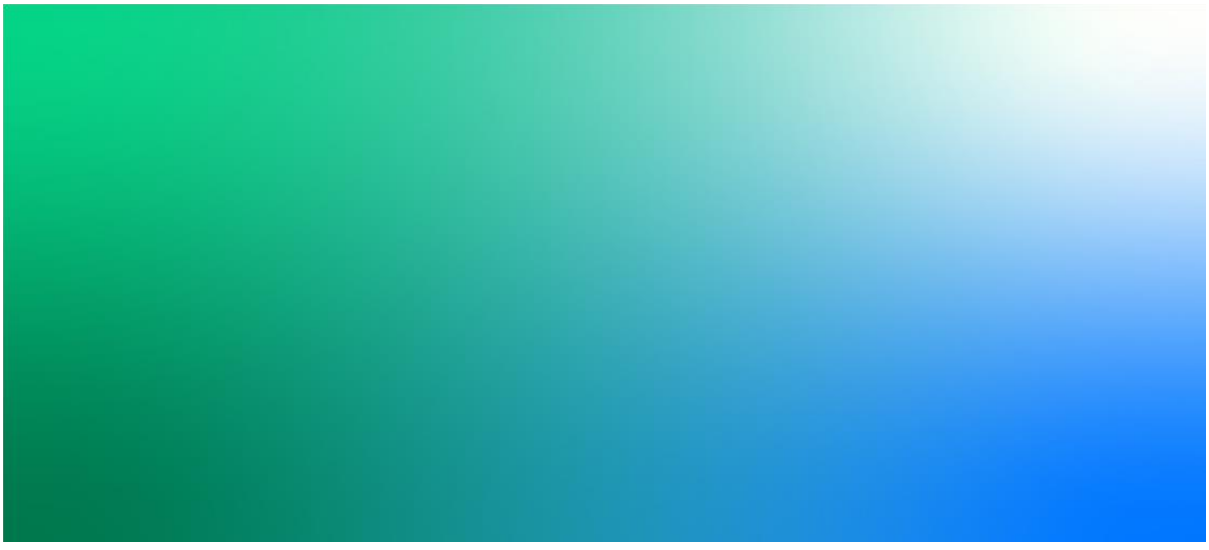
Alternative Temporary Park and Ride and Heavy Goods Vehicle Marshalling Area - Environmental Statement Volume 4 Appendix C.2: Geomorphology Assessment

United Utilities Water Limited

Haweswater Aqueduct Resilience Programme

Planning Application Document RVBC–P&R-APP-RP-002 / ES-TA-C-2
February 28, 2025



Alternative Temporary Park and Ride and Heavy Goods Vehicle Marshalling Area - Environmental Statement
Volume 4 Appendix C.2: Geomorphology Assessment

Client name:	United Utilities Water Limited
Project name:	Haweswater Aqueduct Resilience Programme
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Prepared by:	Jacobs U.K. Limited
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Acronyms and abbreviations

CCoP	Construction Code of Practice
WFD	Water Framework Directive

1. Overview and Scope of the Assessment

1.1 Scope of the Assessment

1) This appendix provides an assessment of the fluvial geomorphology of water features within the study area of the proposed Alternative Facility and supports Chapter 6 Water Environment. Thes covers observations made during a site visit and a supporting desk study, an assessment of likely impacts from the Alternative Facility as well as providing recommendations to mitigate impacts as necessary.

1.2 Study Area

2) The study area for the geomorphology assessment is defined as the planning application boundary of the Alternative Facility with a 100 m buffer zone.

1.3 Baseline Environment

1.3.1 Data Sources and Field Surveys

3) The following data sources have been used to help establish an understanding of the baseline environment:

- Ordnance Survey mapping
- Aerial imagery[1]
- Historic mapping[2]
- Catchment Data Explorer[3].

4) A fluvial geomorphology walkover survey was undertaken on Friday 22 November 2024. The walkover survey consisted of covering the 750 m length of Worston Brook from approximately National Grid Reference SD 76105 42546 to SD 75556 42369. Fluvial geomorphological features and processes were identified and recorded by a suitably qualified and experienced geomorphologist.

1.3.2 Existing Baseline

1.3.2.1 Desk Study

5) Within the study area there is one watercourse, Worston Brook, which flows from east to west through the study area and crosses the planning application boundary at the Pimlico Link Road crossing and at the proposed new drainage outfall location at approximately SD 75826 42451 as shown on Figure 6.7.

