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Strategic Asset Management

Proposal for a methodology to assess the technical performance of urban sewer systems

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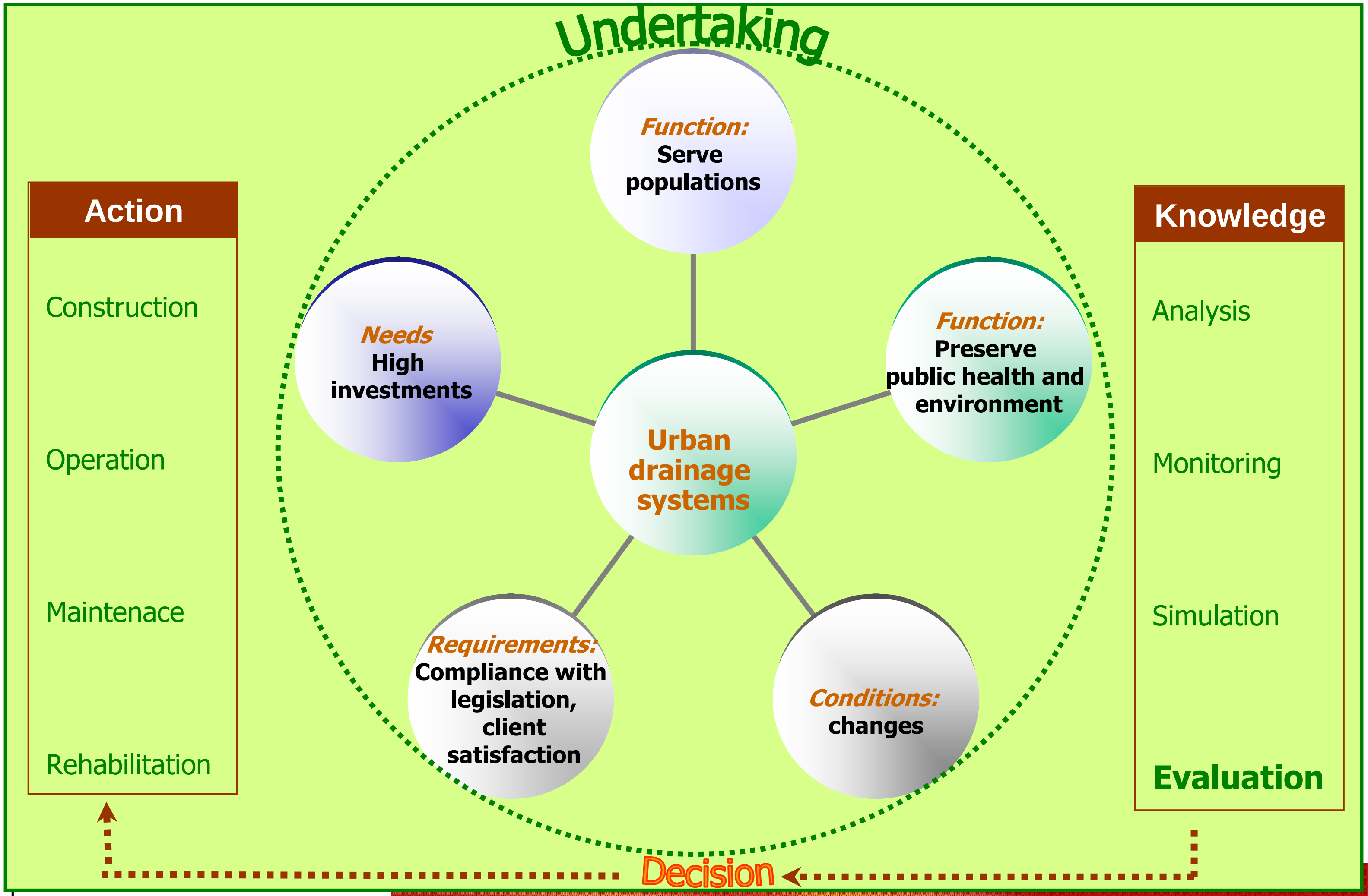
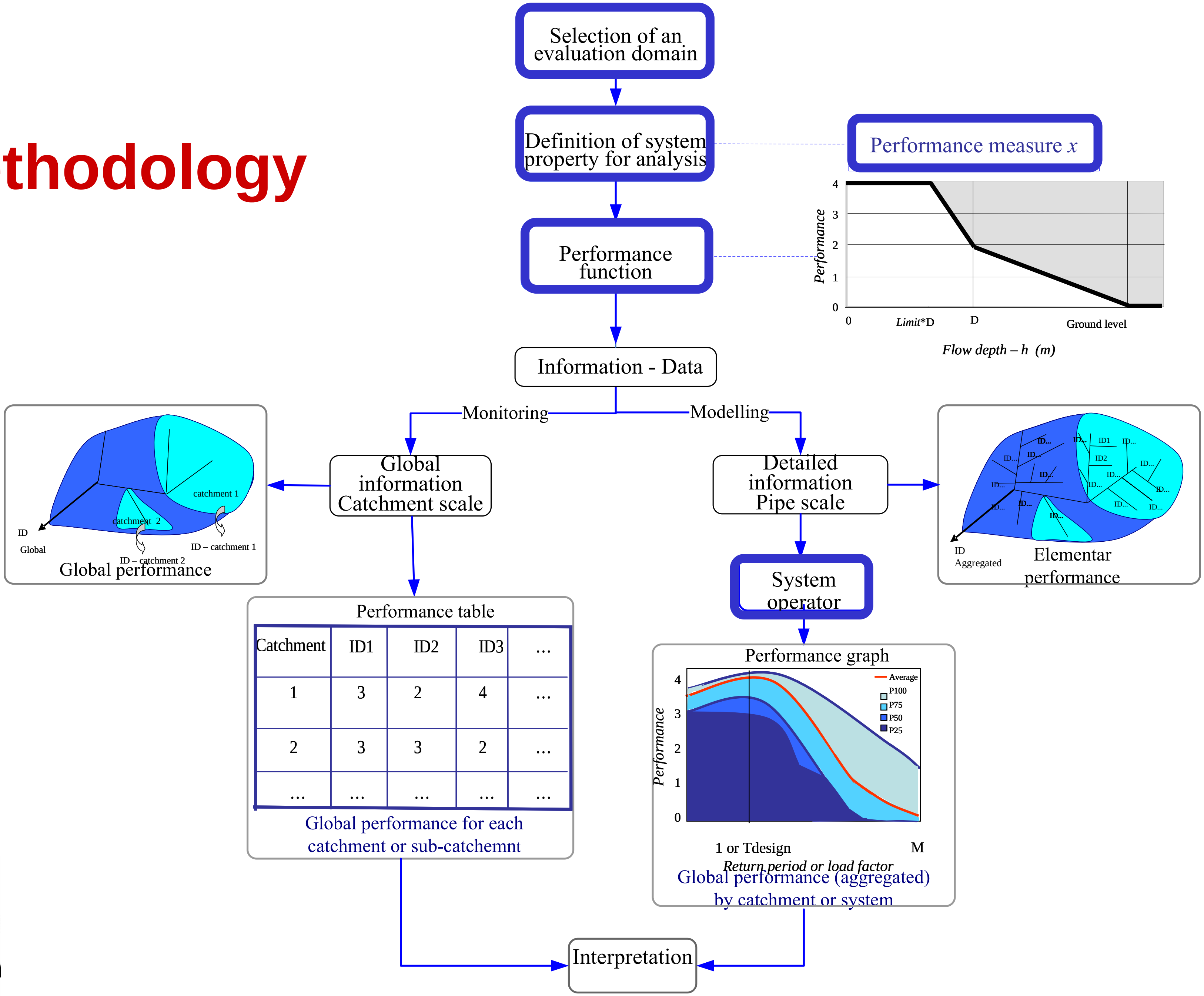
Introduction



