

Curso de treinamento do PAE

Módulos 2 e 3

Modelagem da Cheia de Ruptura Vale a Jusante



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LABORATÓRIO NACIONAL
DE ENGENHARIA CIVIL



COBA, S.A.
COBA, LTDA.



GRUPO BANCO MUNDIAL

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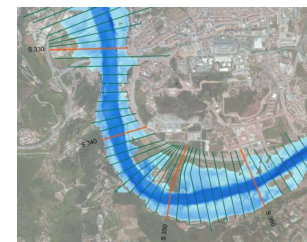
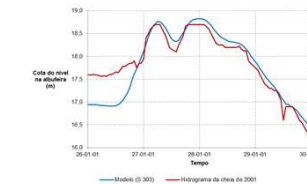
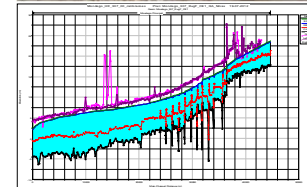
1. Introdução

2. HEC-RAS

3. HEC-GeoRAS no ArcGIS

4. Modelação da Cheia

5. Mapas de Inundação



INTRODUÇÃO



Barragem dos Hospitais, Portugal



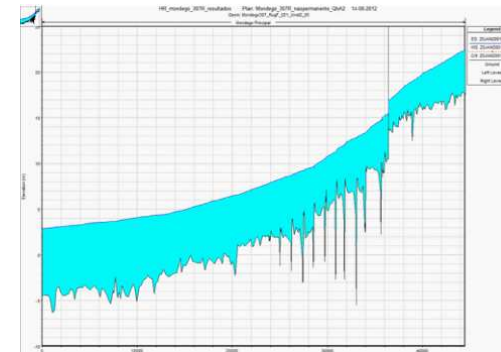
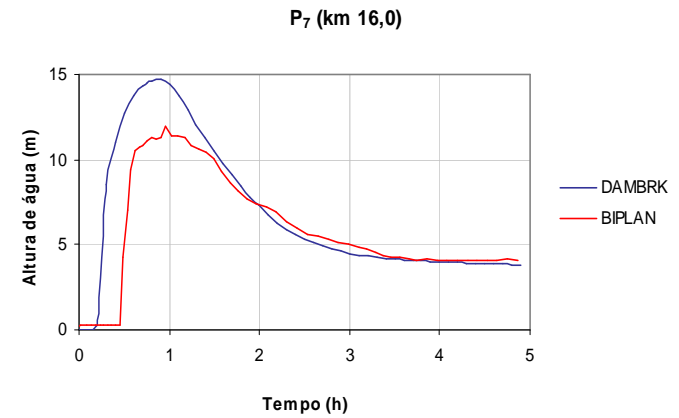
enclavado.blogspot.pt

INTRODUÇÃO - Objectivos

1. Hidrograma de ruptura

2. Propagação da cheia

3. Zona inundada



Modelo HECRAS



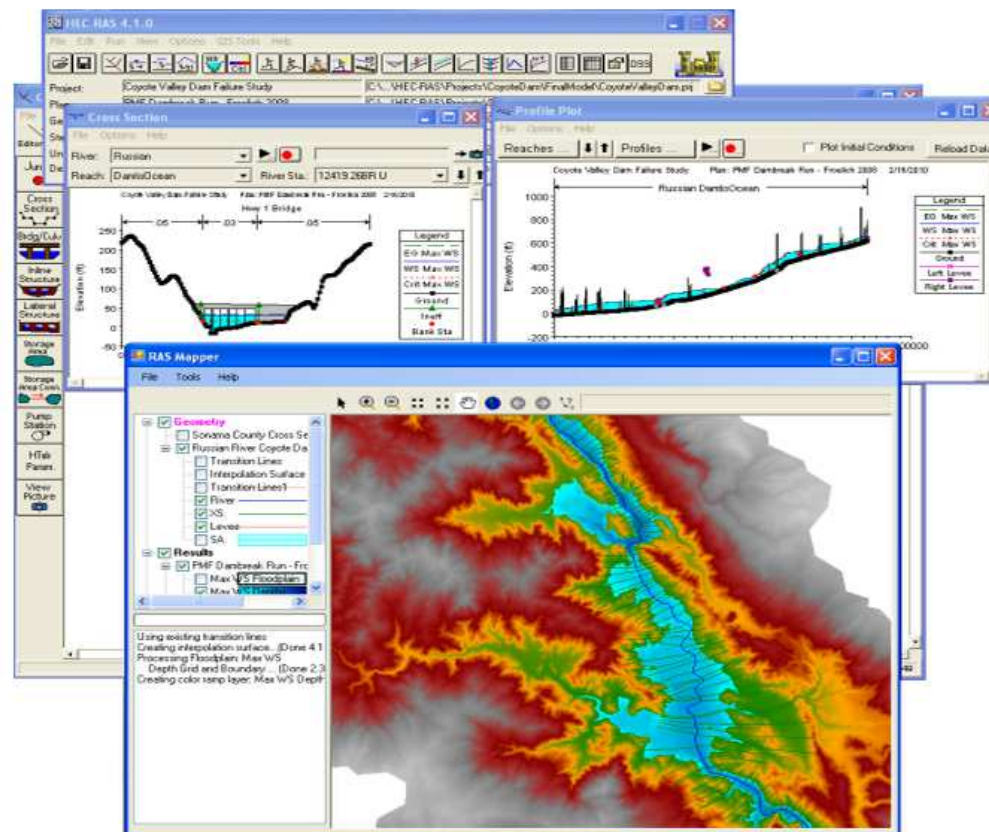
Hydrologic Engineering Center

US Army Corps of Engineers

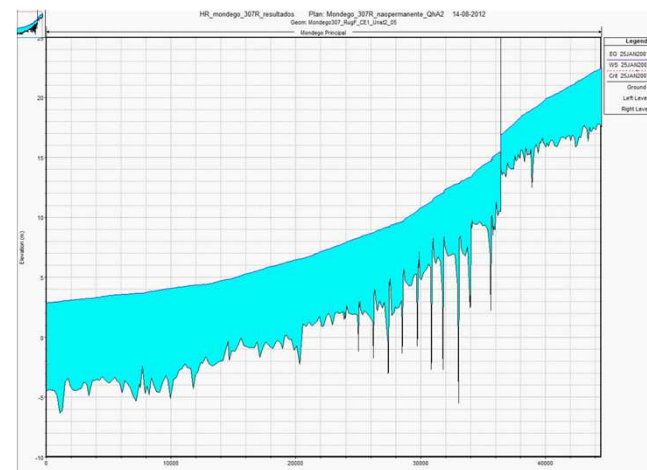
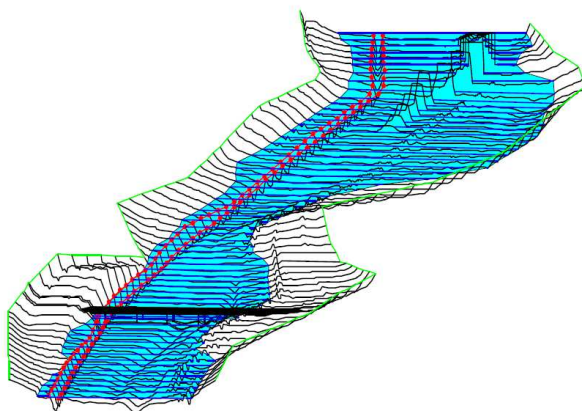
ABOUT NEWSLETTERS SOFTWARE PUBLICATIONS TRAINING VISITORS LINKS CONTACT

HOME > SOFTWARE > HEC-RAS

- HEC-RAS
- HEC-RAS
- Features
- What's New
- Downloads
- Documentation
- Known Issues
- Bug Report
- Suggestions
- Demo
- Sponsors
- Collaborators
- Support Policy



Modelo HECRAS - Funcionalidades



- calcula a curva de regolfo de escoamentos unidimensionais em rios
- regime permanente, lentos ou rápidos, e regime variável
- transporte sedimentar em fundo móvel
- análise de qualidade da água.
- rede de canais - natural ou regularizada
- considera pontes, coletores, diques, confinamentos longitudinais, descarregadores e açudes
- representação gráfica

Modelo HECRAS - características

- **Modelo uni-dimensional – 1D**
 - Domínio de cálculo são as secções
 - Sem escoamento transversal
- **Vantagens:**
 - Modelo bem conhecido;
 - Rápido;
 - Fácil utilização;
 - Grande estabilidade no cálculo;
- **Desvantagens:**
 - Escoamento unidirecional;
 - Não há manutenção do escoamento numa parte da secção;

Modelo HECRAS – equações base

- **Utiliza as equações da continuidade e dos momentos.**

$$\frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} = 0 \qquad \frac{\partial Q}{\partial t} + \frac{\partial(\alpha Q^2/A)}{\partial x} + gA\left(\frac{\partial h}{\partial x} - S_o + S_f\right) = 0$$

- **As perdas de energia são calculadas:**

- fricção - Manning Equation
- Coeficiente para contracções/alargamentos

$$h_e = \underbrace{L\bar{S}_f}_{\text{circled}} + C \left| \frac{\alpha_1 V_1^2}{2g} - \frac{\alpha_2 V_2^2}{2g} \right|$$

- **Equação dos momentos:**

- Ressalto hidráulico, hidráulica de pontes, junção de afluentes

Modelo HECRAS – GUI

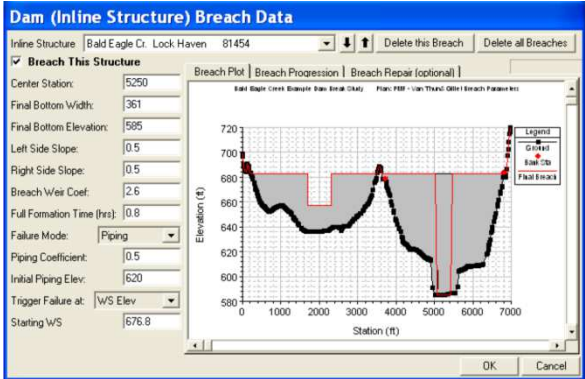
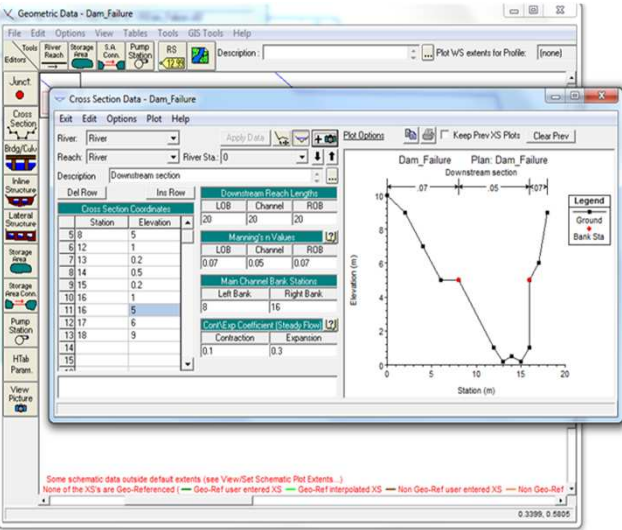
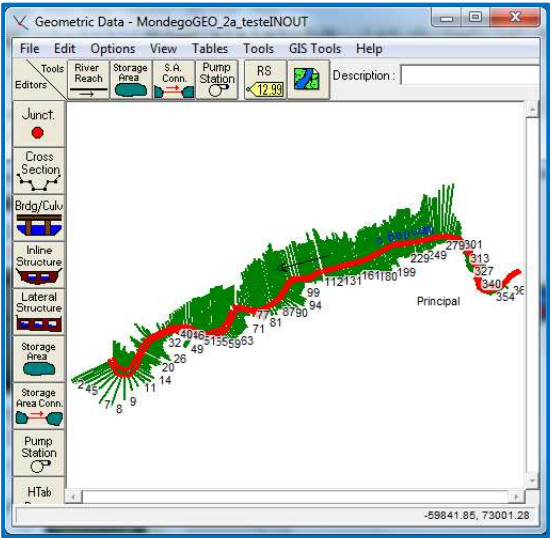
HEC-RAS 4.1.0

File Edit Run View Options GIS Tools Help

Project: Dam_Failure
 Plan: Dam_Failure
 Geometry: Dam_Failure
 Steady Flow:
 Unsteady Flow: Dam_Failure
 Description:

SI Units

Open and save
 Geometric data
 Steady flow data
 Unsteady flow data
 Sediment data
 Water quality data
 Simulations
 Results (plots, tables, data, errors ...)



Modelo HECRAS – mais informação

<http://www.hec.usace.army.mil/software/hecras/documentation.aspx>



HOME > SOFTWARE > HEC-RAS > DOCUMENTATION

HEC-RAS
HEC-RAS
Features
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The documentation for HEC-RAS consists of a User's Manual which describes how to use the interface; a Hydraulic Reference Manual which describes the data required, equations used, solution techniques, and modeling advice; and an Applications Guide which contains seventeen example applications of using various aspects of HEC-RAS. All three documents are in PDF format and can be viewed online or downloaded. To view online or download individual chapters, go to the manual's individual page with the links below.

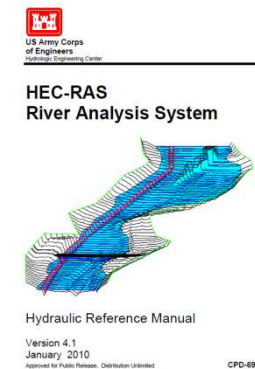
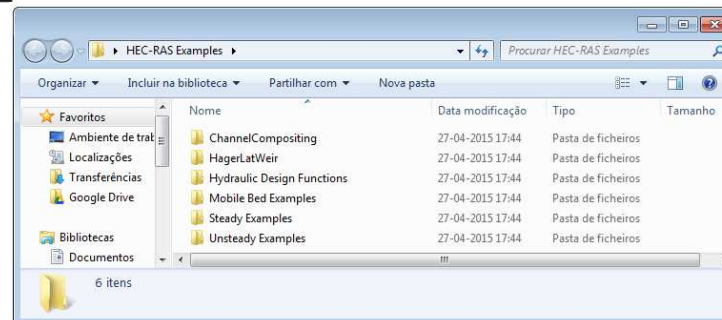
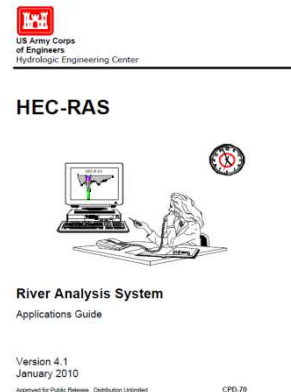
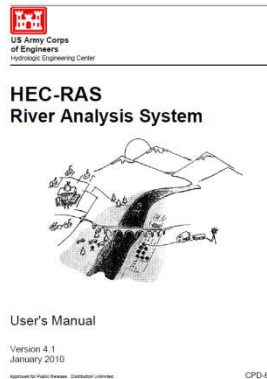
The HEC-RAS documentation is automatically installed during the setup of the program and can be accessed through the Help menu. To view the documentation without installing the program, you may use the links below.

- HEC-RAS 4.1, User's Manual
- HEC-RAS 4.1, Applications Guide
- HEC-RAS 4.1, Hydraulic Reference Manual

See the What's New page for the current release notes listing the bug fixes for this and previous releases. The What's New page also summarizes the current version's features.

