

# Water Distribution System Seismic Vulnerability Assessment

Local Vulnerabilities and Anticipated Performance

Presented to Environmental Services Commission  
October 3, 2019

by Doug Lane, Senior Engineer

# Agenda



**Project Overview and Status**



**Methodology**



**Results**

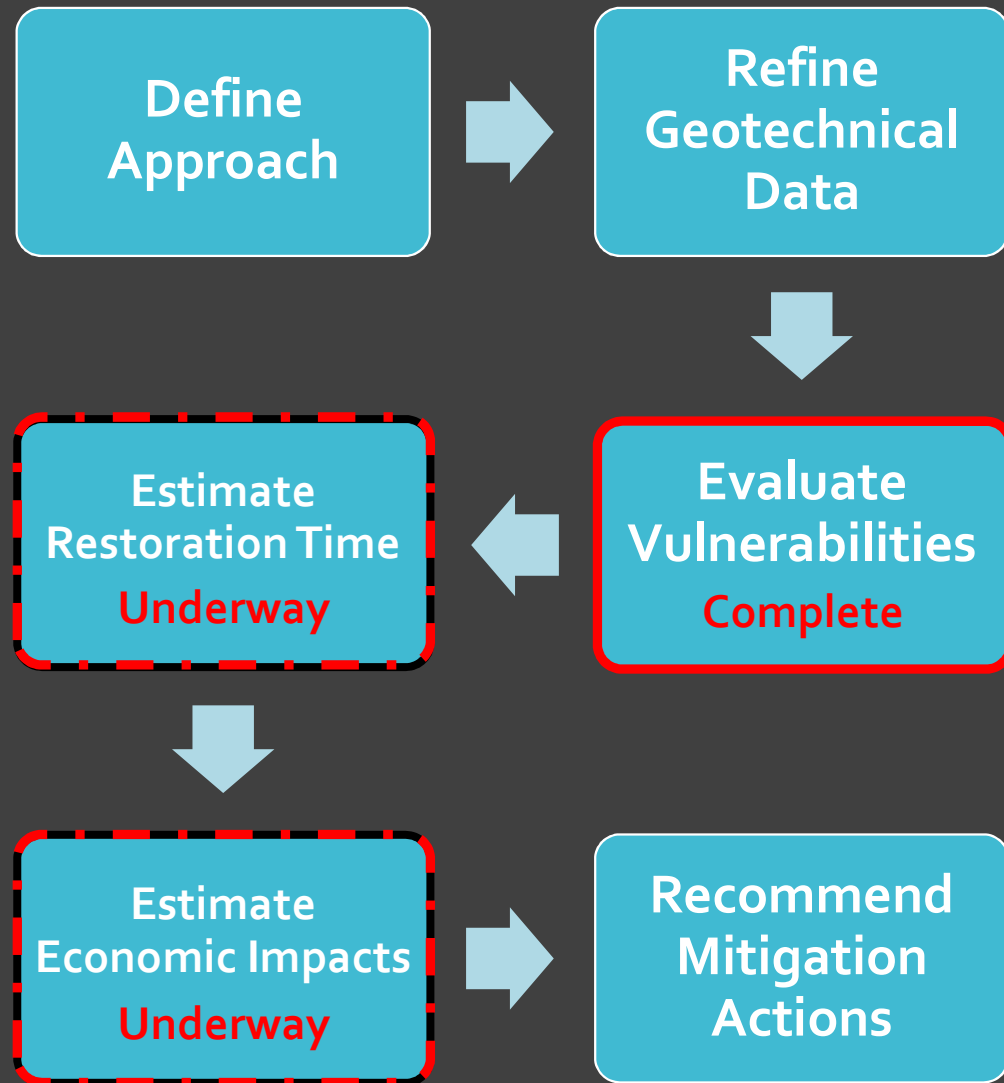


**Next Steps**

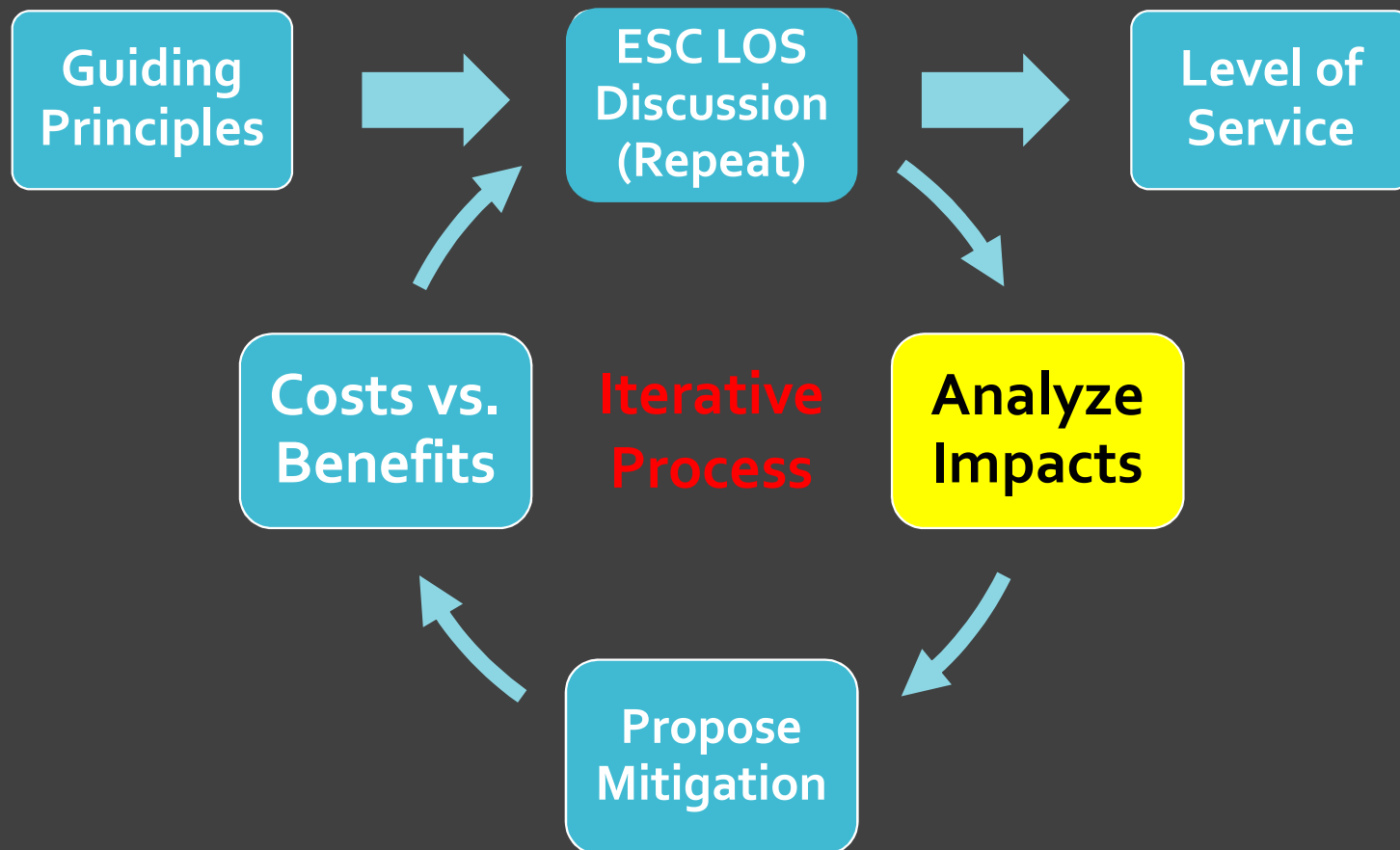


**Goal: ESC is informed; project guidance**

# Project Overview and Status



# Post-Earthquake Level of Service Development



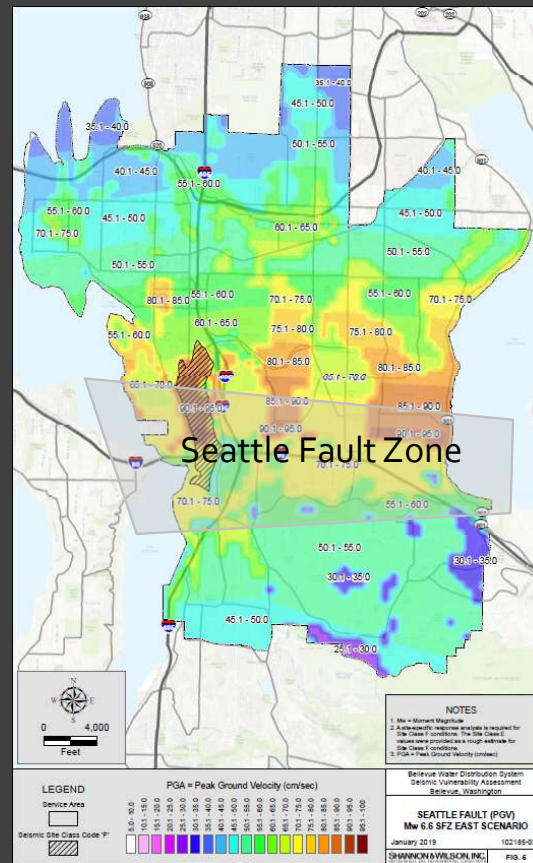
# Restoration Sequence



# Methodology

## Two Modes of Pipe Failure Estimated

### Wave Propagation (Ground Velocity)



### Ground Deformation (Liquefaction)

# Methodology

## Vertical Facility Fragility Estimates

| Reservoirs           | CSZ M9 | SFZ East |
|----------------------|--------|----------|
| Cherry Crest         | 0.34%  | 12.37%   |
| Clyde Hill 465       | 0.19%  | 6.40%    |
| Clyde Hill 390       | 0.38%  | 11.87%   |