Methodology

- Objectives – establishment of a system to be applied at engineering level:
  - Objective, quantitative, systematized and standardized
  - Using systems' data – mathematical modelling or monitoring
  - Based in performance measures defined for each relevant aspect to be assessed that allows to:
    - Collect system's information and translates it into performance, both in time and space, for extended period operational scenarios or loading factors
    - Classify performance
    - Evaluate performance evolution with time and compare among different systems
  - Constitutes a flexible engineering tool to effectively support the management of urban drainage systems
  - Supports decision making

Methodology



Assessing infiltration and inflow impacts on the performance of sewer systems

- Can be due
  - to infiltration from groundwater
  - storm water inflows
    - cross connections
    - storm drains
    - connected impervious areas
    - leaking manholes covers

- I/I effects are relatively obvious but usually there is no objective information on its quantification, origin and economic impact;

Assessing infiltration and inflow impacts on the performance of sewer systems

- Definition of performance indicators to assess I/I impacts:
  - *Hydraulic capacity* - *water level* (PI_1) to be used at pipe scale.

  - *Infiltration:*
  - $\frac{Q_{inf}}{Q_{full}}$ (%) – PI_2 proportion of the sewer full section flow capacity used by the infiltration flow

  - $\frac{Q_{inf}}{Q_{avdwf}}$ (%) – PI_3 infiltration flow as a percentage of the daily mean dry weather flow

Assessing infiltration and inflow impacts on the performance of sewer systems

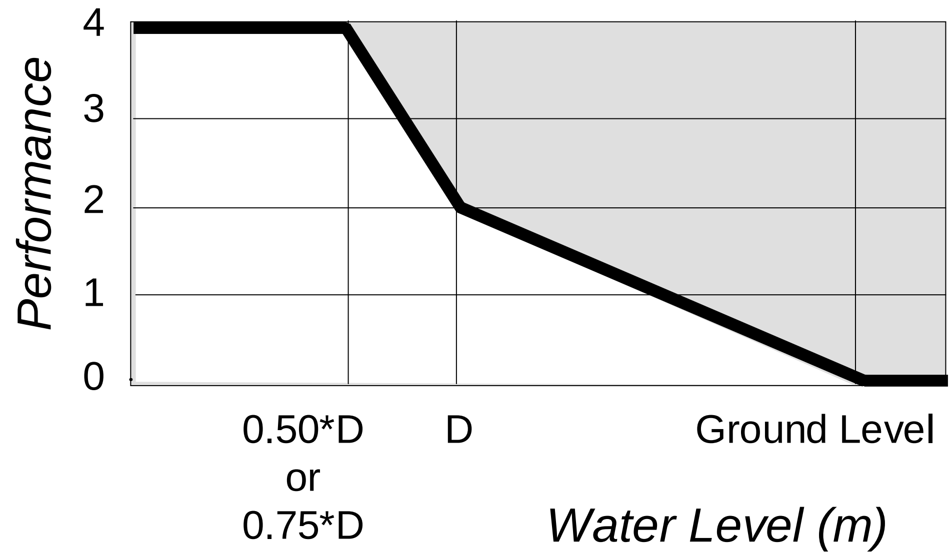
- *infiltration*:
  - $\frac{Q_{inf}}{\text{sewer longitudinal area}}$ (m^3/day/(cm.km)) – PI_4 means infiltration flow per unit sewer wall area
  - *Inflow:*
  - $\frac{Q_{maxinflow}}{Q_{full}}$ (%) – PI_5 proportion of the sewer full section flow capacity used by the maximum inflow reaching the sewer

Assessing infiltration and inflow impacts on the performance of sewer systems

- *Inflow:*
  - $\frac{Q_{inflow}}{Q_{avdwf}}$ (%) – PI_6 inflow expressed as a percentage of the daily mean dry weather flow
  - $\frac{V_{inflow}}{V_{runoff}}$ (%) - PI_7 inflow expressed as a percentage of the catchment runoff

Assessing infiltration and inflow impacts on the performance of sewer systems

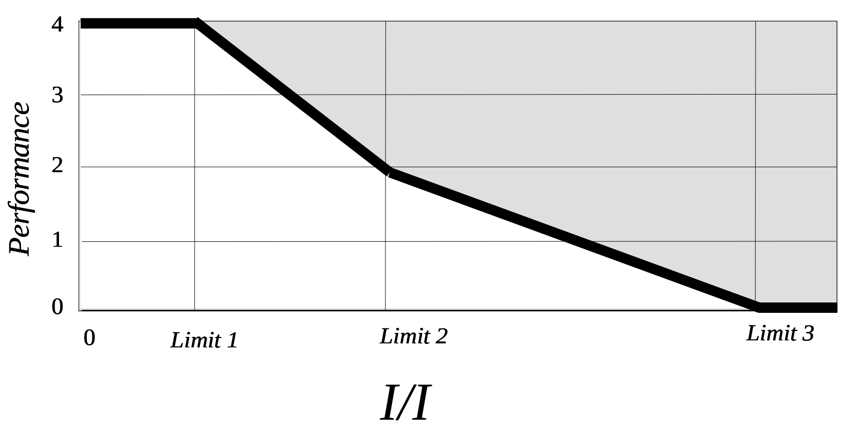
- Definition of performance functions:



Assessing infiltration and inflow impacts on the performance of sewer systems

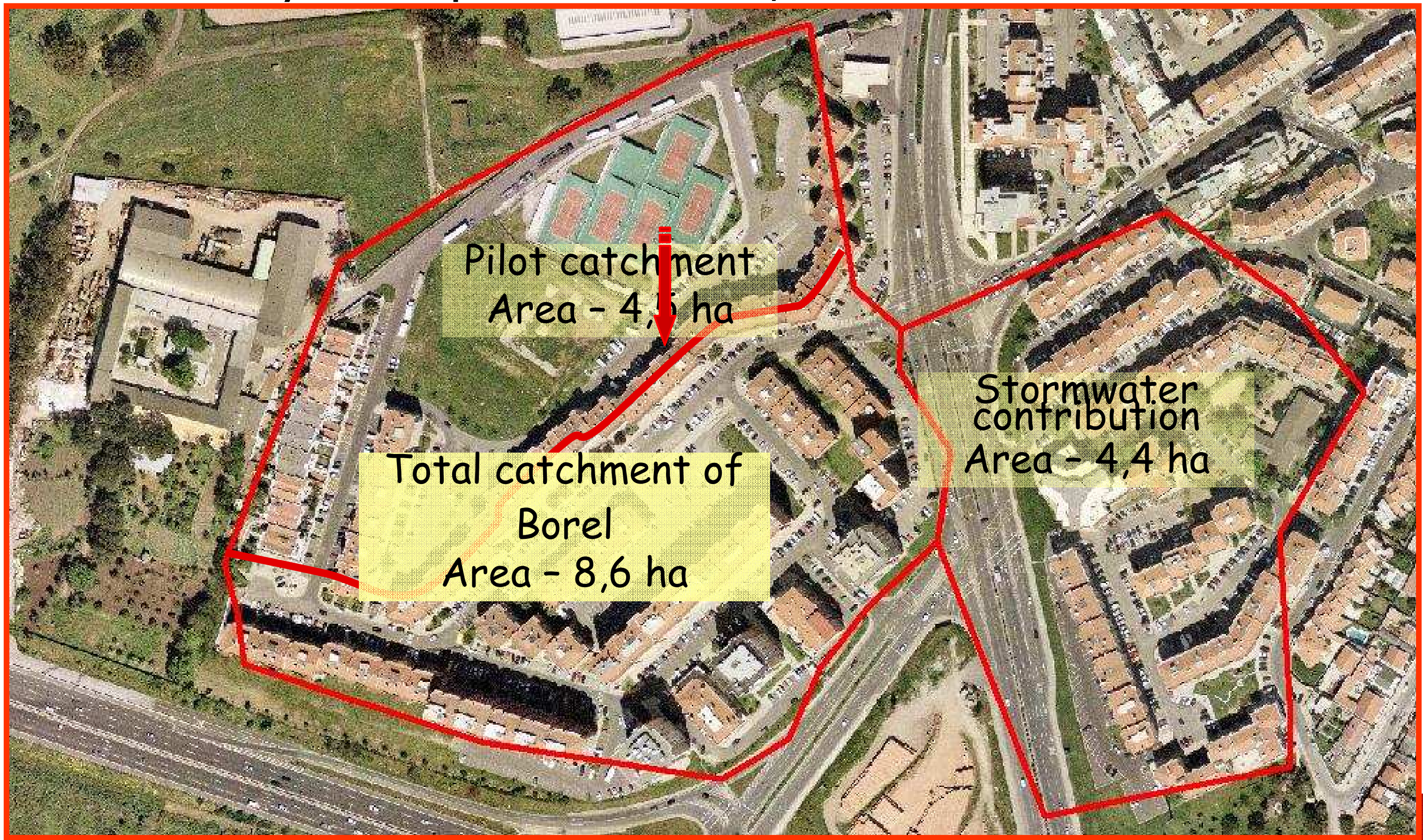
- Definition of performance functions:

System property	Performance Indicator	Limit 1	Limit 2	Limit 3
Infiltration	PI_2	2.5	10.0	25.0
	PI_3	17.0	50.0	67.0
	PI_4	0.5	4.0	7.5
Inflow	PI_5	12.5	25.0	50.0
	PI_6	17.0	50.0	67.0
	PI_7	0.5	0.8	2.6



