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ASSESSING THE FLOODING HAZARD THROUGH A PROBABILISTIC APPROACH INCLUDING EARTHEN LEVEES VULNERABILITY ESTIMATE

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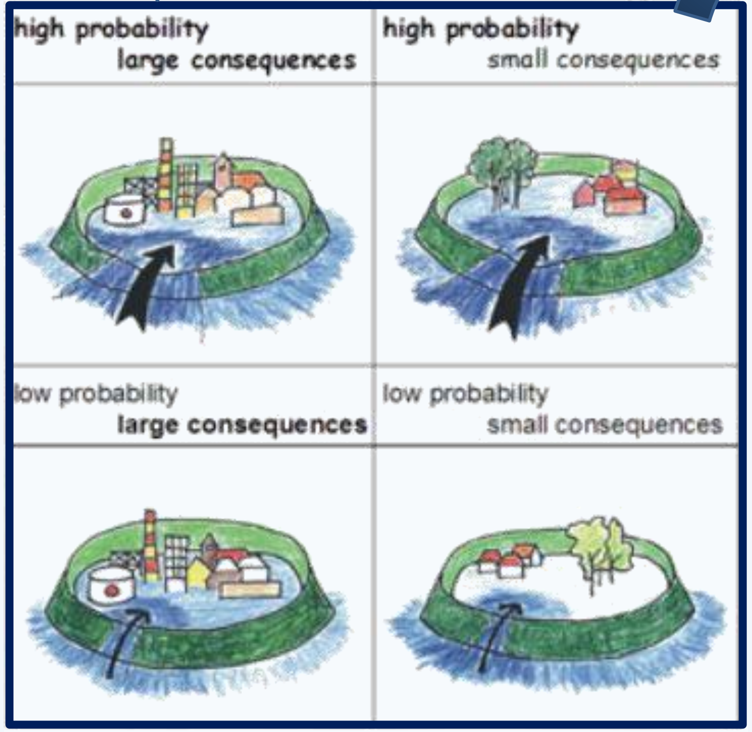
Introduction

In the last 30 years, more than 2500 floods occurred in Europe, causing financial losses and, mostly, ***life losses***.



Source: Rijkswaterstaat, The Netherlands

The Floods Directive, issued by the European Parliament in 2009, invited the EU Member States to minimize the flood risk, improving methods and solutions for large-scale application.

