Cambushinnie Haul Track: Flood Risk Assessment

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Scottish and Southern Electricity Networks
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Cambushinnie Haul Track
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1. Introduction

Scottish and Southern Electricity Networks (SSEN) have commissioned Jacobs UK Ltd. to carry out a Flood Risk Assessment (FRA) to support a planning application for construction of a haul track (the Proposed Development) associated with a new 400kV substation at Cambushinnie. The Proposed Development is situated on land 360 metres (m) north of Glassick Farm, Braco, Dunblane, FK15 9QZ.

1.1 Aims and Objectives

The aim of the FRA is to outline the potential for the Proposed Development to be impacted by flooding; the impacts of the Proposed Development on flooding in the vicinity of the Proposed Development; and the proposed measures which are incorporated into the design of the Proposed Development to mitigate any identified risks.

To achieve this aim, the following objectives have been met:

- Reviewed available information in the public domain from various websites (Scottish Environment Protection Agency (SEPA) Flood Maps, British Geological Survey (BGS), Scottish Government and Scotland's Soils).
- Undertaken a qualitative and quantitative assessment of flood risk from all sources to and arising from the Proposed Development for the construction and operational phases accounting for all information available; and
- Where necessary, identified measures to mitigate for flood risk to and arising from the Proposed Development, including preparation of a surface water drainage strategy to comply with local policy and regulatory requirements.

1.2 Structure

The FRA is structured as follows:

- Section 2 presents a review of both local and national policies relevant to the assessment of flood risk.
- Section 3 describes the setting of the site in relation to the Proposed Development.
- Section 4 presents information on flood risk to the Proposed Development and how flood risk may change in the surrounding area as a result of the Proposed Development.
- Section 5 provides some general guidance to be considered during the construction and operational phases.
- Section 6 presents a summary of the assessment and outlines its key findings.

2. Planning Policy Context

2.1 National Planning Policy

2.1.1 National Planning Framework 4

National Planning Framework 4 (NPF4) is Scotland's national spatial strategy, which was introduced in February 2023 (Scottish Government, 2023). NPF4 supersedes National Planning Framework 3 and Scottish Planning Policy.

Flood risk is addressed in Policy 22 of NPF4. There are several factors in determining the suitability of development proposals, as outlined below:

- The development proposal is essential for operational reasons in its location and has water compatible uses.
- Local Development Plans (LDPs) have identified positive use for development or redevelopment proposals and there is guaranteed long-term safety and resilience based on relevant SEPA advice.
- An existing or proposed flood protection scheme is in place.
- All risks of flooding are understood and addressed and there is no reduction in flood plain capacity, or an increase in flood risk for other areas.
- The development remains safe and operational during a flood, where flood resistant and flood resilient materials and construction methods are used.
- Development proposals must not increase the risk of surface water flooding to others.
- Sustainable urban drainage systems (SuDS) should be in place to manage rain and surface water.

Blue and green infrastructure is addressed in Policy 20 of NPF4. Policy 20 outlines several factors of blue and green infrastructure to determine suitability including the following:

- LDPs should cover multiple functions and benefits of blue and green infrastructure, with a spatial strategy that identifies and protects the infrastructure assets and networks.
- LDPs should encourage the permanent or temporary use of unused or under-used land as green infrastructure. They should also safeguard access rights and core paths, including active travel routes and encourage new and enhanced opportunities for access linked to wider networks.
- Development proposals that could result in loss or fragmentation of existing blue and green infrastructure should only be supported where it can be proved that the development will not cause a deficit in blue or green infrastructure provision, and the overall integrity of the network will be maintained.
- Development proposals shall be supported for incorporating or creating new or enhanced blue and/or green infrastructure.
- Development proposals in regional and country parks will be supported only where they are proved to be compatible with the uses, natural habitats and character of the park.
- Development proposals that include new or enhanced blue and/or green infrastructure will provide effective management and maintenance plans covering the funding arrangements for their long-term delivery and upkeep, and the party or parties responsible for these.
- NPF4 defines a flood risk area for the purposes of planning to be an area at risk of flooding with an annual probability of greater than 0.5%, which must include an appropriate allowance for future climate change. Where the risk of flooding is less than this threshold, areas will not be considered 'at risk of flooding' for planning purposes. This does not mean that there is no risk at all, but that the risk is sufficiently low to be acceptable for the purposes of planning.

2.1.2 SEPA - Technical Flood Risk Guidance for Stakeholders, 2022

SEPA's Technical Flood Risk Guidance for Stakeholders (SEPA, 2022a) states that a precautionary approach should be applied to the completion of FRAs and outlines the information required within an FRA. As a minimum, an FRA should include:

- The likelihood of flooding in the designated area of study, including flood risk from all possible sources.
- Detailed plans (including topographic information), cross-sections and photographs of the specific site.
- An assessment of future climate change.
- Details of any structures that could influence local hydraulics, such as culverts.
- The flood extent for appropriate return periods indicated on a site plan.
- Details of any mitigation measures proposed.

2.1.3 SEPA – Flood Risk and Land Use Vulnerability Guidance, 2024

SEPA's Flood Risk and Land Use Vulnerability Guidance (SEPA, 2024a) describes vulnerability in a flooding context and provides guidance to support applications for the exceptions outlined in Policy 22 of NPF4, namely:

- Essential infrastructure where the location is required for operational reasons.
- Water compatible uses.
- Redevelopment of an existing building or site for an equal or less vulnerable use.

SEPA has five types of land use vulnerability classifications in relation to flooding (SEPA, 2024a). These five categories are:

1. Most vulnerable uses
2. Highly vulnerable uses
3. Least vulnerable uses
4. Essential infrastructure
5. Water compatible uses

Whilst the Proposed Development (i.e. construction of a haul track) is not considered as essential infrastructure its purpose is to facilitate access requirements associated with the development of an electricity substation.

2.1.4 SEPA - Development Management Guidance: Flood Risk, 2018

Within SEPA's Development Plan Guidance: Flood Risk (SEPA, 2018), SEPA states that an FRA is required for all developments at risk of any type of flooding in medium to high risk areas, and for essential infrastructure developments within low to medium risk areas.

2.1.5 SEPA – Flood Risk Standing Advice for Planning Authorities and Developers, 2024

The SEPA Flood Risk Standing Advice (SEPA, 2024b) provides advice for developments at risk of flooding or within a flood risk area. It gives the following advice for building essential infrastructure in flood risk areas:

- The infrastructure must remain operational during floods and not impede water flow.
- Safe and flood-free access and egress should be provided, where possible, for people of all mobilities.
- Finished floor levels (or formation levels) should be set 600mm above the design flood level to provide an allowance for freeboard.
- An allowance for climate change should be included within design flood levels calculation, of which SEPA guidance specifies.
- Designs should be flood resistant or resilient depending on the characteristics of the design flood.
- A minimum riparian corridor width of 10 to 30m from bank top along both banks of all watercourses dependent on channel width.

2.1.6 River Basin Management Plan for Scotland 2021-2027

The River Basin Management Plan (RBMP) for Scotland 2021-2027 (SEPA, 2021) outlines the framework for protecting and improving the benefits provided by the water environment across Scotland. The RBMP sets out actions for improvement, including in relation to sustainable and resilient rural land use and management. One of the ways in which SEPA intend to support this objective is through the application of a spatial approach to identify opportunity areas for intervention and inform decision making. This will include the use of flood risk data to assess opportunities for development in rural areas.

2.2 Local Planning Policy

2.2.1 Perth and Kinross Local Development Plan 2019

The Perth and Kinross Council (PKC) Local Development Plan 2 (LDP2) (PKC, 2019) was adopted in November 2019 and guides all future development and use of land in the PKC Area. It sets out the policies and proposals which the council wishes to use to guide development across the PKC Council Area up to 2029 and beyond.

Policy 52 for new development and flooding includes the following:

- Category 1: Medium to High Flood Risk – A flood risk assessment should be undertaken in accordance with the Flood Risk and Flood Risk Supplementary Guidance where an additional Drainage Impact Assessment is usually required.
- Category 1: Medium to High Flood Risk – No homes or premises should be occupied before flood protection measures are complete and operational.
- Category 2: Low to Medium Flood Risk – Suitable for most forms of development but should still be subject to a Flood Risk Assessment in accordance with the Flood Risk and Flood Risk Supplementary Guidance. Flood resilient materials and construction methods are encouraged in areas where they are adjacent to medium and high-risk areas.
- Category 3: No Flood Risk: There is no need for flood related constraints on development.

Policy 53 for water environment and drainage includes the following:

- Policy 53A: Water Environment – Any development, no matter of location or scale, should protect the water environment in accordance with Water Framework Directive 2000/60/EC. If practical, development could even improve the water environment. Proposals for development which do not accord with the

Scotland River Basin Management Plan will not be permitted unless the development is judged by the Council to be of significant specified benefit to society and/or the wider environment.

- Policy 53B: Foul Drainage – Foul drainage from all developments within and close to settlements which have public sewerage systems will require connection to the public sewer. A private system could be permitted as long as it does not have an adverse effect on the natural environment and if it is a settlement with little or no public sewerage system.
- Policy 53C: Surface Water Drainage – All new development must employ sustainable urban drainage systems (SuDS) measures. Within the SuDS, measures must include relevant temporary measures at the construction phase. The SuDS should achieve multiple benefits including floodwater management, landscape and green infrastructure.
- Policy 53D: Reinstatement of Natural Watercourses - The council will not support development over an existing culvert or the culverting of watercourses as part of a new development unless there is not another practical alternative. Adequate access for maintenance must be provided where necessary. Existing culverts should be opened, and redundant water engineering structures removed whenever possible to benefit wildlife and improve amenity, and a suitable riparian buffer zone between development and the watercourse should be provided.
- Policy 53E: Water Supply – All new development must be served by a satisfactory mains or private water supply which comply with the Water (Scotland) Act 1980 and associated Private Water Regulations, without prejudicing existing users. The developer is responsible for the demonstration of the new supply’s suitability, and that it is safe to be consumed as drinking water.

2.2.2 Perth and Kinross Council Supplementary Guidance – Flood Risk and Flood Risk Assessments 2021

The adopted flood risk and flood risk assessment supplementary guidance (PKC, 2021) is intended to support the planning process in relation flooding and drainage, including when a flood risk assessment will be required and what the assessment should contain.

3. Proposed Development & Site Setting

3.1 Proposed Development

The Proposed Development will involve construction of a new haul track and consists of the following elements:

- The proposed haul track is approximately 1239m in length. The first 550m approximately from the junction with the A822, is proposed to have asphalt surfacing. The remainder of the haul track is proposed to have a Type 1 unbound surface;
- The carriageway cross-section of the haul track is typically 6.5m wide with 1-2m verges, in addition to associated earthworks;
- The proposed haul track will have junctions with the A822, B8033, an existing access track and the existing access track to Braco West Substation;
- A temporary bridge over the Keir Burn (which will be removed following completion of construction and commissioning works associated with the Cambushinnie 400kV substation (separate planning application));
- Temporary access control compound and vehicle wash station;
- Areas associated with drainage. Swales are proposed to accommodate over the edge drainage and pre-earthworks drainage for the haul track. As such, they are positioned on either side of the haul track for the majority of its length, typically at the toe of embankments.
- Areas associated with landscape/screening; and
- Temporary construction areas for laydown and welfare facilities.

Figure 3.1 provides an overview of the location of the Proposed Development.

Figure 3.1: Proposed Development Location Plan

3.2 Site Description

The Proposed Development site is predominantly located within an area of agricultural land, used for livestock grazing purposes. Immediately east of the existing access track to Braco West Substation, the site comprises of commercial forestry plantation dominated by replanted Sitka spruce.

The Proposed Development extends from the A822, in the east, to the B8033, in the west. It then continues from the B8033 to the existing access track to Braco West Substation. The B8033 runs between the village of Braco and Kinbuck.

3.2.1 Topography

SSEN commissioned APEM to undertake a LiDAR aerial survey of the floodplain area in June 2024. The lowest elevation of the haul track associated with the Proposed Development sits at approximately 107m above Ordnance Datum (AOD) at the haul track junction with the A822. The highest elevation in the immediate vicinity of the haul track is 132mAOD, located between the B8033 and the existing access track to Braco West Substation. The site topography is presented in Figure 3.2.

WSP undertook topographic surveys of the watercourses within the floodplain area in July 2024. The surveyed watercourses included the Allan Water, River Knaik, Keir Burn, Feddal Burn and an unnamed watercourse.

