SWADE: Smart WAter Data Exchange

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Creating an Extensible Data Exchange and Analytics Sandbox for Smart Water Infrastructures

Motivation

- Water infrastructure is aging and becoming increasingly complex: multiple infrastructures include stormwater, drinking water, and wastewater systems
- Agencies/utilities largely operate independently with specific regulatory compliance needs
- Data and structural information can help in planning and operation, but is often siloed within agencies and systems
- Decision-makers (agencies and policy makers) need tools to interpret the data, identify problem sources and translate it into actions

Key Premise: Water cycle data (historical and live) and its dependencies, a bulk of which resides within community agencies, if combined and enhanced with other geo-distributed data sources can enable new levels of efficiency and resilience.

Goals

- Structure the interconnection of different water infrastructures given an understanding of their reliance / impact on each other under normal operation and under extreme events
- Identify specific information required to enable a data-driven approach to extract and address gaps / opportunities at varying spatial and temporal granularities
- Determine barriers (societal, policy/regulatory) on gathering, sharing and usage of this data
- Identify challenges in translating (restricted) data to meaningful information for timely decision making, possibly under large disruptions (e.g., earthquakes)

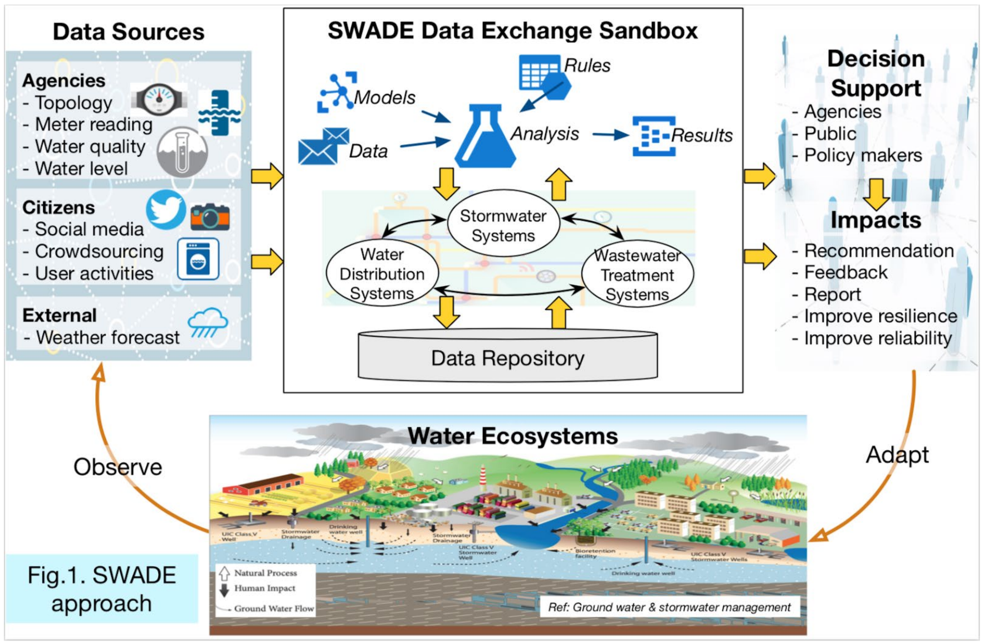
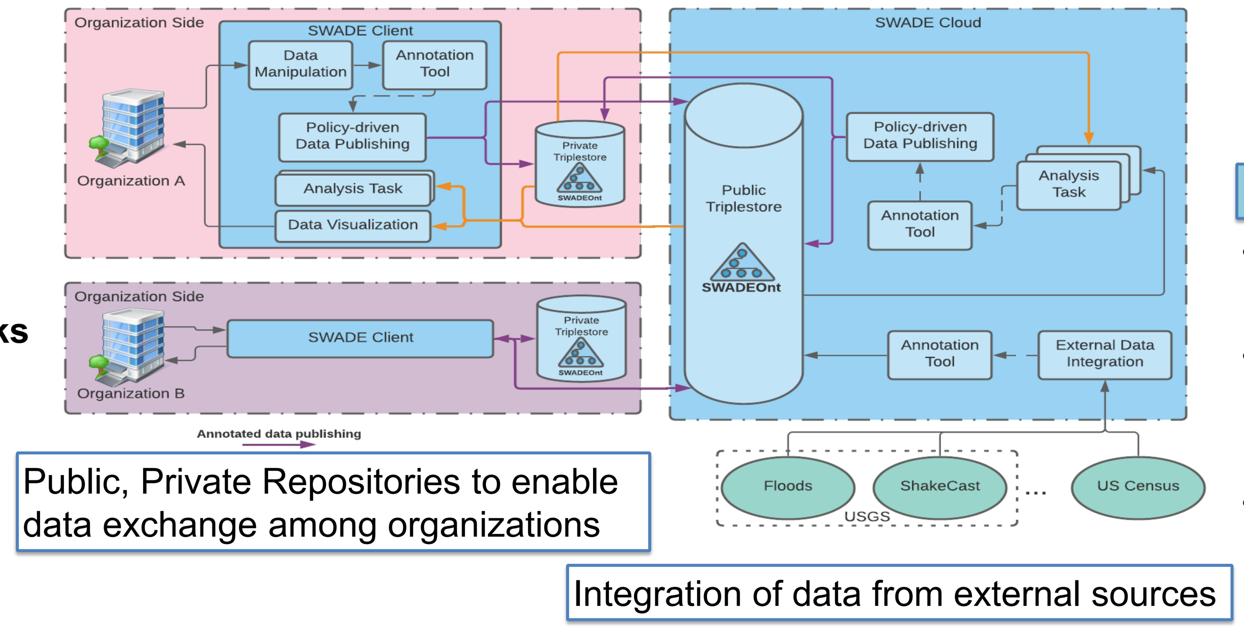


