




# Performance Based Earthquake Engineering and Assessment Tool for Gas Storage and Transmission Systems

## OpenSRA Workshop - January 11, 2022

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# Outline

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  - Task 3 – Develop OpenSRA
  - Task 4 – Targeted Research
  - Task 5 – Validation and Demonstration Sites
  - Task 6 – User Workshop
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# Project Goals

- Develop open-source seismic risk analysis software for natural gas infrastructure (*OpenSRA)* to provide regulators and owners a tool to analyze seismic risk in California
- Utilize recent advances in seismic hazard analysis and incorporate focused research on gas infrastructure capacities
- Ensure the tool can accommodate regions and infrastructure where there is little-to-much site-specific information to provide efficient, reliable estimates of risk based on the information available

# Tiered Assessment Approach

*Data availability drives uncertainty of the estimate*

## Level 1 – Statewide

- Statewide maps: Geologic units (2010, CGS), Vs30 (Wills et al., 2015)
- Do not utilize subsurface or site-specific geotechnical data

## Level 2 – Regional

- Maps/datasets available at the regional scale (Bay Area) with higher resolution than Level 1 data
- May use limited/generic subsurface data specific to a region

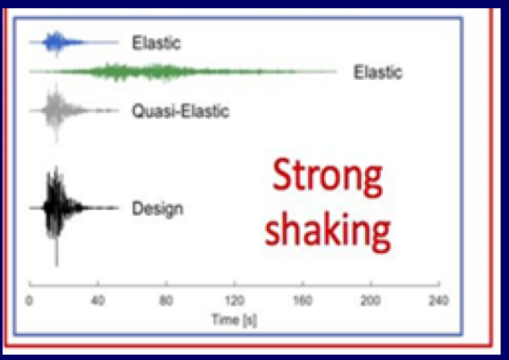
## Level 3 – Site-Specific

- Site-specific geotechnical data (groundwater, CPT/SPT, index tests)

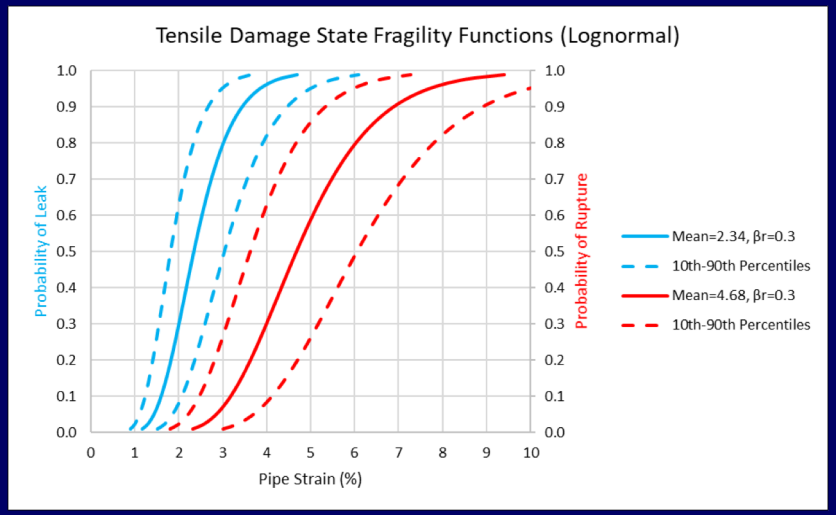
## Level 4 – Advanced Analysis (not part of project scope)

