The Next Generation of Seismic Vulnerability Analysis

Bellevue's Iterative, Probabilistic, Risk-Based Evaluation

May 3, 2019 – Doug Lane, PE, and Matt Maring, PE

CITY OF BELLEVUE WASHINGTON

Optimatics PLAN SMARTER

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Presentation Overview

- Safety Moment
- Project Approach Overview
- Bellevue Water System Overview
- Seismic Risks and Threats
- Geotechnical Seismic Analysis
- Evaluation Approaches and Progress
- Next Steps

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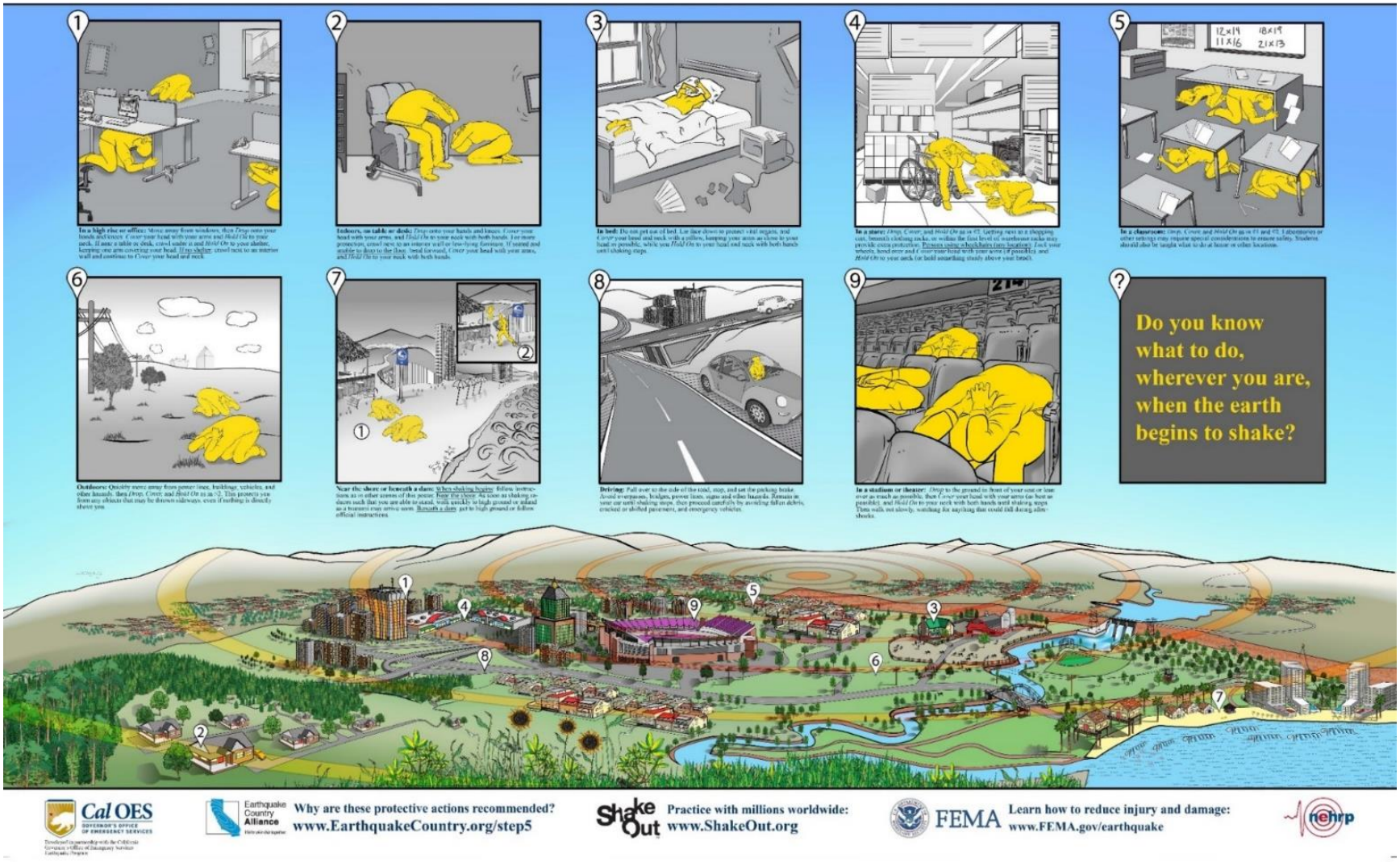
Safety Moment – Earthquake Self Protection



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Project Approach Overview

Project Goals and Priorities

Characterize water system seismic threats

Identify vulnerabilities and potential customer impacts

Determine improvements needed to mitigate risks

Develop level of service goals and implementation plans

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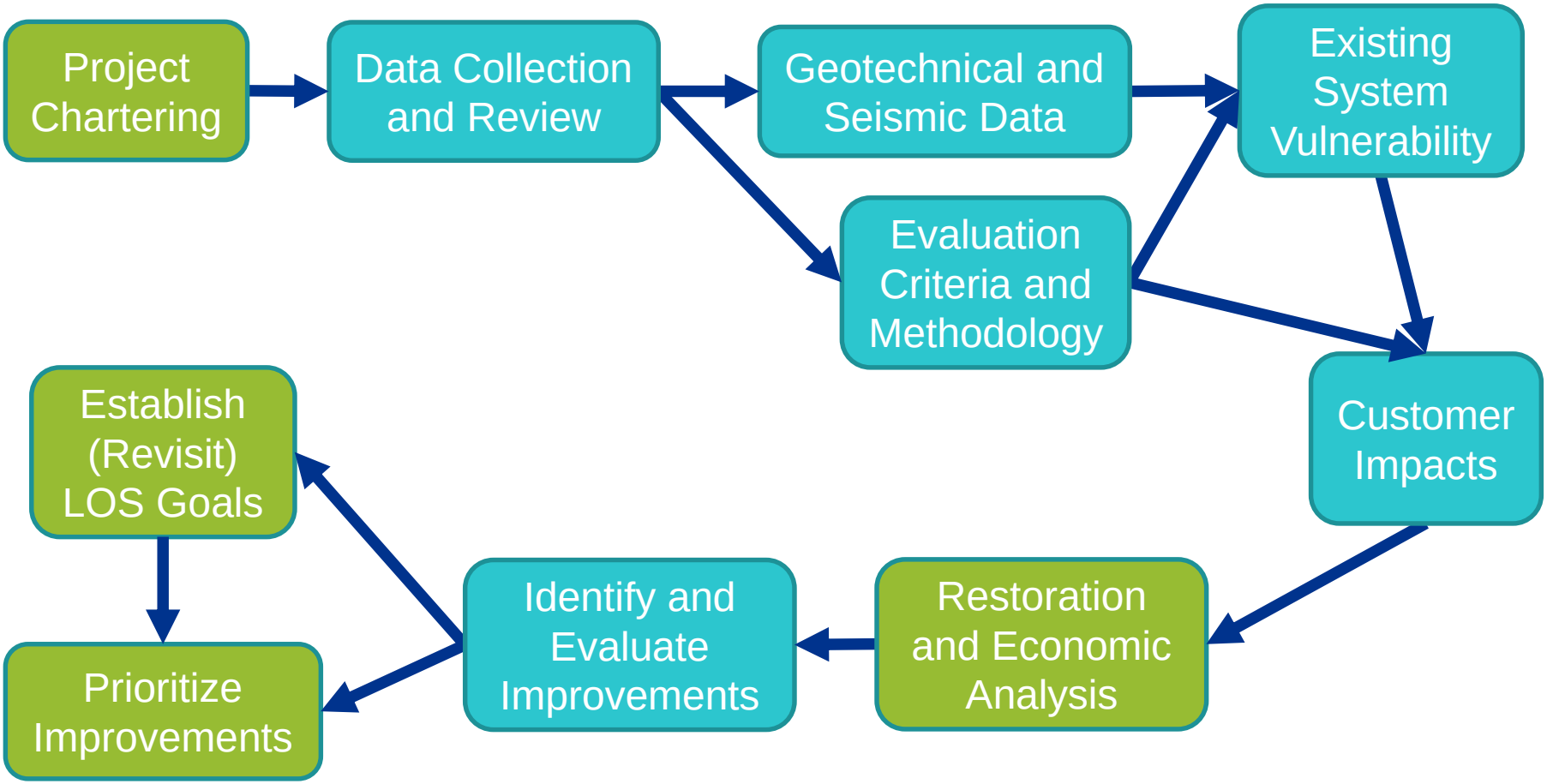
Seismic Vulnerability Assessment Approach



