Asset Management Supports Proactive Planning & Maintenance of a Stormwater System

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CDM Smith

Raleigh

CDM Smith is proud to be celebrating our 75th anniversary in 2022!

Water Partnership with CDM Smith 75th

Proud History. Bold Future.

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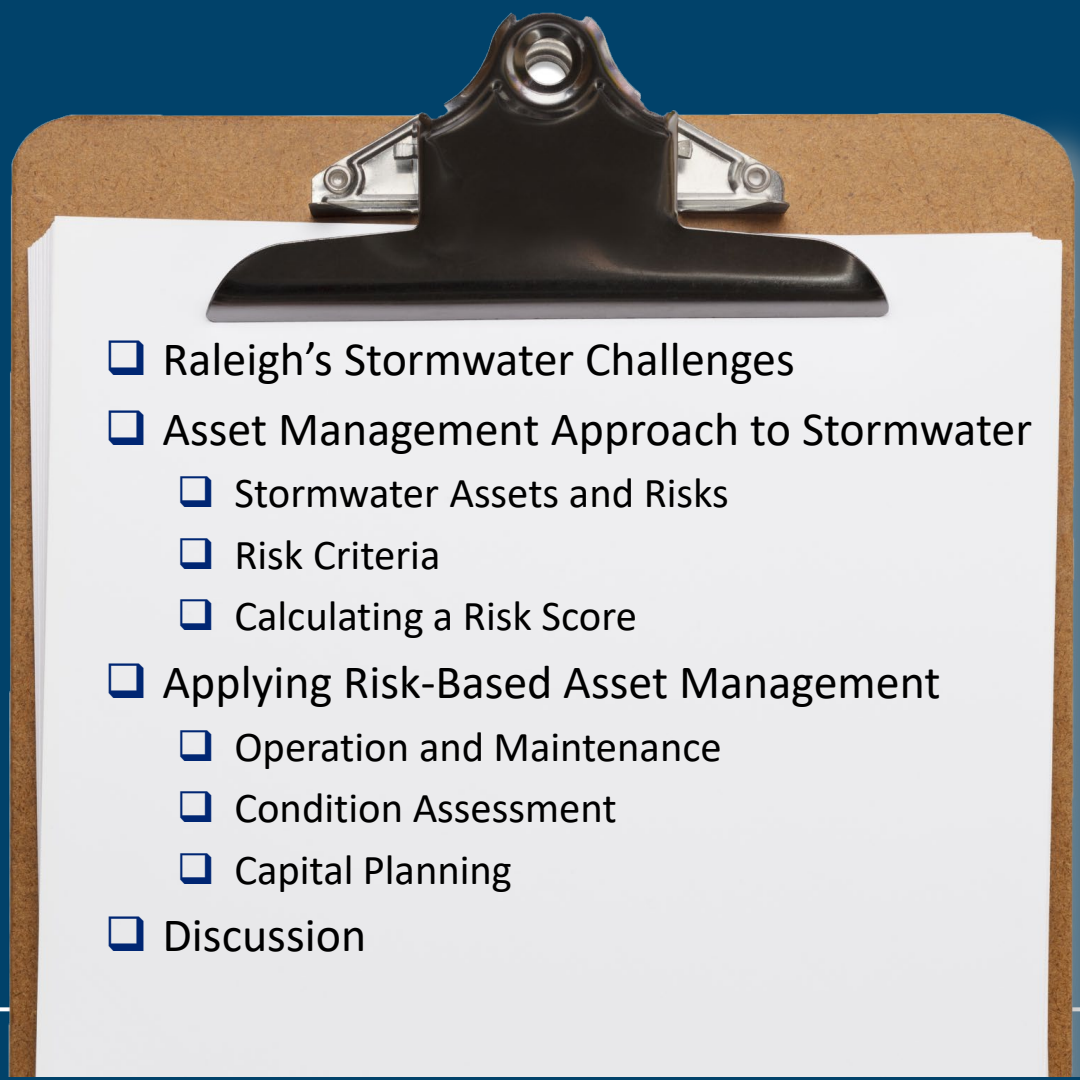
Agenda

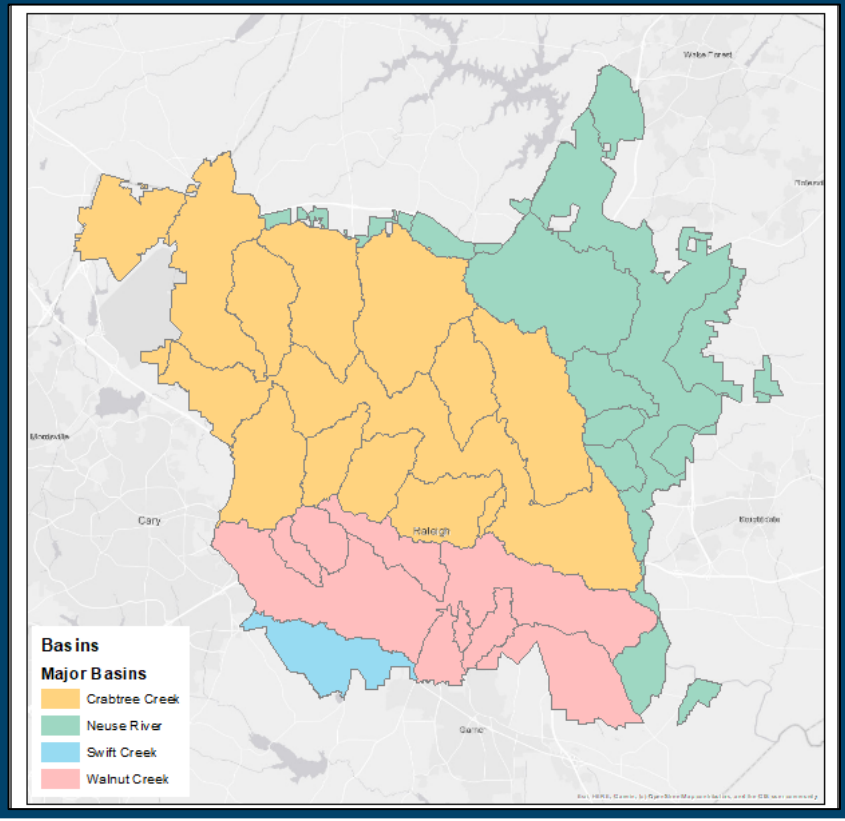


- Raleigh's Stormwater Challenges
- Asset Management Approach to Stormwater
  - Stormwater Assets and Risks
  - Risk Criteria
  - Calculating a Risk Score
- Applying Risk-Based Asset Management
  - Operation and Maintenance
  - Condition Assessment
  - Capital Planning
- Discussion

Raleigh's Stormwater Challenges

Raleigh's Stormwater Challenges

- Stormwater Utility formed, 2004
  - Serves 500,000 customers
- Mission
  - Preserve and protect life
  - Support healthy natural resources
  - Complement sustainable growth
- Constructed Drainage Assets
  - 600 miles of pipe
  - 31,000 inlets and junctions



Raleigh's Stormwater Challenges

- Public impacts caused by infrastructure failure
- Large amount of growth relying on old infrastructure
- Unknown asset condition
- Limited funding

Asset Management Approach To Stormwater

What is Asset Management?

"A Way of Doing Business that Allows Utilities to Achieve the Desired Level of ***Service*** and Acceptable Level of ***Risk*** at the Lowest Lifecycle ***Cost***"

What is it really?

Making Smarter Decisions Related to Utility Management

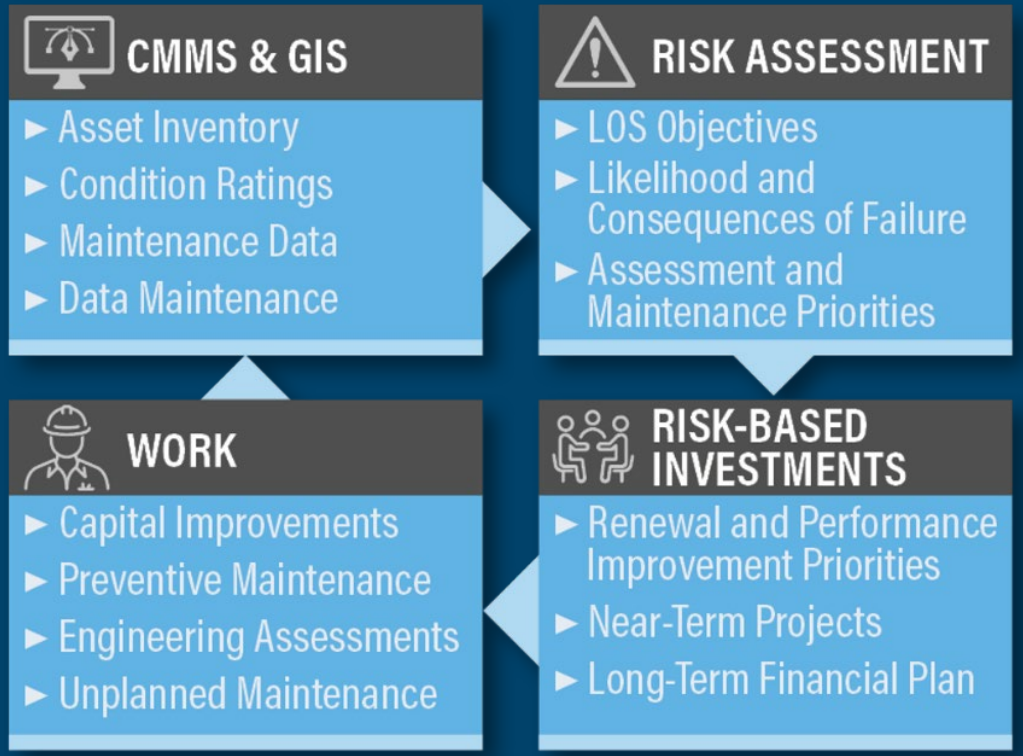
Knowing Your Assets, their location, their function, and their attributes

Employing Technology to determine each asset's condition, performance, significance, impact severity, and risk of failure

Improving Processes by using data to anticipate problems, schedule preventive maintenance, plan renewal, and develop capital improvement programs

Investing in People through proper training and certification to promote buy-in and stewardship

An Asset Management Program Establishes a Sustainable Assessment and Renewal Process



Effective asset management uses a team approach

- Risk framework to identify priorities for inspection and repairs
- Improve business processes to advance program goals

