Gargrave Erosion Study – Key findings

Summary of report:

‘QXE-JBA-XX-XX-RP-EN-0001-S2-P01-Gargrave_Erosion_Scoping_Report’

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Agenda

- Geomorphological change in response to the weir collapse
- Conceptual erosion mitigation measures

Geomorphological change in response to weir collapse

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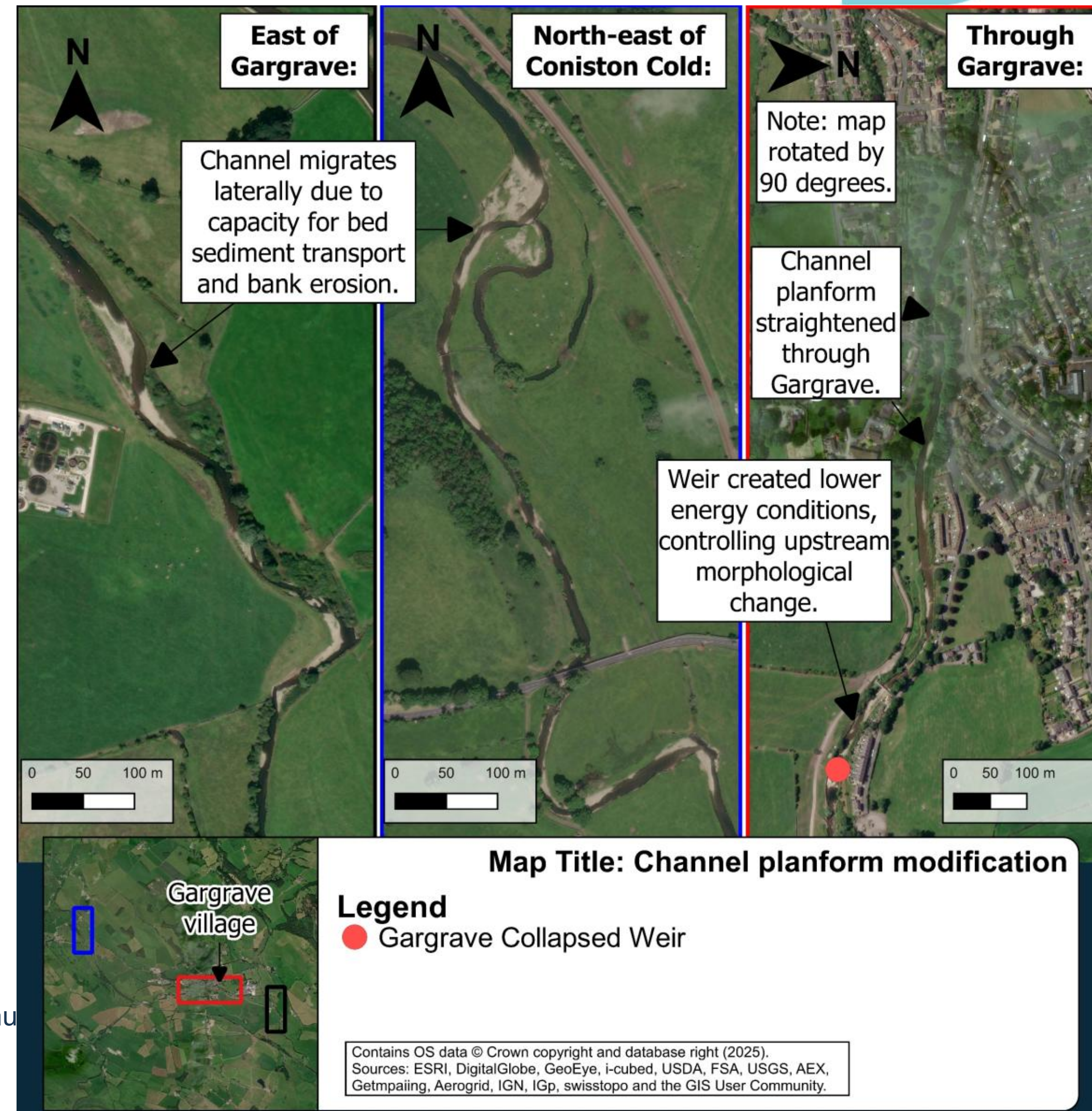
Pre-weir collapse conditions

- Bed and bank erosion was suppressed by the weir:
  - ➢ Created lower energy, depositional conditions upstream – impacts extending upstream to the road bridge.
  - ➢ Artificial stabilisation of bed and bank sediment transport rates.
  - ➢ The 'corridor' within which the river eroded its banks was restricted.

Low energy, depositional conditions upstream of weir.

Pre-weir collapse conditions

- The Aire through Gargrave has been modified, suppressing flow energy and controlling bank erosion, via:
  - The weir
  - Channel straightening
  - Bank protection

