

# **WRc's Use of Focused Electrode Leak Location (FELL) to Assess Gravity Sewers in the United Kingdom, United States, and Germany, Before & After Trenchless Rehabilitation**

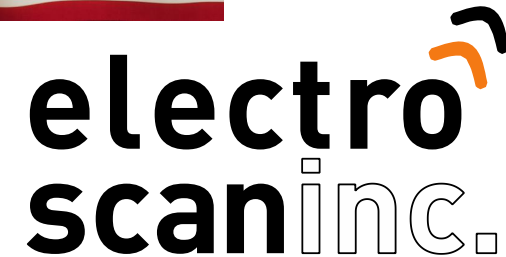
Paper Ref #2299



Peter Henley  
Special Consultant  
WRc plc



Chuck Hansen  
Chairman  
Electro Scan Inc.

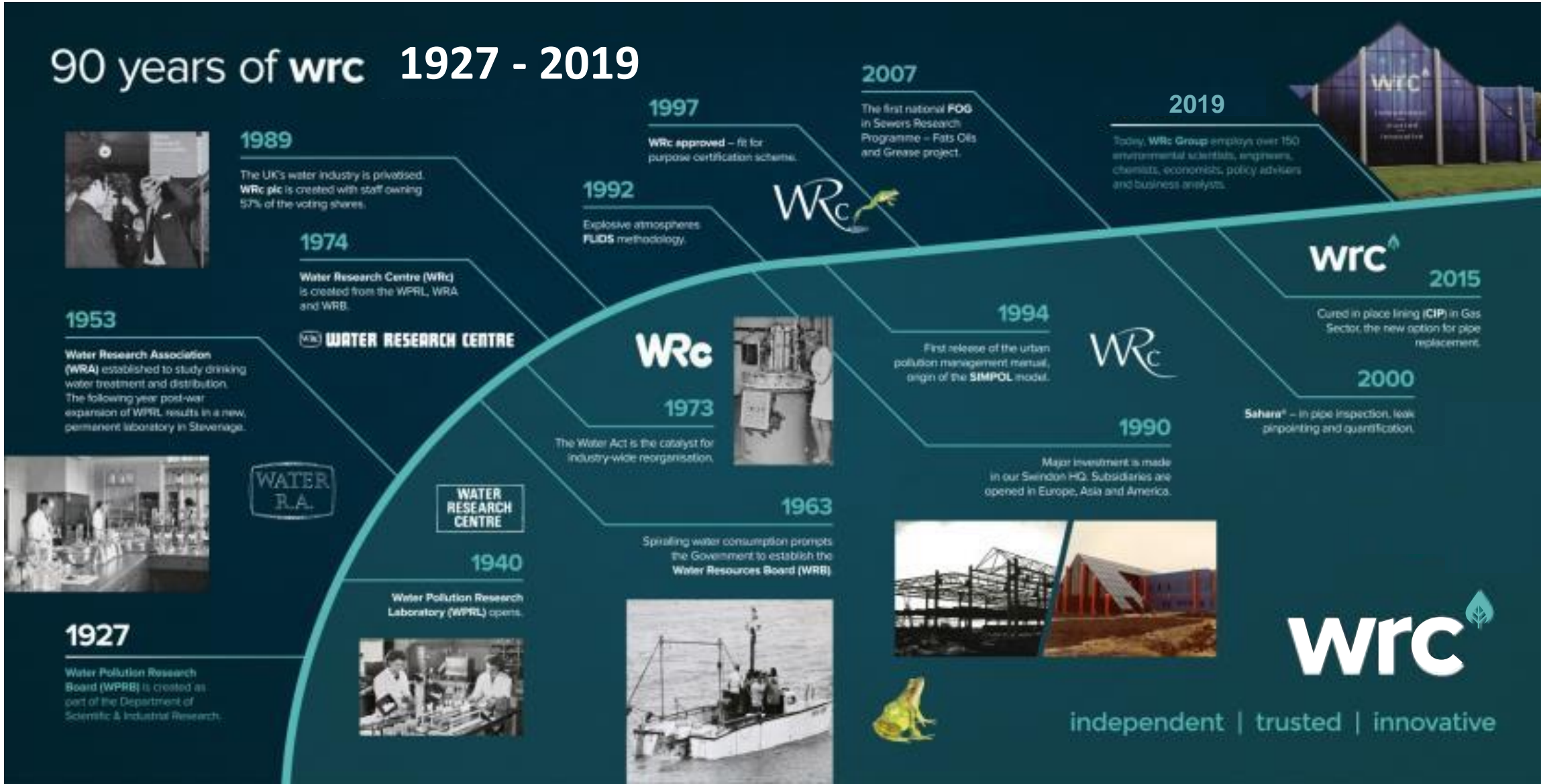


# British Perspective – Peter Henley

**wrc** 



# WRc – Our long history







## group

Established leaders in innovation, we are trusted by a wide range of stakeholders to add value at every level.



## water

Sustainable and robust solutions for water utilities, industry and regulators and their customers.



## gas

Facilitating transformational change for the UK's gas distribution networks in the path to a low carbon future.



## environment

Generating valuable evidence that transforms resource recovery in an evolving circular economy. Strategic consultancy, solutions and technologies to meet a wide range of environmental challenges.



## network

Deployment of innovative technologies for inspection, monitoring and management of pipeline infrastructure.

independent | trusted | innovative



Our independence is valued by all our stakeholders. Regardless of the changing demands of the commercial world, our independence is never compromised.

## The wrc Vision & Values

### trusted

We have earned the trust of industry, government, academia and the public as a centre of excellence. This drives our continued commitment to deliver world class technical and scientific expertise.

### innovative

Throughout our history, we have built our business upon science and engineering excellence, and a foundation of innovation. Whatever the challenge, we nurture and encourage collaboration and new ways of thinking.

“

At WRc, we aim to add value in all that we do. We work with our clients to develop innovative and effective outcomes to help them meet their technical challenges and provide a world-class service to their customers

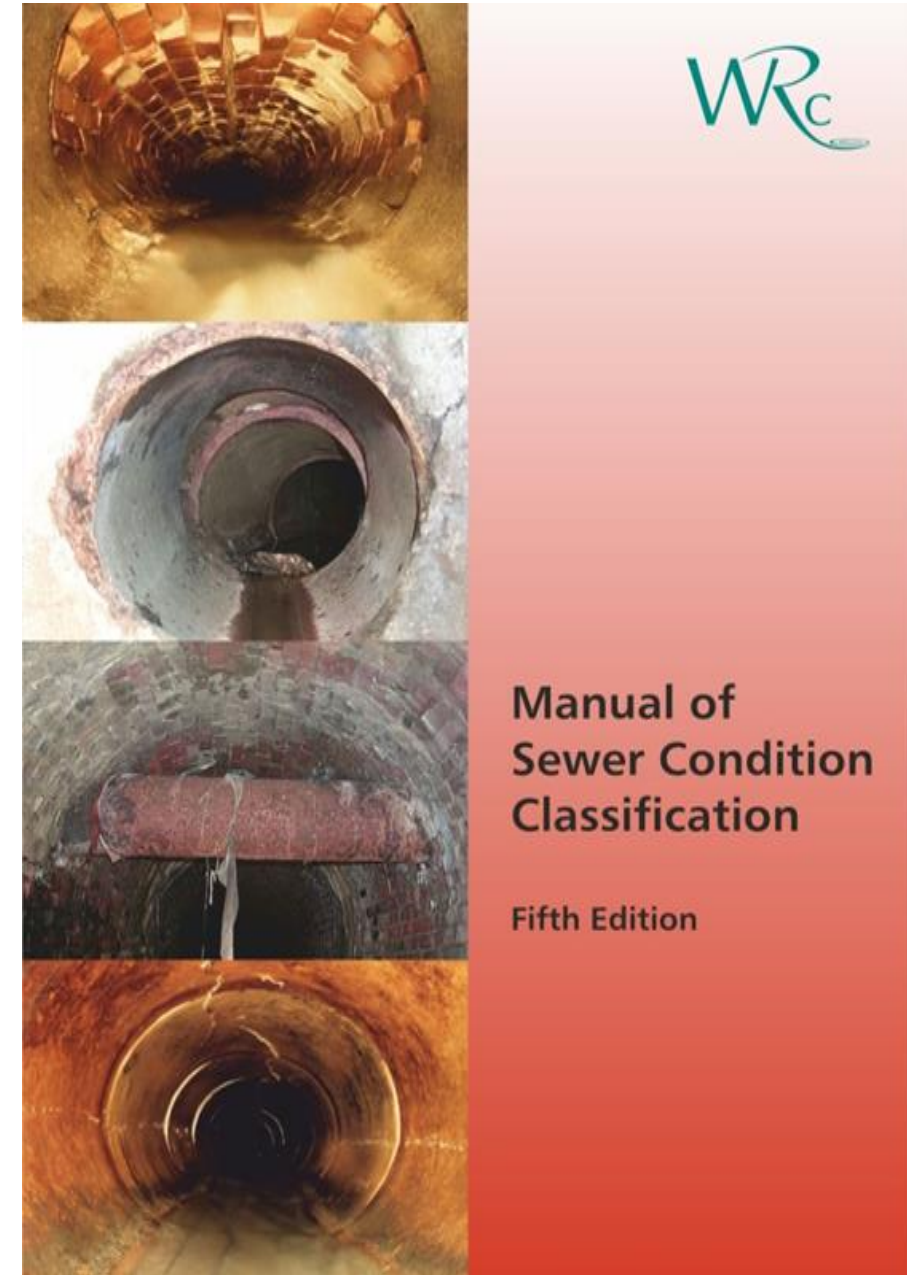
Mark Smith  
CEO, WRc plc

**wrc**  
wrcplc.co.uk



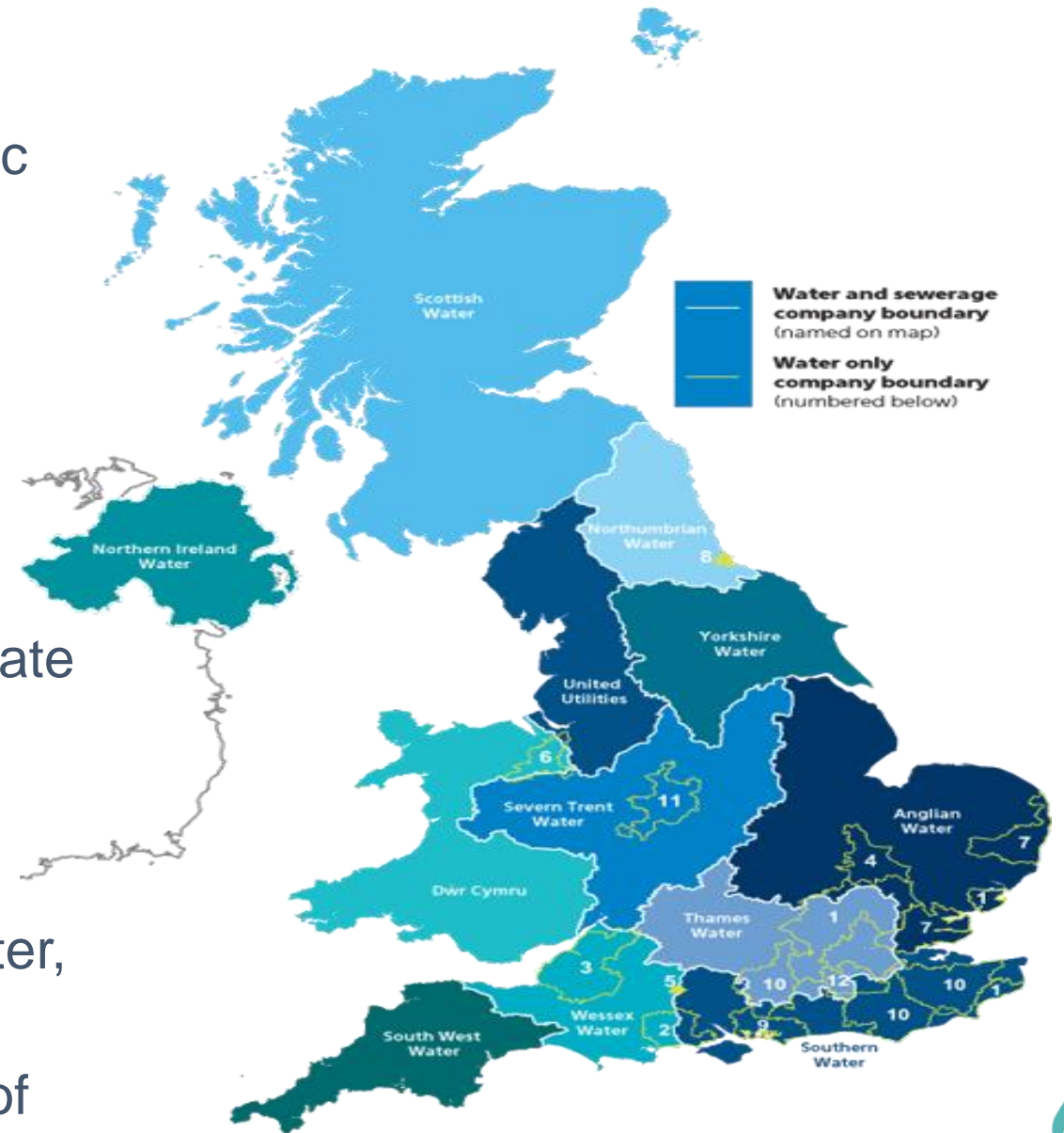
# Manual of Sewer Condition Classification

- WRc have a long history of in assessing the condition of sewers using CCTV
- First MSCC published in 1980 most recent update published in 2013
- Globally recognised and amended for use in the US as the NASSCO PACP standard
- WRc took the step in 2015 to work with Electro Scan Inc. to tackle infiltration



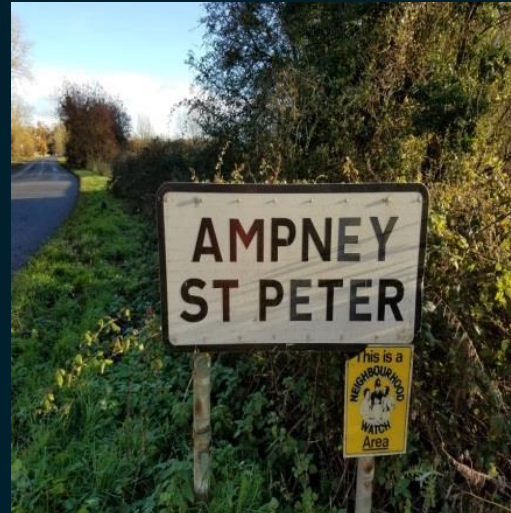
# Infiltration in the UK

- Wet winters in 2012 and 2013 flagged to WRc the need to tackle ground water infiltration
- CCTV provides some of the answers to pinpointing infiltration
- WRc researched the market and decided Electro Scan provided the best inspection solution
- Strategic alliance announced in 2015 to operate Electro Scan exclusively in the UK
- To date we have completed 15 surveys and have scanned in excess of 40kms
- Key clients are Thames Water, Southern Water, Wessex Water and Anglian Water
- Future surveys planned in 2018 for 100kms of sewer inspection

