An innovative approach for removal of heavy metals (zinc, lead, etc) from former mine affected streams and rivers on the Isle of Man

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Introduction

Presenters

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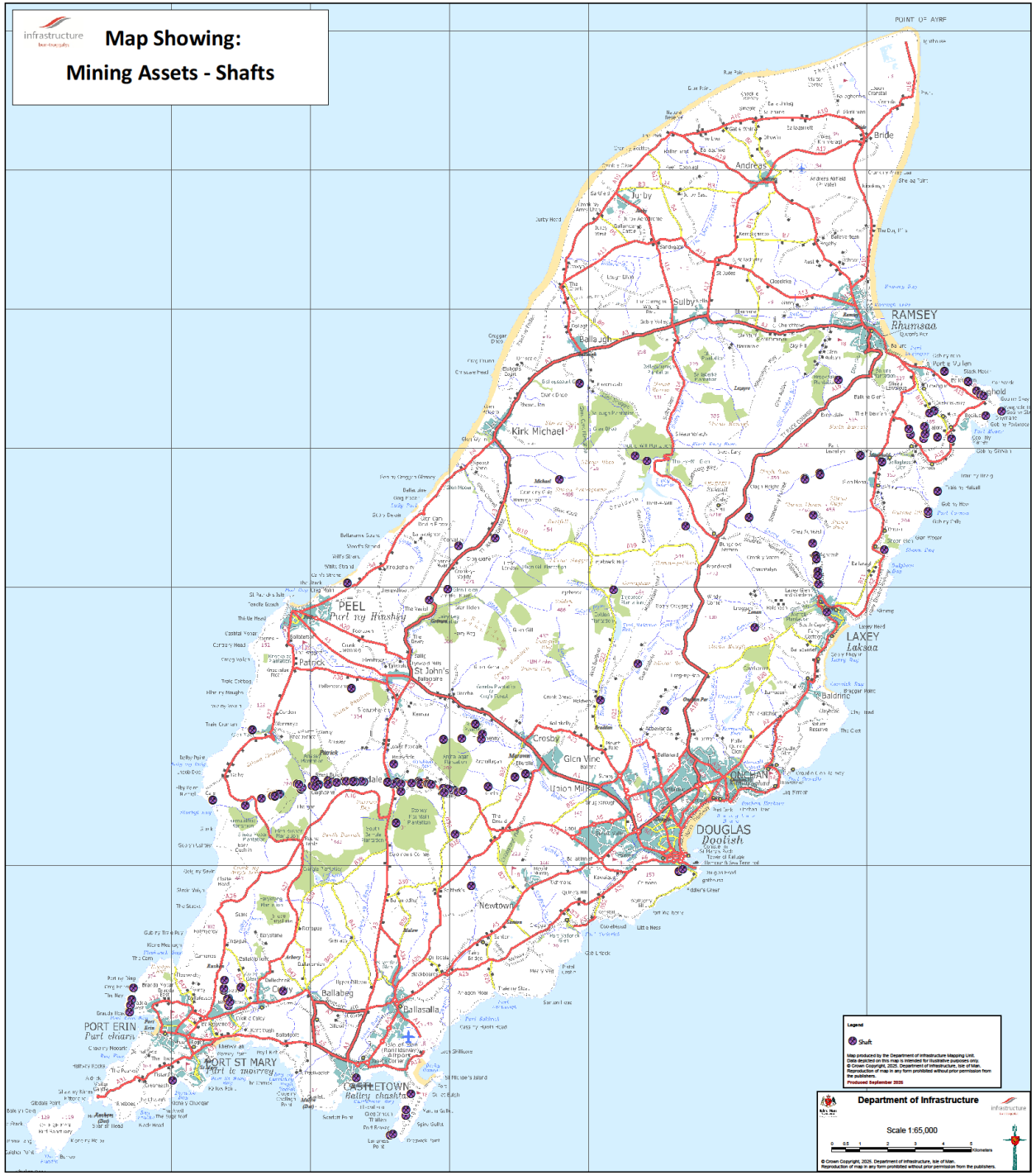
Why is mine water a problem?

Mining history on Isle of Man

- Mining for metals dates back to circa 1300's
- By 1800's, mining starts to become more developed



- Mining activities stretched from Maughold to The Sound
- Mainly concentrated in Laxey and Foxdale areas
- Significant mining location in British Isles
- Metal ore mined and crushed & exported for smelting
- Last mine closed in 1930's

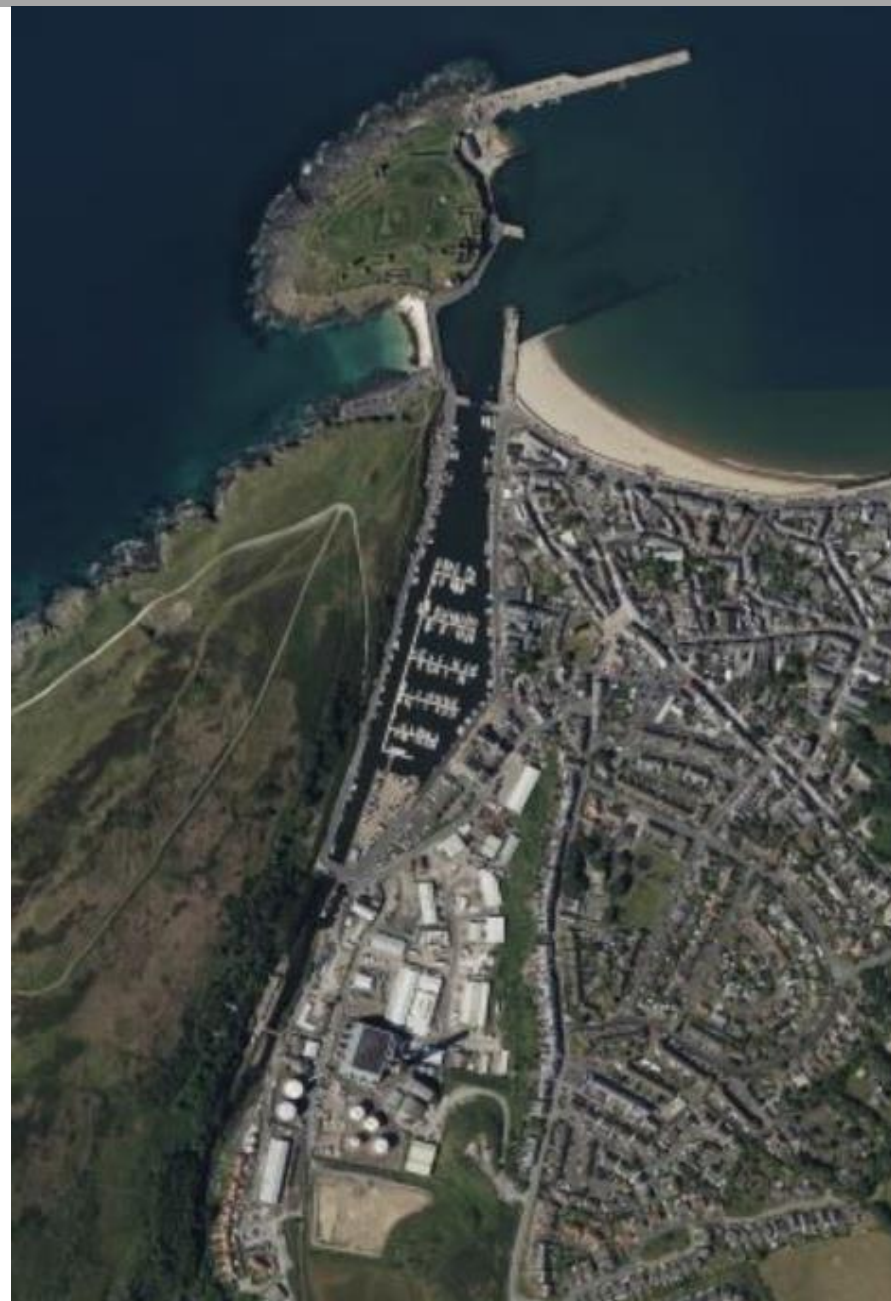
Why is mine water a problem?

