

Using geostatistical models for cost-based optimization of excavated soil management solutions including selective sorting

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Management of excavated soils in brownfield redevelopment projects

Brownfield (Detroit)



Redevelopment plan



Riverfront Project



From detroitmi.gov

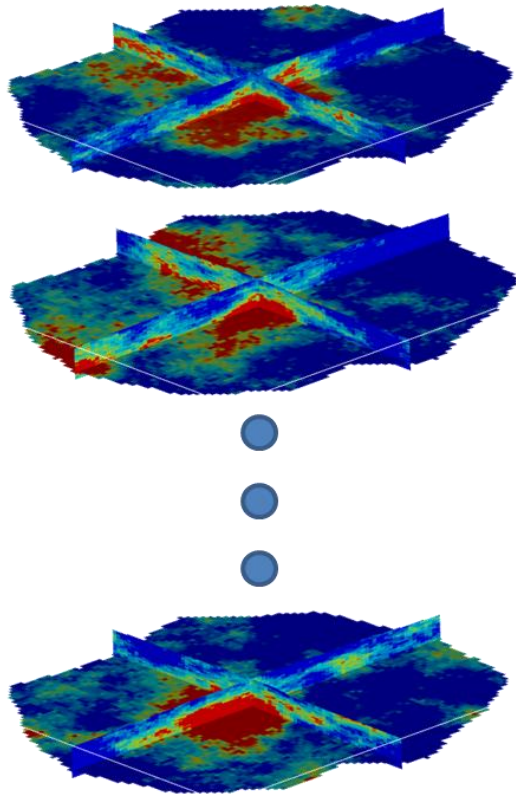
Excavated soil
management issue



Pictograms from:
Fédération Française du Bâtiment

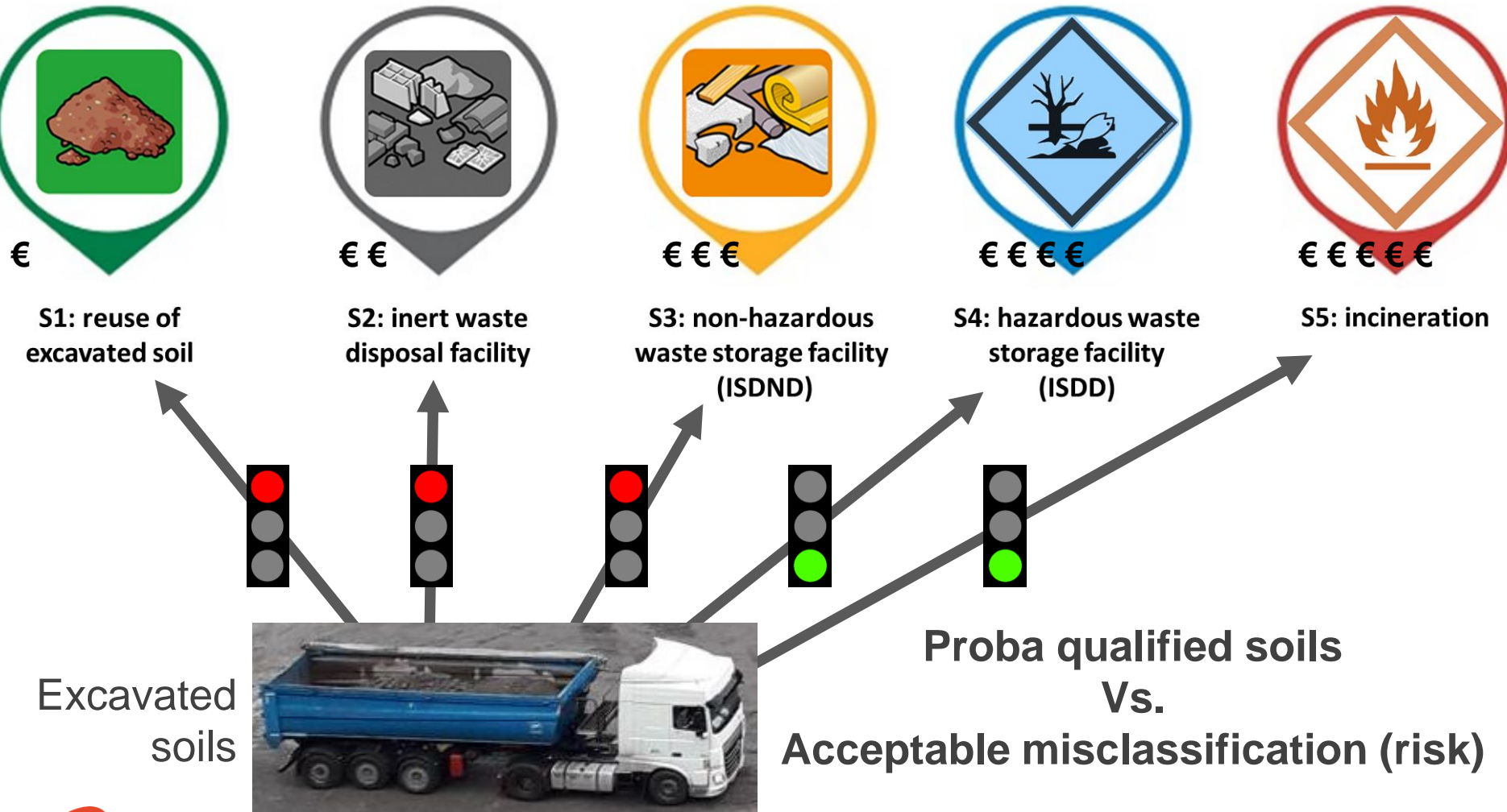
**Which soil management solution
based on acceptance vs. cost criteria?**

