Fanellan Hub 400 kV Substation and Converter Station

Environmental Impact Assessment Report

Volume 4 | Technical Appendices

Appendix 13.1 – Flood Risk Assessment

February 2025

Fanellan Hub

400kV Switching Station and HVDC Converter Station

Flood Risk Assessment
LT459-SWE-XX-XX-T-W-1002

SWECO

Table of contents

Figures

Tables

Executive Summary

This Flood Risk Assessment (FRA) has been prepared under instruction from Scottish and Southern Energy Networks (SSEN) to support the application for the construction of an electrical substation. The proposed development is to be constructed on south-eastern slope of Torr Mor hill near the village of Beauly in the Highland Council district.

A screening review of flood risk to the site was undertaken. The review identified that surface water posed a medium risk whereas fluvial and groundwater posed a high risk of flooding. All other sources of flood risk were considered to be low.

Baseline and post-development hydraulic modelling were conducted near an unnamed watercourse, where the haul road and associated SuDS basin are to be situated. The baseline modelling indicated that the proposed development lies within the floodplain; however, post-development modelling showed that the impact on flooding is negligible.

Sweco has prepared a Drainage Strategy (DS) and Drainage Impact Assessment (DIA) for the proposed development. The development will increase the impermeable area of the site by 240,000m^2. The DS and DIA both demonstrate the proposed development will not increase the peak volume of surface water and groundwater to the receiving watercourses. Furthermore, foul water is to be contained within septic tanks on-site and is designed to significantly reduce the impacts of cross-contamination with surface water.

1. Introduction

Sweco UK Ltd (Sweco) has been commissioned by Scottish and Southern Energy Networks (SSEN) to prepare a Flood Risk Assessment (FRA) for the construction of an electrical sub-station.

This FRA has assessed the flood risk from all sources posed both to and from the proposed development. The FRA should be read in conjunction with the Drainage Impact Assessment (DIA) see document LT459-SWE-XX-XX-D-X-0001 and Drainage Strategy (DS) report see document LT459-SWE-XX-XX-T-C-0501. From here on, any reference to the DIA and DS reports refers to the documents named above.

1.1 Methodology

This FRA has been a desk-based assessment, completed in accordance with the current guidance contained in the National Planning Framework 4 (NPF4)[1] and the supporting Scottish Environment Protection Agency (SEPA) Flood Risk and Land Use Vulnerability Guidance[2]. The steps for completing a site-specific FRA have also been followed using a range of data sources listed below:

- The National Planning Framework 4 (NPF4)[1]
- The SEPA Flood Risk and Land Use Vulnerability Guidance[2]
- SEPA flood mapping[3]
- British Geological Society (BGS) Geological Maps via the Onshore Geoindex[4]
- ScalgoLive[5]
- 1m resolution LiDAR[6]

[1] https://www.gov.scot/publications/national-planning-framework-4/, accessed February 2024
[2] https://www.sepa.org.uk/media/143416/land-use-vulnerability-guidance.pdf, accessed February 2024
[3] https://www.sepa.org.uk/environment/water/flooding/flood-maps/, accessed February 2024
[4] http://mapapps2.bgs.ac.uk/geoindex/home.html, accessed February 2024
[5] https://scalgo.com/, accessed February 2024
[6] https://remotesensingdata.gov.scot/data#/map Accessed August 2024

1.2 Consultations

Table 1-1 outlines the contact made with the local authority, SEPA and Scottish Water and their response.

Table 1-1: Data requests.

Contact	Date	Request for Data	Response
SEPA	22/11/2023	Any flood related information which may be relevant to the study, including data on previous flood events in the area of interest.	The current SEPA Observed Flood Event (OFE) Database holds no records of flooding within the area of interest. We do not hold any other flood related information.
Scottish Water	07/11/2023	Any sewer flooding records which may be relevant to the study.	Scottish Water can confirm that we have checked our GIS (Geographical Information System) records for the location of interest detailed within your request for information and we have no public sewer assets in this area. Therefore, we hold no information regarding sewer flooding within the vicinity.
The Highland Council	01/11/2023	Record of unlicenced abstractions in the area. Also requested any records of flooding in the area.	We hold no details of unlicensed abstractions however we do hold a copy of our Private Water Supply Register as of October 2023. We have reviewed our records of flooding and no have record of flooding to the site or search area. Flooding may have occurred but not reported to the Council.

2. Planning Policy and Legislative Framework

The National Planning Framework 4 (NPF4[1]) is the relevant guidance document that local authorities use in reviewing proposals for development with respect to flood risk. The NPF4 states that for all developments:

- Development in areas at flood risk should be avoided as a first principal.
- A precautionary approach should be taken, regarding the calculated probability of flooding as a best estimate, not a precise forecast.
- All sources of flooding are understood and addressed.
- Will not increase the risk of surface water flooding to others, or itself be at risk.

Policy 22 of the Framework states that:

Development proposals at risk of flooding or in a flood risk area will only be supported if they are for:

- 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; or.
- redevelopment of previously used sites in built up areas where the LDP has identified a need to bring these into positive use and where proposals demonstrate that long-term safety and resilience can be secured in accordance with relevant SEPA advice.

2.1 Local Planning Policy

The Highland Council is the Local Planning Authority for the area. The Local Development Plan (2015)[7] provides guidance concerning relevant policy information for development within this jurisdiction. Policy 64 (Flood Risk) sets out requirements for new developments with regards to water to minimise the impacts of flooding.

Under Policy 64:

Development proposals should avoid areas susceptible to flooding and promote sustainable flood management.

Development proposals within or bordering medium to high flood risk areas, will need to demonstrate compliance with the National Planning Framework 4 (NPF4)[8] through the submission of suitable information which may take the form of a Flood Risk Assessment.

Development proposals out with indicative medium to high flood risk areas may be acceptable. However, where:

- better local flood risk information is available and suggests a higher risk;

[7] https://www.highland.gov.uk/info/178/development_plans/199/highland-wide_local_development_plan, accessed February 2024
[8] https://www.gov.scot/publications/national-planning-framework-4/ accessed February 2024

- a sensitive land use (as specified in the risk framework of Scottish Planning Policy) is proposed, and/or;
- the development borders the coast and therefore may be at risk from climate change;

a Flood Risk Assessment or other suitable information which demonstrates compliance with SPP will be required.

Developments may also be possible where they are in accord with the flood prevention or management measures as specified within a local (development) plan allocation or a development brief. Any developments, particularly those on the floodplain, should not compromise the objectives of the EU Water Framework Directive.

Where flood management measures are required, natural methods such as restoration of floodplains, wetlands and water bodies should be incorporated, or adequate justification should be provided as to why they are impracticable.

According to the SEPA Flood Risk and Land Use Vulnerability Guidance[2] amenity, such as an electrical sub-station, is classified as “Essential Infrastructure”.

3. Site Description

The proposed development site, located at NH 48370 43009, is situated approximately 5 km southwest of the town of Beauly and around 16 km west of the city of Inverness, within the Highland Council district. The context of the proposed development relative to the surrounding area is illustrated in Figure 3-1. The River Beauly flows from the southwest to the northeast, approximately 1.2 km north of the proposed site. To the south of the site, there is an unnamed road signposted for Eskdale.

