SEDINNOVE

INNOVATIVE SEDIMENT RECOVERY

SedNet Lisbon – Sept. 2023

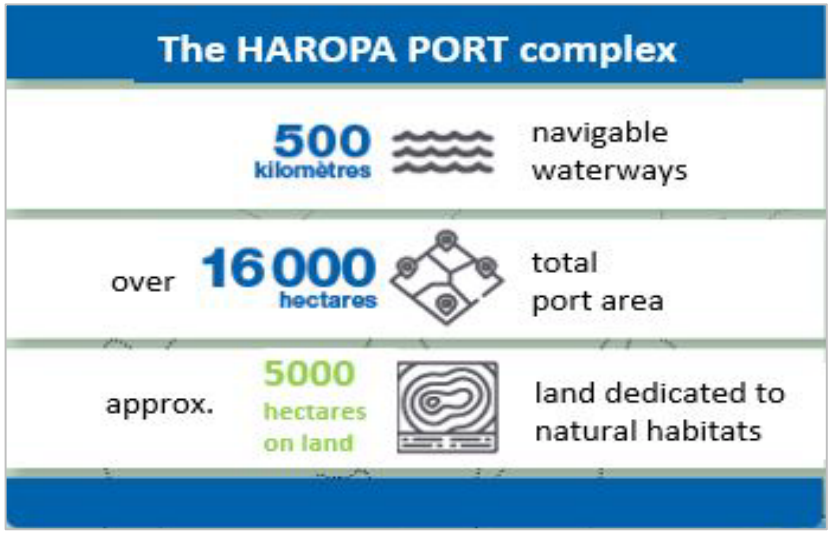
HAROPA PORT Le Havre Rouen Paris

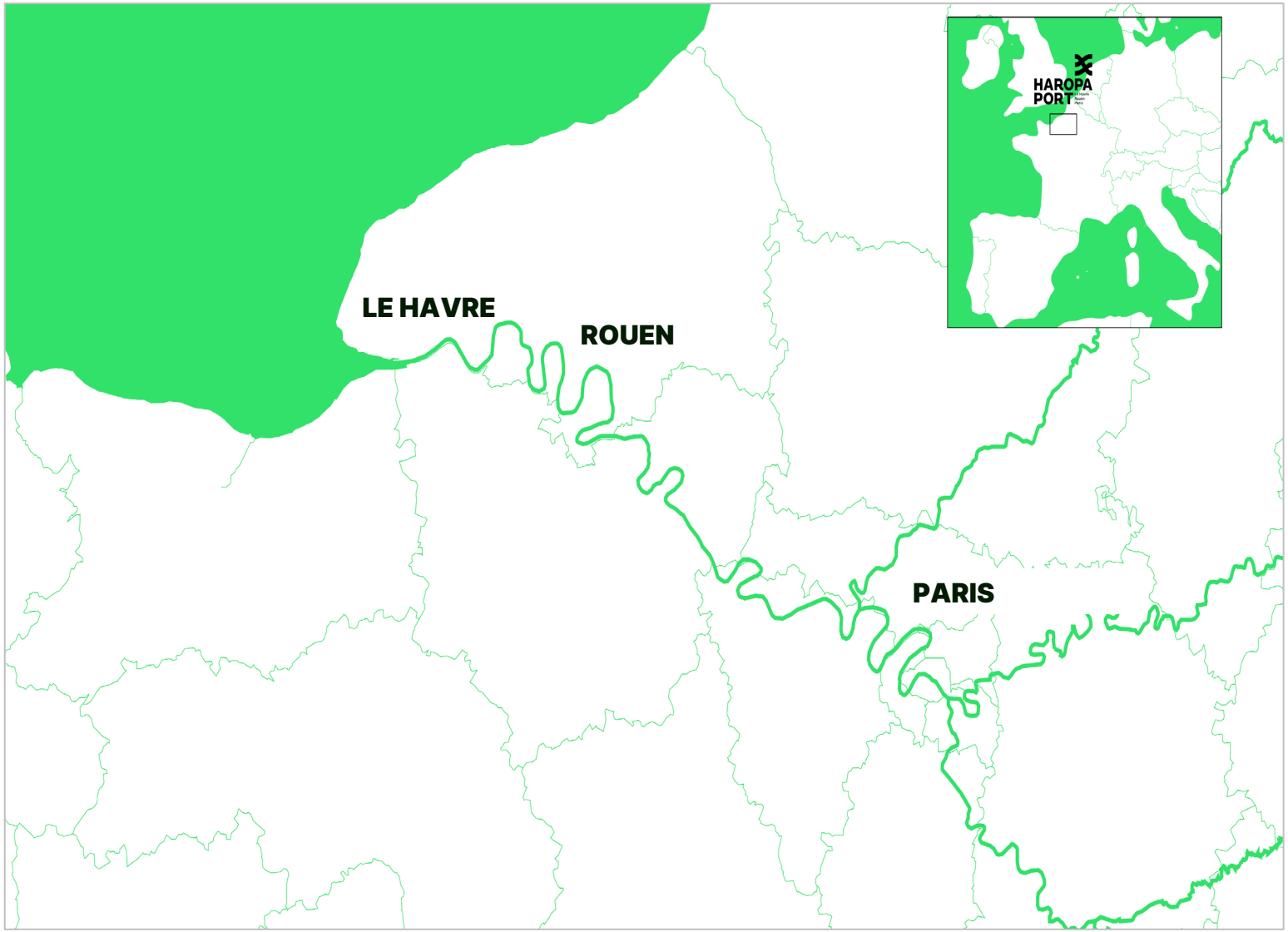
neo-eco
A world without waste

HAROPA PORT

Key figures

- 5th largest port in Northern Europe
- 1st French port for :
  - foreign trade
  - container traffic
  - energy & chemical products,
- 25m consumers catchment area



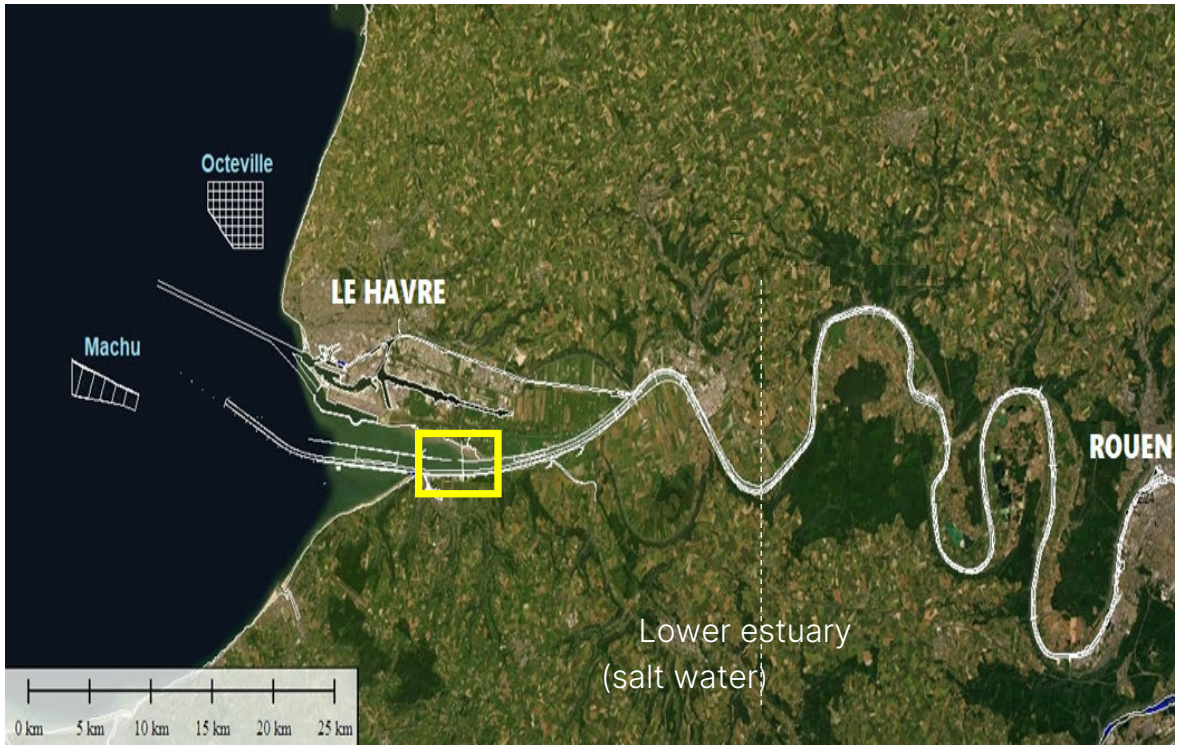


CHALLENGES & PERSPECTIVES

CHANGING CURRENT PRACTICES

6 M m3 dredged sediment / year in the Seine estuary, including **4.5 Mm3 in salt water** (lower estuary)

- 93 % dumped at sea
- 7 % discharged on land for disposal (upstream sector of the estuary)



HAROPA PORT | Rouen launched a project to reinvent the current linear sediment management model :

SEDINNOVE

to identify solutions for recycling sediment from the lower estuary.

NEO-ECO

Engineering bureau specialized in Circular Economy

neo-eco
A world without waste

Key figures

15
years of experience

+500
eco-products developed

35
research partnerships

18
Innovative ERDF (European Regional Development Funds)

15
research thesis

21
start-ups & spin-off

Methodologies

Acting across the entire value chain

CIRCULAR PROJECTS

Innovative Deconstruction & Reconstruction

ECO-MATERIALS

Innovative materials from waste

CIRCULAR ECONOMY STRATEGY

Designing regional recycling loops

METHODOLOGY

Inspired from French national approach « SEDIMATERIAUX »

SEDIMENT

PHASE 1 – FEASIBILITY

- Regulatory characterisation
- Additional analysis from Sédimatériaux
- Selection of the recovery process and possible applications

