CHIPPENHAM MAPPING & MODELLING STUDY

Comparison of Flood Risk Mapping using FMP TUFLOW and Morphological Mapping Techniques

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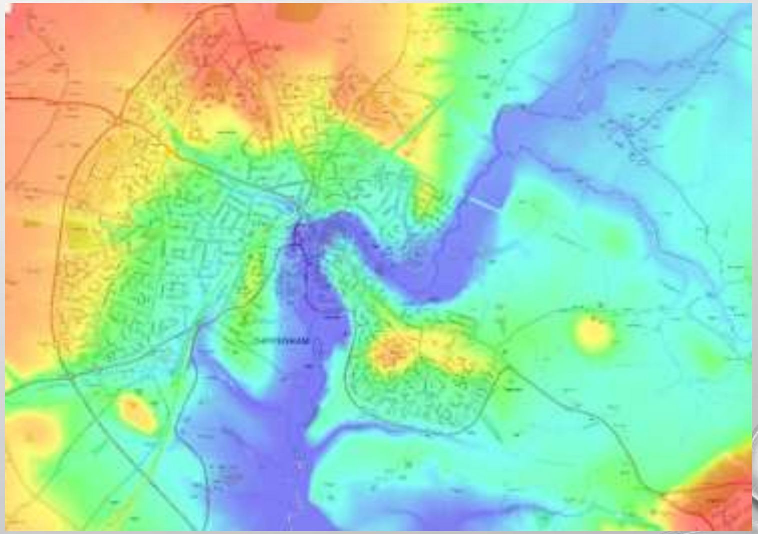
CHIPPENHAM PROJECT OVERVIEW

- Standard Mapping and Modelling project for the Environment Agency through CH2M
- Started in November 2014, modelling commenced following topographic survey in April 2015 by Storm Geomatics
- Calne modelling added as an extension in August 2015
- 2 major rivers, Avon and Marden, and a long record of flows on both these watercourses at Great Somerford and Stanley
- A number of historic flood events, especially 1968 1979 and 2007





PRINCIPLES OF THE HYDROGEOMORPHOLOGICAL METHOD

BASIS OF THE METHOD

STUDY OF ALLUVIAL PLAINS

A **'naturalist'** approach based on the observation and interpretation of floodplain features.

Alluvial plains are composed of **several hydrogeomorphological units** or floodplains separated by terraces that have been shaped by successive floods over centuries.

These features are the results of **sediment accumulation** and **erosion processes**

The method is carried out in two steps:

- Identification of hydrogeomorphological units using aerial photography.
- Field survey and analysis of geomorphological features and their linkages to hydrological processes.

ORIGINS OF THE METHOD

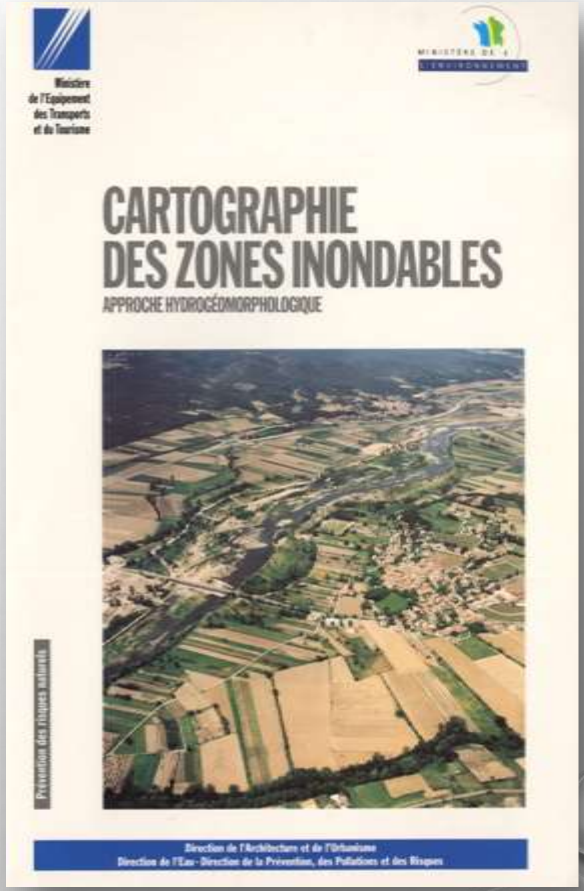
The method was developed by engineers, academics and consultancies, and it was officially approved and adopted by the French Ministry of Transport and Equipment in 1996.

« Cartographie des zones inondables, Approche hydrogéomorphologique » _ 1996.

It has been implemented at national level for the production of an atlas of flood prone areas (Atlas de Zones Inondables) and it is now recommended for the development of flood risk prevention and management plans **in France.**

In 2012, the approach was integrated in technical assessments as part of the implementation of the **Flood Risk Directive*.**

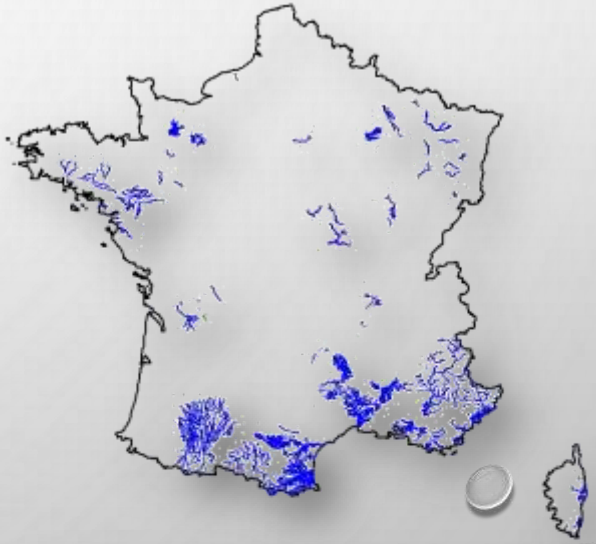
*Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks



ORIGINS OF THE METHOD

In the past 15 years, more than 20,000 km of river has been mapped using this technique in France and abroad (Algeria, Poland, China…).

