Flood Risk Assessment and Drainage Impact Assessment

Prepared by: Georgia Hirst

For: Renewable Energy Systems Ltd

Site: RES Bonnyknox Solar Farm

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Quality Assurance

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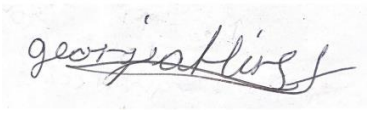
Staff Detail

Initials	Name	Qualifications and Position	Signature
GH	Georgia Hirst	MSc, BSc (Hons), Consultant	
GM	Gary Mackintosh	BSc (Hons, Principal Engineer	
JR	Josh Rigby	BSc (Hons), Manager – Water Environment Team	

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Reference of Terms

Annual Exceedance Probability (AEP)

The AEP is the chance or probability of a natural hazard event (usually a rainfall or flooding event) occurring annually and is usually expressed as a percentage.

Aquifers

Scotland's groundwater bodies are classified (and reclassified) on a regular basis, into one of five categories: high, good, moderate, poor, or bad; those bodies at risk of deteriorating status are also identified. Where the status of a groundwater body is identified as poor or at risk of deterioration, these bodies are prioritised for action to improve the situation. More details can be found in the River Basin Management Plans for Scotland (SEPA, 2009a).

- Principal Aquifers are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale.
- Secondary A Aquifers are 'permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers'.
- Secondary B Aquifers are 'predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers'.
- Secondary Undifferentiated Aquifers are assigned in 'cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type'.
- Unproductive Strata are 'rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow'.

Canal Failure

Canal failure can occur due to high-intensity rainfall or structural failure and can be dangerous due to the rapid release of large volumes of water. It is typically limited to raised canal reaches and can result in a rapid peak in flow followed by a gradual reduction.

Climate Change (CC)

A change in global or regional climate patterns. For flood risk, CC are assessed in terms of allowances which are predictions of anticipated change for peak river flow, peak rainfall intensity, sea level rise and offshore wind speed and extreme wave height. CC scenario data exists across different epochs (time periods) to determine the needs for climate resilience measures. CC data is requested as part of an SEPA PD request. If a separate ESG Flood Risk and CC Assessment is needed, additional CC data will be required.

Fluvial Flooding

Fluvial flooding typically occurs when a river's capacity is exceeded, and the excess water overtops the riverbanks. It can also occur when the watercourse has a high level downstream, perhaps due to structures or blockage, thus limiting conveyance. This creates a backup of water which can overtop the banks. Typical flooding issues occur when the natural floodplain has been urbanised and the river has been confined.

Groundwater Flooding

Groundwater flooding is caused by the emergence of water from beneath the ground at either point or diffuse locations when the natural level of the water table rises above ground level. This can result in deep and long-lasting flooding of low-lying or below-ground infrastructure such as underpasses and basements. Groundwater flooding can cause significant damage to property, especially in urban areas, and can pose further risks to the environment and ground stability.

Sewer Flooding

Flooding from sewers primarily occurs when flow entering a system exceeds available capacity or if the network capacity has been reduced through blockage or collapse. In the case of surface water sewers that discharge to watercourses, the same effect can be caused as a result of high-water levels in the receiving watercourse. As a result, water can begin to surcharge the sewer network, emerging at ground level through gullies and manholes and potentially causing flooding to highways and properties. If this occurs flooding can represent a significant hazard to human health due to the potential for contaminants in flood water.

Source Protection Zones

Source Protection Zones (SPZs) are areas of land through which water infiltrates into a groundwater borehole, well or spring that is used for public drinking water supply. These zones show the risk of contamination from potential pollution. SPZ's have been created as public facing boundaries where discrete groundwater bodies within SPZ's have been dissolved on zone number where common boundaries and overlaps have been removed. SPZs are defined around large and public potable groundwater abstraction sites. The purpose of SPZs is to provide additional protection to safeguard drinking water quality through constraining the proximity of an activity that may impact upon a drinking water abstraction.

- Zone 1 (Inner Protection Zone) is defined by a travel time of 50-days or less from any point within the zone at, or below, the water table. Additionally, the zone has as a minimum a 50-metre radius.
- Zone 2: (Outer Protection Zone) - This zone is defined by the 400-day travel time from a point below the water table. Additionally, this zone has a minimum radius of 250 or 500 metres, depending on the size of the abstraction.
- Zone 3: (Total catchment) - This zone is defined as the total area needed to support the abstraction or discharge from the protected groundwater source. A further Zone 4, or 'Zone of Special Interest' was previously defined for some groundwater sources.

Surface Water Runoff

Surface water runoff is defined as water flowing over the ground that has not yet entered a drainage channel or similar. It usually occurs because of an intense period of rainfall which exceeds the infiltration capacity of the ground. Typically, runoff occurs on sloping land or where the ground surface is relatively impermeable. The ground can be impermeable either naturally due to the soil type or geology, or due to development which places impervious material over the ground surface (e.g. paving and roads).

Tidal Flooding

Tidal flooding is caused by high tides coinciding with a low-pressure storm system which raises sea and tidal water levels, overwhelming coastal and river defences. This may be made worse by gale-force winds blowing the raised body of water up tidal river basins some distance from the coast, due to floodwater being forced up the tidal reaches of rivers and estuaries. Such flooding may become more frequent in future years due to rising sea levels.

Reservoirs Failure

Reservoir failure can be a particularly dangerous form of flooding as it results in the sudden release of large volumes of water that can travel at high velocity, causing deep and widespread flooding. The likelihood of this occurring is low as large reservoirs are managed in accordance with the Reservoirs (Scotland) Act 1975.

SEPA's online reservoir inundation map illustrates the maximum flood extents that could occur in the event of a reservoir.

1. Introduction

1.1 Acknowledgement

1.1.1 This report has been prepared for the sole and exclusive use of Renewable Energy Systems Ltd (RES Ltd) in accordance with the scope of work presented via Letter Agreement, dated 21/11/2023. This report is based on information and data collected by Arthian. Should any of the information be incorrect, incomplete, or subject to change, Arthian may wish to revise the report accordingly.

1.1.2 Arthian have been instructed to provide a Flood Risk Assessment (FRA) and Drainage Impact Assessment (DIA) on Land west of Arbroath with the nearest postcode DD11 2PR (the site) to inform a planning application for the development of a solar photovoltaic (PV).

1.2 Project Understanding

1.2.1 On the SEPA Flood Map for Planning, the proposed site is mainly within an area of Very Low Likelihood (<0.1% AEP). However, there is an area of High to Low Likelihood (10% to 0.1% AEP) of fluvial flooding towards the south of the site and crossing the Access Road, associated with Rottenraw Burn. Therefore, the application requires a Flood Risk Assessment to support the application.

1.2.2 The aim of this report is to assess the potential flood risk to the site, the impact of the proposed development on flood risk elsewhere, and the proposed measures which could be incorporated to mitigate the identified risk (if required). This report has been prepared in accordance with the guidance contained in Scottish Government National Planning Framework 4 (NPF4) published in February 2023.

1.2.3 Angus Council as Lead Local Flood Authority (LLFA) is a statutory consultee for major planning applications in relation to surface water drainage, requiring that all planning applications are accompanied by a Sustainable Drainage Strategy. The aim of the Sustainable Drainage Strategy is to identify water management measures, including Sustainable Drainage Systems (SuDS), to provide surface water runoff reduction and treatment.

1.2.4 This report takes into account the following national and local policies:

- Scottish Government National Planning Framework 4 (NPF4), dated 13 February 2023[1];
- Technical Flood Risk Guidance for Stakeholders – SEPA requirements for undertaking a Flood Risk Assessment, v13, dated June 2022[2];
- SEPA Flood Risk and Land Use Vulnerability Guidance, dated July 2024[3];

[1] https://www.gov.scot/publications/national-planning-framework-4/
[2] https://www.sepa.org.uk/media/162602/ss-nfr-p-002-technical-flood-risk-guidance-for-stakeholders.pdf
[3] land-use-vulnerability-guidance.docx

- CIRIA Guidance: The SuDS Manual (C753) (2017)[4]; and
- Angus Borough Council Local Development and Planning Policies.

1.3 Sources of Information

1.3.1 The following sources of information have been reviewed and assessed for the purpose of this FRA:

- SEPA online flood maps[5];
- British Geological Society (BGS) Interactive Map[6];
- MAGIC Interactive Map[7];
- Angus Council Strategic Flood Risk Assessment (2015 SFRA);
- Tay Estuary and Montrose Basin Local Flood Risk Management Strategy (2016 LFRMS); and
- Angus Council Technical Guidance Flood Risk and Surface Water Drainage Requirements (2023).

1.4 Project Limitations

1.4.1 The wider Arthian limitations are contained within Appendix A.

[4] https://www.ciria.org/Resources/Free_publications/SuDS_manual_C753.aspx
[5] https://map.sepa.org.uk/floodmaps
[6] http://mapapps.bgs.ac.uk/geologyofbritain/home.html
[7] http://www.magic.gov.uk/

2. Site Details

2.1.1 The aim of this section of the report is to outline key environmental information.

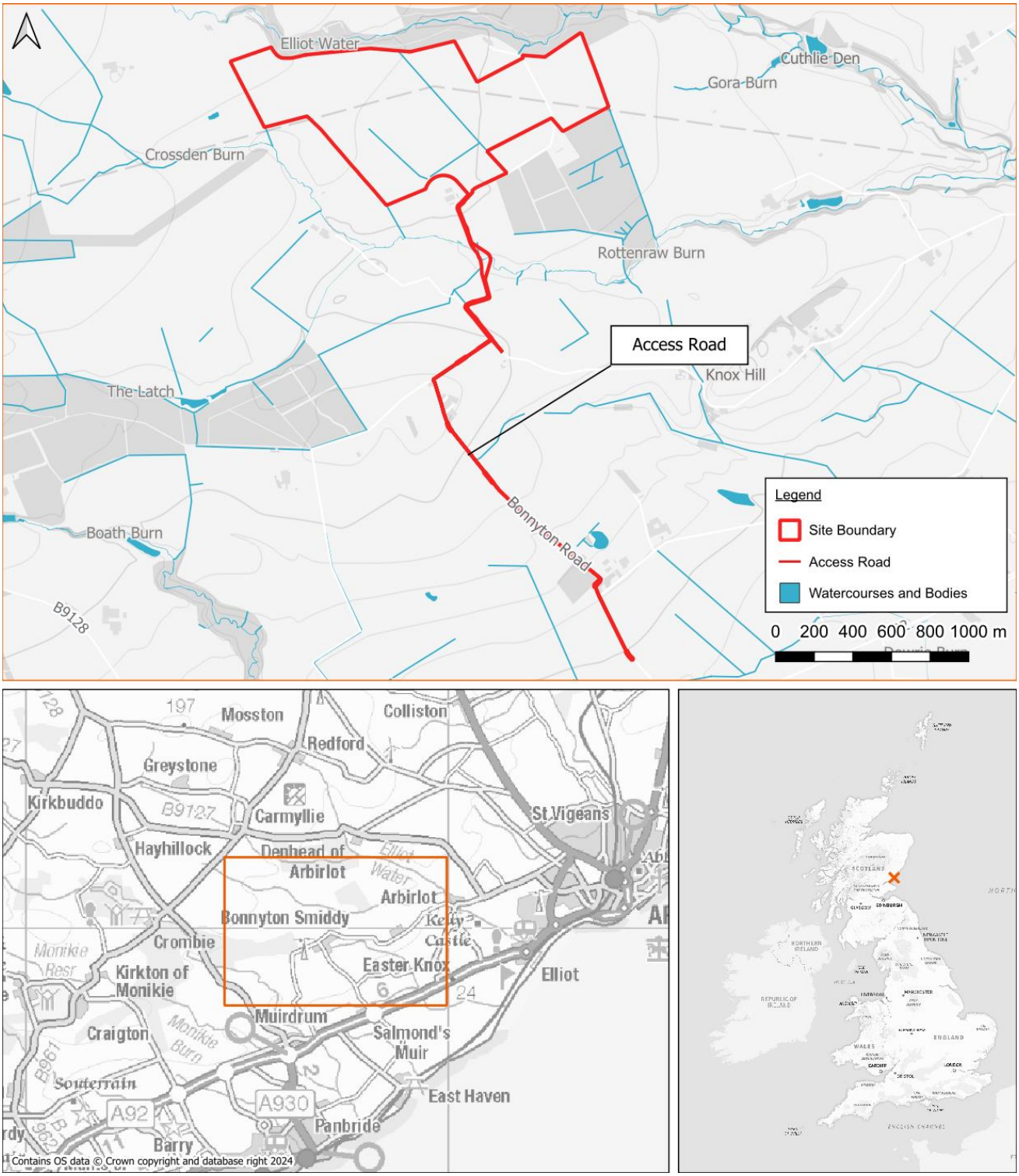


Figure 1: Site Location

2.2 Site Location

2.2.1 The site is located in a rural area of Bonnyknox approximately 4.5km west of Arbroath, Scotland. It is approximately 2km west of Arbirlot Waterfall Tourist Attraction. The National Grid Reference for the site is 356980, 741090.

2.2.2 The Access Road runs from the south of the site for approximately 2.5km.

2.3 Existing Site Conditions

2.3.1 Online mapping (including Google Maps / Google Streetview imagery, accessed 31/07/2024) shows that the site is greenfield which comprises agricultural land with associated single lane roads. The Access Road mainly comprises Bonnyton Road and is surrounded by agricultural land.

2.4 Topography

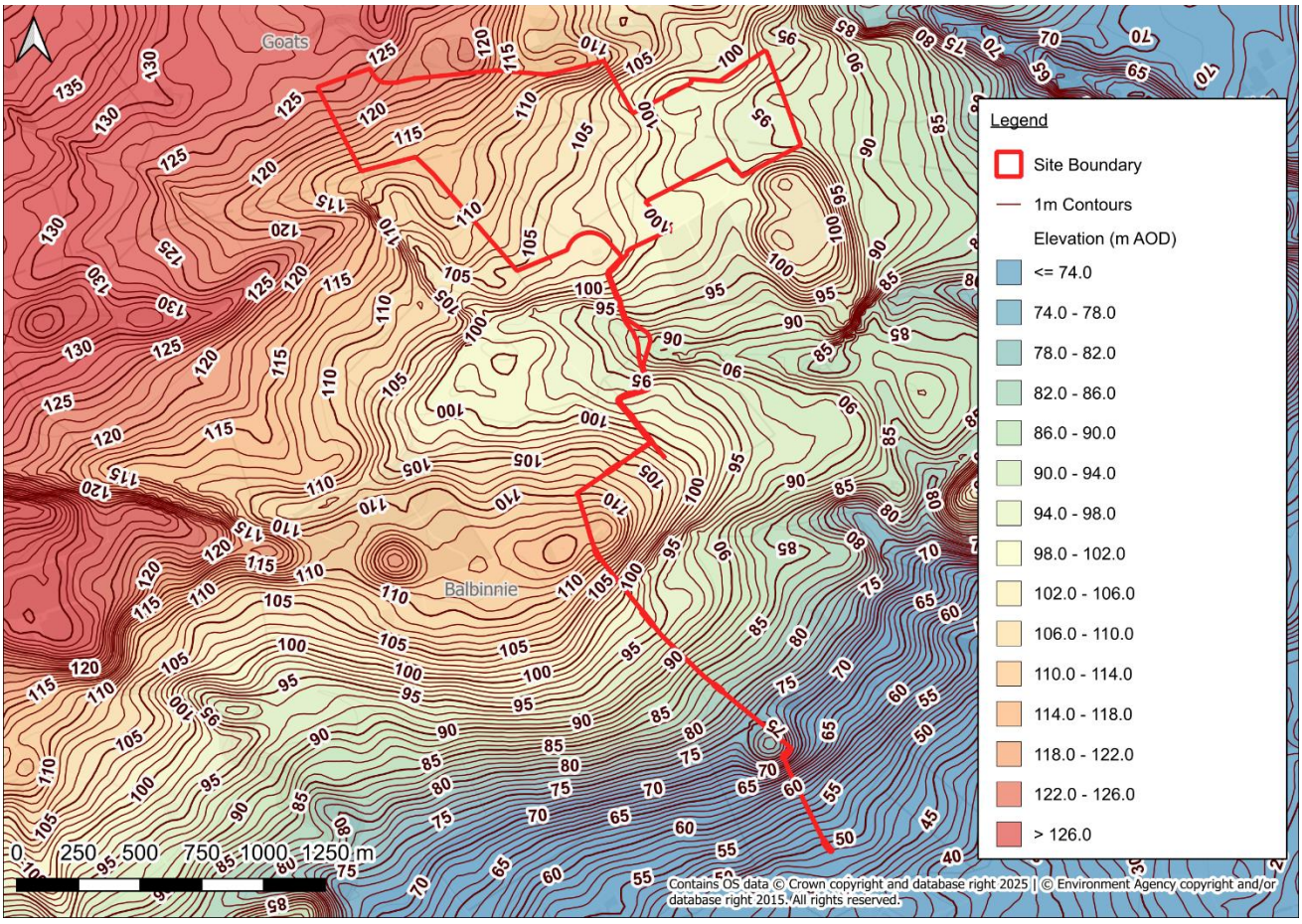


Figure 2: LiDAR Plan

2.4.1 A topographical survey has been undertaken by Arthian Ltd (formerly Mabbett & Associates Ltd) in August 2024 and is included in Appendix B. The topographical survey shows that the site slopes from 123 metres Above Ordnance Datum (m AOD) in the northwest corner to 92m AOD in the east to the site.

