9.1 Risk Assessment

9.1.16 Statewide Loss Estimates: Seismic Lifelines Evaluation, Vulnerability Synthesis, and Identification

Oregon Seismic Lifelines Identification Project

Seismic Lifelines Evaluation, Vulnerability Synthesis, and Identification

Prepared for

Oregon Department of Transportation

May 15, 2012

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Abbreviations

CSZ	Cascadia Subduction Zone
DOGAMI	Department of Geology and Mineral Industries
DTM	digital terrain model
GIS	geographic information system
I	Interstate
LiDAR	light detection and ranging
MPO	Metropolitan Planning Organization
Mw	moment magnitude
ODOT	Oregon Department of Transportation
OR	Oregon Route
OSLR	Oregon Seismic Lifeline Routes
PGA	peak ground acceleration
PMT	Project Management Team, also referred to as the "technical team"
PUC	Public Utility Commission
REDARS2	Risks from Earthquake Damage to Roadway Systems 2 (software program)
SC	Steering Committee
TDD	Transportation Development Division
US	United States Highway
USGS	United States Geological Survey

1.0 Introduction

This report documents the process conducted and conclusions reached in the Oregon Seismic Lifelines Route identification (OSLR) project. The purpose of this project is to facilitate implementation of Policy 1E, Lifeline Routes, in the *1999 Oregon Highway Plan*, which states, "It is the policy of the State of Oregon to provide a secure lifeline network of streets, highways, and bridges to facilitate emergency services response and to support rapid economic recovery after a disaster" (Oregon Department of Transportation [ODOT], 2006). This project helps to implement that policy by identifying a specific list of highways and bridges recommended to comprise the seismic lifeline system. Further, this project establishes a three-tiered system of lifeline corridors to help prioritize seismic retrofits on State-owned highways and bridges. The OSLR project was conducted by the ODOT Transportation Development Division (TDD) from September 2011 through April 2012.

This project advances ODOT's commitment to support a secure lifeline network by addressing issues primarily within the right-of-way of existing highway facilities. The intent of the project is to develop a strategy for the state highway system to support emergency response and recovery efforts by providing the best-connecting infrastructure practicable between service providers, incident areas, and essential supply lines to allow emergency service providers to do their jobs with minimum disruption. It is also intended to support community and regional economic recovery after a disaster event.

This report is not an emergency response plan. ODOT participates in emergency response planning statewide as a First Responder for Transportation and Public Works functions and has a formal Emergency Operations Plan, administered in the Maintenance Division, which includes agreements with other emergency service providers statewide.

Chapter 2 of this report describes the evaluation process for selecting lifeline routes, including the corridors that were considered in the evaluation and the overall evaluation framework. Chapter 3 describes the data sources and results for the evaluation of criteria related to connections and capacity. Chapter 4 describes the results of the seismic vulnerability assessment, and Chapter 5 describes the process for weighting and selecting the lifeline routes. Chapter 6 presents the system of tiered lifeline routes. Chapter 7 describes the roles of the two project oversight committees—the Project Management Team (PMT) and the project Steering Committee (SC), as well as ODOT's coordination with other agencies during this process. Chapter 8 provides conclusions and next steps in the process.

2.0 Seismic Lifeline Route Identification Process

ODOT initiated this project by conducting a literature review of emergency routes planned in other states and countries. The review included detailed research on planning processes undertaken in New Zealand; British Columbia, Canada; California; and Chile. The results of this review showed that most emergency routes are planned primarily for evacuation and emergency response purposes, and do not take into account the need for longer-term response and recovery. The full literature review is provided in Appendix A.

The process of evaluating state highways for inclusion in the seismic lifeline network was established and implemented by the PMT. The PMT was composed of project managers and technical specialists from ODOT, along with the consultant team selected by ODOT for this project. More information on the composition of the PMT and the outcomes of formal PMT meetings is provided in Section 7.2. The PMT began by reviewing ODOT's previous efforts to define criteria for selecting lifeline routes (described in Appendix B). The group also reviewed existing emergency plans and guidance documents. The full list of plans and guidance documents reviewed as part of this effort is provided in Chapter 9. Finally, the PMT established the following process for proceeding in the context of the OSLR project:

- Step 1: Determine the specific components of the state highway system that should be studied for inclusion in the seismic lifeline system
- Step 2: Develop an evaluation framework for comparing highways to each other to identify which should be included in the recommended seismic lifeline system
- Step 3: Analyze the set of highways determined in Step 1 by using the evaluation framework established in Step 2
- Step 4: Solicit and incorporate feedback from the SC on the results of the analysis
- Step 5: Use the results of the evaluation framework analysis, other criteria, and guidance from the SC to propose a system of lifeline routes for consideration by the Oregon Transportation Commission

Sections 2.1 and 2.2 elaborate on Steps 1 and 2. Chapters 3 and 4 provide detail on how Step 3 was conducted. Chapter 5 describes the results of Steps 3 through 5.

2.1 Evaluation Corridor Selection

The PMT began by selecting the highways within the state that may be good candidates for lifeline routes. A map of all state highways is provided in Appendix C. The lifeline route candidate routes were selected to increase the efficiency of the OSLR project and to decrease the effort required to analyze the data along each route. The PMT decided not to evaluate any highways east of U.S. Highway (US) 97 because the potential for widespread damage from a seismic event east of the US 97 corridor is very low. State highways west of US 97 were selected for inclusion in the evaluation because they meet one or more of the following characteristics:

- Likely ability to promote safety and survival through connections to major population centers with survival resources
- Current use as a strategic freight and commerce route
- Connection to one or more of the following key destinations of statewide significance:

- Interstate (I)-84 east of Biggs Junction
- US 20 east of Bend
- The California border on I-5
- The California border on US 97
- A crossing of the Columbia River into southwest Washington
- A port on the Columbia or Willamette River
- A port on the coast
- Portland International Airport
- Redmond Municipal Airport

State highways in western Oregon that were not selected for evaluation are considered important to the overall transportation system and local emergency response and recovery. However, for the purposes of this study, they were found not to be good candidates for identification as regional lifeline routes because they do not connect major population centers, do not connect to destinations of statewide significance, or, in downtown Portland, are not considered the primary facilities. More information on the reasons for selection of each highway is included in Appendix D, the memorandum "Initial Corridors for Evaluation." The following highways were selected to be included in the evaluation:

- I-5, Pacific Highway No. 1 (the California state line south of Ashland to the Washington state line in Portland)
- I-84, Columbia River Highway No. 2 (I-5 in Portland to US 97 at Biggs Junction)
- I-205, East Portland Freeway, Highway No. 64 (I-5 in Tualatin to the Washington state line)
- Oregon Route (OR) 217, Beaverton-Tigard Highway No. 144 (OR 26 in Beaverton to I-5 in Tigard)
- I-405, Stadium Freeway Highway No. 61 (I-5 at the south end of the Marquam Bridge to I-5 at the east end of the Fremont Bridge in Portland)
- US 97, Sherman Highway No. 42 (I-84 at Biggs Junction to US 197 at Shaniko Junction)
- US 197, The Dalles-California Highway No. 4 (I-84 at Biggs Junction to US 197 at Shaniko Junction)
- US 97, The Dalles-California Highway No. 4 (US 197 at Shaniko Junction to the California state line south of Klamath Falls)
- US 101, Oregon Coast Highway No. 9 (the Washington state line in Astoria to the California state line south of Brookings)
- US 30, Lower Columbia River Highway No. 2W (92) (I-405 in Portland to US 101 in Astoria)
- US 26, Sunset Highway No. 47 (US 101 at south of Seaside to I-405 in Portland)
- OR 202, Nehalem Highway No. 102 (US 101 in Astoria to OR 103 in Jewell)
- OR 103, Fishhawk Falls Highway No. 103 (OR 202 in Jewell to US 26)
- OR 18, Salmon River Highway No. 39 (US 101 north of Lincoln City to OR 99W east of Dayton)
- OR 22, Willamina-Salem Highway No. 30 (OR 18 near Willamina to OR 99E Business in Salem)
- US 20 and OR 34, Corvallis-Newport Highway No. 33 (US 101 in Newport to Corvallis-Lebanon Highway [OR 34] east of the Willamette River in Corvallis)

- OR 34, Corvallis-Lebanon Highway No. 210 (Corvallis-Newport Highway east of the Willamette River in Corvallis to I-5 south of Albany)
- OR 126, Florence-Eugene Highway No. 62 (US 101 in Florence to Beltline Highway No. 69 in Eugene)
- OR 126 and OR 569, Beltline Highway No. 69 (Florence-Eugene Highway in west Eugene to I-5)
- I-105, Eugene-Springfield Highway No. 227 (OR 99 in downtown Eugene to I-5)
- OR 38, Umpqua Highway No. 45 (US 101 in Reedsport to I-5 at Anlauf south of Cottage Grove)
- OR 42, Coos Bay-Roseburg Highway No. 35 (US 101 south of Coos Bay to I-5 south of Roseburg)
- US 199, Redwood Highway No. 25 (I-5 in Grants Pass to the California state line)
- OR 99W and OR 99, Pacific Highway West No. 1W (91) (I-5 in Tigard to I-5 in Eugene)
- OR 99E, Pacific Highway East No. 1E (81) (US 26 in central eastside Portland to I-5 in Salem)
- OR 99E Business, Salem Highway No. 72 (I-5 in Keizer to I-5 in Salem)
- OR 224, Clackamas Highway No. 171 (OR 99E in Milwaukie to I-205 in Clackamas)
- OR 224, Clackamas Highway No. 171 (I-205 in Clackamas to OR 212 at Rock Creek Junction in Damascus)
- OR 212, Clackamas-Boring Highway No. 174 (OR 224 at Rock Creek Junction in Damascus to US 26 west of Sandy)
- US 26, Mt. Hood Highway No. 26 (OR 212 west of Sandy to Warm Springs Highway east of Government Camp)
- US 26, Warm Springs Highway No. 53 (Mt. Hood Highway east of Government Camp to US 97 in Madras)
- OR 22, North Santiam Highway No. 162 (I-5 in Salem to Santiam Highway at Santiam Junction)
- OR 34, Corvallis-Lebanon Highway No. 210 (I-5 south of Albany to US 20 in Lebanon)
- US 20, Santiam Highway No. 16 (Lebanon to North Santiam Highway at Santiam Junction)
- US 20, Santiam Highway No. 16 (North Santiam Highway at Santiam Junction to McKenzie-Bend Highway in Sisters)
- US 20, McKenzie-Bend Highway No. 17 (Santiam Highway in Sisters to US 97 in Bend)
- OR 34, Corvallis-Lebanon Highway No. 210 (I-5 south of Albany to US 20 in Lebanon)
- US 20, Santiam Highway No. 16 (Lebanon to North Santiam Highway at Santiam Junction)
- OR 58, Willamette Highway No. 18 (I-5 south of Eugene to US 97 north of Chemult)
- OR 62, Crater Lake Highway No. 22 (I-5 in Medford to Lake of the Woods Highway in White City)
- OR 140, Lake of the Woods Highway No. 270 (Crater Lake Highway in White City to Green Springs Highway in Klamath Falls)
- OR 66, Green Springs Highway No. 21 (Lake of the Woods Highway in Klamath Falls to US 97 in Klamath Falls)

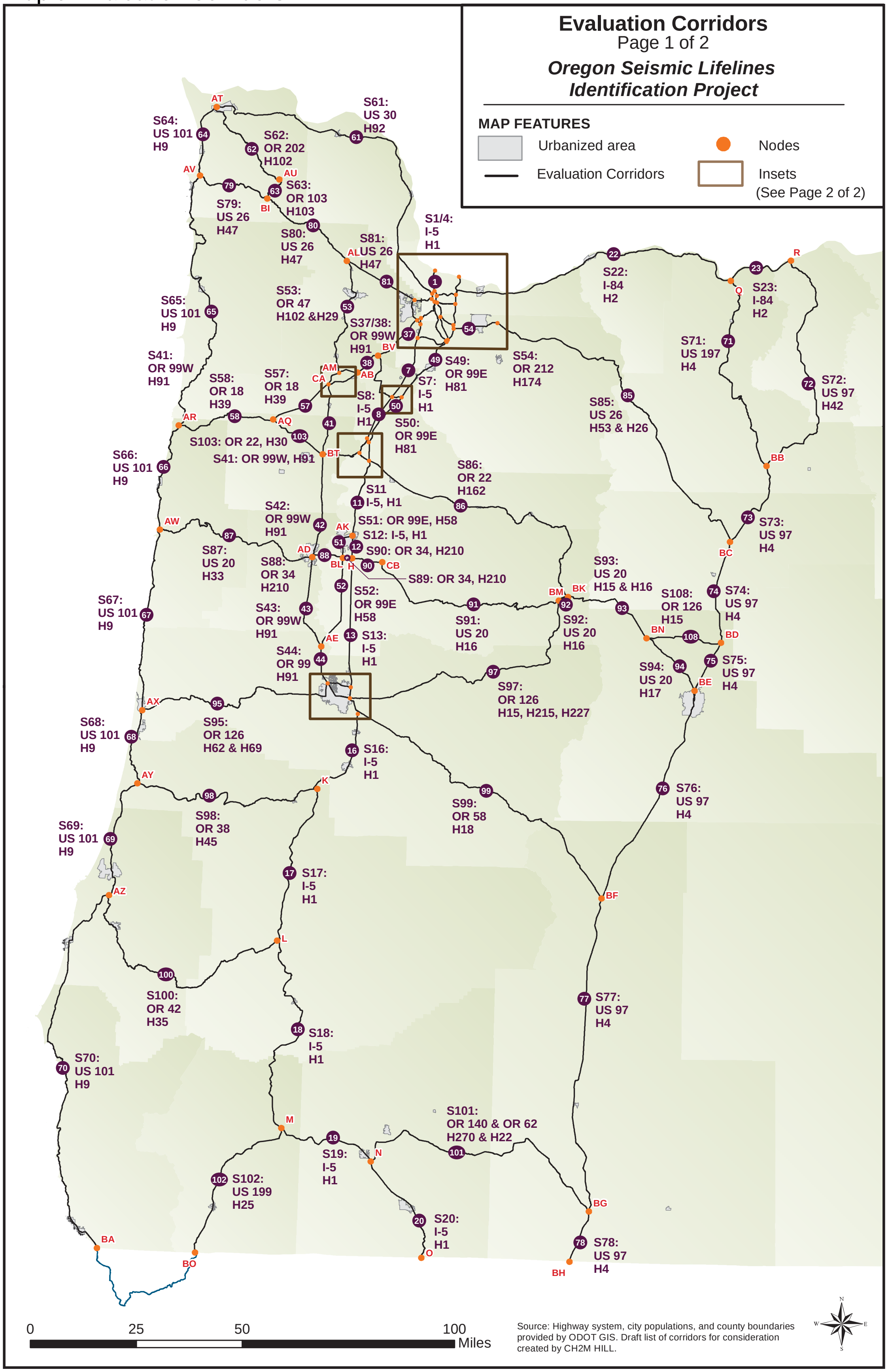
- OR 47, Nehalem Highway No. 102. (US 26 to OR 8 in Forest Grove)
- OR 47, Tualatin Valley Highway No. 29 (OR 8 in Forest Grove to OR 99W near McMinnville)
- OR 219, Hillsboro-Silverton Highway No. 140 (OR 99W in Newberg to I-5 in Woodburn)
- OR 214, Hillsboro-Silverton Highway No. 140 (I-5 to OR 99E in Woodburn)
- US 26, Mt. Hood Highway No. 26 (OR 43 in central Portland to I-205)
- OR 43, Oswego Highway No. 3 (I-5 in downtown Portland to I-205 in Oregon City)
- OR 99E, Albany-Junction City Highway No. 5 (Albany to OR 99W in Junction City)
- OR 126, McKenzie Highway No. 15 (I-5 in Springfield to Highway No. 215 south of Santiam Junction)
- OR 126, Clear Lake – Belknap Springs Highway No. 215 (Highway No. 15 to US 20 west of Santiam Junction)
- OR 126, McKenzie Highway No. 15 (US 20 in Sisters to US 97 in Redmond)

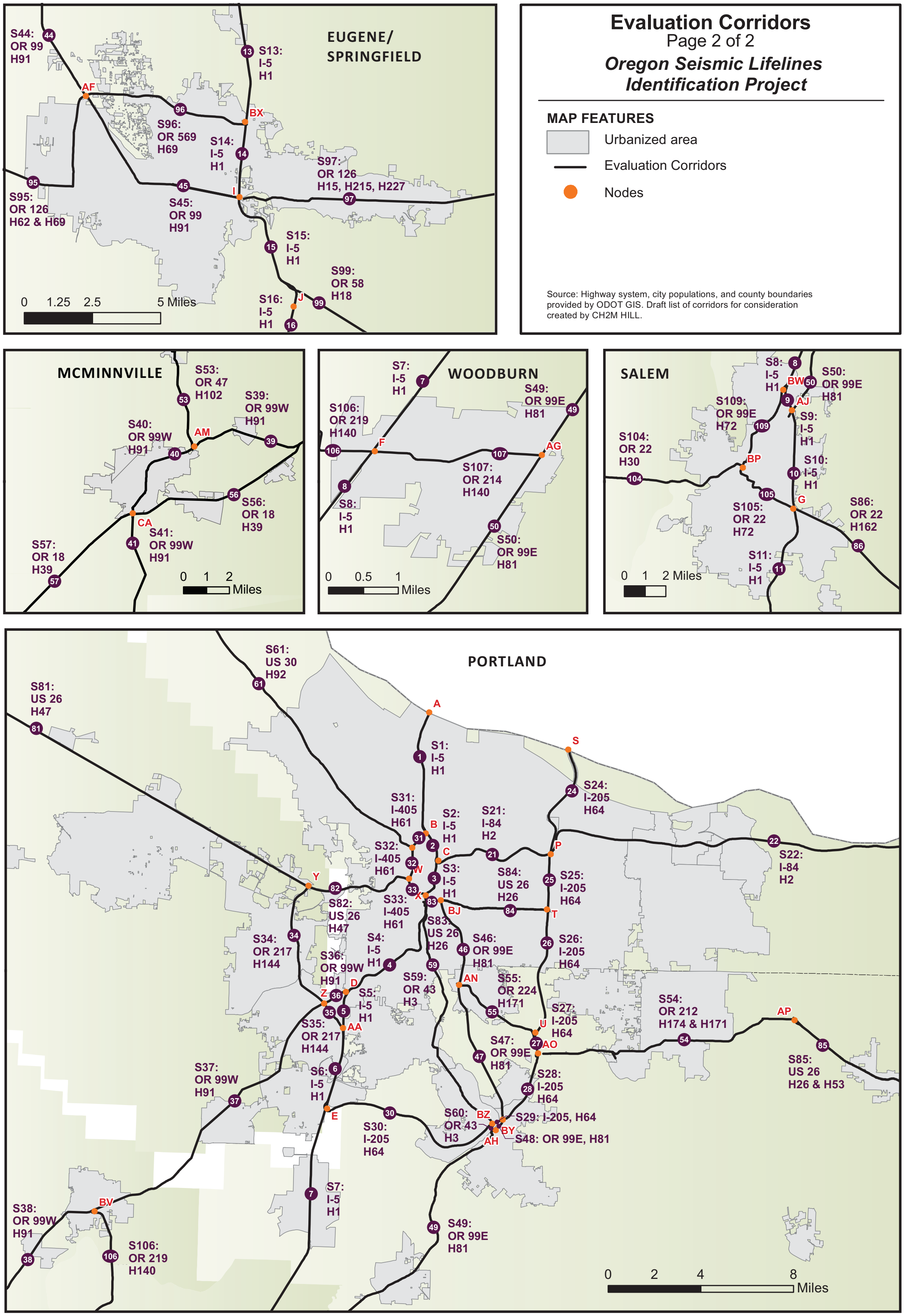
The PMT divided each highway in the above list into a system of “segments” and “nodes” for evaluation. A node is a point at which highways in the above list intersect and a segment is the length of highway between nodes. In addition to being divided into segments, the corridors included in this evaluation were grouped geographically into the following six distinct zones within the western half of the state:

- Coast (US 101 and connections to US 101 from the I-5 corridor)
- Portland Metro (highways within the Portland metro region)
- Valley (circulation between the Portland metro area and other major population centers in the Willamette Valley)
- South I-5 (the section of I-5 south of Eugene/Springfield)
- Cascades (highways crossing the Cascades mountain range)
- Central (the US 97/US 197 corridor from Washington to California)

The division of highways to be evaluated in the OSLR project into segments resulted in a total of 109 segments. Table 2-1 lists each segment in the study and identifies its geographic zone. Figures 2-1 and 2-2 depict the segments and geographic zones visually.

FIGURE 2-1
Map of Evaluation Corridors




Evaluation Corridors
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Oregon Seismic Lifelines Identification Project
MAP FEATURES
Urbanized area
Evaluation Corridors
Nodes
Source: Highway system, city populations, and county boundaries provided by ODOT GIS. Draft list of corridors for consideration created by CH2M HILL.
EUGENE/ SPRINGFIELD
S44: OR 99 H91
S13: I-5 H1
AF
BX
S96: OR 569 H69
S14: I-5 H1
S97: OR 126 H15, H215, H227
S95: OR 126 H62 & H69
S45: OR 99 H91
I
S15: I-5 H1
S99: OR 58 H18
S16: I-5 H1
J
0 1.25 2.5 5 Miles
MCMINNVILLE
S53: OR 47 H102
S39: OR 99W H91
S40: OR 99W H91
AM
S56: OR 18 H39
CA
S41: OR 99W H91
S57: OR 18 H39
0 1 2 Miles
WOODBURN
S7: I-5 H1
S49: OR 99E H81
S106: OR 219 H140
F
AG
S107: OR 214 H140
S8: I-5 H1
S50: OR 99E H81
0 0.5 1 Miles
SALEM
S8: I-5 H1
S50: OR 99E H81
BW
AJ
S109: OR 99E H72
S9: I-5 H1
S104: OR 22 H30
BP
S10: I-5 H1
G
S105: OR 22 H72
S86: OR 22 H162
S11: I-5 H1
0 1 2 Miles
PORTLAND
S61: US 30 H92
S81: US 26 H47
A
S1: I-5 H1
S
S24: I-205 H64
S31: I-405 H61
S2: I-5 H1
S21: I-84 H2
B
C
S32: I-405 H61
P
S22: I-84 H2
S3: I-5 H1
S84: US 26 H26
S25: I-205 H64
W
Y
X
S82: US 26 H47
S33: I-405 H61
BJ
T
S83: US 26 H26
S34: OR 217 H144
S4: I-5 H1
S46: OR 99E H81
S26: I-205 H64
S36: OR 99W H91
D
S59: OR 43 H3
AN
S55: OR 224 H171
S54: OR 212 H174 & H171
Z
S5: I-5 H1
S27: I-205 H64
AP
S35: OR 217 H144
AA
U
AO
S47: OR 99E H81
S85: US 26 H26 & H53
S37: OR 99W H91
S6: I-5 H1
S28: I-205 H64
E
S30: I-205 H64
S60: OR 43 H3
BZ
BY
AH
S29: I-205, H64
S48: OR 99E, H81
S7: I-5 H1
S38: OR 99W H91
BV
S49: OR 99E H81
S106: OR 219 H140
0 2 4 8 Miles

FIGURE 2-2
Map of Geographic Zones

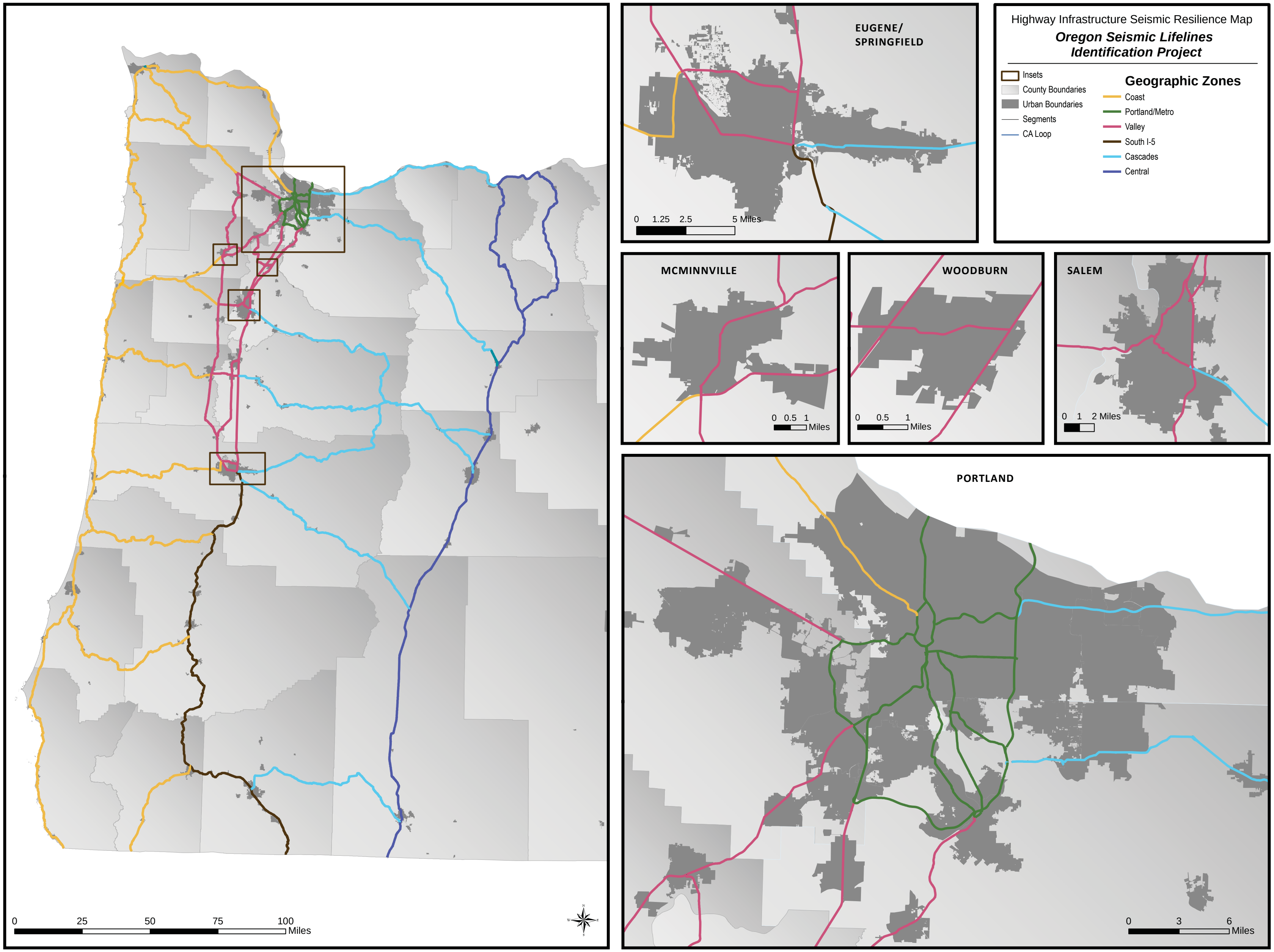


TABLE 2-1
Evaluation Corridors

Segment	Highway	ODOT Highway Number and Name	Node 1	Node 2	Description (Point to Point)	County or Counties	Geographic Zone
1	I-5	1 – Pacific	A	B	Washington border to I-405	Multnomah	Portland Metro
2	I-5	1 – Pacific	B	C	I-405 to I-84	Multnomah	Portland Metro
3	I-5	1 – Pacific	C	X	I-84 to I-405/OR 43/US 26	Multnomah	Portland Metro
4	I-5	1 – Pacific	X	D	I-405/OR 43/US 26 to OR 99W	Multnomah	Portland Metro
5	I-5	1 – Pacific	D	AA	OR 99W to OR 217	Multnomah Clackamas Washington	Portland Metro
6	I-5	1 – Pacific	AA	E	OR 217 to I-205	Washington	Portland Metro
7	I-5	1 – Pacific	E	F	I-205 to OR 214	Washington Clackamas Marion	Valley
8	I-5	1 – Pacific	F	BW	OR 214 to OR 99E Business	Marion	Valley
9	I-5	1 – Pacific	BW	AJ	OR 99E Business to OR 99E	Marion	Valley
10	I-5	1 – Pacific	AJ	G	OR 99E to OR 22	Marion	Valley
11	I-5	1 – Pacific	G	AK	OR 22 to OR 99E	Marion Linn	Valley
12	I-5	1 – Pacific	AK	H	OR 99E to OR 34	Linn	Valley
13	I-5	1 – Pacific	H	BX	OR 34 to OR 569	Linn Lane	Valley
14	I-5	1 – Pacific	BX	I	OR 569 to OR 126/OR 99	Lane	Valley
15	I-5	1 – Pacific	I	J	OR 126 to OR 58	Lane	South I-5
16	I-5	1 – Pacific	J	K	OR 58 to OR 38	Lane Douglas	South I-5
17	I-5	1 – Pacific	K	L	OR 38 to OR 42	Douglas	South I-5
18	I-5	1 – Pacific	L	M	OR 42 to OR 199	Douglas Josephine	South I-5
19	I-5	1 – Pacific	M	N	OR 199 to OR 140	Josephine Jackson	South I-5

TABLE 2-1
Evaluation Corridors

Segment	Highway	ODOT Highway Number and Name	Node 1	Node 2	Description (Point to Point)	County or Counties	Geographic Zone
20	I-5	1 – Pacific	N	O	OR 140 to California border	Jackson	South I-5
21	I-84	2 – Columbia River	C	P	I-5 to I-205	Multnomah	Portland Metro
22	I-84	2 – Columbia River	P	Q	I-205 to US 197	Multnomah Hood River Wasco	Cascades
23	I-84	2 – Columbia River	Q	R	US 197 to US 97	Wasco Sherman	Central
24	I-205	64 – East Portland Freeway	S	P	Washington border to I-84	Multnomah	Portland Metro
25	I-205	64 – East Portland Freeway	P	T	I-84 to US 26	Multnomah	Portland Metro
26	I-205	64 – East Portland Freeway	T	U	US 26 to OR 224	Multnomah Clackamas	Portland Metro
27	I-205	64 – East Portland Freeway	U	AO	OR 224 to OR 212	Clackamas	Portland Metro
28	I-205	64 – East Portland Freeway	AO	BY	OR 212 to OR 99E	Clackamas	Portland Metro
29	I-205	64 – East Portland Freeway	BY	BZ	OR 99E to OR 43	Clackamas	Portland Metro
30	I-205	64 – East Portland Freeway	BZ	E	OR 43 to I-5	Clackamas Washington	Portland Metro
31	I-405	61 – Stadium Freeway	B	V	I-5 to US 30	Multnomah	Portland Metro
32	I-405	61 – Stadium Freeway	V	W	US 30 to US 26	Multnomah	Portland Metro
33	I-405	61 – Stadium Freeway	W	X	US 26 to I-5/OR 43/US 26	Multnomah	Portland Metro
34	OR 217	144 – Beaverton-Tigard	Y	Z	US 26 to OR 99W	Washington	Portland Metro
35	OR 217	144 – Beaverton-Tigard	Z	AA	OR 99W to I-5	Washington	Portland Metro
36	OR 99W	1W (91) – Pacific Highway West	D	Z	I-5 to OR 217	Multnomah Washington	Portland Metro