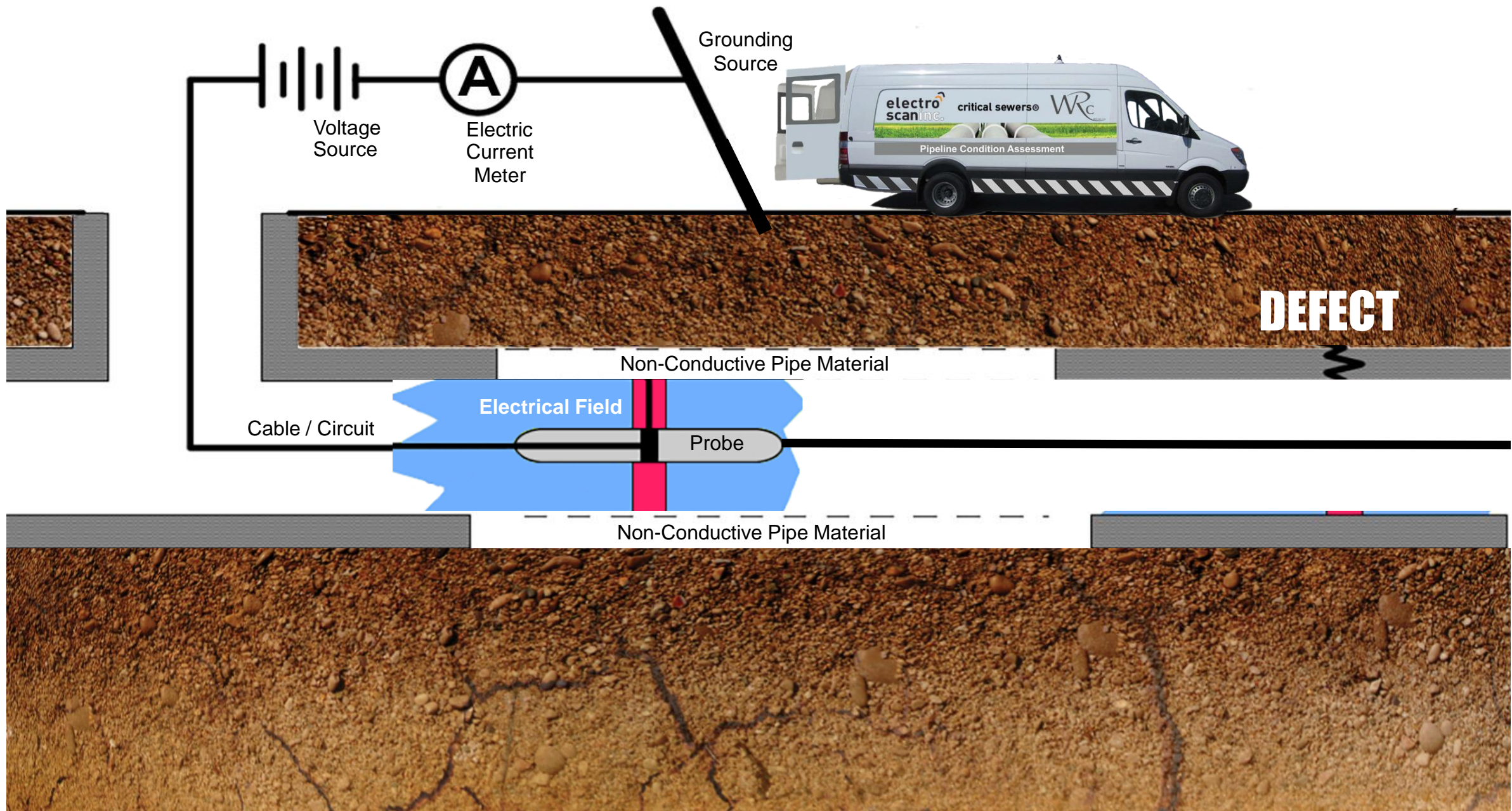




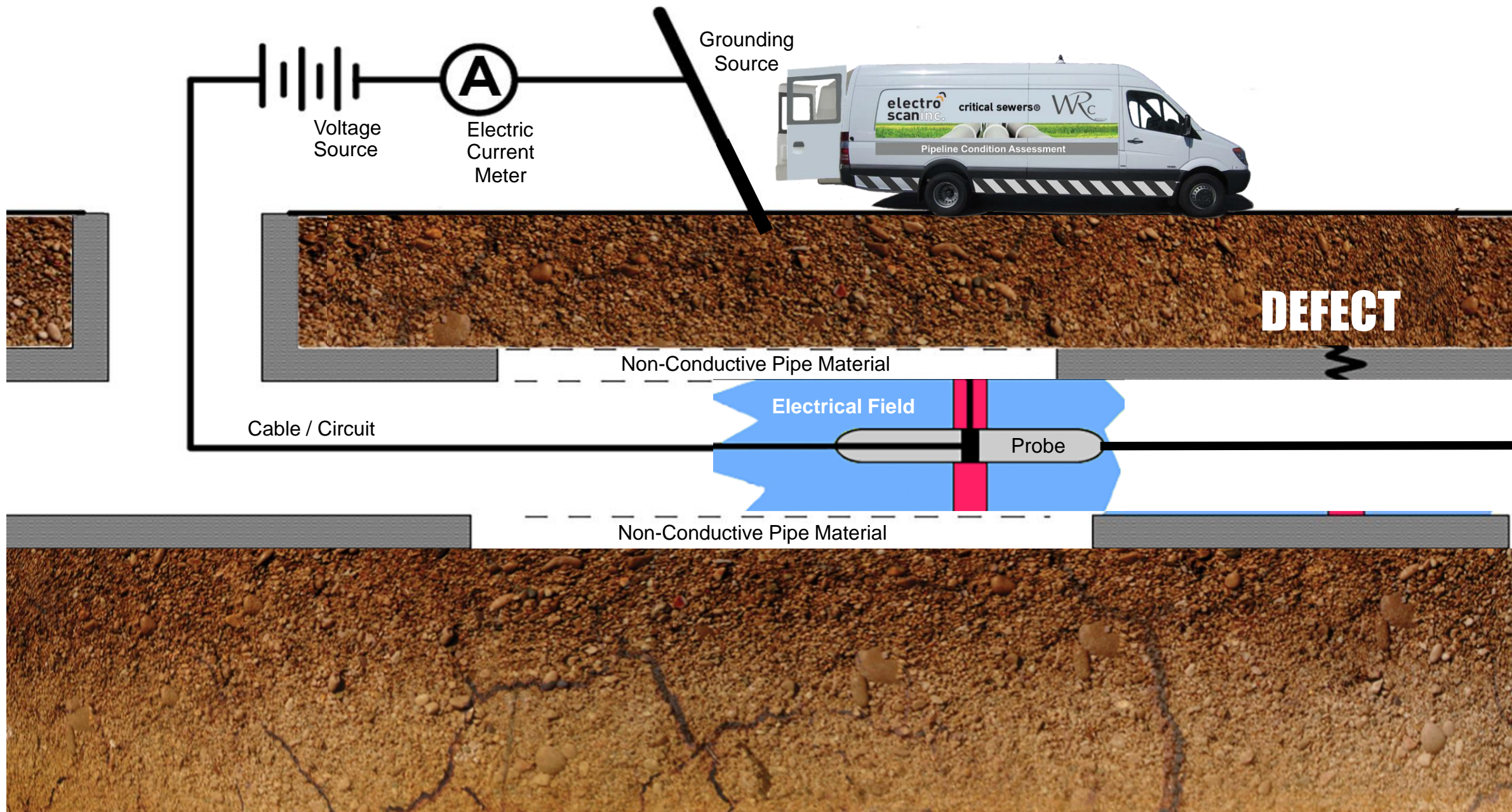
# WRc | Electro Scan – Ampney St Peter



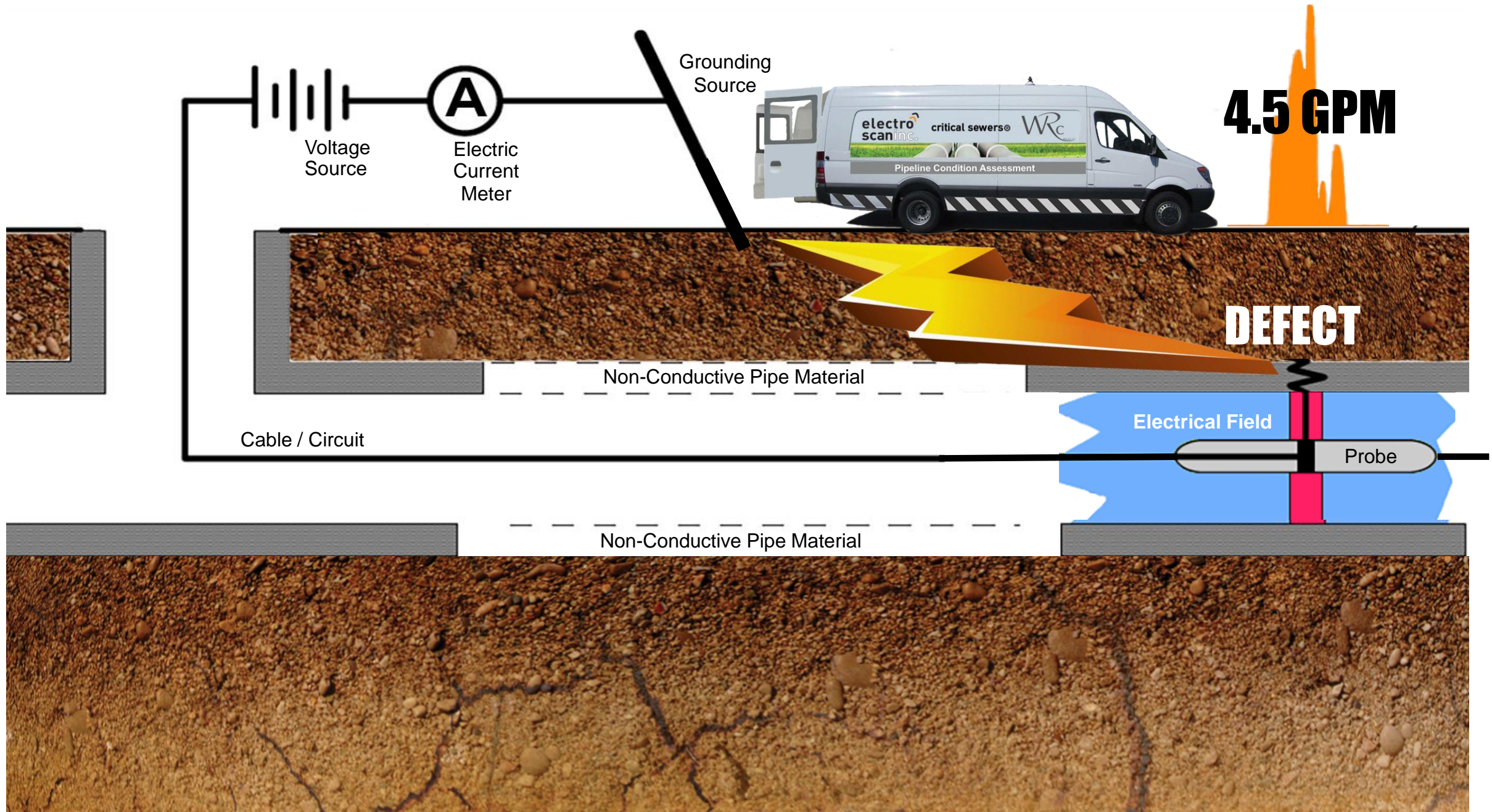








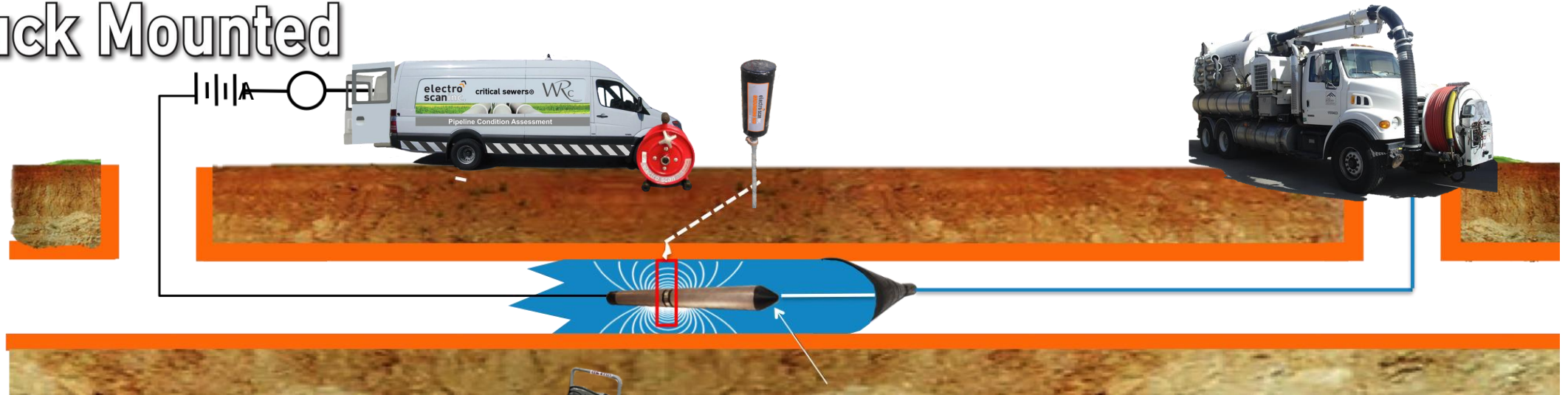




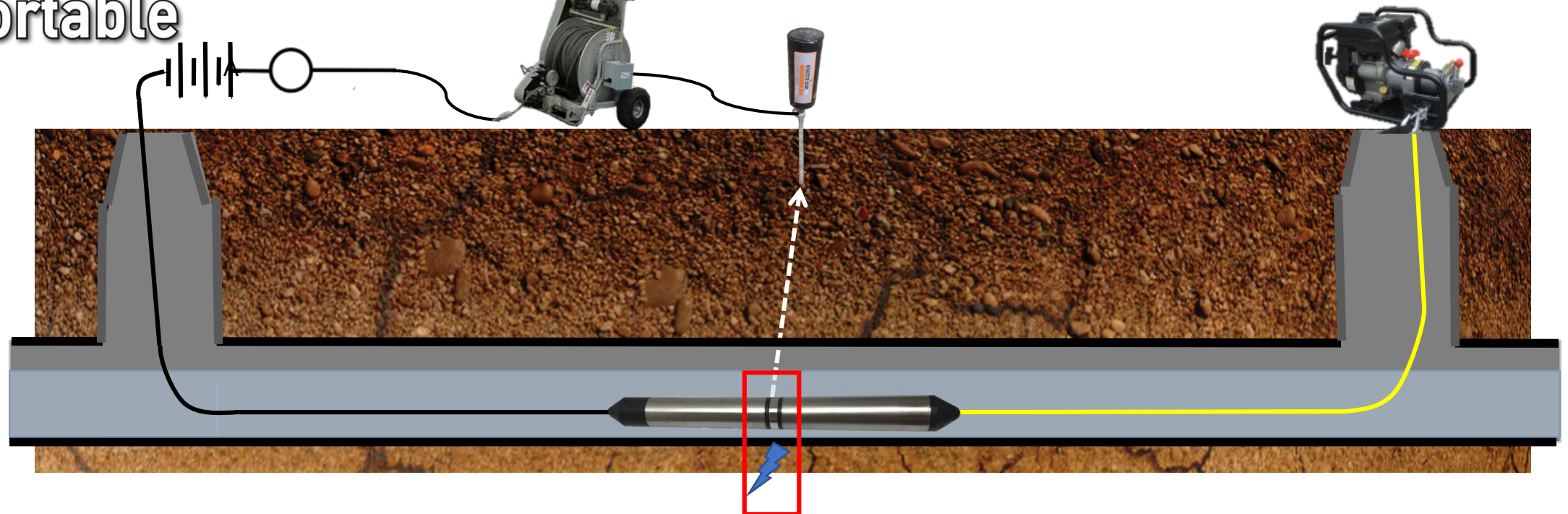


# Common Field Set-Ups for Electro Scanning

## A Truck Mounted



## B Portable



# Project Highlights

- 614 metres of survey completed
- 60 individual defects identified using Electro Scan FELL
- CCTV survey initially failed to identify any major defects
- 155,606 litres per day of inflow

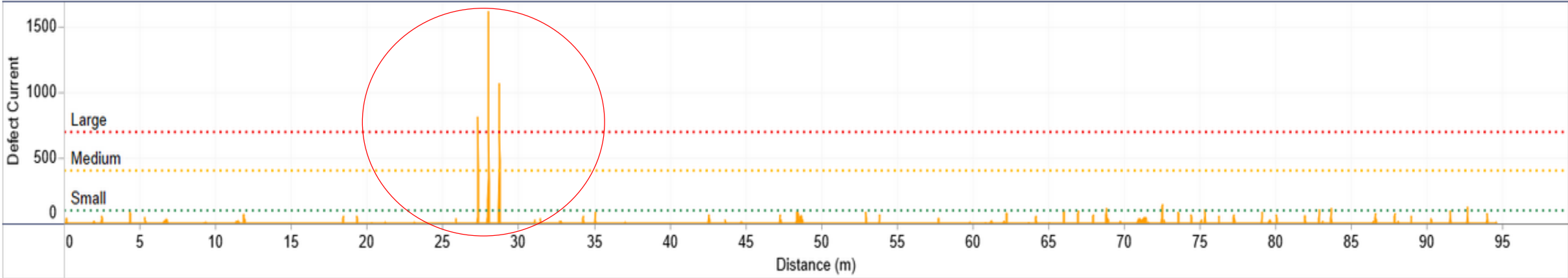
Electro Scanning Inspection  
Ampney St. Peter Project Results from Nov. 18, 2016

Number of Defects				Liters Per Minute					Total LPD
				Minor Defect Flow	Moderate Defect Flow	Severe Defect Flow	Total Defect Flow	% of Total Defect Flow	
Small	Medium	Large	Total						
57	0	3	60	0.85	0.97	0.00	1.80	100%	155,606

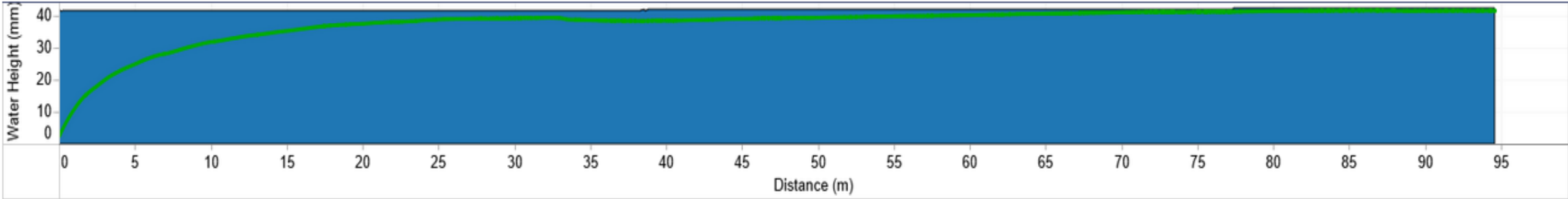


DEFECTS		% OF DEFECT LENGTHS		LPS SUMMARY		DIAMETER & DISTANCE		OPERATOR INFO	
S	7	Small Defects	<div><div></div></div> 0.000800	Minor LPS	0.07	150		WRc Project Ampney St. Peter	
M	0	Medium Defects	0.000000	Moderate LPS	0.54				
L	3	Large Defects	<div><div></div></div> 0.003200	Severe LPS	0.00	<div><div></div></div> 94		Job Ampney St. Peter	
		All Defects	<div><div></div></div> 0.004000	Total LPS	0.62				
						LPD	<div><div></div></div> 53,311	<div><div></div></div> Distance (m)	
				LPD IDM	<div><div></div></div> 6,085	Scan Start			
				Minor LPS %	11.76%	11/18/2016 7:28:24 AM			
				Moderate LPS %	88.24%	11/18/2016 7:30:35 AM			
				Severe LPS %	0.00%				

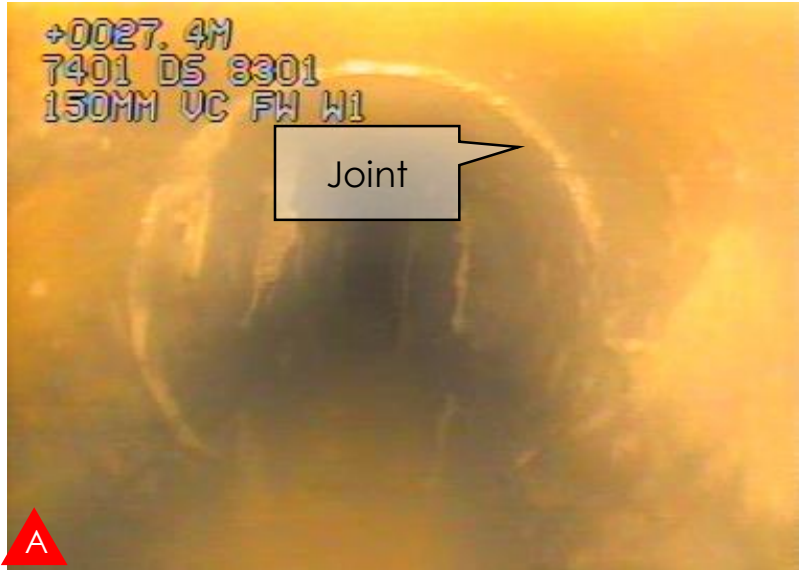
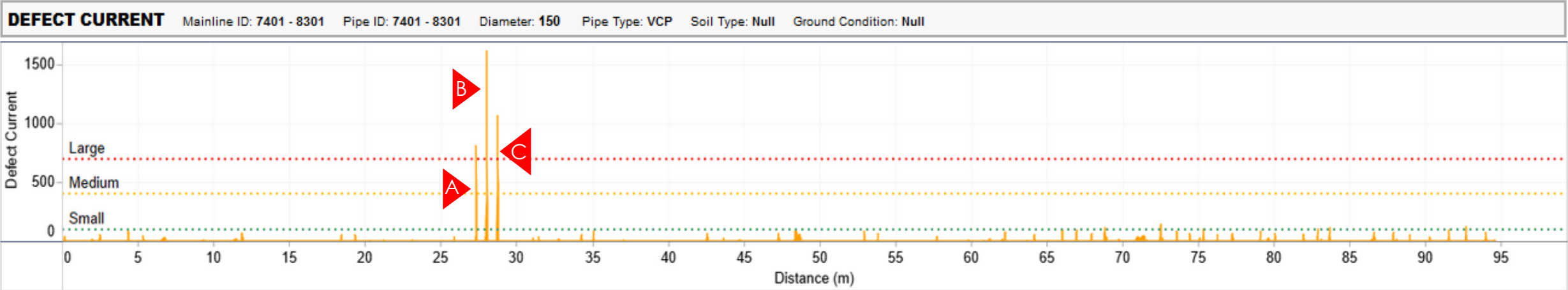
**DEFECT CURRENT** Mainline ID: 7401 - 8301 Pipe ID: 7401 - 8301 Diameter: 150 Pipe Type: VCP Soil Type: Null Ground Condition: Null