| Clyde Hill 335 Rd    | 4.46%  | 33.40%   |
| Clyde Hill 335 Sq    | 0.38%  | 8.12%    |
| Cougar Mt. 1         | 0.19%  | 22.84%   |
| Cougar Mt. 2         | 0.13%  | 23.17%   |
| Cougar Mt. 3         | 2.08%  | 44.67%   |
| Cougar Mt. 3A        | 2.08%  | 44.15%   |
| Factoria             | 5.51%  | 45.69%   |
| Forest Hills         | 0.37%  | 21.10%   |
| Horizon View 1 - NEW | 0.18%  | 13.25%   |
| Horizon View 2       | 4.26%  | 42.58%   |
| Horizon View 3       | 0.13%  | 13.43%   |
| Horizon View 3A      | 0.34%  | 21.92%   |
| Lake Hills North     | 0.18%  | 10.27%   |
| Lake Hills South     | 0.17%  | 10.37%   |
| Meydenbauer N        | 0.39%  | 21.51%   |
| Meydenbauer S        | 0.39%  | 21.51%   |
| N.E. 40th            | 0.36%  | 8.16%    |
| Newport              | 0.17%  | 21.84%   |
| Parksite             | 4.66%  | 46.94%   |
| Pikes Peak           |        |          |
| Sammamish            |        |          |
| Somerset 2           | 0.04%  | 21.93%   |
| Woodridge            | 0.20%  | 17.32%   |