TABLE 2-1
Evaluation Corridors

Segment	Highway	ODOT Highway Number and Name	Node 1	Node 2	Description (Point to Point)	County or Counties	Geographic Zone
37	OR 99W	1W (91) – Pacific Highway West	Z	BV	OR 217 to OR 219	Washington Yamhill	Valley
38	OR 99W	1W (91) – Pacific Highway West	BV	AB	OR 219 to OR 18	Yamhill	Valley
39	OR 99W	1W (91) – Pacific Highway West	AB	AM	OR 18 to OR 47	Yamhill	Valley
40	OR 99W	1W (91) – Pacific Highway West	AM	CA	OR 47 to OR 18	Yamhill	Valley
41	OR 99W	1W (91) – Pacific Highway West	CA	BT	OR 18 to OR 22	Yamhill Polk	Valley
42	OR 99W	1W (91) – Pacific Highway West	BT	AD	OR 22 to US 20	Polk Benton	Valley
43	OR 99W	1W (91) – Pacific Highway West	AD	AE	US 20 to 99E/99W merge	Benton Lane	Valley
44	OR 99	1W (91) – Pacific Highway West	AE	AF	99E/99W merge to OR 569/126	Lane	Valley
45	OR 99	1W (91) – Pacific Highway West	AF	I	OR 569/126 to I-5	Lane	Valley
46	OR 99E	1E (81) – Pacific Highway East	BJ	AN	US 26 to OR 224	Multnomah Clackamas	Portland Metro
47	OR 99E	1E (81) – Pacific Highway East	AN	BY	OR 224 to I-205	Clackamas	Portland Metro
48	OR 99E	1E (81) – Pacific Highway East	BY	AH	I-205 to OR 43	Clackamas	Portland Metro
49	OR 99E	1E (81) – Pacific Highway East	AH	AG	OR 43 to OR 214	Clackamas Marion	Valley
50	OR 99E	1E (81) – Pacific Highway East	AG	AJ	OR 214 to I-5	Marion	Valley
51	OR 99E	58 – Albany-Junction City	AK	BL	I-5 in Albany to OR 34	Linn	Valley
52	OR 99E	58 – Albany-Junction City	BL	AE	OR 34 to 99E/99W merge	Linn Lane	Valley
53	OR 47	102 and 29 – Nehalem and Tualatin Valley	AL	AM	OR 26 to OR 99W	Washington Yamhill	Valley

TABLE 2-1
Evaluation Corridors

Segment	Highway	ODOT Highway Number and Name	Node 1	Node 2	Description (Point to Point)	County or Counties	Geographic Zone
54	OR 212	171 and 174 – Clackamas and Clackamas-Boring	AO	AP	I-205 to US 26	Clackamas	Cascades
55	OR 224	171 – Clackamas	AN	U	OR 99E to I-205	Clackamas	Portland Metro
56	OR 18	39 – Salmon River	AB	CA	OR 99W to OR 99W	Yamhill	Valley
57	OR 18	39 – Salmon River	CA	AQ	OR 99W to OR 22	Yamhill Polk	Coast
58	OR 18	39 – Salmon River	AQ	AR	OR 22 to US 101	Polk Tillamook Lincoln	Coast
59	OR 43	3 – Oswego	X	BZ	US 26 to I-205	Multnomah Clackamas	Portland Metro
60	OR 43	3 – Oswego	BZ	AH	I-205 to OR 99E	Clackamas	Portland Metro
61	US 30	2W (92) – Lower Columbia River	AT	V	US 101 to I-405	Clatsop Columbia Multnomah	Coast
62	OR 202	102 – Nehalem	AT	AU	US 101 to OR 103	Clatsop	Coast
63	OR 103	103 – Fishhawk Falls	AU	BI	OR 103 to US 26	Clatsop	Coast
64	US 101	9 – Oregon Coast	AT	AV	OR 202 to US 26	Clatsop	Coast
65	US 101	9 – Oregon Coast	AV	AR	US 26 to OR 18	Clatsop Tillamook Lincoln	Coast
66	US 101	9 – Oregon Coast	AR	AW	OR 18 to US 20	Tillamook	Coast
67	US 101	9 – Oregon Coast	AW	AX	US 20 to OR 126	Lincoln Lane	Coast
68	US 101	9 – Oregon Coast	AX	AY	OR 126 to OR 38	Lane Douglas	Coast
69	US 101	9 – Oregon Coast	AY	AZ	OR 38 to OR 42	Douglas Coos	Coast
70	US 101	9 – Oregon Coast	AZ	BA	OR 42 to California border	Coos Curry	Coast
71	US 197	4 – The Dalles-California	Q	BB	I-84 to US 97	Wasco	Central

TABLE 2-1
Evaluation Corridors

Segment	Highway	ODOT Highway Number and Name	Node 1	Node 2	Description (Point to Point)	County or Counties	Geographic Zone
72	US 97	42 – Sherman	R	BB	I-84 to US 197	Sherman Wasco	Central
73	US 97	4 – The Dalles-California	BB	BC	US 197 to US 26	Wasco Jefferson	Central
74	US 97	4 – The Dalles-California	BC	BD	US 26 to OR 126	Jefferson Deschutes	Central
75	US 97	4 – The Dalles-California	BD	BE	OR 126 to US 20	Deschutes	Central
76	US 97	4 – The Dalles-California	BE	BF	US 20 to OR 58	Deschutes Klamath	Central
77	US 97	4 – The Dalles-California	BF	BG	OR 58 to OR 140	Klamath	Central
78	US 97	4 - The Dalles-California	BG	BH	OR 140 to California border	Klamath	Central
79	US 26	47 – Sunset	AV	BI	US 101 to OR 103	Clatsop	Coast
80	US 26	47 – Sunset	BI	AL	OR 103 to OR 47	Clatsop Tillamook Washington	Coast
81	US 26	47 – Sunset	AL	Y	OR 47 to OR 217	Washington	Valley
82	US 26	47 – Sunset	Y	W	OR 217 to I-405	Washington Multnomah	Portland Metro
83	US 26	26 – Mt. Hood	X	BJ	I-5/OR 43/US 26 to OR 99E	Multnomah	Portland Metro
84	US 26	26 – Mt. Hood	BJ	T	OR 99E to I-205	Multnomah	Portland Metro
85	US 26	26 and 53 – Mt. Hood and Warm Springs	AP	BC	OR 212 to US 97	Clackamas Wasco Jefferson	Cascades
86	OR 22	162 – North Santiam	G	BK	I-5 to Santiam Junction	Marion Linn	Cascades
87	US 20	33 – Corvallis-Newport	AW	AD	US 101 to OR 99W	Lincoln Benton	Coast
88	OR 34	210 – Corvallis-Lebanon	AD	BL	OR 99W to OR 99E	Benton Linn	Valley
89	OR 34	210 – Corvallis-Lebanon	BL	H	OR 99E to I-5	Linn	Valley

TABLE 2-1
Evaluation Corridors

Segment	Highway	ODOT Highway Number and Name	Node 1	Node 2	Description (Point to Point)	County or Counties	Geographic Zone
90	OR 34	210 – Corvallis-Lebanon	H	CB	I-5 to US 20	Linn	Cascades
91	US 20	16 – Santiam	CB	BM	OR 34 to OR 126	Linn	Cascades
92	US 20	16 – Santiam	BM	BK	OR 126 to OR 22	Linn	Cascades
93	US 20	16 – Santiam	BK	BN	OR 22 to OR 126	Linn Jefferson Deschutes	Cascades
94	US 20	17 – McKenzie-Bend	BN	BE	OR 126 to US 97	Deschutes	Cascades
95	OR 126	62 and 69 – Florence-Eugene and Beltline	AX	AF	US 101 to OR 99/OR 569	Lane	Coast
96	OR 569	69 – Beltline	AF	BX	OR 99/OR 126 to I-5	Lane	Valley
97	OR 126	15, 215, and 227 – McKenzie and Clear Lake-Belknap Springs	I	BM	I-5 to US 20	Lane Linn	Cascades
98	OR 38	45 – Umpqua	AY	K	US 101 to I-5	Douglas	Coast
99	OR 58	18 – Willamette	J	BF	I-5 to US 97	Lane Klamath	Cascades
100	OR 42	35 – Coos Bay-Roseburg	AZ	L	US 101 to I-5	Coos Douglas	Coast
101	OR 62 and OR 140	22 and 270 – Crater Lake and Lake of the Woods	N	BG	I-5 to US 97	Jackson Klamath	Cascades
102	US 199	25 – Redwood	M	BO	I-5 to California border	Josephine	Coast
103	OR 22	30 – Willamina-Salem	AQ	BT	OR 18 to OR 99W	Polk	Coast
104	OR 22	30 – Willamina-Salem	BT	BP	OR 99W to OR 99E Business	Polk Marion	Valley
105	OR 22	72 – Salem	BP	G	OR 99E Business to I-5	Marion	Valley
106	OR 219	140 – Hillsboro-Silverton	BV	F	OR 99W to I-5	Marion Yamhill	Valley
107	OR 214	140 – Hillsboro-Silverton	F	AG	I-5 to OR 99E	Marion	Valley
108	OR 126	15 – McKenzie	BN	BD	US 20 to US 97	Deschutes	Cascades
109	OR 99E Business	72 – Salem	BW	BP	I-5 to OR 22	Marion	Valley

2.2 Evaluation Methodology

The PMT established an evaluation framework for the OSLR project that consists of the following four main components: goals, objectives, criteria, and parameters. **Goals** are the guiding principles for what the set of lifeline routes is meant to accomplish before, during, and after a seismic event. The three main goals identified for Oregon seismic lifeline routes are:

1. Support survivability and emergency response efforts immediately following the event
2. Provide transportation facilities that are critical to life support functions for an interim period following the event
3. Support statewide economic recovery

The three goals were written to capture the need for seismic lifeline routes during three distinct time periods after a seismic event. Goal 1 is intended to refer to immediate and short-term needs after an event. Goal 2 refers to midterm needs after an event. Goal 3 refers to long-term needs after an event.

Objectives are the specific actions that can be implemented to achieve each goal. Each goal has two or three specific objectives. **Criteria** are categories of measurements for how well each segment can achieve the goal. **Parameters** are the specific measurements for each criterion. Although the objectives for each goal are unique, many of the criteria and parameters apply to more than one objective. Overall, 20 unique criteria are applied in this evaluation framework. Table 2-2 provides the objectives and criteria for each goal. Chapter 3 describes the parameters for each criterion in detail.

TABLE 2-2
Evaluation Framework

Goals	Objectives	Criteria
1. Support survivability and emergency response efforts immediately following the event *(immediate and short-term needs)*	1A: Retain routes necessary to bring emergency responders to emergency locations	· Bridge seismic resilience · Roadway seismic resilience · Dam safety · Roadway width · Route provides critical non-redundant access to a major area · Access to fire stations · Access to hospitals · Access to ports and airports · Access to population centers · Access to ODOT maintenance facilities · Ability to control use of the highway
	1B: Retain routes necessary to (a) transport injured people from the damaged area to hospitals and other critical care facilities and (b) transport emergency response personnel (police, firefighters, and medical responders), equipment, and materials to damaged areas	· Route provides critical non-redundant access to a major area · Bridge seismic resilience · Dam safety · Roadway seismic resilience · Access to hospitals · Access to emergency response staging areas
2. Provide transportation facilities critical to life support for an interim period following the event *(midterm needs)*	2A: Retain the routes critical to bring life support resources (food, water, sanitation, communications, energy, and personnel) to the emergency location	· Access to ports and airports · Bridge seismic resilience after short term repair · Dam safety · Roadway seismic resilience · Access to critical utility components (such as fuel depots and critical communication facilities) · Access to ODOT maintenance facilities · Freight access
	2B: Retain regional routes to hospitals	· Access to hospitals
	2C: Retain evacuation routes out of the affected region	· Access to central Oregon · Access to ports and airports · Importance of route to freight movement

TABLE 2-2
Evaluation Framework

Goals	Objectives	Criteria
3. Support statewide economic recovery *(long-term needs)*	3A: Retain designated critical freight corridors	· Freight access · Bridge seismic resilience after short-term repair · Roadway seismic resilience after short-term repair · Route provides critical non-redundant access to a major area · Access to ports and airports · Access to railroads
	3B: Support statewide mobility for connections outside of the affected region	· Access to central Oregon · Access to ports and airports · Access to railroads
	3C: Retain transportation facilities that allow travel between large metro areas	· Route provides critical non-redundant access to a major area · Connection to centers of commerce

The evaluation framework was developed in close coordination with a technical team consisting of transportation planners, roadway maintenance managers, structural engineers, geotechnical engineers, geologists, and emergency response planners. This team researched available information and engaged in several brainstorming sessions to develop a comprehensive set of criteria by which to evaluate the relative value of different highways to serve state transportation needs after a seismic event. This collaboration resulted in the list of 20 unique criteria identified as part of the evaluation framework in Table 2-2. The seismic vulnerability assessment factors that were evaluated for inclusion in this framework are listed in Chapter 4.

Emergency response considerations included transportation routes for emergency services to reach populated areas after an event and the ability to reach key resources, such as hospitals and fire stations, which may be necessary for survival following an event. The police departments are assumed to have the responsibility of monitoring traffic congestion and providing solutions for effective traffic flow. Local fire departments will define the impact area and evacuate damaged structures. The technical team emergency response planners were responsible for the inclusion of emergency response considerations in the evaluation framework; a memorandum documenting their review of existing emergency planning documents relevant to this planning process is provided in Appendix E.

One key consideration in this planning process was the need to develop a system of interdependent lifelines that provide accessibility to all areas of the state. Although the evaluation framework was used to analyze each segment individually, an equally important part of the process for establishing lifelines was to evaluate the system as a whole. In addition to that, the interdependencies of roadway networks and utility corridors were analyzed for each segment and for the system as a whole. More details on the evaluation of the system as a whole are provided in Chapter 6.

To evaluate the performance of a route for groupings of dissimilar criteria, each segment was given a rating of high, moderate, or low with respect to its performance for each criterion. These high, moderate, and low ratings were developed with respect to an absolute standard or with respect to a grouping of other routes to aid the evaluation of alternatives. After all criteria for each roadway segment were evaluated and given a rating, these ratings were combined to give ratings for each objective and goal, and finally an overall evaluation framework rating for the segment.

In addition to the objectives and criteria evaluated for this project, one additional objective and several additional criteria were initially considered for inclusion in the evaluation framework, but were ultimately removed.

The objective that was removed from the evaluation framework is “1C: Limit the number of injuries and fatalities that might happen from the collapse of facilities.” This goal contained four criteria—bridge resilience, roadway resilience, critical non-redundant access, and safety of vehicles on bridges. This objective was initially proposed to support Goal 1 (Initial Survivability), with the idea that some sort of measure of the risk to the travelling public from highway facility failures should be included in the evaluation and that this would support providing a safer transportation system. While this is a worthy objective, it was eventually decided that this goal was at cross purposes with the overriding purpose of this project, which was to identify roadways that are both most critical for use as transportation facilities after a major seismic event and most-easily made acceptably resilient. Inclusion of this goal would have favored selection of the most-vulnerable roadway segments as lifeline routes, rather than the least vulnerable.

The criteria initially considered, but not included in the final framework, are as follows:

- Roadway Functional Classification: This would have been a measure of the importance of the roadway to the local transportation network, as well as its ability to carry traffic. It was removed because other criteria were better able to measure and isolate the pertinent characteristics.
- Congestion: The concern that this was to address was that heavily congested roadways would not necessarily facilitate rapid emergency response. However, it was assumed that post-earthquake traffic would be difficult to predict and the criterion “Ability to Control Use” would be more meaningful as a measure for the ability of a roadway to be put to a dedicated emergency service use.
- Emergency Access Routes: Rather than looking at roadways identified by existing emergency services plans, we looked only at the roadways identified for inclusion in this study and the locations of critical emergency response facilities (hospitals, emergency response staging areas, etc.).
- Access to Mass Care Facilities: It was found that designated mass care facilities are numerous, are activated locally on an as-needed basis, and are located throughout the state, so they are therefore not useful to differentiate between prospective lifeline corridors.
- Interdependent Lifelines: Since comprehensive and specific information on other lifelines (power generation and distribution, fuel, communications, etc.) was not publicly available, this was replaced with “Access to Critical Utilities.”
- Feasibility of Timely Repair: This was quantified in the criteria “Bridge Seismic Resilience After Short-Term Repair” and “Roadway Seismic Resilience After Short-Term Repair.”

3.0 Criteria Assessment

The criteria in the evaluation framework were grouped into three categories—connections, capacity, and resilience. Criteria within each category are listed in Table 3-1. Sections 3.1 and 3.2 describe the results of the connections and capacity criteria evaluations, respectively. Appendix F provides a complete list of the evaluation results and a map for each criterion. The resilience criteria evaluations and results are described in Chapter 4. All criteria are formulated so that a favorable performance is rated "high" and an unfavorable performance is rated "low;" "moderate" indicates a middle rating. Therefore, for example, the seismic criteria are "resilience" criteria, rather than "vulnerability" criteria, because high resilience is good (whereas high vulnerability is bad and would be opposite of the other criteria).

TABLE 3-1
Criteria by Group

Connections	Capacity	Resilience
· Access to fire stations · Access to hospitals · Access to ports and airports · Access to railroads · Access to ODOT maintenance facilities · Access to population centers · Access to emergency response staging areas · Access to critical utilities · Access to central Oregon	· Width of roadway · Ability to control use of the highway · Freight access	· Bridge seismic resilience · Roadway seismic resilience · Bridge seismic resilience after short-term repair · Roadway seismic resilience after short-term repair

3.1 Connections

The "Connections" category of criteria includes all criteria relating to segment proximity to key resources and geographic areas likely to be essential after a seismic event.

3.1.1 Access to Fire Stations

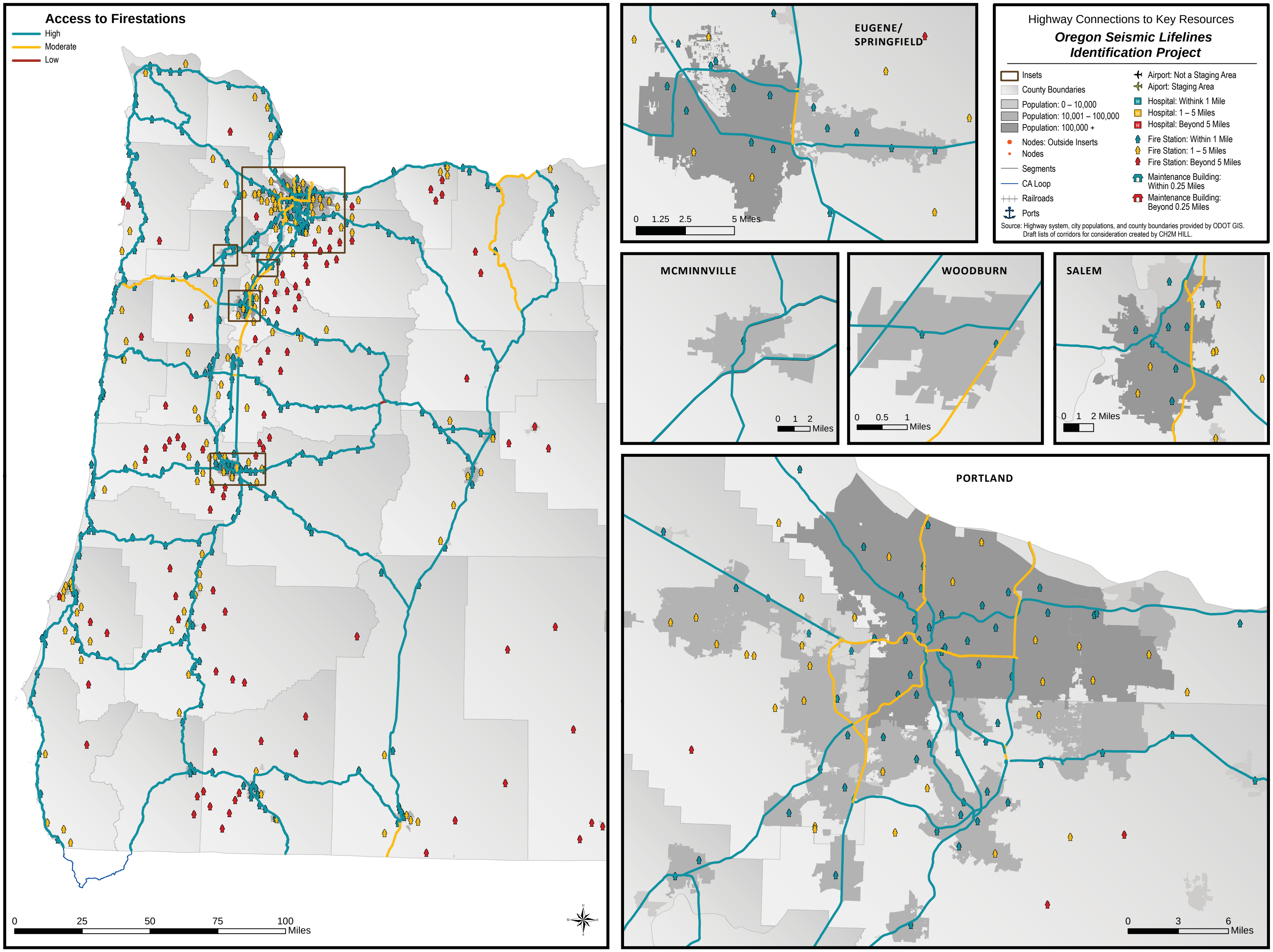
The purpose of this criterion was to evaluate how well each segment provides access to a fire station. The PMT used geographic information system (GIS) technology to evaluate the number of fire stations within 1 mile and 5 miles of each segment. Specifically, the PMT used a subset of the GIS shapefile "public_buildings.shp," which was provided by ODOT GIS department in June 2011 and last updated in 2007. This shapefile includes locations of fire stations, hospitals, schools, and other public facilities. Each segment was rated low, moderate, or high for access to fire stations by using the following parameters:

- Low: No fire stations within 5 miles of the segment
- Moderate: At least one fire station within 5 miles of the segment

- High: At least one fire station within 1 mile of the segment

Fire stations are prevalent in most areas throughout the state, which was reflected in the results of this evaluation. Eighty-two of the 109 corridors rated high for this measure, 26 ranked moderate, and 1 ranked low. Figure 3-1 depicts fire stations within 1 mile and 5 miles of segments, and the ranking of each segment for this criterion.

FIGURE 3-1
Access to Fire Stations



3.1.2 Access to Hospitals

The purpose of this criterion was to evaluate how well each segment provides access to a hospital. The technical team used GIS technology to evaluate the number of hospitals within 1 mile and 5 miles of each evaluation segment. The technical team used a subset of the GIS shapefile "public_buildings.shp," which was provided by ODOT in June 2011 and last updated in 2007. This shapefile includes locations of fire stations, hospitals, schools, and other facilities. According to that database, 46 hospitals are within 5 miles of at least one segment. The hospitals included in Table 3-2are listed by the geographic zones that include a segment that goes to within 5 miles of the hospital, whether or not that hospital is located within that zone.

TABLE 3-2
Hospitals by Geographic Zone within 5 Miles of at Least One Segment

Geographic Zone	Hospitals within 5 Miles of Segments
Coast	Legacy Good Samaritan Hospital
	Legacy Emanuel Hospital
	Columbia Memorial Hospital – Astoria
	Providence Seaside Hospital
	Tillamook County General Hospital
	Willamette Valley Medical Center – McMinnville
	Samaritan North Lincoln Hospital – Lincoln City
	West Valley Community Hospital – Dallas
	Samaritan Pacific Communities Hospital – Newport
	Good Samaritan Regional Medical Center – Corvallis
	Peace Harbor Hospital – Florence
	Sacred Heart Medical Center – Eugene
	Lower Umpqua Hospital – Reedsport
	Bay Area Hospital – Coos Bay
	Southern Coos Hospital – Bandon
	Coquille Valley Hospital
	Three Rivers Community Hospital – Grants Pass
	Curry General Hospital – Gold Beach
Portland Metro	Legacy Good Samaritan Hospital
	Legacy Emanuel Hospital
	Providence Portland Medical Center
	Adventist Medical Center
	Kaiser Sunnyside Medical Center
	Providence Milwaukie Hospital
	Willamette Falls Hospital – Oregon City
	Legacy Meridian Park Hospital
	Providence St. Vincent Hospital
	Oregon Health Sciences University

TABLE 3-2
Hospitals by Geographic Zone within 5 Miles of at Least One Segment

Geographic Zone	Hospitals within 5 Miles of Segments
Valley	Providence St. Vincent Hospital
	Tuality Community Hospital – Hillsboro
	Tuality Community Hospital – Forest Grove
	Providence Newberg Hospital
	Willamette Valley Medical Center – McMinnville
	Legacy Meridian Park Hospital
	Willamette Falls Hospital – Oregon City
	Salem Hospital
	West Valley Community Hospital – Dallas
	Samaritan Albany General Hospital
	Good Samaritan Regional Medical Center – Corvallis
	Sacred Heart Medical Center – Eugene
	McKenzie – Willamette Medical Center
South I-5	Sacred Heart Medical Center – Eugene
	McKenzie – Willamette Medical Center
	Cottage Grove Community Hospital
	Mercy Medical Center – Roseburg
	Three Rivers Community Hospital – Grants Pass
	Providence Medford Medical Center
	Rogue Valley Medical Center – Medford
	Ashland Community Hospital
Cascades	Adventist Medical Center
	Legacy Mt. Hood Medical Center
	Kaiser Sunnyside Medical Center
	Willamette Falls Hospital – Oregon City
	Providence Hood River Memorial Hospital
	Mid-Columbia Medical Center – The Dalles
	Mountain View Hospital – Madras
	Salem Hospital
	Santiam Memorial Hospital
	Samaritan Lebanon Community Hospital
	St. Charles Medical Center – Redmond
	St. Charles Medical Center – Bend
	McKenzie-Willamette Medical Center
	Merle West Medical Center – Klamath Falls
	Providence Medford Medical Center
	Rogue Valley Medical Center – Medford

TABLE 3-2
Hospitals by Geographic Zone within 5 Miles of at Least One Segment

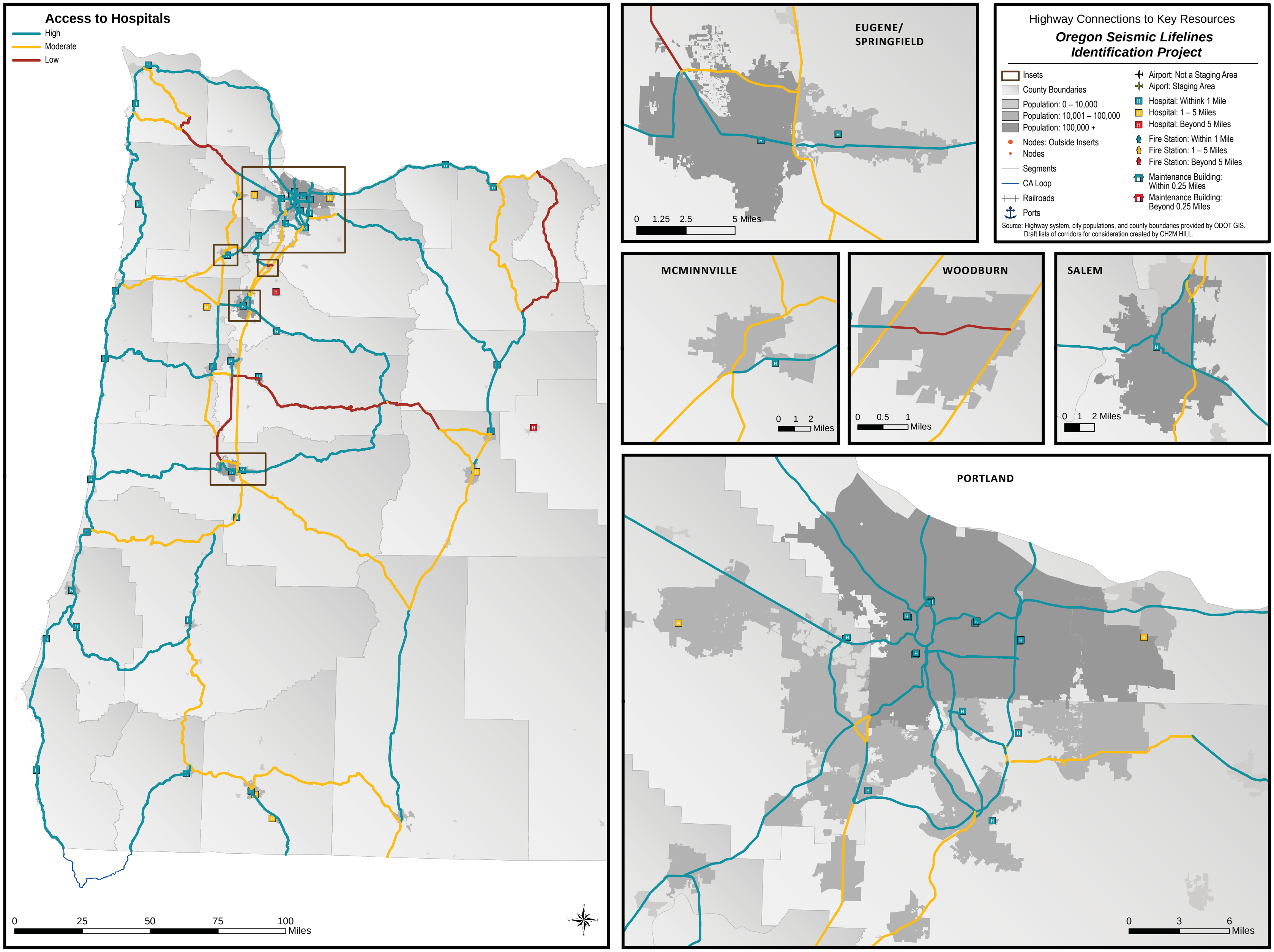
Geographic Zone	Hospitals within 5 Miles of Segments
Central	Mountain View Hospital – Madras
	St. Charles Medical Center – Redmond
	St. Charles Medical Center – Bend
	Mid-Columbia Medical Center – The Dalles
	Merle West Medical Center – Klamath Falls

Each segment was given a rating of low, moderate, or high for access to hospitals by using the following parameters:

- Low: No hospitals within 5 miles of the segment
- Moderate: At least one hospital within 5 miles of the segment
- High: At least one hospital within 1 mile of the segment

Fifty-seven segments ranked high for this criterion, 41 ranked moderate, and 11 ranked low. Figure 3-2 depicts the locations of hospitals within 1 mile and 5 miles of segments, and the ranking of each segment for this criterion.

