

Objectives

- What condition assessment is and why it is important
- Planning and executing an assessment project
- Analyzing your results
- Turning analysis into action

What is condition assessment?

"The process used to describe the condition and/or performance of a system component."

- Improved public safety
- Mitigate flooding risks
- Promote economic development
- Maximize asset life
- Information-based approach to set priorities

Avoiding this ...



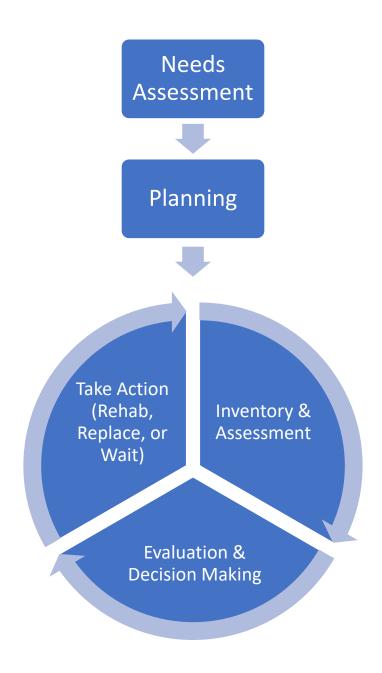
And this ...



And mitigate this ...



Condition Assessment Program Cycle



Needs Assessment

• What is your current state?

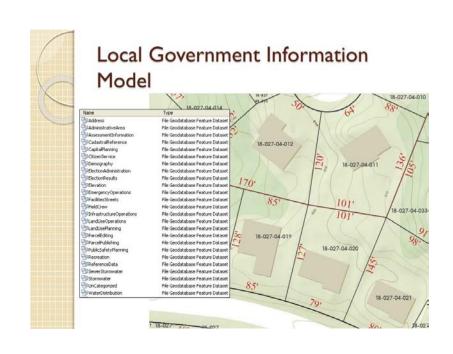
- Identify available data
 - GIS, CAD, drawings, reports, spreadsheets (and more)
- Identify gaps
- Identify technology and software currently being used
- Work order systems, etc

Things to consider

- Database design
- Inventory methods and technology
- Assessment methodologies
- CCTV

Database Design

- Local Government Information Model (LGIM)
 - ESRI's preferred data model
 - Scalable
 - Preconfigured domains and feature classes
 - Modify as needed



Inventory technology

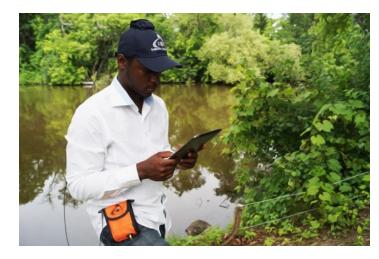
- Collector for ArcGIS
 - Mobile data collection app
 - Rich editing environment
 - Supports offline editing
 - Sync back in office
 - New version of app released in 2018





- External GPS
 - Submeter accuracy
 - Bluetooth to tablet
 - ~\$3,000 per unit





Inspection technology

- Zoom cameras
 - Supplements surface inventory
 - Provides shots of pipes from structure
 - Photos limited to straight-line pipe
 - Helps lower overall project cost by reducing CCTV scope

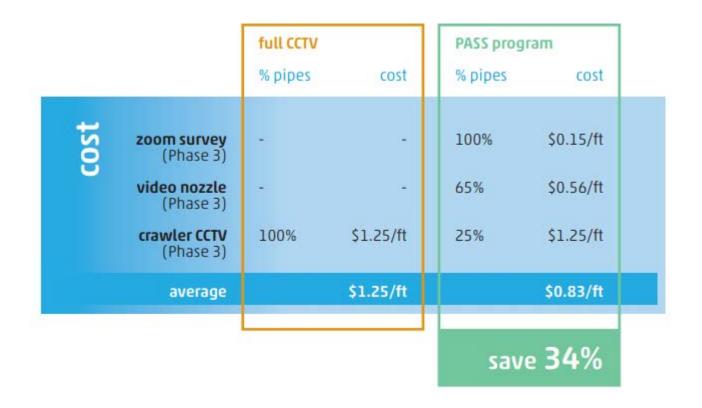






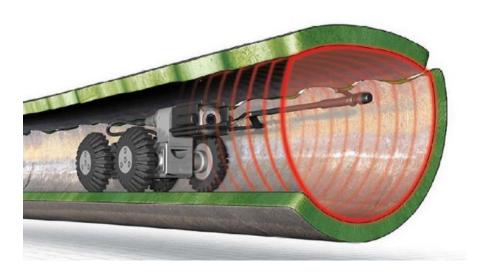
Inspection technology

- Zoom cameras
 - Phased Assessment Strategy for Sewers (PASS)



