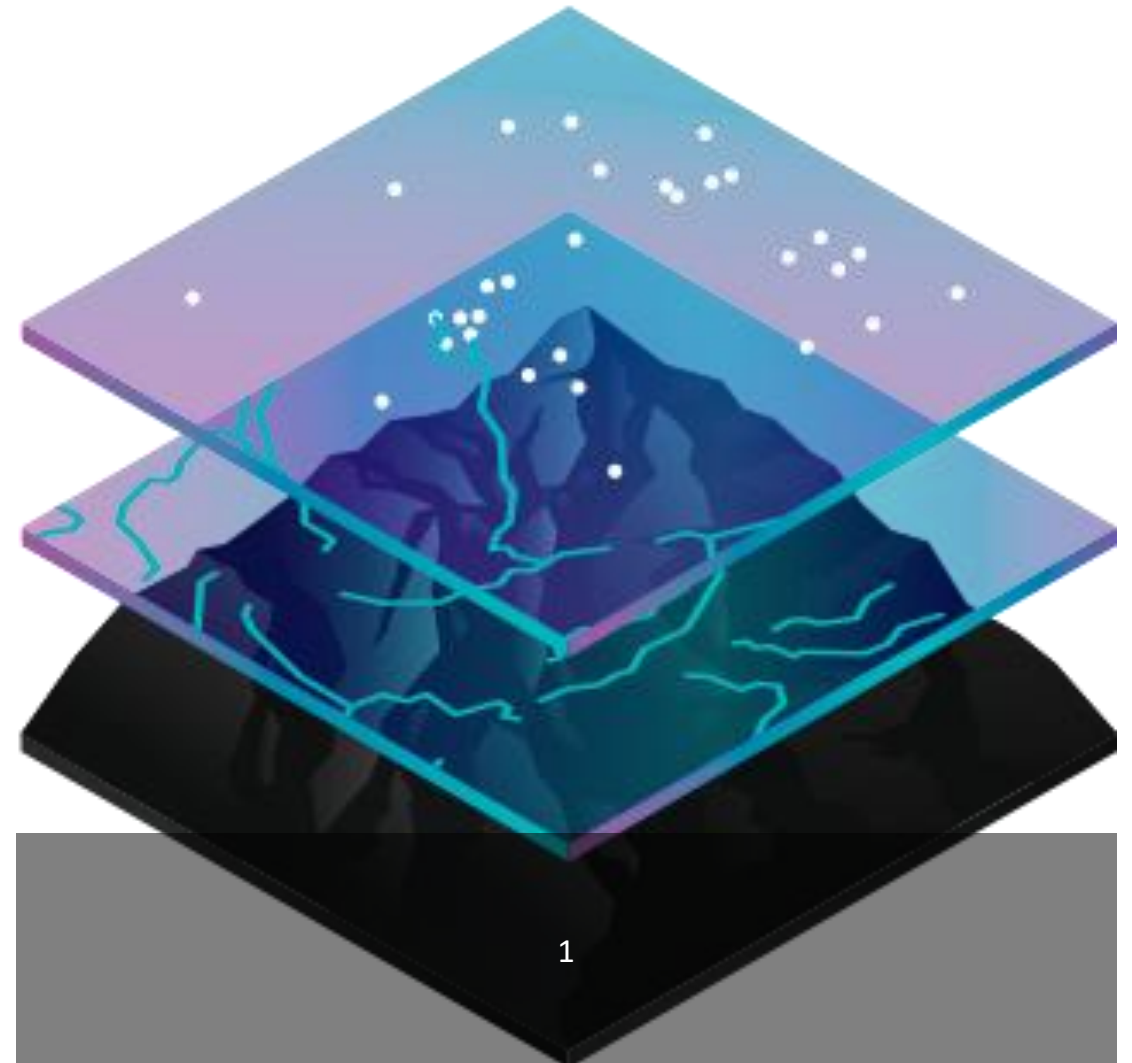


Biodiversity on degraded landscapes



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David



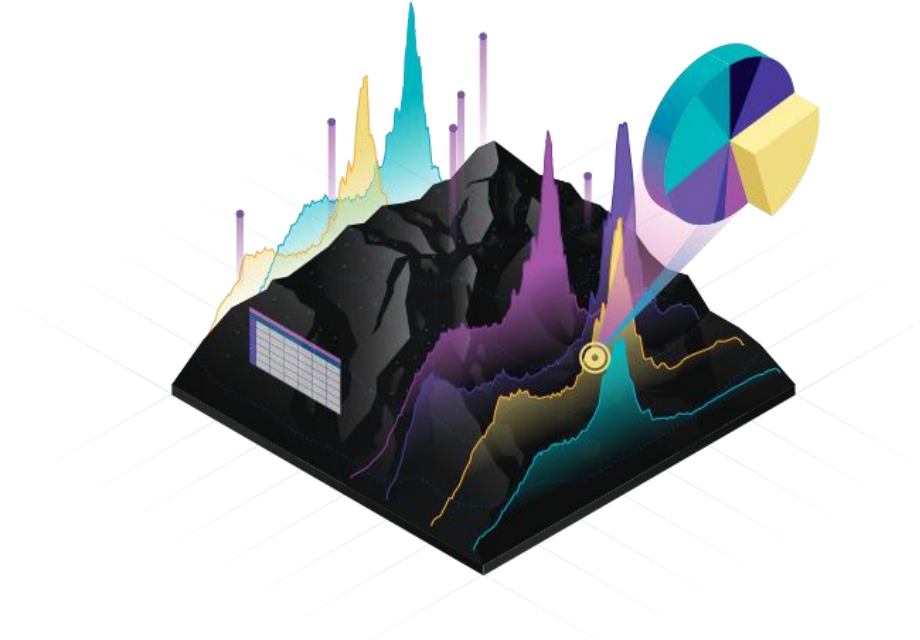
24/04/2024

Structure

Week No	Date	Theme	Tutor
1	31/01/24	Introduction to module and Management Plans	AF
2	7/02/24	Phase 1 Habitat Surveys and National Vegetation Classification (NVC)	AF
3	14/02/24	Natural Flood Salt March – Cwm Ivy	AF
4	21/02/24	Flood risk, climate change and building resilience	AF
5	28/02/24	Habitat Classification	AF
6	6/03/24	LiDAR (theory and application)	AF
7	13/03/24	Near-census GIS (SfM)	MD/AF
8	20/03/24	Remote Sensing (AC)	AC
	27/03/24	Easter Break	
	3/04/24	Easter Break	
	10/04/24	Easter Break	
9	17/04/24	Habitat Creation	AF
10	24/04/24	Biodiversity on degraded landscapes	AF
11	1/05/24	Course Recap & assignment drop in 'surgery'	AF
12	8/05/24	Assignment Presentation	AF

Outline

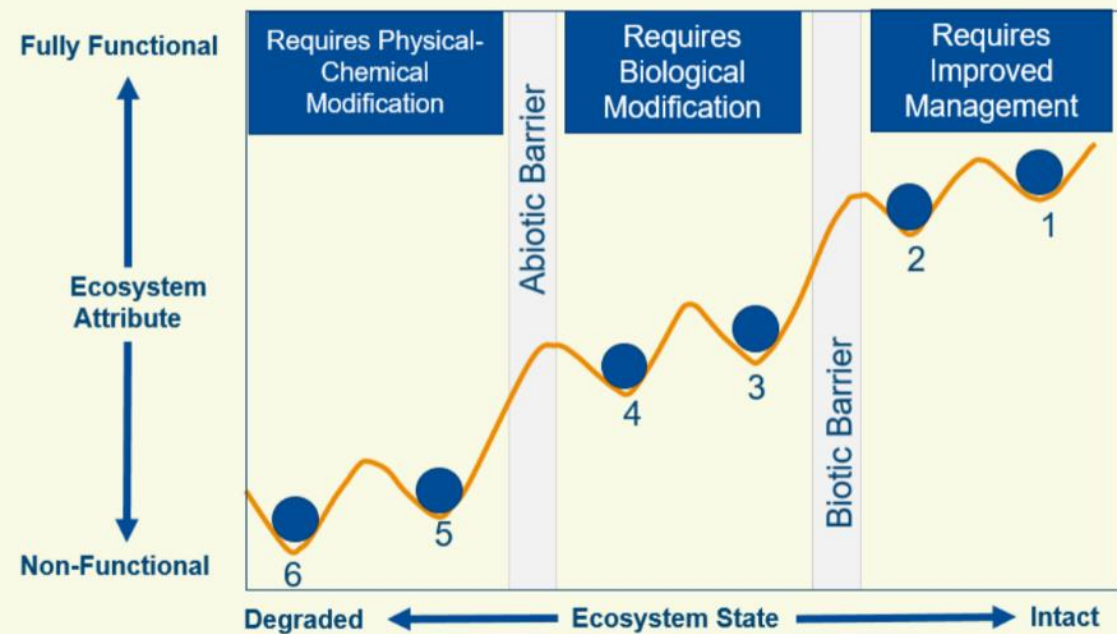
- What is a degraded landscape?
- **Examples of Application**
- **Practical Activity: Biodiversity on degraded landscapes (historic maps)**



Mapping the world's degraded landscapes

Degraded land is land that has lost some degree of its natural productivity due to human-caused processes (World Resources Institute, 2024).

Ecosystem degradation and restoration model



© Adapted from Whisenant (1999), Hobbs and Harris (2001)

Mapping the world's degraded landscapes

- Gibbs and Salmon (2015)
- [Mapping the world's degraded lands - ScienceDirect](#)

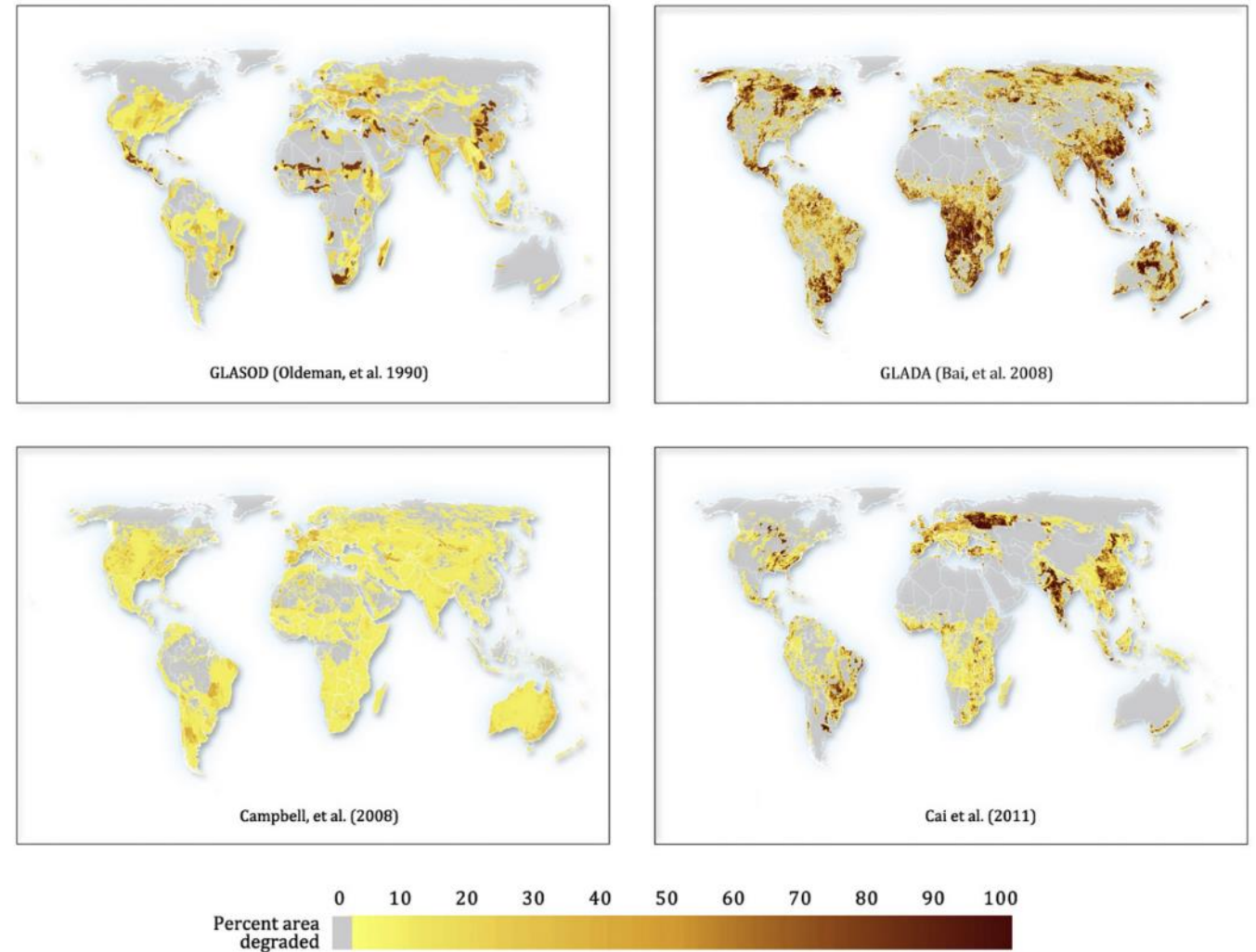


Fig. 1. Maps of land areas (percent of cell area) affected by degradation; each panel represents one of the methods described, all shown with common legend and 20 km grid.

Examples of Application

- Legacy Sites
 - Ex-Industrial sites
 - Mine sites
 - Degraded agriculture
 - Sinkholes
 -
-
- Processes of land degradation: water erosion, wind erosion, soil fertility decline, salinization, waterlogging, lowering of water table.

Examples of Application

- Legacy Sites
 - Ex-Industrial sites
 - Mine sites
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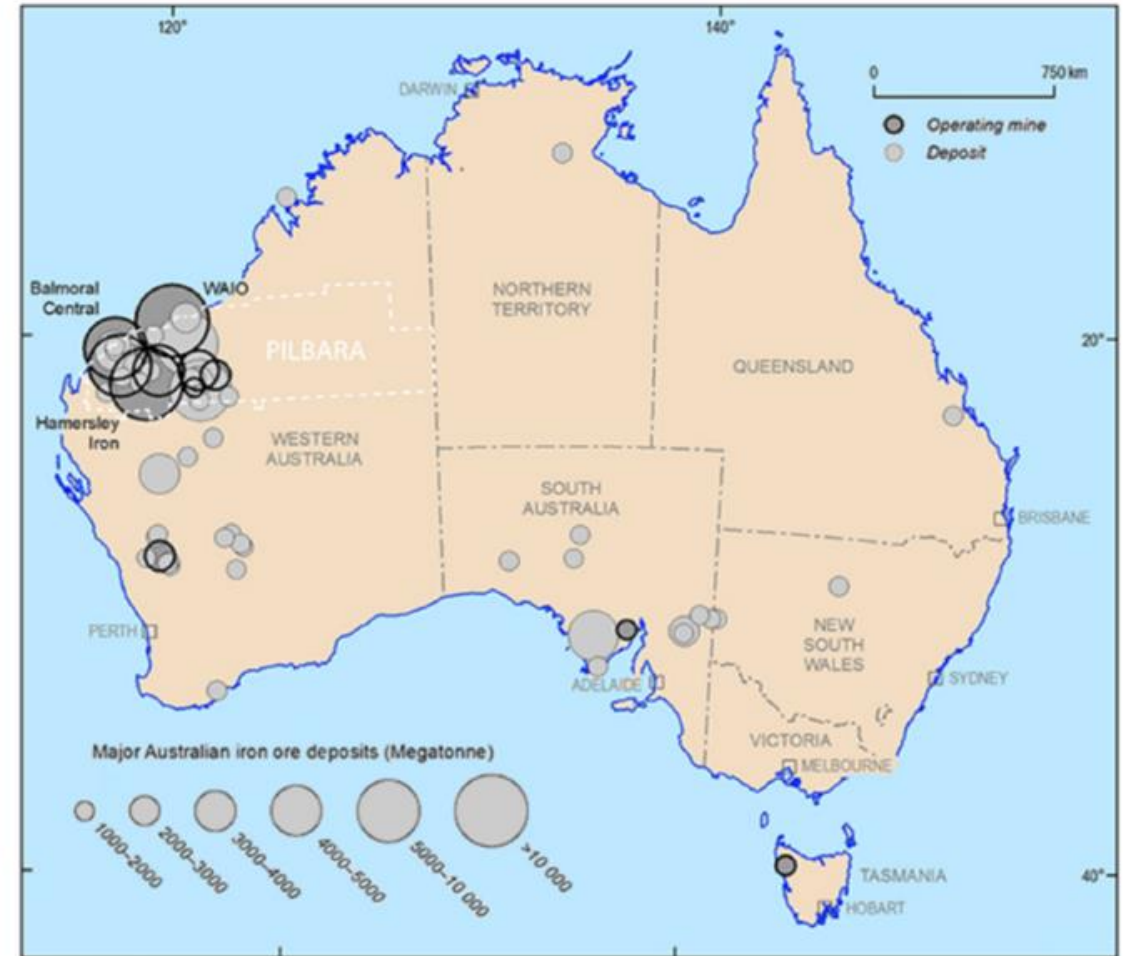
Dr. Alissa Flatley

Understanding hydromorphology for improved catchment management



PhD Research

Geomorphology of small arid zone streams in the Pilbara (Western Australia) and implications for mining river diversion designs



