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Consequence Management: Focus on Restoration and Recovery of the Water System

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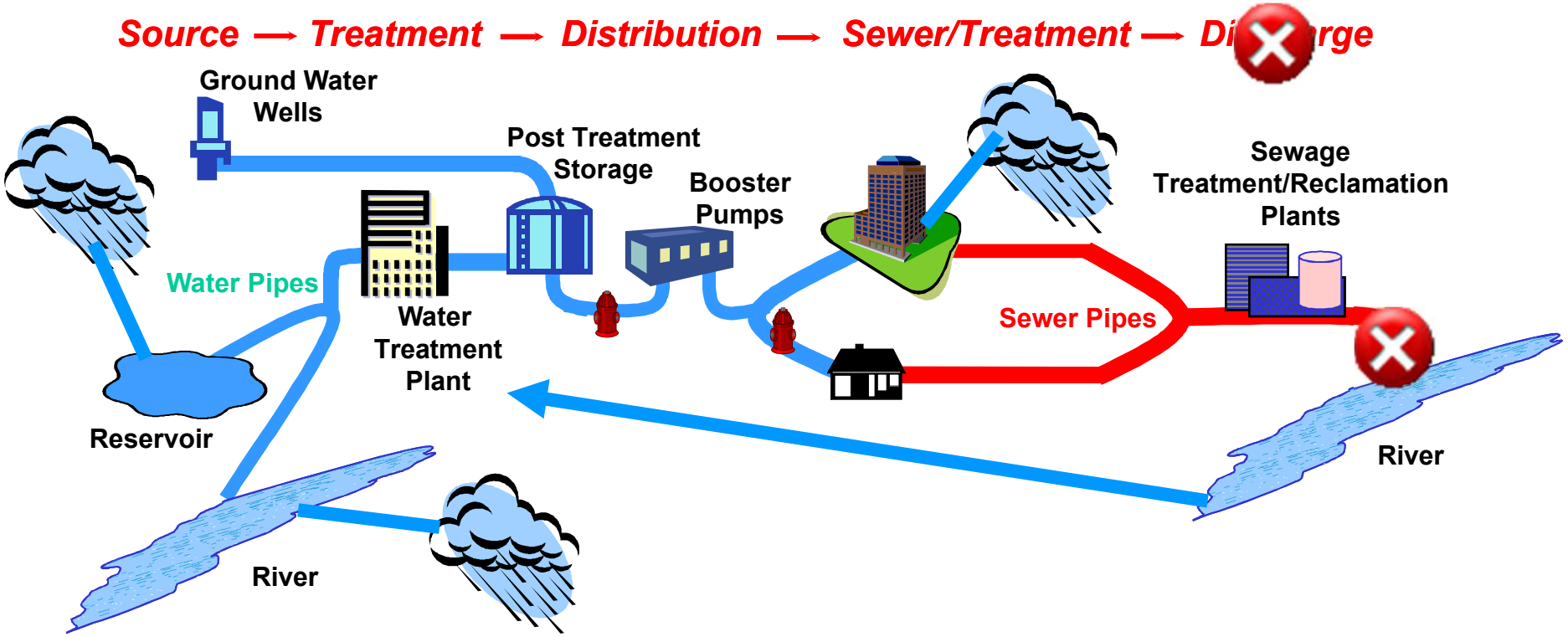
What are the Components of "the Water Infrastructure"?



- Potential for intentional contamination: at source, in treatment, in distribution system, and in massive amounts by wastewater release
- Distribution system (post-treatment) presents the greatest challenges for much of the U.S. through numerous and dispersed access points

"Elements" to Consider for Restoration and Recovery of the Water Infrastructure

Planning

Prevention

Crisis Management

Consequence Management

Recovery

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Responsibilities for Restoration and Recovery of the Water Infrastructure (in the U.S.)

