Homeland Security

SAND2010-6652P

Remediation Planning – Tool Utility for Prioritization of Critical Infrastructure

An Overview and Demonstration of the PATH/AWARE (Prioritization Analysis Tool for All-Hazards/Analyzer for Wide-Area Remediation Effectiveness) Decision Support Toolset

David O. Franco
Sandia National Laboratories

Interagency Biological Restoration Demonstration (IBRD) for Wide-Area Biological Incidents

IBRD project objectives:

- Develop comprehensive guidance for restoration and recovery following a National Planning Scenario 2 attack, considering civilian/military cooperation
- Evaluate the technology gaps that exist today
- Develop technology, where appropriate, to fill these gaps, with an emphasis on saving time and money in the restoration process
    - **Decision support tools provide restoration planners with methods and data for planning and decision-making**

IBRD Program Managers:

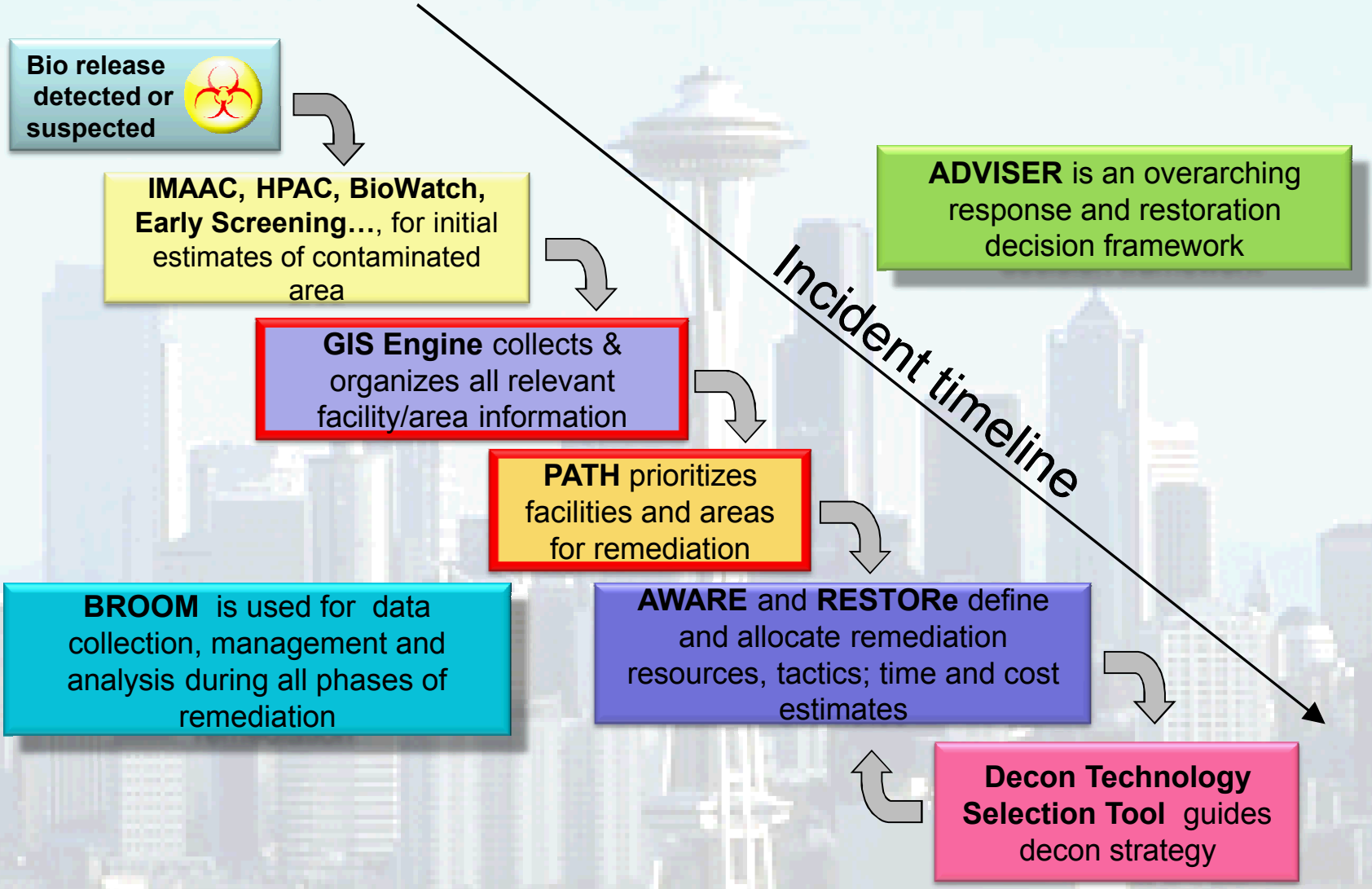
- Chris Russell, DHS-S&T
- Ryan Madden, DoD-DTRA

National Laboratory Participants:

- Sandia National Laboratories
- Lawrence Livermore National Laboratory
- Pacific Northwest National Laboratory
- Los Alamos National Laboratory

Project funded by the Department of Homeland Security - Science & Technology and the Department of Defense - Defense Threat Reduction Agency

Decision support tools provide restoration planners with methods and data for planning and decision-making

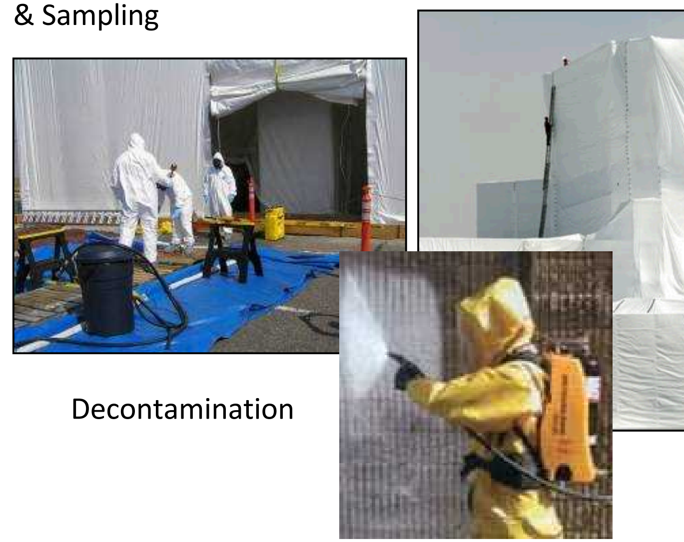


In a wide area restoration, prioritization of CI will be complex and politically charged; furthermore, multiple remediation strategies (and trade-offs) exist

- **Following a wide-area release:**
  - There will be a loss of functionality across many systems in multiple jurisdictions
  - Resources available to restore the area will be extremely limited
  - Time to complete restoration will be lengthy, possibly years
- **Decision makers will want to know:**
  - Which assets have been impacted? What are the functions provided?
  - What are the interdependencies? How will these be factored into the restoration strategy?
  - How long will the cleanup take? When will critical functions be restored?
  - How much money and resources can the feds provide? Where do those resources get applied?
  - If additional resources were available, could the restoration be done in less time? What are the choke points in the process?

First Responders & Sampling

Laboratory Analysis



Decontamination

Prioritization Analysis Tool for all Hazards (PATH) and Analyzer for Wide-Area Restoration Effectiveness (AWARE)
help address these issues

PATH/AWARE supports the development of a Restoration Strategy to effect the efficient achievement of Recovery Objectives

The toolset helps decision-makers:

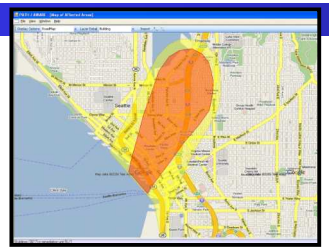
- identify critical infrastructure in area of interest;
- assess impacts on critical services;
- analyze critical infrastructure interdependencies;
- develop an integrated, unified prioritization strategy;
- determine resource requirements for restoration operations;
- identify chokepoints in the process, and
- allocate and manage resources effectively

… during planning and operational phases.

"This is a great tool…[PATH/AWARE] would be central to operations; we could base strategy on analysis. I would love it use it for earthquake planning right now…if there is good analysis, actually can convince elected officials."

Grant Tietje, Planning, Training and Exercise Coordinator, Seattle Office of Emergency Management, June Prioritization TTX, 2009 Seattle WA.