In addition to the above Manuals and Guides the following documents may also be of interest:

- RD-41, A Comparison of the One-Dimensional Bridge Hydraulic Routines from HEC-RAS, HEC-2, and WSPRO, Sep 1995
- RD-42, Flow Transitions in Bridge Backwater Analysis, Sep 1995
- TD-39, Using HEC-RAS for Dam Break Studies, Aug 2014



Modelo HECRAS – mais informação

The image shows a Google search interface with the query 'hec-ras'. The search results are categorized under 'Web'. The first result is from the Hydrologic Engineering Center (hec.usace.army.mil), providing a welcome message and links to downloads, documentation, applications guide, and features. The second result is from Wikipedia, describing HEC-RAS as a computer program for modeling water flow. The third result is a YouTube video titled 'HEC RAS Tutorial' by Isaac Wait, with a duration of 16:47.

Google hec-ras

Web Imagens Vídeos Mapas Livros Mais ▾ Ferramentas de pesquisa

Cerca de 417 000 resultados (0,21 segundos)

HEC-RAS - Hydrologic Engineering Center
www.hec.usace.army.mil/software/hec-ras/ ▾ Traduzir esta página
Welcome to the Hydrologic Engineering Centers River Analysis System (HEC-RAS) web site. As the first of HEC's "Next Generation" (NexGen) software ...

HEC-RAS Downloads
HEC-RAS has been developed for the U.S. Army Corps of ...

HEC-RAS Hydraulic ...
Hydraulic Reference Manual. Version 4.1. January 2010 ...

HEC-RAS Documentation
The documentation for HEC-RAS consists of a User's Manual ...


HEC-RAS Whats New
Version 4.1 of HEC-RAS includes the following new features: New ...

HEC-RAS Applications Guide
Applications Guide ... HEC-RAS is an integrated system of software ...

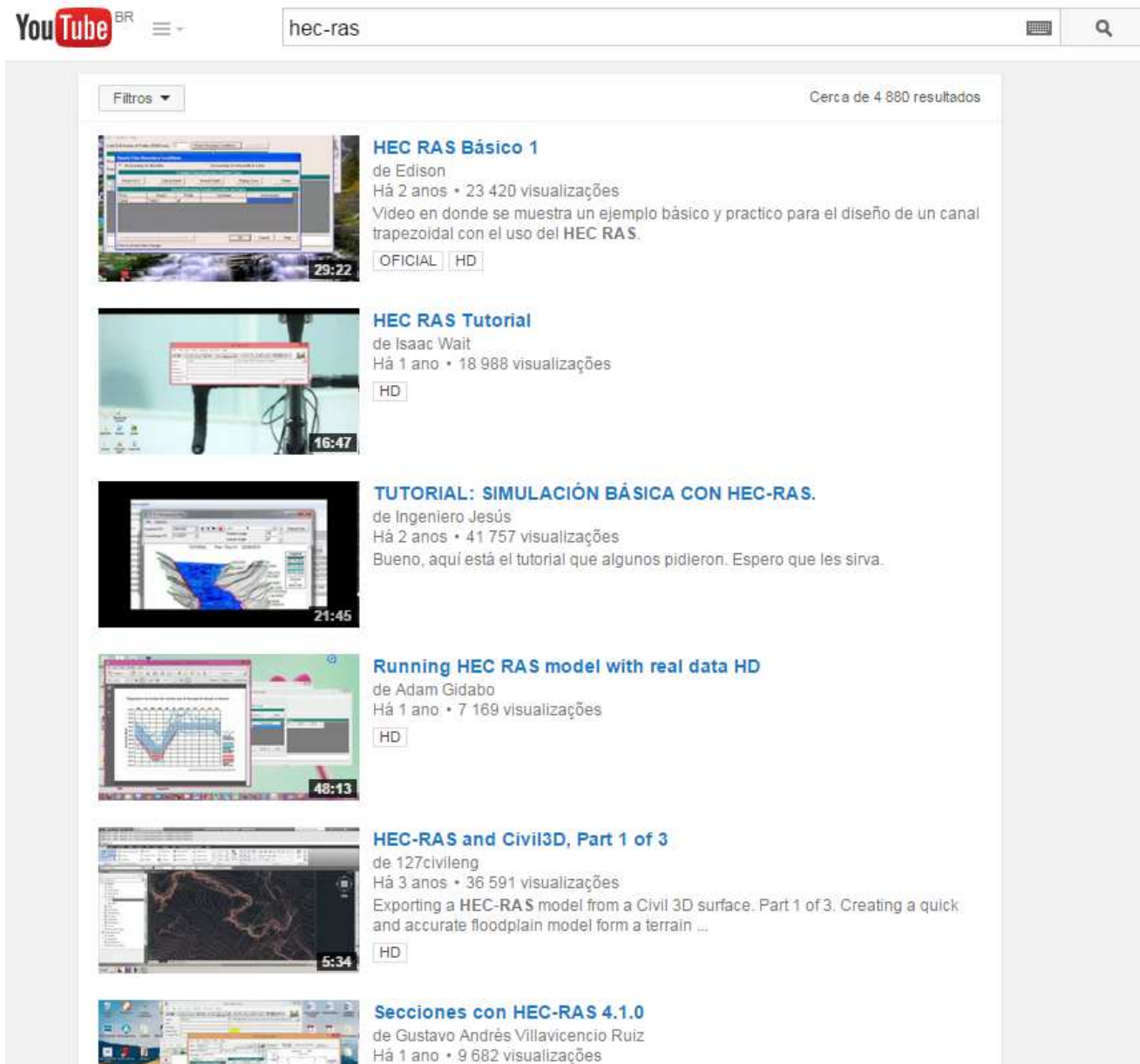
Features
HEC-RAS is designed to perform one-dimensional hydraulic ...

[Mais resultados de army.mil »](#)

HEC-RAS - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/HEC-RAS ▾ Traduzir esta página
HEC-RAS is a computer program that models the hydraulics of water flow through natural rivers and other channels. The program is one-dimensional, meaning ...

HEC RAS Tutorial - YouTube
 www.youtube.com/watch?v=LhOCmncetX4 ▾
13/03/2014 - Carregado por Isaac Wait
HEC RAS Tutorial. Isaac Wait. SubscribeSubscribed ... HEC-RASby Abelardo Herencia Q. unsteady ...

Modelo HECRAS – mais informação



The image shows a screenshot of a YouTube search results page for the query 'hec-ras'. The page features a search bar at the top with the text 'hec-ras' and a search icon. Below the search bar, there are several video results listed. Each result includes a video thumbnail, the video title, the creator's name, the upload date, the number of views, and a duration indicator. The results are as follows:

- HEC RAS Básico 1**
de Edison
Há 2 anos • 23 420 visualizações
Video en donde se muestra un ejemplo básico y practico para el diseño de un canal trapezoidal con el uso del HEC RAS.
OFICIAL HD
- HEC RAS Tutorial**
de Isaac Wait
Há 1 ano • 18 988 visualizações
HD
- TUTORIAL: SIMULACIÓN BÁSICA CON HEC-RAS.**
de Ingeniero Jesús
Há 2 anos • 41 757 visualizações
Bueno, aquí está el tutorial que algunos pidieron. Espero que les sirva.
- Running HEC RAS model with real data HD**
de Adam Gidabo
Há 1 ano • 7 169 visualizações
HD
- HEC-RAS and Civil3D, Part 1 of 3**
de 127civleng
Há 3 anos • 36 591 visualizações
Exporting a HEC-RAS model from a Civil 3D surface. Part 1 of 3. Creating a quick and accurate floodplain model form a terrain ...
HD
- Secciones con HEC-RAS 4.1.0**
de Gustavo Andrés Villavicencio Ruiz
Há 1 ano • 9 682 visualizações

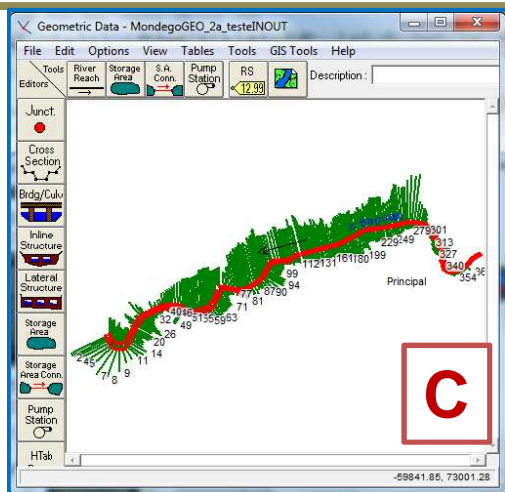
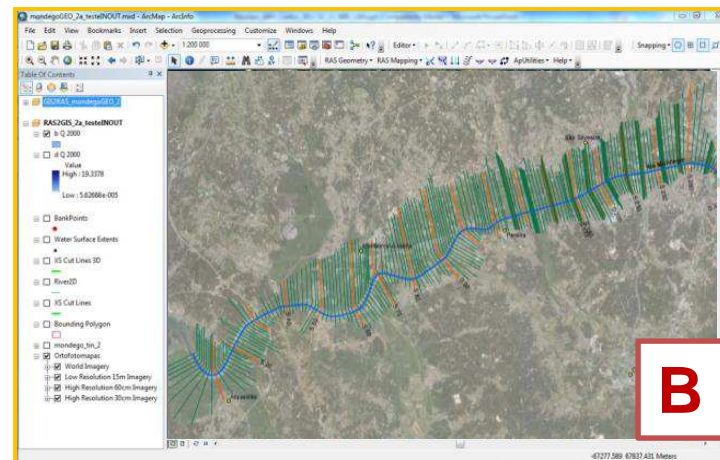
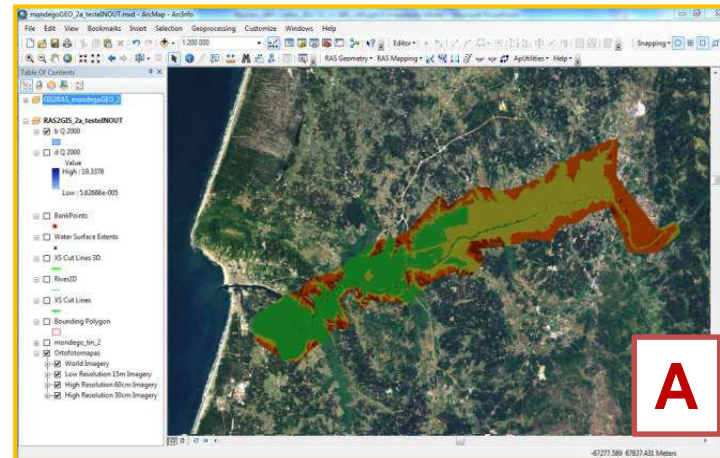
Modelo HECRAS – dados

- 1. Linhas de água**
- 2. Secções transversais**
- 3. Rugosidades**
- 4. Hidrograma da ruptura**
- 5. Condições de fronteira de jusante**

Modelo HECRAS – dados

1. Linhas de água
2. Secções transversais
3. Rugosidades

HEC-GeoRAS



Monteira de Gusmão

Extensão HEC-GeoRAS



HOME > SOFTWARE > HEC-GEORAS > DOWNLOADS

HEC-GeoRAS
HEC-GeoRAS
Downloads
Known Issues
Support Policy

HEC-GeoRAS is a GIS extension that provides the user with a set of procedures, tools, and utilities for the preparation of GIS data for import into HEC-RAS and generation of GIS data from RAS output. While the GeoRAS extension is designed for users with limited geographic information systems (GIS) experience, knowledge of GIS is advantageous. Users, however, must have experience modeling with HEC-RAS and have a thorough understanding of river hydraulics to properly create and interpret GIS data sets.

HEC-GeoRAS 10.2 for ArcGIS 10.2:

This package will install HEC-GeoRAS 10.2 and all its pre-requisites automatically. Documentation is available from the programs Help menu.

ArcGIS 10.2 (ArcView license) with the 3D Analyst and Spatial Analyst extensions are required.

Release Notes: The Animation Tool was not migrated to HEC-GeoRAS 10.2. The native ArcGIS Animation Toolbar must be used.

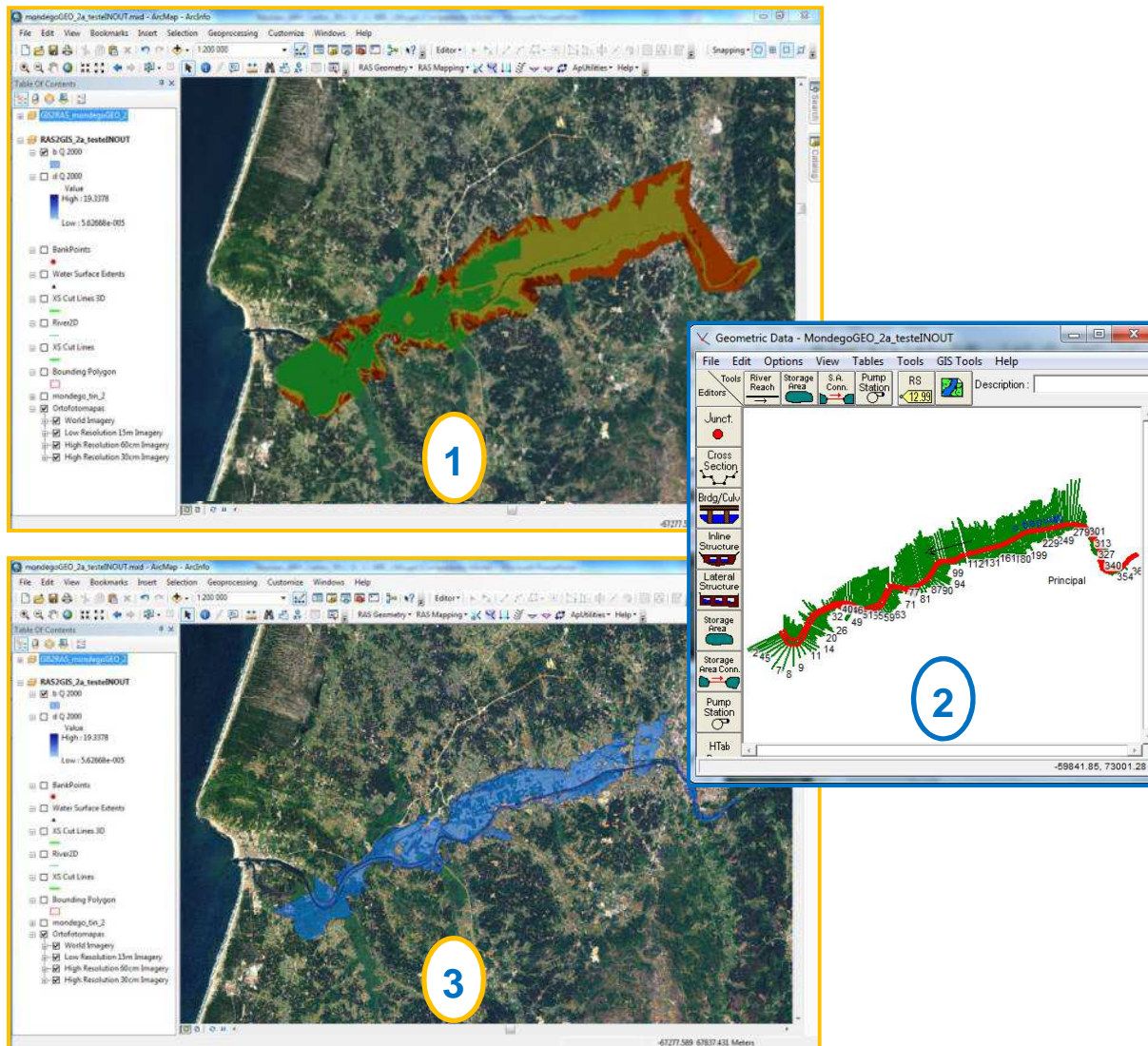
Download HEC-GeoRAS 10.2 **[Updated]** Install Package (12.6 MB)

