Team 02 Presentation 3

HYDROEUROPE

Analysis of Sediment Transport and Nitrate Pollution

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Case Study Overview/Recap

How to mitigate flooding events in current and exacerbated future climate scenarios based on natural solutions?

Methodology

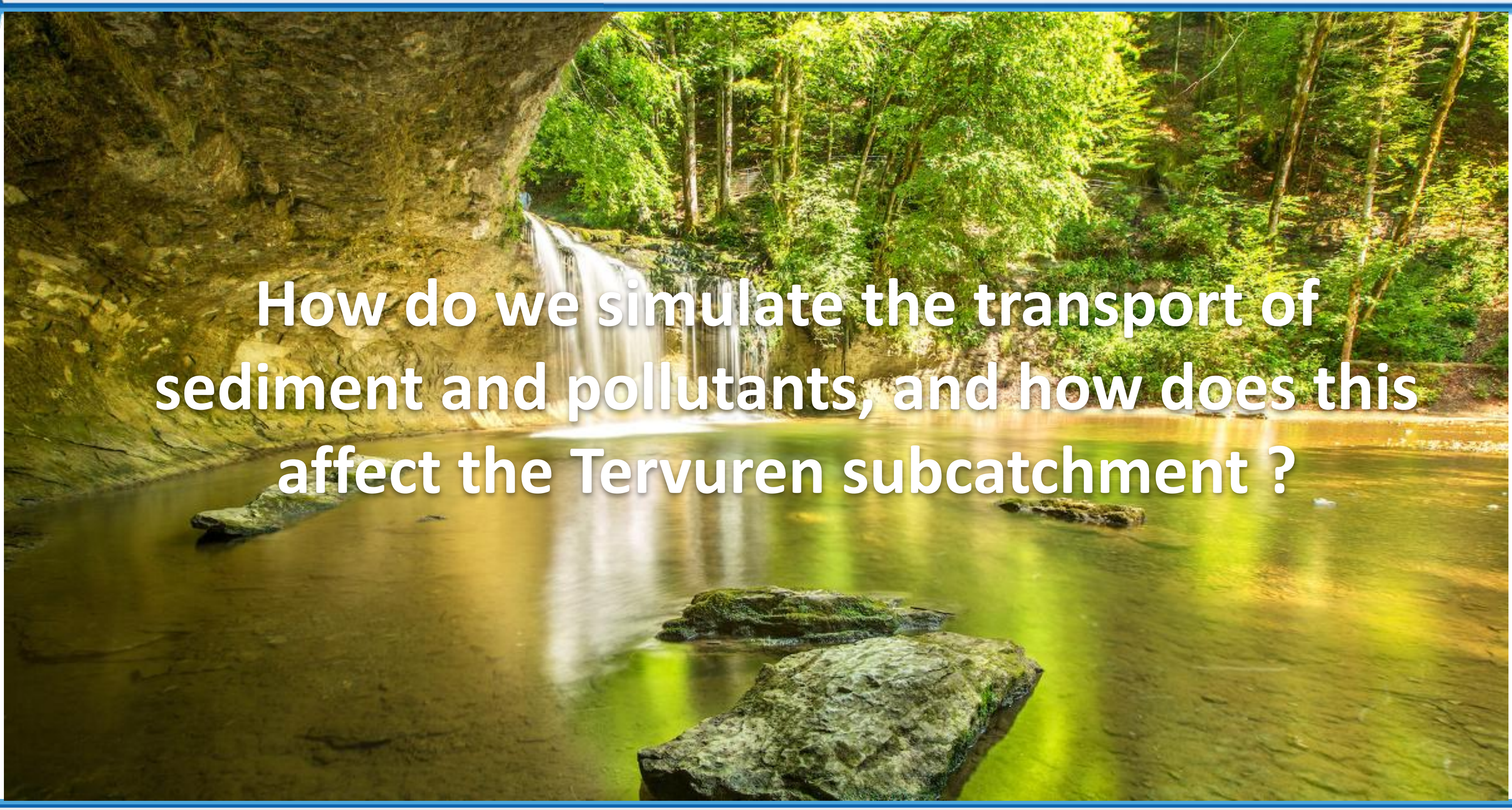
- **Future Climate Scenarios**: **Modelling future climate scenarios** based on seasonality factors and extrapolated rainfall data
- **Risk Areas** : **Identifying high risk areas** by zone **sensitivity**, **high risk** of flooding, **1 foot water depth** and **10% of flooding** area
- **Nature based solutions** : **Implementation** of
→ **Berms, Rain gardens & porous pavements** on strategic zones

Analyses

- **Results : Creating flood maps extent** on urban zones for every return period but more **relevant for low return period** (5 years)
- **Next steps : Sediment Transport and Accidental Pollution Analysis on Tervuren subcatchment**

Comparaison of water depth with and without NBS for 5 years return period

Problem



How do we simulate the transport of sediment and pollutants, and how does this affect the Tervuren subcatchment ?

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Objectives / Methodology

Problem

Modeling Sediment Transport & Accidental Pollution, Tervuren Catchment

- **Water quality protection**: threatening biodiversity and drinking water supplies
- **Impact on vulnerable areas**: Excessive erosion and pollution disrupt aquatic ecosystems, reducing water quality and affecting sensitive environments.
- **Regulatory compliance**: The EU mandates a maximum of **50 mg/L** of suspended solids in water; controlling erosion and pollutants is crucial to meet this standard and protect water bodies.

Objectives

- **Identifying groundwater-sensitive areas**
- **Establishing total risk zones**
- **Comparing with study results**

Methodology

- **Building 1D/2D Hec-Ras model**
- Create **vulnerability maps** for erosion and **groundwater pollution area**
- Reaction plan in case of an accidental pollution

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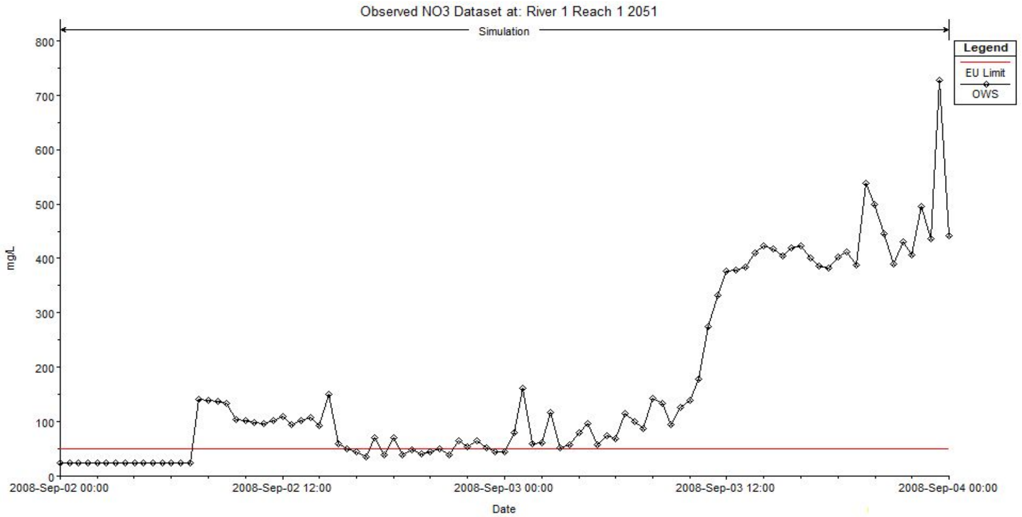
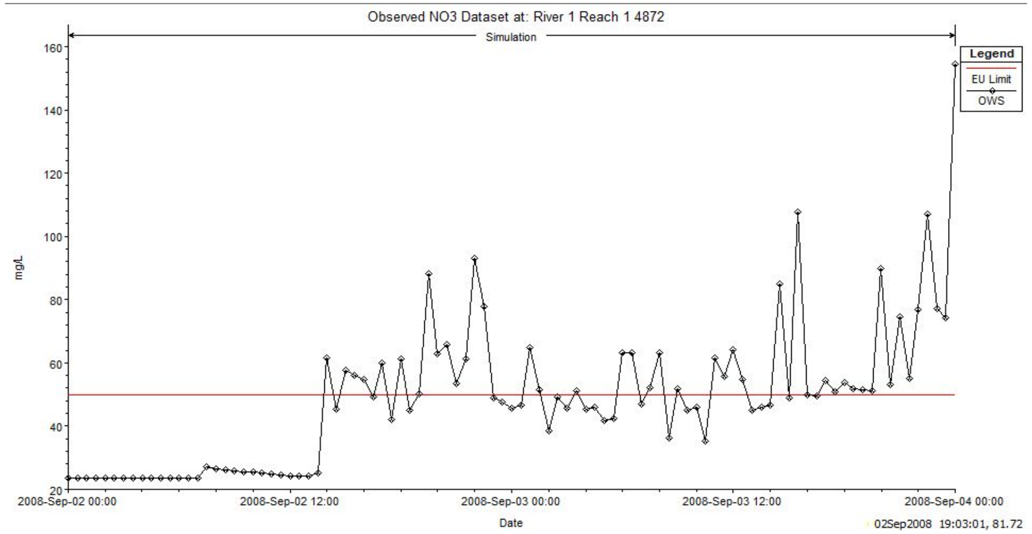
Workflow

