TRANSMISSION

Emmock 400kV Substation
Environmental Impact Assessment (EIA)
Volume 4 | Appendix 11.1

Flood Risk Assessment and Outline Drainage Strategy

November 2024

Scottish & Southern Electricity Networks

TRANSMISSION

CONTENTS

LIST OF ABBREVIATIONS

CAR – Controlled Activities Regulations

DTM – Digital Terrain Model

FRA - Flood Risk Assessment

EIA – Environmental Impact Assessment

FEH – Flood Estimation Handbook

GBR – General Binding Rules

LUC – Land Use Consultants ltd.

NPF4 – National Planning Framework 4

SEPA – Scottish Environment Protection Agency

SSEN – Scottish & Southern Electricity Networks

SUDS – Sustainable Urban Drainage System

1. INTRODUCTION

1.1.1 This appendix presents the Flood Risk Assessment for the Proposed Emmock 400 kV Substation (the Proposed Development). It should be read in conjunction with **Chapter 11: Hydrology and Hydrogeology** and **Chapter 3: Development of the Proposed Development (Volume 2)** of the **EIA Report** for full details of the Proposed Development.

1.1.2 This appendix is supported by the following:

- Figure 11.1.1: Site Location;
- Figure 11.1.2: Tributary watercourse features map;
- Figure 11.1.3: Site and surrounding topography;
- Figure 11.1.4: Catchment Area Delineation (Fithie – red outline, tributary – black outline);
- Figure 11.1.5: Mathematical Model Setup;
- Figure 11.1.6: 200 year + Climate Change Flood Map;
- Figure 11.1.7: Surface Water Flow Pathways;
- Annex 11.1.1 1D Cross Sections with 200 year + Climate Change Peak Water Level;
- Annex 11.1.2 Long Profile with 200 year + Climate Change Peak Water Level; and
- Annex 11.1.3 SEPA checklist.

1.1.3 Kaya Consulting Ltd. was commissioned by SSEN Transmission (via LUC) to carry out an assessment of the risk of flooding at the Proposed Development near Tealing in the Angus Council area. The Site is currently greenfield with proposals for a substation and associated infrastructure.

1.1.4 SEPA indicative flood maps indicate that the Site may at risk of flooding from both fluvial sources, from the Fithie Burn, and surface water flooding mainly from a tributary to the Fithie Burn which is too small to be represented as a fluvial source in the SEPA indicative maps and therefore shows up as surface water flooding. These maps are indicative only and a detailed assessment is required. This flood risk assessment will focus on the fluvial risk from the Fithie Burn and its tributaries but will also consider all sources of flooding to the Site.

1.1.5 The scope of work includes:

- Walkover site visit to visit watercourses and ground truth catchments;
- Review historical maps and relevant information;
- Hydrological analysis of the Fithie Burn and its tributaries to estimate the extreme flows within the Site;
- Prepare a survey specification for topographic survey, including cross-sections of the watercourses;
- Develop a mathematical model to predict extreme water levels at the Site;
- Delineate relevant fluvial flood extent maps;
- Assess flood risk from other sources including surface water runoff, local drainage infrastructure and groundwater;
- Assess flood risk to Site access; and
- Preparation of an FRA report suitable for a planning submission assuming flood risks can be mitigated.

1.1.6 Information made available to Kaya Consulting Ltd for the study includes the following:

- Location plan of the Proposed Development;
- Cross sections and topographical survey;
- Light Detection and Ranging (LiDAR) Digital Terrain Model (DTM) for the southern part of the Site; and
- Photogrammetry DTM for the northern part of the Site and surrounds.

1.1.7 The work carried out to assess the flooding risk of the Site and main findings of the study are summarised in the following sections.

2. LEGISLATIVE AND POLICY ASPECTS

2.1 National Planning Framework 4

2.1.1 Under National Planning Framework 4 (NPF4) Flood Risk Management requires explicit consideration of climate change, consistent with the key over-arching policies of NPF4, for example;

Climate mitigation and adaptation – Policy 2b)
'Development proposals will be sited and designed to adapt to current and future risks from climate change'

2.1.2 In addition, development leading to improvements to channels and river habitats should be encouraged as shown by;

Biodiversity – Policy 3a)
'Development proposals will contribute to the enhancement of biodiversity, including where relevant, restoring degraded habitats and building and strengthening nature networks and the connections between them. Proposals should also integrate nature-based solutions where possible'

2.1.3 In terms of flood risk, the definition of a flood risk area or at risk of flooding is;

For planning purposes, at risk of flooding or in a flood risk area means land or built form with an annual probability of being flooded of greater than 0.5% which must include an appropriate allowance for future climate change.

This risk of flooding is indicated on SEPA's future flood maps or may need to be assessed in a flood risk assessment. An appropriate allowance for climate change should be taken from the latest available guidance and evidence available for application in Scotland. The calculated risk of flooding can take account of any existing, formal flood protection schemes in determining the risk to the site.

Where the risk of flooding is less than this threshold, areas will not be considered 'at risk of flooding' for planning purposes, but this does not mean there is no risk at all, just that the risk is sufficiently low to be acceptable for the purpose of planning. This includes areas where the risk of flooding is reduced below this threshold due to a formal flood protection scheme.

2.1.4 NPF4 defines a flood risk area as one that lies within the 200-year + climate change floodplain and

Assessments need to consider flooding from all sources including;

- *Watercourse/Fluvial Flooding*
- *Pluvial Flooding*
- *Sewer Flooding*
- *Groundwater Flooding*
- *Coastal Flooding*

2.1.5 Access to sites during flooding is defined as;

Egress (safe, flood free pedestrian access and egress), A route for the movement of people (not vehicles) of all abilities (on foot or with mobility assistance) between the development and a place of safety outwith the design flood level.

2.1.6 The key policy related to flood risk management is *Flood Risk and Water Management – Policy 22*. Relevant parts of the policy are extracted below;

Policy Intent – To strengthen resilience to flood risk by promoting avoidance as a first principle and reducing the vulnerability of existing and future development to flooding

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

i. essential infrastructure where the location is required for operational reasons;

ii. water compatible uses;

iii. redevelopment of an existing building or site for an equal or less vulnerable use; or.

iv. 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 longterm safety and resilience can be secured in accordance with relevant SEPA advice

The protection offered by an existing formal flood protection scheme or one under construction can be taken into account when determining flood risk.

In such cases, it will be demonstrated by the applicant that:

- *all risks of flooding are understood and addressed;*
- *there is no reduction in floodplain capacity, increased risk for others, or a need for future flood protection schemes;*
- *the development remains safe and operational during floods;*
- *flood resistant and resilient materials and construction methods are used; and*
- *future adaptations can be made to accommodate the effects of climate change.*

Additionally, for development proposals meeting criteria part iv), where flood risk is managed at the site rather than avoided these will also require:

- *the first occupied/utilised floor, and the underside of the development if relevant, to be above the flood risk level and have an additional allowance for freeboard; and*
- *that the proposal does not create an island of development and that safe access/ egress can be achieved.*

c) Development proposals will:

i. not increase the risk of surface water flooding to others, or itself be at risk.

ii. manage all rain and surface water through sustainable urban drainage systems (SUDS), which should form part of and integrate with proposed and existing blue-green infrastructure. All proposals should presume no surface water connection to the combined sewer;

iii. seek to minimise the area of impermeable surface.

d) Development proposals will be supported if they can be connected to the public water mains. If connection is not feasible, the applicant will need to demonstrate that water for drinking water purposes will be sourced from a sustainable water source that is resilient to periods of water scarcity.

e) Development proposals which create, expand or enhance opportunities for natural flood risk management, including blue and green infrastructure, will be supported

2.2 Local Authority Policy and Guidance with Respect to Flood Risk

2.2.1 The Angus Local Development Plan was adopted by Angus Council on 23 September 2016 and sets out the Council's view on how the area should develop over the next 10 years from 2016 – 2026. Angus Council Development Standards Policy PV12 "Managing Flood Risk" states :

2.2.2 *To reduce potential risk from flooding there will be a general presumption against built development proposals*:

- *on the functional floodplain;*
- *which involve land raising resulting in the loss of the functional flood plain; or*
- *which would materially increase the probability of flooding to existing or planned development.*

2.2.3 *Development in areas known or suspected to be at the upper end of low to medium risk or of medium to high flood risk (as defined in Scottish Planning Policy (2014), may be required to undertake a flood risk assessment. This should demonstrate*:

- *that flood risk can be adequately managed both within and out with the Site;*
- *that a freeboard allowance of at least 500-600mm in all circumstances can be provided;*
- *access and egress to the Site can be provided that is free of flood risk; and*
- *where appropriate that water-resistant materials and construction will be utilised.*

2.2.4 *Where appropriate development proposals will be*:

- *assessed within the context of the Shoreline Management Plan, Strategic Flood Risk Assessments and Flood Management Plans; and*

- *considered within the context of SEPA flood maps to assess and mitigate surface water flood potential.*

2.2.5 Angus Council has also issued technical guidance for developers "Flood Risk and Surface Water Drainage Requirements" Sep 2023. The document is intended as supplementary guidance for preparation of flood risk assessments and design of surface water drainage.

2.2.6 In terms of flooding all development proposals must meet NPF4 requirements for flood risk.

- *the development should not result in an increase in vulnerability under SEPA's Land Use Vulnerability Classes*.
- *Flood Risk Assessments (FRAs) must be undertaken in accordance with the most recent version of SEPA's Technical Flood Risk Guidance for Stakeholders and must include a completed SEPA Flood Checklist.*
- *Freeboard should ideally be 0.6 m as per NPF4.*
- *The FRA must demonstrate that safe and flood-free access and egress to the site can be maintained during the design flood event as defined in NPF4*

2.2.7 For surface water drainage

- *all development proposals must have surface water drainage which meets the requirements of NPF4, per NPF4 Policy 22 items c to e.*
- *The Drainage Assessment must be prepared in line with best practice guidance within the CIRIA SuDS Manual C753 and design calculations must be aligned with Sewers for Scotland (published by Scottish Water) including where appropriate design storms, runoff coefficients and urban creep allowances. Parameter values published in Sewers for Scotland 4th Edition are summarised in the table below (note that these values may be subject to change), together with climate change per current SEPA guidance.*

2.3 SEPA Technical Flood Risk Guidance

2.3.1 SEPA is a statutory consultee to the planning process with respect to flood risk. To support its role and to give guidance to practitioners and local authorities SEPA have published a series of guidance documents. It is noted that SEPA are currently reviewing and updating their planning guidance in response to NPF4. The key documents with direct relevance to flood risk assessment at the time of writing are;

- SEPA (2024a), SEPA Flood Risk Standing Advice for Planning Authorities, July 2024[1] which provides standing advice for Planning Authorities and Developers for lower risk applications, including category 1 exceptions (where there is no land raising or loss of floodplain capacity), category 2 (Development proposals at flood risk solely from surface water) and category 3 (Development proposals at flood risk solely from groundwater).
- SEPA (2024b), Flood Risk and Land Use Vulnerability Guidance, July 2024[2]. This guidance supports Policy 22 of NPF4 by explaining vulnerability in a flooding context, and the relative vulnerability of different land uses to flooding. Policy 22 sets out exceptions where development can be permitted in a flood risk area.
- SEPA (2024c), Climate change allowances for flood risk assessment in land use planning, August 2024, version 5[3]. This outlines the most recent SEPA guidance in terms of flow, rainfall and sea level uplifts for climate change.
- SEPA (2024d) Position Statement on Development Protected by Formal Flood Protection Schemes[4] which provides additional planning guidance with respect to built development behind flood defences.
- SEPA (2022a), Technical Flood Risk Guidance for Stakeholders - SEPA requirements for undertaking a Flood Risk Assessment, June 2022[5]. This is a technical guidance document intended to outline methodologies that may be

---

[1] https://www.sepa.org.uk/media/hbghpr1p/flood-risk-standing-advice.docx

[2] https://www.sepa.org.uk/media/nvnotwqd/land-use-vulnerability-guidance.docx

[3] https://www.sepa.org.uk/media/fxjgfjmf/climate-change-allowances-guidance.docx

[4] https://www.sepa.org.uk/media/nlyfx2v3/development-behind-defences.docx

[5] https://www.sepa.org.uk/media/162602/ss-nfr-p-002-technical-flood-risk-guidance-for-stakeholders.pdf

appropriate for hydrological and hydraulic modelling and sets out what information SEPA requires to be submitted as part of a Flood Risk Assessment.

- SEPA (2018), Land Use Planning System, SEPA Development Plan Guidance Note 2a, July 2018[6]. This document provides additional planning guidance with respect to flood risk.
- SEPA (2022b), SEPA's Triage Framework. Guidance for Planning Authorities & SEPA. December 2022[7].

2.3.2 In addition, *The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended)* (CAR) (the CAR Regulations) describes requirements for any works at or near watercourses that require licensing. SEPA is responsible for the implementation of the CAR Regulations. SEPA's CAR Practical Guide (SEPA, 2023[8]) provides an overview of the CAR Regulations, definition of the regimes, levels of authorisation for activities and outlines the General Binding Rules (GBRs). The latest version of the CAR Practical Guide is available online on the SEPA website and is regularly updated.

2.3.3 With relevance to all developments, the Regulations include a requirement that surface water discharge must not result in pollution of the water environment. It also makes Sustainable Drainage Systems (SuDS) a requirement for new development, except for runoff from a single dwelling and discharges to coastal waters.

2.3.4 SEPA has recently published guidance on recommended riparian corridors that allow space for natural fluvial processes to occur in riparian areas (as well as other attendant environmental benefits including biodiversity, open space, channel maintenance opportunities, pollution reduction and river restoration). The guidance recommends a minimum riparian corridor width of 10 to 30 m from bank top along both banks of all watercourses dependant on channel width (**Table 2.1: SEPA Recommended Riparian Corridors**) (SEPA 2024)[9]. It is important to highlight that buffer strips do not mitigate any identified flood risk that may exist at a site.

Table 2.1 – SEPA Recommended Riparian Corridors

Channel Width	Recommended buffer (each side of channel)
<2 m	10 m
2-15 m	15 m
>15 m	3 0

2.4 Guidance and Policy Constraints with Relevance to Current Site

2.4.1 Based on relevant policies and guidance the following sections outline the principles and constraints under which the flood risk assessment is undertaken.

2.5 Land Use Vulnerability and Design Event

2.5.1 The Proposed Development is for a substation which is classed as an "essential infrastructure" land use as per NPF4 and defined in SEPA (2024b) . Based on NPF4 the Proposed Development should be located outwith the flood risk area (defined as the 1 in 200-year + climate change extent); however, development for essential infrastructure in the flood risk area can be supported under certain circumstances. The design event for this development is the 1 in 200-year event plus climate change.

2.6 Constraints on Developable Area

6 https://www.sepa.org.uk/media/306609/lups-dm-gu2a-development-management-guidance-on-flood-risk.pdf

7 https://www.sepa.org.uk/media/594101/sepa-triage-framework-and-standing-advice.pdf

8 SEPA (2023) The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended): A Practical Guide. https://www.sepa.org.uk/media/dw5de0kh/car-a-practical-guide.pdf

9 SEPA (2024) Recommended Riparian Corridor Layer for use in Land Use Planning, https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.sepa.org.uk%2Fmedia%2Fpuqhuwhn%2Frecommended-riparian-corridor-note.docx&wdOrigin=BROWSELINK

River Flooding

2.6.1 Based on NPF4, substation development should be avoided within the 1 in 200-year + climate change floodplain.

2.6.2 This assessment will identify the 1 in 200-year + climate change floodplain from any watercourse. Suitable buffer widths should be discussed with SEPA and Angus Council.

Surface Water Flooding

2.6.3 Land affected by surface water flooding can generally be developed assuming the surface water flood risk can be managed through the development of the Proposed Development's drainage system and land drainage to manage surface water entering the Site from outside its boundaries. However, in some cases, where sites currently act to store surface water, development could displace surface water and increase flood risk elsewhere. In these cases, there may be a need to leave areas of surface water storage undeveloped and/or provide storage of equivalent volumes of surface water elsewhere in the Site.

2.6.4 The assessment will consider surface water flooding risks for the 1 in 200-year event plus climate change.

Climate Change Considerations

2.6.5 The Proposed Development should be resilient against the impacts of climate change, such that it is not predicted to flood for the design event plus climate change.

2.6.6 The Angus Council guidance does not state a required climate change allowance.

2.6.7 SEPA (2024c) recommends climate change allowances based on UKCP18. For the study area, the impact of climate change is a 39% increase in rainfall total (Tay River Basin Region) for watercourses with catchment areas of less than 30km² or 53% for watercourses with catchment areas greater than 50km². For catchment areas between 30km² and 50km² the highest of the peak rainfall depth and peak river flow should be used. In this instance, the watercourses all have catchment areas of less than 30km² and as such the 39% increase in rainfall total should be employed.

2.6.8 The assessment will consider an increase in rainfall due to climate change of 39%. It will assess the resilience of the Site to the impact of climate change on flows. It is noted that these increases may not be consistent with increases considered by Scottish Water for drainage design.

Development Levels and Finished Floor Levels

2.6.9 SEPA (2018 and 2024a) notes that adequate freeboard should be provided for developments involving the erection of new buildings and in the majority of cases an adequate freeboard allowance would be 600mm above the design flood level (separate to any climate change allowance that may be applied). It is noted that other freeboards can be recommended if supported by appropriate modelling.

2.6.10 The assessment will consider Finished Floor Levels based on the 1 in 200-year + climate change flood levels + freeboard.

Site Access Considerations

2.6.11 It is important that developments can be accessed and left during flood events so that developments do not form islands within flooded areas.

2.6.12 In NPF4 Access to sites during flooding is defined as;

Egress (safe, flood free pedestrian access and egress), A route for the movement of people (not vehicles) of all abilities (on foot or with mobility assistance) between the development and a place of safety outwith the design flood level.

2.6.13 Access requirements with respect to flooding will be considered in this assessment.

2.6.14 It is noted that this assessment can only consider the local access restrictions to the Site and cannot consider wider, regional access issues, e.g., access to hospitals remote to the Site. These wider access issues need to be considered by the appropriate local authority within local plans.

2.7 Other Flooding Risks

Coastal Flooding

2.7.1 The Site is not located on a sea therefore coastal flooding will not be considered further;

Reservoir Flooding

2.7.2 Reservoir inundation maps prepared by SEPA[10] suggest that there is no risk of inundation due to an "*uncontrolled release of water from all possible dam failure scenarios*"

2.7.3 Reservoirs are subject to strict regulation and maintenance in Scotland according to their risk category. Therefore, flooding of this type is highly unlikely in Scotland and the risk of flooding from reservoir breach or failure at the Site is considered low.

2.7.4 SEPA reservoir map and defence asset maps do not indicate that there is a reservoir within the headwaters of the watercourses at the Site.

Site Drainage and Sewer Flooding

2.7.5 The design of the Proposed Development's drainage system is not part of this assessment.

Existing Flood Defences

2.7.6 SEPA (2024d) provides guidance with respect to development behind flood prevention schemes. This Site is not protected by any existing formal flood defences.

Canal Flooding

2.7.7 Canals in Scotland are operated and managed by Scottish Canals. Failures and overtopping of canals are rare and areas at risk are generally known by Scottish Canals who should be consulted for developments located close to any canal.

2.7.8 No canals lie in the vicinity of the Site.

2.8 CAR Regulations

2.8.1 Any crossings or changes to watercourses within the Site may require a CAR license. CAR licences are not required as part of a planning application and are generally conditioned as part of planning consent. However, during the planning process, sufficient information should be provided in a planning application so SEPA can identify whether it is likely that a CAR license would be granted.

[10] https://map.sepa.org.uk/reservoirsfloodmap/Map.htm

3. SITE LOCATION AND DESCRIPTION

3.1.1 The Site is located approximately 7.5km north of the city of Dundee to the west of the village of Tealing in Angus. The Site is shown in **Figure 11.1.1: Site Location** and is mainly comprised of agricultural land. The Proposed Development includes a substation and associated infrastructure.

3.1.2 The Fithie Burn (**Photo 3.1: The Fithie Burn, south of the Site**) rises in farmland to the west and flows in an easterly direction along the southern boundary of the Site. At the eastern bounds of the Site, the burn passes under Emmock Road flowing south east away from the Site. Approximately 75m upstream of Emmock Road an unnamed tributary enters the main channel from the north.

Photo 3.1: The Fithie Burn, south of the Site

3.1.3 The tributary discharges from a culvert under the fields approximately 560m north of the Fithie Burn channel; at this location the culvert outlet discharges to an open channel. Based on a site walkover in November 2023 following Storm Babet, there was evident flooding occurring in this field close to the eastern Site boundary, which correlates well with the SEPA pluvial flood maps. There was evidence of ponding in the south eastern corner of the field (immediately north of the tributary culvert outlet).

3.1.4 As the tributary channel continues south parallel to Emmock road, significant erosion to the channel banks was observed (**Photo 3.2: The tributary, as it flows as an open channel southwards adjacent to Emmock Road**), which presumably occurred during the Storm Babet event.

Photo 3.2: The tributary, as it flows as an open channel southwards adjacent to Emmock road

3.1.5 An additional walkover assessment was undertaken in February 2024 to delineate the upstream catchment of the tributary to inform the flood risk assessment. A watercourse / drain was noted to flow from west to east along the base of Craigowl Hill. During normal flow conditions, the watercourse enters a culvert under agricultural fields towards Prieston Farm and then discharges into an open channel to flow eastwards towards Tealing, away from the Site, see **Figure 11.1.2: Tributary watercourse features map**. However, during high flows, the watercourse has been recorded overtopping its banks and flowing southward, overland across the fields to join an open watercourse section which flows south from Prieston Farm. This open channel is then culverted under the public road (a short distance east of Balkemback Farm) and under the field until it forms the tributary watercourse as it exits from the culvert close to the eastern Site boundary.

3.1.6 Following periods of heavy rainfall, flood flows flow overland in the field north of the open channel, creating an ephemeral flood flow in the depression in the topography (**Photo 3.3: The field to the north of the open tributary channel. The watercourse is culverted under this field but flows as overland flow across the field during flood events**). Site visits were carried out on 22 November 2023 and 8 February 2024 and there was evidence of flooding in the area during Storm Babet. Discussions with local farmers also corroborated this flood flow path. The flood flow path is similar to that shown in the SEPA pluvial flood risk mapping.

Photo 3.3: The field to the north of the open tributary channel. The watercourse is culverted under this field but flows as overland flow across the field during flood events

3.1.7 **Figure 11.1.3: Site and surrounding topography** shows the topography of the Site and surrounding area derived from 1m LiDAR phase 1 LiDAR sourced from the Scottish remote sensing portal and additional Photogrammetry DTM data for the area to the north, where there was no LiDAR coverage. This shows land generally falls in a south easterly direction towards the Fithie Burn in the south and the tributary in the east. The valley-like depression where the tributary channel flows overland during floods can also be seen near the eastern boundary of the Site.

