Integrated Watershed Modeling of the Mystic River: Developing the Right Tools for Climate Change Preparedness

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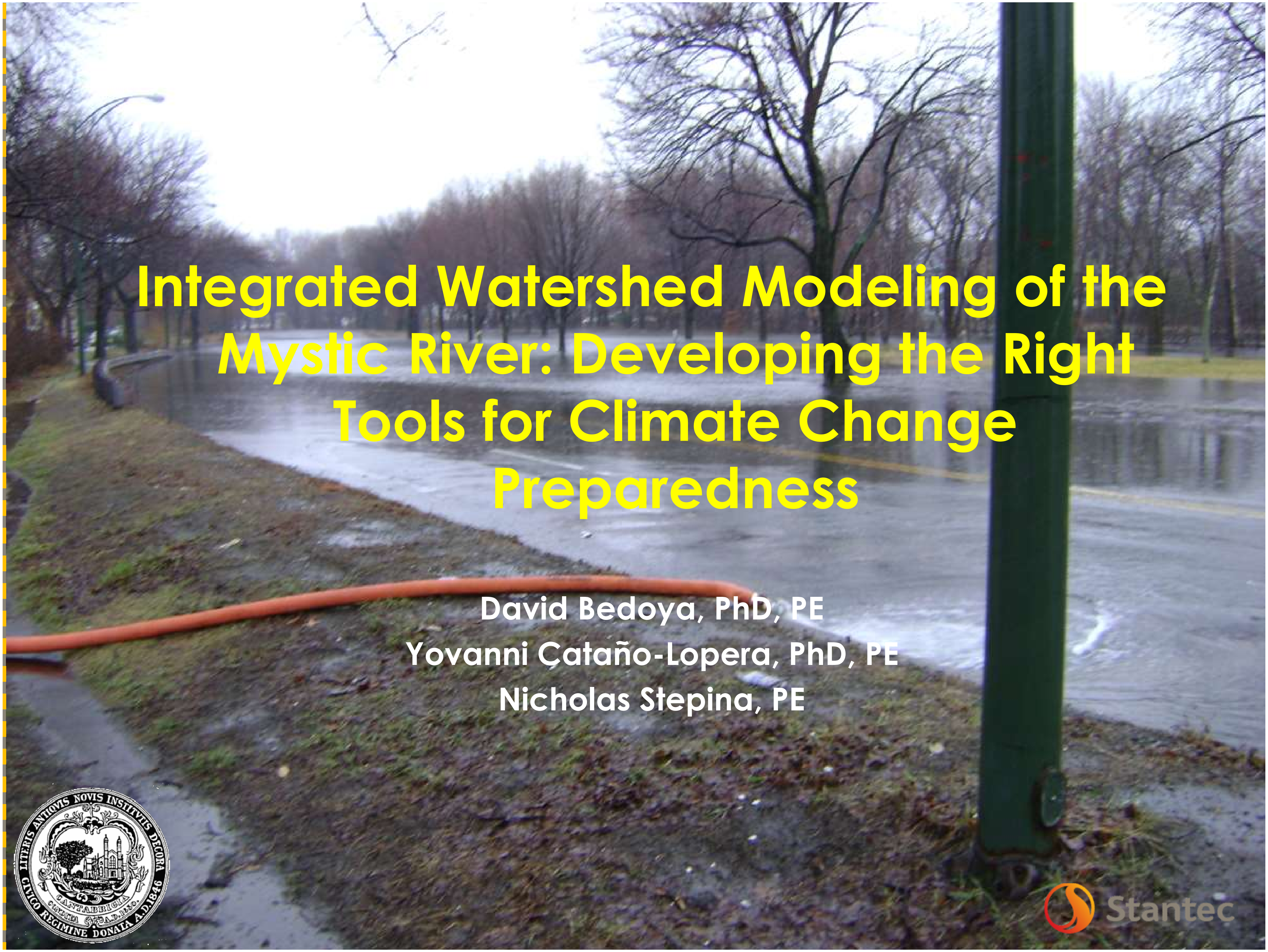

Presentation Overview

1 Cambridge CCVA

2 The Alewife Brook Area

3 Hydraulic Model Integration

4 Hydraulic Model Calibration and Validation

5 Potential Future Uses

6 Conclusions

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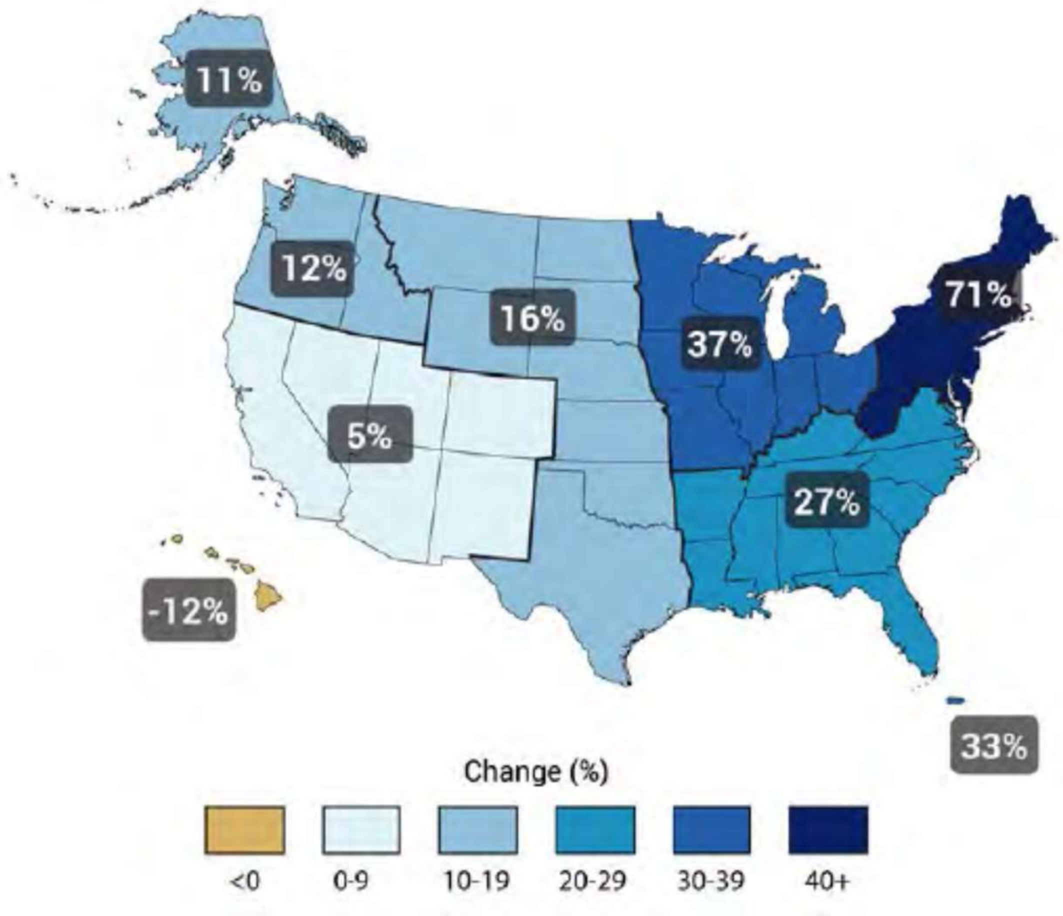
1 Cambridge CCVA, Part 1