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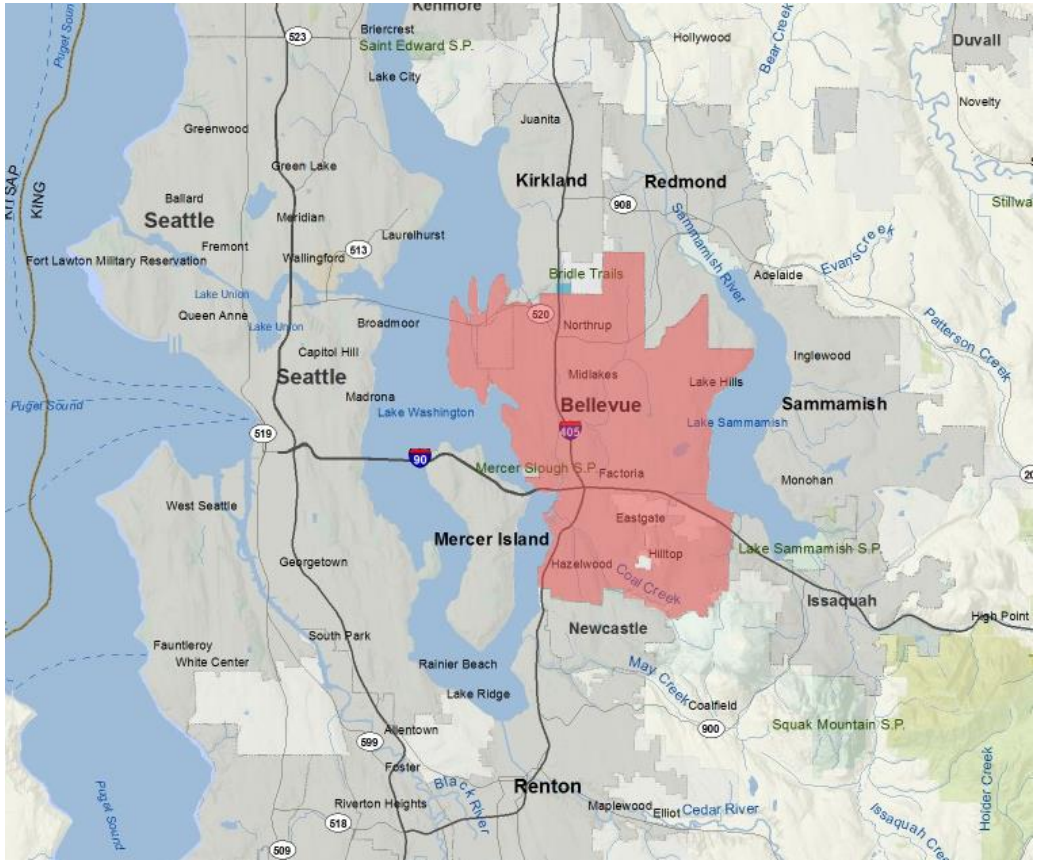
Bellevue Water System Overview

Bellevue Water Service Area

- 150,000+ Population
- 140,000+ Jobs
- 13 Regional Water Supply Inlet Stations
- 69 Pressure Zones
- 24 Storage Tanks
- 22 Pump Stations
- 148 PRV Stations
- 620 Miles of Pipe
- 20-1440 ft Surface Elevations



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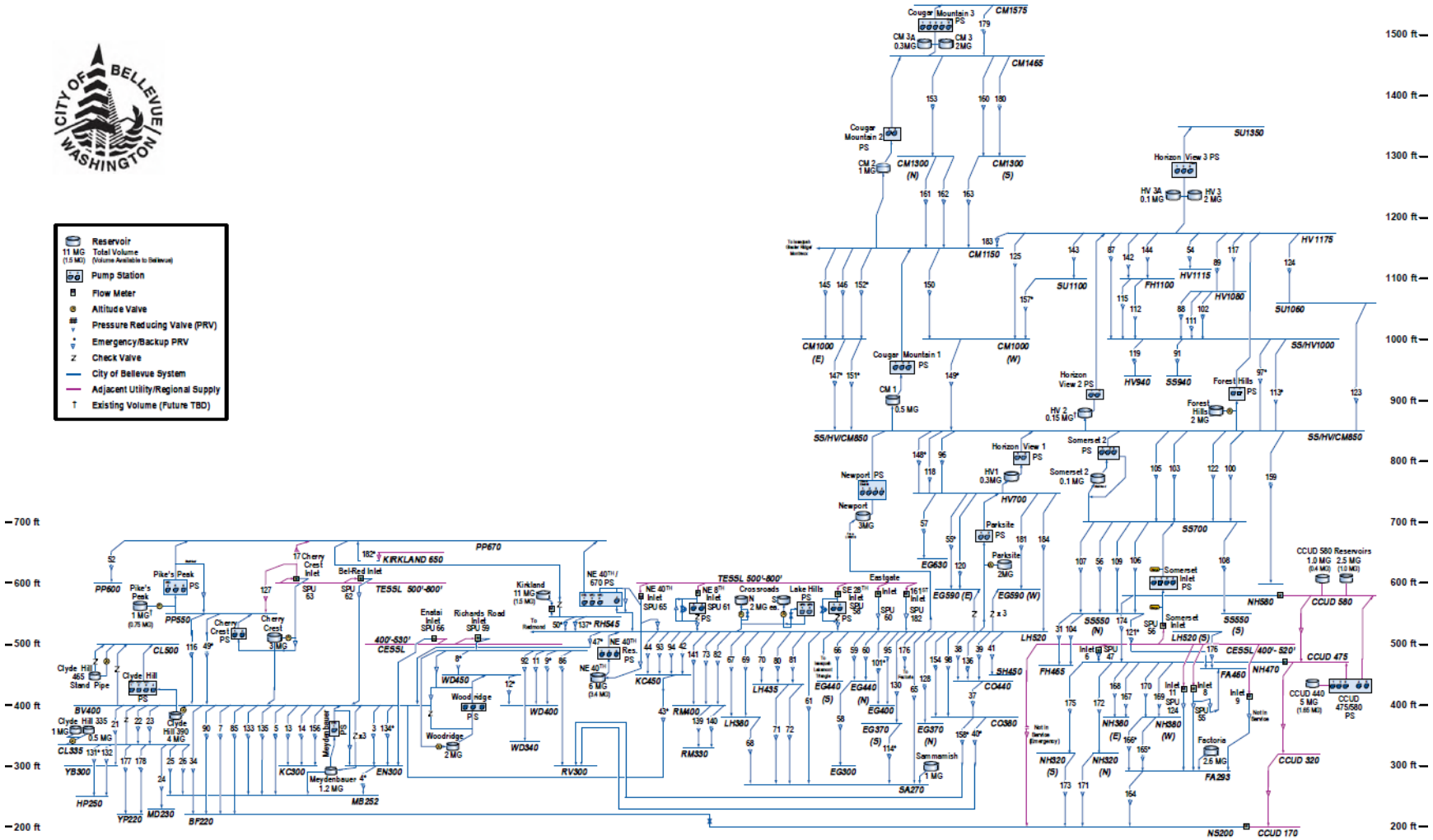
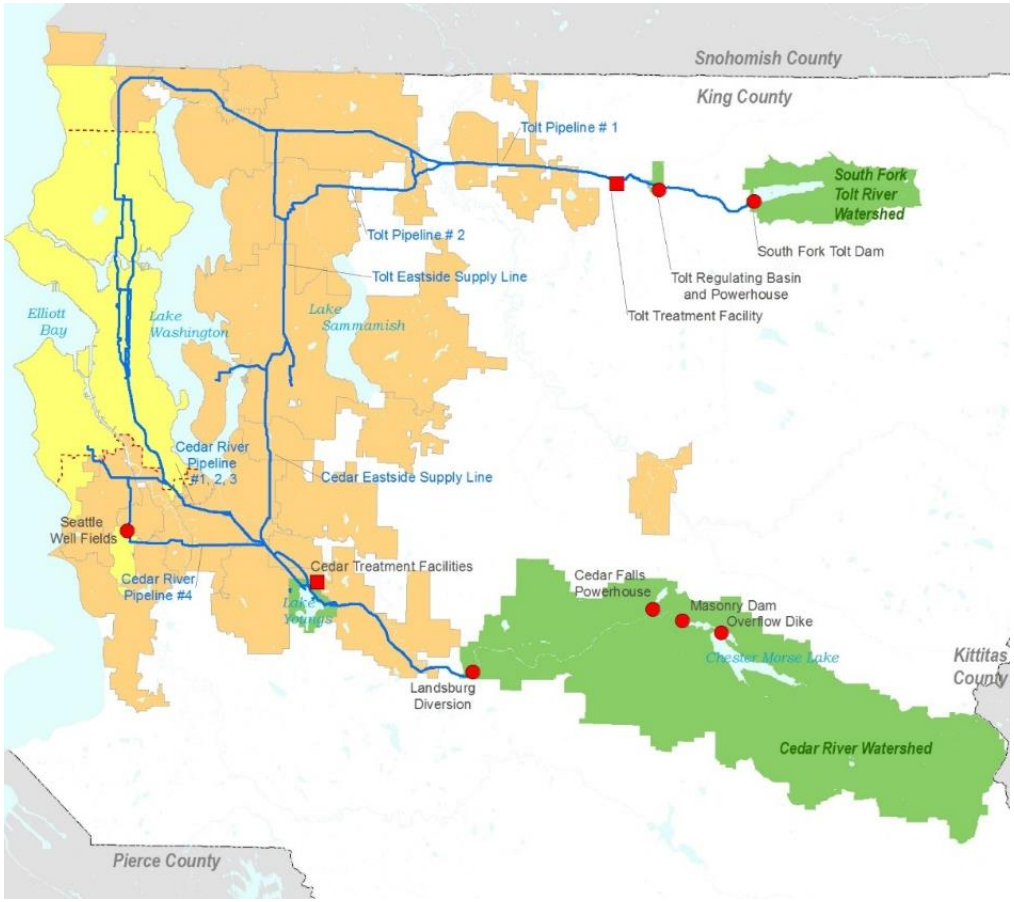
Bellevue Water System Hydraulic Profile



Seattle Public Utilities Regional Supply System



- Cedar and Tolt River Surface Water Supplies
- Cedar Eastside Supply Line
- Tolt Eastside Supply Line
- Wholesale water supply to Bellevue and other regional retail supply systems

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Seismic Risks and Threats

Pacific Northwest Faults and Bellevue Risks

- Cascadia Subduction Zone (CSZ)
- Seattle Fault Zone (SFZ)
- South Whidbey Island Fault (SWIF)

