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Brad Avy, State Geologist

Open-File Report O-17-01

OREGON HOSPITAL AND WATER SYSTEM EARTHQUAKE RISK EVALUATION PILOT STUDY

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2017

DISCLAIMER

Note: A version of this technical report was submitted to the Oregon Health Authority on September 30, 2014 and was released on the OHA website. To make the publication more widely accessible, DOGAMI is releasing the report in open-file report format.

Unless otherwise indicated, building facility photographs used in this report were taken by the author during site visits in 2013-2014.

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EXECUTIVE SUMMARY

A pilot project to evaluate the risk of hospitals and water systems from earthquakes triggered by the Cascadia subduction zone was conducted by the Oregon Department of Geology and Mineral Industries (DOGAMI) in partnership with the Oregon Health Authority (OHA), which has oversight responsibilities on hospitals and drinking water safety for the state. This project was initiated shortly after the release of the 2013 Oregon Resilience Plan by the Oregon Seismic Safety Policy Advisory Commission (2013).

The first goal was to establish a working partnership between OHA and DOGAMI to better understand and improve seismic preparedness of hospitals including their resilience to magnitude 9 Cascadia subduction zone earthquakes and tsunamis. The second goal was to improve awareness of seismic risks to hospital and water system operators in the project study region and to encourage action to increase community resilience, particularly by hospitals. Through site visits, project efforts have successfully provided information helpful to hospitals and water system operators to take steps to better prepare for, respond to, and recover from future earthquakes.

In accordance with needs identified in the 2013 Oregon Resilience Plan, DOGAMI 1) conducted vulnerability assessments of hospitals, 2) improved on the Hazus default database inventory of water systems, 3) conducted vulnerability assessments of water systems, and 4) considered interdependencies between hospitals, water systems, and transportation.

The main tasks involved 1) gathering data on hospitals and water systems, 2) inputting the data into Federal Emergency Management Agency (FEMA) Hazus MH (short for Hazards United States Multi-Hazards) loss estimation software, 3) applying the Hazus loss estimation model to obtain damage, loss, and functionality information, 4) assessing lifeline interdependencies of the hospitals in the region to understand their resilience, including water, transportation, fuel, electricity, and communications, and 5) writing this report.

The project region, which stretches about 50 miles from coastal Lincoln City to McMinnville in the Willamette Valley, has a high seismic hazard due to the close proximity to the Cascadia subduction zone and its potential to trigger a magnitude 9 earthquake and tsunami. The area includes part of the Oregon Coast Range and sections of the Yamhill River and several other rivers. The area has a population of approximately 96,000 people. Key project facilities include two hospitals, five water systems, and sections of U.S. Highway 101 and Oregon Highway 18 between Lincoln City and McMinnville.

The DOGAMI earthquake model for this study included 1,000-year probabilistic ground-shaking motions, which incorporate Cascadia earthquakes, soils that may amplify ground shaking levels, co-seismic landslide hazards, and liquefaction hazards.

Results

From major earthquake shaking, the project area is estimated to incur up to $5.1 billion in building losses, up to 80,000 damaged buildings (**Table 3-1**), up to 12,500 displaced people, and about 1,900 people requiring public shelter. Human suffering in the area is estimated to be up to 2,000 people requiring medical aid, up to 600 people requiring hospital care, up to 90 people with life-threatening injuries, and up to 180 fatalities (refer to **Table 3-1** and **Figure 3-1** in the report). The Hazus results do not take into account impacts from tsunamis.

Hospitals. For each hospital, information on service population, number of beds, construction type and year, replacement value, geologic seismic hazards, and lifeline dependencies have been summarized. Lifeline dependencies of Samaritan North Lincoln Hospital, herein referred to as Lincoln City hospital, and Willamette Valley Medical Center, herein referred to as McMinnville hospital, include water, transportation, fuel, electricity, and communications. The Lincoln City hospital was originally built in 1967, long before 1993, the year Oregon adopted modern seismic design provisions. The eastern half of the hospital is built on loose, sandy soils that appear to be liquefiable (Wes Spang, oral commun., January 6, 2014). McMinnville hospital is a complex of three buildings built after 1993, so construction adheres to modern seismic code.

Note that the estimates listed in Table ES-1, below, regarding hospital functionality do not explicitly take into account estimates for the water system's functionality; those estimates are provided in the following section on water facilities.

On the basis of the number of available hospital beds and the estimated casualties, both hospitals will experience severe, extended bed shortages. Lifeline services should be expected to be severely disrupted by a major earthquake. Lifeline service interruptions may further reduce hospital functionality. The report provides several options that can be considered in disaster planning and disaster response.

Water facilities. Many local water systems involve dams and reservoirs, miles of transmission pipelines, in-town water reservoirs, and pumping stations before the system begins distributing water to communities. For each water facility, DOGAMI gathered information on geologic seismic hazards as well as water treatment plant (WTP) and major water system components, including system replacement value, construction type and year of buildings, city reservoirs (tanks), pump stations, and transmission piping systems. Water usage by Lincoln City hospital and McMinnville hospital is approximately 15,000 gallons/day and 47,000 gallons/day, respectively.

For the study, DOGAMI collected data and modeled five water systems: City of Lincoln City, McMinnville Water and Light, Grand Ronde, Sheridan, and Willamina (Table ES-2). The default Hazus model contains additional water system data for surrounding communities such as Dallas, Amity, and Dayton. From these data and from water district data, it is estimated that over 10,000 km (6,200 mi) of water transmission and distribution pipeline exists in the study region; a major Cascadia earthquake would cause over 5,700 pipeline leaks and 3,500 pipeline breaks. Of the roughly 35,000 households in the study area, the number of households without water service is estimated at 31,000 on day 1 after the earthquake; 30,000 on day 3, 27,000 on day 7, 19,000 on day 30, and none (0) on day 90 (Appendix C, Table 9). Of the 88 facilities associated with the water systems, 65 are estimated to have at least moderate damage from a major Cascadia earthquake Appendix C, Table 7).

Table ES-1. Estimates of probability of at least moderate damage and level of functionality in hospitals after a major Cascadia earthquake.

		McMinnville Hospital	
	Lincoln City Hospital	**Two Taller Buildings**	**Shorter Building**
Probability of at least moderate damage from a major Cascadia earthquake			
	90%	63%	38%
Estimated level of functionality* by bed count			
Day 1 and Day 3	2%	14%	43%
Day 7 and Day 14	10%	36%	61%
Day 30	42%	73%	77%
Day 90	52%	76%	79%

*Does not take into account water system functionality; see text for estimates.

Table ES-2. Estimates of probability of at least moderate damage and level of functionality for five modeled water systems after a major Cascadia earthquake. See Appendix E.

	Water Treatment Plant				
	City of Lincoln City	**McMinnville Water and Light**	**Grand Ronde**	**Sheridan**	**Willamina**
Probability of at least moderate damage					
	50%	39%	90%	97%	51%
Estimated damage cost*					
	~ $51 million of $300 million	~ $61 million of $500 million	~ $5 million of $11.2 million	~ $29 million of $40 million	> $1 million of $10 million
Estimated level of functionality**					
Day 1	52%	61%	22%	14%	49%
Day 3	80%	86%	46%	23%	83%
Day 7	86%	91%	54%	27%	91%
Day 14	87%	92%	57%	31%	91%
Day 30	91%	94%	64%	40%	94%
Day 90	99%	99%	88%	72%	99%

*Damage cost shows two values: the first is the estimated damage cost; the second is the assumed replacement cost for entire water system.

**Lifeline service interruptions may further reduce functionality of water services.

Highways connecting Lincoln City and McMinnville. Our results indicate that 41 of the 169 bridges included in this study are estimated to have at least moderate damage from earthquake shaking. This estimate includes several bridges along coastal Highway 101 in Lincoln City, including those crossing the Siletz River; several bridges along Highway 18 between Lincoln City and McMinnville, including Bear Creek and Slick Rock Creek bridges (between ODOT mileposts 3 and 6); and several bridges in the greater McMinnville area, including bridges west of the McMinnville hospital between ODOT mileposts 45 and 47, and the Three Mile Lane bridge. Three Mile Lane bridge is part of a spur of Highway 18 located between downtown McMinnville and the McMinnville hospital. In addition to damage to bridges from earthquake shaking, damage would occur from tsunami flooding to road segments in low lying portions of Highway 101 especially near the Siletz River; from landslides especially toward the western portion of Highway 18 (ODOT mileposts 13 to 18); and from liquefaction especially between Sheridan and McMinnville. On a project regional scale, it is likely that there would be transportation connectivity problems within the city limits of Lincoln City and McMinnville as well as the on the route between Lincoln City and McMinnville.

Hospital Interdependencies. All modern hospitals—including Lincoln City and McMinnville hospitals—and communities depend on lifeline services including water, transportation, fuel, electricity, and communications. Specific hospital interdependencies are shown in Figure ES-1 and Figure ES-2 (**Figure 3-4** and **Figure 3-5** in the report, respectively). All communities, including the project communities, have a number of critically important facilities that rely on vital pathways that connect people or supplies in order to operate. Damage to critically important facilities or pathways, or both, can disrupt connections and services. Some complex connections in the project area between critically important facilities and the pathways connecting them are illustrated in Figure ES-3 (**Figure 3-6** of the report). Hospitals and water treatment plants are the critically important facilities in this study; bridges on or near Highways 101 and 18 and the water transmission pipeline that crosses under the Yamhill River as well as associated bridges and telecommunication lines are vital pathways, or lifelines.

Figure ES-1. Hospital interdependencies: Lincoln City hospital relies on people, hospital infrastructure and supplies, fuel, water, electricity, transportation, and communications.

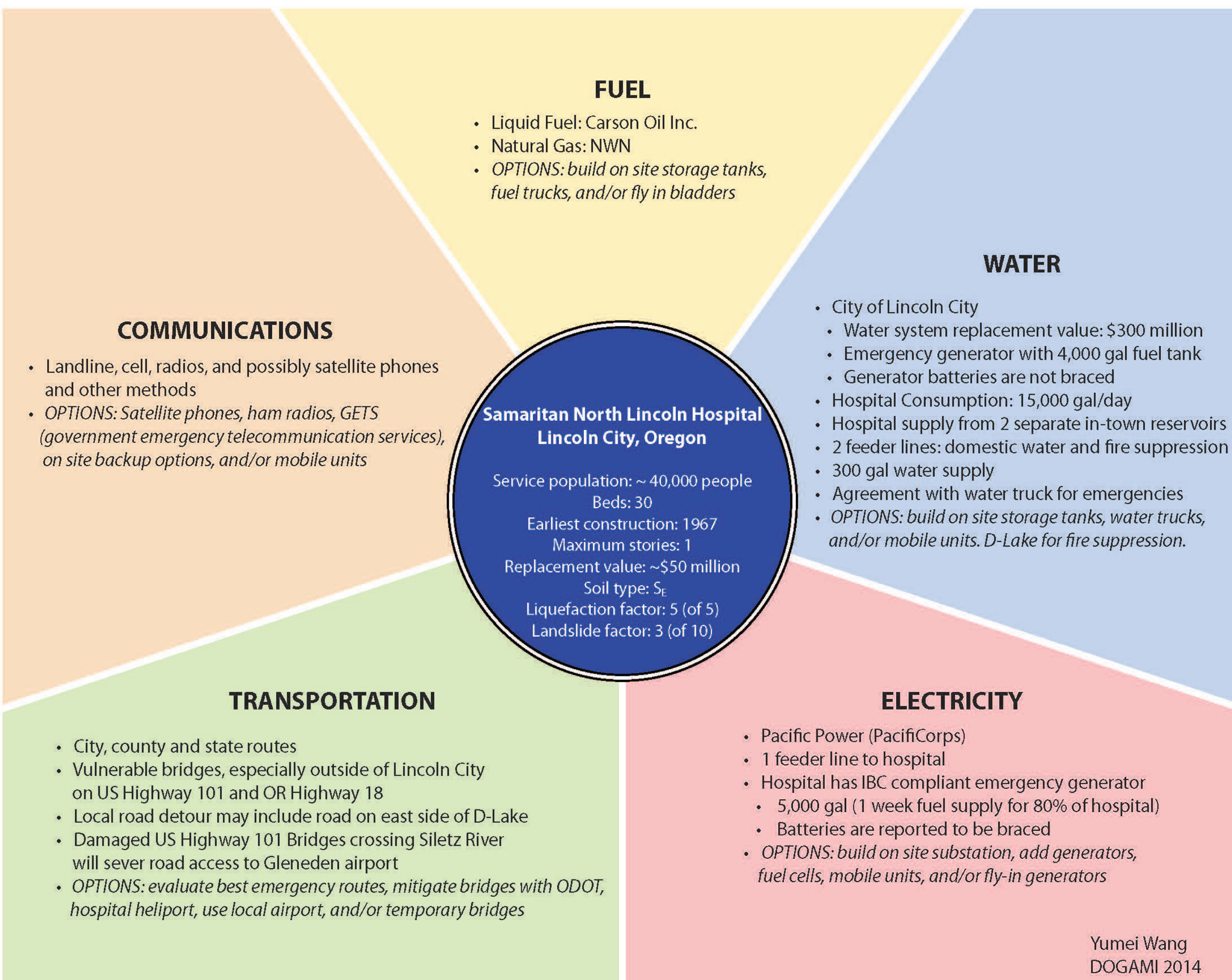


Figure ES-2. Hospital interdependencies: McMinnville hospital relies on people, hospital infrastructure and supplies, fuel, water, electricity, transportation, and communications.

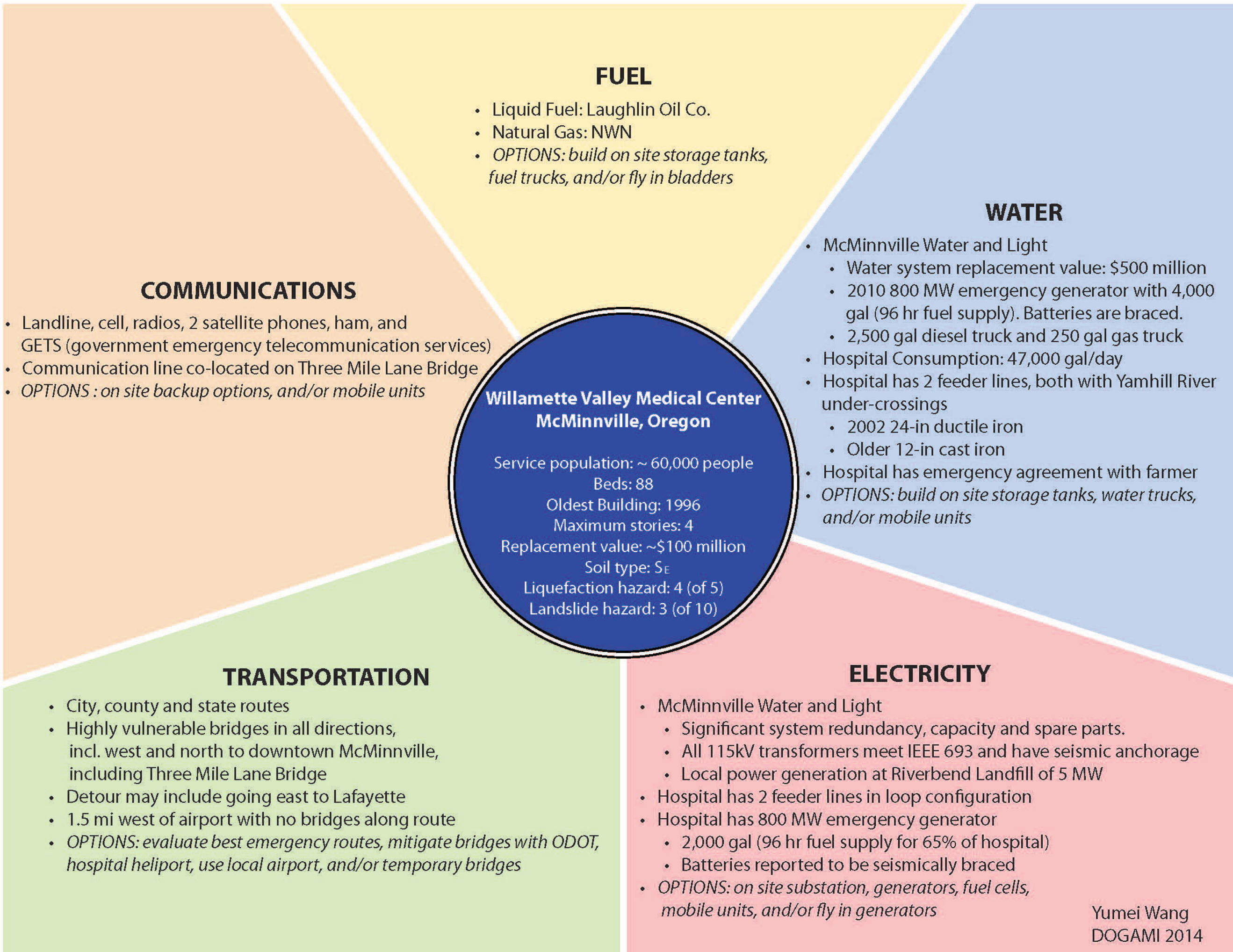
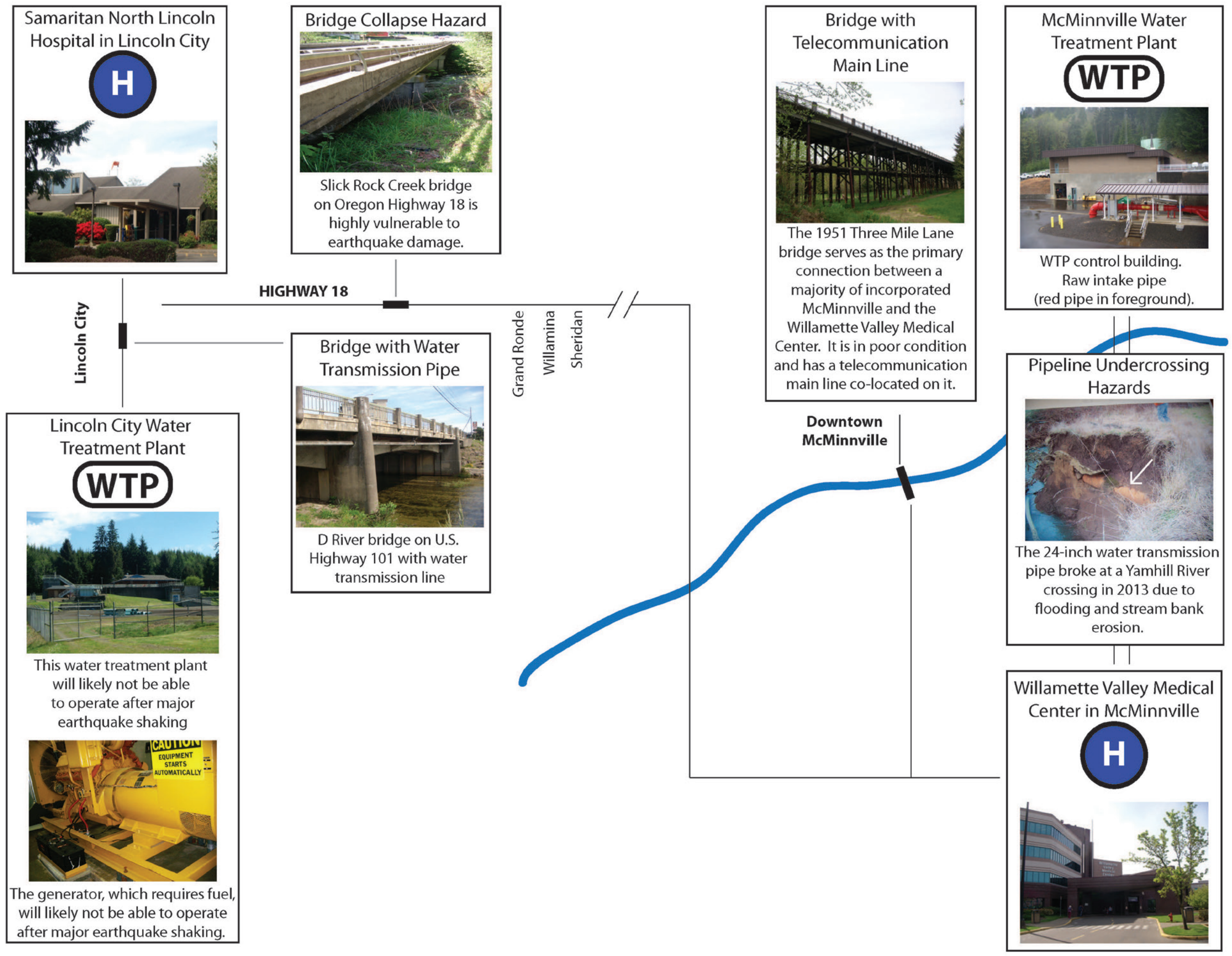


Figure ES-3. Schematic of critical facilities and pathways in the project area include the two hospitals, two water treatment plants, and the highways and pipelines connecting them. The blue line is the Yamhill River.



Conclusions

DOGAMI concludes that:

- Hospitals are important community safety nets in disasters. Hospitals therefore require a high level of ***resilience*** — they should be built and operated to sustain *limited damage*, have *reliable emergency methods* to operate immediately after major earthquakes, and *recover efficiently* to provide services.
- Both pilot study hospitals have seismic vulnerabilities and are expected to incur significant hospital bed shortages for over 90 days after a Cascadia earthquake.
- Both pilot study hospitals have complex water, transportation, and other lifeline dependencies. After a Cascadia earthquake, hospitals are expected to incur severe reductions in functionality due to lifeline damage. Damage to the local water systems and transportation network will slow the response and recovery of hospitals, and hospital services for community members will be impaired.

- Bridges near both pilot study hospitals are expected to incur significant damage during and after a Cascadia earthquake. Bridge damage will limit movement of staff and injured community members as well as supplies such as potable water, gasses, and medications to and from the hospitals.
- All pilot study water systems have seismic vulnerabilities and complex lifeline dependencies and are expected to incur severe reductions in functionality after a Cascadia earthquake. Water service to the hospitals using the normal water pipeline distribution system is expected to be down for weeks to months.
- Specific important results are:
  - Lincoln City hospital is estimated to incur significant damage due to its proximity to the Cascadia subduction zone and will slowly recover to operate at about 52% bed capacity in 90 days. A number of bridges that connect the community and hospital, including bridges crossing the Siletz River, are expected to incur major damage and impede citizen access to the hospital complex.
  - Although the McMinnville hospital has modern seismic structural engineering, design, and construction, it is expected to have a severe reduction in function due to shaking damage. It is expected to recover to about 76% bed capacity in 90 days. A number of bridges that connect the community and hospital, including the Three Mile Lane bridge and nearby Highway 18 bridges to the west of hospital complex, are expected to incur major damage and impede citizen access.
  - The transportation route between Lincoln City and McMinnville will be impassable immediately after a major Cascadia earthquake, which will impede coastal community members from accessing inland hospitals.
- DOGAMI and OHA communications to project partners and site visits to the hospitals and water facilities helped to increase seismic awareness and encourage mitigation actions.
- Hospitals should coordinate with lifeline owners, including local water and transportation districts, to improve hospital resilience.
- Community resilience, including reliable hospital services in earthquake disasters, requires hospitals, lifeline owners, and other partners to conduct resilience planning in order to better protect citizens on a local and regional scale.

Recommendations

Top-priority recommendations. DOGAMI recommends that:

- The pilot project results and this report are shared with project participants and OHA partners to increase awareness about the need to improve seismic resilience. This could involve developing and distributing a fact sheet, publishing this report, and providing workshops in the project area and elsewhere.
- OHA and hospital partners encourage and conduct regularly scheduled seismic site visits by appropriate authorities (such as OHA Health Security, Preparedness and Response representatives) to all of the statewide hospitals and the water districts that serve those hospitals to enhance resilience.
- OHA and hospital partners require seismic preparedness standards for drinking water systems that serve hospitals.
- OHA and hospital partners proactively encourage hospitals to meet safety and preparedness regulations in Oregon Revised Statute 455.400 and The Joint Commission Emergency Management standards EM.02.01.01 and EM.02.02.09.
- OHA and hospital partners encourage hospitals to conduct comprehensive seismic vulnerability assessments and, from the findings, develop long-term mitigation plans to increase hospital resilience. Any significant mitigation actions should be integrated into relevant hospital plans, such as emergency operation plans, capital investment plans, long-range master plans, and risk management plans.

- OHA and hospital partners encourage hospitals to engage in community and regional resilience planning that specifically addresses hospital life-line interdependencies, such as:
  - Establishing partnerships between water districts and hospitals that focus on the reliability of water services to hospitals.
  - Establishing partnerships between transportation districts and hospitals that focus on the reliability of routes to hospitals. For example, until selected bridges are mitigated in McMinnville, community members may need to plan on extensive transportation detours to access the McMinnville hospital, such as using the bridge that is 5 miles east of McMinnville on the SE Lafayette Highway and that crosses the Yamhill River.

Recommendations for future efforts. DOGAMI recommends that:

- Comprehensive seismic evaluations that include structural, non-structural, business continuity and lifeline service vulnerabilities are conducted for all hospitals across the entire state of Oregon.
- Resilience metrics that establish a baseline condition and allow for tracking of improvements are established for hospitals and used by OHA and hospital partners. Resilience metrics can be tied to community resilience planning efforts.
- Hospital resilience planning workshops are conducted using best available information to help reduce losses and speed recovery. As an example, the hospitals in this pilot project should use the damage and functionality estimates from this study to help plan for improving resilience. The workshop may use SWOT (strengths, weaknesses, opportunities, and threats) analysis workgroup techniques and develop SMART (specific, measurable, attainable, realistic, and timely) goals. Hospital resilience planning should address how to provide reliable services by having more reliable 1) staff, 2) flow of goods, and 3) infrastructure performance including lifeline services (e.g., fuel).
- Community resilience planning workshops are conducted using best available information to reduce losses and speed recovery. Workshops may use SWOT workgroup techniques and develop SMART goals. Community resilience planning should address specific characteristics, including local hospitals, clinics, water systems, schools, fire stations, police stations, shelters, and city halls. As examples for communities in this pilot project: Lincoln City should consider future tsunami damage, and McMinnville should consider future damage relating to their large building portfolio of unmitigated, historic buildings. Mitigation actions should be identified and, where appropriate, integrated into relevant community plans such as business plans, city plans, neighborhood plans, and family plans. Tax incentive, local bonding, and other measures may be needed to improve community resilience.

1.0 INTRODUCTION

This hospital and water system earthquake risk evaluation pilot study, includes an evaluation of seismic risk relating to hospitals and water systems in the study area. The pilot study area stretches from coastal Lincoln City to McMinnville, Oregon, and includes portions of U.S. Highway 101 and Oregon Highway 18, which is one of the lifeline routes identified by the Oregon Department of Transportation (ODOT).

This project addressed recommendations put forth in the 2013 Oregon Resilience Plan (OSSPAC, 2013), which is available at: http://www.oregon.gov/OMD/OEM/osspac/docs/Oregon_Resilience_Plan_Final.pdf and http://www.oregon.gov/OMD/OEM/osspac/docs/Oregon_Resilience_Plan_Executive_Summary_Final.pdf. Specific recommendations from that plan include:

- conducting vulnerability assessments of hospitals
- improving the inventory of water systems
- conducting vulnerability assessments of water systems
- considering interdependencies between hospitals, water systems, and transportation

1.1 Project General Description

The seismic risk evaluation included:

- Gathering relevant hospital and water system data
- Inputting the data into Federal Emergency Management Agency Hazus loss estimation software (FEMA, 2010a,b)
- Applying the Hazus loss estimation model to obtain damage, loss, and functionality information
- Assessing interdependencies of the hospitals

Hazus is a software package published by FEMA that can be used to estimate earthquake damage and loss for aspects of hospitals, water systems (excluding dams), and other lifeline systems related to hospital functionality. The default Hazus model uses population data and statistical relationships to estimate the number and kinds of buildings and lifeline systems in a study area. Actual data describing buildings and lifeline systems can be collected and inputted to get a more accurate and meaningful results. DOGAMI enhanced the Hazus inventory where possible by collecting and inputting structure-specific hospital, water facility data, and data for bridges along portions of Highway 101 and Highway 18.

For two of Oregon's hospitals, this pilot study provided:

1. The number the hospital beds in the two hospitals in the study region
2. An estimate of replacement cost of the hospital
3. An estimate of casualties in four levels in the study region
4. An estimate of the amount of damage to hospital buildings from strong earthquake shaking
5. An estimate of level of function by bed count on day 1, day 3, day 7, day 14, day 30, and day 90 after the earthquake

For five of Oregon's water systems, this pilot study provided:

1. Data describing relevant attributes of the major components of the water utility systems
2. An estimate of replacement cost of each system
3. An estimate of the damage state for the potable water system
4. An estimate of pipeline leaks and breaks in the study region
5. An estimate of number of households without water on day 1, day 3, day 7, day 14, day 30, and day 90 after the earthquake

1.2 Purpose and Scope

The Oregon Health Authority (OHA) and Oregon Department of Geology and Mineral Industries (DOGAMI) are developing a state agency partnership with the long-term goal of improving the reliability of public health services in Oregon in the event of a major earthquake, including a magnitude 9 earthquake on the Cascadia subduction zone. OHA has public health and safety responsibilities involving both hospital preparedness during disasters and drinking water quality. DOGAMI has technical expertise on seismic issues.

OHA and DOGAMI staff discussed ways to improve earthquake preparedness and decided to conduct this pilot project. This project is aimed to help OHA and the two major hospitals and water systems in the study area to improve their resilience to future damaging earthquakes, and improve the level of service that they will be able to provide to the communities and region immediately after a disaster. The broader goal is to learn from the pilot study and develop methods to improve earthquake preparedness in hospitals across the state.

The project was completed between October 2013 and September 2014. The scope of the project included three main tasks.

Task 1: Data collection for Hazus and seismic analyses. This task involves obtaining detailed facility and system data for two hospitals and five water systems as well as geologic hazard information. This task was scheduled to occur between October and December 2013. The actual gathering and verification of the data occurred between October 2013 and June 2014. Collecting data for Hazus input was significantly more time consuming than our initial estimates.

Task 2: Hazus and seismic analyses. This task involves data input to the Hazus study region, conducting Hazus and seismic analyses, and evaluating and interpreting analytical results. This task included two brief field surveys of the study region to verify hospital-building types reflected in the 2007 DOGAMI database and to visit water system facilities. This task was scheduled to occur between January and May 2014. The actual timeframe was between January and July 2014. Inputting the data into the Hazus model and trouble-shooting preliminary Hazus results was a significant portion of this task and was more time consuming that our initial estimates.

The Hazus software has an error and cannot efficiently evaluate damage and losses for aspects of user-defined water systems. Therefore, DOGAMI used work-arounds provided by FEMA's Hazus technical support in certain instances, such as for evaluating damage states of certain facilities. In addition, the Hazus software does not perform damage analyses for all aspects of water systems such as dams. Therefore, certain assumptions were made.

DOGAMI performed Hazus analyses by using 1,000-year probabilistic ground motions, which considers magnitude 9 earthquakes triggered by the Cascadia subduction zone.

DOGAMI estimated seismic performance of the hospital buildings, certain aspects of the water system, and the bridges along portions of Highway 101 and Highway 18 using Hazus. In addition to hospital and water system damage and functionality, DOGAMI used Hazus to evaluate regional losses on a statistical basis (as opposed to using building-specific-information for hospital and water system facilities). Hospitals have many interdependencies, including lifeline services. These interdependencies were evaluated outside of the Hazus program.

DOGAMI did not account for damage to dams in Hazus analyses because Hazus does not have algorithms to evaluate dams.

Task 3: Report writing. The report was written in August and September 2014. [This 2017 release has formatting and copy editing changes but no substantive changes.]

1.3 Funding Statement

Funding for this project was made possible in part by the Centers for Disease Control and Prevention via OHA agreement number 144016. The views expressed in written materials or publications and by speakers or moderators do not necessarily reflect the official policies of the Department of Health and Human Services, nor does mention of trade names, commercial practices, or organizations imply endorsement by the U.S. Government. This $98,000 project was funded with 75% federal funds and 25% DOGAMI funds.

1.4 Limitations

Limitations associated with the project involve the limited scope and resources, and limitations with the available data and methods; see section 2.3.1.

1.5 Report Organization

The report is organized in four sections: 1) Introduction, 2) Pilot Project Study, 3) Findings and Conclusions, and 4) Recommendations. Seven appendices provide water system references, the data management process, and detailed Hazus results.

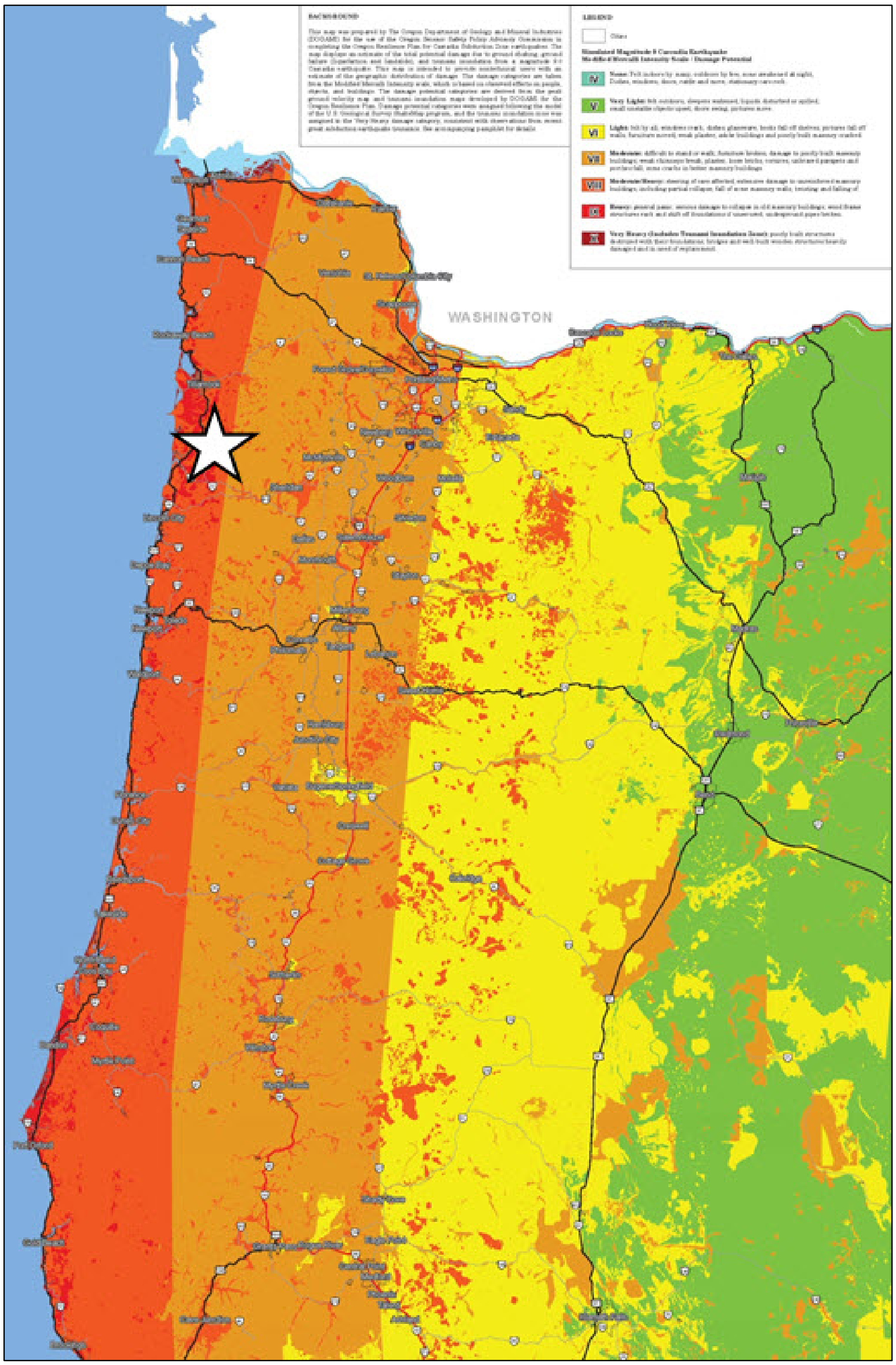
2.0 PILOT PROJECT STUDY

2.1 Project Background

The project area is considered to be in a high seismic hazard region due to its proximity to the Cascadia subduction zone (see **Figure 2-1**). The Cascadia subduction zone has triggered over 40 megaquakes (earthquakes larger than magnitude 8) in the past 10,000 years (Goldfinger and others, 2012). In the future, the Cascadia subduction zone is expected to release a magnitude 9 earthquake with strong ground shaking throughout the project area (**Figure 2-2**). Additional geologic hazards include tsunami inundation, coastal subsidence, earthquake-triggered landslides, and liquefaction (Madin and Burns, 2013).

Figure 2-1. The Cascadia fault with the location of the pilot project area shown by the star. (Modified from Wang and others, 2013, after a figure in *Cascadia*, Winter 2012, p. 3, by DOGAMI).

Figure 2-2. Expected damage zones from a Cascadia subduction zone magnitude 9 earthquake with the location of the pilot project area shown by the star (Source: modified from Madin and Burns, 2013).



Simulated Magnitude 9 Cascadia Earthquake —Modified Mercalli Intensity Scale / Damage Potential

X (maroon) - Very Heavy: (includes Tsunami Inundation Zone): poorly built structures destroyed with their foundations; bridges and well-built wooden structures heavily damaged and in need of replacement.

IX (red) - Heavy: general panic; serious damage to collapse in old masonry buildings; wood frame structures rack and shift off foundations if unsecured; underground pipes broken

VIII (orange-red) – Moderate / Heavy: steering of cars affected; extensive damage to unreinforced masonry buildings, including partial collapse; fall of some masonry walls; twisting and falling of chimneys and monuments

VII (orange) - Moderate: difficult to stand or walk; furniture broken; damage to poorly built masonry buildings; weak chimneys break; plaster, loose bricks, cornices, unbraced parapets and porches fall; some cracks in better masonry buildings.

VI (yellow) - Light: felt by all; windows crack; dishes, glassware, books fall off shelves; pictures fall off walls; furniture moved; weak plaster, adobe buildings and poorly built masonry cracked.

V (green) - Very Light: felt outdoors, sleepers wakened; liquids disturbed or spilled; small unstable objects upset; doors swing, pictures move.

IV (cyan) - None: Felt indoors by many, outdoors by few, some awakened at night, Dishes, windows, doors, rattle and move, stationary cars rock.

Earthquakes and associated geologic hazards often cause damage to infrastructure that impacts the availability of transportation, liquid fuel, electrical, natural gas, and other utility services (CH2M HILL, 2012a,b; Nako and others, 2009; Wang and others, 2013). Moderately sized (magnitude 6) earthquakes can cause damage to nearby communities. For example, in 1993 the Scotts Mills magnitude 5.6 earthquake occurred during spring break when students were on vacation. This earthquake caused approximately $30 million of damage, including the partial collapse of the 1930 unreinforced masonry Columbus Elementary School in McMinnville. The building was later demolished, and a new school was constructed nearby in 1995 (**Figure 2-3**).

Megaquakes can cause extensive, widespread, and prolonged damage. Gap analyses in the 2013 Oregon Resilience Plan indicate that with Oregon's current state of preparedness, extensive damage is expected in western Oregon followed by a long recovery time. For hospitals on the coast and in the Willamette Valley, estimates for recovery range from 18 months to 3 years. For water systems on the coast and in the Willamette Valley, estimates range from 1 month to 3 years. Estimates for other infrastructure have similar damage and recovery timeframes (OSSPAC, 2013).

2.1.1 Hospitals and Earthquakes

Globally, performance of many hospitals during earthquakes has been poor, for example, a Kaiser Permanente hospital in the 1994 magnitude 6.7 Northridge, California earthquake partially collapsed (**Figure 2-4**). In response, California now has laws requiring improved seismic safety and operations of hospitals. When hospitals are out of service, the impact on people and communities can be significant. Although each specific disaster situation differs, FEMA estimates the post-disaster continuity premiums (or economic impact) of loss of function at 5 and 10 times the cost of normal services for whole medical complexes and patient care facilities, respectively (http://www.fema.gov/benefit-cost-analysis).