1. **Model Sediment Dispersion**
   Begin the process of modeling sediment dispersion using HEC-RAS.
2. **Model Nitrate Concentrations**
   Used sediment transportation to obtain nitrate concentration.
3. **Compare Against EU Limits**
   Evaluate nitrate concentrations against EU water standards.
4. **Assess Water Quality Impact**
   Determine the effects of nitrate levels on water quality.
5. **Vulnerability Analysis**
   Superimpose groundwater, drinking water and soil erosion maps to identify areas of vulnerability.

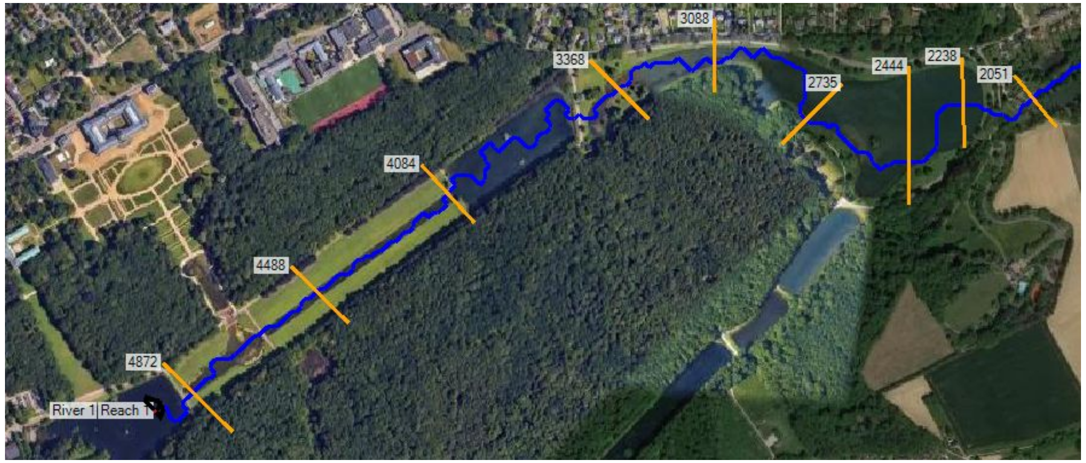
Sediment Transport Analysis

2051 Middle
Max conc. 727 mg/l





- **Concentration Only Method**
- Accounting for **sediment concentration** rather than full sediment continuity
- Steady flow assumption
- No accounting for bed evolution
- Useful for quick assessments of suspended sediment loads



4872 Upstream
Max conc. 155 mg/l

Cross sections

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Sediment Transport Analysis

Sediment Transport

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Nitrate as a pollutant

. **Main Sources:** Fertilizers, animal waste, sewage, industrial runoff

. **Environmental Impact:** Algae blooms, oxygen depletion, fish kills

. **Health Risks:** Contaminated drinking water, blue baby syndrome

Examples:

According to the **U.S. EPA (2021)**, nitrate levels above **10 mg/L** in drinking water can pose serious health risks, especially for infants.

A study by **Ward et al. (2018)** found that populations exposed to nitrate levels exceeding **5 mg/L** in drinking water had an increased risk of certain **cancers** and thyroid disorders.

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Clay Nitrate Load Calculation

The following schematic was followed to calculate the actual nitrate pollutant concentration across the river.

Nitrate Load Calculation in River Cross-Sections

Measure Clay Concentrations → **Apply Adsorption Ratio** → **Calculate Nitrate Load** →

Clay sediment concentrations were measured at each cross-section along the river at 30 min timestep

Clay sediment concentrations were multiplied by clay-nitrate adsorption ratio of 0.001 mg NO3/mg clay

The product of Clay concentration and Nitrate adsorption ratio was taken as the additional nitrate load

Clay Nitrate Load Calculation

The following schematic was followed to calculate the actual nitrate pollutant concentration across the river.

Nitrate Load Calculation in River Cross-Sections

Measure Clay Concentrations → Apply Adsorption Ratio → Calculate Nitrate Load → Add Initial Nitrate Load → Determine Total Nitrate Load

- **Measure Clay Concentrations:** Clay sediment concentrations were measured at each cross-section along the river at 30 min timestep
- **Apply Adsorption Ratio:** Clay sediment concentrations were multiplied by clay-nitrate adsorption ratio of 0.001 mg NO3/mg clay
- **Calculate Nitrate Load:** The product of Clay concentration and Nitrate adsorption ratio was taken as the additional nitrate load
- **Add Initial Nitrate Load:** Initial nitrate load of 23.7 mg NO3/l was added to simulated nitrate concentration at each point
- **Determine Total Nitrate Load:** The resulting sum of initial and additional nitrate load gives the total nitrate load at each cross section of the river

- Max value of 727 mg/l at cross section 2051 (Dense urban area)
- A constant water temperature of 13 C was assumed throughout the river
- NO3 conc and water temperature were input in HEC-RAS for WQA

