19. Road Drainage and the Water Environment

19.1. Introduction

19.1.1. Chapter 19 is the Road Drainage and the Water Environment (RDWE) chapter, presenting the Stage 3 Design Manual for Roads and Bridges (DMRB) assessment of the potential impacts of the Proposed Scheme on the surface water environment in respect of hydromorphology, water quality, surface water resources and flood risk. This chapter is supported by the following technical appendices in Volume 4:

- Appendix 19.1 Road Drainage and the Water Environment, Legislation, Policy and Guidance
- Appendix 19.2 Road Drainage and the Water Environment, Methodology
- Appendix 19.3 Road Drainage and the Water Environment, Baseline
- Appendix 19.4 Hydromorphology Assessment
- Appendix 19.5 Water Quality Assessment and
- Appendix 19.6 Flood Risk Assessment.

19.1.2. Figures 19.1 to 19.12 support this text and associated technical appendices, these are provided within Volume 3.

19.1.3. Chapter 11: Biodiversity should be read in conjunction with this chapter for biodiversity, specifically watercourse crossings. Chapter 12: Geology, Soils and Groundwater should be referred to in relation to groundwater receptors and potential impact and mitigation measures, including those relating to groundwater dependent terrestrial ecosystems.

19.2. Approach and Methods

19.2.1. The assessment of potential impacts has been carried out in accordance with the DMRB LA 113 Road drainage and the water environment standard (LA 113) and the Scotland National Application Annex, which sets out assessment criteria specific to DMRB projects carried out in Scotland.

19.2.2. The approach and methods were informed by relevant European Union (EU) and Scottish legislation, policy and guidance; a full list of which is provided in Volume 4, Appendix 19.1 Road Drainage and the Water Environment, Legislation, Policy and Guidance. This includes the Water Framework Directive (WFD), The Water Environment and Water Services (Scotland) Act 2003, and The Water Environment Controlled Activities Regulations 2011 (as amended).

19.2.3. Sources of information and a detailed methodology for hydromorphology, water quality and flood risk are presented in Volume 4, Appendix 19.2 Road Drainage and the Water Environment, Methodology and summarised below.

19.2.4. The Old Military Road (OMR) improvements are not considered within the operational phase of the project in terms of water quality and flood risk, given that this route will not be used for A83 traffic post-construction and has not been designed to meet DMRB standard specifications.

Study Area

19.2.5. The Study Area incorporates the hydrological catchments the Proposed Scheme is within; the Croe Water and Kinglas Water (which includes Loch Restil), shown on Volume 3, Figure 19.1 Water Framework Waterbodies.

19.2.6. Topography within the study area is heavily influenced by superficial deposits (alluviums and glacial tills) and underlain near-surface bedrock geology, principally schists with igneous intrusions. Land cover across the Study Area is predominantly rough grassland with areas of coniferous plantations; with soils dominated by peaty podzols.

19.2.7. The steep and unstable upper slopes of Glen Croe, with natural propensity for debris slide events has been a key characteristic which has influenced the assessment and design inputs of the RDWE disciplines.

Sources of Information

19.2.8. The sources used for the purposes of this assessment comprise a combination of online sources and findings from various site visits since December 2022. A full list of information sources are provided in Volume 4, Appendix 19.2 Road Drainage and the Water Environment Methodology and include:

- Scottish Environment Protection Agency (SEPA) baseline water environment data, Water Framework Classification data and rainfall data
- NatureScot information on designated and protected sites
- Flood Estimation Handbook (FEH) and National River Flow Archive (NFRA) data
- Historical flood data and OS mapping
- LiDAR, topographical surveys, unmanned aerial vehicle (UAV) digital terrain data and photogrammetry
- Argyll and Bute Councill (A&BC) data on private water supplies
- Past reports, photos and documents
- Site walkover findings, observations and photos

Methods of Baseline Data Collection

19.2.9. A desktop study was carried out to obtain and review publicly available and open-source data including OS mapping, British Geological Survey (BGS) superficial and bedrock geology data (GeoIndex), SEPA Flood Maps, NatureScot designated sites, Scotland's Environment and Scotland's Soils.

19.2.10. The desktop study was informed by data obtained through consultation requests submitted to statutory and non-statutory organisations and key stakeholders including A&BC, Loch Lomond & The Trossachs National Park Authority (LLTNPA), NatureScot, SEPA, Scottish Water and landowners.

19.2.11. Hydromorphological survey of watercourses affected by the Proposed Scheme obtained baseline information on the fluvial geomorphological nature and characteristics. Site visits were also undertaken by flood risk, river engineering and water quality disciplines to support the design and assessment process.

Consultation

19.2.12. The consultation and scoping process undertaken to inform the environmental impact assessment (EIA) scoping is described in Volume 2, Chapter 6 Consultation and Scoping; with responses from consultees provided in Volume 4, Appendix 6.1 Summary of Scoping Consultation Responses.

Sub-Topics Scoped Out of the Assessment

19.2.13. No RDWE items were scoped out. With potential impacts related to groundwater, including assessment of groundwater dependent terrestrial ecosystems, reported within Volume 2, Chapter 12, Geology, Soils and Groundwater.

Assessment Methodology

19.2.14. Assessment methodologies, including baseline receptor sensitivity, magnitude and significance criteria, are detailed in Volume 4, Appendix 19.2 Road Drainage and the Water Environment, Methodology, with further data also provided in Appendix 19.4 Hydromorphology Assessment, Appendix 19.5 Water Quality Assessment and Appendix 19.6 Flood Risk Assessment (all Volume 4).

Hydromorphology

19.2.15. The assessment of potential effects on hydromorphology includes all main watercourses hydrologically linked within 1km of the Proposed Scheme and has been carried out in accordance with DMRB LA 113, Appendix E – Hydromorphological Assessment and the Scotland National Application Annex.

19.2.16. Baseline information has been used to inform the design of the Proposed Scheme to maximise resilience from erosion, scour and sedimentation over its operational lifetime; whilst at the same time minimising potential impacts on the hydromorphological form and function of affected watercourses.

19.2.17. Specific hydromorphological sensitivity and impact magnitude criteria have been developed based on guidance provided in the DEFRA/EA R&D Report FD1914 Guidebook of Fluvial Geomorphology.