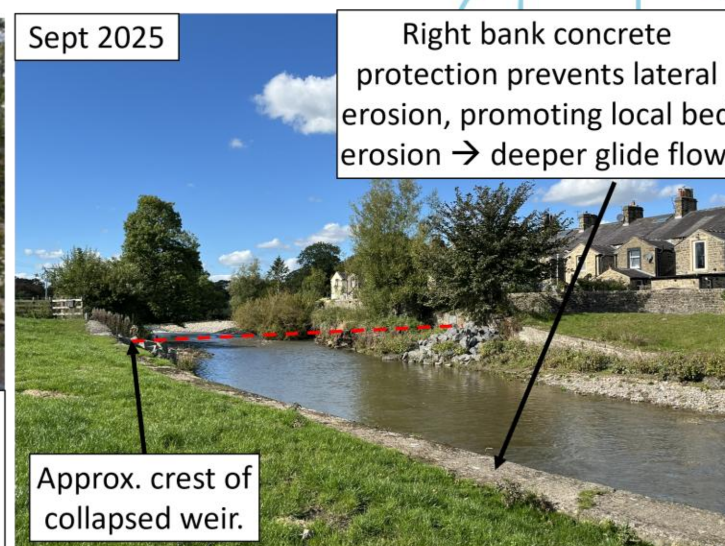


Knick-point (head-cut) erosion

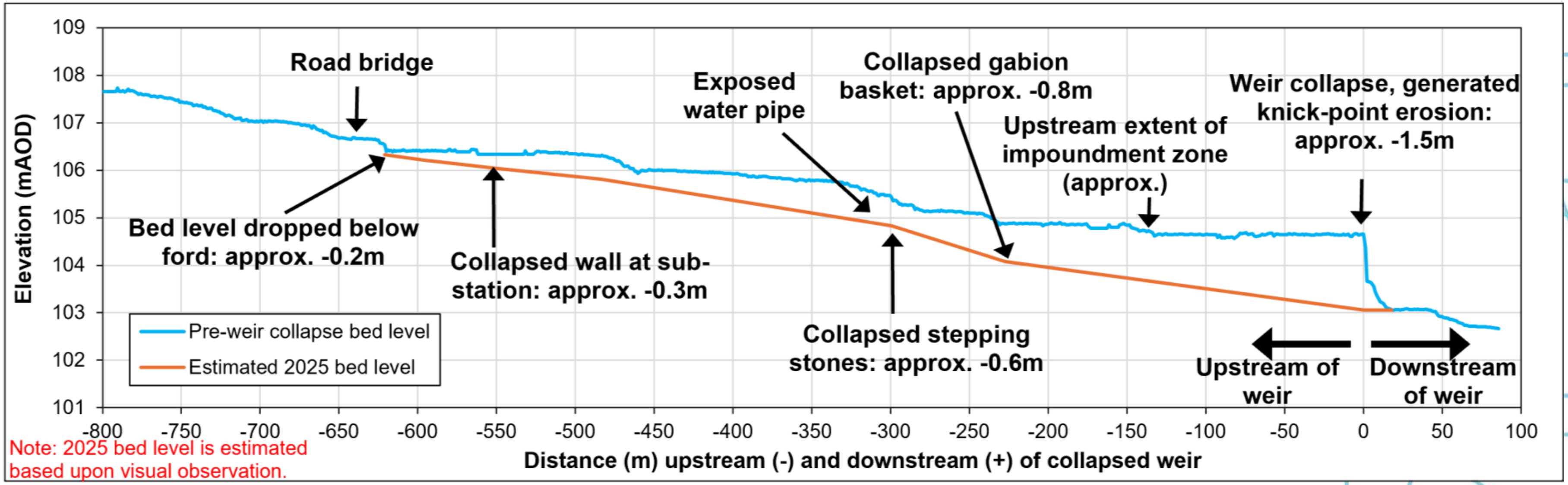
- Weir collapse triggered a knick-point (head cut) erosion to be transmitted upstream.
- Riverbed incision (erosion) into the mobile sediment built up upstream of the weir.
- The river is attempting to regain a natural bed longitudinal profile.
- Drop in bed level has (and is) causing bank instability.

Low energy, depositional conditions upstream of weir.

Bed level dropped by approx. 1.5m following collapse in 2022 → caused bed instability as the channel attempts to re-gain a stable gradient → knick-point erosion (head-cut) tracked up-stream.



Bed profile of the knick-point erosion



At the collapsed weir

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Facing upstream:

Low energy, depositional conditions upstream of weir.

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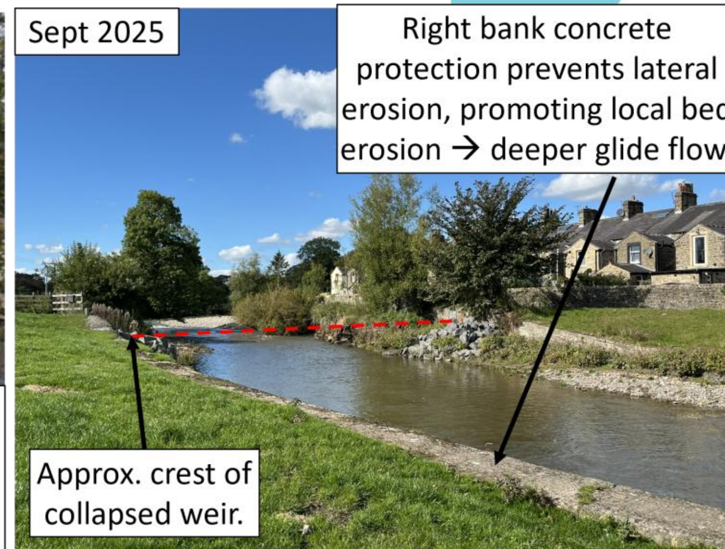
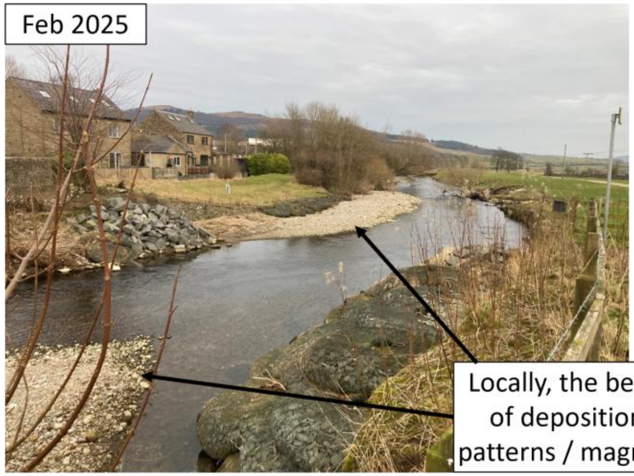


Facing downstream:



Locally, the bed may have generally stabilised here → development of depositional bar features→ however, bars are migratory, and patterns / magnitudes of erosion and deposition may shift over time.

15m upstream of the collapsed weir

Jan 2024

Channel bed level has dropped by approx. 1.5m immediately upstream of the collapsed weir, exposing faces of alluvial material on the left and right banks.

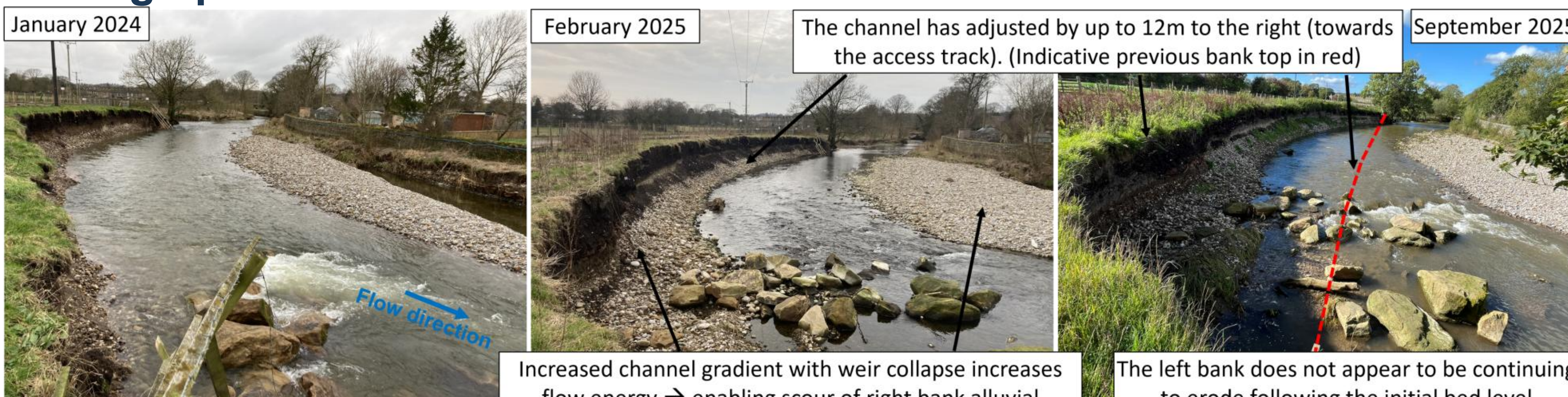
Sept 2025

Since weir collapse and bed level adjustment, the left bank does not appear to have undergone significant further change.

Right bank rock armour + tree roots create a lower energy zone, forming a small gravel bar.