Management of excavated soils in brownfield redevelopment projects



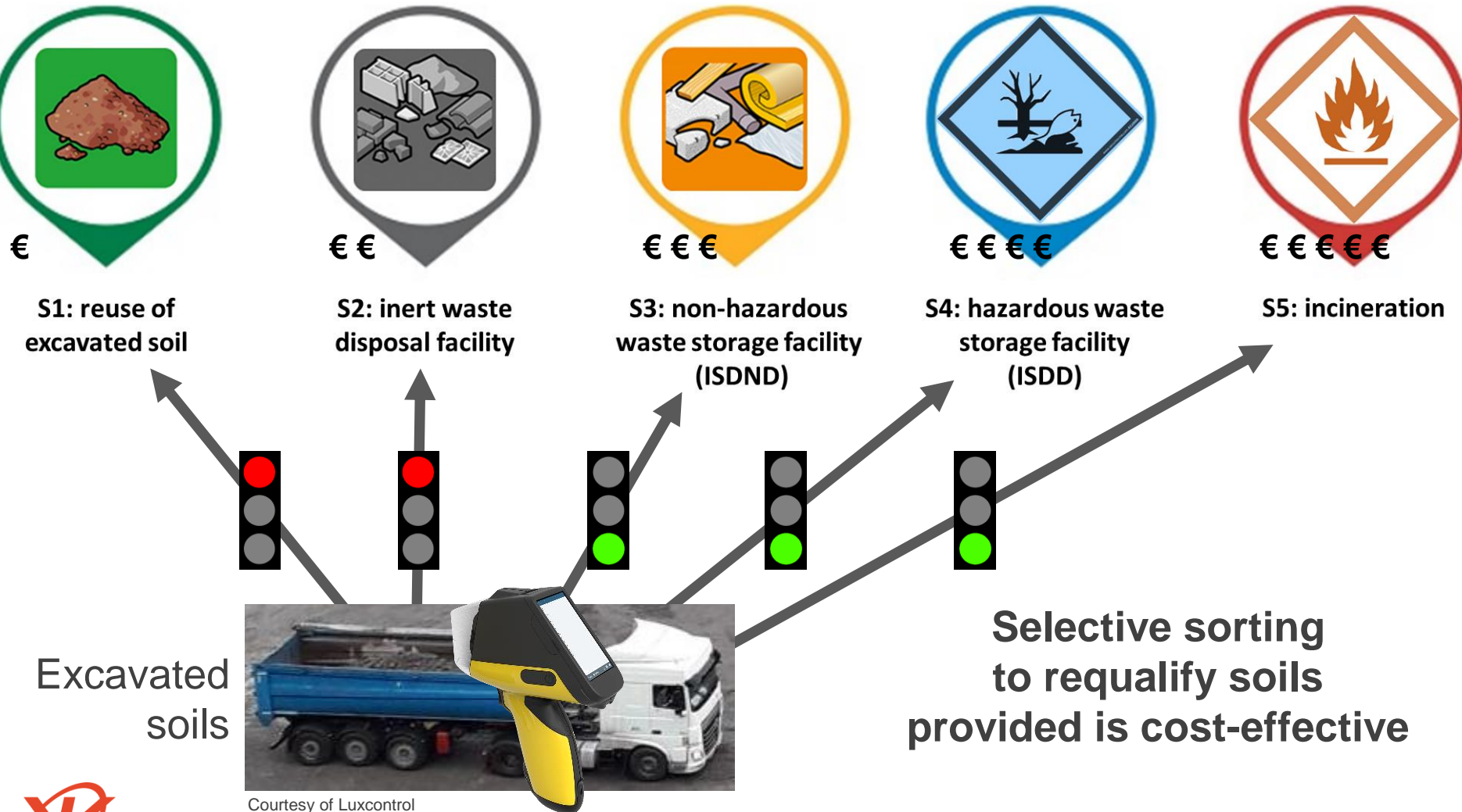
**Taking advantage of
geostatistical soil contamination models
to minimize the cost of
excavated soil management solutions**