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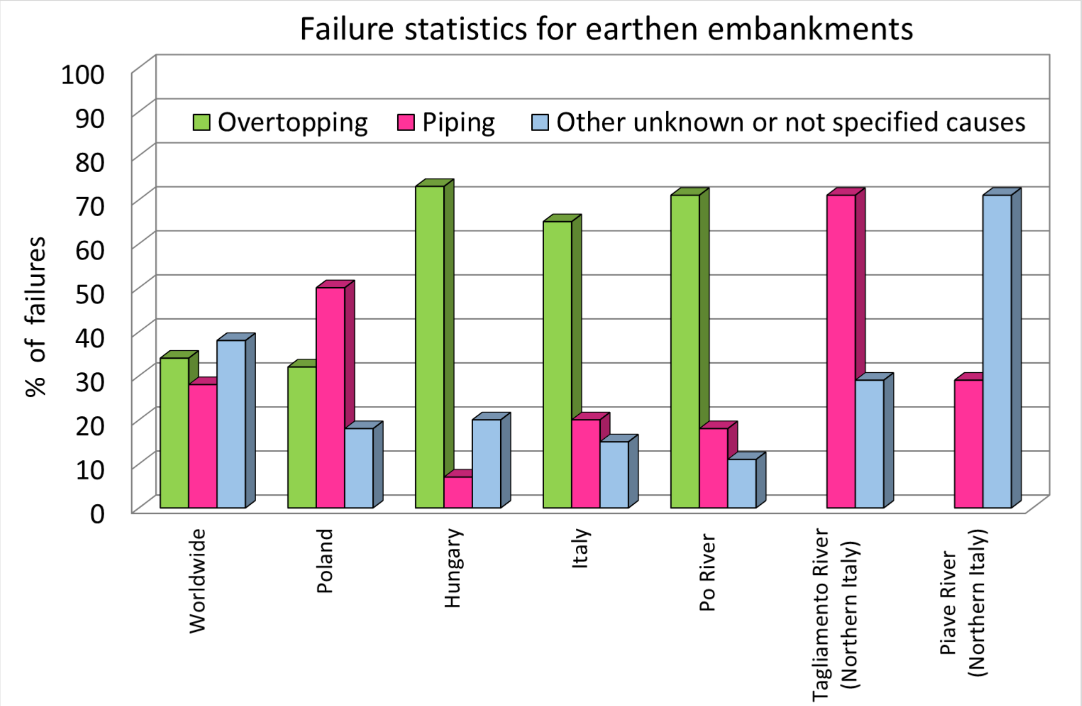
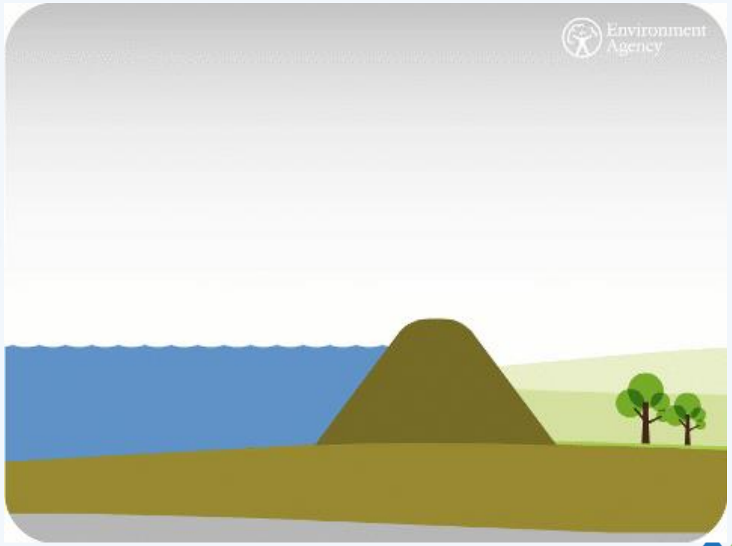
Introduction

River embankments are one of the most important measures for flood protection.

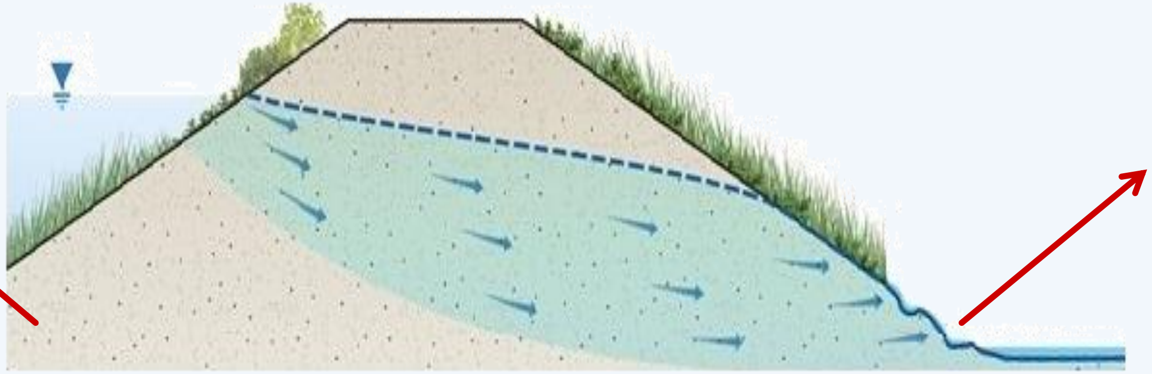


Seepage process



Purpose

Simplified and expeditious approach developed by *Barbetta et al., 2017*



Geotechnical finite element model **SEEP/W**, developed by GEOSTUDIO

Objectives:

- Evaluate the residual flood risk through the analysis of earthen levees' seepage vulnerability;
- Use the simplified procedure, easy to apply, for emergency situations.

