If you don't like the weather … wait a day.

Duluth, 2012

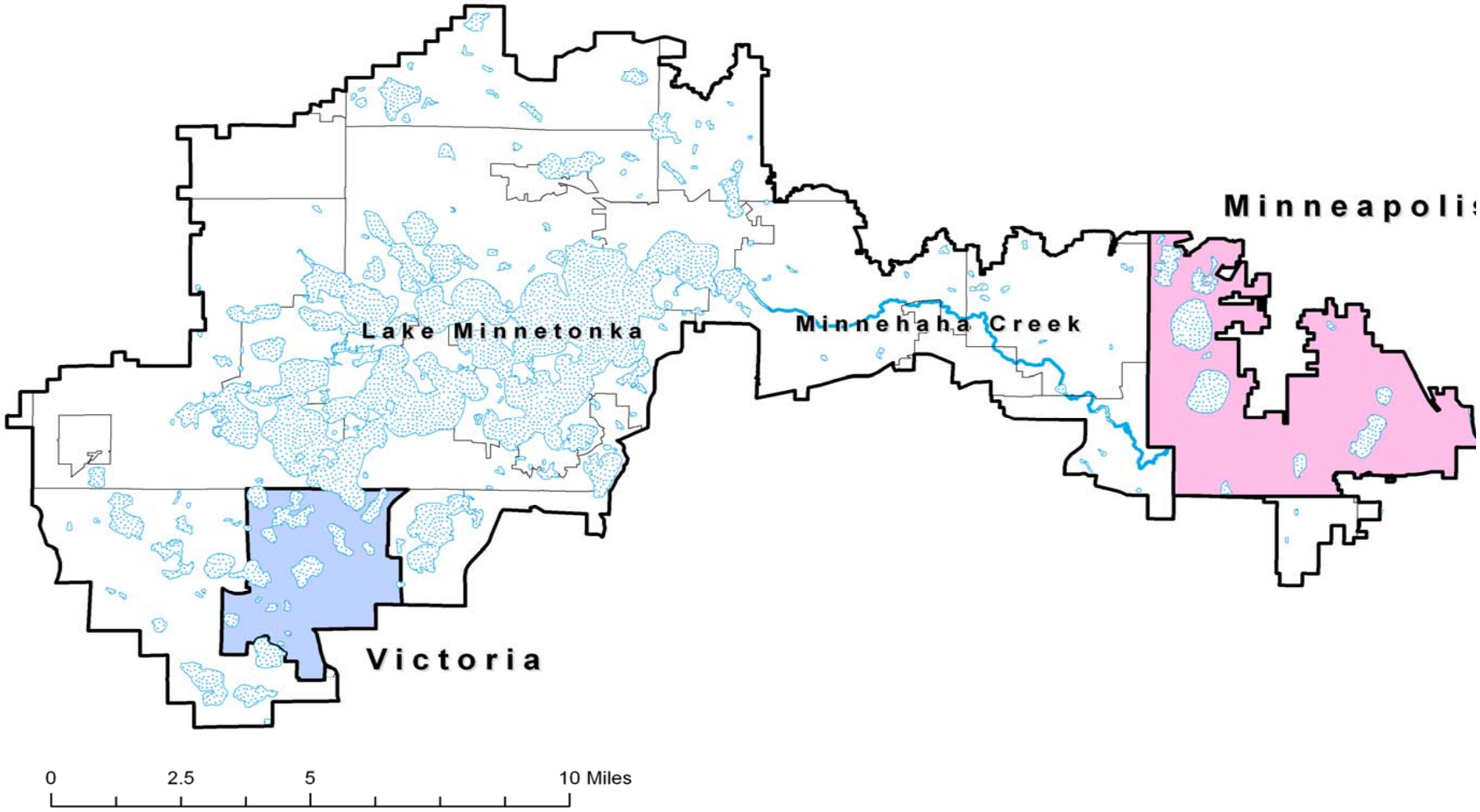
Michael H. Simpson

Center for Climate Preparedness and Community Resilience

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

Antioch University New England

Minnehaha Creek Watershed



Collaboration

Prof. Michael Simpson *Antioch University New England*
Latham Stack, *Syntectic International LLC* Portland OR
Dr. James Gruber, *Antioch University New England*
Dr. Robert Roseen, *University of New Hampshire* -Stormwater Center
Dr. Tom Ballestero, *University of New Hampshire* -Stormwater Center
Dr. Cameron Wake, Earth, Oceans & Space, *University of New Hampshire*
Joel Smith, Stratus LLC, Boulder CO
Dr. Trisha Moore, *University of Minnesota*
Dr. John Gulliver, University of Minnesota
Leslie Yetka, *Minnehaha Creek Watershed District*, MN

