



D2-Decision Deck project

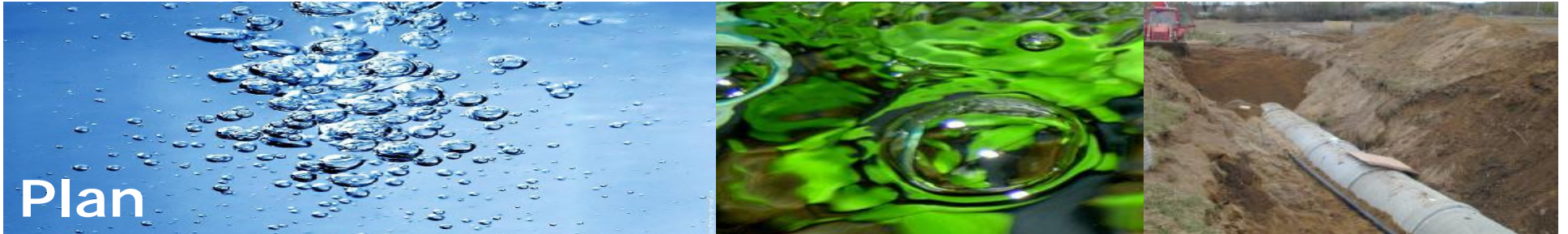
Workshop, February 21-22, 2007 , Paris-Dauphine.

A multi-criteria approach for asset management of waste water networks

Amir NAFI, Vincent MOUSSEAU and Caty WEREY

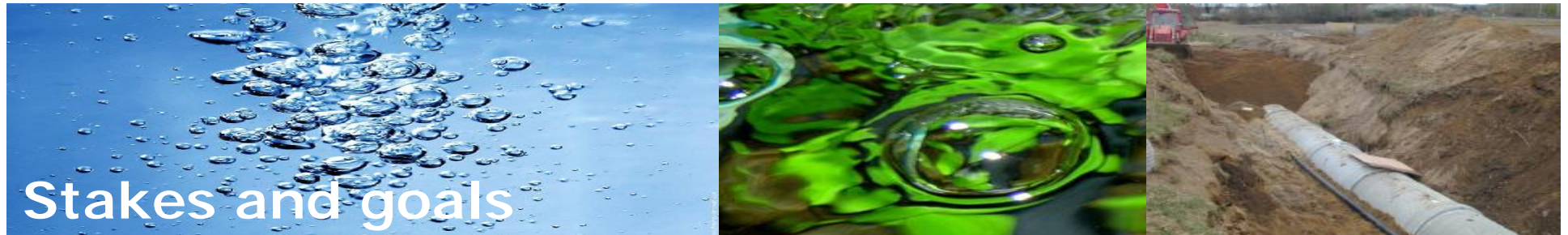


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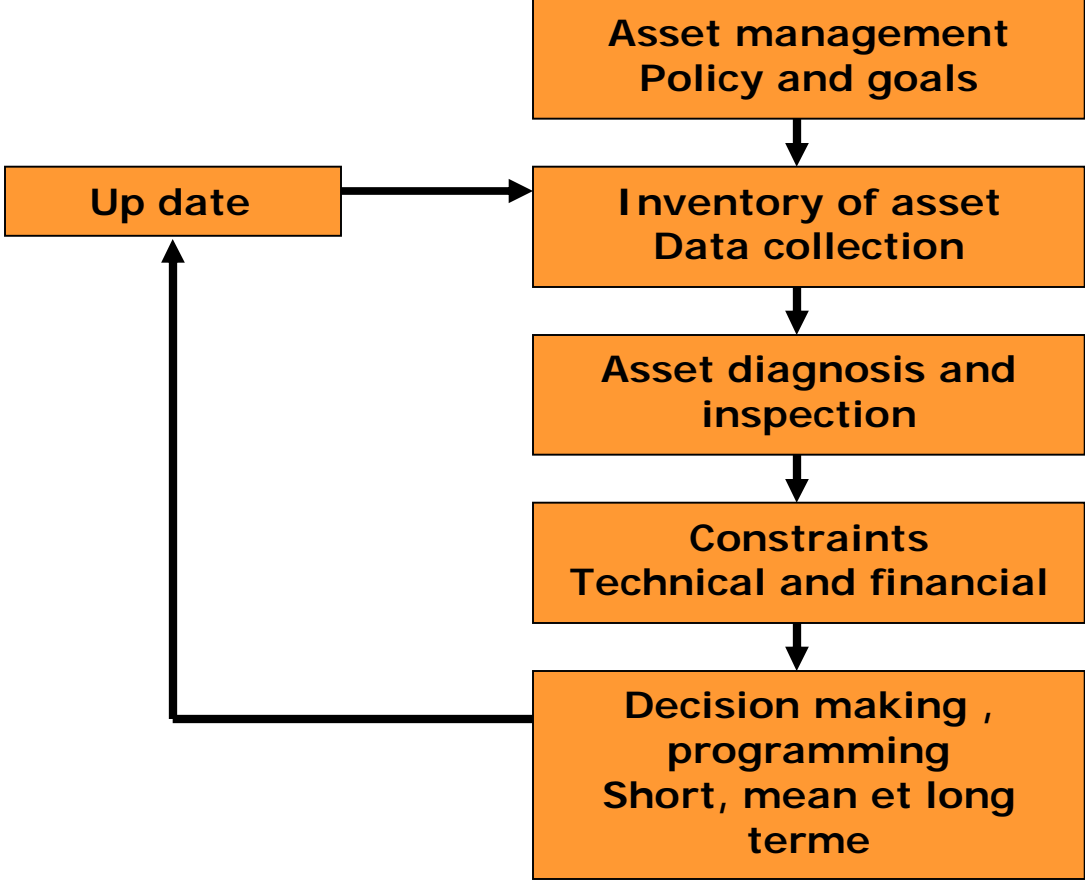
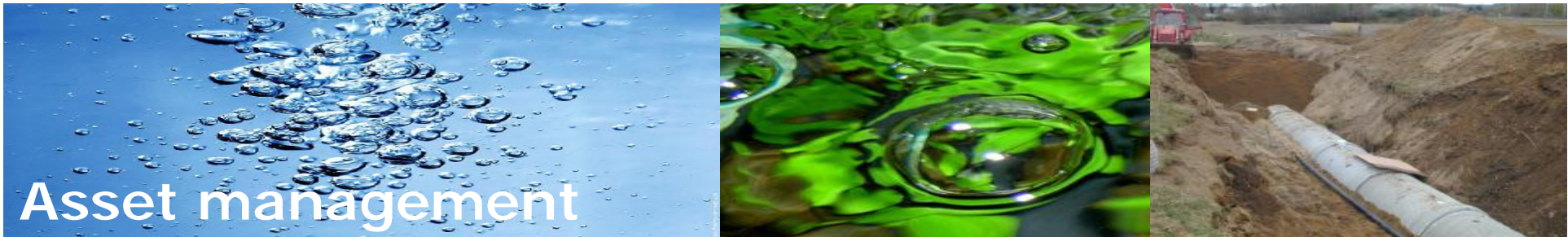
Plan