PHASE 2 – LAB STUDY

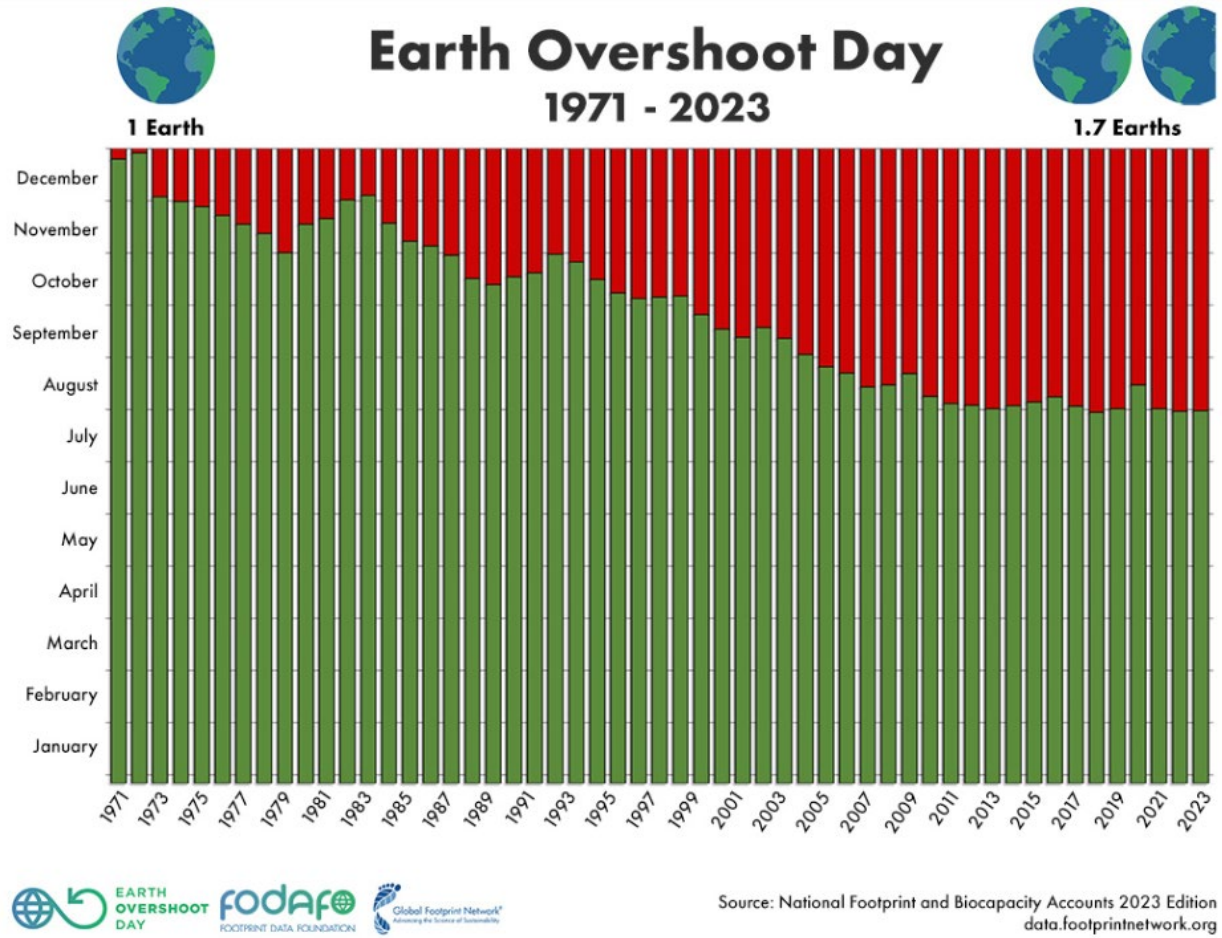
- Formulation study
- Plots analysis
- Design and monitoring of experimental plots
- Validation of the mechanical and environmental feasibility of the intended use under controlled conditions

PHASE 3 – FIELD STUDY

- Steps and preliminary studies
- Design and instrumentalization of a field structure
- Mechanical & environmental monitoring of the structure
- Monitoring groundwater quality
- Validation of technical, mechanical and environmental feasibility in real-life conditions

GENERAL CONTEXT

Depletion of natural resources



GUIDELINE

- Limiting the consumption of natural resources
- Managing the end-of-life of products more sustainably
- Ensuring that regulations evolve in the right direction

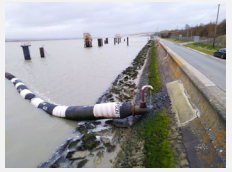
PHASE 1 | FEASIBILITY

Sampling and characterisation

STEP 1 - SAMPLING

REPRESENTATIVE SAMPLING PROCESS


Dredging


Hydraulic discharge (land disposal)


Decantation


Sampling


Homogenisatio

STEP 2 - ANALYSIS

MULTI-USE APPROACH

5 USE CASES

Concrete, road engineering, landscaping, equestrian industry, cement

According to environmental criteria sediments in the lower estuary are considered:

