

TECHNOLOGIES FOR ASSET MANAGEMENT OF COLLECTION SYSTEMS



ORWEF WATER ENVIRONMENT SCHOOL

3-29-17

Michelle Beason, PE Regional Manager National Plant Services, Inc., a Carylon Company

NATIONAL PLANT SERVICES, INC.

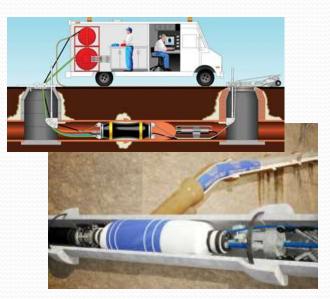
- New Service yard in Hayward, CA.
- Headquarters in Long Beach, CA, since 1981.
- The Carylon Corporation has been in business since 1949 and is comprised of 18 wholly-owned subsidiaries located in 33 locations throughout the United States.

CARYLON COMPANY LOCATIONS









CLEANING

- LARGE AND SMALL DIAMETER PIPE CLEANING
- ROOT REMOVAL
- WWTP CLEANING SERVICES

INSPECTION

- LATERAL AND MAINLINE CCTV INSPECTION
- MULTI-SENSOR
 INSPECTIONS
- MANHOLE INSPECTIONS



- LATERAL LINING
- CENTRIFUGALLY CAST STRUCTURAL COATINGS
- GROUTING
- CIPP POINT REPAIRS

PRESENTATION TOPICS: • WHAT IS ASSET MANAGEMENT? 14 STEPS TO CREATING A PLAN CLEANING TECHNOLOGY INNOVATIONS **RECYCLED WATER JET VAC TRUCKS** • INSPECTION TECHNOLOGIES ADVANCED INSPECTIONS USING LASER/SONAR **ROBOTS** SL RAT – SEWER LINE RAPID ASSESSMENT TOOL TRENCHLESS REPAIR SOLUTIONS GROUTING LATERAL LINING **CENTRIFUGALLY CAST CONCRETE COATING**

What is Asset Management?

What is "Asset Management"?

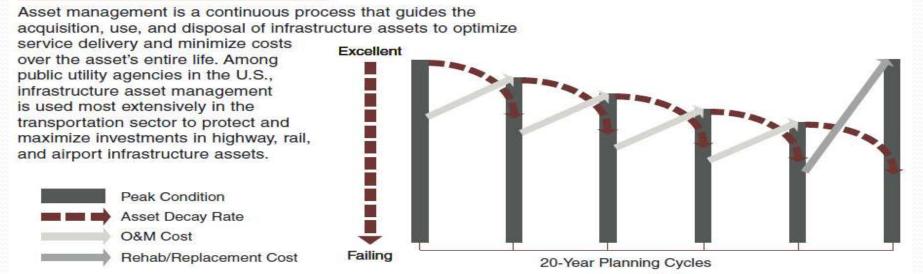
A <u>continuous</u> process that guides the acquisition, use, maintenance, and disposal of infrastructure assets to optimize level of service, at the lowest life cycle cost.

Level of service: providing reliable and efficient service to customers.

Lowest Life Cycle Cost: Lowest cost for repairing and/or rehabilitating an asset over the assets entire life.

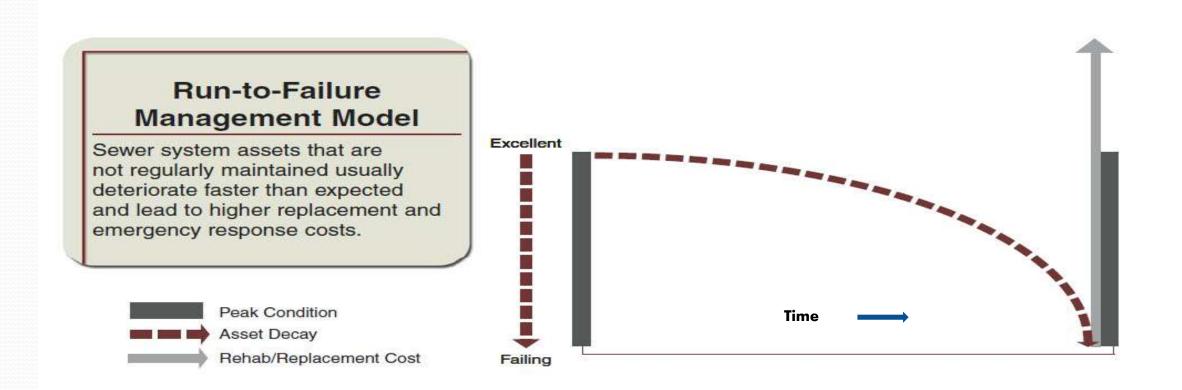
What is "Asset Management"?

What is asset management?



Reference: "SSO Fact Sheet – Asset Management for Sewer Collection Systems", USEPA, April 2002

Run to Failure Method



Copied From "SSO Fact Sheet – Asset Management for Sewer Collection Systems", USEPA, April 2002

Benefits of Asset Management

- Prolonging asset life and aiding in rehabilitation/repair/ replacement decisions
- Saving money by preventing unnecessary maintenance activities.
- Meeting service expectations and regulatory requirements.
- Reducing need for expansions and additions through demand management (I/I reduction, flow balancing, etc)
- Setting rates based on sound operational and financial planning.

The main goal of Asset Management is to MAXIMIZE Planned Maintenance and MINIMIZE Unplanned Maintenance.

DEVELOPING AND MAINTAINING AN ASSET MANAGEMENT PLAN

- 1. What are our Assets
- 2. Current State and Valuation of Assets
- 3. Service Activities on the Assets
- 4. Desired Level of Service
- 5. Performance goals/Indicators
- 6. Condition Assessment
- 7. Capacity Assurance Planning
- 8. Backbone and Critical Facilities Emergency Response
- 9. GIS Based Information system
- 10. Failure impact evaluation and risk management
- 11. Maintenance analysis and frequency planning
- 12. Rehabilitation and replacement Planning
- 13. Financial Management
- 14. Maintain and continuously improve your new AM system.

References

"Asset Management: A Best Practices Guide", US EPA, April 2008

"SSO Fact Sheet – Asset Management for Sewer Collection Systems", USEPA, Office of Wastewater Management, April 2002

"The O&M in CMOM: Operation & Maintenance", Water Environment Federation, O&M Version 2.3a

CLEANING TECHNOLOGY INNOVATIONS RECYCLED WATER JET VACS



Saves Water AND More Efficient

WHAT DO I CLEAN FIRST? HOW OFTEN?

- Establish a regular cleaning frequency depending on the age, material, use, condition of your assets.
- As you clean, record what you find and adjust frequency as needed.
- Have a "Hot Spot" list for those frequent problem areas
 - But then make a plan to FIX those problems!!!!!

RECycler 315 Recycling Jet Vac

- Continuously recycles the wastewater and reuses it to clean the sewer
- Can save over 10,000 gallons per day of drinking water
- 80 to 124 gpm jetting capacity
- Bypass pumping system on board
- Higher efficiency as crews don't have to stop and relocate to fill the water tanks throughout the day
- Automatic filter cleaning operations
- Remote control panel for ease of operation
- Made in Denmark



INSPECTION TECHNOLOGIES



Wastewater Inspection Tools

- CCTV Cameras
 - CCTV with Defect Coding
 - Pan Tilt Zoom, or 360



- Multi Sensor Inspection (MSI) Cameras
 - CCTV
 - Laser
 - Sonar



THE BASICS OF CCTV

- CCTV inspections should be done on a regular frequency to monitor pipe condition.
- It's important to code using a standardized system, either PACP, or your own unique system.
 - What is PACP (Pipeline Assessment and Certification Program)?
 - NASSCO (National Association of Sewer Service Companies) developed the Pipeline Assessment and Certification Program.
 - The objective: consistency between people observing pipe defects, and to be as detailed as possible.
 - Track changes in pipe condition over time
 - 2-day PACP certification class.

PACP – PIPELINE ASSESSMENT AND CERTIFICATION PROGRAM

- Guidelines established in 2002
- Standardized codes and ratings for inspection defects
- Training and certification of operators
- Certification of software vendors (IT Pipes, Wincan, GraniteXP, POSM, etc)
- Guidelines for mapping of data results
 - Structural defects (cracks, manufacture, etc)
 - O&M defects (roots, cleaning, etc)
 - Construction features (manholes, taps, laterals, etc)

PACP GRADES: 1-5

General Assignment of Pipe Condition Grades

- Grade 5 Collapsed or collapse imminent
- Grade 4 Collapse likely in foreseeable future
- Grade 3 Collapse unlikely in near future
- Grade 2 Minimal collapse risk
- Grade 1 Acceptable structural condition

Grade **O** An observation only (lateral, manhole, etc)

PACP Code Example 1

	CODE	
PACP	DESCRIPTIONS	
	Constructional	
BSV	Broken Soil Visible	
BVV	Broken Void Visible	
Н	Hole	
HSV	Hole Soil Visible	
HVV	Hole Void Visible	
D	Deformed	
DV	Deformed Vertically	
DH	Deformed Horizontally	
XP	Collapse	
	Joint Displaced	
JOM	Joint Displaced/Joint Offset Medium (1 to 1.5)	
JOL	Joint Displaced Large /Joint Offset Large (>1.5)	
	Open Joint	
JSM	Joint Open Medium	
JSL	Joint Open Large	
JAM	Joint Angular Medium	
JAL	Joint Angular Large	
SSS	Surface Spalling slight	
	Surface Spalling Medium	
	Surface Spalling Large	
SSSC	Surface Spalling Chemical	
SSSM	Surface Spalling Mechanical	
SSSZ	Surface Spalling Unknown	
SRI	Surface Wear Slight/Roughness Increased	
SRIC	Roughness Increased Chemical	
SRIM	Roughness Increased Mechanical	
SRIZ	Roughness Increased Unknown	
SAV	Surface Damage Aggregate Visible	
SAVC	Surface Damage Aggregate Visible Chemical	

PACP Code Example 2

	CODE
PACP	DESCRIPTIONS
	Constructional
SRV	Surface Wear Large/Aggregate is missing reinforcement visible
SRVC	Aggregate is missing reinforcement visible chemical
SRVM	Aggregate is missing reinforcement visible mechanical
SRVZ	Aggregate is missing reinforcement visible unknown
SRP	aggregate missing and reinforcement is projecting
SRPC	aggregate missing and reinforcement is projecting chemical
SRPM	aggregate missing and reinforcement is projecting mechanical
SRPZ	aggregate missing and reinforcement is unknown
SRC	Reinforcement Corroded
SRCC	Reinforcement Corroded Chemical
SRCM	Reinforcement Corroded Mechanical
SRCZ	Reinforcement Corroded Unknown
SMW	Missing Wall
SMWC	Missing Wall Chemical
SMWM	Missing Wall Mechanical
SMWZ	Missing Wall Unknown
SZ	Surface Damage Other
SZC	Surface Damage Other Chemical
SZM	Surface Damage Other Mechanical
SZZ	Surface Damage Other Unknown
SCP	Surface Damage Corrosion
	Lining Defect
LFD	Lining Detached
LFDE	Lining Defective End
LFB	Lining blistered
111	Lining discoloration
LFCS	Lining Service Cut shifted
LFAC	Lining Abandoned Connection
LFOC	Lining Overcut Service



Observed Cracks

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CCTV Inspection

	Line Segment V	Up Stream MH ♥	Dn Stream MH 🛛	PipeMaterial V	System Type V	PipeSizeHeight ♥	Line Length ♥	Structural Quick V	OM Quick 🛛
Ð	D11MH1734_D11MH	D11MH1734	D11MH2638	Vitrified Clay Pipe	PipeTech	8.00	481.00	5111	0000
± 1	D13MH481_D13MH4	D13MH481	D13MH482	Vitrified Clay Pipe	PipeTech	6.00	390.29	4123	3100
I I	D14MH1983_E14MH	D14MH1983	E14MH1982	Vitrified Clay Pipe	PipeTech	6.00	260.00	5131	4138
+ I	D14MH1984_E14MH	D14MH1984	E14MH1981	Vitrified Clay Pipe	PipeTech	6.00	300.00	3423	2718
· 1	D14MH1986_E14MH	D14MH1986	E14MH1977	Vitrified Clay Pipe	PipeTech	6.00	500.00	5231	4122
	D14MH2805_D14MH	D14MH2805	D14MH1987	Vitrified Clay Pipe	PipeTech	6.00	694.40	5231	4231
D	D14SF564_D14MH1	D14SF564	D14MH1985	Vitrified Clay Pipe	PipeTech	6.00	220.00	332E	1A00
⊕ 1	D7MH773_D7MH768	D7MH773	D7MH768	Vitrified Clay Pipe	PipeTech	12.00	245.90	2111	2Z13
	D8MH2700_D8MH26	D8MH2700	D8MH2656	Vitrified Clay Pipe	PipeTech	8.00	100.00	3100	2100
	E10MH947_E10MH9	E10MH947	E10MH948	Vitrified Clay Pipe	PipeTech	10.00	82.86	5111	0000
	E10MH949_E10MH9	E10MH949	E10MH951	Vitrified Clay Pipe	PipeTech	12.00	325.43	2100	0000
± 1	E10MH950_E10MH9	E10MH950	E10MH948	Vitrified Clay Pipe	PipeTech	10.00	181.67	2100	0000
E		E10SF592	E10MH944	Vitrified Clay Pipe	PipeTech	6.00	0.00	3100	5100
Đ		E10SF592	E10MH944	Vitrified Clay Pipe	PipeTech	6.00	36.70	2100	0000
	E10SF798_E10MH9	E10SF798	E10MH954	Vitrified Clay Pipe	PipeTech	6.00	179.38	2100	2700
⊕ 1	E11MH1568_E11MH	E11MH1568	E11MH1566	Vitrified Clay Pipe	PipeTech	10.00	244.00	1300	2100
	E11MH1573_E11MH	E11MH1573	E11MH408	Vitrified Clay Pipe	PipeTech	15.00	319.00	211C	3500
÷. 1	E12MH1875_E12MH	E12MH1875	E12MH2425	Vitrified Clay Pipe	PipeTech	6.00	85.51	3521	4100
œ T	E12MH2424_E12MH	E12MH2424	E12MH1875	Vitrified Clay Pipe	PipeTech	6.00	77.23	5231	2100
ŧ I	E12MH2425_D12MH	E12MH2425	D12MH311	Vitrified Clay Pipe	PipeTech	6.00	537.92	2111	0000
	E12MH2425_D12MH	E12MH2425	D12MH311	Vitrified Clay Pipe	PipeTech	6.00	537.92	3627	4132
	E12MH2426_E12MH	E12MH2426	E12MH1875	Vitrified Clay Pipe	PipeTech	8.00	170.95	1100	0000
	E12MH480 E13MH2	F12MH480	F13MH2236	Vitrified Clay Pine	PipeTech	6.00	232 71	3111	2100