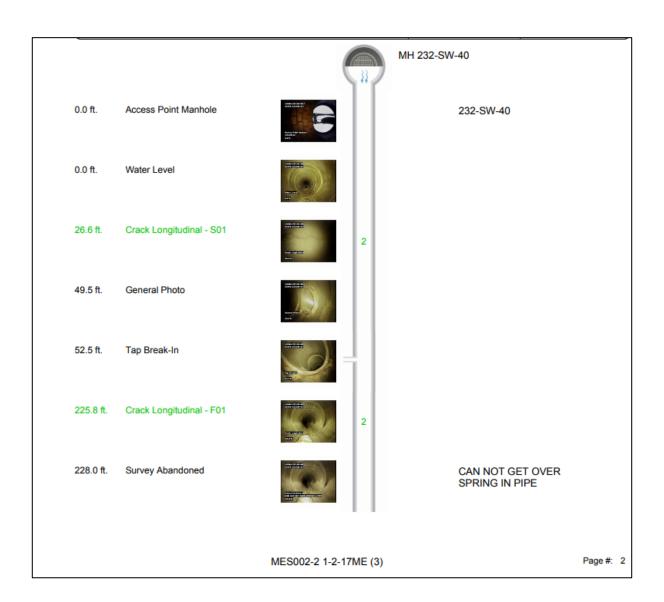
Inspection technology

- CCTV
 - Pipe inspections
 - Reports and videos
 - Can be linked to GIS and ratings symbolized on map
 - ~\$1.50 LF
 - Heavy cleaning expressed as an hourly rate



Inspection technology

CCTV



Inspection technology

• CCTV

Pipe Segm	ent Refere	С	ity	Street	Material		Location C	Sewer Use
Line 23	2-SW-174	Tulsa	a, OK	E 17TH PL	Reinforced Concrete		Light High	Stormwater
Upstre	am MH	Total I	Length	Year Laid	Sh	аре	Location	n Details
MH 23	2-SW-40	3	52		Circ	ular		
DS N	anhole	Length s	surveyed	Year Renewed	Height	Width	Pipe Joint	
MH 232	-SW-107	22	28		30	30 30		oxdot
SPR	80	MPR	N/A	PO Number			Customer	
SPRI	2	MPRI	N/A	1	Mes		shek & Associates	
SPRI		IVIPRI	N/A	Work Order			Purpose	
QSR	2G00	QMR	N/A		Mai		aintenance Related	
C	PR	Surve	yed By	Direction	Date		Media label	
	30	ACE	/MEJ	Downstream	20180122			
0	PRI	Certificati	e Number	Pre-Cleaning	ning Time		Weather	
	2 U-0218-070300598 No Pre-Cleaning 14:38		:38 Very Dry					
	Date Cleaned		leaned		End Time		Additional Info	
					14	:56		

			Structural Ratings			0	& M Ratin	gs	Con	bined Ra	tings
Normal Defects		Grade Rating	No. Occur.	Rating	Grade Rating	No. Occur.	Rating	Grade Rating	No. Occur.	Rating	
			1	0	0	1	0	0	1	0	0
			2	0	0	2	0	0	2	0	0
			3	0	0	3	0	0	3	0	0
			4	0	0	4	0	0	4	0	0
			5	0	0	5	0	0	5	0	0
Contin	Continuous Defects Code ID Length										
			1	40	00		_		2	40	00
CL	F01	199.2	2	40	80	0	0	0	2	40	80
			Subtotals	40		Subtotals	0		Subtotals	40	
SI	UMMA	PV	Pi	pe Rating	80	Pi	pe Rating	0	Overall P	pe Rating	80
	C.MINA		Struct	ural Index	2.0	0	&M Index	0	Ove	erall Index	2.0
			Str. Qu	ick Rating	2G00	O&M Qu	ick Rating	0000	Ovrl. Qu	ick Rating	2G00