Map of major iron ore deposits

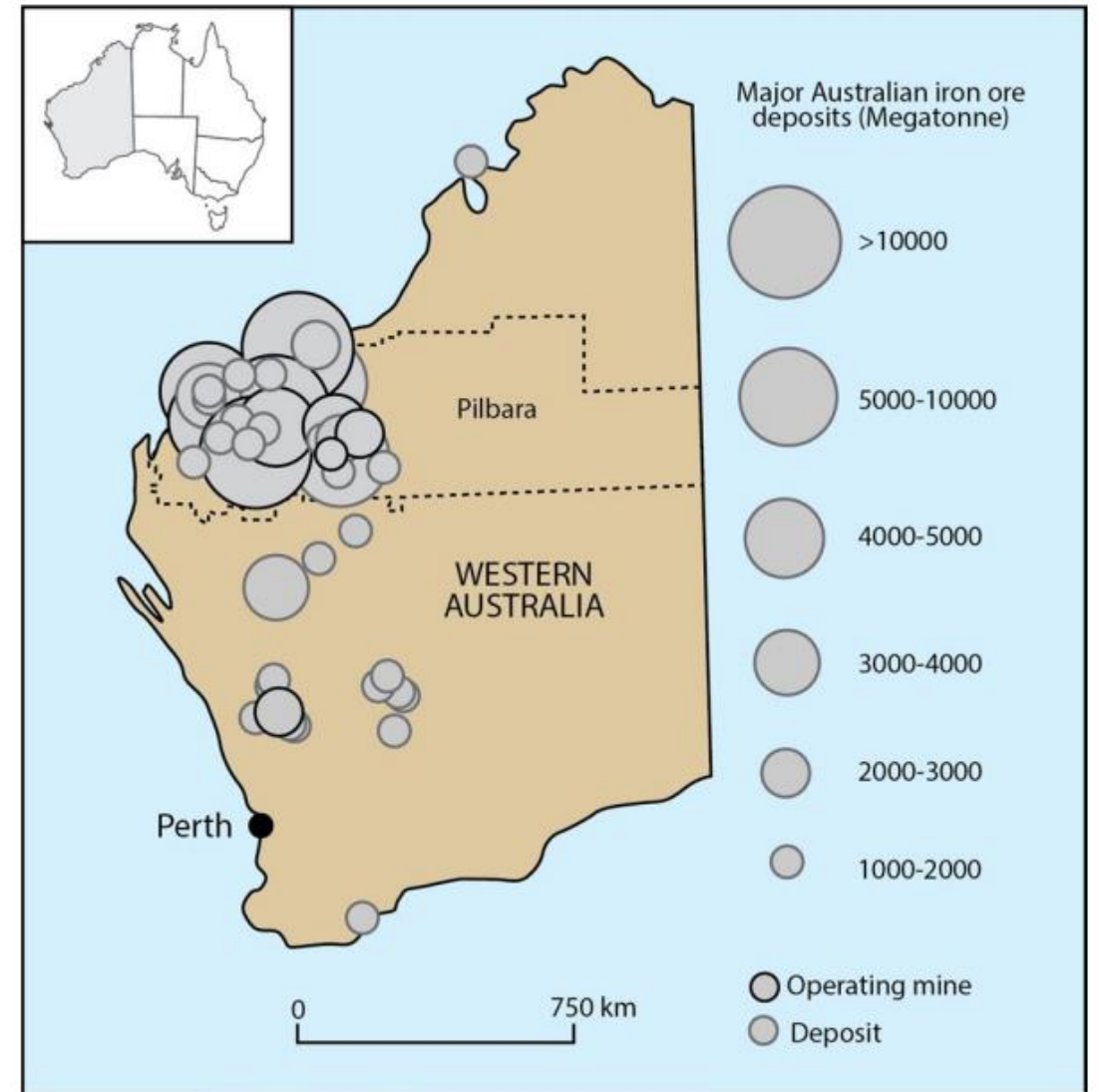


Fig. 1 Map of mining areas in Western Australia with the Pilbara region, outlined. Modified from Geoscience Australia (2016)

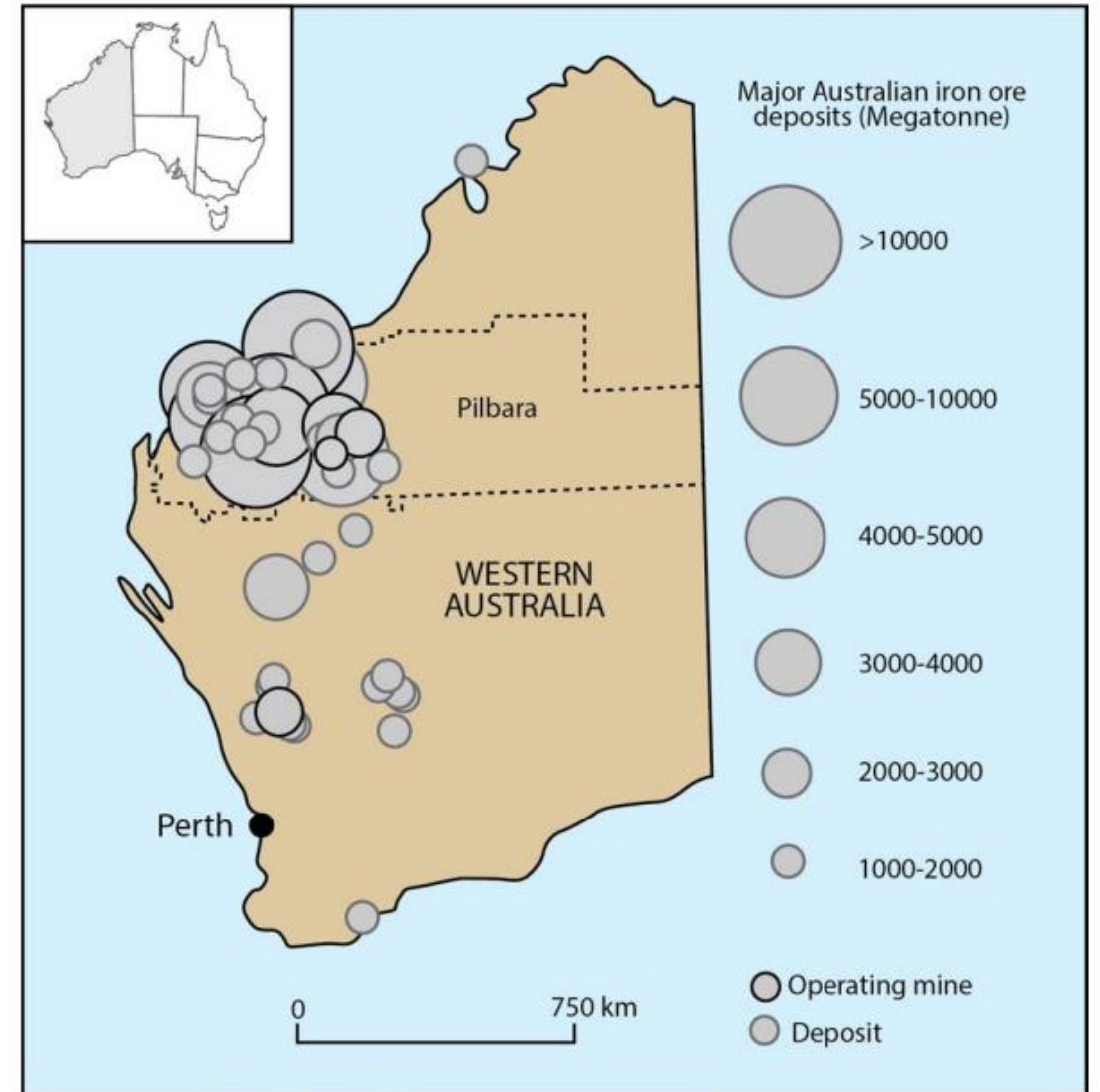
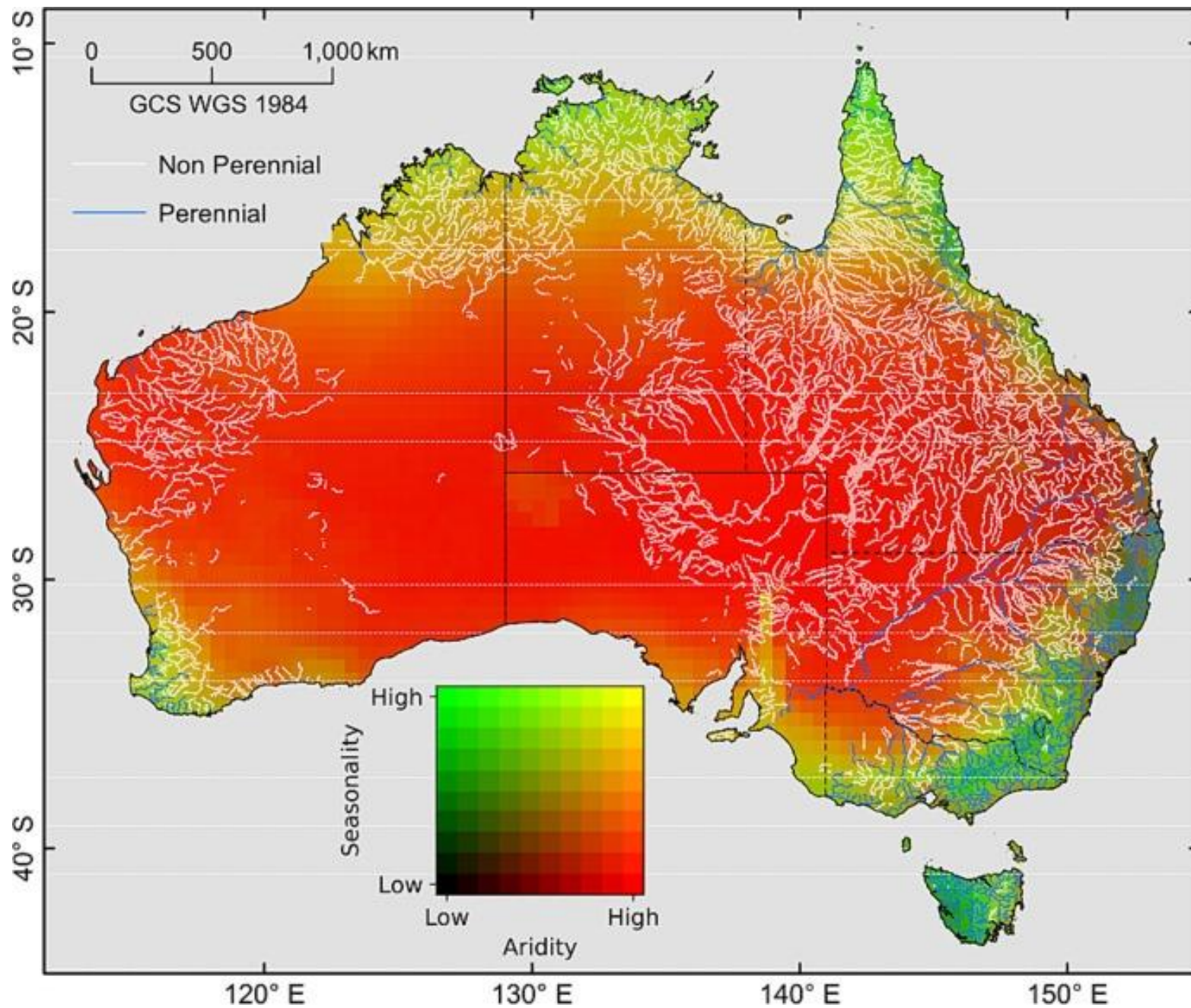


Fig. 1 Map of mining areas in Western Australia with the Pilbara region, outlined. Modified from Geoscience Australia (2016)



[Australian non-perennial rivers: Global lessons and research opportunities - ScienceDirect](#)

PhD Research

Flatley and
Markham, 2020

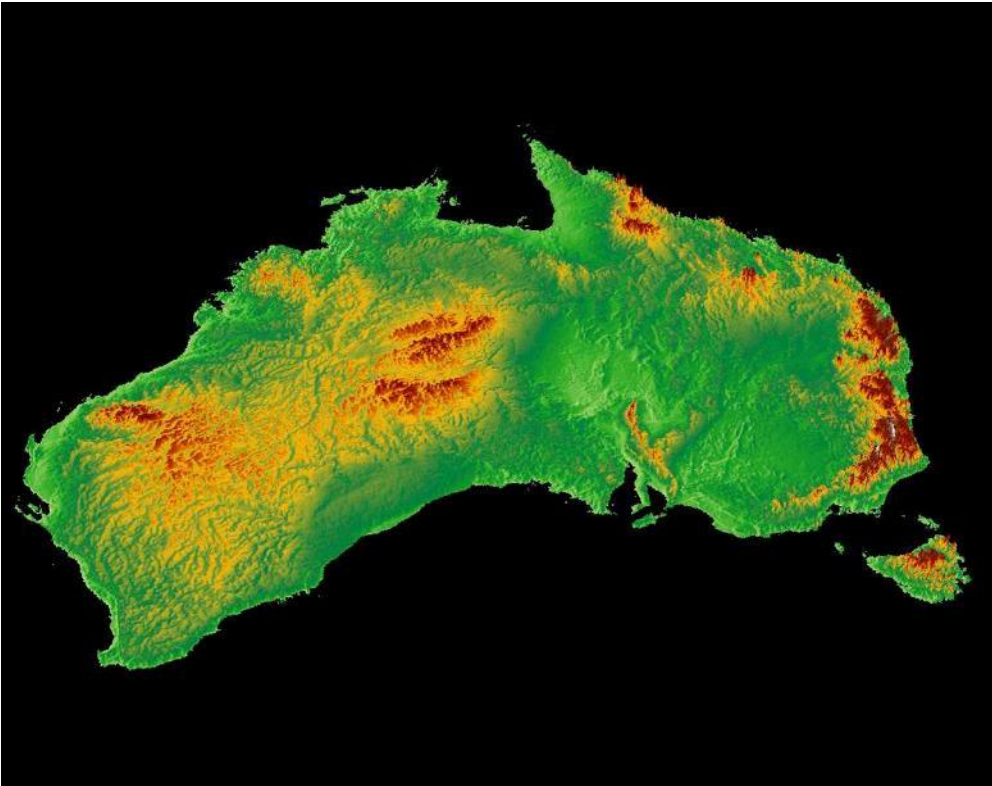
Geomorphology of small arid zone streams in the Pilbara (Western Australia) and implications for mining river diversion designs



Mt Whaleback, Pilbara

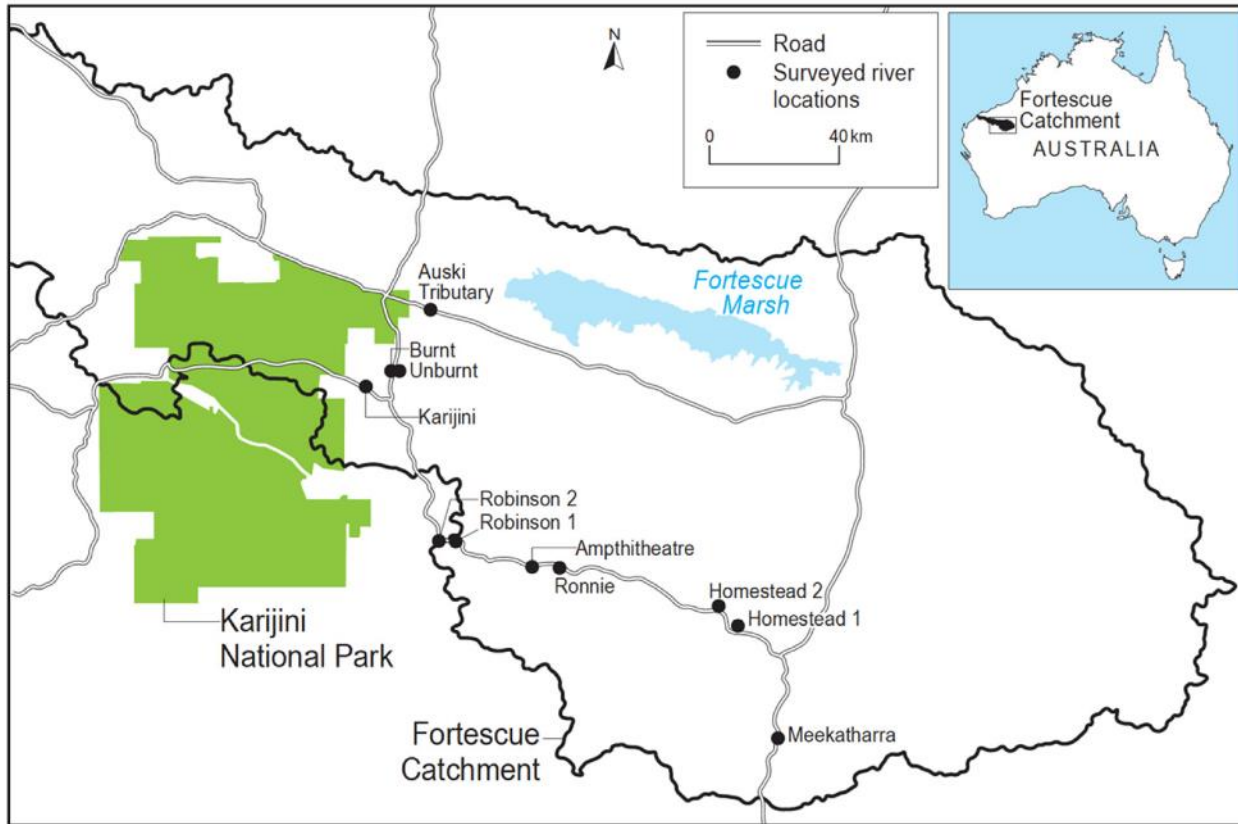
Alissa! What sorts of
spatial data did you use?

Alissa! What sorts of spatial data did you use?



The 3 second (~90m) Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) version 1.0 was derived from resampling the 1 arc second (~30m) gridded DEM (ANZCW0703013355).

Alissa! What sorts of spatial data did you use?



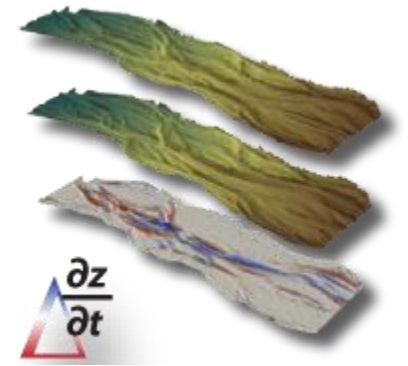
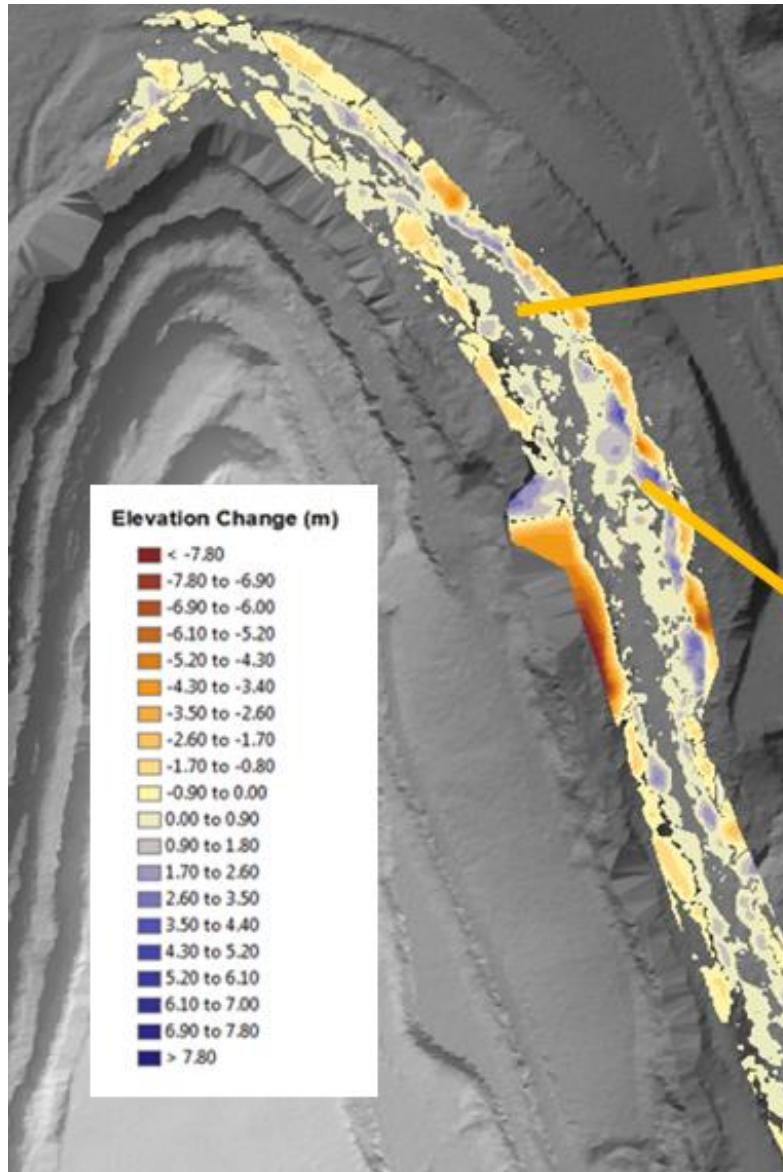
SfM (Structure from Motion) photogrammetry across 10 catchments

Alissa! What sorts of spatial data did you use?