The method has been successfully applied to a wide range of morpho-climatic conditions (Mediterranean, continental, arid and tropical).



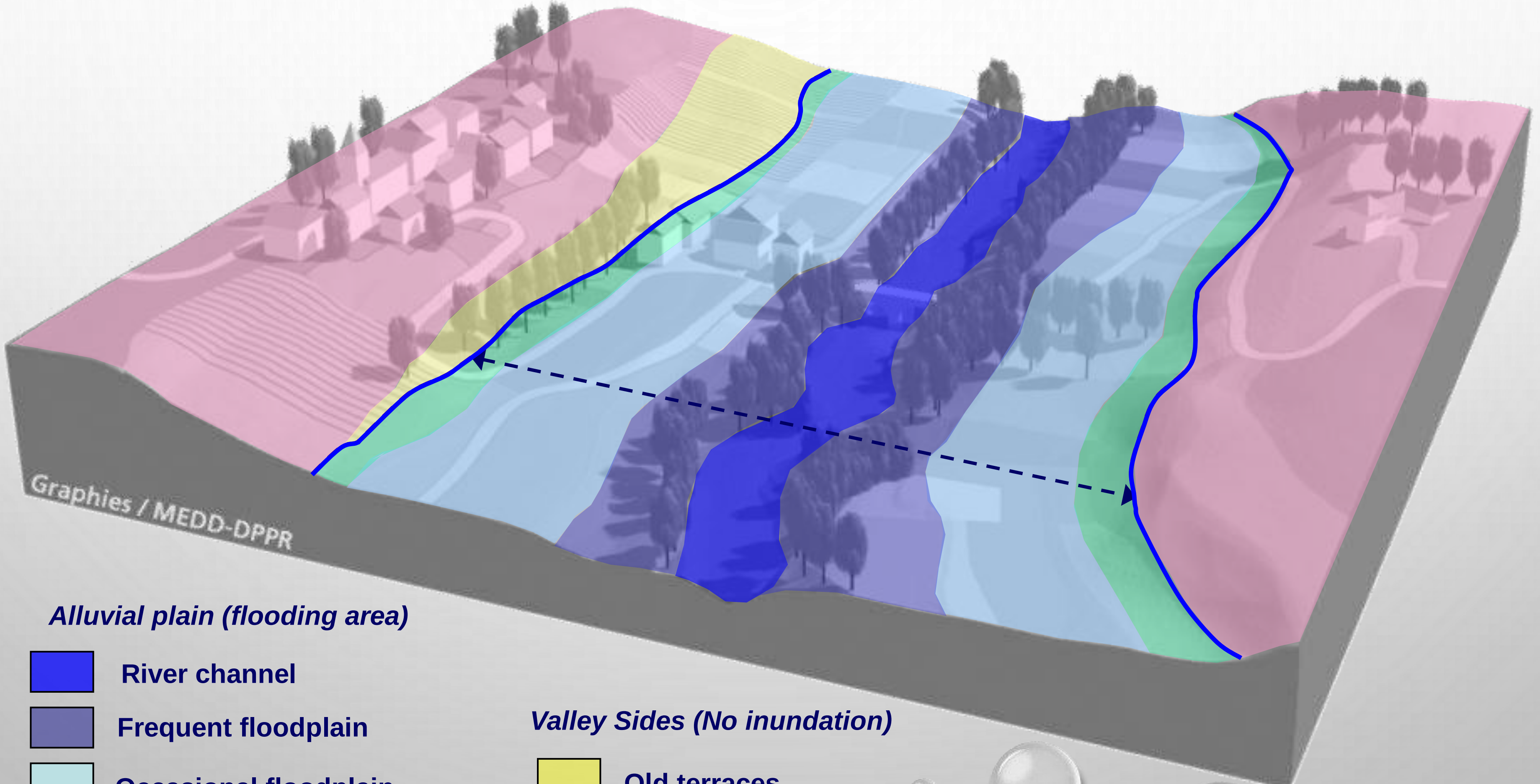
Continental

Arid

Tropical

PRINCIPLES OF THE HYDROGEOMORPHOLOGICAL METHOD

Identification of homogeneous spatial units shaped by different floods and separated by topographical discontinuities



Alluvial plain (flooding area)

- **River channel**
- **Frequent floodplain**
- **Occasional floodplain**
- **Exceptional floodplain**

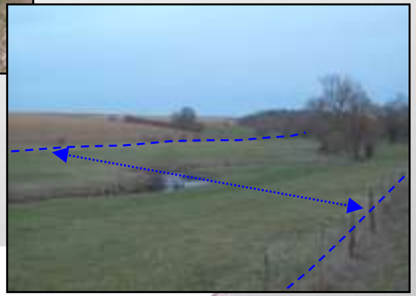
Valley Sides (No inundation)

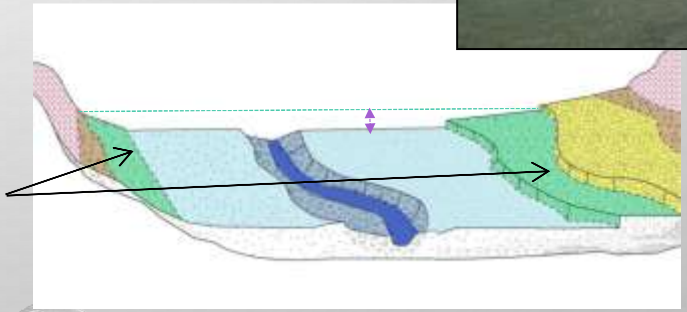
- **Old terraces**
- **Substratum (bedrock)**

Flood zones HGM

HYDROGEOMORPHOLOGICAL UNITS (ACTIVE)

Four active hydrogeomorphological units:





- **The river channel** represents the main river bed and banks.