3.1.8 Scottish Water drawings do not indicate any wastewater networks at the Site.

4. HYDROLOGICAL ASSESSMENT

4.1.1 A hydrological assessment was undertaken to estimate the design flows for the Fithie Burn and the tributary channel.

4.1.2 Catchment characteristics have been extracted from the FEH (Flood Estimation Handbook) web-service. Catchment descriptors are shown are shown in **Table 4.1: Catchment Characteristics of the Fithie Burn and the tributary, based on the FEH CEH Web Service and updated with field observations of catchment areas**. Included in these are the catchment areas for the two watercourses. These were reviewed and re-assessed based on the 5m photogrammetry DTM data and observations from the site visit. The refined catchments are shown in **Figure 11.1.4: Catchment Area Delineation**.

4.1.3 This shows that the catchment draining to the tributary (during flood events) is significantly larger than estimated in the FEH web-service, with an area to the northwest draining to the tributary almost doubling the catchment area to the tributary, the drainage mechanism is described in Section 3 above.

Table 4.1: Catchment Characteristics of the Fithie Burn and the tributary, based on the FEH CEH Web Service and updated with field observations of catchment areas

Parameter	Fithie Burn	Tributary
AREA (km2)	4.31*	4.08*
ALTBAR (m)	195	230
ASPBAR (°)	154	158
ASPVAR	0.76	0.85
BFIHOST	0.576	0.654
BFIHOST19	0.556	0.634
DPLBAR (km)	2.23*	2.16*
DPSBAR (m/km)	80.1	99.5
FARL	1	0.996
LDP (km)	4.76	4.21
PROPWET	0.46	0.46
SAAR (mm)	839	864
SAAR4170 (mm)	871	885
SPRHOST (%)	38.35	33.83
URBCONC1990	-	-
URBEXT1990	0	0
URBLOC1990	-	-
URBCONC2000	-	-
URBEXT2000	0	0
URBLOC2000	-	-
*note the catchment areas have been updated from the values given in the CEH FEH Web Service, based on analysis of DTM data and site observations.		

4.1.4 Given the size of the catchment, design flows were estimated based on rainfall-runoff methods using the FEH Rainfall-Runoff method (using FEH1999 rainfall) and the Revitalised FEH Rainfall-Runoff method (ReFH2.3). Peak flows were estimated for the 1 in 200-year + climate change event. The estimated flows are provided in **Table 4.2: Design Flow Estimates**.

4.1.5 The FEH Rainfall-Runoff method does calculate significantly higher flood flows; however, given the recent and historical flooding to the eastern boundary of the Site and of the existing substation downstream of the Site, the highest flow (FEH Rainfall-Runoff estimate) was used for this assessment.

4.1.6 To account for the effect of climate change a 39% increase in rainfall is applied consistent with the SEPA (2024c)[3] guidance on climate change increases for planning. The SEPA guidance advises that for catchments less the 30km^2 in the Tay catchment area, rainfall intensity should be increased by 39%.

Table 4.2: Design Flow Estimates

Parameter	200 Year + Climate Change (m^3/s)	
	Fithie Burn	Tributary
FEH Rainfall-Runoff	10.3[a]	9.9[b]
ReFH2	4.5[c]	3.0[d]

a Critical storm – 4.9hrs b Critical storm – 4.5hrs c Critical storm – 4.5hrs d Critical storm – 3.5hrs

5. MATHEMATICAL MODELLING

5.1.1 A 1D/2D mathematical model of the Fithie Burn and tributary was developed using Flood Modeller Pro software. The 1D model was developed using cross sections surveyed for the purpose of this assessment. **Figure 11.1.5: Mathematical Model Setup** shows the cross-section locations. Cross-sections in the Fithie Burn are numbered from 0 to 17 and from T0 to T21in the tributary channel, where 0 is the most downstream cross-section in the Fithie Burn.

5.1.2 Four structures were included in the 1D model:

- A weir at T16, see **Photo 5.1: Weir section (T16) to represent overland flow dropping into the open channel (note culvert modelled as blocked based on historical flood mechanisms)**;
- Twin 0.5m diameter culverts at T14 and T13;
- A 0.450m diameter culvert at T6 and T5, see **Photo 5.2: 0.450m culvert at T6-5**; and
- Twin 1.2m diameter culverts at Emmock Road at XS3 and XS2 on the Fithie Burn, see **Photo 5.3: Twin Culverts Under Emmock Road.**

5.1.3 The upstream part of the tributary channel (where it flows overland during flood flows) was modelled in 1D only (see **Figure 11.1.5: Mathematical Model Setup**). This approach assumes that the existing culvert is 100% blocked. The model was checked and no double counting of flood waters could occur.

5.1.4 From T16 downstream where the tributary channel becomes a permanent open channel and for the entirety of the Fithie Burn, the 1D model is linked to the 2D domain. To enable the connection, the 1D cross sections were cut at bank top and connected to the 2D domain dynamically using “link-lines” which allow the exchange of water between the two domains. The 2D floodplain model is constructed based on the 1m LiDAR where available and 5m Photogrammetry where there is no available LiDAR. The grid cell is 1m and a 0.5 second time step was used. A check of the accuracy of the DTM data was undertaken and was deemed suitable for flood mapping purposes.

5.1.5 The model was run with the FEH Rainfall-Runoff model inflow hydrograph with the appropriate design flow, calculated in **Chapter 4**. The design storm was taken as 4.5hr for both channels. The downstream boundary was set as “normal depth” at the measured bed slope at the downstream end of the model.

5.1.6 The Roughness (Manning’s n) parameters used in the model include:

- Values of 0.035 to represent the channel;
- Values of 0.065 for the banks; and
- Values of 0.075 in the grass fields in the 2D domain.

Photo 5.1: Weir section (T16) to represent overland flow dropping into the open channel (note culvert modelled as blocked based on historical flood mechanisms)

Photo 5.2: 0.450m culvert at T6-5

Photo 5.3: Twin culverts under Emmock Road

5.2 Model Results

5.2.1 **Figure 11.1.6: 200 year + Climate Change Flood Map** presents the predicted 200-year plus climate change flood extent. The results show the main channel of the Fithie Burn is predicted to overtop, leading to inundation of the surrounding low-lying areas both north and south of the channel. The twin culvert road crossing (under Emmock Road) is predicted to be under capacity which results in backing up and increased flooding at the Site. Flood waters are predicted to continue eastwards, without returning to the channel so large areas of land downstream of the Site are predicted to be at risk of flooding.

5.2.2 In addition to the main channel, the tributary of the Fithie Burn is also predicted to overflow. To the north of the Site, the channel is contained within a small valley (**Photo 3.3: The Field to the North of the Open Tributary Channel**) before floodwaters are predicted to overtop a field boundary and re-enter the open channel. At this location, flood waters are predicted to overtop the left bank and flood Emmock Road. Flows leaving the channel at this location are not able to return to the tributary. As the channel continues south, the flooding pattern for the tributary is distinct; with flood waters primarily concentrated to the east of the channel. The channel enters a sharp meander and flows west, at this location overtopping of the eastern and southern bank is also predicted. The overflow from the tributary spreads more diffusely over the land, predominantly in a southerly direction. This diffuse flooding pattern suggests that wider areas to the south-east of the tributary are at a heightened risk of inundation.

5.2.3 The 1D cross section result outputs are shown in **Table 5.1: 1D Peak Water Level Results**, with cross sections and long profile provided in **Annex 11.1.1** and **11.1.2**. SEPA's FRA check list is included in **Annex 11.1.3**.

Table 5.1: 1D Peak Water Level Results

Cross Section	200-year + Climate Change Peak Water Level (m AOD)	Max Velocity (m/s)
17	138.46	3.4
16	137.69	2.0
15	135.85	3.1
14	134.72	1.9
13	134.05	2.0
12	132.30	2.1

Cross Section	200-year + Climate Change Peak Water Level (m AOD)	Max Velocity (m/s)
11	130.41	1.9
10	130.01	1.5
9	128.91	2.0
8	128.10	1.5
7	127.03	2.0
6	126.62	1.5
5	126.58	1.0
4	126.45	1.5
3	126.60	1.0
2	125.59	1.9
1	125.10	1.2
0	124.35	1.2
T21	152.21	1.2
T20	149.21	1.0
T19	147.98	1.0
T18	146.65	1.0
T17	145.57	1.1
T16.4	143.18	1.1
T16.3	141.46	1.1
T16.2	139.05	0.8
T16.1	138.20	1.0
T16_U	137.62	0.9
T16_D	136.83	3.1
T15	136.04	2.8
T14	135.21	0.8
T13	134.49	1.6
T12	132.25	2.9
T11	131.66	1.7
T10	130.86	2.9
T9	130.56	1.3
T8	130.62	1.0
T7	130.60	1.1
T6	130.60	0.2
T5	128.75	1.3
T4	128.43	1.4
T3	127.72	1.6
T1	126.83	1.2
T0	126.57	1.4

5.3 Sensitivity Analysis

5.3.1 A model sensitivity analysis provides an illustration of the effects of changing key model parameters on the important model outputs (in our case flood levels). By re-running the model and changing one input parameter at a time, the effect of that input on the model results can be isolated. Repeating this process to account for several model parameters of interest within the range of their possible input values, gives a sensitivity analysis that, when compared with the model assumptions and knowledge of realistic inputs, can provide an indication of the uncertainty associated with the model predictions.

5.3.2 This sensitivity analysis considers the following:

- An increase in Manning's n roughness values by 20%;
- A decrease in downstream slope by 20%; and
- A blockage of to the culvert at T6-T5 by 20%.

5.3.3 Results from these runs were compared to the 'Base Case' 200-year + climate change flow model run and are tabulated in **Table 5.2: 1D Peak Water Level Results**.

Table 5.2: 1D Peak Water Level Results

Cross Section	200-year + Climate Change Peak Water Level (m AOD)	Difference from Base Case (m)		
		Increase in Roughness by 20%	Decrease in downstream slope by 20%	Blockage of a Culvert T6-T5
17	138.46	0.05	0.00	0.00
16	137.69	0.04	0.00	0.00
15	135.85	0.05	0.00	0.00
14	134.72	0.07	0.00	0.00
13	134.05	0.08	0.00	0.00
12	132.30	0.04	0.00	0.00
11	130.41	0.05	0.00	0.00
10	130.01	0.03	0.00	0.00
9	128.91	-0.01	0.00	0.00
8	128.10	0.10	0.00	0.00
7	127.03	0.04	0.00	0.00
6	126.62	0.04	0.00	0.00
5	126.58	0.00	0.00	0.00
4	126.45	0.03	0.00	0.00
3	126.60	0.03	0.00	0.00
2	125.59	0.06	0.00	0.00
1	125.10	0.08	-0.02	0.00
0	124.35	0.08	0.06	0.00
T21	152.21	0.06	0.00	0.00
T20	149.21	0.07	0.00	0.00
T19	147.98	0.07	0.00	0.00
T18	146.65	0.07	0.00	0.00

Cross Section	200-year + Climate Change Peak Water Level (m AOD)	Difference from Base Case (m)		
		Increase in Roughness by 20%	Decrease in downstream slope by 20%	Blockage of a Culvert T6-T5
T17	145.57	0.05	0.00	0.00
T16.4	143.18	0.06	0.00	0.00
T16.3	141.46	0.06	0.00	0.00
T16.2	139.05	0.06	0.00	0.00
T16.1	138.20	0.05	0.00	0.00
T16_U	137.62	-0.02	0.00	0.00
T16_D	136.83	0.06	0.00	0.00
T15	136.04	0.05	0.00	0.00
T14	135.21	0.00	0.00	0.00
T13	134.49	0.04	0.00	0.00
T12	132.25	0.05	0.00	0.00
T11	131.66	0.00	0.00	0.00
T10	130.86	0.03	0.00	0.00
T9	130.56	-0.02	0.00	0.00
T8	130.62	0.01	0.00	0.01
T7	130.60	0.01	0.00	0.01
T6	130.60	0.01	0.00	0.01
T5	128.75	0.05	0.00	-0.02
T4	128.43	0.07	0.00	-0.02
T3	127.72	0.08	0.00	-0.02
T1	126.83	0.09	0.00	-0.01
T0	126.57	0.05	0.00	0.00

5.3.4 The results show that the model behaves as expected:

- The increase in roughness throughout the model to a maximum of 0.1m difference;
- The change in downstream boundary only impacts the final two cross sections in the Fithie Burn and impacts do not propagate back to the Site; and
- Blockage of the crossing at T6-T5 increases levels slightly upstream of the crossing and lowers them downstream; however, this is limited to ± 0.02m as the crossing is already surcharged and overtopped in the base case model.

6. FLOOD RISK ASSESSMENT

6.1 Introduction

6.1.1 The flood risk assessment considers the risk from

- Fluvial flooding;
- Surface water flooding;
- Groundwater flooding;
- Flooding from drainage infrastructure; and
- Safe access.

6.2 Fluvial Flooding

6.2.1 The Fithie Burn drains a catchment to the west of the Site before entering an open channel and running along the southern boundary of the Site. Close to the eastern boundary of the Site, a tributary drains a similar sized catchment before flowing south, through the Site, and enters the Fithie Burn at the south eastern corner of the Site. To assess flood risk at the Site, a Flood Modeller Pro 1D/2D linked mathematical model of the two watercourses was developed and the model was adopted to predict the 200-year + climate change floodplain close to the Site.

6.2.2 **Figure 11.1.6: 200 year + Climate Change Flood Map** shows the predicted flood extent, which shows low lying parts of the Site are predicted to be inundated during the 200-year + climate flood event, with the higher ground to the north and west within the Site outwith the flood extent.

6.2.3 Based on NPF4 land outwith the 200-year + climate change flood extent is suitable for most types of development including for a substation. A substation and associated works would be classed as a “essential infrastructure” land use and development could take place within the 200 year plus climate change flood extent.

6.2.4 The layout of the substation has been designed to avoid the flood risk area and the Proposed Development is outwith the predicted 200 year + climate change flood risk area, with the exception of landscape planting and the SuDS outfall to its discharge in the Fithie Burn. There is no attenuation or treatment proposed for this SuDS outfall that passes through the flood risk area and there is no land raising proposed.

6.2.5 The access to the Site crosses the tributary in the eastern part of the Site, where it is culverted under the field during low flows but flows overland during high flows. In order to maintain safe access to the Site during extreme events and to comply with SEPA guidance the crossing will be designed to pass the 200 year + climate change flow + freeboard (usually 600mm).

6.2.6 Buffer strips are allowed for between the top of bank of a body of water and the Proposed Development in order to allow access to the watercourse for the purpose of watercourse assessment and maintenance. The buffers are in line with SEPA recommended riparian corridors (**Table 2.1: SEPA Recommended Riparian Corridors**), as a minimum and in most locations a 50m buffer to water features has been achieved.

6.3 Surface Water Flooding

6.3.1 There is high ground to the north and northwest of the Site therefore there is potential for surface water to drain to the Site enroute to the Fithie Burn and/or the tributaries. **Figure 11.1.7: Surface Water Flow Pathways** shows the indicative surface water flow pathways within and close to the Site, based on GIS analysis of LiDAR DTM and Photogrammetry DTM topographic data.

6.3.2 The analysis shows that the land to the west of the Site drains south towards the main channel of the Fithie Burn; the land to the east of Emmock Road drains eastwards away from the Site and the land to the south is intercepted by the Fithie Burn. Therefore, the only catchment area able to drain to the Site is limited to the small area north of the Site.

6.3.3 There remains an approximate 47.5 ha catchment that currently flows through the Site to the main channel of the Fithie Burn. The runoff reaching the Site will be captured by interception drains where it enters the Site on the northern boundary and routed round the Site to the Fithie Burn without flooding the Proposed Development and/or those outwith the Site boundary. The substation platform will be raised above surrounding ground levels and ground levels are arranged to route flows away from infrastructure.

6.4 Groundwater Flooding

6.4.1 The SEPA flood maps indicate that the Site is not located within an area predicted to experience groundwater flooding. Given the Site's proximity to the Fithie Burn, it is likely that groundwater levels are influenced by this watercourse. Groundwater monitoring should be conducted as part of any site investigation process. If elevated groundwater levels are detected, appropriate mitigation measures must be implemented. These may include modifications to foundation designs and the strategic placement of drainage features to ensure their effective operation.

6.5 Flooding from Drainage Infrastructure

6.5.1 The Site is comprised of agricultural land and Scottish Water drawings do not indicate that there are existing sewers within the Site, therefore the Site is not thought to be at significant risk from flooding from existing drainage infrastructure.

6.5.2 The detailed design of the Site drainage system has been done by others. Site drainage will be designed with due consideration to the flow pathways for surface water as outlined in the surface water flooding section. Ground levels around buildings should be arranged to route any excess surface water away from the Proposed Development.

6.6 Safe Access

6.6.1 NPF4 defines egress (safe, flood free pedestrian access and egress) as "*A route for the movement of people (not vehicles) of all abilities (on foot or with mobility assistance) between the development and a place of safety outwith the design flood level.*"" Further SEPA's current guidance (SEPA, 2024a) notes "*Safe access and egress means a safe and flood free route, enabling the free movement of people of all abilities (on foot or with assistance) to a secure place outwith the flood risk area. NPF4 allows for some developments to go ahead in flood risk areas.*"

6.6.2 It is understood that the Proposed Development does not include overnight accommodation, however it is recommended that safe access is provided as best practice and NPF4 requires that "*the development remains safe and operational during floods*".

6.6.3 The proposed access track crosses the tributary which, during low flow conditions, is culverted under the fields but flows overland during high flows. In order to maintain safe access to the Site during extreme events and to comply with SEPA guidance the crossing will be designed to pass the 200 year + climate change flow + freeboard (usually 600mm).

7. OUTLINE DRAINAGE STRATEGY

7.1 Existing Drainage and Ground Conditions

7.1.1 At present a detailed Site Investigation report is not available.

7.1.2 It is recommended that ground investigations such as soakaway testing be undertaken to ascertain the underlying geology and the potential for discharging surface water via infiltration solutions. Given the potentially large impermeable areas, this could potentially reduce surface water attenuation features such as detention basins.

7.2 SuDS and Potential Strategies

7.2.1 Sustainable Urban Drainage Systems (SuDS) are used to manage surface water runoff effectively within a development to mitigate against the impacts associated with an increase in the impermeable area such as increased flows and exacerbated flooding downstream.

7.2.2 Attenuating runoff within on-site attenuation cells that discharge to the Fithie Burn at 2-year greenfield runoff rates is the most viable option due to the absence of infiltration testing results.

7.3 Proposed Surface Water Drainage Strategy

7.3.1 The proposed surface water drainage strategy seeks to provide a sustainable and integrated surface water management scheme for the whole Site and aims to maintain or reduce downstream flood risk by managing discharges from the Site to the local water environment in a controlled manner.

7.3.2 The measures outlined in the following sections will be implemented to ensure that greenfield runoff rates are maintained during the construction and operational phases of the Proposed Development.

7.3.3 In compliance with the above, the drainage strategy has been developed to meet the following key principles;

- Mimic existing (greenfield) drainage arrangements as far as possible;
- Avoid increases in the greenfield rate, volume and frequency of offsite discharge;
- Avoid significant deterioration in water quality of discharges and no detrimental impact in downstream water quality;
- Achieve the above criteria for all storms up to and including the 200-year event; and
- Incorporate an allowance for climate change (39%).

7.3.4 Runoff from the substation platform (including the construction compound) will be managed through surface water drainage on the platform conveyed to a swale that will be located downslope of the platform, within the red line boundary. The detention basin will drain to the Fithie Burn via an outfall pipe restricted to the 2-year greenfield runoff rate.

7.3.5 Based on Ordnance Survey mapping and a site walkover survey approximately 47.5 ha of higher land to the north of the Site drains to the Site. We would therefore recommend implementing an interception feature to allow flows outwith the Site to follow the pre-development pathways and will therefore not increase flood risk to the Site or downstream receptors.

7.3.6 Based on Angus Council guidance, as a minimum, storage should be sized for the 30-year plus climate change uplift event with plans demonstrating flooded areas and flow paths of excess water for storms of greater magnitude, when the system is at capacity or exceeded. Detailed storage calculations and volumes are provided in **Section 7.4: Methodology for calculation of run-off and storage volume**.

7.3.7 Expert geotechnical advice will be sought when confirming track material.

7.4 Methodology for calculation of run-off and storage volume

7.4.1 Post-development runoff volumes have been calculated using the Wallingford Procedure.

7.4.2 Runoff volumes were calculated for a range of storm durations and return periods including an allowance for climate change, which is considered at a 39% uplift to rainfall intensity following SEPA guidance (2024c).

7.4.3 In total, impermeable areas at the Site have been conservatively estimated to be 2.84 ha, this assumes that approximately 12.5% of the platform is impermeable and the access track is 100% impermeable (i.e. tarmac). This is based on a substation platform area of 20.491 ha and proposed access track of 0.283 ha.

7.4.4 The run-off factor of the hard-standing areas was set to 1.0 to represent the imperviousness of these areas.

7.4.5 The results indicate that with the Proposed Development in place, approximately 4,406 m^3 of surface water runoff would need to be stored within the drainage system during a 30-year plus climate change uplift storm across the Site. Approximately 7,941 m^3 of surface water runoff would need to be accommodated within the Site during a 200-year plus climate change uplift storm.

7.4.6 Angus Council has been contacted regarding storage requirements but a response was not received at the time of writing. Angus Council's Flood Risk and Surface Water guidance issued in September 2023 states that discharge rates should be no greater than the greenfield runoff rate and volume. There should be no exceedance from the proposed SUDS for up to and including the 1 in 30 year plus climate change event.

7.4.7 As discussed, detailed ground conditions are not known. It may be possible to accommodate such volumes within a mixture of infiltration as well as detention basins (depths ranging between 1-2m depending on slopes etc.) or swales with attenuation. As a minimum, it is recommended that the 30-year plus climate change volume is stored. As an indication, this would require an area of 4,406m^2 (at 1m depth) or 2,203 m^2 (at 2m depth), which could either be one large basin or could be split between a number of basins/ swales. Appropriate buffers would also have to be applied. There is space in the fields south of the substation for the SuDS basins or swales with a discharge point to the Fithie Burn.

7.4.8 Safe flood routing should be provided to allow flows exceeding the capacity of the attenuation feature (s) to route safely towards the Fithie Burn.

7.5 Surface Water Quality

7.5.1 The Proposed Development will be unmanned and will not usually be visited on a daily basis. In addition, when being visited, the types of vehicles are not likely to be larger vehicles such as HGVs etc.