1m lidar at the mine site extent (flown annually from 2015-2018)

Geomorphic Change Detection (GCD)

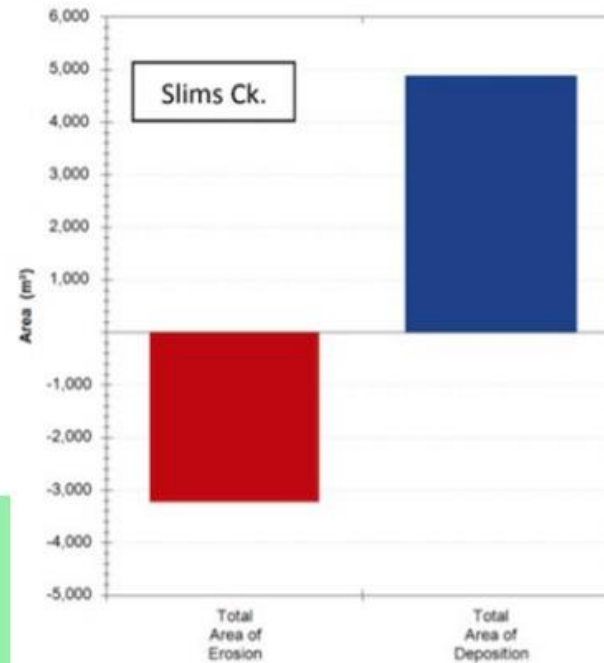


Geomorphic Change
Detection (GCD) - ESSA

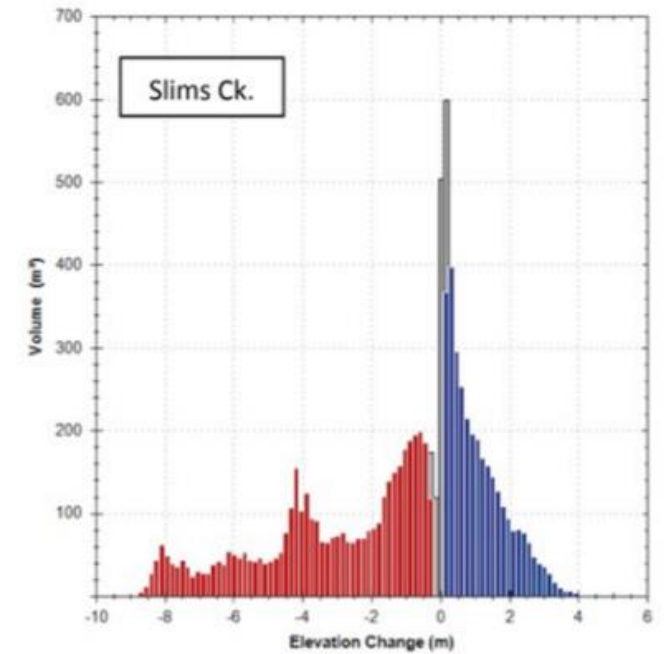
Criteria

How do we know how river diversions are performing?

Flatley et al., 2018



Geomorphic
Change Detection
(GCD) of river
diversion channel

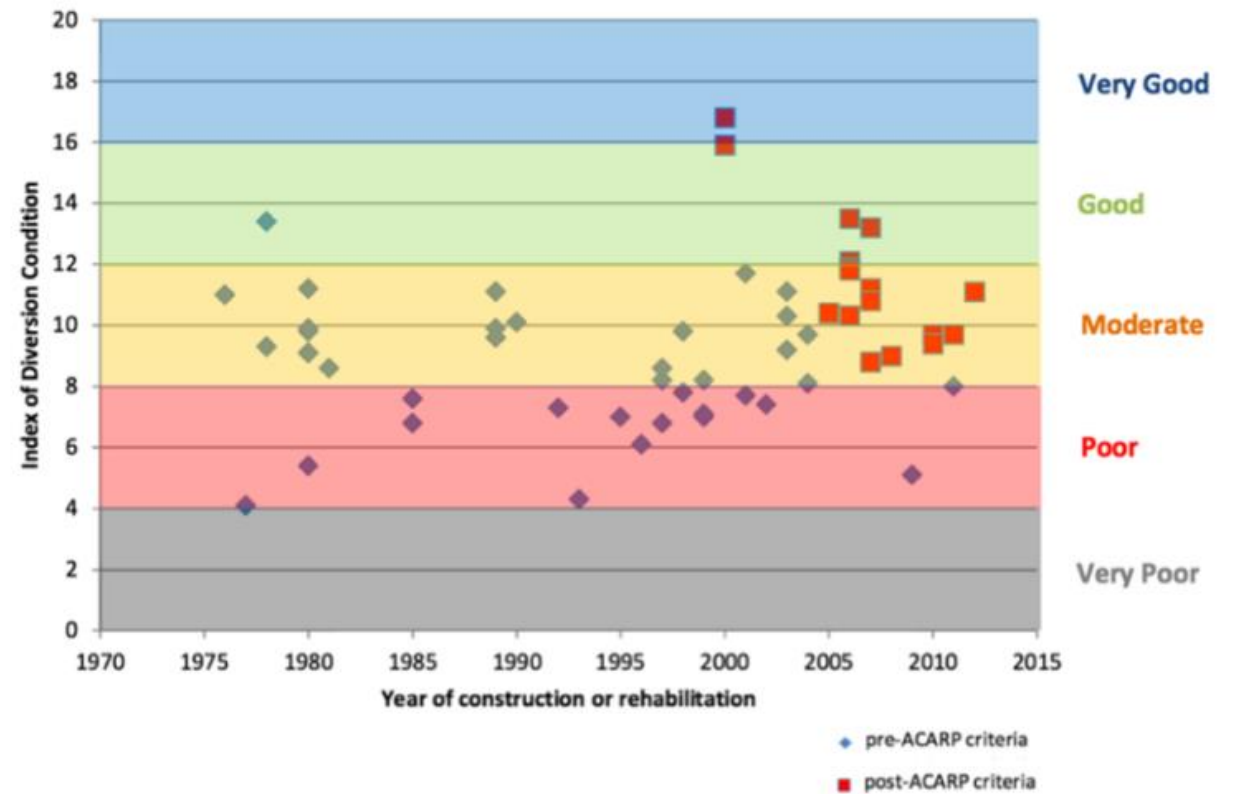


Safe, stable, relinquishable?

Flatley et al., 2018

Conditions that will eventually mimic a natural river channel

Where specific and regionally derived design criteria have been, channels require less intervention and show evidence of better performance, improved environmental conditions.



Location

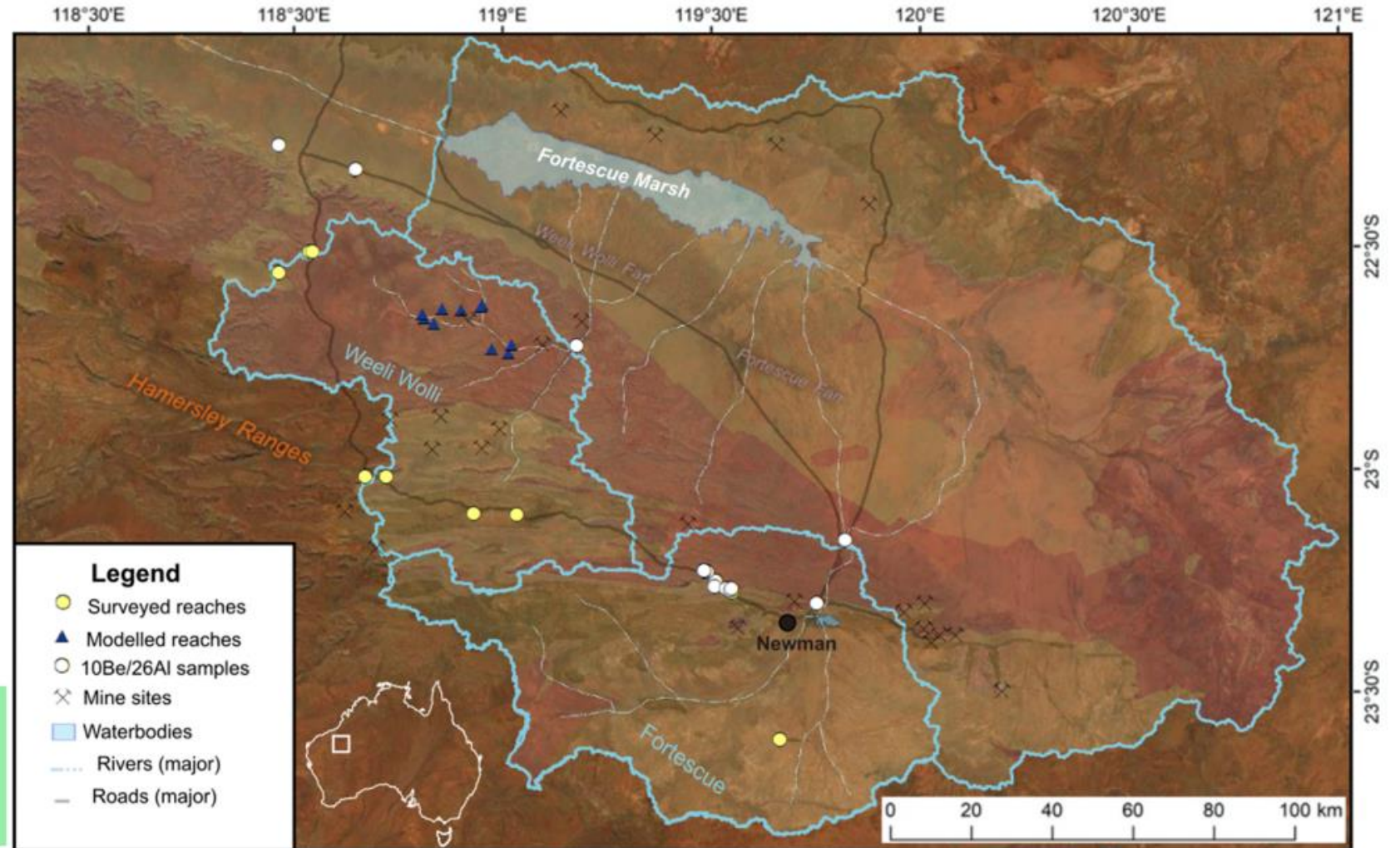
Catchment Management

Headwater Catchments (under 10km²)

Medium

Large

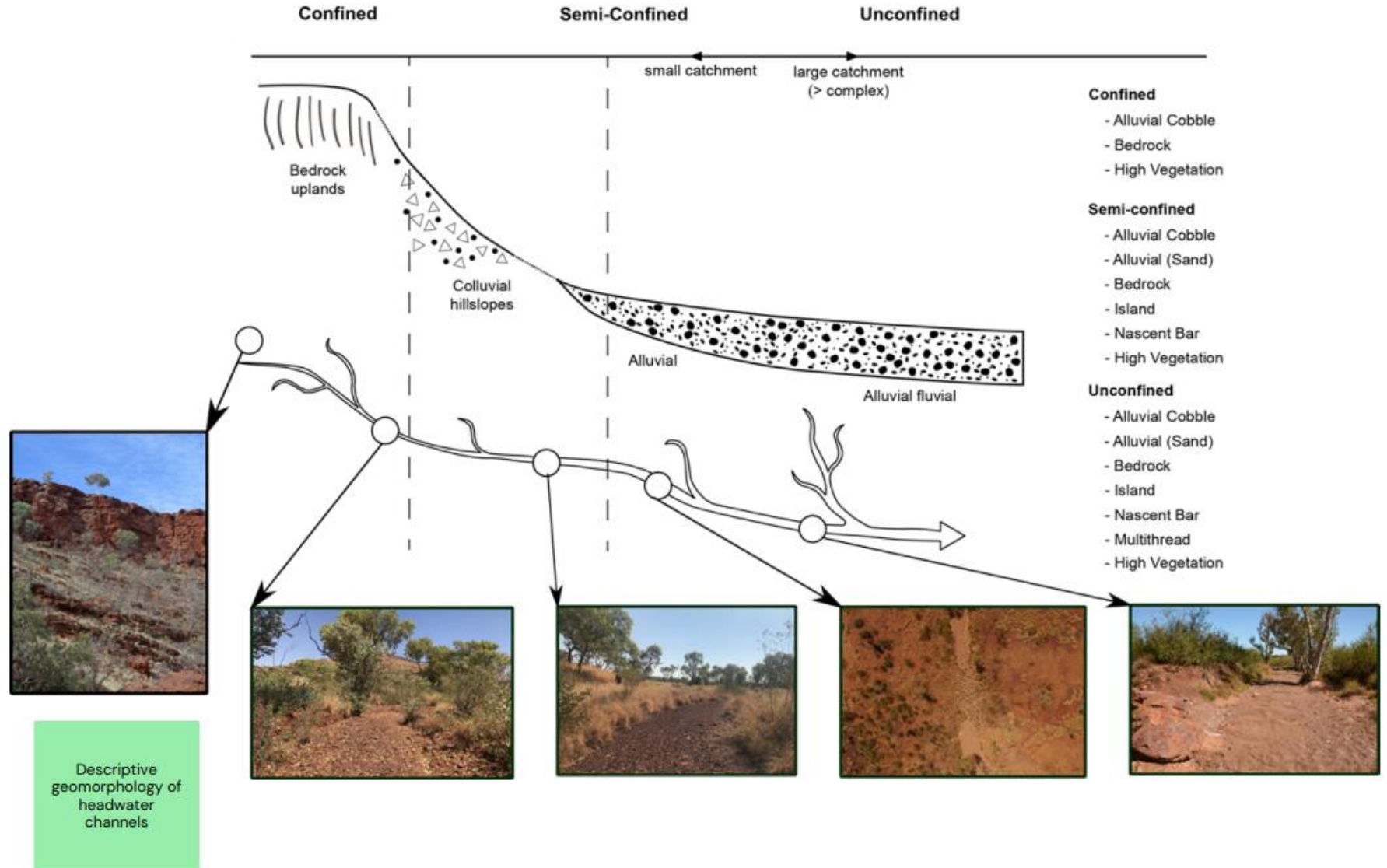
Study Area from
PhD research



Geomorphic Description

(E.g. Channel form, confinement, sediment supply, key in-channel features, roughness – Manning's n)