- NON-INERT (PRESENCE OF CHLORIDES)
- NON-HAZARDOUS
- NON-ECOTOXIC

Grain size	100% < 1mm
Organic matter content	MO < 1,5%
VBS index	VBS = 0,15
GTR Classification	B5
Permeability	K = 10^7
Major elements	SiO2 = 54,34% SiO, Al2O3, FeO, CaO > 80%
Pozzolanic activity	Importante après broyage
Water-soluble sulphates	0,08%
Acid-soluble sulphates	0,07%
Water-soluble chlorides	0,005%
Acid-soluble chlorides	0,02%
Total sulfur	0,04%

PHASE 1 | FEASIBILITY

Study of compatible sectors

STEP 3 - SECTORS

CRITERIA SCORING RESULTS

SECTOR	RATING
CONCRETE	8/10
CEMENT	5/10
ROAD ENGINEERING	8,5/10
LANDSCAPING	4,3/10
EQUESTRIAN FIELD	4,8/10

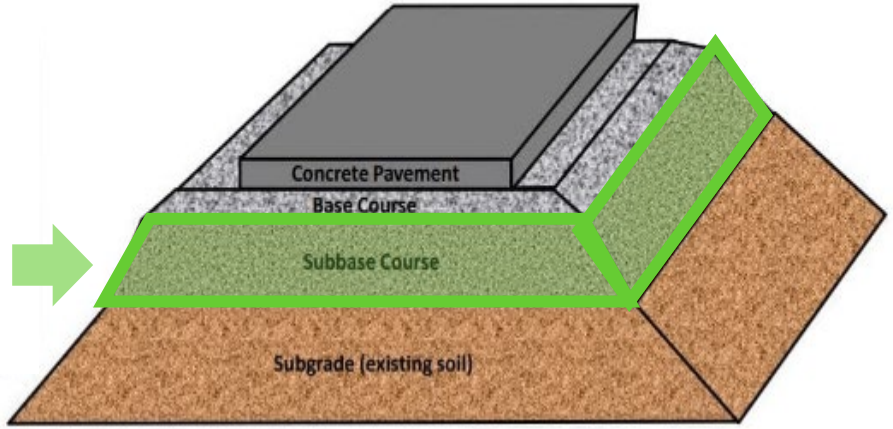
Choice of two applications in these two sectors responding to the needs of HAROPA PORT & local territory needs

PHASE 2 | LABORATORY STUDY

Formulation of the eco-products

STEP 1 - FORMULAS

SUBGRADE COURSE



Integration rate of sediment substituting the sand fraction

50% 70% 100%

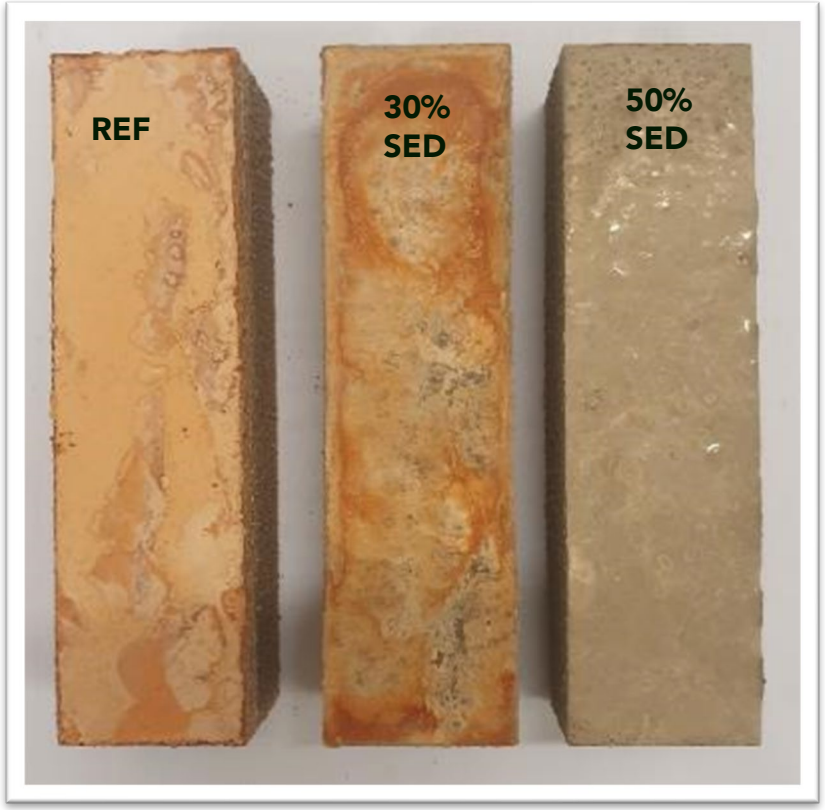
Sourcing of materials from local suppliers for formulations

