Stormwater Management Strategies Under Climate Change: A look at Somerville, MA and Aurora, CO

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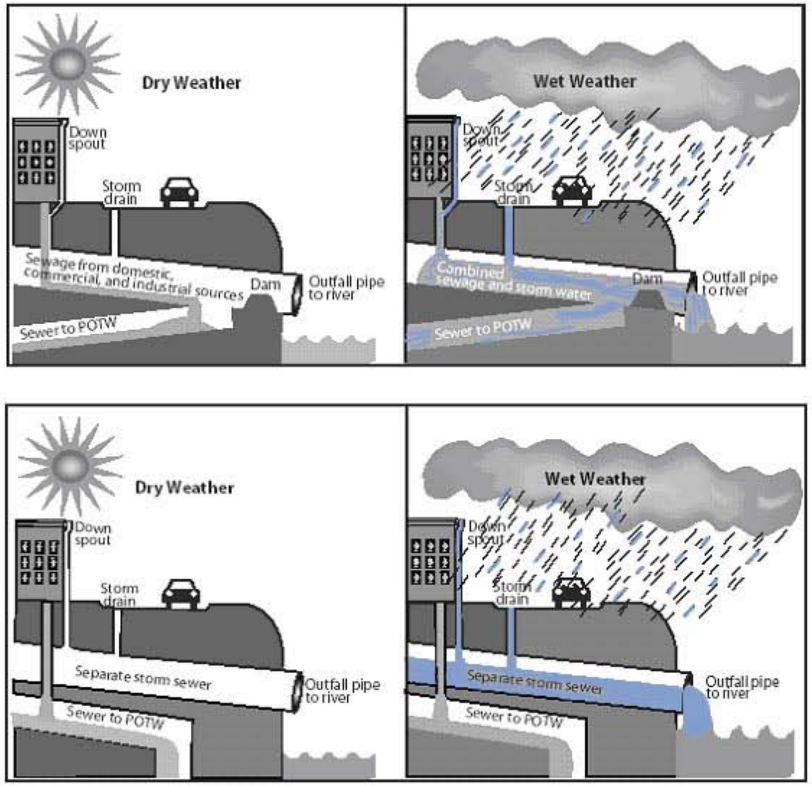
Challenges in Stormwater Management

* Land-use and population changes
* Changed thinking about water quality and importance of non-point source pollution
* Combined sewer systems and CSO overflows
* Over time, stormwater infrastructure will experience less reliability and more flooding



Adding Challenges of Non-Stationarity

* Changes in precipitation amounts and intensity expected
  * "Stationarity is Dead"
  * "Deep uncertainty" about extent and degree of changes
  * Uncertainty about when impacts will begin to occur
  * Uncertainty about climate 20-50 years from now, yet we need to make decisions about infrastructure and long-term land-use planning that could effect the next 50-100 years

Case Studies and their Respective Stormwater Regulations

* Aurora, Colorado
* Somerville, Massachusetts
* Worcester, Massachusetts

Colorado Stormwater Regulations

* Drainage is designed for two types of events: an initial storm and a major storm.
  * The initial storm drainage system (e.g. infrastructure) should be capable of safely handling 2- to 10- year floods.
  * The major storm drainage system (e.g. roads, swales, ditches, floodplains, etc.) should be capable of safely handling the 100-year flood.
* UDFCD also recommends the protection of receiving waters through a four step process, pertaining to management of smaller, frequently occurring events, as opposed to larger storms for which drainage and flood control infrastructure are sized. The four steps are:
  * Employ runoff reduction practices
  * Implement BMPs that provide a water quality capture volume with slow release
  * Stabilize drainageways
  * Implement site specific and other source control BMPs
* Western Water Law
  * Reduce options for infiltration
  * Detention

Massachusetts Stormwater Regulations

* Under the Stormwater Management Standards, stormwater management systems must be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates.
  * Peak discharges must be attenuated for the 2-year and 10-year, 24-hour storm, as well as for the 100-year 24-hour storm if an analysis indicates the discharge will cause flooding up or downstream of the discharge location.
  * The standards also require erosion and sedimentation controls be implemented during the construction phase.
* Source controls, pollution prevention measures, and BMPs in Massachusetts must be designed to remove 80% of the Total Suspended Solids (TSS) load.
* Water quality BMPs must treat the first ½-inch of runoff. In critical areas, such as shellfish beds, coldwater fish habitats, public swimming beaches, and public drinking water recharge areas and reservoirs, BMPs must treat the first 1-inch of runoff.
* Recharge must be provided to offset the recharge lost due to site development to the maximum extent practicable.
* Additional treatment is required for land uses with higher potential pollutant loads.

