City of Cambridge Climate Change Vulnerability Assessment and Adaptation Plan

April 8, 2013

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City of Cambridge

Today's Agenda

Introduction
John Bolduc

Response to January 22nd EAP meeting [3:00-3:30]
Lisa Dickson

Ranking Methodology [3:30-4:15]
Lisa Dickson

Hydrology Protocol [4:15-4:45]
Indrani Ghosh

Next Steps
Lisa Dickson, John Bolduc

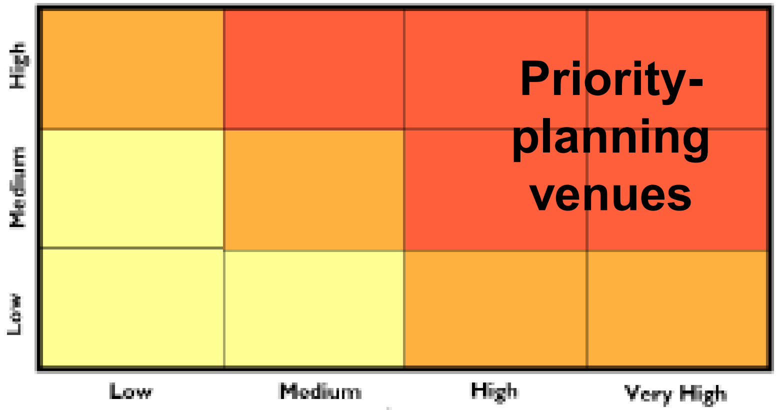
Response to January 22nd EAP meeting

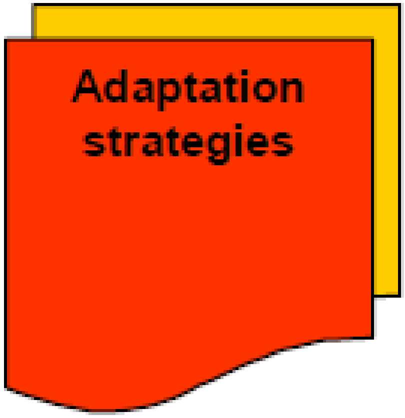
Key Themes and Recommended Response/Approach

1. **Overall project approach:** Should study be focused on a vulnerability assessment approach, an adaptation-focused approach or a hybrid?
2. **Climate change projections:** Will downscaling provide valuable information?
3. **Selection of climate change scenarios**
4. **How should more regional aspects be incorporated?**
5. **Final product:** How will this information be analyzed and integrated into a comprehensive assessment?