[1] Google Earth v7.3.6.9796 (2024). Clitheroe, United Kingdom. 53°52'40.95"N, 2°22'2.12"W, eye alt 1 km. Airbus 2025. [Online]. Available at: https://earth.google.com/ [Accessed: December 2024].

[2] National Library of Scotland (2024). Side by side. [Online] Available at: https://maps.nls.uk/geo/explore/side-by-side/ [Accessed: December 2024].

[3] Environment Agency (2023). Catchment Data Explorer. Available at: https://environment.data.gov.uk/catchment-planning/WaterBody/GB112071065510 [Accessed: December 2024].

6) Worston Brook is not classified under the Water Framework Directive (WFD). It is, however, a tributary to Mearley Brook (outside of the study area), a designated river water body (Mearley Brook, ID: GB112071065510) under The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017[4] (WFD Regulations) which itself is a tributary to the River Ribble. Under River Basin Management Plan cycle 3, Mearley Brook is of 'Moderate' ecological status and 'Supports Good' hydromorphological status.

7) Worston Brook covers a catchment area of approximately 4.96 km^2 from its source on the slopes on Pendle Hill to the confluence with Mearley Brook at Twin Brook Business Park (SD 75554 42338).

8) Within the study area, Worston Brook exhibits a sinuous channel planform through predominately agricultural (grazing and arable) land use and largely unconfined by valley sides. The channel displays a series of meanders from SD 75874 42506 to SD 75684 42412, upstream and downstream that are gently sinuous in planform. Dense riparian tree cover is present in the upper and lower extent of the study area, upstream of the Pimlico Link Road crossing and downstream of SD 75592 42383 towards the confluence with Mearley Brook. Throughout the majority of the reach, riparian cover is intermittent deciduous tree cover, predominantly with grasses to shrubs covering the banks. Aerial imagery indicates in-channel and marginal depositional features, suggesting an active channel bed. The main artificial modification within the study area is the Pimlico Link Road culvert.

9) From a review of historical maps[2], the channel within the study area previously had a much straighter planform, as observed on mapping dated 1847, particularly from SD 75874 42506 to SD 75684 42412. Over time the sinuosity in this reach has increased, and by the 1970s, a similar planform to present was mapped. Land use immediately adjacent to the channel has remained largely unchanged over this time, with the exception of the construction of Pimlico Link Road.

1.3.2.2 Site Visit

10) Weather conditions were dry on the day of the site survey. However, the survey followed a wet week (13 to 19 November 2024) after a previous dry spell (30 October to 12 November 2024). The week of the survey experienced more rainfall than the previous week, with the north-west of England receiving 57 mm of rain, equating to 59% of the long-term monthly average in November.[5] Flows on the day of the survey appeared less than bankfull.

11) The site survey took place along Worston Brook within the study area and extended downstream, following an approximately 750 m reach of Worston Brook from SD 76105 42546 to SD 75556 42369 or thereabouts. It was observed that Worston Brook is a watercourse exhibiting varying flow types and geomorphological characteristics. It is an active watercourse with extensive erosion along both banks, and depositional features associated with meander bends and obstructions (i.e. fallen trees) in the channel. A potential historic cut-off channel was noted from SD 75813 42441 to SD 75795 42430. It is unclear whether this is a natural feature or has been excavated; however, historic mapping indicates that the channel has undergone planform changes (from straight to meandering) in this section. A summary of the observations made on the day is presented in Table 1.1, with photographs of typical conditions presented in Photographs 1 to 9.

[4] The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017. [Online] Available at: https://www.legislation.gov.uk/uksi/2017/407/contents [Accessed: December 2024].