Minneapolis City of

MINNEHAHA CREEK WATERSHED DISTRICT

SYNTECTIC INTERNATIONAL

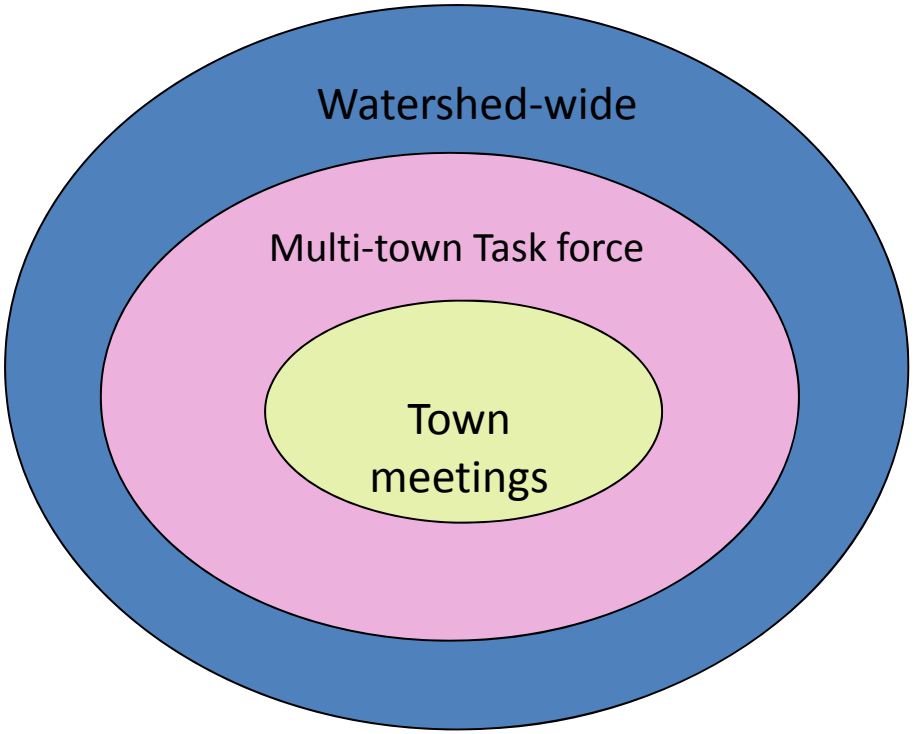
VICTORIA City of Lakes & Parks

UNIVERSITY OF MINNESOTA

STRATUS CONSULTING

SC UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER

Nested Adaptive Management Approach



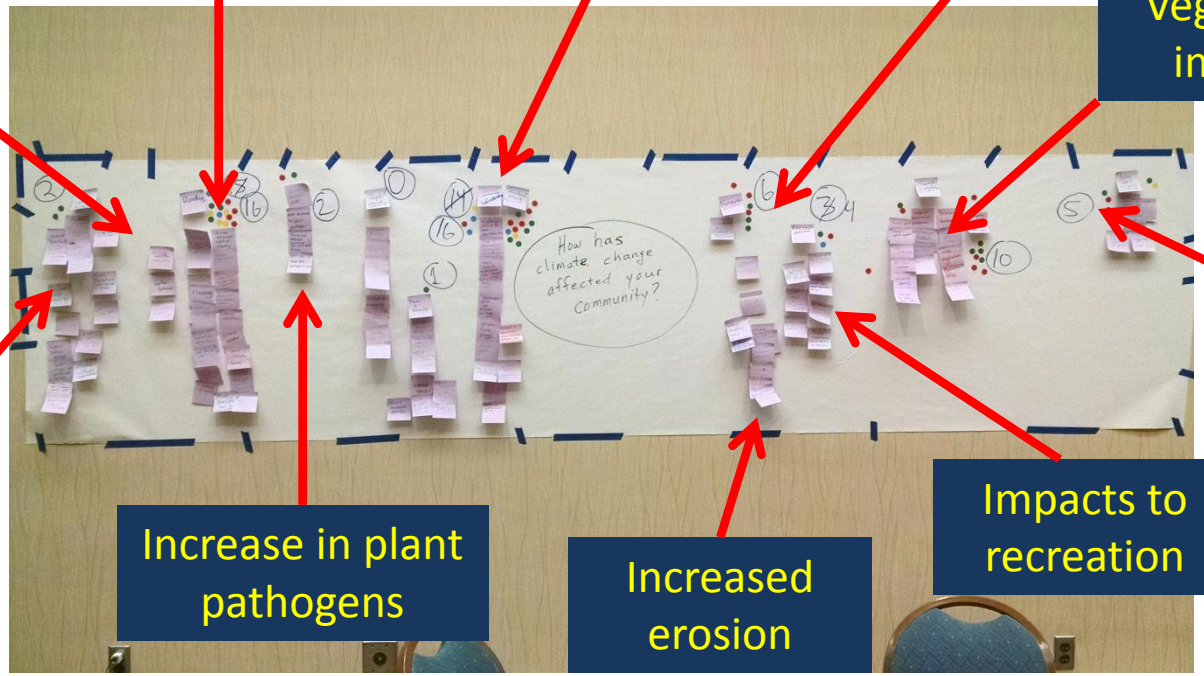
More Intense storms

Impacts from flooding

Impacts on H_2O quality

Longer growing season

Vegetation impacts



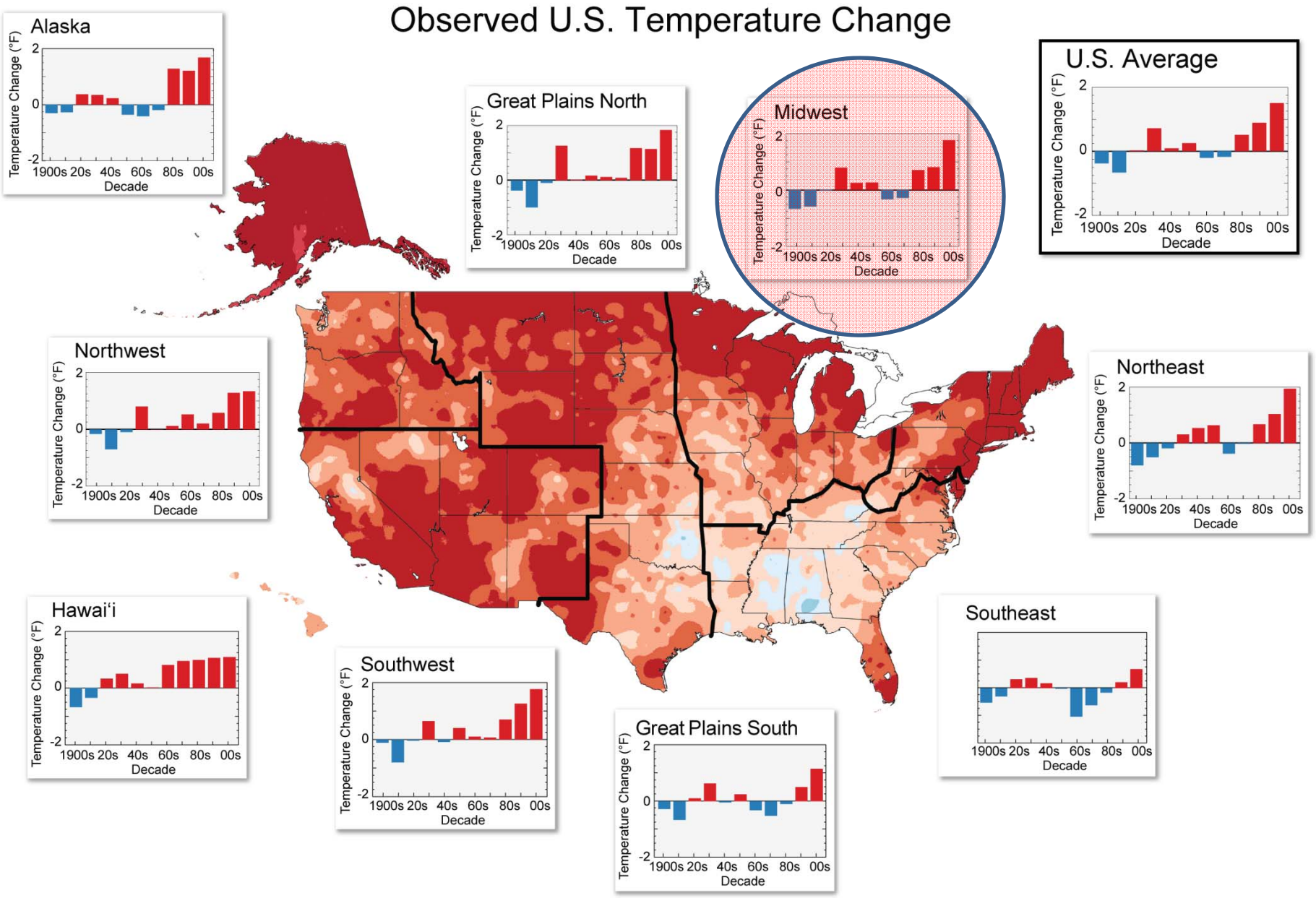
Increased H_2O use

Extended droughts

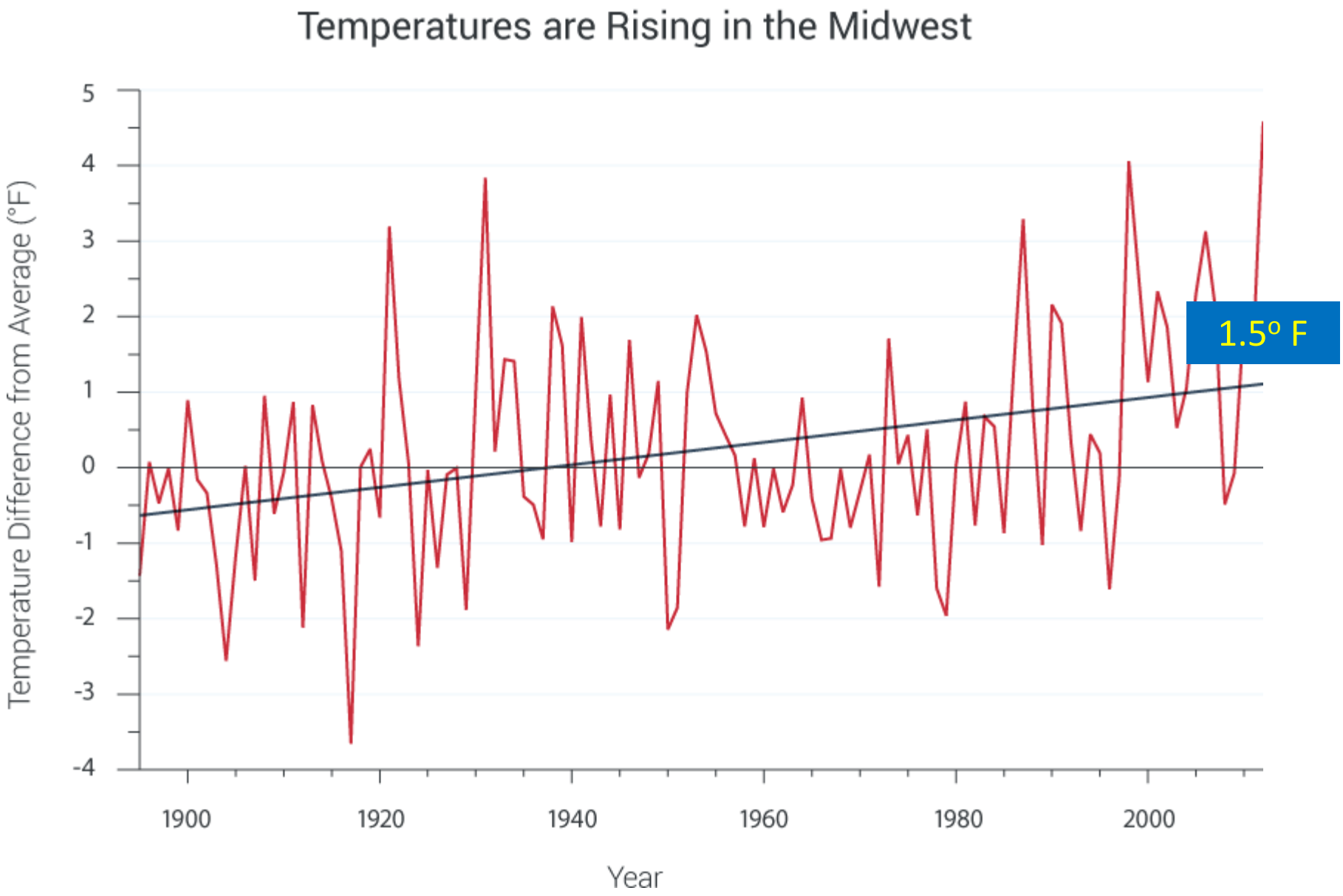
Increase in plant pathogens

Increased erosion

Impacts to recreation

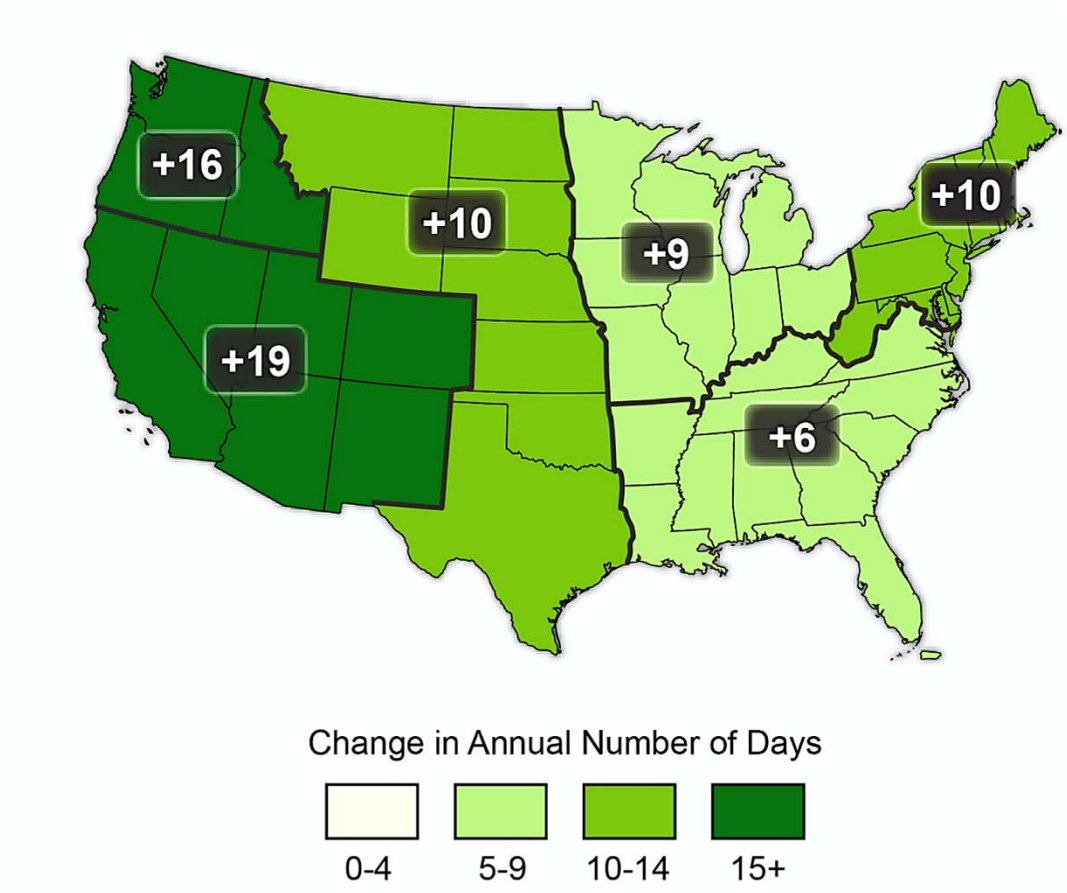

Observed U.S. Temperature Change
Alaska
Great Plains North
Midwest
U.S. Average
Northwest
Northeast
Hawai'i
Southwest
Great Plains South
Southeast
Temperature Change (°F)
2
0
-2
1900s 20s 40s 60s 80s 00s
Decade
Temperature Change (°F)
< -1.5
-1.5 to -1.0
-1.0 to -0.5
-0.5 to 0.0
0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
>1.5

NOAA 2013

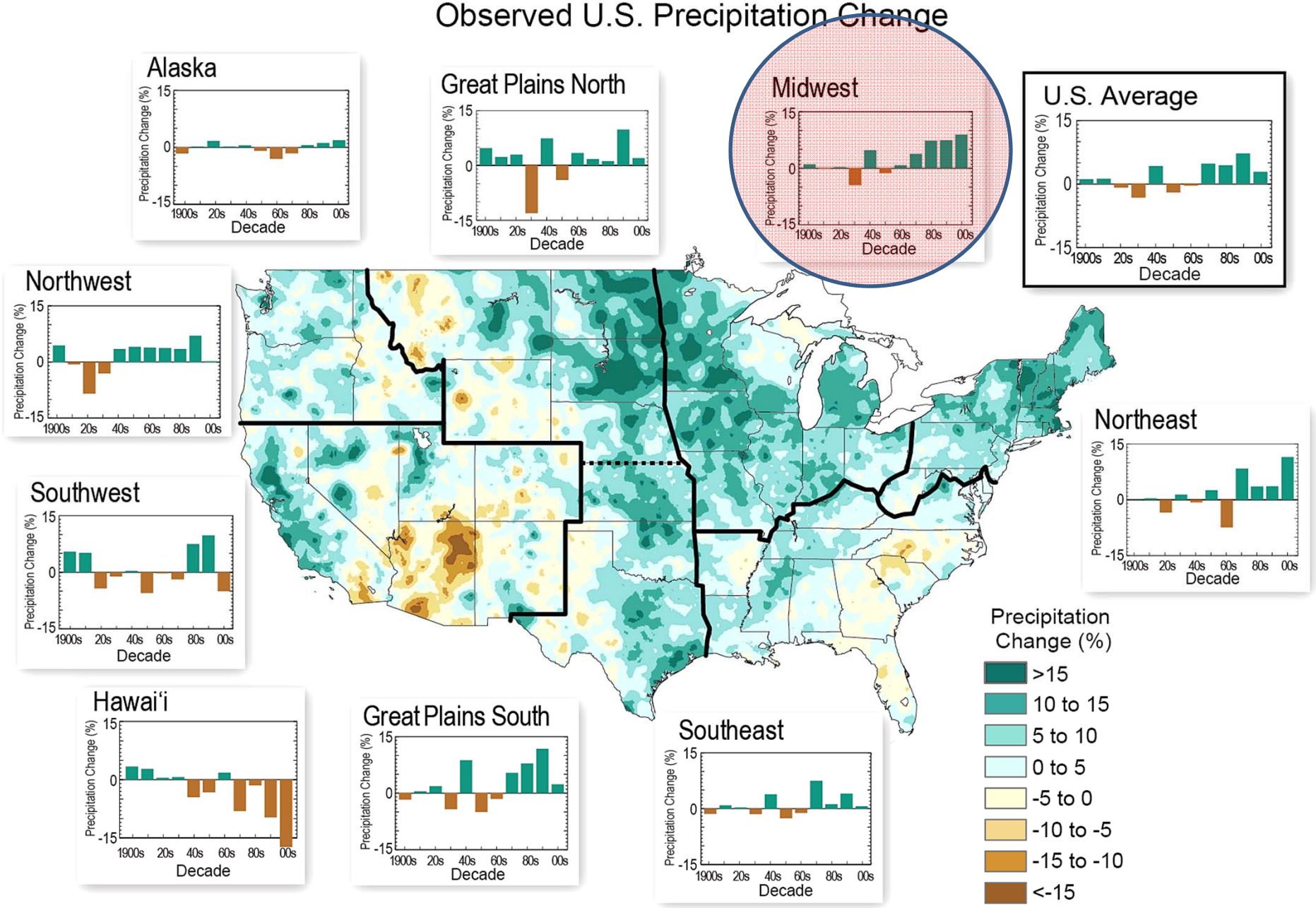


Kunkel et al. 2013

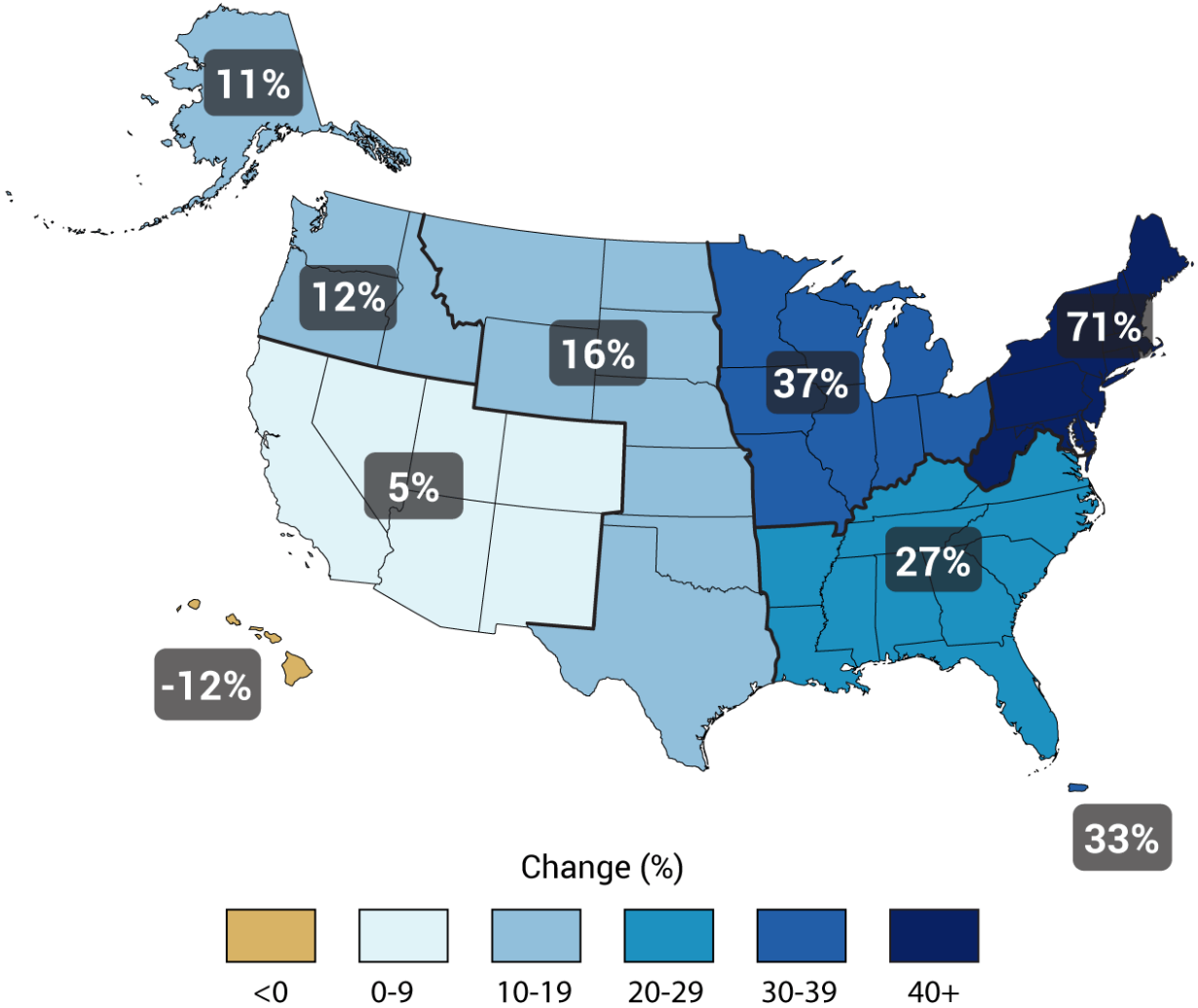
Observed Increase in Frost-Free Season Length



