

WEIR'S IT GONE? ENNERDALE MILL DAM: CONCEPT TO DESTRUCTION



Entwistle N¹. Heritage G¹. Bryant L² & Mills J²

¹ AquaUoS, University of Salford, Salford. M5 4WT

² West Cumbria Rivers Trust, Keswick



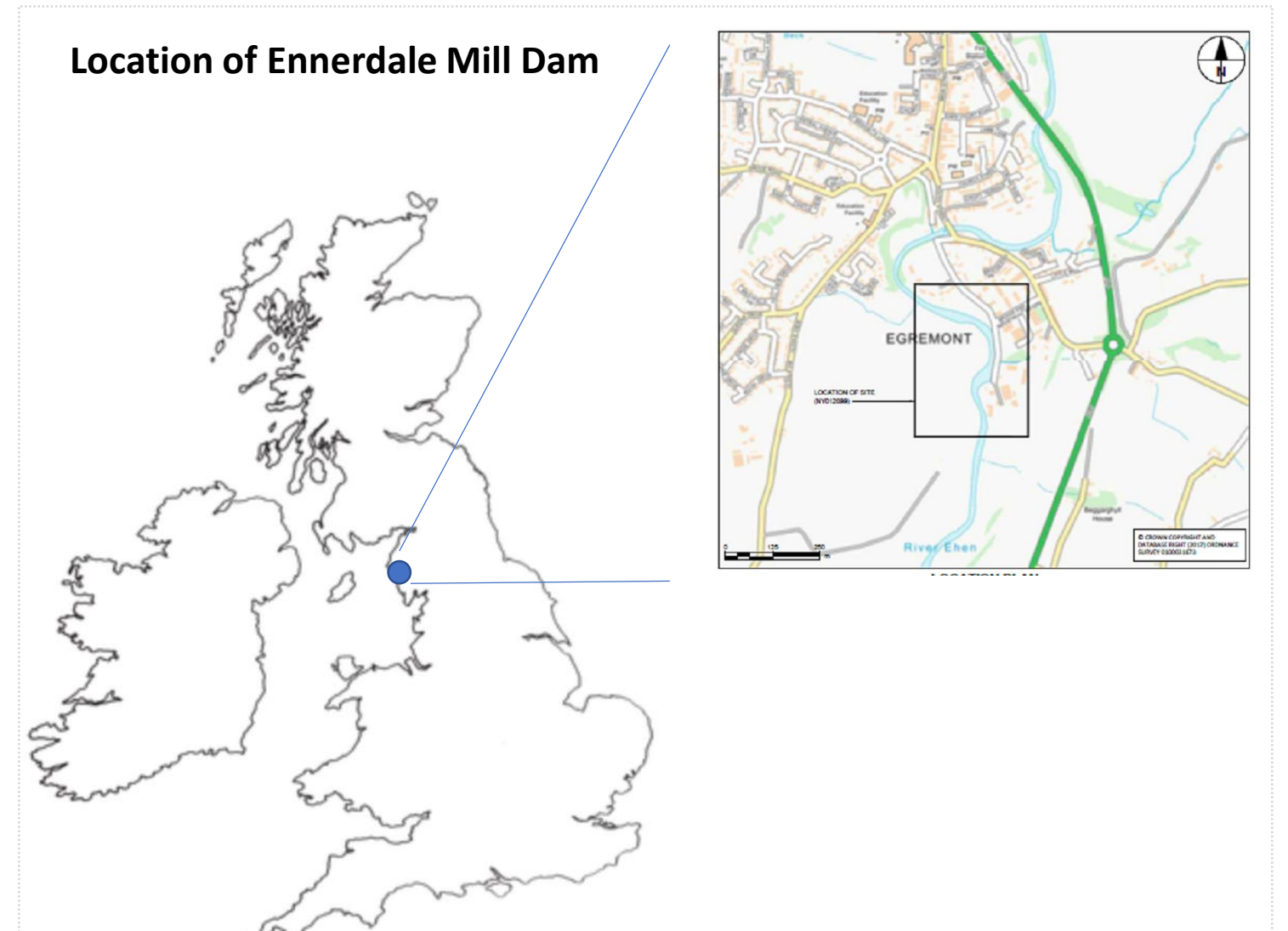
Ennerdale Mill Dam Weir



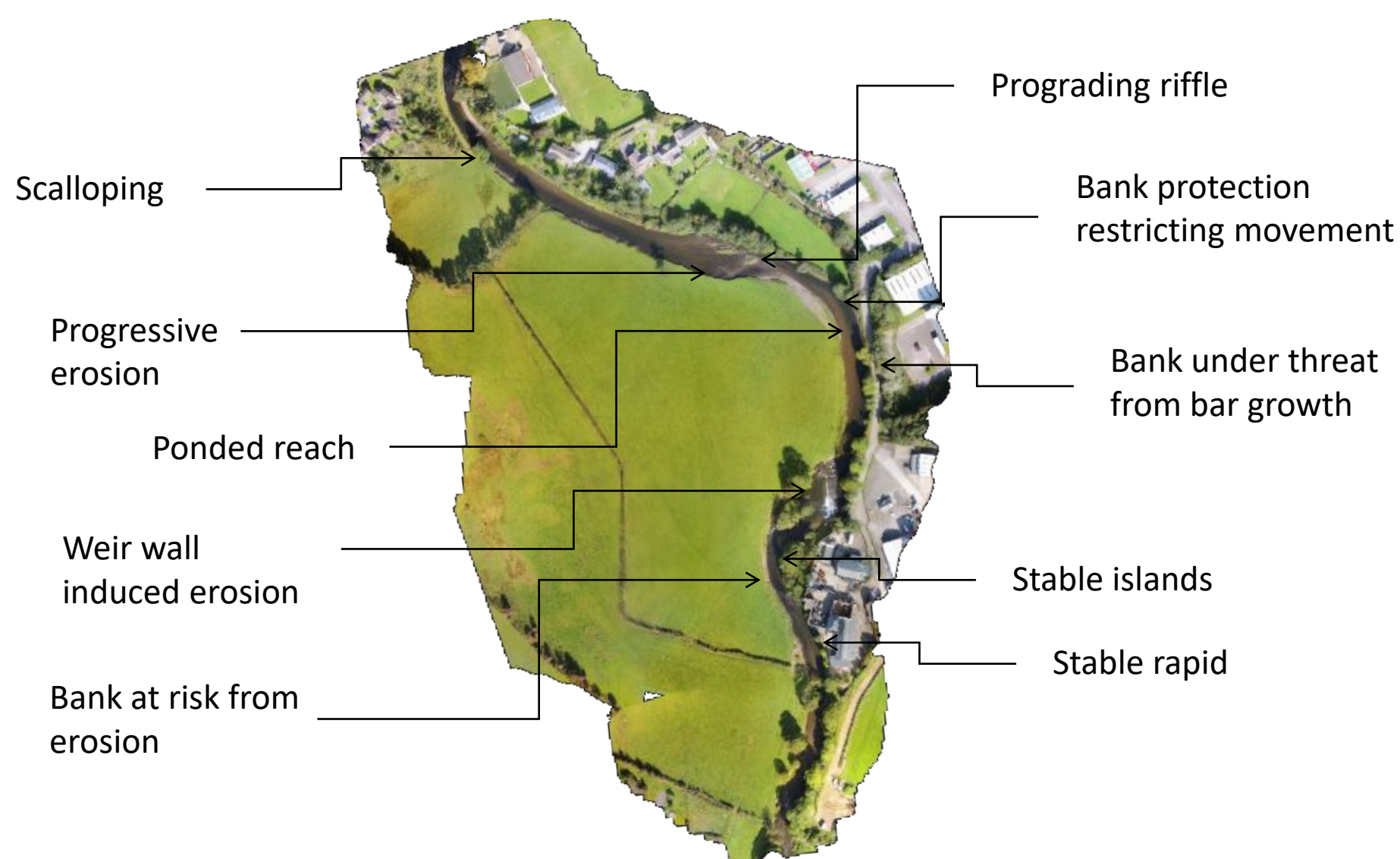
The River Ehen is situated in Ennerdale, West Cumbria and flows from Ennerdale Water, discharging 27 km downstream into the Irish Sea at Sellafield.

It is designated as a European Special Area of Conservation (SAC), designated for Freshwater Pearl Mussels (*Margaritifera margaritifera*) and Atlantic salmon (*Salmo salar*) and also as a Site of Special Scientific Interest (SSSI) for Freshwater Pearl Mussels.

