Jordan Electrics Limited

Proposed Development at Longbar Avenue, Beith

Flood Risk Assessment

FINAL

October 2019

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SEPA Checklist

Flood Risk Assessment (FRA) Checklist

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

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

Development Proposal Summary					
Site Name:		Longbar Ave, Beith			
Grid Reference:	Easting:	232997	Northing:	652633	
Local Authority:		North Ayrshire Council			
Planning Reference number (if known):					
Nature of the development:		Recreational	If residential, state type:		
Size of the development site:		3	Ha		
Identified Flood Risk:	Source:	Fluvial	Source name:	Burn 1	
Land Use Planning					
Is any of the site within the functional floodplain? (refer to SPP para 255)		Yes	If yes, what is the net loss of storage?		m³
Is the site identified within the local development plan?		No	Local Development Plan Name:	Edinburgh Local Development Plan	Year of Publication: 2016
			Allocation Number / Reference:		
If yes, what is the proposed use for the site as identified in the local plan?		Select from List	If Other please specify:		
Does the local development plan and/or any pre-application advice, identify any flood risk issues with or requirements for the site.		Select from List	If so, please specify:		
What is the proposed land use vulnerability?		Highly Vulnerable	Do the proposals represent an increase in land use vulnerability?	No	
Supporting Information					
Have clear maps / plans been provided within the FRA (including topographic and flood inundation plans)?		Yes			
Has sufficient supporting information, in line with our Technical Guidance, been provided? For example: site plans, photos, topographic information, structure information and other site specific information.		Yes			
Has a historic flood search been undertaken?		Yes	If flood records in vicinity of the site please provide details:		
Is a formal flood prevention scheme present?		No	If known, state the standard of protection offered:		
Current / historical site use:		Farmland			
Is the site considered vacant or derelict?		No			
Development Requirements					
Freeboard on design water level:		See Report	m		
Is safe / dry access and egress available?		Vehicular and Pedestrian	Min access/egress level:		m AOD
Design levels:	Ground level:	See Report	m AOD	Min FFL:	mAOD
Mitigation					
Can development be designed to avoid all areas at risk of flooding?		Yes			
Is mitigation proposed?		Yes			
If yes, is compenstory storage necessary?		No			
Demonstration of compensatory storage on a "like for like" basis?		Select from List			
Should water resistant materials and forms of construction be used?		Select from List			

Flood Risk Assessment (FRA) Checklist

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

Hydrology

Is there a requirement to consider fluvial flooding?	Yes			
Area of catchment:	91.8 km²		Is a map of catchment area included in FRA?	Yes
Estimation method(s) used (please select all that apply):	Pooled Analysis; Single Site Analysis; Enhanced Single Site; ReFH2; FEH RRM; Other	[redacted]	If Pooled analysis have group details been included?	Yes
			If other (please specify methodology used):	
Estimate of 200 year design flood flow:	24.3 m^3/s			
Qmed estimate:	m^3/s		Method:	Select from List
Statistical Distribution Selected:	Generalised Logistic		Reasons for selection:	

Hydraulics

Hydraulic modelling method:	2D		Software used:	Flood Modeller
			If other please specify:	And Mannings calc
Number of cross sections:	85			
Source of data (i.e. topographic survey, LiDAR etc):	LiDAR		Date obtained / surveyed:	
Modelled reach length:	>1000 m			
Any changes to default simulation parameters?	no		If yes please provide details:	
Model timestep:	0.5			
Model grid size:	2			
Any structures within the modelled length?	Bridges		Specify, if combination:	100% blocked
Maximum observed velocity:	m/s			
Brief summary of sensitivity tests, and range:				
variation on flow (%)	55 %		Please specify climate change scenario considered:	
variation on channel roughness (%)	20 %			
blockage of structure (range of % blocked)	100 %			
boundary conditions:	Upstream		Downstream	
(1) type	Flow		Normal depth	
Specify if other			Specify if other:	
(2) does it influence water levels at the site?	Yes		No	
Has model been calibrated (gauge data / flood records)?	No			
Is the hydraulic model available to SEPA?	No			
Design flood levels: 200 year	2d m AOD		200 year plus climate change	See Report m AOD
Cross section results provided?	No			
Long section results provided?	No			
Cross section ratings provided?	No			
Tabular output provided (i.e. levels, velocities)?				
Mass balance error:	1 %			

Coastal

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

Comments

Any additional comments:	Read report. An Overland Flow Pathway will be necessary incase of blockage of Culvert 2.

Approved by:	Michael Stewart
Organisation:	Kaya Consulting
Date:	07.10.2019

Note: Further details and guidance is provided in 'Technical Flood Risk Guidance for Stakeholders' which can be accesssed here:- CLICK HERE

1 Introduction

Kaya Consulting Limited was commissioned by Jordan Electrics Limited, through JNP Group Consulting Engineers Glasgow Ltd, to undertake a Flood Risk Assessment in support of a development at Longbar Avenue, Beith in North Ayrshire.

The site is greenfield farmland, situated off Beith Road. The site is bounded to the north by existing residential development on Longshot Road; to the east by Caledonian Road and other industrial property and farmland; to the south by Auchengree Road and a small number of cottages; and to the west by Beith Road and some further greenfield land and cottages. Proposals are for a residential development.

The Powgree Burn flows in a westerly direction to the south and west of the site, to the south of Auchengree Road and Beith Road. Two further burns flow through and close to the site. A study is required to assess the risk of flooding from all sources, including the watercourses, surface water, groundwater and existing infrastructure.

The scope of work includes the following:

- Site visit to identify the site and surrounding features;
- Review of historical maps and available historical flood records;
- Assess flood risk from watercourses based on local topography;
- Assess risk from surface water runoff from adjacent land;
- Recommendations for Finished Floor Levels;
- Assess the risk of flooding from groundwater;
- Assess the risk to site access; and
- Prepare flood risk assessment report suitable for submission with planning application.

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

- Site location map;
- Indicative proposed development layout; and
- A Flood Risk Assessment undertaken by a third party in 2013.

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

Figure 1: General Location of the Site.

Reproduced by permission of Ordnance Survey on behalf of The Controller of Her Majesty's Stationery Office.

2 Legislative and Policy Aspects

2.1 National Planning Policy

The current version of the Scottish Planning Policy (SPP) was published in June 2014 and replaces the previous version which was published in February 2010. The SPP sets out national planning policies which reflect Scottish Government's priorities for operation of the planning system and for the development and use of land. It relates to:

- the preparation of development plans;
- the design of development, from initial concept through to delivery; and
- the determination of planning applications and appeals.

The National Planning Framework (NPF3) provides a statutory framework for Scotland's long term spatial development and sets out the Scottish Government's spatial development priorities for the next 20 to 30 years. The SPP sets out the policy that will help to deliver the objectives of the NPF3.

Relevant extracts from the SPP concerning flood risk are listed below:

Policy Principles

255. The planning system should promote:

- *a precautionary approach to flood risk from all sources, including coastal, water course (fluvial), surface water (pluvial), groundwater, reservoirs and drainage systems (sewers and culverts), taking account of the predicted effects of climate change;*
- *flood avoidance: by safeguarding flood storage and conveying capacity, and locating development away from functional flood plains and medium to high risk areas;*
- *flood reduction: assessing flood risk and, where appropriate, undertaking natural and structural flood management measures, including flood protection, restoring natural features and characteristics, enhancing flood storage capacity, avoiding the construction of new culverts and opening existing culverts where possible; and*
- *avoidance of increased surface water flooding through requirements for Sustainable Drainage Systems (SuDS) and minimising the area of impermeable surface.*

256. To achieve this, the planning system should prevent development which would have a significant probability of being affected by flooding or would increase the probability of flooding elsewhere. Piecemeal reduction of the functional floodplain should be avoided given the cumulative effects of reducing storage capacity.

257. Alterations and small-scale extensions to existing buildings are outwith the scope of this policy, provided that they would not have a significant effect on the storage capacity of the functional floodplain or local flooding problems.

Key Documents

- *Flood Risk Management (Scotland) Act 2009.*
- *Updated Planning Advice Note on Flooding.*
- *Delivering Sustainable Flood Risk Management (Scottish Government, 2011).*
- *Surface Water Management Planning Guidance (Scottish Government, 2013).*

Delivery

258. Planning authorities should have regard to the probability of flooding from all sources and take flood risk into account when preparing development plans and determining planning applications. The calculated probability of flooding should be regarded as a best estimate and not a precise forecast. Authorities should avoid giving any indication that a grant of planning permission implies the absence of flood risk.

259. Developers should take into account flood risk and the ability of future occupiers to insure development before committing themselves to a site or project, as applicants and occupiers have ultimate responsibility for safeguarding their property.

Development Planning

260. Plans should use strategic flood risk assessment (SFRA) to inform choices about the location of development and policies for flood risk management. They should have regard to the flood maps prepared by Scottish Environment Protection Agency (SEPA), and take account of finalised and approved Flood Risk Management Strategies and Plans and River Basin Management Plans.

261. Strategic and local development plans should address any significant cross boundary flooding issues. This may include identifying major areas of the flood plain and storage capacity which should be protected from inappropriate development, major flood protection scheme requirements or proposals, and relevant drainage capacity issues.

262. Local development plans should protect land with the potential to contribute to managing flood risk, for instance through natural flood management, managed coastal realignment, washland or green infrastructure creation, or as part of a scheme to manage flood risk.

263. Local development plans should use the following flood risk framework to guide development. This sets out three categories of coastal and watercourse flood risk, together with guidance on surface water flooding, and the appropriate planning approach for each (the annual probabilities referred to in the framework relate to the land at the time a plan is being prepared or a planning application is made):

- ***Little or No Risk*** *– annual probability of coastal or watercourse flooding is less than 0.1% (1:1000 years)*
  - *No constraints due to coastal or watercourse flooding.*
- ***Low to Medium Risk*** *– annual probability of coastal or watercourse flooding is between 0.1% and 0.5% (1:1000 to 1:200 years)*
  - *Suitable for most development. A flood risk assessment may be required at the upper end of the probability range (i.e. close to 0.5%), and for essential infrastructure and the most vulnerable uses. Water resistant materials and construction may be required.*
  - *Generally, not suitable for civil infrastructure. Where civil infrastructure must be located in these areas or is being substantially extended, it should be designed to be capable of remaining operational and accessible during extreme flood events.*
- ***Medium to High Risk*** *– annual probability of coastal or watercourse flooding is greater than 0.5% (1:200 years)*
  - *May be suitable for:*
    - *residential, institutional, commercial and industrial development within built-up areas provided flood protection measures to the appropriate standard already exist and are maintained, are under construction, or are a planned measure in a current flood risk management plan;*
    - *essential infrastructure within built-up areas, designed and constructed to remain operational during floods and not impede water flow;*

    - *some recreational, sport, amenity and nature conservation uses, provided appropriate evacuation procedures are in place; and*
    - *job-related accommodation, e.g. for caretakers or operational staff.*
  - *Generally not suitable for:*
    - *civil infrastructure and the most vulnerable uses;*
    - *additional development in undeveloped and sparsely developed areas, unless a location is essential for operational reasons, e.g. for navigation and water-based recreation, agriculture, transport or utilities infrastructure (which should be designed and constructed to be operational during floods and not impede water flow), and an alternative, lower risk location is not available; and*
    - *new caravan and camping sites.*
  - *Where built development is permitted, measures to protect against or manage flood risk will be required and any loss of flood storage capacity mitigated to achieve a neutral or better outcome.*
  - *Water-resistant materials and construction should be used where appropriate. Elevated buildings on structures such as stilts are unlikely to be acceptable.*

Surface Water Flooding

- *Infrastructure and buildings should generally be designed to be free from surface water flooding in rainfall events where the annual probability of occurrence is greater than 0.5% (1:200 years).*
- *Surface water drainage measures should have a neutral or better effect on the risk of flooding both on and off the site, taking account of rain falling on the site and run-off from adjacent areas.*

Development Management

264. It is not possible to plan for development solely according to the calculated probability of flooding. In applying the risk framework to proposed development, the following should therefore be taken into account:

- *the characteristics of the site;*
- *the design and use of the proposed development;*
- *the size of the area likely to flood;*
- *depth of flood water, likely flow rate and path, and rate of rise and duration;*
- *the vulnerability and risk of wave action for coastal sites;*
- *committed and existing flood protection methods: extent, standard and maintenance regime;*
- *the effects of climate change, including an allowance for freeboard;*
- *surface water run-off from adjoining land;*
- *culverted watercourses, drains and field drainage;*
- *cumulative effects, especially the loss of storage capacity;*
- *cross-boundary effects and the need for consultation with adjacent authorities;*
- *effects of flood on access including by emergency services; and*
- *effects of flood on proposed open spaces including gardens.*

265. Land raising should only be considered in exceptional circumstances, where it is shown to have a neutral or better impact on flood risk outside the raised area. Compensatory storage may be required.

266. The flood risk framework set out above should be applied to development management decisions. Flood Risk Assessments (FRA) should be required for development in the medium to high category of flood risk, and may be required in the low to medium category in the circumstances described in the framework above, or where other factors indicate heightened risk. FRA will generally be required for applications within areas identified at high or medium likelihood of flooding/flood risk in SEPA's flood maps.