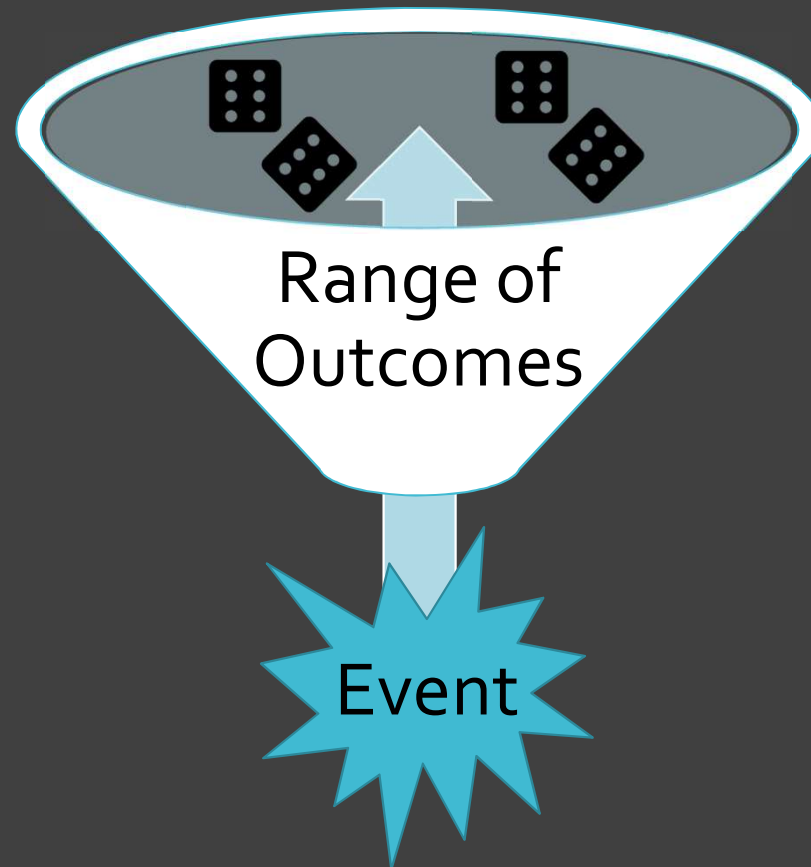
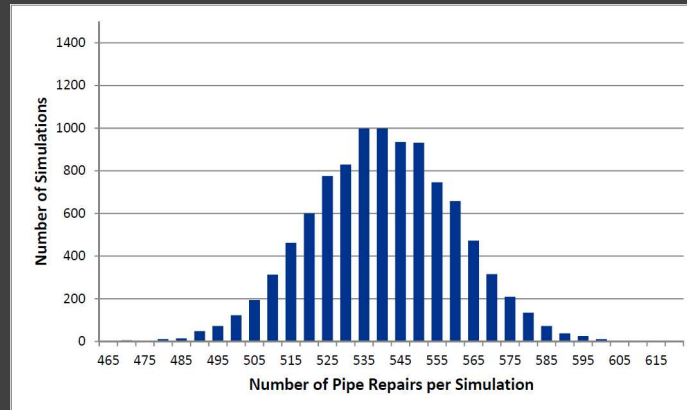
| Wells           |       |        |
|-----------------|-------|--------|
| WD97 Well No. 3 | 1.68% | 41.29% |
| WD97 Well No. 5 | 1.90% | 33.83% |
| WD97 Well No. 6 | 1.90% | 33.83% |
| WD97 Well No. 7 | 1.90% | 33.83% |

| Pump Stations           | CSZ M9 | SFZ East |
|-------------------------|--------|----------|
| Cherry Crest            | 6.36%  | 54.67%   |
| Clyde Hill              | 23.99% | 75.50%   |
| Cougar Mt. 1            | 4.24%  | 61.90%   |
| Cougar Mt. 2            | 3.44%  | 62.29%   |
| Cougar Mt. 3            | 2.79%  | 62.09%   |
| Forest Hills            | 6.94%  | 61.00%   |
| Horizon View 1 - NEW    | 0.63%  | 25.11%   |
| Horizon View 2          | 20.06% | 83.11%   |
| Horizon View 3          | 0.03%  | 19.92%   |
| Lake Hills (Crossroads) | 6.22%  | 55.80%   |
| Meydenbauer             | 0.82%  | 25.55%   |
| NE 8th Inlet            | 0.06%  | 14.46%   |
| NE 40th                 | 6.42%  | 37.96%   |
| Newport                 | 4.27%  | 62.30%   |
| Parksite                | 21.70% | 86.22%   |
| Pikes Peak              |        |          |
| SE 28th Inlet           | 0.04%  | 32.80%   |
| Somerset Inlet          | 0.03%  | 25.85%   |
| Somerset 2              | 0.04%  | 21.93%   |
| Woodridge               | 6.75%  | 68.28%   |
| 161st Ave Inlet         | 0.03%  | 25.08%   |
| 670/NE 40th             | 23.37% | 66.85%   |

