Flood Risk and Warning for the Yahara River Chain of Lakes (RCL)

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University of Wisconsin, Madison

AWRA Wisconsin, 42nd Meeting
March 8, 2018
Motivations

Lake Flooding

Loss

Urban Flooding

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Crop Loss ($ Million)</th>
<th>Property Damage ($ Million)</th>
<th>Total Loss ($ Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>June, 1993</td>
<td>Flood</td>
<td>$12.6</td>
<td>$10.0</td>
<td>$22.6</td>
</tr>
<tr>
<td>May, 1996</td>
<td>Severe Storms</td>
<td>$1.1</td>
<td>$0.15</td>
<td>$3.5</td>
</tr>
<tr>
<td>June, 2000</td>
<td>Flood</td>
<td>$6.1</td>
<td>$3.2</td>
<td>$9.3</td>
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<tr>
<td>Summer, 2002</td>
<td>Drought</td>
<td>$0</td>
<td>$4.4</td>
<td>$4.4</td>
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<tr>
<td>June, 2004</td>
<td>Tornado</td>
<td>$1.5</td>
<td>$0</td>
<td>$1.5</td>
</tr>
<tr>
<td>August, 2005</td>
<td>Tornado</td>
<td>$34.3</td>
<td>$7.5</td>
<td>$41.8</td>
</tr>
<tr>
<td>May, 2006</td>
<td>Flooding</td>
<td>$5.8</td>
<td>$0</td>
<td>$5.8</td>
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<tr>
<td>July, 2006</td>
<td>Flooding</td>
<td>$10.0</td>
<td>$0</td>
<td>$10.0</td>
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<tr>
<td>August, 2007</td>
<td>Flooding</td>
<td>$6.0</td>
<td>$5.0</td>
<td>$11.0</td>
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<tr>
<td>June, 2008</td>
<td>Severe Storms and Flooding</td>
<td>$133.5</td>
<td>$64.4</td>
<td>$197.9</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>$92.6</td>
<td>$87.9</td>
<td>$180.5</td>
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</tbody>
</table>
Objectives

• Characterize Flood Risk

Hazard (Rainfall)  ×  Vulnerability (building)  ×  Damage Curve

Risk

Probability  ×  Loss  =  Probability of Loss

• Develop Flood Forecast and Warning
COMMER Procedure

COmpiling Data

Dam Operation

Rainfall Hazard

Land

Building Assets

2008 Storm

DEM

WISCONSIN

0 125 25

5 Miles

2008 Storm

Monona

Waubesa

Kegonsa
COMMER Procedure

**Compiling Data**
- Dam Operation
- Rainfall Hazard
- Land
- Building Assets

**Modeling**
- SWAT
- Hydrologic
  - Hydrodynamic (Lake-River)
- LIDAR DEM Land Use
- Reimer and Wu, 2016

**Mapping**
- Flood Inundation
- Damage
- Land Use Building Type

Reimer and Wu, 2016
COMMER Procedure

Compiling Data
- Dam Operation
- Rainfall Hazard
- Land
- Building Assets

 Modeling
- SWAT
- Hydrologic
- Hydrodynamic (Lake-River)
- Land Use
- Building Type
- Flood Inundation

 Mapping
- LIDAR DEM
- People Evacuation

 Estimating Loss
- Loss ($)
- Building Loss
- People

 Risk
- Building Type
- Flood Depth
- LIDAR DEM

Reimer and Wu, 2016

Risk
- R: Asset Type
- A: Asset Value
- V: VULN
- E: ECON
- B: Building Type

Risk Table

<table>
<thead>
<tr>
<th>RP</th>
<th>Asset Type</th>
<th>VULN</th>
<th>ECON</th>
<th>Building Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>368</td>
<td>32</td>
<td>1.93</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>460</td>
<td>69</td>
<td>3.44</td>
<td>3</td>
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<tr>
<td>25</td>
<td>699</td>
<td>104</td>
<td>10.00</td>
<td>3</td>
</tr>
<tr>
<td>50</td>
<td>856</td>
<td>375</td>
<td>19.01</td>
<td>3</td>
</tr>
<tr>
<td>100</td>
<td>1538</td>
<td>1096</td>
<td>51.07</td>
<td>3</td>
</tr>
</tbody>
</table>
Total Precipitation (inches)
June 1-15, 2008

Daily Rainfall (in)
Yahara Lakes

$193k
$578k
$19k
$276k

$1.07 Million

Reimer and Wu, 2016
Storm Transposition

**Deterministic**

Lake Delton

Yahara Lakes

**Stochastic**

Hayden et al., 2016

Wright et al., 2017

$2.51$ Million

Reimer and Wu, 2016

$???$ Million
Rainfall Probability

Rainfall Duration (days) | Return Period (years)
--- | ---
2 | 1
4 | 10
6 | 25
8 | 50
10 | 100

10 Year | 25 Year | 50 Year | 100 Year | 250 Year | 500 Year
--- | --- | --- | --- | --- | ---

2 Day | 4 Day | 6 Day | 8 Day | 10 Day
--- | --- | --- | --- | ---
Results:

Loss of Building Infrastructure

- **Mendota**
- **Monona**
- **Waubesa**
- **Kegonsa**

Return Period

$ USD Millions

- 2 Day
- 4 Day
- 6 Day
- 8 Day
- 10 Day

8 Day, 500 RP

6 Day, 500 RP

8 Day, 500 RP

8 Day, 500 RP
Results:

Risk of Building Infrastructure

- 10 Day, 250 RP
- 10 Day, 10 RP
- 8 Day, 250 RP

Building Risk (USD Thousands)

<table>
<thead>
<tr>
<th>Return Period</th>
<th>2 Day</th>
<th>4 Day</th>
<th>6 Day</th>
<th>8 Day</th>
<th>10 Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- A = 602 km²
- Monona
- Waubesa
- Kegonsa

Urbanized

Choked Flow

Historical Constriction

Water Elevation (ft NIOSH)

Mixed
Results:

Evacuation of People

Number (Thousands of People)

Return Period

8 Day, 500 RP

6 Day, 500 RP

8 Day, 500 RP

8 Day, 500 RP

Mendota
Monona
Waubesa
Kegonsa
Results:

Risk of Evacuation

Evacuation Risk (Number of People)

Return Period

Mendota
Monona
Waubesa
Kegonsa
RECALL: Objectives

- Characterize **Flood Risk**

**Vulnerability Mitigation**
Are we prepared today for tomorrow’s *flood*?
Flood Forecasts

Past Rainfall

June 16-23, 2014

Forecast Rainfall

Integrated Models

Watershed

Lake-River

www.infosyahara.org

NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Flood Warning

Lake Mendota
Lake Monona
Lake Waubesa
Lake Kegonsa
RECALL: Objectives

- Characterize **Flood Risk**
  - Probability of Loss
  - Hazard (Rainfall)
  - Physical Damage
  - Hazard Intensity
  - Type 1
  - Type 2
- Vulnerability
  - Mitigation
- Develop **Flood Forecast and Warning**
- Resilience & Preparedness
**Summary**

- **Characterize Flood Risk**
- **Vulnerability Mitigation**

<table>
<thead>
<tr>
<th></th>
<th>LOSS</th>
<th>RISK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Building</td>
<td>Evacuation</td>
</tr>
<tr>
<td>Mendota</td>
<td>500 Year</td>
<td>500</td>
</tr>
<tr>
<td>Monona</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Waubesa</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Kegonsa</td>
<td>500</td>
<td>500</td>
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</tbody>
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**COMMER Procedure**

- Develop Flood Forecast and Warning
- Resilience & Preparedness