- No environmental protection measures considered when mines closed
- Mine water releases lead, zinc, copper, etc into adjacent water courses
- 2 sources:
  - Surface material
  - Mine drainage water
- 2 pathways:
  - Particles within the water
  - Metals dissolved into water

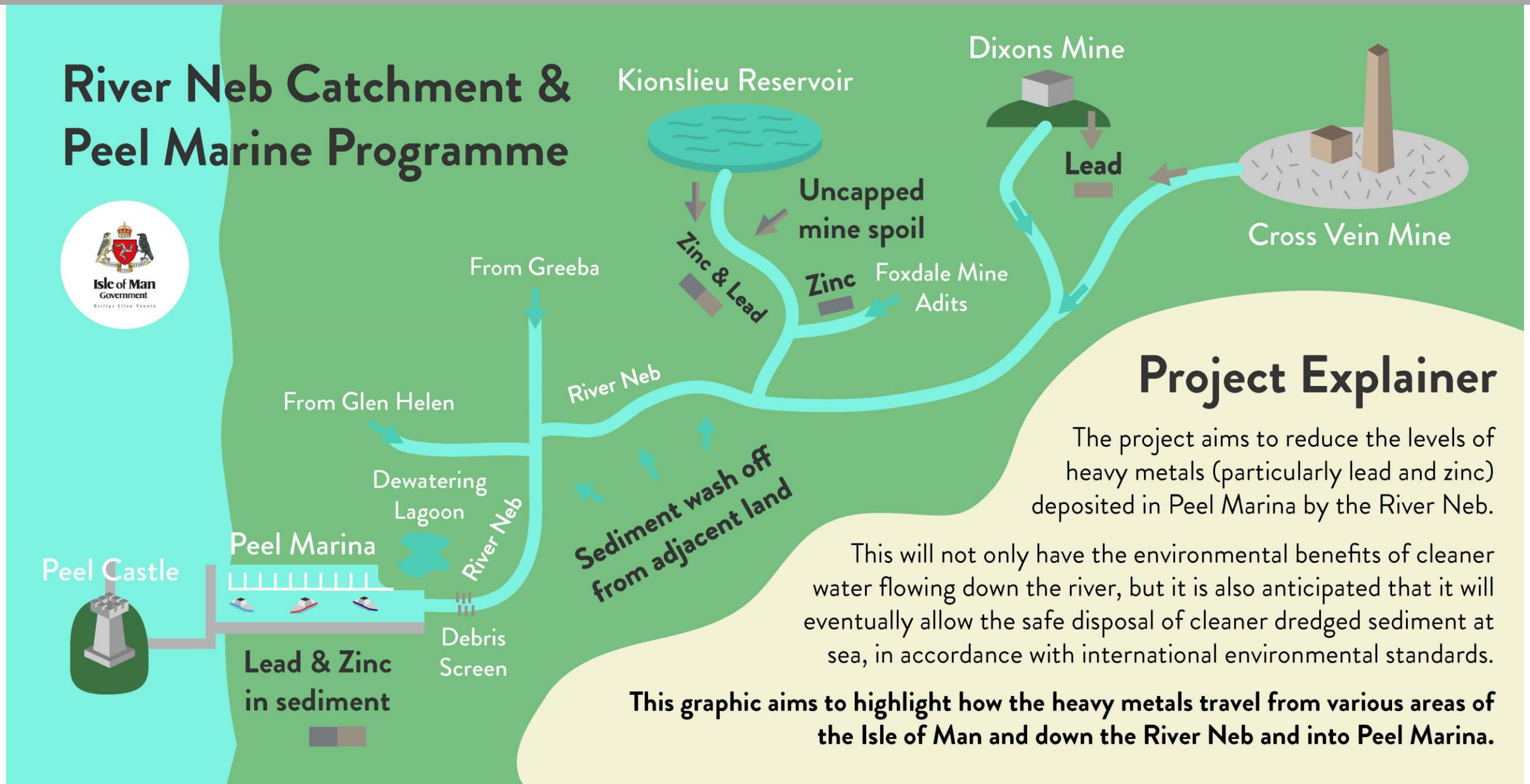
Peel Marina & River Neb Catchment

Peel Marina

- River Neb deposits circa 3,000t of sediment each year into the marina
- Sediment contains lead & zinc from mines in Foxdale area
- Levels of lead & zinc prevent dredged material being deposited at sea
- DEFA and DOI undertaking a number of projects to reduce the levels of lead and zinc within River Neb Catchment



Peel Marina & River Neb Catchment



Project Explainer

The project aims to reduce the levels of heavy metals (particularly lead and zinc) deposited in Peel Marina by the River Neb.

This will not only have the environmental benefits of cleaner water flowing down the river, but it is also anticipated that it will eventually allow the safe disposal of cleaner dredged sediment at sea, in accordance with international environmental standards.

This graphic aims to highlight how the heavy metals travel from various areas of the Isle of Man and down the River Neb and into Peel Marina.

Peel Marina & River Neb Catchment

Short term

- Peel Marina dredged in 2020 and 2021
- Cross Vein Mine Remediation
- Kionslieu Reservoir Settlement Pond