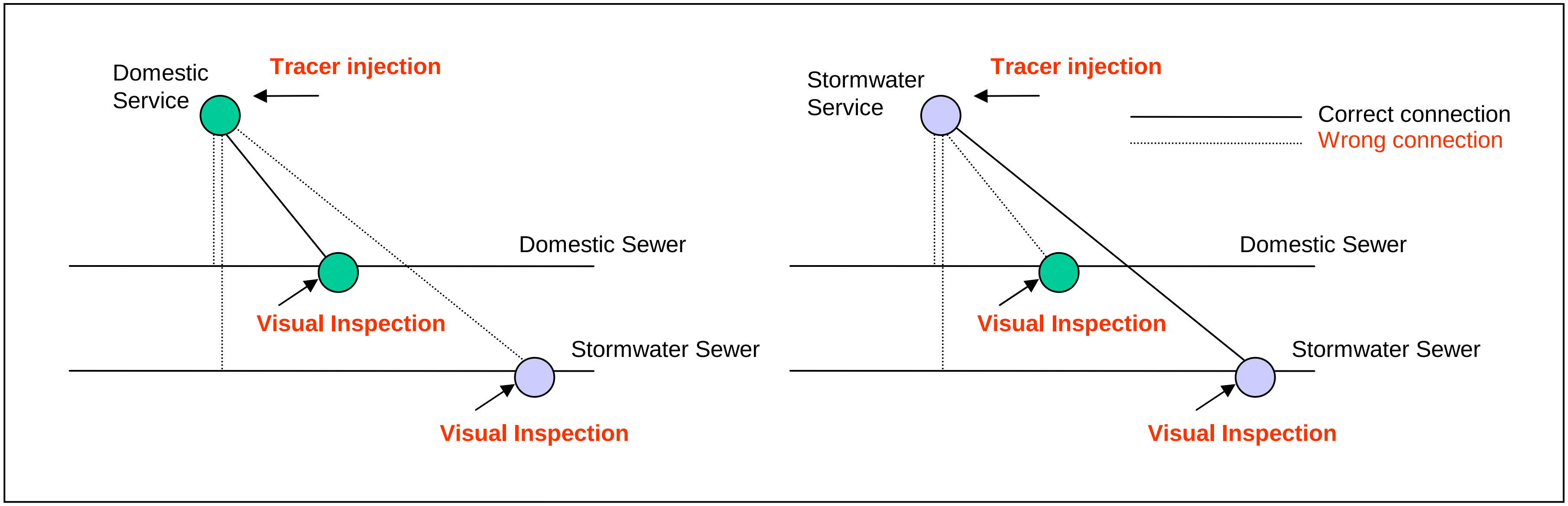
Description of a case study

- Objectives: Evaluate and quantify Infiltration/Inflow (I/I) effects on system performance;



Visual inspection

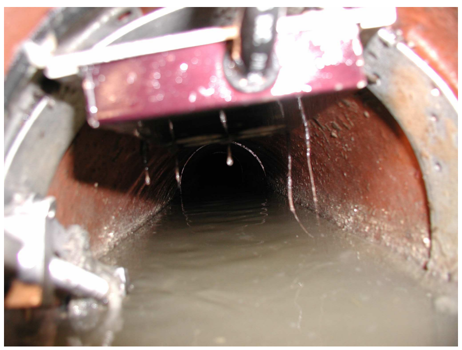
- domestic and stormwater systems
- manholes, service connections and stormwater inlets;
- Sulpho-Rodamine B (tracer).

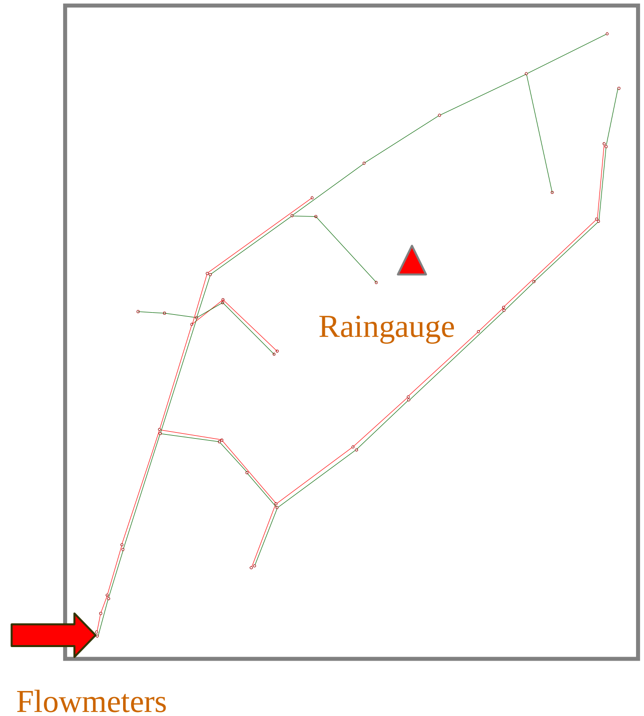


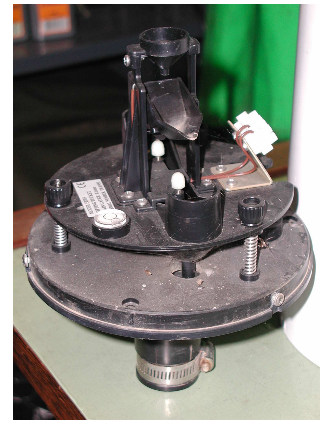
Visual inspections

- 12.5 % of wrong service connections;
- 14.3 % of stormwater connections;
- 6.5% of storm inlet connections;
- Discharges containing oils and fats in the stormwater system;
- Connections made directly in the pipes;
- About 5% of the catchment area was contributing with storm water to the domestic sewer system.

