Cascadia Subduction Zone

CASCADIA EARTHQUAKE TIME LINE

EVENTS IN HUMAN HISTORY

KNOWN CASCADIA EARTHQUAKES ALONG THE CASCADIA SUBDUCTION ZONE IN NORTHERN CALIFORNIA, OREGON, AND WASHINGTON

Earthquake of Magnitude 9+ (fault breaks along entire subduction zone)
Earthquake of Magnitude 8+ (fault breaks along southern half of subduction zone)

Comparison of the history of subduction zone earthquakes along the Cascadia Subduction Zone in northern California, Oregon, and Washington, with events from human history. Ages of earthquakes are derived from study and dating of submarine landslides triggered by the earthquakes. Earthquake data provided by Chris Goldfinger, Oregon State University; time line by Ian P. Madin, DOGAMI.
House Resolution 3

Goals:
- Protect lives
- Achieve rapid economic recovery following event
- Based on Cascadia Subduction Zone EQ, tsunami
  - Magnitude 9 Event - 500 year return period
- 50-years to implement recommendations
- Plan to Legislature by February 28, 2013
The Oregon Resilience Plan

Coordinated by Oregon Seismic Safety Policy Advisory Commission (OSSPAC)

Task Groups
- Magnitude 9 Event – The Scenario
- Business Continuity
- Critical & Essential Buildings
- Energy
- Information & Communications
- Transportation
- Tsunami Risk Mitigation
- Water & Wastewater

Kobe, Japan - 1995
Water & Wastewater Resilience Plan

- Co-chairs: Mark Knudson (TVWD) and Mike Stuhr (PWB)
- Participants included representatives of ~45% of state
  - Portland, TVWD, Salem, Gresham, Eugene, Coos Bay, Bend, Pendleton
  - PSU, OSU, U of P, multiple consultants
- Four zones: Tsunami, Coast, Valley, East
- Approach
  - Identify event (maps)
  - Identify requirements & expectations
  - Identify performance of existing systems
  - Identify interdependencies
  - Identify “gaps” in systems performance
  - Generate recommendations
Why Are Water Systems Vulnerable?

- Causes of damage
  - Tsunami (inundation)
  - Shaking (acceleration & velocity)
  - Permanent Ground Deformation (landslide, liquefaction, subsidence)
  - Cumulative effects
- System Vulnerability
Why Are Water Systems Vulnerable?

- Large, complex systems, multiple failures
  - Source, treatment, pumping, storage, distribution
Why Are Water Systems Vulnerable?

- Recovery highly dependent on other systems
  - Energy, transportation, people, equipment, financial
Why Are Water Systems Vulnerable?

Location, location, location
Why Are Water Systems Vulnerable?

Age, age, age (and condition)
Why Are Water Systems Vulnerable?

- Pipelines vulnerable to structural damage
Why Are Water Systems Vulnerable?

- Pipelines vulnerable to ground deformation
Why Are Water Systems Vulnerable?

Connections to structures
Why Are Water Systems Vulnerable?

- Leaks, breaks & damage “after the meter”
Why Are Water Systems Vulnerable?

- Collateral damage
Resiliency Requirements & Expectations

Goals for time to restore systems
- Assumes “should be” resiliency improvements over 50 years
- For 30%, 60% and 90% operational capacity
- Based on input of economic interests; < 2 weeks
- Based on availability of interdependent sectors; energy & transpo
- Based on practical limitations; people, material & equipment

Goals set for key functional components
- Emergency Water Distribution
- Fire Fighting
- Water source, treatment, transmission & distribution
- Wastewater collection, treatment & disposal
### Resiliency Goals (Valley)

#### Target States of Recovery: Water & Waste Water Sector

<table>
<thead>
<tr>
<th>Event occurs</th>
<th>0-24 hours</th>
<th>1-3 days</th>
<th>1 week-2 weeks</th>
<th>2 weeks-1 month</th>
<th>1 month-3 months</th>
<th>3 month-6 months</th>
<th>6 month-1 year</th>
<th>1 year-3 years</th>
<th>3+ years</th>
</tr>
</thead>
</table>

**Domestic water supply**
- Potable water available at supply source. (WTP, wells, impoundment)
  - **R** (Red)
  - **Y** (Yellow)
  - **G** (Green)
  - **X** (Crossed out)

**Main transmission facilities, pipes, pump stations, and reservoirs (“backbone”) operational**
- **G** (Green)
- **X** (Crossed out)

**Water supply to critical facilities available.**
- **Y** (Yellow)
- **G** (Green)
- **X** (Crossed out)

**Water for fire suppression – at key supply points.**
- **G** (Green)
- **X** (Crossed out)

**Water for fire suppression – at fire hydrants.**
- **R** (Red)
- **Y** (Yellow)
- **G** (Green)
- **X** (Crossed out)

**Water available at community distribution centers/po ints**
- **Y** (Yellow)
- **G** (Green)
- **X** (Crossed out)

**Distribution system operational**
- **R** (Red)
- **Y** (Yellow)
- **G** (Green)
- **X** (Crossed out)

**Wastewater systems**
- **R** (Red)
- **Y** (Yellow)
- **G** (Green)
- **X** (Crossed out)

**Threats to public health & safety controlled.**
- **R** (Red)
- **Y** (Yellow)
- **G** (Green)
- **X** (Crossed out)

**Raw sewage contained & routed away from population**
- **R** (Red)
- **Y** (Yellow)
- **G** (Green)
- **X** (Crossed out)

**Treatment plants operational to meet regulatory requirements**
- **R** (Red)
- **Y** (Yellow)
- **G** (Green)
- **X** (Crossed out)