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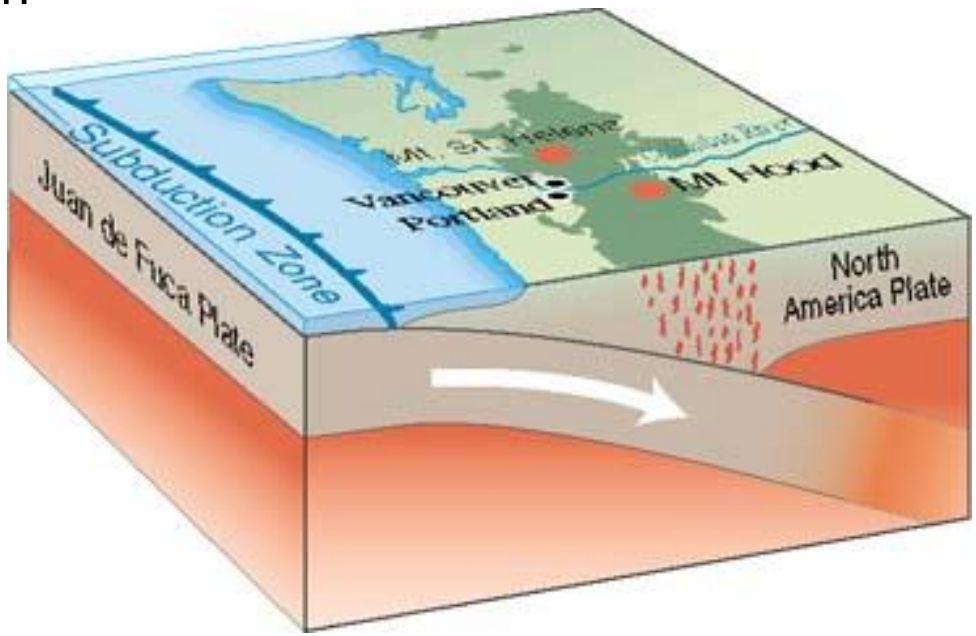
Cascadia Subduction Zone Earthquake

- “The Big One”
- Magnitude 9.0
- ~500 year event
- Longer (~3 minutes) duration
- Pacific Ocean epicenter
- Broad regional impacts



(U.S. Geological Survey)

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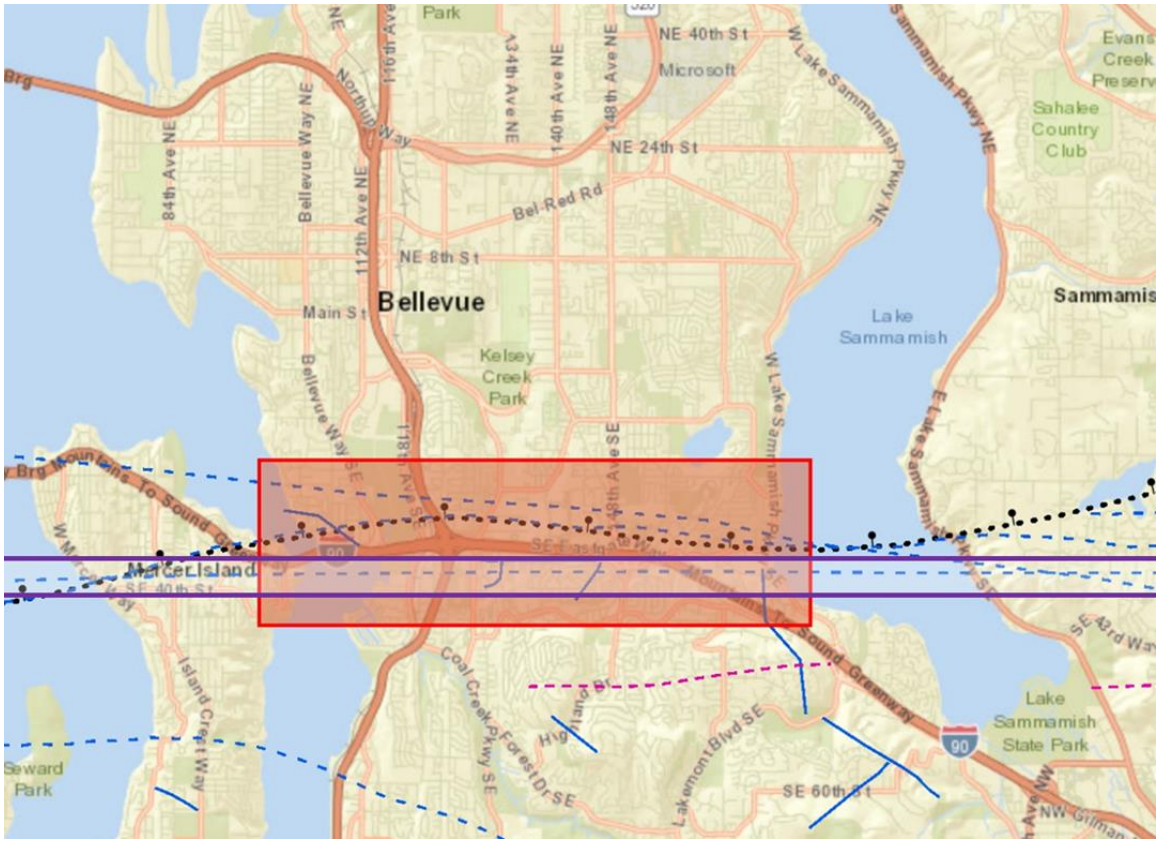
Seattle Fault Zone Earthquakes

- The actual “Big One”?
- Magnitude 6.6 (800+ year) to Magnitude 7.2 (4,000+ year)
- Short duration
- Shallow fault
- Epicenter near or under Bellevue
- Severe localized impacts



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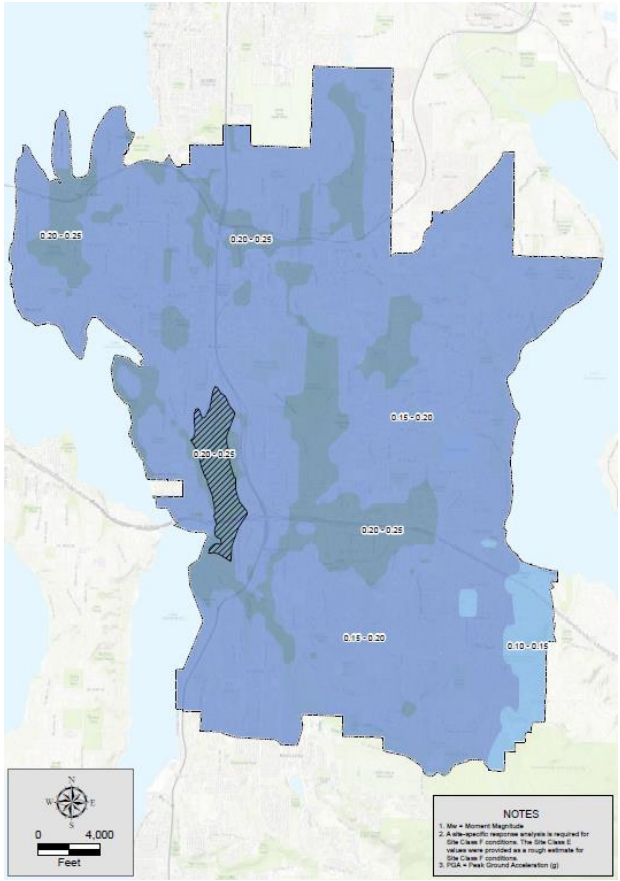
Geotechnical Seismic Analysis

Peak Ground Acceleration (PGA)