Ranking Methodology

Vulnerability & Risk Assessment





Step 1 – EAP focus

Climate Projections
Scenario Development

Step 2 – TAC focus

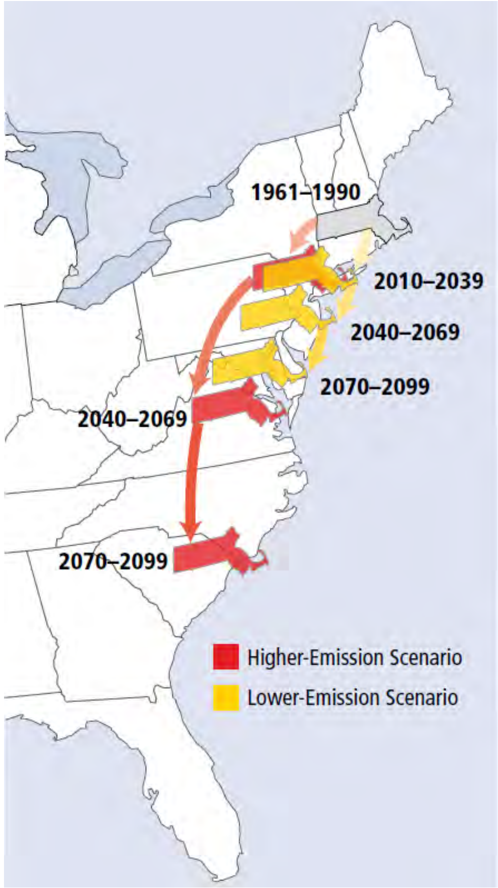
Vulnerability & Risk Assessment

Step 3

Adaptation Planning and Design

Step 1 a: Climate Projections

Temperature



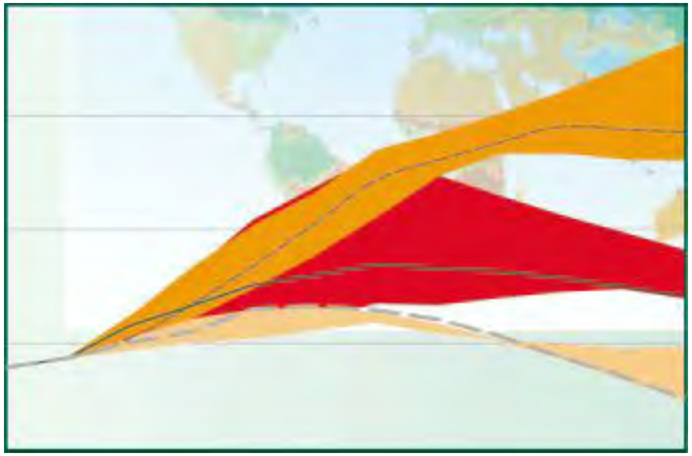
Precipitation

Extreme events

Sea level rise

Step 1b: Scenario Planning

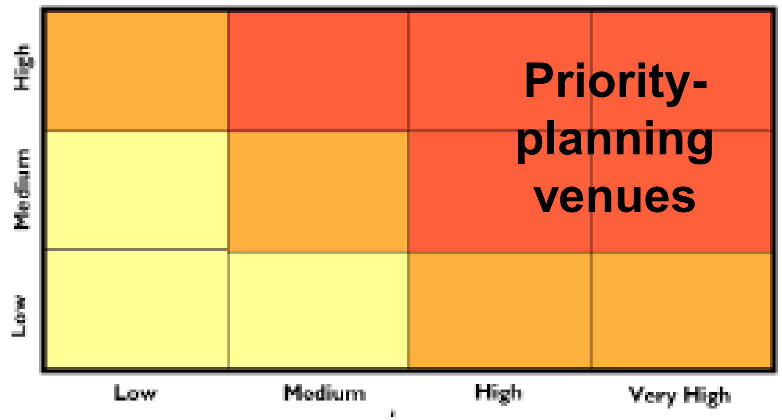
Possible futures

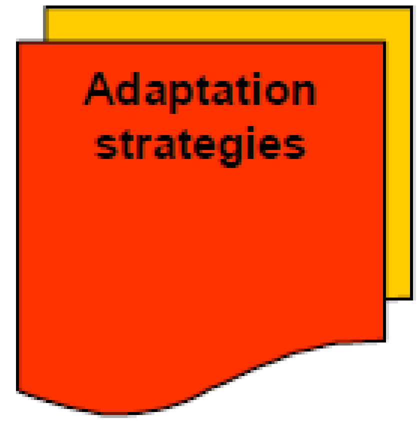


GHG emission scenarios

Climatic parameters

Vulnerability & Risk Assessment





Step 1 – EAP focus

Climate Projections
Scenario Development

Step 2 – TAC focus

Vulnerability & Risk Assessment

Step 3

Adaptation Planning and Design

Identify the Targets

Infrastructure

Energy
- Electricity & gas (NSTAR)
- Steam (Veolia)

Transportation
- Highways, bridges, & roads (MassDOT)
- Local roads including pathways (City, DCR)
- Transit: subways, buses, and commuter rails (MBTA)
- Parking (City & private)

Water & Wastewater
- Water supply & distribution
- Stormwater system
- Sewer system

Critical Services
- Public safety
- Hospitals
- Child care & elderly center
- Telecom/ IT

Public Health
- Heat/temperature vulnerabilities
- Air quality
- Disease vectors

Economic
- Economic indicators/economic activity
- Retail goods and services
- Ridership at relevant T-stations (who can get to work or not)
- Number of employees
- Assessed value of real estate
- Property tax collections

Natural systems
- Urban forestry
- Habitat

Exercise – Vulnerability Ranking

		Sensitivity: Low → High				
		S0	S1	S2	S3	S4
Adaptive Capacity Low ↓ High	AC0	V2	V3	V4	V5	V5
	AC1	V1	V2	V3	V4	V5
	AC2	V1	V1	V2	V3	V4
	AC3	PO	V1	V1	V2	V3
	AC4	PO	PO	PO	V1	V2

Table 1: Sensitivity Ranking

		Projected Climate Changes for Scenario 1 (2030)					
Critical Elements	*Temperature*	*Temp Ranking*	*Precipitation*	*Precip Ranking*	*Sea Level Rise*	*SLR Ranking*	*Overall Ranking*
Water Supply Reservoir	Increase in yearly average temp by 2 degrees	S2*	Decrease in summer	S4	0.5 feet	S0	6
	more heat waves	S3	more frequent, intense rain events	S4			7
			more icing in winter	S1			1

* ***S = Sensitivity.*** The scoring is based on the severity of the impact to the water supply reservoir. Each assigned ranking will be associated with a footnote explaining why that value was assigned. For example, a yearly increase of two degrees F in average temp could negatively impact the

Table 2: Adaptive Capacity Ranking

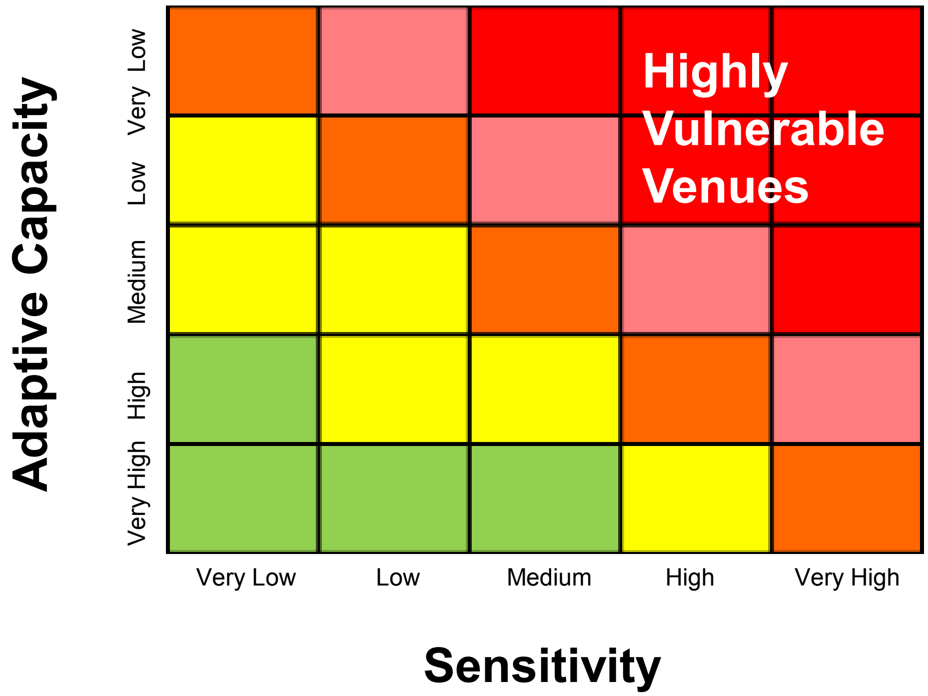
	Projected Climate Changes for Scenario 1 (2030)						
Critical Elements	*Temperature*	*Temp Ranking*	*Precipitation*	*Precip Ranking*	*Sea Level Rise*	*SLR Ranking*	*Overall Ranking*
Water Supply Reservoir	Increase in yearly average temp by 2 degrees	AC1*	Decrease in summer	AC3	0.5 feet	AC0	1
	more heat waves	AC3	more frequent, intense rain events	AC3			6
			more icing in winter	AC1			1

