# LT470 – Carnaig Substation

# Flood Risk Statement

Prepared for

J Murphy & Sons Ltd

Scottish & Southern Electricity Networks (SSEN)

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## Contents

# 1. Introduction

## 1.1. Background

J Murphy & Sons (Murphy) has commissioned Tony Gee and Partners LLP (TG) to produce a Flood Risk Statement (FRS) to inform the design and planning application for the proposed development 400kV Carnaig Substation.

The proposed location for the 400kV substation is adjacent to the existing Loch Buidhe substation, north of Bonar Bridge. The new substation will enable the connection of a proposed 400kV line between Banniskirk Substation and Beauly Substation.

The flood risk statement should be proportionate to the development proposal and design stage. At the time of writing this FRS, no detailed design has been produced and hence the FRS presented here is Level 1 (screening study) based on a desktop approach. Where the FRS has identified potential flood risk impacts, flood mitigation measures have been considered, and recommendations based on engineering judgement are made on appropriate development design and possible mitigation measures.

## 1.2. Sources of Flooding

The assessment of flood risk has considered all sources of flooding, as listed below:

- Pluvial Flooding
- Fluvial Flooding
- Groundwater Flooding
- Flooding from Sewers and Water Mains
- Flooding from Land Draining and Artificial Drainage
- Flooding from the Failure of Water Retaining Structures
- Coastal/Tidal Flooding

## 1.3. Assessment Criteria

*Table 1: SEPA Flooding Likelihood*

| Flooding Class | Likelihood Description |
|---|---|
| High Likelihood | A flood event is likely to occur in the defined area on average once in every ten years (1:10). Or a 10 % chance of happening in any one year. |
| Medium Likelihood | A flood event is likely to occur in the defined on average once in every two hundred years (1:200). Or a 0.5 % chance of happening in any one year. |
| Low Likelihood | A flood event is likely to occur in the defined area on average once in every thousand years (1:1,000). Or a 0.1 % chance of happening in any one year. |

It should be noted that Scottish Planning Policy (SPP) uses risk categories to describe flood zones which correspond with SEPA's likelihood terminology, i.e., SEPA's Low Likelihood of flooding category is equivalent to the Low Risk of flooding category in SPP.

# 2. Methodology

A systematic approach was undertaken in order to assess the substation against flood risk, as generally identified in ETR 138:

1. Establish any historical flooding records (Provided by SSE) for the substation;
2. Review publicly available flood Maps;
3. Review SEPA Mapping to identify if the site may be protected by a flood protection scheme sponsored by the appropriate public body;
4. Identify mitigation measures if easily deliverable or further investigation work where required if site is unprotected by a public scheme.
5. Undertake site visit to view local conditions against information collated in the above desktop study – to be completed at a later date.

Tony Gee and Partners has been commissioned by Murphy, to undertake an FRS for Carnaig Substation, specifically to address whether the substations are at risk from a 1:200-year event for all publicly available sources of flooding, and to identify the flood impact.

Tony Gee have prepared a Preliminary Sources Study Report (PSSR). This covers a high-level summary of publicly available known issues, including whether a flood protection scheme is being implemented by the appropriate public body, and will serve as the basis for any recommendations for further study or the most appropriate flood protection system if unprotected by a public scheme.

## 2.1. Guidance

The site FRS provided is prepared to meet the requirements of the following documents:

- SEPA 'Technical Flood Risk Guidance For Stakeholders';
- Energy Networks Association (2009) 'Engineering Technical Report 138' (ETR 138);
- DEFRA / SEPA 'Coastal flood boundary conditions for UK mainland and islands'; and
- Scottish Planning Policy (SPP).

SEPA's guidance (SEPA, 2022) outlines the methodologies that may be appropriate for hydrological modelling, including the information SEPA requires to be submitted as part of a Flood Risk Assessment (FRA).

ETR 138 (Energy Networks, 2018) is a report presenting a risk-based methodology and provides guidance on how to improve the resilience of substations to flood events.

The report provides an overview on the impact of flooding on the UK electricity supply system and subsequent risks upon society. It provides guidance on flood risk information, mapping and planning requirements for flood defences to the electricity network.

ETR 138 sets out a systematic methodology for FRAs for substation sites, with a process for determining mitigation based on a cost/benefit assessment.