60m upstream of the collapsed weir

Facing upstream:

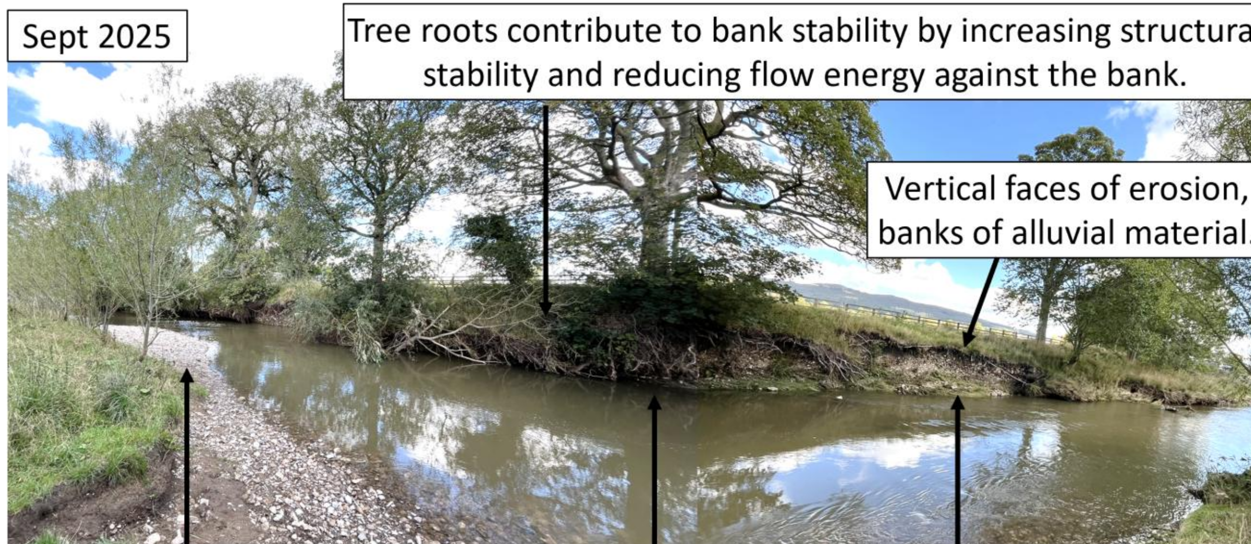


Increased channel gradient with weir collapse increases flow energy → enabling scour of right bank alluvial material → deposition on the inside of the meander bend pushes energy towards the right bank, promoting scour.

The left bank does not appear to be continuing to erode following the initial bed level adjustment. However, patterns of erosion and deposition may change over time.

170m upstream of the collapsed weir –

left bank erosion adjacent to Mill Lane

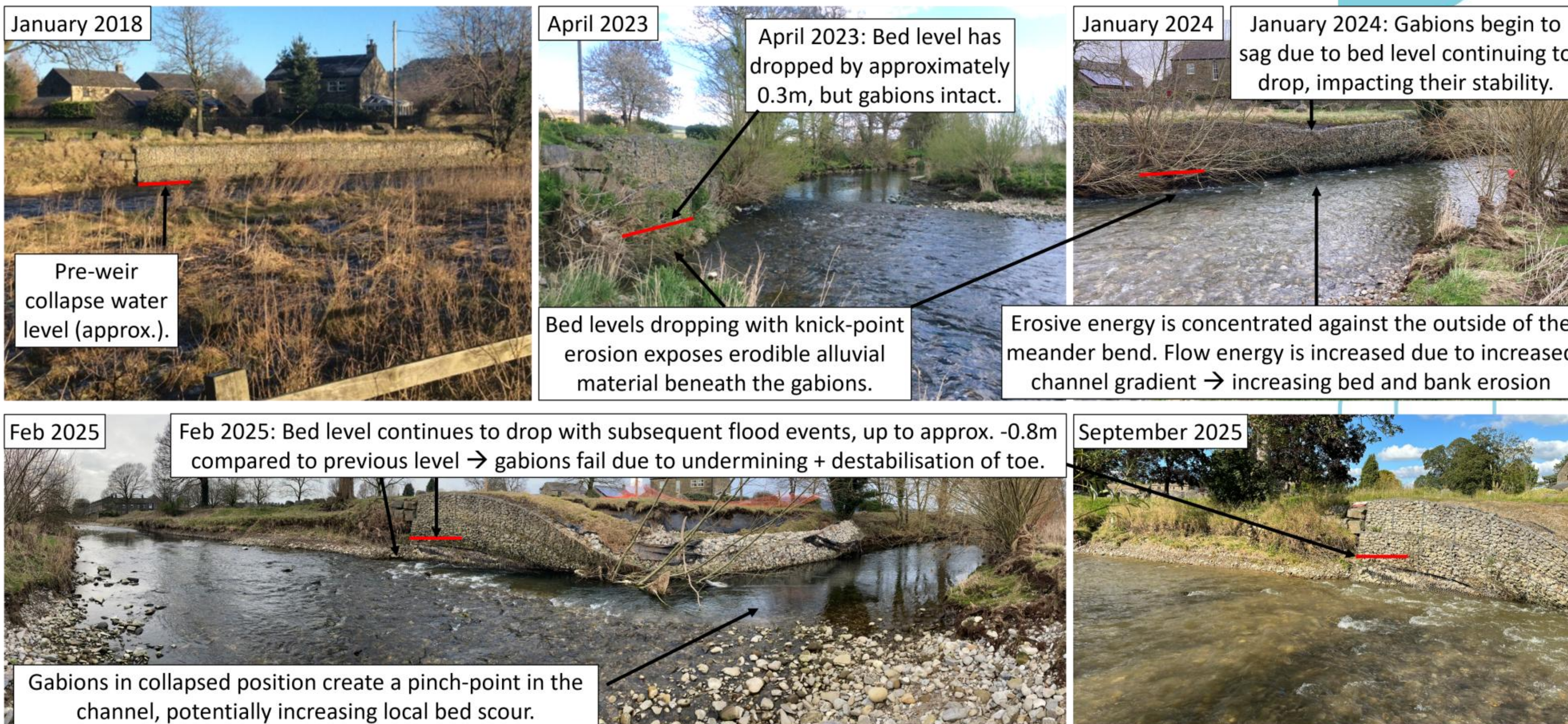


Pre-weir collapse, moderate pockets of bank erosion existed on the outside of the bend (left bank), but banks were largely vegetated and stable.

Increased sediment flux through the reach may be contributing to increased deposition on inside of the meander bend → pushing flow energy towards the outside of the bend.

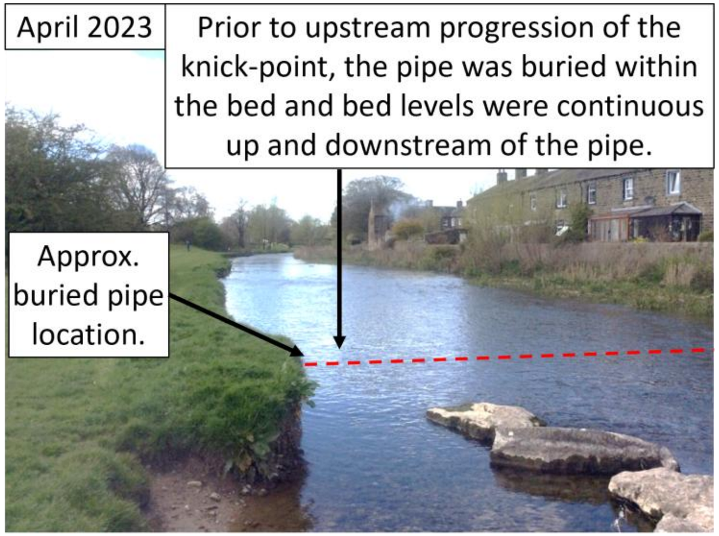
With upstream progression of the knick-point erosion, bed levels dropped creating steeper banks with exposed alluvium + flow energy increased due to the increased channel gradient → causing bank erosion and undercutting of trees → channel has shifted towards Mill Lane.

