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TECHNICAL MANAGEMENT OF SEWER NETWORKS
A Simplified Decision Tool

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Introduction

In wastewater collection systems the technical asset management comprises the core of the management activity:

- procurement
- operation
- maintenance
- rehabilitation

Operation and maintenance activities:

- sewer rehabilitation
- line cleaning
- close circuit television inspection
- pump station servicing

Decision Support Models - Rehabilitation

The majority of the asset management strategies implemented focus on the proactive rehabilitation of critical sewers. Several models have been developed to support decisions regarding rehabilitation:

- Burgess model (Burgess, 1988)
- APOGEE (Macgilchrist and Mermet, 1989)
- MARESS (Reyna, 1993)
- Aflak model (Aflak, 1994)
- PIPES (Lim and Pratti, 1997)
- RERAUVIS (RERAU, 1998)
- CARE-S (CARE-S, 2005)

Models are based on the knowledge of the condition of the sewer pipes determined through previous inspection and the evaluation.

Decision Support Models - Inspection

There is also a growing demand for conducting periodical sewer inspections to comply with the legislation.

Models to assist decisions regarding selective inspection of sewers:

- AQUA-WertMin (Baur and Herz, 2002)
- SCRAPS (Hahn et al, 2002)

Several other authors have developed tools to prioritize inspection and/or rehabilitation interventions based on expert, optimization or statistical approaches.

Model Development

The present expert model was developed with the objective of implementing a proactive management plan based in conditions of scarce information available.

In order to establish priorities, the model evaluates the risk of failure or performance deficiency of sewer reaches in a scale of 1 to 10, by applying the following general expression:

$$E = K \sum W_i \times P_i$$

E – evaluation result (1 to 10 classification);

K – correction factor, taken into account the know-how about the system (higher than 0);

W_i – weight factor of parameter i (0 to 10 classification);

P_i – ponderation factor of parameter i (0 to 100% ponderation).

Parameters and weight factors – Pipe material

The following results were taken into account:

- flexible pipes systems have, on average, just 20% of the defect rates of rigid pipe systems (Stein, 2005)
- concrete pipes older than 30 years have higher water/cement relation (CARE-S, 2005)

Material / age	***Weight***
Cement based (> 30 years)	10
Cement based (≤ 30 years)	9
Stoneware / Cast iron	6
PVC/ HDPE/ PP (> 15 years)	5
Clay	4
PVC/ HDPE/ PP (≤ 15 years)	2
PVC/ HDPE/ PP Corrugated	1

Parameters and weight factors – Pipe diameter

The following observations were considered:

- decrease of defects rate with the increase of the sewer size (Davies et al, 2001b)
- serviceability problems, such as siltation, protruding connections, infiltration, fat deposition, encrustation, and root infestation tend to have a disproportionally greater effect in the performance of smaller diameter sewers (Fenner and Sweeting, 1999)

Diameter	***Weight***
>1600	1
900-1600	3
600-900	5
315-500	8
200-300	10

Parameters and weight factors – Sediment build up

The risk of sediment build up is directly associated with self-cleaning velocities. Therefore, it was defined as a function of pipe diameter, slope and flow velocities for half-pipe conditions:

- higher risk: corresponds to negative slopes
- high risk: velocities below 0.9 m/s
- medium risk: velocities in the range of 0.9 m/s to 1.5 m/s
- low risk: flow velocities over 1.5 m/s

	Diameter [mm]				Weight
	200-300	315-500	600-900	≥1000	
Slope [%]	≤ 0	≤ 0	≤ 0	≤ 0	10
	0 - 0.50	0 - 0.25	0 - 0.12	0 - 0.08	8
	0.50 - 1.35	0.25 - 0.70	0.12 - 0.30	0.08 - 0.225	5
	> 1.35	> 0.70	> 0.30	> 0.225	1

Parameters and weight factors – Pipe abrasion

The phenomenon of abrasion depends of several parameters, namely amount, size, shape and hardness of the solid particles and. For the model, it was considered only the effect of the flow velocity:

- higher risk: flow velocities over 5.0 m/s
- high risk: flow velocities between 3.0 m/s and 5.0 m/s
- intermediate risk: medium risk: velocities in the range of 1.5 m/s to 3.0 m/s
- minimum risk: flow velocities below 1.5 m/s

	Diameter [mm]				***Weight***
	200-300	***315-500***	***600-900***	***≥1000***	
Slope [%]	> 15.00	> 7.50	> 3.50	> 2.5	10
	5.25 - 15.00	2.75 - 7.50	1.25 - 3.50	1.00 - 2.50	6
	1.35 - 5.25	0.70 - 2.75	0.30 - 1.25	0.225 - 1.00	3
	≤ 1.35	≤ 0.70	≤ 0.30	≤ 0.225	1

Parameters and weight factors – Sewer depth

Davies et al (2001a) reported that the defect rate decrease steadily to a depth of 5.5 m, below which the defect rate begins to increase with depth. It was suggested that this reflects the decreasing influence of surface factors, such as road traffic and utility/surface maintenance activity, and the increasing effect of overburden factors.

Depth [m]	***Weight***
>5.5	10
2 - 5	1
<2	7

Parameters and weight factors – Risk of corrosion

The production and release of hydrogen sulphide to the sewer atmosphere depends on several factors, such as the physical and chemical properties of the environment (wastewater and air), the flow conditions and the upstream conditions. In the developed approach, the risk of corrosion was just related with the risk of sediment build up, considering also that the existence of a rising main discharging upstream represents the highest risk .

Corrosion	***Weigth***
Forced main upstream	10
Risk of sediment build up 10	8
Risk of sediment build up 8	6
Risk of sediment build up 5	3
Risk of sediment build up 1	1

Ponderation factors

Because not all parameters analysed have the same impact in the performance of the sewer, different ponderations where attributed in order to establish priorities for cleaning or inspection activities.

Parameter	***Ponderation [%]***	
	Inspection	***Cleaning***
Material / age	20.0	15.0
Diameter	10.0	15.0
Sediment build up	-	40.0
Abrasion	20.0	-
Depth	10.0	-
Corrosion	35.0	-
Section reduction	-	15.0
Manhole with drop	5.0	-
Manhole with retention	-	15.0

Case Study

SIMTEJO covers a total area larger than 1000 km^2 and serves approximately 1.5 million inhabitants from six municipals divided in 26 sub-systems that include:

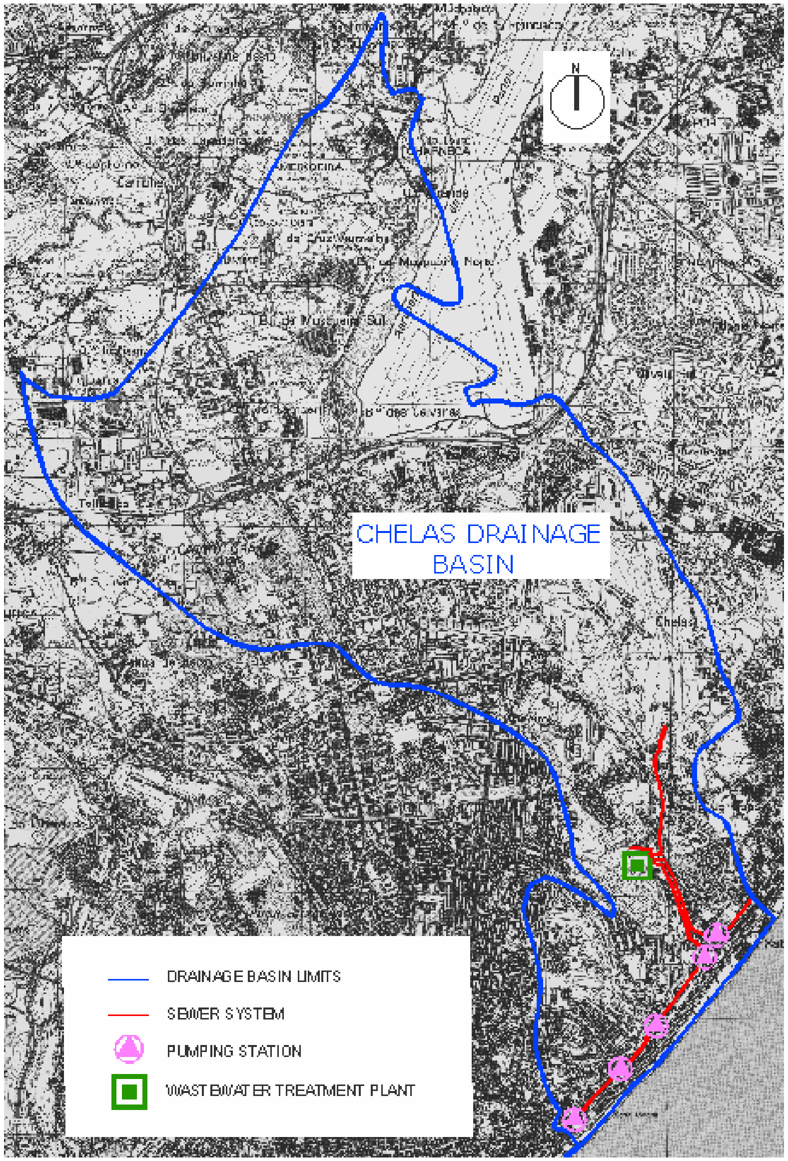
- 26 Wastewater Treatment Plants
- 55 Pumping Stations
- 125 km of gravity sewers and pressure mains