SPP is a non-statutory document which sets out the Scottish Government's policy on how nationally important land use planning matters should be addressed.

In paragraphs 255 to 268, SPP sets out guidance for development within areas of flood risk, including the responsibilities of planning authorities in regulating and controlling development in such areas in order to prevent increased risk of flooding in the future. SPP emphasises the need to apply sustainability principles to the prevention of flooding and the control of future development.

## 2.2. Data Sources

The FRS considers flood risk from fluvial, pluvial and coastal flood events, based on data from the following sources:

- Site visits;
- Eyewitness accounts (where provided);
- Digital Terrain Models and LiDAR data (where available);
- Biennial Reports
- Strategic Flood Risk Assessments;
- Flood Risk Management Plans;
- Historical flood events;
- Previous flood studies; and
- SEPA Flood Maps

## 2.3. Approach

The FRS for the substation was progressed using the following approach:

- Step 1: Data gathering and assessment, including desk top study of available information and utility search local to substation;
- Step 2: Review information from SEPA and relevant Council to obtain flood records;
- Step 3: Site visit of the proposed substation site;
- Step 4: Data collation, including full photographic record;
- Step 5: Assessment of flood risk using appropriate method.

The residual flood risk will be classed as negligible (where little or no risk is identified), low (where theoretical risk is identified but mitigating factors may influence flood levels) or moderate to high (where modelled levels or historical events show risk to the substation site).

# 3. Topographical Data

LiDAR data is used where it is available to achieve an approximate representation of topography and features. Where LiDAR is not available, aerial photography derived 2 m DSM is used with a Vertical accuracy of +/- 50 cm RMSE. In particularly remote areas, DTM data may be the only data set available.

Where DTM is used, due to the prominent influence that buildings and roads have on pluvial flow pathways and flood plains that include urban areas, it may be appropriate to represent these features within the DTM. Buildings may be represented by either 'stamping' them onto the DTM or by using appropriate Manning's roughness values to represent buildings as part of the model grid.

# 4. Flood Risk Statement Methodology

Based on our experience in the use of SEPA Flood Risk Management Map resource, the methodology progressed was based on a process of data collection and visual inspection in advance of progressing the FRS.

The reason for this approach is that SEPA maps are based on relatively high-level topographical data, and they exclude consideration of existing flood defence works. While these principles deliver a highly valuable resource to determine national levels of risk and resilience, it has been found that on a local basis natural or manmade feature can protect sites in a manner acceptable for the asset type without further intervention.

Therefore, in its simplest form an assessment of the risk of flooding to a site might only require some basic information. This may include a record of finished levels related to nearby watercourses, appropriate photographs and/or any nearby known validated historical flood levels.

## 4.1. Desk Study Methodology

The SEPA Flood Risk Management Maps may not represent a likely flooding scenario, and a Desk Study methodology has been used to approximate the risk.

This process involves identifying the source and type of flooding in in the local area and evaluating whether the natural topography and / or man-made features would limit flood water reaching the distribution substation site. This shall be confirmed with a site walkover.

The methodology includes a review of historic flood records and other data sources available to assist in identifying or confirming conclusions of the assessment.

It should be noted that detailed flood modelling and associated assessment of risk on a quantitative basis is outside of the scope of this study.

# 5. Preliminary Source Study

This section presents the information gathered on the existing topographical, geological, hydrological, and hydrogeological conditions of the proposed Carnaig site and its immediate surroundings.

## 5.1. Location

The substation is being proposed in Loch Buidhe, just off the Lochbuie Road, IV24 3AT. National grid reference NH 65098 97444.


*Figure 1: Arial image of the proposed site location (Google Earth)*

## 5.2. Topography

Using OS height data (OS Maps, 2024) to identify the levels and gradients within the Carnaig site. It was found that the lowest point within the site area is in the north-west corner which lies at approximately 210m AOD. The high point was identified at the south-east of the proposed site which lies at approximately 235m AOD. The height difference throughout the site is approximately 25m with an average slope of 1 in 21.2 (4.72%).

The wider topography surrounding the substation is shown in Figure 2 below using Scotland Topographical Maps (Scotland Topographical, 2024). The proposed substation platform level approximately 220m AOD and topography slopes south-east to north-west.