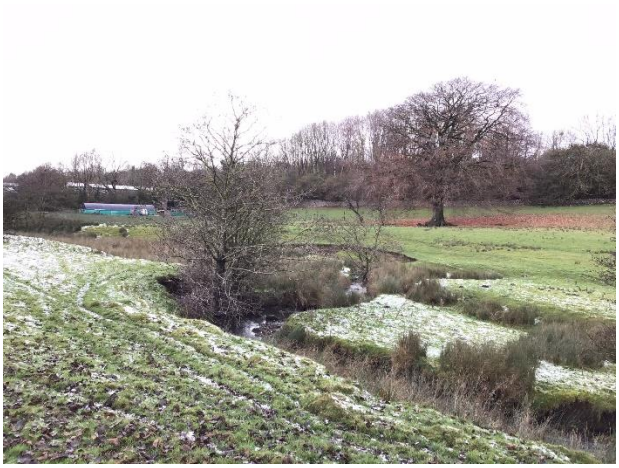
[5] Environment Agency (2024). Rainfall and river flow: weekly reports for England. [Online] Available at: https://www.gov.uk/government/publications/weekly-rainfall-and-river-flow-reports-for-england [Accessed: December 2024].

12) The majority of erosion is present on the outer bends of meanders. Extensive poaching was recorded on the left bank where the proposed outfall location is (refer to Figure 6.7).

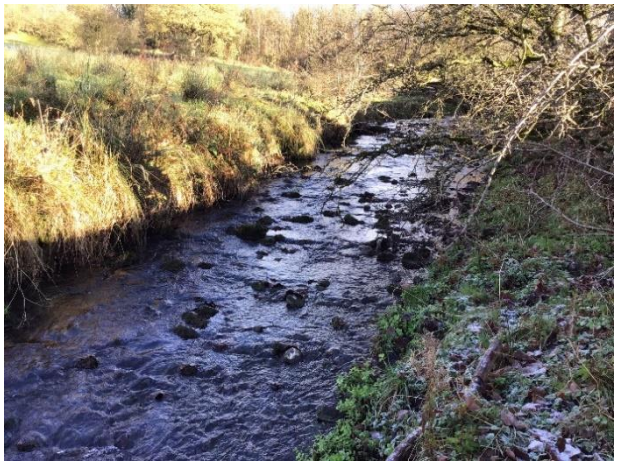
13) Coarse sediment point bars, consisting of gravels to cobbles, were noted on the inside of meander bends. Sediment accumulation was also noted where trees have fallen into the channel and fine sediment released from poaching. A trash screen at SD 75916 42501 prevents livestock from accessing the channel and poaching the channel upstream.

Table 1.1: Summary of Baseline Conditions

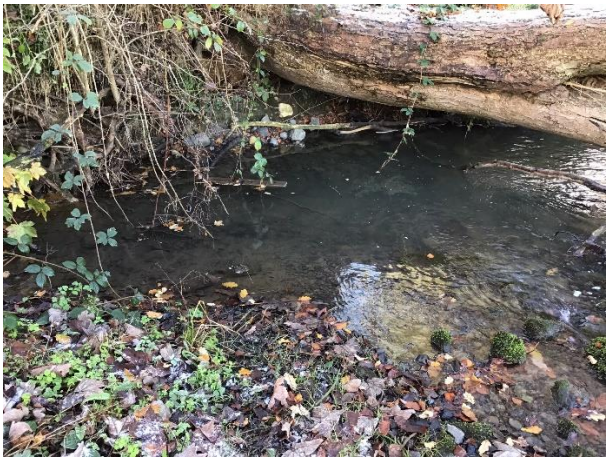
Attribute	Description
Valley Shape	U-shaped
Floodplain extent	Semi-continuous along both banks
Floodplain width	Varied. Constrained at culvert outlet, to approximately 50-60 m wide throughout most of the study area, where left bank is more connected to the flood plain and the right bank is semi-connected.
Riparian zone	Continuously vegetated along both banks up to and beyond 10 m.
Riparian vegetation	Largely deciduous trees along left-hand bank. Some hawthorns. Grasses and occasionally tree or shrub along right-hand bank.
Bank conditions	Largely vertical and undercut through much of the study reach. At the inside of any channel bends, bank gradient was gently sloping (i.e., less than 45°). Intermittent poaching – extensive at site of outfall along left-hand bank.
Bank composition	Composite earth (i.e., soils, gravels and cobbles).
Bed conditions	Largely coarse gravel to cobble. Finer gravels within interstices. Poorly sorted, mobile with light-coloured substrate, some consolidation in places. Silt where trees have fallen into channel and at the site of the outfall.
Flow types	Varied throughout reach. There is a particular flow type for the step pool geomorphology which can by known as "tumbling flow" at top of reach and pool riffle for remainder. Broken and unbroken standing waves at bed forms and smooth or rippled at pools/plane-beds.
Morphological processes and features	Extensive erosion along both banks. Alternates depending on bend direction. Step pool sequences for first 30 – 40 m, but shallow. Pool-riffle for remainder. Inside bends and obstructions (i.e. trees) facilitate bar formation. Potential cut-off channel approximately 30 m downstream of outfall location, unsure whether natural process or excavated.
Dominant reach-scale process	Lateral adjustment
Reach function	Sediment exchange
Water width	Approximately 4 m for first 100 m of the reach then approximately 6 m for remainder of reach, on average.
Water depth	Approximately 0.1 m on average
Bankfull width	Approximately 5 m on average
Bankfull depth	Approximately 0.8 m on average



