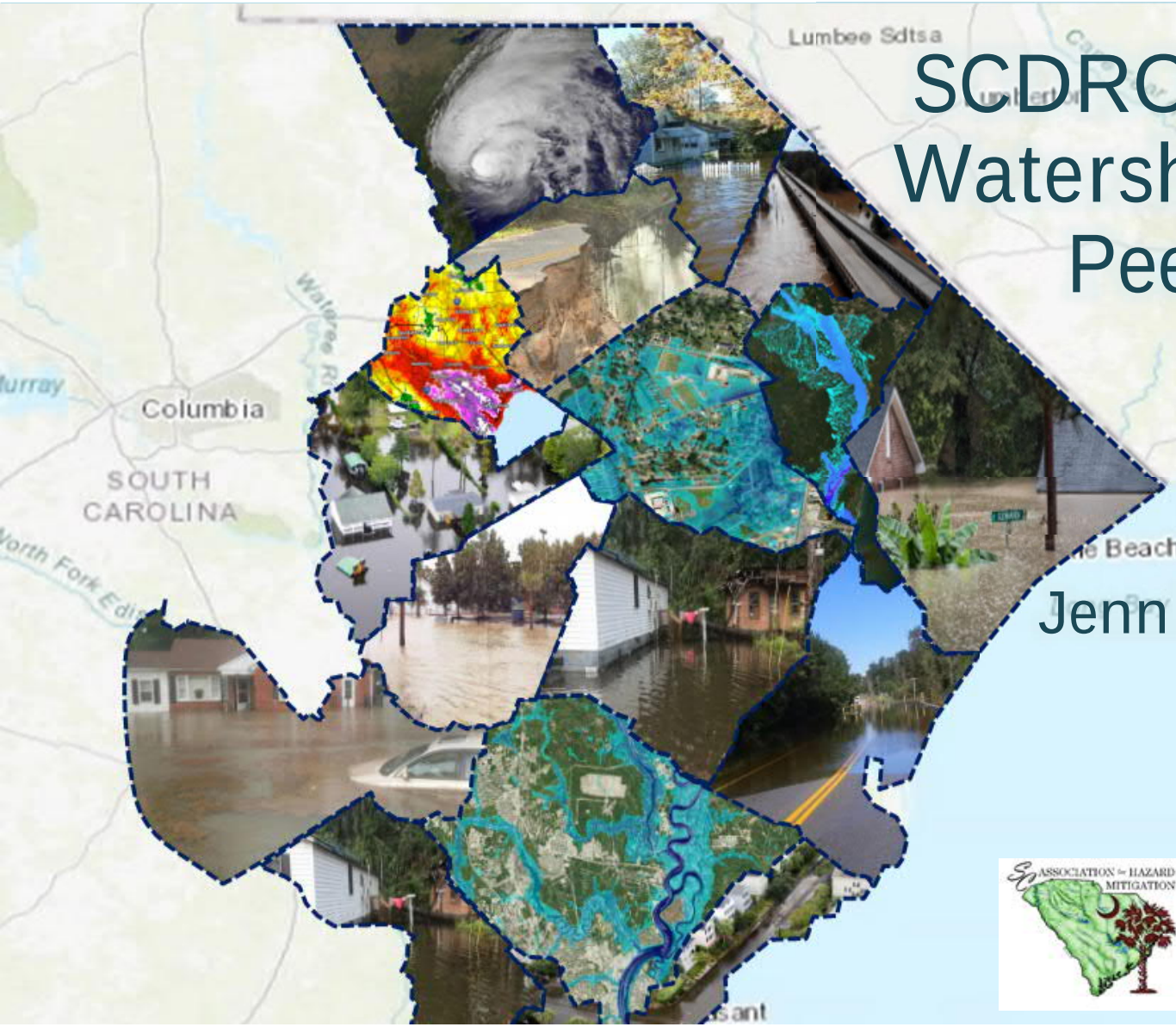


SCDRO Comprehensive Watershed Study for the Pee Dee and Santee Watersheds

March 3, 2020

Jennifer Housman, AECOM
Tyson James, AECOM

SC Association for Hazard Mitigation

Disaster Recovery
While I breathe, I hope!

AECOM

SCDRO
Comprehensive Watershed Study
for the
Pee Dee & Santee Watersheds

The Process

STAGE 1: RESEARCH & GATHER IDEAS

A total of 198 project ideas were collected from:

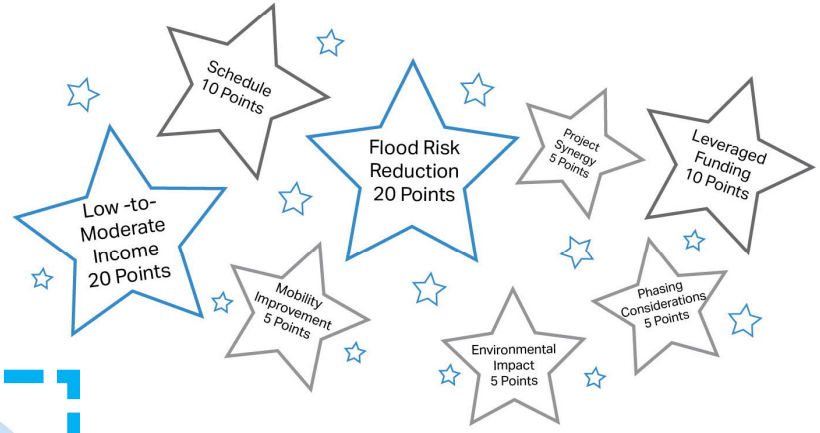
- 160+ Letters to local, state & Federal entities
- 200+ People in Public Meetings
- SCDRO's Consultant, Academia & NPO's

STAGE 2: QUALIFY PROJECTS

Project ideas had to meet the requirements of the CDBG-Mitigation grant including low and moderate income and flood damaged areas.

STAGE 3: EVALUATE PROJECTS

149 Grant Eligible project ideas were ranked against each other by 8 categories and awarded a maximum of 80 points.



STAGE 4: BENEFIT COST RATIO

The top 37 ranked project ideas were analyzed to determine how much the benefit would outweigh the mitigation cost. Up to 20 points were awarded.

