Asset Management

Sewer Conditions – Sewer Inspection

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Sewer Systems

It's characteristics

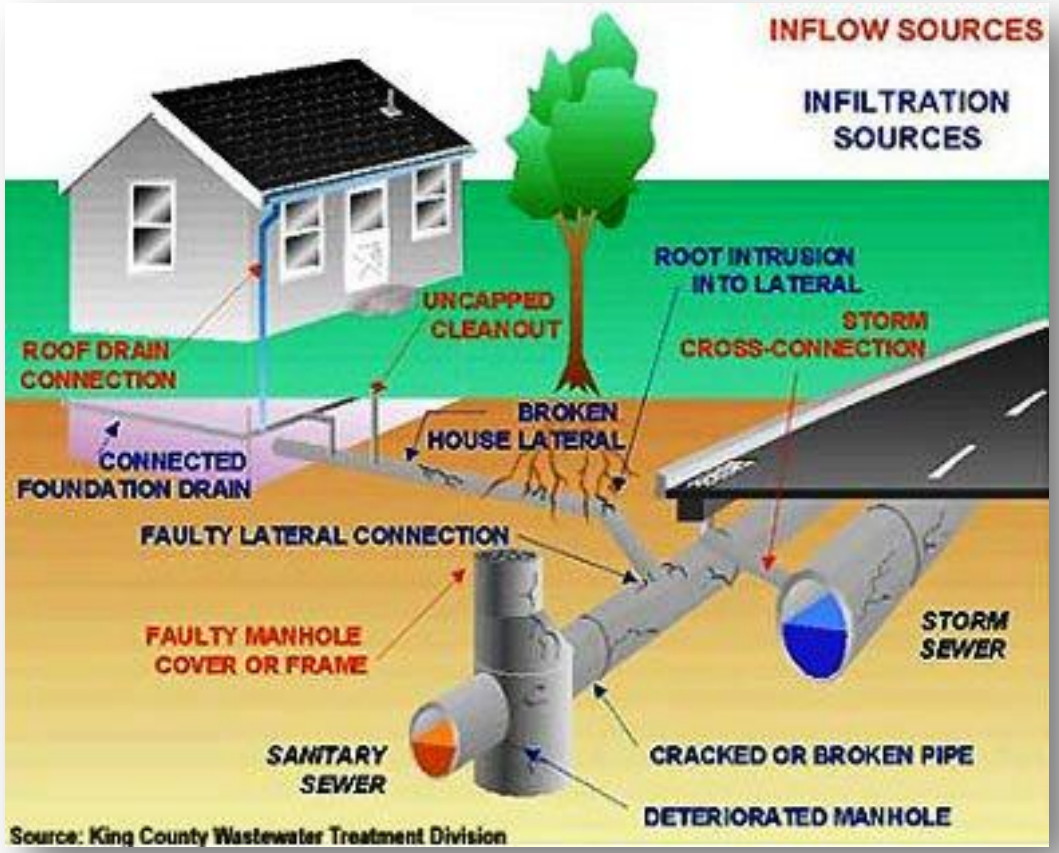
Main function:

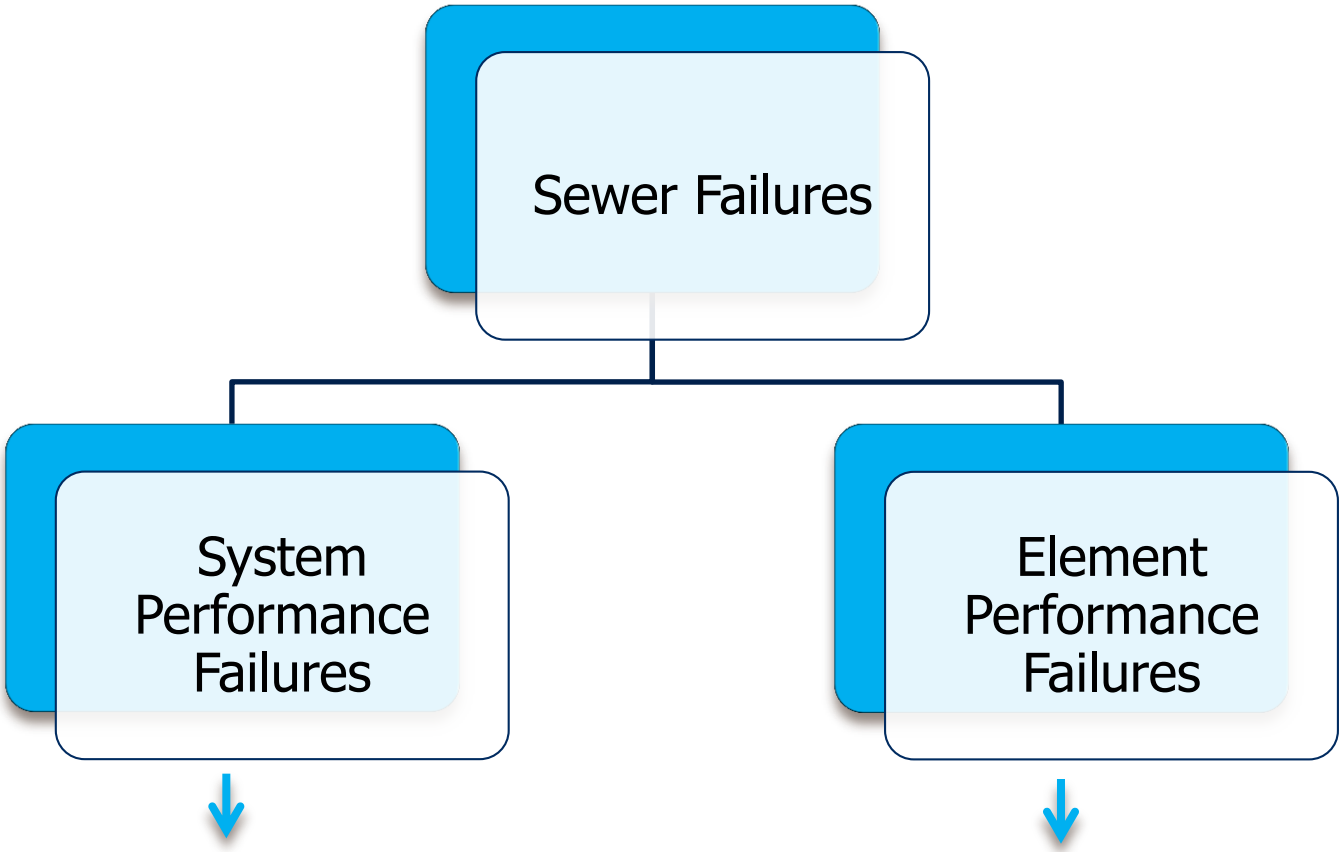
- preventing urban flooding,
- mitigating possible health hazards,
- improving overall aesthetics of urban area.

Sewerage systems are capital intensive infrastructure systems characterised by process and structure complexity.

Sewer systems

Deficiencies





- Flooding
- Frequent CSOs
- Soil contamination
- Exposure to health hazards

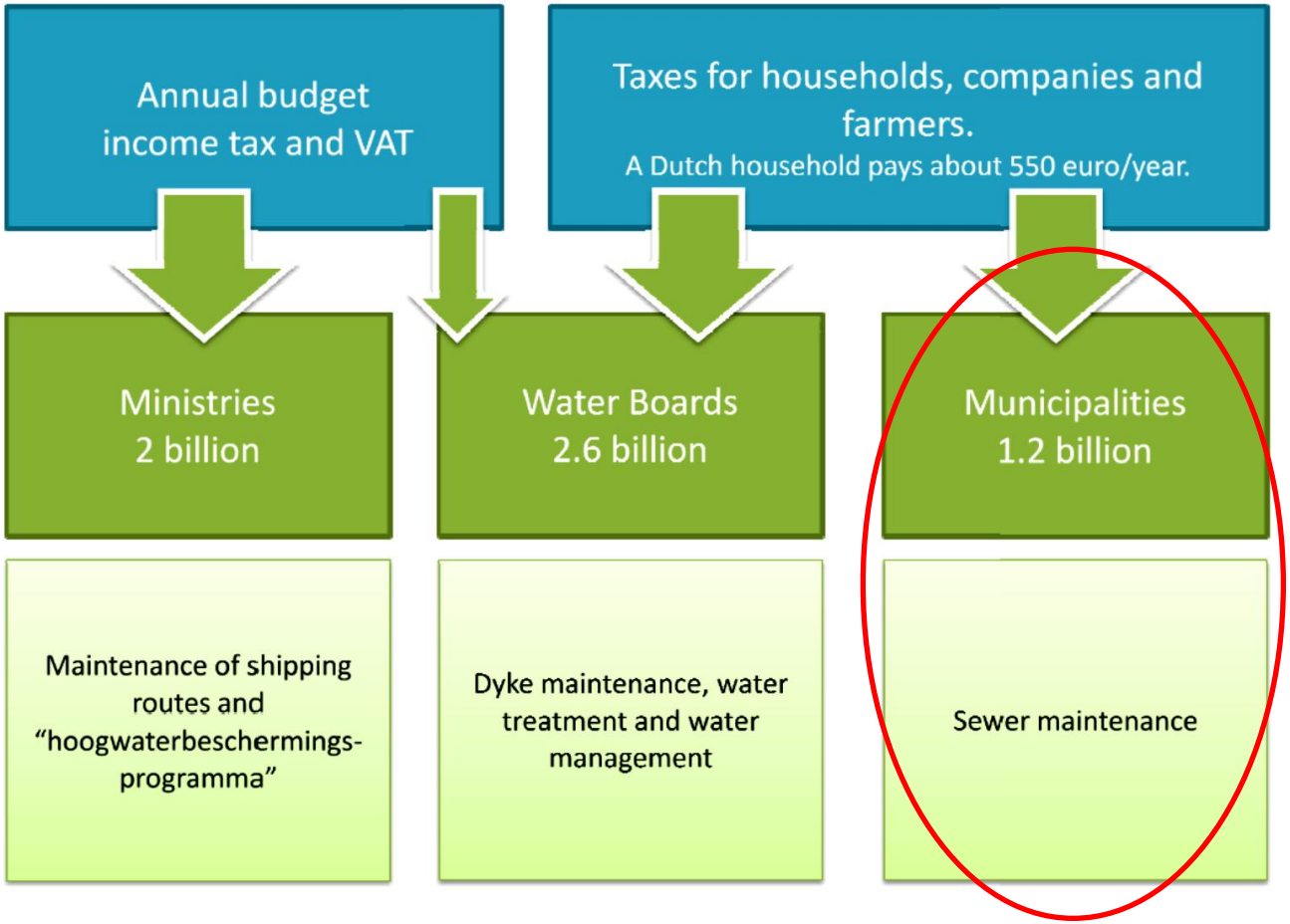
- Collapse of structural elements
- Breakdown of mechanical elements