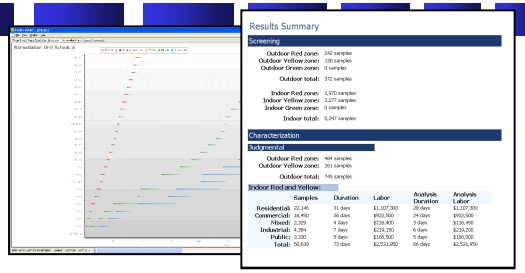
PATH/AWARE software infrastructure integrates a Graphical Information System (GIS), Prioritization module, and Resource Allocation module



Map Displays

Google maps

External Databases:
Local Tax, HSIP,
HAZUS…



Timelines and Costs

GIS Engine

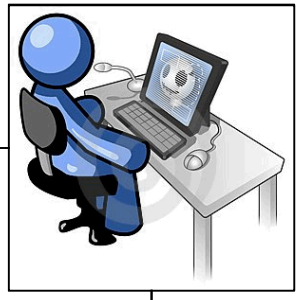
Facility/Area/Asset Database

AWARE

User-defined Scenario

PATH

Prioritized Asset List



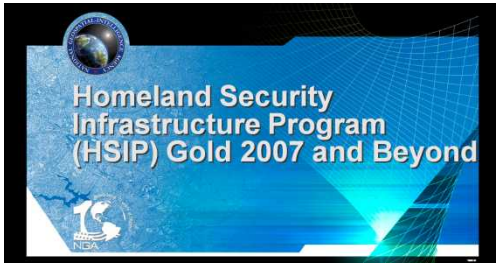
User-defined Restoration Objectives

User-defined Remediation Resources

PATH/AWARE utilizes multiple asset and facility datasets

- **King/Pierce County GIS (as a specific urban example…)**
  - Virtually all county-wide buildings and structures
  - Additional useful attributes (use description, assessed value, plot sizes, building footprints)
  - We have access to these databases -- similar access expected for other urban areas
- **DHS Homeland Security Infrastructure Program (HSIP)**
  - Geo-located critical assets and infrastructures
  - Gold and Freedom levels, restrictions on Gold level use
- **FEMA HAZUS-MH**
  - Residential and non-residential geo-located building inventories
  - Nationwide coverage
  - Transportation infrastructure is also included
- **Emporis**
  - US and Canadian cities
  - Major buildings (>5 floors) in database
  - Many key attributes (size, age, type of HVAC, use, floor space etc.)

KCGIS Center



EMPORIS RESEARCH

The 8-step Prioritization Methodology[1] identifies specific actions to be taken to develop an objective and defensible Prioritization Strategy; PATH/AWARE supports the execution of these actions

Develop remediation schedule and analyze consequences

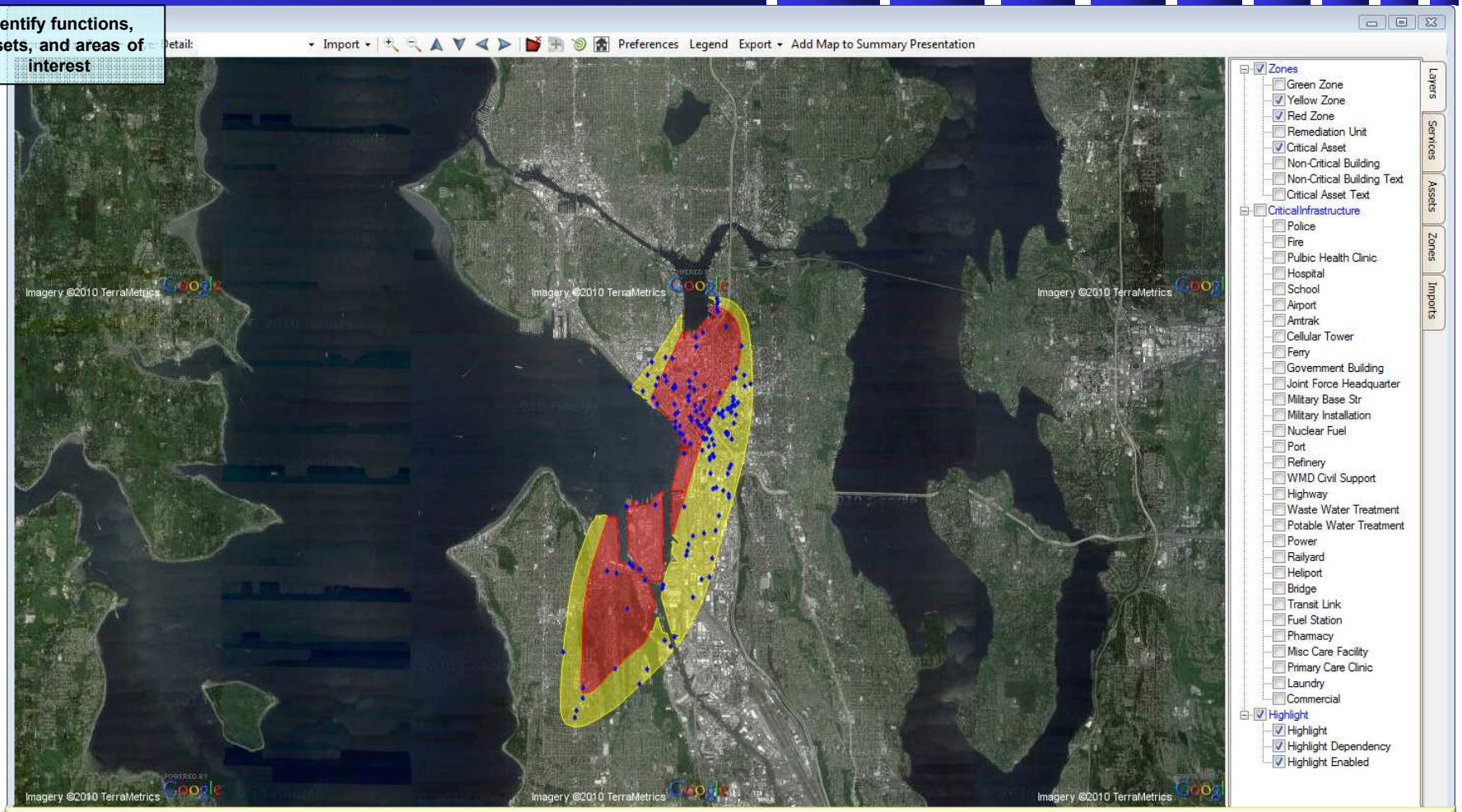
Step 1	**Set remediation objectives and associated measures**	e.g., Minimize health effects, minimize economic disruption, and maximize public satisfaction. Measures include morbidity rate, GDP ,and population size.
Step 2	**Identify functions, assets, and areas of interest**	e.g., Functions: lifelines, access, habitability. Assets: water treatment plant, roads, houses. Areas of interest: contaminated areas.
Step 3	**Establish prioritization assessment zones for information gathering and scheduling**	e.g., Divide extent of contamination zone into smaller prioritization zones per land use, contamination, economic importance. This is an optional step.
Step 4	**Define metrics for functions and desired operational levels; Define descriptors for assets**	e.g., Access function 0.0 No access available. 0.2 Access only for select personnel. 1.0 Open access. Minimal acceptable level is 0.2.
Step 5	**Gather status information on assets and functions; compare to desired operational levels to prioritize functions**	e.g., Access at level 0.0: below minimal level. Health at level 0.8: at minimal level. Power at level 1.0: above minimal level.
Step 6	**Identify strategy to improve function status**	e.g., Remediate hospital to improve health status. Remediate highway to improve access. Truck in food to improve food status.
Step 7	**Rank-order assets to enable above strategy to improve function status**	e.g., Asset rank order: 1. Interstate 5 2. Airport 3. Downtown hospital
Step 8	**Develop remediation schedule according to prioritization and analysis of consequences**	e.g., Schedule remediation 1. Interstate 5 : Days 1–5 2. Hot spot area : Days 3–20 3. Downtown hospital : Days 20–40

1) Seattle Urban Area Consequence Management Guidance for a Wide-Area Biological Attack: A Technical Supplement to the Puget Sound Regional Biological Attack Recovery Plan Annex (DRAFT)

PATH/AWARE Case Study

After a wide-area biological release, a strategy will be needed to remediate the area, prioritize critical infrastructure, and ultimately enable the achievement of recovery objectives

Identify functions, assets, and areas of interest



PATH/AWARE supports this mission by providing an analysis-based strategy for the Prioritization of Critical Infrastructure

Multiple databases were accessed to provide information including total area, number of buildings, indoor area, and usage type

Deposition Zone Summary

Zone Size

Red zones:	4.74	square miles are highly contaminated
Yellow zones:	5.18	square miles are moderately contaminated
Green zones:	2.81	square miles are insignificantly contaminated