267. Drainage Assessments, proportionate to the development proposal and covering both surface and foul water, will be required for areas where drainage is already constrained or otherwise problematic, or if there would be off-site effects.

268. Proposed arrangements for SuDS should be adequate for the development and appropriate long-term maintenance arrangements should be put in place.

2.2 SEPA Flood Maps

The SEPA flood maps show the likely extent of flooding for high, medium and low likelihood for fluvial, flows.

Consultation of the maps suggests the site is not at risk of flooding from the Powgee Burn. However, flooding from surface water (pluvial) sources is identified close to the western site corner. SEPA flood maps are indicative. A more detailed study is required to assess the risk of flooding from all sources.

2.3 SEPA Technical Flood Risk Guidance

The latest version of SEPA 'Technical Flood Risk Guidance for Stakeholders' would need to be consulted when undertaking flood risk assessments (Current version is 12, May 2019). This technical guidance document is intended to outline methodologies that may be appropriate for hydrological and hydraulic modelling and sets out what information SEPA requires to be submitted as part of a Flood Risk Assessment.

SEPA Policy 41 sets out roles and responsibilities of SEPA and Planning Authorities.

2.4 SEPA Flood Risk and Land Use Vulnerability Guidance

The Version 2 of the guidance (2017) states that:

"*The purpose of this guidance is to:*

- *aid understanding of the relative vulnerability to flooding of different land uses;*
- *assist in the interpretation of SEPA's Flood Risk Planning Guidance, which is based upon the risk framework.*

SEPA has created this guidance to assist in our assessment of the vulnerability to flooding of different types of land use. Table 1 classifies the relative vulnerability of land uses, grouping them into five categories from Most Vulnerable through to Water Compatible Uses.

The classification comprises five categories: 1. Most Vulnerable Uses; 2. Highly Vulnerable Uses; 3. Least Vulnerable Uses ; 4. Essential Infrastructure; 5. Water Compatible Uses.

The classification (Table 1) is linked to the risk framework in SPP by a matrix of flood risk (Table 2). Table 2 gives a very brief outline of SEPA's likely planning response for each of the three flood risk categories of the risk framework relative to each of the five vulnerability categories.

In producing this guidance, SEPA has sought to refine and enhance the vulnerability classification and definitions identified in the SPP risk framework.

Table 1: SEPA Land Use Vulnerability Classification[1]

1. Most Vulnerable Uses	2. Highly Vulnerable Uses	3. Least Vulnerable Uses	4. Essential Infrastructure	5. Water Compatible Uses[3]
For the purpose of this guidance, **Most Vulnerable Uses** include land uses that are defined as both ***civil infrastructure*** and ***most vulnerable*** in the SPP 2014 glossary. Civil infrastructure is denoted with an asterisk (*) in the list below. Most Vulnerable Uses therefore comprise: • police stations* • ambulance stations* • fire stations* • command centres and telecommunications installations required to be operational during flooding* • emergency dispersal points* • hospitals* • residential institutions such as residential care homes/ prisons, nurseries, children's homes and educational establishments* • basement dwellings • single dwelling houses in remote rural locations • dwelling houses situated behind informal embankments[2] • caravans, mobile homes, chalets and park homes intended for permanent residential use • holiday caravan and camping sites • installations requiring hazardous substance consent (but where there is demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or with energy infrastructure, that require a coastal or water-side location, or other high flood risk areas, then the facilities should be classified as **Essential Infrastructure – see column 4).**	Comprise: • buildings used for dwelling houses • social services homes (ambulant /adult) • hostels and hotels • student halls of residence • non-residential uses for health service • landfill and sites used for waste management facilities for hazardous waste	Comprise: • shops • financial, professional, and other services • restaurants and cafés • hot-food takeaways • drinking establishments • nightclubs • offices • general industry • storage and distribution • non-residential institutions not included in Most Vulnerable or Highly Vulnerable Uses • assembly and leisure • land and buildings used for agriculture and forestry that are subject to planning control • waste treatment (except landfill and hazardous waste facilities) • minerals working and processing (except for sand and gravel)	Comprises: • essential transport infrastructure (including mass evacuation routes) that has to cross the area at risk • essential utility infrastructure that has to be located in a flood risk area for operational reasons (this includes electricity generating power stations and grid and primary sub-stations, sewage treatment plants and water treatment works, wind turbines and other energy generating technologies) • installations requiring hazardous substance consent only where there is demonstrable need to locate such installations for the bulk storage of materials with port or other similar facilities, or with energy infrastructure that requires a coastal, water-side, or other high flood risk area location.	Comprise: • flood control infrastructure • water transmission infrastructure and pumping stations • sewage transmission infrastructure and pumping stations • sand and gravel workings • docks, marinas and wharves • navigation facilities • MOD defence installations • ship building, repairing, and dismantling • dockside fish processing and refrigeration and compatible activities requiring a waterside location • water-based recreation (excluding sleeping accommodation) • lifeguard and coastguard stations • amenity open space • nature conservation and biodiversity • outdoor sports and recreation and essential facilities such as changing rooms • essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific operational warning[4] and evacuation plan.

[1] Developments that combine a mixture of uses should be placed in the higher of the relevant classes of flood risk vulnerability. The impact of a flood on the particular land use could vary within each vulnerability class. In particular, a change of use to a dwelling house within the 'Highly Vulnerable' category could significantly increase the overall flood risk, especially in relation to human health and financial impacts. Any proposal for a change of use to a dwelling house should therefore be supported by a flood risk assessment. The redevelopment (including change of use) of an existing building or site provides a valuable opportunity to reduce the vulnerability of that site to flooding and therefore to reduce overall flood risk. This can be achieved through changes to less vulnerable land uses and improvements to the management of flood risk on the site.

[2] Embankments not formally constituted under flood prevention legislation including agricultural flood embankments constructed under permitted development rights.

[3] Advice in the SPP risk framework on these activities is limited. The nature of the above activities necessitates locations that are prone to flooding. Generally, it is difficult to recommend a specific annual return period to guide development decisions for such uses. SEPA would recommend that the risk of flooding should be assessed giving particular consideration to:

Table 2: SEPA Matrix of Flood Risk (to be read in conjunction with our Flood Risk Planning Guidance)

Classification / Flood Risk	**Most Vulnerable Uses**	**Highly Vulnerable Uses**	**Least Vulnerable Uses**	**Essential Infrastructure**	**Water Compatible Uses**
Little or no risk (<0.1% AP)	No constraints	No constraints	No constraints	No constraints	No constraints
Low to medium risk (0.1% - 0.5% AP)	Generally not suitable for Civil Infrastructure: where Civil Infrastructure must be located in these areas, or is being substantially extended, it should be designed to be capable of remaining operational and accessible during extreme flood events (i.e. 0.1% AP). Generally not suitable for other Most Vulnerable Uses unless site-specific factors suggest a more favourable approach should be taken, or where one of the following apply: • Redevelopment of an existing building, including changes of use to an equal or less vulnerable use to the existing use. • Redevelopment of a previously developed site where it involves the demolition of existing buildings and/or erection of additional buildings within a development site, and the proposed land use is equal or less vulnerable than the existing land use. • Where the principle of development on the site has been established in an up-to-date, adopted development plan or the National Planning Framework and flood risk issues were given due consideration as part of the plan preparation process and our assessment of risk has not changed in the interim.	Generally suitable for development though an FRA may be required at upper end of the probability range (i.e. close to 0.5% AP).	Generally suitable for development though an FRA may be required at upper end of the probability range (i.e. close to 0.5% AP).	Generally suitable for development.	Generally suitable for development.
Medium to high risk within built up area (>0.5% AP)	Generally not suitable for development unless one of the following apply: • Redevelopment of an existing building, including changes of use to an equal or less vulnerable use to the existing use. • Redevelopment of a previously developed site where it involves the demolition of existing buildings and/or erection of additional buildings within a development site, and the proposed land use is equal or less vulnerable than the existing land use. • Where the principle of development on the site has been established in an up-to-date, adopted development plan or the National Planning Framework and flood risk issues were given due consideration as part of the plan preparation process and our assessment of risk has not changed in the interim.	Generally not suitable for development unless one of the following apply: • Redevelopment of an existing building, including changes of use to an equal or less vulnerable use to the existing use. • Redevelopment of a previously developed site where it involves the demolition of existing buildings and/or erection of additional buildings within a development site, and the proposed land use is equal or less vulnerable than the existing land use. • Where the principle of development on the site has been established in an up-to-date, adopted development plan or the National Planning Framework and flood risk issues were given due consideration as part of the plan preparation process and our assessment of risk has not changed in the interim. • The site is protected by a flood protection scheme of the appropriate standard that is already in existence and maintained, is under construction, or is planned for in a current flood risk management plan.	Generally not suitable for development unless one of the following apply: • Redevelopment of an existing building, including changes of use to an equal or less vulnerable use to the existing use. • Redevelopment of a previously developed site where it involves the demolition of existing buildings and/or erection of additional buildings within a development site, and the proposed land use is equal or less vulnerable than the existing land use. • Where the principle of development on the site has been established in an up-to-date, adopted development plan or the National Planning Framework and flood risk issues were given due consideration as part of the plan preparation process and our assessment of risk has not changed in the interim. • The site is protected by a flood protection scheme of the appropriate standard that is already in existence and maintained, is under construction, or is planned for in a current flood risk management plan.	Suitable for essential infrastructure, designed and constructed to remain operational during floods (i.e. 0.5% AP), and not impede water flow.	Generally suitable for development - job related accommodation and some recreational, sport, amenity and nature conservation uses are only suitable provided that appropriate evacuation procedures are in place

Medium to high risk within undeveloped and sparsely developed area (>0.5% AP)	Generally not suitable for development unless one of the following apply: • Redevelopment of an existing building, including changes of use to an equal or less vulnerable use to the existing use. • Redevelopment of a previously developed site where it involves the demolition of existing buildings and/or erection of additional buildings within a development site, and the proposed land use is equal or less vulnerable than the existing land use. • Where the principle of development on the site has been established in an up-to-date, adopted development plan or the National Planning Framework and flood risk issues were given due consideration as part of the plan preparation process and our assessment of risk has not changed in the interim.	Generally not suitable for development unless one of the following apply: • Redevelopment of an existing building, including changes of use to an equal or less vulnerable use to the existing use. • Redevelopment of a previously developed site where it involves the demolition of existing buildings and/or erection of additional buildings within a development site, and the proposed land use is equal or less vulnerable than the existing land use. • Where the principle of development on the site has been established in an up-to-date, adopted development plan or the National Planning Framework and flood risk issues were given due consideration as part of the plan preparation process and our assessment of risk has not changed in the interim.	Generally not suitable for development unless one of the following apply: • Redevelopment of an existing building, including changes of use to an equal or less vulnerable use to the existing use. • Redevelopment of a previously developed site where it involves the demolition of existing buildings and/or erection of additional buildings within a development site, and the proposed land use is equal or less vulnerable than the existing land use. • Where the principle of development on the site has been established in an up-to-date, adopted development plan or the National Planning Framework and flood risk issues were given due consideration as part of the plan preparation process and our assessment of risk has not changed in the interim.	Generally suitable where a flood risk location is required for operational reasons and an alternative lower-risk location, is not available – development should be designed and constructed to be operational during floods (i.e. 0.5% AP), and not impede water flow.	Generally suitable for development - job related accommodation and some recreational, sport, amenity and nature conservation uses are only suitable provided that appropriate evacuation procedures are in place, and an alternative, lower risk location is not available.

2.5 Flood Risk Management (Scotland) Act 2009

The Flood Risk Management (Scotland) Act 2009 came into force on 26 November 2009. The Act repealed the Flood Prevention (Scotland) Act 1961 and introduces a more sustainable and streamlined approach to flood risk management, suited to present and future needs and to the impact of climate change. It encourages a more joined up and coordinated process to manage flood risk at a national and local level.

The Act brings a new approach to flood risk management including a framework for coordination and cooperation between all organisations involved in flood risk management, new responsibilities for SEPA, Scottish Water and local authorities in relation to flood risk management, a revised and streamlined process for flood protection schemes, new methods to enable stakeholders and the public to contribute to managing flood risk; and SEPA to act as a single enforcement authority for the safe operation of Scotland's reservoirs.

2.6 Controlled Activities Regulations (CAR)

The Water Environment (Controlled Activities) (Scotland) Amended Regulations 2013 (CAR) brings new controls for discharges, abstractions, impoundments and engineering works in or near inland waters. Any such work requires authorisation (licence) from the Scottish Environment Protection Agency (SEPA) who are responsible for the implementation of the Act. The Regulations include a requirement that surface water discharge must not result in pollution of the water environment. It also makes Sustainable Drainage Systems (SuDS) a requirement for new development, with the exception of runoff from a single dwelling and discharges to coastal waters.

2.7 Climate Change

The SPP states that "*planning system should promote a precautionary approach to flood risk from all sources, including coastal, water course (fluvial), surface water (pluvial), groundwater, reservoirs and drainage systems (sewers and culverts), taking account of the predicted effects of climate change."*

One of the sustainable policy principles within the National Planning Framework is supporting climate change mitigation and adaptation including taking account of flood risk.