Fig.1. SWADE approach

- Data exchange architecture used to perform analysis tasks across different water organizations
- analysis performed automatically adapts to organization's data format



Challenges

IT Challenges

- Geo-distributed infrastructure, dynamically changing environment and physical (hydraulic) variables
- Heterogeneity of data sources at varying granularities
- Multiple Stakeholders requiring different combinations of information at different times
- Current approaches agnostic to these challenges: (1) requires significant effort to acquire and understand data; (2) delays in processing information; (3) high levels of data redundancy; (4) lack of infrastructure for data exchange

Interdisciplinary Challenges

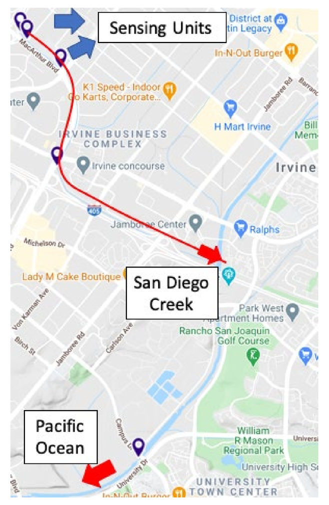
- Modeling joint system structure and data interactions within and across systems
- Inter-agency and community data exchange constraints and barriers (data handling, privacy, security)
- Citizen/Community engagement for water-knowledge co-production

Community Engagement

- Stakeholder workshops and data challenge events
  - Workshop to survey stakeholders (agencies, policy makers, academics, industry groups, etc.)
  - What tools will be valuable to them? What are their concerns (privacy, data sharing, accessibility)? What tools can be built to facilitate cooperation?
- Engagement for platform creation and community data instantiation
  - Engagement from SWADE stakeholders to help design and develop platform
  - Leverage currently used tools, datasets, and data formats
- Validation Studies with Community Water Networks
  - Scenario Creation with Partner Agencies
  - Deployment of SWADE Tools for Analysis
- SWADE Internships
  - Embedding students as interns at various agencies
  - Undergraduate and High School Research Opportunities

Domain: Stormwater

Focus Problem: Source Identification for Dry Weather Monitoring



Network Structure and Time Series Analysis

- Detect contamination events and sources rapidly
- Understand role of network structure and its relationship to data generated using time-series analytics