Inspection technology

CCTV



Material UNK Pipe Width 30 Pipe Height 30 Inspection Date 1/21/2018 Start Time 1/22/2018, 8:38 AM End Time 1/22/2018, 8:56 AM Operator ACE/MEJ Certificate Number U-0218-070300598 Very Dry Weather No Pre-Cleaning Cleaned Flow Control Inspection Direction Downstream Inspection Length 228.0 Quick Structural Rating 2G00 Quick O&M Rating 0000 Quick Overall Rating 2G00 Structural Pipe Rating 80 O&M Pipe Rating 0 Overall Pipe Rating 80 Structural Pipe Rating Index 2.00 0.00 O&M Pipe Rating Index 2.00 Overall Pipe Rating Index Hyperlink (Report) More info Hyperlink (Video) More info

Downstream MH

MH 232-SW-107

CCTV Scoping

- By Size
 - 18" 54"
- By area
 - Entire systems, regardless of size
- By criticality
 - Major roads
 - Critical facilities

CCTV Scoping

By Size (18" to 54")



CCTV Scoping

- By Size
 - 18" 54"
- By area
 - Entire systems, regardless of size
- By criticality
 - Major roads
 - Critical facilities

CCTV Scoping

By Area



CCTV Scoping

- By Size
 - 18" 54"
- By area
 - Entire systems, regardless of size
- By criticality
 - Major roads
 - Critical facilities

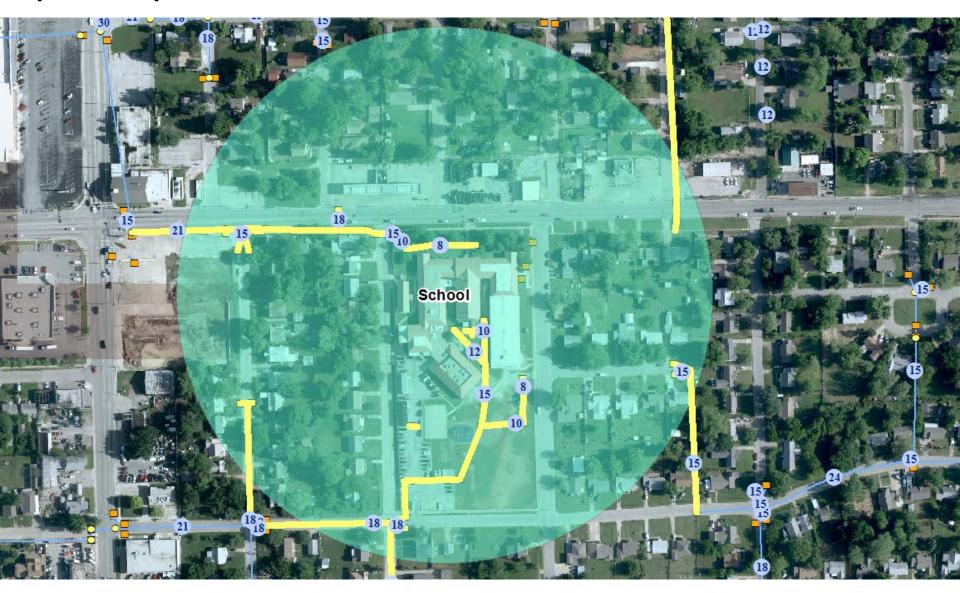
CCTV Scoping

By Criticality – Major Roads



CCTV Scoping

By Criticality – Critical Facilities



NASSCO

- National Association of Sewer Service Companies
 - Formed in 1976
 - Member based
 - Sets industry standards for the assessment and rehabilitation of storm, sanitary, and water infrastructure



PACP and MACP

- Pipeline Assessment & Certification Program
- Manhole Assessment & Certification Program
- Started in 2002
- Goal was to introduce standardization and consistency into condition evaluations
- Derived from England's Water Research Centre (WRC) codes
- Certification required every 3 years



