

# Remote survey of large gravel riverbeds using digital photogrammetry and image analysis

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# The problem: How to survey large gravel riverbeds

- Conventionally using cross-sections:
  - Coarse spatial and temporal resolution
  - Unreliable estimates of morphological change
- Remote survey (measurement using non-contact methods) allows 'snapshot' of the riverbed:
  - Temporal resolution set by image interval
  - Spatial resolution set by image scale

# The research project

- To use digital photogrammetry and image analysis to obtain riverbed surfaces of the Waimakariri river for 3 epochs:

- February 1999

- March 1999

- February 2000

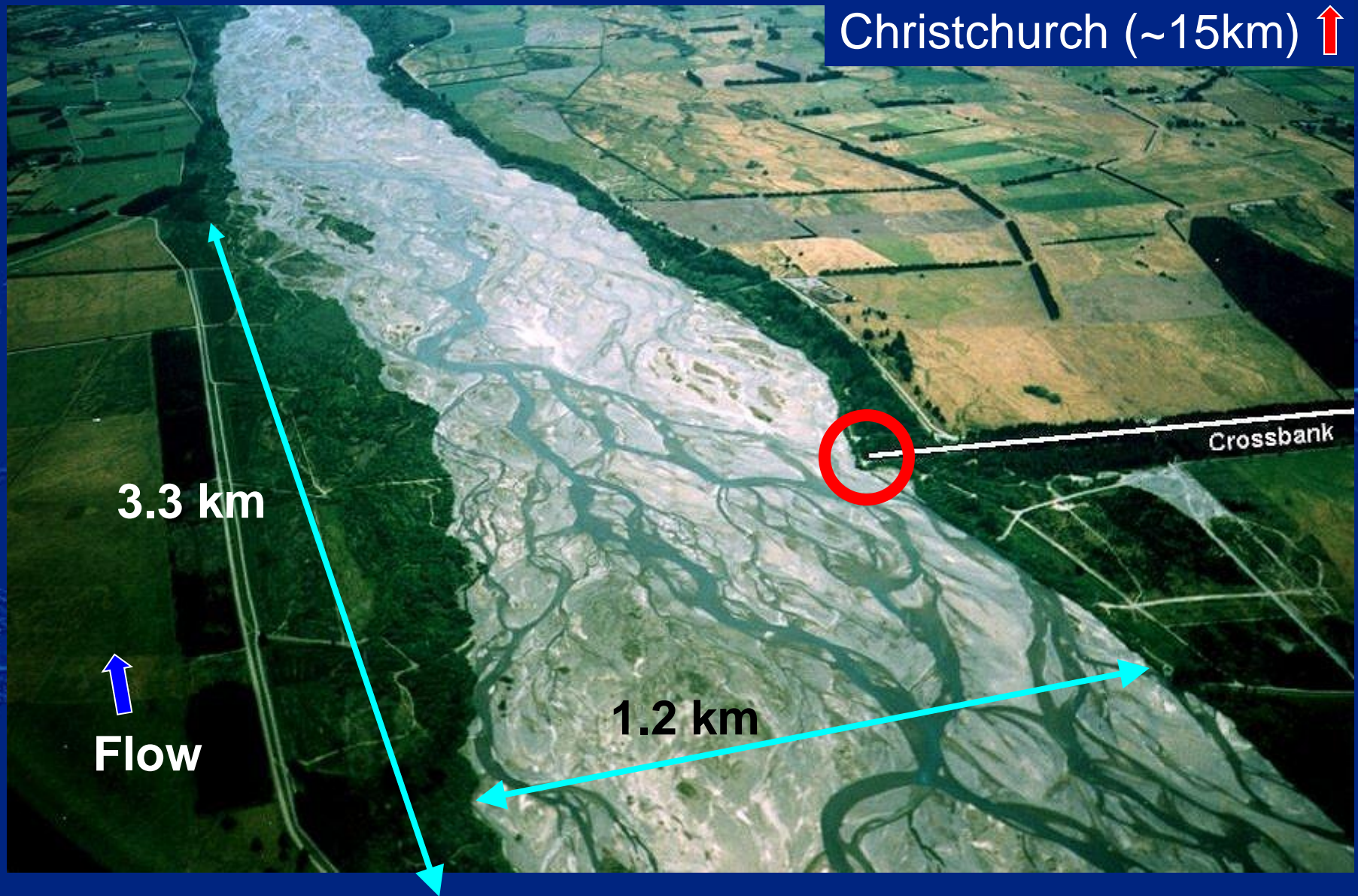


Large (bankfull) flood event  
Annual change

- *May 2000 (Laser altimetry) - See poster paper by Hicks et al.*



# The field site: The Waimakariri River



# Remote survey method - Aim

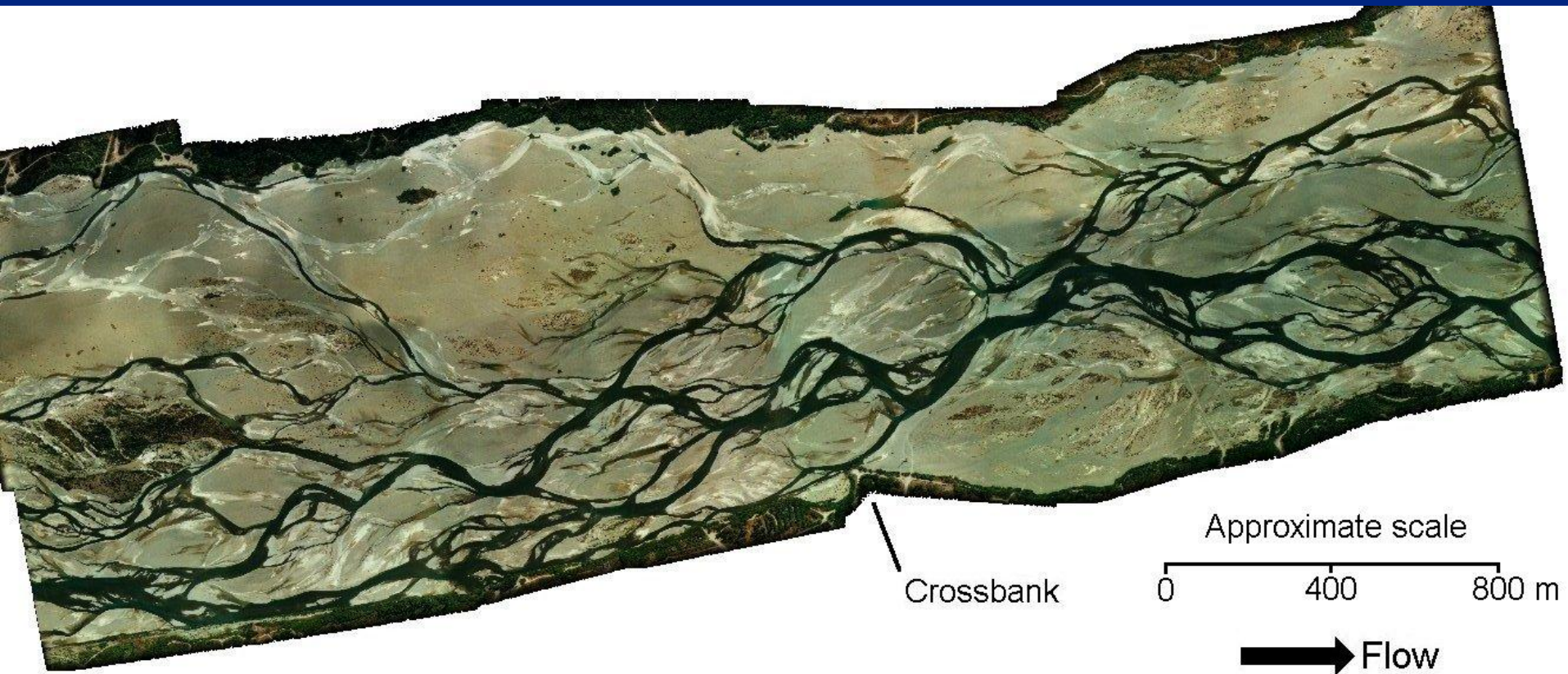
**Aerial  
photographs**



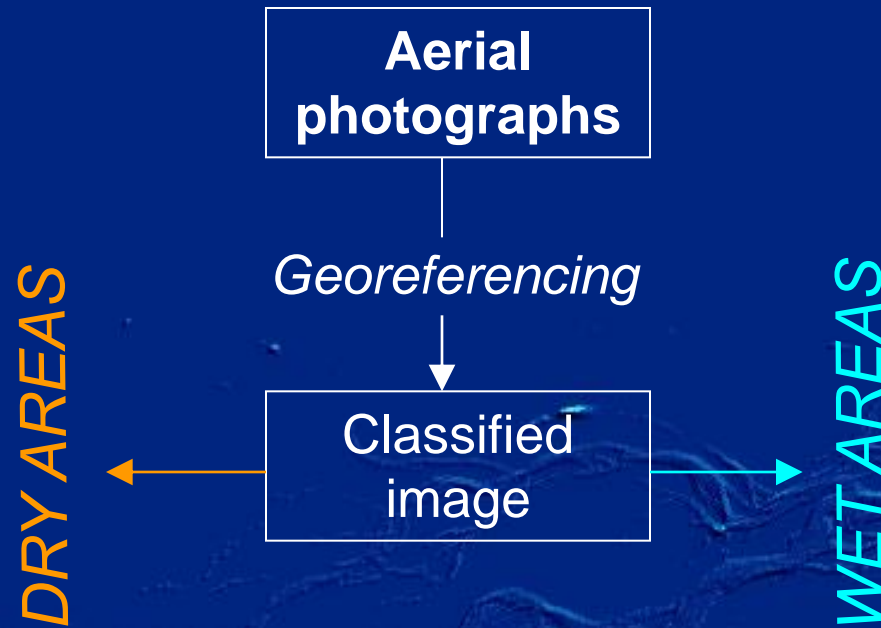
**Final riverbed  
surface (DEM)**



# Aerial photographs - Feb 1999

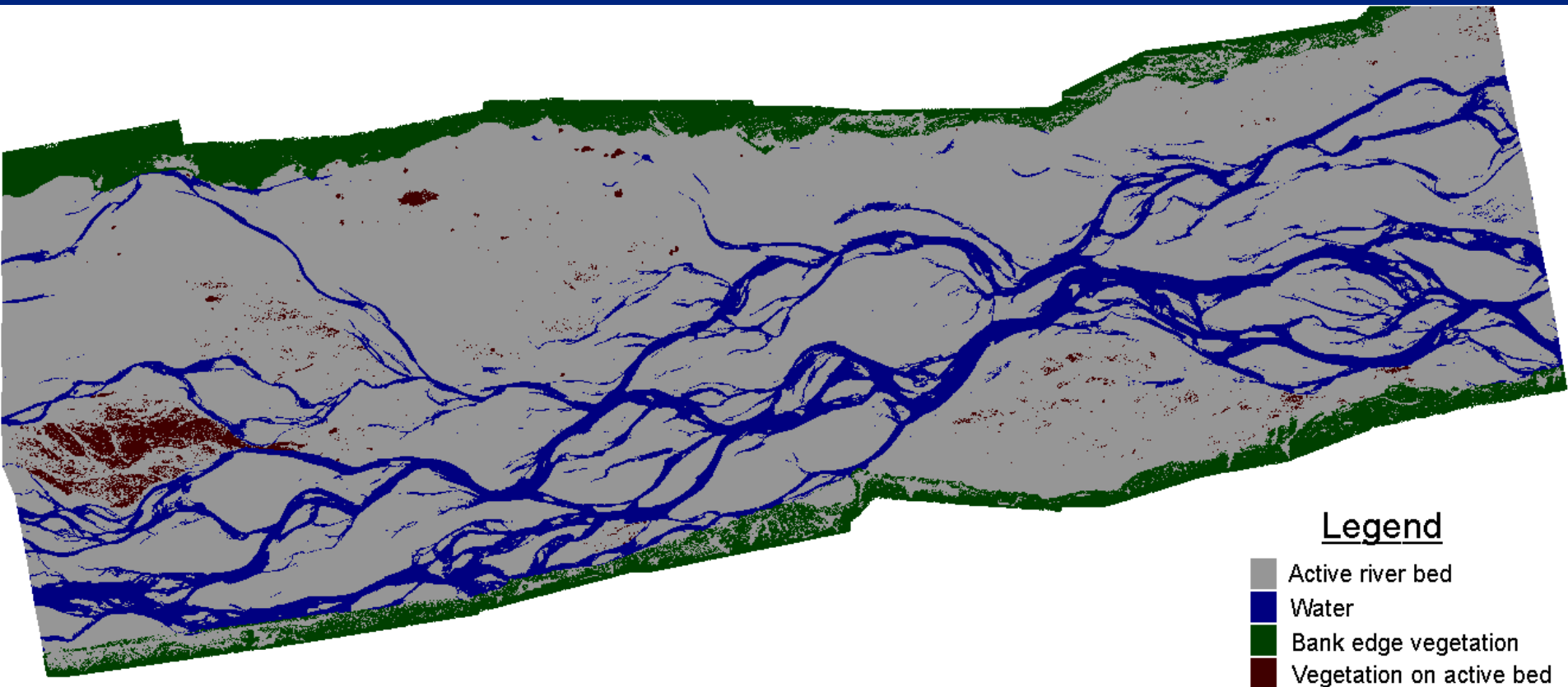