HEC-GeoRAS 10 Example Data Sets:

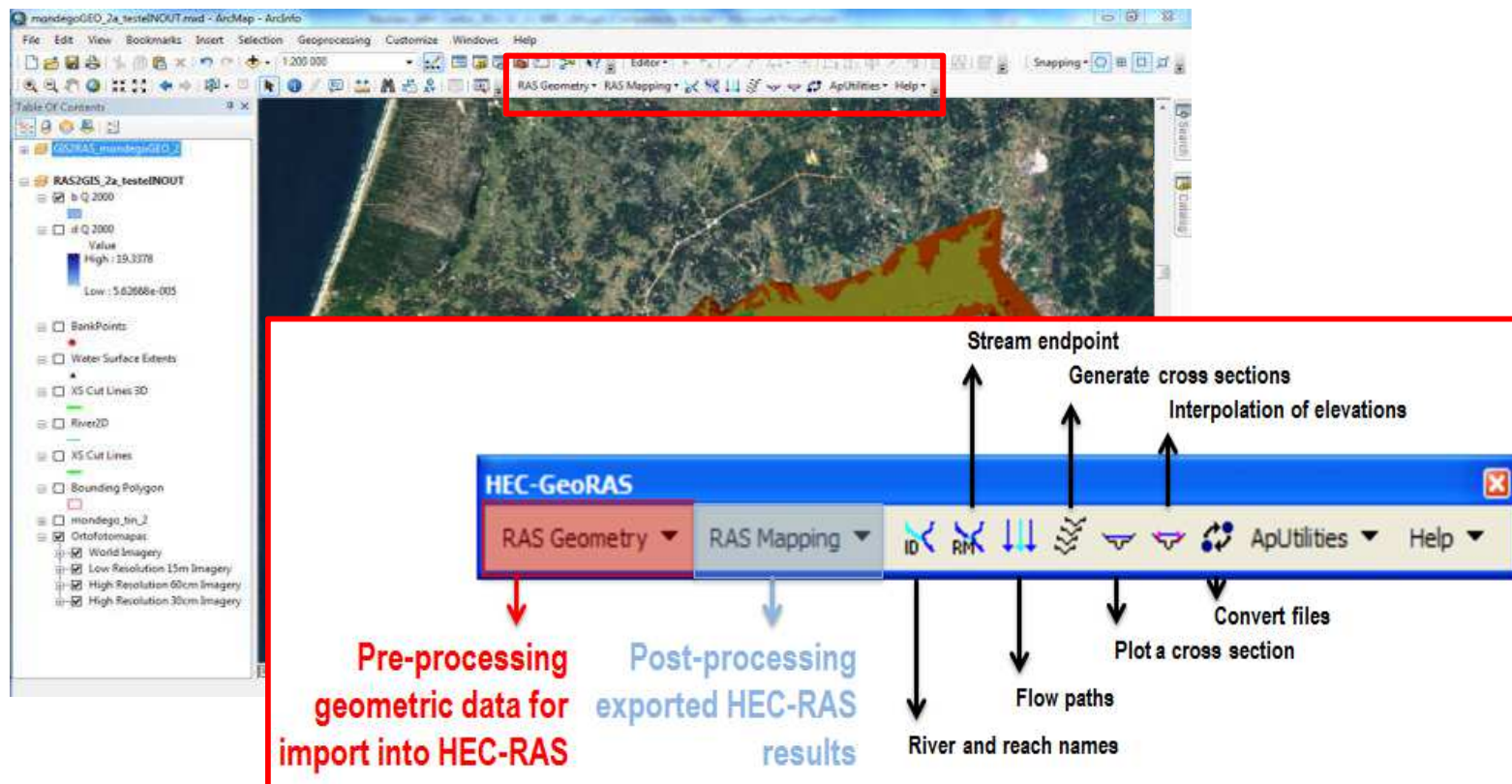
Examples: [What are these datasets?]

- Wailupe Import Example (5.96 MB)
- Baxter Example (44.7 MB)
- Terrain Tiles Example (11.9 MB)

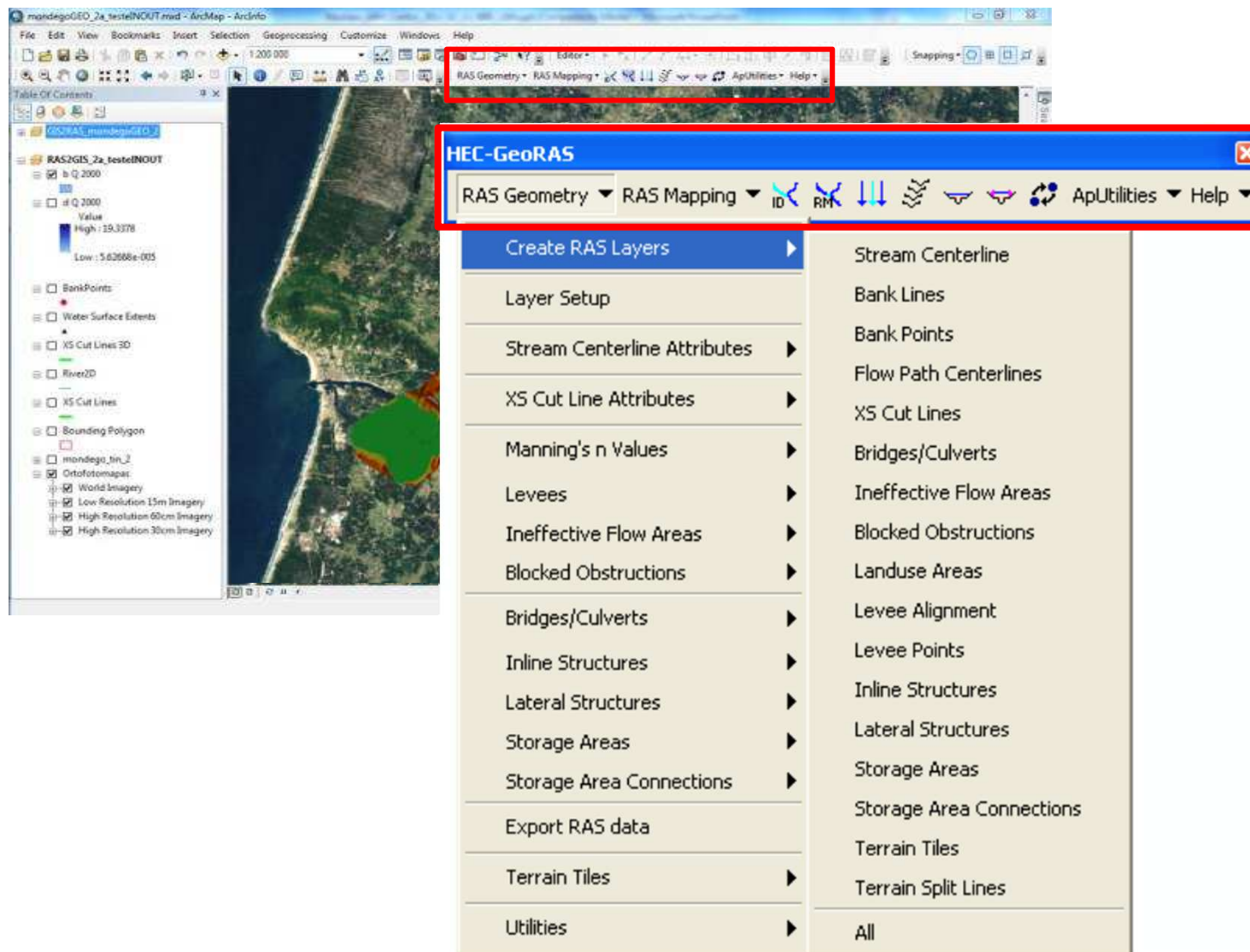
Extensão HEC-GeoRAS - Funcionamento



Extensão HEC-GeoRAS - GUI






Extensão HEC-GeoRAS – Aplicação



Extensão HEC-GeoRAS – mais informação

The image displays the ArcGIS interface with the HEC-GeoRAS extension. The ArcGIS window title is "mandegeo_2a_testeINOUT.mxd - ArcMap - ArcInfo". The HEC-GeoRAS window title is "HEC-GeoRAS". The HEC-GeoRAS menu bar includes "RAS Geometry", "RAS Mapping", "ID", "RM", "ApUtilities", and "Help". The "Help" menu item is highlighted with a red box. The ArcGIS Table of Contents shows a list of layers including "RAS2GIS_2a_testeINOUT", "RAS2GIS_2a_testeINOUT Value", "BankPoints", "Water Surface Extents", "XS Cut Lines 3D", "River2D", "XS Cut Lines", "Bounding Polygon", "mandegeo_in_2", "Ortofotomapas", "World Imagery", "Low Resolution 15m Imagery", "High Resolution 60cm Imagery", and "High Resolution 30cm Imagery". The HEC-GeoRAS User's Manual cover is shown, featuring the US Army Corps of Engineers logo and the text "HEC-GeoRAS GIS Tools for Support of HEC-RAS using ArcGIS® 10". The cover also includes a 3D terrain model, the title "User's Manual", the version "Version 10", the date "May 2012", and the code "CPD-83". A file explorer window is open, showing the folder "hecgeoras_tutorials" with subfolders "BaxterExample10", "TerrainTiles10", and "WailupeImportExample10".

Extensão HEC-GeoRAS – mais informação

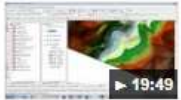
Google   


Web Imagens Vídeos Mapas Notícias Mais ▾ Ferramentas de pesquisa


Cerca de 47 300 resultados (0,34 segundos)

HEC-GeoRAS - Hydrologic Engineering Center
www.hec.usace.army.mil/software/hec-georas/ ▾ Traduzir esta página
HEC-GeoRAS is a set of procedures, tools, and utilities for processing geospatial data in ArcGIS using a graphical user interface (GUI). The interface allows the ...
Downloads - Known Issues - Support Policy

HEC-GeoRAS Downloads - Hydrologic Engineering Center
www.hec.usace.army.mil/.../hec-georas/downloads.a... ▾ Traduzir esta página
HEC-GeoRAS is a GIS extension that provides the user with a set of procedures, tools, and utilities for the preparation of GIS data for import into HEC-RAS and ...

HEC-GeoRAS - GEOMETRÍA (HEC-RAS) - YouTube
 www.youtube.com/watch?v=VuOLSMM7X8o
03/01/2014 - Carregado por Hidraulica para todos
A partir de las curvas de nivel se genera un Modelo Digital de Elevación y con la extensión de ArcGIS "HEC ...

HEC-GeoRAS y HEC-RAS - YouTube
 www.youtube.com/watch?v=HWWhEVyqU70 ▾
14/03/2014 - Carregado por Josue Diaz
En este video se muestran los pasos para crear los archivos en Hec-GeoRAS que seran exportado a HEC-RAS ...

HEC-Georas-Tutorial -1-Floodplain Map - YouTube
 www.youtube.com/watch?v=KM2XWb5dNoQ ▾
14/03/2014 - Carregado por Yassir Abduljaleel
In this tutorial we will be convert the DEM to Tin then build the floodplain map for a river in Spokane county .

[PDF] Tutorial on using HEC-GeoRAS 10.1 with ArcGIS 10.1 an...
web.engr.oregonstate.edu/.../Geo_RAS/georastutoria... ▾ Traduzir esta página
Adapted from HEC-GeoRAS - Hydrologic Engineering Center ... You can download HEC-RAS and HEC-GeoRAS from the US Army Corps of Engineers.

Extensão HEC-GeoRAS – mais informação

The image shows a screenshot of a YouTube search results page for the query 'hec-georas'. The page displays several video results, each with a thumbnail, title, author, view count, and duration. The results are as follows:

- HEC-Georas-Tutorial -1-Floodplain Map**
de Yassir Abdaljaleel
Há 1 ano • 7 289 visualizações
In this tutorial we will be convert the DEM to Tin then build the floodplain map for a river in Spokane county .
12:07
- HEC-GeoRAS y HEC-RAS**
de Josue Diaz
Há 1 ano • 11 590 visualizações
En este video se muestran los pasos para crear los archivos en Hec-GeoRAS que seran exportado a HEC-RAS. Los archivos del ...
33:00
- HEC-GeoRAS - GEOMETRÍA (HEC-RAS)**
de Hidraulica para todos
Há 1 ano • 7 511 visualizações
A partir de las curvas de nivel se genera un Modelo Digital de Elevación y con la extensión de ArcGIS "HEC-GeoRAS" se obtiene ...
19:49
- MODELACIÓN DE RÍOS: Tutorial sobre el uso de HEC-GeoRAS con ArcGIS**
de everlass
Há 2 meses • 170 visualizações
Windows 8 Pro / ArcGIS 10.2 for desktop / HEC-GeoRAS 10.2 / AutoCAD Civil 3D 2014.
18:39
- HEC-GeoRAS**
de Scott Isenberg
HEC_Georas_Tutorial -2-,Floodplain Map 9:22
HEC-Georas-Tutorial -1-Floodplain Map 12:07
Ver a lista de reprodução completa (7 vídeos)
- hecgeoras tutorial parte 1**
de Reymundo Azael Martinez Castillo
Há 3 anos • 8 224 visualizações

APLICAÇÃO – variáveis do sistema

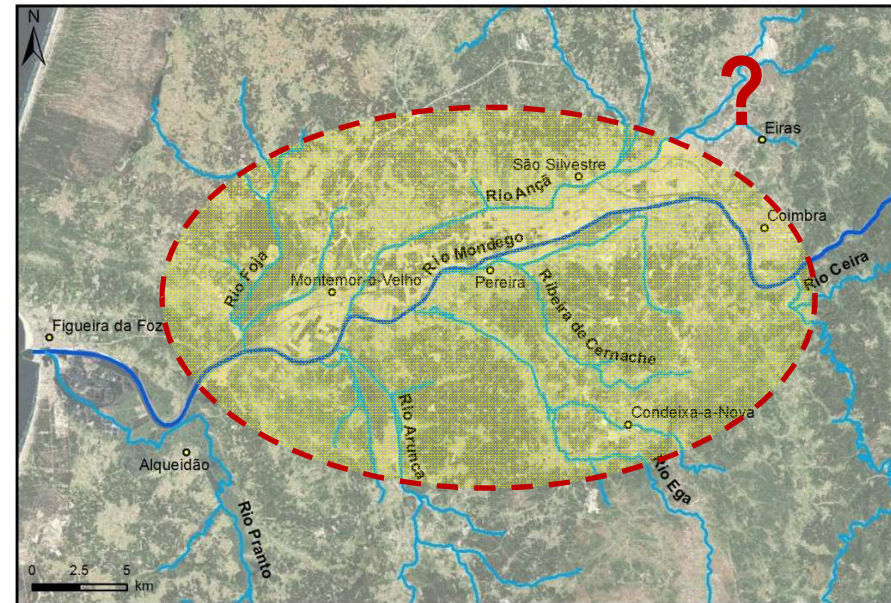
■ Delimitação da área em estudo

- Linhas de água - limite de jusante
- Área inundável

■ Outros elementos

- Açudes, diques, canais
- Ocupação do solo

■ Hidrograma da ruptura



APLICAÇÃO – Informação Base

- **Levantamentos atualizados de:**
 - leitos dos rios e zonas adjacentes (1/500, 1/1000 ou 1/2000)
 - infra-estruturas (açudes, pontes, etc)