7.5.2 Surface water at the Site will be treated via SuDS measures in the form of a swale. A water quality risk assessment should be undertaken using the SuDS hazard mitigation indices in accordance with the SuDS Manual, CIRIA Report C753.

7.5.3 Considering the low expected traffic volumes and appropriate containment of any hazardous substances, the residual pollution hazard level is considered to be low hazard levels similar to that of a low traffic road and non-residential car parking with infrequent change.

8. SUMMARY AND CONCLUSIONS

8.1.1 Kaya Consulting Ltd. was commission by SSEN Transmission (via LUC) to carry out an assessment of the risk of flooding at the Proposed Development.

8.1.2 The Fithie Burn and its tributary flows through and along the southern and eastern boundaries of the Site. A mathematical model of these watercourses was developed to predict the 200-year + climate change flood extent. **Figure 11.1.6: 200 year + Climate Change Flood Map** shows the flood extent, showing low lying area within the Site that would be inundated in the 200-year + climate change event.

8.1.3 Based on NPF4 land outwith the 200-year + climate change extent would be suitable for most types of development including a substation. Finished floor levels for any buildings to be raised a suitable freeboard above the 200-year + climate change flood levels.

8.1.4 A flow pathway analysis estimates a surface water catchment approximately 47.5ha in area is able to drain to the northern boundary of the Site enroute to the Fithie Burn. Flow generated from this catchment reaching the Site will be captured by interception ditches where it enters the Site and is routed around the Site to the Fithie Burn or other suitable discharge and/or storage locations without flooding the proposed development and/or those outwith the Site boundary.

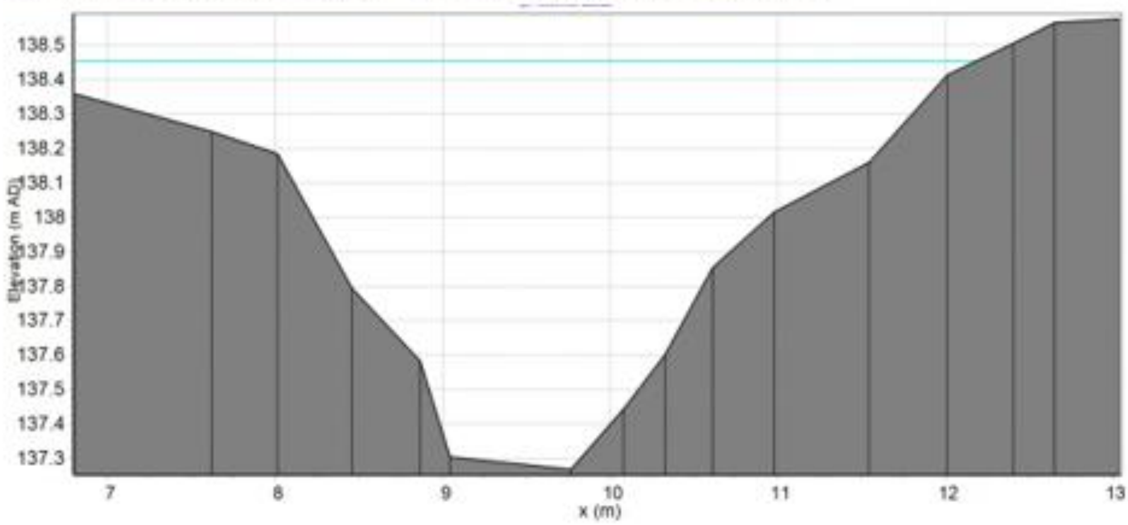
8.1.5 The Site is not thought to be at significant risk from groundwater or existing drainage infrastructure as a primary source.

8.1.6 An outline drainage strategy for the proposed substation is provided. Further consultation with Angus Council is recommended at the detailed design stage.

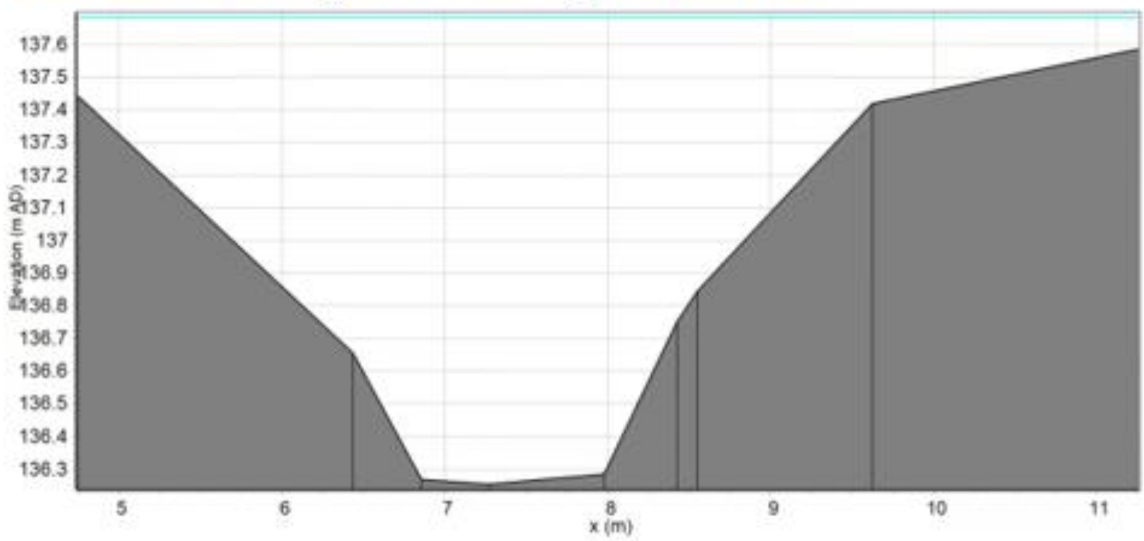
8.1.7 It should be noted that the risk of flooding can be reduced, but not totally eliminated, given the potential for events exceeding design conditions and the inherent uncertainty associated with estimating hydrological parameters for any given site.

ANNEX 11.1.1 – 1D CROSS SECTIONS WITH 200-YEAR + CLIMATE

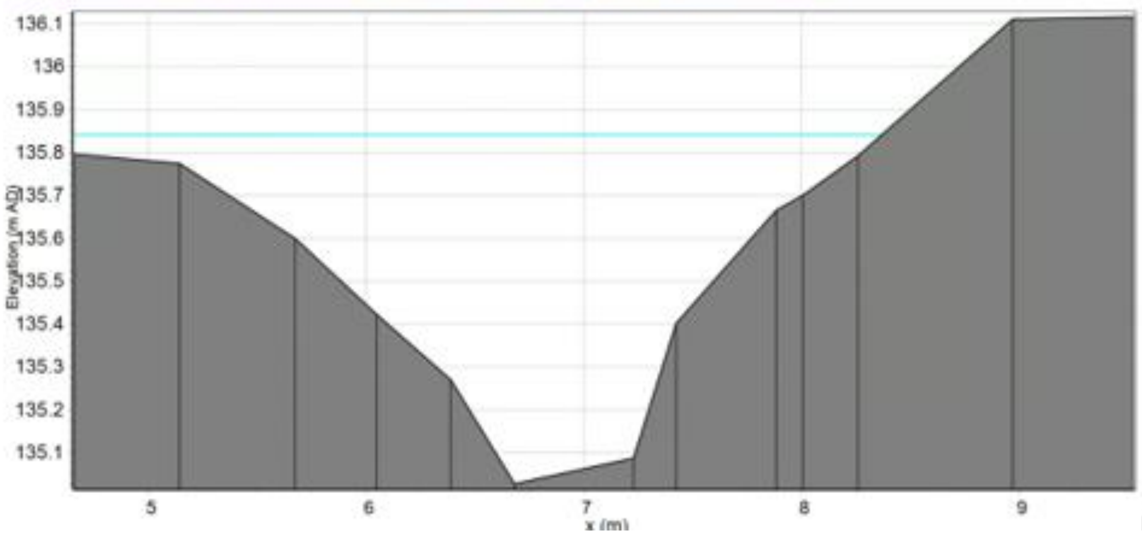
Cross Section 17 with 200-year + Climate Change Peak Water Level



Cross Section 16 with 200-year + Climate Change Peak Water Level



Cross Section 15 with 200-year + Climate Change Peak Water Level

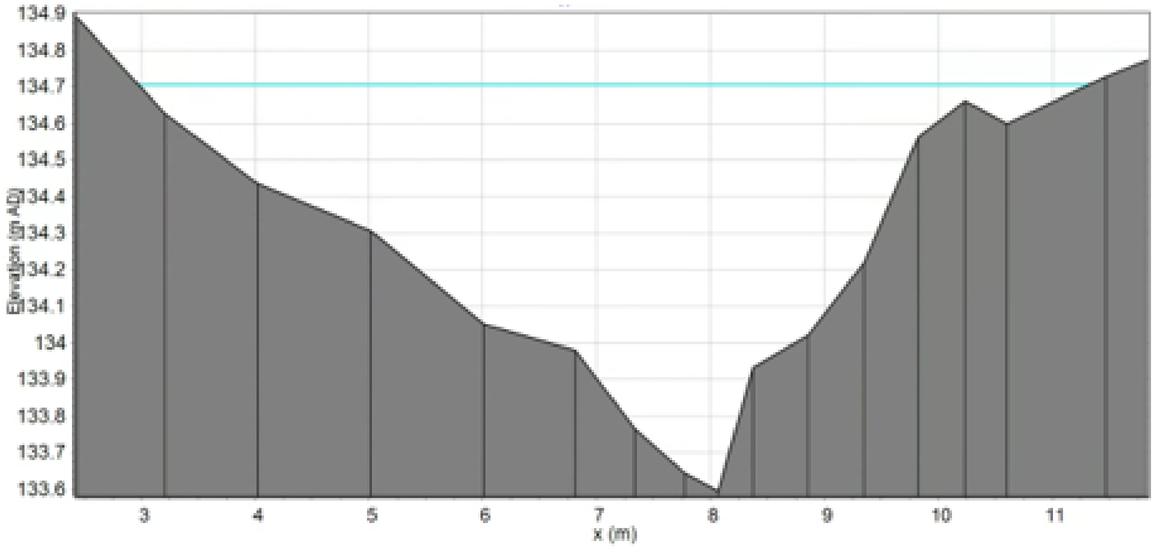


CHANGE PEAK WATER LEVEL

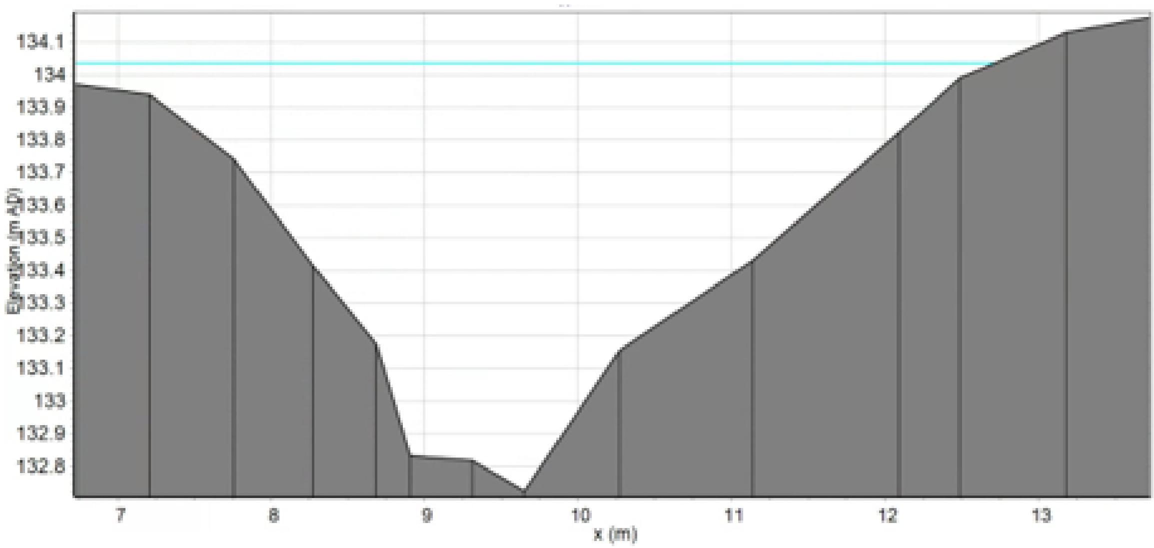
Scottish & Southern Electricity Networks

TRANSMISSION

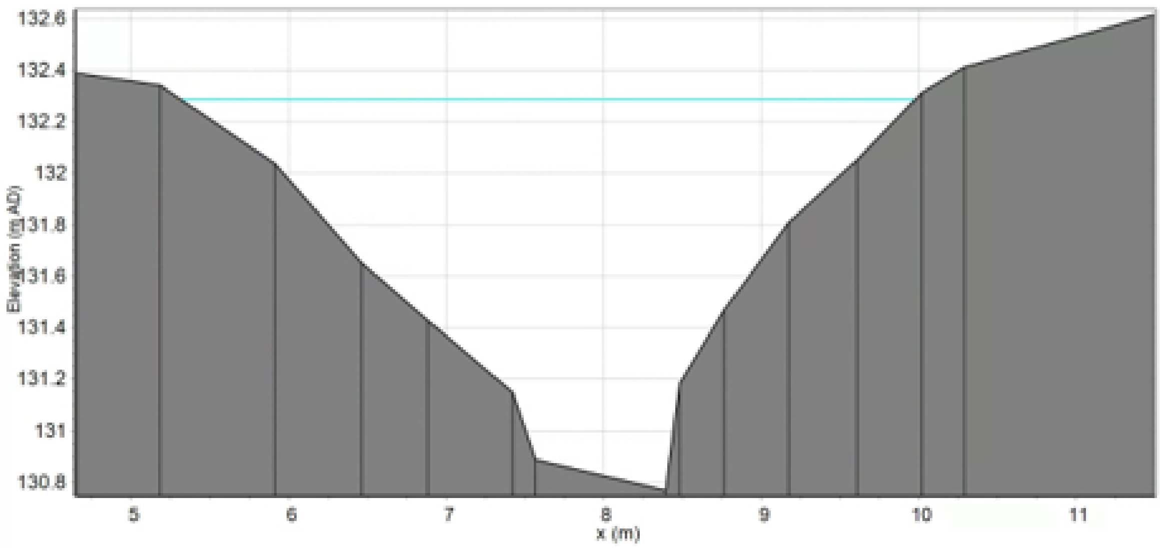
Cross Section 14 with 200-year + Climate Change Peak Water Level



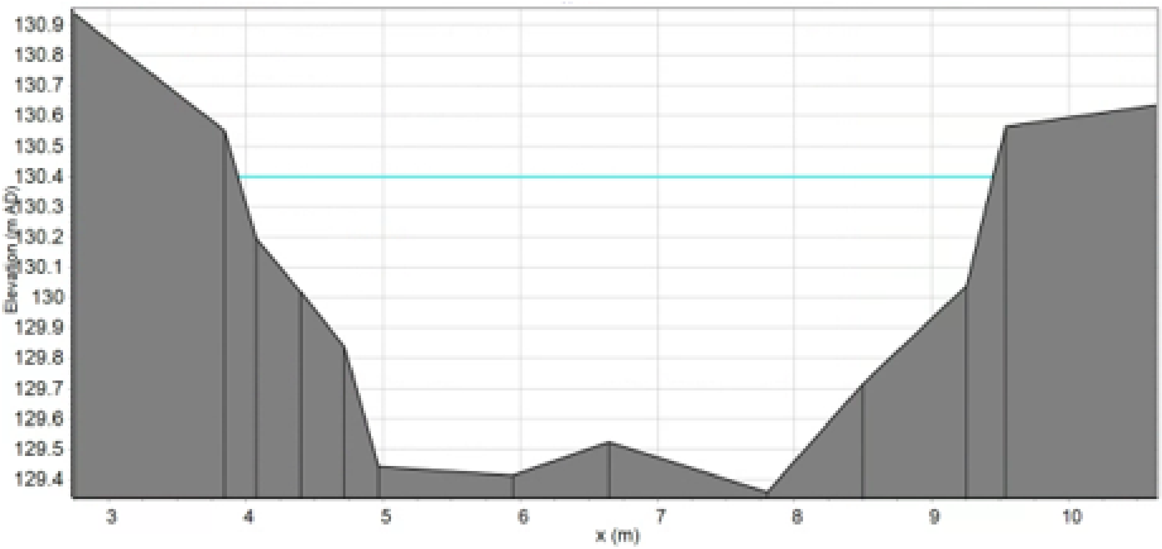
Cross Section 13 with 200-year + Climate Change Peak Water Level



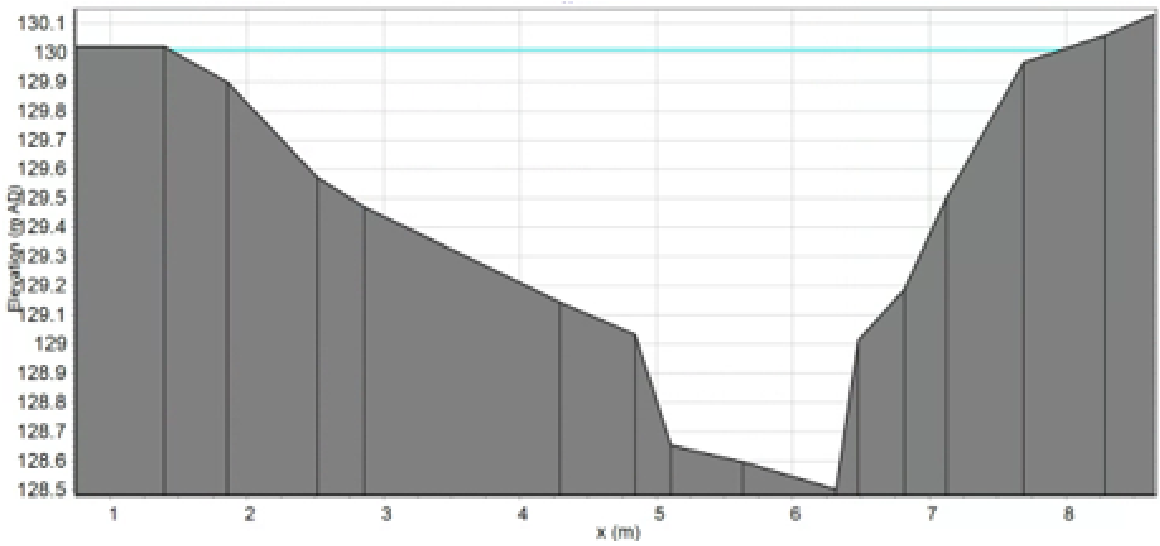
Cross Section 12 with 200-year + Climate Change Peak Water Level



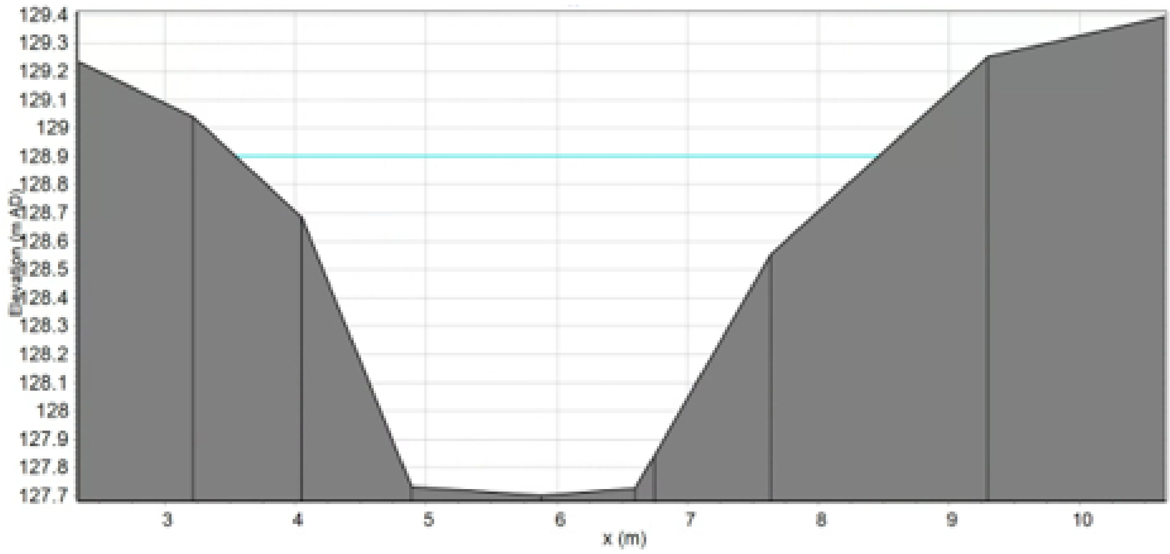
Cross Section 11 with 200-year + Climate Change Peak Water Level



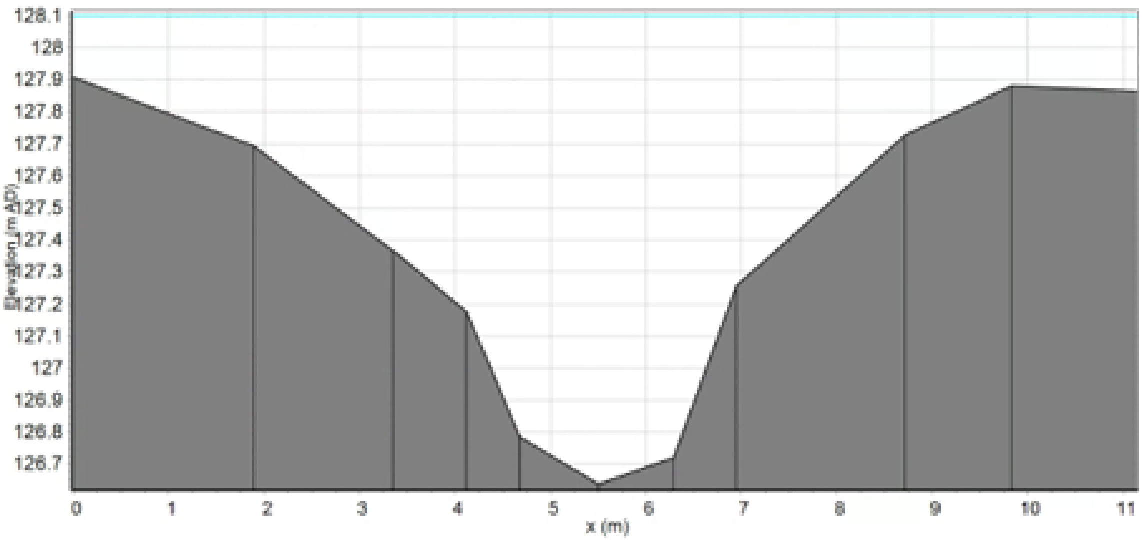
Cross Section 10 with 200-year + Climate Change Peak Water Level