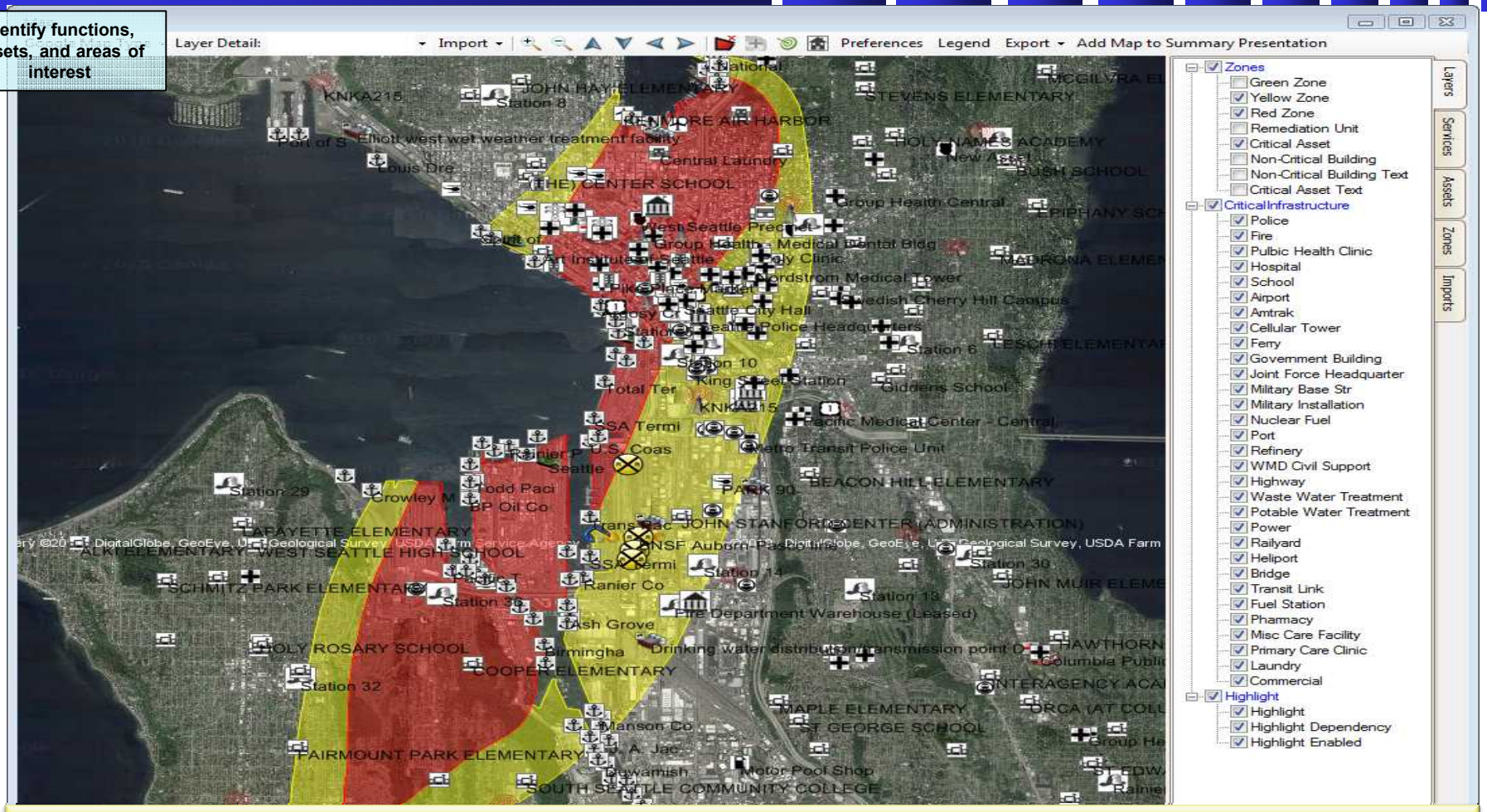
Indoor Area

Usage	# Red Bldgs	Red Area (ft²)	% of Red Area	# Yellow Bldgs	Yellow Area (ft²)	% of Yellow Area
Residential	3,139	26,445,655	45%	3,600	19,996,212	37%
Commercial	481	19,592,242	33%	496	12,524,772	23%
Industrial	267	7,245,533	12%	486	14,094,416	26%
Mixed	60	2,340,666	4%	51	970,679	2%
Public	94	3,542,123	6%	127	6,605,618	12%
Total	4,041	59,166,218		4,760	54,191,697	

This scenario included ~10 square miles and over 4000 buildings in the red and yellow zones; this information impacted the prioritization and remediation strategies

Critical Infrastructure datasets enabled decision-makers to identify what assets are in the contaminated area(s)

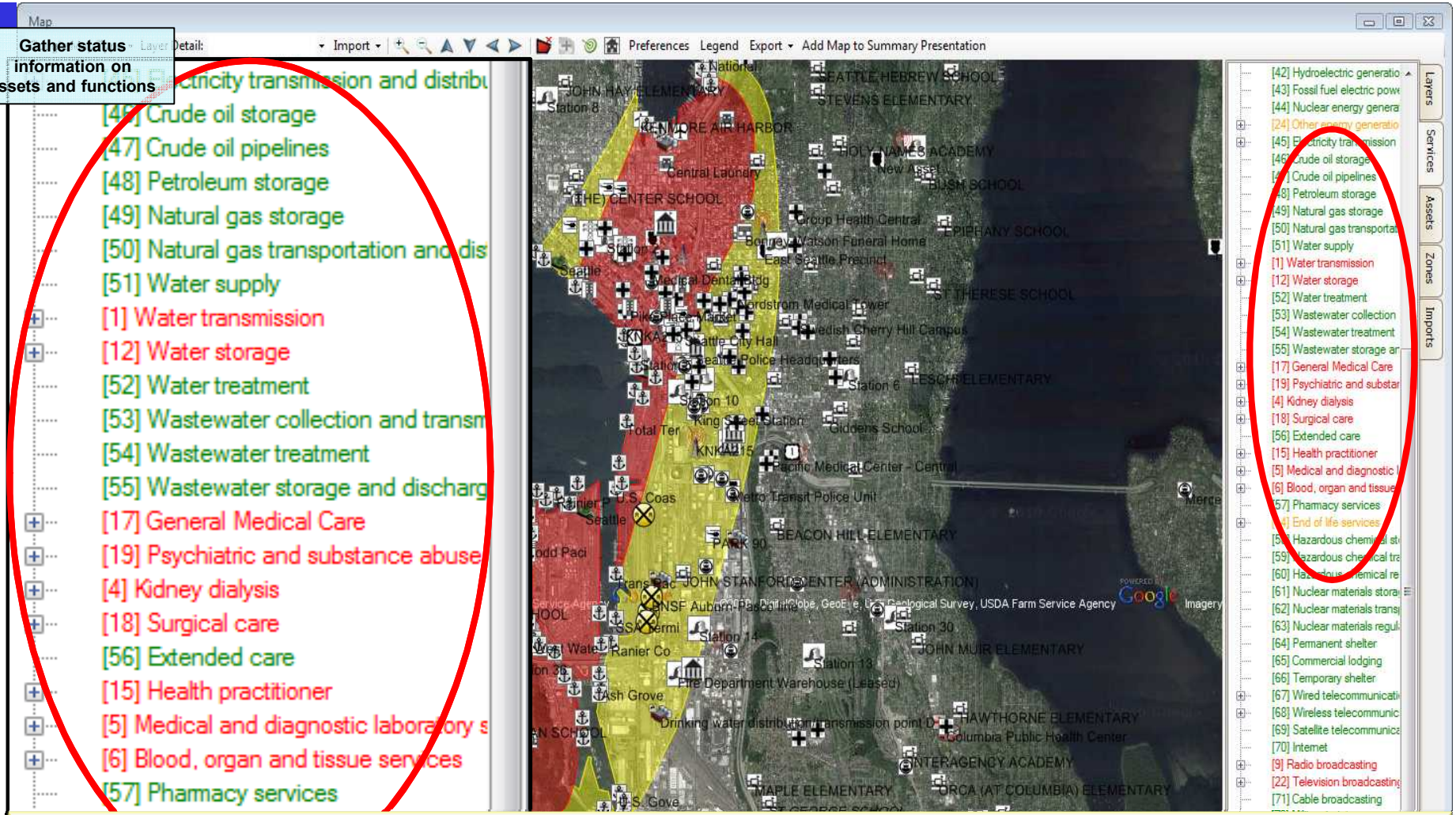
Identify functions, assets, and areas of interest



In this scenario, many of the region's hospitals and shipping ports were in the contaminated area; this is likely to have a significant impact on critical functions such as healthcare and cargo shipping

The status of the region's critical services is determined based on the assets in the contaminated area, enabling users to identify impacted services

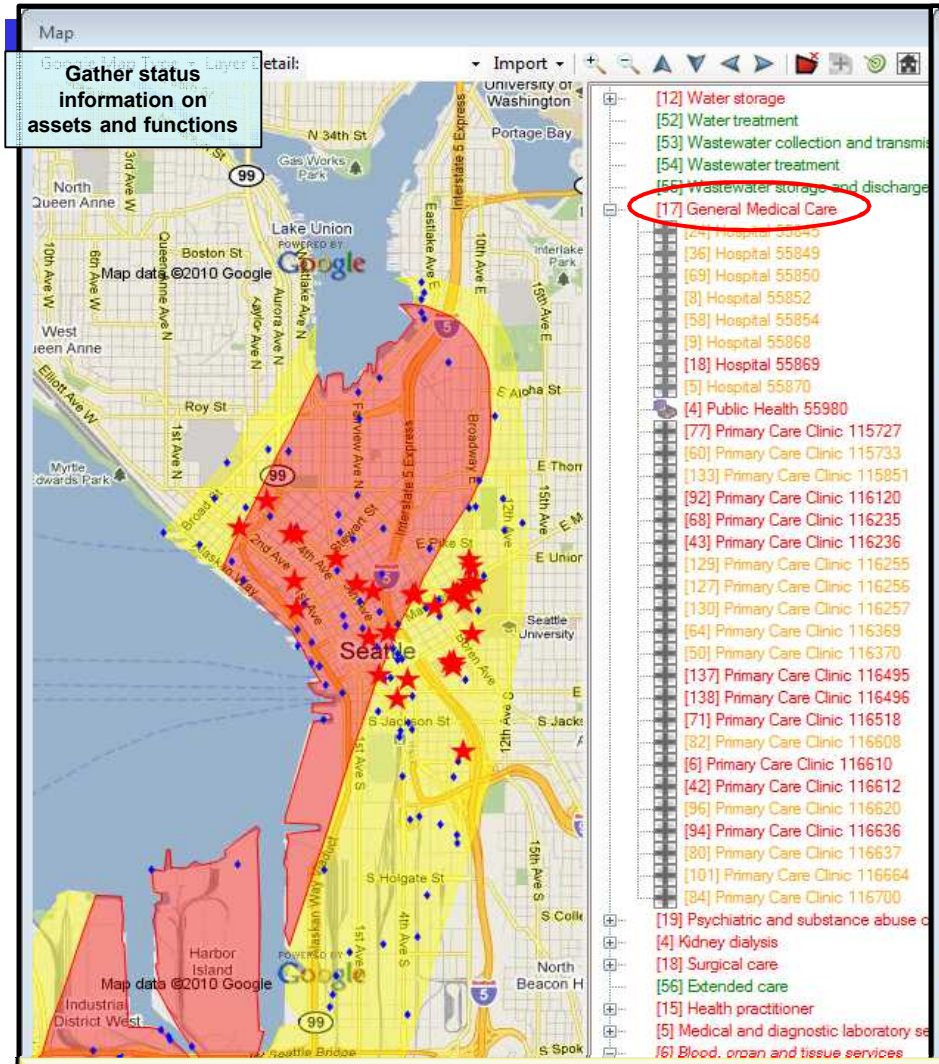
Gather status information on assets and functions