Flow and rain monitoring



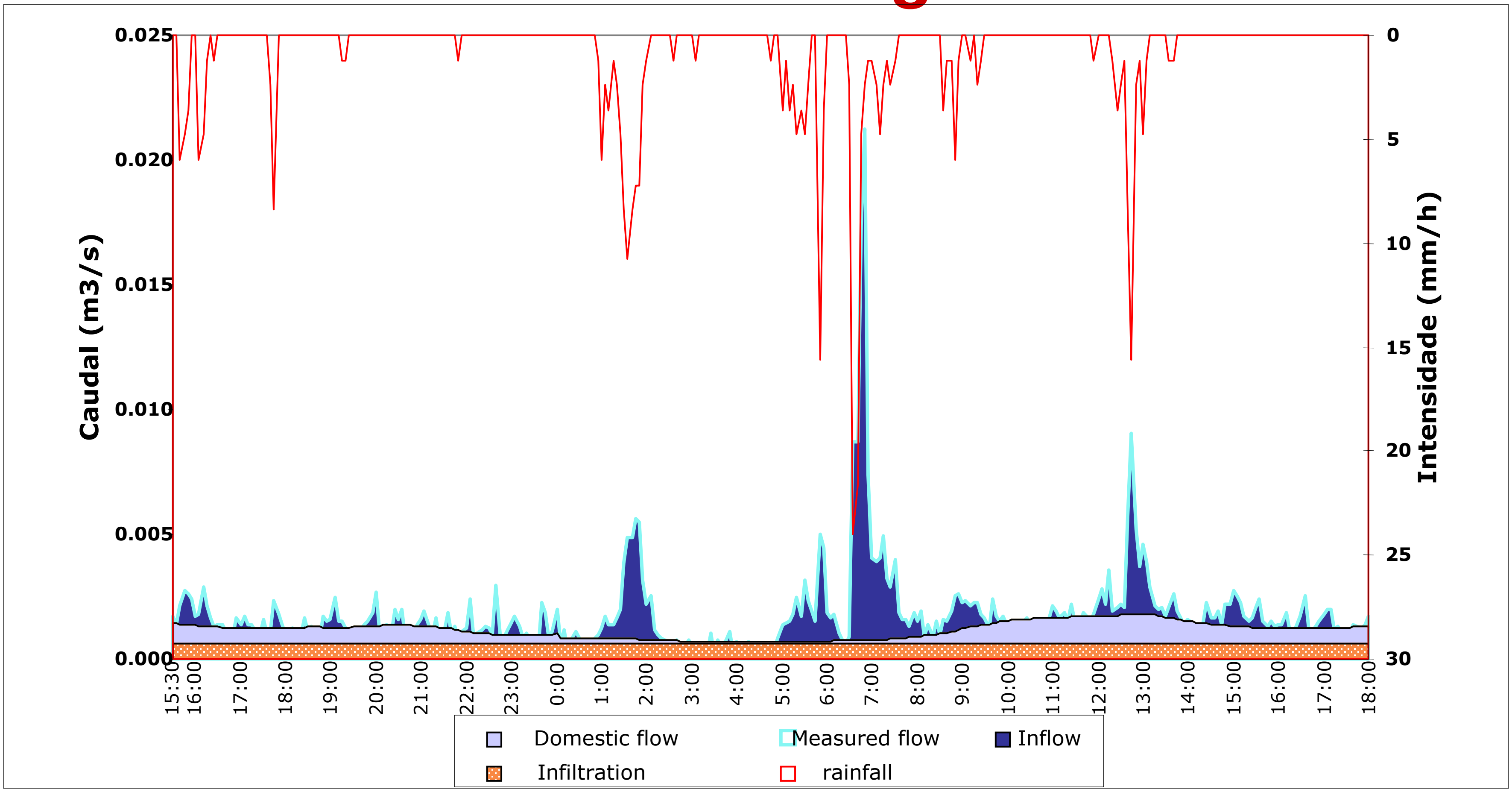




Monitoring period

- *one and a half year* of measurements for <u>domestic system</u> and <u>rainfall</u>
- *two months* of measurements for <u>stormwater system</u>

