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USAR
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Using Sediment As a Resource

WikiSed &
Operational Sediment Management System "OSMS"

October 13 & 14, 2020

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Hoogheemraadschap van Schieland en de Krimpenerwaard
Brightlingsea Harbour Commissioners
ARMINES
Waterwegen en Zeekanaal NV
Westcountry Rivers Trust

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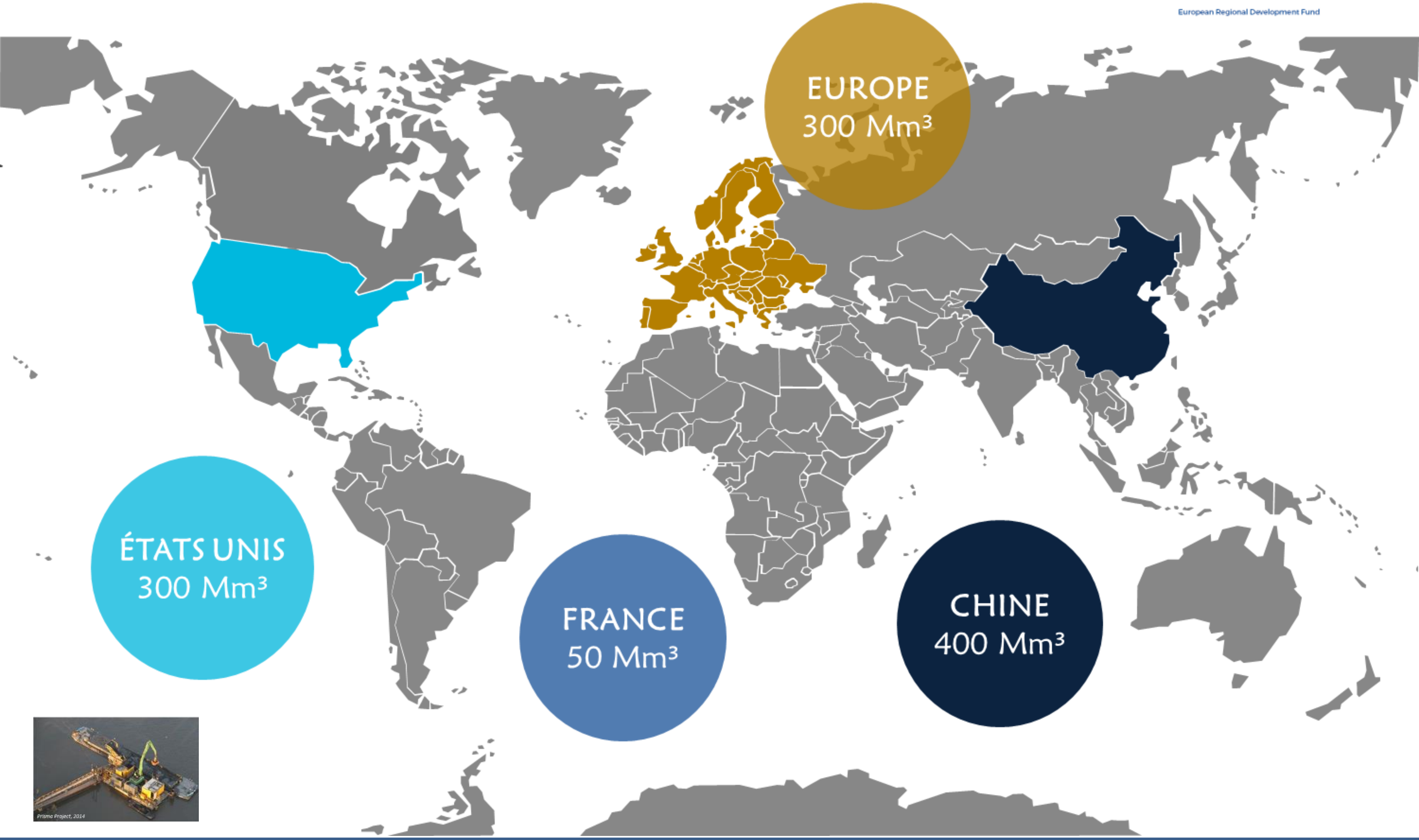

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Context

In France, dredging operations generate more than 50 Mm3 of sediment per year.

Dredged sediments

Consequences

- *Siltation of waterways*
- *Flood risk*
- *Environmental issues*
- *Economic issues*

Sediments management

Immersion

Storage

Saturation of storage centers
Possible treatment before storage

Need to find alternatives that are part of a sustainable sediment management approach

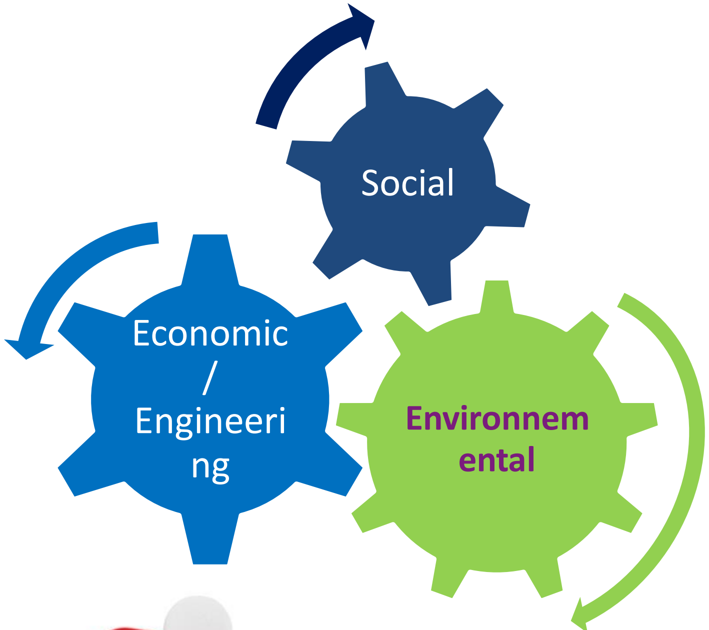
Valorization

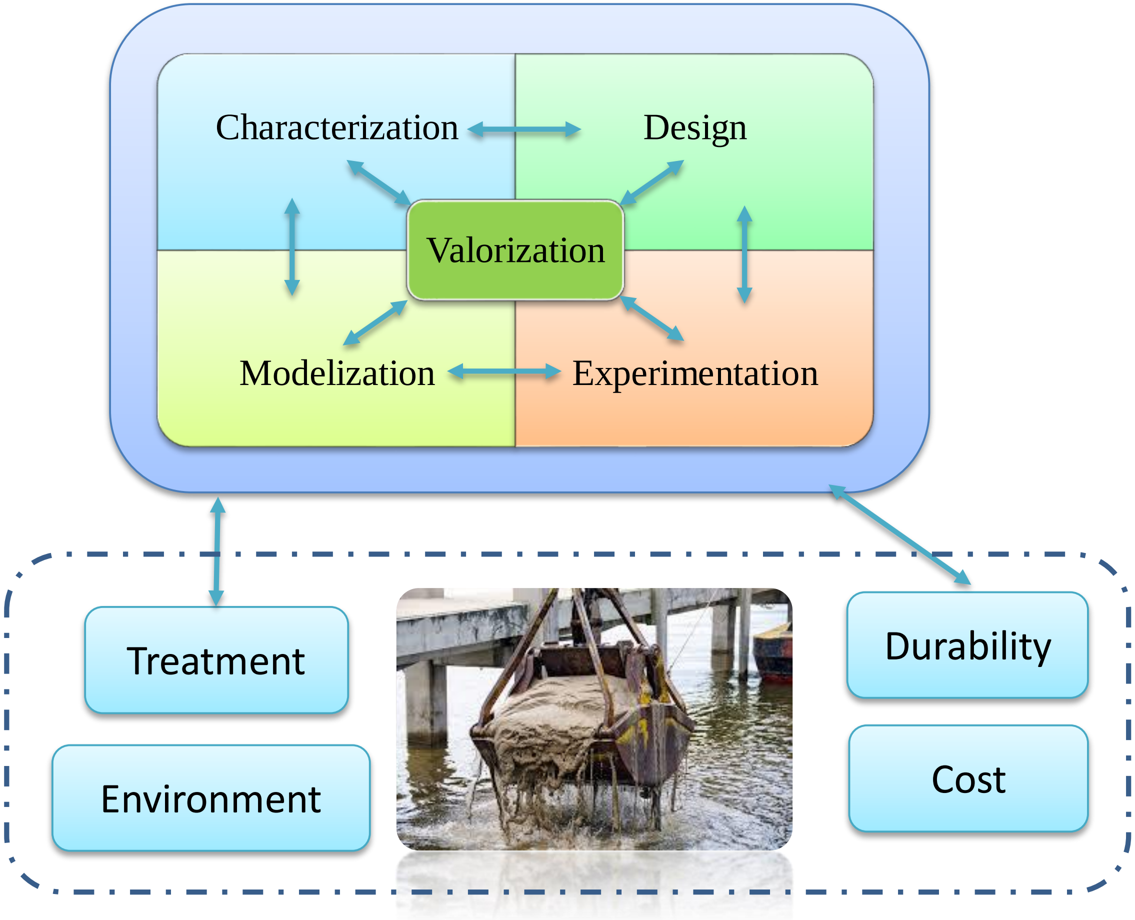
Which field?
How?
Technical feasibility?
Environmental acceptability?
cost?

