Geotechnical Environmental Ecological Water Construction Management

Proactive By Design.
Our Company Commitment

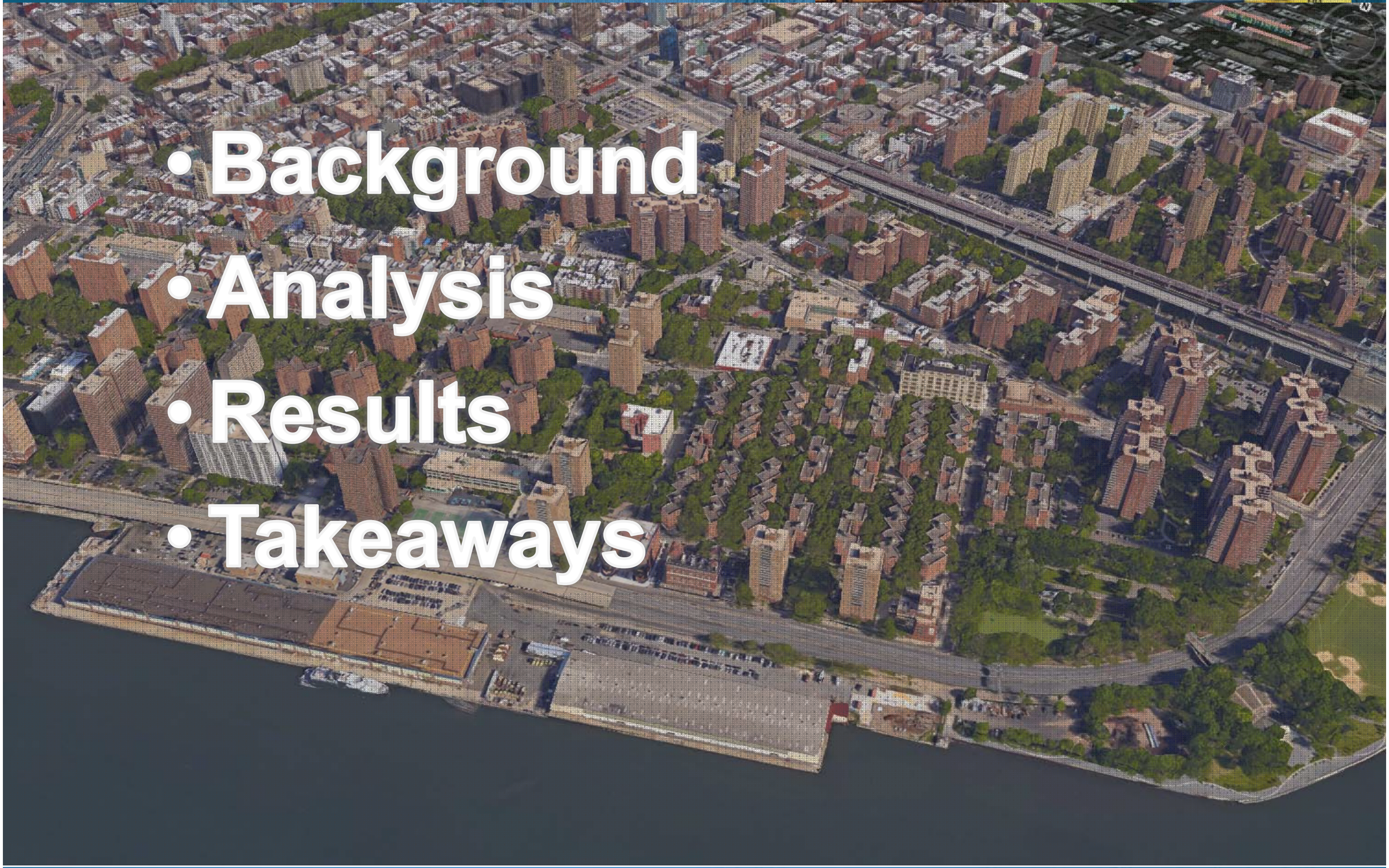
Surface Flood-induced Groundwater Seepage Modeling for Coastal Flood Hazard Areas

CONNECTICUT
Association of Flood Managers

Annual Conference 2016

Bin Wang, Chad Cox, Cassandra Wetzel and Dan Stapleton

OUTLINE



- Background
- Analysis
- Results
- Takeaways

BACKGROUND

- Properties flooded during Sandy 2012
- Damage assessment and recovery completed
- Improvements for resiliency against future risks
- Load calculation using the Design Flood Elevation (DFE)

BACKGROUND

GEOTECHNICAL ENVIRONMENTAL ECOLOGICAL WATER CONSTRUCTION MANAGEMENT

NATIONAL FLOOD INSURANCE PROGRAM

Effective September 5, 2007

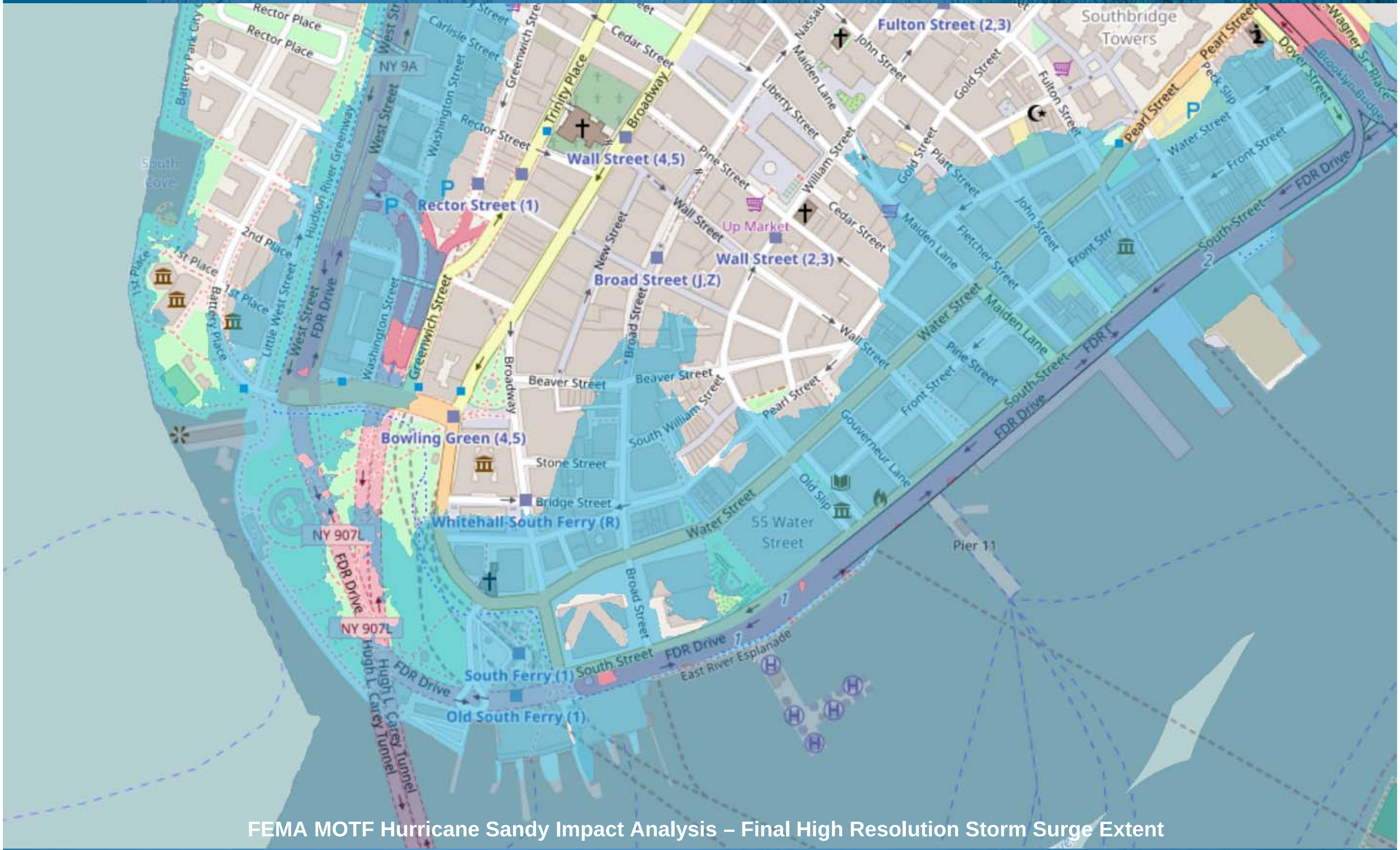
GEOTECHNICAL ENVIRONMENTAL ECOLOGICAL WATER CONSTRUCTION MANAGEMENT

BACKGROUND

NATIONAL FLOOD INSURANCE PROGRAM

BACKGROUND

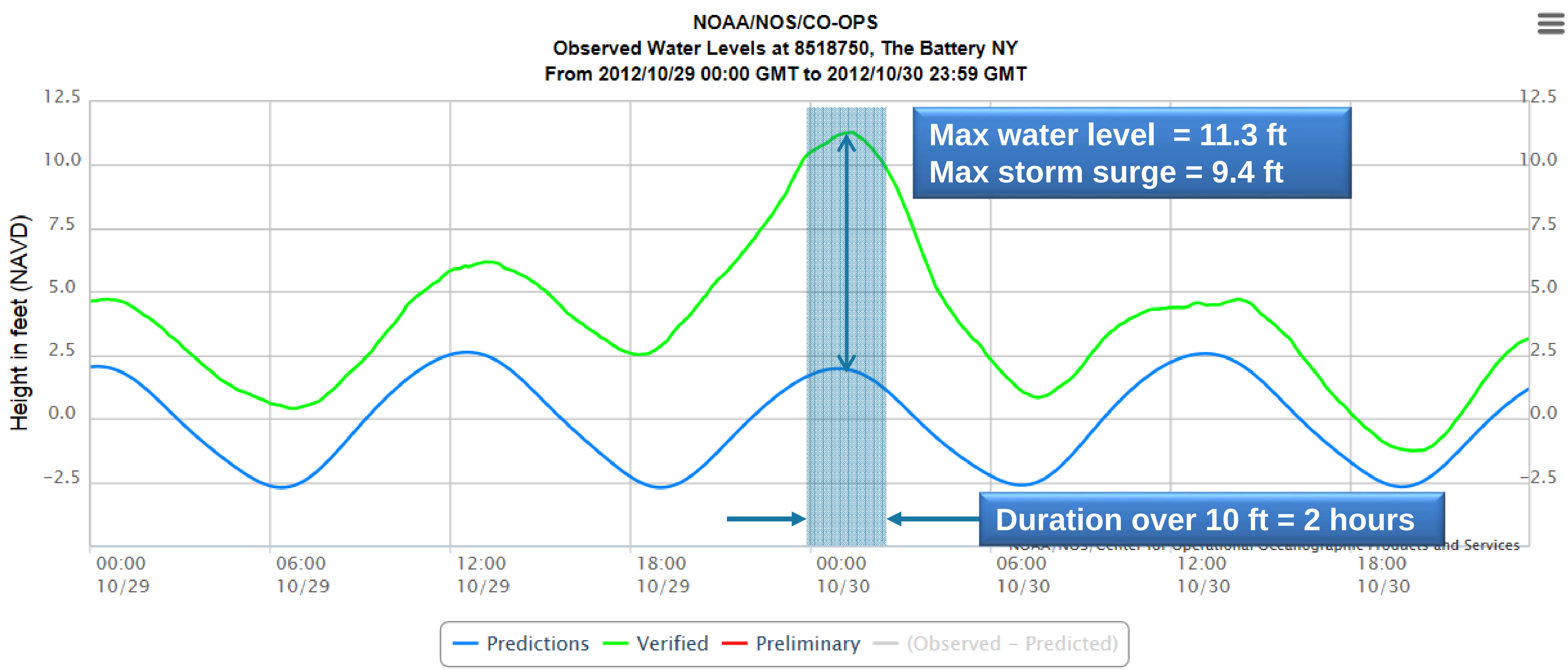
Geotechnical | Environmental | Ecological | Water | Construction Management



