David & Claire MacTaggart

Proposed development at Hallrule Farm, Bonchester Bridge Scottish Borders

Flood Risk Assessment

Final

November 2018

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SEPA CHECKLIST

Flood Risk Assessment (FRA) Checklist

(SS-NFR-F-001 - Version 13 - Last updated 15/04/2015)

This document should 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						
Site Name		Hallrule Farm, Boinchester Bridge				
Grid Reference	Easting:	358753		Northing: 613949		
Local Authority		Scottish Borders Council				
Planning Reference number (if known)						
Nature of the development		Residential		If residential, state type:		
Size of the development site		10.45	Ha			
Identified Flood Risk	Source:	Fluvial		Source name:	Hallrule Burn	
Supporting Information						
Have clear maps / plans been provided within the FRA (including topographic and flood inundation plans)		Yes				
Has a historic flood search been undertaken?		Yes				
Is a formal flood prevention scheme present?		No		If known, state the standard of protection offered		
Current / historical site use						
Hydrology						
Area of catchment		5.41	km^2			
Qmed estimate			m^3/s	Method:	Catchment Descriptors	
Estimate of 200 year design flood flow		10.38	m^3/s			
Estimation method(s) used *		Rainfall-runoff		If other (please specify methodology used):		
				If Pooled analysis have group details been include[d]	Select from List	
Hydraulics						
Hydraulic modelling method		1D dynamic		Software used:	ISIS	
If other please specify						
Modelled reach length		1033	m			
Any structures within the modelled length?		Bridges		Specify, if combination		
Brief summary of sensitivity tests, and range:						
variation on flow (%)		20	%			
variation on channel roughness		±20%				
blockage of structure (range of % blocked)		50	%	Reference CIRIA culvert design guide R168, section 8.4		
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		m AOD	200 year plus climate change		m AOD

Flood Risk Assessment (FRA) Checklist

(SS-NFR-F-001 - Version 13 - Last updated 15/04/2015)

Coastal						
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			
Development						
Is any of the site within the functional floodplain? (refer to SPP para 255)		Yes		If yes, what is the net loss of storage		m^3
Is the site brownfield or greenfield		Greenfield				
Freeboard on design water level (m)		0.6	m			
Is the development for essential civil infrastructure or vulnerable groups?		No		If yes, has consideration been given to 1000 year design flood?	Select from List	
Is safe / dry access and egress available?		Vehicular and Pedestrian		Min access/egress level		m AOD
If there is no dry access, what return period is dry access available?			years			
If there is no dry access, what is the impact on the access routes?	Max Flood Depth @ 200 year event:		m	Max Flood Velocity:		m/s
Design levels	Ground level		m AOD	Min FFL:		mAOD
Mitigation						
Can development be designed to avoid all areas at risk of flooding?		Yes				
Is mitigation proposed?		No				
If yes, is compenstory storage necessary?		Select from List				
Demonstration of compensatory storage on a "like for like" basis?		Select from List				
Should water resistant materials and forms of construction be used?		Yes				
Comments						
Any additional comments:		Development will be located outside the predicted functional floodplain.				

Approved by: M Stewart
Organisation: Kaya Consulting Ltd
Date: 16.08.2017

1 Introduction

Kaya Consulting Ltd. was commissioned by David & Claire MacTaggart through Ferguson Planning to undertake a flood risk assessment for a proposed development at Hallrule Farm, Bonchester Bridge, Scottish Borders. The site is currently undeveloped.

The Hallrule Burn flows in an easterly direction through the site and is the main source of flooding risk. SEPA Indicative Flood Maps show site partially within the floodplain. Therefore, a flood risk assessment is required to assess the risk of flooding from the watercourse, as well as flood risk from surface water runoff, groundwater and any existing drainage systems.

The scope of the work for the flood risk assessment includes:

- Walkover site visit;
- Liaison with the local council to obtain relevant information;
- Review of historical maps;
- Assessment of design flows for the unnamed watercourse;
- Construction of mathematical model of the Hallrule Burn;
- Assessment of flood risk from the river and other sources;
- Identification of outline flood management measures, if required; and
- Report suitable for submission with the planning application and consistent with SEPA and council guidance (assuming all flood issues can be mitigated for).

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

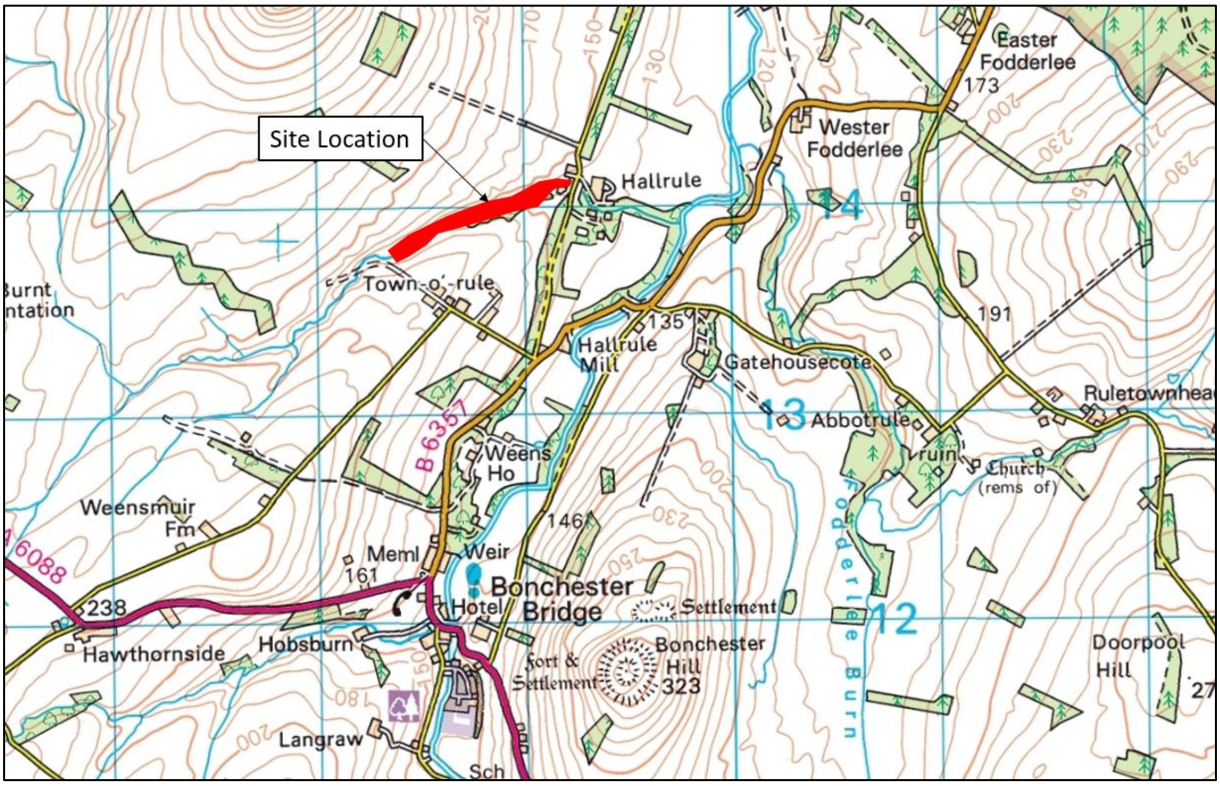
- Watercourse cross sections specifically obtained for this study in 2017; and
- Proposed site location;

A general location map of the site is shown in Figure 1.

The development is for holiday housing and associated roads and drainage.

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 site location



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 (NPF) 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 NPF.

Some extracts from the SPP 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 National Indicative River and Coastal Flood Map (Scotland)

The SEPA third generation flood map shows the likely extent of flooding for high, medium and low likelihood events for fluvial, pluvial (surface water) and tidal flows. Consultation of the maps show part of the site within the floodplain of the Hallrule Burn. SEPA maps are indicative and detailed assessment is required for any site in close proximate of SEPA flood extent.

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 10, July 2018). 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 4 of the guidance (2018) 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 centers and telecommunications installations required to be operational during flooding* • emergency dispersal points* • hospitals* • schools* • care homes* • nurseries • residential institutions, e.g. prisons, children's homes • basement dwellings • isolated dwelling(s) in sparsely populated areas • dwelling houses situated behind informal embankments[2] • caravans, mobile homes, chalets and park homes intended for permanent residential use • holiday caravan, chalet, 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 • environmental monitoring stations • 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:

1. Specific locational requirements of the development and availability of alternative locations;
2. Consideration of any loss of floodplain storage (in riverside developments) that may increase flood risk to nearby existing development and options to mitigate against this;
3. Appropriate mitigation measures, including water resistance and resilience measures;
4. Health and safety implications and the need for access, egress, and evacuation, with specific consideration of, and provision of, measures to provide for these where:
    - The development will attract the public especially vulnerable people such as children and old people.
    - Large numbers of the public may gather and where evacuation routes are limited.
    - Hazardous materials are stored or processed.

[4] In this context, specific warning does not mean a formal flood warning from SEPA. SEPA does not support the provision of flood warning as a viable reason to develop in flood risk areas. Warning is a non-structural measure that does not physically prevent flooding and has associated uncertainties.

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). May be suitable for other Most Vulnerable Uses if the risk from a 0.1%AP event can be alleviated through appropriate mitigation, 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.	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.	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.	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

	• 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.	• 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.	• 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.		
Medium to high risk within undevelop ed 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.