# Remote survey method - Step 1



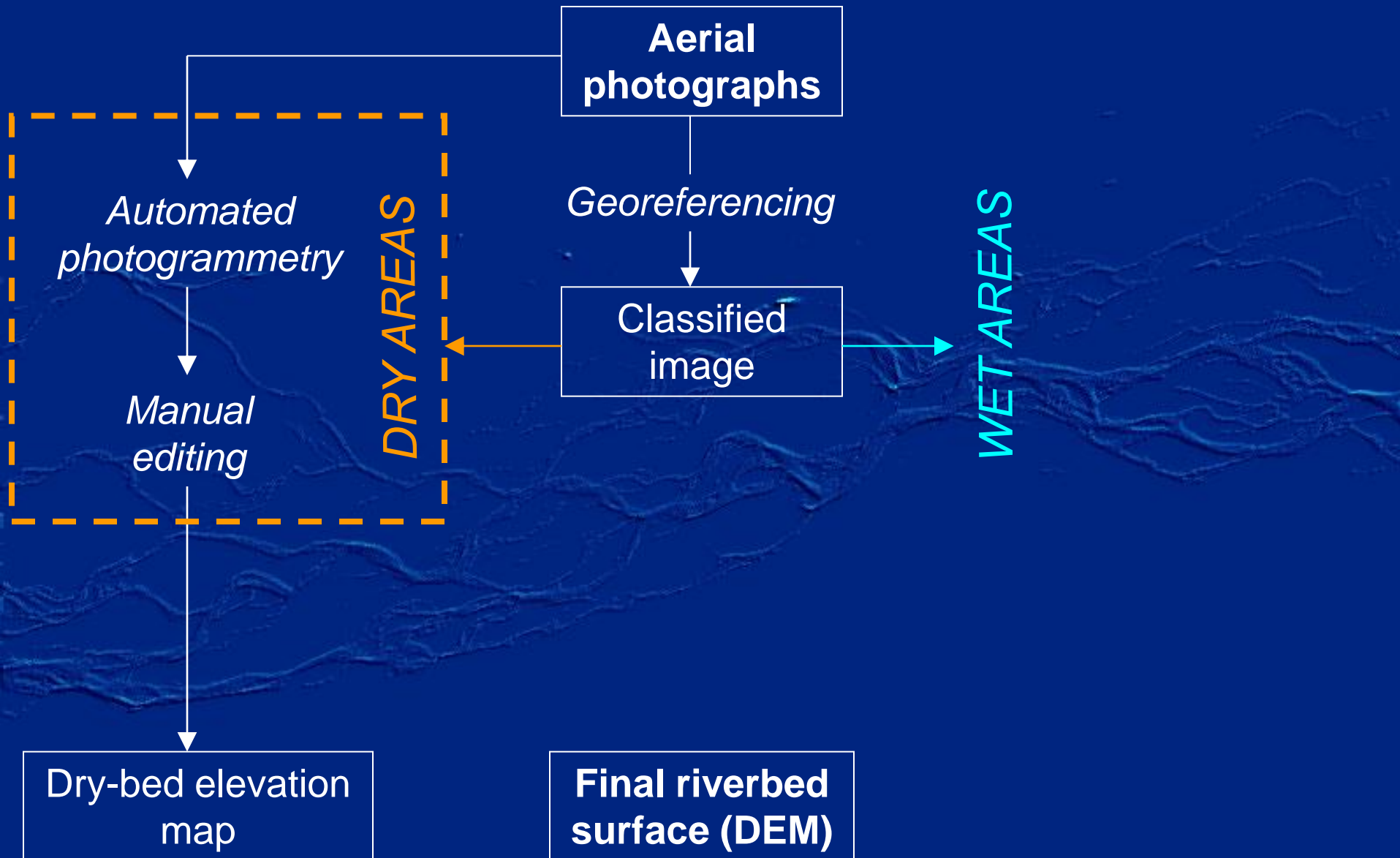
**Final riverbed  
surface (DEM)**

# Classified image - Feb 1999





# Remote survey method - Step 2



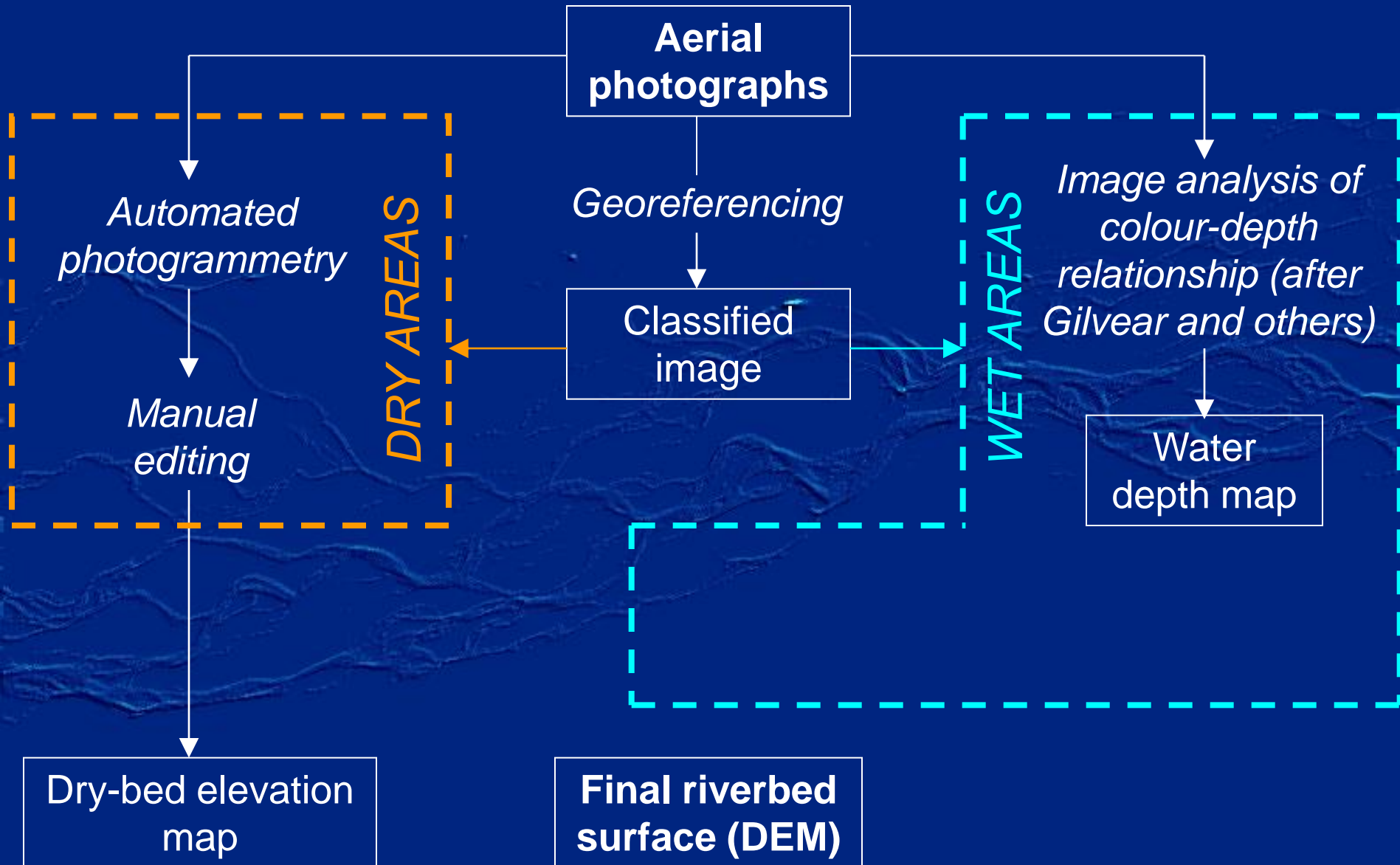
# Remote survey method - Step 3

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graph TD; AP[Aerial photographs] --> AP2[Automated photogrammetry]; AP --> G[Georeferencing]; AP2 --> ME[Manual editing]; ME --> DBEM[Dry-bed elevation map]; G --> CI[Classified image]; CI --> IACD[Image analysis of colour-depth relationship (after Gilvear and others)]; IACD --> WDM[Water depth map]; CI --> DBEM; WDM --> FRSD[Final riverbed surface (DEM)]; DBEM --> FRSD;