FEMA MOTF Hurricane Sandy Impact Analysis – Final High Resolution Storm Surge Extent

BACKGROUND

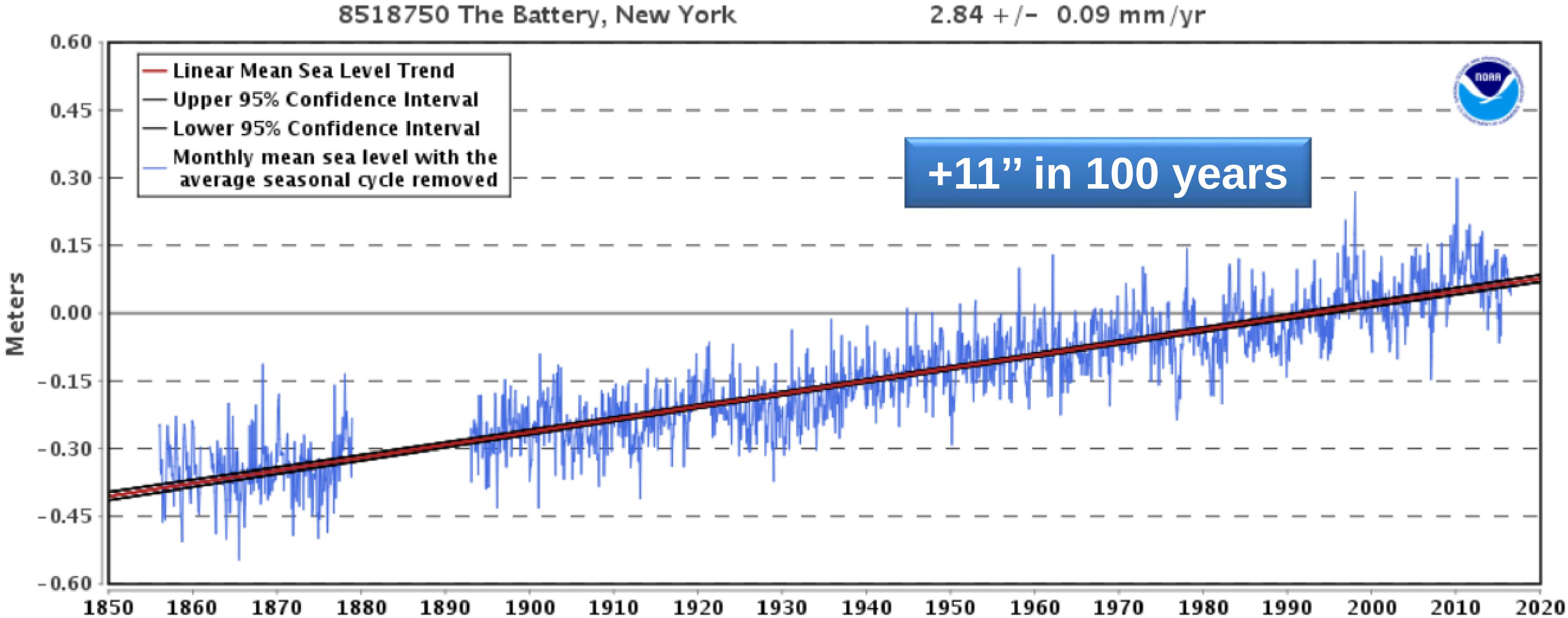
Hurricane Sandy 2012
Observed Water Levels at The Battery



BACKGROUND

GEOTECHNICAL ENVIRONMENTAL ECOLOGICAL WATER CONSTRUCTION MANAGEMENT

Mean Sea Level Trend
8518750 The Battery, New York



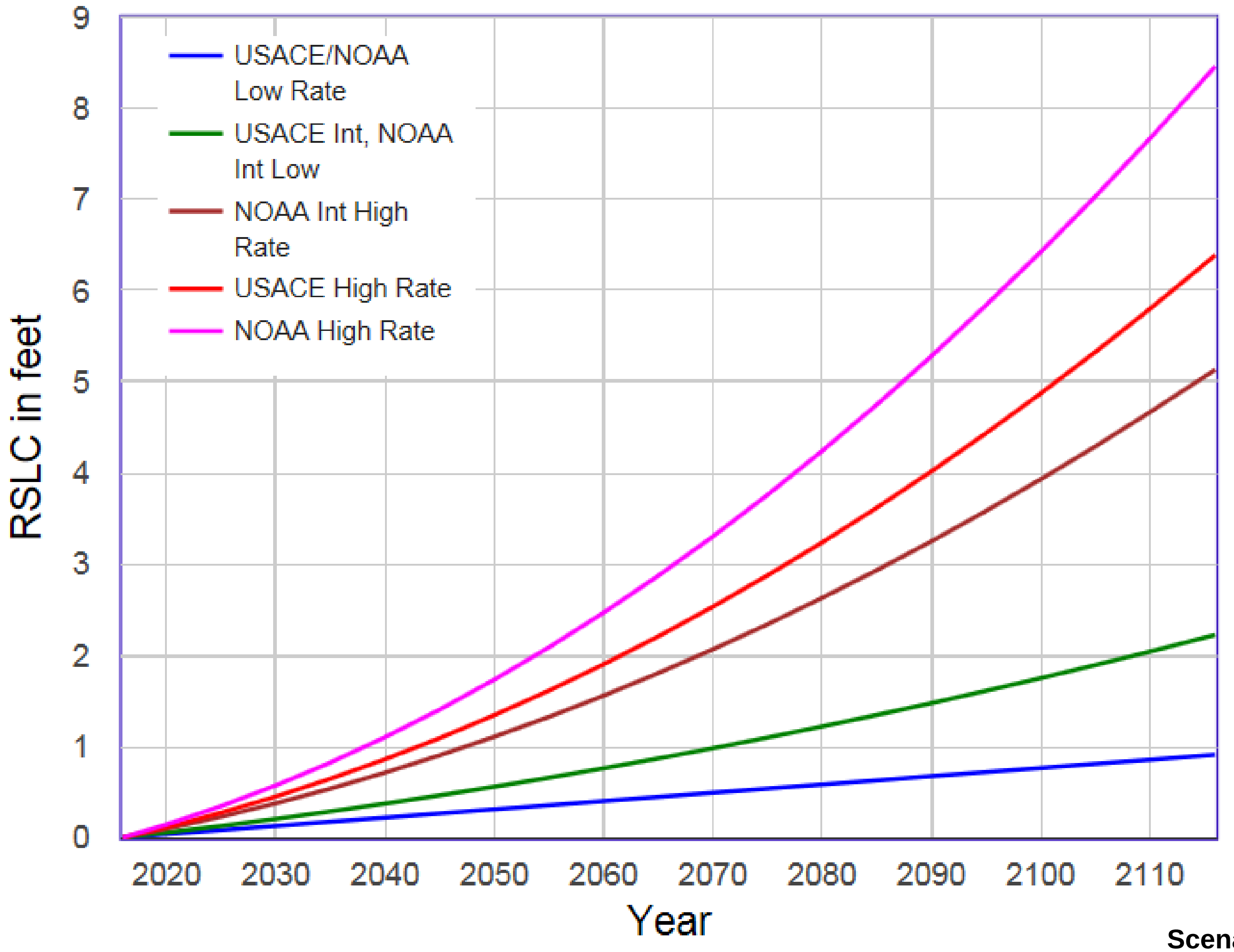
EXPORT TO TEXT | EXPORT TO CSV | SAVE IMAGE

The mean sea level trend is 2.84 millimeters/year with a 95% confidence interval of +/- 0.09 mm/yr based on monthly mean sea level data from 1856 to 2015 which is equivalent to a change of 0.93 feet in 100 years.

