Loreburn Housing Association

Land North of Selkirk Road, Moffat

Flood Risk Assessment

Revised Final

October 2019

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Document Information and History

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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:		Selkirk Road, Moffat				
Grid Reference:	Easting:	308228	Northing:	604554		
Local Authority:		Dumfries and Galloway Council				
Planning Reference number (if known):						
Nature of the development:		Residential		If residential, state type:		
Size of the development site:			Ha			
Identified Flood Risk:	Source:	Fluvial		Source name:	Crosslaw, Frenchland, Small Drain	
Land Use Planning						
Is any of the site within the functional floodplain? (refer to SPP para 255)		No		If yes, what is the net loss of storage?		m^3
Is the site identified within the local development plan?		Select from List		Local Development Plan Name:		Year of Publication:
				Allocation Number / Reference:		
If yes, what is the proposed use for the site as identified in the local plan?		Select from List		If Other please specify:		
Does the local development plan and/or any pre-application advice, identify any flood risk issues with or requirements for the site.		No		If so, please specify:		
What is the proposed land use vulnerability?		Highly Vulnerable		Do the proposals represent an increase in land use vulnerability?	Yes	
Supporting Information						
Have clear maps / plans been provided within the FRA (including topographic and flood inundation plans)?		Yes				
Has sufficient supporting information, in line with our Technical Guidance, been provided? For example: site plans, photos, topographic information, structure information and other site specific information.		Yes				
Has a historic flood search been undertaken?		Yes		If flood records in vicinity of the site please provide details:		
Is a formal flood prevention scheme present?		No		If known, state the standard of protection offered:		
Current / historical site use:		Fields				
Is the site considered vacant or derelict?		No				
Development Requirements						
Freeboard on design water level:		0.6	m			
Is safe / dry access and egress available?		Vehicular and Pedestrian		Min access/egress level:		m AOD
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?		Yes				
If yes, is compenstory storage necessary?		Yes				
Demonstration of compensatory storage on a "like for like" basis?		Yes				
Should water resistant materials and forms of construction be used?		Select from List				

SEPA

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:		km^2	Is a map of catchment area included in FRA?	Select from List
Estimation method(s) used (please select all that apply):	Pooled Analysis ☐		If Pooled analysis have group details been included?	Select from List
	Single Site Analysis ☐			
	Enhanced Single Site ☐			
	ReFH2 ☐			
	FEH RRM ☐			
	Other ☑		If other (please specify methodology used):	
Estimate of 200 year design flood flow:		m^3/s		
Qmed estimate:		m^3/s	Method:	Catchment Descriptors
Statistical Distribution Selected:	Select from List		Reasons for selection:	

Hydraulics

Hydraulic modelling method:		Linked 1D 2D		Software used:	Flood Modeller
				If other please specify:	
Number of cross sections:					
Source of data (i.e. topographic survey, LiDAR etc):		Topographic		Date obtained / surveyed:	Jul-05
Modelled reach length:			m		
Any changes to default simulation parameters?				If yes please provide details:	
Model timestep:					
Model grid size:					
Any structures within the modelled length?		Select from List		Specify, if combination:	
Maximum observed velocity:			m/s		
Brief summary of sensitivity tests, and range:					
variation on flow (%)		Jan-00	%	Please specify climate change scenario considered:	20
variation on channel roughness (%)		20	%		
blockage of structure (range of % blocked)		25-50	%		
boundary conditions:		**Upstream**			**Downstream**
(1) type		Flow			Normal depth
	Specify if other			Specify if other:	Head-Time
(2) does it influence water levels at the site?		No			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
Cross section results provided?		Yes			
Long section results provided?		Yes			
Cross section ratings provided?		No			
Tabular output provided (i.e. levels, velocities)?		Yes			
Mass balance error:			%		

Coastal

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

Comments

Any additional comments:

Approved by: **MS, CA**
Organisation: **Kaya Consulting Ltd.**
Date: **21-Aug-19**

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 Ltd. was commissioned by Loreburn Housing Association through Asher Associates to undertake a Flood Risk Assessment for a proposed development on land north of Selkirk Road, Moffat.

The proposed development site is located to the east of the centre of Moffat. The site is greenfield measuring approximately 24 ha in plan area.

Development proposals include the construction of Extra Care Bungalows within the southern part close to Moffat Hospital and residential housing elsewhere.

There are three watercourses which could affect the site; Crosslaw Burn, which flows south along the central area of the site before passing under Selkirk Road and flowing away from the site; Frenchland Burn, a small watercourse which also flows south approximately 500 m to the south east of the site; and a Small Drain which flows east to west into the northern area of the site. The Birnock Water, a larger watercourse also flows south and south-west; however, the Birnock is located approximately 350 m to the west of the site and would not affect the site.

A flood risk assessment is required to consider the flood risk from the above watercourses, Scottish Water sewer system, surface water runoff from adjacent land and from groundwater.

The scope of work includes the following:

- Site visit and walkover survey;
- Hydrological analysis and calculation of design flows each watercourse;
- Assessment of the risk of flooding from the adjacent watercourses based on mathematical modelling;
- Assessment of the risk of flooding from local drainage network;
- Assessment of the risk of flooding from surface water runoff;
- Assessment of the risk of flooding from other sources including groundwater;
- Flood risk assessment based on the above; and
- Prepare and submit a technical report summarising the findings of the study and recommendations.

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

- Site location plan;
- Historical flooding photos; and
- Topographical survey of site and watercourses.

A general site location plan is shown in Figure 1.

1.1 Background

A Flood Risk Assessment for the southern half of the site was prepared previously and submitted to SEPA in March 2017, based on development proposals at that time. This involved construction, in the western part of the site, of residential properties associated with a respite care facility linked to the adjacent Moffat Hospital and social housing within the eastern part of the site. Part of this development encroached on the 200 year floodplain with landraising and compensatory storage proposed as part of the development. However, SEPA objected to landraising unless the development was proved to be 'exceptional' and could not be located elsewhere.

Subsequent to this Kaya Consulting Ltd. was commissioned by Dumfries and Galloway Council to prepare the Moffat Flood Study. The assessment included an extensive topographical survey and mathematical modelling of the Birnock, Crosslaw and Frenchland Burn. This report builds on the modelling work undertaken in the council study.

The current proposals involve no built development within the predicted floodplain, except from an access road which will require landraising and the provision of compensatory storage. A meeting was held with SEPA in March 2018 and a pre-application response was provided on the 22nd March (Reference: PCS/158112) summarising the meeting and SEPA's interpretation of the planning regulations regarding the application site. SEPA stated that, if formally consulted, they would be unlikely to object to the development, as long as certain principles could be adhered to (six general points, summarised in Table 1). Table 1 also details how these points are addressed in this report.

Table 1: SEPA consultation response and location of where points have been addressed in report

No.	Issue	Where Addressed in Report
1	The submission of appropriate modelling information for this site and verification from SEPA.	Section 5 and Appendix
2	All 'standard' residential development units (considered to be 'highly vulnerable' in relation to SEPA's Land Use Vulnerability Guidance) are to be located outwith the 1 in 200 year functional floodplain and mitigated to the appropriate standard (1 in 200 year flood level + freeboard).	Section 7
3	All 'critical infrastructure'/extra care units (considered to be 'civil infrastructure' in relation to SEPA's Land Use Vulnerability Guidance) are to be located outwith the 1 in 1000 year flood extent and mitigated to the appropriate standard (1 in 1000 year + freeboard).	Section 7
4	Any new bridge crossing that is constructed (e.g. shown in the southwest area of sketch masterplan drawing, ref: AA4777/EW/22) will be designed to the appropriate level i.e. capable of conveying the 1 in 200 year design flow plus an allowance for climate change (20% according to latest guidance).	Section 7
5	Any land raising proposed within the functional floodplain is for the purposes of facilitating safe road/pedestrian access and not to enable buildings or further development. Any floodplain volume lost as a result of land raising must be appropriately assessed and the compensatory storage to be provided will require to conform to SEPA's technical guidance.	Section 7

In March 2019, an updated Flood Risk Assessment was reviewed by SEPA as part of a pre-planning consultation. SEPA stated that, if formally consulted, they would object to the development, based on the information provided in the March FRA.

Following subsequent correspondence with SEPA regarding the March 19 objection (see Appendix D), the original assessment has been updated which seeks to address additional comments made by SEPA, see Table 2.

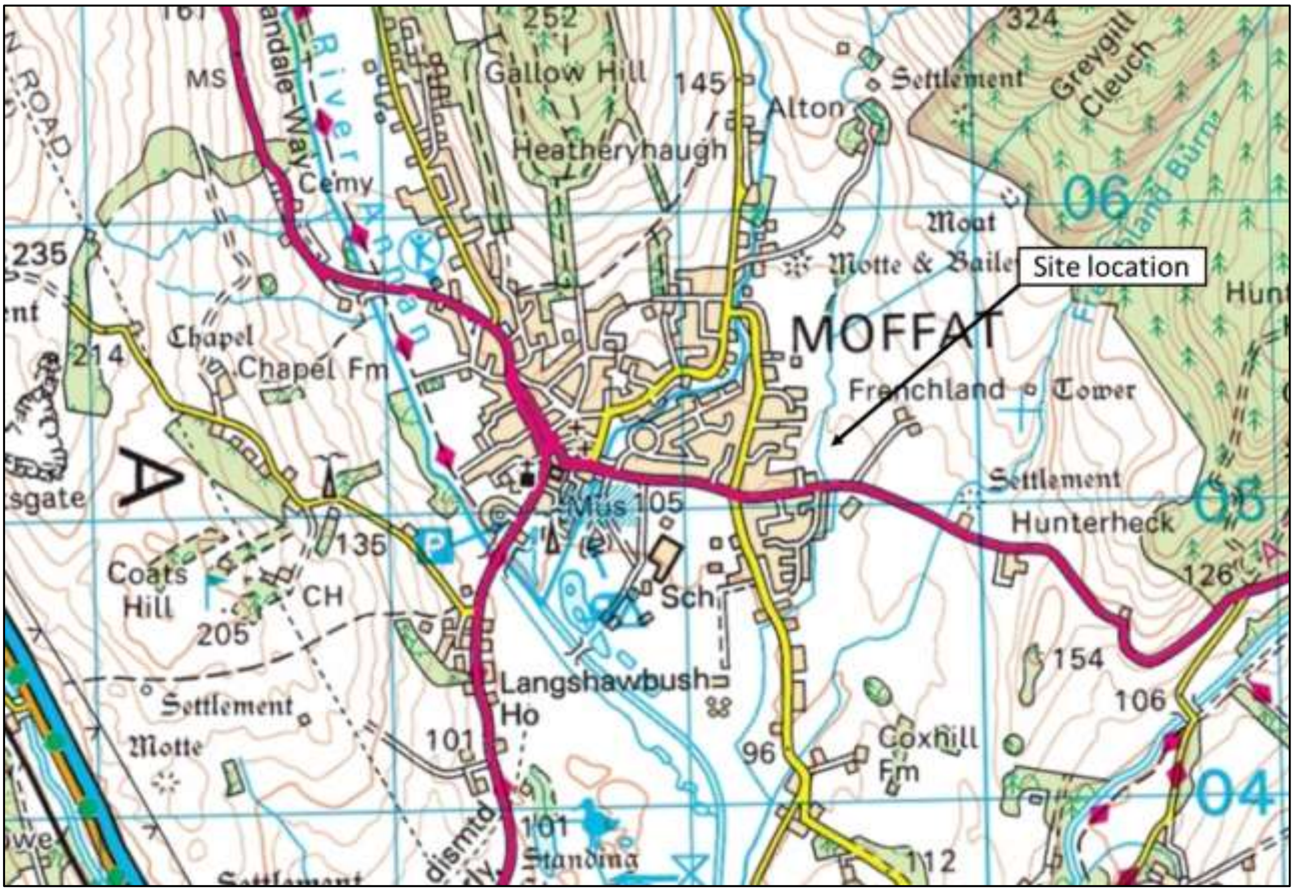
Table 2: SEPA consultation response of March 19 and location of where points have been addressed in report