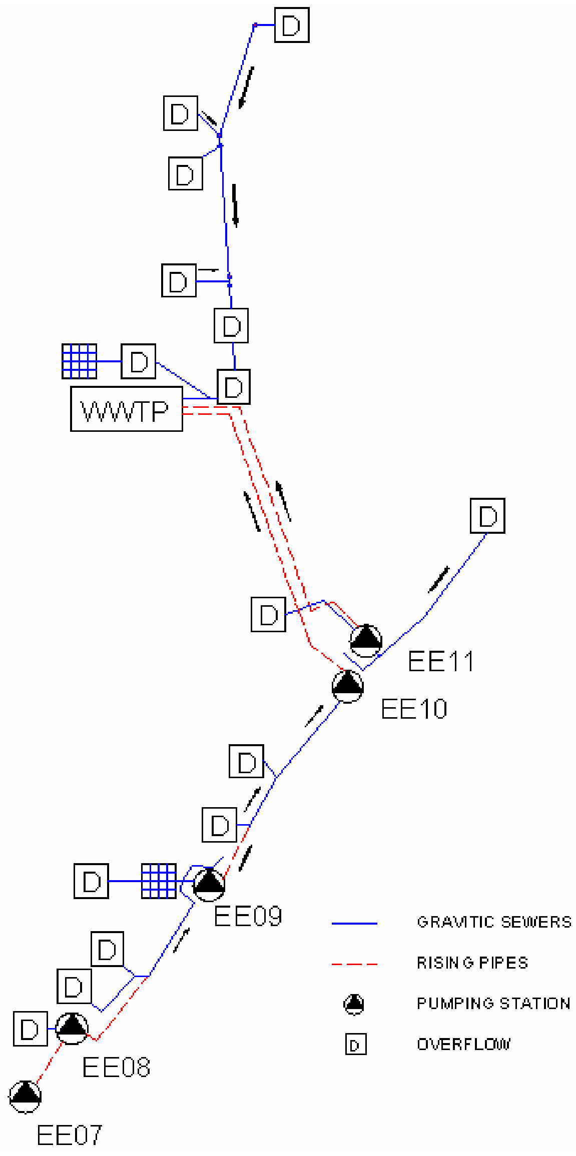

SUBSYSTEMS OF
MAFRA'S MUNICIPALITY
SUBSYSTEM
OF VILA FRANCA
DE XIRA
SUBSYSTEM
OF BUCELAS
SUBSYSTEM OF
ALVERCA
SUBSYSTEM
OF FRIELAS
SUBSYSTEM
OF SÃO JOÃO
DA TALHA
SUBSYSTEM
OF BEIROLAS
SUBSYSTEM
OF CHELAS
SUBSYSTEM
OF ALCÂNTARA

