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Oregon Department of Geology and Mineral Industries
Brad Avy, State Geologist

OPEN-FILE REPORT O-19-02

RESILIENCE GUIDANCE FOR OREGON HOSPITALS

by Yumei Wang[1] and Kyra L. Nourse[2]

2019

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TABLE OF CONTENTS

LIST OF CREW GUIDANCE DOCUMENTS ATTACHED TO THIS REPORT

Guidance documents are included with this report as PDFs.

- Preparing Hospitals for Earthquakes: Structural and Nonstructural Issues
- Emergency Power for Hospitals: Preparing for Cascadia
- Emergency Water for Hospitals: Preparing for Cascadia

1.0 INTRODUCTION

Most hospital buildings in Oregon were constructed prior to any knowledge of the risk of a magnitude 9 Cascadia earthquake and tsunami and before significant seismic building code provisions were enacted in the mid-1990s (Lewis, 2007). Oregon's coastal hospitals are especially vulnerable due to their proximity to the Cascadia subduction zone. Seismic vulnerability is increased by poor construction as a result of inadequate building codes and by long-term disruptions of emergency fuel and water supplies likely to follow a major earthquake. Given current conditions, post-earthquake operations are expected to be severely impacted, which will limit the ability of hospitals to provide healthcare services to their communities (Wang, 2017, 2018).

As part of the Coastal Hospital Resilience Project, the Oregon Health Authority (OHA) Healthcare Preparedness Program (HPP) regional liaisons and the Oregon Department of Geology and Mineral Industries (DOGAMI) are partnering with the 11 hospitals along the Oregon coast to engage in disaster preparedness planning. Leadership at all 11 coastal hospitals are committed to preparing to be able to provide healthcare services immediately after a Cascadia earthquake and tsunami (Wang and others, 2019). Preparing for Cascadia earthquakes will also help with preparing for other types of disasters, such as winter storms and human-caused disasters.

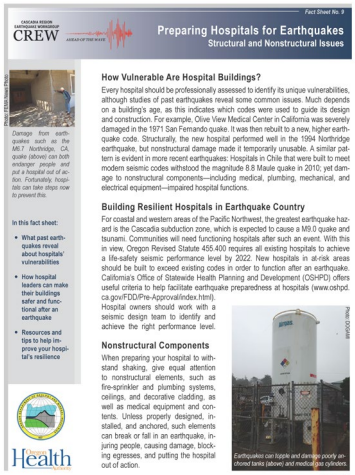
Hospital decision makers, including leadership, facility managers, emergency planners and other personnel, require practical scientific information and technical guidance on Cascadia disaster preparedness. This report, which is part of the Coastal Hospital Resilience Project, includes three Cascadia Region Earthquake Workgroup (CREW) guidance documents designed to assist hospitals personnel in their preparedness efforts.

2.0 GUIDANCE DOCUMENTS

The CREW guidance documents provide basic information on the importance of preparing hospitals by addressing issues related to building structures and the power and water services required to operate the hospital. They are designed to be easy to understand, promote resilience action planning, and point to detailed reference documents.

These guidance documents indicate that, at the current time, the State of Oregon does not expect state emergency assistance to be available to the coastal hospitals until about three weeks after a Cascadia earthquake and tsunami. This means that coastal hospitals will need to be largely self-sufficient, relying on help from their county and community partners alone. This three-week timeframe is consistent with the Oregon Resilience Plan (Oregon Seismic Safety Policy Advisory Commission, 2013) and the Oregon Fuel Action Plan (Oregon Department of Energy, 2017).

The three guidance documents are:


Fact Sheet No. 9

CREW

Preparing Hospitals for Earthquakes
Structural and Nonstructural Issues

How Vulnerable Are Hospital Buildings?

Every hospital should be professionally assessed to identify its unique vulnerabilities, although studies of past earthquakes reveal some common issues. Much depends on a building's age, as this indicates which codes were used to guide its design and construction. For example, Olive View Medical Center in California was severely damaged in the 1971 San Fernando quake. It was then rebuilt to a new, higher earthquake code. Structurally, the new hospital performed well in the 1994 Northridge earthquake, but nonstructural damage made it temporarily unusable. A similar pattern is evident in more recent earthquakes: Hospitals in Chile that were built to meet modern seismic codes withstood the magnitude 8.8 Maule quake in 2010; yet damage to nonstructural components—including medical, plumbing, mechanical, and electrical equipment—impaired hospital functions.

Damage from earthquakes, such as the M6.7 Northridge, CA, quake (above) can both endanger people and put a hospital out of action. Fortunately, hospitals can take steps now to prevent this.

In this fact sheet:

- What past earthquakes reveal about hospitals' vulnerabilities
- How hospital leaders can make their buildings safer and functional after an earthquake
- Resources and tips to help improve your hospital's resilience

Building Resilient Hospitals in Earthquake Country

For coastal and western areas of the Pacific Northwest, the greatest earthquake hazard is the Cascadia subduction zone, which is expected to cause a M9.0 quake and tsunami. Communities will need functioning hospitals after such an event. With this in view, Oregon Revised Statute 455.400 requires all existing hospitals to achieve a life-safety seismic performance level by 2022. New hospitals in at-risk areas should be built to exceed existing codes in order to function after an earthquake. California's Office of Statewide Health Planning and Development (OSHPD) offers useful criteria to help facilitate earthquake preparedness at hospitals (www.oshpd.ca.gov/FDD/Pre-Approval/index.html). Hospital owners should work with a seismic design team to identify and achieve the right performance level.

