# Design Response to flooding issues City of Madison, WI

City Engineering
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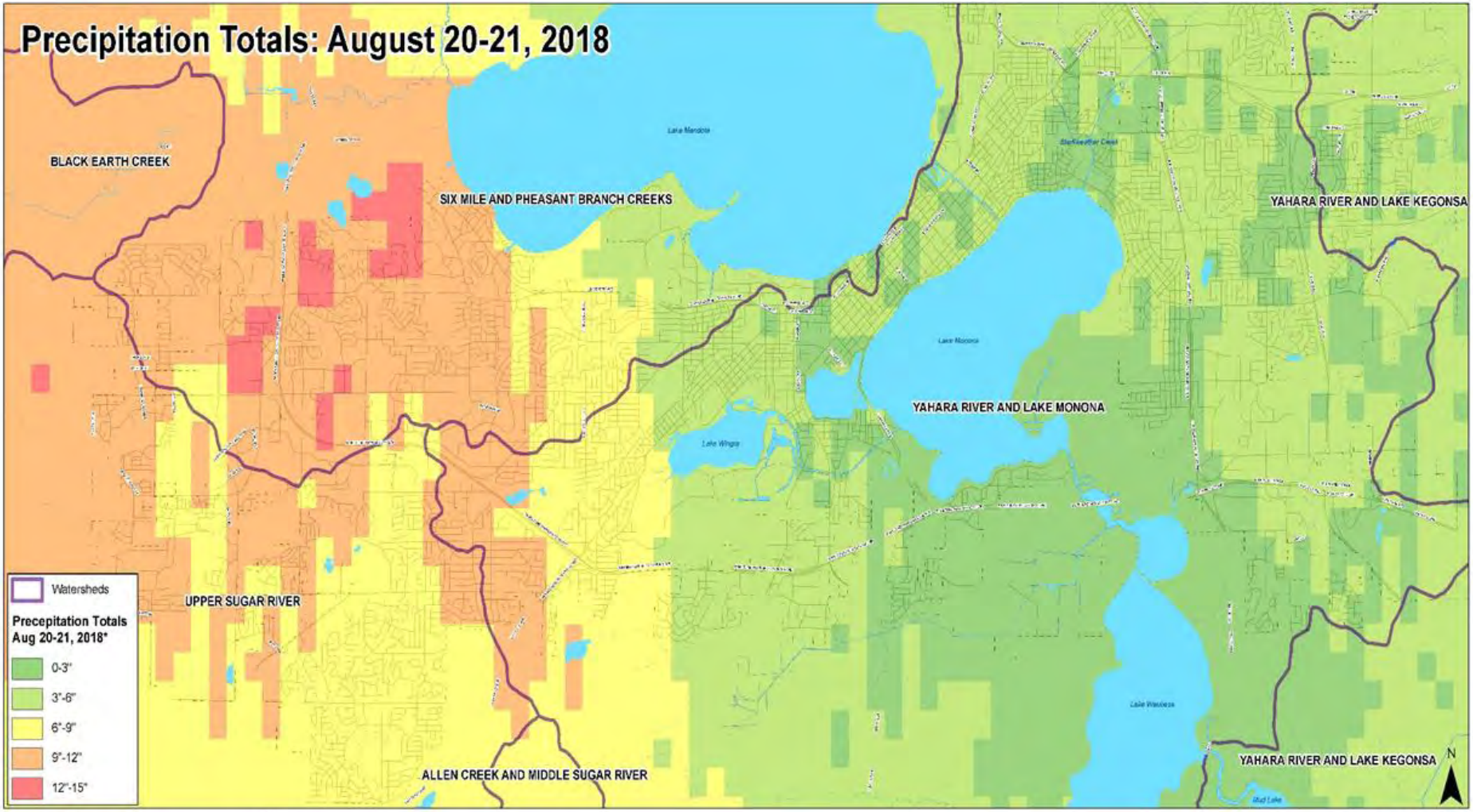
# Presentation Overview

- **BRIEF** FLOODING REVIEW - AUGUST 2018/19
  - Flash Flooding (2018)
  - Lake Level Flooding (2018/19)
- WHAT DOES THE FUTURE HOLD
  - Climate Change Concerns
  - Changing Rainfall Patterns
- CITY OF MADISON ORDINANCES
  - Design Changes
  - Existing Stormwater Ordinance
  - Proposed Ordinance Modifications
- CONTINUED EFFORTS
  - Watershed Studies
  - Green Infrastructure

Flooding in Madison as a result of August 20, 2018 storm event had two parts:

1) Urban Flash Flooding
2) Lake Level Flooding

# Flash Flooding Rainfall August 20/21, 2018




KMKX Radar that was "bias corrected" using rain gauges by UW Professor Dan Wright