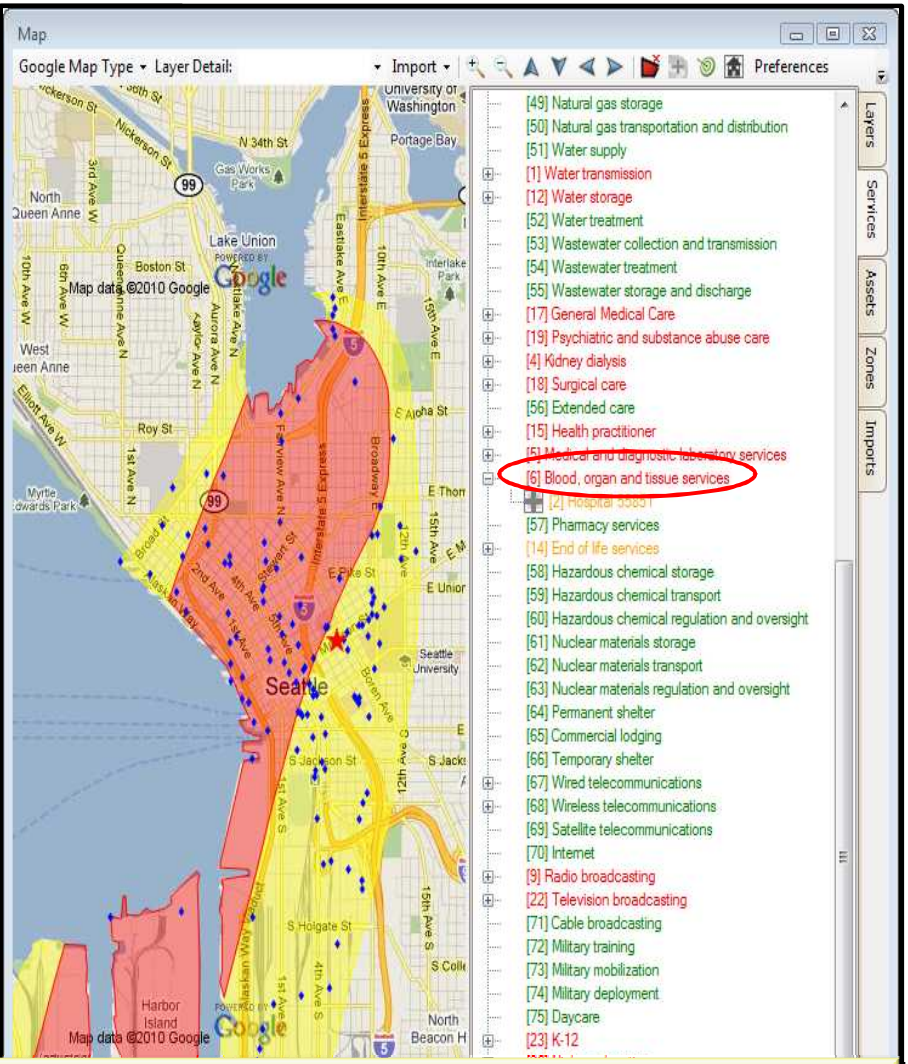


In addition to General Medical Care, many other medical services were negatively impacted; some services such as power transmission and distribution continued to function normally.

Selecting a service enables the user to identify the assets within the region that provide that service

Gather status information on assets and functions

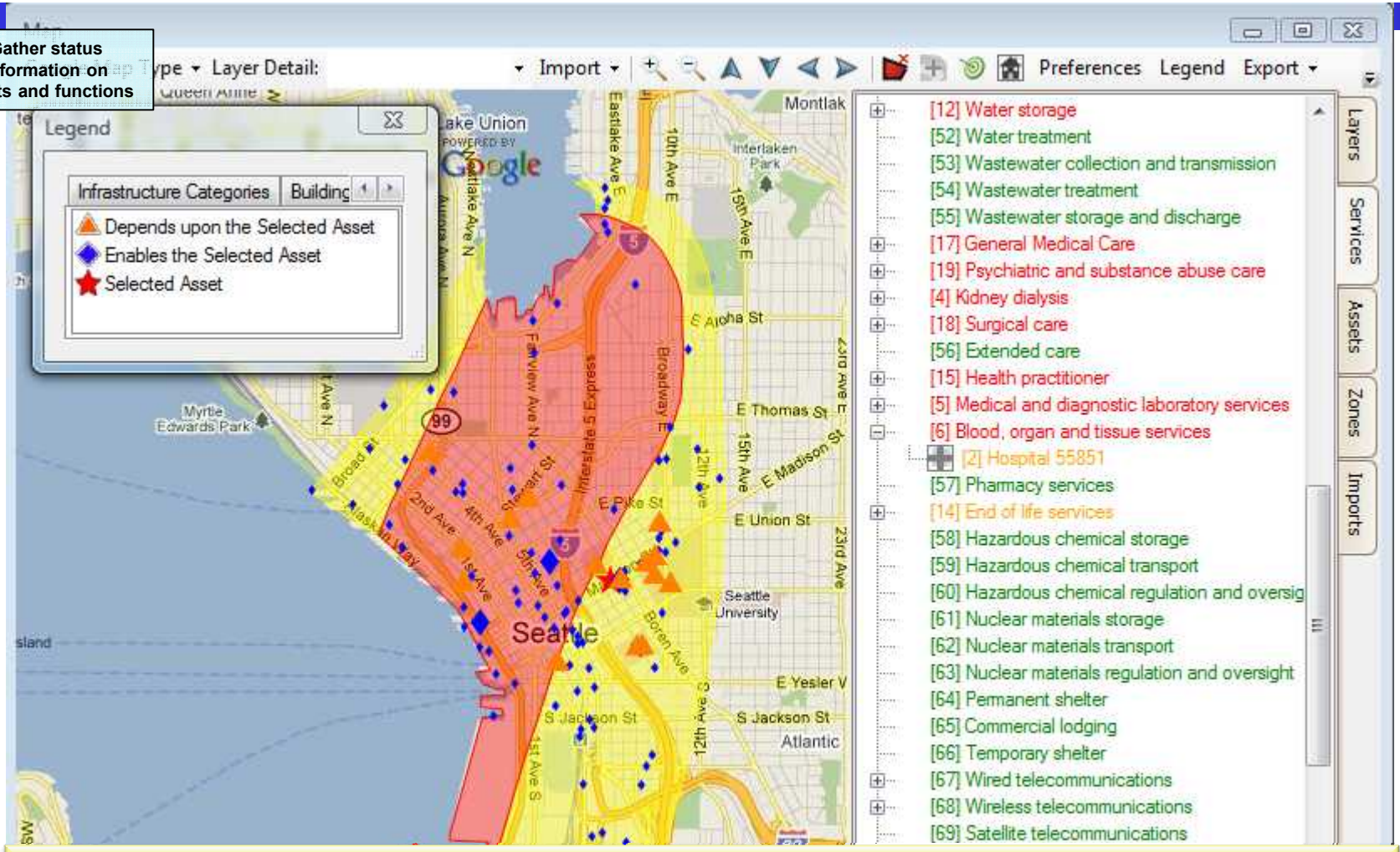




Many hospitals provide general medical care, but only the region's centralized blood center (Hospital 55851) provides critical blood, organ and tissue services

For each asset, the users identified the asset-to-asset interdependencies to help assess the criticality of that asset to the region