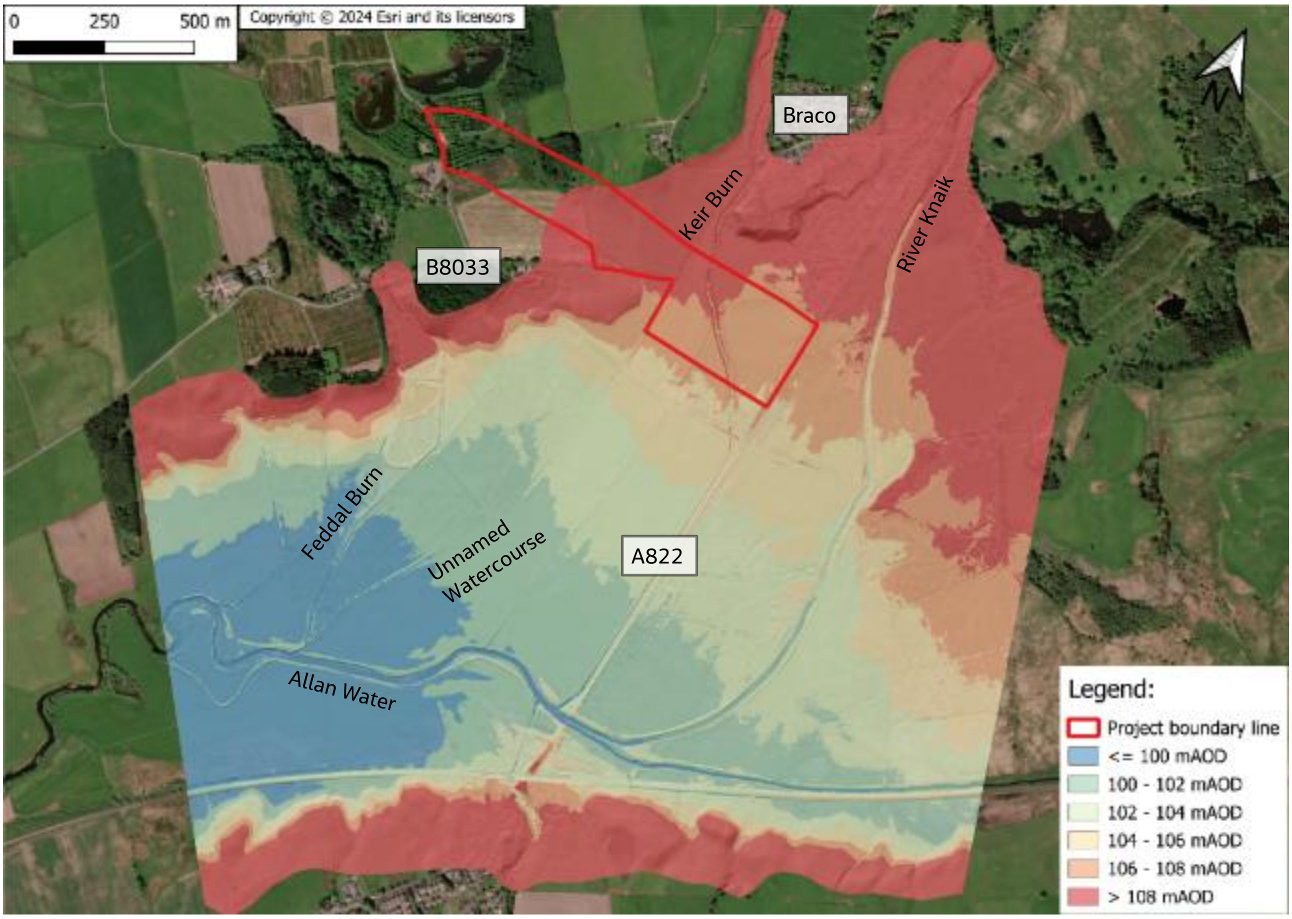

Figure 3.2: Site Topography

3.2.2 Hydrology

The Proposed Development boundary is located within the catchments of the Kier Burn (also referred to as Bullie Burn) and an unnamed tributary of the Allan Water. A summary of the various water bodies located within close proximity of the Proposed Development are outlined below:

- All of the Proposed Development to the west of the B8033, in addition to a small area to the south-east of the B8033, drains to an unnamed tributary of the Allan Water. The unnamed tributary generally flows south and then south-west before discharging into the Allan Water approximately 900m downstream of the A822.
- The Keir Burn is located to the east of the B8033 and drains the eastern area within the Proposed Development boundary. It flows southwards adjacent to Braco and passes beneath Feddal Road at the Bridge of Keir. To the south of Braco, the Keir Burn has been artificially straightened along much of the A822 before discharging into the Allan Water approximately 50m downstream of the A822.
- To the south, outwith the Proposed Development Boundary, some of the land is residual catchment of the Allan Water.
- The River Knaik is located outwith the Proposed Development boundary, to the east of the A822. It crosses to the east of the A822 at the Old Ardoch Bridge before flowing adjacent to Braco. It flows generally southwards, before crossing the A822 again to the south of Braco and then discharging to the Allan Water approximately 50m downstream of the A822.
- The Feddal Burn is also located outwith the Proposed Development boundary. It flows in a generally easterly direction, before crossing beneath the B8033 to the south-west of the Proposed

Development. It then flows southwards before discharging into the Allan Water approximately 900m downstream of the A822.

- There are several ponds that lie in close proximity to the existing access track to Braco West Substation, with two ponds either side of the existing access track approximately 500m north-west of the B8033. These are located outwith the Proposed Development boundary.

Figure 3.3 shows the hydrological features within the area of the Proposed Development.

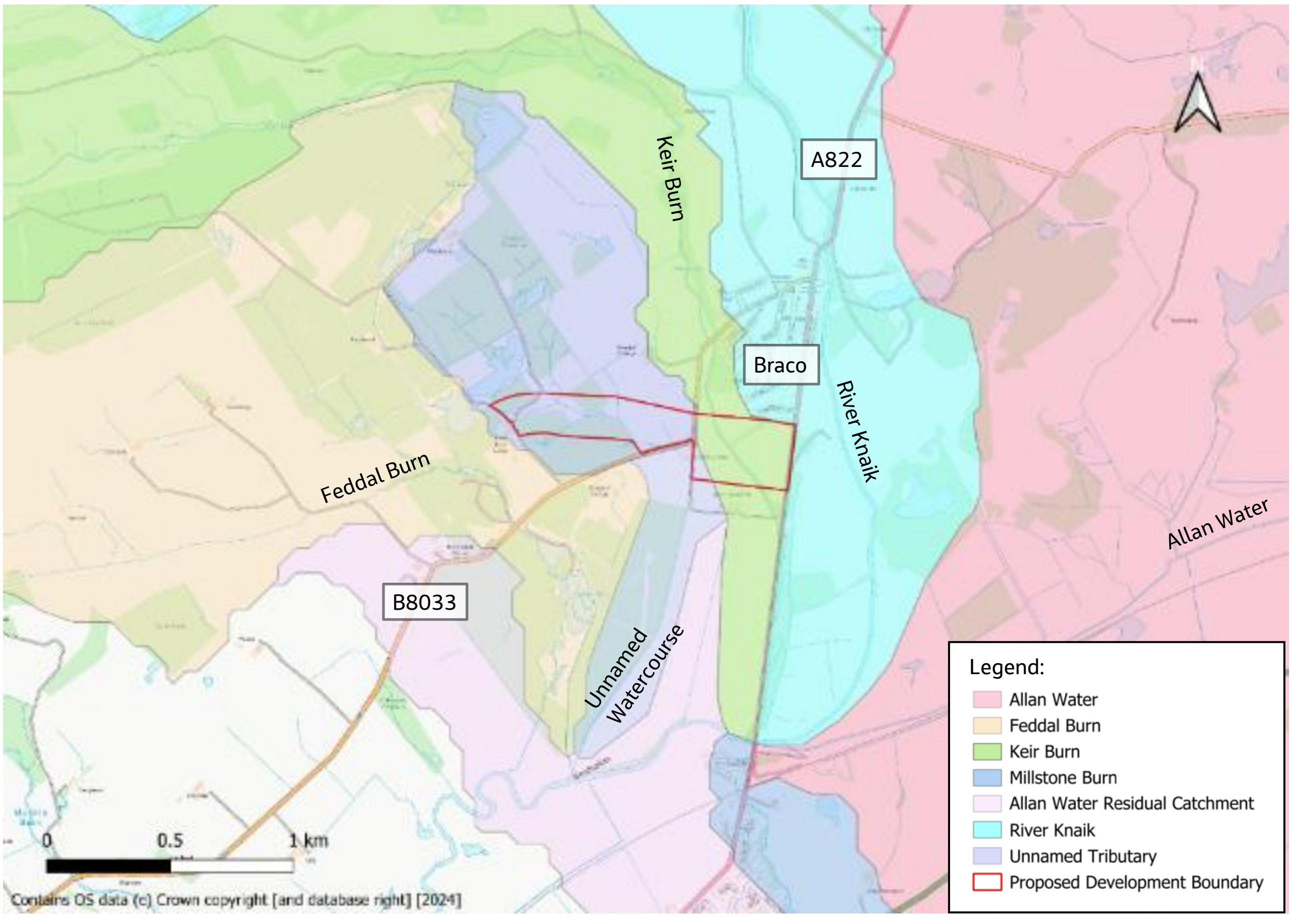

Figure 3.3: Catchments and Hydrological Features in the Area Surrounding the Proposed Development

3.2.3 Soils, Geology and Hydrogeology

3.2.3.1 Soils

The National Soil Map of Scotland (Scottish Government, 2024a) classifies the soils across the majority of the Proposed Development to be Alluvial Soils. Alluvial Soils are developed in recent river, estuary or marine deposits. They have high porosity, soft strata and typically have a varied sediment composition.

Brown Earth soils are located to the west of the Proposed Development. Brown Earth soils are described as being generally free draining, moderately acidic soils with brown mineral top soils and brown or yellowish subsoils. Where these are less well drained the soils are duller and subsoils have rust coloured or grey patches.

3.2.3.2 Geology

The British Geological Survey (BGS) GeoIndex viewer (BGS, 2024) identifies a number of superficial deposits across the Proposed Development site. A large area of alluvium, comprising clays, silts, sands and gravels, is present towards the east of the Proposed Development, in the vicinity of the B8033 and the A822. Glaciofluvial ice contact deposits, comprising gravels, sands and silts are present to the west of the alluvium deposits.

The Proposed Development boundary also appears to encroach on an area of Glaciofluvial sheet deposits to the north of the site, comprising sand and gravel, locally with lenses of silt, clay or organic material. In addition, a small proportion of the site towards the north-western extent appears to encroach on an area of Devensian Till, consisting of a heterogenous mixture of clay, sand, gravel, and boulders varying widely in size and shape.

The bedrock geology underlying the haul track is described as a purple and brown, medium-grained and coarse-grained sandstones from the Dunblane Sandstone Member, with subsidiary purple mudstones and rare pebbly sandstone beds.

A Ground Investigation survey was undertaken in October 2024 within the Proposed Development boundary and a Ground Investigation Report (Balfour Beatty, 2025) has subsequently been prepared. As part of the survey, nine boreholes were taken, including two by rota-sonic and core drilling, and seven by continuous percussion boring. Twenty-two trial pits were excavated by machine and four pavement cores were also undertaken.

The general sequence of strata encountered at the borehole on the left bank of the Keir Burn comprised the following: sandy clayey topsoil, sand and gravel, clay, sand, clay, and sandstone. The general sequence of strata encountered at the borehole on the right bank of the Keir Burn comprised the following: sandy clayey topsoil, gravel, sand, sand and gravel, clay, sandstone, and basalt. Basalt was encountered at 17.20mbgl on the right bank of the Keir Burn. The material excavated at the trial pits generally comprised sands and gravels.

3.2.3.3 Hydrogeology

The Proposed Development overlies the Arbuthnott-Garvock Group aquifer, which is designated as a moderately productive aquifer where the dominant groundwater method of flow is through fractures and other discontinuities (Scottish Government, 2024b).

According to the British Geological Survey (BGS) GeoIndex viewer (BGS, 2024), there are no borehole records within the Proposed Development boundary.

Groundwater was encountered at multiple locations during the Ground Investigation in October 2024. Groundwater strikes were recorded at all seven of the continuous percussion boring boreholes at depths of between 1.0m below ground level (bgl) and 2.50mbgl. Groundwater was also encountered at 14 trial pits at depths of between 1.0mbgl and 2.80mbgl.

Eight of the boreholes were fitted with perforated standpipes to allow for groundwater monitoring to be carried out. Groundwater readings taken between November 2024 and December 2024 showed groundwater at depths of between 3.30mbgl and 0.00mbgl.