Key Findings

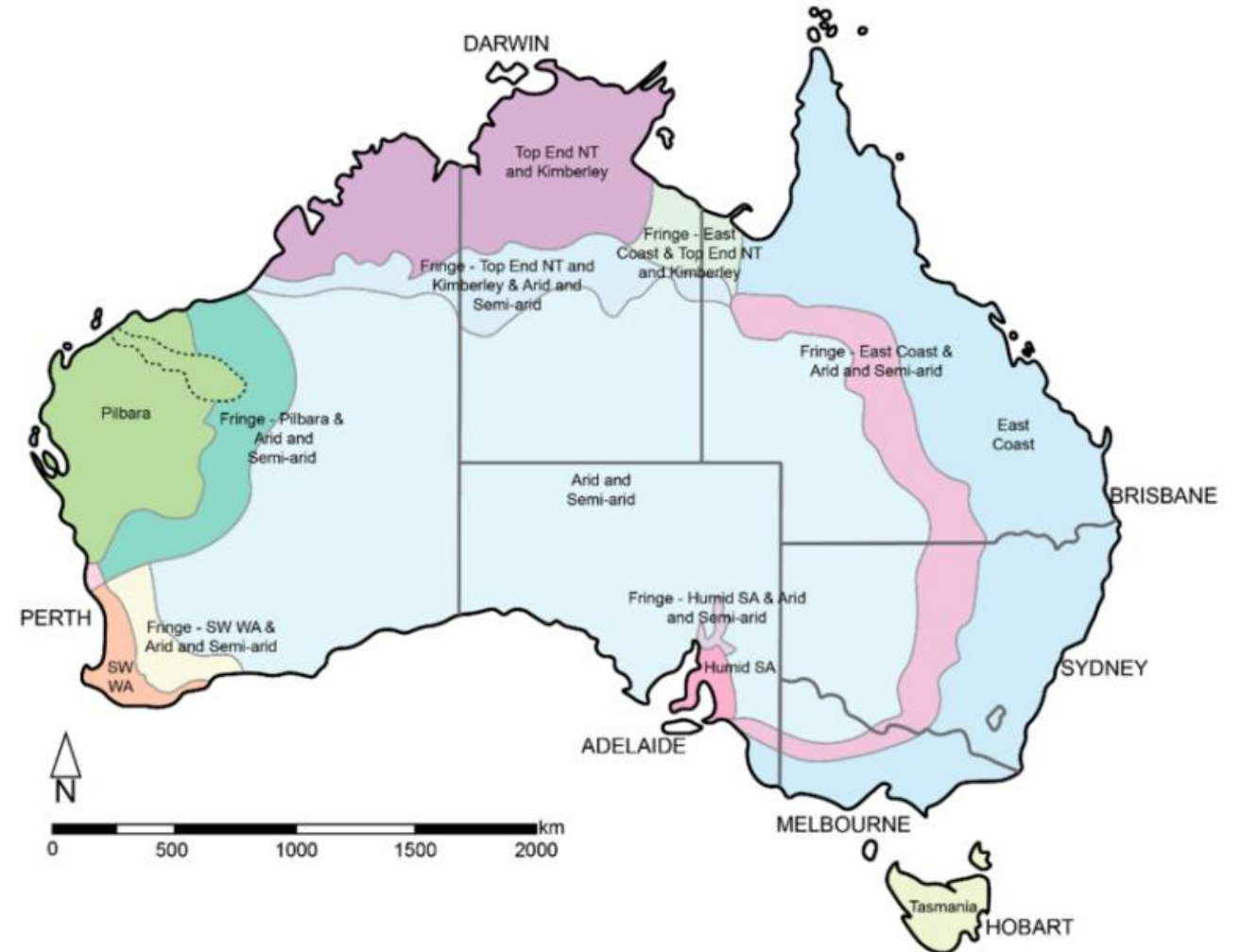


Rainfall/Streamflow

Catchment Management

Flatley and
Rutherford, 2022

Minimal gauging for rainfall, no
gauging for streamflow



Adopted regions
for RFFE technique
in Australia

Rainfall/Streamflow

Catchment Management

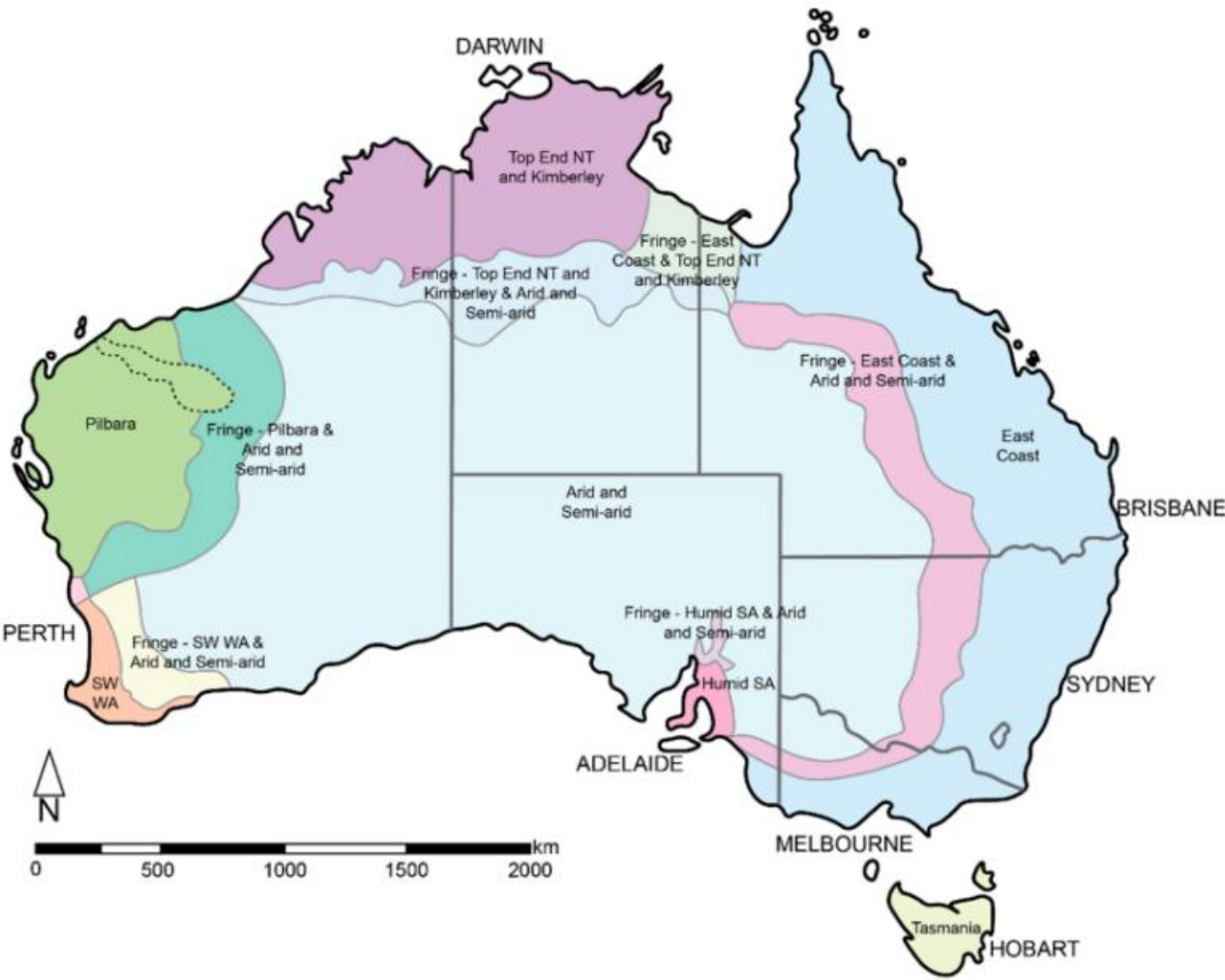
Flatley and
Rutherford, 2022

Minimal gauging for rainfall, no
gauging for streamflow

Ireland's in the
Pilbara



Adopted regions
for RFFE technique
in Australia



Rainfall/Streamflow

Catchment Management

Flatley and
Rutherford, 2022

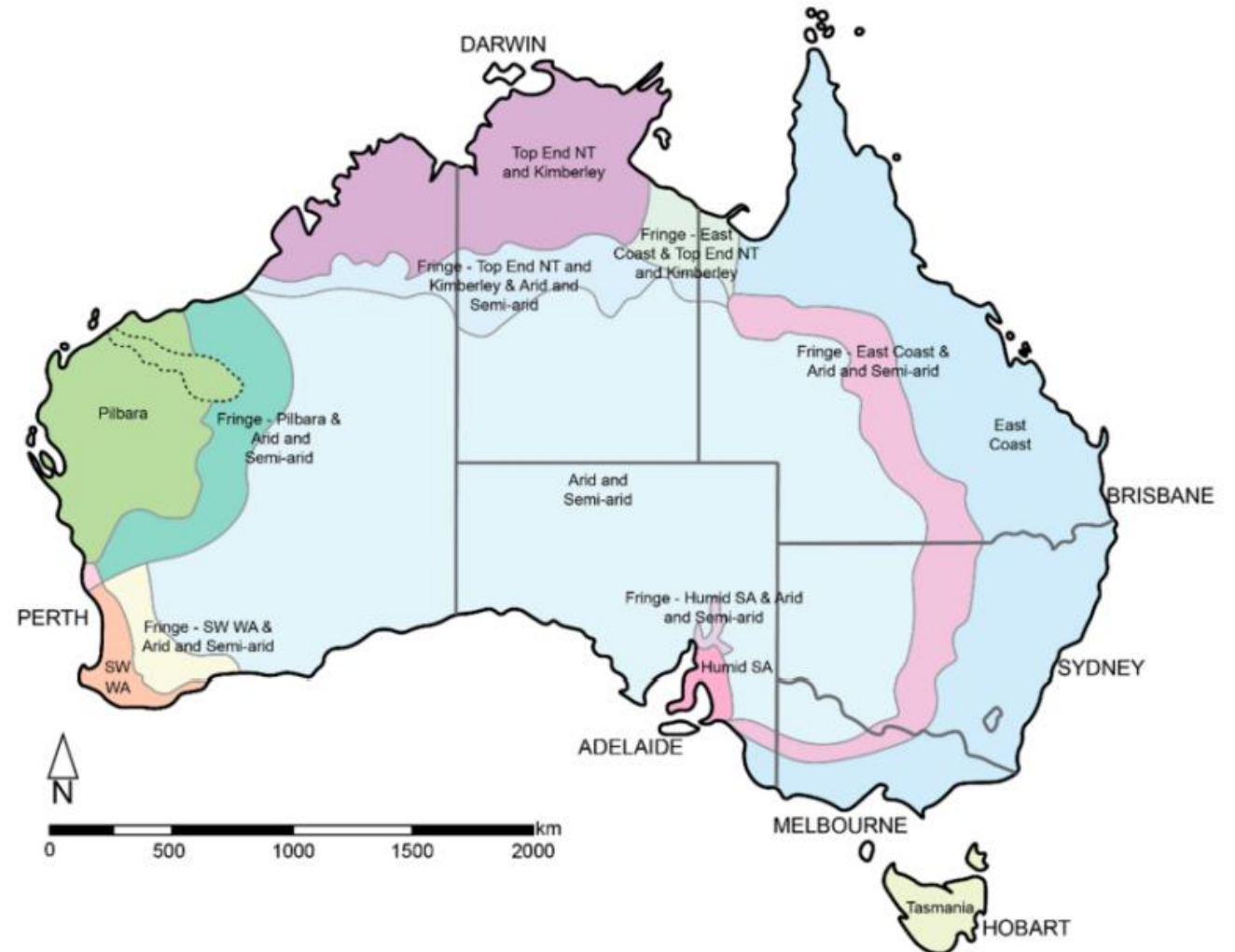
Comparison of Regionalisation Techniques for Peak Streamflow Estimation in Small Catchments in the Pilbara, Australia

Alissa Flatley, Ian Rutherford

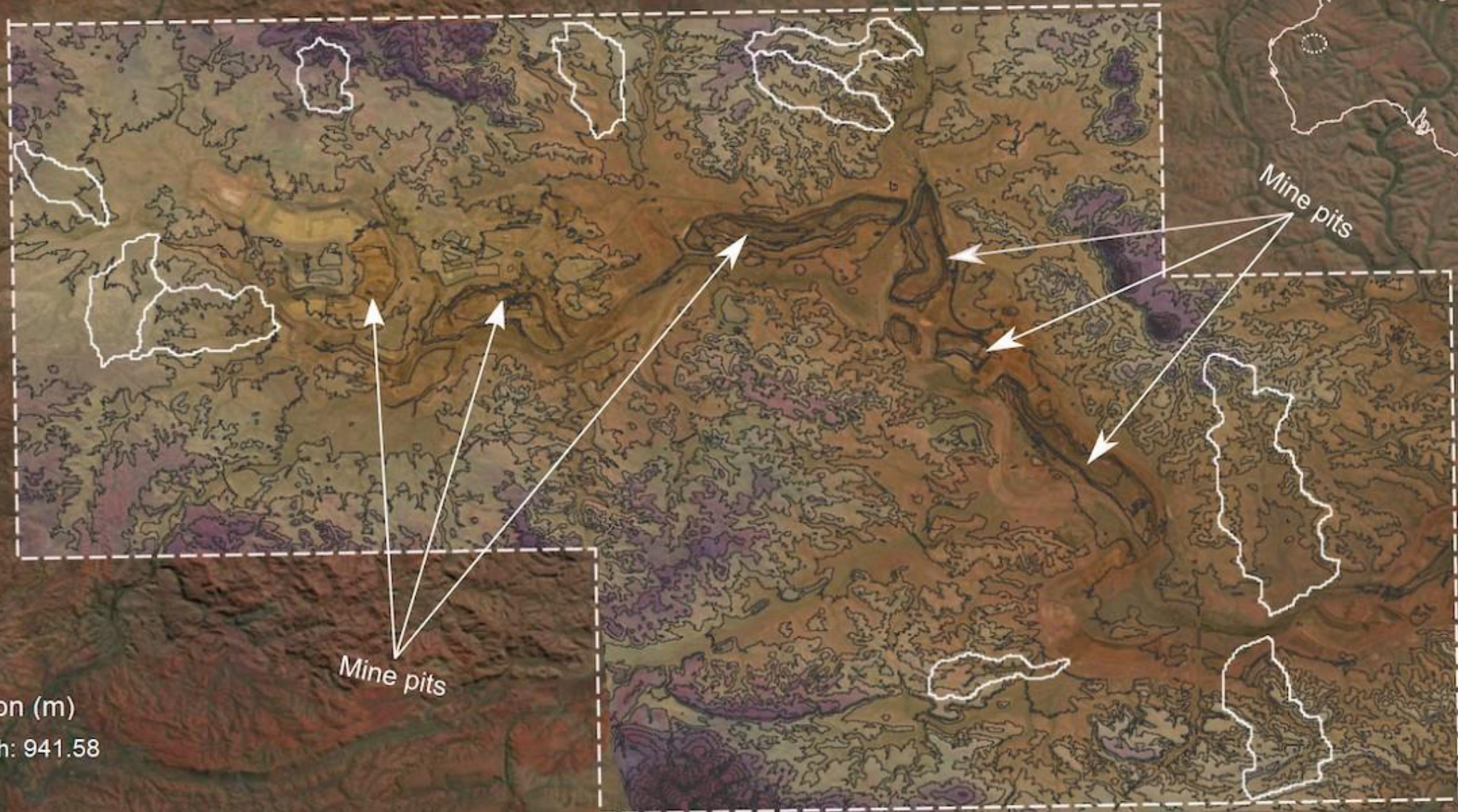


Journal article | 2022 | Hydrology

Arid and semi-arid regions typically lack high-resolution river gauging data causing difficulties in understanding rainfall-runoff..



Adopted regions
for RFFE technique
in Australia



Elevation (m)

High: 941.58

Low: 498.78

Contour interval = 20m

1m lidar extent

5km

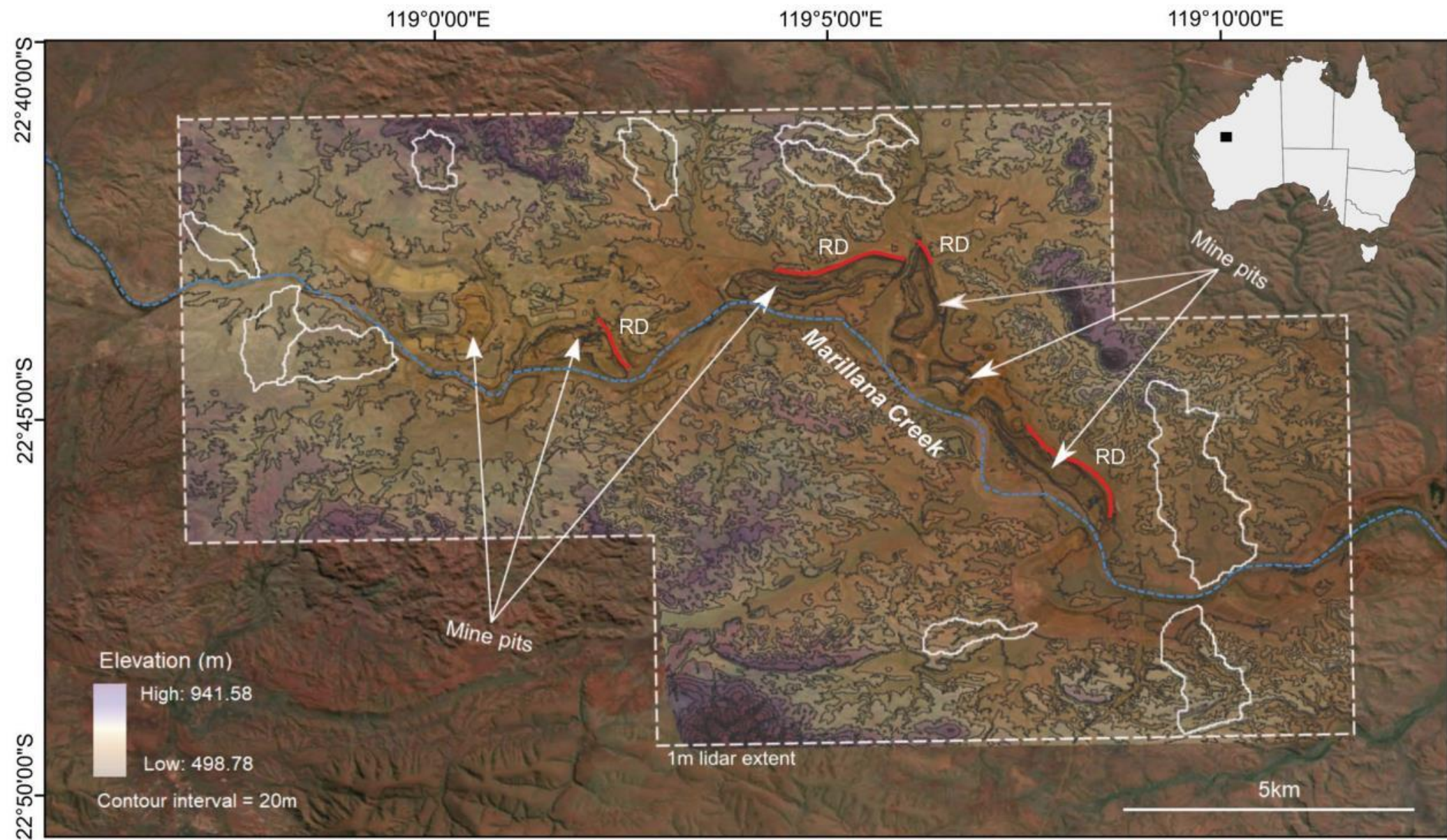


Fig. 3 Map of the Yandi mine site, in the Marillana sub-catchment, WA. Map shows the extent of the wide area map 1 m resolution DEM, with selected headwater catchments outlined in white. River diversion channels (RD) are shown in red

Table 1 Catchment description for natural channels used in this study

Catchment	Area (km ²)	Lat	Long	Equal area slope (m/km)	Channel length (km)
1	1.05	−22.712	118.956	18.54	1.13
2	0.96	−22.694	119.002	40.57	0.71
3	1.68	−22.695	119.046	16.65	1.10
4	1.48	−22.691	119.087	22.97	1.64
5	1.71	−22.697	119.085	37.61	1.55
6	1.95	−22.732	118.965	12.49	1.37
7	5.99	−22.766	119.159	22.48	2.06
8	3.23	−22.804	119.161	22.72	1.30
9	1.10	−22.796	119.109	26.71	1.17
10	2.42	−22.736	118.980	16.85	1.21