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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

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 recommend a 20% increase in peak flow for the 0.5% AEP (1:200) event, in accordance with DEFRA (Department of Environment, Food and Rural Affairs) and recent Scottish Government research. Although the 2009 climate change predictions (UKCP09) provides information on spatial variations, for current studies a 20% increase in peak flows is assumed.

It is recommended that any site drainage design considers future estimates of increased precipitation and follows an adaptive approach.

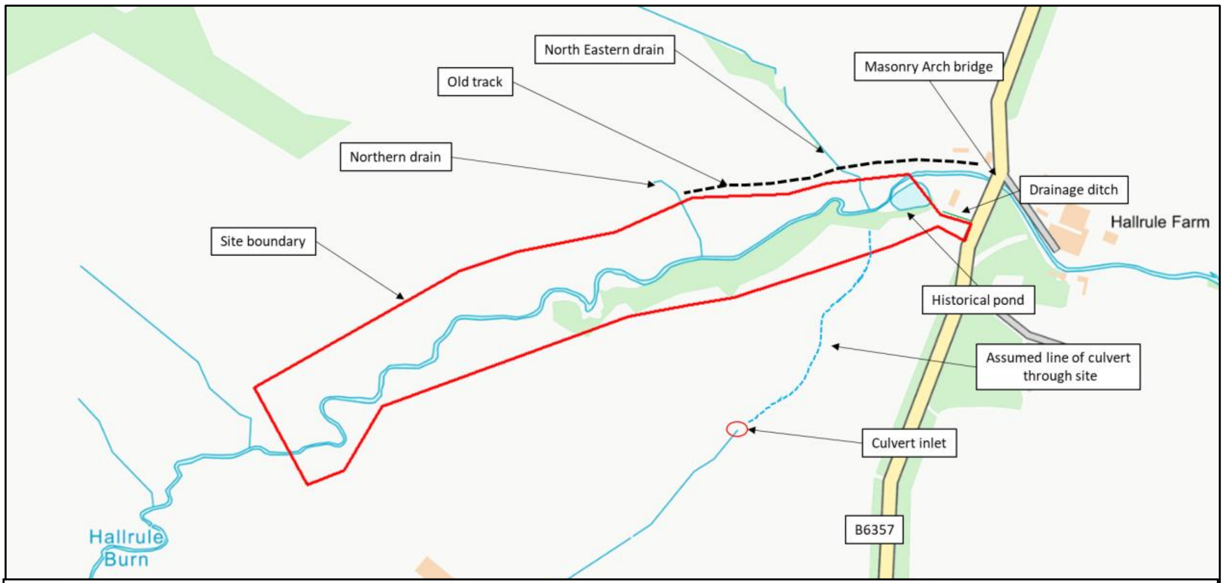
The Climate Change (Scotland) Act 2009 also makes reference to adaptation to climate change.

3 Site Location and Description

The proposed development site is located in an area to the west of Hallrule Farm, 2.4 km to the north of the town of Bonchester Bridge, Scottish Borders. The site sits on the valley of the Hallrule Burn surrounded by woodlands (Photo 1). Agricultural land bounds the site to the north, south and west; farm buildings and the B6357 road bounds the eastern edge of the site.

The site is greenfield and currently undeveloped, measuring approximately 10.45ha in area. The proposed development plans are for holiday chalets. A detailed site location plan is provided in Figure 2.

Figure 2: Detailed site location



Ordnance Survey mapping indicates a pond close to the eastern boundary of the site; however, during a site walkover this pond could not be viewed and is believed to be drained. A land drain was noted between the north east site boundary and a private property, likely installed to intercept surface water runoff from reaching private property to the north.

Three small watercourses are shown to drain into the Hallrule Burn. The North Eastern Drain falls south in a deep incised channel approximately 0.8 m by 1.1 m deep before flowing over an old track on entering the site, see Photo 2. Ground levels rise east and west of the track; hence, flood waters would not expect to leave this channel upstream of the site. Upon reaching the site the channel drops almost vertically before entering the Hallrule Burn.

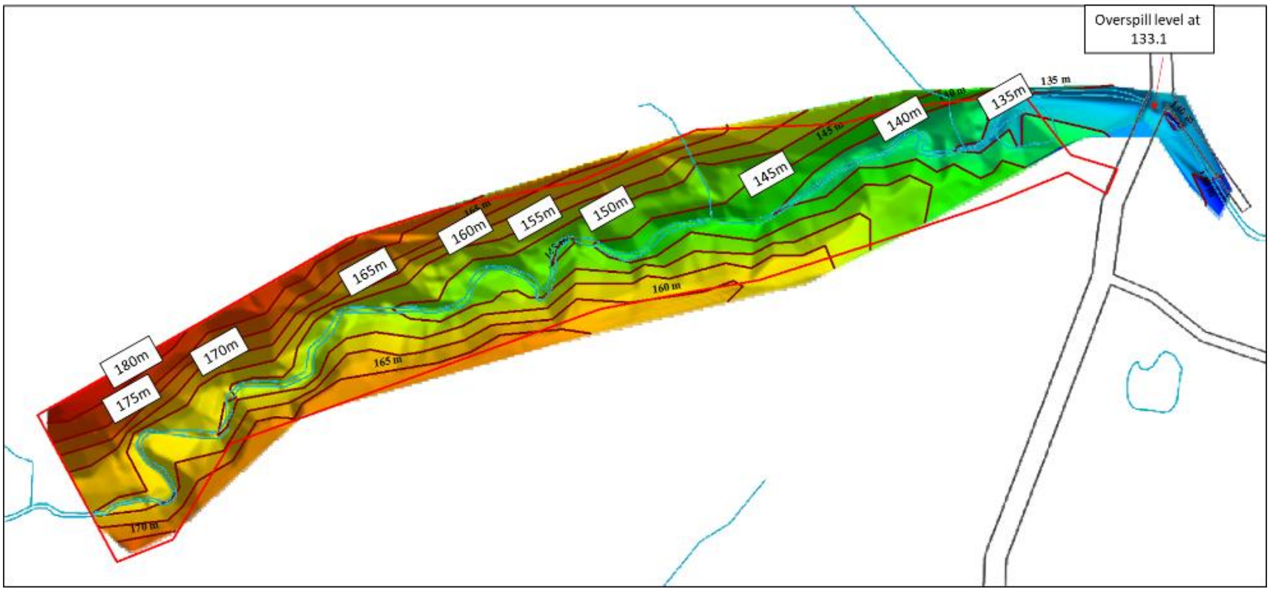
The Northern Drain is shown on Ordnance Survey maps. Land upstream of the site falls towards the location of the channel and any flows in the channel will stay within the indicated line of the channel shown on the map. This area was dry and well vegetated during the site visit and the channel within the site could not be accessed due to the steepness of the land on the northern side of the site.

Approximately 170 m to the south of the site, a channel drains agricultural land before entering a culvert under the adjoining field before discharging into the channel. The inlet to the drain could not be accessed during the site visit; however, based on a vegetation line taken from satellite imagery, the approximate line of the culvert is shown in Figure 2.

The general topography of the site was derived based on a topographical survey undertaken for this assessment and is shown in Figure 3.

The site ranges in elevation from around 180m AOD (Above Ordnance Datum) in the west and falls to approximately 135m AOD in the east, which is the lowest elevation within the site. The site slopes relatively steeply towards the burn on either side of the watercourse. Ground levels on the B6357 have also been surveyed which indicates that overtopping level on the road at the downstream end of the site is approximately 133.1 m AOD.

Figure 3: Site topography



The Hallrule Burn flows in an easterly direction through the middle of the site (Photo 3 and 4), in a steep sided valley. Approximately 650m downstream of the site the burn enters the Rule Water. The catchment of the Hallrule Burn at the downstream end of the site was measured to be 5.4 km^2. The Hallrule Burn runs under the B6357 immediately downstream of the site (Photo 5). The bridge is a masonry arch in construction and measures approximtey 5 m wide and 3m high from the arch to the bed.

Photo 1: Development site looking north from the upstream end

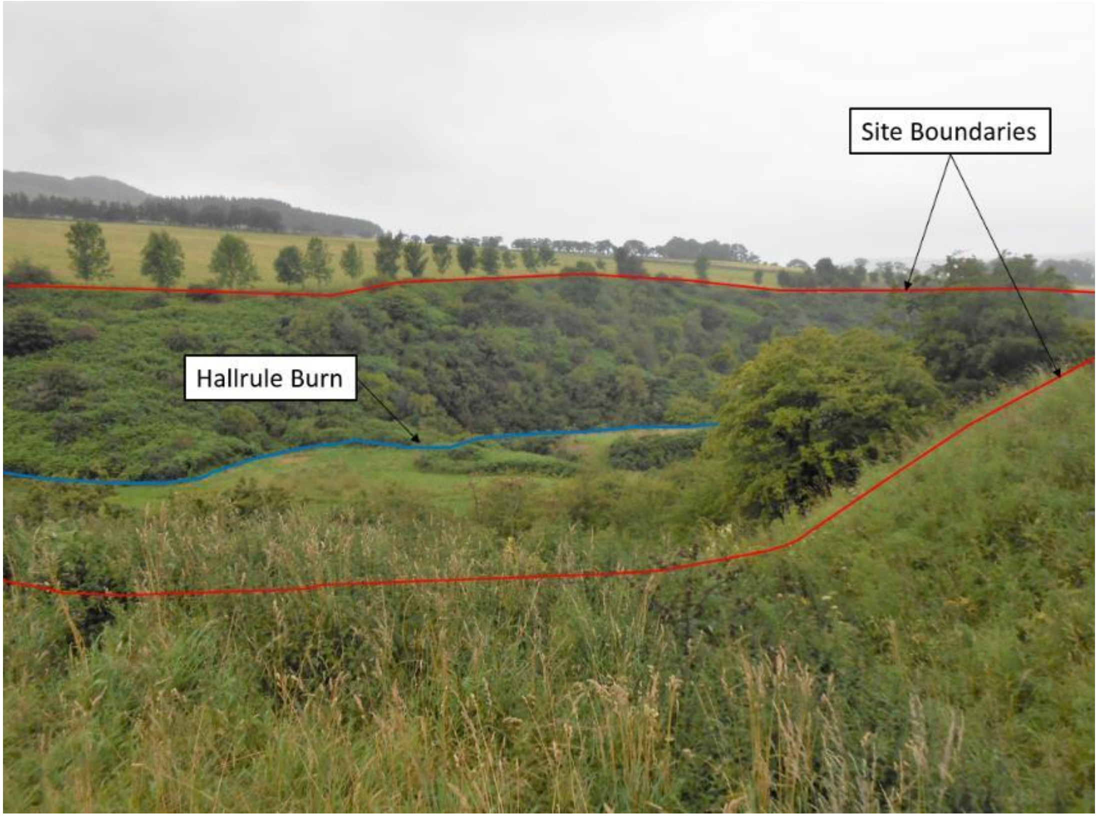


Photo 2: North Eastern Drain passing over track and entering north east corner of site