Figure 2-3. This 1930 Columbus Elementary School in McMinnville was destroyed in the 1993 Scotts Mills, Oregon earthquake. The unreinforced masonry school building was later demolished; in 1995 a new school was constructed nearby. (Source: https://msd.orvsd.org/schools/elementary-school/columbus-elementary-school)

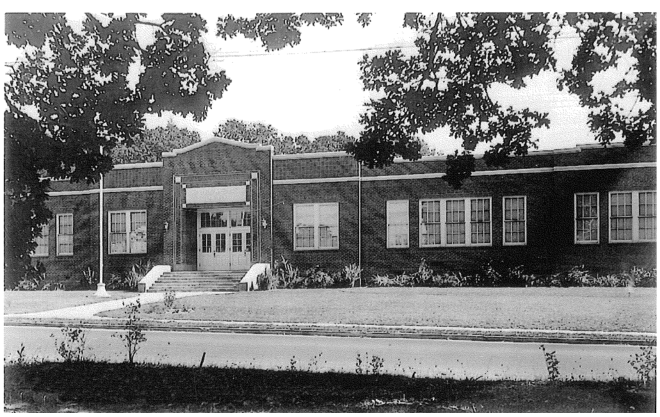


Figure 2-4. Damage to a Kaiser Permanente hospital in the 1994 magnitude 6.7 Northridge, California earthquake. (Photo by Gary B. Edstrom, https://en.wikipedia.org/wiki/1994_Northridge_earthquake#/media/File:Kaiser_Permanente_Building_After_Northridge_Earthquake.jpg

In Oregon, hospitals are required to meet seismic building code requirements at the time the facility is built. Many pre-1995 hospitals in Oregon have significant seismic structural deficiencies and may not be able to withstand a Cascadia earthquake. Since 2002 Oregon has required that due to the important services provided by hospitals, by the year 2022 hospitals must be seismically prepared for major earthquakes including those from the Cascadia subduction zone. The specific requirements are noted in Oregon Revised Statute 455.400 (https://www.oregonlegislature.gov/bills_laws/Archive/2013ors455.pdf):

Subject to available funding, if a building evaluated under section 2 (4) of this 2001 Act is found to pose an undue risk to life safety during a seismic event, the acute inpatient care facility, fire department, fire district or law enforcement agency using the building shall develop a plan for seismic rehabilitation of the building or for other actions to reduce the risk. Subject to available funding, all seismic rehabilitations or other actions to reduce the risk must be completed before January 1, 2022. If the building is listed on a national or state register of historic places or properties or is designated as a landmark by local ordinance, the plan for seismic rehabilitation or other actions shall be developed in a manner that gives consideration to preserving the character of the building. [2001 c.798 §3]

Hospitals and their partners have been preparing for many types of disasters for many decades. Hospitals are encouraged to prepare for disasters, for example, through Healthcare Preparedness Capabilities: National Guidance for Health System Preparedness (http://www.phe.gov/Preparedness/planning/hpp/reports/Documents/capabilities.pdf) by the U.S. Department of Health and Human Services. In addition, the hospital industry has standards on preparing for disasters, such as emergency management standard EM.02.01.01, which are general guidelines for hospital plans on emergency response and recovery, and standard EM.02.02.09, both issued by The Joint Commission. The Joint Commission is an independent, not-for-profit organization, which accredits and certifies health care organizations and is recognized nationwide as a symbol of quality that reflects an organization's commitment to meeting certain performance standards (http://www.jointcommission.org/). EM.02.02.09 (http://www.emergency-planning.com/products/hics-system/jacho/) states,

As part of its Emergency Operations Plan (EOP), the [organization] prepares for how it will manage utilities during an emergency. The hospital identifies an alternative means of providing for the following utilities in the event that their supply is compromised or disrupted (Eps 1-5). As part of its EOP, the hospital identifies alternative means of providing the following:

- *Electricity*
- *Water needed for consumption and essential care activities*
- *Water needed for equipment and sanitary purposes*
- *Fuel required for building operations or essential transport activities that the hospital would typically provide*
- *Medical gas/vacuum systems*
- *Utility systems that the hospital defines as essential (for example, vertical and horizontal transport, heating and cooling systems, and steam for sterilization)*
- *The hospital implements the components of its EOP that require advance preparation to provide for utilities during and [sic] emergency*

Hospitals depend on many intricate internal systems, such as electrical power and medical gases, and other systems typically outside of the hospital complex, such as water systems, which are needed for normal healthcare operations as well as for fire suppression. Planning tools that include lessons from recent disasters in the United States are available (Hanfling and others, 2013; Wizemann and others, 2013).

2.1.2 Water Facilities and Earthquakes

Past performance of many water systems in worldwide earthquakes has been poor. This is related to the fact that water treatment facilities and transmission pipelines are often constructed on riverine soils where there is a concentration of liquefiable soils. Earthquakes can shake loose, sandy, water-saturated soils to the point where the sand grains separate and the soils temporarily turn into a thick sandy soup-like liquid. These liquefied soils can affect building structures and buried pipelines. **Figure 2-5** shows an example of a sand boil. Sand boils occur when liquefaction triggered at depth transports fluidized soils to the ground surface, where the soils form the boil. This site is within several miles of a water treatment plant that suffered liquefaction damage in a 2007 earthquake. **Figure 2-6** shows a water transmission pipeline at a river crossing that failed due to liquefaction and subsequent ground movement toward the river.

Communities depend on water systems to operate, and people require water to sustain their lives. Yet, despite the importance of water systems, only limited earthquake mitigation efforts have been conducted on water facilities and transmission pipelines in Oregon. As part of this project, DOGAMI compiled and shared a list of seismic references for water facilities with partnering water districts in the project area and with Oregon's main water districts (Appendix A). Many larger water districts have or are completing seismic vulnerability assessments of their systems and have or are making plans to improve seismic performance of their systems.

Figure 2-5. Liquefaction sand boil in the 2007 Kashiwazaki Japan earthquake. (Photo by Alex Tang)

Figure 2-6. Water transmission pipeline failure at a river crossing in the 2007 Kashiwazaki, Japan earthquake. (Photo by Yumei Wang)

2.2 Pilot Project Study Area

The pilot project study area includes an irregular boundary that stretches from Lincoln City on the west to McMinnville on the east. The study area was defined using the minimum census (tract) data polygons that include Highway 18 between Lincoln City and McMinnville and the local watersheds that supply the water systems for those cities. Samaritan North Lincoln Hospital, herein referred to as Lincoln City hospital, and Willamette Valley Medical Center, herein referred to as McMinnville hospital, were the two hospitals included in this study. The water districts for Lincoln City, McMinnville, and the communities of Grand Ronde, Willamina, and Sheridan, which are located along Highway 18 between Lincoln City and McMinnville, are included in this study. The study area is shown in **Figure 2-7**.

The project area, hospitals, and water districts were determined by OHA and DOGAMI. Additional smaller communities that are included in the Hazus default inventory are also included but no contact was made with those communities. The project area includes 20 census tracts in four counties (**Table 2-1**): Lincoln (four tracts), Yamhill (eleven tracts), Polk (three tracts), and Tillamook (two tracts). According to year 2000 census data, the population in the project area was about 96,000 people. The current population is higher.

Figure 2-7. Pilot project study area map. "H" symbols indicate hospital locations and "WTP" symbols indicate water treatment plants.

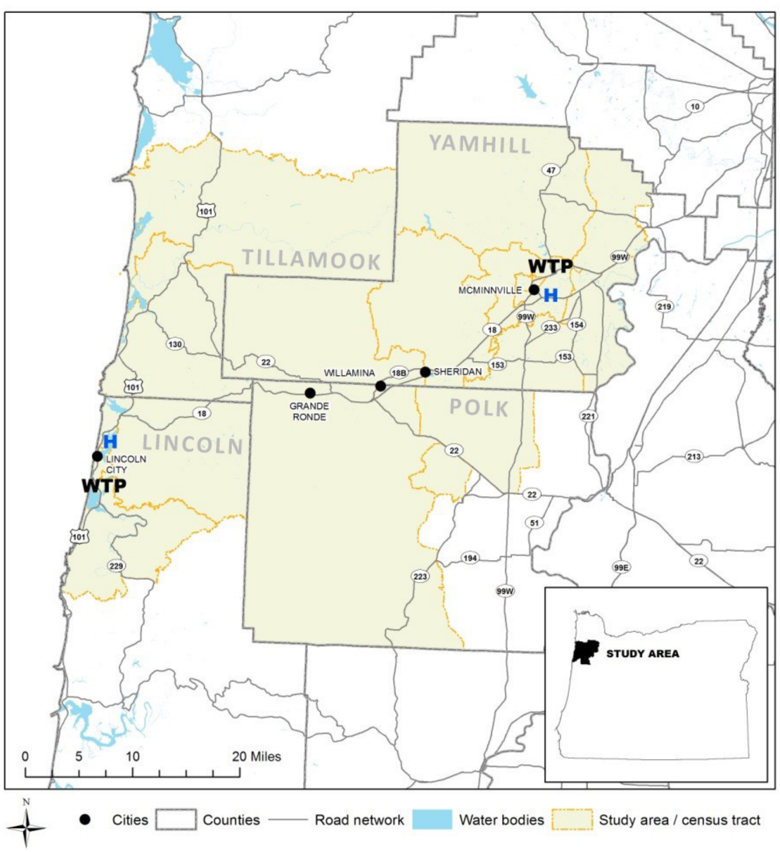


Table 2-1. Census tracts (STFID) by county in the pilot project study area.

County	Census Tract (STFID)
Lincoln	41041950100
Lincoln	41041950300
Lincoln	41041950400
Lincoln	41041950600
Polk	41053020100
Polk	41053020201
Polk	41053020400
Tillamook	41057960700
Tillamook	41057960800
Yamhill	41071030300
Yamhill	41071030400
Yamhill	41071030501
Yamhill	41071030502
Yamhill	41071030600
Yamhill	41071030701
Yamhill	41071030702
Yamhill	41071030801
Yamhill	41071030802
Yamhill	41071030900
Yamhill	41071031000

STFID here is a FIPS (Federal Information Processing Series; available via https://www.census.gov/geo/maps-data/maps/2010tract.html) unique identifier for every census tract in the United States. The first two digits are the state code, the next three digits identify the county, and the next six digits identify the census tract.

2.3 Project Method

The method included working with OHA personnel and partners to shape the focus of the pilot project, collect and developing data on geologic earthquake hazards and facilities inventories, running analyses and evaluations to estimate damage and impacts, evaluating the results, and developing conclusions and recommendations. Information on assumptions, method limitations, data collection and verification, Hazus analyses, and hospital interdependencies evaluation are provided.

2.3.1 Method Limitations and Uncertainties

DOGAMI had limited time and resources to perform this study, which includes developing and collecting hazard and facilities input data, verifying the characteristics and locations of the facilities, and collecting and analyzing additional facilities that were discovered during site visits.

DOGAMI used Hazus-MH, a FEMA-developed software tool, to evaluate damage. Hazus-MH is a robust model with limitations and uncertainties (FEMA, 2010a). Limitation and uncertainties are inherent in any loss estimation methodology. They arise in part from incomplete scientific knowledge concerning earthquakes and their effects on buildings and facilities. Limitations and uncertainties also result from the approximations and simplifications that are necessary for comprehensive analyses. Incomplete or inaccurate inventories of the built environment, demographics, and economic parameters add to the uncertainty. "These factors can result in a range of uncertainty in loss estimates produced by the HAZUS Earthquake Model, possibly *at best* a factor of two or more" (FEMA, 2010b, p. 2-1). Although Hazus-MH software offers users the opportunity to prepare comprehensive loss estimates, it should be recognized that even with state-of-the-art techniques uncertainties are inherent in any such estimation methodology (FEMA, 2010b).

Any region or city studied will have an enormous variety of buildings and facilities of different sizes, shapes, and structural systems constructed over years under diverse seismic design codes. Similarly, many types of components with differing seismic resistance will make up transportation and utility lifeline systems. Due to this complexity, relatively little is certain concerning the structural resistance of most buildings and other facilities. Further, there simply are not sufficient data from past earthquakes or laboratory experiments to permit precise predictions of damage based on known ground motions even for specific buildings and other structures. To deal with this complexity and lack of data, buildings and components of lifelines are lumped into categories based on key characteristics. Relationships between key features of ground shaking and average degree of damage with associated losses for each building category are based on current data and available theories. While state of the art in terms of loss estimation, these relationships do contain a certain level of uncertainty (FEMA, 2010b).

There are a variety of limitations and uncertainties to our approach and analytical tools for the pilot project. We start by assuming that strong ground shaking with 1,000-year probabilistic ground motions has occurred, then estimate damage, loss, and impacts. Estimated losses are incomplete and the estimates involve large uncertainties, especially where inventories are limited to the default data within Hazus. It is important to understand that the DOGAMI results are simply estimates and it is not possible to "predict" exact damage, loss, functionality, or failures. Furthermore, due to interdependencies, in an actual earthquake, impacts may vary and may even be far greater or less, than estimated and described in this report.

Some specific limitations include:

- 2000 census data (rather than more recent data: FEMA Hazus uses 2000 census data)
- The smallest regional unit used is a census tract. This affects many algorithms. For example, with the exception of user-defined values for hospitals and water facilities, earthquake-induced landslide hazards and liquefaction hazards are considered by Hazus to be uniform across each census tract. Thus, some damage is overestimated and some is underestimated. For example, pipeline damage in terms of breaks and leaks may be overestimated due to permanent ground deformations hazards estimated within Hazus from the landslide and liquefaction hazard maps.

Similarly, bridge damage may be underestimated in areas, especially in areas with severe liquefaction.

- No dam analyses algorithms are made available
- No hazardous materials (hazmat) spills algorithms are made available
- Errors with potable water facilities algorithms for inputting data
- Recovery time for hospitals is dependent only on the Hazus damage state
- Backup generator information is not used by the Hazus model
- Default data for inventory except hospitals, water systems, and bridges

2.3.2 Assumptions

For the pilot project, we made a variety of assumptions when running the analyses:

- For earthquake ground motions, we used the 1,000-year probabilistic ground motions developed by the U.S. Geological Survey in the Hazus program. For the pilot study region, we compared these probabilistic ground motions, which are dominated by Cascadia subduction zone earthquake ground motions, with ground motions from a magnitude 9 Cascadia subduction zone earthquake and determined that they are a good representation for Cascadia ground motions.
- For water systems, we assumed that that the functionality of the water treatment plant (WTP) is representative of the entire water system.
- We estimated the water system replacement cost with the operator. Due to uncertainties in the costs of each specific facility and component in each system, we assigned the entire replacement cost to the WTP rather than distributing the costs throughout the system. Thus, the loss estimate is heavily weighted to the predicted damage of the WTP.

2.3.3 Data Collection and Verification

Madin and Burns (2013) was the main source for geologic hazard map data. Additional geologic hazard data came from Burns and others (2008), CH2M HILL (2012a,b), Goldfinger and others (2012), Mickelson (2011), Wang and Priest (1995), Wang and Clark (1999), and Wang and others (2013). Information, mostly on infrastructure, came from Lewis (2007), Nako and others (2009), and Read (2013). Basic project information on hospitals and water systems was provided by OHA personnel, including Alan Visnick, Michael Swinhoe, and Anthony Fields (refer to the Acknowledgements section). OHA contacted hospitals and water facilities to request their partnership on this pilot project; everyone contacted agreed to participate. OHA provided DOGAMI contact information for project partners well as information on hospital beds and generators. OHA also provided information on generic hospital preparedness.

DOGAMI contacted the seven primary partners, which were the two hospitals and five water districts. DOGAMI also contacted Oregon Department of Transportation (ODOT), and others, including the City of McMinnville and Yamhill County. To collect information for each facility, DOGAMI had several email and phone discussions with each partner. Furthermore, DOGAMI conducted a field visit to meet with key personnel from hospitals and water districts to help verify information to be used for Hazus analyses and the interdependency evaluation as well as to address any seismic preparedness questions from our partners. On April 14, 2014, DOGAMI met with McMinnville hospital. On April 23, 2014, DOGAMI met with McMinnville Water and Light (MWL). On May 1, 2014, DOGAMI met with Lincoln City hospital and City of Lincoln City water district. DOGAMI found some discrepancies, including omissions, between data collected by phone and by email and field visits. Our partners were professional and forthcoming during field visits and provided important information.

Figure 2-8 shows a community-scale map of the Lincoln City hospital (Samaritan North Lincoln Hospital) and major facilities of the City of Lincoln City water district. **Figure 2-9** shows a map of the greater McMinnville area, which highlights the major facilities of the McMinnville water district (McMinnville Water and Light [MWL]). **Figure 2-10** shows a community-scale map of the McMinnville hospital (Willamette Valley Medical Center) and major facilities of the MWL.

This Data Collection and Verification section is organized by geologic hazard information, hospital information, water system information, and transportation information.

Figure 2-8. Community-scale map of Lincoln City showing the Lincoln City hospital (blue "H" icon), features of the water system (blue tanks) that feed the hospital and community, and portions of the transportation system (yellow) (Basemap: Google Earth)

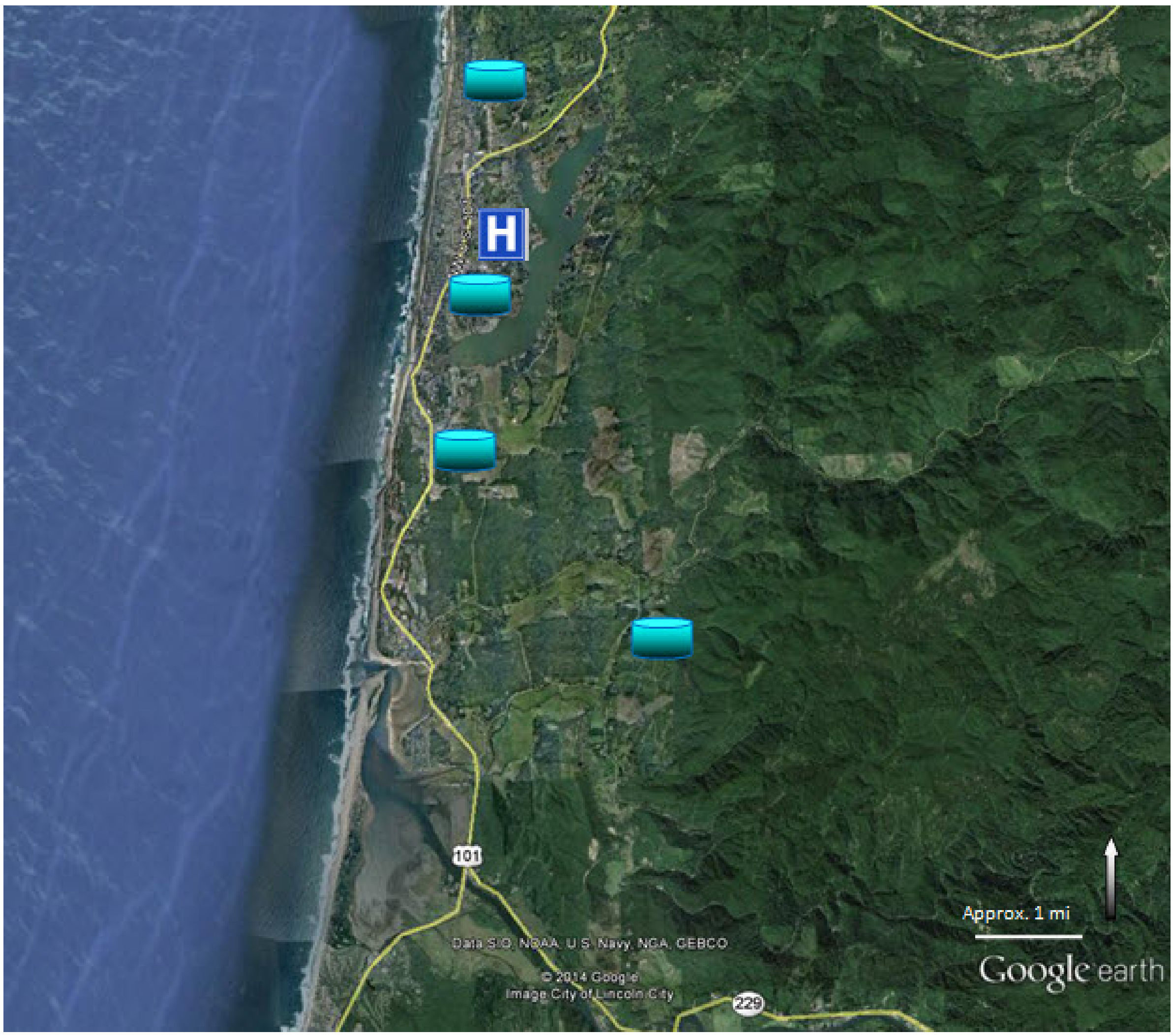


Figure 2-9. Map of greater McMinnville area showing the McMinnville hospital southeast of downtown (blue "H" icon), and locations of the major features of the water system that feed the hospital and community, including lake reservoirs, water treatment facilities, and in-town reservoirs. (Source: Robert Klein, McMinnville Water and Light)

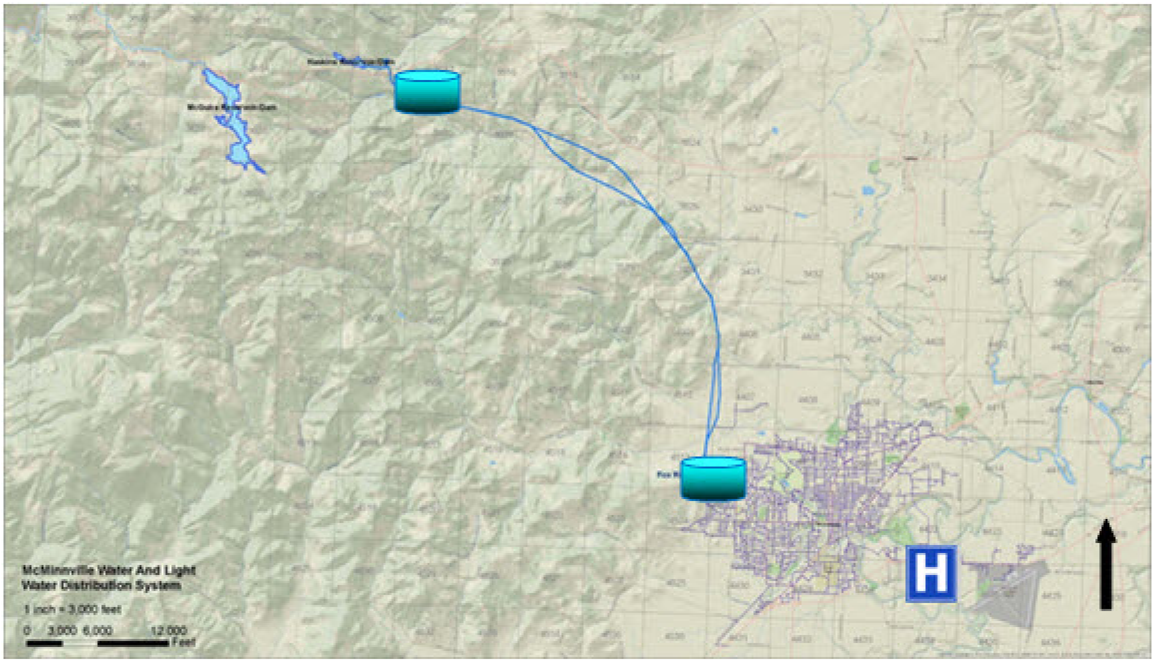
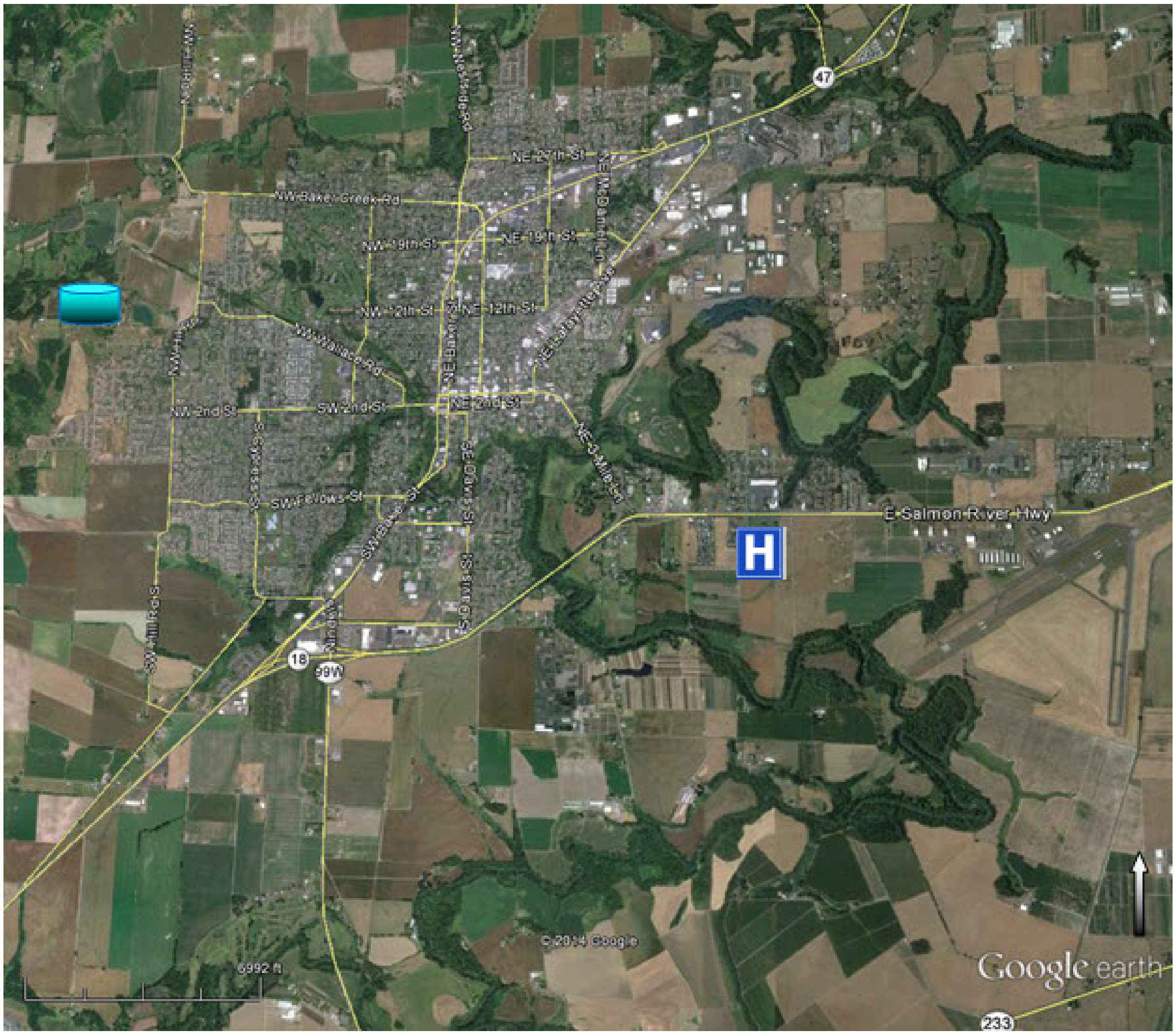


Figure 2-10. Map of McMinnville area showing the McMinnville hospital southeast of downtown (blue "H" icon), location of the major features of the water system that feed the hospital and community (blue tank), and major transportation routes (yellow). (Basemap: Google Earth)



2.3.3.1 Geologic Hazard Information

After reviewing 500-, 1,000-, and 2,500-year probabilistic ground motion data, DOGAMI decided to use the 1,000-year probabilistic ground motion data that are available in the Hazus data set. The ground motion values are comparable or slightly higher than the mean Cascadia magnitude 9 peak ground acceleration (PGA) values and were selected on the basis of the values being similar or slightly higher. DOGAMI attempted to input user-defined Cascadia magnitude 9 ground motion data for the Hazus analyses. However, spurious outputs resulted for hospital damage when using these values. These spurious results could not be resolved. Therefore DOGAMI used probabilistitic ground motions, which include Cascadia earthquakes, as input values.

Except at the user-defined hospital and water facilities sites where we selected site-specific values based on site observations, geotechnical data, or available statewide data, DOGAMI used statewide landslide hazard and liquefaction hazard maps (Madin and Burns, 2013). Figure 2-11 and Figure 2-12 show the non–user-defined ground movements from landslide hazards and liquefaction hazards, by census tract, that were incorporated into Hazus analyses. The soil type was determined from site geotechnical data or from the statewide maps. For the remainder of the project area, soil type D (Building Seismic Safety Council, 2004) was selected because DOGAMI had initially attempted to use the statewide soil type map in combination with the user-defined Cascadia magnitude 9 ground motion data, but that attempt failed due to the above-mentioned spurious results with ground motion maps.

Figure 2-11. Plot of the study region showing permanent ground displacement due to landslide hazards by census tract within the project area. Refer to the Lincoln City and McMinnville hospitals in Figure 2-7 as location reference points.

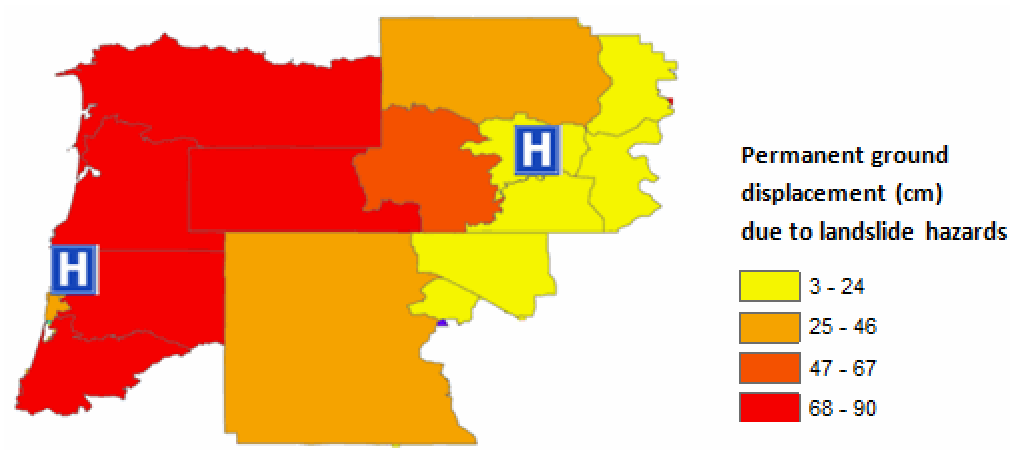
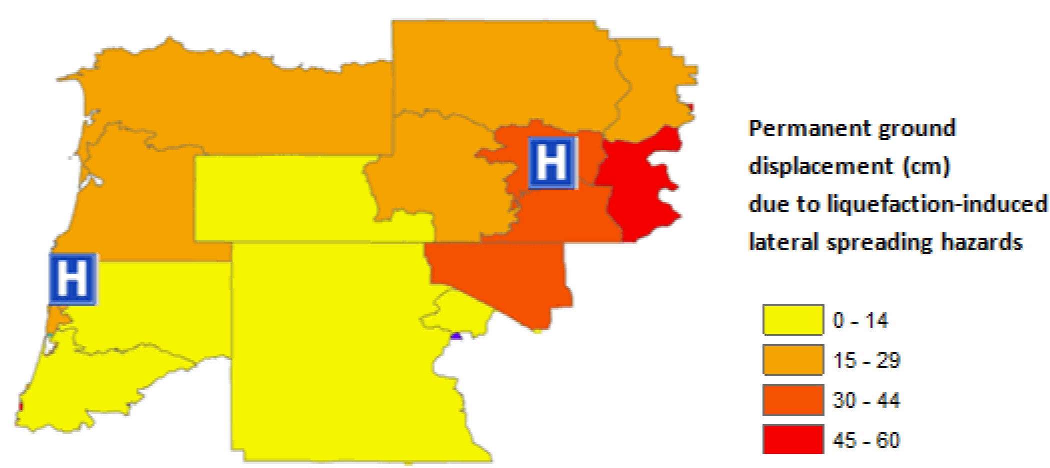


Figure 2-12. Plot of the study region showing of permanent ground deformation due to liquefaction-induced lateral spreading hazards by census tract within the project area. Refer to the Lincoln City and McMinnville hospitals in Figure 2-7 as location reference points.



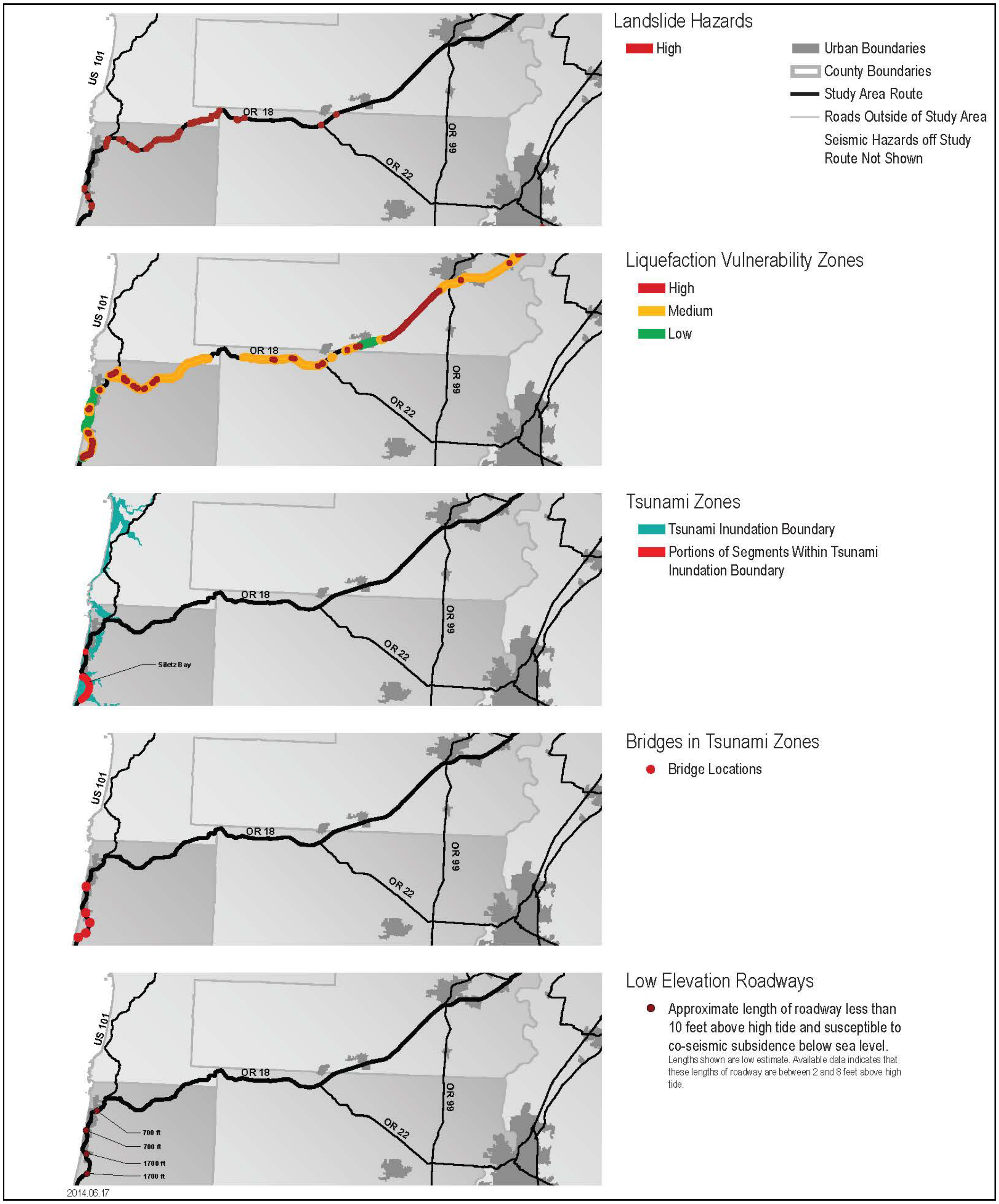
For the Lincoln City hospital, statewide hazard maps (Madin and Burns, 2013) indicated these values: soil type C, liquefaction hazard rating 2 (of 5 with 5 being the highest hazard), landslide hazard value 5 (of 10 with 10 being the highest hazard). However, on the basis of our project information, we used these input values for the project area: soil type E, liquefaction hazard rating 5, and landslide hazard value 3. The final input values are provided in the Hazus analyses for earthquake damage and loss section of the report (section 2.4).

For the McMinnville hospital, statewide hazard maps (Madin and Burns, 2013) indicated these values: soil type D, liquefaction hazard rating 3 (of 5 with 5 being the highest hazard), landslide hazard value 7 (of 10 with 10 being the highest hazard). However, from our project information, we used these input values: soil type E, liquefaction hazard rating 4, landslide hazard value 3. The final input values are provided in the Hazus analyses for earthquake damage and loss section of the report (section 2.4).

In 2011, ODOT contracted with CH2M HILL to help develop statewide seismic lifeline routes. After evaluating multiple hazards and risk, Highway 18 and parts of Highway 101 were selected to be statewide lifeline routes (CH2M HILL, 2012a, 2012b). On the basis of the CH2M HILL evaluation, the transportation route between Lincoln City and McMinnville has these hazards (**Figure 2-13**):

- High landslide hazards, especially along portions of Highway 101 and the western portions of Highway 18
- Liquefaction hazards along most of Highway 101 and 18, with extensive portions of high hazard west of McMinnville
- Tsunami hazards along portions of Highway 101, including at D River and Siletz Bay
- Tsunami hazards for bridges along Highway 101, including five bridges in Lincoln City
- Low-elevation (flooding) hazards along portions of Highway 101, which may experience co-seismic subsidence during Cascadia earthquakes

Figure 2-13. Hazard maps along Oregon Highways 101 and 18 showing, from top to bottom, landslide hazards, liquefaction vulnerability zones, tsunami zones, bridges in tsunami zones, and low-elevation roadways. (Source: Gary Conner, CH2M HILL, written communication, June 18. 2014)



2.3.3.2 Hospital Information

Hospitals are complex systems with specialized services. Hospitals can experience structural damage, such as supporting walls or columns buckling; non-structural damage, such as suspended ceilings falling down; contents damage, such as medical supplies falling off shelves; mechanical equipment damage, where chillers, boilers, and medical gas systems become inoperable; emergency equipment damage, where generators and fire suppression systems become inoperable; fires; and hazardous materials spills. These impacts can reduce the functionality of hospital services. Below is information for the Lincoln City and McMinnville hospitals that was considered important to earthquake disaster preparedness and analysis. **Figure 2-14** through **Figure 2-20** show the hospital structures as well as some potential hazards.

Lincoln City hospital. The Lincoln City hospital is a one-story wood frame building constructed in 1967. The structure includes wood-framed additions and includes both vertical and plan irregularities in its shape. It operates 25 hospital beds but is licensed to operate 30 beds. It is located above the tsunami zone as shown on the April 22, 2013, DOGAMI Tsunami Evacuation Map of Lincoln City North and is founded on hazardous soils that are subject to amplification from the ground shaking in the western portion of the site and liquefaction with associated lateral displacement in the eastern portion of the site. Hazus input parameters include a low code design level for Hazus structural type W2 (Wood, Greater than 5,000 sq. ft.), soil type E, landslide hazard value 3, and liquefaction hazard value 5.

The hospital has an emergency generator that can support 80% of hospital needs. The generator is housed in a reinforced masonry structure that, based on the age of construction, may be seismically deficient, and may experience damage. It has fuel tank capacity of 5,000 gallons and requires a fuel type of diesel #2 to operate. The hospital has a 300-gallon water supply and an agreement in place for an emergency water truck (Nick Berryhill, written commun., September 25, 2014).

Figure 2-14. Lincoln City (Samaritan North Lincoln) hospital. Front entrance. (Photo by Yumei Wang)

Figure 2-15. Lincoln City (Samaritan North Lincoln) hospital structure with boilers and mechanical equipment necessary for hospital operations. (Photo by Yumei Wang)

Figure 2-16. Lincoln City (Samaritan North Lincoln) hospital patient room with nonstructural damage potential, such as falling suspended ceiling tiles and medical equipment. (Photo by Yumei Wang)

Figure 2-17. Lincoln City (Samaritan North Lincoln) hospital with contents damage potential, such as medical supplies falling from shelves that have not been seismically secured. (Photo by Yumei Wang)

Figure 2-18. Lincoln City (Samaritan North Lincoln) hospital has potentially hazardous chemicals that are not secured to withstand earthquake shaking and may spill. (Photo by Yumei Wang)

McMinnville hospital. The McMinnville hospital complex includes three steel-framed buildings with sections of one-, two-, three-, and four stories that were constructed between 1996 and 1998, and is considered to include modern seismic design requirements as required in the then building code. Two buildings are considered to be mid-rises and have sections that are four stories in height. The structures include both vertical and plan irregularities in their shape and various seismic joints connecting the buildings. The hospital is licensed to operate 88 beds. It is founded on hazardous soils that are subject to amplification of ground shaking and the potential to liquefy and move laterally due to liquefaction. The Hazus input parameters include high code design levels for Hazus structural types S2L, S2M, and S2M (steel-braced frame, low rise and mid rise), soil type E, landslide hazard value 3, and liquefaction hazard value 4.