Observed Cracks

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Line Segment V	Up Stream MH 🔽	Dn Stream MH 🛛	PipeMaterial V	System Type V	PipeSizeHeight V	Line Length 🛛	Structural Quick V	OM Quick
14SF564_D14MH1	D14SF564	D14MH1985	Vitrified Clay Pipe		6.00	220.00	332E	1A00
CCTV Observation	ns	· · · · ·	÷					
AcuteDefect V	R3Category 🗸	Score 🛛	DefectType 🛛	CodeCategory V	SubCategory 🛛	Description V	Distance / 🗸	Remarks
NO	No Action		AMH	Configuration	Structure	Manhole	0.00	START OF IN
NO	No Action		MWL.	Inspection	Water Level	Water Level	0.00	
NO	No Action	1	TFA	Configuration	Side Sewer Locatio	Tap Factory Activ	8.40	
NO	No Action		TFA	Configuration	Side Sewer Locatio	Tap Factory Activ	9.60	2
NO	No Action		SSS	Structural	Pipe Deterioration	Surface Spalling	13.30	
NO	No Action		SSS	Structural	Pipe Deterioration	Surface Spalling	18.00	5
NO	No Action		RFJ	Operational	Roots	Roots Fine Joint	21.10	
NO	No Action		RFJ	Operational	Roots	Roots Fine Joint	25.20	
NO	No Action		TFC	Configuration	Side Sewer Locatio	Tap Factory Capp	46.60	e
NO	No Action		TFC	Configuration	Side Sewer Locatio	Tap Factory Capp	48.30	-
NO	No Action		СМ	Structural	Crack	Crack Multiple	49.30	
NO	No Action		CC	Structural	Crack	Crack Circumfere	55.70	-
NO	No Action		CL	Structural	Crack	Crack Longitudina	70.10	-
NO	No Action		TFC	Configuration	Side Sewer Locatio	Tap Factory Capp	71.20	0
NO	No Action		TFC	Configuration	Side Sewer Locatio	Tap Factory Capp	73.30	
NO	No Action		RFJ	Operational	Roots	Roots Fine Joint	77.30	-
NO	No Action		TFC	Configuration	Side Sewer Locatio	Tap Factory Capp	95.60	c
NO	No Action		TFC	Configuration	Side Sewer Locatio	Tap Factory Capp	97.60	-
NO	No Action		LR	Structural	Alignment	Alignment Right	111.00	
NO	No Action		TBA	Configuration	Side Sewer Locatio	Tap Break-in Acti	114.70	- -
NO	No Action		TFC	Configuration	Side Sewer Locatio	Tap Factory Capp	120.60	
NO	No Action		TEC	Configuration	Cido Couver Leastia	Tan Eastan, Cana	100.40	

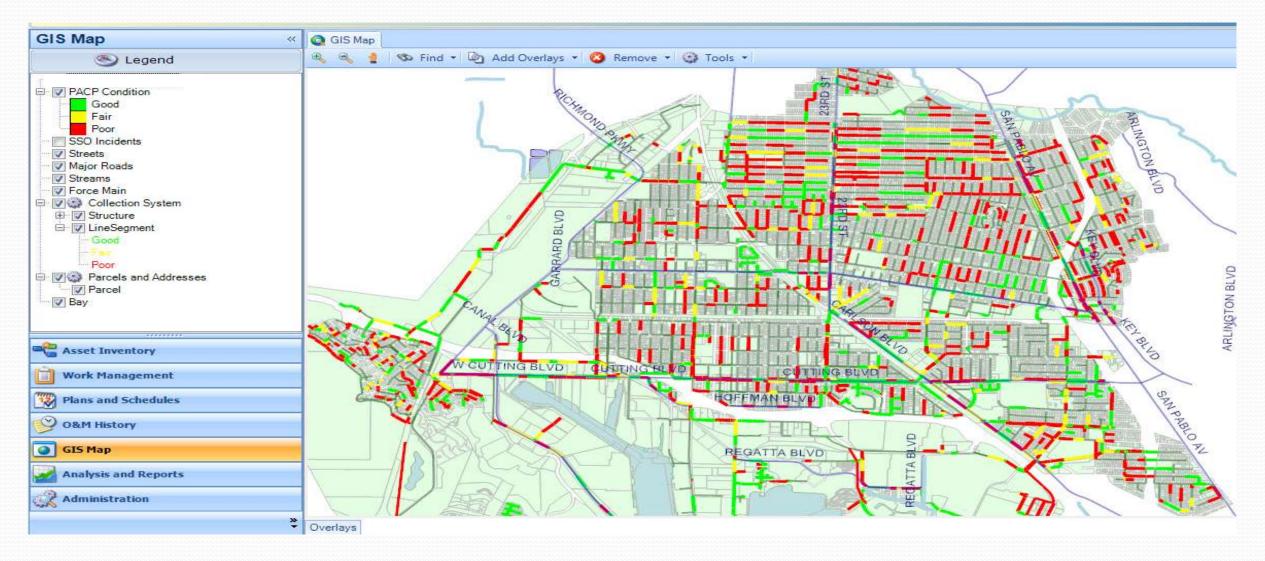
Starting	access point:	Easting:		North	hg:		Elevation:		Coordinate sy	æm:	GPS accura	cy:
Grade	Amount of Structural Defects	Structural Structural Segment Grade	Structural Pipe	Structural Quick Rating	Structural Pipe Rating Index	Amount of O&M Defects	O&M Segment Grade	O&M O&M Pipe Rating	O&M Quick Rating	O&M Pipe Rating Index		rall Pipe Overall Pipe Rating Index
1	0	0				0	0					
2	148	296				0	0]				
3	173	519	845	563Z	2.584098	0	0	4	4100	4	849	2.588415
4	0	0				1	4	1				
5	6	30				0	0					

National Plant Services Inc. 1461 Harbor Ave Long Beach, CA 90813-2741 Phone: 562-436-7600 Fax: 562-495-1528

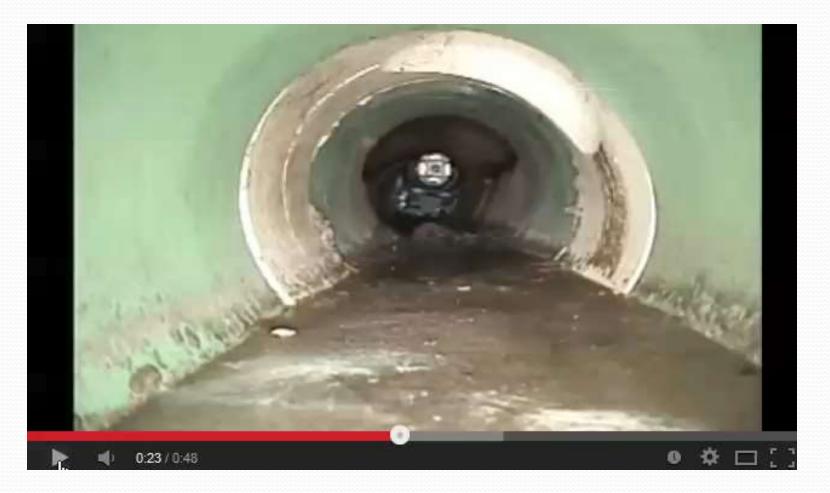


Surveyed by:	Owner:	Start date/time:	Upstream manhole No:	Pipeline segment ref:	Sheet number:
MORENO NPS		2016/11/02	N21-MH0036A	N21-MH0036A_N21-MH	
				0035A	

Distance (Feet) (Meters)	Video Ref.	Group/ Modifier/ Descriptor Severity	Continuous Defect	S/M/L	V Inches	alue (mm)	%	Joint	Circumferential Location		Image Ref.	Family	Rating	Remarks
					1st	2nd			At/From	to				
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0.0	25	MWL					5							
0.0	32	MWM					50					O&M	4	
0.0	88	SAV	S01					J	12	12	SACRAMENTO REGIONAL-N21- MH0036A-N21- MH0035A SAV at 0.0 ft (D).jpg	S	3	
0.0	127	SSS	S02						10	2	SACRAMENTO REGIONAL-N21- MH0036A-N21- MH0035A SSS at 0.0 ft (D).jpg	S	2	
764.3	1460	SAV	F01					J	12	12	SACRAMENTO REGIONAL-N21- MH0036A-N21- MH0035A SAV at 764.3 ft (D).jpg	S	3	
764.3	1475	SSS	F02					J	10	2	SACRAMENTO REGIONAL-N21- MH0036A-N21- MH0035A SSS at 764.3 ft (D).jpg	S	2	
764.3	1505	АМН									SACRAMENTO REGIONAL-N21- MH0036A-N21- MH0035A AMH at 764.3 ft (D).jpg			N21-MH0035A



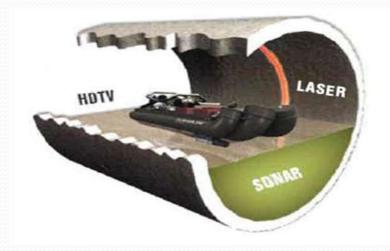
LATERAL LAUNCH CAMERAS



MULTI-SENSOR INSPECTIONS: Why Laser and Sonar?

• LASER

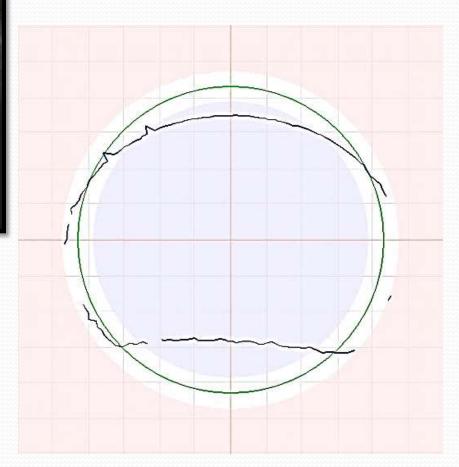
- Measure Ovality
- Measure Corrosion
- Measure large defects/cracks
- Help design rehab projects size of lining needed, etc
- SONAR
 - Prioritize and Direct Cleaning
 - Determine large defects in the pipe under water



Example of Findings: Ovality



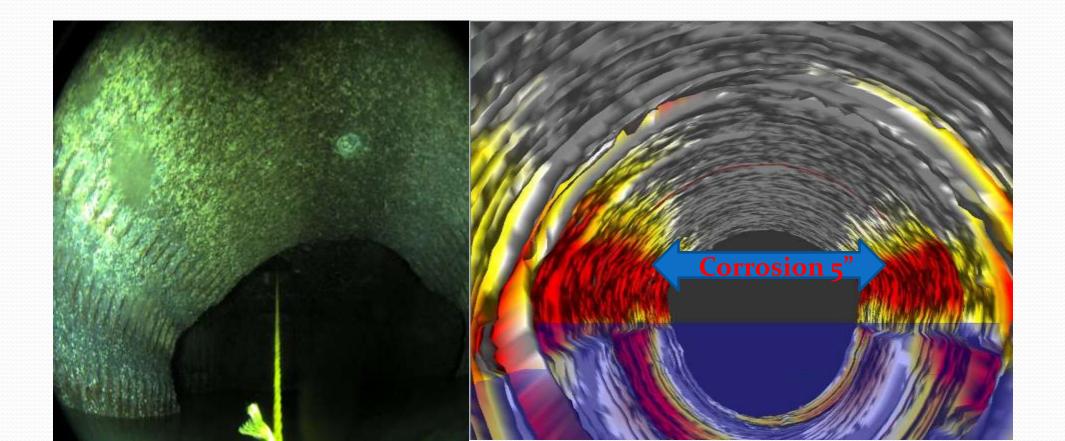
Observed Maximum Ovality: 21.2%



Example of Findings: Corrosion

Conventional CCTV

Laser Profiling



CORROSION IN CONCRETE PIPES



H₂S GAS IS PRODUCED BY THE SLIME LAYER UNDER THE WATER LINE. IT IS THEN OXIDIZED TO SULFURIC ACID BY THIOBACILLUS BACTERIA LIVING ON THE NON-SUBMERGED SURFACES, WHICH THEN 'EATS' THE CONCRETE, EXPOSING THE REBAR REINFORCEMENT, AND CAN LEAD TO COLLAPSE OF THE PIPE.