**WATER HEIGHT AND PROBE SPEED** Mainline ID: 7401 - 8301 Pipe ID: 7401 - 8301 Diameter: 150 Pipe Type: VCP Soil Type: Null Ground Condition: Null



# 7401 – 8301: CCTV Comparisons



# Project Summary

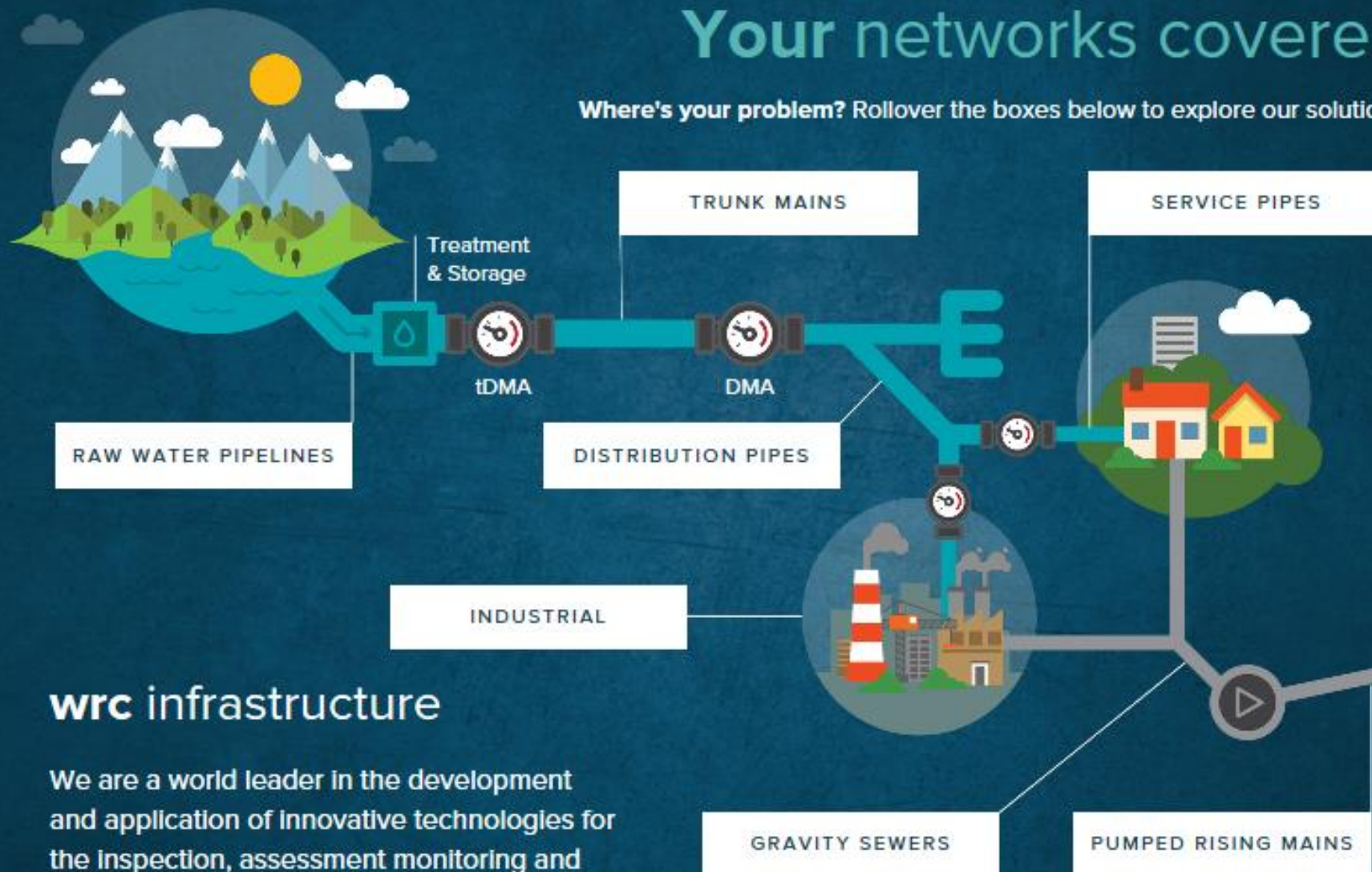
- Electro Scan was easy to use and has few operational issues
- Results are consistent and show repeatability
- Identifies Infiltration sources where CCTV fails
- Not dependent on weather or ground water levels
- Doesn't replace Visual Inspection but provides an addition to the engineers tool box to find & quantify leaks.





## Your networks covered

Where's your problem? Rollover the boxes below to explore our solutions.



## wrc infrastructure

We are a world leader in the development and application of innovative technologies for the inspection, assessment monitoring and management of pipeline infrastructure.

# WRc | Electro Scan Testing



**Institute for Underground Infrastructure  
Gelsenkirchen, Germany**





# Short Liner Lateral CIPP Testing



Bild 21 Dicht saniertes Schadensbild (keine Auffälligkeiten)

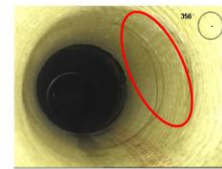


Bild 22 Feuchtigkeit ohne Infiltration

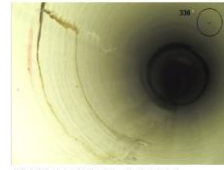


Bild 23 Verfärbung, Beispiel 1



Bild 24 Verfärbung, Beispiel 2



Bild 25 Fließen

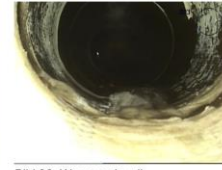


Bild 26 Wasserschwall

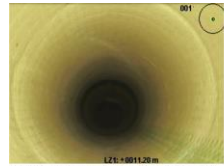


Bild 15 Dicht saniertes Schadensbild (keine Auffälligkeiten)

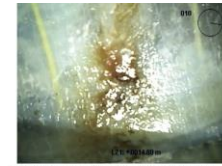


Bild 16 Feuchtigkeit und Verfärbung

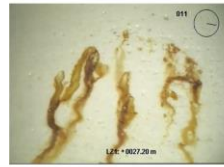


Bild 17 Verfärbung



Bild 18 Tropfen



Bild 19 Fließen

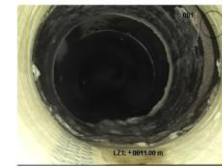
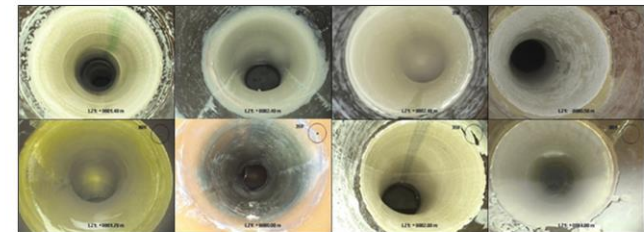


Bild 20 Wasserschwall

IKT - Institut für Unterirdische Infrastruktur,  
Gelsenkirchen  
[www.ikt.de](http://www.ikt.de)

## IKT-Warentest „Kurzliner für Hausanschlüsse“ - Auszug aus dem Forschungsbericht -



Gelsenkirchen, Oktober 2018



# Field Photos: 19 & 20 September 2017







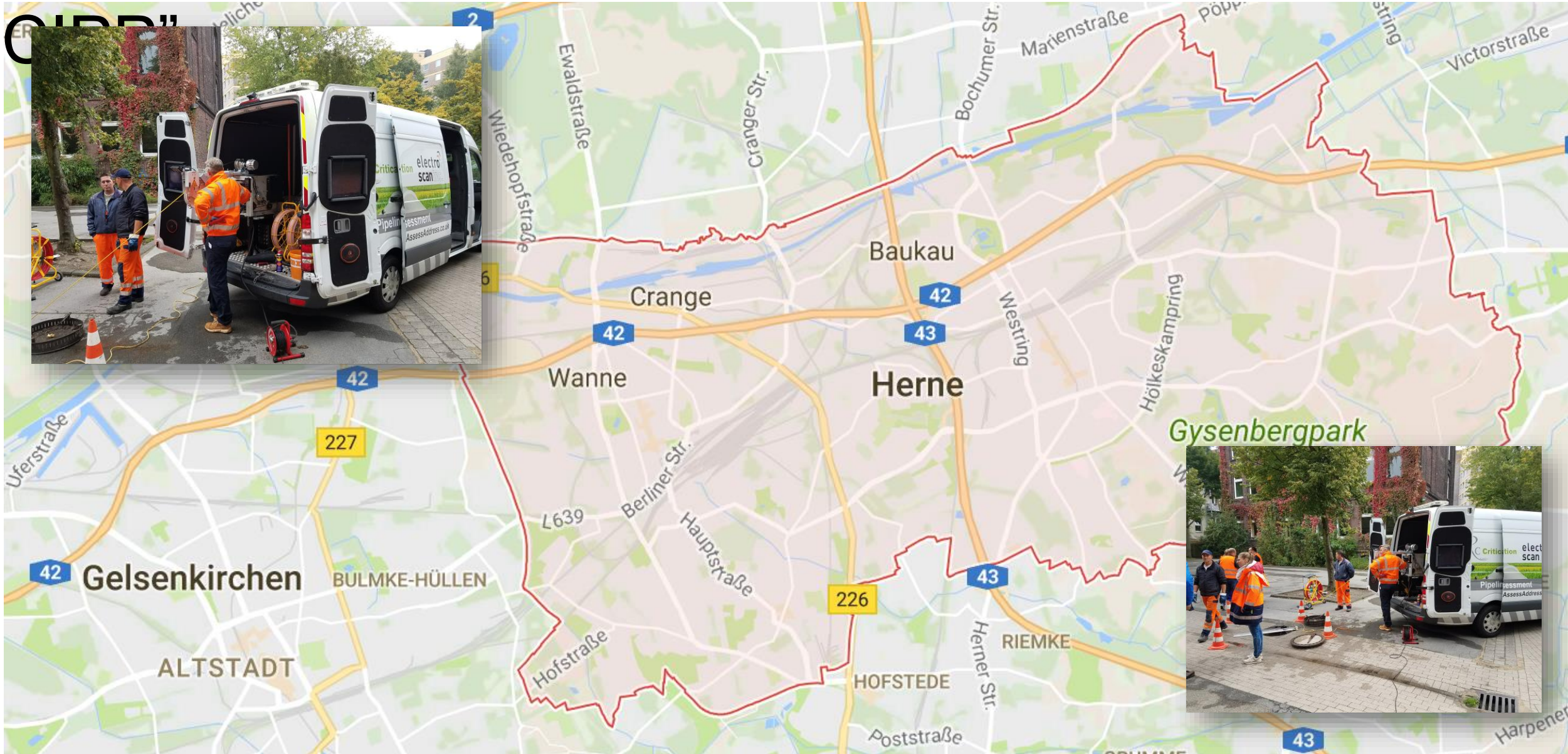
independent | trusted | innovative

electro<sup>scan</sup>inc.