Planning – Water Utilities with technology support primarily from USEPA/NHSRC and Department of Homeland Security

Prevention – Law enforcement and intelligence community (in cooperation with water utilities – affected by planning)

Crisis Management – Primarily DHS (in cooperation with local authorities – affected by planning)

Consequence Management – USEPA/NHSRC (in cooperation with the water utilities – affected by planning)

Recovery – Water utility with Federal and state support (affected by planning)

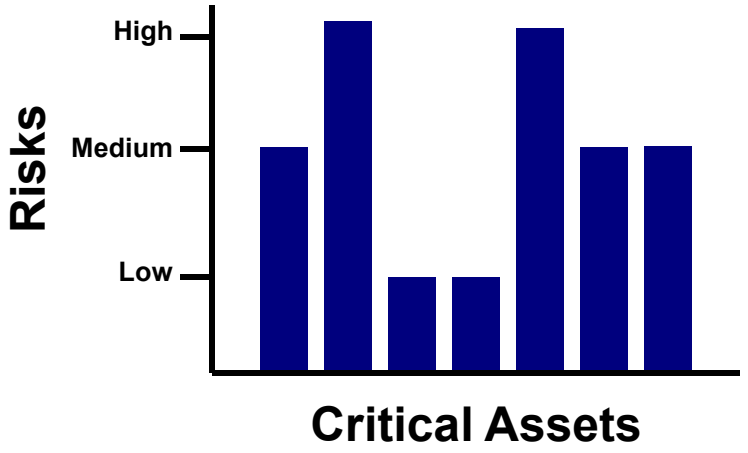
Planning for Restoration and Recovery of the Water Infrastructure

How well are we protected?

How to Balance Risk?

What can we afford to do?

DECISIONS!



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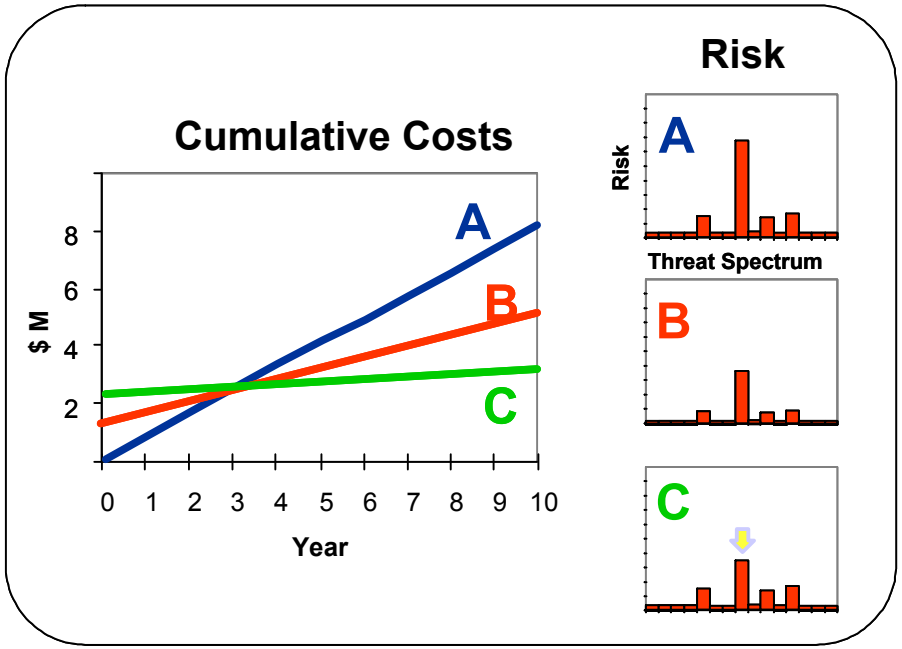
Planning for Restoration and Recovery of the Water Infrastructure

Because… The goal should be…to minimize risk at the lowest cost



Long-term costs can be reduced by effective planning up front!

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What do Water Utilities Need?

- ***Definition of the Threat – what, how much, physical characteristics***
- **Understanding of Physical Vulnerabilities/Assessments – What does the system look and act like?**
- ***Early Warning Systems – Combines Sensors And Models – Dual-Use for Security and Water Quality***
- ***Hydraulic Models – Calibrated Hydraulic Models Capable Of Correctly Predicting Contaminant Fate And Transport***
- ***Optimization of Sensor Locations – minimize # of sensors and optimize data transfer***
- ***Source Location Identification in Real Time – allows for response based on knowledge of where contaminant will go next, in what concentration, and when***
- ***Optimization of Response Options – minimization of risk/consequences by changing flows, in situ treatment, etc.***