****A= Adaptive Capacity.*** As with the Sensitivity Analyses, there would be a footnote associated with each ranking so the reasoning behind it is transparent and open for change if new information becomes available.

Exercise – Vulnerability Ranking

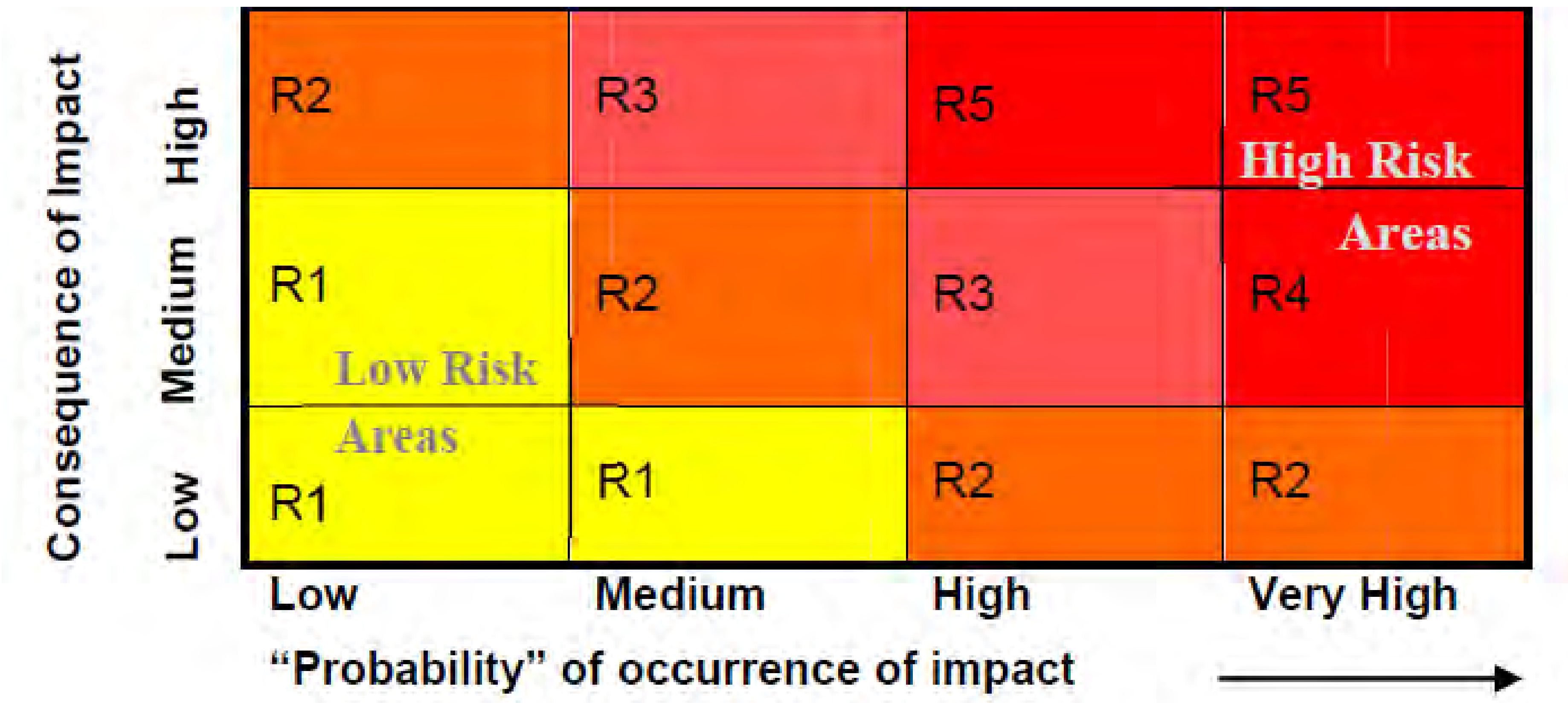
		Sensitivity: Low → High				
		S0	S1	S2	S3	S4
Adaptive Capacity Low ↓ High	AC0	V2	V3	V4	V5	V5
	AC1	V1	V2	V3	V4	V5
	AC2	V1	V1	V2	V3	V4
	AC3	PO	V1	V1	V2	V3
	AC4	PO	PO	PO	V1	V2