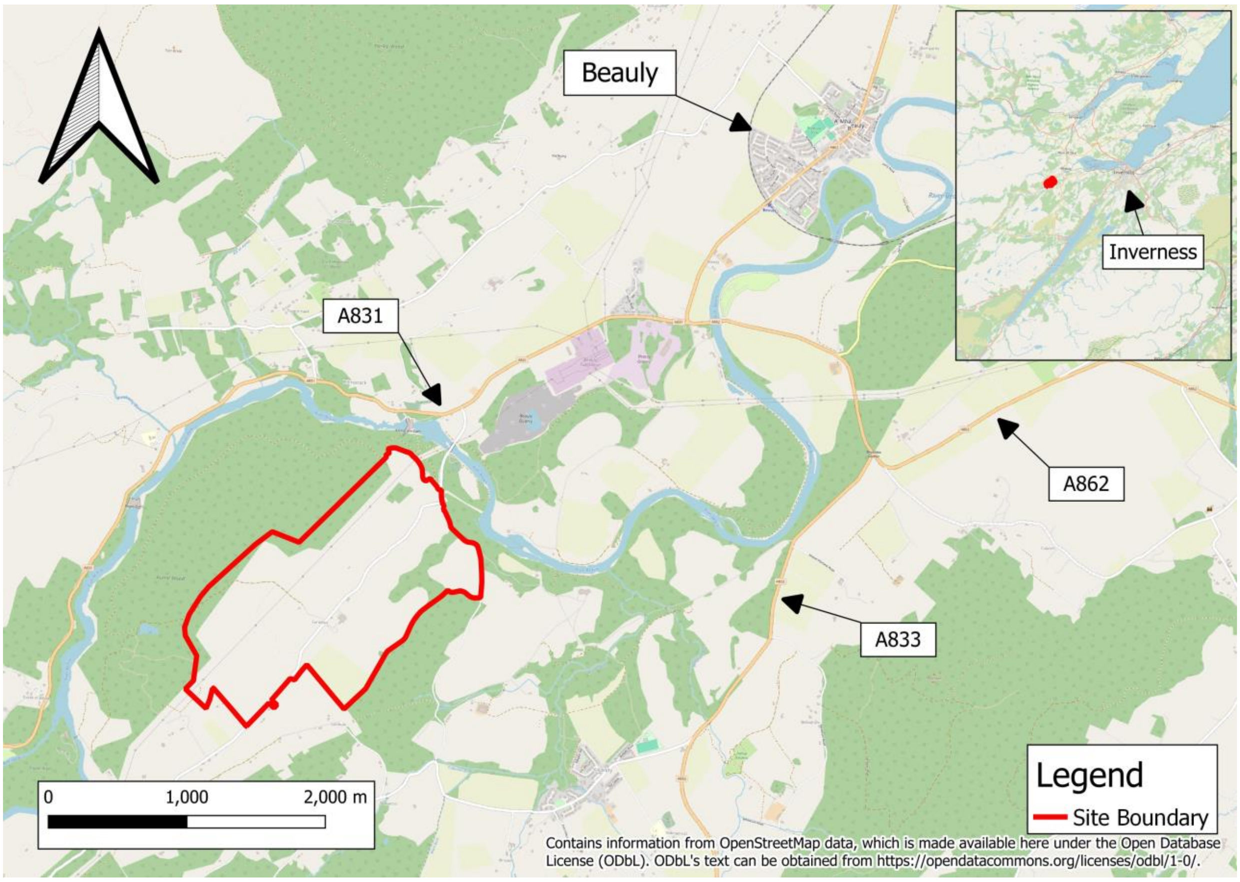

Figure 3-1: Geographical location of proposed works.

3.1 Proposed Development

The proposed Fanellan Hub development, as depicted in Figure 3-2 and detailed in the layout drawings included in the DIA and DS, consists of a platform area measuring 240,000 m² and associated haul road and SuDS which will form the study area for this FRA. This development will accommodate an associated 400 kV substation and buildings constructed atop the platform. The earthworks platform is elevated at a level of 127m AOD and features a series of landforms (landscape bunds) designed to shield the buildings and associated substation infrastructure from view.

Figure 3-2: Fanellan Hub Site Layout.

Access to the substation will be provided via a 5-metre-wide asphalt access road, along with a network of internal asphalt-bound access roads within the substation's perimeter. The switching station area of the platform will consist of a build-up of at least 1m of crushed rock and will predominantly be made of free-draining material. The converter station area will comprise a number of buildings and hardstand areas that will be impermeable.

The development will also include welfare buildings equipped with drinking water facilities, as well as a foul water system. A security perimeter fence will enclose the substation, and associated unbound access tracks will provide maintenance access to overhead line towers and preserve existing rights of access.

The outline drainage network and attenuation system have been designed in accordance with 'Sewers for Scotland v4.0'[9], 'the SuDS Manual'[10], and specific flooding guidance provided by The Highland Council. All SuDS attenuation features are engineered to store surface water runoff for the 0.5% Annual Exceedance Probability (AEP) rainfall event, plus an additional 42% climate change uplift.

Given the extensive scale of the platform, it is proposed to divide the switching station and converter station areas into separate catchments for the purposes of attenuation. This strategy aims to match pre-development discharge rates and ensure that there is no increased risk of downstream flooding to the smaller watercourses in the area. The site's location, broadly at the high point of the surrounding land, means that the watercourses are not equipped to handle large volumes of runoff.

3.2 Topography

A topographic map of the area, based on 1m resolution LiDAR[6] (in the vicinity of the proposed development site) can be seen on Figure 3-3. The map shows that the sub-station is situated on the south easterly slope of Torr Mor hill, which reaches an elevation of 156.3m AOD.

9 https://www.scottishwater.co.uk/-/media/ScottishWater/Document-Hub/Business-and-Developers/Connecting-to-our-network/All-connections-information/SewersForScotlandv4.pdf , accessed February 2024

10 https://www.susdrain.org/resources/SuDS_Manual.html ,accessed February 2024

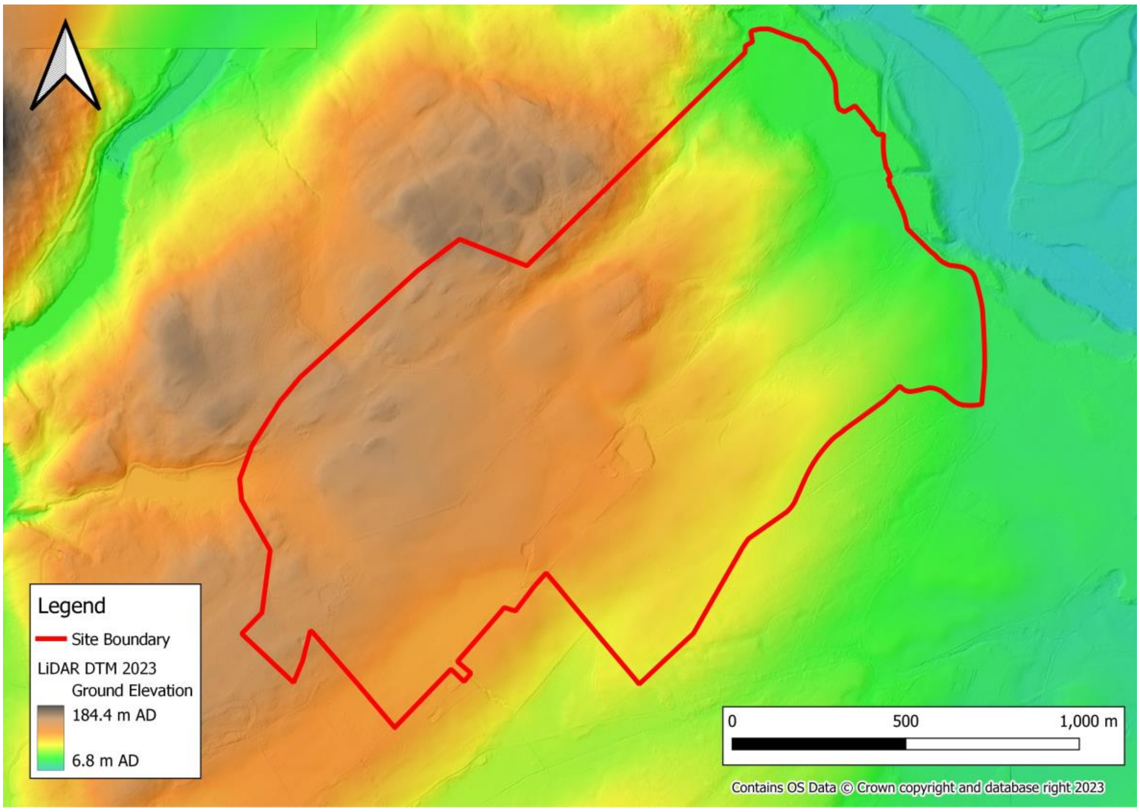

Figure 3-3: Site topography.

