Keeping the Lights On:

Energy Facility Flood Mitigation Projects in New England – Takeaways for Protecting Critical Assets and Infrastructure

Proactive By Design.
Our Company Commitment

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Topics

- Background
- Flood Resilience Options
- GZA's Work
  - Permanent Flood Control Solutions
  - Temporary and Mobilized Solutions
  - Testing
- Conclusions/Takeaways

Background

- Climate change/sea level rise/larger events
- Super Storm Sandy
  - 8.1M homes without power in 17 states
  - 57k utility workers assist in returning power to NYC
- Post-Super Storm Sandy Lessons
  - Restoring power can be:

Time consuming

Costly

A public relations nightmare

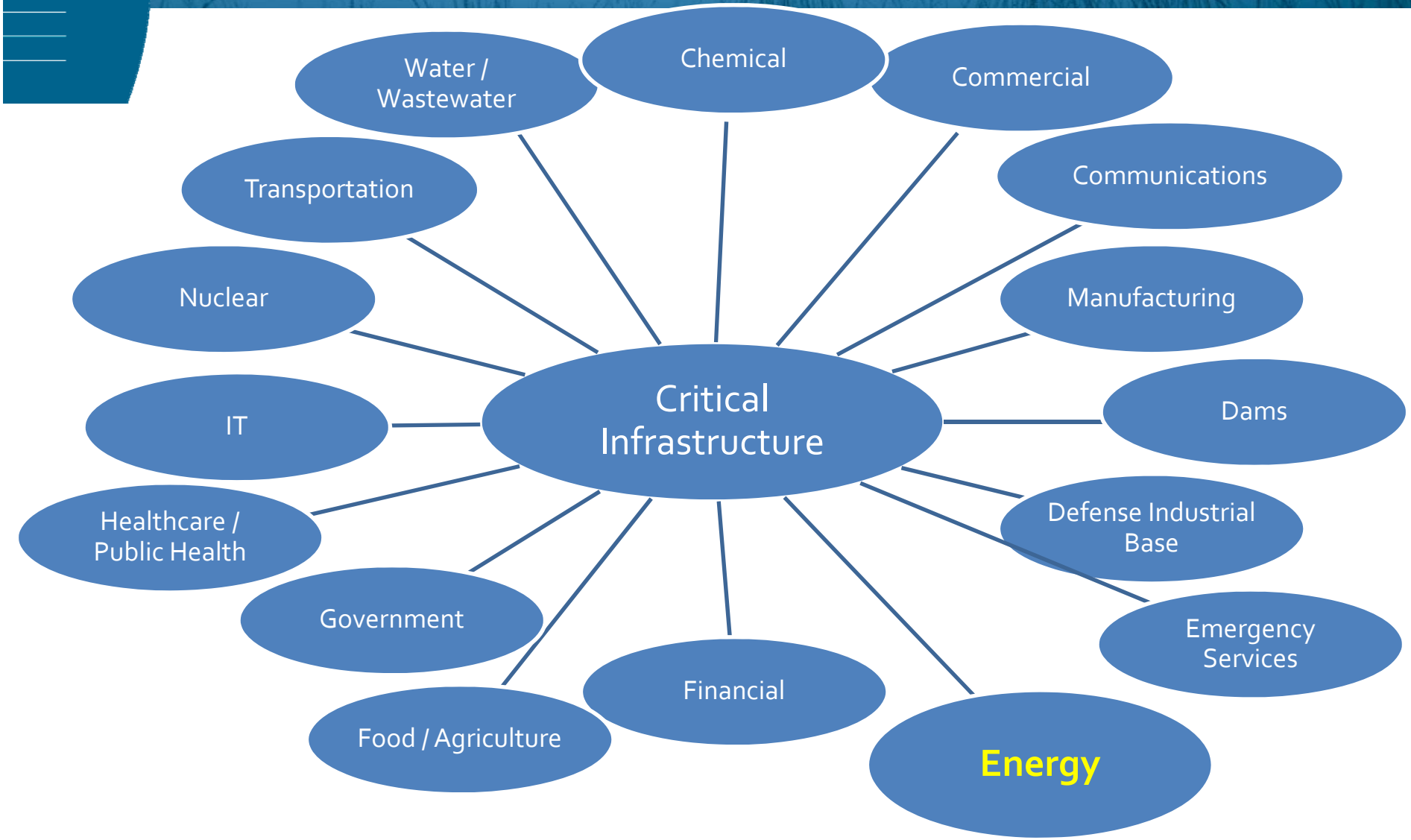
Flood Risk Mitigation – Substation Specific Issues