# Day One – Herne, Germany – “Local Sectional



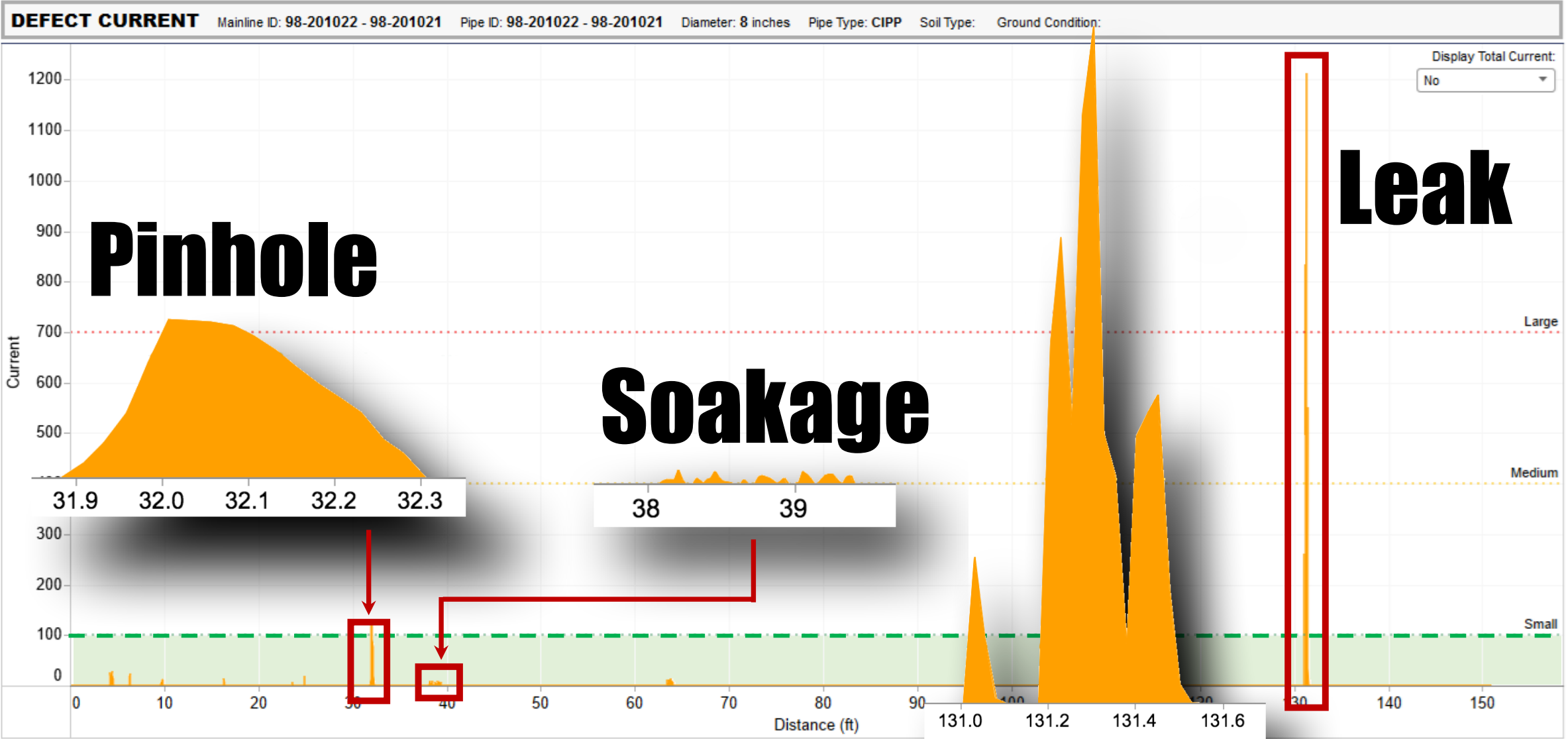


# Day Two – Gelsenkirchen, Germany – “Lab CIPP



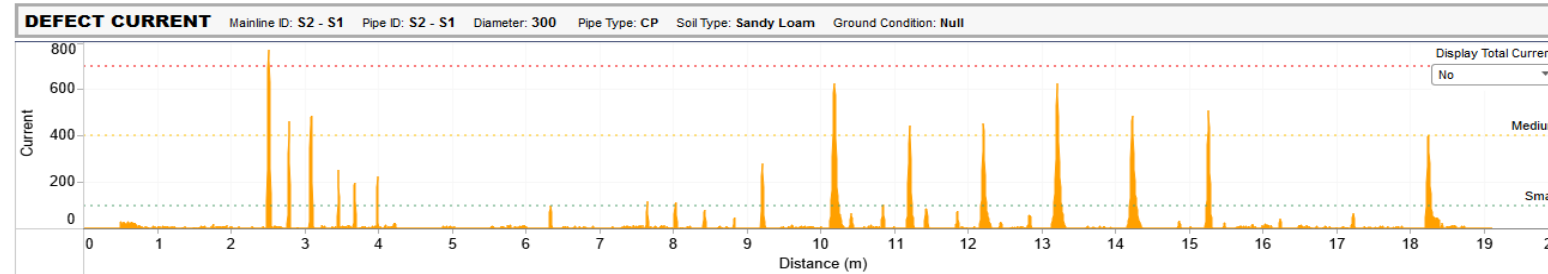


# 3 Kinds of Defects Found During Testing

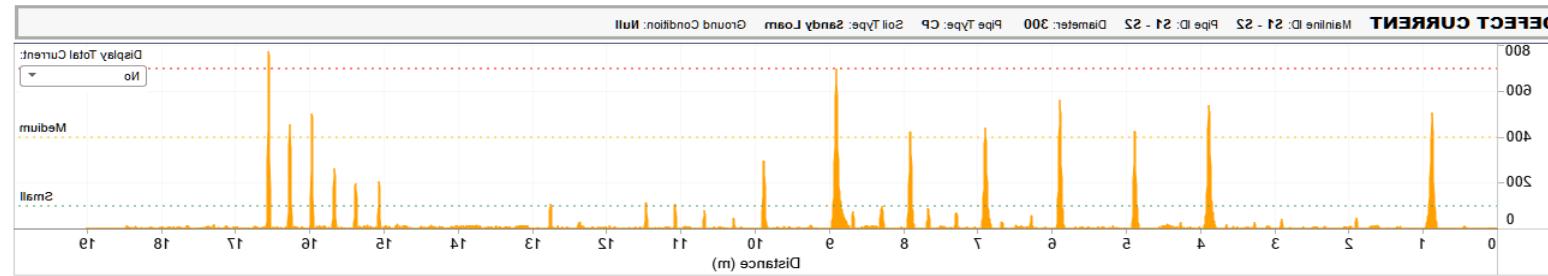


# Each Survey Tested for Repeatability

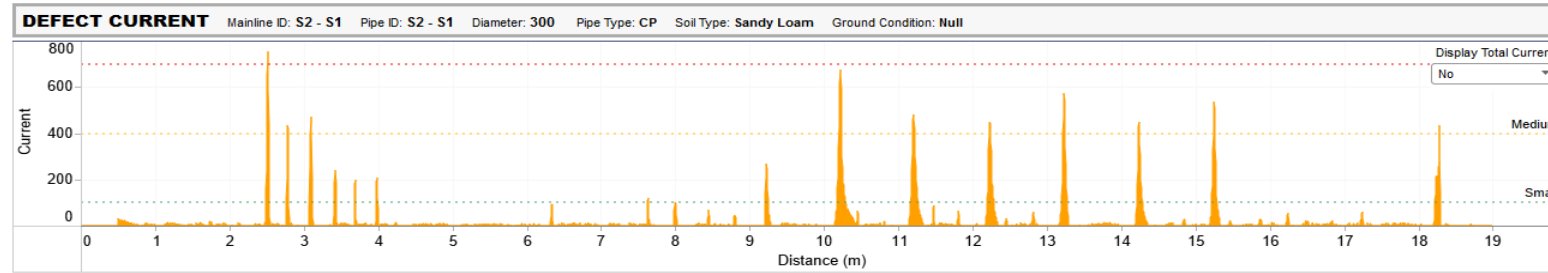
Scan 1  
Upstream



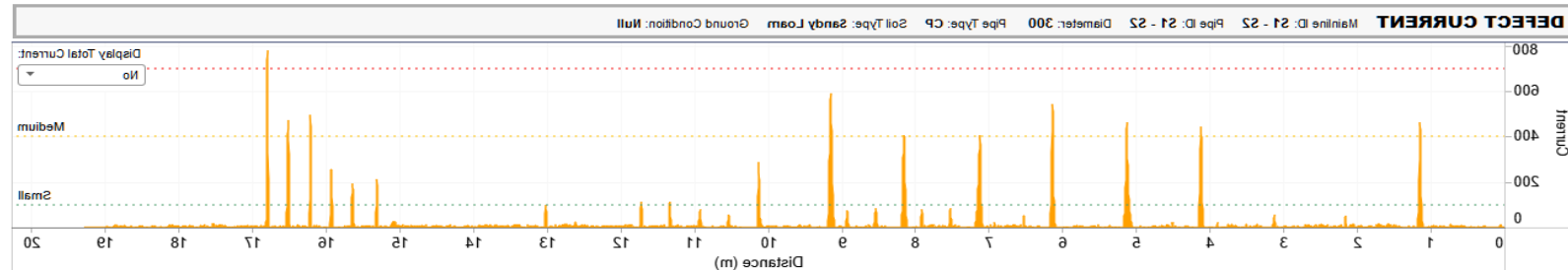
Scan 2  
Downstream



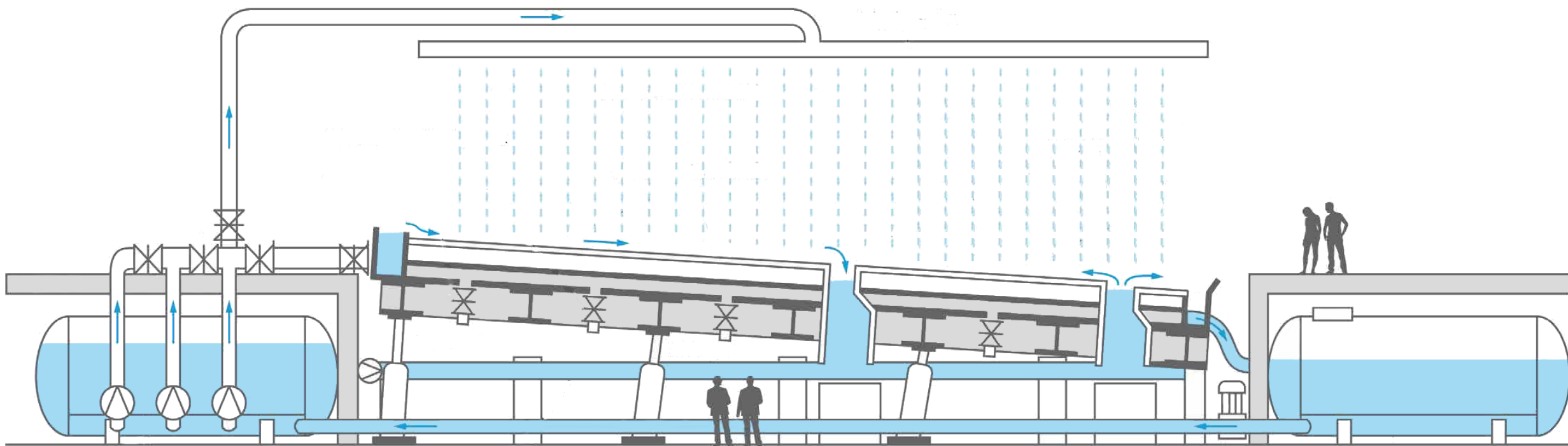
Scan 3  
Upstream



Scan 4  
Downstream







# American Perspective – Chuck Hansen

**electro**<sup>↗</sup>  
**scan**inc.

**HANSEN**  
Hansen Analytics, LLC





# 2012

New Zealand

England

Japan

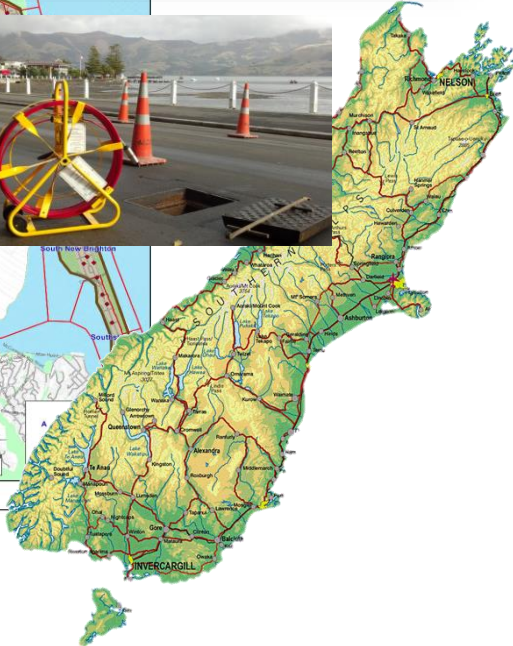
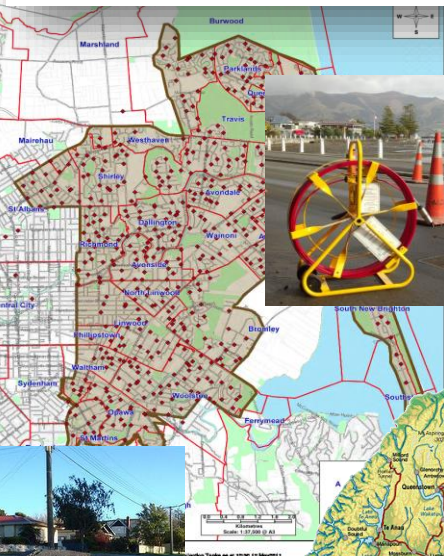


Magnitude: 6.3 M<sub>L</sub>

Date: 22 February 2011, 12:51 pm NZDT

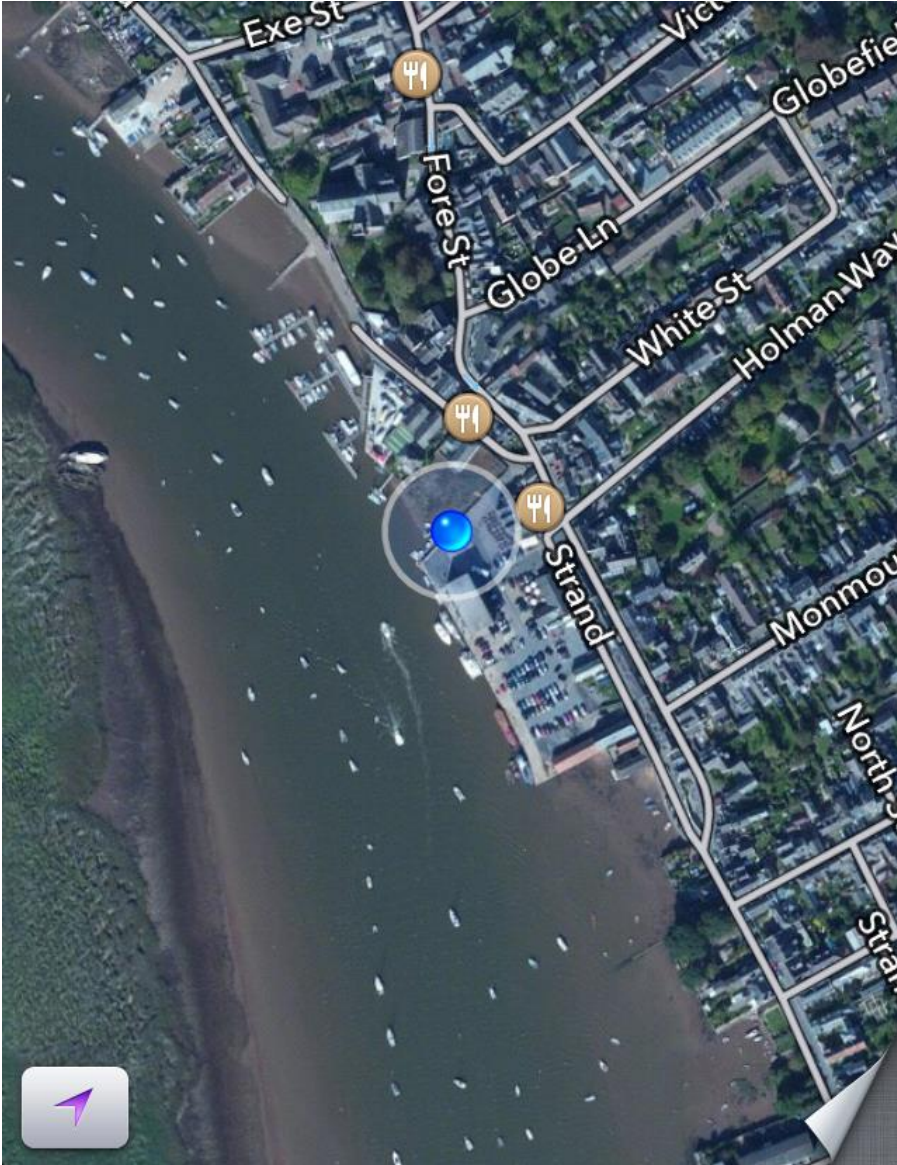
Areas affected: New Zealand

Casualties: 185 deaths; 1500–2000 injuries





# Topsham Demonstration 8 Nov 2012

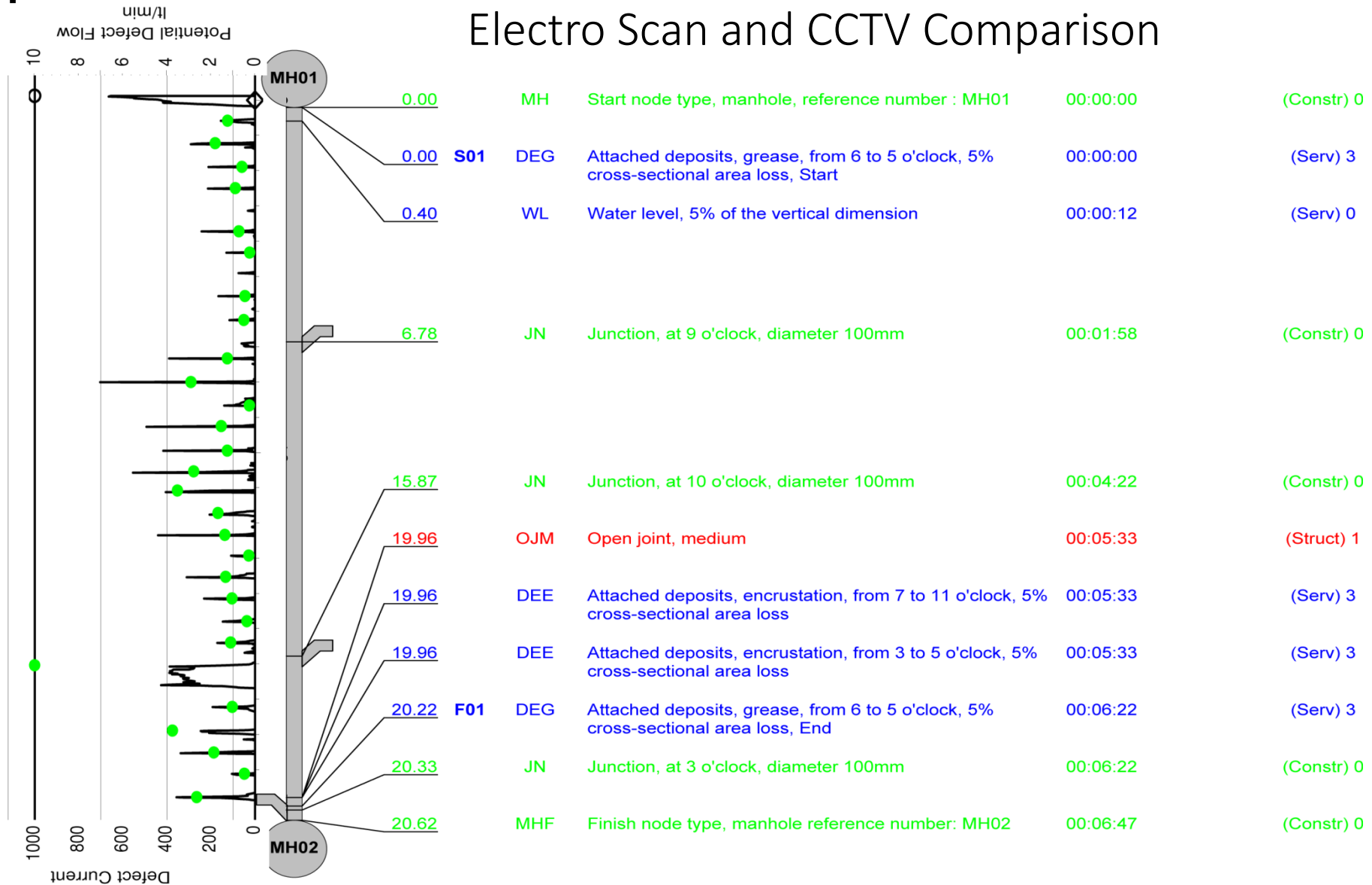




# Topsham Demonstration 8 Nov 2012



## Electro Scan and CCTV Comparison





# Topsham Demonstration 8 Nov 2012

Defect Identified: Joint Defect  
CCTV Call Out: None



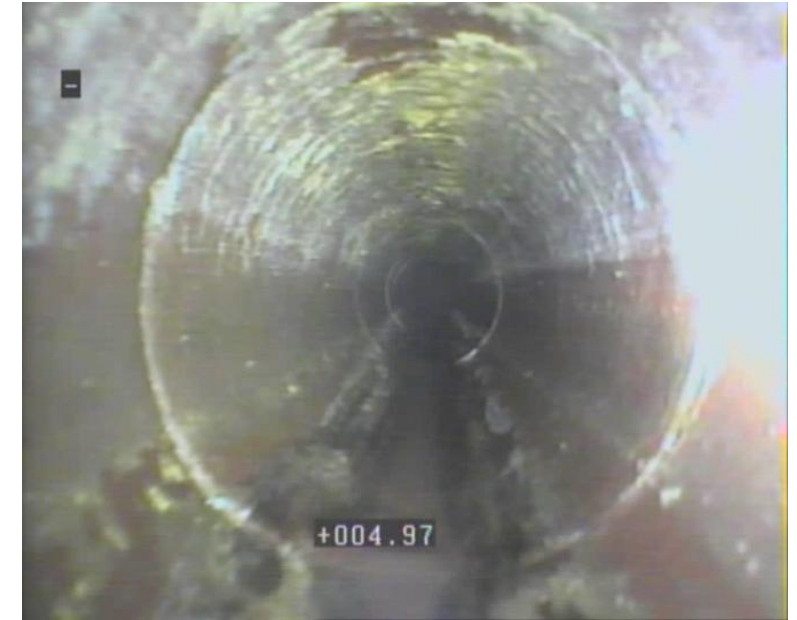
Defect Start (m)	Defect End (m)	Defect Length (mm)	Defect Max Current	Defect Severity
3.951	3.951	0	161	S

Defect Identified: Joint Defect  
CCTV Call Out: None



Defect Start (m)	Defect End (m)	Defect Length (mm)	Defect Max Current	Defect Severity
4.563	4.563	0	116	S

Defect Identified: Joint Defect  
CCTV Call Out: None



Defect Start (m)	Defect End (m)	Defect Length (mm)	Defect Max Current	Defect Severity
5.072	5.072	0	112	S

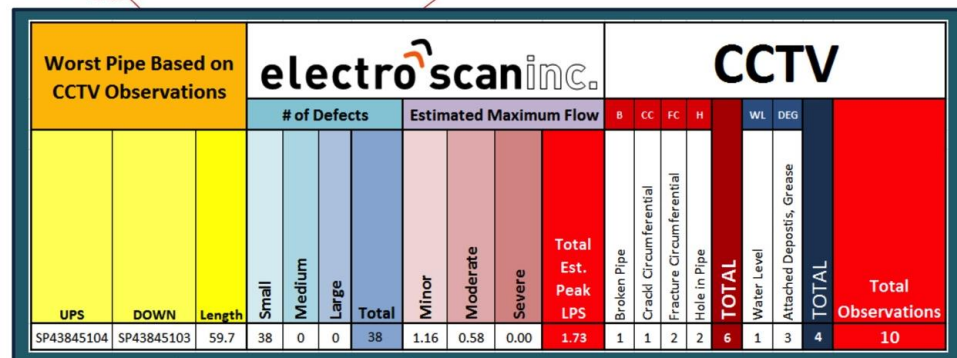
# Withybrook, England



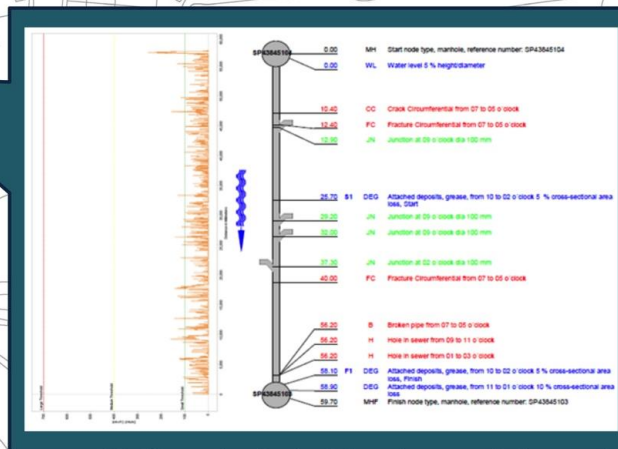
Electro Scan Product Trial  
Presented to Severn Trent Services  
Birmingham, England



