Flood Inundation Mapping Alert Network (FIMAN)
Hurricane Florence Success Stories and Future Vision

https://fiman.nc.gov/fiman/

North Carolina Emergency Management
The Genesis: 1999... Hurricane Dennis followed by Hurricane Floyd
NC Flood Warning Program Goals

• Real-time flood inundation mapping (current and forecast)
• Alerts
• Leverage vast investment in data
• Assist in risk-based decisions during and before disaster
• Prevent and reduce the loss of lives and property
What is FIMAN?
What is an Inundation Library?

“Library” of flood inundation mapping near gaging stations

+ Gaging Stations
+ Telemetry
+ Pre-made inundation libraries
+ Web tool to efficiently communicate

Real-time flood mapping solution

N. Fork Catawba River @ HWY 221

North Carolina Emergency Management
Home Screen / Current Severity

FIMAN - Flood Inundation Mapping and Alert Network

Gage Level

Gage Symbols
- Green: Current Condition
- Yellow: Forecast Peak Condition
- Light Blue: Rain Last 24 Hours

Risk Ratings
- Green: Normal
- Yellow: Monitor
- Orange: Minor Flooding
- Red: Moderate Flooding
- Deep Purple: Major Flooding
- Light Blue: Not Risk Rated
- Gray: Out of Service

Trend
- Green Up Arrow: Rising
- Red Down Arrow: Falling
- Black Slanted Lines: Constant
Search by Type, Owner, Etc
Gage View - Dashboard Concept

• Three Tabs
  – **Current:** Provides most recent inundation extent
  – **Scenario:** Planning tool for visualization and impact
  – **Forecast:** Shows timeline using NWS forecast data

• Info Widgets
  – Interactive for rainfall, stage, flow, forecast, impacts

North Carolina Emergency Management
Current Inundation Level and Map
Gage Stage Charts
Flood Impacts/Damages

Tar River at Greenville Buildings in Inundation Extent
Scenario Stage: 23.7 Ft

This table reflects counts of buildings inside the FIMAN inundation extent where structural damages ($) may occur. Additional buildings may be shown (color coded) in the map indicating buildings inside the inundation extent that may not sustain structural damages due to elevated first floor elevations or site-specific conditions.

- Additional buildings may be impacted outside of the inundation extent.

<table>
<thead>
<tr>
<th>Estimated Damages</th>
<th>Flood Depth</th>
<th>Occupancy Type</th>
<th>Building ID</th>
</tr>
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<tbody>
<tr>
<td>$410,949</td>
<td>2</td>
<td>Commercial</td>
<td>3714755415</td>
</tr>
<tr>
<td>$291,021</td>
<td>2.9</td>
<td>Residential</td>
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<td>$206,505</td>
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<td>3714758259</td>
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<td>$161,017</td>
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<td>Residential</td>
<td>3714755811</td>
</tr>
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<td>$110,619</td>
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<td>Residential</td>
<td>3714723049</td>
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<td>$106,043</td>
<td>0.8</td>
<td>Commercial</td>
<td>3714755010</td>
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<tr>
<td>$101,725</td>
<td>-3</td>
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<td>3714753604</td>
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<td>$76,250</td>
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<td>Commercial</td>
<td>3714755533</td>
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<td>$52,000</td>
<td>5.6</td>
<td>Commercial</td>
<td>371472162</td>
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<tr>
<td>$35,785</td>
<td>-1.7</td>
<td>Residential</td>
<td>371471685</td>
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</table>

TOTAL

266 buildings damaged $3,237,000
Flood Scenario Mode
Forecast

North Carolina Emergency Management
Gage Summary Reports

Tar River at Greenville
Site ID: 02084000

Last Updated: 2/10/16 2:45 PM

<table>
<thead>
<tr>
<th>Current Stage / Elevation</th>
<th>Current Flow</th>
<th>Impacted Structures / Damages</th>
<th>Forecasted Peak / Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.2 ft</td>
<td>13100 cfs</td>
<td>1 Buildings $3,000</td>
<td></td>
</tr>
<tr>
<td>12.7 ft (NAVD 88)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ELEVATION / STAGE**

**FLOOD**

**LEGEND**
- Major Flooding
- Moderate Flooding
- Minor Flooding
- Monitor
- Normal Conditions

**FLOW**

**Impact Summary**
- Road Impact: None reported at this time
- Building Impact: 1 buildings impacted; $3,000 estimated damages
- Utility Impact: None reported at this time
- Other Impact: Some farmland flooded; water overflow lowlands adjacent to river.