Sewer systems

Top failure events and their main causes

Top event	Cause
Flooding Frequent CSOs	load ↗ and/or capacity ↘
Soil contamination	load ↗ and/or strength ↘
Exposure to health hazards	load ↗ and/or protection ↘
Collapse of structural elements Breakdown of mechanical elements	load ↗ and/or strength ↘

Dutch Water Related Expenses

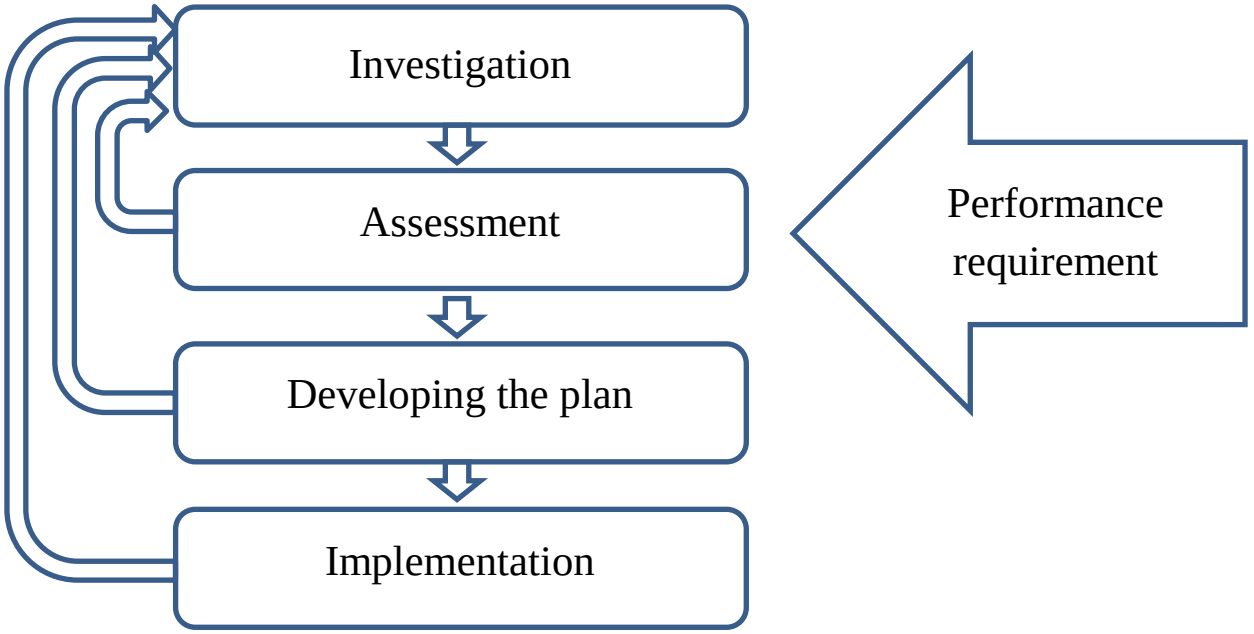


Sewer Asset Management

Definition (one of many)

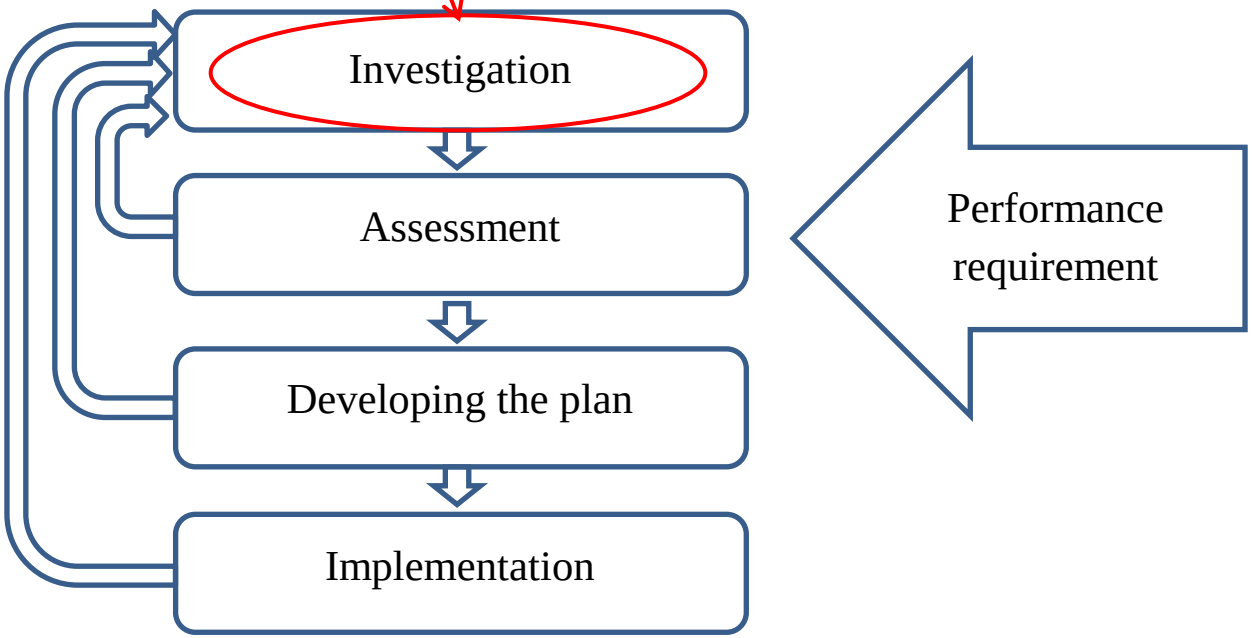
Sewer asset management aims at maintaining a certain minimum level of service at the lowest cost for rehabilitation and maintenance while meeting environmental/sanitary requirements.

Sewer system management process
Schematisation



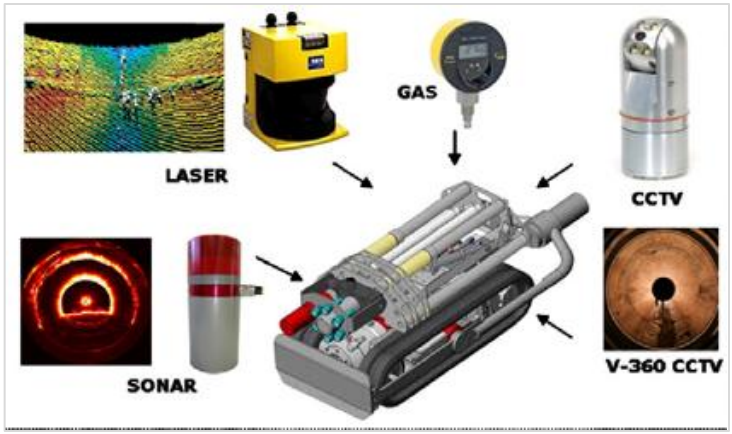
NEN-EN 752 standard.

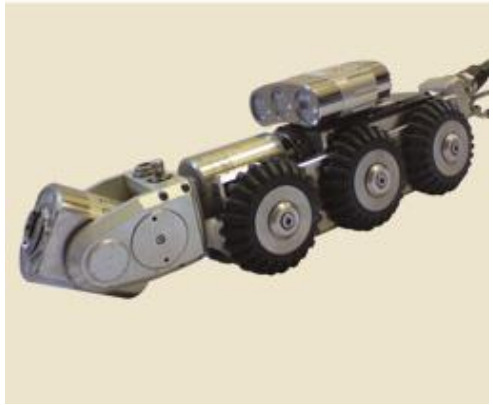
Why sewer inspection?



Why start an investigation?