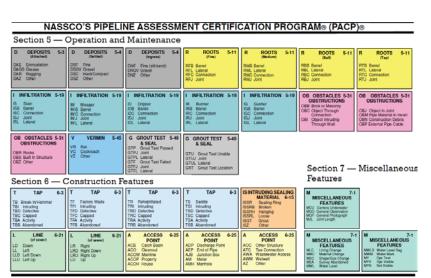


PACP and MACP

- Industry standard for condition assessment
- Large code library
- Organized into 4 code "families"
 - Structural
 - Operation & Maintenance (O&M)
 - Construction Features
 - Miscellaneous Features



Section 4 — Structural Defect Coding C CRACK 4-3 CL Longludinal CL Congludinal CL Computerial CL Multiple CL Congress CL Congludinal CL Congress CL C





Structural Defect Codes

NASSCO'S PIPELINE ASSESSMENT CERTIFICATION PROGRAM® (PACP®)

Section 4 — Structural Defect Coding

MMS Mortar Missing Small MMM Mortar Missing Med.

Displaced Missing Dropped Invert

C CC CM CS CH	CRACK 4-3 Longitudinal Circumferential Multiple Spiral Hinge (2, 3, 4)	F FRACTURE 4-9 FL Longitudinal FC Circumferential FM Multiple FS Spiral FH Hinge (2, 3, 4)	B BSV BVV	BROKEN 4-17 Soil Visible Void Visible	H HSV HVV		1	D DEFORMED 4-25 (Rigid) DR Deformed Rigid No modifiers used.	D DEFORMED 4-25 (Flexible) DFBR Bulging Round DFBI Bulging Inv.Curv. DFC Creasing DFE Elliptical	D DEFORMED 4-25 (Brick) DTBR Bulging Round DTBI Bulging Inv.Curv.
	COLLAPSE 4-37 Collapse No descriptors and no modifiers used.	J JOINT 4-43 JOS Offset Small JOM Offset Medium JOL Offset Large	JOM	JOINT 4-43 D Offset Small Defect ID Offset Medium Defect D Offset Large Defect	JSM	JOINT 4-43 Separation Small Separation Med. Separation Large	3	J JOINT 4-43 JAS Angular Small JAM Angular Medium JAL Angular Large	S SURFACE 4-51 DAMAGE SRI Roughness Increased SAV Aggregate Visible SAP Aggregate Projecting SAM Aggregate Missing	S SURFACE 4-51 DAMAGE SRV Reinforcement Visible SRP Reinforcemt. Projecting SRC Reinforcemt. Corroded SMW Missing Wall
S SSS SSC SCP SZ	Surface Spalling Coating	LF LINING 4-67 FEATURES LFAC Abdn'd Connection LFAS Annular Space LFB Blistered Lining LFCS Service Cut Shifted BRICKWORK 4-97	LFDC	LINING 4-67 FEATURES Detached Discoloration Defective End Delamination	LFOC LFRS LFUC LFW LFZ		7	WF WELD 4-85 FAILURE WFC Circumferential WFL Longitudinal WFM Multiple WFS Spiral WFZ Other	RP POINT REPAIR 4-89 RPL Liner RPLD Liner Defective RPP Patch RPPD Patch Defective	RP POINT REPAIR 4-89 RPR Replacement RPRD Replmt. Defective RPZ Other RPZD Other Defective