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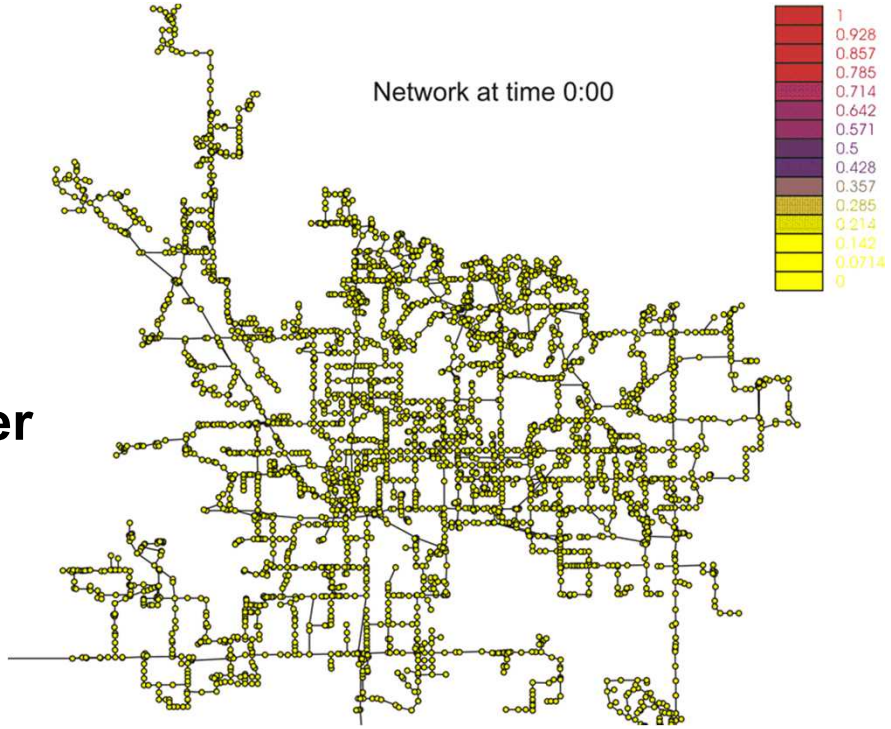
Sandia's Water Security Program

Focus has been on:

- **Developing methodologies for risk assessments**
- **Detection and modeling for consequence minimization**
- **Detection and modeling for water quality management**
- **Development of sensor technologies**
- **Linking treatment with security**
- **Concentrates on the treated water distribution system**



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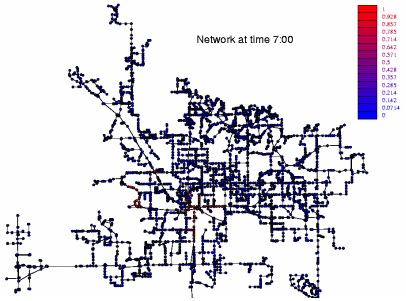
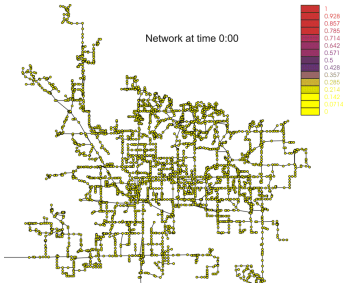
Applications to Restoration and Recovery of the Water Infrastructure

Implications to treated water delivery systems are obvious!



Network models are analyzed *a priori* to identify consequences and optimal sensor locations

Sensors on-line collecting data at discrete locations within a water distribution system



Sensor data from multiple locations are analyzed in real-time with network models to define possible consequences

EWS allows decision makers to take appropriate action(s) to minimize consequences

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Applications to Restoration and Recovery of the Water Infrastructure

Source water systems, reservoirs, and waste (reclaimed) water can be treated similarly!!

For contamination of the surface systems – Need to understand:

- **Source term (what is/are the contaminant(s))**
- **Locations of the contaminant (where is it and what is it "attached" to?**
- **Transport properties of the contaminants (reaction kinetics, sorption characteristics)**
- **Flows and stocks in the surface water system (rates and quantities in rivers, storage capacity of reservoirs, etc.)**
- **Weather influences on transport (wind, rainfall)**
- **Susceptibility of systems to contaminant damage (treatment facilities, reservoir soils, etc.) – Consequence assessment**