2.4.2 Topographic levels to metres Above Ordnance Datum (m AOD) have also been derived from a 1m

resolution 'Light Detecting and Ranging' (LiDAR) Digital Terrain Model (DTM) which was provided on Scalgo. Between the topographic survey and the Scalgo LiDAR data there are discrepancies, however the slopes and ground elevation generally corresponds showing that the site slopes from approximately 125m AOD in the northwest corner to approximately 94m AOD in the east of the site. Additionally, the Access Road slopes from approximately 100m AOD in the north to 48m AOD in the south (Figure 2).

2.4.3 For the purpose of this FRA, the topographic survey will be focused on.

2.5 Hydrology

2.5.1 There is an unnamed land drain in the centre of the site. The nearest river is Rottenraw Burn which is located approximately 120m south of the site boundary. Rottenraw Burn flows to the east.

2.5.2 The Access Road crosses Rottenraw Burn 120m south of the site boundary and passes in close proximity to two other land drains.

2.6 Geology

2.6.1 Reference to the British Geological Survey (BGS) online mapping (1:50,000 scale) indicates that the site is underlain by superficial deposits of Glacial Till generally comprising Diamicton (Figure 3).

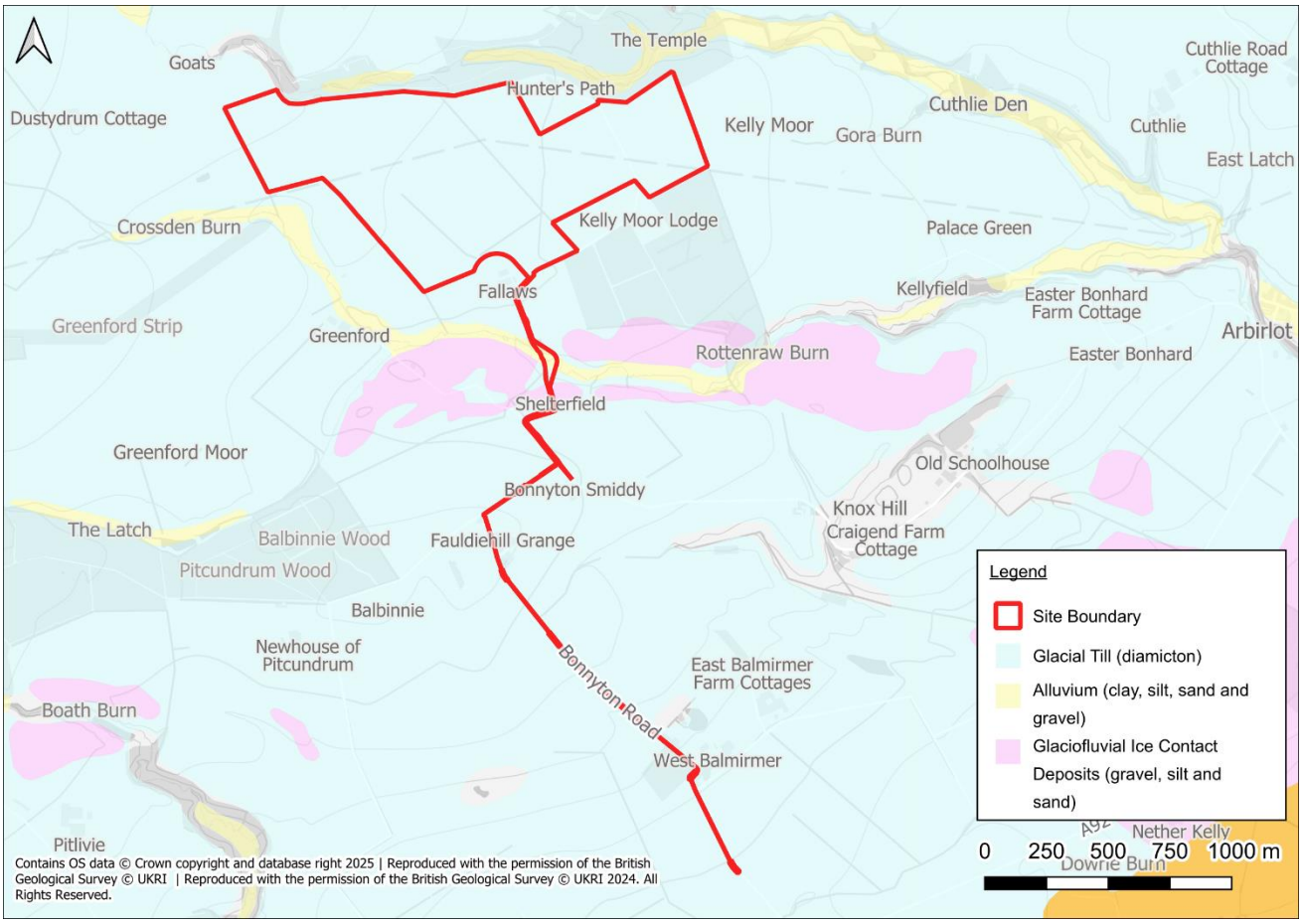


Figure 3: Superficial Deposits

2.6.2 The Access Road is also mainly underlain by Glacial Till, however, there is a small area underlain by Alluvium (comprising clay, silt, sand and gravel) and Glaciofluvial Ice Contact Deposits (comprising gravel, silt and sand) (Figure 3).

2.6.3 The site is identified as being underlain by Dundee Flagstone Formation consisting of sandstone, siltstone and mudstone (Figure 4). The Access Road is also underlain by the Dundee Flagstone Formation but also runs through areas underlain by Ochil Volcanic Formation consisting of andesite and pyroxene (Figure 4).

2.6.4 The geological mapping is available at a scale of 1:50,000 and as such may not be accurate on a site-specific basis.

2.6.5 The closest historical BGS borehole record (BGS Ref: NO54SE13020/8) is located in the north of the site (NGR 357442, 741205). The borehole record indicates that the following geology was encountered:

- Topsoil to 0.4m below ground level (bgl); and
- Clay from 0.4m to 8.0m bgl.

2.6.6 No water strikes were encountered.

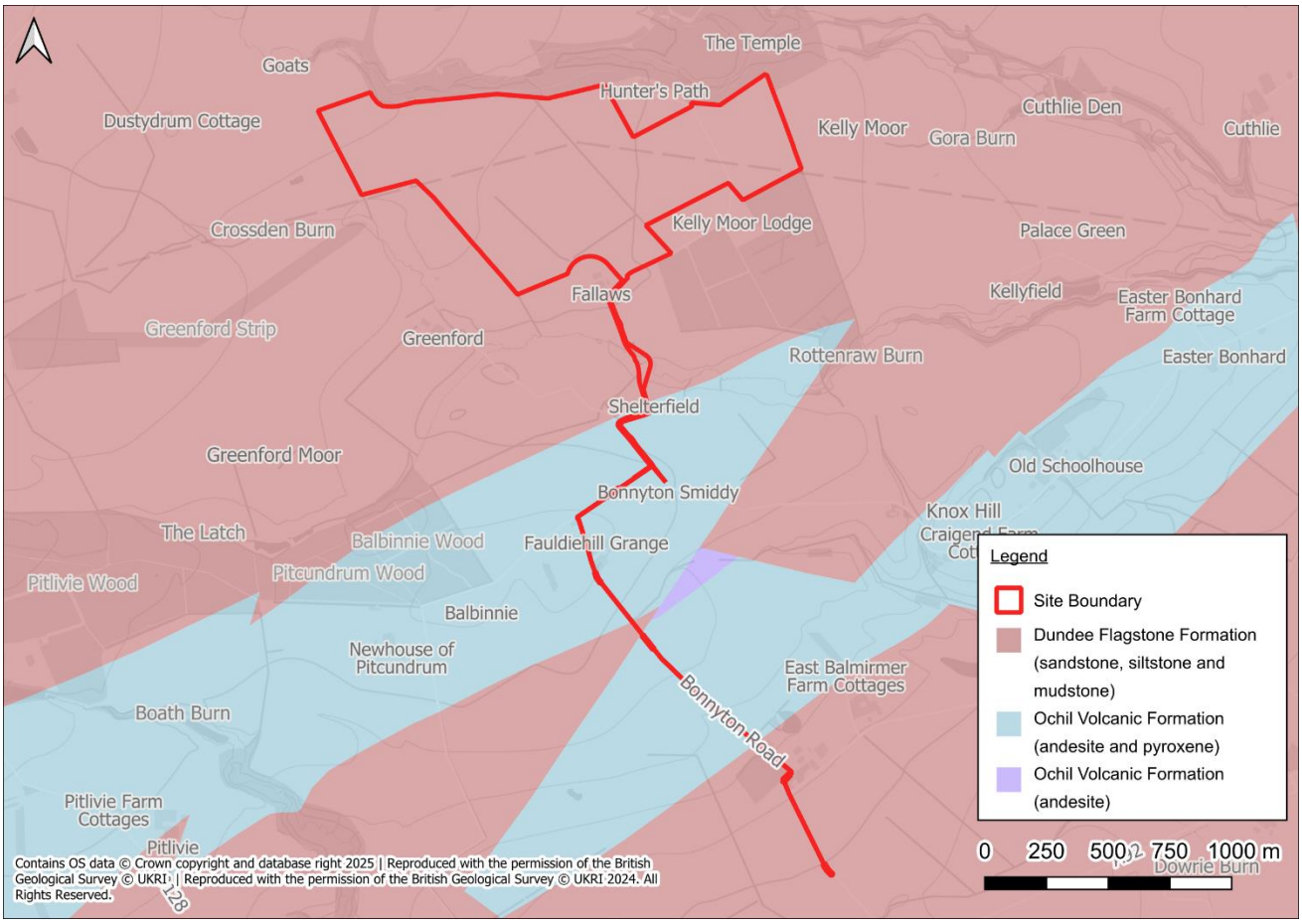


Figure 4: Bedrock Deposits

2.7 Hydrogeology

2.7.1 According to the Scotland's Environment Online Map [accessed 25/02/2025], the superficial deposits are classified as a Moderately Productive Aquifer.

2.7.2 Scotland's Environment Map also provides 'Special Protection Areas' data [accessed 25/02/2025], indicates that the site is not located within a Special Protection Area.

2.8 Development Proposals

2.8.1 The proposed development is for a solar farm which includes access tracks, a substation compound, two temporary construction compounds and 14 inverters. The proposed locations of the solar panels can be seen in the development plan drawing 05114-RES-LAY-DR_PT-003 and is included in Appendix C.

3. Relevant Planning Policy and Guidance

3.1 Introduction

3.1.1 The aim of this section of the report is to discuss the main aspects of the local and national planning policies that are relevant to any proposed development on the site and relevant guidance and legislation.

3.2 Assessment of Flood Risk

3.2.1 The flood risk from fluvial (main rivers) and coastal flooding is assessed through the use of the SEPA Flood Maps. This map defines three zones of different flood risk:

- High Likelihood - Each year this area has a 10% chance (1 in 10 annual probability) of flooding.
- Medium Likelihood -Each year this area has a 0.5% chance (1 in 200 annual probability) of flooding.
- Low Likelihood - Each year this area has a 0.1% chance (1 in 1000 annual probability) of flooding.

3.2.2 The future climate change flood maps include for the potential risk up to the 2080's – medium likelihood only.

3.3 Local Policy

3.3.1 Angus Council's Local Development Plan contains the following policies relating to flood risk and drainage:

"**Policy PV12 Managing Flood Risk:**

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), see Table 4) may be required to undertake a flood risk assessment. This should demonstrate:

- *that flood risk can be adequately managed both within and outwith 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*."

3.3.2 SEPA Land Use Vulnerability

3.3.3 In accordance with SEPA Flood Risk and Land Use Vulnerability Guidance (July 2018), any proposed residential development should be considered 'highly vulnerable' and assessed against the 1 in 200-year flood event (0.5% AEP) for the duration of its lifetime.

3.3.4 SEPA Climate Change Allowances

3.3.5 SEPA's climate change allowances guidance (v3, April 2023) sets out required allowances for climate change that must be used for flood risk assessment following the adoption of NPF4 in February 2023. The climate change allowances listed in the guidance are a prediction of anticipated change in peak river

flow, peak rainfall intensity or sea level rise caused by future climate change. Allowances for the Tay region are provided in the table below.

Table 1: SEPA Climate Change Allowances – Tay Scotland Region

Source of Flooding	Climate Change Allowance
Fluvial	+53%
Coastal (Sea Level Rise)	+0.85m
Rainfall Intensity	+39%

3.3.6 For watercourses with catchments less than 30km^2, the rainfall intensity allowance should be applied to the rainfall used to calculate the flows. For watercourses with a catchment area between 30-50km^2, the rainfall intensity allowance should be applied if the resultant flow increase is greater than using river flow uplift directly.

3.3.7 SEPA Flood Map Classification

3.3.8 SEPA's indicative flood maps show areas considered to have the potential of flooding from rivers (fluvial), coastal, and surface water (pluvial) sources. Whilst the nature of these maps means that they do not necessarily represent flooding in high detail at a site-specific level, they can provide an understanding of general areas that may be prone to flooding from a particular source. The table below provides the annual exceedance probability (AEP) for each probability band.

Table 2: SEPA Flood Map Classification

Source of Flooding	High Probability (AEP)	Medium Probability (AEP)	Low Probability (AEP)
Fluvial Present Day	10%	0.5%	+0.1%
Fluvial Future (2080s)	-	0.5% (incl. allowance for future climate change)	-
Coastal Present Day	10%	0.5%	0.1%
Coastal Future (2080s)	-	0.5% (incl. allowance for estimated sea level rise)	-
Pluvial Present Day	10%	0.5%	0.1%

3.4 Consultation

3.4.1 A product data request was submitted to SEPA in July 2024, a response was received on 27/08/24 and has been included in Appendix D.

3.4.2 A consultation request was submitted to the LLFA in July 2024, a response is awaited.

4. Assessment of Flood Risk

4.1 Tidal Flood Risk

4.1.1 The site is situated at a minimum of approximately 92m AOD and the Access Road is at a minimum of approximately 48m AOD. Therefore the site and Access Road are significantly above sea level and there is **Negligible** risk from tidal flooding.

4.2 Fluvial Flood Risk

4.2.1 The site is wholly situated within an area of Very Low Likelihood, which is considered to have a <0.1% annual chance of flooding from rivers or the sea.