Source: 2014 U.S. National Climate Assessment Report

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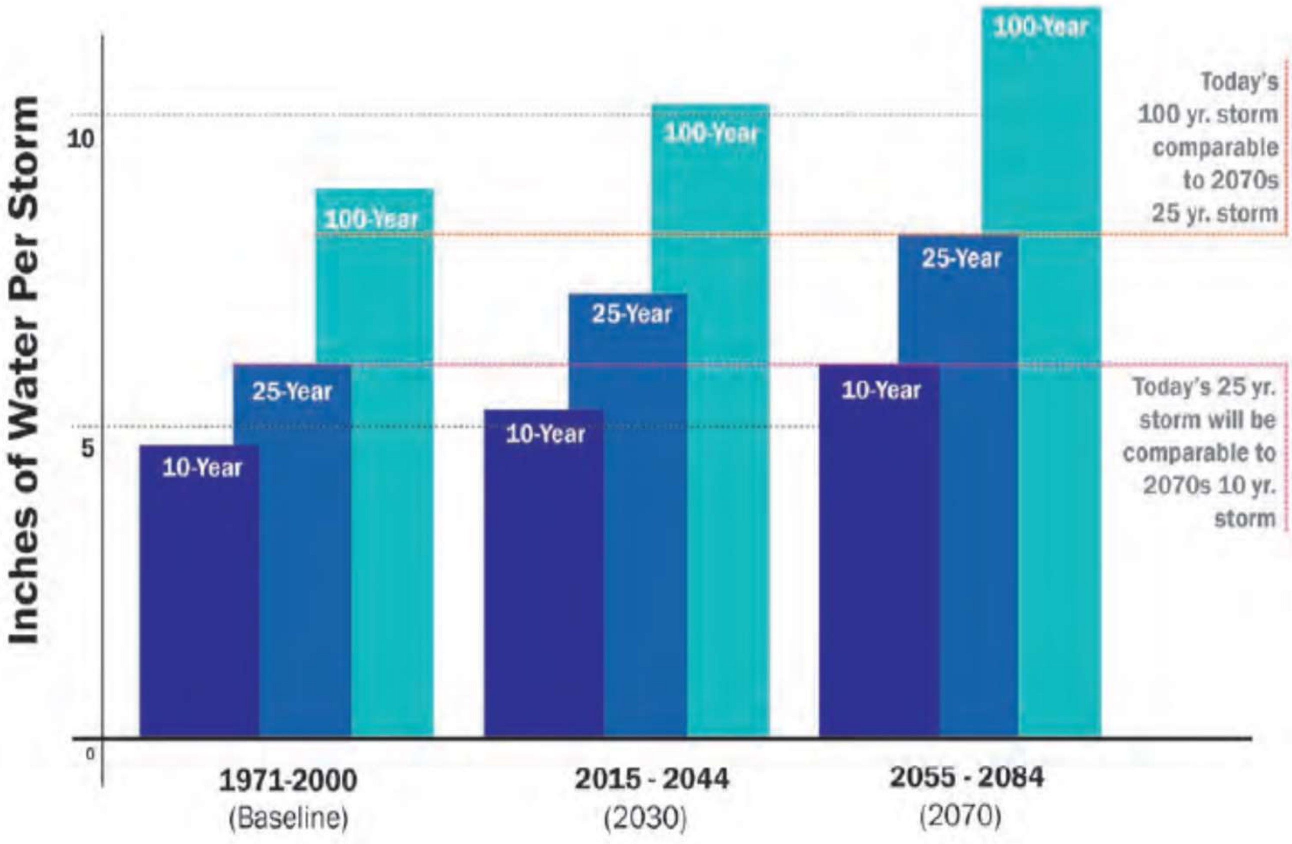
Cambridge CCVA, Part 1

Increase in Precipitation



Source: 2015 Cambridge CCVA, Part 1

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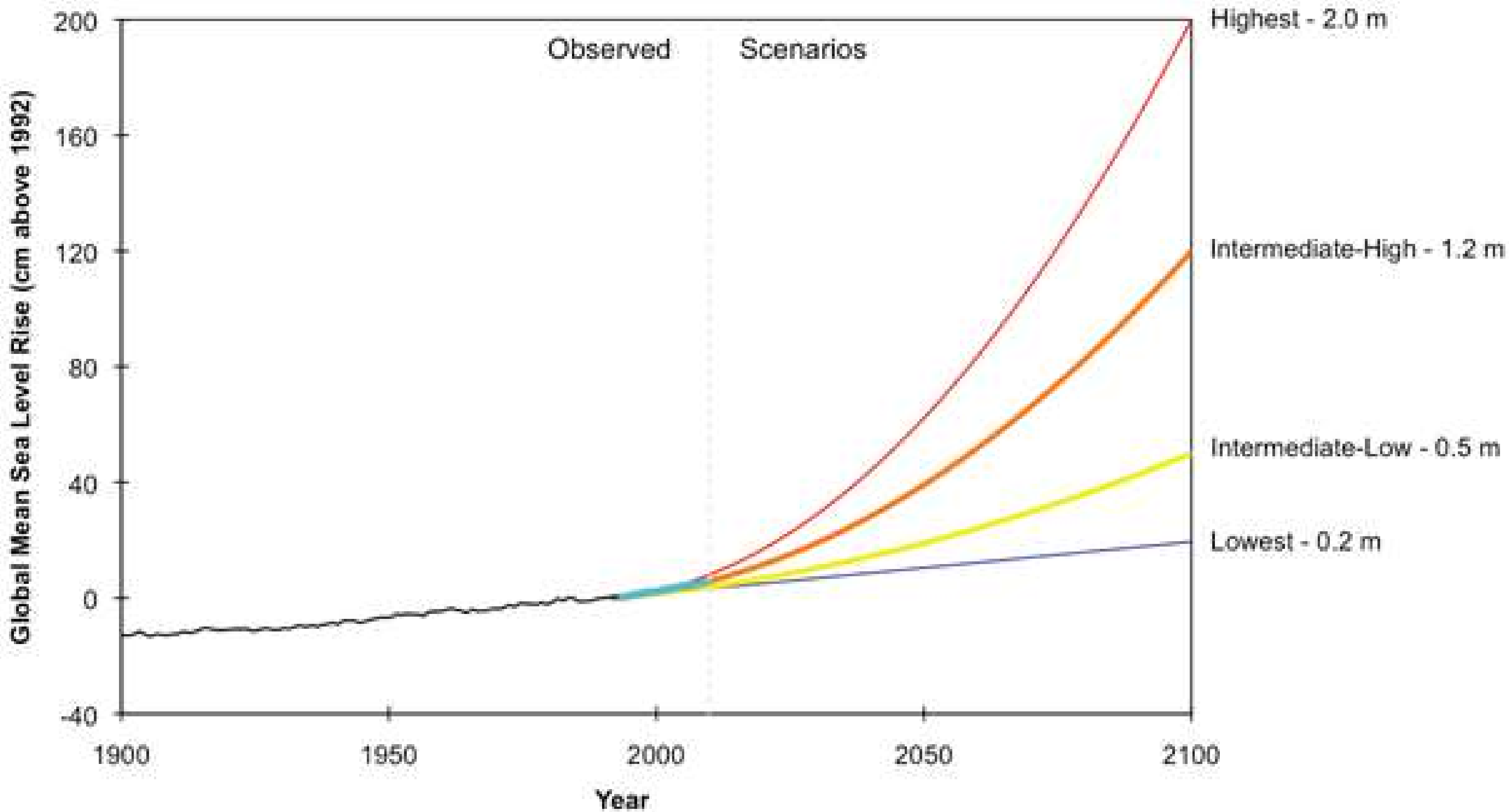
Cambridge CCVA, Part 1

SLR/SS



Source: NOAA (2012). Global Sea Level Rise Scenarios for the United States National Climate Assessment

