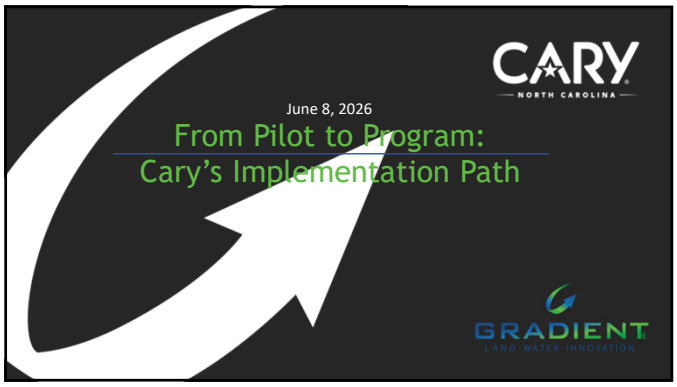
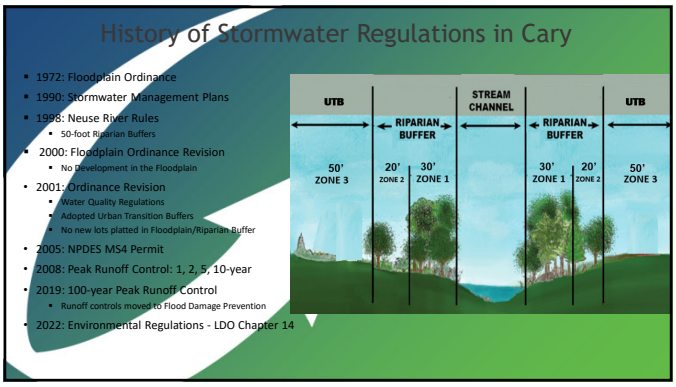

CARY
NORTH CAROLINA
June 8, 2026
From Pilot to Program:
Cary's Implementation Path
GRADIENT
LAND · WATER · INNOVATION

1


History of Stormwater Regulations in Cary
1972: Floodplain Ordinance
1990: Stormwater Management Plans
1998: Neuse River Rules
50-foot Riparian Buffers
2000: Floodplain Ordinance Revision
No Development in the Floodplain
2001: Ordinance Revision
Water Quality Regulations
Adopted Urban Transition Buffers
No new lots platted in Floodplain/Riparian Buffer
2005: NPDES MS4 Permit
2008: Peak Runoff Control: 1, 2, 5, 10-year
2019: 100-year Peak Runoff Control
Runoff controls moved to Flood Damage Prevention
2022: Environmental Regulations - LDO Chapter 14
UTB
RIPARIAN BUFFER
STREAM CHANNEL
RIPARIAN BUFFER
UTB
50' ZONE 3
20' ZONE 2
30' ZONE 1
30' ZONE 1
20' ZONE 2
50' ZONE 3

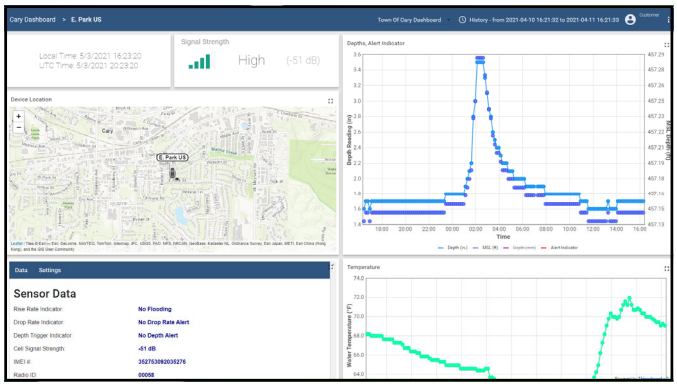
2


"If at first you don't succeed, try, try again"