Nonstructural Components

When preparing your hospital to withstand shaking, give equal attention to nonstructural elements, such as fire-sprinkler and plumbing systems, ceilings, and decorative cladding, as well as medical equipment and contents. Unless properly designed, installed, and anchored, such elements can break or fall in an earthquake, injuring people, causing damage, blocking egresses, and putting the hospital out of action.

Peter Dolan

Earthquakes can topple and damage poorly anchored tanks (above) and medical gas cylinders.

Health

Page 1 of 2

CREW Fact Sheet No. 9, 2 pages

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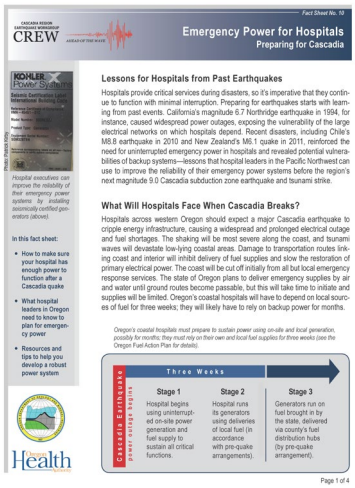
Fact Sheet No. 10

CREW

Emergency Power for Hospitals
Preparing for Cascadia

KOHLER Power Systems

Hospital executives can improve the reliability of their emergency power systems by installing seismically certified generators (above).

In this fact sheet:

- How to make sure your hospital has enough power to function after a Cascadia quake
- What hospital leaders in Oregon need to know to plan for emergency power
- Resources and tips to help you develop a robust power system

Lessons for Hospitals from Past Earthquakes

Hospitals provide critical services during disasters, so it's imperative that they continue to function with minimal interruption. Preparing for earthquakes starts with learning from past events. California's magnitude 6.7 Northridge earthquake in 1994, for instance, caused widespread power outages, exposing the vulnerability of the large electrical networks on which hospitals depend. Recent disasters, including Chile's M8.8 earthquake in 2010 and New Zealand's M6.1 quake in 2011, reinforced the need for uninterrupted emergency power in hospitals and revealed potential vulnerabilities of backup systems—lessons that hospital leaders in the Pacific Northwest can use to improve the reliability of their emergency power systems before the region's next magnitude 9.0 Cascadia subduction zone earthquake and tsunami strike.

What Will Hospitals Face When Cascadia Breaks?

Hospitals across western Oregon should expect a major Cascadia earthquake to cripple energy infrastructure, causing a widespread and prolonged electrical outage and fuel shortages. The shaking will be most severe along the coast, and tsunami waves will devastate low-lying coastal areas. Damage to transportation routes linking coast and interior will inhibit delivery of fuel supplies and slow the restoration of primary electrical power. The coast will be cut off initially from all but local emergency response services. The state of Oregon plans to deliver emergency supplies by air and water until ground routes become passable, but this will take time to initiate and supplies will be limited. Oregon's coastal hospitals will have to depend on local sources of fuel for three weeks; they will likely have to rely on backup power for months.

Oregon's coastal hospitals must prepare to sustain power using on-site and local generation, possibly for months; they must rely on their own and local fuel supplies for three weeks (see the Oregon Fuel Action Plan for details).

Health

Page 1 of 4

CREW Fact Sheet No. 10, 4 pages

Emergency Power for Hospitals: Preparing for Cascadia

- How to make sure your hospital has enough power to function after a Cascadia quake
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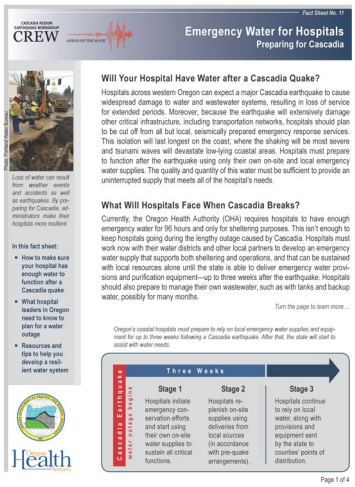
Fact Sheet No. 11

CREW

Emergency Water for Hospitals
Preparing for Cascadia

Loss of water can result from weather events and accidents as well as earthquakes. By preparing for Cascadia, administrators make their hospitals more resilient.

In this fact sheet:

- How to make sure your hospital has enough water to function after a Cascadia quake
- What hospital leaders in Oregon need to know to plan for a water outage
- Resources and tips to help you develop a resilient water system

Will Your Hospital Have Water after a Cascadia Quake?

Hospitals across western Oregon can expect a major Cascadia earthquake to cause widespread damage to water and wastewater systems, resulting in loss of service for extended periods. Moreover, because the earthquake will extensively damage other critical infrastructure, including transportation networks, hospitals should plan to be cut off from all but local, seismically prepared emergency response services. This isolation will last longest on the coast, where the shaking will be most severe and tsunami waves will devastate low-lying coastal areas. Hospitals must prepare to function after the earthquake using only their own on-site and local emergency water supplies. The quality and quantity of this water must be sufficient to provide an uninterrupted supply that meets all of the hospital's needs.

What Will Hospitals Face When Cascadia Breaks?

Currently, the Oregon Health Authority (OHA) requires hospitals to have enough emergency water for 96 hours and only for sheltering purposes. This isn't enough to keep hospitals going during the lengthy outage caused by Cascadia. Hospitals must work now with their water districts and other local partners to develop an emergency water supply that supports both sheltering and operations, and that can be sustained with local resources alone until the state is able to deliver emergency water provisions and purification equipment—up to three weeks after the earthquake. Hospitals should also prepare to manage their own wastewater, such as with tanks and backup water, possibly for many months.