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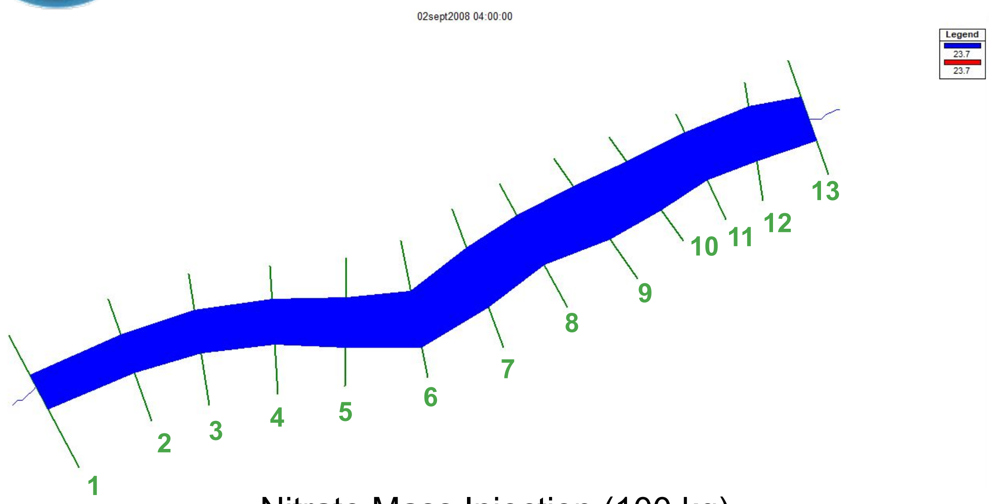
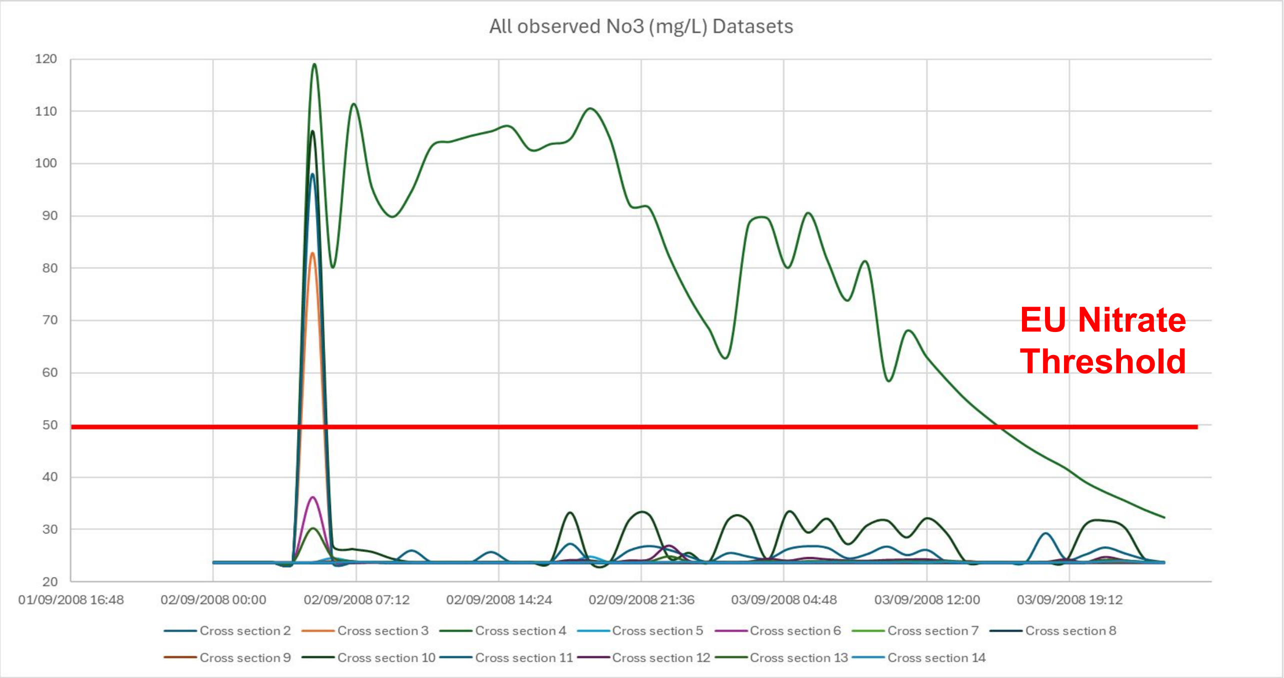
Mass Injection Event to Simulate Accidental Spills



Nitrate Mass Injection (100 kg)



C > 50 mg/L	Initial limit breach	Final drop below limit
	02:58:30	04:56:00
	duration above 50	01:57:30

Pollution Timing

	Distance	Distance between each cross section (m)	Time (s)	Velocity (m/s)
Cross section 1	591.6	65.2272	0	0
Cross section 2	526.4	48.4632	0	0
Cross section 3	477.9	53.9496	0	0
Cross section 4	424.0	49.0728	30	1.64
Cross section 5	374.9	49.0728	150	0.33
Cross section 6	325.8	50.292	150	0.34
Cross section 7	275.5	42.0624	140	0.30
Cross section 8	233.5	46.9392	130	0.36
Cross section 9	186.5	41.4528	120	0.35
Cross section 10	145.1	39.624	120	0.33
Cross section 11	105.5	41.4528	120	0.35
Cross section 12	64.0	42.672	130	0.33
Cross section 13	21.3	21.336	130	0.16
Cross section 14	0.0	70	150	0.47

Transport through cross-sections

Sediment Transport

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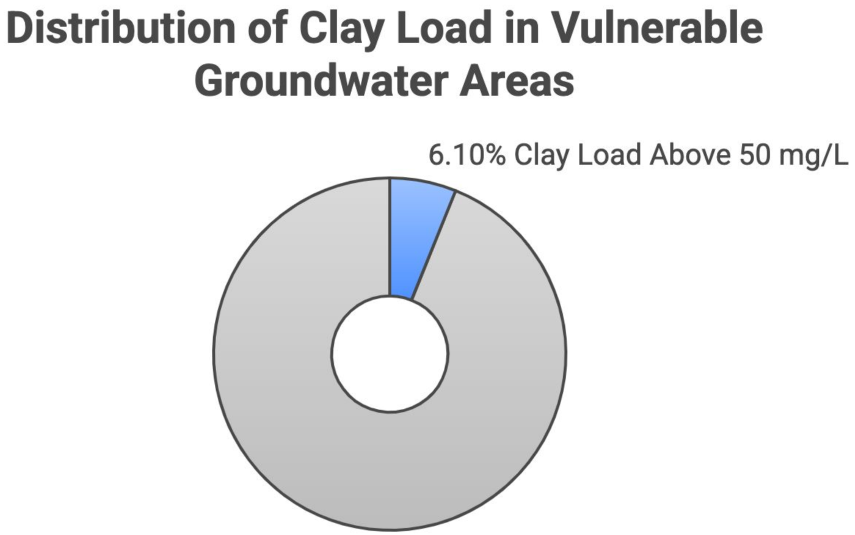
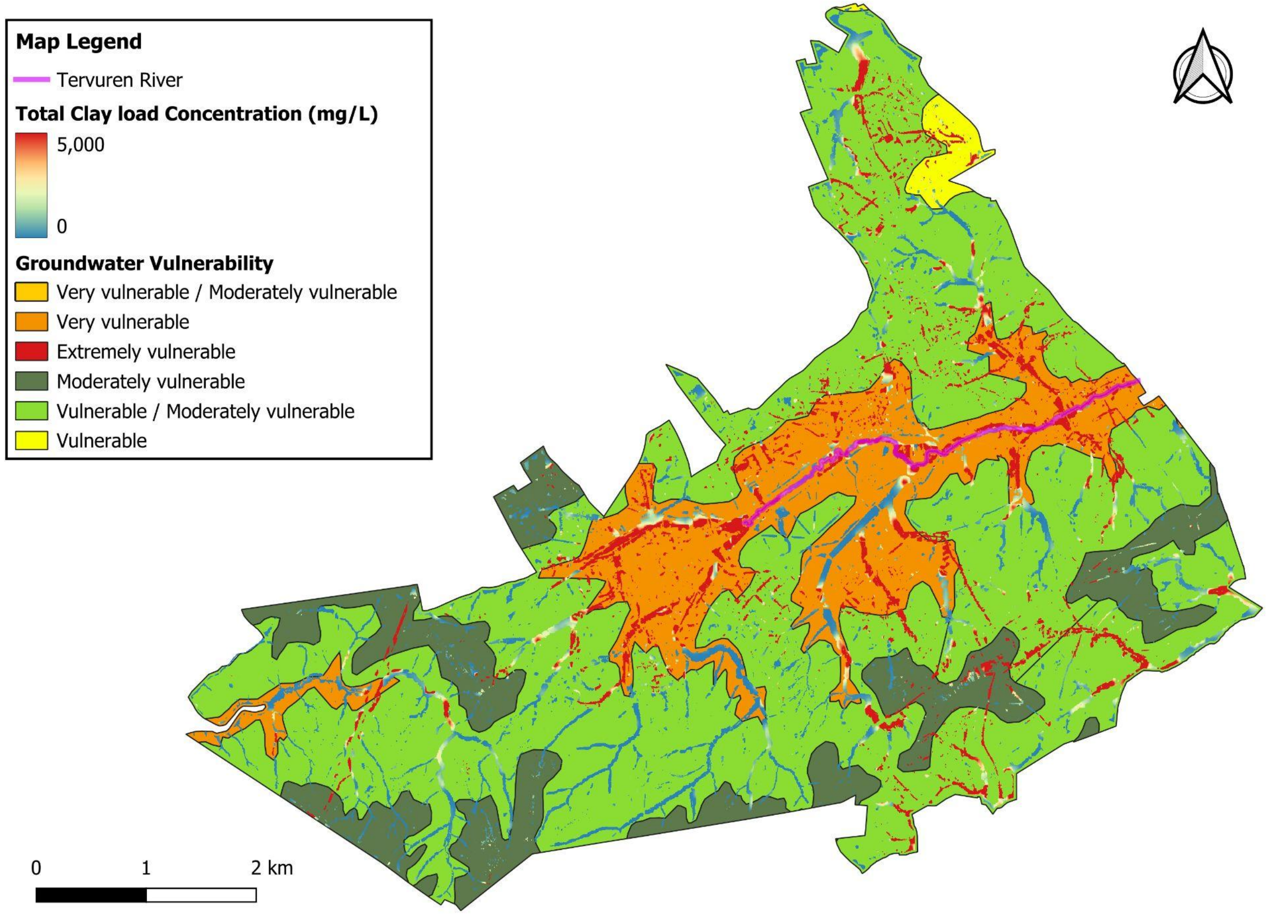
Results and Analysis