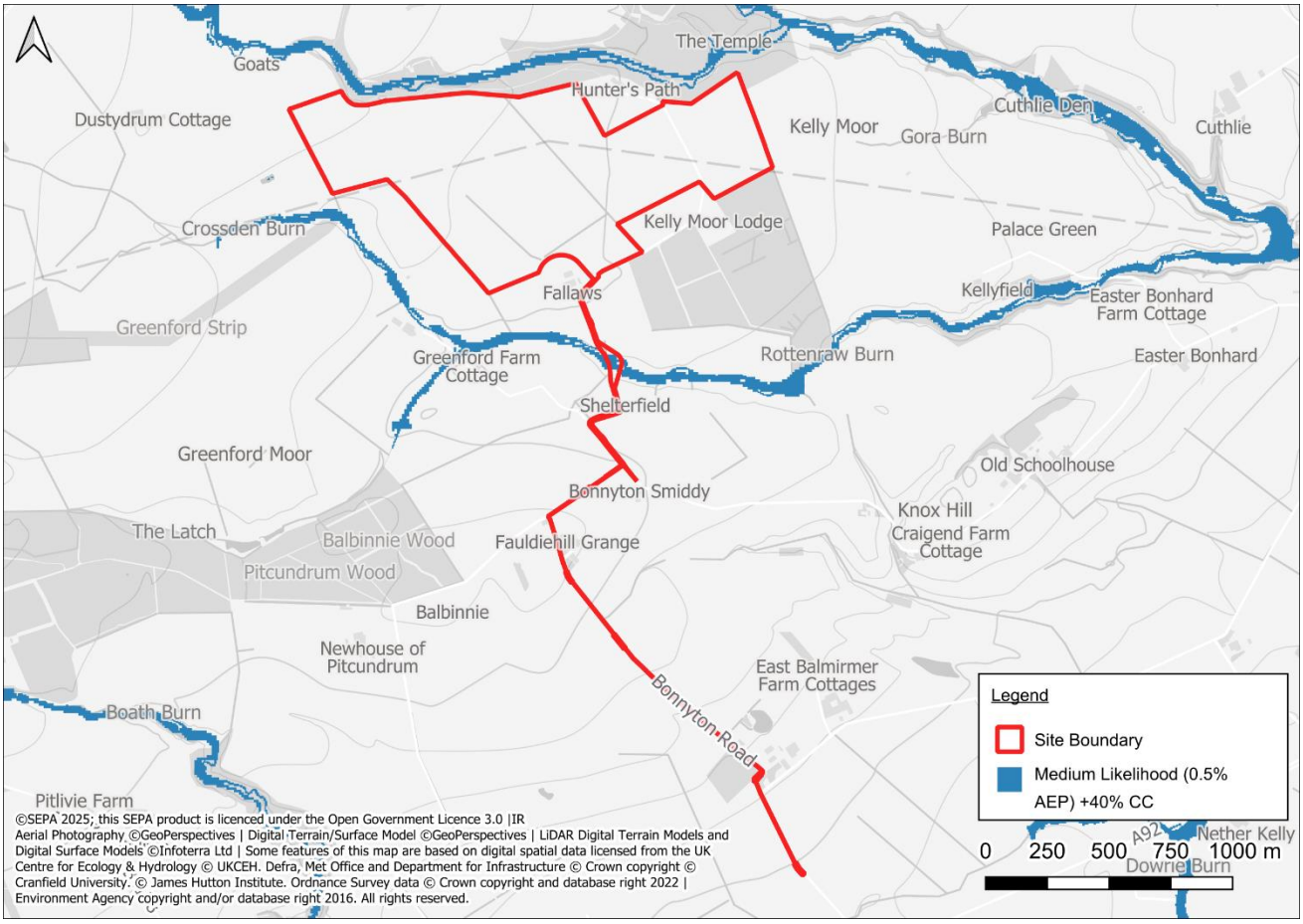


Figure 5: SEPA's Flood Map for Planning

4.2.2 The Access Road is also mainly within an area of Very Low Likelihood (<0.1%), with the exception of a small area which falls within a Medium Likelihood (0.5% AEP) +40% CC (Figure 5). The risk appears to be associated with Rottenraw Burn and is likely reflecting the watercourse channel. Additionally, a new crossing is proposed (discussed further below) and the risk will remain below the access road, and therefore will not present loss of floodplain volume and there will be no increased flood risk.

4.2.3 There is an unnamed land drain within the centre of the site. The nearest river is Rottenraw Burn which is

located approximately 120m south of the site and flows across the Access Road. Rottenraw Burn flows in an easterly direction.

4.2.4 According to Angus Council's Technical Guidance (2023), for a watercourse (the unnamed land drain) that is 1 to 5m wide there should be a minimum buffer of 6 to 12m. Furthermore, the proposed solar panels will be at least 6m from the unnamed land drain creating a 12m buffer (Figure 6).

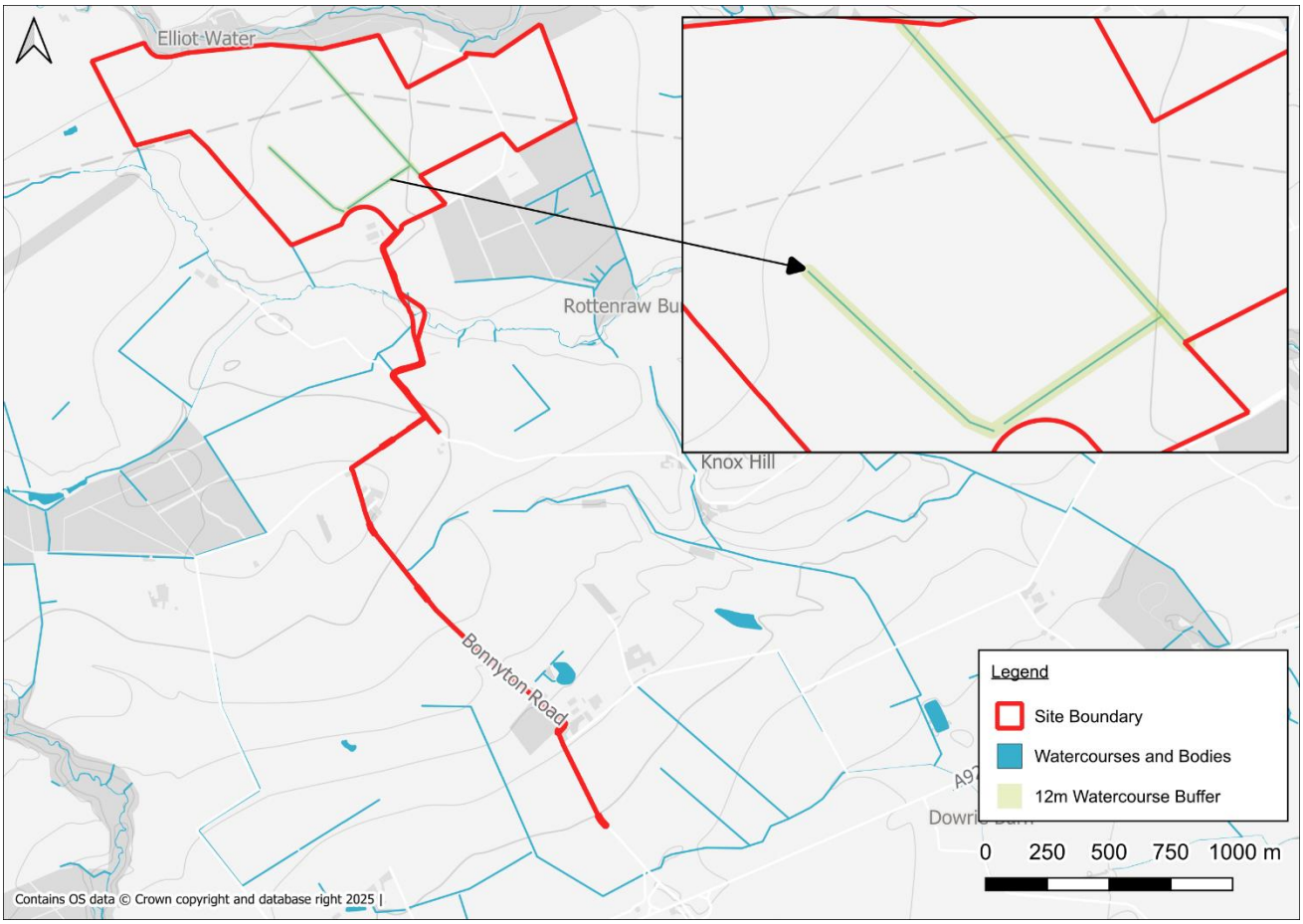


Figure 6: Watercourse Buffer Zone

4.2.5 Nevertheless, the proposed panels will be raised above the surrounding ground levels and associated infrastructure waterproofed, thus the risk can be considered Low.

4.2.6 There is no site specific information within third party reports relating to fluvial flood risk.

SEPA Product Data

4.2.7 The SEPA Product Data was received on 27/08/24 and highlighted that there have been no records of flooding onsite or within 2km. Additionally, SEPA provided sewer data and borehole groundwater levels, which have been discussed within the appropriate sections below. There were no other records for the site.

Culvert Capacity Assessment

4.2.8 RES Ltd have proposed a new crossing over Rottenraw Burn with the primary purpose for maintenance access, which can be seen in Figure 7. In order to ensure that the new crossing will not exacerbate flood risk to the site or the surrounding areas, a culvert capacity assessment has been undertaken by Arthian Ltd in May 2025 (culvert drawings and calculations can be found in Appendix E). This involved using the topographic survey (included in Appendix B) and inputting enclosed culvert calculations with the 1 in 200 year flow event within Rottenraw Burn to establish a minimum culvert sizing.

4.2.9 The top of the Access Road on the culvert, based on the topographic survey, is around 89.3m AOD. The minimum sizing of the proposed culvert is 1.8m (w) x 1.8m (d) x 12m (l). The reinforced box culvert is proposed to have 150mm concrete headwall, 75mm concrete blinding and includes around 600mm of stone cover to the finished road level, however this is subject to detailed design.

4.2.10 The maximum flow of water that the box culvert can pass is 8.073m^3/s, the peak flow during a 1 in 200 year return period is 5.24m^3/s and even when it is partially full the peak flow will increase to 11.947m^3/s temporarily due to a higher velocity caused by a decrease in the wetted perimeter. Overall, the proposed sizing for the culvert would therefore be adequate

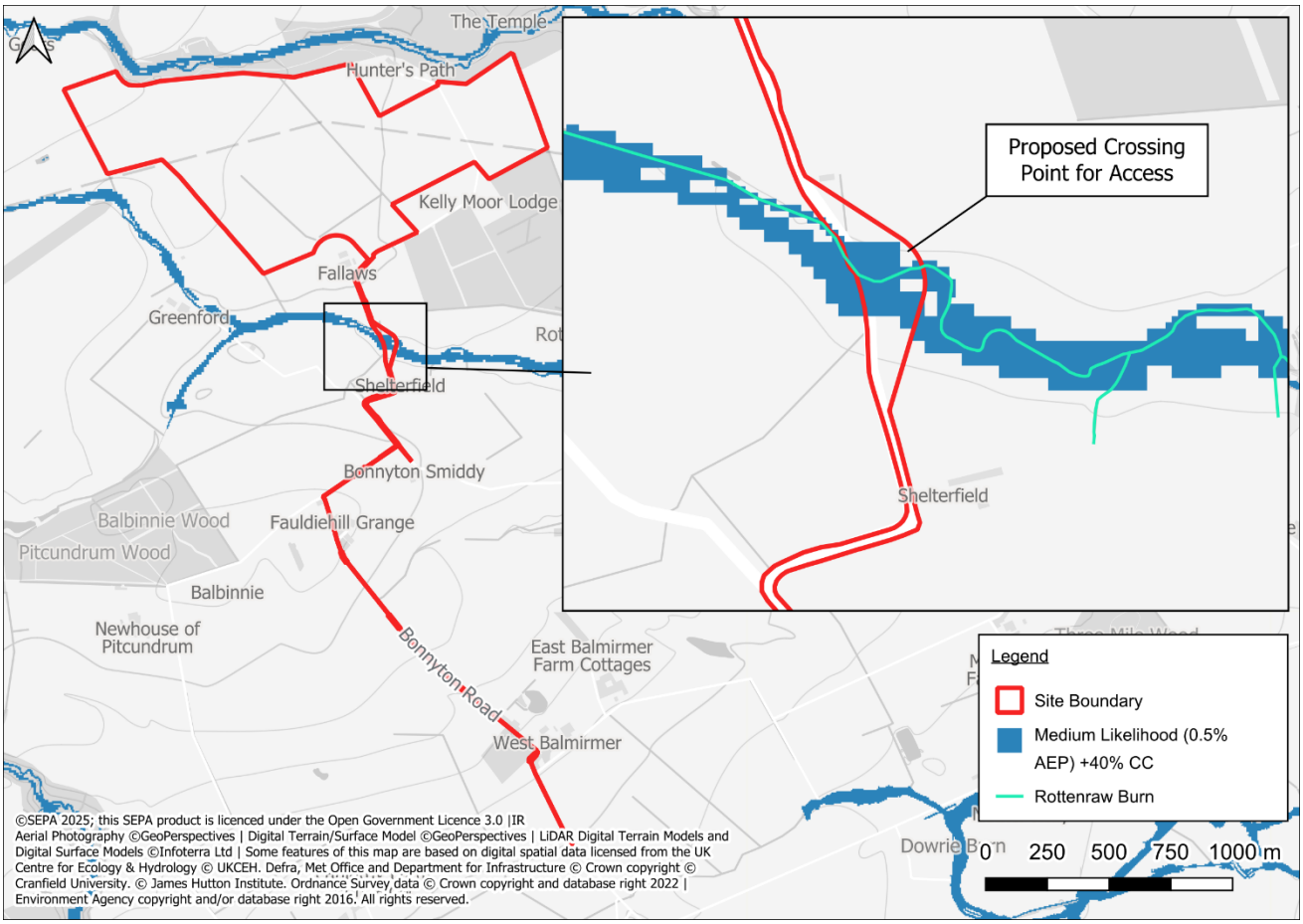


Figure 7: Proposed Crossing of Rottenraw Burn and Medium Likelihood +CC% of Fluvial Flooding

4.2.11 Given the nature of the development and the new culvert crossing proposed, the site is therefore

considered to be at **Low** risk of fluvial flooding.

4.3 Surface Water Flood Risk

4.3.1 The SEPA 'Flood Risk from Surface Water' map (Figure 8) (updated May 2025) indicates that the site is mainly at Very Low Likelihood of surface water flooding, meaning it has a <0.1% annual probability of flooding. There are areas of ponding in the east of the site that has Low to High Likelihood of surface water flooding. The Access Road is also mainly within an area of Very Low Likelihood of surface water flooding with the exception of an area to the north and far south of the access. The area to the north indicates Low to High Likelihood of surface water flooding, however this is associated with Rottenraw Burn and corresponds with the extents seen in the fluvial section which follows the river channel and areas of local depressions. The isolated surface water to the far south indicate Low to Medium Likelihood of surface water flooding.

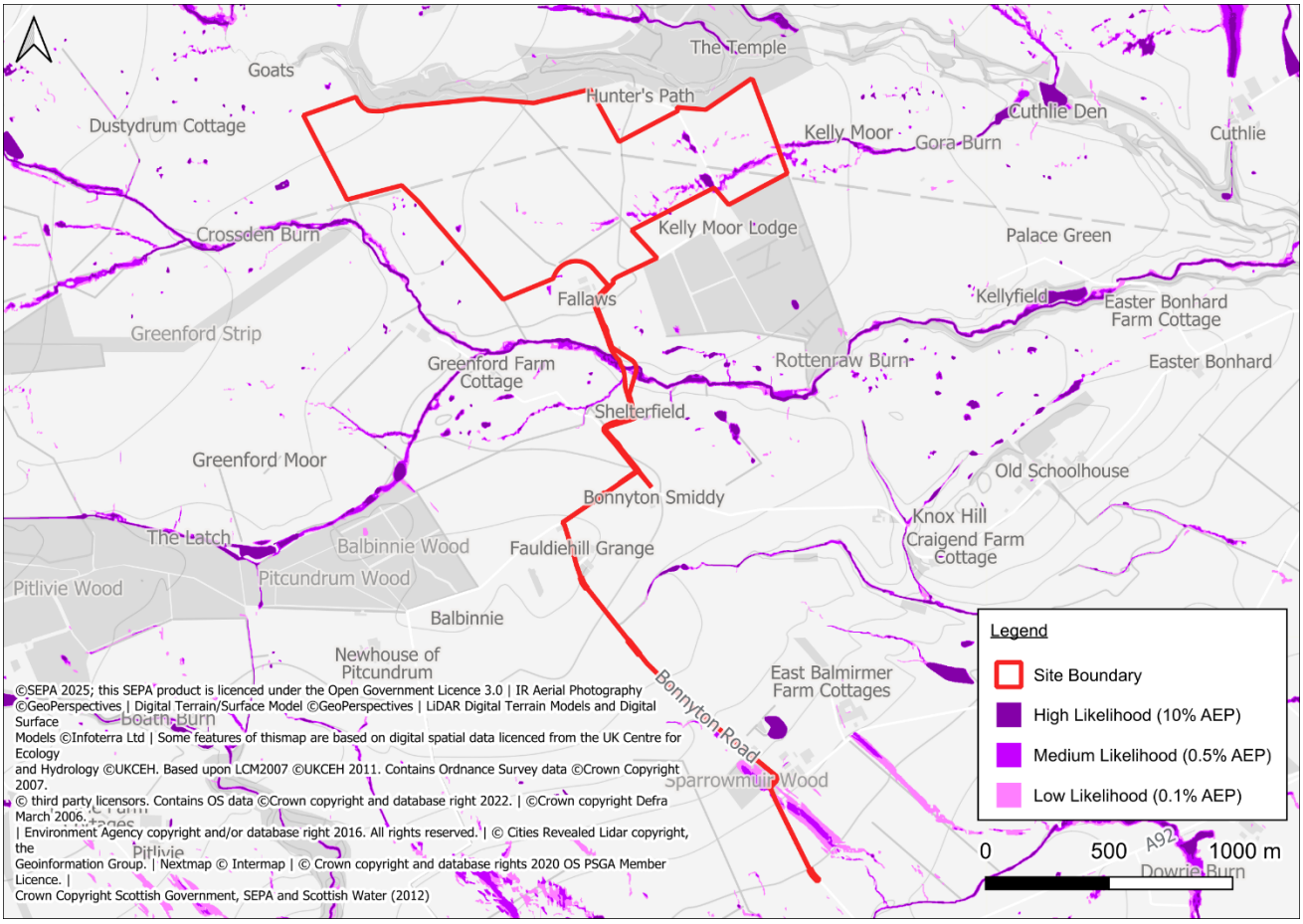


Figure 8: SEPA's Long-Term Flood Risk Map (Flood Risk from Surface Water)

4.3.2 During a High Likelihood scenario (excluding the depths associated with Rottenraw Burn channel), flood depths are anticipated below 0.3m, which is considered passible by vehicles and/or people. During a Medium and Low Likelihood scenario (excluding the depths associated with Rottenraw Burn channel), the flood depths are mainly below 0.3m with the exception of a small isolated area in the east of the site with depths expected between 0.3 and 1.0m.