FIGURE 3-2
Access to Hospitals



3.1.3 Access to Ports and Airports

The purpose of this criterion was to evaluate how well each segment provides connections to air and sea transport. Supplies and other resources needed after a seismic event may be best transported through a combination of modes; therefore, it is important to know which segments can provide access to either air or sea travel. The technical team used GIS technology along with knowledge of the local roadway system to evaluate the proximity of each segment to ports and publicly owned airports in a qualitative manner. The technical team used the following two GIS shapefiles of the locations of ports and airports for this evaluation, provided by ODOT in June 2011: “Oregon_ports.shp” and “public_use_airports.shp.” All ports and airports were included in this evaluation regardless of size or state of infrastructure repair. The ports and airports within 5 miles of at least one segment are listed in Table 3-3. Airports may be within five miles of segments in more than one geographic zone. In total, 61 airports statewide and 20 ports are within 5 miles of a segment.

TABLE 3-3
Ports and Airports by Geographic Zone within 5 Miles of at Least One Segment

Geographic Zone	Airports within 5 Miles of Segments	Ports within 5 Miles of Segments
Coast	Portland Downtown Heliport	Port of Astoria
	Astoria Regional Airport	Port of Bandon
	Scappoose Industrial Airport	Port of Brookings Harbor
	Seaside Municipal Airport	Oregon International Port of Coos Bay
	Nehalem Bay State Airport	Port of St. Helens
	Tillamook Airport	Port of Suislaw
	Pacific City State Airport	Port of Garibaldi
	Siletz Bay State Airport (Lincoln County)	Port of Gold Beach
	Newport Municipal Airport	Port of Coquille River
	Toledo State Airport	Port of Nehalem
	Wakonda Beach State Airport (Lincoln County)	Port of Newport
	Corvallis Municipal Airport	Port of Port Orford
	Florence Municipal Airport	Port of Portland
	Lakeside State Airport	Port of Umpqua
	Southwest Oregon Regional Airport (North Bend)	Port of Tillamook Bay
	Bandon State Airport	Port of Toledo
	Roseburg Regional Airport	Port of Alsea
	Cape Blanco State Airport	
	Gold Beach Municipal Airport	
	Brookings Airport	
	Illinois Valley Airport	
	Mahlon Sweet Field (Eugene)	
	Independence State Airport	
	McMinnville Municipal Airport	

TABLE 3-3
Ports and Airports by Geographic Zone within 5 Miles of at Least One Segment

Geographic Zone	Airports within 5 Miles of Segments	Ports within 5 Miles of Segments
Portland Metro	Portland International Airport Portland Downtown Heliport	Port of Portland
Valley	Skyport Airport (Cornelius) Hillsboro (Portland) Airport Sportsman Airpark (Newberg) McMinnville Municipal Airport Aurora State Airport McNary Field (Salem) Independence State Airport Albany Municipal Airport Corvallis Municipal Airport Mahlon Sweet Field (Eugene)	None
South I-5	Cresswell Hobby Field Cottage Grove State Airport Roseburg Regional Airport George Felt Airport (Douglas County) Myrtle Creek Municipal Airport Grants Pass Airport Rogue Valley International – Medford Airport Ashland Municipal – Summer Parker Field	None
Cascades	Rogue Valley International – Medford Airport Klamath Falls Airport Cresswell Hobby Field Oakridge State Airport Crescent Lake State Airport Lebanon State Airport McKenzie Bridge State Airport Santiam Junction State Airport Sister Eagle Air Airport Roberts Field (Redmond) Bend Municipal Airport Davis Airport (Gates) McNary Field (Salem) Madras City-County Airport Valley View Airport (Estacada) Country Squire Airpark (Sandy)	Port of Cascade Locks Port of Hood River Port of The Dalles

TABLE 3-3
Ports and Airports by Geographic Zone within 5 Miles of at Least One Segment

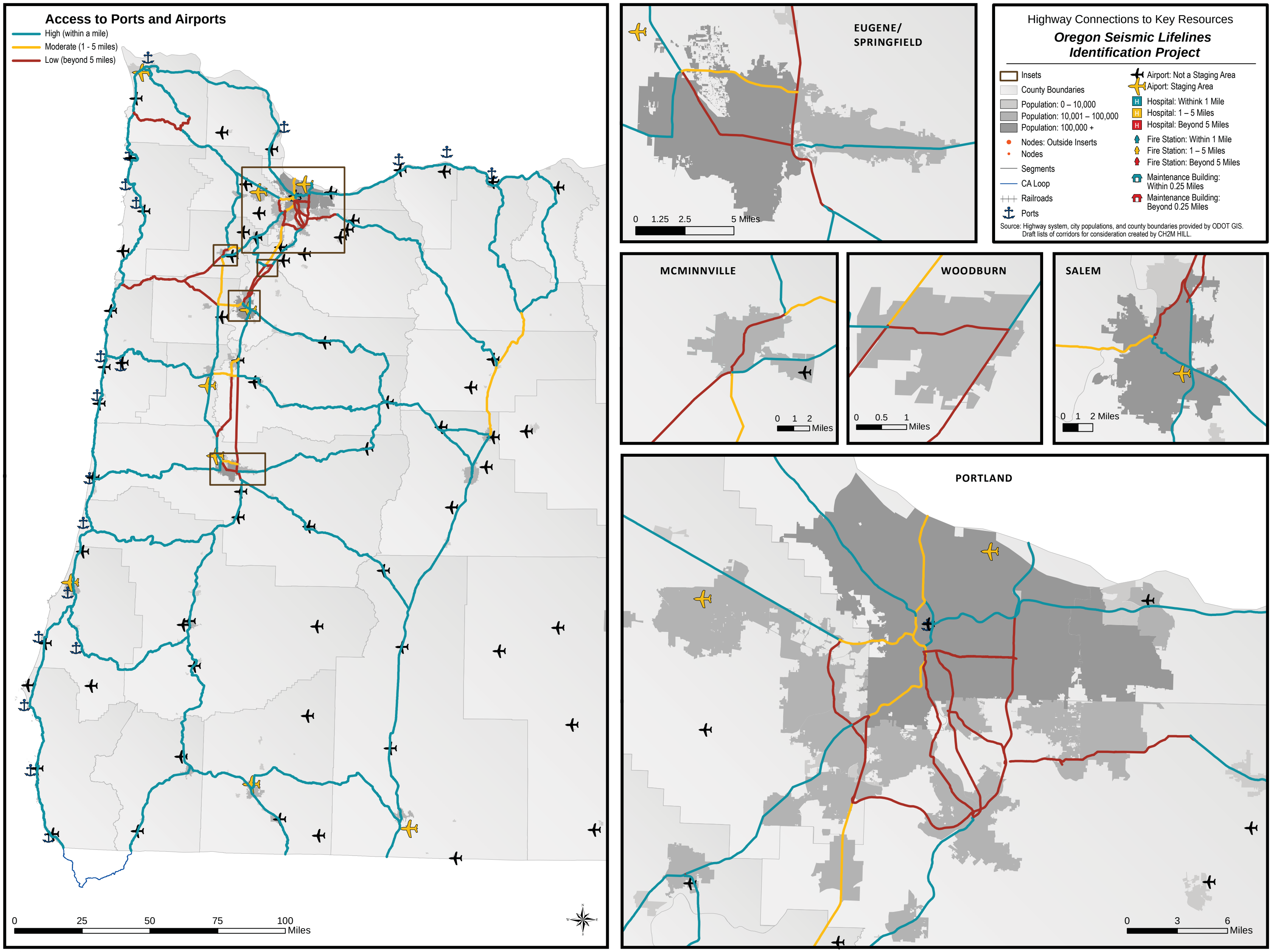
Geographic Zone	Airports within 5 Miles of Segments	Ports within 5 Miles of Segments
	Sandy River Airport (Sandy)	
	Troutdale (Portland) Airport	
	Cascade Locks State Airport	
	Ken Jernstedt Airfield (Hood River)	
	Columbia Gorge Regional/The Dalles Municipal Airport	
Central	Wasco State Airport	None
	Madras City-County Airport	
	Roberts Field (Redmond)	
	Bend Municipal Airport	
	Sunriver Airport (Deschutes County)	
	Beaver Marsh State Airport (Klamath County)	
	Chiloquin State Airport	
	Klamath Falls Airport	

Each segment was given a rating of low, moderate, or high for access to ports and airports using the following parameters:

- Low: Segment doesn't provide ready access to airport or port
- Moderate: Segment leads to an arterial that leads to an airport or port
- High: Segment provides direct access to airports or port

Fifty-seven segments ranked high for this criterion, 16 ranked moderate, and 36 ranked low. Figure 3-3 depicts the locations of ports and airports and the ranking of each segment for this criterion.

FIGURE 3-3
Access to Ports and Airports



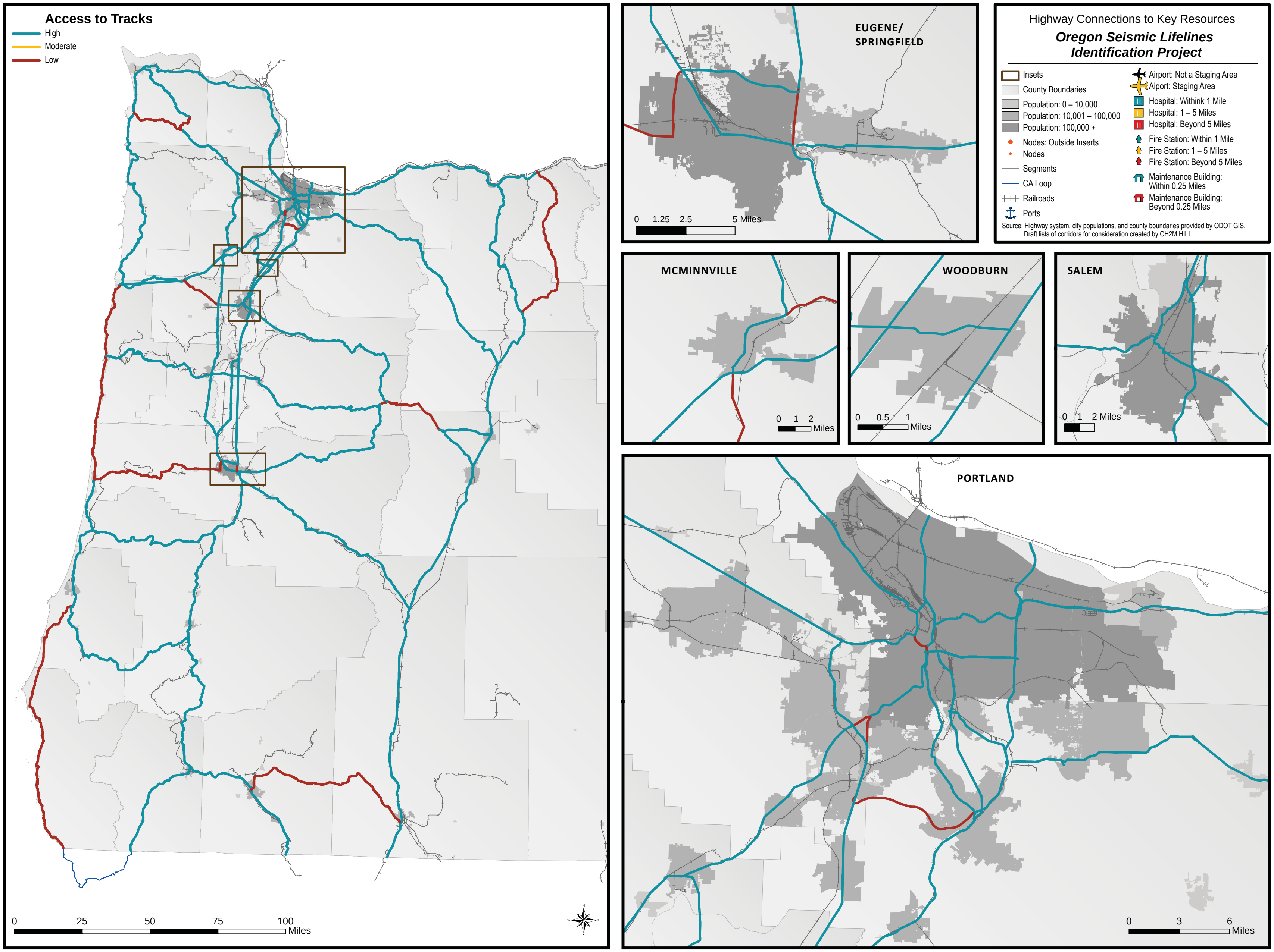
3.1.4 Access to Railroads

The purpose of this criterion was to evaluate which segments may provide access to rail transportation following a seismic event. Access to railroads does not have to be at an established rail depot or intermodal yard, but was considered to be anywhere where highways and railroads intersect—with the assumption that materials could be transferred from rail to truck or vice versa. The technical team used GIS technology to evaluate the proximity to railroads for each segment. The team used the GIS shapefile "railroads.shp" for the analysis. This shapefile was last updated in 2010 and includes the Oregon State Railway system line work. Segments were determined to be within one of the following two categories in this criterion:

- Low: Segment provides no direct access to a railroad
- High: Segment intersects with railroad or closely parallels railroad

The rail network is extensive throughout western Oregon; therefore, most segments ranked high for this criterion. In total, 93 segments ranked high and 16 ranked low. Figure 3-4 depicts the locations of railroads and the ranking of each segment for this criterion.

FIGURE 3-4
Access to Railroads



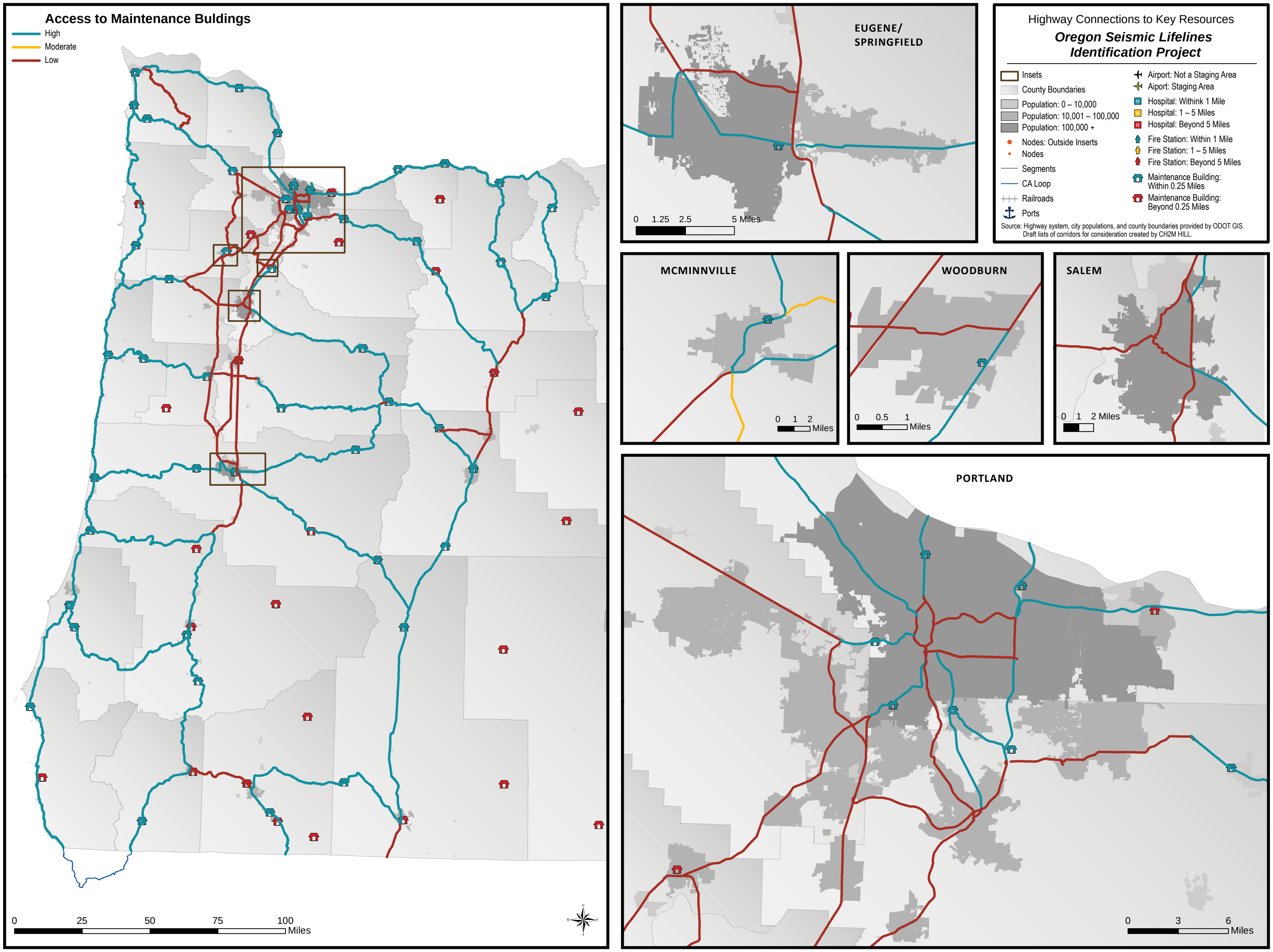
3.1.5 Access to ODOT Maintenance Facilities

The purpose of this criterion was to determine which segments provide access to one or more ODOT maintenance facilities. ODOT stores heavy equipment for use in removing road debris and other blockages at its maintenance facilities. Removing roadway obstacles may become crucial following a seismic event so that transporting personnel and other resources to an affected area can begin. The technical team used GIS technology to evaluate the number of ODOT maintenance facilities within 0.25 mile of each segment. The radius for maintenance facilities is different than that for hospitals and fire stations because highway maintenance facilities are always located adjacent to highways, and the purpose of this criterion is to differentiate between highways. The technical team used a subset of the GIS shapefile "maintenance_buildings.shp," which was provided by ODOT in June 2011 (no information is available about how recently "maintenance_buildings.shp" has been updated). Forty-nine maintenance facilities are located within 0.25 mile of the segments. Each segment was then given a rating of low or high for access to maintenance facilities by using the following parameters:

- Low: No maintenance facilities within 0.25 mile of the segment
- High: At least one maintenance facility within 0.25 mile of the segment

Fewer than half of the segments had a maintenance facility located within 0.25 mile. Forty-five segments ranked high for this criterion and 64 ranked low. Figure 3-5 depicts the locations of maintenance facilities and the ranking of each segment for this criterion.

FIGURE 3-5
Access to ODOT Maintenance Facilities



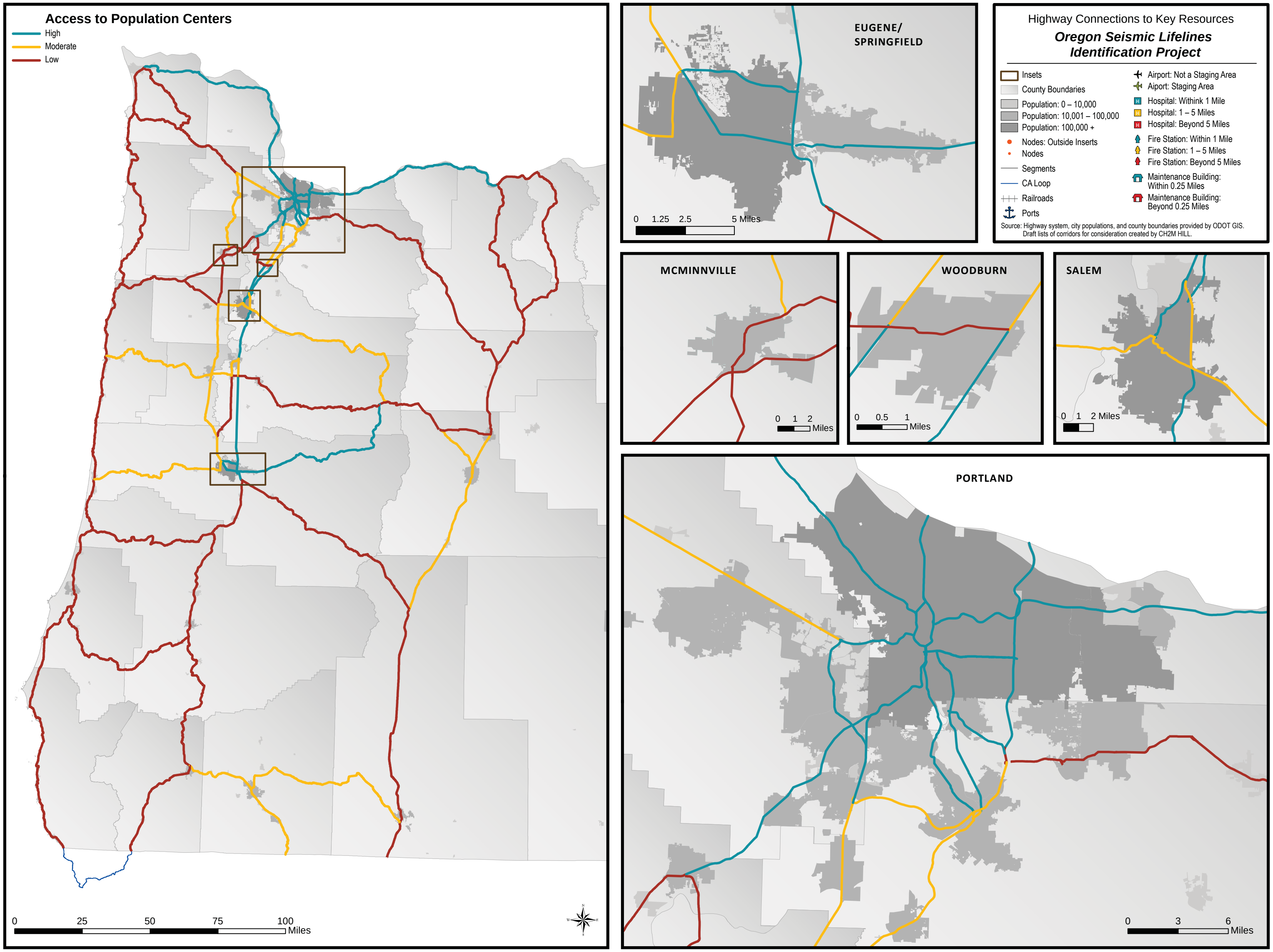
3.1.6 Access to Population Centers

The purpose of this criterion was to determine approximately how many people could be reached with each segment. The technical team used GIS technology to assess the number and size of population centers that each segment intersects. The data source was an ODOT shapefile labeled "cities_population.shp" that includes 2010 population values for incorporated cities, derived from the 2010 U.S. Census. Each segment was assigned a value of high, moderate, or low by using the following parameters:

- Low: Sum of population values for all population centers along the segment is less than 10,000
- Moderate: Sum of population values for all population centers along the segment is between 10,000 and 100,000
- High: Sum of population values for all population centers along the segment is greater than 100,000

The results for this criterion were mixed. Thirty-six segments ranked high for this criterion, 28 ranked moderate, and 45 ranked low. Figure 3-6 depicts population centers by size and the ranking of each y segment for this criterion.

FIGURE 3-6
Access to Population Centers



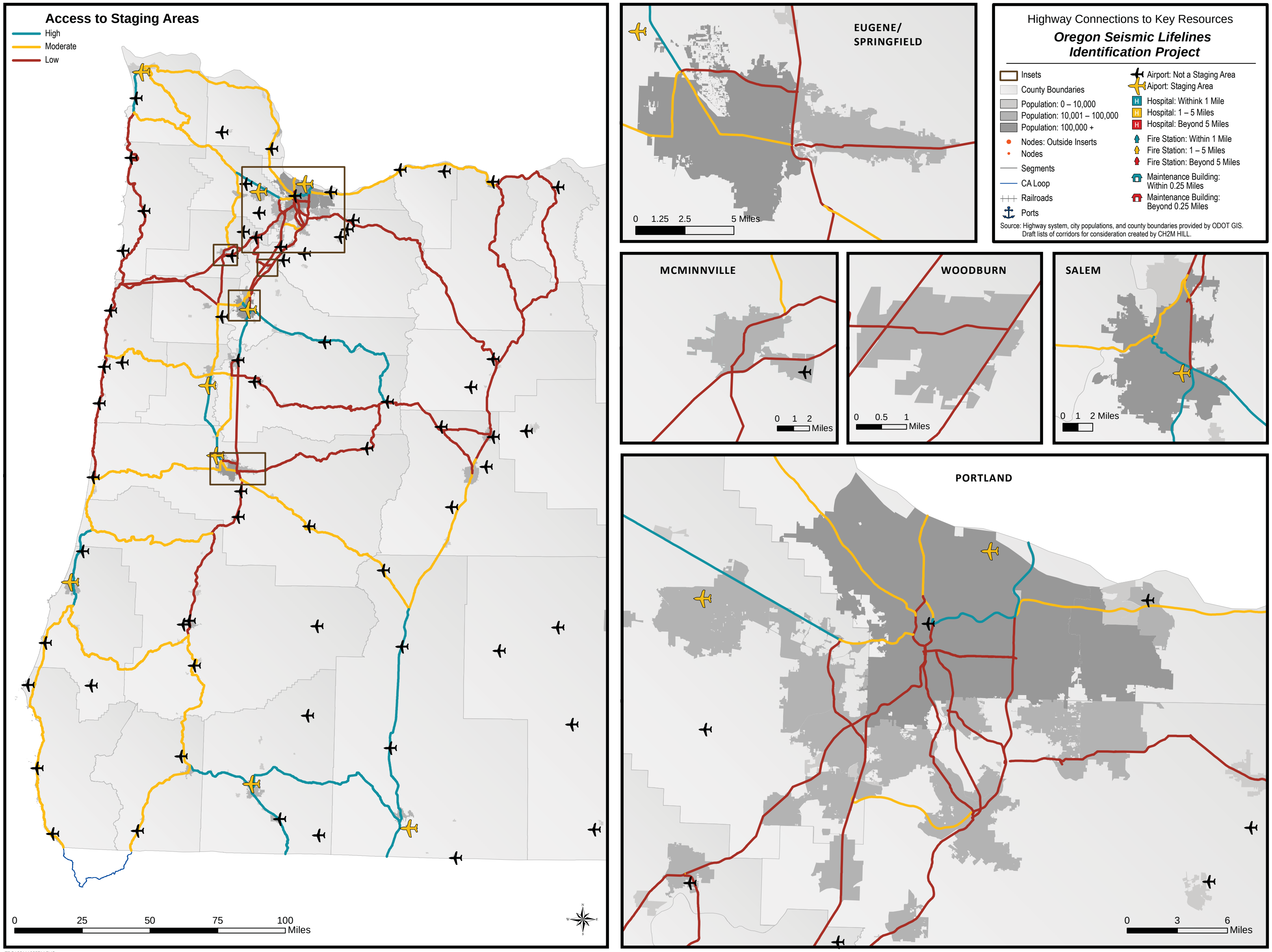
3.1.7 Access to Emergency Response Staging Areas

Staging areas are temporary sites where personnel, equipment, and commodities are kept while awaiting tactical assignments for emergency response. The purpose of this criterion was to determine which segments provide access to those staging areas. The State of Oregon has designated nine staging areas at airports located throughout the state. These staging areas are Portland International Airport, Eugene/Mahlon Sweet Field, Salem Municipal/McNary Field, Hillsboro Airport, Corvallis Airport, Rogue Valley International Airport (Medford), Astoria Airport, Klamath Falls Airport, and Southwest Oregon Regional Airport (North Bend). The technical team used GIS technology to evaluate the proximity of each segment to the staging areas by using the following parameters:

- Low: Segment doesn't provide ready access to a staging area
- Moderate: Segment leads to an arterial that leads to a staging area
- High: Segment provides direct access to a staging area

Because there are relatively few staging areas, few segments ranked high for this criterion. In total, 15 segments ranked high for this criterion, 28 ranked moderate, and 66 ranked low. Figure 3-7 depicts the locations of staging areas and the ranking of each segment for this criterion.

FIGURE 3-7
Access to Staging Areas



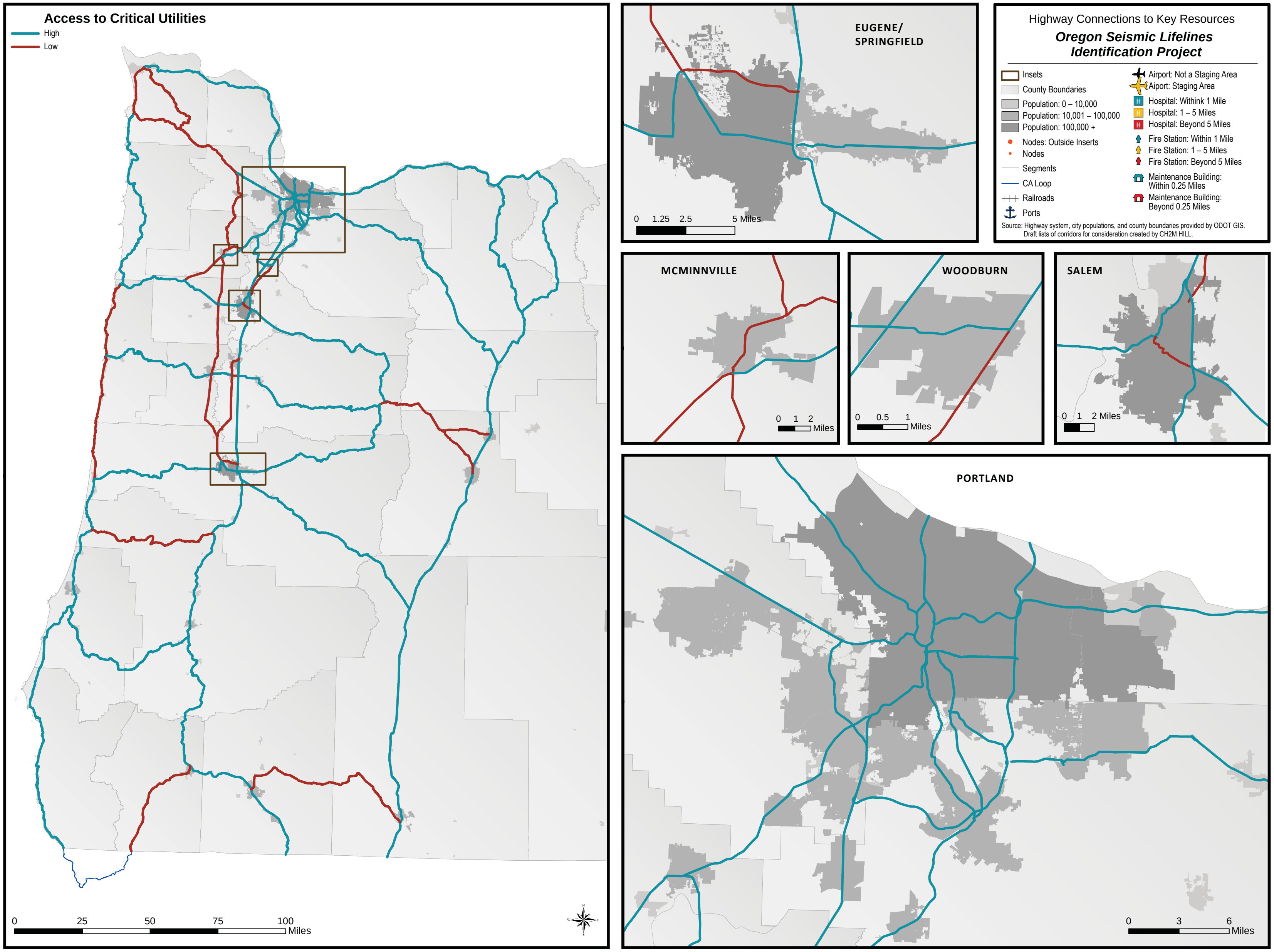
3.1.8 Access to Critical Utilities

The purpose of this criterion was to determine which segments provided key access to utility infrastructure. The technical team used professional judgment and general knowledge of key utility facilities to determine which segments provided access to critical utility assets. This set of segments was then presented to Portland General Electric, Bonneville Power Administration, Northwest Natural, and PacifiCorp to refine and expand. Both Portland General Electric and Bonneville Power Administration provided comments to the technical team and added several segments to the list of those that provide access to critical utilities. The parameters for this criterion are as follows:

- Low: Segment does not provide access to critical utility infrastructure
- High: Segment provides access to critical utility infrastructure

Because many critical utility components are located throughout the state, the majority of the segments ranked high for this criterion. Eighty-one segments ranked high for this criterion and 28 ranked low. Figure 3-8 depicts the ranking of each segment for this criterion.