Validation of formulas with optimised and maximised integration rates

CONCRETE FOR MARINE USE

Integration rate of sediment substituting the sand fraction

0% 30% 50%


REF
30%
SED
50%
SED


REF
29/04
REF
29/04

PHASE 2 | LABORATORY STUDY

Assessment of performance and sustainability

STEP 2 - SUSTAINABILITY

SHORT-TERM

Verification of compliance with target performance for each formulation developed

EXAMPLES OF ANALYSIS

SUBGRADE COURSE

- Behaviour with hydraulic binders
- Resistance class

CONCRETE

- Fresh state testing of concrete
- Resistance class

The objective is to identify if the integration of sediment impacts the behaviour of the eco-material

PART OF THE RESULTS

CONCRETE Formulation	Compressive Strength class (MPa) 28 days	Moy
Témoin	90,260	84,9
	79,600	
	60,170	
30% SED	92,340	86,3
	83,280	
	83,370	
50% SED	72,600	83,9
	90,030	
	89,000	

OBJECTIVE > 35 MPa

SUB-GRADE COURSE	Comp.%	W(%)	masse vol-dry Mg/m3	GVmoy	Rthmoy 7 days
(sed;sab)	(100,0)	13.7	1.73	3%	0.18
	(80,20)	13.3	1.85	1.5%	0.22
	(70,30)	13	1.88	1.2%	0.26
	(60,40)	12	1.92	1%	0.26
	(50,50)	11	1.97	1%	0.27

OBJECTIVE : Gv < 5% & Rth > 0,2

PHASE 2 | LABORATORY STUDY

Assessment of performance and sustainability

STEP 2 - SUSTAINABILITY

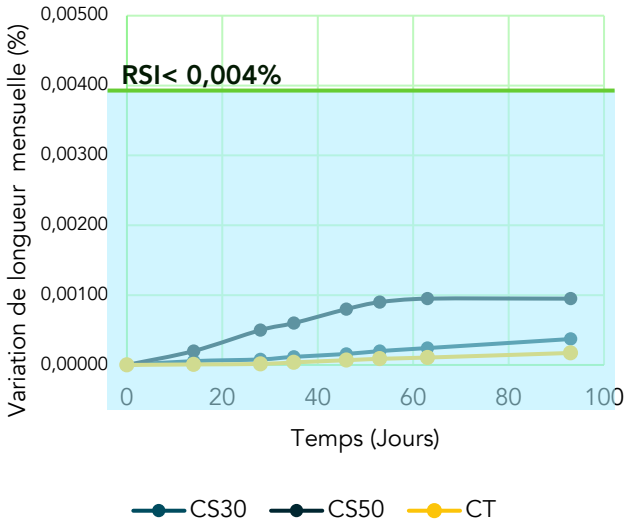
LONG-TERM

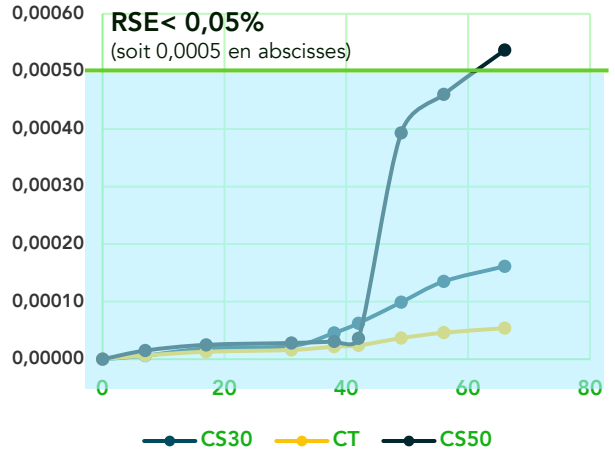
- Testing applications according to several **criteria over a long period of time**.
- Simulating attacks to which concrete, and subgrade may be subjected in **real-life conditions**.

- Validation of the durability of the subgrade materials with a 70%-80% sediment substitution
- Validation of the performance and resistance of XS3 concrete with a 30% sediment substitution over the long term (without reinforcement)

PART OF THE RESULTS

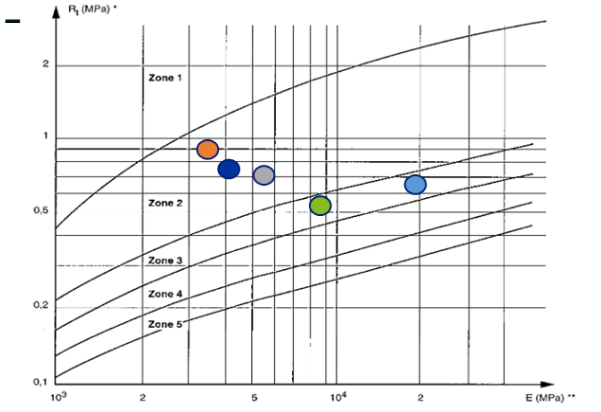
SULFATIC ATTACKS – CONCRETE





FINAL PERFORMANCES – SUBGRADE COURSE

Ref	Comp.
F1	(100,0)
F2	(80,20)
F3	(70,30)
F4	(60,40)
F5	(50,50)