SEPA has recently released updated climate change recommendations by River Basin Region, based on UKCP18. These climate change uplifts range from 24% to 56%. For smaller catchments, an increase in peak rainfall intensity allowances of between 35% and 55% are now recommended.

It is recommended that any site drainage design considers future estimates of increased precipitation and follows an adaptive approach. For many council areas there are recommendations to consider a 30% increase in flows to account for the combination of climate change and urban spread.

The Climate Change (Scotland) Act 2009 also makes reference to adaptation to climate change.

3 Site Location and Description

3.1 Site Description

The site is greenfield farmland, situated off Beith Road. The site is bounded to the north-west by existing residential development on Longshot Road; to the north-east by Caledonian Road and other industrial property and farmland; to the south-east by Beith Road and a small number of cottages; and to the south-west by Beith Road and some further greenfield land and cottages. Proposals are for a residential development. The site boundary is shown in Figure 2.

Figure 2: Site Boundary

The topography of the site was assessed based on 1m resolution LiDAR DTM data. Gradients within the site generally slope towards the north-western site boundary, but any surface runoff would ultimately drain towards the south-west towards Beith Road. Ground levels vary between highs of approximately 53.5m AOD at the eastern site boundary to lows of 39.5m AOD at the north-western site boundary adjacent to Beith Road.

The surrounding ground levels generally slope in a westerly or southerly direction towards the Powgree Burn. This means that some ground levels to the north of the site could slope towards the site. Caledonia

Road that runs along the north-eastern site boundary is built upon a former railway embankment, meaning it is significantly raised above the levels of the site and ground further to the east, this may obstruct local surface water pathways. Auchengree Road lies above the levels of the site at the southern site corner.

Figure 3 shows the topography of the site and surrounding area using contours. Figure 4 shows the location of cross-sections through the site. Figures 5 and 6 show the cross-sections through the site.

Figure 3: Topography of the site and surrounding area (Contours – 2m)

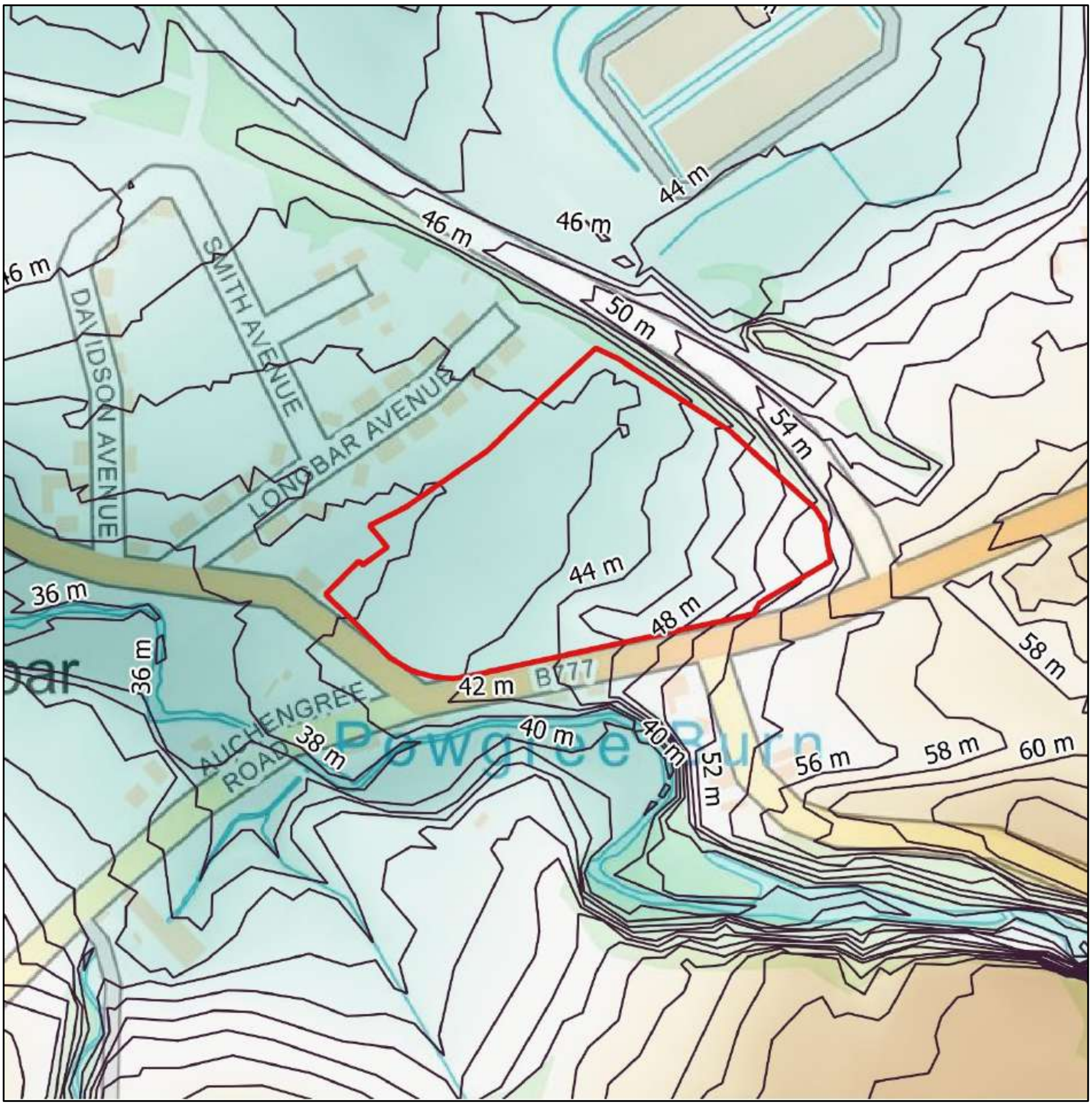


Figure 4: Location of cross-sections through the site and surrounding area

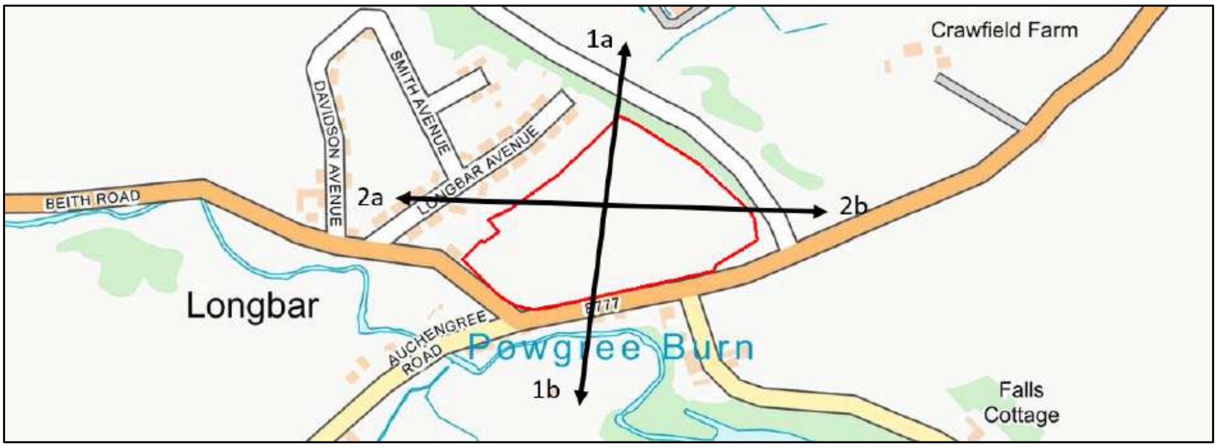


Figure 5: Cross-section 1

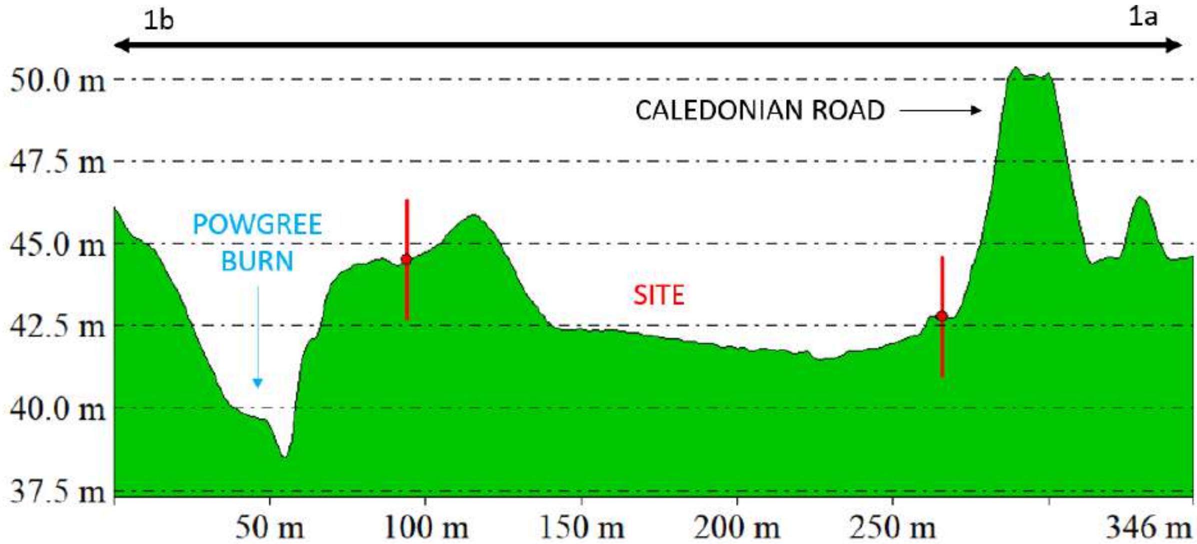
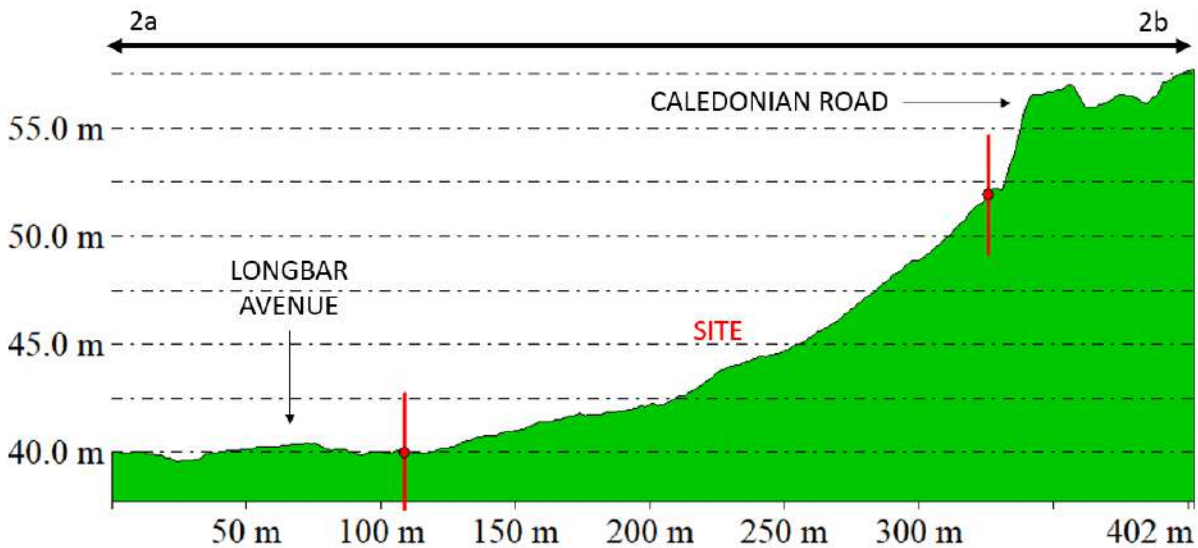


Figure 6: Cross-section 2



The Powgree Burn flows in a westerly direction to the south and west of the site, to the south of Auchengree Road and Beith Road. The site lies approximately 35m from this watercourse, at its closest. The watercourse has a relatively large catchment of approximately 10km² adjacent to the site. This watercourse discharges into the River Garnock approximately 1km downstream of the site in Glengarnock. A short distance upstream of the site the Powgree Burn passes under Auchengree Road via a stone, arch bridge. A tributary discharges into the watercourse just upstream of this structure. The watercourse lies within a relatively deep valley of between 3m and 4m within the vicinity of the site. Ground levels between the watercourse and the site continue to rise up until they reach the site.

A site visit confirmed the existence of Burn 1, a watercourse that flows adjacent to the north-eastern site boundary, flowing in a north-westerly direction. This watercourse is thought to drain areas to the east of the site (See Section 5.2). The watercourse enters the site via a concrete culvert of approximately 0.45m diameter (Inlet 1/ Culvert 1, Figure 7). The watercourse is separated from the site by a raised walkway that connects Longbar Avenue with Caledonian Road. The site visit confirmed that this watercourse flows within a channel of approximately 3m wide and 1m high bounded between the raised walkway and the raised Caledonian Road. The watercourse appears to be culverted approximately half-way along the site boundary (Culvert 2, Figure 7). While the channel of 3m wide by 1m high continues further downstream, this channel is dry. It is difficult to confirm the exact route of the culverted section. However, it would be anticipated that the watercourse would follow the line of the channel and connects into Burn 2 culvert at Junction 1 (Figure 7) at the northern corner of the site.