Asset Management Approach to Stormwater

Stormwater Assets and Risks

STORM SEWERS

- Gravity Mains
- Manholes
- Inlets/Catch Basins
- End Structures
- Overland Flow Path
- Pump Station
- Force Mains/Valves

CHANNELS

- Swales
- Open Channels (constructed, natural)
- Floodplains
- Riparian Areas

CROSSINGS

- Culvert
- Embankment
- Bridge Channel/ Abutments/Piers
- End Structures

CONTROL STRUCTURES

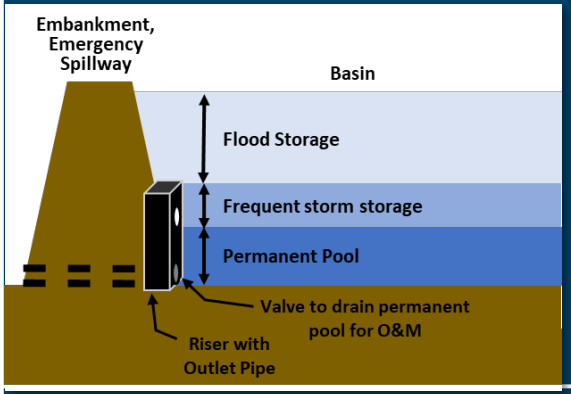
- Basin/Storage
- Pollutant Control
- Embankment
- Discharge Control
- End Structure
- Valves/Gates
- Gross Solids Controls

Stormwater System Asset Classes and Types*

* Asset categories established for the U.S. Army Corps of Engineers (USACE), Construction Engineering Research Laboratory (CERL)

USACE-CERL's Standardized Stormwater Asset Categorization System

- **Components**
  - Types
  - Descriptions
  - Units
- **Subcomponents**
  - Types
  - Descriptions
  - Units
- **Attributes**
  - Types
  - Descriptions
  - Acceptable Values
- **Assessments**
  - Methods
  - Descriptions
- **Defects & Deficiencies**
  - Condition
  - Performance
  - Descriptions
- **Work Activities**
  - Inspection
  - Maintenance
  - Renewal



A Risk Framework for a Stormwater

Likelihood of Stormwater System Failures (Condition, Performance)

RISK

Consequences of Stormwater System Failures (Significance, Impact Severity)

Damage
- Buildings
- Roads/Trails
- Utilities
- Property
- Human Life
- Habitat/Aquatic Life

Lost Access
- To Buildings
- For Vehicles
- For Pedestrians

Socio-Economic Impact
- Displacement
- Business Loss
- Property Value
- Recreation
- Disadvantaged Community

Level of Service (LOS) objectives define the risk framework baseline

- Desired performance goals for flood, erosion, water quality mitigation
- Owner responsibilities (community, other agency, property owner)
- Often incorporate design, regulatory requirements
- Represents consensus on public expectations

Original Level of Service objectives established for Raleigh in 2002

Level of Service	Operation and Maintenance		Program Management and Compliance		Capital Improvement Projects	
	Program Components	Stakeholder Voting Tally	Program Components	Stakeholder Voting Tally	Program Components	Stakeholder Voting Tally
A	Fully Preventative/ 100% Routine	9	Comprehensive Planning, NPDES Compliance, Full Implementation	7	$6 million/year (16-year program)	7
B	Mixture of Routine and Inspection Based	7	Pro-Active Planning, NPDES Compliance, Systematic Implementation	9	$4 million/year (25-year program)	9
C	Inspection Based Only	6	Priority Planning, NPDES Compliance, Partial Implementation	6	$3 million/year (33-year program)	6
D	Responsive Only	0	n/a	0	$2 million/year (50-year program)	0

Asset Management Approach to Stormwater

Likelihood of Failure (LoF) Risk Criteria

Likelihood of Failure (LoF):

Condition Risk Assessment – Scores and Methods

Condition Scores

1. Fully functional/reliable: no defects/deterioration
2. Fully functional/reliable: minor defects/deterioration
3. Partially functional/reliable: evident defects/deterioration
4. Marginally functional/reliable: serious defects/deterioration
5. Barely functional/reliable: extensive defects/deterioration

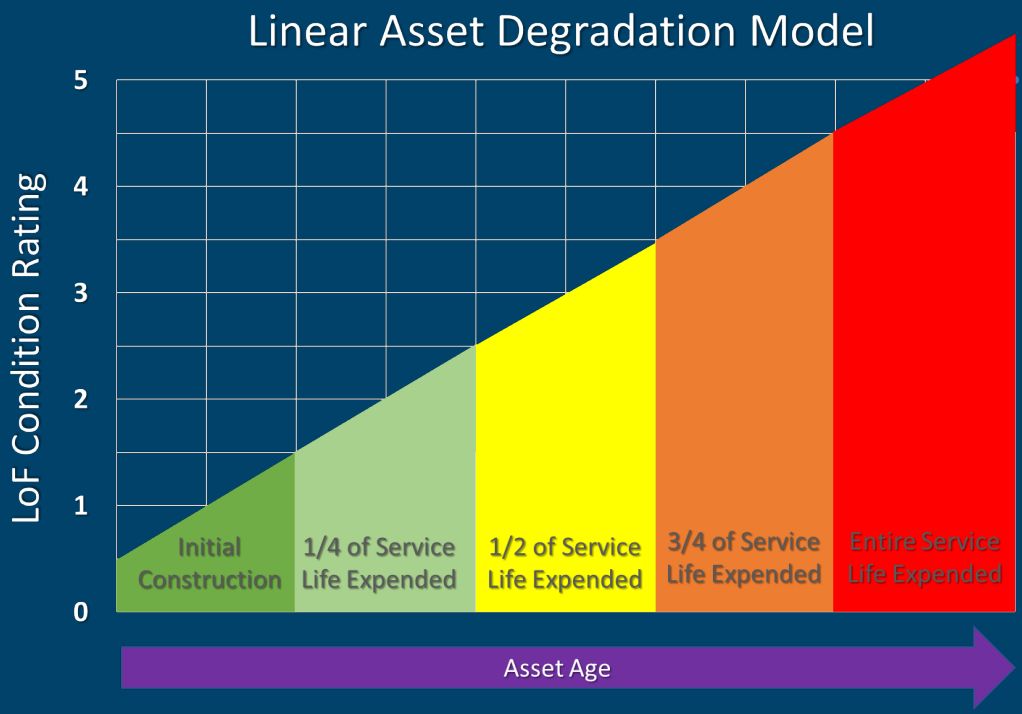
Assessment Methods

- Primary: Recent Inspection
  - CCTV with NASSCO PACP assessment
  - Visual assessment via field inspection, pole camera, drone
  - Geomorphic assessment (e.g., BEHI, NBS)
  - Habitat/biological survey (e.g., QHEI, IBI, various rapid assessments)
- Secondary: Surrogate Parameters
  - Service life estimates via age, material
  - Service requests/maintenance history
  - Physical attributes (depth, joint density)
  - Published water quality assessment

Likelihood of Failure (LoF):

Condition Risk Assessment – Pipe Assessments

- Desktop: Use age, material, depth, maintenance history as a surrogate for pipe condition (score 1-5)
- Screening-level: Pole camera inspections to identify/ prioritize pipes for detailed inspection (score 1-5)
- Detailed Inspection: CCTV inspection and full PACP assessment

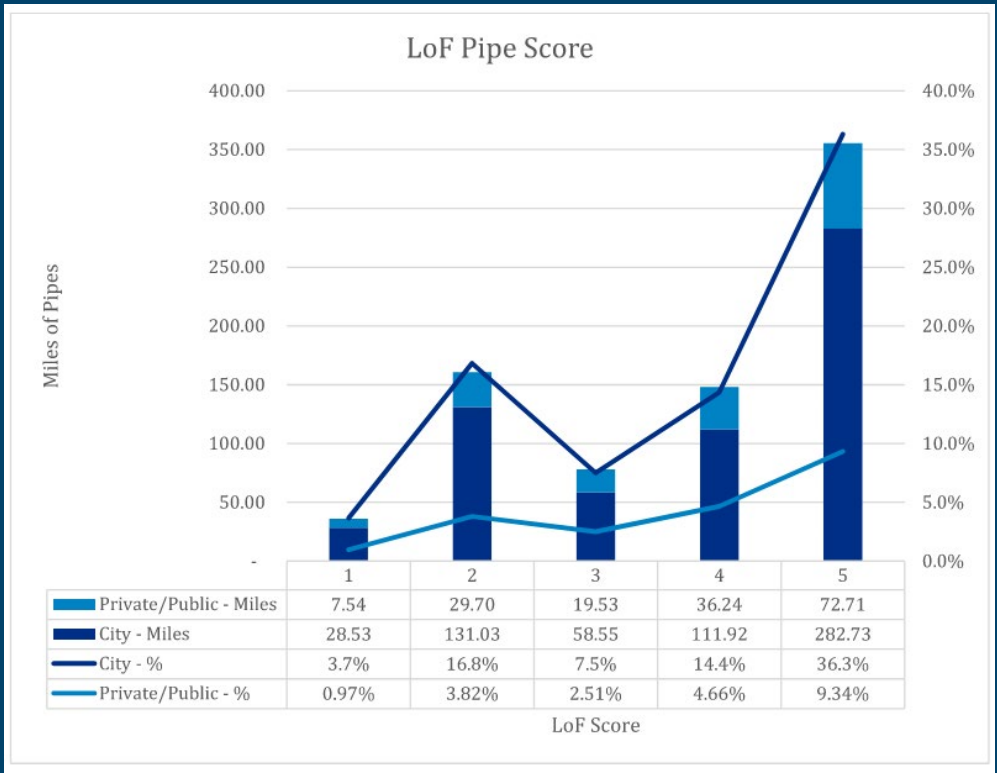


Source: Raleigh NC

Likelihood of Failure (LoF):

Condition Risk Assessment – Pipe Assessments

Material	Miles	Service Life
<Null>	2.92	80
	0.06	80
Brick	0.52	60
CMP	70.14	50
Concrete	1,469.12	80
CPP	104.87	90
Iron	7.48	50
Metal	1.05	50
Other	1.15	80
Prestressed Concrete Cylinder Pipe	0.04	80
PVC	34.84	90
Stone	0.62	90
Vitrified clay	15.80	80



Likelihood of Failure (LoF):