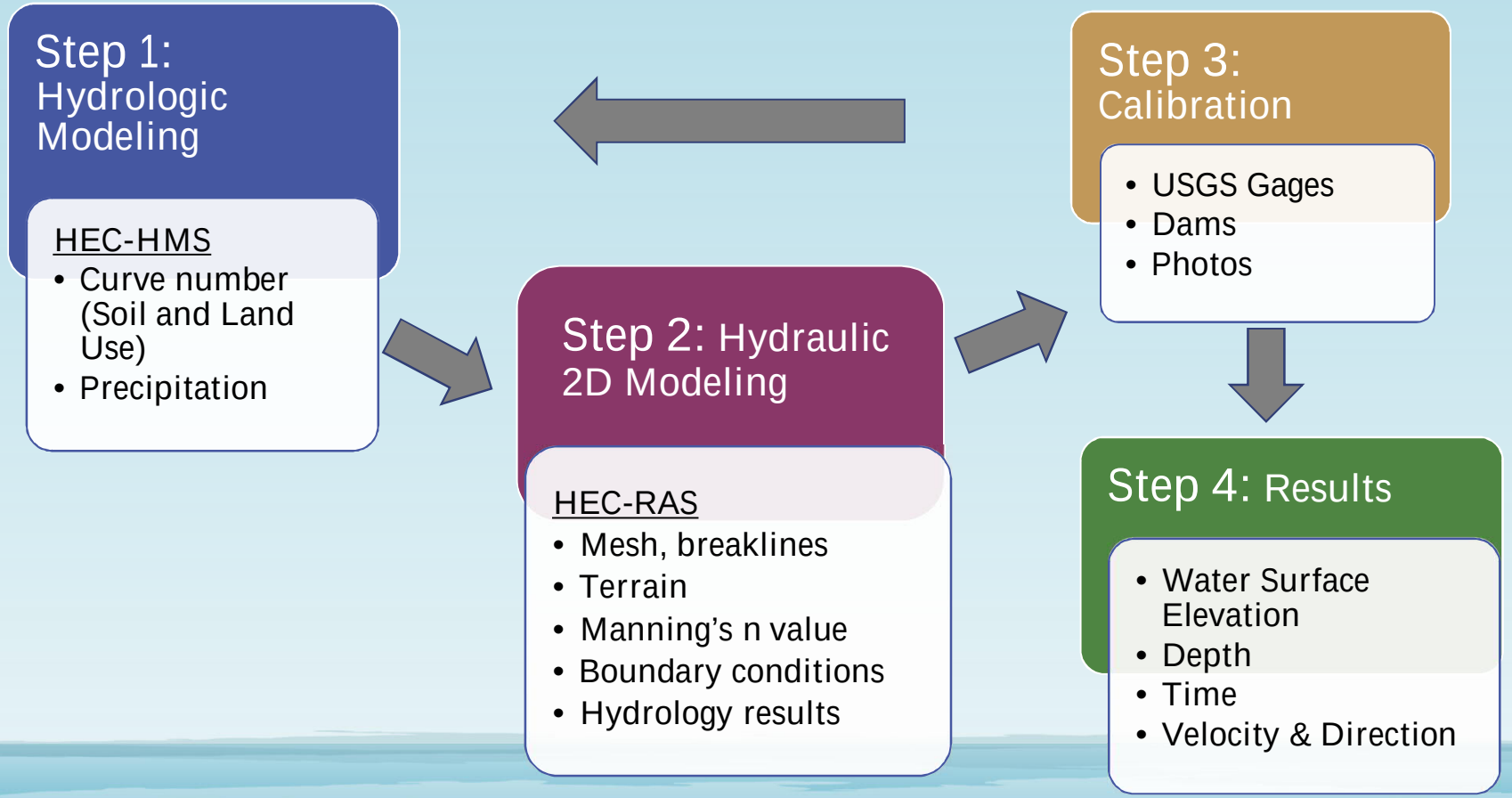
STAGE 5: FINAL RANKING

All 198 project ideas were scored. All 149 qualified project ideas were ranked. SCDRO to determine how to allocate grant funding.

Flood Modeling was critical to:

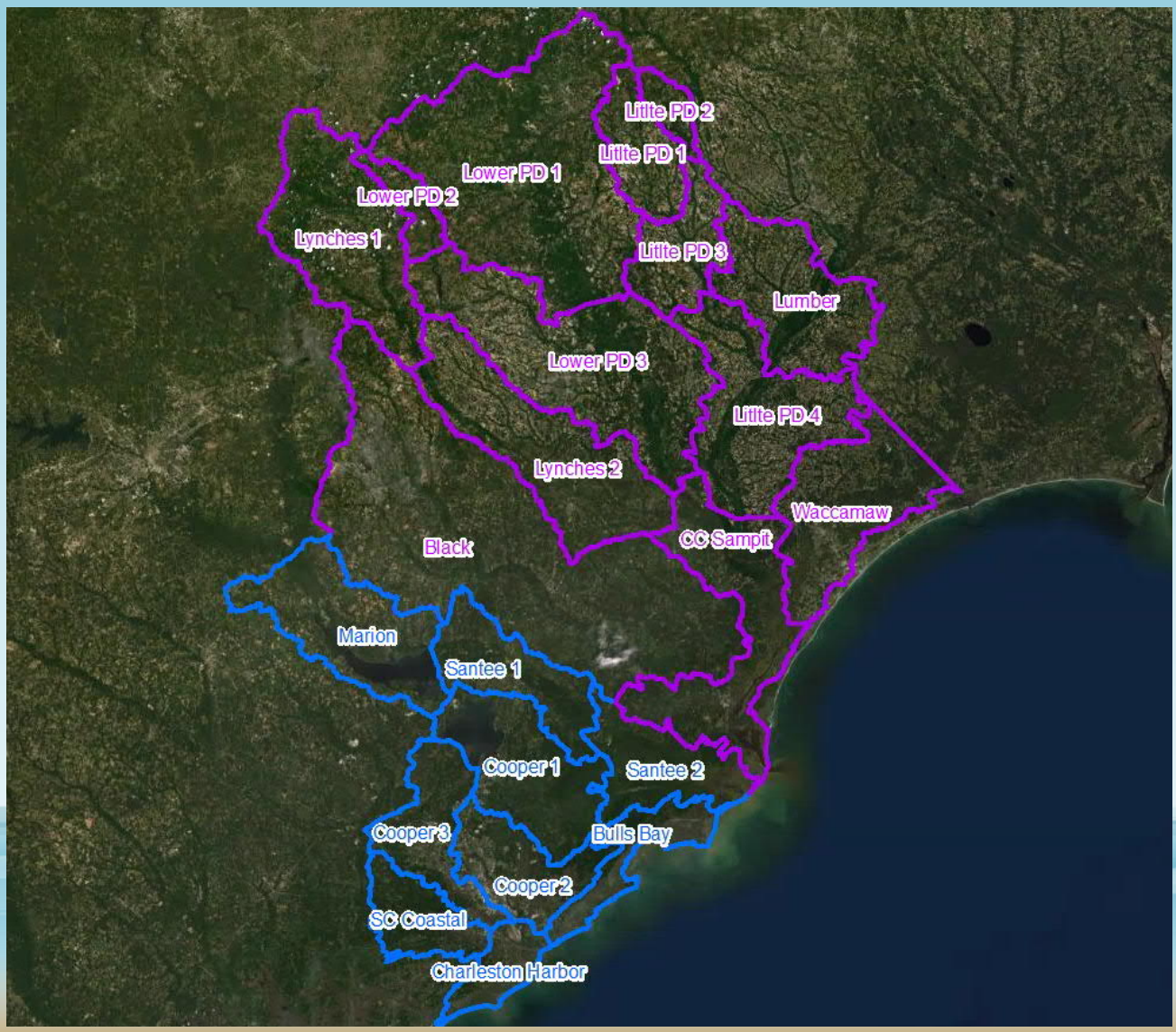
1. Rank projects through quantitative means
2. BCA
3. Raster Deliverables for future use
4. Gain better understanding of watersheds

Flood Modeling



2D Models

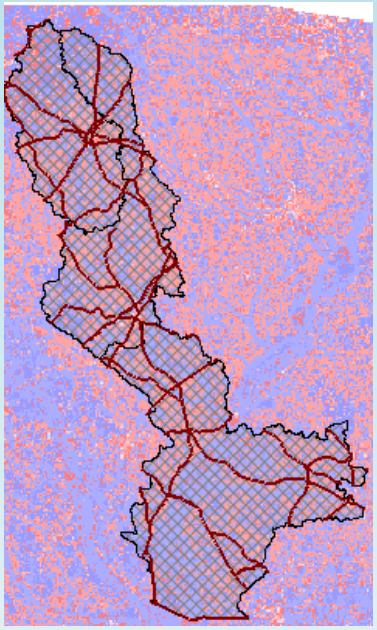
- Santee Watershed
  2015 Oct Storm Event
- Pee Dee Watershed
  2016 Hurricane Matthew
- 16 Models
- 22 Meshes