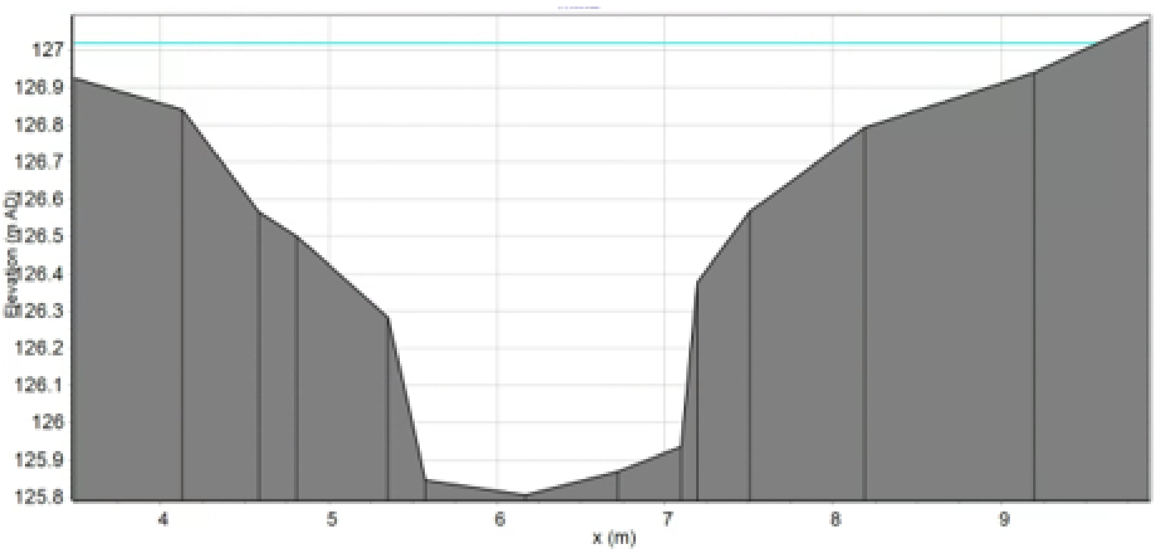
Cross Section 9 with 200-year + Climate Change Peak Water Level



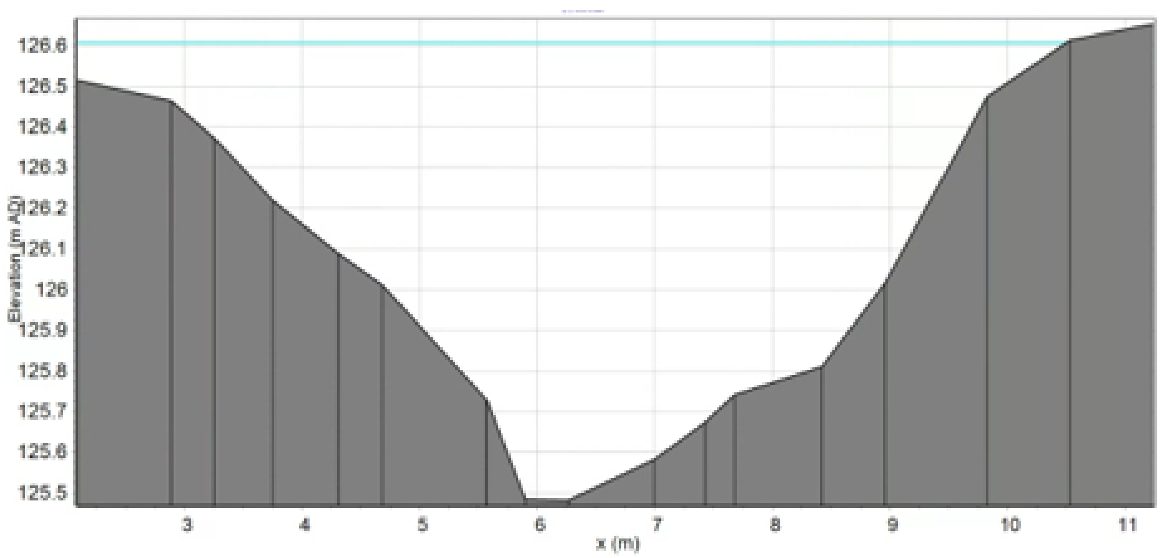
Cross Section 8 with 200-year + Climate Change Peak Water Level



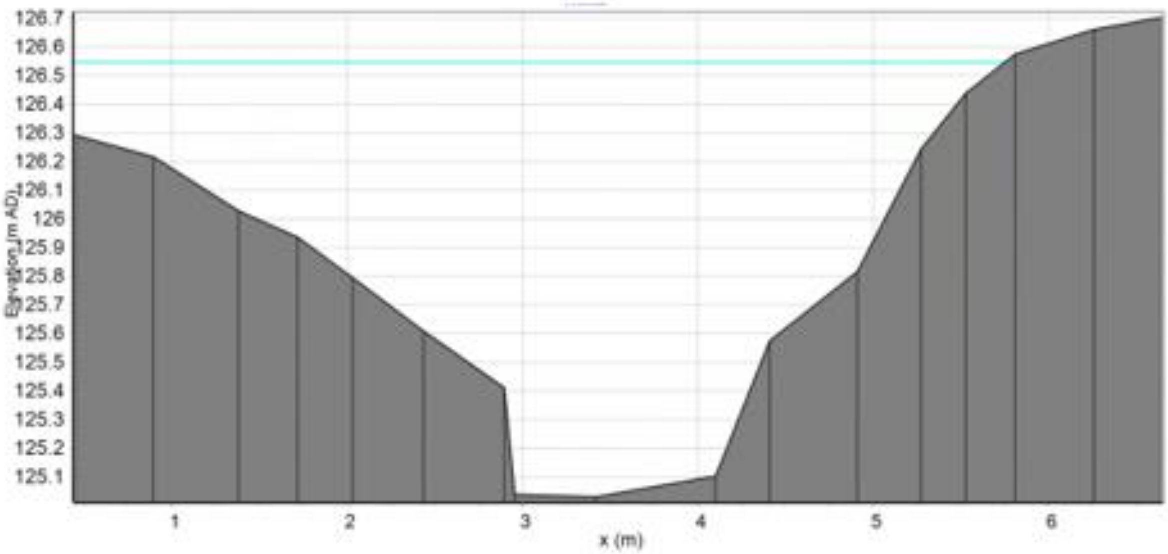
Cross Section 7 with 200-year + Climate Change Peak Water Level



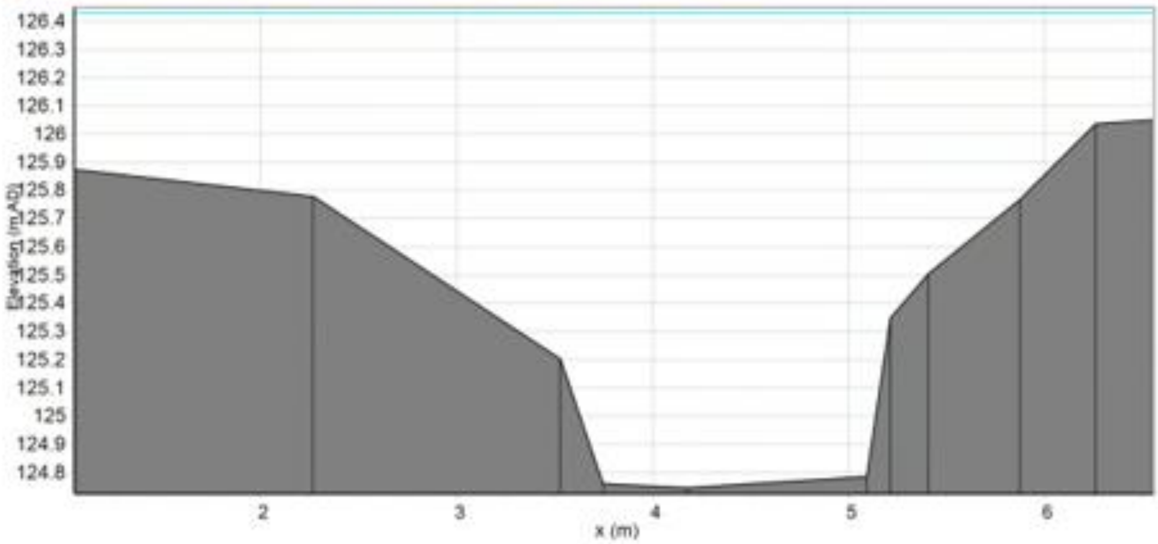
Cross Section 6 with 200-year + Climate Change Peak Water Level



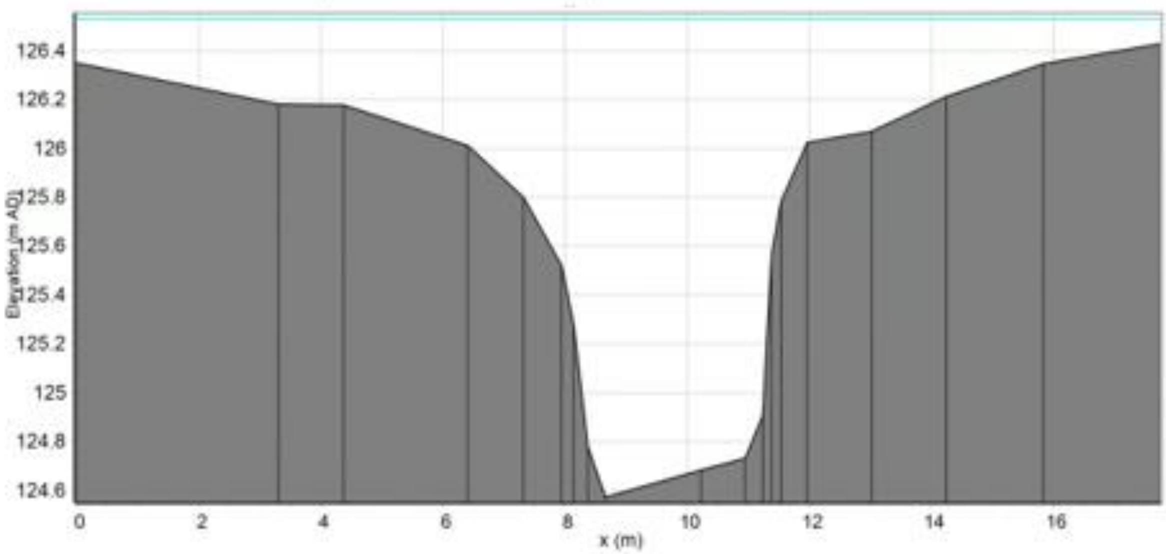
Cross Section 5 with 200-year + Climate Change Peak Water Level



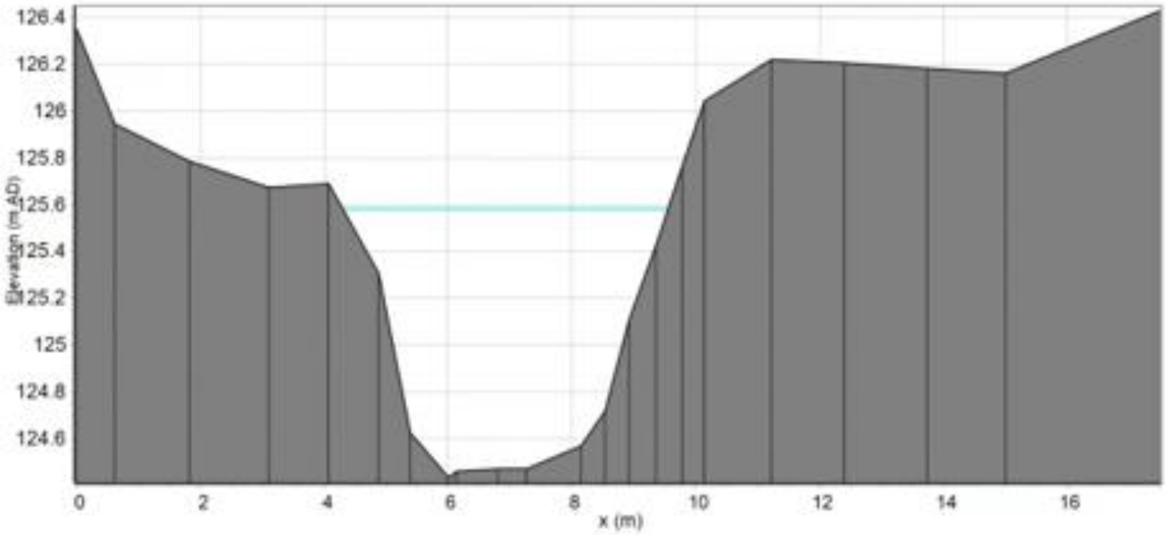
Cross Section 4 with 200-year + Climate Change Peak Water Level



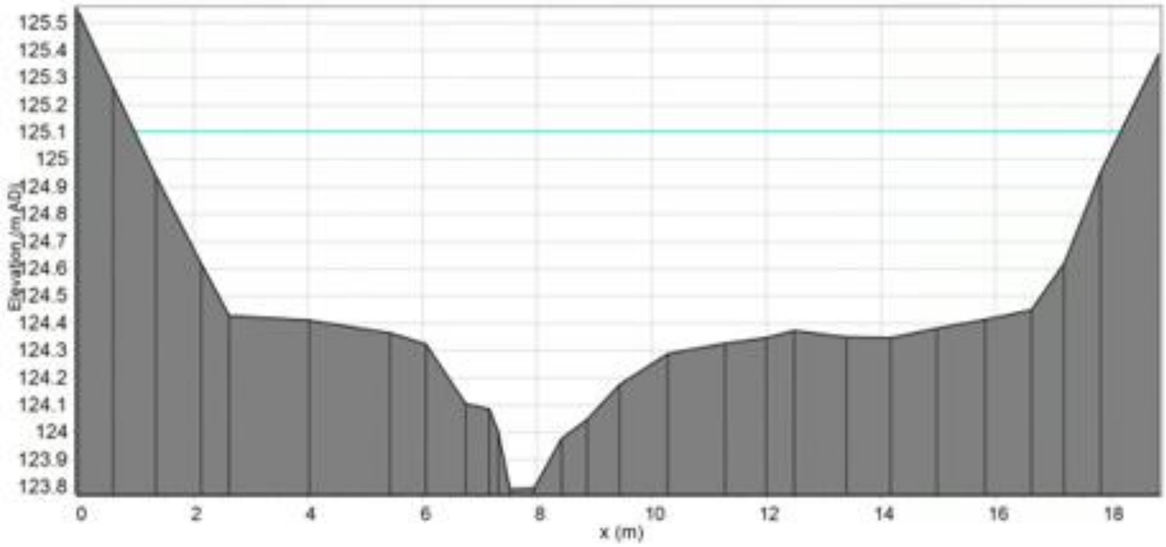
Cross Section 3 with 200-year + Climate Change Peak Water Level



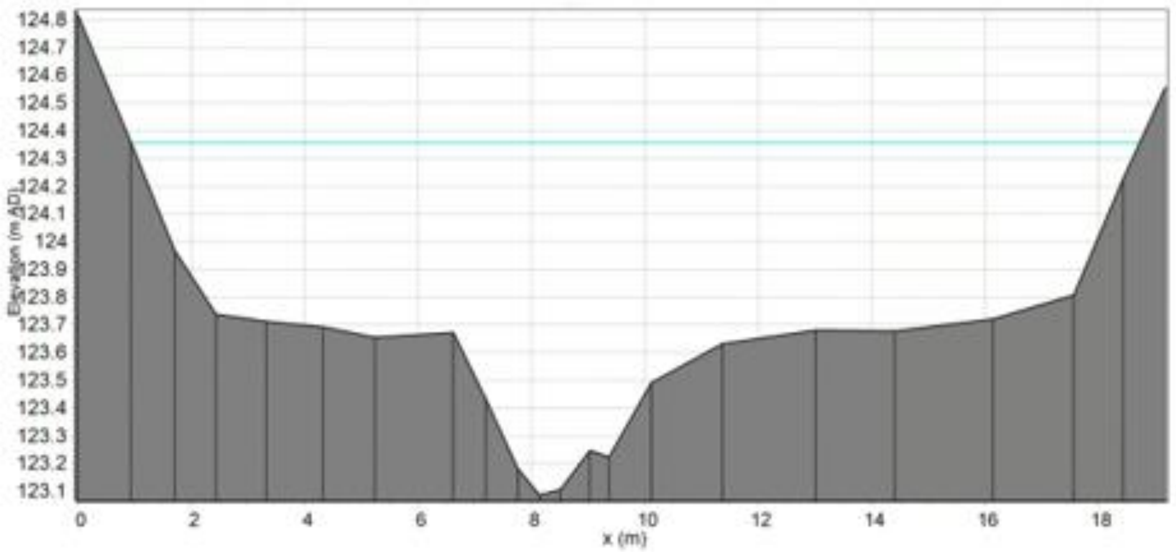
Cross Section 2 with 200-year + Climate Change Peak Water Level



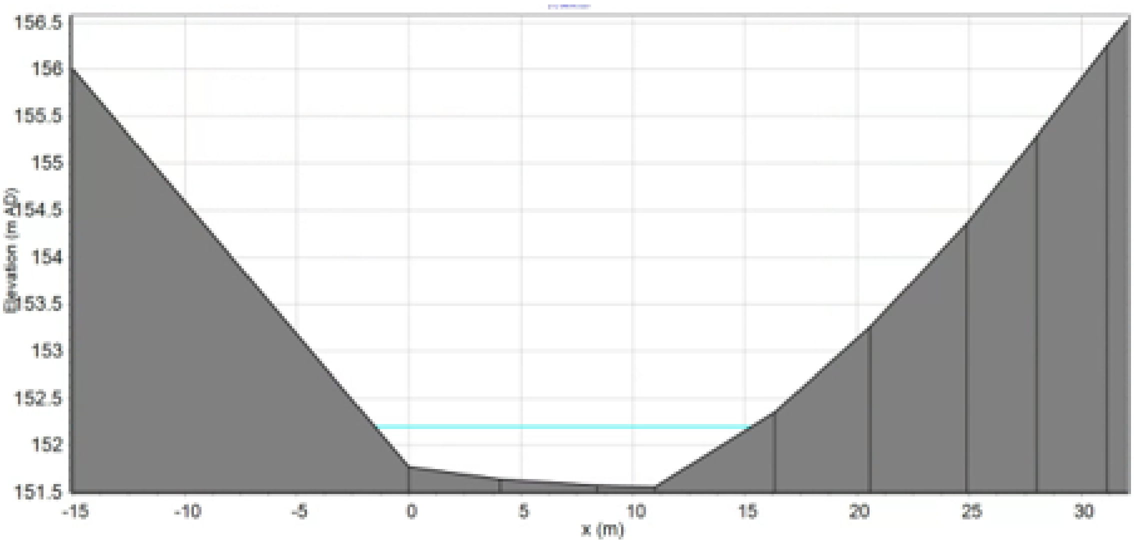
Cross Section 1 with 200-year + Climate Change Peak Water Level



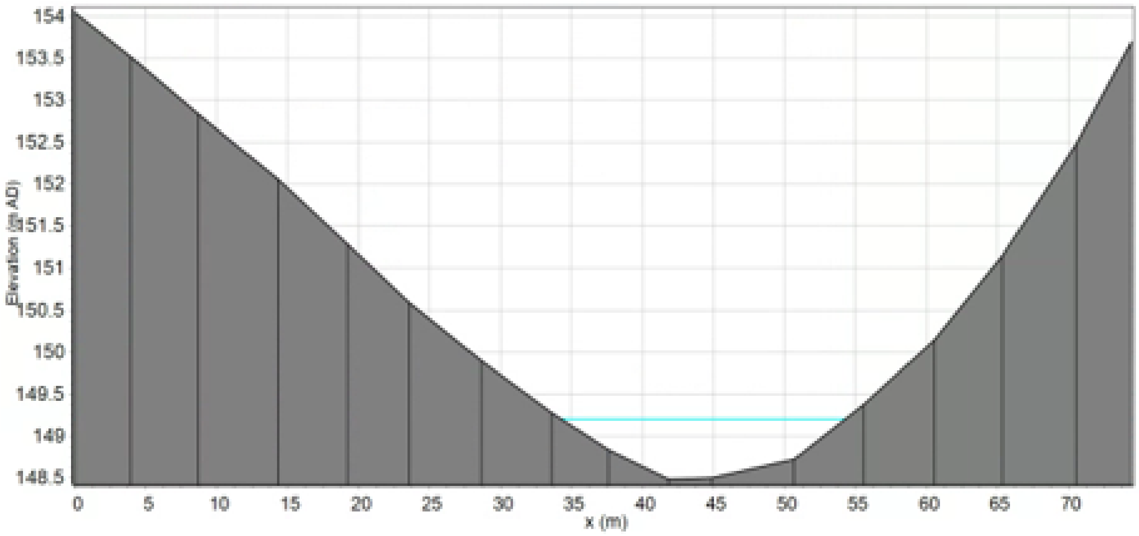
Cross Section 0 with 200-year + Climate Change Peak Water Level



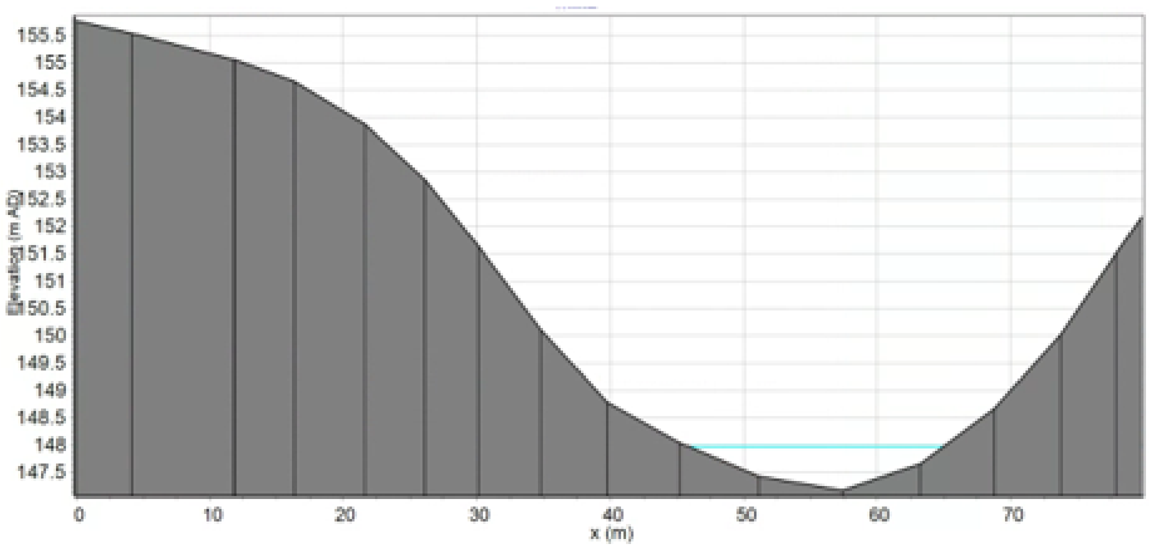
Cross Section T21 with 200-year + Climate Change Peak Water Level