- **The frequent floodplain** is located next to the river banks and is regularly inundated by frequent floods. It is generally linked to the presence of riparian vegetation connected to groundwater.

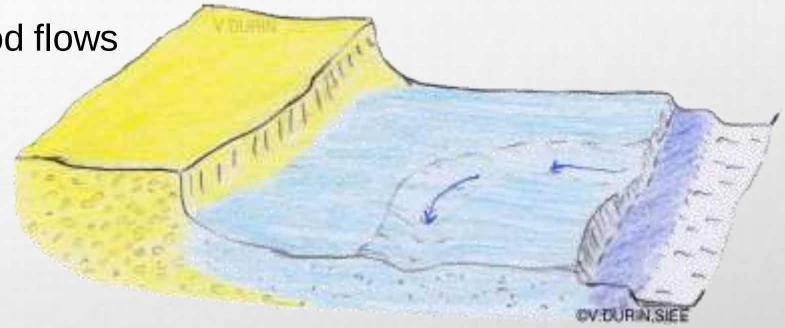
- **The occasional floodplain** is shaped by large floods and covers most of the width of the alluvial plain.

- **The exceptional floodplain** corresponds to transitional areas between the occasional floodplain and the hillside that are very rarely inundated.

HYDROGEOMORPHOLOGICAL UNITS (ACTIVE)

- **SECONDARY HYDROGEOMORPHOLOGICAL UNITS**

The method also records secondary hydrogeomorphological units that are the results of flood flows across the floodplain

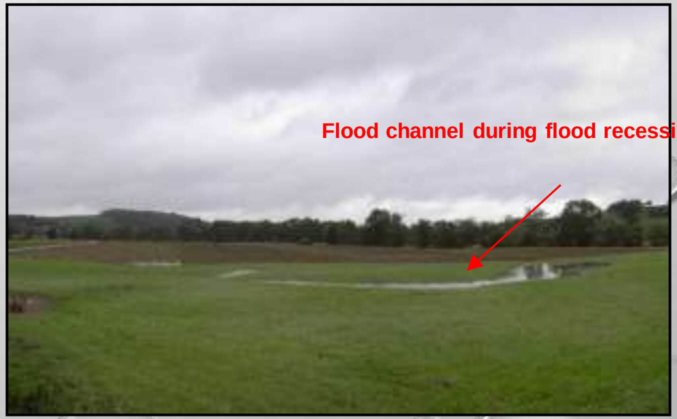


Flood channels and **flood runners** are **elongated depressions observable on frequent and occasional floodplains**.

They can originate either from :

- **Floodplain flows** during large floods.
- Or they are linked to **old abandoned river beds (i.e. paleochannels)**

They are often found in river meanders.



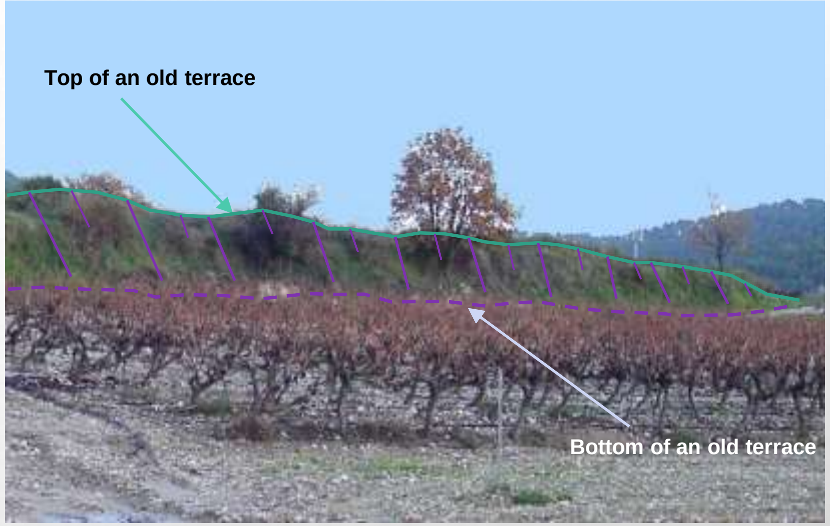
PRINCIPLES OF HYDROGEOMORPHOLOGY

PHYSICAL IDENTIFICATION CRITERIA OF HYDROGEOMORPHOLOGICAL UNITS

The identification and delineation of hydrogeomorphological units are based on two main criteria:

Morphology: the identification of river terraces, break in slope, micro-topographies and any other **topographical structures.**

Sedimentology: the analysis of grain size, the nature and colour of superficial formations.



L'Ouvèze (84)

Coupe dans le talus d'une terrasse

Coupe dans le lit majeur

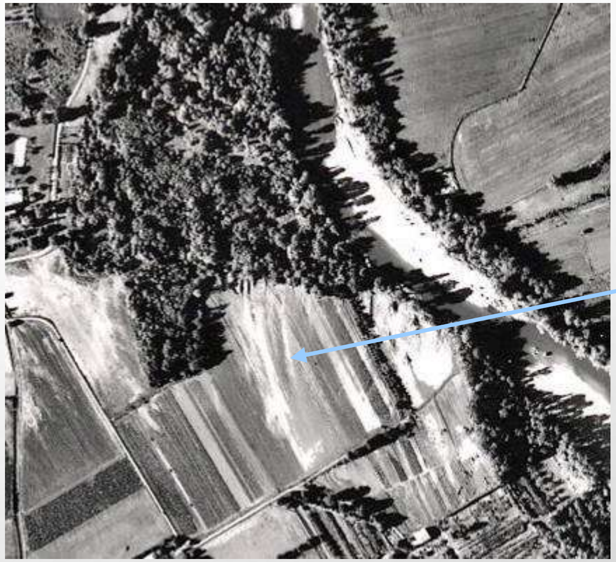
PRINCIPLES OF HYDROGEOMORPHOLOGY

Additional clues

Flooding traces: erosion, fine sediment deposition in the floodplain, flow ‘marks’ observable on aerial photography.