19.2.18. The hydromorphological assessment includes both desk-based investigations and field surveys to provide an understanding of watercourse character, dominant processes and likely impact. The desk-based assessment has applied available digital data, geographical information system (GIS) analysis, including detailed digital terrain model (DTM) data (derived from an Unmanned Aerial Vehicle (UAV) flown quarterly), to characterise the hydromorphological form and function of the affected watercourses and any recent channel change.

Surface Water Resources and Water Quality

19.2.19. The assessment of potential effects on surface water resources (including private water supplies) and water quality were informed by desk-based study to determine potential hydrological connectivity and risks. The assessments are cognisant of potential impacts and effects during construction and operation of the Proposed Scheme and consider construction pollution, pollution from routine runoff and pollution from accidental spillages.

19.2.20. The assessment of the operational routine runoff and accidental spillage effects on surface water quality were carried out in accordance with DMRB LA 113 methods. These are only applicable to the A83 operation, with the OMR improvements a temporary measure during construction of the A83 upgrade and not designed to comply with DMRB standard specifications.

Flood Risk

19.2.21. The assessment of potential impacts on flood risk involves the application of knowledge attained from site visits, hydrological analysis, modelling, flood risk mechanism analysis and sensitivity testing to reach an informed judgment of the flood risk to and from the Proposed Scheme.

19.2.22. Importance classification, impact magnitude and significance have been based on DMRB LA 101, LA 104 and LA 113 in addition to SEPA Flood Risk and Land Use Vulnerability Guidance.

Limitations of the Assessment

19.2.23. Limitations of the assessment of potential impacts on the water environment have been described in detail in Volume 4 Appendix 19.2 Methodology and referenced where appropriate within the technical appendices (Appendix 19.4 Hydromorphology, Appendix 19.5 Water Quality, Appendix 19.6 Flood Risk).

19.2.24. The key limitations include the uncertainties of the ground condition as the various stages of Ground Investigation (GI) are yet to be completed, which could affect the design. It should also be noted that the Beinn Luibhean hillside is a dynamic system which responds to fluvial flows, debris flows and landslide events. These events in terms of magnitude and frequency are difficult to predict, and therefore design for.

19.2.25. There are also limitations of the Highways England (now National Highways) Water Risk Assessment Tool (HEWRAT) assessments and the input data. There are also numerous uncertainties with regards to the hydrological estimation (factors such as small catchments not accurately defined by the Flood Estimation Handbook) and modelling (factors such as the resolution of the topographic data, the accuracy of surveys of hydraulic structures, the availability of data on past flooding and the limitations of the modelling software).

19.2.26. The above limitations are not considered to impair the assessment process, with sufficient data available and conservative assumptions applied for a robust and proportionate assessment.

19.3. Baseline Conditions

19.3.1. Baseline conditions in respect of hydromorphology, flood risk, surface water resources and water quality are detailed in full (Appendix 19.3) and are summarised below. The hydrological catchments, for overall context, are displayed on Volume 3, Figure 19.1, Water Framework Directive Waterbodies.

19.3.2. Sensitivity/importance criteria for all receptors are set out in Volume 4, Appendix 19.2, Road Drainage and the Water Environment, Methodology and the baseline character set out in Appendix 19.3 Road Drainage and the Water Environment, Baseline.

19.3.3. The assessment of potential impacts of the Proposed Scheme on the attributes of the surface water environment in this chapter comprises the following:

- Hydromorphology: the sensitivity of, and potential impacts upon, fluvial landforms associated with river systems, and the flow and sediment transport processes which create and sustain them.
- Surface Water Resources/ Supply: Potential impacts on the quality and quantity of surface water fed water supplies.
- Surface Water Quality: potential impacts on the quality of the water from construction and operational runoff of pollutants, including both acute impacts from soluble pollutants and chronic impacts from sediment related pollution and from spillage events.
- Flood Risk: potential risk of flooding from all sources to the Proposed Scheme or elsewhere as a result of the Proposed Scheme.

Hydromorphology

19.3.4. With regards to hydromorphology, 45 watercourse receptors have been identified as hydrologically connected to the Proposed Scheme within 1km, of these 41 pass beneath the A83 and/or OMR, with four beneath the B828. Of the 45 watercourses, 43 are in the Croe Water catchment (Glen Croe) and 2 in the Kinglas Water catchment.

19.3.5. Generally, the watercourse gradients are much steeper upslope of the existing A83 (~0.6 to 0.7m/m) and the gradients reduce as the watercourses approach the glen floor (~0.1 to 0.3m/m where the watercourses cross the OMR) and join the Croe Water (shown on Volume 3, Figure 19.2 Water Feature References). These watercourses are currently crossed by the A83, and existing pressures and artificial modifications are evident such as catch pits, culverts, drop chambers, and cascades with baffles which disrupt natural flows and sediment transfer processes.

There are 63 bridge and culvert structures identified as crossing the 45 watercourse receptors (some of which are crossed multiple times).

19.3.6. A baseline assessment of the potential for geomorphological adjustments in each of the 22 watercourses crossed by the A83 in Glen Croe was undertaken to identify those at greatest risk from scour or erosion and debris flow events. Using a combination of topographical assessment, photographic evidence, and a hillslope geomorphology reports, in which the hillslope was characterised as active, unstable, potentially unstable or marginally stable. The highest risk watercourses coincide with the locations of the proposed debris flow shelter (DFS) and debris flow protection wall where there is the greatest potential for debris flow and significant volumes of erodible, poorly consolidated, material.

19.3.7. Field data was collected to characterise the sediment found in the watercourses affected by the Proposed Scheme. More than 90% of the sediment recorded in each of the watercourses was <100mm in diameter.

19.3.8. Baseline conditions of the 45 identified watercourse receptors are assessed in detail within Volume 4, Appendix 19.3, Road Drainage and the Water Environment, Baseline.