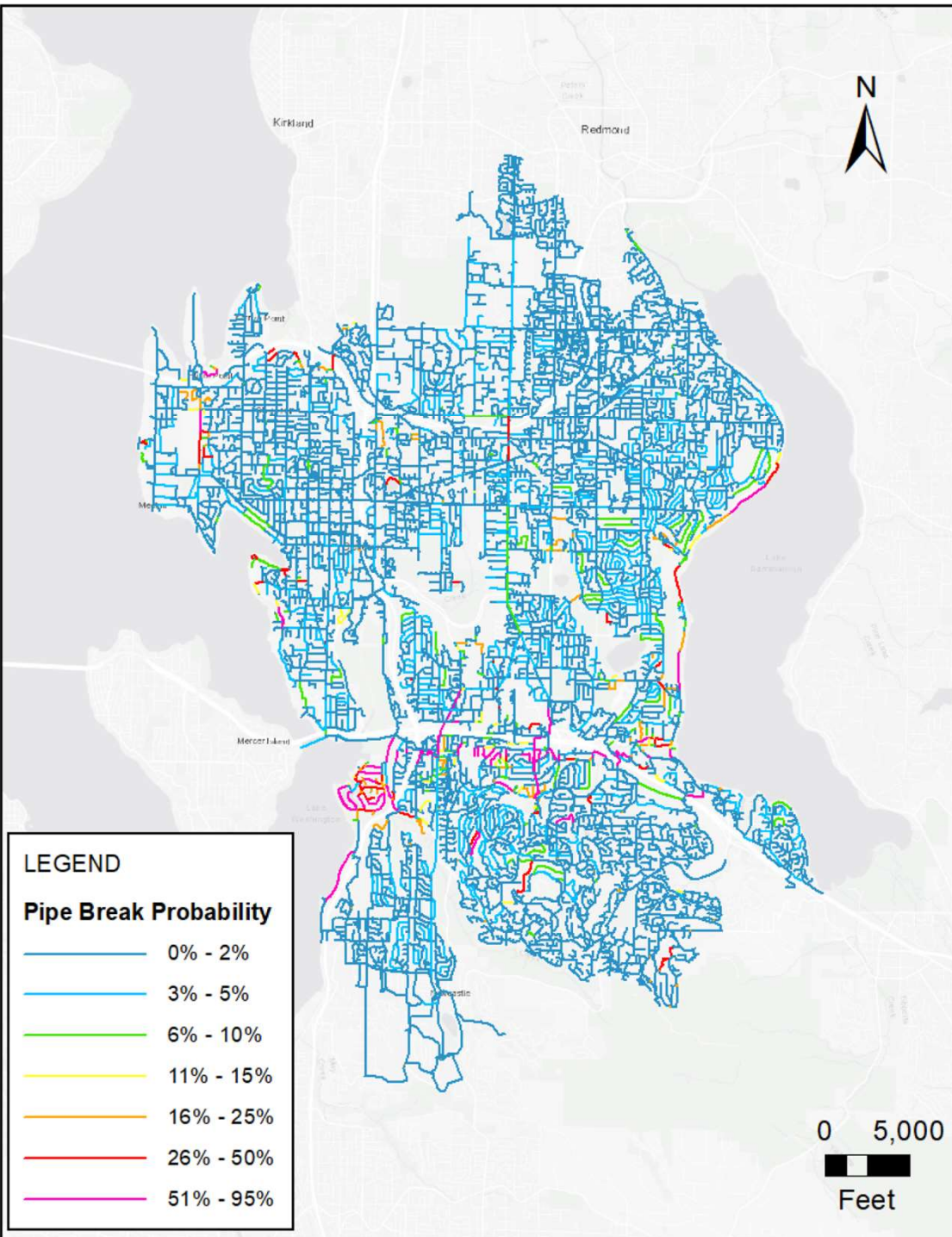
| Inlets             |       |        |
|--------------------|-------|--------|
| 161st Inlet        | 0.03% | 25.08% |
| Bel Red Inlet      | 0.05% | 12.90% |
| Cherry Crest Inlet | 0.03% | 9.31%  |
| Eastgate Inlet     | 0.05% | 24.75% |
| Enatai             | 0.03% | 25.41% |
| Inlet #11          | 0.03% | 26.85% |
| Inlet #6           | 0.04% | 17.77% |
| Inlet #8           | 0.02% | 15.99% |
| NE 40th Inlet      | 0.05% | 5.51%  |
| NE 8th Inlet       | 0.06% | 14.46% |
| Richards Road      | 0.07% | 27.30% |
| SE 28th Inlet      | 0.04% | 32.58% |