Performance Risk Assessment – Scores and Methods

Performance Scores

1. Meets design criteria / performance expectations
2. Satisfies performance expectations; no factor of safety
3. Adequate performance for current conditions
4. Less than adequate performance for current conditions
5. Needs major investment to meet performance expectations

Assessment Methods

- Primary: Modeling
  - Flooding: frequencies, depths, extents
  - Hydromodification: flow/velocity exceedance frequency, shear stress
  - Pollution: loading, removal, transport, assimilation
- Secondary: Surrogate Parameters
  - Eyewitness accounts
  - LiDAR interpretation of stream corridors, elevation changes
  - Theoretical stream, riparian area widths

Likelihood of Failure (LoF):

Performance Risk Assessment – H&H Model Results

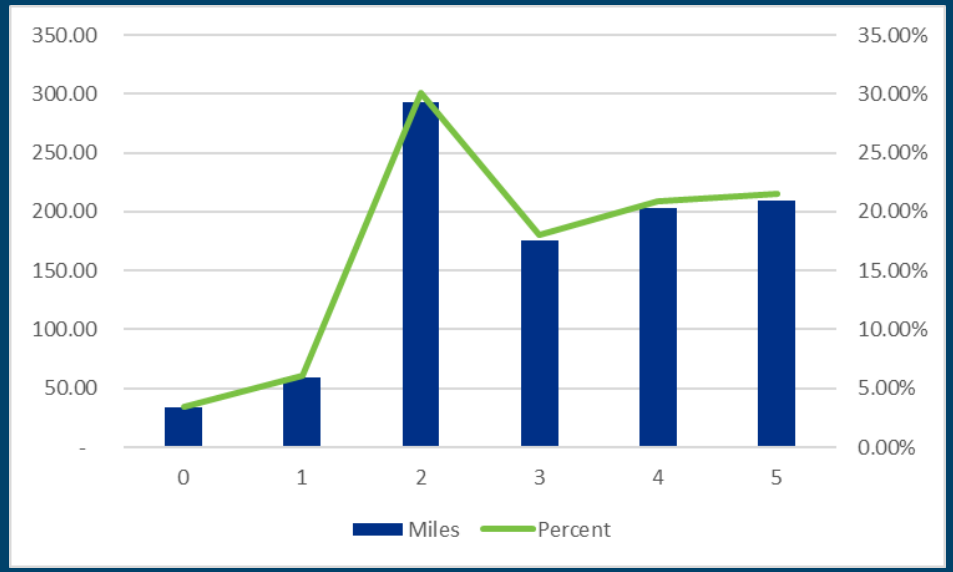
- Determine peak flood elevation, extent for key recurrence intervals (RIs)
  - Buildings: 100-year RI
  - Roads: RI depends on traffic, overland flow path
- Relate peak flood elevation, extent, frequency to elevations of roads, buildings, other facilities.

Likelihood of Failure (LoF):

Combined Condition and Performance Score

LoF = max(Condition, Performance)

- *Condition = Condition 1st, Surrogate 2nd*
- *Performance = 1 (No known issue) or 4 (CIP Budget Project)*



LoF	Miles	Percent
0	33.97	3.49%
1	58.94	6.05%
2	292.95	30.09%
3	175.09	17.98%
4	203.51	20.90%
5	209.23	21.49%
Grand Total	**973.70**	**100.00%**

Asset Management Approach to Stormwater

Consequence of Failure (CoF) Risk Criteria

Consequence of Failure (CoF):

Asset Significance – Scores and Methods

Significance Scores

1. Minor: Limited to vicinity of the asset
2. Local: Limited to a few properties
3. Neighborhood: Limited to drainage in neighborhood
4. Sub-Watershed: Impedes drainage of a subwatershed
5. Watershed-wide: Significantly affects entire community

Assessment Methods

- Primary:
  - Drainage Area
  - Accessibility for Emergency Repair
    - Deep manhole
    - No/blocked easement
    - Steep slope
    - Wetland
- Secondary: Surrogate Parameters
  - Asset cross-section / conveyance
  - Accessibility for Emergency Repair
    - Deep manhole
    - No/blocked easement
    - Steep slope
    - Wetland

Consequence of Failure (CoF):
Asset Significance – Flow Conveyed

Risk Score	Drainage Area- Pipe	Drainage Area- Channel	Pipe Diameter
5	Trunk: > 150-acre drainage area	River: > 5 sq. mi drainage area	>72-inches
4	Major/Neighborhood: > 50-acre, ≤150-acre drainage area	Stream: >2 sq. mi, ≤ 5 sq. mi. drainage area;	>36-inches; <72-inches
3	Minor/Block: > 5-acre, ≤ 50-acre drainage area	Perennial: >$^{1}/_{2}$ sq. mi., ≤2 sq. mi. drainage area	>12,-inches; <36-inches
2	Lot/Street: ≤ 5-acre drainage area	Intermittent: >5-acre, ≤1/2 sq mi drainage area	< 12-inches
1	No pipe, pump station	Ephemeral: up to 5-acre drainage area	No pipe, pump station

Consequence of Failure (CoF):

Impact Severity – Scores and Methods

Impact Severity Scores

1. Minor damage to non-critical property or infrastructure
2. Limited damage/socio-economic impact, accessibility limits,
3. Moderate damage/socio-economic impact, property access loss
4. Substantial damage/socio-economic impact, neighborhood access loss
5. Catastrophic damage/socio-economic impact, widespread access loss

Assessment Methods

- Primary:
  - Building/content & infrastructure damage
  - Loss-of-function costs (displacement, detours, lost work, utility outages)
  - Lost emergency service (health, police, fire)
  - Environmental damage
- Secondary: Surrogate Parameters
  - Transportation type/volume
  - Land use/population density
  - Utility type/service area
  - Use designation of waterbodies

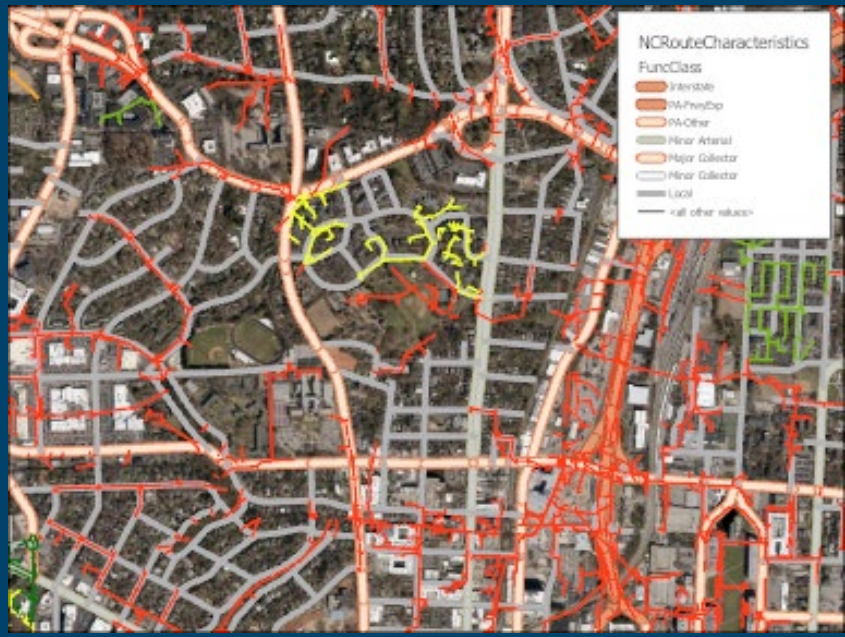
Consequence of Failure (CoF):

Impact Severity – Transportation

Interruption of traffic (# vehicles) and emergency access:

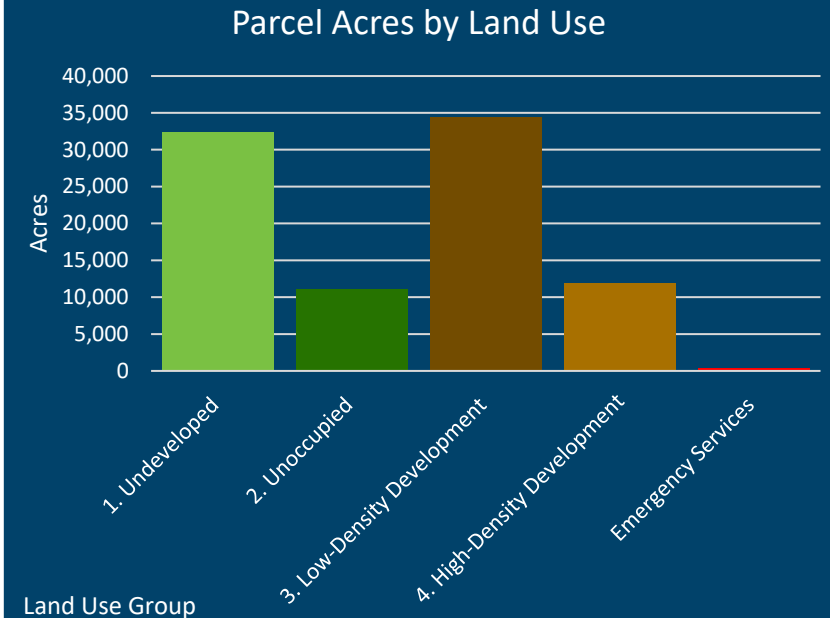
1. Minor - Pedestrian infrastructure – trials, bike paths, residential drives, and sidewalks
2. Limited - Local infrastructure – city and private streets
3. Moderate - Neighborhood infrastructure – collectors and roads with single access points
4. Substantial - District infrastructure – minor arterials and bus routes
5. Catastrophic - Regional infrastructure – interstates, Iowa and United States routes, railroads, airports, and major arterials (freeways and expressways)