The hospital has an emergency generator that can support 65% of hospital needs. DOGAMI was not able to view the generator at the time of our site visit because it was locked and the keys were not easily available. It has fuel tank capacity of at least 2,000 gallons and requires diesel fuel to operate. The hospital has an agreement in place for emergency water from local farmer (Jim Bratcher, oral commun., April 14, 2014).

Figure 2-19. The one-story front entrance of McMinnville hospital (Willamette Valley Medical Center) is next to a four-story building (on the left). (Photo by Yumei Wang)

Figure 2-20. Medical gasses at McMinnville hospital (Willamette Valley Medical Center) are stored without seismic considerations. (Photo by Yumei Wang)

2.3.3.3 Water System Information

Water systems typically involve source water, storage, treatment, transmission, and distribution. They range from simple to complex and may involve dams, surface water reservoirs, tank-style reservoirs, water treatment plants, and various types of piping. All of these components can experience damage, which can reduce the functionality of water services. In accordance with Hazus pipe categories, we provide information on pipelines in terms of ductile and brittle—where ductile pipes perform better than brittle pipes in earthquakes. Corroded pipelines would be considered as brittle. Below is information on the water systems for Lincoln City, Grand Ronde, Willamina, Sheridan, and McMinnville that was considered important to earthquake disaster preparedness and analysis. **Figure 2-21** through **Figure 2-27** show the parts of the Lincoln City and McMinnville water systems as well as potential hazards.

Lincoln City water system. The City of Lincoln City water system is supplied by surface water and includes a water treatment plant, three city reservoirs, seven pumping stations throughout the city, approximately seven miles of transmission pipe, and over 100 miles of distribution pipes. The approximate replacement value of the system has been estimated at $300 million (Lani Hankins, written commun., January 2, 2014). It serves a population of approximately 21,000 people and provides 100% of the water for the hospital, which uses approximately 15,000 gallons per day. The water system's biggest customer is the Chinook Winds Casino.

The water treatment plant, constructed in 1982, has a capacity of 6 million gallons per day and includes a 1982 pump house and 1999 control building (**Figure 2-21**). These three buildings are reinforced masonry. Hazus input parameters for the water treatment plant include PWTS, which represents a small-capacity potable water treatment facility; three buildings of Hazus structural type RM1L, which represents low-rise, reinforced masonry buildings; soil type D; landslide hazard value 3; and liquefaction hazard value 2. The three city reservoirs are welded steel on-the-ground tanks with these construction dates and capacities: 1972, one million gallons; circa 1980, two million gallons; 2009, 4.25 million gallons. The water treatment plant and five of the seven pump stations have auxiliary power on site. The two exceptions are the pump station located at NE 36th Drive and NE Quay Avenue and the Drift Creek raw water station, which have wiring for portable generators. The generator at the plant does not appear to be seismically resistant (**Figure 2-22**).

The transmission pipeline is approximately 97% ductile pipe and 3% brittle pipe. The maximum diameter of the transmission pipe is 24 inches. Four bridges carry transmission pipes: D River bridge on Highway 101, Schooner Creek bridge on Highway 101, West Devils Lake bridge, and Drift Creek bridge. Transmission pipes also traverse zones of landslide activity, and active landslides are expected to move during a Cascadia earthquake. The transmission pipeline, which exists on an active landslide that parallels High School Road in Lincoln City, is being monitored for potential damage. It is part of a loop configuration of the system that can be used for distribution in the event of landslide damage.

Figure 2-21. City of Lincoln City water treatment plant, which is a critically important facility and part of the water system that serves the local hospital. (Photo by Yumei Wang)

Figure 2-22. Batteries for the emergency generator at the City of Lincoln City water treatment plant. The batteries have not been seismically restrained and may not operate the generator after a Cascadia earthquake. (Photo by Yumei Wang)

Grand Ronde water system. This system is spring fed with four intakes and does not have a water treatment plant. It includes a 1940s or 1950s wood office building; a 1980s pre-fabricated building, which is pump house with a capacity of 170 gallons per minute wired to allow for an emergency generator; and a second pumping station with a capacity of 50 gallons per minute located in a vault installed in 2000. There are seven reservoirs located throughout the greater Grand Ronde community.

Approximately 35 miles of distribution pipes are PVC (polyvinyl chloride) material type, which is considered to be ductile. Except for two of the six bridge crossings, 100 percent of the distribution system is PVC. The oldest PVC pipe dates back to 1973. The maximum diameter of pipe is 12 inches. The approximate replacement value of the system has been estimated at $11.2 million (Karl Ekstrom, oral commun., January 3, 2014). The system serves a population of approximately 3,000. The system's customer base is residential with no industry. The Grand Ronde water system shares an intertie with the nearby Spirit Mountain Casino water system; the Grand Ronde system is the casino's backup system for fire and other emergencies.

Seven on-the-ground community reservoirs exist at five locations. Hazus classification is "PSTGS" (on-ground small steel tank) for all the reservoirs. The 2013 and 2014 reservoirs have been built with earthquake design standards. The location, year built, storage capacity, and construction type, provided by Grand Ronde water district personnel, are:

- Reid: 1996, 500,000, bolted steel
- Reid: 2013, 500,000, bolted steel
- Salmon River: 1995, 500,000, bolted steel
- Rowell: 1975, 150,000, welded steel
- Hebo: 1996, 50,000, bolted steel
- Fort Hill: 1984, 103,000, bolted steel
- Fort Hill: 2014, 500,000, bolted steel

For modeling purposes, for Hazus input parameters, we designated the wood office building as the water treatment plant and assigned it as "pre-code" due to its construction timeframe in the 1940s. Other parameters include soil type D, landslide hazard value 3, and liquefaction hazard value 2.

There are six bridges with colocated pipelines made of either ductile iron or steel pipes, which are considered to be ductile. The performance of these pipelines depends on not only the pipe but also the bridges. The two most critical bridge crossings are on Highway 18 and cross the South Yamhill River at Valley Junction and John Road. An additional bridge crossing of lesser importance exists over the South Yamhill River at the intersection of Highway 22 and Hebo Road. There are three bridge crossings over the Gold Creek with pipelines that, if broken, would have a lesser impact to the community.

Willamina water system. This system is supplied by surface water from Willamina Creek and includes a water treatment plant, three city reservoirs, one pumping station, approximately five miles of transmission pipe, and less than 50 miles of distribution pipe (Justin Riggs, oral commun, December 31, 2013). The approximate replacement value of the system has been estimated at $10 million (Justin Riggs, oral commun, December 31, 2013), which was used in the analyses. Given the system's components, DOGAMI judges that the actual replacement cost would be higher. The Willamina water system serves a population of approximately 2,000 people. The water system's biggest customers include Willamina school district, a local meat factory, and the timber industry.

The system incorporates four buildings: a water treatment plant, a control building, a water intake building, and a pump house. The water treatment plant, which is reported to be a light frame steel building constructed in 2000, has a capacity of 700 gallons per minute. The system also includes 1970s wood frame control building, a 2000 reinforced concrete intake building, and a 2000 pump located in a vault. The Hazus input parameter for the water treatment plant is PWTS, which represents a small capacity potable water treatment facility. We assigned it as a Hazus "high code" due to the plant's construction year of 2000, and also used parameters of soil type D, landslide hazard value 3, and liquefaction hazard value 2.

There are three on-the-ground city reservoirs. The year built, storage capacity, and construction type, provided by Willamina water district personnel, are:

- 2000, 400,000 gallons, steel tank
- 1980, 1,000,000 gallons, steel tank
- 1958, 250,000 gallons, steel tank

The pipeline is approximately 50% ductile pipe and 50% brittle pipe. Most of the current pipeline is 8-inch diameter ductile iron, which is being replaced with PVC due to rust problems. One bridge that carries a pipeline that brings water from southwest Willamina to the southeastern portion of town. If this bridge or pipeline is damaged, then water services in the southeast will be impaired.

Sheridan water system. This system has two water sources: the South Yamhill River and from springs located approximately nine miles to the northwest of the community. It includes a water treatment plant, four city reservoirs, one pumping station, approximately 10 miles of transmission pipe, and 18 miles of distribution pipes. The approximate replacement value of the system has been estimated at $40 million (Ken Hamilton, oral commun., January 7, 2014). It serves a population of approximately 6,000 people. Its biggest customer is the Federal Corrections Institution, which consumes between 300,000 to 500,000 gallons per day.

The system incorporates two buildings including a water treatment plant, which is reported to be a light frame steel building constructed in 1970 with a 1.5 million gallon per day capacity, and a 1999 pumping station located in a reinforced masonry building with a wood roof. The Hazus input parameter for the water treatment plant is PWTS, which represents a small capacity potable water treatment facility.

We assigned the water treatment plant as “low code” due to its construction year of 1970 and also used parameters of soil type D, landslide hazard value 3, and liquefaction hazard value 2.

There are four on-the-ground community reservoirs. The year built, storage capacity, and construction type, provided by Sheridan water district personnel, are:

- 1946, 286,000 gallons, concrete built into the hillside
- 1955, 500,000 gallons, welded steel
- 1989, 1,800,000 gallons, welded steel
- 1999, 1,500,000 gallons, bolted steel

The pipeline is approximately 99% ductile pipe and 1% brittle pipe. The 10-mile transmission line that connects the springs to the treatment plant ranges from 6 to 16 inches in diameter. Approximately three to four miles is 16-inch ductile iron and six miles is steel. The distribution pipe is mostly PVC, with limited asbestos cement (1,500 feet in multiple locations), ductile iron, and steel (with only 320 feet).

There are three river crossings. The most important river crossing is a suspension bridge with a dedicated water transmission pipeline that is an 8-inch-diameter steel pipe. The bridge was built before the 1960s and includes steel posts with cable suspension. If this bridge or pipeline is damaged, then water services will be impaired. The remaining two river crossings are undercrossings of the South Yamhill River with a buried 8-inch PVC pipe and a 14-inch ductile iron pipe near the Bridge Street bridge.

McMinnville water system. The McMinnville water system includes two earthen dams, a water treatment plant including five buildings, four city reservoirs, approximately 25 miles of transmission pipe including a 24-inch-diameter tunnel, over 150 miles of distribution pipes, and three additional buildings. The approximate replacement value of the system has been estimated at $500 million (Robert Klein, oral commun., February 18, 2014). The water system serves a population of approximately 32,000 people. It provides 100% of the water for the hospital, which uses approximately 47,000 gallons per day. Its largest customers include the hospital and the local steel mill.

McGuire dam, which has 3.25 billion gallons of storage capacity, was originally constructed in the 1960s. In 2004, it was raised by 30 ft. Water from McGuire reservoir is piped to the Haskins dam reservoir. Haskin dam, which has 250 million gallons of storage capacity, was originally constructed in the 1920s. In 1996 the dam experienced landslide damage on its left abutment. At that time, the dam was upgraded. Both dams are expected to perform satisfactorily in a Cascadia earthquake (Robert Klein, oral commun., April 23, 2014). A 1,100 foot existing tunnel with 24-inch ductile iron pipe exists between the dams and water treatment plant. In 2014 a new 2,200-foot tunnel with 36-inch-diameter steel pipe will be completed.

The water treatment plant, constructed in 1977, has a capacity of 30 million gallons per day (**Figure 2-23**). Hazus input parameters for the water treatment plant include PWTM, which represents a medium capacity potable water treatment facility; a 1977 and 1995 building type RM1L, which represents low-rise reinforced masonry buildings; three 2010 building type C2L, which represents low-rise reinforced concrete buildings; soil type D; landslide hazard value 3; and, liquefaction hazard value 1. The water treatment plant has an emergency generator that appears to be seismically resistant (**Figure 2-24**). Not all of the equipment is seismically restrained (**Figure 2-25**). Installing seismic restraints for mechanical equipment may require engineering analyses or special techniques, such as discussed in FEMA publication 412 (2005).

Figure 2-23. McMinnville Water and Light water treatment plant showing the control building. This is a critically important facility that serves the local hospital. (Photo by Yumei Wang)

Figure 2-24. McMinnville Water and Light water treatment plant showing the chemical building and emergency generator (foreground). (Photo by Yumei Wang)

Figure 2-25. McMinnville Water and Light water treatment plant showing equipment without adequate seismic anchorage. Note the missing upper nut on center bolt. Proper seismic restraints of mechanical equipment may require seismic analyses. (Photo by Yumei Wang)

The transmission pipelines in the system vary in size, age, and material type. The transmission pipeline is approximately 75% ductile pipe and 25% brittle pipe. There are two 10-mile stretches of transmission pipelines between the water treatment plant and the four city reservoirs at Fox Ridge. One of the pipelines is mostly circa 1940s 16-inch welded steel with limited asbestos cement pipe. The second pipeline is circa 1970s 24-inch include ductile iron pipe. There are three interties.

The four city reservoirs are located at Fox Ridge (**Figure 2-26**). The year built, storage capacity, and construction type are:

- circa 1910s, 2,200,000 million gallons, wood
- 1910s, 3,200,000 million gallons, wood
- 1964, 7,000,000 gallons, with an upgrade in 1995, pre-stressed reinforced concrete
- 1995, 10,500,000 gallons, pre-stressed reinforced concrete (**Figure 2-27**)

There are no seismic valves for the transmission lines or reservoirs; thus it is possible that the contents can be completely drained (Robert Klein, oral commun., May 1, 2014) in the event of transmission pipeline failure. The maximum diameter of the transmission pipe in the system is 42 inches.

Transmission pipes in the source water area and that lead to the city reservoirs traverse zones of landslide activity, and active landslides are expected to move during a Cascadia earthquake. There are also two major pipeline undercrossings beneath the Yamhill River. These are susceptible to earthquake-induced liquefaction and ground movement associated with liquefaction, as well as nonseismic bank erosion and flooding. No bridges carry transmission pipes.

Figure 2-26. McMinnville Water and Light Fox Ridge reservoirs (identified in blue) and control building (gray rectangular building to the right of the lower round tank) on a lidar basemap.

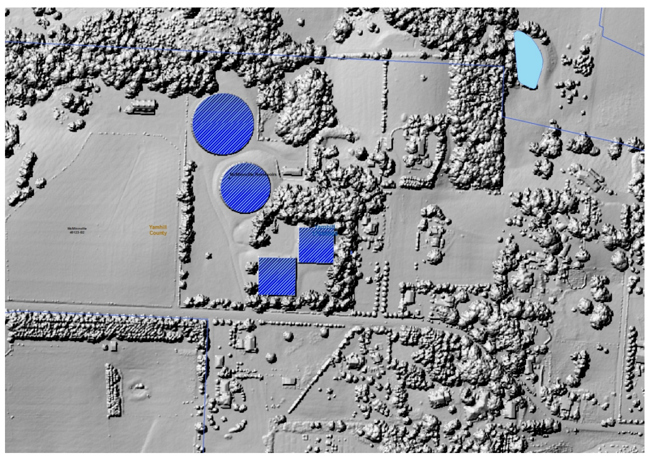


Figure 2-27. McMinnville Water and Light showing two of the four Fox Ridge reservoirs. These are the pre-stressed concrete tanks. (Photo by Yumei Wang)

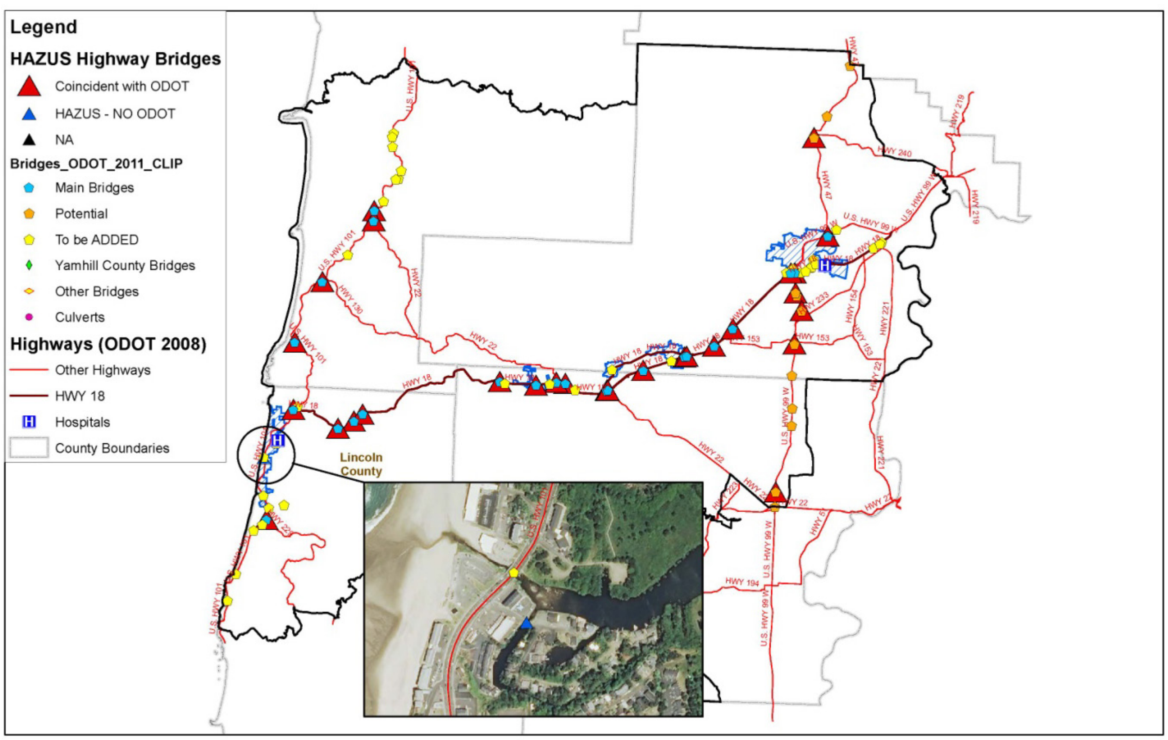
2.3.3.4 Transportation Information

DOGAMI reviewed the bridge inventory from Hazus, the National Bridge Inventory, and data from ODOT. We consolidated bridge inventories, resolved some discrepancies, and selected all bridges on highways 101, 18, 47, and 99 in the project area, totaling 73 bridges. The highways connect Lincoln City and McMinnville and extend north and south of McMinnville. The project area includes two Western Pacific Railroad bridges that geographically intersect with Highway 99, which are assumed to be collapse hazards that may affect mobility on Highway 99. The project area includes a total of 169 bridges, including 96 bridges not on the four above-mentioned highways. The project area also includes major roadway segments, including Highway 18, which is considered to be an ODOT seismic priority lifeline route (CH2M HILL, 2012a).

ODOT bridge engineers Bruce Johnson and Albert Nako were very helpful in selecting bridges to be included in this study. ODOT provided their bridge inventory to DOGAMI and estimated replacement values for the 73 project area bridges, which DOGAMI incorporated in Hazus analyses. ODOT geologist Curran Mohney provided landslide information on Highway 18, which can impact the road segments.

DOGAMI had difficulty determining ownership of some bridges, for example, the bridge east of the D River bridge on Highway 101 (indicated by the blue dot on the inset photo in **Figure 2-28**). Although DOGAMI inquired, the state, county, and city did not appear to have ownership records. This single-span bridge has a water pipeline on it. Due to the proximity to the Cascadia fault, shaking hazards, tsunami hazards, and liquefaction hazards, this bridge and pipeline are likely to experience damage.

Figure 2-28. Hazus-generated map showing project area bridge inventory discrepancies between the Hazus bridge database and the ODOT bridge database. The photo inset (Google Earth basemap) shows the single span bridge east of the D River bridge where ownership could not be determined. This is not a damage map.



DOGAMI evaluated bridge characteristics for 73 bridges to determine Hazus bridge categories. ODOT assisted DOGAMI with bridge characteristics and classification questions. ODOT also provided results from their earlier seismic analyses, which were made by using a software tool called REDARS (Nako and others, 2009). The ODOT model results indicated nine bridges, with construction dates ranging from 1930 to 1980 and up to 619 feet in length, with high damage states. Two of those bridges cross the Yamhill River on Highway 18 just west of the McMinnville hospital. This information allowed DOGAMI to focus on ODOT-identified "problem" bridges before we ran our model, and we later compared our results with ODOT's analyses on selected bridges. The two bridges west of McMinnville hospital had similar results from both models.

As DOGAMI collected transportation data, it became evident that several locations between Lincoln City and McMinnville would likely experience damage and would become choke points, that is, require long detours or be impassable. The western segment of Highway 18 is landslide prone and will likely experience significant ground deformation from co-seismic landslides. Highway 18 between Sheridan and McMinnville is prone to liquefaction and will likely experience liquefaction-induced permanent ground deformation from ground settlement and lateral displacement. From a 2009 ODOT study (Nako and others, 2009), Bear Creek bridge and Slick Rock Creek bridge on Highway 18 are expected to incur major damage during a Cascadia earthquake. **Figure 2-29** shows the inadequate width of bearing seats for Bear Creek bridge; bridge deck girders could slip off their supports during horizontal ground motions and render the bridge inoperable. This expected damage is supported by this study.

Figure 2-29. Bear Creek bridge on Highway 18 is expected to incur major damage during a Cascadia earthquake (Nako and others, 2009). One seismic deficiency relates to the inadequate width of the bearing seats; the bridge deck girders could slip off their supports during horizontal ground motions and render the bridge inoperable. (Photo by Yumei Wang)

The Three Mile Lane bridge was previously identified by City of McMinnville as a top priority to upgrade due to maintenance and modernization issues (**Figure 2-30**). According to communications with city personnel, the city has been seeking funds to conduct non-seismic upgrades since before 2008. Below is text from city documents that indicate the importance of this bridge to the McMinnville hospital (M. Bisset, Community Development Director, written communication to T. Potter, Area 3 Manager, Oregon Department of Transportation, Region 2, April 27, 2012). This bridge has significant seismic vulnerabilities, which are illustrated in **Figure 2-31** and **Figure 2-32**.

April 27, 2012 letter was sent from the City of McMinnville to ODOT to reiterate a 2008 City resolution requesting "that the Oregon Department of Transportation and Oregon Transportation Commission include the project to replace the Three Mile Lane (OR Hwy 18 McMinnville Spur) bridge in the 2010 -- 2013 Statewide Transportation Improvement Program." The 2008 resolution states "Three Mile Lane serves as the primary connection between a majority of incorporated McMinnville and the area's main hospital, Willamette Valley Medical Center. Therefore, the roadway is an essential facility for McMinnville emergency service providers, and its capacity and function play a crucial role in emergency response times to the hospital."

The resolution further includes the following:

The Oregon Department of Transportation (ODOT) owns and maintains the

- *Three Mile lane (OR Hwy 18 McMinnville Spur) bridge crossing the South Yamhill River. The City understands that ODOT's most recent inspection of the 1000-foot long bridge, which was constructed in 1951, resulted in a "Poor and Structurally Deficient" condition rating for the structure.*
- *"Three Mile Lane (OR Hwy 18 McMinnville Spur) is an arterial that provides a critical and vital link between the Three Mile Lane I Highway 18 corridor and the greater McMinnville area north and west of the South Yamhill River.*
- *Further, Three Mile Lane functions as an important freight connection between Highway 18 and much of the City's industrial and commercial lands. Thus, the roadway is important to the economic livelihood and well-being of the City and surrounding region.*
- *The City is in the process of drafting its Transportation System Plan (TSP), and has identified the replacement of the Three Mile Lane bridge as an important transportation system need and priority." (Note: The City's TSP was adopted in May 2010, and the plan does include the bridge replacement by ODOT as a priority project.)*

Figure 2-30. The 1951 Three Mile Lane bridge crosses the Yamhill River and connects downtown McMinnville and the hospital. It is in poor condition and has a telecommunication main line colocated on it. (Photo by Yumei Wang)

Figure 2-31. Close-up of Three Mile Lane bridge showing various ages and types of materials in the substructure, including steel and wood. This photo shows the inadequate seismic design, construction, and maintenance, including split timber members. As supported by our analyses, it will likely be inoperable after a major earthquake. (Photo by Yumei Wang)

Figure 2-32. Close-up of the south abutment of Three Mile Lane bridge showing colocated lifelines, including a major telecommunication line. Earthquake-induced bridge damage could disrupt communication services. (Photo by Yumei Wang)

2.4 Hazus Analyses for Earthquake Damage and Loss

DOGAMI used FEMA Hazus software, which provides a publically available standardized method to estimate earthquake damages and losses. The current [2014] version of the software, Hazus Multi-Hazard (MH) 2.1 (FEMA 2010a,b) has been certified only for Esri® ArcView® 10, Service Pack 1, which was the GIS software DOGAMI used to conduct the analysis.

DOGAMI used the FEMA Comprehensive Data Management System (CDMS) to input new data and to update and manage datasets, which are currently used to support analysis in Hazus-MH (FEMA, 2014). DOGAMI used CDMS to assist with inputting new site-specific level data into the study region's datasets according to CDMS pre-defined formats, which requires raw data processing, conversion of external data sources into Hazus-MH compliant data, and transfer of data into and out of statewide datasets. Some potable water facilities (PWF) data could not be processed by CDMS due to existing software bugs, and workarounds provided by Hazus technical support were used to integrate data into Hazus. All new data brought into the system were validated (http://www.fema.gov/protecting-our-communities/hazus/comprehensive-data-management-system). See Appendix B for DOGAMI's notes on the CDMS input procedures and the mapping scheme used for the PWF workarounds.

The Hazus earthquake model is designed to produce loss estimates for use by federal, state, regional, and local governments in planning for earthquake risk mitigation, emergency preparedness, response, and recovery. The methodology deals with nearly all aspects of the built environment and a wide range of loss types. Extensive national databases embedded in Hazus contain information such as demographic aspects of the population in a study region, square footage for different occupancies of buildings, and numbers and locations of bridges. Embedded parameters have been included as needed. Using this information, users can carry out general loss estimates for a region. The Hazus methodology and software are flexible enough so that locally developed inventories and other data that more accurately reflect the local environment can be substituted, resulting in increased accuracy (FEMA, 2010b).

DOGAMI's earthquake model incorporated 1,000-year probabilistic ground motions, which include Cascadia magnitude 9 ground motions; site-specific geologic hazard parameters for soil type, landslide hazard, and liquefaction hazard for hospitals and water facilities; and soil type D, landslide hazards, liquefaction hazards, and a water table of 5 feet below the ground surface for the study region.

DOGAMI used the following Hazus input parameters for the hospitals, which were described in the hospital information section of the report (**Table 2-2**). The Hazus input parameters for the water and transportation facilities are voluminous and are located in Appendices E and F, respectively.

Table 2-2. Hazus input parameters for hospitals.

	Soil Type	Liquefaction Hazard	Landslide Hazard	Structural Type	Year Built	Seismic Design Level
Lincoln hospital	E	5	3	W2	1967	Low Code
McMinnville hospital complex	E	4	3	S2M	1996–98	High Code
	E	4	3	S2M	1996–98	High Code
	E	4	3	S2L	1996–98	High Code

See the Hazus user guide (2010b) for definitions of parameters.

Hazus output results. The results from Hazus (**Table 3-1**) indicate that the project area is estimated to incur the following from major earthquake shaking: $1.3–$5.1 billion in building losses; 19,000–80,000 damaged buildings; 3,500–12,500 displaced people; 1,400–5,000 displaced households; about 1,900 people requiring public shelter; and about 700 households requiring public shelter. The region is estimated to suffer 500–2,000 people who require medical aid; 150–600 people who require hospital care; 20–90 people with life-threatening injuries; and 40–180 fatalities due to earthquake shaking. The results are provided as a range due to uncertainties associated the Hazus analyses and the fact that Hazus provides damage estimates, not absolute predictions. Tsunami casualties have not been estimated and would be in addition to the earthquake casualties.

Approximately 0.84 million tons of debris would be generated from the earthquake damage (Appendix C). Due to the different type of material handling requirements, Hazus separates the debris into two categories 1) brick/wood, and 2) reinforced concrete/steel. Of the total amount, 42% is brick/wood and 58% is reinforced concrete/steel. This does not include tsunami-generated debris. Assuming a carrying capacity of 25 tons per truck, about 33,640 truckloads would be required to remove the debris. Although a range of estimates is not provided, uncertainties are associated with this analysis.

The Hazus results provide detailed exposure, damage, loss, and functionality information and are further presented in Section 3: Findings and Conclusions, and are included in Appendices C, D, E, F, and G. Appendix C includes a 19-page earthquake event report. Appendix C also includes results on a county level for casualties, economic losses to buildings, hospital functionality, potable water system facility damage, potable water system performance, potable water pipeline damage, direct economic loss for utilities, transportation highway bridge functionality, highway road functionality, direct economic loss for transportation, and debris on the census tract level. The Hazus study region data set was provided to OHA as 125-MB Hazus-packaged .hpr file (OHA-EQ Final_8-22-14.hpr) along with the 2014 report. All of the Hazus input parameters are included in the Hazus study region data set. Key elements are provided below.

Lincoln City hospital, which has licensed 30 beds, has a 90% probability of having at least moderate damage and a 59% probability of at least extensive damage. The eastern half of the Lincoln City hospital is built on soils that appear to be liquefiable (Wes Spang, oral commun., January 6, 2014). An estimate of the level of function immediately after major Cascadia earthquake by bed count on day 1, day 3, day 7, day 30, and day 90 is made. Lincoln City Hospital is estimated to have less than 2% functionality on day 1 and day 3; about 10% on day 7 and day 14; 42% on day 30, and 52% on day 90. Lifeline service interruptions may further reduce the functionality of the hospitals. Also see Appendix C; additional information on hospitals is in Appendix D and Section 3, Findings and Conclusions.

McMinnville hospital, which has 88 beds, is a complex of three modern buildings. Two of the buildings have a 63% probability of having at least moderate damage and a 27% probability of at least extensive damage. The third building, the shortest building, has a 38% probability of having at least moderate damage and a 23% probability of having at least extensive damage. After a major Cascadia earthquake, it is estimated that by bed count the two taller buildings will have about 14% functionality on day 1 and day 3; about 36% on day 7 and day 14; 73% on day 30, and 76% on day 90 (Appendix D). It is estimated that the shorter building will have about 43% functionality on day 1 and day 3; about 61% on day 7 and day 14; 77% on day 30, and 79% on day 90. More information is located in Appendix C; additional information on hospitals is in Appendix D and Section 3, Findings and Conclusions.

Of the 88 facilities associated with the water systems, 65 are estimated to have at least moderate damage from a major earthquake including the City of Lincoln City, Grand Ronde, Willamina, Sheridan, and McMinnville Water and Light water systems. It is estimated that over 10,000 km (6,200 mi) of water transmission and distribution pipeline exists in the study region, and a major Cascadia earthquake would cause over 5,700 pipeline leaks and 3,500 pipeline breaks. Of the roughly 35,000 households, households without water service are estimated at 31,000 on day 1 after the earthquake; 30,000 on day 3; 27,000 on day 7; 19,000 on day 30; and none (0) on day 90. Direct economic losses for the potable water facilities in the project area are estimated at $195 million, which results with a loss ratio of about 17%. Lifeline service interruptions may further slow the recovery process. More information is located in Appendix C; additional information on water systems is in Appendix E and Section 3, Findings and Conclusions.

Our results indicate that 41 of the 169 bridges included in this study are estimated to have at least moderate damage from earthquake shaking. The functionality of the 169 bridges at day 1 is estimated at 58%; 64% on day 3; 67% on day 7, 69% on day 30, and 78% on day 90. The direct economic losses for bridges are estimated at $175 million, which results in a loss ratio of about 19%.

Three specific bridge examples are: the 1930, 182-foot-long Slick Rock Creek bridge, located at milepost 5.34 on Highway 18, is estimated to have a 88% probability of at least moderate damage. Repair costs are estimated at $2.4 million. The 1930, 99-foot-long Bear Creek bridge, located at milepost 3.96 on Highway 18, is estimated to have a 87% probability of at least moderate damage. Repair costs are estimated at $1.8 million. The Three Mile Lane bridge in McMinnville is estimated to have a 80% probability of at least moderate damage, with repair costs at approximately $11 million. Also see Appendix C; information on each bridge is in Appendix F, and additional information is in Section 3, Findings and Conclusions.

2.5 Hospital Interdependencies Evaluation

When earthquakes strike, lifeline systems, including water, waste water, transportation, fuel, electricity and communications are often damaged. Damage can disrupt lifeline services including the flow of resources and provision of services that rely on the lifeline services. Furthermore, most of these lifeline systems have some level of dependency on other lifeline systems, which often exacerbates the impact. Due to the characteristics of lifeline systems and our economy, impacts can spread far beyond the area shaken by the earthquake. Negative impacts can start on a local level and grow to regional, statewide, national, and even global levels in the worst cases. Community level resilience is critical to minimize lifeline damage and service disruptions to safeguard local socioeconomic wellbeing.

All hospitals are dependent on lifeline services to operate. Hospitals may be impacted because they consume large quantities of water. To illustrate how lifelines relate to one another, a water system relies on the electrical system for electricity; if that electrical system becomes inoperable, then the water system may be able to generate electricity using emergency generator(s). However, the generator(s) would likely require a steady supply of diesel fuel that must be brought in from offsite locations. To supply diesel fuel, the transportation system is needed. The communication system is required to arrange for these logistics. Without water, waste water systems cannot function as designed.

Another example is water pipelines colocated on bridges at river crossings. If a bridge with a water pipe collapses, then even if the water pipe is earthquake resistant, it can break and truncate water services. **Figure 2-33** shows a 10-inch-diameter water transmission pipe colocated on the D River bridge on U.S. Highway 101 in Lincoln City, which is located in the tsunami flood zone. This bridge is estimated to experience tsunami inundation. in which event the water transmission pipe would likely break. This particular pipeline on this bridge will soon be replaced (Lani Hankins, oral commun., May 1, 2014). The new pipeline, which is expected to perform well in a Cascadia earthquake and tsunami, will be a river undercrossing. It will be better protected from tsunami forces and will be designed to higher earthquake standards than the pipeline shown in **Figure 2-33**.

Figure 2-33. A 10-inch-diameter water transmission pipeline is colocated on the D River bridge on coastal Highway 101. This bridge is expected to experience tsunami inundation; in that event the pipeline is expected to incur breaks caused by bridge damage. A new, more reliable transmission pipe will be constructed under the river. (Photo by Yumei Wang)

State-of-the-practice methods are not readily available to determine and evaluate hospital interdependencies on lifelines. Although Hazus damage and loss software can be used to evaluate hospital damage and functionality, it does not explicitly address hospital interdependencies on lifelines. As such, DOGAMI determined the typical lifeline services that hospitals require based on our expertise, available literature, and discussions with hospital experts (Hanfling and others, 2013; Judy Mitrani-Reiser, oral commun., December 20, 2013; Todd and others, 1994; Wizemann and others, 2013). DOGAMI developed schematic diagrams to clearly and transparently show the lifeline service needs of hospitals to operate.

2.5.1 Normal, Disrupted, and Emergency Operations

Figure 2-34, **Figure 2-35**, and **Figure 2-36**, respectively, illustrate hospital interdependencies during three phases of operations: Phase 1, Normal Operations; Phase 2, Disrupted Operations due to damage, where lifeline services are compromised or non-existent; and Phase 3, Emergency Operations, where lifeline services are provided in a temporary, emergency mode. **Figure 2-34** indicates that:

- Normal hospital operations involve people, goods, and infrastructure:
  - "People" refers to building occupants including staff and patients,
  - "Goods" refers to medicine, linens, blood supply, etc. housed in the hospital,
  - "Infrastructure" refers to the hospital's infrastructure (including structural, nonstructural and components) AND lifeline services from outside providers
- Hospitals rely on five lifelines to operate in normal conditions: fuel, water (and waste water), electricity, transportation, and communication
- These lifelines function interdependently, that is, the five lifeline sectors are dependent on each other to some degree
- Fuel and water systems function as a supply chain (as depicted by a supply chain pattern in a solid rectangle)
- Communications and transportation systems function as a network (as depicted by a network pattern in a dotted oval)
- Electricity systems function as a hybrid of supply chain and network (as depicted by a supply chain and network pattern in a dotted rounded rectangle)
- Colors that represent industry standards, where possible, were used. The solid green circular lines indicate that there is a balanced connection among the lifelines.

Figure 2-34. Hospital interdependencies: normal operations involve people, goods, and infrastructure, which rely on fuel, water (and waste water), electricity, transportation, and communications. See text for explanation.

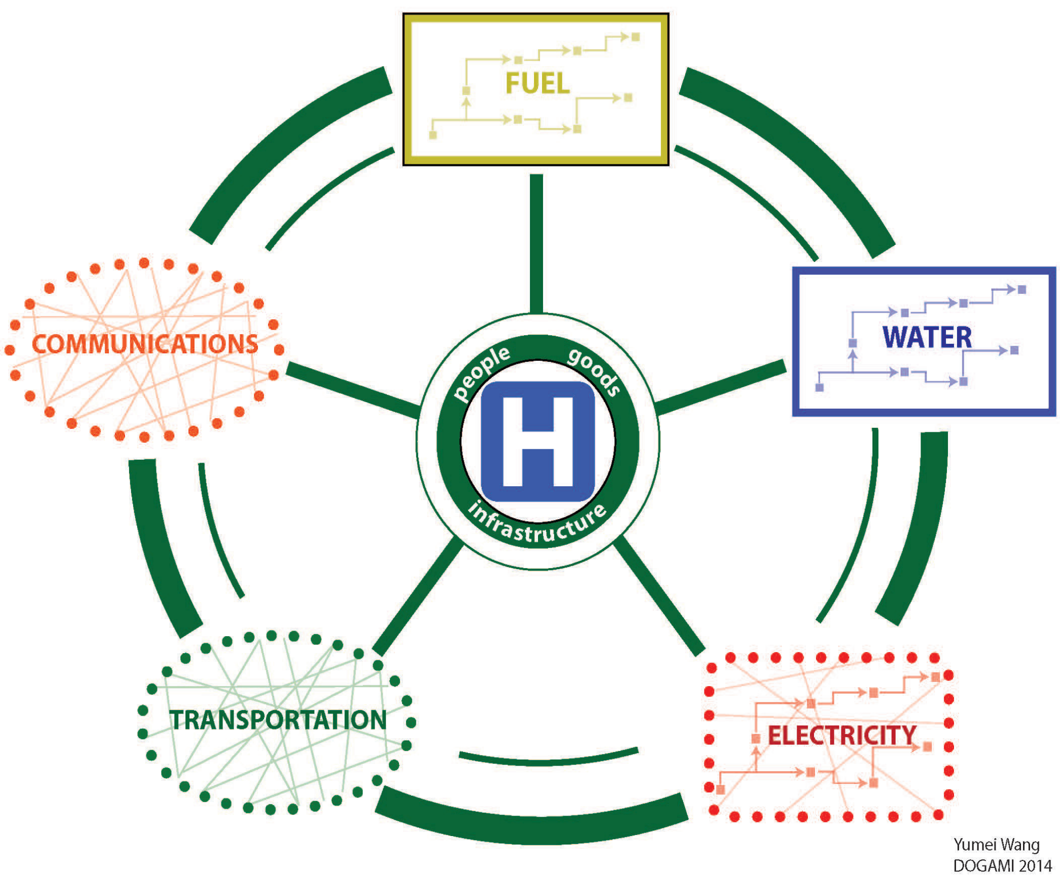


Figure 2-35 shows possible conditions after a Cascadia earthquake where lifeline services are compromised or nonexistent due to earthquake damage. Post-earthquake disaster conditions will require hospitals, hospital partners, and lifeline operators to identify the damage and restore operations. The broken red circular lines indicate that the connection among the lifelines are no longer balanced and have been compromised.

