Berwick Bank Windfarm

Technical Appendix 11.1: Flood Risk Assessment

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1. Introduction

1.1 Context

ITPEnergised (ITP) has been appointed by Berwick Bank Wind Farm Ltd (The Client) to provide support and input to the onshore component of the Environmental Impact Assessment Report (EIAR) submission to support a planning application for the onshore transmission works in connection with the Berwick Bank Windfarm.

This Flood Risk Assessment (FRA) has been prepared as Technical Appendix 1 to Chapter 11: Geology, Hydrology, Soils & Flood Risk within the onshore EIAR. The purpose of this report is to outline any potential flood risks to the Proposed Development, the impact of the Proposed Development on flood risk elsewhere, and the proposed measures which could be incorporated to mitigate any identified flood risk.

The Site has been visited by an experienced ITP Hydrologist and Civil Engineer on several occasions between 2020 and 2022 to inform this assessment.

1.2 Policy and Guidance

This assessment has been completed in accordance with guidance presented within the National Planning Framework for Scotland 4 (NPF4)[1] (which superseded Scottish Planning Policy (SSP) and NPF3) and taking cognisance of the Flood Risk Management (Scotland) Act 2009.

The assessment also references and takes due consideration (where appropriate) of the following principal guidance and policy documents:

- CIRIA (2004) Development and Flood Risk – Guidance for the Construction Industry, Report C624;
- East Lothian Council Local Development Plan (2018)
- East Lothian Council Local Development Plan: Strategic Flood Risk Assessment (2018)
- Scottish Environment Protection Agency (2015) Flood Risk and Land Use Vulnerability Guidance (Reference: LUPS-GU24), Version 4, July 2018;
- Scottish Environment Protection Agency (2017) SEPA Development Plan Guidance Note 2a: Development Management Guidance: Flood Risk (Reference: LUPS-DM-GU2a), Version 2, July 2018;
- Scottish Environment Protection Agency (2018) Flood Risk Management Strategy Forth Estuary;
- Scottish Environment Protection Agency (2019) Technical Flood Risk Guidance for Stakeholders (Reference: SS-NFR-P-002) May 2019; and
- The Strategic Development Planning Authority for Edinburgh and South East Scotland (2013) Strategic Development Plan.

[1] The Scottish Government (2023) National Planning Framework 4, February 2023

1.3 Site Location

The site is situated near Torness and the village of Innerwick, south-east of Dunbar located in East Lothian. The centre of the site is OSGB36, British National Grid (BNG) 373977, 674114 and is approximately 598 ha in size.

The extent of the site runs from the settlement of Branxton in the south, Bilsdean in the south-east, the coastline at Skateraw and Torness in the north, Oxwell Mains Cement Works and Quarry in the north-west and Fouracres in the west. The land on which the site is located is predominantly agricultural land with sparse settlements spread throughout, connected by small local roads and tracks. The A1 trunk road and East Coast Main Line (ECML) railway cut through the site in a north-west to south-east direction running parallel to the coast. Torness Power Station (Nuclear) is located to the south-east of the proposed landfall at Skateraw.

1.4 Proposed Onshore Development

The Onshore Transmission Works (OnTW) shall include the following:

- a new onshore substation;
- landfall works;
- onshore cables within a cable corridor between the landfall and the new onshore substation, and between the new onshore substation and the SPEN Branxton substation; and
- associated ancillary infrastructure.

The Branxton substation is being developed by SPEN and is subject to a separate planning application.

1.5 Topography

Ground levels within the site vary due to the scale of the site and the sloping topography towards the coastline. The highest elevations within the site are approximately 120mAOD around the location of the proposed SPEN Branxton substation whilst the lowest elevations are at sea level along the coastline. The topography at the site generally falls in a north eastern direction.

1.6 Geology and Hydrogeology

1.6.1 Geology

1.6.1.1 Superficial

Review of the British Geological Survey (BGS) online geology maps[2] indicates that the superficial deposits within the site extents are predominantly Glaciofluvial deposits consisting of gravel, sand and silt. Areas of alluvial deposits are present along the extents of watercourses and raised marine deposits can be found at the landfall location. There are also some sparse areas of Till further inland where this becomes the predominant deposit (beyond site extents).

1.6.1.2 Bedrock

Review of the BGS online geology maps indicates that the bedrock geology underlying the central and southern areas of the site is the Ballagan Formation consisting of sandstone, siltstone and dolomitic limestone. In the northern area of the site, near to the coastline the underlying bedrock

[2] British Geological Survey (2022) Natural Environment Research Council – online Geology of Britain Viewer, available at: http://mapapps.bgs.ac.uk/geologyofbritain/home.html

geology is dominated by various limestone units including Hurlet Limestone, Blackhall Limestone and Lower Limestone Formation consisting of limestone, argillaceous rocks and subordinate sandstone.

The bedrock geology in the central and southern areas of the site are part of the Inverclyde Group rock unit whilst the northern area is part of the Strathclyde Group rock unit.

1.6.2 Hydrogeology

Review of the BGS online hydrogeology maps indicates that the site is underlain by moderately productive aquifers where flow is virtually all through fractures and other discontinuities.

SEPA classifications identify the site to be within the Torness Coastal groundwater body and the Torness groundwater body which both have an overall status of Good.

1.7 Hydrological Context

1.7.1 Local Hydrology

The site area is divided into four catchments shown in SEPA's Baseline Confluence Inter Catchments data file;

- Dry Burn at the mouth
- East Lothian Coastal between Thornton Burn and Dry Burn
- Thornton Burn at the mouth
- East Lothian Coastal between Dunglass Burn and Thornton Burn

The Dry Burn catchment is approximately 19km^2 and is classified as being of Moderate status (SEPA, 2020, under the Water Framework Directive). With respect to the Proposed Development, the majority of the onshore cable corridor between the landfall location and new onshore substation is located within this catchment near to its divide with the 'East Lothian Coastal between Thornton Burn and Dry Burn' catchment.

The East Lothian Coastal between Thornton Burn and Dry Burn catchment is approximately 4km^2. The main watercourse in this catchment is unnamed and originates from the agricultural land to the west of Innerwick and flows to the west and north of the proposed onshore substation location and is not classified by SEPA. This watercourse has been surveyed for the purpose of informing the drainage strategy for the onshore substation and it has been identified that it is heavily modified with multiple culverts and discharges to the Dry Burn to the north of the settlement of Skateraw.

The Thornton Burn catchment is approximately 14km^2 and is classified as being of Good status. With respect to the Proposed Development, the majority of the onshore cable corridor between the new onshore substation location and the new SPEN substation at Branxton is located within this catchment. The new SPEN substation location is situated at the confluence point of the upper reaches of the Thornton Burn known as the Braidwood Burn (predominant watercourse) and the Ogle Burn (tributary to the Braidwood Burn).

The East Lothian Coastal between Dunglass Burn and Thornton Burn catchment is approximately 17km^2 with no named watercourses present. A short section of proposed access track to the proposed Branxton grid substation is located within the western extents of the catchment. The site boundary extends further east into this catchment however, no further Proposed Development is to be located in this catchment.

With respect to the Proposed Development, the main watercourses are:

- Dry Burn
- Thornton Burn / Braidwood Burn

- Unnamed Watercourse between Innerwick and Skateraw (hereafter referred to as the Innerwick Burn)

A hydrological summary and catchment characteristics of the main watercourses local to the Proposed Development have been obtained from the FEH Web Service[3] and are shown in Table 1 below.

Table 1 – Hydrological characteristics of local catchments

Waterbody Catchment	Area (km^2)	SAAR[1] (mm)	URBEXT[2] (%)	SPRHOST[3] (%)	PROPWET[4]
Dry Burn	19.09	727	0.0007	29.97	0.430
Thornton Burn / Braidwood Burn	14.10	753	0.0000	30.70	0.430
Innerwick Burn	1.88	671	0.0130	33.71	0.430

[1]SAAR = Standard Annual Average Rainfall
[2]URBEXT = Extent of Urban and Suburban Land Cover
[3]SPRHOST = Standard Percentage Runoff using UK Hydrology of Soil Types (HOST) Classification
[4]PROPWET = Proportion of Time the Soil Moisture Deficit (SMD) was equal to, or below, 6mm during 1961-1990

The catchments summaries indicate they experience relatively low annual rainfall (for Scottish catchments) and are all essentially completely rural.

2. Planning and Guidance Context

2.1 National Planning Framework

This report has been prepared in accordance with NPF4 Policy 22 relating to Flood Risk and Water Management, which states:

*"**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.

Policy Outcomes:

- *Places are resilient to current and future flood risk.*
- *Water resources are used efficiently and sustainably.*
- *Wider use of natural flood risk management benefits people and nature."*

Furthermore, NP4 states that development proposals at risk of flooding or in a flood risk area will only be supported if they are for:

- *"Essential infrastructure where the location is required for operational reasons;*
- *Water compatible uses;*
- *Redevelopment of an existing building or site for an equal or less vulnerable use; or.*
- *Redevelopment of previously used sites in built up areas where the LDP has identified a need to bring these into positive use and where proposals demonstrate that*

[3] UK Centre for Ecology & Hydrology (2022) Flood Estimation Handbook Web Service, Developed by Wallingford HydroSolutions

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

2.2 East Lothian Council Local Development Plan (LDP) 2018

ELC LDP 2018 provides the following policies that are relevant to flood risk assessment.