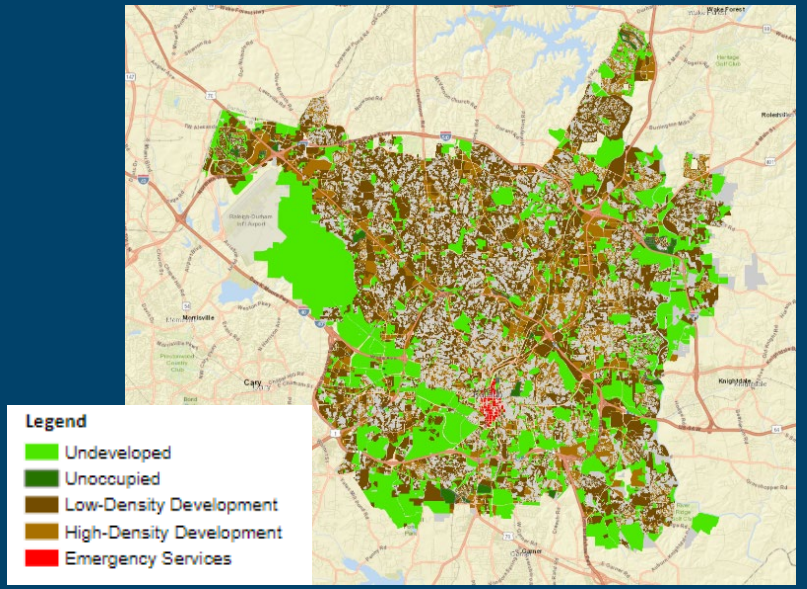
NC DOT Functional Class



Consequence of Failure (CoF):
Impact Severity – Buildings/Facilities

Description: Land use of properties containing and/or abutting on a ROW, easement, or property containing the stormwater asset

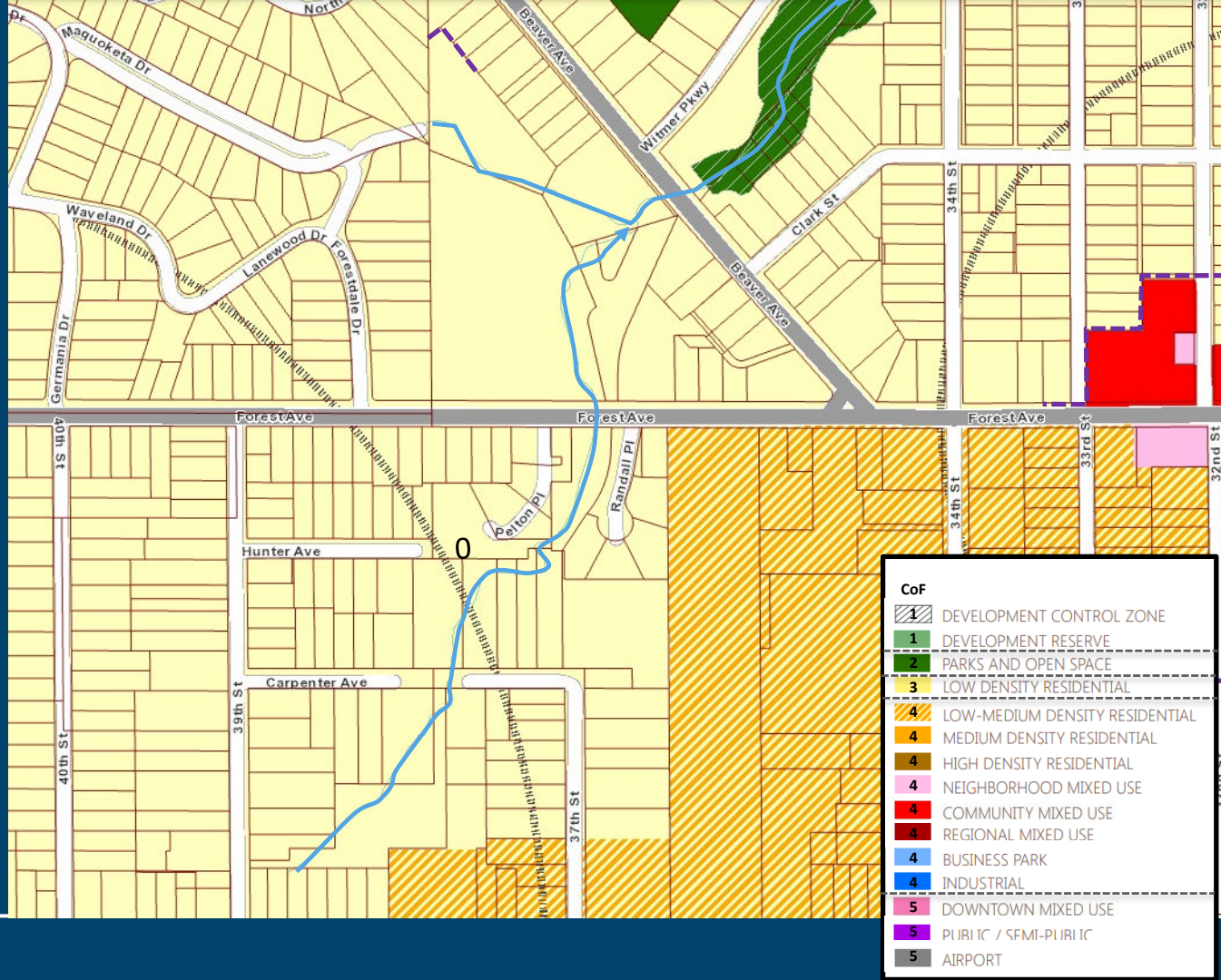




Source: Wake County Parcel Data Land Use Descriptions and Assessed Value

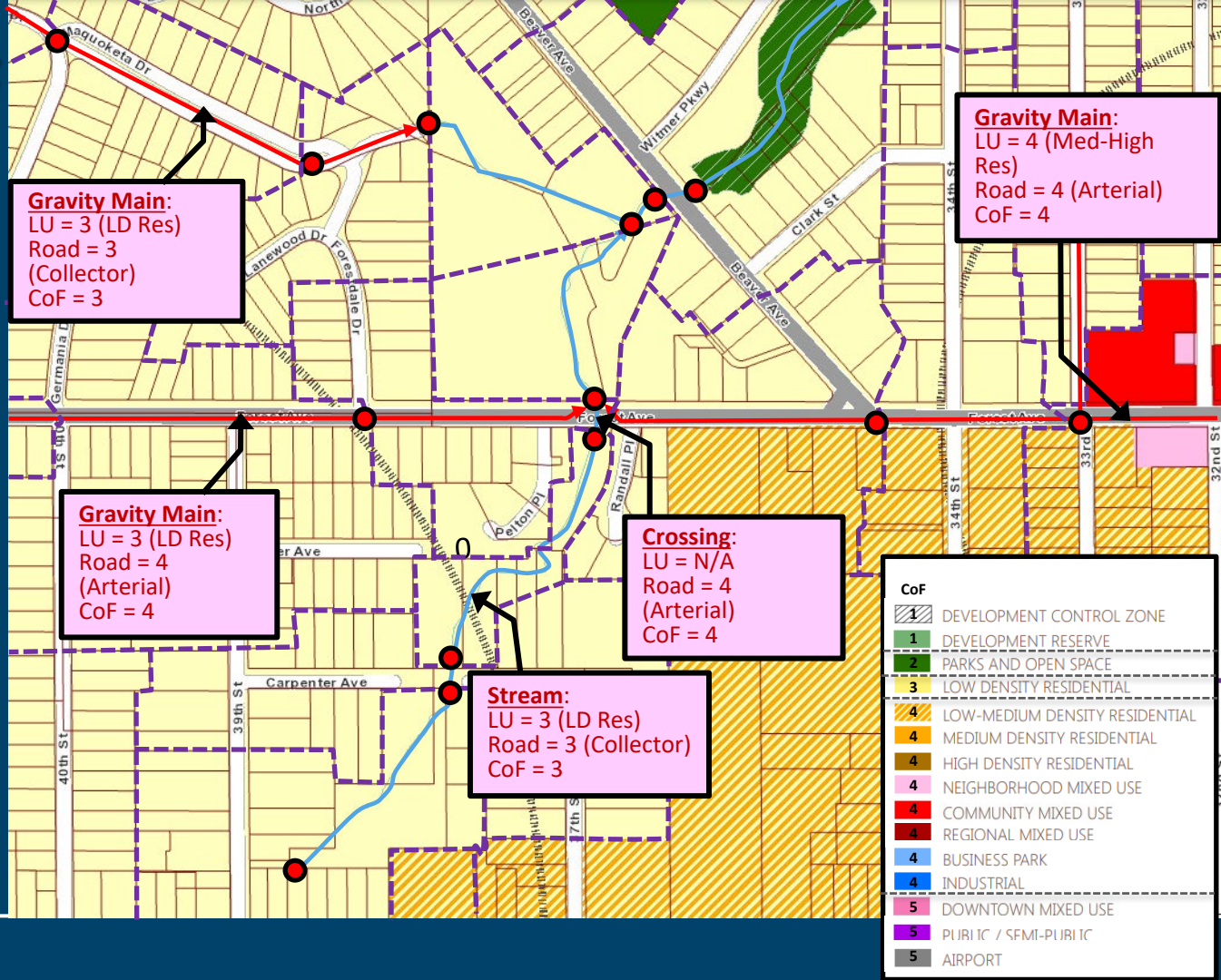
Consequence of Failure (CoF): Impact Severity – Buildings/Facilities

- Financial impacts (e.g., damage, lost use) are primary consequence measure, but time-consuming
- Land use provides surrogate for initial risk assessment



Assigning CoF to an Asset

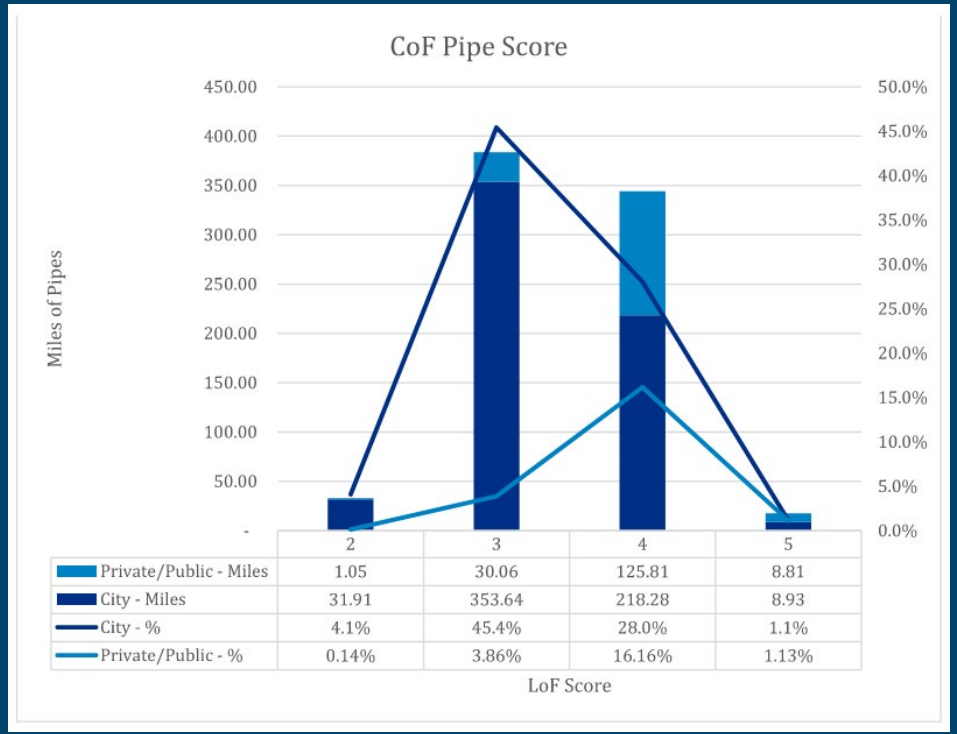
- Delineate assets
- Delineate catchments along property lines.
- "Assign" catchment to asset receiving flow.
- Define asset CoF = highest risk property, roadway, or utility within catchment.