**NOTE:** Additional buildings may be impacted outside of flood inundation extent. Damages do not include content and inventory.

**Estimated Damages based on Current Flood Elevation of 13 ft (NAVD 88)**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Total Damages</th>
<th>Residential Damages</th>
<th>Commercial Damages</th>
</tr>
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<tbody>
<tr>
<td>Sub Surface</td>
<td>$3,000</td>
<td>1</td>
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</tr>
<tr>
<td>0-1 ft</td>
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<tr>
<td>1-2 ft</td>
<td>$0</td>
<td>0</td>
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</tr>
<tr>
<td>2-3 ft</td>
<td>$0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3-4 ft</td>
<td>$0</td>
<td>0</td>
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</tr>
<tr>
<td>4-5 ft</td>
<td>$0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&gt;5 ft</td>
<td>$0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$3,000</strong></td>
<td><strong>$3,000</strong></td>
<td><strong>0</strong></td>
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</table>

North Carolina Emergency Management
### Statewide Flooding Gage Summary Report

<table>
<thead>
<tr>
<th>BM Branch</th>
<th>County</th>
<th>Gage Name</th>
<th>Gage Type</th>
<th>Current</th>
<th>Forecast</th>
<th>Trend</th>
<th>Flood Time Peak</th>
<th>Flood Time Min/Normal</th>
<th>Flood Stage (%)</th>
<th>Buildings Damaged*</th>
<th>Buildings Damaged*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Ed</td>
<td>Edgecombe</td>
<td>Tar River at Tarboro</td>
<td>Riverine</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Rising</td>
<td>Fri (03/01) PM</td>
<td>Sun (03/03) PM</td>
<td>24.1</td>
<td>26.7</td>
<td>2.6</td>
</tr>
<tr>
<td>Central Nash</td>
<td>Nash</td>
<td>Tar River Below Dam near Langley Crossing</td>
<td>Riverine</td>
<td>Monitor</td>
<td>Monitor</td>
<td>Rising</td>
<td>Fri (03/01) PM</td>
<td>Sun (03/03) PM</td>
<td>14.9</td>
<td>1.0</td>
<td>-15.0</td>
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<tr>
<td>Central Johnston</td>
<td>Johnston</td>
<td>Neuse River at Smithfield</td>
<td>Riverine</td>
<td>Minor</td>
<td>Minor</td>
<td>Constant</td>
<td>Sun (03/02) AM</td>
<td>Sun (03/03) AM</td>
<td>15.8</td>
<td>17.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Central Northampton</td>
<td>Northampton</td>
<td>Roanoke River at Roanoke Rapids</td>
<td>Riverine</td>
<td>Minor</td>
<td>Minor</td>
<td>Constant</td>
<td>Max (03/04) AM</td>
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<tr>
<td>Central Edgecombe</td>
<td>Edgecombe</td>
<td>Tar River at 97 at Rocky Mount</td>
<td>Riverine</td>
<td>Monitor</td>
<td>Monitor</td>
<td>Rising</td>
<td>Wed (02/27) PM</td>
<td>Thu (02/28) AM</td>
<td>20.2</td>
<td>20.5</td>
<td>0.3</td>
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<tr>
<td>Central Edgecombe</td>
<td>Edgecombe</td>
<td>Fishing Creek near Enfield</td>
<td>Riverine</td>
<td>Monitor</td>
<td>Monitor</td>
<td>Rising</td>
<td>Wed (02/27) PM</td>
<td>Wed (02/27) PM</td>
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<td>Riverine</td>
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<td>Monitor</td>
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<td>Wed (02/27) PM</td>
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<td>22.3</td>
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<td>Swift Creek at Hilliard</td>
<td>Riverine</td>
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<td>Monitor</td>
<td>Failing</td>
<td>Sat (03/05) PM</td>
<td>Sun (03/03) PM</td>
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<td>8.1</td>
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<td>Minor</td>
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<td>Eastern Pitt</td>
<td>Pitt</td>
<td>Tar River at Us 264 Bypass near Rock Springs</td>
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<td>Minor</td>
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<td>Fri (03/01) PM</td>
<td>15.3</td>
<td>17.5</td>
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<tr>
<td>Eastern Pitt</td>
<td>Pitt</td>
<td>Tar River at Greensville</td>
<td>Riverine</td>
<td>Monitor</td>
<td>Monitor</td>
<td>Rising</td>
<td>Fri (03/01) PM</td>
<td>Fri (03/01) PM</td>
<td>13.3</td>
<td>1.1</td>
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<tr>
<td>Eastern Robeson</td>
<td>Robeson</td>
<td>Lumbee River at Lumbee</td>
<td>Riverine</td>
<td>Minor</td>
<td>Minor</td>
<td>Failing</td>
<td>Fri (03/01) PM</td>
<td>Fri (03/01) PM</td>
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<td>45.7</td>
<td>0.8</td>
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<tr>
<td>Eastern Bladen</td>
<td>Bladen</td>
<td>CAPE FEAR R AT WLM O HUSKE LOCK NR TARHEEL NC</td>
<td>Riverine</td>
<td>Minor</td>
<td>Minor</td>
<td>Failing</td>
<td>Fri (03/01) PM</td>
<td>Fri (03/01) PM</td>
<td>44.9</td>
<td>45.7</td>
<td>0.8</td>
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<tr>
<td>Eastern Lenoir</td>
<td>Lenoir</td>
<td>Neuse River at Kinston</td>
<td>Riverine</td>
<td>Minor</td>
<td>Minor</td>
<td>Failing</td>
<td>Fri (03/01) PM</td>
<td>Fri (03/01) PM</td>
<td>14.5</td>
<td>16.5</td>
<td>2.0</td>
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<tr>
<td>Eastern Greene</td>
<td>Greene</td>
<td>Contohora Creek at Hootie</td>
<td>Riverine</td>
<td>Monitor</td>
<td>Monitor</td>
<td>Rising</td>
<td>Fri (03/01) PM</td>
<td>Fri (03/01) PM</td>
<td>13.7</td>
<td>13.7</td>
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<td>Neuse River near Goldsboro</td>
<td>Riverine</td>
<td>Monitor</td>
<td>Monitor</td>
<td>Rising</td>
<td>Fri (03/01) PM</td>
<td>Fri (03/01) PM</td>
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<td>1.1</td>
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<tr>
<td>Eastern Duplin</td>
<td>Duplin</td>
<td>Sweetwater Creek at 3162</td>
<td>Riverine</td>
<td>Monitor</td>
<td>Monitor</td>
<td>Rising</td>
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<td>Fri (03/01) PM</td>
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<td>12.1</td>
<td>0.7</td>
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<tr>
<td>Eastern Brunswick</td>
<td>Brunswick</td>
<td>Wilmington - Cape Fear R r US 17/76</td>
<td>Coastal</td>
<td>Normal</td>
<td>Monitor</td>
<td>Rising</td>
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<td>Fri (03/01) PM</td>
<td>-0.6</td>
<td>3.0</td>
<td>3.6</td>
</tr>
</tbody>
</table>
Real Time Alerts