- ***"Policy NH9: Water Environment:*** *Where relevant, new development should protect and, where appropriate, enhance the water environment, in line with the Water Framework Directive 2000 (WFD) and the Water Environment and Water Services (Scotland) Act 2003 (WEWS).*

  Development proposals that would have a detrimental impact on the water environment will not be supported."

- ***"Policy NH10: Sustainable Drainage Systems****: All development proposals must demonstrate that appropriate provision for Sustainable Drainage Systems (SuDS) has been made at the time of submitting a planning application, except for single dwellings or developments in coastal locations that discharge directly to coastal waters where there is no or a low risk to designated bathing sites and identified Shellfish Waters. Sufficient space for proposed SuDS provision, including the level and type of treatment appropriate to the scheme of Proposed Development, must be safeguarded in site layouts. Provision must also be made for appropriate long-term maintenance arrangements to the satisfaction of the Council.*

  A drainage assessment may also be required to show the impact of a 1 in 200-year rainstorm event. SuDS schemes should be designed with an allowance for climate change.

  Proposals must also demonstrate through a design-led approach how SuDS proposals are appropriate to place and designed to promote wider benefits such as placemaking, green networks and biodiversity enhancement."

- ***"Policy NH11: Flood Risk****: Development that would be at unacceptable risk of flooding will not be permitted. New development within areas of medium to high risk of coastal or watercourse flooding (with greater than 0.5% annual probability of flooding) should generally be avoided in accordance with the provisions set out in Advice Box 8.*

  All relevant development proposals will be assessed based on the probability of a flood affecting the site and the nature and vulnerability of the proposed use, taking into account the following:

  a) the characteristics of the site and any existing or previous development on it;

  b) the design and use of the proposed development, including use of water resistant materials and construction;

  c) the size of the area likely to flood;

  d) depth of flood water, likely flow rate and path, and rate of rise and duration;

  e) the vulnerability and risk of wave action for coastal sites;

  f) committed and existing flood protection methods: extent, standard and maintenance regime;

  g) the effects of climate change, including an appropriate allowance for freeboard;

  h) surface water run-off from adjoining land;

  i) culverted watercourses, drains and field drainage;

j) cumulative effects, especially the loss of storage capacity;

k) cross-boundary effects and the need for consultation with adjacent authorities;

l) effects of flood on access including by emergency services; and

m) effects of flood on proposed open spaces including gardens.

2.3 SEPA Flood Risk and Land Use Vulnerability Guidance

2.3.1 Context

This guidance outlines how SEPA assess the vulnerability to flooding of different land use with the following categories:

- Most Vulnerable Uses;
- Highly Vulnerable Uses;
- Least Vulnerable Uses;
- Essential Infrastructure; and
- Water Compatible uses.

The following paragraphs are extracted from the guidance for context:

"This guidance classifies land uses according to how they are impacted by flooding, i.e. their relative susceptibility and resilience to flooding, and any wider community impacts caused by their damage or loss.

The classification recognises that certain types of development, and the people who use and live in them, are more at risk from flooding than others (e.g. children, the elderly and people with mobility problems that may have more difficulty in escaping fast flowing water).

The term 'land use vulnerability' is used in this guidance to differentiate between a range of land uses, taking account of flooding impacts on land uses in terms of their relative susceptibility and resilience to flooding. It also reflects wider community impacts caused by their damage or loss. For example, a police station is not more likely to suffer damage (be susceptible) or less able to recover (be resilient) than a comparable office building. However, it is in a more vulnerable category than an office use because a higher value is placed upon the wider community impacts that would be caused by its potential loss or damage during a flood event. Similar considerations apply to the inclusion of hazardous waste facilities within the highly vulnerable category and other waste treatment facilities being within the less vulnerable category."

2.3.2 Proposed Development Suitability

With reference to Table 1 (SEPA Land Use Vulnerability Classification)[4] of the guidance the proposed developed is considered **Essential Infrastructure** category.

With reference to Table 2 (SEPA Matrix of Flood Risk) of the guidance, the proposed **Essential Infrastructure** development is suitable within any fluvial flood risk zone however for sites located in 'medium' to 'high' risk (i.e. >0.5% AEP) within sparsely developed and / or undeveloped areas the following criteria applies:

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

[4] Scottish Environment Protection Agency (2018): Flood Risk and Land Use Vulnerability Guidance

3. Flood Risk Assessment

3.1 Sources of Information

3.1.1 National Floodplain Mapping and Risk Assessment

Strategic level information regarding the current flood risk at the Site has been obtained from SEPA via the online Indicative Flood map and National Flood Risk Assessment (NFRA) Portal[5].

3.1.2 Mapping and Terrain Data

Ordnance Survey (OS) Mapping, LiDAR data, the site topographic survey and satellite imagery have been used to set the context of the application site and its immediate surroundings.

3.1.3 Historic Flooding

A focussed internet search was undertaken to identify any significant historical flooding events with the vicinity of the site.

3.1.4 Strategic Flood Risk Assessment

The East Lothian Council Strategic Flood Risk Assessment (SRFA)[6] has been reviewed with respect to sources of flooding within the vicinity of the site.

3.2 Screening Assessment

A Screening Assessment is used to identify if any sources of flood risk require a more detailed analysis and specification of bespoke mitigation measures.

The assessment has been undertaken with consideration of the three main infrastructure elements:

- Landfall Infrastructure
- Onshore Cable Route
- Onshore Substation

There are a number of potential sources of flooding which have been evaluated in accordance with best practice and NPF4 such as:

- Flooding from rivers or fluvial flooding;
- Flooding from the sea or tidal / coastal flooding;
- Flooding from land;
- Flooding from groundwater;
- Flooding from sewers; and
- Flooding from infrastructure failure / blockage (e.g., reservoirs, canals, and other artificial sources.

The flood risk from each of these potential sources is discussed in the following Tables 2-4.

[5] Scottish Environment Protection Agency (2022): NFRA data explorer tool, available at: https://www.sepa.org.uk/data-visualisation/nfra2018/
[6] East Lothian Council (2018): Local Development Plan Strategic Flood Risk Assessment

Table 2 – Landfall Infrastructure Flood Risk Screening Assessment

Potential Flood Source	Screening Assessment of Flood Risk at Site[1]	Justification	Requiring Further Consideration i.e. Technical Assessment?
Fluvial flooding	Low	The proposed landfall location is located approximately 60m from the eastern bank of the Dry Burn at the coastline. Review of SEPA flood maps indicates the Dry Burn is not susceptible to flooding as its low to high risk flooding extents are largely confined to the channel. Given the locality of the landfall location to the downstream extents of the Dry Burn there may be some residual risk of out of bank flows as the watercourse opens up onto the coastline. Any out of bank flows would quickly disperse over the flat coastline and into the sea.	No
Tidal flooding	Medium	Review of SEPA flood maps indicates that the landfall location is likely to be partially located within tidal flooding extents. Given the national strategic scale of SEPA mapping it is difficult to discern to what risk the flooding is associated with. The future coastal flood mapping indicates that the site will be partially at medium risk to tidal flooding. As such, it is recommended that a site-specific coastal flood risk assessment is undertaken to quantify the risk more accurately.	Yes
Flooding from land	Negligible	Review of SEPA flood maps indicates that there is no significant accumulation of surface water flooding within the landfall location. The land gently slopes towards the coastline and with minimal upgradient catchment there is negligible risk of surface water flooding.	No
Groundwater flooding	Low	Review of SEPA flood maps indicates that the site is not in an area identified at risk of groundwater flooding. A review of the site-specific Ground Investigation Report and subsequent groundwater monitoring logs indicate that groundwater at the landfall location was not encountered during the borehole investigation and that a minimum depth to groundwater during a 5-month monitoring period was 3m.	No
Flooding from sewers / artificial drains	None	The landfall location is located at the shoreline with only a single property in close proximity downgradient at Skateraw Harbour. As such no sewers within the vicinity of the landfall location pose a flood risk.	No
Flooding due to infrastructure failure / blockage	None	Review of available mapping confirms that there are no significant impoundments of water upgradient and in hydraulic continuity with the Proposed Development area which would pose a flood risk to the site in the event of failure.	No

Table 3 – Onshore Cable Route Flood Risk Screening Assessment

Potential Flood Source	Screening Assessment of Flood Risk at Site	Justification	Requiring Further Consideration i.e. Technical Assessment?
Fluvial flooding	Low – Medium	The onshore cable route interacts with the Dry Burn, Innerwick Burn and Braidwood Burn (Thornton Burn). It is noted that the finished cable route will be buried and will therefore not be sensitive to risk of fluvial flooding. However, watercourse crossing locations have the potential to be at risk of flooding or increase flood risk elsewhere if above ground crossings are proposed instead of the typical open cut trench method or HDD methods. Individual crossing locations are assessed below. The cable route runs approximately parallel to the **Innerwick Burn** between the proposed substation location and the discharge location to the Dry Burn. The cable route is proposed to cross the Innerwick Burn twice. One crossing is located at the downstream extents of the burn prior to discharge to the Dry Burn. At this location an existing 900m diameter culvert is present beneath an existing track. The proposed cable crossing will extend this culvert on both sides by approximately 5m and the cables will be laid above the culvert. There is a potential flood risk associated with this existing culvert and extension and therefore further assessment is required. An additional watercourse crossing of the **Innerwick Burn** is proposed to the immediate north of onshore substation location. This crossing will be undertaken using typical open cut trench method and therefore the cables will be buried beneath the bed of the channel. As such, no flood risk is associated with this crossing. A cable bridge crossing is proposed across the **Braidwood Burn**. The watercourse is located in a prominent steep valley feature of approximately 20m depth. Burying the cable route beneath the watercourse in this location is not viable in terms of construction given the steep slopes either side of the watercourse and as such a bottomless arch culvert is proposed to route the cable over the watercourse extents. SEPA flood maps indicate the flooding extents of the Braidwood Burn to be confined to the channel and immediate overbanks within the valley. There is a potential risk that the proposed crossing may impact flood flows and therefore further assessment is required.	Yes