4. Flood Risk Assessment

4.1 Fluvial Flood Risk

Fluvial flooding is defined as flooding which arises where excessive rainfall causes the water level in a river, lake or stream to rise and overflow onto the surrounding banks, shores and neighbouring land. It occurs when excessive rainfall causes a waterbody to exceed its capacity.

4.1.1 Mapped SEPA Flood Risk

The functional floodplain is defined by SEPA as the 0.5% AEP (200-year) flood extent. Fluvial flood risk is separated into three risk categories: high, medium and low. Table 4.1 defines the magnitude of flood events associated with these categories (SEPA, 2024c).

Table 4.1: Risk category classifications for the SEPA Flood Maps

Risk Category	Annual Exceedance Probability (AEP)	Return Period
High	10%	1 in 10 year
Medium	0.5%	1 in 200 year
Low	0.1%	1 in 1,000 year

Figure 4.1 shows the fluvial flood risk from SEPA Flood Maps. It should be noted that SEPA Flood Maps do not show watercourses with catchment sizes less than $3km^2$.

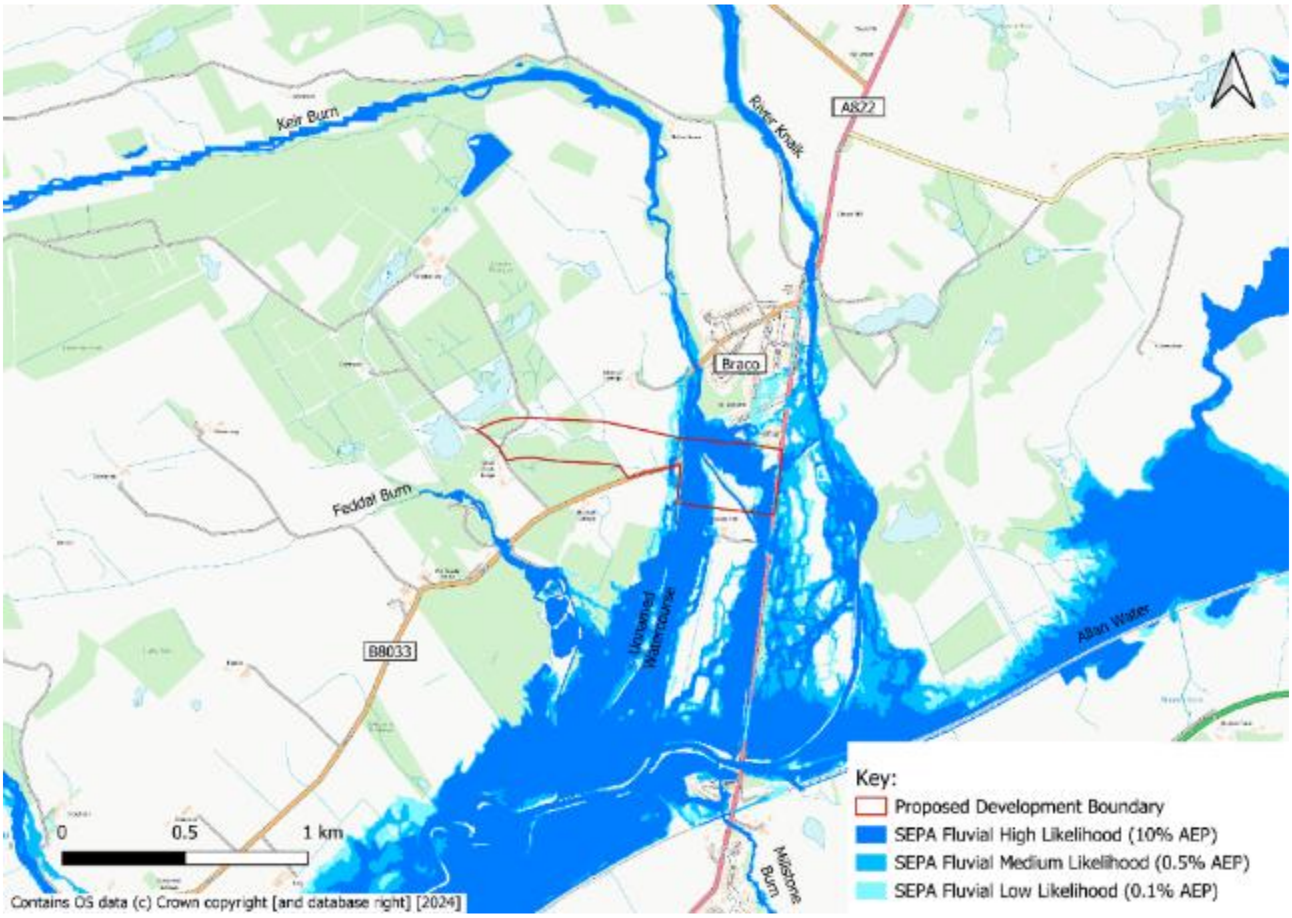

Figure 4.1: SEPA Flood Map Fluvial Risk of Flooding

The SEPA flood mapping shows that the area within the Proposed Development boundary is at risk from fluvial flooding, specifically towards the east of the Proposed Development, from the A822, extending to the immediate west of where the B8033 crosses the Proposed Development boundary. The fluvial flooding at this location is associated with the Allan Water and five of its tributaries, namely the River Knaik, the Keir Burn, Feddal Burn, Millstone Burn and an unnamed watercourse. This area is at risk from fluvial flooding for the 10%, 0.5% and 0.1% AEP flood events. In terms of coverage, the majority of the affected area is inundated during the 10% AEP flood event, with an increased area of flooding shown for the 0.5% and 0.1% AEP events.

The Proposed Development connects to the A822 and B8033. It is noted that both of these roads appear to be at risk of flooding in close proximity to the Proposed Development for the three SEPA scenarios.

The SEPA flood mapping also shows a future projection for the medium likelihood (0.5% AEP) scenario, inclusive of climate change, based on projections for the 2080s. This scenario is broadly similar to that of the low likelihood (0.1% AEP) scenario, as shown in Figure 4.2.

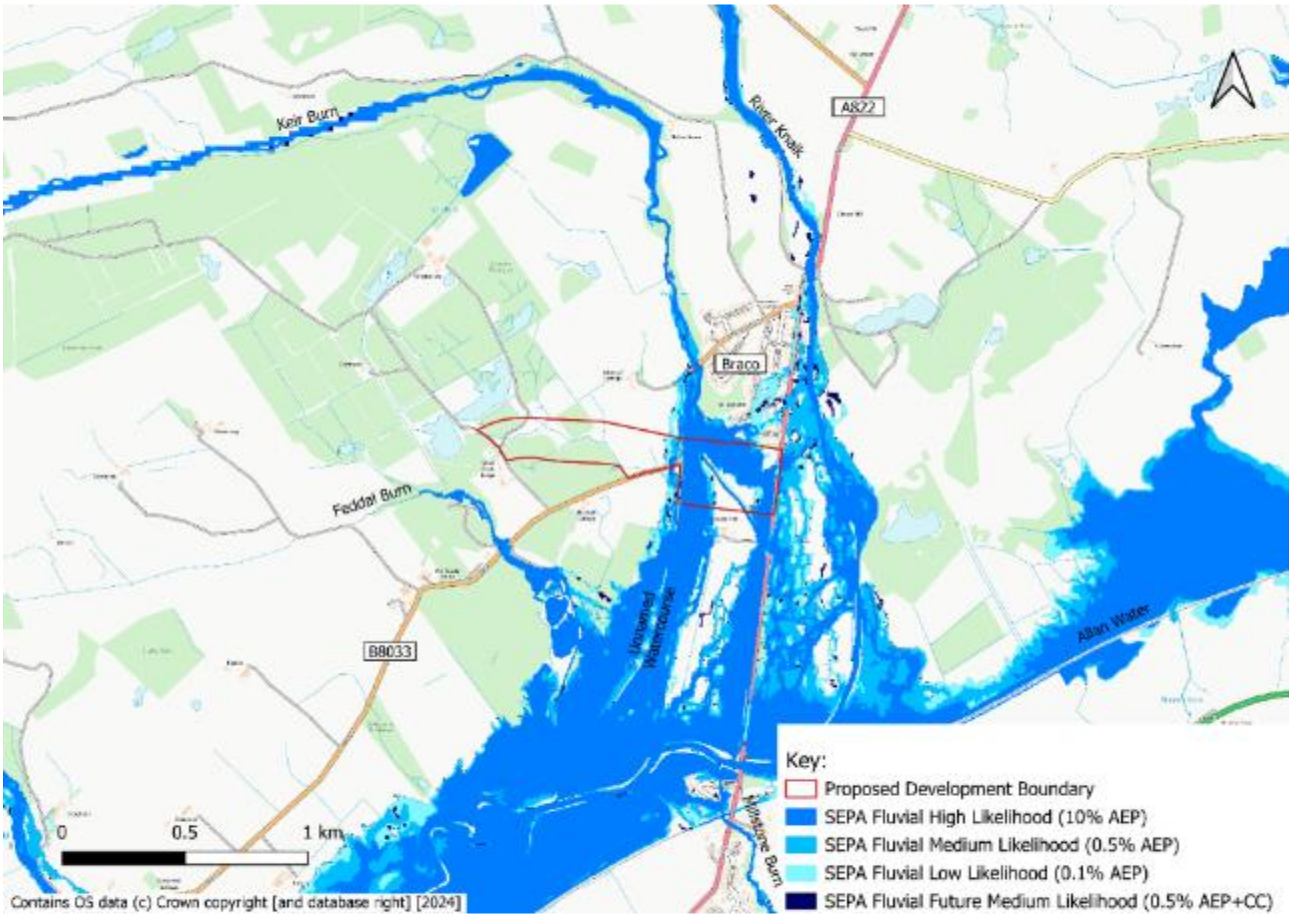

Figure 4.2: SEPA Flood Map Fluvial Risk of Flooding, including Future Scenario

4.1.2 Hydraulic Modelling

Given the limitations of the SEPA Flood Map, which is based on high level hydraulic modelling, a hydraulic model has been developed for the area of the Proposed Development. The model adopts a linked one-dimensional (1D)/two-dimensional (2D) technique, where it represents the river channel as a 1D component using Flood Modeller software, which is linked dynamically to the floodplain, which is represented in 2D, using TUFLOW software.

A baseline hydraulic model was developed to reflect the existing situation and includes a representation of the Allan Water, River Knaik, Keir Burn, Feddal Burn, Millstone Burn and an unnamed watercourse (which includes small watercourses north of the B8033). Peak flows for these watercourses which are within the vicinity of the Proposed Development have been derived with further information on the hydrological methods contained within Appendix A.

It should be noted that the hydraulic modelling software has a numerical convergence tolerance of +/- 10 millimetres (mm) on water levels and that there are further uncertainties within the survey data and hydrological and hydraulic parameters used to construct the model.

Once simulated, 1D and 2D model outputs were extracted and mapped, with specific comparison made to:

- peak flood hydrograph and level within the channel;
- peak flood depth within the floodplain;
- spatial flood extent;
- peak water velocity;

- flood inundation volume; and
- historic flood records for verification purposes.

4.1.3 Modelled Baseline Fluvial Flood Risk Comparison

A high-level comparison between the hydraulic model and the SEPA flood modelling is presented in Figure 4.3. It should be noted that the modelled flood extents presented in Figure 4.3 are for the 0.5% AEP Event plus climate change in accordance with current SEPA guidance. This corresponds to a 0.5% AEP event in the year 2100. Whereas, SEPA future flood maps have not been updated in line with current SEPA guidance and the medium likelihood future scenario is based on projections for the 2080s. As such, Figure 4.3 is not intended to provide an exact like-for-like comparison.