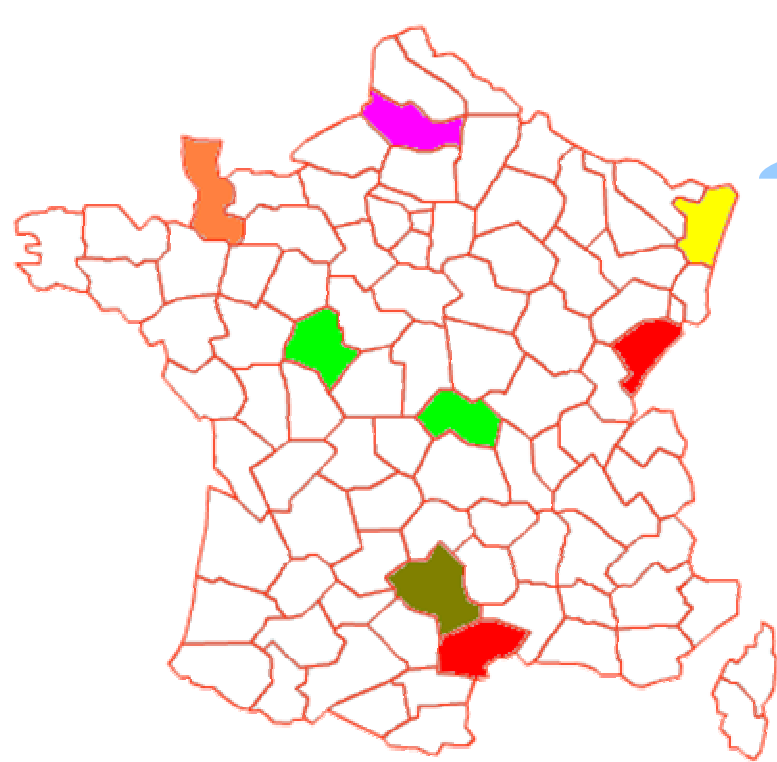
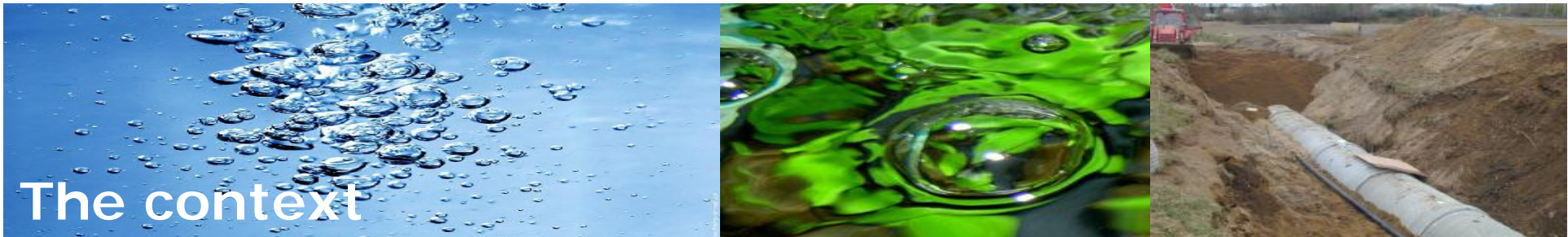
- q **Stakes and goals of the study**
- q **The context**
- q **The problematic**
- q **Proposed approach**
- q **Electre-Tri method**
- q **Implementation**
- q **Analysis of the results**
- q **Conclusion and outlook**



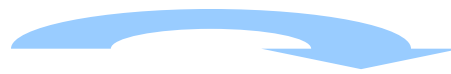
Stakes and goals

- q Long term policy for asset management
- q The use of available data in County Council of Bas-rhin
- q Respect of financial constraint by sewers selection
- q Proposing a way to select deteriorated sewers
- q Implementation of the approach in waste water utility
- q Identification of deteriorated sewers for rehabilitation
- q Considering possible improvement for Electre-tri method