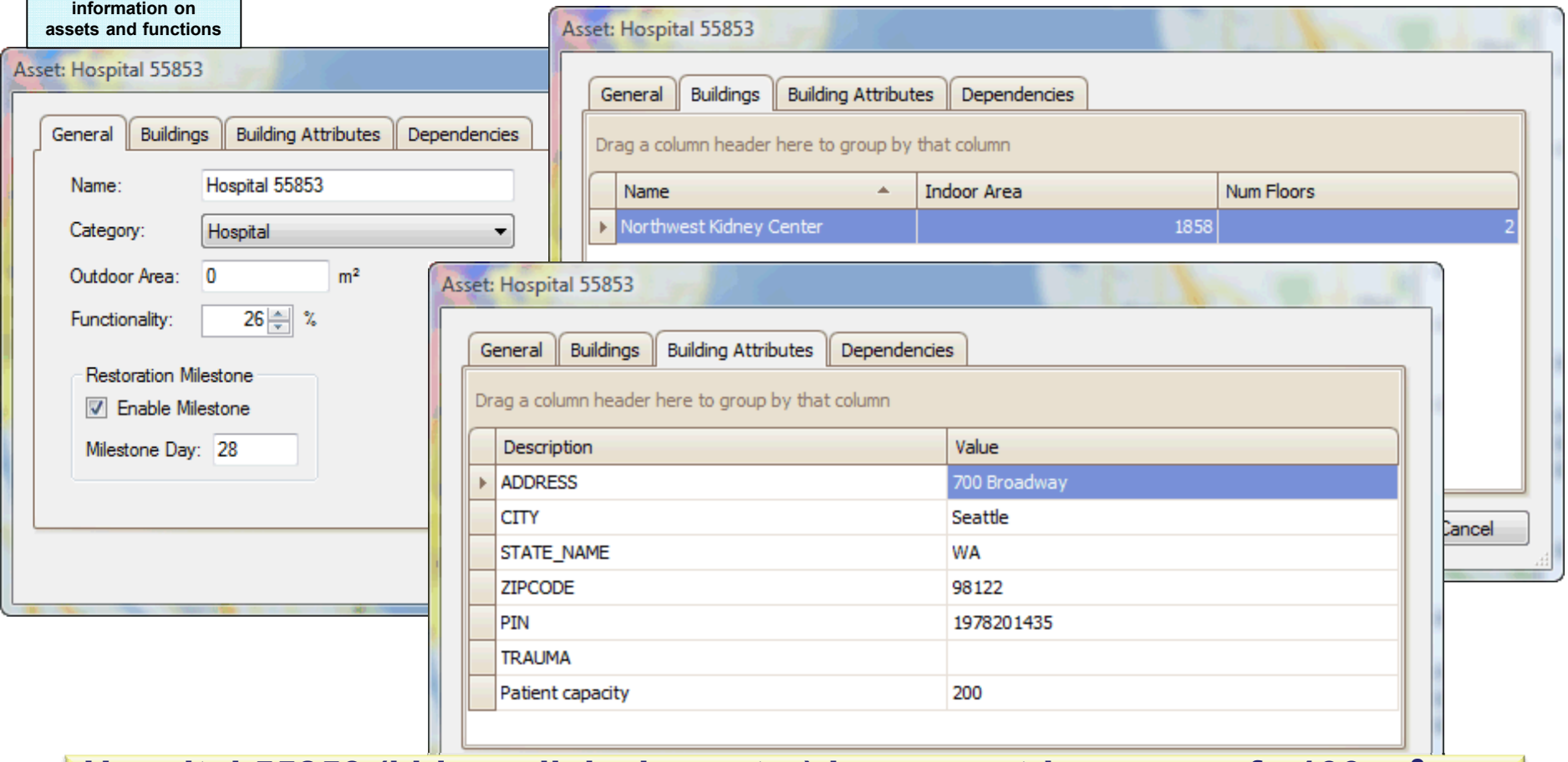
Gather status information on assets and functions



Hospital 55851 enables many other medical facilities to function by providing critical blood, organ, and tissue services. Without this asset, these hospitals may not be able to function as needed

For each asset, data including structural, geographical, and contact information is provided , informing asset remediation planning efforts

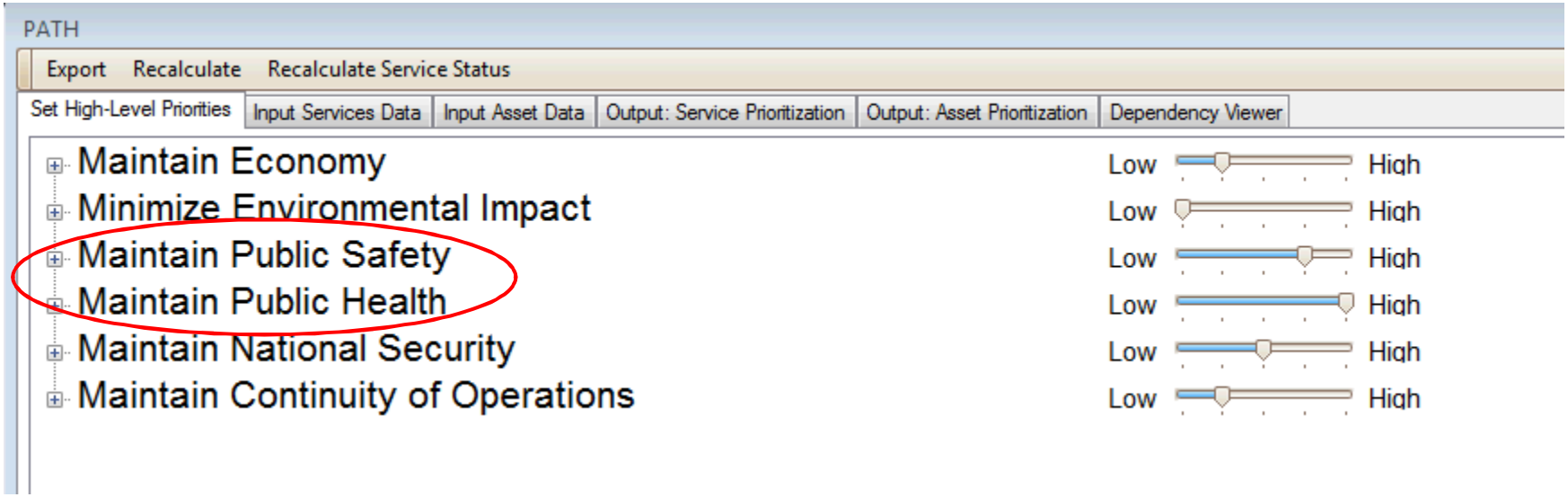
Gather status information on assets and functions



Hospital 55853 (kidney dialysis center) has an outdoor area of ~100 m², indoor area of ~900 m², employs 700 staff, is currently 25% functional, and has a 4 week restoration constraint

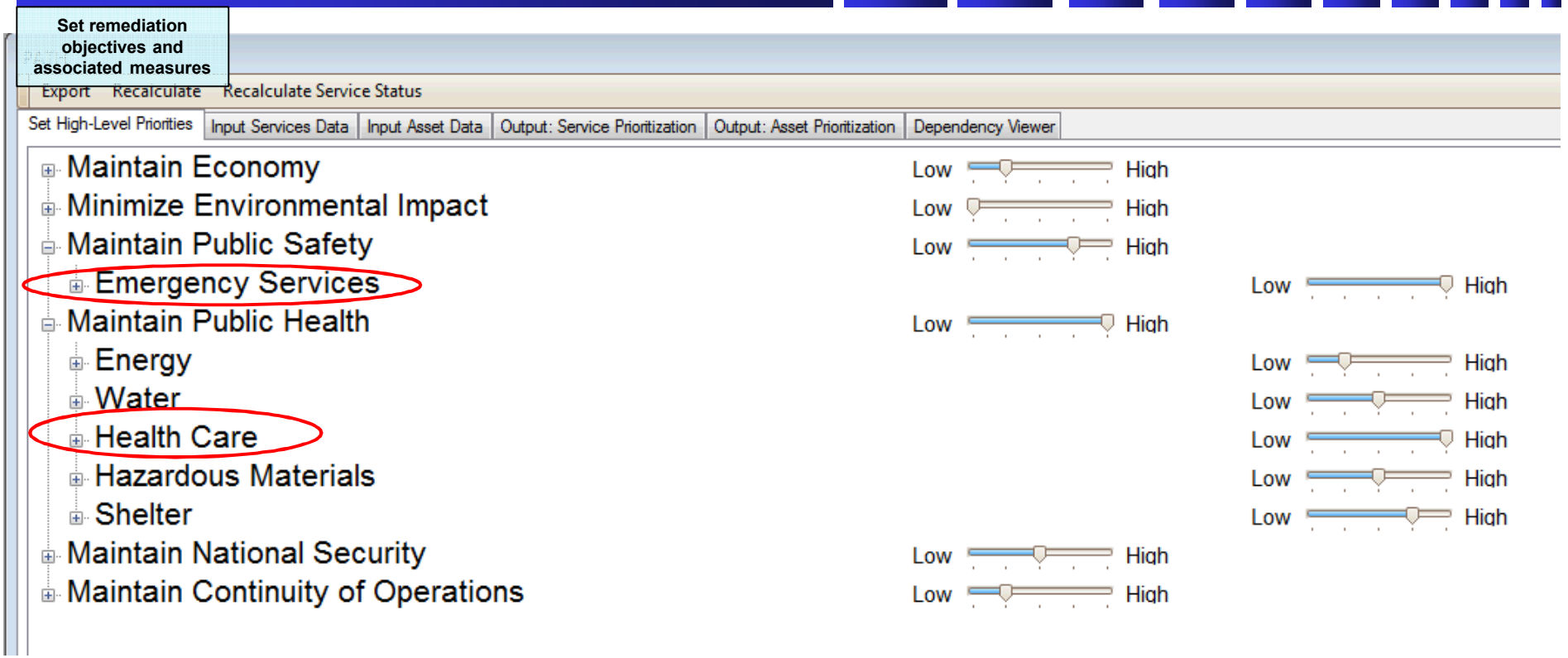
High-level priorities were established by decision-makers; these overall priorities drive the Prioritization strategy development

Set remediation objectives and associated measures



In this case study, Maintain Public Health and Maintain Public Safety were established as the highest priority objectives; Maintaining National Security and the Maintaining Economy were also important