# Methodology

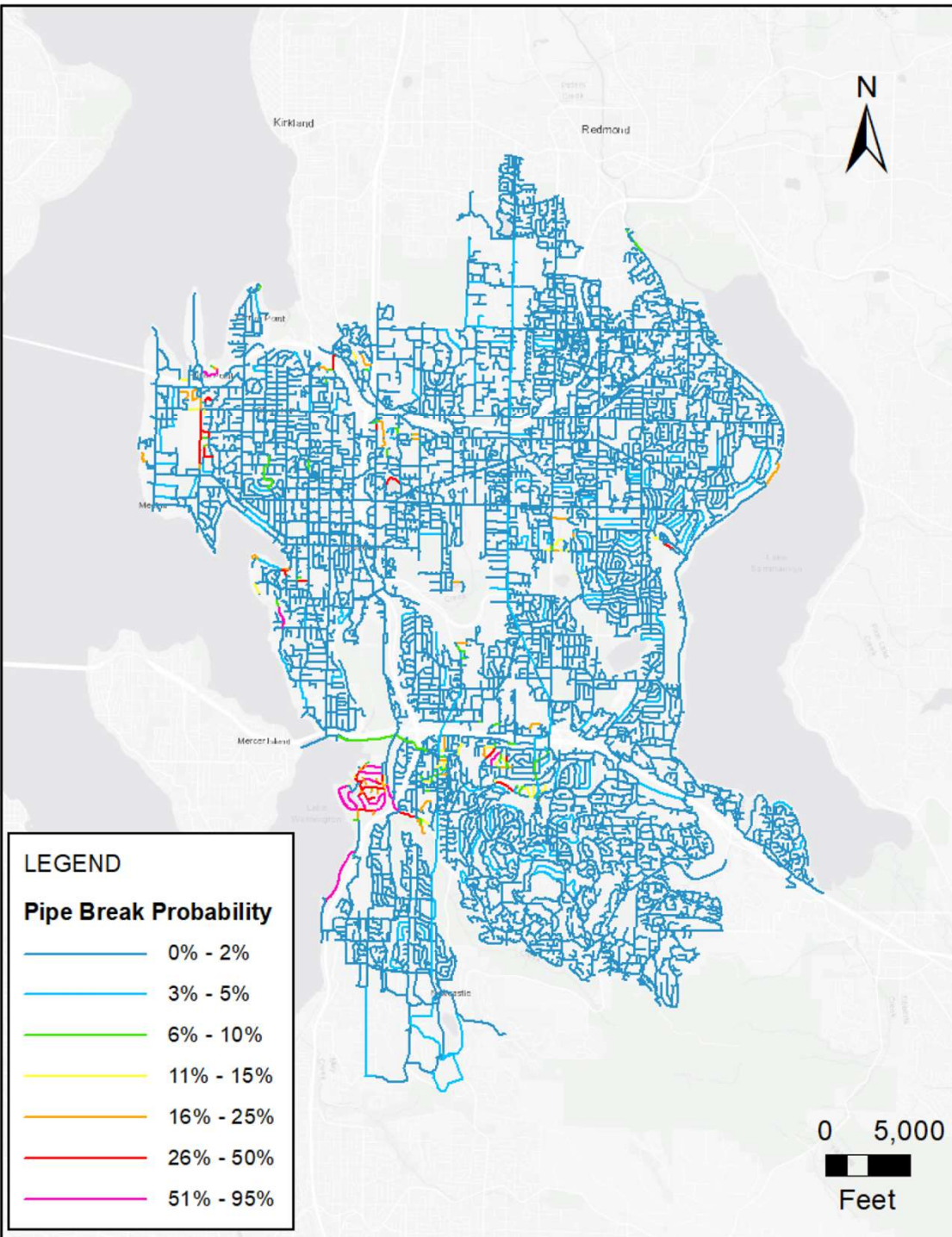
## Monte Carlo Simulations



# Seattle Fault Pipe Break Probabilities

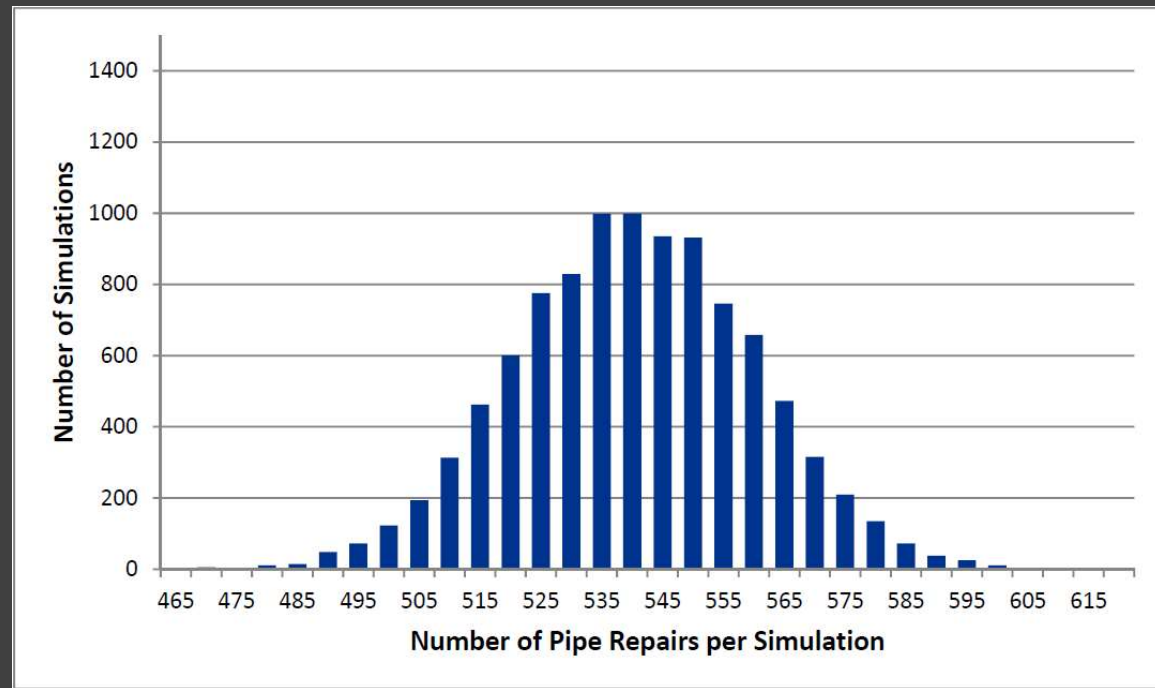


# Cascadia Subduction Zone Pipe Break