Land use: vegetation will change according to soil type and moisture

The presence of shallow water tables: streams often occur in combination with water tables occurring close to the surface, helping with the identification of hydrogeomorphological units.



Erosion marks in a field after a flood

(Gardon 2002)

A change in vegetation colour indicates the presence of water under the surface.

ADDITIONAL ELEMENTS

Additional elements include land use and artificial and natural structures affecting river flow and flooding frequency.

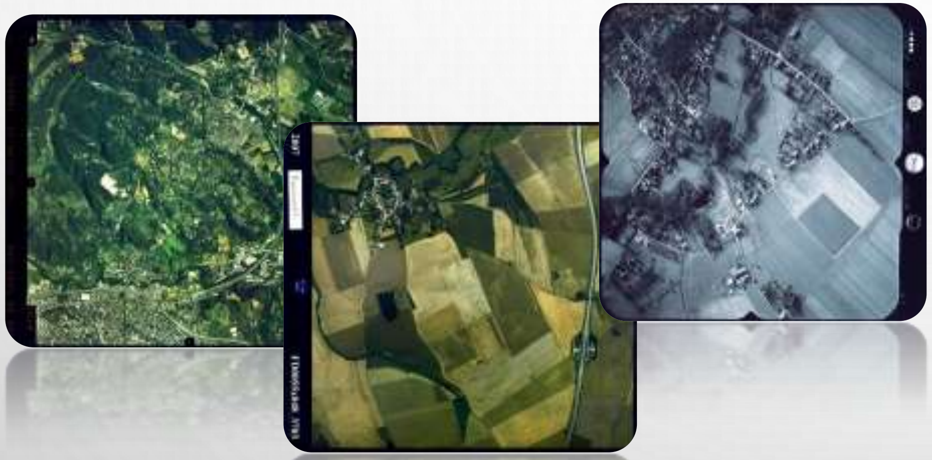
They are identified and located on the hydrogeomorphological units without quantifying their potential impacts on flooding zone.

- **Natural:** the riparian zone

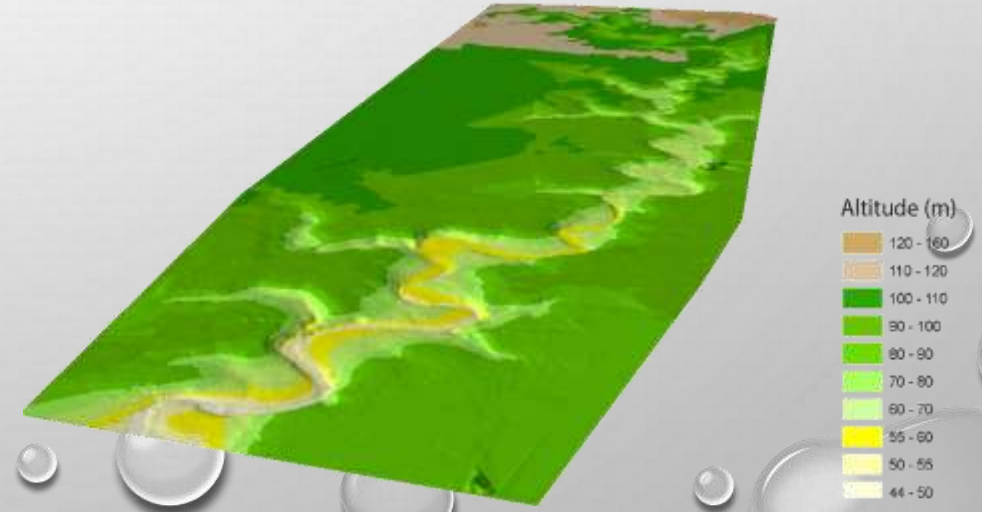
- **Artificial:** Bridges, embankments, weirs, sluice gates

IMPLEMENTATION (1)

Interpretation of stereoscopic aerial photography



In the absence of stereoscopic aerial photography, a Digital Elevation Model or lidar data can be used in combination with standard aerial photos.

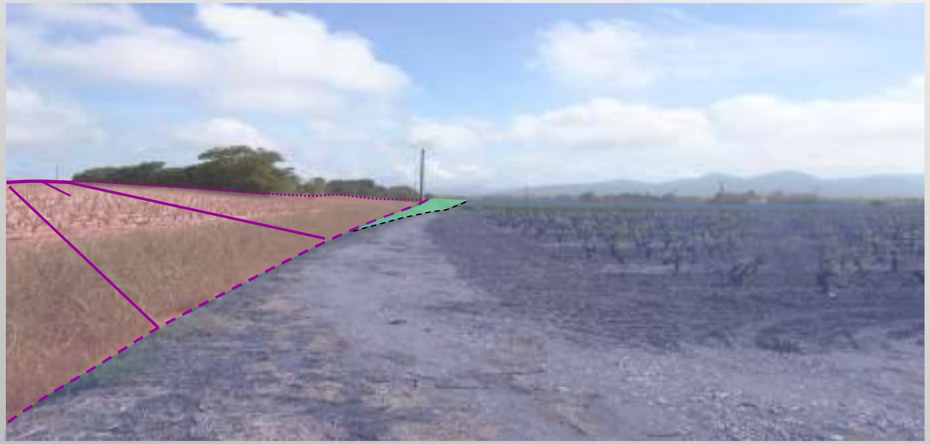


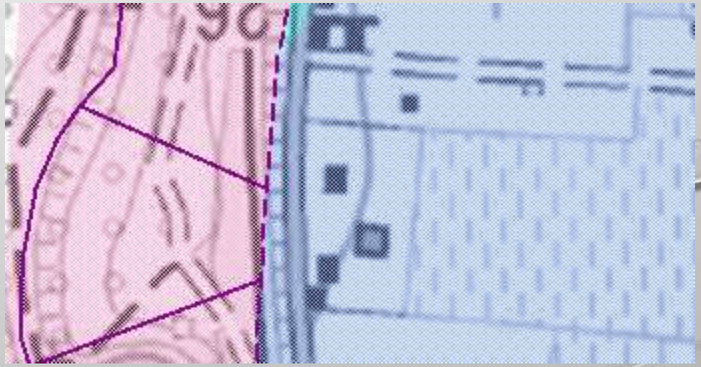
IMPLEMENTATION (2)