Sensor Placement

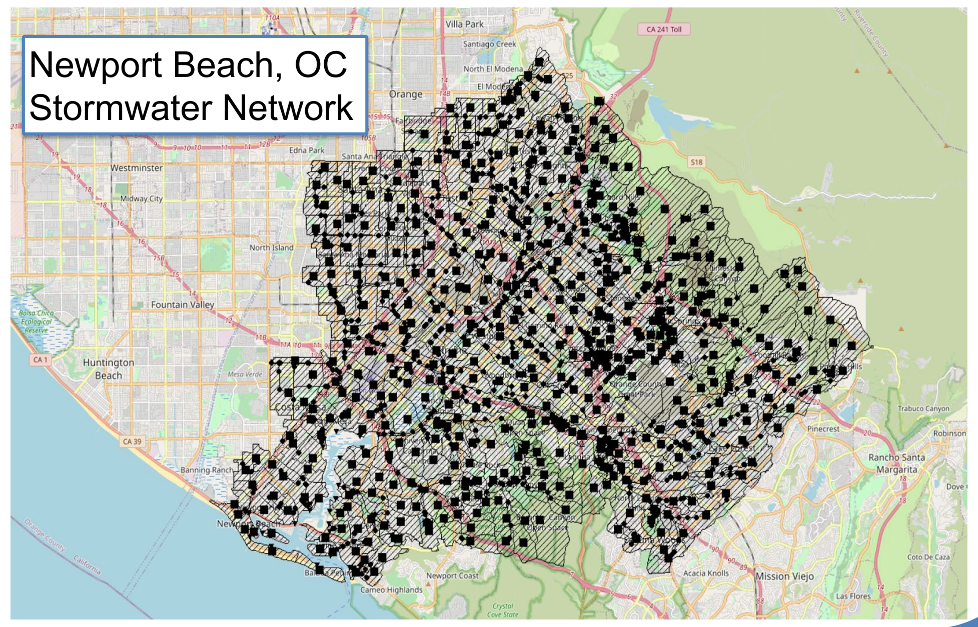
- Wet weather and Dry weather monitoring
- Consider tradeoff between Budget and Quality of Monitoring
- What kind of sensors should be considered? Where?

Resource-efficient monitoring

- Deployment & operational costs: underwater installation, human grab sampling.
- Efficiently switching between coarse-grained monitoring (efficient, but less accurate) and fine-grained monitoring (expensive, but high accuracy)

Generalizable data analytics

- Allow other agencies and communities to reuse successful models
- Train Machine Learning models that are robust to location-specific biases / patterns



Domain: Drinking Water

Focus Problem: Infrastructure Resilience to Extreme Events

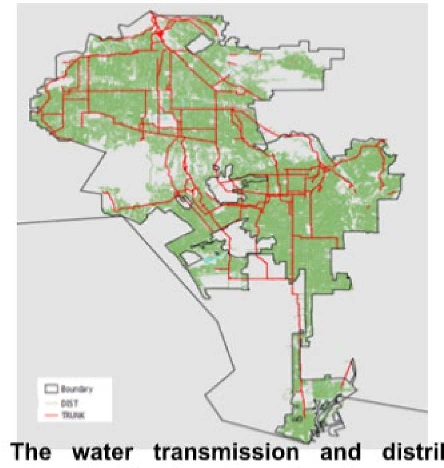
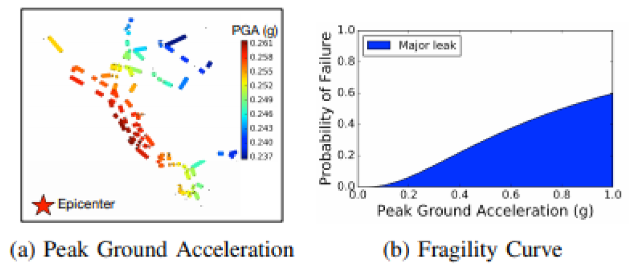


Figure 1: The water transmission and distribution pipeline systems for the City of Los Angeles.



