NEWEA & NYWEA Joint Spring Meeting 2016

MANAGING BOSTON'S INVESTMENTS IN BURIED INFRASTRUCTURE THROUGH SYSTEMATIC EVALUATION OF CONDITION AND RISK

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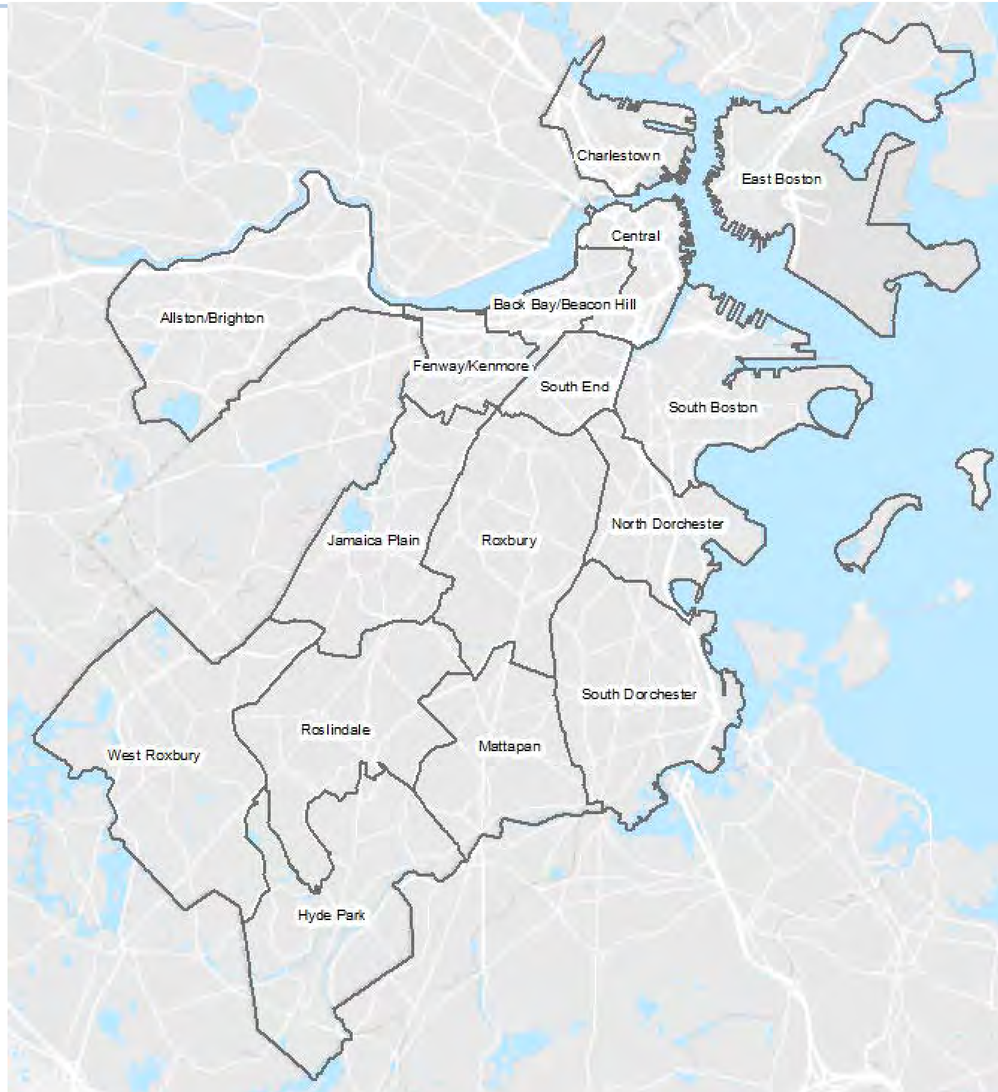
City of Boston

City of Boston:

- 48 square miles
- 655,884 est. population (2014)
- Largest city in New England
- Founded in 1630

BWSC is responsible for:

- 800+ miles of sanitary/combined
- 600+ miles of storm
- 80,000+ structures
  - Manholes
  - Catch Basins
  - Regulators
  - Tide Gates
  - Siphons
  - Outfalls



Boston Water & Sewer Commission (BWSC) Wastewater & Storm Drain Facilities Plan

Objective was to develop facility plans for the City's sewer and storm drain systems that are aligned with the Commission's long-term service goals and supported by effective operations, maintenance, and engineering practices.

Main deliverable was a 25-year plan for system upgrades, capital improvements and system maintenance.

11 tasks varying from regulatory to operational maintenance to climate strategies;

Task D – Asset Condition Assessments

Asset Condition Assessments

The primary goal of the asset condition assessments is to gain an understanding of the physical characteristics of the system, including both conditions that may require maintenance and the structural condition of the asset.

The simplified approach:

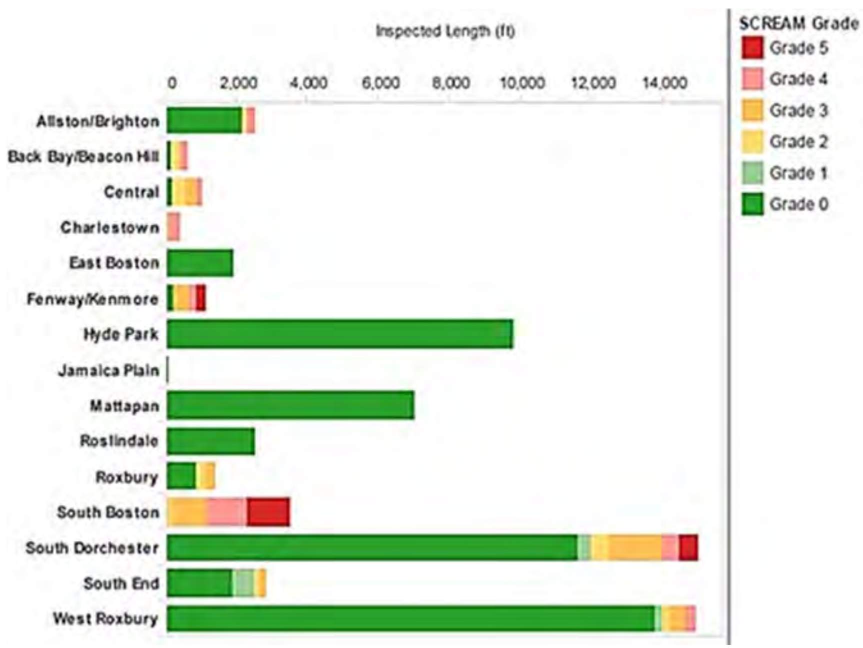
- **Conduct a Historical Review** – understand existing inspection data and processes. Determine recent CCTV work in order not to duplicate.
  - The past five years of inspection records were analyzed.
- **Implement SCREAM Condition Assessment Tool** – use SCREAM to store, score and analyze inspection data. Identify capital improvement projects.
- **Conduct Pipe Inspections** – project initially included 23 miles of CCTV

Asset Condition Assessments – Historical Review

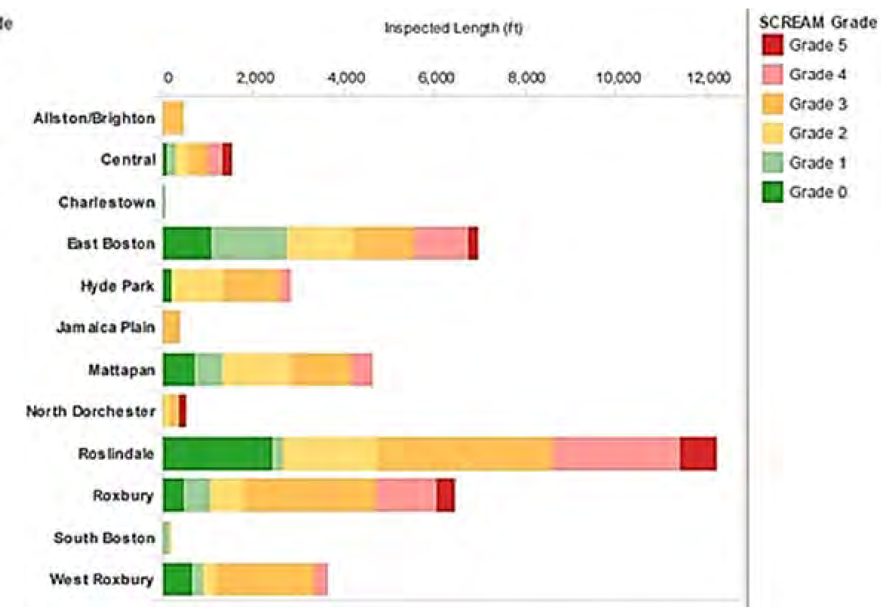
- Finding 1: Methods used for these inspections and the management of data related to the inspections has varied significantly.
  - Not all data was incorporated into CASSWORKS (CMMS).
- Finding 2: Significant CCTV or related work completed in recent years that cannot be linked to GIS.
  - Only 53% could be mapped to GIS.