Observed U.S. Precipitation Change

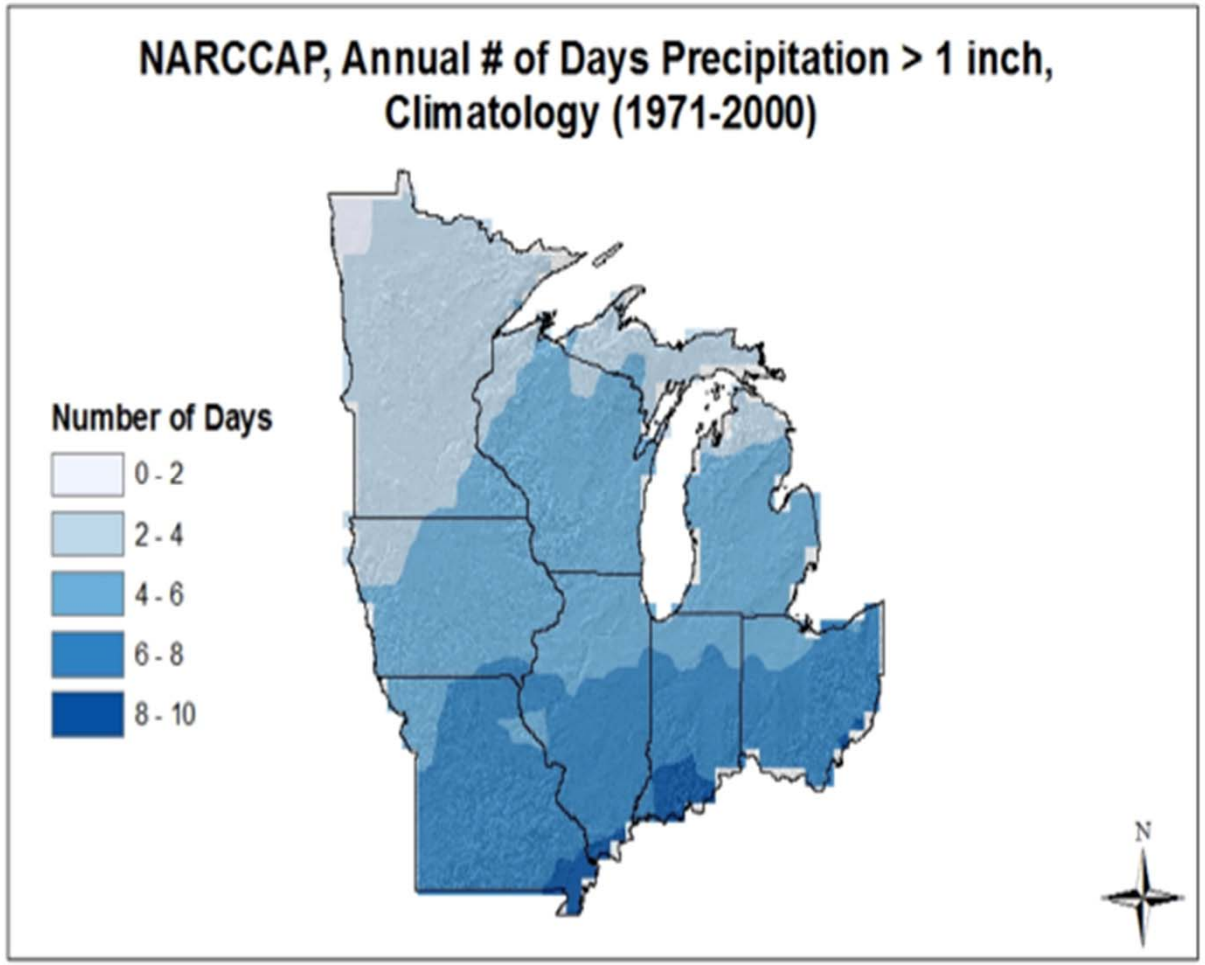


Observed Change in Very Heavy Precipitation



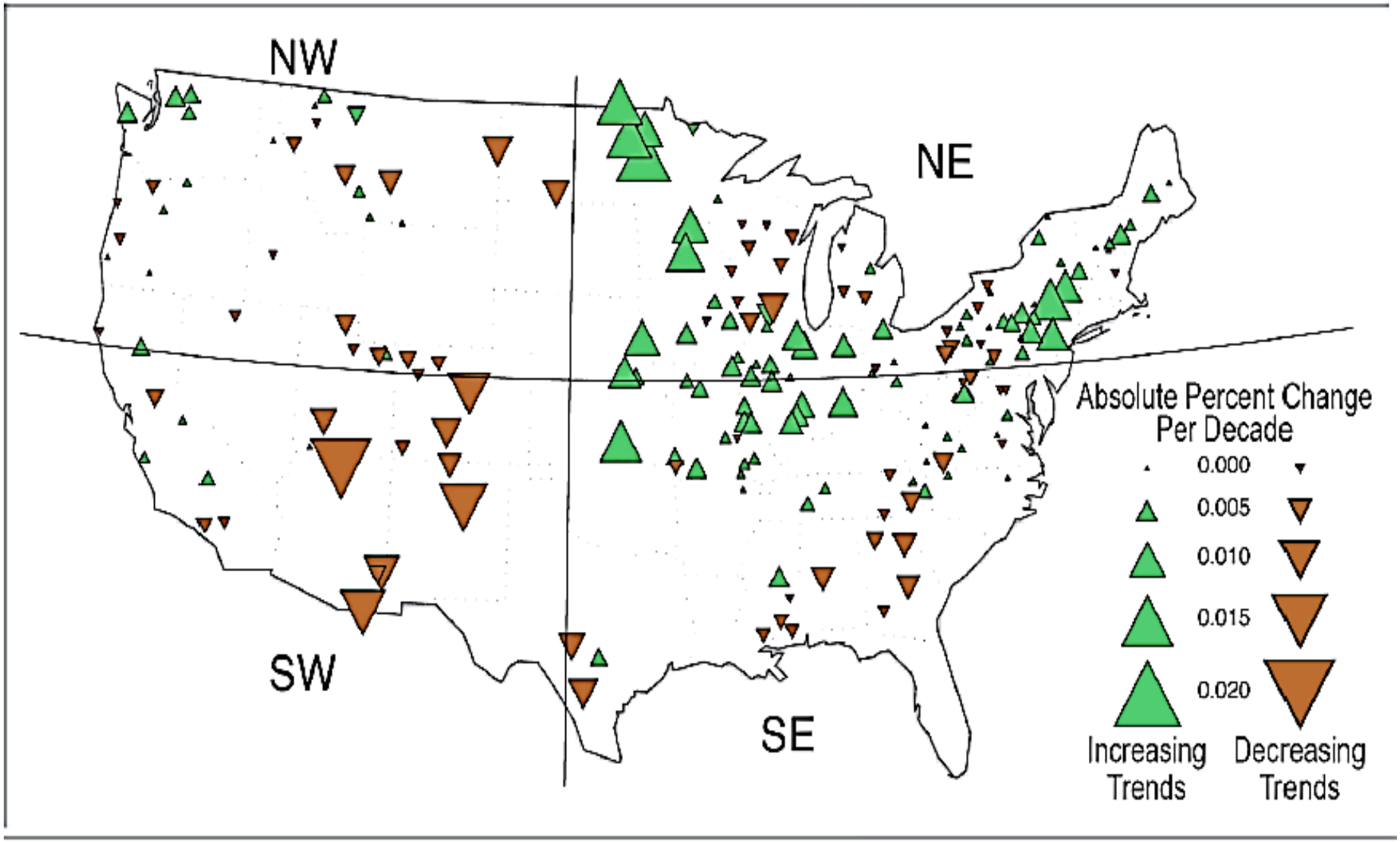
NCA 3

Annual Number of Days where Precipitation Exceeds 1” (1970-2000)