The site boundary is situated on a relatively uneven surface, with elevations changes of up to 60m. The highest elevation of the site is approximately 149m AOD in the northeast corner while the lowest point is around 89m AOD in the southwestern corner.

3.3 Geology, Hydrogeology and Soil Conditions

According to the BGS[4], the proposed site location is underlain by breccia, conglomerate and sandstone with subsidiary mudstone. The superficial deposits of the site are described as diamicton till. The site is underlain with a lower old red sandstone, class 2B which has the characteristics of a moderately productive aquifer, according to Scotland's environment aquifer dataset[11].

3.4 Catchment Characteristics

The proposed development site is not affected by any notable watercourses due to its elevated location near the peak of Torr Mor. However, there are several drainage paths that channel surface water from the site toward the River Beauly. According to the terrain analysis within Scalgo Live, seven flow paths have been identified, which can be seen in Figure 3-4.

[11] https://map.environment.gov.scot/sewebmap/, accessed October 2023

Flow paths 4, 5, and 6 lead directly to the River Beauly, while flow path 1 is first attenuated in a small, unnamed loch before reaching the River Beauly. Flow paths 2, 3 and 7 merge into the Bruiach Burn prior to their confluence with the River Beauly.

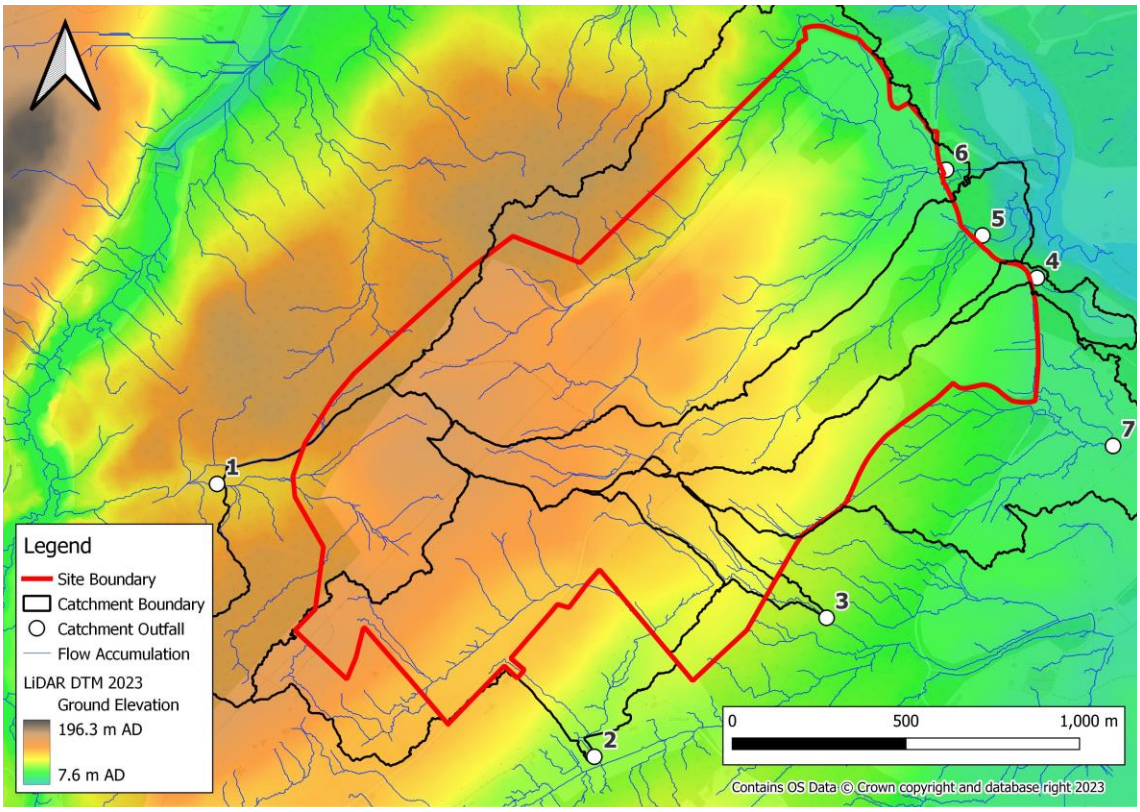

Figure 3-4: Catchment areas of the 6 drainage paths from the site boundary.

4. Existing Source of Flood Risk

Existing sources of flood risk have been assessed to understand the baseline conditions upon which any impacts arising from the development can then be evaluated. Relevant potential sources of existing flood risk include:

- Fluvial (rivers);
- Coastal
- Pluvial (rainfall / surface water);
- Sewer flooding;
- Reservoir; and
- Groundwater flooding.

4.1 Historical Flooding

The Highland and Argyll Local Flood Risk Management Plan[7] does not include any areas of flood history close to the proposed development.

A consultation response from SEPA (received 22nd of November 2023) revealed that the current SEPA Observed Flood Event (OFE) Database holds no records of flooding within the area of interest. Also, they do not hold any other flood related information.

A review of available information including local news websites also found no further evidence that the area had previously experienced any form of flooding. This lack of information may however reflect the rural and sparsely populated nature of the area.

4.2 Fluvial Flood Risk

The SEPA fluvial flood map[3] (Figure 4-1) indicates that the site is not at risk of fluvial flooding, for both the current and future scenarios. However, the small drainage ditches and flow paths identified in the map may not be fully represented on SEPA's fluvial flood maps, likely owing to their limited size and the site's rural setting. Given the site's location near the crest of a hill, it is considered that the platform will not be at risk from fluvial sources, however, it may be at risk from pluvial sources (assessed in Section 4.4). However, the access road to the site crosses a relatively small drainage channel, which may accumulate sufficient flow to pose a flood risk, especially following the construction of the SuDS basin and the embankments associated with the haul access road. To understand the flood risk implications at the haul road crossing of the channel hydraulic modelling was undertaken.