Asset Condition Assessments – Historical Review

- Finding 3: Historical inspections that were able to be mapped were uploaded and scored in SCREAM.
  - Score results were misleading because of poor data.



Historical Inspections



2012 CCTV Contract

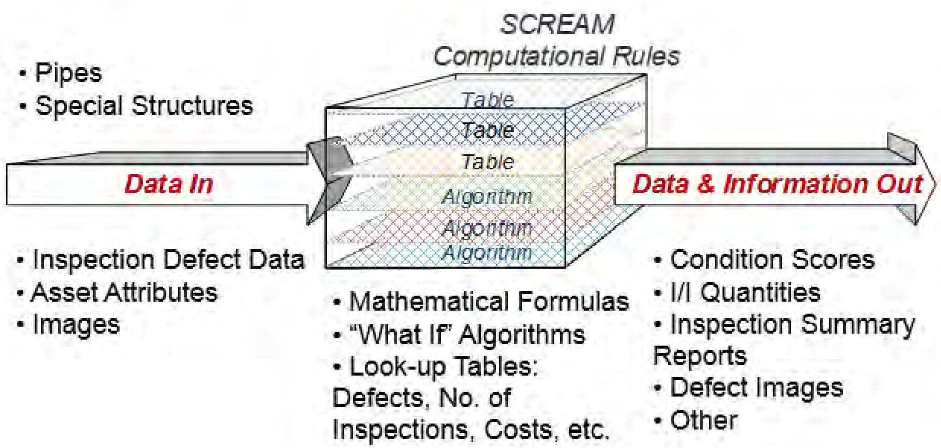
Asset Condition Assessments – SCREAM Condition Assessment Tool

SCREAM is an industry-standard tool for condition assessments and analytical/asset condition scoring.

SCREAM is designed to:

- Collect/compile condition assessment field data (both pipes and special structures) – centralized database.
- Score the inspections.
- Provide a link to view videos and photos.
- Prioritize infrastructure assets and summarize info through web reports.
- Provide input for risk calculations.
- Create work orders with summary information about inspections.

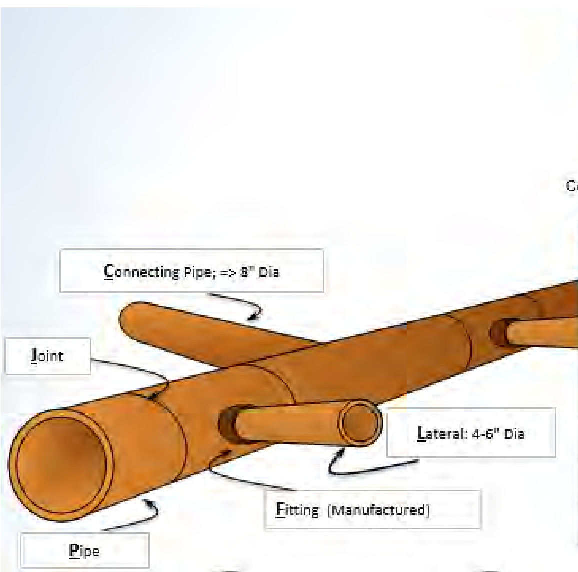
System
Condition
Risk
Enhanced
Assessment
Model



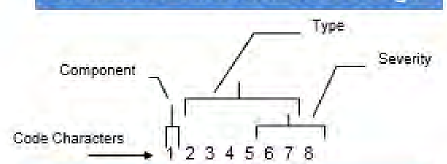
Asset Condition Assessments – SCREAM Condition Assessment Tool

SCREAM's Defect Coding System

- Provides a quick, consistent way for an operator to convert the defect image into the appropriate defect code
- Codes include structural, maintenance & inflow/infiltration conditions
- Extensive list (~700 defect codes) to cover all possible defects
- Uses 4-8 alphanumeric characters



SCREAM 8 Character Code Design



Component Acronym	Description
P	Pipe
C	Connecting Pipe
L	Lateral
F	Fitting (Manufactured)
J	Joint
A	Access (Inventory Info)

SCREAM's Defect Code Example:

PCrkLng1

(Pipe, Crack Longitudinal, Hairline)

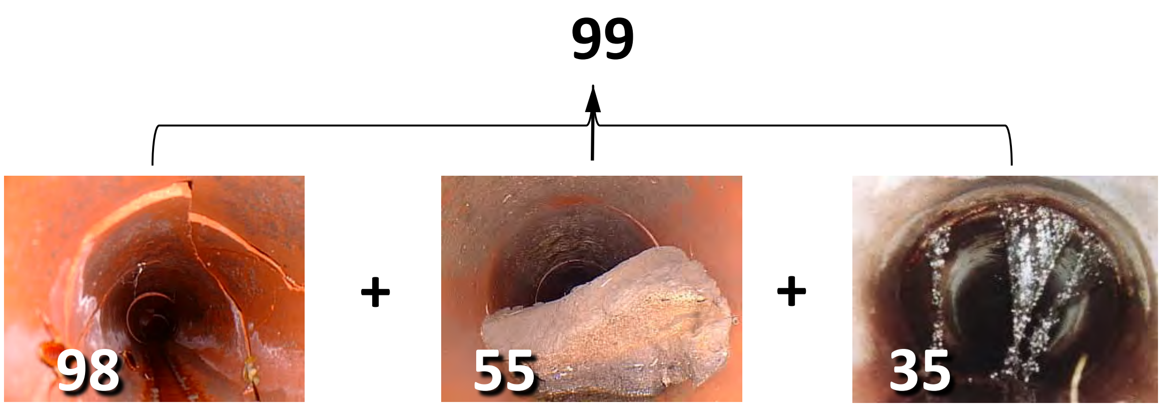
Asset Condition Assessments – SCREAM Condition Assessment Tool

SCREAM's Scoring System

- Scores on a 1-100 scale which provides more granularity
  - 1 = new condition; 100 = failed condition
- Starts with the score of the worst defect and incrementally adds the others