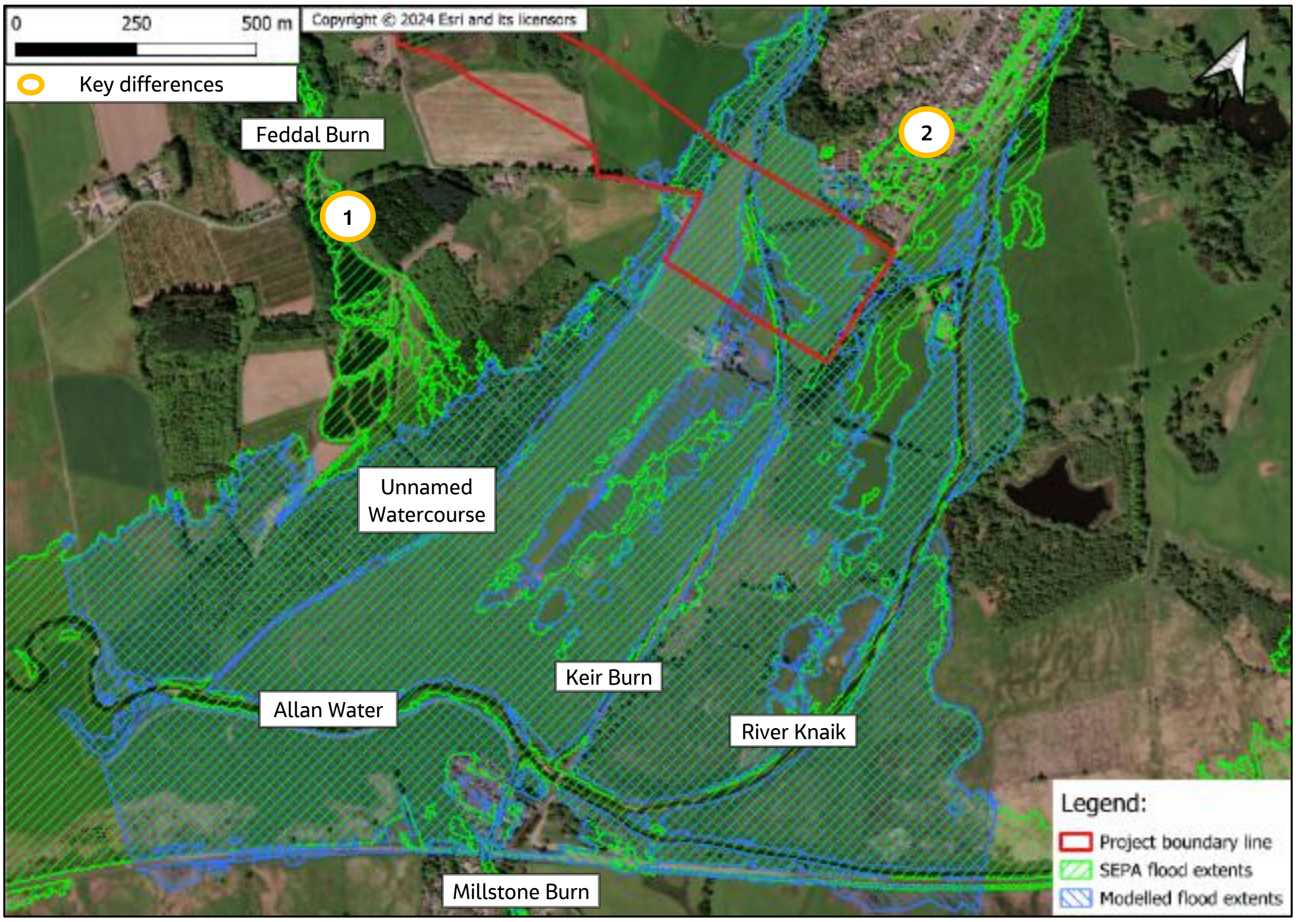

Figure 4.3: Hydraulic Model (0.5% AEP Event plus Climate Change) vs SEPA Flood Maps (Medium Likelihood, Future Scenario)

Overall, the hydraulic model generally supports the SEPA flood modelling for the 0.5% AEP plus climate change scenario, however a few key differences have been identified. These are summarised below:

1. Flooding is not shown along the Feddal Burn as it has not been modelled within the hydraulic model. This was deemed appropriate as there are no proposed works to the watercourse and it is sufficiently far enough away as to not directly interact with the Proposed Development. However, its flow contribution is included as a model inflow.
2. Flooding along the River Knaik is not as widespread as indicated by the SEPA flood mapping. There is nothing within the survey data to indicate that flooding should occur within this area. Peak channel flow has been calculated as $90m^3/s$, channel width is approximately 11 to 15m and channel depth is between 2 and 3m. Subsequently, for flooding to occur within the hydraulic model, water levels would need to

increase by around 1 to 1.5m from current results. This disparity is likely due to the use of more detailed topographical survey information within the Braco hydraulic model.

As mentioned previously, the SEPA Flood Map is based on high level hydraulic modelling and outdated SEPA guidance so it is understandable that there will be differences. Based on the above, these differences are understood and considered acceptable.

4.1.4 Modelled Baseline Fluvial Flood Risk

This section provides an overview of the baseline fluvial flood risk in the vicinity of the Proposed Development provided by the hydraulic modelling. This review presents the baseline case for the design flood event (0.5% AEP event, inclusive of climate change), as shown in Figure 4.4.

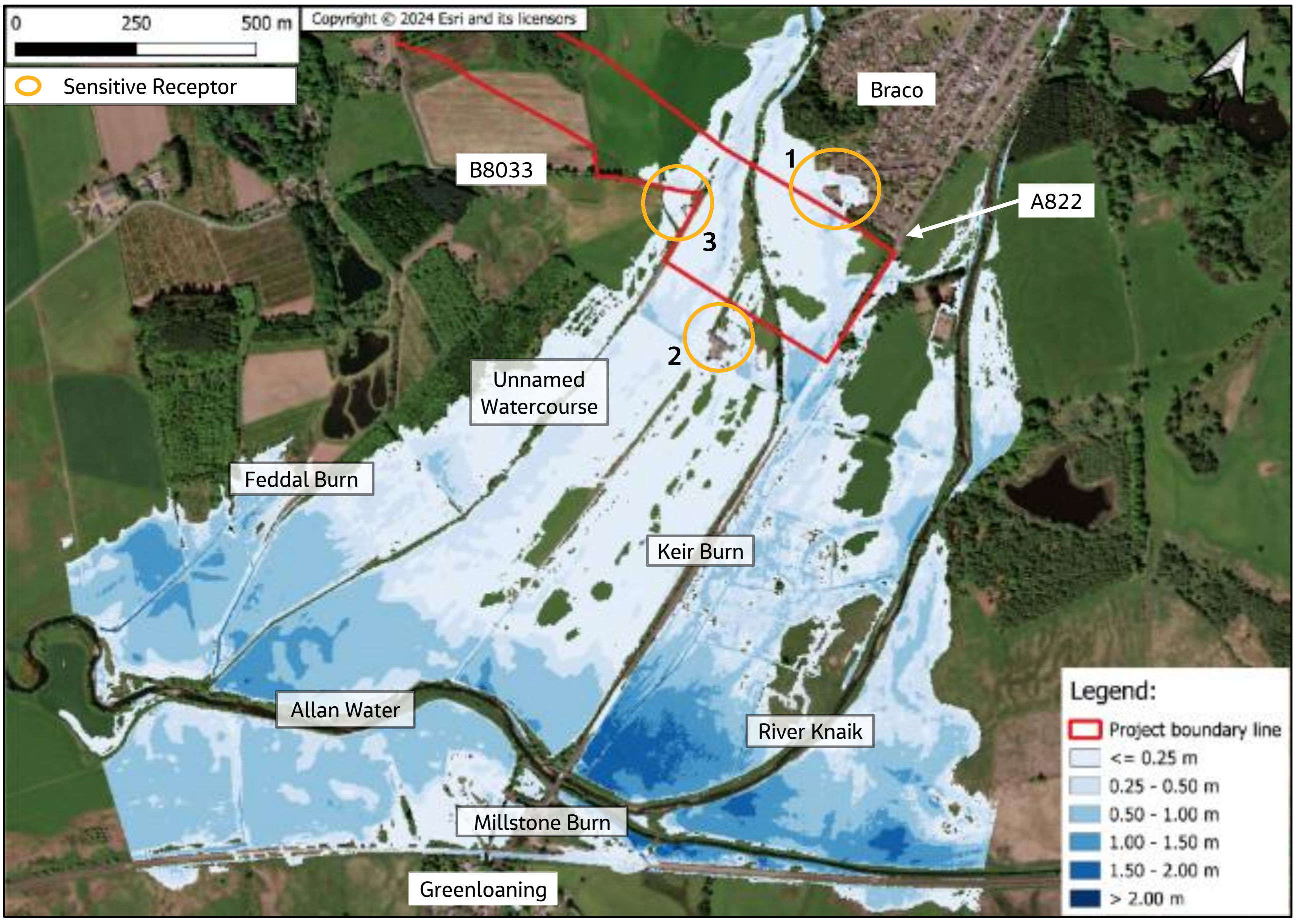

Figure 4.4: Baseline Flood Depth (0.5% AEP, plus Climate Change)

In the baseline case, flooding is extensive between Braco and Greenloaning due to flooding from the Allan Water, the unnamed watercourse, Keir Burn, River Knaik, Feddal Burn and Millstone Burn. The flooding becomes more widespread in the vicinity of the Allan Water where the tributaries converge. The majority of the land within the Proposed Development to the east of where the B8033 crosses the Proposed Development boundary is submerged, as well as a narrow area to the immediate west of the B8033.

For the majority of the affected land within the Proposed Development boundary, water depths do not exceed 0.25m for the baseline scenario, however there are areas up to 0.5m and isolated pockets up to 1.0m deep. Within the hydraulic model study area, flood depths typically increase towards the Allan Water.

Within the Proposed Development boundary, the Keir Burn is the primary contributing factor to flooding. In the design event, there is overtopping of the left and right banks of Keir Burn to the west of Braco. The flood water spreads as it travels downstream, inundating much of the area between the unnamed watercourse and the A822.

In the vicinity of the Proposed Development, a number of sensitive receptors are affected, including:

1. A number of properties on Greenhaugh Way and Commander's Grove.
2. Keirallan Farm buildings.
3. Loaning View cottage and outbuilding on the B8033, beside the unnamed tributary.

In addition, the A822 is impassible to the south of Braco over a length of approximately 40m for a period of six hours, with floodwater extending approximately 300m along the road. There is also shallow floodwater encroachment on the A822 to the south of Braco in the 1 in 2 year (50% AEP) event. In the baseline case for the design event, floodwater also overtops the B8033 over a considerable length and will be impassible in places.

On this basis, the Proposed Development has a **high** risk of flooding from fluvial sources.

4.1.5 With Scheme Fluvial Flood Risk

To assess existing flood risk and the potential impact of the Proposed Development, hydraulic modelling compares the baseline scenario against two additional scenarios: the Proposed Development (without mitigation) scenario and the Proposed Development (with mitigation) scenario. These modelling scenarios are simulated for a range of flood events including the design flood event in accordance with SEPA requirements (SEPA, 2022a).

Within the area affected by fluvial flood risk, the permanent works associated with the Proposed Development include the following:

- A surfaced haul track, typically 6.5m wide with 1-2m verges, which is on embankment through the affected area.
- Junction tie-ins with the A822 and B8033, where the haul track is at-grade.
- A single span temporary bridge over the Keir Burn.
- Pre-earthworks drainage in the form of swales either side of the road embankment.
- Proposed screening at the junction with the A822, and within the field to the north-west of the Keirallan Farm buildings.

4.1.5.1 Pre-mitigation impacts

Pre-mitigation impacts related to the Proposed Development are presented in Figure 4.5.