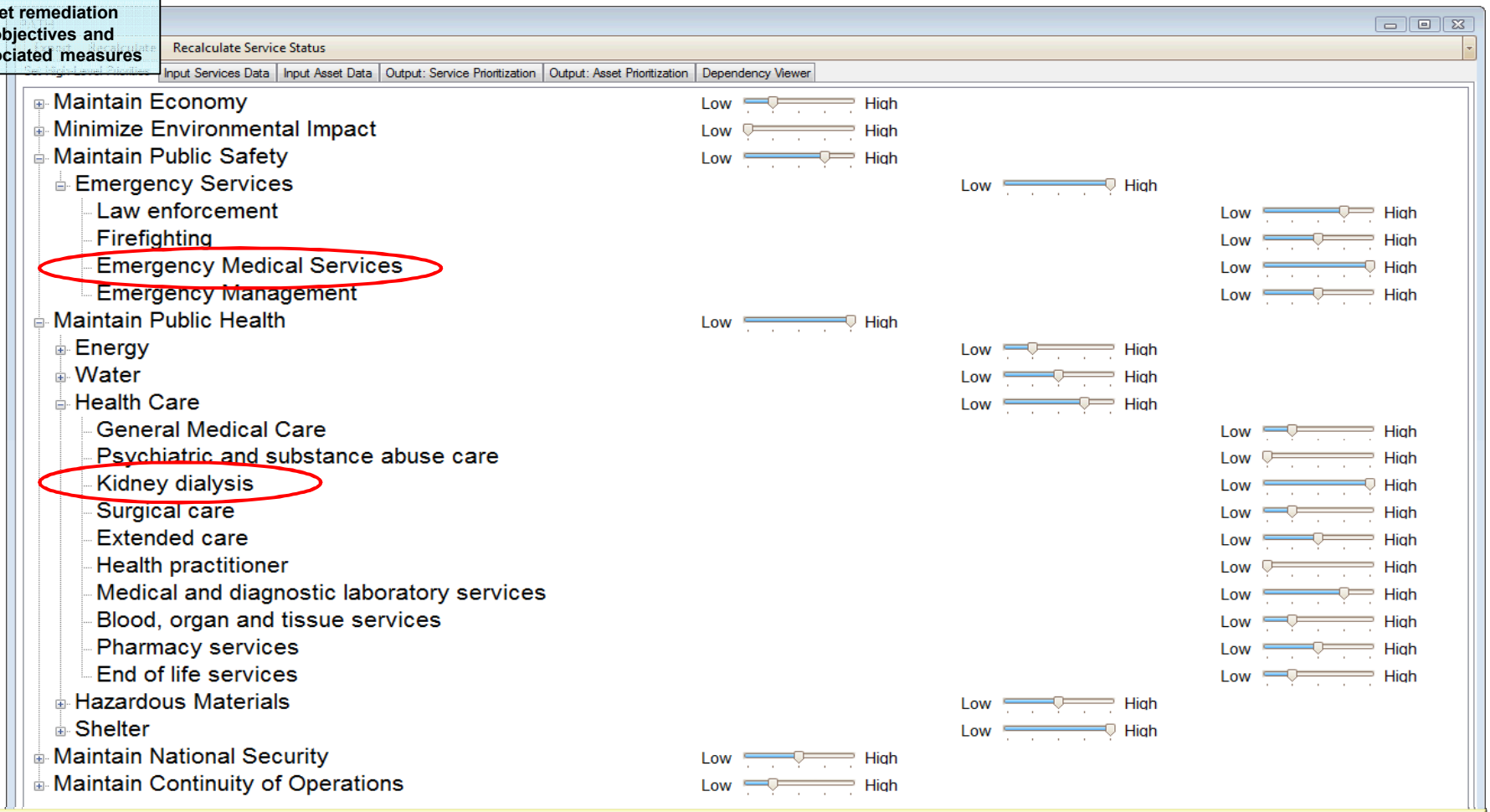
Within each High-level Priority is a set of Functions that support the achievement of that Priority; these Functions are also weighted against one another



Within the Maintain Public Health and Maintain Public Safety objectives, Healthcare and Emergency Services were identified as the most important functions

Each function is further broken down into sub-functions or services which are also weighted; it is likely the experts in these sectors will assist in setting these weightings

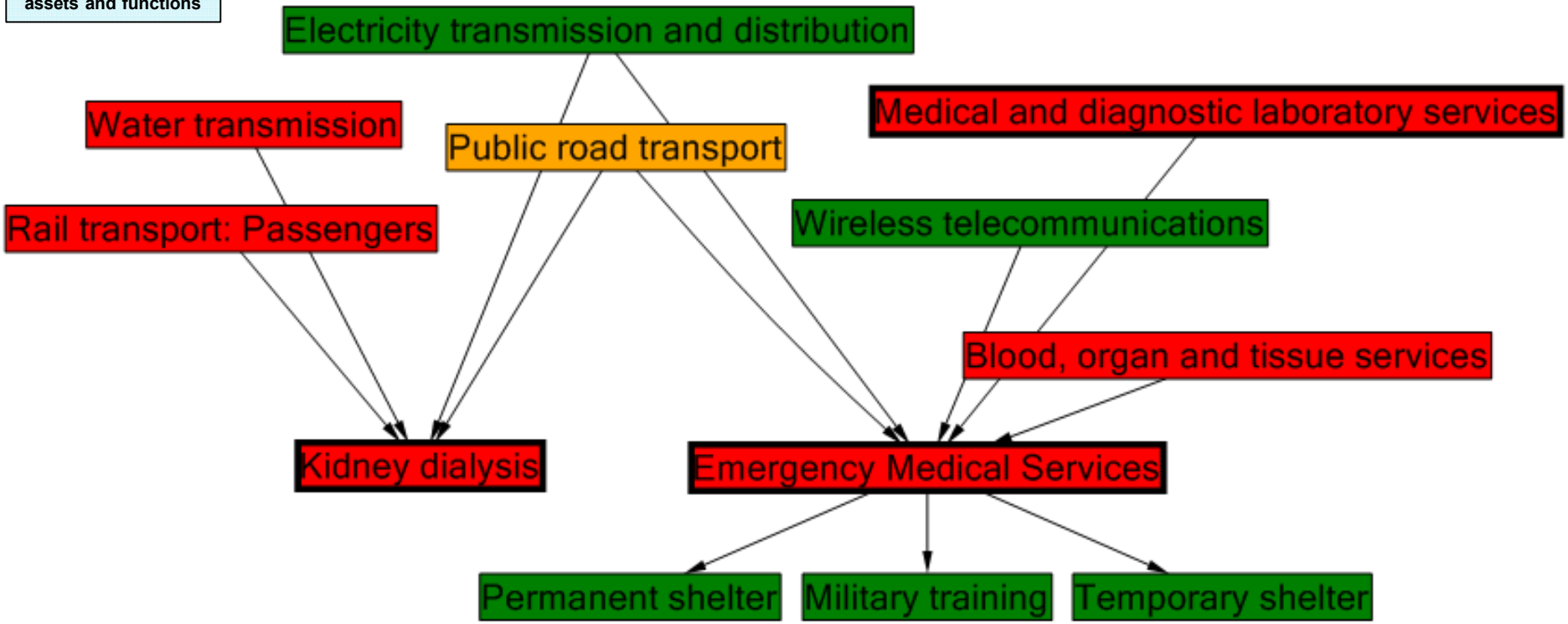
Set remediation objectives and associated measures



Within the Emergency Services and Healthcare functions, Emergency Medical Services and Kidney Dialysis were the highest priority services due to the demand and consequences of a reduced capability in these areas

Highly prioritized services are dependent upon other services to operate normally; these dependencies must be accounted for in the Prioritization Strategy

Gather status information on assets and functions



To enable kidney dialysis services, water transmission, public road transport, and rail transport will have to be restored as well. For emergency medical services, blood, organ, and tissue services and medical laboratory services will have be restored also

Service interdependencies, along with scenario inputs (e.g., service status) and user inputs (e.g., objective weightings,) are used to generate a Service Priority List

Identify strategy to improve function status

	Service Name	Function Name	Reason
1	Water transmission	Water	Enabling Service
2	Public road transport	Transportation	Enabling Service
3	Rail transport: Passengers	Transportation	Enabling Service
4	Kidney dialysis	Health Care	Contribution To Priorities
5	Medical and diagnostic laboratory services	Health Care	Enabling Service
6	Blood, organ and tissue services	Health Care	Enabling Service
7	Courier service	Postal and shipping	Enabling Service
8	Emergency Medical Services	Emergency Services	Contribution To Priorities
9	Radio broadcasting	Telecommunications	Enabling Service
10	Emergency Management	Emergency Services	Enabling Service
11	Law enforcement	Emergency Services	Contribution To Priorities
12	Water storage	Water	Enabling Service
13	Firefighting	Emergency Services	Contribution To Priorities
14	End of life services	Health Care	Enabling Service
15	Health practitioner	Health Care	Enabling Service

The Service Priority List served as the basis for a strategic plan to restore critical services and accomplish the achievement of the High-level Restoration Priorities (Maintain Public Health and Safety)

Prioritization algorithms generate a rank-ordered list of assets by applying user-weighted recovery objectives, functions and services across asset metrics

(User-input Weightings on Recovery Objectives, Functions ✖ **Pre-populated Asset Metrics** = **Calculated Score for Contribution to Recovery Objectives)** ✚ **User-input Subjective/ Qualitative Considerations (e.g., dependencies)**

⬇

Rank-ordered Asset List

✖

Hospital metrics, e.g.,:
For Public Health: # staffed beds
For Local Economy: # employed

=

Hospital A (0.5)
Port (0.3)
Hospital B (0.2)