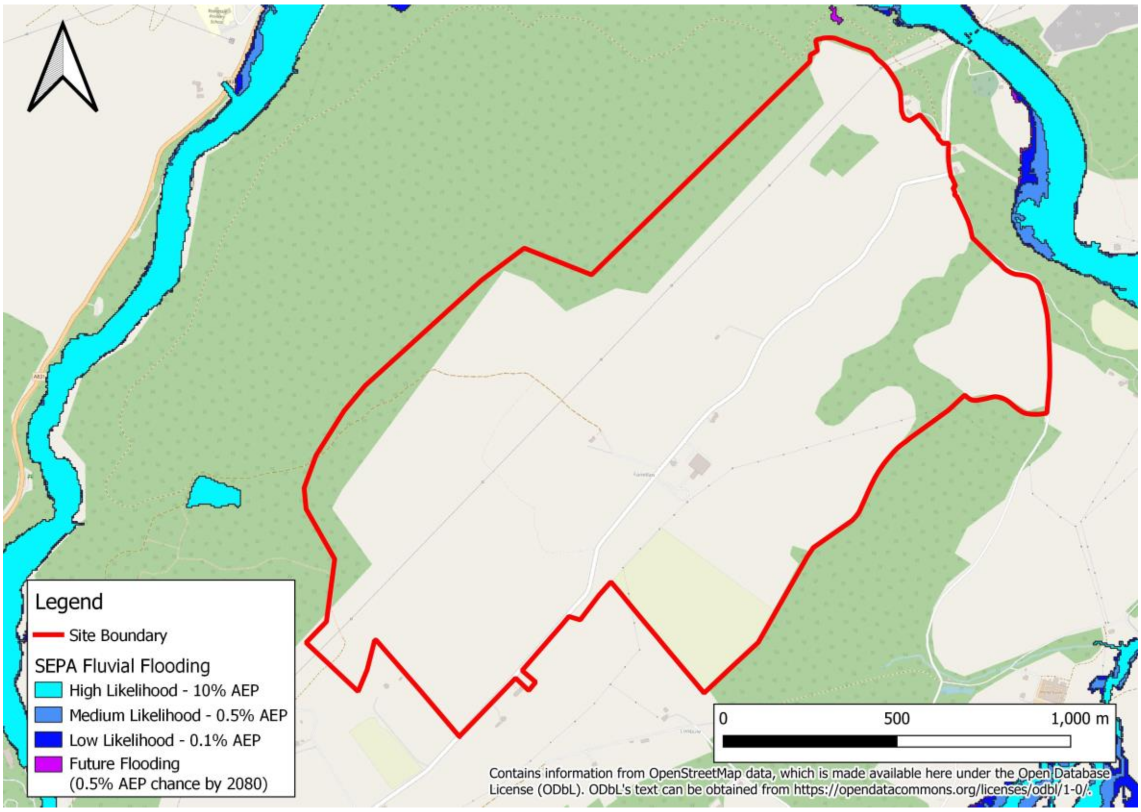

Figure 4-1. Extract from SEPA Fluvial Flood mapping.

4.2.1 Hydraulic Modelling

A two-dimensional hydraulic model was created to assess the flood risk at the haul road crossing of the unnamed watercourse within TUFLOW modelling software (version 2023). The model was developed using a variety of data sources, including:

- Google satellite and street view imagery[12]
- A LiDAR based digital terrain model (DTM) publicly available from the Scottish government website[6]
- Scalgo Live[5]
- OS OpenMap data (watercourse alignment) available from the Ordnance Survey Data Hub[13]

An overview of the model, highlighting key features, is presented in Figure 4-2.

[12] https://www.google.co.uk/maps Accessed February 2024

[13] https://osdatahub.os.uk/downloads/open/OpenMapLocal Accessed August 2024

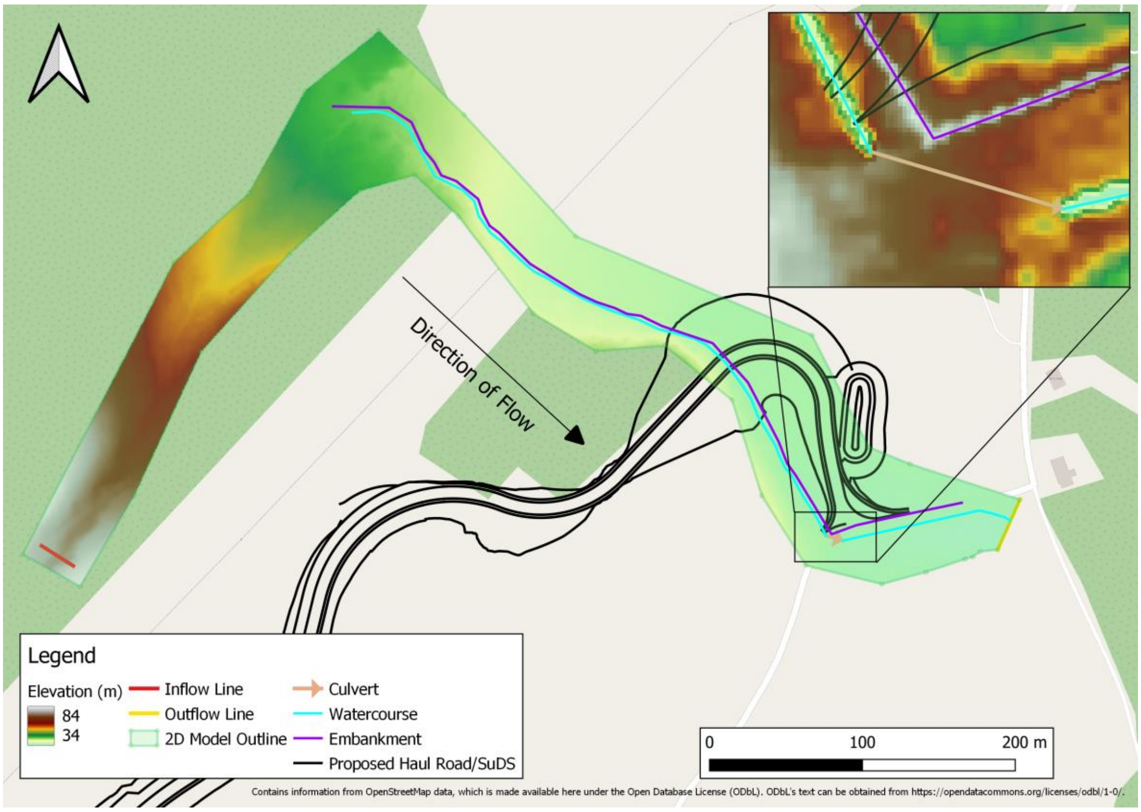

Figure 4-2. Model Overview

The model utilised 1m resolution LiDAR[6] data. However, due to the small size of the unnamed watercourse, this was not fully represented within the DRM across the area of interest. A cross-section was extracted from the LiDAR data where the watercourse and embankment were most accurately depicted. This cross-section, along with observations from Google Street View (see Appendix A), was used to define the watercourse dimensions throughout the model extents within the Scalgo Live DTM. The channel was estimated to be approximately 1m wide at the top of the banks and 60cm deep, while the embankment was also assumed to be 60cm in height. The enhanced Scalgo Live DTM was extracted for use within Tuflow.

4.2.1.1 Model Roughness

Model roughness varies throughout the model area. Polygons representing different land use types were used to define a range of appropriate Manning's values[14]. For example, 0.035 represented the watercourse whereas the culvert was given a Manning's value of 0.018. This was applied to the model to represent roughness. A list of the generic Manning's values and their associated land use types is shown in Table 4-1.

[14] https://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm Accessed August 2024

Table 4-1. Manning's values applied to model.

Land Use Types	Manning's n Value
Buildings	0.03
General Surface (Residential yards)	0.04
General Surface (Step)	0.025
General Surface (Grass Parkland)	0.03
Water (Inland)	0.035
Natural Environment (Coniferous/Non Coniferous Trees)	0.1
Roads Tracks and Paths (Manmade)	0.02
Roads Tracks and Paths (Dirt Tracks)	0.025
Roads Tracks and Paths (Tarmac)	0.02
Roads Tracks and Paths (Pavement)	0.02
Default value	0.04
General Land, short grass, fences	0.055
Culvert	0.018

4.2.1.2 Boundary Conditions

Inflow

The inflow was generated through the use of ReFH2 hydrographs, which were inserted into the upstream extent of the model. The catchment is ungauged, therefore catchment descriptors purchased from the FEH web service[15] and were used as the input for the ReFH2 software. The descriptors purchased were from a donor catchment located in close proximity and was considered to be hydrologically similar to the catchment of interest. This approach was taken because the catchment was not represented on FEH mapping. Adjustments were made to the catchment descriptors (Area, FARL and DPLBAR) to improve the accuracy of the estimation. Further detail is provided in Appendix B.