Turn the page to learn more...

Oregon's coastal hospitals must prepare to rely on local emergency water supplies and equipment for up to three weeks following a Cascadia earthquake. After that, the state will start to assist with water needs.

Health

Page 1 of 4

CREW Fact Sheet No. 11, 4 pages

Emergency Water for Hospitals: Preparing for Cascadia

- How to make sure your hospital has enough water to function after a Cascadia quake
- What hospital leaders in Oregon need to know to plan for a water outage
- Resources and tips to help you develop a resilient water system

3.0 KEY MESSAGES FROM THE COASTAL HOSPITAL RESILIENCE PROJECT

As part of the Coastal Hospital Resilience Project, OHA and DOGAMI have emphasized seven key messages to hospitals as a means to improve their resilience. Although these seven key messages are in general alignment with traditional disaster preparedness practices, the messages are more holistic and broadly community based. The third key message involves the use of the three guidance documents.

The seven key messages are:

1. **Identify alternate care sites.** If a hospital is in a defined tsunami hazard zone or has pre-1995 buildings, it is likely to experience significant damage. If the damage prevents use of the hospital, then it would be important for the hospital to have an alternate care site. Leadership for hospitals in the tsunami hazard zone have been informed of the amount of time that it will take for a tsunami to arrive at the hospital site. This time is referred to as the tsunami arrival time. Hospital decision makers should adopt defense options, such as creating efficient tsunami evacuation routes and protecting the hospital with wave and energy dissipating walls.
2. **Plan to be locally self-sufficient for three weeks.** After that, state support will be provided to the county, and the county will support the hospital.
3. **Evaluate seismic vulnerabilities and prepare using the guidance documents:**
    a. Preparing Hospitals for Earthquakes: Structural and Nonstructural Issues
    b. Emergency Power for Hospitals: Preparing for Cascadia
    c. Emergency Water for Hospitals: Preparing for Cascadia
4. **Develop a hospital resilience action plan.** Include strategies for mitigating vulnerabilities in the building, power, and water supplies. Determine ways to implement the action plan, including working out financial resources.
5. **Engage in the Oregon Coastal Hospital Resilience Network.** Collaborate with other coastal hospitals, OHA, and other partners to learn about options to accelerate resilience activities.
6. **Partner with the community, including the county emergency manager and power and water service providers.** It is critical to work closely with county emergency managers because they will assist with emergency response needs during disasters. This includes providing emergency fuel requirements for hospital emergency generators to be integrated into the Oregon Department of Energy's State Fuel Action Plan (2017).
7. **Be a community resilience champion.** Share with others the steps hospital personnel are taking to improve hospital resilience and encourage others to take similar actions. Discuss areas of concern with others and work with the community to find solutions. Remember that everyone in the community relies on healthcare services.

4.0 ACKNOWLEDGMENTS

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- Jenny Demaris, Lincoln County Emergency Manager
- Wayne Stinson, Douglas County Emergency Manager
- Mike Murphy, Coos County Emergency Manager
- Jeremy Dumire, Curry County Emergency Manager

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CASCADIA REGION EARTHQUAKE WORKGROUP
CREW
AHEAD OF THE WAVE

Preparing Hospitals for Earthquakes
Structural and Nonstructural Issues

Photo: FEMA News Photo

Damage from earthquakes such as the M6.7 Northridge, CA, quake (above) can both endanger people and put a hospital out of action. Fortunately, hospitals can take steps now to prevent this.

In this fact sheet:

- **What past earthquakes reveal about hospitals' vulnerabilities**
- **How hospital leaders can make their buildings safer and functional after an earthquake**
- **Resources and tips to help improve your hospital's resilience**

How Vulnerable Are Hospital Buildings?

Every hospital should be professionally assessed to identify its unique vulnerabilities, although studies of past earthquakes reveal some common issues. Much depends on a building's age, as this indicates which codes were used to guide its design and construction. For example, Olive View Medical Center in California was severely damaged in the 1971 San Fernando quake. It was then rebuilt to a new, higher earthquake code. Structurally, the new hospital performed well in the 1994 Northridge earthquake, but nonstructural damage made it temporarily unusable. A similar pattern is evident in more recent earthquakes: Hospitals in Chile that were built to meet modern seismic codes withstood the magnitude 8.8 Maule quake in 2010; yet damage to nonstructural components—including medical, plumbing, mechanical, and electrical equipment—impaired hospital functions.

Building Resilient Hospitals in Earthquake Country

For coastal and western areas of the Pacific Northwest, the greatest earthquake hazard is the Cascadia subduction zone, which is expected to cause a M9.0 quake and tsunami. Communities will need functioning hospitals after such an event. With this in view, Oregon Revised Statute 455.400 requires all existing hospitals to achieve a life-safety seismic performance level by 2022. New hospitals in at-risk areas should be built to exceed existing codes in order to function after an earthquake. California's Office of Statewide Health Planning and Development (OSHPD) offers useful criteria to help facilitate earthquake preparedness at hospitals (www.oshpd.ca.gov/FDD/Pre-Approval/index.html). Hospital owners should work with a seismic design team to identify and achieve the right performance level.

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When preparing your hospital to withstand shaking, give equal attention to nonstructural elements, such as fire-sprinkler and plumbing systems, ceilings, and decorative cladding, as well as medical equipment and contents. Unless properly designed, installed, and anchored, such elements can break or fall in an earthquake, injuring people, causing damage, blocking egresses, and putting the hospital out of action.

Photo: DOGAMI

Earthquakes can topple and damage poorly anchored tanks (above) and medical gas cylinders.