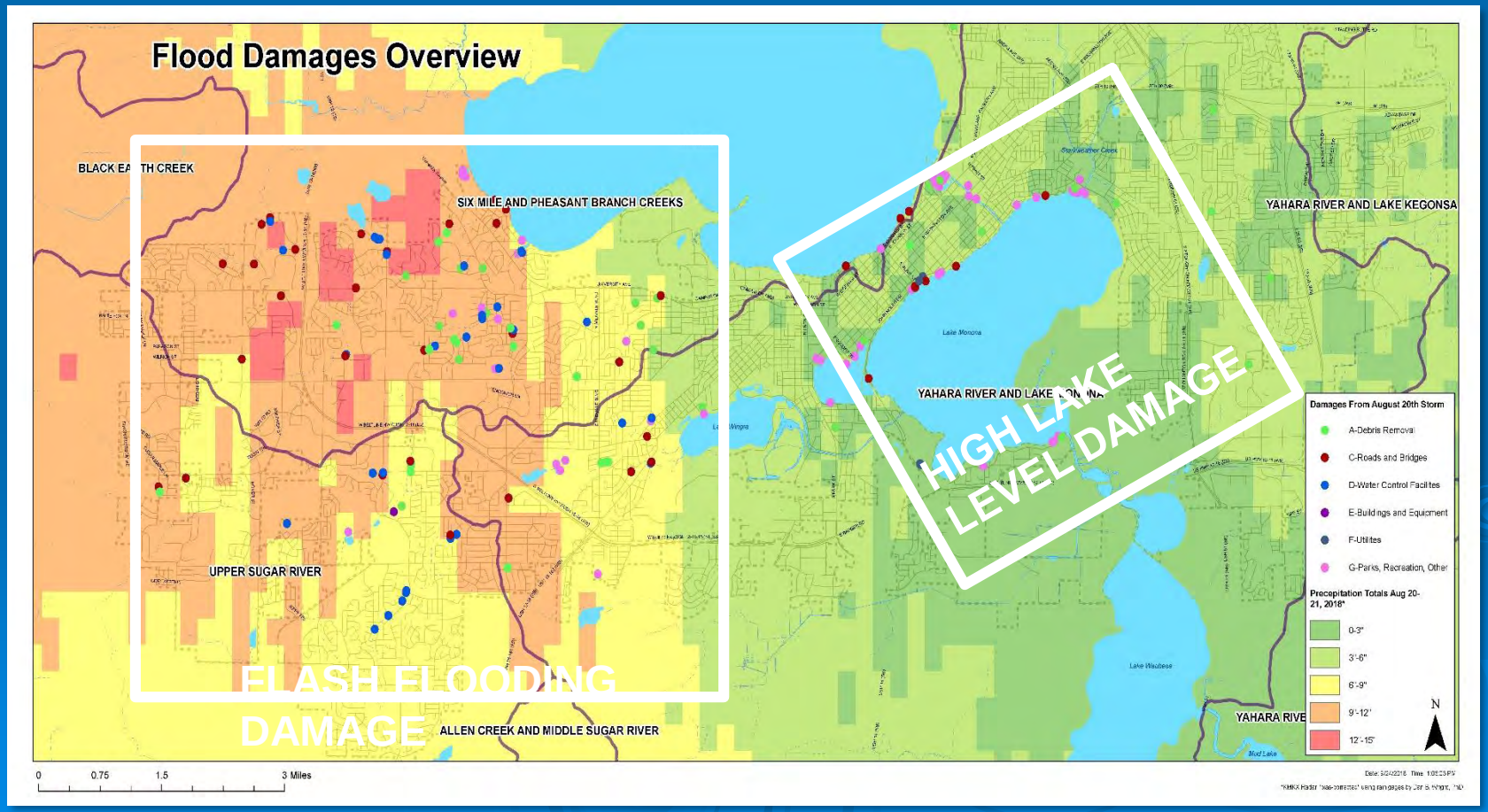
# Historic Flooding: Flash Flooding


## Recurrence Interval

**PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]**

| Duration | Average recurrence interval (years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | **0.381** (0.327-0.447) | **0.437** (0.373-0.511) | **0.531** (0.453-0.623) | **0.613** (0.520-0.722) | **0.732** (0.605-0.889) | **0.829** (0.670-1.02) | **0.929** (0.728-1.16) | **1.04** (0.782-1.32) | **1.18** (0.861-1.54) | **1.30** (0.922-1.71) |
| 10-min | **0.559** (0.478-0.654) | **0.639** (0.547-0.749) | **0.777** (0.663-0.912) | **0.898** (0.761-1.06) | **1.07** (0.886-1.30) | **1.21** (0.981-1.49) | **1.36** (1.07-1.70) | **1.52** (1.14-1.93) | **1.73** (1.26-2.25) | **1.90** (1.35-2.50) |
| 15-min | **0.681** (0.583-0.798) | **0.780** (0.667-0.913) | **0.948** (0.808-1.11) | **1.10** (0.928-1.29) | **1.31** (1.08-1.59) | **1.48** (1.20-1.81) | **1.66** (1.30-2.07) | **1.85** (1.40-2.36) | **2.11** (1.54-2.75) | **2.32** (1.65-3.05) |
| 30-min | **0.939** (0.804-1.10) | **1.08** (0.921-1.26) | **1.31** (1.12-1.54) | **1.52** (1.29-1.79) | **1.82** (1.50-2.20) | **2.06** (1.66-2.52) | **2.30** (1.81-2.88) | **2.57** (1.94-3.27) | **2.93** (2.13-3.81) | **3.21** (2.28-4.22) |
| 60-min | **1.19** (1.02-1.40) | **1.38** (1.18-1.62) | **1.71** (1.46-2.01) | **1.99** (1.69-2.35) | **2.40** (1.99-2.92) | **2.74** (2.21-3.36) | **3.09** (2.42-3.85) | **3.45** (2.60-4.40) | **3.96** (2.88-5.15) | **4.36** (3.09-5.72) |
| 2-hr | **1.45** (1.25-1.69) | **1.69** (1.46-1.97) | **2.11** (1.81-2.45) | **2.47** (2.11-2.88) | **2.99** (2.49-3.61) | **3.42** (2.78-4.17) | **3.87** (3.05-4.80) | **4.34** (3.30-5.49) | **4.99** (3.66-6.46) | **5.51** (3.94-7.18) |
| 3-hr | **1.60** (1.39-1.86) | **1.88** (1.62-2.17) | **2.35** (2.03-2.73) | **2.77** (2.37-3.22) | **3.38** (2.83-4.07) | **3.88** (3.17-4.72) | **4.41** (3.49-5.46) | **4.97** (3.79-6.28) | **5.75** (4.24-7.42) | **6.37** (4.57-8.28) |
| 6-hr | **1.89** (1.65-2.17) | **2.20** (1.91-2.53) | **2.75** (2.38-3.16) | **3.24** (2.79-3.74) | **3.98** (3.36-4.78) | **4.60** (3.79-5.56) | **5.26** (4.20-6.48) | **5.97** (4.60-7.51) | **6.98** (5.18-8.96) | **7.79** (5.62-10.1) |
| 12-hr | **2.20** (1.93-2.51) | **2.52** (2.21-2.87) | **3.10** (2.71-3.54) | **3.64** (3.16-4.18) | **4.47** (3.82-5.36) | **5.19** (4.32-6.25) | **5.96** (4.81-7.31) | **6.81** (5.28-8.52) | **8.02** (6.01-10.3) | **9.02** (6.55-11.6) |
| 24-hr | **2.51** (2.21-2.84) | **2.87** (2.53-3.25) | **3.53** (3.10-4.00) | **4.14** (3.62-4.71) | **5.08** (4.36-6.03) | **5.88** (4.93-7.03) | **6.76** (5.48-8.23) | **7.71** (6.02-9.58) | **9.08** (6.84-11.5) | **10.2** (7.46-13.0) |