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Flood Modeling in the CCVA

Riverine Overbank Flooding from Precipitation

- Captured using HEC-RAS model

Sewer System Flooding from Precipitation or River Backups

- Captured Using City's Infoworks ICM Model

Riverine Overbank Flooding from SLR/SS events

- Captured using ADCIRC in the BH-FRM

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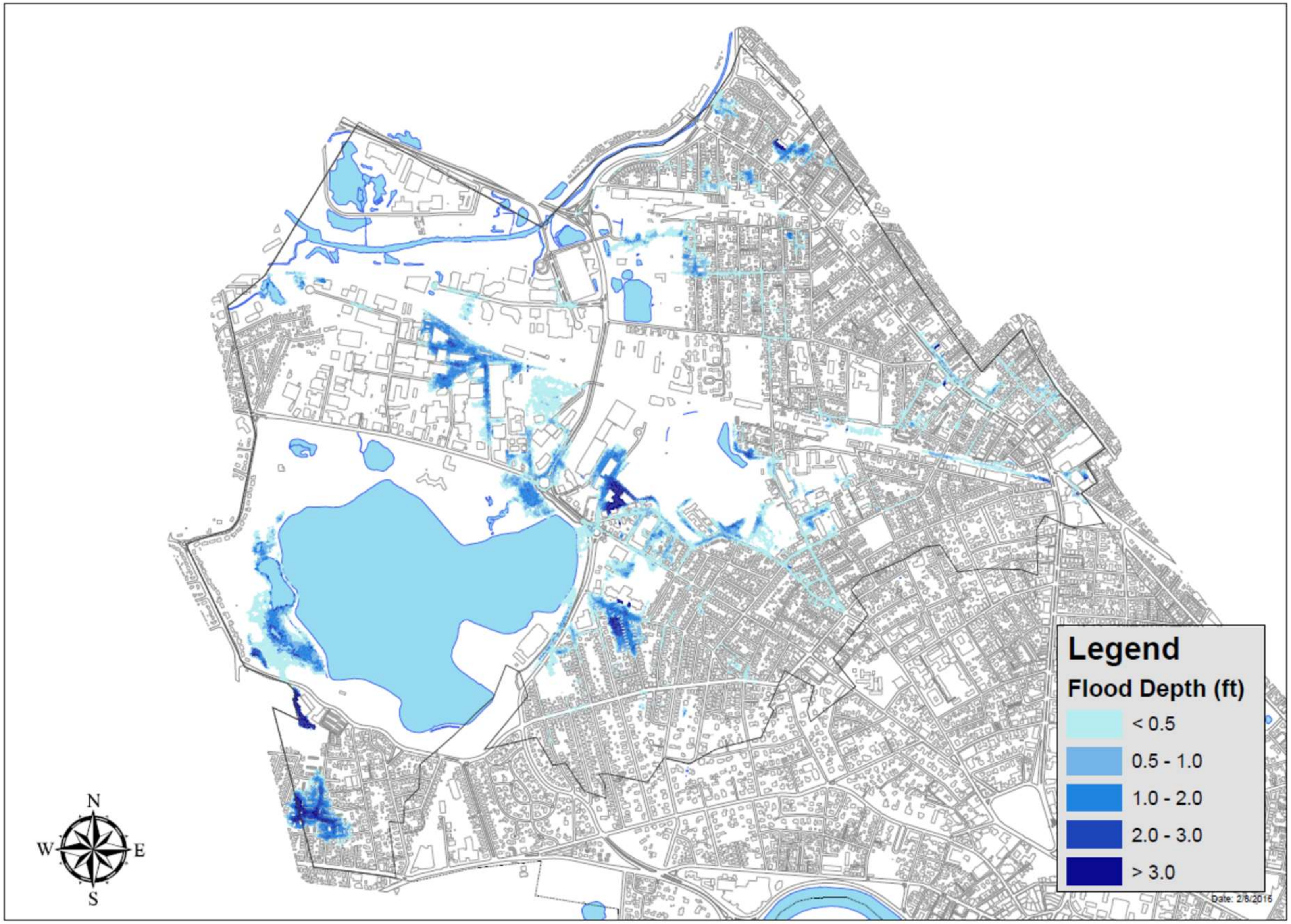
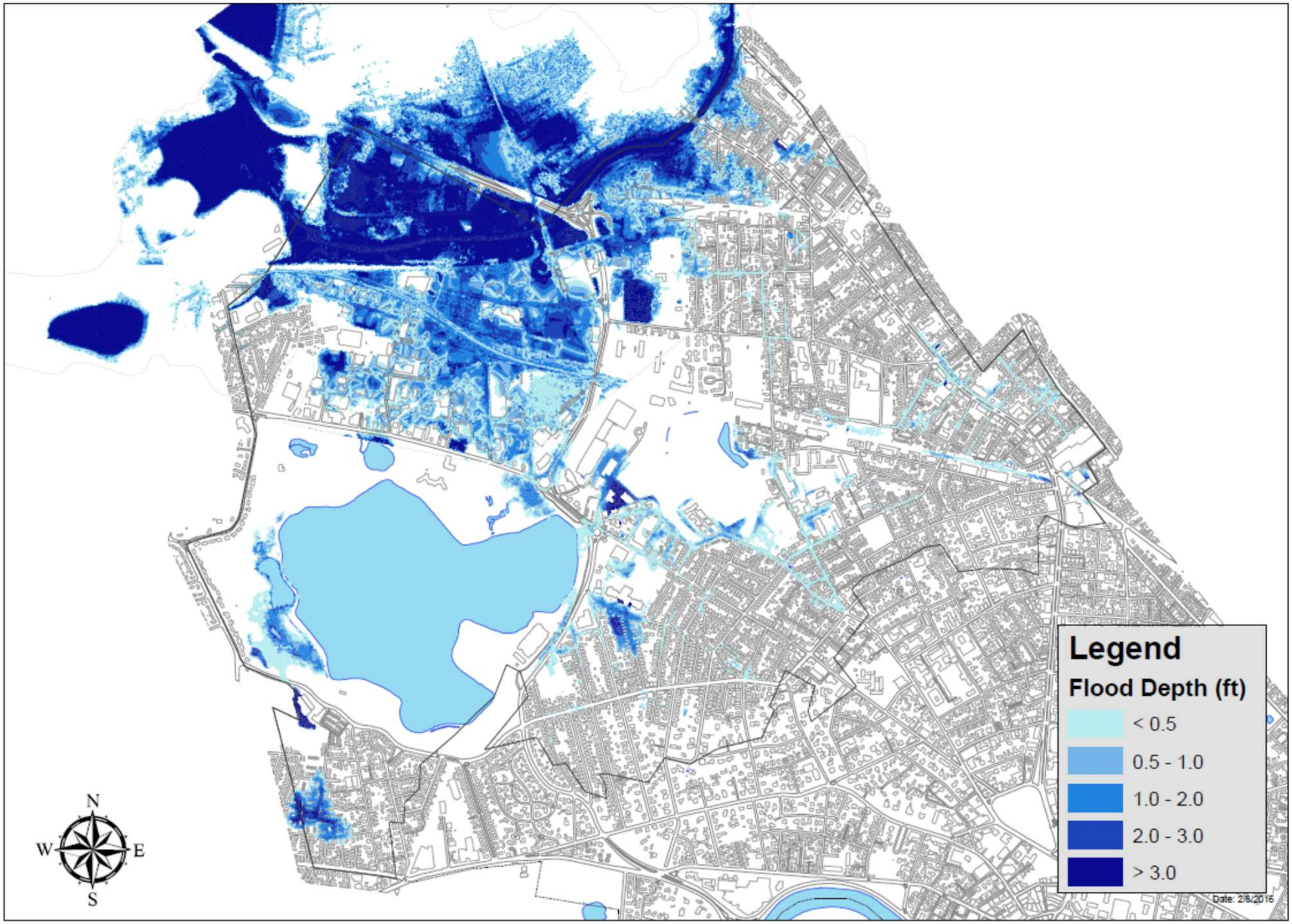
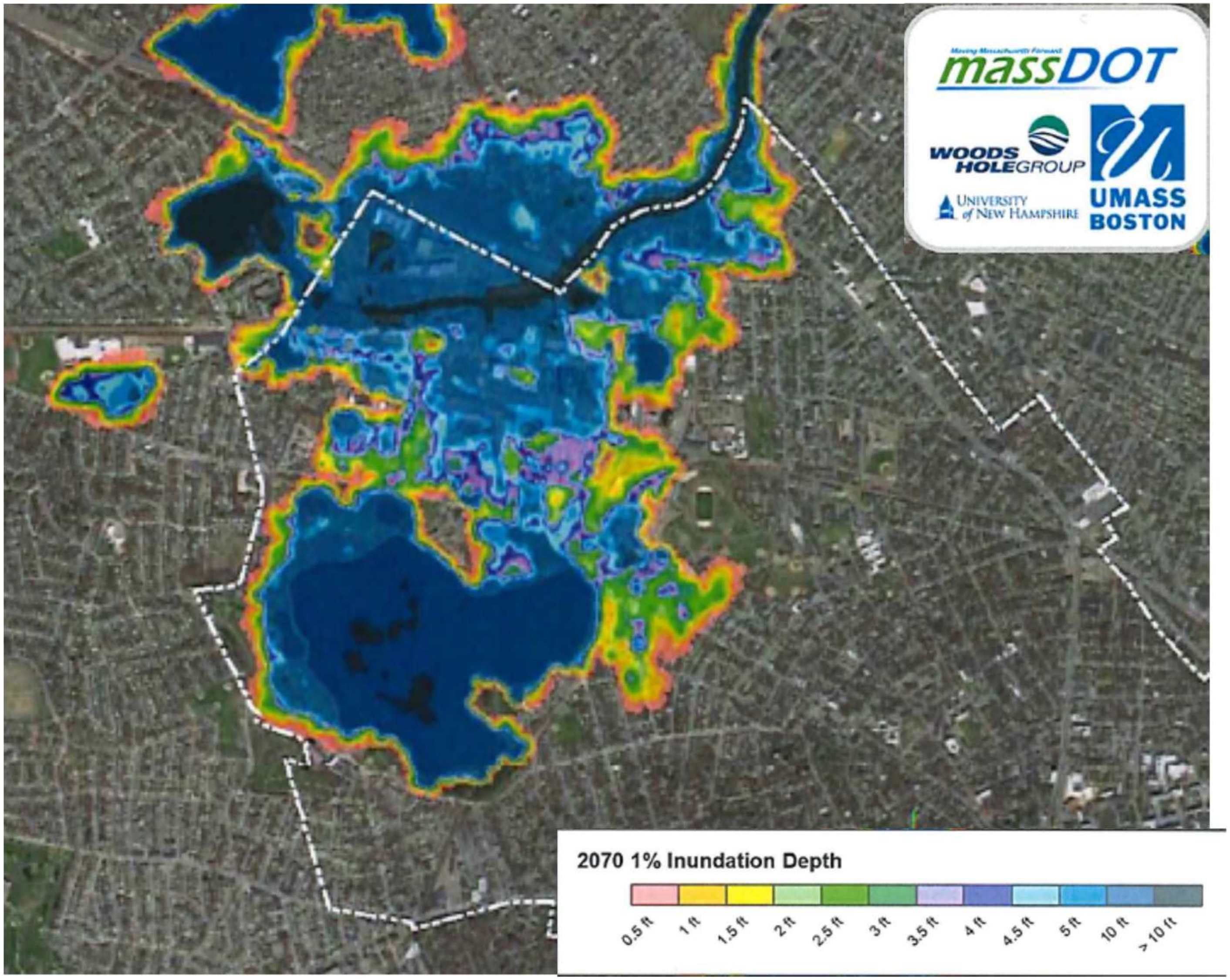
Sewer System Flooding from Precipitation