Decision-Making Process Under 'Deep Uncertainty'

* "decision-makers do not know or cannot agree upon" the future conditions or performance of the system about which they need to make decisions

Decision-Making Process Under 'Deep Uncertainty'

* Robust Decision Making
* Adaptive Planning
  * Trigger Points
  * Staged adaptations
* Crucial for making above strategies successful
  * Flexibility

Decision-Making Process Under 'Deep Uncertainty'

- Robust Decision Making
  - Robert Lempert
  - Poses robustness, rather than optimum performance, as decision criteria
  - "trading some optimal performance for less sensitivity to assumptions, satisficing over a wide range of futures, and keeping options open"
  - It is critical that decision making schemes consider multiple representations of the future
  - "the existence of robust strategies depends on both the degree of uncertainty and the richness of the available decision options"

Decision-Making Process Under 'Deep Uncertainty'

* Trigger Points
  * strategy for implementing Adaptive Planning
* "Automatic policy adjustment"
  * Bhadwal, Barg, and Swanson
* "Some of the inherent variability in socio-economic and ecological conditions can be anticipated, and monitoring of key indicators can help trigger important policy adjustments to keep the policy functioning well. Built-in policy adjustment mechanisms help policies respond well in a variety of plausible and clearly identified future circumstances."
* "They can speed up the process of response to conditions that are more or less anticipated. They can be used in complicated policy environments by… allowing for fine-tuning of the system [in the future as conditions are better understood]."

Looking for Options and Flexibility

* LID and BMP
* Operation improvements
* Sizing: economies of scale vs. distributed solutions
* Timing and phased solutions
  * Make decisions now that ensure we can implement adaptation in the future as they are needed
  * Making use of growing knowledge of the system
  * How can we optimize the timing of adaptation implementation

Colorado Model

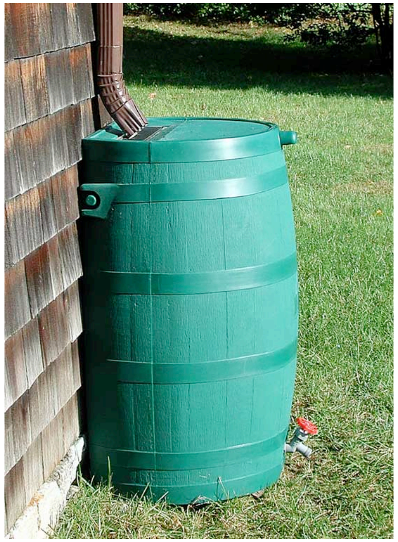
* Large-scale model with regional stormwater approaches
* Detention
* Colorado Urban Hydrograph Procedure determines precipitation input and runoff volumes

Somerville Model

* Calibration and verification
* LID options in SWMM to test:
  * Rain barrels
  * Porous pavement
  * Infiltration trench
  * Vegetative swale
  * Bioretention cell