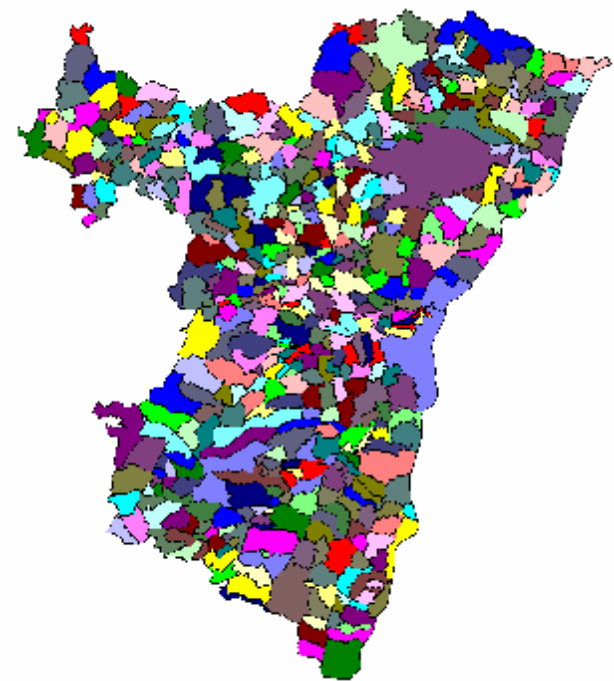


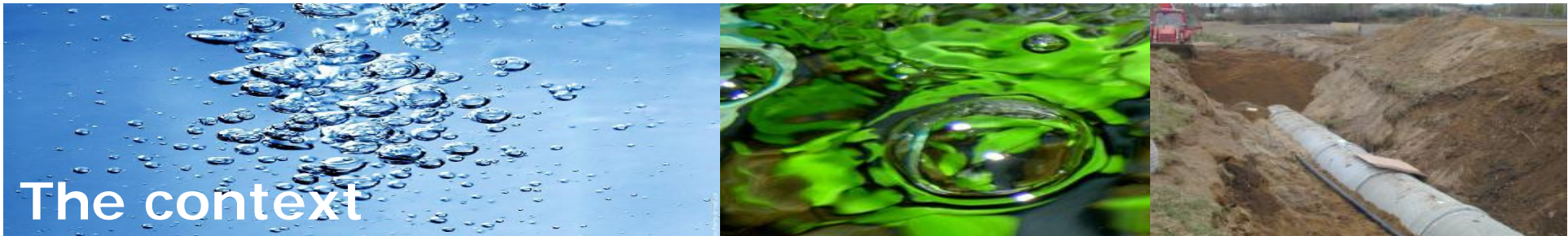


Context



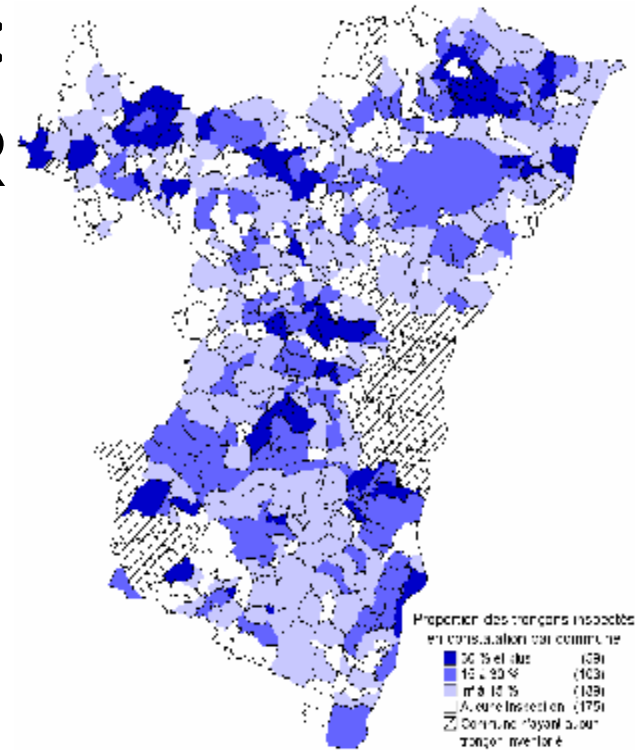
sewerage utilities



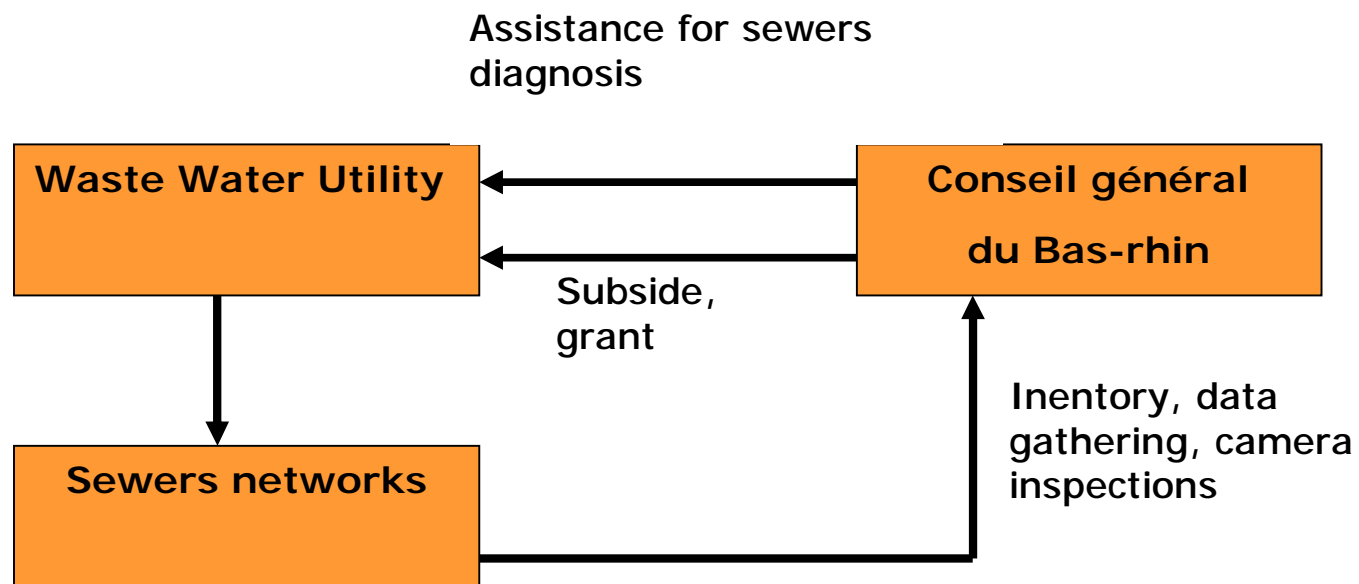
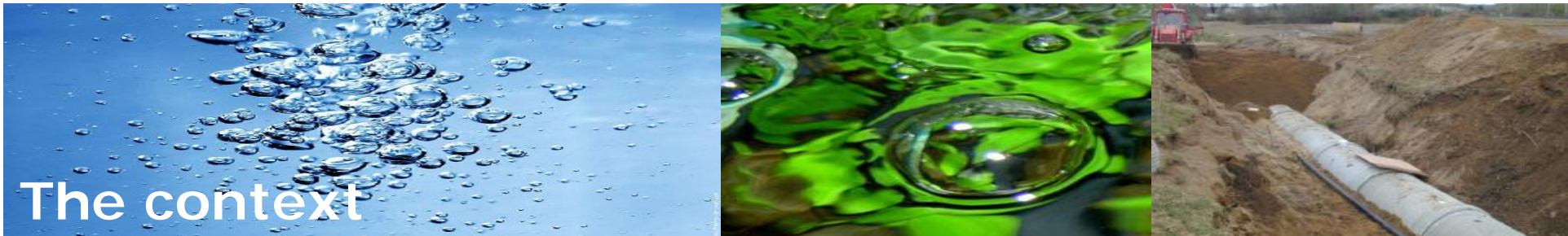