**Major trunk lines and pump stations operational**
- **R** (Red)
- **Y** (Yellow)
- **G** (Green)
- **X** (Crossed out)

**Collection system operational**
Evaluating Pipeline System Performance
PGA, Landslides & Liquefaction

Peak Ground Acceleration (PGA)

Permanent Ground Deformation (PGD) due to landslides
Evaluating Pipeline System Performance
System Specific Mapping
Estimate of main line leaks & breaks

- "Seismic Fragility Formulations for Water Systems"
  American Lifeline Alliance, 2011
- Based on empirical data from prior events
- Input: Peak Ground Velocity, Permanent Ground Deformation, length of pipe, pipe material
- Output: number of main leaks & breaks by pipe type

Estimate of service line leaks & breaks

- Based on anecdotal data for similar events
- About 7% of all service lines fail (2% on utility side & 5% on customer side)
**Water Pipeline System Performance**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Main Lines</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length, Number</td>
<td>4,592 miles</td>
<td>385,600 connections</td>
</tr>
<tr>
<td>Number of Breaks</td>
<td>2,656</td>
<td>7,712 (utility side)</td>
</tr>
<tr>
<td>Number of Leaks</td>
<td>941</td>
<td>19,280 (customer side)</td>
</tr>
<tr>
<td><strong>Total Leaks &amp; Breaks</strong></td>
<td><strong>3,597</strong></td>
<td><strong>26,992</strong></td>
</tr>
</tbody>
</table>

- **Unprecedented number of pipeline failures**
  - Equivalent of ~16 years of breaks

- **Will required ~3 months to repair**
  - Assumes 3 hrs/break, 12hrs/d, 7d/wk, unlimited materials, equipment & transportation
  - Does not include repairs to customer-side
Evaluating Facility Performance
Performance of Reservoirs & Pump Stations

- **Oregon Seismic Code**
  - Before 1960 = none
  - 1960-70 = 0.06 g
  - 1970-90 = 0.12 g
  - 1990-2000 = ~ okay
  - 2000 → = stringent

- **Pump Stations**
  - 1/3 - major damage
  - 1/3 - some damage
  - 1/3 - minor affects

- **Reservoirs**
  - 2/3 - major damage
  - 1/6 - some damage
  - 1/6 - minor damage
Resiliency Goals

Water & Wastewater System Performance

Available Capacity (percent)

Time After Event (months)

- Eastern - W&WW
- Valley - Water
- Valley - Wastewater
- Coast (non-Tsunami) Water
- Coast (non-Tsunami) - Wastewater
Existing Condition

Water & Wastewater System Performance

Available Capacity (percent)

Time After Event (months)

- Eastern - W&WW
- Valley - W&WW
- Coast (non-Tsunami) - W&WW
Findings & Conclusions

- Significant gap between goals and existing state
- If CSZ EQ occurs today, it will result in dramatic change in “life as we know it” for W & WW
  - Most water systems will drain contents
  - Major structural damage to supply facilities, WTPs, pump stations
  - Change in traditional firefighting methods
  - Emergency water distribution required
  - Significant risks to public health & safety

- Water generally better prepared than wastewater
  - Wastewater limitations will create critical public health risks
  - Need for wide-emergency sanitation
  - Contamination of rivers, steams
  - Contamination downstream of Portland – sewage & chemicals
Findings & Conclusions

- **Eastern Oregon will experience limited impacts**
  - Can serve as resource for staffing, material & equipment

- **Tsunami areas will take years to recover, if ever**

- **Coast critically impacted; up to 3 years**
  - High seismic impacts due to proximity to fault, PGD & subsidence
  - Highly isolated due to transportation & energy disruptions

- **Extensive impacts to Valley; 6 months – 1 year**
  - Extensive damage to facilities built prior to early 1990s
  - Recovery hampered by impacts to transportation & energy
  - Staffing, access to material & equipment critical limitations
Findings & Conclusions

Resiliency upgrades will improve recovery times
- Focus on system “backbone” & water supply to critical facilities
- Coordinate with first responders to plan priorities & response
- Coast (non-tsunami) could recover in 1 - 6 months
- Valley could recover in < 1 month
- Significant improvements in public health & safety

Costs will be significant but can be managed
- Have long-term plan for making improvements over 50 years
- Invest in “backbone” and “low hanging fruit”
- Include seismic improvements with ongoing investments
- Incremental costs are limited when part of replacement & maintenance of aging infrastructure
**Recommendations**

- Reset public expectations for recovery times
  - “72 hours” not realistic – more like “72 days”
  - Emergency water distribution systems

- Require seismic response plans by all sectors
  - Include business continuity, employee & family support

- Require seismic assessments for all systems
  - Part of periodic update of master plan
  - Characterize risks, impacts & recover times

- Fire & water agencies to set joint standards
  - Water supply & fire fighting expectations
  - Identify key water supply points & standards
Recommendations

- Include seismic upgrades as part of CIP
  - Focus on establishing hardened supply “backbone”
  - Additional priorities - master plan & asset management
  - State to include seismic requirements in design review
  - Industry associations to establish pipeline standards

- Agencies to set post-event compliance goals
  - Expectations for regulatory compliance & standards
  - Expectations for emergency water distribution
  - Expectations for temporary sanitation & waste disposal
Next Steps - State Plan

- Report to Legislature
  - Report being finalized by OSSPAC
  - Present to Legislature by February 28, 2013
  - Potential legislative & regulatory actions
Next Steps - TVWD Plan

TVWD Seismic Resiliency Plan
- Updated design standards
- Budget proposal
  - Facility assessment
  - Integration with master plan & asset management
  - Prioritization of capital improvements
  - Coordination with fire & emergency responders
  - Business recovery & continuity planning