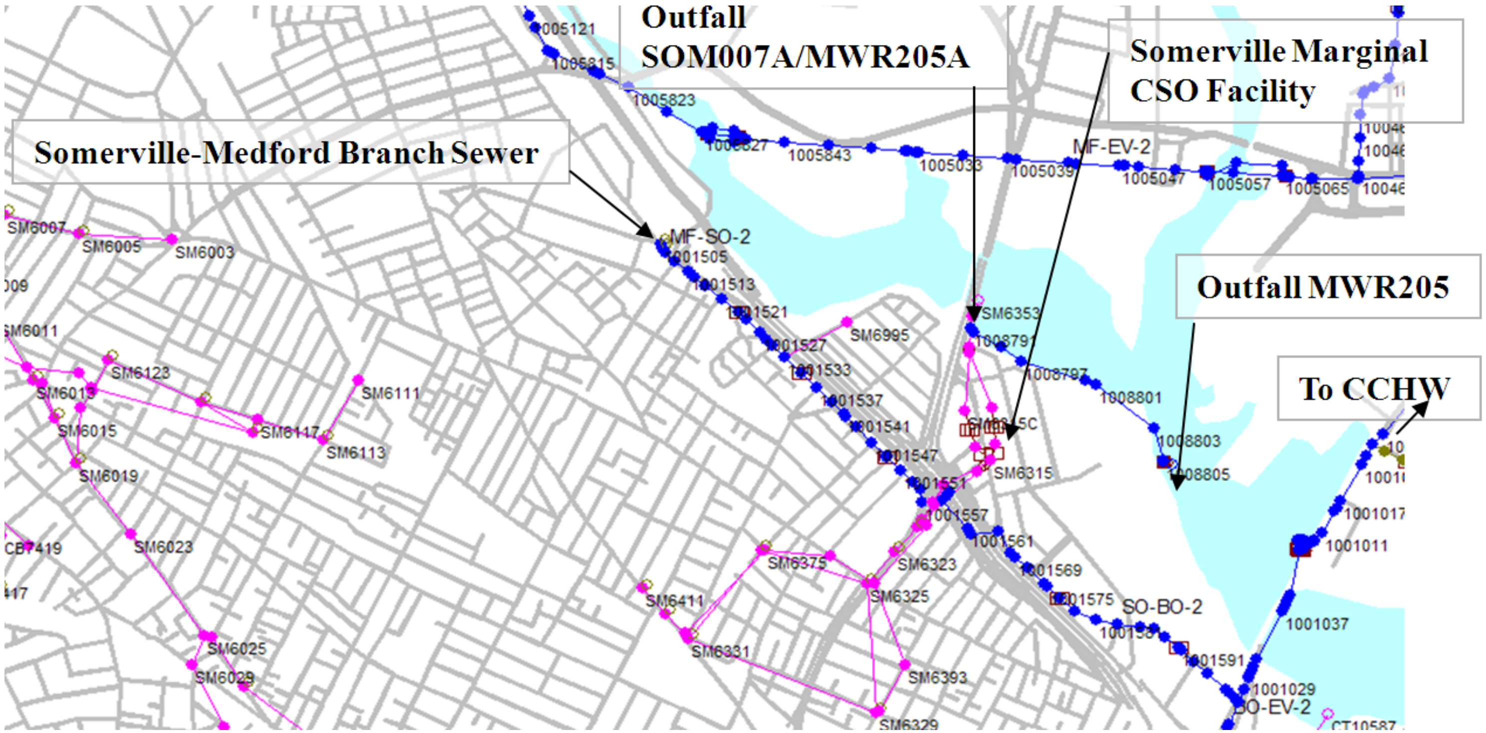
Part of the Solution : Low Impact Development (LID)

* Green roofs
* Porous pavement
* Vegetated strips
* Rain barrels



Future Scenarios

* Choosing precipitation inputs
* Challenge of creating hypothetical scenarios in a complicated model



Design Events: Stationary Criteria

Massachusetts

Extreme Precipitation Tables

Northeast Regional Climate Center

Data represents point estimates calculated from partial duration series. All precipitation amounts are displayed in inches.

Smoothing	Yes
State	Massachusetts
Location	near 18 Madison St, Somerville, MA 02143, USA
Longitude	71.099 degrees West
Latitude	42.388 degrees North
Elevation	96 feet
Date/Time	Fri, 18 Feb 2011 14:35:53 -0500

Extreme Precipitation Estimates

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr
1yr	0.33	0.51	0.64	0.83	1.04	1.29	**1yr**	0.90	1.20	1.48	1.81	2.20
2yr	0.35	0.53	0.67	0.88	1.10	1.39	**2yr**	0.95	1.28	1.62	2.04	2.57
5yr	0.42	0.65	0.81	1.09	1.39	1.77	**5yr**	1.20	1.61	2.06	2.59	3.26
10yr	0.47	0.74	0.93	1.27	1.65	2.12	**10yr**	1.42	1.91	2.47	3.12	3.91
25yr	0.55	0.88	1.12	1.54	2.04	2.65	**25yr**	1.76	2.39	3.10	3.94	4.96
50yr	0.62	1.00	1.29	1.80	2.43	3.18	**50yr**	2.10	2.81	3.74	4.74	5.94
100yr	0.71	1.16	1.49	2.11	2.87	3.78	**100yr**	2.47	3.35	4.45	5.66	7.10
200yr	0.82	1.33	1.72	2.47	3.41	4.52	**200yr**	2.94	3.98	5.34	6.79	8.52
500yr	0.98	1.62	2.11	3.06	4.29	5.72	**500yr**	3.70	5.01	6.77	8.61	10.77

Colorado

Table 3.2-1 Point Rainfall Depths (inches)

Return Period	1-Hour Rainfall	6-Hour Rainfall
2-Year	1.00	1.40
5-Year	1.35	1.95
10-Year	1.60	2.22
25-Year	2.00	2.80
50-Year	2.25	3.14
100-Year	2.65	3.40
500-Year	3.24	4.29

Precipitation Scenarios

* Current design storms
* Flat 15% increase to current design storms
* Downscaled GCM predictions
* Trend-fitting for high- and low-frequency storm events