No.	Issue	Where Addressed in Report
1	Compliance to the points raised in the 'letter of comfort' i.e. items provided in Table 1 above.	See Table 1
2	Submission of outstanding FRA outputs e.g. modelled cross sections, long profile, velocities, FRA checklist, bridge blockage assessments and associated flood extents/levels	Section 5 and Appendix
3	Justification on the change of flood estimation technique adopted for the Birnock Water	Section 4.2
4	Demonstration of a credible blockage scenario is put forward and justified, in order to refine the floodplain extent associated with a blockage scenario of the Auldton Road bridge structure	Appendix D, Section 7.1
5	Update to Figure 11 to clearly illustrate the flood depths and extents associated with an appropriate bridge blockage scenario	N/A
6	A reasonable assessment of blockage to the culvert and water gate structures in addition to the floodplain extents and levels associated with blockage	Section 5.5
7	Clarification on the floodplain associated with the small drains	Section 5.5
8	Submission of a combined flood risk map to show the flood extents associated with all sources of 'functional floodplain' including those separately assessed in Section 7 of the FRA. This will comprise the main watercourses (Crosslaw Burn, Birnock Water, Frenchland Burn) in addition to the small watercourses (drains, ditches) and blockage of key structures (Auldton Road Bridge, water gates, culverts)	Section 5.5
9	Demonstration of appropriate compensatory storage that complies with SEPA technical guidance and provides a neutral or better effect on flood risk	The development is at masterplan stage and final layouts have not been decided; however, it is likely that there is sufficient volume to provide compensatory storage within the design
10	Site layout and finished floor levels to demonstrate the highly vulnerable' and 'critical infrastructure' uses are appropriately sited and mitigated in relation to flood risk.	Section 7.5

The main issue SEPA required further information on related to the clarification of structure blockages and resulting floodplains. This is now discussed in the Sections outlined above; however, in summary, where channel structures are proposed to be removed for development they have been removed as part of the sensitivity analysis, if structures will remain then they have been included in the modelling. Model results indicate that the channels have sufficient capacity to accommodate blockages of structures without a change to the modelled flood extent except for a small reach where development is not proposed.

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 (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 flooding 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):

1. ***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 third generation flood maps show the likely extent of flooding for high, medium and low likelihood for fluvial, pluvial (surface water) and tidal flows. Consultation of the map indicates that part of the site is within the mapped fluvial floodplain of the adjacent watercourses.

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 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 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.

2.4 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.

2.5 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.

2.6 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 previously recommended 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 Scottish Government research.

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.

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

3 Site Location and Description

The site proposed for development is located to the east of the town of Moffat, between the A708 (Selkirk Road) and local access road leading to Auldton Cottages to the north. Figure 2 shows a detailed site location. The site is currently undeveloped, comprising of grass and scrub vegetation, Photo 1.

The site is bounded by existing residential development to the west and open land to the north and east. The A708 bounds the site to the south. The land ownership boundary is shown in red (approximately 24 ha in area) on Figure 2.

The general topography of the site was derived from topographical survey of the site and 1m LiDAR data which is illustrated in Figure 3. The site generally slopes in a southerly direction towards the A708. The highest elevation within the site is 133.5 m AOD (Above Ordnance Datum), at the north-east corner of the site and the lowest elevation is approximately 105 m AOD, found along the southern boundary of the site, next to the Crosslaw Burn culvert under the A708. The A708 is elevated above the site as it runs east to west along the southern boundary of the site, ground levels reach around 106.8 m AOD on the road. High ground rises to the east and north of the site.

The Crosslaw Burn is a small watercourse measuring between 3.5 – 5 m in width passing through the site in a southerly direction, see Photo 1. Within the site the natural channel is in poor condition having historically been moved and diverted along field boundaries; in addition, the channel is crossed by several field crossings for access to land on either side of the burn. At the downstream boundary of the site, the Crosslaw Burn passes under the A708 via a large conspan arch culvert, see Photo 2 and 3. The culvert is made of corrugated metal and measures approximately 2.1 m wide and 1.05 m deep. The A708 is raised above the land to the south; however, there is a 0.6 m diameter bypass culvert located under the raised road to allow flood waters to pass under the road and back into the Crosslaw, see Photos 4 and 5.

The Frenchland Burn runs south and south west approximately 500 to the south east of the site. The channel measures approximately 5m wide as it passes under the A708. The A708 bridge is comprised of a large masonry arch culvert and was surveyed measuring approximately 4.9 m wide by 2.2 m deep, see Photos 6 and 7. It should be noted that the Frenchland Burn is situated at a higher elevation to the site; hence, the risk of flooding of the site from flood waters overtopping the burn has been considered in this assessment.

Around 1.25 km downstream of the site the Crosslaw Burn and the Frenchland meet before discharging into the River Annan. At this location, the bed of the channel is around 92 m AOD compared to 105 m AOD upstream of the A708 at the site.

A tributary of the Crosslaw Burn drains land to the east of the site. The small drain flows south then westwards towards the site. The channel measures approximately 2 m wide and around 0.7 m deep and has also been diverted along field boundaries. The drain passes through a number of field boundaries before entering the Crosslaw Burn within the centre of the site.

The Birnock Water drains a large catchment to the north of the site before flowing south, around 350 m to the west of the site. The channel has been heavily modified as it passes within a deep channel close to adjacent residential properties. Close to the northern boundary of the wider area the channel passes under two road bridges; Ballplay Road and a local access road leading to Auldton Cottages.

The proposed development will comprise of solely residential development, in the form of respite care housing and social housing. Moffat Hospital lies along the western boundary of the site and there is a need for local development to serve the Hospital residential care services. It is necessary that the development is located close to the hospital buildings for operational requirements.

Figure 2: Detailed site location

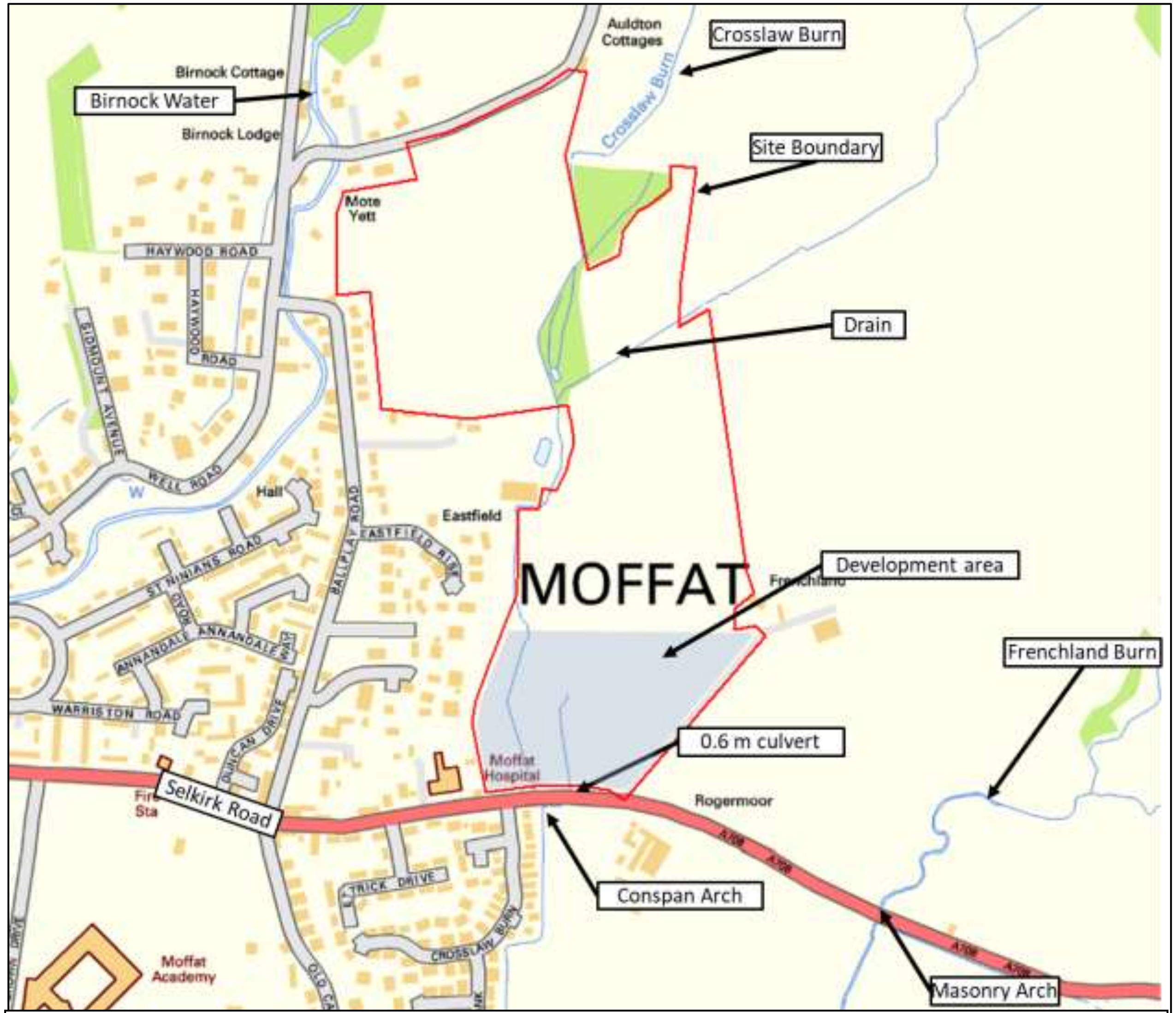


Figure 3: Site topography based on site topographical survey and 1 m LiDAR (m AOD)