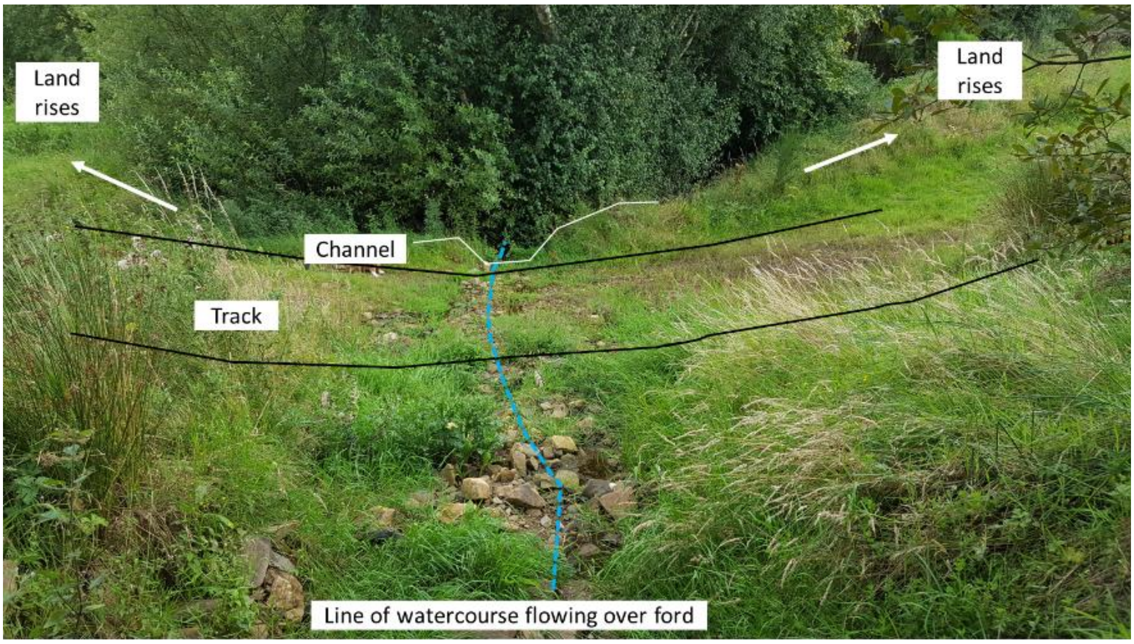


Photo 3: Hallrule Burn at the upstream end of site

Photo 4: Hallrule burn at the downstream end

Photo 5: B6357 road bridge (view from upstream side)

4 Hydrological Analysis

The hydrological assessment makes estimates of design flows for the Hallrule Burn downstream of the site.

4.1 Catchment Description

The catchment at the site was estimated to be 5.41 km^2 using the Flood Estimation Handbook (FEH) web service. It is rural and its extent is shown in Figure 4 and the catchment characteristics are shown in Table 1.

Figure 4: Hallrule Burn catchment obtained from FEH Web Version

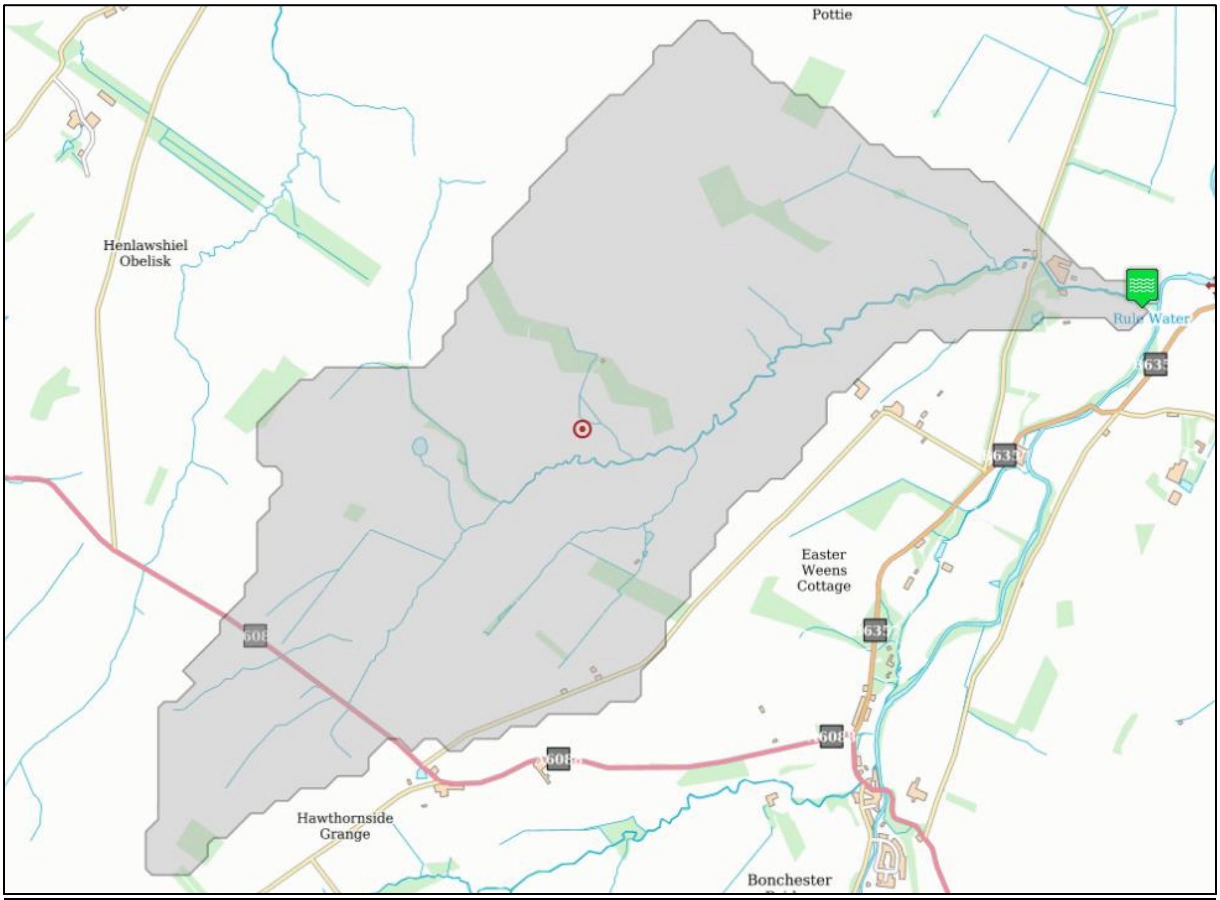


Table 1: Catchment characteristics for the Hallrule Burn at site

Parameter	Value
EASTING (m)	359700
NORTHING (m)	613900
AREA (km²)	5.41
ALTBAR (m)	227
ASPBAR (°)	102
ASPVAR	0.4
BFIHOST	0.427
DPLBAR (km)	3.09
DPSBAR (m/km)	80.4
FARL	1
LDP	5.61
PROPWET	0.57
SAAR (mm)	847
SAAR4170 (mm)	832
SPRHOST	37.9
URBCONC1990	-999999
URBEXT1990	0
URBLOC1990	-999999
URBCONC2000	-999999
URBEXT2000	0
URBLOC2000	-999999

4.2 Estimation of design flows

Design flows for the river were estimated using the industry standard Flood Estimation Handbook (FEH), the Revitalised Flood Hydrograph (ReFH) 2 method and the Institute of Hydrology (IH) small catchment method (Report 124).

The different flow estimation methods calculate a range of flows which are tabulated in Table 2, FEH method generated the most conservative flow and as a result is used for the assessment giving a 200 year return period flow estimate of 10.4m^3/s.

The effects of climate change are considered by increasing the 200 year design flow by 20% (i.e. 12.5m^3/s).

Table 2: Comparison of return period flow estimates for the Hallrule Burn downstream the site

Return Period (years)	200 year return period flow (m^3/s)	200 year return period + 20% flow (m^3/s)
FEH Rainfall-Runoff[a]	10.4	12.5
ReFH2[b]	8.6	10.4
IH124[c]	5.6	6.75

a Catchment design storm duration = 4.9 hrs, 2013 rainfall was used
b Catchment design storm duration = 3.5 hrs. Winter storm was used as the catchment is rural
c SAAR = 847mm, Area = 5.41km2, SOIL= 0.40, URBEXT = 0

5 Hydraulic Assessment

In order to predict water levels along the Hallrule Burn in the vicinity of the site, a 1D mathematical model of a section of the river was constructed. The model is based on Flood Modeller software.