- Security
- Safety
- Accessibility and Space Limitations
- Underground Penetrations

Plus typical issues:

- Cost
- Maintenance
- Schedule
- Compatibility with future projects
- Site constraints
- Permitting – comp. storage
- Risks/benefits
- Adaptability to climate change

Protecting Critical Infrastructure



Flood Resilience Options

- Physical Options
  - No Flooding
  - Controlled Flooding
- What gets protected?
- Longevity of Solution
  - Long-term
  - Interim
  - Mobilized

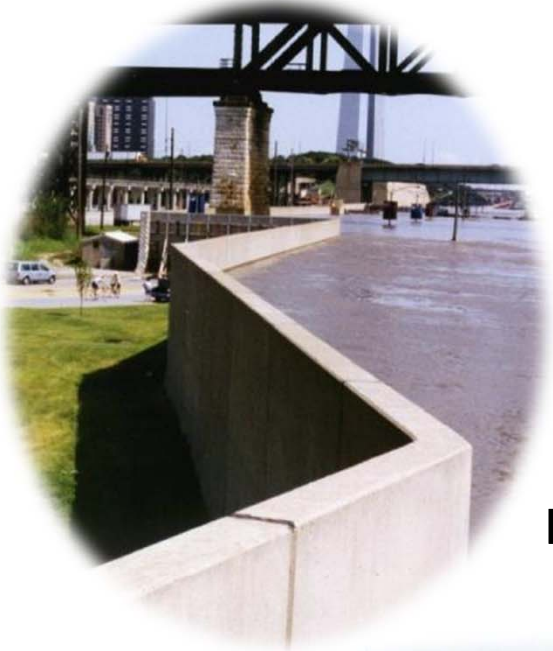
Floodwall protects Our Lady of Lourdes Hospital in Binghampton, NY along Susquehanna River in 2011 during Tropical Storm Lee