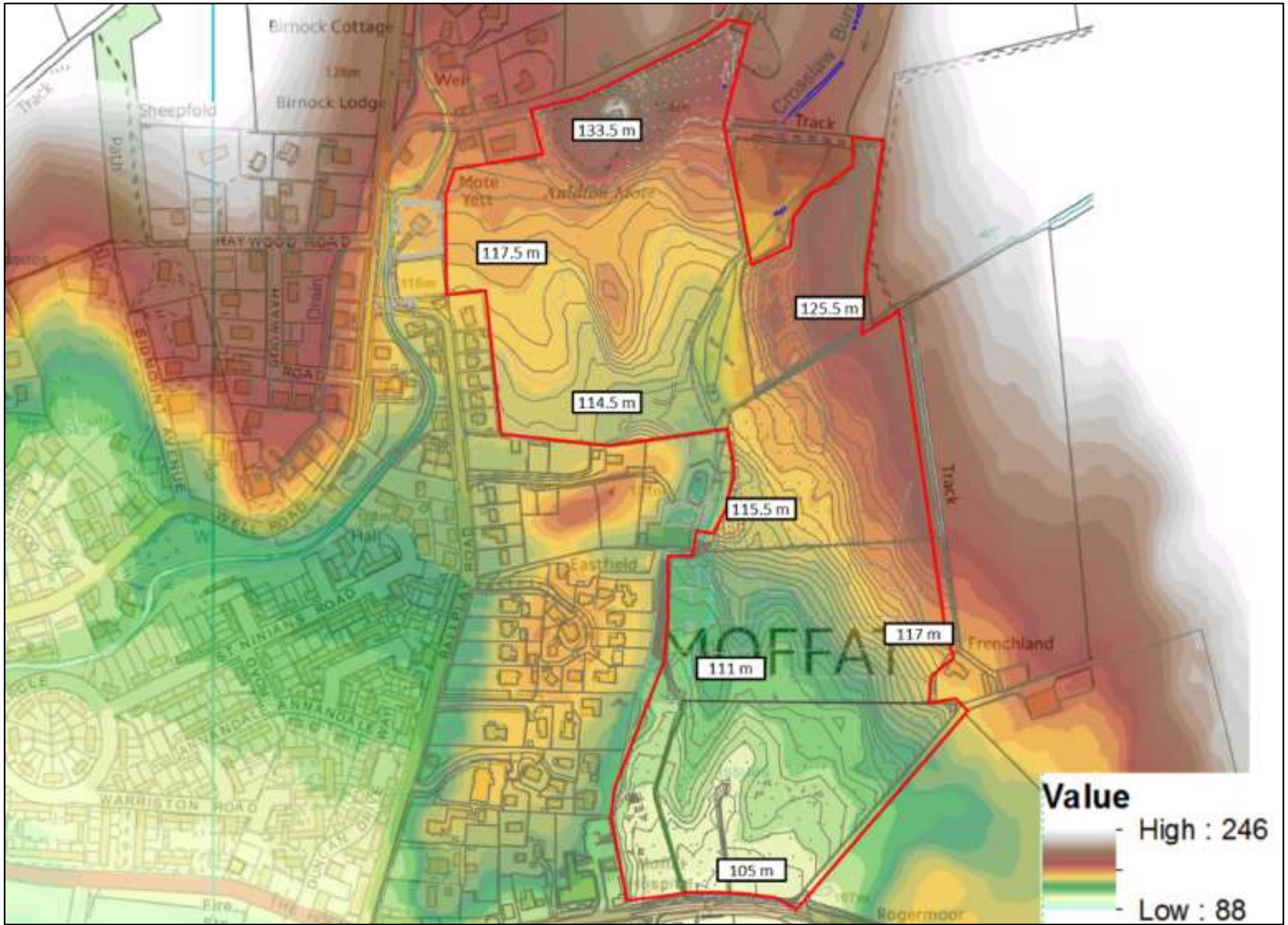


Photo 1: View of the site and Crosslaw Burn channel (looking north)

Photo 2: Crosslaw Burn culvert (downstream side)

Photo 3: Crosslaw Burn culvert (upstream side)

Photo 4: 0.6 m bypass culvert (upstream face)

Photo 5: Open ditch draining back to main Crosslaw Burn

Photo 6: Frenchland Burn

Photo 7: A708 road bridge over Frenchland Burn.

Photo 8: Drain channel looking upstream

4 Hydrological Analysis

In August 2018 Kaya Consulting Ltd. completed the Moffat Flood Study for Dumfries and Galloway Council. As part of the assessment a catchment wide hydrological analysis was undertaken to inform mathematical modelling of watercourses throughout the town. This assessment makes use of the findings of the recent study.

This hydrological assessment makes estimates of the design flows for the following watercourses immediately upstream of the River Annan:

- Crosslaw Burn (Small Drain flow apportioned based on catchment size);
- Frenchland Burn; and
- Birnock Water.

4.1 Design flows for Crosslaw Burn

The catchment area of the Crosslaw Burn immediately upstream of the confluence with the River Annan was calculated to be around 2.32 km^2, extracted from the Flood Estimation Handbook (FEH) online web service. Other catchment characteristics are shown in Table 3.

Table 3: Catchment characteristics for the Crosslaw Burn at River Annan confluence

Parameter	Crosslaw Burn
EASTING (m)	309250
NORTHING (m)	604050
AREA (km^2)	2.32
ALTBAR (m)	199
ASPBAR (°)	232
ASPVAR	0.73
BFIHOST	0.509
DPLBAR (km)	2.62
DPSBAR (m/km)	121.5
FARL	1
FPEXT	0.0743
LDP	4.7
PROPWET	0.72
SAAR (mm)	1362
SAAR4170 (mm)	1395
SPRHOST	40.87
URBCONC1990	-
URBEXT1990	0.0027
URBLOC1990	-
URBCONC2000	0.5
URBEXT2000	0.0129
URBLOC2000	0.502

The burn is not gauged and its catchment area is small, in addition there are no adjacent catchment of similar size to use as a donor. Based on this, the 200 year flow was estimated using the Institute of Hydrology (IH) Small Catchment Method (IH 124) and FEH Rainfall Runoff method. The method which produced the most conservative results was the FEH Rainfall Runoff method which produced a 1 in 200 year flow of 6.9 m^3/s and 8.3 m^3/s for the 200 year plus climate change event. This gives approximately 3.0$m^3/s/km^2$ and is considered reasonable for this part of the country.

Table 4: Comparison of design flows for Crosslaw Burn at Annan confluence

Return Period (years)	200 year return period flow (m^3/s)	200 year return period + 20% flow (m^3/s)	1000 year return period flow (m^3/s)
FEH Rainfall-Runoff[a]	6.9	8.3	10.7
IH124[b]	4.8	5.8	5.9
ReFH2	4.5	5.4	4.3

a Critical Storm Duration = 4.1 hours

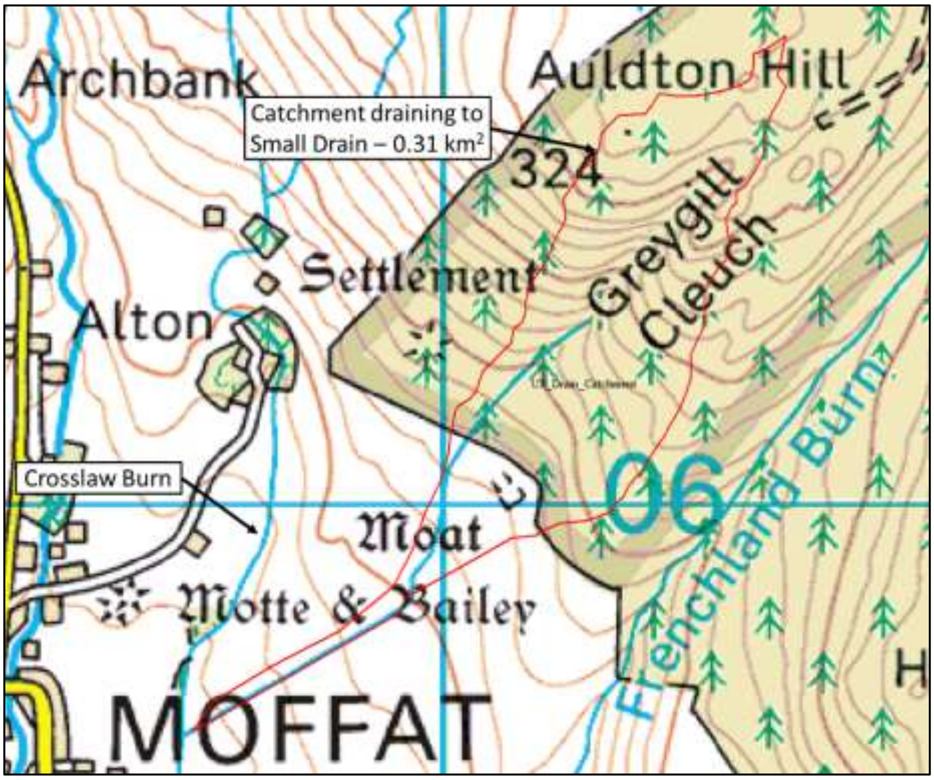
b SAAR = 1339 mm, Area = 1.9 km2, SOIL = 0.30, URBEXT = 0

c Critical Storm Duration = 2.75 hours

The Small Drain is a tributary of the Crosslaw Burn. The catchment draining to the Small Drain has been estimated to measure approximately 0.31 km^2.

The IH124 method estimates a 200 year flow of 0.75 m^3/s for the channel; however, as the channel is included in the Crosslaw Burn catchment a comparison was also undertaken by estimating the 200 year event through apportioning the catchment which indicates a flow of approximately 0.92 m^3/s. To be conservative the higher (0.92 m^3/s) is used to represent the Small Drain.

