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FIRST SCIENTIFIC MEETING

MULTICRITERIA EVALUATION FOR URBAN STORM DRAINAGE

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MULTICRITERIA EVALUATION FOR URBAN STORM DRAINAGE

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Presentation Plan

- Introduction
- Objectives
- Proposed Methodology
- Case Study
- Critical Evaluation of the Set of Indicators
- Conclusions

Introduction

- **Intense urbanization process**
  - Significant hydrologic and environmental impacts
  - Pollution of receiving waters
  - Floods

Introduction

BMP:

- Techniques based on storage and infiltration of stormwater

- A great diversity of solutions:
  - trenches
  - swales
  - retention/infiltration basins
  - extended detention ponds/wetlands
  - roof storage
  - porous pavements, etc.

Introduction

Introduction

BMP:

- Allow different arrangements in the site
- Difficulty to choose the best arrangement to a particular site
- Need to take into account different criteria:
  - technical,
  - environmental,
  - social
  - sanitary and
  - costs

Introduction

Conception of stormwater systems employing BMP

- Elimination Phase:

  exclusion of techniques which are not feasible for physical, hydrological, geotechnical, structural and environmental reasons

- Evaluation Phase:

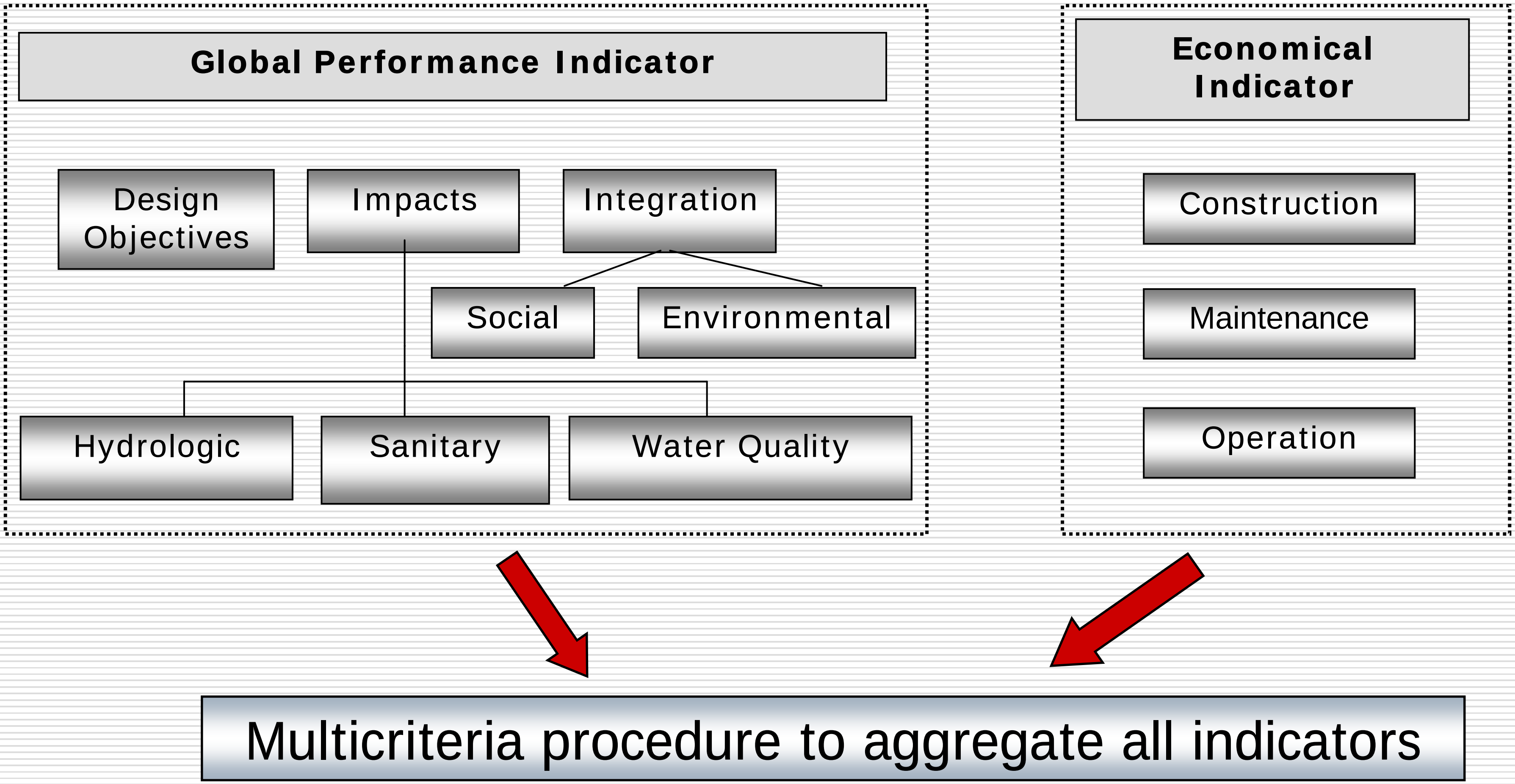
  evaluation of scenarios of possible arrangements of different drainage solutions