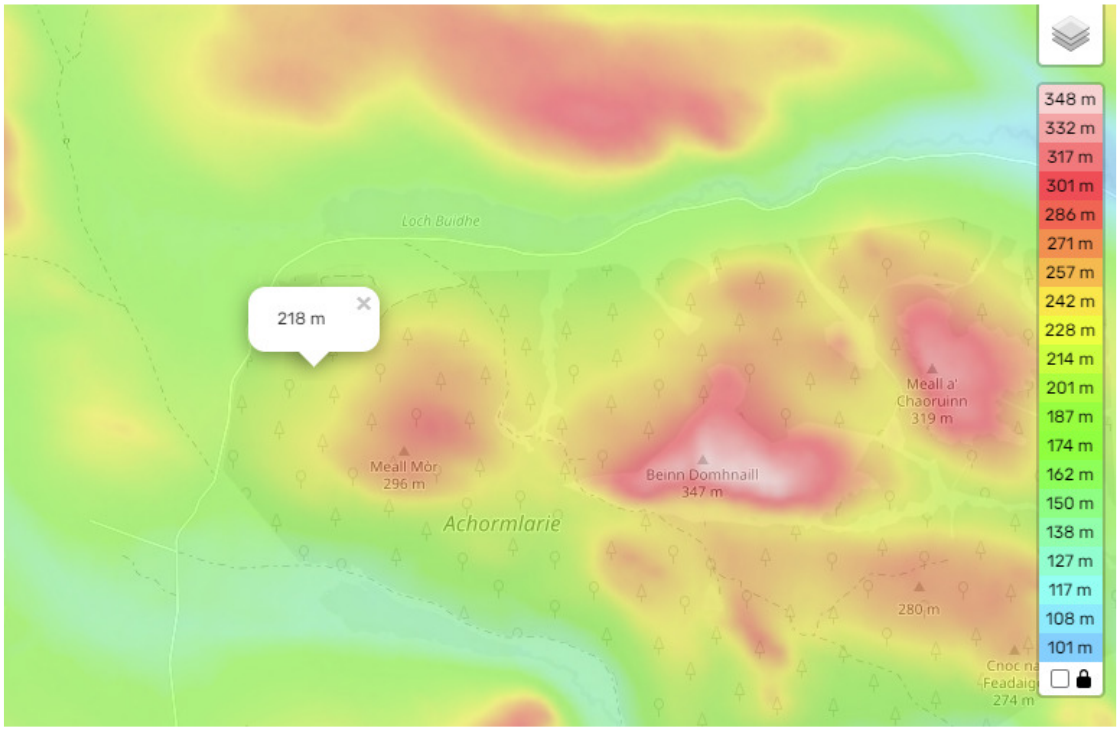


*Figure 2: Topographical map (Scotland Topographical, 2024)*

## 5.3. Geology and Soil

### 5.3.1. Geology

The geological conditions of the proposed site were identified utilising the British Geological Society (BGS, 2024) Spatial Resources online geological mapping system. This indicated that the site had superficial deposits that were recorded as Peat Formation, and bedrock deposits were recorded as Altnaharra Psammite Formation.

SSEN appointed IGNE (IGNE, 2024) in 2023 to undertake a ground investigation for the proposed Carnaig substation location. The ground investigation included cable percussion boreholes, sonic boreholes, trial pits, soakaway pits and peat probing. At the time of writing the report, the factual report has not been produced but some preliminary logs have been received. Table 1 shows the ground profile which has been taken from borehole BH11.

*Table 2: Ground Profile*

| Depth to base of strata (m) | Thickness (m) | Description |
|---|---|---|
| 1.9m | 1.9m | Peat – Dark brown spongy pseudo-fibrours peat with routlets |
| 2.5m | 0.6m | Gravel – Greyish brown very sandy silty fine to course gravel subangular and subrounded of various lithologies |

| | | |
|---|---|---|
| | | including granite and psammite with traces of peat. Sand is fine to course. |
| 6.0m | 3.5m | Sand – Grey gravelly silty fine to coarse sand. Gravel is subangular and subrounded of various lithologies including granite and psammite fine to course. |
| 7.65m | 1.65m | Gravel – Brownish grey very sandy very silty fine to course gravel. Subangular and subrounded of various lithologies including granite and psammite with cobbles. Sand is fine to course. |
| 8.1m | 0.45m | Possible bedrock |

### 5.3.2. Soil

Different soil types have different infiltration characteristics, the efficiency of which is dependent upon the structure and infiltration capacity. Scotland's Soil map (Scotland's Soil, 2024) has been utilised to obtain soil data. It classes the soil at the proposed Carnaig Hub site as "*Freely Drained*".