Figure 2-35. Hospital interdependencies: disrupted operations due to damage can render lifeline services compromised or nonexistent. This figure shows examples of disrupted operations after recent earthquakes in California and Chile. (Photos courtesy of Technical Council on Lifeline Earthquake Engineering)

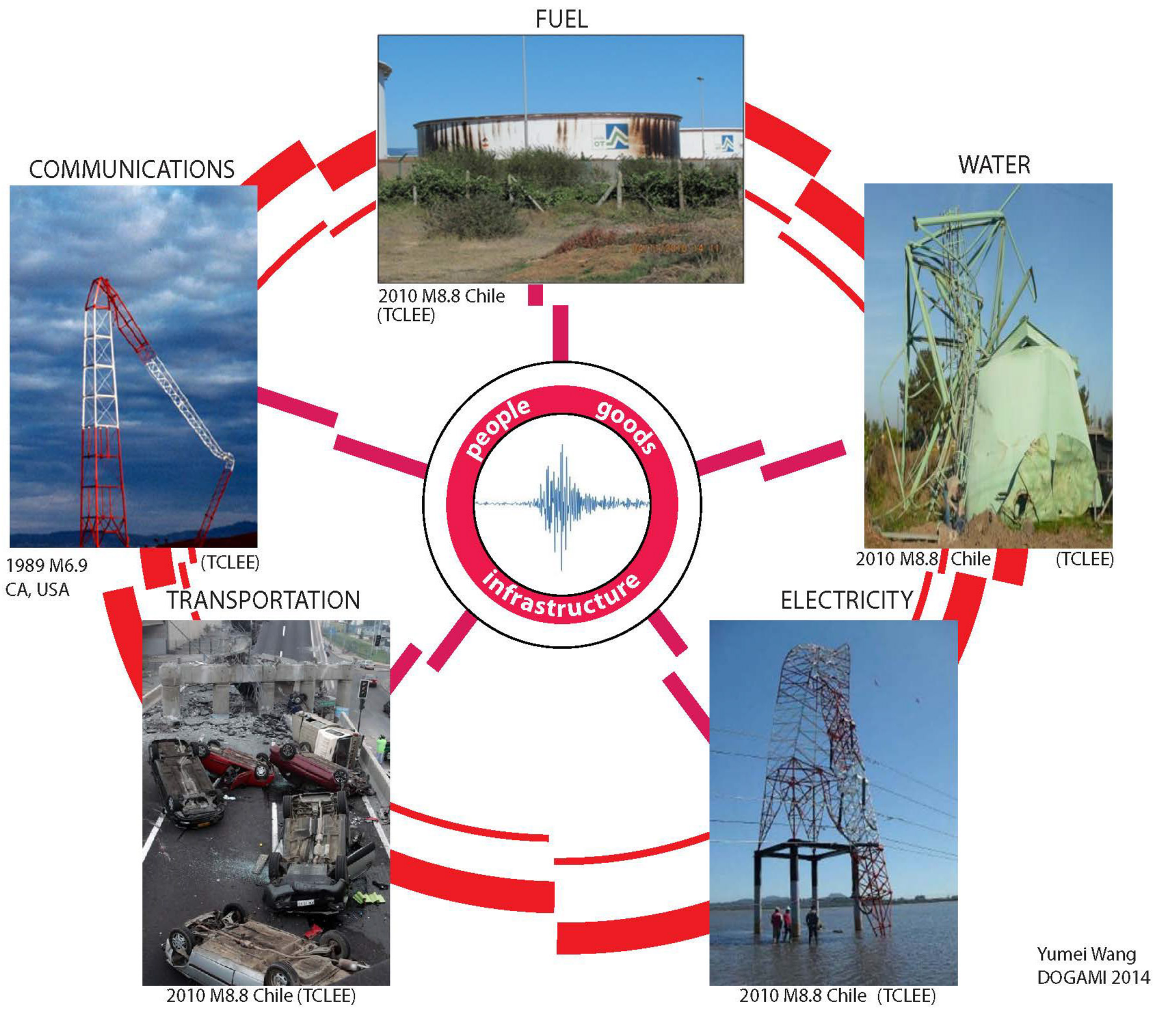


Figure 2-36 shows possible conditions after a Cascadia earthquake where traditional means of obtaining lifeline services are compromised or nonexistent due to earthquake damage. Oftentimes, limited services are provided by using nontraditional methods. As examples, water may be provided by potable water trucks and mobile water treatment plants, and electricity may be provided by emergency generators. Emergency bridges and mobile communication units can be used. Fuel supplies can be trucked or flown in. Many key supplies can be expedited through the advanced setup of memorandums of understandings (MOUs). The partially connected orange circular lines indicate that balance is being restored among the lifelines so that services are being provided, but in an emergency mode.

Figure 2-36. Hospital interdependencies: emergency operations can provide lifeline services in a temporary, emergency mode such as during Cascadia earthquake disaster conditions. This figure shows various options. (Photos courtesy of Technical Council on Lifeline Earthquake Engineering)

DOGAMI interviewed hospital personnel at Lincoln City hospital and McMinnville hospital to assess lifelines services required by each hospital. Lifeline interdependencies were compiled by DOGAMI and reviewed by hospital personnel. Options to improve the availability of disrupted lifeline services were considered and documented. The purpose of providing this information is to encourage future integrated vulnerability studies, planning, and mitigation. Specific lifeline information for each hospital is in Section 3, Findings and Conclusions.

Lincoln City hospital is dependent on the City of Lincoln City for their water supply. As with most water systems in Oregon, many parts of the system were built before knowledge of the Cascadia earthquake threat. Portions of the system have been upgraded, are being upgraded, or are planned to be upgraded. For example, the 10-inch water pipe on D River bridge will soon be eliminated (see **Figure 2-33**). The transmission pipe on the Schooner Creek bridge will be replaced with an undercrossing by about 2016.

McMinnville hospital is dependent on McMinnville Water and Light (MLW) for their water supply. Two MWL water lines feed the hospital, a 24-inch ductile iron pipeline constructed around 2000 and an older 12-inch cast iron pipe. Both transmission pipelines have Yamhill River undercrossings and may experience liquefaction and lateral spreading related leaks and/or breaks. MWL also owns and operates the electrical system that services the hospital using two feeder lines. This system has a loop configuration around the hospital, which is desirable due to the redundancy. According to MWL personnel, the system has extra capacity, a high level of redundancy, and a limited local generation capacity (John Dietz, oral commun., May 1, 2014). All 10 high power transformers in their system meet earthquake standards (IEEE 693, Recommended Practice for Seismic Design of Substations, https://standards.ieee.org/findstds/standard/693-2005.html) and are seismically anchored; only three of the 10 are required to operate their entire system. Although the system has not been analyzed for earthquake risk, it is possible that the local electrical system will perform adequately in a major earthquake. MWL owns a 2,500-gallon diesel fuel truck and 250-gallon gas truck that can be deployed during emergencies.

2.5.2 Project Area Critical Facilities and Pathways

All modern communities depend on lifeline services including water, transportation, fuel, electricity, and communications. All communities, including the project communities, have a number of critically important facilities that rely on vital pathways that connect people or supplies to or from them in order to operate. Critically important facilities or pathways, or both, can be damaged, which can disrupt connections and services.

Critical facilities are very often dependent and interdependent on additional critical facilities and the pathways in a hierarchical manner. Many local water systems involve dams and reservoirs as the water source, miles of transmission pipelines, in-town water reservoirs and pumping stations before transitioning to a distribution system that feeds the community with lower-level facilities and pathways.

For example, the McMinnville water system stores its water supply behind two critical facilities—two dams—upstream from the water treatment plant. The main dam, McGuire Dam, had a seismic upgrade in 2004 and is expected to perform well in a Cascadia earthquake. Haskins Dam, which has an active landslide on its left abutment, also supplies the water treatment plant and is also considered to be a critical facility. After water is processed in the water treatment plant, the water travels about 10 miles along two critical pathways, which are transmission pipes, to another critical facility with four in-town reservoirs, and so on.

The highest-level critical facilities considered in this pilot project are the two hospitals and two water treatment plants in Lincoln City and McMinnville, and the key pathways are the major state highways connecting the two hospitals. The bridges and roadways on or near Highways 101 and 18 and the water transmission pipeline the crosses under the Yamhill River are vital components along the pathways. Bridges and roadways can be damaged by shaking, landslides, and liquefaction. For example, landslides on Highway 18 between mileposts 13 and 18 can block or damage the highway. Similarly, colocated lifelines on the bridges, including water and telecommunication, can be damaged. In addition, underground pipelines, such as the water transmission pipelines that feed the McMinnville hospital and that undercross the Yamhill River, can be damaged.

DOGAMI interviewed hospital and water system personnel to explore transportation detour options to the hospitals. The purpose was to discuss local vulnerabilities and encourage future integrated vulnerability studies, planning, and mitigation to determine viable detours. Information from the interdependency evaluation was used to develop project findings, conclusions, and recommendations.

3.0 FINDINGS AND CONCLUSIONS

This pilot project provides information that is helpful to hospitals, water districts, and communities to take steps to better prepare for Cascadia earthquakes and other disasters. Potential uses of study data and results include more detailed seismic analyses, seismic strengthening and mitigation planning, resilience planning, emergency management applications, land-use planning, zoning and regulations, capital planning, and prioritization for communities.

3.1 Overview of Project Method

As part of this project, DOGAMI communicated with hospital and water facility partners. We learned that hospital partners were unaware of the regulations set forth by ORS 455.400 on hospital seismic readiness. We found that site visits were invaluable because our partners were more forthcoming with providing data for modeling purposes and DOGAMI was able to conduct better data verification. We also found that site visits spurred better seismic preparedness planning and seismic mitigation by both hospital and water facility partners. In any future efforts, requests for information should be conducted during field visits near the start of the project.

As part of Hazus modeling, we found that certain user-specified data such as hospital buildings, bridges, and liquefaction and landslide hazard maps were easy to input into Hazus. Conversely, certain data were difficult to input, including ground motion hazard maps and water facilities including pipelines, because specific Hazus formatting was required. The ground motion data were never resolved, but the water facilities input was made possible by workarounds provided by FEMA Hazus technical support staff.

3.2 Overview of Hazus Analysis Results

The results from the Hazus analyses have been separated into 1) communities, 2) hospitals, 3) water facilities, and 4) highways connecting Lincoln City and McMinnville. **Table 3-1** is the Hazus Global Summary. **Figure 3-1** depicts Hazus results for the study region and includes results for hospitals, water systems, bridges, highways, and earthquake ground motions (for spectral accelerations at 1.0 second). **Figure 3-2** depicts Hazus results for Lincoln City and includes results for the hospitals, water systems, bridges, highways, and earthquake ground motions (for spectral accelerations at 1.0 second). **Figure 3-3** depicts Hazus results for McMinnville and includes results for the hospitals, water systems, bridges, highways, and earthquake ground motions (for spectral accelerations at 1.0 second).

Table 3-1. Hazus report global summary. See Appendix C for full Hazus report.

Hazus-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	0.80 - 3.30
	Building Contents	0.10 - 0.20
	Business Interruption	0.20 - 1.00
Infrastructure	Lifelines Damage	
	Total	1.30 - 5.10

Estimated Building Damage (Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	10 - 40	0 - 1	0 - 1	11 - 50
Major	6 - 30	0 - 2	0 - 1	7 - 30
Total	17 - 70	1 - 4	0 - 2	19 - 80

Estimated Casualties : Day Time

Severity Level	Description	# Persons
Level 1	Medical Aid	500 - 2,000
Level 2	Hospital Care	150 - 600
Level 3	Life-threatening	20 - 90
Level 4	Fatalities	40 - 180

Estimated Shelter Needs

Type	Households	People
Displaced Households	1,400 - 5,000	3,500 - 12,500
Public Shelter	746	1,866

Comments :

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, goetechnical, and observed ground motion data.

Earthquake Information

Location :

Origin Time:

Magnitude : 9.00

Epicenter Latitude/Longitude :
/

Depth & Type :/P

Fault Name :
NA

Maximum PGA : 0.00

Ground Motion /Attenuation :

Information Sources:

Comments :

Population and Building Exposure (2002 D&B) (2000 Census)

Population: 95,503

Building Exposure : ($ Millions)

Residential	6,159
Commerical	885
Other	719
Total	7,763

Counties :
- Lincoln,OR
- Polk,OR
- Tillamook,OR
- Yamhill,OR

Major Metro Area :

Time of report: August 22, 2014 2:02 pm

Figure 3-1. Hazus results for the study region include modeling results for hospitals, water systems, bridges, highways, and earthquake ground motions (in the legend, "_PDsExceedModerate" refers to the probability of at least moderate damage, and "eqTract_Sa10" refers to spectral accelerations at 1.0 second).

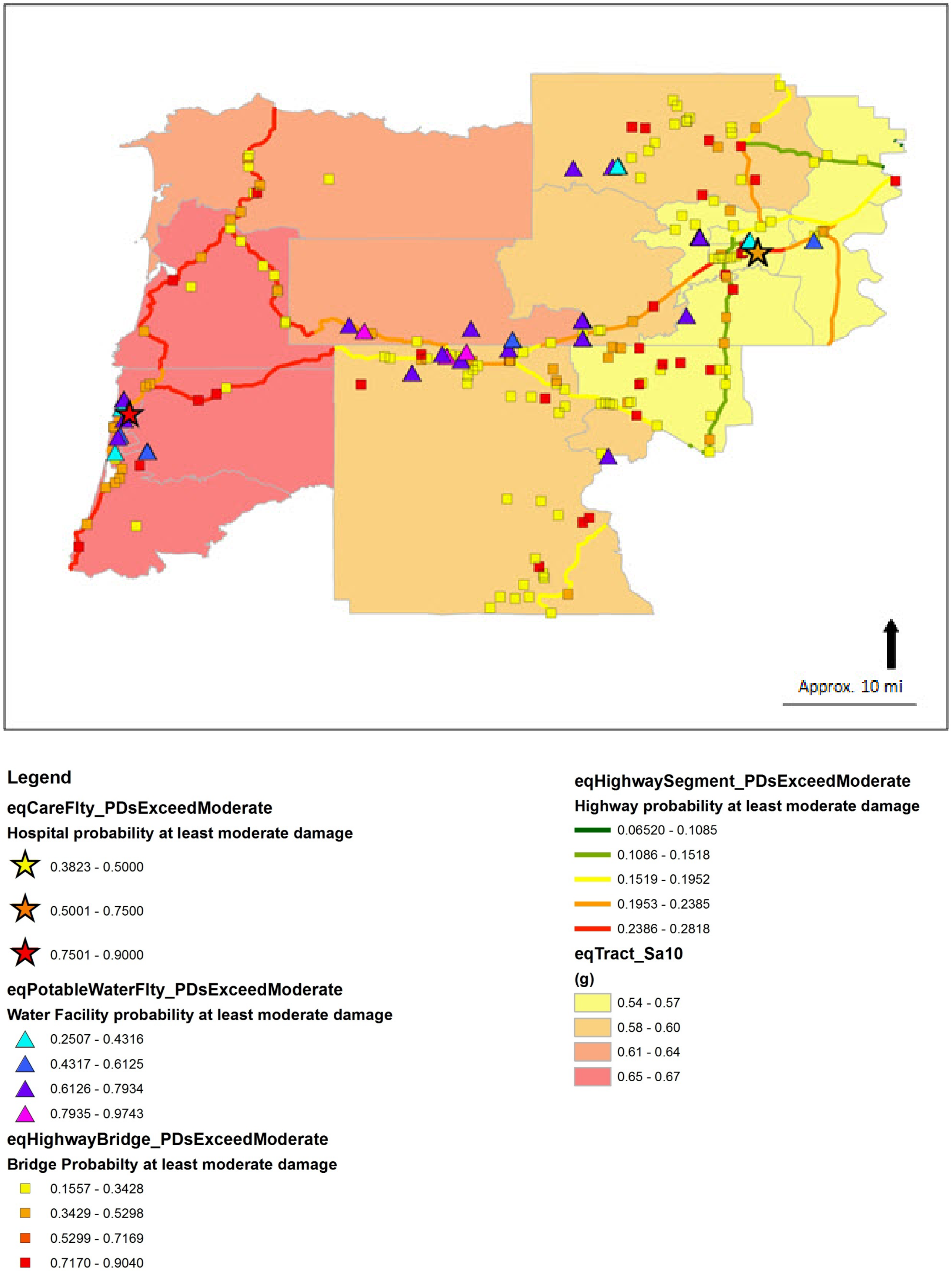


Figure 3-2. Hazus results for Lincoln City includes results for hospitals, water systems, bridges, highways, and earthquake ground motions(In the legend, "_PDsExceedingModerate" refers to the probability of at least moderate damage and eqTract_Sa10 refers to spectral accelerations at 1.0 second).

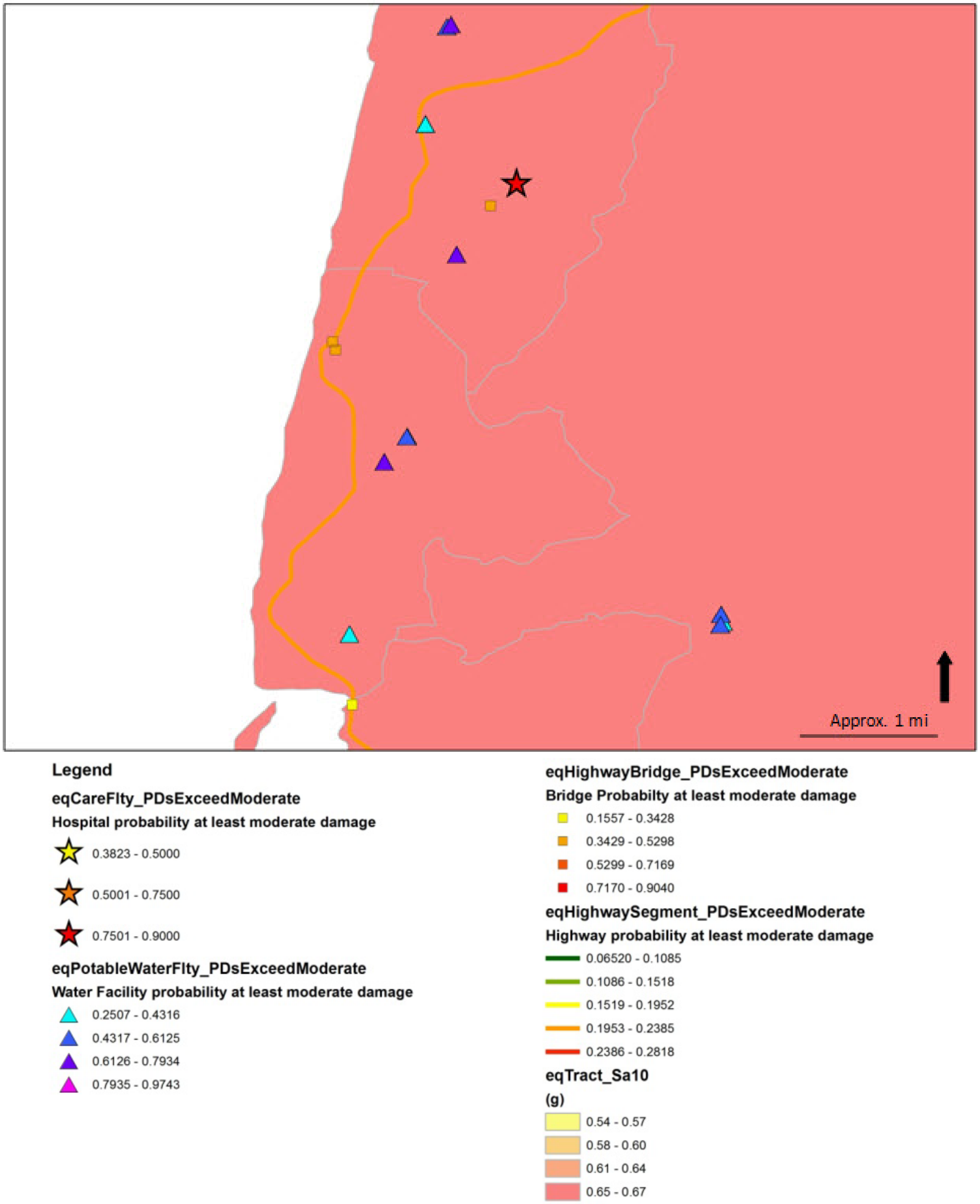
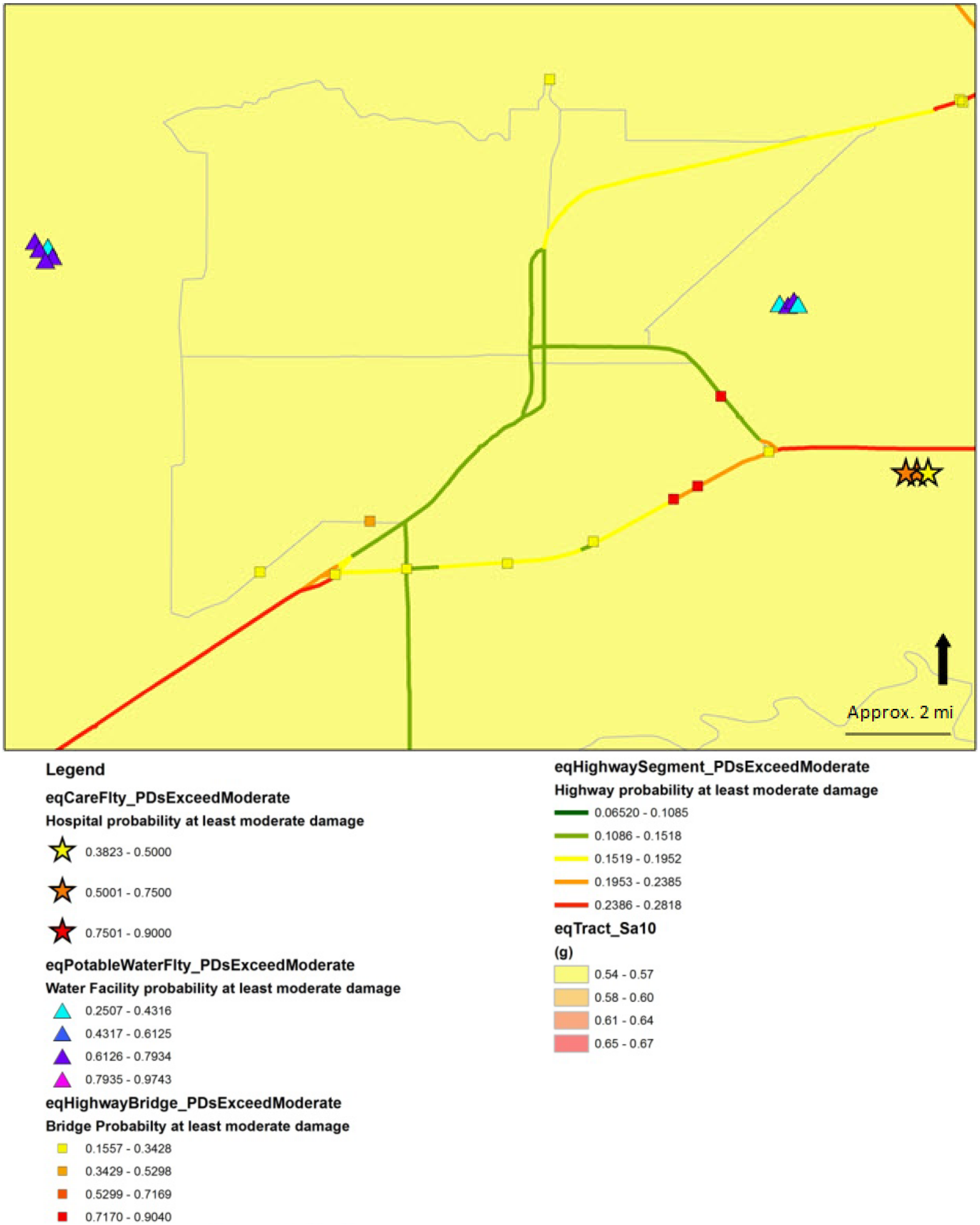


Figure 3-3. Hazus results for McMinnville includes results for hospitals, water systems, bridges, highways, and earthquake ground motions (In the legend, "_PDsExceedingModerate" refers to the probability of at least moderate damage and "eqTract_Sa10" refers to spectral accelerations at 1.0 second).



3.2.1 Communities

From major earthquake shaking, the project area is estimated to incur up to $5.1 billion in building losses, up to 80,000 damaged buildings, up to 13,000 displaced people, and about 1,900 people requiring public shelter. The region is estimated to suffer up to 2,000 people who require medical aid, up to 600 people who require hospital care, up to 90 people with life-threatening injuries, and up to 180 fatalities (see **Table 3-1**).

3.2.2 Hospitals

For each hospital, information on service population, number of beds, construction type and year, replacement value, geologic seismic hazards, and lifeline dependencies have been summarized below, and in **Table 3-2**.

Lincoln City hospital has a 90% probability of having at least moderate damage. The eastern half of Lincoln City hospital is built on soils that appear to be liquefiable (Wes Spang, oral commun., January 6, 2014). Lincoln City Hospital is estimated to have less than 2% functionality on day 1 and day 3; about 10% functionality on day 7 and day 14; 42% functionality on day 30, and 52% functionality on day 90, immediately after a major Cascadia earthquake (**Table 3-2**).

McMinnville hospital is comprises a complex of three modern buildings. Two of the buildings have a 63% probability of having at least moderate damage. The third building, the shortest building, has a 38% probability of having at least moderate damage. After a major Cascadia earthquake, it is estimated that by bed count, the two taller buildings will have about 14% functionality on day 1 and day 3; about 36% functionality on day 7 and day 14; 73% functionality on day 30, and 76% functionality on day 90. It is estimated that the shorter building will have about 43% functionality on day 1 and day 3; about 61% functionality on day 7 and day 14; 77% functionality on day 30, and 79% functionality on day 90 (**Table 3-2**).

On the basis of available hospital beds and estimated casualties, both hospitals will experience severe and extended bed shortages. It should be expected that lifeline services would be severely disrupted by a major earthquake. As such, several options have been provided that can be considered in disaster planning and disaster response (**Figure 3-4** and **Figure 3-5** in section 3.3). Additional information is in Appendix D.

Table 3-2. Estimates of probability of at least moderate structural damage and level of functionality in hospitals after a major Cascadia earthquake (Appendix D).

		McMinnville Hospital	
	Lincoln City Hospital	**Two Taller Buildings**	**Shorter Building**
Probability of at least moderate damage from a major Cascadia earthquake			
	90%	63%	38%
Estimated level of functionality* by bed count			
Day 1 and Day 3	2%	14%	43%
Day 7 and Day 14	10%	36%	61%
Day 30	42%	73%	77%
Day 90	52%	76%	79%

*Does not take into account water system functionality.

3.2.3 Water Facilities

Many local water systems involve dams and reservoirs as the water source, miles of transmission pipelines, in-town water reservoirs and pumping stations before transitioning to a distribution system that feeds the communities. For each of the water facilities, information was gathered on geologic seismic hazards, water treatment plant, and major water system components including system replacement value, construction type and year of buildings, reservoirs (tanks), pump stations, and details on the transmission piping system. Water usage by Lincoln City hospital and McMinnville hospital is approximately 15,000 gallons/day and 47,000 gallons/day, respectively.

DOGAMI explicitly collected and included data for five water systems in the study area: City of Lincoln City, Grand Ronde, Willamina, Sheridan, and McMinnville Water and Light. Additional default water system data were included for Dallas, Amity, and Dayton. It is estimated that over 10,000 km (6,200 mi) of water transmission and distribution pipeline exists in the study region; a major Cascadia earthquake would cause over 5,700 pipeline leaks and 3,500 pipeline breaks. Exact locations of pipeline damage were not included in this evaluation. In general, pipeline damage is expected to be greater where 1) pipelines are made of brittle material such as cast iron or have corroded, 2) shaking levels are higher toward the western portion of the project area, and 3) there is permanent ground deformation such as from landslides or liquefied soils that have moved. As an example, the McMinnville hospital has two water feeder lines, both with Yamhill River undercrossings, which are part of the McMinnville water distribution system. Both river undercrossing are considered to be potentially hazardous zones due to liquefaction hazards. The 12-inch undercrossing is likely to be more susceptible to earthquake damage than is the 24-inch undercrossing due to differences in pipe material types. The 12-inch pipe is made of cast iron, which is a brittle material type and can easily break during earthquake-induced ground displacements, whereas the 24-inch pipe is a ductile material, which can tolerate more ground displacements. The actual soil and slope conditions at each site are also important to vulnerabilities.

DOGAMI results indicate that of the roughly 35,000 households, the number of households without water service are estimated at 31,000 on day 1 after the earthquake, 30,000 on day 3, 27,000 on day 7, 19,000 on day 30, and none (0) on day 90. Of the 88 facilities associated with the water systems, 65 are estimated to have at least moderate damage from a major earthquake.

Table 3-3 includes the probabilities of at least moderate damage for the five water districts, the estimated damage cost, and estimated functionality. Each water district is further described below. Additional information is in Appendix E.

Table 3-3. Estimates of probability of at least moderate damage and level of functionality for five modeled water systems after a major Cascadia earthquake. See Appendix E.

Water Treatment Plant	City of Lincoln City	McMinnville Water and Light	Grand Ronde	Sheridan	Willamina
Probability of at least moderate damage					
	50%	39%	90%	97%	51%
Estimated damage cost*					
	~ $51 million of $300 million	~ $61 million of $500 million	~ $5 million of $11.2 million	~ $29 million of $40 million	> $1 million of $10 million
Estimated level of functionality**					
Day 1	52%	61%	22%	14%	49%
Day 3	80%	86%	46%	23%	83%
Day 7	86%	91%	54%	27%	91%
Day 14	87%	92%	57%	31%	91%
Day 30	91%	94%	64%	40%	94%
Day 90	99%	99%	88%	72%	99%

*Damage cost shows two values: the first is the estimated damage cost; the second is the assumed replacement cost for entire water system.

**Lifeline service interruptions may further reduce functionality of water services.

The water treatment plant at City of Lincoln City is estimated to have a 50% probability of at least moderate damage. Assuming a replacement cost of $300 million for the entire water system, a rough estimate of $51 million of damages may occur. The functionality of the water treatment plant is 52% on day 1 after the earthquake, 80% on day 3, 86% on day 7, 87% on day 14, 91% on day 30, and 99% on day 90.

The water treatment plant in McMinnville (McMinnville Water and Light) is estimated to have a 39% probability of at least moderate damage. Assuming a replacement cost of $500 million for the entire water system, a rough estimate of $61 million of damage may occur. The functionality of the water treatment plant is 61% on day 1 after the earthquake, 86% on day 3, 91% on day 7, 92% on day 14, 94% on day 30, and 99% on day 90.

The water treatment plant at Grand Ronde is estimated to have a 90% probability of at least moderate damage. (Recall that for the purposes of modeling, the wood office building is the proxy for the water treatment plant; see section 2.3.3.3.) Assuming a replacement cost of $11.2 million for the entire water system, a rough estimate of $5 million of damage may occur. The functionality of the water treatment plant is 22% on day 1 after the earthquake, 46% on day 3, 54% on day 7, 57% on day 14, 64% on day 30, and 88% on day 90.

The water treatment plant at Sheridan is estimated to have a 97% probability of at least moderate damage. Assuming a replacement cost of $40 million for the entire water system, a rough estimate of $29 million of damage may occur. The functionality of the water treatment plant is 14% on day 1 after the earthquake, 23% on day 3, 27% on day 7, 31% on day 14, 40% on day 30, and 72% on day 90.

The water treatment plant at Willamina is estimated to have a 51% probability of at least moderate damage. Assuming a replacement cost of $10 million for the entire water system, a rough estimate of over $1 million of damage may occur. The functionality of the water treatment plant is 49% on day 1 after the earthquake, 83% on day 3, 91% on day 7, 91% on day 14, 94% on day 30, and 99% on day 90.

3.2.4 Highways Connecting Lincoln City and McMinnville

Our results indicate that 41 of the 169 bridges included in this study are estimated to have at least moderate damage from earthquake shaking. These include several bridges along coastal Highway 101 in Lincoln City, including bridges crossing Siletz River; several along Highway 18 between Lincoln City and McMinnville, including Bear Creek and Slick Rock Creek bridges (between ODOT mileposts 3 and 6); and several in the greater McMinnville area, including bridges west of the McMinnville hospital between ODOT mileposts 45 and 47 and the Three Mile Lane bridge, which is a spur of Highway 18 located between downtown McMinnville and the McMinnville hospital. In addition to damaged bridges, road segments of the highways would incur damage from tsunami flooding in low-lying portions of Highway 101, especially near the Siletz River; landslides, especially toward the western portion of Highway 18 (ODOT mileposts 13 to 18); and liquefaction, especially between McMinnville and Sheridan. On a project scale, it is likely that there would be a number of transportation connectivity problems both within the city limits of Lincoln City and McMinnville as well as the route between Lincoln City and McMinnville. Bridge results are located in Appendix F.

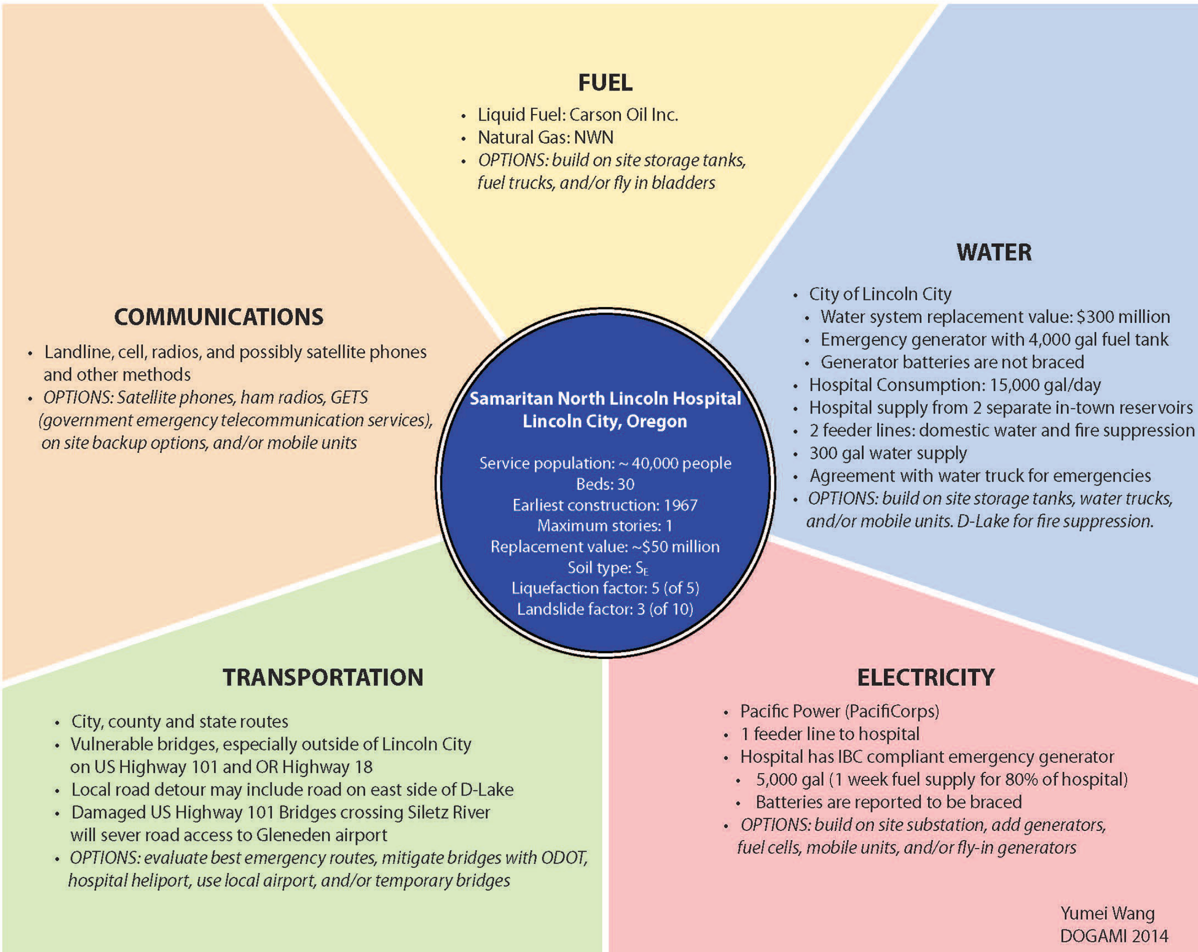
3.3 Overview of Hospital Interdependencies Evaluation Results

To provide hospital services the Lincoln City hospital and the McMinnville hospital require lifeline services including water, transportation, fuel, electricity, and communications (**Figure 3-4** and **Figure 3-5**). In this report DOGAMI has brought together information on the lifelines and depicted the interdependencies in a holistic manner. In addition, options have been provided on how the two hospitals might prepare in order to minimize impacts and speed recovery. This information will assist hospital partners in better understanding and identifying lifeline complexities and needs so that partners can improve hospital resilience.

3.3.1 Lincoln City Hospital

The Lincoln City hospital obtains water from the City of Lincoln City via two feeder lines, one for domestic water and one for fire suppression. The hospital receives its fuel and natural gas from Carson Oil and NW Natural, respectively. Its electricity is from a single feeder line from Pacific Power. The hospital has an emergency generator and multiple communication methods. There is road access to the hospital from the north, west, and south; D Lake is 2 blocks east of the hospital. During an earthquake, all lifeline systems are expected to incur damage due to shaking, liquefaction, landslides, and tsunamis. Options are available to improve the resilience of each lifeline and include increasing the on-site capacities of diesel fuel, water, emergency communication equipment and working out local transportation detours (**Figure 3-4**). Each option requires careful evaluation to be synchronized with the conditions relating to the hospital to ensure that it would be effective. Because many local bridges and roads are expected to be damaged and access to nearby Gleneden airport will likely be unavailable, working with the transportation districts to develop alternate and reliable routes for short-, medium, and long-term is advised.

Figure 3-4. Hospital interdependencies: Lincoln City hospital relies on people, hospital infrastructure and supplies, fuel, water, electricity, transportation, and communications.



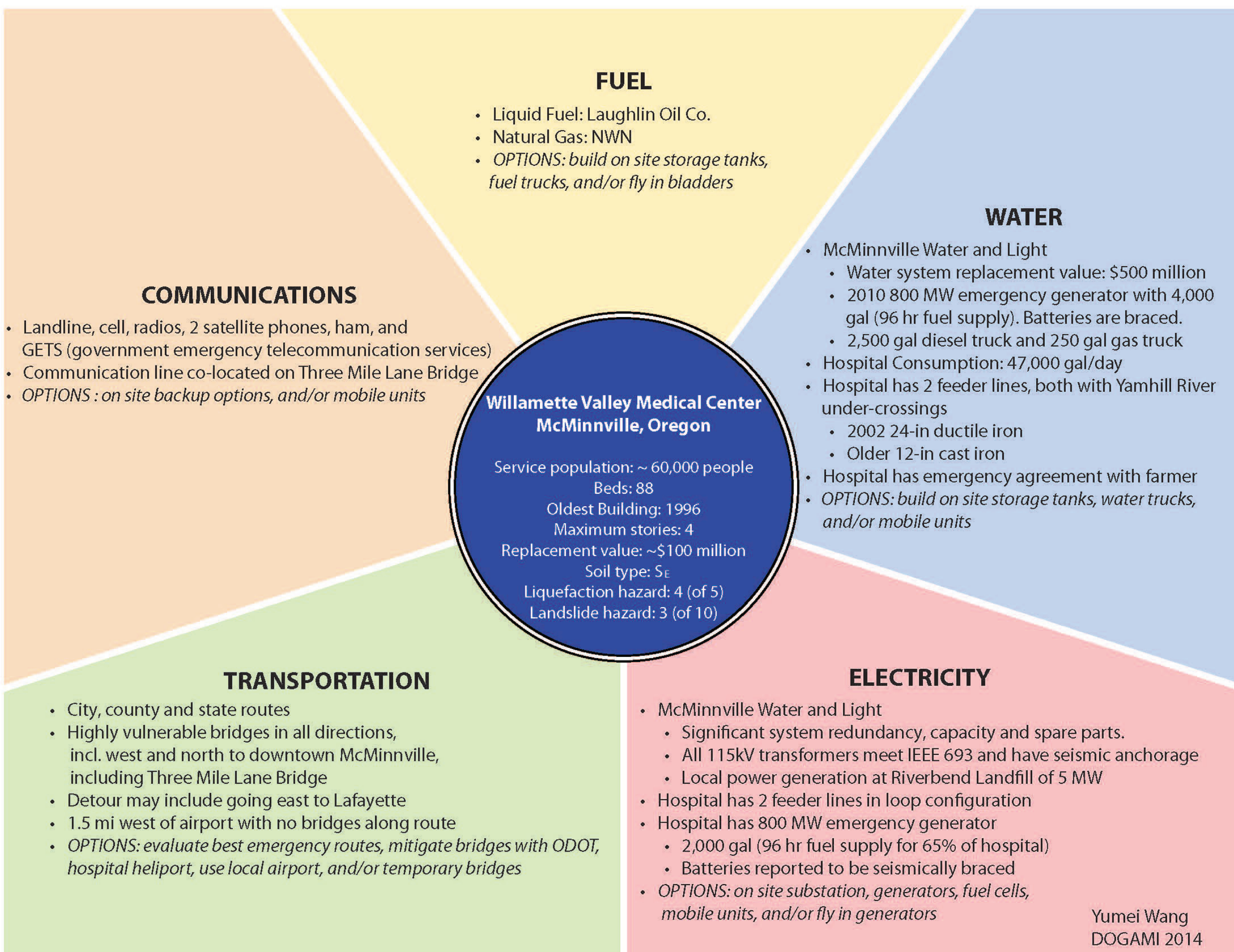
One of the biggest lifeline interdependency challenges for the Lincoln City hospital is the availability of a sufficient quantity of potable water. The City of Lincoln City provides water to the Lincoln City hospital. Water in the water system originates from Schooner Creek near the water treatment plant, flows through about seven miles of transmission pipes, including being temporarily stored in water reservoirs located in Lincoln City, and is finally delivered in distribution pipes that connect to the hospital. The entire water system is located in a coastal city in close proximity to the Cascadia fault, which can trigger several minutes of strong shaking. Due to the standards of practice and regulations for designing and building water systems in Oregon, the Lincoln City water system is inherently exposed to a high likelihood for damage to its transmission pipelines and other equipment, which have not been constructed to tolerate extreme ground movements. It is possible to mitigate portions of the water system to a higher seismic performance level in order to provide more reliable water to the hospital.