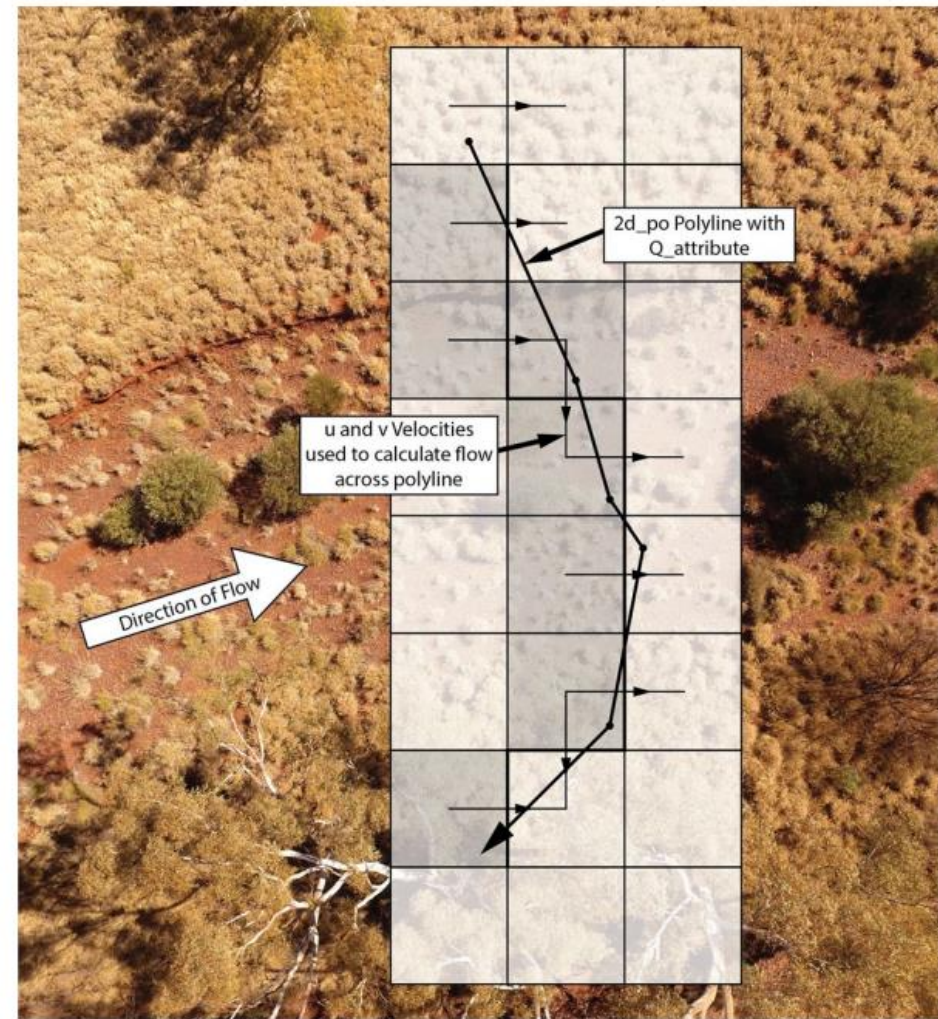
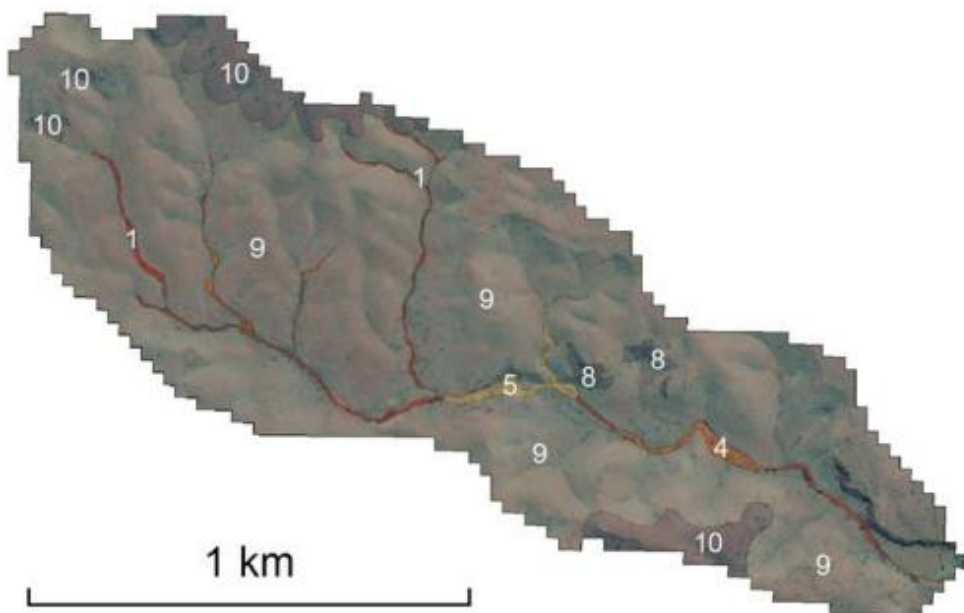
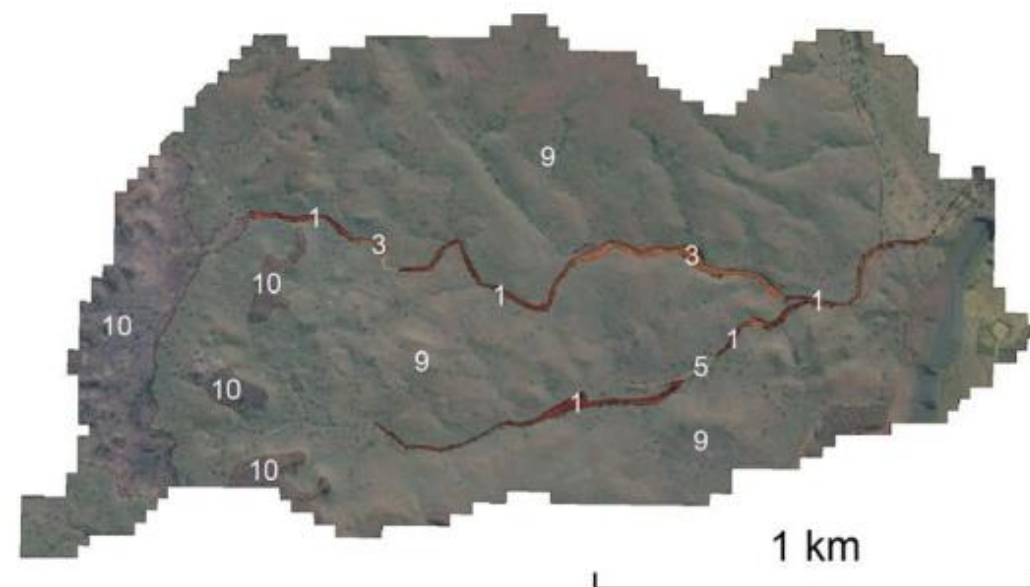


Fig. 4 Diagram showing a 2D Plot-output polyline (2D_po) and method of calculating flow across each cross section in the river channel. Each polyline is a digitised cross-section within the TUFLOW model of the river channels and a reporting location for hydraulic output (e.g. Q_attribute representing discharge). Modified from BMT (2018)

Catchment 5



Catchment 10



Manning's Roughness Values

1 Single channel (> cobble)	4 Bar (island)	8 High Floodplain Roughness	11 Road
2 Single channel (sand)	5 Bar (nascent)	9 Moderate Floodplain Roughness	12 Developed/Urban
3 Single bedrock	6 Highly vegetated channel	10 Low Floodplain Roughness	

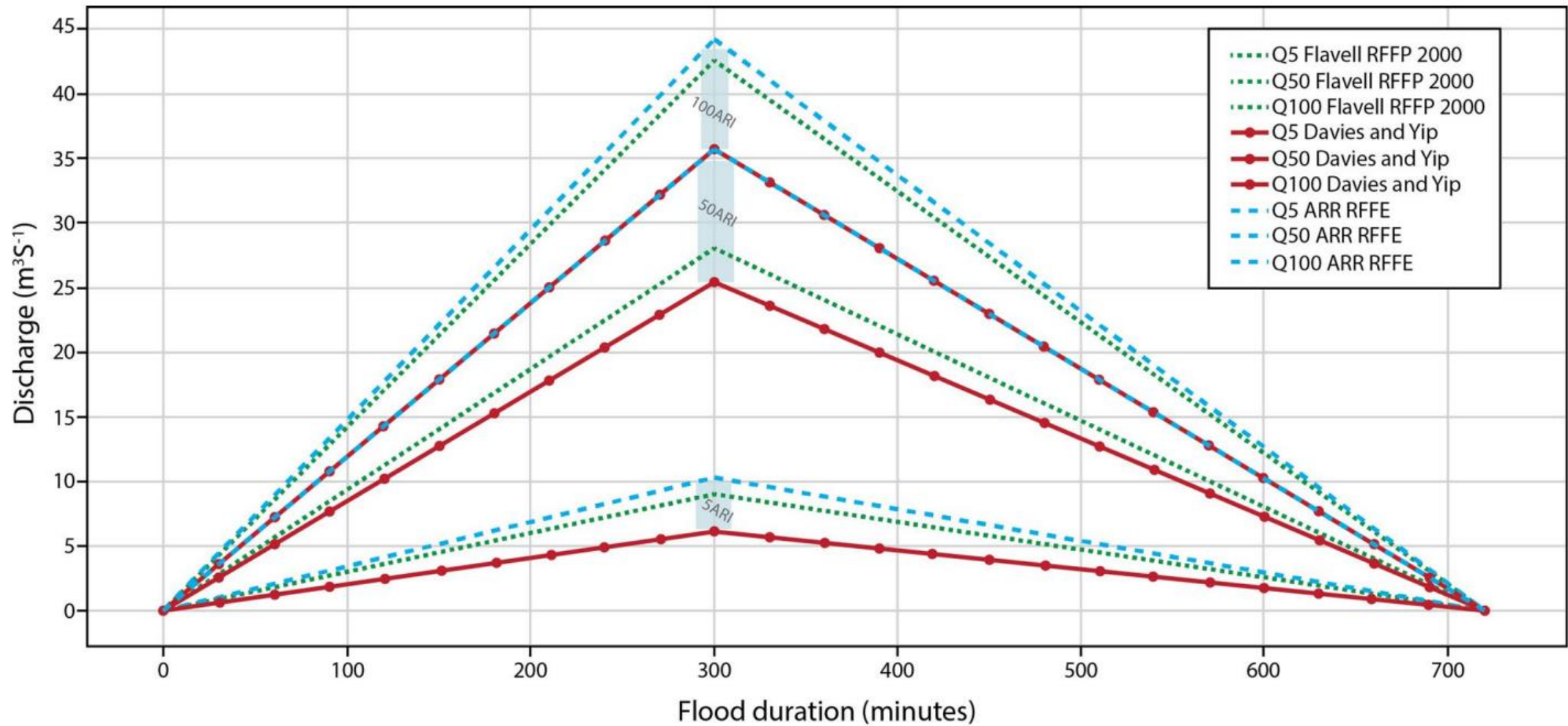


Table 5 Proposed guideline hydraulic values for natural headwater channels

Stream Type	Velocity (m/s)			Stream power (W/m ²)			Bed shear stress (N/m ²)		
	5 ARI	50 ARI	100 ARI	5 ARI	50 ARI	100 ARI	5 ARI	50 ARI	100 ARI
All headwater channels combined	1–2	2–3	2–3	1–6	5–16	6–26	16–72	48–124	50–164
Single Channel ($\geq$ cobble)	1–1.7	1.6–2.8	1.8–3.3	1.3–12.6	1.7–22.3	2.7–22.1	25.4–69.4	44–135	54–157
Single channel (sand)	0.8–1.6	1.35–1.8	0.4–2.0	0.4–2.3	0.2–1.9	0.8–6.4	9.4–22.8	11–38	14–51
Bedrock/confined channel	0.9–1.8	1.8–2.9	2–3.3	0.9–8	2.9–14.5	5.1–18	14.9–95.7	70–170	73–200
Island barform channel	1–1.4	1.8–2.2	2–2.5	1.3–2.9	2.9–7.2	4.3–14	24.4–60	52.8–100	50–144
Heavily vegetated channel	1.5–1.7	2.2–2.5	2.5–2.8	1.5–3.1	2.6–6.3	4.2–12	19.7–51.9	63–103	44.95–55.76

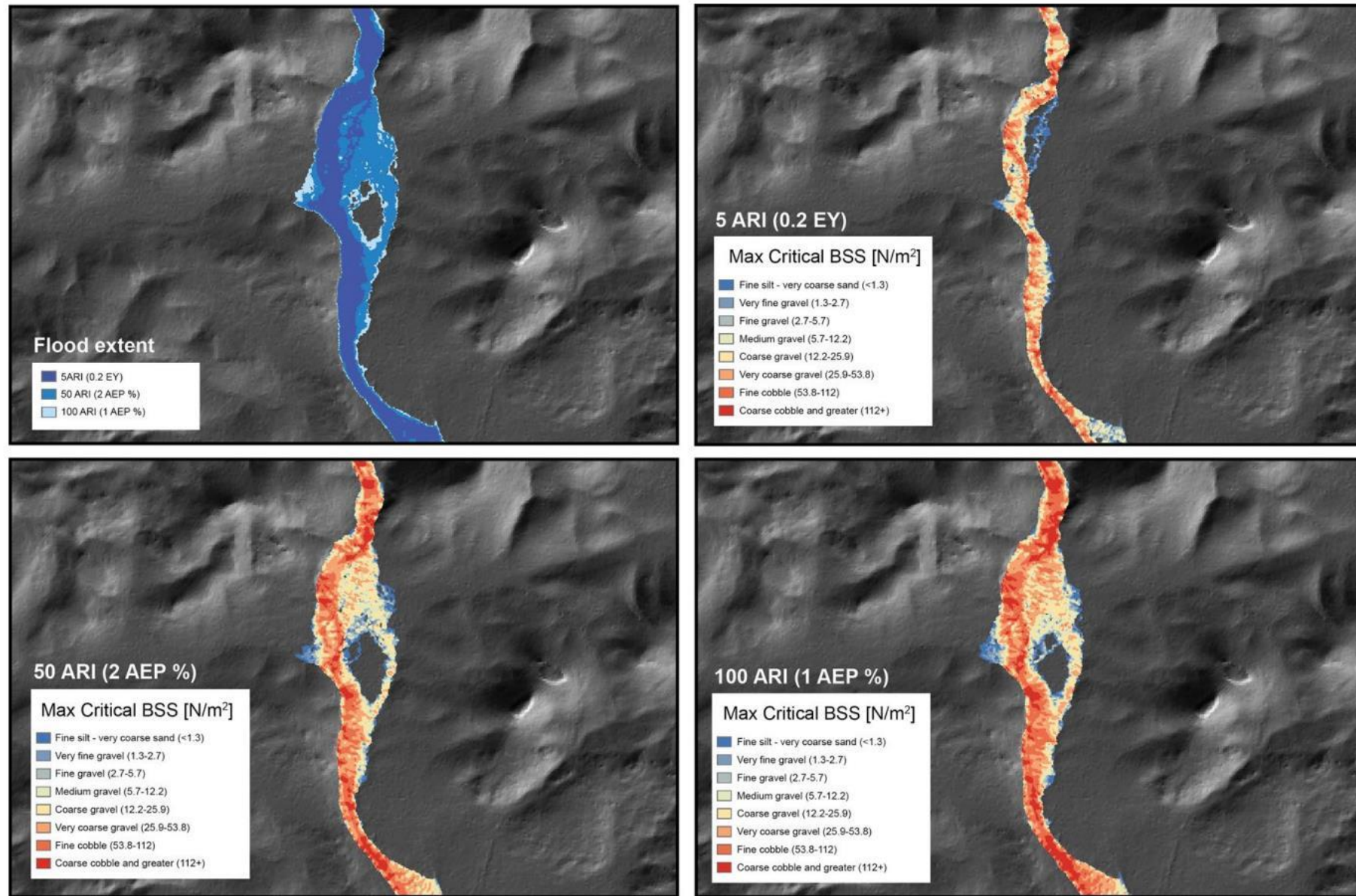


Fig. 11 Flood extent and critical bed shear stress for C7 across the 0.2 EY, 2 AEP (%), and the 1 AEP (%). Flood extent has been clipped to show the catchment outlet

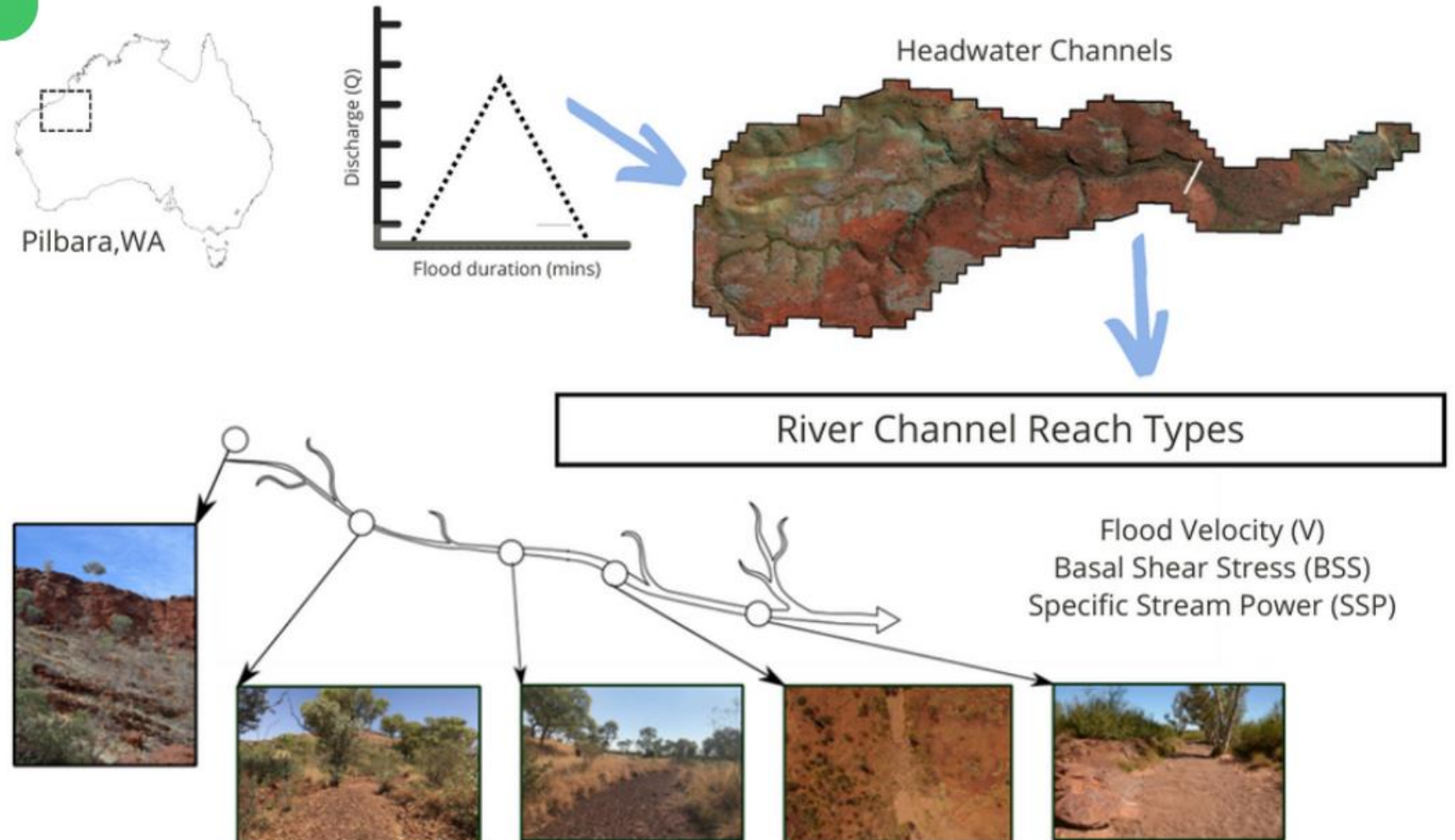
Table 6 Comparison of the hydraulic values derived in the headwater channels in the Pilbara compared with the ACARP criteria (Queensland) where ACARP values are derived from White et al. (2014b)

Stream type	Velocity (m/s)		Stream power (W/m ²)		Shear Stress (N/m ²)	
	Frequent floods (2ARI-5 ARI)	Rare (50 ARI)	Frequent floods [†] (2ARI-5 ARI)	Rare Floods (50 ARI)	Frequent floods (2ARI-5 ARI)	Rare floods (50 ARI)
This study						
All headwater channels	1–2	2–3	1–6	5–16	16–72	48–124
Single channel (≥ cobble)	1–1.7	1.6–2.8	1.3–12.6	1.7–22.3	25.4–69.4	44–135
Single channel (sand)	0.8–1.6	1.35–1.8	0.4–2.3	0.2–1.9	9.4–22.8	11–38
Bedrock/confined channel	0.9–1.8	1.8–2.9	0.9–8	2.9–14.5	14.9–95.7	70–170
Island barform channel	1–1.4	1.8–2.2	1.3–2.9	2.9–7.2	24.4–60	52.8–100
Heavily vegetated channel	1.5–1.7	2.2–2.5	1.5–3.1	2.6–6.3	19.7–51.9	63–103
ACARP						
Supply limited (low sediment supply)	1–1.5	1.5–2.5	15–35	50–100	< 40	< 100
Transport limited (high sediment supply)	0.5–1.1	0.9–1.5	35–60	80–150	< 40	< 50
Bedrock controlled	1.3–1.8	2.3	50–100	100–350	< 55	< 120

The hydraulic values in this study were created for a 5 year ARI whereas the ACARP values are for a 2 year ARI, but these both fall under the frequent flood range and are therefore compared as such

[†]Frequency descriptor comes from the Australian Rainfall and Runoff (ARR2016) preferred terminology for flood risk (Book 1, Chapter 2.2.5)

Key Findings



New geomorphic
criteria for river
diversion channels

What about the future?