4.3.3 Depths associated with Rottenraw Burn channel, do not exceed flood depths of 1.0m. However, a new culvert crossing (discussed above) has been proposed and the flood depths will be below the Access Road.

4.3.4 Access and egress is provided via a road that runs through the east of the site and exits in the south, which is considered achievable.

4.3.5 Additionally, the proposed development will be raised above surrounding ground levels and will not be impacted by surface water.

4.3.6 Any potential surface water flooding arising at or near to the site would be directed east, away from the site, following the local topography.

4.3.7 There is no site specific information within third party reports relating to surface water flood risk.

4.3.8 It can therefore be concluded that the site is at **Low** risk of surface water flooding.

4.4 Groundwater Flood Risk

4.4.1 The superficial deposits comprise Glacial Till which is underlain by Dundee Flagstone Formation. The superficial deposits are largely considered impermeable. The closest borehole, located in the north of the site, found no water strikes were encountered.

4.4.2 There are no records of groundwater flooding at or near to the site. The SEPA product Data, which is included in Appendix D, stated that the site is not identified as an area where groundwater contributes to flooding.

4.4.3 Groundwater levels correspond with river levels. As such groundwater flooding could occur during periods of prolonged high water levels along the unnamed land drain.

4.4.4 It is worth noting that there may be an increased risk to the site during the construction stage and therefore water resistant materials should be utilised.

4.4.5 It can therefore be concluded that the risk of groundwater flooding is **Low.**

4.5 Sewer Flooding

4.5.1 Sewer flood risk is typically hard to predict.

4.5.2 The SEPA Product Data highlights that there is private sewage within Fallaws Farm which is located adjacent to the south of the site.

4.5.3 There is no site specific information within third party reports relating to sewer flooding.

4.5.4 It can therefore be concluded that the risk of sewer flooding is **Low.**

4.6 Reservoir and Canal Flooding

4.6.1 There are no canals within the vicinity of the site.

4.6.2 The SEPA 'Reservoirs Map' shows that the site is not at risk of flooding from reservoirs.

4.6.3 It can therefore be concluded that there is **Negligible** risk of flooding from artificial sources.

4.7 Residual Flood Risks

4.7.1 A residual risk is an exceedance event, such as the greater than 1 in 1000 year (<0.1% AEP) flood event that would overtop the unnamed land drain and potentially impact the site. As the probability of a 1 in 1000 year flood event occurring is <0.1% in any given year, the probability is low and, therefore, no further mitigation beyond what is proposed is required.

4.7.2 In the event of the defences failing or an exceedance event occurring, the residual risk to people working within the site can be managed through the implementation of an appropriate site management plan, which recognises the residual risks and details what action is to be taken by staff in the event of a flood to put occupants in a place of safety.

4.8 Summary of Flood Risk

4.8.1 It can be concluded that the site is at Negligible to Low risk of flooding from all sources.

Table 3: Summary of Risk

Source of Flooding		Summary of Risk
Tidal Flood Risk		**Negligible**
Fluvial Flood Risk		**Low**
Surface Water Flood Risk		**Low**
Groundwater Flood Risk		**Low**
Artificial Sources of Flood Risk	**Sewer Flooding**	**Low**
	Reservoir and Canal Flooding	**Negligible**

Mitigation

4.8.2 In general, the following mitigation measures should be embedded into the master planning process:

- Fixed panels will be utilised throughout the site;
- The minimum height of the lowest part of the fixed solar panel units will be 0.6m above ground level;
- Electrical infrastructure associated with the panels can be adequately waterproofed to withstand the effect of flooding. Where possible the sensitive electrical equipment has been located in parts of the site that are within Very Low Likelihood of fluvial flooding. Where this hasn't been possible, panels and equipment will be raised 0.6m above the 1% AEP flood extents or where this is not possible as high as practicable. Panels not located within the flood extent will be raised to a minimum of 0.15m above surrounding ground levels.

5. Soil Management

5.1.1 The management of soil is essential to ensure the natural drainage of the site is maintained and to avoid an increase in surface water flooding.

5.1.2 In the absence of site management, integrated drainage systems could develop within the site. An unmanaged drainage network could lead to the rate of infiltration being compromised and ultimately being bypassed, resulting in increased surface water flows passing to the wider fluvial network.

5.1.3 There is no UK environmental managing runoff from solar panel installations. Research undertaken in the United States (US) by Cook and McCuen[8] recommend that the vegetation cover beneath the panels is well maintained or that a buffer strip be placed after the most down gradient row of panels.

5.1.4 The Maryland Department for the Environment Storm water Design Guidance for solar panel installations[9] recommends 'non-structural techniques like disconnecting impervious cover' to reduce runoff by promoting overland filtering and infiltration. The following must also be considered:

- Runoff must sheet flow onto and across vegetated areas to maintain the disconnection.
- Disconnecting impervious surfaces works best in undisturbed soils. To minimise disturbance and compaction, construction vehicles and equipment should avoid areas used for disconnection during installation of the solar panels. Where disturbance is unavoidable, post construction soil treatment (deep ploughing) to restore soil condition may be required.
- Groundcover vegetation must be maintained in good condition in those areas receiving disconnected runoff. Typically, this maintenance is no different than other lawn or landscaped areas. However, areas receiving runoff should be protected (e.g., planting shrubs or trees along the perimeter) from future compaction.

5.1.5 To minimise the potential impacts from soil compaction and changes in flow pathways a number of mitigation techniques have been suggested as follows. To meet soil protection guidance, DEFRA objectives of Construction Code of Practice for the Sustainable Use of Soils on Construction Sites are recommended.

5.1.6 Soil compaction will be limited during the construction phase by a number of measures;

- Using only light machinery to install the solar panels and low ground pressure vehicles to be used during extreme rainfall events.
- Where construction has resulted in soil compaction, the areas between panel rows would be tilled / scarified to an appropriate depth and then re-seeded with an appropriate vegetation cover.

[8] https://www.sandiegocounty.gov/content/dam/sdc/pds/ceqa/JVR/PreBoard/Appendices/JVR%20FEIR%20Appendix%20U%20-%20Hydrology%20Technical%20Memorandum%20-%20Final.pdf
[9]https://mde.maryland.gov/programs/water/StormwaterManagementProgram/Documents/ESDMEP%20Design%20Guidance%20Solar%20Panels.pdf

- During the first few years there should be frequent inspections of the planting and soil to ensure it is growing properly, isn't bare and isn't compacted. Any remedial work should occur as soon as possible.
- During operation, maintenance of infrastructure will be limited and only require light machinery, therefore no change in the existing permeability of the soil would be caused.

5.1.7 The presence of appropriately maintained vegetation at all times across the site will mitigate potential increases in runoff and soil erosion, which can be a contributing factor to greater runoff.

5.1.8 Any existing field or tile drainage system would be restored where affected by construction.

5.1.9 All access tracks will be made out of granular material and will therefore be permeable, reducing the potential increase in surface runoff.

6. Drainage Impact Assessment

6.1 Introduction

6.1.1 The site currently comprises undeveloped land which is not formally drained and is therefore considered to be 100% permeable.

6.1.2 NPF4 requires that all development proposals will:

- Not increase the risk of surface water flooding to others, or itself be at risk;
- 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; and
- Seek to minimise the area of impermeable surface.

6.1.3 Angus Council's Technical Guidance for Flood Risk and Surface Water Drainage (2023) states that:

"SuDS should also be designed to ensure that:

- *there should be no exceedance from the proposed SuDS for up to and including the 1 in 30 year critical rainfall event inclusive of a 39% uplift for climate change;*
- *there should be no surface water flooding from the proposed SuDS to the proposed buildings, or outwith the site for up to and including the 1 in 200 year critical rainfall event inclusive of a 39% uplift for climate change.*

The CIRIA C753 SuDS Manual recommends managing runoff on the surface. Above ground SuDS should therefore be used to provide surface water attenuation and treatment."

6.1.4 The proposed development will comprise natural ground cover post construction albeit with the introduction of solar panels on raised frames and limited areas of hardstanding associated with substations and inverters. The site will remain wholly largely permeable following development.

6.2 Drainage Hierarchy

6.2.1 In accordance with the Scottish Planning Policy and SEPA guidance, every development with a surface water drainage system will ensure the disposal of surface water without threating buildings or people and have facilities to separate and remove silt/pollutants. It is also stated within the Land Use Planning System – General Policy (LUPS-GU4) and the Controlled Activities Regulations (CAR) that surface water must discharge to ground or water by means of sustainable urban drainage (SuDS) authorised by SEPA.

6.2.2 The surface water hierarchy (SPP and SEPA guidance) is to utilise soakaway systems or infiltration as the preferred option, followed by discharging to an appropriate watercourse. If this is not feasible, the final option is to discharge to an existing public sewer.

Surface Water Discharge to Soakaway

6.2.3 The first consideration for the disposal of surface water is infiltration (soakaways and permeable

surfaces). As described above the site is underlain by superficial deposits of Glacial Till which is underlain by Dundee Flagstone Formation.

6.2.4 The majority of the site will comprise natural ground cover post development albeit with the introduction of solar panels on raised frames and limited areas of hardstanding associated with substations and inverters. Any proposed access or surfacing will be permeable. The site will therefore remain wholly largely permeable following development, as per the existing situation.

6.2.5 It can be concluded that soakaways may not be necessary for the discharge of surface water runoff.

Surface Water Discharge to Watercourse

6.2.6 Where soakaways are not suitable a connection to watercourse is the next consideration. SEPA regulates watercourse discharges under the CAR.

6.2.7 The unnamed land drain which is located in the centre of the site.

6.2.8 Any surface water runoff in excess of the infiltration capacity of the ground may naturally drain into the surrounding land drain as per the existing scenario. As no new connections will be required, discharge falls under the General Binding Rules 10 and 11 (GBR10 & 11), complying with conditions.

Surface Water Discharge to Sewer

6.2.9 As described above, a connection to the land drain is feasible and therefore a connection to the public surface water sewer is not required.

6.3 Surface Water Discharge

6.3.1 The Scheme will be free draining through perimeter gaps around all panels, there will be minimal increase in impermeable area meaning the proposals will not increase surface water risk elsewhere.

6.3.2 As a result of the construction of the solar panels, some rainfall will be intercepted by the surface of the solar panels before reaching ground level. Intercepted rainfall will either run down the face of the panels, due to the angle at which they are positioned, and drip onto the ground below or will be lost due to evaporation from the face of the panels.

6.3.3 Where rainwater drips onto the ground below, the energy of the flow from the surface of the panels is likely to be greater than that of the rainfall (especially where rainwater collects at the bottom edge of the solar array before dripping onto the ground below) which could result in the erosion of ground without appropriate mitigation. The erosion of the ground could then result in the formation of rivulets which could increase the speed of runoff throughout the site.

6.3.4 In order to mitigate against potential erosion, the existing intensively managed agricultural land will be replaced by planted wildflower and grassland below the solar panels. The planted surface will act as a level spread / energy dissipater to promote low erosivity sheet flow during the operation of the solar farm. The vegetation will be managed organically and will either be mowed or used for light grazing.

6.3.5 The panels forming the solar array will not be tightly compacted and will not form one continuous surface.

Small gaps will exist between each panel, which will allow water to drip onto the ground below from several locations rather than as concentrated runoff from the bottom edge. This spread of water dripping will reduce the potential for erosion to occur.

6.3.6 The access track will be designed to be permeable, thereby allowing surface water runoff to percolate into the ground below.

6.3.7 Electrical infrastructure associated with the panels will be sited on concrete pads. The concrete bases will be surrounded by gravel filled filter trenches, constructed to limit the lateral flow of water away from the equipment and replace the loss of natural infiltration caused by the concrete bases themselves. Surface water would be stored within the gravel sub- base prior to infiltrating into the ground as per the existing situation.

6.3.8 Based on the above, the proposed development is likely to provide betterment over the existing surface water runoff regime.

6.3.9 An Outline Construction Environment Management Plan (CEMP) should be utilised to describe water management measures to control surface water runoff and drain hardstanding and other structures during the construction, operation and maintenance, and decommissioning phases. This will ensure compliance with SEPA's Pollution Prevention Guidelines (PPGs) or Guidance for Pollution Prevention (GPPs). Some of the measures have been outlined below.

6.3.10 During construction of the proposed development, temporary construction lay-down areas will be provided.

6.3.11 It is recommended that temporary drainage measures are implemented within the lay-down areas to ensure there is no increase in surface water runoff as a result of the construction compound.

6.3.12 In addition, construction of the proposed development has the potential to result in the compaction of soils thereby reducing the soil's ability to accept surface water runoff. It is recommended that the movement of large vehicles is limited where possible to proposed access tracks in order to reduce the potential for soil compaction to occur. Vehicles should be fitted with low pressure tyres to further reduce the impact on the underlying soil.

6.3.13 The aforementioned techniques will discourage soil erosion within the site, whilst maintaining the existing overland flow paths.

6.4 Event Exceedance

6.4.1 Any surface water runoff in excess of the infiltration capacity of the ground may naturally drain into the unnamed land drain as per the existing scenario.

6.5 Maintenance

6.5.1 Maintenance of communal drainage features such as permeable surfacing will be the responsibility of the site owner.

6.5.2 Maintenance schedules for permeable surfacing is included in Appendix F. Maintenance of the separator will be as per the manufacturer's guidance.

6.6 Foul Water Discharge

6.6.1 Given the nature of the site, no welfare facilities are anticipated to be required and therefore no direct connection to public sewers is proposed. Any maintenance workers on site will utilise mobile welfare facilities if necessary.

6.7 Other Considerations

6.7.1 Maintenance access to Rottenraw Burn and the unnamed land drains should be retained.

6.7.2 A 6m buffer should be established on either side of the unnamed land drain to be in line with the Technical Guidance (discussed above).

7. Conclusions and Recommendations

7.1 Conclusions

7.1.1 The site is wholly situated within an area of Very Low Likelihood of fluvial flooding. The Access Road is mainly within an area of Very Low Likelihood, with the exception of the area that crosses Rottenraw Burn. A new culvert has been proposed at the crossing of Rottenraw Burn along the Access Road to ensure flood risk is not increased.

7.1.2 The risk of flooding from all sources has been assessed and it can be concluded that all sources have a Negligible to Low risk.

7.1.3 The solar panels will be mounted on raised frames and therefore raised above surrounding ground level allowing flood water to flow freely underneath. Therefore, there will be no loss of floodplain volume as a result of the proposed development.