Field observation

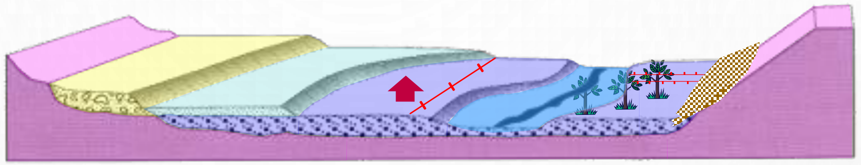
The features identified and delineated on the maps using aerial photography are validated in the field by experts. They will specifically concentrate on:

- **the identification of river terraces**
- **the correct positioning and delineation of hydrogeomorphological units on the map**





MAP CONTENT



The way maps are presented is standardised.

Two groups of features

1. Hydrogeomorphological features

-River channel, floodplain, terraces, valley side

2. Land use and artificial structures

-Weirs, bridges, etc

Modern alluvial floodplain

- River channel
- Frequent floodplain
- Occasional floodplain
- Terrace

Valley side (outside the flood limit)

- Old terrace
- Bedrock

Artificial structures

- Embankments linked to infrastructure (e.g. train line)
- Embankments, levees, walls
- Land buildup

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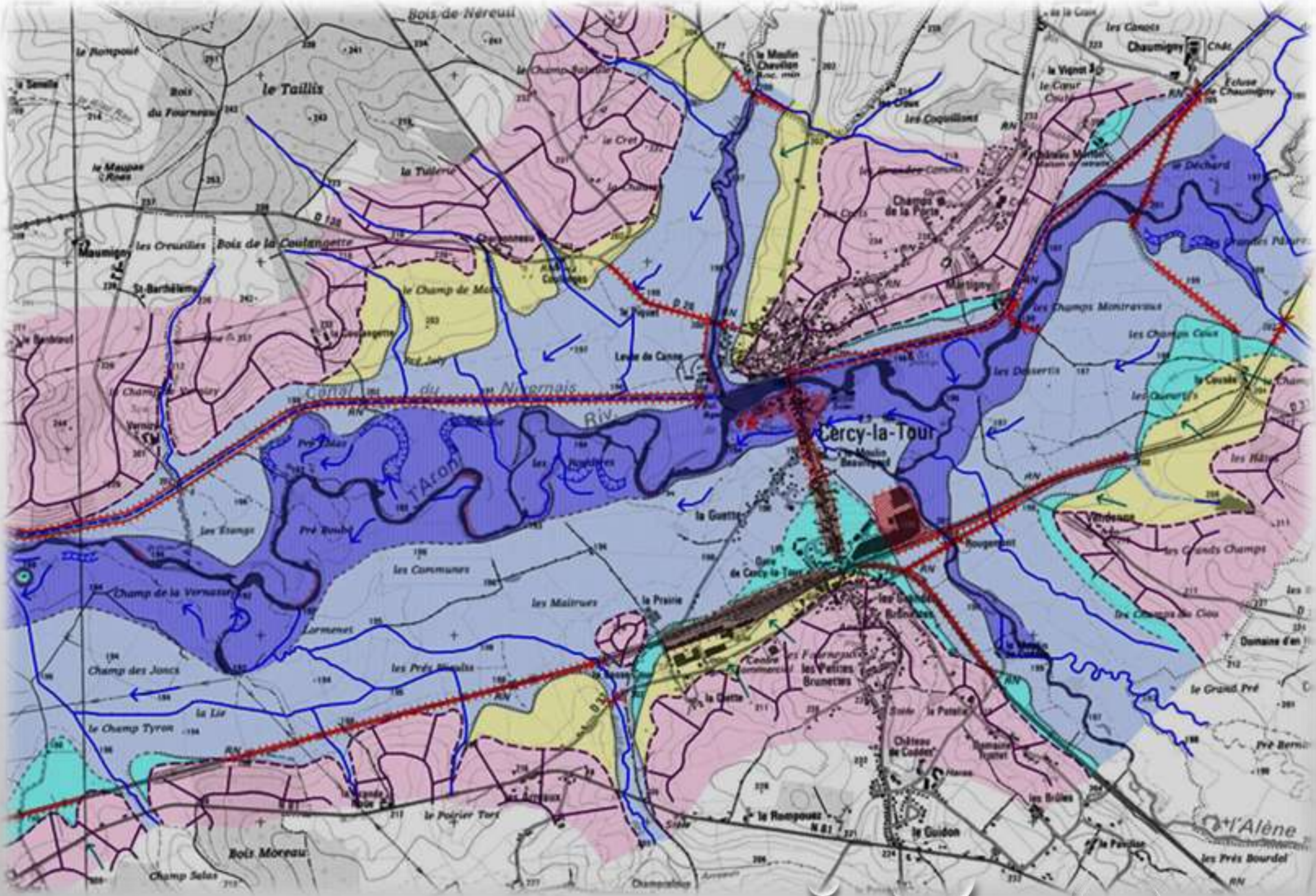
FINAL MAP

EdenvaleYoung



CASE STUDY COMPARISON OF HYDROGEOMORPHOLOGICAL AND HYDRAULIC MODEL OUTPUTS

RIVER AVON AT CHIPPENHAM

HYDROGEOMORPHOLOGICAL STUDY OF THE RIVER AVON

Aim

Demonstrate the relevance and potential use of the hydrogeomorphological method for the assessment of flood risk in UK rivers.