The default ReFH2 parameters were adopted which established that the critical storm duration is 1 hour 54-minutes with a 6-minute time step for the summer rainfall profile. Inflows were inserted into the hydraulic model through a lumped inflow line at the upstream end of the burn. To increase the confidence in the flow estimates a sensitivity analysis was undertaken, this was through a comparison of the ReFH2 flow rates with those derived through the FEH Statistical Approach (WINFAP5) using default parameters. Results showed that the ReFH2 results were slightly higher therefore making the chosen approach more conservative. More detail on the hydrological calculations is provided in Appendix B.

Downstream Boundary

An outflow line was placed at the downstream end of the watercourse. The location was considered far enough away from the area of interest and at a ground elevation low enough to not impact on predicted flood levels.

[15] https://fehweb.ceh.ac.uk/ Accessed August 2024

4.2.1.3 Model Performance

All simulations have a mass and volume balance error below 1%.

4.2.1.4 Baseline Model Results

Figure 4-3 illustrates the baseline flood map for the 0.5% AEP + CC storm event. The model predicts that flows will exceed bank capacity, but the embankment will prevent water from entering the adjacent field to the east. In several areas, water is expected to flow into the floodplain west of the watercourse and overtop the road to the south when the culvert under the road becomes surcharged, subsequently re-entering the channel downstream and spilling onto the southern field.

At the location of the proposed haul road, water is modelled to exceed bank capacity. Consequently, the proposed development which includes raising land within the floodplain, necessitating post-development modelling to assess the impact of the development on flooding (see Section 6.2). Therefore, the risk of fluvial flooding is classed as high.

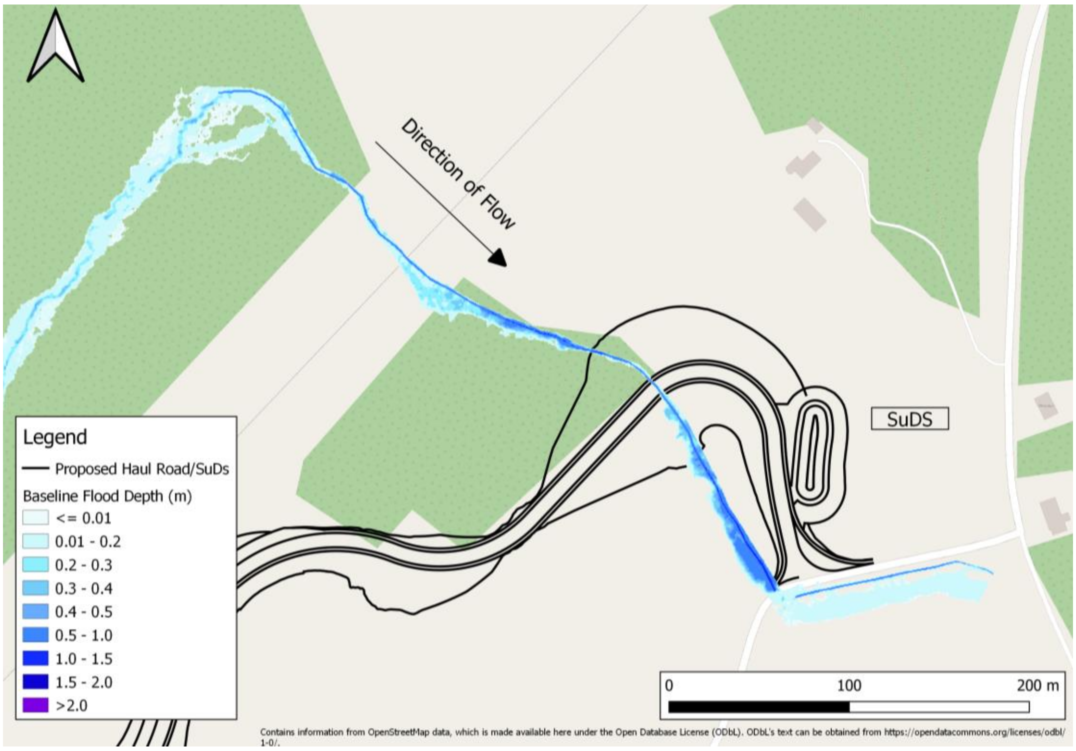

Figure 4-3 Baseline 0.5%AEP +CC flood extents.

4.2.1.5 Post Development Modelling

The baseline model has been altered to reflect the post development scenario through:

- **Surface water runoff** - The proposed development, includes SuDS that are designed to ensure that there will be no increase in water discharge into the receiving watercourses. Flow attenuation from the SuDS to the watercourse is limited to the 50% AEP plus a 42% climate change uplift for all events up to and including the 0.5%AEP event. This change has not been included within the model, this is a conservative approach.

- **Haul Road Culvert** - The haul road will be culverted over a small watercourse with bottomless bridge structure with a minimum aperture of 3m wide by 3m tall. This avoids impacts to the channel while being sufficiently sized to convey flows from the 0.5% AEP plus 42% climate change events. Additionally, the proposed culvert size will reduce the risk of blockages that could create alternative flow pathways, potentially increasing flood risk elsewhere.

Results from the post-development model can be seen in Figure 4-4.

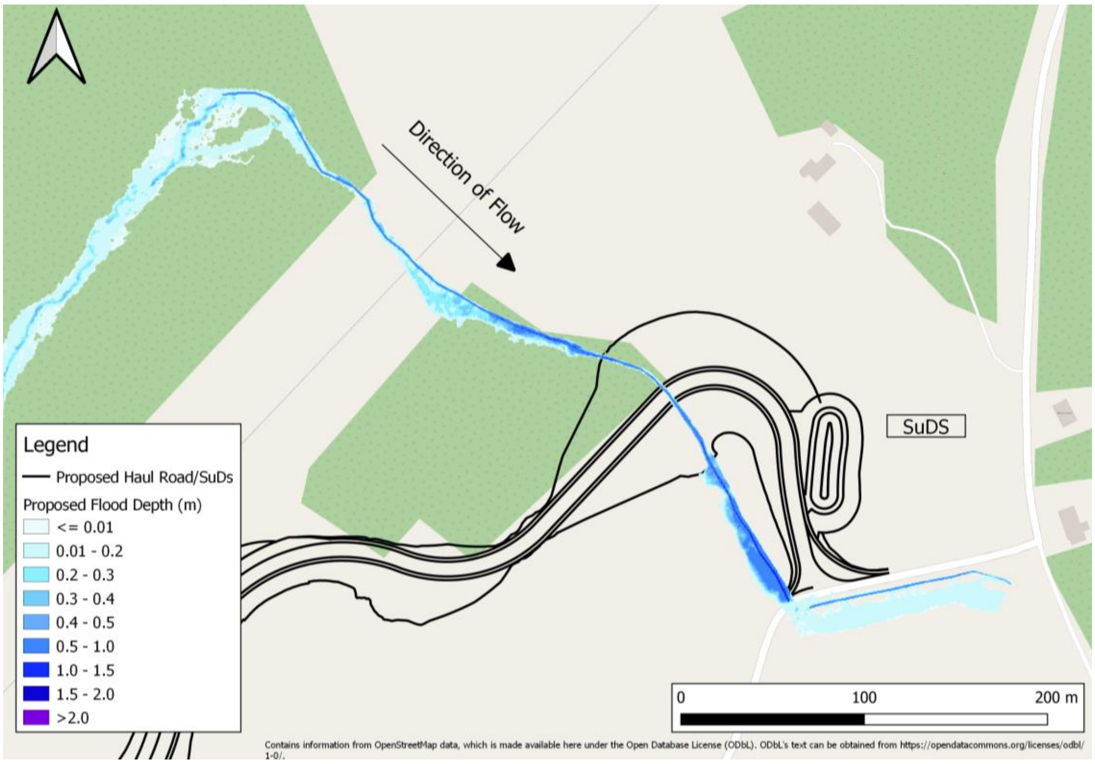

Figure 4-4. Proposed 0.5%AEP +CC flood extents.