Sewer inspection techniques





Sewer inspection

Visual inspection - CCTV

1. Cleaning

Sewer inspection

Visual inspection - CCTV

2. Installation of camera

Sewer inspection

Visual inspection - CCTV

3. Assessment

Assessment of the footage

Visual inspection - CCTV

Nederlandse norm

NEN-EN 13508-2 (en)

Toestand van de buitenriolering -
Coderingssysteem bij visuele inspectie

Conditions of drain and sewer systems outside buildings -
Part 2: Visual inspection coding system

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

NEN

List of defects

CCTV

8.2 Codes relating to the fabric of the pipeline

Table 4 — Details of codes relating to the fabric of the pipeline

Main Code	Additional information	Description
Deformation		
BAA		The cross sectional shape of the pipeline has been deformed from its original shape. The employing authority may specify whether this code is to be used either for flexible pipes only, or for pipes of all materials.
	Characterisation	The orientation of the deformation: — vertical (A) – the height of the pipe has been reduced — horizontal (B) - the width of the pipe has been reduced.
	Quantification	The percentage change in the dimension which reduces.
	Circumferential location	If the deformation is localised then the circumferential location should be recorded.
Fissure		
BAB		
	Characterisation 1	The nature of the fissure : — surface crack (A) – a crack only in the surface; — crack (B) – crack lines visible on the pipe wall, pieces still in place; — fracture (C) – crack visibly open in a pipe wall, pieces still in place.
	Characterisation 2	The orientation of the fissure: — longitudinal (A) – A crack or fracture which is mainly parallel to the axis of the pipe; — circumferential (B) – A crack or fracture which is mainly around the circumference of the pipe;

List of defects + description

CCTV

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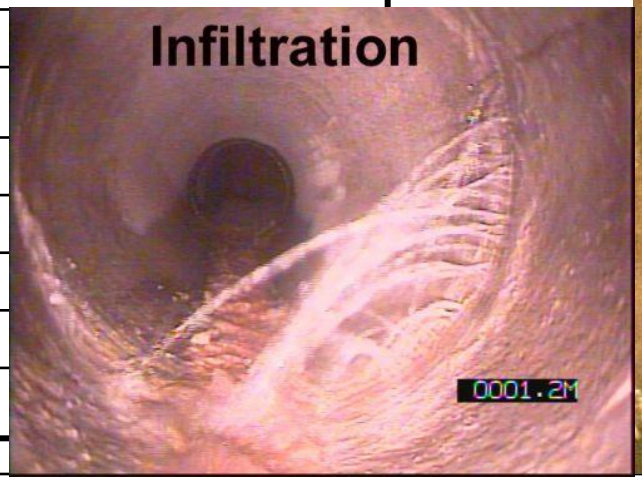
BAA	Deformation
BAB	**Fissure**
BAC	Break/Collapse
BAD	Defective brickwork or masonry
BAE	Missing mortar
BAF	**Surface damage**
BAG	Intruding connection
BAH	Defective connection
BAI	Intruding sealing material
BAJ	Displaced joint
BAK	Lining defect
BAL	Defective repair
BAM	Weld failure
BAN	Porous pipe
BBA	**Roots**
BBB	Attached deposits
BBC	Settled deposits
BBD	Ingress of soil
BBE	Other obstacles
BBF	**Infiltration**



TEST

All stand up!

- 4 photos
- 2 possibilities

Choose the right by:

A: hand up

B: hand down

Error = sit

Good = remain standing

BAA	Deformation
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BAD	Defective brickwork or masonry
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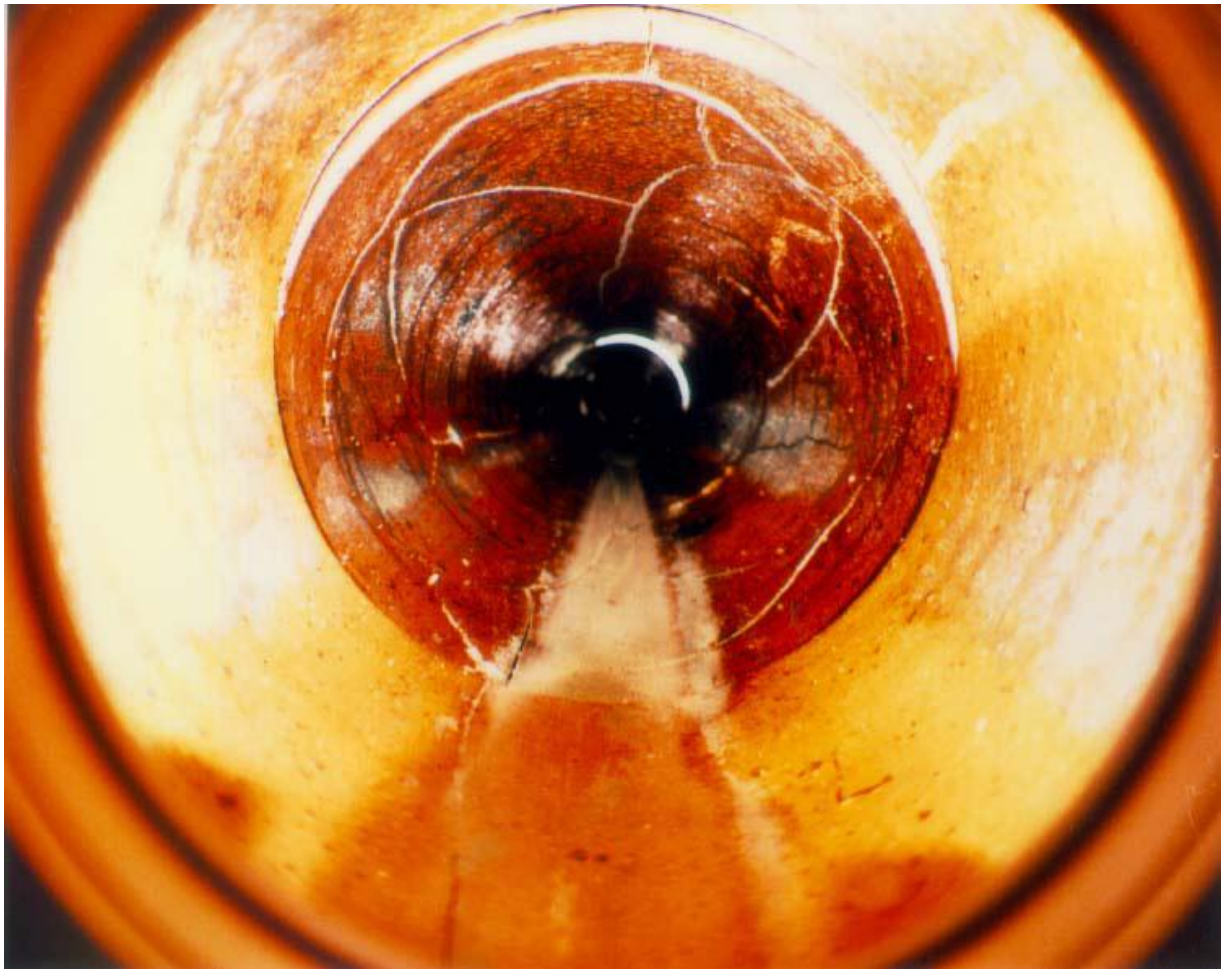
roots