Historic mapping shows evidence of Burn 2 running in a south-westerly direction under Caledonian Road and along the site boundary within the gardens of the adjacent Longbar Avenue properties. This watercourse was not identified on site. It is thought that this drainage channel has been culverted through the site (Figure 7, Culvert 3 also See Section 5.3). The culverted reach of Burn 1 (Culvert 2) may connect into this culvert close to the northern site corner (Junction 1). Manholes were identified on Beith Road just outwith the site and flows could be heard within the culvert at this location. The watercourse daylights just downstream of Beith Road via a circular culvert and flows in an open channel, discharging into the Powgree Burn around 50m downstream (Outlet 1). The culvert outlet could not be measured due to heavy brush but a visual estimate of between 0.5m and 1m diameter was made.

Figure 7 shows the relevant watercourses and water features within the vicinity of the site.

Figure 7: Watercourses and other relevant features

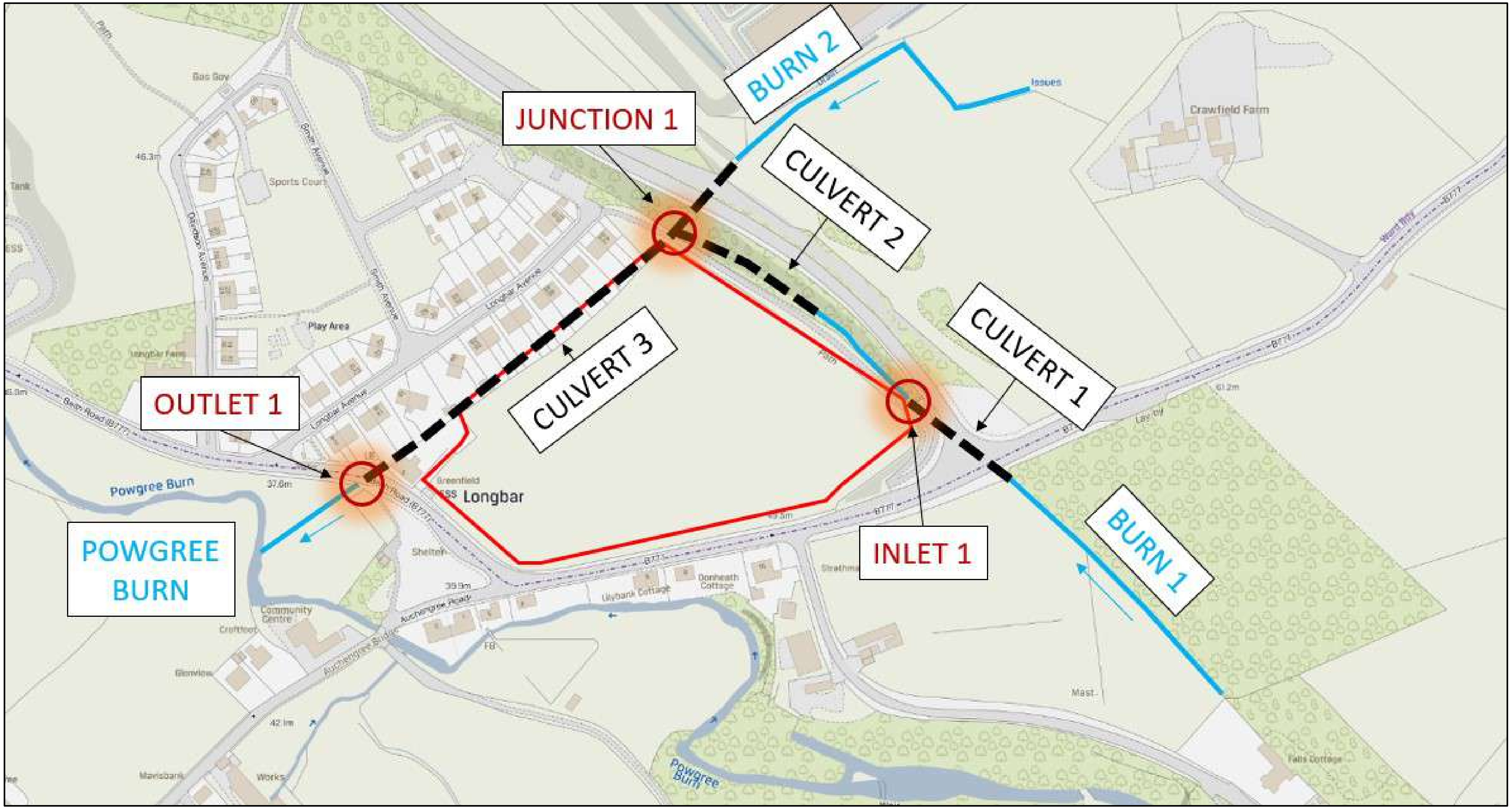


Photo 1: Site looking from junction of Beith Rd and Auchengree Rd looking eastwards

Photo 2: Site looking from the junction of Caledonian Rd and Auchengree Rd looking west

Photo 3: Site looking from halfway along north-eastern site boundary towards the west

Photo 4: Raised footpath looking from northern corner to the south-east. Note Burn 1 on left

Photo 5: Inlet 1 where it outfalls into Burn 1 within the site.

Photo 6: Burn 1 located between Caledonian Road and the raised footpath

Photo 7: Outlet 1 just downstream of Beith Rd

Photo 8: Powgree Burn to the south, south-west of the site

3.2 Historical Flood Events & Consultation

A review of the British Hydrological Society (BHS) Chronology of British Hydrological Events website was undertaken searching for the following keywords: “Longbar”, “Beith”, “Glengarnock” “Kilbirnie”; “Powgree Burn” and “River Garnock”. Searched keywords refer to nearby locations and watercourses marked on current and historic maps. Only River Garnock provided a flood record taken from British Rainfall in 1904 recorded in Dalry. The record detailed heavy flooding due to intensive rainfall. Dalry is a significant distance downstream of the site and this record does not signify that flooding occurred at the site. However, the absence of references for the does not necessarily prove that flooding has not or will not occur. Most references are only recorded in urban areas.

A thorough internet search was conducted to highlight any history of flooding in and around the surrounding area and the site.

North Ayrshire are moving forward with proposals for the Upper Garnock Flood Prevention Scheme. This would protect the nearby settlements of Kilbirnie and Glengarnock from flooding from the River Garnock and Powgree Burn. Plans of the proposed defences show that defences on the Powgree Burn are limited to areas of Glengarnock.

No other evidence of flooding occurring along the Powgree Burn was uncovered during the search. No evidence of flooding within the vicinity of the site was uncovered during the search.

North Ayrshire Council were consulted to support this assessment. We await a response at time of publication.

4 Hydrological Analysis

A hydrological analysis was undertaken to estimate the design flows that could reach the Powgree Burn and Burns 1 and 2 adjacent to the site.

4.1 Estimation of Design Flows for the Powgree Burn

The contributing catchment area of the Powgree Burn was estimated to be approximately 10.3km², just downstream of the site, according to the FEH Web-service. LiDAR DTM data for the catchment suggests that the contributing catchment area is likely to be marginally smaller than the FEH estimate at approximately 9.9km². There is only approximately 4% difference between these estimates and so the larger FEH web-service catchment was used to provide more conservative design flows.

The catchment descriptors were extracted from the FEH Web-service and are shown in Table 1. The delineated catchment area is shown in Figure 4.

Table 1: Catchment descriptors for the Powgree Burn

Parameter	Value
EASTING (m)	232700
NORTHING (m)	652550
AREA (km²)	10.295
ALTBAR (m)	100
ASPBAR (°)	260
ASPVAR	0.29
BFIHOST	0.336
DPLBAR (km)	3.81
DPSBAR (m/km)	41.4
FARL	1
LDP	7.41
PROPWET	0.61
SAAR (mm)	1413
SAAR4170 (mm)	1446
SPRHOST	39.23
URBCONC1990	0.568
URBEXT1990	0.0053
URBLOC1990	1.099
URBCONC2000	0.737
URBEXT2000	0.0116
URBLOC2000	1.173

Flows were estimated based on the FEH Rainfall-Runoff method and the ReFH2 rainfall-runoff method. The results are shown in Table 2. The methods were undertaken using the standard parameters and the default catchment descriptors.

Table 2: Design flows for the Powgree Burn, downstream of the site

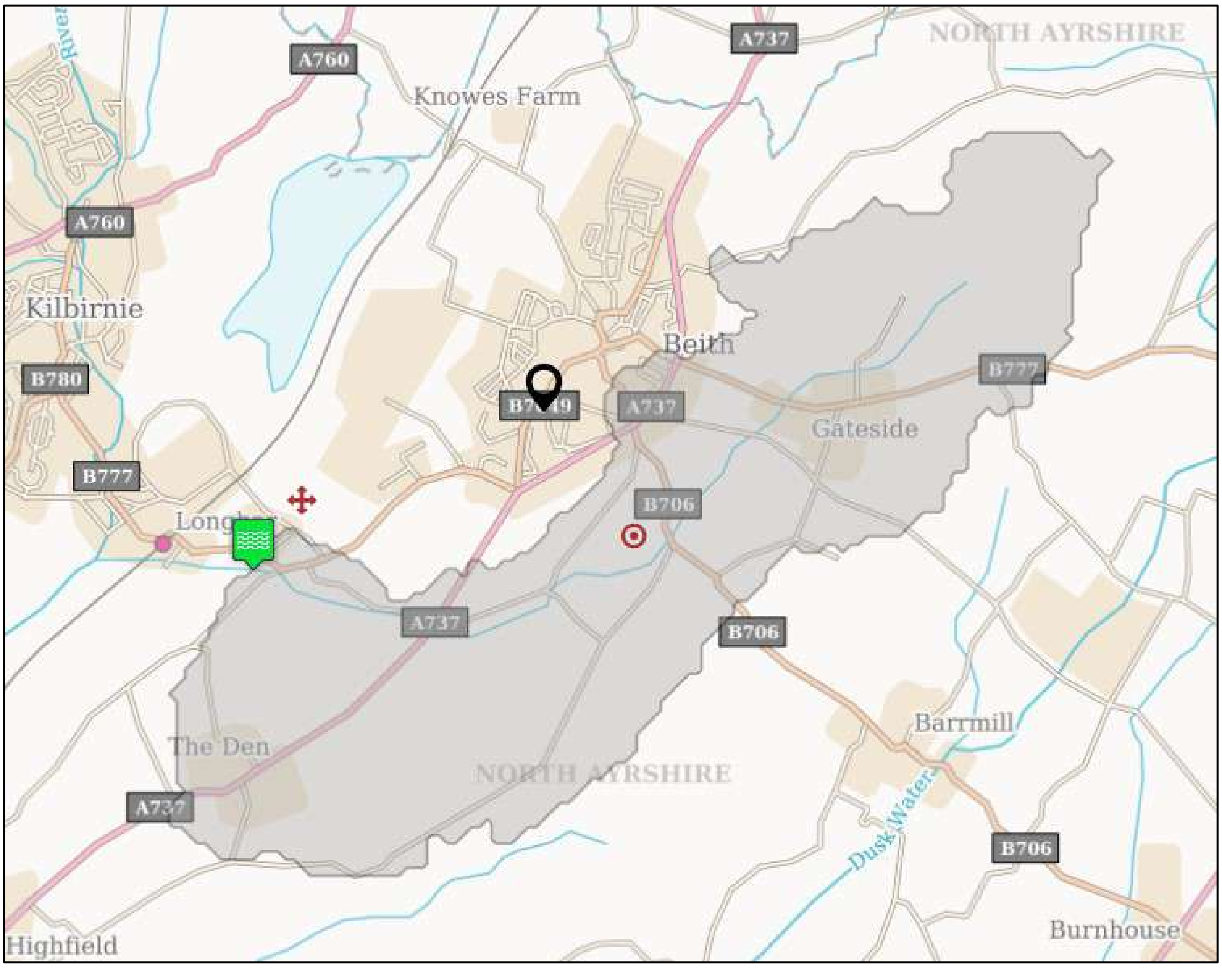
Estimation Method	1 in 200-year flow (m^3/s)	1 in 200-year + 55% CC flow (m^3/s)
FEH Rainfall-Runoff Winter [a]	19.9	33.42
ReFH2 Winter [b]	24.3	40.82

a Critical Storm Duration = 8.5 hours
b Critical Storm Duration = 6.5 hours

The more conservative (higher) flows estimated using the ReFH2 were used to support this assessment.

SEPA recommend a climate change uplift for the West of Scotland of 55% peak rainfall intensity. This was undertaken for the FEH Rainfall-Runoff and ReFH2 methods by increasing the 200-year peak rainfall by 55%.