Case Study

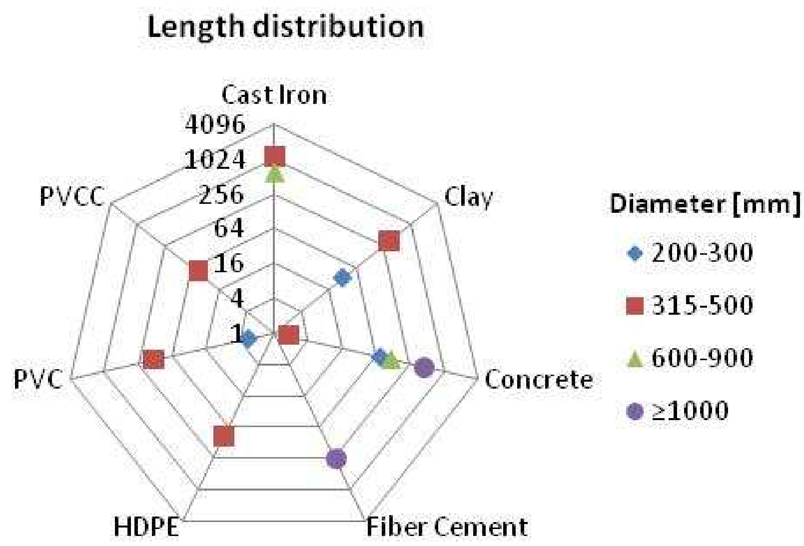
The Chelas sewer subsystem serves more than 140 000 inhabitants and it is divided into four main trunk sewers, comprising:

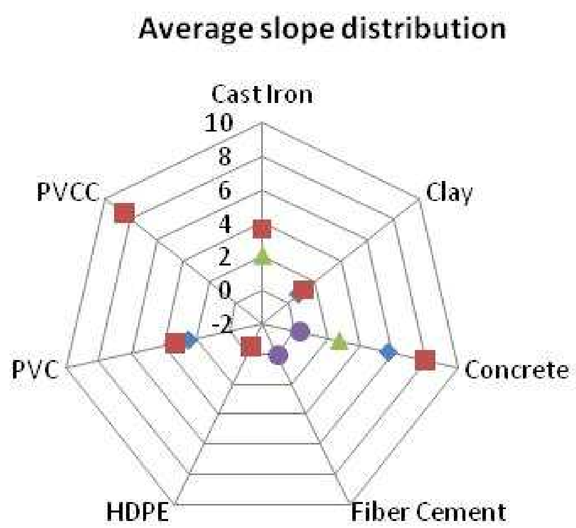
- 4.8 km of gravity sewers and pressure mains
- 131 manholes
- 12 overflows
- 5 pumping systems
- 1 wastewater treatment plant