The extent of the modelled reach is approximately 1.33km as shown in Figure 5.

5.1 Mathematical Modelling of Hallrule Burn

The Hallrule Burn flows in an open channel before passing under the B6357 which is included in the model. Details of the bridge is provided in Table 3.

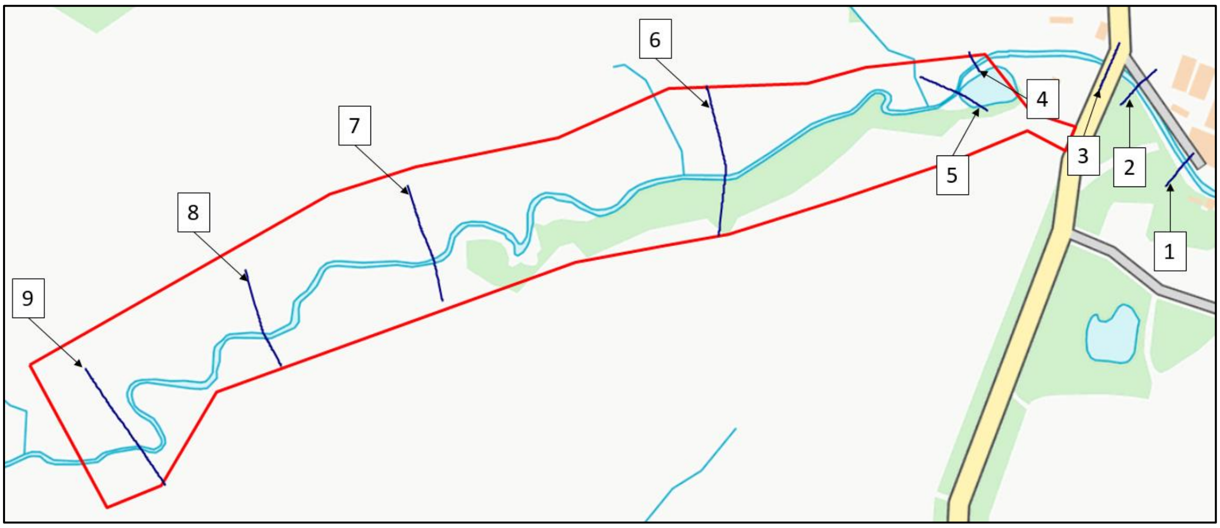
Table 3: Bridge details

Structure	Location	Details
Bridge	Local road	Masonry single arch bridge; 6m span opening; 5.5m width; soffit level 132.46m AOD.

A total of 9 cross sections were surveyed and included in the model (Figure 5).

The channel friction (Manning's roughness coefficient, *n*) was set at 0.035 in the main channel and 0.080 on the left and right overbanks. Sensitivity analysis was undertaken with roughness values increased by 20%.

Figure 5: Cross section locations (denoted blue)



The upstream boundary condition is a flow hydrograph boundary (1 in 200 year flow as described in Section 4) with the shape based on rainfall-runoff hydrograph and peak adjusted to design flow rate. The downstream end of the model is a normal depth boundary which slope was set at 1 in 100 based on the slope of the river bed.

The bridge was modelled using the standard Flood Modeller arch bridge module, using default parameters, based on the topographical survey provided by the client.

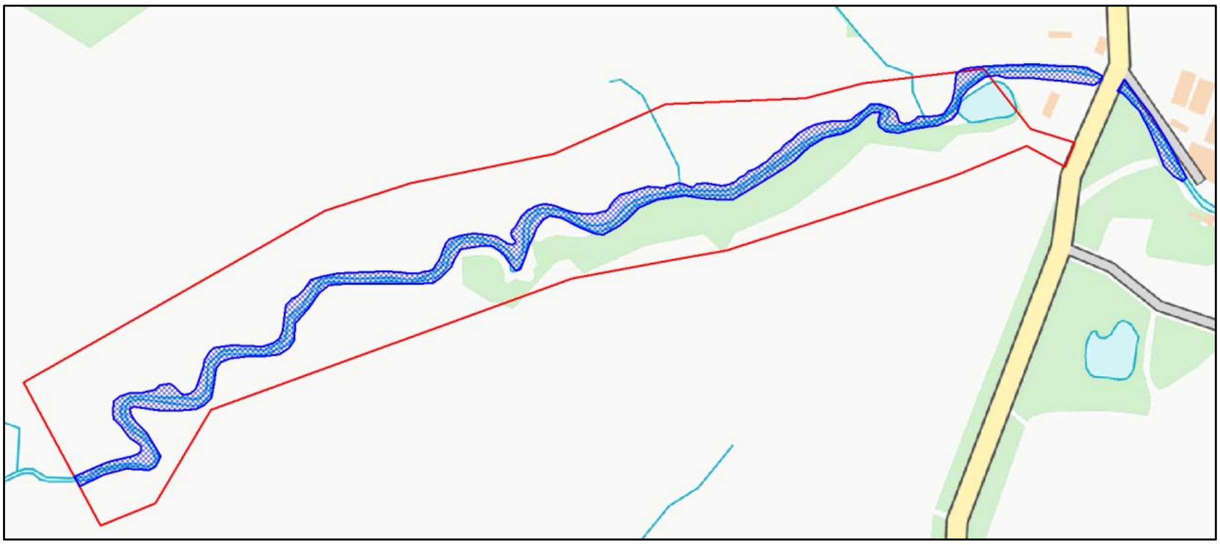
5.2 Model results

The model was run with 1 in 200 year flow with and without climate change. Predicted peak water levels at all cross sections along the modelled channel are given in Table 4 (to be read in conjunction with Appendix 1). The results indicate that the predicted water level for both the 200 and 200 plus climate change events are confined within low-lying ground close to the channel, overtopping of the main channel occurs only few points covering small flat areas along the edge of the burn. The bridge is not predicted to be overtopped or surcharged. The predicted flood extent is shown in Figure 6.

Table 4: Predicted 200 year flood levels (m AOD) (with and without climate change). XS in the site highlighted in light blue

XS	200 year Water level (m AOD)	200 year +CC Water level (m AOD)
9	159.4	159.5
8	153.5	153.6
7	148.9	149.0
6	141.2	141.3
5	134.3	134.3
4	133.5	133.6
3	130.8	130.9
2	130.0	130.1
1	128.8	129.0

Figure 6: 200yr event flood map (flood extent denoted in blue)



5.3 Sensitivity Analysis

A model sensitivity analysis provides an illustration of the effect of changing key model parameters on the important model outputs (in our case flood levels). By re-running the model for a range of scenarios and changing one input parameter for each model run, the effect of each input on the model results can be isolated. If model parameters are varied within the range of possible input values, then a sensitivity analysis can also provide an indication of uncertainty associated with the model predictions.

The sensitivity analysis considers changes in parameters as outlined in Table 5 and results shown in Table 6.

Table 5: Model sensitivity analysis runs

Scenario no.	Change to model
1	Flow increased by 20%
2	Manning's n increased by 20%
3	Manning's n decreased by 20%
4	Blockage of bridge by 50%
5	Downstream boundary increased by a factor of 2

Table 6: Sensitivity analysis results.

XS in the site highlighted in light blue

XS	Baseline Case water level (m AOD)	Water level (m AOD)				
		Sc1	Sc2	Sc3	Sc4	Sc5
9	159.4	0.1	0.1	-0.1	0.0	0.0
8	153.5	0.1	0.1	-0.1	0.0	0.0
7	148.9	0.1	0.1	-0.1	0.0	0.0
6	141.2	0.1	0.1	-0.1	0.0	0.0
5	134.3	0.0	0.1	-0.1	0.0	0.0
4	133.5	0.1	0.1	-0.1	0.0	0.0
3	130.8	0.1	0.1	-0.1	0.4	0.0
2	123.0	0.1	0.1	-0.1	0.0	0.0
1	128.8	0.2	0.1	-0.1	0.0	0.0

A 20% increase in flow causes peak water level to increase approximately 0.1m throughout the site.

The sensitivity analysis shows that increasing and decreasing channel and floodplain by ±20%, water levels would increase and decrease in the same proportion, i.e. 0.1m at the site.

Blockage of the bridge by 50% shows that water levels at the site only would be affected at the upstream side of the bridge. The bridge is not predicted to be surcharged or overtopped.

Changes on the downstream boundary slope are not predicted to increase or decrease water levels at the site, therefore the downstream boundary is considered to be located far downstream enough to not change water levels.

6 Flood Risk Assessment

The flood risk assessment considers flooding from:

- Hallrule Burn;
- Surface water runoff, including minor drains;
- Groundwater;
- Site access; and
- Site drainage and local sewer.

6.1 Flood risk from Hallrule Burn

The Hallrule Burn flows in an easterly direction through the middle of the site before passing under the B6357 and entering the Rule Water downstream of the site. The burn drains a catchment of approximately 5.4 km^2 downstream of the site.

A 1D hydraulic model was constructed using Flood Modeller mathematical modelling software. The model included 9 surveyed channel cross sections and details of a masonry arch bridge. The model was run for 200 year and 200 year plus climate change flows.

Modelling results indicated that flows are predicted to be retained within the bottom of the valley, either within bank or flooding land adjacent to the bank. Ground levels rise steeply from the channel and changes in flow, Manning’s n or bridge blockage has limited impact on flood levels or the flood inundation extent. areas along the reach.