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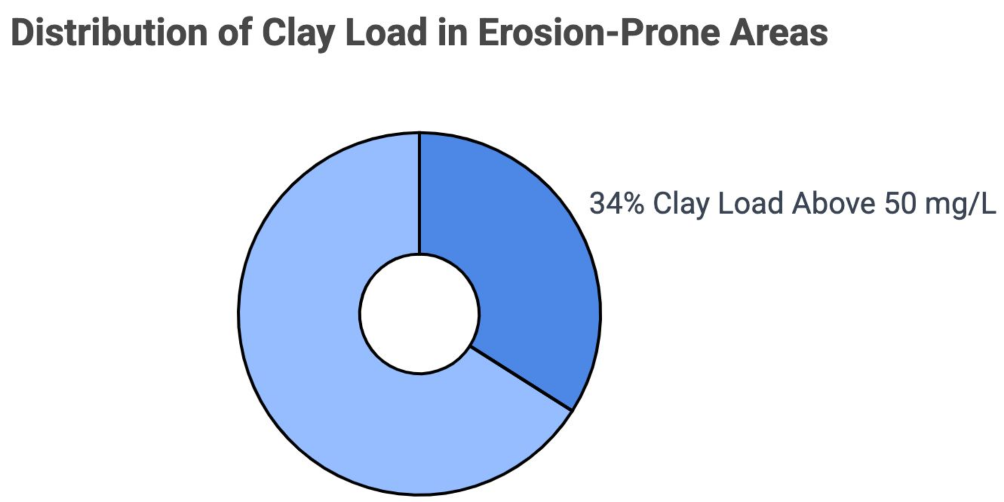