$$DS = \max(DS) + ((100 - \max(DS) * (A*\text{Weight } A + B*\text{Weight}))$$

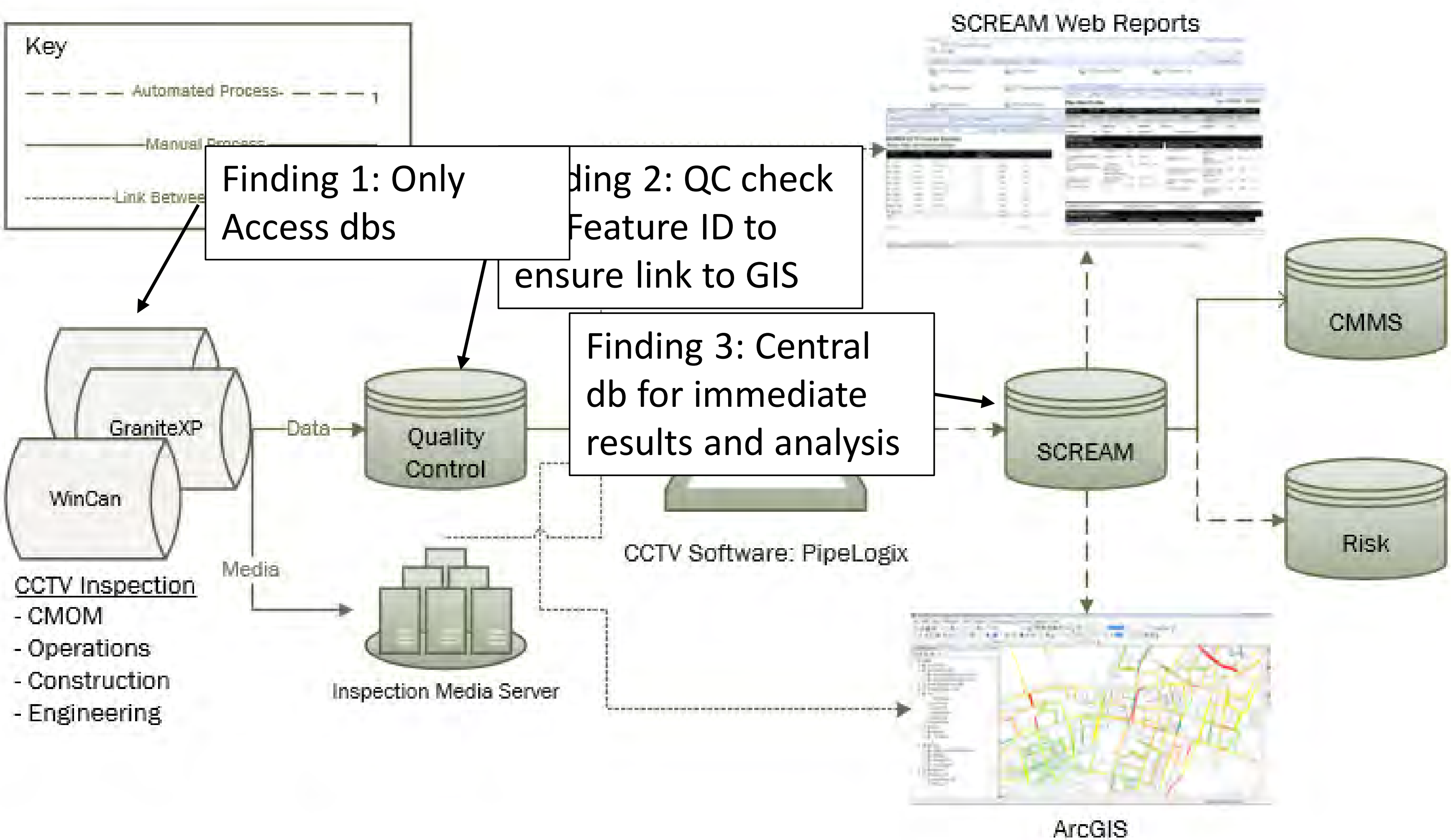
Analogy to medical triage



Scale: 1 (new) -100 (failed)

Triage is the process of determining the priority of patients' treatments based on the severity of their condition.
http://en.wikipedia.org/wiki/Triage

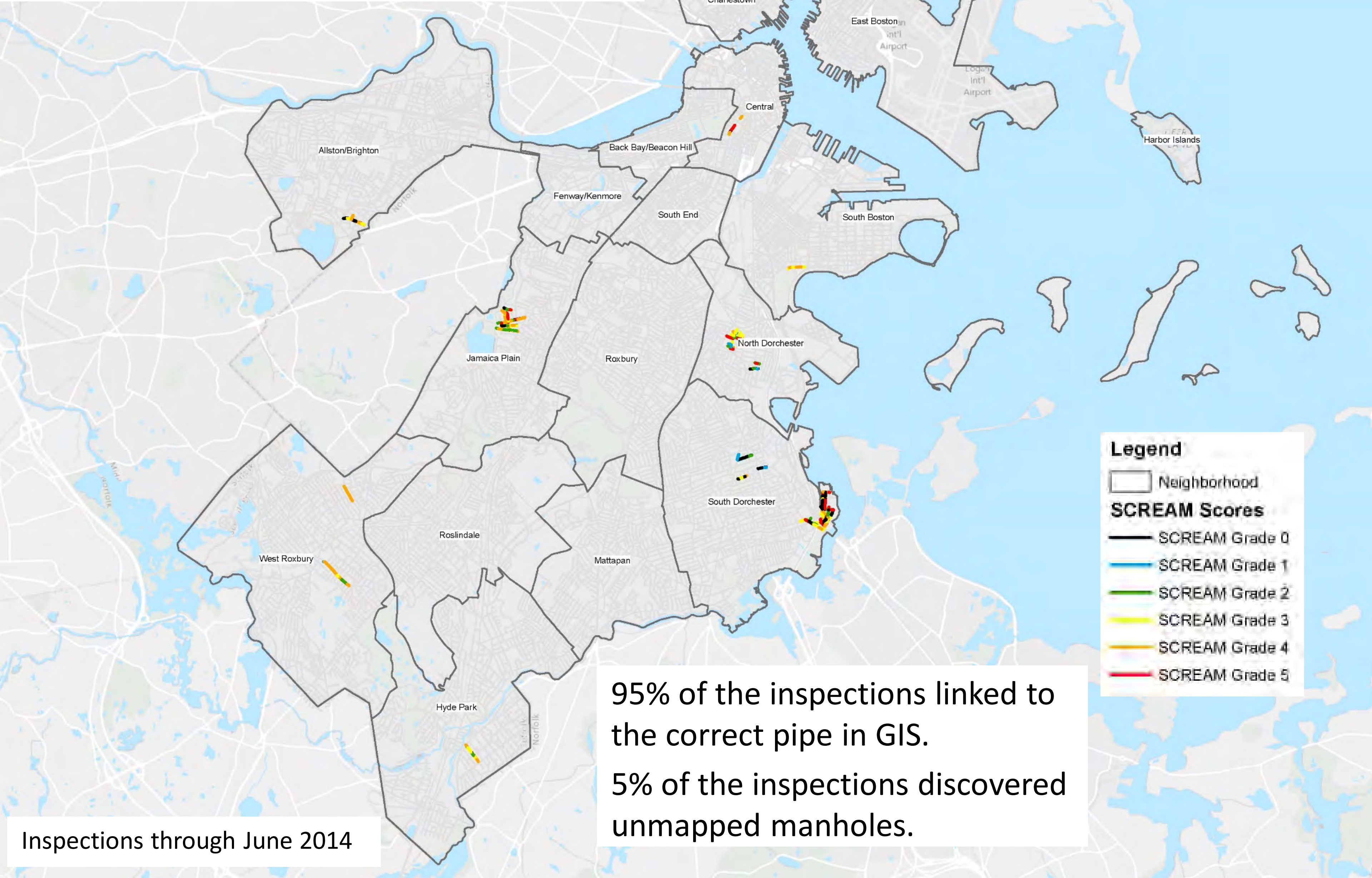
Asset Condition Assessments – SCREAM Condition Assessment Tool



Asset Condition Assessments – Pipe Inspections

- Inspections conducted from October 2012 through June 2014 throughout Boston.
- A pilot inspection run was performed at four locations, allowing refinement of the SCREAM inspection process.
- Once corrections were implemented, work resumed and a total of 9.43 miles of sewers were inspected.
  - Pre-populating Granite XP database with GIS
  - Requiring pictures for major defects