Based on SPP and the results of this assessment, we would recommend there is no development (including SuDS) within the 200 year + climate change floodplain in the site. We would also recommend there is no development within a 10m buffer on either side of the floodplain area to allow for maintenance and to account for any uncertainties in the modelling.

It is recommended that Finished Floor Levels are set at least 1 m above the 200 year plus climate change levels tabulated in Table 4 and referenced with Figure 5 (cross section location).

6.2 Surface water runoff from adjacent land, including minor drains

The risk of surface water runoff directly from adjacent drains has been assessed as well as from general surface water ingress to the site, see Figure 8 for reference.

North East drain

High ground rises to approximately 350 m AOD, around 1 km to the north of the site. Two drains are noted on Ordnance Survey maps falling south and flowing through the site. The catchment of the North Eastern Drain has been delineated and is predicated to measure approximately 80 ha. The drain is confined within a deep channel with ground levels which rise up away from the channel. Upon reaching the northern boundary of the site the channel discontinues and water flows over an old track, ground levels rise up to the east and west of the track, resulting in flood waters continuing south towards the site. Within the site the channel slope is steep, almost vertical and flood waters fall to the burn some 10 m below. Due to the steep slope of the drain within and out with the site, and the fall of ground east and west of the channel, flood waters are not predicted to overtop the channel and spread. If development is proposed along the north of the site, it is recommended that this channel is formalised and directed towards the Hallrule Burn in a new channel.

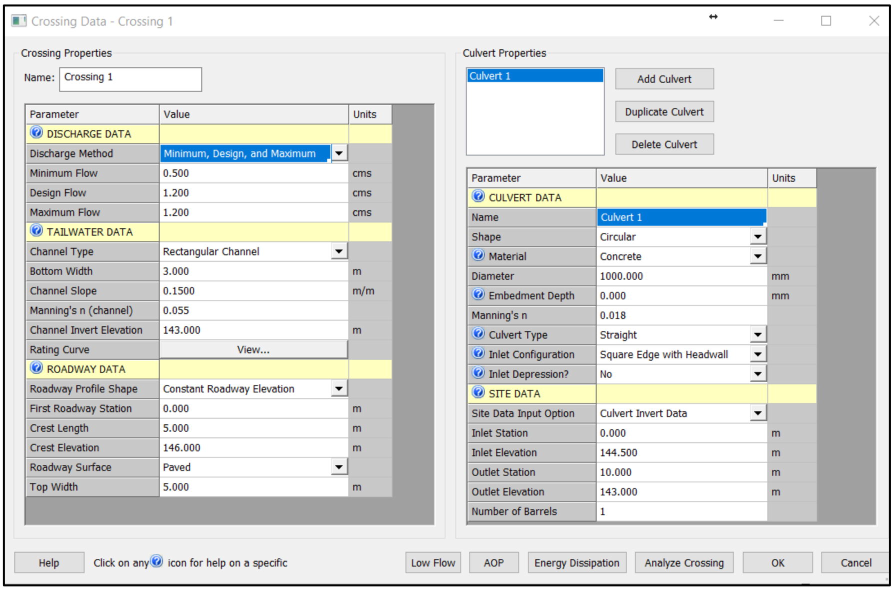
For a catchment of 80 ha, a 200 year flow would be of the order of approximately 1 m^3/s based on the IH124 method. For a slope of 1 in 5 (based on topographic survey) a channel measuring 0.25 m and 0.7 m deep with 1 in 2 side slopes, would be sufficient to convey the 200 year plus climate change flow with 0.3 m freeboard.

<u>Northern drain</u>

The Northern Drain could not be identified during the site visit. Following the site visit and review of 1 to 25,000 Ordnance Survey contours, it is confirmed that ground levels also rise to the east and west of the drain which has a catchment that measures approximately 20 ha. However, the track does not continue to the location of the drain channel and discontinues around 30 m to the east of the drain. The drain falls steeply within a deep channel before discharging to the Hallrule Burn. It is recommended that, if development is proposed within the north of the site, this channel is formalised within the site so that flood waters are not able to spread within the site, upstream of the Hallrule Burn.

Based on design drawings, the Northern Drain will be culverted. Assuming a conservative flow of 1.2 m^3/s, based on the 200 year plus climate change of the larger North Eastern Drain, a culvert of 1 m diameter would be able to pass the flow without surcharging, see calculation parameters below.

Figure 7: Culvert calculations



<u>Southern drain</u>

High ground rises to approximately 255 m AOD, around 1.5 km to the south west of the site. An open drain rises to the east of Town-o'-rule and flows towards the site before entering a culvert and passing under land along the southern boundary of the site. The culvert discharges within the site but could not be accessed due to the steepness of the channel.

The catchment of the southern drain has been delineated and is predicated to measure approximately 25 ha. Upstream of the site the drain is confined within a sloping valley with ground levels rising up away from the channel. The capacity of the culvert could not be ascertained; however, due to the steep slope of the drain within and out with the site, and the fall of ground east and west of the channel, any flood waters not able to enter the culvert upstream of the site are not predicted to overtop the wider channel and spread.

The proposed access track will likely cross the line of the culvert of the Southern Drain. It is recommended that if the drain is encountered during the site investigations then the culvert is replaced with a similar size pipe and gradient. It is also recommended that the road is raised sufficiently so that in the event of a blockage to the culvert (to the south of the site), dry access can be maintained. It is also recommended that emergency bypass culverts are constructed at the lowest point in the road to allow any overland flow to pass under the road to maintain dry access.

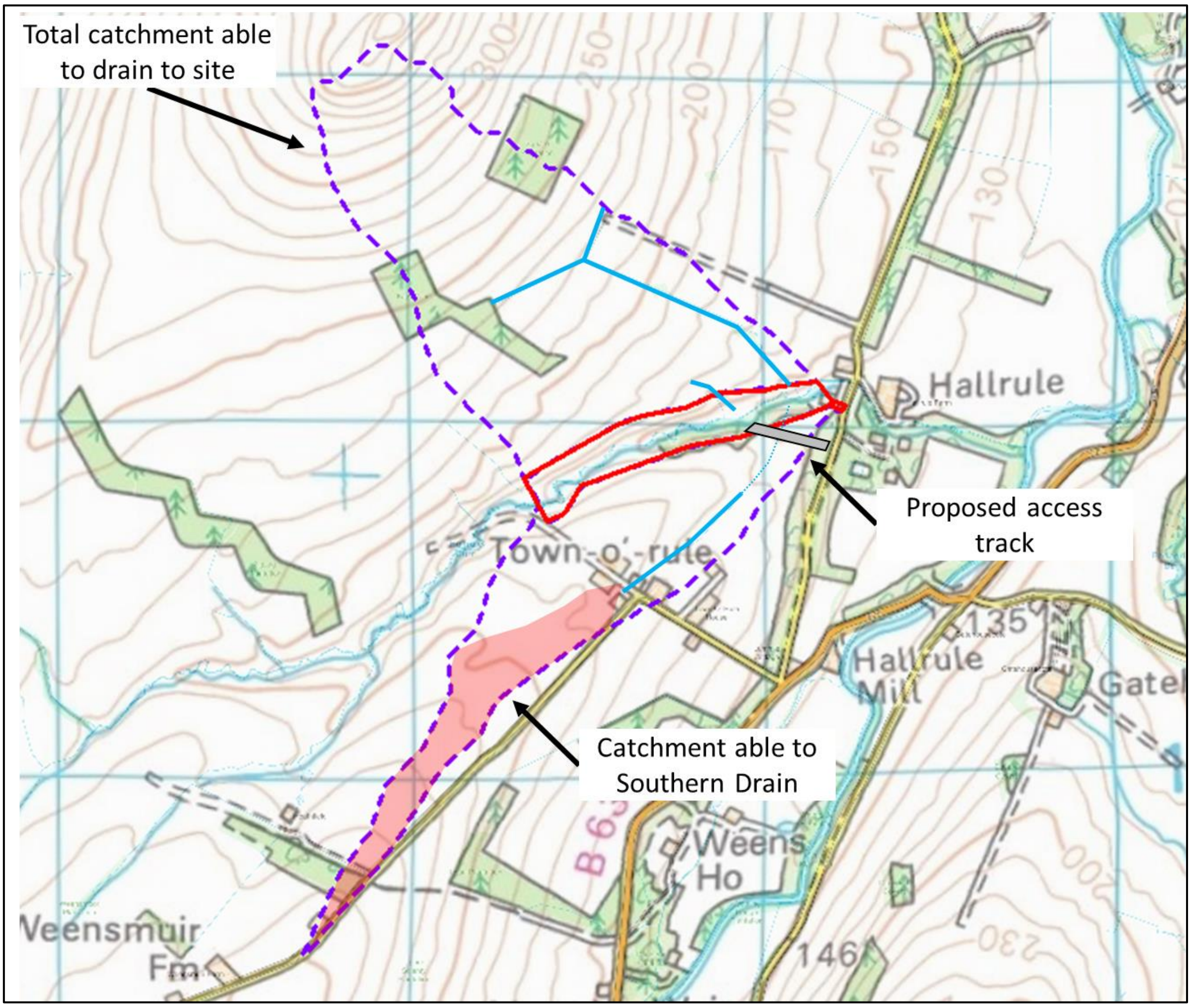
General surface water

Inflow from three drains has been assessed and described above, ground levels rise to the north and south of the site and surface water runoff would be expected to reach the site from high ground. It is likely that in areas not falling towards a drain channel, surface water would reach the site in a distributed manner across the northern and southern boundaries.