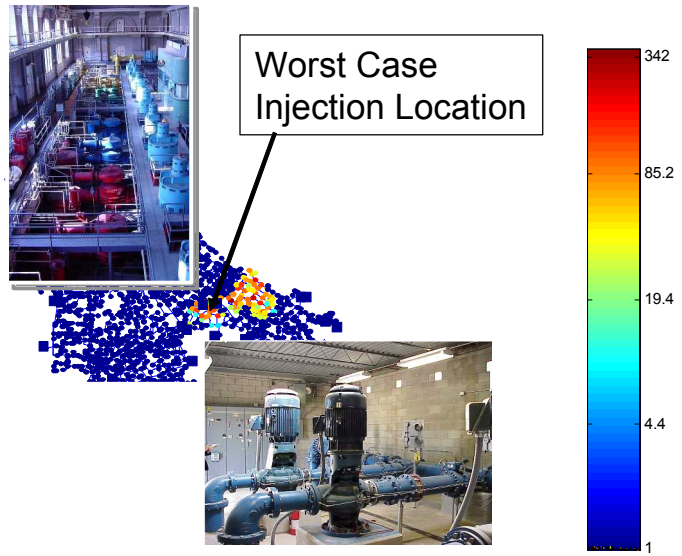
Applications to Restoration and Recovery of the Water Infrastructure

Sandia has teamed with EPA to develop EWS models

For Instance: Estimate Consequences of a contamination attack

Use Monte Carlo forward models to quantify consequences associated with different threats

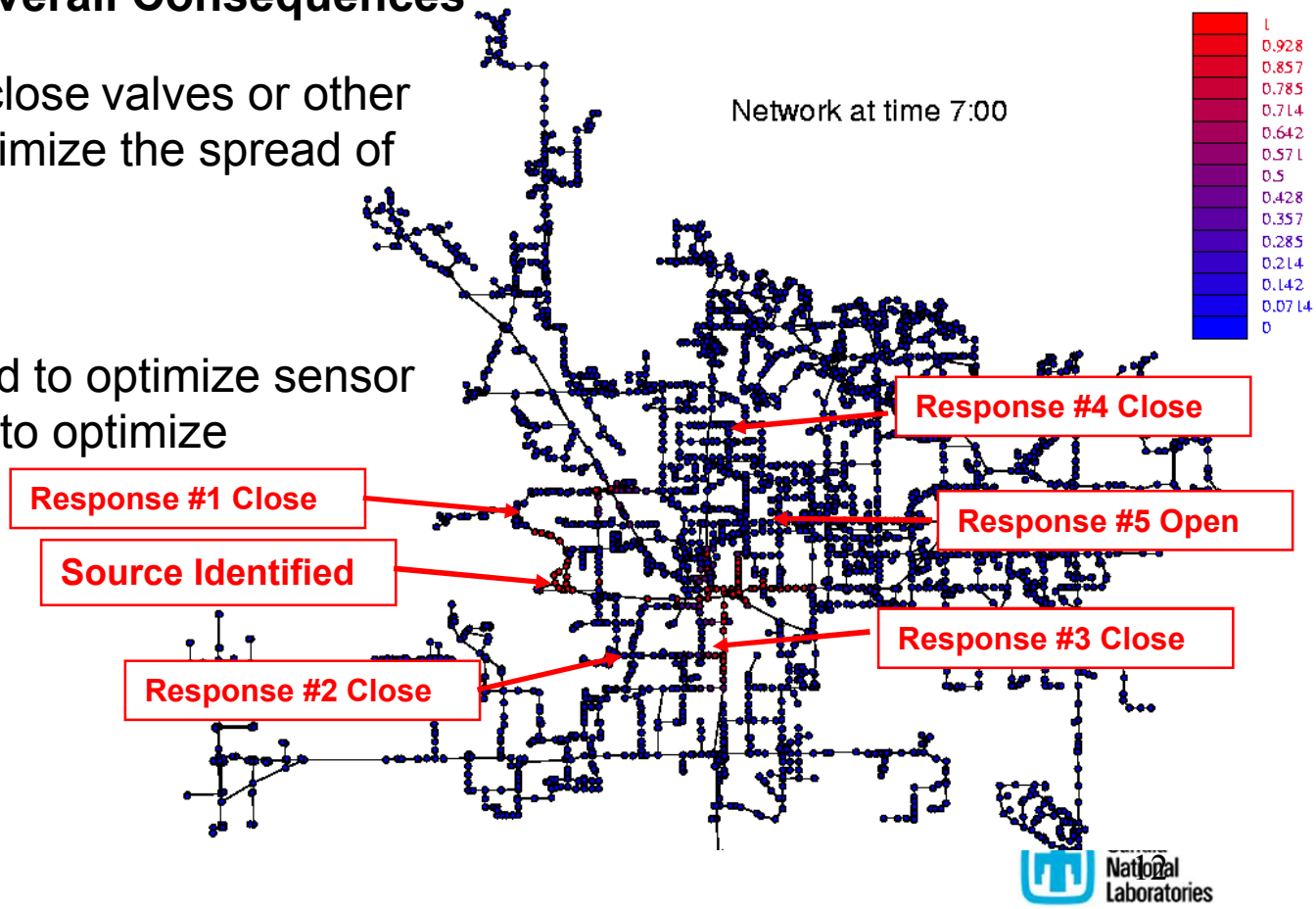
Sample on: demand, source location, source strength, source length, etc.