### 5.3.3. Rainfall

According to the Wallingford Procedure 'Winter Rain Acceptance Potential' (WRAP) map, the soil classification for the site is Class 5. This soil class has a Standard Percentage Runoff (SPR) of 0.5, a "*high*" runoff rate and a "*very low*" WRAP. Described as soils of wet uplands with peaty or humose surface horizons and impermeable layers at shallow depths.

A review of the watercourse catchment and rainfall characteristics was undertaken using data from the FEH web service (FEH Web Service, 2024). For the overall GBW catchment, the standard average annual rainfall (SAAR) is given as 1,038mm.

## 5.4. Hydrology

According to the Scottish Environment Protection Agency (SEPA), the site lies within Highland Scotland District. Within this, the Carnaig substation lies in the Loch Buidhe catchment.

### 5.4.1. Local River Network

The proposed site is within the river catchment of the An Aidh River.

## 5.5. Flood Zone Classification

The Scottish Environment Protection Agency Flood Map for Planning is located in an area described as *"High Likelihood"* of flooding as shown in Figure 5. This is categorised as being the high level for flood risk and comprises land assessed as having a 10% chance of flooding each year for surface water flooding.

## 5.6. Hydrogeology

The proposed site is not located within any source protection zones (SPZs) (Scottish Government, 2014).

### 5.6.1. Aquifers

According to the Scottish Environment Protection Agency Water Classification Maps, the proposed site is in the location of "*moderate*" productive aquifer.

### 5.6.2. Groundwater Vulnerability

Groundwater Vulnerability refers to the intrinsic geological and hydrogeological characteristics that determine the ease at which groundwater may be contaminated by human activities. The more vulnerable the groundwater is, the more easily it can be contaminated by surface water.

According to the Scottish Environment Protection Agency Water Classification Maps (SEPA, 2024), the site has a "*good*" potential groundwater vulnerability.

### 5.6.3. Groundwater level

SSEN appointed IGNE (IGNE, 2024) in August 2023 to undertake a ground investigation for the proposed substation location. The ground investigation included cable percussion boreholes, sonic boreholes, trial pits, soakaway pits and peat probing. The plan of the GI works is shown in Figure 3.