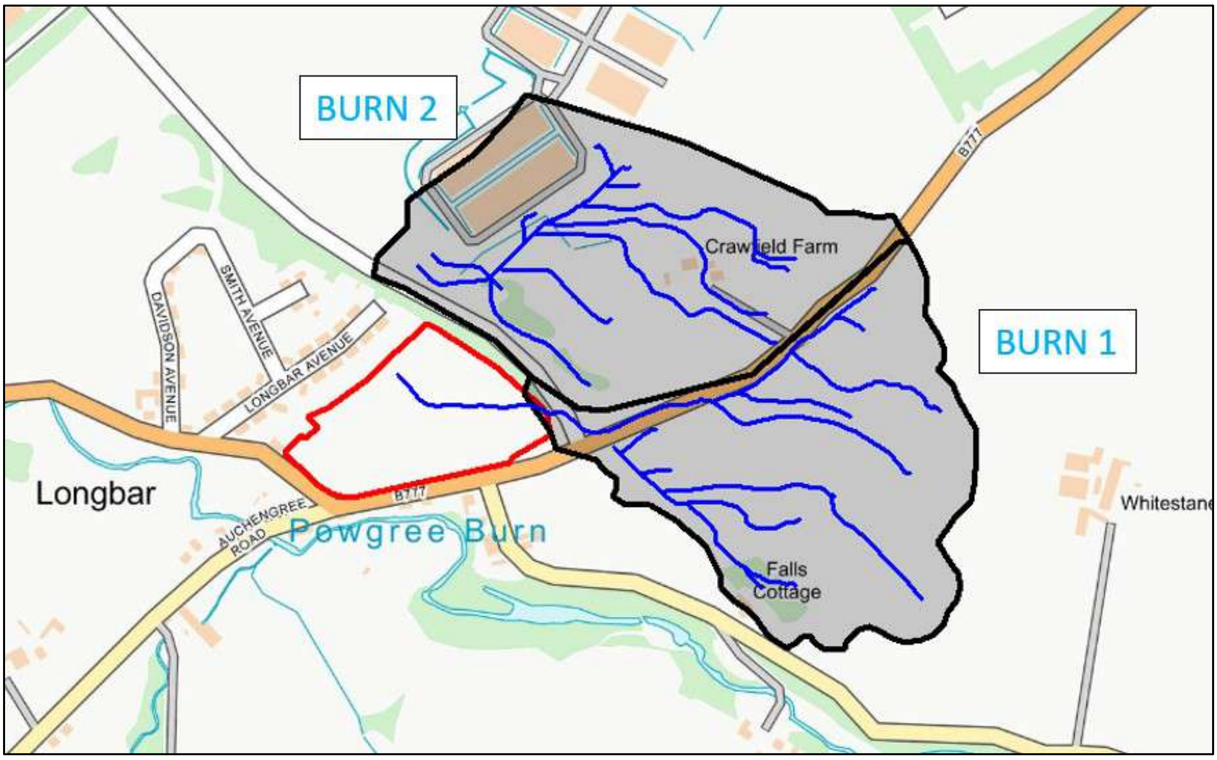
Figure 8: Catchment area extracted from the FEH Web-service



4.2 Estimation of Design Flows for Burns 1 & 2

Due to being smaller than 0.5 km² the catchment areas for Burns 1 and 2 could not be extracted from the FEH Web-service. 1m LiDAR DTM data was used to estimate the contributing catchment areas for each watercourse. Both catchment areas were estimated to measure approximately 0.11 km². The estimated catchments are shown in Figure 9.

Figure 9: Estimated catchment areas of Burns 1 and 2



Catchment descriptors were extracted from the FEH Web-service for the nearest representative catchment, i.e. nearest catchment with an area of 0.5km². Some descriptors like AREA and DPLBAR were adjusted to better represent Burns 1 and 2. The descriptors for this catchment are shown in Table 3. Adjusted descriptors are marked in red.

Both Burns 1 and 2 were noted to have similar characteristics and the same descriptors were chosen to estimate the flows for both burns. Where there was any discrepancy the most conservative parameter from each Burn was employed. For example, the slope gradient (DPSBAR) was based on the steeper catchment.

It should be noted that Burn 1 enters the site via a 0.45m diameter culvert. This will restrict the flows entering the site. Assuming a maximum possible velocity of 3.5 m/s this gives a maximum culvert capacity of approximately 0.56 m^3/s, broadly the same as the 1 in 200-year flow. However, it suggests that the culvert capacity could impact on the 200 year + climate change flows at the site. Such a restriction is not considered in the flood risk assessment (full unconstrained flow is allowed to reach the site), but should be considered when reviewing the conclusions of the assessment.

Burn 2 is thought to be culverted through the site. The dimensions upstream of the site could not be measured meaning the capacity of the culvert cannot be estimated.

Table 3: Catchment Descriptors for Burns 1 and 2

Parameter	Value
EASTING (m)	232900
NORTHING (m)	653200
AREA (km^2)	0.51 (0.11)
ALTBAR (m)	61
ASPBAR (°)	291
ASPVAR	0.73
BFIHOST	0.32
DPLBAR (km)	1.09 (0.25)
DPSBAR (m/km)	31.2 (72)
FARL	1
LDP	2.36 (0.5)
PROPWET	0.61
SAAR (mm)	1400
SAAR4170 (mm)	1480
SPRHOST	39.76
URBCONC1990	-999999
URBEXT1990	0
URBLOC1990	-999999
URBCONC2000	-999999
URBEXT2000	0
URBLOC2000	-999999

Flows were estimated based on the FEH Rainfall-Runoff method and the ReFH2 rainfall-runoff method. The results are shown in Table 4. Results based on culvert capacity are also shown. The methods were undertaken using the standard parameters and the default catchment descriptors, except where shown in red in Table 3.

Table 4: Design flows for Burns 1 and 2

Estimation Method	1 in 200-year flow (m^3/s)	1 in 200-year + 55% CC flow (m^3/s)
FEH Rainfall-Runoff Winter [a]	0.54	0.90
ReFH2 Winter [b]	0.52	0.87
Burn 1 – Culvert Capacity	0.56 (Restricted by Culvert)	0.56 (Restricted by Culvert)
Burn 2 – Culvert Capacity	Unknown	Unknown

a Critical Storm Duration = 1.7 hours
b Critical Storm Duration = 2.5 hours

The more conservative (higher) flows estimated using the FEH Rainfall-Runoff were used to support this assessment. SEPA recommend a climate change uplift for the West of Scotland of 55% peak rainfall intensity. This was undertaken for the FEH Rainfall-Runoff and ReFH2 methods by increasing the 200-year peak rainfall by 55%.

It should be emphasised that these results should be interpreted as Burn 1 receiving a 1 in 200-year peak flow of 0.54 m^3/s and Burn 2 a 1 in 200-year peak flow of 0.54 m^3/s. The combined peak flow from the two watercourses would therefore be 1.08 m^3/s.

5 Flood Risk Assessment

The flood risk assessment considers the risk from:

- Powgree Burn;
- Drainage Channel;
- Surface water flooding;
- Groundwater flooding;
- Drainage systems;
- Safe Access;

5.1 Powgree Burn

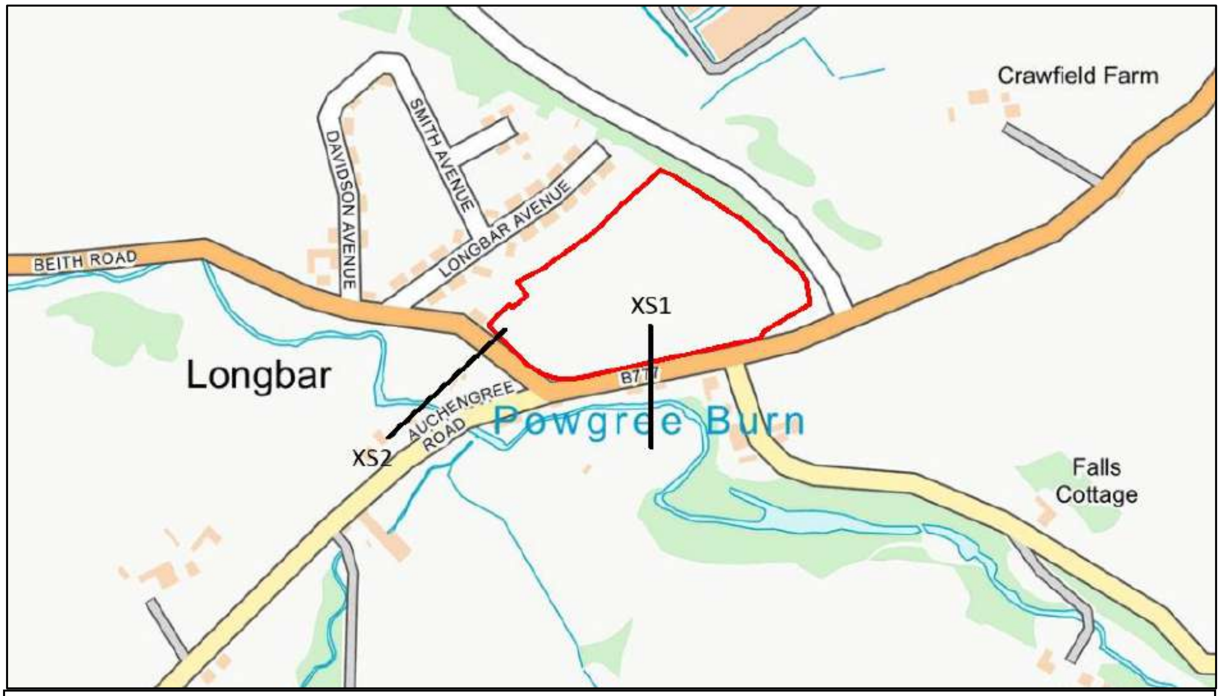
The Powgree Burn flows in a westerly direction to the south and west of the site and the site lies approximately 35m from this watercourse, at its closest.

The watercourse lies within a relatively deep valley close to the site. The valley is around 20-30m wide and sits around 3m below the level of the site. Given the size of the catchment and the design flow (24.3 m^3/s), it is unlikely that the site is at risk of flooding from the burn. For this reason, it was decided to undertake a series of conservative Manning's equations to confirm the conveyance capacity of the watercourse.

5.1.1 Manning's Calculations

A number of cross-sections were taken through the watercourse. Valley dimensions were determined to range between 10m and 30m wide and 2m and 3m deep. Two representative cross-sections were chosen for final comparison provided in this report, one upstream of Auchengree Bridge and another downstream. Figure 9 shows the location of the cross-sections.

Figure 10: Cross-sections



A conservative Manning's roughness value of 0.06 was used in the calculation.

The equation used is the following:

$$Q = VA$$

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

Q = Flow (m^3/s)
V = Velocity (m/s)
A = Flow Area (m^2)
n = Manning's n roughness
R = Hydraulic Radius (m)
S = Slope Gradient (m/m)

Table 3 shows the results. Figures 10 and 11 provide a visual representation of results by showing the predicted water level for the 1 in 200-year + 55% climate change flow of approximately 41 m^3/s.

The results suggest that both XS1 and XS2 have sufficient capacity to convey the 1 in 200-year + 55% climate change flow without flows rising enough to reach the site. Water levels remain a minimum of 4m below the adjacent levels of the site at XS1. Water levels remain a minimum of 1.7m below the levels of the site at XS2.