Figure 4: Small Drain catchment



4.2 Design flows for Birnock Water

Upstream of the River Annan, the Birnock Water drains a relatively large catchment (12.05 km^2) to the north west of the site. Catchment characteristics are provided in Table 5.

Table 5: Catchment characteristics for the Birnock Water at River Annan confluence

Parameter	Birnock Water
EASTING (m)	308550
NORTHING (m)	604750
AREA (km^2)	12.05
ALTBAR (m)	367
ASPBAR (°)	205
ASPVAR	0.38
BFIHOST	0.429
DPLBAR (km)	5.39
DPSBAR (m/km)	205
FARL	1
FPEXT	0.0207
LDP	8.99
PROPWET	0.72
SAAR (mm)	1557
SAAR4170 (mm)	1545
SPRHOST	44.48
URBCONC1990	0.522
URBEXT1990	0.0056
URBLOC1990	0.118
URBCONC2000	0.759
URBEXT2000	0.0059
URBLOC2000	0.102

Due to the size of the catchment, design flows were calculated based on the FEH Rainfall-Runoff method, ReFH2 method. The appropriate (and different) storm durations were calculated for each catchment and for each method.

The above design flow calculations are summarised in Table 6.

Table 6: Design flows for the Birnock Water upstream of River Annan

Method	200 year return period design flow (m^3/s)	200 year plus climate change design flow (m^3/s)	1000 year return period design flow (m^3/s)
ReFH2[a]	33.4	40.1	49.5
FEH Rainfall Runoff[b]	34.8	41.8	51.6

a Critical Storm Duration = 3.25 hours

b Critical Storm Duration = 5.5 hours

The Birnock Water flows provided in Table 6 have been updated to reflect the Moffat Flood Study, which has been passed to SEPA. It should be noted that the model sensitivity analysis assesses changes in flows including the effect of the 1000 year event.

4.3 Design flows for Frenchland Burn

The catchment draining the Frenchland Burn was obtained from the FEH online web service. Catchment characteristics are provided in Table 7.

Table 7: Catchment characteristics for the Frenchland Burn at River Annan confluence

Parameter	Frenchland Burn
EASTING (m)	309300
NORTHING (m)	604050
AREA (km^2)	4.04
ALTBAR (m)	269
ASPBAR (°)	221
ASPVAR	0.51
BFIHOST	0.464
DPLBAR (km)	3.32
DPSBAR (m/km)	130.8
FARL	1
FPEXT	0.0241
LDP	6.06
PROPWET	0.72
SAAR (mm)	1422
SAAR4170 (mm)	1447
SPRHOST	42.7
URBCONC1990	-
URBEXT1990	0
URBLOC1990	-
URBCONC2000	-
URBEXT2000	0
URBLOC2000	-

Using the Institute of Hydrology (IH) Small Catchment Method (IH 124), ReFH2 and FEH Rainfall Runoff methods, the method which predicted the most conservative results was the FEH Rainfall Runoff method which produced a 1 in 200 year flow of 11.7 m^3/s and 14.0 m^3/s for the 200 year plus climate change event, see Table 8.

Table 8: Comparison of design flows for Frenchland Burn

Return Period (years)	200 year return period flow (m^3/s)	200 year return period + 20% flow (m^3/s)	1000 year return period (m^3/s)
FEH Rainfall-Runoff[a]	11.7	14.0	17.5
ReFH Version 2[b]	9.4	11.3	14.1
IH124[c]	8.1	9.7	12.1

a Critical Storm Duration = 4.9 hours

b Critical Storm Duration = 3.25 hours

c SAAR = 1446 mm, Area = 3.26 km2, SOIL = 0.30, URBEXT = 0

Consistent with SEPA guidance consideration is made of the effect of climate change by 2080 by increasing flows by 20%.

5 Flood Modelling

As previously discussed, Kaya Consulting Ltd. was commissioned to undertake the Moffatt Flood Study, as part of the assessment a dynamically linked 1D-2D hydraulic model was constructed of the River Annan, Birnock Water, and Crosslaw and Frenchland Burns.

Results of the study indicated that the site would not be at risk of flooding from the Birnock Water up to and including the 1000 year event; therefore, this watercourse has not been included in this assessment to estimate the functional floodplain at the site.

As part of the March 2019 objection, SEPA requested that a credible blockage scenario for Auldton Road Bridge (crossing the Birnock Water close to the north western corner of the site) is justified, this was requested as blockage of the bridge is not included in the base case runs for the Moffat Flood Study.

The Auldton Road bridge is a single span crossing raised significantly above the bed of the channel and there have been no historical instances of blockage in the past. The bridge does not provide a restriction on flows. Therefore, based on SEPA guidance there is not a significant risk of blockage and flooding to the site. A sensitivity analysis was subsequently undertaken with a 20% blockage to the bridge which confirmed that overtopping of the Birnock Water is not predicted.

To estimate fluvial flood risk at the proposed development site, the River Annan and Birnock link was removed, and the remaining models were shortened to represent a reach from approximately 400m upstream of the northern boundary close to Alton Cottages down to approximately 460 m downstream of the A708 Road bridge) and associated floodplains. In addition, cross sections of the Small Drain were surveyed and included in the model.

5.1 Model Construction

5.1.1 Survey

In addition to the topographic survey undertaken for the first assessment in January 2017 and also in November 2018, a comprehensive river channel survey of all four watercourses was also undertaken as part of the Moffat Flood Study. The survey included channel cross-sections and hydraulic structures (i.e. bridges, culverts and weirs) throughout the study area.

In total the topographical survey included the following:

Crosslaw Burn
- 41 Surveyed river channel cross sections
- 6 Surveyed Hydraulic structures

Frenchland Burn
- 18 Surveyed river channel cross sections
- 2 Surveyed Hydraulic structures

Small Drain (2018 survey)
- 13 Surveyed river channel cross sections
- 1 Surveyed Hydraulic structure

The locations of surveyed channel cross sections are shown in Figures 4 to 6.

Figure 5: Upper and Lower Crosslaw Sections (note Crosslaw model stops at cross section C46)