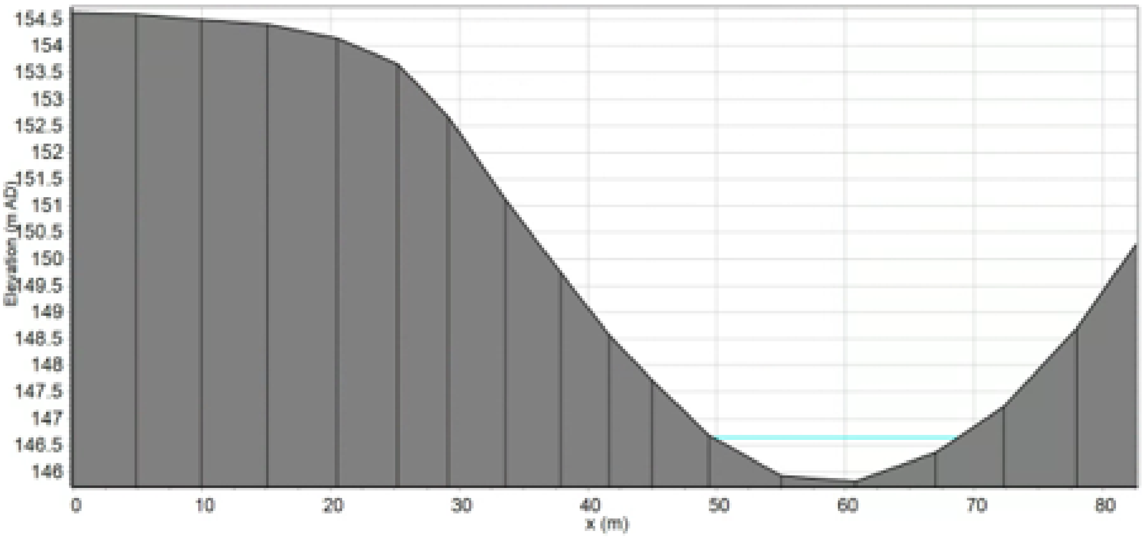
Cross Section T20 with 200-year + Climate Change Peak Water Level



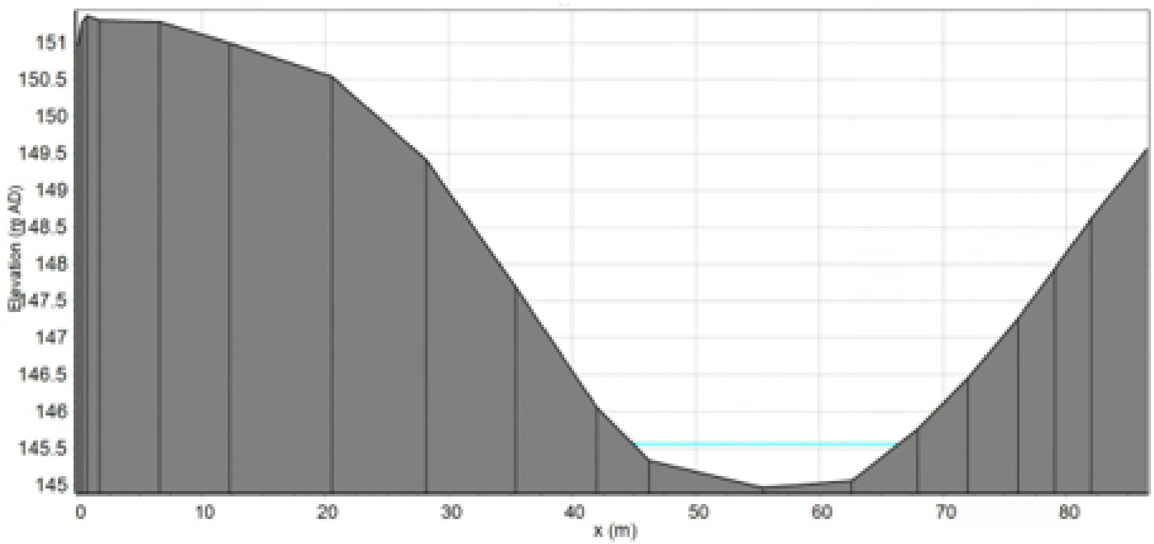
Cross Section T19 with 200-year + Climate Change Peak Water Level



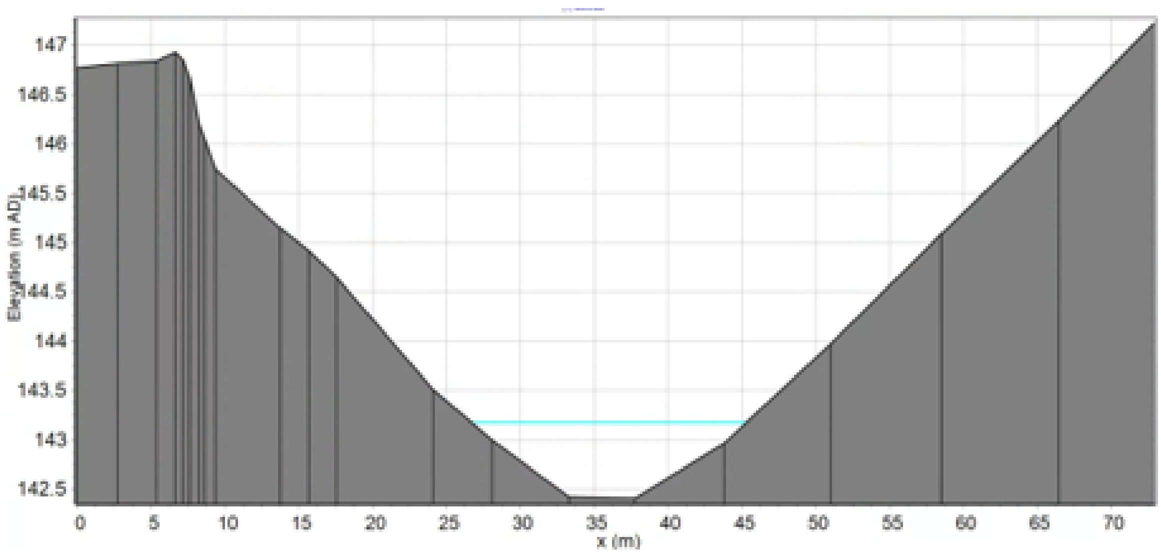
Cross Section T18 with 200-year + Climate Change Peak Water Level



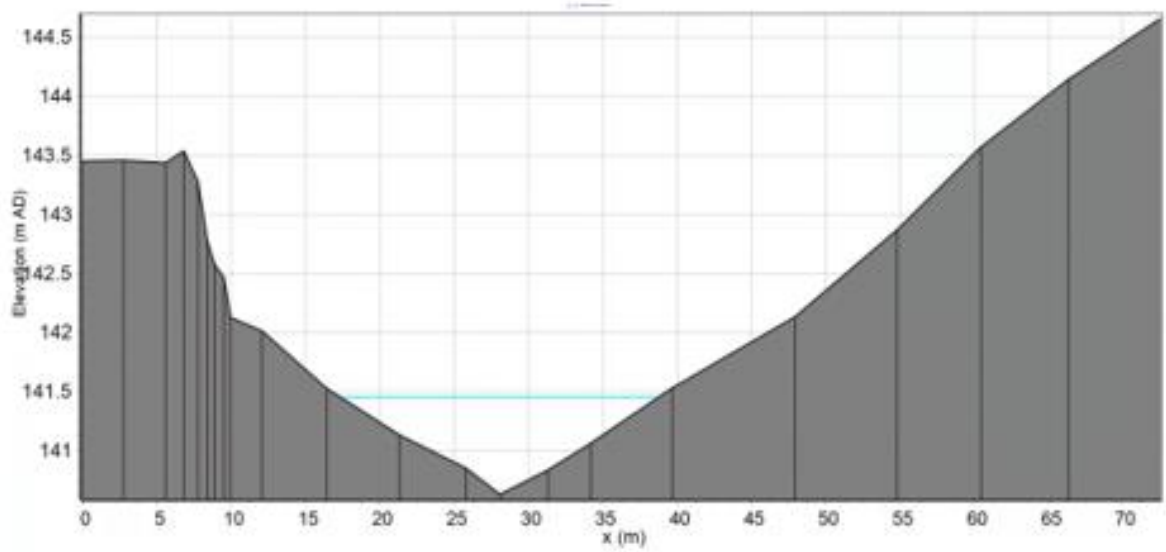
Cross Section T17 with 200-year + Climate Change Peak Water Level



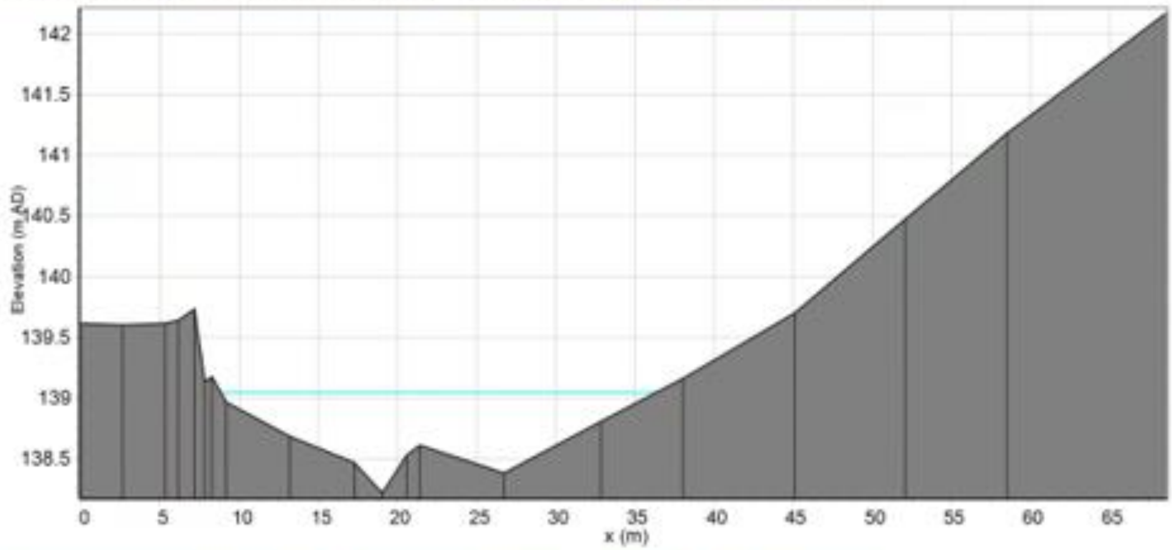
Cross Section T16.4 with 200-year + Climate Change Peak Water Level



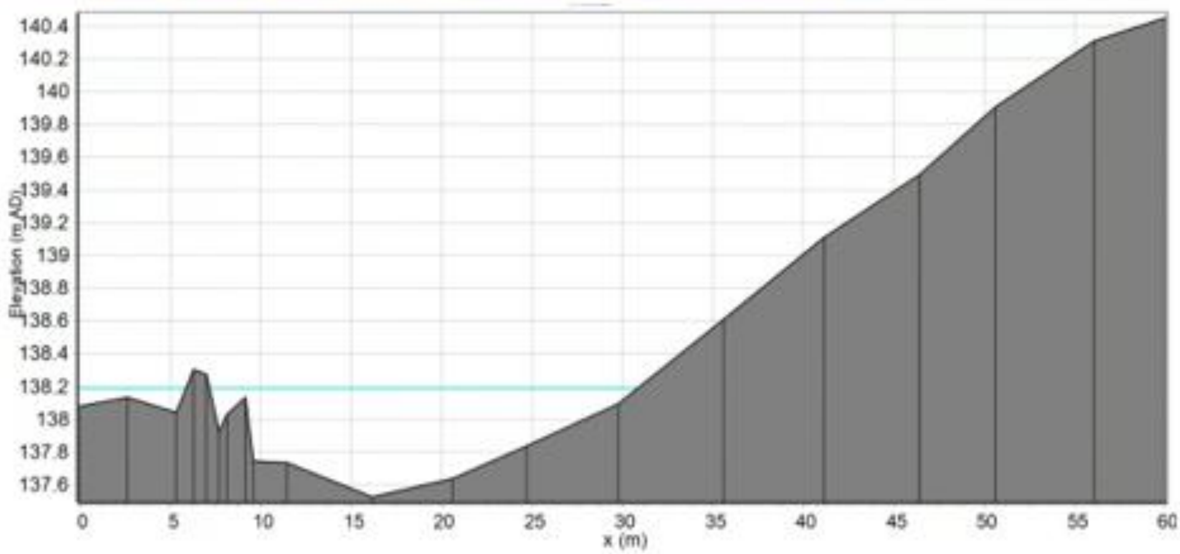
Cross Section T16.3 with 200-year + Climate Change Peak Water Level



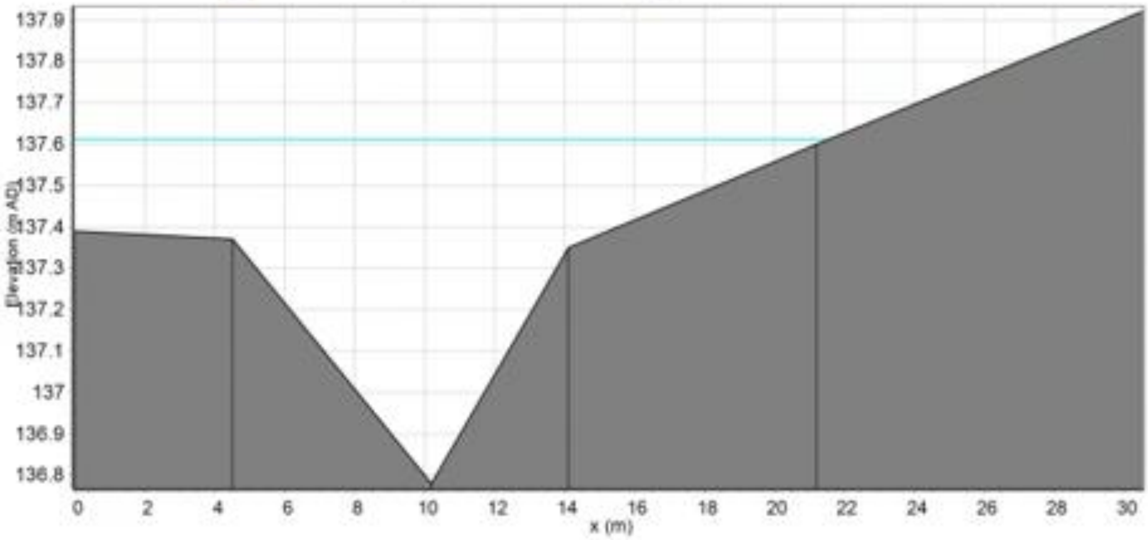
Cross Section T16.2 with 200-year + Climate Change Peak Water Level



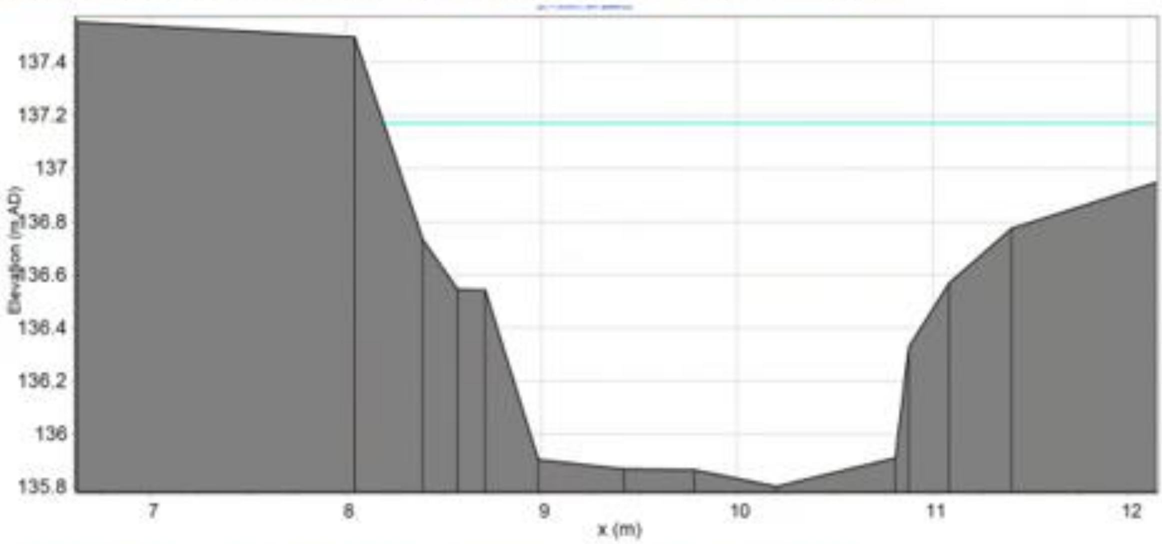
Cross Section T16.1 with 200-year + Climate Change Peak Water Level



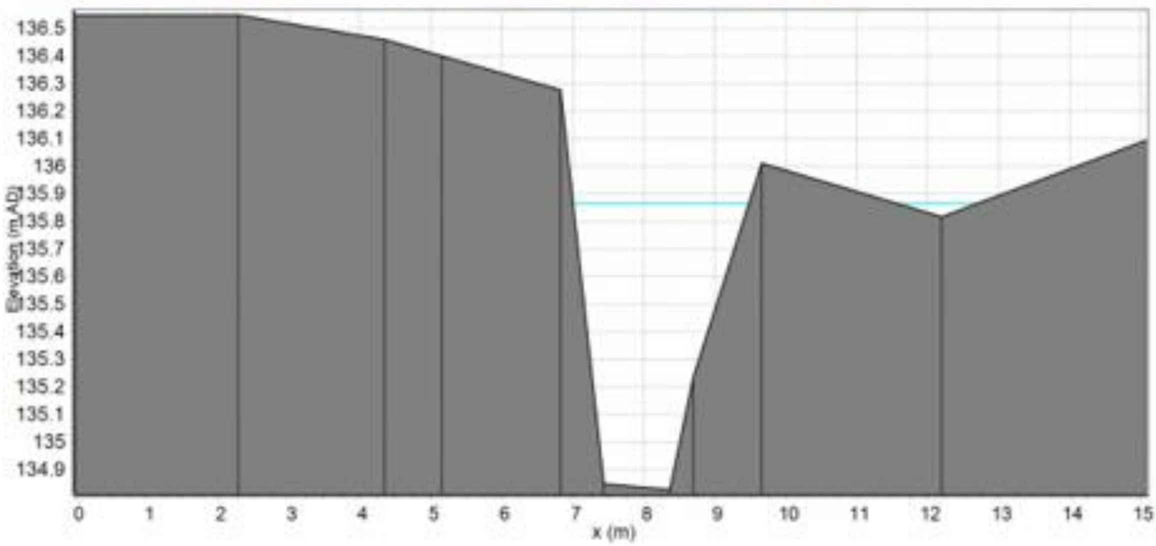
Cross Section T16_US with 200-year + Climate Change Peak Water Level



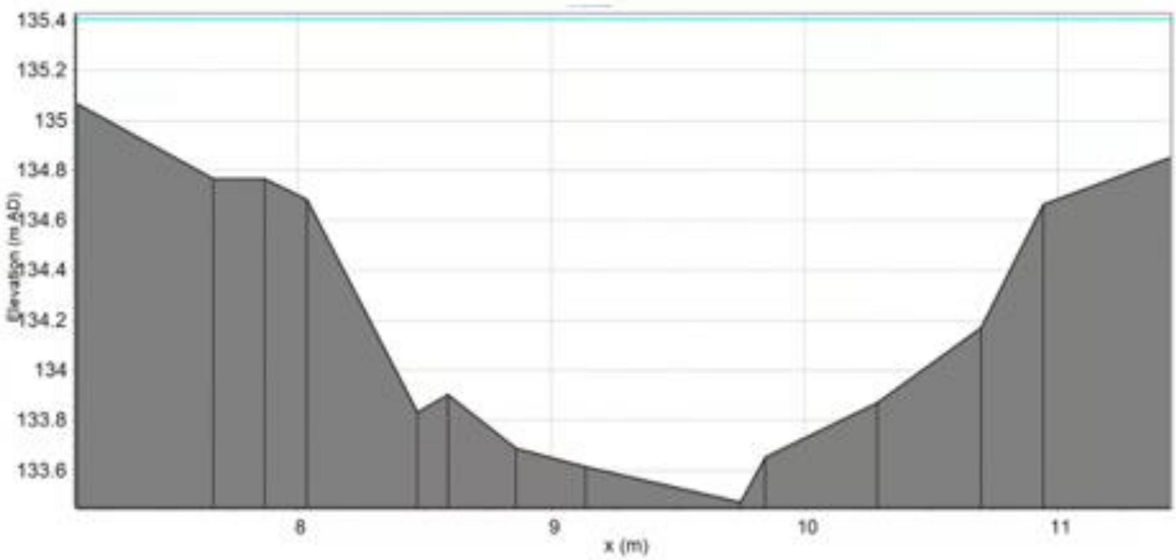
Cross Section T16_DS with 200-year + Climate Change Peak Water Level