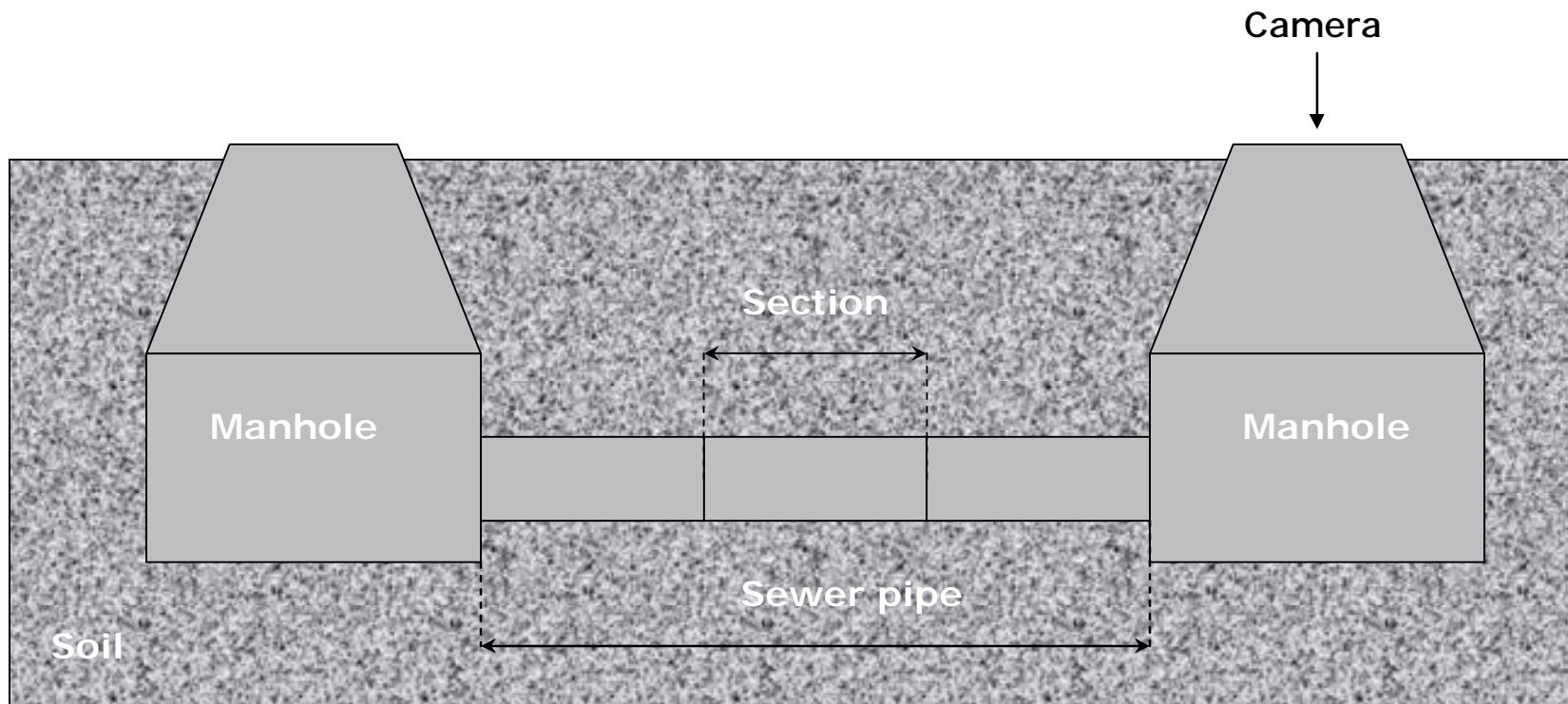
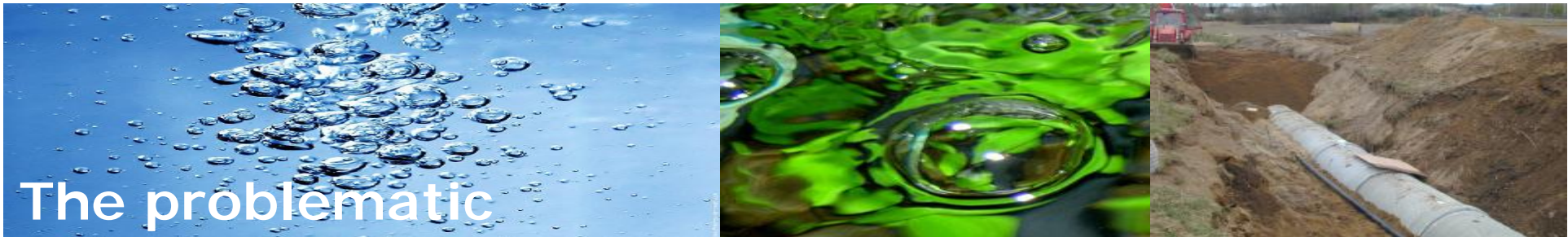
The context