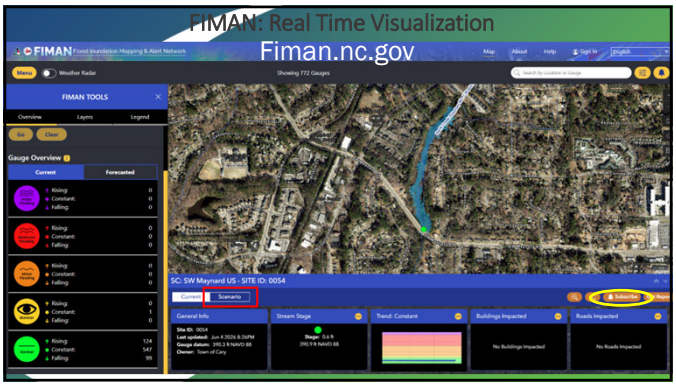
3


Stream and Rain Gauge Network
Town of Cary
STREAM FLOOD MONITORING PROJECTS
Citizen Awareness
Emergency Communication
Maintenance
Model Calibration
WALNUT CREEK-NEUSE RIVER BASIN
SWIFT CREEK BASIN
AWARE

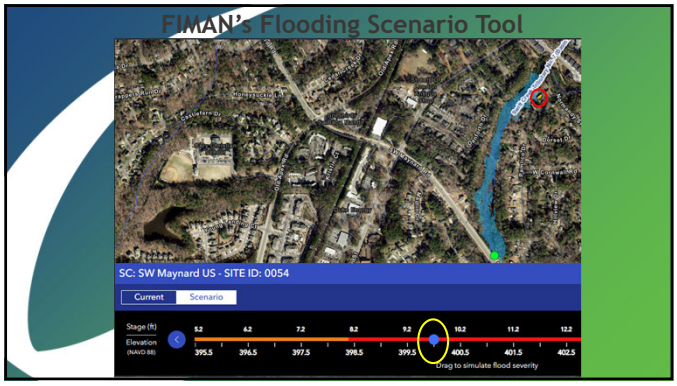
4


Cary Dashboard > E. Park US
Signal Strength
High
Sensor Data
Data
Settings

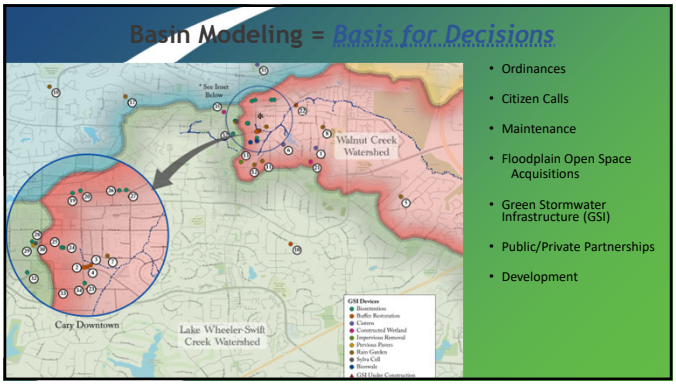
5


FIMAN: Real Time Visualization
Fiman.nc.gov
FIMAN TOOLS
Gauge Overview
SC: SW Maynard US - SITE ID: 0054

6


FIMAN's Flooding Scenario Tool
SC: SW Maynard US - SITE ID: 0054
Current
Scenario
Stage (ft)
Elevation (NAVD 88)
Drag to simulate flood severity

7


Basin Modeling = Basis for Decisions
Walnut Creek Watershed
Cary Downtown
Lake Wheeler-Swift Creek Watershed
Ordinances
Citizen Calls
Maintenance
Floodplain Open Space Acquisitions
Green Stormwater Infrastructure (GSI)
Public/Private Partnerships
Development

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Swift Creek Model Development

1. Stormwater Infrastructure Data
2. Land Cover Data
3. Soils Data
4. LiDAR Topographical Data
5. Rainfall Data
6. Stream Flow/Stage Monitoring Data
7. Stream Monitoring and Precipitation Data

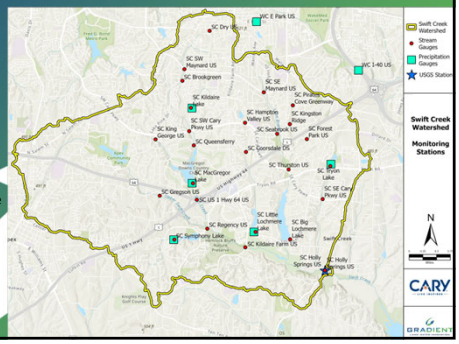
9

Swift Creek Watershed Monitoring Network

7 Precipitation Gauges
- 2021-present
- 5 inside, 2 outside
- Rainfall intensity and depth
- 10-minute intervals

26 stream gauges
- Flow depth (2022-Present)
- 16 crossings, 6 lakes, 4 in-line with streams