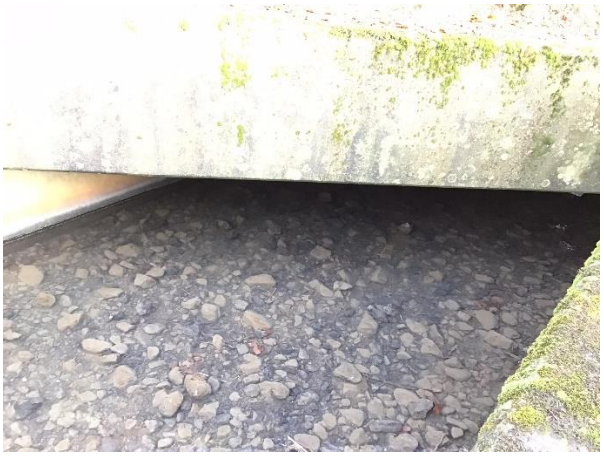
Photograph 1: Meandering Channel Planform, with Vertical Banks Cut into Shallow Wide Valley



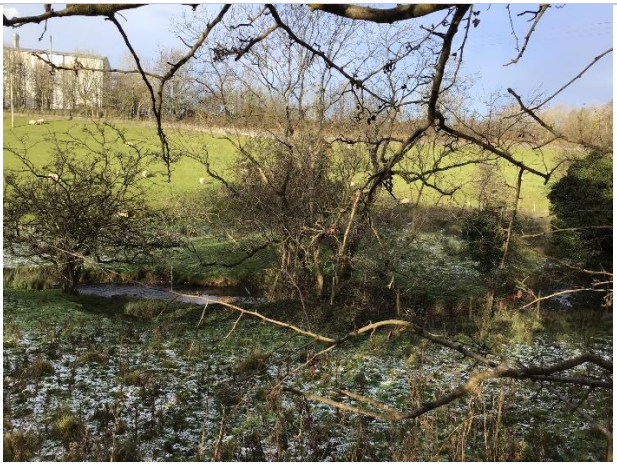
Photograph 2: Riffle with Coarse Bed Material



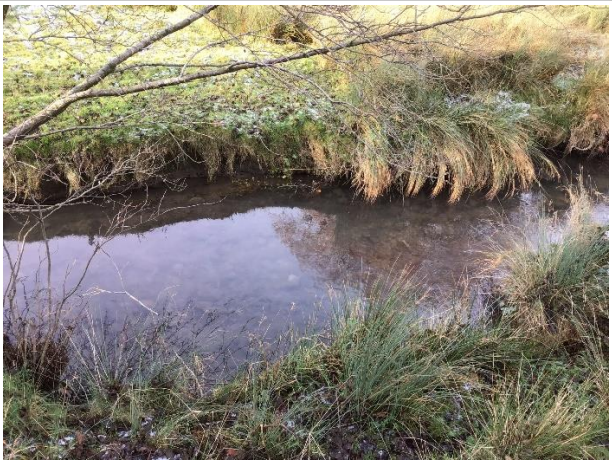
Photograph 3: Fine Sediment Accumulation Around Fallen Tree and Woody Material In Channel