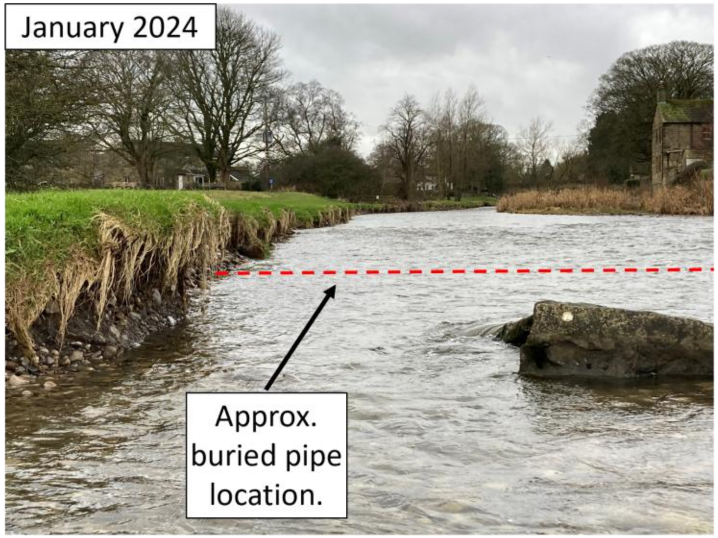
230m upstream of the collapsed weir –
left bank gabion collapse adjacent to Mill Lane