Photo Source: fema.gov

Flood Resilience - Option 1
No Flooding

Re-Build above DFE

Permanent Barrier



Mobilized Barrier

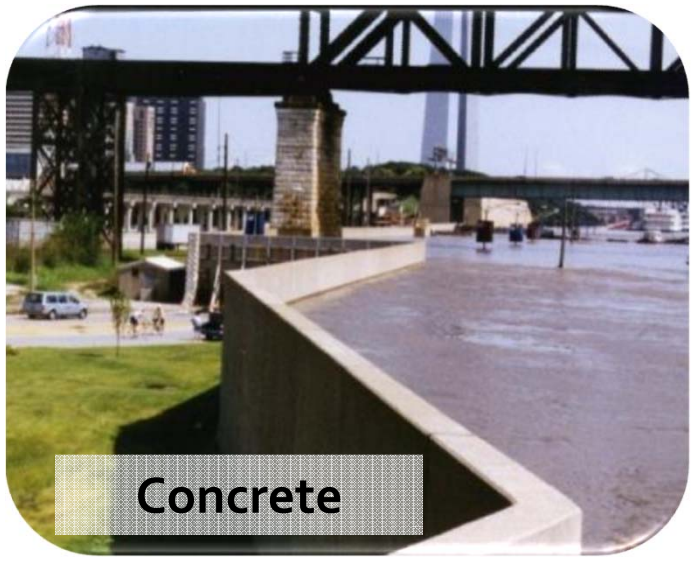
Interim Barrier

Flood Resilience - Option 2 Controlled Flooding

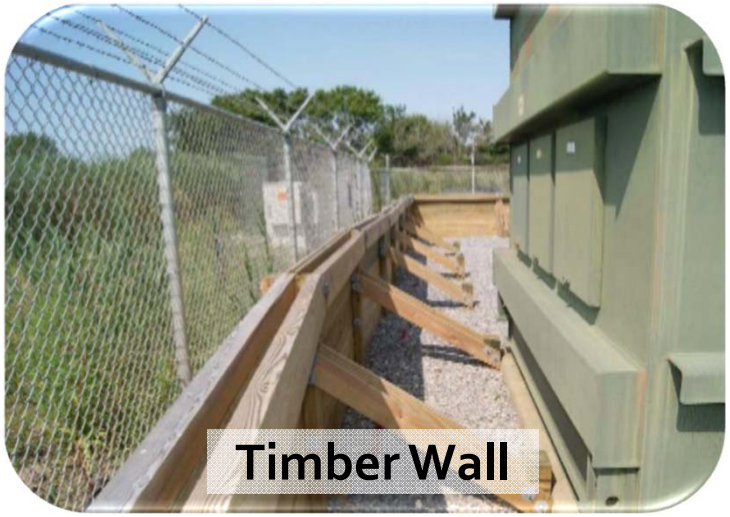
Raise Panels / Equipment

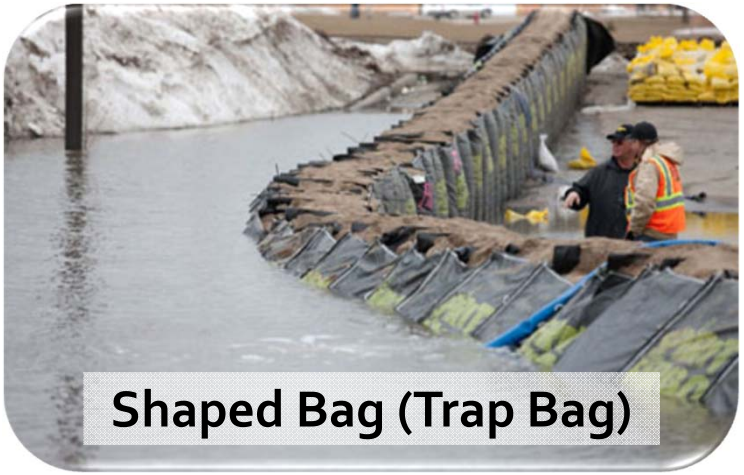
Dry Floodproofing

Permanent Flood Control Barriers



Interim
Flood Control Barriers