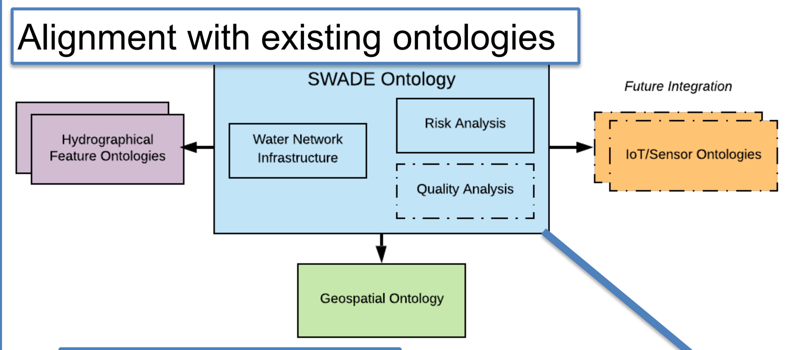
(a) Peak Ground Acceleration (b) Fragility Curve

Fig. 7: (a) PGA of pipelines for a magnitude of 5.5 earthquake. (b) Fragility curve for pipe damage.

Exploiting robust simulations

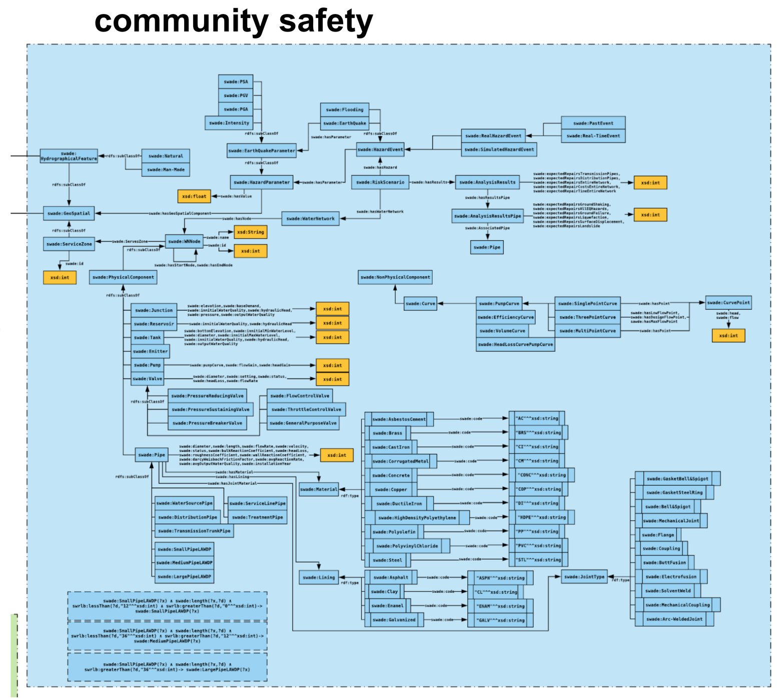
- Identify seismic event scenarios with significant impacts on water distribution networks
- Enable additional instrumentation and retrofit to provide rapid predictions for community safety

Alignment with existing ontologies



SWADE Ontology

- Vocabulary to enable interoperability of water organizations
- Currently: Definition of water networks and relevant components, geographical elements, hazards, and risk analysis results
- Next: Create vocabulary to represent drinking water systems and water quality analysis