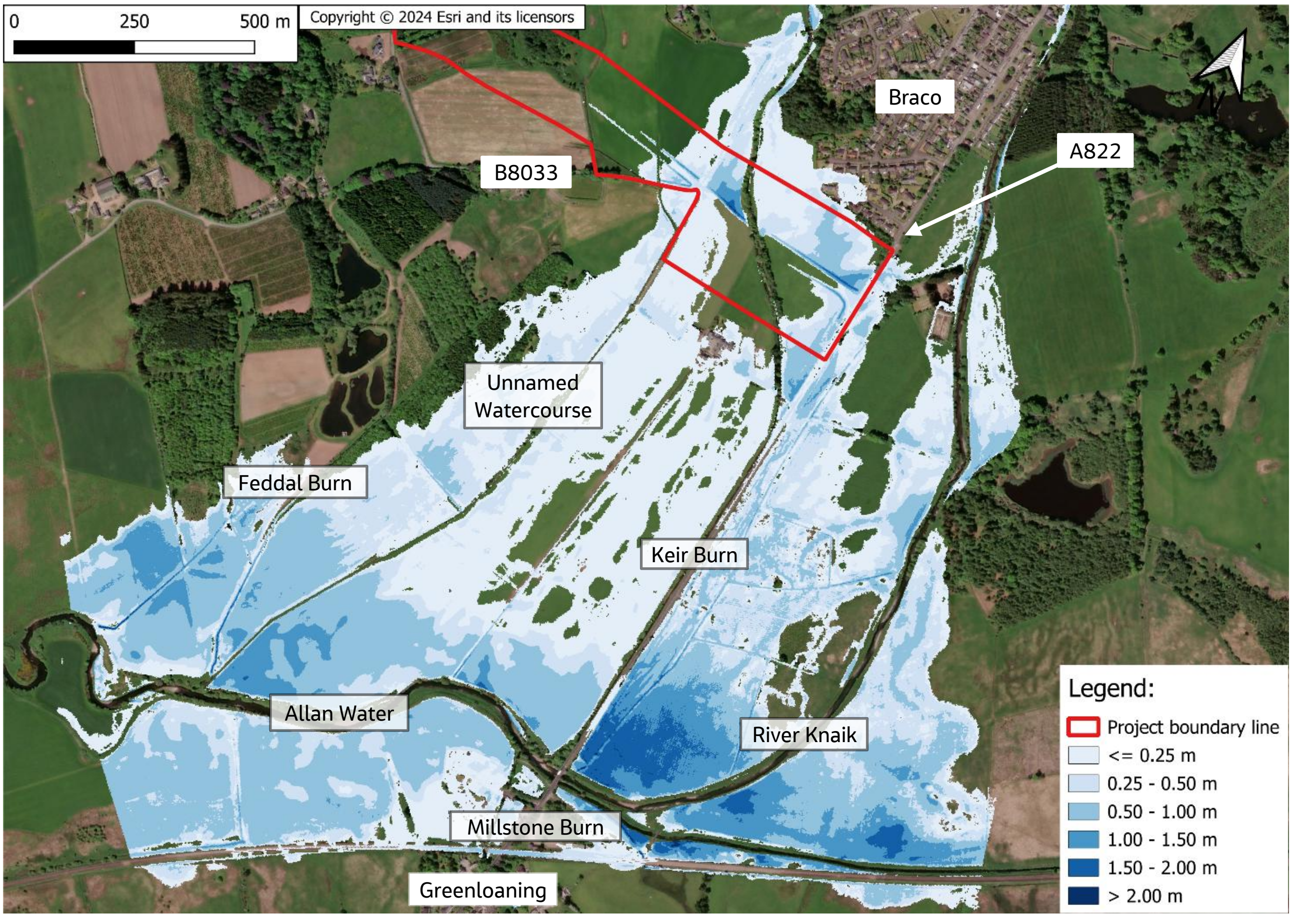

Figure 4.5: Design Flood Depth, without Mitigation (0.5% AEP, plus Climate Change)

The corresponding difference in depth between the baseline and design scenario pre-mitigation for the peak water levels is presented in Figure 4.6.

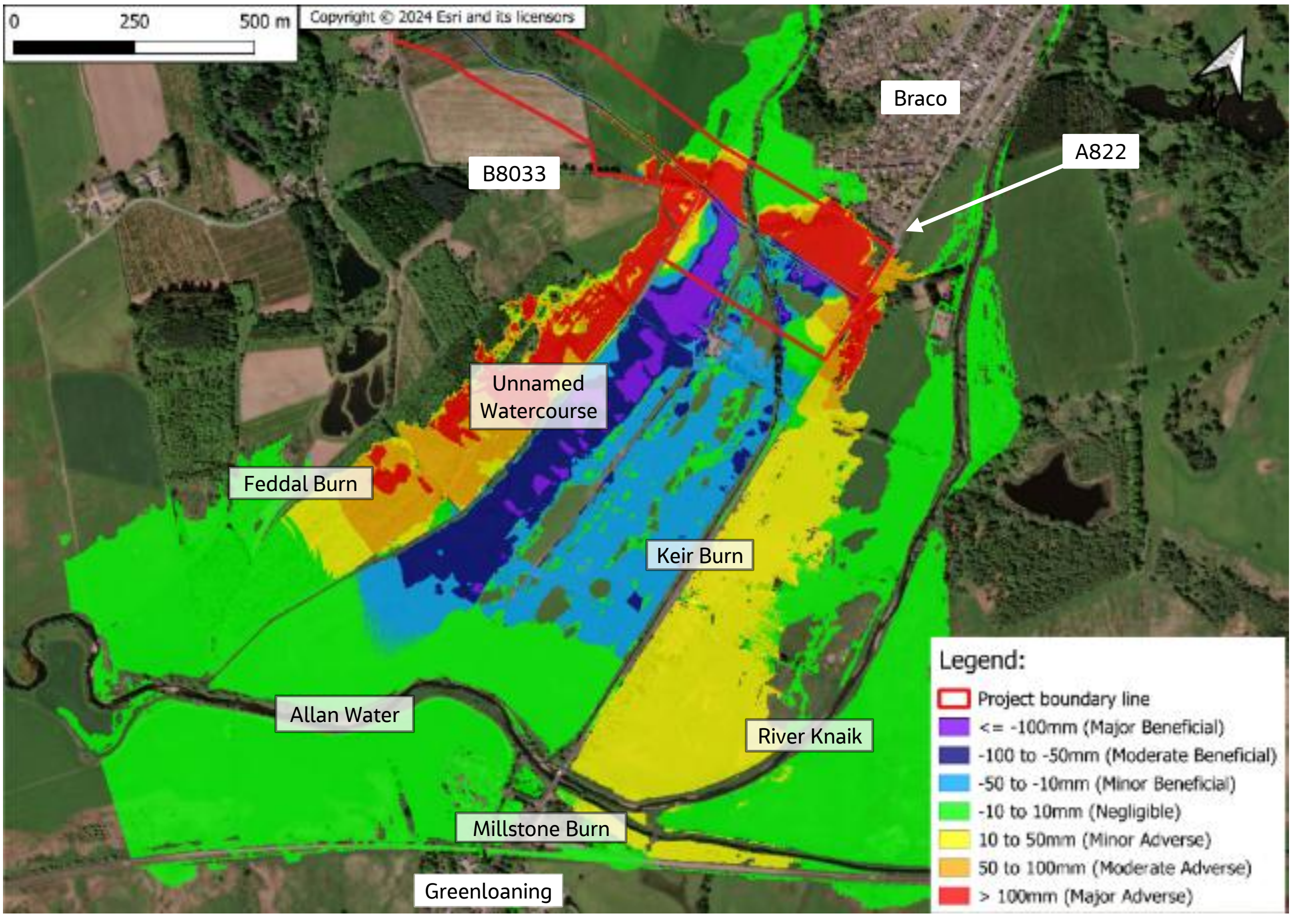

Figure 4.6: Design Pre-Mitigation vs Baseline Depth Difference (0.5% AEP Plus Climate Change)

A close-up of the impacts within the Proposed Development boundary is shown in Figure 4.7.

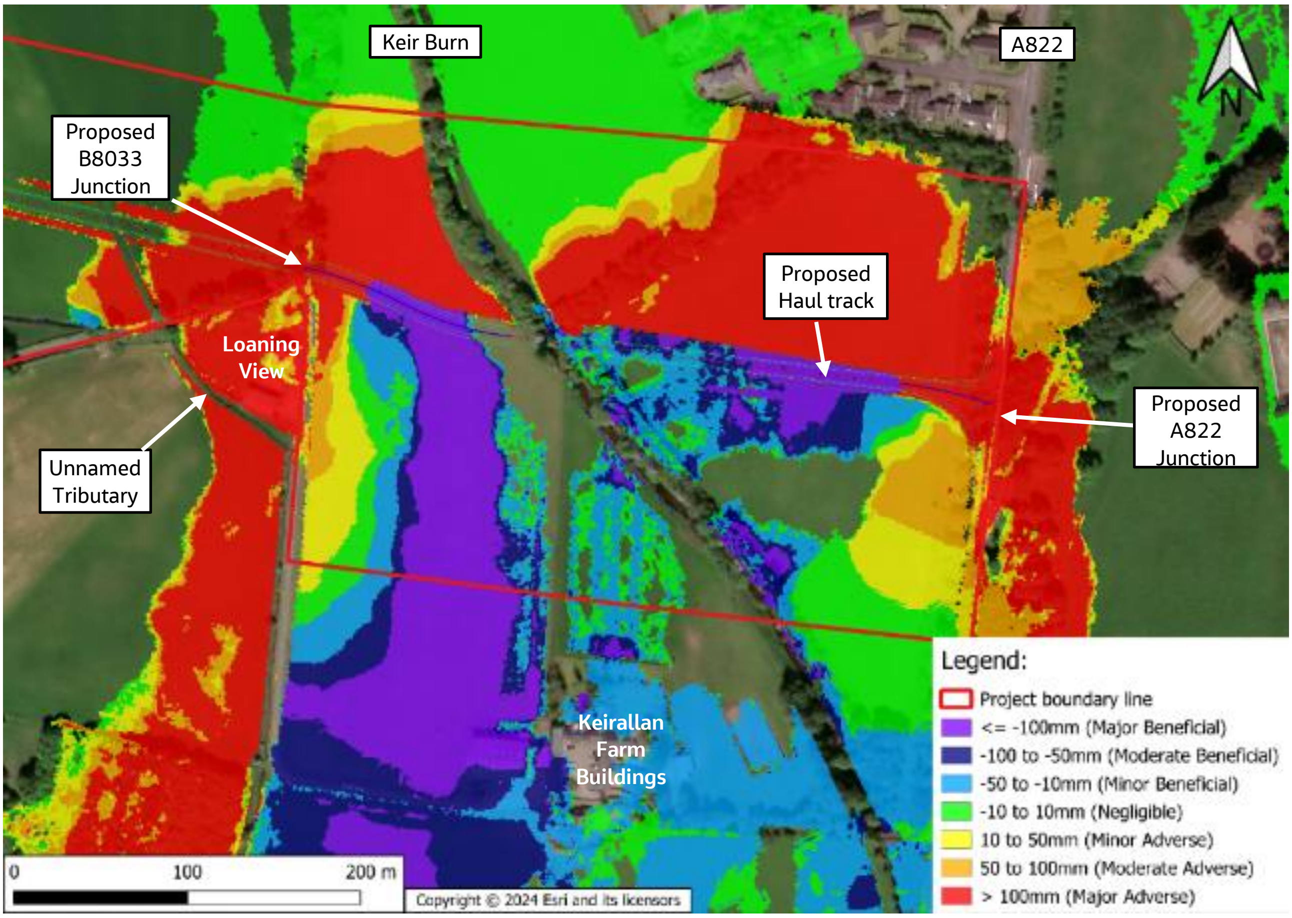

Figure 4.7: Design Pre-Mitigation vs Baseline Depth Difference at the Proposed Development (0.5% AEP Plus Climate Change)

Assessment of risk arising to the Proposed Development

As stated in section 4.1.4, the Proposed Development has a **high** risk of flooding from fluvial sources.

In the with scheme scenario, without mitigation, flood water overtops the haul track at its proposed junctions with the A822 and the B8033. These junction locations correspond with low points in the vertical alignment to tie-in with these existing roads. In the vicinity of the B8033, the haul track is flooded over an approximate length of 110m, and remains impassible (flood depths exceeding 300mm) for at least 3 hours.

In a flood event, the swales adjoining this section of the Proposed Development will become inundated. These appear as major adverse effects up to approximate chainage 700m of the proposed haul track, as shown in Figure 4.6.

Assessment of risk arising from the Proposed Development

This section provides an overview of the impact of the Proposed Development on fluvial flood risk in the absence of any flood mitigation measures.

The design of the embankment is not intended to support the storing of water on a permanent basis. Clause 2.2(f) of the Reservoirs (Scotland) Act 2011 details that roads and railways embankments are not controlled structures under the definition of the legislation, as defined by Clauses 1.3 and 1.4 of the Act.

As shown in Figure 4.6 and Figure 4.7, hydraulic modelling of the with-scheme condition without mitigation shows that the Proposed Development generally has a major adverse effect upstream of the proposed haul track compared to the baseline scenario. This is due to the proposed road embankment damming much of the out of bank flow from the Keir Burn. Peak water depths on the right (west) bank of the Keir Burn are reported with a range of between 0.50m to in excess of 1.50m immediately alongside the northern embankment of the haul track. This relates to an increase of greater than 100mm compared to the baseline scenario.

As a consequence of the above, peak water levels increase to the west of the unnamed tributary as water from the right bank floodplain of the Keir Burn is forced west of the B8033, where it overtops the proposed haul track at the low point of the vertical alignment. This has a major adverse effect on Loaning View. Downstream, the bank of the unnamed tributary acts as a barrier, containing flood water from Keir Burn to the west. These adverse effects extend approximately 1km downstream of the proposed haul track.

Similarly, as water from the left bank of the Keir Burn is also impeded by the proposed haul track embankment, flood water encroaches upon the junction bellmouth of the proposed junction with the A822, increasing flooding on the A822 to the south-east of Braco. The A822 remains impassible for over 6.5 hours, with floodwater extending approximately 420m along the A822. Out of bank flow from the River Knaik also likely contributes to flooding at this location. These adverse impacts extend for over 1km southwards beyond the Allan Water to the adjacent railway line.