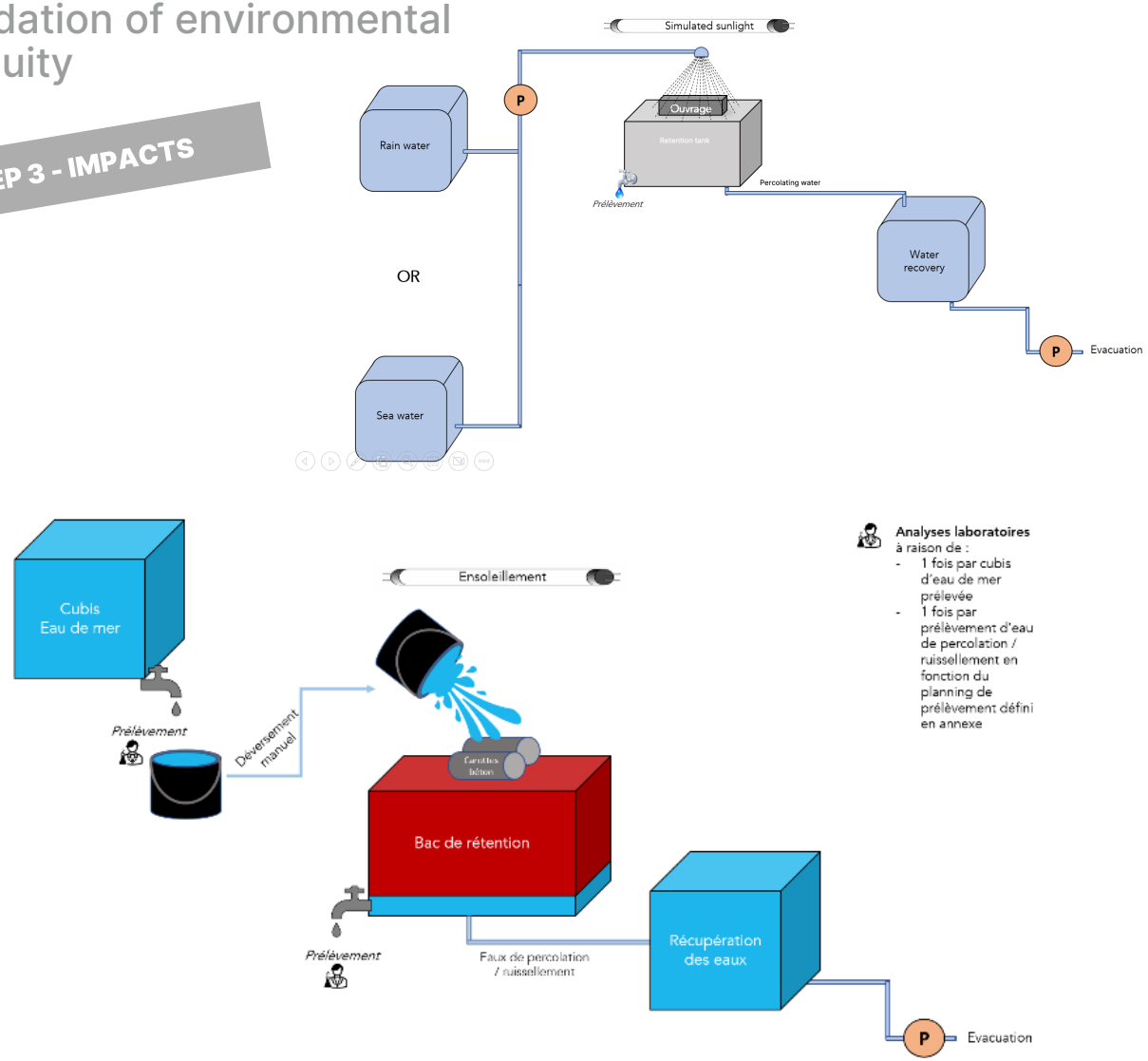


(Et ; Rt)	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5
Mechanical performance classes	$P_{méc}1$	$P_{méc}2$	$P_{méc}3$	$P_{méc}4$	$P_{méc}5$

PHASE 2 | LABORATORY STUDY

Validation of environmental inocuity

STEP 3 - IMPACTS



- Neo-Eco developed a laboratory dedicated to assessing the environmental quality of the eco-products that are created.
- Testing protocols have been validated by governmental bodies.