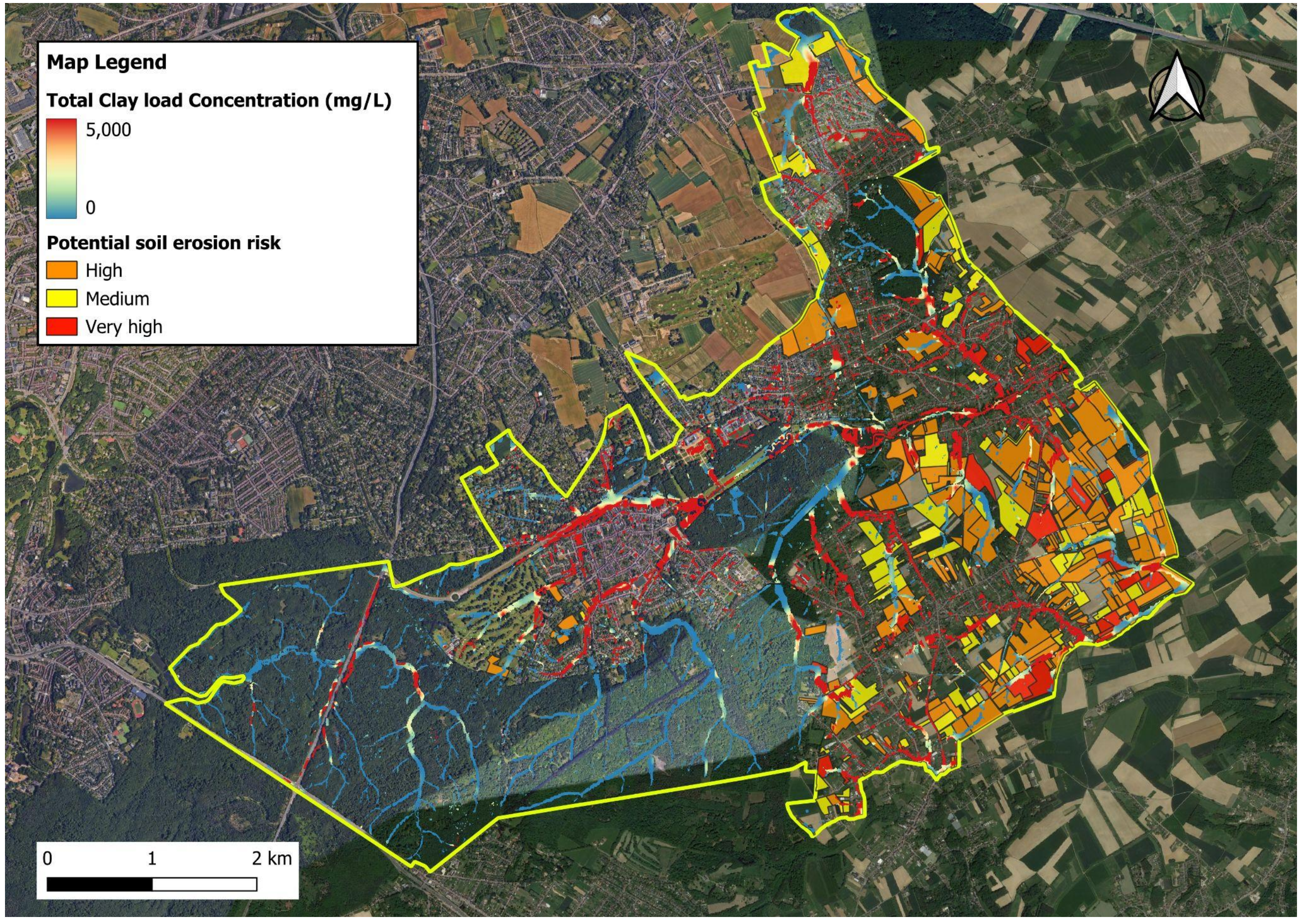

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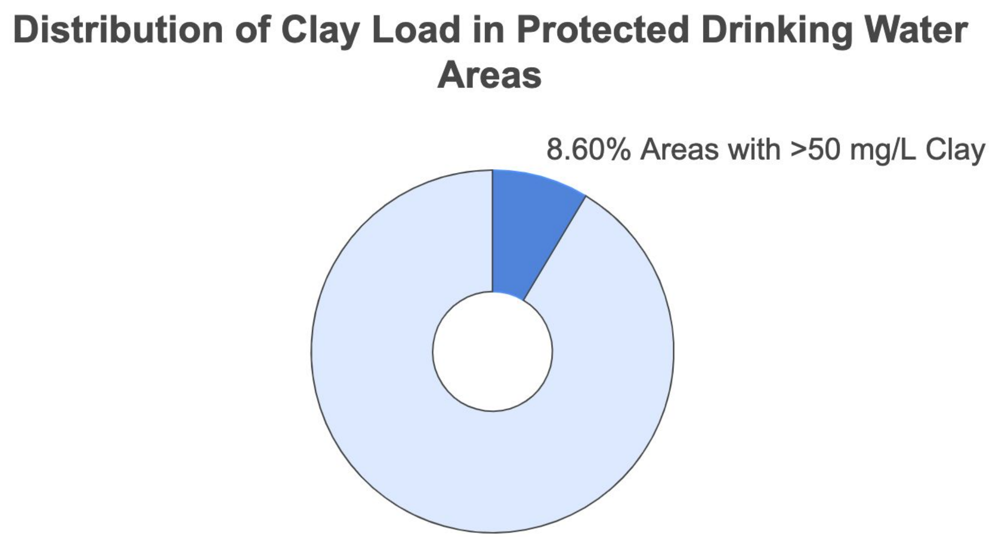
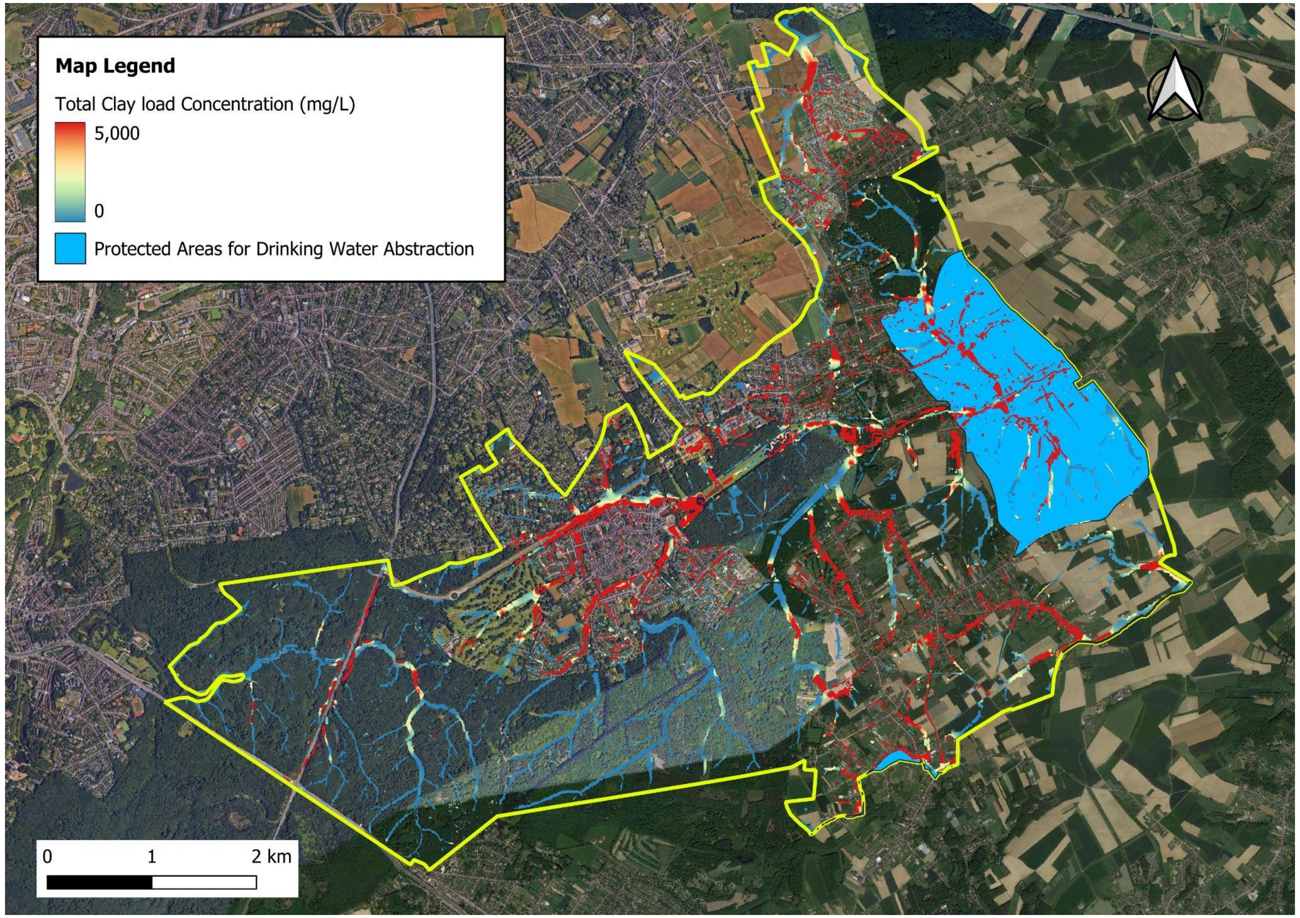




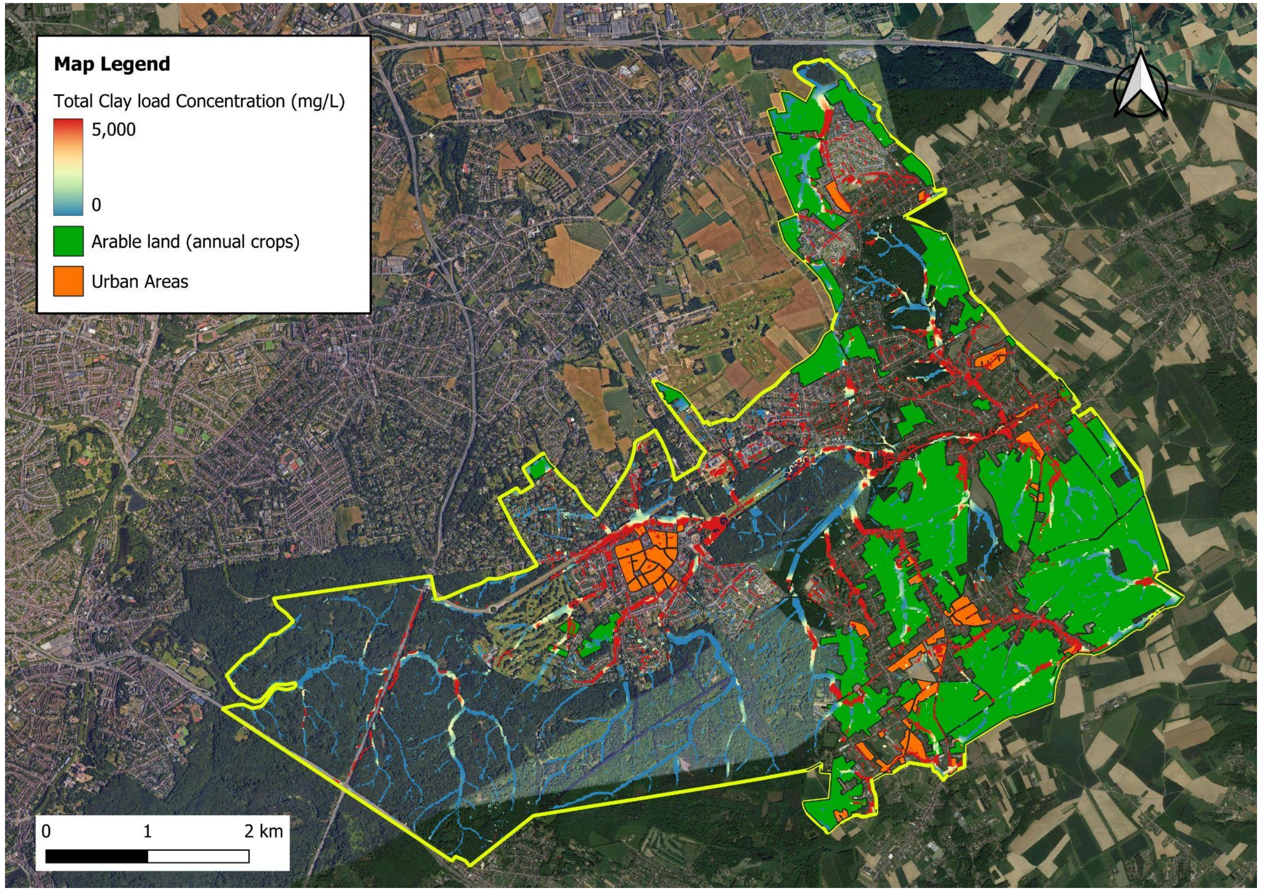
Analysis

- Urban areas prevent rainwater to infiltrate, carrying
  sediment into the river