The post-development modelling predicts negligible changes in flood levels and footprints on either side of the proposed development. This conclusion is further supported by the depth difference and wet/dry change analysis conducted and shown in Figure 4-5. The post-development scenario is expected to displace water identified within the footprint of the proposed development vertically rather than laterally. Notable depth changes are only anticipated within the culvert through the embankment, with a maximum increase on water level of 142mm.

Consequently, it is considered that the model demonstrates that the development will not contribute to any significant increase in fluvial flood risk in the surrounding areas.

The detailed design of the culvert should consider the use of wingwalls on the inlet to ensure that flood flows are directed underneath the embankment. The perimeter of the embankment should include drainage / cut off ditches to direct any overland flow south, through pipes under the existing highway and back into the existing channel. The modelling showed that receptors are not at risk of fluvial flooding when the Haul Road was added into the post-development scenario.

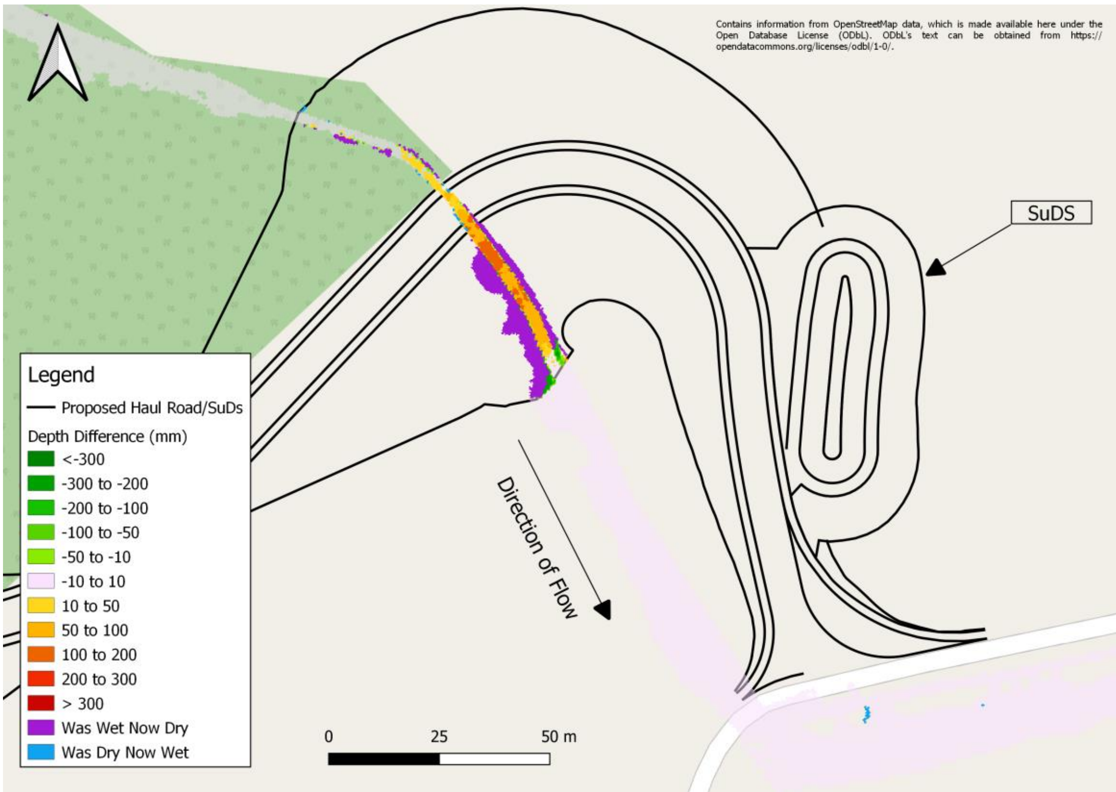

Figure 4-5. Proposed vs Baseline Depth difference and wet/dry change.

4.3 Coastal Flood Risk

The site is located inland and at an elevation above the reach of any risk from coastal flooding. Therefore, flood risk is considered low.

4.4 Pluvial (Surface Water) Flood Risk

The SEPA Surface Water Flood Map[3] (referenced in Figure 4-6) indicates that several areas within the site's red line boundary are subject to a high (10% AEP) chance of flooding in any given year. These vulnerable locations correspond with topographic low points within the site's boundary. Considering the relatively small extent of these surface water flooding areas, the risk of flooding is assessed as medium.

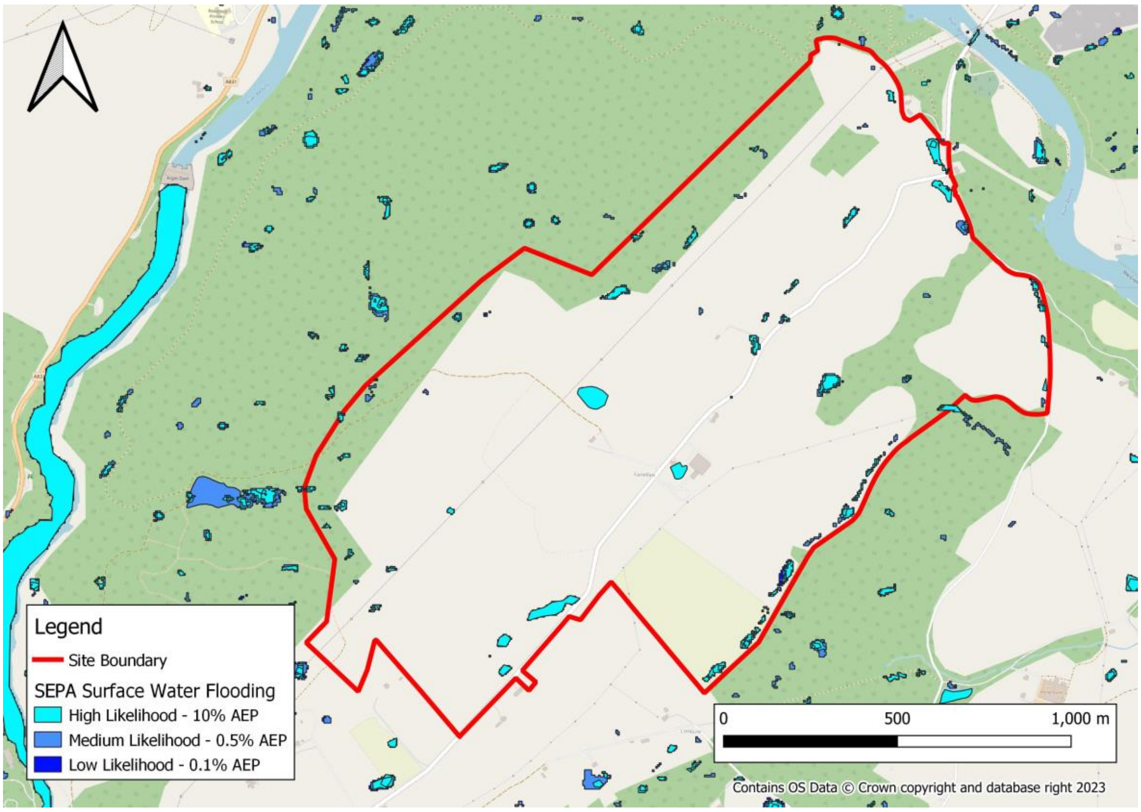

Figure 4-6: Extract from SEPA Surface Water Flood mapping.