## Seismic Demand



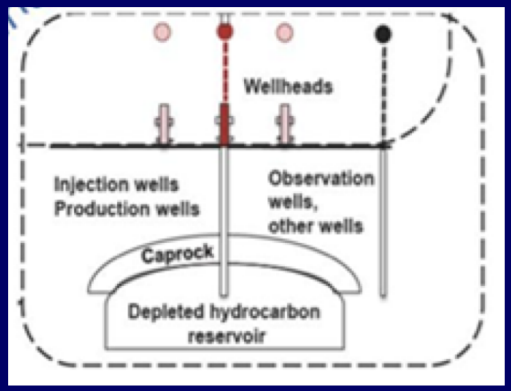

## Component and System Fragilities

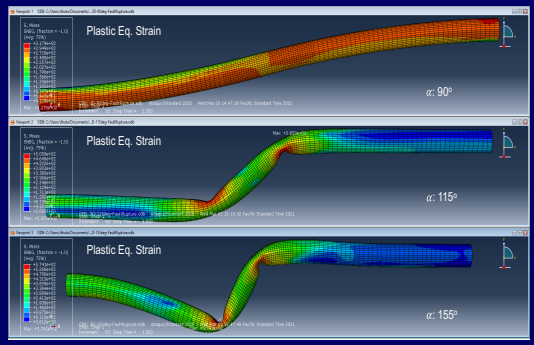



OpenSRA

## Capacity

Surface Elements



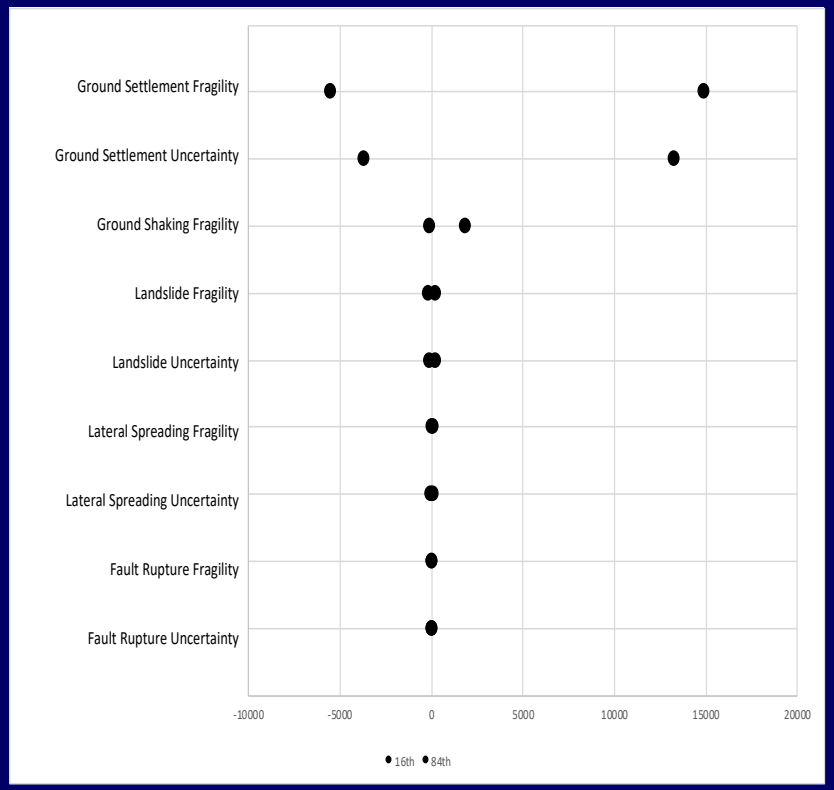

Subsurface Interface

# Task 2 – Sensitivity Analyses

- Performed sensitivity analyses using preliminary version of OpenSRA
- Results were used to focus efforts in Task 4 – Targeted Research

# Task 2 – Sensitivity Analyses Findings

- Fragility curves have a greater impact than demand parameter models
- Epistemic uncertainty in ground shaking fragility model is larger than other demand parameters
- Epistemic uncertainty from liquefaction-induced lateral spreading can lead to catastrophic failures
- Surface fault rupture has little impact statewide but can have a significant impact at a site.