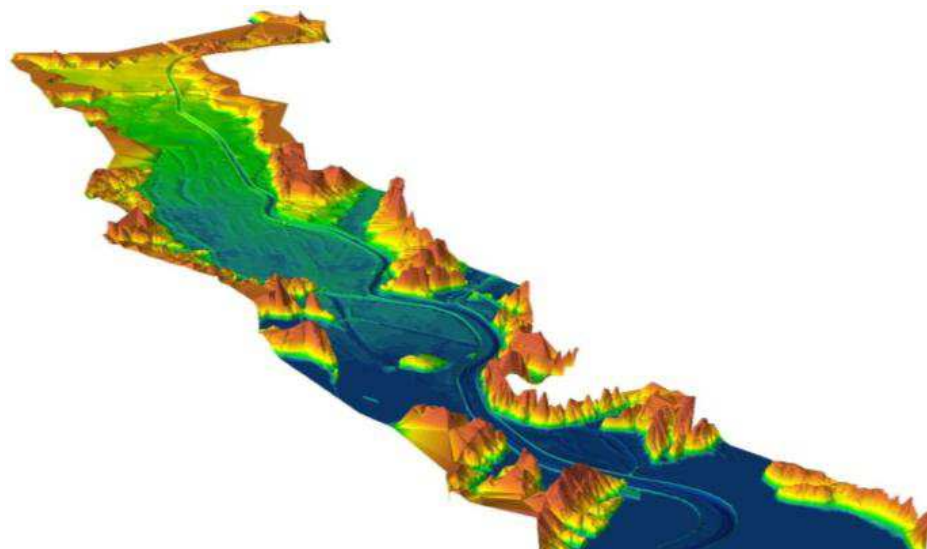
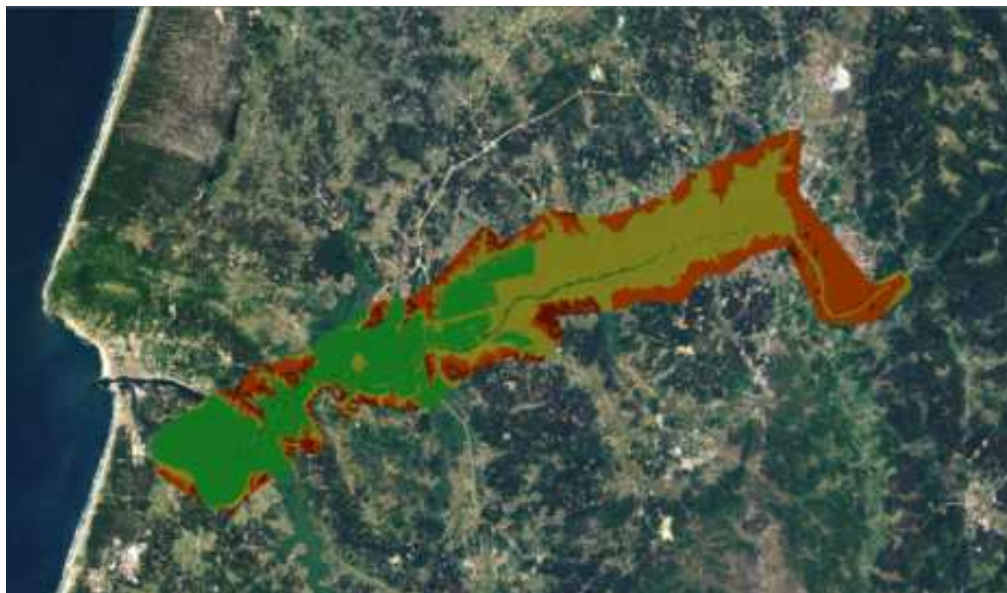
- **Cartografia da ocupação do território**
 - densidade populacional
 - edificações/construções, rede viária e ferroviária, infra-estruturas, zonas agrícolas e atividades económicas existentes)

- **Outros estudos**

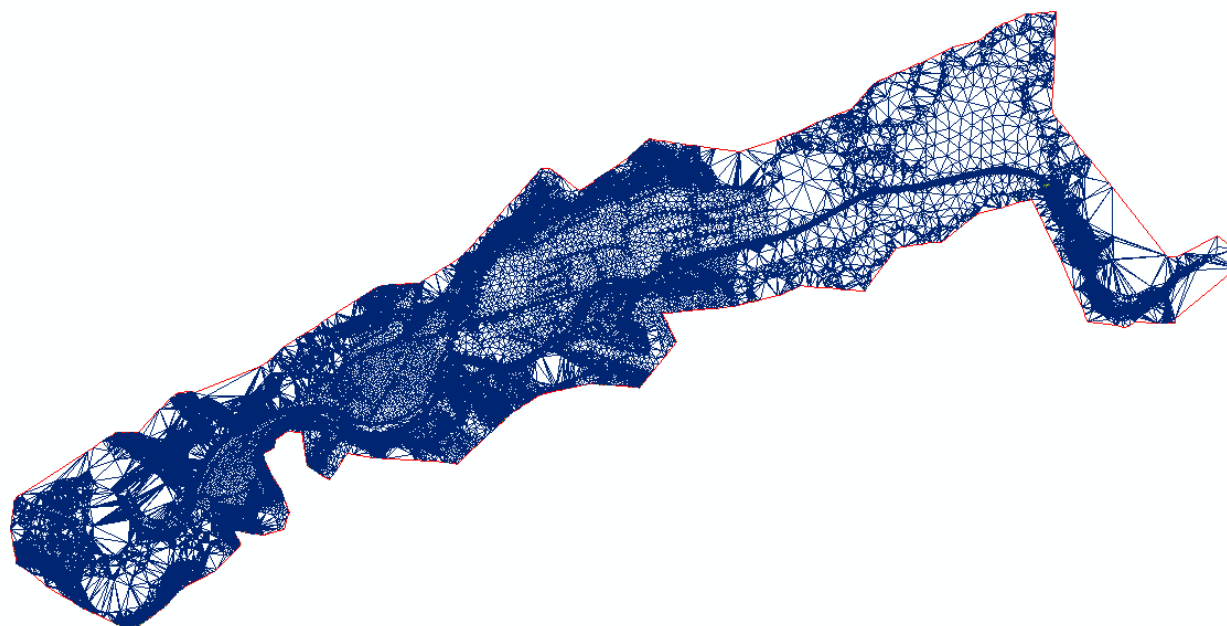
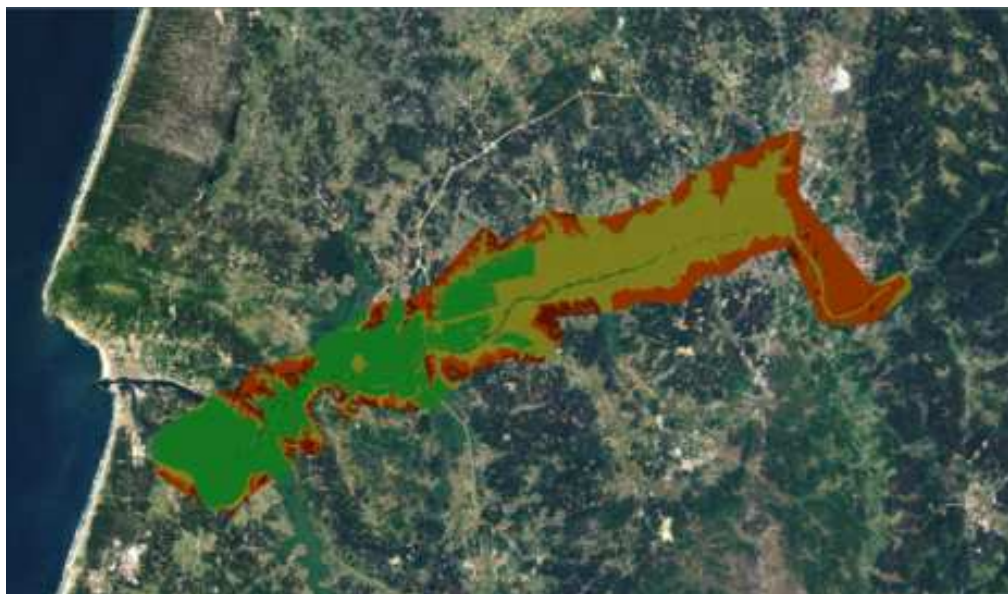
APLICAÇÃO – Informação Base

- Quais as fontes?
 - **Observação em campo**
 - **Levantamentos**
 - **Organismos públicos locais e centrais**
 - **Projetos/estudos anteriores**
 - **Publicações científicas nacionais e internacionais**
- **Tratamento da informação**
 - Análise da qualidade
 - Verificação com outras fontes
 - Adaptação para o estudo
- **Sistema de referência único** para **todos** os dados:
 - Ex: SIRGAS2000