```

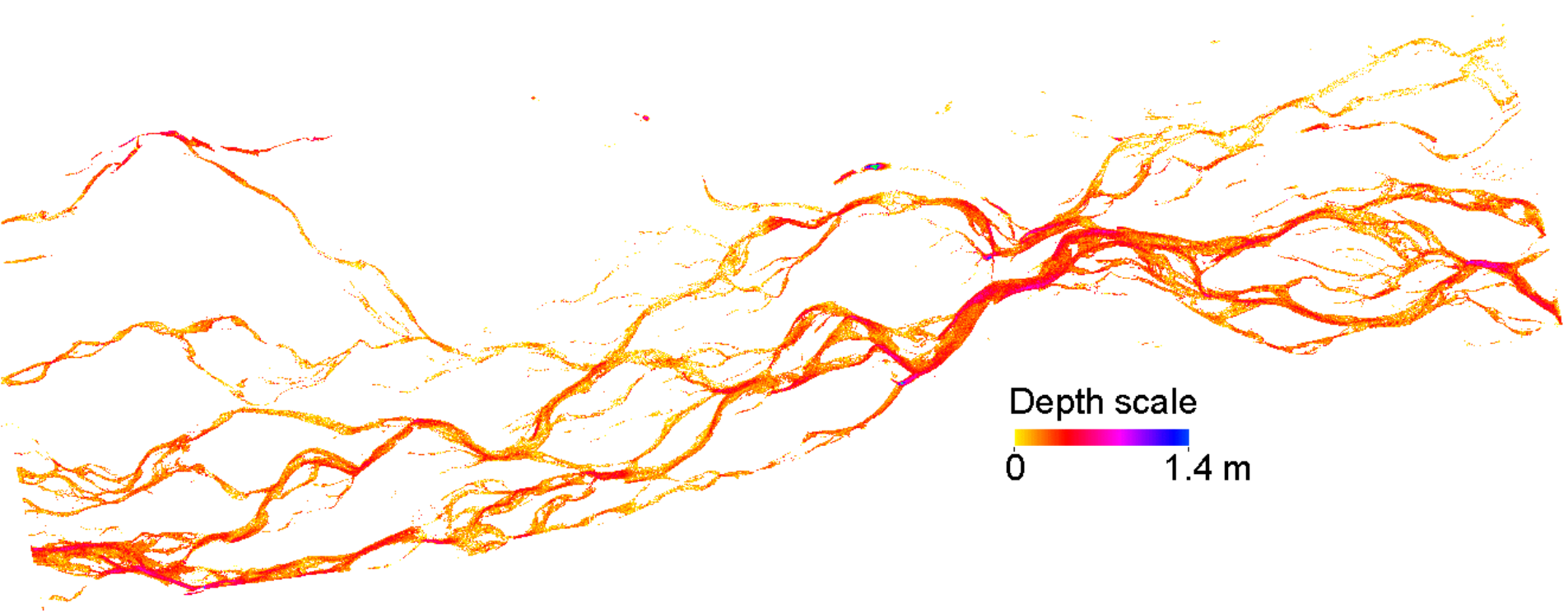
The diagram illustrates the workflow for Step 3 of a remote survey method, set against a background of a riverbed topographic map. The process begins with **Aerial photographs**. This input splits into two main processing paths:

- Dry Areas Path (Orange dashed box):** Aerial photographs are processed through *Automated photogrammetry* and *Manual editing* to generate a **Dry-bed elevation map**. This entire section is labeled **DRY AREAS** in orange text.
- Wet Areas Path (Cyan dashed box):** Aerial photographs are first *Georeferenced* to create a **Classified image**. This image then undergoes *Image analysis of colour-depth relationship (after Gilvear and others)* to produce a **Water depth map**. This entire section is labeled **WET AREAS** in cyan text.

Both the **Dry-bed elevation map** and the **Water depth map** are integrated to produce the final output: the **Final riverbed surface (DEM)**.



# Water depth map - Feb 1999





# Remote survey method - Step 4

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graph TD; AP[Aerial photographs] --> AP2[Automated photogrammetry]; AP --> GE[Georeferencing]; AP2 --> ME[Manual editing]; ME --> DBEM[Dry-bed elevation map]; GE --> CI[Classified image]; CI --> IACDR[Image analysis of colour-depth relationship]; CI --> EWSEM[Estimated water surface elevation map]; IACDR --> WDM[Water depth map]; DBEM --> FRS[Final riverbed surface DEM]; EWSEM --> FRS; WDM --> FRS;
```

The flowchart illustrates the process of creating a Final riverbed surface (DEM) from aerial photographs. The process is divided into two main areas: DRY AREAS and WET AREAS.

