



**Haweswater Aqueduct Resilience Programme - Proposed Bowland
Section**

Environmental Statement

Volume 4

Appendix 7.3: Geomorphology Proformas

June 2021



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1. Introduction

- 1) Fluvial geomorphology site walkover surveys were undertaken in 2019 and 2020. This document provides the fluvial geomorphology baselines for the watercourses in the assessment area, based on data from the site walkovers. Where it was not possible to visit a watercourse, the baseline assessment was formed using desk-based sources only. Mitigation, reinstatement requirements, and potential enhancements have also been identified based on the assessment made as part of the Environmental Statement. Watercourse locations are shown in Figure 7.2 of the Environmental Statement.

2. Geomorphology Proformas

2.1 Cod Gill (W206)

- 2) The section of this watercourse that would interact with the Proposed Bowland Section was not visited during the site visit. The findings are partly based on desk-based observations.

Watercourse baseline	
Value	Medium
WFD Surface Water Body	Hindburn
Reach function	Transfer
Reach process	Stable
Flow	Uniform - Smooth flow
Substrate	Unsorted loose/mobile silt
Features observed	Natural: None within surveyed reach. Evidence of erosion downstream of surveyed reach Artificial: 450 m long embankment along left bank (Illustration 1), evidence of channel realignment at upstream end of surveyed reach. Culverting downstream of surveyed reach
Land use	Rough pasture on both banks, with a road along the right bank
Riparian vegetation	Grass and sedge, occasional trees (Illustration 2)
Scheme Interaction	
Scheme components	Temporary outfall, discharge of construction and site run-off, discharge of commissioning flows, and dewatering impacts (during construction)
Mitigation requirements (Enabling)	No specific mitigation would be required. Impacts would be mitigated by embedded mitigation
Mitigation requirements (Construction)	No specific mitigation would be required. Impacts would be mitigated by embedded mitigation
Mitigation requirements (Commissioning)	Mitigation for the commissioning flows would likely take the form of green bank protection opposite the outfall, with scour matting around the outfall. A monitoring programme to identify changes in the bed and banks on a daily basis for the duration of the commissioning phase is also recommended. United Utilities would be notified of any changes and remediation would be sought. The remediation could include additional scour matting and green bank protection at the location of any new erosion as well as channel reinstatement after the commissioning phase
Mitigation requirements (Operational)	No impacts would be anticipated during this phase
Mitigation requirements (Decommissioning)	No impacts would be anticipated during this phase
Reinstatement requirements (where watercourse is physically crossed, or riparian zone is interrupted)	Reinstatement could be required if the commissioning flows cause erosion to the bed and banks If the commissioning flows cause erosion, it is recommended the bed be reinstated with natural material and augmented with coarser material. During the reinstatement, coarse material is also recommended to be placed along the bank toe to stabilise the bank. It is recommended a decomposable

geotextile be used on the upper the banks, to allow for vegetation re-establishment along the upper and mid bank and aid stabilisation. It is recommended that all reinstatement work be supervised by an Environmental Clerk of Works with expertise and experience in channel restoration to ensure appropriate reinstatement

Reinstatement of bed, banks, and riparian vegetation following the removal of the temporary outfall

Photo(s) of watercourse



Illustration 1: Downstream view from right bank. Embankment on left bank



Illustration 2: Upstream view from right bank showing riparian vegetation

2.2 Unnamed Watercourse 169 (W215)

Watercourse baseline	
Value	Low
WFD Surface Water Body	Hindburn
Reach function	Source
Reach process	Stable
Flow	Uniform – smooth flow
Substrate	Consolidated silt. No sorting
Features observed	Natural: 3 m of erosion on left bank (Illustration 3) Artificial: None
Land use	Rough pasture on both banks
Riparian vegetation	Continuous sedge and grass coverage along both banks
Scheme Interaction	
Scheme components	Construction access route
Mitigation requirements (Enabling)	Mitigation measures would be required for the impact the access road crossing of Unnamed Watercourse 169 has on the River Hindburn. These measures would be employed following the removal of the culvert (see reinstatement requirements)
Mitigation requirements (Construction)	Mitigation measures would be required for the impact the access road crossing has on the River Hindburn. These measures would be employed following the removal of the culvert (see reinstatement requirements)
Mitigation requirements (Commissioning)	No impacts would be anticipated during this phase
Mitigation requirements (Operational)	No impacts would be anticipated during this phase
Mitigation requirements (Decommissioning)	No impacts would be anticipated during this phase
Reinstatement requirements (where watercourse is physically crossed, or riparian zone is interrupted)	Following removal of the culvert required for the access road crossing, it is recommended the bed be reinstated with natural material and augmented with coarser material. It is recommended that all reinstatement work be supervised by an Environmental Clerk of Works with experience in channel restoration to ensure appropriate reinstatement Reinstatement of bed, banks, and riparian vegetation following the removal of the temporary culvert