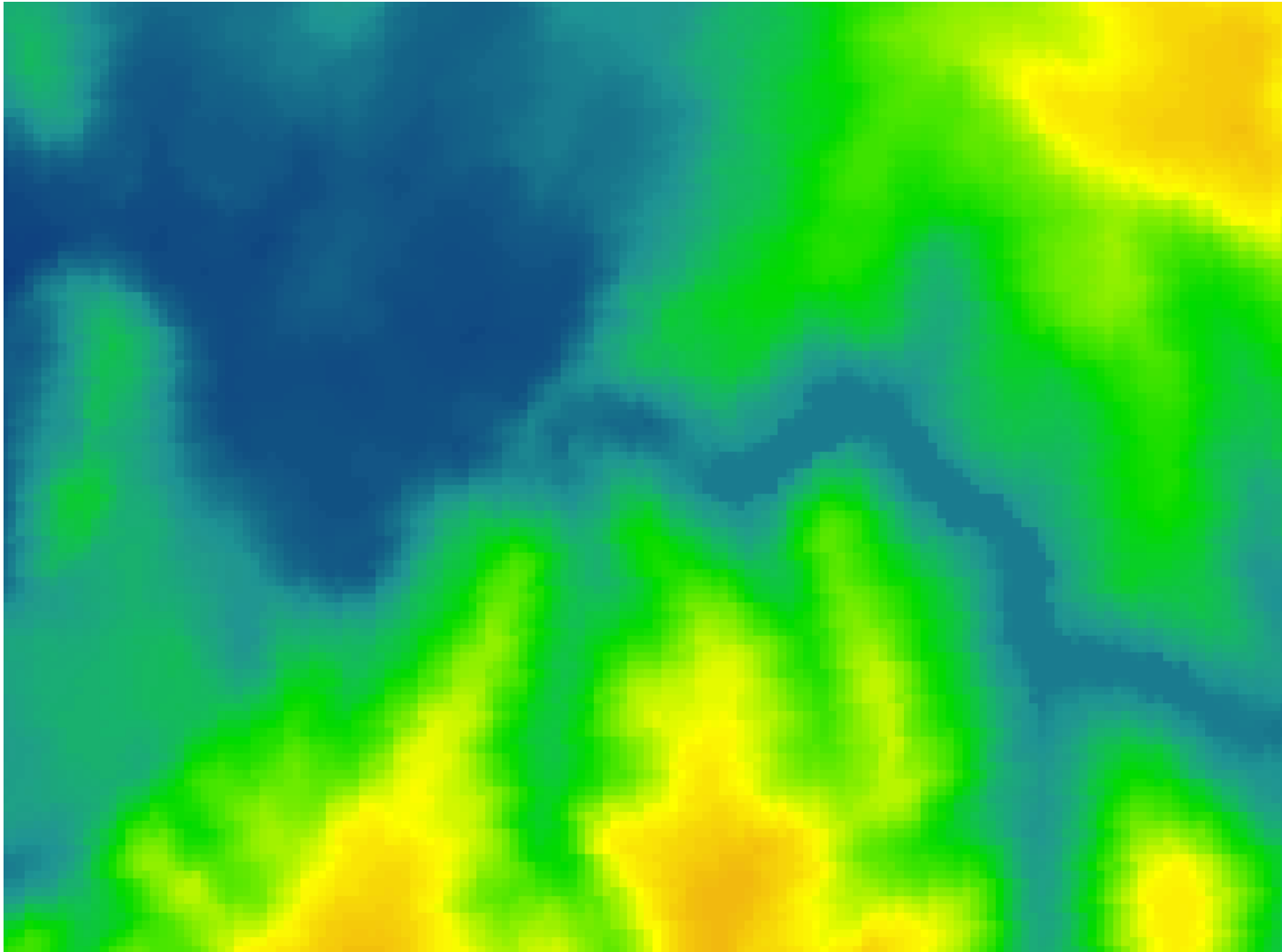
APLICAÇÃO – MDT



APLICAÇÃO – MDT: TIN



APLICAÇÃO – MDT: RASTER

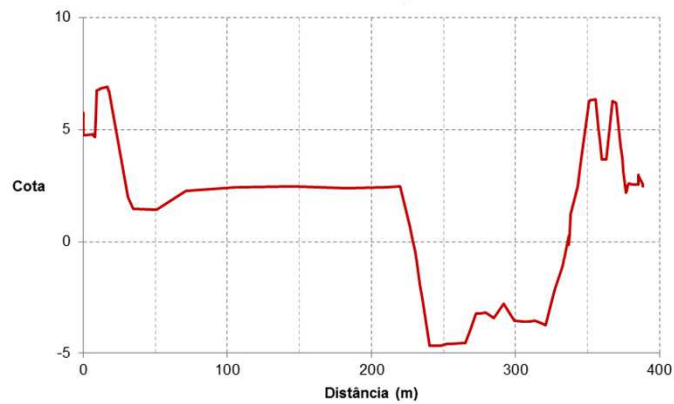


APLICAÇÃO – MDT: TIN

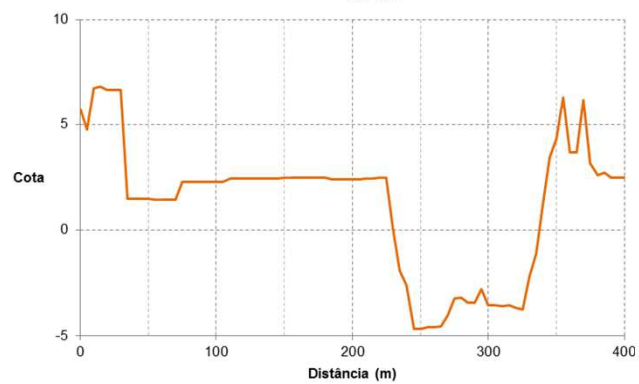
- Escala



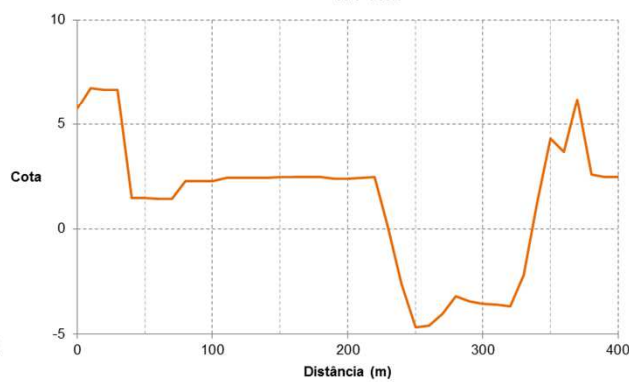
TIN original



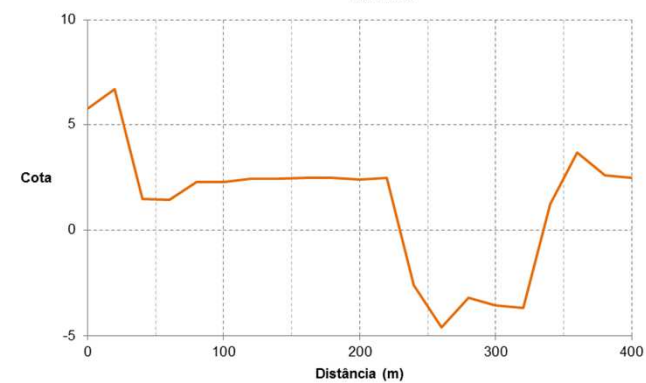
TIN 5m



TIN 10m

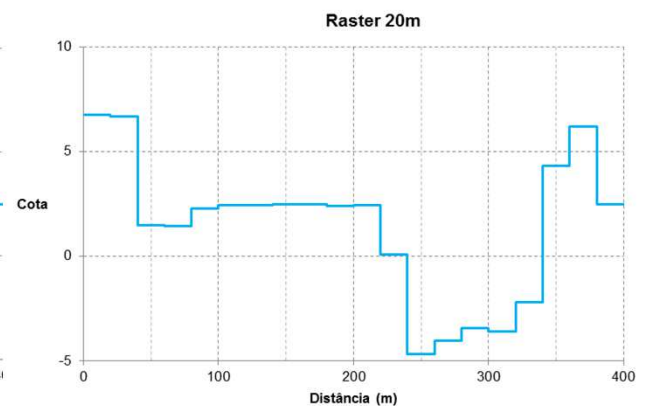
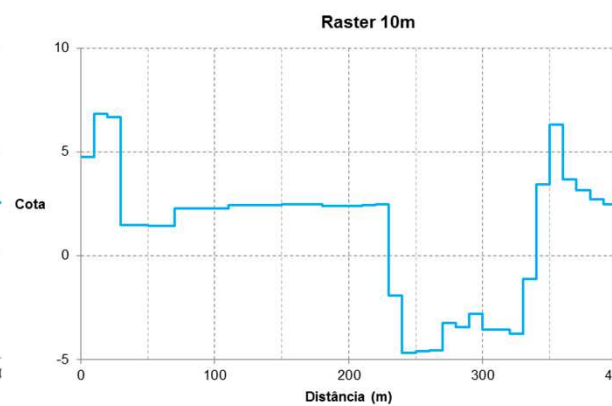
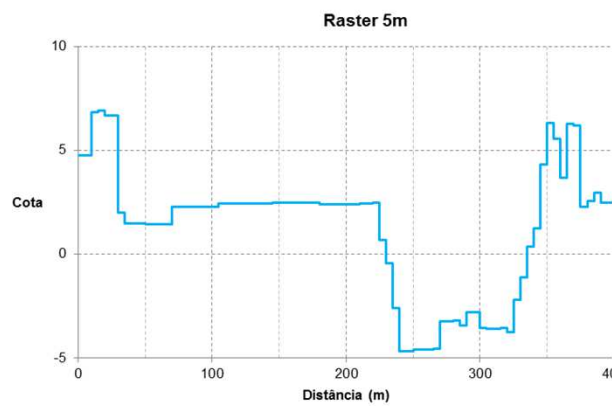
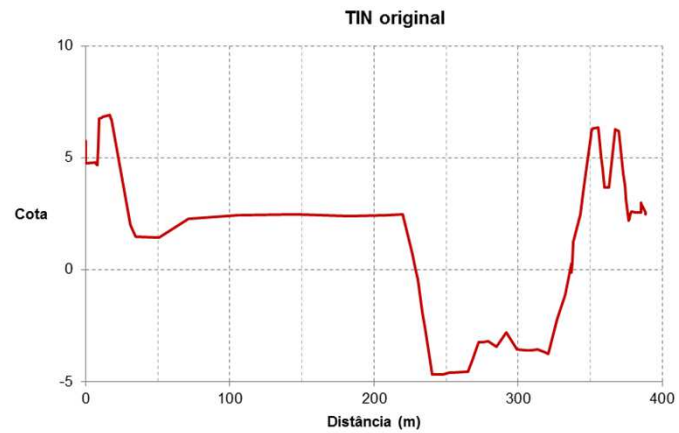
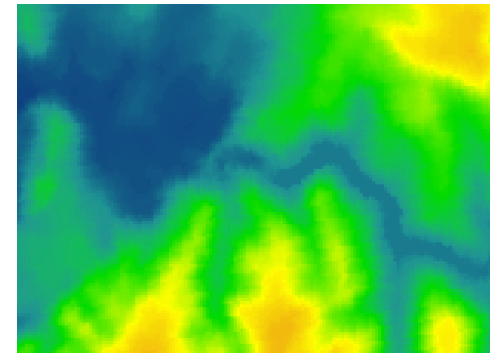


TIN 20m



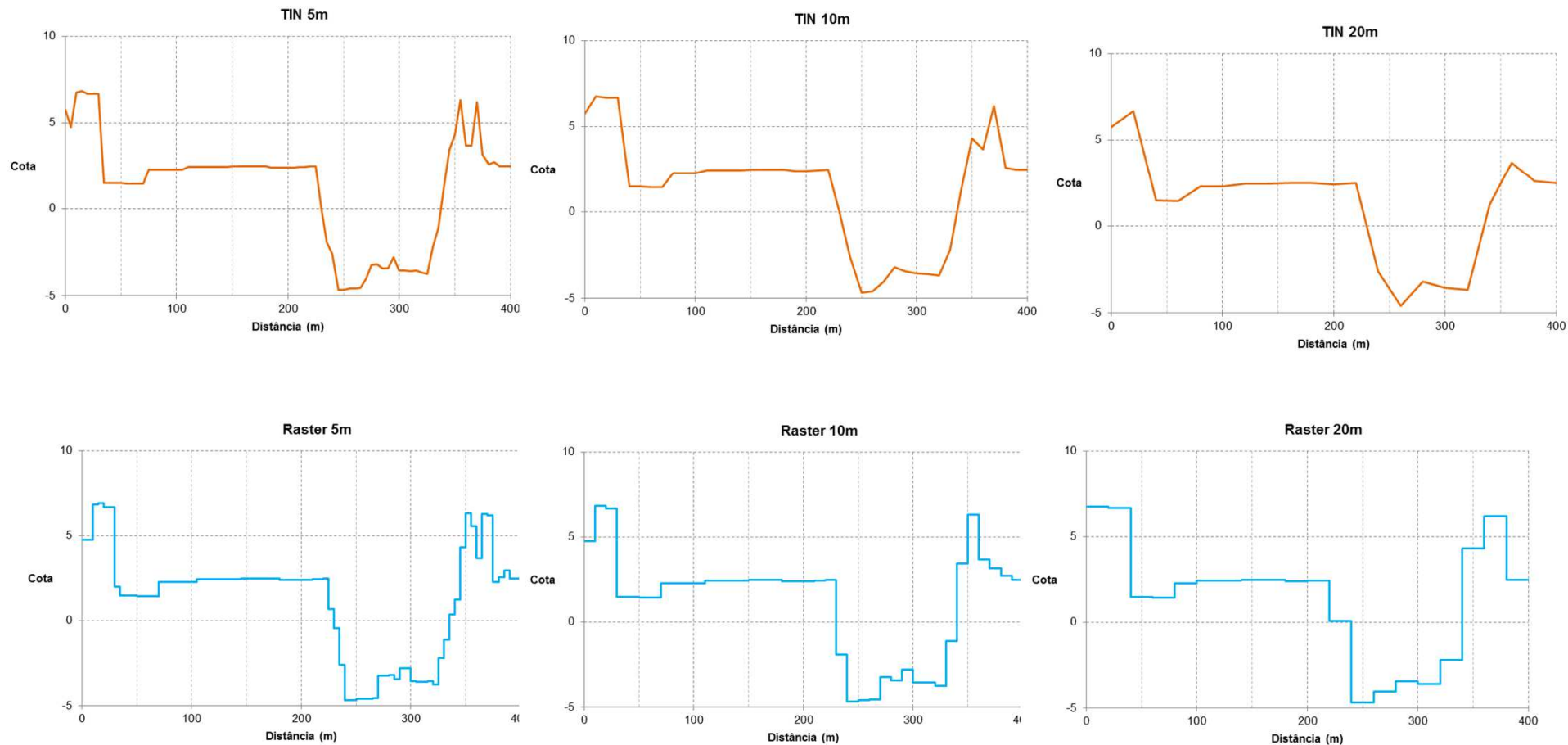
APLICAÇÃO – MDT: RASTER

- Escala



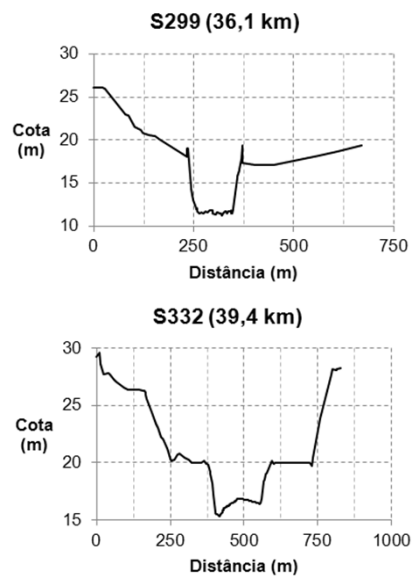
APLICAÇÃO – MDT: TIN vs RASTER

- Escala



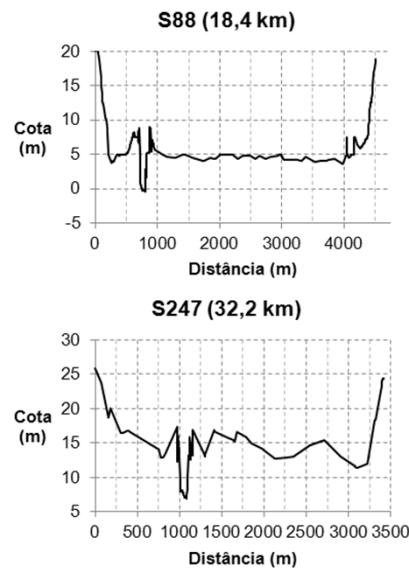
APLICAÇÃO – Secções tipo

Montante



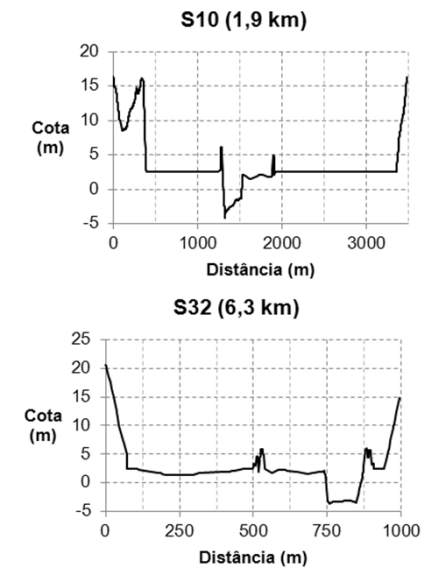
- ✓ Secção mais curta
- ✓ Leito central encaixado
- ✓ Margens curtas

Jusante



- ✓ Secção larga
- ✓ Leito de cheia com grande capacidade
- ✓ Diques no leito central

Estuário



- ✓ Secção larga
- ✓ Leito de cheia com grande capacidade
- ✓ Termina sem diques

APLICAÇÃO – Ocupação do solo

VEGETAÇÃO



CONSTRUÇÃO



APLICAÇÃO – Ocupação do solo

- **Fontes:**

- Carta de Ocupação do Solo
- Fotografia aérea (Microsoft BING, Google, etc)
- Observação no local