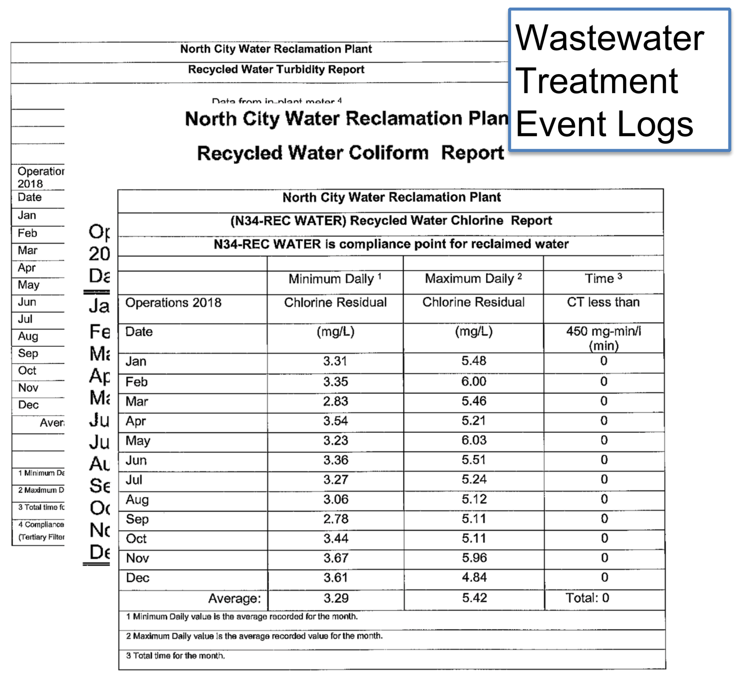


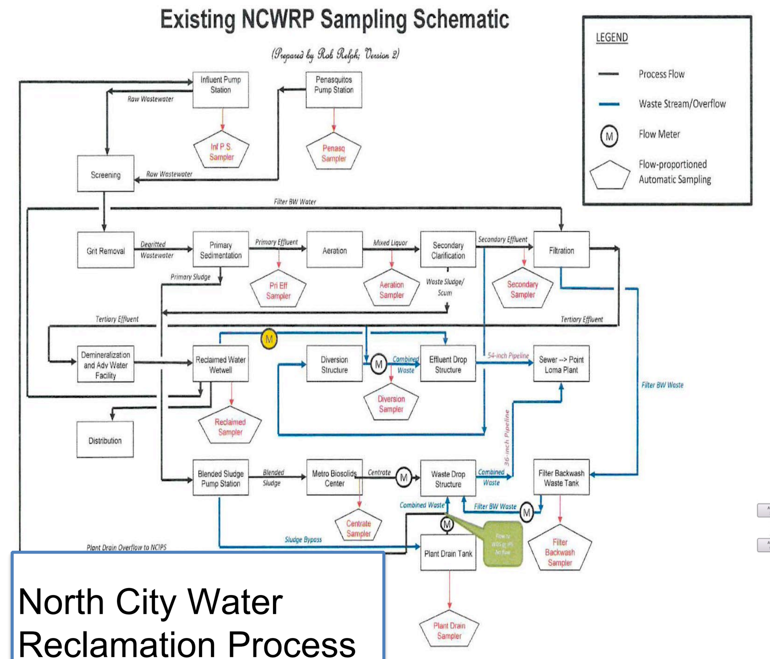
Domain: Wastewater

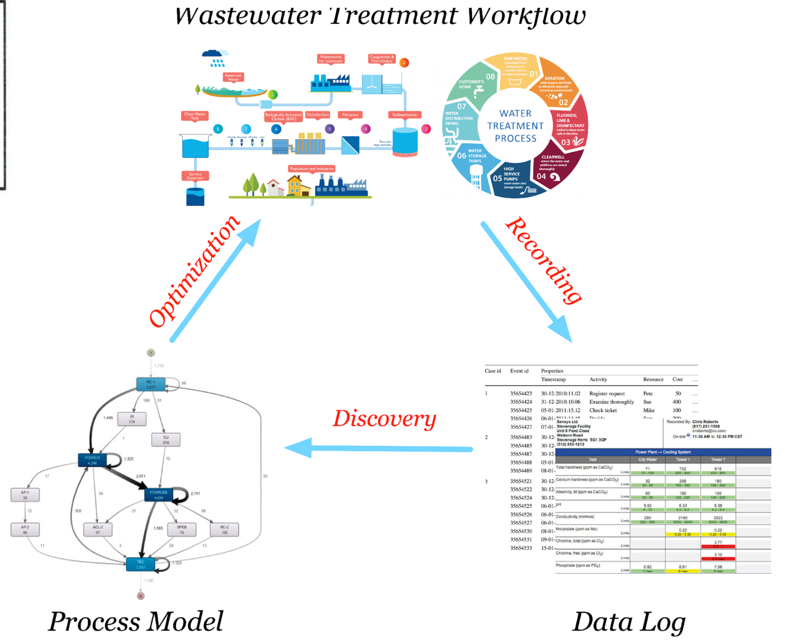
Focus Problem: Process Mining for Wastewater Treatment Plants

Mining Implicit or Hidden Knowledge

- Extract implicit knowledge and experience from historical treatment event logs
- Model discovered knowledge or structural properties (e.g., interdependent flows, timing constraints)
- Improve the practical wastewater treatment workflow based on discovered knowledge and experience







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