Photo(s) of watercourse



Illustration 3: View from left bank to right bank of bank erosion

2.3 Unnamed Watercourse 384 (W461)

Watercourse baseline	
Value	Low
WFD Surface Water Body	Hodder - conf Easington Bk to conf Ribble
Reach function	Transfer
Reach process	Stable
Flow	Varied depending on geomorphological features present - rippled, broken waves, and smooth flow all observed
Substrate	Poorly sorted and partly consolidated gravels (fine and coarse) and silt
Features observed	Natural: None Artificial: Culvert (Illustration 4), outfalls, trash screen
Land use	Rough pasture on both banks. Left bank fenced
Riparian vegetation	Grasses, shrubs, and occasional deciduous trees along both banks (Illustration 5)
Scheme Interaction	
Scheme components	Temporary outfall, discharge of construction and site run-off, construction access route, dewatering impacts (during construction), and surplus material storage.
Mitigation requirements (Enabling)	No specific mitigation would be required. Impacts would be mitigated by embedded mitigation
Mitigation requirements (Construction)	No specific mitigation would be required. Impacts would be mitigated by embedded mitigation
Mitigation requirements (Commissioning)	No impacts would be anticipated during this phase
Mitigation requirements (Operational)	No impacts would be anticipated during this phase
Mitigation requirements (Decommissioning)	No impacts would be anticipated during this phase
Reinstatement requirements (where watercourse is physically crossed, or riparian zone is interrupted)	Reinstatement of bed, banks, and riparian vegetation following the removal of the culverts for the temporary access routes and temporary outfall

Photo(s) of watercourse



Illustration 4: Downstream view of culvert inlet



Illustration 5: Upstream reach - downstream view of riparian vegetation

2.4 Unnamed Watercourse 385 (W462)

Watercourse baseline	
Value	Medium
WFD Surface Water Body	Hodder - conf Easington Bk to conf Ribble
Reach function	Exchange
Reach process	Incising with some lateral adjustment
Flow	Varied depending on geomorphological features present - rippled, unbroken waves, and smooth flow all observed
Substrate	Poorly sorted and partly consolidated gravels (fine and coarse) and silt
Features observed	Natural: Berms (Illustration 6), 3 m of bank erosion Artificial: None
Land use	Arable land on left bank. Rough pasture on right bank
Riparian vegetation	Grass, sedge, and a semi-continuous line of trees on both banks
Scheme Interaction	
Scheme components	Construction access route, and dewatering impacts (during construction)
Mitigation requirements (Enabling)	No specific mitigation would be required. Impacts would be mitigated by embedded mitigation
Mitigation requirements (Construction)	To mitigate the impact of dewatering, it is proposed that (treated) construction water is discharged at the head of the watercourse. This would be limited to greenfield run-off rates for the catchment upgradient of the portal in order to mimic catchment hydrology as much as possible Mitigation measures would be required for the impact of the construction access route crossing. These measures would be employed following the removal of the culvert (see reinstatement requirements)
Mitigation requirements (Commissioning)	No impacts would be anticipated during this phase
Mitigation requirements (Operational)	No impacts would be anticipated during this phase
Mitigation requirements (Decommissioning)	No impacts would be anticipated during this phase
Reinstatement requirements (where watercourse is physically crossed, or riparian zone is interrupted)	Reinstatement requirements (where watercourse is physically crossed, or riparian zone is interrupted). Following removal of the culvert required for access road crossing, it is recommended the bed and banks are reinstated with natural material and augmented with coarser material. During the reinstatement, coarse material is also recommended to be placed along the bank toe to stabilise the bank with a decomposable geotextile used on the upper banks, to allow for vegetation re-establishment along the upper and mid bank and aid stabilisation. It is recommended that all reinstatement work be supervised by an Environmental Clerk of Works with experience in channel restoration to ensure appropriate reinstatement

Photo(s) of watercourse



Illustration 6: Downstream view of fine sediment berms

2.5 Unnamed Watercourse 386 (W463)

3) This watercourse was not visited during the site visit. The findings are based on desk-based observations.

Watercourse baseline	
Value	Low
WFD Surface Water Body	Hodder - conf Easington Bk to conf Ribble
Reach function	Not possible to determine
Reach process	Not possible to determine
Flow	Not possible to determine
Substrate	Not possible to determine
Features observed	Natural: None visible Artificial: Crossed by two drystone walls
Land use	Pasture on both banks
Riparian vegetation	Continuous grasses and shrubs on both banks
Scheme Interaction	
Scheme components	Temporary outfall, discharge of construction and site run-off, construction access route, and surplus material storage.
Mitigation requirements (Enabling)	No specific mitigation would be required. Impacts would be mitigated by embedded mitigation
Mitigation requirements (Construction)	No specific mitigation would be required. Impacts would be mitigated by embedded mitigation
Mitigation requirements (Commissioning)	No impacts would be anticipated during this phase
Mitigation requirements (Operational)	No impacts would be anticipated during this phase
Mitigation requirements (Decommissioning)	No impacts would be anticipated during this phase
Reinstatement requirements (where watercourse is physically crossed, or riparian zone is interrupted)	Reinstatement of bed, banks, and riparian vegetation following the removal of the culverts for the temporary access routes and temporary outfall