BACKGROUND

GEOTECHNICAL ENVIRONMENTAL ECOLOGICAL WATER CONSTRUCTION MANAGEMENT

Estimated Relative Sea Level Change Projections From 2016 To 2116 - Gauge: 8518750, The Battery, NY (2.77 mm/yr)



USACE SLR Scenarios

+6.4’ in 100 years

+2.2’ in 100 years

+0.9’ in 100 years

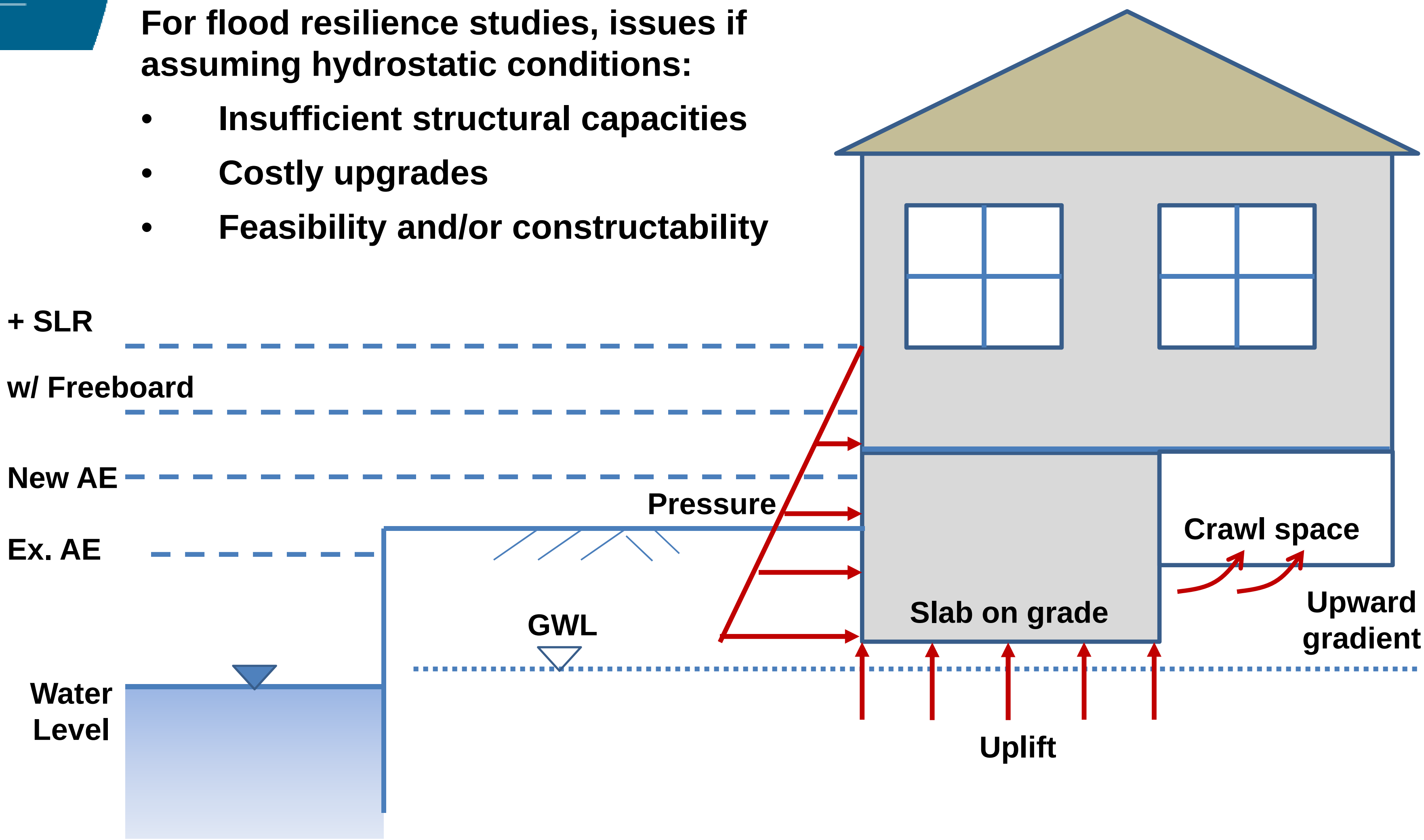
Scenarios assigned with equal probabilities

BACKGROUND

GEOTECHNICAL ENVIRONMENTAL ECOLOGICAL WATER CONSTRUCTION MANAGEMENT

For flood resilience studies, issues if assuming hydrostatic conditions:

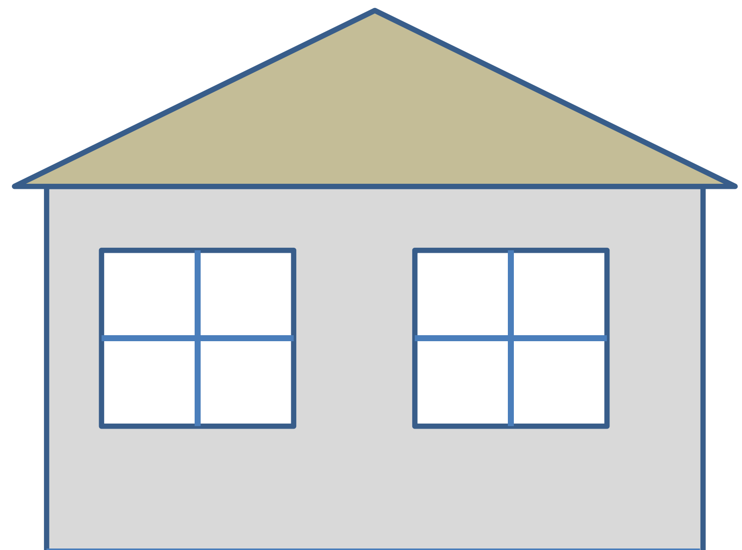
- **Insufficient structural capacities**
- **Costly upgrades**
- **Feasibility and/or constructability**

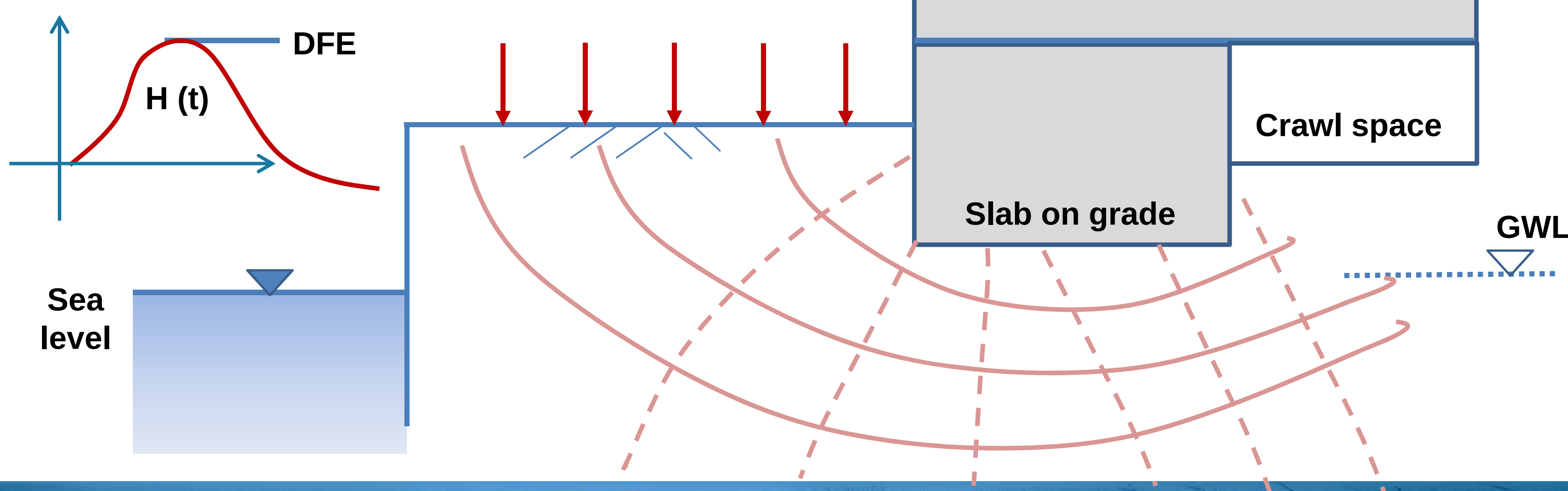


ANALYSIS

Numerical Transient Seepage Modeling:

- **2-dimensional finite element model**
- **Stage hydrographs with design flood elevations (DFE)**
- **DFE = BFE + 1' Freeboard + 3' SLR**
- **Various improvement options**
- **Refined results**





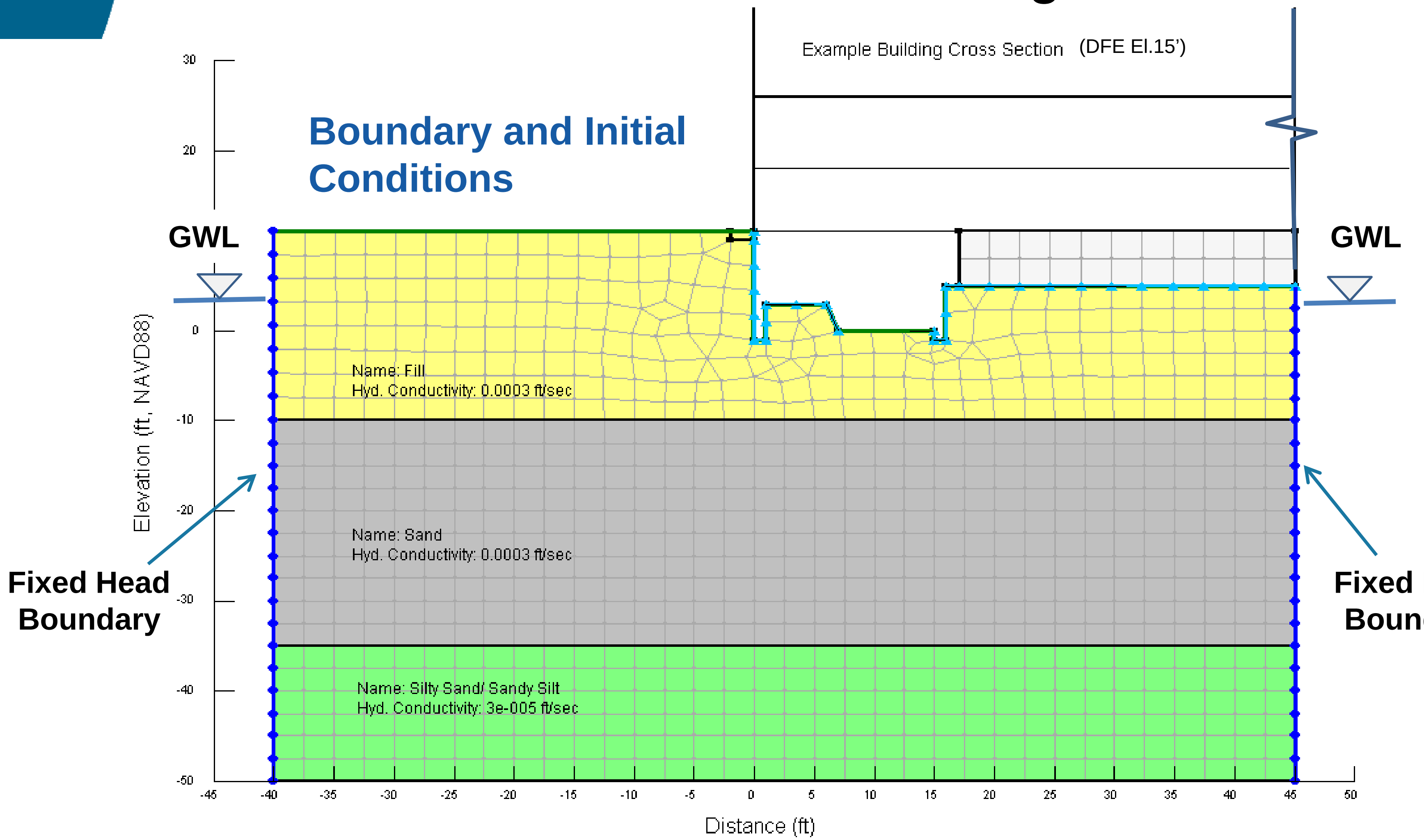
Groundwater flow analysis

SEEP/W analyzes groundwater flow within porous materials. Its formulation enables analyses ranging from simple saturated steady-state problems to sophisticated saturated/unsaturated time-dependent problems.