Peel Marina Dredging 2020 & 2021

Cross Vein Mine Remediation

Stage 1 – Stop unauthorised vehicles disturbing surface

Stage 2 – Roadside drainage improvements

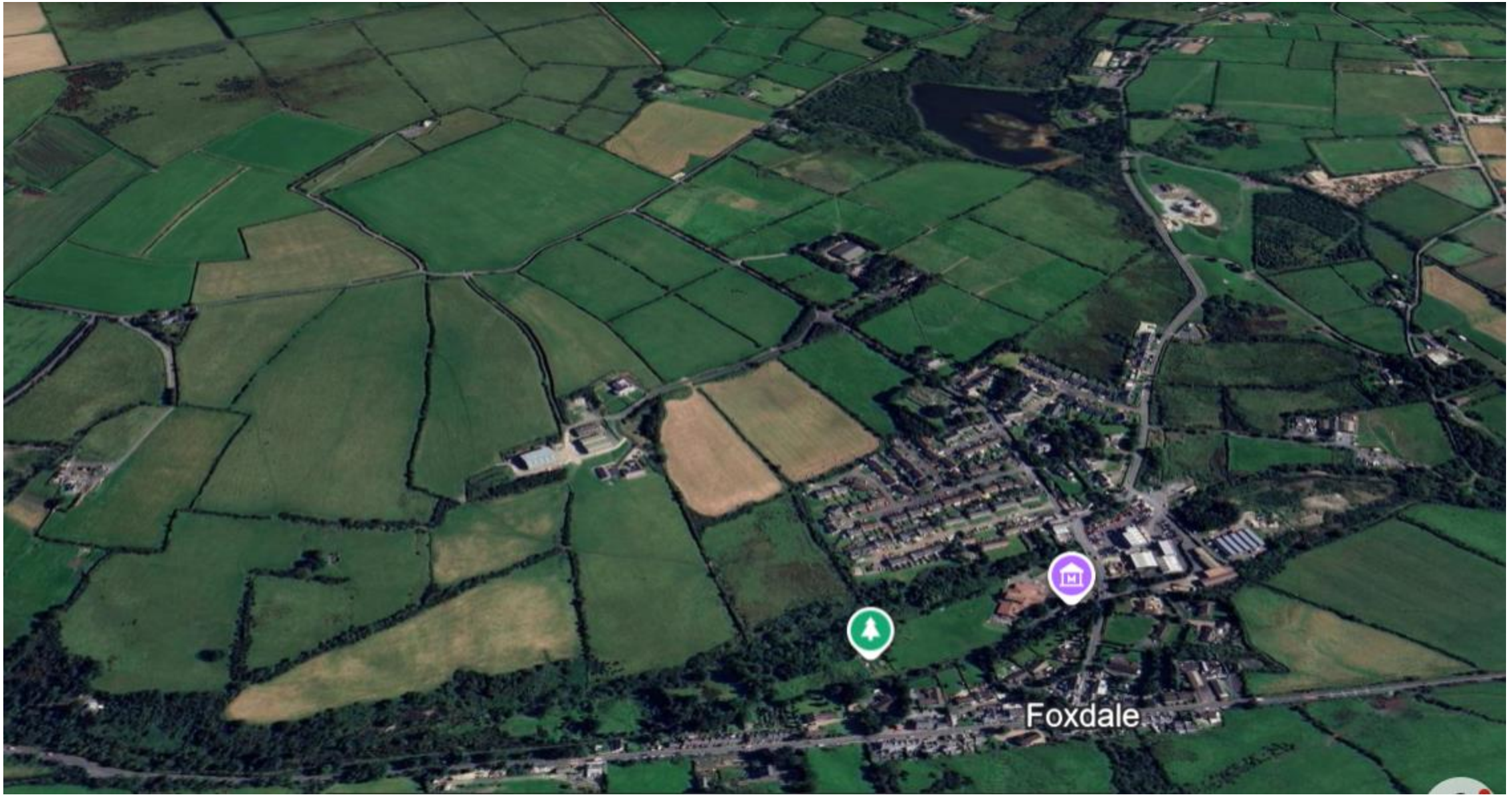
Cross Vein Mine Remediation

Stage 3 – Install leaky dams

Cross Vein Mine Remediation

Stage 4 – Cap majority of Deads area with treated material
Stage 5 – Dixon's Mine washfloor

Kionslieu Reservoir Settlement Pond



Peel Marina & River Neb Catchment

Long term

- Identify other sources
- Research methods of reducing dissolved zinc & lead from mine water

Mine Water: Mining Influenced Water is a global problem

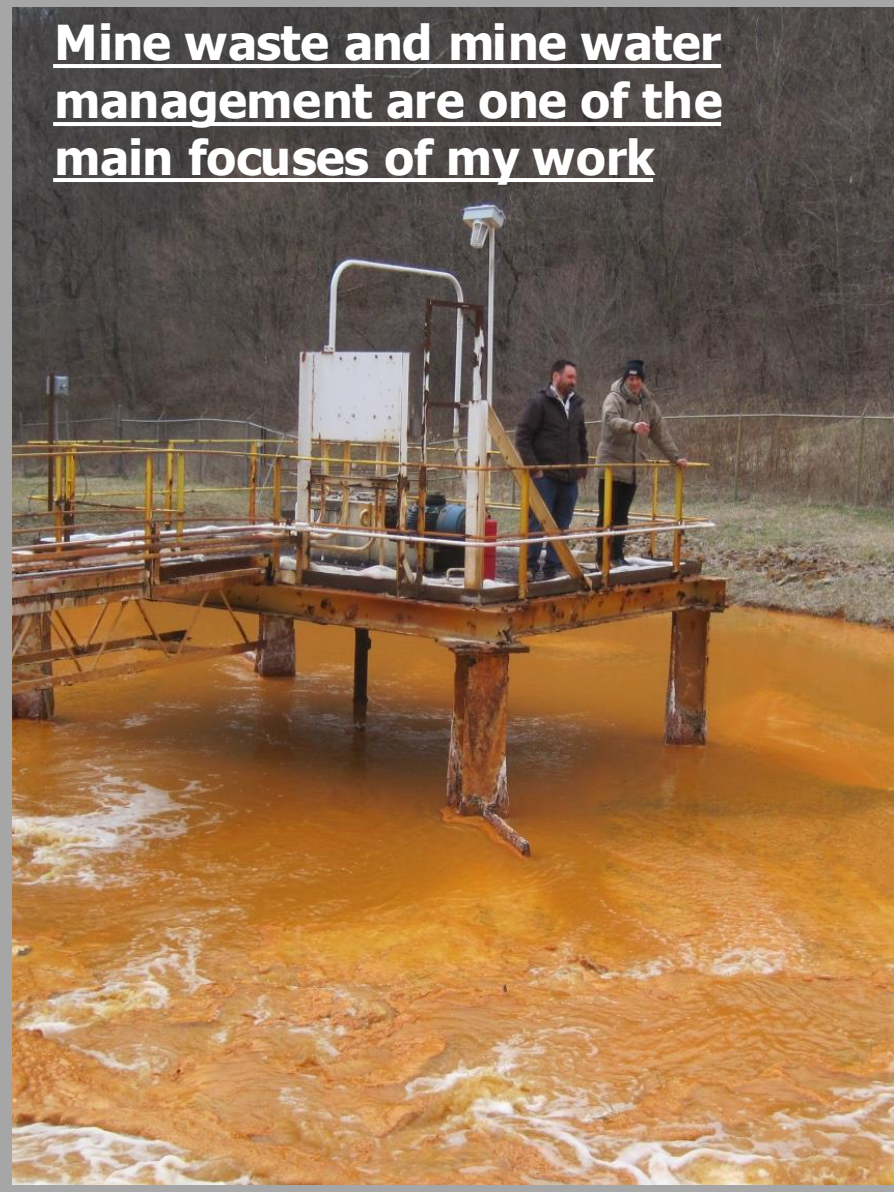
- Estimates of the total number of abandoned mines globally are not available, however it is likely to be **in the millions**[1].

- In England and Wales alone **>2100 km** of rivers fail to achieve European Union Water Framework Directive standards (WFD), 2000/60/EU. Even when excluding coal mine drainage (a major pollution source in England and Wales), **226 water bodies are impacted** by pollution from non-coal mines with **a further 226 probably impacted**[2,3].