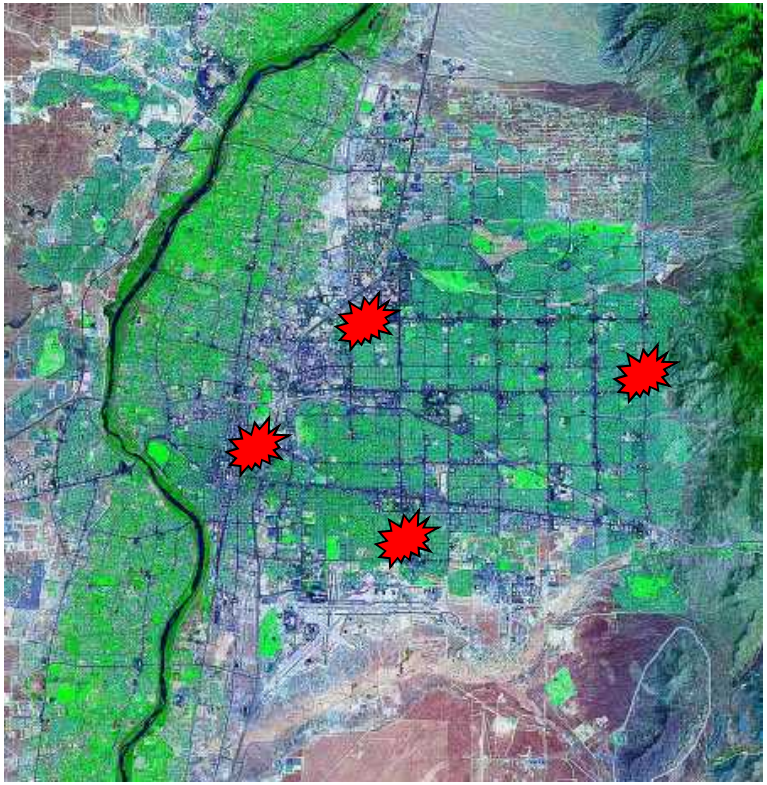
Applications to Restoration and Recovery of the Water Infrastructure

In The Event of a Contamination Event, Efficient Response Will Limit Overall Consequences

- Where/when to open/close valves or other control features to minimize the spread of the contaminant?
- How clean is clean?
- The same models used to optimize sensor locations can be used to optimize responses



Applications to Restoration and Recovery of the Water Infrastructure



- Watersheds are interconnected with the overall water infrastructure
- More in some locations than the image to the left
- The same models used to optimize sensor locations can be used to optimize responses to surface contamination
- Because…contaminant transport is basically defined by a hydrologic network driven by topography, geology, weather, & engineered features
- Response protocols can be developed via *a priori* analyses of the fate and transport of contaminants from various scenarios (locations, materials, timing, etc.)

Applications to Restoration and Recovery of the Water Infrastructure

- **Much has been done in the U.S. to develop tools for early warning systems for protection of the water infrastructure**
- **These are generally for finished water in the distribution system**
- **More needs to be done to develop specific protocols for response to contamination events**
- **Tools that allow stakeholders to ascertain risk to spread of contaminants need to be exercised – to allow for reasoned decisions regarding response (minimize consequences)**
- **Tools developed for EWS can be applied to surface contaminants & used to evaluate scenarios so that decision-makers are prepared (understand consequences, have responses available at the right place and time).**

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