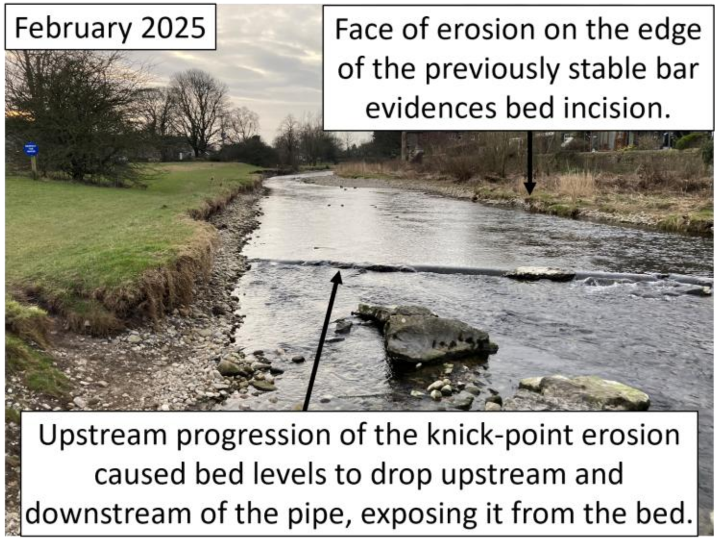


300m upstream of the collapsed weir –
destabilised stepping stones

300m upstream of the collapsed weir –
exposed water pipe

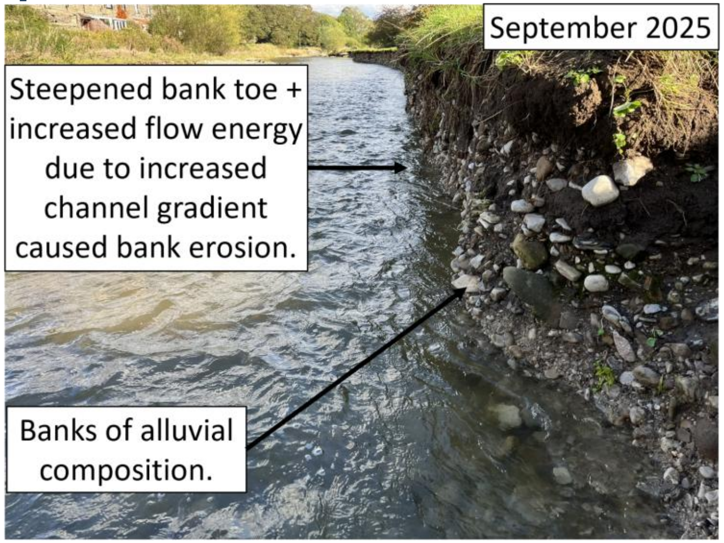


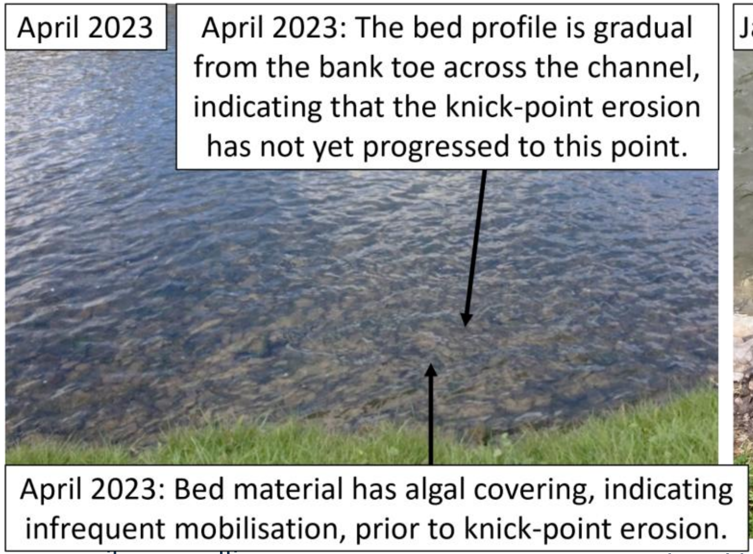


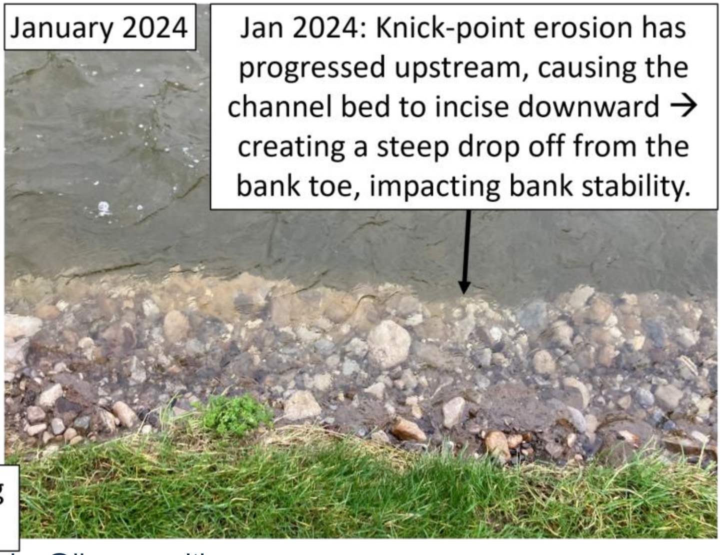


450m upstream of the collapsed weir –

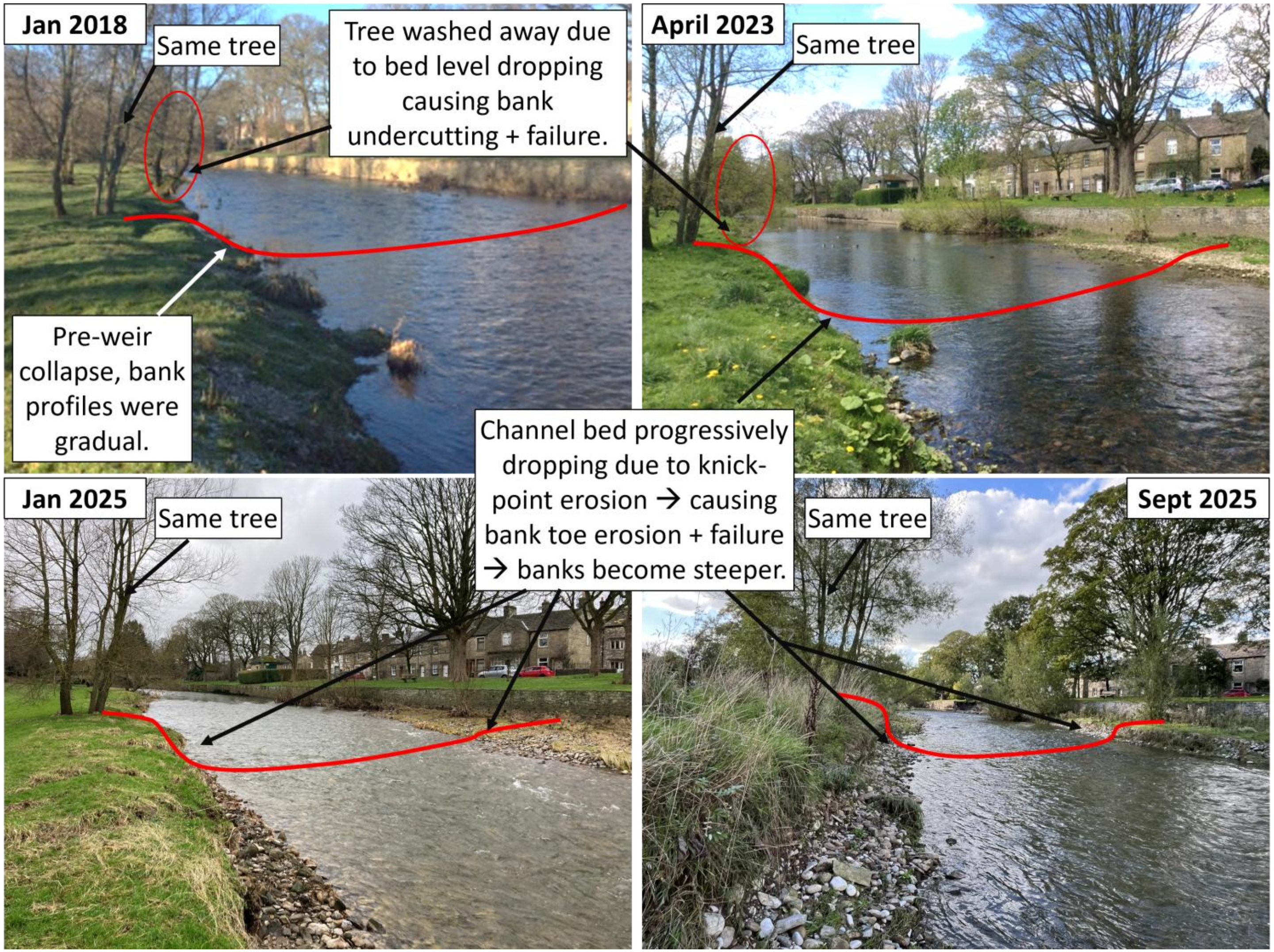
right bank erosion through the park





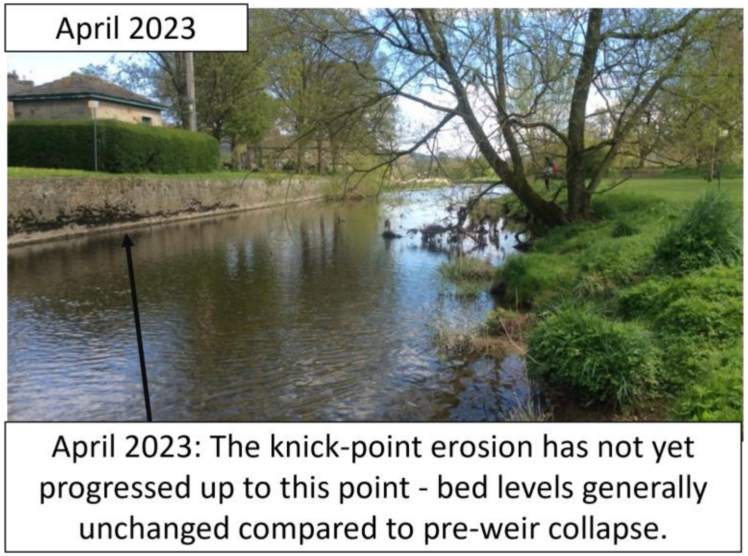


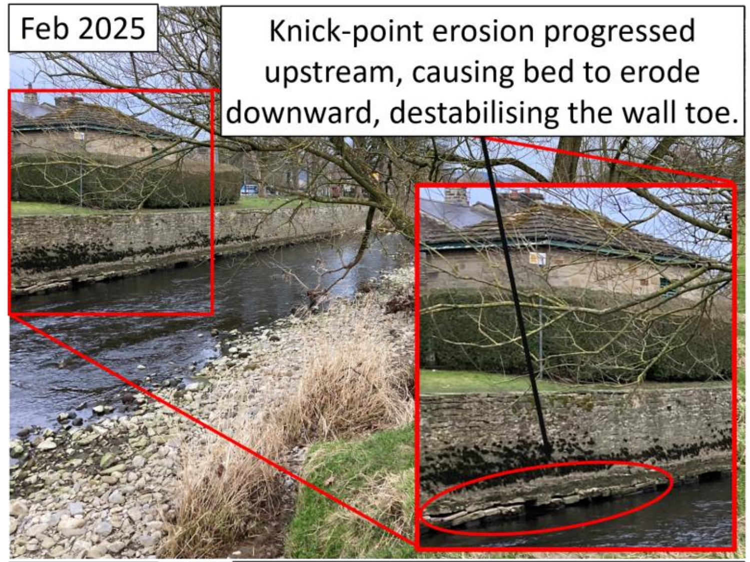
480m upstream of the collapsed weir –
right bank erosion through the park