Optimization principle



Courtesy of Luxcontrol

Optimization principle



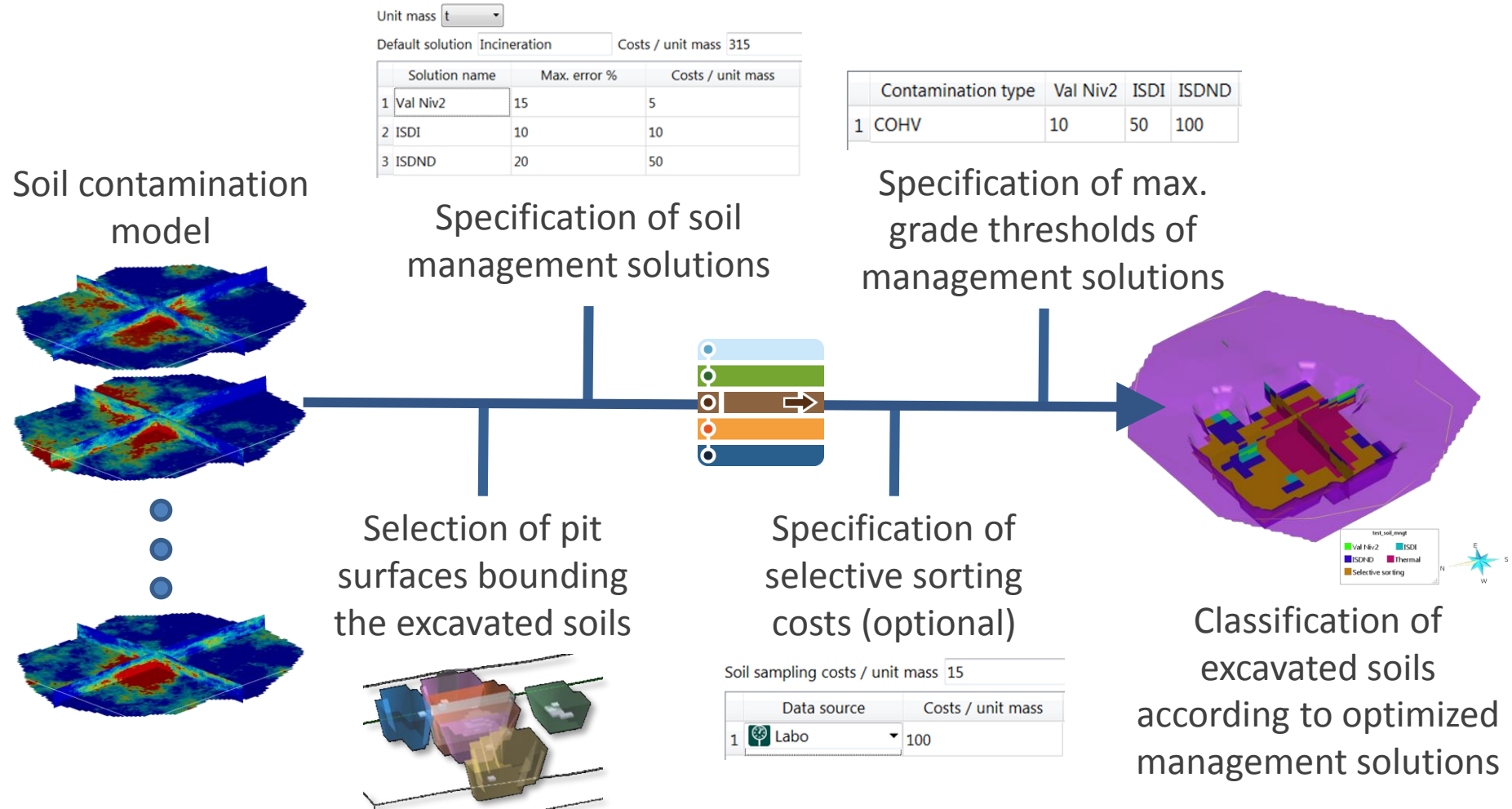
Optimization principle

Minimizing the management costs of excavated soils

- Several possible management solutions $S_1, S_2 \dots S_N$ based on:
 - Costs per unit of mass: $C_1 < C_2 < \dots < C_N$
 - Acceptable (grade-based) soil contamination levels: $L_1 < L_2 \dots < L_N$
- Soil contamination uncertainties (geostatistical model)
 - Estimated probabilities for soils to be qualified for each management solution: $P_1 < P_2 < \dots < P_N$
- Best management solution S_i
 - The less expensive one with $P_i \geq 1$ – acceptable misclassification probability (risk)
- Use of selective sorting at cost C_S if cost-effective
 - Attempt to requalify soils from solution S_{i+1} to less expensive solution S_i
 - Decision criterion: $P_i > \frac{C_S}{C_{i+1} - C_i}$



SRModeling workflow



Presentation of the case study

- Industrial soils contaminated by organochlorides: PCE & TCE
- Geostatistical modeling of the soil contamination
- Definition of a redevelopment plan (virtual scenario)
- Identification of soil contamination sources based on health risk criteria
- Excavated soil management issues
 - For remediation purposes based on health risk criteria
 - For redevelopment purposes

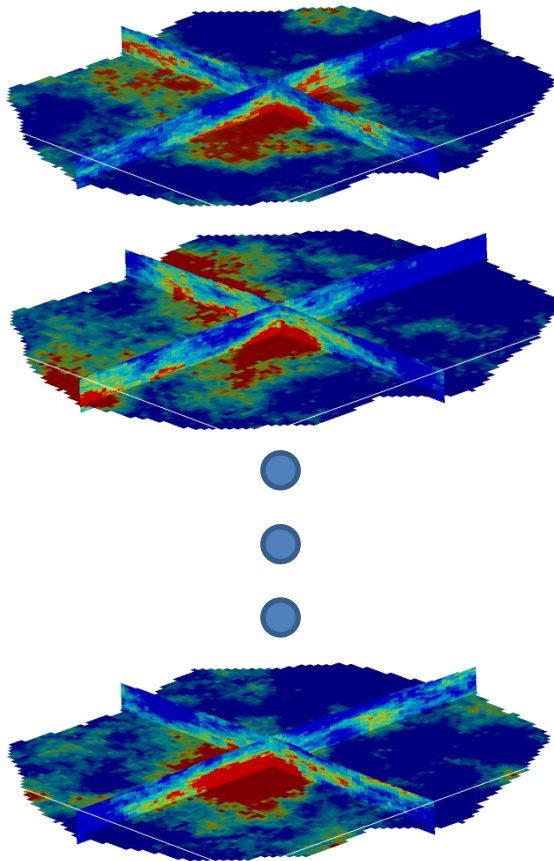
References:

GeoSiPol (2012). *Etudes de démonstration de l'intérêt de la géostatistique dans le domaine des sites et sols pollués*, www.geosipol.org

Mathieu et al (2014), *Bilan coût/avantage de la géostatistique : prolongement d'un cas d'étude de démonstration GeoSiPol*, RNR 2014 (ADEME)