Mobilized Flood Control Barriers


Aquafence


Invisible Wall


Floodstop

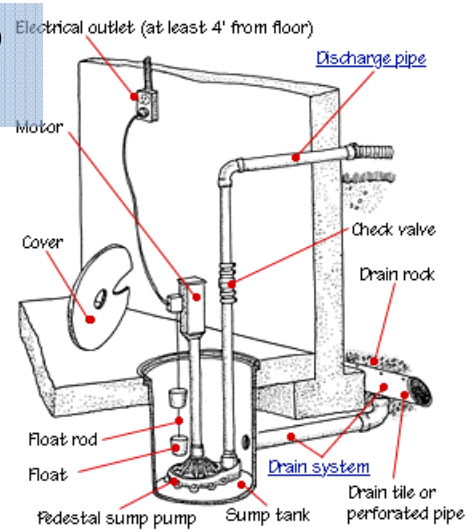

Sand Bag


Bladder Dam

Flood Control Barriers
Control of Water

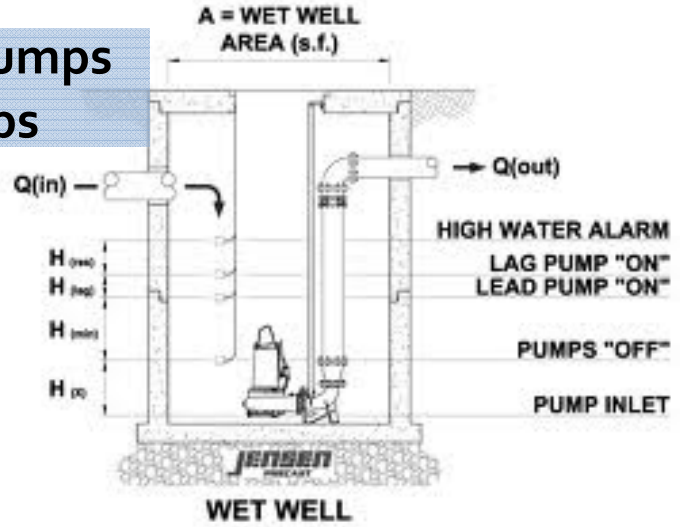
Duck bill

Interior Sump & Pump



Flap gates

Exterior Sumps & Pumps

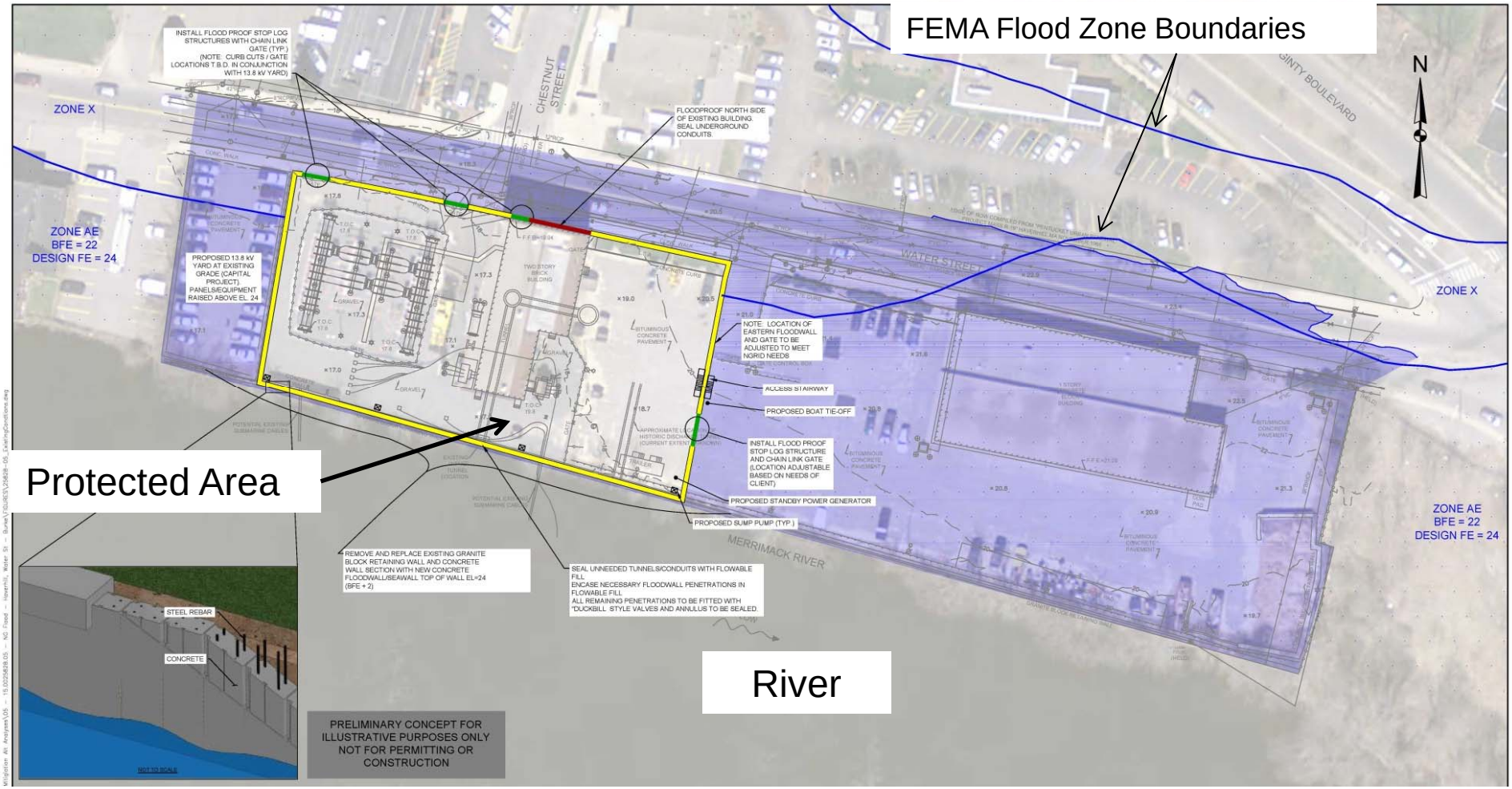


Project Overview

- Permanent flood control concepts