Why do we care about long-term landscape in the Pilbara?



To improve understanding of landscape processes



To understand future landform behavior – e.g post-mining (Mt Whaleback)

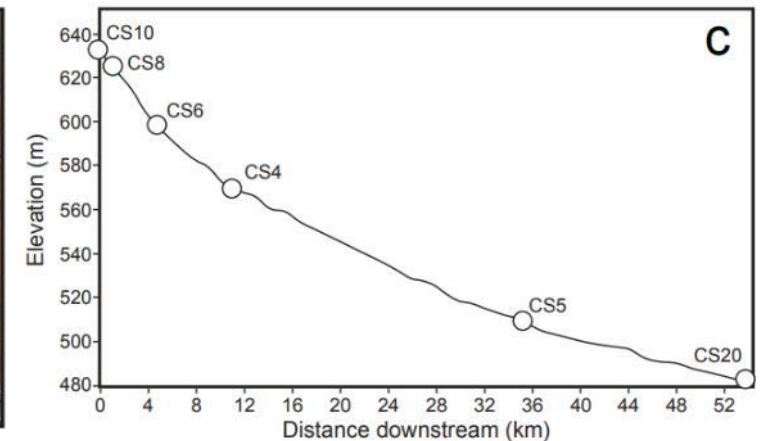
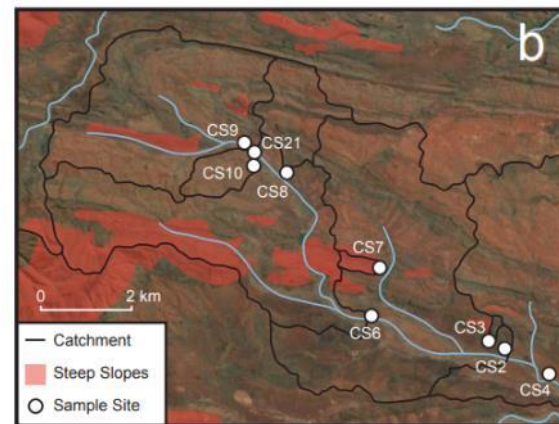
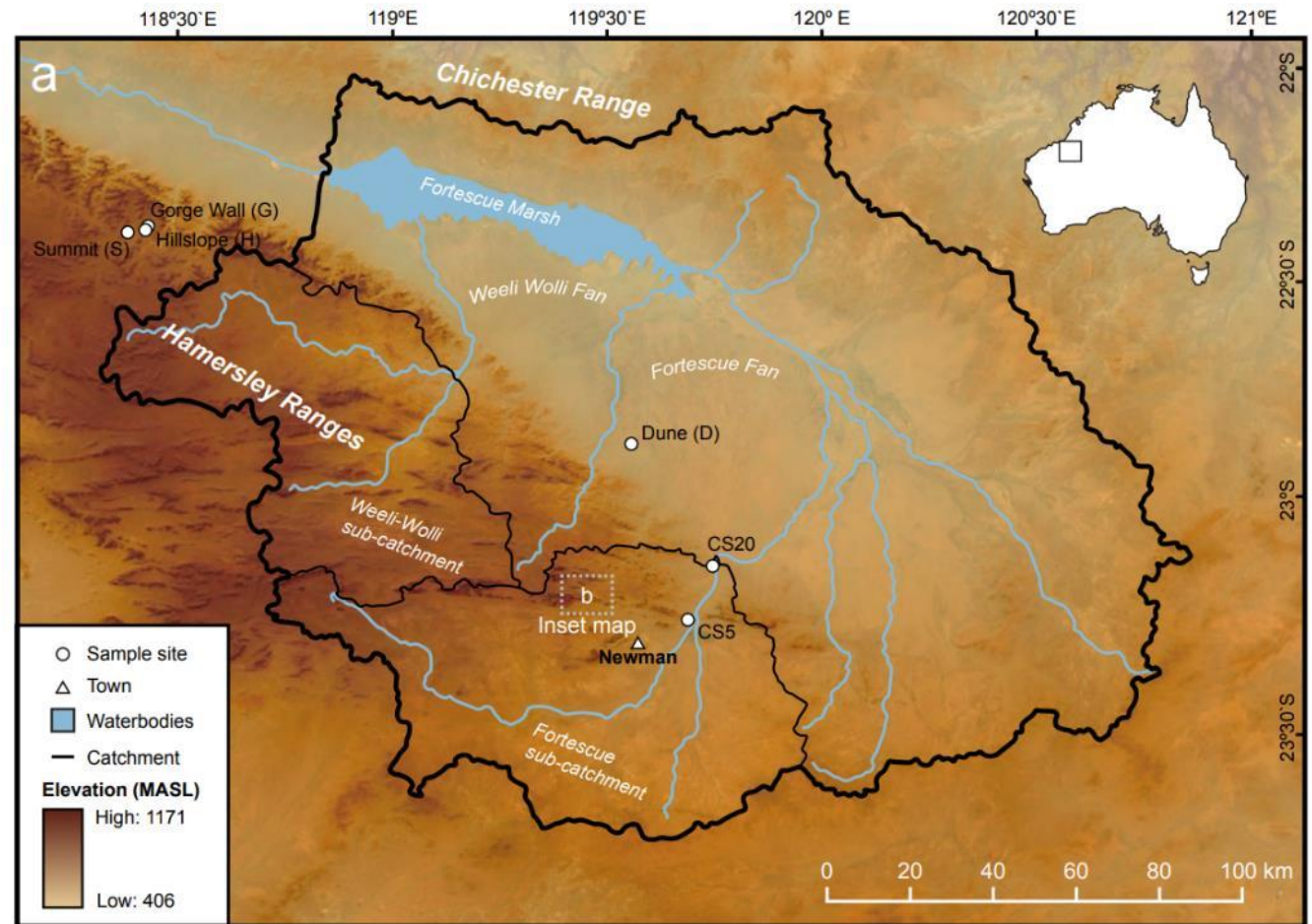


To determine sediment pathways

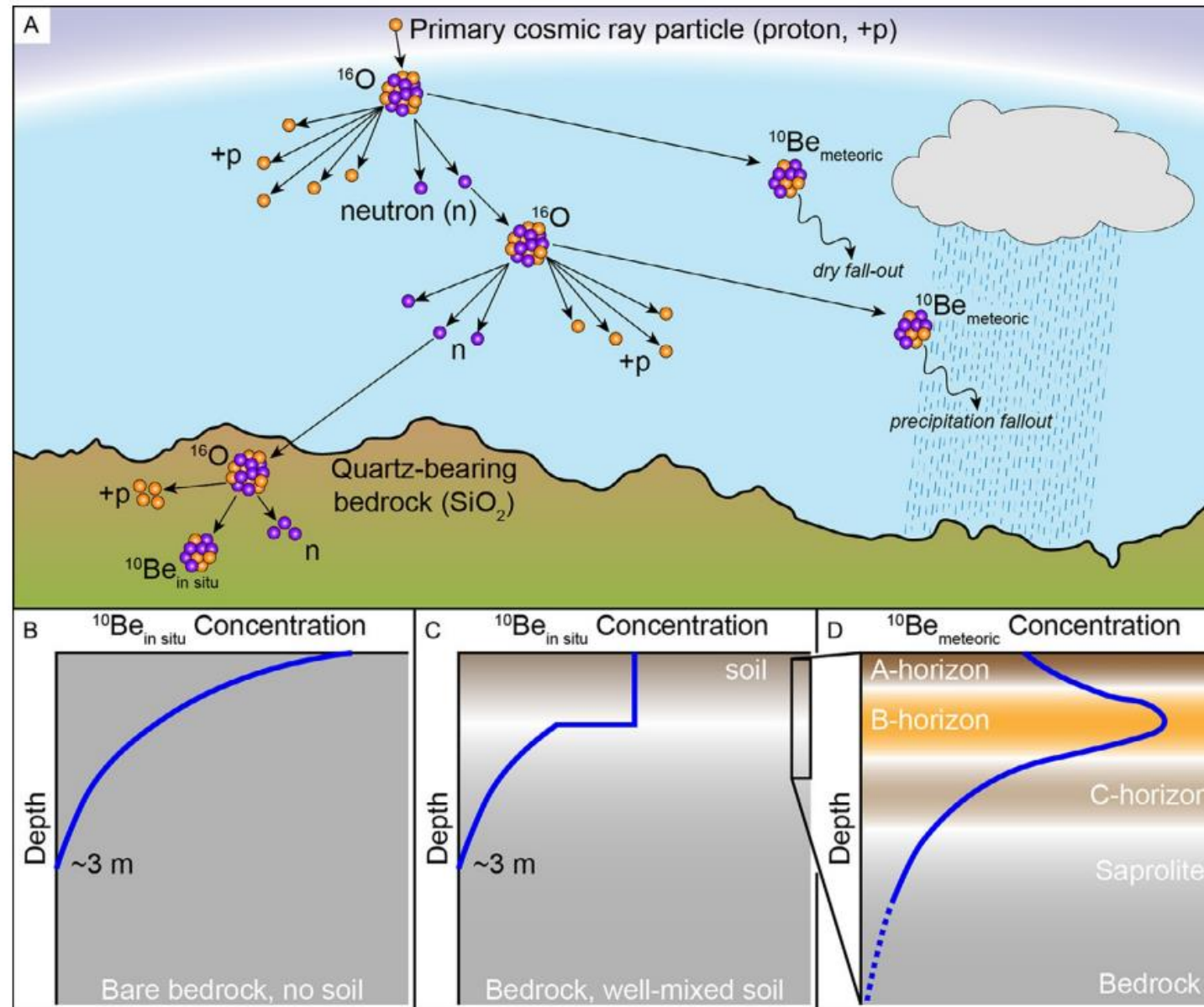


To quantify sediment yields...

Why do we
care about
long-term
landscape
in the
Pilbara?



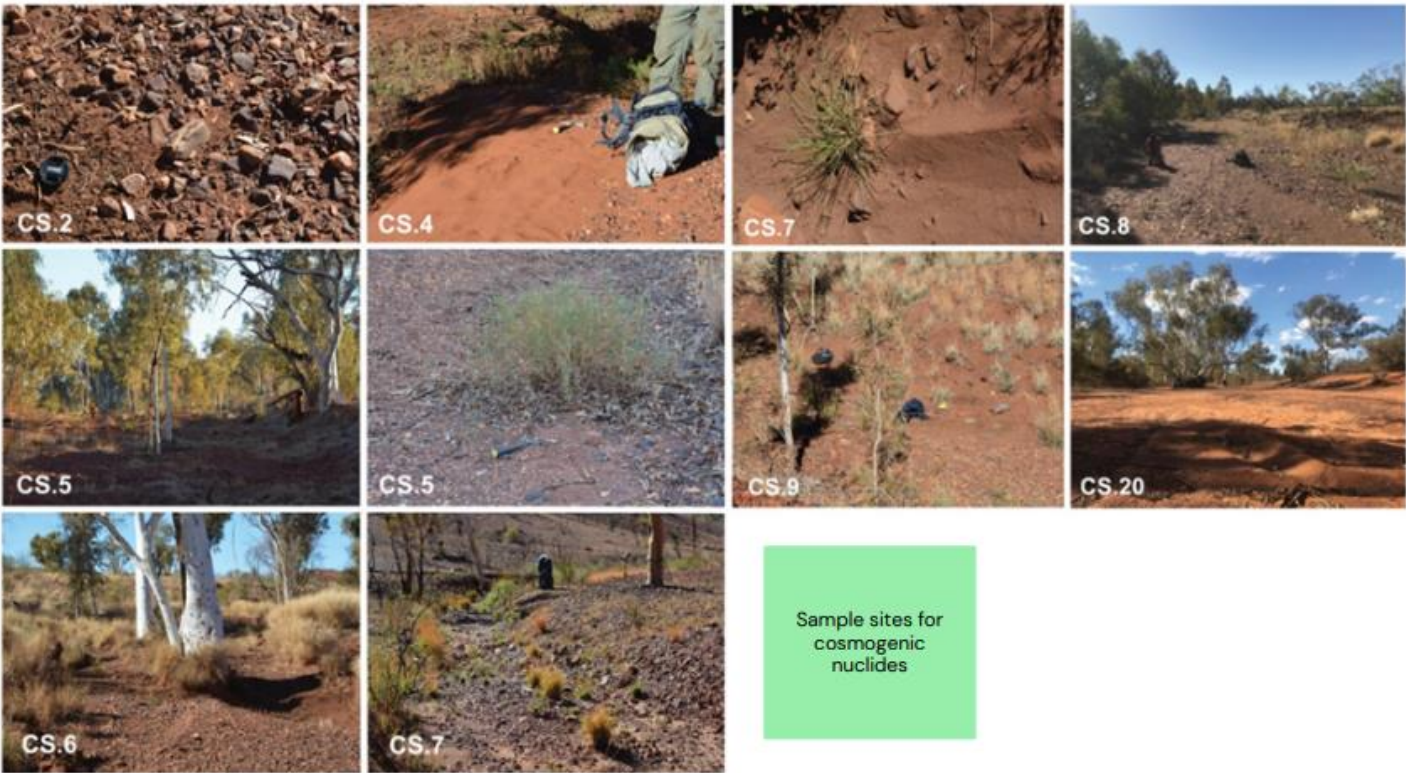
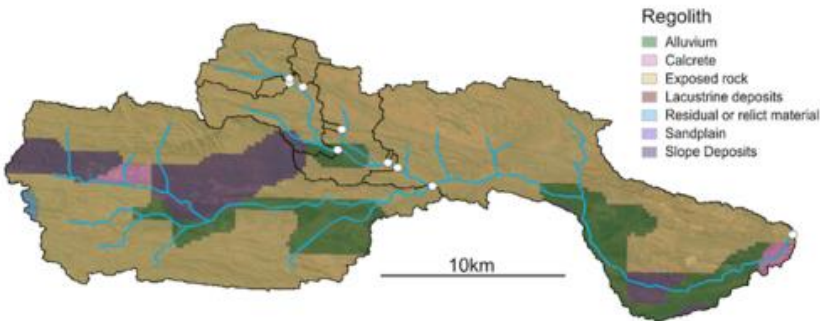
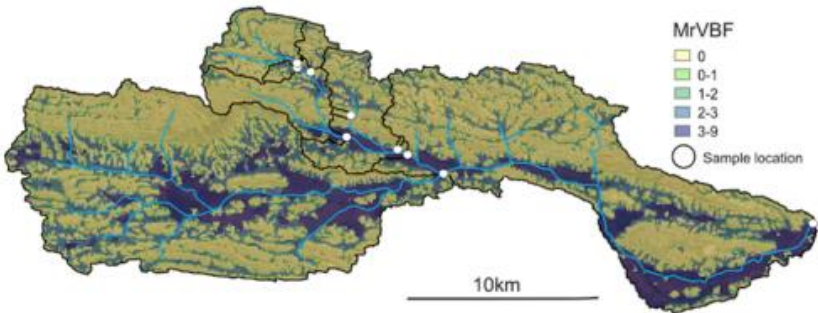
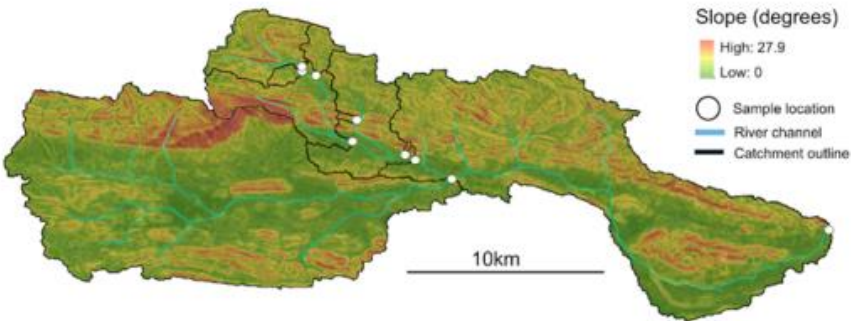
Why do we care about long-term landscape in the Pilbara?