→ USAR Projet (Using Sediment As a Resource) : Promote the use of sediment, namely in civil engineering

Using sediment as a resource

Complex decision
multi parameters





Using sediment as a resource

Inventory catalog — WikiSed

Software — OSMS

WikiSed + OSMS → Help users and decision makers

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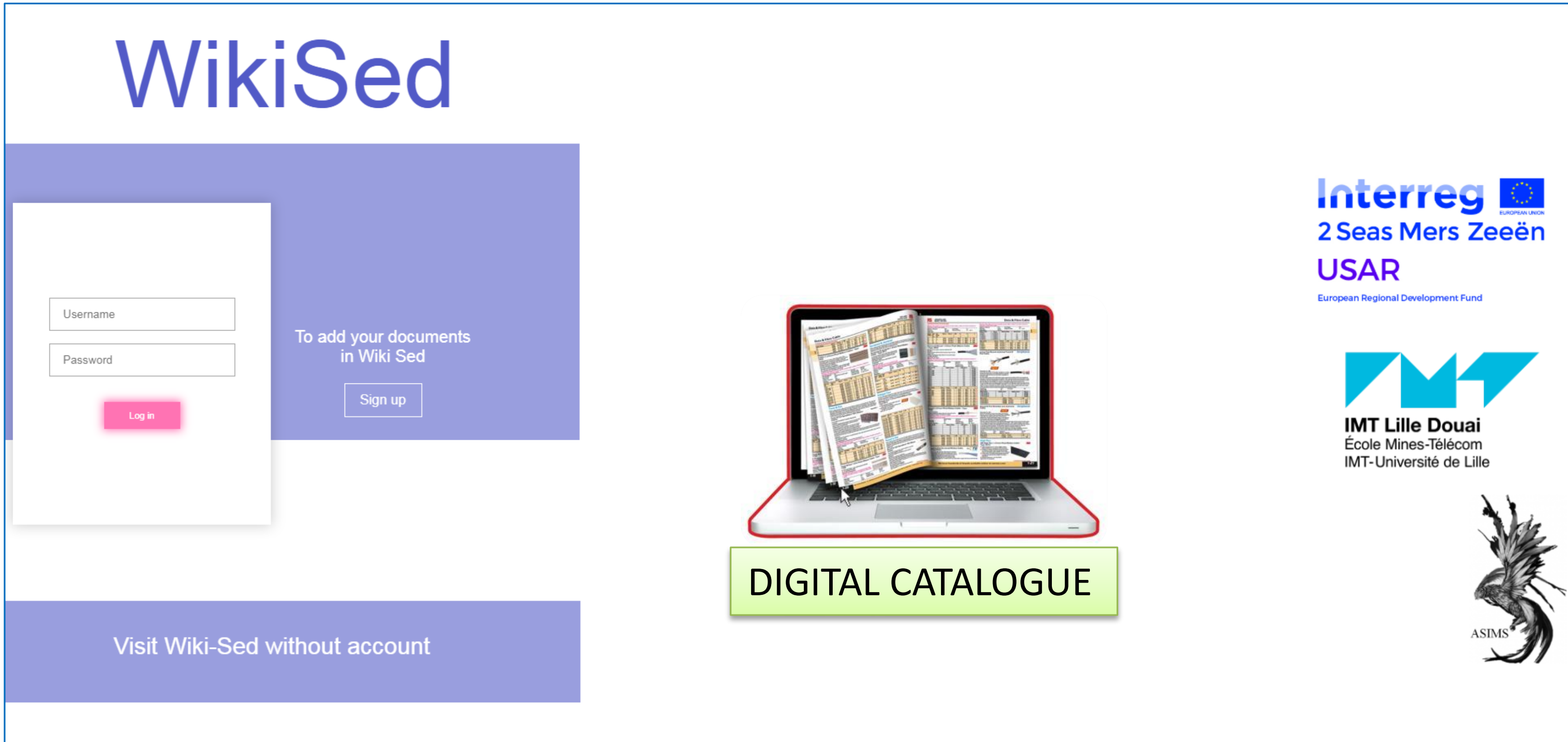
Web Link : http://wikised.phenixmat.com/

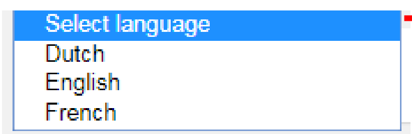


WIKISED

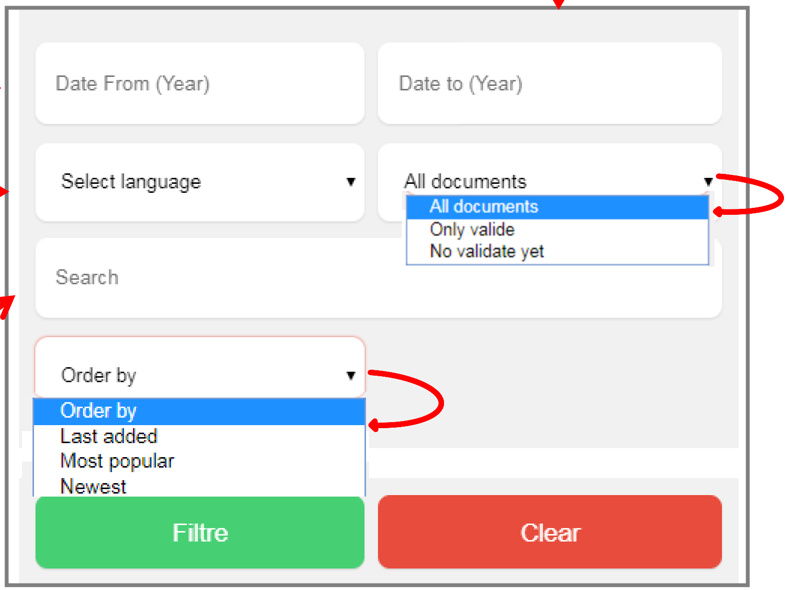
- Search a document, view / download a document
- Filter by : key word, date of publication, author, country etc.
- Search by category