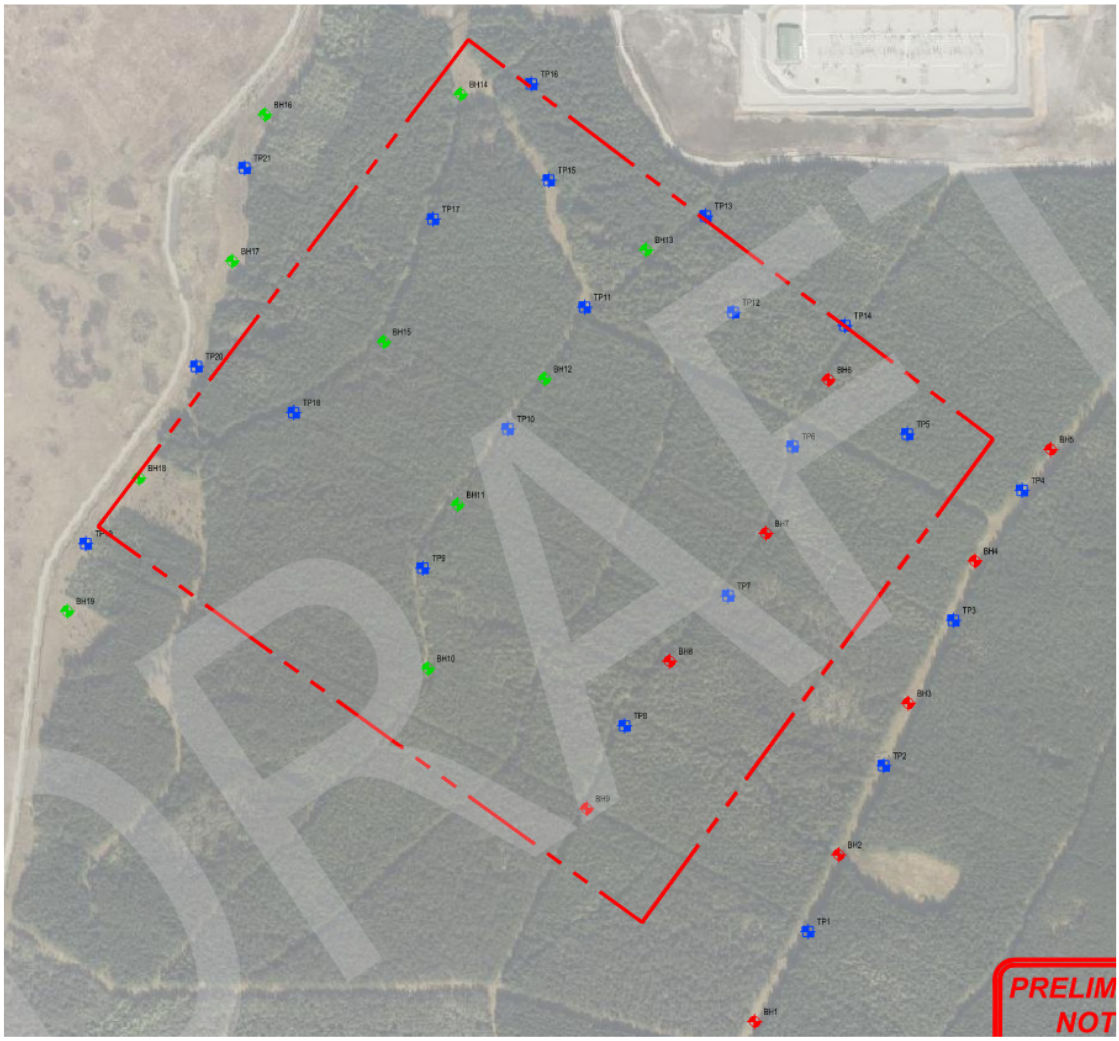


*Figure 3: Ground Investigation locations*

The groundwater level has been recorded throughout the ground investigation works and continues to be recorded at the time of writing this report. The water level measurements taken from the ground level is found to be varied throughout the site. Table 3 below shows the highest depth to water recorded across the water monitoring stations from 14th November 2023 to 10th January 2024.

*Table 3: Depth to water (groundwater)*

| Borehole | Date recorded | Depth to Water (m) | Depth (mOD) |
|---|---|---|---|
| BH02 | 14/11/2023 | 1.71 | 234.80 |
| BH03 | 11/12/2023 | Dry | N/A |
| BH04 | 11/12/2023 | 0.23 | 235.37 |
| BH06 | 10/01/2024 | 2.00 | 217.88 |

| | | | |
|---|---|---|---|
| BH07 | 09/01/2024 | 3.23 | 219.77 |
| BH09 | 11/12/2023 | 0.11 | 221.62 |
| BH11 | 09/01/2024 | 2.99 | 209.18 |
| BH13 | 20/11/2023 | 0.41 | 206.65 |
| BH15 | 13/11/2023 | 0.47 | 200.76 |
| BH16 | 10/01/2024 | 2.06 | 183.97 |
| BH18 | 11/12/2023 | 0.06 | 193.41 |

The groundwater is found to be highest around the west corner adjacent to the road where it was recorded at being 0.06m below ground level (bgl) (BH18). However, this borehole is remote of the proposed platform location and associated drainage network and may not be representative what the groundwater at the location of the platform. The groundwater was at its lowest towards the east of the site where it was recorded at being 3.23m bgl (BH07).

## 5.7. Existing Hydrological Features

The desk study found surface water bodies within a 5km radius are Lochs.