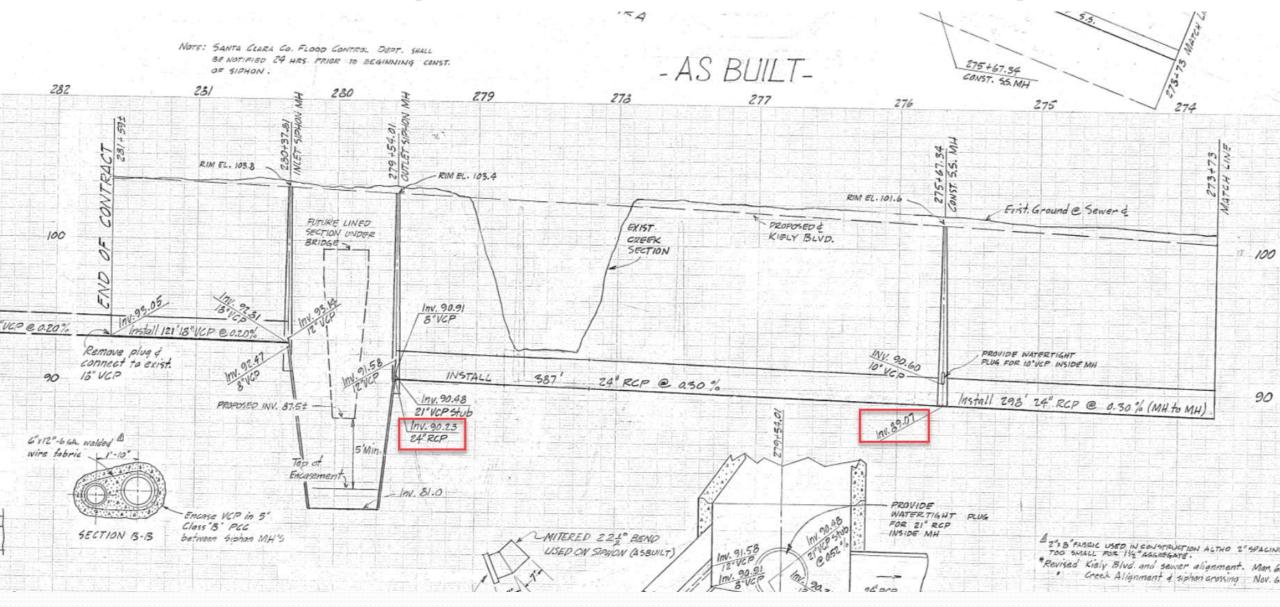
A Note about Hydrogen Sulfide (H2S) Gas

Flows greater than 2 fps will greatly reduce this. New sewers should be designed to take into consideration these necessary flows.

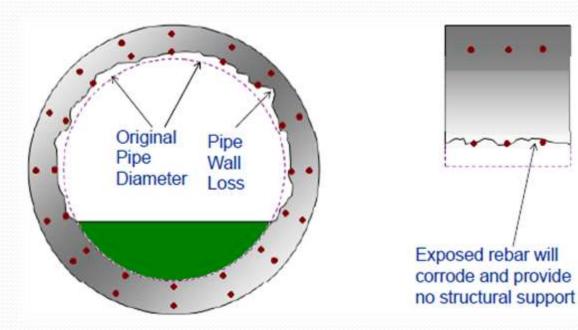
For older sewers without the necessary velocity, monitoring and routing flushing of the pipes can help reduce the amount of H₂S gas.

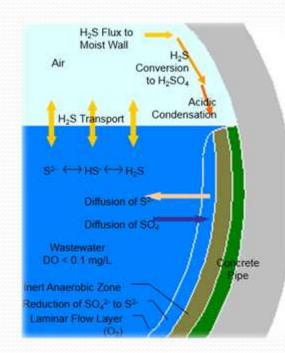
Purchase an aeration system that adds oxygen and changes the chemistry of H₂S Gas into harmless sulfates.

Fall: 90.23' - 89.07' = 1.16 feet elevation difference Distance between MHs = 380 feet So, slope is 1.16 feet of fall/380 feet of run = 0.003 x 100 = 0.3% slope



What Happens with Large Wastewater Pipelines: A Quick Primer on Corrosion (example of RCP)





TECHNOLOGY PHOTOS	NAME	PURPOSE	MIN SIZE (INCH)	MAX SIZE (INCH)	DEPLOY LENGTH (LF)	CCTV	HD CCTV	LASER	SONA
	Pole Camera	Pole mounted zoom cameras make it quick and easy to inspect pipes from the topside of a manhole	6"	120"	From Manhole opening only	x			
CUES OEN OWNERL ZOOM CAMERA	Conventional CCTV Cameras	We have a large fleet of CCTV cameras including CUES, Envirosight, and Aries that fit on multiple small and large powered tractor platforms	2"	120"	2,000	×			
CCTV-SONAR	National Plant Services TV/Sonar/Laser Float	Float that is configurable with live CCTV cameras, sonar, laser sensors	21"	240"	2,000	×		x	×
	Carylon Collapsible TV/Sonar Float	Collapsible float that is configurable with live CCTV cameras, sonar, laser sensors	21"	240"	2,000	x		×	×
E	LIDAR Scanners/3D Laser	Highly accurate LIDAR laser scanners that can be mounted to tractor or float, and used in conjunction with CCTV and sonar. Used to determine corrosion and ovality changes.	30"	35'	2,000		9	x	6
Ce I	Diode Laser Profiler	CCTV camera and laser head in one. Creates a profile of the interior diameter to determine corrosion and ovality of pipelines. Tractor and Floating platform.	6"	54"	2,000	x		x	
いいで	Fly Eye MSI Float (Small)	Sonar, Ring Laser, and "fish eye" HDCCTV Assessment in pipelines - Autonomous/ Battery Operated	18*	33"	4,200		x	x	x
	Fly Eye MSi Float (Large)	Sonar, Ring Laser, and "fish eye" HDCCTV Assessment in pipelines - Autonomous/ Battery Operated	36"	118"	6,000		x	x	x
	Sonar Submarine	Sonar of siphons, and full or partially full pipelines - Autonomous/Battery Operated	16*	118"	6,000				x
	Sonar	Live Feed Sonar used to inspect siphons or pipelines. This is the same sonar that is used on the Carylon Collapsible Float.	8"	30'	2,000				×
Alles.	Laser Skid	Laser Profiling in dry to partially full pipelines - used with conventional CCTV Camera	12"	48"	2,500				

Types of Lasers

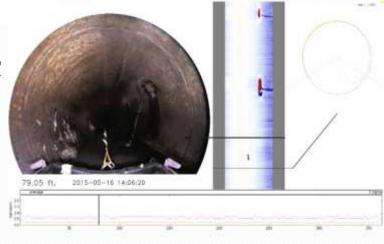
- 3D Laser data in xyz planes
- 2D Laser data in xy planes
- Ring Laser ring of light projected inside pipe, measured with camera
- Diode Laser two very accurate point lasers that spin to create a spiral scan

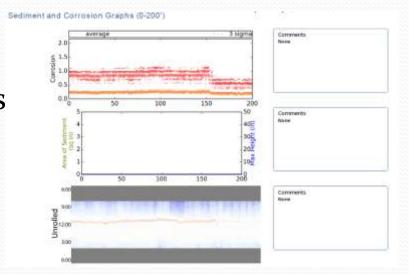
3D Laser

- Several hundred thousand measurements in every direction (X,Y,Z) as the platform moves throughout the pipe.
- Measures corrosion levels, ovality, deflection, and large defects.
- Accuracy from 1/16" to $\frac{1}{4}$ "



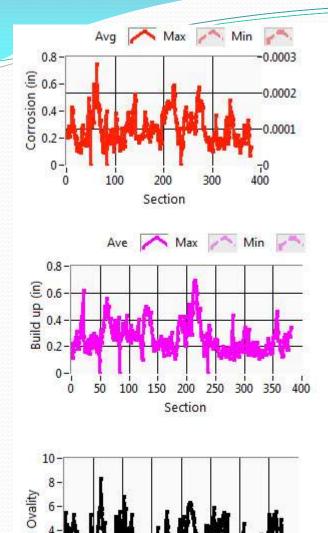












300 350 400

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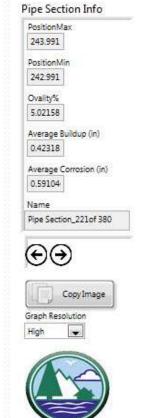
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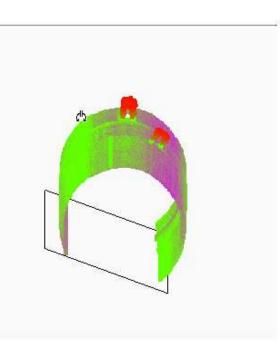
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100 150

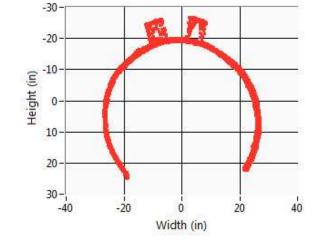
200 250

Section

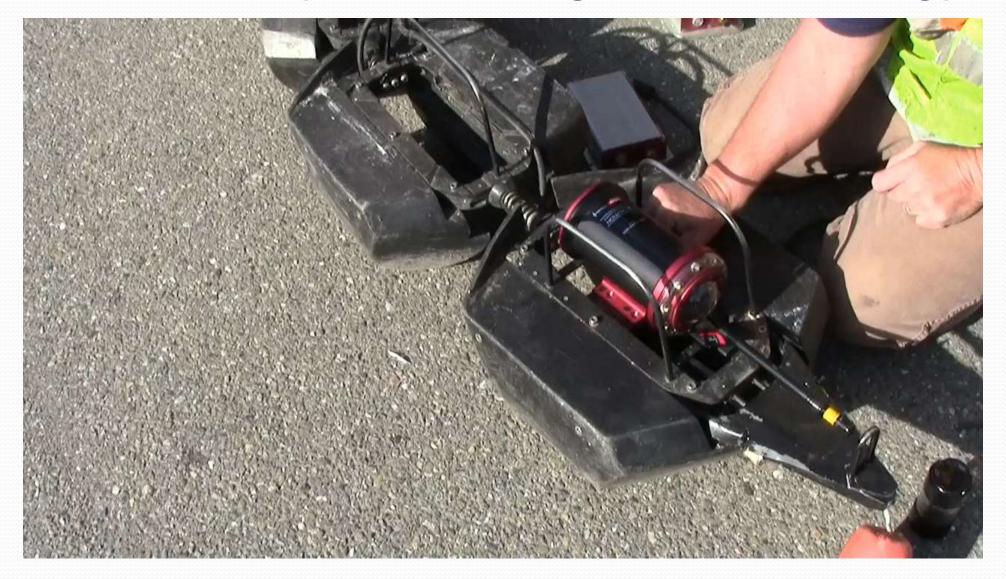








Field Deployment of Ring Laser Technology



When to Crawl...When to Float

- Level and velocity of flow;
- Restrictions or options available for flow control;
- Diameter or dimensions of the conveyance asset;
- Access to the pipeline;
- Available head space during high and low flow conditions;
- Anticipated debris that will remain in the pipeline during inspection;
- Depth of asset.