Potential Flood Source	Screening Assessment of Flood Risk at Site	Justification	Requiring Further Consideration i.e. Technical Assessment?
Tidal flooding	None	The potential for tidal flood risk is only associated with the landfall location. The cable route is sufficiently inland to remain unaffected by tidal flooding.	No
Flooding from land	None	The finished cable route will be buried and therefore not sensitive to surface water flooding. Review of SEPA flood maps indicates that there is no significant accumulation of surface water flooding along the cable route.	No
Groundwater flooding	Low	Review of SEPA flood maps indicates that the site is not in an area identified at risk of groundwater flooding. A review of the site-specific Ground Investigation Report indicates that trials pits located along the full cable route were excavated to depths of a maximum of 3m and groundwater was not encountered in any of the pits.	No
Flooding from sewers / artificial drains	None	The finished cable route will be buried and therefore not sensitive to sewer flooding.	No
Flooding due to infrastructure failure / blockage	None	Review of available mapping confirms that there are no significant impoundments of water upgradient and in hydraulic continuity with the Proposed Development area which would pose a flood risk to the site in the event of failure.	No

Table 4 – Onshore Substation Flood Risk Screening Assessment

Potential Flood Source	Screening Assessment of Flood Risk at Site	Justification	Requiring Further Consideration i.e. Technical Assessment?
Fluvial flooding	None	The onshore substation is located close to the banks of the Innerwick Burn at a minimum distance of 70m to the south of the watercourse. Flooding extents of the Innerwick Burn are not modelled by SEPA given its small scale (<2km^2 catchments size). The channel in this location is well formed and any out of bank flows would be predominantly to the north given the overall fall towards the coastline. The proposed substation platform finished level is approximately 10m higher than the watercourse banks.	No
Tidal flooding	None	The onshore substation is located sufficiently inland to remain unaffected by tidal flooding.	No
Flooding from land	Medium	Review of SEPA flood maps indicates that there is no significant accumulation of surface water flooding in the vicinity of the onshore substation location. The existing ground levels slope moderately towards the Innerwick Burn and the A1 / railway line. It is known that existing surface water flooding issues are present to the east of the Innerwick Burn at the A1 and railway line crossing. This low lying area is prone to flooding due to the transport infrastructure blocking any natural runoff routes and the area does not naturally drain to the watercourse. An existing drainage route is present next to the Railway Cottage property that conveys runoff to the east. This low lying area is approximately 10m below the proposed finished substation platform level and thus any accumulation of surface water flooding in this area would not reach the substation platform. Given the sloping topography of the substation site and wider local area, there is a risk of upgradient runoff shedding onto the substation platform if not properly managed. The proposed drainage strategy for the substation (see EIAR Technical Appendix 11.2) provides upgradient cut-off drains to negate the risk of upgradient surface water runoff flowing onto the platform – refer to Appendix 11.2 for further details. Additionally, the proposed drainage strategy will route surface water runoff away from the existing surface water flooding issue area and thus provide a betterment to this pre-existing flooding.	Yes – covered in Appendix 11.2
Groundwater flooding	Negligible	Review of SEPA flood maps indicates that the site is not in an area identified at risk of groundwater flooding. A review of the site-specific Ground Investigation Report indicates that trials pits near to the	No

Potential Flood Source	Screening Assessment of Flood Risk at Site	Justification	Requiring Further Consideration i.e. Technical Assessment?
		substation location did not encounter groundwater. Given the sloping nature of the existing ground levels at the substation location, to form a level platform, a cut into existing ground levels is required at the southern extent of the substation. The maximum cut required down to formation level will be approximately 10m below existing ground level. Review of borehole monitoring data has been used to inform the formation level and to ensure it is located a minimum of 1m above groundwater levels.	
Flooding from sewers / artificial drains	Low	No existing sewer infrastructure is located within the extents of the onshore substation. Any existing field drains crossing the substation location extent will be re-routed to enable existing land drainage regimes to be retained at much as reasonably possible. The substation will be drained formally and runoff from the developed surfaces will be attenuated in order to not increase flood risk offsite.	No
Flooding due to infrastructure failure / blockage	None	Review of available mapping confirms that there are no significant impoundments of water upgradient and in hydraulic continuity with the Proposed Development area which would pose a flood risk to the site in the event of failure.	No

3.3 Flood Risk Screening Assessment Review

Based on the outcome of assessments in Table 2, 3 & 4 the following risks shown in the below Table are to be assessed further.

- Flooding from the sea or tidal / coastal flooding with respect to the landfall location
- Fluvial flooding with respect to watercourse crossings for the onshore cable route
- Flooding from land (overland flow) to the proposed substation – mitigation and discussion of this is provided in EIAR Appendix 11.2 (Drainage Strategy Report).

All outcomes detailed above are risk to the Proposed Development. The screening assessment confirms that no risk from the Proposed Development require further assessment.

3.4 Further Assessment

3.4.1 Landfall Location Coastal Flood Assessment

SEPA flood maps indicate that the landfall location may be partially located within an area at risk of coastal flooding. As such an estimate has been undertaken of the coastal flood extent to quantify the risk to the landfall location throughout the lifetime of the development of 35 years.

As part of this assessment, the vulnerability of the landfall infrastructure has been evaluated by SSE-R with respect to potential future flooding. It was concluded that buried cables and transition joints bays at the landfall location would be resilient to flooding once installed (given that the infrastructure will be underground) which meets the *Land Use Vulnerability Requirements* set out in Section 2.3.2.

A conservative flood extent has been developed based on the Coastal Flood Boundary (CFB) Model. Table 5 provides a summary of the development of the design level coastal flood extent.

Table 5 – Coastal Flood Design Level

Parameter	Unit	Value	Description
1 in 200yr Water Level	mAOD	3.94	From CFB Model – Chainage 3482, C2_t200 Value
Wave Overtopping allowance (CF=20)	m	0.89	Based on EA Technical Report FD2308/TR2 (2005). Determined via Joint Probability Analysis
Sea level rise 2075 epoch	m	0.58	RCP8.5 from UKCP18 (95th percentile)
Design Level	mAOD	5.41	

Drawing 001 shows the estimated design coastal flood extent in relation to the landfall location. This assessment indicates that there is likely to be some transition joint bay infrastructure located marginally seaward of the design flood level.

In addition, the Dynamic Coast dataset has been assessed to consider any future coastal erosion at the landfall location. No anticipated coastal erosion is mapped within the vicinity of the landfall location.

Taking the above into account, the residual risk to the buried landfall infrastructure (cables and transition joint bays) is 'low'. Despite there being some overlap with the predicted coastal flood level, the infrastructure will be made flood resilient (ensuring any access points to underground infrastructure are sealed and protect from water ingress) so that it remains safe and operational for the development lifetime.

3.4.2 Watercourse Crossing Flood Assessment: Innerwick Burn

As previously described, a watercourse crossing is proposed over the Innerwick Burn immediately upstream of its discharge location to the Dry Burn. The proposed crossing is to utilise an existing 900mm diameter culvert beneath a track access. In order to accommodate the cable route, this existing culvert would be lengthened on both sides by approximately 5m.

SEPA generally prefer alternative solutions to culvert crossings unless adequate justification is provided. In this instance it is believed that there is suitable justification in that the crossing is to be located on a minor unnamed watercourse (called Innerwick Burn for reporting purposes only), utilising an existing culvert albeit with a short extension required, to facilitate an Essential Infrastructure project and associated cable route infrastructure.

The extension of the culvert may have the potential to exacerbate any existing flooding issue with the culvert. As previously discussed, the Innerwick Burn has been heavily modified with multiple culverts upstream of this location. These culverts have been subject to a site survey and culvert survey (to inform the proposed substation drainage strategy). A series of culverts route the burn through the settlement of Skateraw and the downstream exit point of this system (immediately upstream of the proposed crossing location) has been surveyed and found to be an 800mm diameter concrete pipe. As this pipe diameter is less than the proposed extended culvert diameter, its capacity is less and any potential flood risk within the burn will be further upstream where the capacity reduces. There is a limited short section of open watercourse between the Skateraw culvert exit point and the proposed extended culvert and thus negligible additional runoff would enter the downstream culvert. As such the culvert extension does not pose any material increased flood risk as the Skateraw culvert is more susceptible to flooding due to its smaller diameter and capacity. In addition, the smaller diameter upstream culvert reduces the risk of potential blockages to the proposed extended culvert from upstream debris and considering the short section of open watercourse between the two culverts, the overall blockage risk of the proposed extended culvert is very low.

This Further Assessment therefore shows that there is negligible risk to the onshore cable route watercourse crossing at this location with respect to fluvial flooding.