^{10}Be produced in situ via spallation of ^{16}O in quartz (SiO_2)-bearing bedrock remains locked in the quartz mineral crystal structure (^{10}Be in situ)

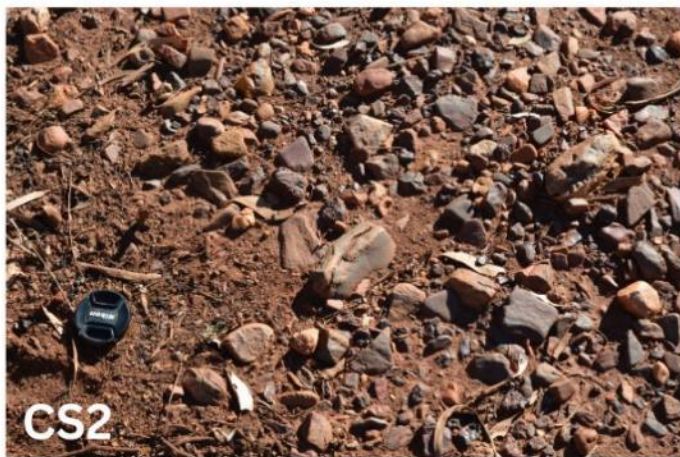
Denudation/Erosion

$^{10}\text{Be}/^{26}\text{Al}$



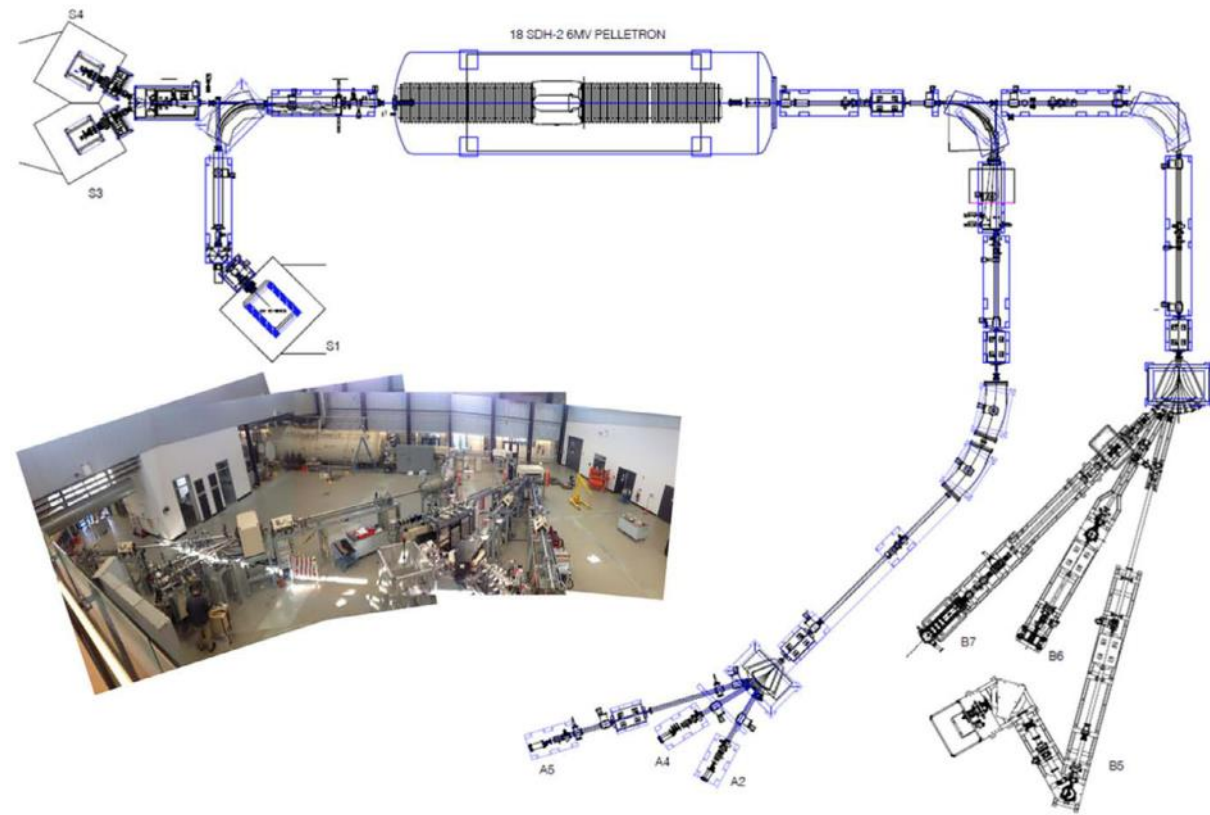
Sample sites for
cosmogenic
nuclides

Morphometric
analysis and
catchment
description



Methods

- Standard $^{10}\text{Be}/^{26}\text{Al}$ preparation
- Measured on 6MV SIRIUS AMS
- Erosion rates calculated using CRONUS (<https://hess.ess.washington.edu/>)



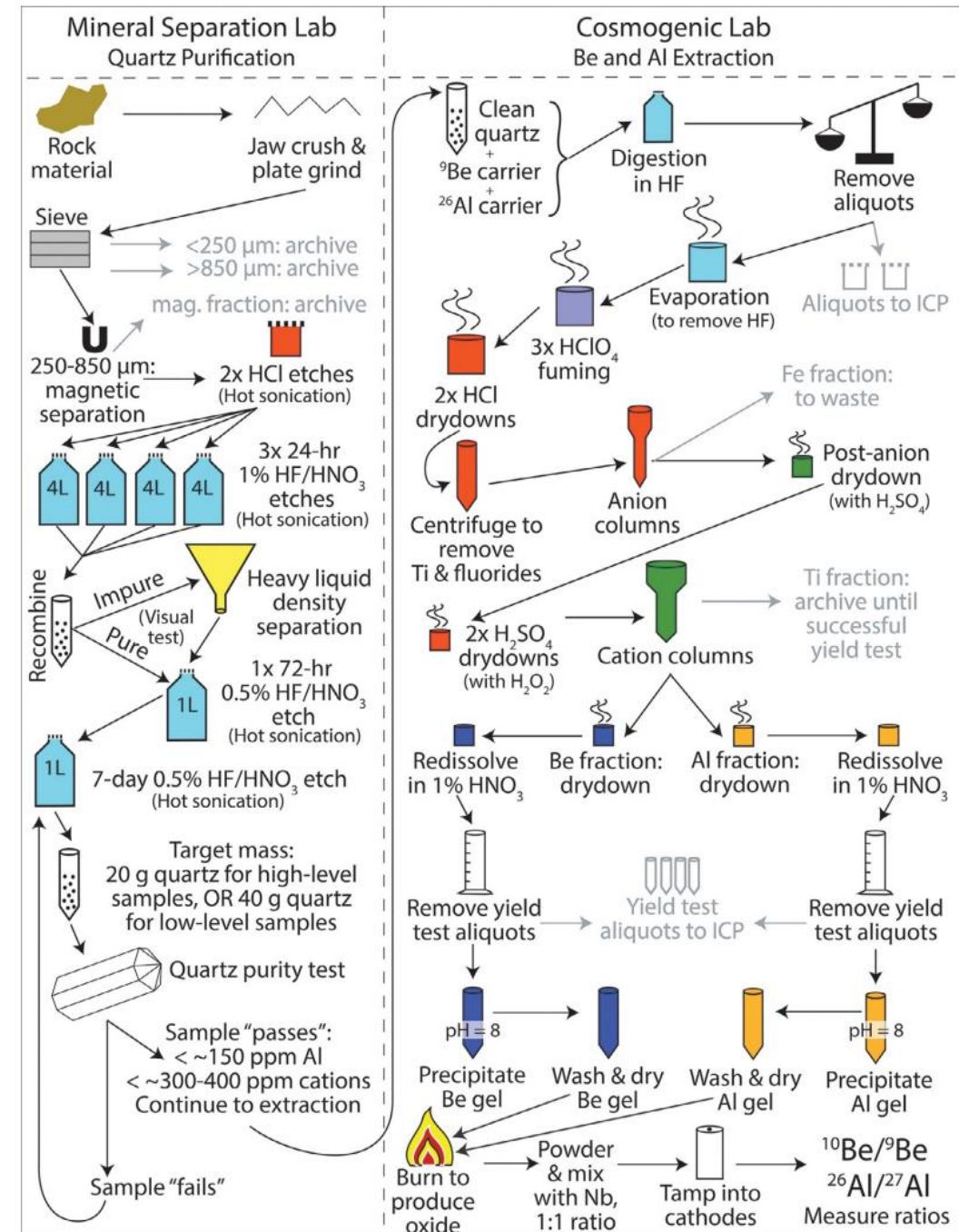
Pastuovic et al, 2015

- Sensitivity Analysis + corrections made for topographic shielding, and catchment lithology (% quartz) using BASINGA (Charreau et al., 2019)
- Catchment wide attributes (slope, regolith, geology, MrVBF)

Methods

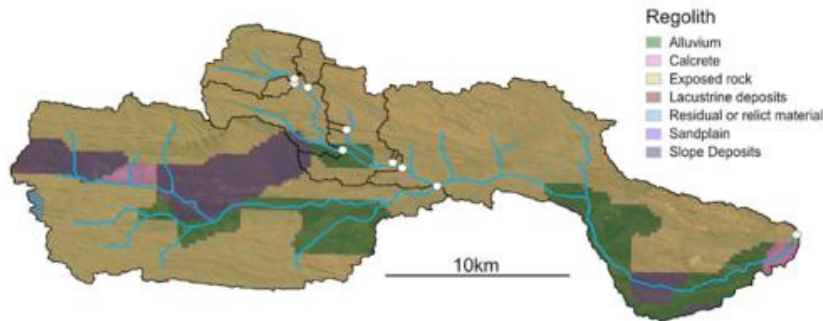
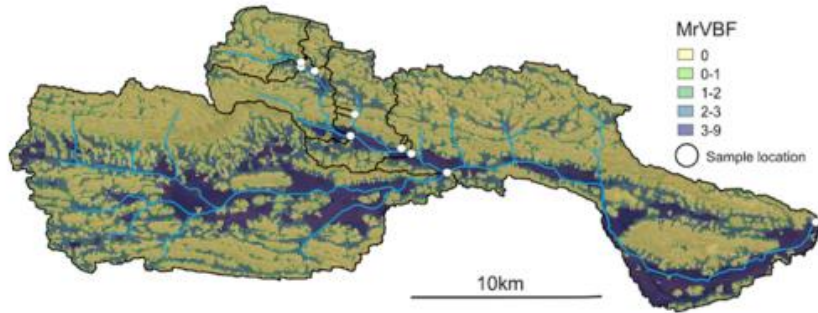
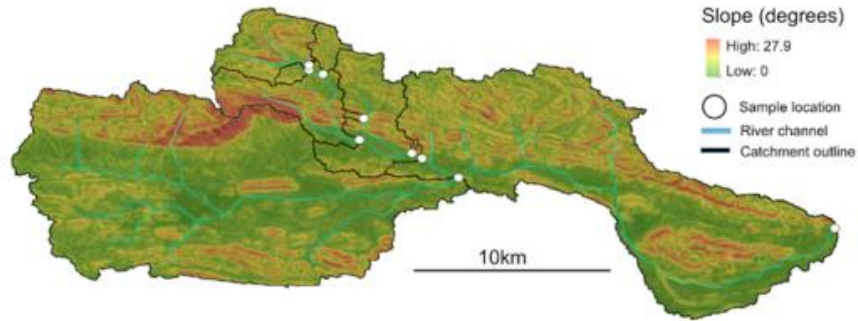
- Standard $^{10}\text{Be}/^{26}\text{Al}$ preparation
- Measured on 6MV SIRIUS AMS
- Erosion rates calculated using CRONUS
(<https://hess.ess.washington.edu/>)

TL;DR



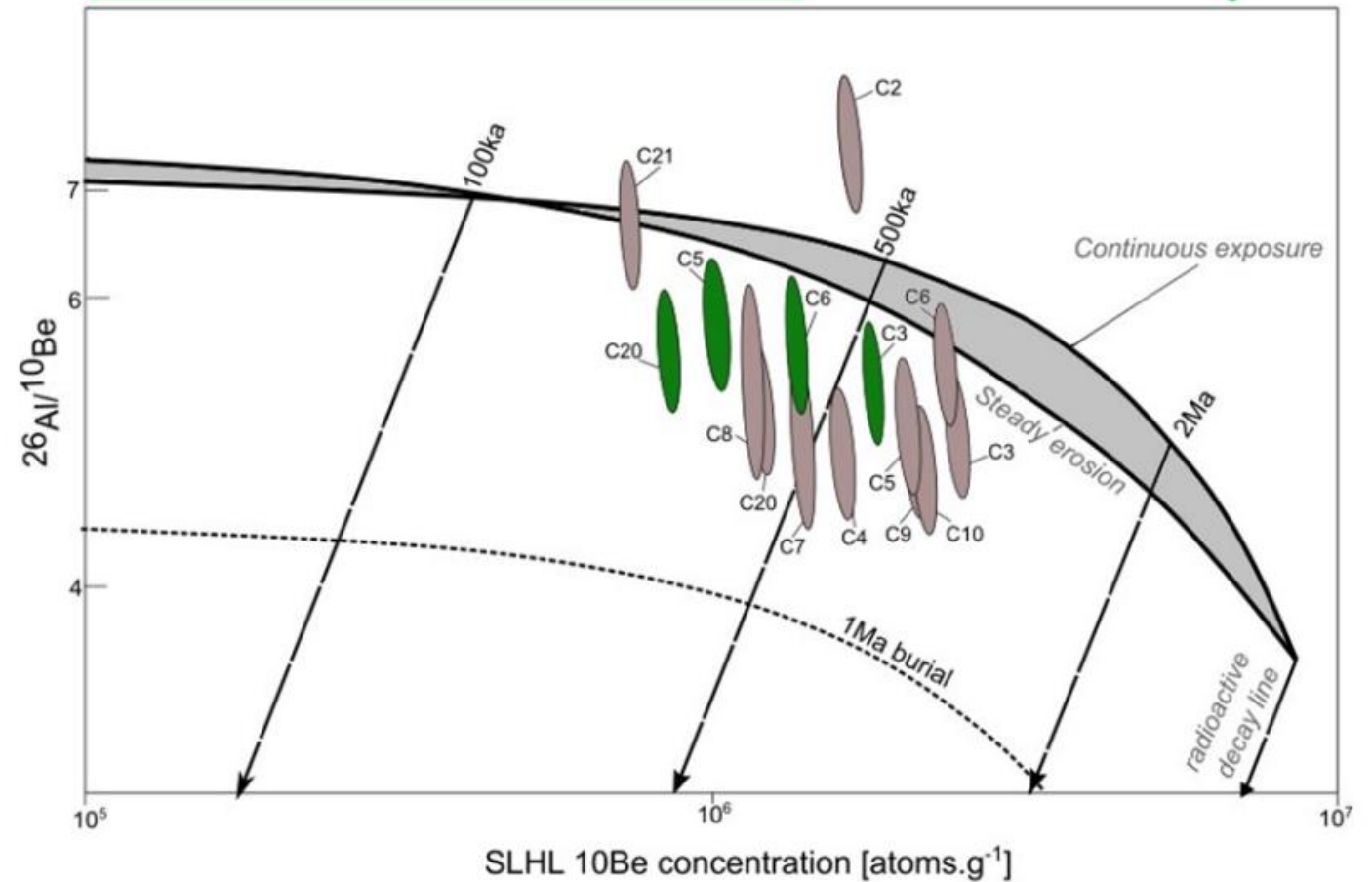
Denudation/Erosion

$^{10}\text{Be}/^{26}\text{Al}$



Key Findings

Cosmogenic nuclide 'banana plot'. Two nuclide logarithmic plot with burial isochrones (dotted lines) and decay lines (dashed lines). X-axis shows the ^{10}Be concentration at sea-level, high latitude (SLHL). Samples that have been shielding will plot under the steady-state erosion line because the $^{26}\text{Al}/^{10}\text{Be}$ ratio will decrease from the shorter half-life of ^{26}Al compared to ^{10}Be .



Denudation/Erosion

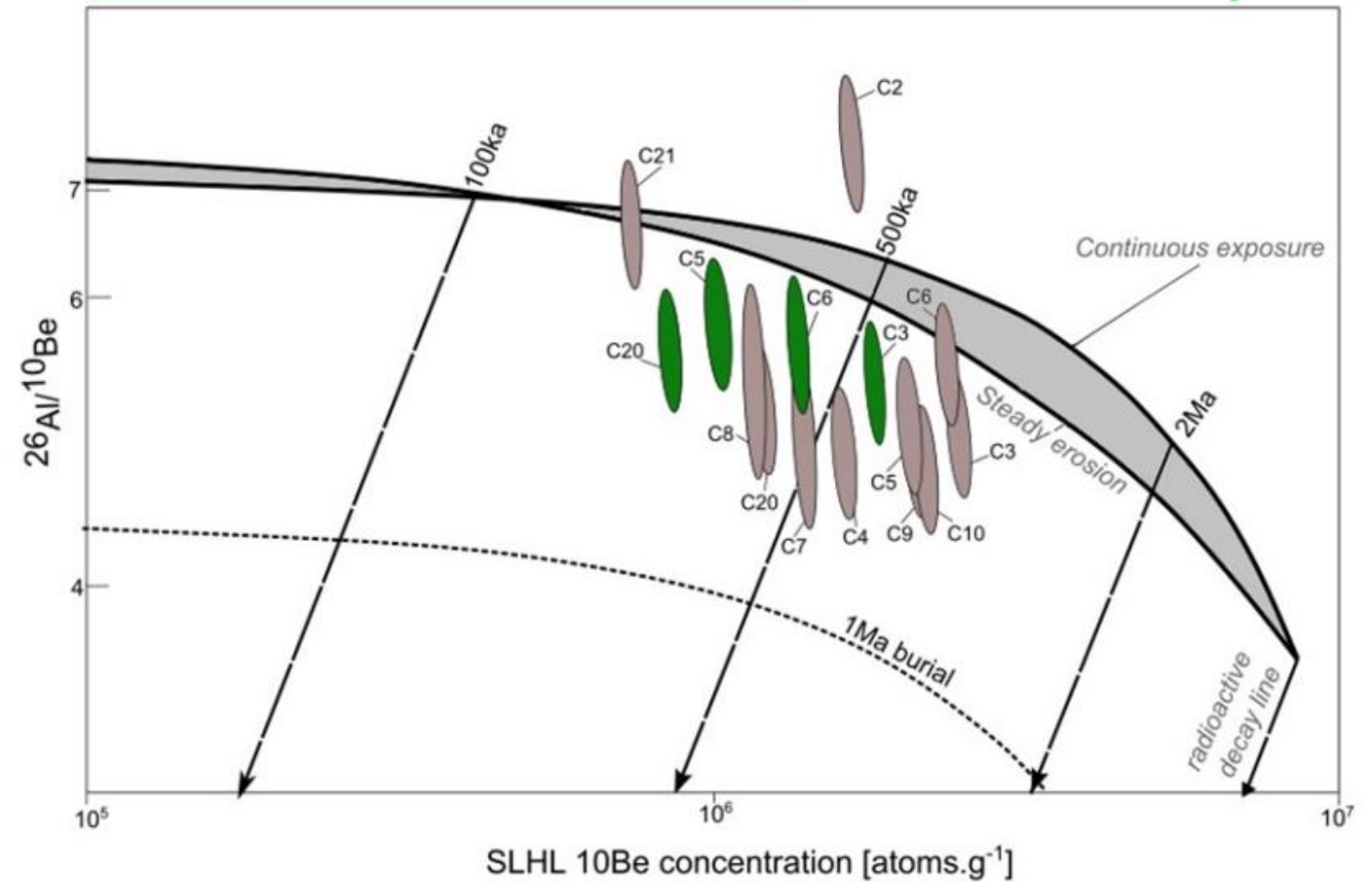
$^{10}\text{Be}/^{26}\text{Al}$



Sediment pathways

Key Findings

Cosmogenic nuclide 'banana plot'. Two nuclide logarithmic plot with burial isochrones (dots) and decay lines (dashed lines). X-axis shows the ^{10}Be concentration at sea-level, high latitude (SLHL). Samples that have been shielding will plot under the steady-state erosion line because the $^{26}\text{Al}/^{10}\text{Be}$ ratio will decrease from the shorter half-life of ^{26}Al compared to ^{10}Be .