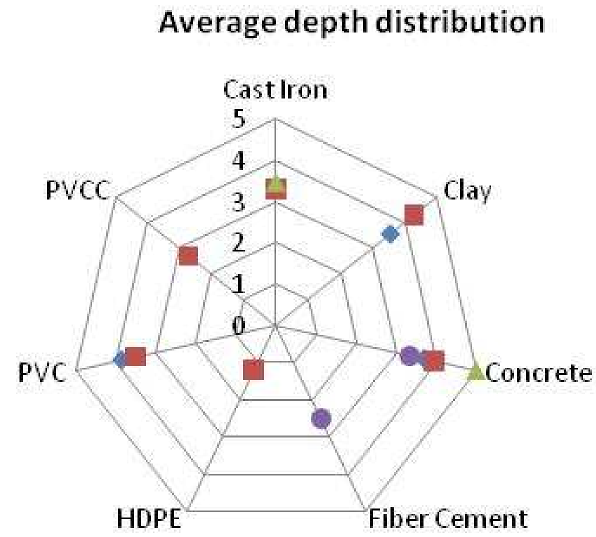

CHELAS DRAINAGE BASIN
DRAINAGE BASIN LIMITS
SEWER SYSTEM
PUMPING STATION
WASTEWATER TREATMENT PLANT


WWTP
EE11
EE10
EE09
EE08
EE07
GRAVITIC SEWERS
RISING PIPES
PUMPING STATION
OVERFLOW

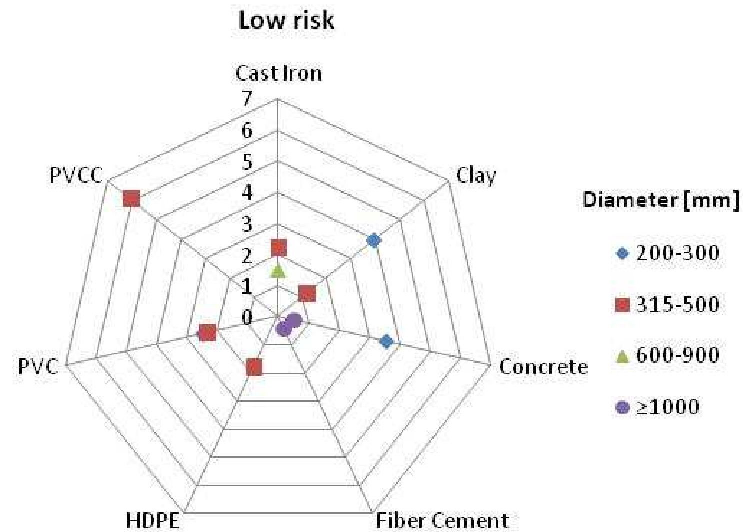
Case Study – Network characteristics

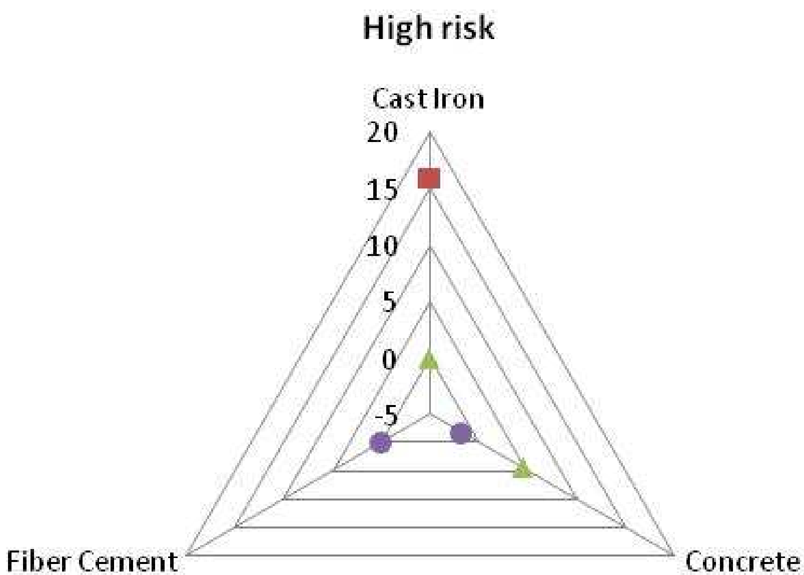


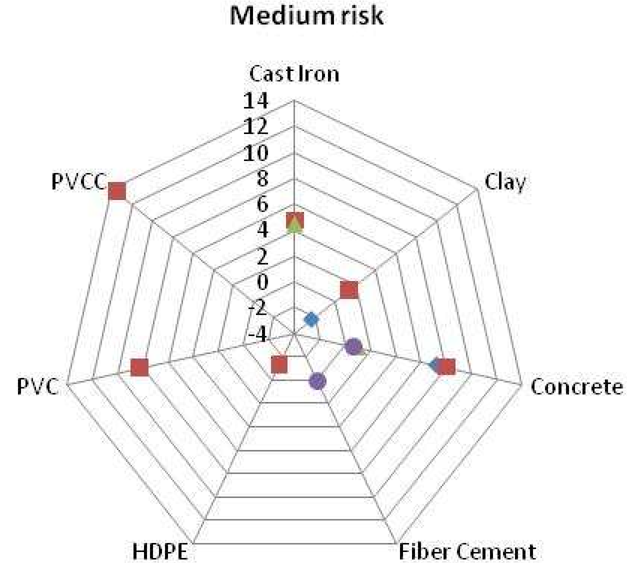




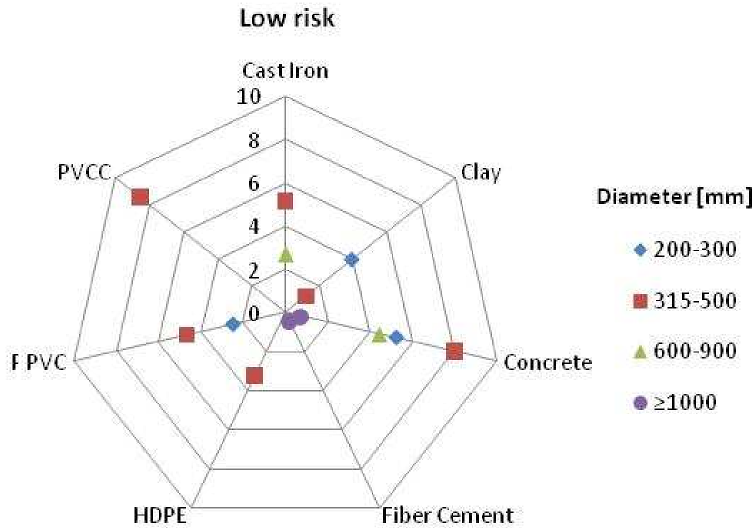
Case Study – Inspection results