3.4.3 Watercourse Crossing Flood Assessment: Braidwood Burn

As previously described, it is proposed to construct a cable route bridge over the Braidwood Burn due to the challenging topography making the typical open cut trench method or HDD techniques unviable. The proposed bridge will include a bottomless arch culvert to convey flows within the Braidwood Burn. SEPA's guidance on watercourse crossings states that they should follow best practice guidelines[7] and be able to convey the 1 in 200-year flow. As such, an assessment of the proposed culvert capacity in comparison with the anticipated 1 in 200-year flow within the Braidwood Burn is required to determine any potential flood risk associated with the crossing.

3.4.3.1 Braidwood Burn Peak Flow Assessment

An estimate of the peak flow within the Braidwood Burn at the proposed crossing location has been undertaken using catchment characteristics obtained from the FEH Web Service in combination with the industry standard Revitalised Flood Hydrograph V.2 (ReFH2) software.

The estimated 1 in 200-year flow within the Braidwood Burn at this location is **11.47m^3/s**. The ReFH2 analysis is presented in Appendix A.

[7] SEPA (2010) Engineering in the water environment: Good practice guide, River Crossings, 2nd Edition

3.4.3.2 Culvert Capacity Assessment

The proposed bottomless arch culvert will be constructed from corrugated steel arch multiplate and will have a span and rise of 8 and 4m respectively. The span will entirely encompass the existing width of the Braidwood Burn channel (approximately 3-4m wide).

The proposed crossing details drawing are presented in Appendix B.

Given that the proposed culvert's cross-sectional area is significantly larger than the channel cross-sectional area, it is proposed to provide culvert capacity estimates using two methods to demonstrate that there is sufficient capacity to convey the 1-200 year flow.

The first methodology for estimating the culvert capacity is through the application of the Colebrook-White equation for calculating the flow within a pipe. This equation has its limitations in this application as it is generally for calculating flows within full pipes with a single pipe roughness assumed. The equation has been used to initially estimate full pipe flow (using the 8m span as the pipe diameter) and halving this result to estimate the flow within the culvert.

As a conservative approach, the pipe roughness used within the equation has been based on the worst-case roughness for this application, the rock armour along the base of culvert length. The equivalent pipe roughness for this material has been estimated to be 750mm. Comparatively, the roughness for the corrugated steel is approximately 30mm.

The existing slope along the watercourse over the proposed extent of the culvert has been estimated to be 1 in 40 using site survey information. However, as a conservative estimate, the capacity calculation will use a slope of 1 in 100.

A summary of the parameters and results is shown below in Table 6.

Table 6 – Colebrook-White Equation Summary

Parameter	Units	Value	Description
Pipe Diameter	mm	8000	Span of bottomless arch culvert
Slope	m/m	0.01	Conservative estimate from survey information
Pipe Roughness	mm	750	Conservative estimate for full pipe roughness
Equation Results			
Full Pipe Flow Capacity	*m^3/s*	*201*	Calculated from Colebrook-White Equation
Estimated Culvert Capacity	**m^3/s**	**~100**	Half of the full pipe calculation

The conservative estimate above indicates that the culvert would have a capacity of approximately $100m^3/s$. This estimate is almost 10 times greater than the estimated peak flow in the watercourse for the 1 in 200-year event. There is therefore a high confidence in this estimate that the culvert would be more than capable to convey the design flow.

The second methodology for estimating the culvert's ability to convey the design flow is to undertake a cross-sectional comparison of the culvert and the floodplain within the valley. For this assessment, the capacity of the channel itself has been ignored to provide a conservative estimate as the required cross-sectional of the floodplain to convey the design flow will be greater given its higher roughness value than the channel. From the topographic survey, the following parameters of the valley have been estimated:

- Floodplain width (i.e., valley base, ignoring channel) – 11m
- Lefthand valley slope (looking downstream) – 1 in 4

- Right valley slope (looking downstream) – 1 in 1.3
- Longitudinal valley slope – 1 in 40

The above information has been used to estimate the required cross-sectional area to convey the design flow using the open channel Manning's Equation. For the equation, a Manning's Coefficient of Roughness of 0.07 has been used which is equivalent to a floodplain with medium to dense brush. Similar to the previous assessment, a conservative slope estimate of 1 in 100 has been used despite accurate topographic survey information.

A copy of the Manning's Equation results are provided in Appendix C.

The Manning's equations indicates that a cross-sectional area of approximately 11m^2 is required to convey the design flow within the floodplain. Comparatively the cross-sectional area of the bottomless arch culvert is approximately 50m^2 (excluding channel capacity). Similar to the previous assessment, this methodology indicates that the bottomless arch culvert has a considerable excess capacity to easily convey the design flows without restriction.

This Further Assessment therefore shows that there is negligible risk to the onshore cable route watercourse crossing with respect to fluvial flooding.

3.4.4 Flooding from Land Assessment

The flood risk screening assessment has identified a 'Medium' flood risk to the onshore substation from overland flow from the upgradient natural catchment.

The proposed drainage strategy for the substation (see EIAR Technical Appendix 11.2) provides upgradient cut-off drains to negate the risk of upgradient surface water runoff flowing onto the platform – refer to Appendix 11.2 for further details. Additionally, the proposed drainage strategy will route surface water runoff away from the existing surface water flooding issue area and thus provide a betterment to this pre-existing flooding.

This Further Assessment therefore shows that there is a low risk to the onshore substation from flooding from land.

4. Conclusions

ITPEnergised (ITP) has been appointed by Berwick Bank Wind Farm Ltd (The Client) to provide support and input to the onshore component of the Environmental Impact Assessment Report (EIAR) submission to support a planning application for the onshore transmission works in connection with the Berwick Bank Offshore Windfarm.

In accordance with national planning policy and guidance, all potential sources of flooding to the site have been considered and no history of flooding at the site has been identified.

The flood risk assessment has been undertaken in consideration of the three main element of the Proposed Development; the landfall location, onshore cable route and onshore substation.

With respect to the landfall location, the assessment confirms that the site is overall at 'no risk' or 'low risk' of flooding from all sources with the exception of flooding from sea or tidal / coastal. Further assessment was undertaken to derive a design coastal flood level for the expected lifetime of the development of 35 years. The design flood level indicates that some of the landfall location infrastructure would be sited marginally seaward of the boundary. However, an assessment of the infrastructure undertaken by SSE-R concluded that cables and transition joints bays at the landfall location would be resilient to flooding once installed and remain operational. As such, the landfall infrastructure is considered to be at 'low' residual risk of flooding from sea or tidal / coastal sources.

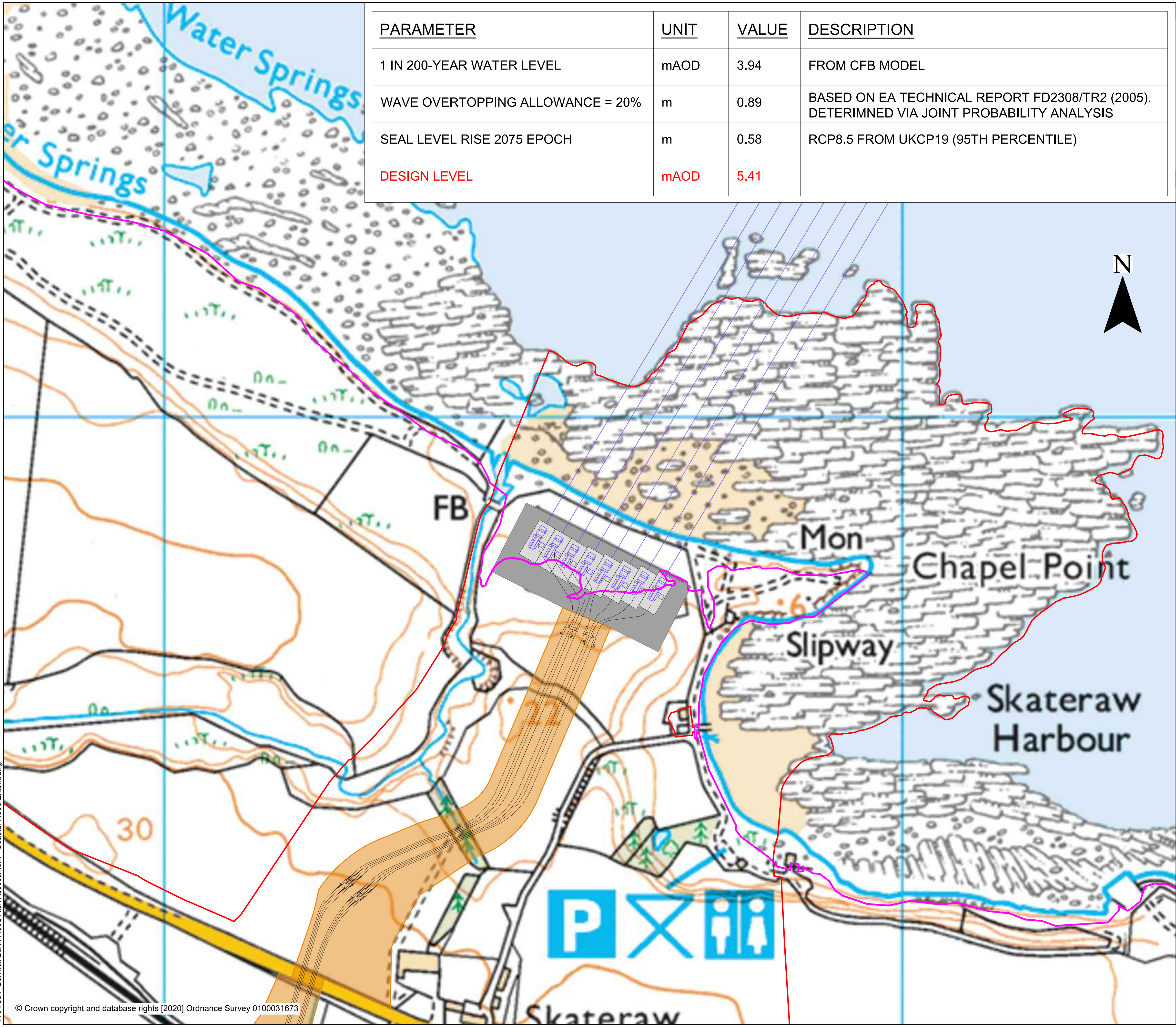
With respect to the onshore cable route, the flood risk screening assessment confirms that the site is overall at 'no risk' or 'low risk' of flooding from all sources with the exception of flooding from fluvial sources in relation to two proposed watercourse crossing. Further assessment was undertaken for both crossings to assess any potential flood risk in greater detail. The assessment of the Innerwick Burn crossing has shown that any flood risk within the watercourse would be attributed to the existing upstream culvert given that it has a lower capacity than the proposed culvert to be extended to facilitate the cable crossing. The assessment of the Braidwood Burn crossing has provided two approaches to estimate the culvert's ability to convey the predicted 1 in 200 year flow in the watercourse with constriction. Both methods undertaken provided conservative estimates of the culvert capacity and it has been shown that it is capable of conveying the design flow without restriction.