7.1.4 The proposed development is free draining through perimeter gaps around all panels, allowing for infiltration as existing within the grassland/vegetation surrounding and beneath the panels. There will be minimal increase in impermeable area meaning the proposals will not increase surface water flood risk elsewhere.

7.1.5 Any surface water exceeding the infiltration capacity of the surrounding strata will naturally drain to the unnamed land drains in line with the existing scenario.

7.1.6 The heavily managed agricultural land will be replaced with grassland. This will help to reduce run off rates by increasing the roughness of the ground, help to increase infiltration by reducing compaction, and improve water quality by reducing erosion and mobilisation of pollutants. As a result, runoff rates may be reduced following development when compared to the existing greenfield scenario.

7.2 Recommendations

Maintenance access to the unnamed land drains should be retained.

- A 6m buffer should be established on either side of the unnamed land drain to be in line with the Technical Guidance (discussed above).

Appendices

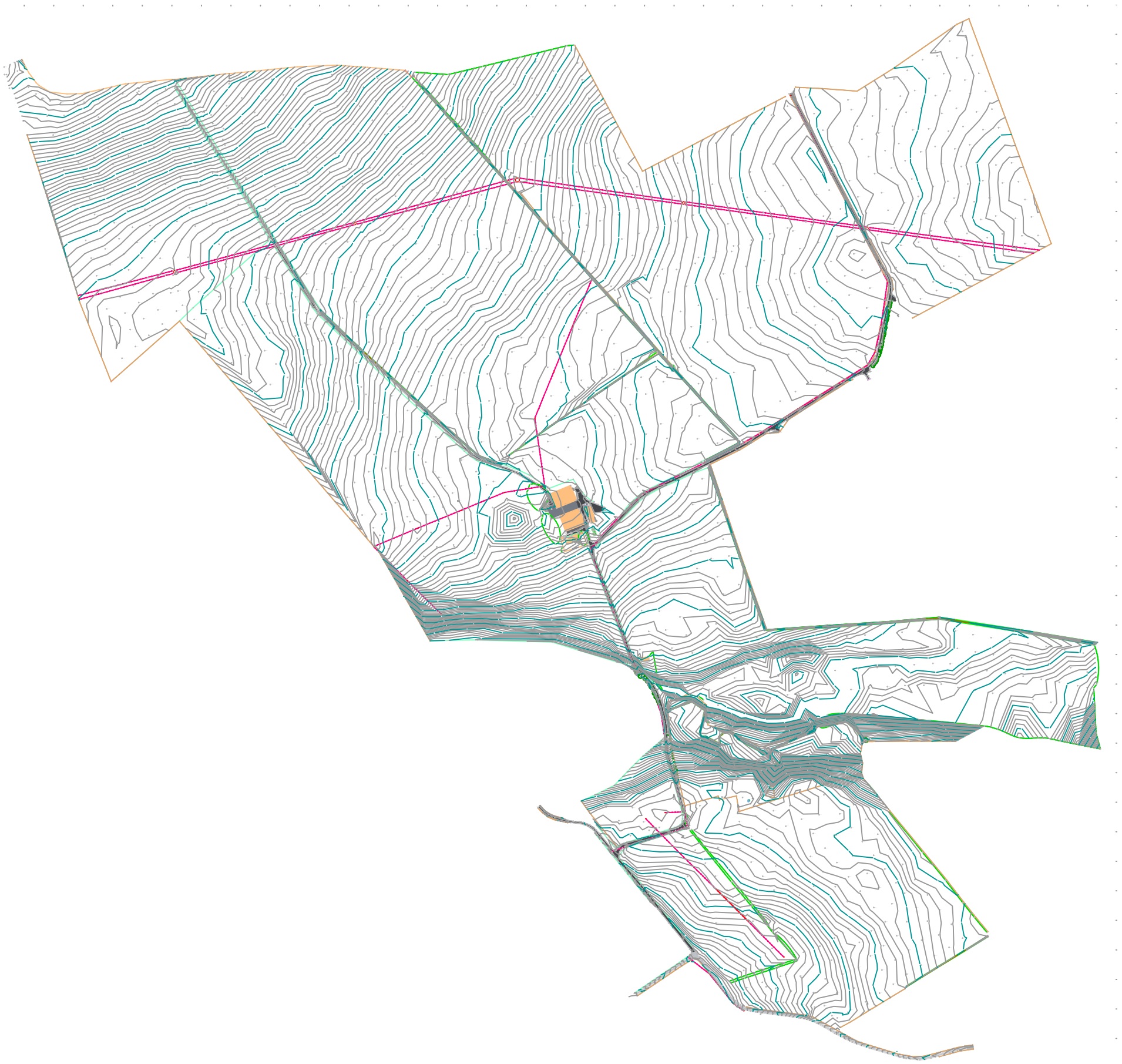
Appendix A- Limitations

Limitations

This report contains recommendations from Arthian, which are based on the information listed in the report and reflect the professional opinions of an experienced Environmental Consultant. Arthian obtained, reviewed, and evaluated information from the Client and others to prepare this report. The conclusions, opinions, and recommendations presented in this report are based on this information. However, Arthian does not guarantee the accuracy of the information provided and will not be held responsible for any opinions or conclusions reached based on information that is later proven to be inaccurate.

This report was prepared exclusively for the Client and for the specific purpose for which Arthian was instructed. It is not intended for use by anyone other than the Client without Arthian's written consent. Any unauthorized use of this report is at the sole risk of the user. Anyone using or relying on this report, other than the Client, agrees to indemnify and hold harmless Arthian from any claims, losses, or damages arising from the performance of the work by the Consultant.

Appendix B – Topographic Survey



north

0 10 25 50 100

Scale 1:1000 (metres)

Rev.	Description	Drawn	Date
-	Topographic Survey at Bonnyknox	SP	29/08/24

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Client
Renewable Energy Systems Ltd.

Project
Proposed Solar PV Development at Bonnyknox, Arbroath, DD11 2PY

Drawing
Topographic Survey at Bonnyknox

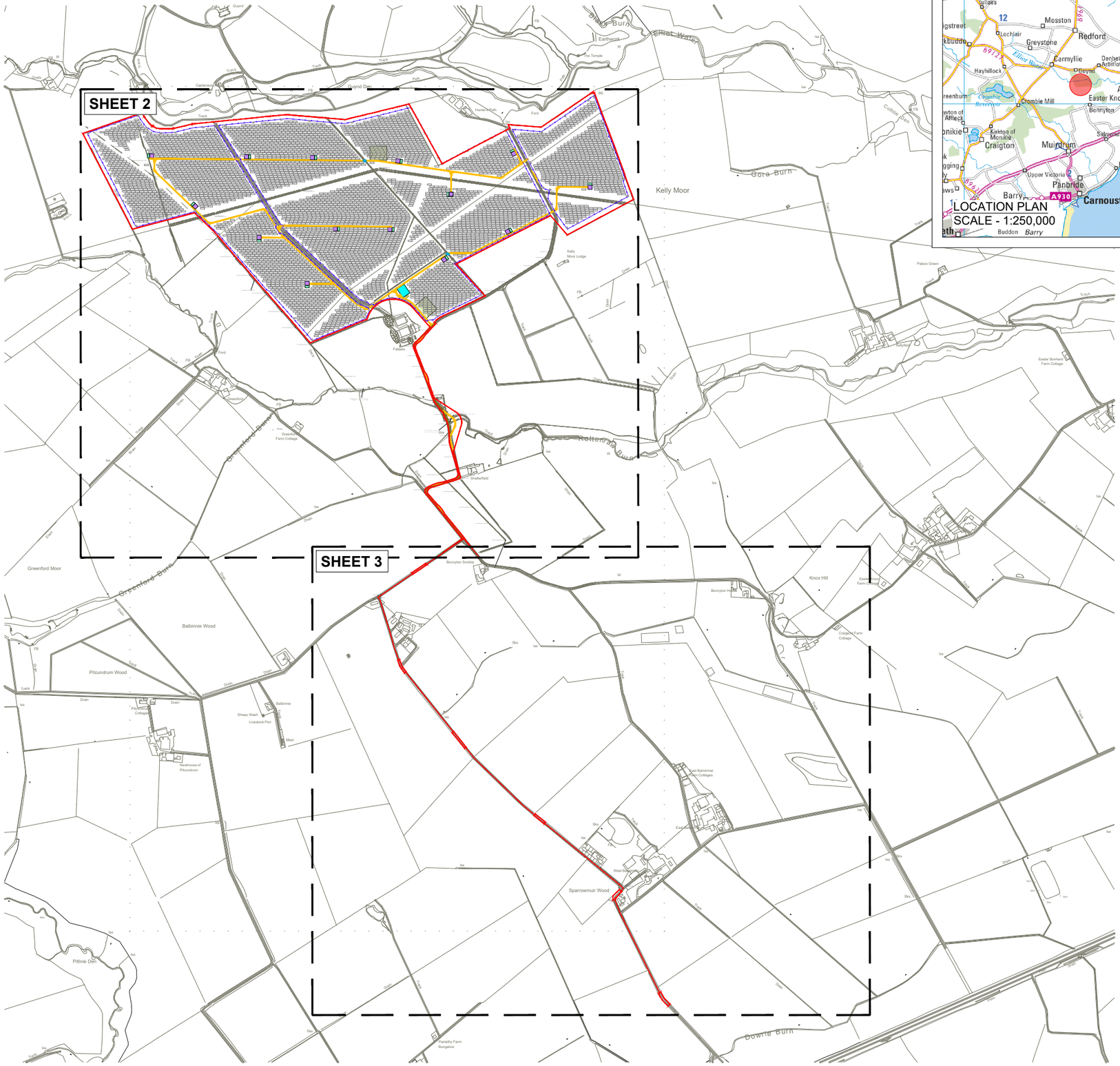
Status
Issue

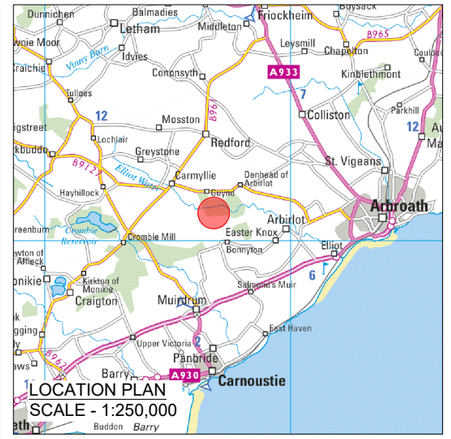
Scale 1:7500 Sheet A3

Drawn SP Check GM Date 29/08/24

Drawing No: 313625 PL_001 Rev X

Appendix C – Proposed Development Plan





KEY:

- SITE BOUNDARY (*OUTSIDE OF LINE DENOTES BOUNDARY*)
- EXISTING ACCESS TRACK
- PROPOSED ACCESS TRACK
- SOLAR PV ARRAY
- INVERTER SUBSTATION
- HARDSTAND
- SUBSTATION COMPOUND
- TEMPORARY CONSTRUCTION COMPOUND
- SPARES CONTAINERS
- PERIMETER FENCE LINE
- GATE (PERIMETER FENCE)
- CCTV
- PROPOSED DITCH CROSSING
- VISIBILITY SPLAY

OVERVIEW
SHEET 1 OF 3

ISSUE	DRAWN	CHKD	APPD	DATE	REVISION NOTES
4	FG	JM	CC	2025-05-13	Site boundary update
3	FG	JM	CC	2025-01-28	Passing places added
2	FG	JM	SL	2024-11-26	Battery storage compounds removed
1	FG	JM	SL	2024-11-12	First Issue

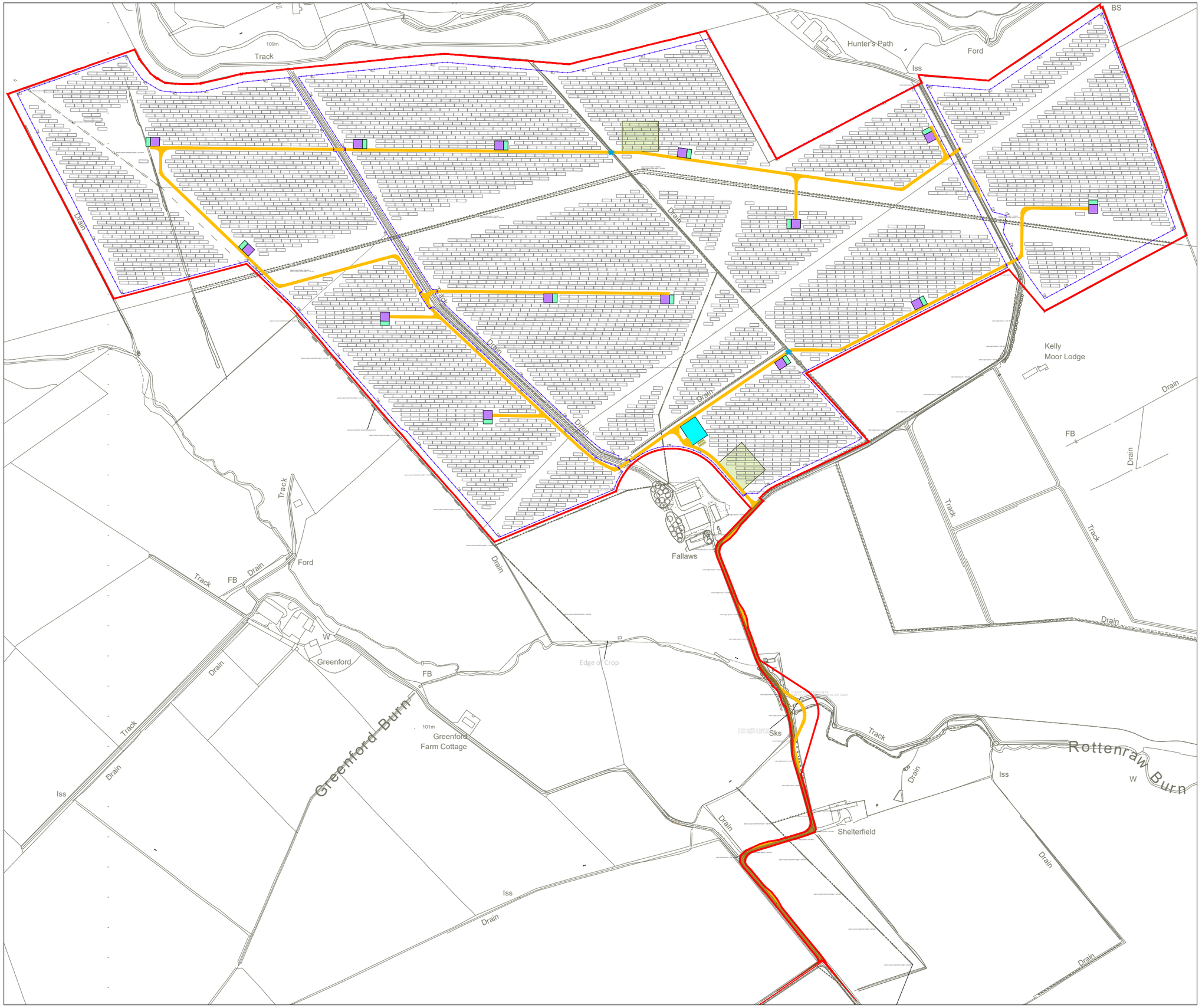
PURPOSE: PERMITTING	COORDINATES: OSGB 1936
SCALE: 1:15,000 @A3	DATUM: N/A
LAYOUT DRAWING: N/A	T-LAYOUT NO: N/A

PROJECT TITLE
BONNYKNOX

DRAWING TITLE
FIGURE 4
INFRASTRUCTURE LAYOUT

RES DRAWING NUMBER	REV
05114-RES-LAY-DR-PT-003	4

BEAUFORT COURT,
EGG FARM LANE,
KINGS LANGLEY,
HERTS WD4 8LR. UK
TEL +44 (0) 1923 299200
WWW.RES-GROUP.COM



KEY:

- SITE BOUNDARY (*OUTSIDE OF LINE DENOTES BOUNDARY*)
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SHEET 2 OF 3

ISSUE	DRAWN	CHKD	APPD	DATE	REVISION NOTES
4	FG	JM	CC	2025-05-13	Site boundary update
3	FG	JM	CC	2025-01-28	Passing places added
2	FG	JM	SL	2024-11-26	Battery storage compounds removed
1	FG	JM	SL	2024-11-12	First Issue

PURPOSE: PERMITTING	COORDINATES: OSGB 1936
SCALE: 1:6,000 @A3	DATUM: N/A
LAYOUT DRAWING: N/A	T-LAYOUT NO: N/A

PROJECT TITLE
BONNYKNOX

DRAWING TITLE
FIGURE 4
INFRASTRUCTURE LAYOUT

RES DRAWING NUMBER	REV
05114-RES-LAY-DR-PT-003	4

BEAUFORT COURT,
EGG FARM LANE,
KINGS LANGLEY,
HERTS WD4 8LR. UK
TEL +44 (0) 1923 299200
WWW.RES-GROUP.COM

KEY:

- SITE BOUNDARY (*OUTSIDE OF LINE DENOTES BOUNDARY*)
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SHEET 3 OF 3

ISSUE	DRAWN	CHKD	APPD	DATE	REVISION NOTES
4	FG	JM	CC	2025-05-13	Site boundary update
3	FG	JM	CC	2025-01-28	Passing places added
2	FG	JM	SL	2024-11-26	Battery storage compounds removed
1	FG	JM	SL	2024-11-12	First Issue

PURPOSE: PERMITTING	COORDINATES: OSGB 1936
SCALE: 1:6,000 @A3	DATUM: N/A
LAYOUT DRAWING: N/A	T-LAYOUT NO: N/A

PROJECT TITLE
BONNYKNOX

DRAWING TITLE
FIGURE 4
INFRASTRUCTURE LAYOUT

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05114-RES-LAY-DR-PT-003	4

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EGG FARM LANE,
KINGS LANGLEY,
HERTS WD4 8LR. UK
TEL +44 (0) 1923 299200
WWW.RES-GROUP.COM

Appendix D – SEPA Product Data

Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

RESPONSE TO F0197636

Request Timeline

Date	Status
31/07/2024	EIR Request received [statutory deadline 29/08/2024]
27/08/2024	EIR Response issued

Requested Information

[…] to undertake a Flood Risk Assessment and Drainage Strategy in support of a proposed solar photovoltaic in Arbroath, known as the site hereon. I attach a site location plan and the site details below.