There is also a major adverse effect on peak water levels to the south of the Proposed Development. As the proposed haul track restricts flow across the floodplain, water re-enters the channel at the proposed Keir Burn bridge, resulting in increased flows being passed downstream. The resultant increase in peak water levels downstream causes overtopping at the south-west bank of the Keir Burn, approximately 50m downstream of the proposed haul track. This has a major adverse effect on Keirallan Farm buildings.

The proposed bridge over the Kier Burn can accommodate the design event (0.5% AEP plus an allowance for climate change) with sufficient freeboard to soffit level.

There are major beneficial affects to areas immediately downstream of the proposed haul track, as much of the flood water is held behind the haul track, and redirected either side of the proposed junction locations, as described above. These beneficial affects extend for around 1km, and are similar in extent to the adverse affects.

There is negligible impact on Braco, and refuge areas for livestock downstream of the Proposed Development appear largely unaffected.

4.1.5.2 Mitigation

An iterative process has been applied to establish appropriate mitigation options. This included consideration of the following:

- Flood relief culverts;
- Bunds;
- Land reprofiling; and
- Modification to existing flood embankment.

The mitigation measures considered are illustrated in Figure 4.8.

Figure 4.8: Considered Mitigation Measures

The following paragraphs provide further details on each of these options and their suitability for inclusion as final mitigation measures to address the flooding impacts observed as a result of the Proposed Development.

Flood relief culverts have been iteratively modelled to provide conveyance of flood waters through the haul track embankment in order to replicate existing flooding mechanisms. This process has resulted in the following mitigation proposals:

- 56 flood relief culverts in eight clusters positioned along the proposed haul track. These comprise two circular 0.5m diameter culverts, 12 square 1x1m box culverts and 42 square 0.5x0.5m box culverts.

The introduction of an 80m long bund (400mm in height) was considered to redirect flood water through one of the culvert clusters in order improve the functionality of the culvert, thereby conveying more of the flood water downstream of the proposed haul track. The bund was intended to tie-in to the upstream side of the proposed haul track embankment at chainage 80m approximately. However, this option was discarded as it only reduced peak water levels by around 100mm to the immediate west of the bund.

A localised area of minor land reprofiling was also considered downstream of the proposed haul track at chainage 60m approximately. This reduced the size of the dry island, and subsequently the size of the restriction on flood water flowing from the north, to allow more water to continue southwards. It is noted that this would also have reduced the area available for refuge for livestock. This option was also discarded as it had negligible benefits.

The final mitigation measure proposed is the modification of an existing flood embankment downstream of the proposed haul track. This involves raising the existing flood embankment on the right (south-west) bank of the Keir Burn by 200mm over a length of 30m to reduce overtopping and remove the associated impacts on Keirallan farm buildings.

The proposed mitigation measures are presented in Figure 4.9.

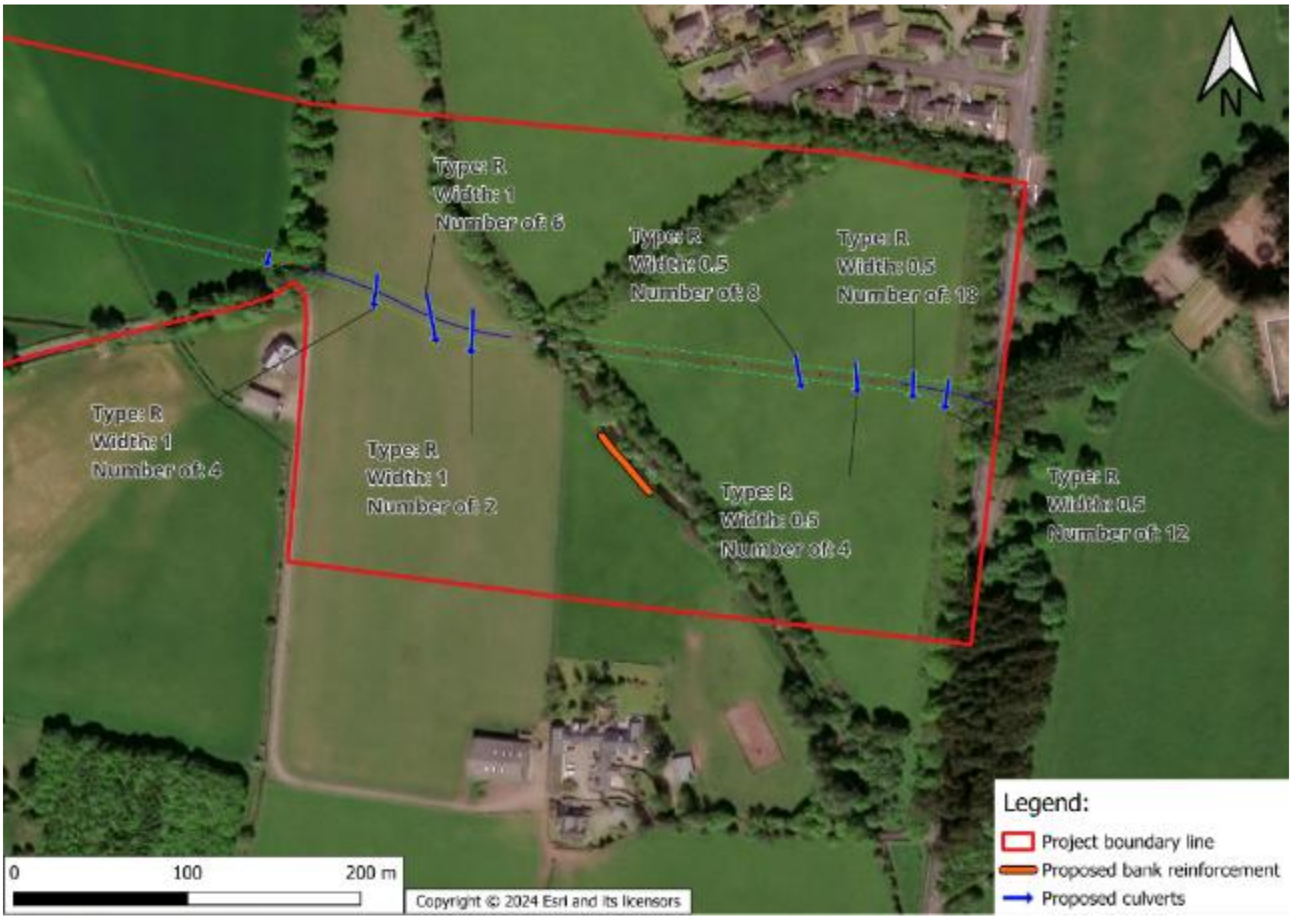

Figure 4.9: Proposed Mitigation Measures

4.1.5.3 Post-mitigation impacts

The results of the hydraulic modelling post-mitigation are illustrated in Figure 4.10.

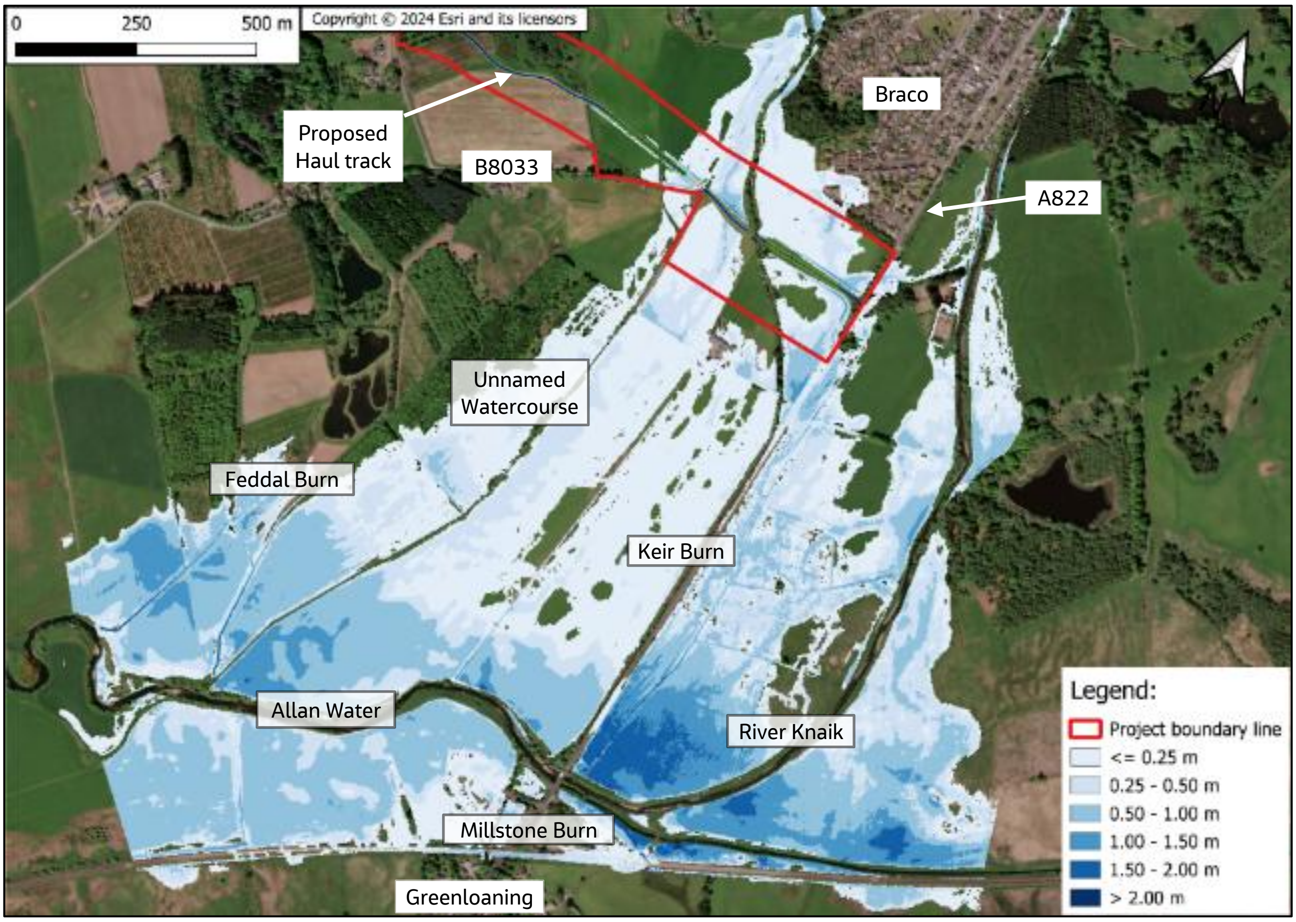

Figure 4.10: Design Flood Depth, with Mitigation (0.5% AEP, plus Climate Change)

A comparison between baseline and post-mitigation flood depths at the peak water level are presented in Figure 4.11.