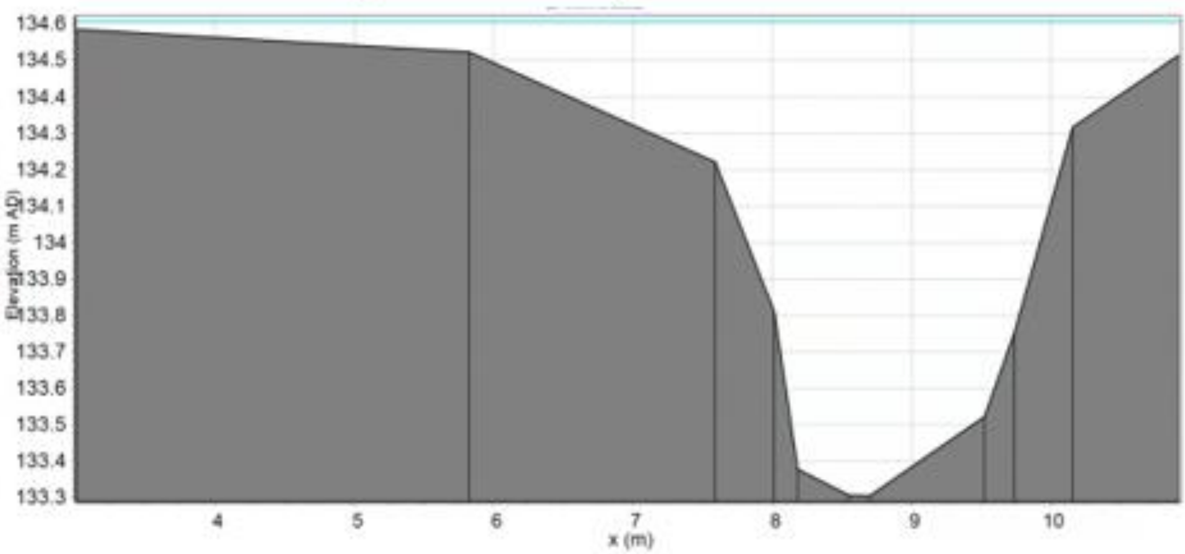
Cross Section T15 with 200-year + Climate Change Peak Water Level



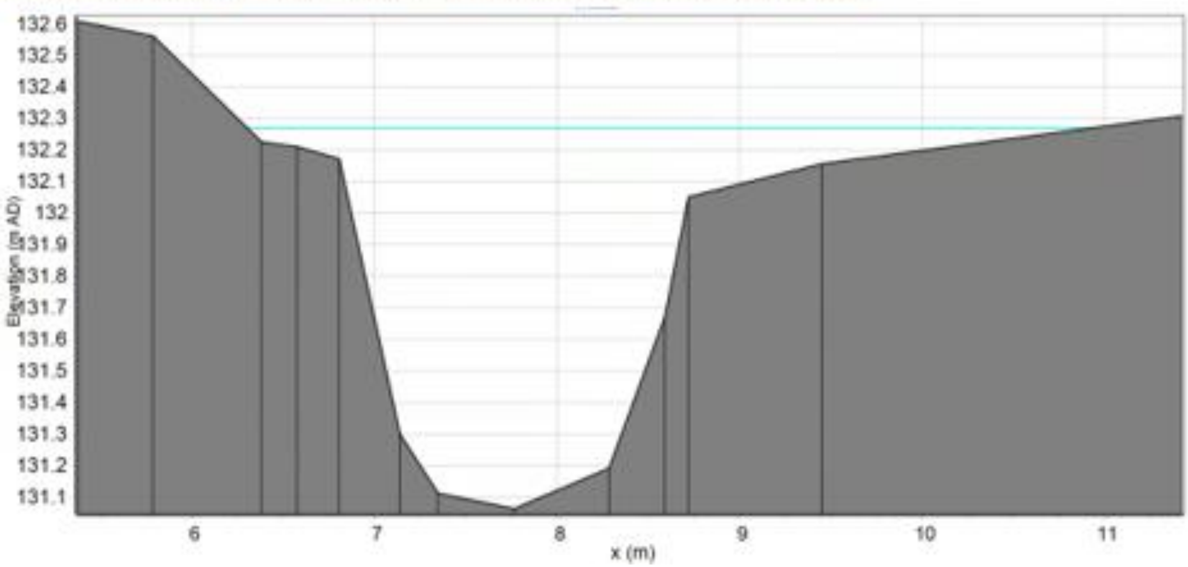
Cross Section T14 with 200-year + Climate Change Peak Water Level



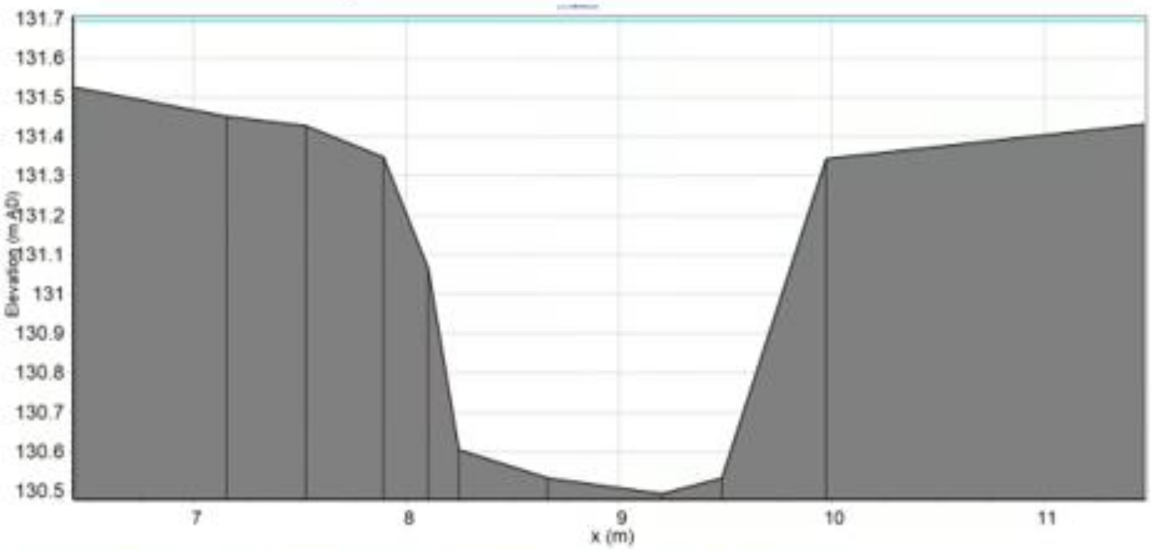
Cross Section T13 with 200-year + Climate Change Peak Water Level



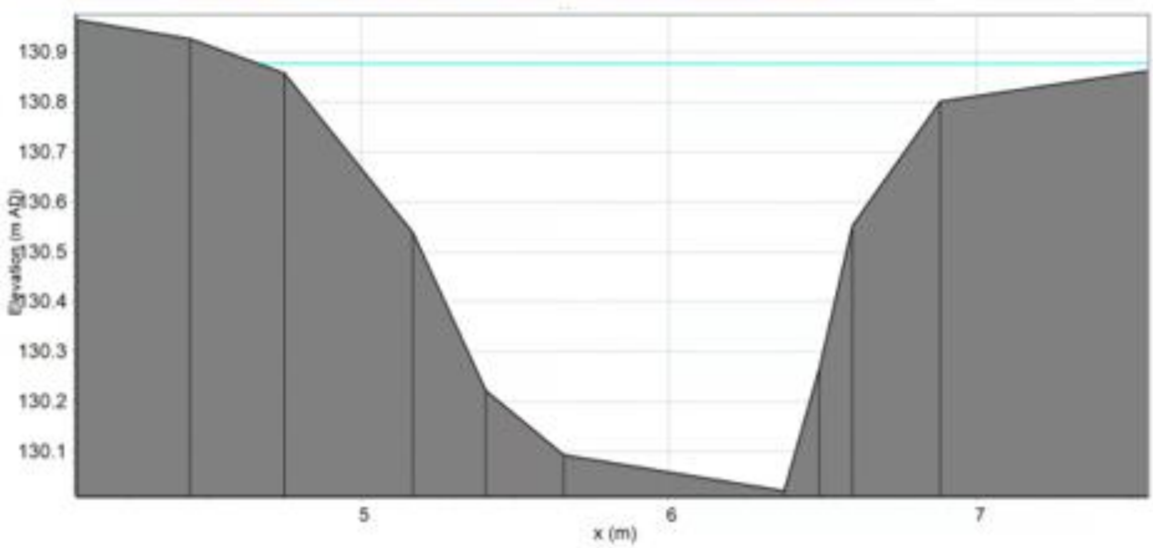
Cross Section T12 with 200-year + Climate Change Peak Water Level



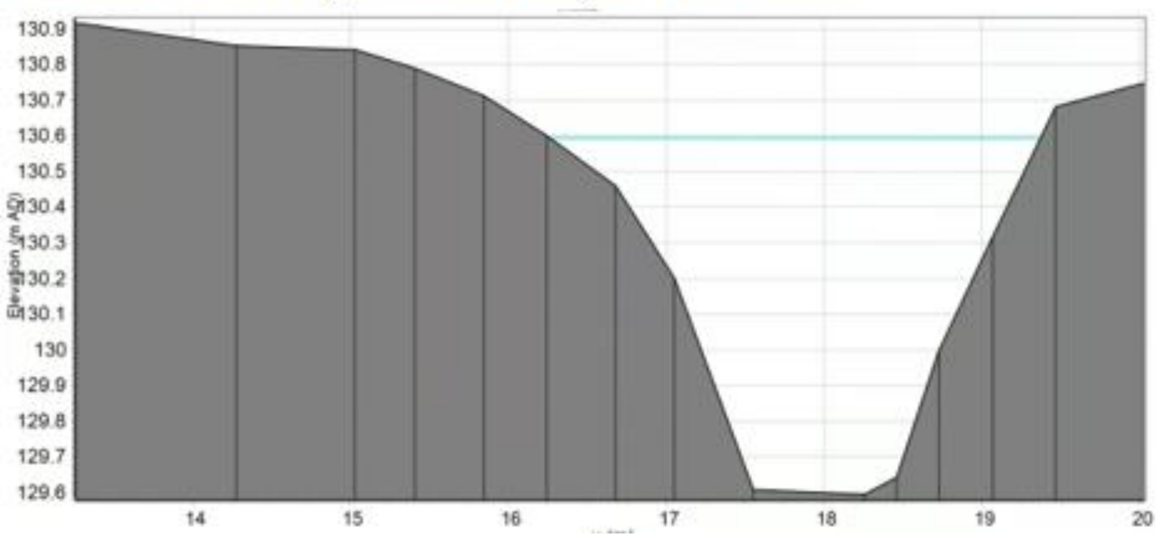
Cross Section T11 with 200-year + Climate Change Peak Water Level



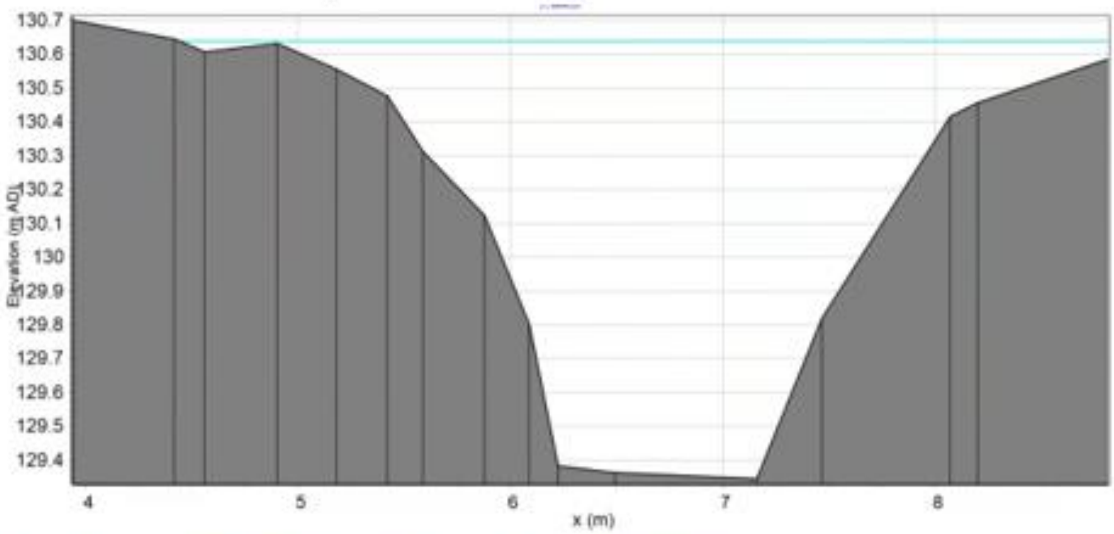
Cross Section T10 with 200-year + Climate Change Peak Water Level



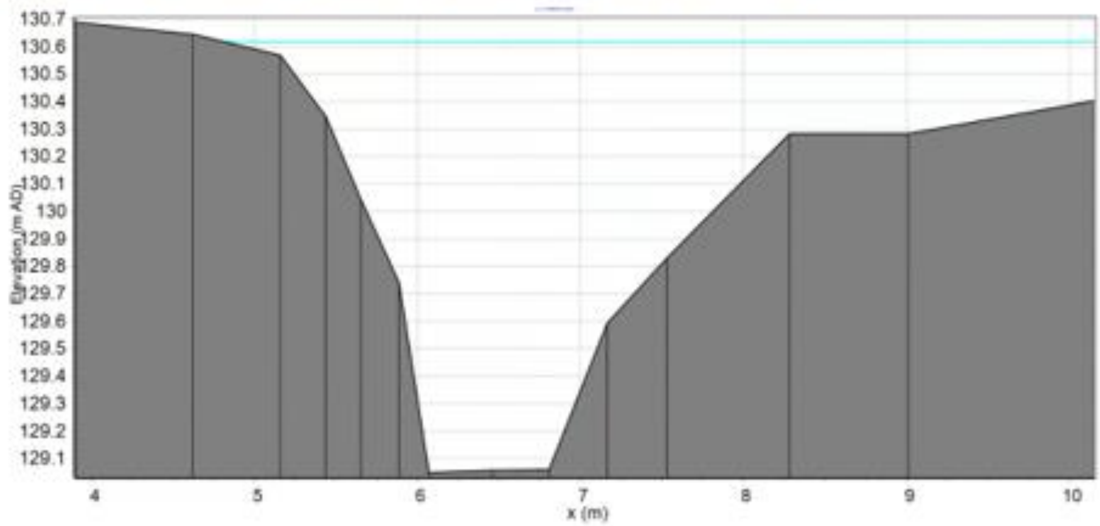
Cross Section T9 with 200-year + Climate Change Peak Water Level



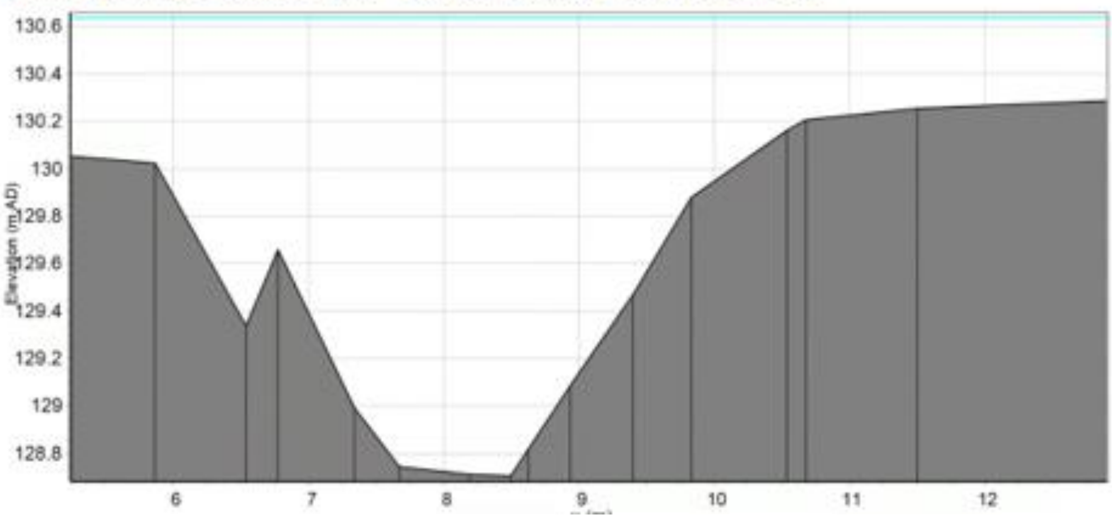
Cross Section T8 with 200-year + Climate Change Peak Water Level



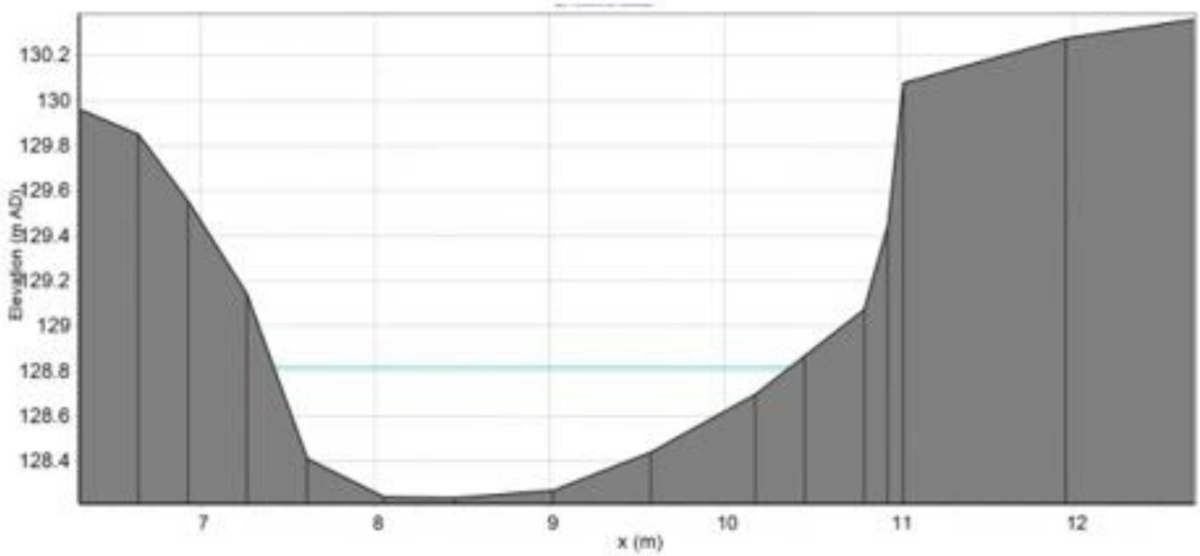
Cross Section T7 with 200-year + Climate Change Peak Water Level



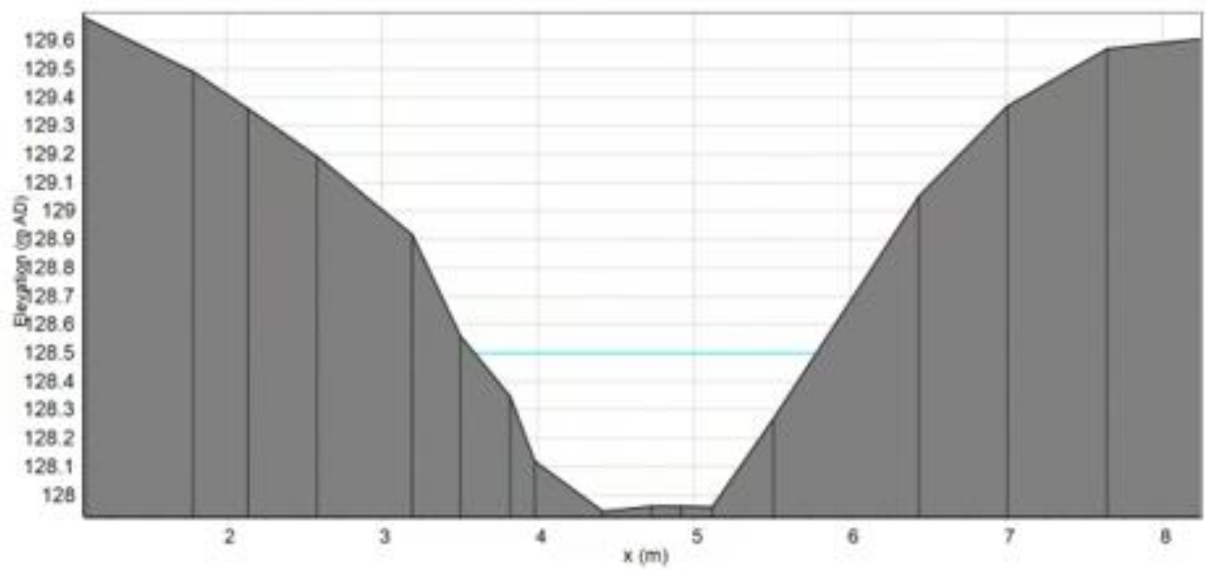
Cross Section T6 with 200-year + Climate Change Peak Water Level



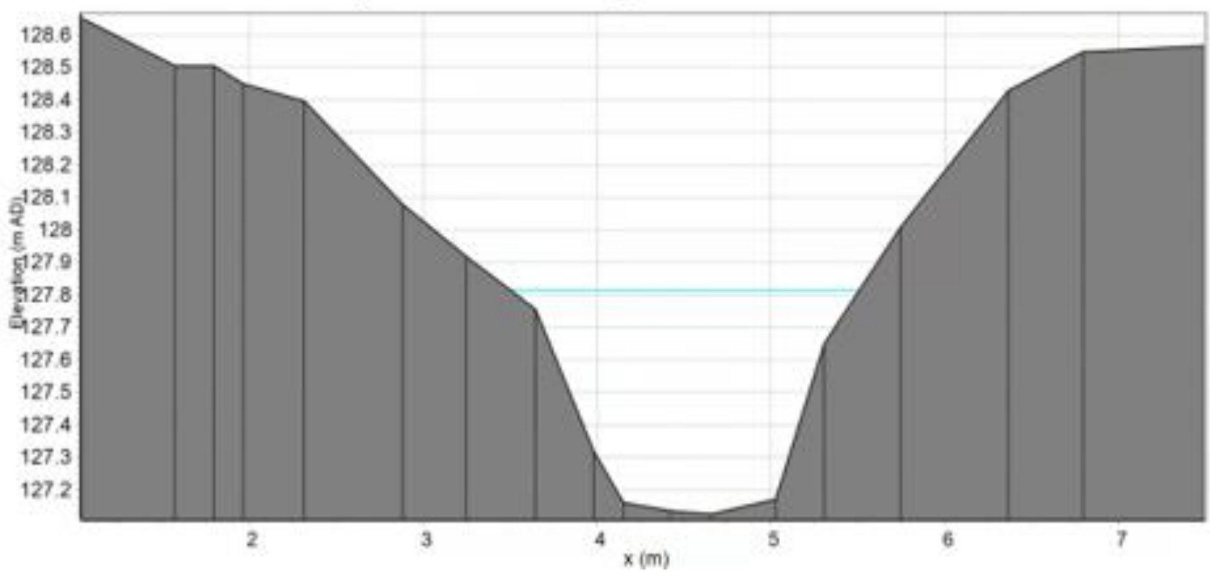
Cross Section T5 with 200-year + Climate Change Peak Water Level