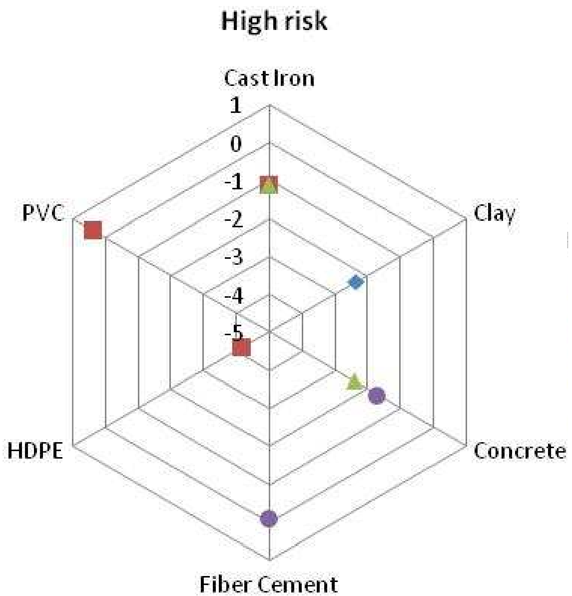


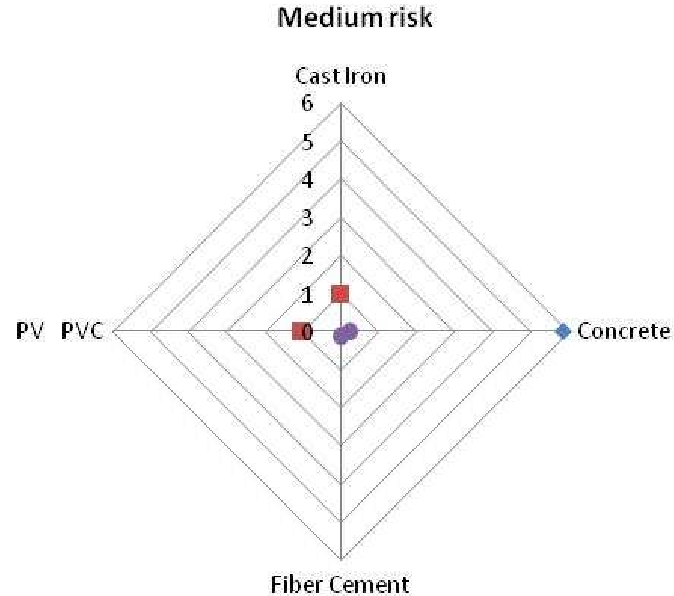




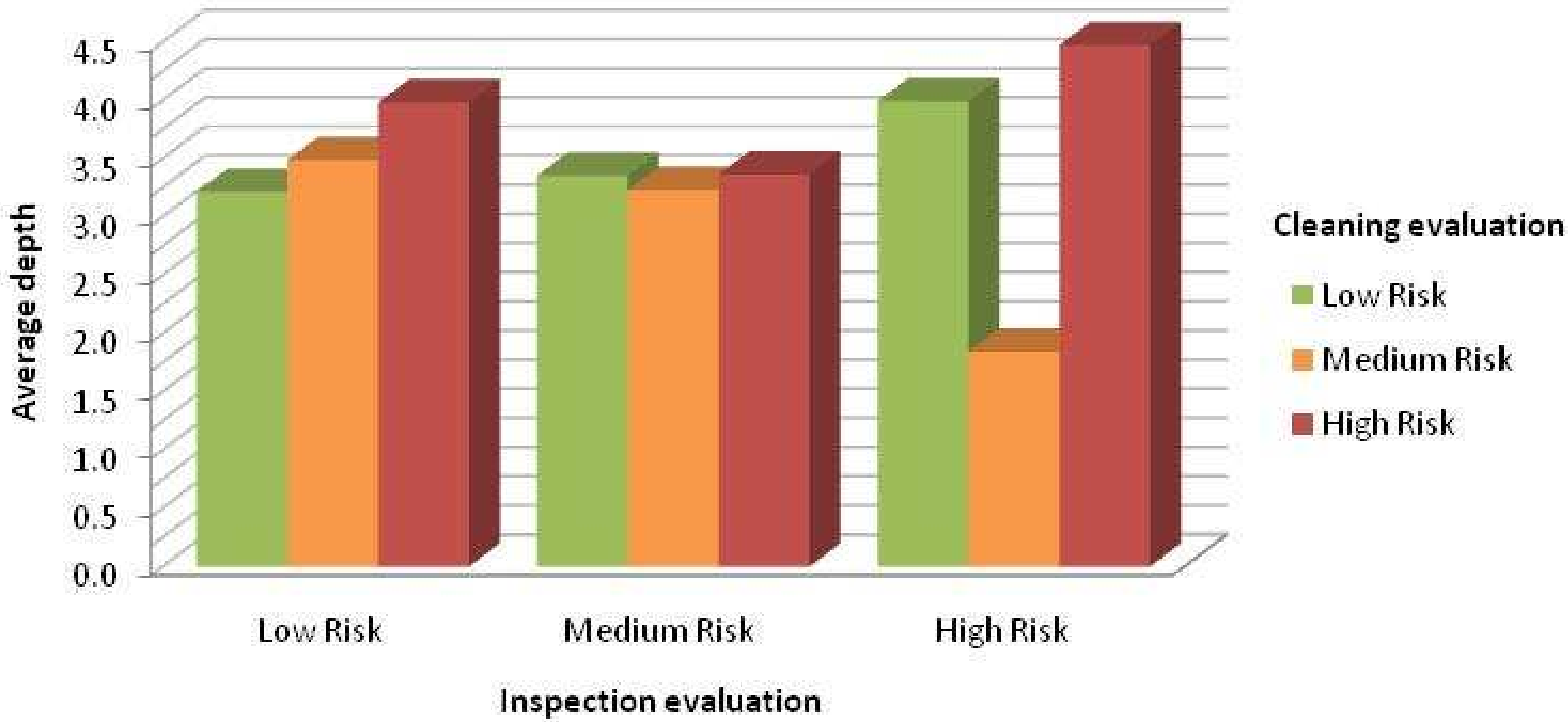
Case Study – Cleaning results







Case Study – Cleaning / Inspection results



Conclusions

Due to the scarcity of information and records, it was selected a general expert system using several parameters that are known to influence the performance of sewer networks. Parameters or variables such as sewer condition, land use, wastewater characteristics, were not taken into account due to lack of appropriate data.

The presented model, despite the crude approach in which is based, is presently in implementation stage. This will allow future developments such as:

- calibration of the parameters and weight factors based on the data from the cleaning and inspection operations
- possibility of increasing the accuracy of the model trough the consideration of further relevant factors, namely the structural sewer condition