FIMAN - Flood Inundation Mapping and Alert Network

Alerts for Tar River at Greenville

Stage
- 15.5 ft. Major Flooding
- 13.5 ft. Moderate Flooding
- 9.5 ft. Minor Flooding
- 8.5 ft. Monitor

Alerts will be sent when the following conditions are met:
- Rises Above
- Falls Below
- Forecast to Rise
- Forecast to Fall

Selected conditions will be applied to all gage alerts.

View your alert settings for the following Gage:
Tar River at Greenville

Current: 3.5 ft
Flow: 428 cfs

Risk Ratings:
- Normal
- Monitor
- Minor Flooding
- Moderate Flooding
- Major Flooding
- No Data Available
- Out of Service

Trend:
- Rising
- Falling
- Constant

Gage Symbols:
- Current Condition
- Forecast Peak Condition
- Rain Last 24 Hours

Alerts will be sent when:
- Rises Above
- Falls Below
- Forecast to Rise
- Forecast to Fall

Subscribe/Unsubscribe

Save

North Carolina Emergency Management

Department of Public Safety

DPS

NAC

NORTH CAROLINA
Media Promoting Use of FIMAN

Florence flooding: Monitoring potential flooding in your area with FIMAN

RALEIGH, N.C. (WTVD) — The aftermath of Florence has left many communities largely underwater.

Luckily, the NC Flood Inundation Mapping and Alert Network has created an amazing piece of software that allows users to home in on a specific river in their area and see where the water is predicted to flood out to.