O&M Defect Codes

OBZ Other

NASSCO'S PIPELINE ASSESSMENT CERTIFICATION PROGRAM® (PACP)®

Section 5 — Operation and Maintenance

	operation and	- I - I - I - I - I - I - I - I - I - I				
D DEPOSITS 5-3 (Attached)	D DEPOSITS 5-4 (Settled)	D DEPOSITS 5-4 (Ingress)	R ROOTS 5-11 (Fine)	R ROOTS 5-11 (Medium)	R ROOTS 5-11	R ROOTS 5-11
DAE Encrustation DAGS Grease DAR Ragging DAZ Other	DSF Fine DSGV Gravel DSC Hard/Compact DSZ Other	DNF Fine (silt/sand) DNGV Gravel DNZ Other	RFB Barrel RFL Lateral RFC Connection RFJ Joint	RMB Barrel RML Lateral RMC Connection RMJ Joint	RBB Barrel RBL Lateral RBC Connection RBJ Joint	RTB Barrel RTL Lateral RTC Connection RTJ Joint
I INFILTRATION 5-19 IS Stain ISB Barrel ISC Connection ISJ Joint ISL Lateral	I INFILTRATION 5-19 W Weeper WB Barrel WC Connection WJ Joint WL Lateral	I INFILTRATION 5-19 ID Dripper IDB Barrel IDC Connection IDJ Joint IDL Lateral	I INFILTRATION 5-19 IR Runner IRB Barrel IRC Connection IRJ Joint IRL Lateral	I INFILTRATION 5-19 IG Gusher IGB Barrel IGC Connection IGJ Joint IGL Lateral	OB OBSTACLES 5-31 OBSTRUCTIONS OBB Brick or Masonry OBC Object Through Connection OBI Object Intruding Through Wall	OB OBSTACLES 5-31 OBSTRUCTIONS OBJ Object in Joint OBM Pipe Material in Invert OBN Construction Debris OBP External Pipe Cable
OB OBSTRUCTIONS OBR Rocks	V VERMIN 5-45 VR Rat VC Cockroach	G GROUT TEST 5-49 & SEAL GTP Grout Test Passed GTPJ Joint	G GROUT TEST 5-49 & SEAL			

GTUJ Joint

GTUL Lateral

GRT Grout Test Location

GTF Grout Test Failed

Section 7 — Miscellaneous

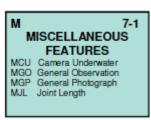


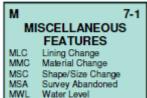
Construction & Miscellaneous Defect Codes

Section 6 — Construction Features

T TAP TB Break-In/Hamme TBI Intruding TBD Defective TBC Capped TBA Activity TBB Abandoned	6-3	T TAP TF Factory Made TFI Intruding TFD Defective TFC Capped TFA Activity TFB Abandoned	6-3	T TAP TR Rehabilitate TRI Intruding TRD Defective TRC Capped TRA Activity TRB Abandoned	od	TSC TSA	TAP Saddle Intruding Defective Capped Activity Abandoned	6-3			6-15
L LINE (of sewer) LD Down LL Left LLD Left Down LLU Left Up	6-21	L LINE (of sewer) LR Right LRD Right Down LRU Right Up LU Up	6-21	A ACCES POIN ACB Catch Ba ACO Cleanout ACOM Mainline ACOP Property ACOH House	T sin	ADP AEP AJB AM AMH		6-25	ATC AWA AWW	ACCESS POINT Other Structure Tee Connectio Wastewater Ad Wetwell Other	n

Section 7 — Miscellaneous Features





M 7-1
MISCELLANEOUS
FEATURES
MWLS Water Level Sag
MWM Water Mark
MY Dye Test
MYV Dye Visible
MYN Not Visible



PACP Codes

- Codes used to describe defects or observations consist of 3 items:
 - Group broad category (i.e. R Roots)
 - Descriptor further defines the defect (F Fine, M Medium, B Ball, or T Tap)
 - Modifier extension of the Group/Descriptor Code and provides more detailed information (B – Barrel, J – Joint, L – Lateral)
- So, the code **RMB** would indicate a Root Medium entering through the Barrel of the pipe.

R ROOTS 5-11 (Fine)	R ROOTS 5-11 (Medium)	R ROOTS 5-11	R ROOTS 5-11
RFB Barrel	RMB Barrel	RBB Barrel	RTB Barrel
RFL Lateral	RML Lateral	RBL Lateral	RTL Lateral
RFC Connection	RMC Connection	RBC Connection	RTC Connection
RFJ Joint	RMJ Joint	RBJ Joint	RTJ Joint

Analyzing Your Results



PACP Condition Grades

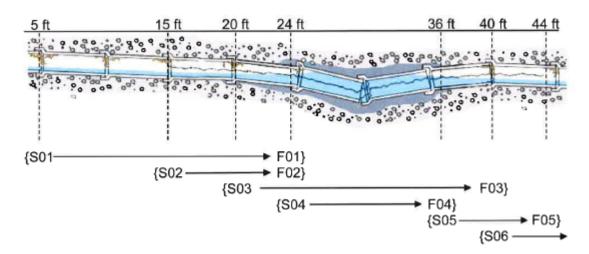
- 5: Most significant defect grade
- 4: Significant defect grade
- 3: Moderate defect grade
- 2: Minor to moderate defect grade
- 1: Minor or no defects

Defect grades are already determined by the software; you just have to make sure you are coding defects correctly!