Centralized Data Viewer

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Acart								PROFILER	
Pipe Segment Reference	U17D1-1_U17A3-2		Iron Horse Trail		01701-1_0	17A3-2		1	
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r Rinc to Invert wher			- All				Service States	Second State	
p Rim to Invert wher p Grade to Invert			U17D1-1	Downstream		U17A3-2	24in, Reinforced Co	Second State	
s Rom to Inwert Amer 5 Grade to Inwert 5 Rom to Grade	U17A3-2		U17D1-1 3 June 2014	Downstream		U17A3-2 16:18:20	Service States	Second State	
y Rom to Inwert wher o Grade to Inwert o Rom to Grade 5 Manthole			3 June 2014				24in, Reinforced Co	Second State	
r Rim to Invent wher I Grade to Invent I Manhole Sen To Grade			3 June 2014				24in, Reinforced Co	Second State	
Rm to lowert oner Grade to lowert Rm to Grade Marituile sen Rm to invert ont Grade to Invert							24in, Reinforced Co	Second State	
Rim to Invert Grade to Invert Am to Grade Maritolie een Rim to Grade on Grade to Invert een Rim to Grade		and the other distances in the other distance	3 June 2014			16:18:20	24in, Reinforced Co 0.68ft ade: Remarks	Second State	
Rim to Invert ner Grade to Invert Rim to Grade Mantheire en Rim La Invert en Grade to Invert en Rim to Grade tenal	U17A3-2	and the other distances in the other distance	3 June 2014			16:18:20	24in, Reinforced Co 0.68ft	increte Pipe	
Rim to Invert mer Grade to Invert Am to Grade Mantaine wer Rim to Grade tersal tersal tersal	U17A3-2 Reinforced Concrete Pipe Cricular	Distan 0	3 June 2014		Joint Clock 1	16:18:20 Clock 2 Gr 0 0 0 0	24in, Reinforced Co 0.68tt ade: Remarks USMH U17D1-1	increte Pipe	
Rim to Invert refer Grade to Invert Rim to Grade Manhaire win Rim to Invert win Rim to Grade tend tend tend tend tend	U17A3-2 Reinforced Concrete Pipe Circular 24	Distan 0 0 0,1	3 June 2014 00:00:06 00:00:06 Access Point Manhole Water Level Laser/Sonar Debris			16:18:20 Clock 2 Gr 0 0 0 0	24in, Reinforced Co 0,68tt ade Remarks USMH U17D1-1 Debris to 3.3*	increte Pipe	
Ren to lowert oner Grade to lowert Machine sen Ren to Grade sen Ren to Grade to Sade to Insert sen Ren to Grade terse app to to the sen terse terse terse	U17A3-2 Reinforced Concrete Pipe Cricular	Distan 0	3 June 2014		Joint Clock 1	16:18:20 Clock 2 Gr 0 0 0 0	24in, Reinforced Co 0.68tt ade: Remarks USMH U17D1-1	increte Pipe	
Rim to Invert mer Grade to Invert Martine sen Rim to Invert sen Rim to Invert sen Rim to Grade tersel see ight im se loet Longth	U17A3-2 Reinforced Concrete Pipe Circular 24	Distan 0 0 0.1	3 June 2014		Joint Clock 1	16:18:20 Clock 2 Gr 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	24in, Reinforced Co 0.68ft uSMH U17D1-1 Debris to 3.3" Debris to 3.3" Debris to 3.3" Debris to 3.3" Debris to 3.3"	increte Pipe	
P Rim to Invert wher o Grade to Invert o Rim to Grade i Manhime som Rim to Grade som Rim to Grade own Rim to Grade ater ater age age age age to for Longth mag Method	U17A3-2 Reinforced Concrete Pipe Circular 24	Distan 0 0.1 0.1 4.5 49.9 100	June 2014 Oc.00:06 Access Foint Manhole Water Level Liser/Sonar Debris Laser/Sonar Debris Liser/Sonar Debris Liser/Sonar Debris Liser/Sonar Debris Liser/Sonar Debris Liser/Sonar Debris	Value 1 Value 2	Joint Clock 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	16:18:20 Clock 2 Gr 0 0 0 0 0 0 0 0 0 0 0	24in, Reinforced Co 0.68tt ade Remarks USMH U17D1-1 Debris to 3.3" Debris to 3.3" Debris to 3.3" Debris to 6.3" Debris to 6.6" General Observation	increte Pipe	
Rem to invert oner Crade to invert Rem to Grade Manhaie sen Rem to Grade to m Grade to Invert sen Rem to Grade therei see age night tim se Joert Longth may Method	U17A3-2 Reinforced Concrete Pipe Circular 24	Distan 0 0.1 0.1 4.5 49.9 100 350.1	June 2014 Oc.00:06 Access Fourt Manhole Wate: Level Liser/Sonar Debris Liser/Sonar Debris Liser/Sonar Debris Liser/Sonar Debris Liser/Sonar General Observation Liser/Sonar General Observation	Value 1 Value 2	Joint Clock 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Clock 2 G 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	24in, Reinforced Co 0,68tt ade Remarks USMH U17D1-1 Debris to 3.3" Debris to 3.3"	increte Pipe	
potream MH gr Rim to Invert writer gr Cirade to Invert gr Cirade to Invert gr Cirade to Invert com Rim to Grade com Rim to Grade tourn Grade to Invert com Rim to Grade tateral tater seght Auto per Loser Longth ming Method write Category Inspection	U17A3-2 Reinforced Concrete Pipe Circular 24	Distan 0 0.1 0.1 4.5 49.9 100	June 2014 Oc.00:06 Access Foint Manhole Water Level Liser/Sonar Debris Laser/Sonar Debris Liser/Sonar Debris Liser/Sonar Debris Liser/Sonar Debris Liser/Sonar Debris Liser/Sonar Debris	Value 1 Value 2	Joint Clock 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	16:18:20 Clock 2 Gr 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	24in, Reinforced Co 0.68tt ade Remarks USMH U17D1-1 Debris to 3.3" Debris to 3.3" Debris to 3.3" Debris to 6.3" Debris to 6.6" General Observation	increte Pipe	Wilume

Laser Diode

• Two precise lasers spin on the end of the camera head to create a spiral 3D image of the inside of the pipe with accuracy of 0.5% of pipe diameter

10

5

0

-5

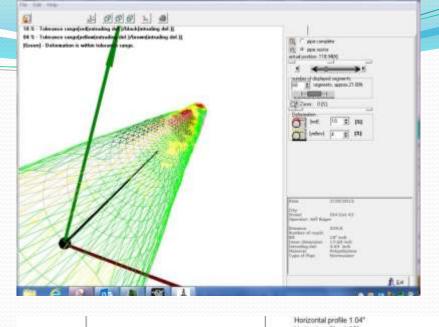
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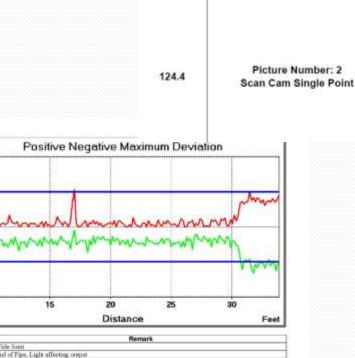
8

10

• Good for 6" to 54"

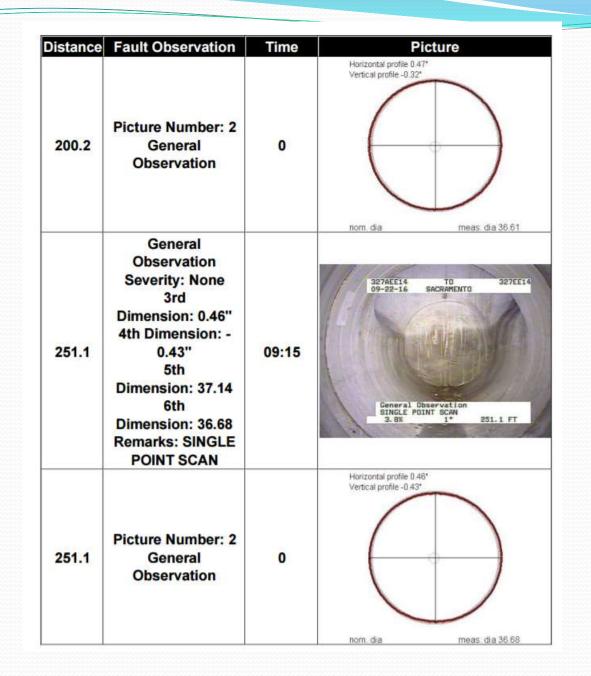






Created with the TPOSM report generator

Horizontal profile 1.04* Ventual profile -1.38*

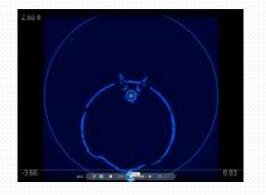


Sonar

- Continuous Acoustic scanning
- 360 degrees per second.
- Used to determine inside dimensions and changes in pipe shape and size, and to quantify the amount of debris in the pipe.
- Accuracy from ¹/₄" to ¹/₂"
- Inspects pipelines from 8" to 108" diameter.





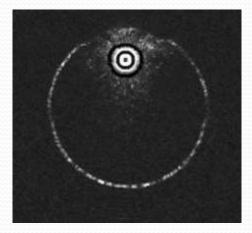


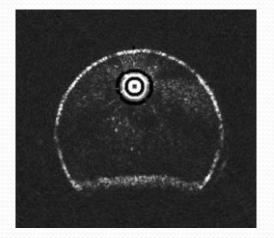


ACTUAL SONAR SCAN MPEG

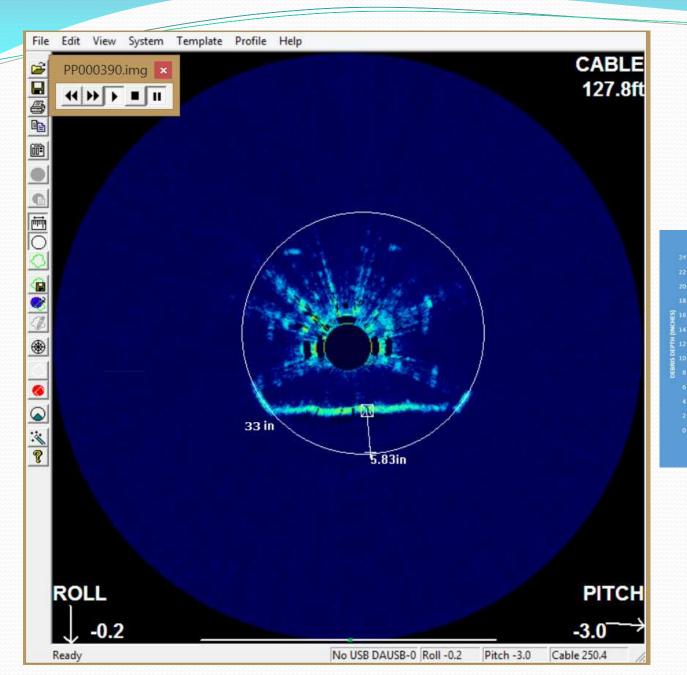
RELATIVELY CLEAN SIPHON

SIPHON WITH DEBRIS





We process this sonar data and provide debris quantities at each location. MPEG sonar movies are also provided for import into your asset management system.



SONAR PROCESSING



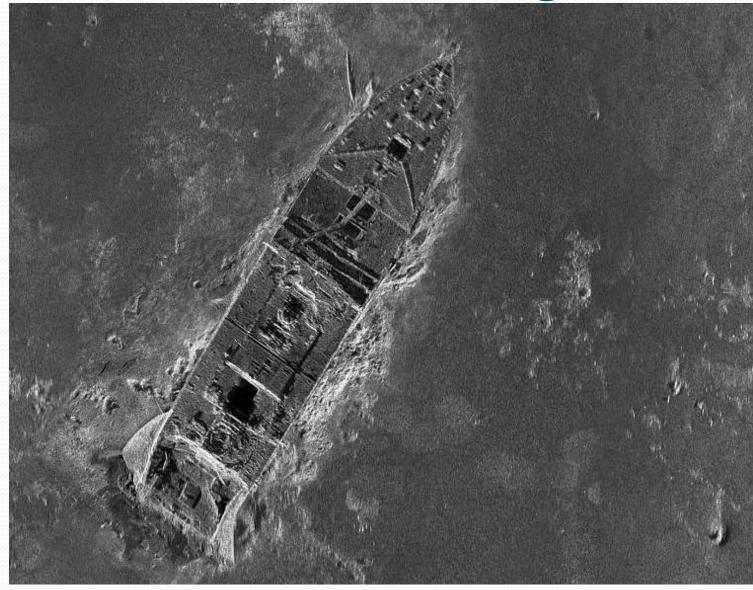
New Multi-Beam Sonar Technology

Dam Tubes Fly Over - BV5000 3D Scanner

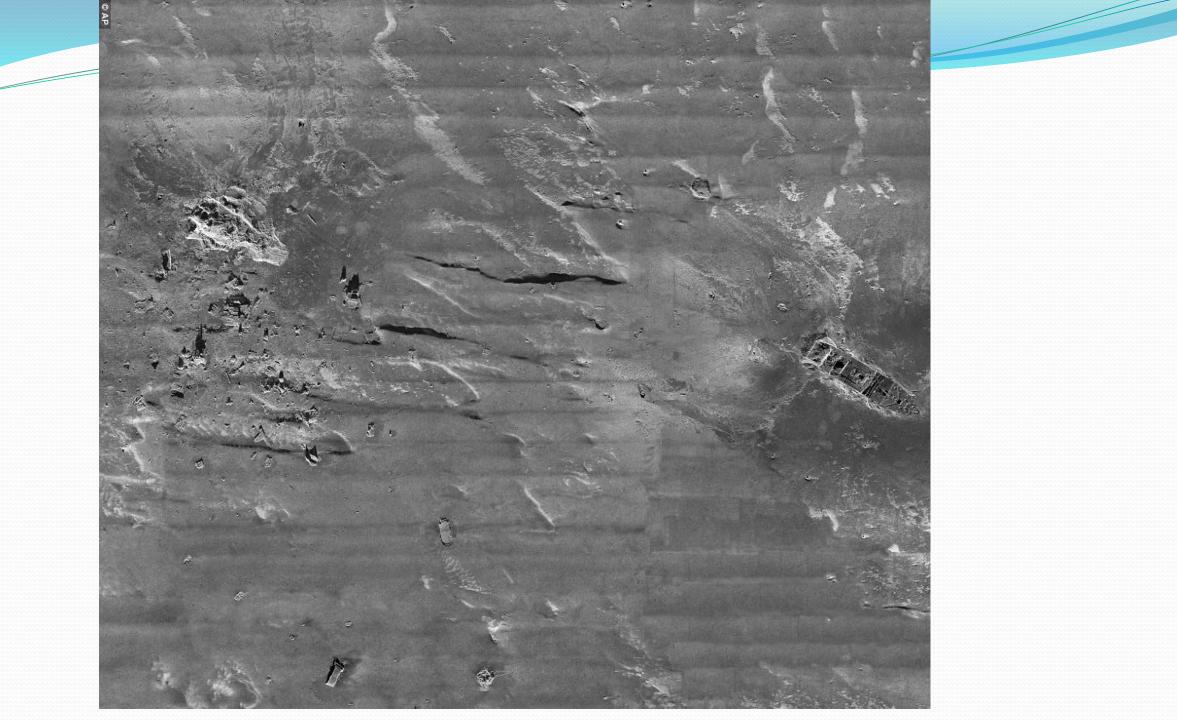




Titanic – New Sonar Images Reveal Much







So now what do we do with all this CCTV and Laser Data?

Implementing a Risk Based, Criticality Assessment Program

RISK =

Х

Probability of Failure

(Projected time between failures)

Consequence of Failure

(Dollar costs of failure)

Probability

How do we Estimate Probability of Failure?

- Assess pipe physical properties and in-situ conditions (system inventory)
 - Age
 - Material
 - Construction Methods
 - Depth of Cover
 - Traffic Loading
 - Soils Conditions
- Condition Assessment
 - Calculate Damage Severity Index (DSI) or PACP score
 - Project historical records of failure allowing for degradation
- Capacity Analysis -
 - Evaluate system for hydraulic inadequacies
- Engineering Analysis

Probability = In-Situ Factor x DSI or PACP Rating

AGE DOES NOT CORRELATE TO CONDITION Regular Inspections are Key!