Objective

- **Proposal of a Multicriteria Methodology to evaluate and choose best project alternatives for urban drainage systems according to indicators that evaluate all relevant aspects:**
  - Technical
  - Environmental
  - Sanitary
  - Social
  - Construction, maintenance and operation costs.

Proposed Methodology

Evaluation Phase



Proposed Methodology

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Evaluation Phase – Performance Indicators

Criterion	Indicator	Weight (%)
Objective	Ability of the system to drain an area in safe conditions - low flooding (I_O)	10,0
Impacts	Hydrologic impacts to the downstream flow (I_{H1})	14,1
	Aquifer recharge (I_{H2})	4,9
	Sanitary impacts on the possibility of disease transmission (I_{S1})	8,1
	Sanitary impacts on the possibility of insects' proliferation (I_{S2})	7,9
	Impact on the quality of surface waters (I_{Q1})	10,9
	Impact on the quality of the groundwater water (I_{Q2})	7,7
Insertion	Environmental integration with the creation and preservation of habitats (I_{A1})	9,4
	Environmental integration for landscape enhancement (I_{A2})	5,9
	Social indicator of creating leisure and recreation areas (I_{SC1})	6,2
	Social indicator of impact on the traffic conditions (I_{SC3})	5,1
	Social indicator related with the possibility of using the drainage technique to other technical functions (I_{SC3})	4,2
	Social indicator of expropriating areas (I_{SC4})	5,6

Proposed Methodology

Evaluation Phase – Performance Indicators

Weights Definition

- Interviews with representatives of:
  - Technical Municipal Services;
  - Designers of Urban Stormwater Systems;
  - Environmental Regulatory Bodies;
  - Researchers.
- Tendency analysis with the results of the interviews.

Proposed Methodology

Evaluation Phase – Performance Indicators

Aggregation Procedure

$$Ip = \frac{\sum_{i=1}^{n} I_i \, w_i}{\sum_{j=1}^{j=m} \left(\sum_{i=1}^{n} I_i \, w_i \right)_j / m}$$

Where:

Ip: global performance indicator;

Ii: the performance indicator for the scenario *i*;

wi: the weight of the indicator *i*;

n: number of performance indicators;

m: number of scenarios.

Proposed Methodology

Evaluation Phase – Cost Indicator

Net Present Value (NPV) of building, maintenance and operation costs of the system during 30 years (average lifetime adopted for urban drainage structures)

Equation

$$Ic = \frac{\overline{C}}{C_i}$$

Where:
Ic: cost indicator i;
$\overline{C}$: average updated global cost (NPV) of the different alternatives;
Ci: global cost (NPV) of the alternative.

Proposed Methodology

Aggregation Model – System AvDren

System AvDren (software)

- Performance Evaluation:
  - estimates performance individual indicators
  - takes into account all the project alternatives
- Cost Evaluation:
  - considers operation, maintenance and buiding costs
  - unitary costs are inserted by the user

Proposed Methodology

Aggregation Model – System AvDren

System AvDren

- Developed using Microsoft Visual Basic 6.0 language in the Windows environment

- Avaliable at www.ehr.ufmg.br

Presents results in a Graph I_C x I_P (Cost x Performance)

Case Study

Technopolis (Bordeaux, France)

- Site devoted to industrial and service activities

- Total drainage area of 23 ha:
  - 6 ha of streets and car parks
  - 6 ha for buildings

Case Study

Technopolis (Bordeaux, France)

- Stormwater design according to three scenarios:
  - Scenario I:
    Conventional pipe system
    No restriction on maximum downstream flow
  - Scenario II:
    Conventional system + a detention basin
    Restricted downstream flow
  - Scenario III:
    BMP system
    Use of porous pavements, ditches and a detention basin
    Restricted downstream flow.