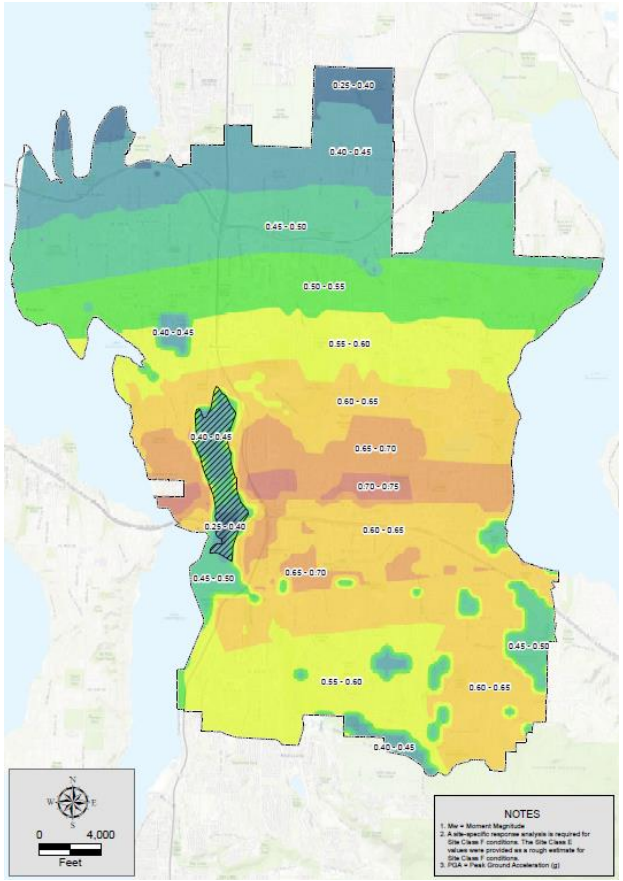
Cascadia Subduction Zone

Mw 9.0



Seattle Fault Zone East

Mw 6.6



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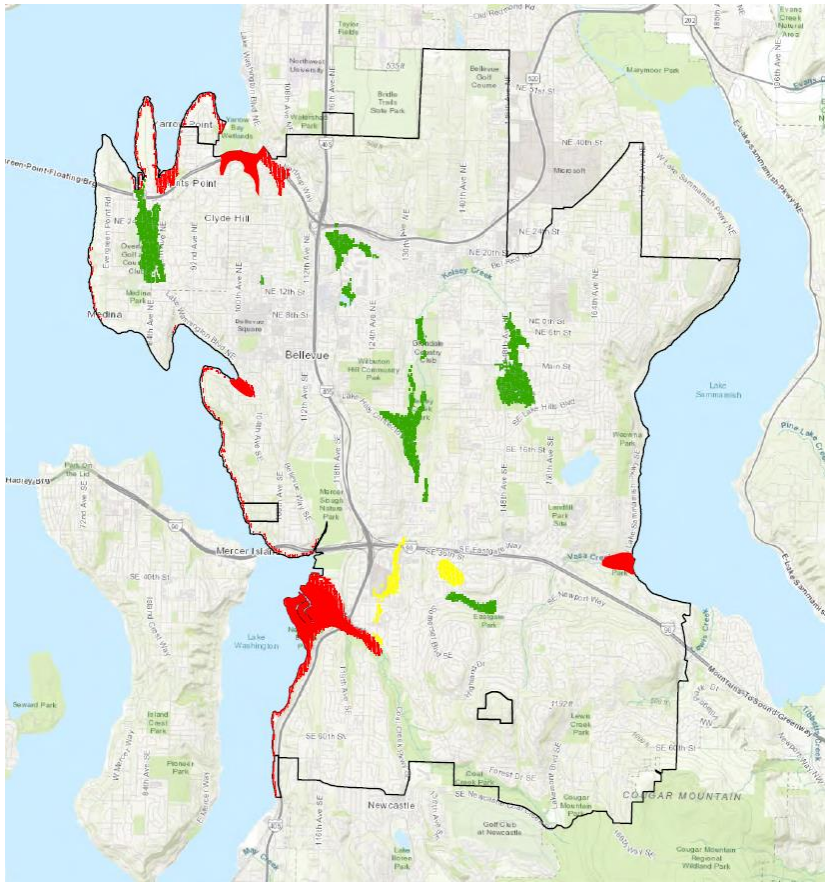
Liquefaction and Subsidence Risks

Cascadia Subduction Zone

Mw 9.0



Seattle Fault Zone East

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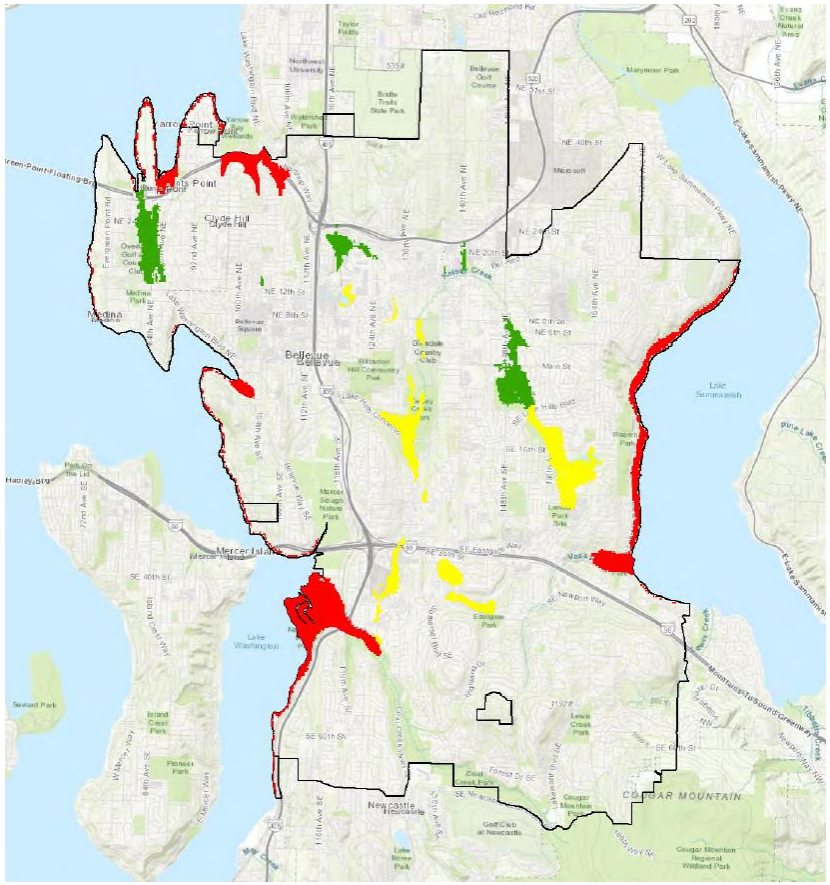

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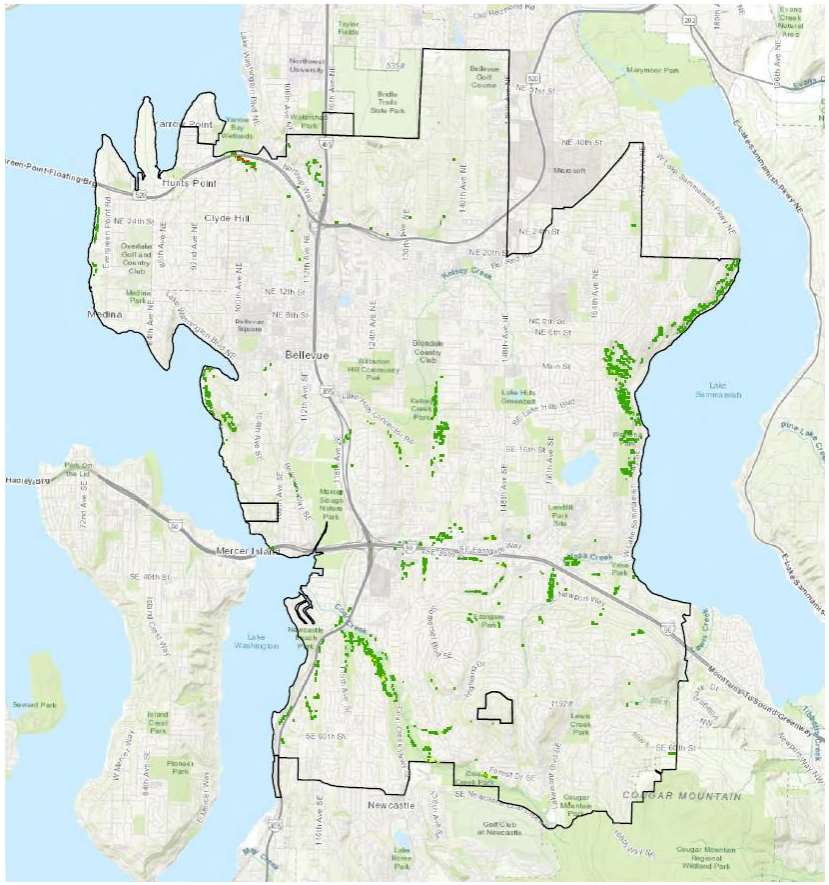
Landslide and Slope Stability Risks

Cascadia Subduction Zone

Mw 9.0



Seattle Fault Zone East

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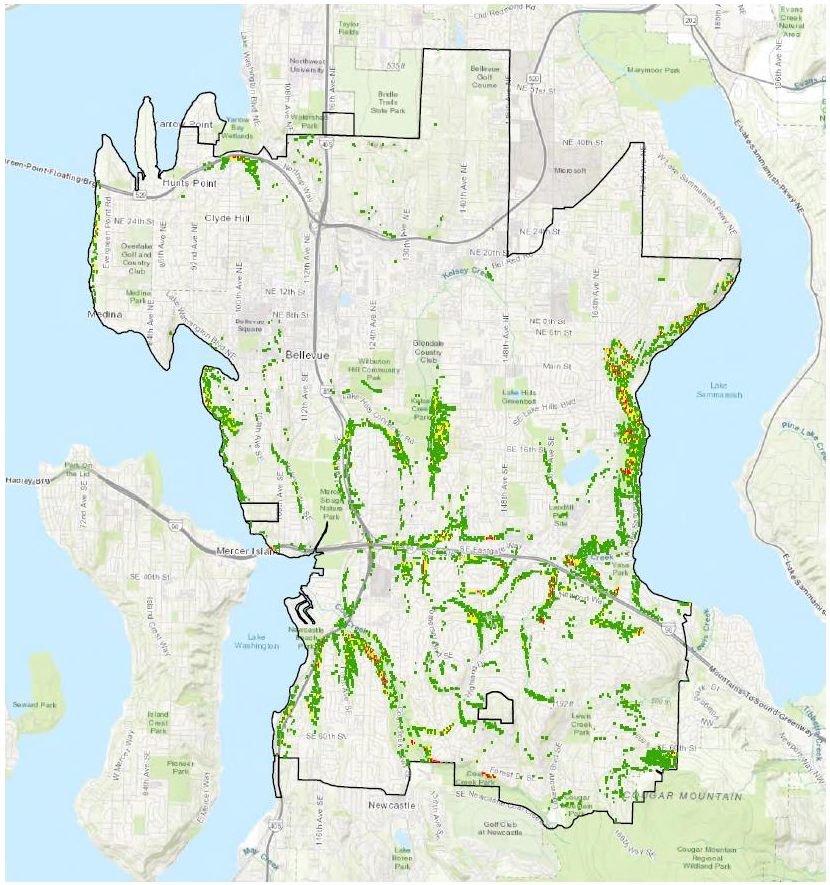

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Evaluation Approach and Progress

Facility Hazus Vulnerability Analysis

Compare current facility to code requirements

Select Hazus fragility curve corresponding to “code level”