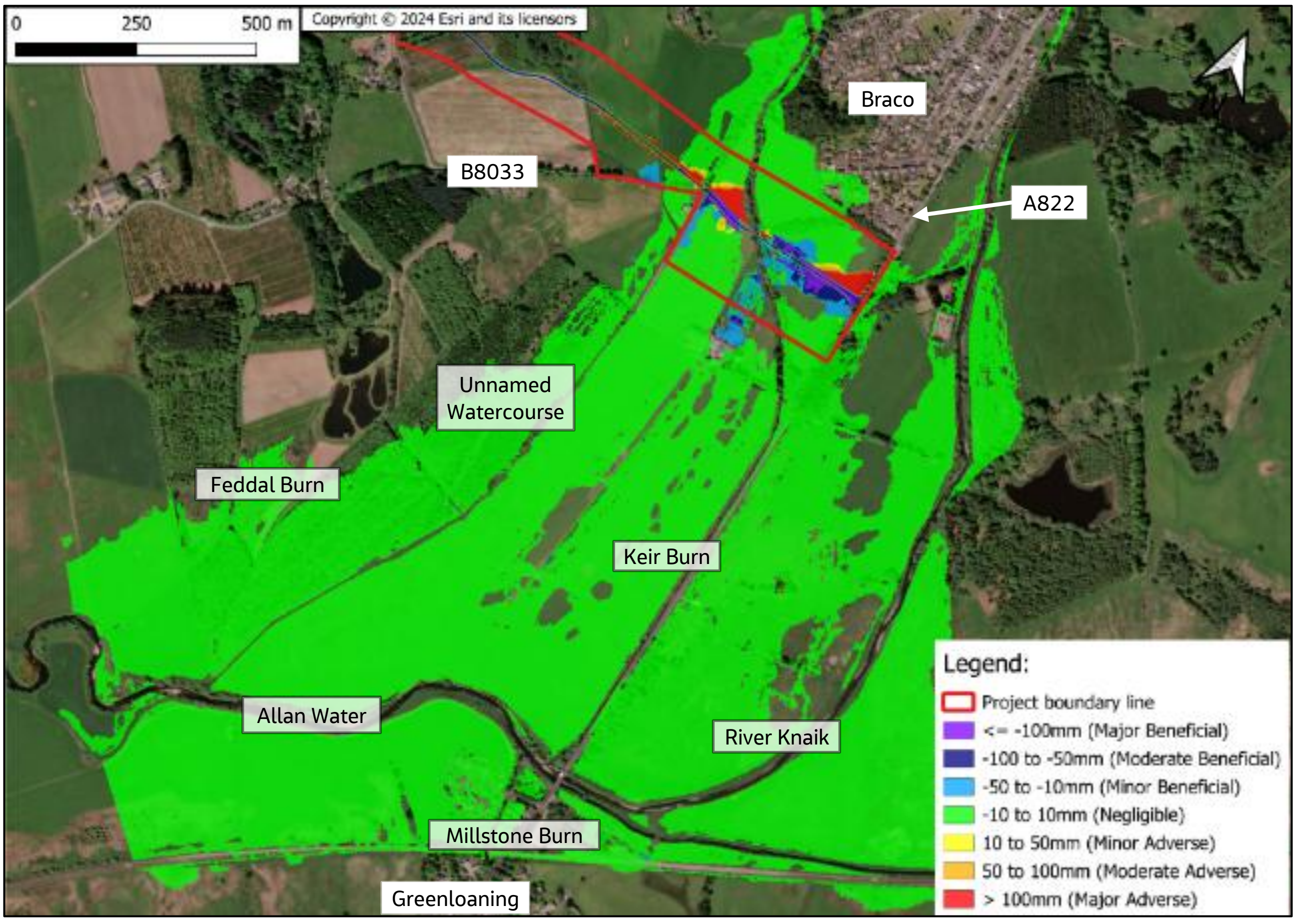

Figure 4.11: Design Post-Mitigation vs Baseline Depth Difference (0.5% AEP, plus Climate Change)

As shown in Figure 4.11, post-mitigation, all adverse impacts are limited to within 60m of the proposed haul track embankment, and are subsequently within the Proposed Development Boundary.

Figure 4.12 provides a closer view of the results presented in Figure 4.11 in the vicinity of the Proposed Development.

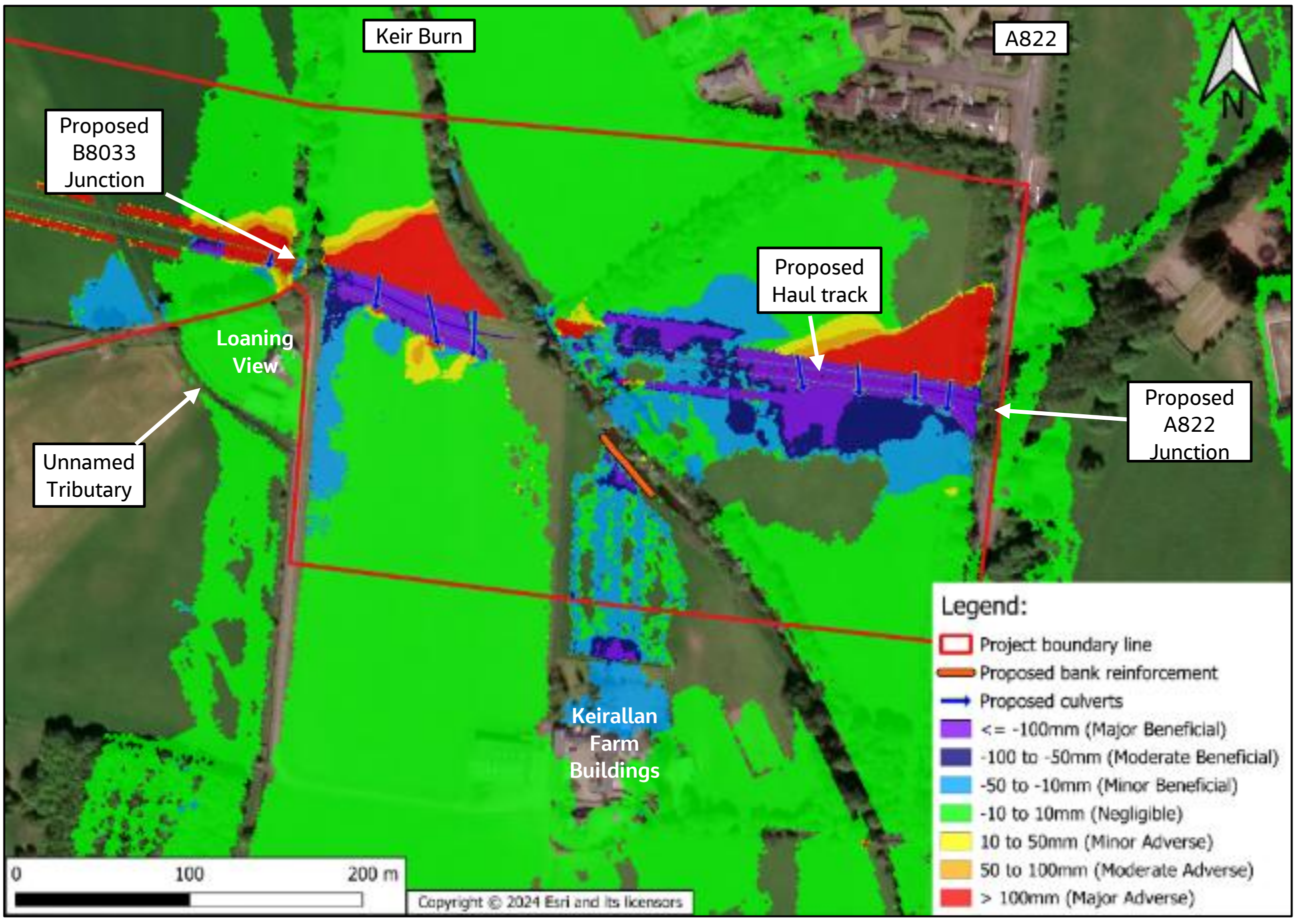

Figure 4.12: Design Post-Mitigation vs Baseline Depth Difference (0.5% AEP Plus Climate Change) – Close-up of Proposed Development

Figure 4.12 shows, as per pre-mitigation, that the majority of the adverse impacts are located upstream of the Proposed Development, as the proposed haul track embankment continues to act as a barrier to flood water flow. However, the introduction of flood relief culverts has effectively reduced the size of the barrier by 34m, allowing more flood water to disperse downstream to better mimic baseline conditions. As such, the area affected by an increase in peak water levels has substantially reduced.

Post-mitigation, there are no adverse impacts downstream of the Proposed Development boundary. In particular, the flood relief culverts to the west of the Proposed Development have significantly improved impacts to the west of the B8033 and the unnamed tributary, compared to the pre-mitigation scenario.

The modification of the existing embankment on the Keir Burn has removed the flow path to Keirallan Farm buildings, and actually provides a beneficial effect overall in terms of reducing flooding impacts. Based on the modelling results, post-mitigation, there is no increased impact on flood risk to Loaning View or properties on Greenhaugh Way and Commander's Grove compared to baseline levels.

As per pre-mitigation, the proposed bridge over the Kier Burn can accommodate the design event (0.5% AEP plus an allowance for climate change) with 586mm freeboard to soffit level. It is the intention that the proposed bridge over the Kier Burn is temporary (in place for up to 5 years) and will be removed following the completion and commissioning of the Cambushinnie 400kV substation. It has been calculated that there is a 2.48% chance of a 200 year (0.5% AEP) event occurring at least once in a period of 5 years.

There are negligible impacts to the A822 and B8033, and unlike pre-mitigation, flood water no longer overtops the proposed haul track in the vicinity of the proposed junction with the A822. However, overtopping of the proposed haul track still occurs at the low point of the vertical alignment, to the west of the B8033. In the design event (0.5% AEP + CC), the depth of water on the haul track reaches approximately

120mm over a length of 50m. There is a 6.5 hour period during the design event where there is flooding on the road, of which the flood depth exceeds 50mm for 3.5 hours. The proposed haul track starts to experience limited flooding at the 0.5% AEP event, where the flood water encroaches up to 20mm in depth but does not overtop.

Within the modelled area, a freeboard of at least 300mm is achieved along the majority of the haul track during the design event. There are two locations where this freeboard is not achieved. The first location is for an approximate length of 30m from the proposed junction with the A822, where the vertical alignment of the proposed haul track falls to tie in with the A822, which approximately coincides with the level of floodwater. The second location is over an approximate length of 130m on the approaches to the proposed junction with the B8033, in the vicinity of where floodwater overtops the haul track. In both instances the proposed haul track is tying into existing ground levels.

Post-mitigation, the extent of flooding on the A822 is reduced from a length of 420m pre-mitigation to approximately 300m. It is considered to be impassible to the south of the proposed haul track for at least six hours, with flood depths exceeding 300mm over that time period. This is similar to the baseline scenario. Flooding still occurs on the haul track, however depths do not exceed 200mm. However, as per the baseline scenario, the B8033 remains impassible to the north of the Proposed Development. The haul track is not proposed to remain operational when the A822 and B8033 are flooded.

The modelling results indicate that the A822 becomes impassible to the south of the proposed haul track during the 0.5% AEP event, however this is only over a length of 6m. Whereas the B8033 becomes impassible to the north of the proposed haul track during the design event. During the design event, it is still possible to access the proposed haul track from the A822 if travelling southwards.

With the introduction of these proposed mitigation solution in the form of flood relief culverts there comes a potential risk that these culverts become blocked. A worst-case scenario of 100% blockage of all culverts is effectively represented within the pre-mitigation scenario which is discussed in Section 4.1.5.1. As reported in the pre-mitigation scenario, flood water overtops the haul track at its proposed junctions with the A822 and the B8033. Where water levels increase west of the B8033, as it overtops the proposed haul track, it is transferred downstream towards Loaning View. These adverse effects extend approximately 1km downstream of the proposed haul track.

4.2 Surface Water Flood Risk

4.2.1 Assessment of risk arising to the Proposed Development

Surface water flooding typically occurs during or following intense periods of rainfall, where the ground's ability to absorb rainfall is overwhelmed or unable to enter drainage systems.

SEPA flood maps define three areas at risk of flooding:

- The area at risk from a 10% AEP flood (high probability).
- The area at risk from a 0.5% AEP flood (medium probability).
- The area at risk from a 0.1% AEP flood (low probability).

The SEPA surface water flood risk maps (shown in Figure 4.13) show the Proposed Development is largely not at risk of flooding from surface water.