Another significant challenge will be serving the injured population, including tsunami casualties, when the road system and fuel availability will be impaired.

3.3.2 McMinnville Hospital

The McMinnville hospital obtains water from McMinnville Water and Light via two feeder lines with undercrossing beneath the Yamhill River (**Figure 3-5**). The hospital receives its fuel and natural gas from Laughlin Oil Company and NW Natural, respectively. Its electricity is from two feeder lines from McMinnville Water and Light. The hospital has an emergency generator and multiple communication methods. There is road access to the hospital from the north, west and east, and an open field to the south. During an earthquake, all lifeline systems are expected to incur damage due to shaking, liquefaction, and landslides. [Note that the original version of this paper incorrectly listed tsunamis as a hazard for McMinnville.] Options are available to improve the resilience of each lifeline and include increasing the on-site capacities of diesel fuel, water, emergency communication equipment and working out local transportation detours (**Figure 3-5**). Because many local bridges to the west and leading to downtown McMinnville are expected to be damaged, working with the city and transportation districts to develop alternate and reliable routes for short-, medium, and long-term is advised. The airport to the east of the hospital may provide emergency support.

Figure 3-5. Hospital interdependencies: McMinnville hospital relies on people, hospital infrastructure and supplies, fuel, water, electricity, transportation, and communications.



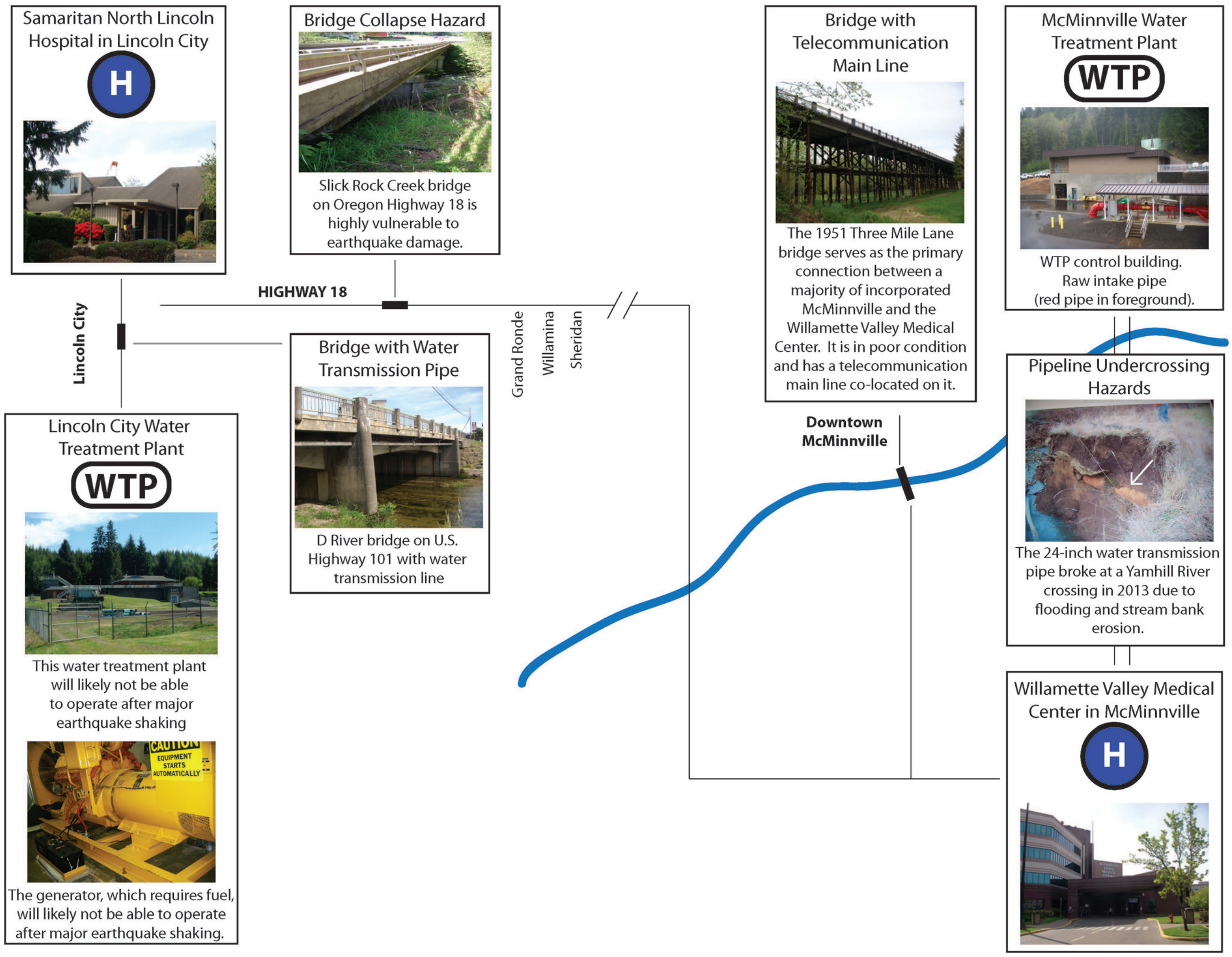
One of the biggest lifeline interdependency challenges for the McMinnville hospital is the availability of a sufficient quantity of potable water. According to water system personnel, two of the most significant seismic vulnerabilities in McMinnville's water system involve the two subparallel 10-mile transmission pipes between the water treatment plant and the four in-town reservoirs at Fox Ridge. Furthermore, none of the reservoirs have seismic valves; thus it is possible that the contents can be completely drained (Robert Klein, oral commun., April 23, 2014).

Another significant challenge for the McMinnville hospital will be serving the injured population, including casualties from collapse-prone buildings, when the road system and fuel availability will be impaired. McMinnville has over 1,060 historic buildings on the city registry with buildings built from 1850s to 1960s. Many buildings in McMinnville's historic district were constructed between the 1910s and 1930s (Doug Montgomery, oral commun., March 5, 2014, and subsequent written commun.). The vast majority of the historic buildings are significantly seismically deficient, and some will have extensive damage and cause injuries requiring hospital care. To access the hospital, extensive road detours may be needed, such as going five miles east to the SE Lafayette highway to cross the Yamhill River on a newer bridge.

3.3.3 Project Area Critical Facilities and Pathways

The highest-level critical facilities in this pilot project are the two hospitals and two water treatment plants in Lincoln City and McMinnville, and the key pathways are the major state highways and pipelines that connect the two hospitals. Some complex connections in the project area between the critically important facilities and the pathways connecting them are illustrated in **Figure 3-6**. Hospitals, depicted by "H," and water treatment plants, depicted by "WTP," are the facilities; the bridges on or near Highways 101 and 18 and water transmission pipeline crossing under the Yamhill River are vital pathways. Not only bridges but the lifelines on the bridges, including water and telecommunication, can be damaged. Similarly, underground pipelines such as the water transmission pipelines undercrossing the Yamhill River that feed the McMinnville hospital, can be damaged. Facilities are further dependent and interdependent on additional facilities and the paths in a hierarchical manner.

Figure 3-6. Schematic of critical facilities and pathways in the project area include the two hospitals, two water treatment plants, and the highways and pipelines connecting them. The blue line is the Yamhill River. (Photos by Yumei Wang except Pipeline Undercrossings Hazard, courtesy of Robert Klein, McMinnville Water and Light)

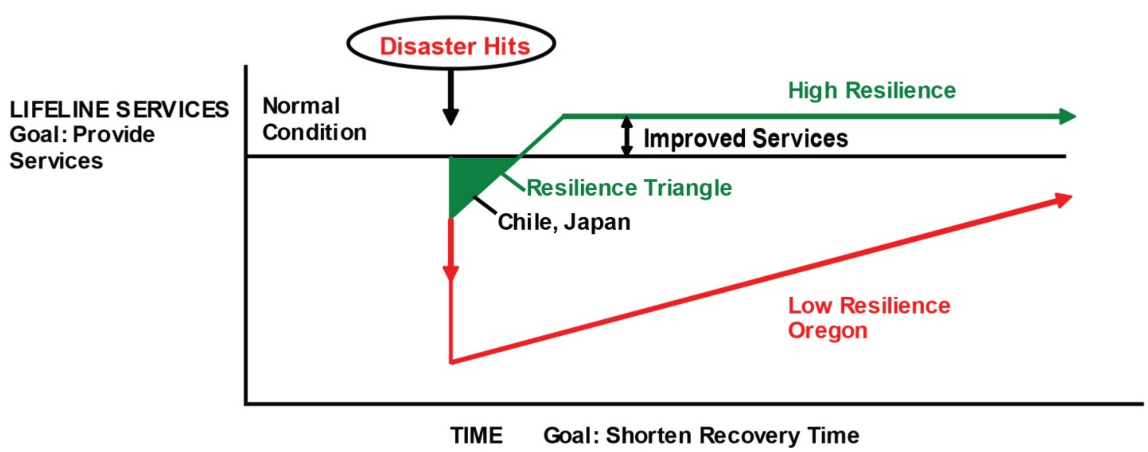


3.4 Conclusions

Results from this limited study as well as from past studies including the 2013 Oregon Resilience Plan show that Oregon hospital and potable water sectors have low resilience to Cascadia earthquakes. Healthcare and water services are expected to have significant damage, severe reductions in service functionality, and a slow recovery period. Oregon healthcare and water services are expected to be severely impacted when a Cascadia earthquake strikes.

Resilience was represented by a diagram with a triangle in 2006 by MCEER (Multidisciplinary Center for Earthquake Engineering Research, University at Buffalo, The State University of New York). MCEER describes the resilience process as when disasters strike, damage to critical infrastructure results in diminished performance. Over time, infrastructure is restored to its original functionality. According to MCEER, four "Rs" — robustness, redundancy, resourcefulness, and rapidity — represent the fundamental properties of disaster resilience (http://mceer.buffalo.edu/research/resilience/Resilience_10-24-06.pdf). In 2013, Wang and others enhanced the MCEER description by graphically simplifying it, and expanding it to allow for improved services as well as Oregon's low resilience condition was compared to the lifeline performance of two recent significant earthquakes. **Figure 3-7** is a succinct graphical representation of disaster resilience including losses, recovery time, and level of lifeline services, and explicitly compares high resilience to low resilience. The basic principle of the resilience triangle is that the smaller the triangle, the higher the resilience. A state of high resilience is depicted by the green triangle. Thus, achieving higher resilience requires minimal reductions in critical lifeline services after a disaster, speedy recovery of those services, and an overall improved service level as a result of rebuilding damaged systems and implementing better systems. As observed by the author on post-earthquake lifeline investigations they have high levels of earthquake resilience on the basis of their performance after the 2010 magnitude 8.8 earthquake in Chile and 2011 magnitude 9.0 earthquake in Japan. This is in part due to the frequency of earthquakes in Chile and Japan, combined with their past and current seismic building codes and overall citizen awareness of earthquake hazards. Recovery in Oregon is expected to be slow, as depicted by the red upwardly sloping line toward the normal condition level.

Figure 3-7. Resilience triangle (green) illustrates that high resilience is due to a combination of limited losses, an efficient recovery, and services that are improved to a higher level than before the disaster. (Source: Wang and others, 2013)



From the study results and findings, DOGAMI concludes that:

Hospitals are important community safety nets in disasters. Hospitals require a high level of ***resilience***—they need to incur limited damage, have reliable emergency methods to operate immediately after major earthquakes, and recover efficiently to provide improved services in order to best serve our communities.

- Both pilot study hospitals have seismic vulnerabilities and are expected to incur significant hospital bed shortages for over 90 days after a Cascadia earthquake.
- Both pilot study hospitals have complex lifeline dependencies, with strong dependency on water, transportation, and other lifelines. Due to lifeline damage, hospitals are expected to incur severe reductions in functionality after a Cascadia earthquake. Damage to local water systems and transportation networks will slow the response and recovery of hospitals, and hospital services for community members will be impaired.
- Both pilot study hospitals have nearby bridges that are expected to incur significant damage and limit transportation mobility of people and supplies to and from the hospital after a Cascadia earthquake. This includes staff, injured community members, and supplies to operate the hospital, such as potable water, gasses, and medications.
- Each pilot study water system has seismic vulnerabilities, complex lifeline dependencies, and is expected to incur severe reductions in functionality after a Cascadia earthquake. Water service to the hospitals using standard methods in the water pipeline distribution system is expected to be down for weeks to months.
- Areas of active landslides are expected to move during a Cascadia earthquake. Some prehistoric landslides and slopes that have not previously failed are also expected to move. Loose, saturated sandy soils are expected to experience liquefaction during a Cascadia earthquake. Infrastructure, including water transmission pipes and highways that traverse zones of landslide and liquefaction activity, is expected to be damaged.
- Specific important results are:
    - Lincoln City hospital is estimated to incur significant damage due to its proximity to the Cascadia fault and will slowly recover to operate at about 50% bed capacity in 90 days. A number of bridges, including bridges crossing the Siletz River, that connect the community and hospital are expected to incur major damage and impede citizen access to the hospital complex.
    - Although the McMinnville hospital has modern seismic structural engineering, design and construction, it is expected to have a severe reduction in function due to shaking damage. It is expected to recover to 79% bed capacity in 90 days. A number of bridges that connect the community, including the Three Mile Lane bridge and nearby Highway 18 bridges to the west of hospital complex and hospital, are expected to incur major damage and impede citizen access.
    - The transportation route between Lincoln City and McMinnville will be impassable immediately after a major Cascadia earthquake, which will impede coastal community members from accessing inland hospitals.
- DOGAMI and OHA communications on this pilot project and site visits to the hospitals and water facilities helped to increase seismic awareness and encourage mitigation actions.
- Hospitals need to coordinate with lifeline owners, including local water and transportation districts, to improve hospital resilience.
- Community resilience, including reliable hospital services in earthquake disasters, requires hospitals, lifeline owners, and other partners to conduct resilience planning in order to better protect citizens on a local and regional scale.

4.0 RECOMMENDATIONS

From this study, DOGAMI has developed top-priority recommendations aimed at OHA and its partners and future effort recommendations, which are aimed at OHA, hospital partners, and communities.

4.1 Top-Priority Recommendations

DOGAMI recommends the following as top priority:

- Share pilot project results with project participants and OHA partners to increase awareness about the need to improve seismic resilience. This could involve developing and distributing a fact sheet, making this report widely available, and providing workshops in the project area and elsewhere.
- OHA and hospital partners encourage and conduct regularly scheduled seismic site visits by appropriate authorities (such as OHA Health Security, Preparedness and Response representatives) to all of the statewide hospitals and the water districts that serve those hospitals to enhance resilience.
- OHA and hospital partners require seismic preparedness standards for drinking water systems that serve hospitals.
- OHA and hospital partners proactively encourage hospitals to meet safety and preparedness regulations in Oregon Revised Statute 455.400 and standards EM.02.01.01 and EM.02.02.09 by The Joint Commission.
- OHA and hospital partners encourage that hospitals conduct comprehensive seismic vulnerability assessments and, from the findings, develop long-term mitigation plans to increase hospital resilience. Any significant mitigation actions should be integrated into relevant hospital plans, such as emergency operation plans, capital investment plans, long-range master plans, and risk management plans.
- OHA and hospital partners encourage hospitals to engage in community and regional resilience planning that specifically addresses hospital lifeline interdependencies.
  - Establish partnerships between water districts and hospitals that focus on the reliability of water services to hospitals. Evaluate the hospital water demand (e.g., supply for 3 days, 7 days, 30 days) and compare it to the capacity of local water reservoirs within the water district. Consider mitigation, such as strengthening the distribution pipes from the nearest in town reservoir to the hospital, or adding interties to improve redundancy in the distribution system.
  - Establish partnerships between transportation districts and hospitals that focus on the reliability of routes to hospitals. Viable transportation detours should be determined in advance of earthquake disasters. For example, until selected bridges are mitigated in McMinnville, community members may need to plan to take transportation detours to access the McMinnville hospital. As a possible example which was not extensively examined as part of this study includes using the bridge that is five miles east of McMinnville on the SE Lafayette Highway that crosses the Yamhill River, extends on Highway 99 south to Dayton, and joins with Highway 18, which connects to the hospital toward the west (**Figure 4-1**).

Figure 4-1. The new bridge on SE Lafayette Highway may be a viable emergency detour for McMinnville residents needing to cross the Yamhill River to access the hospital assuming the bridges in McMinnville are impassable. (Photo by Yumei Wang)

4.2 Future Efforts

DOGAMI recommends the following efforts to improve earthquake resilience:

- Conduct comprehensive seismic evaluations that include structural, non-structural, business continuity and lifeline service vulnerabilities are conducted for all hospitals across the entire state of Oregon.
- Establish resilience metrics that provide a baseline condition and allow for tracking of improvements for hospitals, and communities, and used by OHA and hospital partners. Hospital resilience metrics can be tied to community resilience planning efforts. The ability of hospitals, water systems, or any other physical or social system to function after an earthquake is influenced by the degree of dependency of each system on the others. A hospital may suffer minimal damage but be unable to fulfill its function because of damage to the power or transportation system. Efforts to develop a hospital facility or community resilience index that takes into account these interdependencies are needed and may require significant research and development. The effort may involve conducting a literature review on resilience indices, considering regional vulnerabilities and selected interdependencies, soliciting input from State and Federal partners, and developing preliminary resilience indices.
- Conduct hospital resilience planning workshops using best available information to reduce losses and speed recovery. As an example, the hospitals in this pilot project should use damage and functionality estimates from this study to help plan for improving resilience. Questionnaires may be developed, for example, for lifelines operators that provide services to hospitals that address current weaknesses and potential needs. The workshop may use SWOT (strengths, weaknesses, opportunities, and threats) workgroup techniques and develop SMART (specific, measurable, attainable, realistic, and timely) goals. Hospital resilience planning should address how to provide reliable services during a disaster by having available staff, flow of goods, and infrastructure performance including lifeline services (e.g., fuel and water).
- Conduct community resilience planning workshops using best available information to reduce losses and speed recovery. Questionnaires to community leaders may be developed, for example, to address current civic infrastructure weaknesses and potential needs. Workshops may use SWOT workgroup techniques and develop SMART goals. Community resilience planning should address specific characteristics of their community, including the local hospitals, water systems, schools, fire stations, police stations, shelters, and city halls. As examples for communities in this pilot project, Lincoln City should consider future tsunami damage, and McMinnville should consider future damage relating to their large building portfolio of unmitigated, historic buildings. Mitigation actions should be identified and, where appropriate, integrated into relevant community plans, such as business plans, city plans, neighborhood plans, and family plans. Tax incentive, local bonding, and other measures may be needed to improve community resilience.

5.0 ACKNOWLEDGMENTS

DOGAMI staff Mat Tilman, GIS specialist, and Rudie Watzig, IT specialist, were important and integral parts of this pilot project team. Without their expertise and contributions, this project would not have been possible. The author gratefully acknowledges their support.

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Appendix A: References for Water Facilities

Compiled by Yumei Wang, May 2014

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WATER SYSTEM SEISMIC ANALYSIS SOFTWARE

EPA's epanet network analyses http://www.epa.gov/nrmrl/wswrd/dw/epanet.html

MCEER GIRAFFE water system analyses for consumption and essential care activities http://mceer.buffalo.edu/publications/catalog/reports/Seismic-Response-Modeling-of-Water-Supply-Systems-MCEER-08-0016.html

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http://www.oregon.gov/energy/docs/Earthquake%20Risk%20Study%20in%20Oregon%E2%80%99s%20Critical%20Energy%20Infrastructure%20Hub%202013.pdf

Acronyms:

ALA - American Lifelines Alliance www.americanlifelinesalliance.org
ASCE - American Society of Civil Engineers
IBC - International Building Code
IEEE - Institute of Electrical and Electronics Engineers
MOTEMS – Marine Oil Terminal Engineering and Maintenance Standards, State of California
PRCI - Pipeline Research Council International
TCLEE - Technical Council on Lifeline Earthquake Engineering (under ASCE)

Buildings

Current IBC (for new buildings)
New IBC seismic provisions adopt ASCE 7 and only provide a few exceptions or alternatives to ASCE 7 (ref. ASCE 7-2005: Minimum Design Loads for Buildings and Other Structures, newest edition ASCE 7-10)

ASCE 31 and ASCE 41 (31 for evaluation of existing buildings; 41 for mitigation)
Seismic Evaluation of Existing Buildings, SEI/ASCE 31-03
Seismic Rehabilitation Of Existing Buildings ASCE/SEI 41/06
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Tanks, Piping and Control Equipment, incl. Natural Gas Piping and Well Facilities

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ALA Guide for Seismic Evaluation of Active Mechanical Equipment, 2008 (for walk through assessments)

ALA Oil and Natural Gas Pipeline Systems Guidelines and Commentary (for scoping studies)

ALA Guideline for the Seismic Design and Retrofit of Piping Systems (for scoping study purposes; used to develop B31E)

Appendix B: Comprehensive Data Management System (CDMS) Procedure Summary

Description of Hazus update process

Prepared by Matt Tilman

1. **Back up the core Hazus database in its entirety**

2. **Open the CDMS application**
    1. Using the "Query/Export Statewide Datasets" option
        a. Define your project area (usually by County or Census Tract)
        b. Select your data layers by "Data Category"
        c. Select your Hazards (usually Earthquake and/or Flood)
        d. Click "Search"
        e. Click "Export to Geodatabase" in the next screen
        f. Once the database is created successfully, it will have an auto-generated name, for example:
        g. CDMS_GeoDBExport_2112014142831.mdb.
        h. Rename the database to something with more meaning to your project, for example: CDMS_GeoDBExport_YamhillCounty_Bridges.mdb
        i. Now DELETE the layer(s) you just exported
    2. Exit CDMS
    3. With your newly exported geodatabase, CDMS_GeoDBExport_YamhillCounty_Bridges.mdb, make your edits, updates, and deletions using a GIS application.
    4. Save this exported geodatabase that you just modified
    5. Close the geodatabase
    6. Exit your GIS application
    7. Open the CDMS application
    8. Using the "Import into CDMS Repository from File" option
        a. Click the Browse button and find and select your geodatabase, for example: CDMS_GeoDBExport_YamhillCounty_Bridges.mdb
        b. Select your hazards (usually Earthquake and/or Flood)
        c. Select "Hazus-MH Inventory Category"
        d. Select "Hazus-MH Inventory Dataset (Layer)".
        e. NOTE: At this point Hazus will notify you of the attribute field names that must have values. If any attributes are missing, you must Exit CDMS and return to step 4 and repeat steps 4 thru 9 again.
        f. If all attributes have been filled out correctly, click Continue
    9. Exit CDMS

3. **Run Hazus-MH 2.1**

Mapping scheme for Hazus workaround for potable water system data

Prepared by Mourad Bouhafs, FEMA Technical Support.

DOGAMI Field	Hazus Field	Hazus Module*
ADDRESS	ADDRESS	hz
CITY	CITY	hz
CONTACTPERSON	CONTACT	hz
ANALYSISCLASS	UTILFCLTYCLASS	hz
CAPACITYMILLIONGALLONSDAY	CAPACITY	hz
DAILYDEMAND	DEMAND	hz
STATE	STATEA	hz
REPLACEMENTCOSTTHOUS	COST	hz
MISCCOMMENTS	COMMENT	hz
TELEPHONENUMBER	PHONENUMBER	hz
ZIPCODE	ZIPCODE	hz
DESIGNLEVEL	DESIGNLEVEL	eq
EARTHQUAKEBUILDINGTYPE	EQBLDGTYPE	eq
LIQUEFACTIONSUSCEPTIBILITY	LQFSUSCAT	eq
LANDSLIDESUSCEPTIBILITY	LNDSUSCAT	eq
NUMBEROFSTORIES	NUMSTORIES	hz
HazusID	NAME	hz

*Hazus Module: hz – hazards; eq, earthquake.

Appendix C: Hazus-MH Earthquake Event Report and Results

Hazus-MH: Earthquake Event Report

Region Name: Yumei

Earthquake Scenario: 1000 yr Soil A 6-24-14

Print Date: August 22, 2014

Note: For the Hazus run, the region was temporarily named "Yumei." See text for soil types actually used in the scenario.

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

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Table of Contents

General Description of the Region

General Description of the Region

Hazus is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 4 county(ies) from the following state(s):

Oregon

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 1,822.48 square miles and contains 20 census tracts. There are over 34 thousand households in the region which has a total population of 95,503 people (2002 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 48 thousand buildings in the region with a total building replacement value (excluding contents) of 7,763 (millions of dollars). Approximately 92.00 % of the buildings (and 79.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 2,540 and 2,065 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 48 thousand buildings in the region which have an aggregate total replacement value of 7,763 (millions of dollars) . Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 75% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

Hazus breaks critical facilities into two (2) groups: essential facilities and high potential loss facilities (HPL). Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 4 hospitals in the region with a total bed capacity of 113 beds. There are 51 schools, 20 fire stations, 11 police stations and 1 emergency operation facilities. With respect to high potential loss facilities (HPL), there are 52 dams identified within the region. Of these, 2 of the dams are classified as 'high hazard'. The inventory also includes 12 hazardous material sites, 0 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within Hazus, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 1 and 2.

The total value of the lifeline inventory is over 4,605.00 (millions of dollars). This inventory includes over 398 kilometers of highways, 169 bridges, 19,532 kilometers of pipes.

Table 1: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	169	906.80
	Segments	72	1,402.10
	Tunnels	0	0.00
		Subtotal	**2,308.90**
Railways	Bridges	0	0.00
	Facilities	0	0.00
	Segments	40	94.20
	Tunnels	0	0.00
		Subtotal	**94.20**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	1	1.20
		Subtotal	**1.20**
Ferry	Facilities	1	1.30
		Subtotal	**1.30**
Port	Facilities	0	0.00
		Subtotal	**0.00**
Airport	Facilities	2	21.30
	Runways	3	113.90
		Subtotal	**135.20**
		Total	**2,540.80**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	202.10
	Facilities	88	861.20
	Pipelines	0	0.00
		Subtotal	**1,063.30**
Waste Water	Distribution Lines	NA	113.10
	Facilities	16	1,204.10
	Pipelines	0	0.00
		Subtotal	**1,317.20**
Natural Gas	Distribution Lines	NA	75.40
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**75.40**
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**0.00**
Electrical Power	Facilities	0	0.00
		Subtotal	**0.00**
Communication	Facilities	5	0.60
		Subtotal	**0.60**
		Total	**2,456.50**

Earthquake Scenario Parameters

Earthquake Scenario

Hazus uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

Note: See text for soil types actually used in the scenario.

Scenario Name	1000 yr Soil A 6-24-14
Type of Earthquake	Probabilistic
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	1,000.00
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	9.00
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Direct Earthquake Damage

Building Damage

Building Damage

Hazus estimates that about 26,708 buildings will be at least moderately damaged. This is over 55.00 % of the buildings in the region. There are an estimated 4,902 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the Hazus technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	65	0.63	74	0.63	96	0.88	110	1.01	70	1.43
Commercial	187	1.82	282	2.39	581	5.32	704	6.47	504	10.29
Education	10	0.10	12	0.10	19	0.17	24	0.22	17	0.34
Government	5	0.05	7	0.06	14	0.13	19	0.18	14	0.28
Industrial	72	0.70	105	0.89	228	2.09	284	2.61	203	4.13
Other Residential	1,971	19.14	2,531	21.49	3,504	32.07	4,732	43.50	2,784	56.79
Religion	23	0.23	30	0.25	46	0.42	58	0.53	40	0.82
Single Family	7,962	77.34	8,734	74.18	6,438	58.92	4,948	45.48	1,271	25.93
Total	10,295		11,774		10,927		10,879		4,902	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	9,878	95.95	10885	92.45	8,094	74.08	6,170	56.72	1,532	31.26
Steel	60	0.58	85	0.72	276	2.53	447	4.10	366	7.46
Concrete	115	1.12	156	1.32	291	2.66	398	3.66	275	5.61
Precast	70	0.68	75	0.63	179	1.64	250	2.30	199	4.05
RM	19	0.18	12	0.11	26	0.24	37	0.34	23	0.47
URM	93	0.90	201	1.71	465	4.25	611	5.61	563	11.49
MH	61	0.59	360	3.06	1,595	14.60	2,966	27.26	1,944	39.66
Total	10,295		11,774		10,927		10,879		4,902	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 113 hospital beds available for use. On the day of the earthquake, the model estimates that only 20 hospital beds (18.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 36.00% of the beds will be back in service. By 30 days, 66.00% will be operational.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	**Total**	**At Least Moderate Damage > 50%**	**Complete Damage > 50%**	**With Functionality > 50% on day 1**
Hospitals	4	3	0	0
Schools	51	16	0	0
EOCs	1	1	1	0
PoliceStations	11	3	0	0
FireStations	20	9	0	0

Transportation and Utility Lifeline Damage

Table 6 provides damage estimates for the transportation system.

Table 6: Expected Damage to the Transportation Systems

System	Component	Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 % After Day 1	With Functionality > 50 % After Day 7
Highway	Segments	72	0	0	72	72
	Bridges	169	35	6	135	136
	Tunnels	0	0	0	0	0
Railways	Segments	40	0	0	40	40
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	1	0	0	1	1
Ferry	Facilities	1	1	1	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	2	1	0	2	2
	Runways	3	0	0	3	3

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, Hazus performs a simplified system performance analysis. Table 9 provides a summary of the system performance information.

Table 7 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	88	65	2	26	82
Waste Water	16	16	0	0	15
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	5	5	0	4	5

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	10,107	5729	3517
Waste Water	5,655	2780	1693
Natural Gas	3,770	952	580
Oil	0	0	0

Table 9: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	34,745	30,599	29,704	26,983	19,199	0
Electric Power		7,319	4,634	2,454	895	10

Induced Earthquake Damage

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 0 ignitions that will burn about 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (millions of dollars) of building value.

Debris Generation

Hazus estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 0.84 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 42.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 33,640 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Social Impact

Social Impact

Shelter Requirement

Hazus estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 2,699 households to be displaced due to the earthquake. Of these, 1,866 people (out of a total population of 95,503) will seek temporary shelter in public shelters.

Casualties

Hazus estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 10 provides a summary of the casualties estimated for this earthquake

Table 10: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	8	2	0	1
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	42	12	2	4
	Industrial	11	3	1	1
	Other-Residential	371	90	9	16
	Single Family	341	65	4	7
	Total	**773**	**172**	**16**	**28**
2 PM	Commercial	596	177	29	56
	Commuting	1	1	2	0
	Educational	183	54	9	17
	Hotels	8	2	0	1
	Industrial	81	24	4	8
	Other-Residential	86	21	2	4
	Single Family	87	17	1	2
	Total	**1,042**	**297**	**47**	**88**
5 PM	Commercial	516	154	25	48
	Commuting	23	33	53	10
	Educational	16	5	1	1
	Hotels	13	4	1	1
	Industrial	51	15	2	5
	Other-Residential	137	33	3	6
	Single Family	136	26	2	3
	Total	**892**	**269**	**87**	**74**

Economic Loss

Economic Loss

The total economic loss estimated for the earthquake is 3,544.50 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 2,574.53 (millions of dollars); 19 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 62 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.00	24.69	69.93	3.28	5.35	103.26
	Capital-Related	0.00	10.60	65.99	1.96	1.74	80.28
	Rental	28.15	36.47	28.77	1.09	2.47	96.96
	Relocation	100.07	30.84	42.87	5.18	21.54	200.50
	Subtotal	**128.22**	**102.60**	**207.56**	**11.51**	**31.10**	**481.00**
Capital Stock Losses							
	Structural	177.14	63.35	71.35	21.90	34.31	368.05
	Non_Structural	612.95	267.98	230.73	80.45	84.56	1,276.66
	Content	172.76	58.50	107.62	52.60	42.10	433.58
	Inventory	0.00	0.00	3.18	10.51	1.56	15.25
	Subtotal	**962.85**	**389.83**	**412.87**	**165.45**	**162.53**	**2,093.54**
	Total	**1,091.08**	**492.43**	**620.43**	**176.96**	**193.63**	**2,574.53**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, Hazus computes the direct repair cost for each component only. There are no losses computed by Hazus for business interruption due to lifeline outages. Tables 12 & 13 provide a detailed breakdown in the expected lifeline losses.

Hazus estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 14 presents the results of the region for the given earthquake.

Table 12: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	1,402.08	$177.77	12.68
	Bridges	906.82	$173.72	19.16
	Tunnels	0.00	$0.00	0.00
	Subtotal	**2308.90**	**351.50**	
Railways	Segments	94.18	$4.65	4.94
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**94.20**	**4.70**	
Light Rail	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Bus	Facilities	1.23	$0.42	33.95
	Subtotal	**1.20**	**0.40**	
Ferry	Facilities	1.33	$1.33	100.00
	Subtotal	**1.30**	**1.30**	
Port	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Airport	Facilities	21.30	$7.71	36.20
	Runways	113.89	$11.82	10.38
	Subtotal	**135.20**	**19.50**	
	Total	**2540.80**	**377.40**	

Table 13: Utility System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	861.20	$147.10	17.08
	Distribution Lines	202.10	$46.63	23.07
	Subtotal	**1,063.34**	**$193.72**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	1,204.10	$368.48	30.60
	Distribution Lines	113.10	$22.49	19.88
	Subtotal	**1,317.23**	**$390.97**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Lines	75.40	$7.70	10.22
	Subtotal	**75.40**	**$7.70**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Electrical Power	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Communication	Facilities	0.60	$0.16	28.19
	Subtotal	**0.57**	**$0.16**	
	Total	**2,456.54**	**$592.55**	

Table 14. Indirect Economic Impact with outside aid
(Employment as # of people and Income in millions of $)

LOSS		Total	%

Appendices

Appendix A: County Listing for the Region

Lincoln,OR

Polk,OR

Tillamook,OR

Yamhill,OR

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Oregon					
	Lincoln	16,001	1,457	275	1,732
	Polk	11,091	666	130	796
	Tillamook	4,886	482	67	549
	Yamhill	63,525	3,553	1,131	4,685
Total State		**95,503**	**6,158**	**1,603**	**7,762**
Total Region		**95,503**	**6,158**	**1,603**	**7,762**

Direct Economic Losses For Buildings

August 26, 2014 *All values are in thousands of dollars*

	Capital Stock Losses					Income Losses				
	Cost Structural Damage	Cost Non-struct. Damage	Cost Contents Damage	Inventory Loss	Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Oregon										
Lincoln	98,232	362,070	112,783	1,957	26.57	57,421	24,784	36,096	36,252	729,596
Polk	34,716	112,306	37,494	1,479	18.45	17,370	4,805	6,907	6,957	222,032
Tillamook	32,018	105,587	32,908	773	25.04	17,966	3,716	4,863	7,376	205,206
Yamhill	203,083	696,697	250,391	11,044	19.20	107,738	46,975	55,392	46,379	1,417,700
Total	368,048	1,276,660	433,575	15,252	22.32	200,496	80,280	103,258	96,964	2,574,534
Region Total	**368,048**	**1,276,660**	**433,575**	**15,252**	**22.32**	**200,496**	**80,280**	**103,258**	**96,964**	**2,574,534**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Study Region : working copy of FINAL region 8-22-14
Scenario : 1000 yr Soil A 6-24-14

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Earthquake Hazard Report

Hospital Functionality

August 26, 2014

	Total # of Beds	At Day 1 # of Beds	At Day 1 %	At day 3 # of Beds	At day 3 %	At day 7 # of Beds	At day 7 %	At day 30 # of Beds	At day 30 %	At day 90 # of Beds	At day 90 %
Oregon											
Lincoln											
Small Hospital	25	0	1.70	0	1.90	2	9.80	10	41.50	13	52.40
Total	**25**	**0**	**1.70**	**0**	**1.90**	**2**	**9.80**	**10**	**41.50**	**13**	**52.40**
Yamhill											
Medium Hospital	88	21	23.60	21	24.07	39	44.43	65	74.33	68	76.77
Total	**88**	**21**	**23.60**	**21**	**24.10**	**39**	**44.40**	**65**	**74.30**	**68**	**76.80**
Total	**113**	**14**	**12.70**	**15**	**13.00**	**31**	**27.10**	**65**	**57.90**	**73**	**64.60**
Region Total	**113**	**14**	**12.65**	**15**	**12.98**	**31**	**27.12**	**65**	**57.92**	**73**	**64.58**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

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Earthquake Hazard Report

Potable Water System Facility Damage

August 26, 2014

	# Facilities	Average for Damage State				
		None	Slight	Moderate	Extensive	Complete
Oregon						
Lincoln	19	0.25	0.24	0.33	0.15	0.02
Polk	16	0.04	0.22	0.41	0.25	0.08
Yamhill	53	0.13	0.25	0.38	0.19	0.06
Total	**88**	**0.14**	**0.24**	**0.37**	**0.20**	**0.05**
Region Total	**88**	**0.14**	**0.24**	**0.37**	**0.20**	**0.05**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

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Earthquake Hazard Report

Potable Water System Performance

August 26, 2014

	Total Households	# of households without water									
		At day 1		At day 3		At day 7		At day 30		At day 90	
		Count	%	Count	%	Count	%	Count	%	Count	%
Oregon											
Lincoln	7,295	5,357	73.40	4,763	65.30	2,830	38.80	0	0.00	0	0.00
Polk	3,970	2,877	72.50	2,669	67.20	2,098	52.80	0	0.00	0	0.00
Tillamook	2,033	1,987	97.70	1,981	97.40	1,966	96.70	1,632	80.30	0	0.00
Yamhill	21,447	20,378	95.00	20,291	94.60	20,089	93.70	17,567	81.90	0	0.00
Total	**34,745**	**30,599**	**88.10**	**29,704**	**85.50**	**26,983**	**77.70**	**19,199**	**55.30**	**0**	**0.00**
Region Total	**34,745**	**30,599**	**88.10**	**29,704**	**85.50**	**26,983**	**77.70**	**19,199**	**55.30**	**0**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

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Earthquake Hazard Report

Potable Water Pipeline Damage

August 26, 2014

	Pipeline Length (KM)	Total Number of Leaks	Total Number of Breaks
Oregon			
Lincoln	1,634	982	303
Polk	2,506	1,283	441
Tillamook	2,120	1,485	1,187
Yamhill	3,847	1,979	1,585
Total	**10,107**	**5,729**	**3,517**
Region Total	**10,107**	**5,729**	**3,517**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

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Earthquake Hazard Report

Direct Economic Loss For Utilities

August 26, 2014

All values are in thousands of dollars

	Potable Water	Waste Water	Oil Systems	Natural Gas	Electric Power	Communication	Total
Oregon							
Lincoln							
Facilities	50,553	65,487	0	0	0	81	116,121
Pipelines	4,996	2,330	0	798			8,124
Total	55,549	67,817	0	798	0	81	124,245
Polk							
Facilities	5,280	41,267	0	0	0	0	46,547
Pipelines	6,978	3,461	0	1,186			11,625
Total	12,258	44,728	0	1,186	0	0	58,172
Tillamook							
Facilities	0	105,001	0	0	0	0	105,001
Pipelines	14,839	7,454	0	2,554			24,847
Total	14,839	112,455	0	2,554	0	0	129,848
Yamhill							
Facilities	91,263	156,722	0	0	0	78	248,064
Pipelines	19,813	9,243	0	3,166			32,222
Total	111,076	165,965	0	3,166	0	78	280,285
Total	**193,722**	**390,965**	**0**	**7,704**	**0**	**159**	**592,550**
Region Total	**193,722**	**390,965**	**0**	**7,704**	**0**	**159**	**592,550**