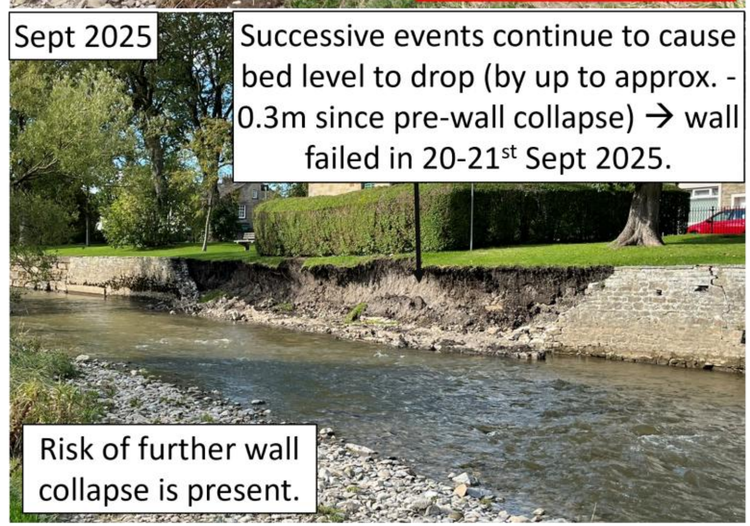


550m upstream of the collapsed weir –

September 2025 wall collapse at substation

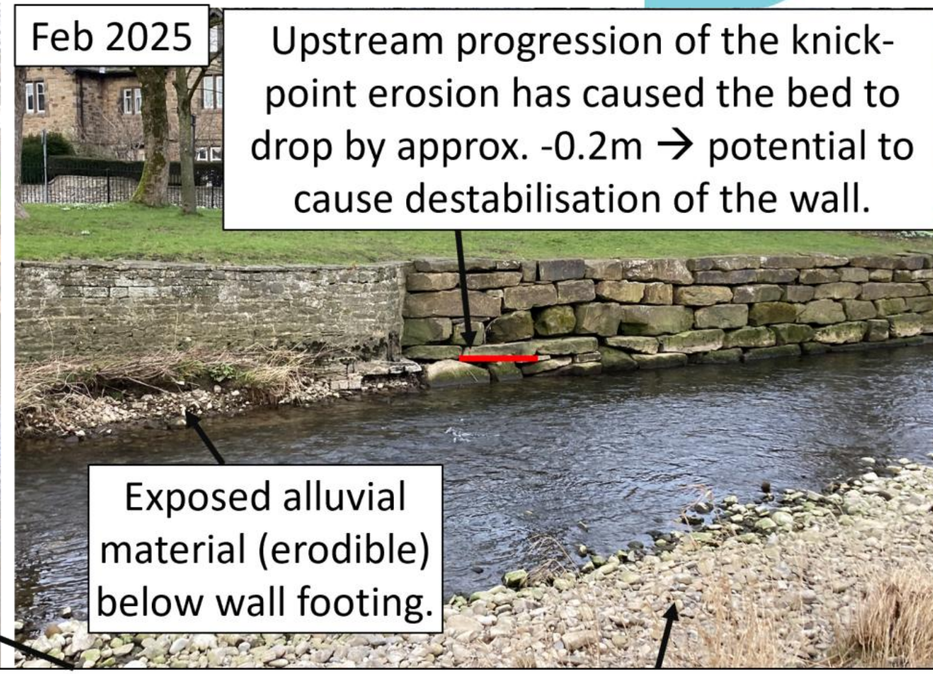




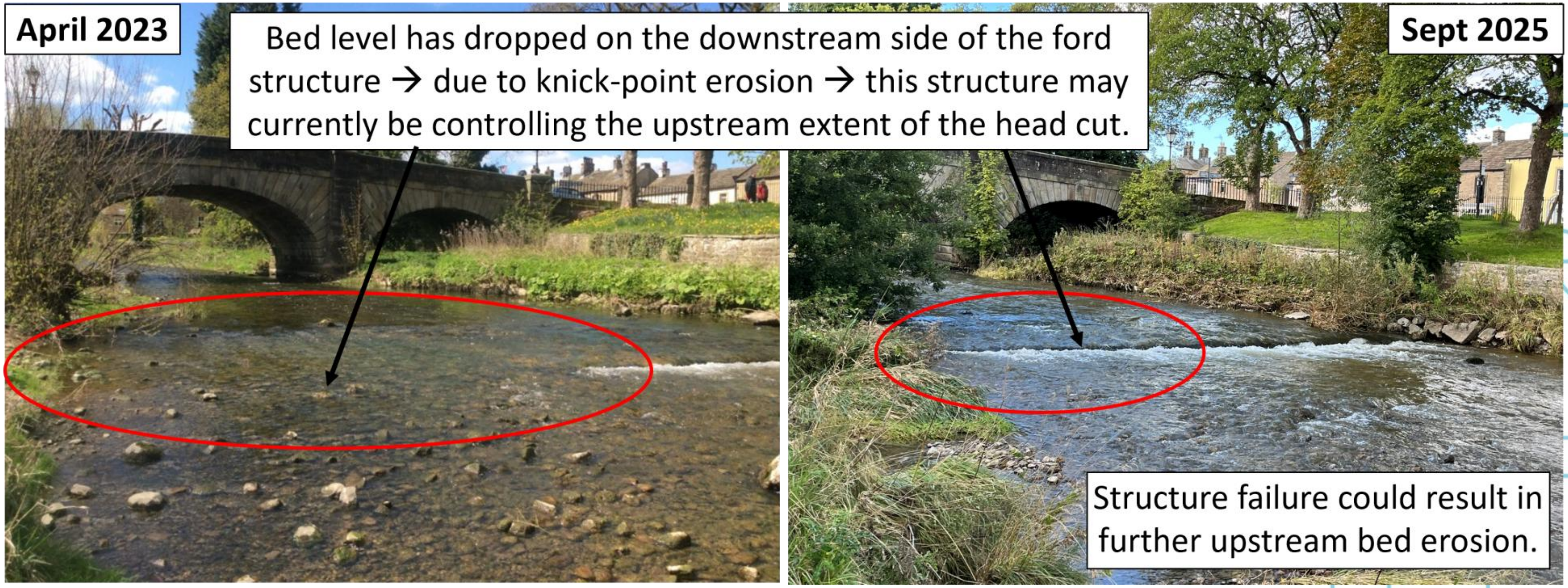


600m upstream of the collapsed weir –

bed erosion at wall downstream of ford



625m upstream of the collapsed weir –
ford controls upstream extent of knick-point erosion



780m upstream of the collapsed weir –
upstream stepping stones

Morphological change upstream of the ford is not significant → the knick-point erosion has not progressed upstream beyond the stone ford. Banks remain vegetated and bed sediment has an algal covering in 2023 and 2025, indicating infrequent mobility.

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Summary of morphological changes

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- The impacted reach is undergoing a transition phase, attempting to regain a dynamic equilibrium of erosion and deposition.
- The channels morphological energy has increased towards its natural state. Therefore, the ‘corridor’ within which the river will adjust will be maintained into the future.
- Erosion management designs should seek to work with and accommodate the natural processes, where possible.
- Where infrastructure exists that cannot be set back, bank or bed protection measures should be designed to accommodate for the new channel geometry and increased energy.