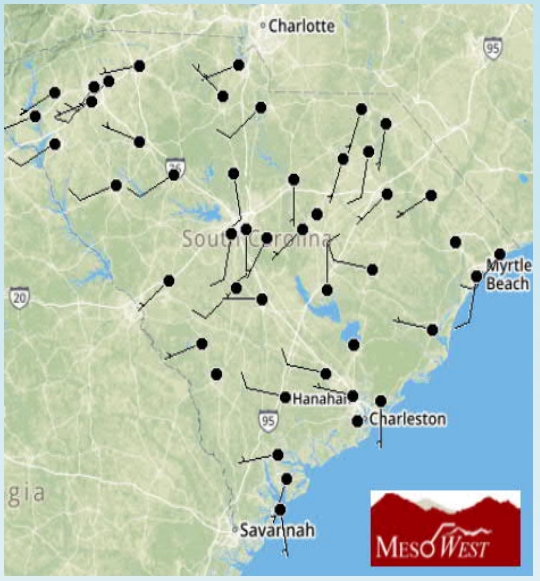
Step 1: Hydrologic Model using HEC-HMS

Watershed Delineation
(HUC 8)

Curve Number
(Land Use & Soil Type)



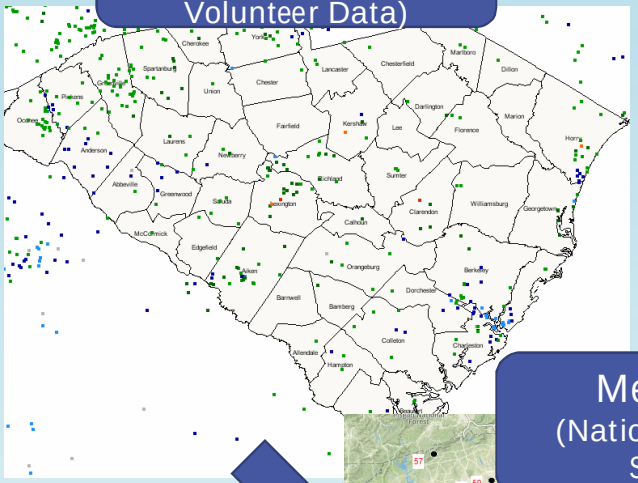
Precipitation
(CoCoRaHS & MesoWest)



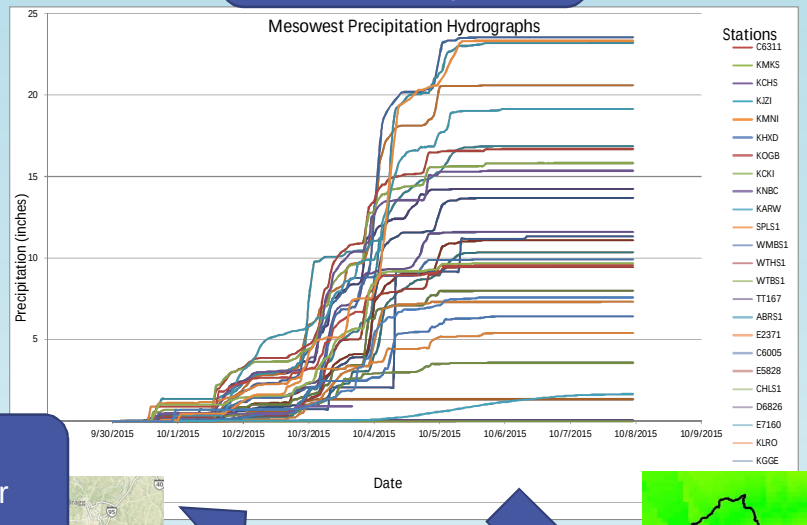
Gage Analysis for Boundary Conditions

Step 1: Precipitation

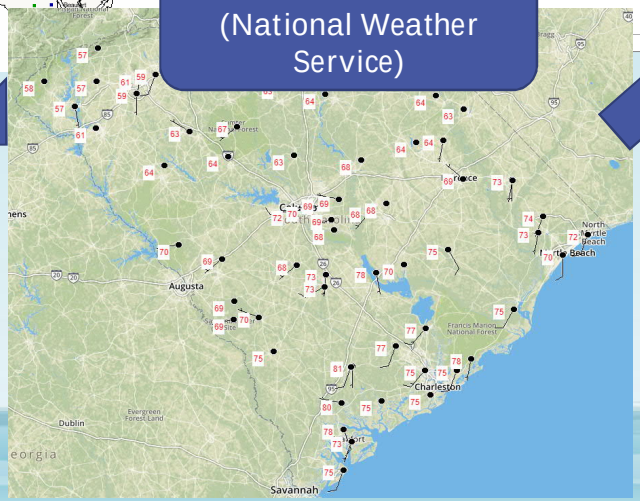
CoCoRaHS
(Daily Precipitation, Volunteer Data)



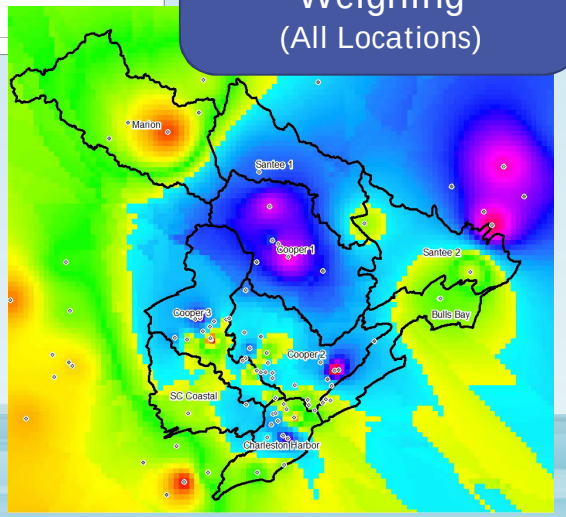
Hydrograph
(Standardize & Correct)



MesoWest
(National Weather Service)



Thiessen Polygons & Inverse Distance Weighing
(All Locations)



Step 1: Gage Hydrographs

USGS Gage Data
(Historical Data)

Boundary Condition Hydrograph
(Dam Discharge, or Coastal)