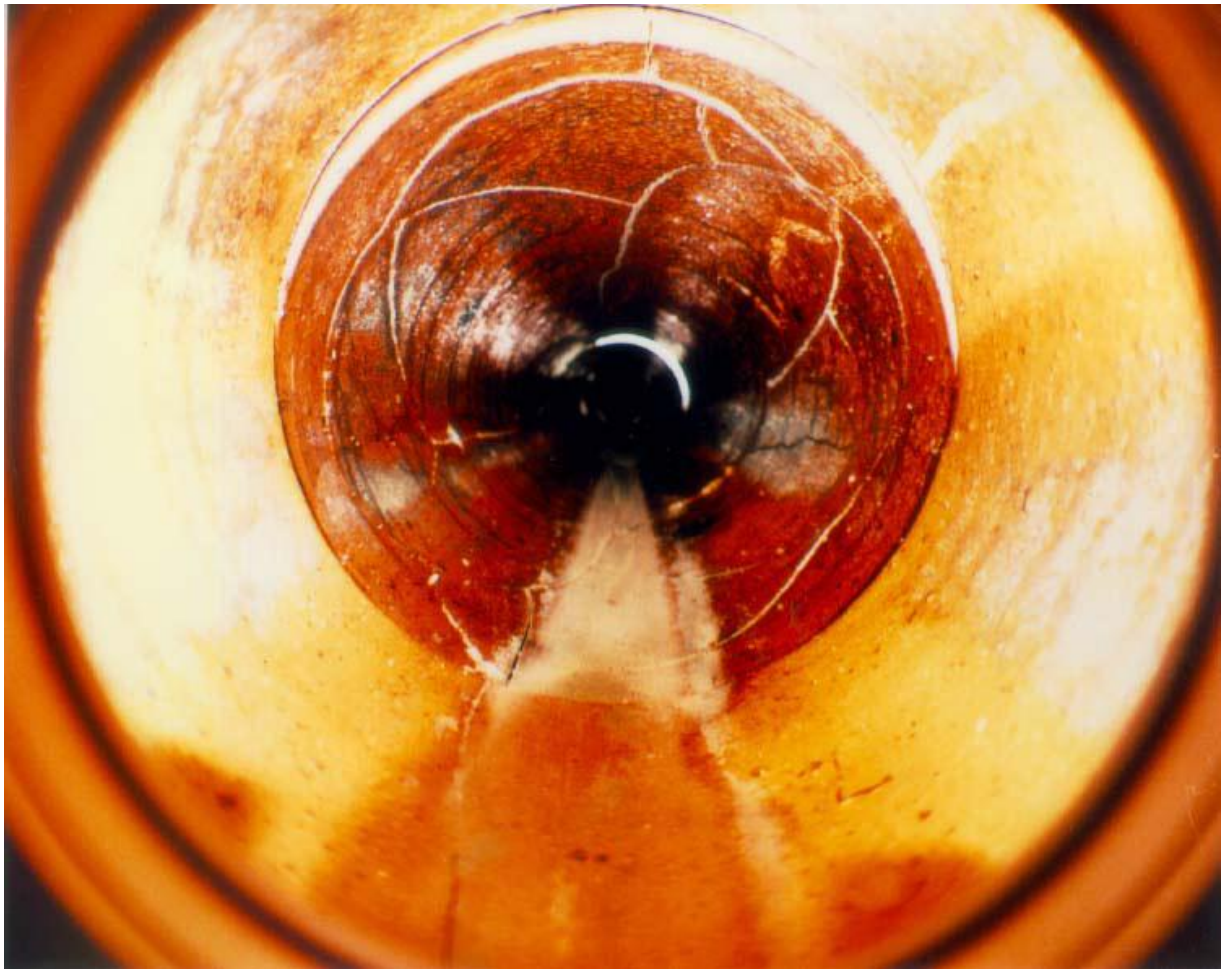
cracks



~~roots~~

Bron: lmaclean.ca

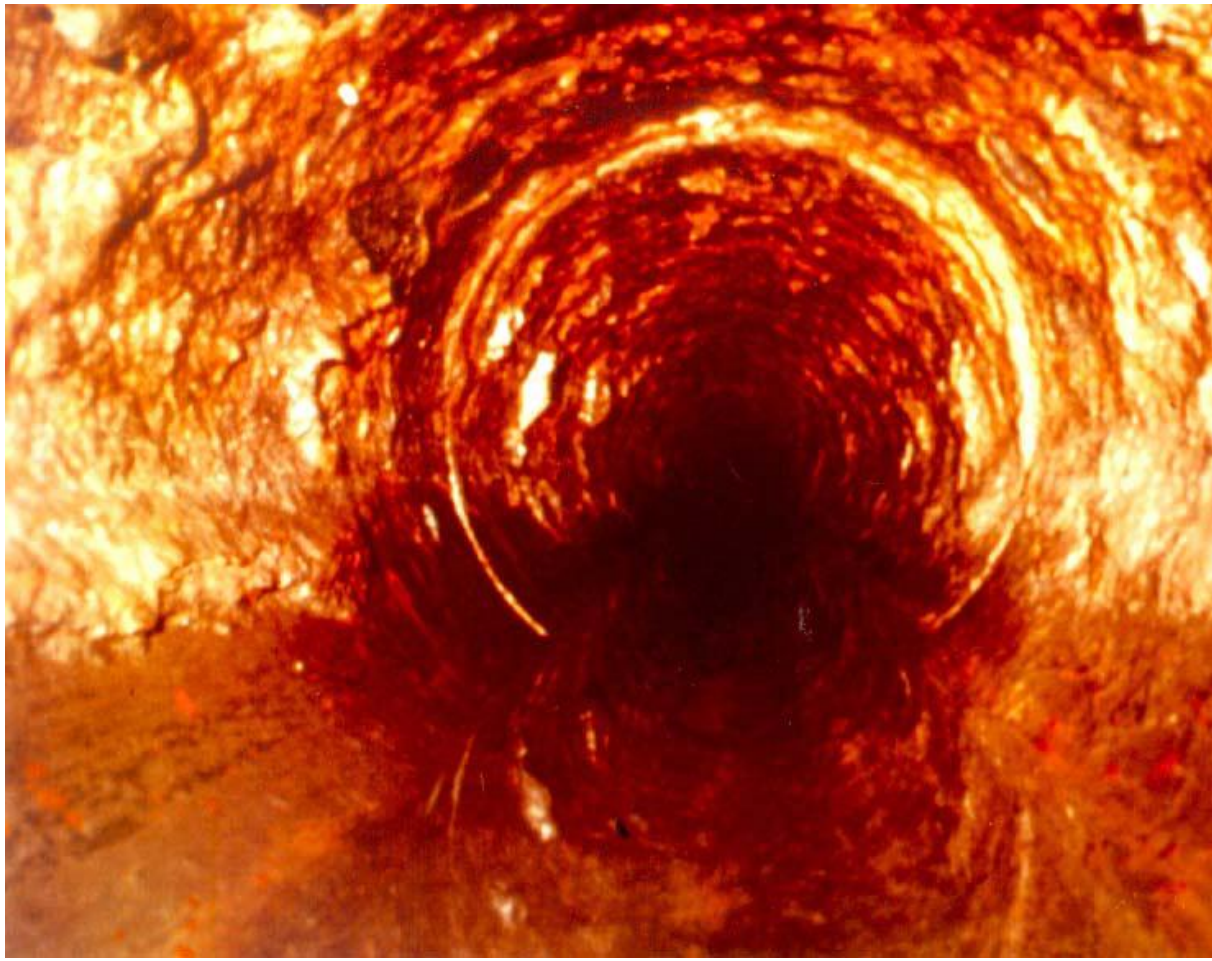
cracks



surface damage

Bron: lmaclean.ca

attached deposits



surface damage

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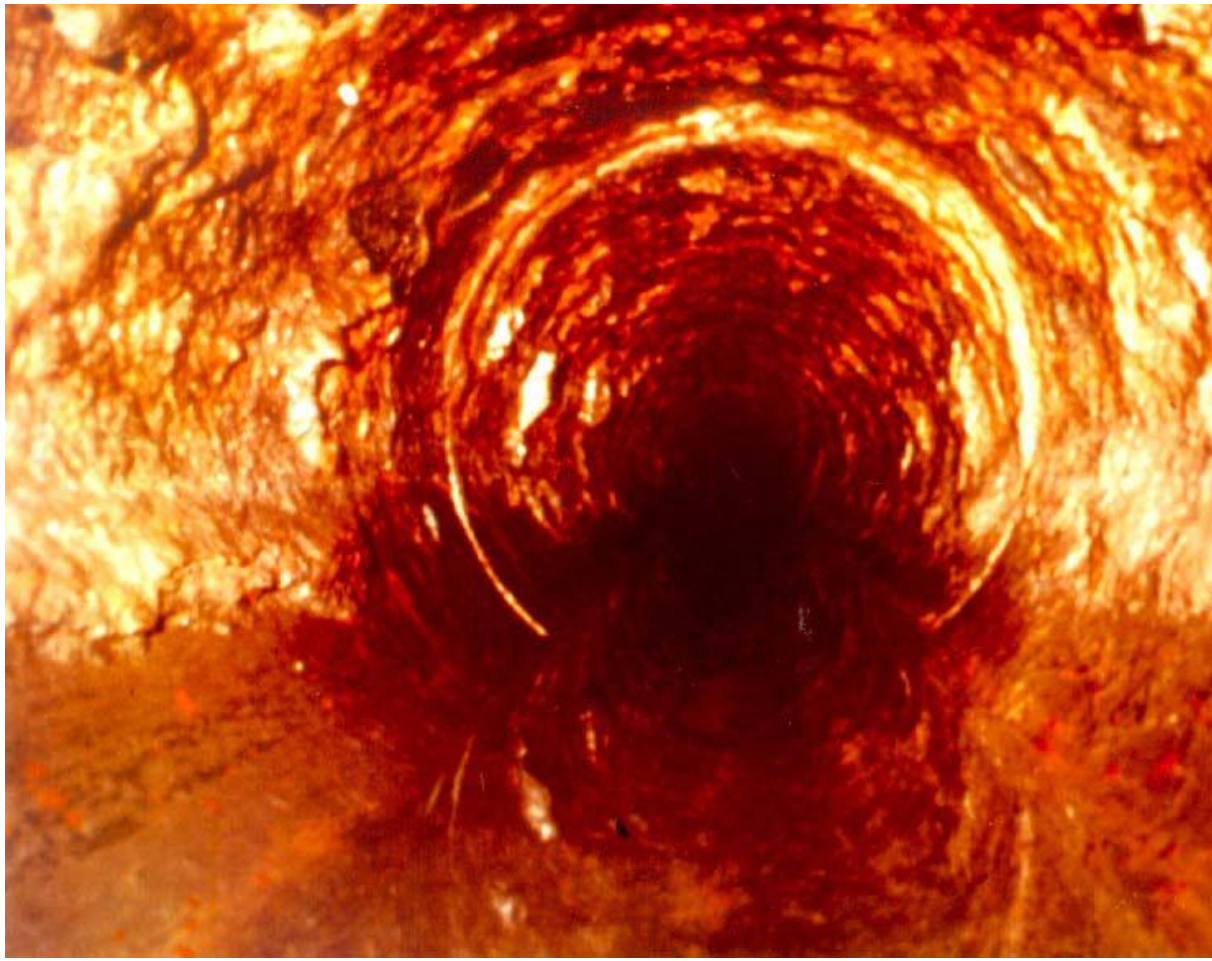