FIGURE 3-8
Access to Critical Utilities



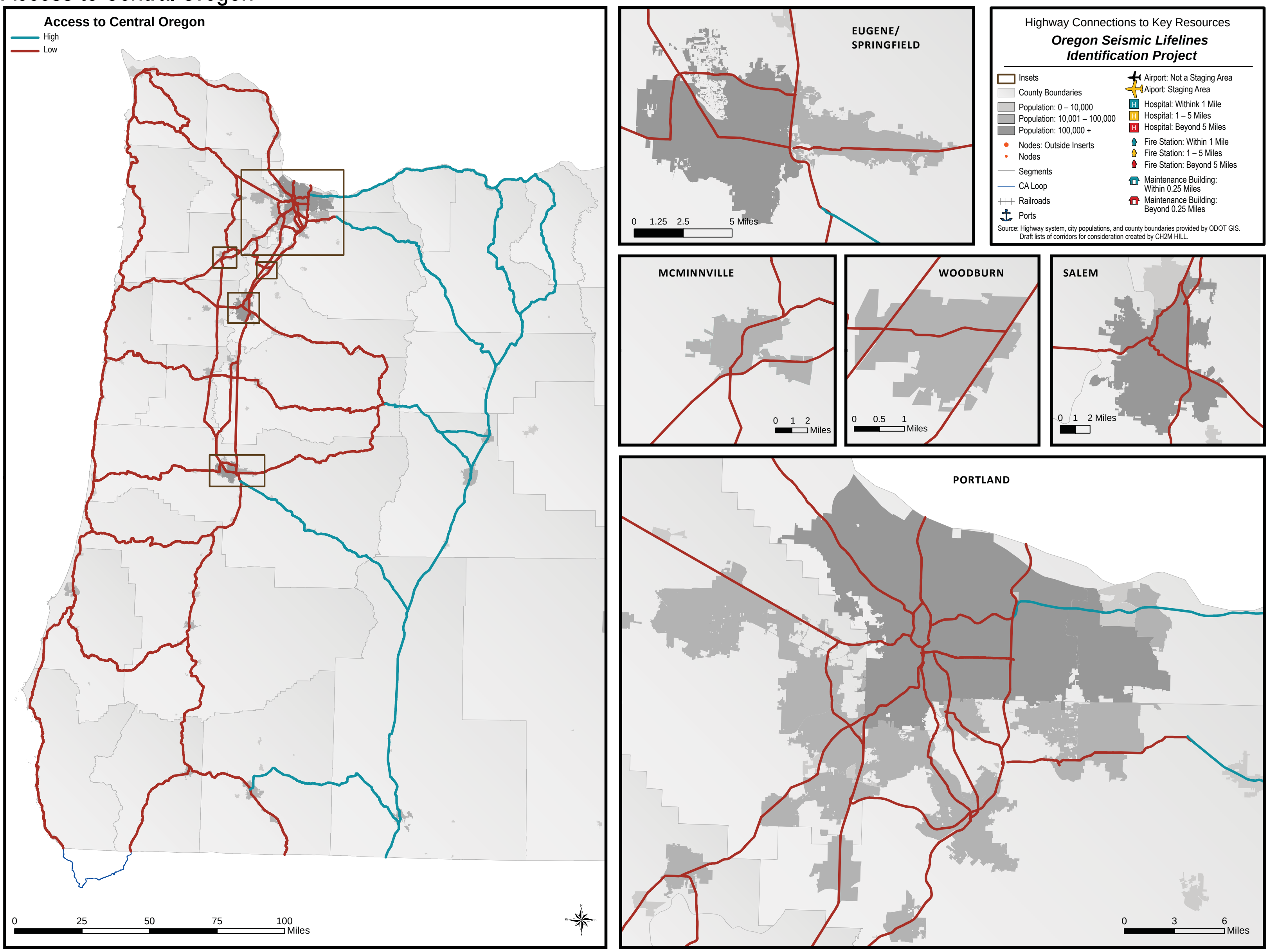
3.1.9 Access to Central Oregon

The purpose of this criterion was to evaluate which segments may be able to provide routes for freight and personnel from out of state resources to be moved into hard hit areas in the Willamette Valley and further west. US 97 and US 84 both provide connections to adjoining states, important links to external resources in a major disaster, and Redmond Airport has been identified as a staging area for federal emergency support in an event likely to, at least temporarily, disable the Portland Airport. In addition, due to lower risk of significant damage from a Cascadia Subduction Zone (CSZ) event, Central and Eastern Oregon provide areas to which evacuated or otherwise displaced citizens can go. The technical team used maps of the segments to evaluate the access to central Oregon for each segment. The parameters for this criterion were as follows:

- Low: Segment does not provide access to central Oregon
- Moderate: Two-lane roadway that provides access to central Oregon
- High: High-capacity roadway that provides access to central Oregon (connects to US 97)

Two segments ranked high for this criterion, 14 ranked moderate, and 93 ranked low. Figure 3-9 depicts the ranking of each segment for this criterion.

FIGURE 3-9
Access to Central Oregon



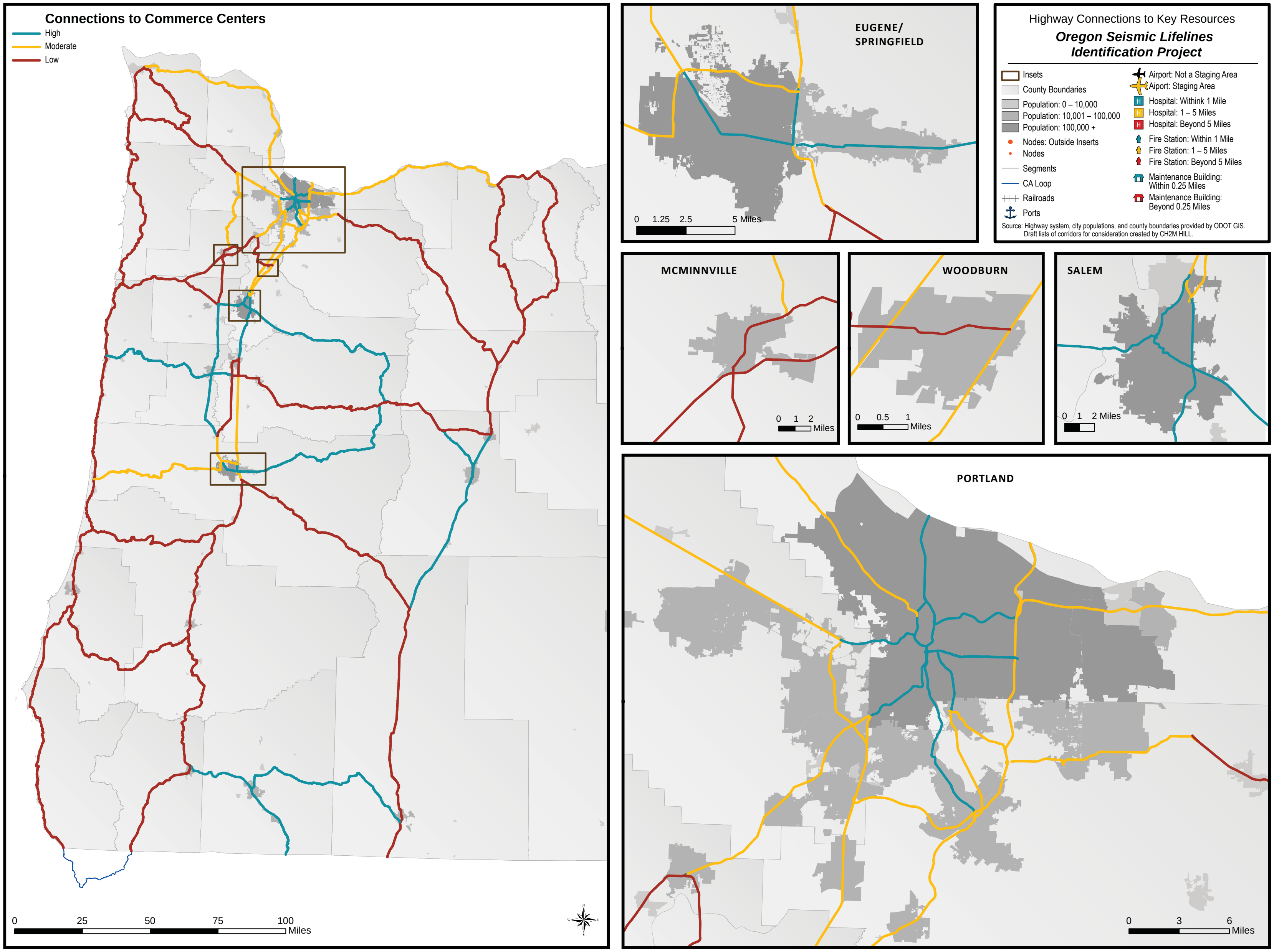
3.1.10 Connection to Centers of Commerce

The purpose of this criterion was to evaluate which segments would provide access to major centers of commerce. Highways that serve centers of commerce can be critically important for long-term economic recovery. Centers of commerce were defined as the central business districts within the boundaries of the six Metropolitan Planning Organizations (MPO) within the state (Portland, Salem-Keizer, Corvallis, Bend, Eugene-Springfield, and Rogue Valley). The technical team used GIS maps of segments overlaid with a shapefile of urban growth boundaries and local knowledge of the locations of central business districts to determine the level of connection to centers of commerce for each segment. The parameters for this criterion were as follows:

- Low: Segment does not connect to an urban growth boundary of an MPO
- Moderate: Segment connects to an MPO urban growth boundary, but not to a central business district
- High: Segment provides direct access to a central business district in an MPO

Thirty-two segments ranked high for this criterion, 32 ranked moderate, and 45 ranked low. Figure 3-10 depicts the locations of urban growth boundaries and the ranking of each segment for this criterion.

FIGURE 3-10
Connection to Centers of Commerce



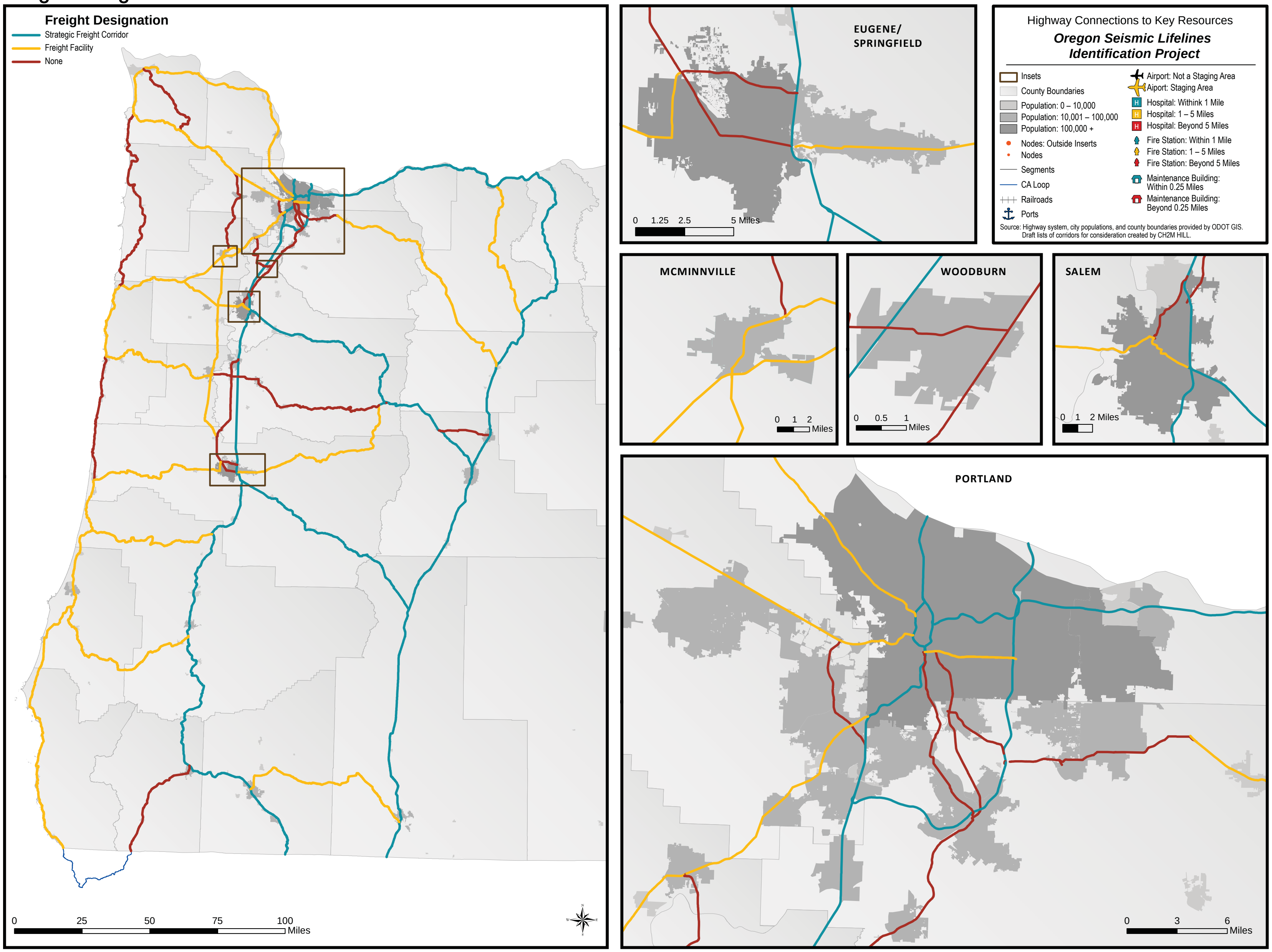
3.1.11 Importance of Segment to Freight Movement

The purpose of this criterion was to evaluate the long-term importance of each segment to economic recovery, as determined by the designations in the *Oregon Freight Plan* (ODOT, 2011b). The technical team used the *Oregon Freight Plan* along with professional judgment related to emergency operations plans for getting materials and personnel into the state after a disaster and other related knowledge to identify the relative importance of each segment to freight movement in the state. The parameters for this criterion were as follows:

- Low: No mention of the highway in Chapter 4 of the *Oregon Freight Plan* or as determined by the PMT or SC
- Moderate: Highway that provides connectivity to a freight facility, as listed in Tables 4.4, 4.5, 4.6, and 4.7 in the *Oregon Freight Plan*, or as determined by the PMT or SC
- High: Strategic freight corridor as depicted in Figure 4.13 in the *Oregon Freight Plan* or as determined by the PMT or SC

Forty-five segments ranked high for this criterion, 34 ranked moderate, and 30 ranked low. Figure 3-11 depicts the ranking of each segment for this criterion.

FIGURE 3-11
Freight Designation



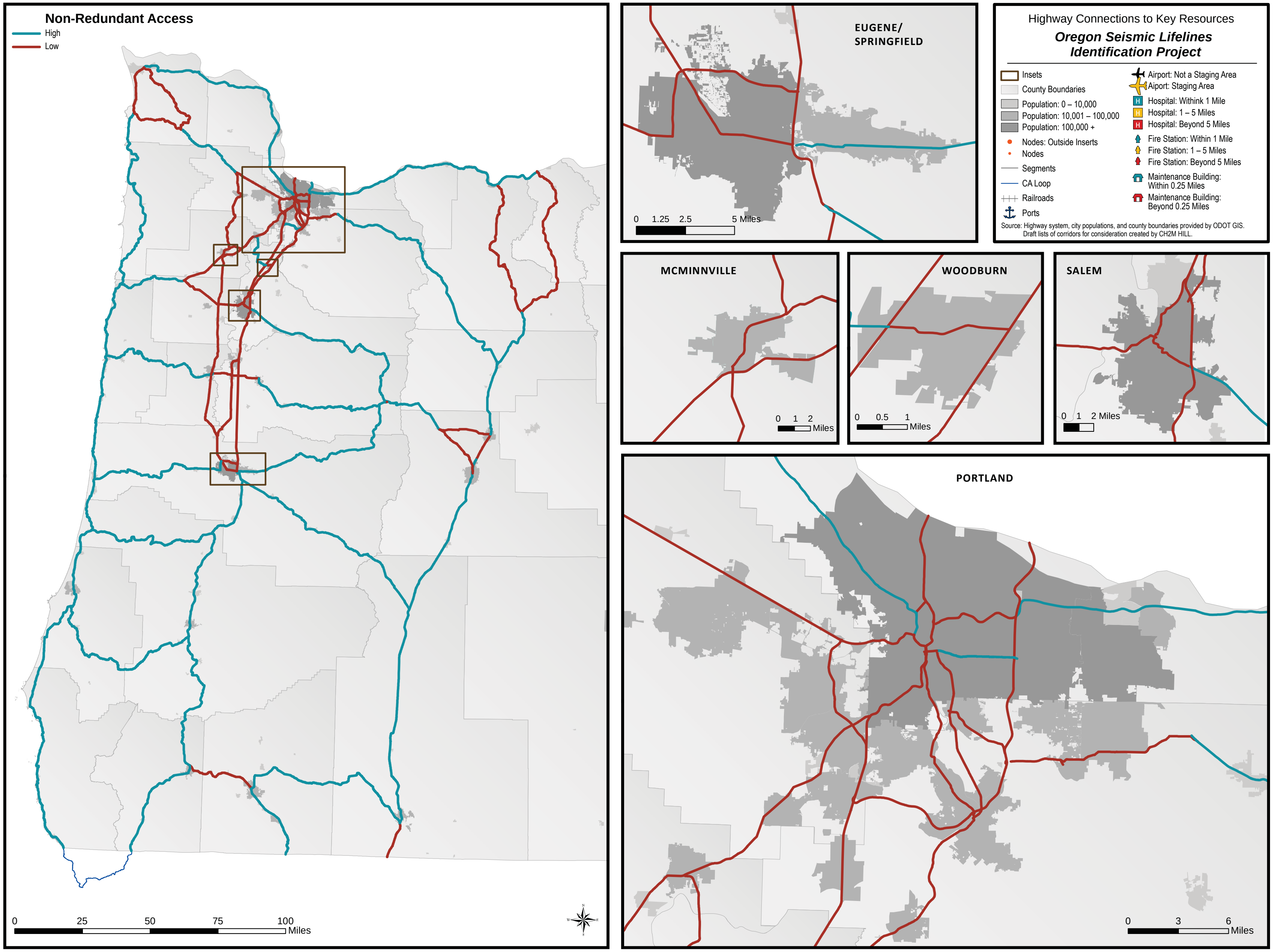
3.1.12 Segment Provides Critical Non-redundant Access

The purpose of this criterion was to determine which segments provide access to an area that cannot be accessed by any other roadway. The technical team used local knowledge of the roadway system along with GIS mapping of state highway routes and local roads to evaluate each segment. The parameters for this criterion were as follows:

- Low: At least one alternate roadway (state or locally owned) exists that provides access to the same area for which the segment provides access
- High: No alternate roadway exists that provides access to the same area for which the segment provides access

Thirty-six segments ranked high for this criterion and 73 ranked low. Figure 3-12 depicts the ranking of each segment for this criterion.

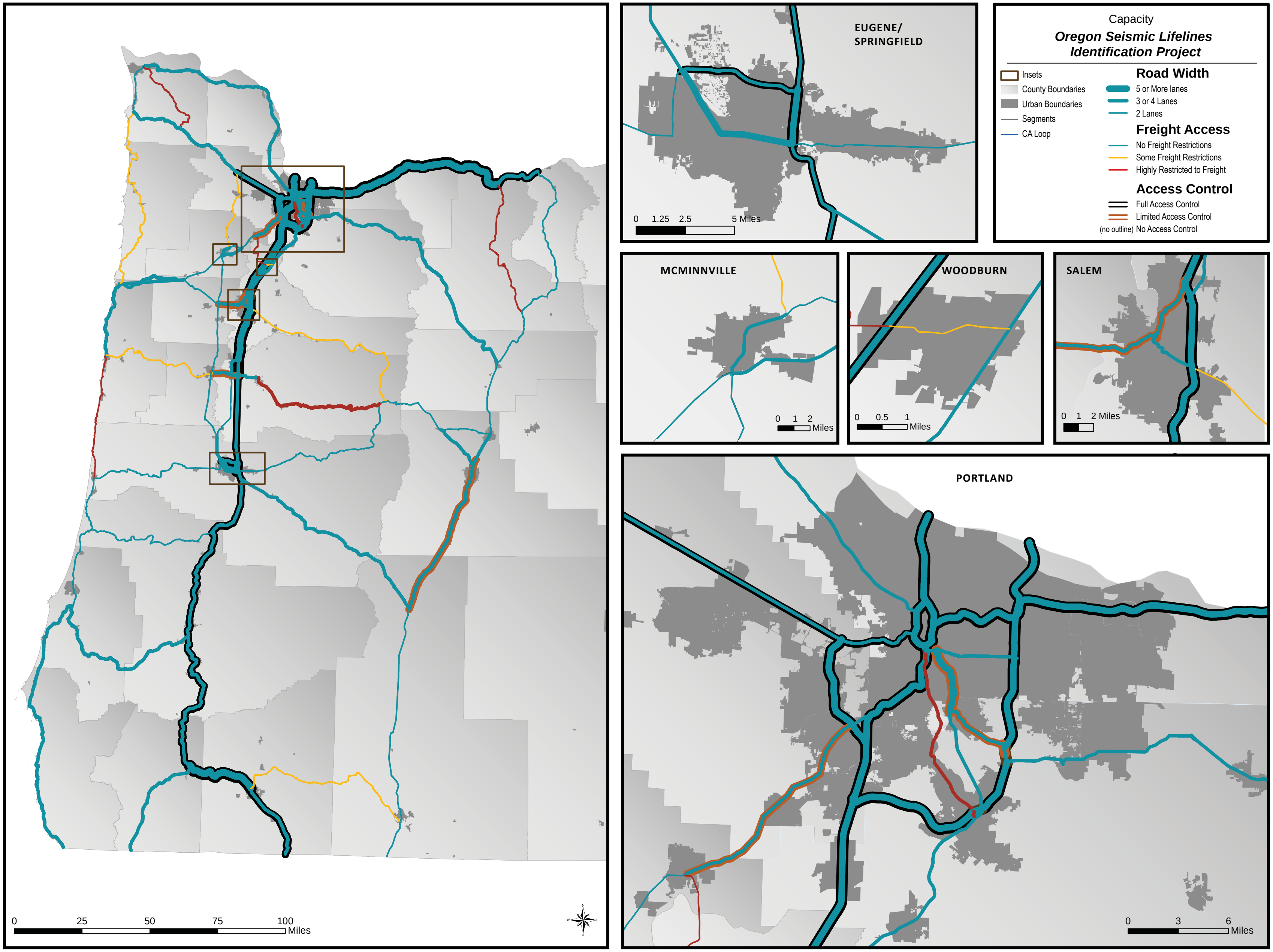
FIGURE 3-12
Route Provides Critical, Non-redundant Access



3.2 Capacity

The criteria listed under the capacity category measure the characteristics of the roadway itself—width, whether access is controlled, and whether freight access is currently restricted. These criteria may be important in the case of a seismic event because they can help determine how usable the actual roadway will be for large volumes of traffic, quick evacuation, or moving freight to and from populated areas. Capacity criteria parameters are shown in Figure 3-13.

FIGURE 3-13
Capacity



3.2.1 Roadway Width

The technical team used the number of lanes on each segment as a general indicator of its width. To determine the number of lanes, the technical team used the GIS shapefile "number_of_lanes.shp" provided by ODOT in June 2011. Each segment was examined by using this GIS shapefile and given a value of high, moderate, or low. In cases for which the segment had more than one cross section, the evaluators used judgment to identify the most-prevalent cross-section. The parameters for the roadway width criterion were as follows:

- Low: Two or three lanes
- Moderate: Four or five lanes
- High: Six or more lanes

Twenty-nine segments ranked high for this criterion, 47 ranked moderate, and 33 ranked low.

3.2.2 Ability to Control Use

The ability to control use of the roadway refers to the level of access control for each roadway—the number of uncontrolled and controlled intersections and driveways along the roadway. Control of access can be important during a seismic event because roadways with a high ability to control use may better be able to be used for moving vehicles quickly in and out of a populated area. At the time of this study, no official database was available for use in this evaluation; therefore, the technical team used professional judgment and knowledge of the state highway system to determine relative levels of access control on each segment. The parameters for this criterion were as follows:

- Low: No access control
- Moderate: Limited access control (such as an expressway)
- High: Full access control (such as on an interstate freeway)

Thirty-eight segments ranked high for this criterion, 8 ranked moderate, and 63 ranked low.

3.2.3 Freight Access

The level of freight restriction on a roadway can be important after a seismic event because it can indicate whether supplies may be easily brought into a populated area. The technical team used the ODOT "Motor Carrier Transportation Division Freight Mobility Map" to evaluate the level of freight restrictions on each segment. This map is presented in Appendix G. The parameters for this criterion were as follows:

- Low: Highly restricted to truck and oversize load traffic (shown as a black and yellow route on the Freight Mobility Map)
- Moderate: Some restrictions for length or width; will not accommodate oversize and overweight loads (shown as a blue or magenta route on the Freight Mobility Map)
- High: No freight restrictions (shown as an orange route on the Freight Mobility Map)

Ninety-five segments ranked high for this criterion, six ranked moderate, and eight ranked low.

4.0 Seismic Vulnerability Assessment

This chapter presents the results of a seismic vulnerability assessment that focused on the segments listed in Chapter 2. It describes existing data, data sources, the methodology used to estimate and synthesize seismic hazards and vulnerability on each roadway segment, and the makeup and evaluation of the resilience criteria used in the evaluation framework.

The purpose of the seismic vulnerability assessment was to identify relative vulnerabilities between routes to aid in the identification of preferred seismic lifeline routes. Much of the information used for this assessment is not of sufficient detail and accuracy to be used in an engineering evaluation of the seismic performance of each individual structure, roadway grade, and adjacent earth slope throughout the study area. There are inconsistencies related to factors such as coverage, age, and level of detail of the data in the available information across the entire study area for all facilities evaluated. However, the information used was found to be adequate for the planning purposes of this study because it provides useful indicators of the overall seismic vulnerability of individual structure, roadway grade, and adjacent earth slope and is sufficient for evaluating the likely seismic resilience of each route.

Full engineering evaluations of all structures and geotechnical conditions would be far beyond the scope of this study. This study is intended to provide guidance about where detailed engineering evaluations should begin to improve the seismic resilience of Oregon's statewide transportation network.

4.1 Approach

This section defines seismic hazards that may affect lifeline routes, identifies seismic events that were evaluated in this project, and lists the available data sources with an assessment of completeness and relevance of the data.

4.1.1 Seismic Hazards Affecting Lifeline Routes

The following seismic hazards have the potential to affect the seismic vulnerability of structures (such as bridges, retaining walls, culverts, and tunnels) and roadway grades along the lifeline routes:

- **Ground Shaking**. Ground shaking is a function of the distance to the earthquake epicenter, the magnitude of the earthquake, regional bedrock properties, and the stiffness of the site-specific soils. It includes the potential for ground amplification because of soft soil deposits. The effects of ground shaking, including the intensity, frequency content, and duration of the shaking, can physically damage structures (such as bridges, culverts, retaining walls, and tunnels), as well as trigger other seismic hazards (such as liquefaction and landslides).
- **Coseismic Deformation**. During a subduction zone earthquake, the tectonic plates undergo elastic deformation on a regional scale, resulting in the potential for several meters of permanent uplift or subsidence that could occur along the entire rupture zone, as expected along the entire Oregon Coast for the CSZ magnitude 9.0 event. Coseismic subsidence can affect tsunami wave heights and run-up. I f the ground subsides during the seismic event, the *effective* tsunami wave and associated run-up are increased by the amount of subsidence. In addition, coseismic deformation can reduce ground elevations along low-elevation roadway grades to the extent that the elevations end up below design sea level following coseismic subsidence.

- **Liquefaction**. Soil liquefaction is a phenomenon by which loose, saturated, and sandy/silty soils undergo almost a complete loss of strength and stiffness because of seismic shaking. Its occurrence along highway corridors is likely most significant at bridge sites (which are often near bodies of water) or along roadways that are adjacent to bodies of water (such as estuaries, rivers, and lakes). Liquefaction may cause failure of retaining walls from excessive earth pressure, movement of abutments and slopes caused by lateral spreading (liquefaction-induced slope instability), and loss of bearing or pile capacity for bridge abutments and pile caps.
- **Cyclic Degradation of Clays**. The cyclic degradation of clays is a process by which clayey soils may lose the majority of their strength and stiffness because of cyclic shaking. Cyclic degradation of clays is typically associated with sensitive and soft clays. As with liquefaction, these susceptible soils are typically located at or adjacent to bodies of water.
- **Landslides**. Landslide hazards are most likely to occur at locations of steeply sloping ground within the Coast Range and Cascade Mountains, or near alluvial channels. Landslides located above a roadway may lead to the blockage of a road from debris buildup. Landslides located below a roadway may cause undermining and loss of road grade. Landslides can occur at locations with recognized slope instabilities, but they can also occur in areas without a historic record of landslide activity.
- **Fault Rupture**. During shallow crustal earthquakes, the rupture of a fault may propagate to the ground surface and lead to horizontal and/or vertical displacements of the ground. These displacements may be on the order of several meters and will depend on the size of the earthquake and the proximity of the fault plane to the ground surface. The effect of fault rupture is much more devastating for structures, such as bridges, than it is for roadways. However, the thoroughness of current mapping of faults for the State of Oregon is uncertain and very few of the observed earthquakes in Oregon are associated with mapped crustal faults. It is anticipated that, given the heavy vegetative cover for a lot of Oregon and the short period of time for which records have been kept, not all active faults have been identified.
- **Tsunamis**. Tsunamis may affect lifeline routes near and adjacent to the coastline. The resulting water forces can damage structures within the tsunami run-up zone, and can also cause debris buildup or inundation and the washing away of roadway grades.
- **Seiche Waves**. Seiche waves are resonance waves that are caused by seismic shaking of enclosed bodies of water, and often occur at distances far from the earthquake epicenter.