To ensure that the pluvial flood risk is managed as a result of the development, which includes the creation of approximately 240,000m^2 of impermeable area, a drainage strategy has been developed. This includes dividing the platform into four catchments (Converter Station, two catchments for the Switching Station and a final catchment collecting run-off and ground water from rock cuttings to the west of the convertor station) to align surface water attenuation with the pre-development greenfield runoff catchments as detailed in the DS and DIA.

SuDS will be utilised to store and attenuate the additional surface water produced by the development for events up to the 0.5% AEP plus a 42% climate change uplift. The Switching Station will be constructed with a granular substrate to facilitate attenuation. Surface water will be directed to a filter drain that leads to the SuDS basins via a carrier drain. The water will be temporarily held in the SuDS basin before being released to the original site drainage features at a controlled rate through a flow control chamber. Due to their small nature, the drainage features will receive flows at a lower rate than the calculated greenfield runoff rate to ensure there is no detriment to the small watercourses. Furthermore, during normal conditions, the flow within the drainage features will be retained to normal flow rates.

The resilience of the system to the exceedance (0.1% AEP) event has also been tested, confirming that any overflow will be managed within the SuDS infrastructure through an attenuation exceedance route leading to a cut-off ditch. This route ensures that water is diverted to the existing drainage features without increasing the flow during a 0.5% AEP event plus 42% climate change uplift.

The SuDS basin/Haul road located to the northeast of the development will have drainage ditches around the base to direct any overland flow back into the watercourse via a pipe under the unnamed road to the south.

Receptors will remain unaffected due to the SuDS features installed on the site.

For more detailed information on the pre- and post-development runoff rates, please refer to the DS and DIA.

4.5 Risk of Flooding from Sewers

No historical evidence of sewer flooding within the area was found as Scottish Water hold no sewer assets in this area. Therefore, risk of sewer flooding is considered low.

Foul water generated on the site will be treated and discharged to a septic tank. As usage of the foul system is expected to be low, the risk of overflow and impact on receptors close by is significantly reduced.

4.6 Risk of Flooding from Reservoirs

The SEPA reservoir inundation map[16] indicated that the proposed development is not at risk of reservoir flooding due to the site's elevation. The risk associated with reservoir flooding is therefore low.

4.7 Groundwater Flood Risk

A review of the geological information (referenced in Section 3.3) indicates that the proposed development is underlain by aquifers with moderate productivity regarding groundwater. There has been no evidence of previous groundwater flooding in the area.

Groundwater level monitoring and observations made during ground investigation indicate that groundwater is shallow, and present in both the superficial Glacial Till (within granular sands and gravels) and the underlying bedrock conglomerate. Groundwater flow within the bedrock is expected to be predominantly within weathered rock and through fractures, evident within the conglomerate. The rate of flow of groundwater will therefore vary depending on the degree of fracturing. Consequently, the risk of groundwater flooding at this site is considered to be high.

Groundwater ingress onto the site is expected to increase as a result of cutting into the bedrock for the platform. These flows are expected to fluctuate based on the level of bedrock fracturing. Mitigation (drainage) measures are incorporated in the site layout to manage the risk of groundwater flooding and is detailed in the DIA. Receptors are considered safe from groundwater risks due to the implementation of mitigation measures.

[16] https://map.sepa.org.uk/reservoirsfloodmap/Map.htm accessed October 2023

4.8 Summary of Flood Risk

A summary of the estimated level of flood risk from each source to and from the development (including receptors) can be found in Table 4-2..

Table 4-2: Summary of flood risk screening assessment

Source of Flood Risk	Baseline Flood Risk	Post Development Flood Risk
Fluvial	High	Low
Pluvial (Surface Water)	Medium	Low
Coastal	Low	Low
Sewer	Low	Low
Reservoir	Low	Low
Groundwater	High	Low

5. Flood Risk Vulnerability Guidance

This assessment is based on the SEPA Flood Risk and Land Use Vulnerability Guidance[2]. The guidance outlines different types of developments and which classification they fall under (under Table 1 and Table 2 in the guidance).

The proposed development represents essential utility infrastructure (power stations and grid and primary sub-stations) and is classed as 'Essential Infrastructure'. The proposed development is also in the category: 'Medium to high risk within undeveloped and sparsely developed area (>0.5% AEP)'. Under this category, the guidance states:

"Generally suitable where a flood risk location is required for operational reasons and an alternative lower-risk location, is not available – development should be designed and constructed to be operational during floods (i.e. 0.5% AEP), and not impede water flow."

The proposed development aims to minimise the impact on fluvial, groundwater, and pluvial flood risks by implementing SuDS features designed to store and attenuate flows for events up to the 0.5% AEP plus Climate Change event. Water will be discharged into the receiving watercourses at a rate that is less than or equal to the pre-development greenfield runoff rate, as detailed in the Drainage Strategy.

6. Conclusion

The proposed development entails constructing a new electrical substation near Beauly, within The Highland Council district. An assessment of available data classifies the site, under baseline conditions, as having a medium risk of surface water flooding and a high risk of fluvial and groundwater flooding, while other potential flooding sources are assessed as low risk. Baseline and post-development modelling were conducted near an unnamed watercourse, where the haul road and associated SuDS basin are situated. The baseline modelling indicated that the proposed development lies within the floodplain; however, post-development modelling showed that the impact on flooding is negligible. Additionally, it is recommended that the detailed design of the scheme considers mitigation measures such as wingwalls to channel flow into the culvert and drainage ditches around the perimeter to redirect overland flow back to the watercourse, that could ensure the risk of flooding is minimised during residual and exceedance events.

The DIA and DS demonstrate that the development will include SuDS measures, which aim to store, attenuate, and redirect surface and groundwater flooding away from the site, comply with guidance from the local authority and the SEPA. These measures are expected to have a neutral or even beneficial effect on flood risk both upstream and downstream.

Receptors near the site are considered to be unaffected by the proposed development.

Appendix A

Google Streetview Assumptions

Figure A-1 images used for assumptions about channel and embankment geometry. Blue line = top of bank. Green line = toe of channel. Yellow line = embankment

Appendix B

Hydrology Note

As the catchment of interest in this study is essentially rural and ungauged, design flows were derived using methods endorsed by the Flood Estimation Handbook (FEH), to create inflow files for the hydraulic model. Catchment descriptors were purchased from the FEH web service[15], however due to the size of the catchment of interest, this is not included in the FEH catchment model. Therefore, a donor catchment, the Bruiach Burn tributary, was purchased, and descriptors were adjusted for the catchment of interest. Both the catchment of interest and donor catchment are shown in Figure A-1.