Results of Vulnerability Assessment

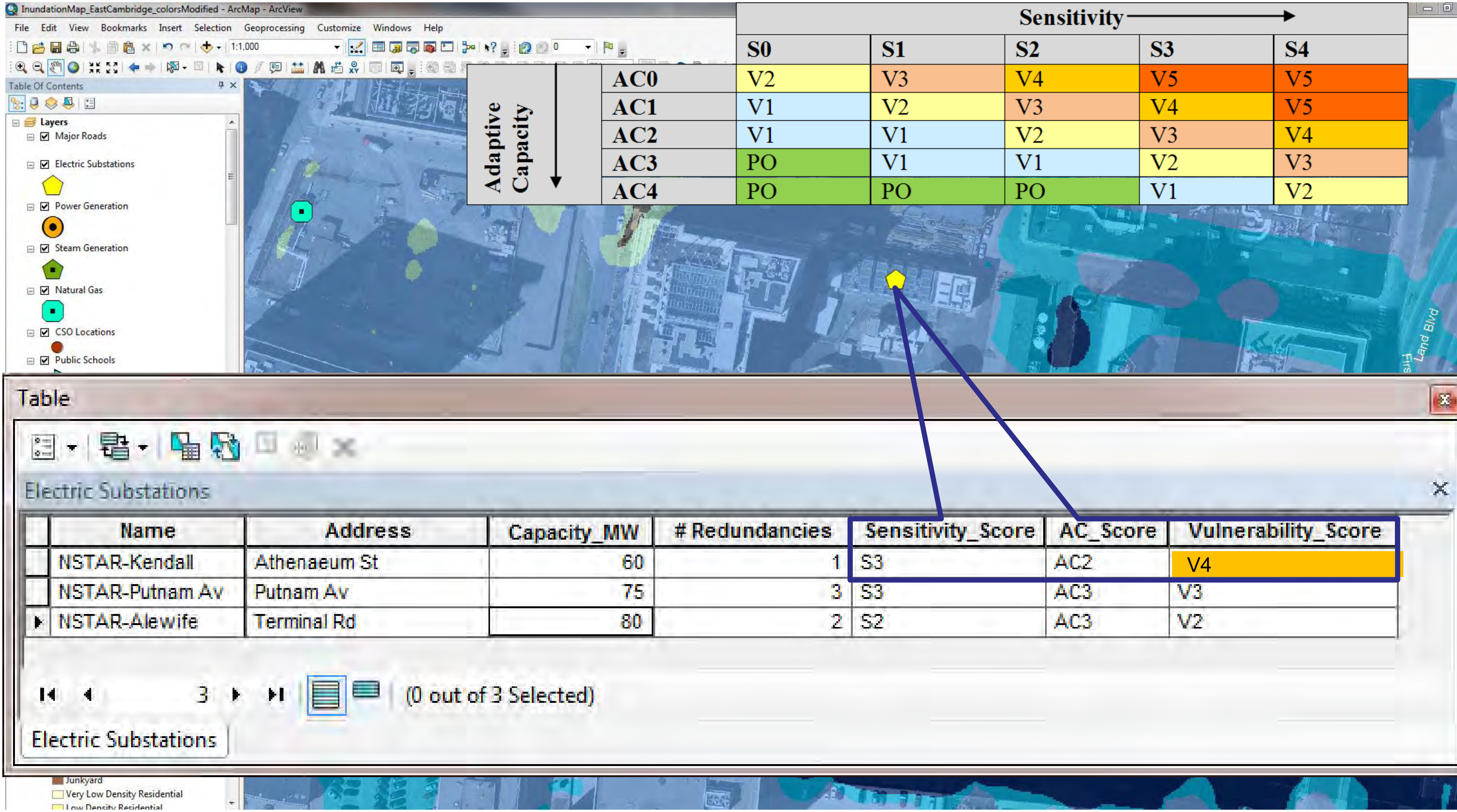


The Highly Vulnerable elements will be called out in narrative form within this chart. Footnotes will provide additional resources and sources for additional data, where appropriate.

Risk Assessment



Linking GIS and Vulnerability



		Sensitivity →				
		S0	S1	S2	S3	S4
Adaptive Capacity ↓	AC0	V2	V3	V4	V5	V5
	AC1	V1	V2	V3	V4	V5
	AC2	V1	V1	V2	V3	V4
	AC3	PO	V1	V1	V2	V3
	AC4	PO	PO	PO	V1	V2

Electric Substations

Name	Address	Capacity_MW	# Redundancies	Sensitivity_Score	AC_Score	Vulnerability_Score
NSTAR-Kendall	Athenaeum St	60	1	S3	AC2	V4
NSTAR-Putnam Av	Putnam Av	75	3	S3	AC3	V3
NSTAR-Alewife	Terminal Rd	80	2	S2	AC3	V2