Consequence of Failure (CoF):

Combined Asset Significance and Impact Severity Score

- COF Significance = max of Diameter, Depth, Under Building and Right of Way
- COF Impact = max of Landuse/Zoning and Transportation
- Consequence is the average of the max of Impact and max of significance



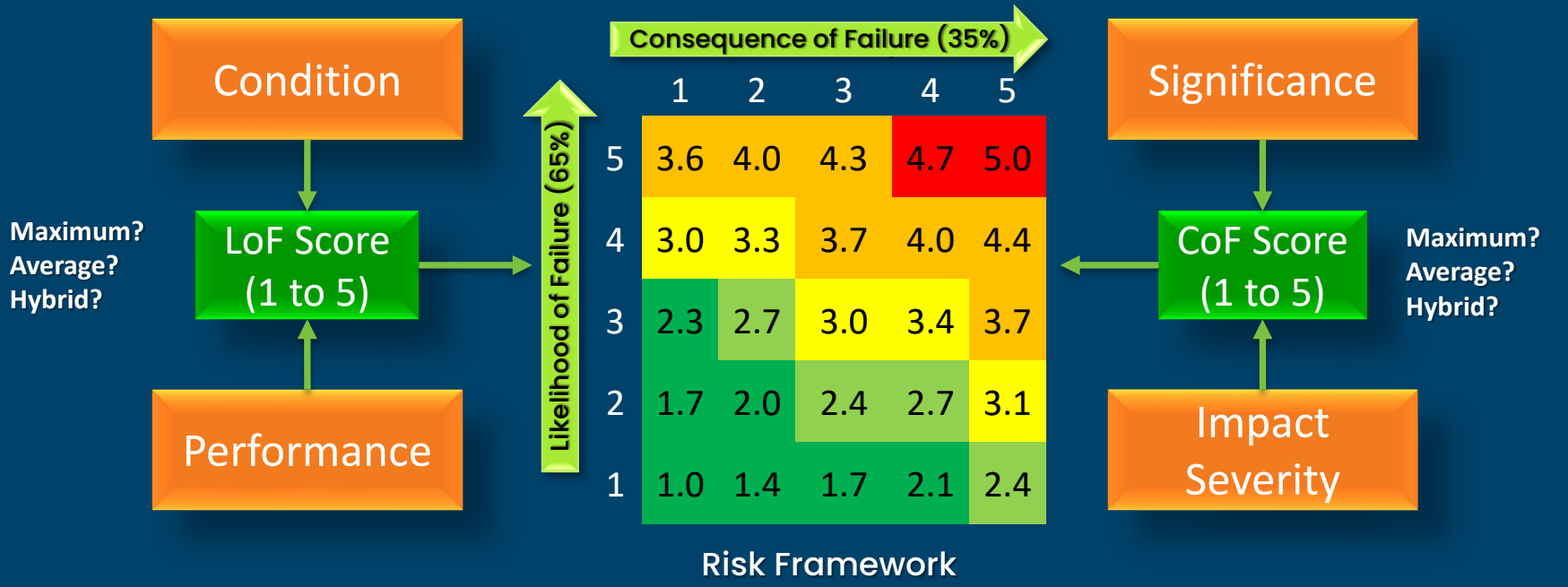
	2	3	4	5
Private/Public - Miles	1.05	30.06	125.81	8.81
City - Miles	31.91	353.64	218.28	8.93
City - %	4.1%	45.4%	28.0%	1.1%
Private/Public - %	0.14%	3.86%	16.16%	1.13%

Asset Management Approach to Stormwater

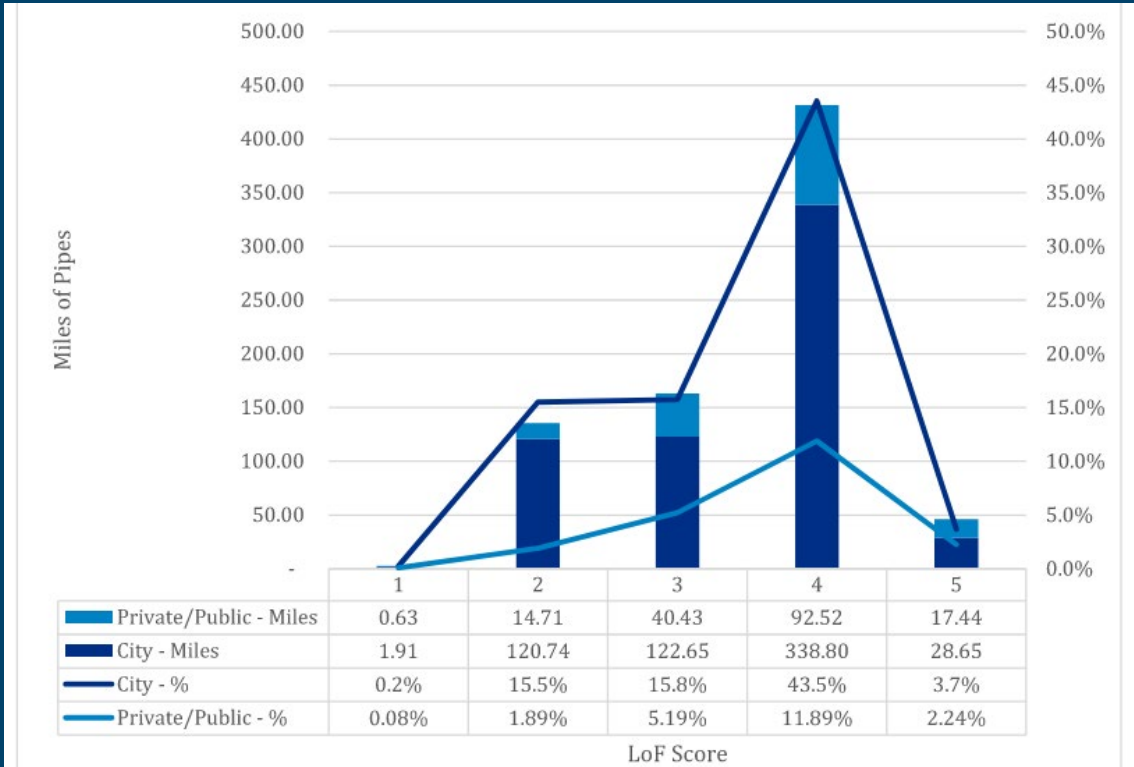
Calculating a Risk Score

Calculating a Risk Score: fn (LoF, CoF)

Risk identifies what is both likely to fail (LoF) and consequential if it does fail (CoF)
Risk is used to prioritize inspection, maintenance, renewal, and enhancement



Calculating a Risk Score: fn (LoF, CoF)



	1	2	3	4	5
Private/Public - Miles	0.63	14.71	40.43	92.52	17.44
City - Miles	1.91	120.74	122.65	338.80	28.65
City - %	0.2%	15.5%	15.8%	43.5%	3.7%
Private/Public - %	0.08%	1.89%	5.19%	11.89%	2.24%

Applying Risk-Based Asset Management

Operation and Maintenance

Applying Risk-Based Asset Management:
Reactive → Preventative Maintenance and Renewal

Condition Assessment Inspections

Routine Maintenance

e.g., debris removal, exercise pump stations, vegetation management

Minor Repairs

e.g., structural point repairs, erosion/wildlife damage, sediment removal, vegetation replacement, pollutant control "rejuvenation"

Maintenance-Level Asset Renewal

e.g., replacement or rehabilitation of assets to restore structural and operational integrity

Capital Projects

e.g., design and contracted construction of asset rehabilitation, replacement, or enhancement

City of Raleigh MS4 Permit

Regulatory Requirements

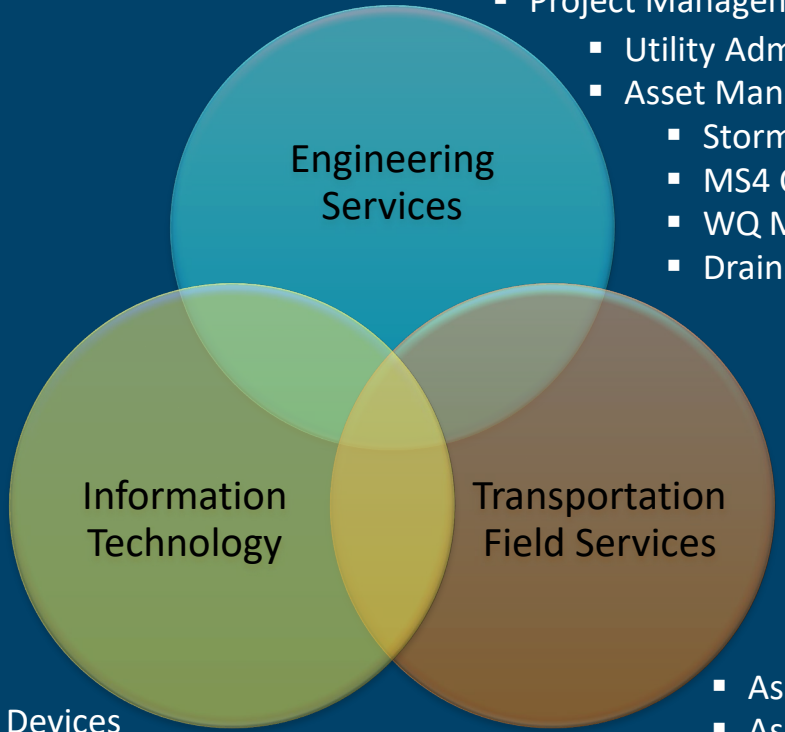
Part II, Section G, 2. “BMPs for Pollution Prevention and Good Housekeeping for Municipal Operations”

(g) “Inspection and Maintenance (I&M) for municipally owned or maintained stormwater control measures (SCMs) and the storm sewer system.”