Overlay predicted seismic ground motions

Evaluate damage probabilities based for use in multi-break modeling analysis

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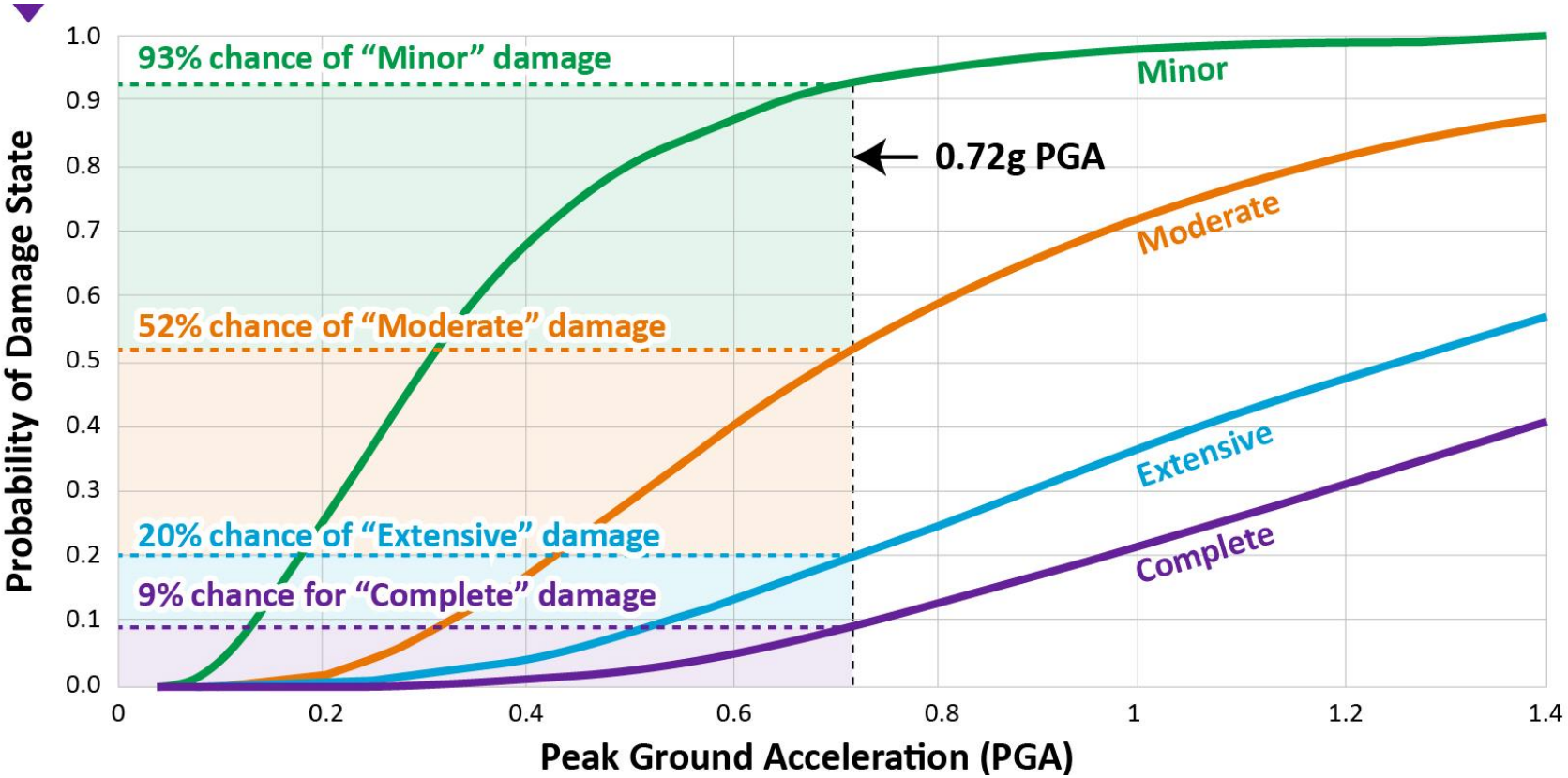
Facility Hazus Vulnerability Analysis



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Pipeline ALA Vulnerability Analysis

Identify location, material, and size of pipes via GIS

Apply appropriate ALA fragility equation based on pipe classification

Overlay predicted seismic ground motion and displacement

Evaluate leak and break probability for use in multi-break modeling analysis

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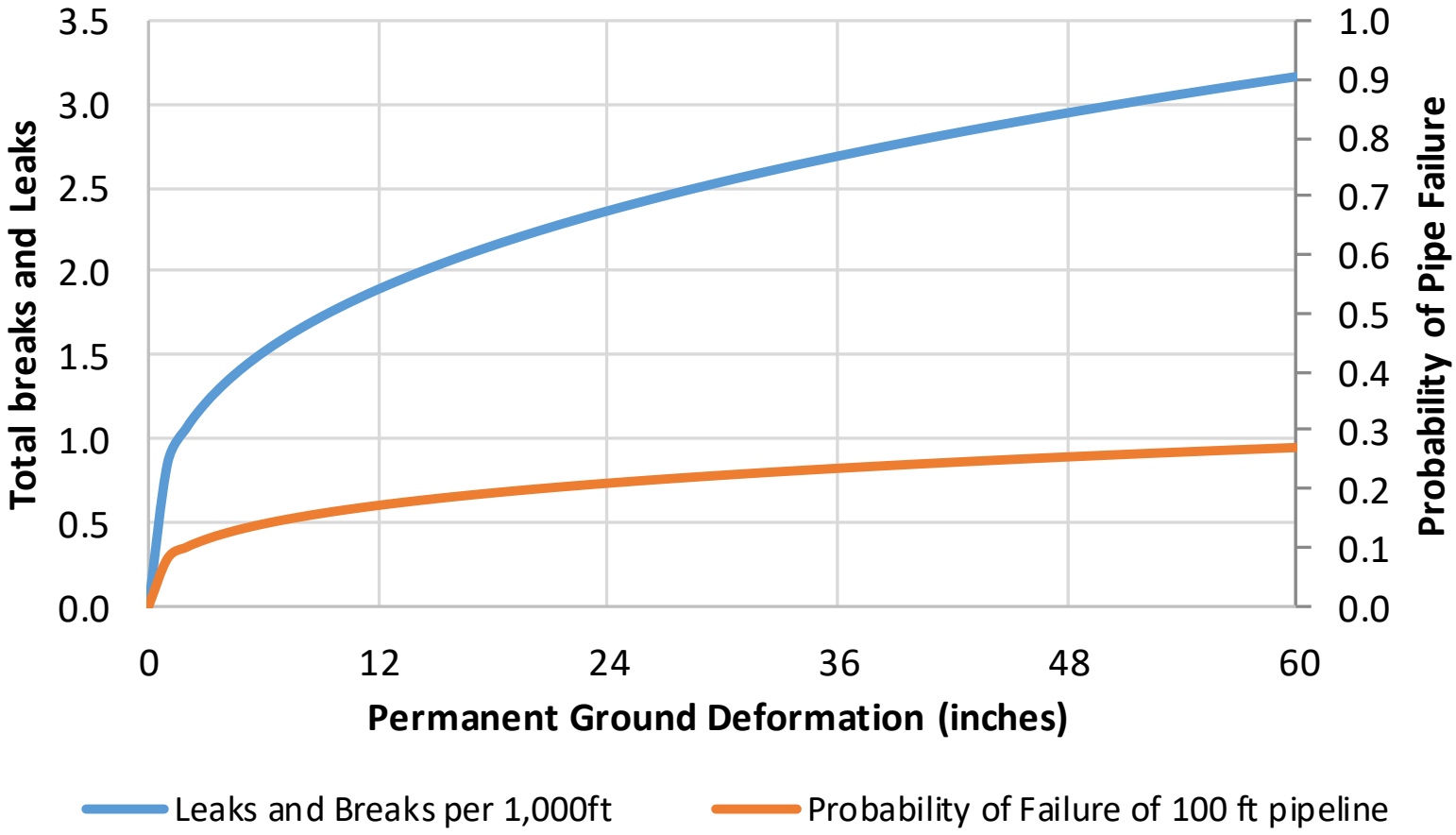
Pipeline ALA Vulnerability Analysis