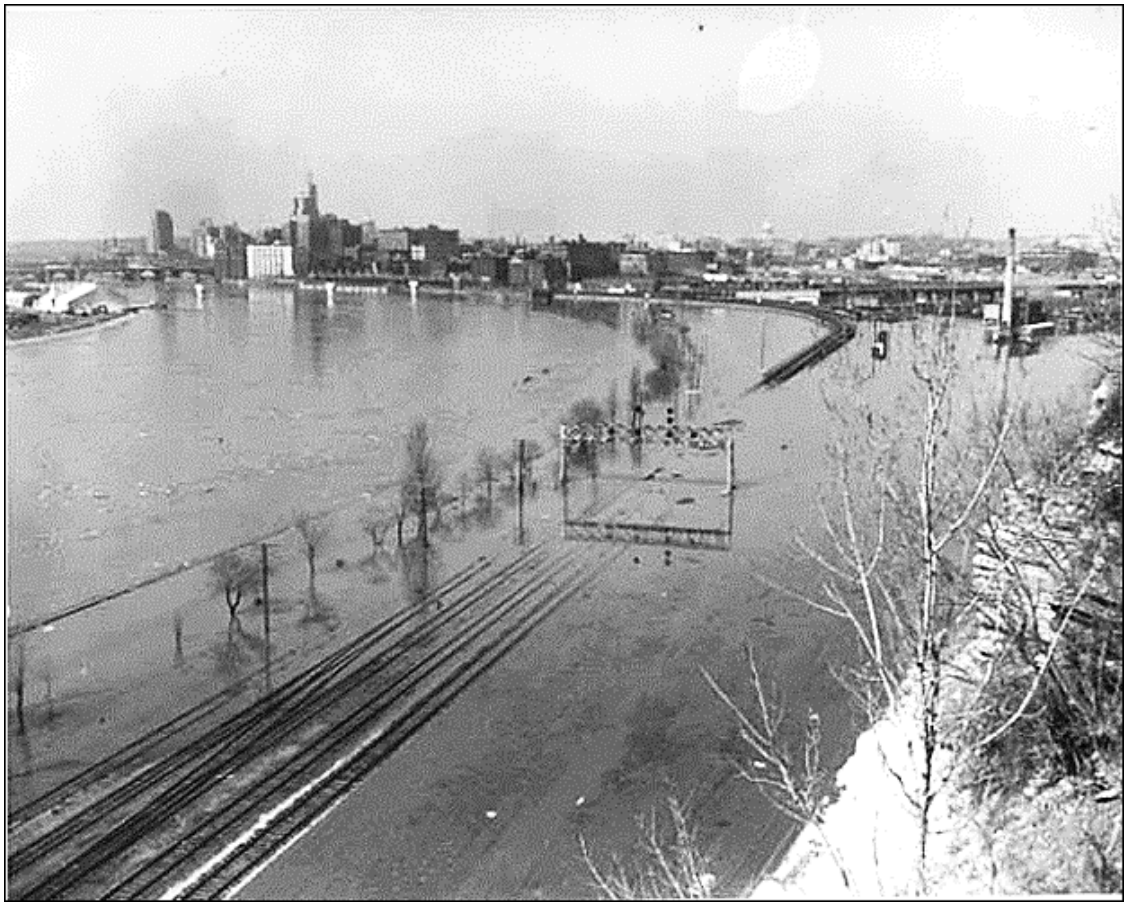
MN ICAT 2013

Trends in Flood Magnitude



NCA 3

April 1965



St Paul, MN

FEMA

July 1987

I-494

Minneapolis

FEMA

April 1997

East Grand Forks, MN

FEMA

August 2007

Rushford, MN

FEMA

June 2012

Duluth, MN

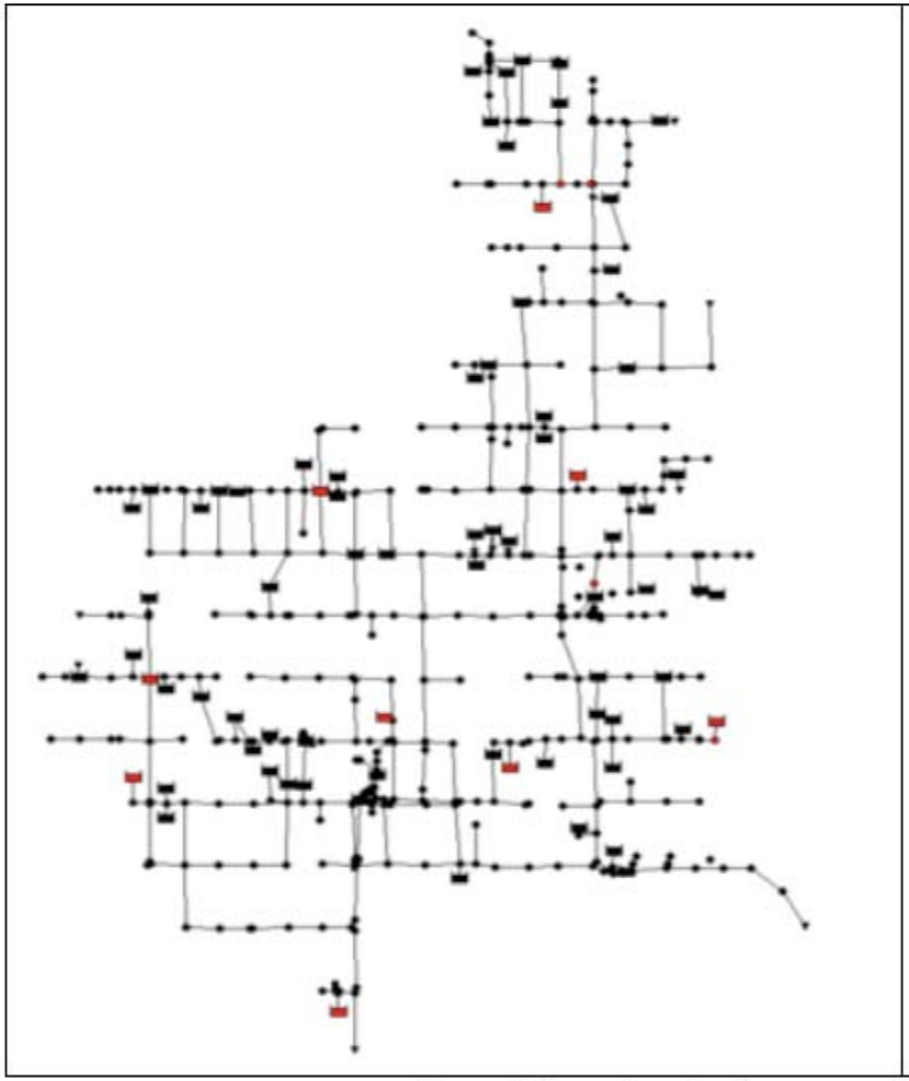
MPR

June 2014

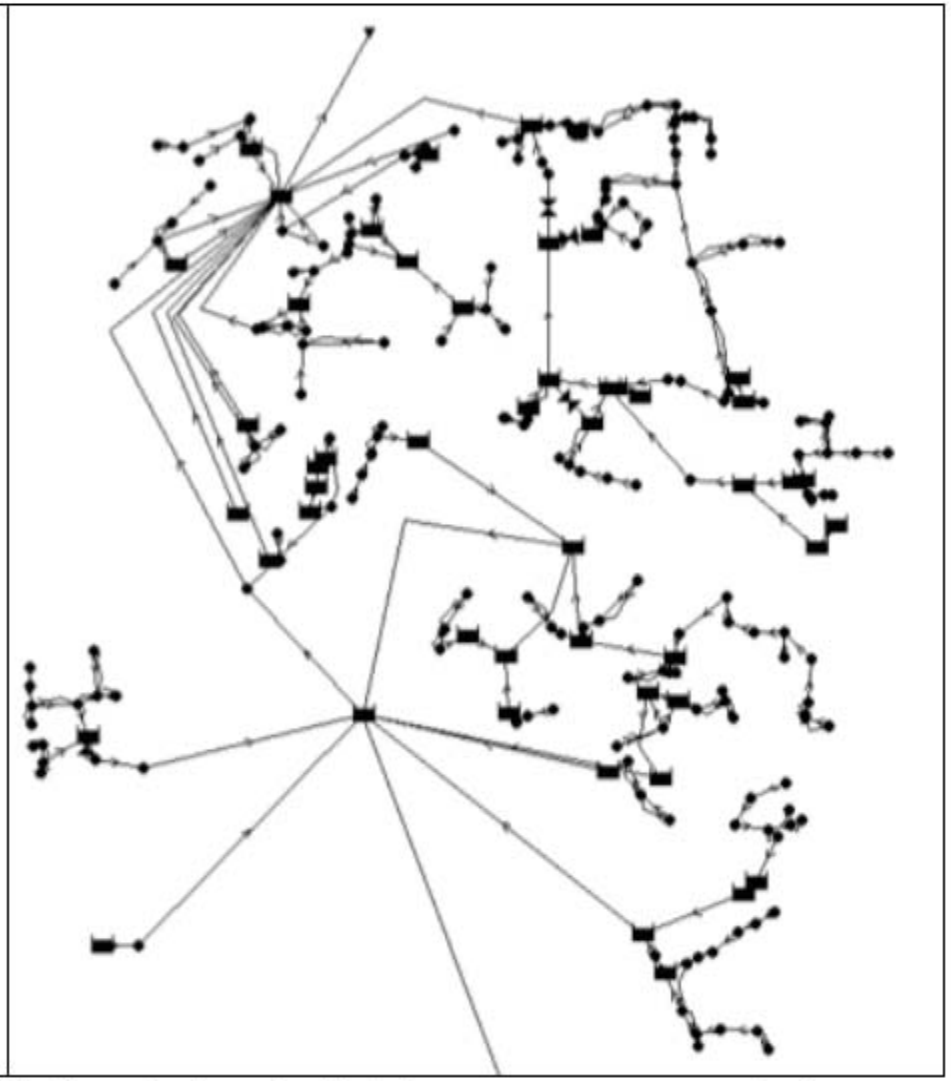
Minneapolis, MN

Star Tribune

Urban Research: Assessing Resilience



Minneapolis



Victoria

Stormwater Infrastructure

Historically the design storm was 10 yr – 24 hr precipitation event

Applied Research Approach

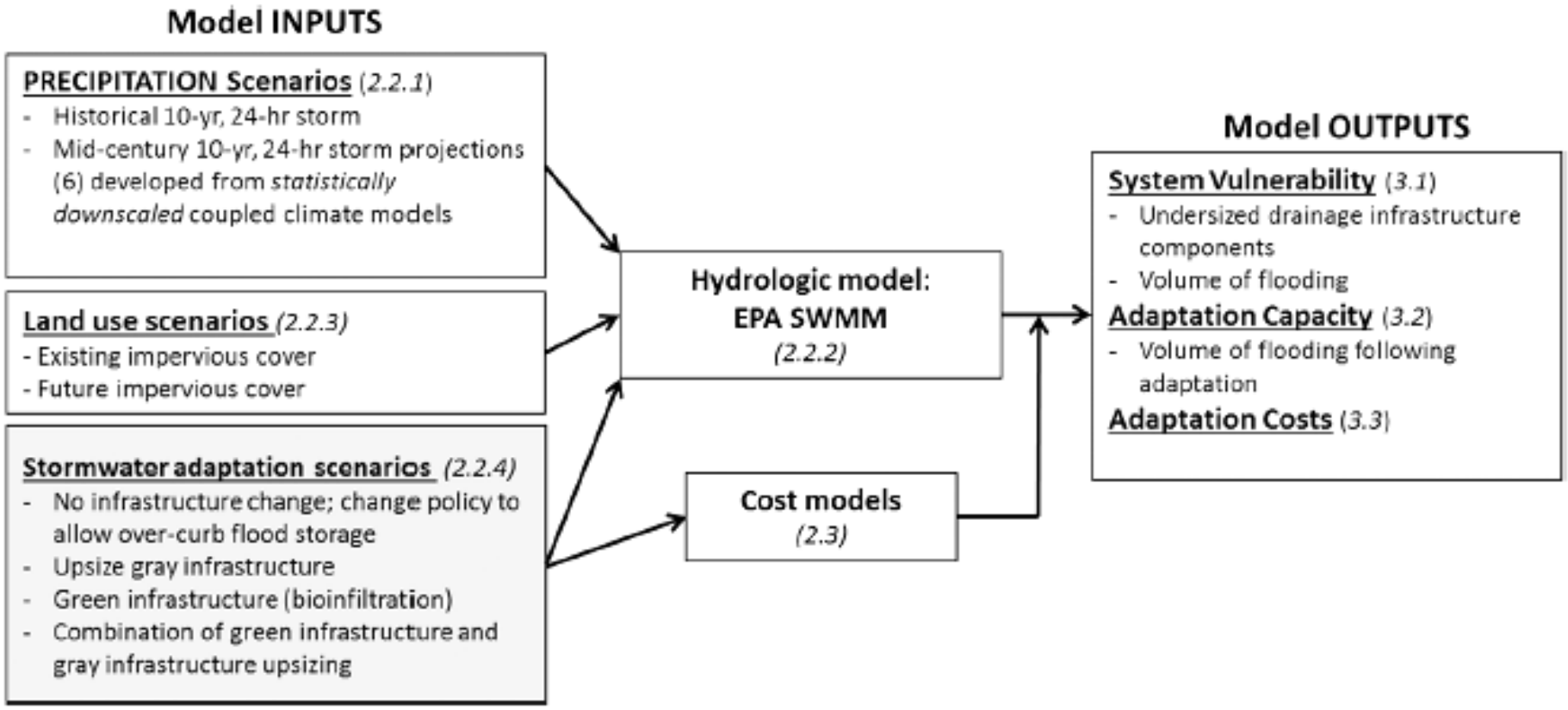
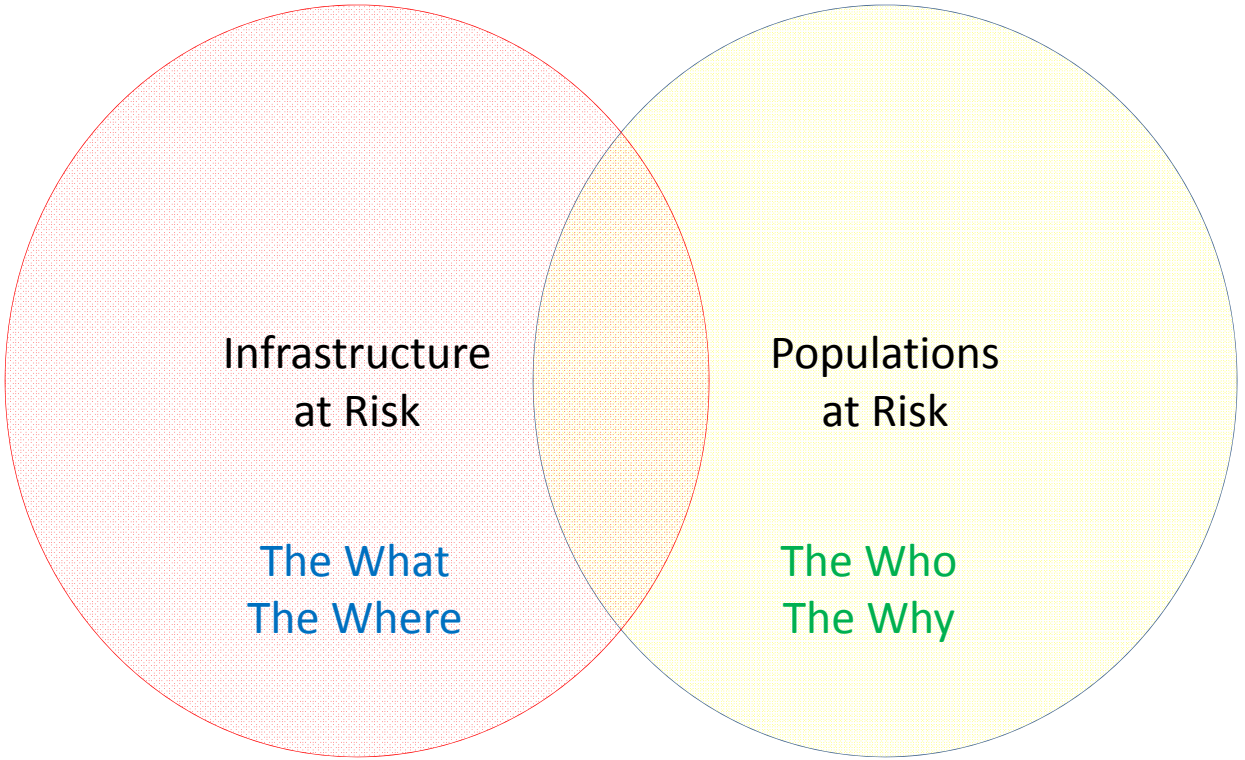


Fig. 2 Overview of study approach. Numbers in parentheses refer to the corresponding section in the text

Moore 2016

Assessing Vulnerability

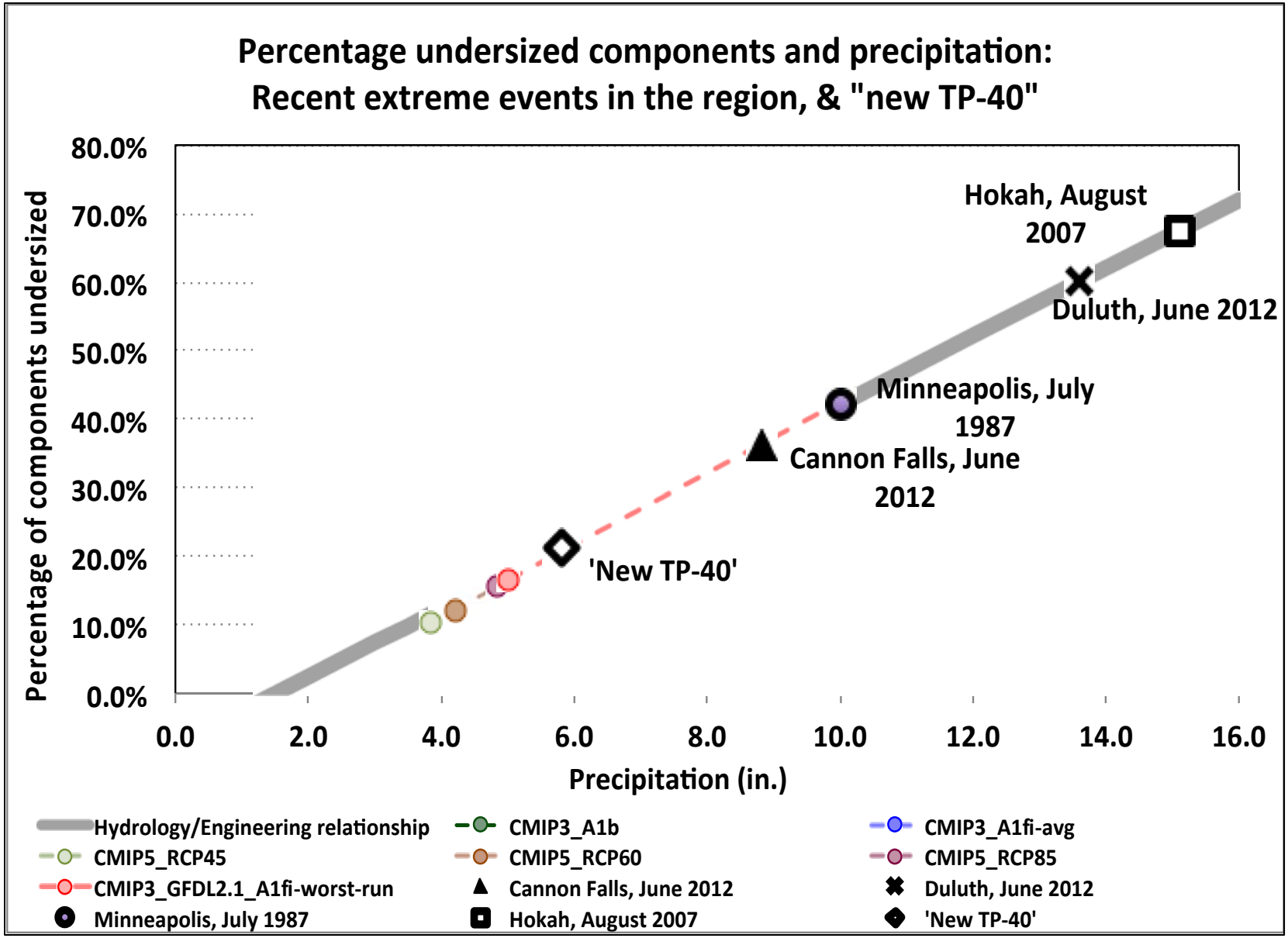


Downscaling GCMs:
to Project Potential Precipitation

Generation:	Model:	Grid_size:	Scenario:	Precip (in) ML	Precip (in) +95%ci	%Δ_over _recent_NCDC: ML	%Δ_over _recent_NCDC: +95%ci	% undersized components ML	% undersized components +95%ci
Historical	NCDC	Station	Recent	3.93				11%	
CMIP3	CM2.1	9-grid	A1b	4.81	7.53	22.3%	91.6%	15%	30%
CMIP3	CM2.1	9-grid	A1fi	5.09	7.08	29.5%	80.2%	17%	27%
CMIP3	CM2.1	6-grid	A1b	5.13	6.16	30.5%	56.7%	17%	23%
CMIP3	CM2.1	6-grid	A1fi	4.94	7.10	25.7%	80.7%	16%	27%
CMIP3	CM2.1	4-grid	A1b	4.15	6.16	5.6%	56.8%	12%	23%
CMIP3	CM2.1	4-grid	A1fi	4.99	10.13	27.1%	157.8%	16%	43%
CMIP3	PCM	9-grid	A1b	3.97	6.69	1.1%	70.3%	11%	25%
CMIP5	CCSM4	9-grid	rcp45	3.83	5.82	-2.5%	48.1%	10%	21%
CMIP5	CCSM4	9-grid	rcp60	4.25	6.06	8.1%	54.2%	13%	22%
CMIP5	CCSM4	9-grid	rcp85	4.08	6.09	3.8%	54.9%	12%	22%
CMIP5	CM3	9-grid	rcp60	4.29	7.29	9.2%	85.5%	13%	28%
CMIP5	CM3	9-grid	rcp85	5.18	7.88	31.9%	100.6%	17%	32%
CMIP5	CM3	6-grid	rcp60	4.08	6.33	3.7%	61.1%	12%	23%
CMIP5	CM3	6-grid	rcp85	5.66	7.67	44.1%	95.2%	18%	30%
Average, all GCMs/Scenarios/Grids:			A1b	4.51	6.63	14.9%	68.9%	14%	25%
			A1fi	5.01	8.07	27.4%	105.4%	16%	33%
			rcp45	3.83	5.82	-2.5%	48.1%	10%	21%
			rcp60	4.20	6.56	7.0%	66.9%	12%	25%
			rcp85	4.97	7.21	26.6%	83.6%	16%	28%

Climate modeling results: Current and Future

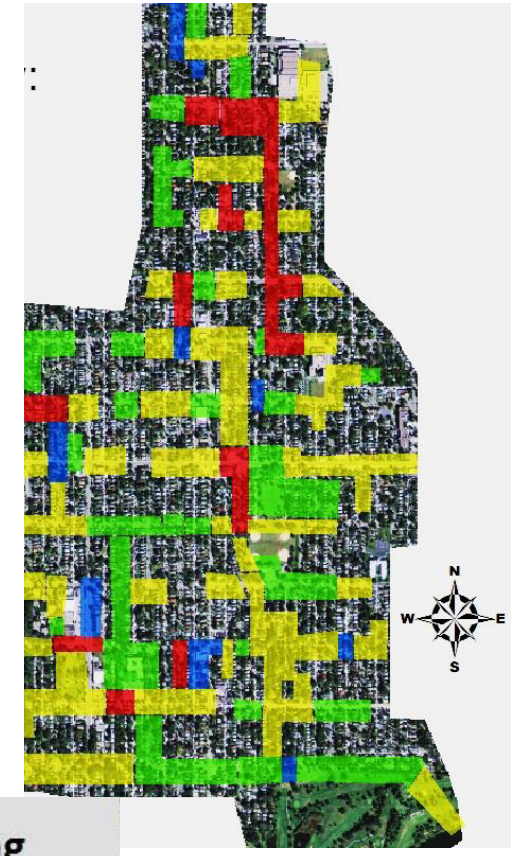
	Return period (years)	Recent climate	mid-21st cent. Optimistic	mid-21st cent. Moderate	mid-21st cent. Pessimistic
	2.5	2.5	2.84	3.3	6.86
	5	3.17	3.47	4.11	8.4
	7.5	3.57	3.88	4.66	9.39
"Design Storm"	10	3.86	4.19 +9%	6.56 +70%	10.13 +147%
	25	4.84	5.28	6.74	12.75
	50	5.67	6.22	8.31	15.03
	75	6.2	6.82	9.39	16.5
	100	6.59	7.27	10.23	17.59


Percentage undersized components and precipitation:
Recent extreme events in the region, & "new TP-40"
Percentage of components undersized
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Precipitation (in.)
Hokah, August 2007
Duluth, June 2012
Minneapolis, July 1987
Cannon Falls, June 2012
'New TP-40'
Hydrology/Engineering relationship
CMIP3_A1b
CMIP3_A1fi-avg
CMIP5_RCP45
CMIP5_RCP60
CMIP5_RCP85
CMIP3_GFDL2.1_A1fi-worst-run
Cannon Falls, June 2012
Duluth, June 2012
Minneapolis, July 1987
Hokah, August 2007
'New TP-40'