Discharge from Cwmystwyth mines, Sept, 2025

[1] C. Wolkersdorfer, Water management at abandoned flooded underground mines: fundamentals, tracer tests, modelling, water treatment, 2008, https://doi.org/ 10.1007/978-3-540-77331-3 no. January 2008.
[2] A.P. Jarvis, W.M. Mayes, Prioritisation of abandoned non- coal mine impacts on the environment: the national picture, 2015, https://doi.org/10.13140/ 2.1.2024.1440.
[3] W.M. Mayes, D. Johnston, H.A.B. Potter, A.P. Jarvis, A national strategy for identification, prioritisation and management of pollution from abandoned noncoal mine sites in England and Wales. I. Methodology development and initial results, Sci. Total Environ. 407 (21) (2009) 5435–5447, https://doi.org/10.1016/j. scitotenv.2009.06.019

Mine Water: Mining Influenced Water is a global problem



Mine Water Treatment

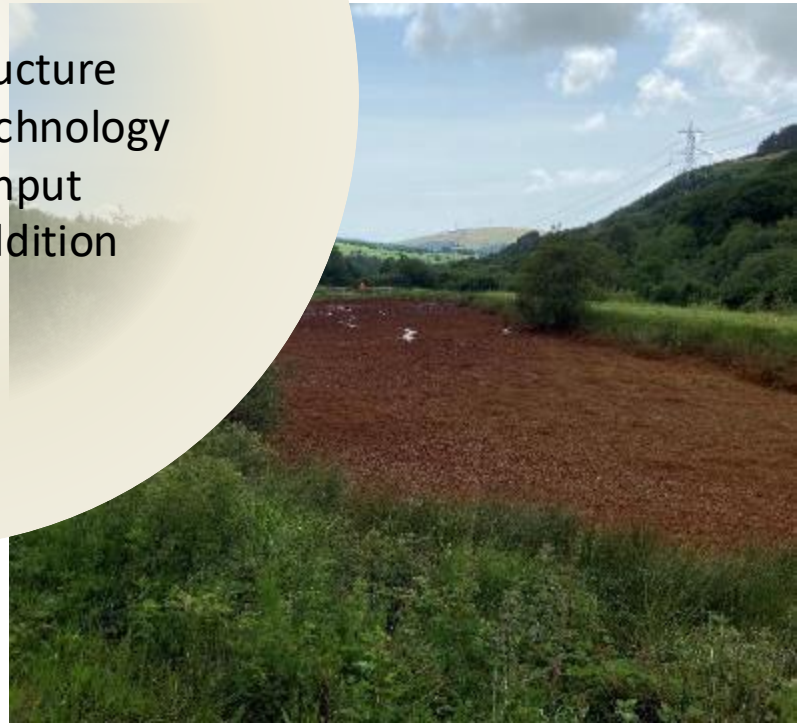
Active, Passive and Semi-Passive Treatment

Active

- "Hard" infrastructure
- Continuous reagent addition
- Energy input
  Stirring/pumping

Passive

- "Soft" infrastructure
- Nature-based technology
- No energy input
- No reagent addition



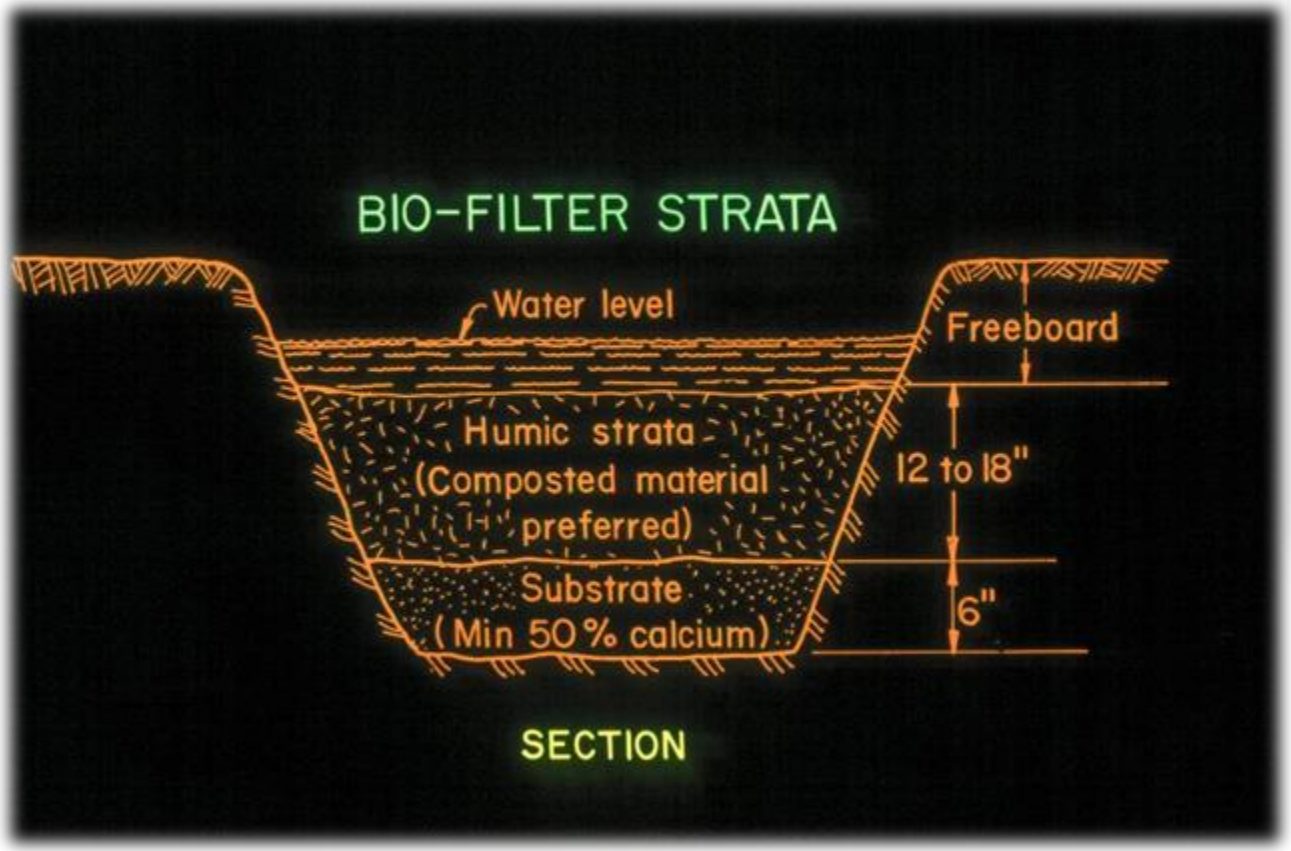
See: Kleinmann, R., Sobolewski, A. and Skousen, J., 2022. The Evolving Nature of Active, Passive, and Semi-Passive Mine Water Treatment Technologies. *IMWA symposium Christchurch, NZ*

Active Mine Water Treatment

Passive Mine Water Treatment - NbS

Removing iron is easy (just add air!)…

Passive Mine Water Treatment - NbS



Images courtesy of Dr Jeff Skousen University of West Virginia

Passive Mine Water Treatment of Mn & Zn

Limestone Media

Zinc is soluble under typical conditions, so passive treatment can be more difficult

Day zero

After about three months

dark coating indicates Mn removal.