Geostatistical soil contamination model

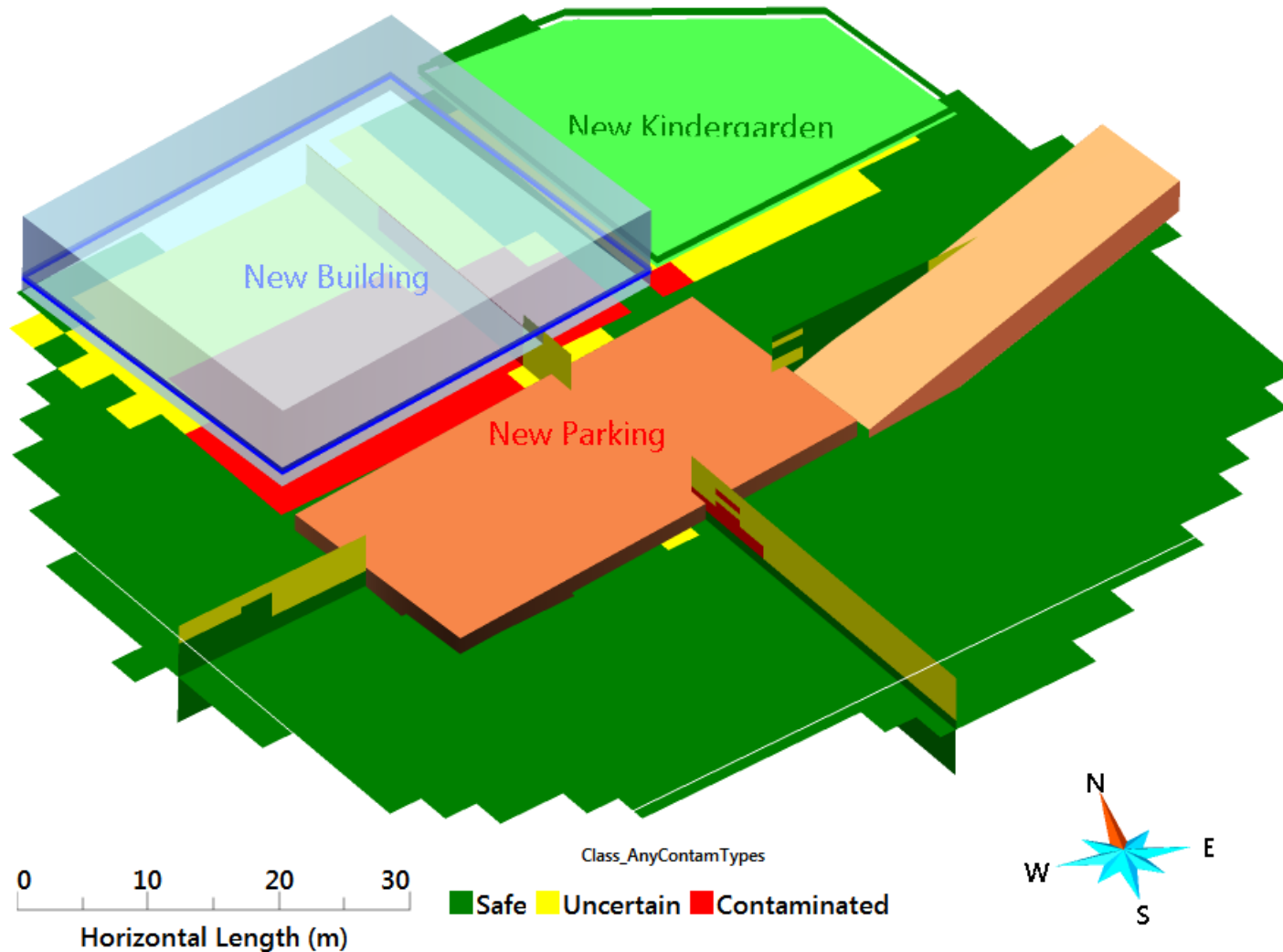


Quantifying the spatial uncertainties