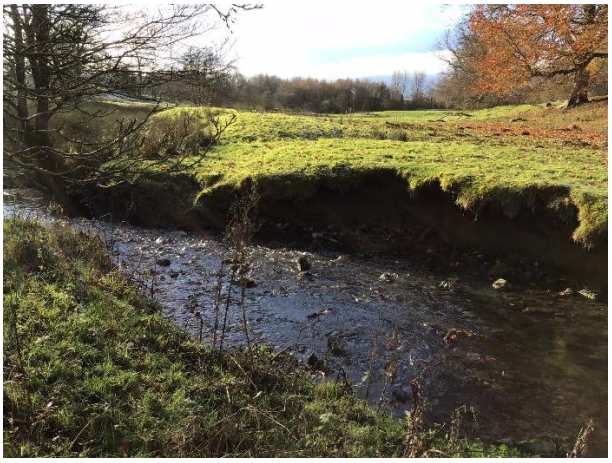
Photograph 4: Coarse Bed Material at Pimlico Link Road Culvert Outlet



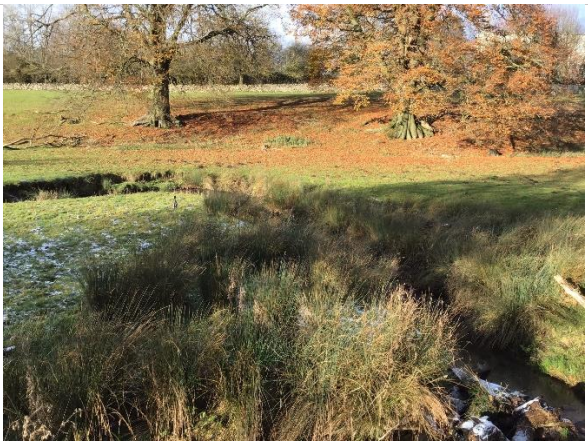
Photograph 5: Trash Screen and Fencing Limits Livestock Access to Channel and Helps Bank Stability



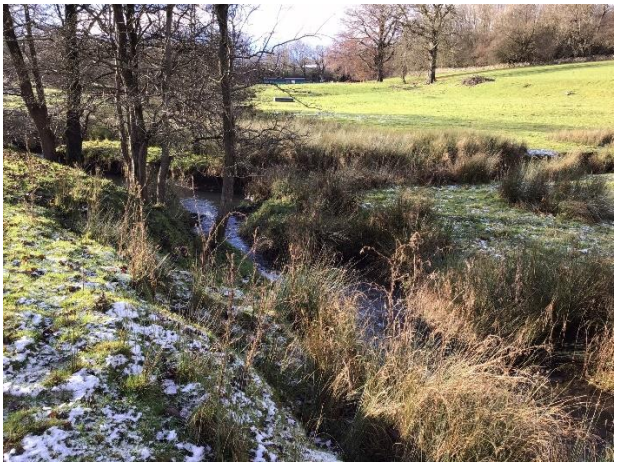
Photograph 6: Fine Sediment Released from Poaching on Left Bank at Proposed Outfall Location



Photograph 7: Bank Erosion and Undercutting Upstream of Proposed Outfall Location



Photograph 8: Outer Meander in Background, Straight Cut-Off Channel in Foreground, Downstream of Proposed Outfall Location



Photograph 9: Straight Cut-Off Channel, Looking Downstream from Left Bank. Main Channel Re-Joins from Right

1.3.2.3 Summary of Baseline Importance

14) From recorded observations during the site visit and from desk study, Worston Brook within the study area is an unstable, single-thread channel exhibiting lateral adjustment, and a range of morphological features including step-pool and pool-riffle. Existing human activities include the Pimlico Link Road culvert, poaching from livestock and some fencing to restrict access to banks. It is not known whether the cut-off side channel downstream of the proposed outfall location is natural and a result of the lateral adjustment of the channel, or artificially formed. Based on the importance criteria in Table 6.5 within Chapter 6 Water Environment, Worston Brook is determined as being of medium importance for fluvial geomorphology.

1.4 Assessment of Likely Significant Effects

1.4.1 Introduction

15) The assessment has been undertaken conservatively based upon activities (as described in Chapter 3 Description of the Alternative Facility). The methodology for this assessment is outlined in Chapter 6 Water Environment. Section 1.4.2 considers the effects without mitigation, whilst Section 1.4.3 considers effects after the implementation of proposed mitigation.

1.4.2 Likely Significant Effects Prior to Mitigation

1.4.2.1 Construction

16) Likely significant effects anticipated during construction are detailed in Table 1.2.