# Historic Flooding:
## 1- FLASH FLOOD
## 2- LAKE LEVEL FLOODING



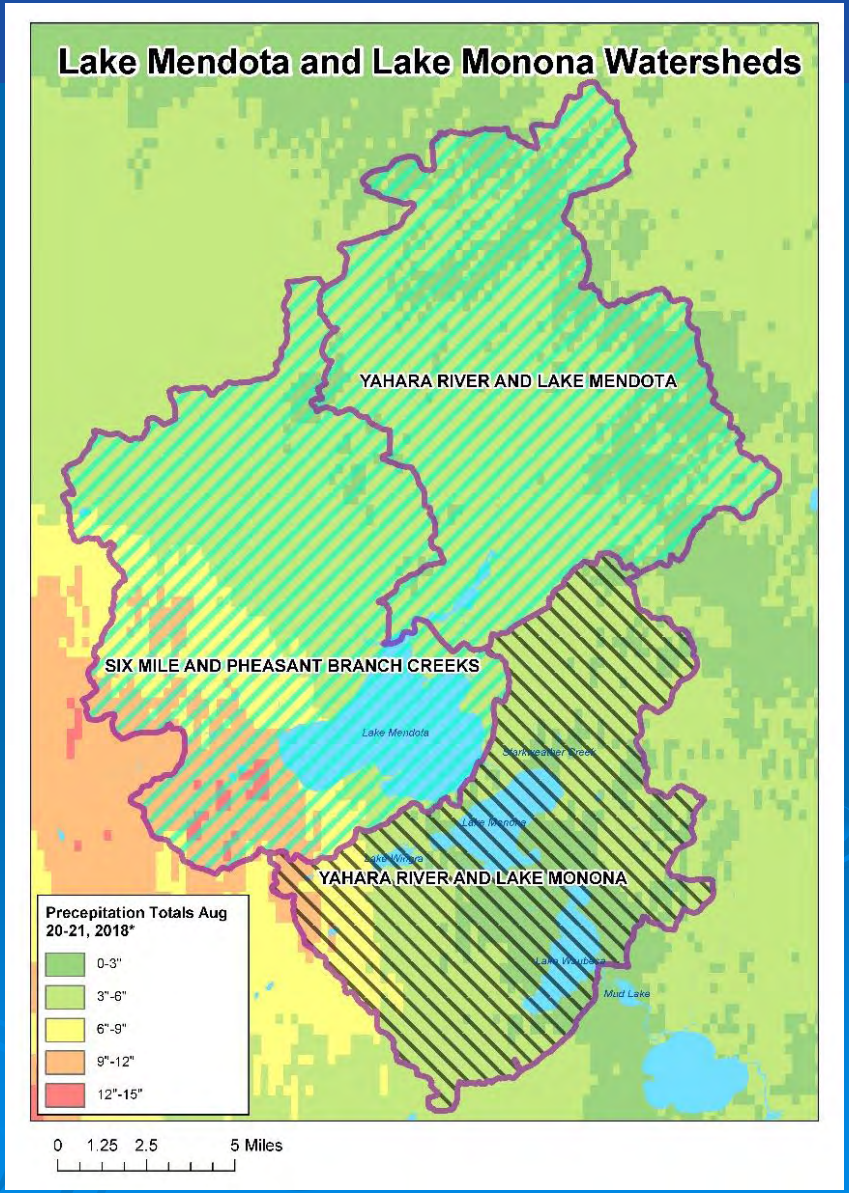
# Historic Flooding: Flash Flooding

Odana Golf Course, Madison, WI

Commerce Dr, Madison, WI

# Historic Flooding: Lake Level Flooding

- It typically takes about 2-3 days for water from the watershed to get to Lake Mendota.
- This storm hit mostly the urbanized area so lake response was faster.
- Caution – look at the limited watershed area hit by this storm.

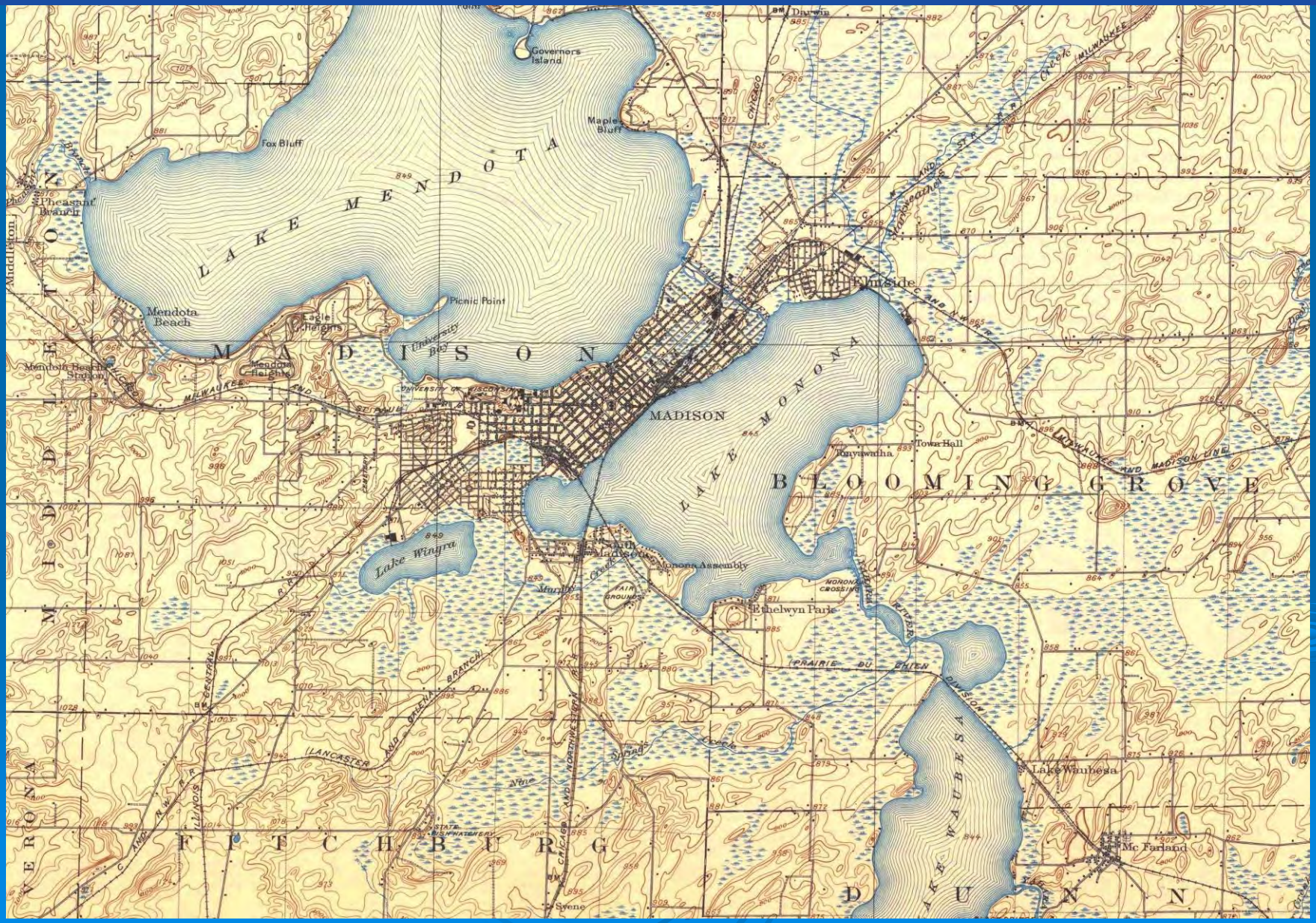


# Historic Flooding: Lake Level Flooding

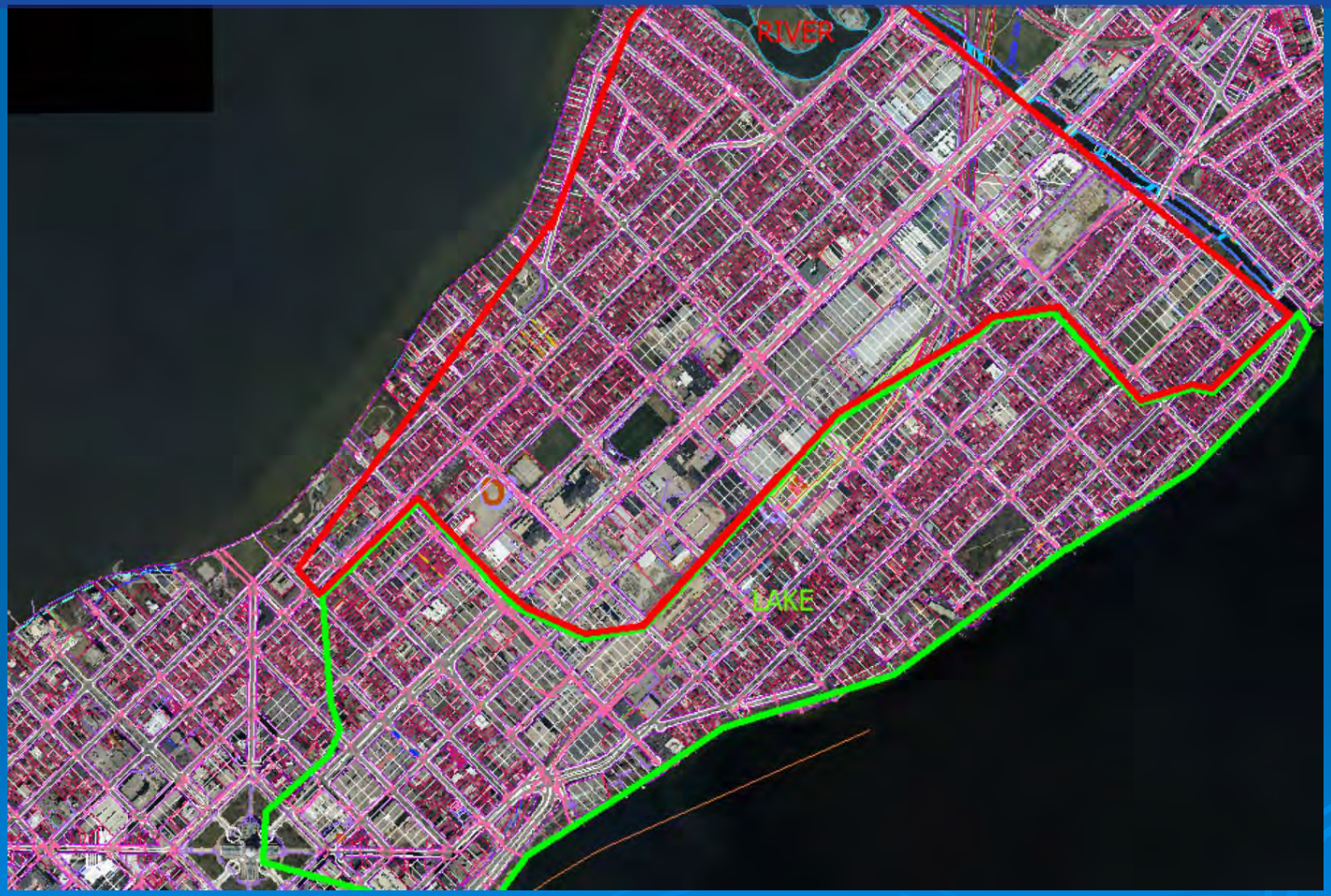
The Issues:

- Low and Enclosed Areas
- Submerged Storm Sewer System
- Historic Wetlands

# Historic Flooding: Lake Level Flooding



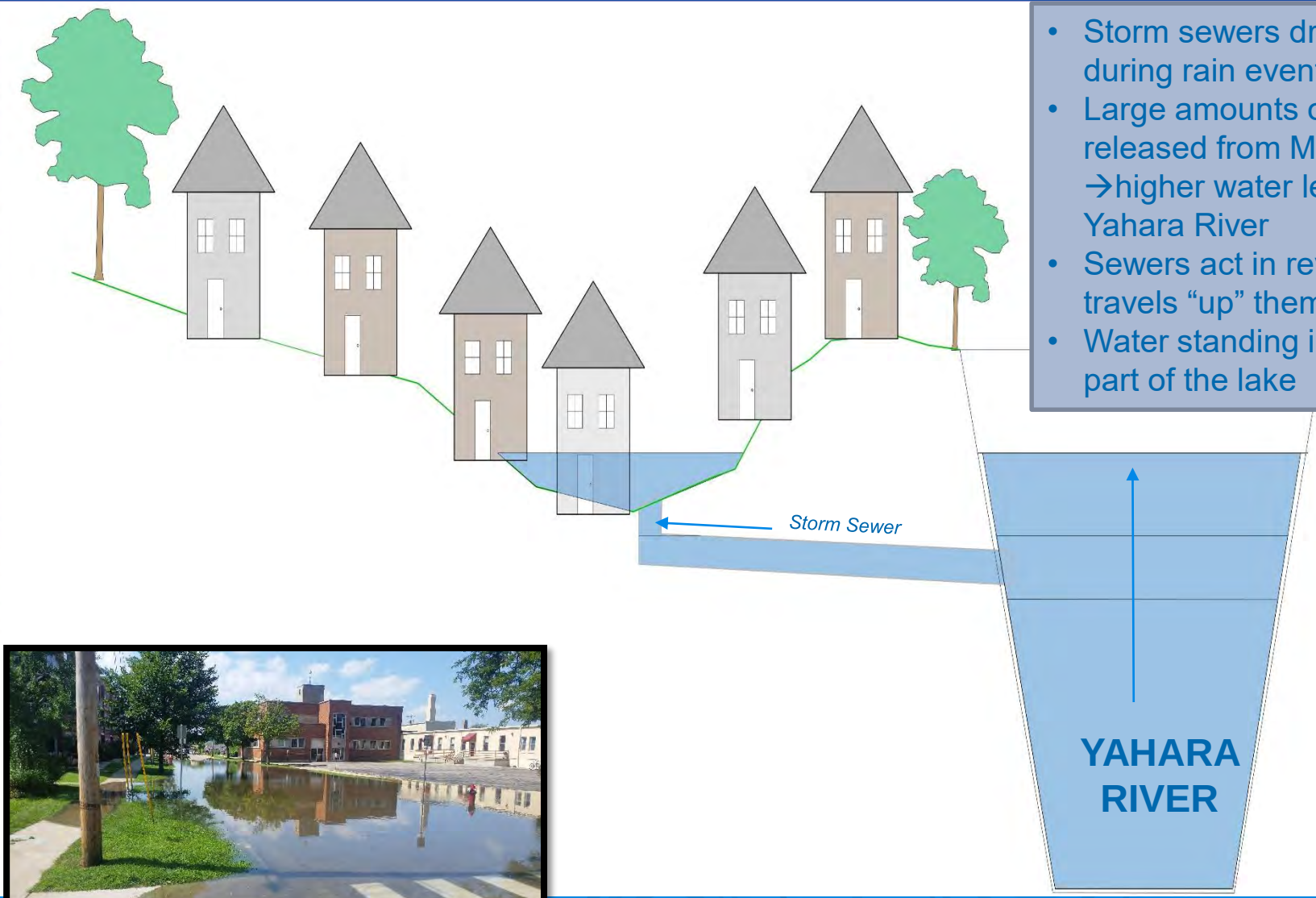
# Historic Flooding: Lake Level Flooding




- These low areas became a backwater of Lake Monona and the Yahara River

# Historic Flooding: Lake Level Flooding

- Storm sewers drain Isthmus during rain events
- Large amounts of water released from Mendota →higher water levels in Yahara River
- Sewers act in reverse, water travels “up” them
- Water standing in isthmus is part of the lake

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# Lake Level Flooding – what are we doing?

Lake Level Management - Look at ways to move the water out of Monona, Waubesa and Kegonsa faster. Dane County is working on the following:

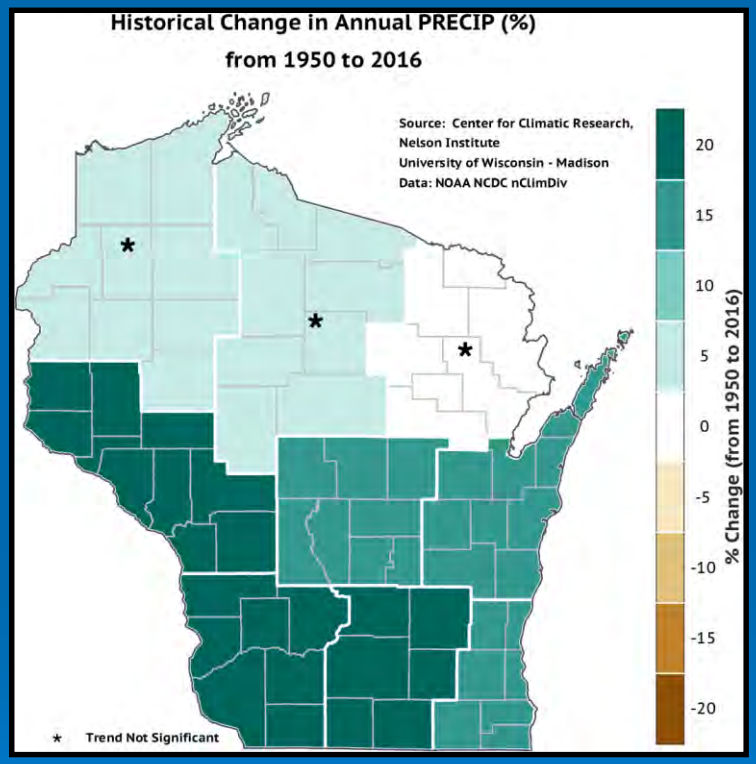
- Dredging
- Aquatic Plant Management
- Structural changes at Tenney Lock house