of the soil contamination

Contaminant grade
realizations



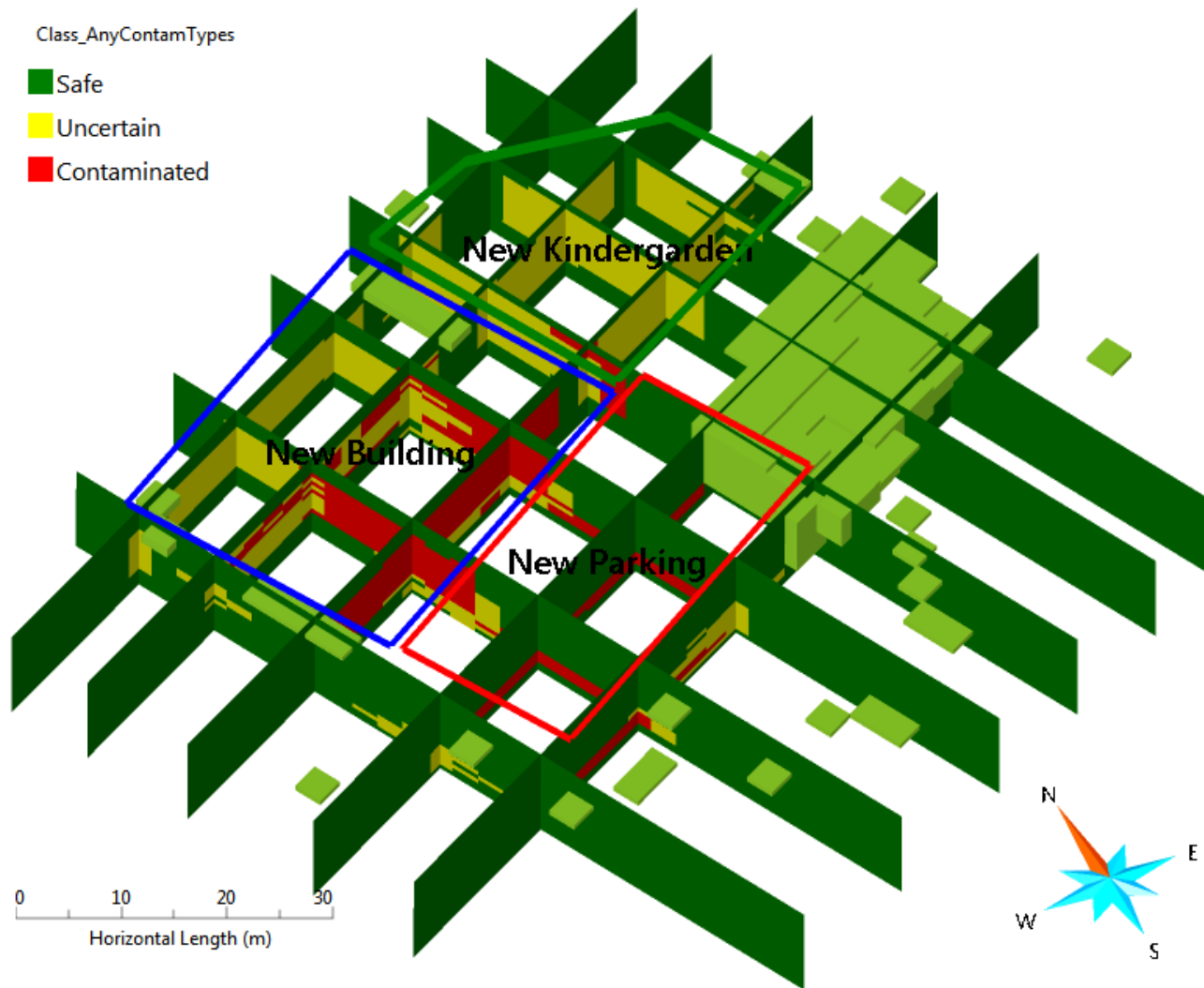
Redevelopment plan (virtual scenario)