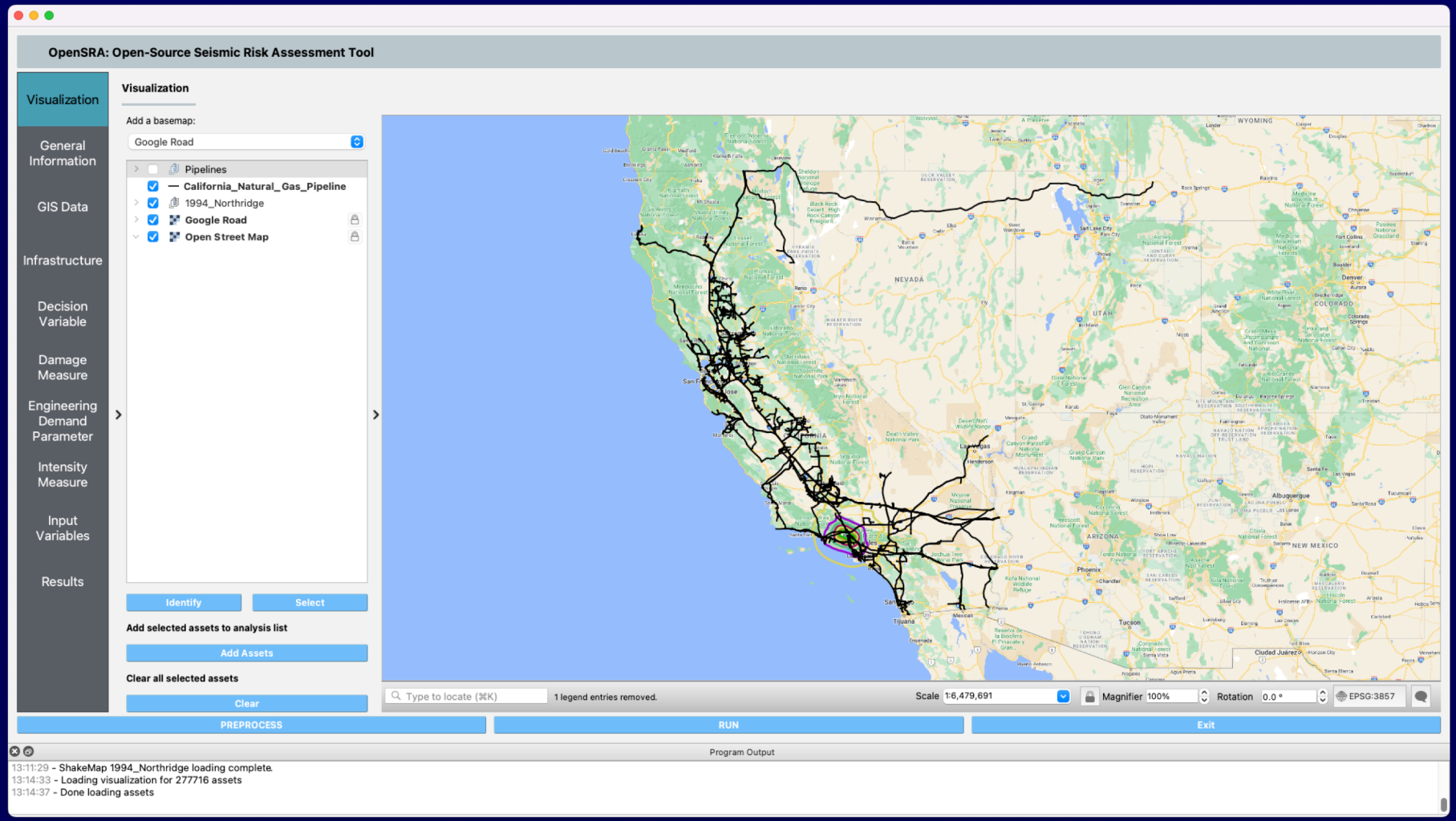
# Task 3 – OpenSRA Development

- OpenSRA is based on the PEER PBEE methodology and incorporates results from:
  - UCERF3 Seismic Source Characterization
  - NGA-West 2 Ground Motion Characterization
  - Polynomial Chaos Calculation Scheme
- Results of Task 4 have been integrated into the code
- Preliminary executable software is available and can be refined over the next 2 months

# Task 3 – OpenSRA Development

- Straightforward – Analyses are performed using a graphical user interface
- Visual – Can visualize infrastructure, demand parameters and results
- Fast – minutes not hours
- Flexible – User can add new infrastructure and new or site-specific fragility curves