Riverine and Sewer System Flooding from Precipitation



Riverine Flooding from SLR/SS



CCVA Part 1, Conclusions

Charles River

- Riverine overbank flooding risk is small
- Sewer system flooding is greatly exacerbated
- SLR/SS flooding risk is small and flow pathways are localized

Alewife Brook

- Riverine overbank flooding is significantly increased
- Sewer system flooding is increased
- SLR/SS flood risk and severity are greatly increased by the end of the century

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2 The Alewife Brook Area

- This region of Cambridge is the most vulnerable to flooding under climate change
- Flooding risk is augmented by increased precipitation up to mid-century as well as SLR/SS at the end of the century
- The Alewife area will be impacted by both riverine and sewer system flooding

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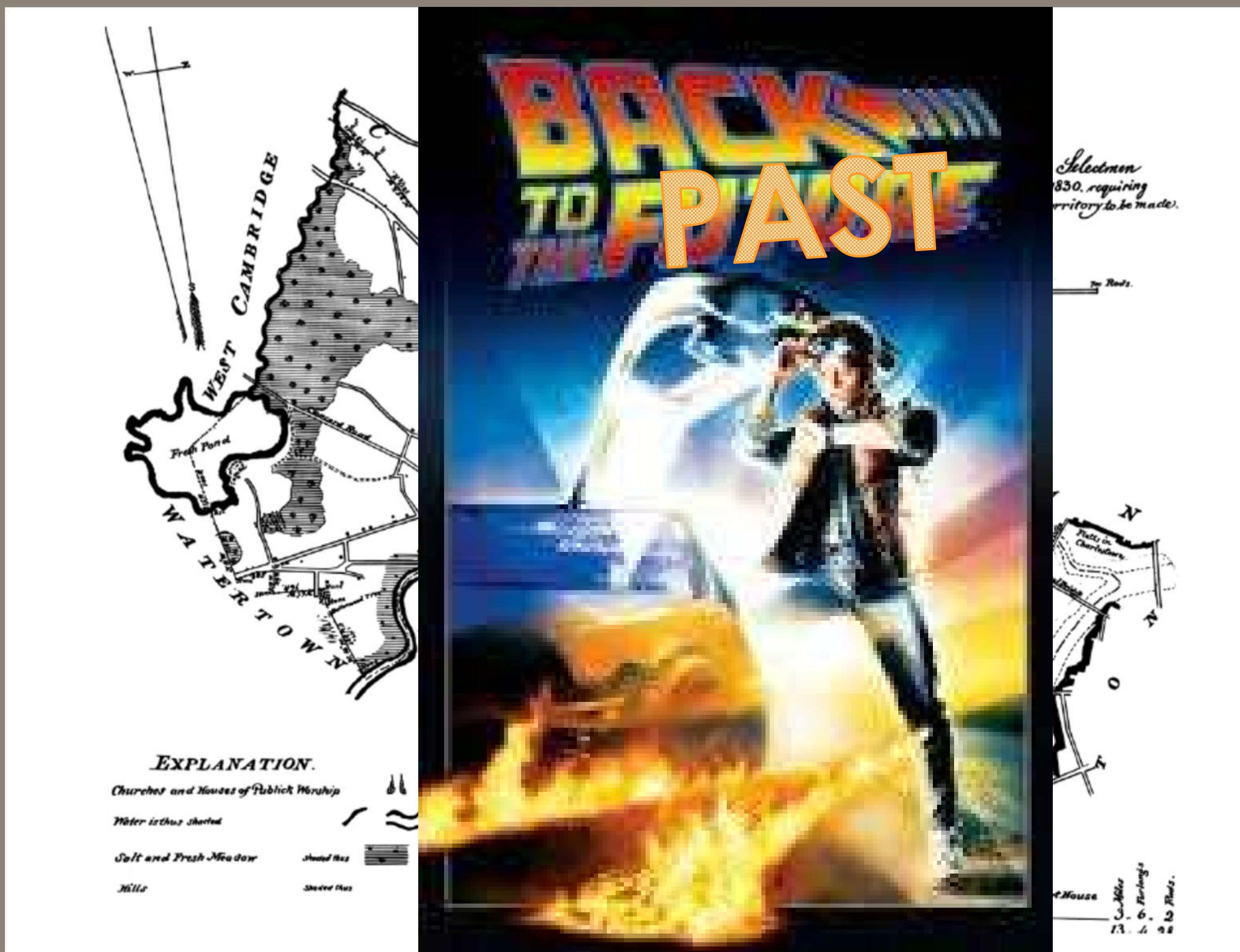
2. The Alewife Brook area in the Future –Title of the Movie?