✚

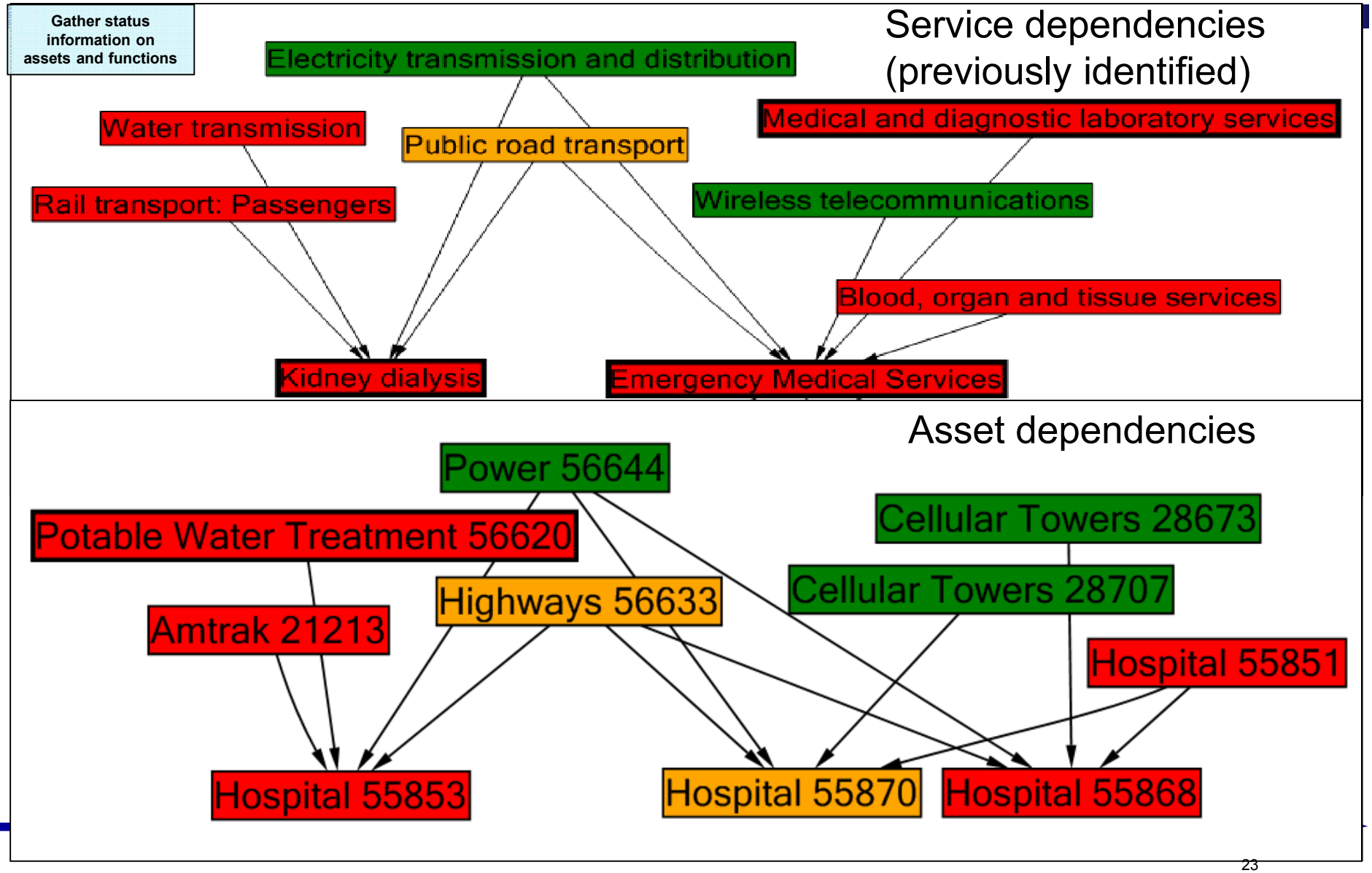
Hospital B: unique capability.
All assets depend on Hwy I-5.
Hospital A has a work-around.
Port depends on railyard.

⬇

1. Highway I-5
2. Hospital B (0.2)
3. Port railyard
4. Port (0.3)
5. Hospital A (0.5)

Port metrics, e.g.,:
For National Economy: shipping volume
For Local Economy: revenue

Asset dependencies are area-specific, typically reflect the service dependencies previously identified, and must be also be accounted for



The output is an analysis-based Asset Priority List specific to this particular scenario and situation

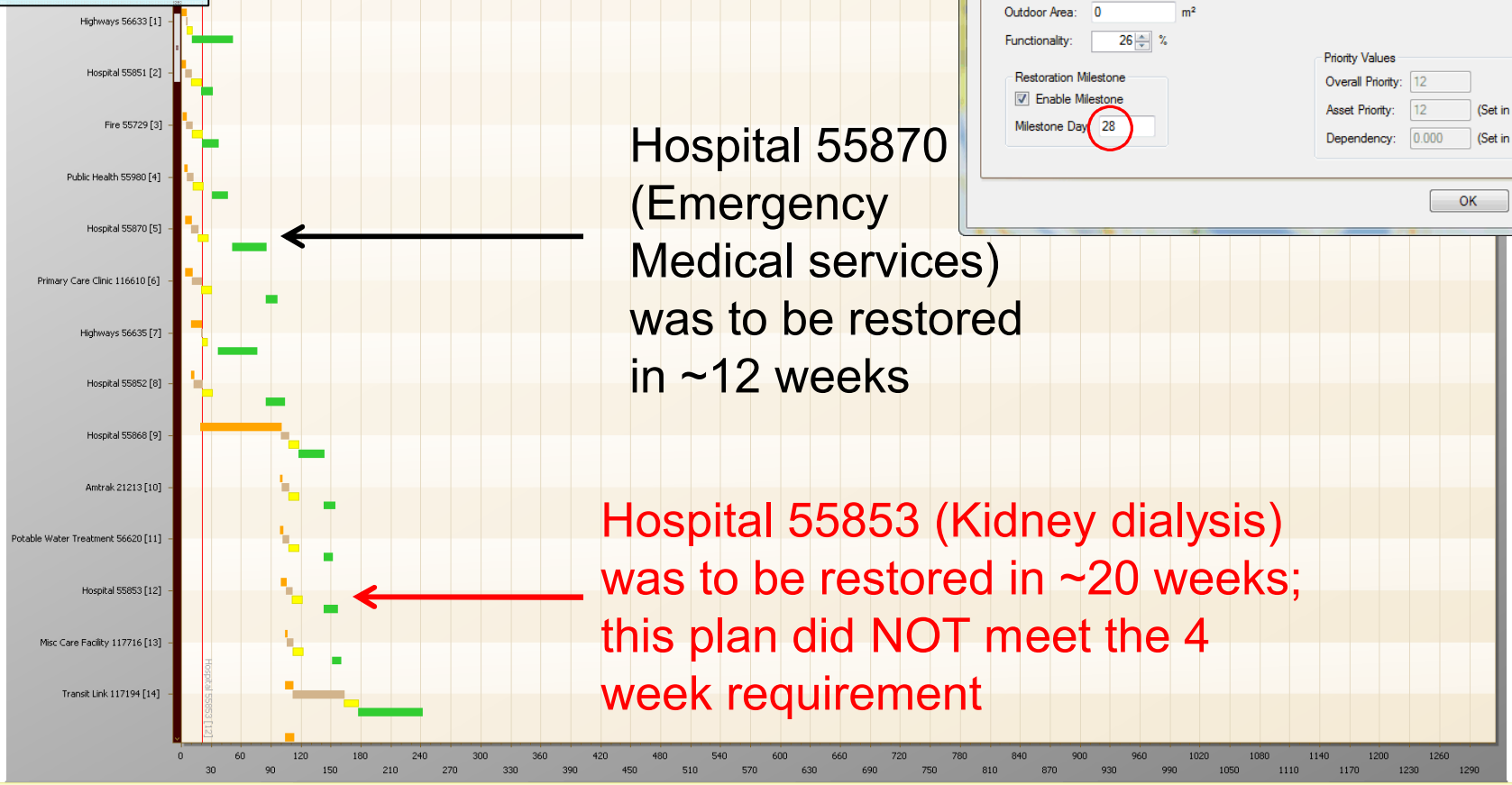
Rank-order assets to enable strategy to improve function status

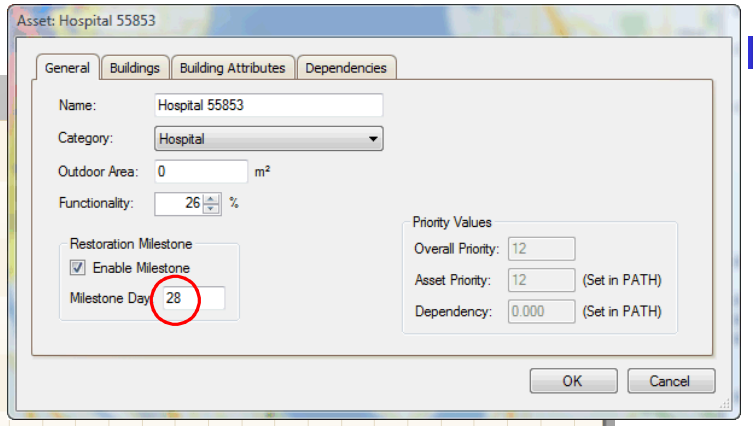
		t Name	Infrastructure Category Name	Reason
⊞	1	Highways 56633	Highways	Enabling Asset
⊞	2	Hospital 55851	Hospital	Enabling Asset
⊞	3	Fire 55729	Fire	Enabling Asset
⊞	4	Public Health 55980	Public Health	Enabling Asset
⊞	5	Hospital 55870	Hospital	Contribution To Prio
⊞	6	Primary Care Clinic 116610	Primary Care Clinic	Enabling Asset
⊞	7	Highways 56635	Highways	Enabling Asset
⊞	8	Hospital 55852	Hospital	Enabling Asset
⊞	9	Hospital 55868	Hospital	Contribution To Prio
⊞	10	Amtrak 21213	Amtrak	Enabling Asset
⊞	11	Potable Water Treatment 56620	Potable Water Treatment	Enabling Asset
⊞	12	Hospital 55853	Hospital	Contribution To Prio
⊞	13	Misc Care Facility 117716	Misc Care Facility	Contribution To Prio
⊞	14	Transit Link 117194	Transit Link	Enabling Asset
⊞	15	Commercial 56636	Commercial	Contribution To Prio