SEEP/W can be applied to the analysis and design of geotechnical, civil, hydrogeological, and mining engineering projects.

BASE RUN

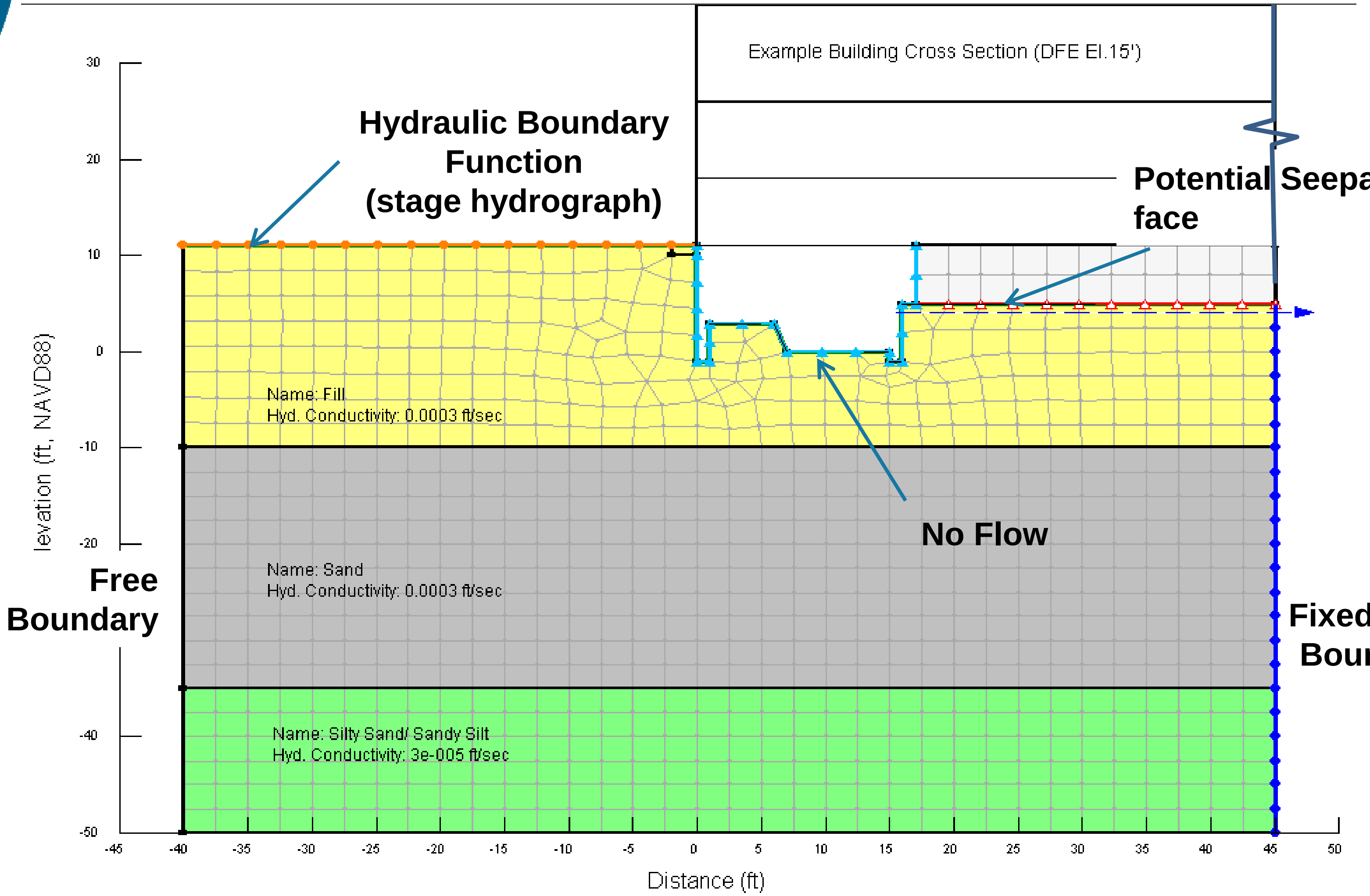
Finite Element Model – Existing Conditions