Conceptual erosion mitigation measures

4 key measures

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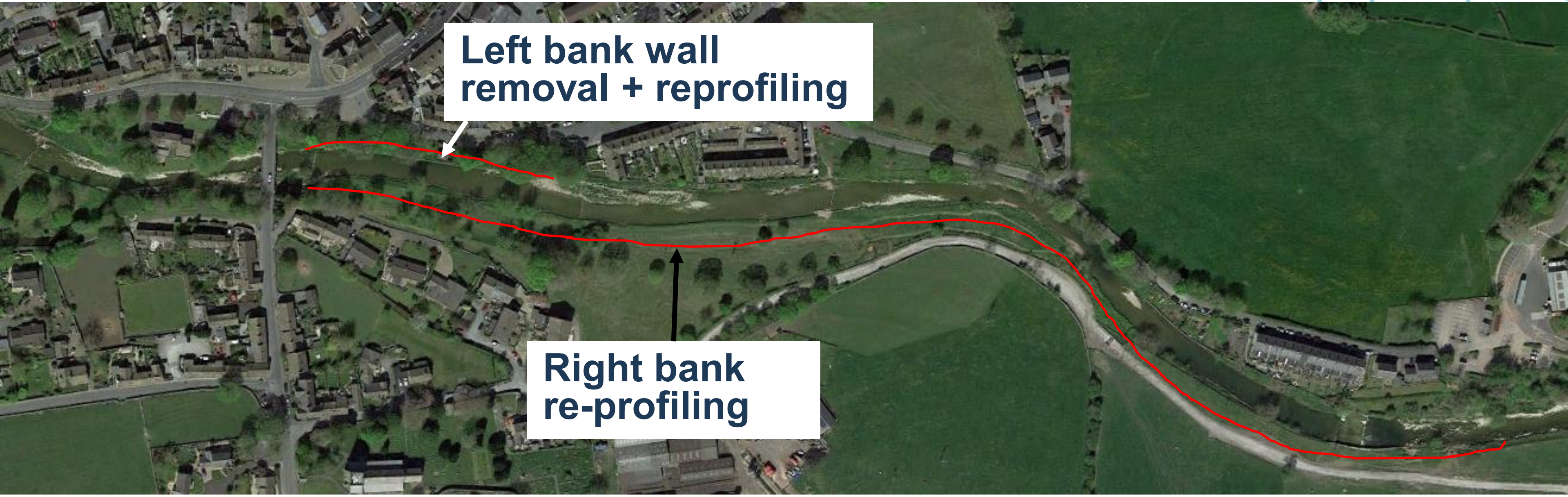
Channel width increasing and bank reprofiling

Aims:

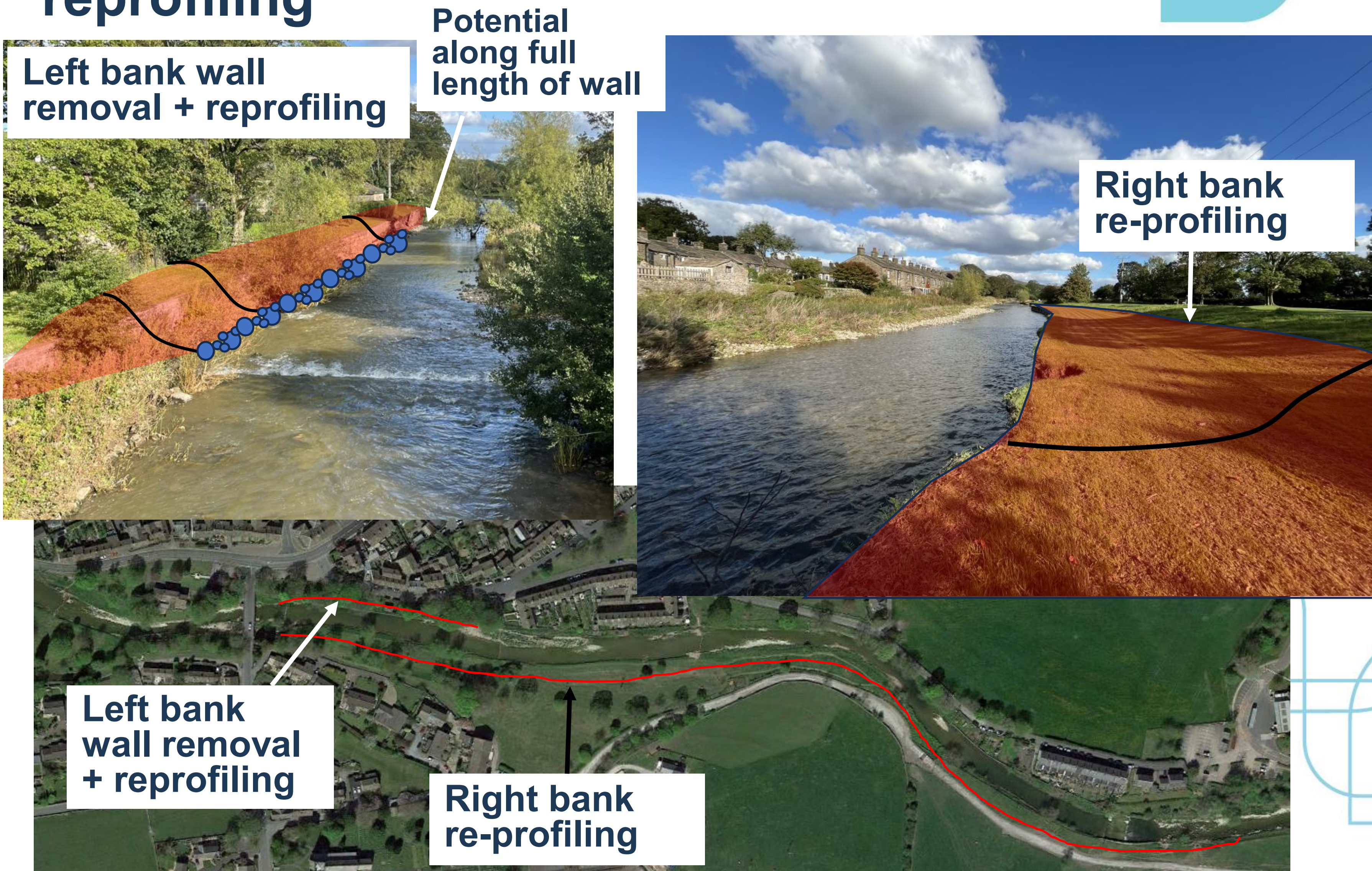
- Reduce hydraulic flow confinement = reduce erosive energy.
- Provides space for natural morphological adjustment + evolution.

Implementation:

- Right (southern bank) along length of impacted reach and along failing left bank wall DS of bridge.
- May be targeted to identified constraints and opportunities.