**DRY AREAS (Orange dashed box):**

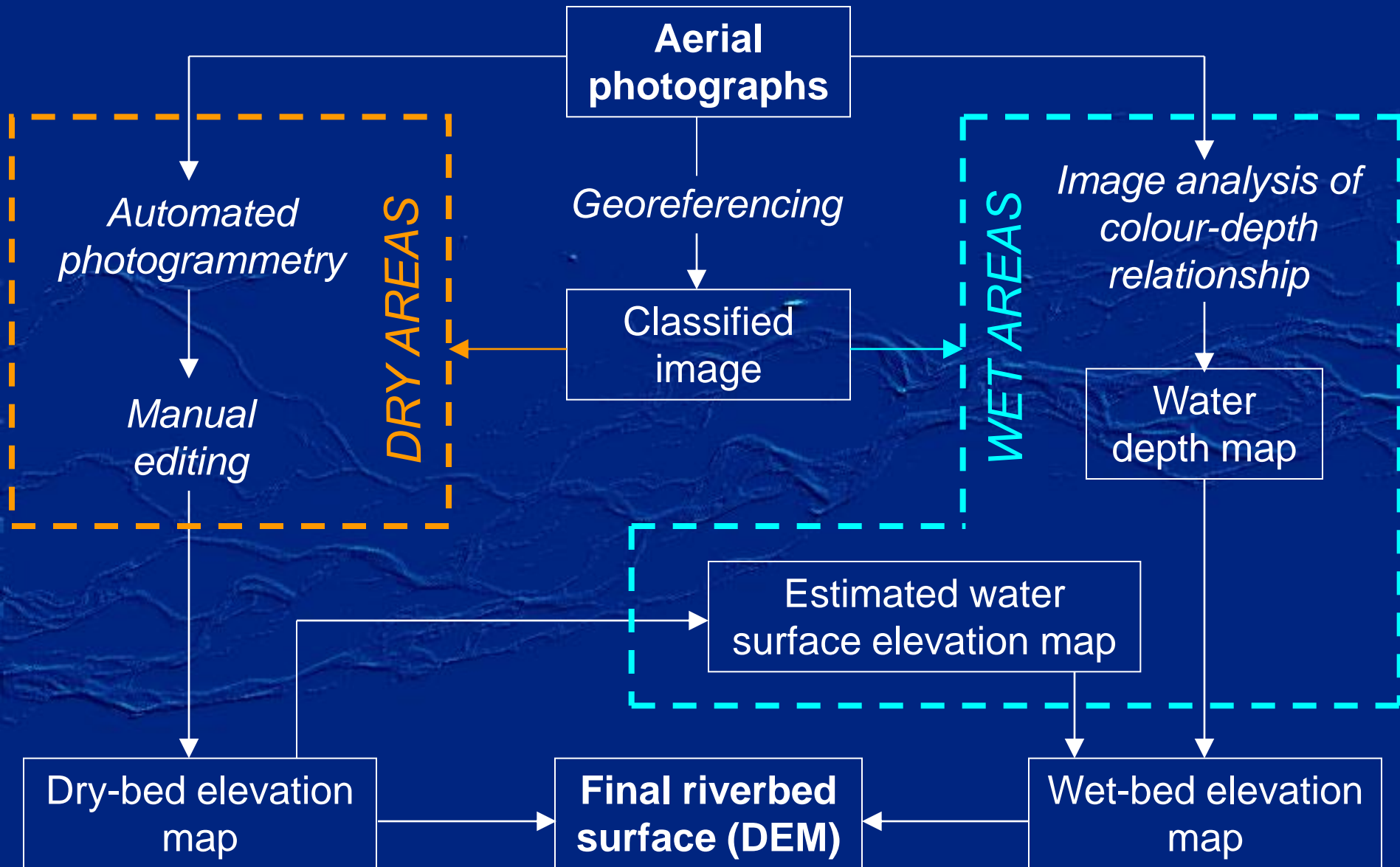
- Aerial photographs** are processed through **Automated photogrammetry** and **Manual editing** to produce a **Dry-bed elevation map**.

**WET AREAS (Cyan dashed box):**











- Aerial photographs** are processed through **Georeferencing** to create a **Classified image**.
- The **Classified image** is used for **Image analysis of colour-depth relationship** to produce a **Water depth map**.
- The **Classified image** is also used to produce an **Estimated water surface elevation map**.