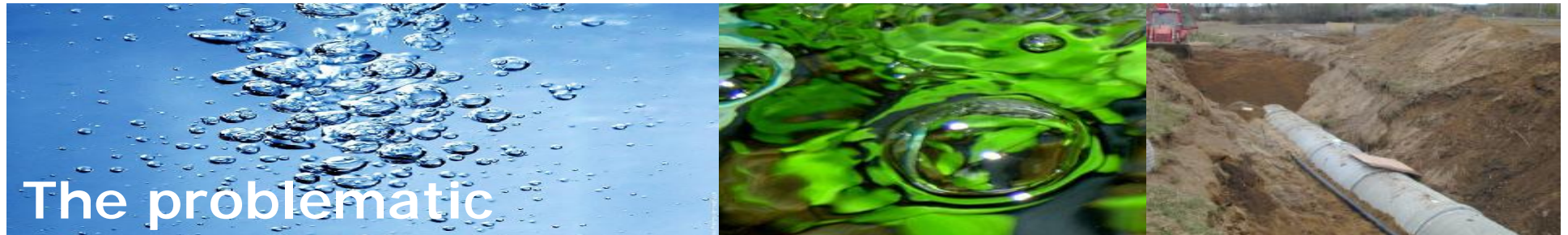
Sewers inventory in 2003: ↳ Data base called CHIMER



<p>Data on the pipe and its environment</p> <p>5 100 km (4 600 km waste water)</p>	<p>Defects noticed by CCTV inspections under « local » codification</p> <p>32 232 inspections</p> <p>89 311 defects</p>
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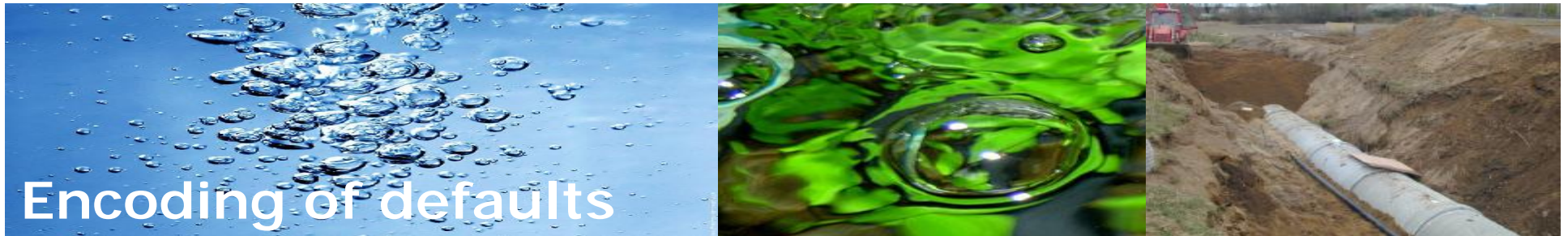






RERAU methodology

- q Defects: actual physical state of the pipe, observed by special cameras
- q Dysfunctions: consequences of defects
- q Impacts: effects of the dysfunctions if vulnerability: segment and environment.
- q Direct observation (O): it is the case of CCTV inspection
- q Observation-based estimations (E/O): some time results of defects observed by CCTV
- q Estimations based on risk factors (E/R): step before CCTV inspection.



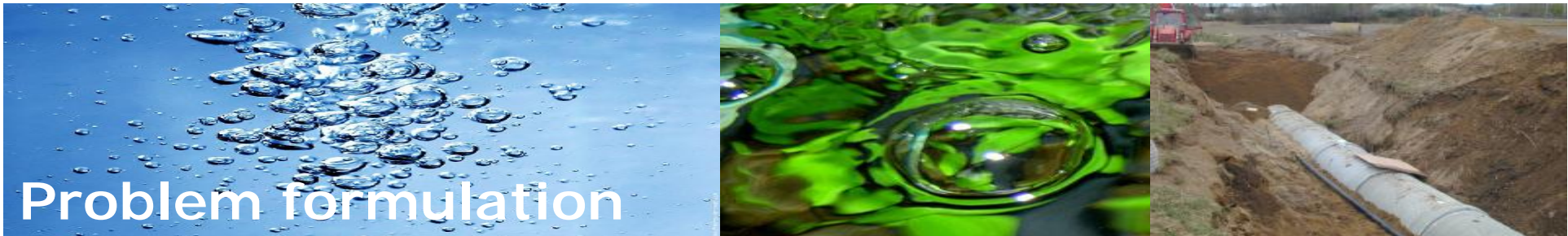
Encoding of defaults

EN 13508-2 standard codification (2003)

Defect: Break/collapse		
Main code	Additional information	description
BAC	characterisation	The nature of the observation is: - Break (A)– pieces of pipe visibly displaced - Missing (B)– missing pieces of wall - Collapse (C)– complete loss of structural integrity
	quantification	The length of the observation in millimetres
	Circumferential location	The position of the observation



Identification	Dysfunctions
INF	Infiltration
EXF	Exfiltration
HYD	Decrease of hydraulic capacity
DEB	Flooding
DEV	Overflow
ENS	Sand silting
BOU	Blockage
RAC	Ongoing degradation from roots intrusion
EFF	Risk of collapse
DSC	Destabilisation of ground-pipe system
ATC	Ongoing corrosion
ABR	Ongoing degradation from abrasion