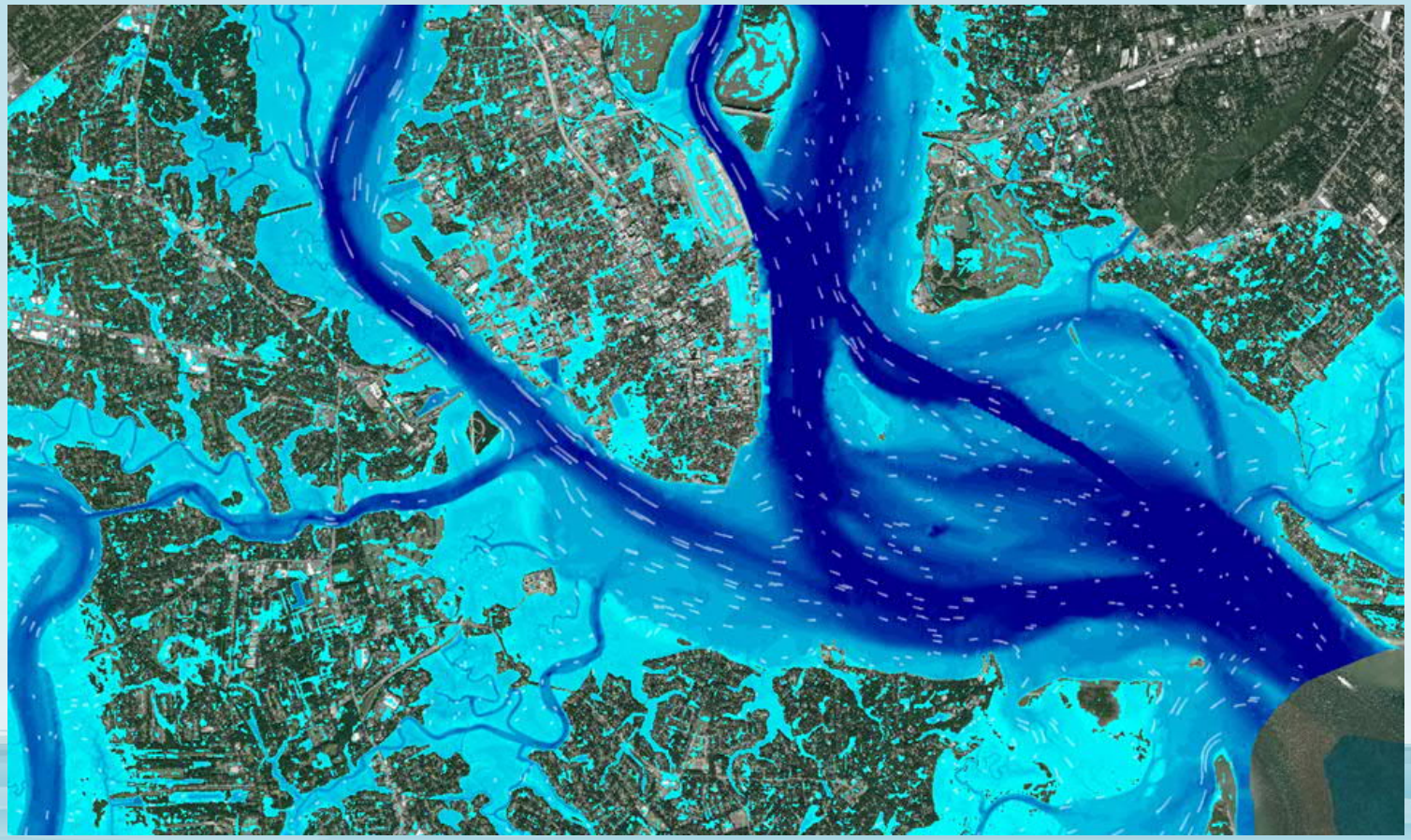
Calibration Check

Missing Data

HEC-HMS 4.2 (Hydrologic) & 2D HEC-RAS 5.0.6 (Hydraulic) Modeling

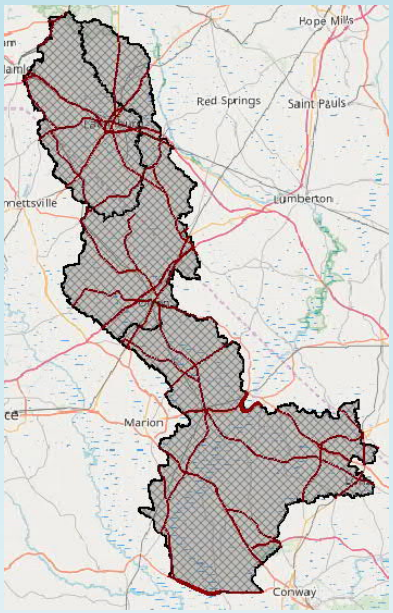
Hydrologic Engineering Center (HEC)

- Developed by the U.S. Army Corps of Engineers
- HMS for runoff, Rain-on grid input
- Perform two-dimensional (2D) unsteady flow river hydraulic calculations
- Products include: peak flow, water surface elevations, flooding depths, velocity, direction of flow, time, etc.



Step 2: Hydraulic Model using HEC-RAS

Mesh & Breaklines
(2D Cells)



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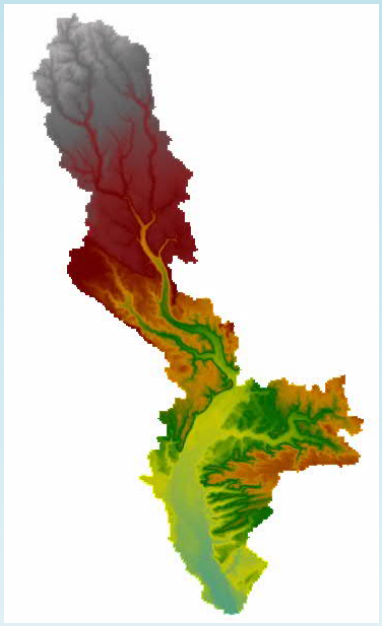
Terrain
(LiDAR from SCDNR)



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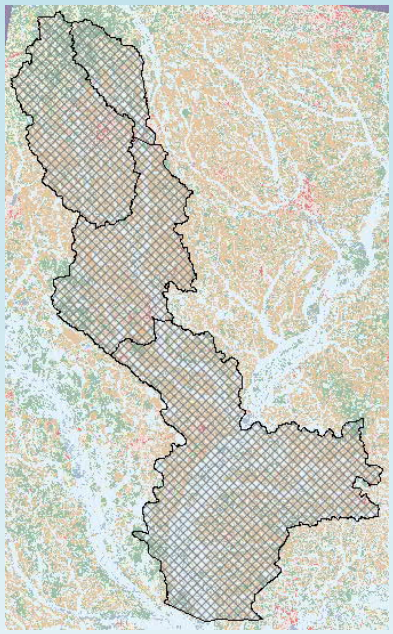
Manning's n Value
(Roughness for speed)



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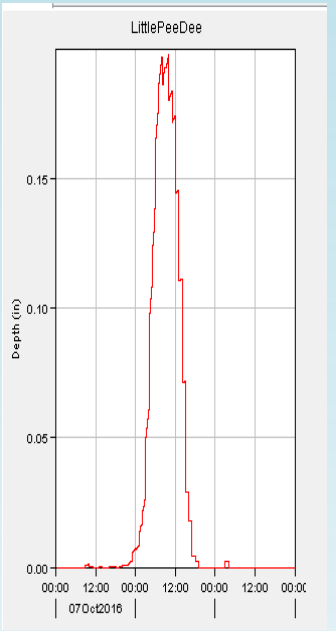
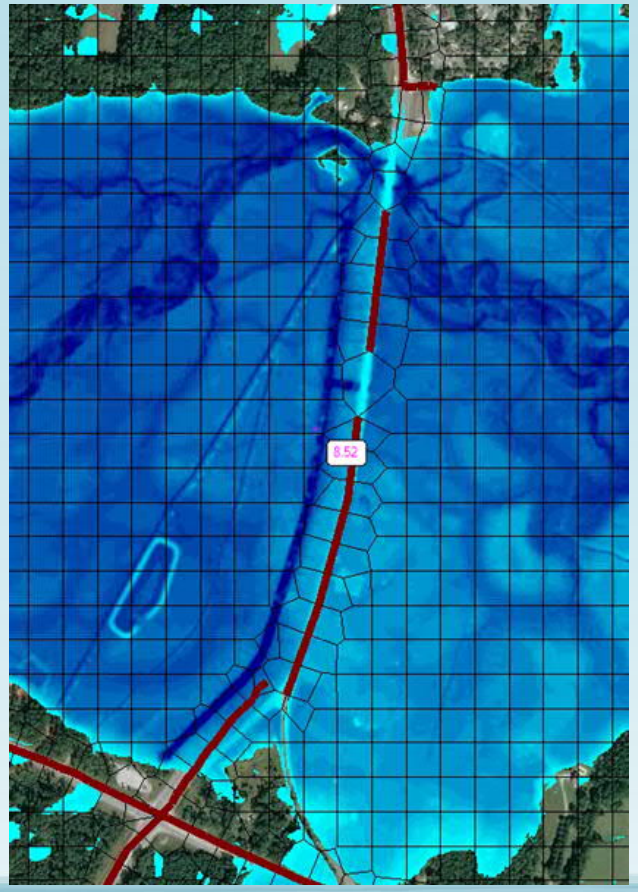
Boundary Conditions