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Oregon Health Authority

Tips & Tools for Existing Buildings

- **Arrange for subject experts to examine the hospital's site and buildings using the Hospital Seismic Evaluation Checklist in FEMA 577.**
- **Use FEMA P-767 to learn how to reduce seismic risks incrementally.**
- **Remember to assess mechanical equipment rooms and systems; include them in your mitigation plans.**

How Ready Is Your Hospital for the Next Earthquake?

Assess existing buildings and systems to identify vulnerabilities that must be mitigated to enable your hospital to withstand an earthquake and remain operational.

- Engage qualified, licensed structural engineers to use ASCE 41 to conduct seismic engineering evaluations of both structural and nonstructural features.
- Use FEMA P-1019 to evaluate the emergency power system; prepare to function on such power for three weeks (see CREW fact sheet #10).
- Use CDC guidelines to assess the hospital's water needs and plan for water outages; prepare the hospital to function on emergency water supplies for three weeks (see CREW fact sheet #11).

Develop and implement a resilience action plan based on your findings; be sure to consult your local partners, including emergency managers, water districts, electricity providers, school and elected officials, and other healthcare providers.

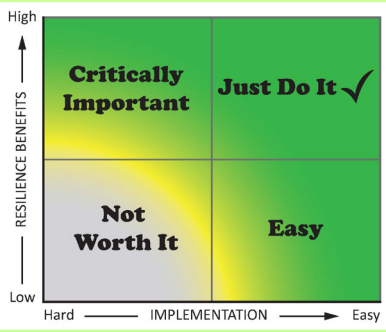
ASCE 41: What to Expect

Ask the structural engineer who performs your ASCE 41 assessment to provide an executive summary for non-experts, along with a section called "Expected Building Performance" that specifies whether the existing building meets the hospital's immediate-occupancy performance level objective. If not, it should explain the key issues, compare the building to the performance of a new-code building, and describe:

- The building, structural systems, and renovations/retrofits completed since original construction.
- The documents reviewed, assumptions made during evaluation, and performance level for evaluation
- Structural and nonstructural deficiencies, what they mean in terms of expected seismic performance, the part(s) of the building that would experience the most damage, how the building can be retrofitted, and the impacts of completing retrofits.

Upgrading Existing Hospitals

Upgrade incrementally to improve safety and achieve greater functionality after an earthquake by ranking and implementing proposed upgrades to achieve the greatest impact with available resources.



Featured Resources

ASCE 41-17: *Seismic Evaluation and Retrofit of Existing Buildings*. American Society of Civil Engineers (2017).

FEMA E-74: *Reducing the Risks of Nonstructural Earthquake Damage* (2012b).

FEMA 577: *Design Guide for Improving Hospital Safety in Earthquakes, Floods, and High Winds* (2007), and FEMA P-767: *Earthquake Mitigation for Hospitals* (2013).

Emergency Power for Hospitals (CREW Fact Sheet #10) and *Emergency Water for Hospitals* (CREW Fact Sheet #11).

Office of Statewide Health Planning and Development (OSHPD): www.oshpd.ca.gov/FDD/Pre-Approval/index.html

Oregon

Oregon Coastal Hospitals Preparing for Cascadia (DOGAMI Open-File Report 0-18-03), [see especially Appendix A: Technical Resources List for Hospitals]. www.oregongeology.org/pubs/ofr/O-18-03_report.pdf

Oregon Health Authority (OHA) Prepare for Earthquakes website: http://public.health.oregon.gov/Preparedness/Prepare/Pages/Prepare-ForEarthquake.aspx

Oregon Revised Statute (ORS) 455.400: https://www.oregonlaws.org/ors/455.400

Hospitals in Oregon can apply to the Seismic Rehabilitation Grant Program for up 2.5 million to support seismic upgrades: www.orinfrastructure.org/Infrastructure-Programs/Seismic-Rehab/

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Emergency Power for Hospitals
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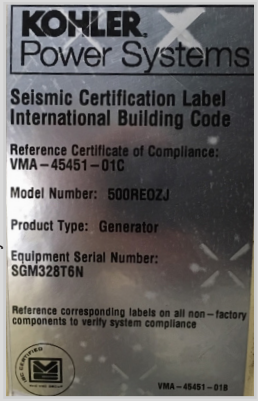

Photo: Patrick Kirby

Hospital executives can improve the reliability of their emergency power systems by installing seismically certified generators (above).

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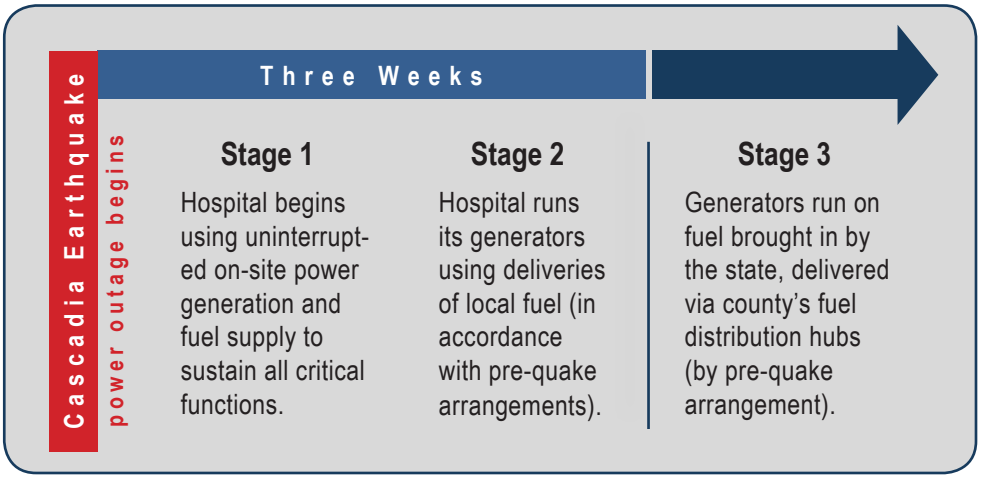
Oregon's coastal hospitals must prepare to sustain power using on-site and local generation, possibly for months; they must rely on their own and local fuel supplies for three weeks (see the Oregon Fuel Action Plan *for details).*