Surface Water Resources and Water Quality

19.3.9. There are a total of 15 minor unnamed watercourses without a WFD classification; whilst there are two WFD classified waterbodies, the Croe Water (ID: 10215) and Kinglas Water (ID: 10217) are identified as having hydrological connectivity with the Proposed Scheme. The Croe Water is described as having ‘Moderate’ overall WFD status, whist the Kinglas Water is a heavily modified waterbody described as having ‘Poor’ ecological potential. Though Loch Restil, the standing body of freshwater at the northernmost end of the Proposed Scheme does not have a WFD classification, it is hydrologically important in sustaining blanket bog associated with the Beinn an Lochain Site of Special Scientific Interest (SSSI).

19.3.10. No public water supplies were identified within the extent of the Study Area; whilst one surface water sourced PWS is identified. Associated with a property at the head of Glen Croe, the PWS is sourced from the southwestern slope of Beinn Luibhean, below the existing A83.

19.3.11. Baseline conditions of identified surface water resources and water quality receptors are assessed in Volume 4, Appendix 19.5, Water Quality Assessment.

Flood Risk

19.3.12. The baseline provided detail on the two areas of interest for the Flood Risk Assessment (FRA); the small hillside watercourses and the High Glen Croe tributary / Croe Water as they flow along the valley floor.

19.3.13. The small watercourses are characterised by the steep terrain with little attenuation on the hillside. Montane scrub vegetation dominates the hillside which provide minimal resistance to slow water pathways. Various incised channels cut vertically through the hillside towards the existing A83, some of which are ephemeral. Whilst the channels do provide flow paths, with velocities that are typically high and shallow depth, the open nature of the hillside is also conducive to sheet flow outwith channel dimensions. Whilst SEPA surface water flood maps do not highlight flood risk on these eastern slopes of Glen Croe, historic events highlight the mixed nature of surface water flooding. With evidence of both flooding from existing channels and events relating to overland flow directly from the hillside cascading onto the road. The baseline 1D modelling emphasised the controlling factor on velocities being the steep terrain downstream of the road.

19.3.14. The Croe Water flows from the eastern slope of Glen Croe to then meander along the base of Glen Croe. Glen Croe is flat and wide at the upstream extent, however the High Glen Croe tributary that flows through upper Glen Croe and its respective floodplain remains relatively narrow, this channel has a confluence with the Croe Water at the valley floor (NGR NN 2390 0592). With the Croe Water flowing approximately south towards Ardgartan, on Loch Long (sea loch). Consultation from SEPA and Argyll and Bute Council provided no records of flooding from the High Glen Croe tributary / Croe Water. The SEPA flood map extents begin upstream of the confluence of the High Glen Croe tributary and the Croe Water, continuing to the channel mouth at Loch Long.

19.3.15. The baseline site-specific model flood maps aligned with SEPA flood mapping and allowed for the identification of flood receptors and their current risk. Nine receptors are within the 0.5% Annual Exceedance Period (AEP) plus climate change extent. These include residential dwellings, agricultural structures, the OMR and A83. Receptor details are provided in Volume 4, Appendix 19.6 Flood Risk Assessment.

19.3.16. The current road drainage is designed to efficiently remove water from the A83 and OMR carriageway corridors, passing flows downslope, with no planned attenuation.

19.3.17. Baseline conditions of identified flood risk receptors are included in Volume 4, Appendix 19.6, Flood Risk Assessment.

Future Baseline

19.3.18. In respect of hydromorphology, the hillside is a dynamic system which responds to fluvial flows, debris flows and landslide events. These events will continue, and with climate change may occur more frequently. These events can bring significant changes to the depth and widths of the channels, but historically, over time, the watercourses/hydromorphological processes have stabilised to step-pool/cascade morphology which is to be expected on these steep slopes. The greatest changes to the baseline would be from any future engineered interventions required following debris flow events to restore the integrity of the A83 in alignment with the watercourses.

19.3.19. In respect of surface water resources and water quality, and on the basis that the Proposed Scheme does not proceed to construction, there shall continue to be untreated runoff discharging to the local slopes and ultimately into the water environment. Any increase in the volume of traffic could increase in the overall pollutant load/concentration in surface runoff. Conversely, anticipated climatic changes with predicted increases in volume and intensity of precipitation, is likely to increase surface runoff leading to higher flows, increase buffering and dilution capacity of receiving waterbodies.

19.3.20. It is predicted that the OMR diversionary route will continue to be routinely used for A83 traffic, with climate change impacts to rainfall likely to require this route to be opened on more frequent occasions, with associated untreated routine runoff or accidental spillages from the OMR discharging to local surface waters, matching the future baseline for the A83.

19.3.21. In respect of flood risk, it is reasonably anticipated that the future baseline scenario from climate change predictions will involve larger events occurring more frequently. The current road drainage directs runoff to hillside and local surface channels, without attenuation. Furthermore, larger, more intense pluvial events could also exacerbate flooding.

19.4. Embedded Mitigation

19.4.1. This section details RDWE measures considered as embedded, with Section 19.6 detailing RDWE specific mitigation.

19.4.2. Embedded mitigation measures have either been incorporated into the design of the Proposed Scheme (refer to Chapter 4: The Proposed Scheme) or are regulatory requirements to address potential adverse impacts, as summarised in Table 19.1.

19.4.3. Hydromorphologists worked within the design team, alongside river engineers, flood modellers and geotechnical specialists to develop a design that during operation, protects the critical infrastructure, is viable to construct and minimises impact to the water environment.

19.4.3.1. The Proposed Scheme drainage design incorporates sustainable drainage systems (SuDS) for the treatment of surface runoff from the carriageway prior to discharging back to the water environment (Volume 4, Appendix 19.5, Water Quality Assessment). This includes the provision of measures such as over-the-kerb filter drains and SuDS detention basins to promote settlement of suspended solids and removal of sediment-bound pollutants. Outwith the extent of the DFS, drainage channels will be upsized to 1% AEP plus climate change and provide additional capacity. In addition to the above, introduced SuDS features on the A83 shall offer further attenuation prior to discharge, including a detention basin on Network 1 (designed for 0.5% AEP plus climate change). As there is no existing formalised treatment of surface runoff, the Proposed Scheme drainage design represents betterment when compared with the baseline scenario.