The hazards listed previously all have relevance to seismic lifeline routes. However, fault rupture, cyclic degradation of clayey soils, and seiche wave hazards were not further evaluated for the following reasons:

- **Fault rupture** hazard was not considered for the CSZ event because this event is not a crustal event. Although the Klamath Falls Fault Zone was considered for the Klamath Falls scenario, fault rupture was not considered to have a significant influence on the identification of lifeline routes.
- **Cyclic degradation of clayey soils** was not considered because limited information is available for evaluating this hazard on a statewide basis. In addition, potentially liquefiable sandy soils are often located very near soft clayey soils (such as those in estuarine and alluvial environments). Therefore, when evaluating seismic hazards on a regional scale, liquefaction hazards were assumed to be a proxy for the cyclic degradation of clayey soils hazard.

- **Seiche wave** hazards were not considered because they only occur in enclosed bodies of water that, within Oregon, are not located sufficiently near state highway routes to affect post-earthquake travel along these routes. In addition, seiche waves are typically limited in height and are anticipated to generally not affect bridges or roadway grades.

4.1.2 Definition of the Seismic Events

Many potential scenarios for seismic events could affect Oregon. Each scenario has its own set of risks and challenges. To effectively conduct the seismic vulnerability assessment, the consultant team assumed a certain set of seismic scenarios. After coordination and consultation with ODOT and the Department of Geology and Mineral Industries (DOGAMI), the consultant team recommended that the following seismic events be evaluated in the seismic vulnerability assessment:

- CSZ moment magnitude (Mw) 9.0 earthquake scenario, which has the potential to affect all of western Oregon (as well as northern California, western Washington, and southwestern British Columbia)
- A design-level Klamath Falls crustal earthquake scenario, Mw 6.5, which is limited to the Klamath Falls region

These two events were chosen as the basis for this seismic vulnerability evaluation because (1) a CSZ event has the potential to simultaneously affect all of western Oregon, potentially crippling the statewide transportation network with roadway outages over a widely dispersed area, and (2) the Klamath Falls area is the only region of the state with known significant seismic hazard that is not at a significant level of risk from the CSZ event.

A Cascadia Subduction Zone event has the potential to simultaneously affect all of western Oregon, potentially crippling the statewide transportation network.

Local, near-surface fault events in other areas of western Oregon were not included in this study for the following two reasons: (1) we are looking at the relative vulnerability of roadways; adequate information to determine the relative vulnerability of various roadways west of the Cascades is obtained from the CSZ evaluation alone; and (2) the available information on the location and relative risks of surface faults is not sufficient to distinguish the level of hazard on one roadway relative to another in a way that would justify a choice about which one has better value as a lifeline.

4.1.3 Data Sources

The main sources of data used to analyze the seismic vulnerability of each highway segment are as follows:

- **ODOT GIS Database.** ODOT has developed an Oregon highway systems database that includes GIS data on jurisdictional boundaries, population, locations and seismic vulnerabilities of public buildings, locations of unstable slopes, and the statewide tsunami inundation boundary.
- **DOGAMI References.** DOGAMI has produced numerous references that address geologic hazards statewide.
- **U.S. Geological Survey (USGS) Seismic Hazard References.** USGS has documented seismic hazards throughout the United States under their national seismic hazard mapping project. This includes a database of all known potential active faults and folds (which are potential sources of earthquakes), as well as estimates of uniform hazard ground shaking on bedrock.

- **Risks from Earthquake Damage to Roadway Systems (REDARS2) Data.** The ODOT-funded Portland State University research project to use the REDARS2 software to evaluate the seismic vulnerability of the highway system in western Oregon has produced significant data on the vulnerability of the bridges within the study region.

In addition to these databases, DOGAMI and the Federal Emergency Management Agency have conducted evaluations of the potential impacts of a major seismic event in Oregon, and these studies were used to glean pertinent information about seismic hazards and vulnerabilities of the Oregon highway system.

The following are additional sources of information used to evaluate routes:

- Local knowledge of CH2M HILL staff who have lived and worked in these regions
- Interviews with key maintenance and technical staff at ODOT
- Interviews of technical and field staff at DOGAMI
- Public mapping databases, including aerial photographs, digital terrain models (DTMs), and transportation GIS databases

4.1.4 Accuracy and Precision of Available Data

The goal of the seismic vulnerability assessment was to use the best available data to make informed and rational seismic lifelines route decisions at the current time. A complete and thorough engineering evaluation would require a much larger project and longer timeframe than is currently prudent. However, the available data is believed to have been judiciously used to enable the development of reasonable criteria and procedures for selecting a backbone system of seismic lifeline routes that will meet ODOT's needs.

The goal of the seismic vulnerability assessment was to use the best available data to make informed and rational seismic lifelines route decisions at the current time.

Only during the last 15 years have comprehensive efforts been undertaken to compile statewide hazard and vulnerability data addressed in this study, including data on bridge seismic vulnerabilities, existing landslides, and predicted tsunami inundation zones. Most of these studies have been either comprehensive (statewide) but imprecise, or precise but not comprehensive.

Some statewide information (for example, the landslide data) has been compiled from various sources and is based on varied data-gathering technologies and data-evaluation methods. Therefore, the data are highly variable and are not precise or consistent as a whole. Some older statewide or region-wide data have been used in this project in place of more recent site-specific information to provide a platform to make relative comparisons (rather than absolute measures) of seismic risks along various candidate lifeline routes.

4.2 Vulnerability Assessment Methodology

This section describes the methodology for analyzing potential highway damage levels, bridge vulnerabilities, roadway grade vulnerabilities, and other vulnerabilities.

4.2.1 Bridge Vulnerabilities

Bridges are primarily vulnerable to the following seismic hazards:

- Ground shaking, which can results in structural damage of the bridge elements

- Liquefaction, which can result in movement or failure of the abutments and/or the bridge piers
- Tsunamis that can scour or result in large loads on bridge piers and abutments and, if high enough, can damage the bridge superstructure
- Landslides that can undermine a bridge
- Coseismic deformation, which can result in the bridge being below design sea level

The assessment of bridge vulnerabilities to ground shaking hazards was based on the results of the REDARS2 analyses, which have been developed consistently across the study region and are currently the best available and most-complete data for assessing bridge vulnerabilities. The REDARS2 vulnerability assessments were based on a few indicative parameters, such as location, ground motion, year of construction, and bridge configuration and materials of construction. The HAZUS bridge evaluation methodology (slightly modified to calibrate it to the bridge damage levels seen in the Northridge Earthquake) that is currently used in REDARS2 and the results of its application to the study region bridges have not been verified with detailed seismic vulnerability assessments. However, it is believed that these results represent the best available data and are sufficient for use in the seismic vulnerability assessment to make planning decisions about the best routes to include in a seismic lifeline backbone system for the study region.

REDARS2 reports each bridge at Damage States 1 through 5, with 1 being no damage and 5 being collapse. Bridges reported as Damage States 1 (no damage) and 2 (cosmetic damage) are considered to have low structural seismic vulnerability and are not counted in any of the bridge resilience criteria evaluations. Bridges reported as Damage State 3 (minor repairable damage) are considered to have moderate structural seismic vulnerability and are counted in the bridge resilience criteria evaluations pertaining to short-term effects. Bridges reported as Damage States 4 (major damage) or 5 (collapse) are considered to have high structural seismic vulnerability and are counted in the bridge resilience criteria evaluations pertaining to short-term and long-term effects.

The results of the REDARS2 analysis are expected to be relatively accurate for the bridge population as a whole, but not necessarily accurate for any specific bridge.

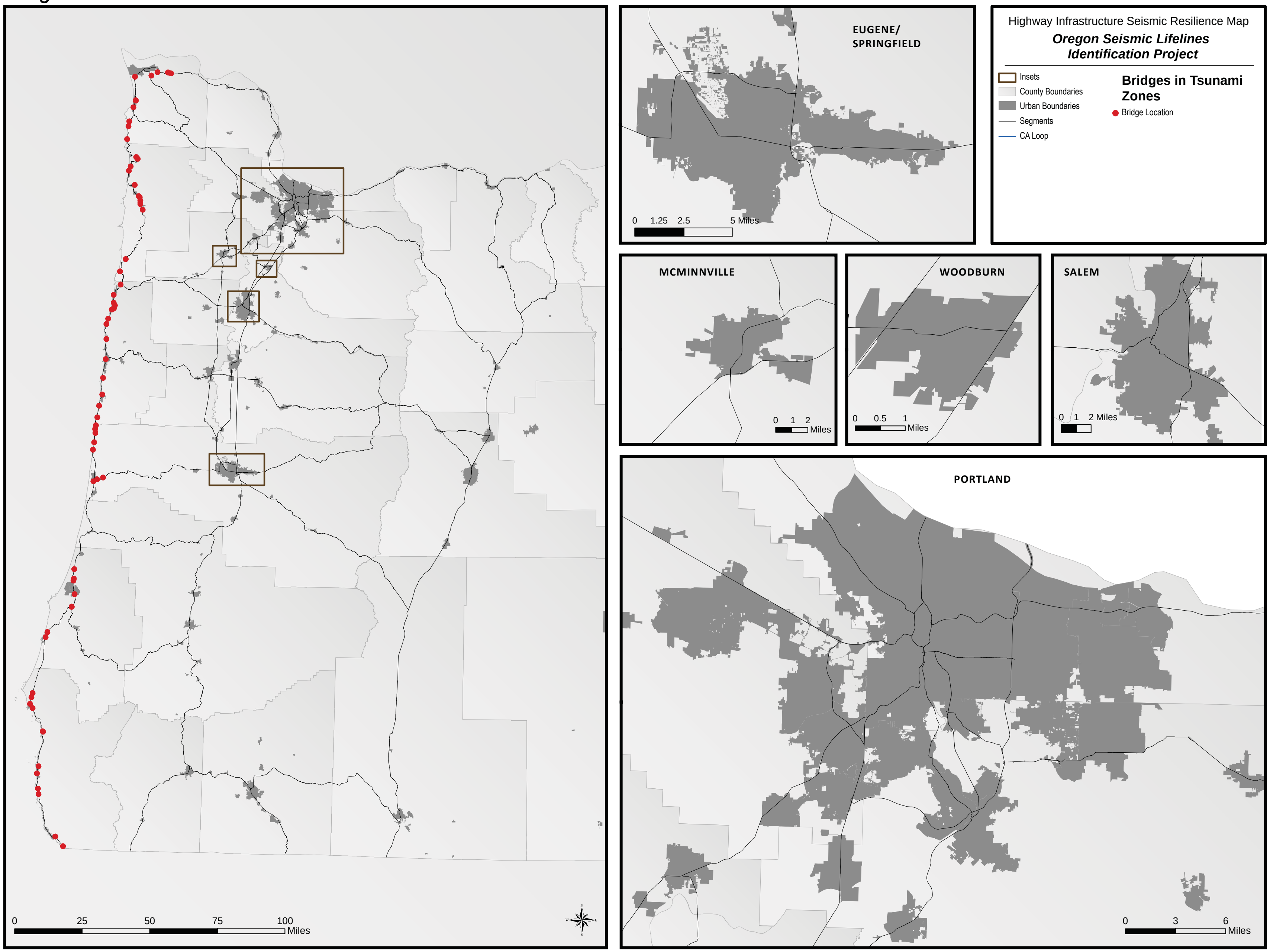
The results of the REDARS2 analysis are expected to be relatively accurate for the bridge population as a whole, but not necessarily accurate for any specific bridge. Assessment of the seismic vulnerability of specific bridges requires detailed engineering analysis of the structural details and geotechnical conditions of each bridge site. This sort of detailed analysis is beyond the capabilities of the REDARS2 software and requires more data than are readily available for the entire population of bridges in the study.

The coseismic deformation hazard has been included in the roadway seismic vulnerability assessment but not in the bridge vulnerability assessments because the effects of the coseismic deformation hazard are not necessarily influenced by the bridge structure. Instead, the effects are more related to the roadway elevation.

Detailed information about liquefaction risk is readily available for only a few bridge sites. Therefore, the liquefaction risk to bridges has been based on an assessment of geologic formations and the presence of surface water.

Tsunami hazards were assessed by using the information published by DOGAMI, which is discussed in the next section. Bridges located within tsunami inundation zones are shown in Figure 4-1.

FIGURE 4-1
Bridges in Tsunami Zones



4.2.2 Roadway Grade Vulnerabilities

Roadway grades are vulnerable to the following seismic hazards:

- Ground shaking, which can result in structural damage of roadway elements, including culverts, retaining walls, and abutments
- Liquefaction, which can result in movement or failure of the slopes and ground under and adjacent to the roadway
- Landslides, which can results in failure of the slope above the roadway and/or failure of the slope below the roadway (Landslides may be new or reactivated because of seismic shaking. Landslide potential is most prominent in the Coast Range and Cascade Mountains, although landslide hazards are also located near alluvial channels. Landslides above a road may lead to the blockage of a road from debris buildup, or landslides below a road may result in loss of road grade.)
- Tsunamis, which can scour or deposit debris on the roadways making them inaccessible
- Coseismic deformation, which can result in the roadway grade being below design sea level

Several sources of data used to evaluate the roadway grade hazards are described as follows.

ODOT GIS Database Layers

The ODOT GIS database was used to evaluate the landslide hazard, as well as the liquefaction hazard with the following GIS layers/databases:

- unstable_slopes: A layer that indicates a point location for noted unstable slopes was used to evaluate the landslide hazard.
- wb_oregon and statewide_wetland: These layers provide an indication of bodies of water and wetland areas. Given that liquefaction requires saturated soils, the presence and proximity to these features was used in providing an indication of liquefaction hazard.

DOGAMI References

The following DOGAMI references were used to collect data related to the landslide, liquefaction, and tsunami hazards:

- **Active Slope Data.** Databases on active and potentially active slopes in western Oregon were used to evaluate the landslide hazard. These include the recently compiled SLIDO 2 database, which is a statewide landslide database, and a map of potentially rapid moving landslides in western Oregon. Although this information is not specifically for seismic sources, documenting existing landslides can give an indication of the potential for seismic induced landslides. These databases are based primarily on coarse-scale DTMs, but some data are based on a much more-detailed light detection and ranging (LiDAR) evaluation. Therefore, despite anticipation that the data may not be correct, they were used to evaluate the relative landslide hazard among various routes. The active slope data were aggregated with the western Oregon regional seismic hazard assessments and USGS topographic maps to provide an overall rating of landslide vulnerability along each segment.
- **Geologic Mapping Data.** Geologic mapping of surficial (surface) soil formation was used to assess the liquefaction hazard. It is well documented that younger (Holocene) and recent fill soils are much more prone to liquefaction than are older soil deposits.

- **Western Oregon Regional Seismic Hazard Assessments.** Ground shaking, liquefaction, and landslide hazards have been estimated and mapped for many counties and most metropolitan areas in western Oregon. These hazard maps were used in assessing the liquefaction and landslide hazards.
- **Tsunami Hazard Estimates.** Tsunami run-up and inundation boundary estimates and coseismic deformation mapping along the Oregon coast were used to assess the tsunami and coseismic deformation hazards.
- **Topographic Mapping.** Topographic mapping based on the recently completed LiDAR surveys in several regions of western Oregon were used in assessing landslide hazards.

USGS Data

The USGS topographic maps were used to help assess landslide hazards. Topographic maps are generally based on publically available DTMs. These maps were used in combination with DOGAMI data to determine an overall level of landslide vulnerability for each segment.

Many of the previously listed data sources (such as landslide and tsunami) alone do not completely represent the referenced hazard. One major concern for the seismic vulnerability assessment is that the selection of routes by using multiple data sources from the previously listed agencies could be made based on inconsistent data. An example would be deciding that one route from the valley to the coast is less vulnerable because of the information contained in the DOGAMI landslide database SLIDO 2; when in reality, the routes may have equal risk, but one route was evaluated with more-detailed information (for example, LiDAR data instead of DTM data). To mitigate this possibility, the induced landslide risk from a seismic event along each route has been developed by aggregating the data from different sources and applying engineering judgment to produce a map of risk zones for use by the OSLR project. The project also used as many duplicate sources of information for each hazard as are available, to minimize the potential for the results to be driven by one data source; for example, the landslide risk was assessed by using topographic information, DOGAMI SLIDO 2 database, and the “unstable_slopes” information from ODOT.

To make use of the USGS topographic map data in the evaluation framework for identifying seismic lifelines, the landslide hazards have been quantified with a single measureable parameter. This parameter for landslides is the total miles of landslide-vulnerable roadway. Initially, a number of variables were considered in an attempt to qualify the relative risk of the landslide zones. These variables included items such as distance from the roadway, distance above or below the roadway, and type of landslide deposit. However, the project team found that the differentiation of risks between slides and segments was not significant enough to warrant taking this information into account in the final assessment. Figure 4-2 is a map showing areas of landslide vulnerability.

For liquefaction, the liquefaction risk and water boundary data were reviewed and liquefaction risk of high, moderate, or low was assigned to each zone. In the assessment of liquefaction hazard to roadways, only the miles of segment passing through areas of moderate or high vulnerability were tabulated for each segment to derive the overall total miles of liquefaction susceptibility. These same zones of moderate and high risk for liquefaction vulnerability were used to assess the bridge liquefaction risk. Figure 4-3 is a map showing areas of liquefaction risk.

Tsunami vulnerability is simply measured as the length of roadway within the tsunami inundation zone. The lengths of roadways within tsunami zones are shown in Figure 4-4.

Coseismic subsidence vulnerability has been quantified as the length of roadway that has the potential to be below the highest measured tide after a seismic event. Figure 4-5 identifies these low-elevation roadways. In addition to susceptibility to coseismic subsidence, these low-elevation roadways are very likely to experience tsunami inundation and, given their proximity to the groundwater level, are likely prone to liquefaction.

FIGURE 4-2
Landslide Hazards

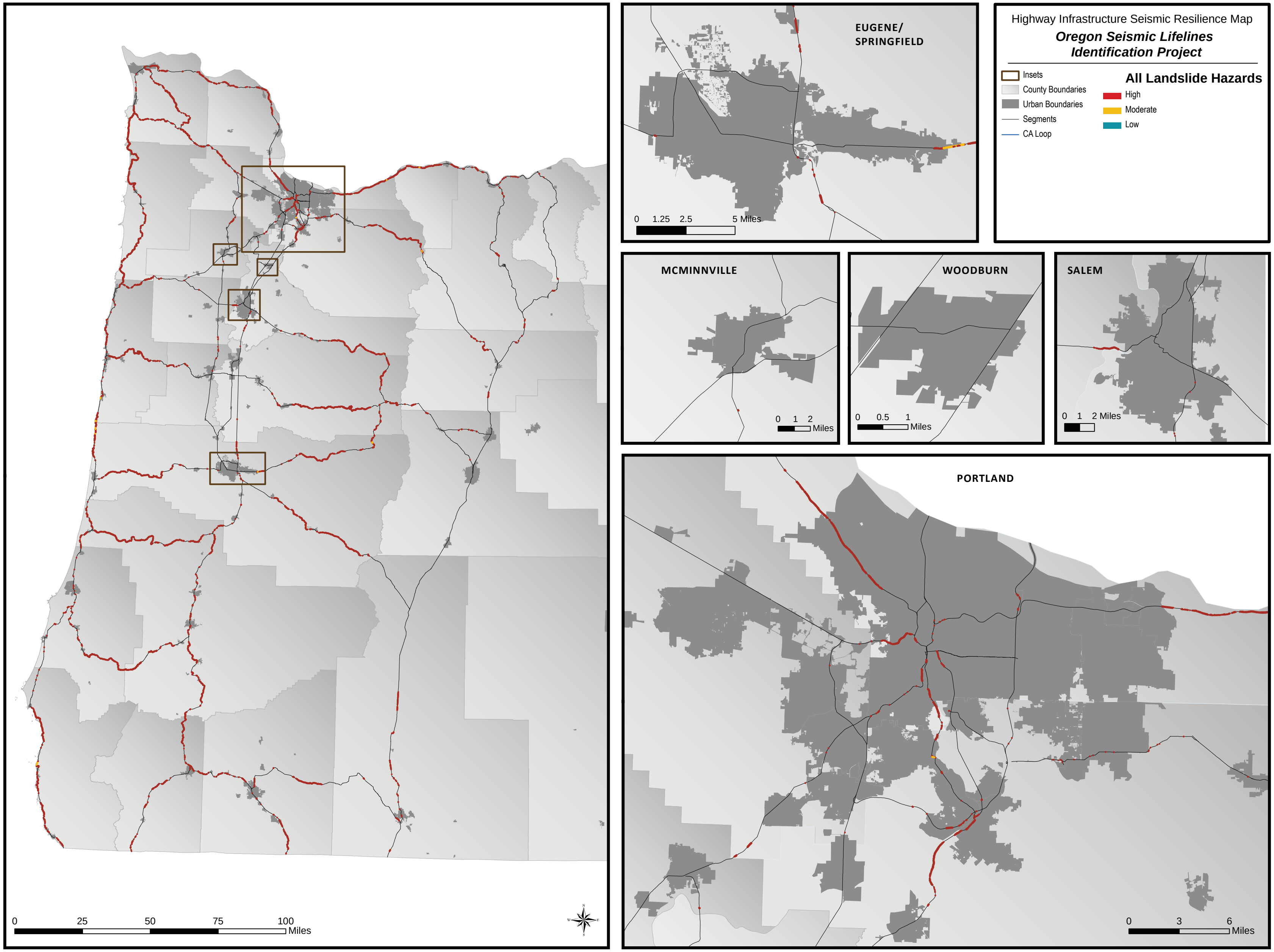


FIGURE 4-3
Liquefaction Vulnerability Zones

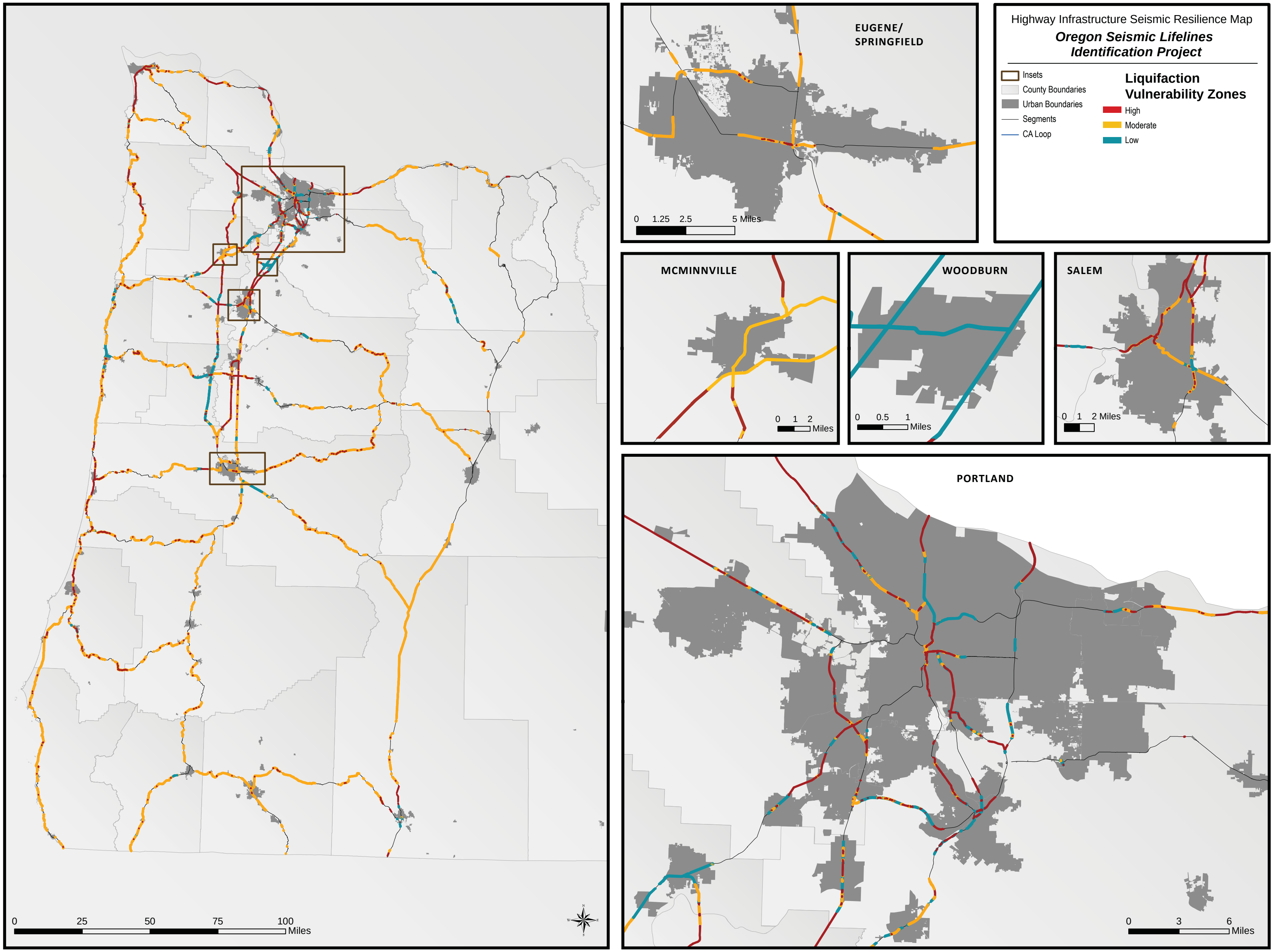


FIGURE 4-4
Tsunami Zones

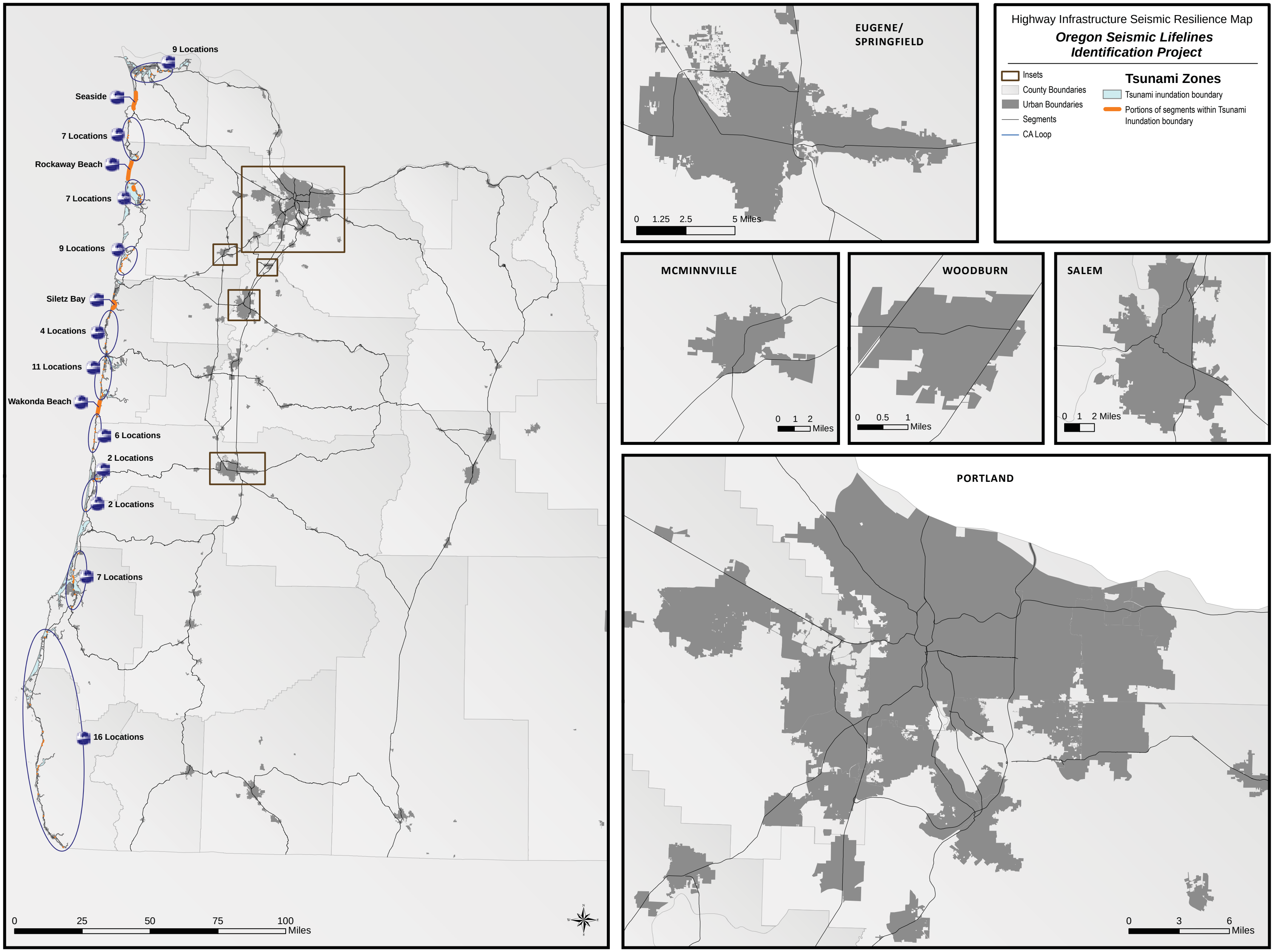
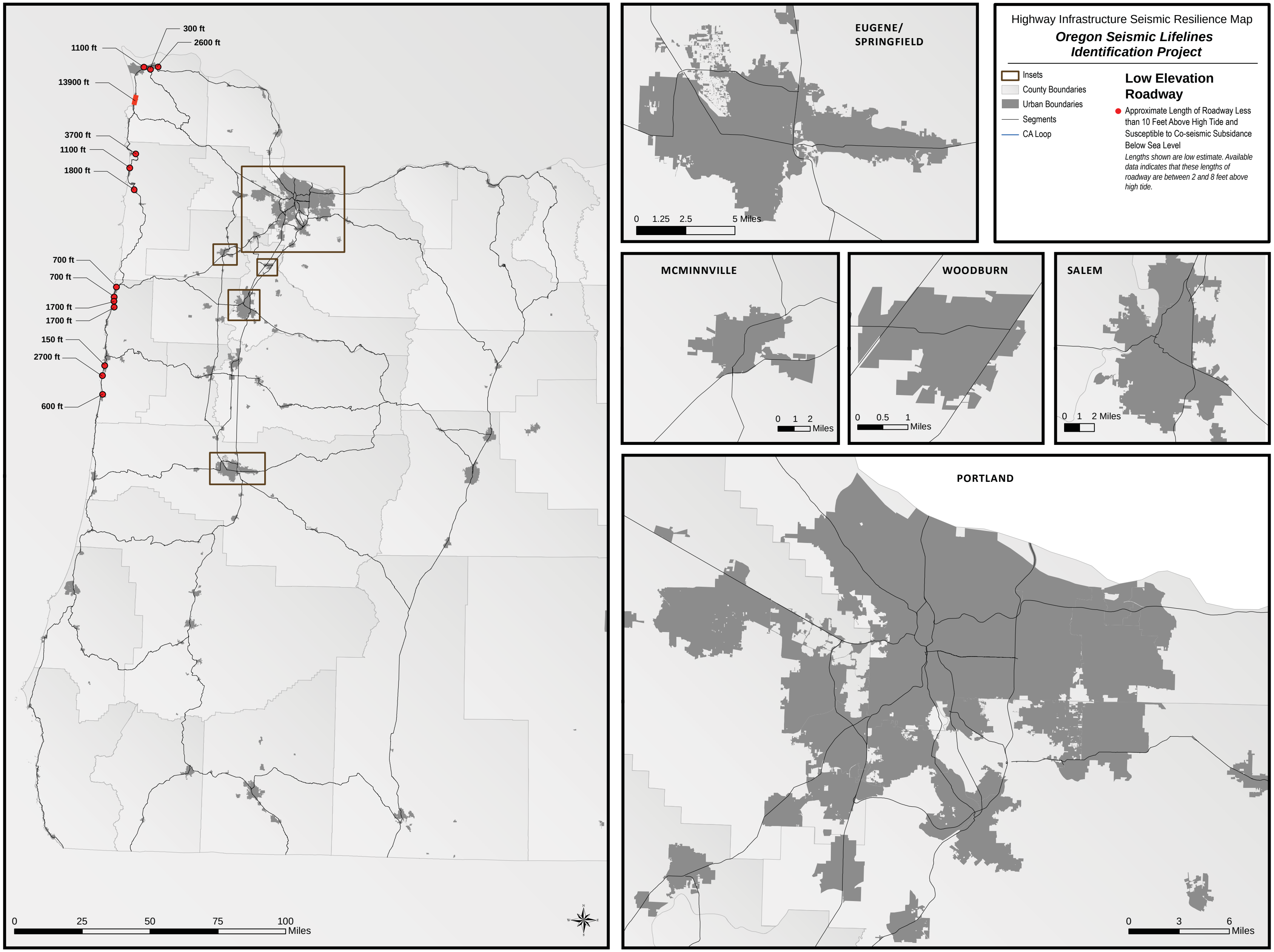


FIGURE 4-5
Low Elevation Roadways



4.2.3 Other Vulnerabilities

Tunnels generally perform well in seismic events; however, some amount of rock fall and structural damage is likely, particularly at portals. The length of tunnels along each segment has been tabulated. Figure 4-6 identifies tunnel locations in the study area.