roots

obstacle

roots

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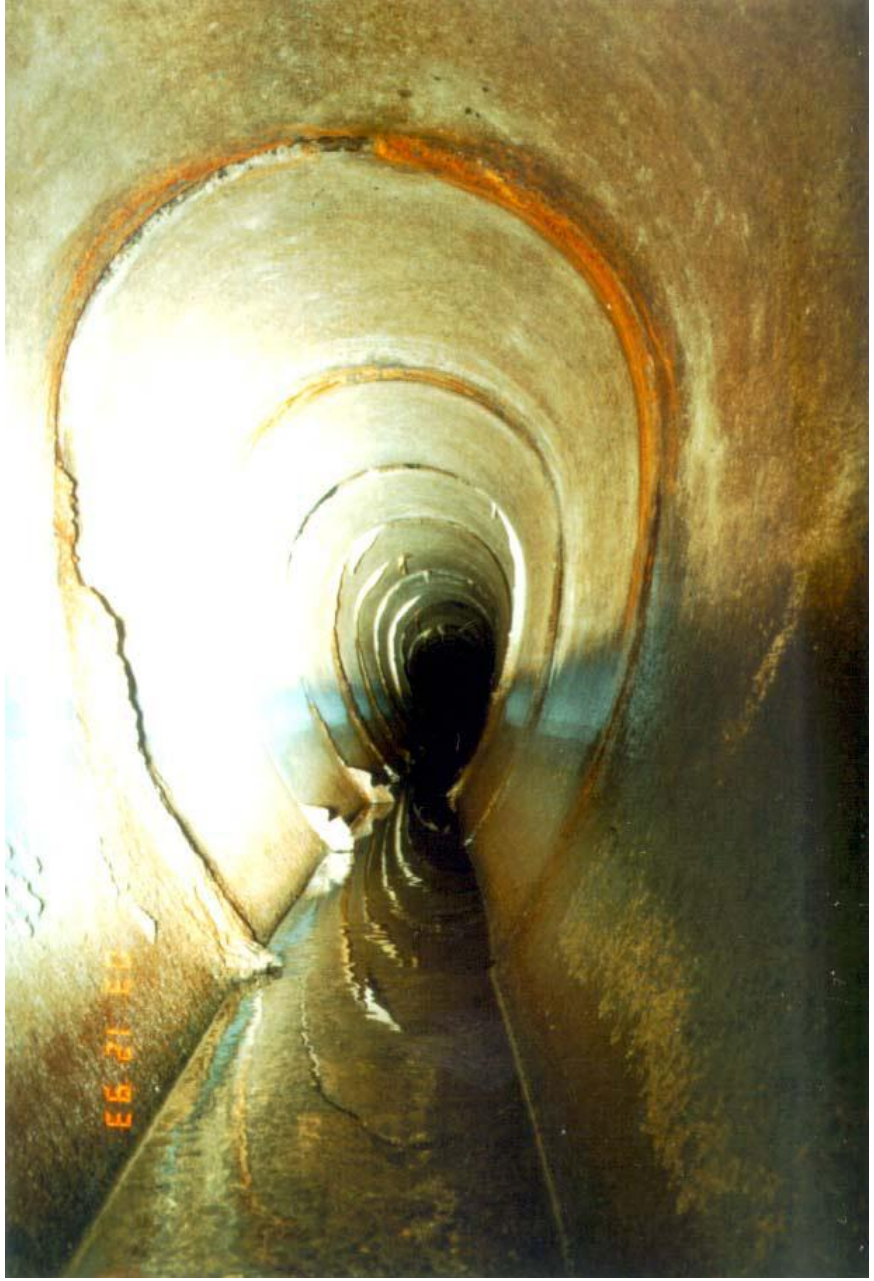
~~obstacle~~

infiltration

ingress of soil



infiltration

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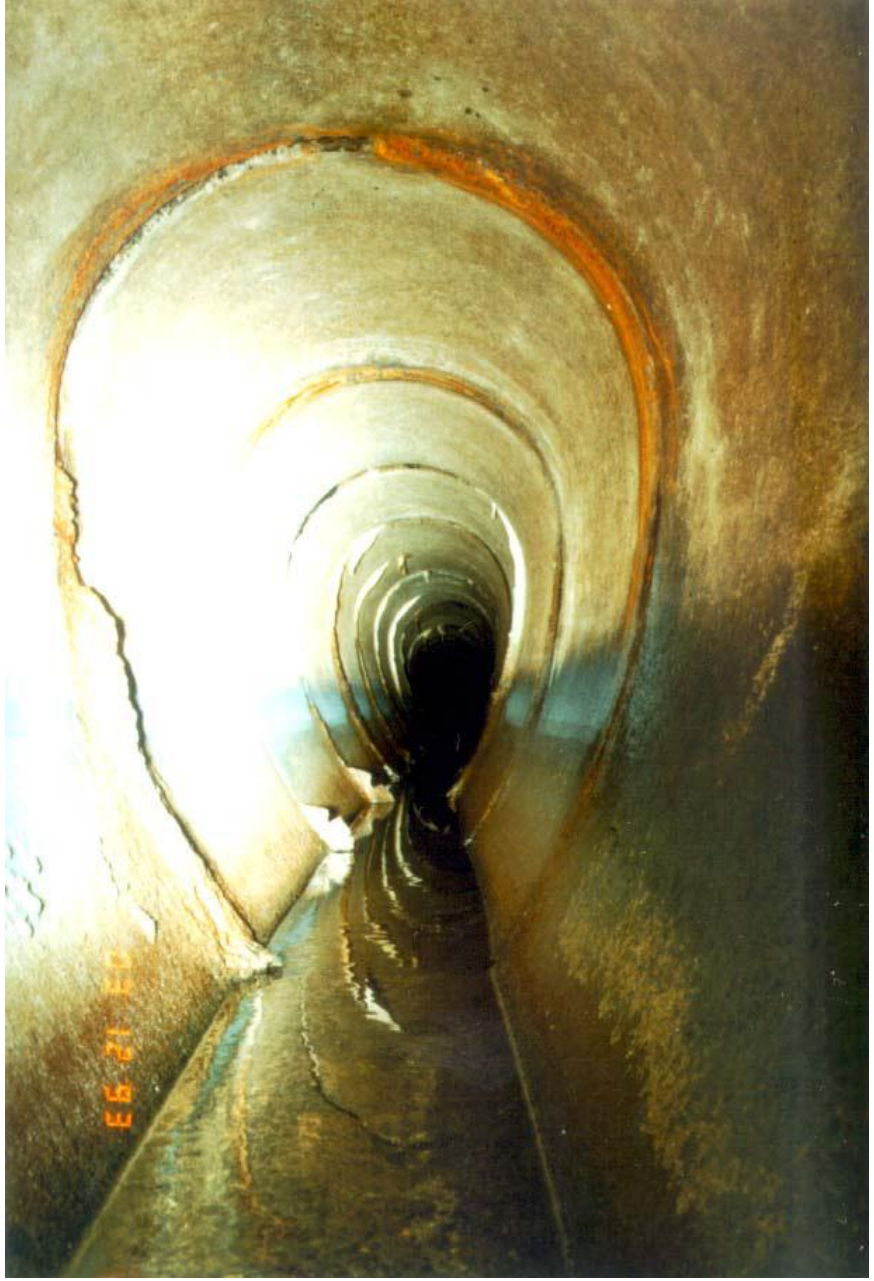
~~ingress of soil~~



Results

How many are still standing?

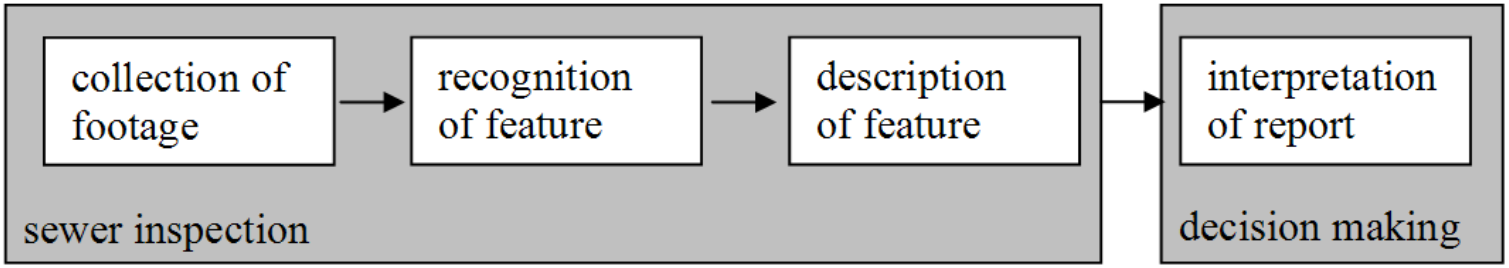
Gambling: good chance is 0.5

4 photos → 1/16

~ 35 students → ~ 2 ?