### 5.7.1. Lochs

The ‘Loch Buidhe’, ‘Loch an Lagain’ and ‘Loch Laro’ are waterbodies that could be classified as lochs and are located nearby the proposed substation. The nearby lochs are shown in Figure 4. Loch Buidhe is located 0.57km to the north and Loch an Lagain is located 1.1km to the south of the proposed substation. Loch Laro is further afield at 3.7km north-west from the proposed site. Loch Buidhe is 162m AOD and Loch an Lagain is 137m AOD, both are which lower than the proposed substation which lies at approximately 210m AOD.

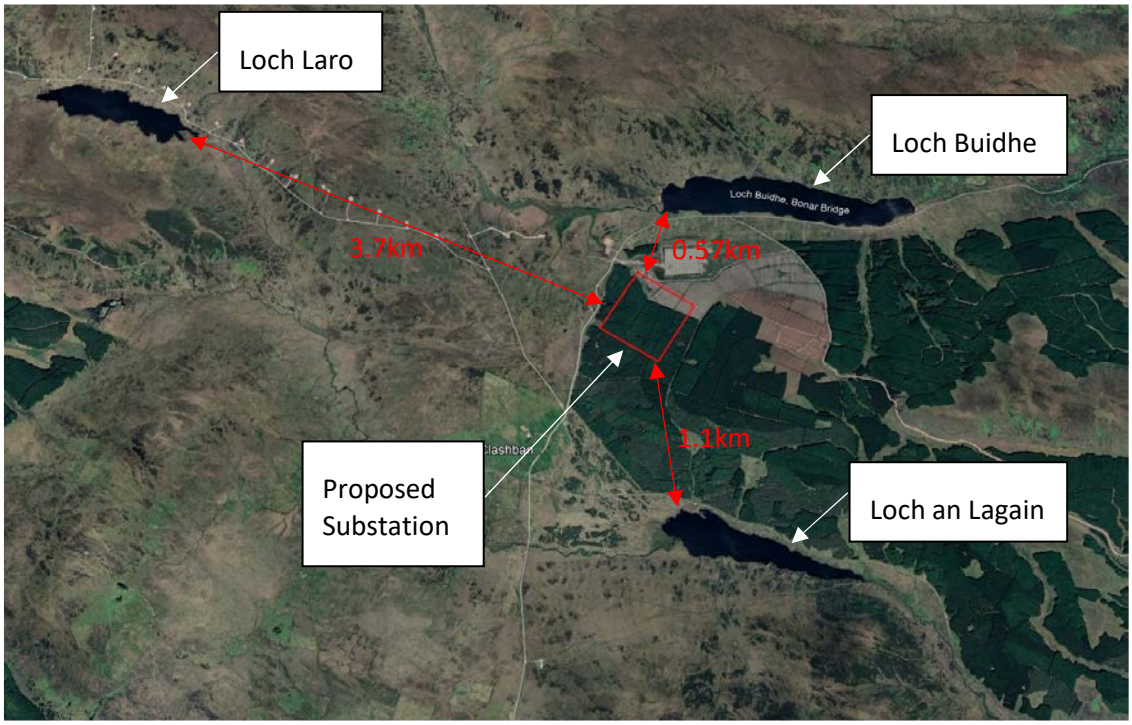


*Figure 4: Nearby lochs (Google Earth)*

## 5.8. SEPA Flood Maps

SEPA maps have been used to identify the flooding potential for pluvial, fluvial and coastal sources, shown in Figure 5 below. The maps have identified that surface water flooding is prominent with the site extends. The information shown in Figure 5 contains public sector information licensed under the Open Government Licence v3.0. It must be noted that there are limitations with the accuracy of the SEPA flooding maps as it does not account for existing flooding protection. Additionally, surface water flow paths are of low confidence and a site visit is recommended to validate these findings.