Step 2: Hydraulic Model using HEC-RAS

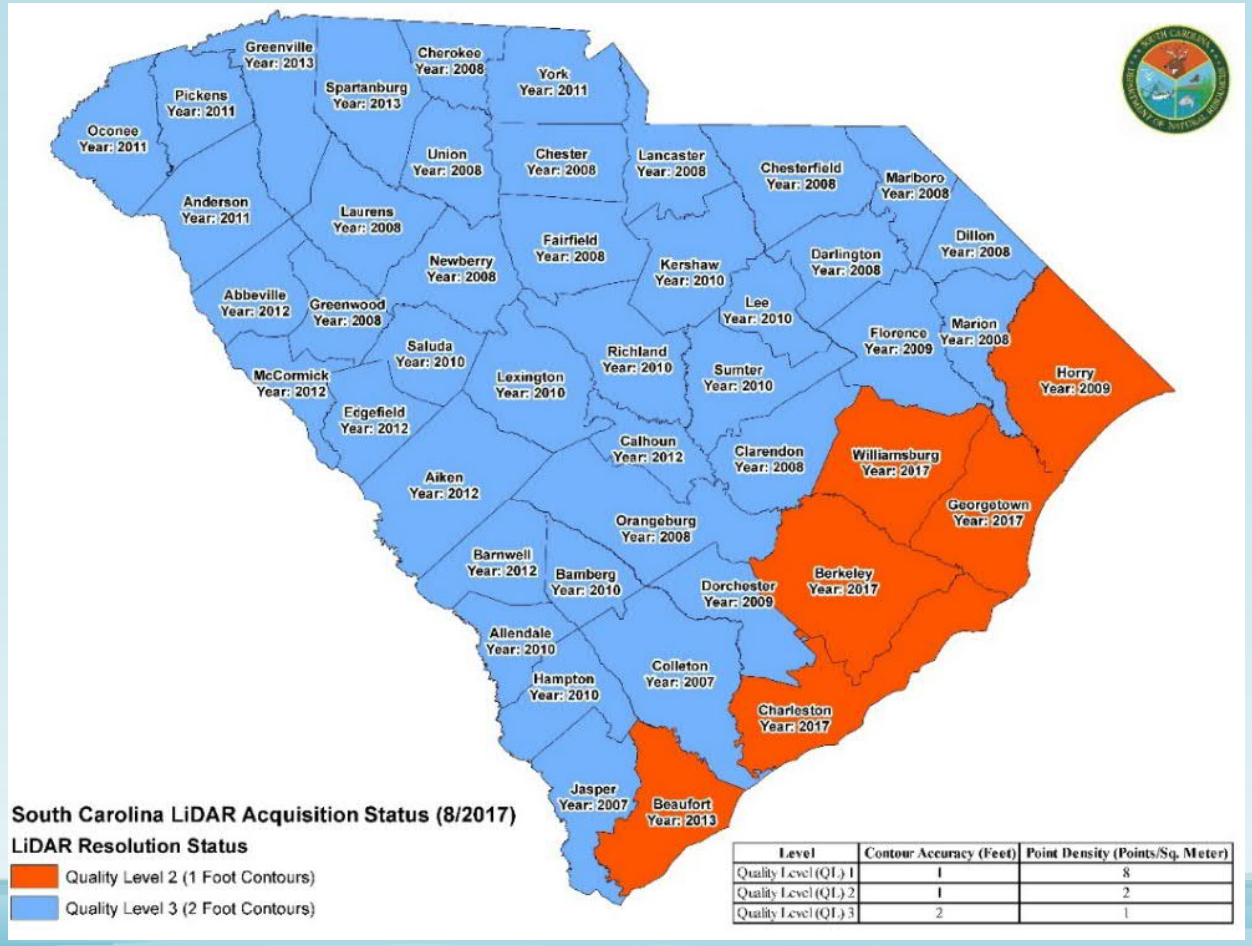
Watershed	Model	2D Mesh Name	Number of Cells	Average Cell Size (feet)
Santee	Lake Marion	LM	384,086	200
Santee	Cooper River 1	C1	238,281	250
Santee	Cooper River 2	C2	230,522	200
Santee	Cooper River 3	C3	238,180	200
Santee	Santee River 1	S1	250,842	200
Santee	Santee River 2	S2	246,692	200
Santee	South Carolina Coastal	SCC1	286,699	150
Santee	Charleston Harbor	CH1	273,807	125
Santee	Bulls Bay	BB1	153,433	200
Pee Dee	Lower Pee Dee	LPD1	316,029	350
Pee Dee	Lower Pee Dee	LPD2	307,402	350
Pee Dee	Lower Pee Dee	LPD3	230,263	350
Pee Dee	Little Pee Dee	LiPD1	86,874	300
Pee Dee	Little Pee Dee	LiPD2	28,070	300
Pee Dee	Little Pee Dee	LiPD3	94,144	300
Pee Dee	Little Pee Dee	LiPD4	214,228	300
Pee Dee	CC Sampit	CCS	117,802	400
Pee Dee	Lynches	L1	211,064	300
Pee Dee	Lynches	L2	230,068	300
Pee Dee	Lumber	Lumber	234,251	250
Pee Dee	Black	B1	250,440	475
Pee Dee	Waccamaw	W1	201,629	275



Mesh & Breaklines

- Number of Cells under 300k
- Only Major Breaklines and any other applicable locations such as berm

Step 2: Hydraulic Model using HEC-RAS



Level	Contour Accuracy (Feet)	Point Density (Points/Sq. Meter)
Quality Level (QL) 1	1	8
Quality Level (QL) 2	1	2
Quality Level (QL) 3	2	1

Terrain

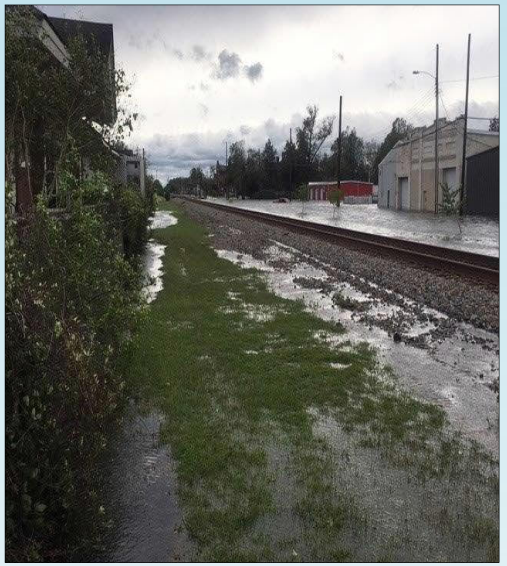
- Main Source: SCDNR
- Added Bathymetry from NOAA, USACE, & Coastal Carolina University for Coastal Areas
- Added an Average Lake Bathymetry to account for drought

Step 3: Calibration

Lakes & Dams

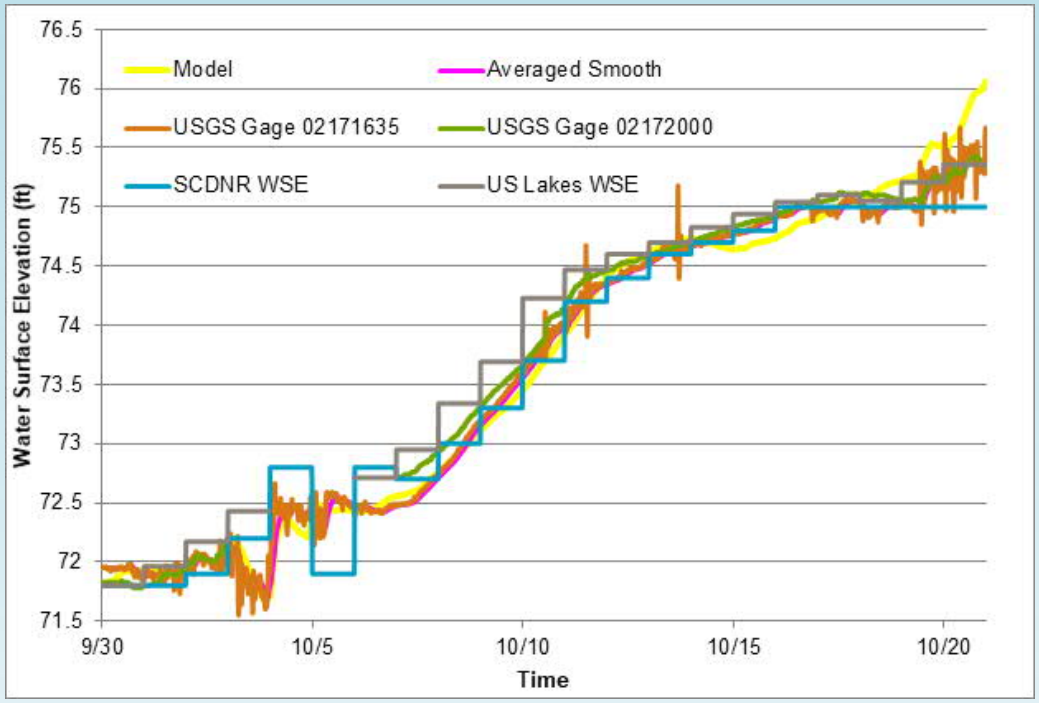
USGS Gages (Department of Interior)