Source: John Sullivan, Cambridge Historical Commission

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Challenges of a non-integrated approach

- Different flooding types occur at different times
- Flooding is generated by factors of different scale (local or system level for sewer flooding) versus watershed or regional for riverine flooding
- High degree of inter-dependence between systems
- Running scenarios and combinations of scenarios becomes cost and time prohibitive (it's also the worst nightmare for a hydraulic modeler-high chances of error)

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3 Hydraulic Modeling Integration

- River Models don’t include pipe systems
- Sewer models don’t include river systems
- Coastal models don’t include pipe systems or hydrology

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Mystic River Watershed Model Integration

- Watershed scale riverine geometry and hydrologic catchments directly imported from FEMA model used for FIS
- Pipe model was obtained from Cambridge and MWRA regional sewer model
- Both models were integrated seamlessly
- The Cambridge floodplain was generated with a high resolution 2D grid, which includes flow path obstacles
- Operation of the AED was assumed different than FEMA based on communications and calibration

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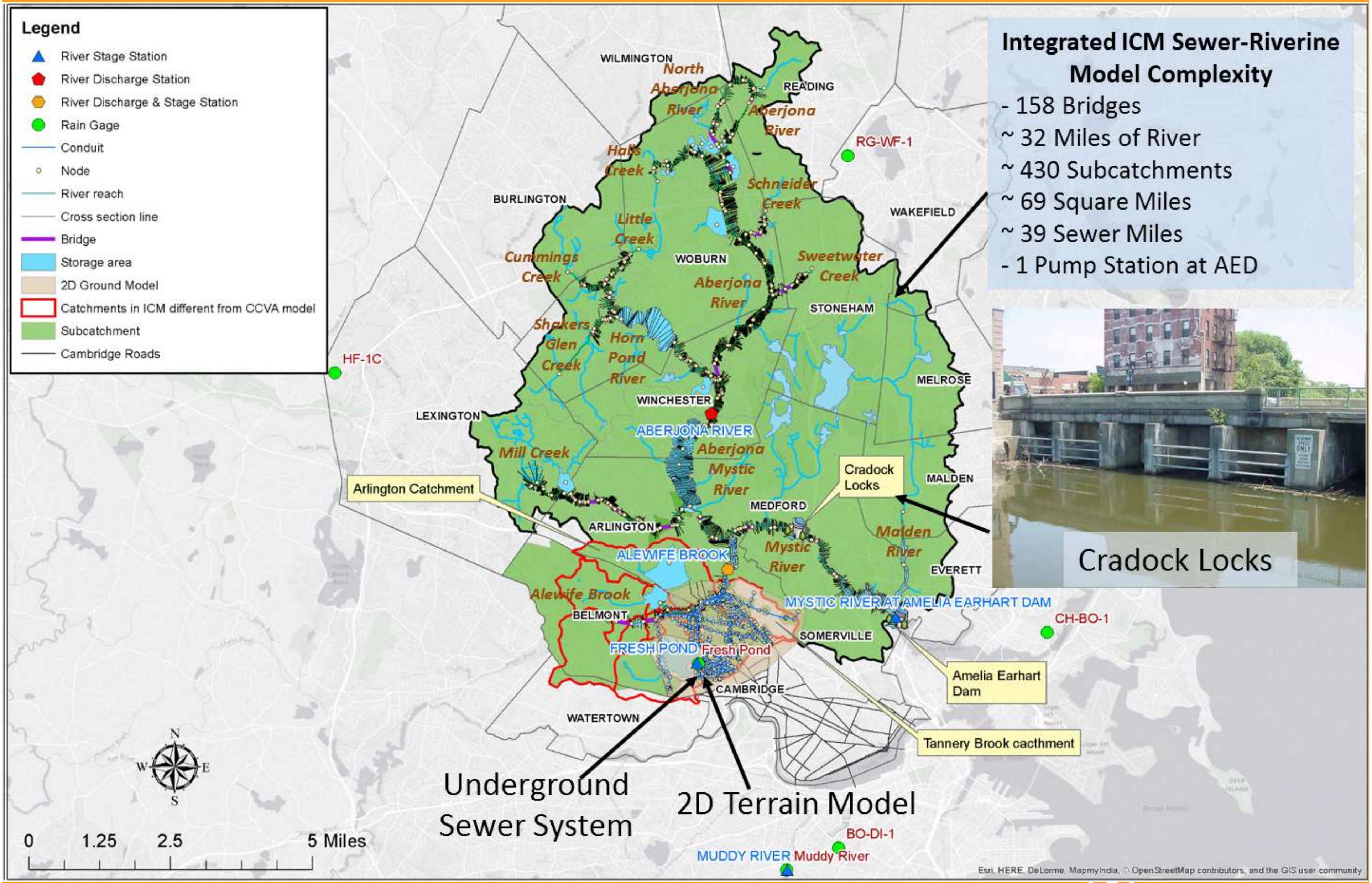
Mystic River Watershed Model Integration

Integrated ICM Sewer-Riverine Model Complexity

- 158 Bridges
~ 32 Miles of River
~ 430 Subcatchments
~ 69 Square Miles
~ 39 Sewer Miles
- 1 Pump Station at AED