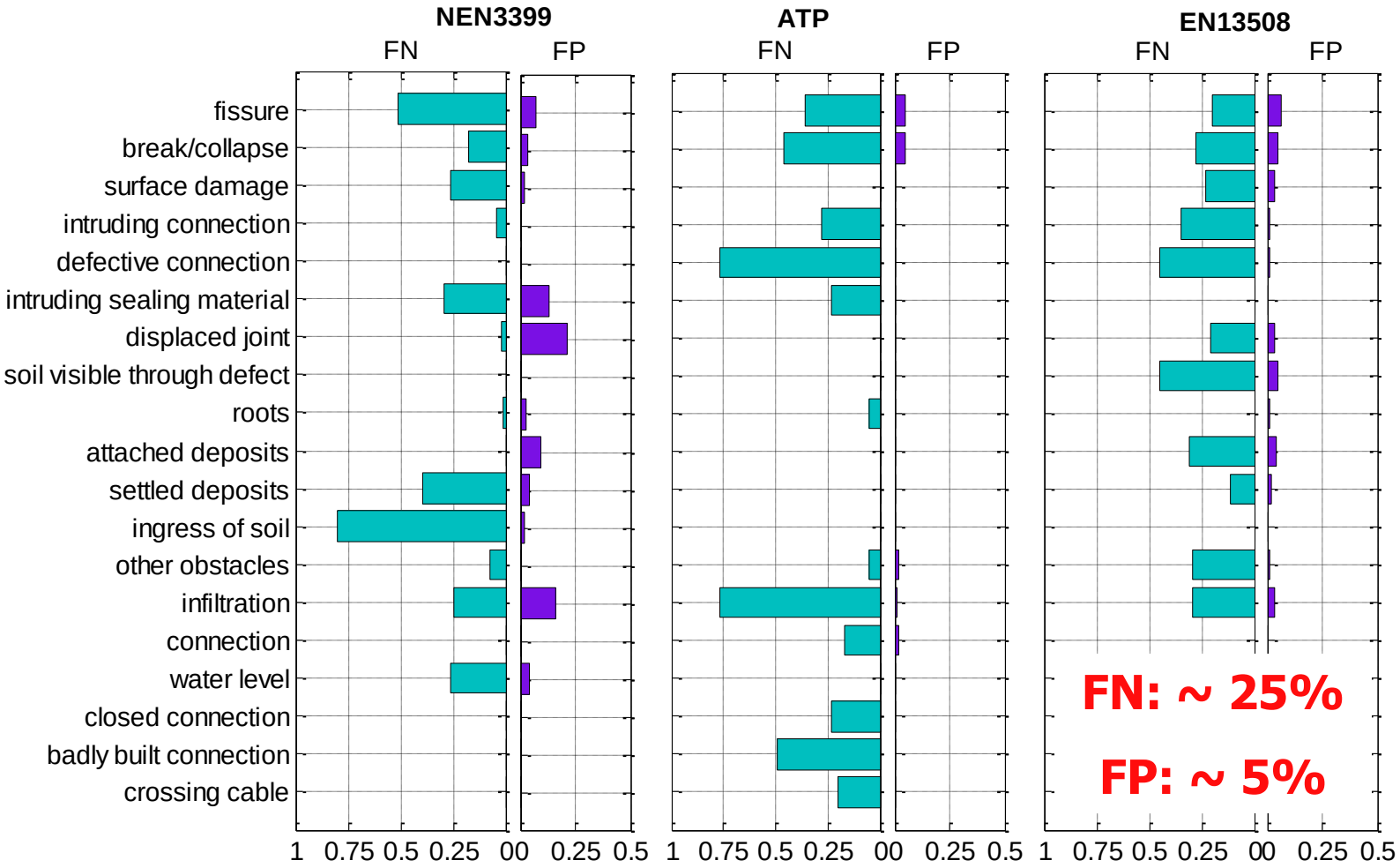
From inspection to decision making

← Visual inspection - CCTV



In every step of the process errors can occur.

Examination results



Main conclusions

Feature recognition

- Probability of a false negative significantly larger than the probability of false positive (people cannot process all visual information).
- P(Fn) =~ 25%
- P(Fp) =~ 5%
- Same results for experienced and un-experienced inspectors.

Feature description

- Probability of an incorrect feature description is larger than probability of a correct description.

Interpretation

- Systematic deviation between experts.

Changes in the SOBEK model

CCTV inspection results

Code	Description	Class	SOBEK calculation changes
BAF	surface damage	3	k = 1.7 mm
		4	k = 3 mm
		4	k = 4.5 mm
		5	k = 6 mm
BBB	attached deposits	3	pipe diameter decrease 15%
		3	pipe diameter decrease 20%
		4	pipe diameter decrease 35%
		4	pipe diameter decrease 45%
-	measured slope (settlement)	-	slope is 0.0
			slope decreased 35%
			slope decreased 55%
			slope decreased 70%

Sewer inspection

Drill core sampling

1. Drilling

Sewer inspection

Drill core sampling

2. Sample taking

Sewer inspection

Drill core sampling

3. Sample storing

Sewer inspection

Drill core sampling

4. Sample analysis

Determining of sewer conditions

Municipality of the Hague

The most common defects in the municipality of the Hague are: surface damage (BAF) and crack (BAB).

CCTV classification for BAF/BAB with associated action

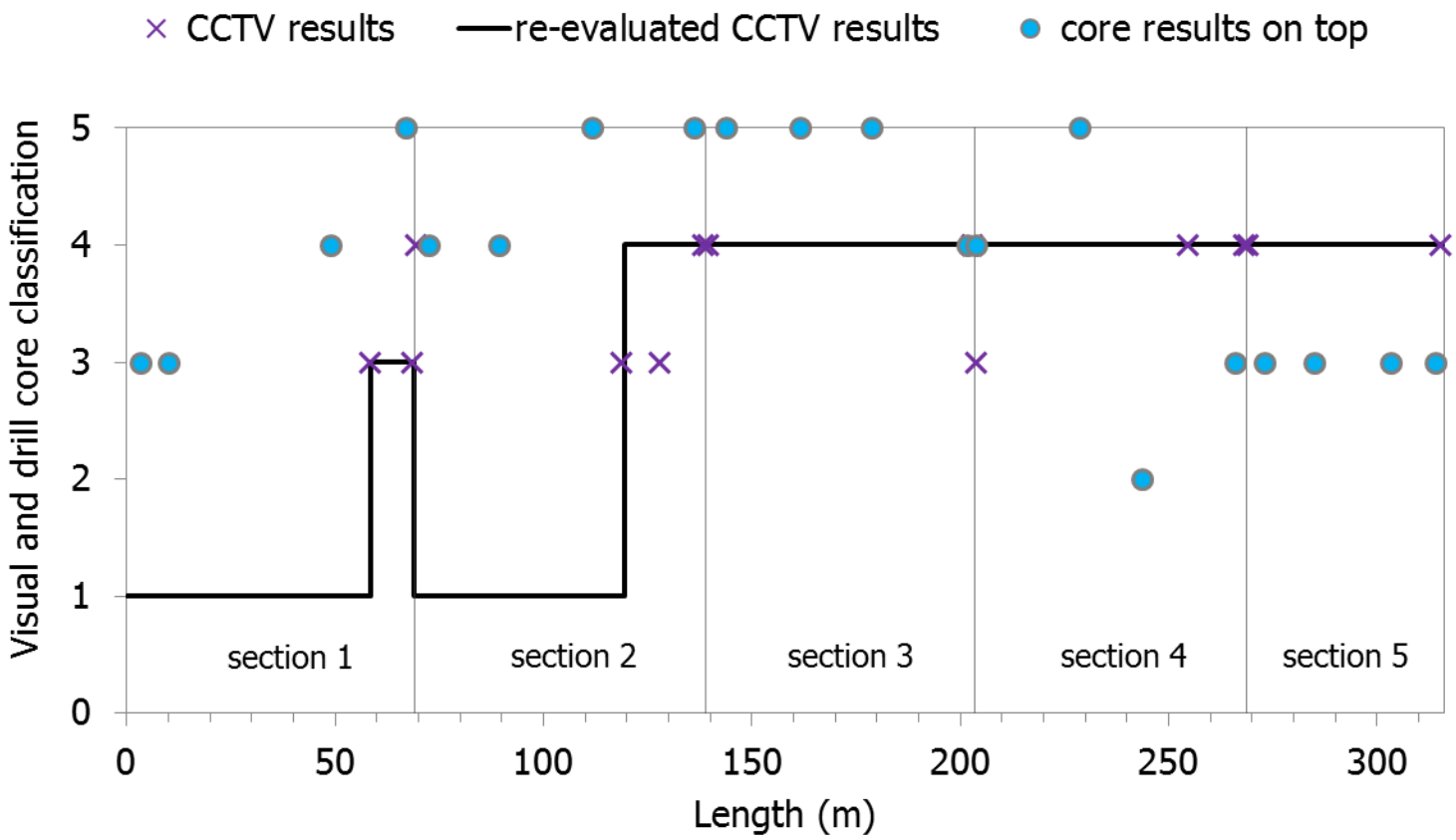
Classification	1	2	3	4	5
BAF	no	no	no	drill core	replacement
BAB	no	no	no	replacement	replacement