19.4.4. In respect of flood risk, the following embedded mitigation measures have been incorporated within the design of the Proposed Scheme. The DFS catch pit will capture all overland flows and pass below the A83 in upsized culverts. A83 culverts have all been designed to accommodate the 0.5% AEP plus climate change flows with an additional allowance for freeboard. OMR improvements include culvert upgrades to 2% AEP, with a lower standard applied due to the temporary use of this route during A83 works. Resilience has been added however through upsizing to accommodate the Q50 (2% AEP) event plus free board.

19.4.5. Enhancement of the Croe Water (riparian zone) is proposed as part of the Biodiversity Net Gain (BNG) strategy (Volume 4, Appendix 4.1, Biodiversity Net Gain/Natural Capital Assessment). This includes fencing and planting alongside the Croe Water to create buffer areas and reduce fine sediment and nutrient supply to the watercourse as well as shading and sheltering. This would improve water quality, hydromorphology and biological quality elements in this more sensitive area which would help towards achieving Water Framework Directive objectives and offset some of the modifications in the headwaters, in the less ecologically sensitive watercourses.

Table 19.1 - Embedded Mitigation Measures

Mitigation Reference	Phase	Mitigation Measures
RDWE-EMB-01	Design	To ensure the continuity of hydrological and sediment flows from upstream to downstream of the A83 as well as the long-term resilience of the downstream watercourses, the following measures have been incorporated into the design of the catch pit and associated culverts and downstream watercourses: • catch pit to have longitudinal and lateral gradient (both 5%); • culvert inlet of the A83 crossing positioned away from the back face of the rock cut to minimise blockage and damage; • culvert inlet grate to allow sediment <100mm to be transferred downstream; • culvert drop-chamber to be angled to reduce deposition/accumulation of sediment; • low flow channel within the culvert to promote movement of sediment through the structure and reduce the need for maintenance; • dissipation measures within the open channel to slow the flow; • transition structures to accommodate vertical misalignments; • dissipation pools and bank and bed protection at the transition to minimise scour; • bank reprofiling to promote (geotechnical) stability; and • fencing to prevent livestock and encourage hillside vegetation growth.
RDWE-EMB-02	Design	Small informal catch pit upstream of OMR crossings where sediment deposition and potential blockage assessed as a higher risk.
RDWE-EMB-03	Design	The Appointed Contractor will comply with the requirements of the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (also known as the CAR Regulations) in relation to water features which require engineering work and construction activities, particularly in relation to sediment management and fuel/hydrocarbon control. The Appointed Contractor shall develop designs and detailed method statements for planned work activities and installations including bank reinforcement, outfalls, watercourse crossing structures, in-channel works, concrete application, watercourse diversions/realignments and SuDS. Any disposal to sewer will require approval from Scottish Water. These shall incorporate mitigation measures in accordance with good practice from including SEPA WAT-RM-08 / WAT-SG-29 / WAT-SG-75 / general pollution guidance / pollution prevention guidelines and CIRIA C532. The Appointed Contractor will be encouraged to minimise environmental effects and seek opportunities for enhancement, plus undertaking prompt remedial actions, as applicable. These methods shall be subject to pre-construction approval from SEPA and development of such will be a contractual requirement, including obtaining necessary consent for construction water runoff (SEPA Application - Form N). Appropriate specialists, including drainage engineers and hydromorphologists, should be involved in design and site supervision to optimise these key activities. Works within or adjacent to water features may require a CAR licence, registration or compliance with the General Binding Rules (GBR). Where required, a CAR application would be made to SEPA and this would include detailed information on the proposed activity, the potential impacts to the water environment, mitigation measures included in the design and a detailed construction methodology for all engineering activities.

Mitigation Reference	Phase	Mitigation Measures
RDWE-EMB-04	Construction	In relation to flood risk, the Appointed Contractor will develop a Flood Response Plan (as part of the CEMP) including measures to be implemented when working within the functional floodplain (defined here as the 0.5 % AEP (200-year) flood extent. This shall include weather forecast reviews, preventative actions, remedial actions and temporary drainage strategies.
RDWE-EMB-05	Design / Construction	In relation to service diversions and to avoid damage to existing services from excavations and ground penetration, including temporary severance of private water supplies through damage to infrastructure, the Appointed Contractor will: • locate and map all private water supply assets and other service infrastructure prior to construction; • take measures to prevent damage to services and to avoid pollution during service diversions, excavations and ground works; and • provide a temporary alternative water supply (e.g. bottled or tankered) if services are to be disrupted or diverted by the works.
RDWE-EMB-06	Design / Construction	For works within areas identified as potentially containing contaminated land following further GI or during construction, the Appointed Contractor will reduce the risk of surface water pollution to an acceptably low level through further site investigation to determine the level of contamination prior to proceeding. They shall also install temporary treatment facilities or other methods to avoid polluting the water environment. Potential contamination shall be raised with SEPA at earliest opportunity, with further actions agreed.

19.5. Potential Impacts

19.5.1. This section summarises the assessment of potential impacts, applying embedded mitigation identified, on water environment receptors, resulting from the construction and operation of the Proposed Scheme in respect of hydromorphology, surface water resources, water quality and flood risk.

19.5.2. Volume 3, Figure 19.3, The Proposed Scheme and Watercourses identifies key features of the Proposed Scheme and local watercourse features. Reference should also be made to the respective technical appendices, where the assessments are described in detail and results are reported in full, with further figures referenced:

- Volume 4, Appendix 19.4 Hydromorphology Assessment
- Volume 4, Appendix 19.5 Water Quality Assessment and
- Volume 4, Appendix 19.6 Flood Risk Assessment.

Construction

19.5.3. Impacts resulting from construction of the Proposed Scheme are ordinarily temporary (acute) in nature but can have longer-term (chronic) effects on the hydromorphology, water quality and flood risk; and in turn, effects on the overall ecological health and potential of the watercourses.

19.5.4. It is recognised that the watercourses in this area, particularly in the Croe Water hydrological catchment, are currently adversely impacted by physical modifications and maintenance regimes (e.g. A83 culverts, OMR culverts, sediment trapping and clearance), but the scale of the works to ensure that the A83 is appropriately protected are extensive and would further interrupt the flow and sediment regimes of these watercourses.