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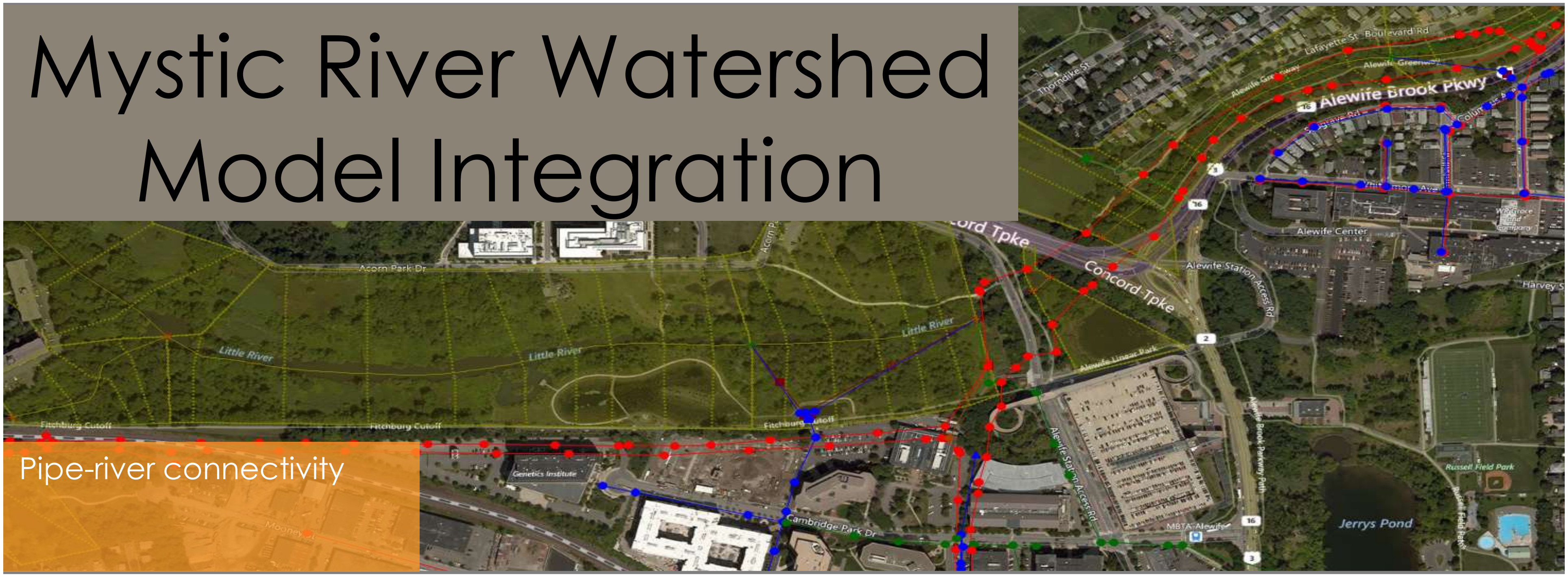
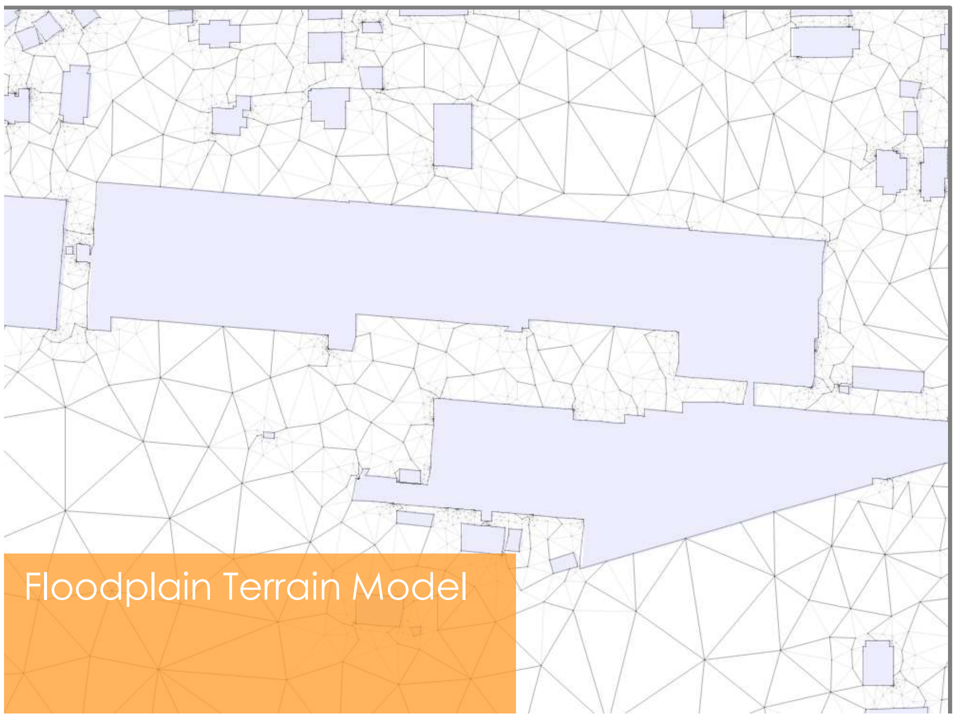
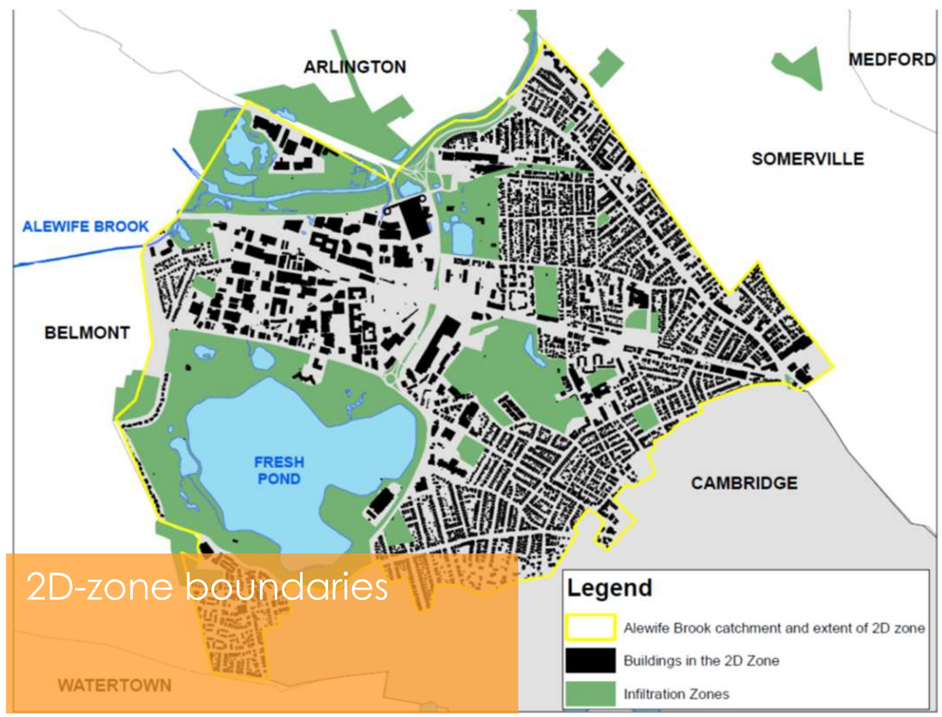
Mystic River Watershed Model Integration



Pipe-river connectivity



Floodplain Terrain Model



2D-zone boundaries

4 Hydraulic Model Calibration and Validation

Photos courtesy of Cambridge DPW

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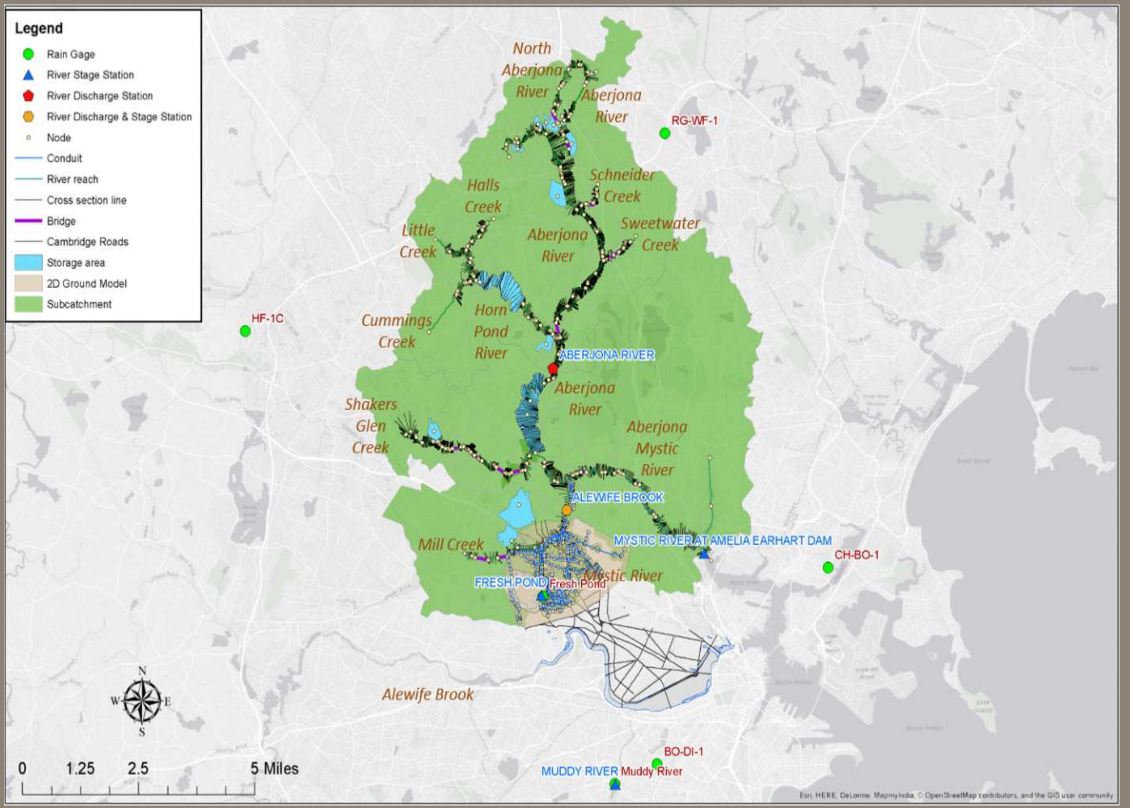
4 Hydraulic Model Calibration and Validation- Selected Storms