Case study carried out in partnership between Edenvale Young and Riverdene Consultancy on 10 km of the river Avon near Chippenham.

Objectives:

- ⇨ Application of the hydrogeomorphological method to a British river alongside traditional hydraulic modelling techniques.
- ⇨ Comparison of flood risk boundaries produced by the hydrogeomorphological methods and by hydraulic models.
- ⇨ Assessment of flooding frequencies associated with flood boundaries identified by the hydrogeomorphological method using hydraulic models and historical data.

HYDROGEOMORPHOLOGICAL STUDY OF THE RIVER AVON

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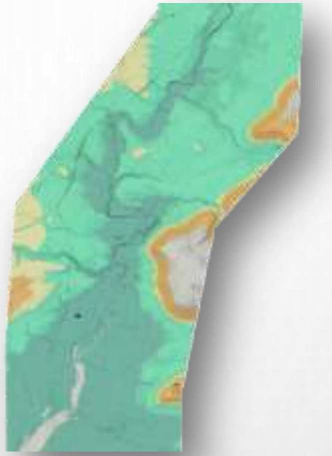
1. MATERIAL



Data:

- ❖ geological maps
- ❖ topographical maps and aerial photo
- ❖ Lidar data (DEM)

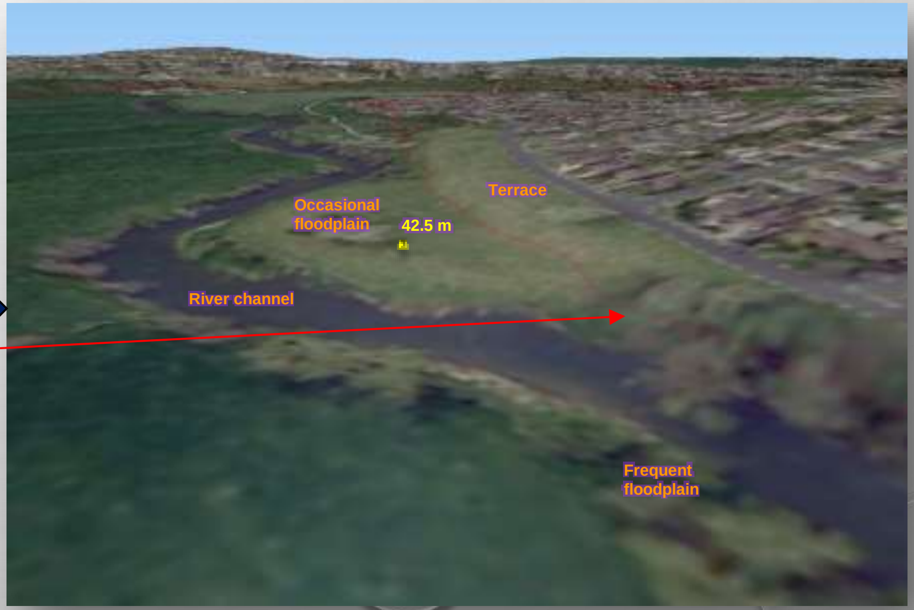
⬇

GIS processing using Qgis

In this case, because of the lack of stereoscopic aerial photography, we used a **three-dimensional model generated** using lidar data and aerial photography in QGIS.

This provided a morpho-topographical model that could be used

- ⇨ To identify hydrogeomorphological units.
- ⇨ To delineate the outer limits of the flooding area (contact plaine alluviale / encaissant).



Completion time: 4 days (1 person)

HYDROGEOMORPHOLOGICAL STUDY OF THE RIVER AVON

2. FIELD WORK

Carried out in July 2015 by two surveyors **over 2.5 days**.

Stone and brown-red earth

Fine dark-brown earth and silt

Objectives:

- Identify the exact nature of hydrogeomorphological units in transitional areas, especially at the interface between the occasional floodplain and old terraces **(sediment analysis)**
- Validate the outside flood boundaries, especially in urban areas.
- Identify additional flood features such as flood runners, flood channels etc

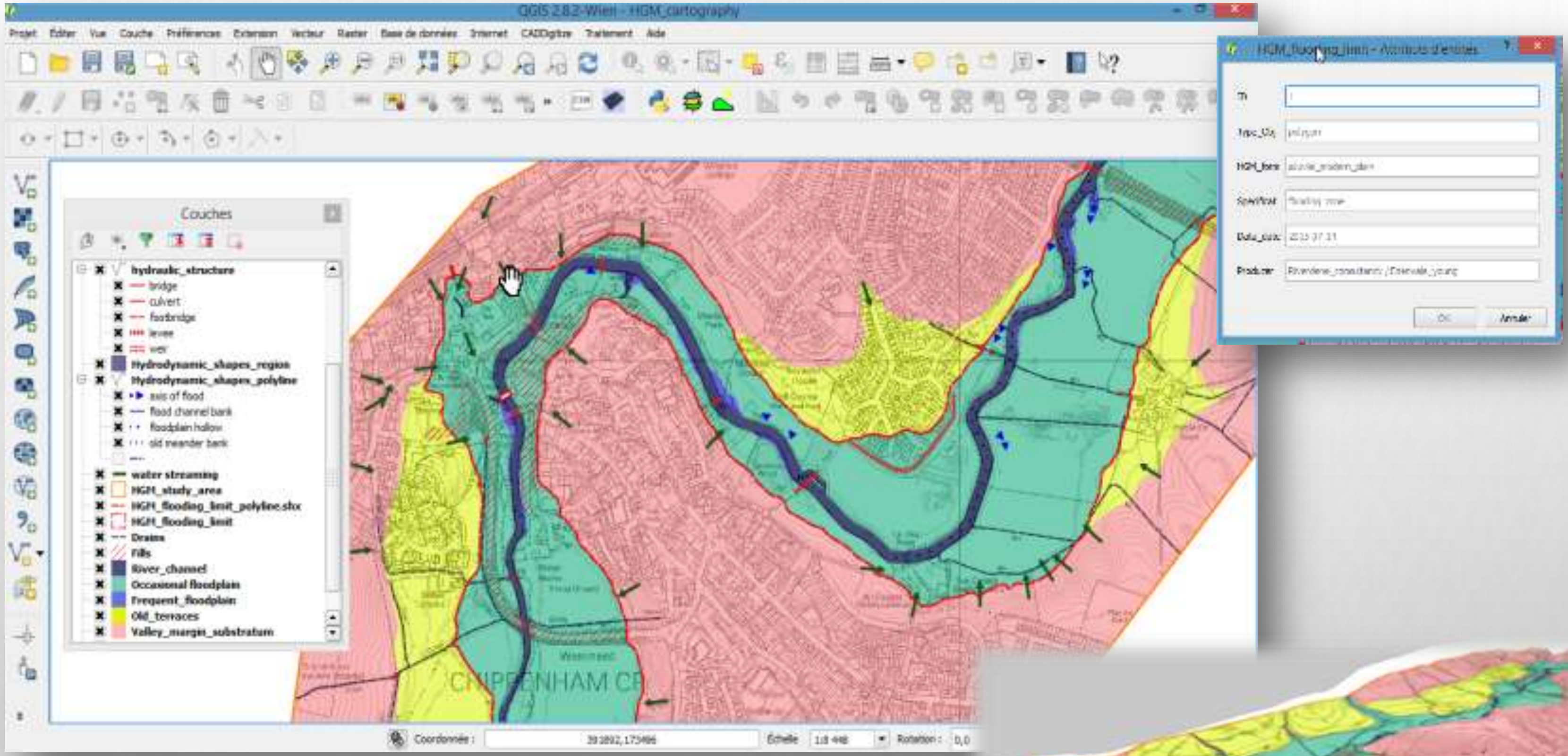
Completion time: 5 days (2 x 2.5 days)