Table 1.2: Summary of Likely Significant Effects During Construction

Effect	Description of Effect	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance of Effect
Increased fine sediment input	Construction activities within the catchment and along the bank (for the outfall) could result in the temporary delivery of fine sediment to the channel. This could result in sediment deposition on bed features within the channel. Any changes would likely be localised, temporary and reversible once construction is complete and larger flows pass through the channel.	Worston Brook	Medium	Moderate	Moderate (Significant)
Changes to flow regime and dynamics	The outfall for to Worston Brook could alter the flow regime and cause erosion locally. The temporary nature of the outfall and discharge means flows and flow dynamics would be reversible. Any erosion is likely to be irreversible but should be viewed in the context of erosive baseline conditions.			Moderate	Moderate (Significant)
Bank instability	Temporary construction activities on the bank and bed for the installation of the new drainage outfall could alter bank stability. The channel is already exhibiting erosion on the bank opposite the proposed new outfall and at meanders upstream and downstream of this location. The channel is also currently poached at the outfall location. Removal of riparian vegetation for any construction works could lead to further instability of the banks. However, construction periods are temporary, any bank disturbance would stop once construction ends and recolonisation of bank material and the riparian zone would work to restabilise the banks over time.			Moderate	Moderate (Significant)

1.4.2.2 Operation

17) Likely significant effects anticipated during operation are detailed in Table 1.3.

Table 1.3: Summary of Likely Significant Effects During Operation

Effect	Description of Effect	Receptor	Receptor Importance	Magnitude of Impact	Significance of Effect
Changes to flow regime and dynamics	A new outfall for operational drainage from the Alternative Facility to Worston Brook could alter the flow regime and cause erosion locally over the operation of the Alternative Facility. The reach is already unstable from erosion on the bank opposite the outfall location and on meanders upstream and downstream of the proposed outfall location.	Worston Brook	Medium	Major	Large (Significant)
Channel adjustment	If the left bank around the proposed outfall location is protected, for example with fencing to protect from poaching, the channel may respond to this change and could result in erosion and deposition elsewhere in the reach.			Moderate	Moderate (Significant)

1.4.2.3 Decommissioning

18) Likely significant effects anticipated during decommissioning are detailed in Table 1.4.

Table 1.4: Summary of Likely Significant Effects During Decommissioning

Effect	Description of Effect	Receptor	Receptor Importance	Magnitude of Impact	Significance of Effect
Increased fine sediment input	Decommissioning activities within the catchment and along the bank for the removal of site compound, hardstanding area, Site Drainage Attenuation Area, drainage outfall, surface water drainage pipes and access roads, could result in the temporary delivery of fine sediment to the channel. This could result in localised and temporary smothering of bed features within the channel. Any changes are likely reversible as bankfull flows following decommissioning would likely move the sediment downstream and into the remaining river network.	Worston Brook	Medium	Moderate	Moderate (Significant)
Changes to flow regime	Removal of the operational outfall to Worston Brook could alter the flow regime locally, as there would no longer be an inflow from the outfall location. This could impact local channel morphology, by reversing flows back to baseline conditions.			Minor	Slight (Not significant)
Disturbance of bed and banks	Removal of the operational outfall to Worston Brook could temporarily disturb local channel bed and bank material. Removal of riparian vegetation for any works could exacerbate bank instability. However, impacts would be temporary.			Moderate	Moderate (Significant)

1.4.3 Proposed Mitigation and Residual Effects

19) General mitigation is described in Section 6.6.3 in Chapter 6 Water Environment. Good practice measures are contained within Appendix A.2 Construction Code of Practice. All mitigation is located within the planning application boundary.

20) Additional mitigation for impacts on fluvial geomorphology during construction, operation and decommissioning is detailed below.

1.4.3.1 Construction

21) Construction impacts for the control of sediment to the channel, works on the bank and in-channel can be mitigated as per Chapter 6 Water Environment, Section 6.6.3. At the location of the outfall structure, this would include:

- Minimising vegetation clearance along the riparian corridor and floodplain
- Providing on-site silt collection equipment such as siltbusters
- Implementing a sediment management plan to manage any fine sediment releases or silt-laden runoff during construction. This could involve the use of silt fencing set back along bank tops, for example
- Constructing the outfall structure off-site before excavating the bank material and capturing sediment between the installed outfall and the watercourse prior to operation
- Good practice guidance for outfalls[6].

