

RESILIENT WASHINGTON

Recommendations 1, 8, and 9

Summary of Gap Analysis and Implementation Plan

Prepared by the Washington Geological Survey (DNR)



RECOMMENDATION 1: MAKE SCHOOLS RESILIENT: STRUCTURALLY, SOCIALLY, EDUCATIONALLY

Summary:

- **Stakeholders:** Everyone who has children in school or will have children in school, OSPI, DNR, citizens.
- **Implementation/Expectations for achieving the action:**
 - Need capital funds to do school evaluations. Repair or replace school buildings, beginning with those with the highest level of risk. Districts develop hazard mitigation plans to make them eligible for federal funding (when available).
 - Enact legislation that requires school districts to conduct at least one earthquake safety drill per school year. Schools in mapped tsunami hazard zones should conduct a pedestrian evacuation drill annually. Such a law should explicitly require drop, cover, and hold as the state's approved earthquake safety technique.
- **Resources needed:**
 - Funding for doing the initial evaluations of buildings. After initial evaluations and prioritization more funding has to be identified for developing plans for remediation and eventually completing the work on the buildings themselves.
 - Legislative support for stronger wording of the bill, actually requiring school EQ and evacuation drills, not just suggesting them.
- **Current efforts:**
 - DNR is doing some seismic analysis of schools using FEMA grants
 - SB 1279 in legislature now, but wording not strong enough

RECOMMENDATION 8: IDENTIFY AND MAP IN GREATER DETAIL SOURCES OF SEISMICITY AND GEOLOGICALLY HAZARDOUS AREAS AND DEVELOP PLANS FOR MITIGATION OF IDENTIFIED HAZARDS

Summary:

- **Stakeholders:** Washington citizens, U.S. Geological Survey, DNR, WA EMD, academic institutions such as University of Washington, local, county, and state agencies, utilities, WASHDOT, private sector businesses
- **Implementation/Expectations for achieving the action:**
 - High resolution geologic mapping to investigate active faulting
 - More extensive seismic network
 - Need more comprehensive paleoseismic studies to identify and characterize active crustal faults and to better determine the recurrence times of Cascadia M8-9 interface earthquakes.
 - Need to monitor slip and seismicity in the offshore portion of the Cascadia subduction zone, using seafloor GPS and seismometers.
 - Update the seismic scenario catalog to help local jurisdictions creating mitigation plans.

- Develop liquefaction and site class maps for counties and cities for appropriate identification for earthquake hazard critical area ordinances
- Mitigation requires accurate estimates of strong shaking from identified fault sources
- **Resources needed:**
 - Funding to conduct systematic seismic exploration studies (seismic reflection and refraction) of the shallow crust in WA State, focusing on sedimentary basins with major population centers.
 - Funding for installation and operation of seafloor geodesy and offshore seismic monitoring. Funding to better understand whether turbidites were generated from strong shaking from great earthquakes.
 - Two DNR FTEs for geological mapping
 - Need to have two positions at DNR that work exclusively on earthquakes and active faults
 - Two positions at DNR for subsurface database management
 - One planning position at DNR for outreach in working with planners to help implement
 - Sufficient funding for developing detailed maps of shallow soils, collecting sub-surface data, and conducting seismic reflection/refraction studies in selected areas to determine shallow structure. This information would be used in computer simulations of ground shaking from future large earthquakes, to map in detail the seismic hazard.
- **Current efforts:**
 - USGS makes national seismic hazard maps that characterize hazard for rock sites.
 - Seattle urban seismic hazard maps (2007) provided more detail on seismic hazard by including soft soils and basin effects.
 - Improving building codes and design standards to make buildings, transportation networks, and infrastructure less vulnerable to earthquake shaking.
 - M9 Project maps expected ground shaking for M9 Cascadia earthquakes using computer simulations.
 - DNR has two mapping geologists and limited subsurface data staff

RECOMMENDATION 9: IMPROVE LIFE SAFETY IN COMMUNITIES AT RISK OF LOCAL TSUNAMIS

- **Stakeholders:** DNR, EMD, UW, NOAA, FEMA, coastal residents, employees of coastal businesses, tourists, U.S. Coast guard, first-responders.
- **Implementation/Expectations for achieving the action:**
 - Constructing enough vertical evacuation structures to ensure that everyone who is in harm's way from a locally generated tsunami has an evacuation option, in particular, for areas where no natural vertical evacuation is possible.
 - Collaboration with technical partners at DNR, UW, and NOAA and local governments, perform detailed inundation modeling for design of tsunami evacuation refuges.
 - Integrate safe haven structures into school funding.
 - Change local zoning to encourage structures in tsunami hazard zones to be designed as safe havens.
 - Mandate new hotel construction to incorporate safe havens.
- **Resources needed:**
 - 1 FTE for tsunami inundation modeling: DNR
 - More funding from FEMA grant programs
 - Explicit support for such structures in the common school construction fund
- **Current efforts:**
 - One structure built at Ocosta Elementary School; one structure in design phase at Long Beach; others in consideration at the Quinault Casino; Port of Grays Harbor to replace the port EOC; a fire station at Ocean Park; planning to move Taholah infrastructure out of tsunami hazard zone
 - Efforts are dependent on grant funding at this time