BASE RUN

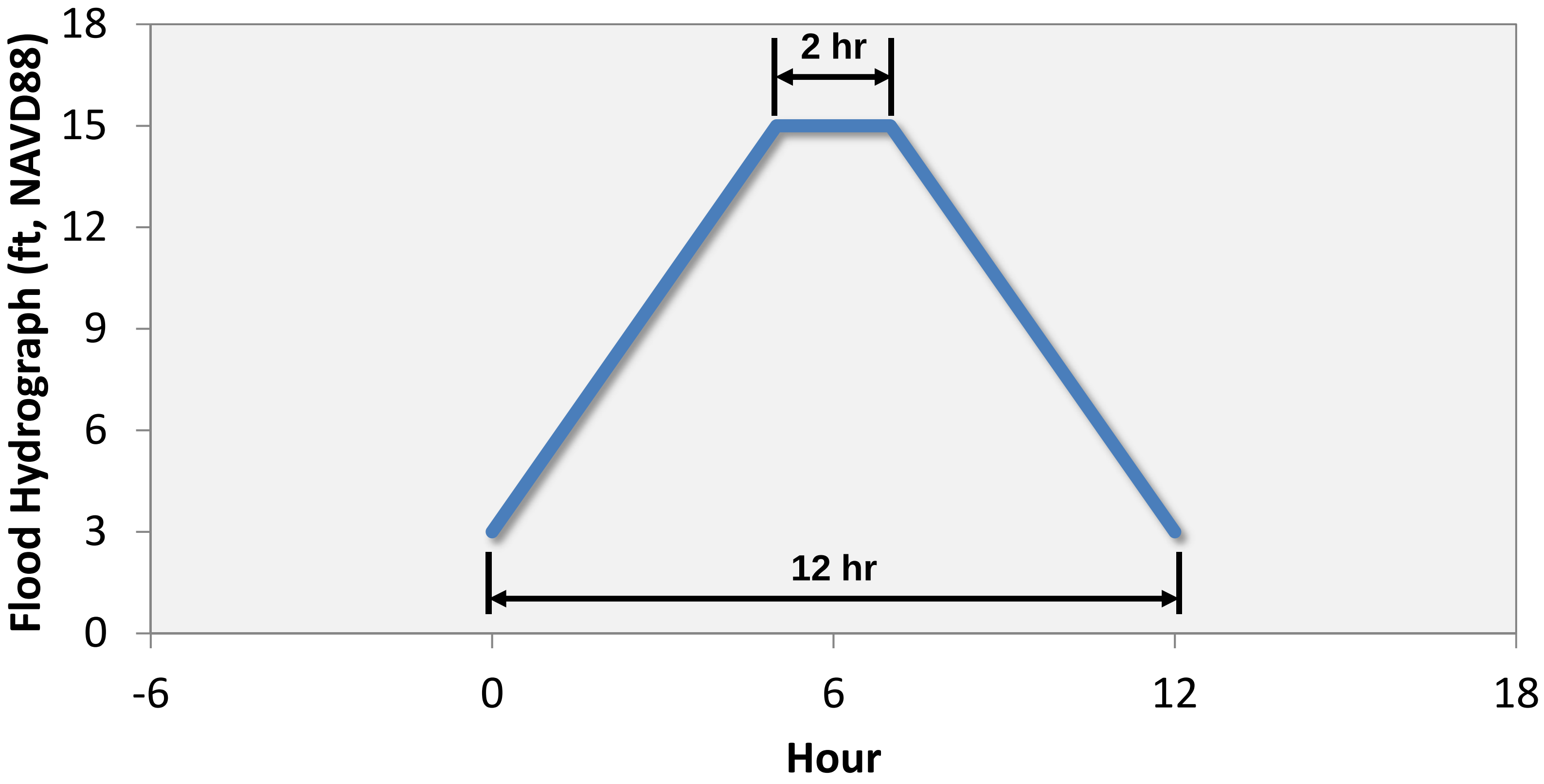
GEOTECHNICAL ENVIRONMENTAL ECOLOGICAL WATER CONSTRUCTION MANAGEMENT

Finite Element Model – Transient Stage



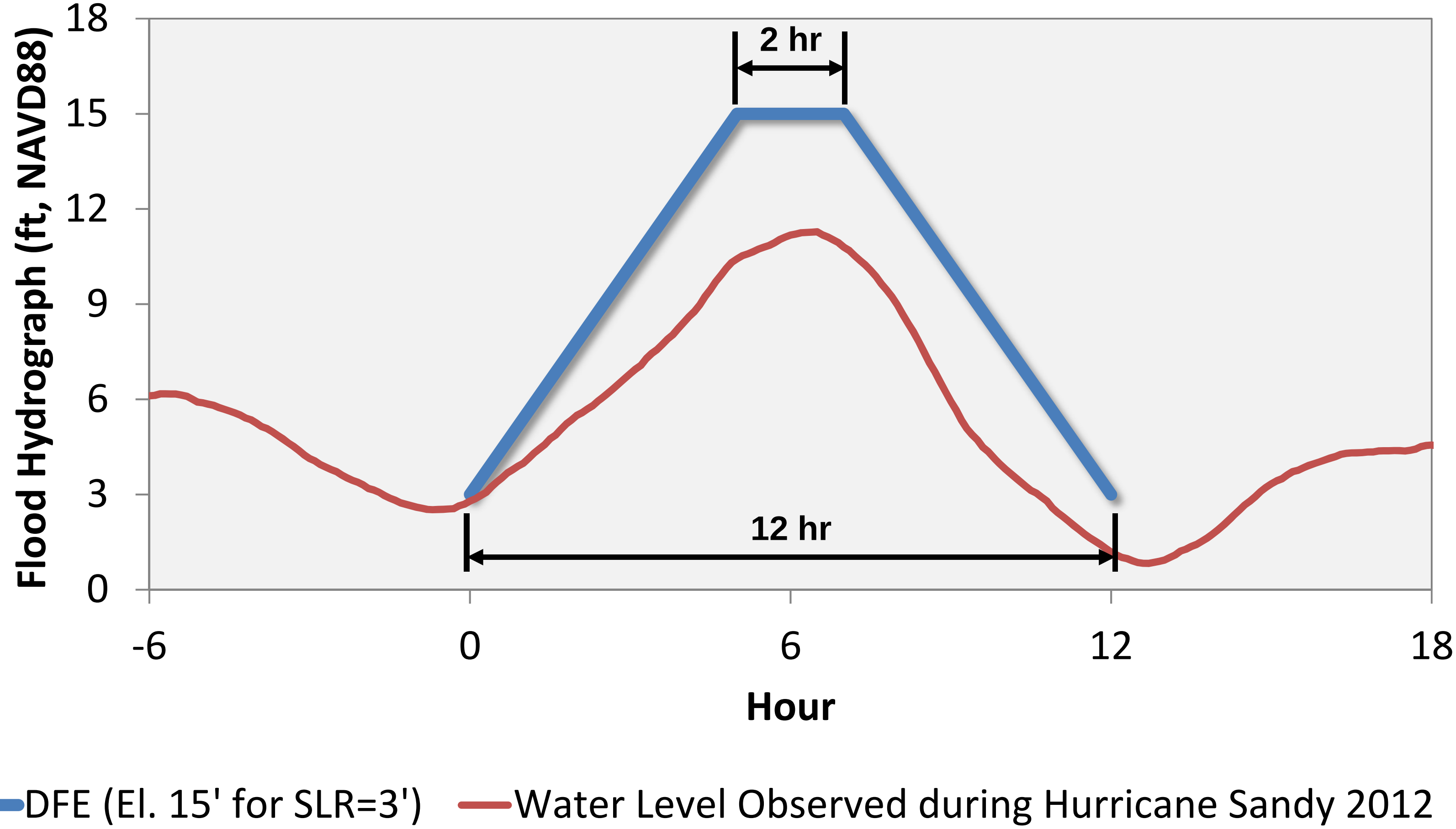
INPUT

Stage Hydrograph



INPUT

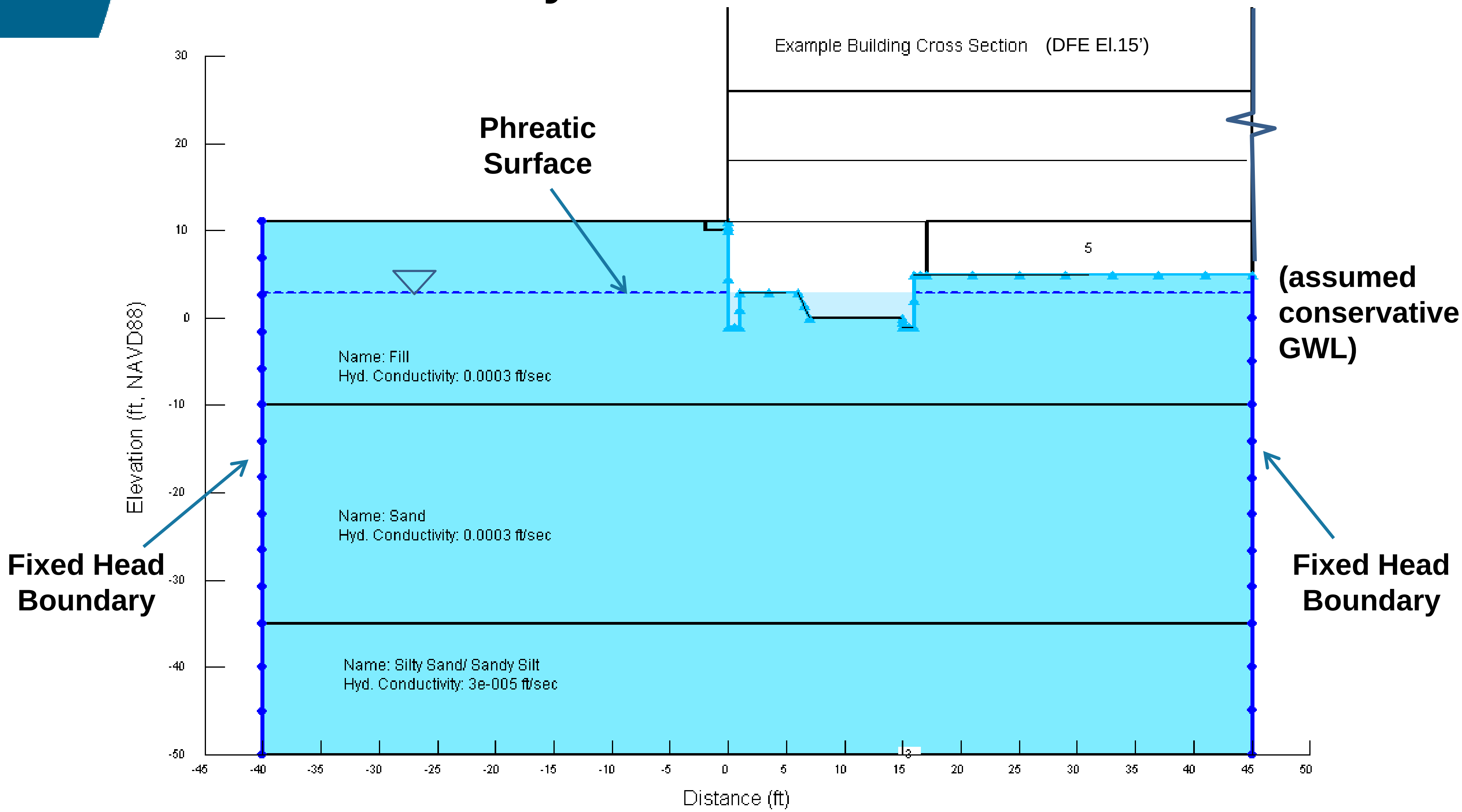
Input Hydrograph



BASE RESULTS

GEOTECHNICAL ENVIRONMENTAL ECOLOGICAL WATER CONSTRUCTION MANAGEMENT

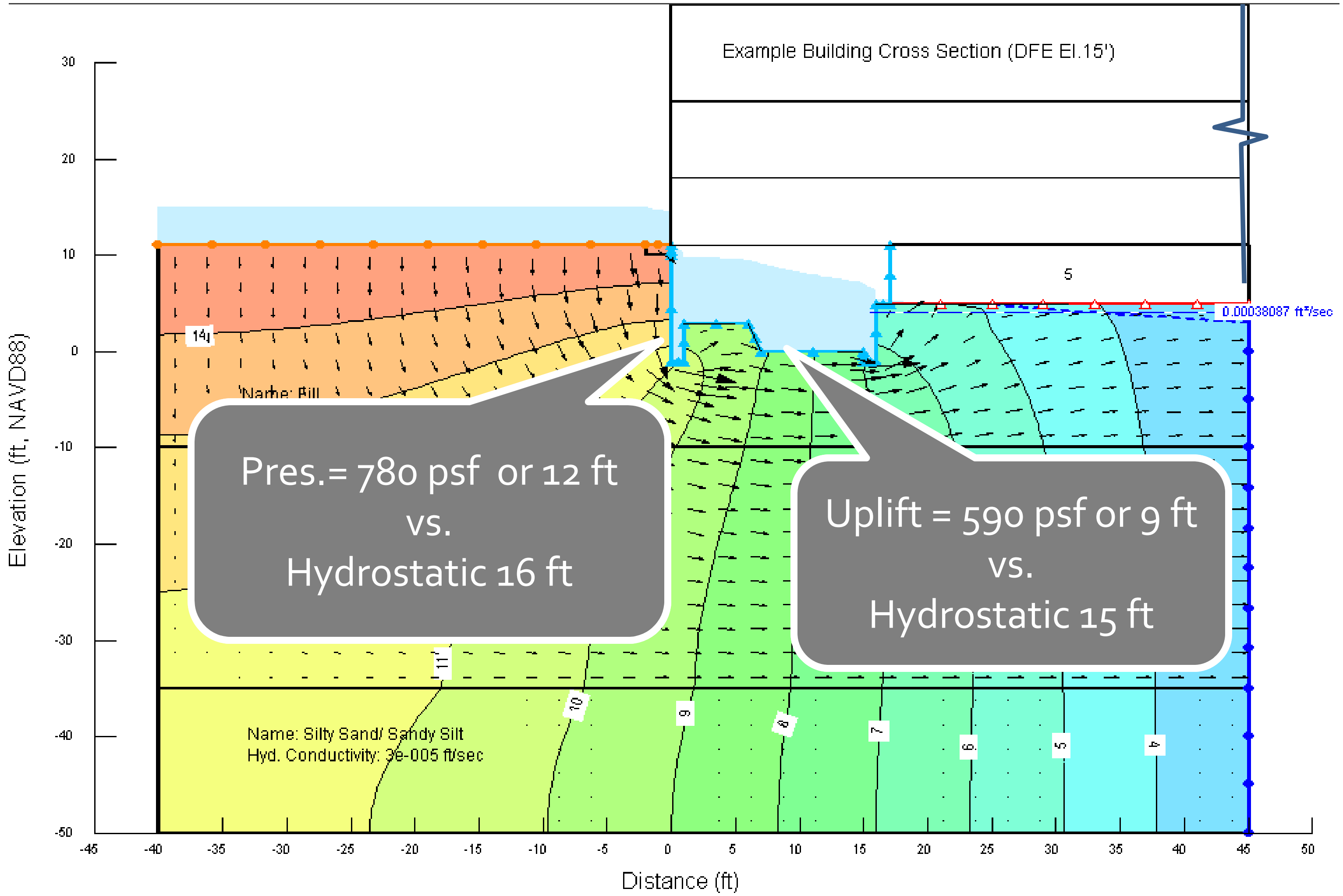
Steady State - Initial Conditions



BASE RESULTS

GEOTECHNICAL ENVIRONMENTAL ECOLOGICAL WATER CONSTRUCTION MANAGEMENT