## 'Worst Pipe' Based on CCTV Observations



## MH 5104 to MH 5103



DO NOT SCALE  
USE WRITTEN DIMENSIONS ONLY

## HEALTH & SAFETY

### SIGNIFICANT RESIDUAL RISKS




ORIGINATOR	MH	DRAWN	MH	DATE	27/11/13
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SEVERN  
TRENT

PROJECT TITLE	A5S/11496 WITHYBROOK FAS
---------------	--------------------------

WITHYBROOK SEWER PLAN  
(SHEET 2 OF 2)

ISSUE STATUS			
SCALE	DWG NO	REV	ORIGINAL SHEET
1:500	A5S-11496-CA002	-	A1

		Severn Trent Water Ltd		OnSite Central Limited Blackpole, Worcester Worcestershire WR3 8TJ Tel. Fax	
<h3 style="text-align: center;">Project-information</h3>					
Project name: ASS/11496 Withybrook FA		Contract number: CS2021		Contact: Gary Kinley	
				Date: 03/07/2013	

Client	<b>Severn Trent Water Ltd</b>
Contact:	<b>Gary Kinley</b>
Position:	
Road	<b>Longbridge Office, Stratford Road</b>

		Seven Trent Water Ltd		OnSite Central Limited Blackpool, Worcester Worcestershire WR3 8TJ Tel: Fax:	
<h2>Inspection report</h2>					
Date: 05/06/2013		Job N°: C5021		Weather: No rain or snow	
Operator: MH		section number: 4		P/LR: SP43544503X	
Video Volume No.: 00001		Flow Cnt: No flow control		Temperature: above freezing	
Year laid: Z		Cleaned: No		Strat. Drain: No	
Road: OVERTSTONE ROAD		Div/Std:		start MH: SP43544503	
Place: WHITHYBROOK		Drain. Area:		end MH: SP435445031	
Location: Road		Standard: BS EN 13509-2:2003		Total length: 47 m	
Purpose: Other		Shape/Size: Circular 150		Circular 150	
Type: Gravity drain/sewer		Material:		Vitrified clay (i.e. all clayware)	
Use: Foul		Lining:		Pipe length: 1.	
Comment:					

Site  
Contact:  
Position:  
Road  
Town  
County  
Telephone:  
Fax:  
Mobile:  
E-Mail:

Contractor  
Contact:  
Position:  
Road  
Town  
County  
Telephone:  
Fax:  
Mobile:  
E-Mail:

1:275 pos#

Depth: 1.42

SP43844302

Severn Trent Water Ltd

**OnSite™**

**Inspection report**

OnSite Central Limited  
Blackpole, Worcester  
Worcestershire WR3 8TJ  
Tel. Fax.

Date: 06/06/2013	Job N°: C52021	Weather: No rain or snow	Operator: MH	section number: 14	PLR: SP43844301X
Video Volume No.: 90091	Flow Ctrl: No flow control	Temperature: above freezing	Year laid: Z	Cleaned: No	Strat. Diam: not known

Road: MAIN STREET	Dir/Dist: Drain Area: BS EN 13508-2:2003	start MH: SP43844301
Place: WHITHYBROOK		end MH: SP43844302
Location: Road		Total length: 42.8 m

Purpose: Other	Shape/Size: Circular 150	Pipe length: 1m
Type: Gravity drain/sewer	Material: Vitrified clay (i.e. all clayware)	
Use: Foul	Lining Type:	

Comment:

1:325	position	code	observation	MPEG	photo	grade
Depth: 1.49						
0.00	MH	Start node type, manhole, reference number: SP43844301	00:00:00		(Misc)	
0.00	WL	Water level 5 % height/diameter	00:00:00		(Serv)	
11.30	RFJ	Fine Roots at joint	00:01:19		(Serv)	
12.40	RFJ	Fine Roots at joint	00:01:38		(Serv)	
13.90	RFJ	Fine Roots at joint	00:01:58		(Serv)	
16.60	RMJ	Mass Roots at joint 5 % cross-sectional area loss	00:02:28		(Serv)	
17.00	CC	Crack Circumferential from 07 to 05 o'clock	00:02:40		(Strud)	
30.80	FC	Fracture Circumferential from 07 to 05 o'clock	00:04:33		(Strud)	
42.80	MHF	Finish node type, manhole, reference number: SP43844302	00:06:32			

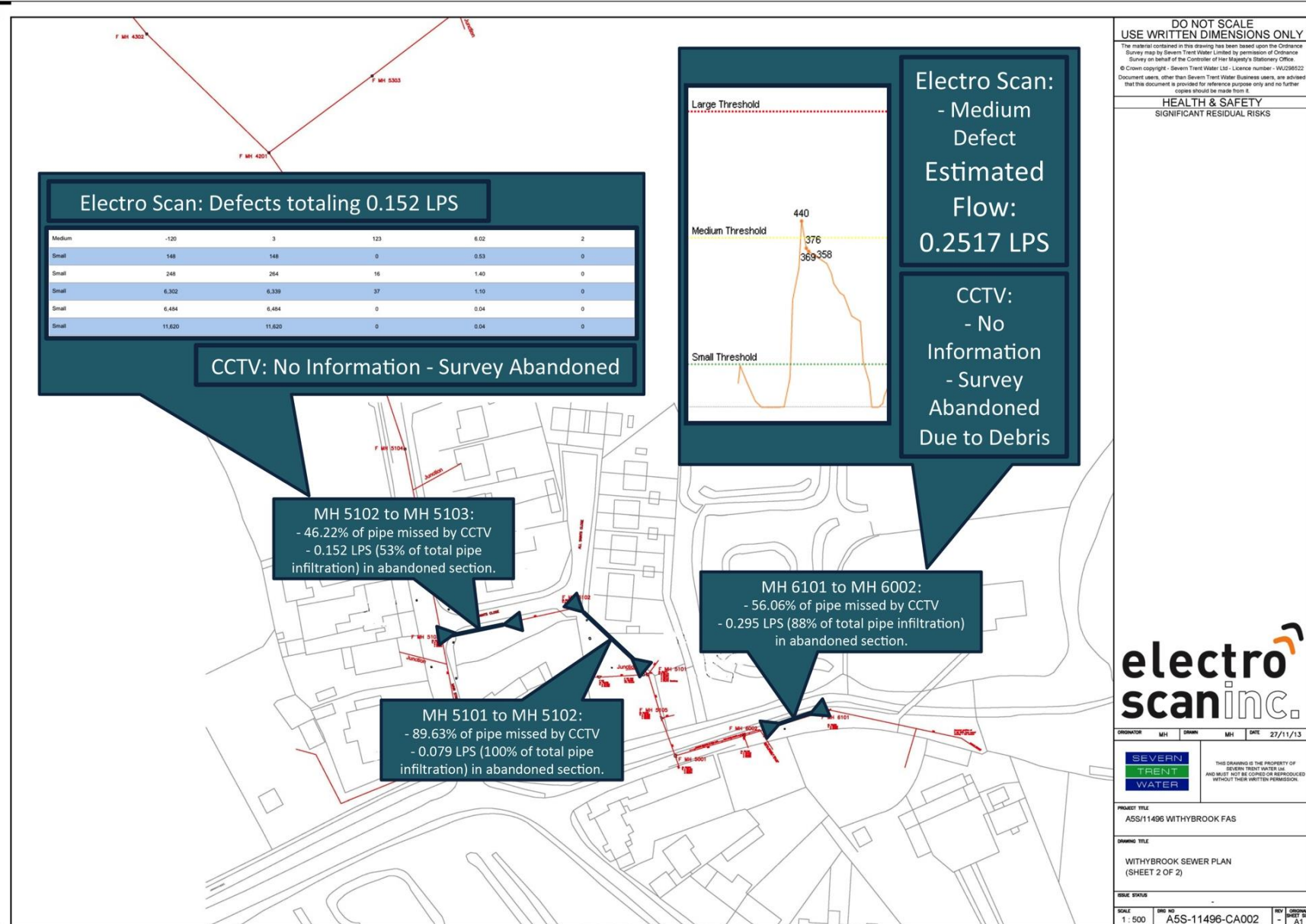
Structural Defects

Service Defects

Contaminational Problems

Miscellaneous Features

# 'Defect Flows' Missed by Prior CCTV 'Abandoned Surveys'





## Withybrook

TOTALS	976.8	552	12	8	572	343.07	159.14	52.88	555.09	555.09	791,187.6	2	1	45	1	8	1	0	4	2	2	66	2	1	2	18	0	0	23	32	2	6	14	5	2	11	1	1	0	0	6	18	13	111	0	0	0	2	7	9	209
--------	-------	-----	----	---	-----	--------	--------	-------	--------	--------	-----------	---	---	----	---	---	---	---	---	---	---	----	---	---	---	----	---	---	----	----	---	---	----	---	---	----	---	---	---	---	---	----	----	-----	---	---	---	---	---	---	-----

# Innovation Bulletin



18<sup>th</sup> February 2014  
Ref: ABC 0000  
(for completion by Standards Team)



## Electro Scan

The Next Generation in Sewer Leak Detection | Finding Infiltration Missed by CCTV

### Brief description

Electro Scan is a revolutionary technology that locates defects having the potential for causing infiltration into sewers and other pipes. Not dependant upon any visual identification of infiltration at the time of the survey, the solution provides an estimated liters per second (l/s) for each defect. Most sewer pipe materials such as clay, plastic, concrete, reinforced concrete, resin linings, and brick are poor conductors of electrical current. As a result, if a defect exists in the wall of a pipe, then the leakage of electrical current will indicate the source of a potential water leak, whether or not water infiltration or exfiltration actually occurs at the time of the Electro Scan.

Electro Scan has been in the UK for just over a year, and has been adopted by two other UK water companies, after multiple catchment studies. Recently, Severn Trent Services completed two successful trial projects.

### Benefits

The Electro Scan technology is able to:

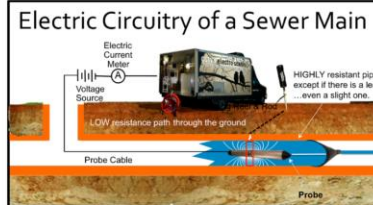
- Automatically locates sources of infiltration, whether visible or not, in pipes 75mm to 600mm
- Measure and quantify each defect found (estimated LPS of infiltration), no matter the weather conditions
- Provide repeatable, objective data
- Performed without specialized certification
- Help prioritize rehabilitation programs
- Certify relined pipes and repairs as "leak-free"
- Evaluate surcharged pipes (including siphons) without the need to bypass or empty
- Maintain an almost-zero survey abandonment rate
- Perform scans in pipes filled with fats, oils, and grease (FOG)
- Immediately processes data and presents it in a cloud-based application

With treatment works processing from 10-40% of water that should drain into rivers & streams, contributes to the reduction of our carbon footprint by reducing pump runtimes. CCTV Truck add-on for large mains or push rod versions available.



### Details

Electro-scanning is carried out by applying an electrical potential (voltage) between an electrode (probe) in an electrically nonconductive pipe and a grounding stake on the surface. The water in the pipe is at a level that ensures that the pipe is full at the probe location, during the survey. The probe is pulled through the pipe at a speed of 10 m/minute and the variation of electric current flowing between the probe and the fixed electrode on the surface is measured. When the probe is close to a pipe defect the electric current increases because the defect decreases the electrical resistance of the pipe wall. All data is automatically collected and sent to a web-based cloud platform for instant processing and display.



For further  
information contact:

[sean@anthire.com](mailto:sean@anthire.com)

or

[info@electroscan.com](mailto:info@electroscan.com)





# Monterey, California

July 2015



17 Mile Drive  
→  
Pebble Beach



	Scans	Distance	S	M	L	GPM	GPD	GPD/IDM
Total:	3	1,032	40	5	5	40.84	58,810	123,261

Date	Mainline (From.. To..)	Pipe Type	Diameter							
7/8/2015	G12-015 to G12-007	VCP	1	200.1	10	2	2	11.80	16,992	74,732



G12-015 to G12-007



DEFECTS	% OF DEFECT LENGTHS	GPM SUMMARY	DIAMETER & DISTANCE	OPERATOR INFO
S 10	Small Defects 0.003100	Minor GPM 12.138	6	Tech Electronics
M 2	Medium Defects 0.001900	Medium GPM 3.800	200.00 ft	Project
L 2	Large Defects 0.001900	Severe GPM 5.870		Phone
	All Defects 0.006900	Total GPM 11.808		Job
		GPM per Scan 16.992		Scan Start
		Minor GPM % 18.03%		Atmospheric Test
		Medium GPM % 32.28%		7/8/2015 9:27:47 AM
		Severe GPM % 49.75%		

DEFECT CURRENT	Machine: MH-100	Diameter: 6 inches	Pipe Type: VCP	Soil Type: Ground Condition:

**Total Defect Flow: 11.8 GPM**

**July 8, 2015**



	Scans	Distance	S	M	L	GPM	GPD	GPD/IDM
<b>Total:</b>	<b>3</b>	<b>1,032</b>	<b>40</b>	<b>5</b>	<b>5</b>	<b>40.84</b>	<b>58,810</b>	<b>123,261</b>

Date	Mainline (From.. To..)	Pipe Type	Diameter	Distance (ft)	Small	Medium	Large	GPM	GPD	GPD/IDM
7/8/2015	G12-015 to G12-007	VCP	1	200.1	10	2	2	11.80	16,992	74,732
	D08-049 to D08-020	CIPP	2	331.4	12	2	2	17.93	25,819	27,428
	D08-019 to D08-020	CIPP	3	500.4	18	1	1	11.11	15,998	21,101



G12-015 to G12-007



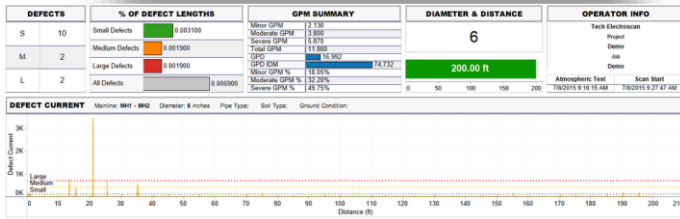
D08-049 to D08-020



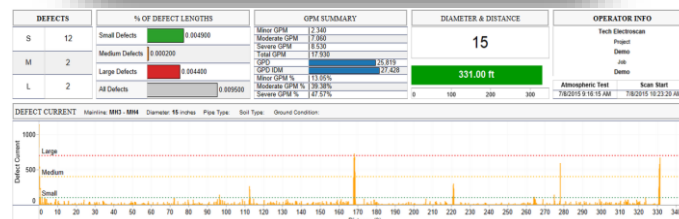
D08-019 to D08-020



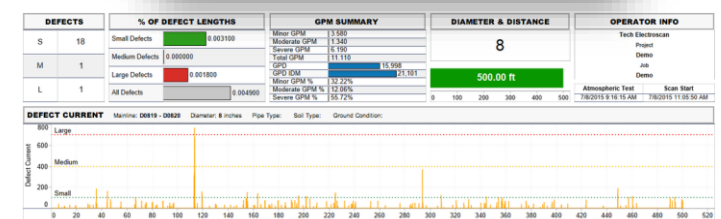
Dale Hartley  
WRc



Total Defect Flow: 11.8 GPM



Total Defect Flow: 17.93 GPM



Total Defect Flow: 11.11 GPM

July 8, 2015

# CIPP Acceptance Video By Contractor

P/O No.	Pipeline Segment Reference	Date	Time	Location (Street Name and number)	Locality
14077	Shot 12 CITY ID L12	20150205	06:18	DELA VINA AVENUE	Monterey CA

Further Location of	Rim to Grade

Downstream Manhole	Height
D08-020	8

Width	Shape	Media Number
	Circular	

Purpose	
C	

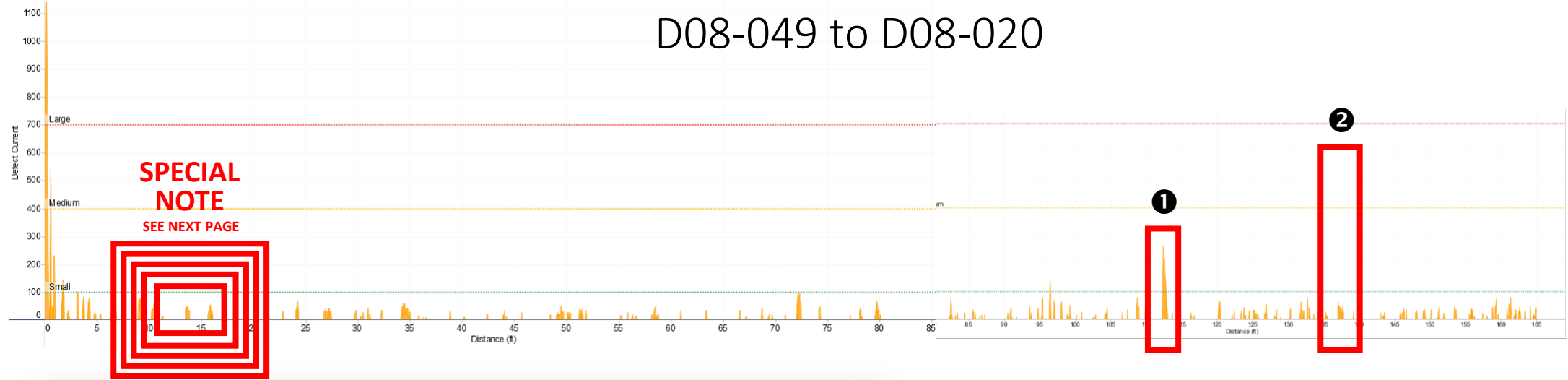
Distance (Feet)	Group/Description	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Rating	Quick	Index
0.0	AMH	0	0	0	0	0	0	0000	
0.0	MWL								
33.6	TB								
37.8	TF								
117.4	TF								
123.4	TB								
140.7	TB								
255.3	TF								
286.5	TF								
332.3	TB								
358.3	TB								
390.6	TB								
506.7	AMH								