Inspections summarized by neighborhood



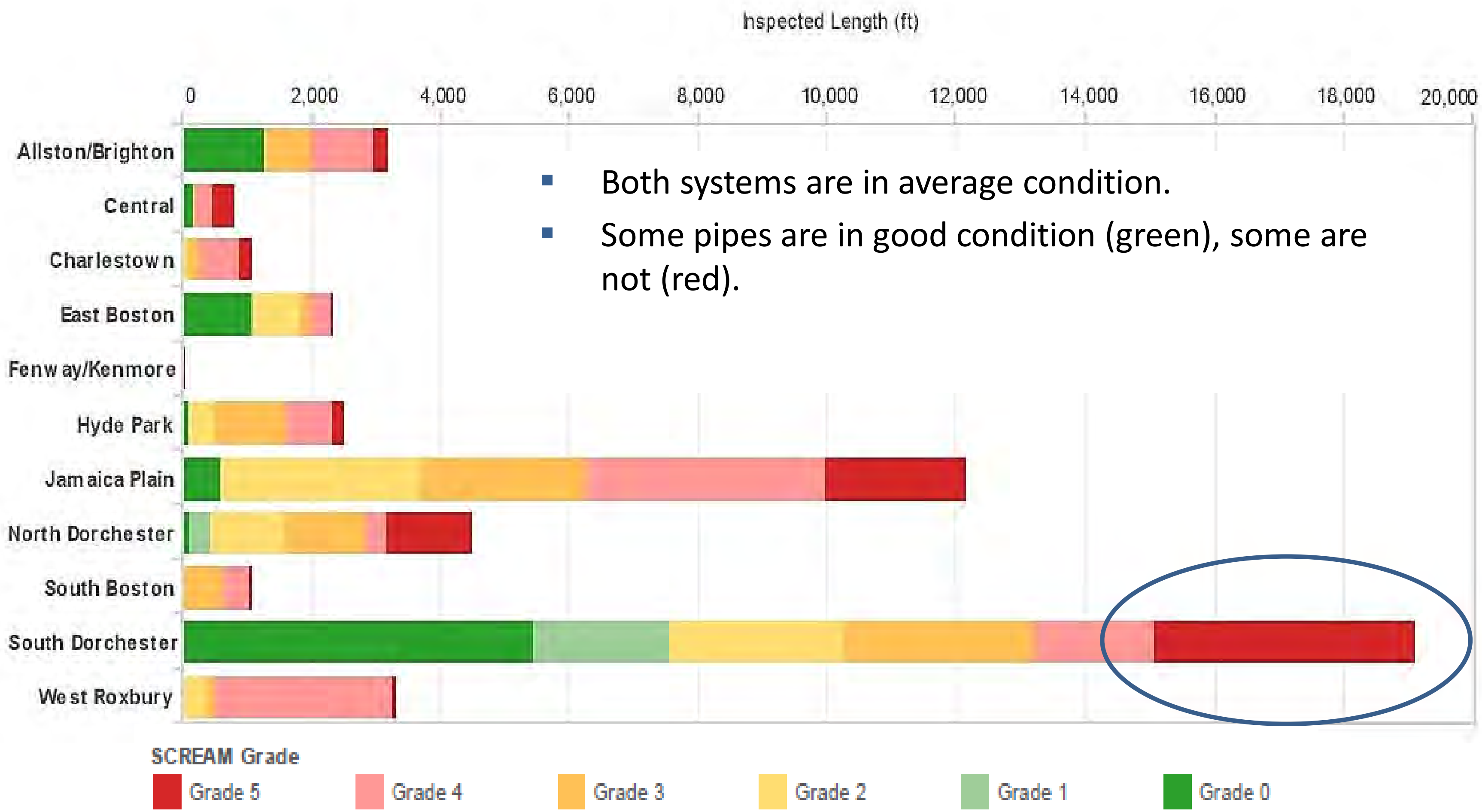
95% of the inspections linked to the correct pipe in GIS.

5% of the inspections discovered unmapped manholes.

Inspections through June 2014

Asset Condition Assessments – Pipe Inspection Results

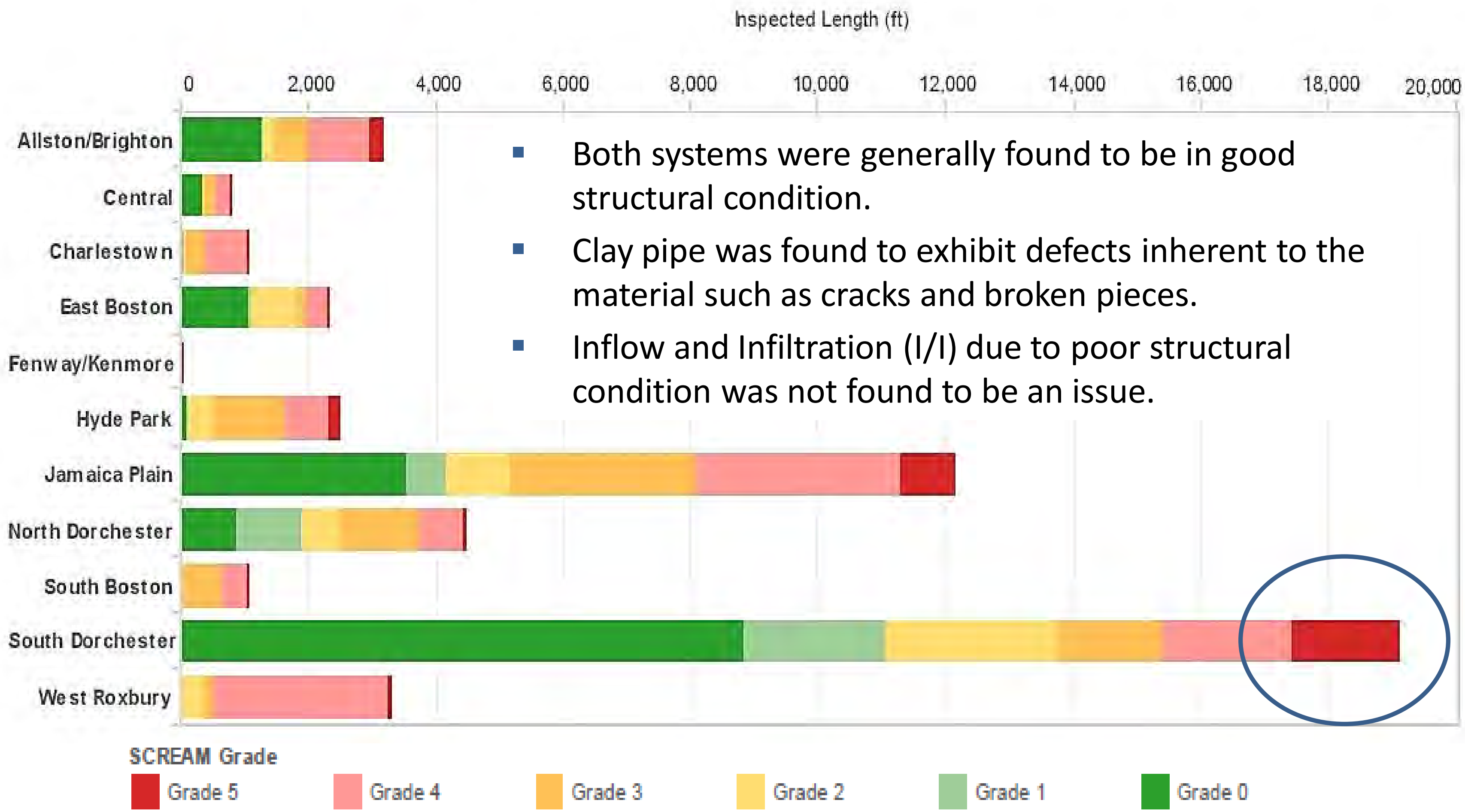
- SCREAM Total Score = Structural + Maintenance + I/I



- Both systems are in average condition.
- Some pipes are in good condition (green), some are not (red).