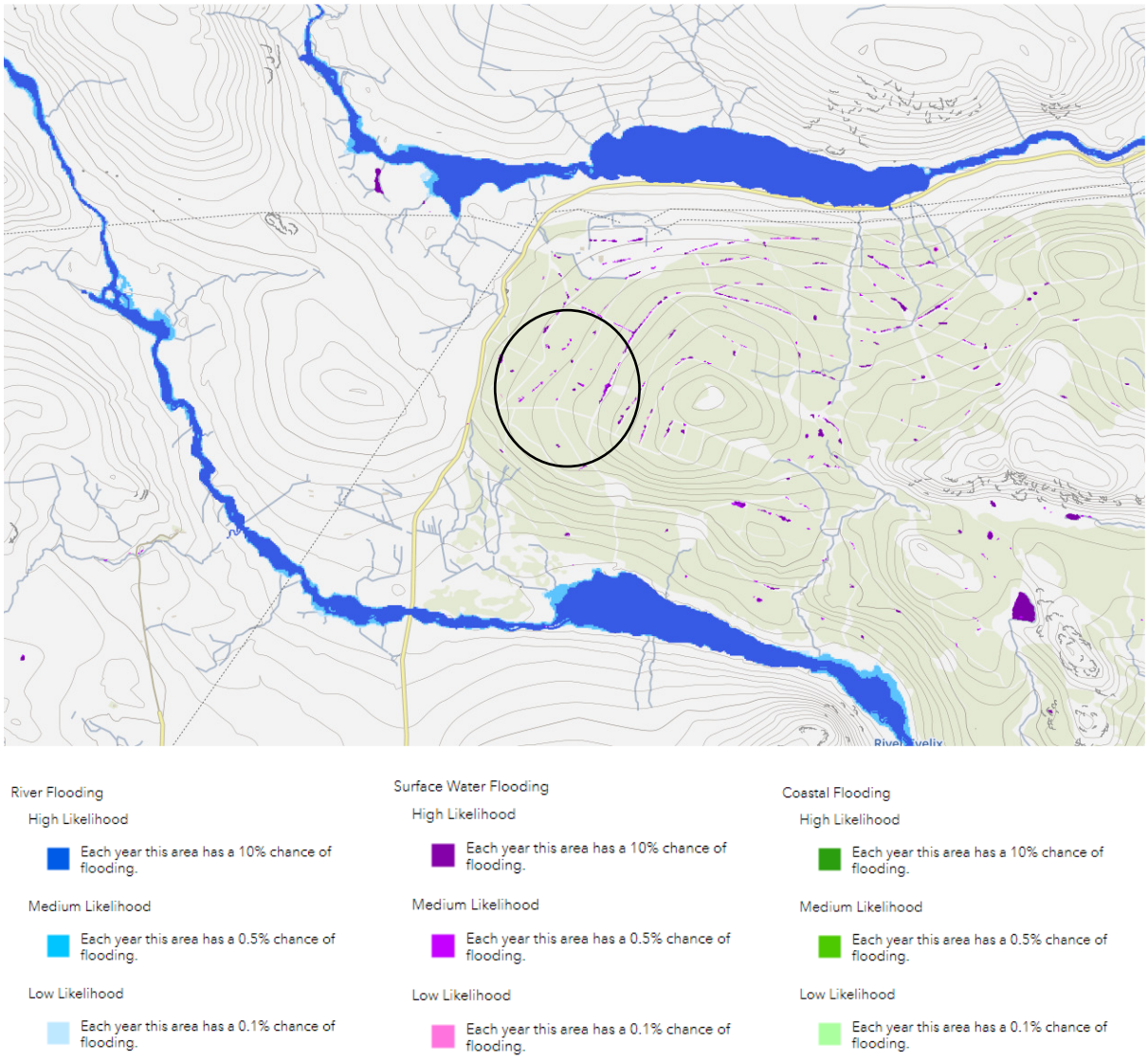


*Figure 5: SEPA Flooding Maps for River, Surface water and Coastal*

# 6. Site Visit

## 6.1. Introduction

A walkover to observe and record the surface water network draining the site was undertaken by Tony Gee and Murphy's on the 30th January 2024. The walkover survey identified key hydraulic structures and catchment features, which allowed for further understanding of the surface water network. The purpose of the visit was to identify geological and geomorphological features, and to obtain and understanding of the local topography and hydrological regime for input to design flood statement. Along with this, information was obtained relating to visible constraint to the implementation of potential required flood protection measures for the proposed substation development.

## 6.2. Contamination Sources

The proposed substation is bounded by the existing substation to the north and Loch Buie Road to the west. The land within the proposed substation extents is predominantly woodland, with the main underfoot material being peat. To the north-east there is an area of felled trees, the remaining area to the east and south contains further woodland. There are no identified contaminations sources within the upstream catchment.