Minneapolis: Hiawatha Catchment

3.9 “

6.6 “

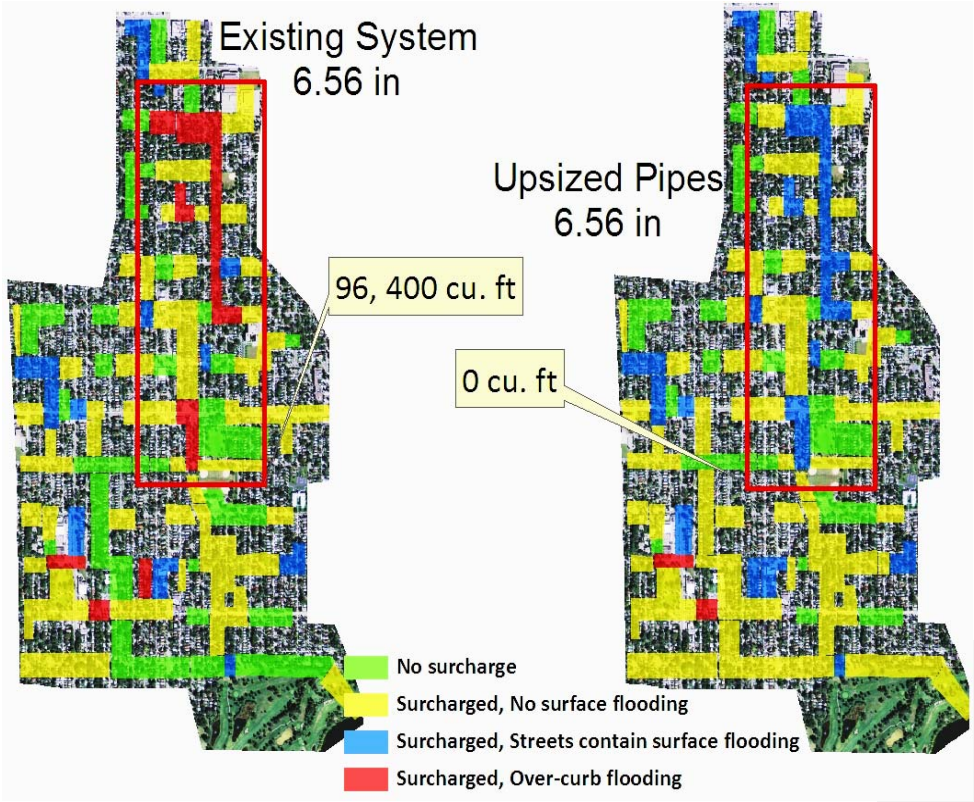


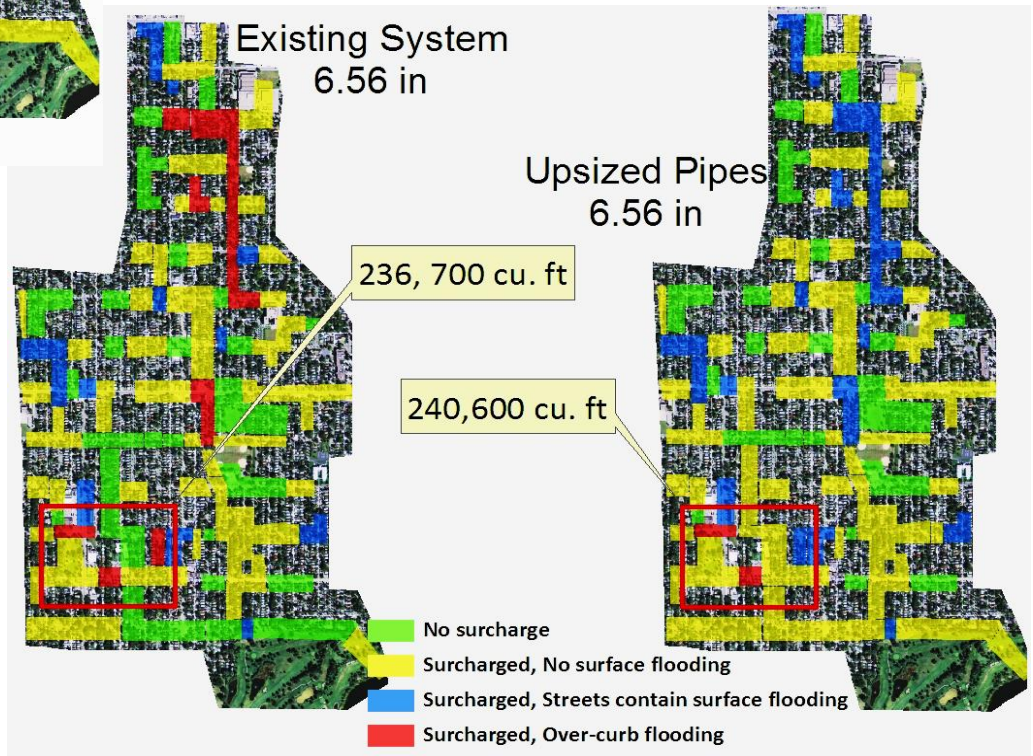
10.1 “

Pipe Adequacy and Surface Flooding

- No surcharge
- Surcharged, No surface flooding
- Surcharged, Streets contain surface flooding
- Surcharged, Over-curb flooding

10-yr Event	Flood Volume (over curb)	Increase Undersized Pipes to Eliminate Over- Curb Flooding	
	MG	Ft of Pipe	Cost
3.9”	2.92	3,439	$6.5M
6.6”	6.34	20,405	$38.8M
10.1”	34.11	---	---

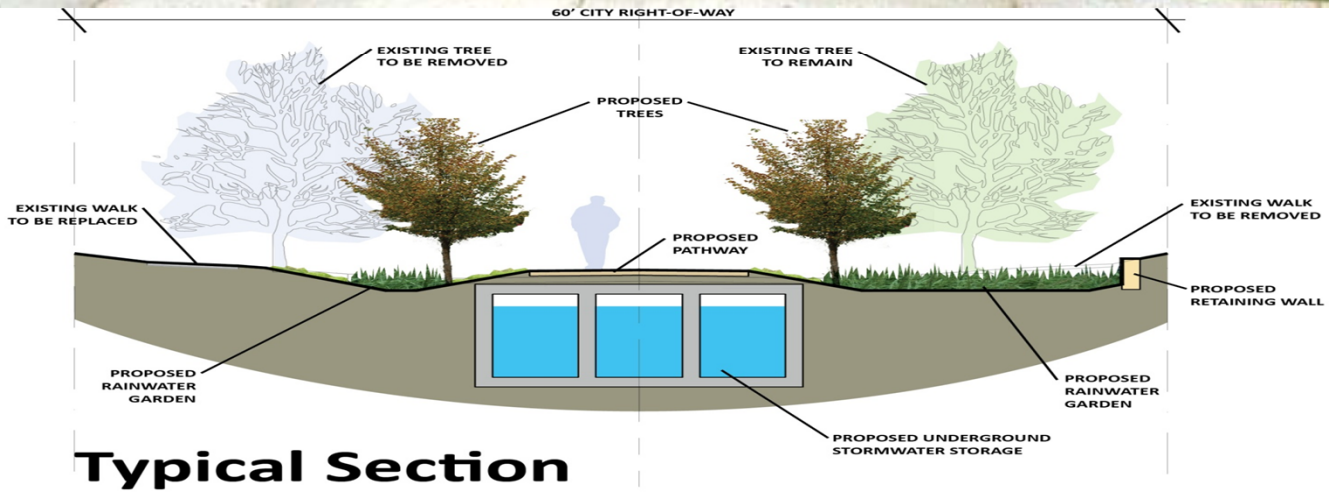

Existing System
6.56 in
Upsized Pipes
6.56 in
96, 400 cu. ft
0 cu. ft
No surcharge
Surcharged, No surface flooding
Surcharged, Streets contain surface flooding
Surcharged, Over-curb flooding


Existing System
6.56 in
Upsized Pipes
6.56 in
236, 700 cu. ft
240,600 cu. ft
No surcharge
Surcharged, No surface flooding
Surcharged, Streets contain surface flooding
Surcharged, Over-curb flooding

Flooding after Pipe Upsizing

Precipitation (inches)	Flooding (MG)	Street Flooding (storage) (MG)	Over-Curb Flooding (MG)	Over-Curb Flooding (acre-feet)
Hiawatha				
6.56	10.1	1.4	8.7	26
8.07	20.0	2.6	17.4	58
10.10	40.1	4.8	35.3	107
Victoria				
6.56	1.56	0.65	0.91	2.79
8.07	7.37	4.38	2.99	9.18
10.10	16.68	9.21	7.47	22.93

37th Avenue Greenway Flood Project (2011)

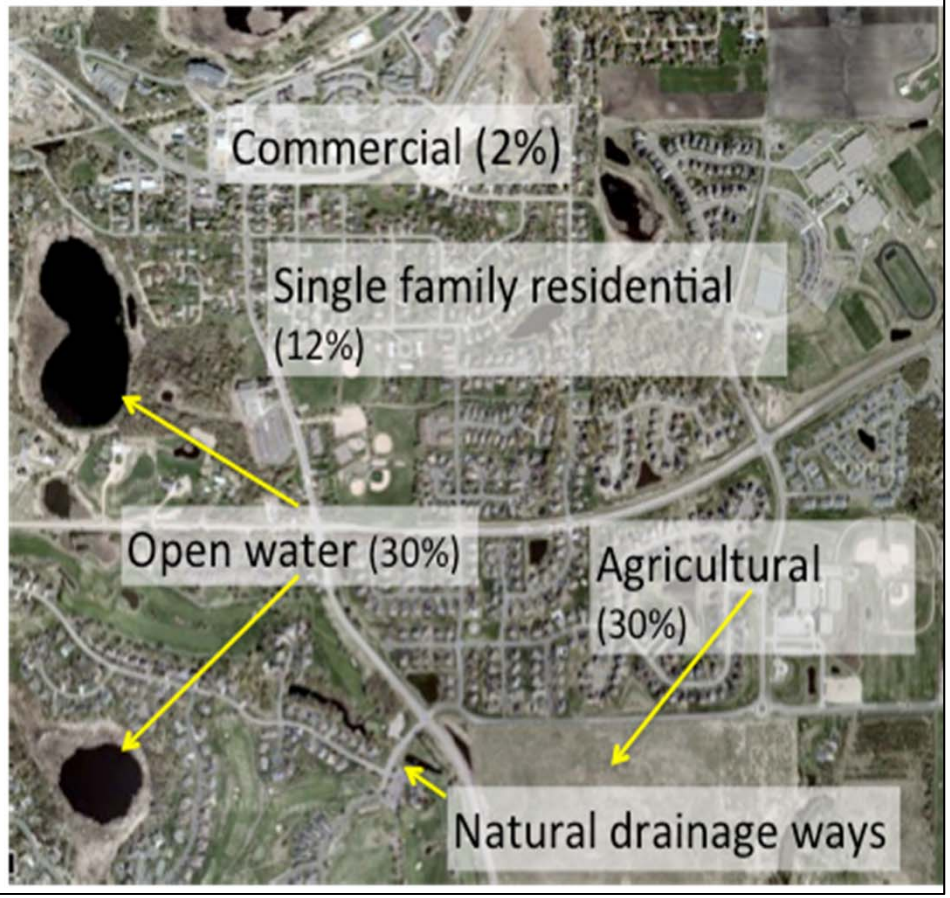


Typical Section

Upsizing Pipes cost/foot	Upsizing Pipes cost/MG	Dry Detention Basin cost/MG	Underground Storage cost/MG
$ 835	**$ 1,772,000** **($ 1.72/gal)**	**$ 107,000** **($ .11/gal)**	**$ 2,400,000** **($ 2.40/gal)**

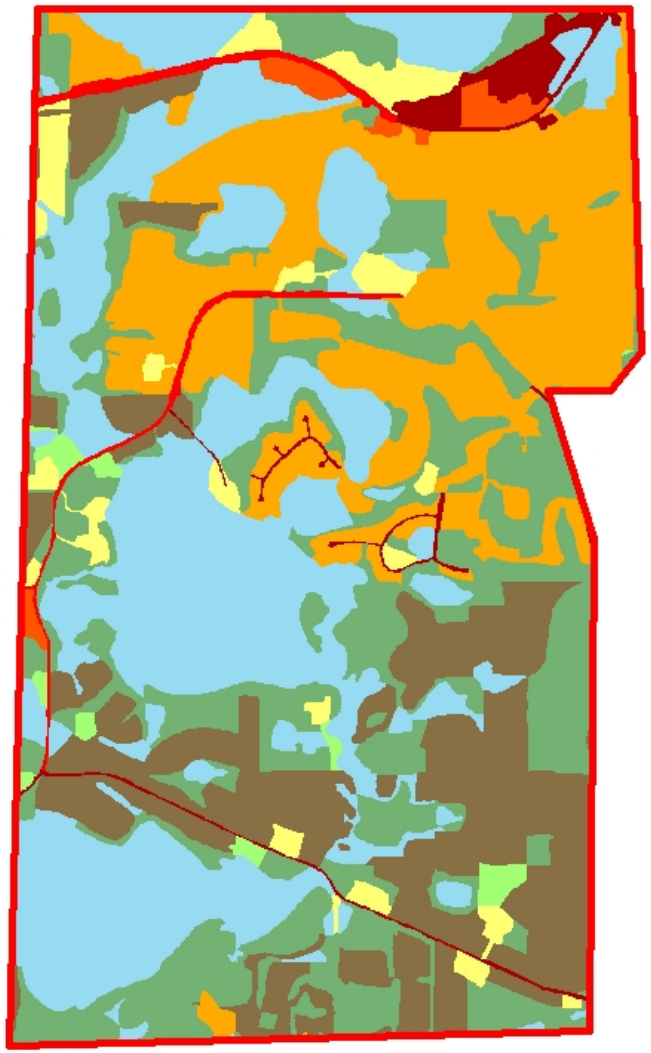
Victoria Land-use & SW Infrastructure

- **Land Use**
  - Primarily agricultural (30%) and open water (30%)
  - Downtown commercial (2%) and residential (12%)
- **Existing stormwater infrastructure**
  - 43 stormwater ponds
  - 25 pipe miles



Local Growth and Land Use Changes

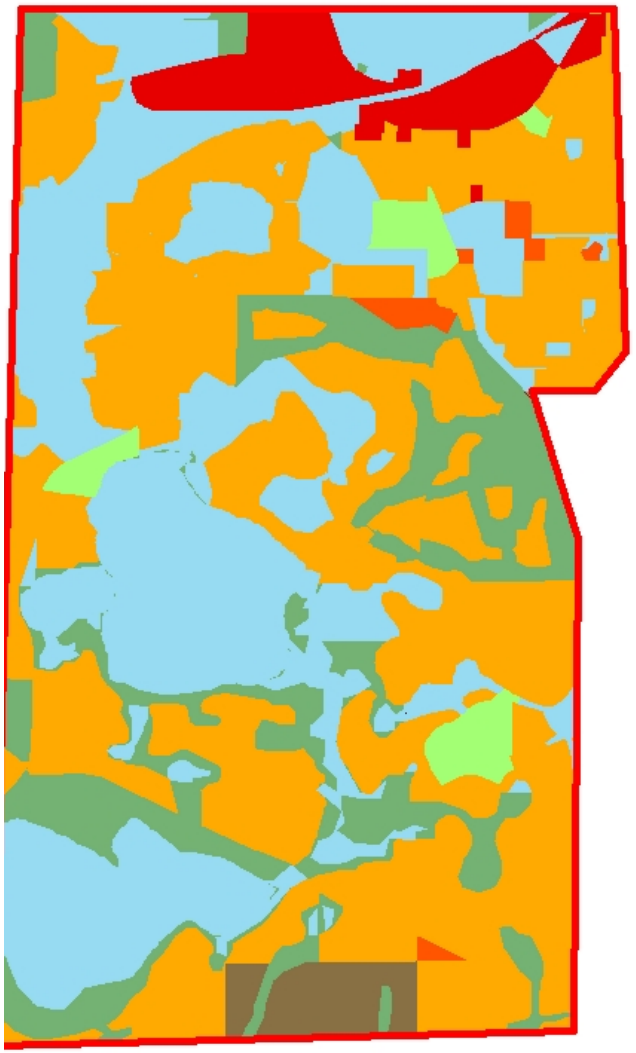
Existing



Land Use

- Forest or grass
- Open water / wetland
- Agriculture
- 4% to10% impervious
- 11% to25% impervious
- 26 to50% impervious
- 51% to75% impervious
- 76% to 90% impervious
- 90% to100% impervious