Risk Assessment

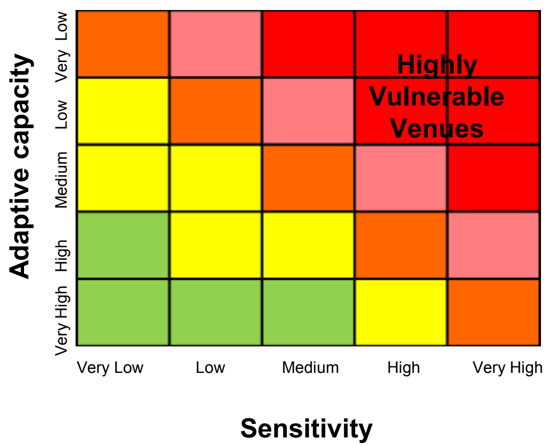
Priority Planning Venues

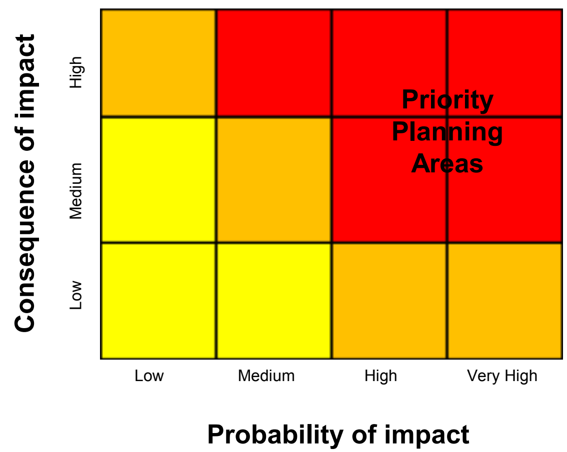
I = Infrastructure Consequence, T = Training Consequence, O = Operations Consequence.

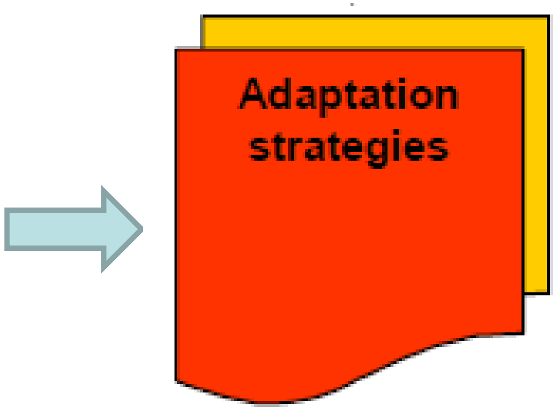
Magnitude of Consequence				
High	Aviation (O)	Power plant (I)	Electrical Utilities (I) Heat exhaustion for training (T) Heat exhaustion for operations (O) Storm damage for infrastructure (I)	Transportation system (I) Evacuation (O) Access (O)
Medium	Structural damage to Railroad bridge (I)	Wastewater treatment (I) Storm damage for operations (O)	Electrical utility cost (I) Infrastructure flooding for operations (O)	Damage to physical infrastructure from flooding (I)
Low	Water quality (I)	CSO discharge (I)		
	More likely than not	**Likely**	**Very likely**	**Extremely likely**

Probability/Likelihood of Occurrence of Consequence

Climate Change Assessment







Step 2

Vulnerability & Risk Assessment

Step 3

Adaptation Planning and Design

Questions / Discussion

Hydrology Protocol

Scope of Study

Impacts Analyzed

- **Precipitation**
- **Sea level rise**
- Storm surge (future EAP meeting)

Systems Analyzed

Hydrology

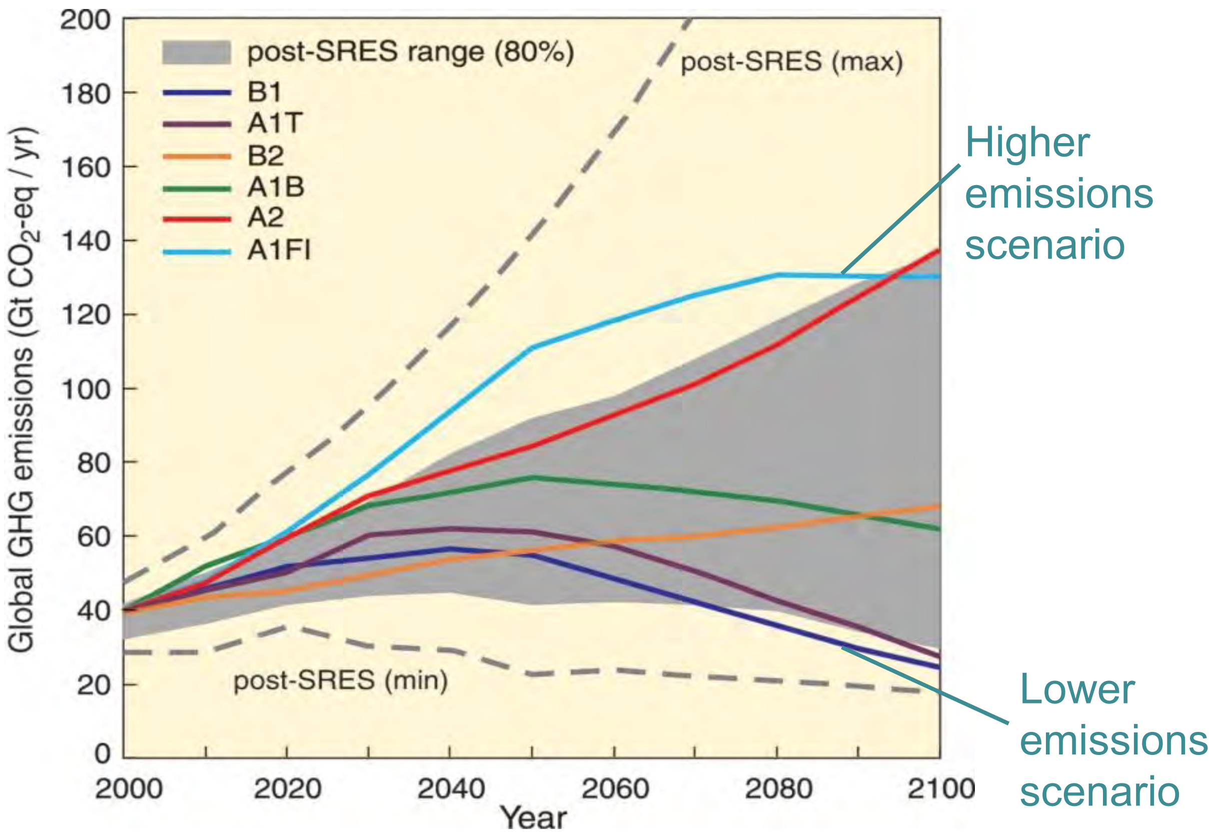
- Lower Charles River Basin
- Mystic River Basin
- Alewife Brook
- Fresh Pond Reservoir