Asset Condition Assessments – Pipe Inspection Results

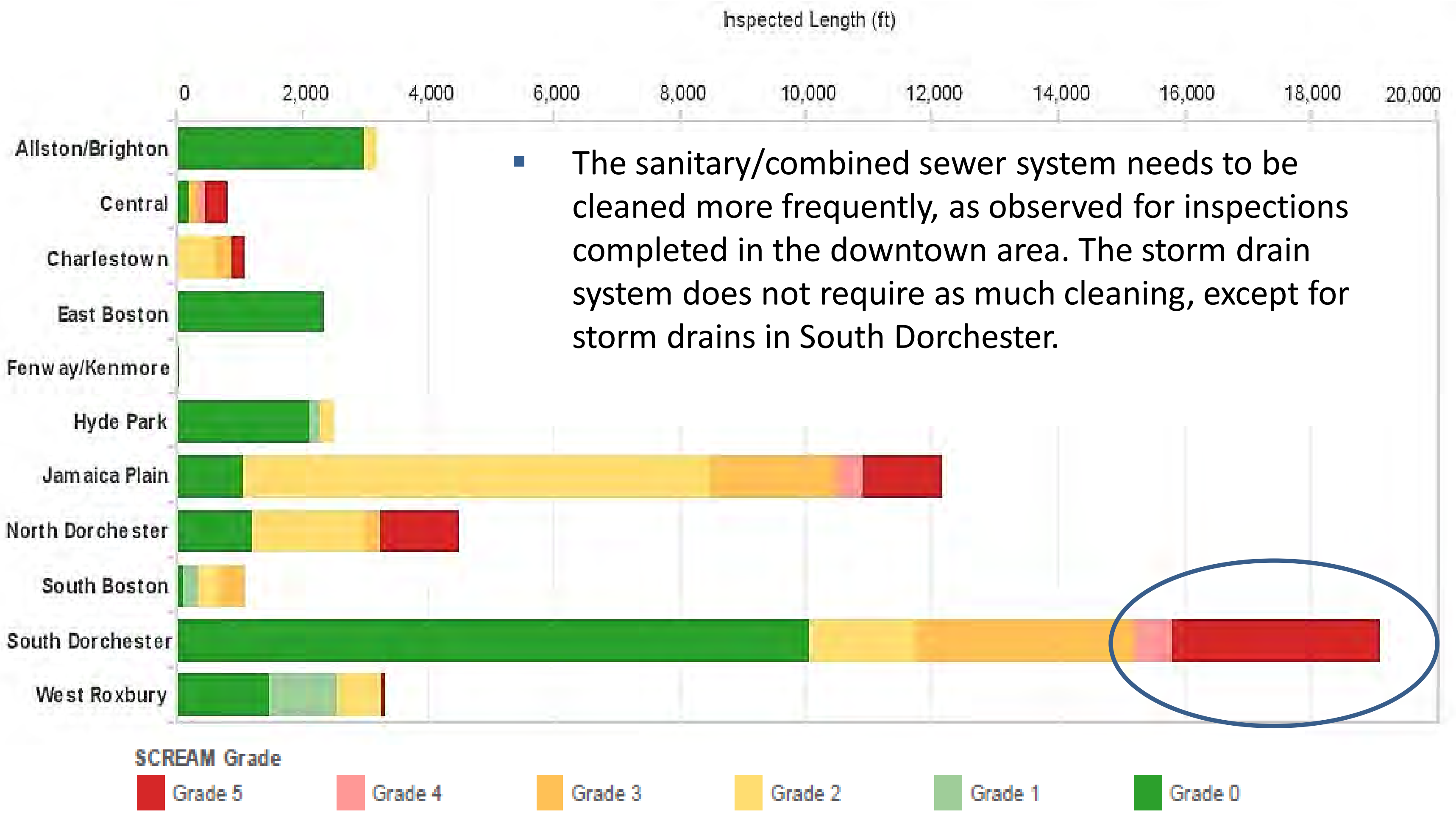
- SCREAM Structural Score = Structural + I/I



- Both systems were generally found to be in good structural condition.
- Clay pipe was found to exhibit defects inherent to the material such as cracks and broken pieces.
- Inflow and Infiltration (I/I) due to poor structural condition was not found to be an issue.

Asset Condition Assessments – Pipe Inspection Results

- SCREAM Maintenance Score = Maintenance



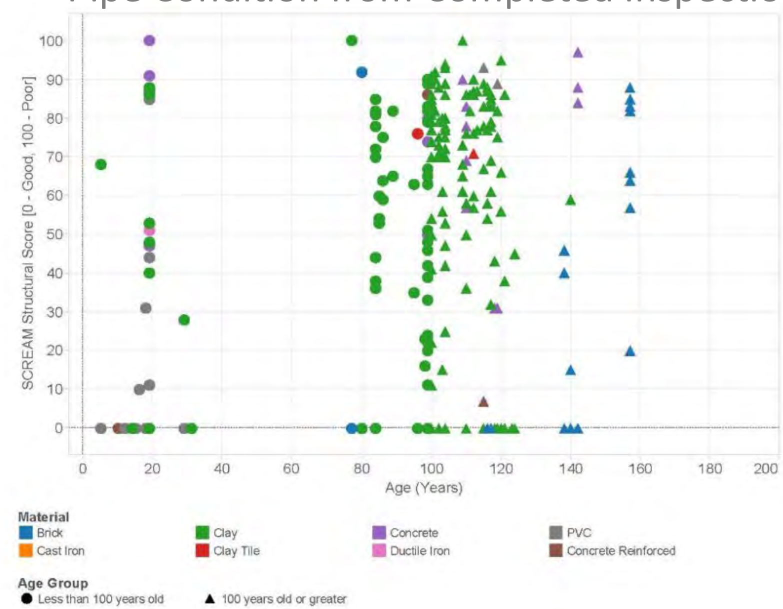
- The sanitary/combined sewer system needs to be cleaned more frequently, as observed for inspections completed in the downtown area. The storm drain system does not require as much cleaning, except for storm drains in South Dorchester.

Asset Condition Assessments – Pipe Inspection Results: Sanitary/Combined

- There is not a strong correlation between age and condition.
- Decay curves may not address real-world factors that influence the condition of an asset
- Inspection data provides a better measure of impacts related to:
  - Environmental Factors
  - Installation
  - Operating Practices
  - Maintenance

Pipe Condition as a Function of Age

Pipe Condition from Completed Inspections



Is this enough to develop a CIP?
What about long-term?

Classic Risk Equation Was Used to Calculating BWSC Assets' Risk Scores

Risk = consequence of failure x likelihood of failure

How severe are the consequences of failure?

How likely is it for the infrastructure to fail?

- Quantify the consequence associated with failure
- Quantify the likelihood of failure
- Use risk equation to quantify relative risks of assets

COF and LOF score ranges from 1 to 10
Risk Scores may range from 1 to 100

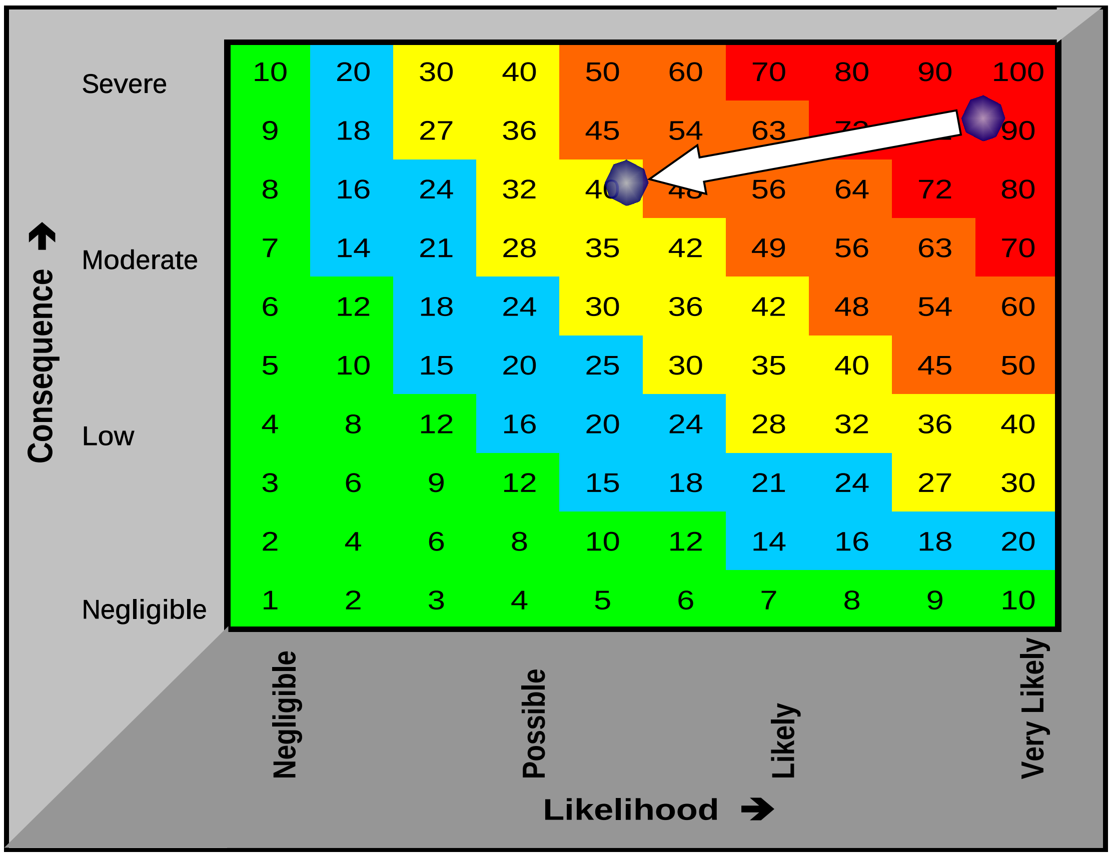
Risk Matrices

Consequence of Failure (COF)	Likelihood of Failure (LOF)
Financial (cost of repair/replacement)	Physical Condition (observed or predicted) - Decay Curves - SCREAM Inspection
Public Health and Regulatory	Maintenance (observed or historic) - CASSWORKS Emergency WOS - SCREAM Inspection
Loss of Service: Critical and High-Volume Customer Service Impact	Wet Weather Performance
Public Image	Sediment Build-up - Sag if found during an inspection
Environmental Impacts	Corrosion