  - 11 substations in New England
  - Design Flood Elevation (DFE)
    - Set based on ASCE-24
    - Base Flood Elevation (BFE) +2 (or +3)

- Interim flood control concepts
  - 22 substations in New England
  - Flood Contingency Plans (FCPs)
    - Temporary controls (2-3 years)
    - Mobilized controls

Permanent Flood Control Concept Plans



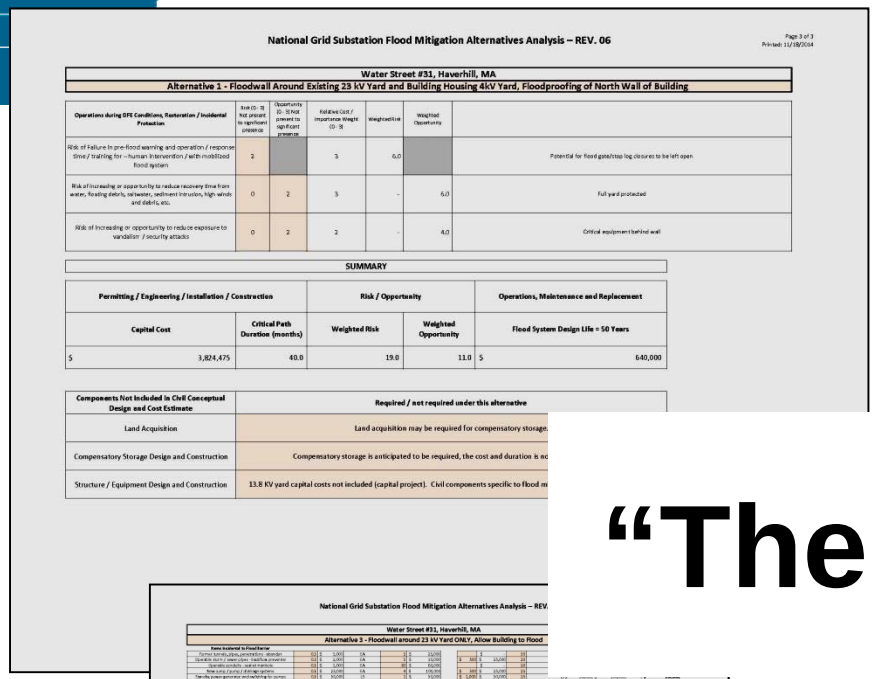
Permanent Concepts – Site Specific Realties