Infrastructure

- Charles River Dam
- Amelia Earhart Dam
- Water J. Sullivan Water Purification Facility
- Drinking Water Distribution System
- Stormwater Collection System
- Wastewater Collection System

Scenarios Used

- Changes analyzed for 2030 and 2070 considering 30-yr averaging period and compared to 1971-2000 base period
- Both higher- and lower-emissions scenarios considered for multiple GCMs



Source: IPCC 2007

Temperature Analysis

	Baseline 1971-2000	2015-2044 (2030s)		2055-2084 (2070s)	
		Lower	Higher	Lower	Higher
Annual Temperature (°F)					
Summer Temperature (°F)					
Winter Temperature (°F)					
Over 90°F (days/year)					
Over 100°F (days/year)					

Precipitation Analysis

- Mean Precipitation
  - Changes in mean annual precipitation
  - Changes in summer and winter precipitation
- Extreme Precipitation
  - Average precipitation intensity
  - Number of heavy precipitation events
  - Once-a-year extreme precipitation events
  - 24-hr design storms
  - MWRA design storms
  - Shorter duration events
  - Longer duration events

Mean Precipitation

	1971-2000	2015-2044 (2030s)		2055-2084 (2070s)	
		Lower	Higher	Lower	Higher
Annual Precipitation (in.)					
Summer Precipitation (in.)					
Winter Precipitation (in.)					

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Extreme Precipitation Analysis

	Baseline 1971-2000	2015-2044 (2030s)		2055-2084 (2070s)	
		Lower	Higher	Lower	Higher
Average precipitation intensity (in./day)					
# days per year > 2 in. rain (days)					
Max. 5-day precipitation per year (in.)					

Design Storms

	Present	2030s		2070s	
		Lower	Higher	Lower	Higher
2-yr 24-hr					
10-yr 24-hr					
25-yr 24-hr					
100-yr 24-hr					
MWRA 3-month design storm	1.84				
MWRA 1-yr design storm	2.79				
MWRA 1-yr 6-hour design storm					