RESILIENT WASHINGTON

Recommendation 1 Gap Analysis and Implementation Plan

Prepared by the Washington Geological Survey (DNR) with help from Barbra Thurman, OSPI

RECOMMENDATION 1: MAKE SCHOOLS RESILIENT: STRUCTURALLY, SOCIALLY, EDUCATIONALLY

- A) As part of a single statewide project, perform consistent, cost-effective, comprehensive assessments of school buildings to prioritize the seismic risk of the state's schools. Apply the new SSC-developed assessment process, which addresses seismic hazard, liquefaction, and structural and non-structural deficiencies.
- **Stakeholders:**
 - Anyone that has had children in school or will have children in school.
 - OSPI, School Districts, Public & Private schools, ESDs, DNR, the public.
 - **Needs/Expectations for achieving the Action:**
 - Initially we would like to see school seismic safety surveys done throughout the state for every school district and school building by geologists and engineers. Then once we have an inventory and evaluation we can determine a priority for building remediation. We can then develop plans and funding mechanisms for the remediation.
 - Funding, time and staffing
 - **Current Efforts:**
 - So far DNR and structural engineers along with EMD and FEMA have done pilot studies at several school locations throughout state.
 - Pre-Disaster Mitigation efforts
 - **Gaps & Barriers to achieving the Action:**
 - The biggest thing standing under way at this time is funding for the initial investigations by geologists and engineers.
 - Funding, time and staffing for follow up once initial investigations have been conducted
 - **Available Resources:**
 - DNR has some staff and seismic equipment that can be used. We've also already established the methodology.
 - **Resources Needed:**
 - More funding needs to be made available for doing the initial evaluations of buildings.
 - After initial evaluations more funding has to be identified for developing plans for remediation and eventually completing the work on the buildings themselves.
 - **Implementation Plan:**
 - **Short Term:**
 - Ask for capital or other funds to do the school evaluations over a six-year to eight-year period.
 - Based on the priorities revealed from the assessment, devise a plan to repair or replace school buildings, beginning with those with the highest level of risk.
 - **Long Term:** Repair or replace schools as outlined in the plan.

B) Enact legislation that requires school districts to conduct at least one earthquake safety drill per school year. Schools in mapped tsunami hazard zones should conduct a pedestrian evacuation drill annually. Such a law should explicitly require drop, cover, and hold as the state’s approved earthquake safety technique.

- **Stakeholders:**
 - Families, children, just about everyone, OSPI, Districts, schools
- **Needs/Expectations for achieving the Action:**
 - Children and families would have better understanding of what earthquake safety is and what to do during an earthquake
 - Legislative support and action
- **Current Efforts:**
 - SHB 1279
 - There has been some introduction of bills this year to the legislature. The bills were overly complicated and were difficult to pass
- **Gaps & Barriers to achieving the Action:**
 - New legislative wording does include both EQ and tsunami drills; however, the EQ drill is a “may” as opposed to a “should” or “must”
- **Available Resources:**
 - We believe this could be done within existing resources is just a matter of identifying that one of the required drills is an earthquake drill. SB 1279 aims to do this.
- **Resources Needed:**
 - Legislative support for stronger wording of the bill, actually requiring school EQ and evacuation drills, not just suggesting them.
- **Implementation Plan:**
 - **Short Term:**
 - DNR and OSPI meet to layout a legislative strategy
 - Let districts and school know of the new legislation.
 - **Long Term:** Use the existing Great Washington ShakeOut Earthquake Drill registration to track metrics related to progress and participation for EQ drills.

C) Enact legislation that requires all school districts to develop mitigation plans, whether on their own or by participating in a city or county mitigation planning process.