Table 5: Results of the Manning's Equation for XS1 and XS2 – Powgree Burn

PARAMETER	XS1	XS2
INPUT		
Manning's *n* roughness	0.06	0.06
Channel Slope (m/m), S	1 in 125	1 in 125
Water Level (m AOD)	40.7	38.1
OUTPUT		
Flow Area (m²), A	26.47	24.89
Wetted Perimeter (m)	29.73	35.17
Hydraulic Radius (m), R	5.6	4.95
Velocity (m/s), V	0.42-2.00	0.4 – 1.9
Froude, F	0.3-0.6	0.3-0.5
Flow, Q (Combined Sections)	41.0	41.0

Figure 11: XS1 - With 1 in 200-year + 55% climate water level

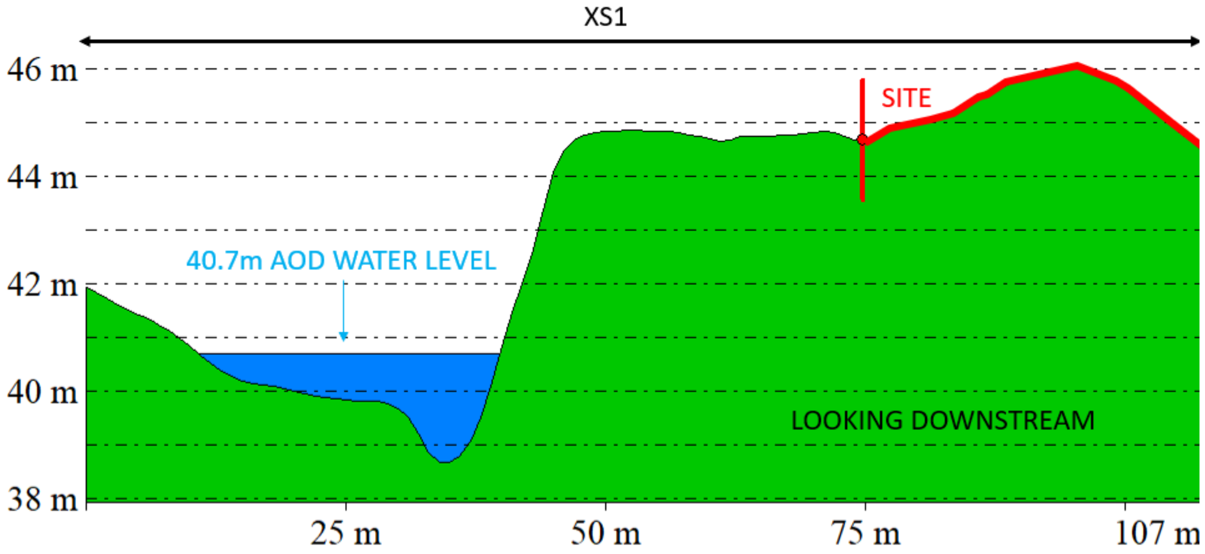
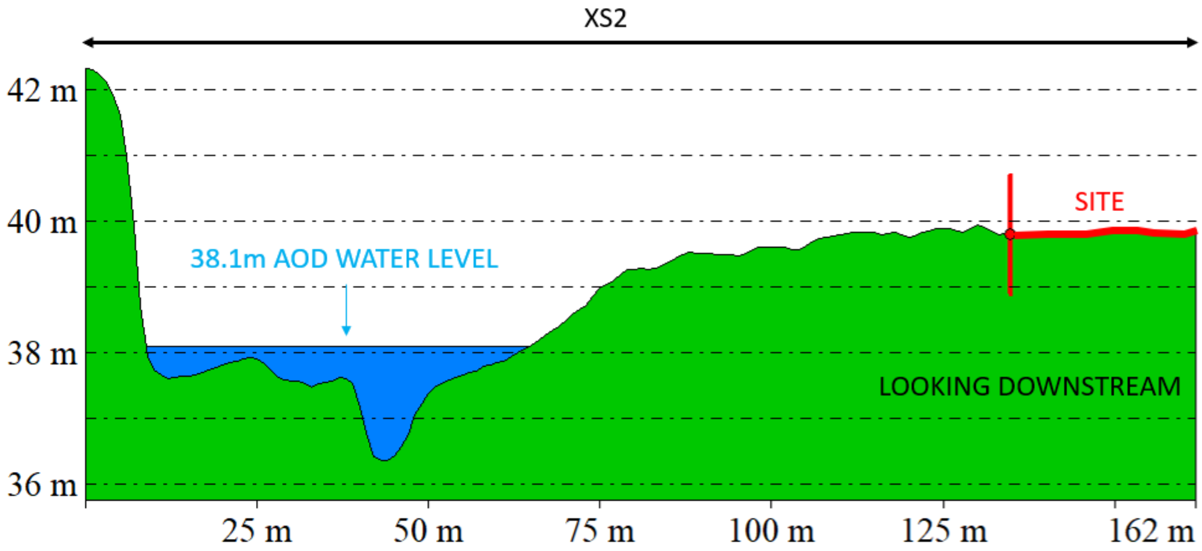


Figure 12: XS2 - With 1 in 200-year + 55% climate water level



5.1.2 Bridge Overspill – 2D Modelling

Auchengree Bridge lies between XS1 and XS2. This is a large, stone, arch bridge. It was difficult to confirm dimensions of this structure in the field due to access issues at this location. It was decided to model the bridge as if it was 100% blocked using a 2D model.

The 2D model was developed using 1m LiDAR DTM data. This was considered a suitable method to represent overland flow pathways once they spill out of bank.

A 2D domain (or “active area”) was defined to represent the Powgree Burn. This was sized to represent areas approximately 500m upstream and downstream of the site. Model predictions have higher uncertainties close to the upstream and downstream bounds of the model and so placing the site of interest away from the boundaries reduces uncertainties at the site.

The model was run using a 2m grid resolution and 0.5 second timestep. The 2D domain was run using Manning's “*n*” roughness values of 0.1 to represent some heavier brush along the banks of the watercourses. Some areas within the domain may have lower friction but using higher values is more conservative.

The upstream inflow boundary was located approximately 500m upstream of the site and the 1 in 200-year + CC flow was used. A steady flow was applied as inflow at the upstream boundary. The downstream boundary was set as a normal depth slope gradient boundary downstream of the site within a well-defined valley. The downstream boundary slope was set as 0.01 (1 in 100), equivalent to measured channel slope gradient in this area.

Auchengree Bridge was represented as 100% blocked by raising the ground levels within the 2D model to block the river channel up to road level. This was achieved using a “Z” polygon. Ground levels were raised to 39m AOD.

The default Flood Modeller advanced parameters and the ADI Solver was used. The mass balance error did not exceed a percent volume error of 1%, once the initial wetting of the domain had occurred.

A sensitivity analysis was undertaken to confirm the stability of the model and its sensitivity to model parameters.

The model was run for the following scenarios:

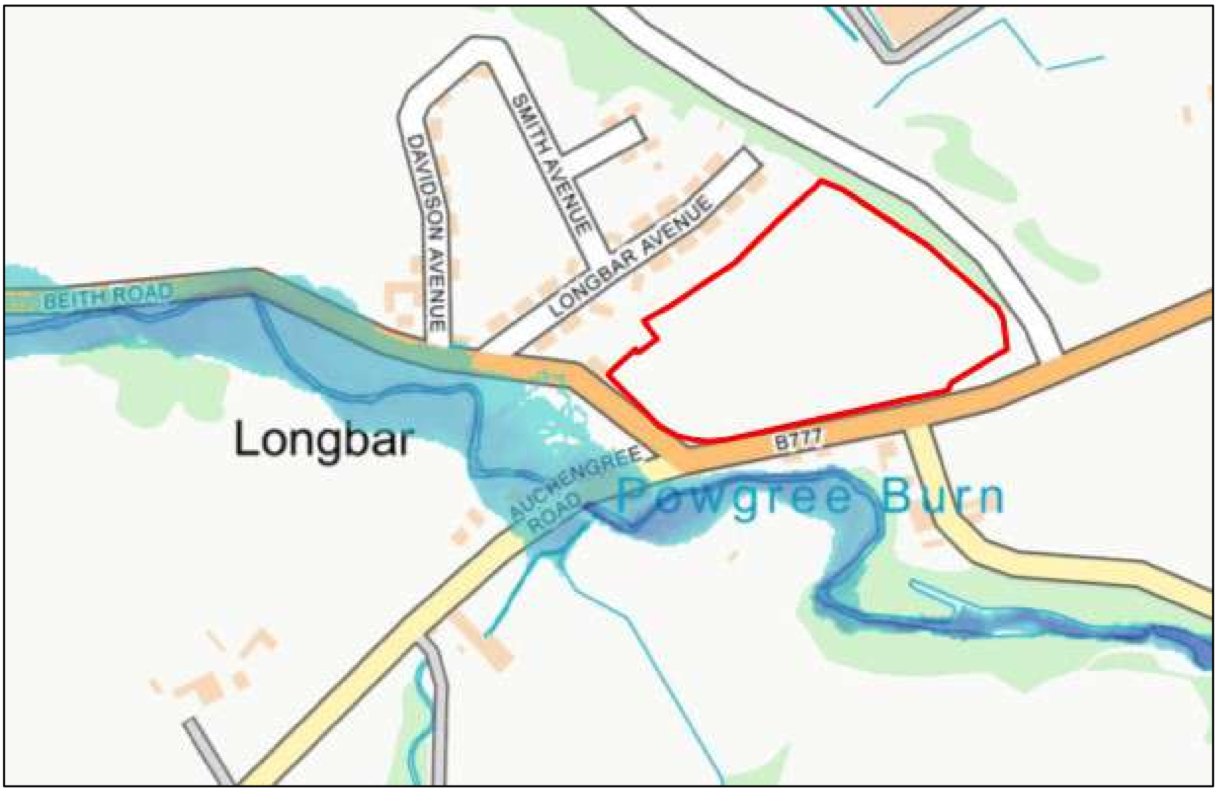
1. 1 in 200-year + 55% Climate Change with 100% blocked Auchengree Bridge
2. 1 in 200-year + 55% Climate Change with 100% blocked Auchengree Bridge – Increased Manning’s ”*n*” by 20%.
3. 1 in 200-year + 55% Climate Change with 100% blocked Auchengree Bridge – downstream boundary reduced to 1 in 200.

The modelled water levels along the reach adjacent to the site were compared between the three modelled scenarios. The results suggest that the changes to these parameters do not have a significant impact on water levels at the site. Water levels rise a maximum of 0.15m in Scenario 2, adjacent to the site. Water levels do not change for Scenario 3, adjacent to the site. This suggests that the model is not sensitive to changes in these model parameters.

The flood maps for Scenario 1 is shown in Figure 13.

The results suggest that in the event of a 100% blockage of Auchengree Bridge flows would spill over the bridge and return back into the main channel without impacting on the site.

Figure 13: 1 in 200-year + 55% and 100% blockage of Auchengree Bridge Flood Map



5.1.3 Flood Risk and Finished Floor Levels

The results of the assessment in Section 5.1.1 and 5.1.2 suggest that the site does not lie within the floodplain of this watercourse for a 1 in 200-year or 1 in 200-year + 55% climate change event.

Nevertheless, Finished Floor Levels should be raised a minimum of 0.6m above the 1 in 200-year + CC water levels. The site is generally a minimum of 0.6m above the adjacent 1 in 200-year + CC water levels in the Powgree Burn. To provide additional mitigation it is recommended that Finished Floor Levels of properties along the south-western site boundary where Beith Road runs parallel to the Powgree Burn are raised above the levels of Auchengree Road.

5.2 Burn 1

Burn 1 flows adjacent to the north-eastern site boundary. The watercourse lies within a well-defined channel of a minimum of approximately 3m wide at top of bank and 1m high. The watercourse lies between a raised walkway and raised Caledonian Road. This is represented in Figure 14. The channel flows as open channel for a reach along the site boundary but is then culverted for a given reach (Figure 15, Culvert 2). The channel exists along the entire site boundary, even for the areas where the watercourse is culverted. Therefore, in the event of blockage of Culvert 2 flows would be anticipated to continue to flow along the line of the channel (Figure 15). Calculations in Section 5.2.1 suggest that flows would remain in bank. Once flows reach Junction 1 flows would accumulate and then overtop in a south-westerly direction along the line of Culvert 3, if they cannot enter the culvert at Junction 1.

5.2.1 Manning's Calculations

A Manning's equation was used to estimate the channel capacity (Burn 1) and confirm if it would be able to pass the 1 in 200-year flow, even in the event of blockage of Culvert 2

Slope gradients of the watercourse start off steep and become shallower as the watercourse flows downstream. The minimum slope gradient based on the site visit and LiDAR DTM data is considered to be 1 in 100. Channel Manning's roughness values were thought to be around 0.05, but more conservative values of 0.07 were used to account for any uncertainty.

The equation used is the following:

$$Q = VA$$

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

Q = Flow (m^3/s)
V = Velocity (m/s)
A = Flow Area (m^2)
n = Manning's n roughness
R = Hydraulic Radius (m)
S = Slope Gradient (m/m)

Table 6 shows the results from the Manning's equation.

The results suggest that the channel can convey the 1 in 200-year + CC flow at a depth of 0.62m, giving a 0.38m freeboard to the top of bank. This suggests that in the event of blockage of the culverted reach flows would remain contained within the channel of Burn 1 between the raised footpath and Caledonian Road.

A sensitivity analysis was undertaken to confirm that the channel would have sufficient capacity. Increasing the Manning's n roughness values to 0.1 would result in water depths of approximately 0.8m, providing a freeboard of 0.2m. Reducing the downstream slope gradient to 1 in 200 would have a similar impact with depths rising to 0.8m. Bank-full capacity of the channel, as modelled in Table 6, was estimated to exceed 1.5 m^3/s. The results of this assessment suggest that the results do not rely strongly on the parameters used. Flows are considered likely to remain within the channel in a 1 in 200-year + CC event regardless of the parameters used.

However, in the event that the channel were overtopped flood waters would be able to flow into the site (see Figure 14). Therefore, mitigation measures for this residual risk are discussed below (Section 5.22).