Methodology

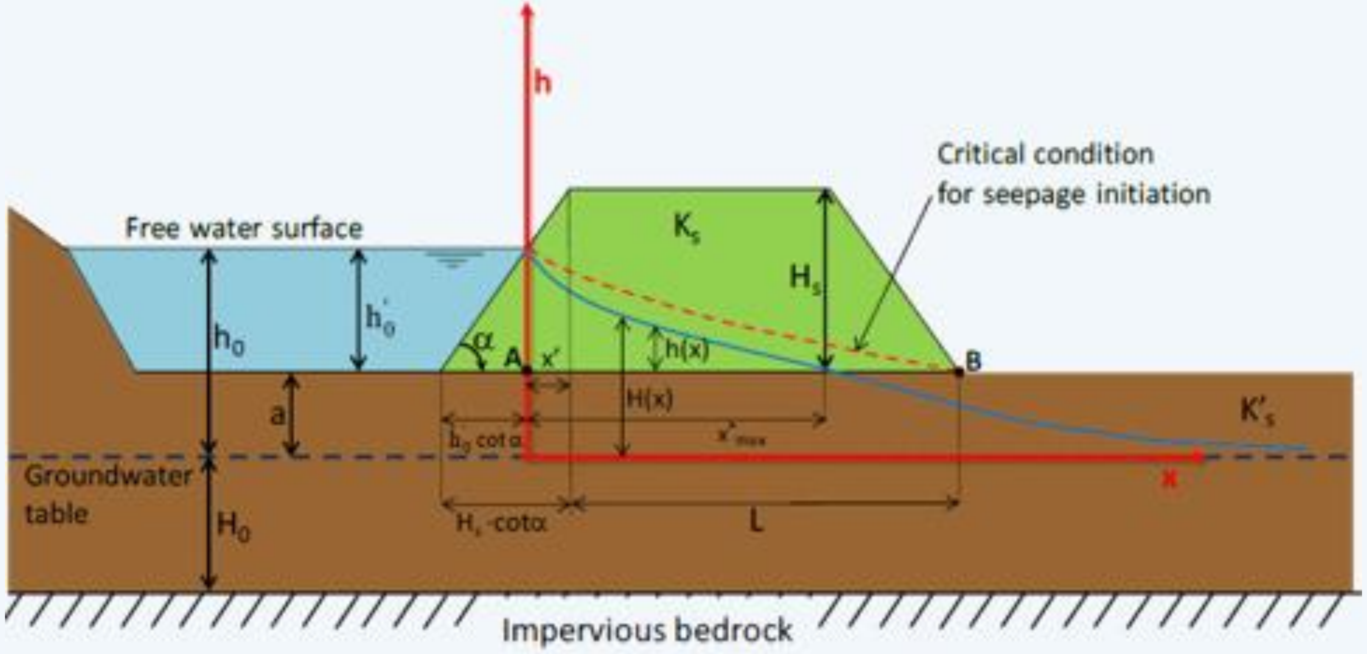
Seepage process assessment - Simplified procedure (Barbetta et al., 2017)

Marchi's equation →

$$H(x) = (h'_0)\left[1 - erf\left(\frac{x}{2}\sqrt{\frac{\xi}{K_S H_0 D}}\right)\right]$$

→ x_{max}

- $x_{max} < L + x'$ No vulnerable
- $x_{max} > L + x'$ **Vulnerable**



h'_0 is the hydraulic head in the river;
H_0 is the groundwater depth;
D is the duration of the flood event;
ξ is the soil porosity;
K_S is the hydraulic conductivity.

Methodology

GeoStudio 2023.1.2

Seepage process assessment – Geotechnical finite element model SEEP/W

SEEP/W, part of GeoStudio software, is a finite element model capable to resolve the simple saturated steady state problems and also saturated/unsaturated time dependent problems.