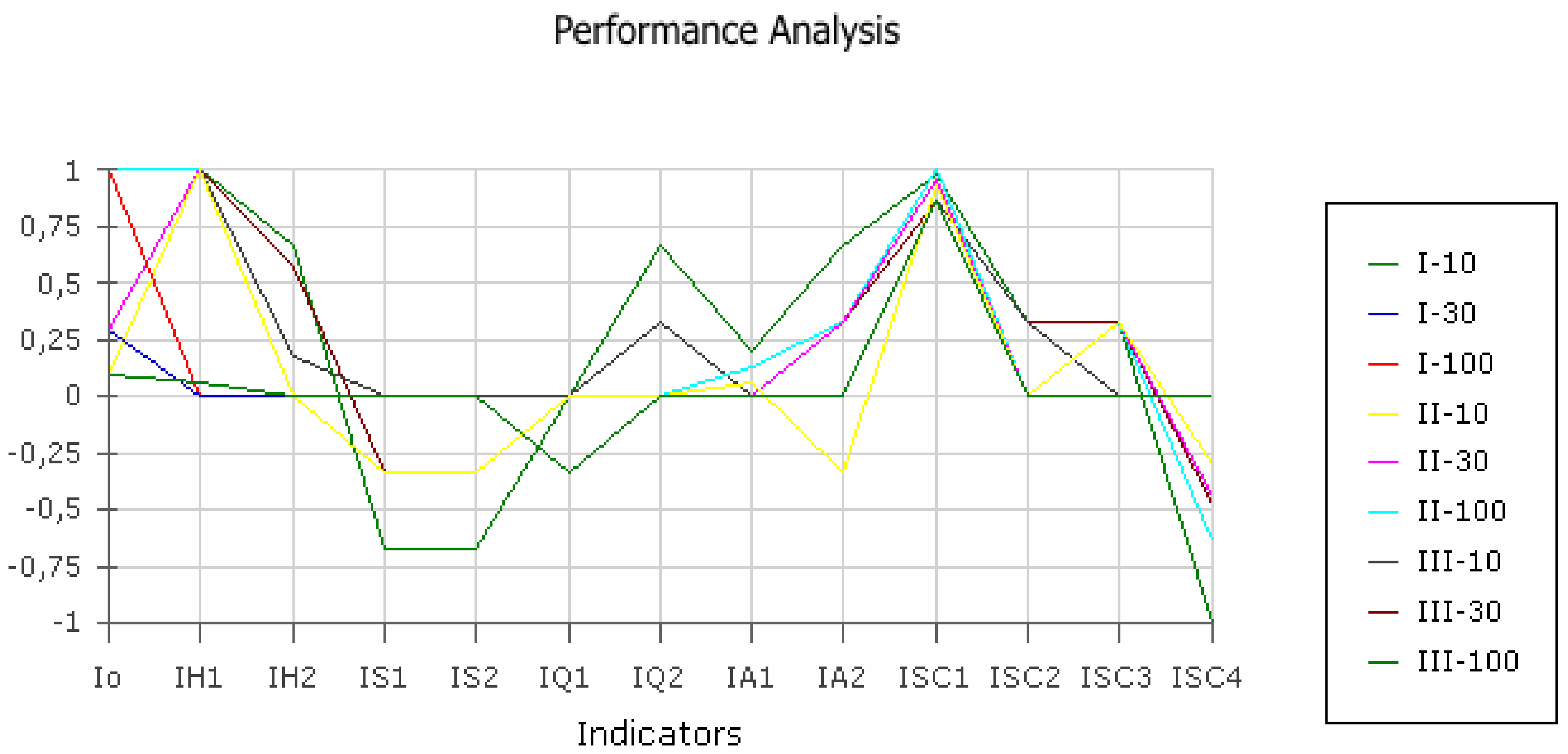
Case Study

Technopolis (Bordeaux, France)

- Return periods for all the three scenarios:
  - T = 10 y
  - T = 30 y and
  - T = 100 y