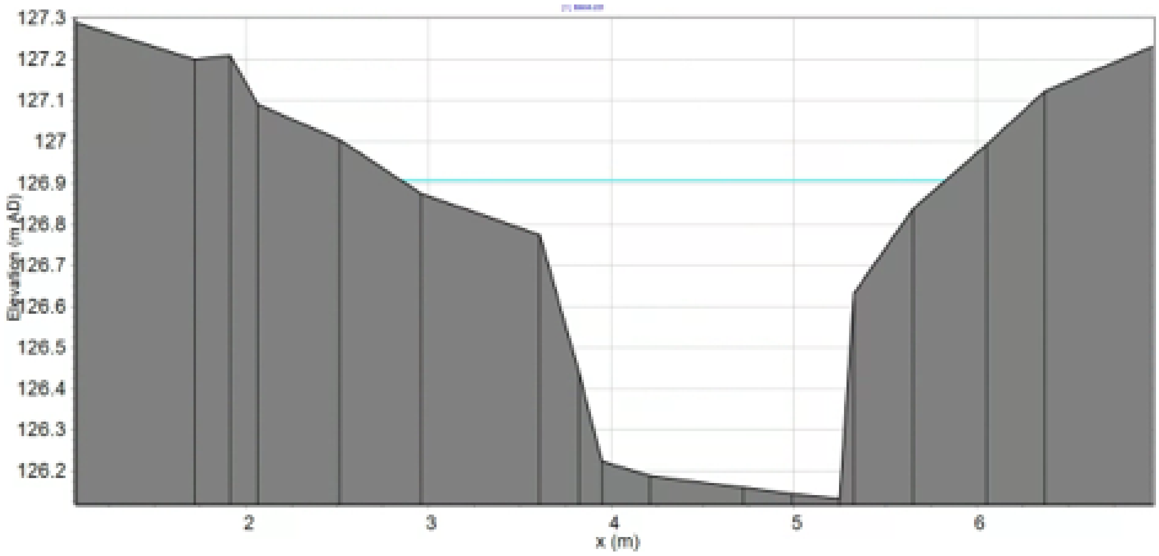
Cross Section T4 with 200-year + Climate Change Peak Water Level



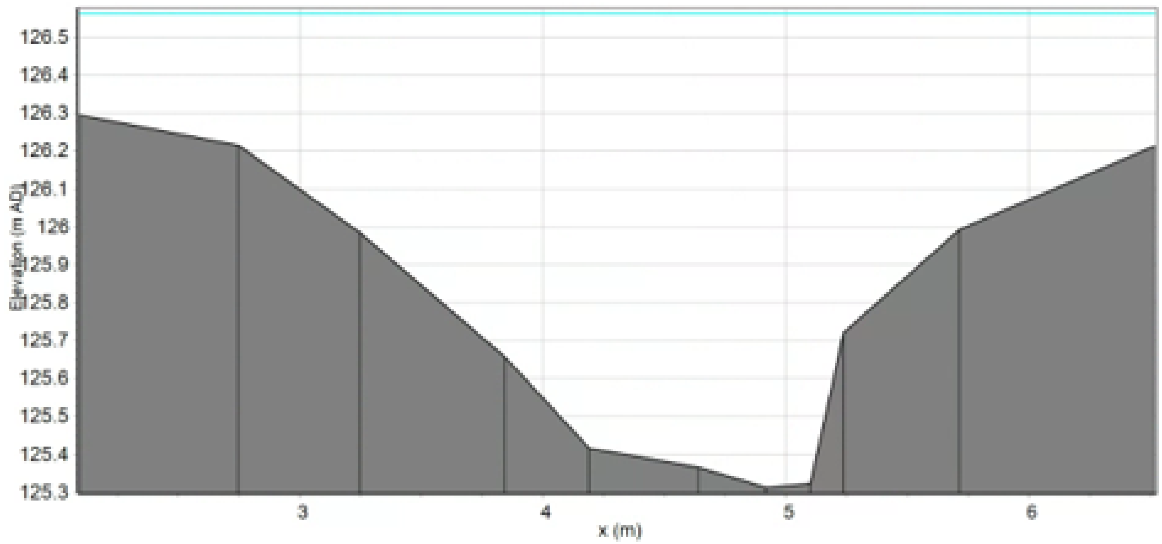
Cross Section T3 with 200-year + Climate Change Peak Water Level



Cross Section T1 with 200-year + Climate Change Peak Water Level

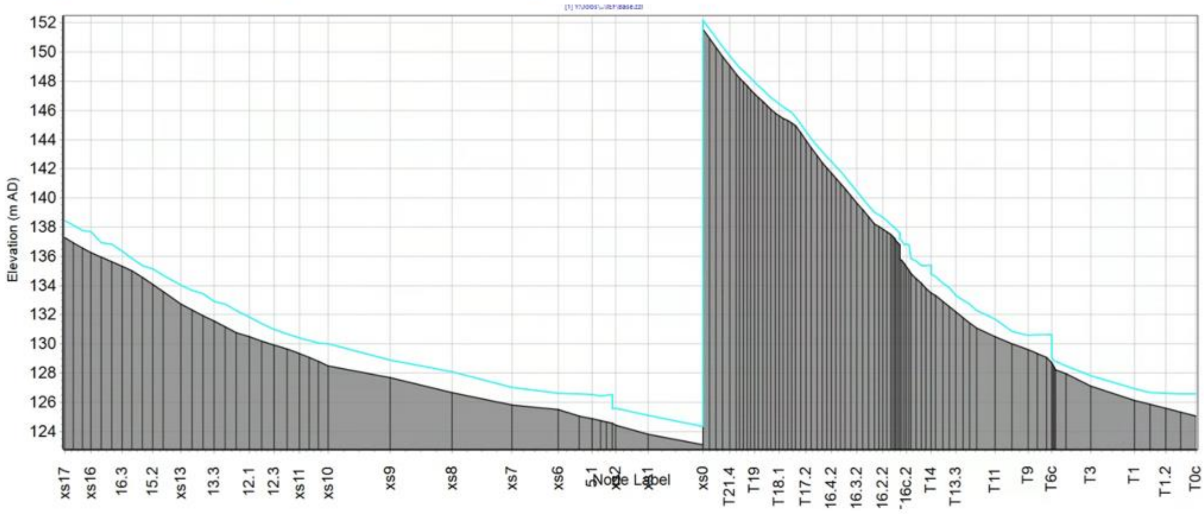


Cross Section T0 with 200-year + Climate Change Peak Water Level



ANNEX 11.1.2 – 1D CROSS SECTIONS WITH 200-YEAR + CLIMATE CHANGE PEAK WATER LEVEL

Long Profile with 200-year + Climate Change Peak Water Level



ANNEX 11.1.3 – SEPA CHECK LIST

SEPA Scottish Environment Protection Agency

Flood Risk Assessment (FRA) Checklist

(SS-NFR-F-001 - Version 14 - Last updated 28/05/2019

This document must be attached within the front cover of any Flood Risk Assessments issued to Local Planning Authorities (LPA) in support of a development proposal which may be at risk of flooding. The document will take only a few minutes to complete and will assist SEPA in reviewing FRAs, when consulted by LPAs. This document should not be a substitute for a FRA.

Development Proposal Summary

Site Name:		Emmoch Substation		
Grid Reference:	Easting:	339435	Northing:	737255
Local Authority:		Angus Council		
Planning Reference number (if known):				
Nature of the development:		Commercial	If residential, state type:	
Size of the development site:		97	Ha	
Identified Flood Risk:	Source:	Fluvial	Source name:	Fithie Burn

Land Use Planning

Is any of the site within the functional floodplain? (refer to SPP para 255)	Yes	If yes, what is the net loss of storage?		m^3
Is the site identified within the local development plan?	Select from List	Local Development Plan Name:		Year of Publication:
		Allocation Number / Reference:		
If yes, what is the proposed use for the site as identified in the local plan?	Select from List	If Other please specify:		
Does the local development plan and/or any pre-application advice, identify any flood risk issues with or requirements for the site.	No	If so, please specify:		
What is the proposed land use vulnerability?	Essential Infrastructure	ɔ the proposals represent an increase in land use vulnerability?	Yes	

Supporting Information

Have clear maps / plans been provided within the FRA (including topographic and flood inundation plans)?	Yes		
Has sufficient supporting information, in line with our Technical Guidance, been provided? For example: site plans, photos, topographic information, structure information and other site specific information.	Yes		
Has a historic flood search been undertaken?	Yes	If flood records in vicinity of the site please provide details:	
Is a formal flood prevention scheme present?	No	If known, state the standard of protection offered:	
Current / historical site use:	Agriculture		
Is the site considered vacant or derelict?	No		

Development Requirements

Freeboard on design water level:			m			
Is safe / dry access and egress available?		Vehicular and Pedestrian		Min access/egress level:	fied in detail	m AOD
Design levels:	Ground level:	See Cross Section Tab	m AOD	Min FFL:	see table	mAOD

Mitigation

Can development be designed to avoid all areas at risk of flooding?	Yes
Is mitigation proposed?	No
If yes, is compenstory storage necessary?	No
Demonstration of compensatory storage on a "like for like" basis?	
Should water resistant materials and forms of construction be used?	

Scottish & Southern Electricity Networks

TRANSMISSION

Flood Risk Assessment (FRA) Checklist

(SS-NFR-F-001 - Version 14 - Last updated 28/05/2019)

Hydrology

Is there a requirement to consider fluvial flooding?		Yes			
Area of catchment:		[illegible]	km²	Is a map of catchment area included in FRA?	Yes
Estimation method(s) used (please select all that apply):		Pooled Analysis ☐		If Pooled analysis have group details been included?	
		Single Site Analysis ☐			
		Enhanced Single Site ☐			
		ReFH2 ☑			
		FEH RRM ☑			
		Other ☐		If other (please specify methodology used):	
Estimate of 200 year design flood flow:		see design flow table	m³/s		
Qmed estimate:			m³/s	Method:	
Statistical Distribution Selected:				Reasons for selection:	Most conservative

Hydraulics

Hydraulic modelling method:		Linked 1D 2D		Software used:	Flood Modeller
				If other please specify:	
Number of cross sections:		44			
Source of data (i.e. topographic survey, LiDAR etc):		Survey		Date obtained / surveyed:	Jul-05
Modelled reach length:		Varbale	m		
Any changes to default simulation parameters?		No		If yes please provide details:	
Model timestep:		0.5			
Model grid size:		1m			
Any structures within the modelled length?		Culvert		Specify, if combination:	multiple culverts
Maximum observed velocity:		3.27	m/s		
Brief summary of sensitivity tests, and range:					
variation on flow (%)		/	%	Please specify climate change scenario considered:	
variation on channel roughness (%)		20	%		
blockage of structure (range of % blocked)		20	%		
boundary conditions:		**Upstream**			**Downstream**
(1) type		Flow			Normal depth
	Specify if other			Specify if other:	
(2) does it influence water levels at the site?		Yes			No
Has model been calibrated (gauge data / flood records)?		No			
Is the hydraulic model available to SEPA?		No			
Design flood levels:	200 year	see table	m AOD*	*see tables*	m AOD
Cross section results provided?		Yes			
Long section results provided?		Yes			
Cross section ratings provided?		No			
Tabular output provided (i.e. levels, velocities)?		Yes			
Mass balance error:		1	%		

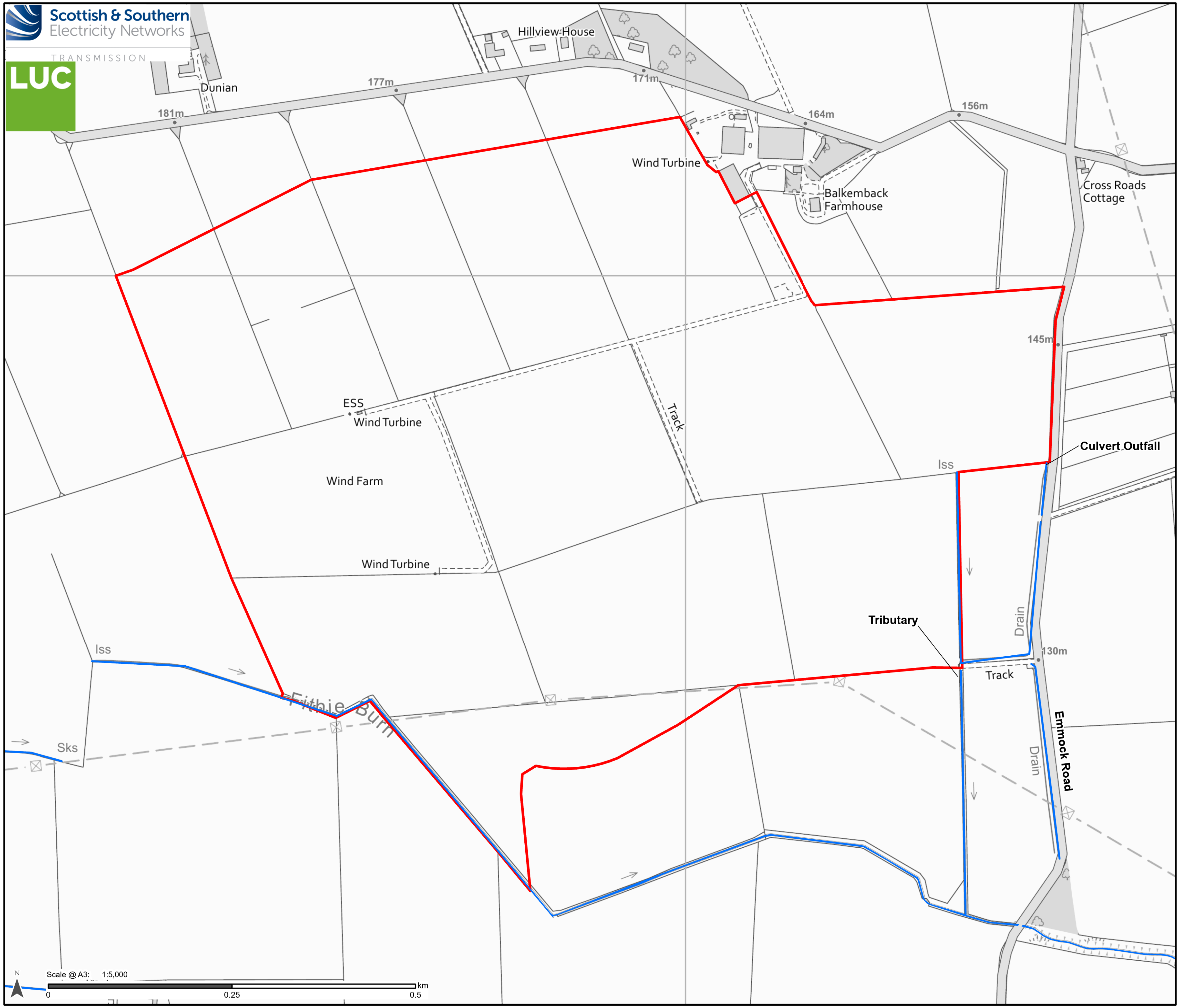
Coastal

Is there a requirement to consider coastal / tidal flooding?	No			
Estimate of 200 year design flood level:		m AOD		
Estimation method(s) used:	Select from List		If other please specify methodology used:	
Allowance for climate change (m):		m		
Allowance for wave action etc (m):		m		
Overall design flood level:		m AOD		

Comments

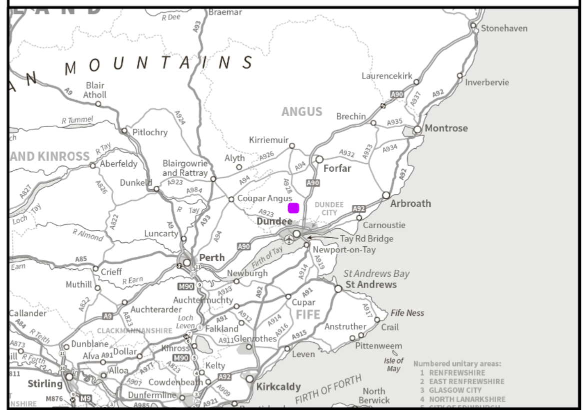
Any additional comments:	

Approved by: **N Chisholm**
Organisation: **Kaya Consulting Ltd.**
Date: **14-Jun-24**



Emmock red line boundary

OS surface watercourses and waterbodies



Project No: LT382

Project: Emmock 400 kV Substation

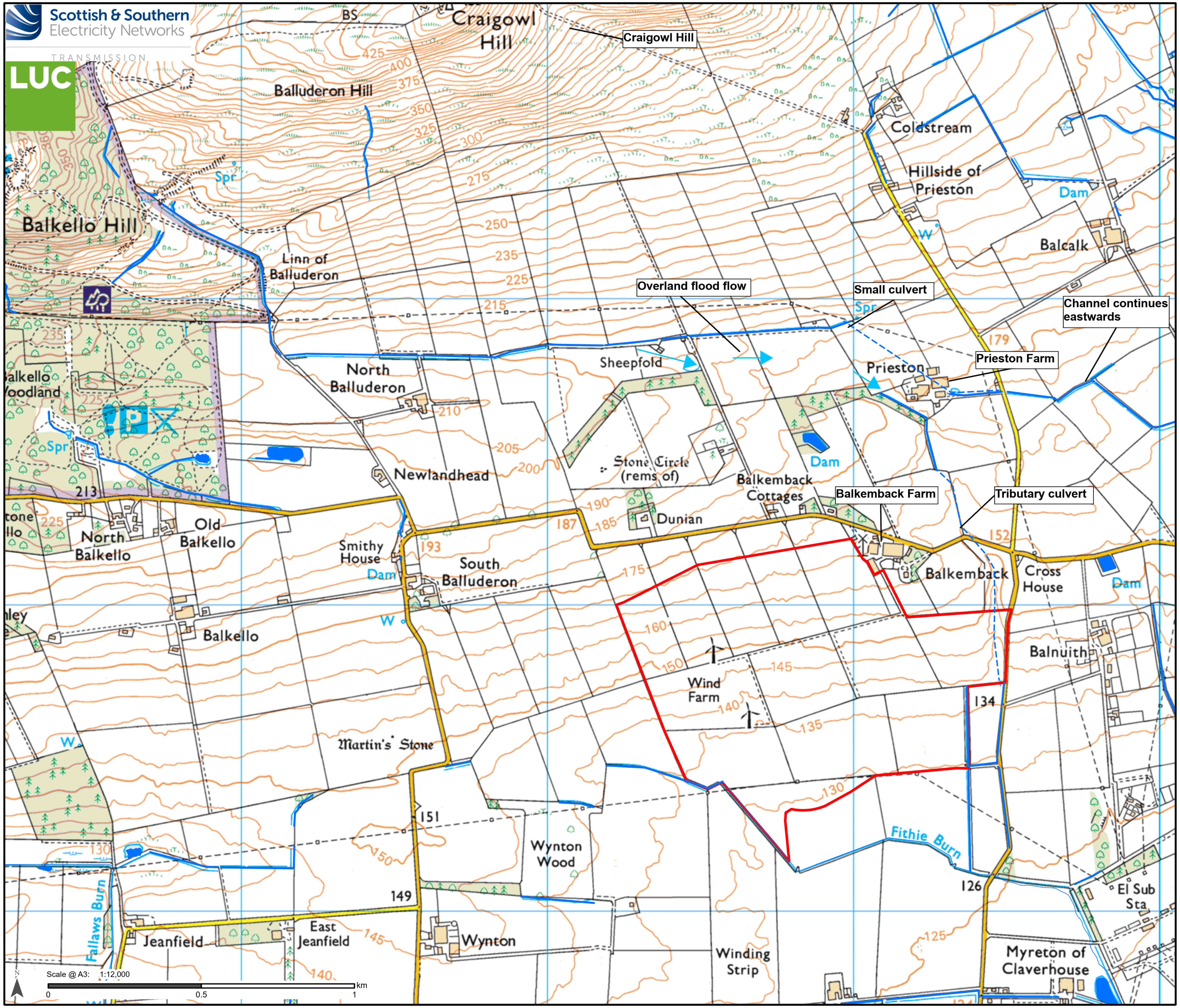
Title:

Hydrology Site Location

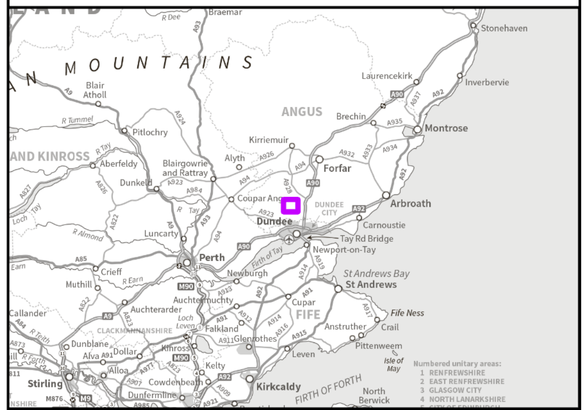
Drawn by: IB

Date: 16/09/2024

Figure: 11.1.1



- Emmock red line boundary
- OS surface watercourses and waterbodies
- Approximate route of Culvert