The principal quality of the software is due to its ability to allow seepage analysis as a function of time.

Input data

- Geometric characteristics of the levee (Length; height; slope);
- Geotechnical parameters of the soil (volumetric water content Θ; volumetric compressibility m_v; hydraulic conductivity K);

\+ Meshing process + Boundary conditions

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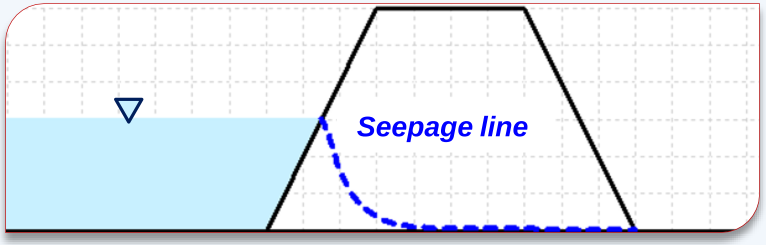

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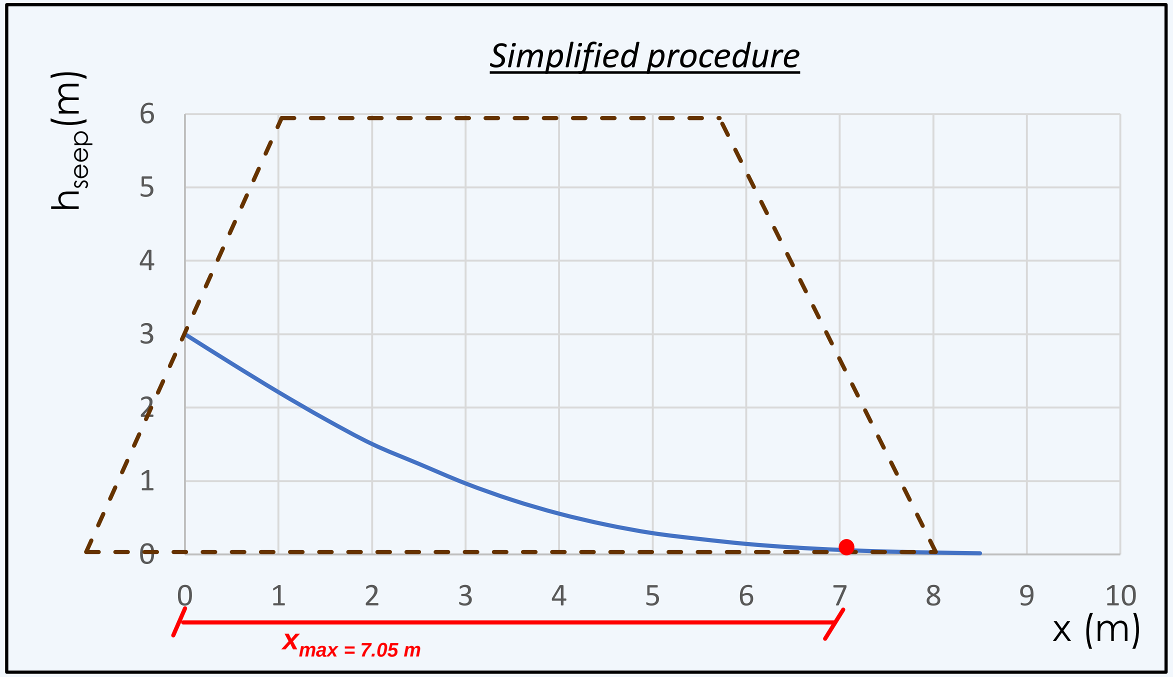
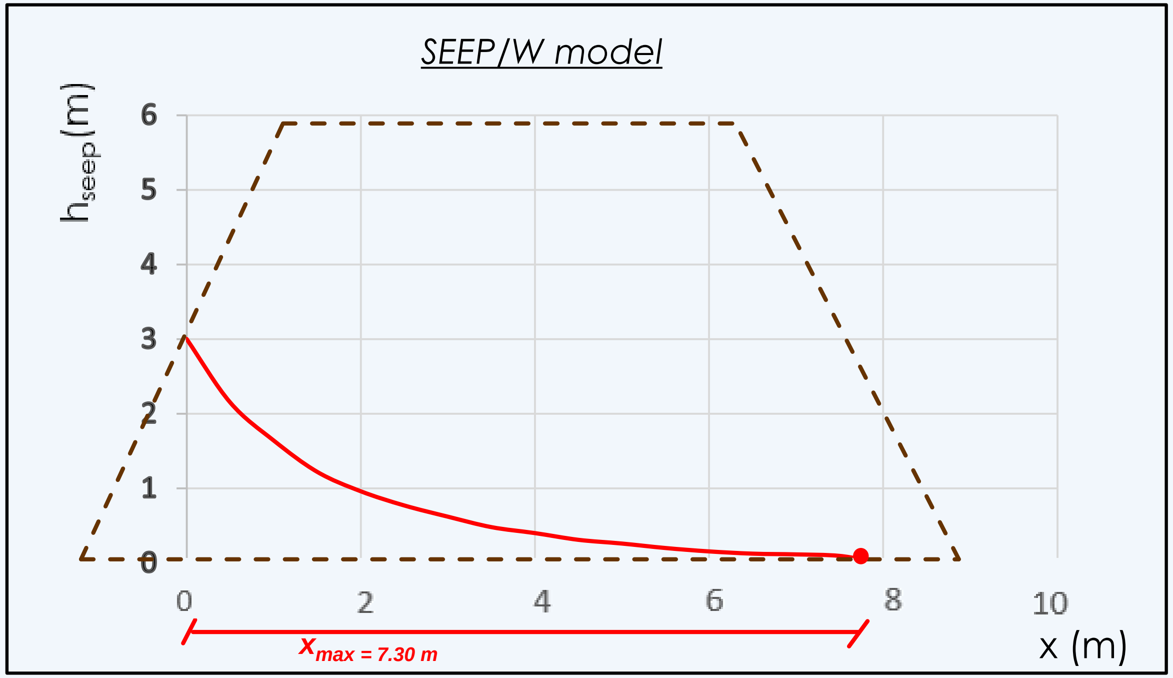
Results