- Water drains quickly channel rainwater into river from roads and disturbed land

- Construction can expose areas of bare soil which erodes and its washed into the river

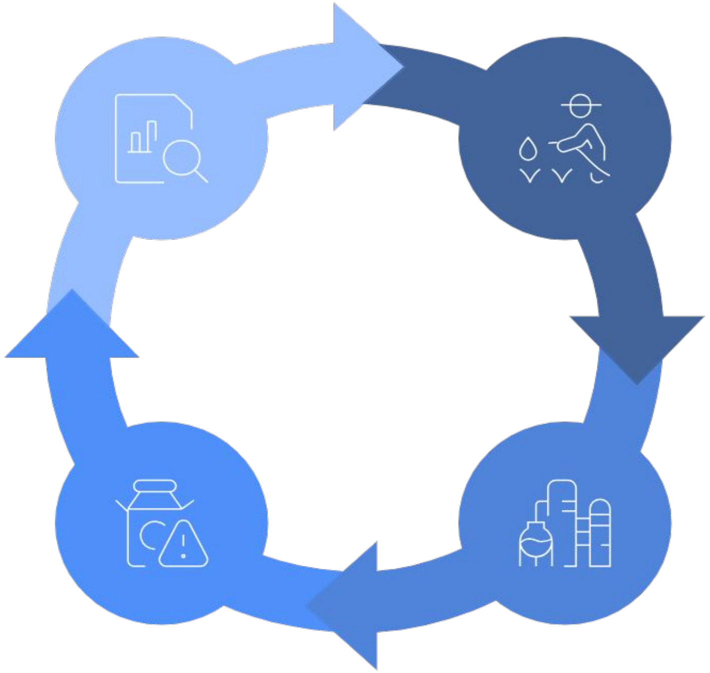
- Agricultural areas, have pervious soil that allows to infiltrate, reducing direct sediment transport
- Sediment settle before reaching waterways
- Vegetation cover (grass, crops) reduces sediment loss during rain events



Recommendations

Conduct Monitoring and Research
Conducting ongoing water quality testing and assessments to track effectiveness of measures.

Implement Sustainable Farming Practice
Implementing eco-friendly agricultural methods to reduce nitrate runoff, such as precision fertilisation, cover crops and buffer zones



Ensure Regulatory Compliance
Ensuring adherence to legislation and standards to control pollution, such as The EU Nitrates Directive

Apply Advanced Water Treatment
Utilizing technologies such as biological nitrogen removal and reverse osmosis to purify water and remove nitrates

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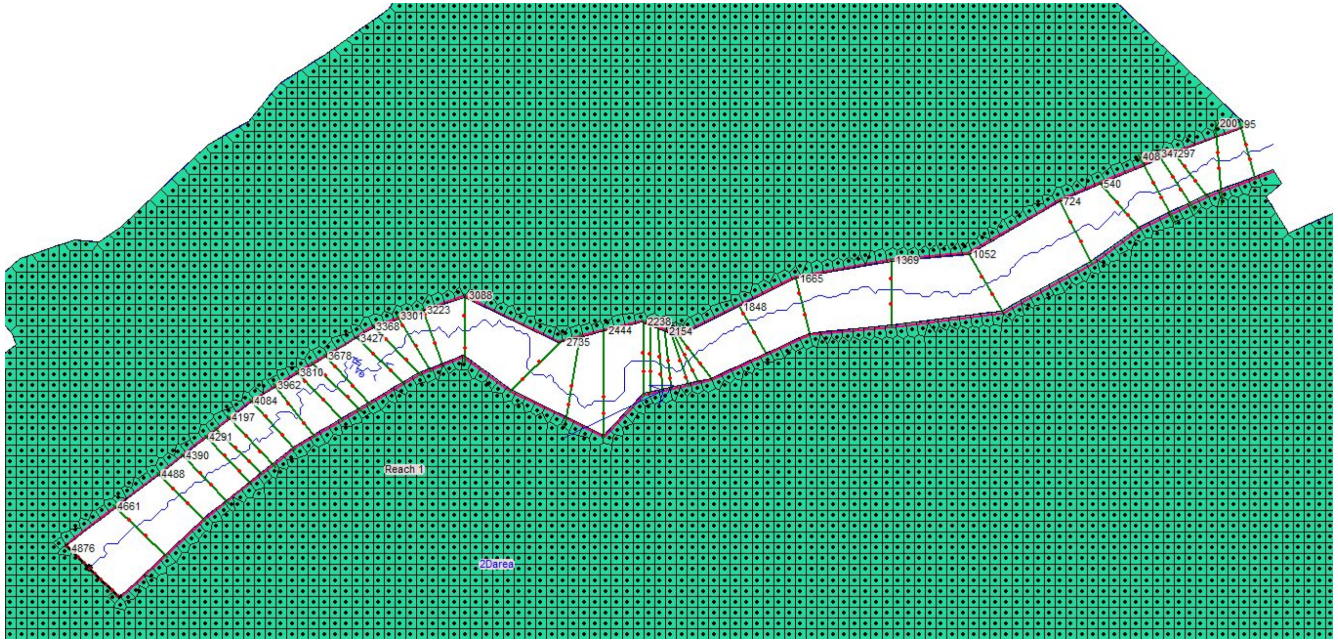
Challenges

1D/2D model coupling, rainfall



Issues encountered :

- Digital instability preventing model convergence.
- Excessive extrapolation between cross sections.
- Interpolation errors in steep slope areas.
- 1D/2D connection issues affecting water transfer.

Solutions implemented :

- Variable time step to improve solver stability.
- Added many cross-sections to limit interpolation errors.
- Adjustment of the 2D mesh for better flow accuracy.
- Fixed 1D/2D connections to ensure proper stream exchange.

Results :

- Simulation stable and functional but problem with Water Quality Analysis module.
- Version incompatibility between HEC-RAS and the Water Quality Analysis module.
- Lack of time to resolve issues and test an alternative solution.