Extreme Precipitation Analysis

Shorter Duration Storms

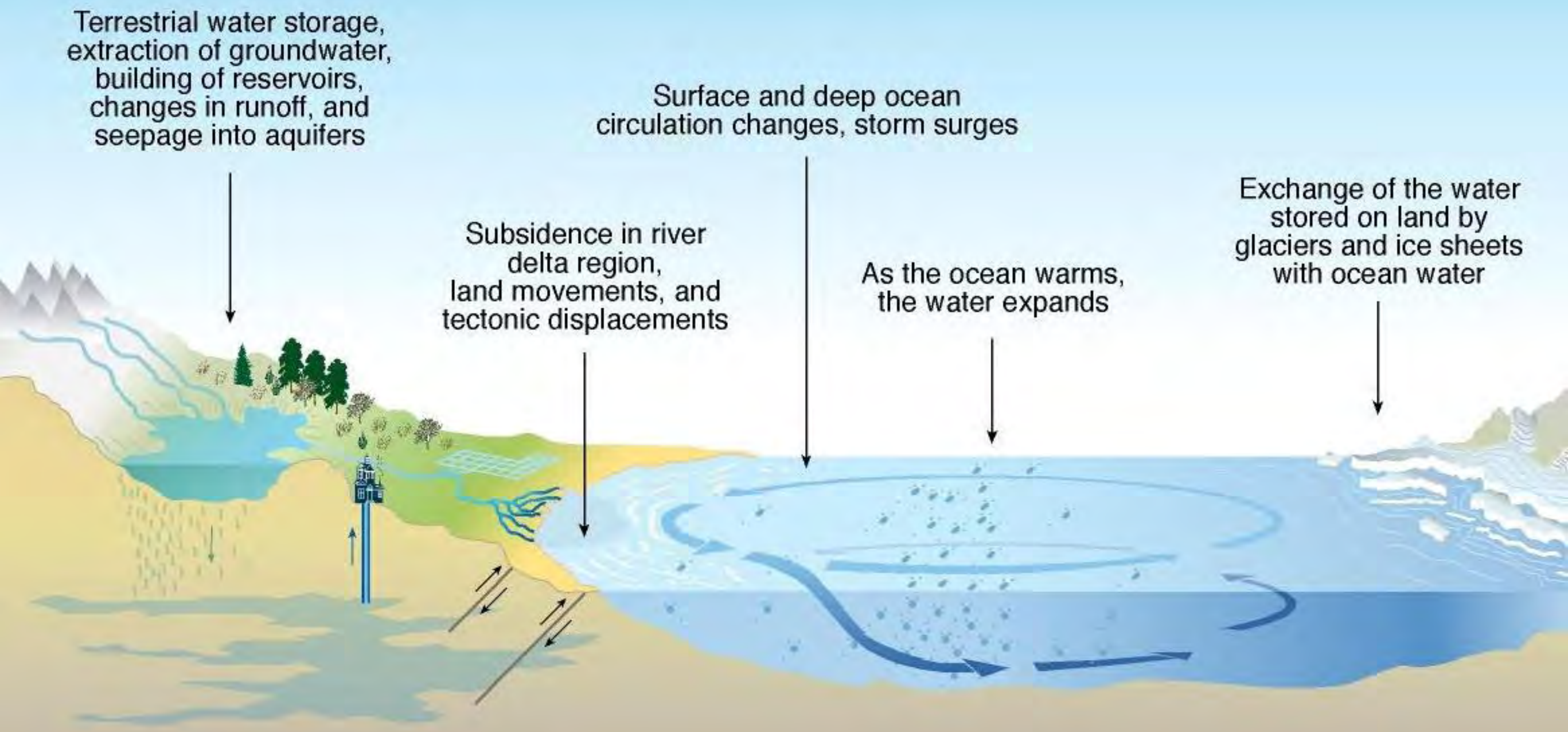
	1-hr			2-hr			6-hr		
	Present	2030s	2070s	Present	2030s	2070s	Present	2030s	2070s
2-yr	0.96			1.29			2.05		
10-yr	1.44			1.93			3.14		
25-yr	1.80			2.42			3.99		
100-yr	2.55			3.44			5.79		

Longer Duration Storms

	2-day			4-day			7-day		
	Present	2030s	2070s	Present	2030s	2070s	Present	2030s	2070s
2-yr	3.47			3.97			4.72		
10-yr	5.27			6.00			7.17		
25-yr	6.70			7.60			9.10		
100-yr	9.65			10.88			13.07		