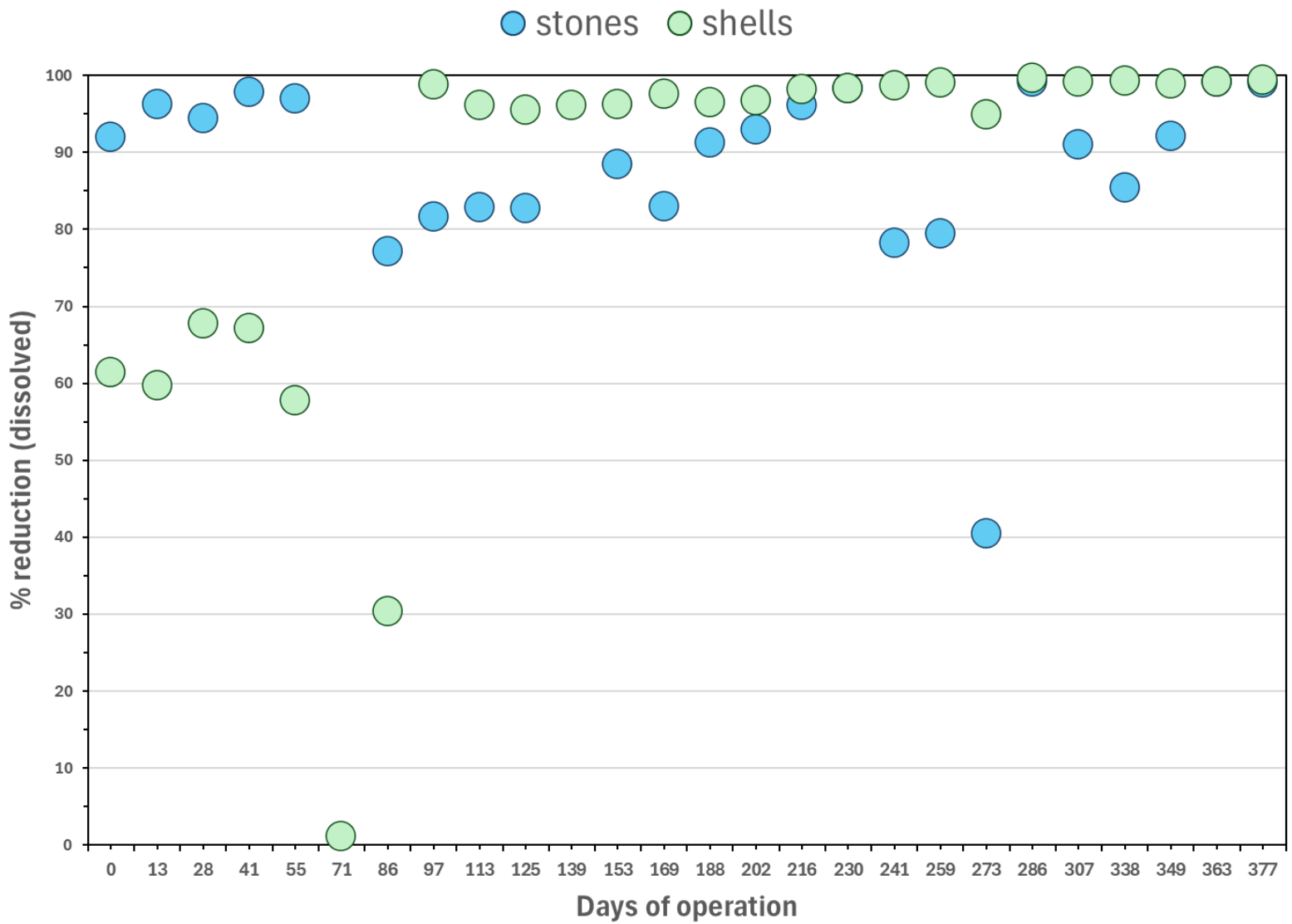
Treatment of Kionslieu Reservoir Stream

Operated at average flows of 0.5 and 0.6 l/min for ~1 year

The work also formed part of an MSc project (Yagiz Kaya , Cardiff University)

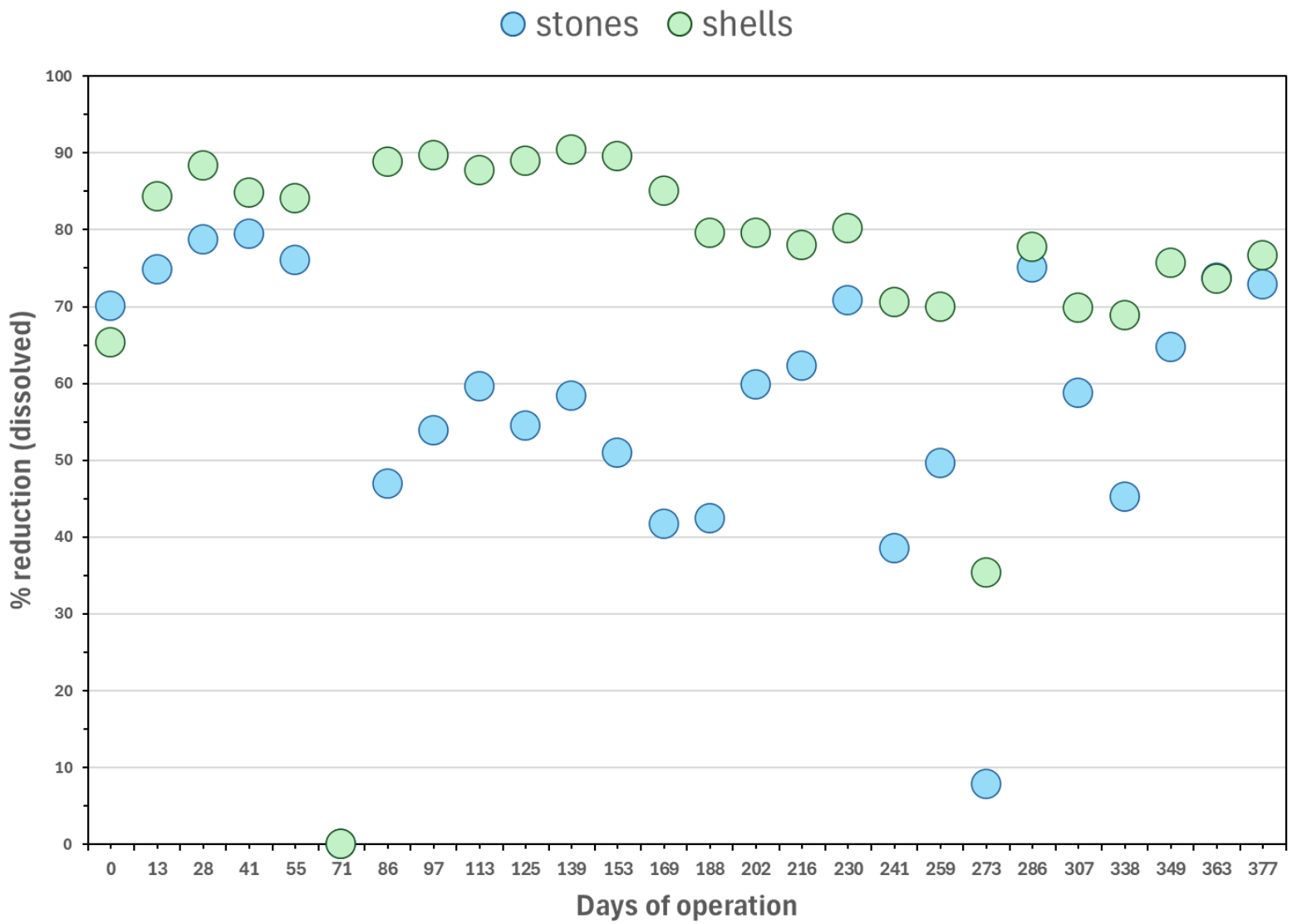
Treatment of Kionslieu Reservoir Stream

Removal of dissolved manganese (Mn)