Flow and rain monitoring



➢ During rain events flow in the domestic system varies according to rain intensity

Mathematical modelling

Anual water consumption

Dry weather flow patterns

Mapping data

\+

Inspection information

Hydraulic model → Calibration → Verification

Monitoring data

Borel Domestic Sewer System Model

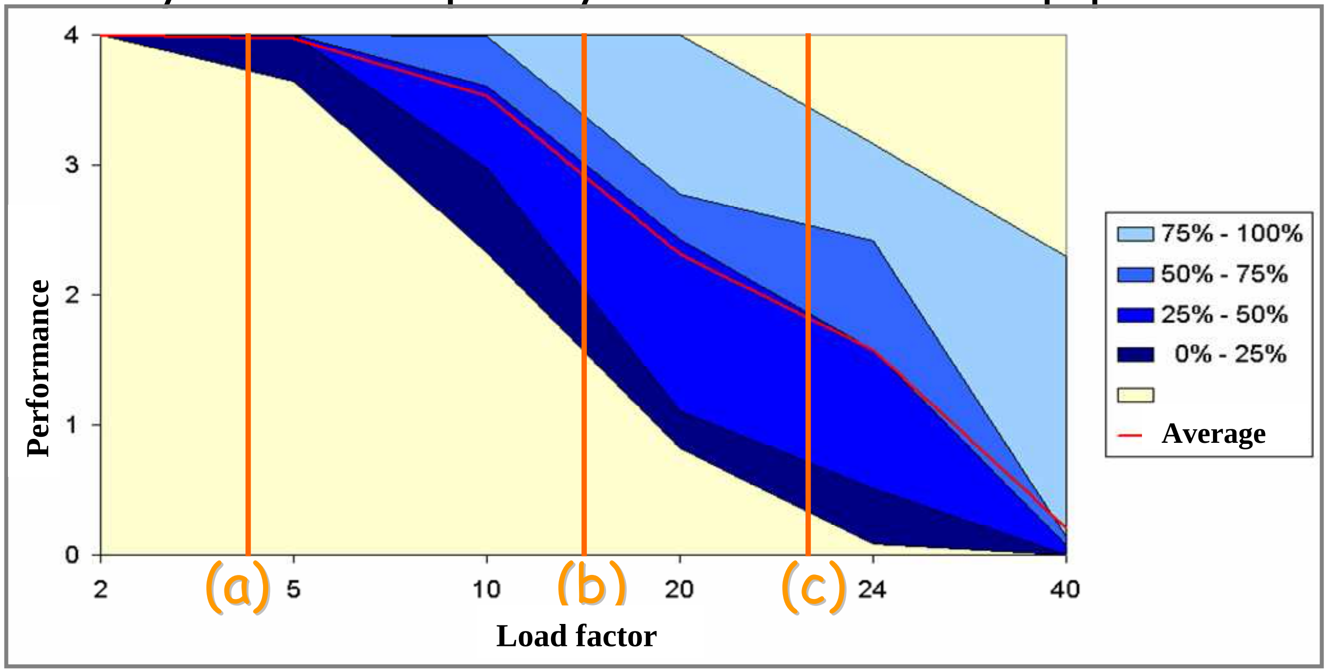
Mathematical modelling

Stormwater inflow to the domestic sewer during rainfall events

Event Intensity	Low	Medium	High
Domestic wastewater volume (m^3)	50.77	110.43	114.16
Measured volume (m^3)	84.11	174.15	261.68
Stormwater inflow volume (m^3)	33.34	63.72	147.52
Volume difference due to wrong connections(%)	66	58	129
Measured peak flow (m^3/s)	0.006	0.021	0.032
Main impact in system performance	None	Reached Q_{full}	Surcharging