Probabilities

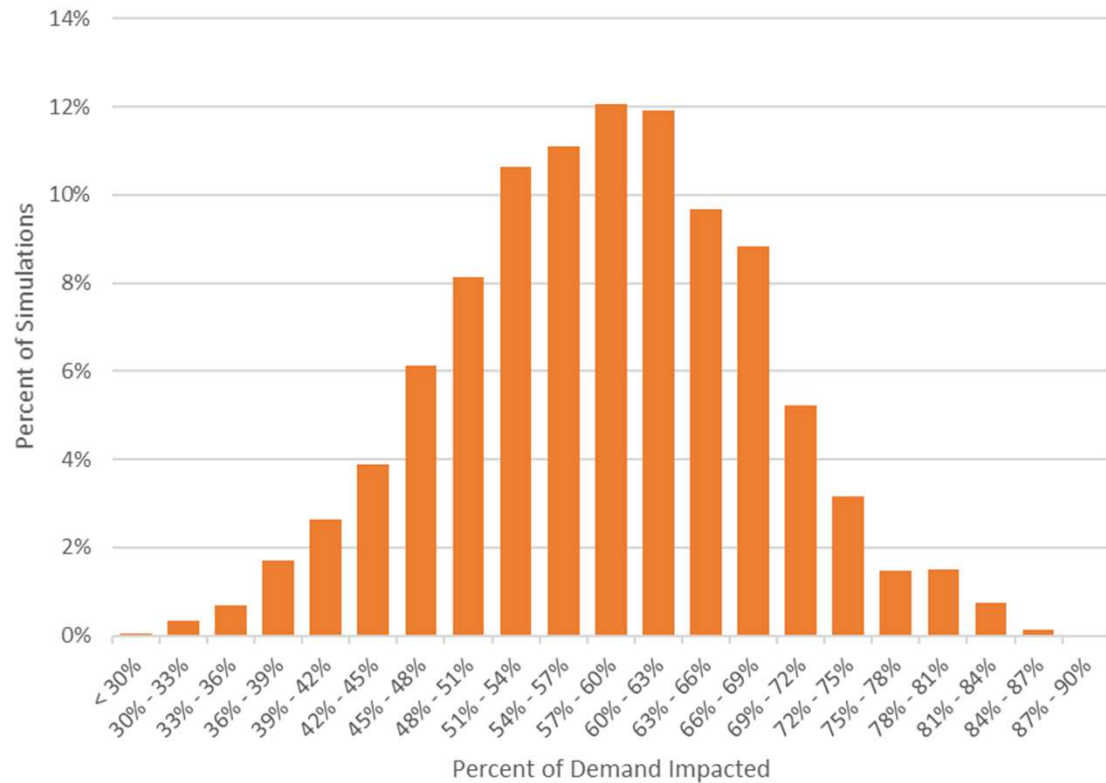


# Seattle Fault

## Immediate Pipe Repair Histogram



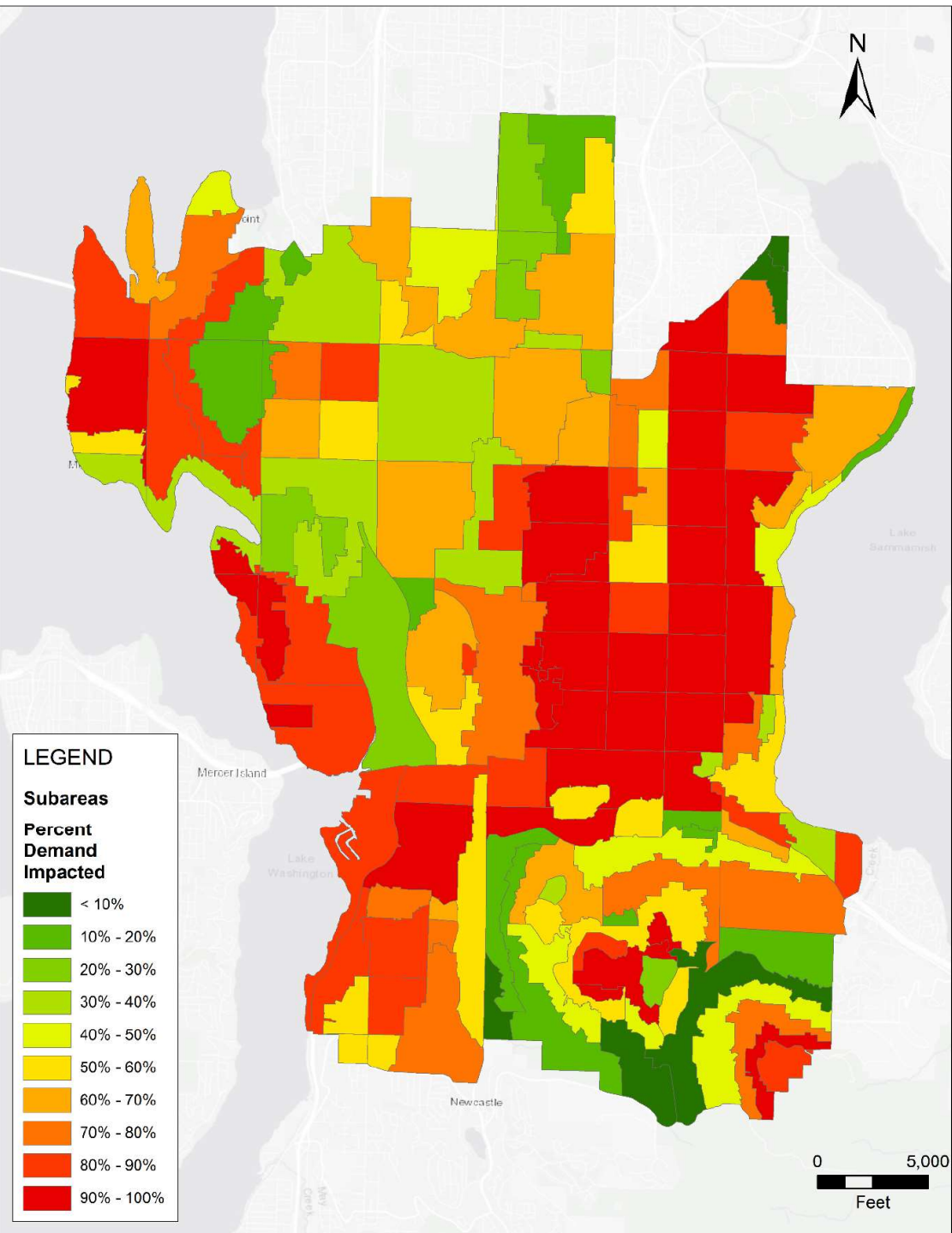
# Seattle Fault Immediate Service Impact Histogram