Drill core classification according to "The Hague"

	class 1	class 2	class 3	class 4	class 5
Splitting tensile strength (N/mm^2)	>6	5-6	2.6-4.9	2.5-2	<2
Water absorption (%)	<8	8-9	9-11	11-13.5	>13.5
Specific weight (kg/m^3)	>2275	2230-2275	2190-2229	2150-2189	<2150

Experimental results – comparison

Final conditions assessment

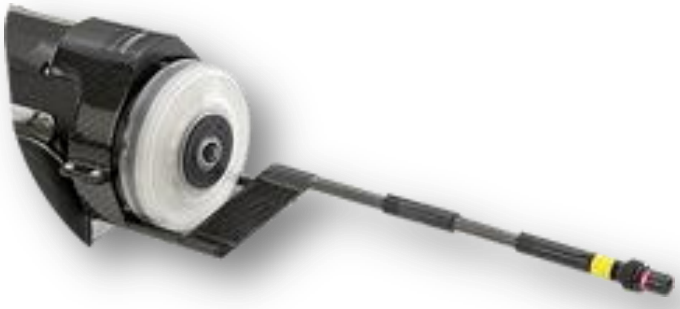


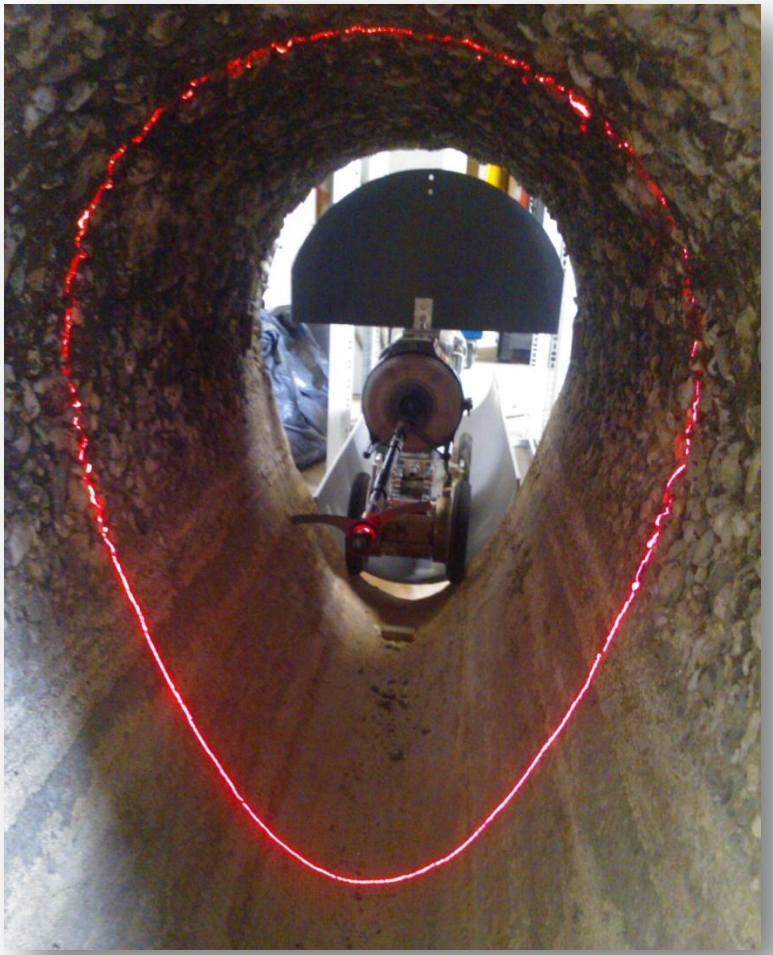
Main conclusions

- The quality of final core classification depends on selection of parameters and their classification.
- Different factors like non-uniform deterioration, height/diameter ratio, experimental uncertainty and damage during drilling influence the proper estimation of the splitting tensile strength which makes results unreliable.
- There is no obvious correlation between results of visual inspection and results of drill core analysis.