# Task 3 – OpenSRA Development




*Much Thanks to Barry Zheng of Slate*

# Task 4 – Targeted Research

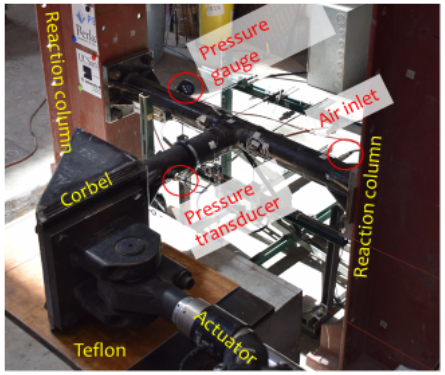
**Some Highlights:**

- **Fragility curves developed for underground pipelines (UCB et al.), above-ground storage facility infrastructure (UCSD/UNR), and wells/caprocks (LBNL)**
- **Developed fast polynomial chaos calculation procedure (UCB)**
- **Component and system pipeline tests performed (UCSD & UNR)**
- **Recommendations on sensors and monitoring (UCB)**
- **Models for subsurface fault & shaking effects on wells (LBNL)**
- **New lateral spread procedure & soil-pipeline response models developed (UCB et al.)**
- **All subtasks supported implementation into *OpenSRA***

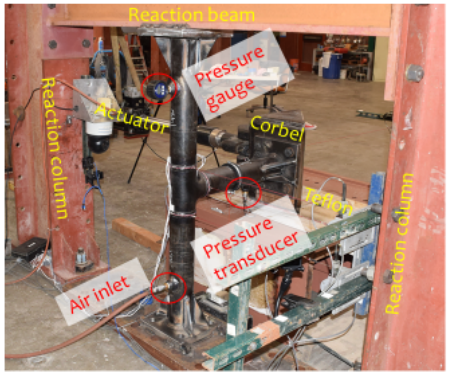
# Task 4d – Laboratory Testing

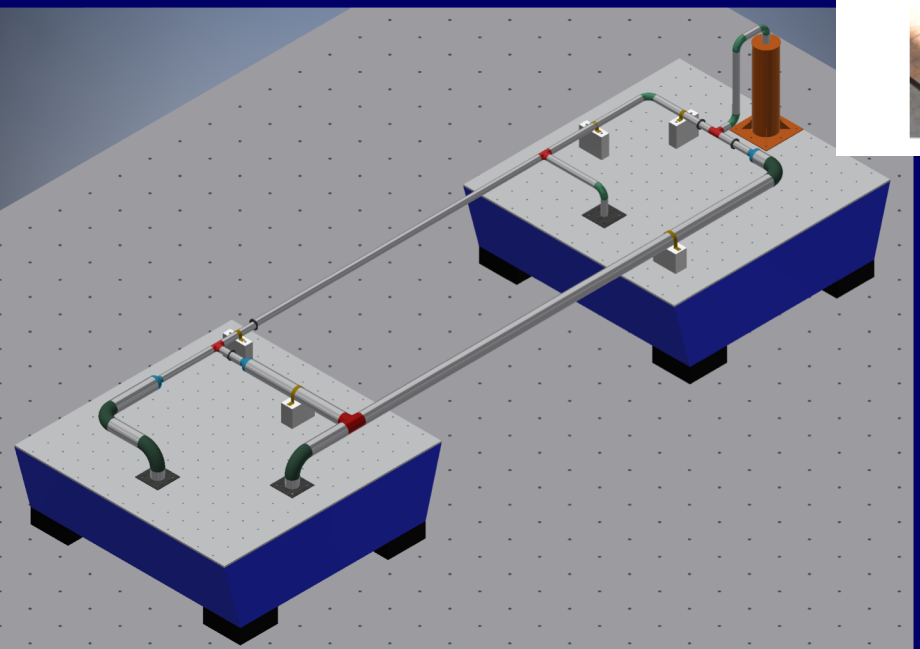
## Test setup

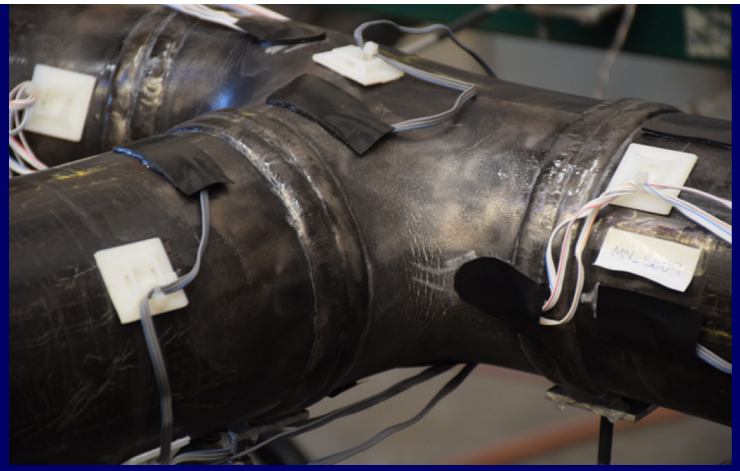
In-plane (IP) test




In-plane (OP) test

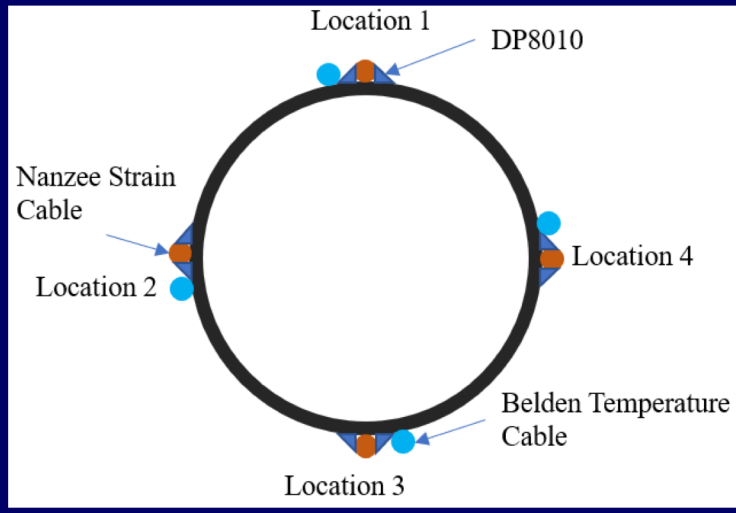




# Task 4e – Field Tests


**(A) Before and (B) During the bending test**

# TAC Comments Helpful

**EXAMPLES**:

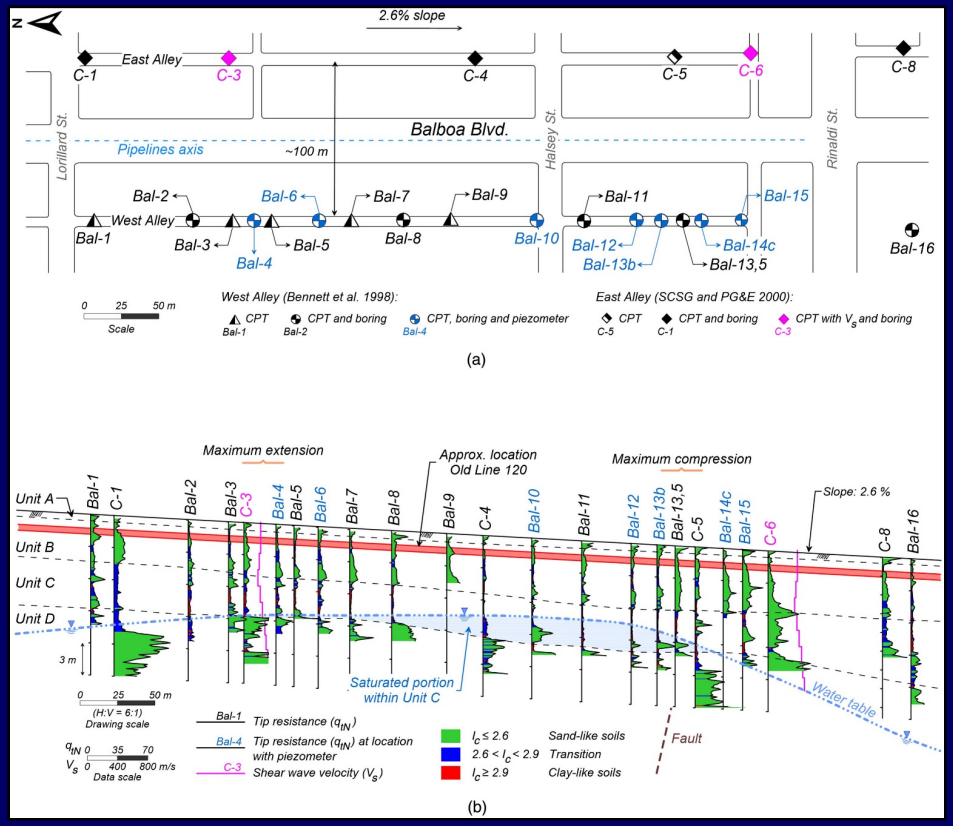
- **Focus on transmission lines, not distribution**
- **Evaluation of service laterals is of minor importance**
- **Focus on well trees and vertical tanks at storage facilities**
- **Remove Java from OpenSRA**
- **Software security review will be extensive**