WikiSed

Filter by date of publication



Research by key words



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Add a new documents online

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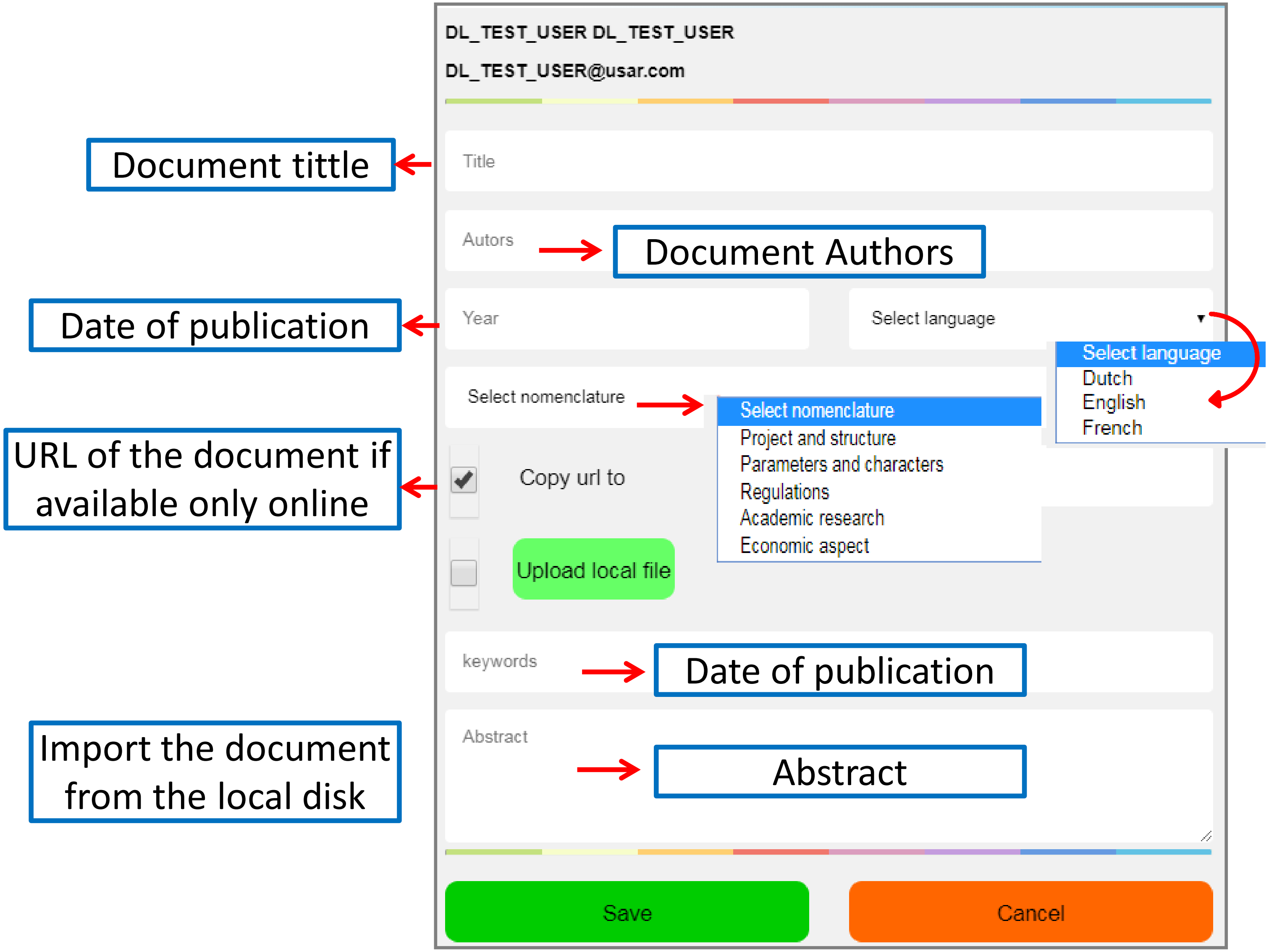
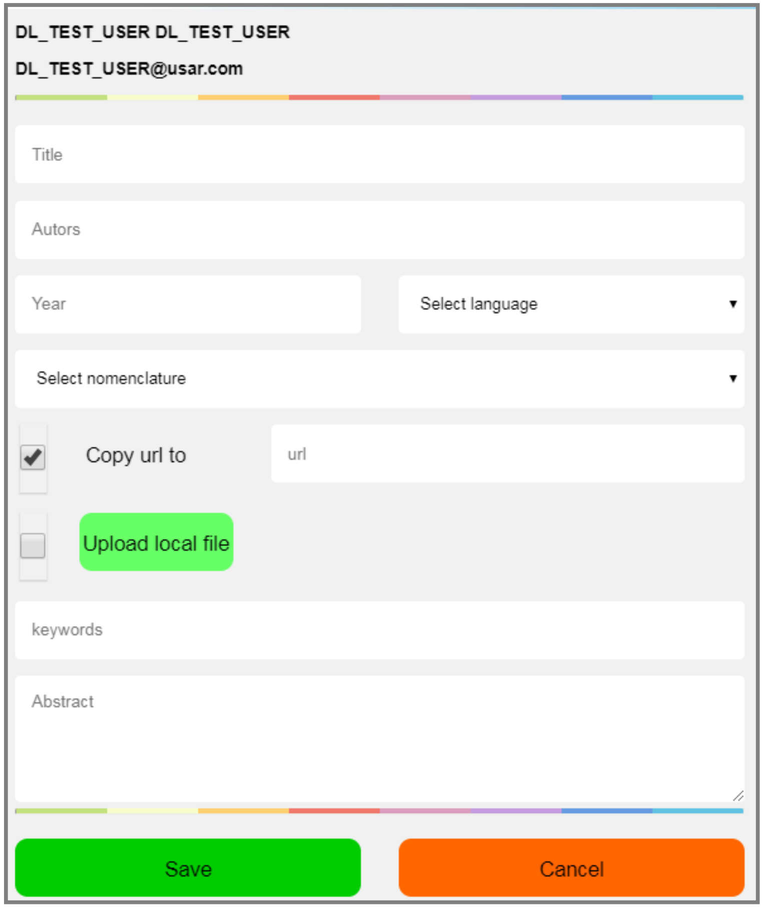


Add a new documents online



→ scientific committee verification

↓

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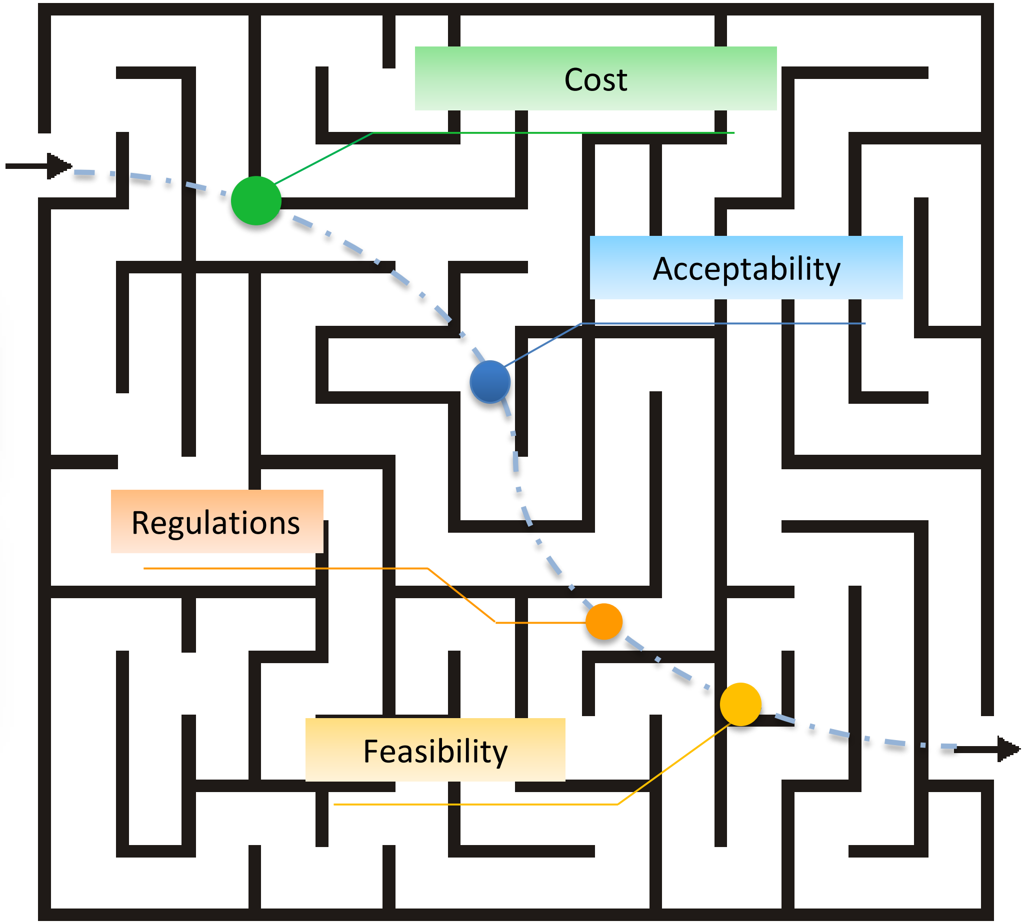
Operational Sediment Management System (OSMS)

Sediment
« Waste »



Materials, products

Using Sediment As A Resource

Operational Sediment Management System (OSMS)

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OSMS Optimization process

Embankments

Economic aspect

Road

Optimization of the mixing and the treatment of dredged sediments

Technical feasibility

Environmental impact

Concrete

Agricultural spreading

Propose the optimal solution that meets technical and environmental requirements at the lowest cost.