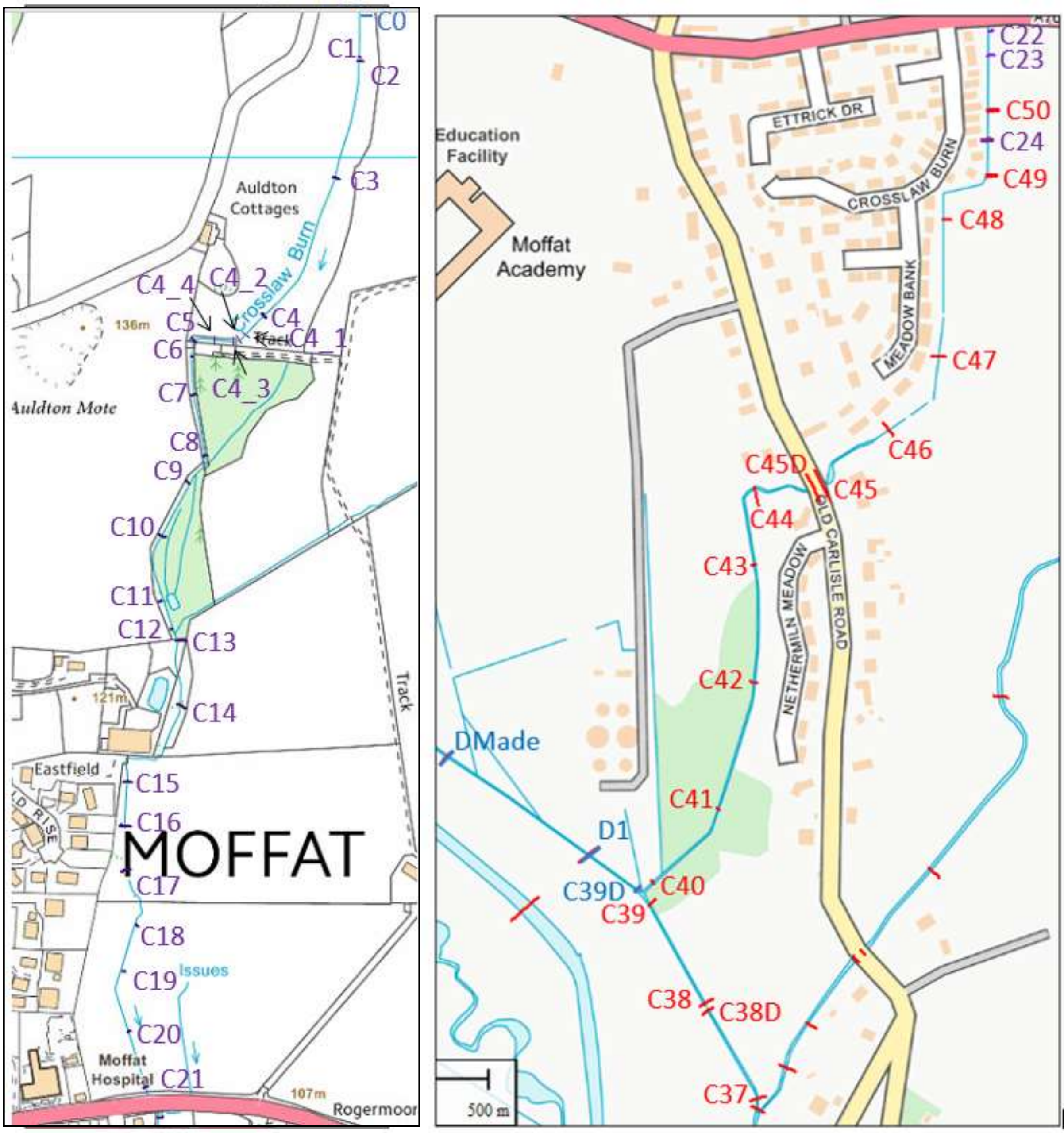


Figure 6: Small Drain cross sections

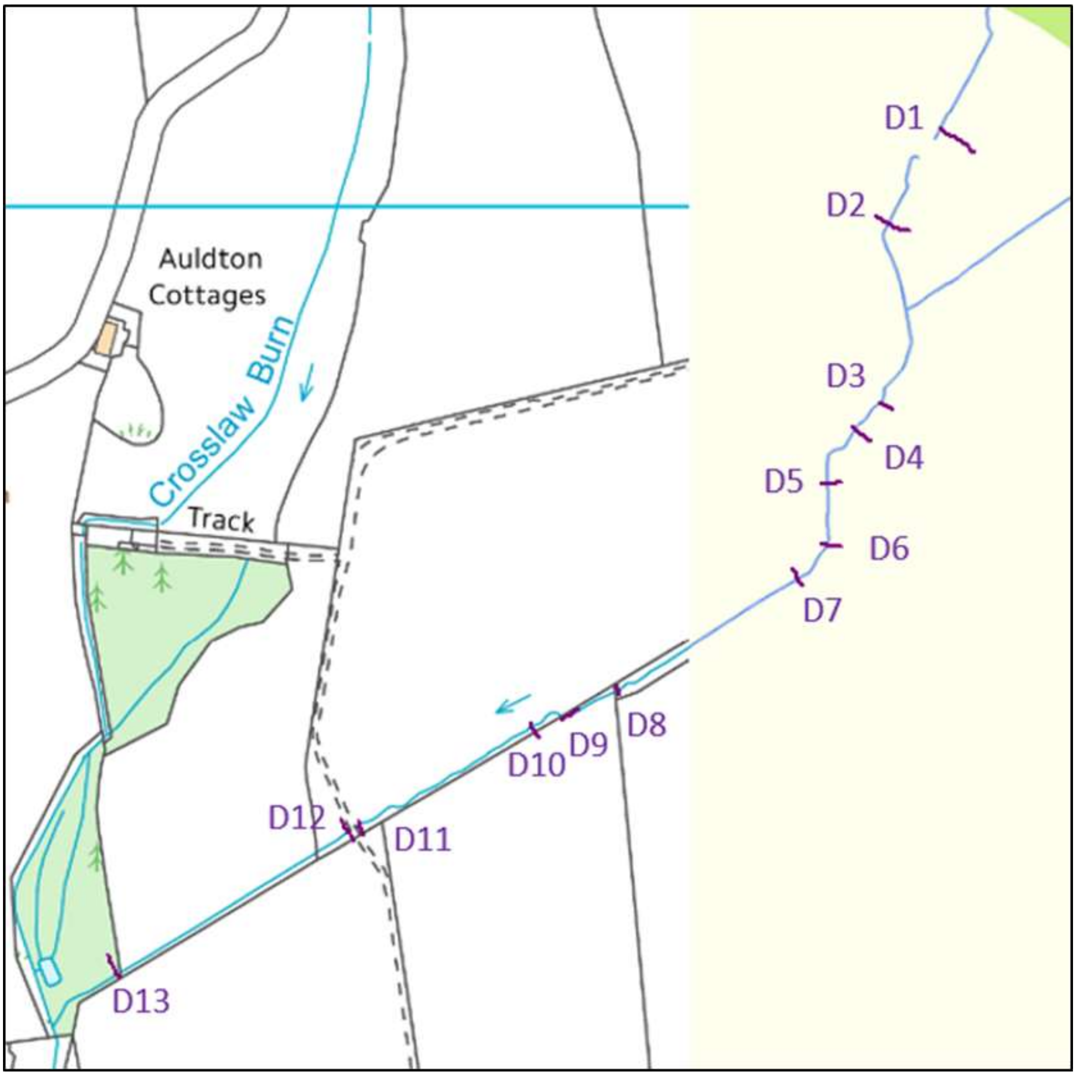
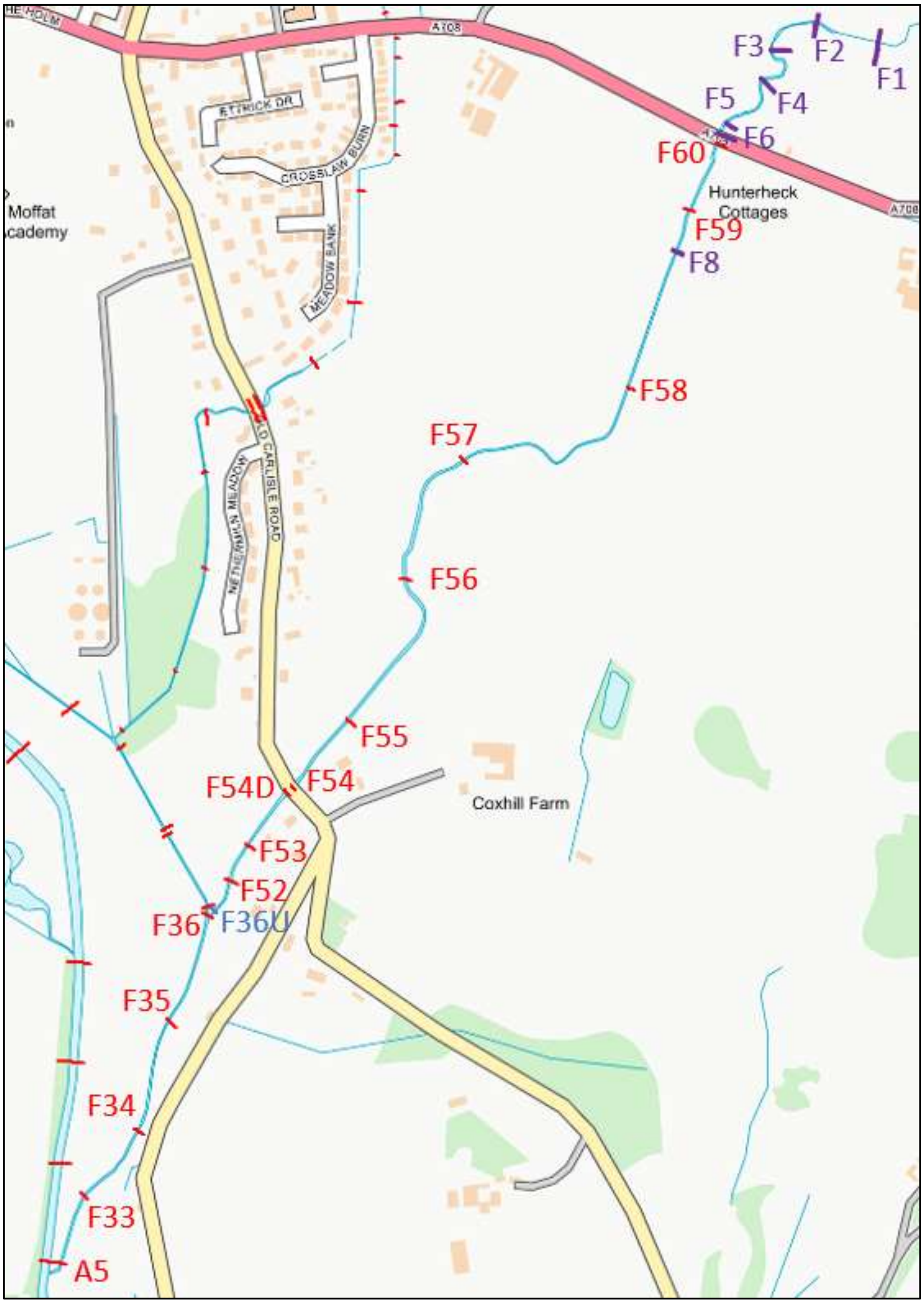


Figure 7: Frenchland model cross sections (Note. Frenchland Burn model stops at F8)



5.1.2 Modelled Structures

There are a number of key structures on all watercourses. A list of structures included in the model is provided in Table 9.

Table 9: Modelled structures (all use default parameters unless otherwise specified)

River	Feature	Location	Description	Dimensions	Modelled unit
Crosslaw	Field Agricultural Circular Culvert	309663, 606093	Track culvert	4.7m long and 0.7m diameter.	Culvert
Crosslaw	Field Agricultural Circular Culvert	309534, 605816	Field Culvert	3.85m long and 0.75m diameter	Culvert
Crosslaw	Field Agricultural Circular Culvert	309189, 604082	Track culvert	5m long and 0.8m diameter	Culvert
Crosslaw	A 708 culvert	309462, 605061	Culvert under road	17m long 2m wide and 1m high arch culvert.	Culvert with arch conduit
Crosslaw	Old Carlisle Road Crosslaw road	309300, 604595	stone arch bridge	2.4m wide and 1.5m high to arch middle.	Arch bridge
Crosslaw	Field Agricultural Circular Orifice	309189, 604082	Orifice	1.35m in diameter.	Orifice
Frenchland	A708 Road Bridge	309857, 604926	Stone Arch bridge under road	5m wide and 2.2m to middle of the arch.	Arch bridge
2D domain	A708 Road bridge orifice	309462, 605061	Bypass opening east of the A708 Road bridge	0.6m diameter (modelled at 50% blocked)	Circular Orifice
Small Drain	Field crossing	309656, 605641	Field crossing	0.7 m diameter (modelled at 50% blocked)	Culvert with circular conduit