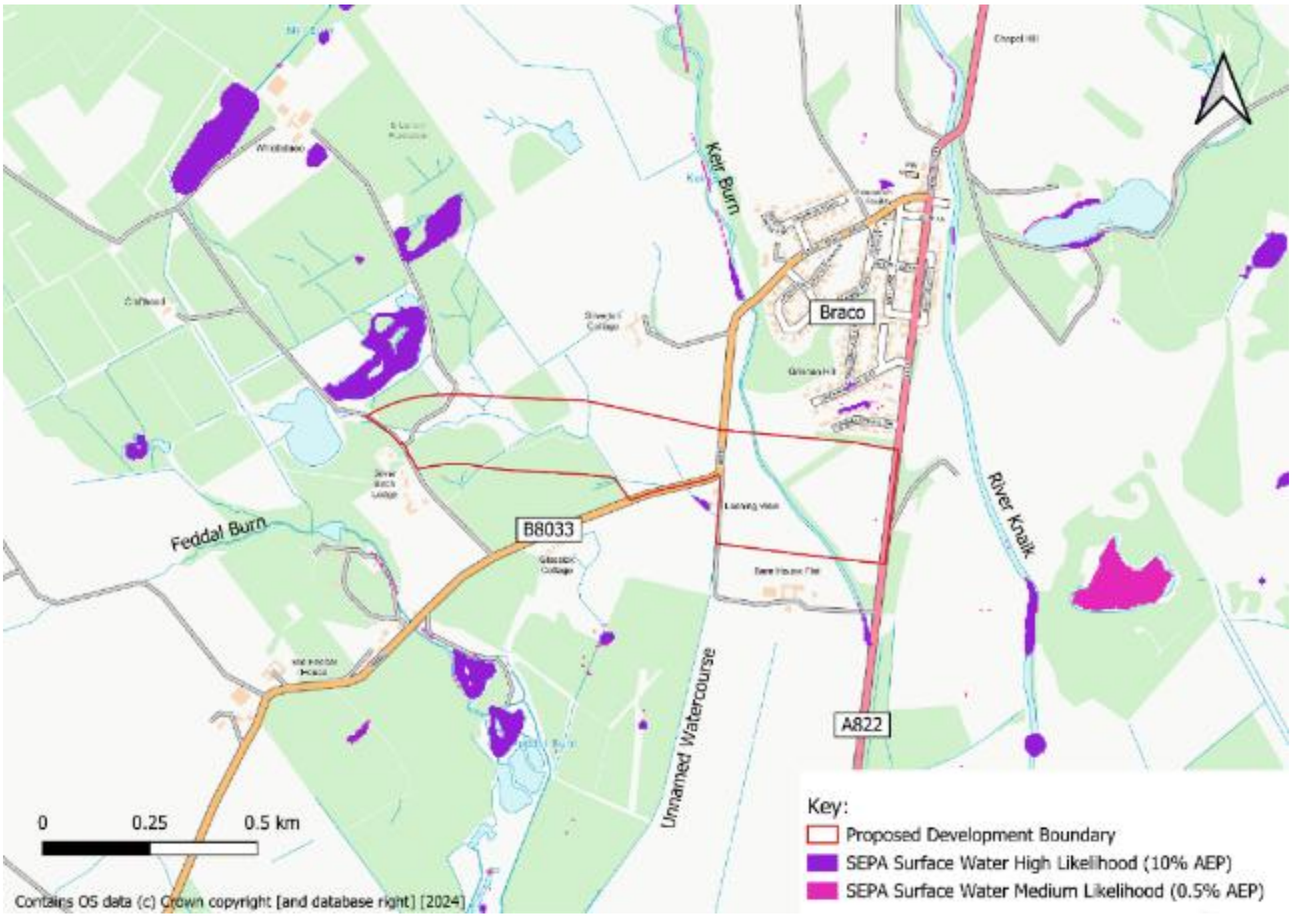

Figure 4.13: Risk of Surface Water Flooding

There are two very small, isolated pockets which have a medium probability of flooding. These are likely small, localised depressions in the landscape that are highlighted by the pluvial modelling process. One of the areas is immediately adjacent to the Keir Burn, and the other is to the west of the A822.

No formal drainage infrastructure has been identified on the site. However, field drains are likely to be present within areas of farmland and ditches are likely present within the tree plantation, towards the western extent of the Proposed Development.

On this basis, the Proposed Development has a **low** risk of flooding from surface water.

4.2.2 Assessment of risk arising from the Proposed Development

Surface water from the Proposed Development will be managed by a new surface water drainage system. The proposed drainage design has been developed by WSP and comprises filter drains within the verges of the haul track, which discharge to swales at the toe of the embankments. The swales are also proposed to act as pre-earthworks drainage and discharge to the Keir Burn and the unnamed watercourse.

As discussed in section 4.2.1, ditches and field drains are likely present within the vicinity of the Proposed Development. Where existing water features interact with the scheme, culverts of an appropriate size will be provided to mitigate flood risk impacts.

On this basis, the risk of surface water flooding from the Proposed Development is a **low**.

4.3 Groundwater Flood Risk

4.3.1 Assessment of risk arising to the Proposed Development

Groundwater flooding can occur in low-lying areas when groundwater levels rise above surface levels, or within underground structures.

Within the Proposed Development boundary, the area to the east of the Keir Burn has been identified as a low likelihood area for groundwater to act as a contributory factor to flooding.

As detailed in section 3.2.3.3, groundwater monitoring has been carried out at eight locations within the footprint of the proposed haul track. Groundwater has been encountered at depths less than 1mbgl at all six monitoring locations to the west of the B898, with four sites providing readings of less than 0.5mbgl, including a ground level reading at approximate chainage 700m.

Given the proximity to the Keir Burn and unnamed watercourse, shallow groundwater readings are to be expected due to hydraulic conductivity between groundwater and the surface water of the adjacent watercourses. Due to the high groundwater table, groundwater may be encountered during excavations. However, in terms of flood risk, fluvial flooding is considered the dominant source of flooding, whereas the risk of groundwater flooding occurring alone is considered low.

On this basis, the Proposed Development has a **low** risk of flooding from groundwater.

4.3.2 Assessment of risk arising from the Proposed Development

As detailed in section 4.3.1, groundwater has been encountered at ground level to the west of the B8033. As such, the Proposed Development could impact on groundwater flooding. However, these impacts will likely be isolated occurrences which do not have implications beyond the immediate vicinity of the Proposed Development. In addition, as stated in section 4.3.1, the high groundwater table is due to the proximity of the adjacent watercourses and fluvial flooding remains the dominant source of flooding.

Therefore, other than dealing with shallow groundwater emergence during any excavation works, the risk of groundwater flooding from the Proposed Development to third parties is considered **low**.

4.4 Flood Risk from Sewers/Mains

4.4.1 Assessment of risk arising to the Proposed Development

Flooding from sewers primarily occurs when flow entering a sewer system exceeds the available capacity or if the network capacity has been reduced through blockage or collapse. In the case of surface water sewers that discharge to watercourses, the same effect can be caused as a result of high-water levels in the receiving watercourse. As a result, water can begin to surcharge the sewer network, emerging at ground level through gullies and manholes and potentially causing flooding to highways and properties. If this occurs flooding can represent a significant hazard to human health due to the potential for contaminants in flood water. As there are no sewers identified within the Proposed Development boundary, the likelihood of flooding is **negligible**.

Scottish Water mapping indicates that there is a water supply pipe which runs alongside the B8033. The risk of a failure in a water main is **low**.

4.4.2 Assessment of risk arising from the Proposed Development

There will be no new connection to third-party sewers or drains as a result of the Proposed Development.

As such, the risk of flooding from sewers and drainage systems within the Proposed Development to third parties is considered to be **negligible**, for which mitigation measures are not considered necessary.

4.5 Flood Risk from Other Sources

4.5.1 Assessment of risk arising to the Proposed Development

The risk of flooding associated with reservoirs, canals and other artificial structures is considered to be **negligible** given the absence of any such structures in the vicinity of the Proposed Development.

Similarly, the risk of flooding from tidal/coastal sources is considered **negligible** due to the nearest mapped coastal flooding being over 13km from the Proposed Development as well as the difference in elevation.

4.5.2 Assessment of risk arising from the Proposed Development

The Proposed Development does not involve any works which would impact on the integrity of reservoirs, canals or other artificial structures. As such the risk is considered to be **negligible**.

Similarly, the Proposed Development will not involve any works which would lead to an increased tidal flood risk impact to others. As such the risk is considered to be **negligible**.

5. Construction and Operational Flood Risk

5.1 Introduction

This section provides an overview of flooding risks and general guidance for an appointed Contractor to consider in the planning of the works, as well as SSEN during the operational phase.

5.2 Flood Risk during Construction

As detailed in section 4.1, the Proposed Development is at high risk of fluvial flooding. As such, works towards the eastern extent of the Proposed Development would affect fluvial flood processes should a high risk flood event occur.

It is the appointed Contractor's responsibility to manage flood risk during the construction phase, including any risk to and from the temporary works, as well any necessary mitigation measures. The appointed Contractor will need to develop a Flood Response Plan (including emergency evacuation plans), as well as monitor SEPA flood warnings, water levels and weather conditions. As part of this, it may be beneficial for the Contractor to sign up for SEPA's Floodline to receive flood alert messages for the area.

It is recommended that temporary works, construction materials, construction equipment and site compounds are located outwith the functional flood plain (1 in 200 year (0.5% AEP) flood event) as these would exacerbate flood storage losses, which could adversely impact sensitive receptors. It could also lead to damage to and/or from the construction elements. Where relocation outwith the floodplain is not feasible, consideration should be given to making such elements resilient to minimise impacts during flood events.

Construction works within the functional floodplain pose a health and safety risk to site operatives, and could put human life at risk. This is also applicable to the location of site compounds. Such facilities should be raised above peak water levels.

Excavations (e.g. for pre-earthworks drainage), particularly within floodplains can lead to groundwater penetration. In particular, it is noted that there is a low risk of groundwater contributing to flooding to the east of the Keir Burn. Excavations can also lead to pooling of pluvial runoff.

As detailed in section 4.1.5.3, the onset of flooding for the A822 is during the 1 in 2 year (50% AEP) event. As such, access to the Proposed Development could be affected during the construction phase. This could impact the construction programme.

Where there are any requirements to replace or install culverts at any encountered crossings these will need to be designed to current standards. These should be designed to accommodate the 1 in 200-year flow plus an allowance for climate change.

As part of the haul track construction there will be a requirement for additional temporary infrastructure, for example, areas for laydown and welfare facilities as well as a vehicle wash station. These will be only utilised for the duration of the construction phase. It is expected that a surface water management plan will be developed as part of the Construction Environmental Management Plan (CEMP). This management plan associated with the CEMP will include measures to ensure that runoff from these areas is dealt with through the use of construction SuDS, with discharges limited to the greenfield runoff rate. All measures relating to regulatory compliance will be put in place associated with the use of these temporary infrastructure locations.

5.3 Flood Risk during Operation

It has been identified that the Proposed Development is at high risk of fluvial flooding. SSEN will need to manage flood risk to operatives during the operational phase, in addition to considering access requirements. As stated in section 4.1.5.3, floodwater will encroach on the A882, B8033 and the proposed haul track during the design event. The A822 and B8033 will also be impassible in places. As such, consideration will need to be given to assessing appropriate access routes to the substation. Whilst it has been determined that the

Proposed Development and adjoining road network will experience flooding but remain accessible during the design event, this may not be the case for larger events. It is proposed that the bridge over the Kier Burn is temporary in nature and will be removed offsite when no longer required. It is proposed intention that the land surrounding the haul track will be maintained and function as per its current land use.

It is recommended that SSEN prepare a Flood Response Plan (including emergency evacuation plans), as well as monitor SEPA flood warnings, water levels, weather conditions and sign up to SEPA's Floodline to receive flood alert messages for the area.

To ensure that the proposed flood relief culverts through the track embankment remain functional, these will be subjected to regular maintenance by the SSEN Operations team. This will include ensuring that the openings remain free of sediment, rubbish and debris and remove any obstructions including large branches and any other barriers.

6. Summary and Conclusions

6.1 Summary

The aim of this FRA is to outline the potential for the Proposed Development to be impacted by flooding as well as the potential impacts of the Proposed Development on flooding to receptors in the immediate vicinity or downstream of the development. The FRA has been prepared in line with the requirements of NPF4 as well as local authority guidance on the assessment of flood risk for planning purposes.

Table 6.1 presents a summary of the flood risk to and arising from the Proposed Development, including measures proposed to mitigate identified risks.

Table 6.1: Summary of flood risk

Flood Source	Risk to the Proposed Development	Risk Arising from the Proposed Development	Mitigation Proposed
Fluvial	High	High	Flood relief culverts have been proposed to redistribute flood water to better replicate existing flooding mechanisms. Modifications to an existing embankment are also proposed to mitigate adverse effects.
Surface water	Low	Low	A surface water drainage strategy has been developed for the Proposed Development to manage runoff.
Groundwater	Low	Low	No
Sewers and Mains	Low	Negligible	No
Other Sources (e.g. reservoirs, canals, tidal/coastal)	Negligible	Negligible	No

6.2 Conclusions

The Proposed Development is located within an area which is at 'high risk' from fluvial flooding. No significant risks were identified from flooding from other sources assessed. Mitigation measures have been proposed for fluvial and surface water flooding.

Fluvial flood mitigation measures have been proposed to replicate existing flooding mechanisms across the modelled area. The proposal includes the introduction of 56 culverts to provide conveyance of flood waters through the haul track embankment, as well as the modification of an existing flood embankment on the right bank of the Keir Burn downstream of the proposed haul track to reduce overtopping and associated impacts on a sensitive receptor. A maintenance regime will be adopted to ensure ongoing operation as intended of the flood relief culverts which will include removal of debris and obstructions at the culvert openings.

As there is an increased impermeable surface area, a surface water drainage strategy for the Proposed Development has been developed to manage and treat runoff from these areas. This comprises the use of filter drains within the verges of the haul track, which discharge to swales at the toe of the haul track embankments. The swales also act as pre-earthworks drainage and discharge to the Keir Burn and the unnamed watercourse. The discharge rates have been restricted to the greenfield runoff rate in line with Perth and Kinross Council requirements (PKC, 2021).

Overall, it has been demonstrated that the risk of flooding to the Proposed Development has been managed through implementation of mitigation and that the Proposed Development is unlikely to lead to an increase in flood risk elsewhere.

Whilst the drainage for the Proposed Development has been designed to meet the requirements of the local authority, there is a residual risk that the drainage will be unable to cope with events larger than the design event.

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Appendix A. Hydrology Report

[PROVIDED SEPARATELY]