With respect to the onshore substation, the assessment confirms that the site is overall at 'no risk' or 'low risk' of flooding from all sources except 'flooding from land' which the screening assessment classified as 'medium' risk. The mitigation for this and full details are provided in the Drainage Strategy Report (EIAR Technical Appendix 11.2) which confirm that the onshore substation is considered at 'low' residual risk of flooding from land.

In accordance with SEPA guidance and NPF4, the Proposed Development is considered 'Essential Infrastructure' and is suitable within any flood risk zone, with further consideration required for developments in sparsely developed / undeveloped areas of 'medium' to 'high' risk, The screening assessment and technical assessments have shown that for all sources of flooding, the residual flood risk to the development and from the developed is considered to be 'no' to 'low' risk.

Taking all of the above into account it is considered there are no overriding impediments to the development being granted planning permission on the grounds of flood risk.

Drawings



PARAMETER	UNIT	VALUE	DESCRIPTION
1 IN 200-YEAR WATER LEVEL	mAOD	3.94	FROM CFB MODEL
WAVE OVERTOPPING ALLOWANCE = 20%	m	0.89	BASED ON EA TECHNICAL REPORT FD2308/TR2 (2005). DETERIMNED VIA JOINT PROBABILITY ANALYSIS
SEAL LEVEL RISE 2075 EPOCH	m	0.58	RCP8.5 FROM UKCP19 (95TH PERCENTILE)
DESIGN LEVEL	mAOD	5.41	

NOTES

1. DRAWING PRODUCED WITH REFERENCE TO INFORMATION PROVIDED BY SSE VIA PROJECT FILE SHAREPOINT.

LEGEND

- SITE BOUNDARY
- LANDFALL COMPOUND
- ONSHORE CABLE
- JOINT BAY
- CABLE CORRIDOR
- OFFSHORE CABLE
- 2075 COASTAL DESIGN FLOOD LEVEL - 5.41mAOD

REV	DATE	DESCRIPTION	BY	CHK
00	03/22	INITIAL ISSUE	SD	ZR

CLIENT:
SSE RENEWABLES

PROJECT:
BERWICK BANK OFFSHORE WINDFARM

DRAWING TITLE:
FLOOD RISK ASSESSMENT
COASTAL FLOOD EXTENT

SCALE: 1:5,000 @ A3

DATE: MARCH 2022

DRAWING NUMBER: **FRA-001**

REV: **00**

DRAWING STATUS: DRAFT ISSUE

ITPENERGISED
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FRA-001_Berwick Bank Flood Risk Assessment - Coastal Flood Extent.dwg

Appendix A - Braidwood Burn ReFH2 Analysis

UK Design Flood Estimation

Generated on Saturday, March 5, 2022 10:30:08 AM by steph
Printed from the ReFH2 Flood Modelling software package, version 3.2.7650.24314

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH2)

Site details Checksum: 26FF-0551

Site name: FEH_Catchment_Descriptors_373700_673250

Easting: 373700

Northing: 673250

Country: Scotland

Catchment Area (km²): 11.58

Using plot scale calculations: No

Model: 2.3

Site description: None

Model run: 200 year

Summary of results

Rainfall - FEH 2013 model (mm):	74.69	Total runoff (ML):	169.42
Total Rainfall (mm):	49.15	Total flow (ML):	535.60
		Peak flow (m³/s):	11.47
Peak Rainfall (mm):	13.37		

Parameters

Where the user has overriden a system-generated value, this original value is shown in square brackets after the value used.
** Indicates that the user locked the duration/timestep*

Rainfall parameters (Rainfall - FEH 2013 model)

Name	Value	User-defined?
Duration (hh:mm:ss)	04:30:00	No
Timestep (hh:mm:ss)	00:30:00	No
SCF (Seasonal correction factor)	0.69	No
ARF (Areal reduction factor)	0.95	No
Seasonality	Winter	No

Loss model parameters

Name	Value	User-defined?
Cini (mm)	101.42	No
Cmax (mm)	423.17	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?

Tp (hr)	2.35	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.24	No
BL (hr)	38.06	No
BR	2.36	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0	No
Urbext 2000	0	No
Impervious runoff factor	0.7	No
Imperviousness factor	0.4	No
Tp scaling factor	0.75	No
Depression storage depth (mm)	0.5	No
Exporting drained area (km^2)	0.00	Yes
Sewer capacity (m^3/s)	0.00	Yes

Time series data

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
00:00:00	1.405	0.000	0.339	0.000	0.237	0.237
00:30:00	2.635	0.000	0.649	0.032	0.235	0.267
01:00:00	4.900	0.000	1.250	0.158	0.235	0.392
01:30:00	8.951	0.000	2.429	0.463	0.241	0.704
02:00:00	13.367	0.000	3.980	1.117	0.262	1.379
02:30:00	8.951	0.000	2.901	2.372	0.313	2.685
03:00:00	4.900	0.000	1.668	4.198	0.410	4.608
03:30:00	2.635	0.000	0.921	6.277	0.566	6.843
04:00:00	1.405	0.000	0.497	8.254	0.782	9.036
04:30:00	0.000	0.000	0.000	9.701	1.048	10.749
05:00:00	0.000	0.000	0.000	10.132	1.340	11.472
05:30:00	0.000	0.000	0.000	9.654	1.627	11.281
06:00:00	0.000	0.000	0.000	8.639	1.887	10.527
06:30:00	0.000	0.000	0.000	7.387	2.109	9.496
07:00:00	0.000	0.000	0.000	6.122	2.290	8.411
07:30:00	0.000	0.000	0.000	5.046	2.432	7.478
08:00:00	0.000	0.000	0.000	4.140	2.541	6.681
08:30:00	0.000	0.000	0.000	3.335	2.623	5.958
09:00:00	0.000	0.000	0.000	2.595	2.680	5.275
09:30:00	0.000	0.000	0.000	1.909	2.714	4.623
10:00:00	0.000	0.000	0.000	1.275	2.728	4.003
10:30:00	0.000	0.000	0.000	0.737	2.723	3.460
11:00:00	0.000	0.000	0.000	0.364	2.705	3.069
11:30:00	0.000	0.000	0.000	0.155	2.677	2.833
12:00:00	0.000	0.000	0.000	0.052	2.646	2.698
12:30:00	0.000	0.000	0.000	0.010	2.612	2.622
13:00:00	0.000	0.000	0.000	0.000	2.578	2.578
13:30:00	0.000	0.000	0.000	0.000	2.544	2.544
14:00:00	0.000	0.000	0.000	0.000	2.511	2.511
14:30:00	0.000	0.000	0.000	0.000	2.479	2.479
15:00:00	0.000	0.000	0.000	0.000	2.446	2.446
15:30:00	0.000	0.000	0.000	0.000	2.414	2.414
16:00:00	0.000	0.000	0.000	0.000	2.383	2.383
16:30:00	0.000	0.000	0.000	0.000	2.352	2.352
17:00:00	0.000	0.000	0.000	0.000	2.321	2.321
17:30:00	0.000	0.000	0.000	0.000	2.291	2.291
18:00:00	0.000	0.000	0.000	0.000	2.261	2.261
18:30:00	0.000	0.000	0.000	0.000	2.231	2.231
19:00:00	0.000	0.000	0.000	0.000	2.202	2.202
19:30:00	0.000	0.000	0.000	0.000	2.173	2.173
20:00:00	0.000	0.000	0.000	0.000	2.145	2.145
20:30:00	0.000	0.000	0.000	0.000	2.117	2.117
21:00:00	0.000	0.000	0.000	0.000	2.089	2.089
21:30:00	0.000	0.000	0.000	0.000	2.062	2.062