End Inspection MH D08-020

Segment	Structural								O & M								Overall							
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Rating	Quick	Index	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Rating	Quick	Index	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Rating	Quick	Index
14077_D08-019_D08-020_20150205_06 18	0	0	0	0	0	0	0000		0	0	0	0	0	0	0000		0	0	0	0	0	0	0000	



# D08-049 to D08-020



# D08-049 to D08-020

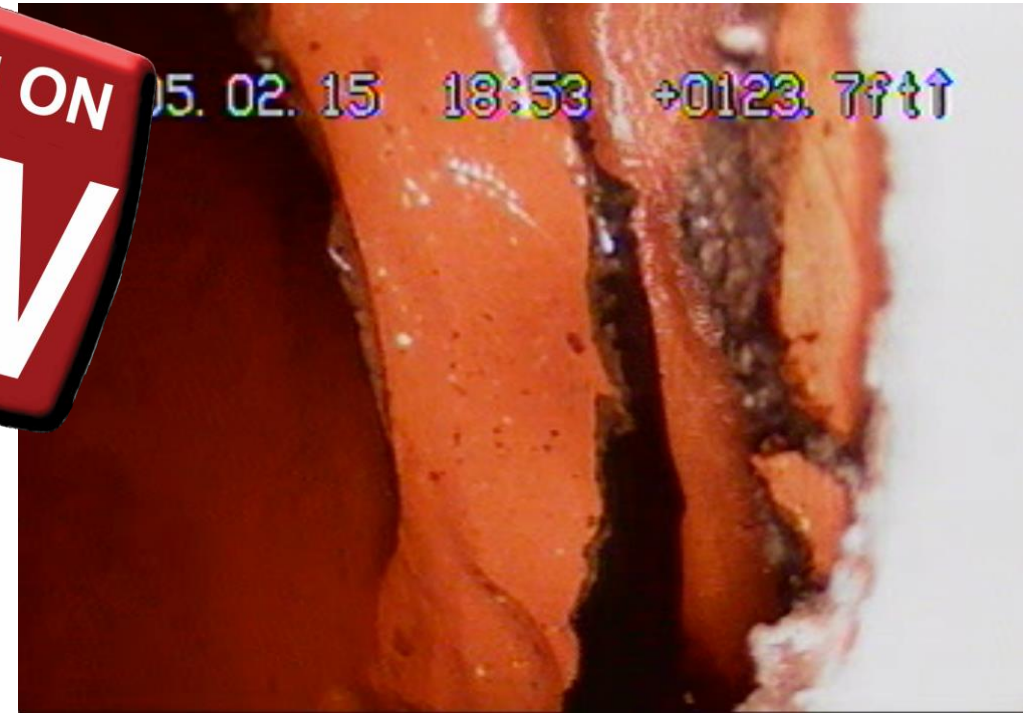
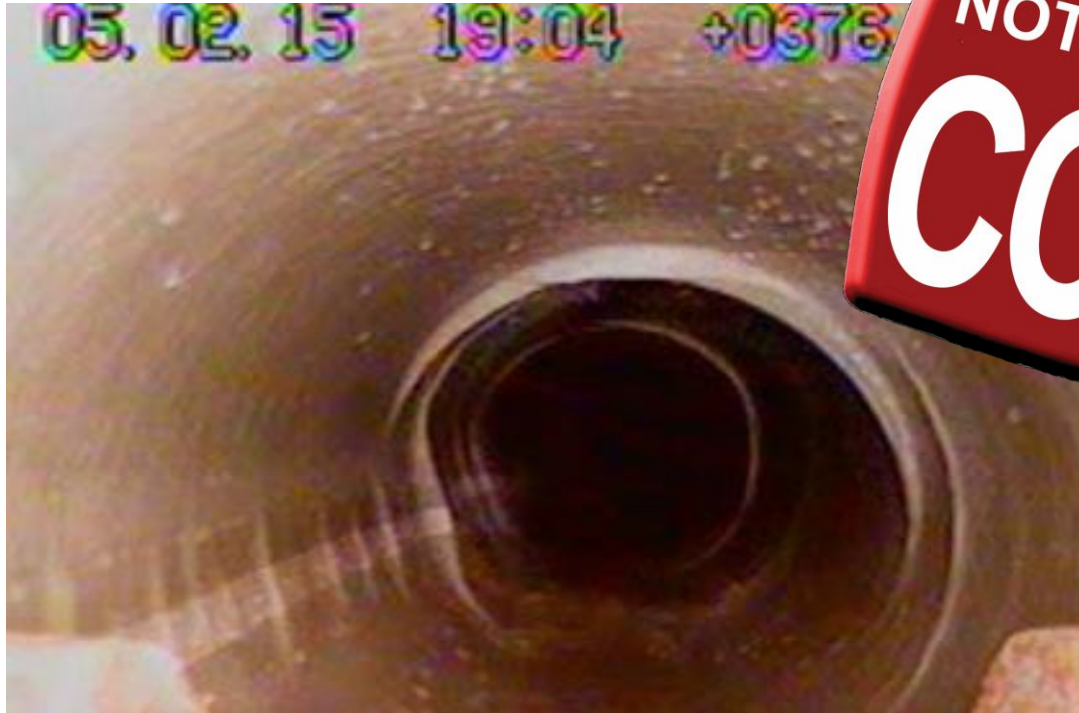
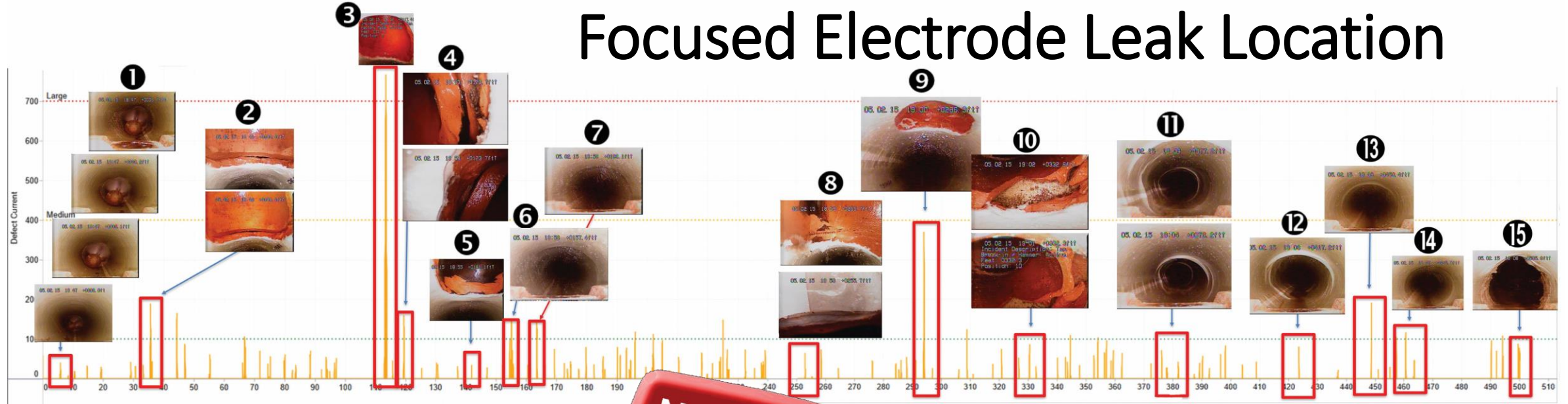
<b>Surveyors name</b> Jose Aguilar	<b>Certificate Number</b> 0	<b>System Owner</b> City of Monterey CA	<b>Survey Customer</b> City of Monterey CA	<b>Drainage Area</b>	<b>Sheet</b> 1
<b>P/O No.</b> 14077	<b>Pipeline Segment Reference</b> Shot 13 POST. City ID L15	<b>Date</b> 20150203	<b>Time</b> 05:39	<b>Location (Street Name and number)</b> Del Monte Ave	<b>Locality</b> Monterey CA
<b>Further Location details</b>		<b>Upstream Manhole Number</b> D08-049	<b>Rim to Invert</b>	<b>Grade to Invert</b>	<b>Rim to Grade</b>
<b>Downstream Manhole Number</b> D08-020	<b>Rim to Invert</b>	<b>Grade to Invert</b>	<b>Rim to Grade</b>	<b>Use of Sewer</b> Sanitary	<b>Direction</b> Downstream
				<b>Flow Control</b>	<b>Height</b> 15
<b>Width</b>	<b>Shape</b> Circular	<b>Material</b> VCP	<b>Ln. Method</b> CP	<b>Pipe Joint Length</b>	<b>Total Length</b> 344
					<b>Length Surveyed</b> 338.3
					<b>Year Laid</b>
					<b>Year Rehabilitated</b>
					<b>Tape / Media Number</b>
<b>Purpose</b> C	<b>Sewer Category</b>	<b>Pre-Cleaning</b> Jetting	<b>Cleaned</b>	<b>Weather</b>	<b>Additional Information</b>

Distance (Feet)	Code		Continuous defect	Value			Joint	Circumferential Location		Image Ref.	Struct. Grade	O&M Grade	Remarks	
	Group/ Descriptor	Modifier/ severity		S/M/L	Inches			%	At / From					To
					1st	2nd								
0.0	AMH												Starting Manhole: D08-049	
0.0	MWL					0								
28.9	TF	A			6			10						
76.2	TF	A			6			10						
107.2	TB	A			4			10						
112.9	TB	A			4			10						
124.6	TF	A			6			10						
172.1	TF	A			6			10						
195.7	TB	A			4			10						
214.2	TB	A			6			12						
224.0	TB	A			4			10						
272.4	TB	A			4			10						
338.3	AMH												End Inspection MH D08-020	

Segment	Structural							O & M							Overall									
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Rating	Quick	Index	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Rating	Quick	Index	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Rating	Quick	Index
14077_D08-049_D08-020_20150203_05 39	0	0	0	0	0	0	0000		0	0	0	0	0	0	0000		0	0	0	0	0	0	0000	



# Focused Electrode Leak Location

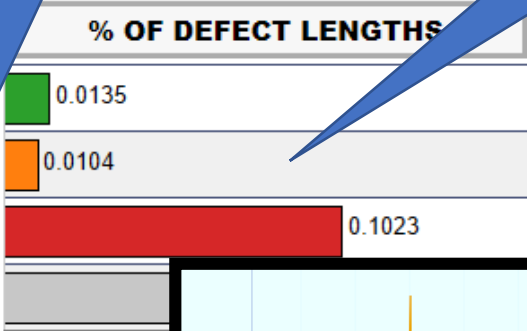


Total # of Defects

% of Pipe Defective by Length

Estimated Leakage Rate

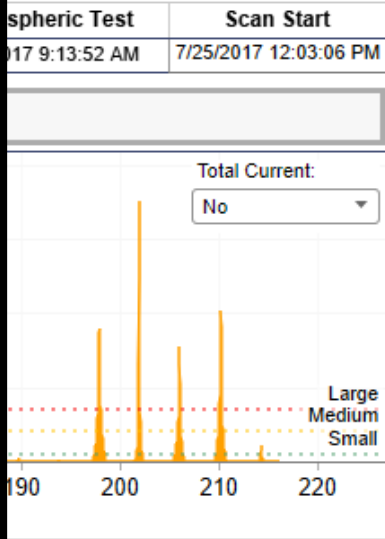
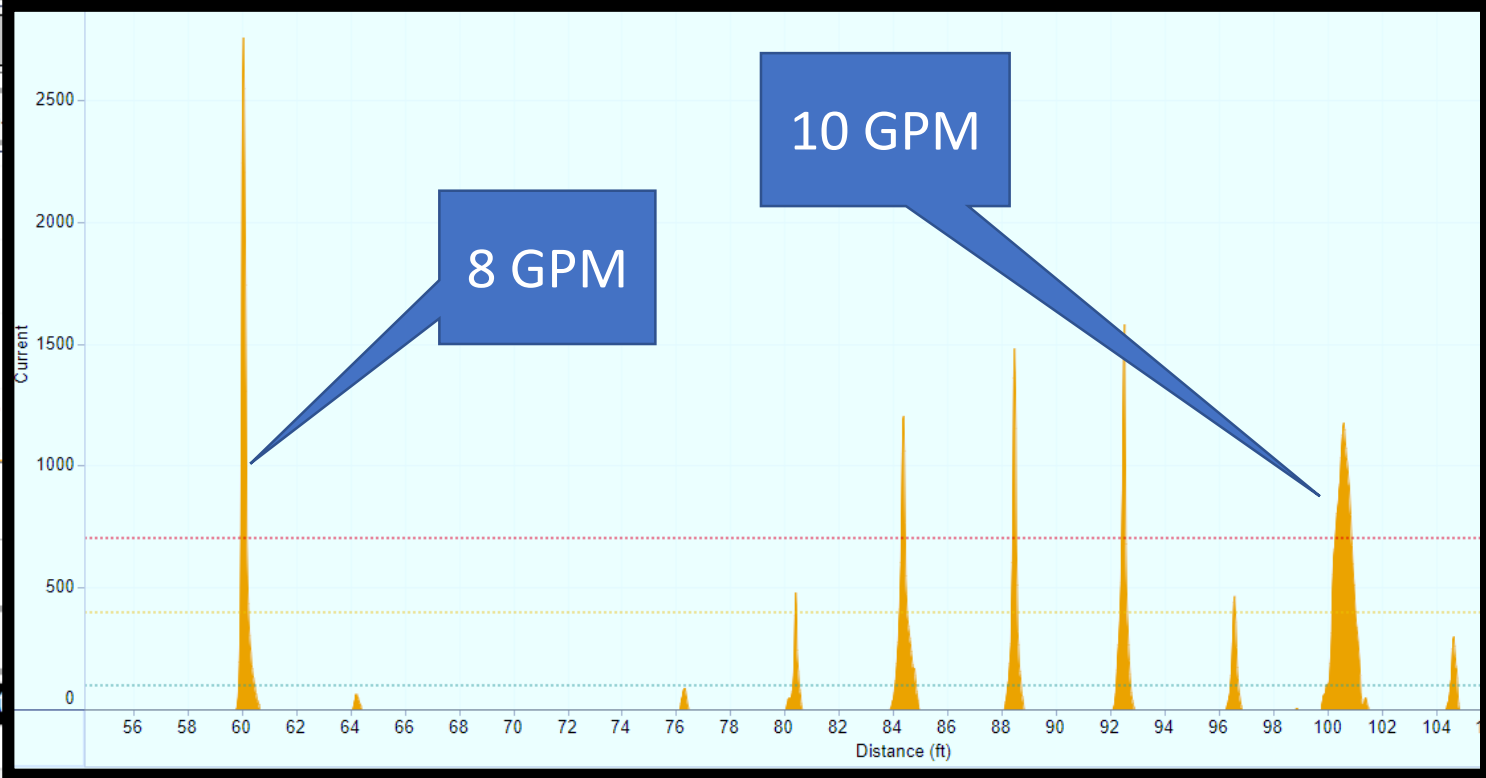
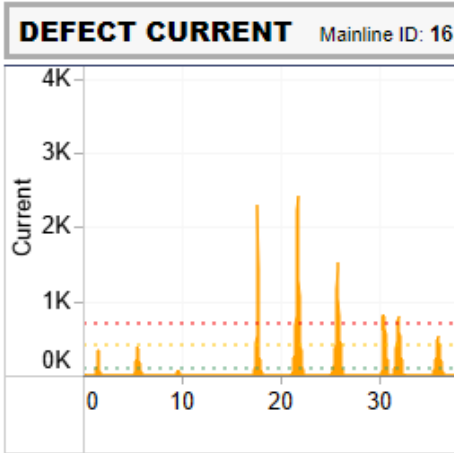
DEFECTS	
Small	12
Medium	6
Large	28
All Defects	46



GPM SUMMARY	
Minor	5.000
Moderate	26.800
Severe	188.650
Total GPM	220.450
GPD	317,448
GPD IDM	969,697
Minor %	1.90%

DIAMETER & DISTANCE	
Diameter	8
Distance	216.00 ft

OPERATOR INFO	
Tech	Tech Electroscan
Project	
Demo	
Job	
Demo	

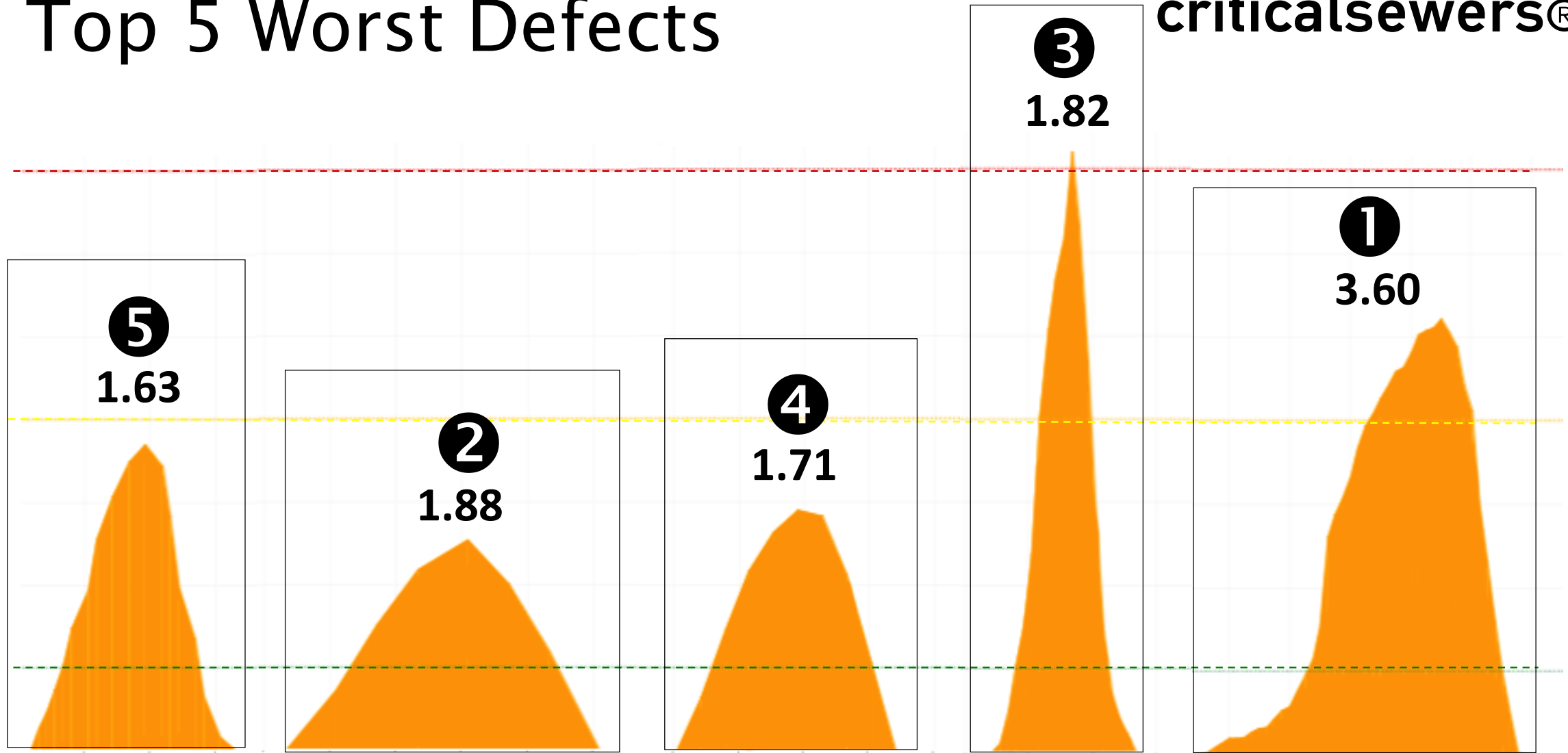


DEFECT BY LOCATION	
Defect Grade	Defect Start (ft)
S	0.05
S	1.53
S	5.51
L	17.70
I	21.75