2.6 River Hodder (W477)

Watercourse baseline	
Value	Medium
WFD Surface Water Body	Hodder - conf Easington Bk to conf Ribble
Reach function	Exchange
Reach process	Laterally adjusting
Flow	Varied depending on geomorphological features present – rippled (Illustration 7), unbroken waves, and smooth flow all observed
Substrate	Poorly sorted, consolidated silt, gravel, and cobbles
Features observed	Natural: Berms, riffles, medial bars (Illustration 8), side bars, 550 m of bank erosion Artificial: weirs, foot and road bridges, Haweswater Aqueduct pipe bridge, 115 m of bank reinforcement
Land use	Rough pasture on both banks
Riparian vegetation	Sparse trees and bushes on both banks
Scheme Interaction	
Scheme components	Temporary outfalls, discharge of construction and site run-off, discharge of commissioning flows, construction access route, overflow, and surplus material storage
Mitigation requirements (Enabling)	Mitigation measures would be required for the impact of the temporary outfalls. These measures would be employed following the removal of the outfalls (see reinstatement requirements)
Mitigation requirements (Construction)	It is recommended that the temporary outfalls are located so that they are not opposite each other. This would reduce the risk of local scour. Other mitigation measures for the temporary outfalls and the access road crossing would be employed following the removal of the structures (see reinstatement requirements). The Construction Code of Practice recommends that the surplus material storage is located at least 10 m from any watercourse. The current designs are not in line with this and mitigation would not be possible. Therefore a residual impact would remain, unless a 10 m buffer could be maintained during construction works.
Mitigation requirements (Commissioning)	No specific mitigation would be required. Impacts would be mitigated by embedded mitigation
Mitigation requirements (Operational)	No specific mitigation would be required. Impacts would be mitigated by embedded mitigation
Mitigation requirements (Decommissioning)	Monitoring for bank erosion and movement/degrading of riffle adjacent to outfall required. Further mitigation to be discussed with the Environment Agency in the event of bed/bank scour being caused
Reinstatement requirements (where watercourse is physically crossed, or riparian zone is interrupted)	Following removal of the bridge required for the access road crossing and the temporary outfalls, it is recommended the bed be reinstated with natural material and augmented with coarser material. During the reinstatement, coarse material is also recommended to be placed along the bank toe to stabilise the bank with a decomposable geotextile used on the upper banks, to allow for vegetation re-establishment. It is recommended that all reinstatement work be supervised by an Environmental Clerk of Works with

experience in channel restoration to ensure appropriate reinstatement. Reinstatement could also be required, if the commissioning flows cause erosion to the bed and banks

Photo(s) of watercourse



Illustration 7: View from left bank to right bank showing rippled flow



Illustration 8: Downstream view of a medial bar

2.7 River Hindburn (W478)

Watercourse baseline	
Value	Very High
WFD Surface Water Body	Hindburn
Reach function	Exchange
Reach process	Stable
Flow	Varied depending on geomorphological features present – rippled, broken and unbroken waves, and smooth flow all observed
Substrate	Loose/mobile bedrock, boulders, and cobbles (Illustration 9). Some sorting
Features observed	Natural: point, lateral and medial bars, berms, riffles, bars, two areas of bank erosion (totalling 35 m) (Illustration 10), large woody debris Artificial: None observed
Land use	Pasture on the right bank and rough pasture on the left bank
Riparian vegetation	Continuous on both banks consisting of deciduous trees and grass
Scheme Interaction	
Scheme components	Downstream of watercourse crossed by access route (Unnamed Watercourse 169) and watercourse receiving commissioning flows (Cod Gill)
Mitigation requirements (Enabling)	Mitigation measures would be required for the impact the access road crossing at Unnamed Watercourse 169 (see Section 2.2) has on the River Hindburn
Mitigation requirements (Construction)	No impacts would be anticipated during this phase
Mitigation requirements (Commissioning)	Mitigation for the commissioning flows would likely take the form of monitoring changes in the bed and banks for erosion daily for the duration of the commissioning phase. United Utilities would be notified of any changes and remediation would be sought. The remediation could include additional scour matting and green bank protection at the location of any new erosion as well as channel reinstatement after the commissioning phase
Mitigation requirements (Operational)	No impacts would be anticipated during this phase
Mitigation requirements (Decommissioning)	No impacts would be anticipated during this phase
Reinstatement requirements (where watercourse is physically crossed, or riparian zone is interrupted)	If the commissioning flows cause erosion, it is recommended the bed be reinstated with natural material and augmented with coarser material. During the reinstatement, coarse material is also recommended to be placed along the bank toe to stabilise the bank. It is recommended a decomposable geotextile be used on the upper banks, to encourage vegetation re-establishment. It is recommended that all reinstatement work be supervised by an Environmental Clerk of Works with expertise experience in channel restoration to ensure appropriate reinstatement Reinstatement of bed, banks, and riparian vegetation following the removal of the temporary bridge and temporary outfalls

Photo(s) of watercourse



Illustration 9: Downstream view of the channel showing a bedrock, boulder, and cobble bed



Illustration 10: Upstream view of the channel showing bank erosion on right bank