The river supports the largest freshwater pearl mussel population in England. Exceptionally high densities (greater than 100 m²) are found at some locations, with population estimates for the entire river exceeding 100,000. The conservation importance of the site is further enhanced by the presence of juvenile pearl mussels, indicating recruitment since 1990.



Channel dynamics around Ennerdale Mill Weir



The River Ehen is an active sinuous single thread channel in the vicinity of Ennerdale Mill Weir exhibiting a well-developed functional in-channel morphology in line with the current coarse sediment supply. Lateral movement has been restricted historically and local deterioration and failure of this protection is allowing the river to adjust its form through bank erosion.

Localised erosion processes in the reach up and downstream of Ennerdale Mill Dam, whilst initially induced by the installation of the weir, are now operating primarily through more local morphological controls. These are likely to continue regardless of any action at the weir and where these are not impacting infrastructure should be considered as a natural phenomenon on an active channel such as the Ehen and should be allowed to continue.

A large volume of coarse sediment is presently stored in an equilibrium state behind the weir. Functional but unnatural features now allow coarse sediment to pass over the weir to continue to supply the river downstream. Potential release of sediment from behind the weir will be quickly assimilated into the natural transport regime downstream and will not accumulate in the long term to impact on the morphology.

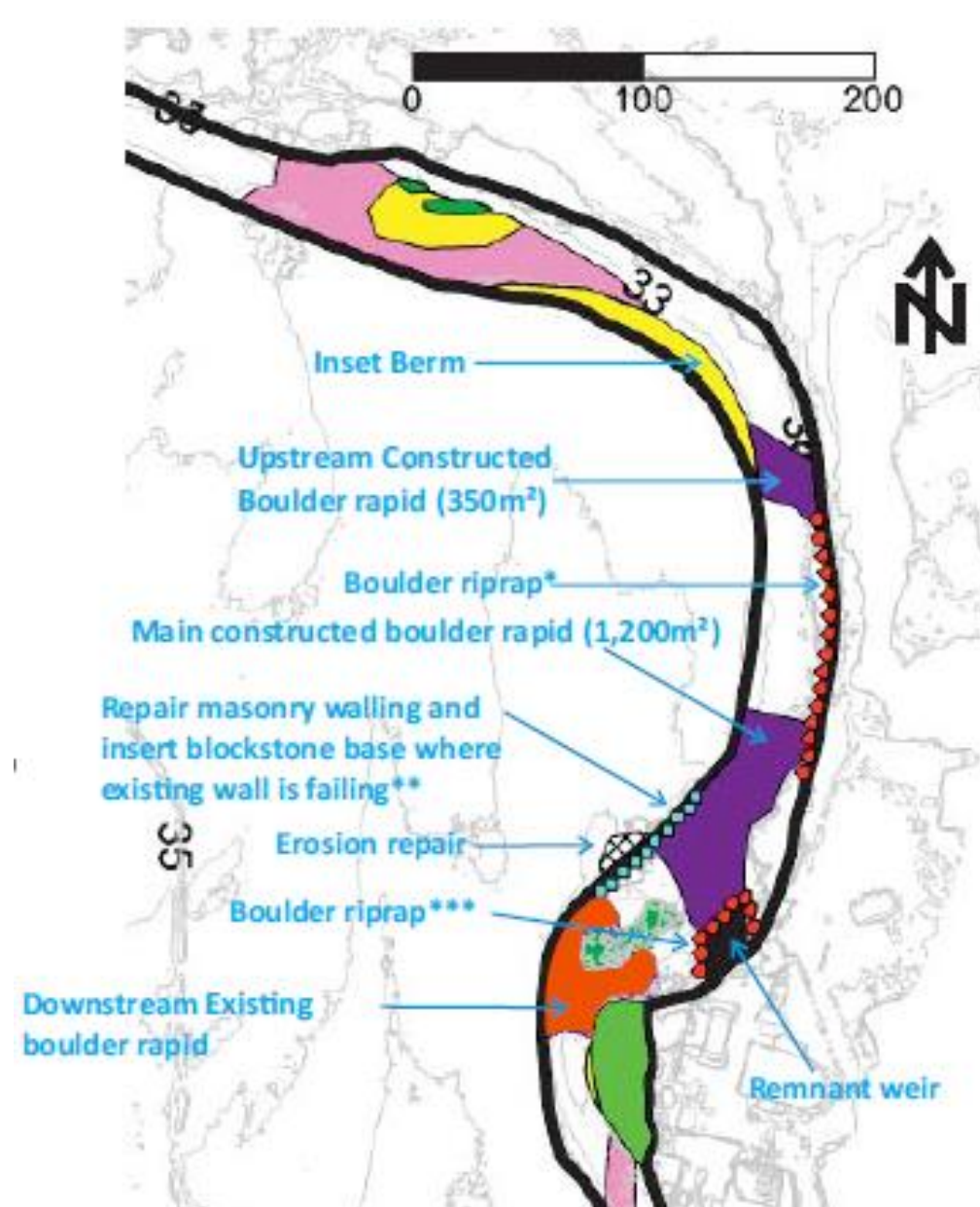
Summary options considered to improve hydromorphic function and fish passage through the reach presently impacted by Ennerdale Mill Weir.