GPD/IDM	
	704
	4,619
	8,490
	27,404
	12,087



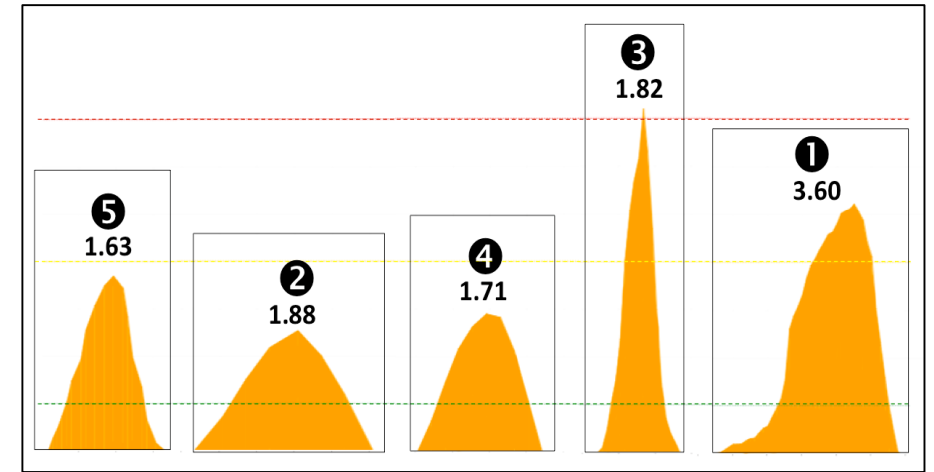
# Top 5 Worst Defects



Top 5 Defects =  $3.60 + 1.88 + 1.82 + 1.71 + 1.63 = 10.64 \text{ GPM}$

# Defect Start, End, and Length criticalsewers®

- No Visual Interpretation
- No Third Party Data Analysis
- GPM, GPD, GPD/IDM



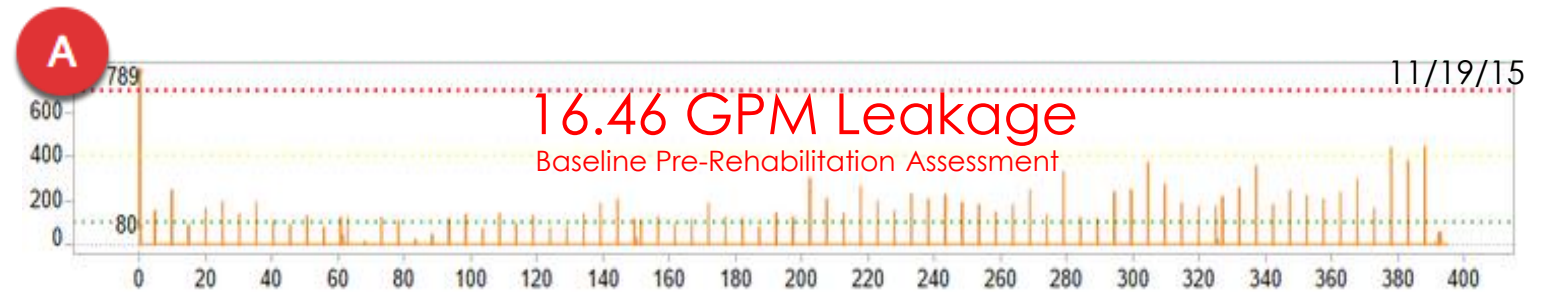
	Defect Start (ft)	Defect End (ft)	Length of Defects (ft)	GPM	% of GPM	GPD	GPD/IDM	
Total:				24,870	99.96%	35,813	56,480	
<b>DEFECT BY LOCATION</b> Mainline ID: 20BC-15 - 20BC-8 Pipe ID: 20BC-15 - 20BC-8 Diameter: 8 inches Pipe Type: Not Known Soil Type: Ground Condition:								
Defect Grade	Defect Start (ft)	Defect End (ft)	Length of Defects (ft)		GPM	% of GPM	GPD	GPD/IDM
M	342.10	342.73	0.62	①	3.60	0.14	5,184	8,176
S	13.22	13.74	0.52	②	1.88	0.08	2,707	4,270
L	207.34	207.61	0.28	③	1.82	0.07	2,621	4,133
S	22.78	23.23	0.45	④	1.71	0.07	2,462	3,883
S	8.59	8.99	0.40	⑤	1.63	0.07	2,347	3,702
S	107.39	107.87	0.48		1.09	0.04	1,570	2,475
S	98.33	98.76	0.43		1.07	0.04	1,541	2,430
S	391.52	391.85	0.32		0.79	0.03	1,138	1,794
S	141.49	141.72	0.23		0.72	0.03	1,037	1,635
S	212.19	212.49	0.30		0.68	0.03	1,037	1,635
S	12.12	12.12	0.00		0.00	0.00	0.00	0.00



# How To Find Leaks & Certify Rehab As Watertight?

Date	Pipe ID	Diameter	Pipe Type	Distance (ft)	Small Defects	Medium Defects	Large Defects	GPM	GPD	GPD/IDM
11/19/2015	<b>A</b> 1-35 - 1-34	8	VCP	395.1	64	2	1	16.46	23,702	39,592

## 1. INSPECT

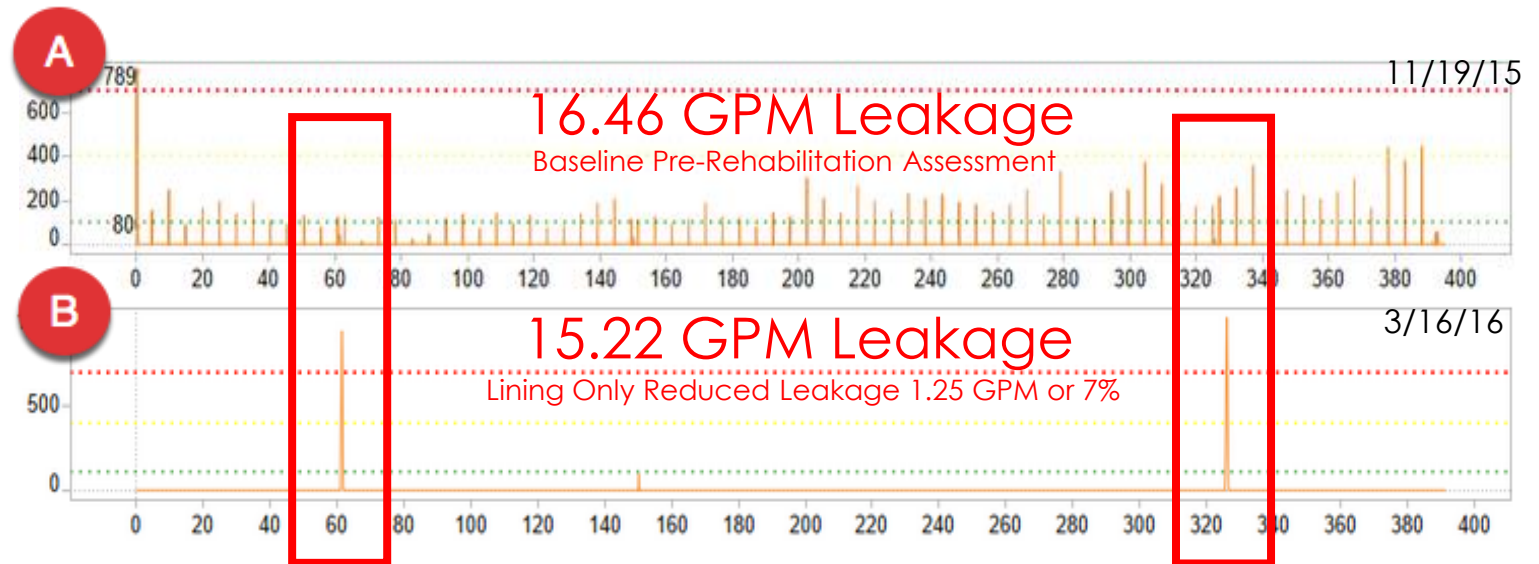


# How To Find Leaks & Certify Rehab As Watertight?

Date	Pipe ID	Diameter	Pipe Type	Distance (ft)	Small Defects	Medium Defects	Large Defects	GPM	GPD	GPD/IDM
11/19/2015	A 1-35 - 1-34	8	VCP	395.1	64	2	1	16.46	23,702	39,592
3/16/2016	B 1-35 - 1-34	8	CIPP	391.3	0	0	2	15.22	21,917	36,968

## 1. INSPECT

## 2. TEST





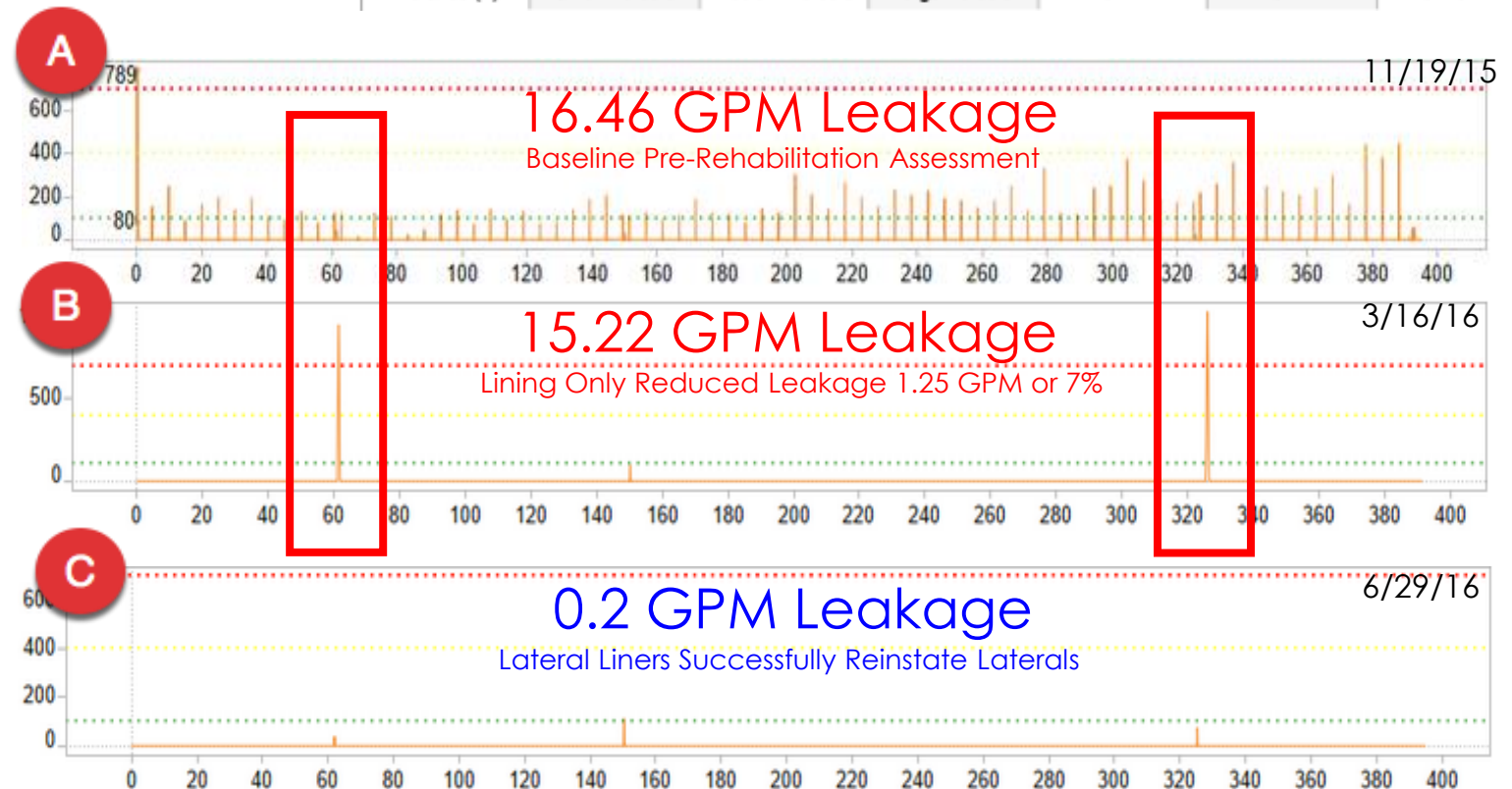
# How To Find Leaks & Certify Rehab As Watertight?

Date		Pipe ID	Diameter	Pipe Type								
11/19/2015	A	1-35 - 1-34	8	VCP	395.1	64	2	1	16.46	23,702	39,592	
3/16/2016	B	1-35 - 1-34	8	CIPP	391.3	0	0	2	15.22	21,917	36,968	
6/29/2016	C	1-35 - 1-34	8	CIPP	394.8	1	0	0	0.20	288	481	
					Distance (ft)	Small Defects	Medium Defects	Large Defects	GPM	GPD	GPD/IDM	