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Operational Sediment Management System (OSMS)

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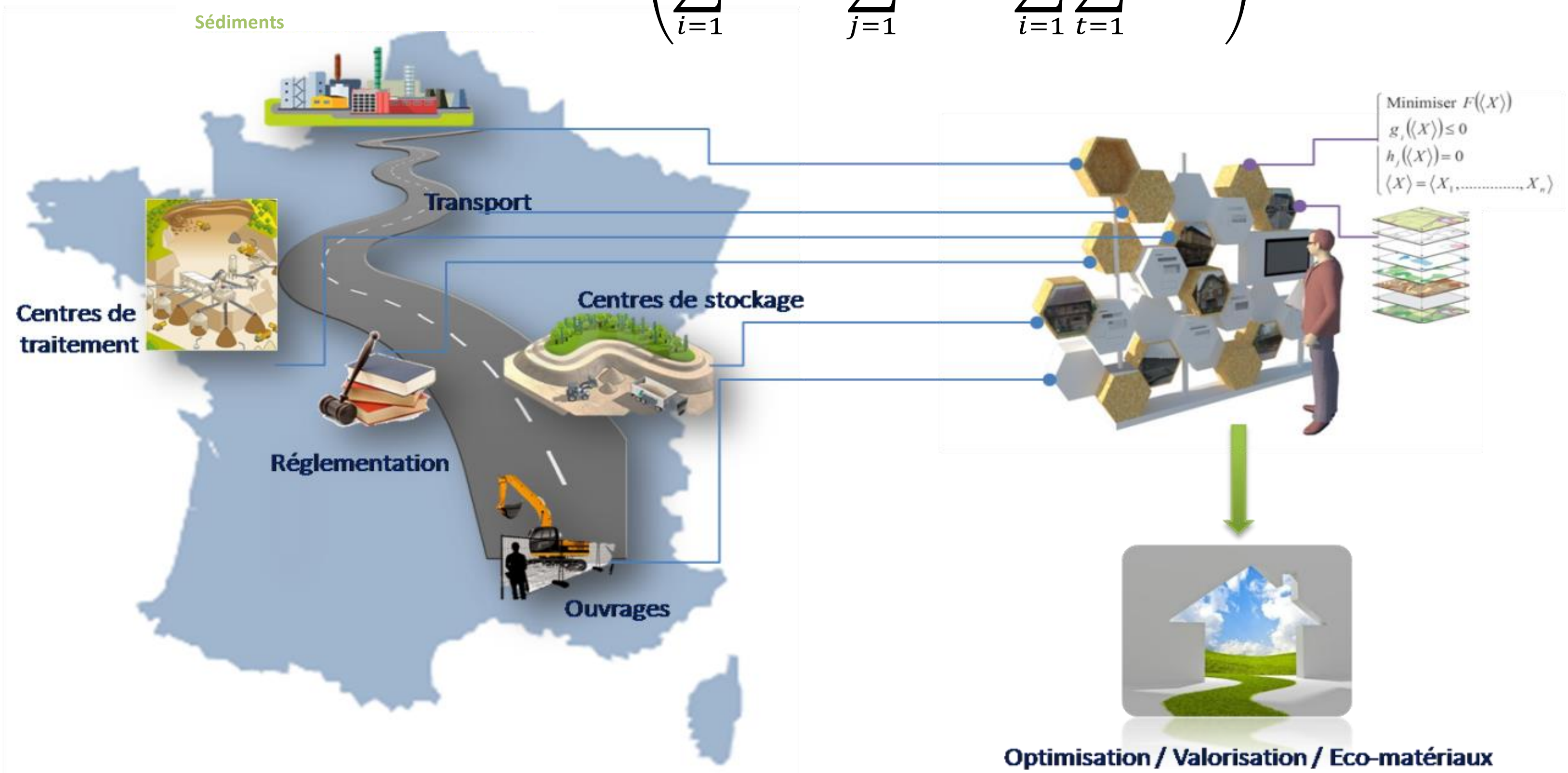
$$Min\left(\sum_{i=1}^{n} C_i x_i + \sum_{j=1}^{m} C_j S_j + \sum_{i=1}^{n}\sum_{t=1}^{|T|} C_{ti} T_{ti}\right)$$



Objective Function : Lower cost for optimal valuation

Operational Sediment Management System (OSMS)

Software : Input data

Sediment

- Name
- Type of sample
- *Characteristics*

. Chemical (as, zn, ...)
. Mechanical (GTR)

- Centre of studies
- dredging date
- dredging location
- *GPS coordinates*
- *Transport costs* T / km
- Operating costs
- Notes

Treatment center

- Unit name

-Type of treatment

- **For each type:**

. Name of treatment
. Cost € / T
. Impact on polluting element%

- Address of the center
- GPS coordinates
- Notes

Storage areas

- Zone Name
- *Type (Inert, Not dangerous, Dangerous)*
- *GPS coordinates*
- *Storage costs € / T*

-Notes

Materials

- Name
- *GPS coordinates*
- *Transportation cost*
- *Operating cost (or purchase)*
- *Characteristics*

. chemical
. mechanics

-Notes

Mathematical model : Constraints

Environmental constraints : Heavy metals

$$e_{si}\left(1-\sum_{t=1}^{|T|}\hat{e}_{sit}T_{ti}\right)\leq e_s+(1-x_i)M$$

Environmental constraints : Organic matter

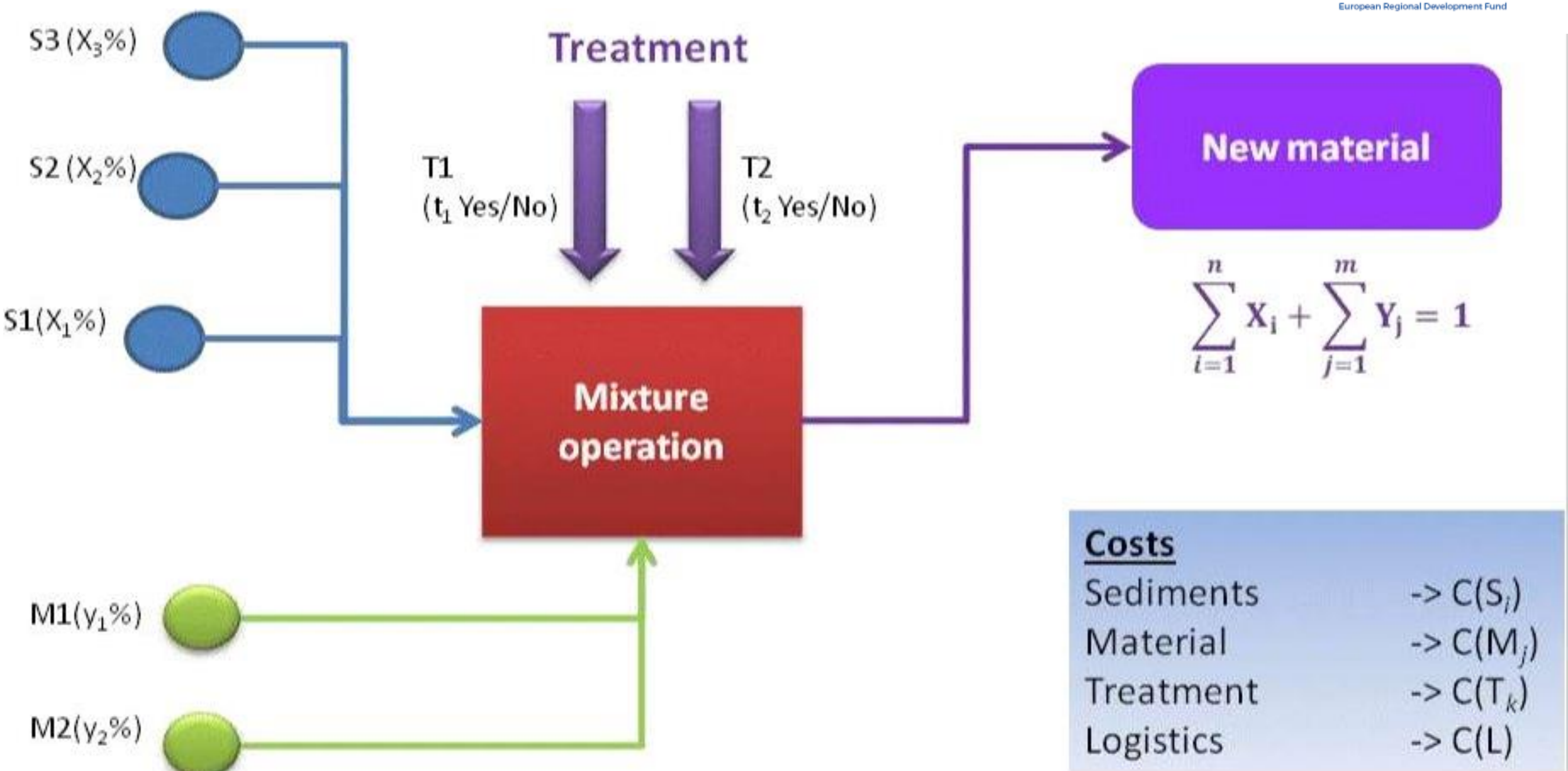
$$e_{Mi}\left(1-\sum_{t=1}^{|T|}\hat{e}_{Mit}T_{ti}\right)\leq e_M\left(1+\sum_{j=1}^{m}S_j\right)+(1-x_i)M$$