Requires the City implement and maintain an inspection and maintenance program for the collection and conveyance system it owns or operates.

City of Raleigh MS4 Permit

Organizational Structure



- Planning & Design
- Project Management
- Utility Administration
- Asset Management
  - Stormwater Control Measures
  - MS4 Compliance
  - WQ Monitoring
  - Drainage Assistance

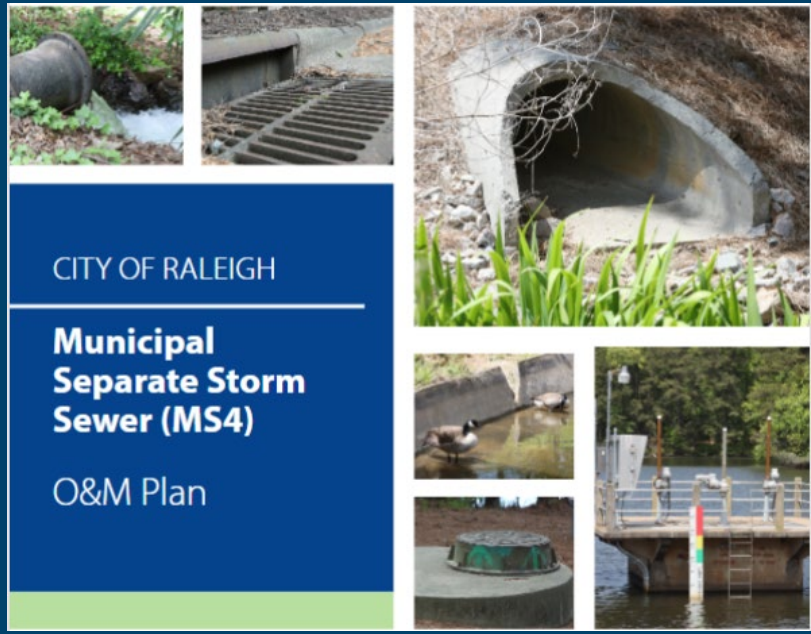
- GIS (Esri ArcGIS)
- CMMS (Cityworks)
- Personal Computers
- Internet-Enabled Mobile Devices
- Data Collection (Esri Survey123 and Collector)

- Street Sweeping
- Concrete/Asphalt Repair
- Deicing/Snow Removal
- Leaf Collection
- Asset Maintenance
- Asset Inspections
- CCTV System and Software (WinCan™)

MS4 Operation & Maintenance Plan

"A comprehensive resource to support staff of multiple City departments successfully manage and execute inspection and maintenance activities".

- Operational Reference
- Training Resource
- Compliance Submittal

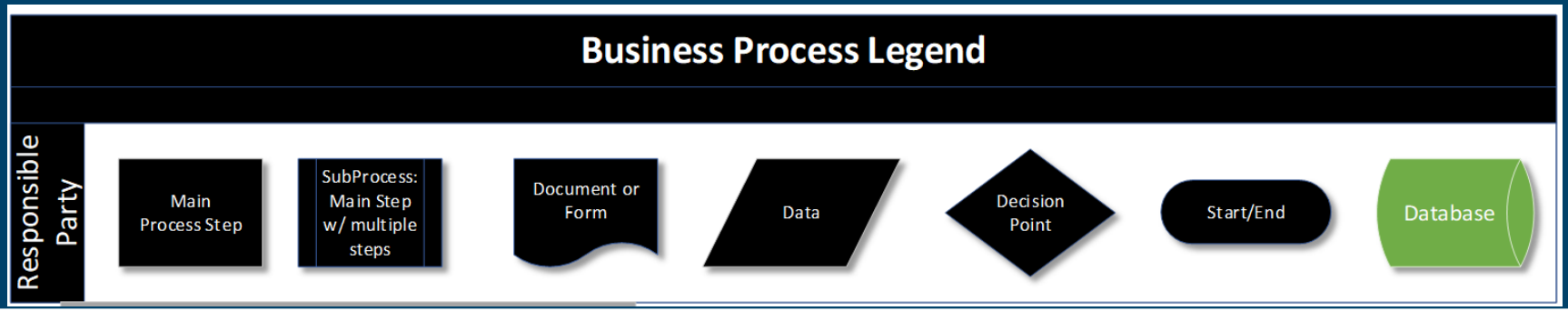


MS4 Operation & Maintenance Plan

- Public Reporting (SeeClickFix™ via website/mobile application)
- Inspection and Maintenance Priority Codes
  1. High: Safety of Public/City Staff (24/7 Response)
  2. Medium: Impacts Asset Performance, Commerce, or Property (Immediate Response)
  3. Low: Recurring Inspections/Preventative Maintenance (Standard Response)

MS4 Operation & Maintenance Plan

- Business Process Workflows
  - Work Origination
  - Inspections
  - Maintenance
  - Seasonal Duties
- Training Curricula
- Standard Operation Procedures
- Critical Schedule Dates
- Metrics and KPIs
- Information Technology & Systems
- Resources and References



Applying Risk-Based Asset Management

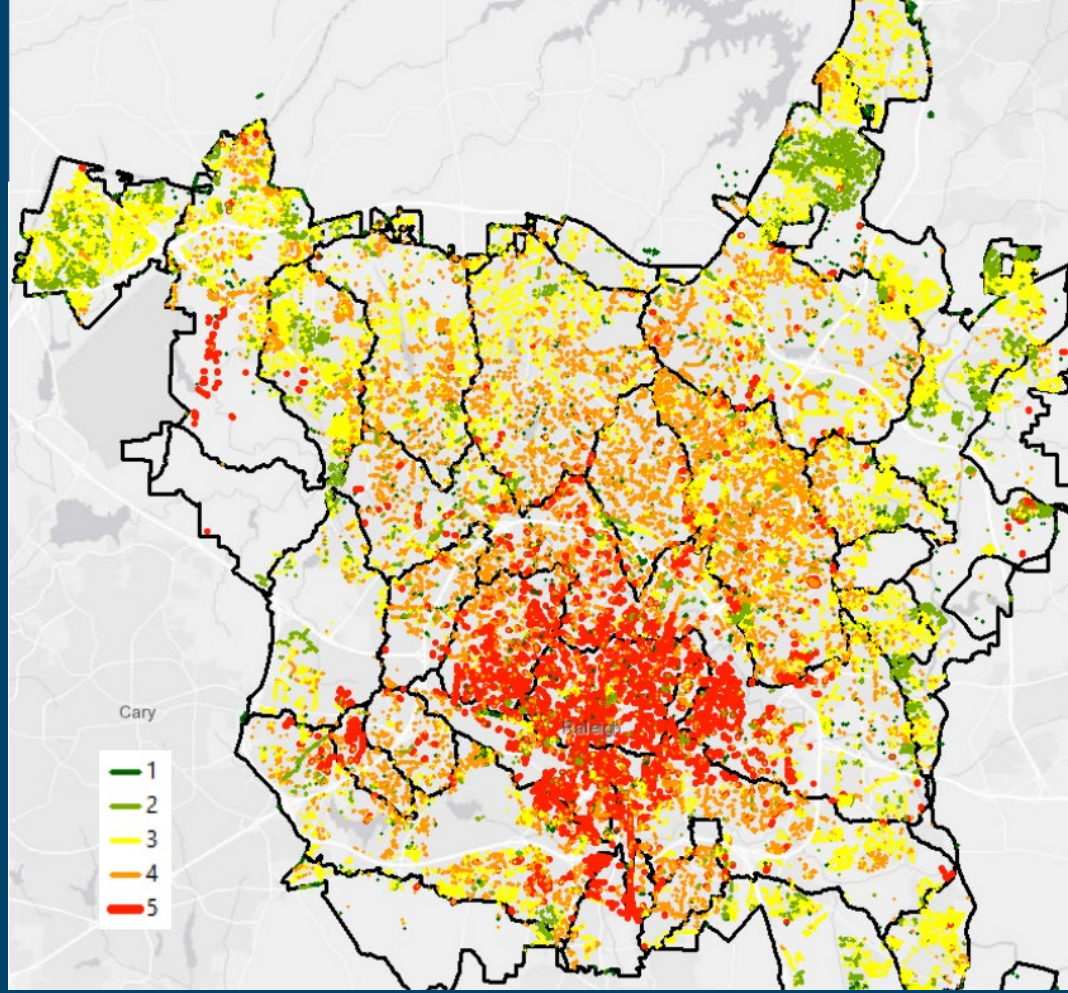
Condition Assessment

Applying Risk-Based Asset Management

- Risk model used to identify priority areas for phased inspections.

