales Creek fault has not been found (R. Wells communication, April 2003).

The Sherwood fault is an east-northeast-trending fault located at Newberg between Parrett Mountain and the Chehalem Mountains. There is no evidence for Holocene (0.01 Ma to present) activity at this fault (Geomatrix, 1995). Blakely and others (2000) suggest, based on magnetic data, that the Sherwood fault may accommodate clockwise rotation of small crustal plates.

1.2.4 Earthquake Risk and Probability

In their probabilistic hazard model, Geomatrix (1995) assigned a higher weight to the separate fault alternative based on changes in behavior along the zone. Under this model, Geomatrix assigned a relatively low probability of activity (20 percent) to the Newberg and Gales Creek faults because there is no evidence of Quaternary seismic activity along these faults. The Mount Angel fault was assigned a 60 percent probability of activity because of its association with recent seismicity.

When modeled as a single continuous fault zone, Geomatrix assigned a 50 percent probability of activity, whereas Wong and others (2000) assigned a 70 percent probability in their probabilistic model for the Portland Metropolitan area. The USGS estimates long term Cenozoic (65 Ma to present) slip rates along the fault up to 0.35 mm/yr (R. Wells communication, April 2003).

Seismic ground acceleration data for the Project site was obtained from the USGS National Seismic Hazard Mapping Project database. One of the values generally used to determine an earthquake's relation to building damage is peak ground acceleration (PGA). According to the USGS, a PGA of 0.10 g (g equals the acceleration as a result of gravity) may be the approximate threshold of damage to older (pre-1965) dwellings or dwellings not made to resist earthquakes. In comparison, some post-1985 dwellings, built to California earthquake standards, have experienced sever shaking (0.60 g) with only chimney damage and damage to dwelling contents.

The PGA at the site corresponding to a 10 percent probability of exceedance in 50 years (approximately 500-year return period) for the study area is 0.18g (USGS, 2003). This value of PGA on rock is an average representation of the acceleration most likely to occur at the site for all seismic events (crustal, intraplate, or subduction) for the 500-year return period.

The USGS database also provides deaggregation information for selected geographic coordinates. The deaggregation information defines the mean magnitude and the mean epicentral distance associated with the return period for a given location. For a 500-year recurrence interval the mean moment magnitude is $M_{7.4}$ at a mean distance of 43 km with an associated PGA of 0.19 g (USGS, 1996).

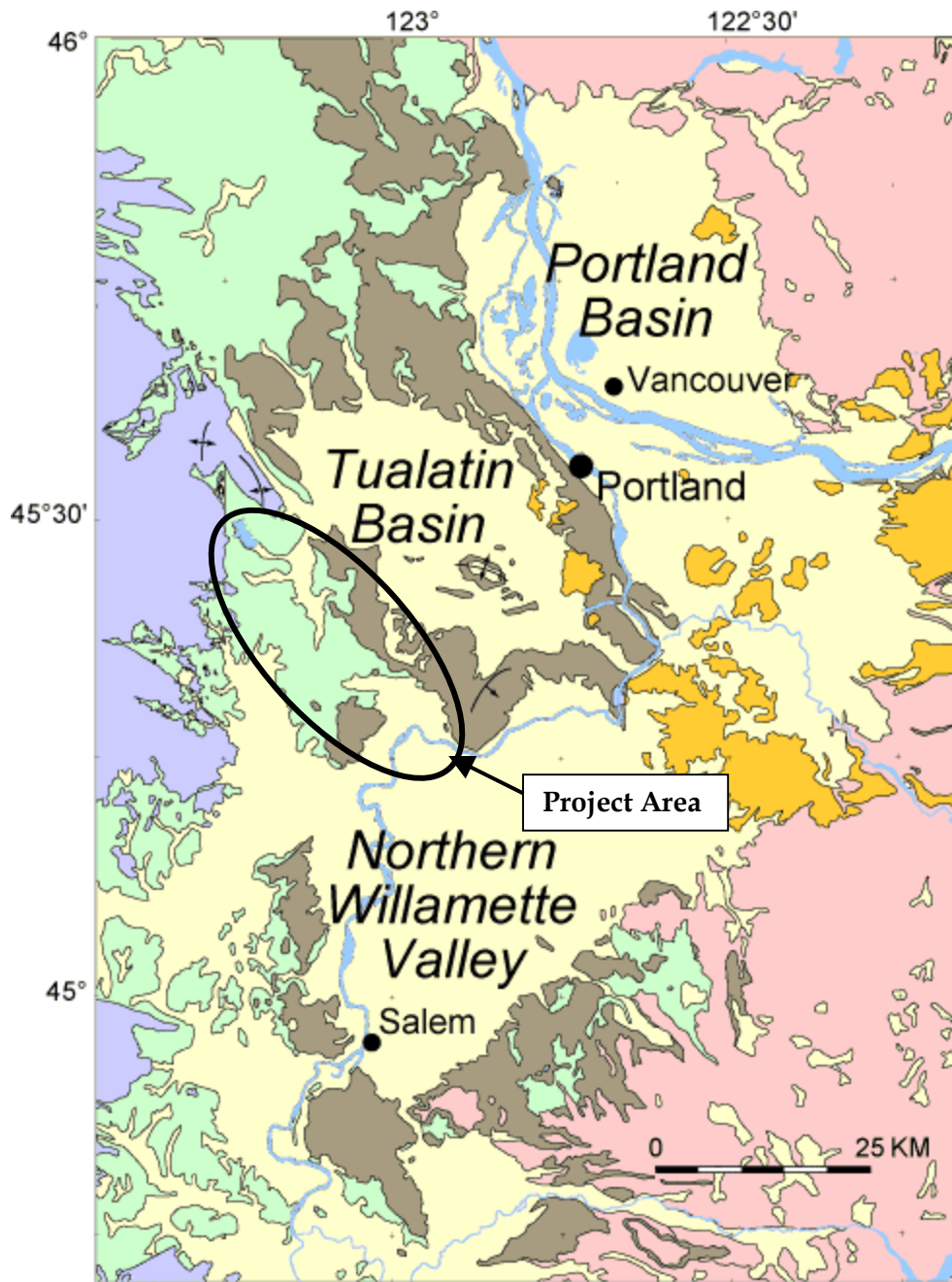
The maximum moment magnitude of a 500-year return period crustal event is predicted to be 6.0 to 6.8 for the study area (Geomatrix, 1995).