1 USGS station (Holly Springs)
- WSE, flow, precipitation, WQ parameters



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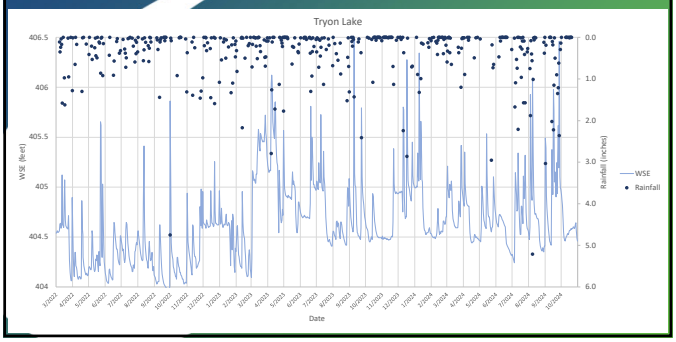
Stream Stage and Rainfall Comparison



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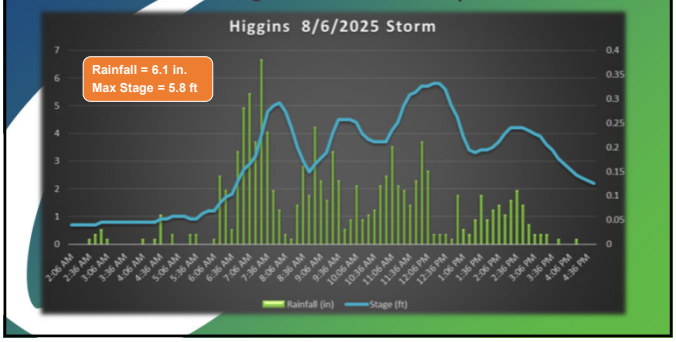
Stream Stage and Rainfall Comparison



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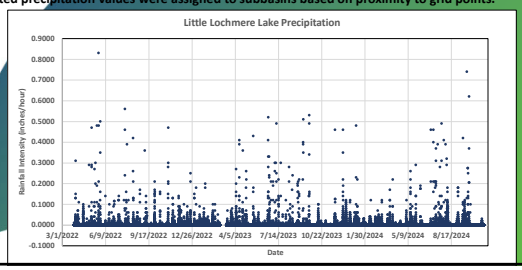
Precipitation Data

- PCSWMM model was setup to run from March 2022-October 2024.
- Precipitation data was Inverse Distance Weighted to grid points across the Swift Creek watershed.
- Weighted precipitation values were assigned to subbasins based on proximity to grid points.



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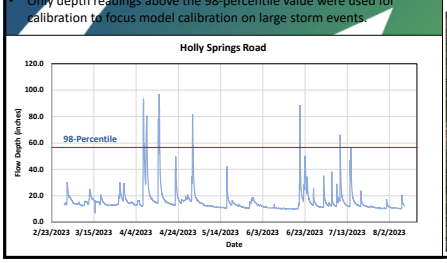
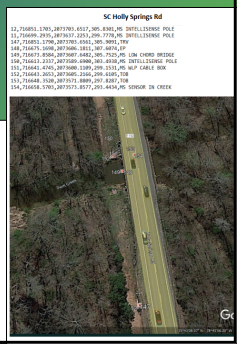
Stream Stage Data

- Station survey data was used to update the model so that station WSE matches model WSE.
- Stations whose location didn't match model junctions were not used in the analysis.
- Only depth readings above the 98-percentile value were used for calibration to focus model calibration on large storm events.