- **Análise das rugosidades**

- Escolha do número de classes
- Definição das áreas

Carta de ocupação de solos



Fotografia aérea

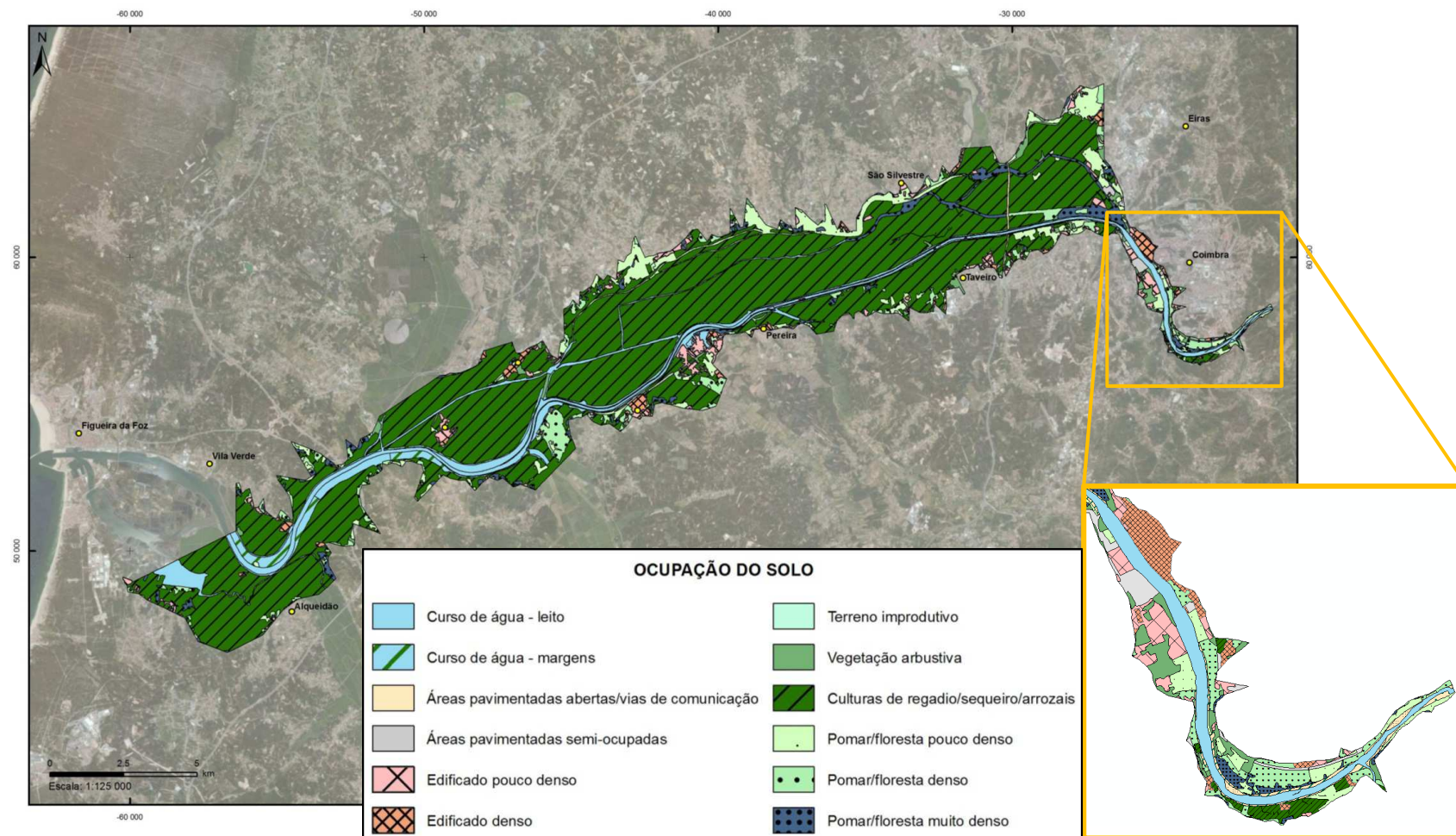


Observação do local

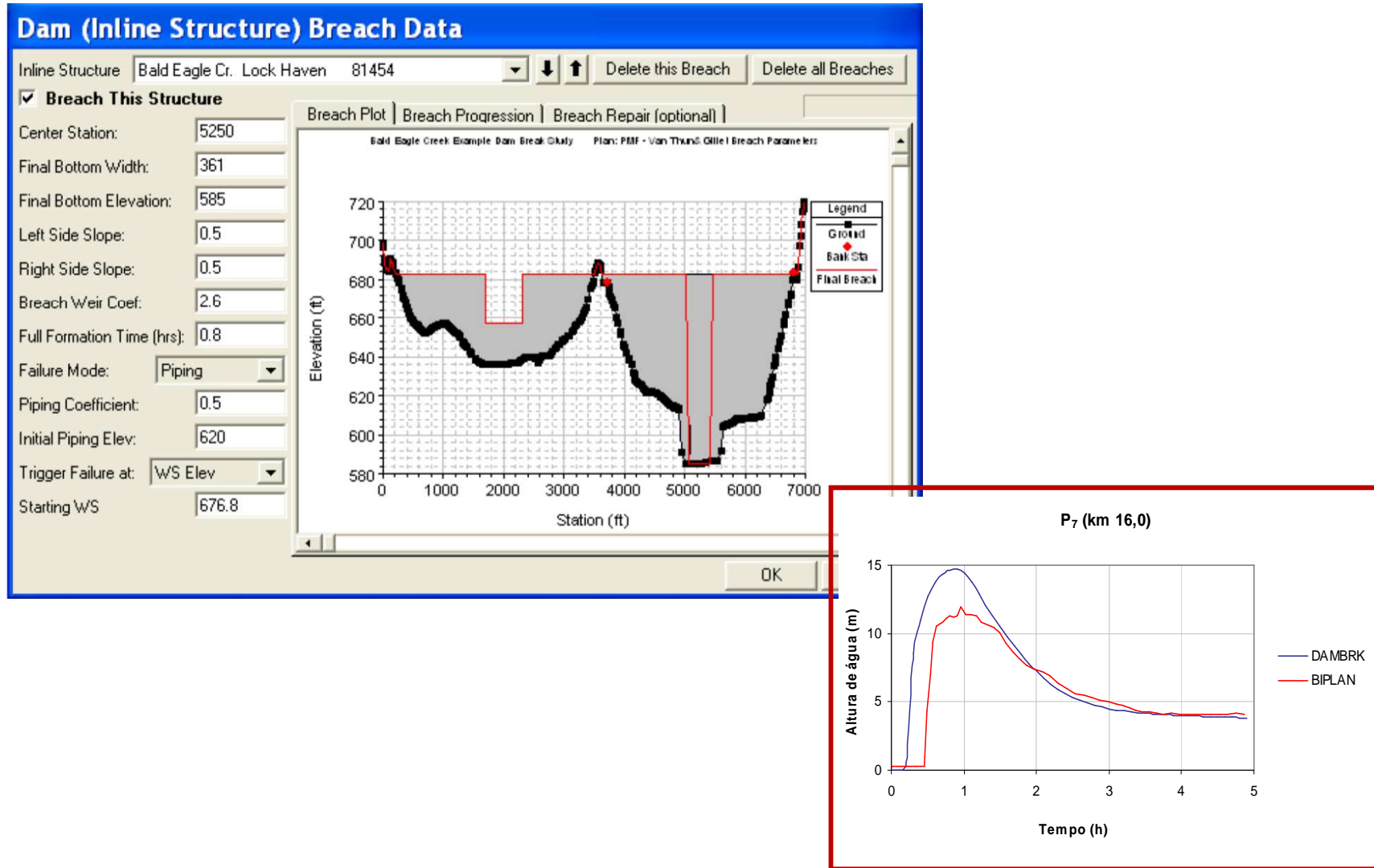


<http://jcduarte.net>

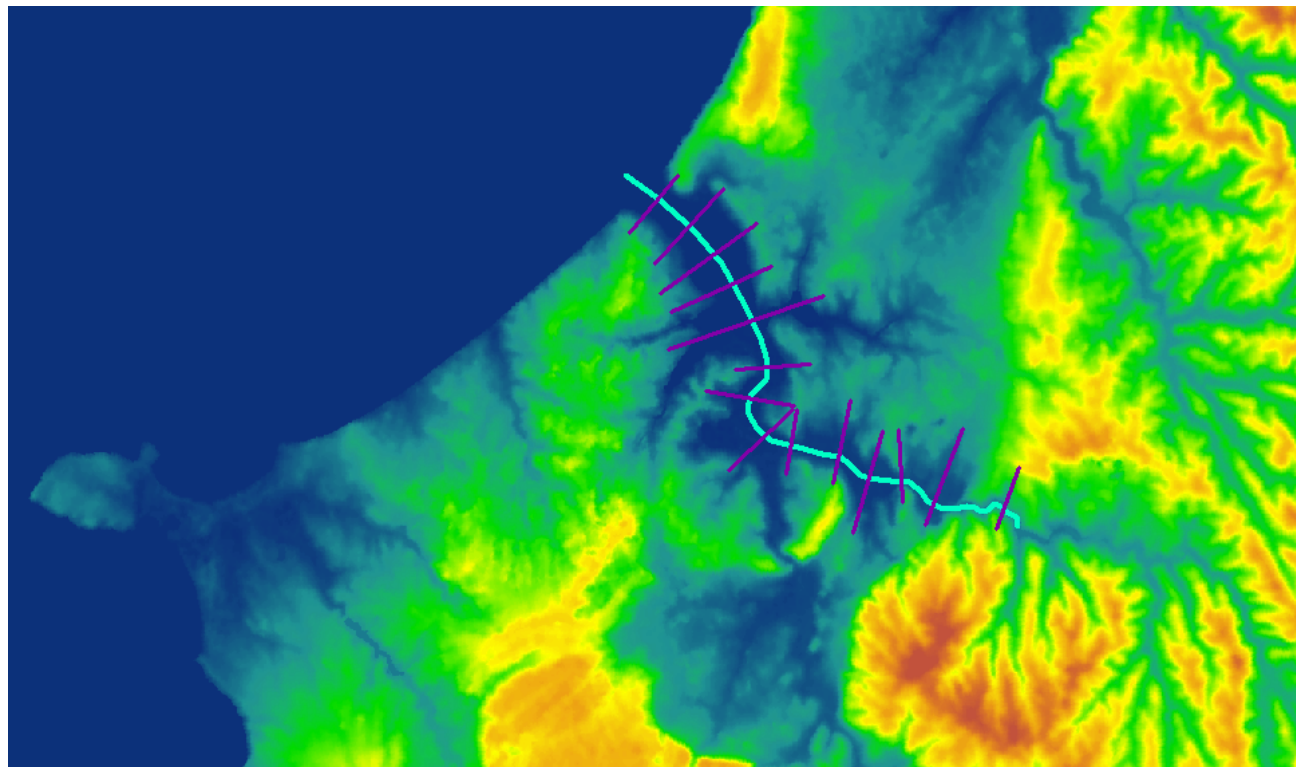
APLICAÇÃO – Ocupação do solo



APLICAÇÃO – HIDROGRAMA DA RUPTURA DA BRECHA



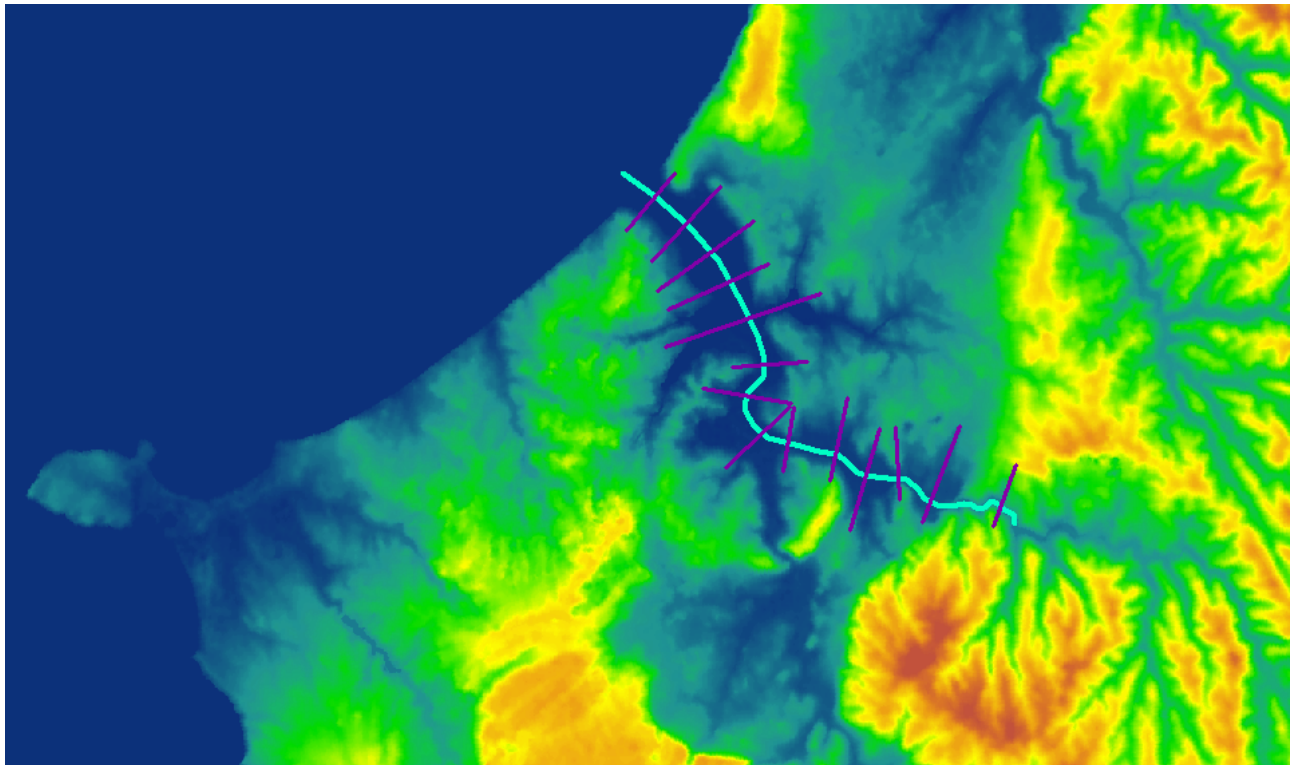
EXERCÍCIO EM HEC-RAS HIDROGRAMA DA RUPTURA DA BRECHA



EXERCÍCIO EM HEC-RAS

HIDROGRAMA DA RUPTURA DA BRECHA

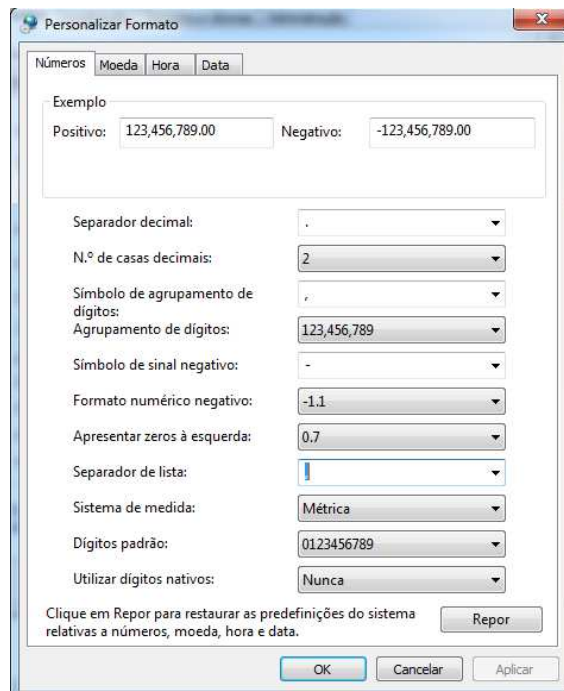
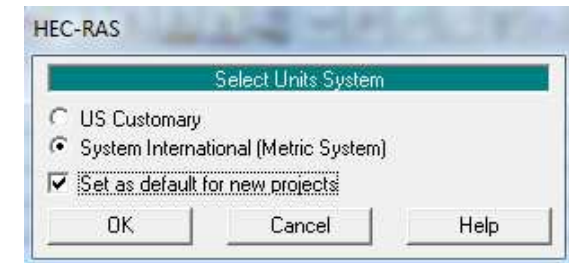
- **Projecto: Óbidos**
 - HEC-RAS: *File > Open Project > “Obidos01.prj”*
 - Pasta: *CursoPAE_modulo2*



EXERCÍCIO EM HEC-RAS

CUIDADOS COM O HEC-RAS

- **Confirmar o sistema de unidades**
- **O separador decimal do Windows deve ser o “.”**
- **O formato de data do Windows deve ser em inglês**

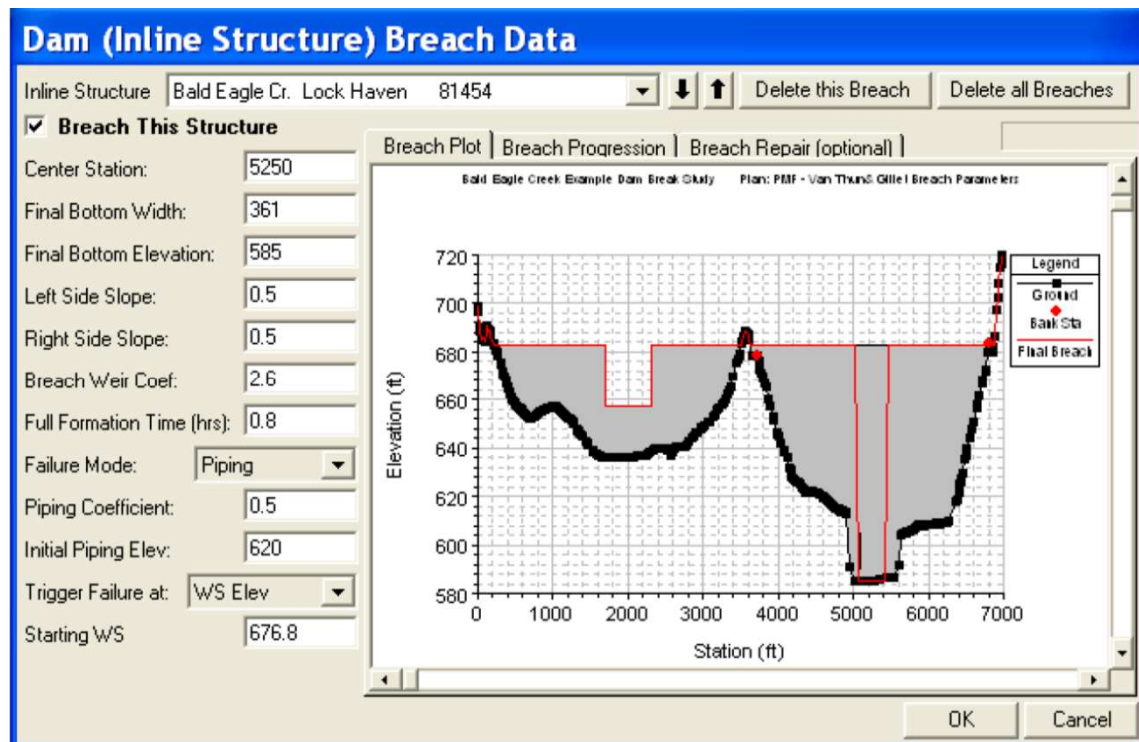


EXERCÍCIO EM HEC-RAS

HIDROGRAMA DA RUPTURA DA BRECHA

- **Hidrograma da ruptura da brecha**
 - HEC-RAS: *Geometric Data > Inline Structure > Breach (Plan Data)*