22:00:00	0.000	0.000	0.000	0.000	2.035	2.035
22:30:00	0.000	0.000	0.000	0.000	2.009	2.009
23:00:00	0.000	0.000	0.000	0.000	1.982	1.982
23:30:00	0.000	0.000	0.000	0.000	1.957	1.957
24:00:00	0.000	0.000	0.000	0.000	1.931	1.931
24:30:00	0.000	0.000	0.000	0.000	1.906	1.906
25:00:00	0.000	0.000	0.000	0.000	1.881	1.881
25:30:00	0.000	0.000	0.000	0.000	1.856	1.856
26:00:00	0.000	0.000	0.000	0.000	1.832	1.832
26:30:00	0.000	0.000	0.000	0.000	1.808	1.808
27:00:00	0.000	0.000	0.000	0.000	1.785	1.785
27:30:00	0.000	0.000	0.000	0.000	1.761	1.761
28:00:00	0.000	0.000	0.000	0.000	1.738	1.738
28:30:00	0.000	0.000	0.000	0.000	1.716	1.716
29:00:00	0.000	0.000	0.000	0.000	1.693	1.693
29:30:00	0.000	0.000	0.000	0.000	1.671	1.671
30:00:00	0.000	0.000	0.000	0.000	1.649	1.649
30:30:00	0.000	0.000	0.000	0.000	1.628	1.628
31:00:00	0.000	0.000	0.000	0.000	1.607	1.607
31:30:00	0.000	0.000	0.000	0.000	1.586	1.586
32:00:00	0.000	0.000	0.000	0.000	1.565	1.565
32:30:00	0.000	0.000	0.000	0.000	1.544	1.544
33:00:00	0.000	0.000	0.000	0.000	1.524	1.524
33:30:00	0.000	0.000	0.000	0.000	1.504	1.504
34:00:00	0.000	0.000	0.000	0.000	1.485	1.485
34:30:00	0.000	0.000	0.000	0.000	1.465	1.465
35:00:00	0.000	0.000	0.000	0.000	1.446	1.446
35:30:00	0.000	0.000	0.000	0.000	1.427	1.427
36:00:00	0.000	0.000	0.000	0.000	1.409	1.409
36:30:00	0.000	0.000	0.000	0.000	1.390	1.390
37:00:00	0.000	0.000	0.000	0.000	1.372	1.372
37:30:00	0.000	0.000	0.000	0.000	1.354	1.354
38:00:00	0.000	0.000	0.000	0.000	1.337	1.337
38:30:00	0.000	0.000	0.000	0.000	1.319	1.319
39:00:00	0.000	0.000	0.000	0.000	1.302	1.302
39:30:00	0.000	0.000	0.000	0.000	1.285	1.285
40:00:00	0.000	0.000	0.000	0.000	1.268	1.268
40:30:00	0.000	0.000	0.000	0.000	1.252	1.252
41:00:00	0.000	0.000	0.000	0.000	1.235	1.235
41:30:00	0.000	0.000	0.000	0.000	1.219	1.219
42:00:00	0.000	0.000	0.000	0.000	1.203	1.203
42:30:00	0.000	0.000	0.000	0.000	1.188	1.188
43:00:00	0.000	0.000	0.000	0.000	1.172	1.172
43:30:00	0.000	0.000	0.000	0.000	1.157	1.157
44:00:00	0.000	0.000	0.000	0.000	1.142	1.142
44:30:00	0.000	0.000	0.000	0.000	1.127	1.127
45:00:00	0.000	0.000	0.000	0.000	1.112	1.112

45:30:00	0.000	0.000	0.000	0.000	1.098	1.098
46:00:00	0.000	0.000	0.000	0.000	1.083	1.083
46:30:00	0.000	0.000	0.000	0.000	1.069	1.069
47:00:00	0.000	0.000	0.000	0.000	1.055	1.055
47:30:00	0.000	0.000	0.000	0.000	1.041	1.041
48:00:00	0.000	0.000	0.000	0.000	1.028	1.028
48:30:00	0.000	0.000	0.000	0.000	1.014	1.014
49:00:00	0.000	0.000	0.000	0.000	1.001	1.001
49:30:00	0.000	0.000	0.000	0.000	0.988	0.988
50:00:00	0.000	0.000	0.000	0.000	0.975	0.975
50:30:00	0.000	0.000	0.000	0.000	0.962	0.962
51:00:00	0.000	0.000	0.000	0.000	0.950	0.950
51:30:00	0.000	0.000	0.000	0.000	0.937	0.937
52:00:00	0.000	0.000	0.000	0.000	0.925	0.925
52:30:00	0.000	0.000	0.000	0.000	0.913	0.913
53:00:00	0.000	0.000	0.000	0.000	0.901	0.901
53:30:00	0.000	0.000	0.000	0.000	0.889	0.889
54:00:00	0.000	0.000	0.000	0.000	0.878	0.878
54:30:00	0.000	0.000	0.000	0.000	0.866	0.866
55:00:00	0.000	0.000	0.000	0.000	0.855	0.855
55:30:00	0.000	0.000	0.000	0.000	0.844	0.844
56:00:00	0.000	0.000	0.000	0.000	0.833	0.833
56:30:00	0.000	0.000	0.000	0.000	0.822	0.822
57:00:00	0.000	0.000	0.000	0.000	0.811	0.811
57:30:00	0.000	0.000	0.000	0.000	0.801	0.801
58:00:00	0.000	0.000	0.000	0.000	0.790	0.790
58:30:00	0.000	0.000	0.000	0.000	0.780	0.780
59:00:00	0.000	0.000	0.000	0.000	0.770	0.770
59:30:00	0.000	0.000	0.000	0.000	0.760	0.760
60:00:00	0.000	0.000	0.000	0.000	0.750	0.750
60:30:00	0.000	0.000	0.000	0.000	0.740	0.740
61:00:00	0.000	0.000	0.000	0.000	0.730	0.730
61:30:00	0.000	0.000	0.000	0.000	0.721	0.721
62:00:00	0.000	0.000	0.000	0.000	0.711	0.711
62:30:00	0.000	0.000	0.000	0.000	0.702	0.702
63:00:00	0.000	0.000	0.000	0.000	0.693	0.693
63:30:00	0.000	0.000	0.000	0.000	0.684	0.684
64:00:00	0.000	0.000	0.000	0.000	0.675	0.675
64:30:00	0.000	0.000	0.000	0.000	0.666	0.666
65:00:00	0.000	0.000	0.000	0.000	0.657	0.657
65:30:00	0.000	0.000	0.000	0.000	0.649	0.649
66:00:00	0.000	0.000	0.000	0.000	0.640	0.640
66:30:00	0.000	0.000	0.000	0.000	0.632	0.632
67:00:00	0.000	0.000	0.000	0.000	0.624	0.624
67:30:00	0.000	0.000	0.000	0.000	0.616	0.616
68:00:00	0.000	0.000	0.000	0.000	0.608	0.608
68:30:00	0.000	0.000	0.000	0.000	0.600	0.600

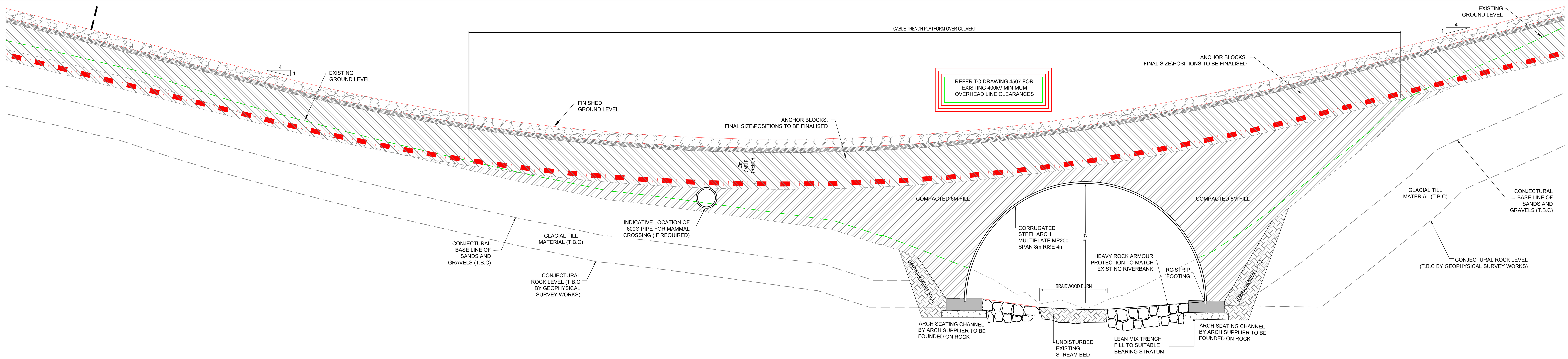
69:00:00	0.000	0.000	0.000	0.000	0.592	0.592
69:30:00	0.000	0.000	0.000	0.000	0.584	0.584
70:00:00	0.000	0.000	0.000	0.000	0.577	0.577
70:30:00	0.000	0.000	0.000	0.000	0.569	0.569
71:00:00	0.000	0.000	0.000	0.000	0.562	0.562
71:30:00	0.000	0.000	0.000	0.000	0.554	0.554
72:00:00	0.000	0.000	0.000	0.000	0.547	0.547
72:30:00	0.000	0.000	0.000	0.000	0.540	0.540
73:00:00	0.000	0.000	0.000	0.000	0.533	0.533
73:30:00	0.000	0.000	0.000	0.000	0.526	0.526
74:00:00	0.000	0.000	0.000	0.000	0.519	0.519
74:30:00	0.000	0.000	0.000	0.000	0.512	0.512
75:00:00	0.000	0.000	0.000	0.000	0.506	0.506
75:30:00	0.000	0.000	0.000	0.000	0.499	0.499
76:00:00	0.000	0.000	0.000	0.000	0.492	0.492
76:30:00	0.000	0.000	0.000	0.000	0.486	0.486