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Oregon Health Authority

Strategy for Post-Earthquake Emergency Power at Oregon Hospitals

Hospitals in western Oregon can improve their resilience by envisioning their post-earthquake emergency power and fuel strategy in three stages and by taking steps now to meet the demands of each stage.

TO PREPARE FOR:	LOCAL/REGIONAL HOSPITAL LEADERSHIP SHOULD:
Weeks 1 – 3 **Stage 1** Hospital switches to on-site emergency power if main power fails; hospital supplies itself with uninterrupted power by running generators using on-site fuel sources.	☐ Reduce the risk of power outages by building redundancy into the electrical system (such as two separate electrical feeder lines into the hospital). ☐ Identify critical functions and install a seismically designed emergency power system sufficient to run them (preferably, 100% of normal load). This should include: • Seismically certified emergency generators, with earthquake-ready components (anchored generator, well-braced batteries, flexible connections for exhaust system, switchgear, etc.). • Fuel storage tanks with earthquake-ready components (fuel pumps, fuel lines, flexible connections, etc.). • An adequate on-site supply of fuel and maintenance supplies (filters). • Earthquake-resistant housing for emergency power equipment to protect against structural and nonstructural damage.
Stage 2 Hospital continues to run generators using local supplies of fuel for three weeks.	☐ Work in advance with county emergency managers and local vendors to plan for deliveries from nearby secure, earthquake-resistant fuel depots (such as non-retail card-lock facilities and retail gas stations) and servicing by qualified technicians.
After 3RD Week **Stage 3** Hospital continues to run generators with fuel sent by State of Oregon to county-designated fuel points of distribution (FPODs).	☐ Prearrange with county emergency managers for the hospital to receive fuel. ☐ Talk to the county about their emergency fuel management plan.* *See an example—*Washington County Emergency Fuel Management Plan*: https://www.co.washington.or.us/EmergencyManagement/plans-and-agreements.cfm

Did You Know?

In line with the *Oregon Fuel Action Plan*, county emergency managers will:

- **Identify critical facilities with priority to receive emergency fuel deliveries when fuel is available.**
- **Designate fuel points of distribution for fuel deliveries by the state.**
- **Identify delivery methods.**
- **Prioritize repair of roads to access critical facilities.**

Emergency generators are best suited to short-term use; recovery of electrical power after a Cascadia event could take months. A local resilient power source could be a better long-term solution. (Learn more on Page 4.)

Photo: DOGAMI

Example of flexible connections.

Nuts and Bolts

The cause of emergency power system failures in past earthquakes is typically nonstructural, including poorly anchored fuel tanks, batteries, and exhaust stacks. When installing seismically certified equipment, use flexible connections and make sure all parts of the system are properly selected, installed, and braced. Arrange for qualified experts to conduct a comprehensive seismic assessment of the emergency power system and mitigate deficiencies. Also, ask experts to examine both site and buildings using the Hospital Seismic Evaluation Checklist in section 2.5 of FEMA 577 *Design Guide for Improving Hospital Safety in Earthquakes, Floods, and High Winds: Providing Protection to People and Buildings* (2007).

Features of a Resilient Emergency Power System

PeaceHealth Peace Harbor Medical Center in Florence, Oregon, applied best practices for earthquake preparedness when installing its on-site emergency power system:

- The hospital campus is served by two separate electrical feeds, and the local utility, Central Lincoln PUD, can switch between the two.
- The emergency power system (including generator, fuel system, and switching gear) was specifically designed by a qualified engineer to be operational after a Cascadia earthquake.
- The emergency power system supplies nearly all hospital functions, including the kitchens. (Only a section of the cafeteria is excluded.)
- The hospital can monitor loads on each branch and subbranch of the power system; and the system is designed to make switching easy to limit the load and supply power to essential functions only.

The hospital's on-site fuel tank is properly anchored and fuel line connections are flexible. (Photo: DOGAMI)

Tips & Tools

Is your generator seismically certified? Is your emergency power system ready to supply the hospital?

Use FEMA's Checklist for Emergency Planning Prior to Emergency or Disaster to evaluate the status of your system. (Find this and related checklists in FEMA P-1019, Appendix D).

Meeting Hospitals' Emergency Power Needs

Hospitals should develop emergency power systems to meet the objectives in their disaster management plans. At a minimum, they should identify the amount of power needed to sustain critical functions. To be fully operational, they must develop emergency power systems that cover 100 percent of their normal electrical loads: This may require designing new systems or upgrading existing systems above the minimum levels specified in building codes.