Treatment of Kionslieu Reservoir Stream

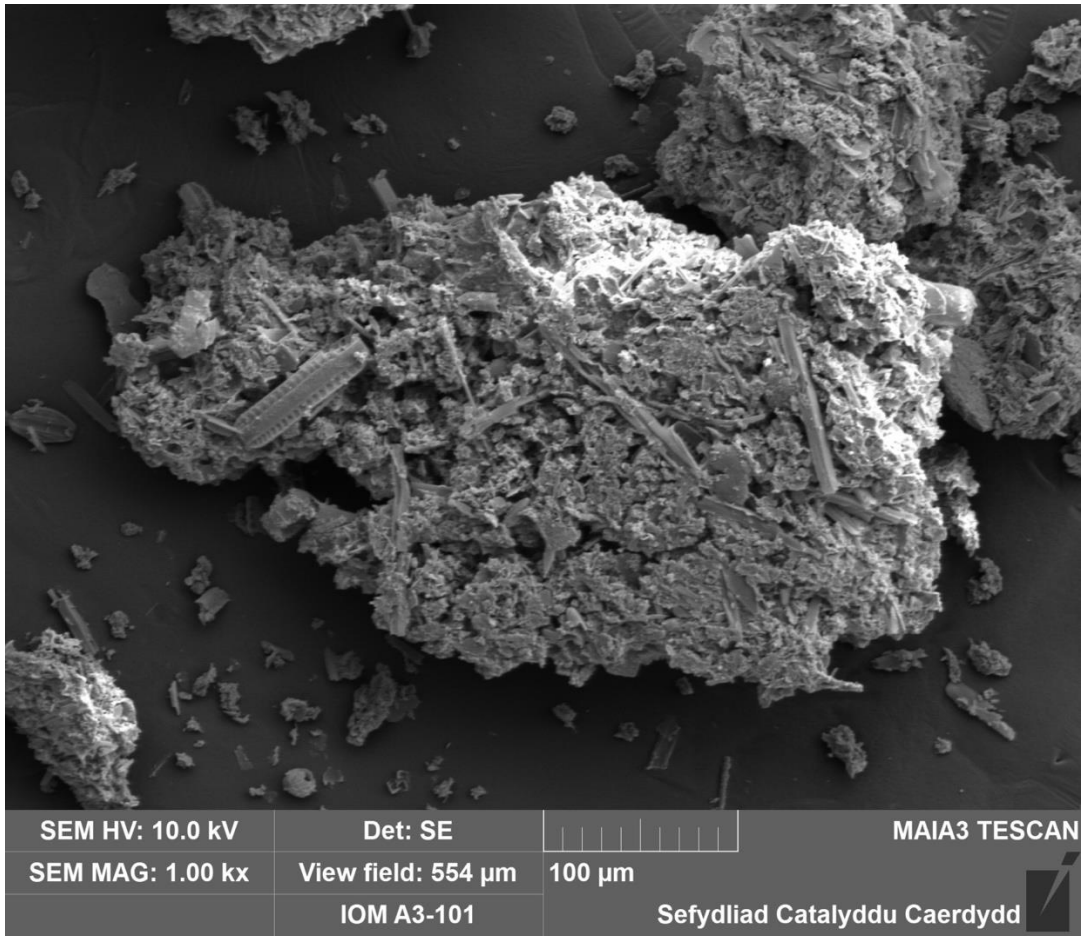
Removal of dissolved zinc (Zn)

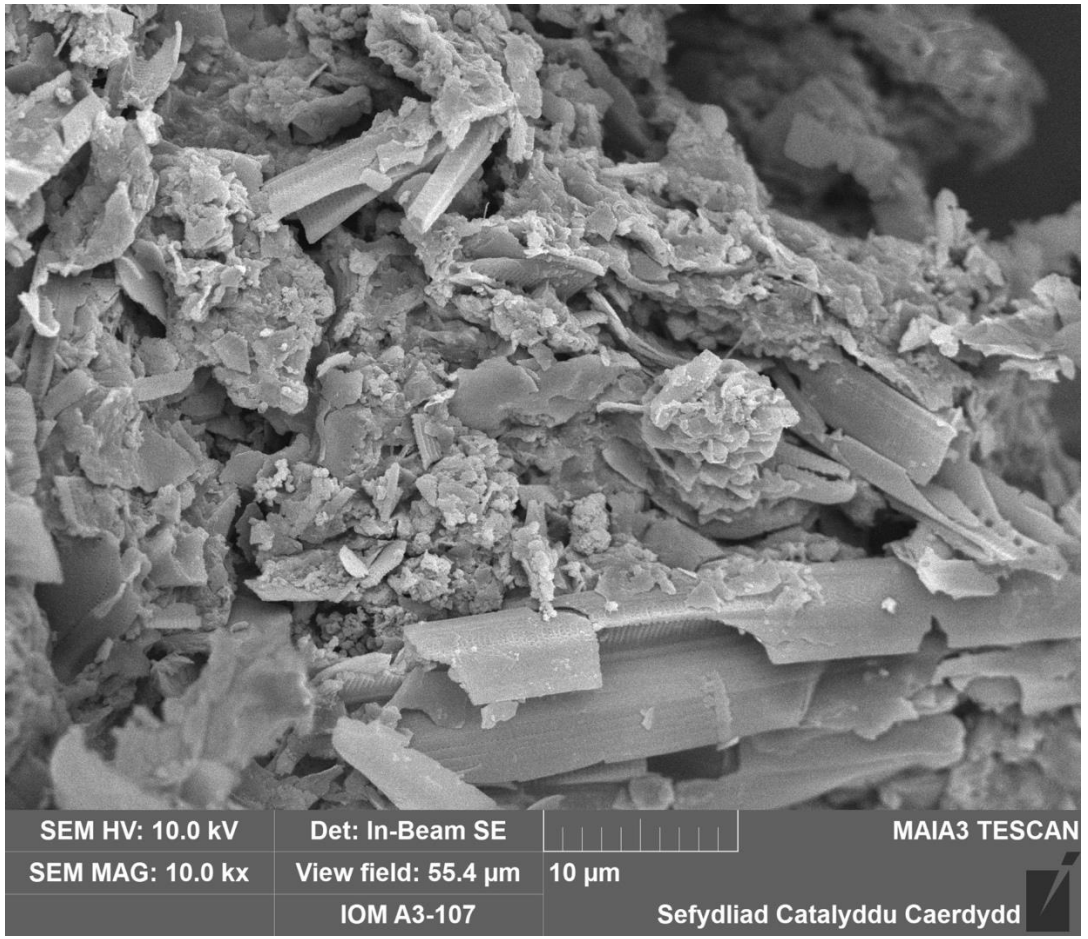


Treatment of Kionslieu Reservoir Stream

How were manganese and zinc being removed?