The Asset Priority List identified the specific assets in the region which provide the high priority services at the greatest capacity; this is the basis for an operational plan to enable the restoration of critical functions and services

The Prioritization Strategy is combined with the Remediation Strategy (AWARE) to produce a Restoration Plan

Develop remediation schedule and analyze consequences





Hospital 55870 (Emergency Medical services) was to be restored in ~12 weeks

Hospital 55853 (Kidney dialysis) was to be restored in ~20 weeks; this plan did NOT meet the 4 week requirement

The Restoration Plan identifies when assets and services will be restored, and enables trade-off analysis and evaluation of milestones

The analysis-based Prioritization Strategy is a starting point for prioritization negotiation and refinement; users will refine the strategy, examine trade-offs, and optimize

Identify strategy to improve function status

Rank-order assets to enable strategy to improve function status

		t Name	Infrastructure Category Name	Reason
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		al 55851	Hospital	Enabling Asset
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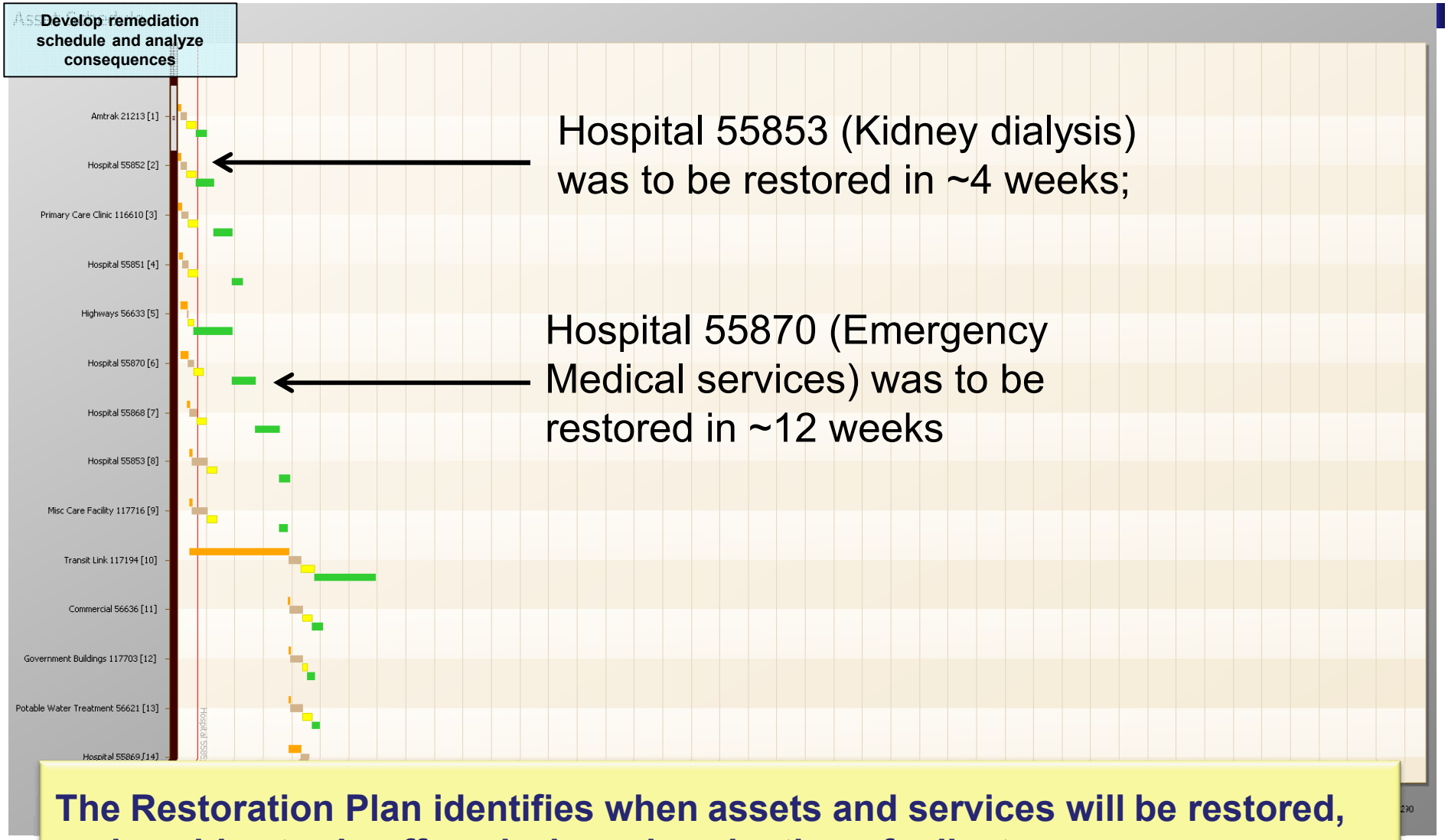
work-around

work-around

By manually moving Hospital 55853 up in priority and developing work-arounds for the movement of patients and water services required, the time to restore the region's kidney dialysis services was greatly reduced

The development of a work-around for public access to those critical facilities, removed a chokepoint and enabled kidney dialysis services to be restored sooner



The Restoration Plan identifies when assets and services will be restored, and enables trade-off analysis and evaluation of milestones

PATH/AWARE automatically generates summary slides of the situation, assumptions, strategy and timelines

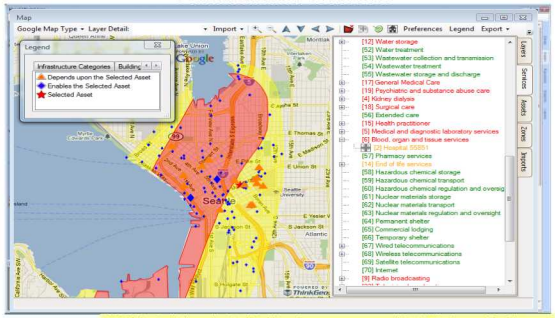
For Exercise Purposes Only

PATH/AWARE
Summary Sheet

IBRD Preparation Exercises
Day 1: 9/8/2009
Day 2: 9/9/2009

For Exercise Purposes Only

Situation: Map display of Northern Hot Zone and Contaminated CI Assets



Multi-jurisdictional prioritization team was assembled 15 days after the release and produced the prioritization strategy presented in this briefing.

For Exercise Purposes Only

Day 1: Example Assumptions and Inputs to Prioritization Strategy

Recovery Objectives and Weightings

Objective	Weight
Maintain Economy	2
Minimize Environmental Impact	2
Maintain Public Safety	5
Maintain Public Health	5
Maintain National Security	2

Functions with Temporary Workarounds

Function Name
Energy
Food/Water
Shelter
Communications (civilian)
Military training
Military mobilization
Military deployment
Wastewater

5

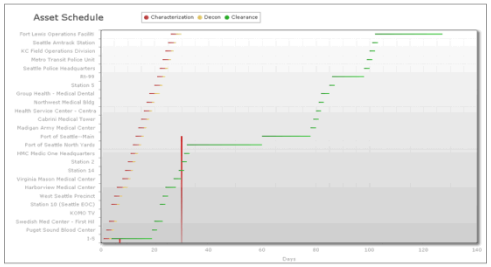
For Exercise Purposes Only

Day 1: Prioritization Strategy for Restoration (Top 10 assets)

Priority	Asset	Justification
1	Interstate-5	Enabling Asset
2	Puget Sound Blood Center	Enabling Asset
3	Harborview Medical Center (Level 1 Trauma Center)	Unique Capability
4	Swedish Hospital	High Objective Score
5	Fire Station #10	High Objective Score
6	West Seattle Precinct	High Objective Score
7	Virginia Mason Medical Center	High Objective Score
8	Port of Seattle Railyards	Enabling Asset
9	Port of Seattle	High Objective Score
10	Seattle University	High Objective Score

6

Restoration Timelines



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Summary slides will be used to present and decisions and plans to Community Leaders, Commanding Officers, Executives, etc.

Summary

- PATH/AWARE is a prototype software capability for the prioritization of critical infrastructure for restoration with all-hazards applications
  - Provides a common operating picture
  - Allows comparison of disparate data from many systems
  - Ranks assets based on restoration objective and function priorities
  - Provides logical, transparent reasoning behind rankings
  - Estimates restoration timelines for alternate prioritization and restoration strategies

"In 40 years of emergency management this is one of the most interesting and exciting projects I've seen…political issues may override, but there's value in showing an objective answer-- it gives a basis for discussion."
Steve Bailey, Pierce County Director of Emergency Management

Back-up Slides

PATH/AWARE Software Technical Specifications

- PC platform with .Net Framework
- C++ programming language
- Uses MS SQL Server (no user fees)
- Stand-alone or server database versions
- ThinkGeo® Mapping Utility (no user fees)
- Access to Local City/County Tax Assessor Databases (requires data formatting for each locale)
- Access to DHS-developed HSIP Critical Asset Database
- Access to FEMA-developed HAZUS Building Database (implementation in progress)