RESULTS

- No exceedance invalidating environmental monitoring for the subgrade course
- No exceedance invalidating environmental monitoring for XS3 concrete

CONCLUSION

After 12 months, it has been demonstrated that the eco-products developed have no harmful impact on the environment

PHASE 2 | LABORATORY STUDY

Operational economic study

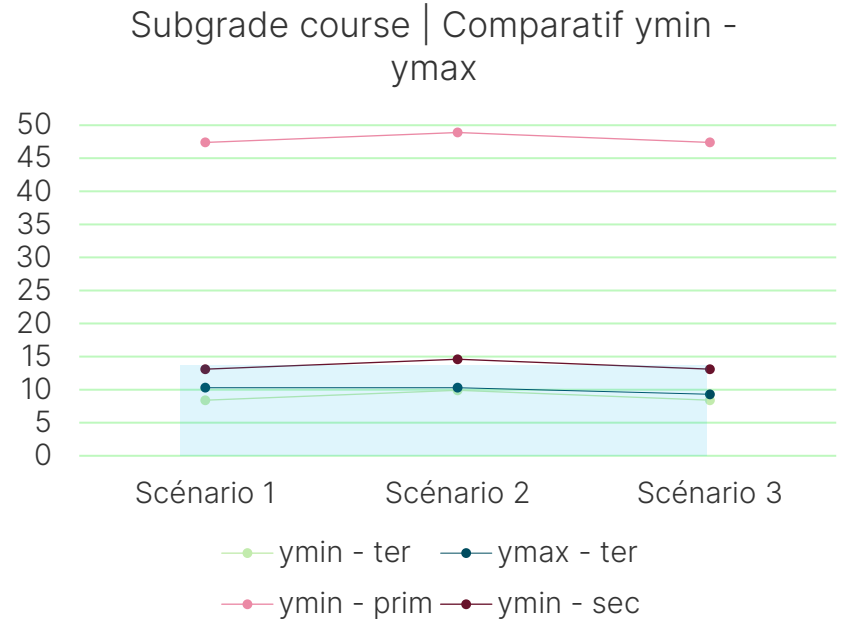
SUBGRADE COURSE

- **Differences in composition and process have limited impact on economic profitability**.

- **The “user” of the sediments can purchase the sediments at a normal aggregate price and stay within its costs.** Incorporating sediments into the sub-base manufacturing process is a real opportunity given the rising cost of raw materials.

- **Manufacture of sediment-based sub-bases show a good market potential and economic gain**.

Producer and sediment owner have a positive economic outcome compared to the reference scenario



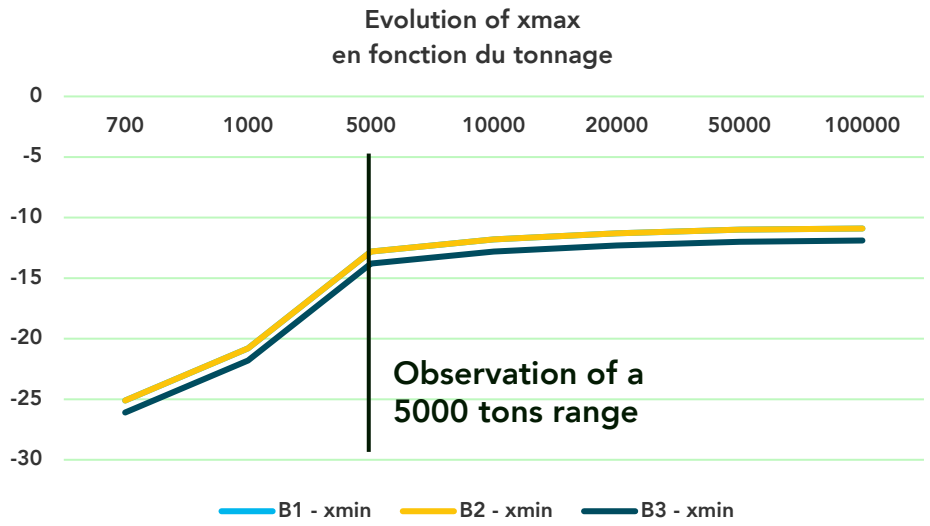
PHASE 2 | LABORATORY STUDY

Operational economic study

CONCRETE

- Economic profitability is not achieved for all the scenarios. It is important to **combine this analysis with the choice of composition**.
- For the same concrete application, **the composition is likely to vary depending on the concrete producer**.
- Project size matters in order to minimize the production cost of sediment-based concrete.

Recommended tonnage for production cost optimization of the sediment-based concrete.



PHASE 3 | PILOT AT SCALE

Deploy the methodology on a larger scale

OBJECTIVE

Test on a normal scale the implementation of the eco-materials

STEP 1 - PILOTS

Identify pilot project

- Internal project of HAROPA PORT
- External project

STEP 2- SEDIMENTS

- Secure sediment deposit
- Verify properties at larger scale
- Validate the preparing process

STEP 3 – WORKS CONTRACTS

- Define protocols
- Implement contracts recommendations
- Chose the right contractor