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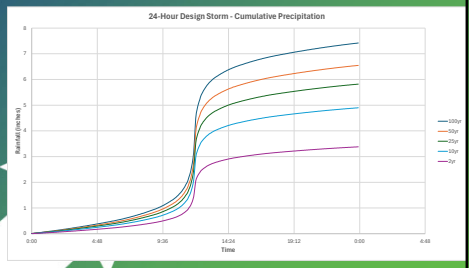
Data Acquisition - Rainfall Data (Design Storms)

1. 24-hour design storms from NRCS Type B Storms.
2. Depths from NOAA Atlas-14



	Precipitation Depth (inches) by Frequency Storm				
Duration	2-year	10-year	25-year	50-year	100-year
24-hour	3.44	5.00	5.93	6.66	7.41

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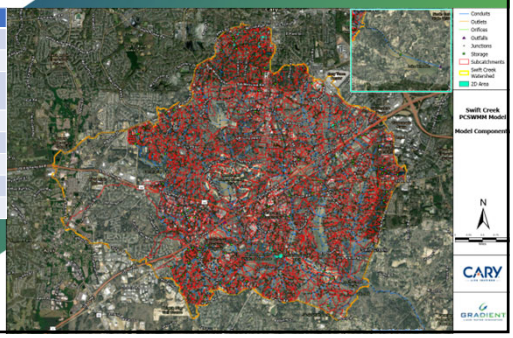
Data Acquisition-Stormwater Infrastructure

Component	Amount
Junctions	8,919
Pipes	115 miles
Open Channels	97 miles
Storage	82
Orifice	17
Outfalls	2
Outlets	18
Weirs	89



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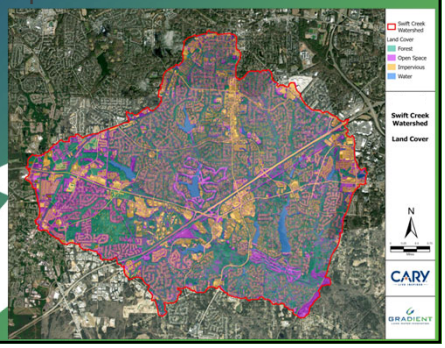
Data Acquisition - Land Cover

1. Impervious Surfaces – building footprints, roadway, asphalt, concrete
2. Pervious Surface – Forest/Lawn/Vegetation.
3. Water Bodies
4. Apex Area Land Cover – Apex Impervious Data and Aerial Imagery
5. Compiled into 4 Types: Forest, Open Space, Impervious, Water



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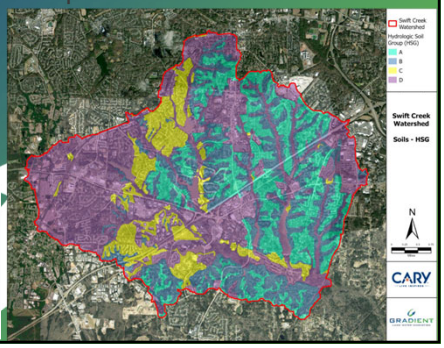
Data Acquisition - Soils

1. USDA Web Soil Survey
2. Hydrologic Soil Groups (HSG) A, B, C, D
3. Used to Calculated Curve Numbers (CN)

HSG Type	Soil Texture Class	% of Watershed
A	Sand	19.4
B	Sandy loam, Loamy sand	33.8
C	Clay loam	20.7
D	Clay	1.1
Other	Urban	22.7
Other	Water	2.3



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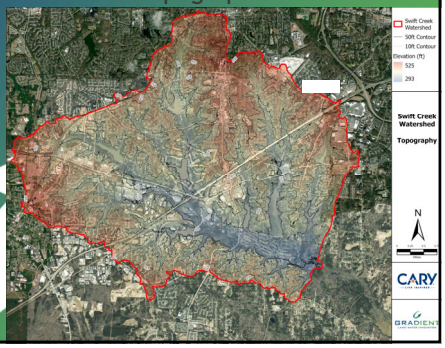
Data Acquisition - LiDAR Topographical Data

1. LiDAR data collected by Cary in 2024
2. LiDAR point data was converted into Digital Elevation Models (DEMs)
3. DEM has 0.5-foot spatial resolution
4. For Apex, the NC QL2 LiDAR was used, 1-meter spatial resolution