	March 2010	May 2006
Start Date/Time	13/8:00	12/17:30
End Date/Time	15/21:00	16/18:30
Total Rainfall (in)	9.59*	7.42*
Peak Intensity (in/hour)	1.32	0.60
Return Period**	>50-yr	~>20-yr

*At Muddy River in Brookline RG

**Based on NOAA Atlas 14 Estimates at Logan Airport



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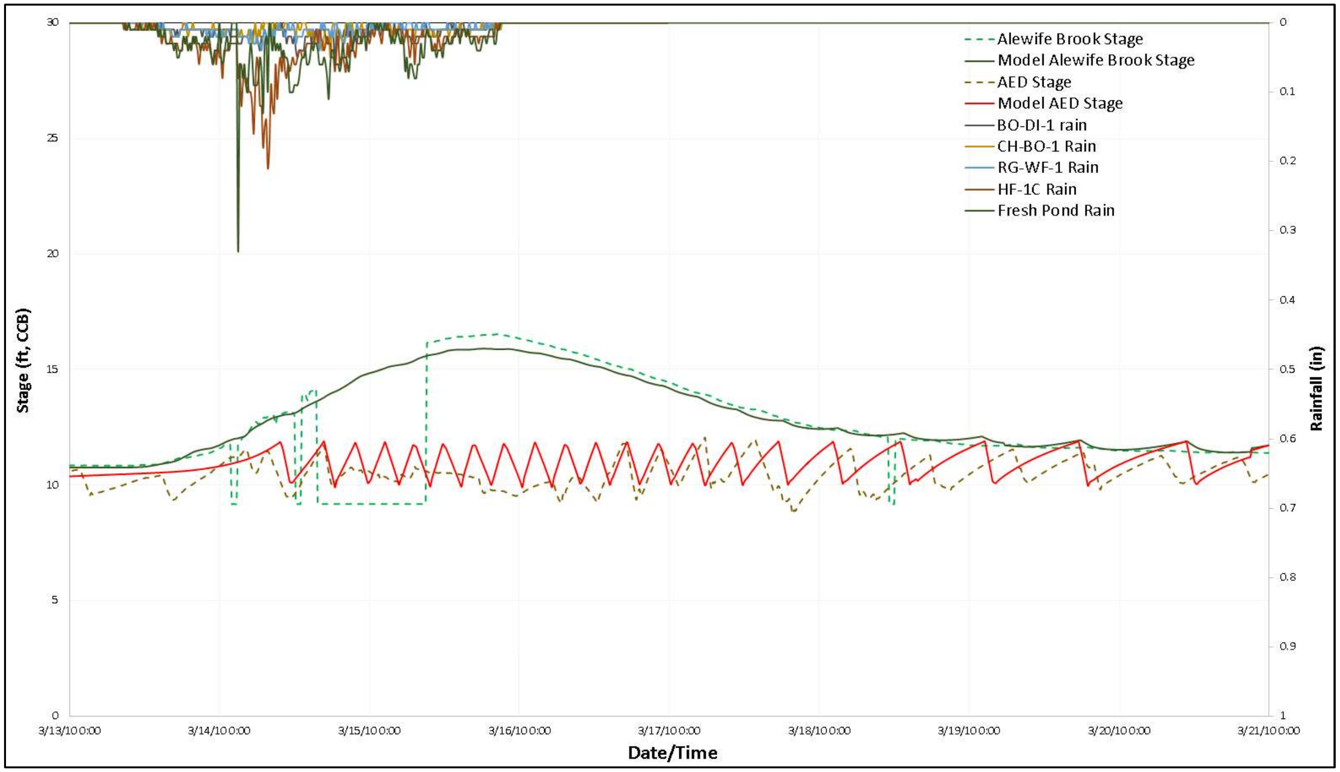
4 Hydraulic Model Calibration -March 2010 River Gages

USGS Station		Model	Meter	Difference (ft)
Alewife Brook	Peak Stage (ft)	15.94	16.52	-0.58
Amelia Earhart Dam	Peak Stage (ft)	11.90	12.05	-0.15



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4 Hydraulic Model Calibration -March 2010 River Gages

Comparison between metered and modeled flows for the March 2010 storm event.

USGS Station		Meter	Model	% Difference
Aberjona River	**Peak Flow (MGD)**	937.16	935.96	-0.1
	Volume (MG)	2957.42	2341.03	-20.8
Alewife Brook	**Peak Flow (MGD)**	142.72	141.58	-0.8
	Volume (MG)	510.54	532.14	4.2

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4 Hydraulic Model Calibration -March 2010 Photographic Evidence

Photographs Courtesy of Cambridge DPW

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4 Hydraulic Model Calibration -March 2010 Photographic Evidence

Photographs Courtesy of Cambridge DPW

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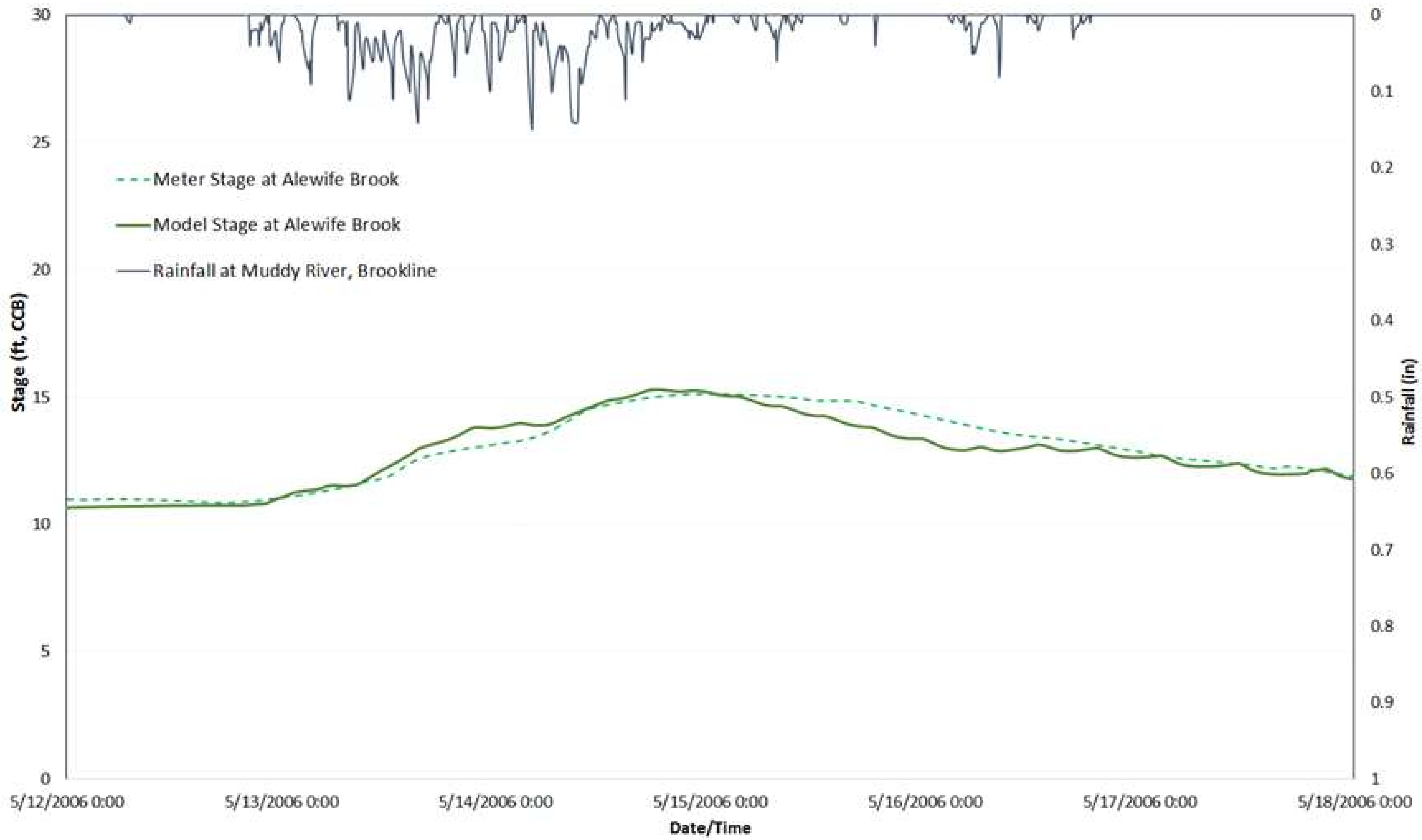
4 Hydraulic Model Validation -Mary 2006