# Task 5 – Validation & Demonstration Sites

- Used 4 demonstration sites to evaluate and to validate demand and capacity models:
  - Balboa Blvd
  - McDonald Island
  - Cordelia Junction
  - Honor Rancho

# Balboa Blvd Demonstration Site

- Simplified geotechnical inputs at Level 1 (i.e., ground water table) underestimate response to 1994 Northridge EQ
- Level 3 inputs are more detailed and result in much closer estimates of response to 1994 Northridge & 1971 San Fernando EQ




(from Ziotopoulou, Davis & Pretel 2021)

# McDonald Island Demonstration Site

- Assessment of McDonald Island subsystems showed negligible probabilities of failure, consistent with observations

# Honor Rancho Demonstration Site

- Negligible damage to wells was calculated for 1971 San Fernando and 1994 Northridge, consistent with observations

# Cordelia Junction Demonstration Site

- Negligible probabilities for compressive and tensile rupture for 1989 Loma Prieta earthquake, consistent with observations

# Task 6 – User Workshop

- January 11, 2023

***Thank you for joining us***

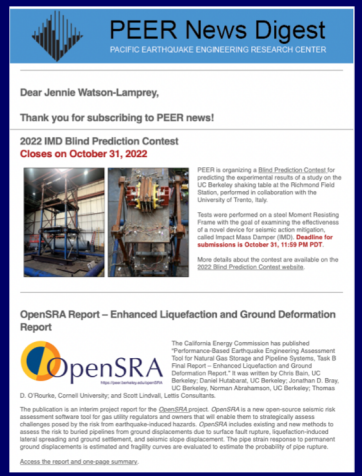
# Task 7 – Project Benefits

- System-wide fragilities and prioritization of mitigation will provide greater reliability of the system.
- Mitigation decisions based on robust quantitative data can focus efforts, resulting in effective disbursement and lower overall costs.

| Performance Metric | Metric Category | Performance Metric Unit | Benchmark Performance | Current Project Performance | Minimum Target Performance | Goal Target Performance | Evaluation Method | Significance of Metric |
|---|---|---|---|---|---|---|---|---|
| OpenSRA website hits | Programmatic - Goals related to data collection, outreach, and project execution | number of hits | NA | 845 per quarter | 50 per year | 100 per year | website tracking | Demonstrate broad project exposure |
| OpenSRA workshop participants | Programmatic - Goals related to data collection, outreach, and project execution | participants | NA | 31 | 10 | 20 | workshop registration | Demonstrate interest and broad use of OpenSRA |
| Accuracy | Technology - Industry standards and barriers being advanced | | NA | - | | | | Demonstrate improvement in accuracy when using the advanced capabilities in OpenSRA |
| Number of pipeline component lab tests | Technology - Industry standards and barriers being advanced | test | NA | 8 tests | 3 tests | 6 tests | completion of test | Demonstrate improvement of fragility calculation. |

# Task 8 – Knowledge Transfer

- Conference Presentations
- *OpenSRA* Website
- PEER Social Media
- PEER Newsletters
- PEER Website
- PEER Reports
- Fact Sheets


# OpenSRA 2023 and Beyond

- Additional funding is being sought to advance research & OpenSRA software
- Will continue to work with owners to adapt and refine for their systems