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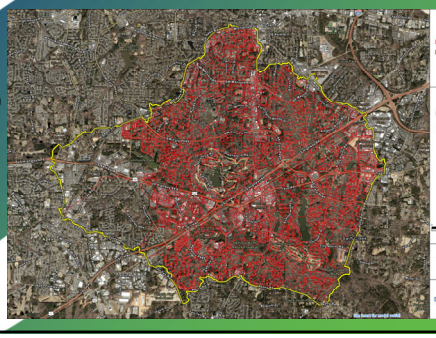
Subbasin Delineation

1. Subbasins delineated using
   - LiDAR
   - Infrastructure data
   - Aerial data
2. 4,607 subbasins
3. Median area = 1.05 ac
4. Apex area has larger subbasins due to lack of stormwater data



GRADIENT

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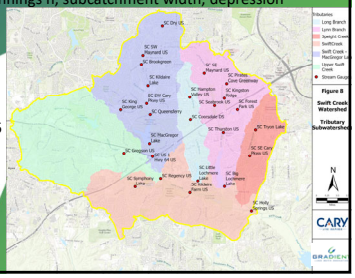
Model Development and Calibration

1. Created a 1-D continuous model for entire watershed
2. 2-D model for focus areas
3. Sensitivity Analysis parameters-CNs, Mannings n, subcatchment width, depression storage, subarea routing
4. Calibrate Model
   - Used 1D model to vary: CNs, subcatchment width, subarea routing
5. Model was calibrated independently for 6 tributary subwatersheds
6. Only the high-impact storms were selected for calibration (98-percentile)



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Model Performance Evaluation

Performance Metrics used to determine best simulation

1. **Nash-Sutcliffe Efficiency (NSE):** Measures overall accuracy of model
2. **R^2:** Measures how well model follows variability in data (trends)
3. **Percent Bias (PBIAS)**: Measures whether model over- or under-estimates

Statistic	Parameter	Performance Evaluation Criteria for Daily and Monthly Time Frame			
		Very Good	Good	Satisfactory	Not Satisfactory
NSE	Flow	0.80-1.0	0.70-0.80	0.50-0.70	0.0-0.50
	Sediment	0.80-1.0	0.70-0.80	0.45-0.70	0.0-0.45
R^2	Flow	0.85-1.0	0.75-0.85	0.60-0.75	0.0-0.60
	Sediment	0.80-1.0	0.65-0.80	0.40-0.65	0.0-0.40
PBIAS	Flow	0.0-5.0	5.0-10.0	10.0-15.0	> 15.0
	Sediment	0.0-10.0	10.0-15.0	15.0-20.0	> 20.0

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Calibration Results

Model performance in reference to flow at Holly Springs Rd. USGS station location.

Time Frame	R^2		NSE		PBIAS	
	Value	Rating[1]	Value	Rating[1]	Value	Rating[1]
Hourly	0.65	-	0.59	-	-12.4	-
Daily	0.81	Good	0.76	Good	-12.2	Satisfactory
Monthly	0.84	Good	0.81	Very Good	-11.7	Satisfactory

[1] Ratings are only available for the daily and monthly time frames.

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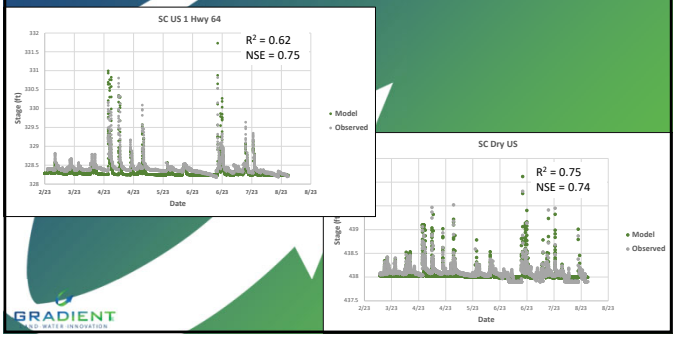
Calibration Results



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Level of Service Analysis

The LOS for Primary and Secondary roads is as follows:

- 11 Primary roads (US or NC highways) = 50-year storm
- 134 Secondary roads = 25-year storm