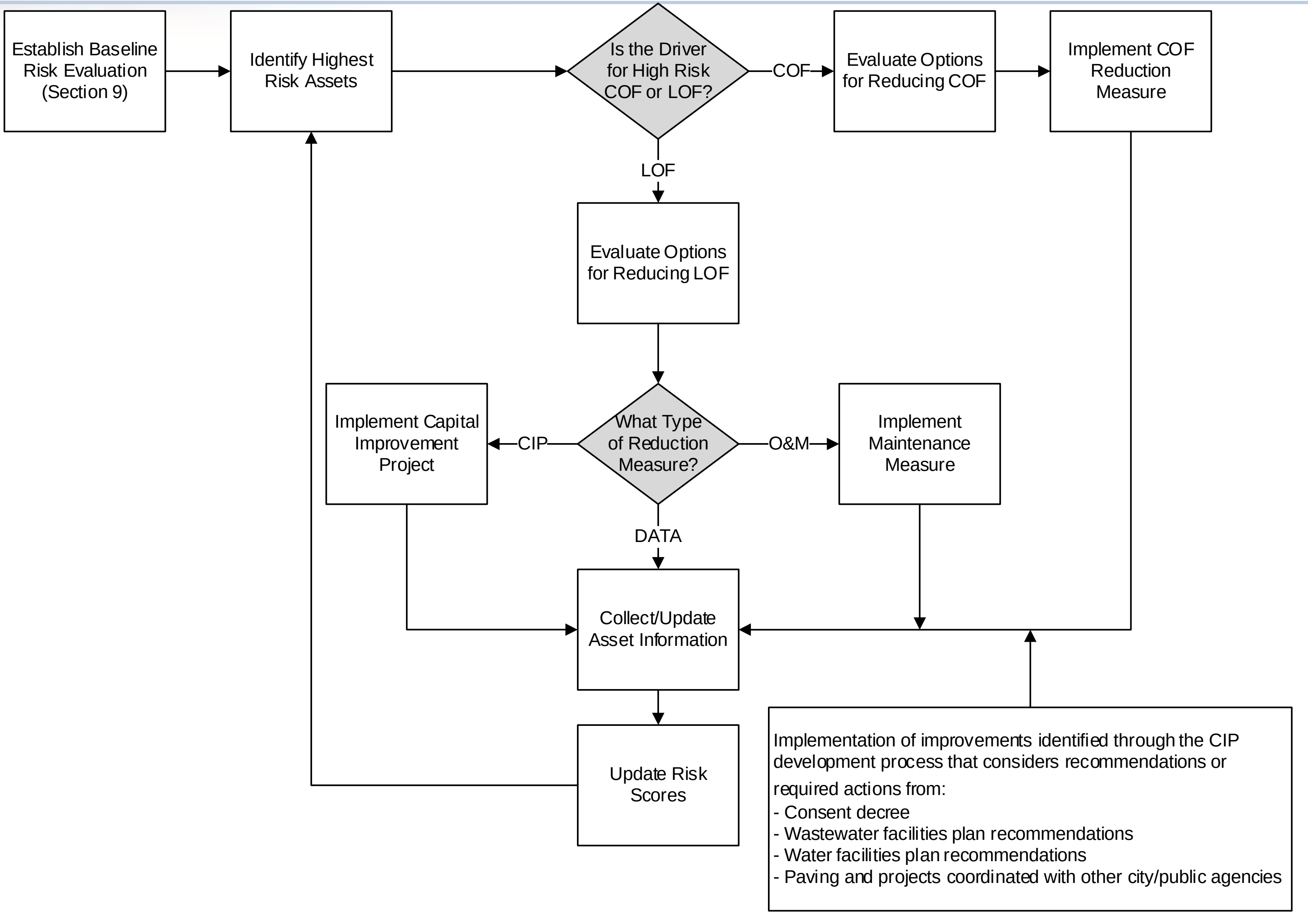
- BWSC GIS
  - Size, Material, Location
- MassGIS
  - Critical Customers
- Hydraulic Model
- Pipe Slope Design Standards
- Water Distribution Study

Risk Assessment -
Risk Reduction Strategies

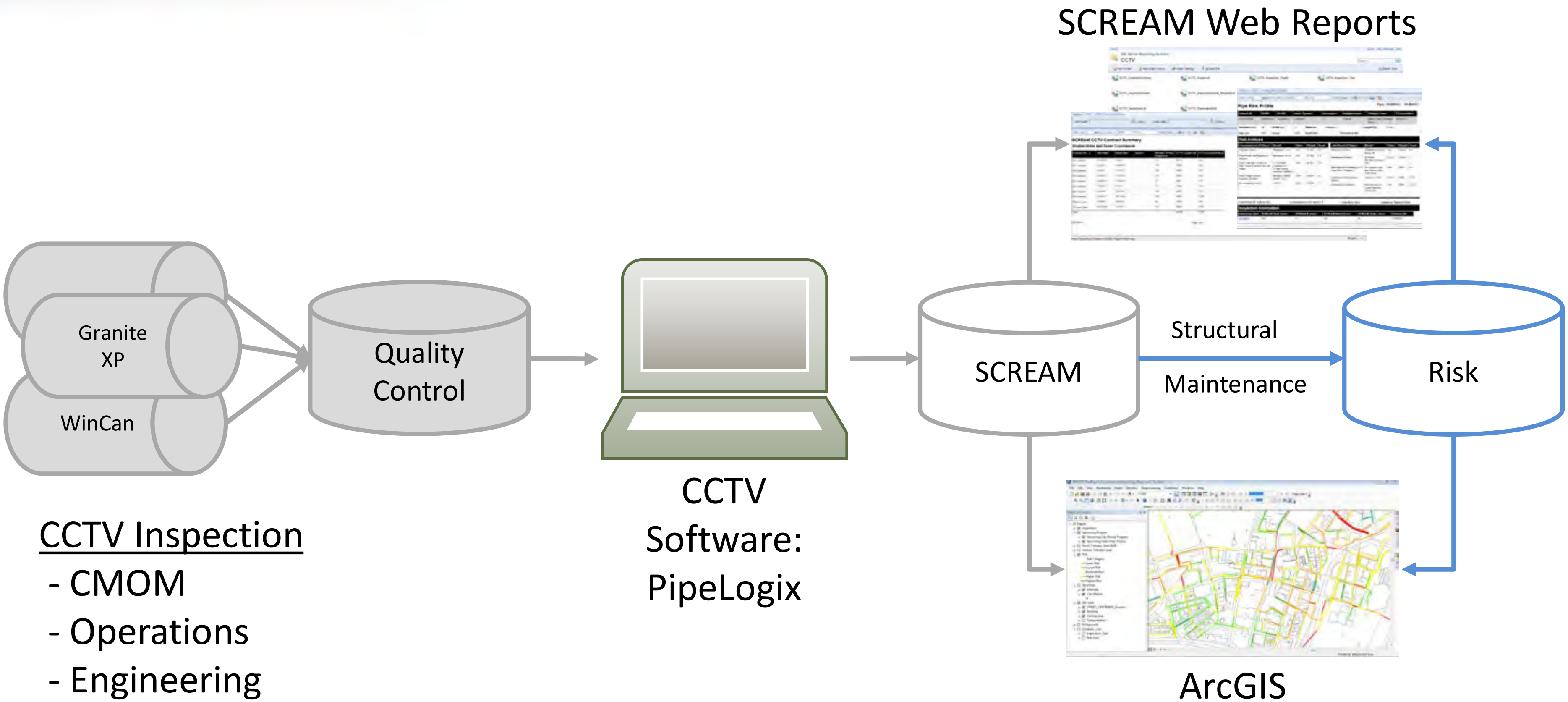
Asset Management is an integrated set of processes to minimize the lifecycle costs of owning, operating and maintaining assets, at an acceptable level of risk, while continuously delivering established levels of service.