Dams can pose significant risk to roadways because of releases of large volumes of water that can wash out roadway grades and scour out bridge foundations. This sudden release of water could be due to a dam failure, intentional rapid drawdown in response to structural damage, or overtopping due to a landslide into the upstream pool. Furthermore, rapid drawdown of water levels can also cause slope failures upstream of the dam along the edge of the reservoir. Dams are classified according to risk level based on the height of the impounded water surface, the volume of water retained by the dam, and the downstream conditions. The three classification levels include High, Significant (this is less than High), and Low. By definition, High and Significant Hazard Dams pose some risk to downstream roadways, while the risk to downstream human infrastructure from Low Hazard Dams is minor or non-existent. Figure 4-7 shows all "High Hazard" and "Significant Hazard" dams in the study area and identifies dams (and associated downstream waterways) that potentially pose a risk to a study route roadway or bridge. An engineering evaluation of the seismic vulnerability of these dams and potential damage due to water release has not been performed; the dams identified in this study are those that have a potential to pose a risk.

In all cases, only one segment was noted to be at risk per dam, in spite of the fact that some dam failures could cause damage on multiple downstream study route segments. In general, the segments farther downstream will be at lower risk due to attenuation of the flood wave and the fact that the farther downstream waterways and crossings generally have a larger capacity. Future engineering evaluations of the risks to lifelines should include the effects on all downstream lifeline routes.

The vulnerability of roadway-supporting structures other than bridges, such as culverts and retaining walls, has not been directly addressed. Generally, these roadway elements are at risk of seismic damage to the same degree and in the same locations as the roadway grade; therefore, the roadway risks described above from landslide and liquefaction are taken as proxies for the risk to these elements for the purpose of identifying seismic lifeline routes.

In addition to performance of the highway system, the performance of other interdependent lifelines is critical to post-earthquake response and recovery. The evaluation of the seismic performance of these interdependent lifelines was beyond the scope of the OSLR project; however, the connectivity of the highway system to these lifelines was included in the connections criteria discussed previously. Future assessments of transportation infrastructure needs related to the overall statewide response and recovery to seismic events should include evaluations of the following issues:

- **Ports, Airports, and Rail Infrastructure.** While connection to ports, airports, and rail facilities were considered in this assessment, the seismic mitigation needs of such facilities were not.
- **Utilities.** Utilities include potable water and wastewater, fuels, telecommunications, and electricity. Utility lifelines are often collocated along highway corridors, and their locations along highway corridors could be (but have not been) considered here in prioritizing lifeline improvements.
- **Hazardous Material Sites.** Damage to nearby facilities that use and store hazardous materials and have the potential for toxic materials releases could affect post-earthquake travel along highway lifeline corridors.

FIGURE 4-6
Tunnels

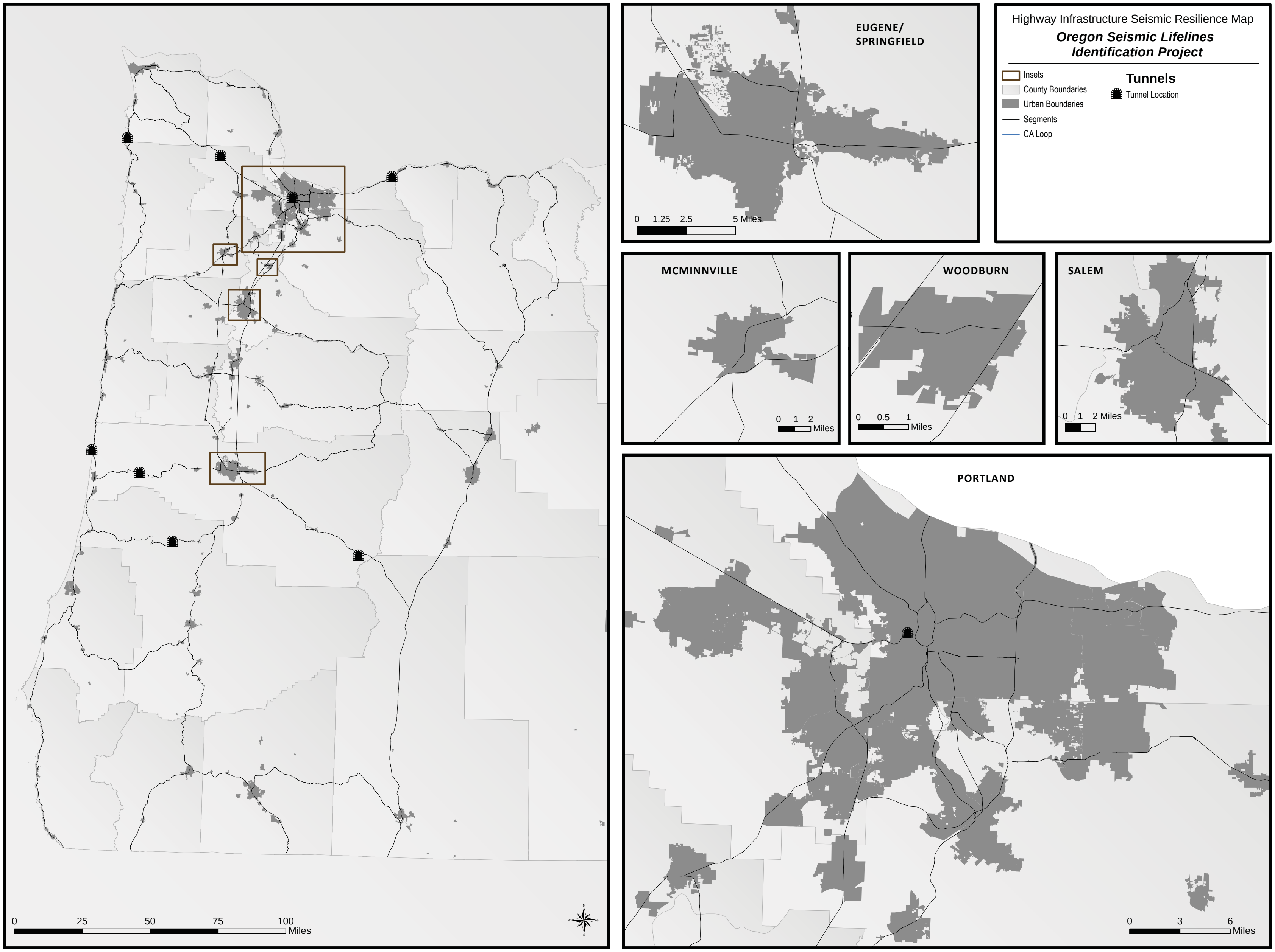
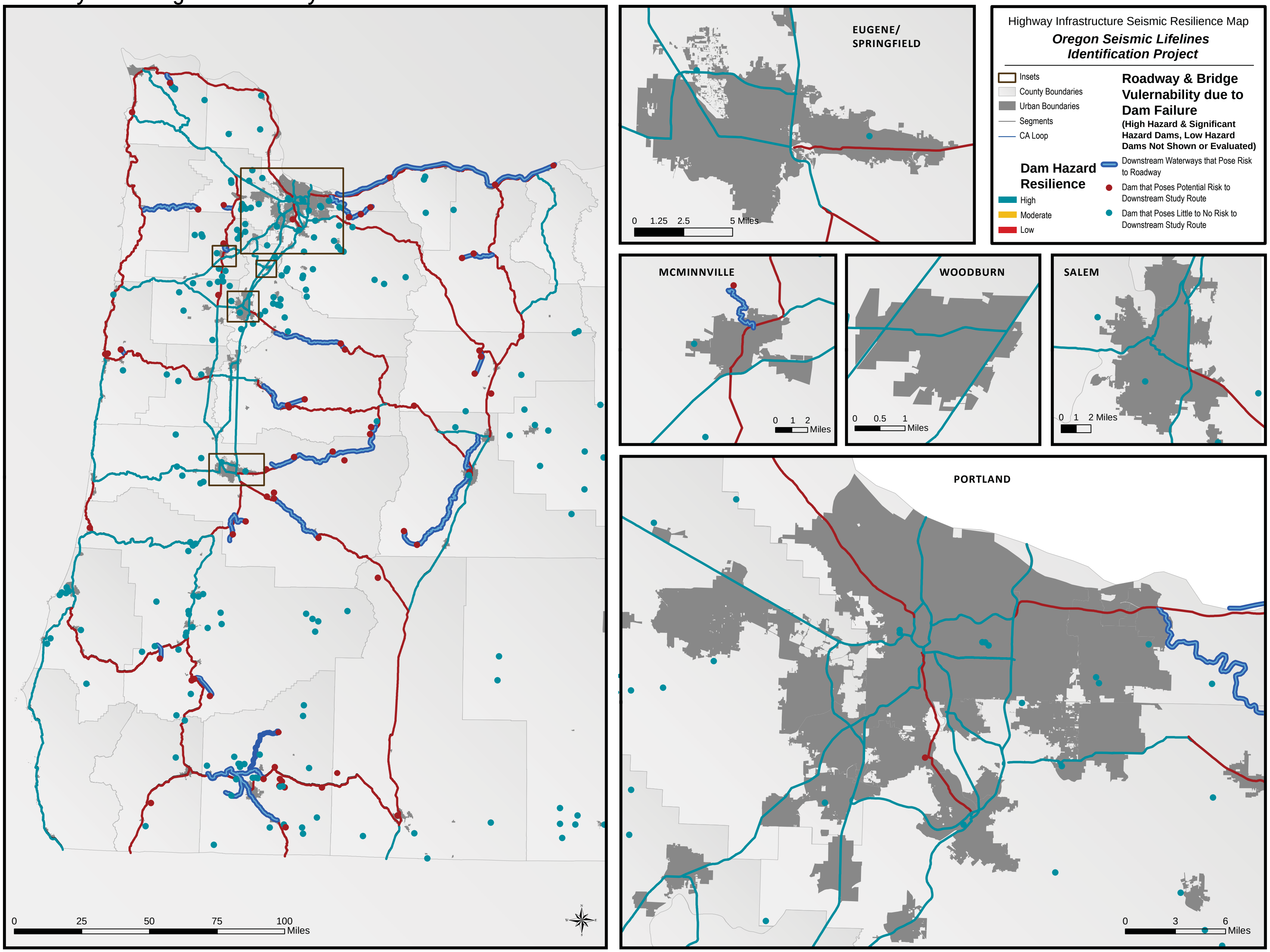


FIGURE 4-7
Roadway and Bridge Vulnerability to Dam Failure



4.2.4 Resilience Criteria

Resilience Criteria Rating

All previously discussed criteria (for connections and capacity) have been rated against an absolute level of performance. For the resilience criteria, the performance of an individual segment is rated relative to other segments. These comparisons are made primarily with respect to the segments within each geographic zone. Comparison within a geographic zone is more useful than a statewide comparison because the seismic hazard is not uniform across the state and the comparison needs to focus on roadways that serve relatively the same function for statewide transportation purposes (for example, there is no need to compare the seismic performance of a road in the Coast Range to that of a road in the Cascade Mountains).

For the bridge and roadway resilience criteria, the ratings are based on the statistical distribution of the risk parameter measurements within the geographic zones. Risk parameter measurements result in a high rating below the 33rd percentile, a moderate rating between the 33rd and 67th percentiles, and a low rating above the 67th percentile. For the criteria addressing dam safety, the presence of a risk results in a low resilience rating and segments without that risk are rated high. No moderate ratings exist for the dam safety resilience criteria.

The results of these seismic vulnerability assessments and resilience criteria ratings are provided in Appendix F.

Bridge Seismic Resilience

The purpose of this criterion is to evaluate the ability of the bridges on the roadway segment to survive the seismic event without affecting the flow of traffic immediately after the conclusion of ground shaking. The project team determined that this criterion should be a function of structural performance, liquefaction risk, and tsunami inundation. The overall bridge risk on each segment, as a function of these different parameters, has been quantified with a bridge risk index. This index is a summation by roadway segment of the following:

- **Bridges Likely to be Closed or Destroyed**. Number of bridges that carry the roadway segment, with Damage States of 3, 4, or 5. At Damage States 3 and 4, the damage may or may not be evident to drivers to the extent that they would not attempt to cross the bridge, but the damage is likely to be significant enough that a bridge inspector would close the bridge to traffic.
- **Overcrossing Bridges Likely to Collapse and Block the Roadway.** Number of bridges that cross the roadway segment with Damage State 5. Bridges with lower damage states may not be usable for traffic, but are not expected to collapse onto the roadway below and would therefore not cause a blockage to traffic on the roadway segment in question.
- **Bridges in Above Categories that can be Bypassed.** Any bridges in the two categories identified previously that can be bypassed by an immediate and direct detour, such as an at-grade freeway diamond interchange, are subtracted from the total.
- **Bridges Likely to be Closed or Destroyed Due to Foundation Failure Resulting from Liquefaction.** Half of the bridges on the segment located in a high liquefaction risk zone and one quarter of the bridges in a moderate liquefaction risk zone are added to the bridge risk index; these adjustments to the bridge risk index are made because even when it occurs, liquefaction does not necessarily cause catastrophic damage.

- **All Bridges in a Tsunami Inundation Zone.** Some bridges in tsunami inundation zones are very large, with roadway surfaces far above the top of the highest expected tsunami wave; therefore, they are less vulnerable to catastrophic damage than small bridges that could have their superstructures carried away by a tsunami wave. However, these large bridges are still at risk of structural foundation damage or scour. Because no previous work quantifying these risks has been performed, all bridges that are within or cross the footprint of the designated tsunami inundation zones have been included in the bridge risk index.

Because bridges can be counted more than once, and fractions of bridges are counted with respect to liquefaction, this risk index is not a measure of the number of bridges expected to be damaged in the seismic events being evaluated, rather, it is a measure of the relative risks to bridge structures on one roadway segment compared with another.

Forty-three segments ranked high for this criterion, 32 ranked moderate, and 34 ranked low. Figure 4-8 depicts the ranking of each segment for this criterion.

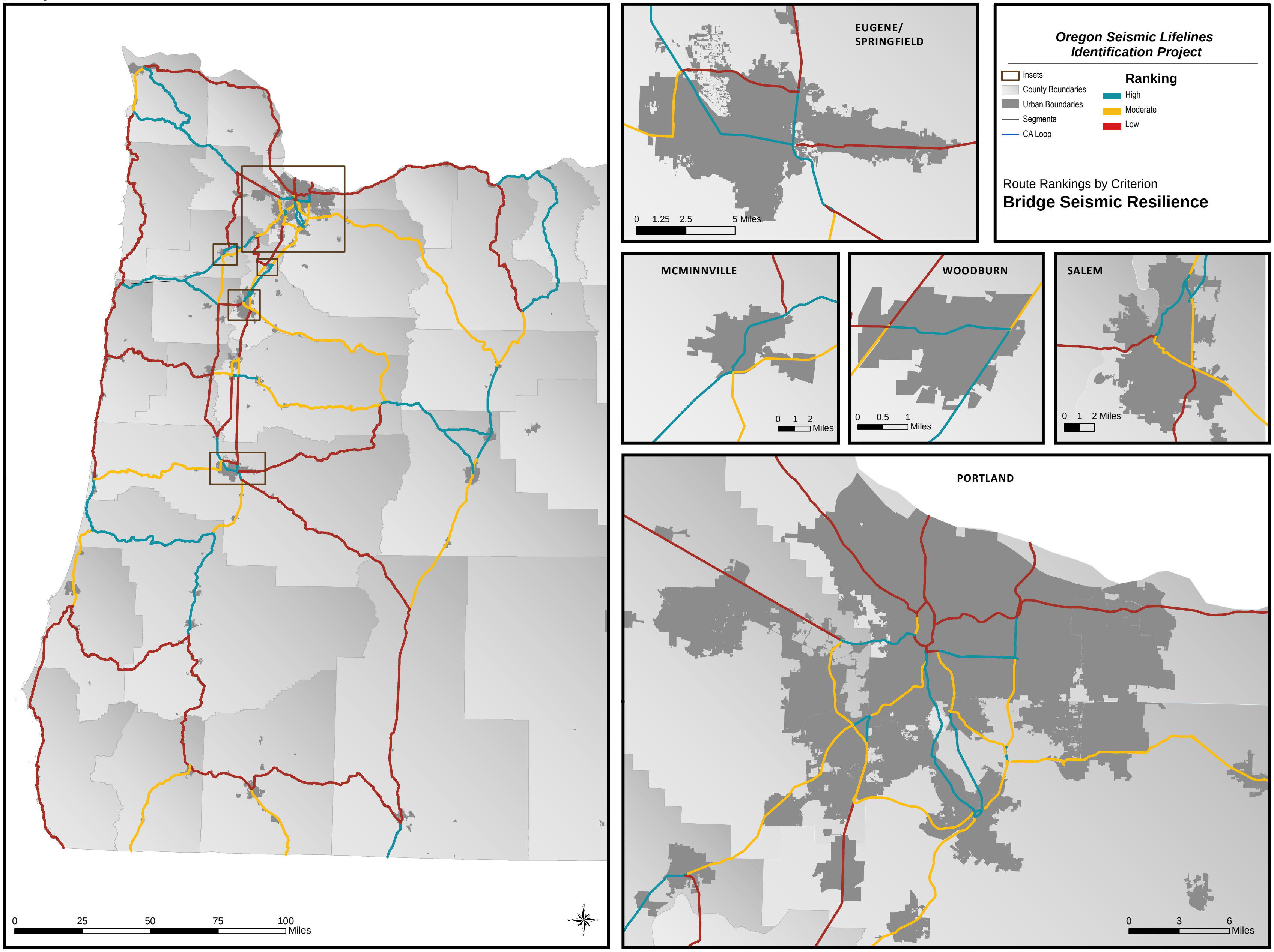
Bridge Seismic Resilience after Short-term Repair

The purpose of this criterion is to evaluate the ability of the bridges on the roadway segment to survive the seismic event without affecting the long-term flow of traffic. The project team determined that this criterion should be a function of structural performance, liquefaction risk, and tsunami inundation. Although the previous criterion for bridge resilience was concerned with short-term blockages of the roadway, the length of bridge was not relevant to that criterion because a roadway blockage is the same regardless of the length. For this criterion, the issue is the amount of time, money, and effort that would be required to open the roadway to traffic; therefore, the length of bridge outage is relevant because it takes much less time to replace a short bridge than a long bridge.

The overall long-term bridge closure risk on each segment has been quantified with a bridge risk index composed of structural performance, liquefaction, and tsunami inundation parameters. Bridges that can be bypassed on available short detours are not subtracted from this index as they are in the short-term index discussed previously because detours and at-grade intersections of major roadways would have an impact on economic recovery and therefore do not fully negate the negative economic recovery impacts resulting from the bridge outage. Bridges that cross the roadway segment in question are not counted because debris from the bridge can be cleared from the roadway in question in a short timeframe. This index is a summation by roadway segment of the following:

- Bridges Likely to Need Replacement or Major Reconstruction: Total length of bridges that carry the roadway segment and have damage states of 4 or 5. At Damage States 4 and 5, full reconstruction of the bridge is likely to be required.
- Bridges Likely to Need Replacement or Major Reconstruction Due to Foundation Failure Resulting from Liquefaction: One-quarter of the bridges on the segment located in a high liquefaction risk zone and one-eighth of the bridges in a moderate liquefaction risk zone (this is half of the liquefaction vulnerable bridges counted in the short term bridge risk index).
- Half of the Bridges in a Tsunami Inundation Zone: As stated previously, no work has been performed to quantify the risk of damage to these bridges, and these numbers are included as a measure of the relative risk on each roadway segment. Therefore, like the liquefaction counts, the numbers of bridges at risk for long-term impact from tsunami inundation are taken to be one half the numbers used for the short-term impact.

FIGURE 4-8
Bridge Seismic Resilience



Thirty-nine segments ranked high for this criterion, 33 ranked moderate, and 37 ranked low. Figure 4-9 depicts the ranking of each segment for this criterion.

Roadway Seismic Resilience

This criterion measures the ability of the roadway to allow the free flow of traffic immediately after the seismic event and is a function of the measured risks from landslides, liquefaction, tsunami inundation, and tunnel damage. The overall risk to the roadway is quantified with a roadway risk index that is the sum of the lengths of roadway that are vulnerable to damage from each of these hazards. As with the bridge resilience criterion, the roadway risk index is not a prediction of the amount of roadway expected to be damaged (some segments are counted twice); rather, it is a measure of the relative risk of blocking damage along the route.

Thirty-seven segments ranked high for this criterion, 35 ranked moderate, and 37 ranked low. Figure 4-10 depicts the ranking of each segment for this criterion.

Roadway Seismic Resilience after Short-term Repair

This criterion measures the ability of the roadway to serve long-term transportation functions—resilience against damage that takes longer than a few weeks to repair. The only parameter measured in the evaluation of this criterion is the length of roadway susceptible to coseismic subsidence below high tide.

Another parameter that could be measured to evaluate this criterion is the length of roadway susceptible to very large landslides; however, this parameter was not included because consistent information about this risk throughout the study area was not available.

One hundred three segments ranked high for this criterion, four ranked moderate, and two ranked low. Figure 4 11 depicts the ranking of each segment for this criterion.

Dam Safety

Roadways that are at risk of bridges or road grades being washed out by upstream dam failures are rated low; roadways that are not at risk are rated high.

Seventy-nine segments ranked high for this criterion and 30 ranked low. Figure 4-7 depicts the ranking of each segment for this criterion.