Pipe Material	Pipeline Length (ft)	Pipe Diam (in)	Estimated Wall Tickness Installed (in)	CCTV Data	Laser Data	Sonar Data	PACP Quick Rating	Maximum Corrosion (in)	Install Year
RCP	384	45	4.5	<10%	No	No	4100	2.50	1940
RCP	277	42	4.5	50-75%	Yes	No	3Q00	2.24	1942
RCP	312	42	4.5	100%	Yes	No	3M25	2.16	1916
RCP	240	42	4.5	<10%	Yes	No	5136	2.12	1942
RCP	23	36	4.0	<10%	No	No	3100	2.00	1915
RCP	189	42	4.5	<10%	No	No	4131	2.00	1908
RCP	197	45	4.5	<10%	No	No	5100	2.00	1908
RCP	37	45	4.5	<10%	No	No	3300	2.00	1908
RCP	159	42	4.5	100%	Yes	No	4F3F	1.97	1923
RCP	567	42	4.5	100%	Yes	No	3Z00	1.93	1942
RCP	387	42	4.5	100%	Yes	No	3Z00	1.88	1942
RCP	77	36	4.0	100%	No	No	3B2B	1.80	1938
RCP	146	42	4.5	100%	Yes	No	4A2F	1.79	1923
RCP	130	42	4.5	100%	Yes	No	4D3D	1.79	1923
RCP	108	42	4.5	100%	Yes	No	3H00	1.78	1942
RCP	502	42	4.5	100%	Yes	No	3W2W	1.76	1942
RCP	139	42	4.5	100%	Yes	No	3E00	1.73	1942
RCP	296	45	4.5	100%	Yes	Yes	413J	1.70	1940
RCP	350	60	6.0	100%	Yes	Yes	2A1I	1.70	2000
RCP	230	42	4.5	100%	Yes	No	3T00	1.69	1942
RCP	436	42	4.5	100%	Yes	No	3T2S	1.69	1942
RCP	82	42	4.5	100%	Yes	No	413B	1.66	1923
RCP	189	45	4.5	100%	Yes	No	453Q	1.64	1908
RCP	398	42	4.5	100%	Yes	No	3S00	1.62	1942
RCP	168	42	4.5	100%	Yes	No	3021	1.61	1942
RCP	1498	42	4.5	75-100%	Yes	No	3Z00	1.60	1938
PVC	304	42	4.5	<10%	No	No	3400	1.60	1969
CMP	19	36	4.0	100%	Yes	No	5434	1.57	1978

						BRO	KEN, FR	ACTURES,	AND CRA	СКЅ											
NT_NUMBER	NT_USMAN	NT_DSMAN	_		Map Length	Cleaned?	Inspected	Street	STRUCTURAL QUICK SCORE	O&M QUICK SCORE	OVERALL PACP RATING	PACP 1	PACP 2	PACP 3	PACP 4	PACP 5	PACP 6	PACP 7	PACP 8	PACP 9	PACP 10
NTG_1692	U17D2-21	U17D2-20	8	VCP-Vitrified	157	Y	153,1	CHERRY HILLS	4100	0000	4	FM				3					
NTG_1181	T20D1-7	T20D1-6	8	VCP-Vitrified	77	Ŷ	82.4	SILVERGATE	5121	0000	3.5	MWLS @	В		2 3	6 8	-	5	1		
NTG_1014	U17A2-22	U17A2-21	8	VCP-Vitrified	303	Y	331,5	HAVEN	3100	DDDD	3	FS									
NTG_2252	T20D1-59	T20D1-60	and the second se	VCP-Vitrified	60.0	Y	191.5	Betlen	3121	3700	2.7	RPP	FS	JOM	MWLS	RMJ ©	1	2	3		-
NTG_2352	T19D1-19	T19D1-13		PVC	299.7303608	Y	286.9	Rolling Hills	3111	4100	2.7	JSM	8	IR	2 D	2 13		1 3			
NTG_2771	U20C1-21	U20C1-20	8	VCP-Vitrified	20	Y	21.4	Betlen	4122	0000	2.7	MWLS @	FM								
NTG_1182	T20D1-11	T20D1-7	8	VCP-Vitrified	66	Y	60.1	SILVERGATE	5131	3312	2.5	FL EL	RFJX 2	RMJ ©	MOL	6	2	1	3		
NTG_901	U16A1-14	U16A1-13	8	VCP-Vitrified	187	Y	174,4	LORETO	4100	2300	2.5	FM	DAE @			1. J.					
NTG_4717	U19A2-1	U19C6-20	8	VCP-Vitrified	217.0	Y	206.6	VOMAC	5135	4111	2.47	REJ	MWLS © X 3	В							
NTG_1051	T16D2-7	T16D2-6	6	VCP-Vitrified	244,9307394	Y	243.8	FOXCROFT	312C	5141	2.15	FS	MWLS @ X2	RMJ	RML	DAE O	IG	顶			
NTG_1016	T1761-17	T17B1-16	8	VCP-Vitrified	178.2769104	Y	140.6	Davona	3128	0000	2.1	MWLS @	FS .								
NTG_1707	U1862-38	U1862-37	8	VCP-Vitrified	226	Y	211.9	WINGED FOOT	3111	3128	2.1	FS	DAE @	JOM	155R	2					
NTG_2499	T19D2-33	T19D2-32	8	VCP-Vitrified	308.7914945	Y	301.9	PADRE	4100	2711	2.1	DAE @	FH2	RFJ	2 B	2 N		1	1		
NTG_4794	U19C3-22	U19C3-21	8	VCP-Vitrified	182	Y	170.4	LANDALE	3129	DDDD	2.1	MWLS @ X3	FS .								
NTG_663	T20D1-26	T20D1-25	8	VCP-Vitrified	131	Y	128.1	Betlen	3100	2 A00	2.1	P5	DAE	DAE @ X 2	\$ S	3		5			5
NTG_1080	U17B1-2	U1761-1	8	VCP-Vitrified	160	Y	157.1	THUNDERBIRD	312E	512E	2.06	FS	MWLS @	DAE @	DSF 🗇	IG		1 2	3		
NTG_1951	U16A1-13	U16A1-12	8	VCP-Vitrified	475	Y	489.3	LORETO	5134	2100	2.06	MWLS @ x 6	MOL	DAE ©	JSM	SCP @	MOL	8			
NTG_2457	U18A1-8	U18A1-7	8	VCP-Vitrified	346	Y	314,8	MADORÁ	3126	0000	2.05	MWLS @ X2	FS	1	9 - 2i	(i))		1 - P			-
NTG_2467	U18A1-29	U18A1-28	8	VCP-Vitrified	193	Y	207.0	CASSANDRA	412G	0000	2.05	MWLS@X3	FM			S. Same		1			
NTG_1096	U1761-12	U1761-11	8	VCP-Vitrified	355	Y	354,7	ALCOSTA	412A	3121	2.04	FM	DAE @	MWLS X 2	MWLS @ X 2	RMJ					
NTG_1687	U17D2-3	U17D2-2	8	VCP-Vitrified	325	Y	336.1	OLYMPIA FIELDS	3121	2F11	2	MWLS @ X3	DAEX 2	DAE 🛇	15	RFJ	FS				
NTG_1833	T1781-7	T1781-5	8	VCP-Vitrified	250.9329403	Y	256,1	TAREYTON	4121	0000	2	FC	MWLS @			-					
NTG_2887	U20C2-21	U20C2-20	8	VCP-Vitrified	128	Y	122.0	CIRCLE	085'1100	3126	2	ISSR	DAE	DAE Ø	CC	S 7	2	1 - U	3		2
NTG_4401	T1782-8	T1782-5	8	VCP-Vitrified	340.5391243	Y	344.3	KITTERY	21.00	2L00	2	DAE @	MWLS @	IW	FC	N		S			
NTG_4625	U17C3-12	U17C3-11	8	VCP-Vitrified	472	Y	449,2	BROADMOOR	2900	2.A00	2	FC	DAE @	MWLS @							
NTG_4627	U17C3-10	U17C3-9	8	VCP-Vitrified	350	Y	358,3	ALMOND	2600	0000	2	FC	MWL5 @ X 2	i i	8 8	8 S		1 (i)			
NTG_657	U17D1-23	U17D1-16	8	VCP-Vitrified	260	¥	259.4	PEBBLE	2200	2100	2	FC	DAE @	MWLS		3		1 1			
NTG_665	T20D1-33	T20D1-27	8	VCP-Vitrified	144	Y	141.8	Betlen	3100	2A11	2	FS	RFJ	DAE ©							
NTG_416	U20D1-35	U20D1-34	8	VCP-Vitrified	287	Y	372.2	REGIONAL	412M	1300	1.96	MWLS Ø	FM	RF1X3	JOM X 2	a ()		1			
NTG_632	U17C1-10	U17C1-9	8	VCP-Vitrified	215	Y	232.6	INVERNESS	3126	1200	1.95	FS	RF1X 2	MWLS @ X 2		1.	i - marca				
NTG_2461	U18A1-5	U18A1-4	8	VCP-Vitrified	368	Y	329.0	ERNWOOD	322D	3216	1.94	FS	MWLS @ X 4	RFJ	RFJ @	RMJ	RML	RFL	F5		
NTG_1773	U17C3-24	U17C3-23	8	VCP-Vitrified	69	Ŷ	82.2	ASHBY	312A	1200	1.93	MWLS @ X2	FS I	RFJX 2	9	0 B		1 5			
NTG_2465	U18A1-31	U18A1-28	8	VCP-Vitrified	227	Y	219,4	BROCKTON	312D	2114	1.9	FS	MWLS © X 5	RFJX3	DSF @	REND					
NTG_2398	U19C1-5	U19C1-4	8	VCP-Vitrified	251	Y	251.9	CORTO	3111	2511	1.875	REJ	FS .	MOL	DAE @	8			1		
NTG_4668	U19C3-12	U19C3-11	8	VCP-Vitrified	115	Y	112.2	OXBOW	3321	4136	1.8	FL .	RFJ	RFJ ©	MMC	SCP @	MWLS @	MOL	HEAVY STEAM	RBC	RMJ @
NTG_4523	U17C2-28	U17C2-25	8	VCP-Vitrified	368	Y	348.1	Sedgefield	3126	1600	1.33	RFJ @	RFLX 2	FS	MWLS © X 2						
NTG_1305	T19D2-34	T19D2-33	8	VCP-Vitrified	279.3580609	Y	284,1	PADRE	4100	3110	1.2	FM	RFJ X 2	RMJ	RFJ 🔘	8 8		1	1		
		1		TOTAL FOOT	AGE	2	8,726.40		1												
							3842 2357 Feb. C.														
-							<i>1</i> /2														