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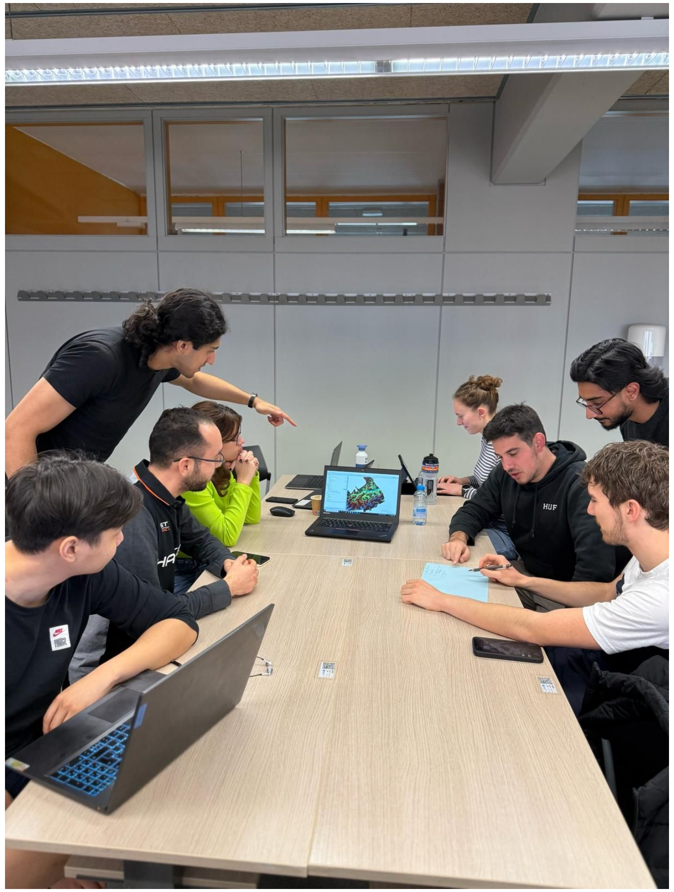
End

Thank you!

Questions?

Delicious sandwiches!!!



Hardwork!!!!!

L to R: Pierre Chen, Ahmad Mahdi, Maziar Fekri, Sofia Zoumi, Ella Nichols, Theo Bertrand, Ali Hassan, Tiberio Potenza

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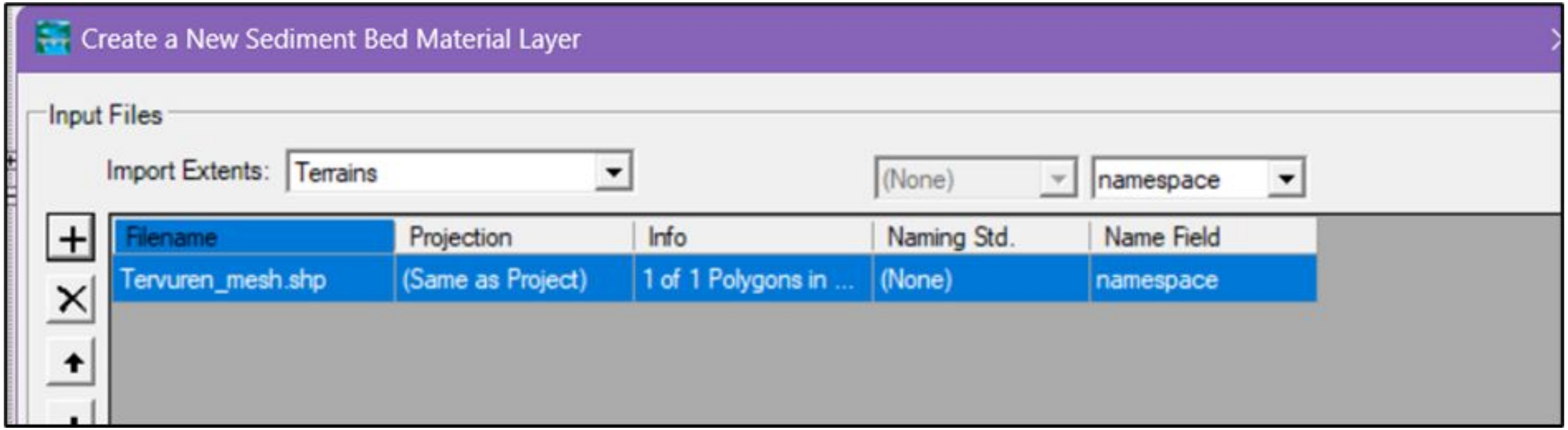
Annex

Clay-Nitrate Adsorption Ratio =	0.001	(mgNO3/mg clay)
Initial Concerntration (average)=	23.7	mgNO3/L
Time	Clay (mg/L)	Total Nitrate Load (mgNO3/L)
02Sep2008 00:00	0	23.7
02Sep2008 00:30	0	23.7
02Sep2008 01:00	0	23.7
02Sep2008 01:30	0	23.7
02Sep2008 02:00	0	23.7
02Sep2008 02:30	0	23.7
02Sep2008 03:00	0	23.7
02Sep2008 03:30	0	23.7
02Sep2008 04:00	0	23.7
02Sep2008 04:30	0	23.7
02Sep2008 05:00	0	23.7
02Sep2008 05:30	0	23.7
02Sep2008 06:00	0	23.7
02Sep2008 06:30	0	23.7
02Sep2008 07:00	0	23.7
02Sep2008 07:30	0	23.7
02Sep2008 08:00	0	23.7
02Sep2008 08:30	0	23.7
02Sep2008 09:00	0	23.7