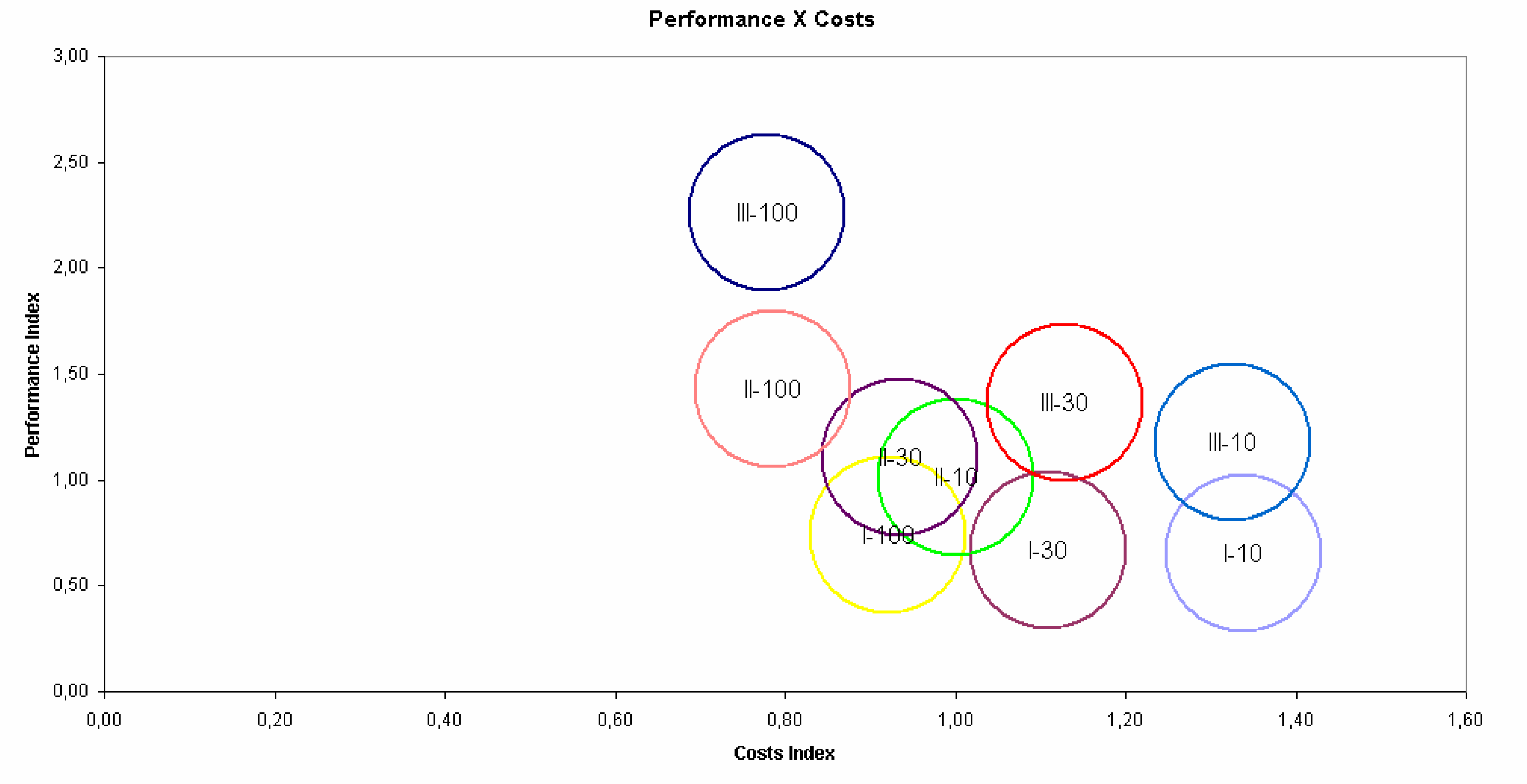
Case Study

Technopolis (Bordeaux, France)

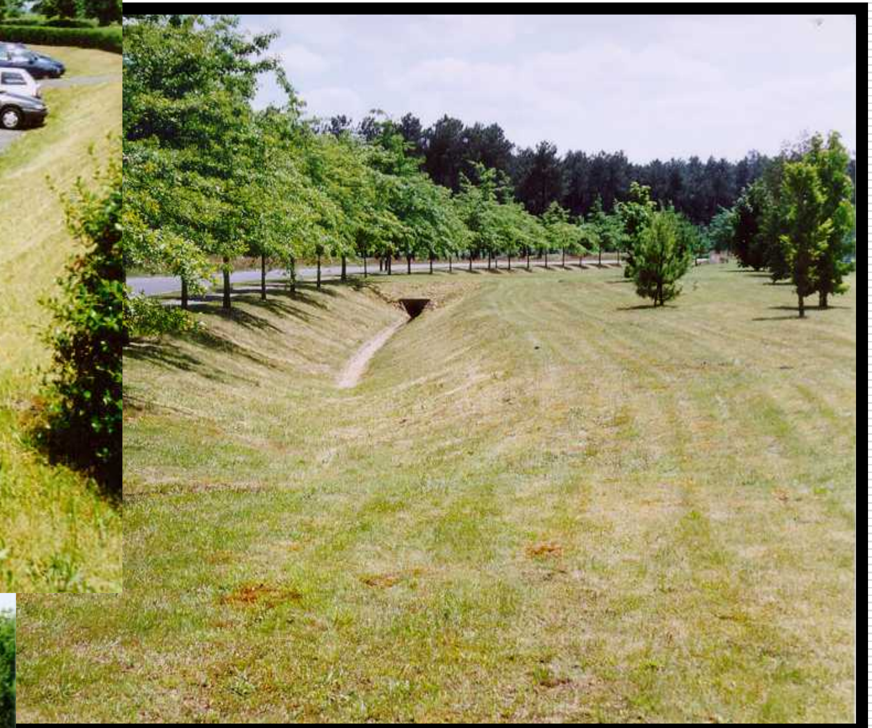


Case Study

Technopolis (Bordeaux, France)