h'_0, the hydraulic head in the river = 3 (m)
D, is the duration of the flood event = 48h;
K_S,the hydraulic conductivity = $1.4*10^{-7}$ m/s

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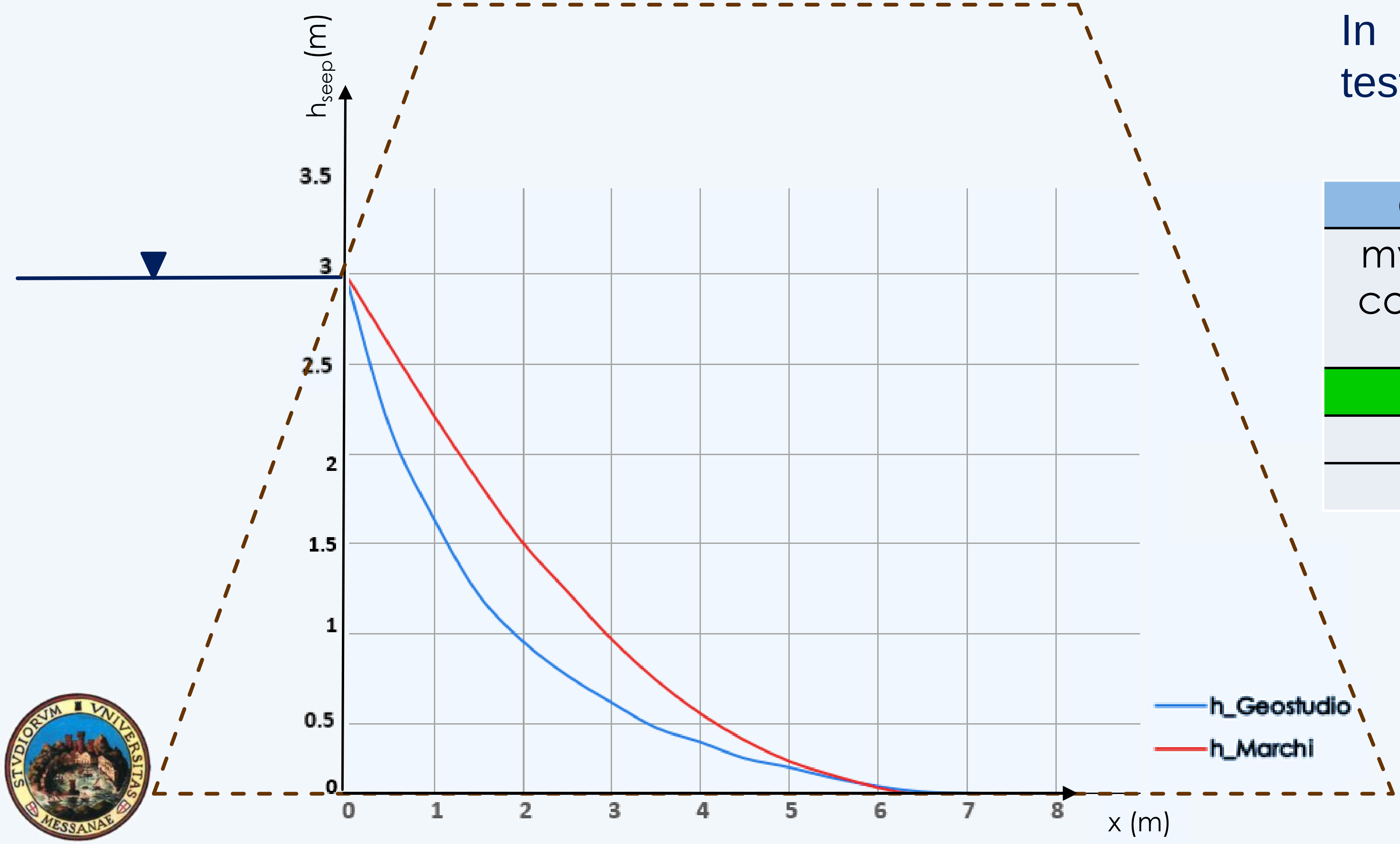
m_v, volumetric compressibility = $1*10^{-8}$ kPa-1

Results

Comparison between saturation lines evaluated by simplified procedure and finit element model SEEP/W



In order to maximize the performances, we tested 3 values of m_v

Critical Hydraulic Conductivity K = $1.4*10^{-7}$		
mv (volumetric compressibility) (kPa-1)	RMSE (m)	Difference in x_{max} (m)
$1*10^{-8}$	**0.30**	**0.30**
$1*10^{-6}$	0.38	1
$1*10^{-5}$	0.49	2

Conclusions And Future Development

After assessing the simplified procedure and the finite element model SEEP/W for the seepage process, we understood that:

1) SEEP/W and the simplified method have similar capacity in estimating the seepage lines, even if the first requires an initial knowledge of the geotechnical parameters that is sometimes too expensive to measure (i.e through experimental analises);
2) Discrepancies may appear in case of specifical geotechnical conditions;
3) A potential practical procedure consist in applying the simplified procedure at large scale to evaluate many kilometers of river embankments with the aim to find, quickly, the seepage vulnerability, while geotechical model could be applied only for the earthen levees with an high vulnerability;

Future Development

- Use the two models for an experimental levee, e.g. we have an experimental site in Umbria region (Italy) for the measurement of geotechincal parameteres;
- For flood risk management, once the two procedures have been verified, the residual flood risk combined with the vulnerability of the seepage could be assessed.

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Thank you for your attention

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