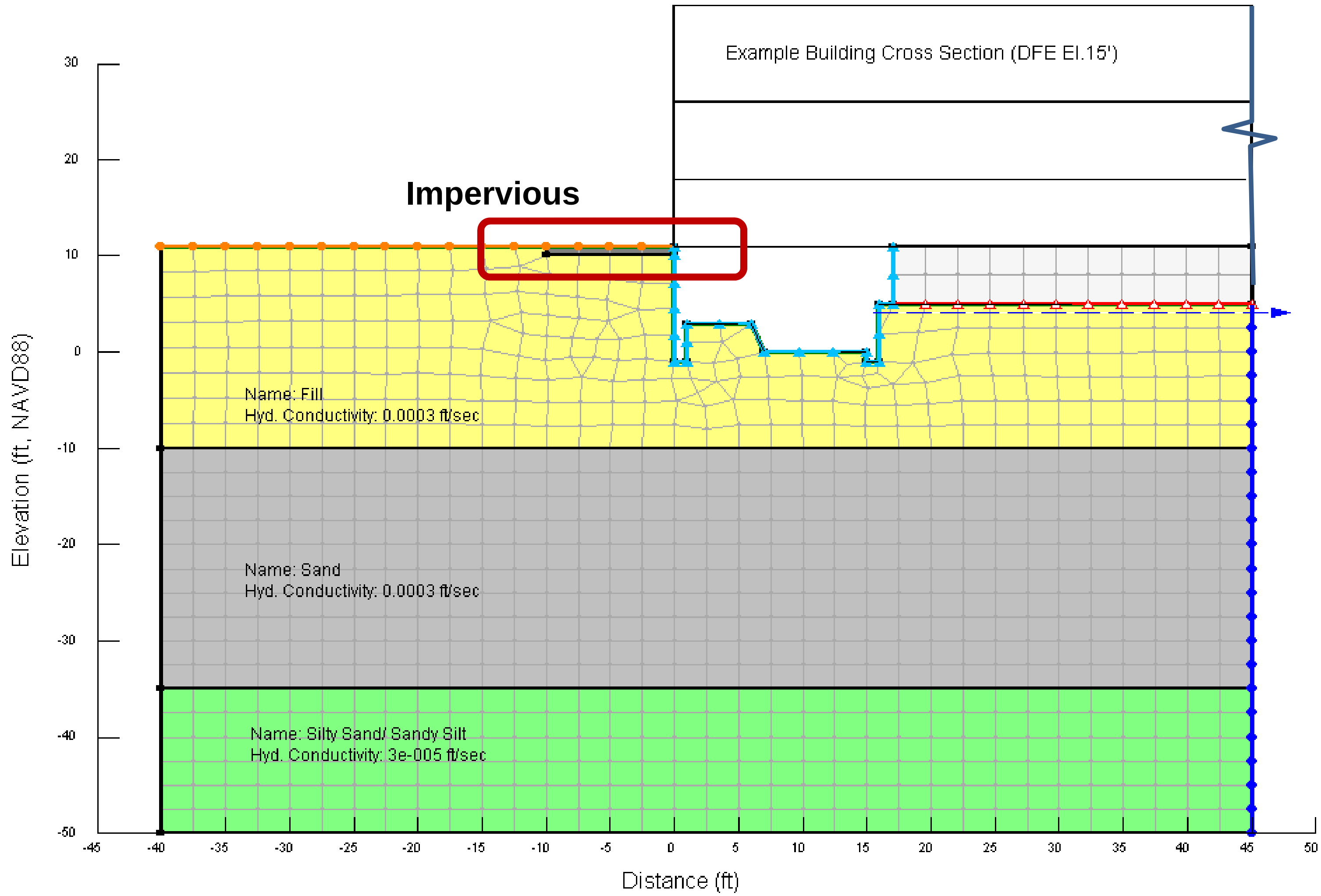
Transient Stage @ Hour 7



IMPROVEMENT #1

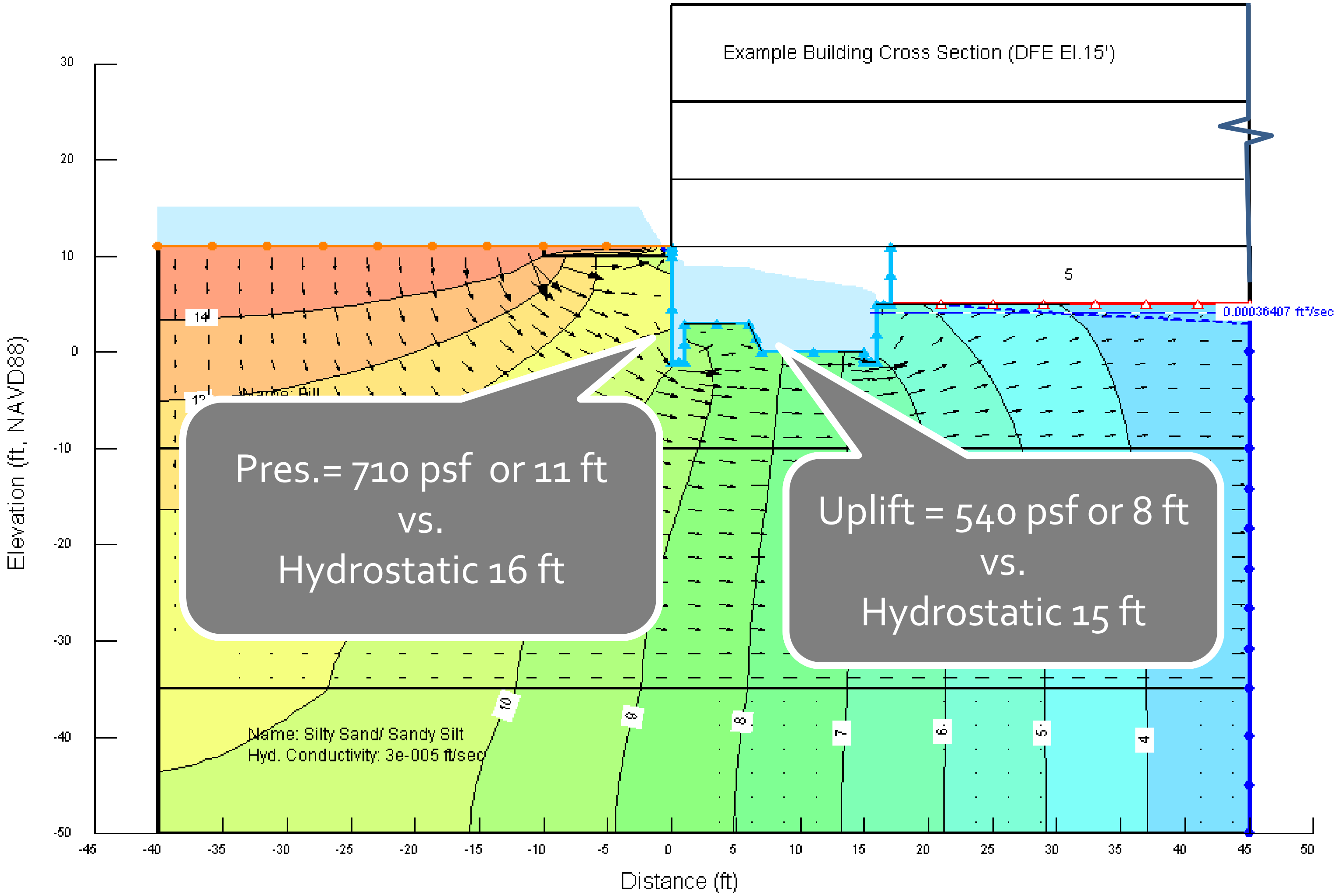
GEOTECHNICAL ENVIRONMENTAL ECOLOGICAL WATER CONSTRUCTION MANAGEMENT

Finite Element Model – 10-ft Impervious Cover



IMPROVEMENT #1

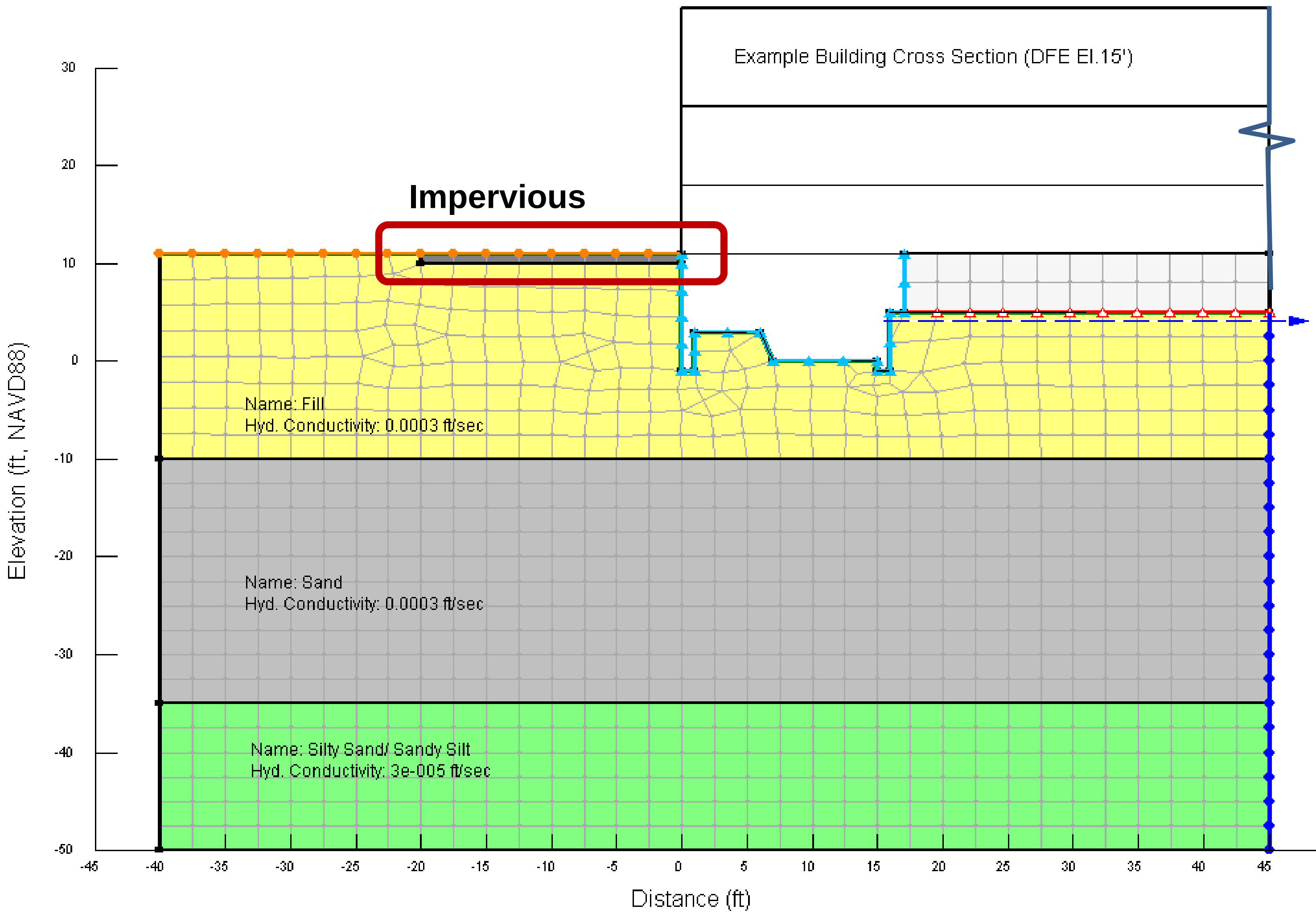
Transient Stage @ Hour 7



IMPROVEMENT #2

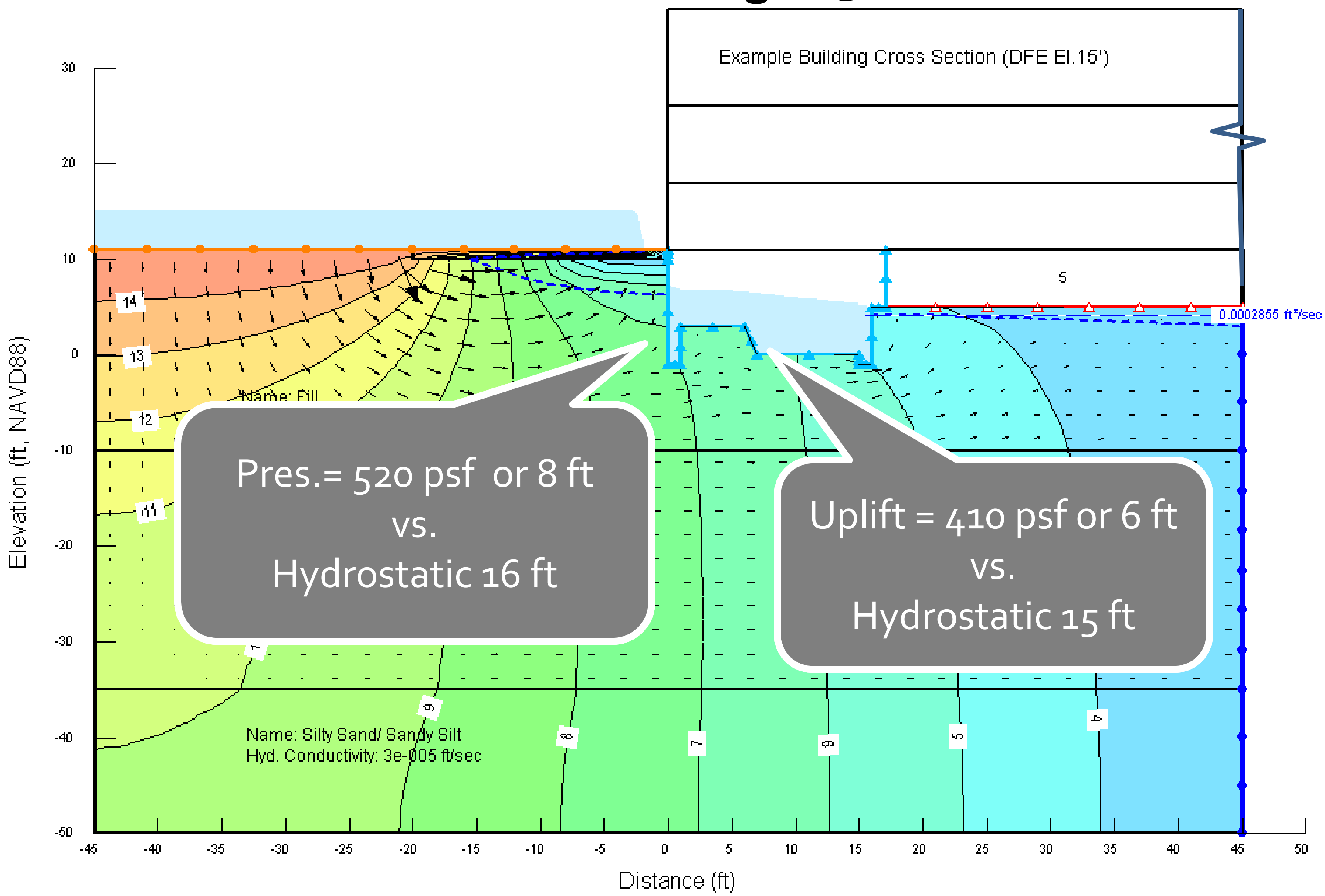
GEOTECHNICAL ENVIRONMENTAL ECOLOGICAL WATER CONSTRUCTION MANAGEMENT

Finite Element Model – 20-ft Impervious Cover