Property constraints

Aging seawall

Historical structures, tunnels/conduits

Flood Control Concept Selection Process



National Grid Substation Flood Mitigation Alternatives Analysis – REV. 06

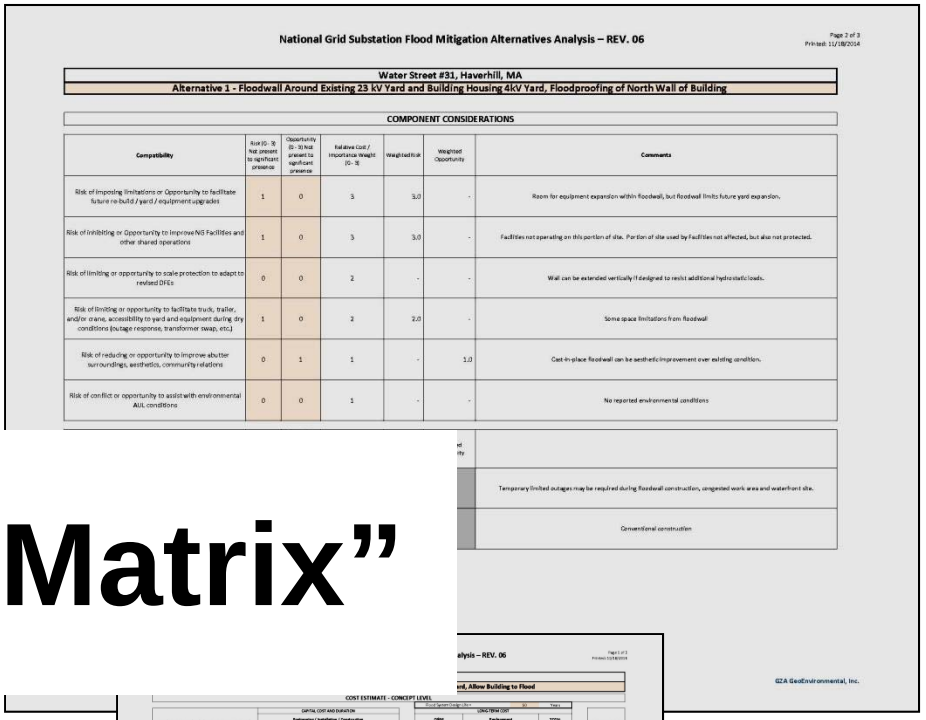
Water Street #31, Haverhill, MA
Alternative 1 - Floodwall Around Existing 23 kV Yard and Building Housing 4kV Yard, Floodproofing of North Wall of Building

Operations during DFE Conditions, Restoration / Incidental Protection	Risk (0 - 3) Not present to significant presence	Opportunity (0 - 3) Not present to significant presence	Relative Cost / Importance Weight (0 - 3)	Weighted Risk	Weighted Opportunity	
Risk of Failure in pre-flood warning and operation / response time / training for – human intervention / with mobilized flood system	2		3	6.0		Potential for flood gate/stop log closures to be left open
Risk of increasing or opportunity to reduce recovery time from water, floating debris, saltwater, sediment intrusion, high winds and debris, etc.	0	2	3	-	6.0	Full yard protected
Risk of increasing or opportunity to reduce exposure to vandalism / security attacks	0	2	2	-	4.0	Critical equipment behind wall

SUMMARY

Permitting / Engineering / Installation / Construction		Risk / Opportunity		Operations, Maintenance and Replacement
Capital Cost	Critical Path Duration (months)	Weighted Risk	Weighted Opportunity	Flood System Design Life = 50 Years
$ 3,824,475	40.0	19.0	11.0	$ 640,000

Components Not Included in Civil Conceptual Design and Cost Estimate	Required / not required under this alternative
Land Acquisition	Land acquisition may be required for compensatory storage
Compensatory Storage Design and Construction	Compensatory storage is anticipated to be required, the cost and duration is no
Structure / Equipment Design and Construction	13.8 KV yard capital costs not included (capital project). Civil components specific to flood m