Tenney Locks

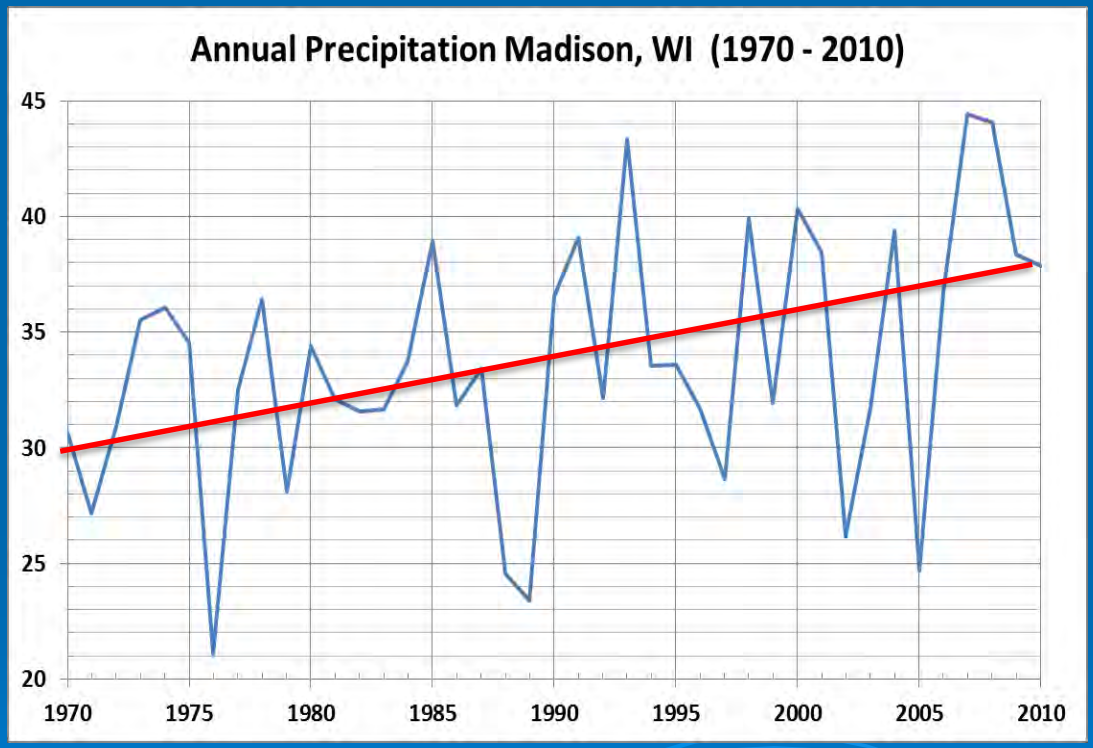
# What Does the Future Hold

- The Westside of Madison experienced flash flooding events in 2016, 2017 & 2018
- The isthmus area flooded in 2018 and was very close to flooding again in 2019.
- Where does the data indicate rainfalls are headed in the future?