- **Stakeholders:**
 - OSPI, districts, schools, children, Legislative representatives
- **Needs/Expectations for achieving the Action:**
 - Funding, time and staffing
- **Current Efforts:**
 - PDM efforts
- **Gaps & Barriers to achieving the Action:**

- Funding, time and staffing
- **Available Resources:**
 - None
- **Resources Needed:**
 - Funding, time and staffing
- **Implementation Plan:**
 - **Short Term:**
 - Districts develop hazard mitigation plans to make them eligible for federal funding (when available) through the Hazard Mitigation Grant Program (HMGP).
 - Identify/secure needed resources to implement PDM.
 - **Long Term:**
 - Districts maintain hazard mitigation plans by regularly revising and updating them.

D) Enact legislation that requires all school districts to develop and maintain comprehensive continuity of operations plans, including provisions for mutual aid (e.g. facility-sharing) between districts.

- **Stakeholders:**
 - OSPI, Districts, schools (Pub & Private), ESDs
- **Needs/Expectations for achieving the Action:**
 - WSSDA HB 1003 model policy; time, staff, resources
- **Current Efforts:**
 - HB 1003 (2016) calls for a model policy for natural disaster school infrastructure recovery. That model policy includes/refers to a (required) COOP.
- **Gaps & Barriers to achieving the Action:**
 - Training and implementation
- **Available Resources:**
 - None
- **Resources Needed:**
 - Time, staff training resources
- **Implementation Plan:**
 - **Short Term:**
 - Train school districts develop continuity of operations plans.
 - **Long Term:**
 - Schools and districts maintain plans through regular training, updates, and exercises.

RESILIENT WASHINGTON

Recommendation 8 Gap Analysis and Implementation Plan

Prepared by Washington Geological Survey with help from Art Frankel, USGS

RECOMMENDATION 8: IDENTIFY AND MAP IN GREATER DETAIL SOURCES OF SEISMICITY AND GEOLOGICALLY HAZARDOUS AREAS AND DEVELOP PLANS FOR MITIGATION OF IDENTIFIED HAZARDS

E) Continue to enhance knowledge of seismic sources impacting the State of Washington through mapping, DNR; PNSN research, field investigation, and seismic monitoring.

- **Stakeholders:**

- DNR, U.S. Geological Survey, WA EMD, academic institutions such as University of Washington, local, county, and state agencies, utilities, WASHDOT, private sector businesses

- **Needs/Expectations for achieving the Action:**

- Improve understanding of impacts of strong earthquakes such as M9 on Cascadia subduction zone or M6-7 earthquake on the Seattle fault in order to facilitate mitigation efforts to increase community resilience to large earthquakes. This will help to reduce loss of life and property and ensure that buildings, transportation networks, and infrastructure are operational after the event.
- Mitigation requires accurate estimates of strong shaking from identified fault sources.
- More extensive seismic network
- Update the seismic scenario catalog to help support local jurisdictions and creating mitigation plans. Priority analyses would focus on the 20 most important seismic scenarios in the state.
- Publish databases necessary to implement seismic provisions of building codes and accurately interpret seismic recordings in real time to allow for quicker response to events
- Develop 3Dgeologic models-tools used to make geologic maps that enhance the predictive value of surface geology-for active fault identification and assessment (identifying active faults is best done by starting with LiDAR analysis followed up with field investigations)
- Compile data into a database that supports hazard mapping and also enables the Pacific Northwest Seismic Network to calibrate their seismic recordings, leading to improved seismic hazard analysis;
- Collect geological and seismic data at schools for contribution into the school seismic safety analysis method; and work with local jurisdictions on implementation of these tools in CAOs and mitigation plans.
- Increase rate of detailed geological mapping

- **Current Efforts:**

- Improving building codes and design standards to make buildings, transportation networks, and infrastructure less vulnerable to earthquake shaking.
- Currently DNR is collecting seismic shear wave data at schools and coordinating that with structural engineering data
- Limited staff to populate subsurface databases at DNR
- Most DNR work is been done under small grants from FEMA last few years

- **Gaps & Barriers to achieving the Action:**

- Need more comprehensive paleoseismic studies to identify and characterize active crustal faults and to better determine the recurrence times of Cascadia M8-9 interface earthquakes.
- Need to conduct more studies on active faulting