National Grid Substation Flood Mitigation Alternatives Analysis – REV. 06

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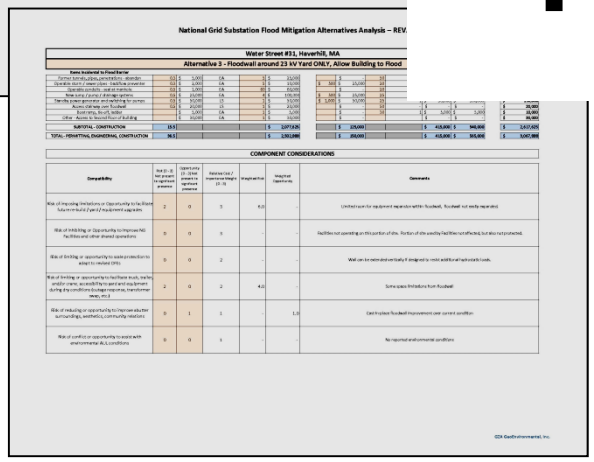
COMPONENT CONSIDERATIONS

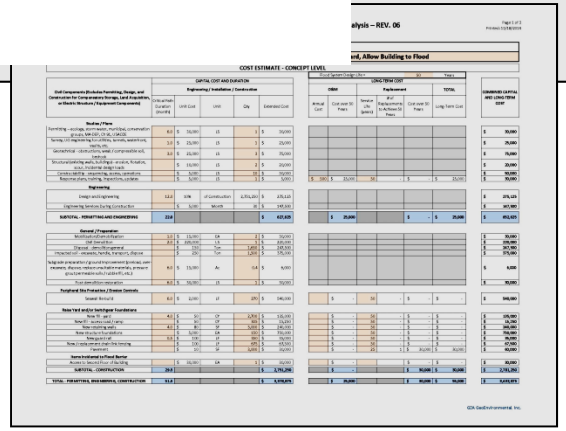
Compatibility	Risk (0 - 3) Not present to significant presence	Opportunity (0 - 3) Not present to significant presence	Relative Cost / Importance Weight (0 - 3)	Weighted Risk	Weighted Opportunity	Comments
Risk of imposing limitations or Opportunity to facilitate future re-build / yard / equipment upgrades	1	0	3	3.0	-	Room for equipment expansion within floodwall, but floodwall limits future yard expansion.
Risk of inhibiting or Opportunity to improve NG Facilities and other shared operations	1	0	3	3.0	-	Facilities not operating on this portion of site. Portion of site used by Facilities not affected, but also not protected.
Risk of limiting or opportunity to scale protection to adapt to revised DFEs	0	0	2	-	-	Wall can be extended vertically if designed to resist additional hydrostatic loads.
Risk of limiting or opportunity to facilitate truck, trailer, and/or crane, accessibility to yard and equipment during dry conditions (outage response, transformer swap, etc.)	1	0	2	2.0	-	Some space limitations from floodwall
Risk of reducing or opportunity to improve abutter surroundings, aesthetics, community relations	0	1	1	-	1.0	Cast-in-place floodwall can be aesthetic improvement over existing condition.
Risk of conflict or opportunity to assist with environmental AUL conditions	0	0	1	-	-	No reported environmental conditions
						Temporary limited outages may be required during floodwall construction, congested work area and waterfront site.
						Conventional construction



National Grid Substation Flood Mitigation Alternatives Analysis – REV.

Water Street #31, Haverhill, MA
Alternative 3 - Floodwall around 23 kV Yard ONLY, Allow Building to Flood

COMPONENT CONSIDERATIONS



alysis – REV. 06

Water Street #31, Haverhill, MA
Alternative 2 - Floodwall around 23 kV Yard ONLY, Allow Building to Flood

COST ESTIMATE - CONCEPT LEVEL

GZA GeoEnvironmental, Inc.