# What Does the Future Hold?
# Climate Change Concerns



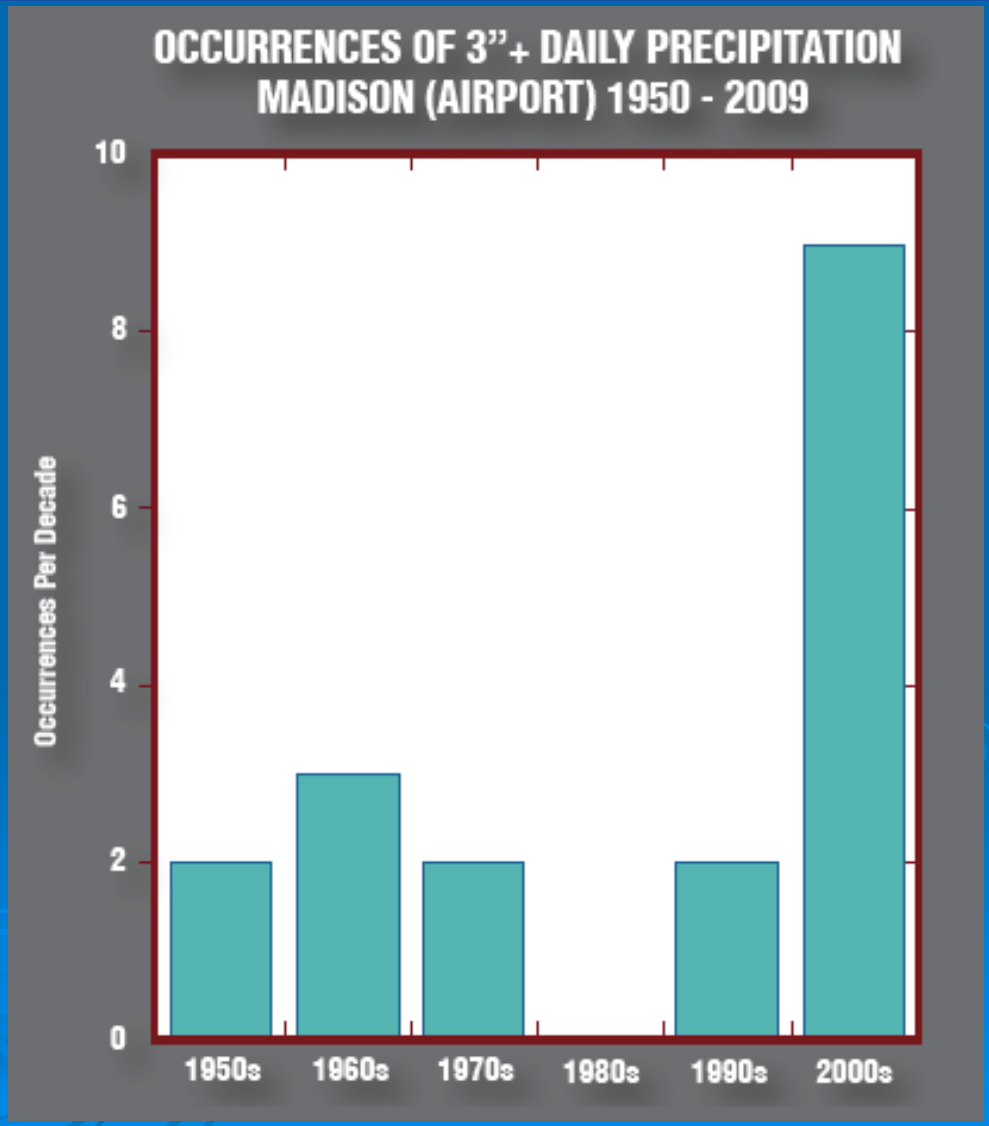

Rain and snow has increased by 15% since *1950*




WISCONSIN INITIATIVE ON CLIMATE CHANGE IMPACTS

# What Does the Future Hold? Climate Change Concerns

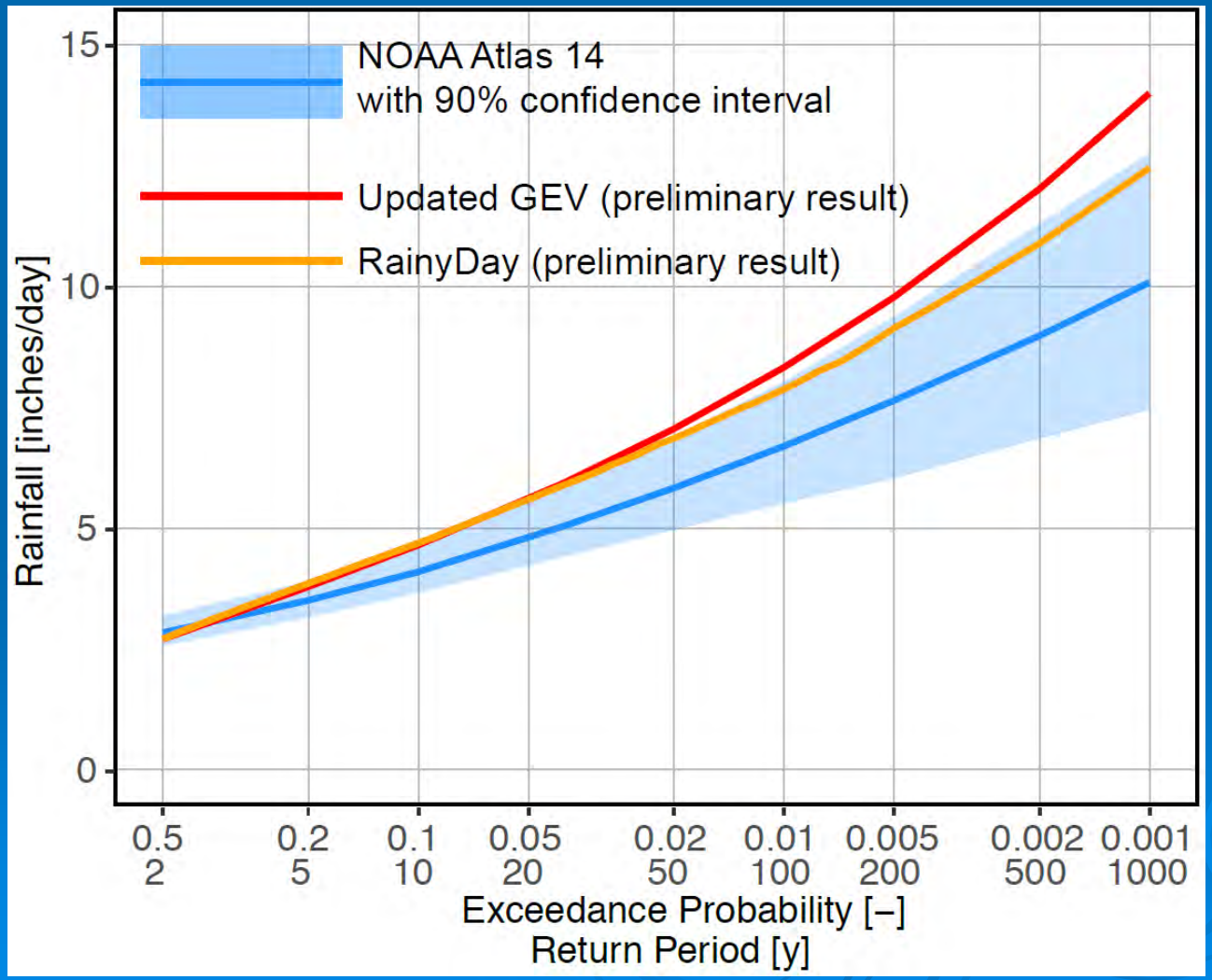
- More rain
- More rain events greater than 3”




*Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin.*

# What Does the Future Hold? Changing Rainfall Patterns

## Professor Dan Wright - RainyDay




24-hour rainfall return periods:

Blue = NOAA Atlas 14

Orange from RainyDay

Red is based on our analysis of roughly 60 years of data from the "Charmany Farm" rain gage, which is off Mineral Point near S. Rosa Rd.

# City of Madison Ordinances: Design Changes

Existing Madison Design Standards for New Development:

- Storm Sewer Pipes – 10 Year Event
- Culverts under a road - 25 or 50-Year Event
- Drainage of enclosed depressions – 25 Year Event
- Roads are expected to act as overflow during extreme events – not modeled in a rigorous manner
- Detention basins designed to detain the 100-yr event.

# City of Madison Ordinances: Existing MGO– New Development

- Existing New Development standards:
  - Reduce Total Suspended Solids from new development by 80%
  - Treat Oil & Grease from parking lots
  - Infiltrate 90% of predevelopment infiltration
  - Detention of the 1,2,10 & 100 year events to predevelopment levels

# City of Madison Ordinances: Proposed MGO– New Development

Proposed Madison Design Standards for New Development:

Storm Sewer Pipes – 10 Year event

- Culverts under a road – 100 Year event
- Drainage of enclosed depressions – 100 Year event
- Roads are expected to act as overflow during extreme events – elevations will be modeled
- Public outlots dedicated at low points draining to ponds or greenways. Easements not allowed.
- Prior approved detention at the plat level meeting the 10 year event no longer grandfathered – lots required 100-year detention
- PROPOSED ORD CHANGE - Detention for new development to include the design for the 200-year event.

# City of Madison Ordinances: Proposed MGO– New Development

Proposed Madison Design Standards for New Development:

- No water leaves ROW or public property in 100 Year event.
- 500-year event is routed through the development – water may leave ROW or public lands but no structural flooding.
- Deed restrict properties for minimum opening elevation on buildings where critical (next to ponds/greenways).

# City of Madison Ordinances: Proposed MGO– New Development

NEW DEVELOPMENT – what do these changes mean:

1) More work by staff to review and design systems
2) More dedication of land by developers for overflows
3) More dedication of land for additional detention
4) Potentially larger pipes
5) Increase in volume needed for detention approximately 10-15% - that does not necessarily translate to area directly.

# City of Madison Ordinances: Existing MGO– Re-Development

- Existing Re-development standards:
  - Reduce Total Suspended Solids from new pavement by 60%
  - Treat Oil & Grease from parking lots

# City of Madison Ordinances: Existing Stormwater Ordinance

Proposed Madison Design Standards for Re-development:

If re-development has proposed impervious cover that exceeds 80% of the existing site impervious cover, the site shall meet the following criteria:

- Reduce peak runoff rates from the site by 15% compared to existing conditions during a 10-year design storm.
- Reduce runoff volumes from the site by 5% compared to existing conditions during a 10-year design storm.
- The required rate and volume reductions using green infrastructure for at least the first 1/2 inch of rainfall.