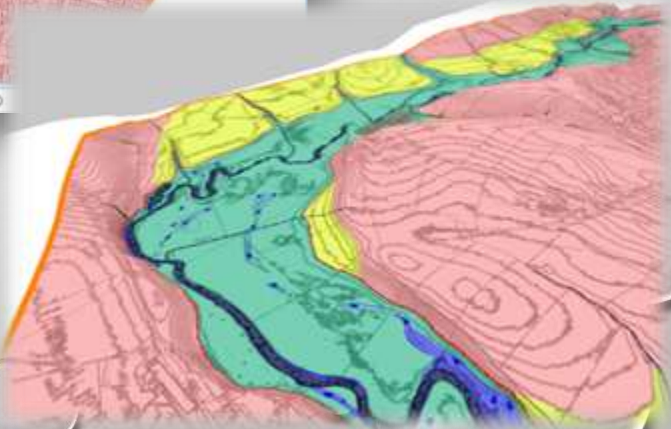
HYDROGEOMORPHOLOGICAL MAP

3. MAPPING

⇨ Done using QGIS.

Completion time: 6 days (2 x 3 days)





3-D map and visualisation tools

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COMPARISON HYDROGEOMORPHOLOGY - HYDRAULIC

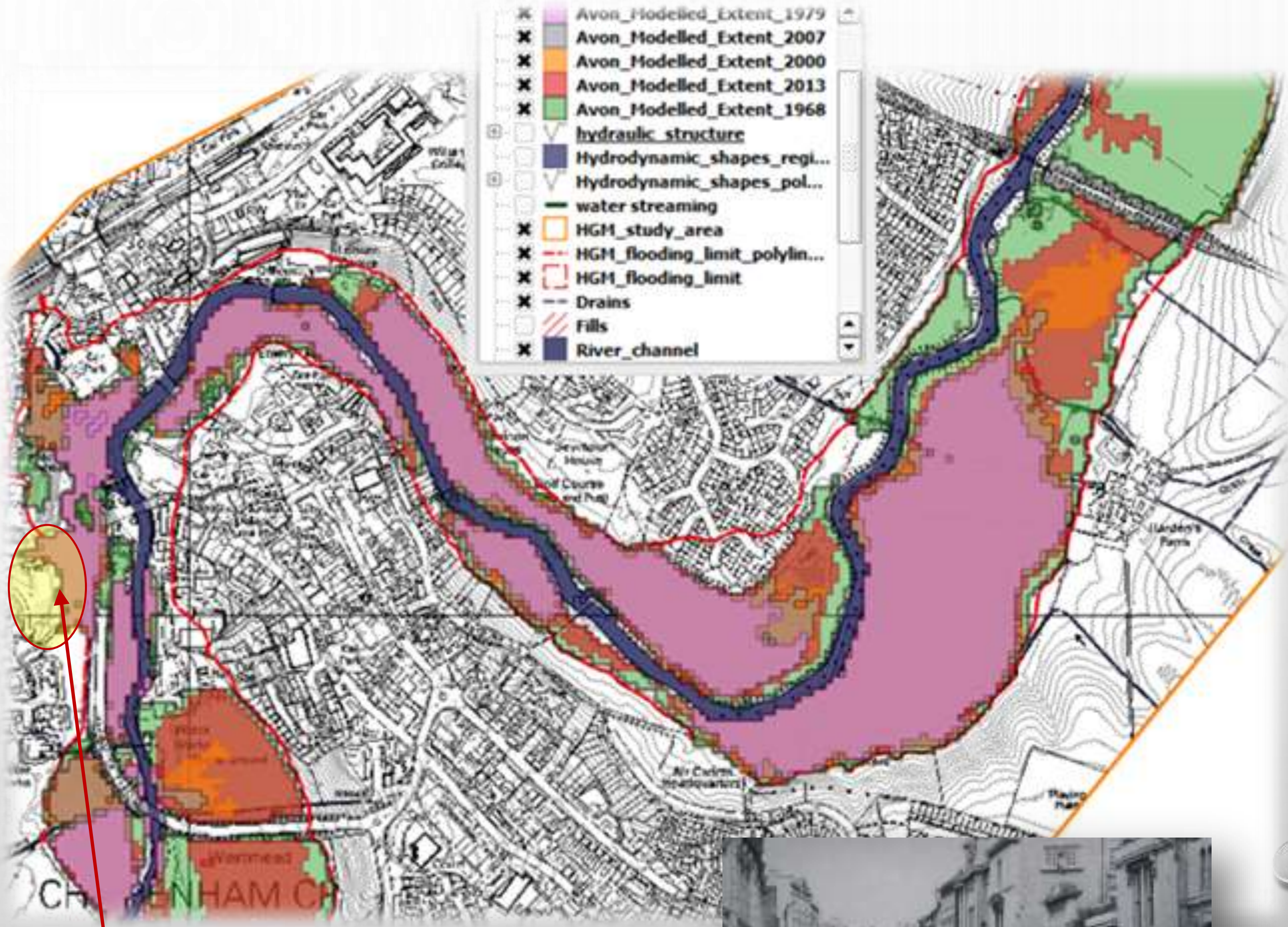
1. HISTORIC FLOOD MODELISATION

5 historical floods were modelled and compared to boundaries derived using the hydrogeomorphological method:

Q_{100} 1979 et Q_{200} 1968

⇨ **All history flood areas were contained within the hydrogeomorphological boundaries *.**

⇨ **The highest recorded historical floods** 1968 (Q_{200}) **nearly covers the area identified as the occasional floodplain** except in urban areas that have been embanked or filled.



(*) NB error in the interpretation linked to lack of access and the presence of woodland hiding the features fron the air

The 1968 flood

COMPARISON HYDROGEOMORPHOLOGY - HYDRAULIC

2. FLOOD MODELLING

3. Comparison to Q200, Q500…and Q1000

Q200

Q500

Q1000

- With the exception of built-up urban areas **the 500 year flood (Q500) best matches the boundaries identified by the hydrogeomorphological method.**
- **The Q1000 area cover and slightly exceed the hydrogeomorphological boundaries** with some spillages on the lower parts of old terraces and hill slopes.
- **Flow recurrence corresponding to hydrogeomorphological boundaries:**

Q500 < X < Q1000

COST-EFFECTIVE METHOD FOR FLOOD RISK ASSESSMENT AND SCREENING

❖ The hydrogeomorphological assessment was implemented **in 15 days** compared to **5 months** for producing detailed hydraulic model simulations.

❖This is in line with previous experience abroad where the cost of the hydrogeomorphological method was estimated to be about **1/5th** (**20%) of modelling costs** (not including equipment).

❖Beyond the Chippenham case study, the methodology has been validated abroad using **simulation models** and **real scale events** over the past 15 years.