- Over half of service is immediately lost in most likely scenario
- Due to rapid leaks, all service lost in about 2-3 days

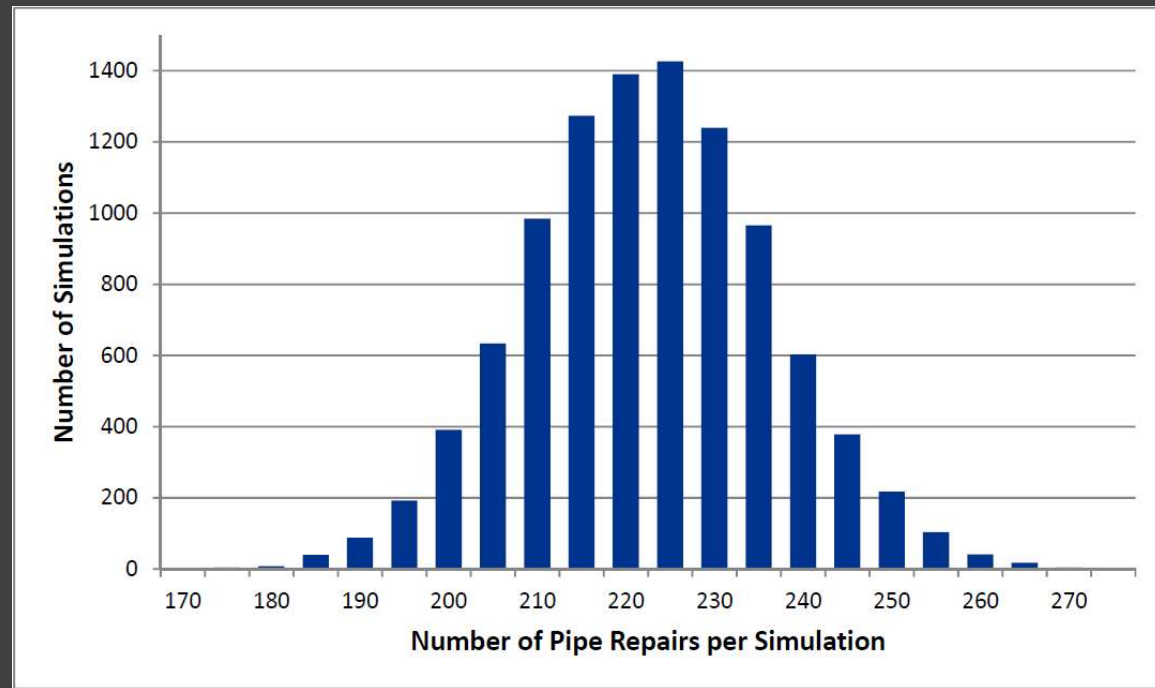
# Seattle Fault

## Immediate Impacts Map (Most Likely Outcome)



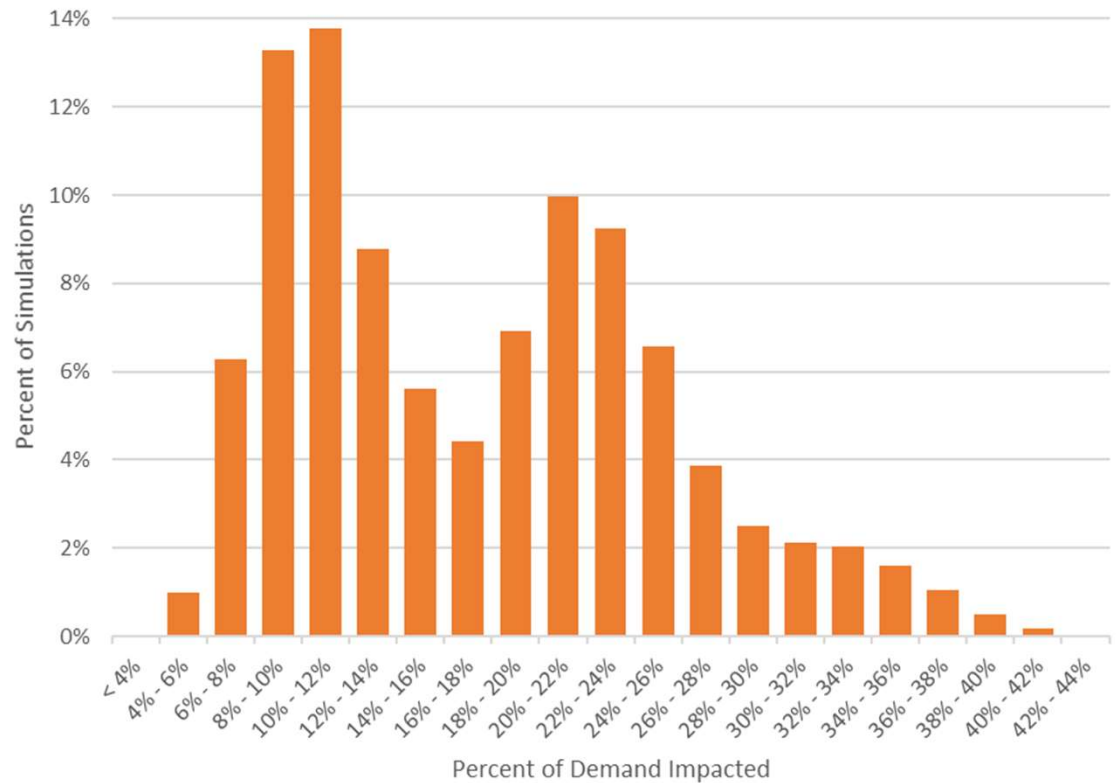
# Cascadia Subduction Zone

## Immediate Pipe Repair Histogram



# Cascadia Subduction Zone

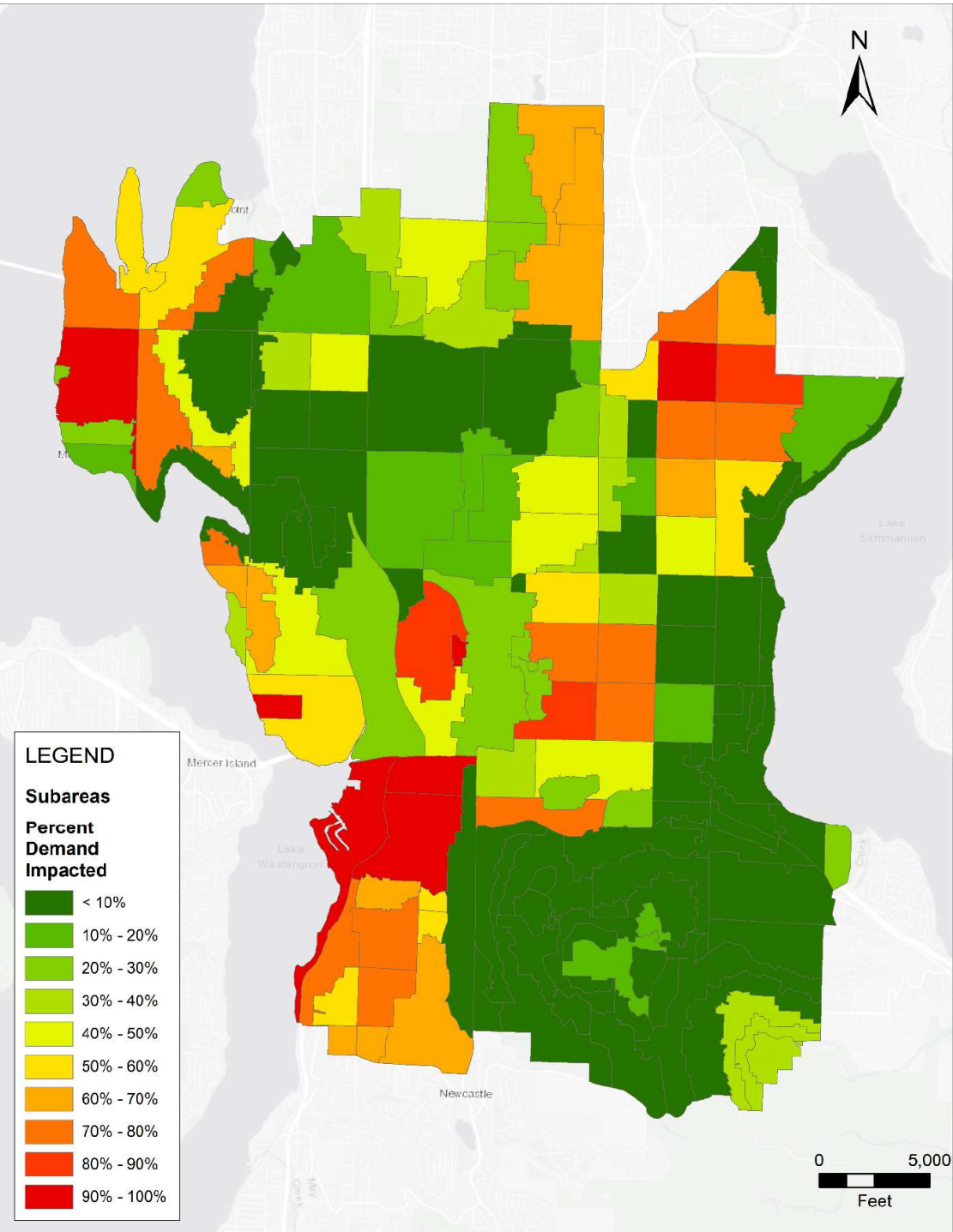
## Immediate Service Impact Histogram



- The two “humps” on the graph denote failures in different SPU supplies (Tolt vs. Cedar)

# Cascadia Subduction Zone

## Immediate Impacts Map (Most Likely Outcome)



## Critical Customer Impacts

| Location              | Seattle Fault<br>% Runs Impacted | Cascadia<br>% Runs Impacted |
|-----------------------|----------------------------------|-----------------------------|
| Overlake (NE 10th)    | 29%                              | 0%                          |
| Overlake (NE 12th)    | 42%                              | 0%                          |
| Kaiser Permanente     | 9%                               | 0%                          |
| Seattle Childrens     | 84%                              | 2%                          |
| City Hall             | 25%                              | 0%                          |
| Newport HS            | 98%                              | 75%                         |
| Bellevue HS           | 98%                              | 22%                         |
| Sammamish HS          | 98%                              | 24%                         |
| Interlake HS          | 98%                              | 97%                         |
| North Bellevue CC     | 71%                              | 31%                         |
| South Bellevue CC     | 41%                              | 0%                          |
| Crossroads CC         | 89%                              | 7%                          |
| WSDOT EOC/ Road Maint | 0%                               | 0%                          |
| WSDOT Bridge Maint    | 96%                              | 88%                         |

## Next Steps

## Project Tasks



**Estimate restoration time  
(underway)**



**Economic impacts evaluation  
(underway)**



**Recommend mitigation actions**



**Re-visit level of service goals**

## Next Steps

## Near-Term Actions



Revise engineering  
standards



Consider logical “low-  
hanging fruit” in 2021  
budget



Develop Emergency  
Water Supply Master  
Plan



Evaluate Opportunities  
for Hazard Mitigation  
Grants

Questions?