IMPROVEMENT #2

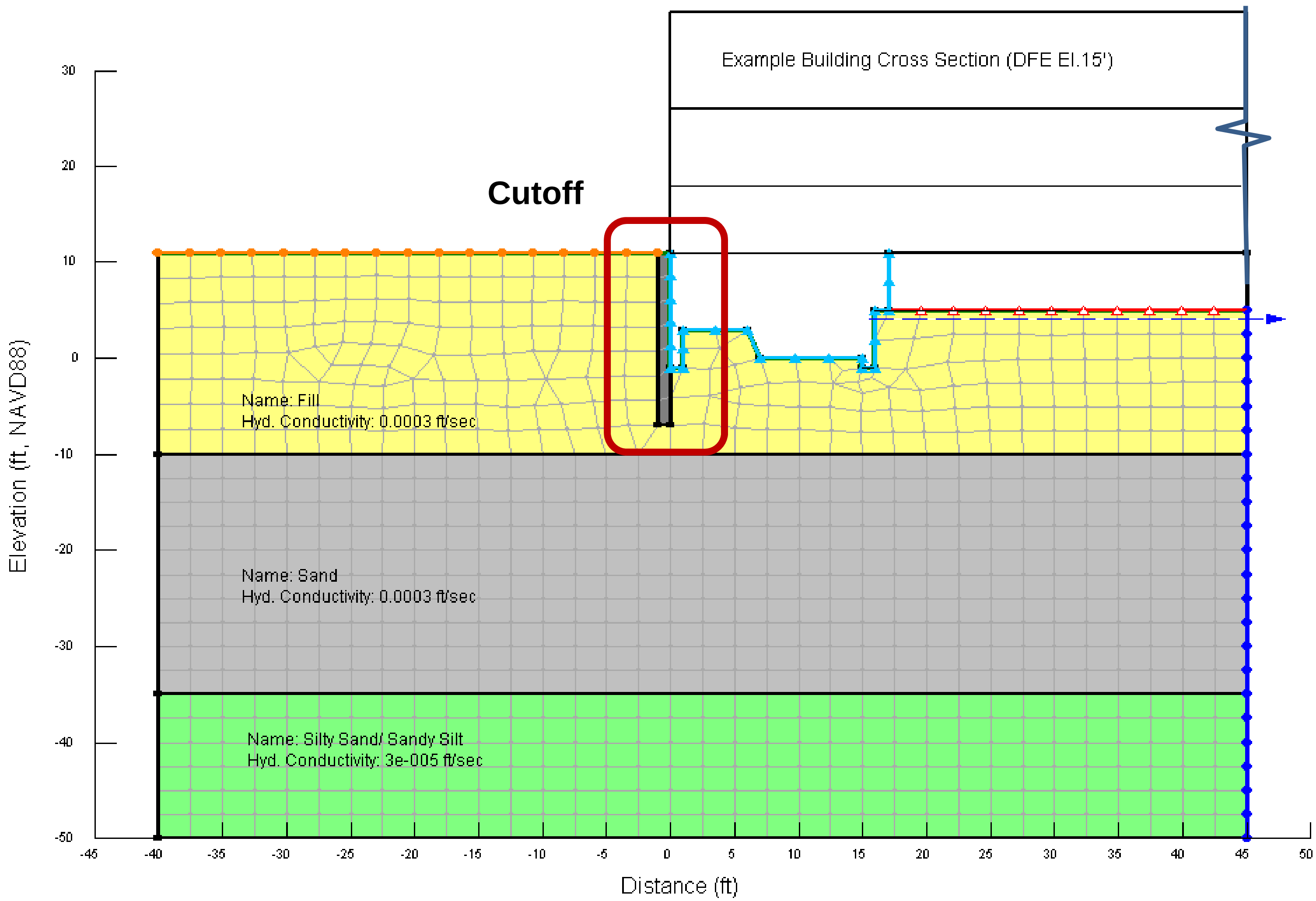
Transient Stage @ Hour 7



IMPROVEMENT #3

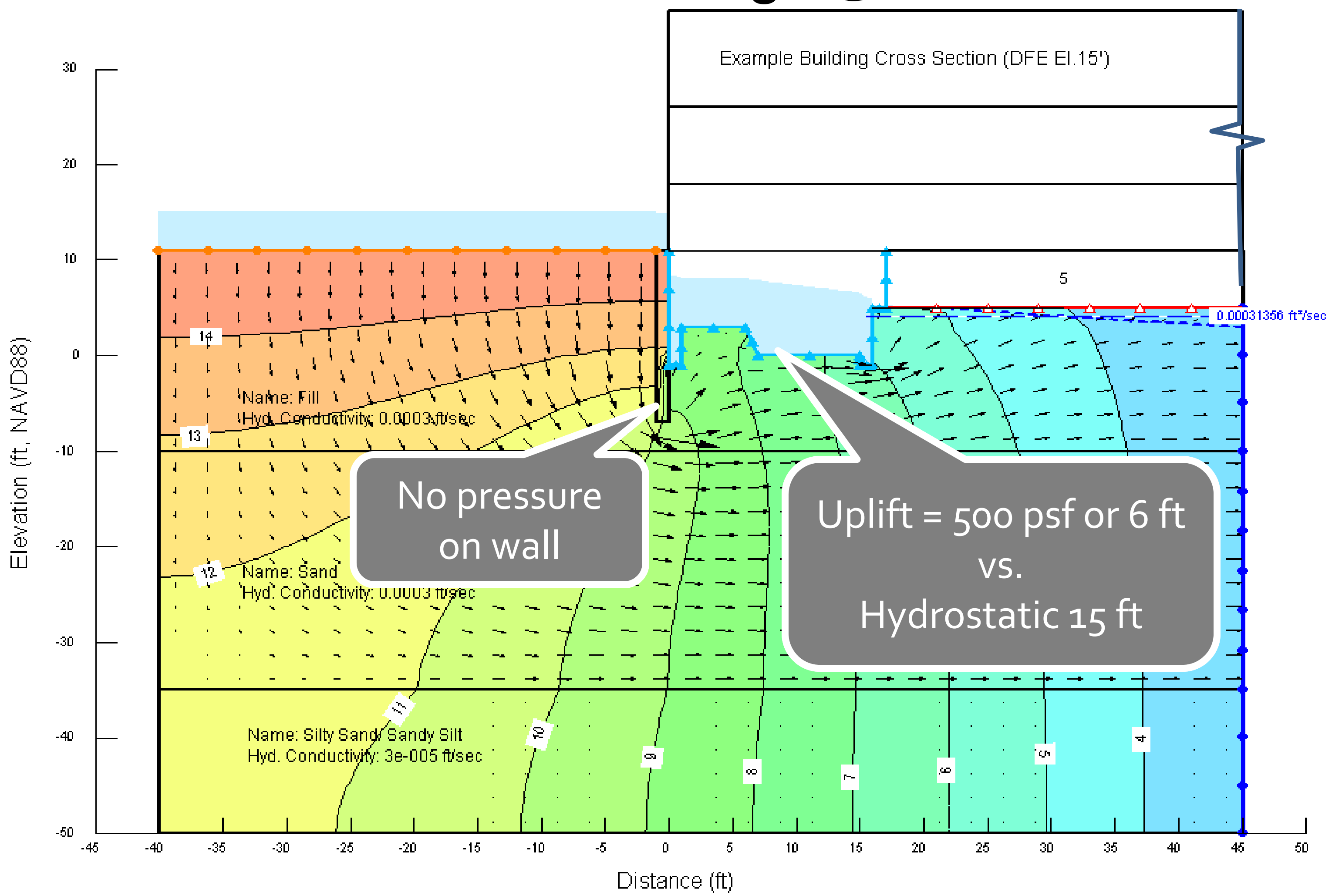
GEOTECHNICAL ENVIRONMENTAL ECOLOGICAL WATER CONSTRUCTION MANAGEMENT

Finite Element Model – 6-ft Cutoff

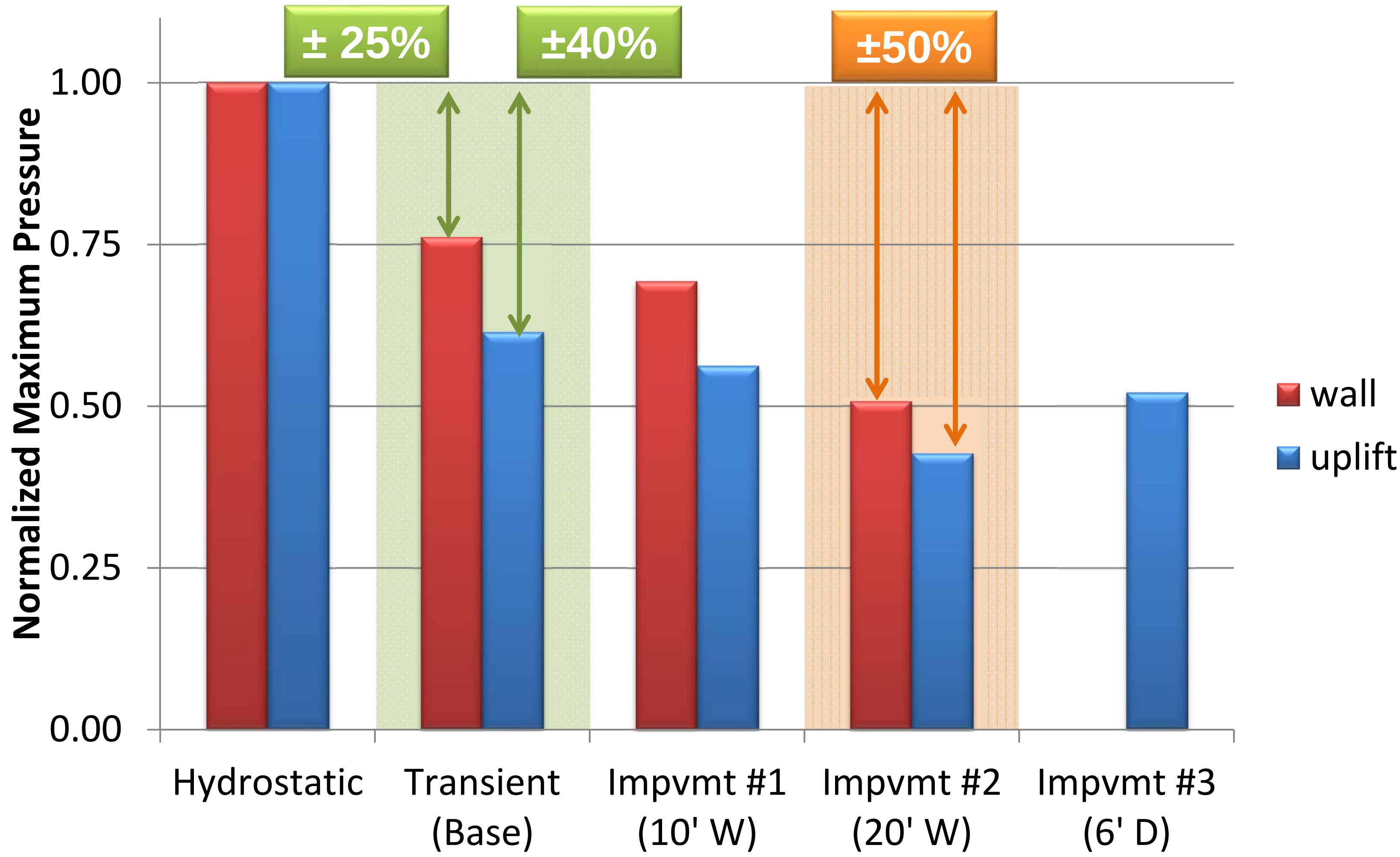


GEOTECHNICAL ENVIRONMENTAL ECOLOGICAL WATER CONSTRUCTION MANAGEMENT

Transient Stage @ Hour 7

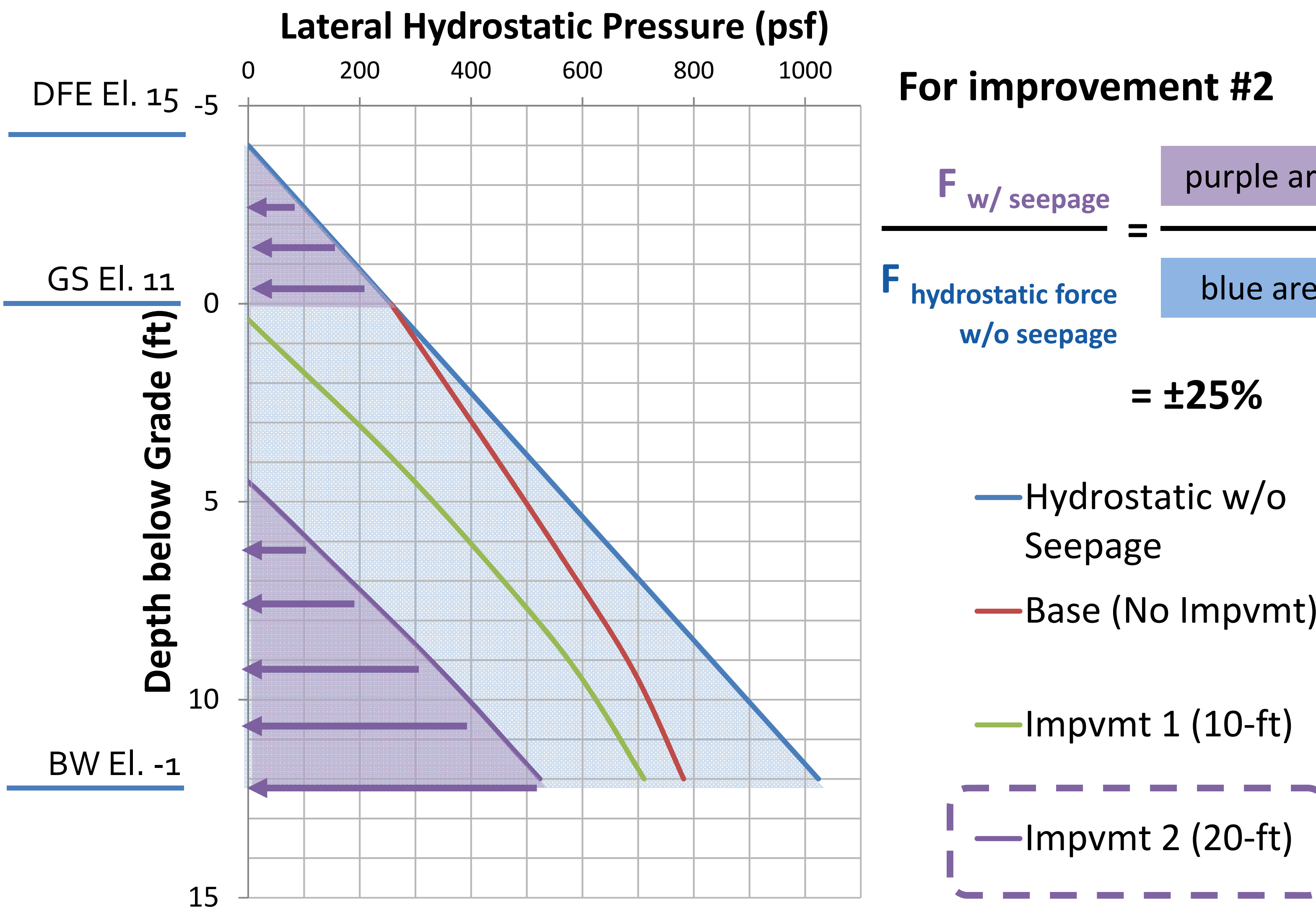


SUMMARY



± 25%
±40%
±50%
Normalized Maximum Pressure
1.00
0.75
0.50
0.25
0.00
Hydrostatic
Transient (Base)
Impvmt #1 (10' W)
Impvmt #2 (20' W)
Impvmt #3 (6' D)
wall
uplift

SUMMARY



For improvement #2

$$\frac{F_{\text{w/ seepage}}}{F_{\text{hydrostatic force w/o seepage}}} = \frac{\text{purple area}}{\text{blue area}}$$

= ±25%

TAKEAWAYS

- **Flooding impacts the below-grade portion of structures;**
- **Transient vs steady state;**
- **Infiltration and flow path;**
- **Site-specific parameters**
- **Effective for resiliency improvement studies**

THANK YOU

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