According to the SEPA online mapping the site is at Low to High probability of fluvial flooding within the south of the site associated with the watercourse.

Site Details

Site Name	BESS Bonnyknox
Address	Land west of Arbroath
Postcode	DD11 2PR (nearest postcode)
NGR	356834, 740927

Data Request

Please provide any of the following information to enable us to complete our assessment:

Historical Flooding Information

1) Any records, photographs, flood extents from known historic events in the area

Technical Data

2) Any hydraulic models covering the site
3) Raw and processed results for the model(s) above
4) Hydraulic modelling report for the model(s) above
5) Modelled floodplain levels and flows for node points within and in the immediate vicinity of the Site taking into account the most recent climate change allowances (where these have been modelled);
6) Hydrology report and/or flood estimation calculation records for the model(s) above
7) Survey data used to build the model or inform nearby studies

Supporting Data

Flood/coastal defence survey data

8) Operational procedures for hydraulic structures
9) The date and type of modelling that flood levels have been derived from;
10) The technical report summarising the modelling methodology;
11) Confirmation that the data is appropriate/relevant to inform flood risk within the Site;
12) Details of any flood defences within the vicinity of the Site (i.e type, crest levels, Standard of Protection, condition, etc) and any associated breach and/or overtopping flood extents and depths;
13) Hazard mapping detailing the depth, velocity and associated hazard rating for the Site;
14) Any information in relation to on-Site drainage;
15) Any information in relation to groundwater flooding in the area. Where possible, please provide borehole locations and ground water levels;
16) Any information/mapping of historical flooding events on Site from all sources of flooding (i.e fluvial, tidal, surface water, groundwater, sewer, reservoir, canal, etc). Where available please can you provide flood levels, estimated return periods, photographs and other such data that may be relevant to our assessment;

Response

We confirm that we have handled your request under the terms of the Environmental Information (Scotland) Regulations 2004 (EIRs).

Q	Response	Data Reuse
[1]	**Any records, photographs, flood extents from known historic events in the area** SEPA's Observed Flood Event Database currently has no records of flooding affecting your site of interest or within 2 km of National Grid Reference 356834, 740927. SEPA's Observed Flood Event database is a collection of flood event records known to SEPA at this time and does not constitute a complete record of all flooding that may have occurred in the area. This information was correct at the time of this request, to the best of SEPA's knowledge. If we do not hold any records of flooding for an area this does not mean it has never flooded (it just means that we do not have a record of it flooding). We recommend you also contact Angus Council who may hold more complete records. Contact details can be found in the 'Application of Regulations and Exceptions' section below. <u>Exceptions/Regulations Applied:</u> **Regulation 9 – Advice and Assistance** **Regulation 10(4)(a) – Information not held**	Data reuse does not apply.

Q	Response	Data Reuse
	Regulation 14(1)(b) – Other Authority	
[2]	**Any hydraulic models covering the site** We are unable to provide the models which underly our Flood Maps, as our maps are developed using licensed data supplied to SEPA by many providers. Whilst the published maps are available under the Open Government Licence, this is not the case for the underlying data and models used to generate the mapping due to our obligations to these data licensors. If a Local Authority has undertaken a flood study within the area, they may be able to provide this information. We recommend you also contact Angus Council who may hold more complete records. Contact details can be found in the 'Application of Regulations and Exceptions' section below. <u>Exceptions/Regulations Applied:</u> **Regulation 9 – Advice and Assistance** **Regulation 10(5)(c) – Intellectual property rights**	Data reuse does not apply.
[3]	**Raw and processed results for the model(s) above** Please see response to Q2.	Data reuse does not apply.

Q	Response	Data Reuse
	Exceptions/Regulations Applied: **Regulation 9 – Advice and Assistance** **Regulation 10(5)(c) – Intellectual property rights**	
[4]	**Hydraulic modelling report for the model(s) above** Please see response to Q2. Exceptions/Regulations Applied: **Regulation 9 – Advice and Assistance** **Regulation 10(5)(c) – Intellectual property rights**	Data reuse does not apply.
[5]	**Modelled floodplain levels and flows for node points within and in the immediate vicinity of the Site taking into account the most recent climate change allowances (where these have been modelled)** Please see response to Q2. Exceptions/Regulations Applied: **Regulation 9 – Advice and Assistance**	Data reuse does not apply.

Q	Response	Data Reuse
	Regulation 10(5)(c) – Intellectual property rights	
[6]	**Hydrology report and/or flood estimation calculation records for the model(s) above** Please see response to Q2. <u>Exceptions/Regulations Applied:</u> **Regulation 9 – Advice and Assistance** **Regulation 10(5)(c) – Intellectual property rights**	Data reuse does not apply.
[7]	**Survey data used to build the model or inform nearby studies** Please see response to Q2. <u>Exceptions/Regulations Applied:</u> **Regulation 9 – Advice and Assistance** **Regulation 10(5)(c) – Intellectual property rights**	Data reuse does not apply.
[8]	**Operational procedures for hydraulic structures**	Data reuse does not apply.

Q	Response	Data Reuse
	We do not hold any information for hydraulic structures including flood defences. Flood defence information for Scotland can be accessed by professional organisations who are flood risk management practitioners or by individuals who provide significant input to flood risk management activities in Scotland. This is available through the Scottish Flood Defence Asset Database (SFDAD), which you can register to access here: www.scottishflooddefences.gov.uk/. SFDAD has been produced using information from local authorities on their flood schemes. The information available varies between schemes and may be out of date. SFDAD therefore does not present a comprehensive picture of flood defences in Scotland. You can access the database but the associated terms and conditions with the database include: • The data is only viewable and cannot be downloaded from the website. • The use of the database is limited for viewing the contents for internal business use only to help inform flood risk management activities.	

Q	Response	Data Reuse
	• The data must not be copied, transferred, assigned, distributed, modified, used to create derived products, commercially used or used to reverse engineer the contents of the database. • The data within the database must not be used to identify flood risk for individual properties or point locations. We recommend that you contact the Flood Risk Management team at the local council, who are the local flood risk management authority and are responsible for flood defences for that area. They may be able to provide further details on flooding and flood alleviation in this area. Contact details for Angus Council can be found in the 'Application of Regulations and Exceptions' section below. <u>Exceptions/Regulations Applied:</u> **Regulation 9 – Advice and Assistance** **Regulation 10(4)(a) – Information not held** **Regulation 14(1)(b) – Other Authority**	
[9]	**The date and type of modelling that flood levels have been derived from**	Data reuse does not apply.

Q	Response	Data Reuse
	SEPA is unable to provide modelled river levels and flows as our flood hazard maps have been produced using methods and data appropriate for national scale mapping rather than detailed local models. It is possible that the local authority may be able to provide this information if they have undertaken a flood study for this area. Contact details for Angus Council can be found in the 'Application of Regulations and Exceptions' section below. Exceptions/Regulations Applied: **Regulation 10(4)(a) – Information not held** **Regulation 14(1)(b) – Other Authority**	
[10]	**The technical report summarising the modelling methodology** The methodology is available on our website under the "Developing our knowledge" section. Scroll down to the flood maps section and your will find methodology summary documents regarding all the maps. www.sepa.org.uk/environment/water/flooding/developing-our-knowledge/ Exceptions/Regulations Applied:	This data is licenced under the current Open Government Licence: www.nationalarchives.gov.uk/doc/open-government-licence/version/3/

Q	Response	Data Reuse
	Regulation 6(1)(b) - Publicly Available	
[11]	**Confirmation that the data is appropriate/relevant to inform flood risk within the Site** The SEPA flood map is designed as a strategic community level tool to support the development of Flood Risk Management Plans, and to raise awareness of flooding issues to the public. The map utilises observed or historic flooding information where available to validate the flood modelling used to produce the maps, however, this is not the only factor in identifying an area potentially at risk of flooding. The absence of any previous history of flooding for a given location does not necessarily infer a lower level of potential risk but may reflect that a flood event of a given magnitude has not been experienced or recorded to-date. This mapping of areas potentially at risk of flooding has been undertaken at a national level, which while representing the best available information at this level, involves necessary limitations and simplifications. These limitations make the maps unsuitable to explicitly quantify the potential flood risk at a street or individual property level. <u>Exceptions/Regulations Applied:</u>	Data reuse does not apply.

Q	Response	Data Reuse
	Regulation 9 – Advice and Assistance	
[12]	**Details of any flood defences within the vicinity of the Site (i.e type, crest levels, Standard of Protection, condition, etc) and any associated breach and/or overtopping flood extents and depths** Please see response to Q8. Exceptions/Regulations Applied: **Regulation 9 – Advice and Assistance** **Regulation 10(4)(a) – Information not held** **Regulation 14(1)(b) – Other Authority**	Data reuse does not apply.
[13]	**Hazard mapping detailing the depth, velocity and associated hazard rating for the Site** In Autumn 2022, SEPA made available the following spatial datasets under the Open Government Licence (OGL): www.nationalarchives.gov.uk/doc/open-government-licence/version/3/ • Flood Hazard Maps (release version 2.0) • Flood Risk Management (FRM) Plan district boundaries • Potentially Vulnerable Areas	This data is licenced under the current Open Government Licence: www.nationalarchives.gov.uk/doc/open-government-licence/version/3/

Q	Response	Data Reuse
	• Flood Risk Management (FRM) Target Areas. SEPA's flood hazard maps (current version 2.1, November 2023) show the risk of flooding from rivers, the sea and surface water, and can be accessed in two ways: • Via the flood map viewer map.sepa.org.uk/floodmaps • Data for use in Geographic Information Systems (GIS) can be downloaded from the Data Publication page www.sepa.org.uk/environment/environmental-data/ These datasets are now available for anyone to view, use and download for free. Please refer to the (FAQs) for further information: www.sepa.org.uk/environment/water/flooding/faqs/ - floodmaps Exceptions/Regulations Applied: **Regulation 6(1)(b) - Publicly Available** **Regulation 9 – Advice and Assistance**	
[14]	**Any information in relation to on-Site drainage**	This data is licenced under the current Open Government Licence:

Q	Response	Data Reuse
	Please see attached for sewage discharge registrations within a 1.5km radius: • **F0197636 - 1.5km Search.xlsx** The public register documentation which SEPA held prior to December 2020 continues to be impacted by the loss of access to our Public Register system. We are providing you with the best information we currently have available but cannot confirm it is complete or accurate. Any use you make of this information will be at your own risk. This data this does not include details (if any) of discharge consents determined pre-2006 and not yet transferred into CAR (Controlled Activities Regulations). These consents are only searchable by house or street name. Exceptions/Regulations Applied: **Regulation 9 – Advice and Assistance**	www.nationalarchives.gov.uk/doc/open-government-licence/version/3/
[15]	**Any information in relation to groundwater flooding in the area. Where possible, please provide borehole locations and ground water levels** The closest groundwater monitoring location is Carmyllie War Memorial Obs BH (Location code: 348952), located ~1.5km northwest of the site at National	This data is licenced under the current Open Government Licence: www.nationalarchives.gov.uk/doc/open-government-licence/version/3/

Q	Response	Data Reuse
	Grid Reference (NGR): NO 55278 42764. Attached are the daily maximum groundwater levels for the full period of record available: • **Carmyllie War Memorial Obs LC348952 BH GWL Day Max.xlsx** Please note there are a further two locations, Crombie Country Park Obs BH (lc: 348956) and Craigmill Burn Obs BH (lc:7926), located approximately 3.5km and 3.9km away, respectively. Some, or all, of the data are available. This information can be provided if required, please also provide the timeframe and data type required if this is the case. If you would like to request this information, please contact foi@sepa.org.uk The site of interest is not located within a river catchment where we have identified that groundwater can be a contributory factor to flooding. This information can be viewed on our website by selecting the Groundwater option under Other Maps.: map.sepa.org.uk/floodmap/map.htm Exceptions/Regulations Applied: **Regulation 9 – Advice and Assistance**	
[16]	**Any information/mapping of historical flooding events on Site from all sources of flooding (i.e fluvial, tidal, surface water, groundwater, sewer,**	Data reuse does not apply.

Q	Response	Data Reuse
	reservoir, canal, etc). Where available please can you provide flood levels, estimated return periods, photographs and other such data that may be relevant to our assessment Please see response to Q1. <u>Exceptions/Regulations Applied:</u> **Regulation 9 – Advice and Assistance** **Regulation 10(4)(a) – Information not held** **Regulation 14(1)(b) – Other Authority**	

Application of Regulations and Exceptions

Section 39(2)

The information you are requesting is environmental information. We have applied Section 39(2) of the Freedom of Information (Scotland) Act 2002 (FOISA). We are therefore handling your request under the Environmental Information (Scotland) Regulations 2004 (EIRs).

Regulation 6(1)(b) Publicly available & easily accessible

As we have advised that information is publicly available & easily accessible we have applied Regulation 6(1)(b), the text of which is reproduced below.

6(1) Where an applicant requests that environmental information be made available in a particular form or format, a Scottish public authority shall comply with that request unless- (b) the information is already publicly available and easily accessible to the applicant in another form or format.

Regulation 9 – Advice and assistance

As we have issued additional information, advice, or assistance we have applied Regulation 9(1) of the EIRs, the text of which is reproduced below.

9(1) A Scottish public authority shall provide advice and assistance, so far as it would be reasonable to expect the authority to do so, to applicants and prospective applicants.

Regulation 10(4)(a) – Information not held

Where we have advised that we do not hold information we have applied Regulation 10(4)(a) of the EIRs, the text of which is reproduced below.

10 (4) A Scottish public authority may refuse to make environmental information available to the extent that;- (a) it does not hold that information when an applicant's request is received.

The exception in Regulation 10(4)(a) is subject to the public interest test in Regulation 10(1)(b) of the EIRs. As SEPA does not hold the information in question there is no conceivable public interest in requiring that the information be made available.

Regulation 10(5)(c) – Intellectual property rights

Flood level information and/or models which underly our Flood Maps is withheld under Regulation 10(5)(c) of the EIRs, the text of which is reproduced below.

(5) A Scottish public authority may refuse to make environmental information available to the extent that its disclosure would, or would be likely to, prejudice substantially;- (c) Intellectual property rights;

A public interest test was carried out in relation to this exemption. We acknowledge that there is a presumption in favour of disclosure under Regulation 10(2)(b) of the EIRs and that SEPA is a taxpayer funded public body with a duty to be open and transparent. We also acknowledge providing underlying modelling could support others to make decisions/ understand and apply to their own flood modelling, providing consistency across projects.