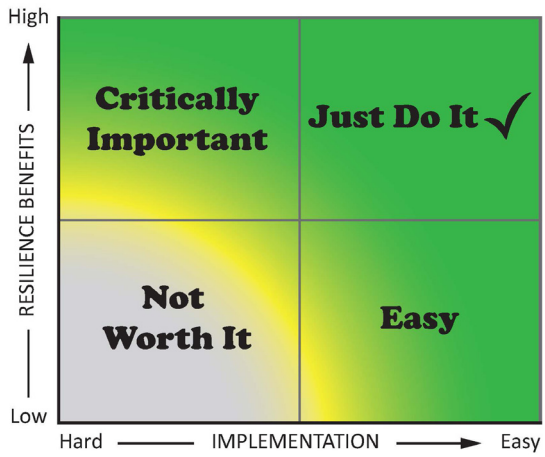
Determining how much emergency power the hospital requires starts with establishing priorities. A good first step is to group medical equipment and support facilities into three power-distribution branches: the equipment branch, critical branch, and life-safety branch (for guidance, see FEMA P-1019, Appendix A; and NFPA 99 Healthcare Facilities Code).

Upgrading Existing Hospitals

To remain functional after a Cascadia earthquake, new hospitals must be built to exceed current code requirements; existing hospitals can upgrade structures and systems incrementally to achieve similar goals.

The diagram (right) shows how to rank and implement proposed upgrades to achieve the greatest impact using available resources.

Hospitals in Oregon can apply to the Seismic Rehabilitation Grant Program for up to $2.5 million to support upgrades: www.orinfrastructure.org/Infrastructure-Programs/Seismic-Rehab/



Resilient Local Power

Most hospitals depend on "centralized generation," making them part of a region-spanning network or "macrogrid." A Cascadia earthquake will damage this system, and it's expected to take months to restore power. Hospitals should therefore consider a "distributed generation" option—a source of local power that is sufficient to supply the hospital indefinitely. Ideally, a local source is coupled with a microgrid (which can be disconnected from the macrogrid when necessary) and with Smart Grid technologies (www.smartgrid.gov).

Local Power Sources in Tillamook County, Oregon

A local source of power is already at work in Tillamook County: Bio-digestors. The digestors turn dairy farm manure into electrical power. Such local generation could be developed as part of a microgrid and could supply the local hospital with power when the macrogrid is down.

Building Resilience through Partnerships

The local power company is a key partner. Ask your company:

- If it has assessed its seismic vulnerability and developed a mitigation plan.
- If it is considering options for local power generation.

For example, Tillamook PUD is exploring alternative energy sources and a microgrid for Tillamook Regional Medical Center and other critical facilities.

Hospitals rely on local fuel suppliers. Ask them about their preparations for earthquakes and other emergencies.

Serving the community in a crisis is a priority for the owners of Sheldon Oil Co. in Tillamook. After a lengthy power outage in 2006 left them hand-pumping fuel for emergency services and others, they installed emergency generators and transfer switches (photo) at their facilities.


Photo: DOGAMI

Tips & Tools

If a hospital's generators fail in a crisis, FEMA and the U.S. Army Corps of Engineers may provide a back-up. Pre-register now using EPFAT (Emergency Power Facility Assessment Tool). Keep in mind that earthquake damage to roads and other routes may delay delivery.

Additional Resources

FEMA P-1019: *Emergency Power Systems for Critical Facilities* (2014).

FEMA 577: *Design Guide for Improving Hospital Safety in Earthquakes, Floods, and High Winds* (2007).

Emergency Power Facility Assessment Tool (EPFAT). https://epfat.usace.army.mil/

Emergency Water for Hospitals: Preparing for Cascadia (CREW Fact Sheet #11).

Oregon

Earthquake Risk Study for Oregon's Critical Energy Infrastructure Hub (DOGAMI Open-File Report 0-13-09). www.oregongeology.org/pubs/ofr/p-O-13-09.htm

Oregon Coastal Hospitals Preparing for Cascadia (DOGAMI Open-File Report 0-18-03) [see especially Appendix A: Technical Resources List for Hospitals]. www.oregongeology.org/pubs/ofr/O-18-03_report.pdf

Oregon Fuel Action Plan (October 2017). Oregon Department of Energy. www.oregon.gov/energy/facilities-safety/safety/Documents/Oregon-Fuel-Action-Plan.pdf

Oregon Health Authority (OHA) Prepare for Earthquakes website. http://public.health.oregon.gov/Preparedness/Prepare/Pages/PrepareForEarthquake.aspx

CASCADIA REGION EARTHQUAKE WORKGROUP
CREW
AHEAD OF THE WAVE

Emergency Water for Hospitals
Preparing for Cascadia

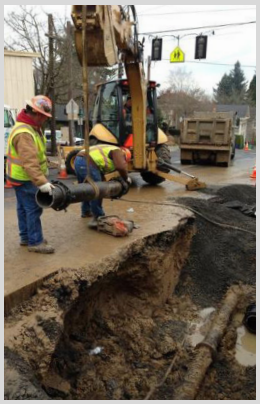


Photo: Portland Water Bureau

Loss of water can result from weather events and accidents as well as earthquakes. By preparing for Cascadia, administrators make their hospitals more resilient.

In this fact sheet:

- **How to make sure your hospital has enough water to function after a Cascadia quake**
- **What hospital leaders in Oregon need to know to plan for a water outage**
- **Resources and tips to help you develop a resilient water system**

Will Your Hospital Have Water after a Cascadia Quake?