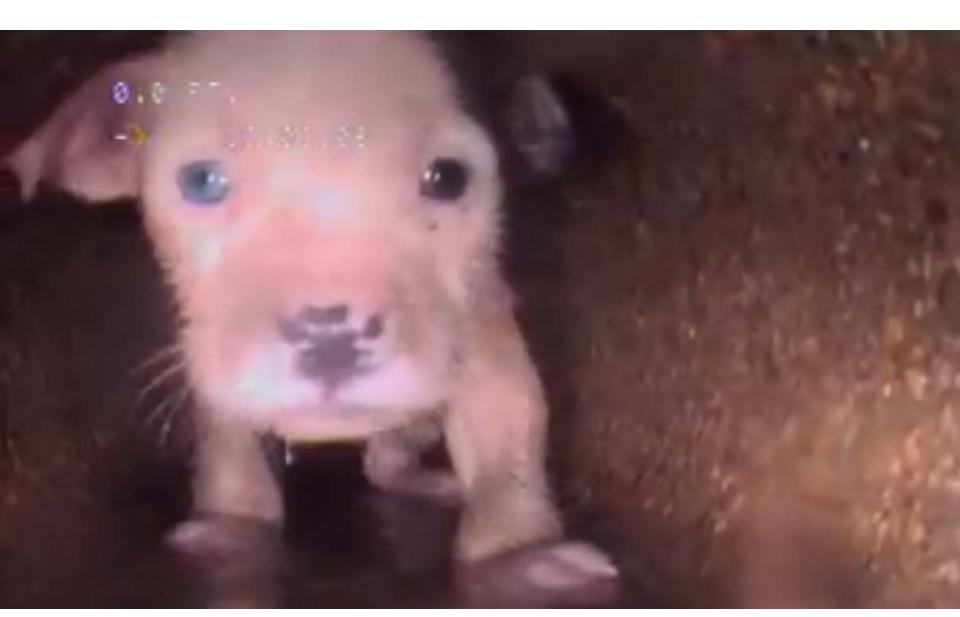


Point and Continuous Defects

- Point defect a discrete defect < 3 feet in length
- Continuous defect
 - Truly continuous 3 feet or longer
 - A crack running longitudinally along the pipe at the 12 o'clock for 42 feet
 - Repeat continuous at 3 of every 4 joints
 - Infiltration Weeper at every pipe joint for 70 feet
- Continuous defects are noted as 2 separate entries with respective "Start" and "End" labels, along with the stationing



Anything you could possibly encounter in a storm pipe can be found in the PACP Code Library.



Assessment methodology

Assessment methodology

- NASSCO software
 - Commercial options available
 - Complies with NASSCO standard (NASSCO-certified)
 - Import into software and export to GIS
 - Data entry forms
 - Generate inspection reports
 - Or you can custom design one yourself









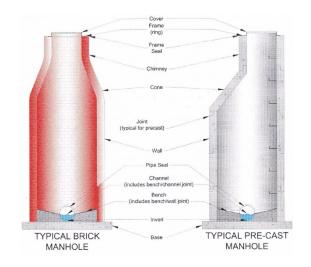
Inventory & Assessment

Inventory – Surface

- Physical data (i.e. feature attributes)
 - Location
 - Feature Type
 - Pipe inventory
 - Pipe size
 - Invert measurements
 - Material
- Photos