It is recommended that local measures are implemented to mitigate against surface water ingress. Ground levels and properties should be raised above local ground levels to encourage flows to discharge into the Hallrule Burn between buildings with no flooding of properties. If a significant number of properties are proposed and this is not practical (i.e., limited space between buildings) then alternative measures could include construction of an interception ditch to capture and route surface water runoff through the site via arranged surface water flow pathways.

Given the steep slope of land to the north of the site there is a risk of surface water entering the site along the northern boundary. However, given the length of the site boundaries to the north and south and limited catchments for the defined drains, flood risk should be able to be managed through simple flood management measures and appropriate design.

Figure 8: Indicative surface water flow pathways within and around the site.



6.3 Groundwater

At the time of writing, there is no information on groundwater levels in the vicinity of the site. No evidence of a spring or well was recorded on the site visit or on historical maps. However, given the slope of land and forested nature of the site there may be small springs and areas of poorly drained ground that will need to be considered at the detailed design stage.

Details of the proposed application are not known at this stage. If elevated groundwater levels are observed during site investigations and construction, then appropriate measures would need to be taken with regards to the design of appropriate types of foundations will need to take account of ground water conditions.

6.4 Site access

Access to the site is proposed from the B6357. Adjacent to the access, the road slopes down to the north at a low point at the arch bridge. As the site entrance is proposed on higher ground to the south of the bridge, waters are not predicted to pond or entering the site.

As discussed above, the proposed access track will likely cross the line of the culvert of the Southern Drain. It is recommended that if the drain is encountered during the site investigations then the culvert is replaced with a similar size pipe and gradient. It is also recommended that the road is raised sufficiently so that in the event of a blockage to the culvert (to the south of the site), dry access can be maintained. It is also recommended that emergency bypass culverts are constructed at the lowest point in the road to allow any overland flow to pass under the road to maintain dry access.

The Hallrule Burn is proposed to be crossed, it is recommended that the soffit of the bridge it set to a level of 1 m above the 200 year plus climate change level.

6.5 Risk of flooding from the site drainage system and local sewers

As the site is greenfield and previously undeveloped, the proposed development would increase runoff over that generated from the site at present. However, current requirements and best practice is to limit the discharge of surface water runoff from the developed site to greenfield runoff rates.

Design of the site drainage system (including SuDS) was not part of this commission. The requirements for SuDS should be discussed and agreed with the local council, SEPA and Scottish Water if any flood mitigation measures implemented are to vest in them.

It is good practice to provide within the development site an appropriate overland flow route through which flood waters could escape in the event of the site being flooded during floods exceeding the design flows or following blockage of the site drainage system.

7 Flood Risk Management Summary and Conclusions

This report describes a flood risk assessment for a proposed development at Hallrule Farm, Bonchester Bridge, Scottish Borders. The site is currently undeveloped.

The Hallrule Burn flows in an easterly direction through the middle of the site before flowing under a large arch bridge and discharging into the Rule Water approximately 650m downstream the site.

A 1D mathematical model was constructed from surveyed cross sections. Modelling results indicated that water levels are largely predicted to stay in bank, overtopping only few points covering small flat areas along the reach. The arch bridge is not predicted to be overtopped or surcharged. Based on SPP we would recommend there is no development (including SuDS) within the 200 year floodplain in the site. The Hallrule Burn is predicted to be crossed to provide access to the site, it is recommended that the soffit of the bridge is set 1 m above the 200 year plus climate change level.

Three drains are shown to flow through the site before discharging into the Hallrule Burn. Due to land rising away from the drains, the assessment indicated that during extreme events flood waters would remain close to the line of the channels and not spread. It is recommended that the channels are maintained and formalised within the site so that flood waters are not able to spread within the site, upstream of the Hallrule Burn. The Northern Drain will be crossed and it has been demonstrated that a culvert of 1m diameter would be sufficient to pass the 200 year flow.

In addition, ground levels rise to the north and south of the site and surface water runoff would be expected to reach the site from high ground. It is likely that in areas not falling towards a drain channel, surface water would reach the site in a distributed manner across the northern and southern boundaries.

It is recommended that local measures are implemented to mitigate against surface water ingress. Ground levels and properties should be raised above local ground levels to encourage flows to discharge into the Hallrule Burn between buildings with no flooding of properties. The site access road is predicted to pass over the culvert of the Southern Drain; it is recommended that the road is raised sufficiently so that in the event of a blockage to the culvert (to the south of the site), dry access can be maintained. It is also recommended that emergency bypass culverts are constructed at the lowest point in the road to allow any overland flow reaching the road embankment to pass under the road. This will maintain dry access to the site.

The site is not predicted to be at significant risk of flooding from any other sources.

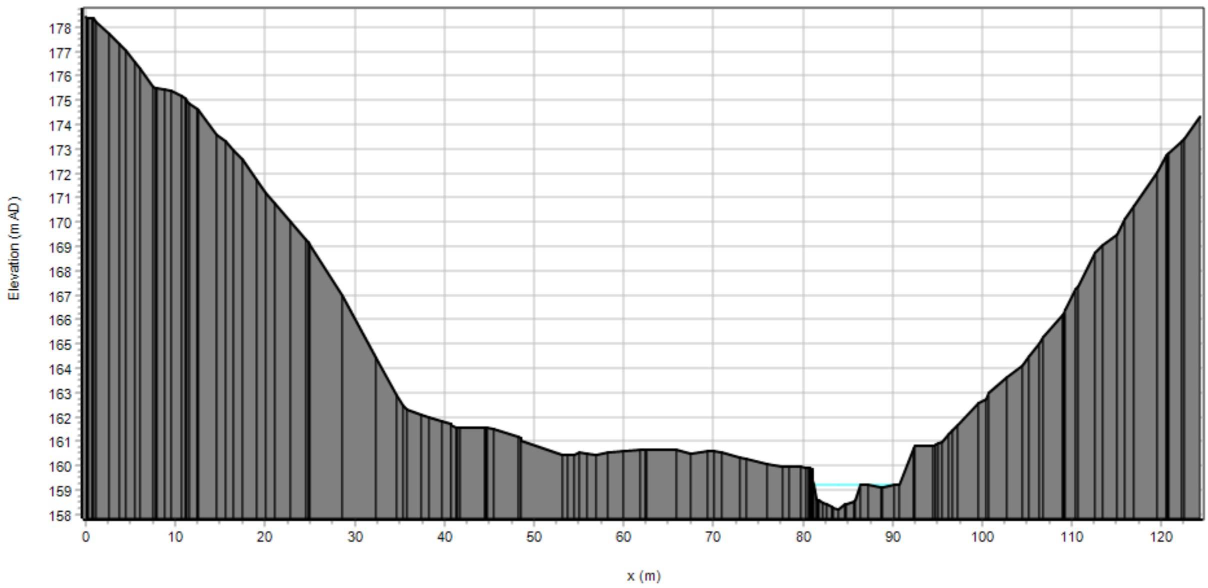
Design of the site drainage system was not part of this commission. It is good practice to provide within the development site an appropriate overland flow route through which flood waters could escape in the event of the site being flooded during floods exceeding the design flows or following blockage of the site drainage system.

As with any design, maintenance is an important requirement for an effective drainage system. Regular maintenance programs need to be implemented for all components of the drainage system.

Appendix - Channel cross sections

200 year return period flood event predicted peak water levels

XS9


Elevation (m AD)
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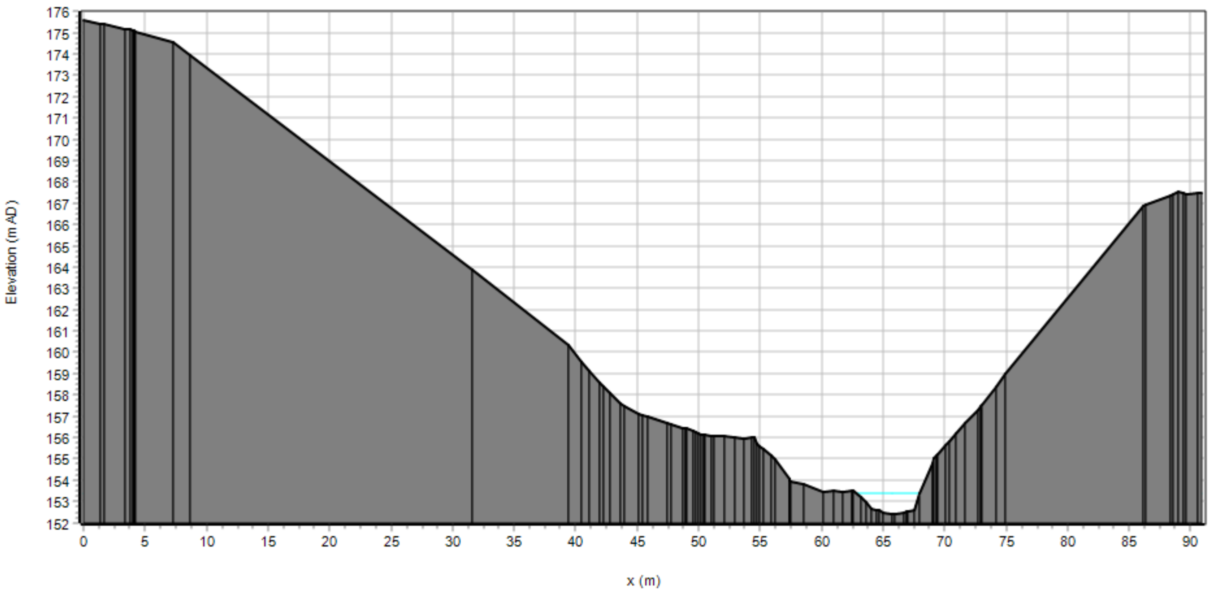
176
175
174
173
172
171
170
169
168
167
166
165
164
163
162
161
160
159
158
0
10
20
30
40
50
60
70
80
90
100
110
120
x (m)