“The Matrix”

Flood Control Concept Selection Process

"The Results"

	Engineering/Installation / Construction		Risk/Opportunity		Operations, Maintenance, & Replacement Cost (thousands)
	Capital Cost (thousands)	Critical Path Duration (months)	Weighted Risk	Weighted Opportunity	Flood System Design Life= 50 years
Alternative 1 – Floodwall around Existing 23kV Yard and Building Housing 4kV yard, Flood-proofing north wall of building.	$3,824	40.0	19.0	11.0	$640
Alternative 2 – Construct new raised 23kV yard, decommission existing 23kV yard, Allow building to flood	$3,379	51.5	15.0	9.0	$55
Alternative 3 – Floodwall around 23kV yard ONLY, Allow building to flood	$2,503	36.5	10.0	1.0	$565

Flood Contingency Plans/ Mobilized Concepts

PHASE 2: 35-INCH FLOODSTOP BARRIER SYSTEM MIN EL. 101.5' (SEE DETAIL) COORDINATE FENCE AND EQUIPMENT CLEARANCES

PHASE 2: PROPOSED 200 GPM PUMP

PHASE 1: SEAL CONDUITS

PHASE 2: PROPOSED 100 GPM PUMP

Flood Contingency Plans/ Mobilized Concepts Testing

Geotextile between cells

Geotextile not folded under

Mock-Up #1 HESCO Testing

End dumped fill

Mock-Up #1
HESCO Testing

Excessive Internal Seepage

Increasing Flow, Piping

Flood Contingency Plans/ Mobilized Concepts Testing

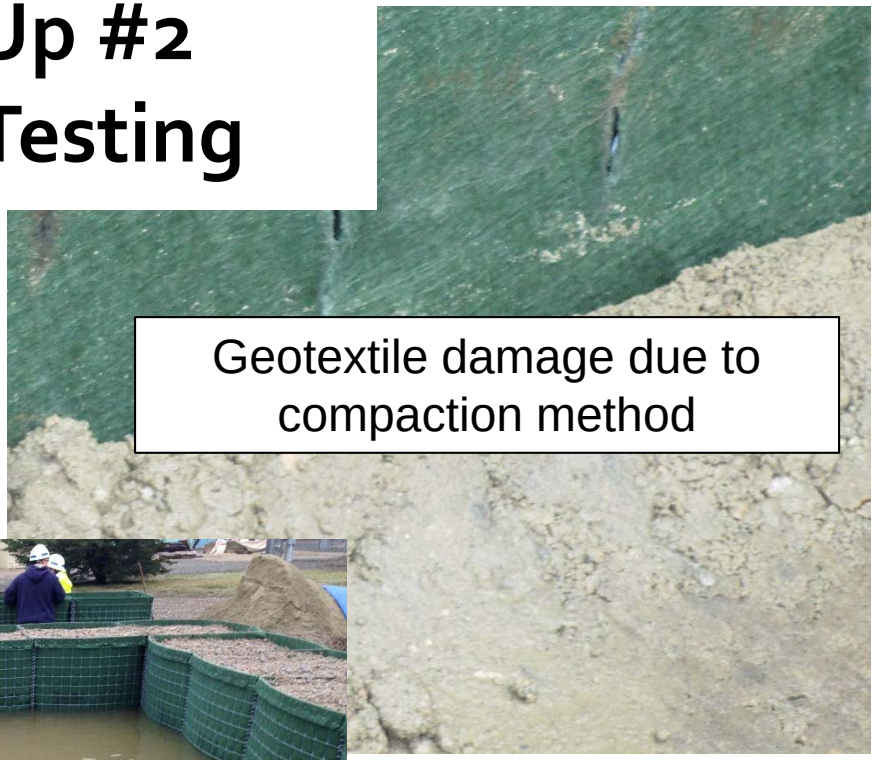
Loss of Strength – Potential Failure of Multiple Cells

Mock-Up #1 HESCO Testing

Loss of Fill – Imminent Failure of Cell

Mock-Up #2
HESCO Testing

Geotextile folded under this time



Geotextile damage due to compaction method

Conclusions/Takeaways

1. Need to listen and understand Client needs
    - Facility – past, present, and future
    - Operations and capabilities
    - What needs protection?

2. Thorough design development is key

3. Proper installation, training, and execution are <u>essential</u>

Contact Info

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