## 1. INSPECT

## 2. TEST

## 3. CERTIFY



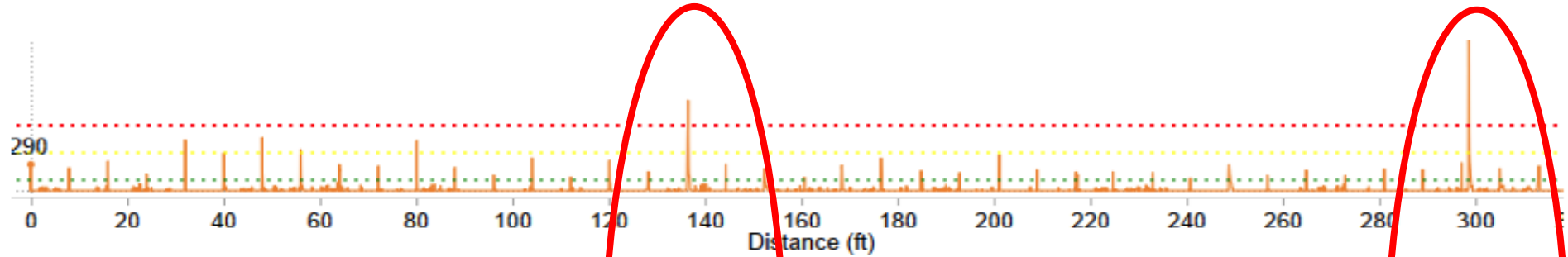


# Repeatability Test

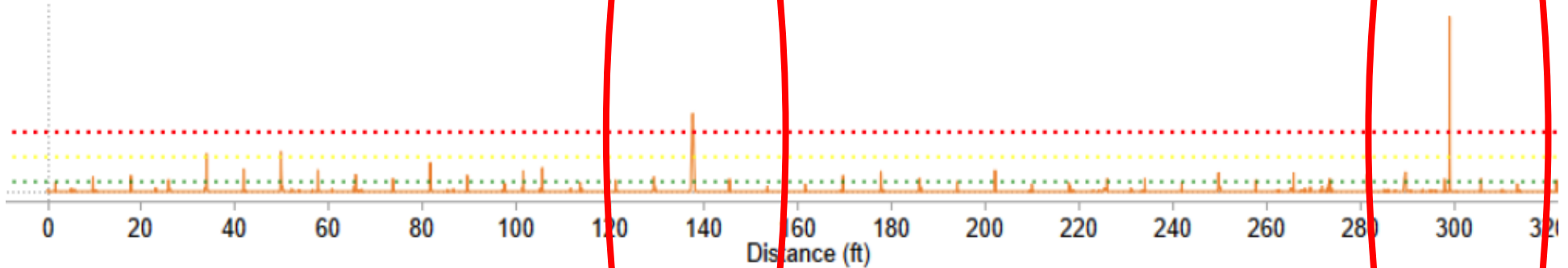
WR<sub>c</sub>

Same Pipe, Same Equipment, Same Day

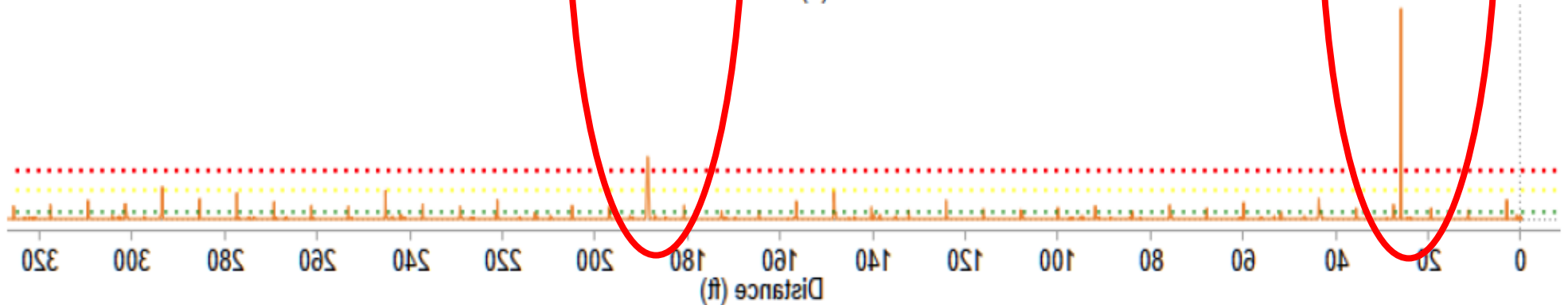
Scan 1



Scan 2

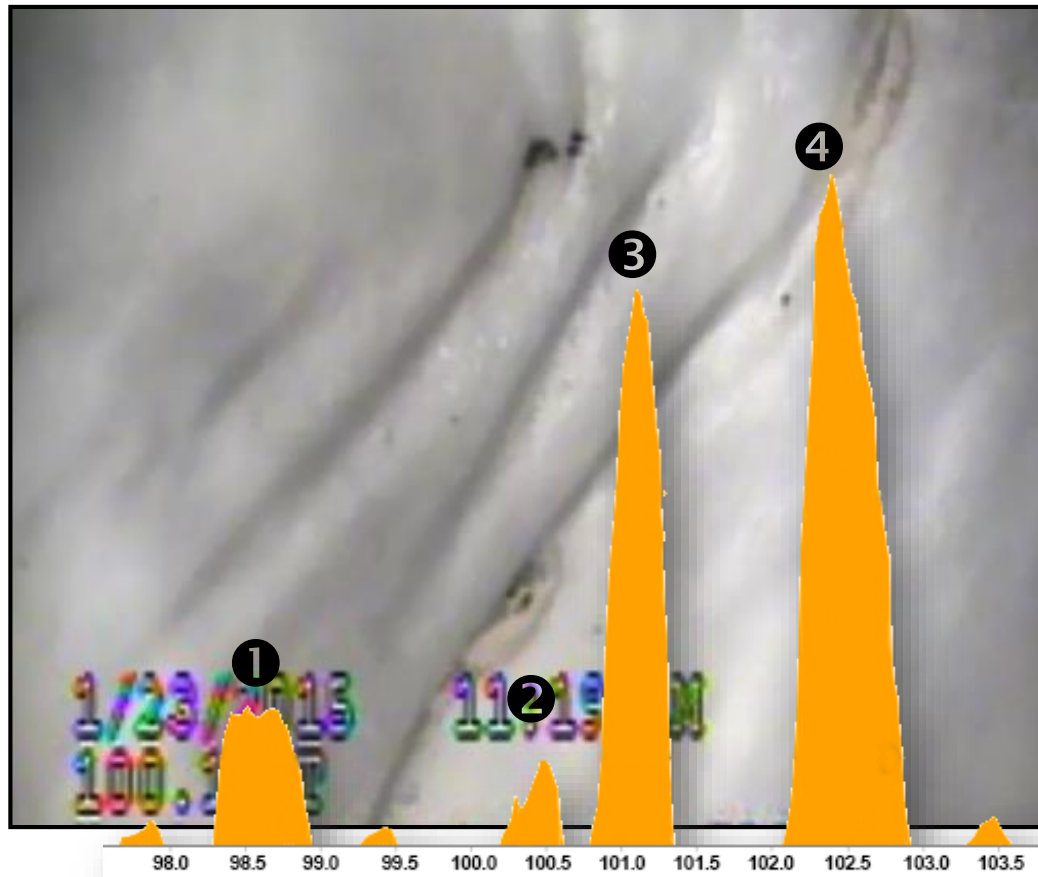


Scan 3



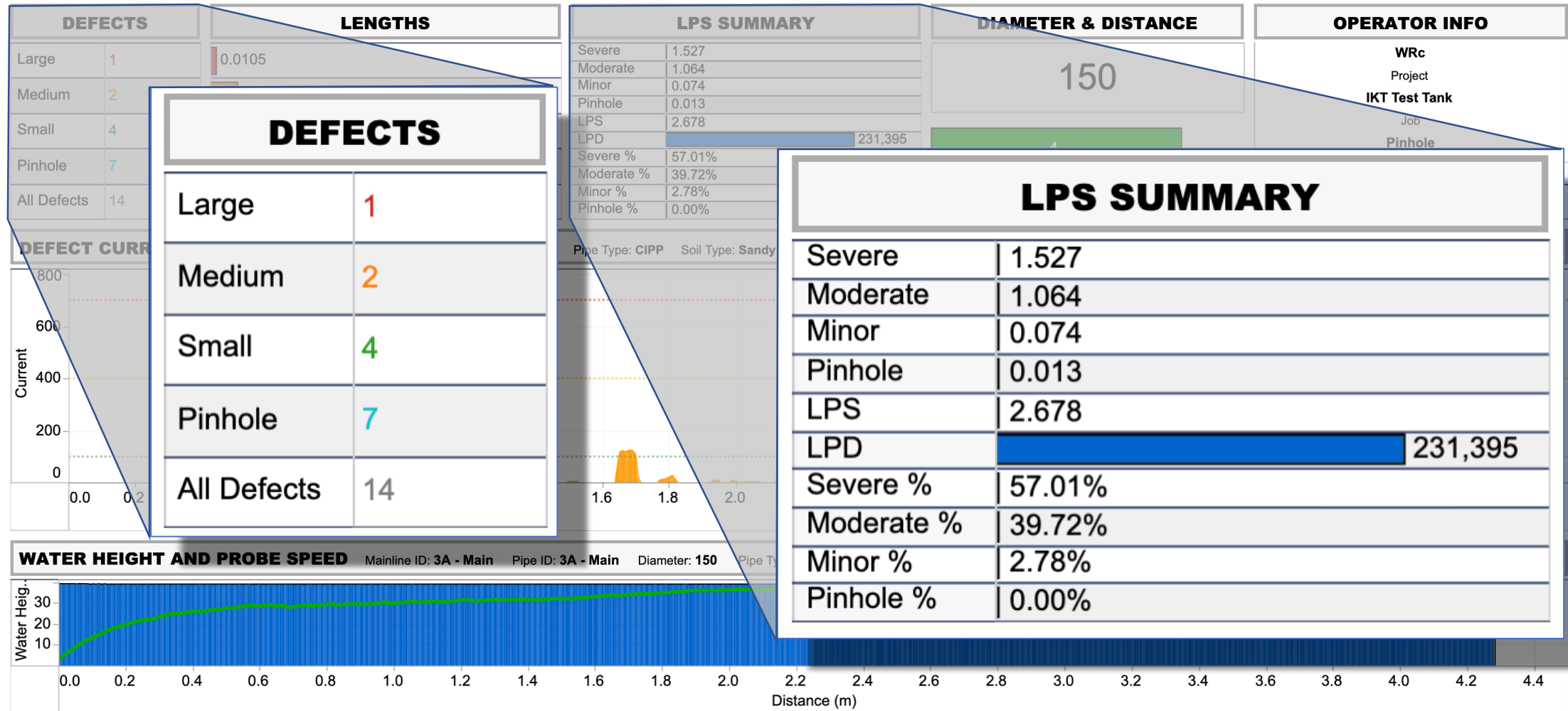


# Blisters, Buckling, Cuts, Fins, Folds, Ridges, Wrinkles



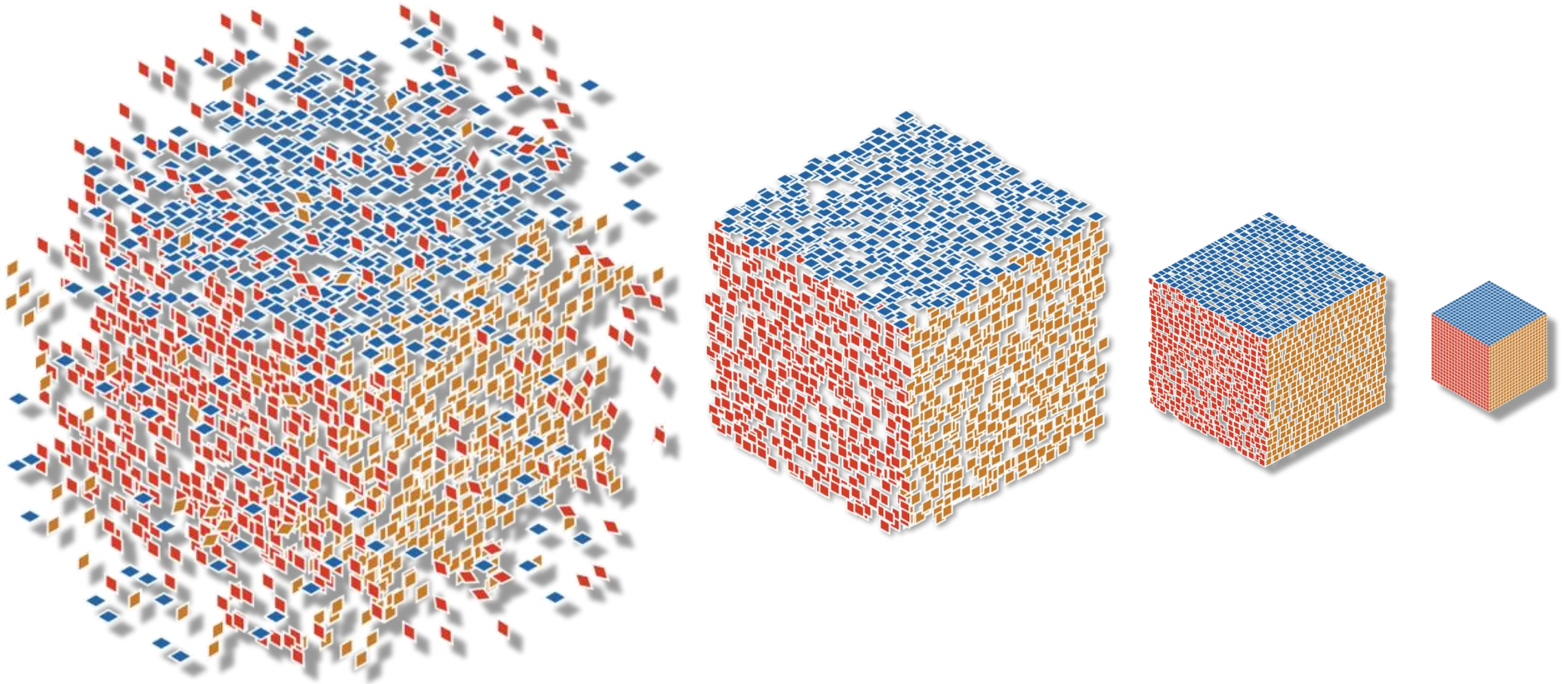
...Leak.

# Since Pinholes Were Not Originally Calculated New Software Was Developed





# Electro Scan is Only One Piece of the Puzzle



# Electro Scan is Only One Piece of the Puzzle



ACOUSTIC



AI-CCTV



REHABILITATION



DYE TESTING



FELL



LASER



SMOKE



SONAR



GIS



SSOs



IoT



MANHOLE



BACKUPS



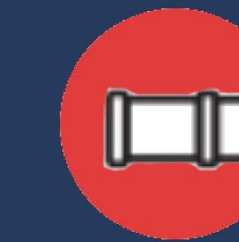
WORK ORDERS



CAPITAL



CRM



MAINS



LATERALS



# **CAPITAL ALLOCATION**



**REPAIR**

**REPLACE**

**RENEW**

# Predictive Capital Investments

## Age-Based Renewal



Risk Group	Length of Pipe (miles)
A	27.32
B	49.39
C	341.96
D	452.33
E	6.94
F	17.07
G	0.14
H	140.92
Z	1827.26





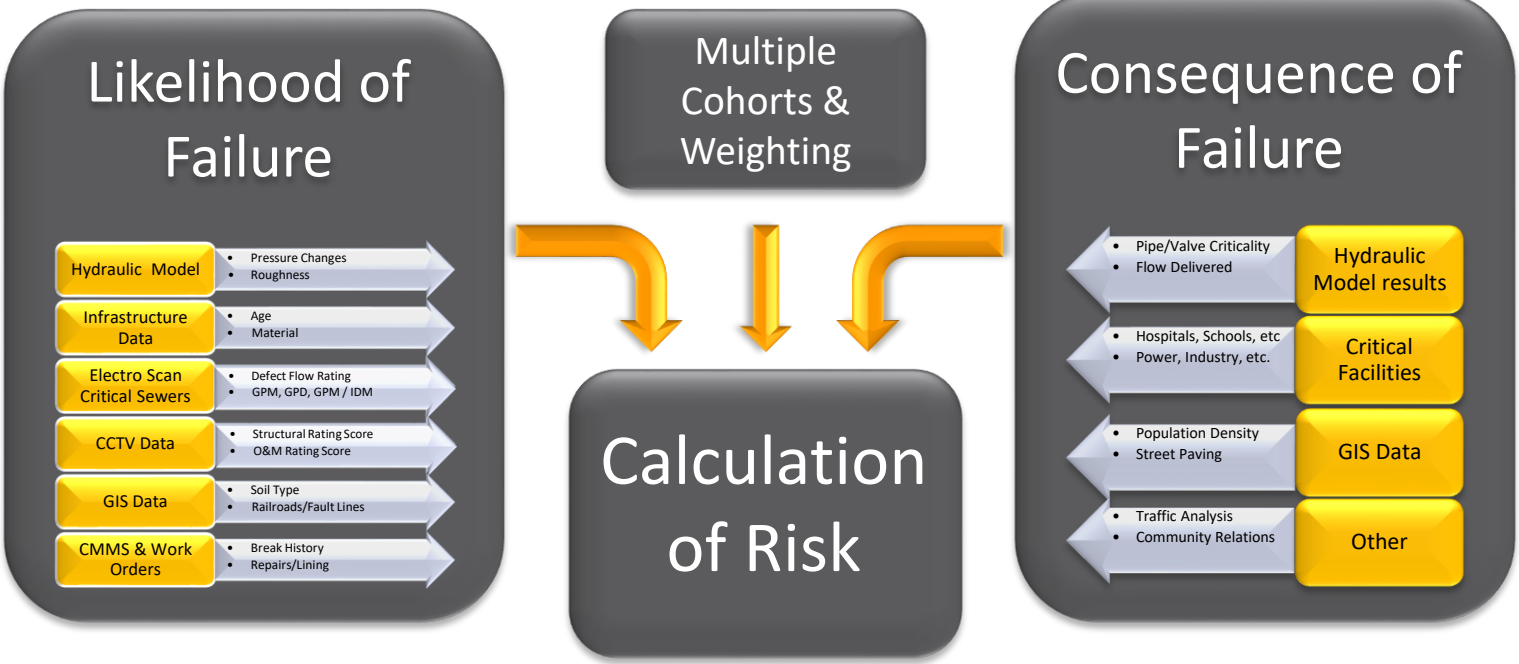
# Predictive Capital Investments

## Age-Based Renewal



Risk Group	Length of Pipe (miles)
A	27.25
B	49.39
C	341.96
D	452.33
E	6.94
F	17.07
G	0.14
H	140.92
Z	1827.26

## Condition-Based Renewal



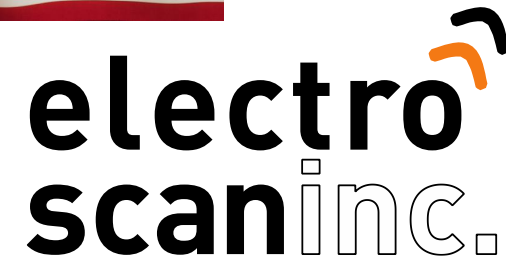
# Thank You



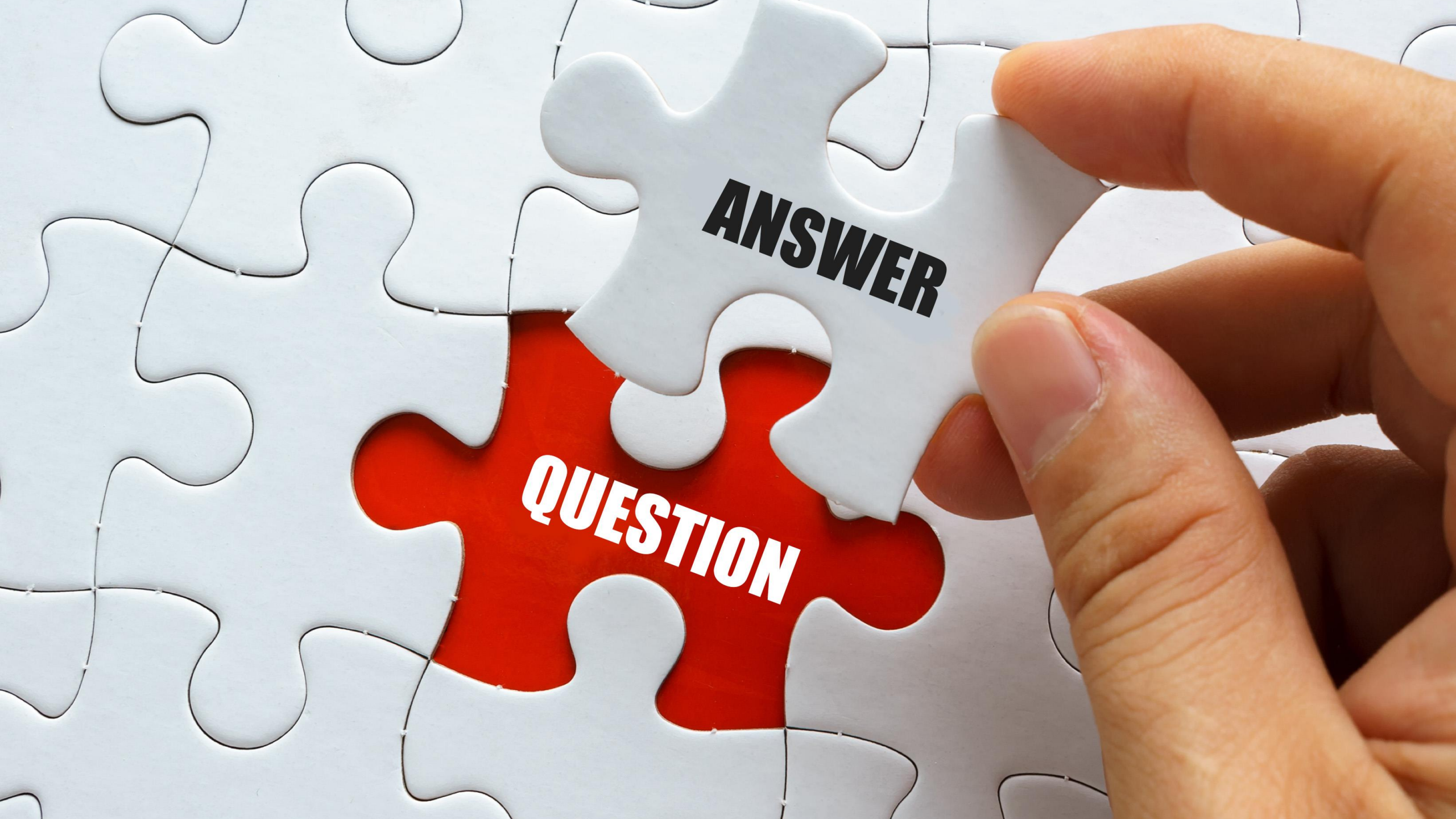
Peter Henley  
Special Consultant  
WRc plc



Chuck Hansen  
Chairman  
Electro Scan Inc.







**ANSWER**

**QUESTION**