XS8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154
153
152
0
5
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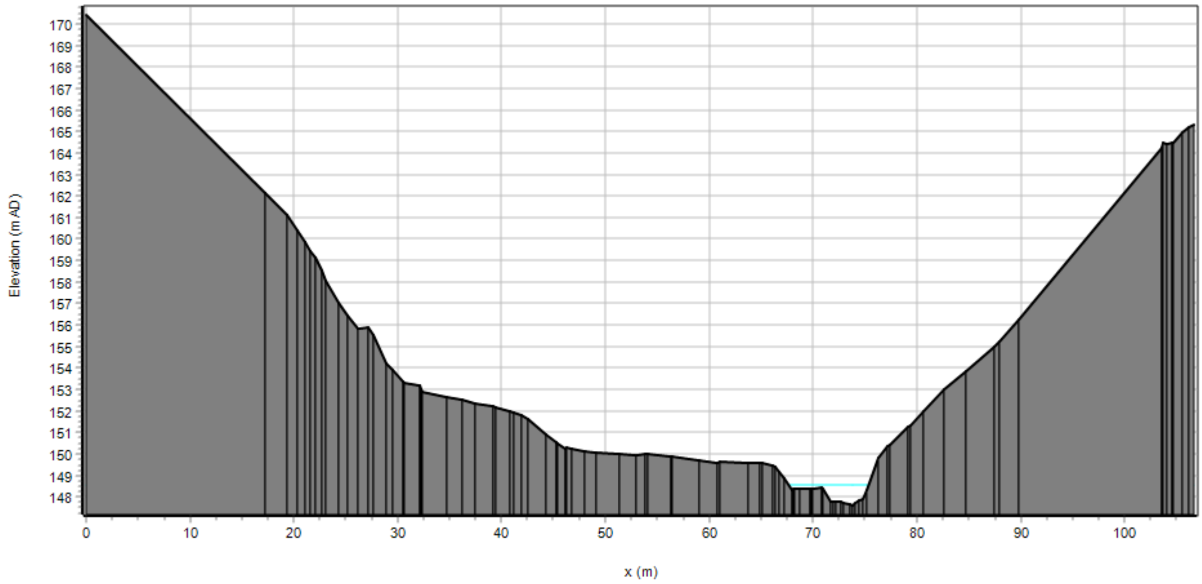
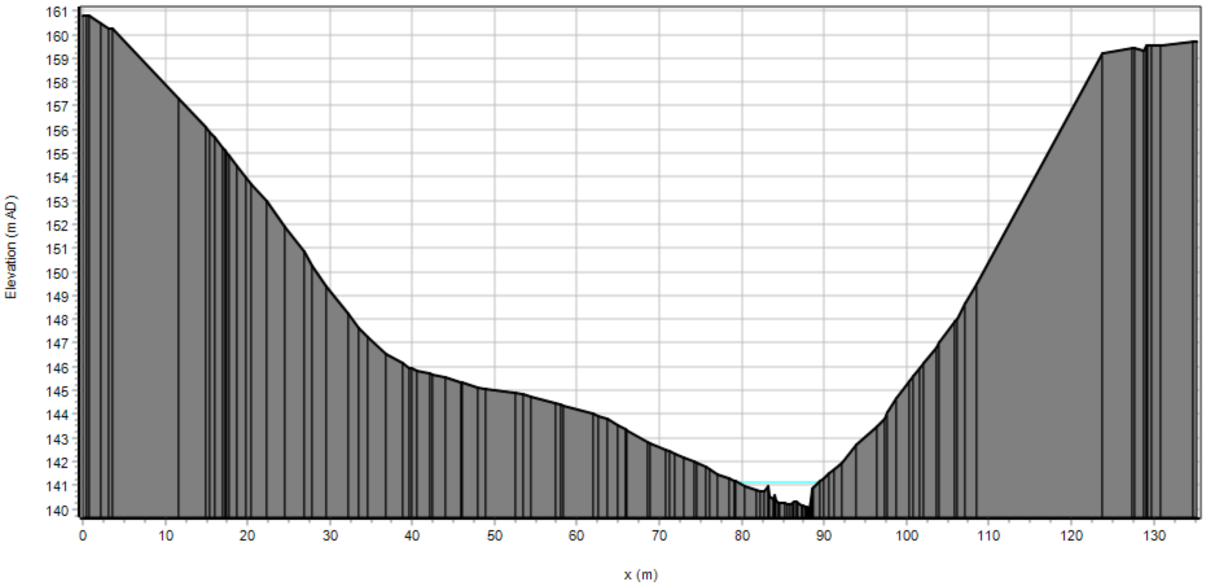
40
45
50
55
60
65
70
75
80
85
90
x (m)

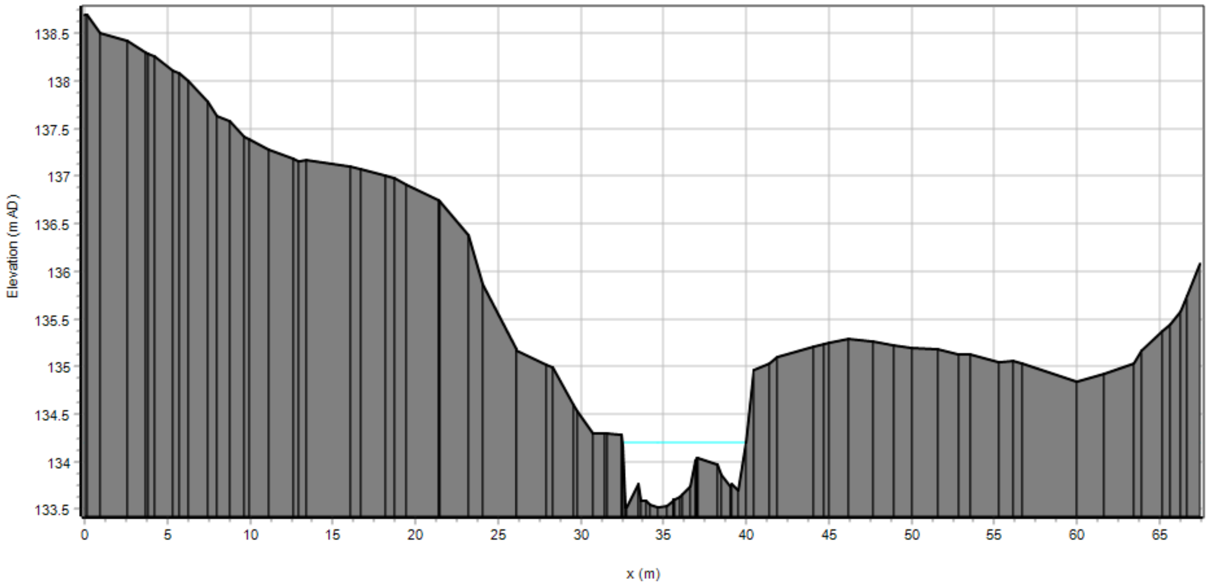
XS7



XS6



XS5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136.5
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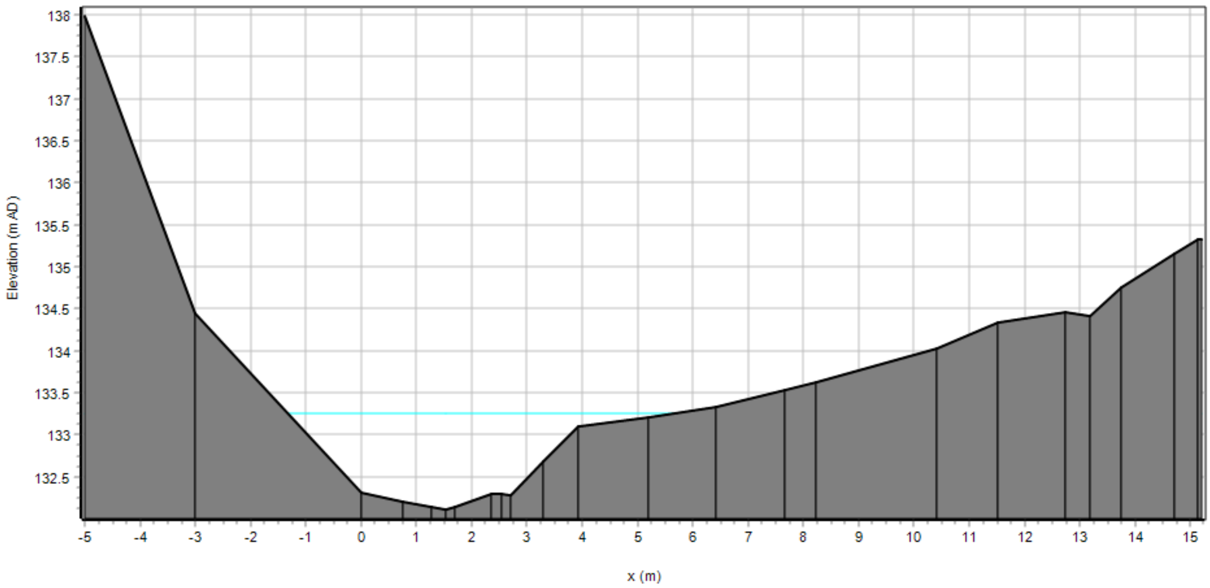
60
65
x (m)