The release of the flood level information and/or models which underly our Flood Maps would be likely to prejudice substantially the intellectual property rights of the license holders, as well as the relationship between SEPA and the license holders. While it is in the public interest for SEPA to be open and transparent, it is not in the public interest for SEPA to compromise its access to datasets that are crucial for it to fulfil its statutory duty with regards to flood risk and forecasting.

On balance, we consider that the public interest in releasing the information is outweighed by the public interest in maintaining the exception and therefore the information is withheld under Regulation 10(5)(c) of the EIRs.

Regulation 14(1)(b) – Other authority

As we do not hold the information requested, but believe that [organisation] may, Regulation 14(1)(b) of the EIRs applies , the text of which is reproduced below.

14(1) Where a Scottish public authority has received a request to make environmental information available and does not hold that information but believes that another public

authority holds the information requested then it shall (b) supply the applicant with the name and address of that other authority,

Contact details:

Freedom of Information Officer

Angus Council

Angus House

Orchardbank Business Park

Forfar

DD8 1AN

03452 777 778

informationgovernance@angus.gov.uk

www.angus.gov.uk/council_and_democracy/freedom_of_information/make_a_request_for_information_not_already_published

What to expect when making a Request for Information

Each request for information, under The Environmental Information (Scotland) Regulations 2004 or the Freedom of Information (Scotland) Act 2002, is formally logged by the authority. The request falls within a process that has two internal stages carried out by the authority; a right of appeal to the Scottish Information Commissioner followed by an appeal to the Court of Session on a point of law only.

•Stage 1 – Request for information
•Stage 2 – Formal Review
•Stage 3 – Appeal for decision by Scottish Information Commissioner (OSIC)
•Stage 4 – Appeal to the Court of Session on a point of law only.

Each enquiry will have a unique Reference Number which should be quoted when you contact us.

How you will be kept informed

You will receive an acknowledgement for your request and Formal Review. We aim to reply to all enquiries promptly, within 20 working days. You will receive a response along with the requested information and/or an explanation regarding any withheld information. We may also contact you if we require clarification or if we are issuing a fees notice.

What happens once your enquiry has been responded to?

If you are not happy with the response or have failed to receive a response, you have the right to request a Formal Review from SEPA.

Guidance on your rights and how to ask for a review is on the Scottish Information Commissioner's website; http://itspublicknowledge.info/YourRights/Askingforareview.aspx

We will ensure that all personal data is processed, recorded and retained in accordance with the requirements of the Data Protection Act 2018 throughout the handling of each request. You have a right to see information about yourself via submitting a Subject Access Request under the Data Protection Act 2018.

What to do if you are not happy with how your enquiry and review were handled

If you are unsatisfied with our Formal Review response or have failed to receive a response, you can then appeal to the Scottish Information Commissioner via the links below.

www.itspublicknowledge.info/appeal
http://www.itspublicknowledge.info/home/ContactUs/ContactUs.aspx

Should you wish to appeal against the Scottish Information Commissioner's decision, you have the right to appeal to the Court of Session on a point of law only. Any such appeal must be made within 42 days after the date of intimation of the decision.

Appendix E – Culvert Drawings and Calculations

Culvert Capacity Estimation

Method used based on standard Manning's equations

Constants Variables

Water Density, Dynamic and Kinematic Viscosity Estimates *(Based on mean water temperature)*

Temperature of water =	7.82	°C
	980.97	K

Density of Water Estimates *(The density of water calculated for the given temperature above using the Thiesen Equation)*

Constants used for water in Thiesen Equation

a^1 =	-3.983035	kg m^3
a^2 =	301.797	kg m^3
a^3 =	522528.9	kg m^3
a^4 =	69.34881	kg m^3
a^5 =	999.97495	kg m^3
Density of water at given temperature	999.862	kg m^3

$$\rho := a^5 \cdot \frac{\left(1 - \frac{(T + a^1)^2 \cdot (T + a^2)}{a^3 \cdot (T + a^4)}\right)}{} = 999.862 \text{ kg m}^{-3}$$

Dynamic Viscosity Estimates	0.001374	N s m^2
The dynamic viscosity calculated using the Vogel equation parameters		
a	-3.7188	
b	578.919	
c	-137.546	
Temperature in Kelvin	280.97	T^k

$$e^{\left(a + \frac{b}{c + T^k}\right)}$$

$$\nu := \frac{\mu}{\rho} = (1.374 \cdot 10^{-6})\ m^2\ s^{-1}$$

Kinematic Viscosity Estimates

Kinematic viscosity of water at specified temperature

Manning's Coefficient based on concrete constructed channel

Metric constant	1	
Coefficient range between 0.011 and 0.025 mean value:	0.018	s m

Peak flow estimaed for 1 in 200 year return period (Q200)	5.24	m^3 s^{-1}

Inputs

Width of box culvert	1.8	m
Depth of box culvert	1.8	m
Vertical drop along culvert	0.07	m
Length of culvert	12	m

Outputs

Total cross-sectional area of culvert	3.24	m^2
Total wetted perimeter of culvert (P^w)	7.2	m
Hydraulic radius	0.450	m
Longitudinal slope of culvert	0.006	
Mean velocity through the culvert at full capacity	2.491691305	m s^{-1}
The maximum flow that the culvert can pass:	8.073079829	m s^{-1}

Since the peak flow rate generated during a rainfall event with a specified annual probability is known the depth of water of water in the channel during the event can be estimated as follows:

Time taken to flow through the culvert:	4.8160	s
Cross-sectional area of partially full culvert:	2.102989238	m^3
Total depth of water in culvert:	1.168327355	m
Flow inertia to gravity or Froude number:	0.7359994	

Since the depth of water during a 1 in 200 year return period is less than would occur during a pipe full the reduction in frictional loss will temporarily increase the flow in the culvert. The following estimates are to determine if this increase in flow would exceed the maximum capacity of the box culvert.

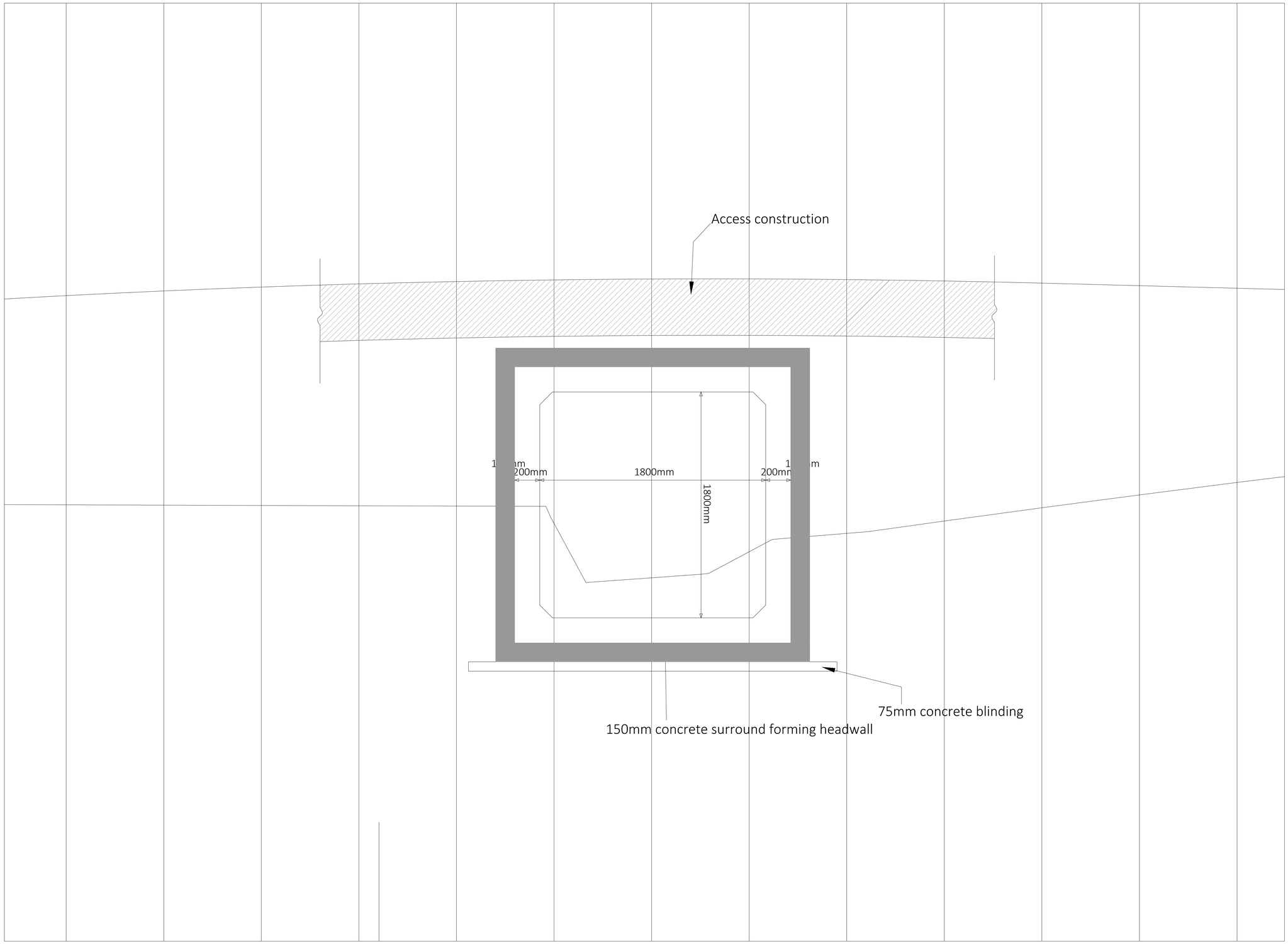
Total wetted perimeter of a partially full culvert:	4.136654709	m
Hydraulic radius of a partially full culvert:	0.508379206	m
Hydraulic diameter of a partially full culvert:	2.033516826	m
Renolds number:	3687188.473	
d'Arcy friction coefficient for turbulent flow:	0.007211295	
Mean velocity of water in partially full culvert:	5.681004842	m^3 s^{-1}
The peak flow that the partially full culvert will pass:	11.94709205	m^3 s^{-1}

Summary Written:

The maximum flow of water that the box culvert can pass in 8.073 cubic metres per second and the peak flow during a 1 in 200 year return period is only 5.24 cubic metres per second and even when partially full the peak flow will increase to 11.947 cubic metres per second temporarily due to a higher velocity caused by a decrease in the wetted perimeter. The proposed 1.8m x 1.8m box culvert would therefore be adequate.

During partually full culvert conditions the Renolds is greater than 4000 and the Froude number is greater than 1 therefore the flow will be supercritical and turbulent.

THIS IS A CAD PRODUCED DRAWING AND SHOULD NOT BE MANUALLY UPDATED



RESIDUAL RISK REGISTER

IN ADDITION TO THE HAZARDS NORMALLY ASSOCIATED WITH THE TYPES OF WORK DETAILED ON THIS DRAWING, PLEASE NOTE THE FOLLOWING :

IDENTIFIED RISK / HAZARD	DESCRIPTION	REF.
–	–	–
IDENTIFIED RISK / HAZARD	DESCRIPTION	REF.
–	–	–

IT IS ASSUMED THAT ALL WORKS WILL BE CARRIED OUT BY A COMPETENT PERSON WORKING, TO AN APPROVED SAFE SYSTEM OF WORK

STATUS

STATUS

REV	DATE	BY	CHKD	APP'D	DESCRIPTION
.	.	.	.	.	.

Arthian

CLIENT
RES Ltd

PROJECT
Bonnyknox Solar Development
Arbroath

DRAWING
Indicative Culvert Details
Proposed Crossing

DRAWING. No.
313625 R01

REV

A3

1:20-	0	200mm	400mm	600mm	800mm	1000	1200	1400
1:100-	0	1m	2m	3m	4m	5m	6m	7m
1:50-	0		1m		2m		3m	
1:5-	0		100mm		200mm		300mm	

UK Design Flood Estimation

Generated on Thursday, May 15, 2025 7:52:35 AM by mackintosh
Printed from the ReFH2 Flood Modelling software package, version 4.1.8720.30358

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

Site details Checksum: 6D47-487F

Site name: FEH_Catchment_Descriptors_357200_740400_v5_0_1

Easting: 357200

Northing: 740400

Country: Scotland

Catchment Area (km²): 8.27

Using plot scale calculations: No

Model: 2.3

Site description: None

Model run: 200 year

Summary of results

Rainfall - FEH22 (mm):	79.74	Total runoff (ML):	147.01
Total Rainfall (mm):	56.06	Total flow (ML):	463.23
Peak Rainfall (mm):	8.50	Peak flow (m³/s):	5.24

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 - FEH22)

Name	Value	User-defined?
Duration (hh:mm:ss)	08:30:00*	No
Timestep (hh:mm:ss)	00:30:00*	No
SCF (Seasonal correction factor)	0.73	No
ARF (Areal reduction factor)	0.96	No
Seasonality	Winter	No

Loss model parameters

Name	Value	User-defined?
Cini (mm)	104.22	No
Cmax (mm)	416.81	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	4.99	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.19	No
BL (hr)	42.16	No
BR	2.15	No

Urbanisation parameters

Name	Value	User-defined?
Sewer capacity (m^3/s)	0	No
Exporting drained area (km^2)	0	No
Urban area (km^2)	0	No
Effective URBEXT2000	0	n/a
Impervious runoff factor	0.7	No
Imperviousness factor	0.4	No
Tp scaling factor	0.75	No
Depression storage depth (mm)	0.5	No

Time series data

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
00:00:00	0.722	0.000	0.181	0.000	0.187	0.187
00:30:00	1.009	0.000	0.255	0.003	0.185	0.188
01:00:00	1.409	0.000	0.360	0.012	0.183	0.195
01:30:00	1.961	0.000	0.510	0.030	0.181	0.212
02:00:00	2.722	0.000	0.723	0.062	0.180	0.242
02:30:00	3.765	0.000	1.029	0.112	0.180	0.292
03:00:00	5.174	0.000	1.470	0.188	0.182	0.370
03:30:00	7.018	0.000	2.096	0.302	0.186	0.488
04:00:00	8.499	0.000	2.697	0.469	0.194	0.663
04:30:00	7.018	0.000	2.357	0.708	0.206	0.915
05:00:00	5.174	0.000	1.814	1.023	0.226	1.249
05:30:00	3.765	0.000	1.360	1.396	0.254	1.650
06:00:00	2.722	0.000	1.005	1.806	0.292	2.097
06:30:00	1.961	0.000	0.735	2.236	0.339	2.576
07:00:00	1.409	0.000	0.533	2.672	0.398	3.070
07:30:00	1.009	0.000	0.385	3.098	0.466	3.564
08:00:00	0.722	0.000	0.277	3.495	0.544	4.039
08:30:00	0.000	0.000	0.000	3.842	0.631	4.473
09:00:00	0.000	0.000	0.000	4.108	0.724	4.832
09:30:00	0.000	0.000	0.000	4.259	0.822	5.081
10:00:00	0.000	0.000	0.000	4.291	0.921	5.212
10:30:00	0.000	0.000	0.000	4.225	1.018	5.243
11:00:00	0.000	0.000	0.000	4.087	1.111	5.198
11:30:00	0.000	0.000	0.000	3.896	1.199	5.095
12:00:00	0.000	0.000	0.000	3.668	1.281	4.949
12:30:00	0.000	0.000	0.000	3.416	1.356	4.772
13:00:00	0.000	0.000	0.000	3.151	1.423	4.574
13:30:00	0.000	0.000	0.000	2.883	1.483	4.366
14:00:00	0.000	0.000	0.000	2.626	1.535	4.161
14:30:00	0.000	0.000	0.000	2.393	1.581	3.974
15:00:00	0.000	0.000	0.000	2.184	1.620	3.804
15:30:00	0.000	0.000	0.000	1.996	1.654	3.650
16:00:00	0.000	0.000	0.000	1.822	1.683	3.506
16:30:00	0.000	0.000	0.000	1.661	1.707	3.368