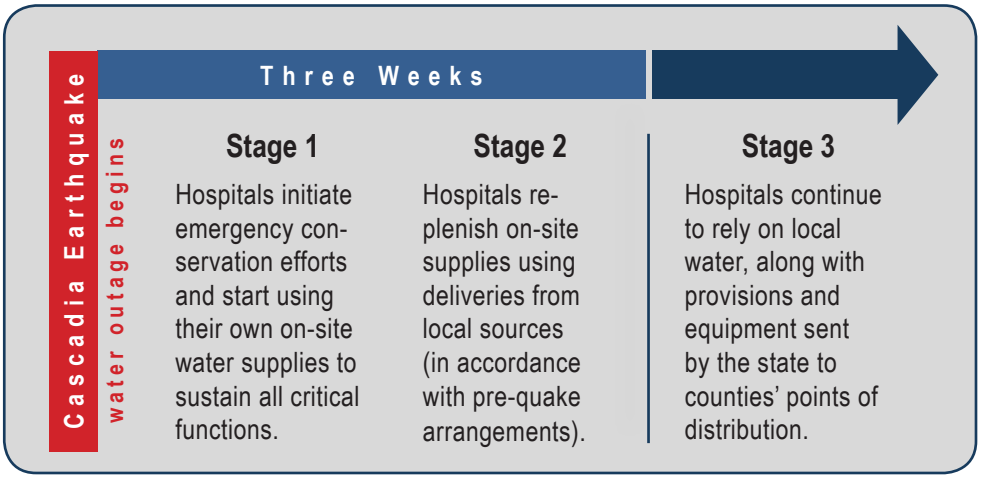
Hospitals across western Oregon can expect a major Cascadia earthquake to cause widespread damage to water and wastewater systems, resulting in loss of service for extended periods. Moreover, because the earthquake will extensively damage other critical infrastructure, including transportation networks, hospitals should plan to be cut off from all but local, seismically prepared emergency response services. This isolation will last longest on the coast, where the shaking will be most severe and tsunami waves will devastate low-lying coastal areas. Hospitals must prepare to function after the earthquake using only their own on-site and local emergency water supplies. The quality and quantity of this water must be sufficient to provide an uninterrupted supply that meets all of the hospital's needs.

What Will Hospitals Face When Cascadia Breaks?

Currently, the Oregon Health Authority (OHA) requires hospitals to have enough emergency water for 96 hours and only for sheltering purposes. This isn't enough to keep hospitals going during the lengthy outage caused by Cascadia. Hospitals must work now with their water districts and other local partners to develop an emergency water supply that supports both sheltering and operations, and that can be sustained with local resources alone until the state is able to deliver emergency water provisions and purification equipment—up to three weeks after the earthquake. Hospitals should also prepare to manage their own wastewater, such as with tanks and backup water, possibly for many months.

Turn the page to learn more....

Oregon's coastal hospitals must prepare to rely on local emergency water supplies and equipment for up to three weeks following a Cascadia earthquake. After that, the state will start to assist with water needs.



OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES 1937

Oregon Health Authority

Strategy for Post-Earthquake Emergency Water at Oregon Hospitals

Hospital leaders can improve the resilience of their hospitals by envisioning their post-earthquake emergency water strategy in three stages and by taking steps now to meet the demands of each stage.

TO PREPARE FOR:	LOCAL/REGIONAL HOSPITAL LEADERS SHOULD:
Weeks 1 – 3 **Stage 1** The hospital responds to the loss of normal water supplies by following the procedures in its emergency water supply plan (EWSP), including making use of on-site emergency water supplies and taking steps to conserve water.	☐ Develop and routinely evaluate an emergency water supply plan (EWSP). ☐ Design or retrofit the hospital's water system to withstand a major Cascadia earthquake. ☐ Develop an earthquake-ready emergency water supply and delivery system that is sufficient for both sheltering and critical functions.
Stage 2 The hospital replenishes its on-site emergency water supplies by transporting water from other local sources, following the pre-disaster arrangements made with the hospital's water supplier, county emergency managers, and other local partners.	☐ Work now with city and county emergency managers, the local water district, and other local partners to identify emergency water supplies and develop a plan for testing water, purifying contaminated water if needed, and delivering water to the hospital. ☐ Install an external plumbing (emergency water) connection so that trucks can deliver water to the facility.
After 3RD Week **Stage 3** The hospital continues to replenish its water supplies locally; it may use water purification equipment and provisions delivered by the state to county-designated community points of distribution (CPODs). (County emergency managers arrange for use and distribution according to predetermined priorities.)	☐ Work now with the county emergency manager to identify the nearest community point of distribution (CPOD), communicate the hospital's needs, and verify that the hospital will receive priority when water purification equipment and other emergency water provisions are available.

To learn more about how you can prepare your hospital for each stage, keep reading this fact sheet and consult the *Emergency Water Supply Planning Guide for Hospitals and Health Care Facilities* by the Centers for Disease Control and Prevention and the American Water Works Association.

Brick veneer installed before the mid-1990s could fall off during an earthquake and break external connections.

Will Backup Systems Work after a Quake?

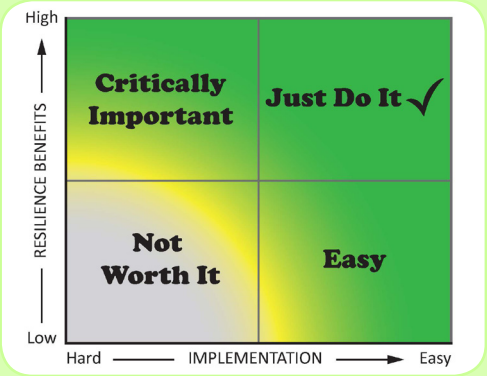
New hospital buildings should be built above current code standards so they're designed to function after an earthquake. When designing an emergency water supply system for an existing building, consider not only the components needed to make it work—such as booster pumps and shut-off valves—but also how to protect all parts of the system from damage during an earthquake.

For example, hospitals must install exterior plumbing connections to receive water from trucks. Design these and other plumbing components to resist earthquake damage. Also, remove or secure falling hazards, such as parapets and cladding, as these may damage connections during an earthquake or block access to them.