Photos



Refine Hydrology and Hydraulics

Step 3: Lake Calibration



Known:

1. Precipitation
2. Lake WSE
3. Discharge from Lakes

Unknown:

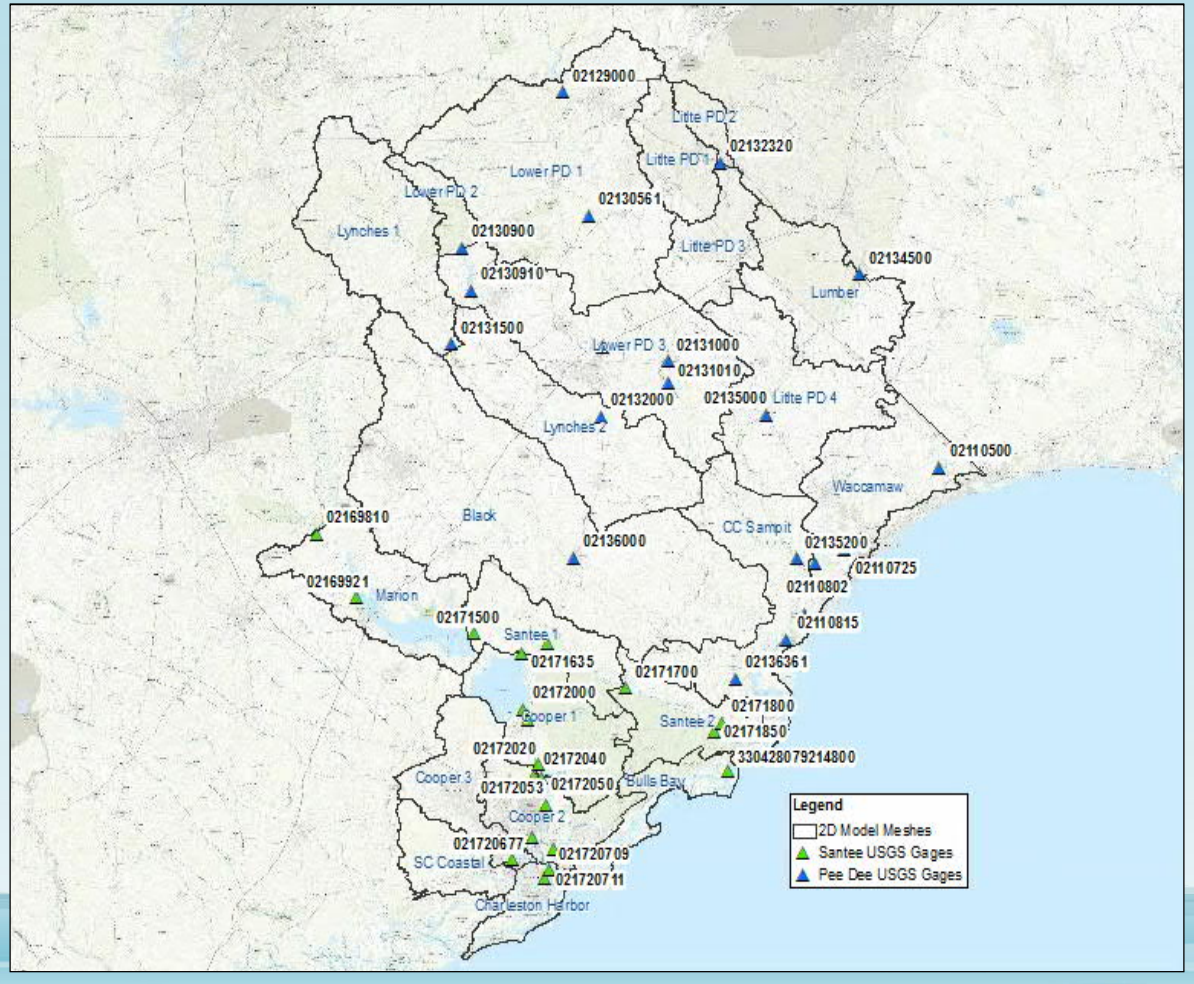
1. Lake Marion to Lake Moultrie

Solution:

- Iterative process with hot start file

Step 3: USGS Gage Calibration

USGS Gages (Department of Interior)



Goals:

1. Within 20% of the peak flow
2. Within 1 foot of peak stage
3. Within 6 hours of the peak time

Results:

- 27 out of 39 gages
- 6 did not meet time
- 6 only met 1 goal

Step 3: Photos & High Water Marks

Location

Trustworthy

Time

Peak

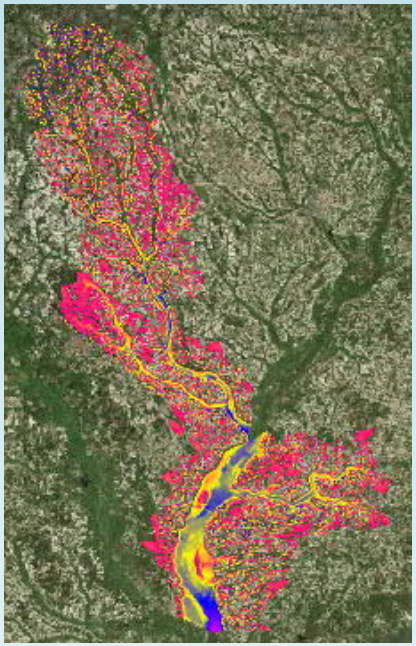
Step 3: Hydrology Calibration

Watershed	Model	2D Mesh Name	Calculated Precipitation	Calibrated Precipitation
Lake Marion	Lake Marion	LM	16.48	16.48
Santee	Cooper River 1	C1	19.59	19.59
Santee	Cooper River 2	C2	18.59	18.59
Santee	Cooper River 3	C3	18.03	18.03
Santee	Santee River 1	S1	19.42	19.42
Santee	Santee River 2	S2	18.80	18.8
Santee	South Carolina Coastal	SCC1	16.31	16.31
Santee	Charleston Harbor	CH1	19.30	19.3
Santee	Bulls Bay	BB1	18.73	7.25
Pee Dee	Lower Pee Dee	LPD1	6.98	4.59
Pee Dee	Lower Pee Dee	LPD2	5.73	4.18
Pee Dee	Lower Pee Dee	LPD3	10.29	9.54
Pee Dee	Little Pee Dee	LiPD1	8.74	8.74
Pee Dee	Little Pee Dee	LiPD2	8.87	5.32
Pee Dee	Little Pee Dee	LiPD3	10.74	12.00
Pee Dee	Little Pee Dee	LiPD4	13.76	13.76
Pee Dee	CC Sampit	CCS	9.55	9.55
Pee Dee	Lynches	L1	5.01	5.01
Pee Dee	Lynches	L2	8.71	8.71
Pee Dee	Lumber	Lumber	13.61	13.61
Pee Dee	Black	B1	7.98	7.00
Pee Dee	Waccamaw	W1	13.38	13.38