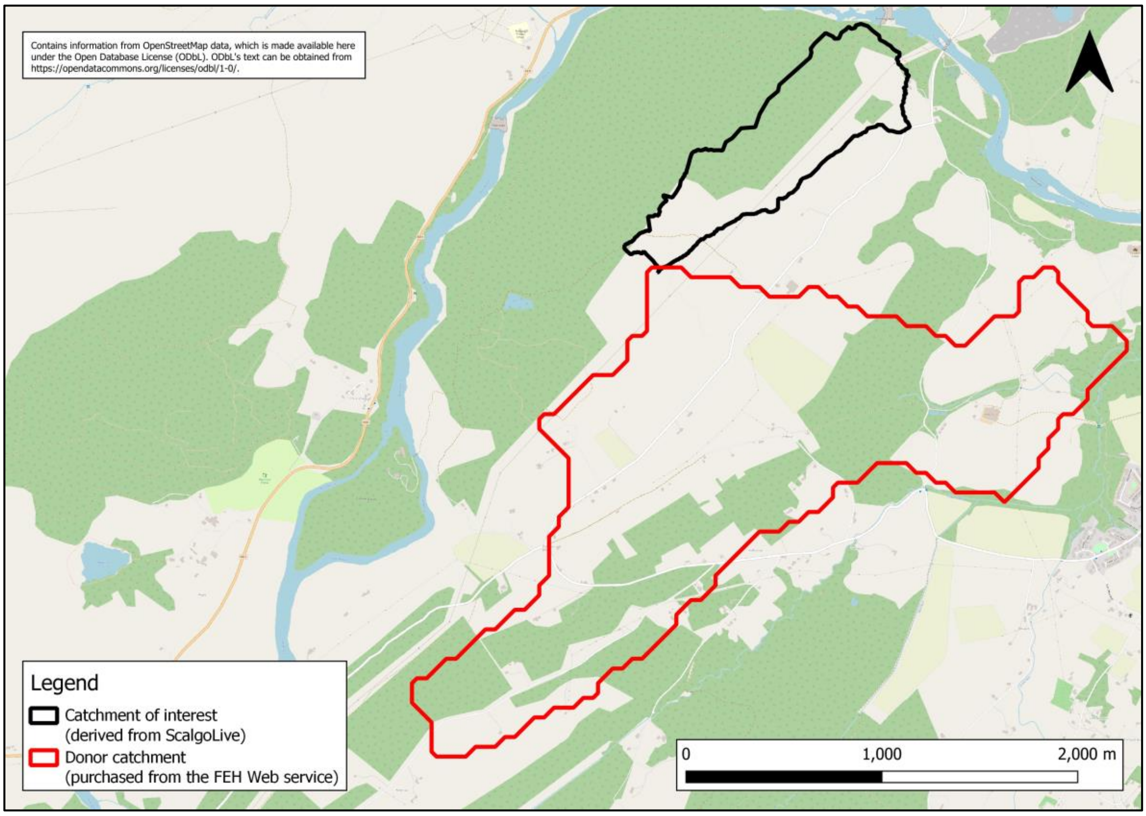

Figure A-1 Catchment of interest and donor FEH catchment

The donor catchment was found to be appropriately similar to the catchment of interest following a review of descriptors and background information. Area, FARL, and DPLBAR values were manually adjusted as shown in Table B-1.

Table B-1 Summary of adjusted catchment descriptors

Catchment Descriptor	Default Value	Adjusted Value	Method
Area	3.58 km^2	0.65 km^2	Area derived using ScalgoLive[5]
FARL	0.994	1	A review of OS and satellite mapping revealed that there is no attenuation from ponds or reservoirs in the catchment. FARL set to 1 to signify no attenuation.
DPLBAR	2.45 km	0.79 km	Derived using the equation: $\mathrm{DPLBAR} = \mathrm{AREA}^{0.548}$ From FEH 5, Adrian Bayliss[17]

The adjusted descriptors were run through ReFH2 (version 4.1) with a summer rainfall profile, a 1 hour 54-minute storm duration and a 6-minute timestep. Hydrographs were then simulated. The climate change allowance suitable for this catchment is 42% according to SEPA[18], due to the catchment being smaller than 30km^2 and being located in the North Highland region. As the peak rainfall allowance is appropriate, the uplift was applied to the rainfall inputs on ReFH2 which resulted in a maximum of ~64% increase in peak river flow for the 200-year return period.

Flows were derived through WINFAP5 using the FEH statistical (pooling group) method as a comparison to ReFH2. The peak flow results for the default pooling group are shown alongside the ReFH2 results in Table B-2. It was found that the ReFH2 flows were slightly higher than the flows derived from the FEH statistical, particularly for the longer return periods. The difference was found to be 7% for the 200-year event.

[17] https://www.ceh.ac.uk/sites/default/files/2021-11/Flood-Estimation%20Handbook-5-Catchment-Descriptors_Adrian-Bayliss.pdf
[18] https://www.sepa.org.uk/environment/land/planning/guidance-and-advice-notes/

Table B-2 Peak flow results from FEH stat and ReFH2

Return Period (year)	FEH Statistical (Pooling Group) method Peak Flow m^3/s	ReFH2 Method Peak Flow m^3/s
2	0.14	0.13
5	0.20	0.18
10	0.24	0.23
30	0.33	0.33
50	0.37	0.38
100	0.44	0.47
200	0.53	0.57
1000	0.79	0.85
200 + 42% Climate Change	0.75	0.93

Ultimately the final choice of method was to use hydrographs derived from ReFH2.4. ReFH2 was favoured over the FEH statistical method due to the small size of the catchment, as the former method is better calibrated to small ungauged Scottish catchments according to SEPA guidance. The FEH dataset has a low number of small, gauged catchments meaning that results are skewed by the characteristics of larger river catchment. Furthermore, the EA guidance states that on average the ReFH2 method gives a slightly reduced biased than the FEH statistical method when estimating QMED on small catchments.

Inflows were inserted into the hydraulic model through a lumped inflow line at the upstream end of the burn. Final hydrographs derived from the ReFH2 method are shown in Figure B-2.

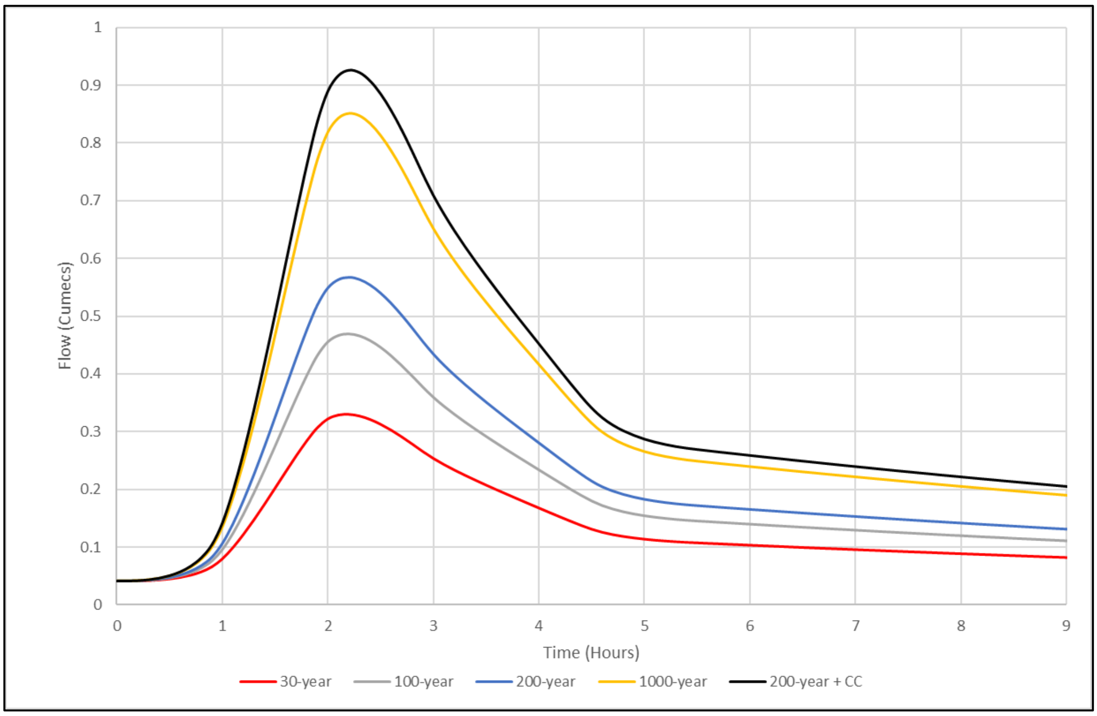

Figure B-2 Final Hydrographs from ReFH2