Mechanical constraints

$$\hat{P}_d^{0.4}\left(\sum_{i=1}^{n}x_i+\sum_{j=1}^{m}S_j\right)\leq\sum_{i=1}^{n}(P_{id}\times x_i)+\sum_{j=1}^{m}(P_{jd}\times S_j)\leq\hat{P}_d^{0.25}\left(\sum_{i=1}^{n}x_i+\sum_{j=1}^{m}S_j\right)$$

$P_{id}\,(P_{jd})$: associated percentage to the diameter *d* in sediment *i* (material *j*)

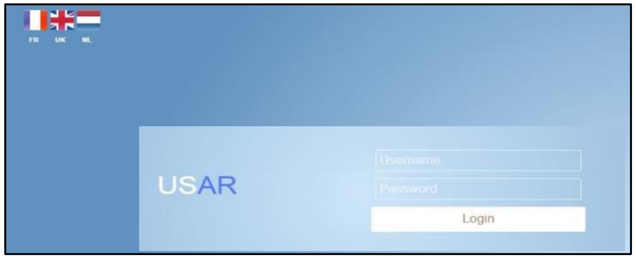
Mathematical model

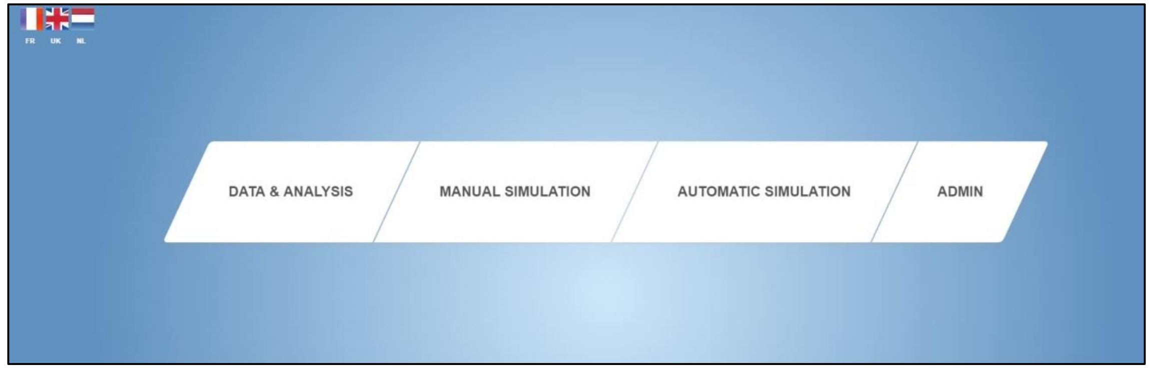


$$\sum_{i=1}^{n} X_i C(S_i) + \sum_{i=1}^{m} Y_j C(M_i) + \sum_{k=1}^{K} T_k C(T_k) + C(L) \rightarrow Min$$

OSMS softwar

Home page





1. Admin import the data, define the constraints, insert the costs, etc.
2. Data & Analysis display on the map the position of the different sediments, quarries, treatment centers, etc.
3. Manual simulation create a project and start a manual analysis
4. Automatic simulation create a project and start automatic analysis

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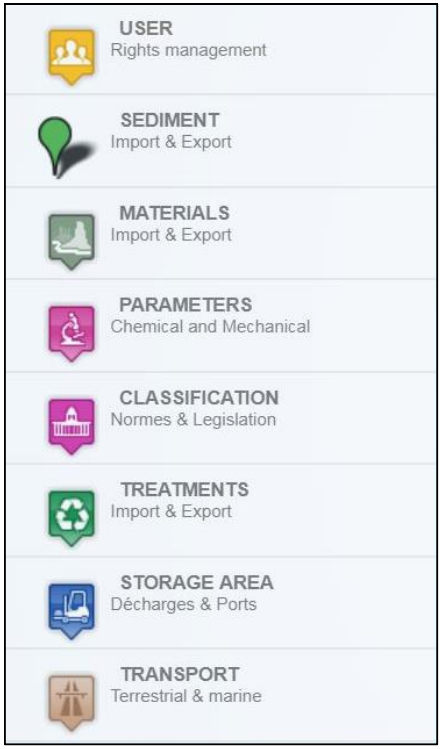