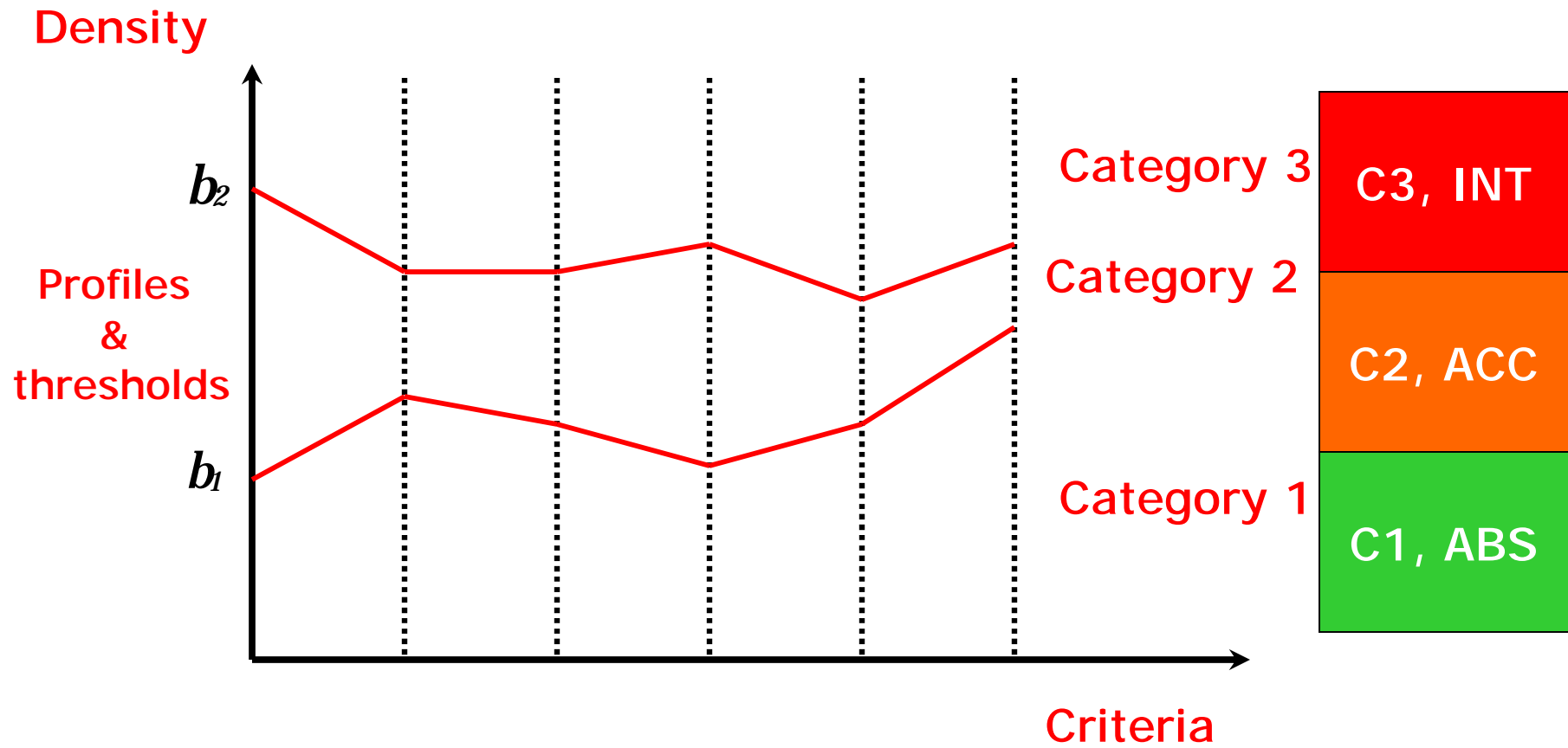
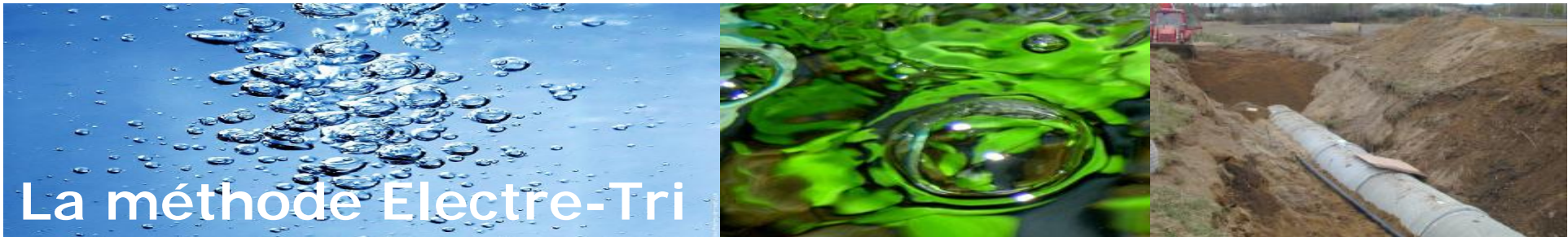


Problem formulation

- q 8 dysfunctions taken into account in decision making, number of criteria equal to 8.
- q Density dysfunction is assessed according to RERAU methodology for each dysfunction corresponding to a criterion.
- q 3 categories for deterioration state: ABS, ACC and INT, 2 profiles to determine
- q We consider an assignment problem of 90 sewers among 337

Criteria

Sewers	Sewers	INF	EXF	HYD	DEB	DEV	...	ENS	Category	Categories
	S1	120	20	30	40	50		60	ACC	
	S2	120	20	30	40	50		60	INT	
	