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Scenario : 1000 yr Soil A 6-24-14

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Earthquake Hazard Report

	Potable Water	Waste Water	Oil Systems	Natural Gas	Electric Power	Communication	Total

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Transportation Highway Bridge Functionality

August 26,2014

	# of bridges	Functionality (%) At day 1	At day 3	At day 7	At day 30	At day 90
Oregon						
Lincoln	17	49.40	56.60	60.70	63.00	72.80
Polk	70	60.10	65.50	68.90	70.70	78.50
Tillamook	21	60.40	66.30	69.80	71.60	79.40
Yamhill	61	60.30	66.30	69.90	71.90	80.10
Total	**169**	**57.50**	**63.70**	**67.30**	**69.30**	**77.70**
Region Total	**169**	**57.50**	**63.70**	**67.30**	**69.30**	**77.70**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Study Region : working copy of FINAL region 8-22-14
Scenario : 1000 yr Soil A 6-24-14

Highway Road Functionality

August 26,2014

	Length (KM)	Functionality (%) At day 1	At day 3	At day 7	At day 30	At day 90
Oregon						
Lincoln	63	79.90	81.80	84.10	94.30	99.90
Polk	85	86.40	89.00	91.30	96.90	99.90
Tillamook	83	76.60	78.20	80.30	93.00	99.90
Yamhill	167	85.00	87.80	90.30	96.50	99.90
Total	**398**	**82.00**	**84.20**	**86.50**	**95.20**	**99.90**
Region Total	**398**	**82.00**	**84.20**	**86.50**	**95.20**	**99.90**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

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Earthquake Hazard Report

Direct Economic Loss For Transportation

August 26, 2014

All values are in thousands of dollars

	Highway	Railway	Light Rail	Bus Facility	Ports	Ferries	Airport	Total
Oregon								
Lincoln								
Segments	35,890	0	0					35,890
Bridges	32,398	0	0					32,398
Tunnels	0	0	0					0
Facilities		0	0	0	0	0	4,150	4,150
Total	**68,289**	**0**	**0**	**0**	**0**	**0**	**4,150**	**72,439**
Polk								
Segments	27,530	1,383	0					28,914
Bridges	55,533	0	0					55,533
Tunnels	0	0	0					0
Facilities		0	0	0	0	0	0	0
Total	**83,063**	**1,383**	**0**	**0**	**0**	**0**	**0**	**84,446**
Tillamook								
Segments	49,398	0	0					49,398
Bridges	17,951	0	0					17,951
Tunnels	0	0	0					0
Facilities		0	0	0	0	0	0	0
Total	**67,349**	**0**	**0**	**0**	**0**	**0**	**0**	**67,349**
Yamhill								
Segments	64,951	3,271	0					68,223
Bridges	67,834	0	0					67,834

Study Region : working copy of FINAL region 8-22-14
Scenario : 1000 yr Soil A 6-24-14

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Earthquake Hazard Report

	Highway	Railway	Light Rail	Bus Facility	Ports	Ferries	Airport	Total
Tunnels	0	0	0					0
Facilities		0	0	418	0	1,331	3,561	5,310
Total	**132,785**	**3,271**	**0**	**418**	**0**	**1,331**	**3,561**	**141,366**
Total	**351,486**	**4,654**	**0**	**418**	**0**	**1,331**	**7,711**	**365,600**
Region Total	**351,486**	**4,654**	**0**	**418**	**0**	**1,331**	**7,711**	**365,600**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Study Region : working copy of FINAL region 8-22-14
Scenario : 1000 yr Soil A 6-24-14

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Earthquake Hazard Report

Debris Results (in thousands of tons) - Printed on: 8/26/2014 10:25:57 AM

	Tract	Brick, Wood & Others	Concrete & Steel	DebrisTotal
1	41041950100	18.31	17.31	35.62
2	41041950300	27.96	38.59	66.55
3	41041950400	25.56	40.11	65.67
4	41041950600	37.27	37.31	74.58
5	41053020100	4.77	8.44	13.22
6	41053020201	8.80	11.91	20.71
7	41053020400	19.20	21.26	40.46
8	41057960700	14.78	16.45	31.24
9	41057960800	15.65	15.64	31.29
10	41071030300	21.84	28.30	50.14
11	41071030400	21.12	26.49	47.61
12	41071030501	18.72	31.32	50.04
13	41071030502	16.77	27.88	44.65
14	41071030600	29.13	48.29	77.42
15	41071030701	13.60	14.77	28.37
16	41071030702	15.48	17.46	32.94
17	41071030801	17.96	38.10	56.05
18	41071030802	10.05	20.74	30.80
19	41071030900	9.36	11.85	21.21
20	41071031000	9.66	12.95	22.62

working copy of FINAL region 8-22-14

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Appendix D: Hazus-MH Hospital Results

Medical Care, Structural Damage

Essential Facilities Results - Medical Care Facilities - Medical Care, Structural Damage Printed on: 6/25/2014 4:45:46 PM

	ID Number	Name	None	Slight	Moderate	Extensive
1	OR000030	SAMARITAN NORTH LINCOLN HOSP	0.018	0.082	0.315	0.218
2	OR000031	WILLAMETTE VALLEY MEDICAL CTR	0.139	0.227	0.364	0.061
3	OR000065	WILLAMETTE VALLEY MEDICAL CTR	0.139	0.227	0.364	0.061
4	OR000066	WILLAMETTE VALLEY MEDICAL CTR	0.432	0.185	0.155	0.026

OHA-EQ study region created on 6-24-14

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Essential Facilities Results - Medical Care Facilities - Medical Care, Structural Damage Printed on: 6/25/2014 4:45:46 PM

	Complete	At Least Slight	At Least Moderate	At Least Extensive
1	0.367	0.982	0.900	0.585
2	0.209	0.861	0.634	0.271
3	0.209	0.861	0.634	0.271
4	0.201	0.568	0.382	0.227

OHA-EQ study region created on 6-24-14

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Medical Care, Functionality

Essential Facilities Results - Medical Care Facilities - Medical Care, Functionality Printed on: 6/25/2014 4:46:10 PM

	ID Number	Name	@ Day 1	@ Day 3	@ Day 7	@ Day 14
1	OR000030	SAMARITAN NORTH LINCOLN HOSP	1.70	1.90	9.80	10.00
2	OR000031	WILLAMETTE VALLEY MEDICAL CTR	13.80	14.30	36.00	36.60
3	OR000065	WILLAMETTE VALLEY MEDICAL CTR	13.80	14.30	36.00	36.60
4	OR000066	WILLAMETTE VALLEY MEDICAL CTR	43.20	43.60	61.30	61.70

OHA-EQ study region created on 6-24-14 Page 1

Essential Facilities Results - Medical Care Facilities - Medical Care, Functionality Printed on: 6/25/2014 4:46:10 PM

	@ Day 30	@ Day 90
1	41.50	52.40
2	72.90	75.90
3	72.90	75.90
4	77.20	78.50

Appendix E: Hazus-MH Water System Results

Inventory

ID Number	Class	Tract	Name	Address	City	Replace-ment Cost (thous. $)	Build-ing Type	De-sign Level
US000063	PWTM	41053020400	OR000072	26690 SALMON RIVER HWY	GRAND RONDE	$11,200.00	W2	PC
US000064	PPPS	41071030502	OR000073		GRAND RONDE		MH	MC
US000065	PSTGS	41053020400	OR000074		GRAND RONDE		DFLT	LC
US000066	PSTGS	41053020400	OR000075		GRAND RONDE		DFLT	LC
US000067	PSTGS	41053020400	OR000076		GRAND RONDE		DFLT	LC
US000068	PSTGS	41053020400	OR000077		GRAND RONDE		DFLT	LC
US000069	PSTGS	41071030502	OR000078		GRAND RONDE		DFLT	LC
US000070	PSTGS	41071030502	OR000079		GRAND RONDE		DFLT	LC
US000071	PSTGS	41071030502	OR000080		GRAND RONDE		DFLT	LC
US000072	PPPS	41053020400	OR000081		GRAND RONDE		MH	MC
US000038	PWTS	41041950100	OR000047	317 S ANDERSON CREEK RD	LINCOLN CITY	$300,000.00	RM1L	MC
US000073	PSTGS	41041950300	OR000082		LINCOLN CITY		DFLT	LC
US000074	PSTGS	41041950300	OR000083		LINCOLN CITY		DFLT	LC
US000075	PSTGS	41041950400	OR000084		LINCOLN CITY		DFLT	LC
US000076	PPPS	41041950100	OR000085	317 S ANDERSON CREEK RD	LINCOLN CITY		RM1L	HC
US000077	PPPS	41041950100	OR000086	317 S ANDERSON CREEK RD	LINCOLN CITY		RM1L	MC
US000082	PPPS	41041950400	OR000091	15TH AND OAR	LINCOLN CITY		RM1L	MC
US000083	PPPS	41041950300	OR000092	36TH AND QUAY	LINCOLN CITY		RM1L	HC
US000084	PPPS	41041950300	OR000093	36TH AND QUAY BACKUP	LINCOLN CITY		RM1L	HC
US000085	PPPS	41041950400	OR000094	15TH AND OAR	LINCOLN CITY		RM1L	MC
US000086	PPPS	41041950400	OR000095	BAYVIEW	LINCOLN CITY		RM1L	HC
US000087	PPPS	41041950100	OR000096	WATER PLANT	LINCOLN CITY		RM1L	MC
US000088	PPPS	41041950300	OR000097	VOYAGE AND VILLAGES	LINCOLN CITY		RM1L	MC
US000040	PDFLT	41071030400	OR000049	HASKINS DAM, YAMHILL COUNTY	MCMINNVILLE		DFLT	LC
US000041	PDFLT	41071030400	OR000050	MCGUIRE DAM, YAMHILL COUNTY	MCMINNVILLE		DFLT	LC
US000042	PSTGC	41071030600	OR000051		MCMINNVILLE		DFLT	LC
US000043	PSTGC	41071030600	OR000052		MCMINNVILLE		DFLT	LC
US000044	PSTGW	41071030600	OR000053		MCMINNVILLE		DFLT	LC
US000045	PSTGW	41071030600	OR000054		MCMINNVILLE		DFLT	LC
US000046	PWTM	41071030400	OR000055		MCMINNVILLE	$500,000.00	RM1L	MC
US000047	PWTM	41071030400	OR000056		MCMINNVILLE		C2L	MC
US000048	PWTM	41071030400	OR000057		MCMINNVILLE		C2L	MC
US000049	PWTM	41071030400	OR000058		MCMINNVILLE		C2L	MC
US000050	PWTM	41071030600	OR000059		MCMINNVILLE		RM1L	MC
US000078	PDFLT	41071030600	OR000087		MCMINNVILLE		W2	MC
US000079	PDFLT	41071030600	OR000088		MCMINNVILLE		S3	MC
US000080	PDFLT	41071030600	OR000089		MCMINNVILLE		S3	MC
US000081	PDFLT	41071030600	OR000090		MCMINNVILLE		RM1L	MC
US000051	PWTS	41071030501	OR000060		SHERIDAN	$40,000.00	S3	LC
US000052	PPPS	41071030502	OR000061		SHERIDAN		RM1L	MC
US000053	PSTGC	41071030501	OR000062		SHERIDAN		DFLT	LC
US000054	PSTGC	41071030501	OR000063		SHERIDAN		DFLT	LC
US000055	PSTGC	41071030501	OR000064		SHERIDAN		DFLT	LC
US000056	PSTGC	41071030502	OR000065		SHERIDAN		DFLT	LC
US000039	PWTS	41071030502	OR000048	190 CHURCHMAN	WILLAMINA	$10,000.00	S3	HC

ID Number	Class	Tract	Name	Address	City	Replace-ment Cost (thous. $)	Build-ing Type	De-sign Level
US000057	PPPS	41071030502	OR000066		WILLAMINA		W2	LC
US000058	PPPS	41071030502	OR000067		WILLAMINA		RM1L	MC
US000059	PPPS	41071030502	OR000068		WILLAMINA		RM1L	MC
US000060	PSTGS	41053020400	OR000069		WILLAMINA		DFLT	LC
US000061	PSTGS	41071030502	OR000070		WILLAMINA		DFLT	LC
US000062	PSTGS	41071030502	OR000071		WILLAMINA		DFLT	LC

Location

ID Number	Class	Tract	Name	Address	City	Latitude	Longitude
US000063	PWTM	41053020400	OR000072	26690 SALMON RIVER HWY	GRAND RONDE	45.0607	-123.57584
US000064	PPPS	41071030502	OR000073		GRAND RONDE	45.09464	-123.685433
US000065	PSTGS	41053020400	OR000074		GRAND RONDE	45.03899	-123.622019
US000066	PSTGS	41053020400	OR000075		GRAND RONDE	45.03907	-123.621725
US000067	PSTGS	41053020400	OR000076		GRAND RONDE	45.06389	-123.582166
US000068	PSTGS	41053020400	OR000077		GRAND RONDE	45.05591	-123.55684
US000069	PSTGS	41071030502	OR000078		GRAND RONDE	45.10191	-123.705178
US000070	PSTGS	41071030502	OR000079		GRAND RONDE	45.09727	-123.544046
US000071	PSTGS	41071030502	OR000080		GRAND RONDE	45.09737	-123.544145
US000072	PPPS	41053020400	OR000081		GRAND RONDE	45.06692	-123.550323
US000038	PWTS	41041950100	OR000047	317 S ANDERSON CREEK RD	LINCOLN CITY	44.93501	-123.971479
US000073	PSTGS	41041950300	OR000082		LINCOLN CITY	45.00419	-124.002562
US000074	PSTGS	41041950300	OR000083		LINCOLN CITY	44.97769	-124.001893
US000075	PSTGS	41041950400	OR000084		LINCOLN CITY	44.95377	-124.010255
US000076	PPPS	41041950100	OR000085	317 S ANDERSON CREEK RD	LINCOLN CITY	44.93528	-123.971185
US000077	PPPS	41041950100	OR000086	317 S ANDERSON CREEK RD	LINCOLN CITY	44.93621	-123.971422
US000082	PPPS	41041950400	OR000091	15TH AND OAR	LINCOLN CITY	44.9567	-124.007574
US000083	PPPS	41041950300	OR000092	36TH AND QUAY	LINCOLN CITY	44.99275	-124.005497
US000084	PPPS	41041950300	OR000093	36TH AND QUAY BACKUP	LINCOLN CITY	44.9927	-124.005484
US000085	PPPS	41041950400	OR000094	15TH AND OAR	LINCOLN CITY	44.95668	-124.007637
US000086	PPPS	41041950400	OR000095	BAYVIEW	LINCOLN CITY	44.93392	-124.014245
US000087	PPPS	41041950100	OR000096	WATER PLANT	LINCOLN CITY	44.93619	-123.97143
US000088	PPPS	41041950300	OR000097	VOYAGE AND VILLAGES	LINCOLN CITY	45.00396	-124.003042
US000040	PDFLT	41071030400	OR000049	HASKINS DAM, YAMHILL COUNTY	MCMINNVILLE	45.31139	-123.357006
US000041	PDFLT	41071030400	OR000050	MCGUIRE DAM, YAMHILL COUNTY	MCMINNVILLE	45.3093	-123.408975
US000042	PSTGC	41071030600	OR000051		MCMINNVILLE	45.21933	-123.242743
US000043	PSTGC	41071030600	OR000052		MCMINNVILLE	45.21863	-123.24236
US000044	PSTGW	41071030600	OR000053		MCMINNVILLE	45.21801	-123.241195
US000045	PSTGW	41071030600	OR000054		MCMINNVILLE	45.21765	-123.241806
US000046	PWTM	41071030400	OR000055		MCMINNVILLE	45.31251	-123.350327
US000047	PWTM	41071030400	OR000056		MCMINNVILLE	45.31215	-123.350333
US000048	PWTM	41071030400	OR000057		MCMINNVILLE	45.31243	-123.349617
US000049	PWTM	41071030400	OR000058		MCMINNVILLE	45.31275	-123.349272
US000050	PWTM	41071030600	OR000059		MCMINNVILLE	45.21883	-123.241601
US000078	PDFLT	41071030600	OR000087		MCMINNVILLE	45.21387	-123.177111
US000079	PDFLT	41071030600	OR000088		MCMINNVILLE	45.21371	-123.17636
US000080	PDFLT	41071030600	OR000089		MCMINNVILLE	45.21414	-123.175857
US000081	PDFLT	41071030600	OR000090		MCMINNVILLE	45.21378	-123.175488
US000051	PWTS	41071030501	OR000060		SHERIDAN	45.1088	-123.396108
US000052	PPPS	41071030502	OR000061		SHERIDAN	45.08476	-123.396213
US000053	PSTGC	41071030501	OR000062		SHERIDAN	45.10865	-123.396454
US000054	PSTGC	41071030501	OR000063		SHERIDAN	45.10866	-123.396861

ID Number	Class	Tract	Name	Address	City	Latitude	Longitude
US000055	PSTGC	41071030501	OR000064		SHERIDAN	45.10834	-123.397149
US000056	PSTGC	41071030502	OR000065		SHERIDAN	45.08447	-123.396897
US000039	PWTS	41071030502	OR000048	190 CHURCHMAN	WILLAMINA	45.08294	-123.489389
US000057	PPPS	41071030502	OR000066		WILLAMINA	45.083	-123.489243
US000058	PPPS	41071030502	OR000067		WILLAMINA	45.08303	-123.489131
US000059	PPPS	41071030502	OR000068		WILLAMINA	45.08278	-123.489111
US000060	PSTGS	41053020400	OR000069		WILLAMINA	45.07033	-123.494355
US000061	PSTGS	41071030502	OR000070		WILLAMINA	45.08279	-123.48928
US000062	PSTGS	41071030502	OR000071		WILLAMINA	45.08316	-123.489415

Damage

ID Number	Class	Tract	Name	Address	City	Class	None	Slight	Moderate	Extensive	Complete	At Least Slight	At Least Moderate	At Least Extensive
US000063	PWTM	41053020400	OR000072	26690 SALMON RIVER HWY	GRAND RONDE	PWTM	0.02	0.079	0.354	0.332	0.215	0.98	0.901	0.547
US000064	PPPS	41071030502	OR000073		GRAND RONDE	PPPS	0.008	0.06	0.285	0.418	0.229	0.992	0.931	0.646
US000065	PSTGS	41053020400	OR000074		GRAND RONDE	PSTGS	0.049	0.26	0.435	0.215	0.042	0.951	0.691	0.256
US000066	PSTGS	41053020400	OR000075		GRAND RONDE	PSTGS	0.049	0.26	0.435	0.215	0.042	0.951	0.691	0.256
US000067	PSTGS	41053020400	OR000076		GRAND RONDE	PSTGS	0.049	0.26	0.435	0.215	0.042	0.951	0.691	0.256
US000068	PSTGS	41053020400	OR000077		GRAND RONDE	PSTGS	0.051	0.265	0.434	0.209	0.04	0.949	0.683	0.249
US000069	PSTGS	41071030502	OR000078		GRAND RONDE	PSTGS	0.046	0.251	0.436	0.223	0.044	0.954	0.704	0.268
US000070	PSTGS	41071030502	OR000079		GRAND RONDE	PSTGS	0.051	0.265	0.435	0.21	0.04	0.949	0.684	0.25
US000071	PSTGS	41071030502	OR000080		GRAND RONDE	PSTGS	0.051	0.265	0.435	0.21	0.04	0.949	0.684	0.25
US000072	PPPS	41053020400	OR000081		GRAND RONDE	PPPS	0.011	0.069	0.302	0.414	0.205	0.989	0.921	0.619
US000038	PWTS	41041950100	OR000047	317 S ANDERSON CREEK RD	LINCOLN CITY	PWTS	0.285	0.217	0.326	0.155	0.016	0.715	0.497	0.171
US000073	PSTGS	41041950300	OR000082		LINCOLN CITY	PSTGS	0.039	0.233	0.436	0.241	0.051	0.961	0.729	0.292
US000074	PSTGS	41041950300	OR000083		LINCOLN CITY	PSTGS	0.039	0.233	0.436	0.241	0.051	0.961	0.729	0.292
US000075	PSTGS	41041950400	OR000084		LINCOLN CITY	PSTGS	0.039	0.232	0.436	0.242	0.051	0.961	0.729	0.293
US000076	PPPS	41041950100	OR000085	317 S ANDERSON CREEK RD	LINCOLN CITY	PPPS	0.446	0.304	0.217	0.031	0.003	0.554	0.251	0.034
US000077	PPPS	41041950100	OR000086	317 S ANDERSON CREEK RD	LINCOLN CITY	PPPS	0.285	0.217	0.326	0.155	0.016	0.715	0.497	0.171
US000082	PPPS	41041950400	OR000091	15TH AND OAR	LINCOLN CITY	PPPS	0.276	0.216	0.331	0.161	0.017	0.724	0.508	0.178
US000083	PPPS	41041950300	OR000092	36TH AND QUAY	LINCOLN CITY	PPPS	0.443	0.304	0.218	0.031	0.003	0.557	0.252	0.035
US000084	PPPS	41041950300	OR000093	36TH AND QUAY BACKUP	LINCOLN CITY	PPPS	0.443	0.304	0.218	0.031	0.003	0.557	0.252	0.035
US000085	PPPS	41041950400	OR000094	15TH AND OAR	LINCOLN CITY	PPPS	0.276	0.216	0.331	0.161	0.017	0.724	0.508	0.178
US000086	PPPS	41041950400	OR000095	BAYVIEW	LINCOLN CITY	PPPS	0.443	0.304	0.218	0.031	0.003	0.557	0.253	0.035
US000087	PPPS	41041950100	OR000096	WATER PLANT	LINCOLN CITY	PPPS	0.285	0.217	0.326	0.155	0.016	0.715	0.497	0.171

ID Num-ber	Class	Tract	Name	Address	City	Class	None	Slight	Mod-erate	Ex-ten-sive	Com-plete	At Least Slight	At Least Mod-erate	At Least Ex-ten-sive
US000 088	PPPS	4104195 0300	OR000 097	VOYAGE AND VILLAGES	LINCOLN CITY	PPPS	0.276	0.216	0.331	0.161	0.017	0.724	0.508	0.177
US000 040	PDFLT	4107103 0400	OR000 049	HASKINS DAM, YAMHILL COUNTY	MCMINNVILLE	PDFLT	0.061	0.286	0.43	0.19	0.034	0.939	0.653	0.224
US000 041	PDFLT	4107103 0400	OR000 050	MCGUIRE DAM, YAMHILL COUNTY	MCMINNVILLE	PDFLT	0.058	0.28	0.431	0.195	0.035	0.942	0.662	0.23
US000 042	PSTGC	4107103 0600	OR000 051		MCMINNVILLE	PSTGC	0.067	0.299	0.426	0.178	0.03	0.933	0.633	0.208
US000 043	PSTGC	4107103 0600	OR000 052		MCMINNVILLE	PSTGC	0.067	0.299	0.426	0.178	0.03	0.933	0.633	0.208
US000 044	PSTGW	4107103 0600	OR000 053		MCMINNVILLE	PSTGW	0.067	0.299	0.426	0.178	0.03	0.933	0.633	0.208
US000 045	PSTGW	4107103 0600	OR000 054		MCMINNVILLE	PSTGW	0.067	0.299	0.426	0.178	0.03	0.933	0.633	0.208
US000 046	PWTM	4107103 0400	OR000 055		MCMINNVILLE	PWTM	0.394	0.221	0.274	0.104	0.007	0.606	0.385	0.111
US000 047	PWTM	4107103 0400	OR000 056		MCMINNVILLE	PWTM	0.269	0.305	0.302	0.117	0.007	0.731	0.427	0.124
US000 048	PWTM	4107103 0400	OR000 057		MCMINNVILLE	PWTM	0.269	0.305	0.302	0.117	0.007	0.731	0.427	0.124
US000 049	PWTM	4107103 0400	OR000 058		MCMINNVILLE	PWTM	0.269	0.305	0.302	0.117	0.007	0.731	0.427	0.124
US000 050	PWTM	4107103 0600	OR000 059		MCMINNVILLE	PWTM	0.407	0.221	0.267	0.098	0.006	0.593	0.372	0.105
US000 078	PDFLT	4107103 0600	OR000 087		MCMINNVILLE	PDFLT	0.316	0.381	0.26	0.04	0.003	0.684	0.302	0.043
US000 079	PDFLT	4107103 0600	OR000 088		MCMINNVILLE	PDFLT	0.068	0.14	0.386	0.328	0.078	0.932	0.791	0.406
US000 080	PDFLT	4107103 0600	OR000 089		MCMINNVILLE	PDFLT	0.068	0.14	0.386	0.328	0.078	0.932	0.791	0.406
US000 081	PDFLT	4107103 0600	OR000 090		MCMINNVILLE	PDFLT	0.412	0.22	0.265	0.096	0.006	0.588	0.367	0.103
US000 051	PWTS	4107103 0501	OR000 060		SHERIDAN	PWTS	0.008	0.018	0.131	0.336	0.507	0.992	0.974	0.843
US000 052	PPPS	4107103 0502	OR000 061		SHERIDAN	PPPS	0.39	0.222	0.276	0.105	0.007	0.61	0.388	0.112
US000 053	PSTGC	4107103 0501	OR000 062		SHERIDAN	PSTGC	0.059	0.282	0.431	0.193	0.035	0.941	0.659	0.228
US000 054	PSTGC	4107103 0501	OR000 063		SHERIDAN	PSTGC	0.059	0.282	0.431	0.193	0.035	0.941	0.659	0.228
US000 055	PSTGC	4107103 0501	OR000 064		SHERIDAN	PSTGC	0.059	0.282	0.431	0.193	0.035	0.941	0.659	0.228
US000 056	PSTGC	4107103 0502	OR000 065		SHERIDAN	PSTGC	0.059	0.282	0.431	0.193	0.035	0.941	0.659	0.228
US000 039	PWTS	4107103 0502	OR000 048	190 CHURCHMAN	WILLAMINA	PWTS	0.189	0.301	0.392	0.109	0.009	0.811	0.51	0.118

ID Number	Class	Tract	Name	Address	City	Class	None	Slight	Moderate	Extensive	Complete	At Least Slight	At Least Moderate	At Least Extensive
US000 057	PPPS	4107103 0502	OR000 066		WILLAMINA	PPPS	0.04	0.154	0.458	0.24	0.107	0.96	0.805	0.347
US000 058	PPPS	4107103 0502	OR000 067		WILLAMINA	PPPS	0.37	0.222	0.286	0.114	0.008	0.63	0.408	0.122
US000 059	PPPS	4107103 0502	OR000 068		WILLAMINA	PPPS	0.37	0.222	0.286	0.114	0.008	0.63	0.408	0.122
US000 060	PSTGS	4105302 0400	OR000 069		WILLAMINA	PSTGS	0.054	0.271	0.434	0.204	0.038	0.946	0.676	0.242
US000 061	PSTGS	4107103 0502	OR000 070		WILLAMINA	PSTGS	0.054	0.271	0.434	0.204	0.038	0.946	0.676	0.242
US000 062	PSTGS	4107103 0502	OR000 071		WILLAMINA	PSTGS	0.054	0.271	0.434	0.204	0.038	0.946	0.676	0.242

Functionality

ID Number	Class	Tract	Name	Address	City	At Day 1	At Day 3	At Day 7	At Day 14	At Day 30	At Day 90
US000063	PWTM	41053020400	OR000072	26690 SALMON RIVER HWY	GRAND RONDE	21.8	46.3	54.1	56.8	64.4	87.5
US000064	PPPS	41071030502	OR000073		GRAND RONDE	15.9	27.7	45.3	59.8	83.9	99.9
US000065	PSTGS	41053020400	OR000074		GRAND RONDE	25.8	55.5	74.9	78.6	79.9	86
US000066	PSTGS	41053020400	OR000075		GRAND RONDE	25.8	55.5	74.9	78.6	79.9	86
US000067	PSTGS	41053020400	OR000076		GRAND RONDE	25.8	55.5	74.9	78.6	79.9	86
US000068	PSTGS	41053020400	OR000077		GRAND RONDE	26.1	56.1	75.5	79.2	80.5	86.4
US000069	PSTGS	41071030502	OR000078		GRAND RONDE	25.3	54.4	73.9	77.6	79	85.3
US000070	PSTGS	41071030502	OR000079		GRAND RONDE	26	56	75.4	79.1	80.4	86.3
US000071	PSTGS	41071030502	OR000080		GRAND RONDE	26	56	75.4	79.1	80.4	86.3
US000072	PPPS	41053020400	OR000081		GRAND RONDE	16.9	29.4	47.7	62.1	85.4	99.9
US000038	PWTS	41041950100	OR000047	317 S ANDERSON CREEK RD	LINCOLN CITY	52.2	79.8	86.2	87.4	90.5	98.6
US000073	PSTGS	41041950300	OR000082		LINCOLN CITY	24.4	52.3	71.8	75.6	77	83.9
US000074	PSTGS	41041950300	OR000083		LINCOLN CITY	24.4	52.3	71.8	75.6	77	83.9
US000075	PSTGS	41041950400	OR000084		LINCOLN CITY	24.4	52.2	71.7	75.5	76.9	83.9
US000076	PPPS	41041950100	OR000085	317 S ANDERSON CREEK RD	LINCOLN CITY	68.7	85.8	95.7	98.2	99.6	99.9
US000077	PPPS	41041950100	OR000086	317 S ANDERSON CREEK RD	LINCOLN CITY	51	68.4	84.5	91.1	98.2	99.9
US000082	PPPS	41041950400	OR000091	15TH AND OAR	LINCOLN CITY	50.1	67.6	84	90.7	98.1	99.9
US000083	PPPS	41041950300	OR000092	36TH AND QUAY	LINCOLN CITY	68.6	85.7	95.7	98.1	99.6	99.9
US000084	PPPS	41041950300	OR000093	36TH AND QUAY BACKUP	LINCOLN CITY	68.6	85.7	95.7	98.1	99.6	99.9
US000085	PPPS	41041950400	OR000094	15TH AND OAR	LINCOLN CITY	50.1	67.6	84	90.7	98.1	99.9
US000086	PPPS	41041950400	OR000095	BAYVIEW	LINCOLN CITY	68.5	85.7	95.7	98.1	99.6	99.9
US000087	PPPS	41041950100	OR000096	WATER PLANT	LINCOLN CITY	51	68.4	84.5	91.1	98.2	99.9
US000088	PPPS	41041950300	OR000097	VOYAGE AND VILLAGES	LINCOLN CITY	50.1	67.6	84	90.8	98.1	99.9
US000040	PDFLT	41071030400	OR000049	HASKINS DAM, YAMHILL COUNTY	MCMINNVILLE	37	73.4	81.9	83.3	87.1	97.6
US000041	PDFLT	41071030400	OR000050	MCGUIRE DAM, YAMHILL COUNTY	MCMINNVILLE	36.6	72.8	81.3	82.8	86.7	97.5
US000042	PSTGC	41071030600	OR000051		MCMINNVILLE	28	60.1	79.1	82.7	83.7	88.7
US000043	PSTGC	41071030600	OR000052		MCMINNVILLE	28	60.1	79.1	82.7	83.7	88.7
US000044	PSTGW	41071030600	OR000053		MCMINNVILLE	28	60.1	79.1	82.7	83.7	88.7
US000045	PSTGW	41071030600	OR000054		MCMINNVILLE	28	60.1	79.1	82.7	83.7	88.7
US000046	PWTM	41071030400	OR000055		MCMINNVILLE	61.2	85.8	91.1	91.9	93.9	99.2
US000047	PWTM	41071030400	OR000056		MCMINNVILLE	54.8	84.2	90	90.9	93.2	99.2
US000048	PWTM	41071030400	OR000057		MCMINNVILLE	54.8	84.2	90	90.9	93.2	99.2
US000049	PWTM	41071030400	OR000058		MCMINNVILLE	54.8	84.2	90	90.9	93.2	99.2
US000050	PWTM	41071030600	OR000059		MCMINNVILLE	62.3	86.4	91.6	92.3	94.2	99.3
US000078	PDFLT	41071030600	OR000087		MCMINNVILLE	62.1	91.7	96.5	96.8	97.6	99.6
US000079	PDFLT	41071030600	OR000088		MCMINNVILLE	30.1	58.8	66.9	69.4	76.1	94.8
US000080	PDFLT	41071030600	OR000089		MCMINNVILLE	30.1	58.8	66.9	69.4	76.1	94.8
US000081	PDFLT	41071030600	OR000090		MCMINNVILLE	62.6	86.7	91.8	92.5	94.3	99.3
US000051	PWTS	41071030501	OR000060		SHERIDAN	13.9	23.1	27.1	30.5	39.6	72
US000052	PPPS	41071030502	OR000061		SHERIDAN	60.1	76.1	89.4	94.3	99	99.9
US000053	PSTGC	41071030501	OR000062		SHERIDAN	27	58.1	77.3	81	82.1	87.6
US000054	PSTGC	41071030501	OR000063		SHERIDAN	27	58.1	77.3	81	82.1	87.6
US000055	PSTGC	41071030501	OR000064		SHERIDAN	27	58.1	77.3	81	82.1	87.6
US000056	PSTGC	41071030502	OR000065		SHERIDAN	27	58.1	77.3	81	82.1	87.6
US000039	PWTS	41071030502	OR000048	190 CHURCHMAN	WILLAMINA	48.5	83.1	90.5	91.3	93.5	99.1
US000057	PPPS	41071030502	OR000066		WILLAMINA	26.6	45.6	68.6	79	92.2	99.9

ID Number	Class	Tract	Name	Address	City	At Day 1	At Day 3	At Day 7	At Day 14	At Day 30	At Day 90
US000058	PPPS	41071030502	OR000067		WILLAMINA	58.4	74.7	88.6	93.7	98.9	99.9
US000059	PPPS	41071030502	OR000068		WILLAMINA	58.4	74.7	88.6	93.7	98.9	99.9
US000060	PSTGS	41053020400	OR000069		WILLAMINA	26.4	56.7	76.1	79.8	81	86.7
US000061	PSTGS	41071030502	OR000070		WILLAMINA	26.4	56.7	76.1	79.8	81	86.7
US000062	PSTGS	41071030502	OR000071		WILLAMINA	26.4	56.7	76.1	79.8	81	86.7

Loss

ID Number	Class	Tract	Name	Address	City	Repair Costs (thous. $)
US000063	PWTM	41053020400	OR000072	26690 SALMON RIVER HWY	GRAND RONDE	5,280
US000064	PPPS	41071030502	OR000073		GRAND RONDE	0
US000065	PSTGS	41053020400	OR000074		GRAND RONDE	0
US000066	PSTGS	41053020400	OR000075		GRAND RONDE	0
US000067	PSTGS	41053020400	OR000076		GRAND RONDE	0
US000068	PSTGS	41053020400	OR000077		GRAND RONDE	0
US000069	PSTGS	41071030502	OR000078		GRAND RONDE	0
US000070	PSTGS	41071030502	OR000079		GRAND RONDE	0
US000071	PSTGS	41071030502	OR000080		GRAND RONDE	0
US000072	PPPS	41053020400	OR000081		GRAND RONDE	0
US000038	PWTS	41041950100	OR000047	317 S ANDERSON CREEK RD	LINCOLN CITY	50,553
US000073	PSTGS	41041950300	OR000082		LINCOLN CITY	0
US000074	PSTGS	41041950300	OR000083		LINCOLN CITY	0
US000075	PSTGS	41041950400	OR000084		LINCOLN CITY	0
US000076	PPPS	41041950100	OR000085	317 S ANDERSON CREEK RD	LINCOLN CITY	0
US000077	PPPS	41041950100	OR000086	317 S ANDERSON CREEK RD	LINCOLN CITY	0
US000082	PPPS	41041950400	OR000091	15TH AND OAR	LINCOLN CITY	0
US000083	PPPS	41041950300	OR000092	36TH AND QUAY	LINCOLN CITY	0
US000084	PPPS	41041950300	OR000093	36TH AND QUAY BACKUP	LINCOLN CITY	0
US000085	PPPS	41041950400	OR000094	15TH AND OAR	LINCOLN CITY	0
US000086	PPPS	41041950400	OR000095	BAYVIEW	LINCOLN CITY	0
US000087	PPPS	41041950100	OR000096	WATER PLANT	LINCOLN CITY	0
US000088	PPPS	41041950300	OR000097	VOYAGE AND VILLAGES	LINCOLN CITY	0
US000040	PDFLT	41071030400	OR000049	HASKINS DAM, YAMHILL COUNTY	MCMINNVILLE	0
US000041	PDFLT	41071030400	OR000050	MCGUIRE DAM, YAMHILL COUNTY	MCMINNVILLE	0
US000042	PSTGC	41071030600	OR000051		MCMINNVILLE	0
US000043	PSTGC	41071030600	OR000052		MCMINNVILLE	0
US000044	PSTGW	41071030600	OR000053		MCMINNVILLE	0
US000045	PSTGW	41071030600	OR000054		MCMINNVILLE	0
US000046	PWTM	41071030400	OR000055		MCMINNVILLE	60,620
US000047	PWTM	41071030400	OR000056		MCMINNVILLE	0
US000048	PWTM	41071030400	OR000057		MCMINNVILLE	0
US000049	PWTM	41071030400	OR000058		MCMINNVILLE	0
US000050	PWTM	41071030600	OR000059		MCMINNVILLE	0
US000078	PDFLT	41071030600	OR000087		MCMINNVILLE	0
US000079	PDFLT	41071030600	OR000088		MCMINNVILLE	0
US000080	PDFLT	41071030600	OR000089		MCMINNVILLE	0
US000081	PDFLT	41071030600	OR000090		MCMINNVILLE	0
US000051	PWTS	41071030501	OR000060		SHERIDAN	29,164
US000052	PPPS	41071030502	OR000061		SHERIDAN	0
US000053	PSTGC	41071030501	OR000062		SHERIDAN	0
US000054	PSTGC	41071030501	OR000063		SHERIDAN	0

ID Number	Class	Tract	Name	Address	City	Repair Costs (thous. $)
US000055	PSTGC	41071030501	OR000064		SHERIDAN	0
US000056	PSTGC	41071030502	OR000065		SHERIDAN	0
US000039	PWTS	41071030502	OR000048	190 CHURCHMAN	WILLAMINA	1,479
US000057	PPPS	41071030502	OR000066		WILLAMINA	0
US000058	PPPS	41071030502	OR000067		WILLAMINA	0
US000059	PPPS	41071030502	OR000068		WILLAMINA	0
US000060	PSTGS	41053020400	OR000069		WILLAMINA	0
US000061	PSTGS	41071030502	OR000070		WILLAMINA	0
US000062	PSTGS	41071030502	OR000071		WILLAMINA	0

Appendix F: Hazus-MH Bridge Results

Highway - Bridge Damage

Transportation System Results - Highway - Bridge Damage Printed on: 6/25/2014 4:48:29 PM