→ GPS coordinates, characterization and cost

→ Sand, gravel, lime, fly ash etc., GPS position, characteristics, costs

→ Physical, chemical and geotechnical parameters

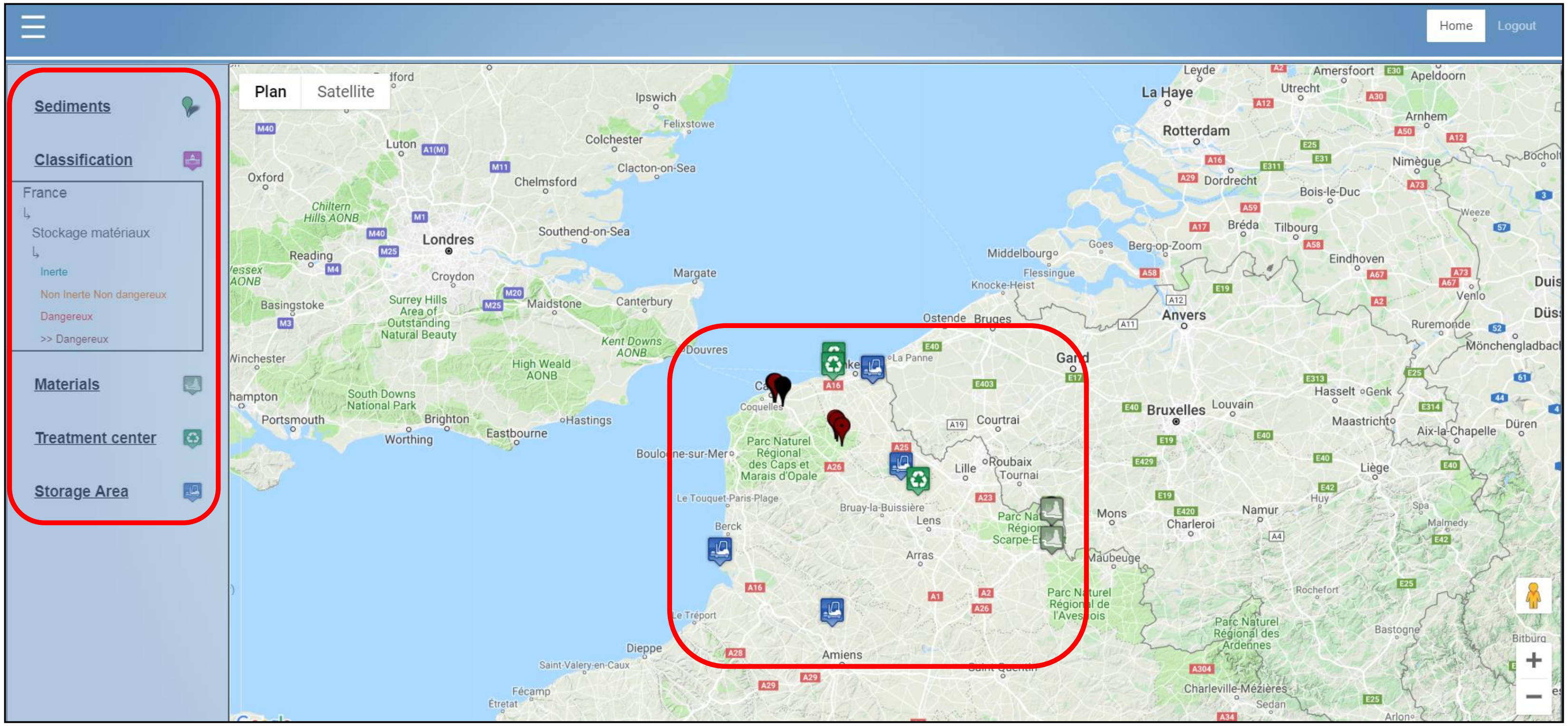
→ Classification of sediments

→ Add a treatment center, GPS coordinates, costs, etc.

→ GPS coordinates, acceptability criteria, costs

→ Type of transport, costs

The GPS coordinates of the project, the sediments, the additive, the materials, treatment centers and storage centers are displayed on the map



A2 | Date de prélèvement: 01/01/2013

Classification environementale | GTR

Paramètres

Paramètre	Symbole	Unité (MOW)	Unité (MOW)	Min Obs.	Max Obs.	Valeur
Granulometrie						
Fraction 0 à 2 um	Fraction_2	%	%	2.53	5.22	4.98
Fraction 0 à 20 um	Fraction_20	%	%	19.82	45.75	45
Fraction 0 à 50 um	Fraction_50	%	%	39.36	83.21	64.08
Fraction 0 à 60 um	Fraction_60	%	%	41.32	88	67.28
Fraction 2 à 60 um	Fraction_2_60	%	%	38.33	83.82	62.3
Fraction 0 à 200 um	Fraction_200	%	%	59.7	98.65	91.67
Fraction 0 à 2000 um	Fraction_2000	%	%	100	100	100
Fraction 0 à 4000 um	Fraction_4000	%	%	100	100	100
Fraction 0 à 5000 um	Fraction_5000	%	%	100	100	100
Fraction 60 à 2000 um	Fraction_60_2000	%	%	12	58.68	32.72
Fraction 2000 um à DMax	Fraction_2000_DMax	%	um	0	0	0
DMax	DMax	um	um	2000	2000	2000
Limite Atterberg						
WL	WL	%	%	40	65	48.67
WP	WP	%	%	33	48	33.34
Ip	Ip	%	%	7	21	15.33
Ic	Ic	%	%	1.57	3.42	1.57
Naturel						
Wn	Wn	%		87.9	169.9	106.13
Hydraulique						
Permeabilité	K	m/s	m/s	0.000001	0.000001	0.000001
Organique						
MO	MO	%	%	4.4	9.4	6.5
Géotechnique						
IPI	IPI	-	-	17	22	22
VBS	VBS	-	-	1	1.99	2.03
Chimique						
Arsenic	As	mg/kg	mg/kg	5.15	14.8	7.06
Cadmium	Cd	mg/kg	mg/kg	0.4	15.6	0.4
Chrome Tot	Cr Tot	mg/kg	mg/kg	13.7	88.4	16
Cuivre	Cu	mg/kg	mg/kg	14.6	439	14.6
Mercure	Hg	mg/kg	mg/kg	0.1	3.09	0.75
Nickel	Ni	mg/kg	mg/kg	8.49	25.7	9.53
Plomb	Pb	mg/kg	mg/kg	32.2	274	34.4
Zinc	Zn	mg/kg	mg/kg	112	1460	112
Carbone Organique Total	COT	mg/kg	mg/kg	13400	44200	20000
Polychlorobiphényles	PCB	mg/kg	mg/kg	0.07	0.07	0.07
Hydrocarbures Totaux	HCT	mg/kg	mg/kg	0	19166	7661
o-Xylene	o-Xylene	mg/kg	mg/kg	0.05	0.09	0.07
Toluene	Toluene	mg/kg	mg/kg	0.05	1.31	0.07
Ethylbenzene	Ethylbenzene	mg/kg	mg/kg	0.05	0.09	0.07
Benzene	Benzene	mg/kg	mg/kg	0.05	0.05	0.05
Naphthalene	Naphthalene	mg/kg	mg/kg	0.012	0.554	0.041
Acenaphthylene	Acenaphthylene	mg/kg	mg/kg	0.068	0.619	0.194
Acenaphthene	Acenaphthene	mg/kg	mg/kg	0.037	4.08	0.051
Fluorene	Fluorene	mg/kg	mg/kg	0.058	1.77	0.64
Phenanthrene	Phenanthrene	mg/kg	mg/kg	0.216	2	0.354
Anthracene	Anthracene	mg/kg	mg/kg	0.125	1.36	0.242
Fluoranthene	Fluoranthene	mg/kg	mg/kg	0.458	6.61	1.14
Pyrene	Pyrene	mg/kg	mg/kg	0.405	5.33	0.749
Chrysene	Chrysene	mg/kg	mg/kg	0.348	3.48	0.668
Benzo[a]pyrene	Benzo[a]pyrene	mg/kg	mg/kg	0.335	3.34	0.613
Indeno[1,2,3-c,d]pyrene	Indeno[1,2,3-c,d]pyrene	mg/kg	mg/kg	0.311	3.56	0.444
Dibenzo[a,h]anthracene	Dibenzo[a,h]anthracene	mg/kg	mg/kg	0.063	0.739	0.207

Classification environementale

- Pays
  - France
    - Stockage matériaux — Inerte | Non Iner... | Dangere... | >>Dange...
    - Immersion fluvial — S | >>S
    - Immersion marin — N1 | N2 | >>N2
  - Maroc
    - déchet — inert | dang | >>dang

characteristics and classifications

Sed_R || Date de prélèvement: 28/02/2018

Classification environnementale | GTR

Granularité

Tamisat 80 um :	Tamisat 2 mm :	Frac 0/50 mm(%) :
29	5	
Dmax :	**D60 :**	**D30 :**
0.2	66	29
D10 :	**Cu :**	**Cc :**
5		

Indice de plasticité | Bleu de méthylène

IP :	VBS :
19	2

Etat

Wn * :	Wopn :

Limites d'Atterberg

Wl * :	Wp * :	Ic :
56	40	2.5

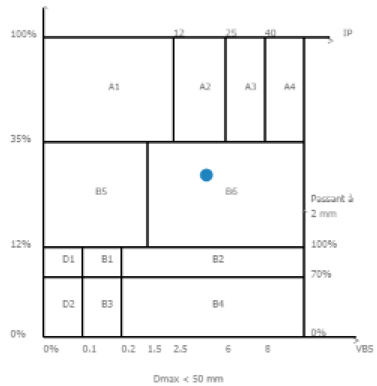
Comportement mécanique

LA :	MDE :	FS :