	
	S90	120	20	30	40	50		60	ABS	





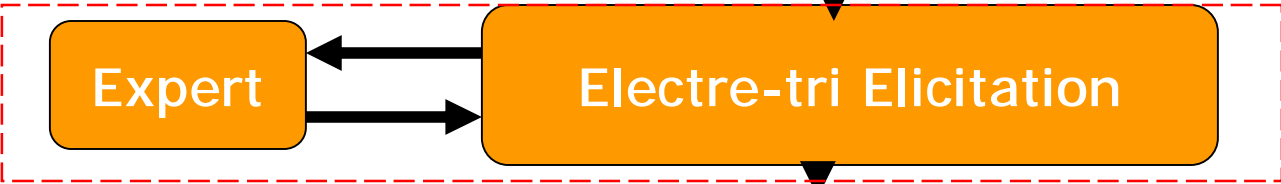
Camera inspections

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EN 13508-2

Density of dysfunctions
RERAU methodology

Table of Performance

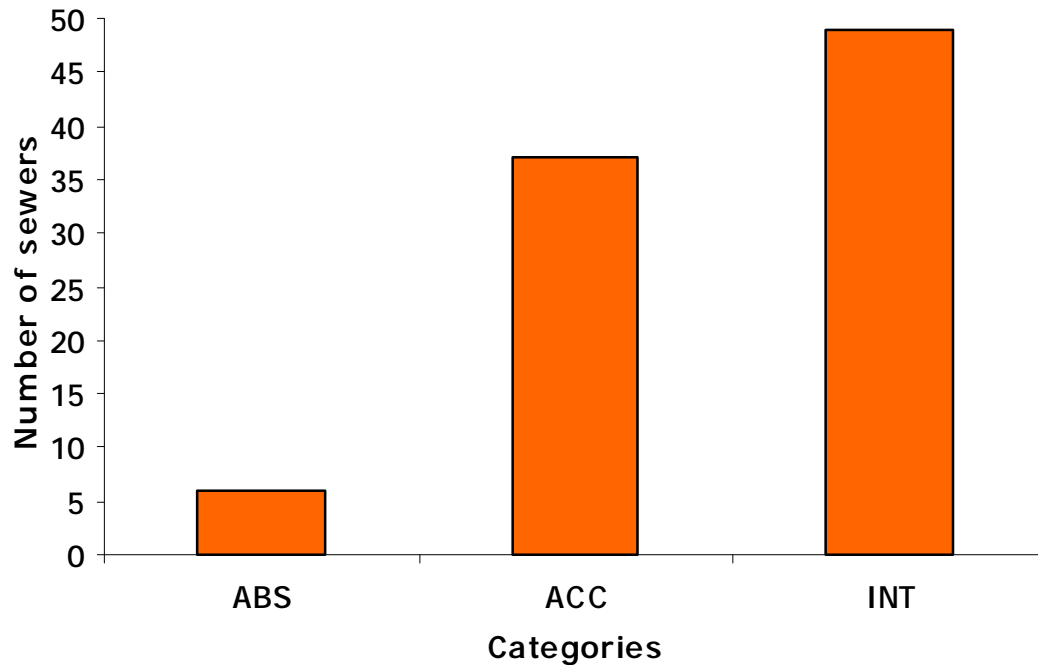
Data collection
and
problem formulation



Electre-tri
method

Infering categories
profiles and thresholds

Results
&
analysis



Expert assignment

q 7 sewers to category ABS

q 37 sewers to category ACC

q 47 sewers to category INT



Electre-tri elicitation, Profiles inference

Catégories		BOU	EFF	ENS	HYD	INF	RAC	ATC	DSC
	Min	0	0	0	0	0	0	1	1
	Max	0	0	0	0	0	0	1	1
	Mean	0	0	0	0	0	0	1	1
ABS	b_1	0.5	2.23	37.53	37.96	40.67	0.5	2	1
	Min	0	0	0	0	0	0	1	1
	Max	12.12	30.77	426.67	426.67	296.23	0	4	1
	Mean	0.40	4.46	75.06	75.92	81.34	0.00	2.03	1
ACC	b_2	7	29	126.70	128.09	300	7	3	1
	Min	0	0	0	0	42.67	0	1	1
	Max	462.5	426.67	960	960	2104.76	462.5	4	4
	Mean	30.09	69.45	178.33	180.26	549.51	24.46	2.80	2.20
INT									



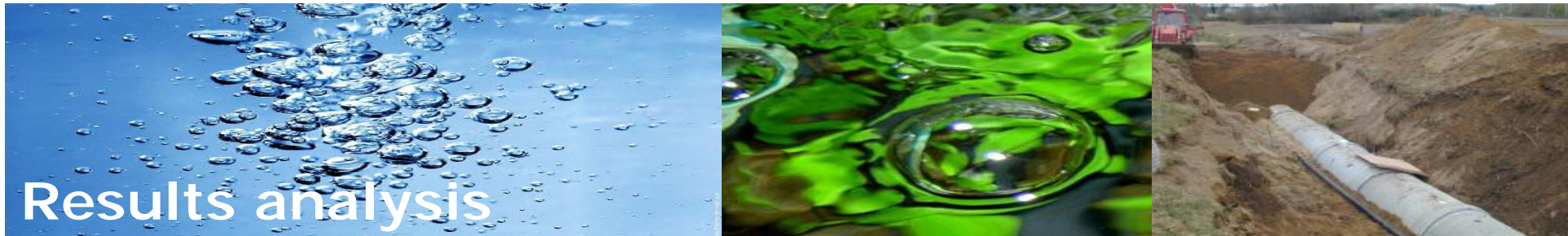
Electre-tri implementation on example, IRIS

Electre-tri implementation and expert assignment

Compatibility Expert & Electre-tri	number	percent (%)
Correctly assigned	85	93
incompatibility	6	7
Sewers analyzed	91	

Weights inference obtained by IRIS

Criteria	BOU	EFF	ENS	HYD	INF	RAC	ATC	DSC
Weights	0.005	0.25	0.005	0.25	0.25	0.24	0.05	0.24



Results analysis

Analysis of sewers not correctly assigned by Electre-tri

Expert	Electre-tri	Id	BOU	EFF	ENS	HYD	INF	RAC	ATCDSC
INT	ACC	12727	0	43,24	2,7	2,7	64,86	0	1 1
INT	ACC	22658	0	0	0	0	738,46	0	1 1
INT	ACC	33120	0	0	0	0	752,94	0	1 1
INT	ACC	33874	103,23	0	103,23	103,23	77,42	103.23	1 1
INT	ACC	42586	0	0	0	0	731,43	0	1 1
ACC	INT	49856	0	30,77	107,69	107,69	292,31	0	1 1

The sewers shown by the table above, are characterized by :

- q accumulation of minor dysfunctions that become the sewer deteriorate
- q presence of a major dysfunction specially infiltration
- q possible error from expert assignment, specially for sewer 49856



Electre-tri implementation on 337 sewers

Electre-tri implementation and sewers not correctly assigned because dysfunctions accumulation