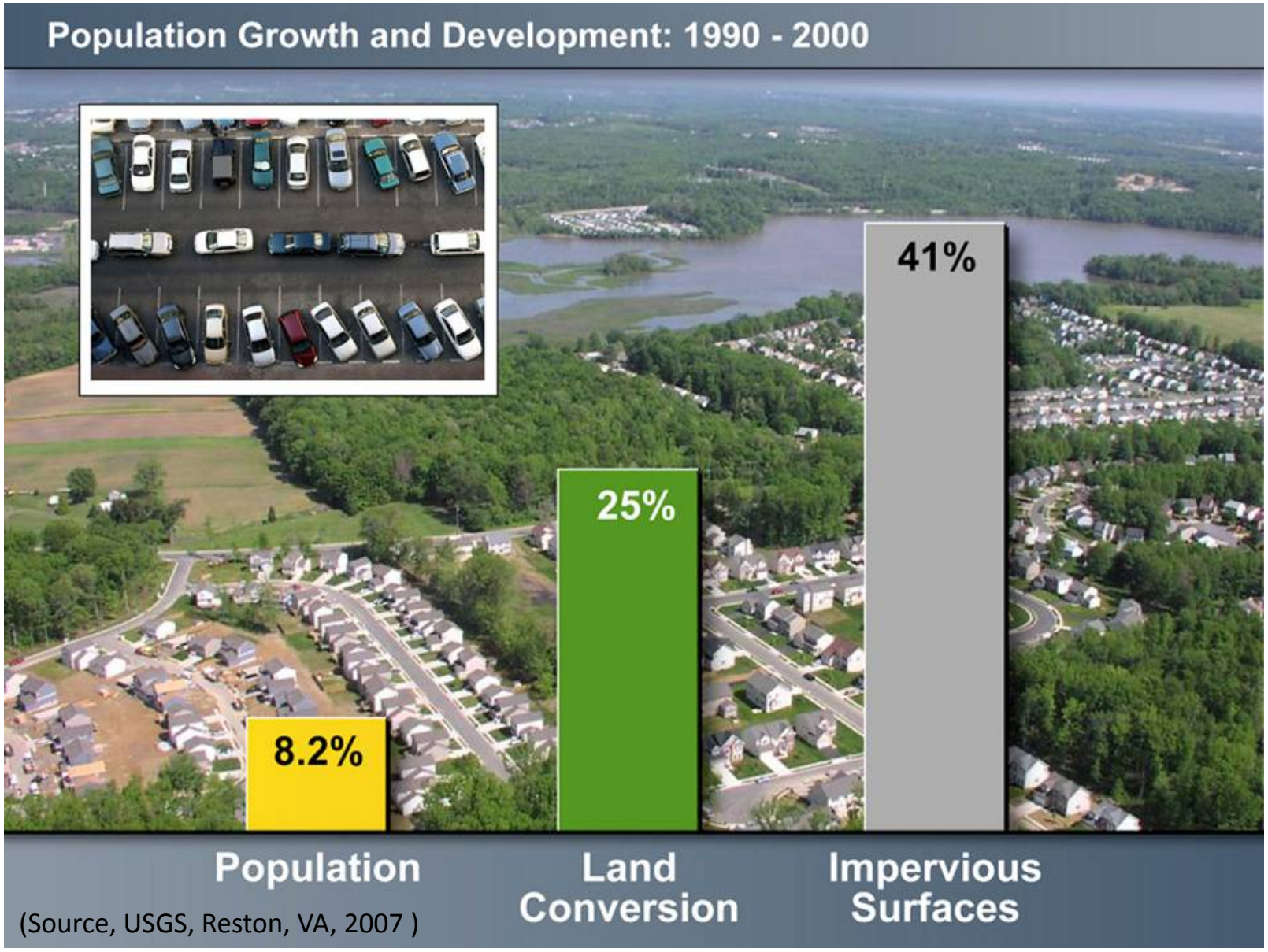
2030 Comp Plan



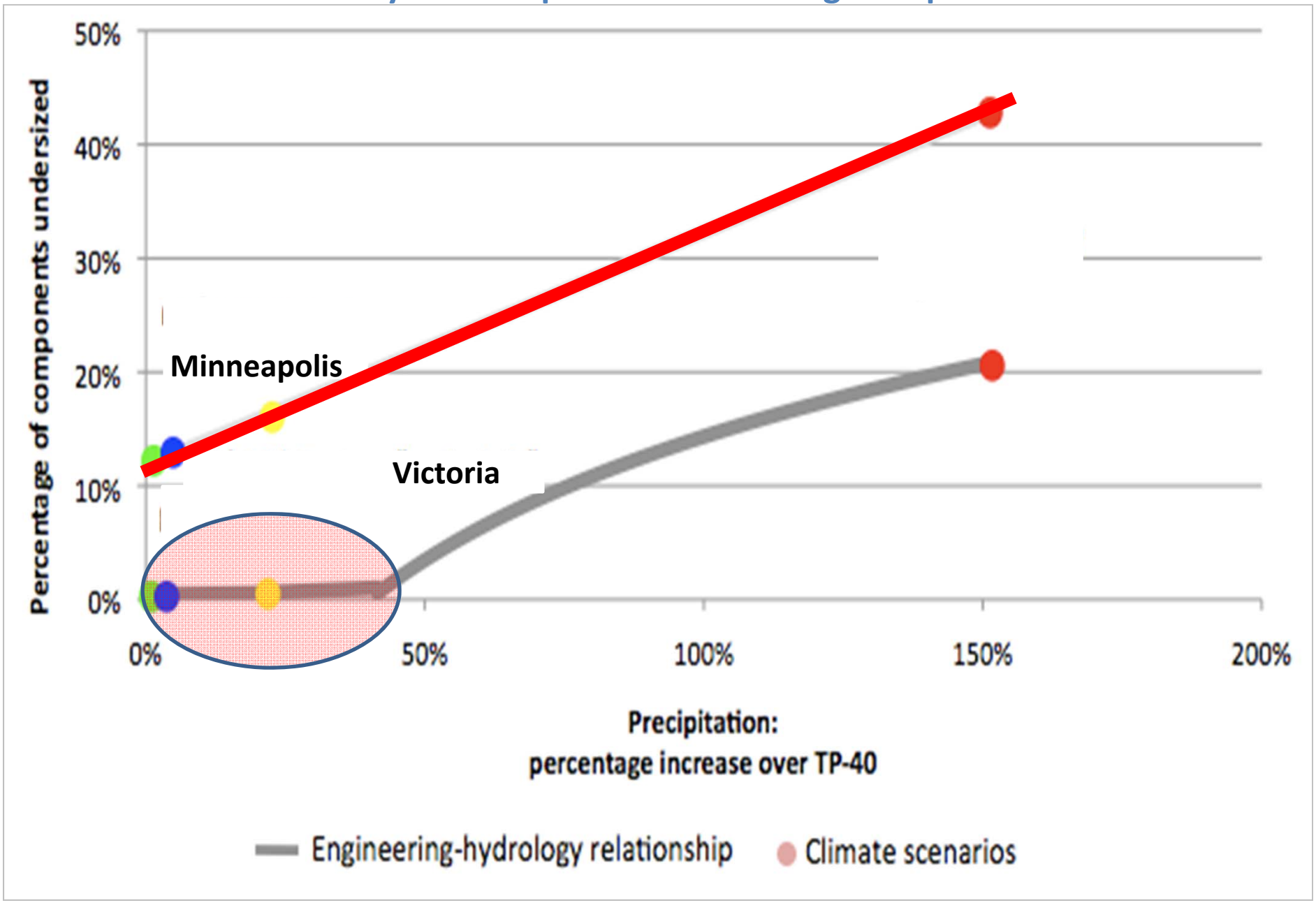
A Changing Landscape

UCONN Cooperative Extension

Changing Trends: Increasing Impervious Surfaces

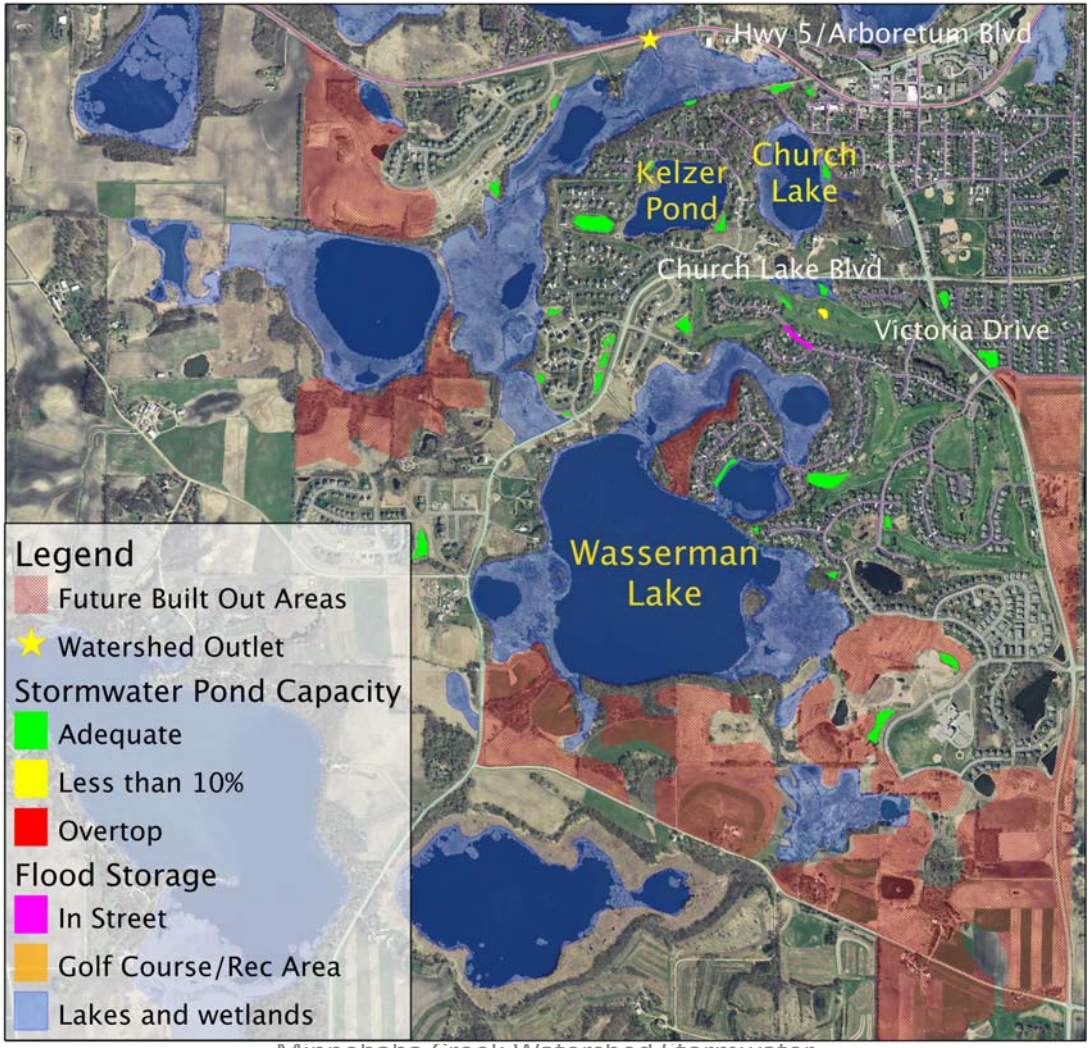


System Response to Increasing Precipitation



City of Victoria

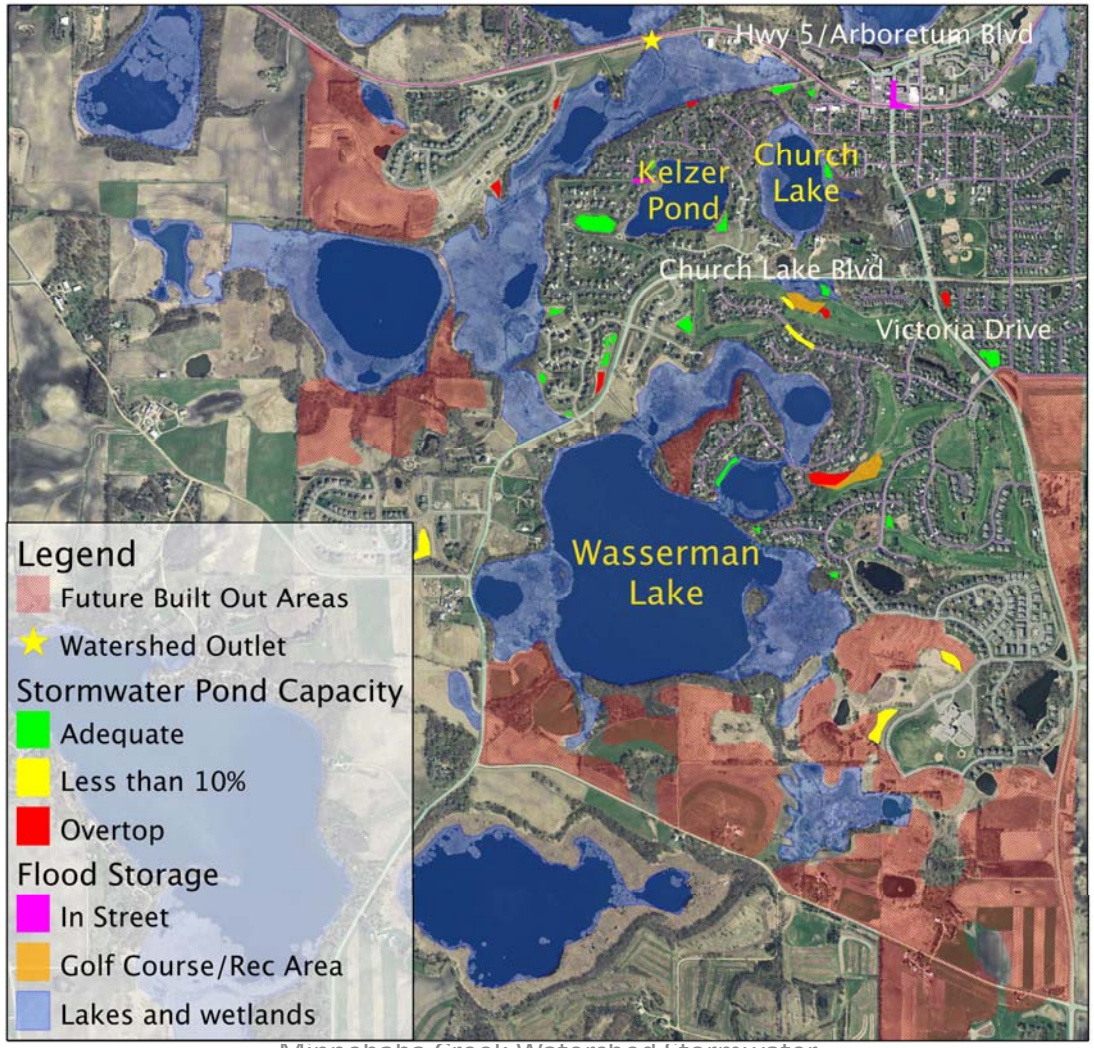
Recent Storms - 3.9” in 24 hrs



City of Victoria

Moderate Projection - 6.6” in 24 hrs

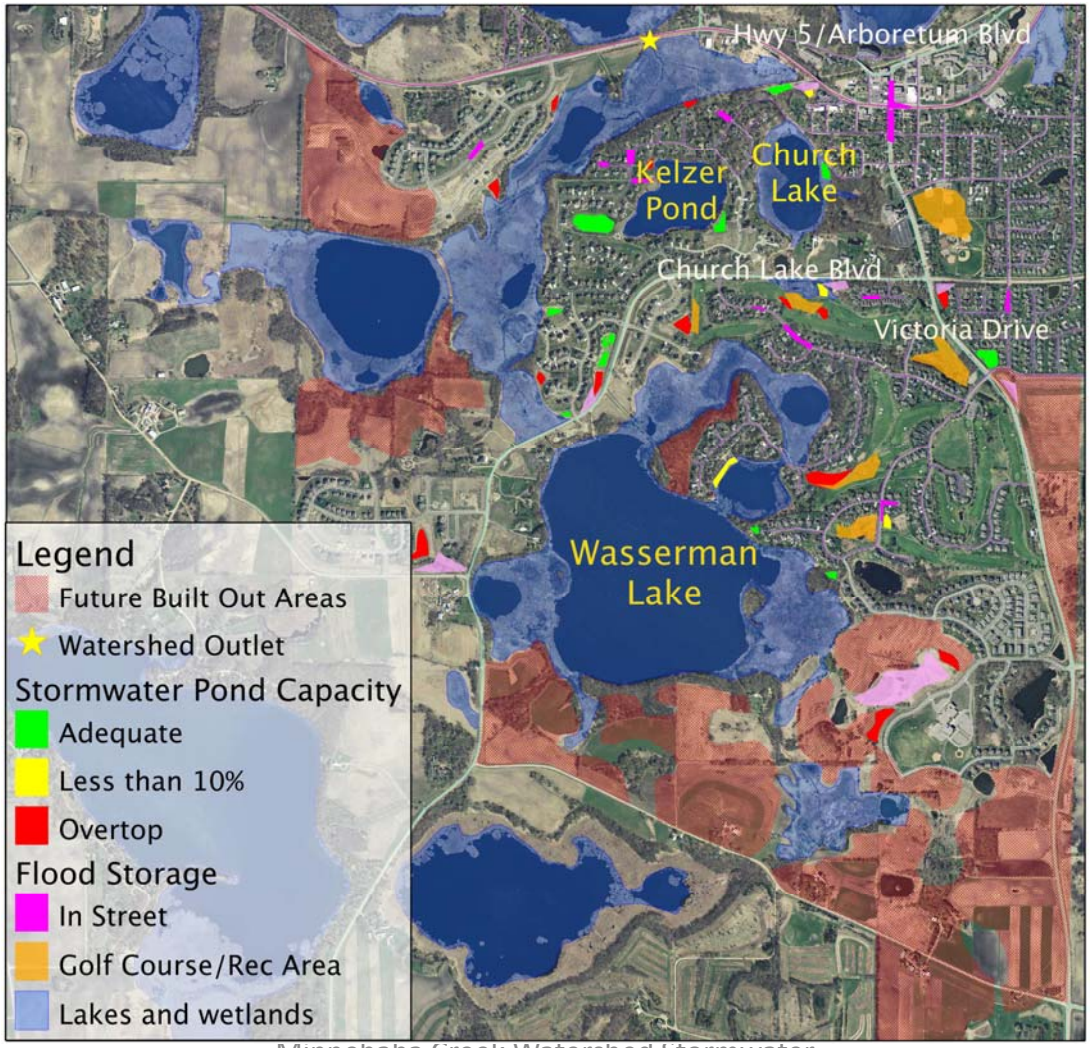
- Increased flooding in some existing ponds
- Some street flooding expected
- Increased flooding in low lying areas