Seismic Hazard Zone

According to the Seismic Zone Map of Oregon (OSSC, 1998), the project area and much of western Oregon is located in seismic zone 3. This corresponds to an intensity VIII earthquake of the Modified Mercalli (MM) Scale, which can produce considerable damage should one occur.

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- Alluvial deposits (Quaternary)
- Boring Lava (Pleistocene)
- Columbia River Basalt (Miocene)
- Western Cascades volcanic rocks (Pliocene-Eocene)
- Marine sedimentary rocks (Miocene-Eocene)
- Basaltic basement (Eocene)

Figure 1-1. Geology of Project Area. Modified from USGS <http://wrgis.wr.usgs.gov/wgmt/pacnw/resfzno.html>.

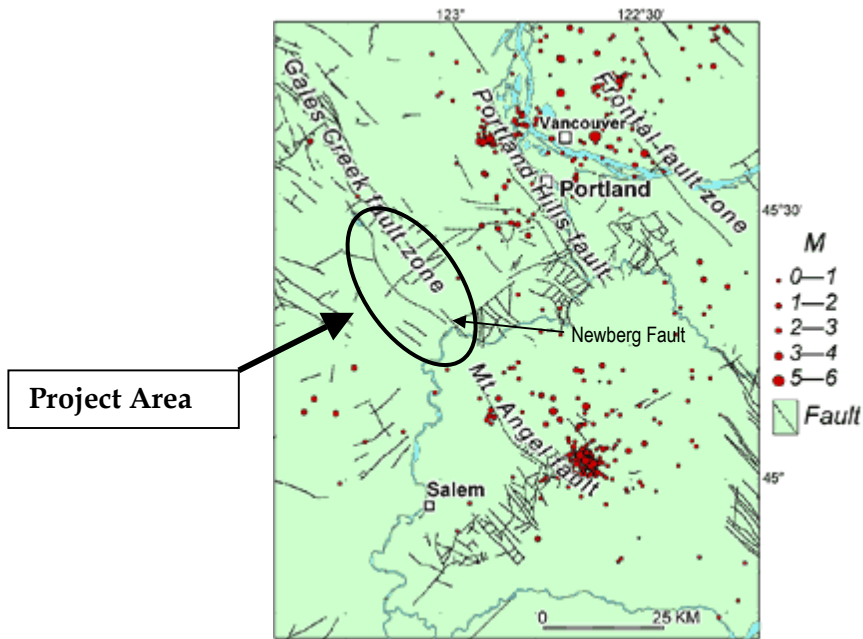


Figure 1-2: Northwest Willamette Valley Faults and Earthquakes
 From <http://wrgis.wr.usgs.gov/wgmt/pacnw/resaq.html>