Figure 14: Cross-section through Burn 1 looking downstream from left to right

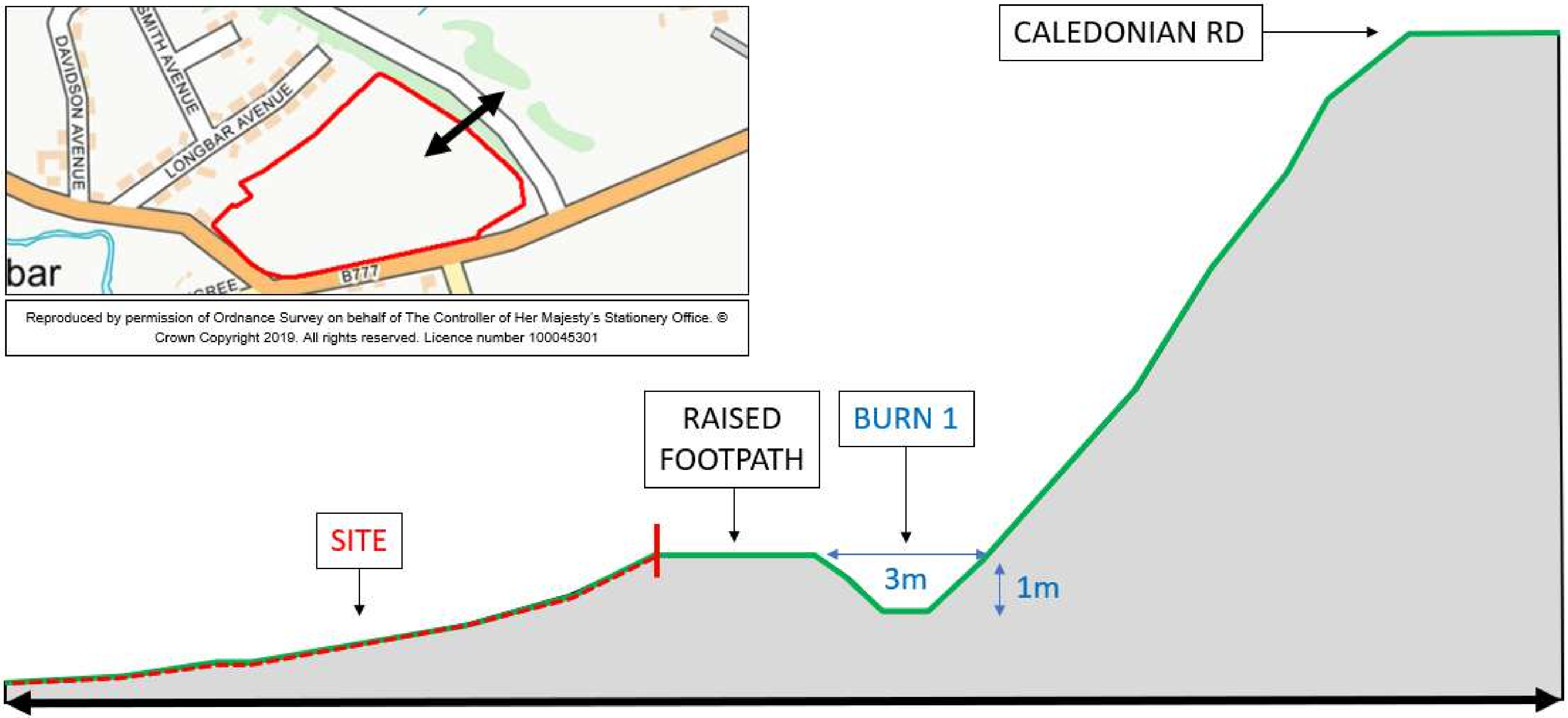


Table 6: Results of the Manning's Equation – Burn 1

PARAMETER	Burn 1 - Cross-Section
INPUT	
Manning's *n* roughness	0.07
Channel Slope (m/m), S	1 in 100
Water Depth (m AOD)	0.62
OUTPUT	
Flow Area (m²), A	1.25
Wetted Perimeter (m)	3.37
Hydraulic Radius (m), R	0.37
Velocity (m/s), V	0.74
Froude, F	0.37
Flow, Q (m³/s)	0.9

5.2.2 Flood Risk and Finished Floor Levels

The results of the Manning's Equation suggest that Burn 1 can convey the 1 in 200-year + CC flow without overtopping, even in the event of blockage of Culvert 2 (Figure 15).

However, flows would be conveyed to the low point at the northern site corner in the event of culvert blockage. From here flows would spill south through the site (Figure 15). To mitigate against this risk, it will be necessary to provide an overland flow pathway along the north-western site boundary parallel to the presumed trajectory of the culvert (Figure 16).

This overland flow pathway will need to be designed to accommodate flows from both Burn 1 and Burn 2, in case of blockage of the culvert in this location. This means a channel capacity of 1.8 m³/s is required.

Assuming a minimum slope gradient of 1 in 200 a trapezoidal channel with a bottom width of 0.5m with a depth of 1m and side slopes of 1 in 2 would give a flow capacity in excess of 1.8 m³/s, assuming Manning's *n* roughness values of 0.05. The final overland flow pathway should be designed and modelled. A freeboard of a minimum of 0.6m should be provided between the predicted 1 in 200-year + CC water level and proposed Finished Floor Levels of the properties.

The overland flow pathway would need to be designed to discharge flows from the site. This would need to be either via the existing culvert or via the proposed surface water disconnecting manhole adjacent to Beith Road, assuming this will discharge into the Powgree Burn downstream and will not have an impact on any existing sewers. Flows from the overland flow pathway should not be discharged into the SuDS pond.

It may be necessary to construct a means for flows to pass from Burn 1 to the Overland Flow Pathway in the event of culvert blockage. This could be an overspill point on the raised footpath or a culvert under the raised footpath.

A schematic of the proposed overland flow pathway is shown in Figure 16.

The site lies below the levels of Burn 1 where it runs parallel to the raised footpath and Burn 1. To further mitigate against the residual flood risk, it is recommended that a cut-off channel, or similar measure, is provided adjacent to the raised footpath to intercept any flows that may spill over the raised footpath. Careful level design will need to be undertaken to ensure that this can be designed to work with the levels of the site.

It is stressed here that these mitigation measures are to deal with residual risks of large blockages of the burns along the edge of the site. The site is not predicted to lie within the functional floodplain of these burns, but it is sensible to provide mitigation in the event of emergency conditions.

Figure 15: Location where flows would spill into the site in event of Culvert blockage

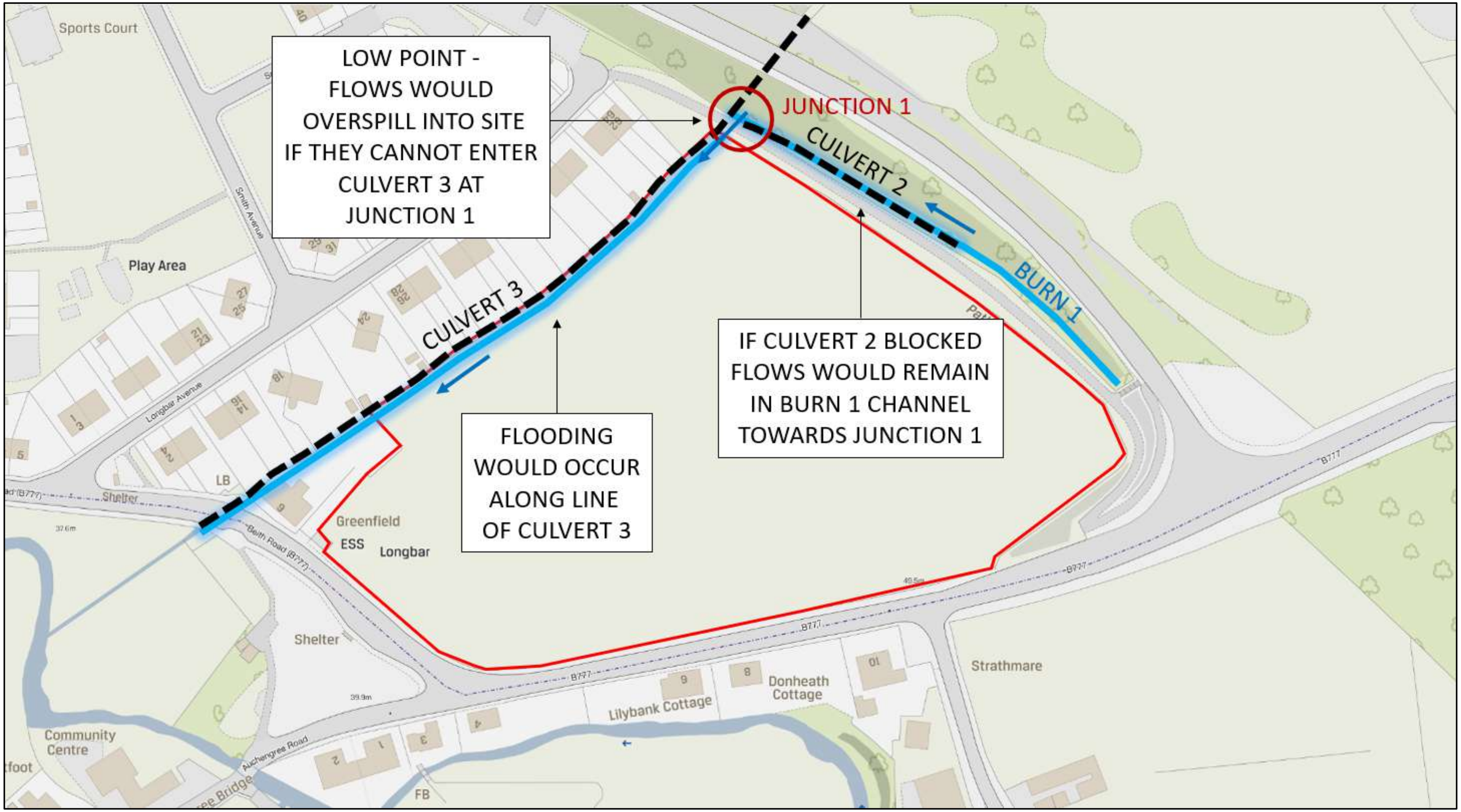
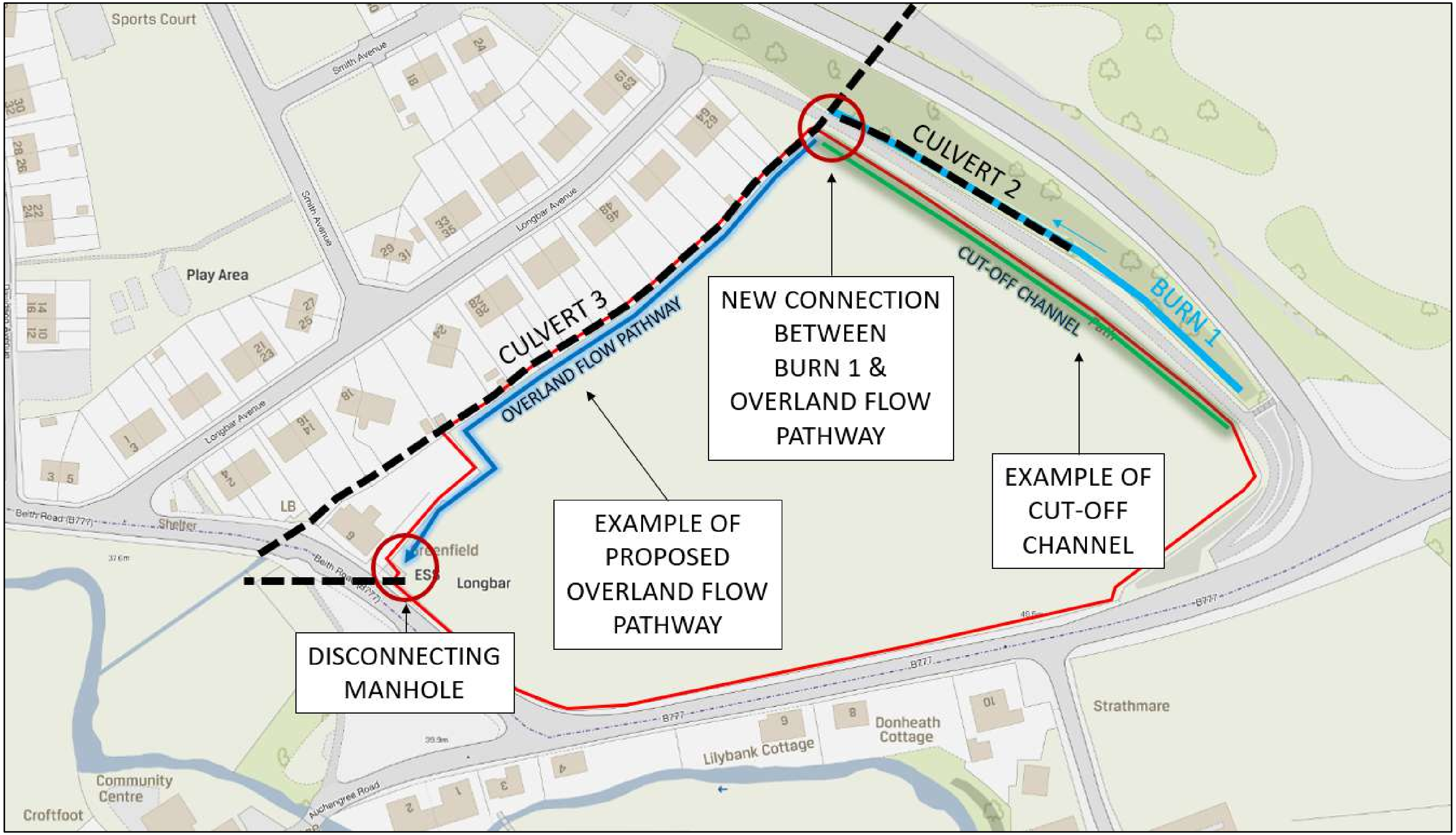


Figure 16: Example Overland Flow Pathway Schematic



5.3 Burn 2

Burn 2 is thought to run in a south-westerly direction under Caledonian Road and along the site boundary within the gardens of the adjacent Longbar Avenue properties. The watercourse was not identified on site and is thought to be culverted within the vicinity of the site.