										SEGN	MENTS EX	HIBITING	INFILTRAT	ION								
and the second se	NT_USMAN	Statement and statement of the local division of the local divisio	NT_DIA		and the second design of the s	Cleaned?		Street	STRUCTURAL QUICK SCORE	O&M QUICK SCORE	RATING	PACP 1	PACP 2	PACP 3	PACP 4	PACP 5	PACP 6	PACP 7	PACP 8	PACP 9	PACP 10	PACP 11
NTG_2352	T1901-19	T19D1-13	8	PVC	299,7303608	Ŷ	286.9	Rolling Hills	3111	4100	2.7	JSM	В	IR			_					
NTG_119E	T16D4-17	T16D4-15	8	VCP-Vitrified	245,48965E	Y	187.5	MILLERIDGE	3025	4231	2,45	DAE O	MWLS © X 3	IW	IR X 2	DAE X 3	10					
NTG_1335 NTG_4367	U17C2-8 U16C1-8	U17C2-7 U16C1-7	8	VCP-Vitrified VCP-Vitrified	177 89	Y	215.6 57.5	BELLE MEADE KITTERY	4534 2600	4133 4131	2.22	MWLS/0 X 3	DAE © MWL5 ©	IS X4 DAE ©	IW ID	DAE	19					
NTG 1051	T16D2-7	T16D2-6	6	VCP-Vitrified	244.9307394	Y	243.8	FOXOROFT	312C	5141	2.15	FS	MWLS © X 2	RMI	RML	DAE	1G	IR				-
NTG 1910	U17A2-4	U17A2-3	8	VCP-Vitrified	269	Y	269.7	GOSHEN	2D00	4132	2.13	MWLS@X3	DAE X 2	IR	PIDVIL	UNCO	10	114	-		0 0	
NTG 783	U17C2-11	U17C2-10	8	VCP-Vit/fied	165	Y	154.6	BELLE MEADE	2D00	5142	2.11	MWLS@X2	DAE Ø	16	IRX2	JW	15					
NTG 638	U1701-8	U17D1-7	8	VCP-Vitrifled	132	Y	136.7	THUNDERB/RD	2D00	5121	2.1	IG	DAE	MWLSO								
NTG 183E	T16D2-1E	T16D2-17	6	VCP-VItrifled	227.0747149	Y	254.5	SHAW	0000	512C	2.1	IG	DAE @									
NTG 1697	U1702-5	U17D2-4	8	VCP-Vitrifled	117	Y	135.9	BRYN MAWR	0000	412B	2.1	DAE @	IR								1	
NTG_1831	T17B1-3	T17B1-2	10	VCP-Vitrified	309,8681379	Y	294.2	Davona	2100	4231	2.1	MWLS Ø	IRX2	DAE @					1			
NTG_1280	U16A1-6	U16A1-4	8	VCP-Vitrifled	248	Y	251.0	ENSENACIA	2600	422B	2.07	MWLS © x 2	MWL	一個	DSF @	S	2 D				1 - R	
NTG_1080	U1781-2	U1781-1	8	VCP-Vitrifled	160	Y	157.1	THUNDERBIRD	312E	512E	2,06	F5	MWLS (0	DAE (D	DSF @	IG						
NTG_1699	U1702-2	U17D2-1	8	VCP-Vitrifled	265	Y	251.6	OLYMPIA FIELDS	2600	422B	2,06	MWLS@X2	DSF @	1R	DAEX 2	DAE Ø					3 - 3	
NTG_510	T1782-5	T1782-4	8	VOP-Vitrifled	176,9907621	Ŷ	155.4	KITTERY	2D00	2600	2	IW	DAE	MWLSO	IW	8 B.					15	
NTG_1698	U1702-7	U17D2-6	8	VCP-Vitrified	139	Y	148,9	BOCA RATON	312A	2A00	2	CM	15 X 2	DAE @ X 3	MWLS @ X2	MWLS	7		1		1	Y
NTG_1681	U18B2-33	U1882-32	8	VOP-Vitrified	313	Y	308.5	FIRCREST	2000	312F	2	DAE	15	MWLS @ X 2	DAE C	OBZ			<u> </u>			(
NTG_1179	T2001-22	T20D1-21	В	VCP-Vitrifled	191	Y	193.7	DILLON	0000	2800	2	DAE	DAE @ X 2	-15								
NTG_119E	T16D4-17	T16D4-15	8	VCP-Vitrified	245,489658	Y	63.3	MILLBRIDGE	2500	312A	2	DAE O	15	MWLSIC	IW	ID	MSA	-	2		1 11	
NTG_1190	T1602-11	T16D2-10	8	VOP-Vitrified	193.95965	Y	178.2	BIDDLEFORD	2800	25.00	2	DAE Ø	15	MWLS @ X 3								
NTG_3536	U19C2-13	U19C2-12	8	VCP-Vitrified	250	Y	227.9	ST RAYMOND	0000	2800	2	DAE Ø	15						-		2 2	
NTG_1201	T16D4-1E	T16D4-17	6	VCP-Vit/fled	278.2744157	Y	261,2	LUDLOW	1100	512	2	DAE ©	IW	IOM	16		-	-				
NTG_2401	U19C1-2	U19C1-1	8	VCP-Vitrified	266	Y	120.5	PEPPERTREE	0000	3120	2	DAE O	IW	MSA		-	-	-				
NTG_1826	T16D2-14	T16D2-13	6	VCP-Vitrified	171.1554211	Ŷ	177.1	BIDDLEFORD	2D00	2F00	2	DAE ©	IW	MWLS ©		<u> </u>	<u> </u>					
NTG_4377 NTG 1176	T16D3-6 T20D1-19	T16D3-2 T20D1-18	15	VCP-Vitrified VCP-Vitrified	306.2150345	Y	288.5	BERNARD TINA	312F 0000	2500	2	DAE O	IW	MWL5 ©		<u> </u>	-			<u> </u>		
NTG 4844	U19C1-20	U19C1-19	8	VCP-Vitrified	354	Ŷ	141,B 352.7	SERRA	2800	3121	2	DAE ©	ID	MWLS O		<u> </u>	-	-				
NTG 4611	U19C2-36	U19C2-35	6	VCP-Vitrified	236	Y	230.1	CALLE VERDE	2000	5124	2	DAE ©	IG	MWLSO		-	-					
NTG 1839	T16D2-20	T16D2-19	8	VCP-Vitrified	243.3831974	Y	207.2	MENNET	2800	4221	2	DAE ©	IR	DAE	MWLS @ X 3	DSF @ X 2	IW				-	
NTG 1192	T16D2-13	T16D2-11	8	VCP-Vitrified	185,8646925	Y	188.5	BIDDLEFORD	2800	412F	2	DAE Ø	18	MWLS @	INTER STR	Dar with						
NTG 1053	716D1-5	T16D1-4	6	VCP-Vitrifled	257.6567395	Ŷ	265.2	SCARBORO	0000	2100	2	DAE @	15 X 2									
NTG_1083	U17D1-10	U17D1-9	8	VCP-Vitrifled	166	Y	165.0	COLONIAL	2400	2E00	2	DAE Ø	MWLS X2	IW	MWLS @		-		-			
NTG_1050	T16D2-E	T16D2-6	8	VCP-Vitrifled	260.638893	Y	260.0	BIDDLEFORD	2100	2100	2	DAE ©	MWLS Ø	15	IW							
NTG_1189	T16D2-10	T16D2-8	8	VCP-Vitrifled	278.8369727	Y	283.9	BIDDLEFORD	2100	4121	2	DAE ©	MWLS O	15	1R				1		S - 5	
NTG_4842	U19C1-22	U19C1-21	8	VCP-Vitrifled	340	Y	342,2	REGIO	2K 00	2100	2	DAE ©	MWLS Ø	IS		1	0		1		S - 3	
NTG_4401	71782-8	T17B2-5	8	VOP-Vitrified	340.5391243	Ŷ	344,3	KITTERY	21.00	21.00	2	DAE @	MWLSO	IW	FC	8 1	2				1	
NTG_2399	U19C1-4	U19C1-2	8	VCP-Vitrified	249	Y	230.6	PEPPERTREE	2200	412H	2	DAE Ø	MWLS@	IR			1		1 7			
NTG_1199	T16D4-20	T16D4-17	8	VOP-Vitrified	259,7450805	Y	251.6	MILLERIDGE	2600	4121	2	DAE ®	MWLS ©	15 X 3	IW X 3	18	2	1			8 - B	S
NTG_2489	U16C2-6	U16C2-5	10	VCP-Vit/fied	182	Y	163.4	MANGOS	2D00	412G	2	DAE @	MWLS @ X 2	DSF	DSF (D	1R	DAE					
NTG_439E	T16D2-17	T16D2-15	8	VOP-Vitrified	256,8979537	Y	224,6	SHAW	2000	422G	2	DAE ©	MWLS © X 2	LR.	DAE		4				8 <u>9</u>	
NTG_1045	T16D2-5	T16D2-3	8	VCP-Vit/fied	196.2142597	Y	190.7	BIDDLEFORD	2E00	422F	2	DAE ©	MWLS © X 2	IR X 2								
NTG_133E	U17C2-9	U17C2-8	8	VCP-Vitrified	416	Y	361.0	BELLE MEADE	2K00	2M00	2	DAE ©	MWLS @X3	15	IW		1				5 <u>5</u>	
NTG_1054	And in case of the local data in the local data	and the second se		the state of the s	226,6928933	Y	the second se	MILLBRIDGE	2600	2100	2	DAE ©	MWLS @ X 3	IWX2	15	IW O						
NTG_2450	and the local division of the local division	U1881-28	-	VCP-Vitrified	389	Y	and the second second	SANDPOINT	2300	2800	2	DAE X 2	DAE ©	15	MWL5 ©	MWI,S	-				-	
NTG_1703	U18B2-43	U18B2-41	8	VCP-Vitrified	145	Y	139.0	WINGED FOOT	2D00	2000	2	DAE X 2	ISX2	MWL5 ©	DAE O	045.5	1011	-				
NTG 131E	and the second	U18B2-36	8	VCP-Vitrified	211	Y	196.3	WINGED FOOT	2F11	322C	2	ISSR IRFA	DAE O	1D	DAE	DAE @	10M					
NTG_4843	U19C1-21	U19C1-19	8	VCP-Vitrified VCP-Vitrified	269	Y	273.6	PEPPERTREE	2311	3321	2	JSM MWLS ©	DAE ©	ID ©	MWL5 @	DSF ©	-					
NTG_4841 NTG_1086	U19C1-24 U17D2-16	U19C1-21 U17D2-15	8	VCP-Vitrified	242	Ŷ	243.8 168.9	PEPPERTREE OLYMPIA FIELDS	3321 2E00	2F00 412E	2	MWLS @	DAE ©	IW IR		-					-	
NTG_1086	NAME AND ADDRESS OF TAXABLE PARTY.	U1882-31	8	VCP-Vitrified	311	Ŷ	335.6	FIRCREST	2200	412E 322F	2	MWLS Ø MWLS Ø	DAE © X 2	18 1D	iw	DAE	-					
NTG_1322	successive statements and statements	U17D2-13	8	VCP-Vitrified		Y	191.9	OLYMPIA FIELDS	2200	3129	2	MWLS © X 2	IW IV	DAE Ø	DSF @	RMU	-					
NTG_1322 NTG_1202	and the second se	T16D4-18	6	of the local division of the local divisiono	249,4566229	Y	257.5	LUDLOW	22600	25:00	2	MWLS © X 2	DAE Ø	IS IS	COT W	MIND					-	



- Proximity to Water Bodies and Sensitive Environmental Areas
- Impacts on adjoining land uses (park or school playground)
- Installed mitigation measures (backflow prevention)
- Volume of spill
- Containment capability
- Mitigation Costs
- Regulatory fines
- Lawsuits and liability exposures
- Loss of production and other

Consequences are categorized in terms of dollar exposures \$\$\$\$

Create a weighted matrix

• Soil type

- Fill = 5, Clay Soil = 4..... Bedrock = 0
- Pipe Material

- Waterways
 - Under a creek = 5..... Far from any water = 0

Implementing a Risk Based, Criticality Assessment Program

RISK =

Х

Probability of Failure

(Projected time between failures)

Consequence of Failure (Dollar costs of failure)

PACP SCORE Material? Construction Methods? Depth of Cover? Traffic Loading? Soils Conditions?

3.5 CLAY (5) NO BACKFILL SHALLOW – 6 FEET UNDER EXPRESSWAY FILL OR BAY MUD (5)

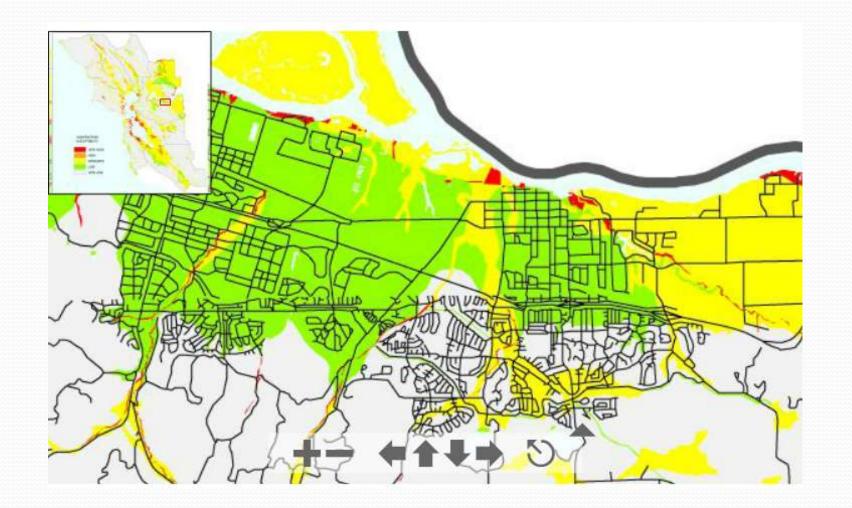


15 FEET FROM A CREEK VOLUME IS HIGH – 24" LINE

LANDFILL ZONES IN SAN FRANCISCO



LIQUEFACTION POTENTIAL – ANTIOCH/PITTSBURGH



<u>Very High</u>	
<u>High</u>	
<u>Moderate</u>	
Low	
Verv Low	

Example of a Criticality and Risk Calculation

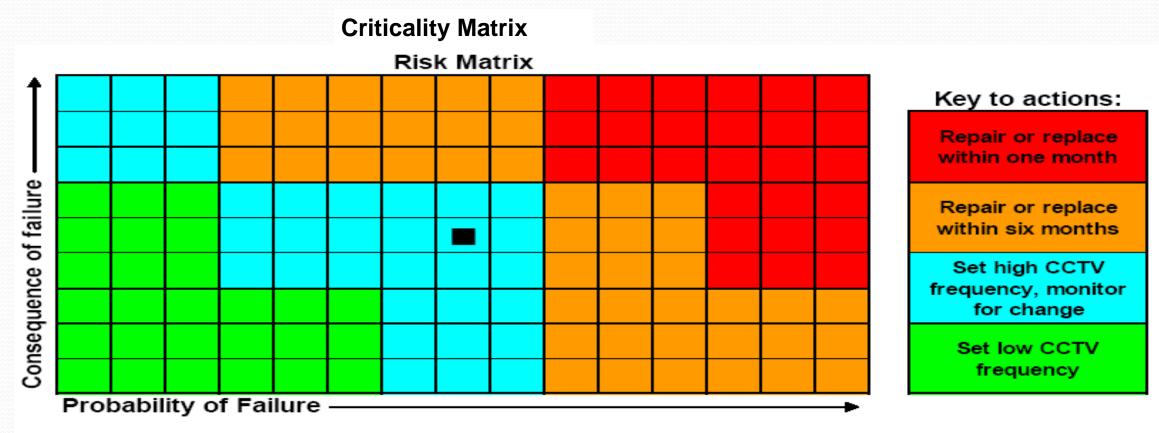


Figure 1: Typical risk probability/consequence matrix, sewer pipe

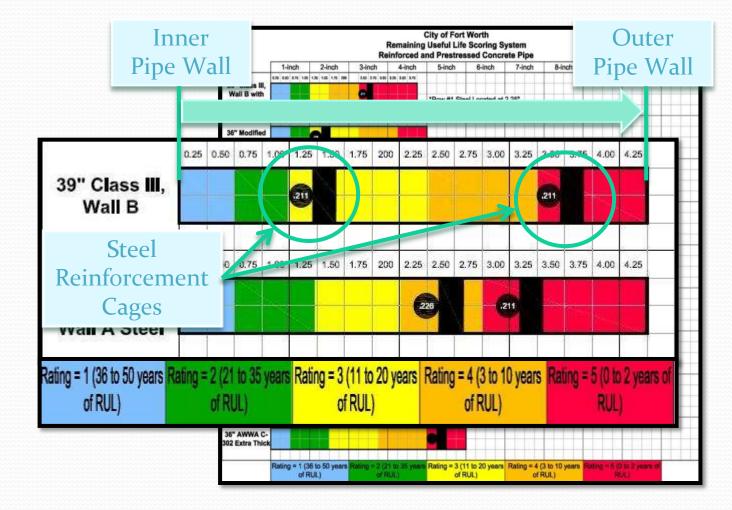
Example Chart to Estimate RUL for RCP

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72	Thickwall													•																		•										