1.4.3.2 Operation

22) The following is recommended to minimise the risk to the outfall and scour of channel bed and bank morphological features during peak flow events:

- Set the outfall back from the bank toe in a drainage channel to minimise the interaction between the headwall and the channel and dissipate energy. This would also provide a buffer for channel adjustment
- Try to maintain the trees and vegetation present adjacent to the outfall. These would act as natural bank protection. If riparian vegetation is removed during construction, replace with similar vegetation types
- Align the outfall so that it discharges downstream at a 45° angle. This would reduce the magnitude of change to flow dynamics and reduce the risk of scour and flows by stilling upstream
- To minimise scour, install flow attenuation features into the headwall. These could take the form of baffles in the headwall, or a stilling basin in the apron of the headwall. The idea being that the change in flow dynamics caused by either feature would dissipate energy and reduce the risk of scour to channel bed and banks
- Monitor the outfall headwall for any potential risk to the headwall and the reach downstream of it. Monitoring could take place across regular, six-monthly visits to the outfall, taking photographs of the study area at agreed locations. Additional monitoring to take place following storm events, when the outfall is likely to be in operation.

[6] Construction Industry Research and Information Association (2019). Culvert, screen and outfall manual (C786). [Online] Available at: https://www.ciria.org/CIRIA/CIRIA/Item_Detail.aspx?iProductCode=C786F [Accessed: December 2024].

23) To manage changes to channel adjustment in response to the outfall structure and any associated livestock fencing, the following is recommended:

- For effective monitoring, erosion markers would be placed along the bank and/or fixed-point photographs taken of the bank. These would then be compared with previous records to determine what (if any) change has occurred. If noticeable change is observed during monitoring, then further intervention (for example, seeded erosion control geotextile) should be considered
- Livestock fencing would be installed to reduce any potential poaching and additional bank failure along this length of watercourse.

1.4.3.3 Decommissioning

24) Impacts during the decommissioning phase are similar to construction regarding sediment runoff from removal of the site and works on the bed and banks. These impacts can be mitigated by following the CCoP.

25) The outfall location should be inspected on completion of the decommissioning works and the area reinstated to its pre-construction condition.

1.4.3.4 Summary of Residual Effects

26) Table 1.5 summarised the residual effects that have been identified on the Alternative Facility following the application of mitigation.

Table 1.5: Likely Significant Effects for Fluvial Geomorphology

Receptor	Description	Significance of Effect Prior to Mitigation	Proposed Mitigation	Magnitude of Impact, Post-Mitigation	Significance of Effect Following Mitigation
Construction Effects					
Worston Brook	Changes to flow regime and dynamics	Moderate (Significant)	Ensure volumes and velocity of water managed to the required Environment Agency permit standard	Minor	Slight
	Increased fine sediment input	Moderate (Significant)	On site sediment removal via SuDS (siltbuster, filter drains and Site Drainage Attenuations Area) Set back outfall from the bank edge Limit riparian vegetation removal and replace where required.	Negligible	Neutral (Not Significant)
	Bank instability	Moderate (Significant)		Minor	Slight (Not Significant)
Operation Effects					
Worston Brook	Changes to flow regime and dynamics	Large (Significant)	Follow good practice guidance for outfalls. Set outfall back, discharge at 45° angle downstream and install flow attenuation features to headwall. Monitor for changes in bank stability and scour of morphological features. Limit riparian vegetation removal and replace where required.	Minor	Slight (Not Significant)
	Channel adjustment	Moderate (Significant)	Monitor for changes in bank stability.	Minor	Slight (Not Significant)

Receptor	Description	Significance of Effect Prior to Mitigation	Proposed Mitigation	Magnitude of Impact, Post-Mitigation	Significance of Effect Following Mitigation
Decommissioning Effects					
Worston Brook	Changes to flow regime and dynamics	Moderate (Significant)	Removal of existing site attenuation area and drainage network including outfall. Return to throughflow input to Worston Brook	Negligible	Neutral (Not Significant)
	Increased fine sediment input	Moderate (Significant)	Follow mitigation proposed in CCoP. Limit riparian vegetation removal and replace where required.	Negligible	Neutral (Not Significant)
	Disturbance of bed and banks	Moderate (Significant)	Follow mitigation proposed in CCoP. Limit riparian vegetation removal and replace where required. Inspection on completion of decommissioning.	Negligible	Neutral (Not Significant)