FIGURE 4-9
Bridge Seismic Resilience After Short-Term Repair

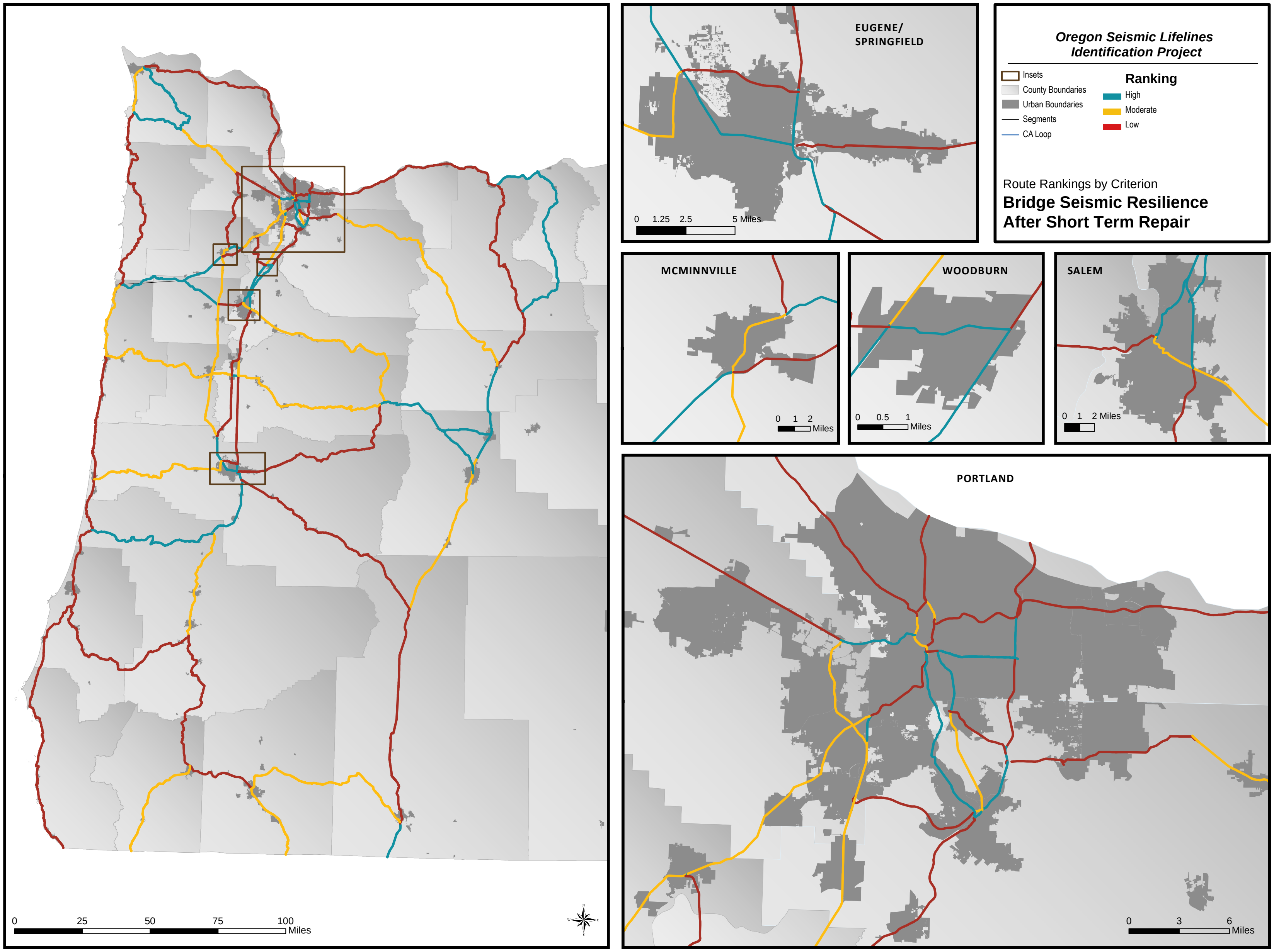


FIGURE 4-10
Roadway Seismic Resilience

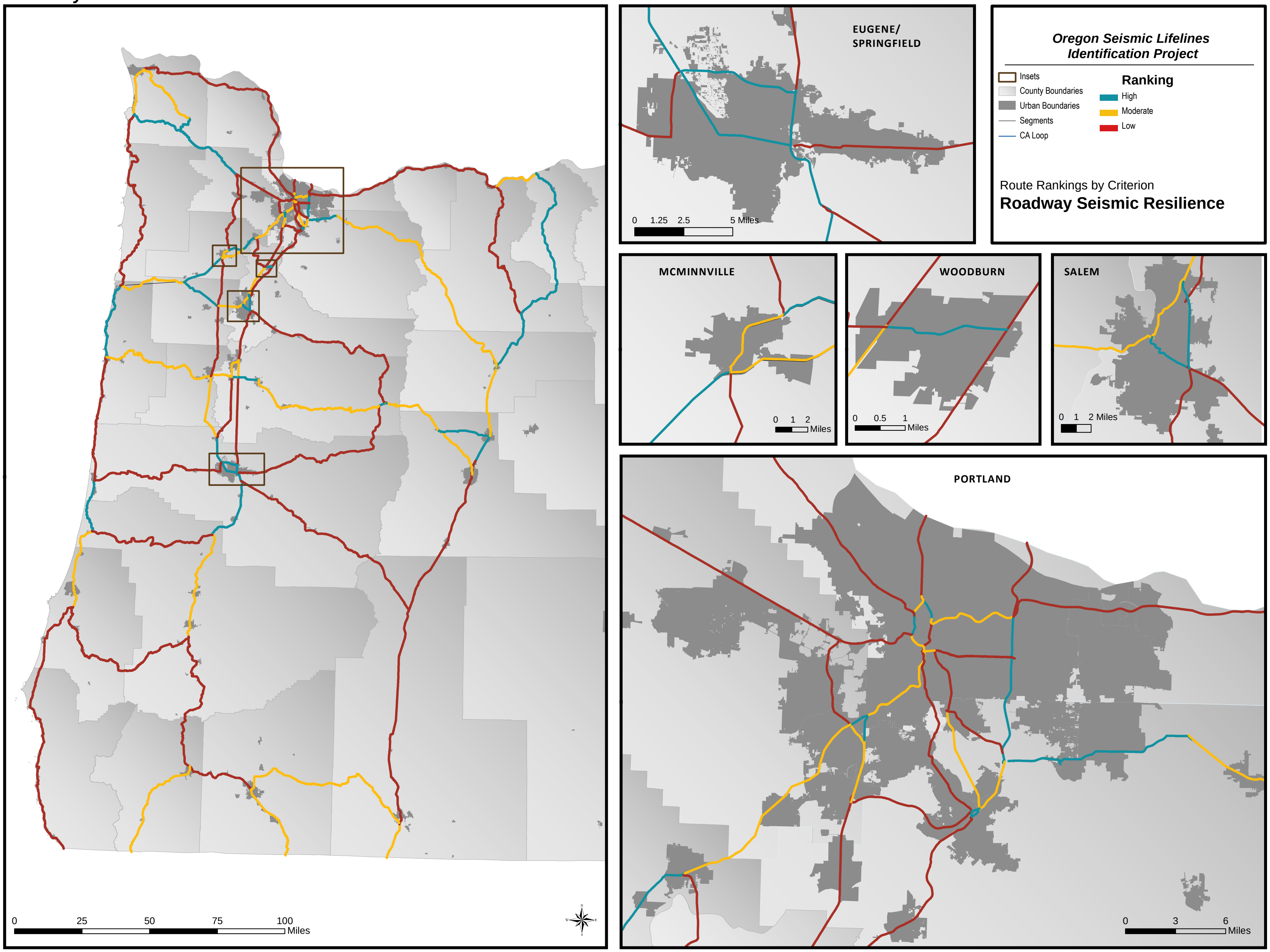
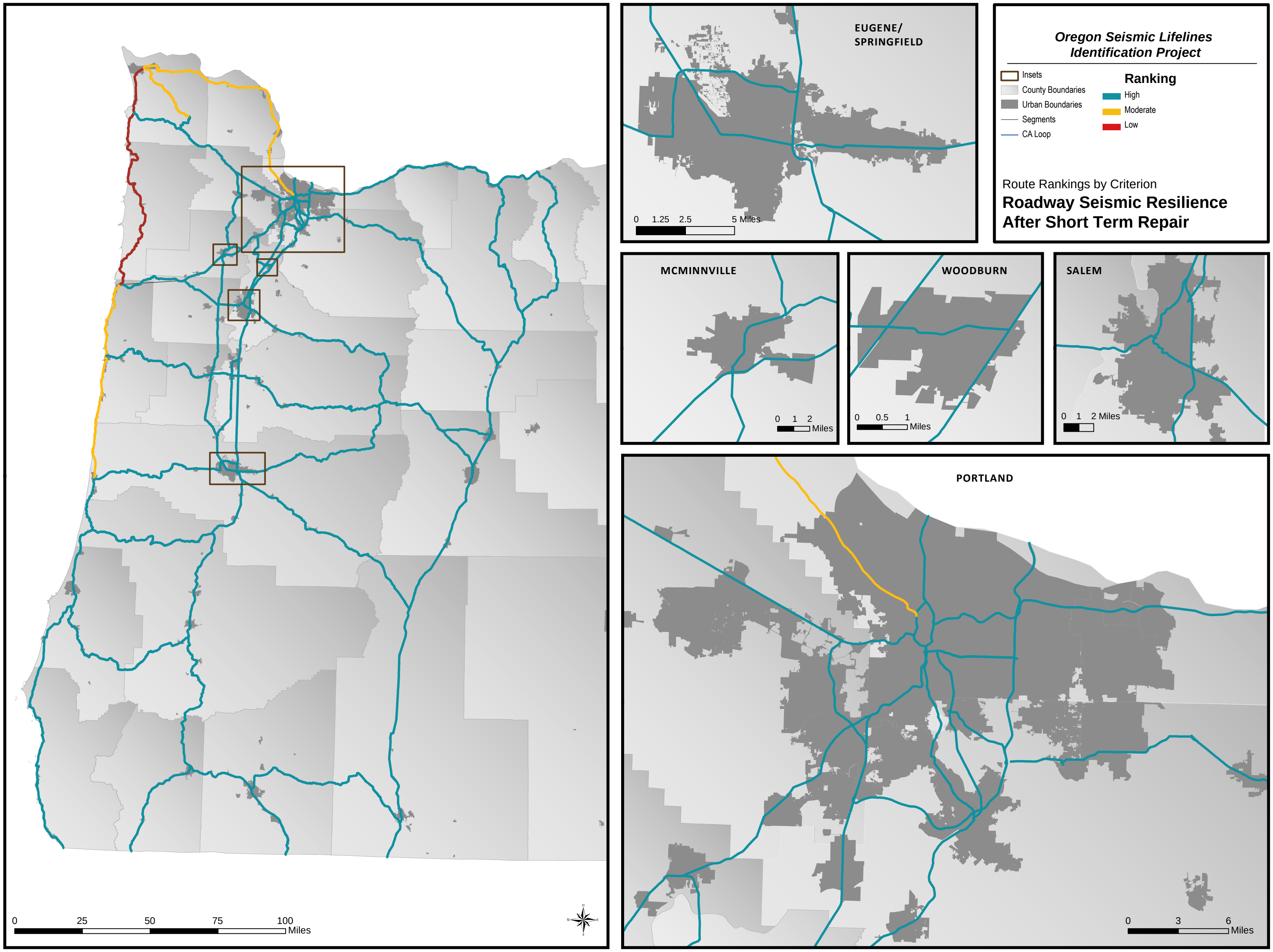


FIGURE 4-11
Roadway Seismic Resilience after Short-Term Repair



5.0 Evaluation Framework Weighting Scenarios and Route Ratings

The relative performance of routes can be evaluated with respect to any individual scoring parameter or criterion. The performance of routes can then also be evaluated for each objective, each goal, and the overall evaluation framework by weighting and aggregating performance ratings for the respective criteria in each. Additionally, the performance of routes can be evaluated by weighting and aggregating ratings for other groupings of criteria.

The weighting and aggregating of performance ratings was accomplished by first assigning a value of 1, 2, or 3 for the ratings low, moderate, and high, respectively. If all criteria were equally important, final ratings could be developed by averaging all criteria. If the criteria are not of equal importance, weighting factors can be applied, as appropriate, to each criterion. Weighting factors for a single criterion can vary for different objectives and criteria groupings.

Members of the PMT provided weightings for the goals, objectives, and criteria within the evaluation framework, as well as weightings for each of the 21 individual criteria independent of the evaluation framework. The weightings from each PMT member were averaged to develop a draft weighting system for the evaluation framework and the list of criteria. Appendix H identifies the PMT average weighting.

The weighting developed by the PMT—for both the evaluation framework and the list of criteria—gives more importance to the connections criteria (the purpose the roadway serves) than to the resilience or capacity criteria (the cost that may be required to ensure the roadway serves its purpose). The percentages of weight given to the criteria and groupings of criteria can be seen on the left and bottom of the page in Appendix H that shows the weights.

For the purpose of providing an alternate evaluation to this PMT weighting, the consultant team developed an alternative weighting scenario that emphasized resilience criteria over connections (this alternative weighting scenario is also shown in Appendix H). The SC reviewed both scenarios and instructed the PMT to use its weighting scenario that focused on connections as the primary criteria for development of the lifeline system. The alternative weighting for the evaluation framework was approved to be used where it provides valuable information for the final identification of lifeline routes. For example, for two routes that have the same or nearly the same rating for the PMT weighting, the route that rates higher with the criteria emphasizing resilience, as reflected in the alternative weighting, may be the best option to select as a lifeline because it may have lower cost for seismic retrofit and/or earthquake damage repair.

The result of the evaluation framework weighting is a rating of each individual roadway segment with respect to the other segments within each geographic zone. These ratings have been combined with other relevant factors for the evaluation, identification, and prioritization of lifeline routes. Other relevant factors include pertinent information about the route not captured or not weighted appropriately by the evaluation framework for the route and/or geographic zone being considered.

The primary factor not evaluated by the framework is network connectivity. A simple example of the need to include network connectivity can be seen in the evaluation of I-5 where most segments rate high or moderate and a few segments are rated low. Low ratings on I-5 are primarily due to the segment being entirely in a rural area, which leads to low ratings on a number of factors like connections to centers of commerce, access to hospitals, etc. Obviously, these low ratings on connectivity criteria are not relevant to the function of these segments of I-5, which serve as the primary interstate route, and in all cases the low rated segments of I-5 are preferable to available alternate routes. Therefore, all of I-5 is identified as a Tier 1 Lifeline, even though some of the individual segments are not rated high with respect to the PMT weighting of the evaluation framework.

Another example of a relevant factor to consider that is not included in the evaluation framework is length of route.

Relevant factors to consider can also be criteria that are part of the evaluation framework, but which may be particularly significant to the segment in question and therefore deserve a higher weighting. Examples of this include segments that provide the only access to a critical facility such as a major airport or fuel depot.

Another example of an evaluation framework criterion being considered outside of the framework is illustrated by the hypothetical case of two alternate routes. Suppose that Route A rates better than Route B on most factors, but each by only a slim margin; however, Route A has a dozen large bridges at risk of collapse and Route B has none. In this case, Route B is likely the better option to identify as a higher-ranked lifeline route due to the potentially much lower cost of ensuring seismic resilience, in spite of the fact that all three methods of weighting the evaluation criteria could show Route A rated better than Route B.

A discussion of the evaluation, identification, and prioritization of each segment using the evaluation framework and other relevant factors follows in Section 6.

6.0 Seismic Lifeline Routes

6.1 Overview and Definitions of the Tiers

Given the existing vulnerabilities of our built environment in Oregon, the many seismic hazards in the natural environment, and the geographic spread of the population, it is quite likely that nearly every roadway in the western half of the state would be needed to serve as a lifeline following a major CSZ event. As the years go by and the effects of age and use require the rehabilitation or replacement of our existing transportation infrastructure, the system will become more seismically resilient as those rehabilitations and replacements are accomplished according to design standards that take into account these recently identified seismic hazards. However, if a CSZ Mw 9.0 were to occur today, it is possible that nearly every state highway in Western Oregon would be impassible, possibly severely limiting ground transportation for many months. A program to immediately (within the next few years) retrofit all seismic lifeline routes in western Oregon to current design standards is likely beyond our means as a society to accomplish. Even if the State were to embark on a program of rapid seismic strengthening of the entire transportation system, it would be prudent to begin where the most benefit is accomplished in the least time for the least cost.

After a catastrophic earthquake, it is anticipated that ground transportation will be supplemented by air and water transport as necessary to address the most-critical needs. Air and water transportation services are much more limited in capacity and availability than ground transportation; consequently, the shorter the distance from a functioning ground transportation system to the area of need, and the fewer numbers of people in need, the more likely it is that the available air and water transportation vehicles and infrastructure will be able to meet all needs.

A prioritized seismic lifeline system should attempt to provide the following three functions:

1. First and foremost, it should provide access to and through the state, allowing access to the seismically vulnerable areas of the state (study area) for emergency responders and economic recovery.
2. Secondly, it should attempt to provide access into each region of the state.
3. Lastly, it should serve as a transportation network that provides redundant access throughout the state.

The PMT used the results of the evaluation framework and a review of system connectivity and key geographic features to identify a three-tiered seismic lifeline system—Tier 1 being the highest priority roadway segment, Tier 2 being the next highest, and Tier 3 being the third highest priority grouping. It is intended that seismically resilient infrastructure along each lifeline route tier would accomplish the three goals listed above and would consist of the following:

- Tier 1: A system that provides access to and through the study area from Central Oregon, Washington, and California, and provides access to each region within the study area
- Tier 2: Additional roadway segments that extend the reach of the Tier 1 system throughout seismically vulnerable areas of the state and that provide lifeline route redundancy in the Portland Metro Area and Willamette Valley
- Tier 3: Roadway segments that, together with Tier 1 and Tier 2, provide an interconnected network (with redundant paths) to serve all of the study area

The purpose of having three tiers of lifeline routes is to establish guidelines for prioritizing seismic retrofits of highways and bridges with the highest priority roadways being those that provide the most critical linkages necessary to serve the greatest number of residents in the study area, at the lowest investment of time and money. Ideally, as discussed previously, vulnerabilities along all three tiers of lifeline routes (as well as the remainder of public transportation facilities statewide) should be addressed. Recognizing potential cost restrictions, use of this tiered system is intended to provide the State of Oregon with guidance for identifying project priorities. It should be noted that this lifeline system is intended to serve statewide transportation needs, not to directly access all locations in the state. Planning for the needs of individuals and local communities is the responsibility of statewide, regional, and local agencies, whose core mission is emergency planning and response. As local response and recovery plans are developed, it is recommended that local earthquake preparation efforts include recognition of the state lifeline routes and could include evaluation of local roadways with a methodology similar to that used here.

The following sections define each tier and describe the recommended tier system within six geographic areas.

6.1.1 Tier 1

The routes identified as Tier 1 are considered the most significant and necessary to provide a functioning statewide transportation system. A functioning Tier 1 lifeline system will allow traffic to flow through the study area and to each region. Required characteristics of the Tier 1 system are as follows:

- Contiguous (all segments connected, with no isolated segments or groups of segments) connection to each geographic region of the study area with access to the most populous areas in those regions
- Access to the most-critical utilities required for statewide response and recovery (in particular fuel depots)
- Access from the east to the most-seismically vulnerable regions of the state
- Redundant crossings of the Willamette River in Portland
- Minimization of cost of retrofit and/or repair (fewest number of routes with least vulnerabilities that provide characteristics in the preceding bullets)

6.1.2 Tier 2

The Tier 2 lifeline routes provide additional connectivity and redundancy to the Tier 1 lifeline system. The Tier 2 system would allow for direct access to more locations, fewer miles to travel between some locations, increased traffic volume capacity, and alternate routes in high-population regions in the event of outages on the Tier 1 system. Requirements for this tier include the following:

- Contiguous (all segments connected, with no isolated segments or groups of segments)
- Redundant routes to provide circulation within the Portland Metro Geographic Zone and north-south movement within the Willamette Valley
- Minimization of cost of retrofit and/or repair (fewest number of routes with least vulnerabilities that provide characteristics in the preceding bullets)

6.1.3 Tier 3

The Tier 3 lifeline routes provide additional connectivity and redundancy to the lifeline systems provided by Tiers 1 and 2.

Together, the Tiers 1, 2, and 3 lifelines will comprise the Oregon Seismic Lifeline System and will accomplish the following:

- Include all of US 101 to provide access to all of the Oregon coast (the most-seismically vulnerable regions of the state)
- Include routes that have been identified as providing access to the most-critical utilities (the final seismic lifeline system includes all segments identified as providing access to critical utilities, except those providing access to power generation facilities on the Santiam and McKenzie rivers).
- Include all routes that have been identified as providing access to emergency response staging areas
- Include all routes that have been designated as strategic freight corridors or freight facilities
- Provide alternate routes between any two nodes that connect two or more segments (any node that is not a dead end)
- Minimize cost of retrofit and/or repair (fewest number of routes with least vulnerabilities that provide characteristics in the preceding bullets)

6.1.4 Study Routes Not Identified as Seismic Lifeline Routes

Several routes included in the study, as listed in Section 2.1, have not been identified as seismic lifeline routes on the statewide Seismic Lifeline Route System. Although these routes may be important for local circulation during a seismic event, they are not likely to function as key corridors on a statewide level. Several of these routes have more-significant and extensive vulnerabilities than do adjacent routes that can serve the same purpose in a statewide system. All of these routes are less favorable than routes included in the Seismic Lifeline Route System with respect to a variety of evaluation framework criteria.

6.2 Proposed Oregon Seismic Lifeline Routes

6.2.1 Seismic Lifeline Tier Designations

Figure 6-1 shows the proposed seismic lifeline routes with tier designations.

The proposed Tier 1 lifeline network shown provides roadway access to within about 50 air miles of all locations in western Oregon. Significant factors in the designation of each study route are discussed as follows by geographic zone. Total roadway miles for each tier are as follows:

- Tier 1: 1,146 miles
- Tier 2: 705 miles
- Tier 3: 422 miles

This provides a total of 2,273 miles of designated lifeline route. Study routes not identified as a seismic lifeline total 298 miles.

Figure 6-2 presents an overlay of the lifeline system on the peak ground acceleration coefficients used for the evaluation of bridge resilience in this study.

FIGURE 6-1
Oregon Seismic Lifeline Routes

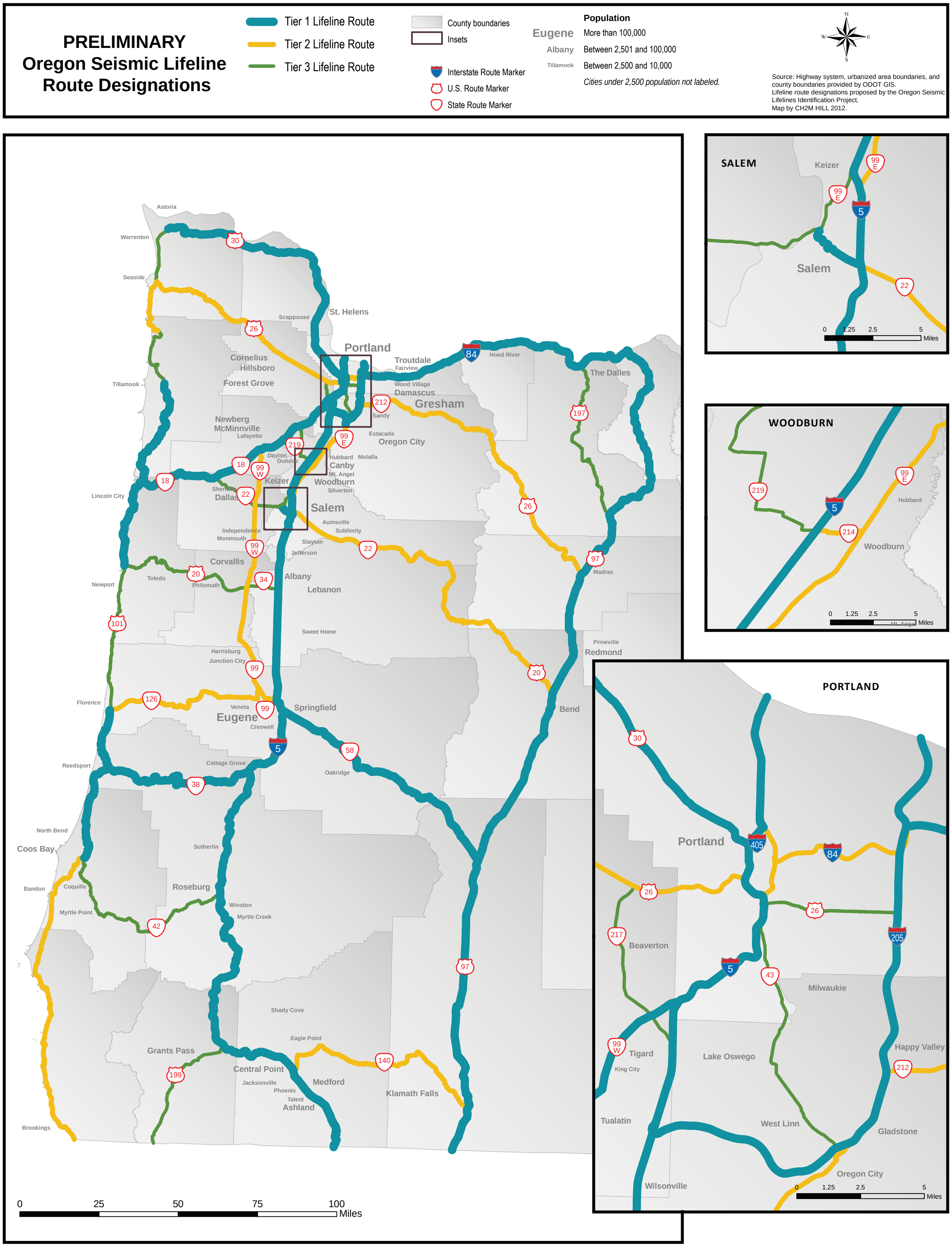


FIGURE 6-2
Lifeline Routes and Seismic Risk

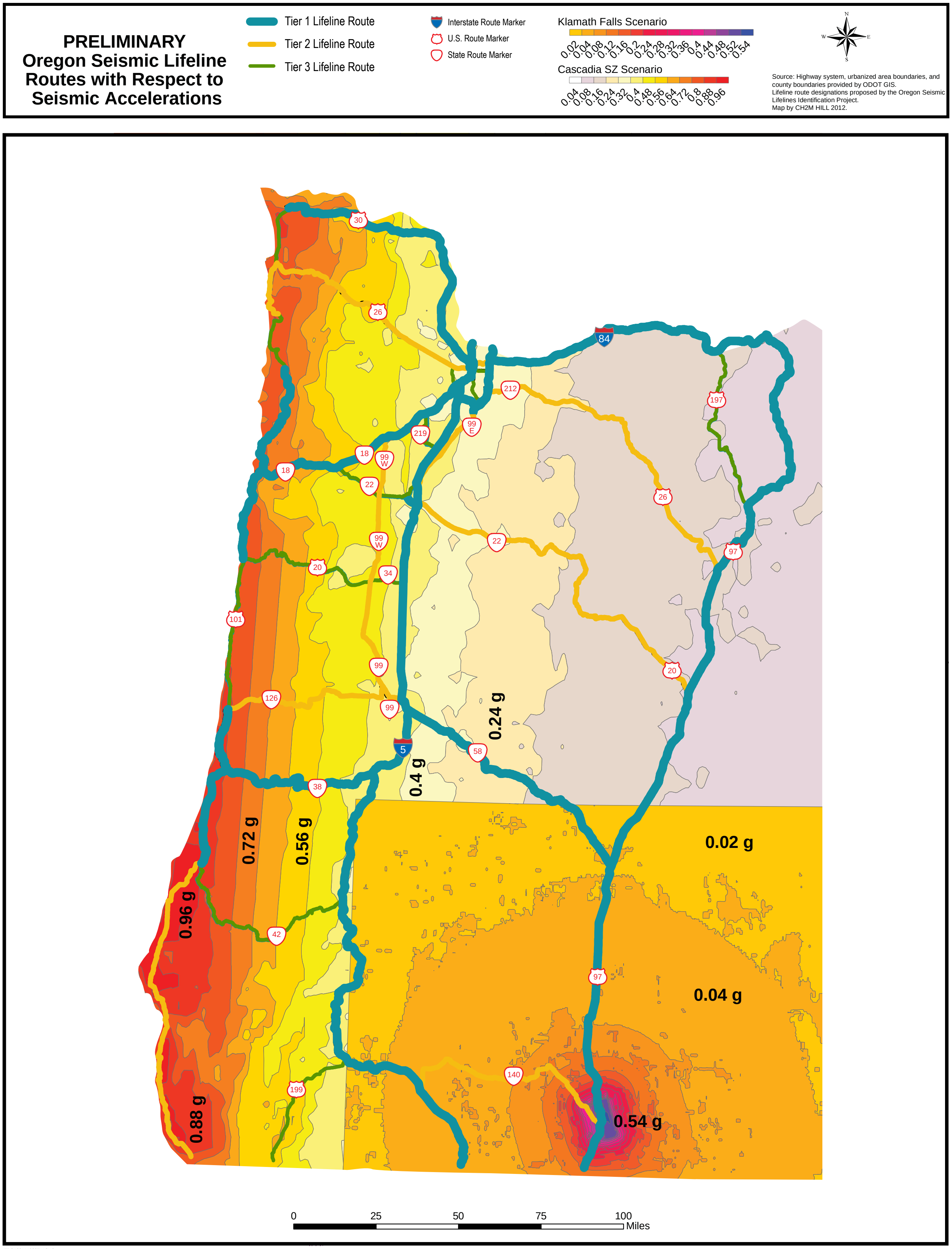


Table 6-1 contains a tabulation of lifeline roadway miles within three classifications of peak ground acceleration (PGA) coefficients, by tier for the CSZ seismic event. These CSZ PGA zones generally correlate to geographic areas with the high acceleration zone being the coast and Coast Range mountains, the moderate acceleration zone the inland valleys, and low acceleration zone the Cascades and central Oregon.

TABLE 6-1
Lifeline Roadway Length by CSZ Seismic Acceleration Zone and Tier (Miles)

CSZ PGA Zone	Approximate PGA (g)	Tier 1	Tier 2	Tier 3	Total
High	0.56 – 0.96	217	211	236	664
Moderate	0.24 – 0.48	540	313	127	979
Low	0.08 – 0.16	389	181	59	630
Total		1,146	705	422	2,273

6.2.2 Lifeline Corridor Definition

In the following discussion, the roadways selected to serve as lifeline routes are referred to as corridors since it is not intended that the identified state highways be used as seismic lifeline routes to the exclusion of other alternatives in the same vicinity. Future seismic vulnerability evaluation and remediation prioritization efforts are likely to identify least cost alternatives for providing a seismically resilient route that include detours off of the identified roadway to bypass critical seismic vulnerabilities. Therefore, the term “corridor” is used to denote that the identified highway, along with easily accessed adjacent roadways as necessary, are intended to serve as the seismic lifeline route.

Future efforts to identify possible detours around seismic vulnerabilities should take advantage of the information available in emergency closure response plans such as the “Pre-Identified Detour Routes for I-5” documents that are available in District Manager offices. Once this information has been reviewed and detailed seismic vulnerability assessments have been conducted, the exact route along specific roadways can be identified within the designated lifeline route corridors and the seismic retrofit needs can be prioritized. However, it is assumed that the final seismic lifeline routes will consist primarily of the roadways identified in this study.

6.2.3 Coast Geographic Zone

The Coast Geographic Zone is the most-seismically vulnerable geographic zone and is the most difficult to access because of geographic constraints. Although it could be argued that the critical post-earthquake needs of the region should dictate that all routes be Tier 1, this is not necessary to meet the statewide transportation goals (listed previously) that govern the identification of Tier 1 routes. Specifically, the conditions of US 101, the extent of the area being studied and limited resources make it infeasible to plan on being able to drive the full length of US 101 or being able to cross the Coast Range on all of the east-west study routes in this zone, nor is this necessary to accomplish the goals and provide the characteristics of the Tier 1 lifeline system. The reality is that the vulnerabilities are so extensive on these routes that the majority of the cost of making the entire lifeline system acceptably resilient is associated with this region. Because of the high vulnerability of the zone, it is paramount that emergency services and recovery resources can reach this zone from other zones. Consequently, the consensus of the PMT and SC was that all needs are best served with a Tier 1 backbone system selected according to the criteria described in Section 6.1.

Tier 1

The Tier 1 system in the Coast Geographic Zone consists of the following three separate access corridors:

- OR 30 from Portland to Astoria
- OR 18 from the Valley to US 101 and north and south on US 101 from Tillamook to Newport
- OR 38 from I-5 to US 101 and north and south on US 101 from Florence to Coos Bay

Tier 2

The Tier 2 system in the Coast Geographic Zone consists of the following three access corridors:

- US 26 from Portland to US 101 and north and south on US 101 from Seaside to Nehalem
- OR 126 from the Valley to US 101 at Florence
- US 101 from Coos Bay to the California border

Tier 3

The Tier 3 system in the Coast Geographic Zone consists of the following corridors:

- US 101 from Astoria to Seaside
- US 101 from Nehalem to Tillamook
- OR 22 from its junction with OR 18 to the Valley
- OR 20 from Corvallis to Newport
- OR 42 from I-5 to US 101
- US 199 from I-5 to the California border

Segments Considered but Not Designated as Lifelines

The only state highways in the Coast Geographic Zone not designated a seismic lifeline are OR 103 and OR 202 from US 26 to Astoria. In spite of significant vulnerabilities on many of the routes, all other segments in the Coast Geographic Zone have been selected to be seismic lifelines because of their wide geographic distribution and the at-risk populations they serve.

Tier Designation Discussion

North Coast (Astoria to Tillamook). A special evaluation of the three possible routes from Portland to Astoria was performed by using the evaluation framework. In this evaluation, the parameters for each segment along each alternate route were summed, and then the evaluation framework methodology was applied to each alternate route composed of the combined segments. Because this analysis showed OR 30 was preferable by most measures, this highway was designated Tier 1.

US 101 from Astoria to Seaside has significant vulnerabilities in the areas of the bay crossing at Astoria and the low-lying area in downtown Seaside; therefore, it was designated Tier 3.

The system of US 26 to US 101 down to Nehalem was designated Tier 2. US 101 from Nehalem to Tillamook was designated Tier 3 because of extensive vulnerabilities in the low-lying areas of Nehalem and Tillamook Bays.

OR 102 and OR 202 were included in the study to evaluate alternate access to Astoria, but were found to not provide significant overall benefit compared to the other routes; therefore, these highways were not designated as lifelines.

Central Coast (Tillamook to Coos Bay). Five state highways were evaluated as east-west lifelines through this section of the Coast Geographic Zone. The project team preferred that the Tier 1 lifelines not be adjacent routes.

Of these five east-west highways, OR 42 was rated lower on most measures and significantly lower for bridge and roadway seismic resilience. This is a case where the segment rated marginally better on several criteria and therefore rated well on the PMT Weighted Evaluation Framework, but rated much worse on resilience criteria. This means that significantly more investment would be required to provide adequate seismic resilience on this route than on other alternatives, with little added benefit. Therefore, this highway was identified as a Tier 3 lifeline.

Of the four routes remaining as candidates to serve as Tier 1 lifelines, two serve the northern portion and two serve the southern portion of this central coast area. Of the two northern routes, OR 18 and OR 20, OR 18 has much better resilience ratings. The southern two routes, OR 126 and OR 38, are comparable on most measures. The best-rated sections of US 101 are between Florence and Coos Bay. OR 126 provides access to the north end and OR 38 provides access to the middle of this section of US 101. It is preferable to access the midpoint of a transportation corridor because this location is most beneficial for emergency response and recovery. A midpoint corridor location allows road and bridge repair crews to start in the middle of this section of US 101 and work both ways away from the center, rather than starting at one end and working the length toward the other end. Selection of OR 38 as a Tier 1 lifeline also provides access to the center of this higher-population area (from Florence to Coos Bay), whereas selection of OR 126 would provide access at the northern end of this area, much farther from Coos Bay. Therefore, OR 38 and US 101 north to Florence and south to Coos Bay were designated Tier 1.

Similarly, because of their central position with respect to more resilient portions of US 101, central location between population centers, and higher resilience ratings, OR 18 and the segments of US 101 north to Tillamook and south to Newport were identified as Tier 1 lifelines. OR 18 did not rate well with the PMT Weight Evaluation Framework; however, this is primarily due to the fact that the segment joins US 101 slightly north of Lincoln City and therefore does not rate well on a number of connections criteria, which are not pertinent to its selection as a Tier 1 route given the function it serves and the close proximity of the connection criteria parameters. OR 18 rates better with respect to the criteria rating and the alternative resilience emphasis rating.

Of the remaining two east-west lifelines, OR 26 has the superior seismic resilience; therefore, this highway was designated Tier 2. OR 20 was then designated Tier 3. US 101 between Newport and Florence also was designated Tier 3.