Technical performance assessment

- Hydraulic capacity – *water level* – pipe scale application



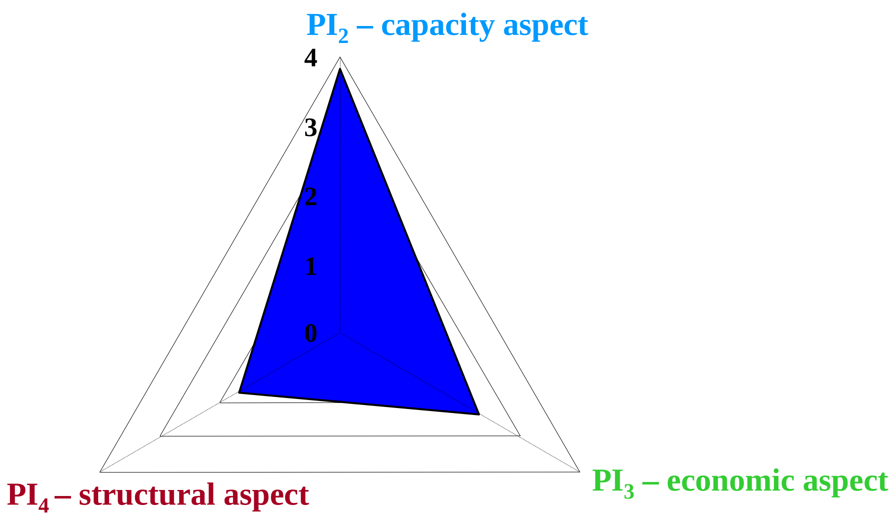
Average Performance

- (a) Low intensity event - Load factor = 3.4 **OPTIMUM**
- (b) Medium intensity event - Load factor = 15 **GOOD**
- (c) High intensity event - Load factor = 23 **UNACCEPTABLE**

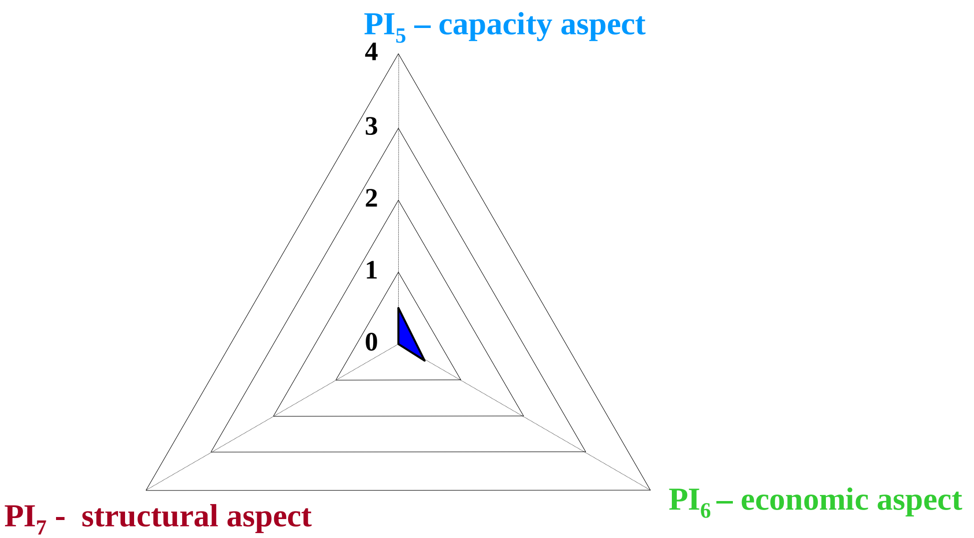
Technical performance assessment

- I/I – PI_2, PI_3, PI_4, PI_5, PI_6, PI_7 – catchment scale application

Infiltration



Inflow



Discussion

- This system seems to be over designed - all pipes have an acceptable performance (above 2) until a loading factor of 12;
- Load factor of 40 there is flooding in the major part of the system.
- There are no individual pipes influencing significantly the overall system's performance.
- Infiltration has no significant consequences in both aspects - hydraulic capacity (PI2) and economic (PI3) but regarding the structural aspect (PI4) the system presents an unacceptable performance.

Discussion

- The system presents an unacceptable performance regarding inflow for the three aspects analyzed (hydraulic, economic and structural):
  - The pipe section is significantly used by inflow with negative consequences in the hydraulic capacity (PI_5), in accordance with the detailed hydraulic performance assessment (PI_1).
  - There is a negative impact regarding the economic aspect (PI_6).
  - Unacceptable stormwater volume reaches the domestic system, meaning that there is an excessive area wrongly connected to the domestic system, in accordance with results of the visual inspections of the structural condition (PI_7).

Conclusions

- Impact of inflow into separate domestic systems can be very significant (even when there is a low number of wrong connections);
- Spatial spreading of wrong connections increase the costs of their detection. (Important to have methodologies for planning correction measures).
- Performance measures provide an objective and quantifiable way to:
  - measure the system performance and improvements
  - predict the benefits in performance provided by the intervention actions;
- The application of PI depends on available data, which means that:
  - can be applied at pipe or catchment scales;
  - the quality and uncertainty of PI results depend on the quality and uncertainty of data used.
- The presented methodology aims to support sewer systems rehabilitation by using PI, as a means of aggregating information on system characteristics and data from monitoring or modelling, and translate it into performance values;
- The methodology can support the decision on when and where to rehabilitate and must consider a set of PI and not only one, in order to give a global view with significant information.