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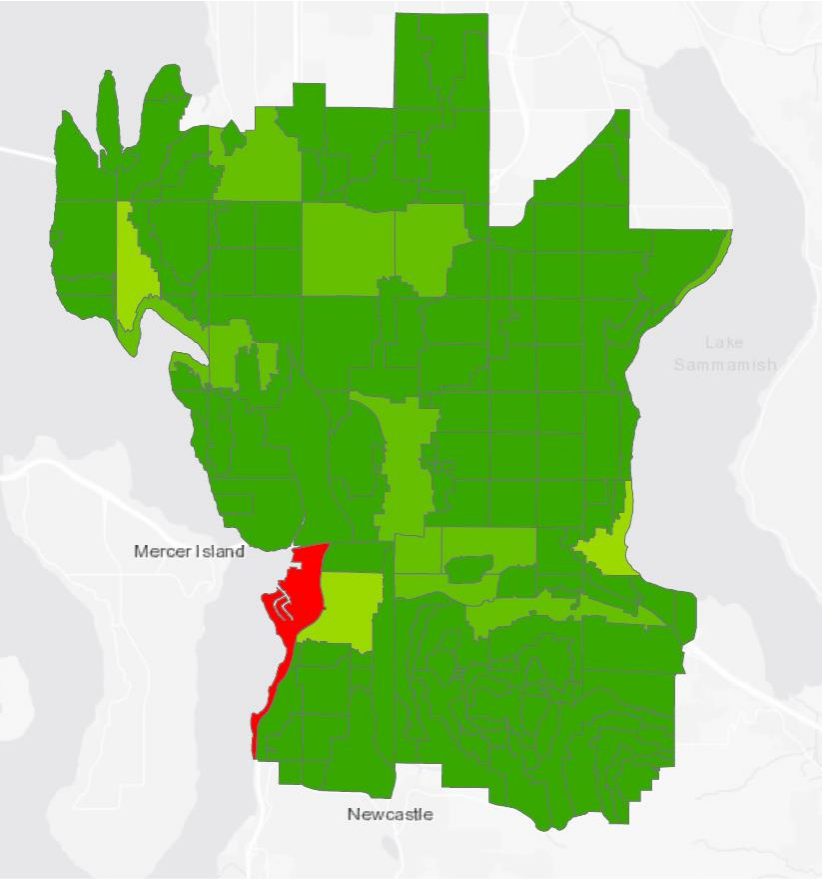
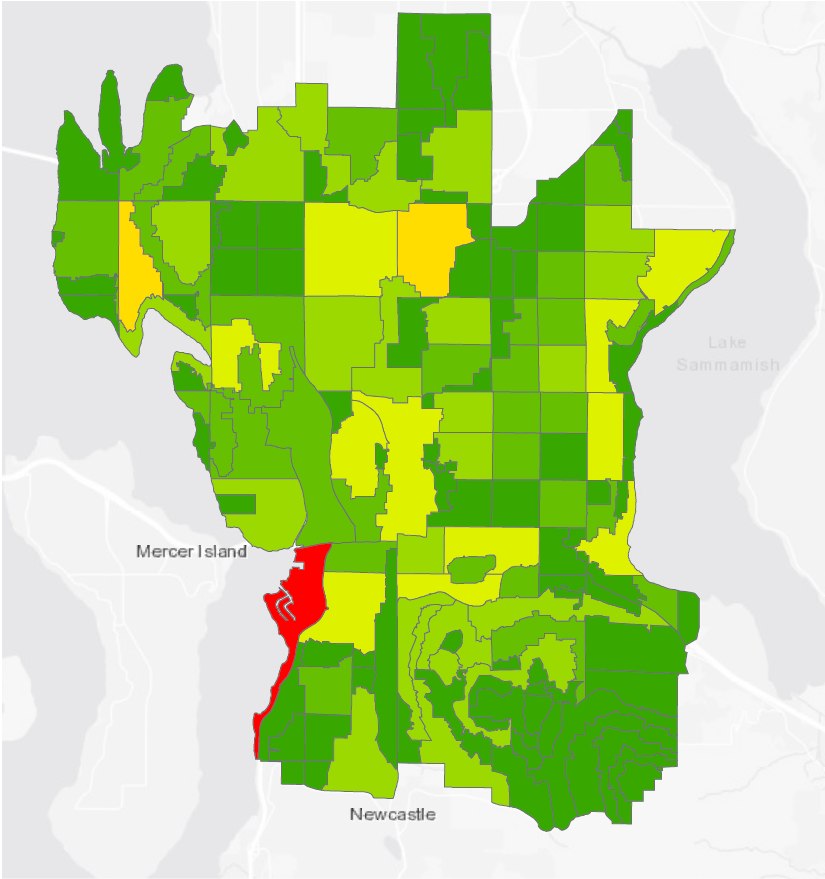
Seattle Fault Zone East – Pipe Failure Distribution

Probable Pipe Break Counts by Analysis Area



Combined Probable Pipe Breaks and Leak Counts by Analysis Area



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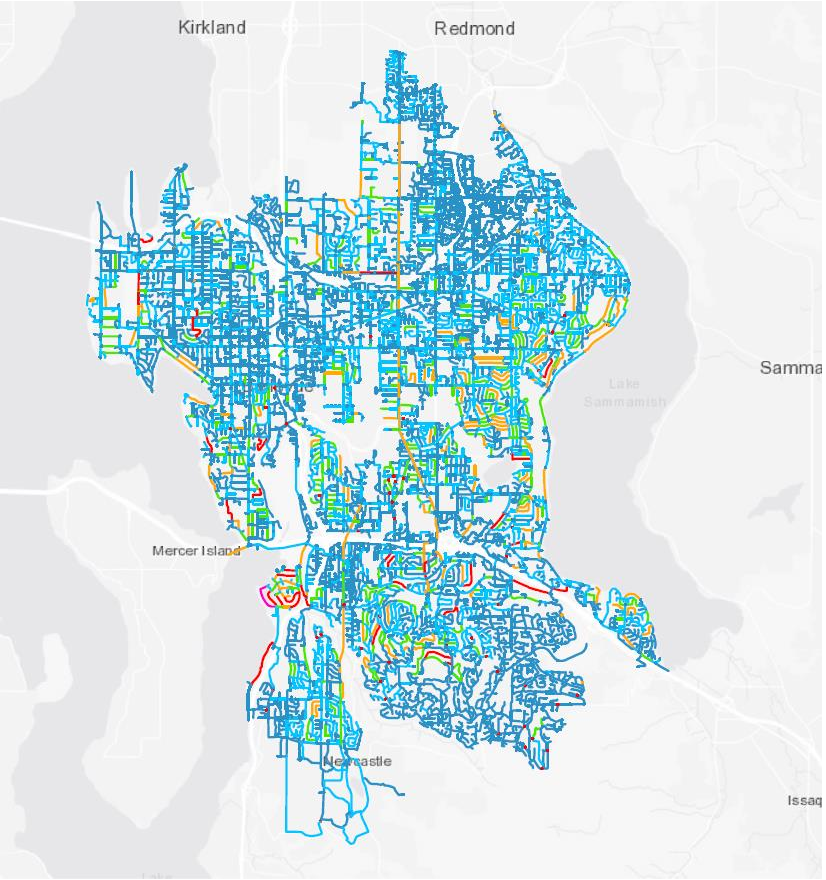
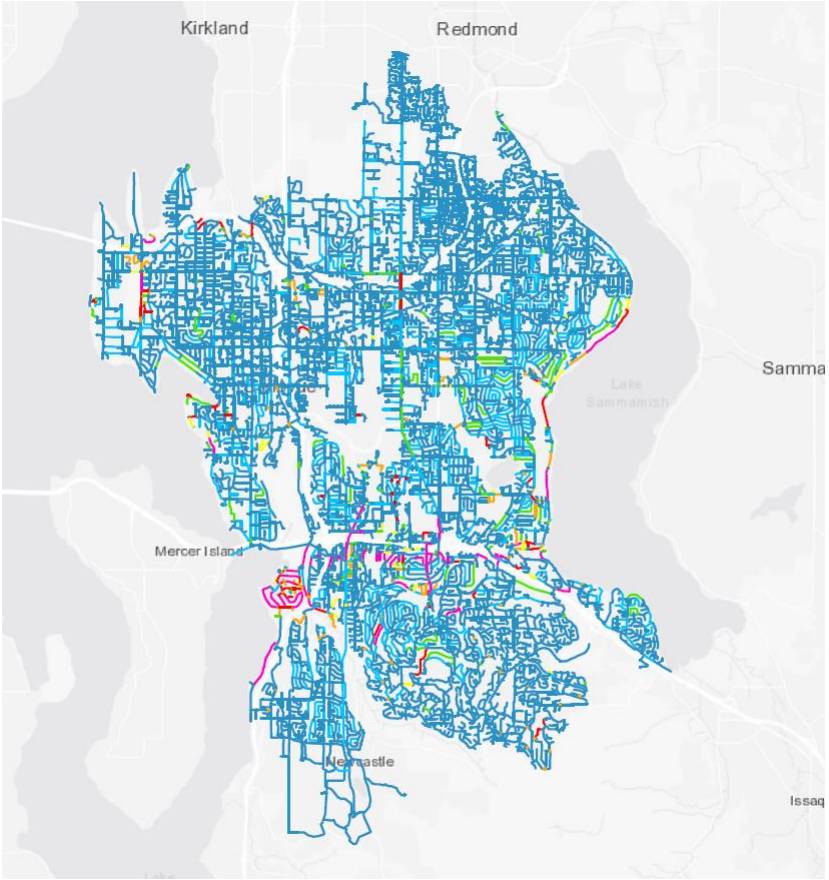
Seattle Fault Zone East – Pipe Failure Probabilities