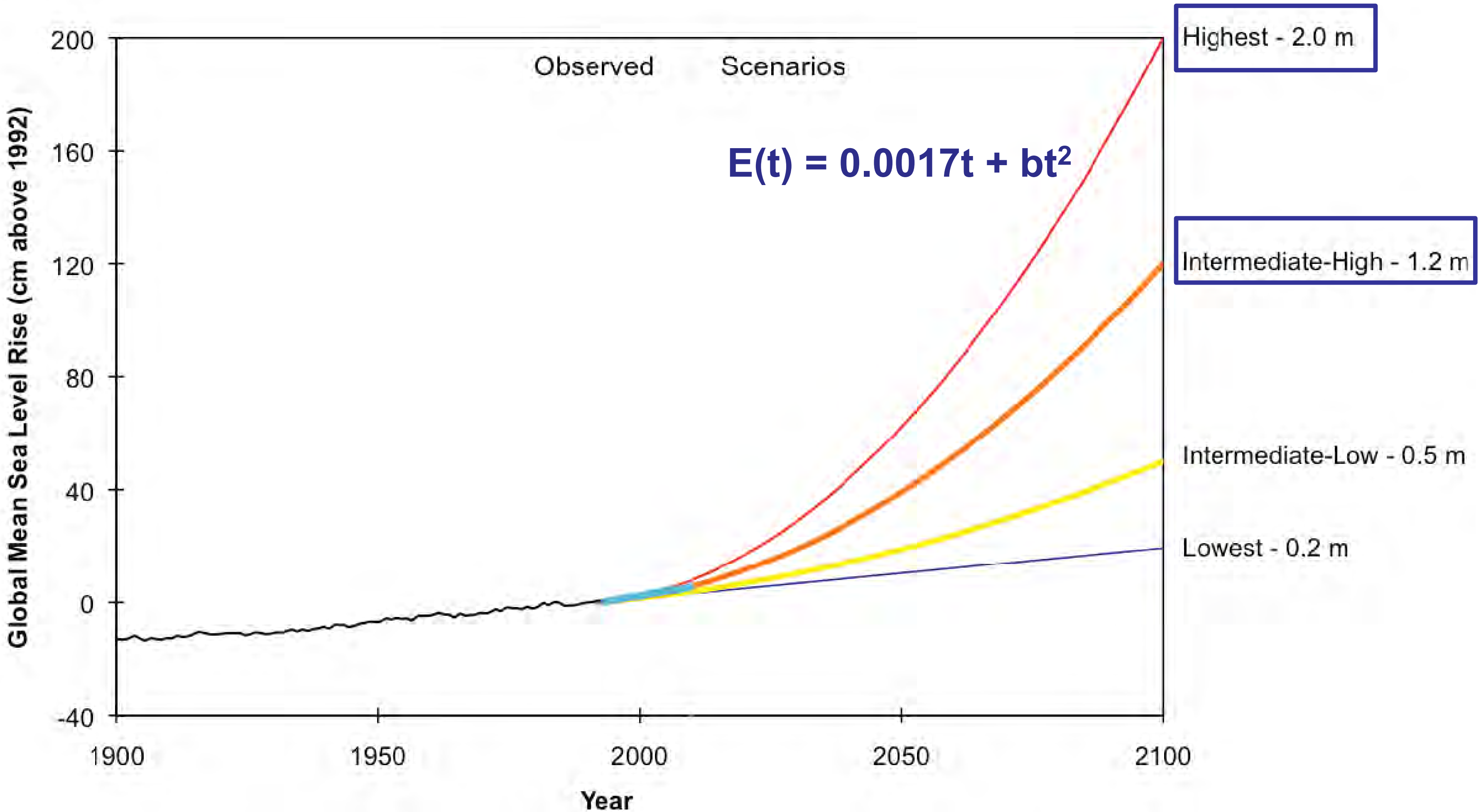
Sea Level Rise

What causes the sea level to change?



Source: IPCC 2007

Sea Level Rise Scenarios



Source: Global SLR Scenarios for United States National Climate Assessment, December 2012

Sea Level Rise Projections

Scenarios	2020	2030	2070	2100
Global SLR (from 2013) – “highest" (feet)	0.21	0.61	3.21	6.23
Global SLR (from 2013) – “intermediate-high" (feet)	0.14	0.38	1.93	3.69
Land subsidence (feet) @ 0.04 in./yr	0.02	0.06	0.19	0.29
Total relative SLR – “highest" (feet)	0.24	**0.66**	**3.39**	6.52
Total relative SLR – “intermediate-high" (feet)	0.16	**0.44**	**2.12**	3.98

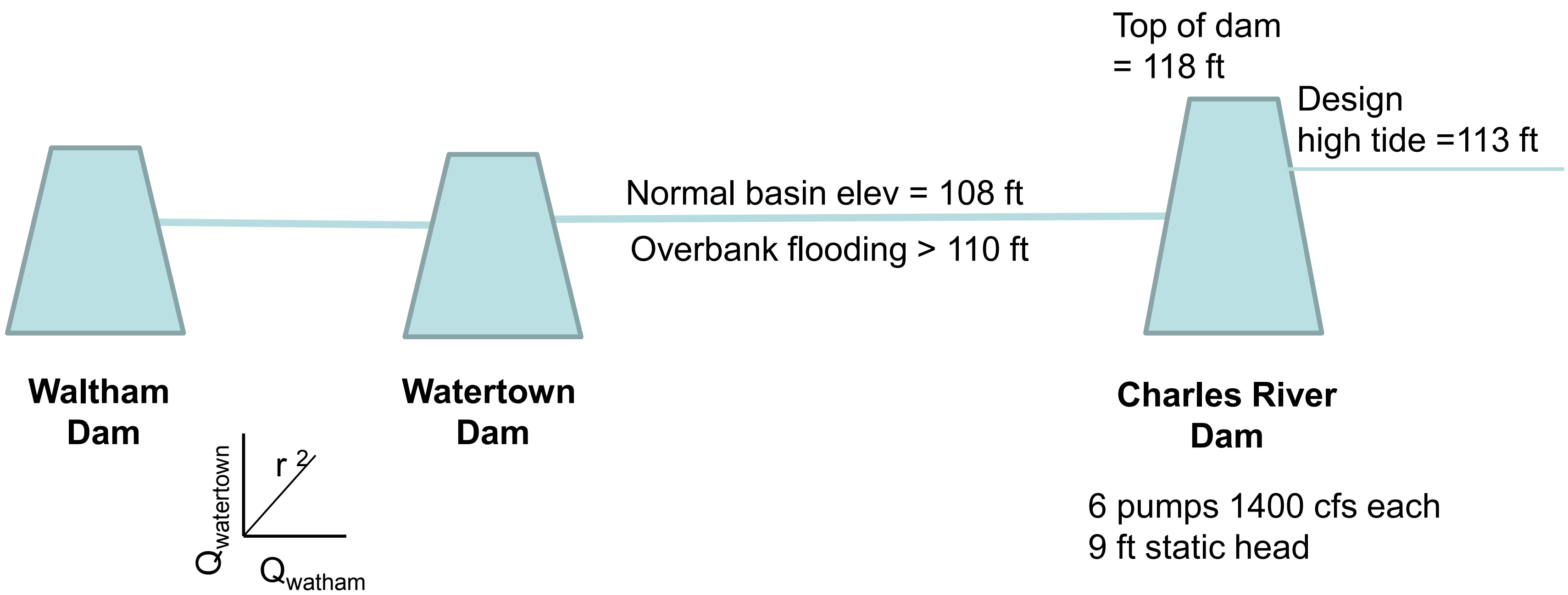
Temperature Impacts on Water Bodies

	Baseline 1971-2000	2015-2044 (2030s)		2055-2084 (2070s)	
		Lower	Higher	Lower	Higher
Charles River annual surface water temperature (°F)					
Alewife Brook annual surface water temperature (°F)					
Charles River average DO (summer)*					
Alewife Brook average DO (summer)*					

*Qualitative analysis

Precipitation Impacts on Lower CR Basin

- Changes in basin elevation
- Higher inflows from the upper Charles River Basin at Waltham Dam
- Higher stormwater inflows to the lower Charles River basin



Note all elevations are in MDC datum

Questions / Discussion

Next Steps