Sewer inspection

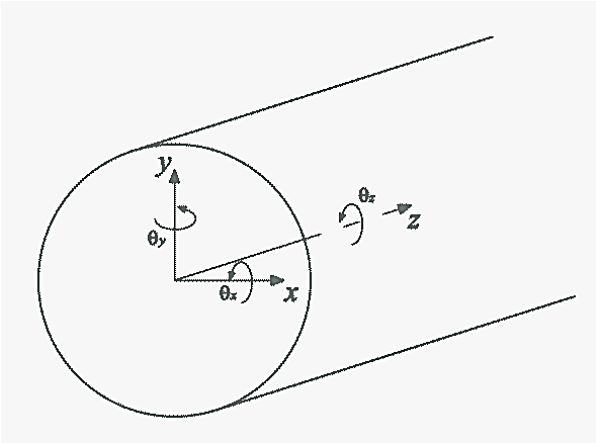
Laser profiling

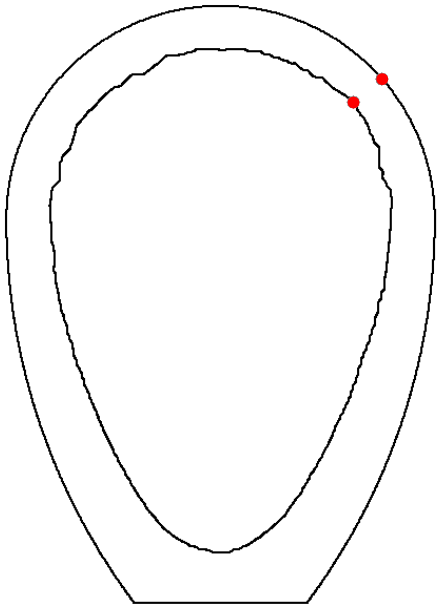


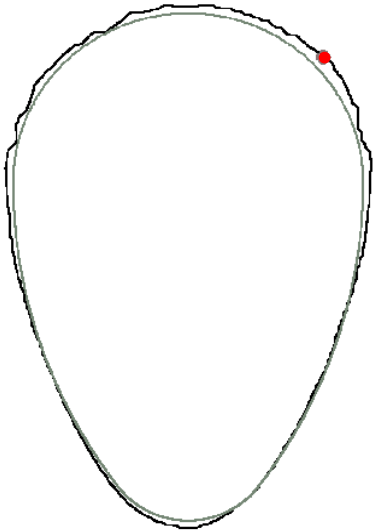


Experimental results

Pipe cross-section with indication of min wall thickness

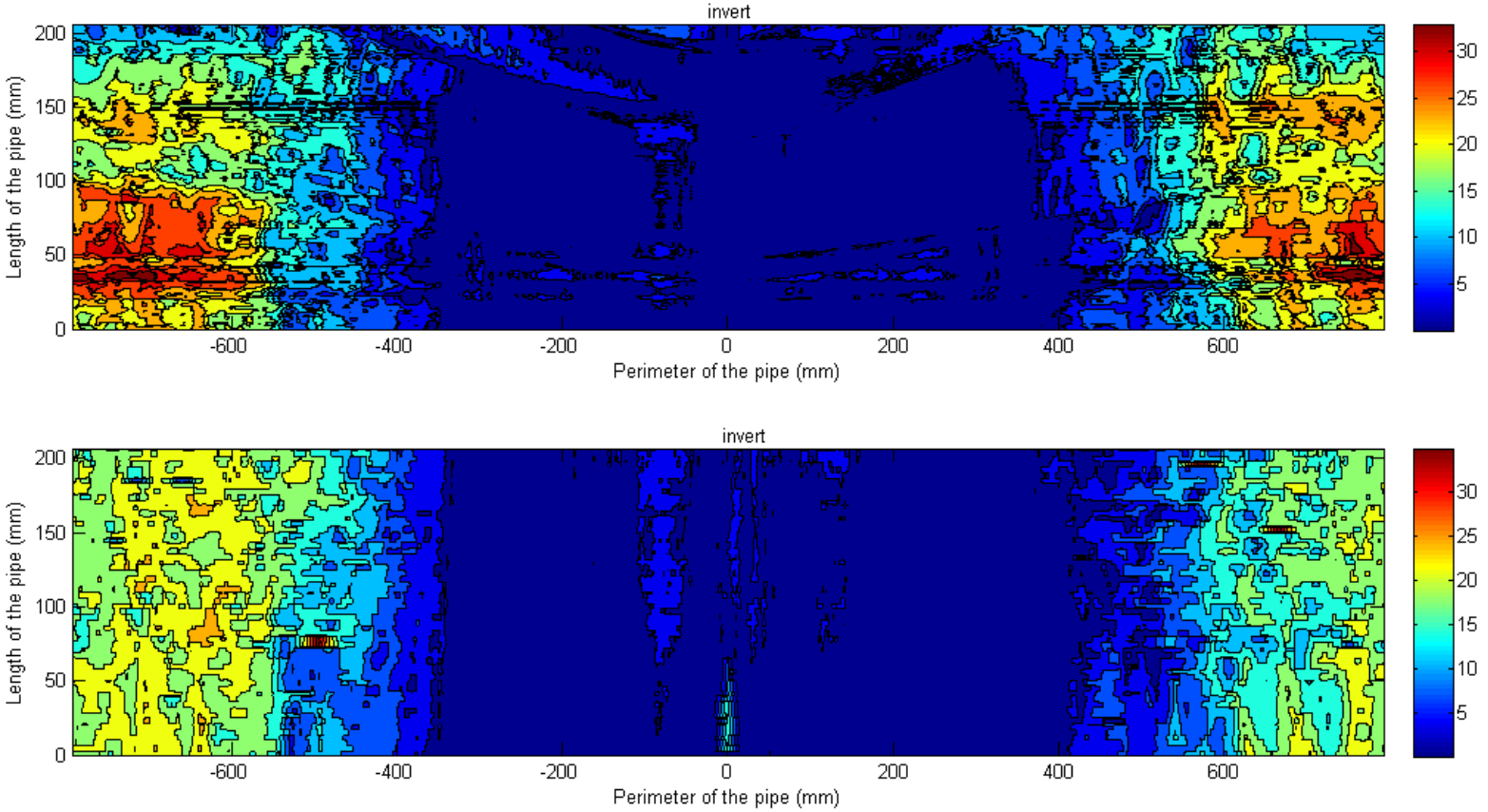






Experimental results

Loss of wall thickness along the length of the pipe



Main conclusions

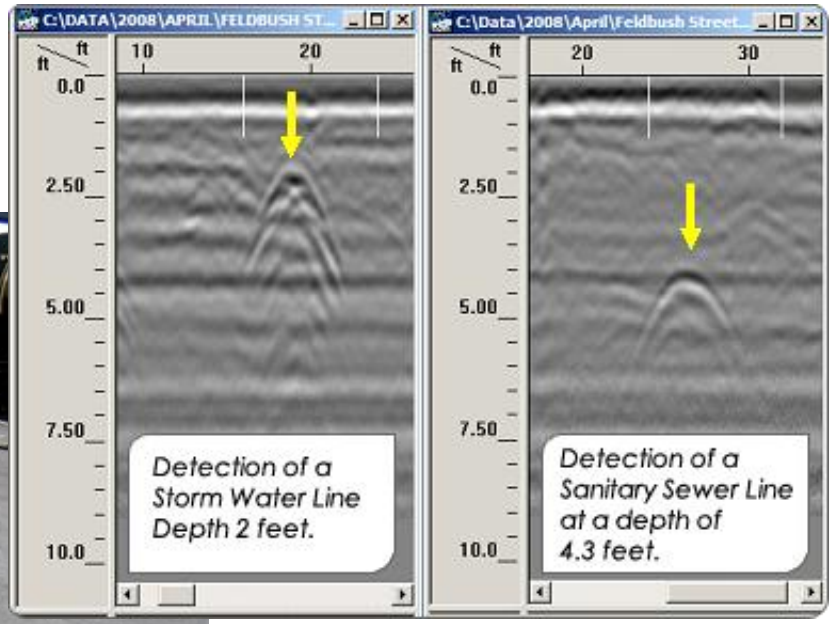
- Laser scanning offers a new and challenging perspective for measuring sewer pipe structural characteristics, such as interior shape and related to this the remaining wall thickness.

Sewer inspection

Person-entry

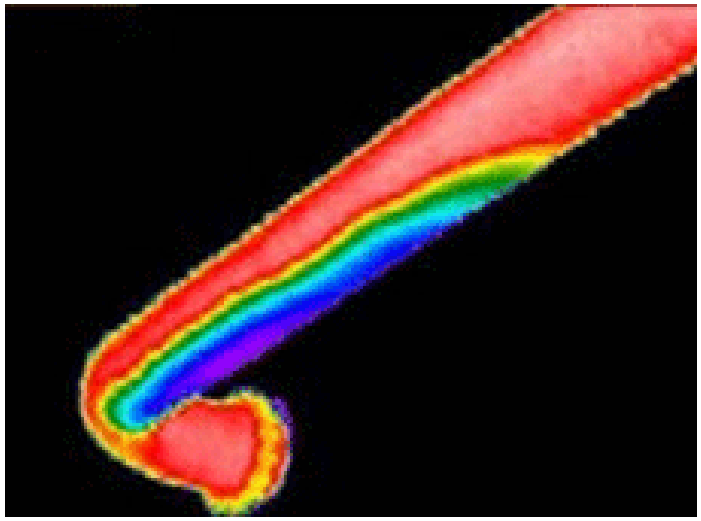
Sewer inspection

Ground Penetrating Radar (GPR)



Sewer inspection

Infra-Red thermography



Sewer inspection

Smoke test

Sewer inspections…

- Ultrasound;

- Microdeflections;

- Advanced systems (e.g. KARO, PIRAT, SSET)…

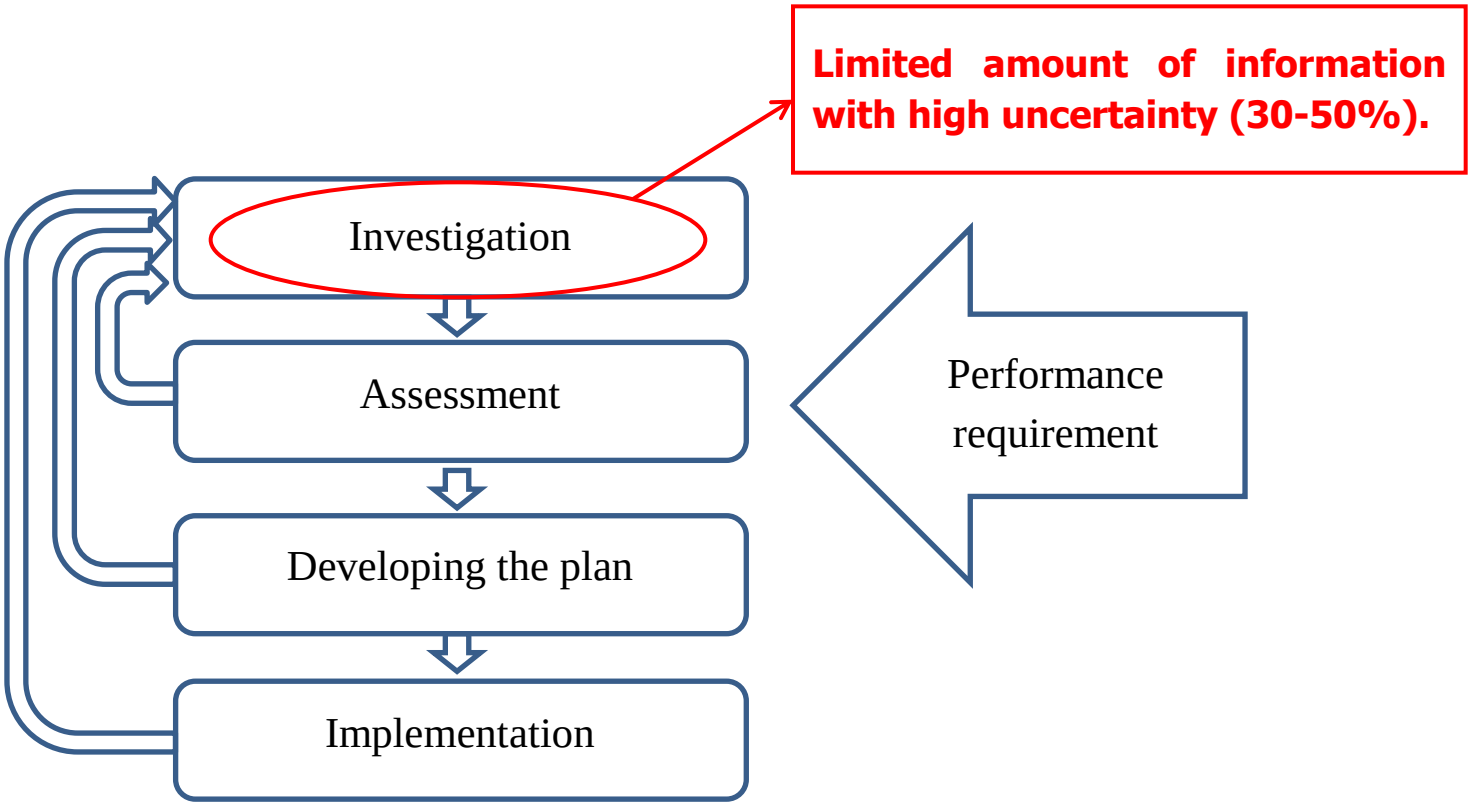
Main conclusions

Each inspection technique has its own limitations:

- Use/Where to use;
- What will be found;
- Advantages;
- Disadvantages.

	Sources of information	Examples
Reports	Final design reports	hydraulic design report, structural design report
	As-built reports	construction report
	System performance reports	operation report, maintenance report
	All underground infrastructure reports	master plan
Measurements	Surveys	complains report
	Soil characteristics measurements	soil texture/structure, aeration, aggressively
	Asset condition investigations	CCTV inspection, person-entry, laser scanning, GPR, core sampling, KARO, PIRAT, SSET
	Hydraulic measurements	water level, velocity
	Hydrological measurements	groundwater table, rainfall measurements
	Water quality measurements	temperature, turbidity, conductivity
	External load measurements	traffic load

Sewer system management process
Uncertainties



How to achieve more effective sewer asset management?

- Need for better understanding of system failure mechanisms.
- Defining what information of what quality is needed at what time for effective asset management.
- Determining how this information can be obtained.
- Developing methods for estimating the probability of failure and the criticality of the asset.