Remaining Useful Life

- Remaining Useful Life developed for each concrete pipe wall specification
- Condition Score for concrete pipes based on location of steel reinforcement cage

 Developed in AutoCAD to maintain a 1:1 scale





Remaining Useful Life: Example of Matrix Criteria

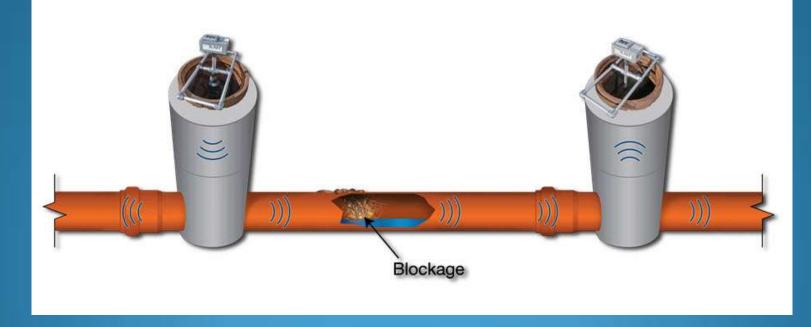
- Rating 1: o to 0.5 inch from inner pipe wall. Action: Re-Inspect in 10-15 Years
- Rating 2: 0.5 to face of first row of steel. Action: Re-Inspect every 5-7 years.
- Rating 3: Face of 1st row of steel to half distance to 2nd row of steel. Action: Re-Inspect every 2-3 Years
- Rating 4: Half the distance to 2nd row of steel to face of 2nd row of steel. Action: Re-inspect in One year
- Rating 5: Face of 2nd row of steel to outer pipe wall surface.
 Action: Immediate Rehabilitation or Replacement

Combine these with Consequence of Failure factors, and it's easy to prioritize what you do when!

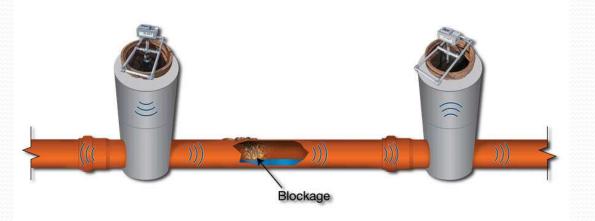
ACOUSTIC ASSESSMENT TOOL

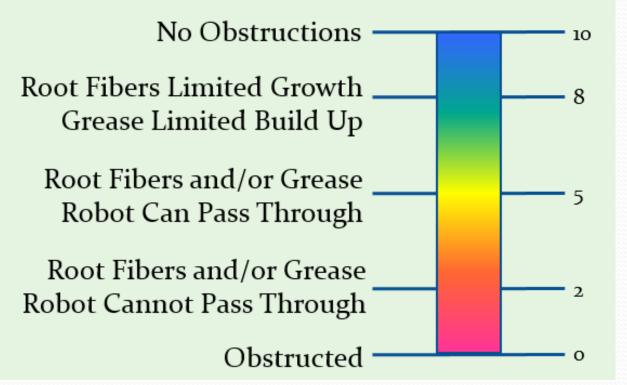
Transmitter

Receiver



So, How Does it Work?

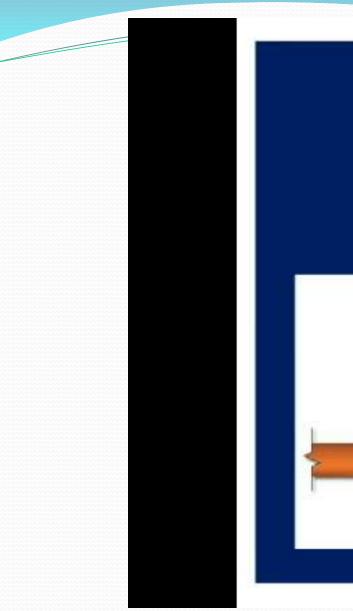




Features of Acoustic Testing

- No Manhole Entry required
- 3 min. test duration
- Real time results of blockage assessment
 - Blockage rating index
- GPS Enabled
- Low Cost- \$0.15-0.30 (average) per L.F.



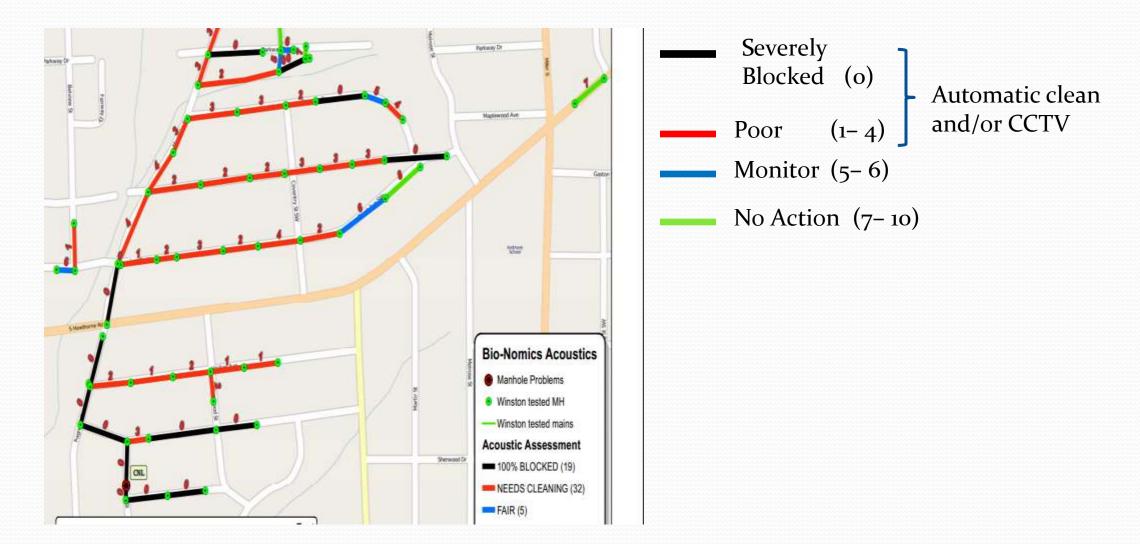


Acoustic Assessment Services





How do we use this information?



Limitations of Acoustic Inspection

- Currently does not indicate what is causing the blockage
 - FOG, Root balls, Non-dispersible, etc.
- Generally does not assess condition of pipe walls
 - Hole Void Visible
- Does not pinpoint the blockage Gives an aggregated score for a line segment
- Does not measure debris level- only aggregated blockage level.
- Under high flow conditions a segment can be assessed with a lower score

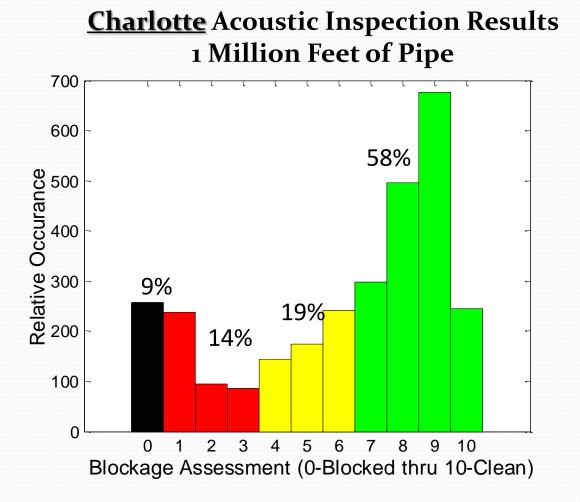
Applications

- Focus cleaning crews in correct locations.
- Eliminate downstream overflows caused by upstream cleaning.
- Avoid repeat overflows in known "Hot Spots" locations.
- Quality Assurance of Post Cleaning.





How Much Cleaning is Wasted?



- Target Historical Problematic Areas
 - >50% Pipes Essentially Clean
 - <10% Need Immediate Action
- Cleaning a Clean Pipe ⇒
 Wastes Resources
- Not Cleaning a Dirty Pipe ⇒ SSO

Case Study II: Targeted Cleaning



"You can see immediately what needs to be cleaned, so it takes the guesswork out and focuses your efforts." – CharMeck Engineer

- **Goal:** Prep Downtown Charlotte, North Carolina prior to DNC
- Approach: Use SL-RAT to quickly identify/prioritize cleaning needs for crews
- Effectiveness:
 - 2 SL-RAT crews inspected 143k ft of pipe in
 ~ 2 weeks
 - Saved **\$100k** + versus traditional approach
 - Focused on 10-15% of pipes that are the most blocked & prioritized the remainder

Applications Enabled By Acoustics

Application Area	How to Use Acoustics	-	
Pre-Cleaning Assessment	Prioritize/focus cleaning often see >50% cleaning reduction – "focus on cleaning the dirtiest pipes"		
Condition Surveys	Quickly & economically assess large areas for asset management & planning		QUICK
Cleaning Interval Determination	Only clean specific segments when below blockage threshold		HITS
Post-cleaning QA	Low-cost method to check cleaning effectiveness and prevent downstream SSO's		
Optimize SSES Contract Resources	Use acoustics to prioritize pre-cleaning & camera resources for contract advantage		
Performance-Based Contracting	Use acoustic inspection to enable SSO targets in cleaning/inspection contracts		
Condition Based Maintenance Program	The "holy grail" – economics of acoustics enables a CBM strategy to focus maintenance activity		FULL POTENTIAL

TRENCHLESS REPAIR SOLUTIONS



WHAT IS INFILTRATION AND INFLOW (I&I)

Infiltration and Inflow is often referred to as I/I and is the occurrence of storm water or ground water entering into municipal wastewater systems.



INFILTRATION PROBLEMS ARE COMMON



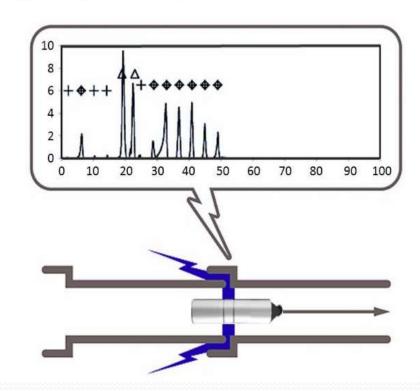
SAMPLE SOURCES OF I/I



How do we find infiltration?

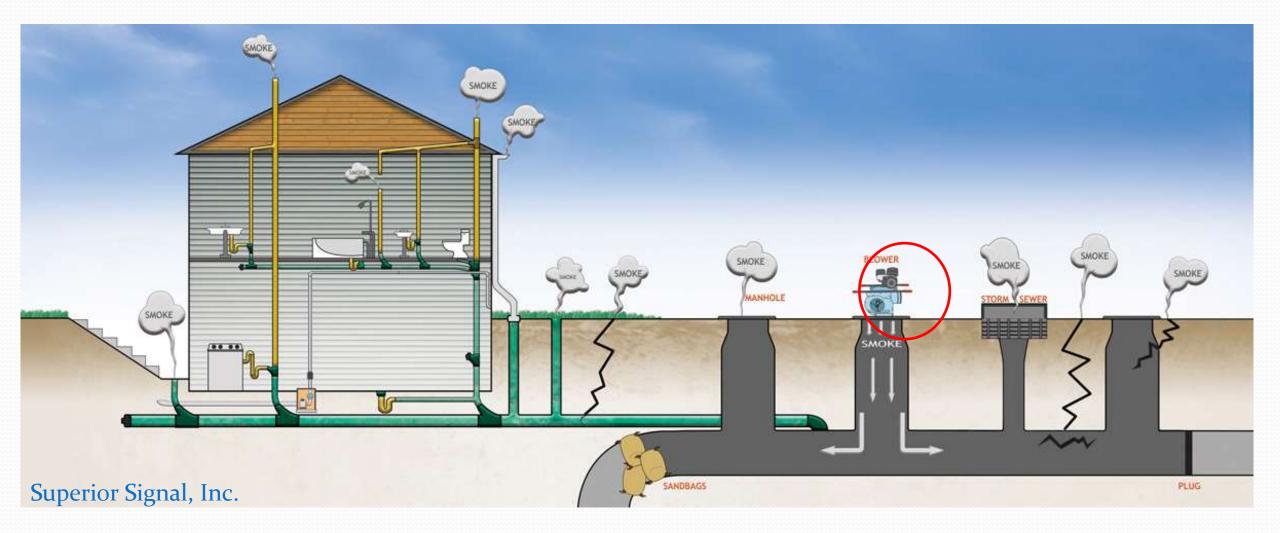
- CCTV Inspections (staining, weeper, gusher)
- Electroscan Inspection
- Air test joints with a grouting packer
- Smoke testing
- Dye Testing

Leaks in sewer pipes are located by measuring the electricity flowing from a probe. As the probe is pulled through a pipe, electricity is used to scan the pipe indicating all defects - hence the term 'Electro Scan.'