19.5.5. Construction activities are likely to include site clearance, demolition, rock excavation by mechanical and potentially blasting/expansion techniques, piling, soil stripping, earthworks excavation and dewatering, which all have a detrimental impact if sediment loading is increased in watercourses. The steep slopes and associated 'flashy' (rapid) hydrological response may lead to surface runoff, slope erosion and entrainment of sediment, leading to siltation of nearby watercourses.

19.5.6. To build the watercourse crossing structures below the DFS and the OMR improvements there will be a requirement for temporary diversions or convergence of watercourses and/or over pumping during the construction phase. There may be temporary disruption to flows and sediment downstream if the watercourses are temporarily conveyed through pipes (gravity fed or pumped). Temporary bunds may be required to pond the water at the upstream end (e.g. use of sandbags to pool the water).

19.5.7. Watercourse realignments and channel reprofiling is required on some of the watercourses between the A83 and OMR to stabilise the slopes to maximise the resilience of the OMR when in operation during construction of the A83 upgrade.

19.5.8. Localised surface water flood risk could be temporarily increased by the modifications to existing flow paths, however, temporary drainage systems and flood response plans will alleviate this. The flood risk assessment applied a precautionary approach to arrive at an informed decision, taking account of modelling of small watercourses, hillslope runoff, analysis of introduced design attenuation and the higher and lower credible limits of flow variation (+/- 5%), to evaluate potential impacts in the Croe Water hydrological catchment. The flood risk assessment outcome is largely determined by the presence of 'highly vulnerable' receptors (high sensitivity) in this catchment.

19.5.9. Potential effects during construction have been evaluated (summarised in Table 19.3), taking account of embedded mitigation.. A number of potentially significant adverse effects have been identified, these effects are fully detailed in Volume 4, Appendix 19.4, Hydromorphology Assessment (Section A19-4.3) and in Volume 4, Appendix 19.5, Water Quality Assessment (Section A19-5.6):

- Hydromorphology – major adverse effect on 11 medium sensitivity watercourses (tributary channels)
- Water Resources – moderate adverse effect on High Glen Croe PWS
- Water Quality – large adverse effect on Croe Water
- Water Quality – moderate adverse effect on tributaries of Croe Water and
- Water Quality – moderate adverse effect on Loch Restil.

19.5.10. Specific mitigation has been proposed, seeking to reduce these potentially significant levels, discussed in Section 19.6.

Operation

19.5.11. Operation of the Proposed Scheme would lead to impacts as a direct result of the measures required to protect critical infrastructure. Specialists (including qualified and experienced hydromorphologists, river engineers and flood modellers) have worked within the design team to develop a concept that protects the critical infrastructure, is viable to construct and that sought to minimise impact to the water environment. However, there are limitations as to what can be achieved due the challenging environment in which the Proposed Scheme is located.

19.5.12. When modelling the design elements, outlined in Section 19.4, the velocity of the hydrological flows can be reduced at the A83 crossings. However, the steep slopes immediately downstream together with the channel topography mean that the potential velocities remain high (>5m/s). The effect of the steep slope dominates the behaviour of the flow and any measures introduced to reduce the velocities through the culvert and immediately downstream are dampened within a very short distance. The transition from the engineered measures to the natural channel provides particular technical challenges.

19.5.13. In addition, the introduction of larger catch pits and culverts, with lower gradients than the natural slopes, mean there is the potential for sediment accumulation within these features. Most of the headwater streams that currently cross the Proposed Scheme site feed into the Croe Water. The Croe Water is a hydromorphologically diverse and ecologically sensitive watercourse and WFD waterbody and will be impacted directly and indirectly. A slight adverse effect to the supply of Croe Water sediment, due to the DFS inlets being grated with 100mm spacings (with substantially more than 90% of all sediment sampled in the tributaries passing as <100mm in diameter).

19.5.14. Furthermore, with the introduction of SuDS measures, applying filter drains and a SuDS detention basin, further sediment accumulation is likely within these features, which would require long-term period maintenance to preserve the functionality and efficiency of those features e.g. removal and replacement of filter media and removal of sediment accumulation from within the SuDS basin.

19.5.15. The flood risk assessment for the operational phase applied a precautionary approach, with a range of factors incorporated in the evaluation process.

19.5.16. Potential effects during operation have been evaluated (summarised in Table 19.4), with most assessed as not significant, taking account of embedded mitigation and good practice. However, a number of potentially significant adverse effects have been identified, these are detailed in Volume 4, Appendix 19.4, Hydromorphology Assessment (Section A19-4.4). As for construction, specific mitigation has been proposed, seeking to reduce these levels, discussed in Section 19.6:

- Hydromorphology – large adverse effect on eight medium sensitivity watercourses (tributary channels) and
- Hydromorphology – moderate adverse effect on five medium sensitivity watercourses (tributary channels).

19.5.17. Beneficial effects to water quality have been identified at the operational phase, following SuDS installation on the A83, with a moderate beneficial (significant) effect identified for water quality on the Croe Water. This is detailed in Volume 4, Appendix 19.5, Water Quality Assessment (Section A19-5.6).

19.6. Specific Mitigation

19.6.1. Mitigation to avoid, minimise, restore or offset potential impacts is a key consideration at all life-stages of a project including throughout design, construction and operation.

19.6.2. Specific mitigation measures (RDWE1 to 8) have been identified in Table 19.2 to address potentially significant impacts on receptors, beyond the embedded mitigation measures previously outlined (Section 19.4)

19.6.3. Standard construction mitigation measures would be included in the construction environmental management plan (CEMP), with associated pollution incident control and flood response plans to address risks to the water environment (including to hydromorphology, water quality, surface water resources and flood risk) during construction. Measures to address issues such as sediment becoming mobilised in construction water runoff, spillages associated with chemicals and fuels and planning for flood events within a construction zone would be included. These types of mitigation are considered good practice and a basic requirement for development to proceed.

19.6.4. The CEMP is also typically used to discharge planning conditions and legal obligations including construction runoff permits (CRP) - formerly referred to as a construction site licences (CSL) and controlled activities regulations (CAR) consent for engineering activities in the water environment, both regulated by SEPA.