Resilience Checklist

Developing a resilient water system starts with understanding the plumbing, including where to find the valves and outlets that control the flow of water and flush the system. Earthquake-ready hospitals should have:

- ☐ Two or more separate water lines (feeds) connecting the hospital to the water district's system.
- ☐ An external plumbing connection for emergency water deliveries.
- ☐ An earthquake-resistant fire-sprinkler system.
- ☐ Shut-off valves in strategic locations.
- ☐ Equipment and components that are seismically designed and—when available—seismically certified.
- ☐ Earthquake-resistant water pipes throughout the hospital and from the water source to the hospital.
- ☐ Flexible connections, such as between buildings.
- ☐ Portable water-purification kits.
- ☐ A seismically designed delivery system, if relying on on-site emergency water sources, such as a well.
- ☐ Seismically designed tanks (AWWA D100) with flexible connections, if relying on large-capacity on-site storage.



Upgrading Existing Hospitals

Upgrading a hospital's systems can be both effective and easier when done step by step:

1. **Assess your system's vulnerabilities.**
2. **Prioritize mitigation based on ease of implementation and highest resilience benefits.**
3. **Plan and upgrade incrementally.**

The Oregon Seismic Rehabilitation Grant Program offers grants of up to $2.5 million to help mitigate seismic vulnerabilities in hospitals.

How Much Water Does Your Hospital Need?

Audit your water-usage and create an emergency water supply plan (EWSP). To learn how, see the CDC's *Emergency Water Supply Planning Guide for Hospitals and Health Care Facilities*.

Start by assessing how your system is used and works normally:

- How much water does the hospital use? For what purposes?
- What type of water (sterile, potable, or non-potable) is needed for each purpose?
- What uses are critical?
- How does the hospital control water and its uses during a shortage?
- Where does the water come from and how does the plumbing system, including wastewater, work?
- Is emergency power needed—and is it available—to maintain water pressure or otherwise run the system and pumps?

Identify Your Hospital's Emergency Water Sources

Work with your water district and local emergency planners to identify on-site and local sources of water (such as groundwater wells) and to determine how water will be tested for quality and purified. Verify that the quantity is adequate to meet the hospital's needs; then estimate how long supplies will last.

A hospital's emergency water supply may include multiple sources, such as water stored inside the building in containers (as shown at right), large on-site tanks, groundwater wells, and surface water. (Photo: DOGAMI)

Is Your Hospital Ready to Receive Emergency Water?

- ☐ Identify sources of tanker trucks to carry potable water; ask the county emergency manager and transportation engineers about likely routes.
- ☐ Arrange for necessary equipment, such as hoses, generators, pumps, and fuel.
- ☐ Regularly test water stored on-site in tanks; develop a plan with the water district to treat contaminated water and test water deliveries.
- ☐ Verify that you have what's needed (such as connections, valves, and backflow-prevention devices) to receive water from trucks. Know how to close connections to the main water supply to prepare the plumbing for delivery of emergency water.

How Resilient Is the Local Water Supply?

Resilience requires robust local water systems, which is why Oregon law requires water districts serving hospitals in western Oregon to assess seismic vulnerabilities and plan mitigation.

Hospitals should work with local water districts to ensure that the part of the system that serves the hospital is a top priority for mitigation, if needed. The district may install seismic shut-off valves, replace rigid connections with flexible connections and brittle pipes with earthquake-resistant pipes, or buy equipment, including seismically certified generators. Programs such as the Safe Drinking Water Revolving Loan Fund offer loans and grants to support the seismic mitigation work of water districts. (To learn more, consult the Infrastructure Finance Authority of the Oregon Business Development Department or the Oregon Office of Emergency Management.)

Hospitals should also ask if the local water district is part of OR-WARN: the Oregon Water/Wastewater Agency Response Network (www.orwarn.org).

What about Wastewater?

Hospitals must prepare to deal with wastewater during a post-Cascadia water outage. Discuss options with the local wastewater utility and review the hospital's plumbing diagrams to decide how to:

- Collect and dispose of (or store) wastewater for at least three weeks.
- Power the wastewater system (if power is required).
- Repair, clean out, and unclog pipes.

If the hospital will adopt special procedures during the crisis, be sure to train personnel and adequately stock whatever supplies will be needed, such as waste bags and disinfection tools.

Additional Resources

Emergency Water Supply Planning Guide for Hospitals and Health Care Facilities (2012). CDC and American Water Works Association: www.cdc.gov/healthywater/pdf/emergency/emergency-water-supply-planning-guide.pdf

FEMA 577 *Design Guide for Improving Hospital Safety in Earthquakes, Floods, and High Winds* (2007).

Emergency Power for Coastal Hospitals: Preparing for Cascadia (CREW Fact Sheet #10).

Oregon

Oregon Coastal Hospitals Preparing for Cascadia (DOGAMI Open-File Report 0-18-03), [see especially Appendix A: Technical Resources List for Hospitals]: www.oregongeology.org/pubs/ofr/O-18-03_report.pdf

Oregon Hospital and Water System Earthquake Risk Evaluation Pilot Study (DOGAMI Open-File Report 0-17-01, [see especially Appendix A: References for Water Facilities]: www.oregongeology.org/pubs/ofr/O-17-01.pdf

Oregon Seismic Rehabilitation Grant Program: www.orinfrastructure.org/Infrastructure-Programs/Seismic-Rehab/

Oregon Health Authority (OHA) Prepare for Earthquakes website: http://public.health.oregon.gov/Preparedness/Prepare/Pages/PrepareForEarthquake.aspx