- Eixo central da brecha
- Largura final da base da brecha
- Cota final da base da brecha
- Declive dos taludes laterais da brecha
- Coeficiente de vazão da brecha
- Tempo de formação total da brecha
- Modo de ruptura: galgamento ou erosão interna
- Coeficiente de “piping”
- Cota inicial de “piping”
- Condição para o início da rotura
- Valor de cota da superfície da água



EXERCÍCIO EM HEC-RAS

HIDROGRAMA DA RUPTURA DA BRECHA

- **Hidrograma da ruptura da brecha**
 - HEC-RAS: *Geometric Data > Inline Structure > Breach (Plan Data)*

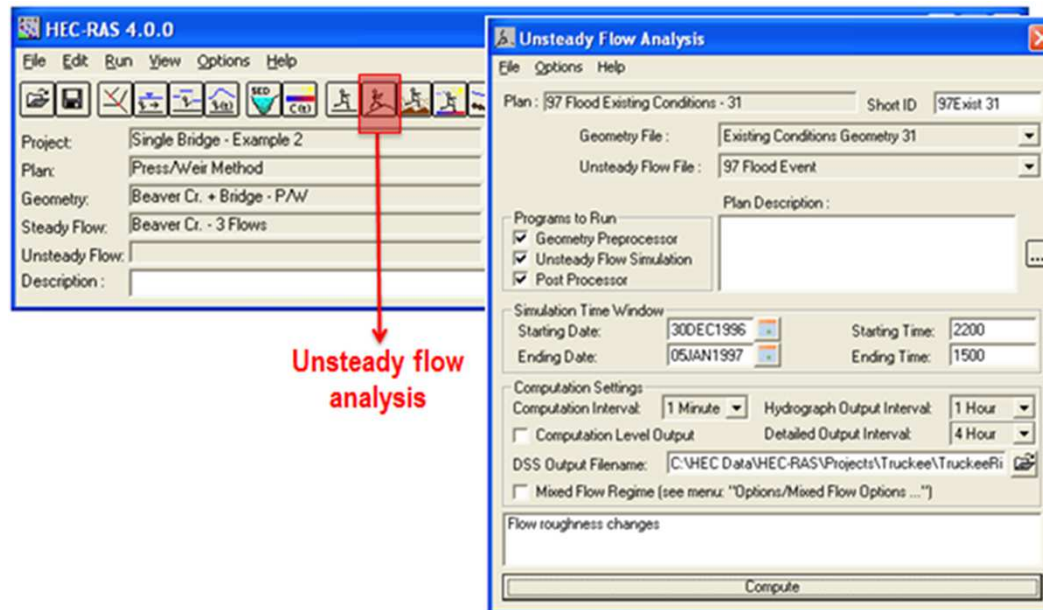
Dam Type	Average Breach Width (B_{ave})	Horizontal Component of Breach Side Slope (H) (H:V)	Failure Time, t_f (hours)	Agency
Earthen/Rockfill	(0.5 to 3.0) x HD	0 to 1.0	0.5 to 4.0	USACE 1980
	(1.0 to 5.0) x HD	0 to 1.0	0.1 to 1.0	FERC
	(2.0 to 5.0) x HD	0 to 1.0 (slightly larger)	0.1 to 1.0	NWS
	(0.5 to 5.0) x HD*	0 to 1.0	0.1 to 4.0*	USACE 2007
Concrete Gravity	Multiple Monoliths	Vertical	0.1 to 0.5	USACE 1980
	Usually $\leq 0.5 L$	Vertical	0.1 to 0.3	FERC
	Usually $\leq 0.5 L$	Vertical	0.1 to 0.2	NWS
	Multiple Monoliths	Vertical	0.1 to 0.5	USACE 2007
Concrete Arch	Entire Dam	Valley wall slope	≤ 0.1	USACE 1980
	Entire Dam	0 to valley walls	≤ 0.1	FERC
	(0.8 x L) to L	0 to valley walls	≤ 0.1	NWS
	(0.8 x L) to L	0 to valley walls	≤ 0.1	USACE 2007
Slag/Refuse	(0.8 x L) to L	1.0 to 2.0	0.1 to 0.3	FERC
	(0.8 x L) to L		≤ 0.1	NWS

*Note: Dams that have very large volumes of water, and have long dam crest lengths, will continue to erode for long durations (i.e., as long as a significant amount of water is flowing through the breach), and may therefore have longer breach widths and times than what is shown in Table 3. HD = height of the dam; L = length of the dam crest; FERC - Federal Energy Regulatory Commission; NWS - National Weather Service

EXERCÍCIO EM HEC-RAS

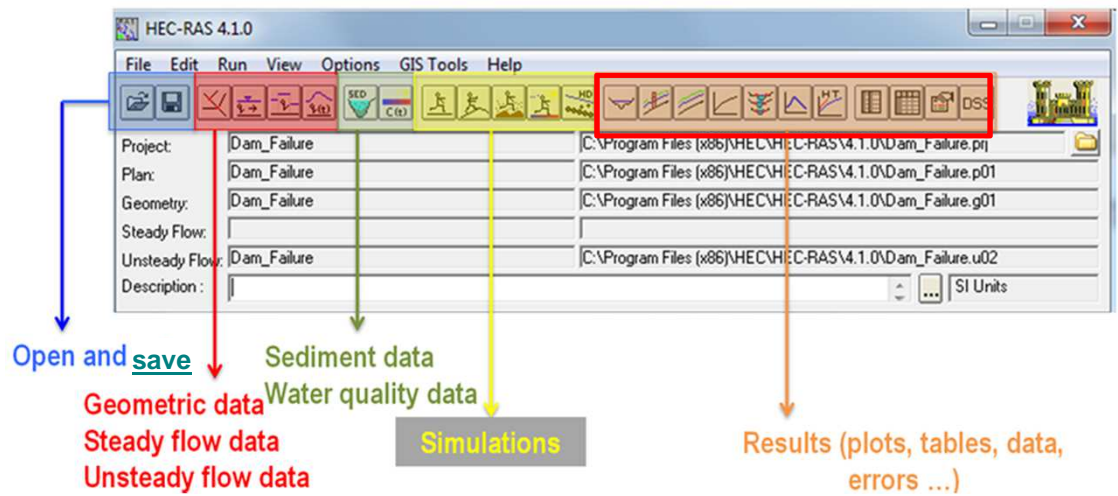
HIDROGRAMA DA RUPTURA DA BRECHA

- **Simulação de regime não permanente**
 - HEC-RAS: *Run > Unsteady Flow Analysis > Compute*



EXERCÍCIO EM HEC-RAS HIDROGRAMA DA RUPTURA DA BRECHA

- Visualizar resultados

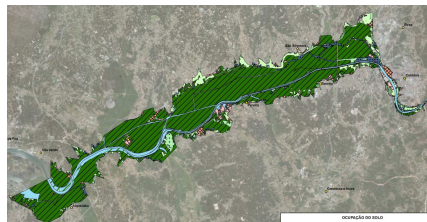


APLICAÇÃO - Calibração do Modelo Numérico

- **Análise das corridas do modelo**
 - Altura de escoamento / cota da superfície de água
 - Velocidades
 - Número de Froude → regime rápido / lento
 - Velocidade de propagação & atenuação do hidrograma

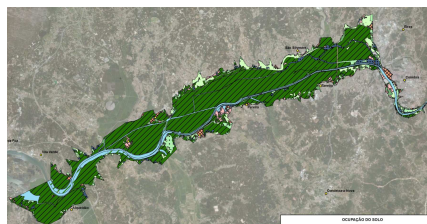
- **Calibração do modelo**
 - Hidrograma da brecha de ruptura
 - Rugosidade – coeficientes de Manning
 - Intervalo de tempo de cálculo - Δt
 - Número de Courant
 - Outros parâmetros característicos do modelo

CALIBRAÇÃO - Rugosidades



observações	A	B	C	D	E	F
	valores de referência	variação -20%	variação +20%	valores mínimos	valores mínimos	valores mínimos
Leito principal						
Leito principal - talvegue	0.040	0.032	0.048	0.025	0.030	0.028
Leito principal - margens	0.045	0.036	0.054	0.035		
Leito principal - margens com árvores espaçadas	0.060	0.048	0.072	0.045	0.050	0.045
Leito principal - margens com árvores densas	0.120	0.096	0.144	0.055		
Áreas artificiais						
Áreas pavimentadas abertas + estradas + parques de estacionamento	0.013	0.010	0.016	0.013	0.013	0.013
Áreas pavimentadas semi-ocupadas	0.040	0.032	0.048	0.040	0.040	0.040
Edificado espaçado	0.200	0.160	0.240	0.100	0.100	0.100
Edificado denso	0.400	0.320	0.480	0.150	0.150	0.150
Campos						
Descampado de areia/terra	0.030	0.024	0.036	0.030	0.030	0.030
Descampado + arbustos	0.050	0.040	0.060	0.050	0.050	0.050
Campo cultivado	0.040	0.032	0.048	0.040	0.040	0.040
Pomar/árvores espaçado	0.060	0.048	0.072	0.060	0.060	0.060
Pomar/árvores denso	0.100	0.080	0.120	0.080	0.080	0.080
Pomar/árvores muito denso	0.120	0.096	0.144	0.100	0.100	0.100

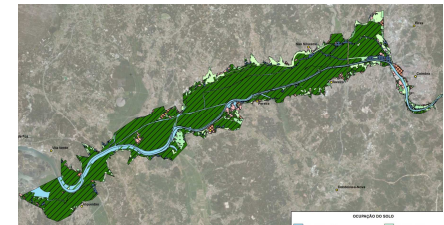
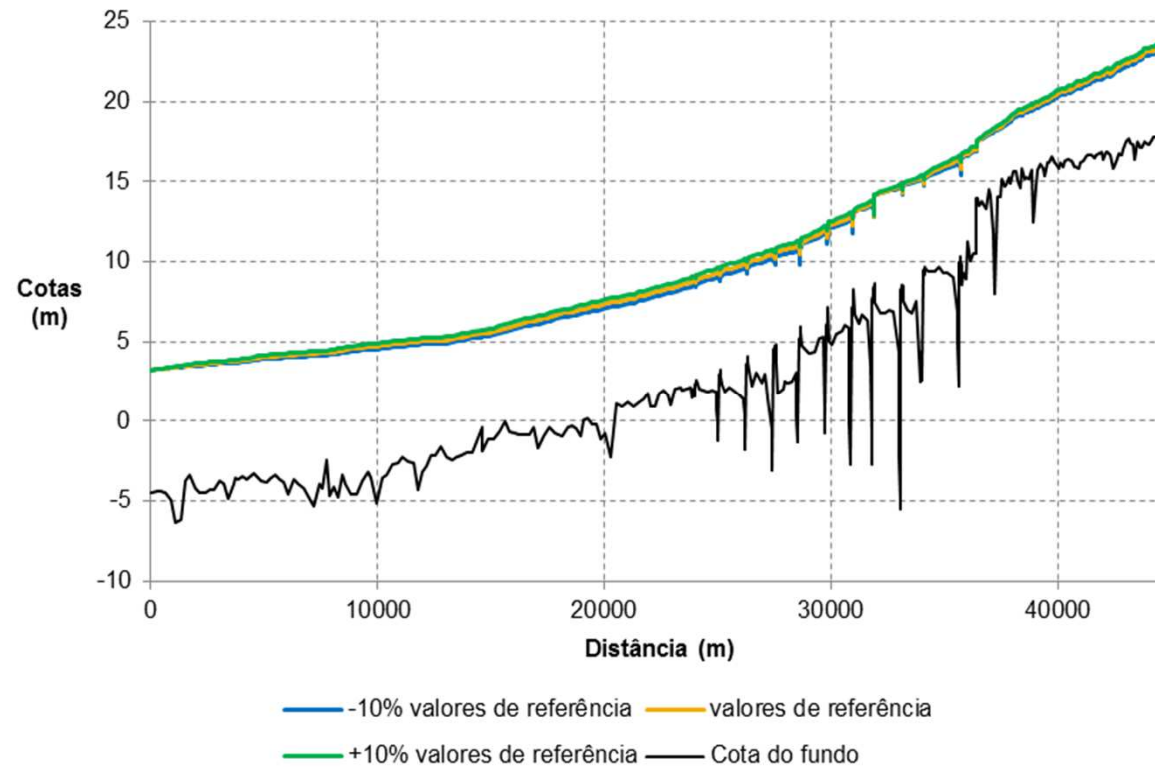
CALIBRAÇÃO - Rugosidades



Combinação final

	A	B	C	D	E	F
observações	valores de referência	variação -20%	variação +20%	valores mínimos	valores mínimos	valores mínimos
Leito principal						
Leito principal - talvegue	0.040	0.032	0.048	0.025	0.030	0.028
Leito principal - margens	0.045	0.036	0.054	0.035		
Leito principal - margens com arvores espaçadas	0.060	0.048	0.072	0.045	0.050	0.045
Leito principal - margens com arvores densas	0.120	0.096	0.144	0.055		
Áreas artificiais						
Áreas pavimentadas abertas + estradas + parques de estacionamento	0.013	0.010	0.016	0.013	0.013	0.013
Áreas pavimentadas semi-ocupadas	0.040	0.032	0.048	0.040	0.040	0.040
Edificado espaçado	0.200	0.160	0.240	0.100	0.100	0.100
Edificado denso	0.400	0.320	0.480	0.150	0.150	0.150
Campos						
Descampado de areia/terra	0.030	0.024	0.036	0.030	0.030	0.030
Descampado + arbustos	0.050	0.040	0.060	0.050	0.050	0.050
Campo cultivado	0.040	0.032	0.048	0.040	0.040	0.040
Pomar/árvores espaçado	0.060	0.048	0.072	0.060	0.060	0.060
Pomar/árvores denso	0.100	0.080	0.120	0.080	0.080	0.080
Pomar/árvores muito denso	0.120	0.096	0.144	0.100	0.100	0.100

CALIBRAÇÃO - Rugosidades



CALIBRAÇÃO – Intervalo de tempo

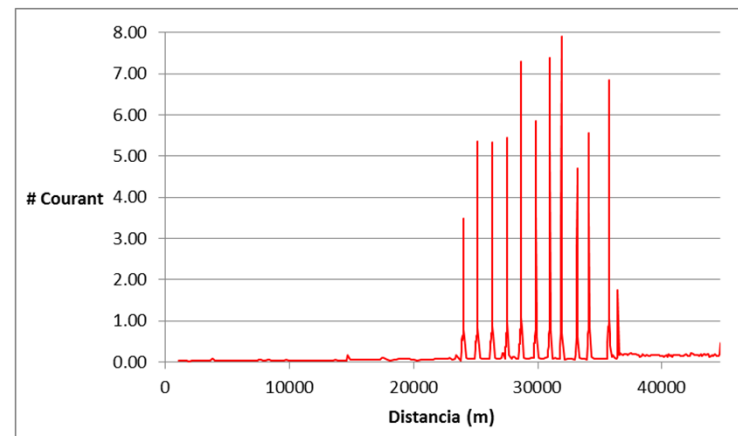
	Corrida 1	Corrida 2	Corrida 3	Corrida 4	Corrida 5	Corrida 6	Corrida 7	Corrida 8
Δt	30min	15min	5min	1min	30s	15s	5s	1s
Tempo de corrida (mm:ss)	00:04	00:05	00:12	00:49	01:35	03:08	07:11	12:24
Máximo erro da superfície livre (m)	0.37	0.42	0.36	0.29	0.26	0.29	0.24	0.14