STEP 4 - WORKS

Set up the pilot site

- Prepare sediment
- Implement the eco-materials
- Setup monitoring tools

STEP 6 - EVALUATE

Long-term monitoring of the pilot

- Environmental impact
- Technical performance

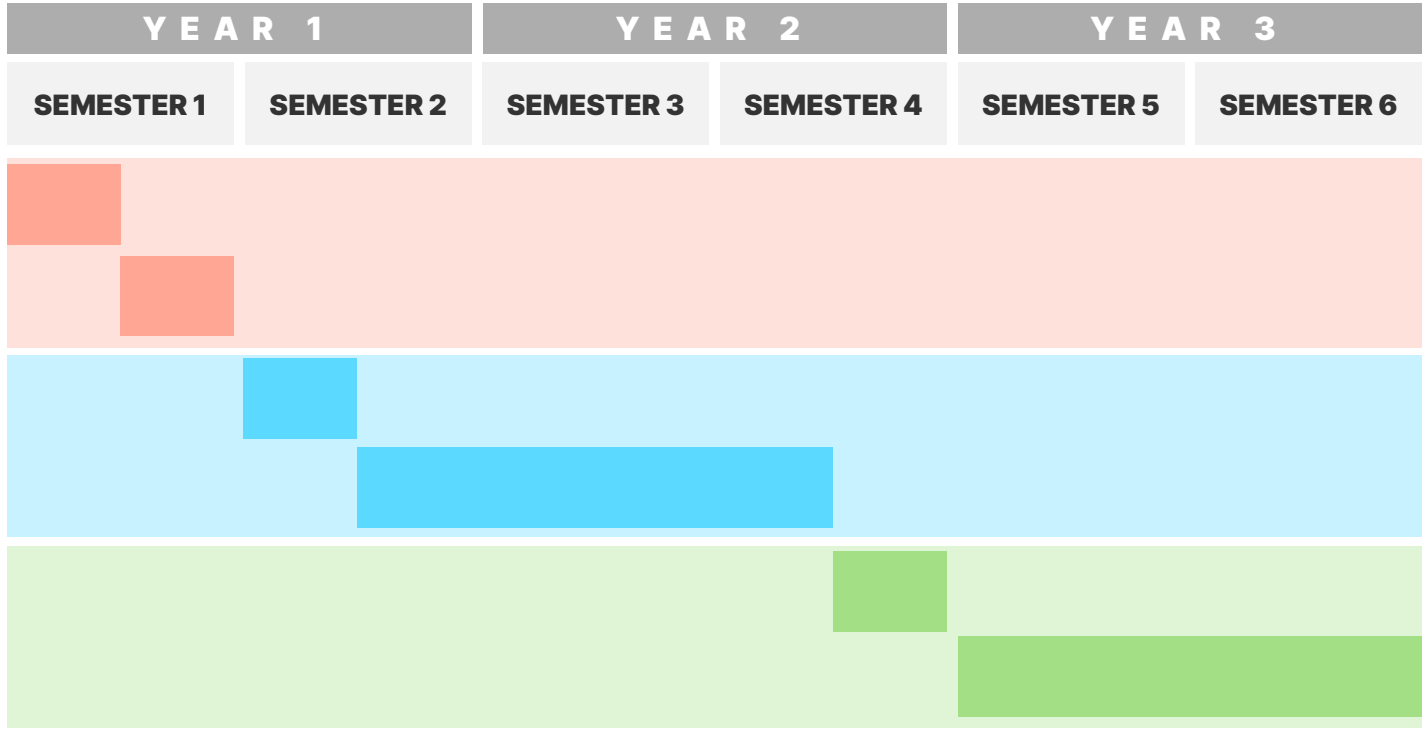
STEP 3 – LEARN

- Provide feedback
- Climb the learning curve
- Replicate

PLANNING

Update on deadlines

TYPICAL PLANNING



PHASE 1 : FEASIBILITY
- Sampling & characterisation (3 months)
- Sectors analysis (3 months)

PHASE 2 : LABORATORY STUDY
- Formulation (3 months)
- Evaluation of environmental impact and durability (12 months)

PHASE 3 : FIELD STUDY
- Previous studies to prepare the pilot site (6 months)
- Set-up of the pilot site and evaluation (depending on the project)

BENEFITS

Responding to environmental challenges through economic performance

SEDINNOVE RESULTS

Characteristics of sediments validation & potential evaluation

Validation of the long-term performance

Validation of local needs and economic pertinence

Validation of the environmental safety

SEDIMENT-BASED TECHNICAL APPLICATIONS READY FOR DEPLOYMENT

MID-TERM BENEFITS

- **Development of innovative sediment management and recovery industries** with job creation
- **Anticipating future shortages of raw materials** in the public works and maritime sectors
- **Limiting greenhouse gas emissions** by increasing waterway transport capacity
- **Preservation of natural resources** through the production of alternative materials

THANK YOU !

Sandrine SAMSON
Ecological Transition Project Director

+33 6 80 31 38 43

sandrine.sansom@haropaport.com

34 Boulevard du Bois Guilbert
76000 Rouen
France

Ludovic GRABNER
Channel & Marine Works Director

+33 7 61 71 73 59

ludovic.grabner@haropaport.com

34 Boulevard du Bois Guilbert
76000 Rouen
France

Benjamin CONSTANT
Associate MD

+33 7 55 60 94 98

bconstant@neo-eco.fr

1 rue de la Source,
59320 Hallennes-Lez-Haubourdin
France