Scenario I	Ip	Ic	Scenario II	Ip	Ic	Scenario III	Ip	Ic
I-10	0.651	1.339	**II-10**	1.011	1.001	**III-10**	1.178	1.326
I-30	0.669	1.109	**II-30**	1.104	0.936	**III-30**	1.364	1.128
I-100	0.742	0.920	**II-100**	1.429	0.786	**III-100**	2.258	0.778



Combined techniques:

- **Porous pavement**
- **Ditches**
- **Detention basin**

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Critical Analysis of the Set of Indicators

Technopolis (Bordeaux, France)

- **Evaluation of the quality of each indicator and the global set of indicators, by their:**

  - accessibility:
    are them easy to calculate?
    are the data for the calculation available?

  - objectivity:
    aren't them ambiguous?
    can they be evaluated in the same way by different appraisers?

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Critical Analysis of the Set of Indicators

Technopolis (Bordeaux, France)

- **Evaluation of the quality of each indicator and the global set of indicators, by their:**
  - relevance:
    is the performance relevant?
  - robustness:
    are results stable under the variation of uncertain parameters?

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Critical Analysis of the Set of Indicators

Technopolis (Bordeaux, France)

- **Evaluation of the quality of each indicator and the global set of indicators, by their:**
  - sensibility:
    do they discriminate different strategies?
  - fidelity:
    can they be estimated with the same and low bias?

Critical Analysis of the Set of Indicators

Technopolis (Bordeaux, France) – Redundancy Analysis

- Redundancy analysis, done by the verification of the correlation of indicators taken by pairs:
  - High values to the R^2 don't mean that the indicators are redundant, but that their definitions have to be verified
  - Low values to the R^2 directly mean that the indicators are not redundant.

Critical Analysis of the Set of Indicators

Technopolis (Bordeaux, France) – Redundancy Analysis

Coefficient of Determination (R^2)												
I_O	0.000	0.034	0.290	0.290	0.018	0.034	0.412	0.290	0.392	0.000	0.290	0.404
	I_{H1}	0.088	0.360	0.360	0.526	0.095	0.325	0.360	0.217	0.333	0.360	0.328
		I_{H2}	0.179	0.179	0.002	0.878	0.173	0.179	0.010	0.263	0.179	0.181
			I_{S1}	1.000	0.324	0.137	0.958	1.000	0.596	0.120	1.000	0.961
				I_{S2}	0.324	0.137	0.958	1.000	0.596	0.120	1.000	0.961
					I_{Q1}	0.003	0.311	0.324	0.112	0.458	0.324	0.316
						I_{Q2}	0.140	0.137	0.019	0.286	0.137	0.144
							I_{A1}	0.958	0.669	0.119	0.958	0.999
								I_{A2}	0.596	0.120	1.000	0.961
									I_{SC1}	0.009	0.596	0.647
										I_{SC2}	0.120	0.128
											I_{SC3}	0.961
												I_{SC4}

Critical Analysis of the Set of Indicators

Technopolis (Bordeaux, France) – Redundancy Analysis

- Example:
  - I_{S1} and I_{S2} have R^2 equal 1 and both depend on the same sources (redundant indicators);
  - I_{S1} and I_{A2} have R^2 equal 1 but don't depend on the same sources (non-redundant indicators);
  - I_{SC1} and I_{SC2} have R^2 equal 0.009 (non-redundant indicators).

Conclusions

- The method is simple and proved to be coherent in different case study tests
- The multicriteria procedure does not require knowledge of complex numerical decision aid methods and may be followed step by step
- It allows the incorporation of performance and cost assessment in a single procedure

Conclusions

- There is the possibility of incorporating a wide range of drainage solutions

- Customization allows to deal with a wide range of different site characteristics and BMP alternatives

Conclusions

- The critical analysis procedure proved to be a relevant tool in improving and validating the set of indicators
- Indicators and indicator weights proposed to Brazilian conditions may possibly be transferable to other tropical developing countries, without substantial modifications

Before finishing this presentation

I would like to invite

all of you to

The 11th International Conference on Diffuse Pollution

Belo Horizonte, August 26-31, 2007

www.acquacon.com.br/dpud2007

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Thank You