# City of Madison Ordinances: Proposed MGO– Re-Development

RE-DEVELOPMENT – what do these changes mean:

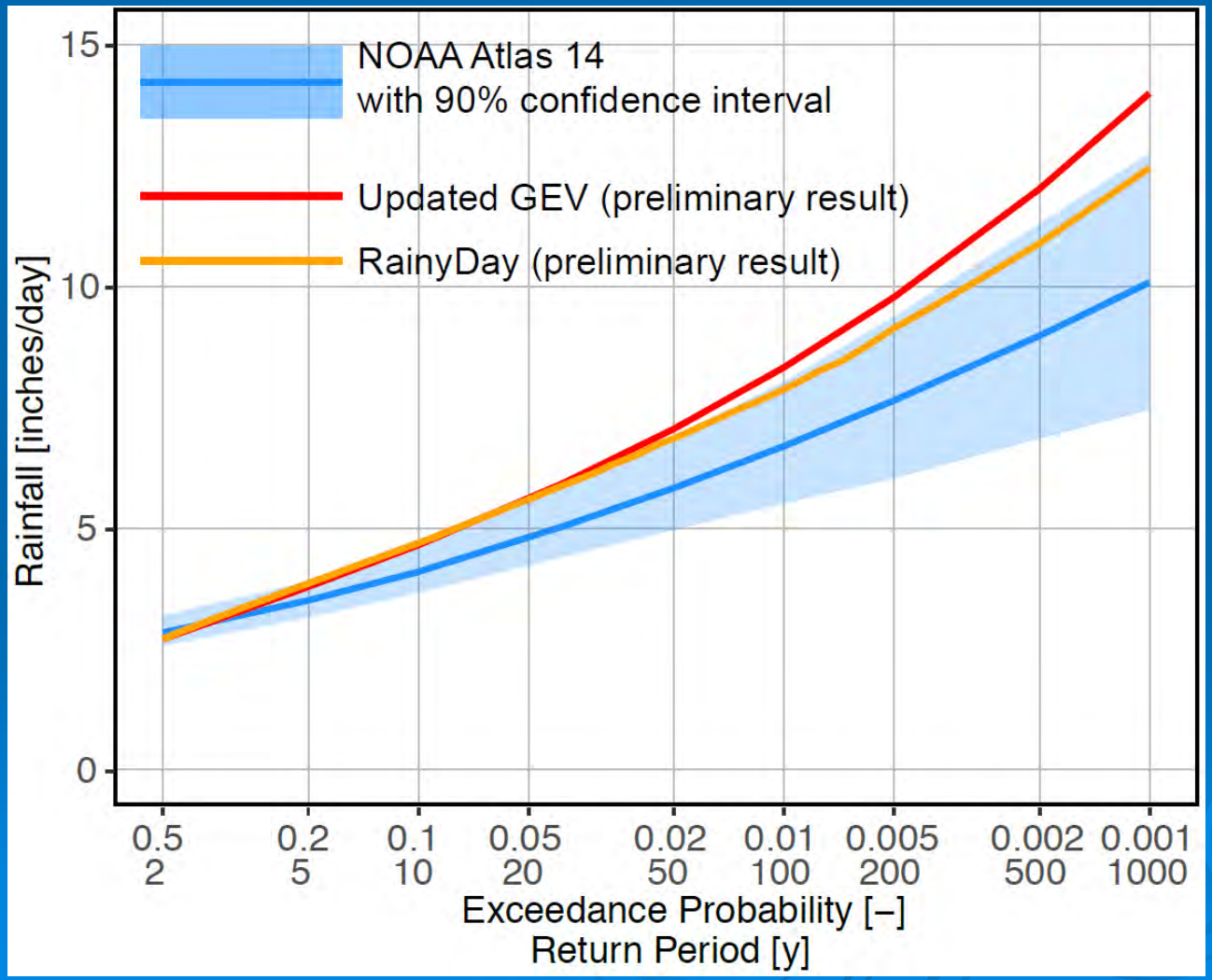
1) Re-development has never had a detention or volume reduction requirement.
2) The requirement may be difficult to meet and add expense to projects.
3) Requirement to treat with Green Infrastructure (GI) will push new buildings towards the use of green roofs.

# City of Madison Ordinances: What did we not do??

- Consider the use of a Madison specific IDF curve – we opted to go to detention of the 200 year in new development.

# What Does the Future Hold? Changing Rainfall Patterns

## Professor Dan Wright - RainyDay

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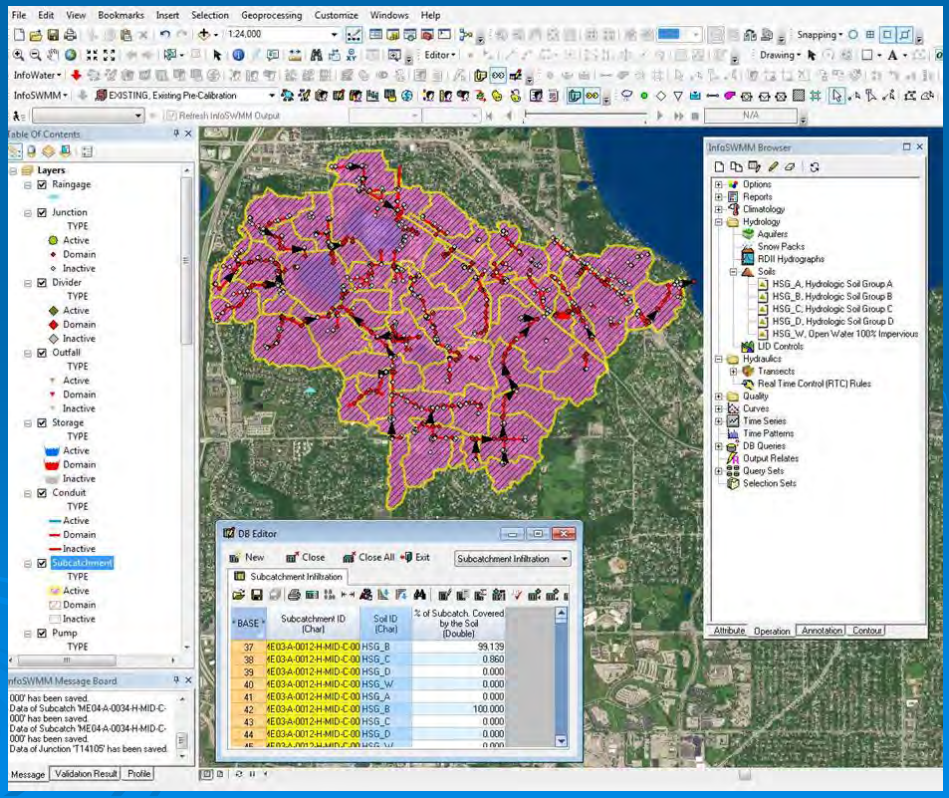
# Continued Efforts: Watershed Studies

- 2019 Starting 8 Studies ($2M +)
- Continue Studies for next 5-8 years
- Total 23+ Studies for Madison