- Need better prediction of ground shaking from potential large earthquakes by using computer simulations.
 - Need improved knowledge of the shallow (< 2 km deep) structure of the crust, especially in sedimentary basins (for example, Seattle, Tacoma, Everett, Bellingham) to improve our computer simulations of shaking for future large earthquakes.
 - Need to monitor slip and seismicity in the offshore portion of the Cascadia subduction zone, using seafloor GPS and seismometers.
 - DNR has limited staff for any of the things listed in needs and expectations
 - more funding needs to be identified for building out the seismic network
- **Available Resources:**
 - USGS funds research in the region, monitoring, and early warning.
 - NSF funds research and M9 Project at University of Washington that is simulating ground shaking for M9 earthquakes and assessing their effects on buildings and ground failure.
 - Limited DNR funds for one FTE plus 24 channel seismic equipment, gravimeter, and magnetometer
 - lidar funding is available to collect lidar over certain areas. It is intended to get lidar coverage for the entire state which would help with active fault identification.
- **Resources Needed:**
 - Funding to conduct systematic seismic exploration studies of the shallow crust in WA State, focusing on sedimentary basins with major population centers.
 - Funding for installation and operation of seafloor geodesy and offshore seismic monitoring. Funding to better understand whether turbidites were generated from strong shaking from great earthquakes.
 - Two DNR FTEs for geological mapping
 - Need to have two positions at DNR that work exclusively on earthquakes
 - Two positions at DNR for subsurface database management
 - One planning position at DNR for outreach in working with planners to help implement
- **Implementation Plan:**
 - **Short Term:**
 - With the limited resources DNR has we will complete geophysical assessments in quadrangle that we are mapping
 - DNR will continue to do geological mapping on two quadrangles per year with external funding
 - Continue to populate subsurface database on a limited part-time basis
 - Continue to apply for outside funding to study sources.
 - **Long Term:**
 - Systematic paleoseismic studies statewide; comprehensive study of coastal subsidence, offshore turbidites, and lake sediments, to develop chronology of Cascadia M8-9 earthquakes.
 - Create statewide hazards and resilience center to integrate scientific findings and develop and implement practical mitigation measures.
 - Improve seismic network; there are many gaps in the seismic network and it is necessary to install more stations and modernize older ones
 - obtain funding for the six FTEs we need to do the earthquake evaluations, subsurface database management, and geological mapping
 - Update the seismic scenario catalog to help support local jurisdictions and creating mitigation plans. Priority analyses would focus on the 20 most important seismic scenarios in the state
 - publish databases necessary to implement seismic provisions of building codes and accurately interpret seismic recordings in real time to allow for quicker response to events

- develop liquefaction and site class maps for counties and cities for appropriate identification for earthquake hazard critical area ordinances
- develop a database that enables the Pacific Northwest seismic network to calibrate their seismic recordings leading to improved seismic hazard analysis
- develop 3-D geologic models to help assess active faults
- work with local jurisdictions on implementation of these tools in critical area ordinances and mitigation plans with the desired outcome of a reduction of losses from earthquakes and more effective response after an earthquake
- develop foundational geologic maps and databases that support the geological hazards programs and local and state government
- develop and maintain an Internet accessible subsurface geotechnical database for the state moving data from geotechnical work geophysical surveys, and other deep wells to provide easily accessible and better resource assessments, hazard maps and databases

F) Prioritize areas for detailed liquefaction and other seismic hazard mapping and accelerate the mapping.

• **Stakeholders:**

- U.S. Geological Survey, WADNR, PNSN, academic institutions such as University of Washington, local, county, and state agencies, utilities, WASHDOT, WA EMD, private sector businesses, citizens

• **Needs/Expectations for achieving the Action:**

- Need to prioritize detailed seismic hazard mapping in coastal areas, 1-5 corridor, and heavily populated areas within sedimentary basins
- Develop liquefaction and site class maps for counties and cities at appropriate scales for use as identification tools for earthquake hazard CAOs;
- Develop foundational geologic maps and databases that support the geological hazards programs and local and state government
- Develop and maintain an Internet accessible subsurface geotechnical database for the state moving data from geotechnical work geophysical surveys, and other deep wells to provide easily accessible and better resource assessments, hazard maps and databases

• **Current Efforts:**

- USGS makes national seismic hazard maps that characterize hazard for rock sites.
- Seattle urban seismic hazard maps (2007) provided more detail on seismic hazard by including soft soils and basin effects.
- M9 Project maps expected ground shaking for M9 Cascadia earthquakes using computer simulations.

• **Gaps & Barriers to achieving the Action:**

- Need better models of the shallow crust, including depth to bedrock in the Seattle basin and other basins, as well as the shear-wave velocity to a depth of about 2 km.
- Need an update of the Seattle seismic hazard maps for a wide range of periods, based on 3D simulations using improved crustal model and source specification.
- Urban seismic hazard maps should be produced for other higher-risk areas of Washington using computer simulations and detailed mapping of soils and sub-surface structure.
- Funding and lack of geologists to do the work

• **Available Resources:**

- Limited funding by USGS

- DNR has one FTE that could be used to do this work part of this work. And we have the necessary seismic equipment
- DNR is doing some subsurface database management on a limited basis. We have part of FTE working on that

- **Resources Needed:**

- Sufficient funding and staffing to develop detailed seismic hazard maps for higher-seismic risk areas of Washington, including Seattle, Tacoma, Bellevue, Redmond, Olympia, Everett, Bellingham, Spokane and Tri-Cities.
- Sufficient funding for developing detailed maps of shallow soils, collecting sub-surface data, and conducting seismic reflection/refraction studies in selected areas to determine shallow structure. This information would be used in computer simulations of ground shaking from future large earthquakes, to map in detail the seismic hazard.