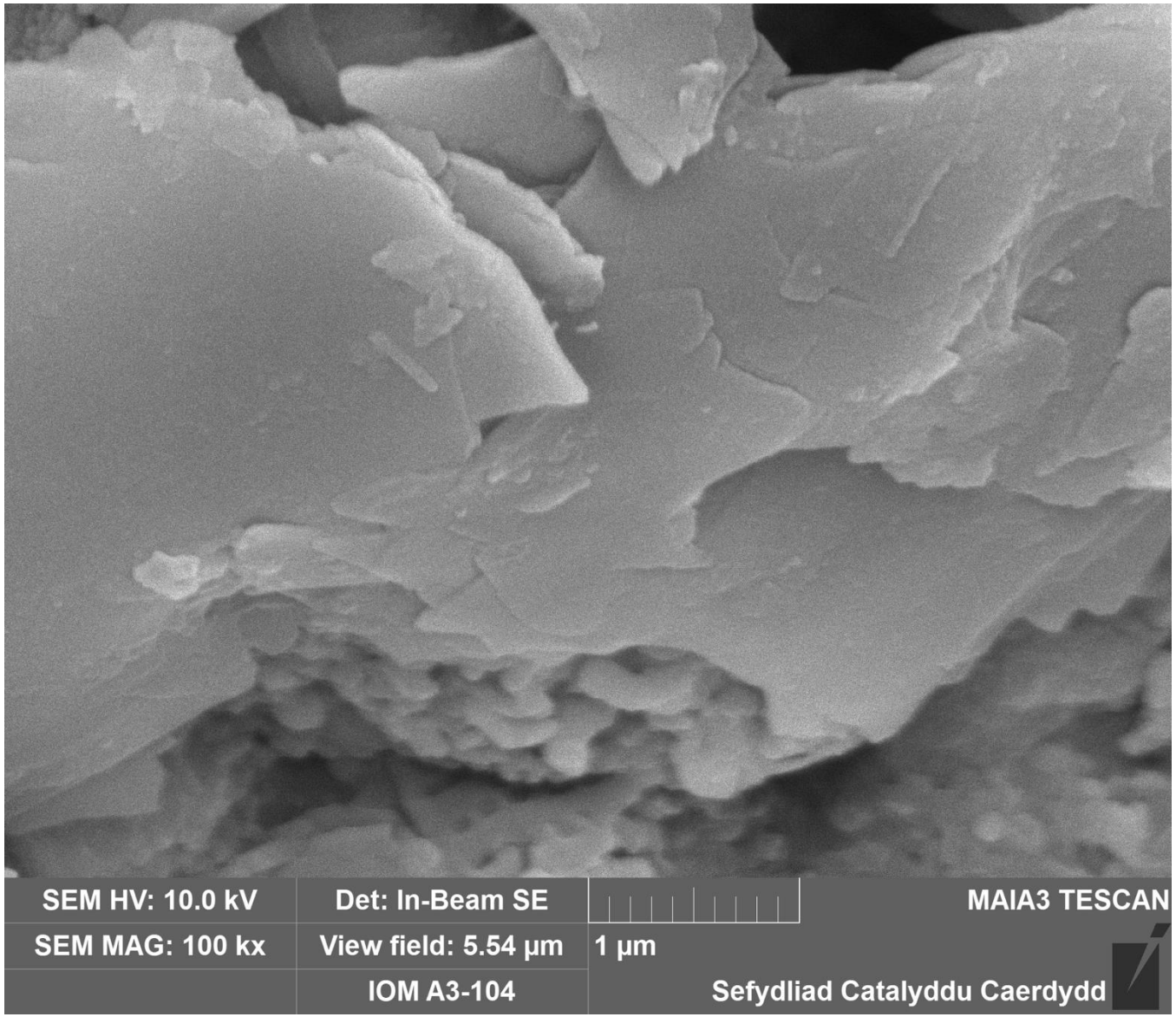
Treatment of Kionslieu Reservoir Stream





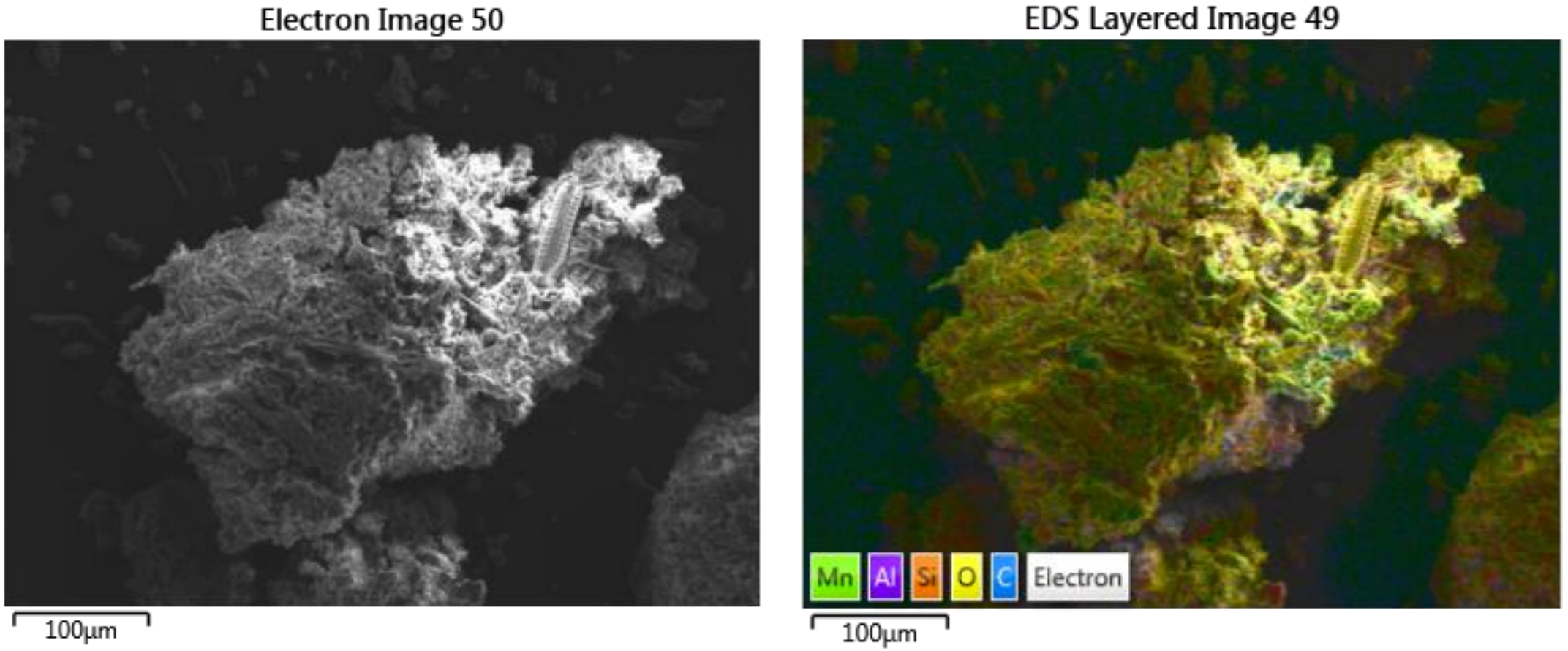
Scanning Electron Microscopy (SEM) images showing mineral precipitates formed in treatment system, note field of view