Risk Assessment -
Risk Reduction Workflow Process



Risk Assessment –
Risk Assessment Tool

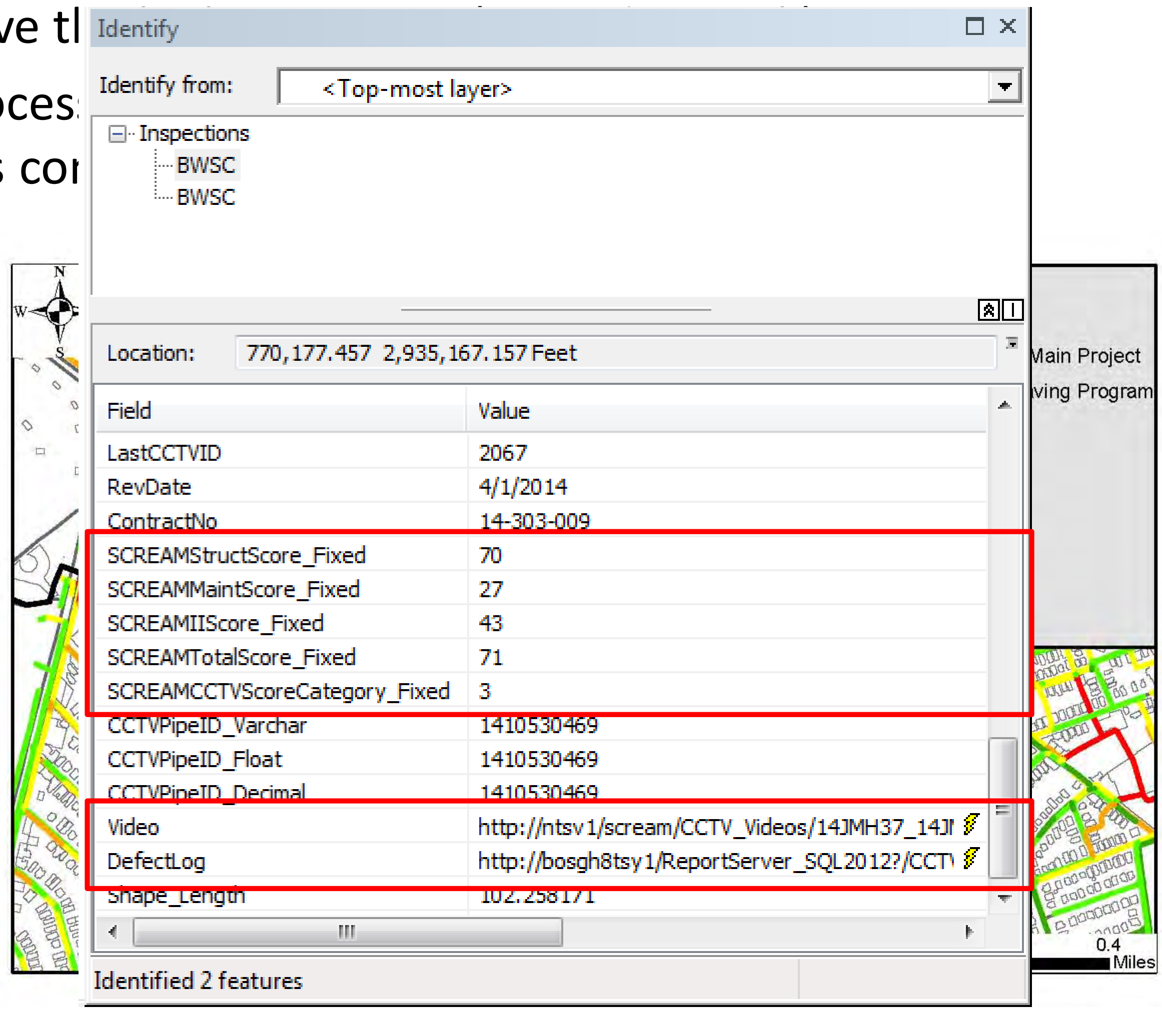


CCTV Inspection
- CMOM
- Operations
- Engineering
- Construction

Risk-based Prioritization – Planning CCTV Inspections

- Where to CCTV next and have tl
- Ability to use systematic proces inspection that incorporates coı

1. Previously Completed Inspections – recorded in SCREAM
2. Risk Scores
3. Outside Factors – as has been done historically; planned development coordination with other public works projects; climate change considerations



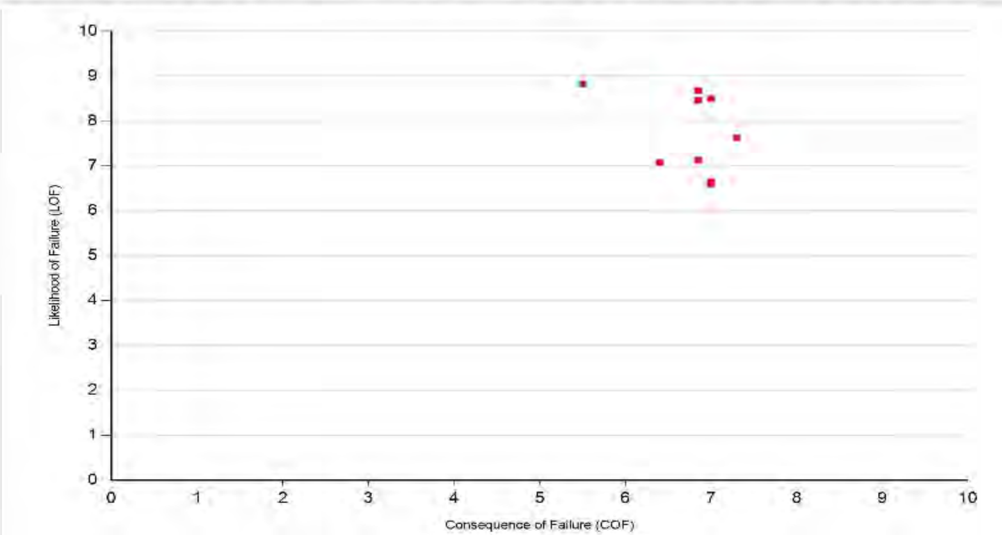
Risk-based Prioritization – Capital Improvement Projects

Pipe Risk Report

Boston Water and Sewer Commission

Number of Pipes: 9

In the chart, click on a point to see the risk profile. In the table, click on the Feature ID to see the risk profile or click on the inspection date to see the inspection



Quickly find the highest risk pipes driven by structural issues

Neighborhood	Tributary Area	P-Connection	Feature ID	US MH	DS MH	Age (yr)	Diam (in)	Material	Length (ft)	LOF	COF	Risk	Risk Category	Maintenance	Condition	Last Inspection
Central	Boston Main Drainage Tunnel	BS-001-P	2512530326	25LMH202	25LMH203	138	15	Unknown	10	8.50	7.00	60	Highest Risk	10.[illegible]0	8.80	2/10/2013
Central	Boston Main Drainage Tunnel	BS-001-P	2311530500	23KMH33	23KMH34	110	28	Non-Reinforced Concrete	123	8.68	6.85	59	Highest Risk	10.[illegible]0	7.80	/29/2013
Central	Boston Main Drainage Tunnel	BS-001-P	2311530182	23KMH32	23KMH33	110	28	Non-Reinforced Concrete	207	8.46	6.85	58	Highest Risk	9.[illegible]0	8.30	/15/2013
Central	Boston Main Drainage Tunnel	BS-001-P	2311530149	23KMH37	23KWC38	110	32	Non-Reinforced Concrete	18	7.63	7.30	56	Highest Risk	10.[illegible]0	5.70	/14/2013
Central	Boston Main Drainage Tunnel	BS-001-P	2311530522	23KMH22	23KMH32	110	28	Asbestos Cement	132	7.13	6.85	49	Highest Risk	7.[illegible]0	6.90	/15/2013
South Dorchester	Columbus Park Connection	BD-009, MB-001-P	1113530044	11MMH12	11MMH11	109	15	Vitrified Clay	318	6.83	5.50	49	Highest Risk	10.[illegible]0	9.90	/21/2013
Central	Boston Main Drainage Tunnel	BS-001-P	2411530303	24KMH356	24KMH355	156	28	Brick	115	6.65	7.00	47	Highest Risk	2.[illegible]0	8.10	/4/2013
Central	Boston Main Drainage Tunnel	BS-001-P	2411530089	24KMH357	24KMH356	156	28	Brick	101	6.60	7.00	46	Highest Risk	1.[illegible]0	8.90	/30/2013
Charlestown	Charlestown Branch Sewer	BC-004-P	2811530345	28KMH21	28KMH22	157	24	Brick	185	7.08	6.40	45	Highest Risk	6.[illegible]0	8.80	1/1/2012