In the event of blockage of the inlet to the culvert, upstream of the site, flows would be anticipated to pool upstream of the site. Caledonian Road is raised 25m above the levels of Burn 2 in this location and it is highly unlikely that flows would be able to reach the site. Flows would pool upstream of the site and likely be conveyed to the north towards Kilbirnie Loch.

If the culvert were to become blocked downstream of Caledonian Road flows might surcharge from manholes. None were identified on site but there may be manholes within the gardens of properties on Longbar Avenue. Flows from these manholes could enter the site along the north-western site boundary.

However, recommendations for an Overland Flow Pathway in Section 5.2.1 would also serve to intercept these surcharging flows and convey them downstream without increasing flood risk to the site or third parties.

5.4 Surface Water Flooding

A Watershed Analysis was undertaken using Global Mapper software using 1m resolution LiDAR DTM data covering the site and surrounding area. This shows local overland flow pathways. The results are shown in Figure 17.

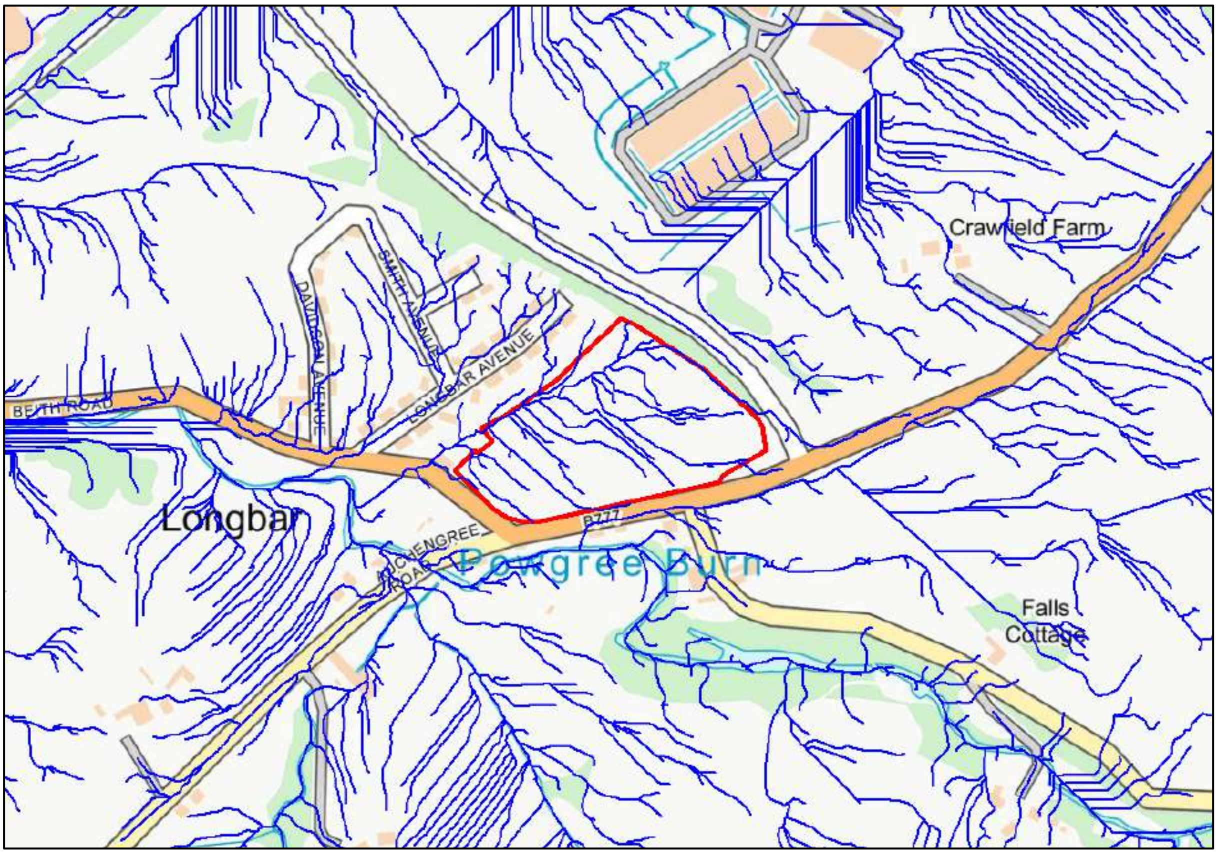
The results of the assessment suggest the following:

- **North:** Some limited surface water originating from the North may flow from properties on Longbar Avenue in a southerly direction and enter the site along the northern site boundary. Surface water on Caledonian Road and the majority of the Longbar Avenue estate would flow away from the site.
- **East:** Surface water on Caledonian Road would predominantly flow in a north-westerly direction away from the site. However, some surface water originating from Beith Road and its junction with Caledonian Road could enter the site close to the south-eastern site boundary.
- **South:** Surface water originating from the south of the site would flow along Beith Road and on towards the Powgree Burn and not impact on the site.
- **West:** Surface water originating from the west of the site would flow away from the site towards Powgree burn and not impact on the site.

Consideration will need to be given to surface water entering the site along the northern site boundary and south-eastern site corner. Overland flow pathways should be maintained to permit flows to enter and flow through the site as they do currently. Alternatively, flows could be intercepted at the site boundary and conveyed through the site leaving the site in the same location as currently.

When designing the development, it is recommended that ground levels are designed to shed surface water away from buildings and towards suitable drainage outlets to mitigate against flooding. Finished Floor Levels should be raised above the surrounding ground levels to further mitigate against the flood risk posed by surface water.

Figure 17: Watershed Analysis - Showing overland flow pathways



5.5 Groundwater Flooding

The SEPA flood map does not show the site to be at risk of flooding from groundwater flooding. Flooding from groundwater as a primary source is uncommon in Scotland.

Groundwater levels within the site are likely to be controlled by water levels within the adjacent Powgree Burn. The results of the assessment of the Powgree Burn suggests the site is unlikely to be at risk of flooding from this watercourse, even in the event of a 1 in 200-year + 55% climate change flood. Groundwater levels controlled by the Powgree Burn are therefore unlikely to pose a significant flood risk to the site.

However, it is recommended that groundwater monitoring is undertaken at the time of the Ground Investigation and that mitigation measures be put in place if evidence of a high water table is identified. High ground water levels may require alterations to the design of foundations and other civil engineering works. SuDS measures will need to take account of groundwater conditions if elevated groundwater levels are identified.

5.6 Proposed Drainage System

The design of the site drainage system is not part of this commission.

The entirety of the site appears to drain naturally into the Powgree Burn via Burn 1 downstream of the site. Surface water from the site should continue to discharge to this location post-development. Runoff from the site will need to be attenuated to the existing greenfield rate. This will mitigate against an increase in flood risk to third parties.

The drainage design would need to comply with the North Ayrshire Council guidance.. Confirmation of attenuation requirements and the discharge rates should be sought from North Ayrshire Council or Scottish Water, depending on the discharge location. Requirements for SuDS should also be agreed with North Ayrshire Council, SEPA, and Scottish Water.

Care should be taken to provide suitable overland flow pathways within the site to convey any excess overland flows in the event of blockage to the drainage system, or events in excess of design conditions. The flow pathways should be designed to convey any excess flows to landscaped areas and suitable discharge locations, without flooding properties, or increasing the risk of flooding to any land outside of the site boundary. Discussion of the management of surface water flooding is provided in Section 5.4.

A maintenance regime should be put in place to ensure all components of the drainage system function as designed.

5.7 Safe Access

The regulatory authorities recommend that dry access and egress be provided during extreme flood events so that residents and visitors can be safely evacuated without any undue risk to life.

The results of the assessment suggest that in the event of a 1 in 200-year + 55% climate change event flows would be contained predominantly within the valley of the Powgree Burn. Any flooding of roads would be limited to Auchengree Road. Site access is proposed via Beith Road meaning that flood free access to and from the site should be possible in such an event.

It is recommended that care be exercised in the design of access points so that the road does not act as a flow pathway routing excess surface water from into the site and flooding properties.

6 Development Requirements

The following requirements will be necessary to enable development of this site:

6.1 Site Specific

- Finished Floor Levels should be raised above the adjacent levels of Beith Road along the south-western site boundary where Beith Road runs parallel to the Powgree Burn.
- An Overland Flow Pathway, as described in Section 5.2, be provided. This would need to be designed in line with the necessary guidance at a later date.
    - Ground Levels and Finished Floor Levels would need to be raised above the levels of the overland flow pathway to provide additional freeboard.
- A Cut-off channel, or similar interception structure, is recommended to mitigate against the residual risk of flows overtopping from Burn 1 into the site.
- Existing overland flow pathways should be maintained to permit flows to enter and flow through the site along the northern site boundary and south-eastern site boundary. Alternatively, flows could be intercepted at the site boundary and conveyed through the site leaving the site in the same location as they do currently.

6.2 General

- Ground levels are designed to shed surface water away from buildings and towards suitable drainage outlets to mitigate against flooding;
- Finished Floor Levels of all habitable development raised above the surrounding ground levels;
- A suitable Drainage Assessment is undertaken to confirm the site can be drained.

7 Summary and Conclusions

Kaya Consulting Limited was commissioned by Jordan Electrics Limited, through JNP Group Consulting Engineers Glasgow Ltd, to undertake a Flood Risk Assessment in support of a development at Longbar Avenue, Beith in North Ayrshire.

The site is greenfield farmland, situated off Beith Road. The site is bounded to the north by existing residential development on Longshot Road; to the east by Caledonian Road and other industrial property and farmland; to the south by Auchengree Road; and a small number of cottages and to the west by Beith Road and some further greenfield land and cottages. Proposals are for a residential development.

An assessment of flood risk posed by the Powgree Burn suggest that the site does not lie within the floodplain of this watercourse for a 1 in 200-year or 1 in 200-year + 55% climate change event.

Nevertheless, Finished Floor Levels should be raised a minimum of 0.6m above the 1 in 200-year + CC water levels. The site is generally a minimum of 0.6m above the adjacent 1 in 200-year + CC water levels in the Powgree Burn. To provide additional mitigation it is recommended that Finished Floor Levels of properties along the south-western site boundary where Beith Road runs parallel to the Powgree Burn are raised above the levels of Auchengree Road.

An assessment was undertaken to determine the flood risk posed by Burn 1.

The results suggest that the site does not lie within the functional floodplain of this watercourse. However, in the event of blockage of Culvert 2 and the inability of flows to re-enter Culvert 3 at Junction 1 flows would be anticipated to be conveyed along the line of Culvert 3 along the site boundary.

To mitigate against this flood risk an Overland Flow Pathway should be provided along the line of Culvert 3 within the site. This overland flow pathway will need to be designed to accommodate flows from both Burn 1 and Burn 2, in case of blockage of the culvert in this location. This means a channel capacity of 1.8 m^3/s is required (See Section 5.22). A freeboard of a minimum of 0.6m should be provided between the predicted 1 in 200-year + CC water level and proposed Finished Floor Levels of the properties. Refer to Section 5.2 for more information. It may be necessary to construct a means for flows to pass from Burn 1 to the Overland Flow Pathway in the event of culvert blockage. This could be an overspill point on the raised footpath or a culvert under the raised footpath.

The site lies below the levels of Burn 1 where it runs parallel to the raised footpath and Burn 1. To further mitigate against the residual flood risk, it is recommended that a cut-off channel, or similar measure, is provided adjacent to the raised footpath to intercept any flows that may spill over the raised footpath. Careful level design will need to be undertaken to ensure that this can be designed to work with the levels of the site. It should be emphasised that this is to protect development from a residual flood risk and it does not lie within the functional floodplain.

For clarity on the flood risk posed by Burn 1, refer to Sections 3.1 and 5.2.

Consideration will need to be given to surface water entering the site along the northern site boundary and south-eastern site corner. Overland flow pathways should be maintained to permit flows to enter and flow through the site as they do currently. Alternatively, flows could be intercepted at the site boundary and conveyed through the site leaving the site in the same location as currently. When designing the development, it is recommended that ground levels are designed to shed surface water away from buildings and towards suitable drainage outlets to mitigate against flooding. Finished Floor

Levels should be raised above the surrounding ground levels to further mitigate against the flood risk posed by surface water.

The site is not considered to be at significant risk of flooding from groundwater sources. However, recommendations have been made in Section 5.4. The design of the site drainage system is not part of this commission. Recommendations with respect to flood risk are provided in Section 5.5.

The results of the assessment suggest that in the event of a 1 in 200-year + 55% climate change event flows would be contained predominantly within the valley of the Powgree Burn. Any flooding of roads would be limited to Auchengree Road. Site access is proposed via Beith Road meaning that flood free access to and from the site should be possible in such an event.

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