5.1.3 DTM

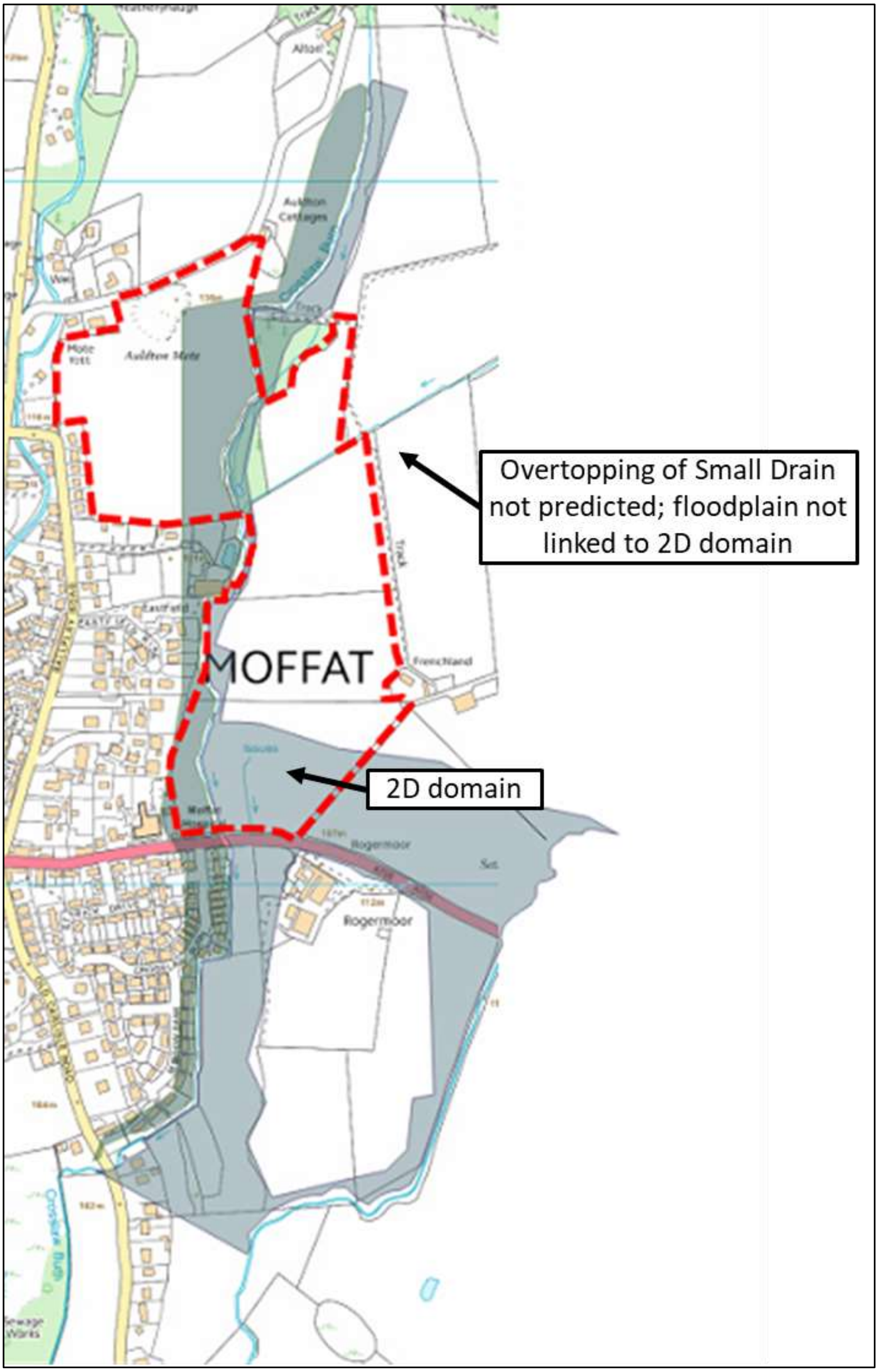
Filtered LiDAR DTM data was downloaded from the Scottish Remote Sensing Portal. The data has a 1m horizontal resolution and covers the entire study area. The LiDAR DTM was augmented by land based topographical survey of channel cross sections.

5.1.4 2D Model Domains

Overbank flows leaving the main watercourses within the study area were represented in 2D. These are shown in Figure 8.

Initial model runs were carried out and the outer boundaries of the 2D domains were adjusted so that flood extents for all the runs considered do not touch boundaries. This removes the active areas where no water would go and reduces model run times without sacrificing model accuracy. This allows a natural flood extent to be generated by the model, unaffected by the domain boundaries.

Figure 8: Combined model 2D domain



5.2 Model Boundaries

5.2.1 Upstream Boundary Condition

The model requires input of flows from the top end of each of the three watercourses, as well as any lateral flows which may enter the watercourses along their modelled lengths. Flows entering the study area from upstream for the Crosslaw Burn, and Frenchland Burn catchments are represented in the model by FEH flow hydrographs derived in Section 3: Hydrological Analysis. Models were run for the duration of the entire flood hydrograph.

Flow Partitioning

Flow contributions from upper catchments was applied at the top end of each watercourse. Lateral inflows were added where relevant and uniformly distributed over a specified length of the watercourses.

As the Frenchland and Crosslaw models do not extend to the River Annan confluences, the design inflows to the watercourses have been apportioned based on the remaining upstream catchment area.

The catchment draining to the Small Drain has been estimated to measure approximately 0.31 km^2. As a result, the 200 year inflow is partitioned to be approximately 0.92 m^3/s.

5.2.2 Downstream Boundary Condition

As discussed, the models have been cut to improve model run time. A normal depth boundary was used at the downstream end of both the 1D and 2D models based on the bed slope.

5.3 Key Model Parameters

Roughness

The following global roughness values were used in the 1D model:
- Main channel: 0.040
- Channel banks: 0.050

Where fences across the section (4 cross sections in the upper part of the Crosslaw Burn), an increased roughness of 0.05 was used. For the 2D domains, SEPA roughness grid were used. This consisted of areas with roughness values varying between 0.02 and 1 depending on land use, as shown in Table 10.

Table 10: 2D model friction grid values

Land use	Roughness value (Manning's n)
Roads	0.020
Grass Fields and Urban Areas	0.033
Rough Ground and wooded area	0.100

Buildings	1.000
Friction patches for stability	0.100

Spill coefficients

The default spill coefficient was revised for in-channel structures. A value of 1.7 represents efficient transfer of water over a sharp crested structure. A weir coefficient of 1.2 was therefore adopted for the spill units representing the flow over structures to account for the less efficient nature of flow. A spill coefficient of 0.5 was adopted for the lateral spills to represent the undefined nature of the channel banks and the heavily vegetated status.

Grid size

For the 2D domains, a uniform grid size of 1m was used.

Time step

Computational timestep used for all domains was 0.25 second.

Structure Blockages

A small drainage ditch rises immediately upstream of the A708 before entering a 0.6 m diameter culvert and passing under the road. Based on a meeting with SEPA, it has been requested that this culvert is subject to a 50% blockage.

Friction patch

To reduce small instabilities a friction patch has been applied to the Crosslaw Burn a short distance upstream of the A708. A Manning's "n" value of 0.1 was selected.

5.4 Model Results

The 1 in 200 year flow was used to estimate the functional floodplain and flood risk water levels at the site. Analysis of the propagation of the flood mechanism shows that floodwaters spill into both the left and right floodplain of the Crosslaw along the modelled reach, due to the limited capacity of the channel and the presence of hydraulic structures. The A708 road provides a significant control on floodwaters at the southern boundary of the site, causing water to pond upstream of the A708 (on both the left and right floodplains) within the site to a level of 105.74 m AOD.

Assessment was also undertaken to estimate the flood extent and levels for the 1 in 200 plus climate change and 1 in 1000 year events (the latter to inform any development classed as critical infrastructure). The impact of the 1000 year event results in an increase in flood level upstream of the A708 to approximately 106.84 m AOD, resulting in overtopping of the road from both floodplains, by a peak flow of 7 m^3/s.

The predicted extent of inundation for the 1 in 200 year and 1 in 1000 year flood events are shown in Figures 9 and 10. The predicted flood water levels at key locations across the site are detailed in Table 11.