Option	Hydromorphic & Heritage gains	Risks & Mitigation	Proposed action
Do Nothing	System will retain altered but functional hydromorphology. Current local channel change will persist. Fish passage remains compromised.	Perceived instability persists. Risk of long term weir outflanking and uncontrolled channel adjustment upstream.	Reject
Complete removal	Long term restoration of a near natural functional hydromorphology. Fish passage facilitated. Historic sluice structure and weir will be lost.	Short term significant uncontrolled channel adjustment up and downstream. Raised risk of bank erosion necessitating widespread revetment works. Headcut processes may work upstream to compromise the stability of the residual weir at the allotments.	Reject
Partial removal	Long term restoration of a near natural functional hydromorphology. Fish passage facilitated. Retention of the historic sluice structure and part of the weir will enhance the heritage value at Ennerdale Mill.	Short term very significant uncontrolled channel adjustment up and downstream. Risk of bank erosion highest along the right bank necessitating widespread revetment works. Left bank offered partial protection by the sediment retained behind the remnant weir. Headcut processes may work upstream to compromise the stability of the residual weir at the allotments.	Reject
Complete removal & in-channel morphologic mitigation	Short to medium term restoration of a near natural functional hydromorphology. Fish passage facilitated. Historic sluice structure and weir will be lost.	Large scale morphologic feature creation necessary to control system response. Short term controlled channel adjustment up and downstream. Adjustment moderated by installed features reduced risk of bank erosion although protection to key infrastructure is recommended.	Reject
Partial removal & in-channel morphologic mitigation	Short to medium term restoration of a near natural functional hydromorphology. Fish passage facilitated. Retention of the historic sluice structure and part of the weir will enhance the heritage value at Ennerdale Mill.	Reduced scale morphologic feature creation necessary to control system response. Short term controlled channel adjustment up and downstream. Left bank offered partial protection by the sediment retained behind the remnant weir although protection to key infrastructure is recommended.	Take forward
Bypass channel	Mimicking cut-off channel processes seen on active single thread systems. Opportunity to create a new near natural morphology along the bypass channel and to retain the features in the former main channel with change occurring at a lowered rate leading to significant increases in hydromorphic diversity. Fish passage facilitated. Retention of the historic sluice structure and entire weir will enhance the heritage value at Ennerdale Mill.	Significant risk of channel switching occurring with the bypass channel gaining dominance over the current main channel. Associated headcut erosion upstream is a significant long term possibility. Channel response is likely to be significant and long term. Requires major change to current use of the right bank floodplain. Raised risk of long term bank erosion necessitating widespread revetment works.	Reject

Works included partial removal of the weir along the centre and right of the channel, repairs to the failed right bank weir walling, boulder blockstone revetment around the remnant weir to ensure stability, retention of the sluice structure to enhance the heritage value of the site, extension of the right bank protection to include all of the access road where it parallels the watercourse, bed excavation and creation of a boulder rapid at the old weir site linking with the extant rapid feature downstream, creation of a second smaller boulder rapid between the old weir and the transvers bar feature upstream and the excavation of an inset berm/point bar on the right bank to reduce flood erosion pressure on the left bank infrastructure.

The principal features remain dynamically stable at the site with fish passage now fully restored. An inner bend chute channel is developing across the point bar which is likely to convert this to a transverse bar feature over time. No changes have been observed to the channel downstream with all fishing pools remaining. Upstream erosion of the right bank persists but this is unrelated to the removal.

Final option for Ennerdale Mill Weir and before and after orthophoto of the local site.



This project was delivered through the Environment Agency's River Restoration Programme, a partnership between the EA, Natural England and West Cumbria Rivers Trust