Treatment of Kionslieu Reservoir Stream



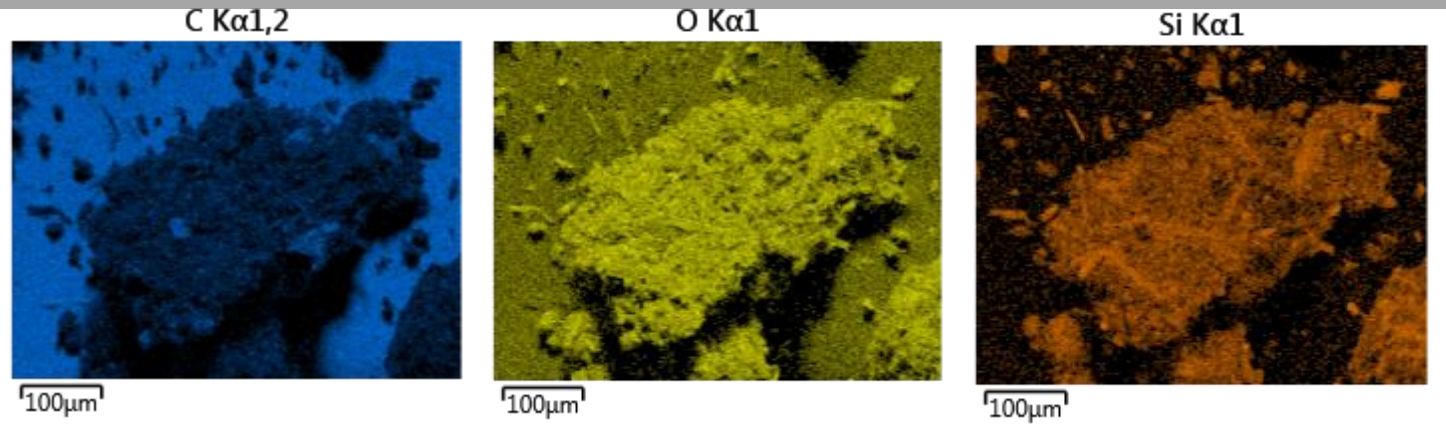
Close-up of mineral precipitates formed in treatment system

Treatment of Kionslieu Reservoir Stream

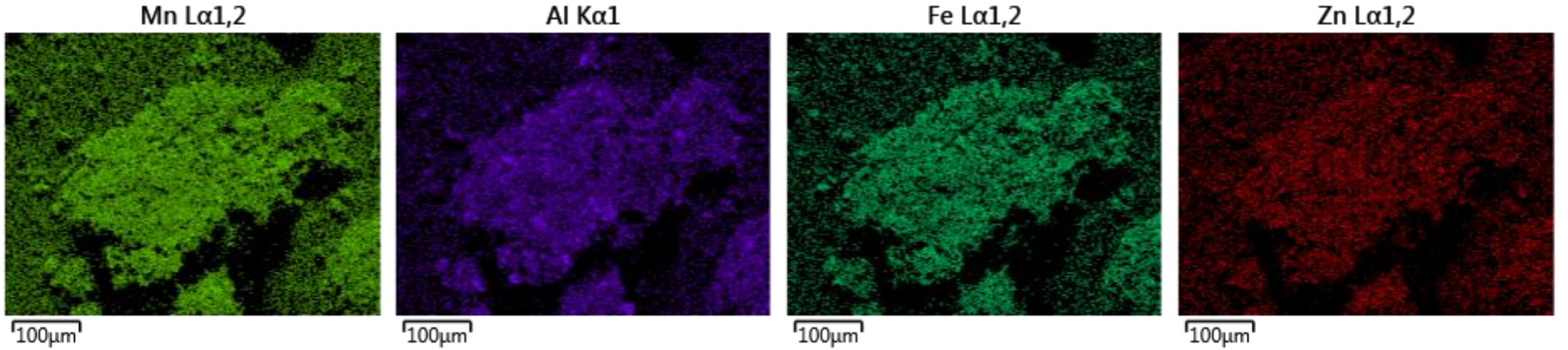


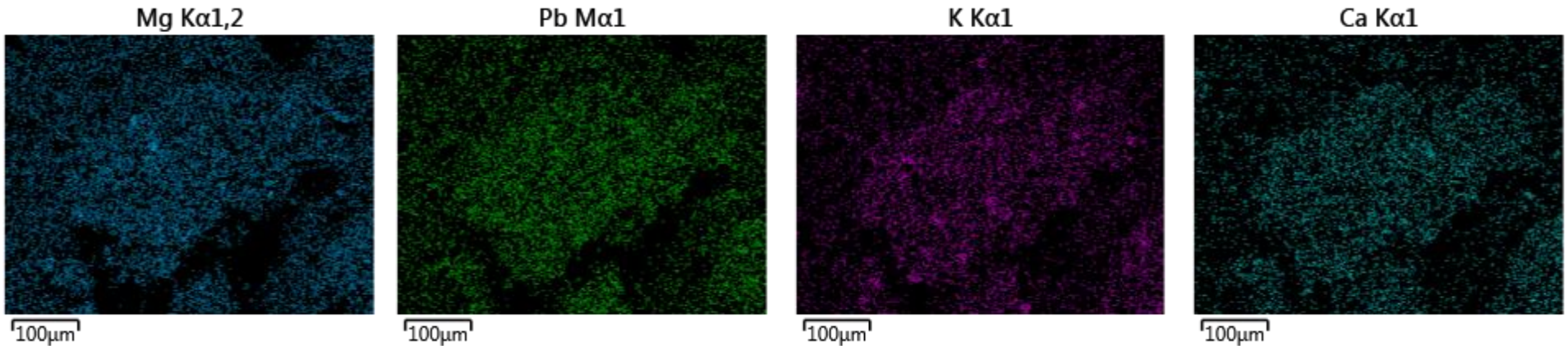
SEM and SEM-EDS (Energy-Dispersive X-ray Spectroscopy) images showing mineral precipitates and elemental analyses

Treatment of Kionslieu Reservoir Stream



SEM-EDS FEG element maps

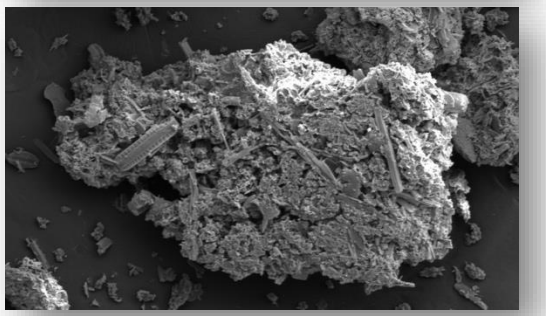




Next steps….

Image courtesy of Dr Jeff Skousen University of West Virginia

Conclusions



- Serendipitous collaboration between UNESCO Chair and Isle of Man Government (*Department of Infrastructure & Department of Environment, Food & Agriculture*) has led to novel technology using waste shells.
- This proof-of-concept work has scope to be developed further in the Isle of Man to a full-scale treatment concept (solving problems of scale-up) with applications globally.
- Given that very many Biosphere Reserves and Geoparks globally have similar mine water problems there is an opportunity for further impactful collaborations for mine waste and mine water management.

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