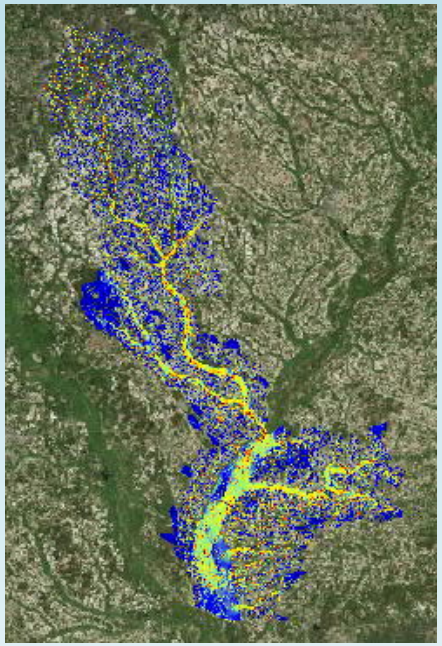
NLCD Classification	All Other Models (Santee, Cooper, etc.)	Lower Pee Dee	Little Pee Dee	CC Sampit	Lumber	Black	Waccamaw	Lynches
Other	0.03	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Open Water	0.03	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Developed, Open Space	0.013	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Developed, Low Intensity	0.05	0.063	0.063	0.063	0.063	0.063	0.063	0.063
Developed, Medium Intensity	0.075	0.094	0.094	0.094	0.094	0.094	0.094	0.094
Developed, High Intensity	0.1	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Barren Land	0.03	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Deciduous Forest	0.12	0.16	0.17	0.16	0.16	0.14	0.16	0.16
Evergreen Forest	0.12	0.16	0.17	0.16	0.16	0.14	0.16	0.16
Mixed Forest	0.12	0.16	0.17	0.16	0.16	0.14	0.16	0.16
Scrub/Shrub	0.05	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Grassland/Herbaceous	0.03	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Pasture/Hay	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cultivated Crops	0.035	0.045	0.06	0.045	0.055	0.04	0.045	0.045
Woody Wetlands	0.1	0.12	0.17	0.12	0.15	0.085	0.12	0.12
Emergent Herbaceous Wetland	0.1	0.15	0.17	0.15	0.16	0.11	0.15	0.15

Step 4: Results

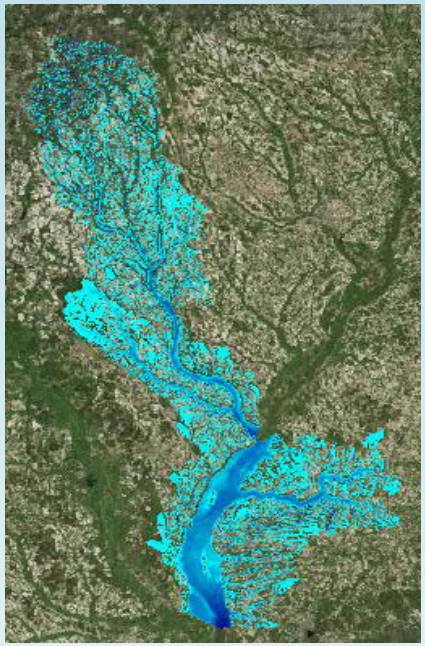
Water Surface Elevation & Flow



Velocity & Direction



Depth & Boundary



2D Models Allows Results anywhere in Model!

Step 4: Results - Waccamaw River – Northeast of Near Conway, SC

Benefit-Cost Analysis

Step 1: Existing Condition Model

- Reduce Mesh Size for better Accuracy
- New boundary Conditions
- Iterate to Replicate Results
- Export Results

Step 2: Mitigation Model

- Verify Data (Google & POC)
- Implement Mitigation
- Export Results

Step 3: Analysis

- Structures (Bing)
- Water Depth Probability Curve (PELV A05)
- Annualized Average Loss
- Loss of Service, etc.
- Repetitive Loss Data

Step 4: Benefit-Cost Ratio

- Convert Data to a dollar amount
- Benefit / Cost

How Mitigation was Implemented?

1. Precipitation

Reduce Precipitation by stormwater system's capacity

2. Terrain

Burn Raster with detention pond, channel, stormwater network

3. Model

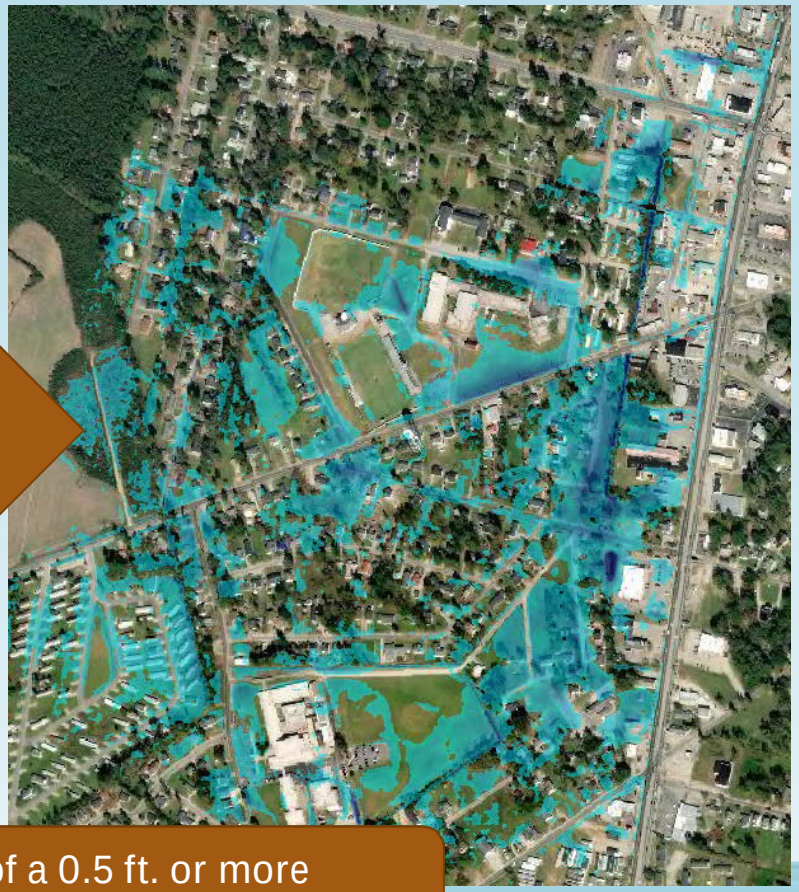
Alter structure such as a bridge, or add a levee with a connection

Reduced Precipitation

Hurricane Matthew Flooding

Stormwater:
Additional 9,250 ft.
of 2 to 4 ft. Pipe
(RCP)