> ... 4084 3368 3088 2735 2444 2238 2051 1665 1369 1052 724 5

Annex



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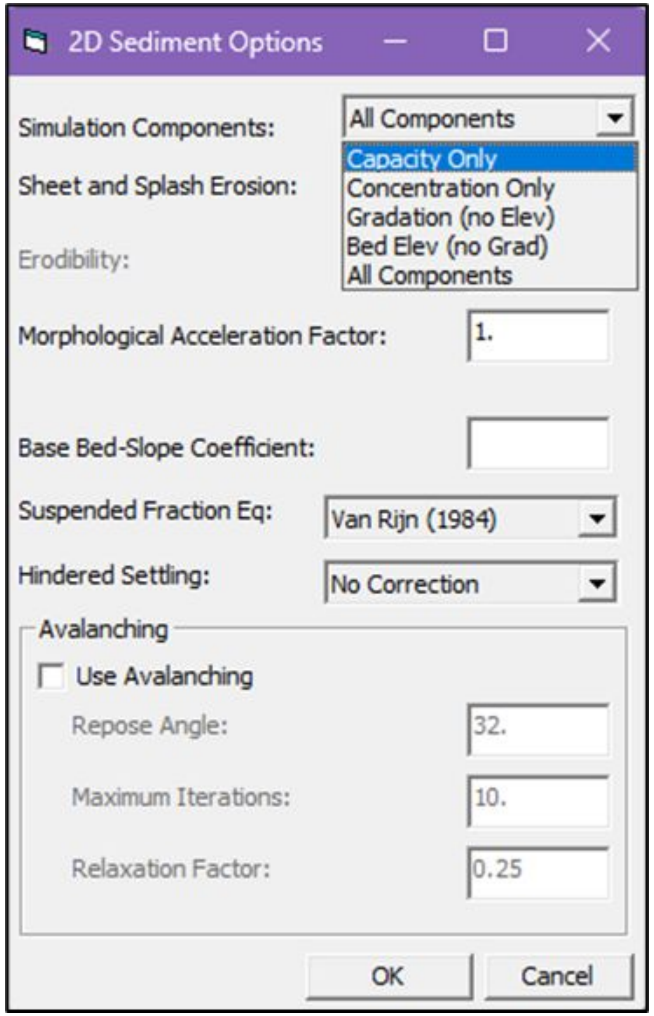
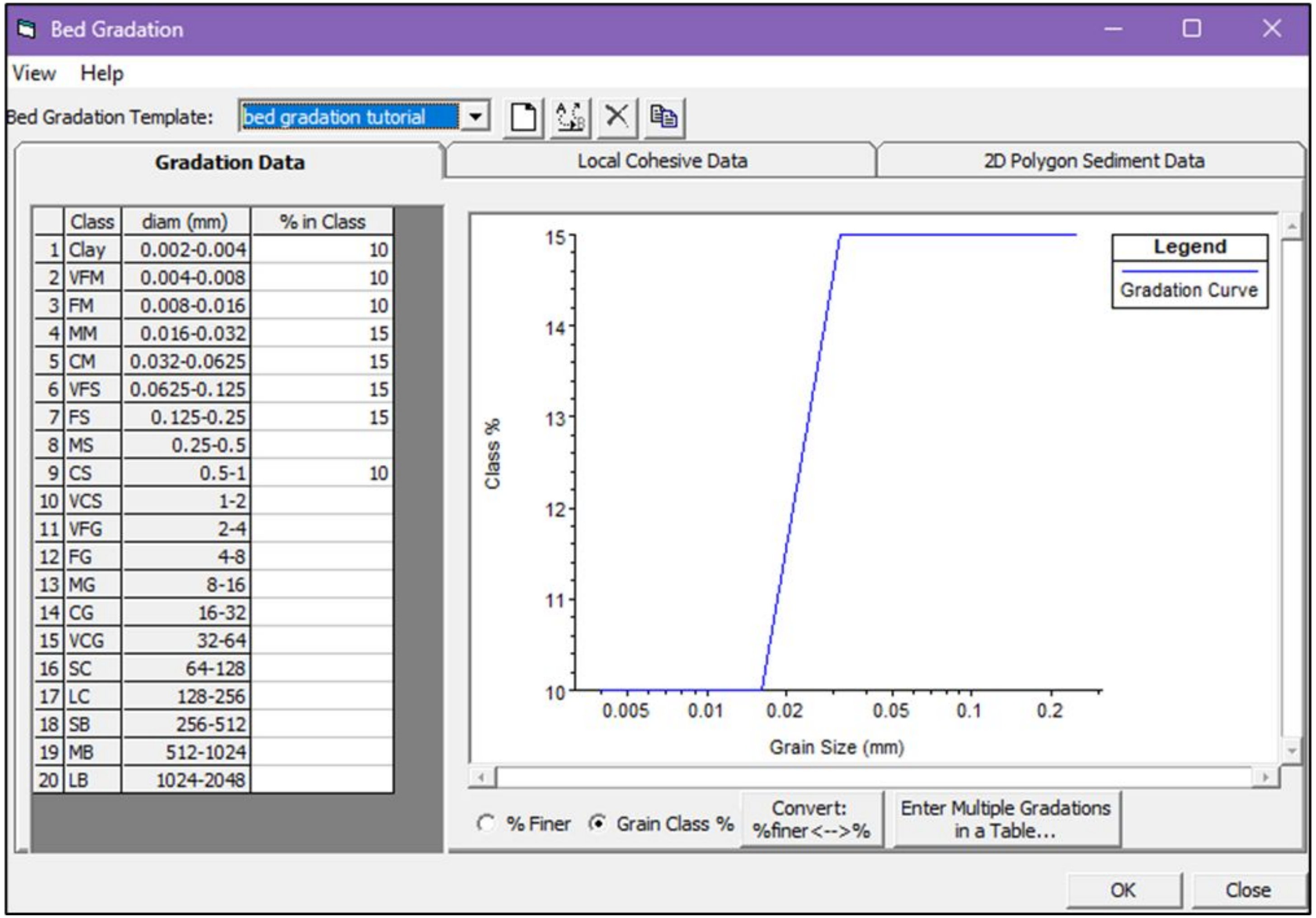
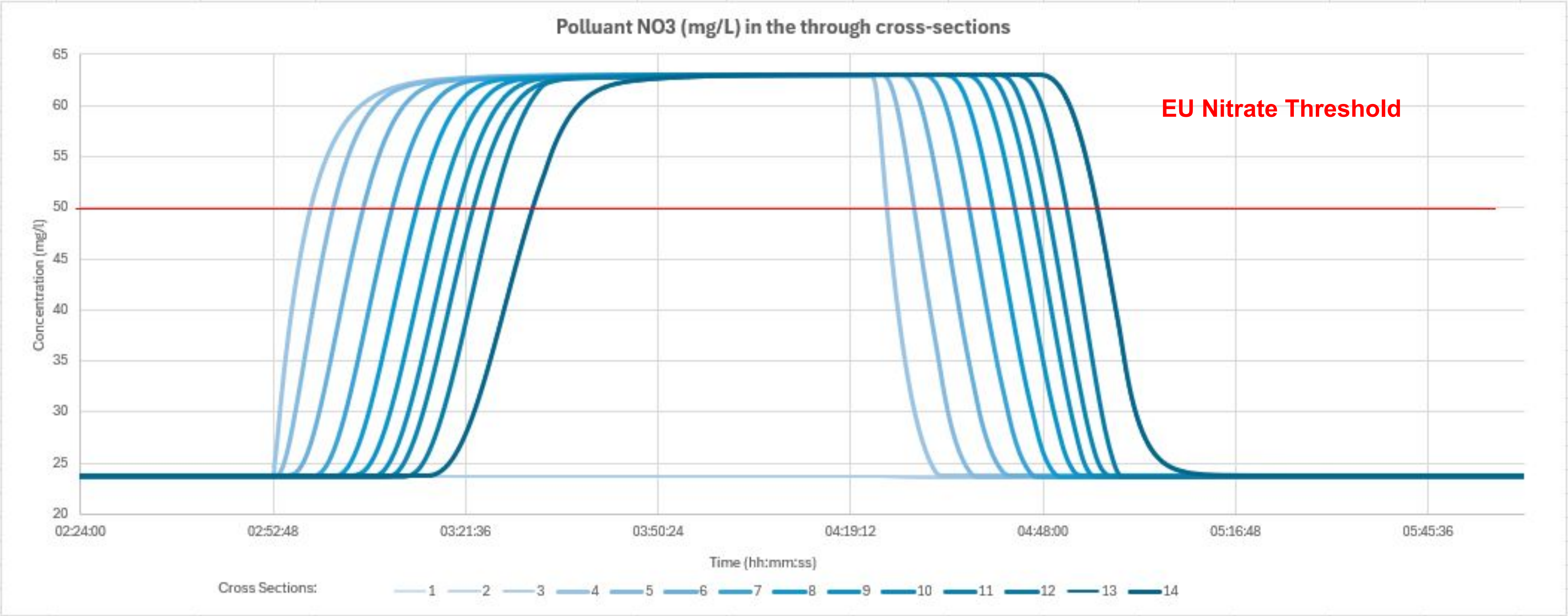


2D Sediment Options
Simulation Components:
All Components
Capacity Only
Concentration Only
Gradation (no Elev)
Bed Elev (no Grad)
All Components
Sheet and Splash Erosion:
Erodibility:
Morphological Acceleration Factor:
1.
Base Bed-Slope Coefficient:
Suspended Fraction Eq:
Van Rijn (1984)
Hindered Settling:
No Correction
Avalanching
Use Avalanching
Repose Angle:
32.
Maximum Iterations:
10.
Relaxation Factor:
0.25
OK
Cancel



Bed Gradation
View
Help
Bed Gradation Template:
bed gradation tutorial
Gradation Data
Local Cohesive Data
2D Polygon Sediment Data
Class
diam (mm)
% in Class
1 Clay 0.002-0.004 10
2 VFM 0.004-0.008 10
3 FM 0.008-0.016 10
4 MM 0.016-0.032 15
5 CM 0.032-0.0625 15
6 VFS 0.0625-0.125 15
7 FS 0.125-0.25 15
8 MS 0.25-0.5
9 CS 0.5-1 10
10 VCS 1-2
11 VFG 2-4
12 FG 4-8
13 MG 8-16
14 CG 16-32
15 VCG 32-64
16 SC 64-128
17 LC 128-256
18 SB 256-512
19 MB 512-1024
20 LB 1024-2048
Legend
Gradation Curve
Class %
15
14
13
12
11
10
0.005
0.01
0.02
0.05
0.1
0.2
Grain Size (mm)
% Finer
Grain Class %
Convert: %finer<-->%
Enter Multiple Gradations in a Table...
OK
Close

Annex



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Challenges

Version Compatibility Problems

Difficulties in integrating different software versions - some allowed models to run and some could not

Software Bugs

Issues within the software that disrupted the modeling process

Time Investment

The significant effort required to address these challenges

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