Pipe Leak Probabilities



Pipe Break Probabilities



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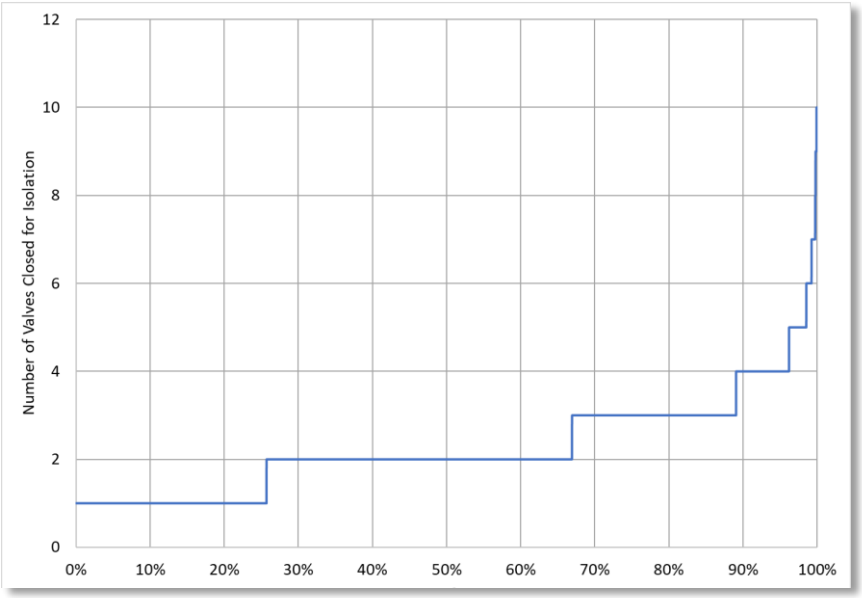
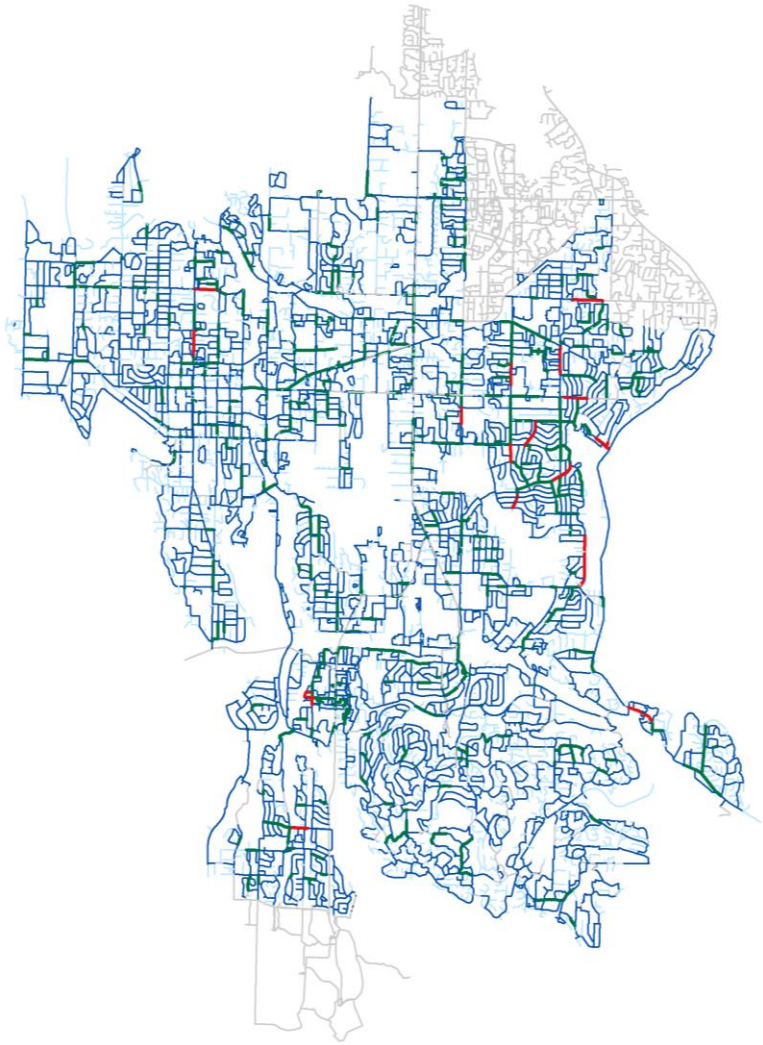
Single Pipe Failure and Criticality Analysis

Number of Valve Closures Required for Pipe Failure Isolation





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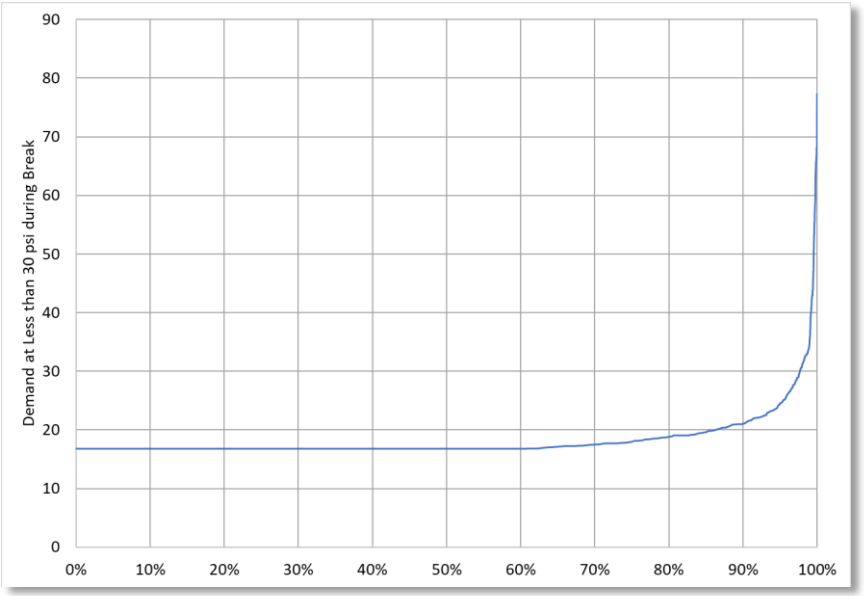
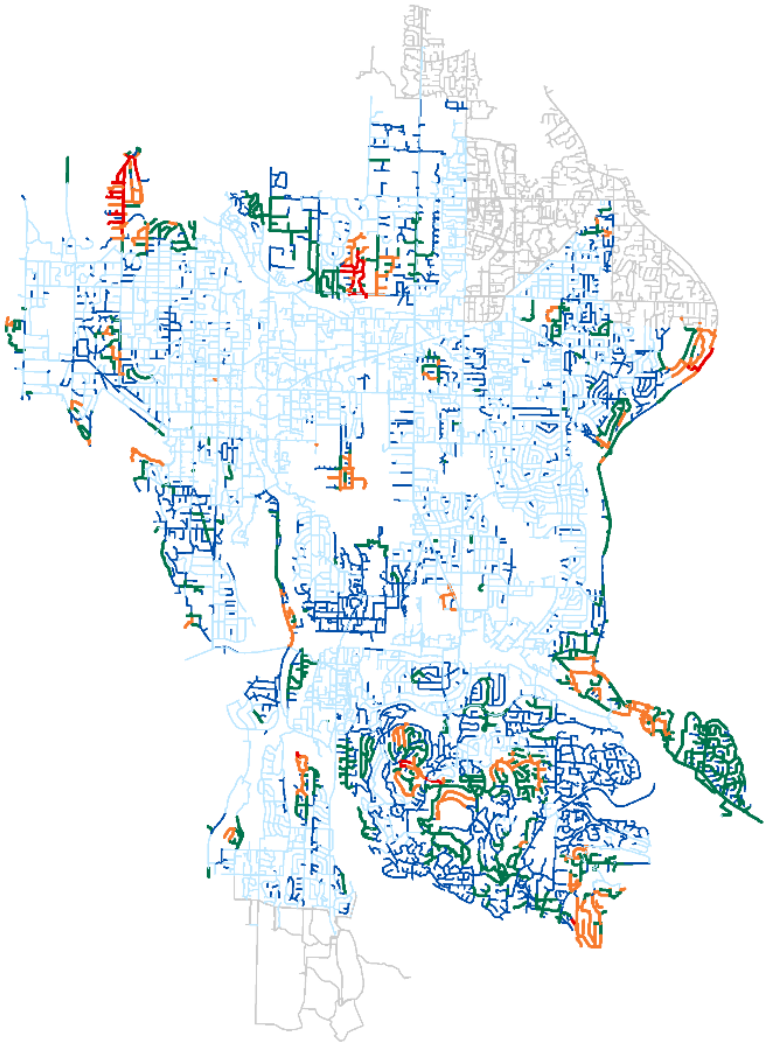
Single Pipe Failure and Criticality Analysis

Demands Supplied below 30 psi during Pipe Breaks Events





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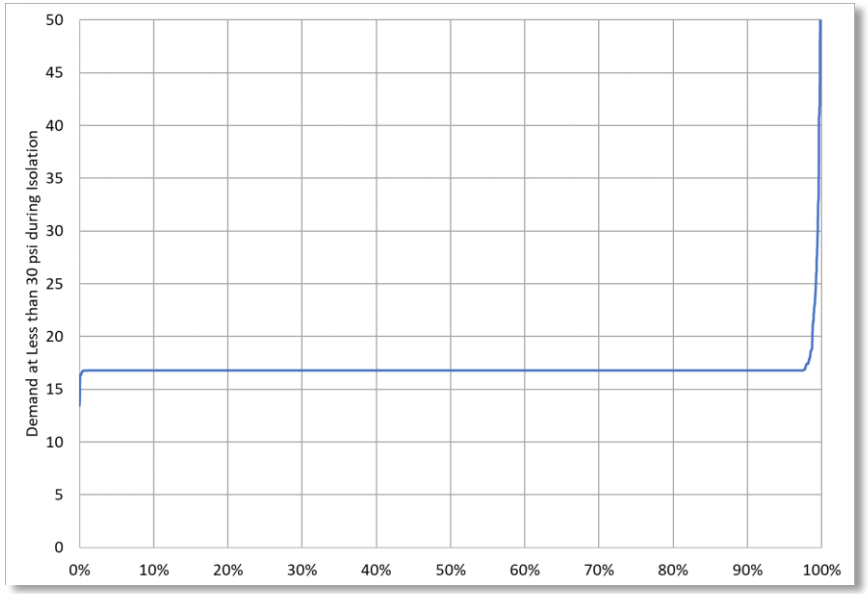