- Structural integrity
- Functional integrity (O&M)
- Construction features





Inventory & Assessment

Inventory - Subsurface

- Manned entry
- Use measuring wheel to record stationing from known entry points
- Record defects in related table
- Tabular data can then be converted into points along the line (linear referencing)

oint Pipe Conditions					
	DISTANCE		PACP_CODE	CONTINUOUS	RATING
	17	Sι	face Aggregate Missing	S01	4
	32	Но	Soil Visible	<null></null>	5
	72	Ta	Break-in Capped	<null></null>	2
	90	Su	face Aggregate Missing	FO1	4
	90	D€	osits Settled Gravel	S02	3
	149	Н	le Soil Visible	<null></null>	5
П	183	7 e	posits Settled Gravel	F02	3





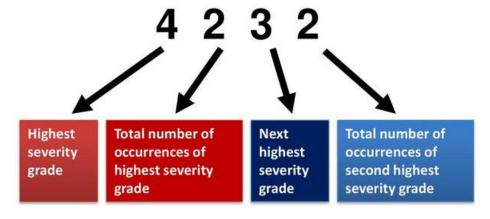


Analyzing Your Results

Rating System

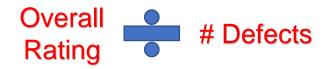
Quick Rating

Overall Rating – sum of all grades



	Occurrences			Segment Grade Scores		
Grade	Structural	O&M	Overall	Structural	O&M	Overall
1	1	3	4	1	3	4
2	3	5	8	6	10	16
3	2	4	6	6	12	18
4	5	0	5	20	0	20
5	3	2	5	15	10	25
	14	14	28	48	35	83

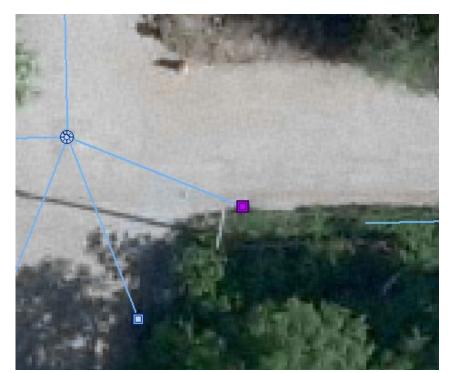
 Rating Index – Overall Rating divided by number of defects



Analyzing Your Results

Surface Ratings

- Defect scores summarized separately for each structure
 - Structural rating
 - O&M rating
 - Combined rating



Defect 1

Field	Value
GEN_MACP_CODE	Cracks & Fractures
COMPONENT	Wall Interior
MACP_CODE	Fracture Multiple
CONTINUOUS	Yes
VALUE_1ST_DIMENSION	4.5
VALUE_2ND_DIMENSION	<null></null>
VALUE_PERCENT	No Rating
EPD	4.5
GRADE_CAT	Structural
COND_GRADE	4
STRUCTURAL_GRADE	18
OM_GRADE	0



Doloot 2		
Field	Value	
GEN_MACP_CODE	Debris & Obstructions	
COMPONENT	Bench/Floor	
MACP_CODE	Deposits Settled Fine	
CONTINUOUS	No	
VALUE_1ST_DIMENSION	<null></null>	
VALUE_2ND_DIMENSION	<null></null>	
VALUE_PERCENT	51-75%	
EPD	1	
GRADE_CAT	O&M	
COND_GRADE	3	
STRUCTURAL_GRADE	0	
OM_GRADE	3	

Structure Rating

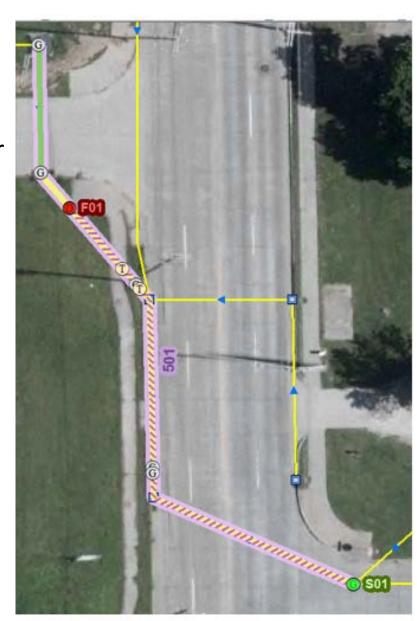
Field	Value
INLETTYPE	Curb Inlet
OMR_STRUCTURAL	18
OMR_OM	3
OMR_COMBINED	21
MRI_STRUCTURAL	4
MRI_OM	3
MRI_COMBINED	3.818182
QOR	4131