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Smoke Testing



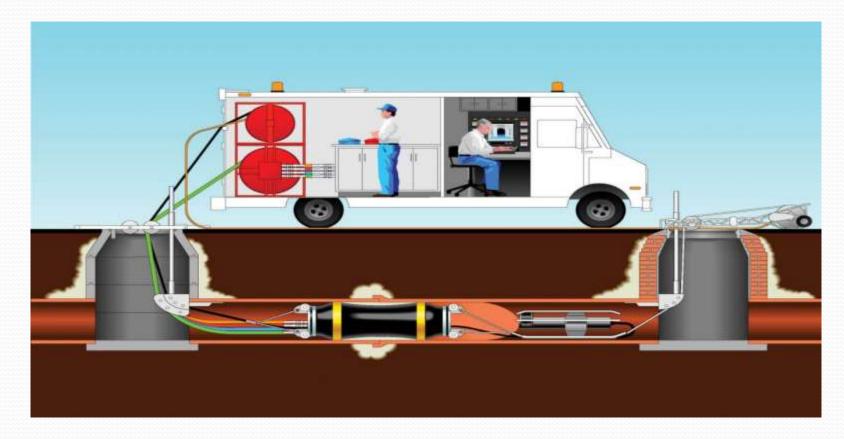
Electroscan



What can I use to Fix.....?

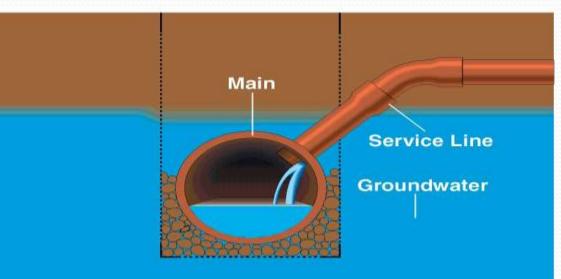
- Water Infiltration
 - Through a joint: grouting
 - Through a broken pipe or lateral: point repair
 - Through a manhole: grouting
- Broken pipe/Hole/Fractures
 - Point Repair in a mainline
 - Lateral lining for a lateral
- Roots
 - Root Foaming
 - Point repair (main line)
 - Lateral Lining (lateral)
- Corrosion in a mainline
 - CIPP lining/sliplining
 - Replace
 - Structural Coatings

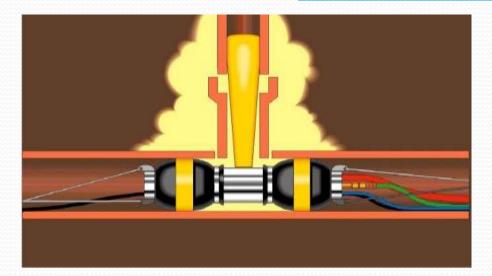
Testing & Sealing of Joints (Via Injection Grouting)

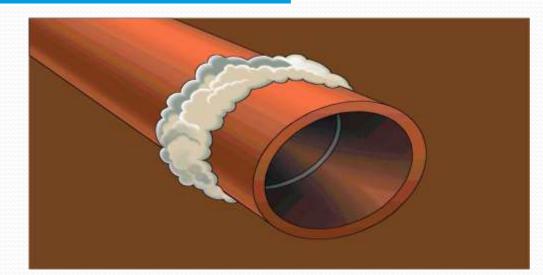


Testing and grouting of pipe joints

Injection Grouting







CHEMICAL GROUTING STOPS INFILTRATION





ANOTHER ALTERNATIVE TO STOP I&I Service Connection Lining

Before



St. Louis, MD Tom Sawyer Constant Appair Prosent St. Louis, MD St. Louis, MD Prosent St. Louis, MD St. Louis, MD<

After

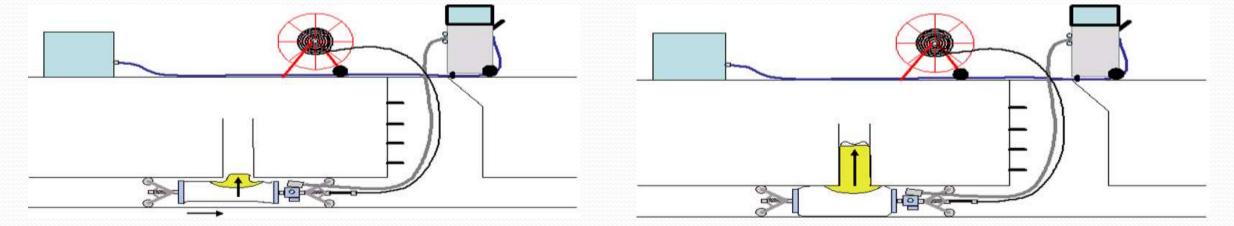
LCR (Lateral Connection Repair)

MTH (Main to House)









Position the packer until the pathfinder engages into the opening of the lateral connection. Make sure the LCR packer takes a center position with the lateral opening. Set the pressure regulator to an inflation pressure of 10 psi. At first, the pressure is built up in the main pipe. Then pressure will be built up in the lateral connection thereby causing the inversion process to start.

LATERAL SERVICE LINE INSPECTION & REPAIR

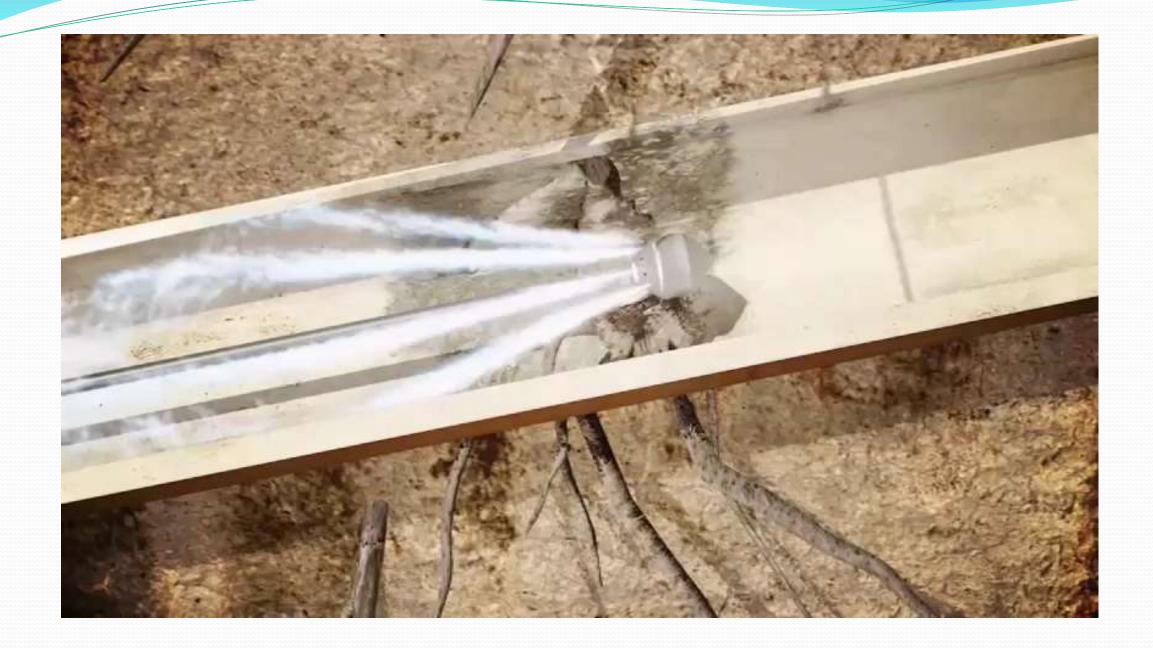






Carylon Corporation

The Environmental Protection Specialists





Trenchless CIPP Short Liners







• Short liner spot repairs to rehabilitate holes, cracks and eliminate sources of heavy infiltration.

Trenchless CIPP Spot Repair

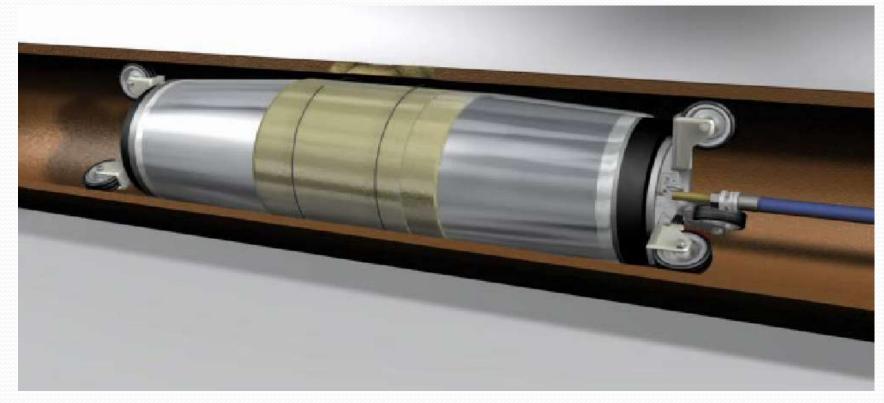
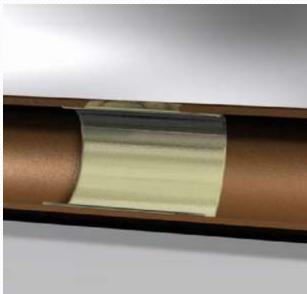
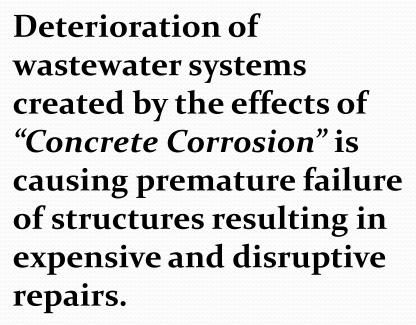


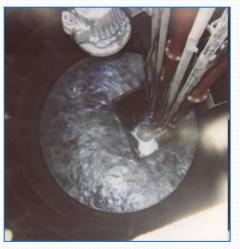
Diagram showing a pipe that has been sectionally repaired.



Spin Cast Pipe Rehab with Corrosion Inhibitor







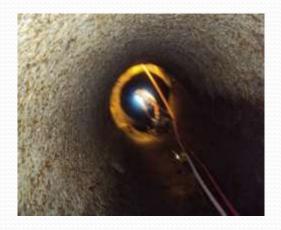


Who Wants to Chemically Grout this Section?



USED TO REHAB STORM AND WASTEWATER PIPELINES

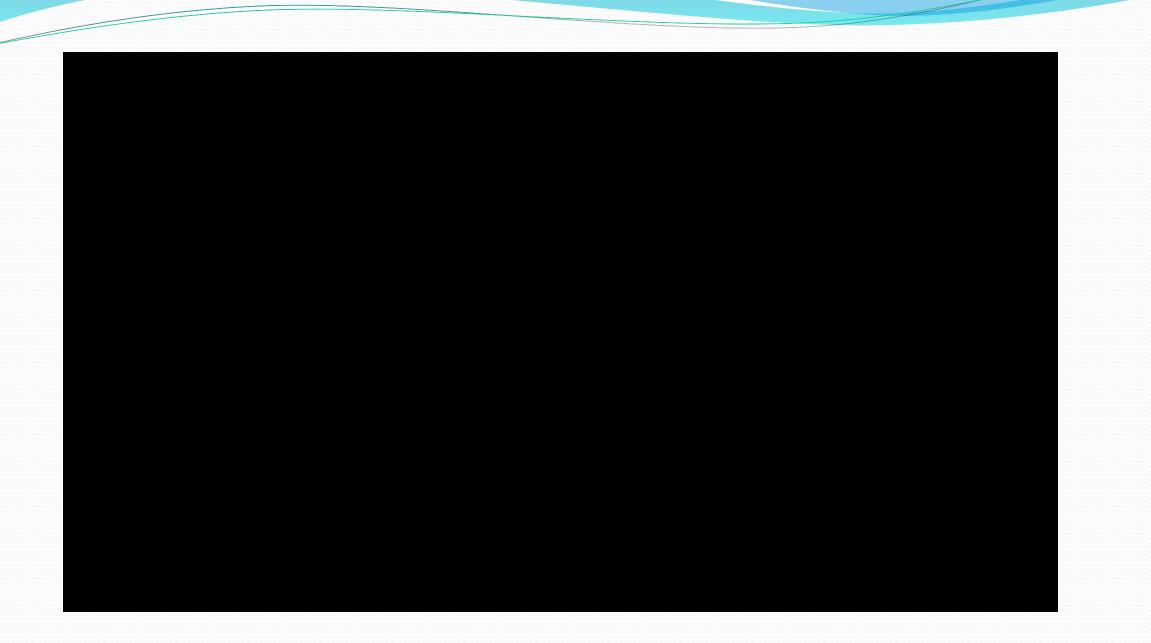
- CENTRIFUGALLY CAST CONCRETE COATING IS APPLIED WITH A ROTATING SPIN CAST NOZZLE
- USED VERTICALLY OR HORIZONTAL
- CONSHIELD[®] ANTIMICROBIAL ADDITIVE IS DOSED INTO THE MIX TO RENDER THE COATING UNINHABITABLE FOR BACTERIA GROWTH, WHICH STOPS THE CORROSION.





96" Centrifugally Cast Spin Cast Pipe Rehab Before and After

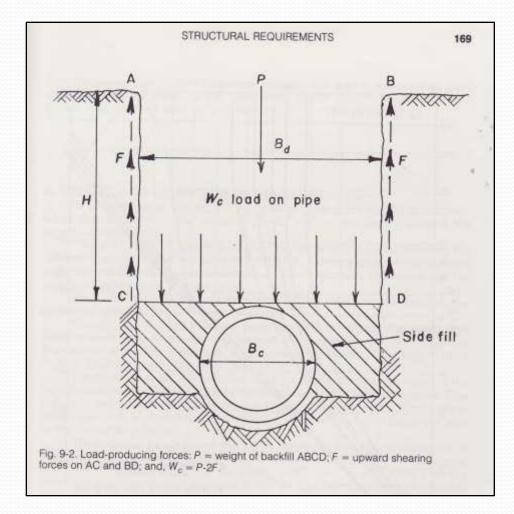




Small Equipment Footprint



Report Graphics Sample



Minnesota DOT 80 feet of 36 in pipe



SR 16, Florida 80feet of 13ft pipe





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