Project No: LT382

Project: Emmock 400 kV Substation

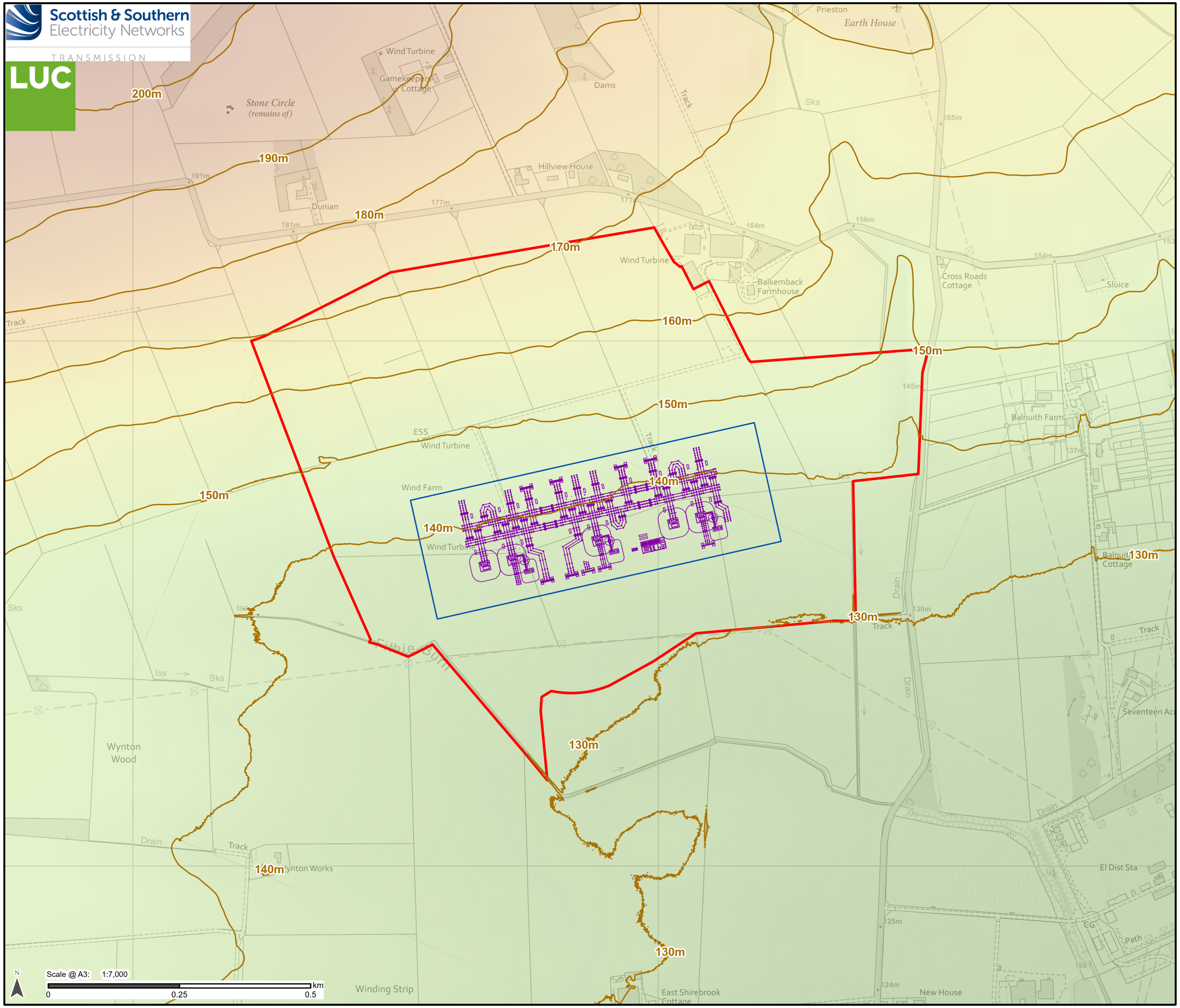
Title:

Tributary Watercourse Features

Drawn by: IB

Date: 07/11/2024

Figure: 11.1.2

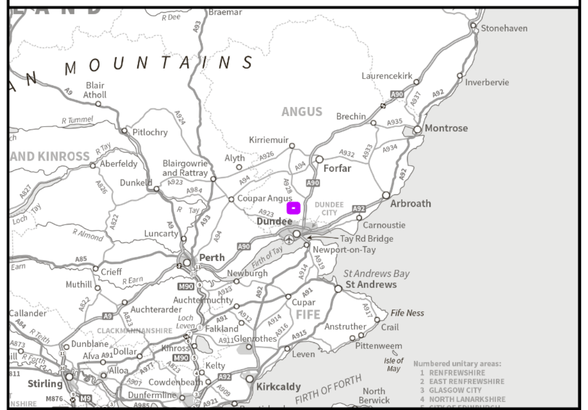


Emmock red line boundary
Substation fence line
Electrical layout
Contour line (10m interval)

Digital Terrain Model (DTM), based on merged 1m LiDAR and 5m Photogrammetry data in the north

250

100



Project No: LT382

Project: Emmock 400 kV Substation

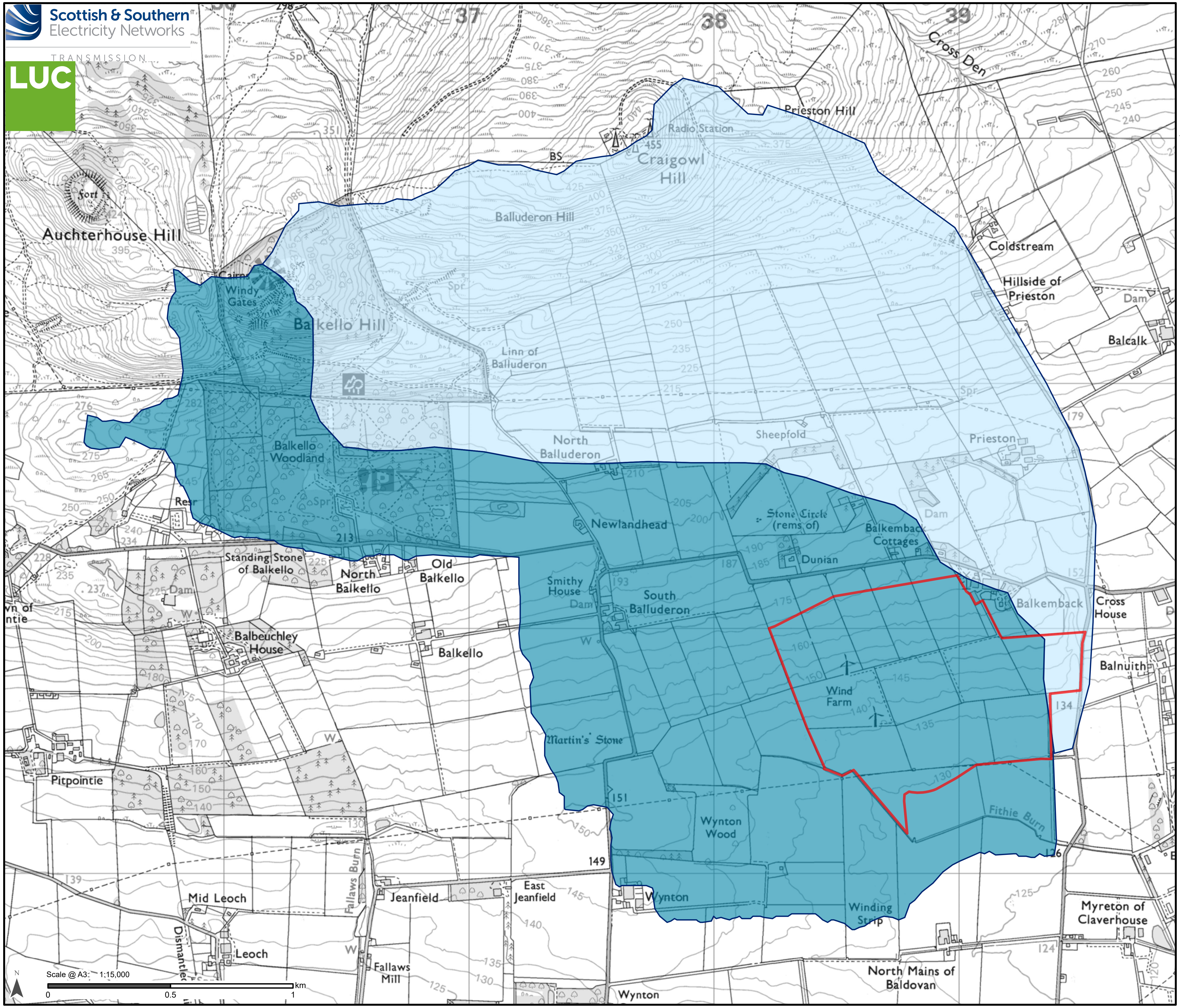
Title:

Site and Surrounding Topography

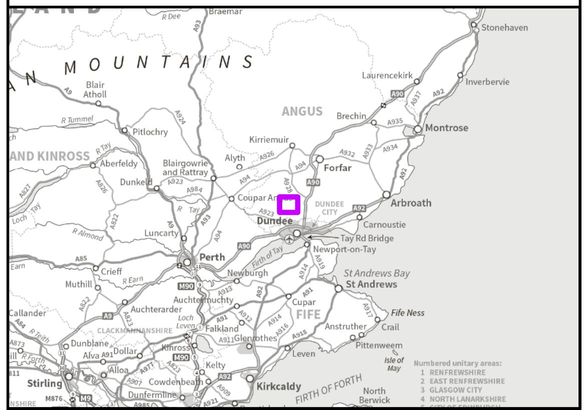
Drawn by: IB

Date: 11/11/2024

Figure: 11.1.3



- Emmock red line boundary
- Tributary Catchment
- Fithie Burn Catchment



Project No: LT382

Project: Emmock 400 kV Substation

Title:

Catchment Area Delineation

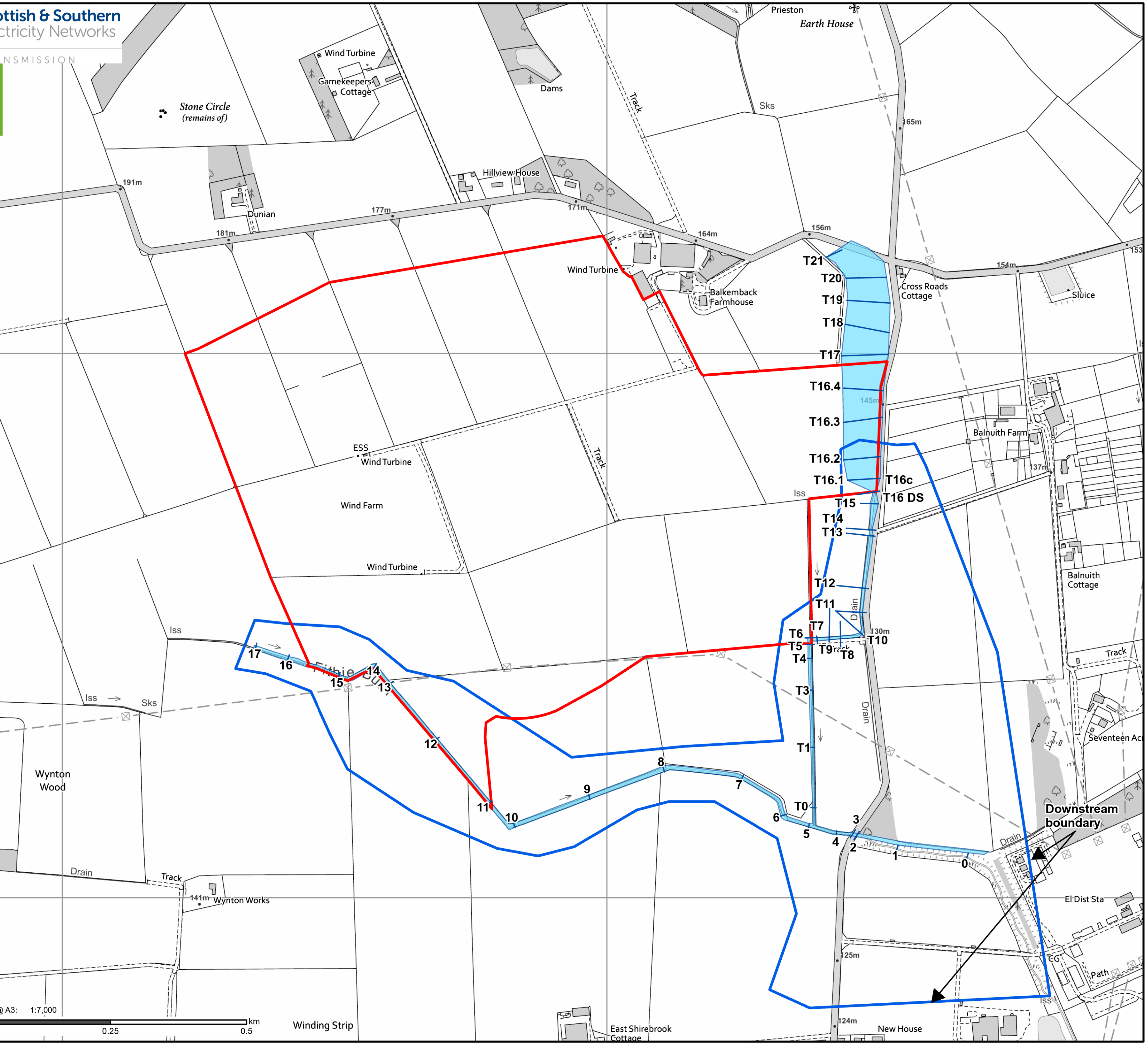
Drawn by: IB

Date: 16/09/2024

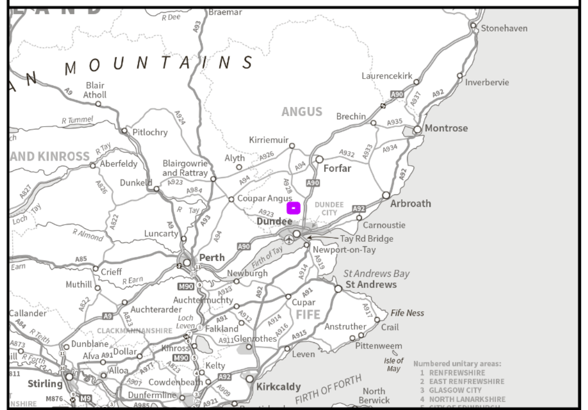
Figure: 11.1.4

Scottish & Southern Electricity Networks
TRANSMISSION

LUC



Emmock red line boundary
1D model area
2D domain
Cross section

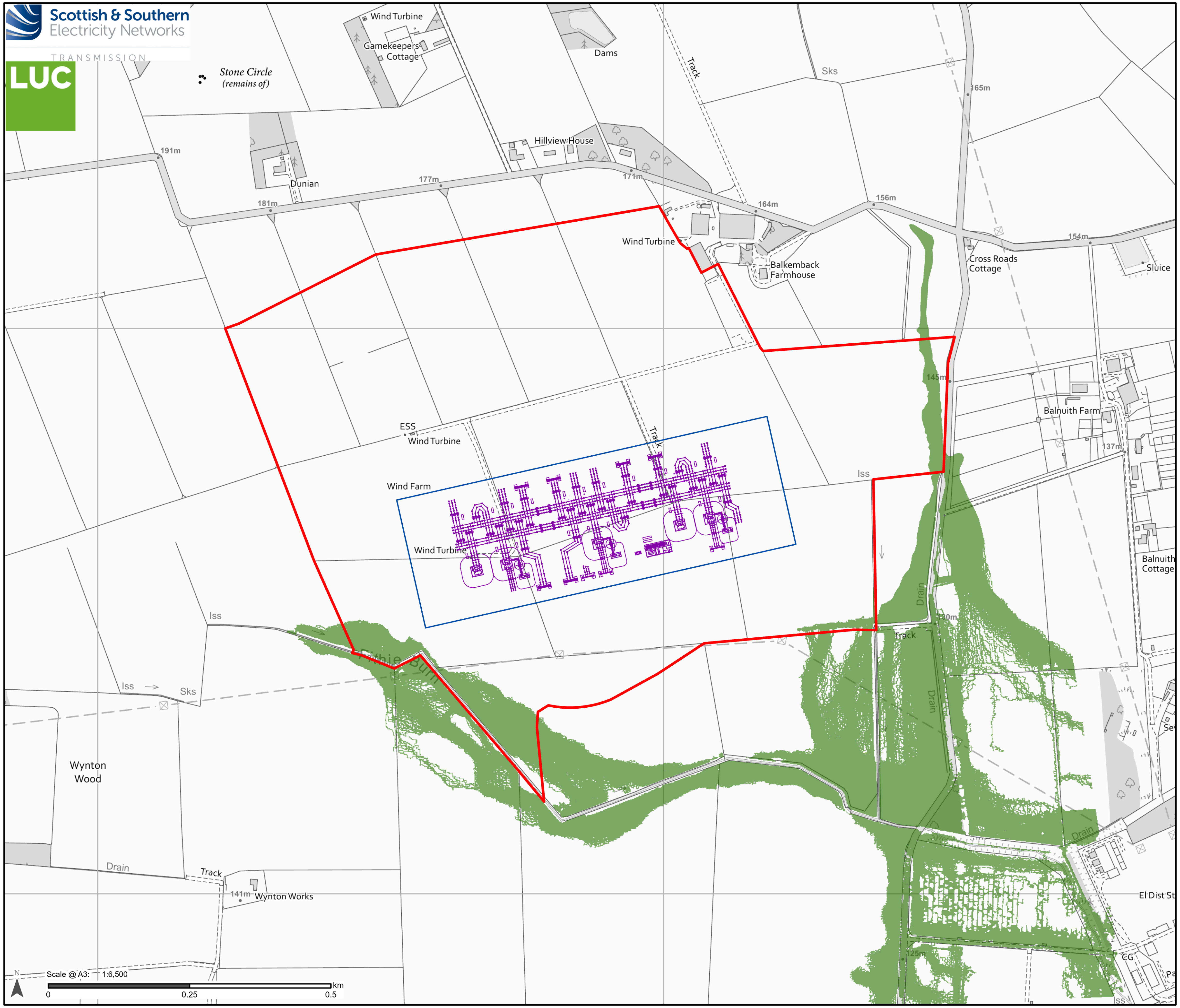


Project No: LT382
Project: Emmock 400 kV Substation

Title:
Mathematical Model Set-up

Drawn by: IB
Date: 07/11/2024

Figure: 11.1.5



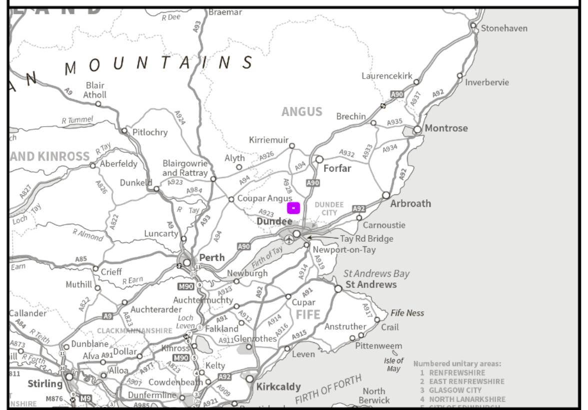
Emmock red line boundary

Substation fence line

Electrical layout

Modelled flood map (200 year + Climate Change Fluvial Flood Map)

Modelled future flood map produced by Kaya Consulting Ltd.



Project No: LT382

Project: Emmock 400 kV Substation

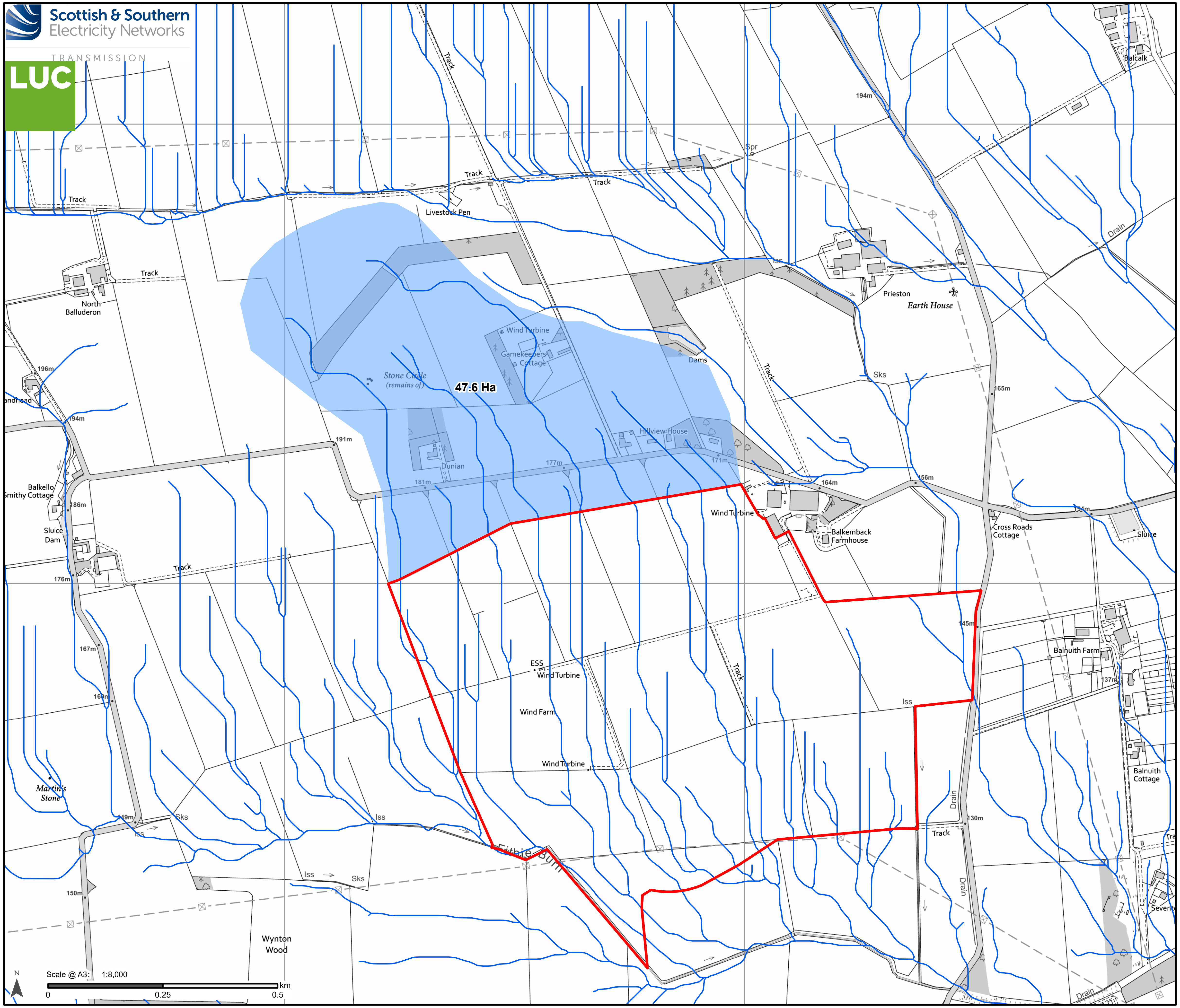
Title:

200 year + Climate Change Fluvial Flood Map

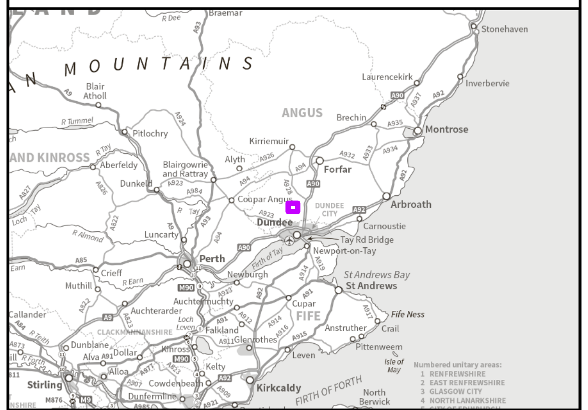
Drawn by: IB

Date: 11/11/2024

Figure: 11.1.6



- Emmock red line boundary
- Flow pathway
- Surface water catchment



Project No: LT382

Project: Emmock 400 kV Substation

Title:

Surface Water Flow Pathways

Drawn by: IB

Date: 16/09/2024

Figure: 11.1.7