	ID Number	Name	None	Slight	Moderate	Extensive
1	OR000120	OR 99W (HWY 001W)	0.442	0.190	0.066	0.243
2	OR000124	OR 99W(HWY 1W)SB	0.660	0.096	0.057	0.060
3	OR000125	OR 99W(HWY 1W)NB	0.502	0.213	0.161	0.077
4	OR000154	HWY 47	0.072	0.102	0.113	0.230
5	OR000158	US 101 (HWY 009)	0.295	0.274	0.158	0.123
6	OR000179	HWY 32 (OR.22)	0.423	0.222	0.094	0.184
7	OR000201	OR 18 (HWY 039)	0.448	0.226	0.085	0.177
8	OR000219	OR 99W (HWY 001W)	0.437	0.192	0.067	0.064
9	OR000356	SLICK ROCK CREEK, OR 18 (HWY 039)	0.054	0.062	0.103	0.265
10	OR000377	OR 18 (HWY 039)	0.614	0.107	0.066	0.075
11	OR000384	HWY 32 (OR.22)	0.441	0.227	0.086	0.145
12	OR000434	OR 18 (HWY 039)	0.441	0.227	0.086	0.167
13	OR000467	HWY 30	0.631	0.103	0.063	0.069
14	OR000492	HWY 130	0.564	0.117	0.076	0.156
15	OR000529	HWY 30	0.626	0.104	0.064	0.072
16	OR000550	HWY 30	0.066	0.102	0.122	0.315
17	OR000635	OR 18 (HWY 039)	0.068	0.099	0.111	0.232
18	OR000638	OR 99W (HWY 001W)	0.082	0.116	0.164	0.287
19	OR000664	US101(HWY009)	0.046	0.053	0.106	0.266
20	OR000731	OR 18 (HWY 039)	0.422	0.195	0.070	0.217
21	OR000809	BEAR CREEK, OR 18 (HWY 039)	0.048	0.084	0.105	0.250
22	OR000810	SALMON RIVER, OR 18 (HWY 039)	0.634	0.090	0.092	0.115
23	OR000836	ROGUE RIVER, OR 18 (HWY 039)	0.435	0.228	0.087	0.125
24	OR000842	US101(HWY009)	0.421	0.247	0.118	0.131
25	OR000843	HWY 32 (OR.22)	0.570	0.116	0.075	0.090
26	OR000844	HWY 32 (OR.22)	0.575	0.100	0.077	0.094
27	OR000845	HWY 32 (OR.22)	0.576	0.115	0.074	0.088
28	OR000846	HWY 32 (OR.22)	0.452	0.259	0.103	0.107
29	OR000847	HWY 32 (OR.22)	0.576	0.115	0.074	0.088
30	OR000848	HWY 32 (OR.22)	0.576	0.115	0.074	0.107
31	OR000856	HWY 32 (OR.22)	0.407	0.233	0.092	0.134
32	OR001084	OAK RIDGE ROAD	0.070	0.100	0.112	0.355
33	OR001633	OR 18 (HWY 039)	0.460	0.215	0.084	0.177
34	OR001634	OR 18 (HWY 039)	0.520	0.246	0.089	0.087
35	OR001635	OR 18 (HWY 039)	0.527	0.244	0.088	0.085
36	OR001726	OR 99W (HWY 001W)	0.082	0.116	0.128	0.258
37	OR001817	OR 18 (HWY 039)	0.483	0.000	0.000	0.208
38	OR001818	OR 18 (HWY 039)	0.454	0.135	0.116	0.189
39	OR002144	OR 99W (HWY 001W)	0.496	0.214	0.075	0.166
40	OR002176	OR 18 (HWY 039) CO	0.496	0.214	0.149	0.092
41	OR002703	US101(HWY009)	0.341	0.174	0.092	0.163
42	OR002714	ROCK CREEK, EAST AVENUE	0.441	0.141	0.134	0.174
43	OR002715	SOUTH YAMHILL RIVER, GRAND RONDE ROAD	0.062	0.082	0.111	0.309
44	OR002716	HARMONY ROAD	0.461	0.135	0.108	0.194
45	OR002717	GOOSENECK ROAD	0.626	0.045	0.078	0.096
46	OR002718	BROWN ROAD	0.638	0.082	0.067	0.075
47	OR002719	BROWN ROAD	0.638	0.101	0.061	0.067
48	OR002754	GRENFELL CO PK RD	0.576	0.088	0.053	0.057
49	OR002755	BISHOP-SCOTT ROAD	0.580	0.087	0.052	0.056
50	OR002756	BISHOP-SCOTT ROAD	0.580	0.087	0.052	0.056
51	OR002757	PIKE ROAD	0.719	0.110	0.066	0.072
52	OR002758	HACKER ROAD	0.719	0.110	0.066	0.072
53	OR002759	ROCKYFORD ROAD	0.684	0.105	0.063	0.070
54	OR002760	TURNER CREEK ROAD	0.647	0.099	0.059	0.160
55	OR002761	TURNER CREEK ROAD	0.641	0.059	0.072	0.084
56	OR002762	OLD RAILROAD GRADE	0.719	0.110	0.066	0.072
57	OR002763	FAIRDALE ROAD	0.073	0.108	0.123	0.320
58	OR002764	OAK RIDGE ROAD	0.084	0.123	0.138	0.287

OHA-EQ study region created on 6-24-14

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Transportation System Results - Highway - Bridge Damage Printed on: 6/25/2014 4:48:29 PM

	ID Number	Name	None	Slight	Moderate	Extensive
59	OR002765	FAIRDALE ROAD	0.641	0.101	0.061	0.066
60	OR002766	OLD MOORES VALLEY	0.641	0.101	0.061	0.066
61	OR002767	MEADOW LAKE ROAD	0.549	0.239	0.084	0.079
62	OR002768	HENDRICKS ROAD	0.075	0.105	0.115	0.230
63	OR002769	REX BROWN ROAD	0.713	0.112	0.067	0.073
64	OR002770	KUTCH ROAD	0.705	0.114	0.069	0.076
65	OR002771	FIR CREST ROAD	0.070	0.101	0.112	0.230
66	OR002772	WESTSIDE ROAD	0.494	0.215	0.075	0.166
67	OR002773	WEST SIDE ROAD	0.439	0.188	0.068	0.243
68	OR002774	MOORES VALLEY RD	0.438	0.162	0.090	0.247
69	OR002775	STONE ROAD	0.671	0.060	0.064	0.071
70	OR002776	KUEHNE ROAD	0.739	0.105	0.062	0.065
71	OR002777	BAYLEY ROAD	0.670	0.083	0.057	0.061
72	OR002778	DAYTON AVENUE	0.104	0.139	0.147	0.286
73	OR002779	WILLIS ROAD	0.576	0.088	0.053	0.057
74	OR002780	BERRY CREEK ROAD	0.720	0.078	0.074	0.085
75	OR002781	NORTH HILL ROAD	0.581	0.087	0.051	0.075
76	OR002789	US 101 (HWY 009)	0.404	0.207	0.130	0.147
77	OR002790	OR 18 (HWY 039)	0.433	0.200	0.117	0.133
78	OR002962	MILL CR RD	0.695	0.068	0.083	0.099
79	OR003026	GRANT ROAD	0.629	0.104	0.063	0.070
80	OR003088	BECK ROAD	0.573	0.089	0.053	0.058
81	OR003184	BAYS CREEK RD	0.645	0.126	0.081	0.096
82	OR003195	IRA HOOKER ROAD	0.365	0.271	0.137	0.095
83	OR003696	DELANEY RD SE	0.554	0.118	0.078	0.099
84	OR003750	BLACK ROCK ROAD	0.698	0.115	0.070	0.078
85	OR003751	PERRYDALE ROAD	0.645	0.025	0.078	0.096
86	OR003752	BALL RD	0.566	0.090	0.055	0.060
87	OR003753	BALL RD	0.566	0.090	0.055	0.060
88	OR003759	GARDNER ROAD	0.072	0.108	0.123	0.292
89	OR003762	HARMONY ROAD	0.461	0.102	0.178	0.138
90	OR003763	DE JONG ROAD	0.069	0.027	0.084	0.311
91	OR003764	ENTERPRISE ROAD	0.638	0.101	0.061	0.067
92	OR003765	WEST PERRYDALE RD	0.573	0.089	0.053	0.058
93	OR003766	BETHEL ROAD	0.071	0.075	0.104	0.341
94	OR003767	BETHEL ROAD	0.583	0.086	0.051	0.055
95	OR003771	BROADMEAD ROAD	0.071	0.101	0.113	0.288
96	OR003776	TUCKER ROAD	0.069	0.099	0.111	0.333
97	OR003777	VAN WELL ROAD	0.069	0.099	0.111	0.260
98	OR003778	VAN WELL ROAD	0.066	0.071	0.102	0.260
99	OR003779	OLD MILITARY ROAD	0.702	0.115	0.070	0.077
100	OR003780	GOOSENECK ROAD	0.069	0.105	0.121	0.310
101	OR003781	GOOSENECK ROAD	0.688	0.083	0.081	0.096
102	OR003782	SAVAGE ROAD	0.660	0.110	0.067	0.076
103	OR003783	HART ROAD	0.638	0.101	0.061	0.140
104	OR003784	GOLD CREEK ROAD	0.448	0.226	0.088	0.174
105	OR003785	GOLD CREEK ROAD	0.614	0.094	0.070	0.081
106	OR003786	GOLD CREEK ROAD	0.648	0.099	0.074	0.085
107	OR003787	GOLD CREEK ROAD	0.682	0.119	0.074	0.083
108	OR003788	FIRE HALL ROAD	0.063	0.103	0.125	0.283
109	OR003794	SMITHFIELD ROAD	0.579	0.087	0.052	0.056
110	OR003796	STARR ROAD	0.567	0.085	0.056	0.062
111	OR003797	STARR ROAD	0.567	0.090	0.054	0.060
112	OR003799	ROBB MILL ROAD	0.709	0.113	0.068	0.075
113	OR003805	BRIDGEPORT ROAD	0.072	0.108	0.133	0.310
114	OR003806	FROST ROAD	0.628	0.097	0.065	0.130
115	OR003807	SOCIALIST VALLEY	0.690	0.117	0.072	0.081
116	OR003813	PEEDEE CREEK ROAD	0.629	0.097	0.065	0.073

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Transportation System Results - Highway - Bridge Damage Printed on: 6/25/2014 4:48:29 PM

	ID Number	Name	None	Slight	Moderate	Extensive
117	OR003814	PEEDEE CREEK ROAD	0.629	0.097	0.065	0.073
118	OR003815	PEDEE CREEK ROAD	0.629	0.104	0.063	0.070
119	OR003816	GAGE ROAD	0.623	0.102	0.065	0.073
120	OR003817	GAGE ROAD	0.693	0.117	0.071	0.080
121	OR003818	GAGE ROAD	0.699	0.107	0.072	0.081
122	OR003819	RONCO ROAD	0.078	0.117	0.135	0.286
123	OR003820	RONCO ROAD	0.698	0.101	0.074	0.084
124	OR003821	SHEYTHE ROAD	0.699	0.115	0.070	0.078
125	OR003822	WILDWOOD ROAD	0.623	0.105	0.064	0.072
126	OR003823	PLEASANT HILL ROAD	0.566	0.079	0.058	0.065
127	OR004175	SE 1ST ST OVER UNNAMED CHANNEL	0.492	0.105	0.069	0.196
128	OR004176	DEPOE BAY, HWY 9	0.048	0.087	0.112	0.274
129	OR004177	FOGARTY CREEK, HWY 9	0.378	0.236	0.097	0.191
130	OR004178	SIJOTA CREEK & GOLF ACCESS, HWY 9	0.378	0.236	0.097	0.105
131	OR004179	MILLPORT SLOUGH HWY 009 AT MP 120.84	0.250	0.243	0.144	0.115
132	OR004180	DRIFT CREEK, HWY 9	0.341	0.209	0.086	0.092
133	OR004181	DRIFT CREEK NORTH, DRIFT CREEK RD	0.045	0.080	0.128	0.275
134	OR004182	SCHOONER CREEK, HWY 9	0.585	0.125	0.082	0.100
135	OR004183	DEVILS LAKE OUTLET, HWY 9 (D RIVER)	0.341	0.209	0.086	0.092
136	OR004184	JACKASS CREEK, HWY 039 AT MP 19.16	0.365	0.304	0.164	0.121
137	OR004185	DEVILS LAKE CREEK, W DEVILS LAKE RD	0.312	0.303	0.180	0.144
138	OR004186	SALMON RIVER, HWY 9	0.389	0.235	0.096	0.193
139	OR004187	CLEAR CREEK, HWY 9	0.564	0.028	0.093	0.126
140	OR004188	FARMER CREEK, HWY 9	0.532	0.000	0.000	0.195
141	OR004189	WEST CREEK (BUN CREEK), HWY 9	0.568	0.116	0.075	0.090
142	OR004190	BEAVER CREEK, HWY 9 AT MP 80.32	0.049	0.061	0.095	0.242
143	OR004191	BEAVER CREEK, HWY 9 AT MP 79.61	0.405	0.233	0.093	0.186
144	OR004192	WEST BEAVER CREEK, HWY 9	0.568	0.116	0.075	0.090
145	OR004193	TIGER CREEK, HWY 9 AT MP 76.64	0.568	0.028	0.092	0.125
146	OR004194	TIGER CREEK, HWY 9 AT MP 76.35	0.565	0.117	0.076	0.091
147	OR004195	HWY 39 OVER CASINO ENTRANCE RD	0.334	0.274	0.146	0.107
148	OR004196	FORT HILL ROAD OVER HWY 39 AT MP 24.66	0.340	0.141	0.177	0.161
149	OR004197	WILLAMINA RIVER, HWY 157	0.479	0.237	0.117	0.105
150	OR004198	COUNTY ROAD TO SHERIDAN OVER HWY 39	0.494	0.225	0.130	0.090
151	OR004199	COZINE CREEK, OLD SHERIDAN RD	0.655	0.097	0.058	0.062
152	OR004200	COZINE CREEK, OLD SHERIDAN RD	0.590	0.000	0.093	0.127
153	OR004201	HWY 39 OVER WPRR	0.496	0.189	0.102	0.154
154	OR004202	BOOTH BEND ROAD OVER HWY 39	0.496	0.214	0.150	0.091
155	OR004203	SOUTH YAMHILL RIVER, HWY 39 AT MP 45.63	0.082	0.108	0.161	0.287
156	OR004204	YAMHILL RIVER OFLOW, HWY 39	0.082	0.116	0.128	0.258
157	OR004205	HWY 39 MCMINNVILLE SPUR OVER HWY 39	0.496	0.198	0.165	0.086
158	OR004206	HWY 39 MCMINNVILLE SPUR	0.082	0.116	0.164	0.287
159	OR004207	FLETCHER RD (LAFAYETTE RD) OVER HWY 39	0.509	0.157	0.156	0.111
160	OR004208	HWY 39 OVER HWY 150	0.509	0.183	0.080	0.169
161	OR004209	YAMHILL RIVER, HWY 39 (DAYTON)	0.606	0.000	0.000	0.169
162	OR004210	WPRR OVER HWY 1W (ST JOE)	0.660	0.096	0.080	0.134
163	OR004211	RUSSELL CREEK, HWY 29	0.586	0.069	0.055	0.061
164	OR004212	LITTLE RUSSELL CREEK, HWY 29	0.580	0.087	0.052	0.056
165	OR004213	WPRR OVER HWY 1W (WHITESON)	0.582	0.051	0.104	0.218
166	OR004214	ASH SWALE, HWY 1W AT MP 47.29	0.442	0.190	0.066	0.069
167	OR004215	PLUM CREEK, HWY 1W AT MP49.75	0.583	0.084	0.052	0.056
168	OR004216	ASH SWALE, HWY 1W AT MP 51.06	0.585	0.086	0.051	0.054
169	OR004217	HWY 1W OVER HWY 30	0.425	0.299	0.146	0.098

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Transportation System Results - Highway - Bridge Damage Printed on: 6/25/2014 4:48:29 PM

	Complete	At Least Slight	At Least Moderate	At Least Extensive
1	0.058	0.558	0.368	0.301
2	0.127	0.340	0.244	0.187
3	0.047	0.498	0.286	0.124
4	0.483	0.928	0.826	0.713
5	0.150	0.705	0.431	0.273
6	0.078	0.577	0.356	0.261
7	0.064	0.552	0.327	0.242
8	0.240	0.563	0.372	0.304
9	0.517	0.946	0.884	0.782
10	0.138	0.386	0.279	0.213
11	0.101	0.559	0.332	0.246
12	0.079	0.559	0.332	0.246
13	0.133	0.369	0.266	0.203
14	0.087	0.436	0.319	0.243
15	0.134	0.374	0.270	0.206
16	0.395	0.934	0.831	0.710
17	0.490	0.932	0.833	0.722
18	0.350	0.918	0.802	0.638
19	0.528	0.954	0.901	0.795
20	0.096	0.578	0.383	0.312
21	0.512	0.952	0.868	0.763
22	0.070	0.366	0.276	0.185
23	0.125	0.565	0.337	0.250
24	0.083	0.579	0.332	0.214
25	0.150	0.430	0.314	0.239
26	0.154	0.425	0.325	0.247
27	0.148	0.424	0.309	0.236
28	0.080	0.548	0.290	0.187
29	0.148	0.424	0.309	0.236
30	0.129	0.424	0.309	0.236
31	0.135	0.593	0.361	0.268
32	0.364	0.930	0.830	0.719
33	0.064	0.540	0.325	0.241
34	0.058	0.480	0.234	0.145
35	0.055	0.473	0.229	0.141
36	0.415	0.918	0.802	0.674
37	0.309	0.517	0.517	0.517
38	0.106	0.546	0.411	0.295
39	0.050	0.504	0.291	0.216
40	0.049	0.504	0.290	0.141
41	0.229	0.659	0.485	0.392
42	0.110	0.559	0.419	0.284
43	0.436	0.938	0.856	0.745
44	0.102	0.539	0.404	0.296
45	0.155	0.374	0.329	0.251
46	0.138	0.362	0.280	0.214
47	0.132	0.362	0.260	0.199
48	0.226	0.424	0.336	0.283
49	0.226	0.420	0.333	0.281
50	0.226	0.420	0.333	0.281
51	0.033	0.281	0.171	0.105
52	0.033	0.281	0.171	0.105
53	0.078	0.316	0.211	0.148
54	0.034	0.353	0.254	0.194
55	0.145	0.359	0.300	0.228
56	0.033	0.281	0.171	0.105
57	0.375	0.927	0.819	0.696
58	0.368	0.916	0.793	0.655

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	Complete	At Least Slight	At Least Moderate	At Least Extensive
59	0.131	0.359	0.258	0.198
60	0.131	0.359	0.258	0.198
61	0.050	0.451	0.212	0.129
62	0.475	0.925	0.820	0.705
63	0.035	0.287	0.175	0.108
64	0.036	0.295	0.181	0.112
65	0.487	0.930	0.829	0.717
66	0.050	0.506	0.291	0.216
67	0.062	0.561	0.373	0.305
68	0.064	0.562	0.400	0.310
69	0.134	0.329	0.269	0.205
70	0.029	0.261	0.156	0.094
71	0.128	0.330	0.247	0.189
72	0.324	0.896	0.757	0.610
73	0.226	0.424	0.336	0.283
74	0.043	0.280	0.202	0.128
75	0.205	0.419	0.332	0.280
76	0.111	0.596	0.389	0.259
77	0.117	0.567	0.367	0.250
78	0.055	0.305	0.237	0.154
79	0.134	0.371	0.267	0.204
80	0.227	0.427	0.338	0.285
81	0.052	0.355	0.229	0.147
82	0.132	0.635	0.364	0.227
83	0.151	0.446	0.328	0.250
84	0.038	0.302	0.187	0.116
85	0.155	0.355	0.330	0.251
86	0.229	0.434	0.343	0.289
87	0.229	0.434	0.343	0.289
88	0.406	0.928	0.820	0.697
89	0.121	0.539	0.437	0.259
90	0.510	0.931	0.904	0.820
91	0.132	0.362	0.261	0.199
92	0.227	0.427	0.338	0.285
93	0.409	0.929	0.854	0.750
94	0.225	0.417	0.330	0.279
95	0.427	0.929	0.828	0.715
96	0.387	0.931	0.832	0.721
97	0.461	0.931	0.832	0.721
98	0.501	0.934	0.862	0.761
99	0.037	0.298	0.184	0.114
100	0.396	0.931	0.826	0.706
101	0.052	0.312	0.229	0.148
102	0.086	0.340	0.229	0.162
103	0.059	0.362	0.260	0.199
104	0.064	0.552	0.327	0.238
105	0.142	0.386	0.293	0.223
106	0.094	0.352	0.253	0.180
107	0.042	0.318	0.199	0.125
108	0.427	0.937	0.834	0.710
109	0.226	0.421	0.334	0.282
110	0.230	0.433	0.348	0.292
111	0.228	0.433	0.342	0.288
112	0.035	0.291	0.178	0.110
113	0.377	0.928	0.820	0.687
114	0.080	0.372	0.275	0.210
115	0.040	0.310	0.193	0.121
116	0.136	0.371	0.274	0.209

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Transportation System Results - Highway - Bridge Damage Printed on: 6/25/2014 4:48:29 PM

	Complete	At Least Slight	At Least Moderate	At Least Extensive
117	0.136	0.371	0.274	0.209
118	0.134	0.371	0.267	0.204
119	0.136	0.377	0.275	0.210
120	0.039	0.307	0.191	0.119
121	0.040	0.301	0.194	0.121
122	0.384	0.922	0.805	0.670
123	0.043	0.302	0.201	0.127
124	0.038	0.301	0.186	0.116
125	0.135	0.377	0.272	0.207
126	0.232	0.434	0.354	0.297
127	0.137	0.508	0.402	0.333
128	0.480	0.952	0.865	0.753
129	0.097	0.622	0.386	0.288
130	0.183	0.622	0.386	0.288
131	0.249	0.750	0.508	0.364
132	0.272	0.659	0.450	0.364
133	0.472	0.955	0.875	0.747
134	0.108	0.415	0.290	0.208
135	0.272	0.659	0.450	0.364
136	0.045	0.635	0.331	0.167
137	0.061	0.688	0.385	0.205
138	0.087	0.611	0.376	0.280
139	0.189	0.436	0.408	0.315
140	0.273	0.468	0.468	0.468
141	0.150	0.432	0.316	0.241
142	0.553	0.951	0.890	0.794
143	0.084	0.595	0.362	0.270
144	0.150	0.432	0.316	0.241
145	0.187	0.432	0.404	0.312
146	0.151	0.435	0.318	0.242
147	0.139	0.666	0.393	0.246
148	0.181	0.660	0.519	0.342
149	0.062	0.521	0.284	0.167
150	0.061	0.506	0.281	0.151
151	0.128	0.345	0.248	0.190
152	0.189	0.410	0.410	0.316
153	0.060	0.504	0.316	0.214
154	0.049	0.504	0.290	0.140
155	0.361	0.918	0.809	0.648
156	0.415	0.918	0.802	0.674
157	0.056	0.504	0.307	0.142
158	0.350	0.918	0.802	0.638
159	0.068	0.491	0.334	0.178
160	0.059	0.491	0.307	0.228
161	0.225	0.394	0.394	0.394
162	0.030	0.340	0.244	0.164
163	0.229	0.414	0.345	0.290
164	0.226	0.420	0.333	0.281
165	0.045	0.418	0.367	0.263
166	0.232	0.558	0.368	0.301
167	0.226	0.417	0.333	0.281
168	0.225	0.415	0.330	0.279
169	0.032	0.575	0.276	0.130

Highway - Bridge Loss

Transportation System Results - Highway - Bridge Loss Printed on: 6/25/2014 4:48:35 PM

	ID Number	Name	Repair Cost (thous. $)
1	OR000120	OR 99W (HWY 001W)	699
2	OR000124	OR 99W(HWY 1W)SB	1,490
3	OR000125	OR 99W(HWY 1W)NB	618
4	OR000154	HWY 47	1,513
5	OR000158	US 101 (HWY 009)	1,650
6	OR000179	HWY 32 (OR.22)	658
7	OR000201	OR 18 (HWY 039)	830
8	OR000219	OR 99W (HWY 001W)	802
9	OR000356	SLICK ROCK CREEK, OR 18 (HWY 039)	2,446
10	OR000377	OR 18 (HWY 039)	1,398
11	OR000384	HWY 32 (OR.22)	542
12	OR000434	OR 18 (HWY 039)	596
13	OR000467	HWY 30	2,227
14	OR000492	HWY 130	333
15	OR000529	HWY 30	601
16	OR000550	HWY 30	2,327
17	OR000635	OR 18 (HWY 039)	1,792
18	OR000638	OR 99W (HWY 001W)	12,262
19	OR000664	US101(HWY009)	5,023
20	OR000731	OR 18 (HWY 039)	704
21	OR000809	BEAR CREEK, OR 18 (HWY 039)	1,823
22	OR000810	SALMON RIVER, OR 18 (HWY 039)	469
23	OR000836	ROGUE RIVER, OR 18 (HWY 039)	385
24	OR000842	US101(HWY009)	529
25	OR000843	HWY 32 (OR.22)	312
26	OR000844	HWY 32 (OR.22)	1,557
27	OR000845	HWY 32 (OR.22)	245
28	OR000846	HWY 32 (OR.22)	195
29	OR000847	HWY 32 (OR.22)	230
30	OR000848	HWY 32 (OR.22)	327
31	OR000856	HWY 32 (OR.22)	390
32	OR001084	OAK RIDGE ROAD	2,322
33	OR001633	OR 18 (HWY 039)	580
34	OR001634	OR 18 (HWY 039)	753
35	OR001635	OR 18 (HWY 039)	540
36	OR001726	OR 99W (HWY 001W)	1,526
37	OR001817	OR 18 (HWY 039)	3,311
38	OR001818	OR 18 (HWY 039)	959
39	OR002144	OR 99W (HWY 001W)	472
40	OR002176	OR 18 (HWY 039) CO	508
41	OR002703	US101(HWY009)	7,489
42	OR002714	ROCK CREEK, EAST AVENUE	1,169
43	OR002715	SOUTH YAMHILL RIVER, GRAND RONDE ROAD	3,644
44	OR002716	HARMONY ROAD	818
45	OR002717	GOOSENECK ROAD	566
46	OR002718	BROWN ROAD	305
47	OR002719	BROWN ROAD	202
48	OR002754	GRENFELL CO PK RD	332
49	OR002755	BISHOP-SCOTT ROAD	270
50	OR002756	BISHOP-SCOTT ROAD	402
51	OR002757	PIKE ROAD	100
52	OR002758	HACKER ROAD	73
53	OR002759	ROCKYFORD ROAD	574
54	OR002760	TURNER CREEK ROAD	148
55	OR002761	TURNER CREEK ROAD	155
56	OR002762	OLD RAILROAD GRADE	213
57	OR002763	FAIRDALE ROAD	1,315
58	OR002764	OAK RIDGE ROAD	1,042

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Transportation System Results - Highway - Bridge Loss Printed on: 6/25/2014 4:48:35 PM

	ID Number	Name	Repair Cost (thous. $)
59	OR002765	FAIRDALE ROAD	207
60	OR002766	OLD MOORES VALLEY	176
61	OR002767	MEADOW LAKE ROAD	2,079
62	OR002768	HENDRICKS ROAD	1,258
63	OR002769	REX BROWN ROAD	97
64	OR002770	KUTCH ROAD	108
65	OR002771	FIR CREST ROAD	1,218
66	OR002772	WESTSIDE ROAD	466
67	OR002773	WEST SIDE ROAD	725
68	OR002774	MOORES VALLEY RD	1,318
69	OR002775	STONE ROAD	283
70	OR002776	KUEHNE ROAD	72
71	OR002777	BAYLEY ROAD	135
72	OR002778	DAYTON AVENUE	1,604
73	OR002779	WILLIS ROAD	271
74	OR002780	BERRY CREEK ROAD	76
75	OR002781	NORTH HILL ROAD	434
76	OR002789	US 101 (HWY 009)	602
77	OR002790	OR 18 (HWY 039)	855
78	OR002962	MILL CR RD	496
79	OR003026	GRANT ROAD	937
80	OR003088	BECK ROAD	667
81	OR003184	BAYS CREEK RD	150
82	OR003195	IRA HOOKER ROAD	1,530
83	OR003696	DELANEY RD SE	298
84	OR003750	BLACK ROCK ROAD	171
85	OR003751	PERRYDALE ROAD	219
86	OR003752	BALL RD	331
87	OR003753	BALL RD	254
88	OR003759	GARDNER ROAD	709
89	OR003762	HARMONY ROAD	1,726
90	OR003763	DE JONG ROAD	1,288
91	OR003764	ENTERPRISE ROAD	346
92	OR003765	WEST PERRYDALE RD	272
93	OR003766	BETHEL ROAD	2,128
94	OR003767	BETHEL ROAD	844
95	OR003771	BROADMEAD ROAD	1,452
96	OR003776	TUCKER ROAD	1,073
97	OR003777	VAN WELL ROAD	1,078
98	OR003778	VAN WELL ROAD	1,055
99	OR003779	OLD MILITARY ROAD	259
100	OR003780	GOOSENECK ROAD	880
101	OR003781	GOOSENECK ROAD	74
102	OR003782	SAVAGE ROAD	115
103	OR003783	HART ROAD	152
104	OR003784	GOLD CREEK ROAD	844
105	OR003785	GOLD CREEK ROAD	234
106	OR003786	GOLD CREEK ROAD	170
107	OR003787	GOLD CREEK ROAD	85
108	OR003788	FIRE HALL ROAD	1,268
109	OR003794	SMITHFIELD ROAD	224
110	OR003796	STARR ROAD	667
111	OR003797	STARR ROAD	745
112	OR003799	ROBB MILL ROAD	48
113	OR003805	BRIDGEPORT ROAD	3,429
114	OR003806	FROST ROAD	170
115	OR003807	SOCIALIST VALLEY	218
116	OR003813	PEEDEE CREEK ROAD	269

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Transportation System Results - Highway - Bridge Loss Printed on: 6/25/2014 4:48:35 PM

	ID Number	Name	Repair Cost (thous. $)
117	OR003814	PEEDEE CREEK ROAD	191
118	OR003815	PEDEE CREEK ROAD	528
119	OR003816	GAGE ROAD	166
120	OR003817	GAGE ROAD	68
121	OR003818	GAGE ROAD	76
122	OR003819	RONCO ROAD	680
123	OR003820	RONCO ROAD	110
124	OR003821	SHEYTHE ROAD	62
125	OR003822	WILDWOOD ROAD	719
126	OR003823	PLEASANT HILL ROAD	300
127	OR004175	SE 1ST ST OVER UNNAMED CHANNEL	583
128	OR004176	DEPOE BAY, HWY 9	7,666
129	OR004177	FOGARTY CREEK, HWY 9	579
130	OR004178	SIJOTA CREEK & GOLF ACCESS, HWY 9	490
131	OR004179	MILLPORT SLOUGH HWY 009 AT MP 120.84	3,348
132	OR004180	DRIFT CREEK, HWY 9	1,110
133	OR004181	DRIFT CREEK NORTH, DRIFT CREEK RD	2,004
134	OR004182	SCHOONER CREEK, HWY 9	483
135	OR004183	DEVILS LAKE OUTLET, HWY 9 (D RIVER)	1,646
136	OR004184	JACKASS CREEK, HWY 039 AT MP 19.16	293
137	OR004185	DEVILS LAKE CREEK, W DEVILS LAKE RD	360
138	OR004186	SALMON RIVER, HWY 9	747
139	OR004187	CLEAR CREEK, HWY 9	686
140	OR004188	FARMER CREEK, HWY 9	966
141	OR004189	WEST CREEK (BUN CREEK), HWY 9	547
142	OR004190	BEAVER CREEK, HWY 9 AT MP 80.32	2,035
143	OR004191	BEAVER CREEK, HWY 9 AT MP 79.61	398
144	OR004192	WEST BEAVER CREEK, HWY 9	547
145	OR004193	TIGER CREEK, HWY 9 AT MP 76.64	679
146	OR004194	TIGER CREEK, HWY 9 AT MP 76.35	550
147	OR004195	HWY 39 OVER CASINO ENTRANCE RD	558
148	OR004196	FORT HILL ROAD OVER HWY 39 AT MP 24.66	2,209
149	OR004197	WILLAMINA RIVER, HWY 157	582
150	OR004198	COUNTY ROAD TO SHERIDAN OVER HWY 39	601
151	OR004199	COZINE CREEK, OLD SHERIDAN RD	453
152	OR004200	COZINE CREEK, OLD SHERIDAN RD	686
153	OR004201	HWY 39 OVER WPRR	565
154	OR004202	BOOTH BEND ROAD OVER HWY 39	589
155	OR004203	SOUTH YAMHILL RIVER, HWY 39 AT MP 45.63	3,362
156	OR004204	YAMHILL RIVER OFLOW, HWY 39	1,112
157	OR004205	HWY 39 MCMINNVILLE SPUR OVER HWY 39	547
158	OR004206	HWY 39 MCMINNVILLE SPUR	11,009
159	OR004207	FLETCHER RD (LAFAYETTE RD) OVER HWY 39	675
160	OR004208	HWY 39 OVER HWY 150	537
161	OR004209	YAMHILL RIVER, HWY 39 (DAYTON)	2,951
162	OR004210	WPRR OVER HWY 1W (ST JOE)	218
163	OR004211	RUSSELL CREEK, HWY 29	753
164	OR004212	LITTLE RUSSELL CREEK, HWY 29	738
165	OR004213	WPRR OVER HWY 1W (WHITESON)	328
166	OR004214	ASH SWALE, HWY 1W AT MP 47.29	821
167	OR004215	PLUM CREEK, HWY 1W AT MP49.75	738
168	OR004216	ASH SWALE, HWY 1W AT MP 51.06	734
169	OR004217	HWY 1W OVER HWY 30	712

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Highway – Bridge Functionality

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	ID Number	Name	@ Day 1	@ Day 3	@ Day 7	@ Day 14
1	OR000120	OR 99W (HWY 001W)	61.30	68.10	70.90	71.70
2	OR000124	OR 99W(HWY 1W)SB	75.20	79.30	81.50	82.00
3	OR000125	OR 99W(HWY 1W)NB	71.10	81.00	87.20	88.20
4	OR000154	HWY 47	19.90	25.80	30.40	31.60
5	OR000158	US 101 (HWY 009)	55.20	66.70	72.80	73.90
6	OR000179	HWY 32 (OR.22)	62.40	70.70	74.50	75.30
7	OR000201	OR 18 (HWY 039)	64.90	73.00	76.40	77.20
8	OR000219	OR 99W (HWY 001W)	60.60	67.40	70.00	70.60
9	OR000356	SLICK ROCK CREEK, OR 18 (HWY 039)	14.90	19.50	23.80	25.00
10	OR000377	OR 18 (HWY 039)	71.80	76.40	79.00	79.50
11	OR000384	HWY 32 (OR.22)	64.20	72.50	75.90	76.60
12	OR000434	OR 18 (HWY 039)	64.30	72.50	75.90	76.70
13	OR000467	HWY 30	73.10	77.50	80.00	80.50
14	OR000492	HWY 130	68.00	73.20	76.30	77.00
15	OR000529	HWY 30	72.70	77.20	79.70	80.20
16	OR000550	HWY 30	19.70	25.90	30.90	32.20
17	OR000635	OR 18 (HWY 039)	19.20	25.00	29.50	30.70
18	OR000638	OR 99W (HWY 001W)	23.40	31.10	37.70	39.10
19	OR000664	US101(HWY009)	13.60	18.10	22.50	23.70
20	OR000731	OR 18 (HWY 039)	59.80	66.80	69.70	70.50
21	OR000809	BEAR CREEK, OR 18 (HWY 039)	16.00	21.30	25.60	26.80
22	OR000810	SALMON RIVER, OR 18 (HWY 039)	73.30	78.20	81.80	82.50
23	OR000836	ROGUE RIVER, OR 18 (HWY 039)	63.70	72.00	75.40	76.20
24	OR000842	US101(HWY009)	64.60	74.20	78.80	79.70
25	OR000843	HWY 32 (OR.22)	68.40	73.50	76.40	77.00
26	OR000844	HWY 32 (OR.22)	67.80	72.60	75.70	76.30
27	OR000845	HWY 32 (OR.22)	68.90	73.90	76.80	77.40
28	OR000846	HWY 32 (OR.22)	68.00	77.50	81.50	82.20
29	OR000847	HWY 32 (OR.22)	68.90	73.90	76.80	77.40
30	OR000848	HWY 32 (OR.22)	68.90	73.90	76.90	77.50
31	OR000856	HWY 32 (OR.22)	61.40	70.00	73.70	74.40
32	OR001084	OAK RIDGE ROAD	19.70	25.60	30.20	31.60
33	OR001633	OR 18 (HWY 039)	65.30	73.20	76.50	77.30
34	OR001634	OR 18 (HWY 039)	73.30	82.10	85.60	86.20
35	OR001635	OR 18 (HWY 039)	73.90	82.60	86.00	86.70
36	OR001726	OR 99W (HWY 001W)	22.30	29.00	34.20	35.50
37	OR001817	OR 18 (HWY 039)	49.70	49.80	50.00	50.60
38	OR001818	OR 18 (HWY 039)	59.70	66.50	71.10	72.10
39	OR002144	OR 99W (HWY 001W)	68.40	76.00	79.00	79.70
40	OR002176	OR 18 (HWY 039) CO	70.30	80.00	85.70	86.70
41	OR002703	US101(HWY009)	50.80	57.90	61.60	62.50
42	OR002714	ROCK CREEK, EAST AVENUE	59.30	66.80	72.00	73.10
43	OR002715	SOUTH YAMHILL RIVER, GRAND RONDE ROAD	17.50	22.90	27.50	28.80
44	OR002716	HARMONY ROAD	60.20	66.80	71.10	72.00
45	OR002717	GOOSENECK ROAD	68.80	72.20	75.30	76.00
46	OR002718	BROWN ROAD	72.40	76.30	79.00	79.50
47	OR002719	BROWN ROAD	73.60	78.00	80.40	80.90
48	OR002754	GRENFELL CO PK RD	66.30	70.00	72.10	72.60
49	OR002755	BISHOP-SCOTT ROAD	66.60	70.30	72.30	72.80
50	OR002756	BISHOP-SCOTT ROAD	66.60	70.30	72.30	72.80
51	OR002757	PIKE ROAD	82.30	87.00	89.60	90.00
52	OR002758	HACKER ROAD	82.30	87.00	89.60	90.00
53	OR002759	ROCKYFORD ROAD	78.40	82.90	85.30	85.80
54	OR002760	TURNER CREEK ROAD	74.40	78.70	81.10	81.70
55	OR002761	TURNER CREEK ROAD	71.10	74.70	77.50	78.10
56	OR002762	OLD RAILROAD GRADE	82.30	87.00	89.60	90.00
57	OR002763	FAIRDALE ROAD	20.80	27.20	32.30	33.60
58	OR002764	OAK RIDGE ROAD	23.30	30.50	36.00	37.40

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Transportation System Results - Highway - Bridge Functionality Printed on: 6/25/2014 4:48:41 PM

	ID Number	Name	@ Day 1	@ Day 3	@ Day 7	@ Day 14
59	OR002765	FAIRDALE ROAD	73.80	78.10	80.50	81.00
60	OR002766	OLD MOORES VALLEY	73.80	78.10	80.50	81.00
61	OR002767	MEADOW LAKE ROAD	75.50	84.00	87.20	87.80
62	OR002768	HENDRICKS ROAD	20.40	26.50	31.10	32.30
63	OR002769	REX BROWN ROAD	81.90	86.70	89.30	89.80
64	OR002770	KUTCH ROAD	81.30	86.20	88.90	89.40
65	OR002771	FIR CREST ROAD	19.50	25.40	29.90	31.10
66	OR002772	WESTSIDE ROAD	68.30	76.00	79.00	79.70
67	OR002773	WEST SIDE ROAD	60.90	67.70	70.50	71.40
68	OR002774	MOORES VALLEY RD	59.50	66.30	69.90	70.90
69	OR002775	STONE ROAD	73.90	77.30	79.80	80.30
70	OR002776	KUEHNE ROAD	83.80	88.20	90.60	91.10
71	OR002777	BAYLEY ROAD	75.30	79.10	81.30	81.80
72	OR002778	DAYTON AVENUE	26.70	34.50	40.50	41.90
73	OR002779	WILLIS ROAD	66.30	70.00	72.10	72.60
74	OR002780	BERRY CREEK ROAD	80.30	84.50	87.40	87.90
75	OR002781	NORTH HILL ROAD	66.70	70.40	72.50	72.90
76	OR002789	US 101 (HWY 009)	60.40	69.40	74.50	75.40
77	OR002790	OR 18 (HWY 039)	62.30	70.80	75.30	76.20
78	OR002962	MILL CR RD	77.40	81.50	84.80	85.40
79	OR003026	GRANT ROAD	73.00	77.40	79.90	80.40
80	OR003088	BECK ROAD	66.00	69.90	72.00	72.40
81	OR003184	BAYS CREEK RD	76.70	82.20	85.40	86.00
82	OR003195	IRA HOOKER ROAD	61.30	72.00	77.30	78.20
83	OR003696	DELANEY RD SE	67.10	72.40	75.40	76.10
84	OR003750	BLACK ROCK ROAD	80.80	85.70	88.50	89.00
85	OR003751	PERRYDALE ROAD	69.30	72.20	75.30	75.90
86	OR003752	BALL RD	65.60	69.50	71.60	72.10
87	OR003753	BALL RD	65.60	69.50	71.60	72.10
88	OR003759	GARDNER ROAD	20.70	27.00	32.00	33.40
89	OR003762	HARMONY ROAD	59.60	67.30	74.20	75.40
90	OR003763	DE JONG ROAD	13.40	16.70	20.20	21.50
91	OR003764	ENTERPRISE ROAD	73.60	77.90	80.30	80.80
92	OR003765	WEST PERRYDALE RD	66.00	69.90	72.00	72.40
93	OR003766	BETHEL ROAD	17.80	22.80	27.10	28.50
94	OR003767	BETHEL ROAD	66.80	70.50	72.50	73.00
95	OR003771	BROADMEAD ROAD	19.80	25.70	30.30	31.60
96	OR003776	TUCKER ROAD	19.50	25.30	29.90	31.30
97	OR003777	VAN WELL ROAD	19.30	25.10	29.70	30.90
98	OR003778	VAN WELL ROAD	16.80	21.60	25.80	27.00
99	OR003779	OLD MILITARY ROAD	81.00	85.90	88.70	89.20
100	OR003780	GOOSENECK ROAD	20.10	26.30	31.30	32.60
101	OR003781	GOOSENECK ROAD	77.80	82.20	85.40	86.00
102	OR003782	SAVAGE ROAD	76.60	81.40	84.00	84.50
103	OR003783	HART ROAD	73.80	78.10	80.60	81.20
104	OR003784	GOLD CREEK ROAD	64.90	73.20	76.80	77.60
105	OR003785	GOLD CREEK ROAD	70.90	75.30	78.10	78.60
106	OR003786	GOLD CREEK ROAD	74.80	79.40	82.30	82.80
107	OR003787	GOLD CREEK ROAD	79.60	84.70	87.60	88.10
108	OR003788	FIRE HALL ROAD	19.40	25.70	30.80	32.10
109	OR003794	SMITHFIELD ROAD	66.50	70.20	72.30	72.80
110	OR003796	STARR ROAD	65.30	69.10	71.30	71.80
111	OR003797	STARR ROAD	65.70	69.50	71.70	72.10
112	OR003799	ROBB MILL ROAD	81.60	86.40	89.10	89.60
113	OR003805	BRIDGEPORT ROAD	21.00	27.70	33.00	34.40
114	OR003806	FROST ROAD	72.50	76.90	79.50	80.10
115	OR003807	SOCIALIST VALLEY	80.20	85.20	88.00	88.60
116	OR003813	PEEDEE CREEK ROAD	72.50	76.80	79.40	79.90