❖The methodology requires little equipment but relies on geomorphological and aerial photography interpretation expertise.

❖The methodology is carried by experts who are able to recognise additional features potentially influencing floods.

❖ This is best used in conjunction with hydraulic modelling, as it pinpoints areas where risk is likely to be increased, allowing modelling to focus on those areas in greater detail.

LIMITATIONS

❖ The information provided are qualitative and do not enable the quantification of flood return periods velocities for identified boundaries.

❖ The impacts linked to the presence of man-made modifications such as bridges or weirs are recorded but cannot be fully taken into account when assessing risk.

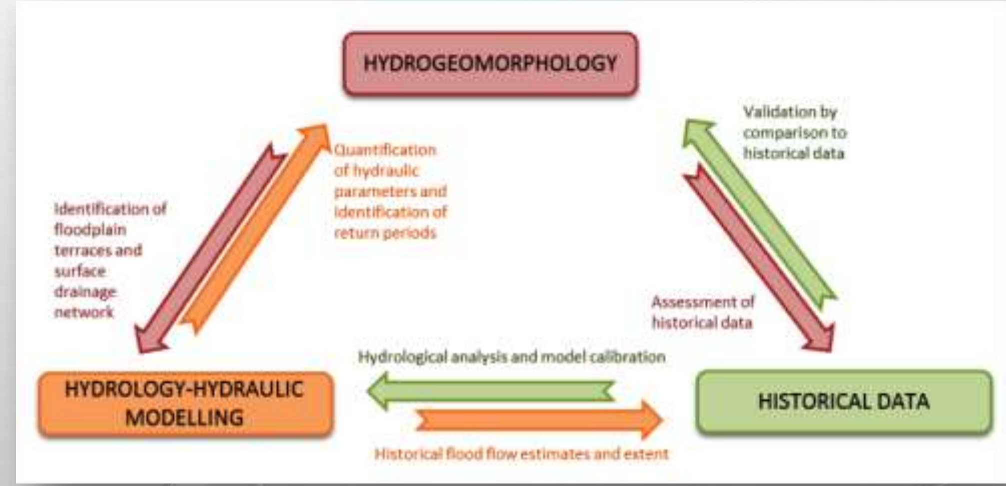
❖ In complex situations where urbanisation has deeply modified the morphology of the floodplain, it may be difficult to identify precisely natural flood boundaries unless old aerial photographies are available.

❖Stereoscopic aerial photography are available but can be expensive because they require manual scanning. As an example, the cost of Chippenham stereo aerial photo would have been £700+VAT. However, it be possible to get cheaper deals by dealing with OS and aerial photo providers directly. Alternaively, Lidar data can be used.

CONCLUSION

- The Chippenham case study demonstrates the potential of using the hydrogeomorphological method for identifying flood risk boundaries for frequent to more exceptional floods.

- The method is compatible and comparable to hydraulic modelling outputs and provides a framework for assessing flood risk in a cost-effective way (useful for screening risks) and validating simulation models along with historical data analysis.
- All three methods are complementary and should ideally be used in combination as they provide similar information and prediction from different perspectives thus building the burden of evidence for flood risk assessment.



More information at www.riverdeneconsultancy.com