Erro máximo semelhante

CALIBRAÇÃO – Número de Courant

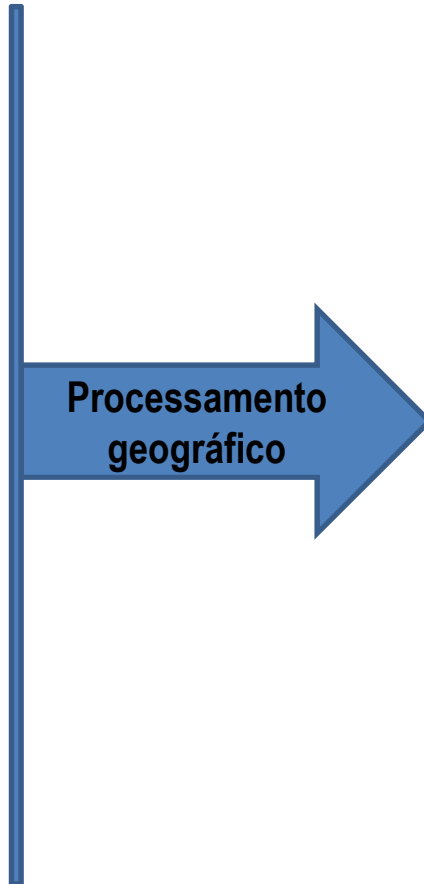
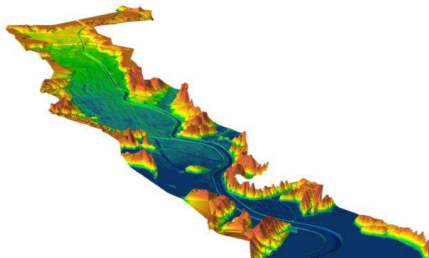
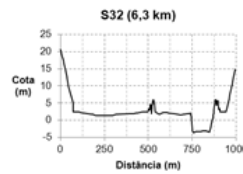
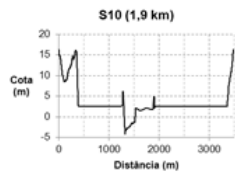
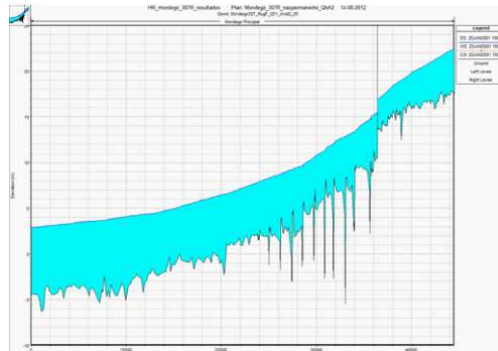
- **Espaçamento entre de secções tem que ser adequado para a estabilização do modelo**
- **Problemas**
 - Instabilidade dos resultados -> variações bruscas das propriedades do escoamento
 - Números de Courant > 1
 - Algumas **secções estavam demasiado próximas/longe**



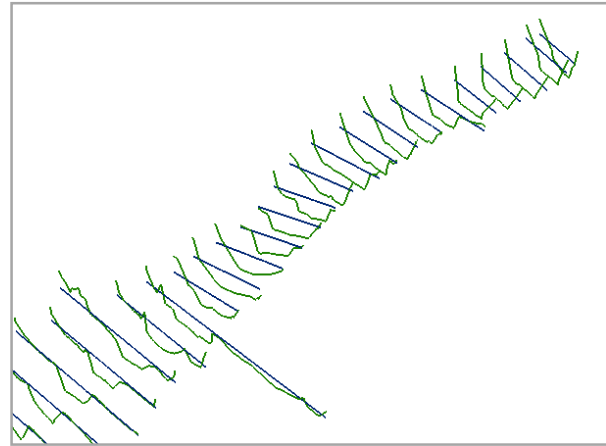
CALIBRAÇÃO – Número de Courant

- **Como resolver?**
 - Homogeneizar / regularizar as distâncias entre secções para atingir número de Courant < 1
 - Eliminar algumas secções
 - Manter as secções mais críticas

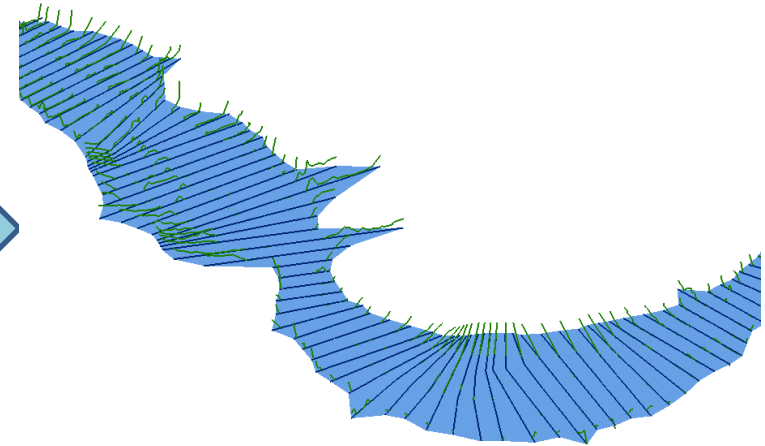
MAPA DE INUNDAÇÃO - Construção



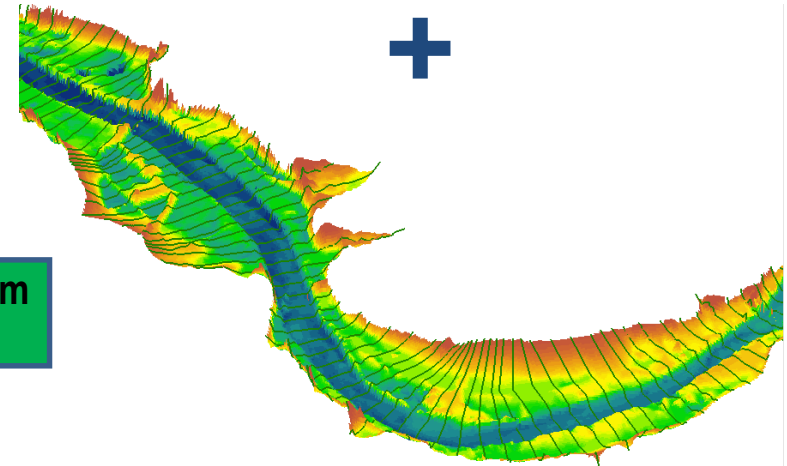
MAPA DE INUNDAÇÃO - Construção



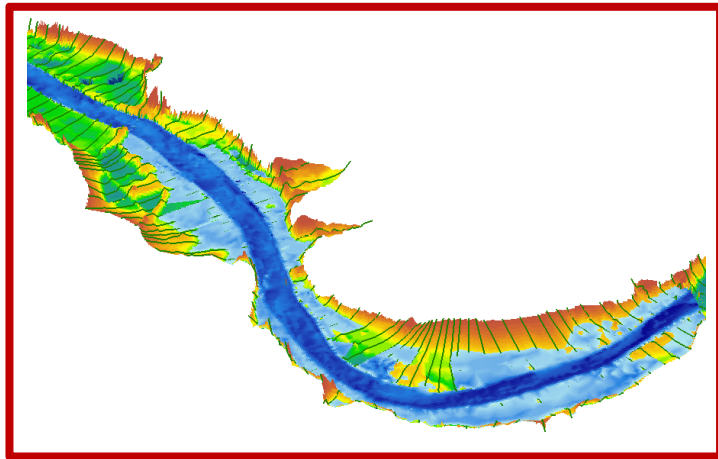
Superfície da água
de cada cenário



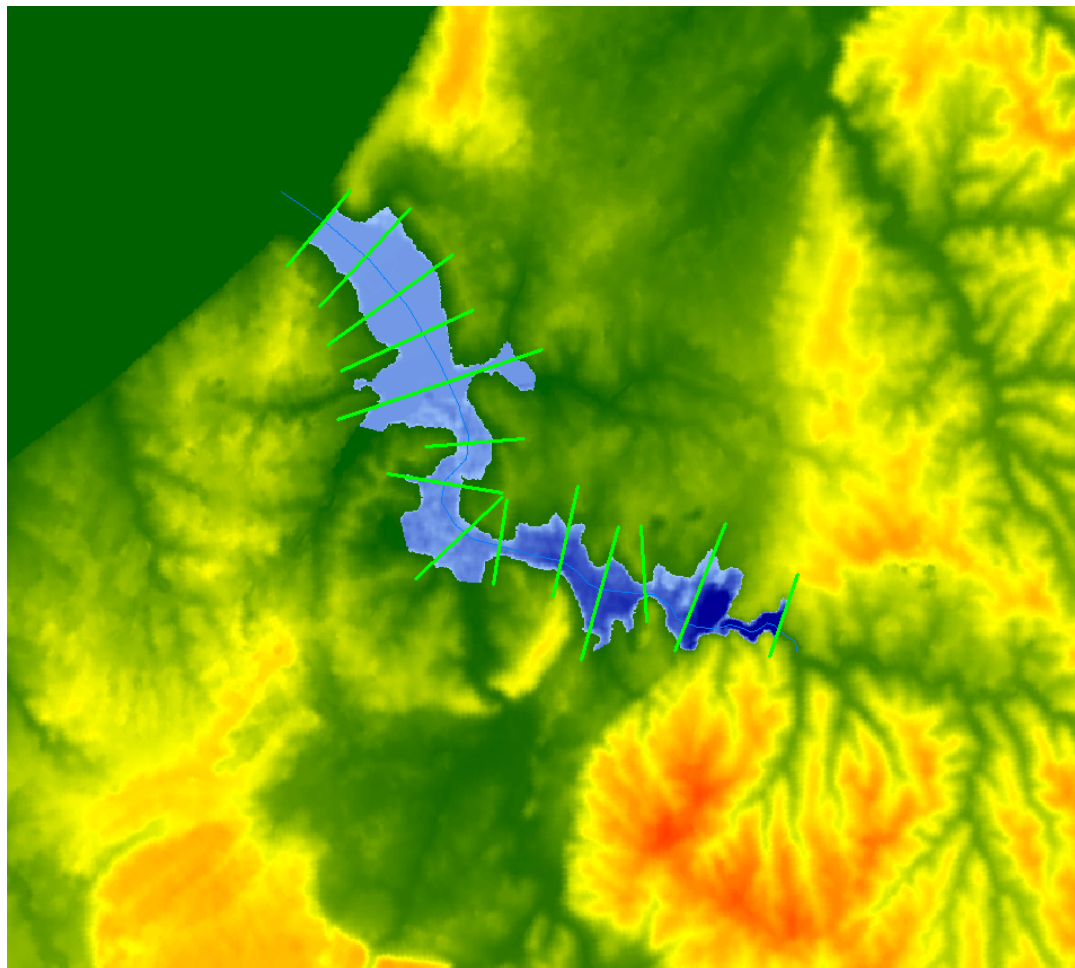
+



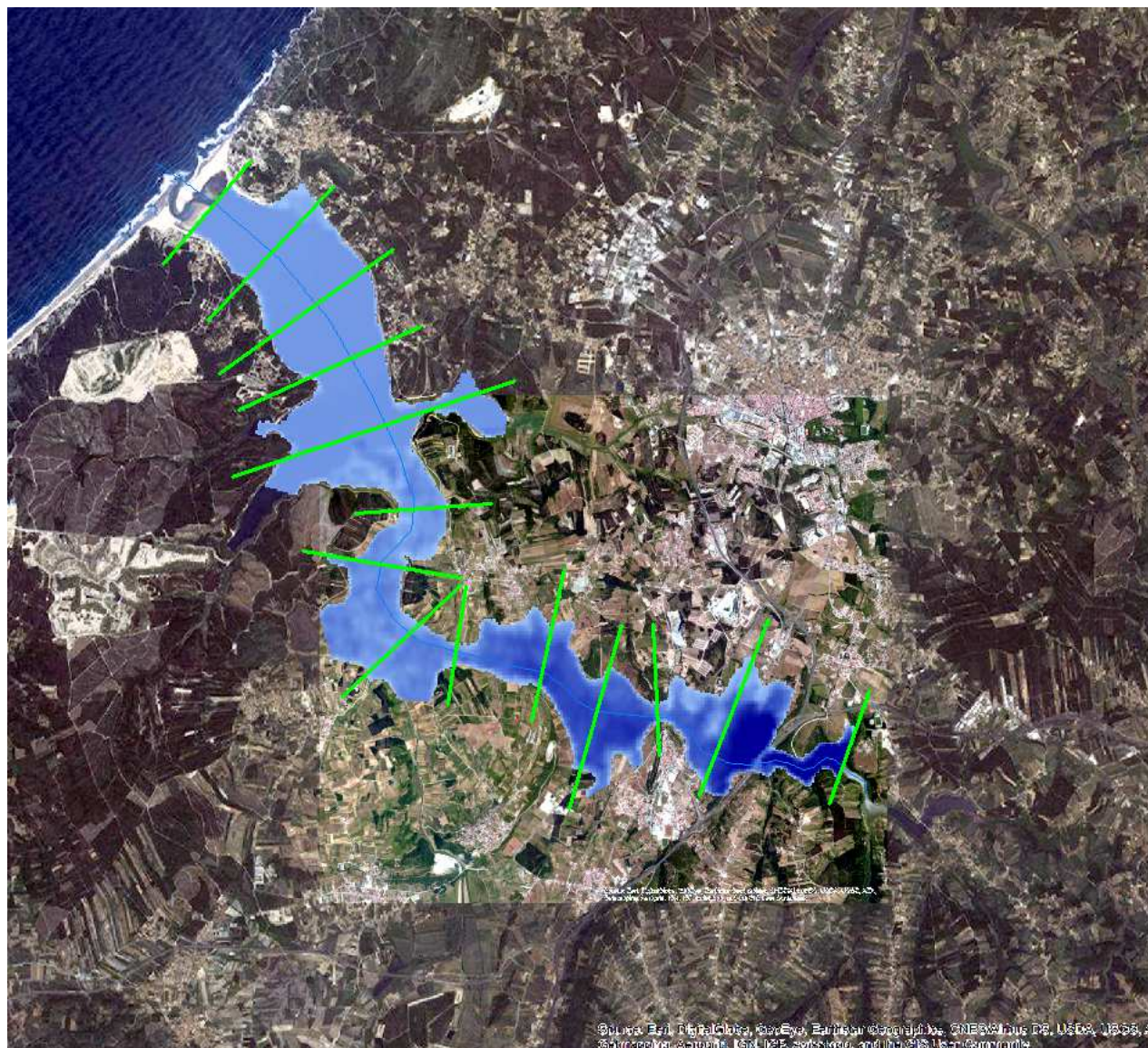
Zona inundável em
cada cenário



DEMONSTRAÇÃO DE HEC-GeoRAS MAPA DE INUNDAÇÃO



DEMONSTRAÇÃO DE HEC-GeoRAS MAPA DE INUNDAÇÃO



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, AeroGRID, IGN, GEBCO, Swisstopo, and the GIS User Community

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, AeroGRID, IGN, GEBCO, Swisstopo, and the GIS User Community

MAPA DE INUNDAÇÃO - Exemplo



CONCLUSÕES

- 1. HEC-RAS + HEC-GeoRAS
são ferramentas MUITO ÚTEIS**
- 2. Os resultados dependem da qualidade dos dados:**
 - geometria das secções
 - ocupação do terreno
 - hidrograma da ruptura
- 3. Os mapas de inundação devem ser analisados e discutidos com cuidado**