Indice portant immédiat | Matière organique

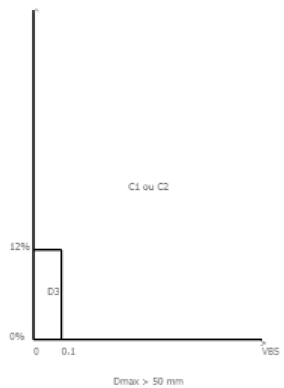
IPI :	MO :
	5

Classification

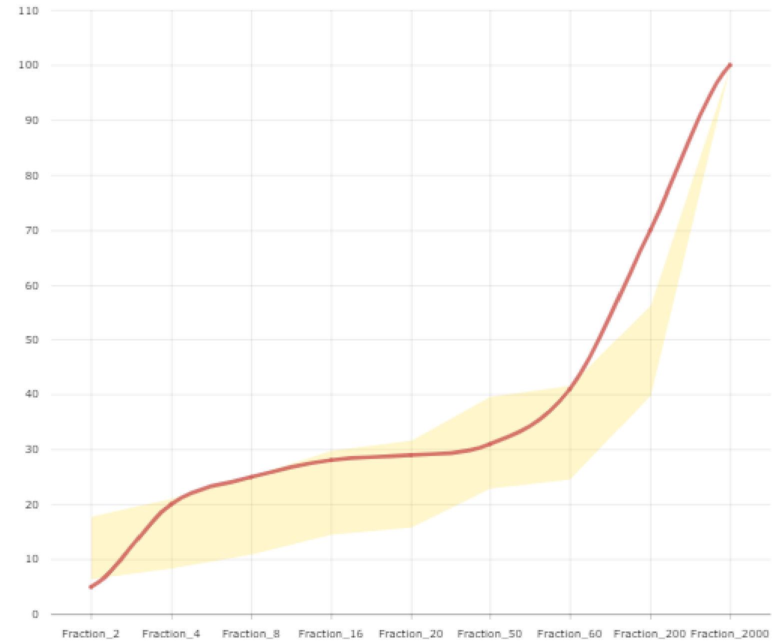


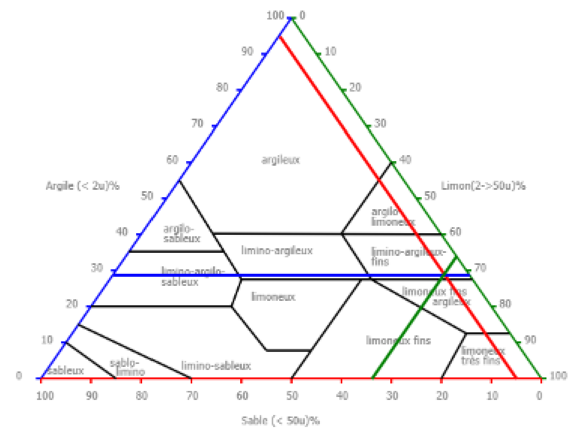
Classement selon la nature - B : Sols sableux et graveleux avec fines. - Sous-classe fonction de la nature - B6 : Sables et graves argileux à très argileux.

F11 : Matériaux faiblement organiques (terres végétales, vases,. . .)

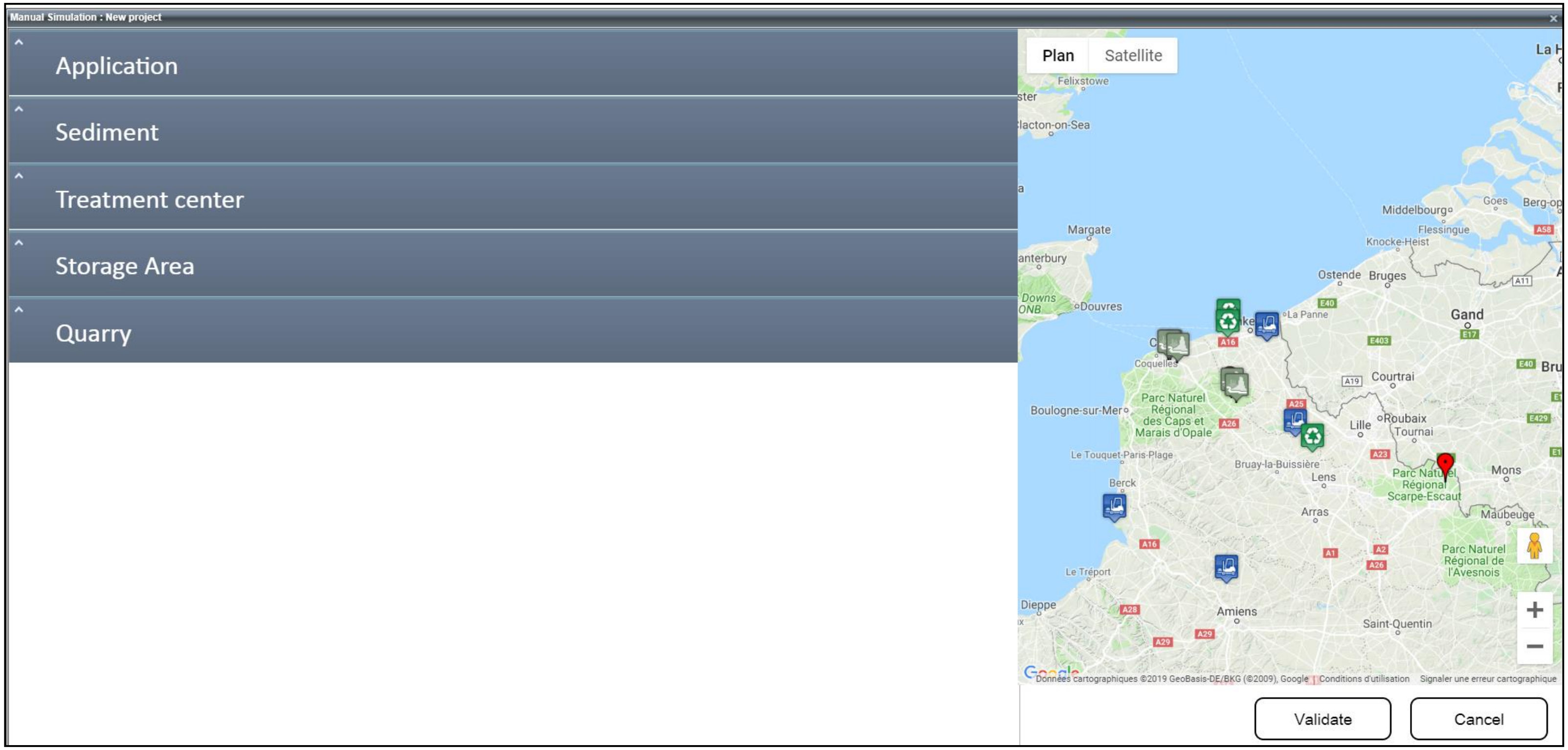


Graphe de granulomètrie





Create a new project and select its characteristics: type of application, sediments, quarries, storage and treatment centers etc.



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Example of results, Road application -1-

⇧ | Editer Projet |

Code	Symbole	Min	Max
Limite Atterberg			
Ic	Ic	0.6	
Organique			
MO	MO		3
Géotechnique			
IPI	IPI		20
Chimique			
Mercure	Hg		0.2
Molybdène	Mo		10
Nickel	Ni		10
Plomb	Pb		10
Antimoine	Sb		0.7
Sélénium	Se		0.5
Zinc	Zn		50
Fluorure	F-		150
Chlorure	Cl-		15000
Sulfate	SO4-		20000
Carbone Organique T...	COT		30000
Hydrocarbures Arom...	HAP		50
Polychlorobiphényles	PCB		1
Hydrocarbures Totaux	HCT		500
Arsenic	As		2
Barium	Ba		100
Cadmium	Cd		1
Chrome Tot	Cr Tot		10
Cuivre	Cu		50

1

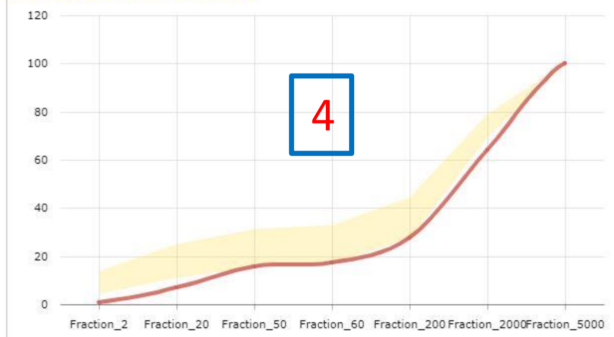
Nouveau matériau 11.08(€)

Sédiments	%	% Max	Coût(€)
B3	15.14	100.0	1.05
C2	5.37	100.0	0.48
Matériaux	**%**	**% Max**	**Coût(€)**
M2	79.47	100.0	9.53