RELATED: Florence flooding: Storm has never been more dangerous than it is right now

As inland waters rise, state keeps wary eye on 167 high-risk dams

Tags: Hurricane Florence, Flooding

Posted September 15
Updated September 16

See where North Carolina flooding is at a glance with flood inundation map. Arrows show is water levels at the location are going up or down. #Florence #Flooding #TurnAroundDontDrown
Web Adaptor

Network

Task Manager

<table>
<thead>
<tr>
<th>Name</th>
<th>PID</th>
<th>Status</th>
<th>User name</th>
<th>CPU</th>
<th>Memory (p...)</th>
<th>Command line</th>
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<td>w3wp.exe</td>
<td>6248</td>
<td>Running</td>
<td>ArcGISWebAdap...</td>
<td>81</td>
<td>1,699,828 K</td>
<td>c:\windows\system32\inetsrv\w3wp.exe -ap &quot;ArcGISWebAdaptorAppPool v4.0&quot; -v &quot;v4.0&quot; -I w3wp.exe</td>
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<tr>
<td>lsass.exe</td>
<td>676</td>
<td>Running</td>
<td>SYSTEM</td>
<td>09</td>
<td>28,024 K</td>
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<tr>
<td>System</td>
<td>4</td>
<td>Running</td>
<td>SYSTEM</td>
<td>05</td>
<td>28 K</td>
<td></td>
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<tr>
<td>System interrupts</td>
<td>-</td>
<td>Running</td>
<td>SYSTEM</td>
<td>03</td>
<td>0 K</td>
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<td>Running</td>
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<td>w3wp.exe</td>
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<td>fileaccess2</td>
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<td>c:\windows\system32\inetsrv\w3wp.exe -ap &quot;fileaccess2 .net 4&quot; -v &quot;v4.0&quot; -I webengine4.dll</td>
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</table>

North Carolina Emergency Management
Adapting the FIMAN framework

<table>
<thead>
<tr>
<th>Issues Identified</th>
<th>Resolution</th>
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</thead>
<tbody>
<tr>
<td>Services not showing up</td>
<td>- Moved services to more powerful ArcGIS Server machine</td>
</tr>
<tr>
<td></td>
<td>- Removed non-critical services</td>
</tr>
<tr>
<td>System performing slowly</td>
<td>- Removed unnecessary services</td>
</tr>
<tr>
<td></td>
<td>- Added indexes to improve DB performance and decrease CPUs</td>
</tr>
<tr>
<td></td>
<td>- Switched to using ESRI basemaps instead of NCEM data</td>
</tr>
<tr>
<td>Failed gages</td>
<td>- Set up stored procedure to push forecast data to real-time (only with available forecast)</td>
</tr>
<tr>
<td></td>
<td>- Incorporated additional USGS SWaTH gages</td>
</tr>
<tr>
<td></td>
<td>- Added new rapid deployment gages to FIMAN (replacing damaged sites or adding new sites)</td>
</tr>
<tr>
<td>Incorrect data</td>
<td>- Modified existing procedure to ensure forecast readings displayed in proper order</td>
</tr>
</tbody>
</table>
Contentnea Creek at Hookerton: 9/19
Support Federal Disaster Declaration
North Carolina Floodplain Mapping Program Initiatives
FIMAN Initiatives

• Low-cost gage research project with NCA&T
• IA and flood inundation boundary extraction research
• Expansion of gage maintenance capability
• Flood inundation for transportation
2018-2019 Gage Installation
DHS Science and Technology Directorate
Internet of Things (IoT): Low-Cost Flood Inundation Sensors

Early Warning Flood Sensors
Flooding is the nation’s leading natural disaster, accounting for the greatest loss of life, property damage and economic impact. Over the past three decades alone, floods have accounted for $8.2 billion in damages and more than 80 fatalities per year. Much of this devastation could be mitigated with deployable Internet of Things (IoT) technology that monitors flood-prone areas in real-time, and rapidly detects and alerts officials, industry and citizens to potential threats.

The Department of Homeland Security’s Science and Technology Directorate (S&T) is working with three small business partners to design, develop and test a network of inexpensive, deployable flood inundation sensors. The sensors will be part of a scalable wireless mesh network that rapidly measures rising water and reports flood conditions back to operations centers, first responders and citizens.

The sensors are designed to be modular, allowing maximum flexibility for communities to configure the sensors to meet specific needs. Once completed, the system can be deployed for years at a time with little-to-no maintenance. Sensor costs, depending upon configuration, are expected to be less than $1,000 per unit—which is 20 times less expensive than many permanent flood sensors used today.