- **Implementation Plan:**

- **Short Term:**

- Develop a more comprehensive and detailed statewide assessment of liquefaction-prone areas: Prioritize areas where liquefaction is likely to have the highest impact; begin assessment around critical facilities; and do detailed studies of areas that are already of interest based on current mapping.

- **Long Term:**

- Reference the updated liquefaction hazard maps in building codes and establish a consistent means of communicating maps and related information to local jurisdictions for use as best-available-science under the Growth Management Act.

G) Work with the planning and public works departments within local jurisdictions and tribes to develop a model ordinance of mitigation measures and an explanation of how it can be used.

- **Stakeholders:**

- *DNR, DOT, PNSN, counties and cities, building owners, DOC, local planning agencies.*

- **Needs/Expectations for achieving the Action:**

- Work with local jurisdictions on implementation of these tools in critical area ordinances and mitigation plans with the desired outcome of a reduction of losses from earthquakes and more effective response after an earthquake

- **Current Efforts:** None

- **Gaps & Barriers to achieving the Action:** Needs to be carried out at the local level

- **Available Resources:**

- **Resources Needed:** Organization, time, funding

- **Implementation Plan:**

- **Short Term:** Districts develop hazard mitigation plans to make them eligible for federal funding (when available) through the Hazard Mitigation Grant Program (HMGP).
- **Long Term:** Districts maintain hazard mitigation plans by regularly revising and updating them.

RESILIENT WASHINGTON

Recommendation 1 Gap Analysis and Implementation Plan

Prepared by the Washington Geological Survey (DNR) with help from Diego Arcas, PMEL, and Frank Gonzalez, University of Washington

RECOMMENDATION 9: IMPROVE LIFE SAFETY IN COMMUNITIES AT RISK OF LOCAL TSUNAMIS

Implement tsunami vertical evacuation plans developed by local and tribal jurisdictions through “Project Safe EMD Haven” to minimize loss of life during local tsunamis.

- **Stakeholders:** DNR, EMD, UW, NOAA, FEMA, coastal residents, employees of coastal businesses, tourists, U.S. Coast guard, first-responders.
- **Needs/Expectations for achieving the Action:**
 - Constructing enough vertical evacuation structures to ensure that everyone who is in harm’s way from a locally generated tsunami has an evacuation option; in particular, for areas where no natural vertical evacuation is possible. Project Safe Haven has identified 75 such sites.
 - Collaboration with technical partners and local governments, perform detailed inundation modeling for design of tsunami evacuation refuges.
- **Current Efforts:**
 - One structure built at Ocosta Elementary School; one structure in design phase at Long Beach; others in consideration at the Quinault Casino; Port of Grays Harbor to replace the port EOC; a fire station at Ocean Park; planning to move Taholah infrastructure out of tsunami hazard zone
 - Efforts are dependent on grant funding at this time
- **Gaps & Barriers to achieving the Action:**
 - Not enough funding available for modeling and planning
 - New design guidelines that are still in draft form (ASCE 7 chapter 16)
 - Site-specific hazard assessments of all remaining candidate sites, including detailed modeling of potential forces on proposed structures.
- **Available Resources:**
 - Limited funding from NTHMP; ad hoc funding from grant programs
- **Resources Needed:**
 - 1 FTE for tsunami inundation modeling: DNR
 - More funding from FEMA grant programs
 - Explicit support for such structures in the common school construction fund
- **Implementation Plan:**
 - Tax policy to encourage safe haven structures; align with goals of the Aquatic Lands Enhancement Account to secure funding as coastal amenities

- **Short Term:** Support one or more local jurisdiction demonstration projects in order to determine the most cost effective approach and identify funding options that may be instituted on a regional or local basis.
- **Long Term:** Integrate safe haven structures into school funding. Change local zoning to encourage structures in tsunami hazard zones to be designed as safe havens. Mandate new hotel construction to incorporate safe havens. Support development of improved methods for detailed, site-specific modeling assessments of the tsunami hazard.