**Final Output:**

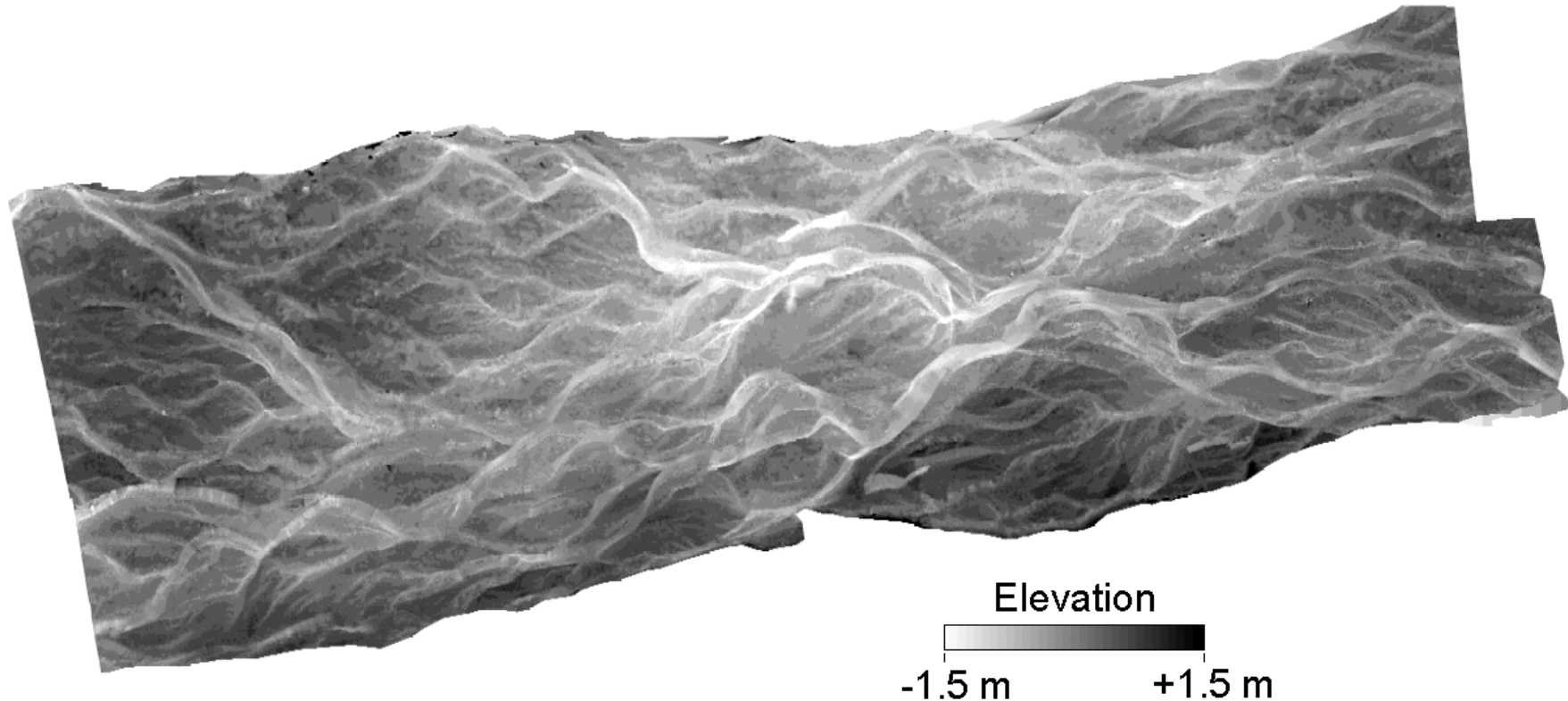
- The **Dry-bed elevation map** and the **Estimated water surface elevation map** are combined to form the **Final riverbed surface (DEM)**.
- The **Water depth map** is also used to refine the **Final riverbed surface (DEM)**.



# Progress to date

Epoch	Photogrammetry	Manual editing	Depth estimates	Final surface
Feb'99				
Mar'99				<b>Oct 2000</b>
Feb'00				<b>Dec 2000</b>

# Final riverbed surface - Feb 1999





# Results of quality assessment

Assessed in terms of mean error (ME) and standard deviation of error (SDE) from data collected by Environment Canterbury & NIWA

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Riverbed zone	Number of points compared	ME (cm)	SDE (cm)
Dry	3703	+16	25
Wet	11232	+34	28

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- Wet points have greater systematic error
  - probably due to underestimation of water depths
- Dry points also have bias
  - this only becomes a problem if error is spatially variable

# Conclusions

- Digital photogrammetry and image analysis represent an effective way of surveying large gravel riverbeds
- ...but there are unresolved issues
  - Systematic bias
  - ‘Banding effect’ found
  - See paper by Lane
- ...and other (better?) technologies now exist
  - Laser altimetry - See poster paper by Hicks *et al.*

# Future work & Further details

- Substantive analysis of surfaces:
  - ‘At epoch’:
    - 2D & 3D topography
    - Water routing
    - Scaling analyses
  - ‘Between epoch’:
    - Planform changes
    - Patterns of erosion and deposition
    - Morphological estimation of bedload transport rate
- Further details about the photogrammetric method can be found in the poster paper by *Westaway et al.*



# DEM of difference:

Feb 1999 (photogrammetry) to May 2000 (laser altimetry)