Government, Industry Meeting Community Needs
In spring 2016, three industry performers—Evigia Systems, Inc., Physical Optics Corporation (POC) and Progeny Systems Corporation—were awarded Small Business Innovation Research (SBIR) Phase I funds to prototype low-cost flood sensors that are ruggedized, submersible and deployable across mesh networks in different environments.

Next Phase: Sensor Refinement and Field Testing
SBIR Phase II, which began in spring 2017, is focusing on the technical refinement of the sensors to harden the sensor housing, increase power through energy harvesting, expand communications network range, transmit imagery, provide GPS location, implement open data exchange standards and monitor performance diagnostics. By summer 2018, nearly 300 sensors will be field deployed with select state, county and city government stakeholders for testing and evaluation over a 6-month period. S&T is working with the three industry performers to identify commercial markets and foster community awareness and adoption.

Industry Performer Sensor Profiles
Evigia Systems, Inc.’s Flood Monitoring and Alert Sensor Network is a scalable IoT network of highly-reliable multi-sensing nodes with wide-area wireless coverage and cloud sensor data processing. This rugged network employs self and remote configurations to deliver optimal efficiency and situational performance.

Physical Optics Corporation’s RAFFAR is a real-time flash flood early warning system that supports a self-healing mesh topology of sensor nodes, each consisting of a radio connected to a submersible flood sensor via a variable length cable to independently monitor waterway conditions. RAFFAR operates autonomously via continuous solar-and-battery power, communicating wirelessly between nodes and emergency data centers using satellite, radio or cellular.

Progeny Systems Corporation’s InIoT flood inundation sensor is a low cost, end-to-end solution that enables alerts, warnings and notifications to responders and citizens of ever-changing flood conditions.

The ruggedized, modular, self-sustaining and configurable sensor can monitor, detect and report situational data to operations centers through a scalable network architecture, enabling real-time decisions that improve disaster prediction and response.

To learn more about Low-Cost Flood Inundation Sensors, contact First.Responder@hq.dhs.gov.
75 Total Gages (25 each from 3 vendors)

- IoT gages operate in clusters
  - 5 gages per cluster for this deployment
- The 3 vendors are deployed at the same sites for equal comparison
  - This means each bridge or culvert will have 3 gages installed
- Resulting in 5 test areas with clusters of 5
  1. Boone
  2. Winston Salem (Mill Creek Area)
  3. Winston Salem (Downtown)
  4. Goldsboro
  5. Lumberton
North Carolina Emergency Management
Adopt a Gage (AAG) Program

The Flood Inundation Mapping Alert Network (FIMAN) provides flood warning information to local community officials and the public. The goal of FIMAN is to reduce the loss of life and flood related property damage by providing timely, detailed, and accurate flood inundation information. FIMAN is a system of integrated datasets and tools that effectively communicates information to community officials and the public. FIMAN uses data from a network of more than 500 gages. In order to provide flood warning information for additional locations in North Carolina more stream gages are being installed. For FIMAN to provide timely and accurate information, data from these gages must be obtained 24 hours a day, seven days a week with no interruptions.

Gage maintenance is critical to being able to provide data to community officials and the public during an event. NCEM has created the Adopt a Gage (AAG) program to partner with local officials to insure that gages located in their community are operational and to notify NCEM when a gage needs repair.

The AAG program would allow a county or local government to adopt the gages in their community and provide us eyes on the ground. AAG partners would use the NCEM/AAG web page to report status information about a gage site, to report problems (debris buildup, damage, theft) or report that the gage is in good condition. The AAG partner would also serve as a local contact that we could use for a quick visit to a gage to perform simple maintenance tasks.

Add a link to the AAG web page where they could sign up as an AAG partner with a drop down menu to choose which gage(s) that would like to adopt.
Future Vision

• Install 37 new Riverine and 13 Coastal gages – generate inundation map libraries and risk calculations
• Extend inundation libraries and risk modeling for 40 existing gages
• Develop inundation libraries at 60 existing gages that currently do not have inundation libraries
• Install 30 low cost water level sensors at high risk bridges and culverts
• Enhance data integration with FIMAN web application
FIMAN Build-Out Plan

- 5-yr plan designed to increase FIMAN coverage for municipalities across the state
- Ranked and Prioritized 320 new gages
- Flood warning for critical infrastructure and roadway overtopping
Questions?

Dan Brubaker, PE, CFM
NCEM/Risk Management
4105 Reedy Creek Road
Raleigh, NC 27607

Main office: 919-825-2341
Direct line: 919-825-2300

dan.brubaker@ncdps.gov