Analyzing Your Results

Subsurface Ratings

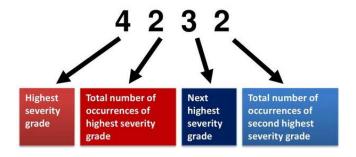
- Using linear referencing ...
 - Point defects plotted as **point** features
 - Continuous defects plotted as **line** features
- Defect scores summarized separately for each segment
 - Structural rating
 - O&M rating
 - Combined rating
- Provides **segment** rating

Field	Value
INSPECTION_ID	501
SURVEY_DIRECTION	Upstream
EPD_STRUCTURAL	0
EPD_OM	13.700187
EPD_COMBINED	13.700187
OPR_STRUCTURAL	0
OPR_OM	27
OPR_COMBINED	27
PRI_STRUCTURAL	0
PRI_OM	1.970776
PRI_COMBINED	1.970776
QOR_STRUCTURAL	0000
QOR_OM	2A00
QOR_COMBINED	2A00



Calculating Likelihood of Failure (LOF)

- Derived from the first 2 numbers of the Quick Rating
- Scale is 1 to 6, with 1 being the least likely, 6 the most



$$LoF = \frac{First 2 numbers of QOR}{10}$$

$$LoF = \frac{42}{10} = 4.2$$

Calculating Likelihood of Failure (LOF)

• If no defects recorded for feature or segment, then add 1.0

$$LoF = \frac{First 2 numbers of QOR}{10}$$

$$LoF = \frac{0}{10} + 1.0 = 1.0$$

Calculating Likelihood of Failure (LOF)

• If second character in the Quick Rating is a letter, than add 1.0 as well

$$LoF = \frac{First 2 numbers of QOR}{10} + 1.0$$

Example: QOR is 5B21 (meaning 15 to 19 occurrences of a Grade 5 defect); therefore:

$$LoF = \frac{50}{10} + 1.0 = 6.0$$

$$A = 10-14$$
, $B = 15-19$, $C = 20-24$, etc

Developing Consequence of Failure criteria

- Size
- Location (for example, crosses under major road)
- Depth (the deeper the pipe, the greater the cost of repair/replacement)
- Service Area
- Proximity to critical facilities
- Environmental impact
- Public Health impact
- Economic impact

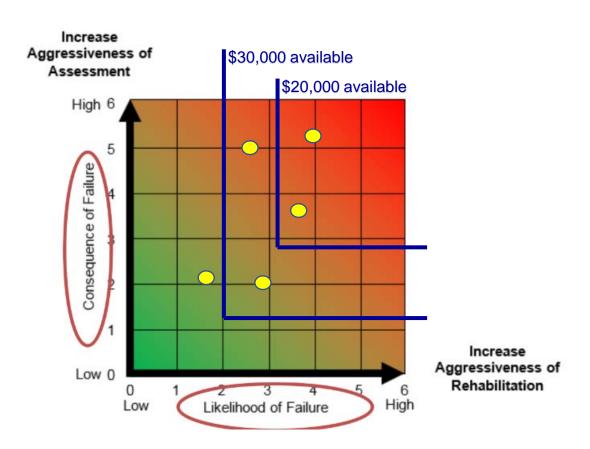
Asset owner involvement is essential!

Calculating Consequence of Failure (COF)

- For each of these criteria you would assign a COF factor rating
 - Scale is 1 to 6, with 1 being the least consequential, 6 the most
- You would then apply a weight to each criteria
- Finally, you would calculate the COF for each feature by multiplying the factor against the weight

Risk Assessment

- Likelihood of Failure (LOF) Determined by condition scores
- Consequence of Failure (COF) Determined by asset owner
- Risk = LOF x COF



Conclusion

- Assets can be managed proactively
- New technologies can augment traditional methods
- Good assessment methods + greater
 assessment frequency can help us better
 understand how assets deteriorate over time

QUESTIONS?