Table 19.2 - Mitigation Measures

Mitigation Reference	Phase	Mitigation Measures
RDWE1	Operation	In relation to inspection and maintenance regimes, there will be frequent inspections and clearance of the catch pit to minimise the risk of blockage and accumulation of flow to the southerly most culvert. Maintenance to clear the culverts from sediment, should this be necessary, will also be conducted Adaptive management of the watercourses will also be undertaken, as and when is necessary. Channels inherently change, and continually adapt to their conditions, a maintenance and management strategy should be developed to protect the critical infrastructure but with consideration for the hydromorphological functioning. Ultimately, working with natural processes, reduces the need for maintenance. A sediment management plan will form part of the maintenance plan.
RDWE2	Design/ Construction	In relation to downslope protection of the A83 culverts, where required, minimise the extent of concrete cascades and/or bed and bank reinforcement, allowing the channel to naturally adjust to geomorphologically effective flows. Where possible, smooth the transition between hard engineered features (concrete cascade and/or bed and bank reinforcement) and the natural channel with boulders (e.g. creation of step-pool features), to gradually naturalise to the unprotected channel.
RDWE3	Operation	In relation to allowing the watercourses and slopes to naturally protect themselves by fencing of the watercourses to prevent livestock access and promote vegetation growth, and in turn, stability. Utilise coir matting and seeding or planting of native shrubs to accelerate hillside stability.

Mitigation Reference	Phase	Mitigation Measures
RDWE4	Construction	In relation to PWS, where an existing PWS is likely to be disrupted in terms of potential impact to water quality or yield during the operational phase, the Appointed Contractor shall suggest alternative PWS solutions in consultation with the owners/users, to be installed ahead of operation (this may be installed as a pre-construction arrangement, to minimise PWS disruption across both phases).

Mitigation Reference	Phase	Mitigation Measures
RDWE5	Construction	For sediment control, the following supplementary measures to embedded mitigation are proposed. Procedures and measures will form part of a Construction Environmental Management Plan (CEMP): • suspend construction works during periods of elevated debris flow risk in all areas that have to potential to be impacted by such flow events; • agree regulatory expectations of thresholds for total suspended solids (TSS) as a maximum sediment level allowable for discharge to surface waters, furthermore, consideration of threshold levels for in-channel sediment levels taking account of baseline conditions (i.e. sediment uplift) • temporary interception, upstream of the construction zone, with over-pumping and diversion to adjacent watercourse(s) will reduce the incoming flows from hillslopes and channels. Channel flows would be reinstated following completion of local works including downstream scour and bank protection; • construction of temporary settlement basins, where topography and earthwork programming allow, to provide retention of runoff from disturbed areas prior to entering watercourse channels, these shall not be positioned within areas susceptible to flood risk, avoiding 0.5% Annual Exceedance Period with climate change (0.5% AEP + CC) zones; • where settlement basins are not feasible, mechanical settlement devices shall be considered to enable treatment for local discharge. These portable devices would be deployed at appropriate locations to reduce construction sedimentation risk as the construction programme progresses; and • construction of other source control methods, such as sediment fences and straw bale filters (downslope of disturbed areas and stockpiles) as required.

Mitigation Reference	Phase	Mitigation Measures
RDWE6	Construction	To aid sediment control, pre-approval from SEPA shall be sought for application of coagulants and flocculants as a contingency measure to promptly aid settlement of suspended solids. In accordance with pre-requisite sediment conditions and methodologies; including chemical type, dosage level and location.
RDWE7	Construction	Given the challenging local conditions, sediment control directly within tributary channels may be appropriate as a further contingency measure, should excess sediment entrainment linked to construction activities occur or be predicted. Ongoing GI and detailed design inputs will inform this requirement, to supplement other sediment control measures. This shall involve the installation of temporary settlement ponds or other engineering interventions to tributaries of Croe Water. These would be positioned on slopes with shallower gradient. Offline features are preferable (adjacent to channel) but online (in-channel) features may also be required to reduce sediment load in minor channels prior to their confluence with the Croe Water. Pre-approval from SEPA for such interventions would enable site preparation ahead of requirement (preferred approach) or initiation of a prompt response, with associated design details provided, taking account of local channel characteristics and constraints (including groundwater level and with avoidance of flood risk 0.5% AEP + CC zones) to determine location, footprint, maintenance plan and reinstatement method.
RDWE8	Operation	In relation to sediment management during operation, should sediment and/or particulates require cleansing from the covered carriageway within the DFS, due to lack of washing effect from reduced precipitation, this will be collected directly from the road surface. This will reduce sediment and sediment-bound contaminants from entering drainage network 1, with associated improvement in water quality discharged to the Croe Water.

19.7. Residual Effects

19.7.1. Residual effects associated with the construction and operation of the Proposed Scheme, cognisant of all mitigation (embedded and specific), are summarised below. Individual assessment (hydromorphology, surface water resources and water quality, and flood risk) results are summarised in Table 19.3 (construction phase) and Table 19.4 (operational phase).

Hydromorphology

19.7.2. The construction of the road and associated resilience measures, including the catch pit and culverts, across the slopes of Glen Croe have the potential to significantly impact the continuity of hydrological and sediment flows from upstream to downstream of the A83 during its operational life. No additional, specific, construction phase mitigation has been identified for hydromorphology.

19.7.3. The magnitude of construction residual effects to 11 watercourses (each of which are tributaries of the Croe Water) are assessed as moderate adverse (significant), due to the intrusive nature of the works to build the DFS/debris flow protection wall and associated catch pit. Of the remaining 34 watercourses, the residual effects from construction are slight adverse (24) and neutral (10).

19.7.4. Specific mitigation to minimise the impact on watercourses, largely relating to the operational maintenance regime that will be adopted have been identified. This includes frequent inspections and clearance of the catch pit to minimise the risk of blockage and accumulation of flow to the most southerly culvert. Maintenance to clear the sediment from culverts, should this be necessary, will also be conducted, with frequency to be determined and depending upon accumulations at various locations from routine and extreme events.

19.7.5. During operation, eight watercourses (each of which are tributaries of the Croe Water) have been assessed as having residual moderate adverse (significant) effects, with other watercourses identified as slight adverse (13) and as neutral (23). One watercourse has been assessed with a residual slight beneficial effect during the operational phase due to the replacement of a culvert with a clear span bridge on the A83 alignment.