Appendix

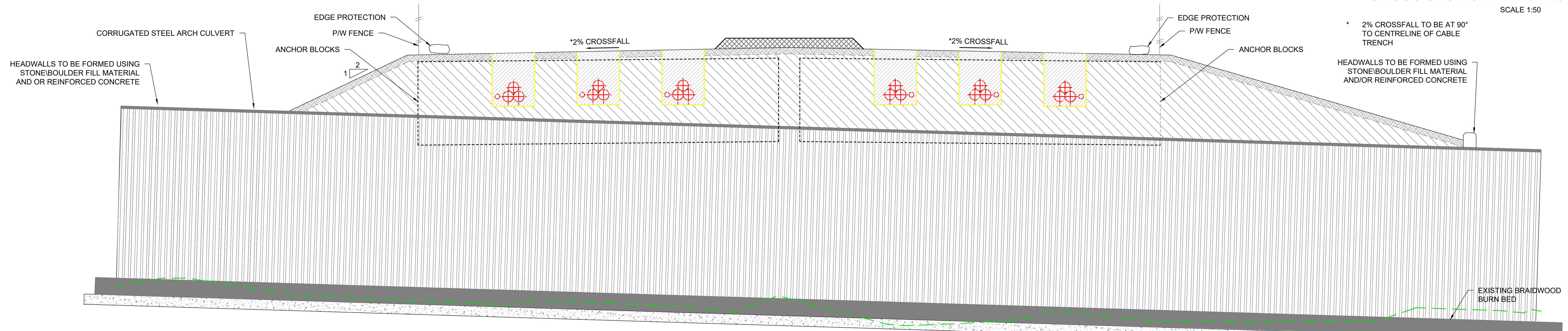
Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	11.58	No
ALTBAR	227	No
ASPBAR	28	No
ASPVAR	0.36	No
BFIHOST	0.68	No
BFIHOST19	0.5	No
DPLBAR (km)	4.66	No
DPSBAR (mkm^{-1})	170.7	No
FARL	1	No
LDP	9.44	No
PROPWET (mm)	0.43	No
RMED1H	8.8	No
RMED1D	36.4	No
RMED2D	47.7	No
SAAR (mm)	764	No
SAAR4170 (mm)	788	No
SPRHOST	30.66	No
Urbext2000	0	No
Urbext1990	0	No
URBCONC	0	No
URBLOC	0	No
DDF parameter C	-0.01	No
DDF parameter D1	0.44	No
DDF parameter D2	0.53	No
DDF parameter D3	0.2	No
DDF parameter E	0.24	No
DDF parameter F	2.21	No
DDF parameter C (1km grid value)	-0.01	No
DDF parameter D1 (1km grid value)	0.43	No
DDF parameter D2 (1km grid value)	0.54	No
DDF parameter D3 (1km grid value)	0.21	No
DDF parameter E (1km grid value)	0.24	No
DDF parameter F (1km grid value)	2.2	No

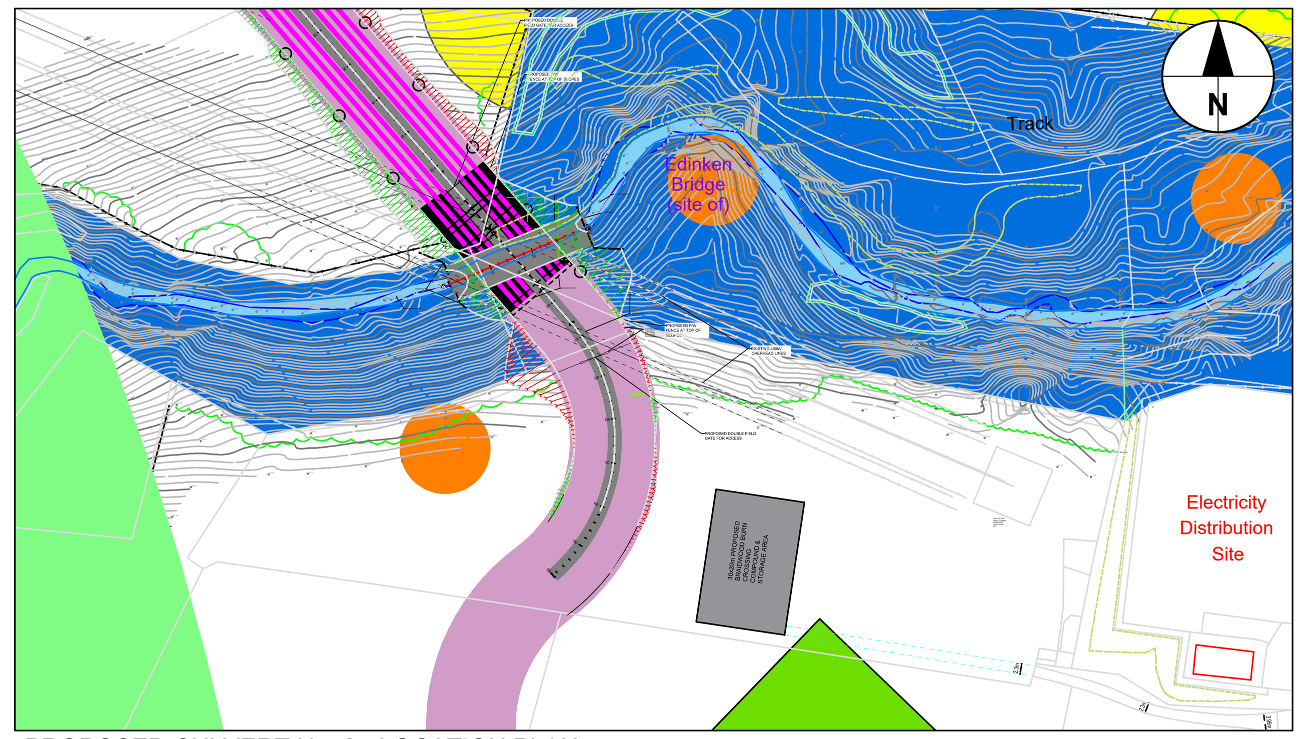
Appendix B - Braidwood Burn Crossing Design



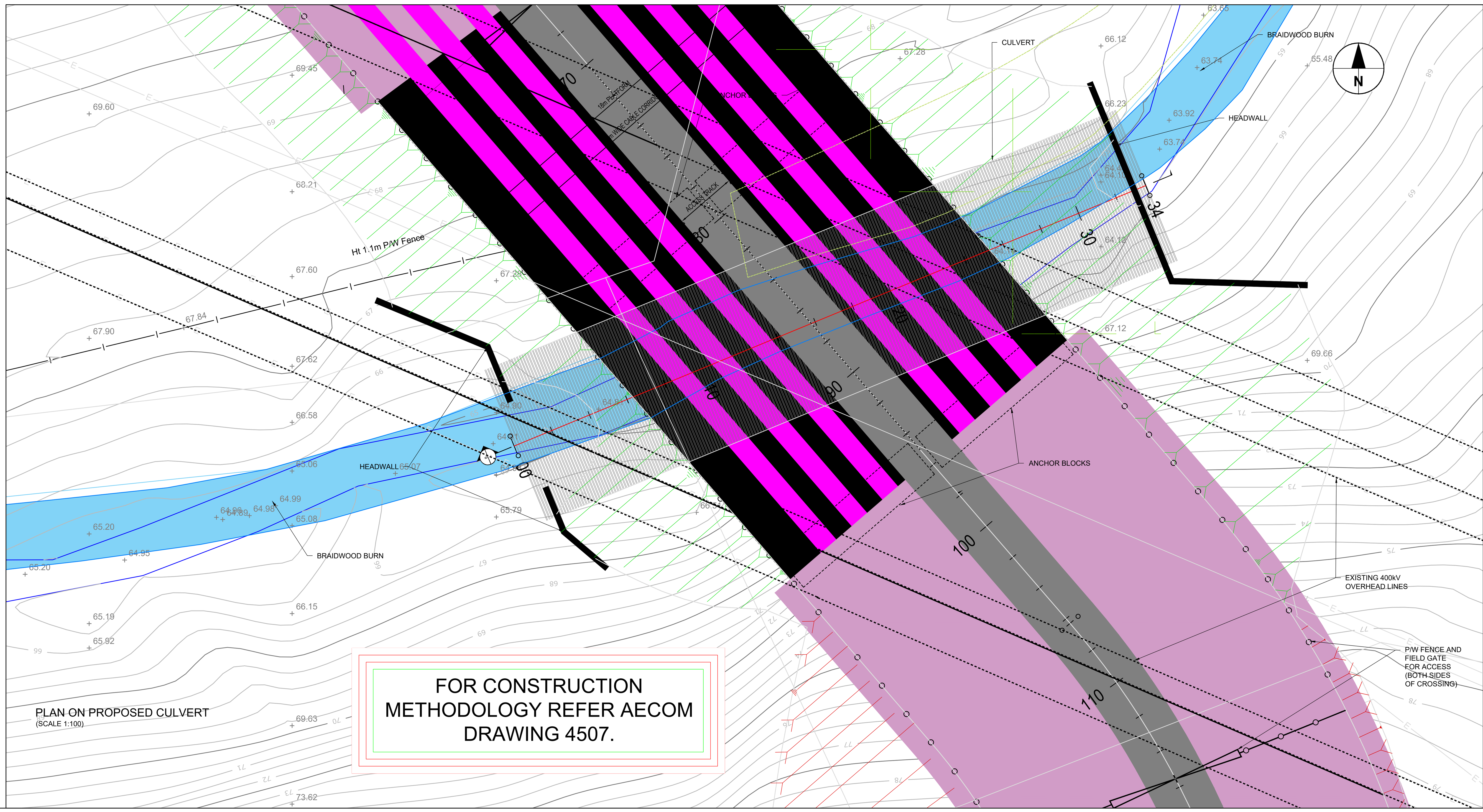
CROSS SECTION A-A THROUGH CULVERT
SCALE 1:50