City of Victoria

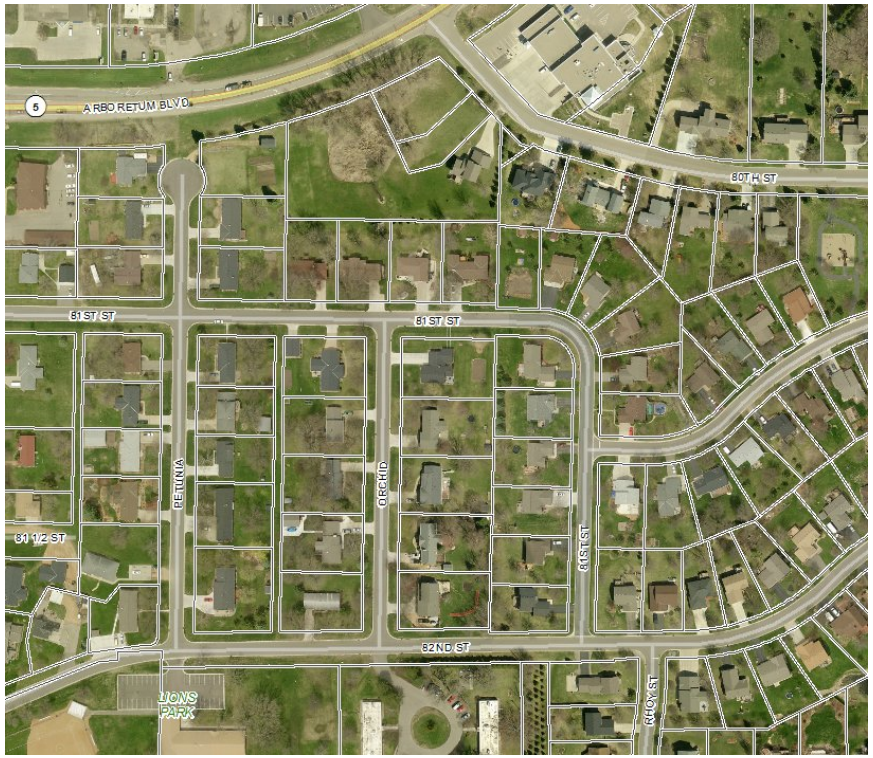
Pessimistic Projection - 10.1” in 24 hrs

- Many ponds overtopped
- More streets flooded
- Significant flooding in recreational areas



The Influence of the City of Victoria Plans and Policies: Looking Ahead and Looking Back

Stormwater Management Two Stage: 100 yr design



The Influence of the City of Victoria Plans and Policies: Looking Ahead and Looking Back

Key policies that increased resilience:

- Shoreland Ordinance
- Wetlands and Buffer required
- Strategic Park Dedication
- Woodland Protection/Preservation
- Stormwater Management Fee Structure

Flooding after Pipe Upsizing

Precipitation (inches)	Flooding (MG)	Street Flooding (storage) (MG)	Over-Curb Flooding (MG)	Over-Curb Flooding (acre-feet)
Hiawatha				
6.56	10.1	1.4	8.7	26
8.07	20.0	2.6	17.4	58
10.10	40.1	4.8	35.3	107
Victoria				
6.56	1.56	0.65	0.91	2.79
8.07	7.37	4.38	2.99	9.18
10.10	16.68	9.21	7.47	22.93

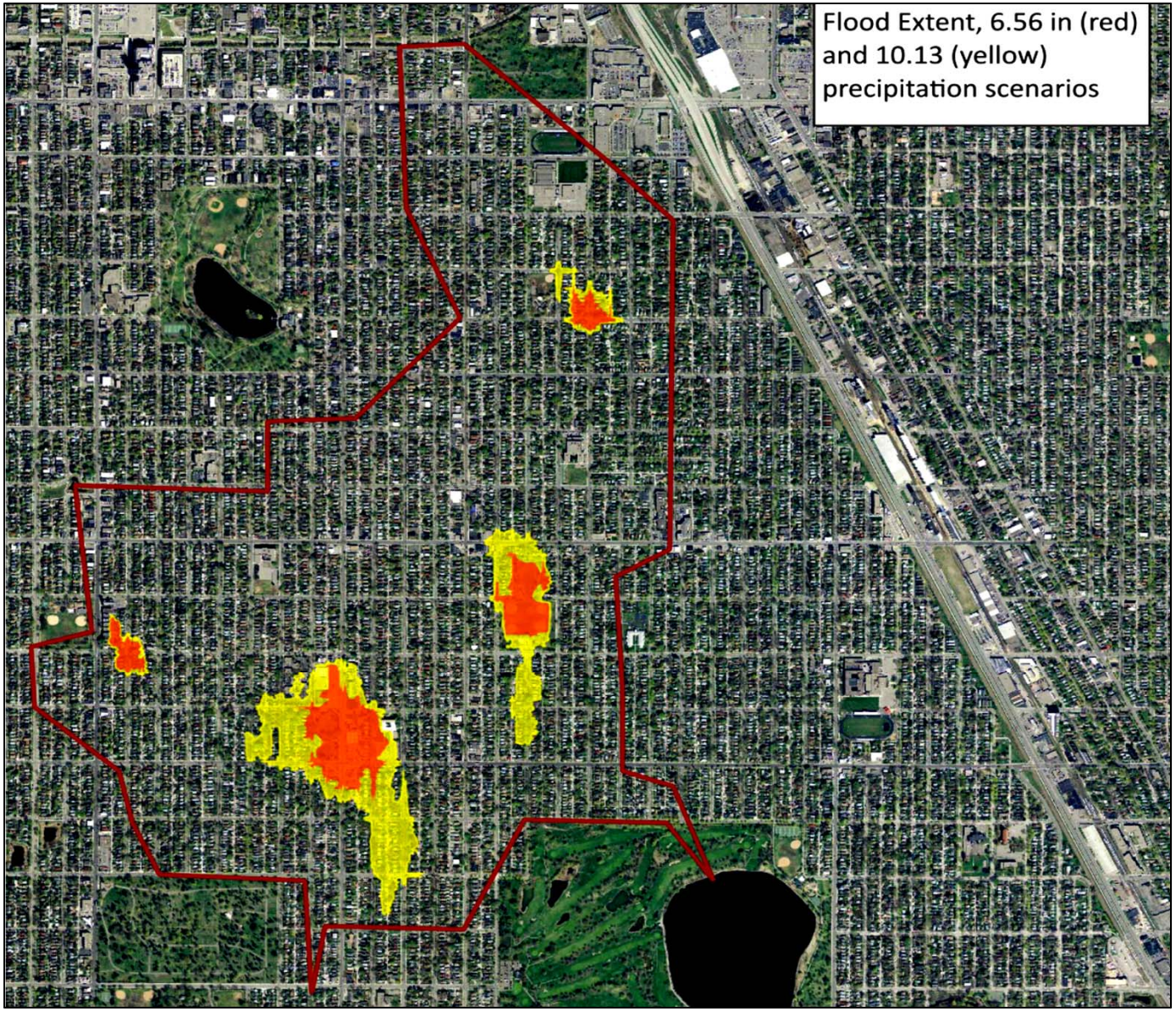
So…where to put the water????

June 2014

Minneapolis, MN

Minnehaha Creek Watershed

Star Tribune


Flood Extent, 6.56 in (red)
and 10.13 (yellow)
precipitation scenarios

		Estimated damage from USACE tables		
Precip (in.)	Over-curb flood volume (MG)	Structure	Contents	Total
3.93	0.86	0	0	0
4.77	1.62	40,881	25,511	66,392
6.56	5.91	638,554	393,863	1,032,418
8.07	14.80	1,195,716	729,412	1,925,128
10.1	34.49	3,378,716	2,041,796	5,420,512

$ 41,000 - $ 157,000 per MG

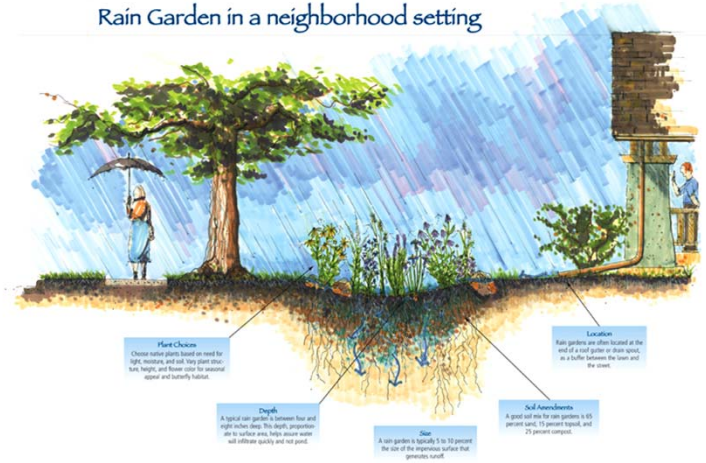
Per Flood

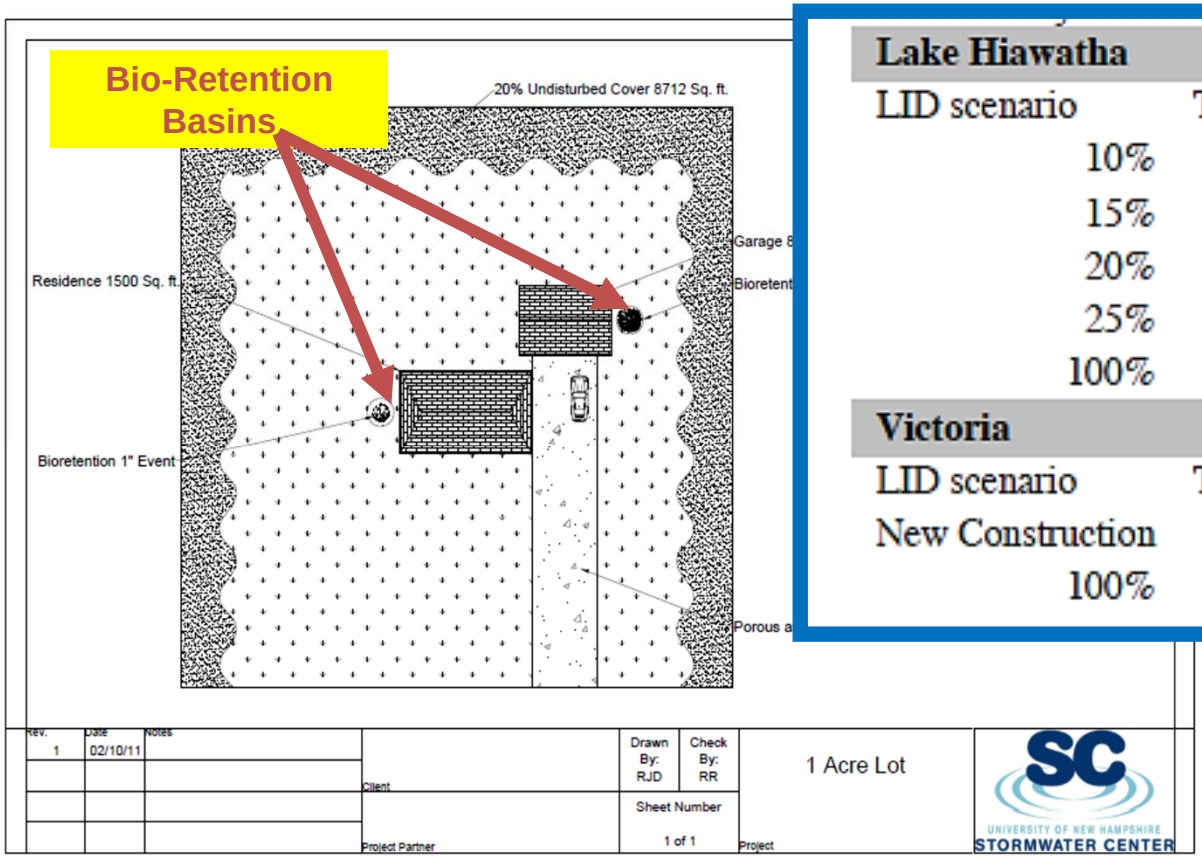
$ 41,000 - $ 157,000 per MG

Upsizing Pipes cost/MG	Dry Detention Basin cost/MG	Underground Storage cost/MG
$ 1,772,000	**$ 107,000**	**$ 2,400,000**
($ 1.72/gal)	**($ .11/gal)**	**($ 2.40/gal)**