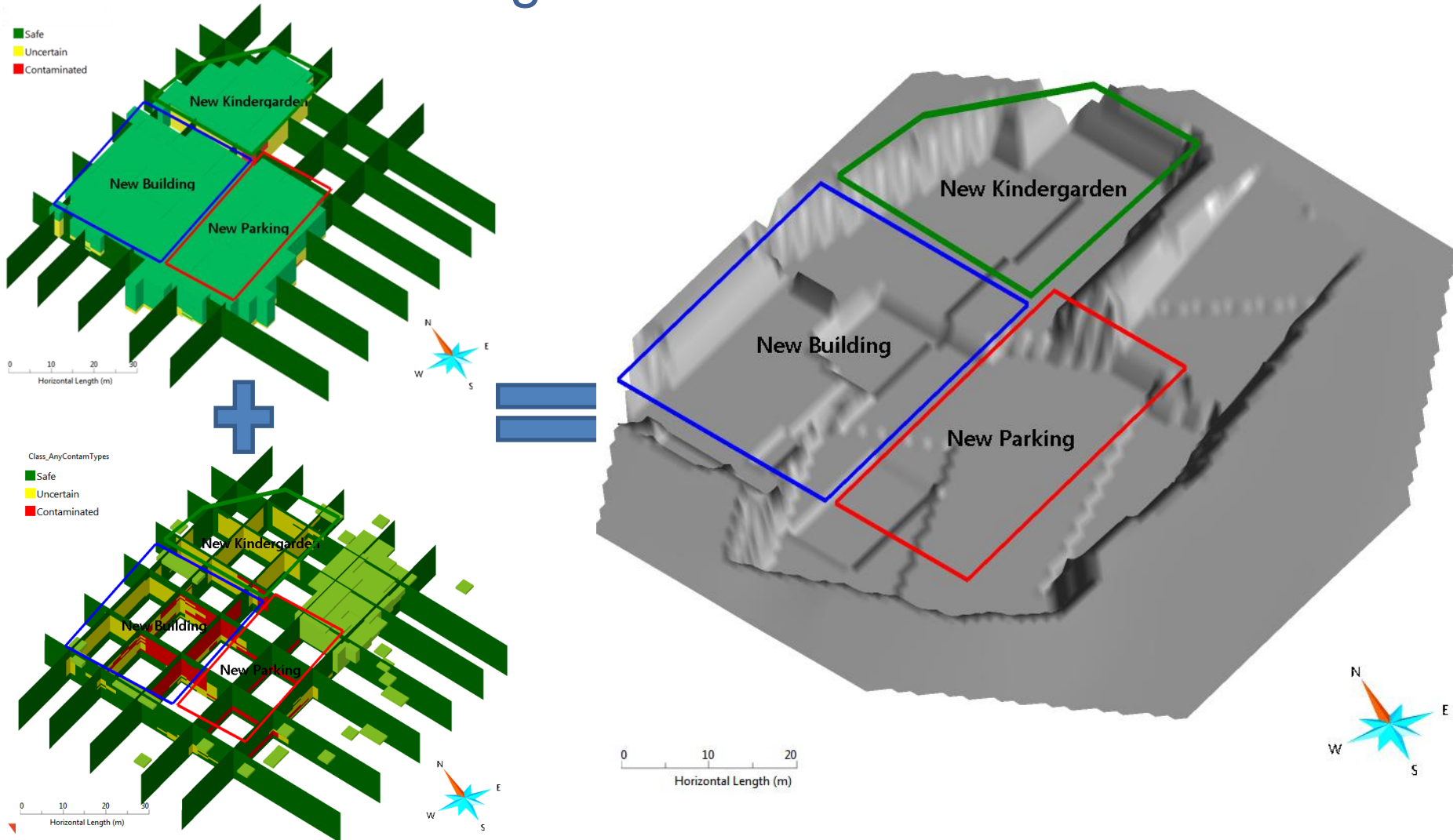
Contaminated soils to be excavated based on health risk criteria