Surface Water Resources and Water Quality

19.7.6. With additional mitigation targeting sediment management, protecting water quality is considered to remain challenging on this complex construction site, with limited available space for standard settlement techniques and an escalating series of intervention measures identified.

19.7.7. Taking account of specific mitigation, including compliance with CEMP and additional sediment management measures, the magnitude of potential impacts to water quality on the Croe Water during construction is reduced to minor adverse, with the significance of residual effects reduced to moderate adverse (significant). The magnitude of residual impacts on the water quality of the tributaries of the Croe Water (medium sensitivity) during construction of the Proposed Scheme is reduced to moderate adverse, with the significance of residual effects remaining as moderate adverse (significant). The tributaries of the Kinglas Water and Loch Restil are considered to remain at minor adverse magnitude, with a slight adverse effect applied to both sets of receptors, representing activities undertaken in the less complex construction zone in this hydrological catchment.

19.7.8. It is considered that the operation of the Proposed Scheme and the provision of a permanent alternative PWS source for the High Glen Croe property would result in a beneficial impact on long-term water quality by removing linkage to runoff from the operational A83. As such, the magnitude of residual impacts on the High Glen Croe PWS during operation is assessed as moderate beneficial, with the significance assessed as moderate beneficial (significant).

19.7.9. In respect of routine runoff and accidental spillages from the A83 carriageway (with no specific mitigation identified, beyond the SuDS embedded in the design), the residual operational effects on all water features are unchanged.

Flood Risk

19.7.10. With no specific mitigation identified (beyond embedded measures), the residual construction and operational flood risk effects to receptors are unchanged.

Summary of Residual Significant Effects

19.7.11. Following application of specific mitigation, there are a number of residual adverse significant effects for construction (Table 19.3) and operation (Table 19.4), with details provided within Volume 4, Appendix 19.4, Hydromorphology Assessment (Section A19-4.6) and Volume 4, Appendix 19.5, Water Quality Assessment (Section A19-5.8).

19.7.12. Residual adverse construction effects will generally be temporary but impacts may extend beyond construction phase:

- Hydromorphology – moderate adverse effect on 11 medium sensitivity watercourses (tributary channels of Croe Water)
- Water Quality – moderate adverse effect on Croe Water and
- Water Quality – moderate adverse effect on tributaries of Croe Water.

19.7.13. For operation, there are both residual adverse and beneficial significant effects, which will generally be considered as long-term impacts:

- Hydromorphology – moderate adverse effect on eight medium sensitivity watercourses (tributary channels of Croe Water)
- Water Resources – moderate beneficial effect on High Glen Croe PWS and
- Water Quality – moderate beneficial effect on Croe Water.

19.7.14. Overall outcomes for RDWE are driven by assessments across all sub-disciplines, with the construction phase having a residual moderate adverse effect (significant). The overall outcome for the operation phase is more nuanced and considered as a residual slight adverse effect, with moderate adverse effects on the hydromorphology of a number of Croe Water tributaries offset by slight-moderate beneficial effects on water resources and water quality across all surface water receptors.

Table 19.3 - Construction Potential Impacts and Residual Effects

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Hydromorphology	1 x High sensitivity watercourse (Croe Water)	Moderate Adverse	Moderate Adverse	Risks of excessive fine sediment reaching watercourses will be managed as far as is practicable by the CEMP (RDWE5) and an escalating series of interventions (RDWE6, RDWE7)	Minor Adverse	Slight Adverse

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Hydromorphology	18 x Medium sensitivity watercourses	11 x Major Adverse 6 x Moderate Adverse 1 x No Change	11 x Large Adverse 6 x Moderate Adverse 1 x Neutral	Risks of excessive fine sediment reaching watercourses will be managed as far as is practicable by the CEMP (RDWE5) and an escalating series of interventions (RDWE6, RDWE7)	11 x Moderate Adverse 6 x Minor Adverse 1 x No Change	11 x Moderate Adverse 6 x Slight Adverse 1 x Neutral

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Hydromorphology	26 x Low sensitivity watercourses	7 x Major Adverse 10 x Moderate Adverse 9 x No Change	17 x Slight Adverse 9 x Neutral	Risks of excessive fine sediment reaching watercourses will be managed as far as is practicable by the CEMP (RDWE5) and an escalating series of interventions (RDWE6, RDWE7)	7 x Moderate Adverse 10 x Minor Adverse 9 x No Change	17 x Slight Adverse 9 x Neutral

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Surface Water Resources	High Glencroe PWS (Medium Sensitivity)	Moderate Adverse	Moderate Adverse	Disruption to PWS in terms of potential impact to water quality or yield will be avoided fully through additional mitigation (RDWE4)	Minor Beneficial	Slight Beneficial

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Water Quality	Croe Water (High Sensitivity)	Moderate Adverse	Large Adverse	Risks of excessive sediment reaching watercourses will be managed as far as is practicable by the CEMP (RDWE5) and additional mitigation measures (RDWE6)	Minor Adverse	Moderate Adverse

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Water Quality	Tributaries of Croe Water (Medium Sensitivity)	Major Adverse	Moderate Adverse	Risks of excessive fine sediment reaching watercourses will be managed as far as is practicable by the CEMP (RDWE5) and an escalating series of interventions (RDWE6, RDWE7)	Moderate Adverse	Moderate Adverse

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Water Quality	Tributaries of Kinglas Water (Medium Sensitivity)	Minor Adverse	Slight Adverse	Risks of excessive fine sediment reaching watercourses will be managed as far as is practicable by the CEMP (RDWE5) and an escalating series of interventions (RDWE6, RDWE7)	Minor Adverse	Slight Adverse

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Water Quality	Loch Restil (High Sensitivity)	Minor Adverse	Moderate Adverse	Risks of excessive fine sediment reaching watercourses will be managed as far as is practicable by the CEMP (RDWE5) and an escalating series of interventions (RDWE6, RDWE7)	Minor Adverse	Slight Adverse

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Flood Risk	1 x Most Vulnerable 12 x Highly Vulnerable 5 x Least Vulnerable 1 x Essential Infrastructure	Negligible	Slight Adverse	None	Negligible	Slight Adverse