Green infrastructure as a Climate Adaptation Tool

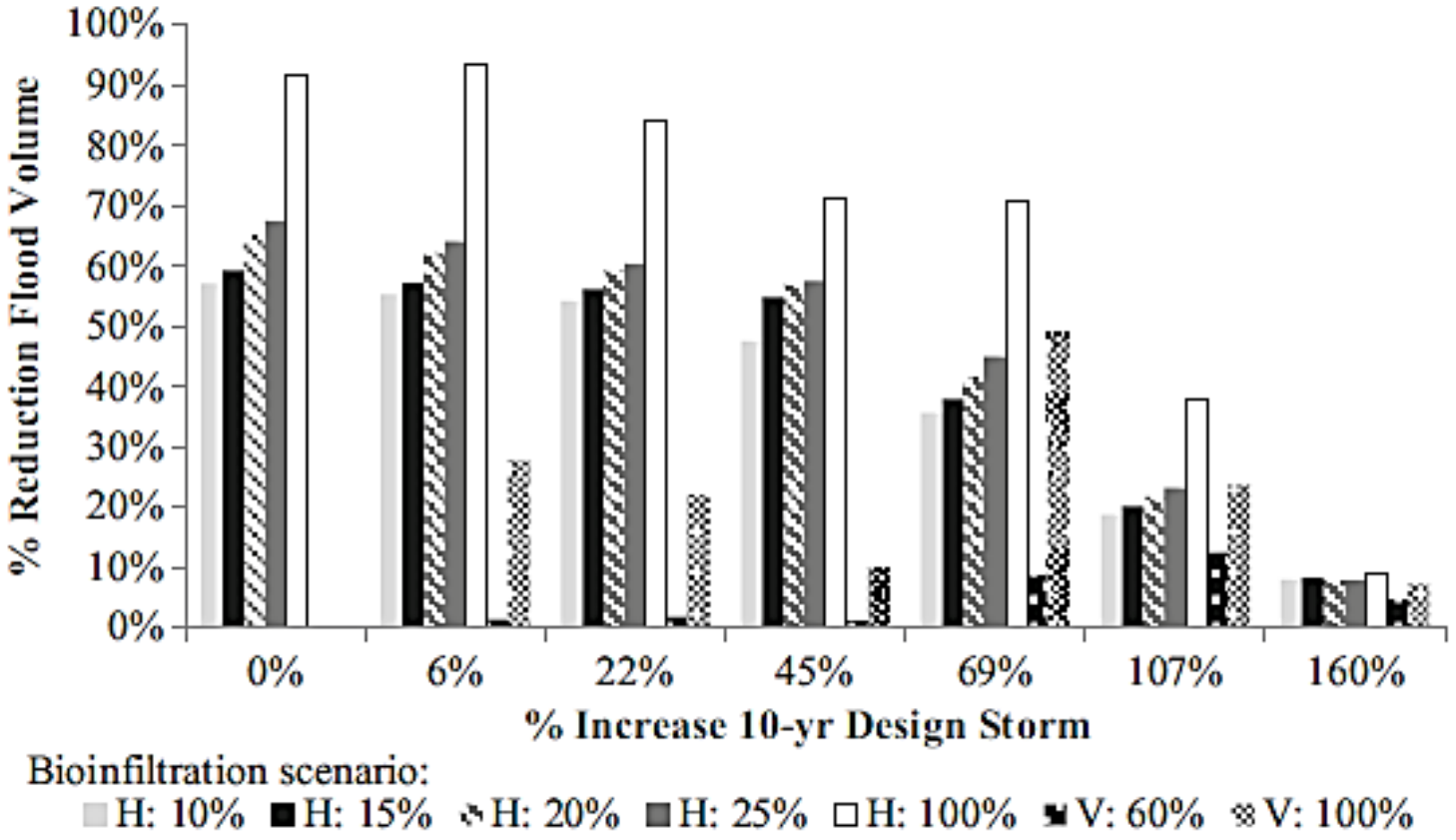
What Can be Done to Accommodate Impact



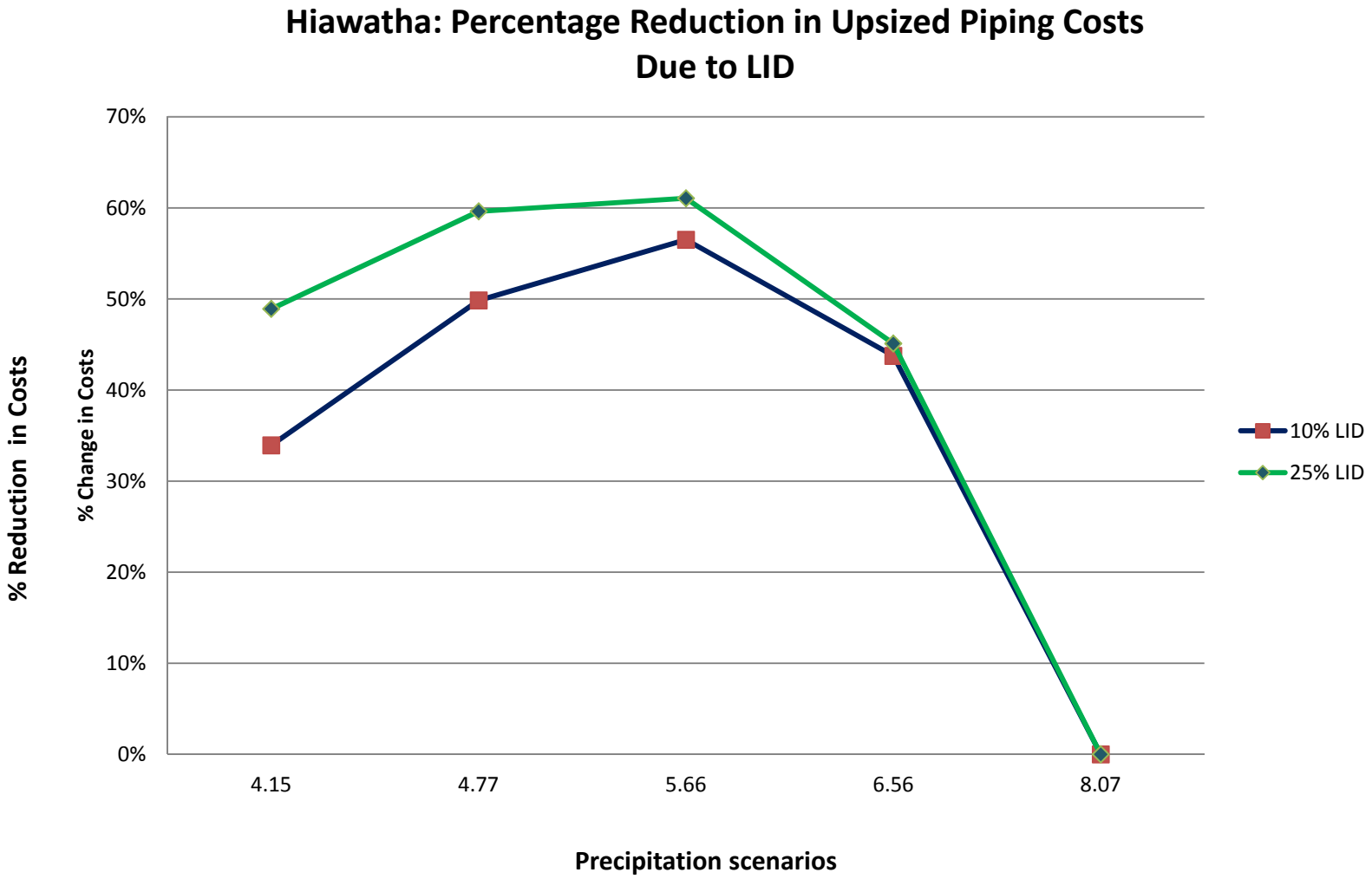


Lake Hiawatha		
LID scenario	Total area (Ac)	Total Volume (MG)
10%	3.4	1.1
15%	5.2	1.7
20%	7.1	2.3
25%	8.9	2.9
100%	34.5	11.3
Victoria		
LID scenario	Total area (Ac)	Total Volume (MG)
New Construction	15.6	5.1
100%	26.5	8.6

Percentage in Flood Volume Reduction w/ implementation of LID



Moore 2016


Hiawatha: Percentage Reduction in Upsized Piping Costs Due to LID
% Reduction in Costs
% Change in Costs
70%
60%
50%
40%
30%
20%
10%
0%
4.15
4.77
5.66
6.56
8.07
Precipitation scenarios
10% LID
25% LID

Costs for Adaptation – City of Mpls (Prelim.)

10-yr Event	Flood Volume (over curb)	Increase Undersized Pipes to Eliminate Over- Curb Flooding		Dry Basin Storage	Under-ground Storage	50% LID - Impact on Peak Flow*
	MG	Ft of Pipe	Cost	Cost	Cost	% Reduced
3.9”	2.92	3,439	$6.5M	$0	$0	-39%
6.6”	6.34	20,405	$38.8M	$151K	$9.8M	-38%
10.1”	34.11	---	---	$715K	$46.5M	-28%

*LID does not provide effective flood control during large storm events

Some Results....

1. **Modeled predictions for precipitation is ~6-10” of rain for a 10-yr event by mid-21st Century.**

2. **In Minneapolis, curb to curb flood storage is expected. Over-curb flooding is expected to increase.**

3. **In Victoria, no significant infrastructure damage is expected, even under pessimistic conditions. Some increase of surface flooding in low lying/recreational areas would be expected.**

4. **In Victoria, past policies and plans have led to the ability of the community to absorb increases in precipitation.**

5. **Adaptation options can manage flood volumes at varying costs.**

6. **Low Impact Development can reduce some flood volume and infrastructure upgrade costs. However, LID provides water quality benefits.**

Strategies for Communities

1. **Use hydrologic models and tools**
2. **Complete vulnerability and risk assessments**
3. **Identify adaptation options and costs**
4. **Involve stakeholders to:**
   - Educate and communicate need for adaptation planning
   - Address land use planning /design standards
   - Adopt assessment tools, reduce impervious cover, promote Low Impact Development
   - Identify funding sources

Involve stakeholders to:

- Educate and communicate need for adaptation planning
- Address land use planning /design standards
- Adopt assessment tools, reduce impervious cover, promote Low Impact Development
- Identify funding sources
- Provide political support to elected and appointed officials

Climatic Change
DOI 10.1007/s10584-016-1766-2

Stormwater management and climate change: vulnerability and capacity for adaptation in urban and suburban contexts

Trisha L. Moore[1] · John S. Gulliver[2] · Latham Stack[3] · Michael H. Simpson[4]

Received: 21 September 2015 / Accepted: 27 July 2016

http://www.communityresilience-center.org/applied-research/

Enhancing climate change adaptation: strategies for community engagement and university-community partnerships

James S. Gruber, Jason L. Rhoades, Michael Simpson, Latham Stack, Leslie Yetka & Robert Wood

Journal of Environmental Studies and Sciences

ISSN 2190-6483

J Environ Stud Sci
DOI 10.1007/s13412-015-0232-1

Springer

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Antioch University New England

Weathering Change: Local Solutions for Strong Communities

September 20, 2017 12:00 – 1:15 PM EDT

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

AUDIENCE QUESTIONS

- **Submit your questions using the side panel Q&A**
- **Send to All Panelists**

Presenter:
Michael Simpson
Antioch University
New England

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

Mission: Strengthen communities to prepare, respond and recover in the face of climate impacts and other disruptions through collaborative, innovative solutions.

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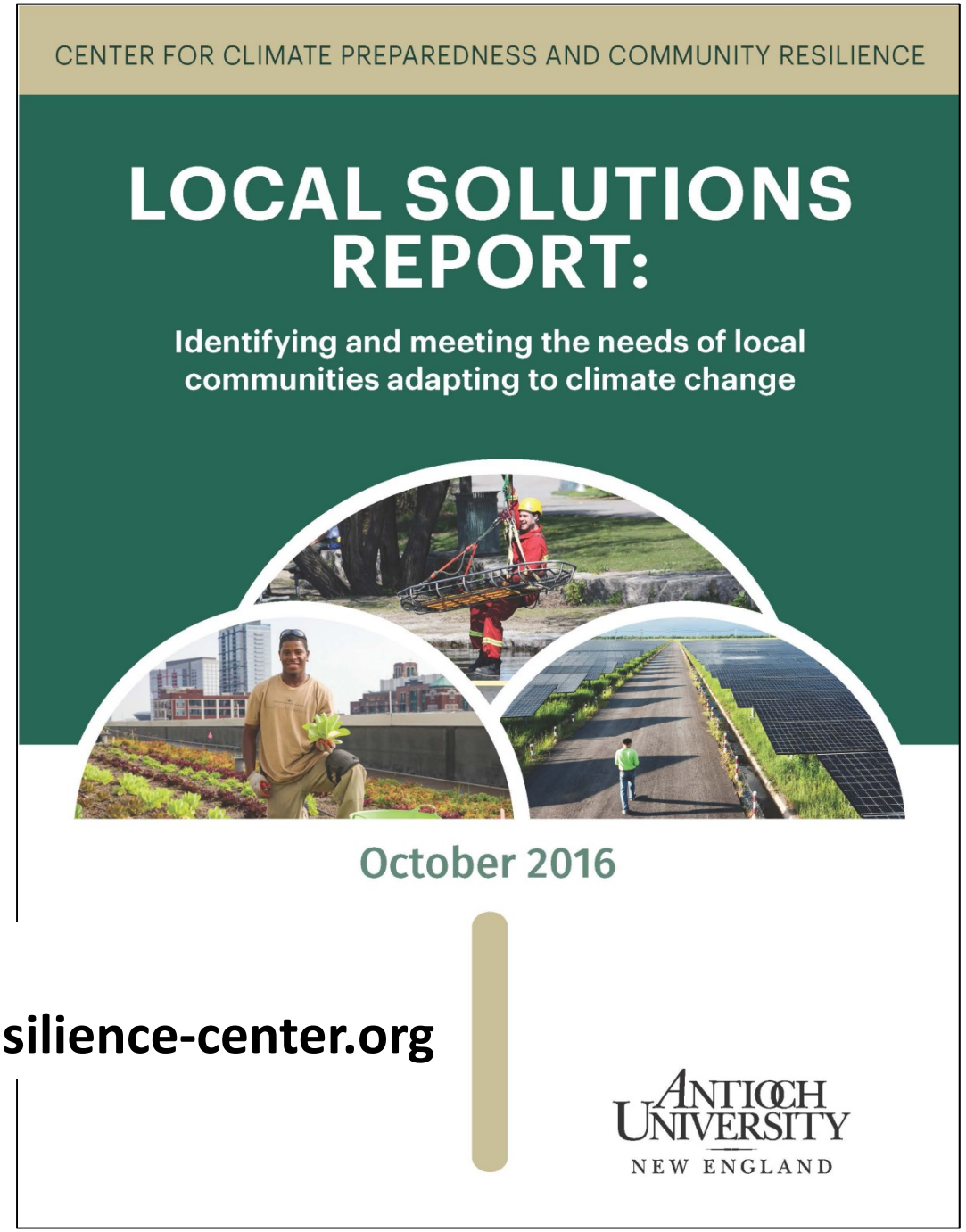


Download the report at
http://www.communityresilience-center.org

ANTIOCH UNIVERSITY

2018
Climate Preparedness Conference:
Local Solutions

ANTIOCH UNIVERSITY NEW ENGLAND

Weathering Change: Local Solutions for Strong Communities

October 18, 2017 12:00 – 1:15 PM EDT

Enhancing the Resilience of Seniors in Your Community

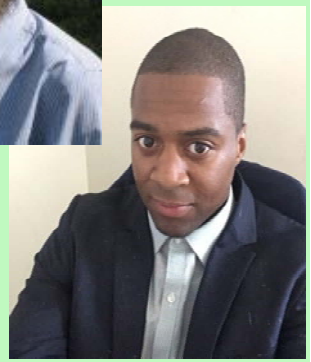
This webinar will focus on the safety and well-being of seniors within the context of climate change. Using a participatory adaptation planning process conducted with members of the senior community in Bridgeport Connecticut as a case study, the presentation will describe seniors' unique characteristics that put them at risk to climate change and will share specific recommendations to enhance their resilience.

Participants will leave the webinar with:

- An understanding of the key factors contributing to seniors' vulnerability;
- Specific recommendations for enhancing seniors' resilience;
- A structured process for engaging seniors and other vulnerable groups in participatory adaptation planning;
- An awareness of considerations when integrating efforts aimed at safeguarding seniors within the context of broader municipal emergency preparedness efforts;
- Insight into how and why to develop municipality-university collaborations to protect seniors and other vulnerable groups.

Presenters:

Jason Rhoades Ph.D.,
Antioch University New England



Terron Jones,
City of Bridgeport CT

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AICP CM credit 1.25 credits pending

Antioch University New England

Weathering Change: Local Solutions for Strong Communities

September 20, 2017 12:00 – 1:15 PM EDT

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

Thank You

Please take the time to fill out the evaluation for this webinar

…so we can continue bring you the topics that are most useful for you

Center for Climate Preparedness and Community Resilience

http://www.communityresilience-center.org/

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