Likelihood of Failure (65%) \ Consequence of Failure (35%)	1	2	3	4	5
5	3.6	4.0	4.3	4.7	5.0
4	3.0	3.3	3.7	4.0	4.4
3	2.3	2.7	3.0	3.4	3.7
2	1.7	2.0	2.4	2.7	3.1
1	1.0	1.4	1.7	2.1	2.4

Risk Framework



Applying Risk-Based Asset Management

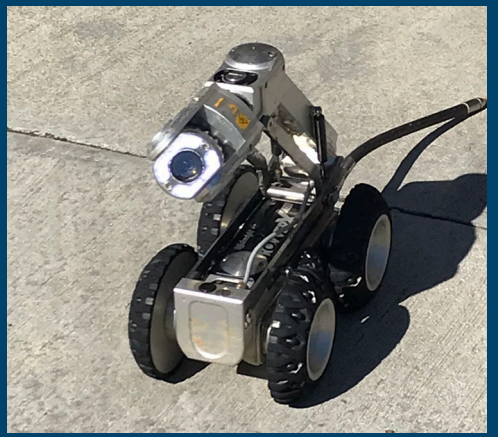
Surrogate Data

- Represent likelihood of failure until condition data collected

Surrogate Factors

- Pipe age / material
- Hydraulic constraints
- Work order intensity
- Joint density

Pole Camera

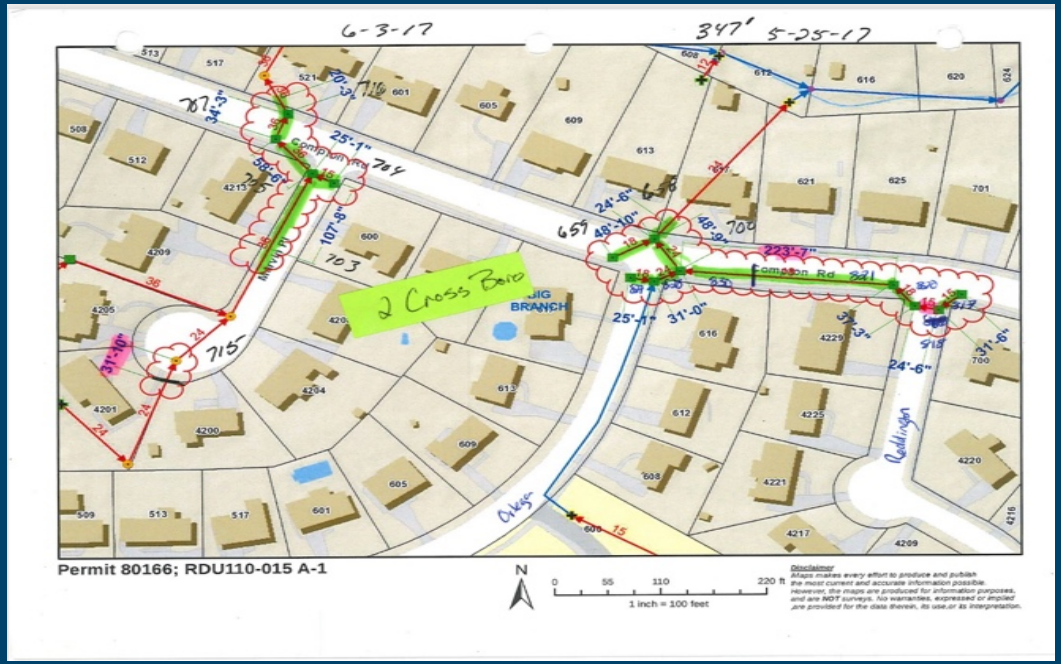


CCTV

Applying Risk-Based Asset Management

Condition Assessment

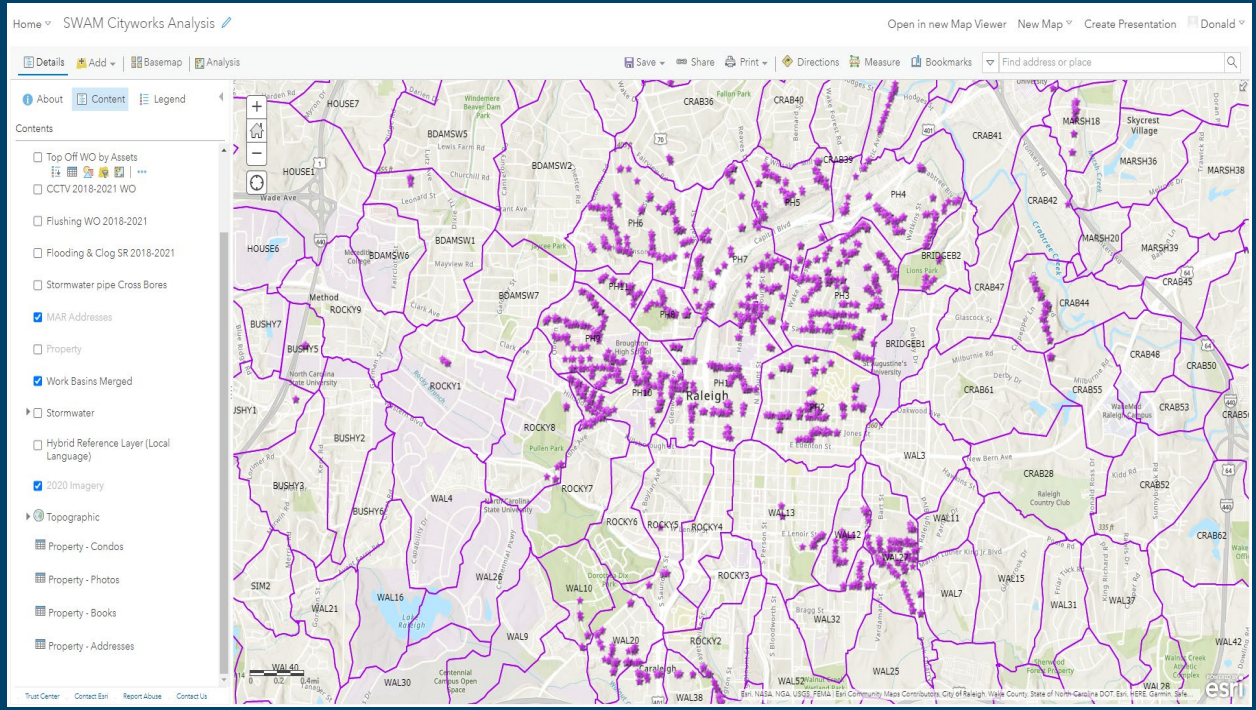
How things were done before process improvements



Applying Risk-Based Asset Management

The Improved Pole Camera Process

- Paperless
- Cityworks
- GIS
- Condition Score tied directly to Asset



Applying Risk-Based Asset Management

Pole Camera Inspection Data Collection

Applying Risk-Based Asset Management

Condition Scoring Captured in Cityworks

Inspection | Email | Print | Save | Close

Inspection | Details

Id: 827581

Location: 10550 LITTLE BRIER CREEK LN

Status: Completed | Resolution:

Insp. Date: 02/4/2022 10:51 AM | Inspected By: Long, Timothy E

Observations

Structural Condition

5 - Immediate Attention

Structural Comments

JOL, SOIL VISIBLE

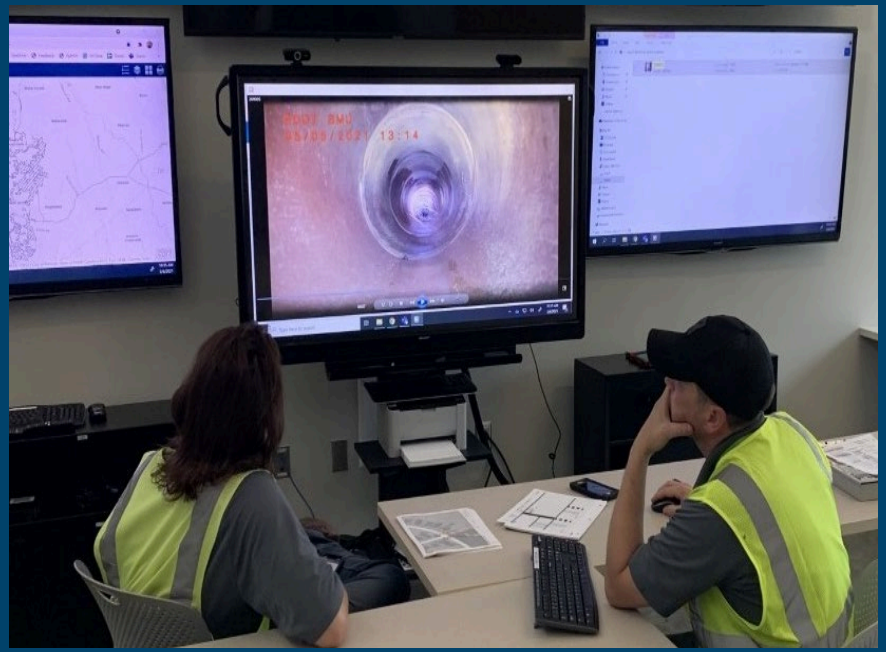
O&M Condition

0 - No Obvious Defects

O&M Comments

Applying Risk-Based Asset Management

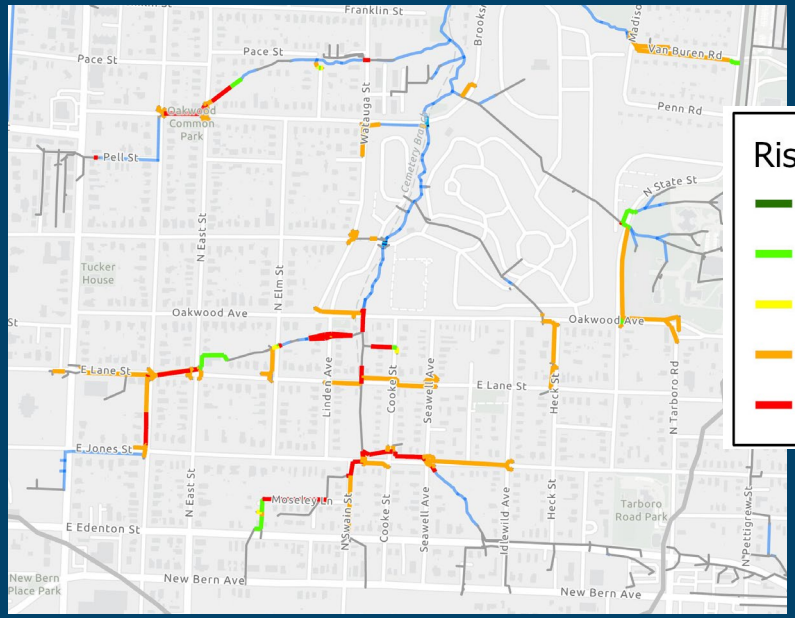
Video Upload & Quality Review

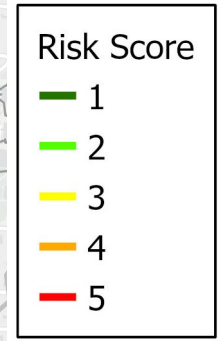


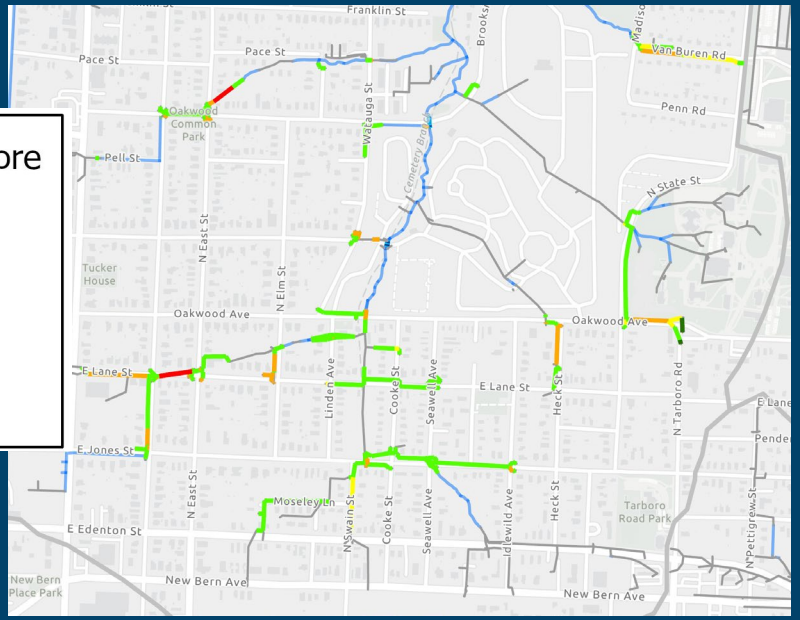
- Automatic Sorting
- Data review
- 2nd Level QA
- Targeted follow up work
- Condition score tied to asset