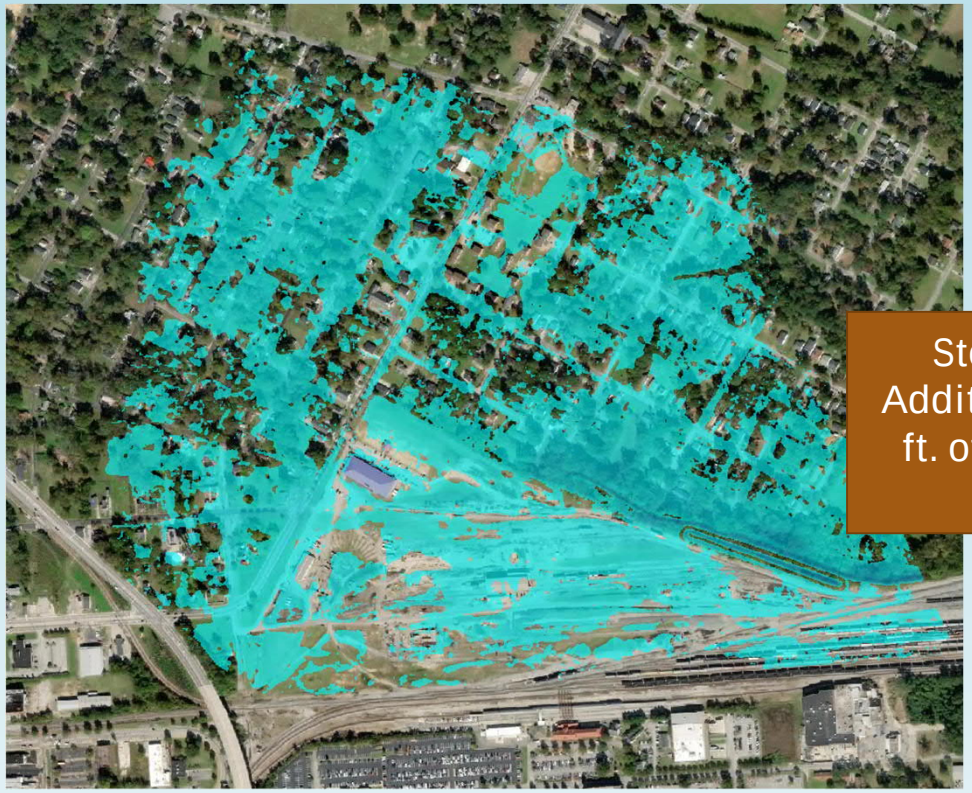
Potential Mitigated Flooding



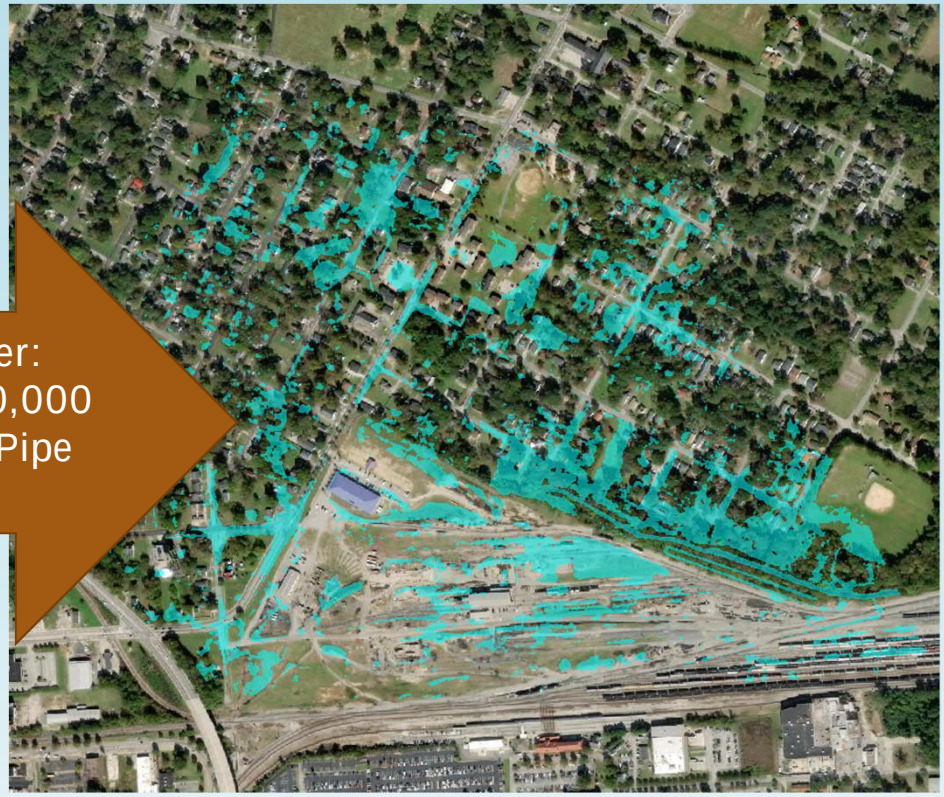
37 Structures see a flood reduction of a 0.5 ft. or more
87 Structures removed from flooding

Reduced Precipitation

Hurricane Matthew Flooding



Potential Mitigated Flooding



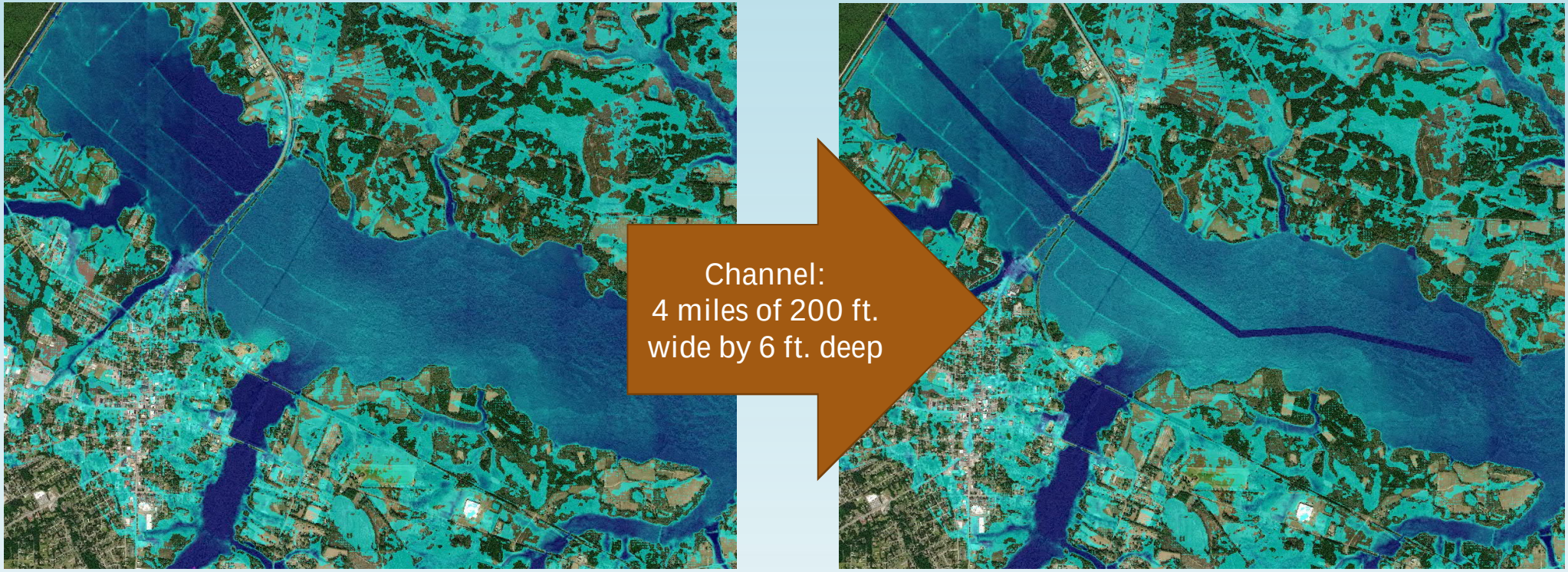
Stormwater:
Additional 10,000
ft. of 30 in. Pipe
(RCP)

185 Structures see a flood reduction of a 0.5 ft. or more
32 Structures see a flood reduction of a 1 ft. or more

Altered Terrain

Hurricane Matthew Flooding

Potential Mitigated Flooding



23 Structures see a flood reduction of a 0.5 ft. or more
7 Structures see a flood reduction of a 3 ft. or more

Altered Terrain

Hurricane Matthew Flooding

Channels &
Driveway Culverts

Potential Mitigated Flooding

Questions?