XS4


Elevation (m AD)
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-3
-2
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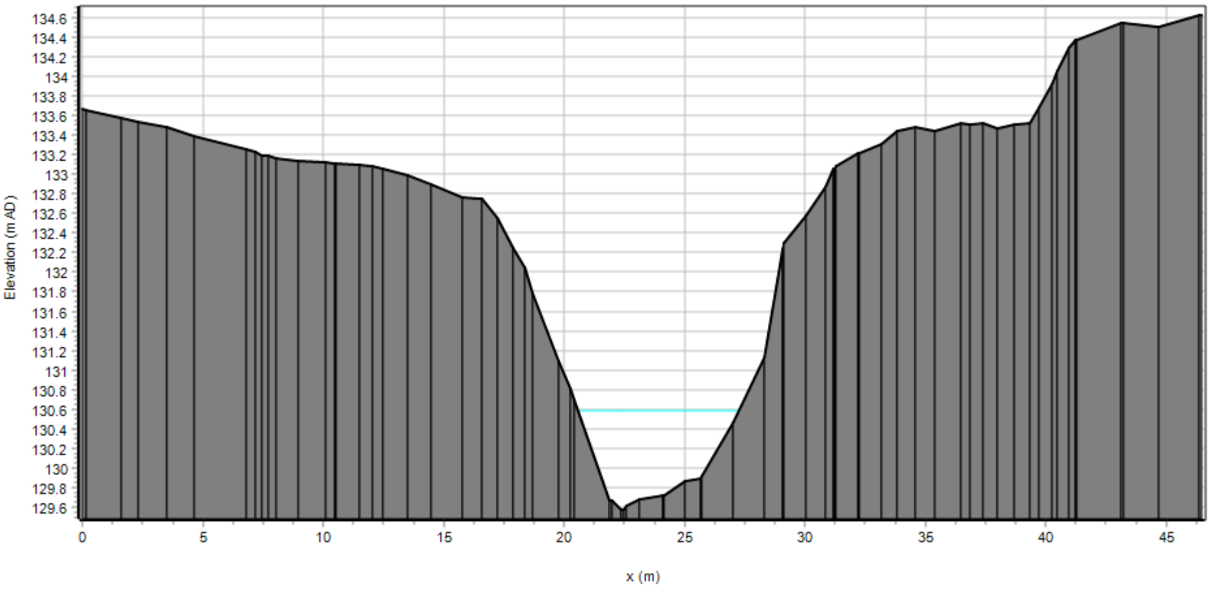
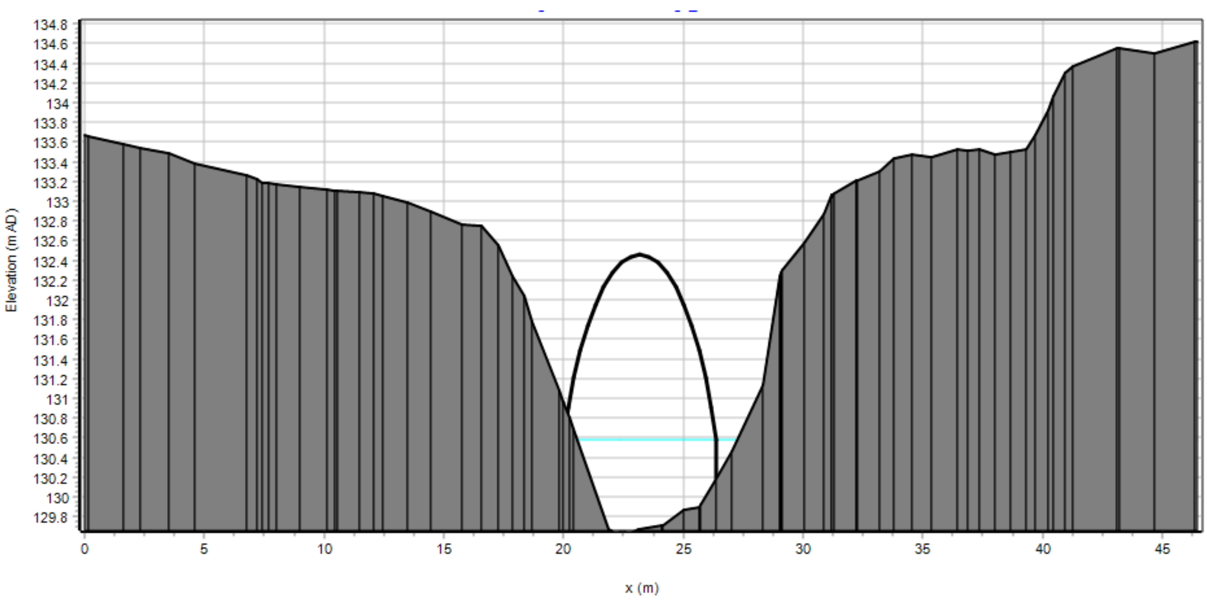
14
15
x (m)

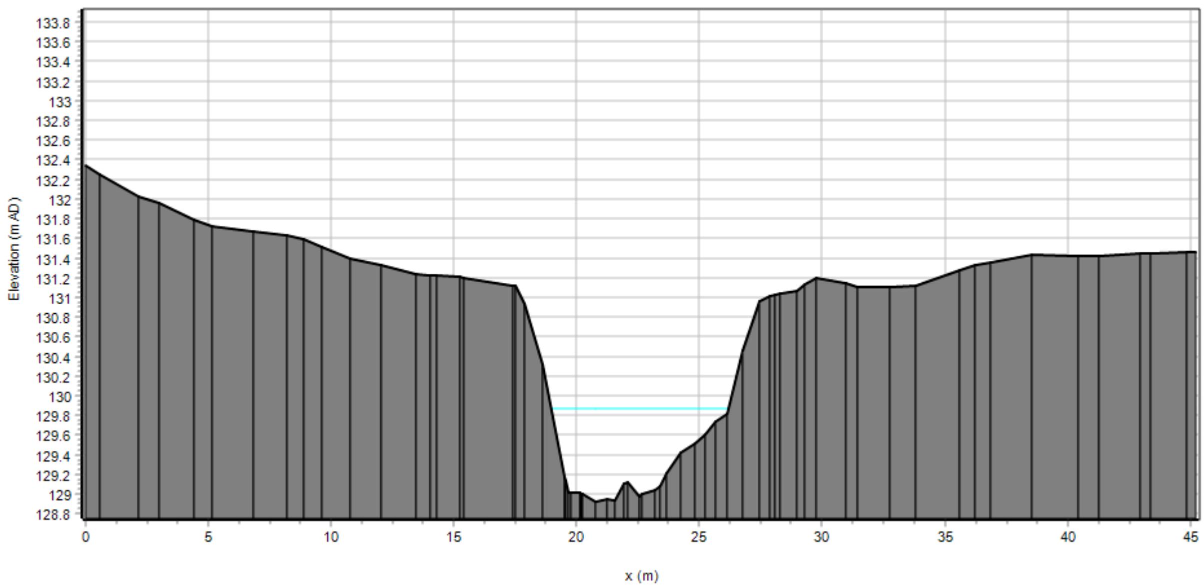
XS3



Bridge



XS2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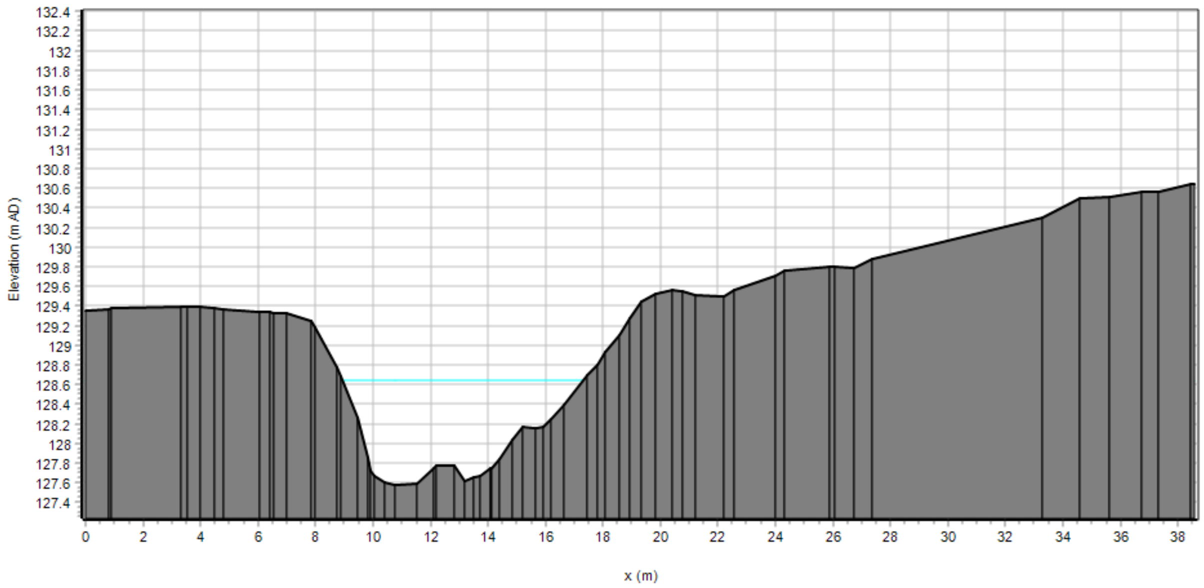
40
45
x (m)

XS1


Elevation (m AD)
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130
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129.2
129
128.8
128.6
128.4
128.2
128
127.8
127.6
127.4
0
2
4
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x (m)