2 3

Nouveau matériau | GTR

Graphe de granulomètrie



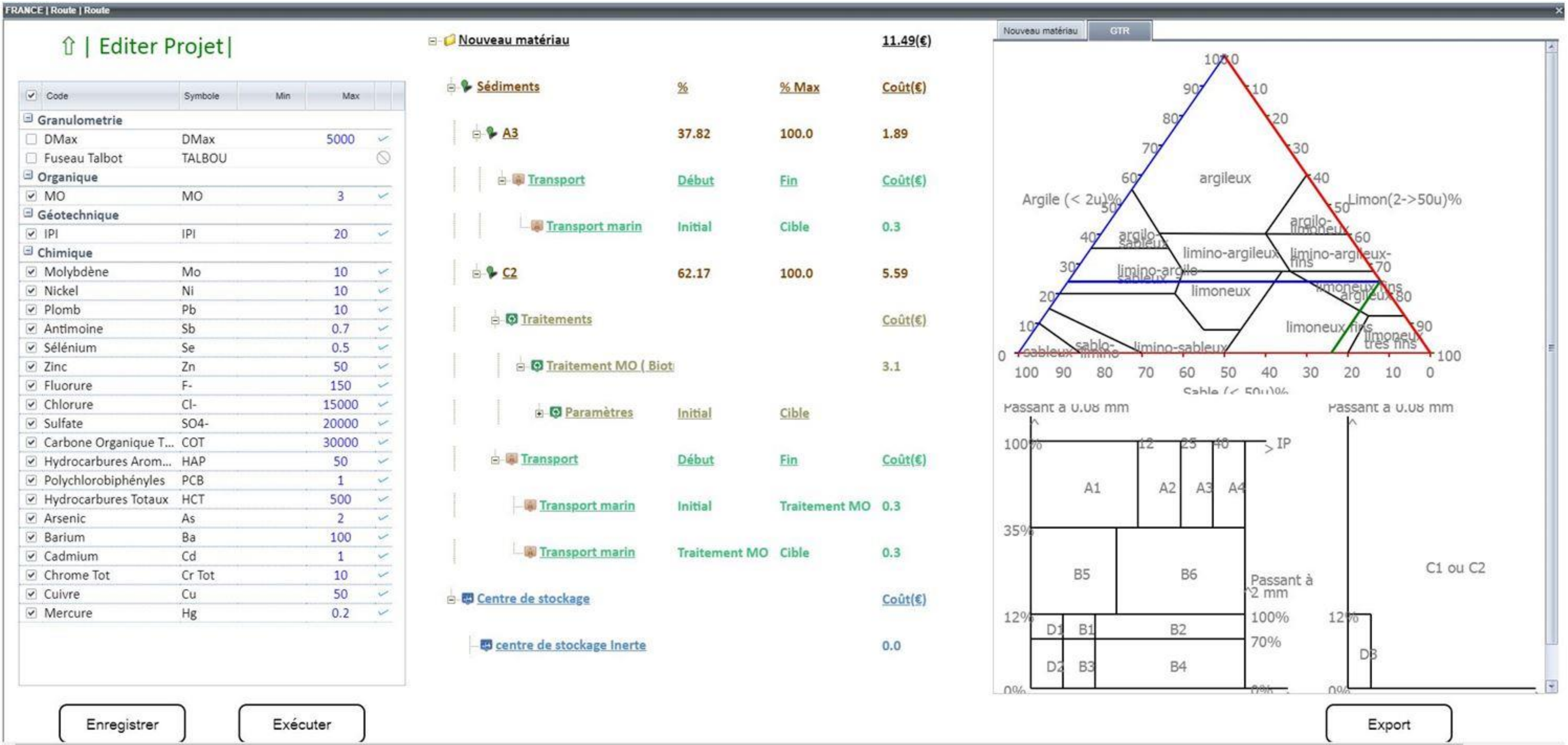
Code	Symbole	Valeur
Limite Atterberg		
Ic	Ic	0.47
Organique		
MO	MO	1.6
Géotechnique		
IPI	IPI	
Chimique		
Arsenic	As	1.41
Barium	Ba	0
Cadmium	Cd	0.2
Chrome Tot	Cr Tot	10

5

- 1 ➔ Limit values of acceptability
- 2 ➔ Mix design
- 3 ➔ Costs
- 4 ➔ Characteristics of the new material
- 5 ➔ New parameters values

Enregistrer | Exécuter | Arbre de décision | Export

Example of results, Road application -2-



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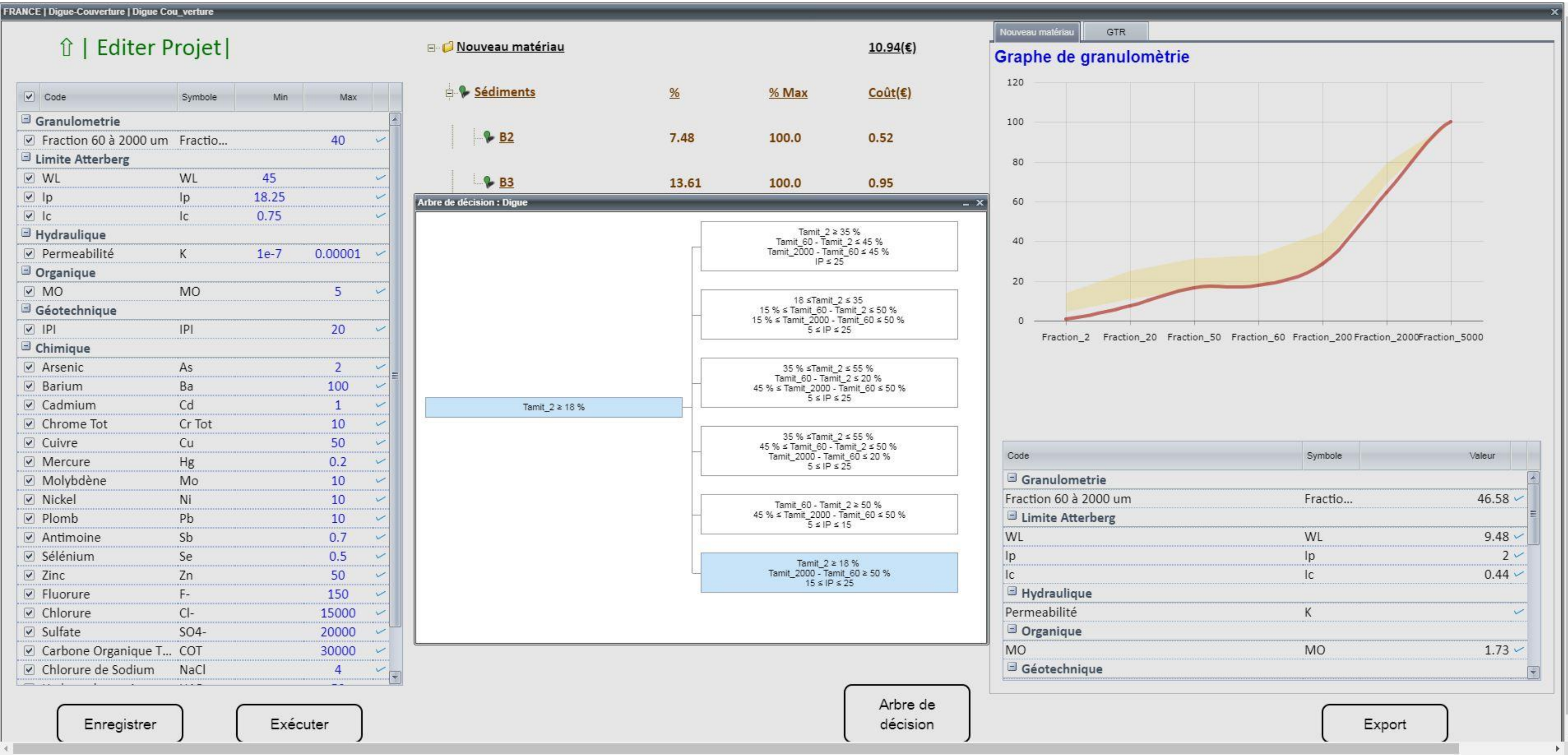
Example of results, Embankments



Thank you for your attention

Contact: ***ahmed.zeraoui@imt-lille-douai.fr***