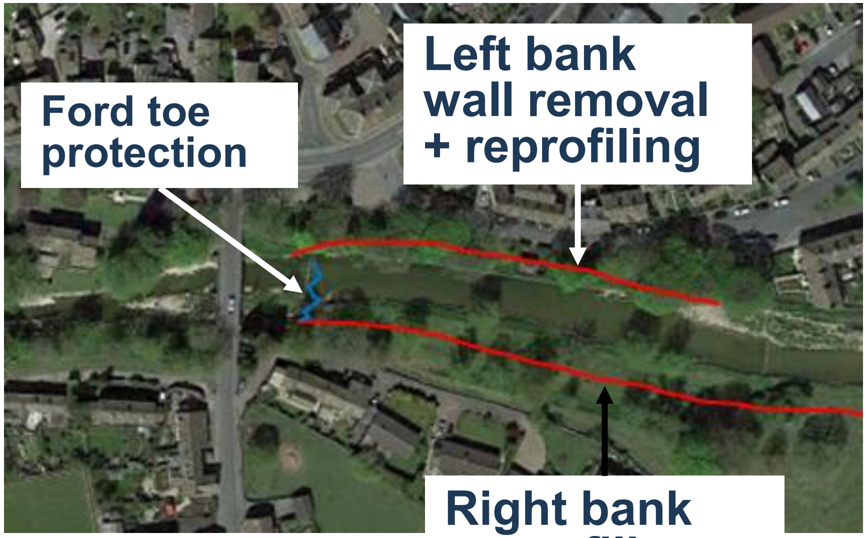


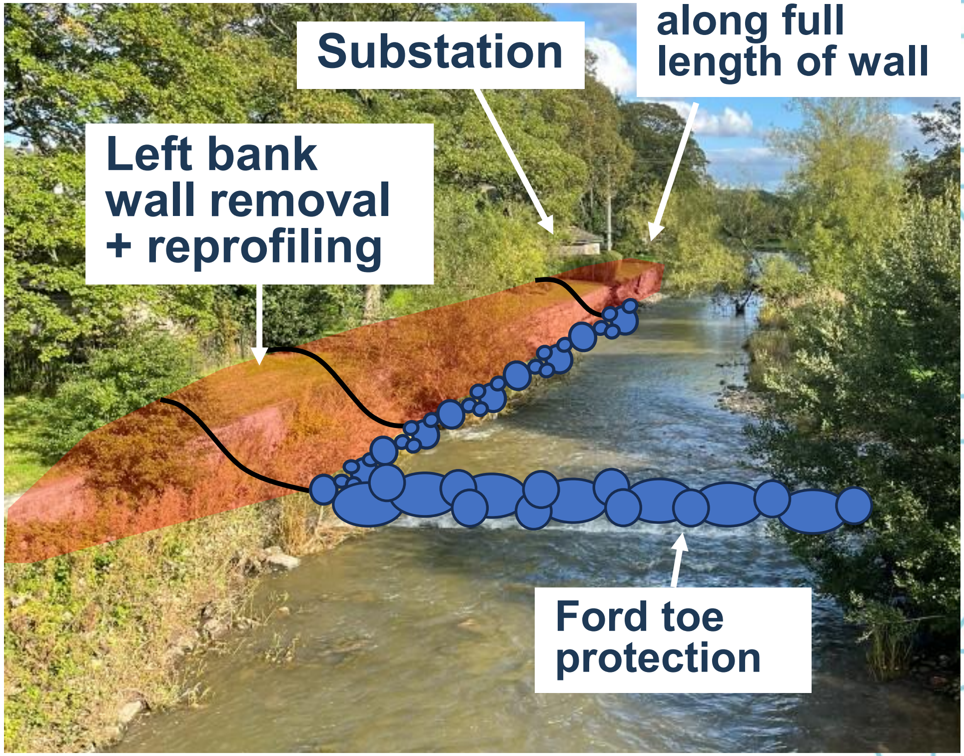
Channel width increasing and bank reprofiling



Stone ford protection measures

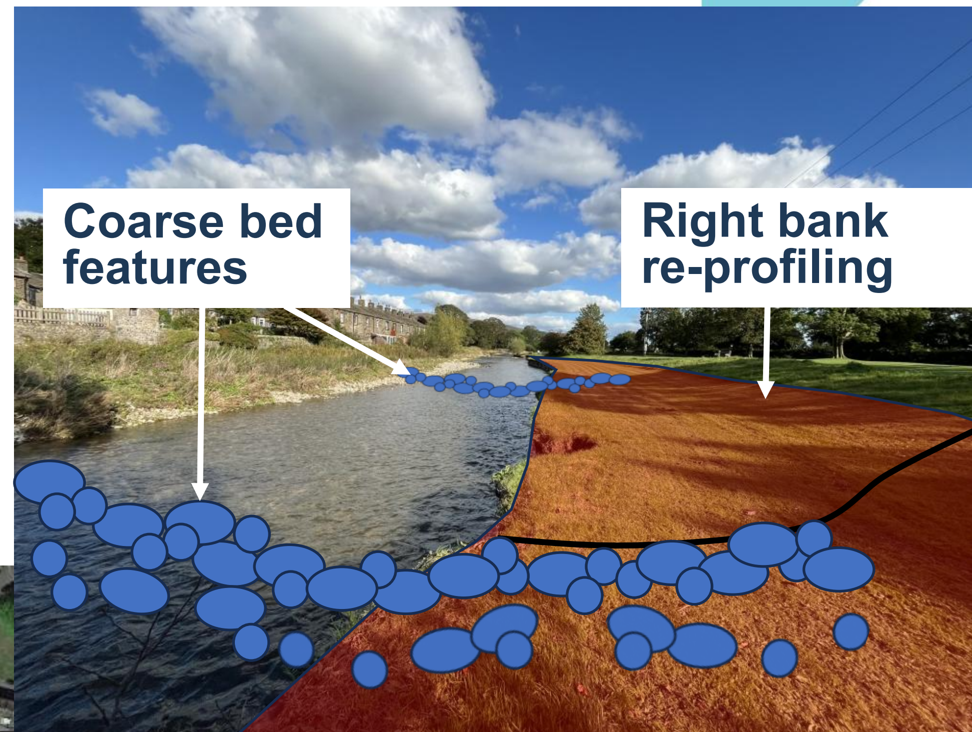
- Small boulder and cobble protection of the downstream toe of the ford.
- Control undermining + collapse of stone ford, mitigating risk of upstream migration of knick-point erosion.

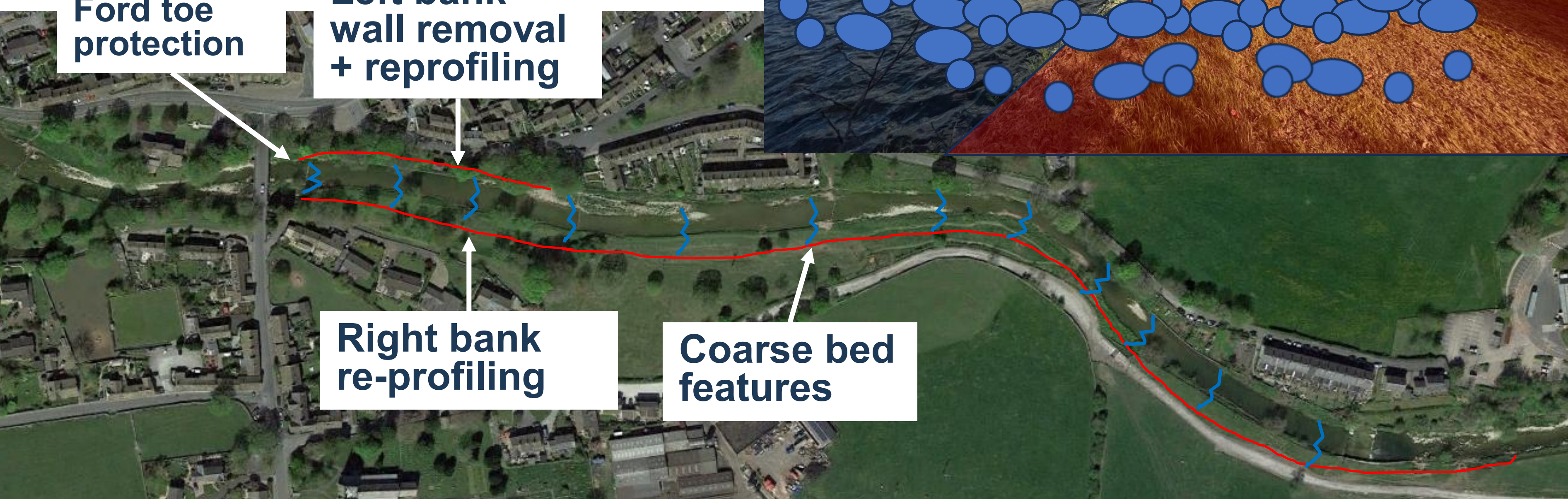




Coarse bed features to control bed erosion

- Rapid or cascade features formed of cobbles and boulders to control bed erosion.
- Positioned at intervals along the impacted reach.
- Provides channel bed stability.
- Works with natural processes.





Targeted infrastructure protection

- Where infrastructure or risk receptors cannot be set back, additional bank or bed protection may be considered.

Questions?

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