Street Name	Street Type	Stream Name	Roadway Overtopping Depth (ft) by Storm Frequency 25yr	50yr	Street Name	Street Type	Stream Name	Roadway Overtopping Depth (ft) by Storm Frequency 25yr	50yr
RAMP US 1 SB to US 64 WB	Primary	Swift Creek	0.05	0.15	Kelekeen Ln	Secondary	NA	0.09	0.09
US 64 Hwy W	Primary	Swift Creek	0.16	0.43	Kilarney Dr	Secondary	NA	0.04	0.04
Agassi Ct	Secondary	NA	0.25	0.27	Lake Pine Dr	Secondary	Williams Creek	0.22	0.3
Ambiance Pl	Secondary	NA	0.5	0.53	LamEash Ln	Secondary	NA	0.12	0.13
Annandale Dr	Secondary	NA	0.16	0.16	Lilly Atkins Rd	Secondary	Speight Branch	0.1	0.12
Berentwood Dr	Secondary	NA	0.09	0.09	Lochside Dr.	Secondary	NA	0.01	0.01
Braelands Dr	Secondary	NA	0.05	0.06	McGregor Downs Lake Bridge	Secondary	Swift Creek	0.01	0.02
Brookridge Dr	Secondary	NA	0.03	0.03	Dairy Dr	Secondary	NA	0.06	0.09
Chalon Dr	Secondary	NA	0.04	0.08	Pamlico Dr	Secondary	NA	0.1	0.13
Ellynn Dr	Secondary	NA	0.11	0.12	Pond St	Secondary	NA	0.26	0.27
Executive Cir	Secondary	NA	0.13	0.16	Queensferry Rd	Secondary	Swift Creek	0.04	0.08
Farmington Woods Dr	Secondary	Long Branch	0.12	0.13	Tarbert Dr	Secondary	NA	0.35	0.35
Foot Path - Swift Creek	Secondary	Swift Creek	0.55	0.58	Thurston Dr	Secondary	Lynn Branch	0.5	0.5
Greenwood Dr	Secondary	Lynn Branch	0.03	0.03	Tryon Rd	Secondary	NA	0.03	0.35
Gregson Dr	Secondary	NA	0.5	0.5	Two Creeks Rd	Secondary	NA	0.14	0.16
Halesworth Dr	Secondary	Long Branch	0.22	0.24	W Chatham St	Secondary	NA	0.4	0.44
Harbor Creek Dr	Secondary	NA	0.25	0.26	Washington St	Secondary	Lynn Branch	0.18	0.19
Heartwood Dr	Secondary	Lynn Branch	0.04	0.05	Wellingborough Dr	Secondary	NA	0.14	0.16
High Meadow Drive	Secondary	NA	0.04	0.04	Wicklow Dr	Secondary	NA	0.58	0.61
Hunters Crossing	Secondary	NA	0.5	0.5	Wicklow Dr	Secondary	NA	0.58	0.61

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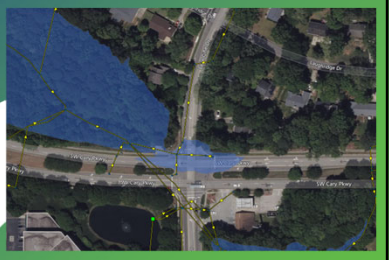
Level of Service Analysis-Future Capital Projects

Flooding of Lake Pine (Secondary Road -Minor Arterial) during the 25-year storm



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Capital Projects Evaluation

- Lake Pine Dr Proposed Improvements
- Culvert Replacement at Brookgreen Dr
  - Supplement two 6.5'Wx7.75'H box culverts with 14'Wx8'H RCBC
  - Replace Six 72" CMPs with two 12'Wx8'H RCBCs
- Model results consistent with HEC-RAS used for no-rise study.

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Model Maintenance & Next Steps

1. Quality Assurance Project Plan for Consistency in Future Modeling (*In Progress*)
2. Update model with available Stormwater Control Measures (SCMs) data
3. Update detention ponds and dams with spillway information, if available
4. Update stormwater infrastructure data, where missing
5. Re-calibrate model using up-to-date rainfall/stream data for a longer time-series
6. Incorporate the updated NOAA Atlas rainfall depths, expected in 2026

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