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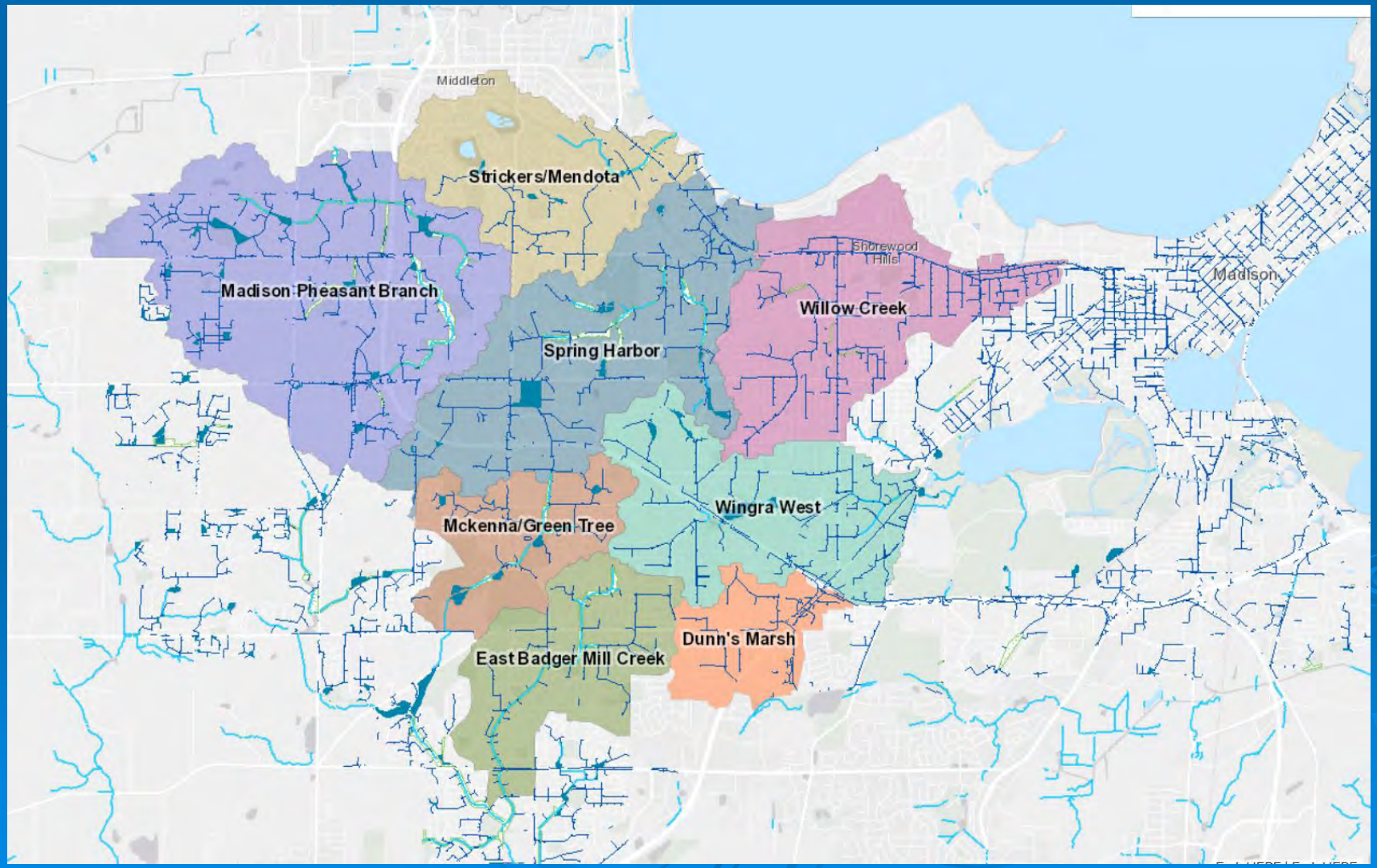

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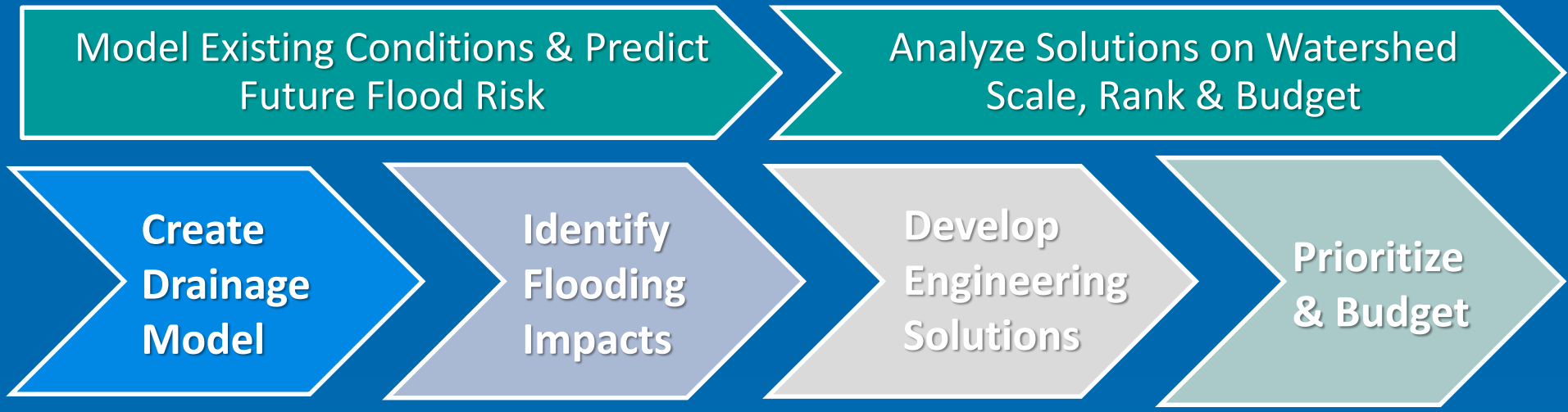

# Continued Efforts: Watershed Studies

- Design Solutions:
  - Must be holistic
  - Not “move the problem elsewhere”
  - Account for climate change
    - Look at **trending increases** in storm frequency and intensity
  - Includes Green Infrastructure analysis options
  - Consider long term maintenance needs
  - Provide benefits relative to cost

# Continued Efforts: Watershed Studies

- General options with Grey Infrastructure:
  - Improve pipe and/or inlet capacity
  - Safe overflow paths
  - Reroute flow
  - Increase storage / detention

# Continued Efforts: Watershed Studies

- General Options with Green Infrastructure
  - Reduce runoff – Green Infrastructure (GI)
  - Incentivize private GI with rate SWU structure
  - Flood studies will explicitly look at GI solutions, Grey solutions and paired solutions.

# Continued Efforts: Watershed Studies

- General Options for Private Property Owners:
  - Flood-proof buildings
  - Local landscaping / grading
  - Solutions on private property to buildings or land

# Continued Efforts: Watershed Studies

- Storm Water Utility Bill Increase
  - 2018 increased 2.3% (avg. residential increase of $2.15/year)
  - 2019 increased 10.1% (avg. residential increase of $9.60/year)
  - **Will continue to increase to fund infrastructure improvements in the future.**

# Continued Efforts: Green Infrastructure

Private Rain Gardens

- Identify locations for terrace rain gardens
- Rain gardens become the responsibility of the property owner
- Average costs including planting is about $3200
- The property owner is required to pay a $200
- Low cost is an incentive for installation

# Continued Efforts: Green Infrastructure

- Pervious pavement pilot constructing approximately 500 feet of pervious sidewalk
- Precast pervious sidewalk
- Test site for a pervious pavement test site being monitored by the USGS and the WDNR.
- Pervious pavement in alleys
- Private property installations

- **LOOK FOR OTHER APPLICATIONS!!**


# Continued Efforts: Green Infrastructure

- Investigating grant programs for rain garden and Green Infrastructure installations

Need to engage the public – City can't achieve flood mitigation goals solely on public property.

# Questions and Discussion