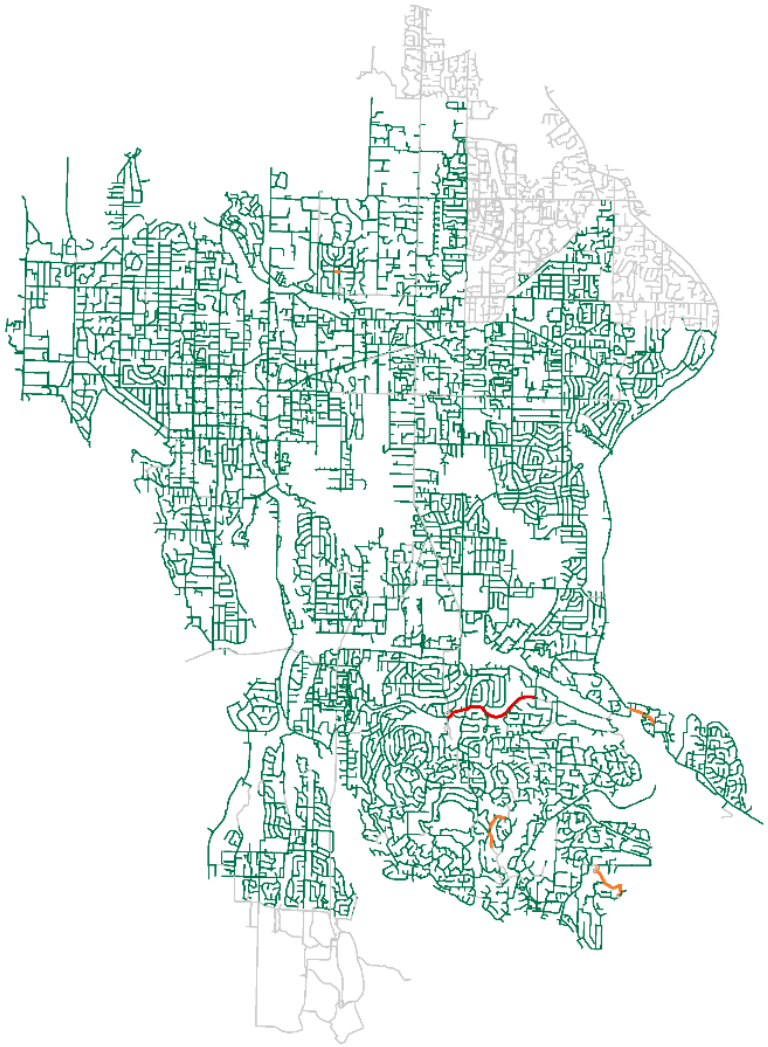

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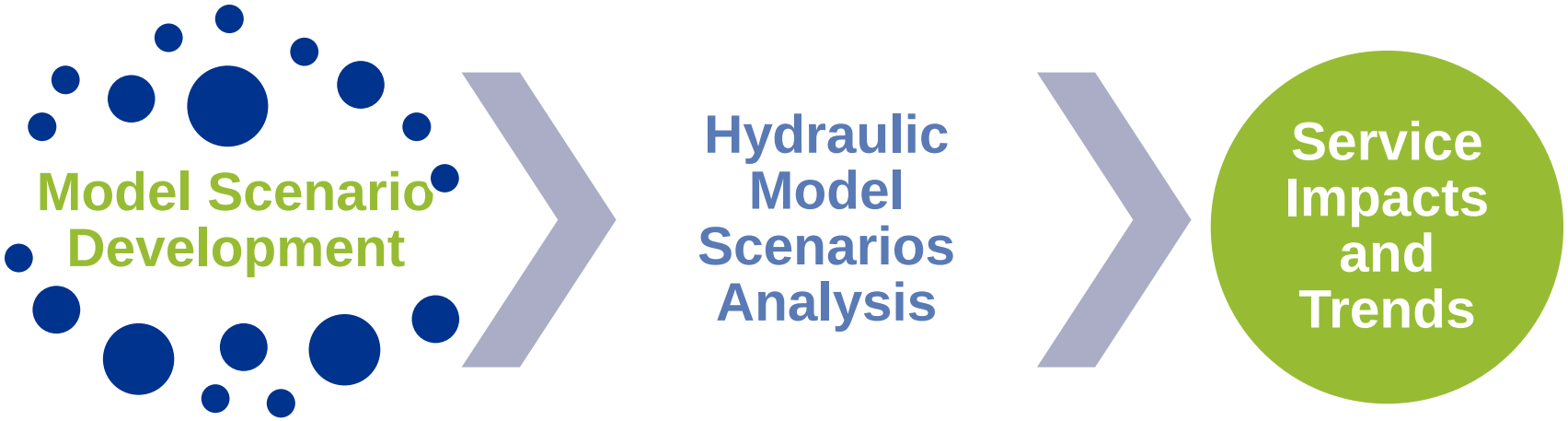
Monte Carlo Scenario Development and Modeling



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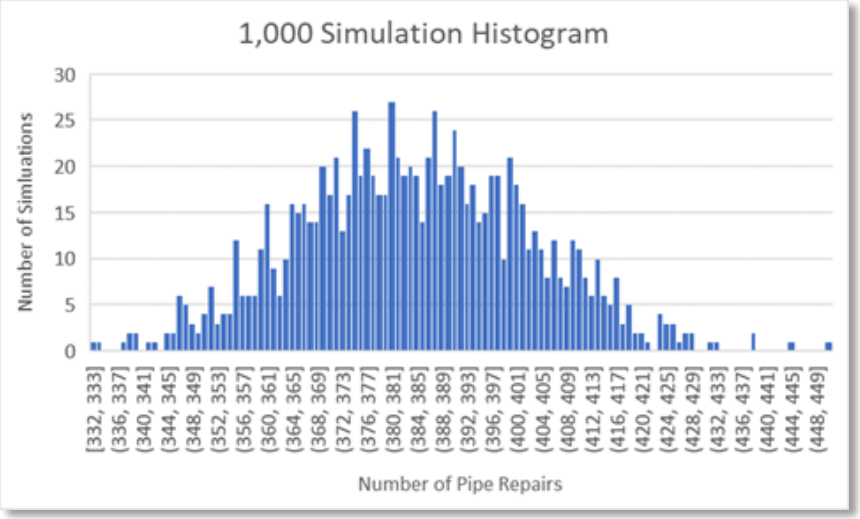
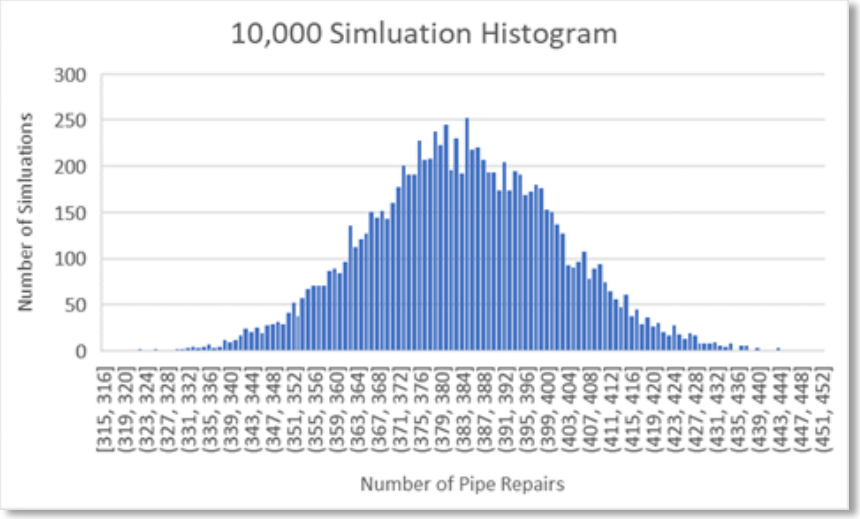
Monte Carlo Simulation Development

Methodology

- Custom Python script developed to simulate scenarios
- Pipe breaks and leaks based on ALA probability of occurrence
- Facility status based on probability of damage from Hazus
- 10,000 simulations for use in multi-break modeling analysis with Optimatics
- Compared damage results to mean expected values by system subarea to confirm results are “helpful”





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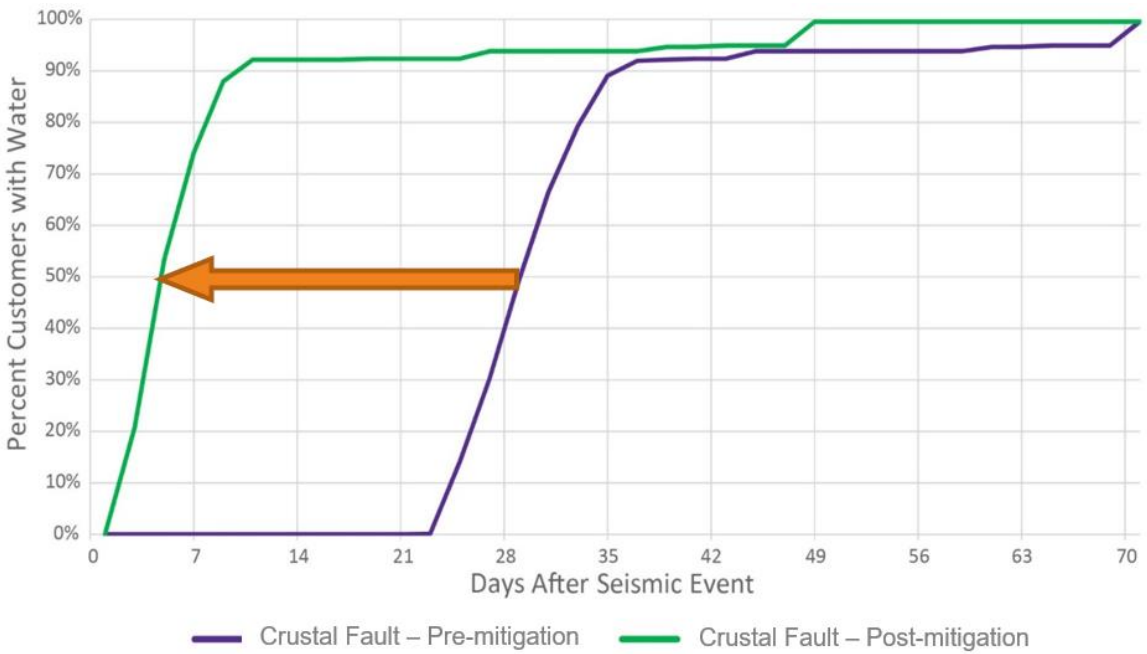
Next Steps

Next Steps

- Multiple Break and Failure Impacts Analysis and Results (All Elements, Iterative, Probabilistic, Monte Carlo Model Evaluations)
- Projected Customer and Economic Impacts
- Restoration Strategies and Service Recovery
- Improvement Alternatives and Benefits Analysis
- Levels of Service and Cost-Benefit Analysis
- Improvement Recommendations and Planning



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Core Team Acknowledgements

City of Bellevue

- Andrew Lee
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Jacobs

- Don Ballantyne
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Optimatics

- Joshua Cantone

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Questions and Discussion

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