Risk-based Prioritization – Capital Improvement Projects

Review the risk profile to understand the risk factors

Pipe Risk Profile

Pipe: 11MMH12 - 11MMH11

Feature ID	US MH	DS MH	Sewer System	Interceptor	Neighborhood	Tributary Area	P-Connection
1113530044	11MMH12	11MMH11	Sanitary	U	South Dorchester	Columbus Park Connection	BD-009, MB-001-P

Diameter (in)	15	**Width (in)**	0	**Material**	Vitrified Clay	**Length (ft)**	317.64
Age (yr)	109	**Slope**	0.00	**Depth (ft)**	7.76	**Freeboard (ft)**	

Risk Analysis

Consequence of Failure	Result	Value	Weight	Score
Financial Impact	Residential, 15 in	5.00	15.00%	0.75
Public Health And Regulatory Impacts	Residential, 15 in.	5.00	30.00%	1.5
Loss of Service: Critical and High Volume Customer Service Impact	No critical and no high-volume customers impacted	1.00	25.00%	0.25
Public Image Impacts; Disruption to Public	Railroad or MBTA Station, 15 in.	10.00	20.00%	2
Environmental Impact	<=100 ft	10.00	10.00%	1

Likelihood of Failure	Result	Value	Weight	Score
Physical Condition	SCREAM Structural Score: 99	9.90	50.00%	4.95
Maintenance History	SCREAM Maintenance Score: 100	10.00	30.00%	3
Wet Weather Flow Based on 10 Year Storm Freeboard	Freeboard is > 0 ft and <= 8 ft or pipe burial depth is > 4 ft and < 8 ft	7.00	7.50%	0.525
Likelihood of Sedimentation Buildup	SCREAM Code: PSag1	4.00	7.50%	0.3
Corrosive Environment	Non Corrosive or Lowest Relative Corrosivity	1.00	5.00%	0.05

Likelihood of Failure: 8.825 **Consequence of Failure: 5.5** **Total Risk: 48.5375** **Category: Highest Risk**

Inspection Information

Inspection Date	SCREAM Total Score	SCREAM II Score	SCREAM Maint Score	SCREAM Struct Score	Contract No
6/21/2013	100	0	100	99	11-206-004

Risk-based Prioritization – Capital Improvement Projects

Review CCTV inspection to determine if pipe should be included in CIP

SCREAM CCTV Inspection

Pipe: 11MMH12 - 11MMH11

Neighborhood	Tributary Area	US MH	DS MH	Feature ID	Street	Diam (in)	Width (in)	Material	Length (ft)*
South Dorchester	BD-009, MB-001 -P	11MMH12	11MMH11	1113530044	76 TAYLOR ST	15	0	Concrete	317.6

Reviewer	Greg DeLuca	**City**	76 TAYLOR ST	**Down Rim to Grade**		**SCREAM Struct Score**	99
Date	06/21/13	**Location Details**		**Flow Control**		**SCREAM Maint Score**	100
Pre Cleaned	Heavy Cleaning	**Up Rim to Invert**	16.36	**Shape**		**SCREAM II Score**	0
CCTV Length*	292.2	**Up Grade to Invert**		**Lining Method**		**SCREAM Total Score**	100
Sewer Type	Sanitary	**Up Rim to Grade**		**Purpose**	Assessment		
Comments	- Merged Inspections Num	**Down Rim to Invert**	16.54	**Contract No**	11-206-004		
Last Review ID	27	**Down Grade to Invert**		**Video Link**	Link to Video		

Defects cbserved (Raw Data)

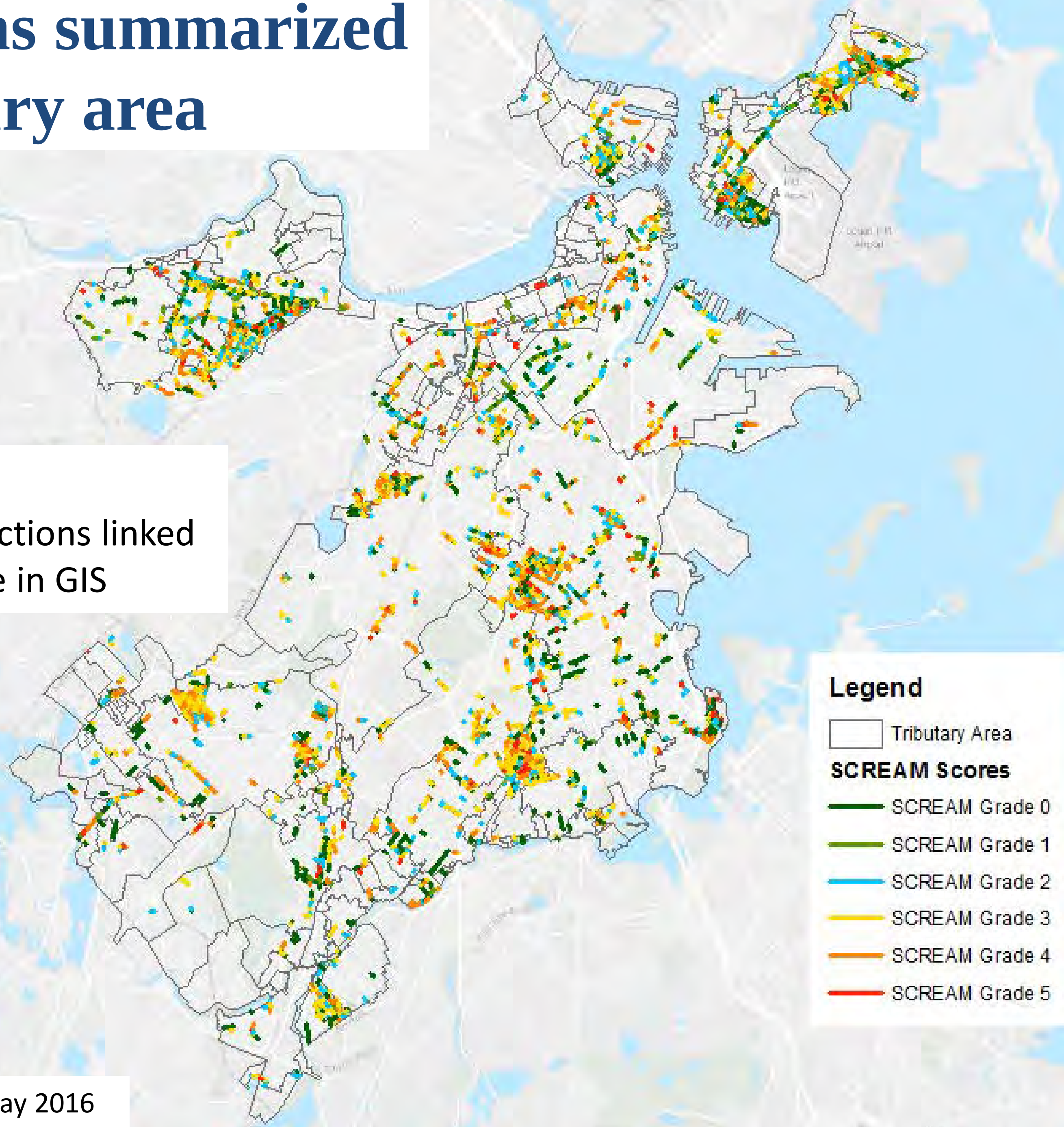
Photo	Dirctn	Start Ftg	End Ftg	SCREAM Code	Defect Family	Component	Type	Severity	Comment
	upstream	0.0		START AGAINST FLOW	Information	Pipe	Start Inspection	Location	
	downstream	0.0		START WITH FLOW	Information	Pipe	Start Inspection	Location	
	upstream	0.0	16.8	PDSet30	Debris	Pipe	Debris Settled	30% Area Loss	

Achieving Long Term Goals

- Measuring the degradation rate of assets.
- Measuring the effectiveness of maintenance strategies.
- More accurately predicting the remaining life of its assets and plan for their replacement.
- Avoiding interruption of service caused by asset failures.
- Focusing on proactive management of its assets rather than reactive activities.
- Maintaining desired levels of service at the lowest life cycle costs with acceptable levels of risk.
- Reducing the overall risk of the sanitary sewer and storm drain system.

Inspections summarized by tributary area

- 183 miles
- 98% of the inspections linked to the correct pipe in GIS



Inspections through May 2016

Questions?

References

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