Southern Coast (Coos Bay to California). The only segments in this area are US 101 from Coos Bay to the Oregon/California border and US 199 from I-5 to the California border. The Tier 1 lifeline network extends to the north end of the southern US 101 segment, which rates in the middle range of the coastal segments, and the roadway serves a highly vulnerable and isolated region; therefore, it was identified as a Tier 2 lifeline. US 199 provides a third connection to the California border and has been designated Tier 3 since the I-5 connection is Tier 1 and US 101 is Tier 2.

6.2.4 Portland Metro Geographic Zone

In addition to encompassing the largest population concentration in the state, the Portland Metro Geographic Zone contains many facilities (such as transportation, communication, and fuel depots) that are critical to statewide earthquake response and long-term economic recovery. For these reasons, this zone has a higher concentration of lifeline routes than do the other geographic zones and has redundant Tier 1 crossings of the Willamette River.

Tier 1

The Tier 1 system in the Portland Metro Geographic Zone consists of the following corridors:

- I-5, excluding the section between the northern and southern I-405 interchangesI-405
- I-205
- OR 99W from I-5 to OR 217

Tier 2

The Tier 2 system in the Portland Metro Geographic Zone consists of the following three access corridors:

- I-84
- I-5 between the northern and southern I-405 interchanges

US 26 from OR 217 to I-405Tier 3

The Tier 3 system in the Portland Metro Geographic Zone consists of the following corridors:

- OR 217
- US 26 from I-5 to I-205
- OR 43

Segments Considered but Not Designated as Lifelines

The following segments were considered but were not designated as lifelines:

- OR 224
- OR 99E from US 26 to Oregon City

Tier Designation Discussion

The single-most significant criteria for lifeline tier designations in the Portland Metro Geographic Zone were the known seismic vulnerabilities of the Willamette River crossings and key interchange structures. For these structures, more-comprehensive seismic vulnerability assessments have been performed than those performed within the REDARS2 evaluation. Since these structures are very large, they represent a significant percentage of the lifeline system bridge deck area and, therefore, potential seismic retrofit cost.

The Willamette River crossings evaluated for this study are the I-405 Fremont Bridge, the I-5 Marquam Bridge, the US 26 Ross Island Bridge, and the I-205 Abernathy Bridge. The US 26 route is not a prime candidate for a variety of reasons other than seismic resilience issues, so this leaves the other three routes as potential candidates for the desired two Tier 1 Willamette River Crossings. Of these three, the Marquam Bridge is the most-seismically vulnerable. In addition, the segment of I-5 north of the Marquam Bridge along with the I-5/I-84 interchange includes several structures that have been determined to have severe seismic vulnerabilities. Therefore, the Tier 1 Willamette River crossings are I-405 and I-205. This also provides one crossing in the downtown area and one on the outer edge of the geographic zone.

I-5, with the exception of the segment between the end points of I-405, is designated Tier 1 because it is arguably the most-important transportation corridor in the state and does not have significantly more identified vulnerabilities than any alternate routes.

I-205 is also Tier 1 for its Willamette River crossing discussed previously and since it serves a significant role—providing access to the Portland International Airport, connecting I-5, to the I-84 and OR 212/ US 26 corridors to the east, and connecting to the Washington state border.

I-405 serves the important function of connecting I-5 to OR 30 and the important fuel and communications facilities in that area, as well as containing the Willamette River crossing discussed previously. Therefore, I-405 has been designated Tier 1.

The final Tier 1 segment in the Portland Metro Geographic Zone is a short piece of OR 99W that provides connection from I-5 to the Tier 1 OR 99W segment in the Valley Geographic Zone.

In spite of the critical seismic vulnerabilities, I-5 between I-405 intersections, and I-84 between I-5 and I-205 have been designated Tier 2 due to the critical function they serve in the statewide transportation network.

US 26 in the Coast Geographic Zone was designated Tier 2 and must be connected to the Portland Metro Geographic Zone by a Tier 1 or 2 segment. The two alternatives for this connection are US 26 to I-405 and OR 217 to OR 99W. US 26 rates better on almost every measure and provides a more direct connection to the Tier 1 lifelines and supporting facilities. Therefore, US 26 was designated Tier 1. OR 217 was designated Tier 3 because it provides significant extra capacity through and around the Portland Metro area.

The remaining routes (US 26 from I-5 to I-205, OR 99E, OR 224, and OR 43) pass through the south and east portions of the city. Of these routes, US 26 from I-5 to I-205 and OR 43 rate the best. Because US 26 provides access to some critical facilities, serves as an alternate route to I-84, and provides a fourth Willamette River crossing, it was designated Tier 3. OR 43 provides an alternative to I-5 south on the west side of the Willamette River and was designated Tier 3, with the exception of the short segment of OR 43 from I-205 to OR 99E.

The short segment of OR 43 from I-205 to OR 99E has not been designated a seismic lifeline route because it would be the fifth Willamette River crossing in the Portland Metro Geographic Zone and is adjacent to the I-205 Tier 2 crossing of the Willamette. OR 224 and OR 99E from US 26 to I-205 would not serve significant functions in the statewide transportation network beyond those already provided by other seismic lifelines in the area and therefore have not been designated as seismic lifeline routes.

The short segment of OR 99E from I-205 to OR 43 was designated Tier 2 to connect with the Tier 2 segment of OR 99E in the Valley Geographic Zone.

6.2.5 Valley Geographic Zone

The Valley Geographic Zone generally consists of two or three north-south routes through the Willamette Valley and a variety of east-west connectors between those routes, intended to provide for redundant routes for north-south movement.

Tier 1

The Tier 1 system in the Valley Geographic Zone consists of the following corridors:

- I-5
- OR 99W from I-5 to OR 18 near Dayton
- OR 18 from OR 99W near Dayton to McMinnville
- OR 22 from I-5 to OR 99E in Salem

Tier 2

The Tier 2 system in the Valley Geographic Zone consists of the following corridors:

- US 26 from OR 47 to OR 217
- OR 99W from McMinnville to Junction City
- OR 99 from Junction City to I-5 in Eugene
- OR 99E from Oregon City to I-5 in Salem
- OR 214 in Woodburn from I-5 to OR 99E

Tier 3

The Tier 3 system in the Valley Geographic Zone consists of the following corridors:

- OR 219 from Newberg to Woodburn
- OR 99E in Salem from I-5 to OR 22
- OR 22 from OR 99W to Salem
- OR 34 from Corvallis to I-5

Segments Considered but Not Designated as Lifelines

The following segments were considered but were not designated as lifelines:

- OR 47
- OR 99W from north of Dayton to the south side of McMinnville
- OR 99E from Albany to Junction City
- OR 569 in Eugene

Tier Designation Discussion

Most segments of I-5 in the Valley Geographic Zone rate as well or better than the alternatives. These ratings, as well as the capacity and importance of I-5, justifies a Tier 1 designation for all of I-5 through this zone.

In the McMinnville area, OR 99W and OR 18 were included as alternate routes. The evaluation framework rating was slightly better for OR 18; therefore, OR 18 through McMinnville and OR 99W from near Dayton to I-5 in Tigard were designated Tier 1 to join to the Tier 1-designated OR 18 in the Coast Geographic Zone. With OR 18 through McMinnville designated Tier 1, the adjacent segments of OR 99W do not serve a significant function; therefore, they are not designated as seismic lifeline routes.

The last route in this zone designated Tier 1 is a piece of OR 22 in Salem that connects the state government offices to I-5.

Routes available to serve as north-south travel alternatives to I-5 are OR 99E, OR 99W, and OR 47. OR 99E, from Oregon City to Woodburn, is very significant because it provides a route from the Portland Metro area to points south without a Willamette River crossing. Large river crossings have some level of seismic vulnerability even when constructed to current code requirement. They also do not generally have many alternatives. Because inclusion of routes that do not require large river crossings is preferred in the seismic lifeline system, OR 99E from Oregon City to Salem was designated Tier 2.

On the other side of the valley, OR 99W provides a route from the Portland Metro area to the south valley without large river crossings. Therefore, it was designated Tier 2 from McMinnville to I-5 in Eugene. In the south Valley, OR 99E was included in the study between Albany and Junction City. However, this route has very low seismic resilience and does not serve a statewide transportation function already served by I-5 and OR 99W. Therefore, OR 99E from Albany to Junction City was not designated a seismic lifeline route.

OR 47 could provide additional north-south travel redundancy; however, it did not rate well with respect to many criteria and therefore was not designated as a seismic lifeline.

US 26 from OR 47 to OR 217 was designated Tier 2 to provide a connection to the Tier 2 segment of US 26 in the Coast Geographic Zone.

OR 214 in Woodburn from I-5 to OR 99E was designated Tier 2 because it provides valuable connectivity between those routes in a short distance.

The following routes, which were rated reasonably well and serve to provide additional connectivity between the north-south routes, were designated Tier 3: OR 219 from Newberg to Woodburn, OR 99E in Salem from I-5 to OR 22, OR 22 from OR 99W to Salem, and OR 34 from Corvallis to I-5.

OR 569 in Eugene has very low seismic resilience and was rated lower than the adjacent alternate segment of OR 99; therefore, OR 569 was not designated as a seismic lifeline route.

6.2.6 South I-5 Geographic Zone

The only roadway in this zone is I-5 from Eugene to the California border. All of I-5 in this zone was designated Tier 1 because of the regional importance of I-5, the connection to California, and the lack of alternate corridors.

6.2.7 Cascades Geographic Zone

The Cascades Geographic Zone lifeline routes consist of five crossings of the Cascade Mountains from western to central Oregon. These routes serve to connect the highly seismically affected western portion of the state to the central portion of the state, which is expected to be far less affected by a CSZ event. In addition, the southernmost route can serve as a connection from Medford to the Klamath Falls area in the event of a seismic event in the Klamath Falls area.

Tier 1

The Tier 1 system in the Cascades Geographic Zone consists of the following corridors:

- I-84OR 58

Tier 2

The Tier 2 system in the Cascades Geographic Zone consists of three corridors:

- OR 212 and US 26
- OR 22 from Salem to Santiam Junction and US 20 from Santiam Junction to Bend
- OR 140 and OR 62

Tier 3

No corridors are designated as Tier 3 in the Cascades Geographic Zone.

Segments Considered but Not Designated as Lifelines

The following segments were considered but were not designated as lifelines:

- OR 34 from I-5 to Lebanon and US 20 from Lebanon to Santiam Junction
- OR 126 from I-5 to Santiam Junction
- OR 126 from US 20 to US 97

Tier Designation Discussion

I-84 serves a critical transportation function for the state and rated well; therefore, it was designated Tier 1. The other route that rated well is the OR 212 to US 26 route from Portland to Madras; however, since it is adjacent to I-84 and less significant as a freight corridor and in providing access to critical utilities, it is also designated Tier 2.

The second Cascades Geographic Zone route designated Tier 1 is OR 58. This selection was intended to provide a Tier 1 route from the southern end of the Willamette Valley to central Oregon. OR 58 was preferred over other routes for the Tier 1 designation because of its importance as a freight route and its central location.

The southernmost Cascades route, OR 140 and OR 62, was designated Tier 2 for the access it provides between Medford and Klamath Falls.

The remaining three routes through the Cascades Geographic Zone begin in Salem, Corvallis, and Eugene and converge at Santiam Junction, then continue to Bend on US 20. Because of their relative ratings, in particular their importance to freight, OR 22 was designated Tier 2. OR 34/US 20 was not designated as a seismic lifeline primarily due to its limited capacity to carry freight traffic. OR 126 was not designated a lifeline because it did not provide significant statewide transportation function beyond that already provided by OR 22 and OR 58. US 20 from Santiam Junction to Bend was designated Tier 2 as a continuation of OR 22. Because OR 126 from Sisters to Redmond rated lower than US 20 and US 97, provided no additional function, and there are few seismic vulnerabilities in this area that would warrant alternate routes, it was not designated as a lifeline.

6.2.8 Central Geographic Zone

Tier 1

The Tier 1 system in the Central Geographic Zone consists of the following corridors:

- I-84 from The Dalles to Biggs Junction
- US 97

Tier 2

No Tier 2 corridors are located in the Central Geographic Zone

Tier 3

The one Tier 3 corridor in the Central Geographic Zone is US 197.

Segments Considered but Not Designated as Lifelines

All segments considered in this zone were designated as lifelines.

Tier Designation Discussion

Because the ground shaking levels in the Central Geographic Zone (east of the Cascades) from a CSZ seismic event are much lower than for the zones to the west, damage in the area is expected to be minimal. US 97 will serve as a critical transportation corridor for the response to and recovery from such an event. Consequently, it is important that all vulnerabilities that do exist are taken care of. Furthermore, US 97 will be an important lifeline in the event of a Klamath Falls area seismic event. For these reasons, US 97 was designated Tier 1.

Two alternate routes connect US 97 north of Madras to I-84 in The Dalles—US 197 and US 97 from US 197 to I-84 at Biggs Junction and then west on to I-84 to The Dalles. The US 97 and I-84 route rated better on most criteria and therefore was designated Tier 1. Because the US 197 route provides access to critical utilities, it was designated Tier 3 rather than being dropped from the system.

Table 6-2 lists each segment studied in the project, its tier designation (or lack thereof) and a brief description of the justification for inclusion or exclusion as a seismic lifeline routes.

TABLE 6-2
Tier Designation by Segment

Seg.	Highway	Geographic Zone	ODOT Hwy No.	Description (Point to Point)	Tier	Tier Designation Justification Notes
1	I-5	Portland Metro	1	Washington border to I-405	1	I-5
2	I-5	Portland Metro	1	I-405 to I-84	2	Significant known vulnerabilities on this segment at I-84 interchange
3	I-5	Portland Metro	1	I-84 to I-405/OR 43/ US 26	2	Significant known vulnerabilities on this segment at I-84 interchange and Marquam Bridge (I-5 over Willamette River), Fremont (I-405) and Abernathy (I-205) bridges selected as Tier 1
4	I-5	Portland Metro	1	I-405/OR 43/US 26 to OR 99W	1	I-5
5	I-5	Portland Metro	1	OR 99W to OR 217	1	I-5
6	I-5	Portland Metro	1	OR 217 to I-205	1	I-5
7	I-5	Valley	1	I-205 to OR 214	1	I-5
8	I-5	Valley	1	OR 214 to OR 99E Bus.	1	I-5

TABLE 6-2
Tier Designation by Segment

Seg.	Highway	Geographic Zone	ODOT Hwy No.	Description (Point to Point)	Tier	Tier Designation Justification Notes
9	I-5	Valley	1	OR 99E Bus. to OR 99E	1	I-5
10	I-5	Valley	1	OR 99E to OR 22	1	I-5
11	I-5	Valley	1	OR 22 to OR 99E	1	I-5
12	I-5	Valley	1	OR 99E to OR 34	1	I-5
13	I-5	Valley	1	OR 34 to OR 569	1	I-5
14	I-5	Valley	1	OR 569 to OR 126/OR 99	1	I-5
15	I-5	South I-5	1	OR 126 to OR 58	1	I-5
16	I-5	South I-5	1	OR 58 to OR 38	1	I-5
17	I-5	South I-5	1	OR 38 to OR 42	1	I-5
18	I-5	South I-5	1	OR 42 to OR 199	1	I-5
19	I-5	South I-5	1	OR 199 to OR 140	1	I-5
20	I-5	South I-5	1	OR 140 to California border	1	I-5
21	I-84	Portland Metro	2	I-5 to I-205	2	Provides connection to east from Tier 2 portion of I-5
22	I-84	Cascades	2	I-205 to US 197	1	Interstate connection to east
23	I-84	Central	2	US 197 to US 97	1	Interstate connection to east
24	I-205	Portland Metro	64	Washington border to I-84	1	Access to airport
25	I-205	Portland Metro	64	I-84 to US 26	1	Connection between other Tier 1 lifelines
26	I-205	Portland Metro	64	US 26 to OR 224	1	Connection between other Tier 1 lifelines
27	I-205	Portland Metro	64	OR 224 to OR 212	1	Connection between other Tier 1 lifelines
28	I-205	Portland Metro	64	OR 212 to OR 99E	1	Connection between other Tier 1 lifelines
29	I-205	Portland Metro	64	OR 99E to OR 43	1	One of two Tier 1 Willamette River crossing in Portland Metro Geographic Zone
30	I-205	Portland Metro	64	OR 43 to I-5	1	Connection between other Tier 1 lifelines

TABLE 6-2
Tier Designation by Segment

Seg.	Highway	Geographic Zone	ODOT Hwy No.	Description (Point to Point)	Tier	Tier Designation Justification Notes
31	I-405	Portland Metro	61	I-5 to US 30	1	Connection between other Tier 1 lifelines, access to fuel, and Portland circulation, one of two Tier 1Willamette River crossings
32	I-405	Portland Metro	61	US 30 to US 26	1	Connection between other Tier 1 lifelines, access to fuel, and Portland circulation
33	I-405	Portland Metro	61	US 26 to I-5/OR 43/US 26	1	Connection between other Tier 1 lifelines, access to fuel, and Portland circulation
34	OR 217	Portland Metro	144	US 26 to OR 99W	3	Low resilience
35	OR 217	Portland Metro	144	OR 99W to I-5	3	Low resilience
36	OR 99W	Portland Metro	91	I-5 to OR 217	1	Connection to Tier 1 route to coast
37	OR 99W	Valley	91	OR 217 to OR 219	1	Connection to Tier 1 route to coast
38	OR 99W	Valley	91	OR 219 to OR 18	1	Connection to Tier 1 route to coast
39	OR 99W	Valley	91	OR 18 to OR 47	0	Redundant to OR 18
40	OR 99W	Valley	91	OR 47 to OR 18	0	Redundant to OR 18
41	OR 99W	Valley	91	OR 18 to OR 22	2	Alternate to I-5
42	OR 99W	Valley	91	OR 22 to US 20	2	Alternate to I-5
43	OR 99W	Valley	91	US 20 to 99E/99W merge	2	Alternate to I-5
44	OR 99	Valley	91	99E/99W merge to OR 569/126	2	Alternate to I-5
45	OR 99	Valley	91	OR 569/126 to I-5	2	Alternate to I-5
46	OR 99E	Portland Metro	81	US 26 to OR 224	0	Redundant to OR 43 and US 26
47	OR 99E	Portland Metro	81	OR 224 to I-205	0	Redundant to OR 43 and US 26
48	OR 99E	Portland Metro	81	I-205 to OR 43	2	Alternate to I-5
49	OR 99E	Valley	81	OR 43 to OR 214	2	Alternate to I-5
50	OR 99E	Valley	81	OR 214 to I-5	2	Alternate to I-5
51	OR 99E	Valley	81	I-5 in Albany to OR 34	0	Redundant to I-5 and OR 99W

TABLE 6-2
Tier Designation by Segment

Seg.	Highway	Geographic Zone	ODOT Hwy No.	Description (Point to Point)	Tier	Tier Designation Justification Notes
52	OR 99E	Valley	81	OR 34 to 99E/99W merge	0	Redundant to I-5 and OR 99W
53	OR 47	Valley	29	OR 26 to OR 99W	0	Redundant to I-5 and OR 99W
54	OR 212	Cascades	174	I-205 to US 26	2	Redundant connection to Central Oregon, less critical to freight than I-84 route to east
55	OR 224	Portland Metro	171	OR 99E to I-205	0	Redundant to OR 43 and US 26
56	OR 18	Valley	39	OR 99W to OR 99W	1	Connection to Tier 1 route to coast
57	OR 18	Coast	39	OR 99W to OR 22	1	Central Tier 1 route to coast
58	OR 18	Coast	39	OR 22 to US 101	1	Central Tier 1 route to coast
59	OR 43	Portland Metro	3	US 26 to I-205	3	Additional capacity in Portland
60	OR 43	Portland Metro	3	I-205 to OR 99E	0	Redundant crossing of Willamette
61	US 30	Coast	92	US 101 to I-405	1	Northern Tier 1 route to coast
62	OR 202	Coast	102	US 101 to OR 103	0	Redundant route to Astoria
63	OR 103	Coast	103	OR 103 to US 26	0	Redundant route to Astoria
64	US 101	Coast	9	OR 202 to US 26	3	Low resilience
65	US 101	Coast	9	US 26 to OR 18	1, 2, 3	Tier 2 access to Nehalem, Tier 3 due to low resilience Nehalem to Tillamook, Tier 1 access from OR 18 to Tillamook
66	US 101	Coast	9	OR 18 to US 20	1	Tier 1 access from OR 18 to Newport
67	US 101	Coast	9	US 20 to OR 126	3	Low resilience
68	US 101	Coast	9	OR 126 to OR 38	1	Tier 1 access from OR 38 to Florence
69	US 101	Coast	9	OR 38 to OR 42	1	Tier 1 access from OR 38 to Coos Bay
70	US 101	Coast	9	OR 42 to California border	2	Access to south coast
71	US 197	Central	4	I-84 to US 97	3	Redundant to US 97 and I-84 but provides access to critical utilities
72	US 97	Central	42	I-84 to US 197	1	North-south lifeline outside of highly CSZ event affected zone
73	US 97	Central	4	US 197 to US 26	1	North-south lifeline outside of highly CSZ event affected zone

TABLE 6-2
Tier Designation by Segment

Seg.	Highway	Geographic Zone	ODOT Hwy No.	Description (Point to Point)	Tier	Tier Designation Justification Notes
74	US 97	Central	4	US 26 to OR 126	1	North-south lifeline outside of highly CSZ event affected zone
75	US 97	Central	4	OR 126 to US 20	1	North-south lifeline outside of highly CSZ event affected zone
76	US 97	Central	4	US 20 to OR 58	1	North-south lifeline outside of highly CSZ event affected zone
77	US 97	Central	4	OR 58 to OR 140	1	North-south lifeline outside of highly CSZ event affected zone and access to Klamath Falls
78	US 97	Central	4	OR 140 to California border	1	North-south lifeline outside of highly CSZ event affected zone and access to Klamath Falls
79	US 26	Coast	47	US 101 to OR 103	2	Intermediate route to coast
80	US 26	Coast	47	OR 103 to OR 47	2	Intermediate route to coast
81	US 26	Valley	47	OR 47 to OR 217	2	Intermediate route to coast
82	US 26	Portland Metro	47	OR 217 to I-405	2	Intermediate route to coast
83	US 26	Portland Metro	26	I-5/OR 43/US 26 to OR 99E	3	Fourth Willamette River crossing in Portland Metro Geographic Zone
84	US 26	Portland Metro	26	OR 99E to I-205	3	Alternate route through Portland, mostly at grade with many detours available
85	US 26	Cascades	53	OR 212 to US 97	2	Redundant connection to Central Oregon, less critical to freight than I-84 route to east
86	OR 22	Cascades	162	I-5 to Santiam Jct	2	Freight route
87	US 20	Coast	33	US 101 to OR 99W	3	Low resilience
88	OR 34	Valley	210	OR 99W to OR 99E	3	Connection from OR 99W to I-5
89	OR 34	Valley	210	OR 99E to I-5	3	Connection from OR 99W to I-5
90	OR 34	Cascades	210	I-5 to US 20	0	Redundant to OR 22
91	US 20	Cascades	16	OR 34 to OR 126	0	Redundant to OR 22
92	US 20	Cascades	16	OR 126 to OR 22	0	Redundant to OR 22
93	US 20	Cascades	16	OR 22 to OR 126	2	Continuation of OR 22 route to Bend
94	US 20	Cascades	16	OR 126 to US 97	2	Continuation of OR 22 route to Bend
95	OR 126	Coast	62	US 101 to OR 99/ OR 569	2	Alternate route to OR 38

TABLE 6-2
Tier Designation by Segment

Seg.	Highway	Geographic Zone	ODOT Hwy No.	Description (Point to Point)	Tier	Tier Designation Justification Notes
96	OR 569	Valley	69	OR 99/OR 126 to I-5	0	Redundant to OR 99
97	OR 126	Cascades	69	I-5 to US 20	0	Redundant to OR 58
98	OR 38	Coast	45	US 101 to I-5	1	Southern Tier 1 route to coast
99	OR 58	Cascades	18	I-5 to US 97	1	Tier 1 route to Central Oregon
100	OR 42	Coast	35	US 101 to I-5	3	Alternate to OR 38
101	OR 140	Cascades	270	I-5 to US 97	2	Medford – Klamath Falls connection
102	US 199	Coast	25	I-5 to California border	3	Access to southern Oregon and CA border
103	OR 22	Coast	30	OR 18 to OR 99W	3	Alternate connection of OR 18 to OR 99W
104	OR 22	Valley	30	OR 99W to OR 99E Bus.	3	east west connection OR 99W to I-5, alternate crossing of Willamette
105	OR 22	Valley	30	OR 99E Bus. To I-5	1	Connection of State Government to I-5
106	OR 219	Valley	140	OR 99W to I-5	3	Alternate crossing of Willamette
107	OR 214	Valley	140	I-5 to OR 99E	2	East west connection OR 99E to I-5
108	OR 126	Cascades	15	US 20 to US 97	0	Redundant to US 20
109	OR 99E Bus.	Valley	72	I-5 to OR 22	3	Alternate to I-5 and OR 22

7.0 Agency Coordination and Involvement

This chapter describes ODOT's coordination with other agencies throughout the life of the OSLR project and the roles of the PMT and SC.

7.1 Coordination with Other Agencies

The ODOT TDD was the sponsor of the planning process. TDD provided the oversight and project management for the OSLR project, but coordinated with many other divisions within ODOT through the PMT and SC. In addition to coordination within ODOT, the PMT coordinated with other agencies, including DOGAMI, the Oregon Department of Water Resources, the Oregon Public Utilities Commission, and statewide Energy Emergency Management Team, as described as follows:

- ODOT coordinated with DOGAMI in a formal way through DOGAMI's participation on the SC. Data available through DOGAMI were used in the evaluation of landslide and liquefaction hazards. However, DOGAMI did not conduct or verify the evaluation.
- ODOT coordinated with the state Department of Water Resources in the assessment of potential dam hazards.
- ODOT coordinated with the Energy Emergency Management Team, a statewide organization representing utility companies, with follow-up through the Public Utility Commission (PUC). ODOT presented the OSLR project to the team and solicited feedback through the team and PUC about state highways that provide critical access to utilities.

7.2 Project Management Team

The PMT served as the technical leadership for the project and was composed of technical specialists within different departments of ODOT and the consultant team chosen for this project. The PMT roster was as follows:

- Nancy Murphy, Project Manager, ODOT TDD
- Amanda Pietz, Interim Planning Unit Manager, ODOT TDD
- Michael Bufalino, Freight Analysis Unit Manager, ODOT TDD
- Shawn Snyder, GIS Analyst, ODOT TDD
- Becky Knudson, ODOT Transportation Planning Analysis Unit
- Albert Nako, Seismic Standards Engineer, ODOT Bridge Standards Unit
- Dawn Mach, Planner, ODOT Bridge Unit
- Curran Mohney, Engineering and Geology Program Lead, ODOT Geo-Environmental
- Rick Carter, PUC
- Gary Conner, Project Manager, CH2M HILL
- Rick Kuehn, Senior Advisor, CH2M HILL
- Kate Lyman, Transportation Planner, CH2M HILL

Five PMT meetings have been held during the OSLR project:

- **PMT Meeting 1, August 2, 2011.** This meeting kicked off the project and included a discussion of roles and responsibilities and an overview of project tasks. Available data and the corridors to be studied in the project were also discussed.

- **PMT Meeting 2, September 19, 2011.** Discussion during this meeting focused on the evaluation corridors to be used in this project, the tiers of lifeline routes, and draft criteria categories. Approval by the PMT of the evaluation corridors to be used in the project was a major decision milestone.
- **PMT Meeting 3, October 26, 2011.** This meeting consisted of discussion of the draft evaluation framework, as well as an overview and the methodology for assessing geotechnical vulnerabilities. The PMT's approval of the draft evaluation framework was a major decision milestone.
- **PMT Meeting 4, December 6, 2011.** During this meeting, the results of the evaluation were reviewed and potential weightings of evaluation criteria were discussed. PMT members were asked to provide numerical rankings of the goals, objectives, and criteria.
- **PMT Meeting 5, March 15, 2012:** During this meeting, the PMT reviewed and approved the final ratings and tiered designations of seismic lifeline routes.

7.3 Project Steering Committee

The SC served as the management team for the OSLR project and was composed of decision makers from different ODOT divisions. The composition of the SC was as follows:

- Nancy Murphy, Project Manager, ODOT TDD
- Amanda Pietz, Interim Planning and Implementation Unit Manager, ODOT TDD
- Bruce Johnson, State Bridge Engineer, ODOT
- Lucinda Moore, ODOT Maintenance and Operations Engineer
- Jerri Bohard, Transportation Development Division Manager
- Paul Mather, ODOT Highway Division Administrator
- Greg Ek-Collins, ODOT Emergency Operations Manager
- Dave Ringeisen, ODOT Transportation Data Section Manager
- Yumei Wang, DOGAMI Geohazards Engineer
- Becky Knudson, ODOT Transportation Planning and Analysis Unit
- Michael Bufalino, ODOT Freight Planning Manager
- Curran Mohney, ODOT Geo-Environmental, Engineering Geology Program Leader

Four SC meetings have been held for the OSLR project:

- **SC Meeting 1, August 2, 2011.** This meeting kicked off the project and included discussion of roles and responsibilities, ways that the SC members could support the project, and identification of corridors for evaluation.
- **SC Meeting 2, October 3, 2011.** Discussion during this meeting focused on the evaluation corridors, data sources, methodology for assessing seismic vulnerability, and draft criteria. The SC's approval of the evaluation corridors was a major decision milestone.
- **SC Meeting 3, January 12, 2012.** This meeting included a review of initial data results, a presentation of weighting scenarios from the PMT's input and for an alternative weighting scenario, and a presentation of draft evaluation framework results.
- **SC Meeting 4, April 23, 2012**. This meeting included a final review and discussion of Tiers 1, 2, and 3 lifeline routes.

8.0 Conclusions and Next Steps

This report provides guidance to ODOT for identifying the roadways that are the most important for response and recovery following a major earthquake and that are also most easily prepared for, and repaired after, a major seismic event. Tier 1 lifelines are the most-critical highways, providing a backbone system for the parts of the state most vulnerable to a CSZ event, and Tiers 2 and 3 lifelines are routes that increase the usability of the system and access to other areas. The next step in the process for planning for a seismic event is to prioritize projects on these lifelines. Although this report provides comparative results for seismic vulnerability on roadways, it does not provide sufficient detail to actually prioritize bridge and roadway seismic retrofits on a given highway. Additional engineering evaluations are needed to determine the needs for bridge and roadway seismic retrofits.

If the Oregon Transportation Commission chooses to accept the findings in this report, the next step in formalizing the seismic lifeline system will be development and adoption of an amendment to Policy 1E, Lifeline Routes, of the *1999 Oregon Highway Plan.*

9.0 References

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