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
17:00:00	0.000	0.000	0.000	1.507	1.728	3.235
17:30:00	0.000	0.000	0.000	1.360	1.744	3.103
18:00:00	0.000	0.000	0.000	1.217	1.756	2.972
18:30:00	0.000	0.000	0.000	1.078	1.764	2.842
19:00:00	0.000	0.000	0.000	0.942	1.769	2.711
19:30:00	0.000	0.000	0.000	0.808	1.770	2.578
20:00:00	0.000	0.000	0.000	0.678	1.768	2.447
20:30:00	0.000	0.000	0.000	0.553	1.763	2.316
21:00:00	0.000	0.000	0.000	0.436	1.755	2.190
21:30:00	0.000	0.000	0.000	0.328	1.744	2.072
22:00:00	0.000	0.000	0.000	0.235	1.730	1.965
22:30:00	0.000	0.000	0.000	0.161	1.715	1.876
23:00:00	0.000	0.000	0.000	0.106	1.698	1.804
23:30:00	0.000	0.000	0.000	0.067	1.680	1.748
24:00:00	0.000	0.000	0.000	0.040	1.662	1.702
24:30:00	0.000	0.000	0.000	0.022	1.643	1.665
25:00:00	0.000	0.000	0.000	0.011	1.624	1.635
25:30:00	0.000	0.000	0.000	0.004	1.605	1.609
26:00:00	0.000	0.000	0.000	0.001	1.586	1.587
26:30:00	0.000	0.000	0.000	0.000	1.568	1.568
27:00:00	0.000	0.000	0.000	0.000	1.549	1.549
27:30:00	0.000	0.000	0.000	0.000	1.531	1.531
28:00:00	0.000	0.000	0.000	0.000	1.513	1.513
28:30:00	0.000	0.000	0.000	0.000	1.495	1.495
29:00:00	0.000	0.000	0.000	0.000	1.477	1.477
29:30:00	0.000	0.000	0.000	0.000	1.460	1.460
30:00:00	0.000	0.000	0.000	0.000	1.443	1.443
30:30:00	0.000	0.000	0.000	0.000	1.426	1.426
31:00:00	0.000	0.000	0.000	0.000	1.409	1.409
31:30:00	0.000	0.000	0.000	0.000	1.392	1.392
32:00:00	0.000	0.000	0.000	0.000	1.376	1.376
32:30:00	0.000	0.000	0.000	0.000	1.360	1.360
33:00:00	0.000	0.000	0.000	0.000	1.344	1.344
33:30:00	0.000	0.000	0.000	0.000	1.328	1.328
34:00:00	0.000	0.000	0.000	0.000	1.312	1.312

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
34:30:00	0.000	0.000	0.000	0.000	1.297	1.297
35:00:00	0.000	0.000	0.000	0.000	1.281	1.281
35:30:00	0.000	0.000	0.000	0.000	1.266	1.266
36:00:00	0.000	0.000	0.000	0.000	1.251	1.251
36:30:00	0.000	0.000	0.000	0.000	1.237	1.237
37:00:00	0.000	0.000	0.000	0.000	1.222	1.222
37:30:00	0.000	0.000	0.000	0.000	1.208	1.208
38:00:00	0.000	0.000	0.000	0.000	1.193	1.193
38:30:00	0.000	0.000	0.000	0.000	1.179	1.179
39:00:00	0.000	0.000	0.000	0.000	1.165	1.165
39:30:00	0.000	0.000	0.000	0.000	1.152	1.152
40:00:00	0.000	0.000	0.000	0.000	1.138	1.138
40:30:00	0.000	0.000	0.000	0.000	1.125	1.125
41:00:00	0.000	0.000	0.000	0.000	1.111	1.111
41:30:00	0.000	0.000	0.000	0.000	1.098	1.098
42:00:00	0.000	0.000	0.000	0.000	1.085	1.085
42:30:00	0.000	0.000	0.000	0.000	1.072	1.072
43:00:00	0.000	0.000	0.000	0.000	1.060	1.060
43:30:00	0.000	0.000	0.000	0.000	1.047	1.047
44:00:00	0.000	0.000	0.000	0.000	1.035	1.035
44:30:00	0.000	0.000	0.000	0.000	1.023	1.023
45:00:00	0.000	0.000	0.000	0.000	1.011	1.011
45:30:00	0.000	0.000	0.000	0.000	0.999	0.999
46:00:00	0.000	0.000	0.000	0.000	0.987	0.987
46:30:00	0.000	0.000	0.000	0.000	0.975	0.975
47:00:00	0.000	0.000	0.000	0.000	0.964	0.964
47:30:00	0.000	0.000	0.000	0.000	0.953	0.953
48:00:00	0.000	0.000	0.000	0.000	0.941	0.941
48:30:00	0.000	0.000	0.000	0.000	0.930	0.930
49:00:00	0.000	0.000	0.000	0.000	0.919	0.919
49:30:00	0.000	0.000	0.000	0.000	0.908	0.908
50:00:00	0.000	0.000	0.000	0.000	0.898	0.898
50:30:00	0.000	0.000	0.000	0.000	0.887	0.887
51:00:00	0.000	0.000	0.000	0.000	0.877	0.877
51:30:00	0.000	0.000	0.000	0.000	0.866	0.866

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
52:00:00	0.000	0.000	0.000	0.000	0.856	0.856
52:30:00	0.000	0.000	0.000	0.000	0.846	0.846
53:00:00	0.000	0.000	0.000	0.000	0.836	0.836
53:30:00	0.000	0.000	0.000	0.000	0.826	0.826
54:00:00	0.000	0.000	0.000	0.000	0.816	0.816
54:30:00	0.000	0.000	0.000	0.000	0.807	0.807
55:00:00	0.000	0.000	0.000	0.000	0.797	0.797
55:30:00	0.000	0.000	0.000	0.000	0.788	0.788
56:00:00	0.000	0.000	0.000	0.000	0.779	0.779
56:30:00	0.000	0.000	0.000	0.000	0.769	0.769
57:00:00	0.000	0.000	0.000	0.000	0.760	0.760
57:30:00	0.000	0.000	0.000	0.000	0.751	0.751
58:00:00	0.000	0.000	0.000	0.000	0.743	0.743
58:30:00	0.000	0.000	0.000	0.000	0.734	0.734
59:00:00	0.000	0.000	0.000	0.000	0.725	0.725
59:30:00	0.000	0.000	0.000	0.000	0.717	0.717
60:00:00	0.000	0.000	0.000	0.000	0.708	0.708
60:30:00	0.000	0.000	0.000	0.000	0.700	0.700
61:00:00	0.000	0.000	0.000	0.000	0.692	0.692
61:30:00	0.000	0.000	0.000	0.000	0.683	0.683
62:00:00	0.000	0.000	0.000	0.000	0.675	0.675
62:30:00	0.000	0.000	0.000	0.000	0.667	0.667
63:00:00	0.000	0.000	0.000	0.000	0.659	0.659
63:30:00	0.000	0.000	0.000	0.000	0.652	0.652
64:00:00	0.000	0.000	0.000	0.000	0.644	0.644
64:30:00	0.000	0.000	0.000	0.000	0.636	0.636
65:00:00	0.000	0.000	0.000	0.000	0.629	0.629
65:30:00	0.000	0.000	0.000	0.000	0.622	0.622
66:00:00	0.000	0.000	0.000	0.000	0.614	0.614
66:30:00	0.000	0.000	0.000	0.000	0.607	0.607
67:00:00	0.000	0.000	0.000	0.000	0.600	0.600
67:30:00	0.000	0.000	0.000	0.000	0.593	0.593
68:00:00	0.000	0.000	0.000	0.000	0.586	0.586
68:30:00	0.000	0.000	0.000	0.000	0.579	0.579
69:00:00	0.000	0.000	0.000	0.000	0.572	0.572

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
69:30:00	0.000	0.000	0.000	0.000	0.565	0.565
70:00:00	0.000	0.000	0.000	0.000	0.559	0.559
70:30:00	0.000	0.000	0.000	0.000	0.552	0.552
71:00:00	0.000	0.000	0.000	0.000	0.545	0.545
71:30:00	0.000	0.000	0.000	0.000	0.539	0.539
72:00:00	0.000	0.000	0.000	0.000	0.533	0.533
72:30:00	0.000	0.000	0.000	0.000	0.526	0.526
73:00:00	0.000	0.000	0.000	0.000	0.520	0.520
73:30:00	0.000	0.000	0.000	0.000	0.514	0.514
74:00:00	0.000	0.000	0.000	0.000	0.508	0.508
74:30:00	0.000	0.000	0.000	0.000	0.502	0.502
75:00:00	0.000	0.000	0.000	0.000	0.496	0.496
75:30:00	0.000	0.000	0.000	0.000	0.490	0.490
76:00:00	0.000	0.000	0.000	0.000	0.484	0.484
76:30:00	0.000	0.000	0.000	0.000	0.479	0.479
77:00:00	0.000	0.000	0.000	0.000	0.473	0.473
77:30:00	0.000	0.000	0.000	0.000	0.468	0.468
78:00:00	0.000	0.000	0.000	0.000	0.462	0.462
78:30:00	0.000	0.000	0.000	0.000	0.457	0.457
79:00:00	0.000	0.000	0.000	0.000	0.451	0.451
79:30:00	0.000	0.000	0.000	0.000	0.446	0.446
80:00:00	0.000	0.000	0.000	0.000	0.441	0.441
80:30:00	0.000	0.000	0.000	0.000	0.435	0.435
81:00:00	0.000	0.000	0.000	0.000	0.430	0.430
81:30:00	0.000	0.000	0.000	0.000	0.425	0.425
82:00:00	0.000	0.000	0.000	0.000	0.420	0.420
82:30:00	0.000	0.000	0.000	0.000	0.415	0.415
83:00:00	0.000	0.000	0.000	0.000	0.410	0.410
83:30:00	0.000	0.000	0.000	0.000	0.406	0.406
84:00:00	0.000	0.000	0.000	0.000	0.401	0.401
84:30:00	0.000	0.000	0.000	0.000	0.396	0.396
85:00:00	0.000	0.000	0.000	0.000	0.391	0.391
85:30:00	0.000	0.000	0.000	0.000	0.387	0.387
86:00:00	0.000	0.000	0.000	0.000	0.382	0.382
86:30:00	0.000	0.000	0.000	0.000	0.378	0.378

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
87:00:00	0.000	0.000	0.000	0.000	0.373	0.373
87:30:00	0.000	0.000	0.000	0.000	0.369	0.369
88:00:00	0.000	0.000	0.000	0.000	0.364	0.364
88:30:00	0.000	0.000	0.000	0.000	0.360	0.360
89:00:00	0.000	0.000	0.000	0.000	0.356	0.356
89:30:00	0.000	0.000	0.000	0.000	0.352	0.352
90:00:00	0.000	0.000	0.000	0.000	0.348	0.348
90:30:00	0.000	0.000	0.000	0.000	0.343	0.343
91:00:00	0.000	0.000	0.000	0.000	0.339	0.339
91:30:00	0.000	0.000	0.000	0.000	0.335	0.335
92:00:00	0.000	0.000	0.000	0.000	0.331	0.331
92:30:00	0.000	0.000	0.000	0.000	0.328	0.328
93:00:00	0.000	0.000	0.000	0.000	0.324	0.324
93:30:00	0.000	0.000	0.000	0.000	0.320	0.320
94:00:00	0.000	0.000	0.000	0.000	0.316	0.316
94:30:00	0.000	0.000	0.000	0.000	0.312	0.312
95:00:00	0.000	0.000	0.000	0.000	0.309	0.309
95:30:00	0.000	0.000	0.000	0.000	0.305	0.305
96:00:00	0.000	0.000	0.000	0.000	0.301	0.301
96:30:00	0.000	0.000	0.000	0.000	0.298	0.298
97:00:00	0.000	0.000	0.000	0.000	0.294	0.294
97:30:00	0.000	0.000	0.000	0.000	0.291	0.291
98:00:00	0.000	0.000	0.000	0.000	0.288	0.288
98:30:00	0.000	0.000	0.000	0.000	0.284	0.284
99:00:00	0.000	0.000	0.000	0.000	0.281	0.281
99:30:00	0.000	0.000	0.000	0.000	0.277	0.277
100:00:00	0.000	0.000	0.000	0.000	0.274	0.274
100:30:00	0.000	0.000	0.000	0.000	0.271	0.271
101:00:00	0.000	0.000	0.000	0.000	0.268	0.268
101:30:00	0.000	0.000	0.000	0.000	0.265	0.265
102:00:00	0.000	0.000	0.000	0.000	0.261	0.261
102:30:00	0.000	0.000	0.000	0.000	0.258	0.258
103:00:00	0.000	0.000	0.000	0.000	0.255	0.255
103:30:00	0.000	0.000	0.000	0.000	0.252	0.252
104:00:00	0.000	0.000	0.000	0.000	0.249	0.249

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
104:30:00	0.000	0.000	0.000	0.000	0.246	0.246
105:00:00	0.000	0.000	0.000	0.000	0.244	0.244
105:30:00	0.000	0.000	0.000	0.000	0.241	0.241
106:00:00	0.000	0.000	0.000	0.000	0.238	0.238
106:30:00	0.000	0.000	0.000	0.000	0.235	0.235
107:00:00	0.000	0.000	0.000	0.000	0.232	0.232
107:30:00	0.000	0.000	0.000	0.000	0.229	0.229
108:00:00	0.000	0.000	0.000	0.000	0.227	0.227
108:30:00	0.000	0.000	0.000	0.000	0.224	0.224
109:00:00	0.000	0.000	0.000	0.000	0.221	0.221
109:30:00	0.000	0.000	0.000	0.000	0.219	0.219
110:00:00	0.000	0.000	0.000	0.000	0.216	0.216
110:30:00	0.000	0.000	0.000	0.000	0.214	0.214
111:00:00	0.000	0.000	0.000	0.000	0.211	0.211
111:30:00	0.000	0.000	0.000	0.000	0.209	0.209
112:00:00	0.000	0.000	0.000	0.000	0.206	0.206
112:30:00	0.000	0.000	0.000	0.000	0.204	0.204
113:00:00	0.000	0.000	0.000	0.000	0.201	0.201
113:30:00	0.000	0.000	0.000	0.000	0.199	0.199
114:00:00	0.000	0.000	0.000	0.000	0.197	0.197
114:30:00	0.000	0.000	0.000	0.000	0.194	0.194
115:00:00	0.000	0.000	0.000	0.000	0.192	0.192
115:30:00	0.000	0.000	0.000	0.000	0.190	0.190

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km²)	8.27	No
ALTBAR	133	No
ASPBAR	108	No
ASPVAR	0.59	No
BFIHOST	0.56	No
BFIHOST19	0.49	No
DPLBAR (km)	3.19	No
DPSBAR (mkm-¹)	28.1	No
FARL	1	No
LDP	6.52	No
PROPWET	0.36	No
RMED1H	8.3	No
RMED1D	37.7	No
RMED2D	48	No
SAAR (mm)	783	No
SAAR4170 (mm)	828	No
SPRHOST	44.42	No
URBEXT2000	0	No
URBEXT1990	0	No
URBCONC	0	No
URBLOC	0	No
DDF parameter C	-0.01	No
DDF parameter D1	0.48	No
DDF parameter D2	0.41	No
DDF parameter D3	0.25	No
DDF parameter E	0.25	No
DDF parameter F	2.2	No
DDF parameter C (1km grid value)	-0.02	No
DDF parameter D1 (1km grid value)	0.48	No
DDF parameter D2 (1km grid value)	0.41	No
DDF parameter D3 (1km grid value)	0.25	No
DDF parameter E (1km grid value)	0.25	No
DDF parameter F (1km grid value)	2.19	No

Appendix F – Maintenance Schedule

Pervious Pavements Maintenance Schedule

Maintenance Schedule	Required Action	Typical Frequency
Regular Maintenance	Brushing and vacuuming (standard cosmetic sweep over whole surface)	Once a year, after autumn leaf fall, or reduced frequency as required, based on site-specific observations of clogging or manufacturer's recommendations – pay particular attention to areas where water runs onto pervious surface from adjacent impermeable areas as this area is most likely to collect the most sediment
Occasional Maintenance	Stabilise and mow contributing and adjacent areas	As required
	Removal of weeds or management using glyphospate applied directly into the weeds by an applicator rather than spraying	As required - once per year on less frequently used pavements
Remedial Actions	Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50 mm of the level of the paving	As required
	Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance or a hazard to users, and replace lost jointing material	As required
	Rehabilitation of surface and upper substructure by remedial sweeping	Every 10 to 15 years or as required (if infiltration performance is reduced due to significant clogging)
Monitoring	Initial inspection	Monthly for three months after installation
	Inspect for evidence of poor operation and/or weed growth - if required, take remedial action	Three-monthly, 48 h after large storms in first six months
	Inspect silt accumulation rates and establish appropriate brushing frequencies	Annually
	Monitor inspection chambers	Annually

Table extract taken from the CIRIA C753 publication 'The SuDS Manual' – Table 20.15