SECTION B-B - LONG SECTION AT CULVERT No. 2 - SCALE: H 1:50,V 1:50

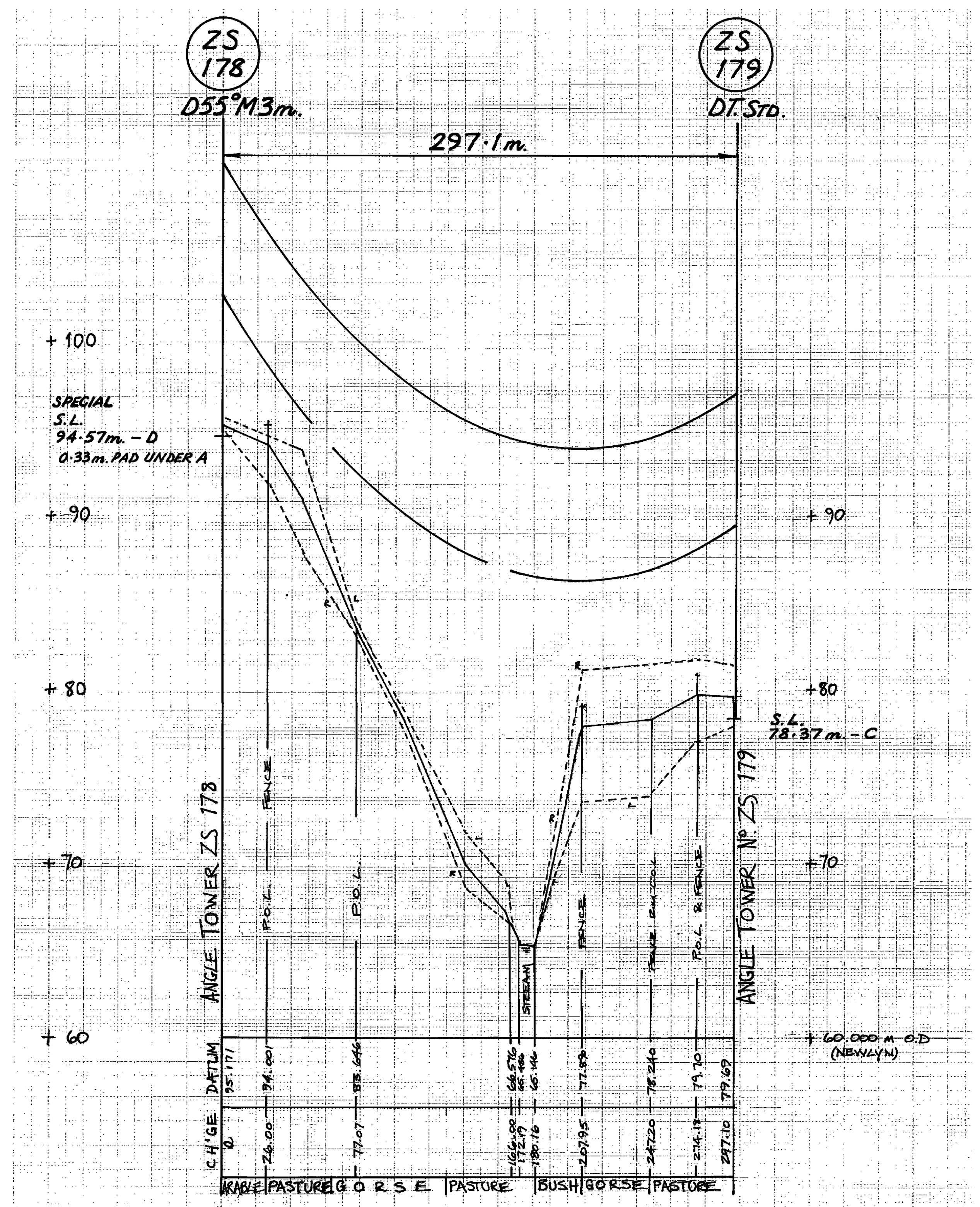


PROPOSED CULVERT No. 2 - LOCATION PLAN
(SCALE 1:1000)



FOR CONSTRUCTION METHODOLOGY REFER AECOM DRAWING 4507.

PLAN ON PROPOSED CULVERT
(SCALE 1:100)



EXISTING SCOTTISH POWER 400kV OVERHEAD LINE PROFILE
(N.T.S)

AECOM

PROJECT
BERWICK BANK OFFSHORE WINDFARM ONSHORE CABLE ROUTE

CLIENT
BERWICK BANK WIND LIMITED

Consultant
Aecom
1 Tanfield
Edinburgh
EH3 5DA
United Kingdom
Fax +44 (0)131 301 8699
Tel +44 (0)131 301 8600
www.aecom.com

Notes

1. FOR DETAILS REFER TO DRAWING 60646019-ACM-XX-00-DR-CE-4507.
2. OVERHEAD LINE HEIGHTS BASED ON SOUTH OF SCOTLAND ELECTRICITY BOARD RECORDS - 400kV OVERHEAD LINE PROFILE TOWER NOs ZS 177-179 - DOCUMENT REFERENCE P.828-30B. ALL HEIGHTS TO BE SITE CHECKED BY APPOINTED CONTRACTOR AT DETAILED DESIGN STAGE.

NOT FOR CONSTRUCTION
FOR INFORMATION

ISSUE/REVISION

Rev	Date	Description	Drn/Chk/Appr
R06	12.10.21	AMENDED TO SSE COMMENTS.	GMcE / CGY / RT
R05	11.10.21	CORRECTED TO SPEN OHL PROFILE DATA	GMcE / CGY / DL
R04	04.10.21	ALIGNMENT AMENDED FOR CLARITY.	GMcE / CGY/DL
R03	28.09.21	OHL LEVELS CORRECTED.	GMcE / CGY / CGY
R02	27.09.21	COMPOUNDS AND OHL HEIGHTS ADDED.	GMcE/CGY/CGY
R01	19.08.21	REVISED TO CLIENTS COMMENTS	DR/CGY/CGY
R0	23.07.21	1st ISSUE	DR/CGY/CGY

Key Plan

Suitability Status
S2 - Suitable For Information

Project Number
60646019

Sheet Title
BRAIDWOOD BURN PROPOSED CULVERT No. 2 TYPICAL DETAILS

Sheet Number
60646019-ACM-XX-00-DR-CE-4506

Scale: As shown @A0 Rev: R06

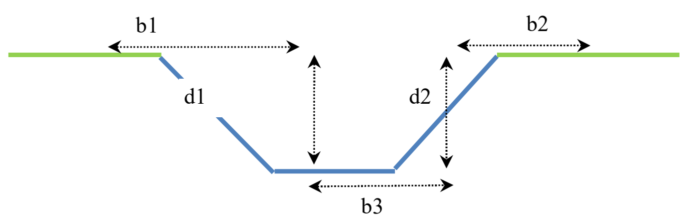
Project Management Initials: Designer: MM/F Checked: DWT Approved: DR ISO A0 841mm x 1189mm

Last saved by: GRAHAM.MCEWAN(2021-10-13) Last Plotted: 2021-10-13

Appendix C - Braidwood Burn Manning's Equation Calculations

Spreadsheet to Determine Open Channel Flow - Using Manning's Equation

Given a typical channel cross section:



Peak Flow to Convey =	11.470	m^3/s	*estimated from ReFH2 analysis - 200-year peak flow*

When channel dimensions are:

b1 =	3.200	(m)	*Adjusted to estimate cross-sectional area required to convey peak flow*
d1 =	0.800	(m)	*Adjusted to estimate cross-sectional area required to convey peak flow*
Left Hand Slope (1 in X)	4.000		*Measured from topographic survey*
b2 =	1.070	(m)	*Adjusted to estimate cross-sectional area required to convey peak flow*
d2 =	0.800	(m)	*Adjusted to estimate cross-sectional area required to convey peak flow*
Right Hand Slope (1 in X)	1.333		*Measured from topographic survey*
b3 =	11.000	(m)	*Base of valley measured from topographic survey*
S =	0.010	(dim)	*Measured from topographic survey (decreased slope for conservative estimate)*
n =	0.07	(dim)	*Estimated from published values and site observations*

Mannings Equation is:

$$V = \frac{R^{0.67} \times S^{0.5}}{n}$$

where:

V	Velocity (m/s)
R	(Cross Sectional Area of ditch) / (Wetted Perimeter)
S	Slope
n	Mannings Coefficient of Roughness
A	Cross Sectional Channel Area (m^2)
P	Wetted Perimeter (m)

Gives:

R =	0.672	m	
V =	1.095	(m/s)	
P =	29.640	m	
A =	10.508	m^2	**Required Cross-Sectional Area**
Q =	**11.503**	(m^3/s bankfull)	

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