“Safe” soils to be excavated based on redevelopment works



Pit surface bounding the soils to be excavated



Excavated soil management solutions

Solution	Cost (€ / tons) <i>from ADEME, 2012</i>	Max. acceptable error (%)
Val Niv2	5	15
ISDI	10	10
ISDND	50	20
Incineration	315	-


Solution	Max. (acceptable) grade threshold (PCE + TCE)
Val Niv2	< 10 ppm
ISDI	< 50 ppm
ISDND	< 100 ppm
Incineration	-

Selective sorting costs per ton

Type	Cost (€ / tons)
Soil sampling	15
COHV analysis	100


Solution-based volumes, masses and management costs of excavated soils

No selective sorting



	Cost	Mass (kg)	Volume (m ³)
Val Niv2	24692.4	4.93848e+6	2599.2
ISDI	17578.8	1.75788e+6	925.2
ISDND	393984	7.87968e+6	4147.2
Incineration	7.24807e+6	2.30098e+7	12110.4
Selective sorting	0	0	0
Total (all excavated soils)	7.68433e+6	3.75858e+7	19782

With selective sorting



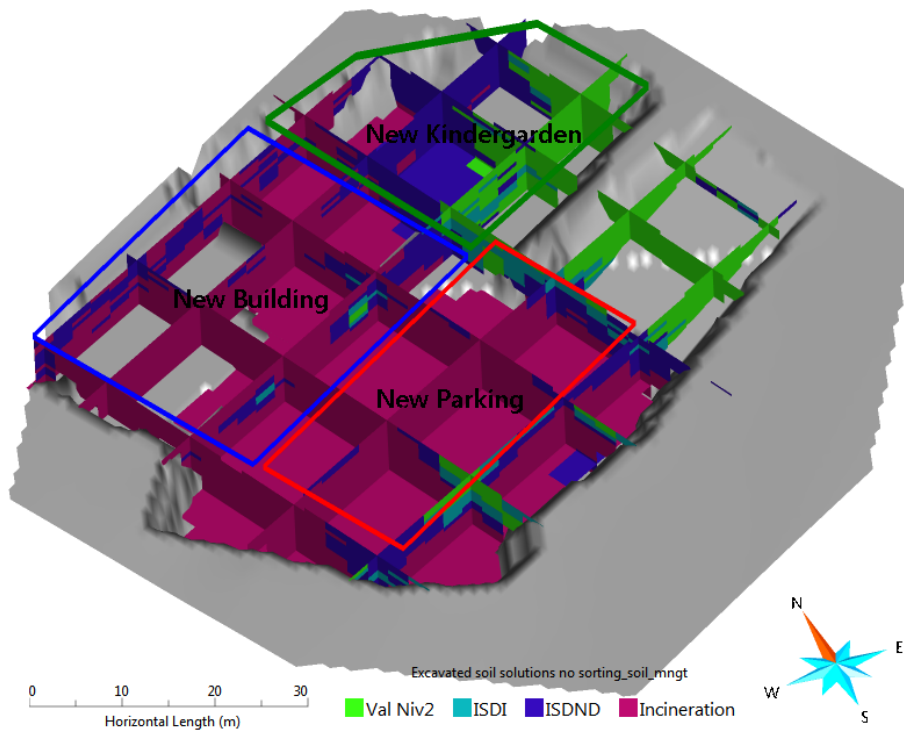
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ISDND	393984	7.87968e+6	4147.2
Incineration	2.48641e+6	7.89336e+6	4154.4
Selective sorting	1.73839e+6	1.51164e+7	7956
Val Niv2 (selective sorting)	34436	6.8872e+6	3624.84
ISDI (selective sorting)	25024.8	2.50248e+6	1317.1
ISDND (selective sorting)	45154.3	903085	475.308
Incineration (selective sorting)	1.51945e+6	4.82364e+6	2538.76
Total (all excavated soils)	6.28511e+6	3.75858e+7	19782