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5 Previous Model Calibration

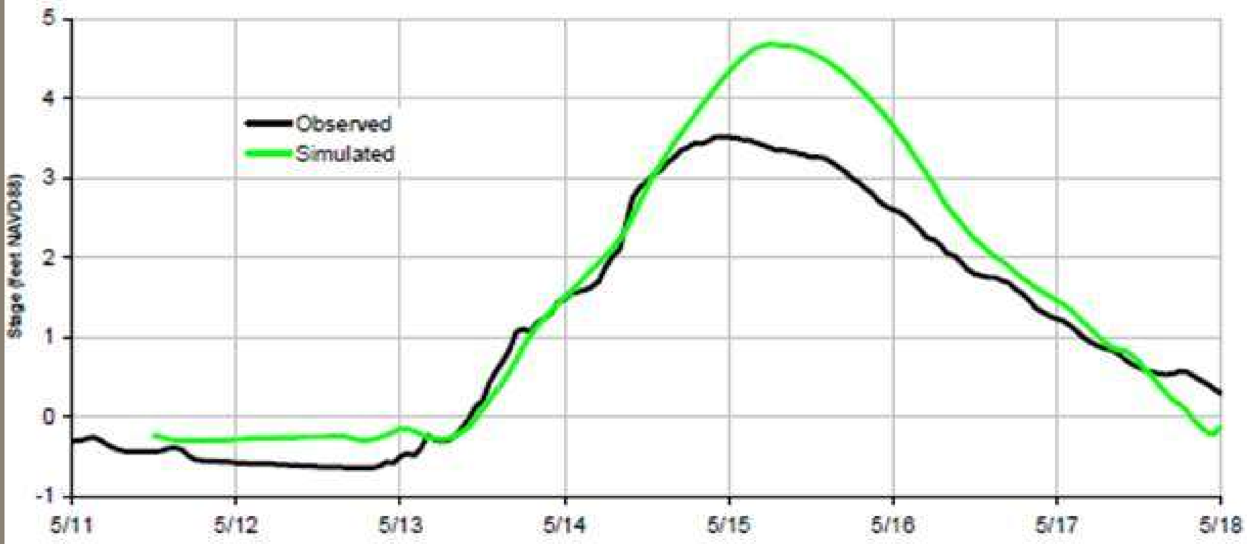

Figure 4: Observed and Simulated Stage for May 2006 Event – Alewife Brook

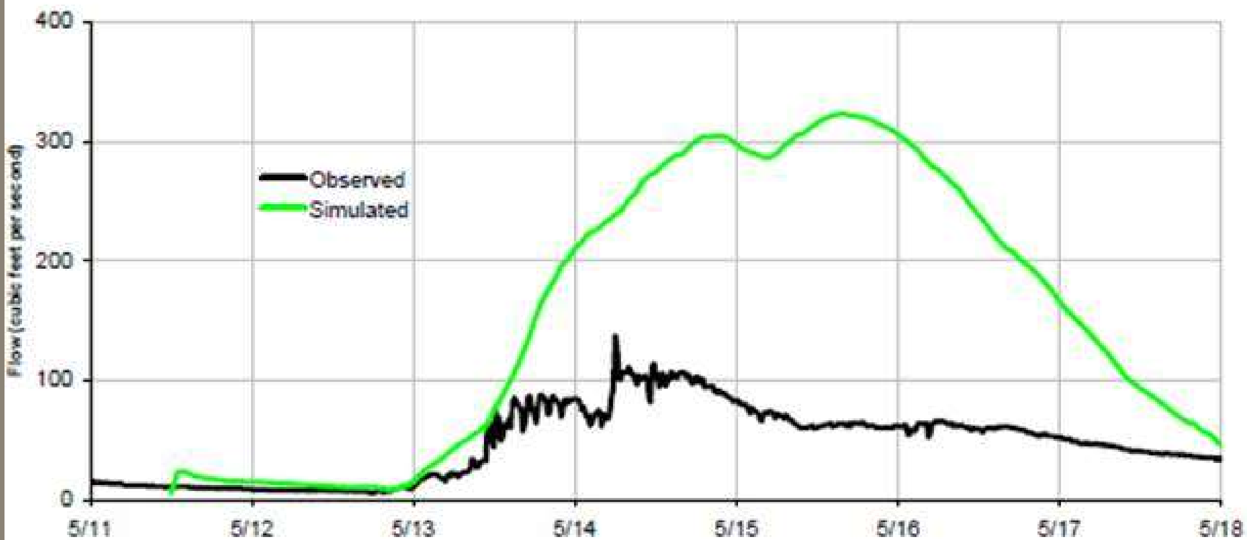

Figure 5: Observed and Simulated Discharge for May 2006 Event – Alewife Brook

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5 Potential Future Uses

- Forecast flood extents during future precipitation-driven scenarios
- Potential to propagate flooding from SLR/SS events
- Potential to asses combinations of precipitation and SLR/SS seamlessly
- Allow for evaluation of mitigation measures at multiple scales alone and in combination

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5 List of Potential Local Measures

	Measure	Sewer System Flooding	River Overbank Flooding from Precipitation	River Overbank Flooding from SLR/SSS
Source Controls	Land Use changes	👍	👎	👎
	Peak flow retention	👍	👎	👎
Pathway Controls	Flow Storage	👍	👎	👎
	Flow Transfer	👍	👎	👎
	Conveyance Capacity Increase	👍	👎	👎
Receptor Controls	System isolation via berms, walls	👍	👍	👍

5 List of Potential Watershed Measures

Measure	Sewer System Flooding	River Overbank Flooding from Precipitation	River Overbank Flooding from SLR/SSS
Smart Reservoir Management	👎	👍	👍
Large Scale Land Use Changes	👍	👍	👍
Removal of Hydraulic Bottlenecks	👎	👍	👍
Increase in pumping and sluicing output	👎	👍	👍

5 List of Potential Regional Measures

Measure	Sewer System Flooding	River Overbank Flooding from Precipitation	River Overbank Flooding from SLR/SSS
Topographic changes in flanking paths	👎	👎	👍
Revamp of the AED (raising top of the dam)	👎	👎	👍
Flow isolation and real-time flow management	👎	👍	👍
Other large scale projects	👎	Unknown	Unknown

Conclusions

- The model has been successfully integrated, calibrated, and validated
- It will be used to update the CCVA, Part 1 and inform the CCVA CCPR
- The watershed integrated can be refined with more information from watershed communities
- It can be used for watershed and regional decision making and to evaluate effectiveness of those decisions

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Thank you!!
Questions?

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