Table 19.4 - Operational Potential Impacts and Residual Effects

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Hydromorphology	1 x High sensitivity watercourse (Croe Water)	Minor Adverse	Slight Adverse	Restricting livestock access to riparian areas and riparian planting, through additional mitigation (RDWE3) will improve the channel/bank stability.	Negligible	Slight Adverse

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Hydromorphology	18 x Medium sensitivity watercourses	8 x Major Adverse 5 x Moderate Adverse 3 x Minor Adverse 1 x No Change 1 x Minor Beneficial	8 x Large Adverse 5 x Moderate Adverse 3 x Slight Adverse 1 x Neutral 1 x Slight Beneficial	Risk of excessive watercourse and bank erosion will be reduced through regular inspection and maintenance (RDWE1) and additional mitigation to improve slope/channel resilience (RDWE2 RDWE3).	8 x Moderate Adverse 5 x Minor Adverse 3 x Negligible 1 x No Change 1 x Minor Beneficial	8 x Moderate Adverse 5 x Slight Adverse 4 x Neutral 1 x Slight Beneficial

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Hydromorphology	26 x Low sensitivity watercourses	2 x Major Adverse 5 x Moderate Adverse 10 x Minor Adverse 9 x No Change	2 x Slight Adverse 5 x Slight Adverse 10 x Neutral / Slight Adverse 9 x Neutral	Risk of excessive watercourse and bank erosion will be reduced through regular inspection and maintenance (RDWE1) and additional mitigation to improve slope/channel resilience (RDWE2 RDWE3).	2 x Moderate Adverse 5 x Minor Adverse 10 x Negligible 9 x No Change	7 x Slight Adverse 19 x Neutral

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Surface Water Resources	High Glen Croe PWS (Medium Sensitivity)	Moderate Adverse	Slight Adverse	Disruption to PWS in terms of potential impact to water quality or yield will be avoided fully through additional mitigation (RDWE4)	Moderate Beneficial	Moderate Beneficial

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Water Quality - Routine Runoff	Croe Water (High Sensitivity)	Moderate Beneficial	Moderate Beneficial	The risk of sediment and sediment-bound contaminants from entering drainage network will be reduced through additional mitigation (RDWE8)	Moderate Beneficial	Moderate Beneficial

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Water Quality - Routine Runoff	Tributaries of Croe Water (Medium Sensitivity)	Minor Beneficial	Slight Beneficial	The risk of sediment and sediment-bound contaminants from entering drainage network will be reduced through additional mitigation (RDWE8)	Minor Beneficial	Slight Beneficial

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Water Quality - Routine Runoff	Tributaries of Kinglas Water (Medium Sensitivity)	Minor Beneficial	Slight Beneficial	None	Minor Beneficial	Slight Beneficial
Water Quality - Routine Runoff	Loch Restil (High Sensitivity)	Minor Beneficial	Slight Beneficial	None	Minor Beneficial	Slight Beneficial
Water Quality - Accidental Spillages	Croe Water (High Sensitivity)	Minor Beneficial	Slight Beneficial	None	Minor Beneficial	Slight Beneficial

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Water Quality - Accidental Spillages	Tributaries of Croe Water (Medium Sensitivity)	Minor Beneficial	Slight Beneficial	None	Minor Beneficial	Slight Beneficial
Water Quality - Accidental Spillages	Tributaries of Kinglas Water (Medium Sensitivity)	Minor Beneficial	Slight Beneficial	None	Minor Beneficial	Slight Beneficial
Water Quality - Accidental Spillages	Loch Restil (High Sensitivity)	Minor Beneficial	Slight Beneficial	None	Minor Beneficial	Slight Beneficial

Topic	Receptor Reference	Potential Effects - Magnitude	Potential Effects - Significance	Mitigation Measures (Beyond Embedded)	Residual Effects (Post-Mitigation) - Magnitude	Residual Effects (Post-Mitigation) - Significance
Flood Risk	1 x Most Vulnerable 12 x Highly Vulnerable 5 x Least Vulnerable 1 x Essential Infrastructure	Negligible	Slight Adverse	None	Negligible	Slight Adverse

Monitoring of Residual Significant Effects

19.7.15. Prior to construction, a monitoring strategy shall be fully developed in relation to residual significant effects predicted for hydromorphology and water quality. These shall identify key measures and locations where adverse effects may be manifested, with adaptive monitoring to react to any additional concerns that become evident. Specific watercourses shall have locations selected, where baseline conditions shall be monitored against levels of change.

19.7.16. Water quality monitoring shall employ the use of portable meters and sample collection for laboratory analysis, recording results for parameters including total suspended solids, turbidity, petroleum hydrocarbons, total dissolved solids and pH. The locations and frequency of monitoring shall be agreed with regulatory bodies, at no less than a monthly frequency.

19.7.17. Adaptive management of the watercourses will also be undertaken, as and when necessary. Channels inherently change, and continually adapt to their conditions; a maintenance and management strategy shall be developed to protect the critical infrastructure but with consideration for the hydromorphological functioning.

19.7.18. The monitoring outcomes shall be linked to the ECoW role within the CEMP, with appropriate and prompt actions enacted to reduce suspected causes of adverse effect (e.g. upstream work activities and/or sediment release).

19.7.19. Visual observations shall supplement routine data collection and may trigger additional monitoring and/or site action. Consideration shall be given to the application of UAV (drones) to regularly document watercourse features, changing erosion/deposition features and map sediment movement in the Croe Water, plus assist in pollution incident investigations, such as tracing sediment plume sources.

19.7.20. Monitoring outcomes shall be reported as part of standard environmental performance management, incorporating lessons learned from the Proposed Scheme and other projects to seek continuous improvements.

Compliance with Planning Policy

19.7.21. Taking embedded and additional mitigation into account, the Proposed Scheme complies with relevant policy relating to the water environment, as set out in Appendix 19.1 Road Drainage and the Water Environment, Legislation, Policy and Guidance. Potential impacts have been minimised through design. While there will be slight adverse effect to the supply of Croe Water sediment, the inclusion of enhancement areas means that the Proposed Scheme will result in enhancement of the Croe Water and a reduction in downstream flood risk due to increased riparian planting. Additionally, there will be a beneficial impact on long-term water quality by removing linkage to runoff from the operational A83.