Figure 9: Modelled 1 in 200 year flood event

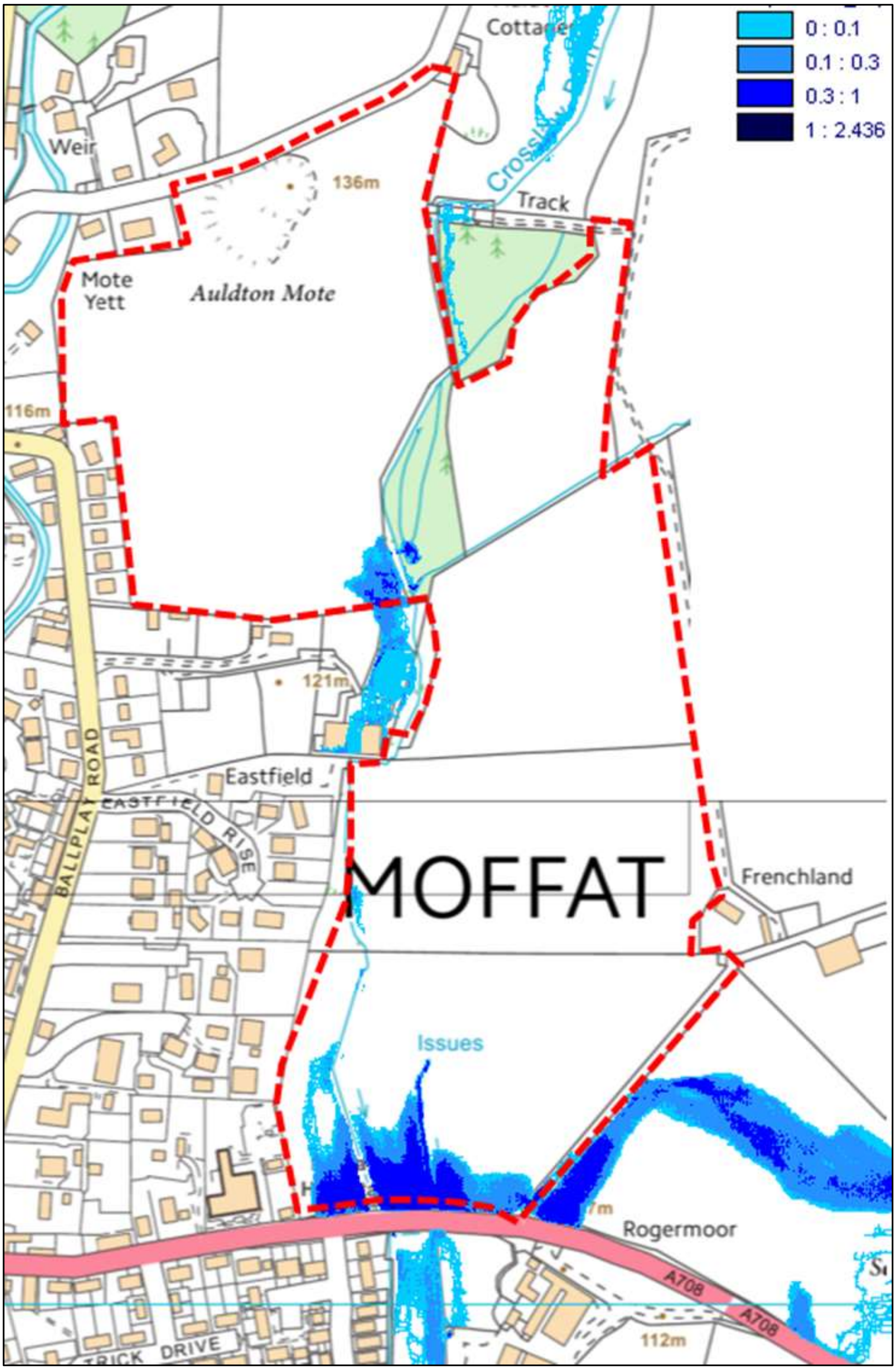


Figure 10: Modelled 1 in 1000 year flood event

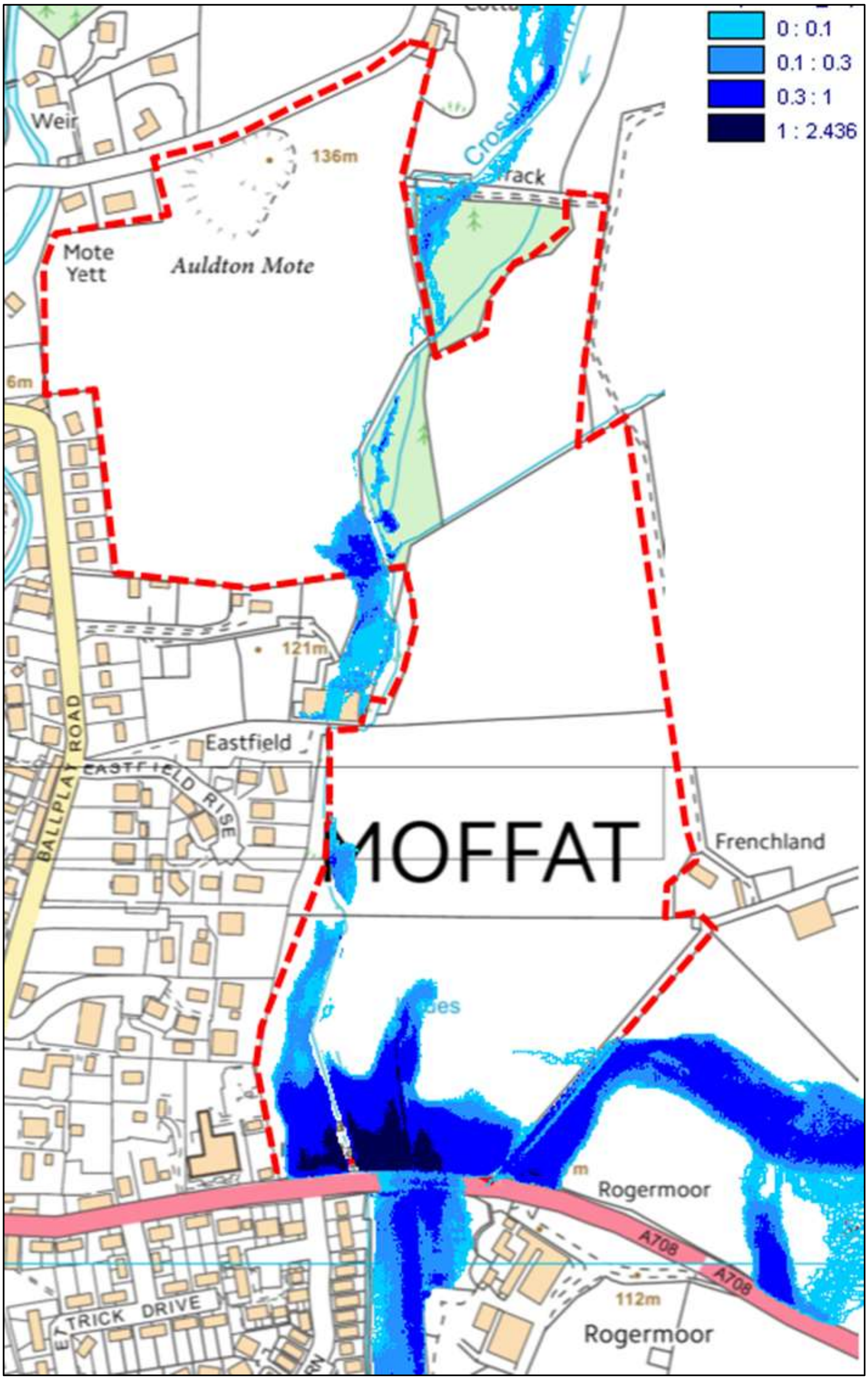
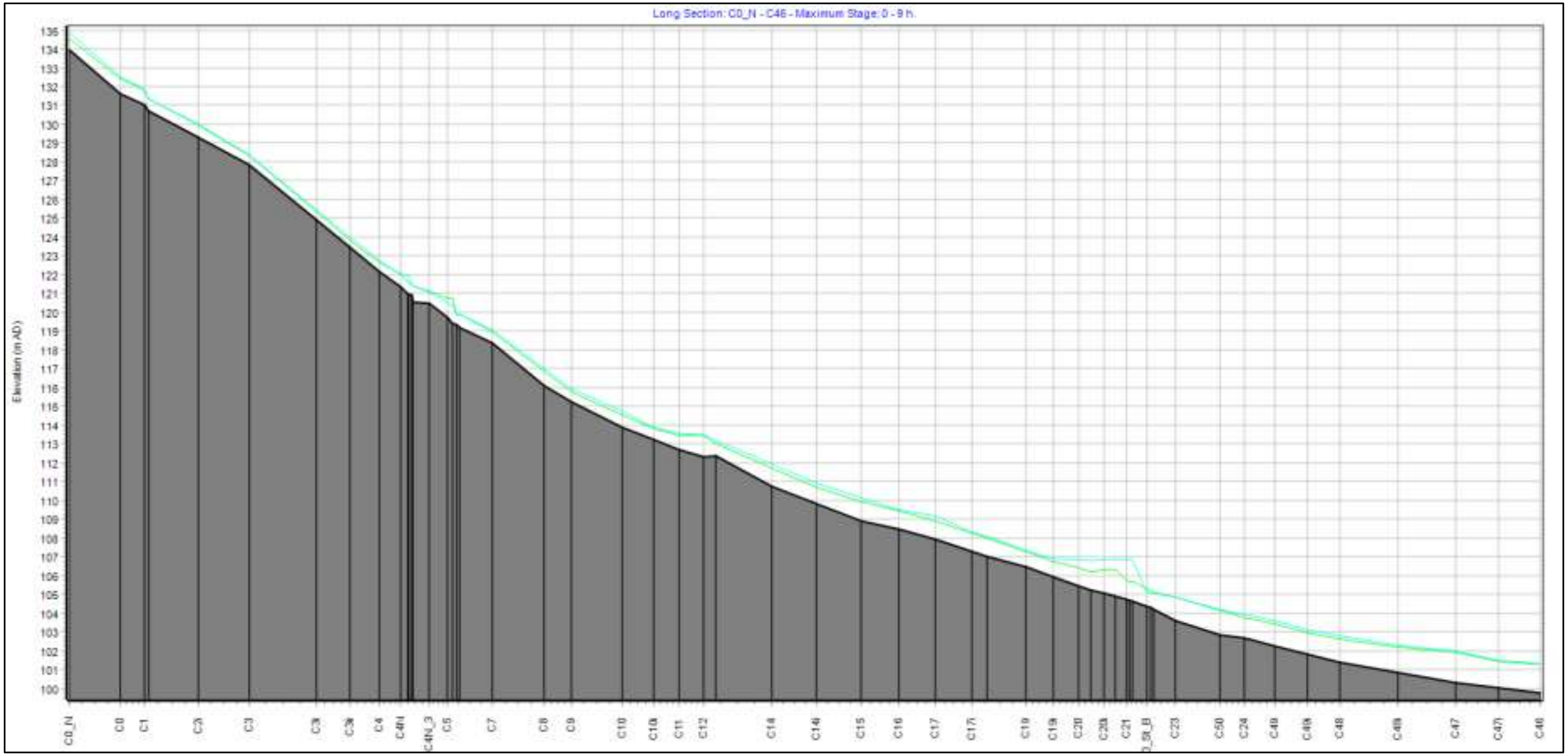


Table 11: 1D model results

Cross section	200 year (m AOD)	200 year plus Climate Change (m AOD)	1000 year (m AOD)	Max Velocity (m/s)
C0_N	134.52	134.63	134.87	2.26
C0	132.46	132.49	132.53	2.47
C1	131.80	131.85	131.89	1.85
C2	131.33	131.36	131.37	2.14
C3	128.30	128.34	128.36	2.07
C4	122.66	122.69	122.78	1.97
C4N	122.04	121.97	121.99	1.49
C4N_1	121.60	121.92	121.97	2.23
C4N_2C	121.41	121.41	121.41	1.42
C5	120.77	120.45	120.47	1.27
C6	119.89	119.86	119.87	1.42
C7	118.98	119.02	119.09	2.36
C8	116.86	116.93	117.03	2.23
C9	115.78	115.84	115.93	2.20
C10	114.52	114.62	114.78	1.37
C11	113.48	113.51	113.56	1.31
C12	113.46	113.48	113.50	0.78
C13	113.05	113.10	113.20	2.00
C14	111.70	111.80	111.93	2.09
C15	109.94	110.04	110.18	1.73
C16	109.46	109.51	109.53	1.87
C17	108.92	109.00	109.18	1.70
C18	108.00	108.07	108.13	1.92
C19	107.31	107.32	107.37	2.11
C20	106.43	106.81	106.85	1.82
C21	105.76	106.79	106.84	2.87
C22	105.15	105.01	105.06	2.24
C23	104.89	104.79	104.88	1.80
C50	104.18	104.08	104.19	2.29
C24	103.79	103.82	103.92	2.07
C49	103.46	103.53	103.61	1.80
C48	102.66	102.70	102.79	1.74
C47	101.94	101.97	102.00	1.19
C46	101.28	101.30	101.33	1.48
F1	123.21	123.29	123.40	2.76
F2	121.08	121.14	121.22	2.68
F3	119.05	119.08	119.11	1.99
F4	117.28	117.32	117.36	2.26

F5	115.03	115.07	115.13	3.16
F6	114.65	114.72	114.80	1.76
F60	114.39	114.43	114.50	2.87
F59	111.61	111.66	111.72	2.98
F8	110.16	110.20	110.26	2.62
D1	134.52	134.63	134.87	2.26
D2	132.46	132.49	132.53	2.47
D3	131.80	131.85	131.89	1.85
D4	131.33	131.36	131.37	2.14
D5	128.30	128.34	128.36	2.07
D6	122.66	122.69	122.78	1.97
D7	122.04	121.97	121.99	1.49
D8	121.60	121.92	121.97	2.23
D9	121.41	121.41	121.41	1.42
D10	120.77	120.45	120.47	1.27
D11	119.89	119.86	119.87	1.42
D12	118.98	119.02	119.09	2.36
D13	116.86	116.93	117.03	2.23

Figure 11: Crosslaw Burn – Peak longitudinal water level profiles for 1 in 200 year (green) and 1 in 1000 year events (blue)



5.5 Sensitivity Analysis

A sensitivity analysis was undertaken considering the following parameters;

- Scenario 1 - Manning's n increased by 20%;
- Scenario 2 - A708 road bridge and 'issues' drain culvert blocked by 50%;
- Scenario 3 - Downstream boundary gradient decreased (to 1 in 200);
- Scenario 4 – Blockages of crossing structures and water gates not able to be removed.