Applying Risk-Based Asset Management

Focus CCTV Inspection on Highest Priority Assets







Surrogate Risk

Post-Inspection Risk

Applying Risk-Based Asset Management

Capital Planning

Objective of Integrated Watershed Master Planning (IWMP)

- Help make informed and strategic decisions about stormwater projects planned over the next several decades.
- Priority projects include repairing and building sustainable stormwater infrastructure
  - Street and neighborhood stormwater culverts/pipes;
  - Dam repairs and rehabilitations;
  - Stream restorations; and,
  - Lake and wetland preservation.
- Reduce flooding and improve water quality.
- Prioritize projects based on need, severity, and funding.

Source: COR Website https://raleighnc.gov/SupportPages/watershed-master-plan

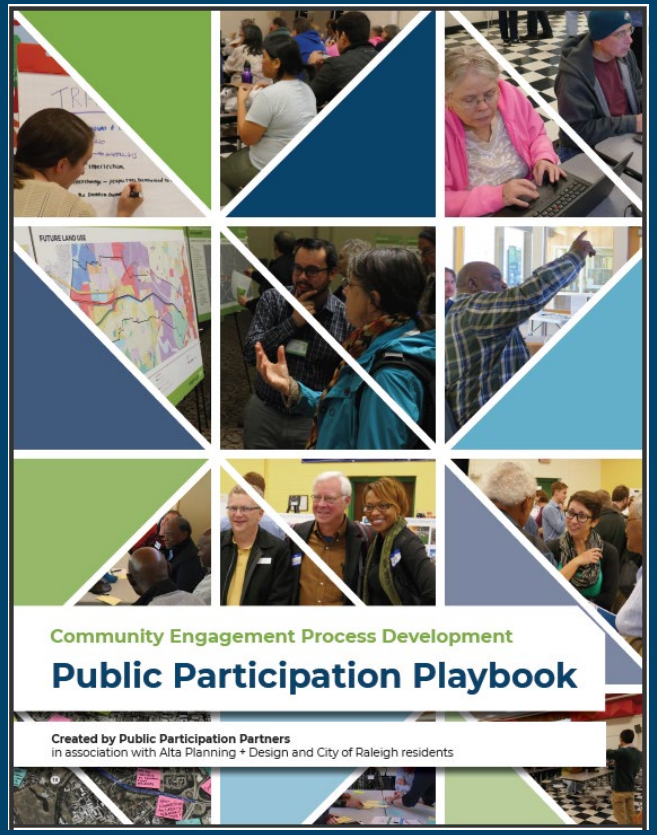
Pigeon House Branch IWMP Scope

- Three phases of work envisioned:
  - Phase 1: Pre-Planning
  - Phase 2: Risk-Based Asset Replacement/Renewal and Flood Mitigation
  - Phase 3: Risk-Based Stream Stability, Habitat, and Water Quality Solutions

Pigeon House Branch Watershed Study:

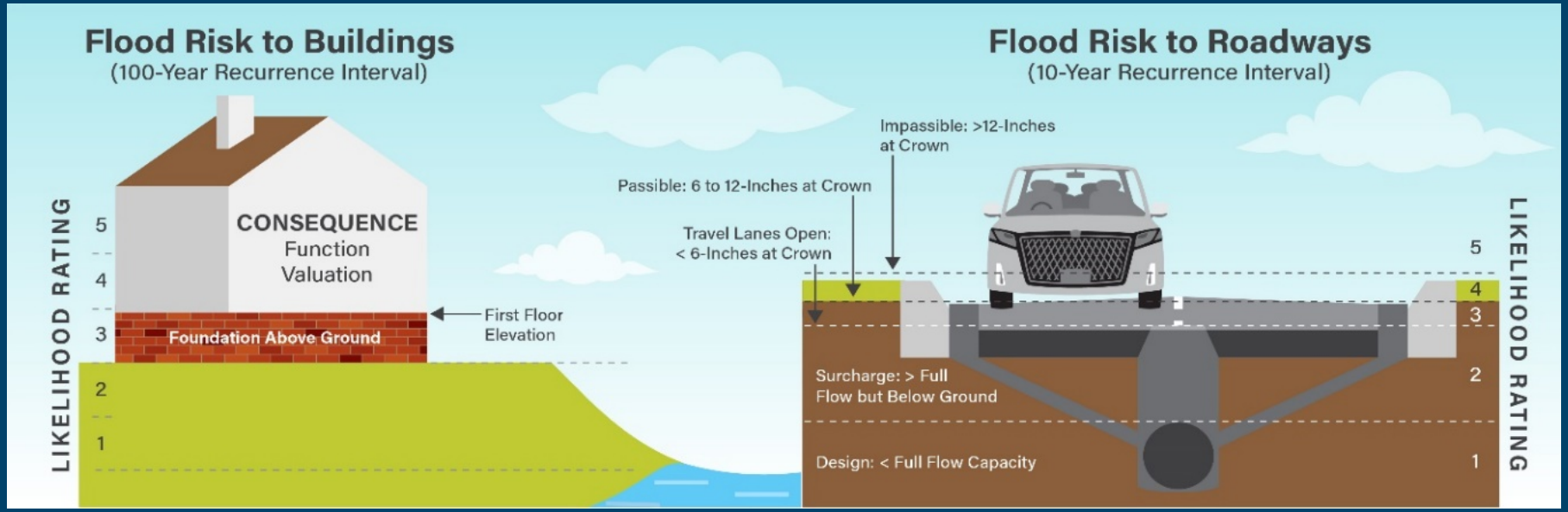
Stakeholder Engagement

- Pigeon House Public Engagement Plan (PEP)
- Public Survey
- On-line GIS Map Development
- Public Meeting(s)
- Other opportunities (TBD)



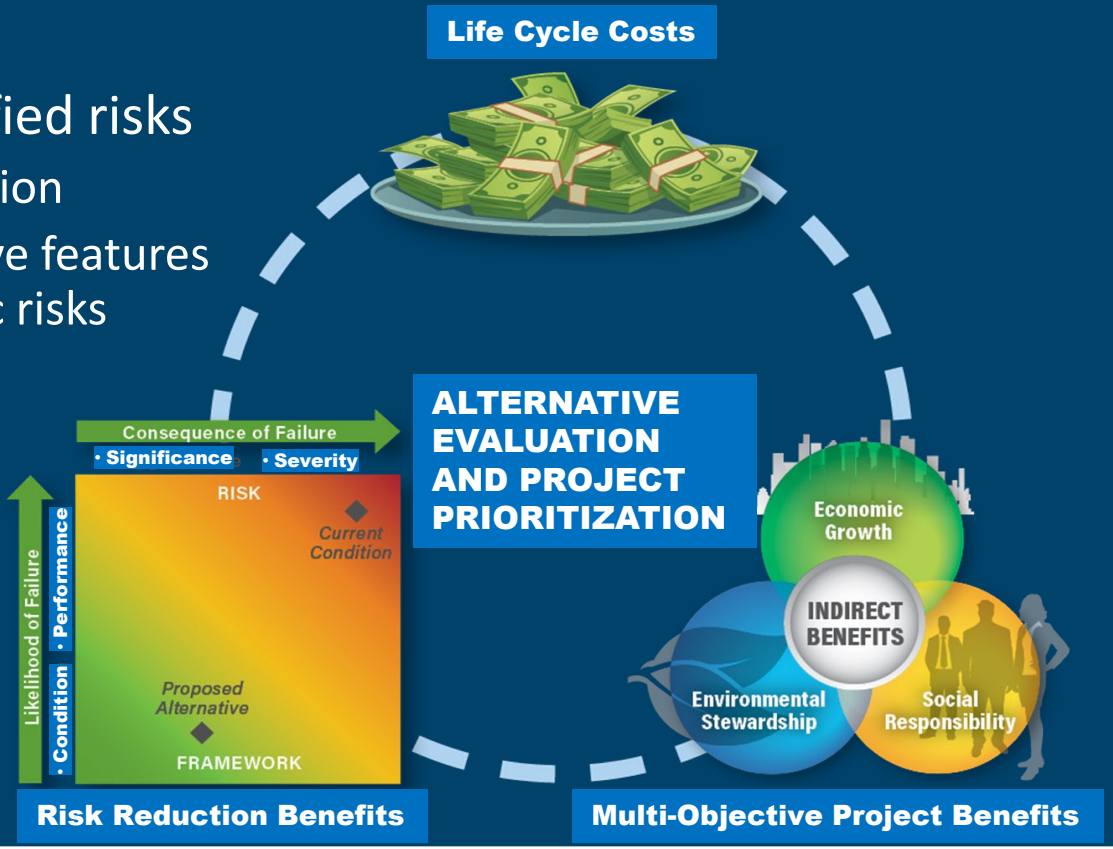
Applying Risk-Based Asset Management:

Characterize Priority Performance Deficiencies



Applying Risk-Based Asset Management:
Evaluate Alternatives

- ID SCMs to reduce identified risks
  - Baseline – O&M, restoration
  - Synergetic, multi-objective features for flood and geomorphic risks
  - Isolated risks
- Cost alternatives
- Evaluate and select preferred alternatives



Effective Asset Management Uses a Team Approach

- Risk framework to identify priorities for inspection and repairs
- Improve business processes to advance program goals

Asset Management Supports Proactive Planning & Maintenance of a Stormwater System

Contact Us!

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