Analysis of assignment

q 27 sewers because of accumulation

q 12 sewers because of a major dysfunction

q 2 sewers because of possible error of expert

Weighted sum for density

$$S_d = \sum_{i=1}^8 w_i \cdot D_i$$

Weighted sum for criteria

$$S_p = \sum_{i=1}^8 w_i \cdot y_i$$

Identifiant	BOU	EFF	ENS	HYD	INF	RAC	ATC	DSC	Sp	Sd
49856	1	1	1	1	1	0	0	0	0,51	81,41
33874	1	0	1	1	1	1	0	0	0,50	21,03
12727	0	1	0	0	1	0	0	0	0,49	26,92
3362	0	1	0	0	1	0	1	0	0,50	16,21
4061	0	1	1	1	1	0	1	0	0,51	71,94
6871	0	1	1	1	1	0	1	0	0,51	26,82
6874	0	1	0	0	1	0	1	0	0,50	46,55
7245	0	1	0	0	0	0	1	0	0,25	7,87
12451	0	1	0	0	1	0	1	0	0,50	16,84
17514	0	1	1	1	1	0	0	0	0,50	70,50
18303	0	1	0	0	1	0	1	0	0,50	20,82
28460	0	1	1	1	1	0	0	0	0,50	17,59
29100	0	0	0	0	1	0	1	0	0,25	73,88
51692	0	1	0	0	0	0	1	0	0,25	11,38
59663	0	1	0	0	1	0	1	0	0,50	14,40
67630	0	1	1	1	0	0	0	0	0,26	8,23
71299	0	1	0	0	1	0	1	0	0,50	22,87
76312	0	1	1	1	1	0	1	0	0,51	30,60
79646	0	0	0	0	1	0	1	0	0,25	71,23
91888	0	1	1	1	0	0	1	0	0,26	16,83
92201	0	1	0	0	1	0	1	0	0,50	13,42
100284	0	1	0	0	1	0	1	0	0,50	21,59
109440	0	1	1	1	0	0	0	0	0,26	6,85
128963	0	1	1	1	1	0	1	0	0,51	29,58
129562	0	1	0	0	0	0	1	0	0,25	3,81
89049	1	0	1	1	1	0	0	0	0,26	30,84
94399	1	0	0	0	1	0	1	0	0,26	16,34



Weighted sum threshold determination

Expert analysis of 15 sewers for threshold estimation

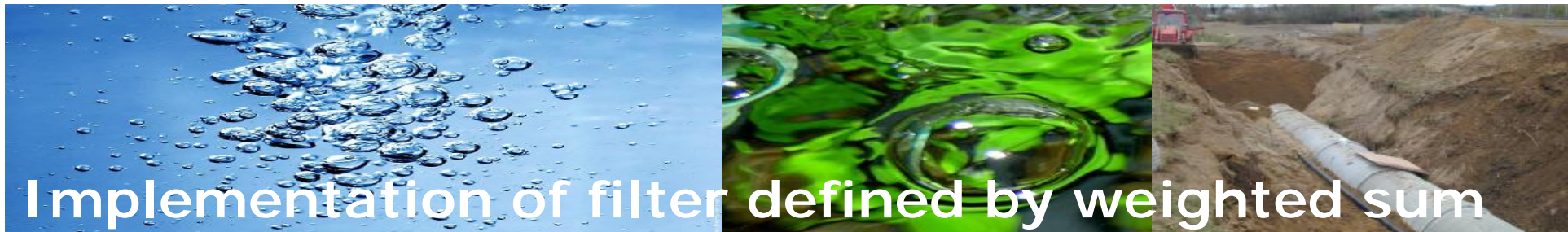
Weighted sum for density

$$S_d = 23$$

Weighted sum for criteria

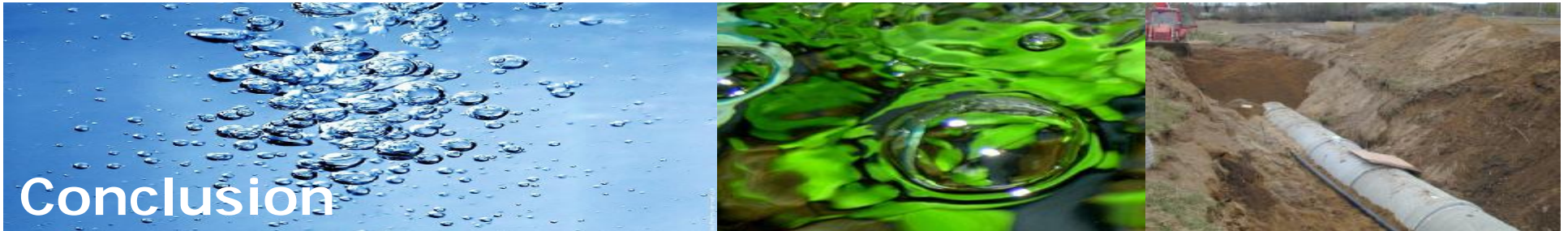
$$S_p = 0,49$$

Identifiant	Sp	Sd	Expert	Electre-tri
49856	0,51	81,41	INT	ACC
33874	0,50	21,03	INT	ACC
12727	0,49	26,92	INT	ACC
3362	0,50	16,21	ACC	ACC
40610	0,51	71,94	INT	ACC
6871	0,51	26,82	INT	ACC
6874	0,50	46,55	INT	ACC
12451	0,50	16,84	ACC	ACC
18303	0,50	20,82	ACC	ACC
28460	0,50	17,59	ACC	ACC
29100	0,25	73,88	ACC	ACC
59663	0,50	14,40	INT	ACC
71299	0,50	22,87	ACC	ACC
79646	0,25	71,23	INT	ACC
100284	0,50	21,59	ACC	ACC



Implementation of filter defined by weighted sum

Identifiant	S _p	S _d	Expert	Electre-tri	Error	Filtre	Error
49856	0,51	81,41	INT	ACC	1	INT	0
33874	0,50	21,03	INT	ACC	1	ACC	1
12727	0,49	26,92	INT	ACC	1	INT	0
3362	0,50	16,21	ACC	ACC	0	ACC	0
40610	0,51	71,94	INT	ACC	1	INT	0
6871	0,51	26,82	INT	ACC	1	INT	0
6874	0,50	46,55	INT	ACC	1	INT	0
12451	0,50	16,84	ACC	ACC	0	ACC	0
18303	0,50	20,82	ACC	ACC	0	ACC	0
28460	0,50	17,59	ACC	ACC	0	ACC	0
29100	0,25	73,88	ACC	ACC	0	ACC	0
59663	0,50	14,40	INT	ACC	1	ACC	1
71299	0,50	22,87	ACC	ACC	0	ACC	0
79646	0,25	71,23	INT	ACC	1	ACC	1
100284	0,50	21,59	ACC	ACC	0	ACC	0
Total					8		3



- q Interactive approach between Expert and analyst
- q Defining of category frontiers according to assignment example
- q Assessing of weights for criteria handled in decision process
- q Interesting results, but inaccuracy due to the non consideration of the accumulation of minor dysfunctions
- q proposing filter with the help of weighted sum
- q reducing the inaccuracy by the use of ad-hoc filter
- q implementing the approach for sewers rehabilitation
- q up dating assignment example and category frontiers
- q improving Electre-tri to take into account accumulation phenomenon