## 6.3. Watercourse

The watercourses are documented in the Drainage Impact Assessment Report, document number: 'CAAI4-JMS-DRAI-XX-RPT-C-0004 P02'.

## 6.4. Surface Water Flows

The land within the proposed substation boundary consists of a woodland within which contained pockets of perched water, this is shown in the photo in Figure 6. The perched water seemed to be stagnated to top of the peat layer, unable to permeate through. Throughout the site the ground conditions were very wet and boggy containing significant amounts of moss and shrubbery, this is shown in the photo in Figure 9. There was an unnamed tributary picked up on site running through the proposed substation boundary, shown in the photo in Figure 8, the tributary flowed from east to west following the contours conveying water from 'Meall Mor' towards the 'Alltan Dubh' catchment. Throughout the site the topography fell from 'Meall Mor' hill on the east to 'Lochbuie Road' to the west. There were no identified existing flood mitigation measures in place in the arrangement upstream of the 'Lochbuie Road' drainage ditch. The observations from the site visit confirm the finding from the SEPA maps.

*Figure 6: Site Photo 01.*

*Figure 7: Site Photo 02.*

*Figure 8: Site Photo 03.*

*Figure 9: Site Photo 04.*

*Figure 10: Site Photo 05.*

*Figure 11: Site Photo 06.*

# 7. Flood Risk Statement

Flood risk will be classed as Negligible (where little or no risk is identified), Low (where theoretical risk is identified but mitigating factors may influence flood levels) or Moderate to High (where SEPA maps or historic events show risk to the site).

## 7.1. Fluvial Flood Risk

The SEPA flood maps show that the proposed substation is not within any Flood Zone which compromises land assessed as having a 0% probability of fluvial flooding each year. Therefore, the flooding from fluvial sources is **Negligible**.

## 7.2. Coastal Flood Risk

The SEPA flood maps show that the proposed substation is not within any Flood Zone which compromises land assessed as having a 0% probability of coastal flooding each year. Therefore, the flooding from coastal sources is **Negligible**.

## 7.3. Pluvial Flood Risk

In addition to fluvial and coastal flood risk, the SEPA flood maps also provide surface water flood maps. This indicates a 10% probability of surface water flooding each year within the proposed site as shown in Figure 5. As such, pluvial flooding is **Moderate to High**.

## 7.4. Groundwater Flood Risk

Groundwater flooding is a “hidden” risk that is often difficult to distinguish from other types of flooding. For example, rising groundwater often forms in low-lying areas which are also susceptible to the accumulation of surface water.

The ground investigation identified that in the worst case, the ground water is approximately 0.06m below ground level. However, this borehole is remote of the proposed platform location and associated drainage network. At the location of the platform, the ground water is varying from 0.11 to 3.23m below ground level. Therefore, groundwater flooding is **Low**.

## 7.5. Lochs

The proposed substation is not located in the extent of flood waters should any of the lochs fail within the catchment. Therefore, flooding from lochs is **Negligible**.

## 7.6. Drainage Infrastructure

There is no Scottish water owned drainage infrastructure nearby to the proposed development. Additionally, the proposed development is upstream from the existing substation, hence proposed site is not in the extent of the flood water should the drainage network fail. As such, flooding from drainage sources is **Negligible**.

# 8. Recommendations

The flooding risk statement concludes that the site being assessed as having **Moderate to High** risk from Pluvial sources, a **Low** risk from groundwater sources and **Negligible** risk from all other sources.

It is believed that the risk from pluvial flooding is increased by the topsoil layer preventing the water from permeating through to the more granular layers. Therefore, it is recommended that the topsoil is removed to increase the permeability of the ground within the proposed development area. The increased ground permeability will reduce the runoff coefficient and have a positive flooding mitigation benefit from pluvial sources. Additionally, it is recommended that upstream drainage is implemented at a sufficient depth across the proposed development. The drainage ditch will cut-off the runoff from the upstream catchment and convey the runoff away from the proposed development.

Implementing these flooding mitigation measures will reduce the risk of flooding from pluvial sources by eliminate additional total runoff from entering the proposed development, and increasing the runoff coefficient from the runoff within the proposed development catchment.

The Development is compliant with NPF4, SEPA Guidance and local planning policy i.e., avoidance of flood risk areas as a first principle.

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