- Selective sorting **cost-effective** to requalify uncertain soils otherwise qualified for “Incineration” (≈ 15 000 tons)
- Estimated savings gained from selective sorting ≈ 1.4 M€

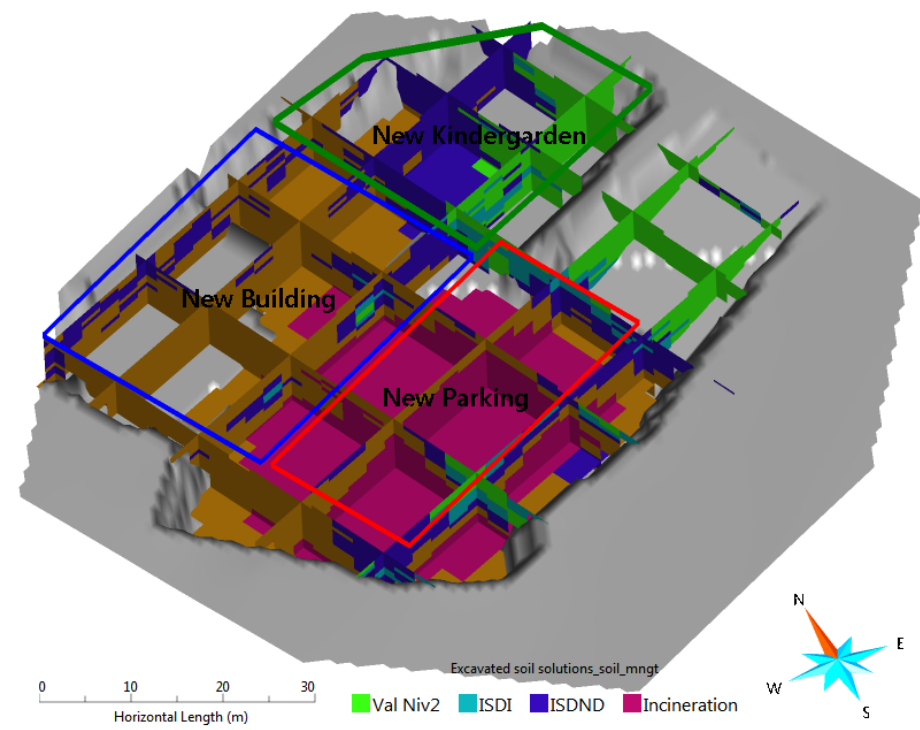


Optimal management solutions for excavated soils

No selective sorting



With selective sorting



Excavated soil solutions

Val Niv2 ISDI ISDND Incineration Selective sorting

- Excavated soil management
 - Strategical and economical issue for both soil remediation and redevelopment purposes
- Proposed solution
 - Minimizing the management costs of excavated soils
 - Based on multiple possible management solutions: different costs and different soil acceptance criteria
 - Based on soil contamination or quality assessments associated with spatial uncertainty
- Quantification of spatial uncertainty
 - Taking advantage of existing geostatistical soil contamination models
Vs. Generating specific geostatistical models
- Resolution of spatial uncertainty
 - Before excavation work: complementary investigations
 - During excavation work: **selective sorting**
- Key aspects and results of the proposed solution
 - Calculation of soil volumes, masses and management costs for each management solution
 - Classification of soils based on a suitable worksite grid: best management solution determined for each gridblock => possible tracking of excavated soils
 - Taking into account soil-dependent geotechnical properties to define excavated soil pits
 - Automatic post-processing of geostatistical soil contamination models
 - User-friendly workflow and tools at all steps (SRModeling software)
- Ongoing improvements
 - Including soil properties (geotechnical, agronomical...) for management solutions based on excavated soil reuse



Acknowledgments

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Thank you for your attention