Denudation/Erosion

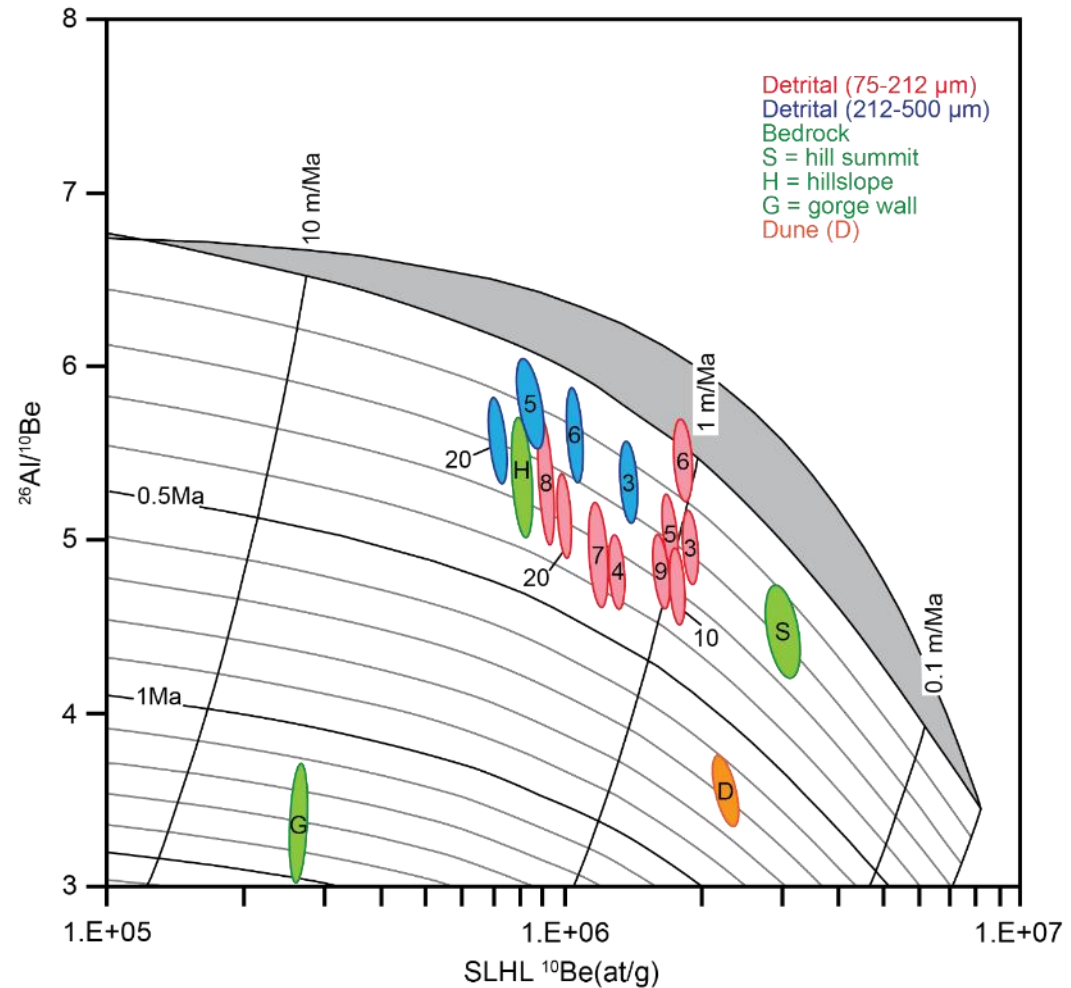
$^{10}\text{Be}/^{26}\text{Al}$

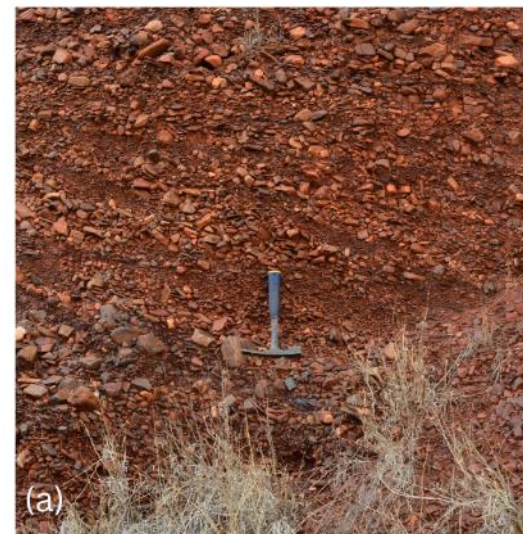
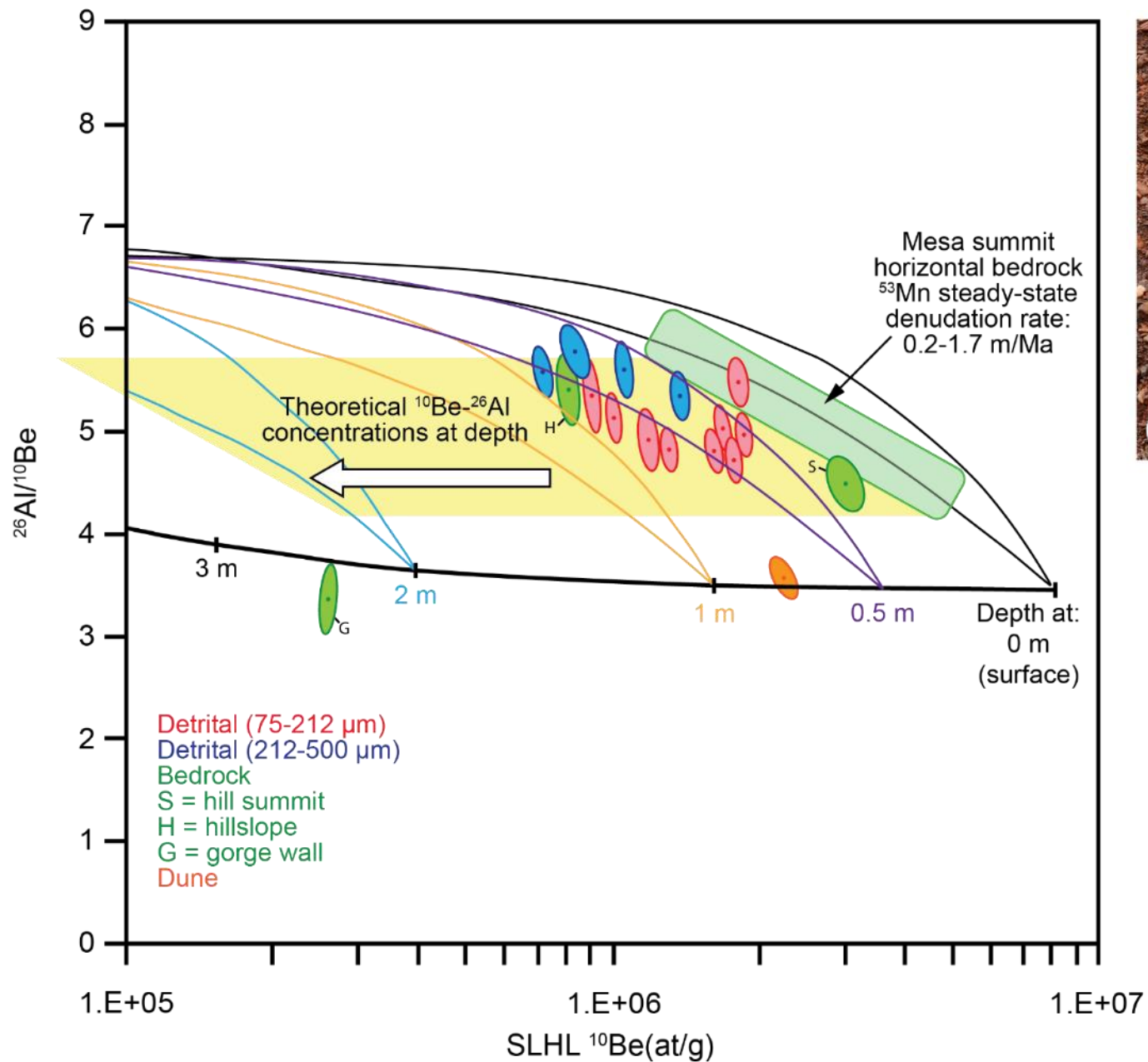


Sediment pathways

Key Findings

Cosmogenic nuclide 'banana plot'. Two nuclide logarithmic plot with burial isochrones (dots) and decay lines (dashed lines). X-axis shows the ^{10}Be concentration at sea-level, high latitude (SLHL). Samples that have been shielding will plot under the steady-state erosion line because the $^{26}\text{Al}/^{10}\text{Be}$ ratio will decrease from the shorter half-life of ^{26}Al compared to ^{10}Be .



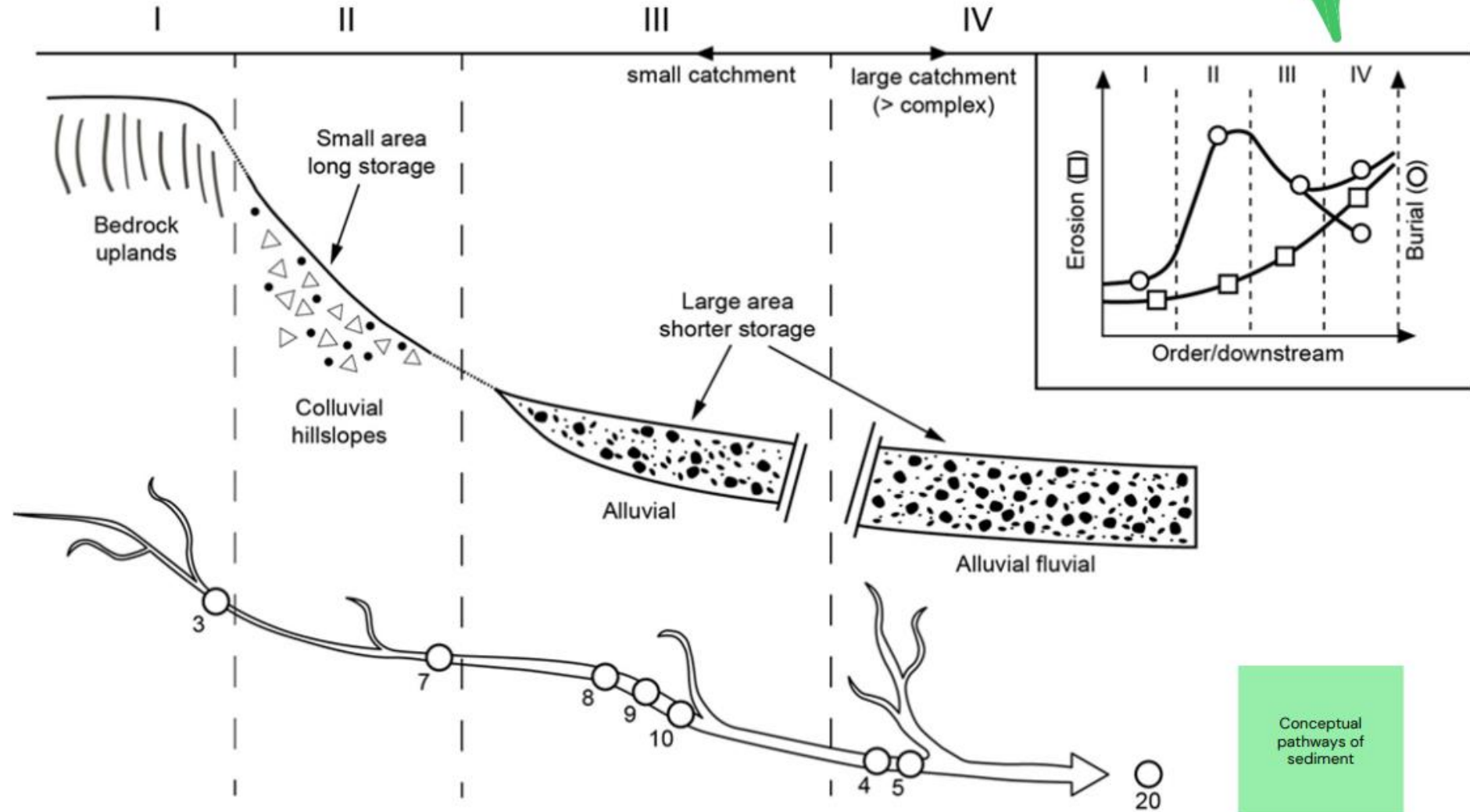


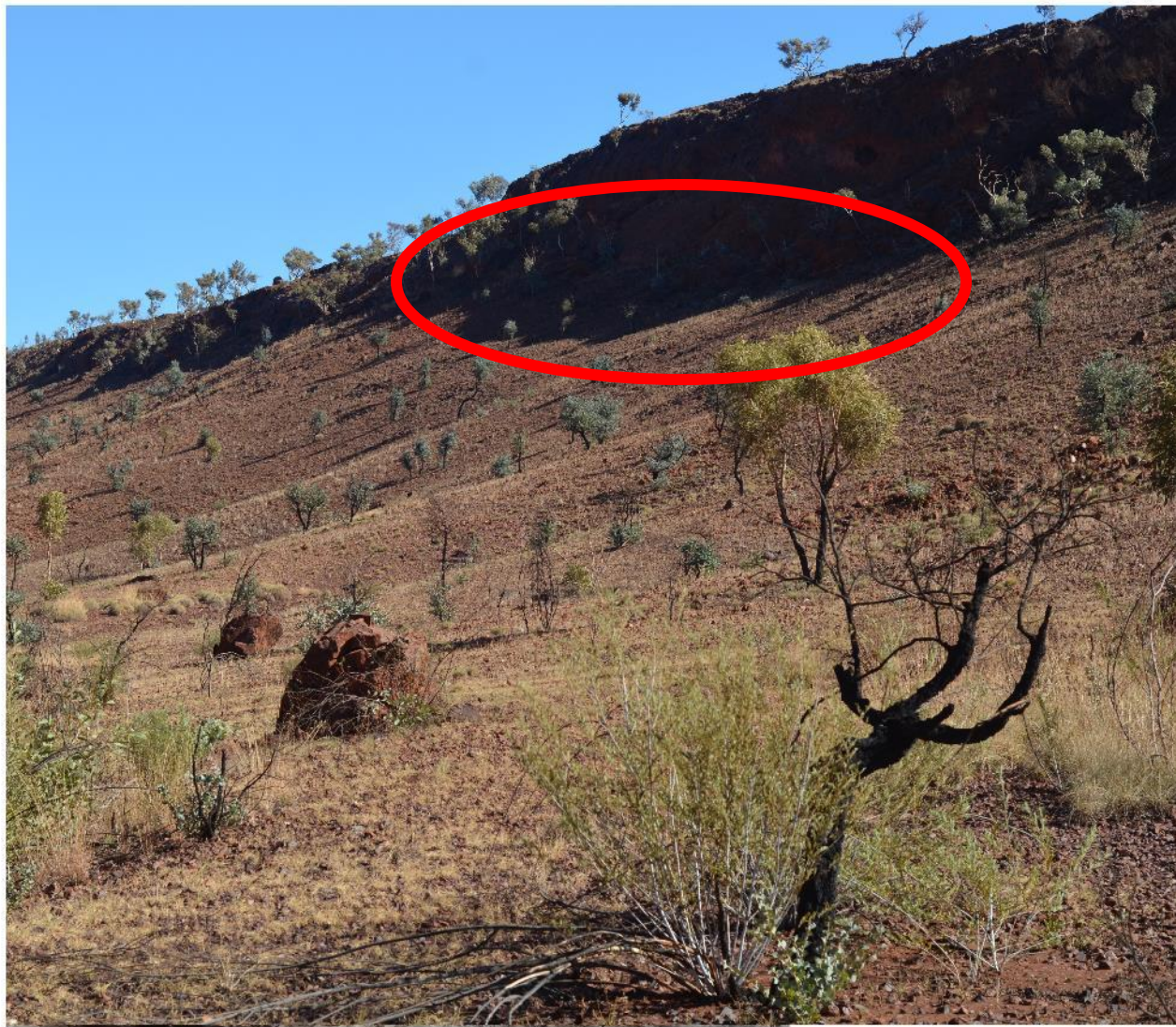
Theoretical ^{10}Be - ^{26}Al concentrations at depth for Pilbara detrital samples. Production rate is smaller at depth which creates a decrease in the $^{26}\text{Al}/^{10}\text{Be}$ ratio as shown.

Denudation/Erosion

$^{10}\text{Be}/^{26}\text{Al}$

Key Findings





Mesa and hillslope with minimal regolith cover, note the BIF-boulder within the landscape and clustered coarse material in the foreground. The rest of the slope is gentle leaving the mesa exposed at the ridgeline. (b) Distinctive layers of BIF with subsurface spalling and bedrock plucking.

Denudation/Erosion

$^{10}\text{Be}/^{26}\text{Al}$

Key Findings



Setting	Erosion Rate (m/Myr)	Qs (ton/ha/yr)	Method
Small	1.54	0.0462	^{10}Be
Medium	1.60	0.048	^{10}Be
Large catchment	2.11	0.063	^{10}Be

New long-term
denudation rates
(and sediment
yields)

Break!

Recommended Links:

[Wales Biodiversity Partnership - Nature Recovery Action Plan \(biodiversitywales.org.uk\)](https://biodiversitywales.org.uk)

Securing a sustainable future: [Environmental Principles, Governance and Biodiversity targets for a Greener Wales](#)

Activity

- Thinking historically!
- Degraded landscapes
- Past impact on current environment
- Georeferencing
- Mapping from start to finish

Aim

In this lab we will be continuing GIS tasks using raster files to explore how we can potentially improve the biodiversity of degraded landscapes. For these activities we will be using and interpreting historic maps. We will build our skills in the following areas:

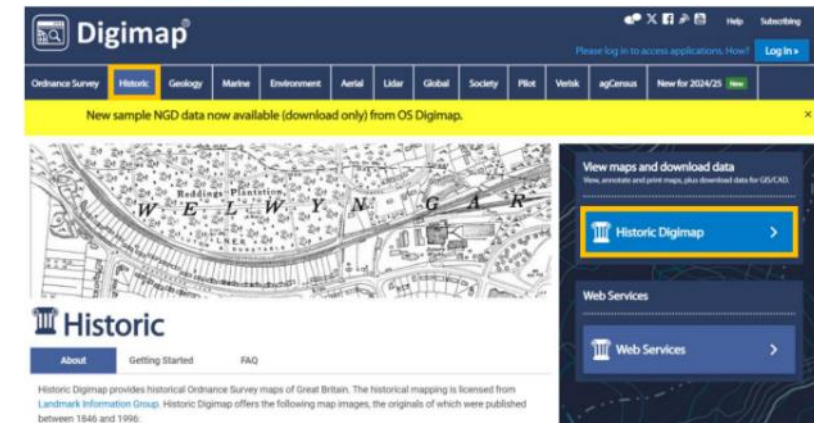
- Georeferencing historic maps
- Symbology and visualisation of complex data
- Map output

Activity 1 – Download historic maps

In this activity we will be importing historic maps. For this first activity we will be exploring the historic maps available for our site of interest. We will be exploring Digimap and extracting historic maps for our area of interest.

Instructions:

- 1) Click on: [Digimap \(edina.ac.uk\)](https://digimap.edina.ac.uk). Navigate to historic imagery.



- 2) Click on the dates to see what historic maps are available for your area of interest. Next, click on the Download icon on the left of your screen (shown in the