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	ID Number	Name	@ Day 1	@ Day 3	@ Day 7	@ Day 14
117	OR003814	PEEDEE CREEK ROAD	72.50	76.80	79.40	79.90
118	OR003815	PEDEE CREEK ROAD	73.00	77.40	79.90	80.40
119	OR003816	GAGE ROAD	72.30	76.80	79.30	79.80
120	OR003817	GAGE ROAD	80.40	85.40	88.20	88.70
121	OR003818	GAGE ROAD	80.40	85.20	88.00	88.50
122	OR003819	RONCO ROAD	22.20	29.20	34.60	36.00
123	OR003820	RONCO ROAD	79.80	84.50	87.40	88.00
124	OR003821	SHEYTHE ROAD	80.90	85.80	88.50	89.00
125	OR003822	WILDWOOD ROAD	72.50	77.00	79.60	80.10
126	OR003823	PLEASANT HILL ROAD	64.90	68.50	70.80	71.30
127	OR004175	SE 1ST ST OVER UNNAMED CHANNEL	60.10	64.80	67.60	68.40
128	OR004176	DEPOE BAY, HWY 9	16.40	22.00	26.50	27.80
129	OR004177	FOGARTY CREEK, HWY 9	59.10	68.00	71.80	72.70
130	OR004178	SIJOTA CREEK & GOLF ACCESS, HWY 9	59.00	67.70	71.60	72.30
131	OR004179	MILLPORT SLOUGH HWY 009 AT MP 120.84	48.10	58.40	64.00	65.00
132	OR004180	DRIFT CREEK, HWY 9	53.00	60.80	64.20	64.90
133	OR004181	DRIFT CREEK NORTH, DRIFT CREEK RD	16.10	21.90	27.10	28.40
134	OR004182	SCHOONER CREEK, HWY 9	70.70	76.30	79.50	80.10
135	OR004183	DEVILS LAKE OUTLET, HWY 9 (D RIVER)	53.00	60.80	64.20	64.90
136	OR004184	JACKASS CREEK, HWY 039 AT MP 19.16	64.50	76.90	83.20	84.30
137	OR004185	DEVILS LAKE CREEK, W DEVILS LAKE RD	59.70	72.50	79.50	80.70
138	OR004186	SALMON RIVER, HWY 9	60.10	68.80	72.70	73.50
139	OR004187	CLEAR CREEK, HWY 9	61.90	65.40	69.00	69.80
140	OR004188	FARMER CREEK, HWY 9	54.40	54.50	54.70	55.20
141	OR004189	WEST CREEK (BUN CREEK), HWY 9	68.20	73.30	76.30	76.90
142	OR004190	BEAVER CREEK, HWY 9 AT MP 80.32	14.20	18.60	22.50	23.60
143	OR004191	BEAVER CREEK, HWY 9 AT MP 79.61	61.40	70.00	73.70	74.50
144	OR004192	WEST BEAVER CREEK, HWY 9	68.20	73.30	76.30	76.90
145	OR004193	TIGER CREEK, HWY 9 AT MP 76.64	62.30	65.70	69.40	70.10
146	OR004194	TIGER CREEK, HWY 9 AT MP 76.35	68.00	73.20	76.20	76.80
147	OR004195	HWY 39 OVER CASINO ENTRANCE RD	58.70	69.80	75.50	76.40
148	OR004196	FORT HILL ROAD OVER HWY 39 AT MP 24.66	50.60	59.30	66.20	67.40
149	OR004197	WILLAMINA RIVER, HWY 157	69.50	78.80	83.40	84.20
150	OR004198	COUNTY ROAD TO SHERIDAN OVER HWY 39	70.40	79.80	84.80	85.60
151	OR004199	COZINE CREEK, OLD SHERIDAN RD	74.90	79.00	81.30	81.70
152	OR004200	COZINE CREEK, OLD SHERIDAN RD	62.50	65.20	68.90	69.70
153	OR004201	HWY 39 OVER WPRR	67.20	75.00	79.00	79.80
154	OR004202	BOOTH BEND ROAD OVER HWY 39	70.30	80.00	85.80	86.70
155	OR004203	SOUTH YAMHILL RIVER, HWY 39 AT MP 45.63	22.70	30.20	36.60	38.10
156	OR004204	YAMHILL RIVER OFLOW, HWY 39	22.30	29.00	34.20	35.50
157	OR004205	HWY 39 MCMINNVILLE SPUR OVER HWY 39	69.50	79.20	85.50	86.50
158	OR004206	HWY 39 MCMINNVILLE SPUR	23.40	31.10	37.70	39.10
159	OR004207	FLETCHER RD (LAFAYETTE RD) OVER HWY 39	67.60	76.10	82.10	83.10
160	OR004208	HWY 39 OVER HWY 150	67.60	74.60	77.80	78.50
161	OR004209	YAMHILL RIVER, HWY 39 (DAYTON)	61.60	61.70	61.90	62.30
162	OR004210	WPRR OVER HWY 1W (ST JOE)	76.00	80.80	83.90	84.60
163	OR004211	RUSSELL CREEK, HWY 29	65.90	69.30	71.50	71.90
164	OR004212	LITTLE RUSSELL CREEK, HWY 29	66.60	70.30	72.30	72.80
165	OR004213	WPRR OVER HWY 1W (WHITESON)	65.90	70.20	74.40	75.30
166	OR004214	ASH SWALE, HWY 1W AT MP 47.29	61.00	67.70	70.30	70.90
167	OR004215	PLUM CREEK, HWY 1W AT MP49.75	66.70	70.30	72.30	72.80
168	OR004216	ASH SWALE, HWY 1W AT MP 51.06	66.90	70.60	72.60	73.00
169	OR004217	HWY 1W OVER HWY 30	69.40	81.20	86.80	87.70

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	@ Day 30	@ Day 90
1	73.40	85.90
2	82.50	86.30
3	88.70	92.90
4	33.60	48.30
5	74.90	82.00
6	76.70	86.30
7	78.50	87.80
8	71.30	76.00
9	27.30	44.00
10	80.20	84.90
11	77.70	85.60
12	77.90	86.80
13	81.10	85.40
14	78.10	86.50
15	80.80	85.30
16	34.80	53.10
17	32.70	47.50
18	41.50	58.10
19	26.10	42.90
20	72.10	83.50
21	29.00	44.90
22	83.30	89.50
23	77.10	84.20
24	80.70	87.70
25	77.80	83.20
26	77.10	82.80
27	78.10	83.50
28	83.00	88.90
29	78.10	83.50
30	78.30	84.50
31	75.50	83.00
32	34.40	54.50
33	78.60	87.80
34	86.90	91.60
35	87.30	91.90
36	37.60	53.30
37	52.30	64.70
38	73.50	83.60
39	80.90	89.50
40	87.30	92.20
41	63.80	73.40
42	74.40	83.80
43	31.30	49.60
44	73.50	83.80
45	76.80	82.60
46	80.10	84.80
47	81.40	85.70
48	73.20	77.50
49	73.40	77.70
50	73.40	77.70
51	90.60	94.40
52	90.60	94.40
53	86.40	90.40
54	82.90	91.10
55	78.80	83.90
56	90.60	94.40
57	36.20	54.60
58	39.80	56.50

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	@ Day 30	@ Day 90
59	81.60	85.70
60	81.60	85.70
61	88.40	92.60
62	34.30	49.00
63	90.30	94.20
64	89.90	93.90
65	33.20	47.90
66	80.90	89.50
67	73.10	85.60
68	72.60	85.30
69	80.90	85.30
70	91.60	95.00
71	82.30	86.20
72	44.10	60.50
73	73.20	77.50
74	88.50	93.00
75	73.70	78.80
76	76.60	84.60
77	77.20	84.60
78	86.10	91.40
79	81.00	85.40
80	73.00	77.40
81	86.70	91.80
82	79.00	84.60
83	76.90	82.80
84	89.50	93.70
85	76.70	82.50
86	72.70	77.20
87	72.70	77.20
88	35.80	53.00
89	76.40	84.10
90	24.10	43.00
91	81.40	85.60
92	73.00	77.40
93	31.20	50.90
94	73.60	77.80
95	34.00	51.20
96	33.90	53.10
97	33.10	49.10
98	29.30	45.60
99	89.70	93.80
100	35.10	53.20
101	86.70	91.80
102	85.10	89.50
103	82.20	89.60
104	78.80	87.90
105	79.30	84.30
106	83.50	88.40
107	88.70	93.10
108	34.50	51.40
109	73.40	77.60
110	72.40	77.00
111	72.80	77.30
112	90.10	94.10
113	36.90	54.90
114	81.10	88.10
115	89.20	93.40
116	80.50	85.10

OHA-EQ study region created on 6-24-14 Page 5

Transportation System Results - Highway - Bridge Functionality Printed on: 6/25/2014 4:48:41 PM

	@ Day 30	@ Day 90
117	80.50	85.10
118	81.00	85.40
119	80.50	85.00
120	89.30	93.50
121	89.10	93.40
122	38.30	55.10
123	88.60	93.10
124	89.60	93.70
125	80.70	85.20
126	72.00	76.80
127	69.90	80.60
128	30.10	47.00
129	74.10	84.30
130	73.20	79.70
131	66.00	73.40
132	65.80	72.20
133	30.80	47.60
134	80.90	86.60
135	65.80	72.20
136	85.10	91.50
137	81.70	89.30
138	75.00	85.10
139	70.90	78.40
140	56.80	68.30
141	77.70	83.20
142	25.80	41.60
143	75.90	85.70
144	77.70	83.20
145	71.20	78.60
146	77.50	83.10
147	77.30	83.50
148	68.70	77.90
149	84.90	90.60
150	86.30	91.20
151	82.30	86.20
152	70.80	78.30
153	80.90	89.00
154	87.40	92.20
155	40.40	57.10
156	37.60	53.30
157	87.10	91.80
158	41.50	58.10
159	83.90	89.90
160	79.80	88.50
161	63.70	73.60
162	85.60	92.40
163	72.60	77.10
164	73.40	77.70
165	76.90	88.00
166	71.60	76.60
167	73.40	77.70
168	73.60	77.80
169	88.40	93.50

OHA-EQ study region created on 6-24-14 Page 6

Highway – Segment Damage

Transportation System Results - Highway - Segment Damage Printed on: 6/25/2014 4:49:40 PM

	ID Number	Name	None	Slight	Moderate	Extensive
1	OR000348	U101	0.761	0.011	0.046	0.000
2	OR000349	S18	0.750	0.001	0.008	0.000
3	OR000350	U101	0.757	0.007	0.032	0.000
4	OR001101	S99W	0.808	0.055	0.051	0.000
5	OR001192	RAMP	0.757	0.007	0.032	0.000
6	OR001193	U101	0.757	0.007	0.032	0.000
7	OR001246	U101	0.757	0.007	0.033	0.000
8	OR001247	U101	0.757	0.007	0.033	0.000
9	OR001248	S18	0.786	0.011	0.023	0.000
10	OR001343	S18	0.720	0.034	0.066	0.000
11	OR001344	S18	0.752	0.038	0.070	0.000
12	OR001345	S18 S	0.779	0.046	0.061	0.000
13	OR001346	S18 S	0.806	0.055	0.051	0.000
14	OR001473	NE 3RD ST	0.806	0.055	0.051	0.000
15	OR001474	THREE MILE LN	0.806	0.055	0.051	0.000
16	OR001550	U101	0.761	0.010	0.044	0.000
17	OR001562	U101	0.779	0.018	0.052	0.000
18	OR001611	S22	0.800	0.040	0.053	0.000
19	OR001631	S22	0.806	0.055	0.051	0.000
20	OR001796	S99W	0.806	0.055	0.051	0.000
21	OR001797	S18	0.721	0.047	0.042	0.000
22	OR001798	THREE MILE LN	0.806	0.055	0.051	0.000
23	OR001801	THREE MILE LN	0.806	0.055	0.051	0.000
24	OR001802	S18	0.724	0.037	0.068	0.000
25	OR001803	THREE MILE LN	0.752	0.038	0.070	0.000
26	OR001804	S18	0.752	0.038	0.070	0.000
27	OR001805	S99W	0.806	0.055	0.051	0.000
28	OR001806	S18	0.779	0.046	0.061	0.000
29	OR001807	S18	0.806	0.055	0.051	0.000
30	OR001808	S18	0.779	0.046	0.061	0.000
31	OR001809	S18	0.806	0.055	0.051	0.000
32	OR001810	S99W	0.806	0.055	0.051	0.000
33	OR001811	S18 S	0.752	0.038	0.070	0.000
34	OR001897	S22	0.801	0.013	0.048	0.000
35	OR001899	S18	0.801	0.011	0.045	0.000
36	OR001900	S18	0.799	0.027	0.055	0.000
37	OR001901	S18	0.775	0.014	0.053	0.000
38	OR001904	U101	0.729	0.007	0.028	0.000
39	OR001905	S18	0.755	0.005	0.024	0.000
40	OR001910	U101	0.761	0.010	0.044	0.000
41	OR002137	S47	0.770	0.036	0.082	0.000
42	OR002142	S219	0.871	0.064	0.045	0.000
43	OR002147	S240	0.804	0.046	0.071	0.000
44	OR002151	S240	0.871	0.064	0.045	0.000
45	OR002186	S99W	0.774	0.052	0.042	0.000
46	OR002188	S99W	0.772	0.048	0.057	0.000
47	OR002189	S47	0.755	0.034	0.082	0.000
48	OR002191	S99W	0.726	0.032	0.081	0.000
49	OR002195	U101	0.713	0.005	0.020	0.000
50	OR002197	S18	0.724	0.047	0.041	0.000
51	OR002198	S99W	0.779	0.047	0.061	0.000
52	OR002200	S99W	0.806	0.055	0.051	0.000
53	OR002201	NE 3RD ST	0.806	0.055	0.051	0.000
54	OR002202	S99W	0.806	0.055	0.051	0.000
55	OR002203	THREE MILE LN	0.806	0.055	0.051	0.000
56	OR002204	S99W	0.806	0.055	0.051	0.000
57	OR002210	S22	0.726	0.004	0.016	0.000
58	OR002211	S22	0.750	0.001	0.009	0.000

OHA-EQ study region created on 6-24-14 Page 1

Transportation System Results - Highway - Segment Damage Printed on: 6/25/2014 4:49:40 PM

	ID Number	Name	None	Slight	Moderate	Extensive
59	OR002212	S22	0.767	0.004	0.022	0.000
60	OR002213	S221	0.725	0.047	0.041	0.000
61	OR002214	S18	0.873	0.050	0.052	0.000
62	OR002215	S18	0.770	0.029	0.053	0.000
63	OR002216	S99W	0.833	0.042	0.041	0.000
64	OR002217	U101	0.779	0.018	0.052	0.000
65	OR002249	S22	0.806	0.055	0.051	0.000
66	OR002267	U101	0.757	0.007	0.031	0.000
67	OR002319	S223	0.803	0.022	0.063	0.000
68	OR002323	U101	0.750	0.000	0.006	0.000
69	OR002648	RAMP	0.779	0.046	0.061	0.000
70	OR002649	RAMP	0.725	0.030	0.079	0.000
71	OR002732	S18	0.779	0.046	0.061	0.000
72	OR002733	S18	0.752	0.038	0.070	0.000

OHA-EQ study region created on 6-24-14 Page 2

Transportation System Results - Highway - Segment Damage Printed on: 6/25/2014 4:49:40 PM

	Complete	At Least Slight	At Least Moderate	At Least Extensive
1	0.182	0.239	0.228	0.182
2	0.242	0.250	0.249	0.242
3	0.204	0.243	0.236	0.204
4	0.087	0.192	0.137	0.087
5	0.203	0.243	0.236	0.203
6	0.203	0.243	0.236	0.203
7	0.202	0.243	0.235	0.202
8	0.202	0.243	0.235	0.202
9	0.180	0.214	0.203	0.180
10	0.179	0.280	0.245	0.179
11	0.140	0.248	0.210	0.140
12	0.114	0.221	0.174	0.114
13	0.088	0.194	0.139	0.088
14	0.088	0.194	0.139	0.088
15	0.088	0.194	0.139	0.088
16	0.185	0.239	0.229	0.185
17	0.152	0.221	0.203	0.152
18	0.107	0.200	0.160	0.107
19	0.088	0.194	0.139	0.088
20	0.088	0.194	0.139	0.088
21	0.190	0.279	0.232	0.190
22	0.088	0.194	0.139	0.088
23	0.088	0.194	0.139	0.088
24	0.172	0.276	0.240	0.172
25	0.140	0.248	0.210	0.140
26	0.140	0.248	0.210	0.140
27	0.088	0.194	0.139	0.088
28	0.114	0.221	0.174	0.114
29	0.088	0.194	0.139	0.088
30	0.114	0.221	0.174	0.114
31	0.088	0.194	0.139	0.088
32	0.088	0.194	0.139	0.088
33	0.140	0.248	0.210	0.140
34	0.138	0.199	0.186	0.138
35	0.143	0.199	0.188	0.143
36	0.119	0.201	0.174	0.119
37	0.159	0.225	0.211	0.159
38	0.236	0.271	0.264	0.236
39	0.216	0.245	0.240	0.216
40	0.185	0.239	0.229	0.185
41	0.112	0.230	0.195	0.112
42	0.020	0.129	0.065	0.020
43	0.079	0.196	0.149	0.079
44	0.020	0.129	0.065	0.020
45	0.131	0.226	0.174	0.131
46	0.124	0.228	0.180	0.124
47	0.129	0.245	0.211	0.129
48	0.160	0.274	0.242	0.160
49	0.262	0.287	0.282	0.262
50	0.188	0.276	0.229	0.188
51	0.112	0.221	0.174	0.112
52	0.088	0.194	0.139	0.088
53	0.088	0.194	0.139	0.088
54	0.088	0.194	0.139	0.088
55	0.088	0.194	0.139	0.088
56	0.088	0.194	0.139	0.088
57	0.255	0.274	0.271	0.255
58	0.241	0.250	0.249	0.241

OHA-EQ study region created on 6-24-14 Page 3

Transportation System Results - Highway - Segment Damage Printed on: 6/25/2014 4:49:40 PM

	Complete	At Least Slight	At Least Moderate	At Least Extensive
59	0.207	0.233	0.229	0.207
60	0.188	0.275	0.229	0.188
61	0.026	0.127	0.077	0.026
62	0.148	0.230	0.201	0.148
63	0.084	0.167	0.125	0.084
64	0.151	0.221	0.203	0.151
65	0.088	0.194	0.139	0.088
66	0.205	0.243	0.236	0.205
67	0.111	0.197	0.174	0.111
68	0.244	0.250	0.250	0.244
69	0.114	0.221	0.174	0.114
70	0.166	0.275	0.245	0.166
71	0.114	0.221	0.174	0.114
72	0.140	0.248	0.210	0.140

OHA-EQ study region created on 6-24-14

Highway – Segment Loss

Transportation System Results - Highway - Segment Loss Printed on: 6/25/2014 4:50:04 PM

	ID Number	Name	Repair Cost (thous. $)
1	OR000348	U101	1,499
2	OR000349	S18	9,107
3	OR000350	U101	346
4	OR001101	S99W	3,909
5	OR001192	RAMP	209
6	OR001193	U101	117
7	OR001246	U101	195
8	OR001247	U101	144
9	OR001248	S18	164
10	OR001343	S18	1,620
11	OR001344	S18	76
12	OR001345	S18 S	82
13	OR001346	S18 S	249
14	OR001473	NE 3RD ST	364
15	OR001474	THREE MILE LN	366
16	OR001550	U101	3,615
17	OR001562	U101	165
18	OR001611	S22	5,926
19	OR001631	S22	850
20	OR001796	S99W	341
21	OR001797	S18	2,199
22	OR001798	THREE MILE LN	142
23	OR001801	THREE MILE LN	30
24	OR001802	S18	3,459
25	OR001803	THREE MILE LN	124
26	OR001804	S18	329
27	OR001805	S99W	331
28	OR001806	S18	213
29	OR001807	S18	34
30	OR001808	S18	315
31	OR001809	S18	56
32	OR001810	S99W	116
33	OR001811	S18 S	126
34	OR001897	S22	628
35	OR001899	S18	4,705
36	OR001900	S18	1,221
37	OR001901	S18	4,170
38	OR001904	U101	16,142
39	OR001905	S18	3,918
40	OR001910	U101	107
41	OR002137	S47	4,137
42	OR002142	S219	388
43	OR002147	S240	3,823
44	OR002151	S240	140
45	OR002186	S99W	3,173
46	OR002188	S99W	2,712
47	OR002189	S47	4,613
48	OR002191	S99W	409
49	OR002195	U101	18,635
50	OR002197	S18	970
51	OR002198	S99W	1,987
52	OR002200	S99W	475
53	OR002201	NE 3RD ST	47
54	OR002202	S99W	497
55	OR002203	THREE MILE LN	83
56	OR002204	S99W	374
57	OR002210	S22	10,703
58	OR002211	S22	2,180

OHA-EQ study region created on 6-24-14 Page 1

Transportation System Results - Highway - Segment Loss Printed on: 6/25/2014 4:50:04 PM

	ID Number	Name	Repair Cost (thous. $)
59	OR002212	S22	8,330
60	OR002213	S221	8,283
61	OR002214	S18	1
62	OR002215	S18	7,491
63	OR002216	S99W	3,065
64	OR002217	U101	138
65	OR002249	S22	395
66	OR002267	U101	3,662
67	OR002319	S223	5,726
68	OR002323	U101	16,423
69	OR002648	RAMP	324
70	OR002649	RAMP	459
71	OR002732	S18	189
72	OR002733	S18	228

OHA-EQ study region created on 6-24-14 Page 2

Highway – Segment Functionality

Transportation System Results - Highway - Segment Functionality Printed on: 6/25/2014 4:50:10 PM

	ID Number	Name	@ Day 1	@ Day 3	@ Day 7	@ Day 14
1	OR000348	U101	80.20	82.60	85.20	87.70
2	OR000349	S18	77.70	78.70	80.40	83.80
3	OR000350	U101	79.30	81.10	83.40	86.30
4	OR001101	S99W	88.30	90.70	92.90	94.10
5	OR001192	RAMP	79.30	81.20	83.50	86.30
6	OR001193	U101	79.30	81.20	83.50	86.30
7	OR001246	U101	79.40	81.30	83.50	86.40
8	OR001247	U101	79.40	81.30	83.50	86.40
9	OR001248	S18	82.10	83.50	85.40	87.90
10	OR001343	S18	78.90	82.20	85.40	88.00
11	OR001344	S18	82.10	85.50	88.60	90.60
12	OR001345	S18 S	85.10	88.00	90.70	92.30
13	OR001346	S18 S	88.10	90.60	92.80	94.00
14	OR001473	NE 3RD ST	88.10	90.60	92.80	94.00
15	OR001474	THREE MILE LN	88.10	90.60	92.80	94.00
16	OR001550	U101	80.10	82.40	84.90	87.60
17	OR001562	U101	82.50	85.00	87.60	89.80
18	OR001611	S22	86.30	88.90	91.20	92.80
19	OR001631	S22	88.10	90.60	92.80	94.00
20	OR001796	S99W	88.10	90.60	92.80	94.00
21	OR001797	S18	79.70	82.10	84.60	87.20
22	OR001798	THREE MILE LN	88.10	90.60	92.80	94.00
23	OR001801	THREE MILE LN	88.10	90.60	92.80	94.00
24	OR001802	S18	79.40	82.80	86.00	88.40
25	OR001803	THREE MILE LN	82.10	85.50	88.60	90.60
26	OR001804	S18	82.10	85.50	88.60	90.60
27	OR001805	S99W	88.10	90.60	92.80	94.00
28	OR001806	S18	85.10	88.00	90.70	92.30
29	OR001807	S18	88.10	90.60	92.80	94.00
30	OR001808	S18	85.10	88.00	90.70	92.30
31	OR001809	S18	88.10	90.60	92.80	94.00
32	OR001810	S99W	88.10	90.60	92.80	94.00
33	OR001811	S18 S	82.10	85.50	88.60	90.60
34	OR001897	S22	84.00	86.40	88.80	90.70
35	OR001899	S18	83.80	86.00	88.40	90.40
36	OR001900	S18	85.10	87.80	90.30	92.00
37	OR001901	S18	81.80	84.40	87.10	89.30
38	OR001904	U101	76.70	78.50	80.80	84.10
39	OR001905	S18	78.80	80.30	82.40	85.50
40	OR001910	U101	80.10	82.40	85.00	87.60
41	OR002137	S47	83.70	87.50	90.80	92.40
42	OR002142	S219	94.60	96.70	98.30	98.60
43	OR002147	S240	87.50	90.80	93.50	94.70
44	OR002151	S240	94.60	96.70	98.30	98.60
45	OR002186	S99W	84.90	87.10	89.30	91.10
46	OR002188	S99W	84.50	87.30	89.90	91.70
47	OR002189	S47	82.20	86.10	89.50	91.30
48	OR002191	S99W	79.40	83.30	86.90	89.20
49	OR002195	U101	75.00	76.50	78.70	82.40
50	OR002197	S18	79.90	82.20	84.70	87.40
51	OR002198	S99W	85.20	88.20	90.80	92.40
52	OR002200	S99W	88.10	90.60	92.80	94.00
53	OR002201	NE 3RD ST	88.10	90.60	92.80	94.00
54	OR002202	S99W	88.10	90.60	92.80	94.00
55	OR002203	THREE MILE LN	88.10	90.60	92.80	94.00
56	OR002204	S99W	88.10	90.60	92.80	94.00
57	OR002210	S22	76.00	77.30	79.30	82.90
58	OR002211	S22	77.80	78.70	80.50	83.80

OHA-EQ study region created on 6-24-14 Page 1

Transportation System Results - Highway - Segment Functionality Printed on: 6/25/2014 4:50:10 PM

	ID Number	Name	@ Day 1	@ Day 3	@ Day 7	@ Day 14
59	OR002212	S22	79.80	81.20	83.20	86.10
60	OR002213	S221	80.00	82.30	84.70	87.40
61	OR002214	S18	93.70	96.00	97.80	98.20
62	OR002215	S18	82.70	85.30	87.90	90.00
63	OR002216	S99W	89.30	91.30	93.10	94.30
64	OR002217	U101	82.50	85.10	87.70	89.80
65	OR002249	S22	88.10	90.60	92.80	94.00
66	OR002267	U101	79.30	81.10	83.40	86.20
67	OR002319	S223	85.20	88.20	90.90	92.50
68	OR002323	U101	77.70	78.60	80.20	83.60
69	OR002648	RAMP	85.10	88.00	90.70	92.30
70	OR002649	RAMP	79.10	82.90	86.50	88.80
71	OR002732	S18	85.10	88.00	90.70	92.30
72	OR002733	S18	82.10	85.50	88.60	90.60

OHA-EQ study region created on 6-24-14 Page 2

Transportation System Results - Highway - Segment Functionality Printed on: 6/25/2014 4:50:10 PM

	@ Day 30	@ Day 90
1	94.70	99.90
2	93.00	99.90
3	94.10	99.90
4	97.40	99.90
5	94.10	99.90
6	94.10	99.90
7	94.10	99.90
8	94.10	99.90
9	94.80	99.90
10	94.80	99.90
11	95.90	99.90
12	96.70	99.90
13	97.40	99.90
14	97.40	99.90
15	97.40	99.90
16	94.60	99.90
17	95.60	99.90
18	96.90	99.90
19	97.40	99.90
20	97.40	99.90
21	94.50	99.90
22	97.40	99.90
23	97.40	99.90
24	95.00	99.90
25	95.90	99.90
26	95.90	99.90
27	97.40	99.90
28	96.70	99.90
29	97.40	99.90
30	96.70	99.90
31	97.40	99.90
32	97.40	99.90
33	95.90	99.90
34	96.00	99.90
35	95.80	99.90
36	96.50	99.90
37	95.40	99.90
38	93.20	99.90
39	93.70	99.90
40	94.60	99.90
41	96.70	99.90
42	99.40	99.90
43	97.70	99.90
44	99.40	99.90
45	96.10	99.90
46	96.40	99.90
47	96.20	99.90
48	95.30	99.90
49	92.40	99.90
50	94.50	99.90
51	96.70	99.90
52	97.40	99.90
53	97.40	99.90
54	97.40	99.90
55	97.40	99.90
56	97.40	99.90
57	92.60	99.90
58	93.00	99.90

OHA-EQ study region created on 6-24-14

Transportation System Results - Highway - Segment Functionality Printed on: 6/25/2014 4:50:10 PM

	@ Day 30	@ Day 90
59	94.00	99.90
60	94.60	99.90
61	99.20	99.90
62	95.70	99.90
63	97.50	99.90
64	95.60	99.90
65	97.40	99.90
66	94.10	99.90
67	96.70	99.90
68	93.00	99.90
69	96.70	99.90
70	95.20	99.90
71	96.70	99.90
72	95.90	99.90

OHA-EQ study region created on 6-24-14 Page 4

Appendix G: Hazus-MH Emergency Facilities and Shelter Results Using Default Data

Emergency Response – Police Station, Structural Damage

Essential Facilities Results - Emergency Response - Police Station, Structural Damage Printed on: 6/25/2014 4:47:14 PM

	ID Number	Name	None	Slight	Moderate	Extensive
1	OR000024	Gaston Police Dept	0.278	0.298	0.191	0.039
2	OR000027	Sheridan Sheriff's Office	0.265	0.298	0.198	0.042
3	OR000038	Mc Minnville POLICE-Dare	0.266	0.281	0.179	0.036
4	OR000053	Lincoln City Police Dept	0.207	0.319	0.269	0.073
5	OR000072	Carlton Police Dept	0.238	0.250	0.158	0.032
6	OR000079	Yamhill Police Dept	0.234	0.250	0.160	0.033
7	OR000144	Amity Police Dept	0.282	0.298	0.190	0.044
8	OR000145	Willamina Police Dept	0.252	0.299	0.207	0.045
9	OR000170	Yamhill County Sheriff's Ofc-RVS-YW	0.052	0.053	0.201	0.294
10	OR000171	Yamhill Crime Victim's Asstnc	0.266	0.281	0.179	0.036
11	OR000179	Dundee Police Dept	0.335	0.374	0.235	0.050

Essential Facilities Results - Emergency Response - Police Station, Structural Damage Printed on: 6/25/2014 4:47:14 PM

	Complete	At Least Slight	At Least Moderate	At Least Extensive
1	0.194	0.722	0.424	0.233
2	0.197	0.735	0.436	0.238
3	0.238	0.734	0.453	0.274
4	0.131	0.793	0.474	0.205
5	0.323	0.762	0.513	0.355
6	0.323	0.766	0.516	0.356
7	0.186	0.718	0.420	0.230
8	0.197	0.748	0.449	0.242
9	0.399	0.948	0.894	0.693
10	0.238	0.734	0.453	0.274
11	0.006	0.665	0.291	0.056

Emergency Response – Police Station, Functionality

Essential Facilities Results - Emergency Response - Police Station, Functionality Printed on: 6/25/2014 4:47:24 PM

	ID Number	Name	@ Day 1	@ Day 3	@ Day 7	@ Day 14
1	OR000024	Gaston Police Dept	27.80	28.50	56.90	57.60
2	OR000027	Sheridan Sheriff's Office	26.50	27.20	55.60	56.30
3	OR000038	Mc Minnville POLICE-Dare	26.50	27.20	54.00	54.70
4	OR000053	Lincoln City Police Dept	20.70	21.40	51.80	52.60
5	OR000072	Carlton Police Dept	23.70	24.30	48.10	48.70
6	OR000079	Yamhill Police Dept	23.30	23.90	47.80	48.40
7	OR000144	Amity Police Dept	28.20	28.80	57.20	58.00
8	OR000145	Willamina Police Dept	25.10	25.80	54.40	55.10
9	OR000170	Yamhill County Sheriff's Ofc-RVS-YW	5.20	5.30	10.40	10.50
10	OR000171	Yamhill Crime Victim's Asstnc	26.50	27.20	54.00	54.70
11	OR000179	Dundee Police Dept	33.40	34.30	70.00	70.80

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Essential Facilities Results - Emergency Response - Police Station, Functionality Printed on: 6/25/2014 4:47:24 PM

	@ Day 30	@ Day 90
1	76.70	78.60
2	76.10	78.20
3	72.50	74.30
4	79.50	83.10
5	64.50	66.10
6	64.40	66.00
7	76.90	79.10
8	75.70	78.00
9	30.60	45.30
10	72.50	74.30
11	94.30	96.80

Emergency Response – Fire Station, Structural Damage

Essential Facilities Results - Emergency Response - Fire Station, Structural Damage Printed on: 6/25/2014 4:47:40 PM

	ID Number	Name	None	Slight	Moderate	Extensive
1	OR000003	Lafayette F.D.	0.271	0.281	0.175	0.035
2	OR000004	Dayton Fire District	0.273	0.280	0.174	0.035
3	OR000229	Carlton Fire Department	0.234	0.250	0.160	0.033
4	OR000230	Yamhill Fire Protection District	0.234	0.250	0.160	0.033
5	OR000231	Willamina Fire District	0.237	0.282	0.195	0.042
6	OR000232	Sheridan Fire District	0.265	0.298	0.198	0.042
7	OR000233	West Valley Fire District	0.237	0.282	0.195	0.042
8	OR000234	McMinnville Fire Department_RVS_YW	0.052	0.053	0.201	0.294
9	OR000235	Amity Fire District	0.237	0.250	0.158	0.032
10	OR000240	Falls City Volunteer Fire Department	0.300	0.342	0.237	0.069
11	OR000241	Polk County Fire District 1	0.256	0.282	0.185	0.038
12	OR000258	Nestucca Rural Fire Protection District	0.200	0.282	0.222	0.054
13	OR000259	Nestucca Rural Fire Protection District	0.199	0.266	0.202	0.047
14	OR000260	Nestucca Rural Fire Protection District	0.187	0.280	0.231	0.059
15	OR000274	Nestucca Rural Fire Protection District	0.166	0.249	0.206	0.052
16	OR000275	Nestucca Rural Fire Protection District	0.214	0.314	0.255	0.064
17	OR000276	Nestucca Rural Fire Protection District	0.150	0.230	0.193	0.050
18	OR000277	North Lincoln Fire & Rescue District 1	0.207	0.319	0.269	0.073
19	OR000321	Dundee Fire Department	0.320	0.358	0.225	0.048
20	OR000329	Depoe Bay Rural Fire Protection District	0.201	0.318	0.274	0.075

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Essential Facilities Results - Emergency Response - Fire Station, Structural Damage Printed on: 6/25/2014 4:47:40 PM

	Complete	At Least Slight	At Least Moderate	At Least Extensive
1	0.238	0.729	0.449	0.273
2	0.238	0.727	0.447	0.273
3	0.323	0.766	0.515	0.356
4	0.323	0.766	0.516	0.356
5	0.245	0.763	0.481	0.287
6	0.197	0.735	0.436	0.238
7	0.245	0.763	0.481	0.287
8	0.399	0.948	0.894	0.693
9	0.323	0.763	0.513	0.355
10	0.052	0.700	0.358	0.121
11	0.239	0.744	0.462	0.277
12	0.242	0.800	0.519	0.296
13	0.286	0.801	0.535	0.333
14	0.243	0.813	0.533	0.302
15	0.327	0.834	0.585	0.379
16	0.153	0.786	0.472	0.217
17	0.377	0.850	0.620	0.427
18	0.131	0.793	0.474	0.205
19	0.048	0.680	0.321	0.096
20	0.133	0.799	0.482	0.208

Emergency Response – Fire Station, Functionality

Essential Facilities Results - Emergency Response - Fire Station, Functionality   Printed on: 6/25/2014 4:47:45 PM

	ID Number	Name	@ Day 1	@ Day 3	@ Day 7	@ Day 14
1	OR000003	Lafayette F.D.	27.00	27.70	54.40	55.10
2	OR000004	Dayton Fire District	27.20	27.90	54.60	55.30
3	OR000229	Carlton Fire Department	23.40	24.00	47.80	48.40
4	OR000230	Yamhill Fire Protection District	23.30	23.90	47.80	48.40
5	OR000231	Willamina Fire District	23.70	24.30	51.20	51.80
6	OR000232	Sheridan Fire District	26.50	27.20	55.60	56.30
7	OR000233	West Valley Fire District	23.70	24.30	51.20	51.80
8	OR000234	McMinnville Fire Department_RVS_YW	5.20	5.30	10.40	10.50
9	OR000235	Amity Fire District	23.60	24.20	48.00	48.60
10	OR000240	Falls City Volunteer Fire Department	29.90	30.70	63.30	64.20
11	OR000241	Polk County Fire District 1	25.50	26.20	53.10	53.80
12	OR000258	Nestucca Rural Fire Protection District	19.90	20.50	47.40	48.10
13	OR000259	Nestucca Rural Fire Protection District	19.80	20.40	45.90	46.50
14	OR000260	Nestucca Rural Fire Protection District	18.60	19.30	46.00	46.70
15	OR000274	Nestucca Rural Fire Protection District	16.60	17.10	40.90	41.50
16	OR000275	Nestucca Rural Fire Protection District	21.40	22.10	52.00	52.80
17	OR000276	Nestucca Rural Fire Protection District	14.90	15.50	37.40	37.90
18	OR000277	North Lincoln Fire & Rescue District 1	20.70	21.40	51.80	52.60
19	OR000321	Dundee Fire Department	32.00	32.80	67.00	67.80
20	OR000329	Depoe Bay Rural Fire Protection District	20.00	20.80	51.10	51.80

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Essential Facilities Results - Emergency Response - Fire Station, Functionality Printed on: 6/25/2014 4:47:45 PM

	@ Day 30	@ Day 90
1	72.60	74.40
2	72.70	74.40
3	64.40	66.00
4	64.40	66.00
5	71.30	73.40
6	76.10	78.20
7	71.30	73.40
8	30.60	45.30
9	64.40	66.00
10	87.90	91.30
11	72.20	74.10
12	70.30	73.00
13	66.60	69.00
14	69.80	72.70
15	62.00	64.60
16	78.20	81.40
17	57.30	59.80
18	79.50	83.10
19	90.30	92.70
20	79.20	82.90

Shelter Results

Shelter Results - Printed on: 6/25/2014 4:56:11 PM

	Tract	Displaced Households	Short Term Shelter Needs
1	41041950100	82	52
2	41041950300	298	180
3	41041950400	320	217
4	41041950600	217	115
5	41053020100	13	8
6	41053020201	77	53
7	41053020400	111	71
8	41057960700	62	39
9	41057960800	85	48
10	41071030300	99	62
11	41071030400	109	70
12	41071030501	139	144
13	41071030502	155	111
14	41071030600	120	76
15	41071030701	110	66
16	41071030702	227	164
17	41071030801	257	188
18	41071030802	124	131
19	41071030900	65	51
20	41071031000	29	20