Scenario 1

The sensitivity analysis shows that varying roughness by 20% results in a minimal change to flood levels across the site. The maximum increase in water level is 0.23m (compared to the 1 in 200 year base case), in the floodplain upstream of the A708 road. The small increase at site does not cause a change in the flood mechanism i.e. no overtopping of the road. It is worth noting that the channel roughness adopted in the base case is already high at 0.05, to represent the inefficiency and vegetated state of the channel.

Scenario 2

Blockage of the structures by 50% shows the greatest impact on the water levels, with a maximum water level of 106.79 m AOD immediately upstream of the A708 road. The increase in water level results in spilling across the A708 from the left floodplain, with a peak flow of 3.2 m^3/s. The 200 year event plus blockage results is higher water levels than the 1000 year event (local to the A708). The impact of blockage on water levels extends 120m upstream of the A708 road.

Scenario 2b

The land owner was consulted regarding the flooding history of the site. The owner indicated that due to the absence of significant vegetation such as wooded areas etc. both culverts have no record of significant blockage. In addition, an informal cattle grill is situated upstream of the inlet providing a level of protection. Based on the above, the likelihood of blockage is low. However, in the event of a blockage to the culvert, flood waters would back up within the channel before flooding low lying land to the east. There is a 0.6 m diameter bypass culvert situated to the east hence, during a 100 % blockage to the culvert emergency flood flow could bypass the main culvert. Ultimately, blockage in both culverts would lead to backing up and overtopping of the A708; hence, water levels in this area could reach the overspill level of the road.

Scenario 3

Adjustment to the downstream boundary of the model (decreasing normal depth slope from 1 in 200 to 1 in 500 for the Crosslaw and from 1 in 34 to 1 in 200 for the Frenchland Burn) shows impact to water levels local to the boundary of 0.56m in the Crosslaw and 0.37 m in the Frenchland. Changes to the downstream boundary have no effect at the site as the upstream water levels are controlled by the A708 road and bridge.

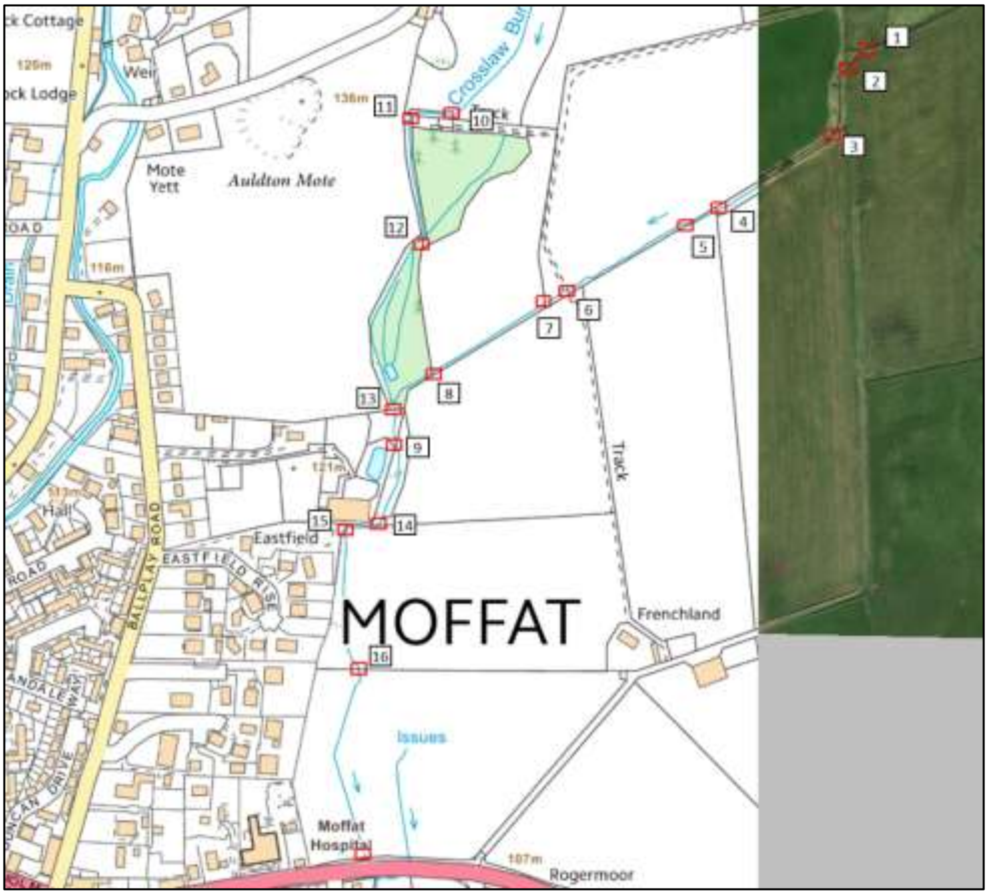
Scenario 4

Following correspondence with SEPA, it was requested that a reasonable assessment of blockage is undertaken on the culverts and water gate structures. Due to the nature of the structures i.e. not formal crossings etc. they were not included in the original assessment. Discussions with the landowner indicated that a number of the structures will be removed as part of the development; however, where structures will not be removed we have modelled a blockage to the local structure or cross section using a “blockage unit” which reduces the available flow area by a percentage – 25%, see Table 12 and Figure 12 below.

Table 12: Crosslaw/Unnamed Drain structures description

Crossing ref	Description	Status
1	Field boundary- Masonry opening	**Blocked 25%**
2	Field boundary- Masonry opening	**Blocked 25%**
3	Field boundary- Masonry opening (1.2mx1.2m)	**Blocked 25%**
4	Field boundary- Wooden water gate	Remove
5	Field boundary- Masonry opening	Remove
6	Track crossing – 0.75m diameter culvert	**Blocked 50%**
7	Field boundary – Masonry Opening	Remove
8	Field boundary- Masonry Opening	**Blocked 25%**
9	Field boundary- Wooden water gate (1.5mx1.5m)	**Blocked 50%**
10	Field boundary- 0.7m pipe	Remove
11	Track crossing – 0.75m diameter culvert	Remove
12	Not present but shown on OS map	N/A
13	Field boundary- Wooden water gate(1.5mx1.5m)	**Blocked 50%**
14	Field boundary- Wooden water gate (1.5mx1.5m)	Remove
15	Field boundary- Wooden water gate (1.5mx1.5m)	Remove
16	Field boundary- Wooden water gate (1.5mx1.5m)	**Blocked 50%**

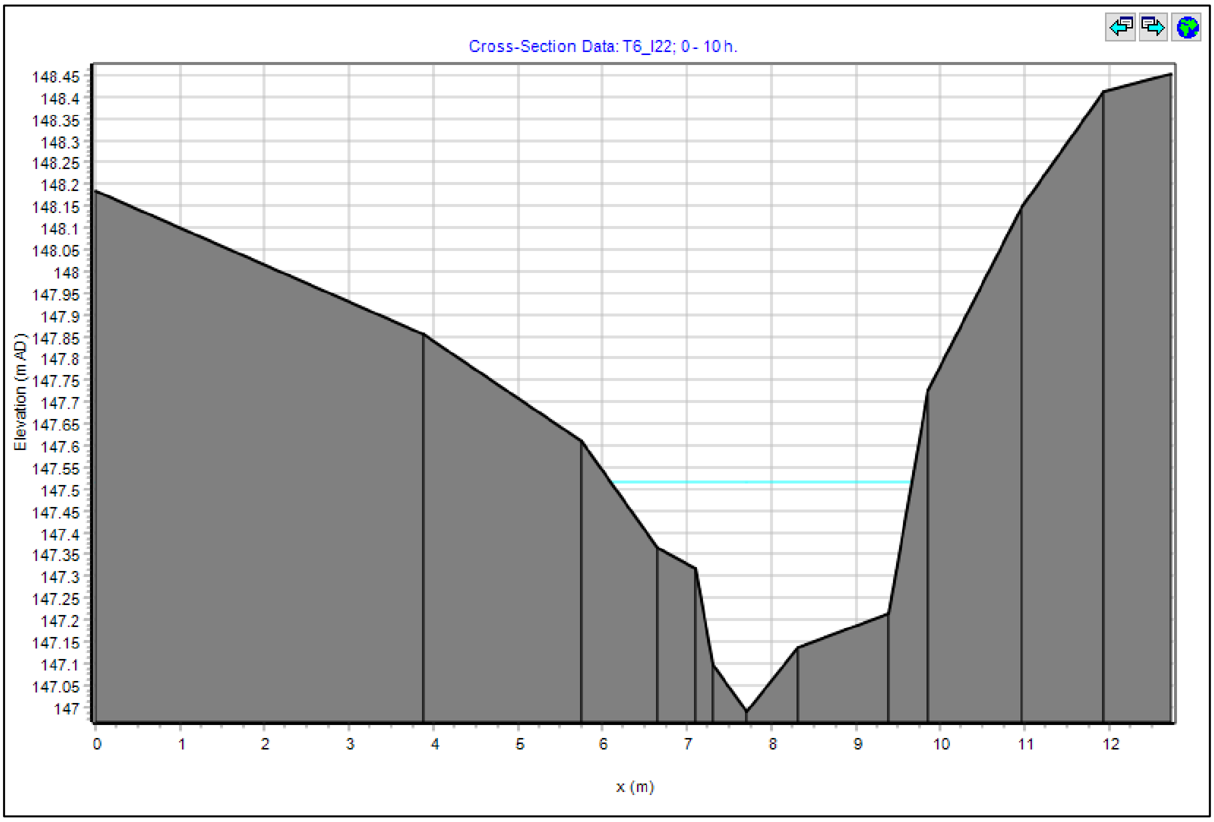
Figure 12: Crosslaw/Small Drain structure locations



Small Drain

Model results indicated that, although water levels in the channel would increase locally to “blocked” structures or channel, overtopping of the channel banks were not predicted. This is due to the relatively small flow compared to the size of the channel, see Figure 13 which shows the cross section result for structure 3 (D6-D7).

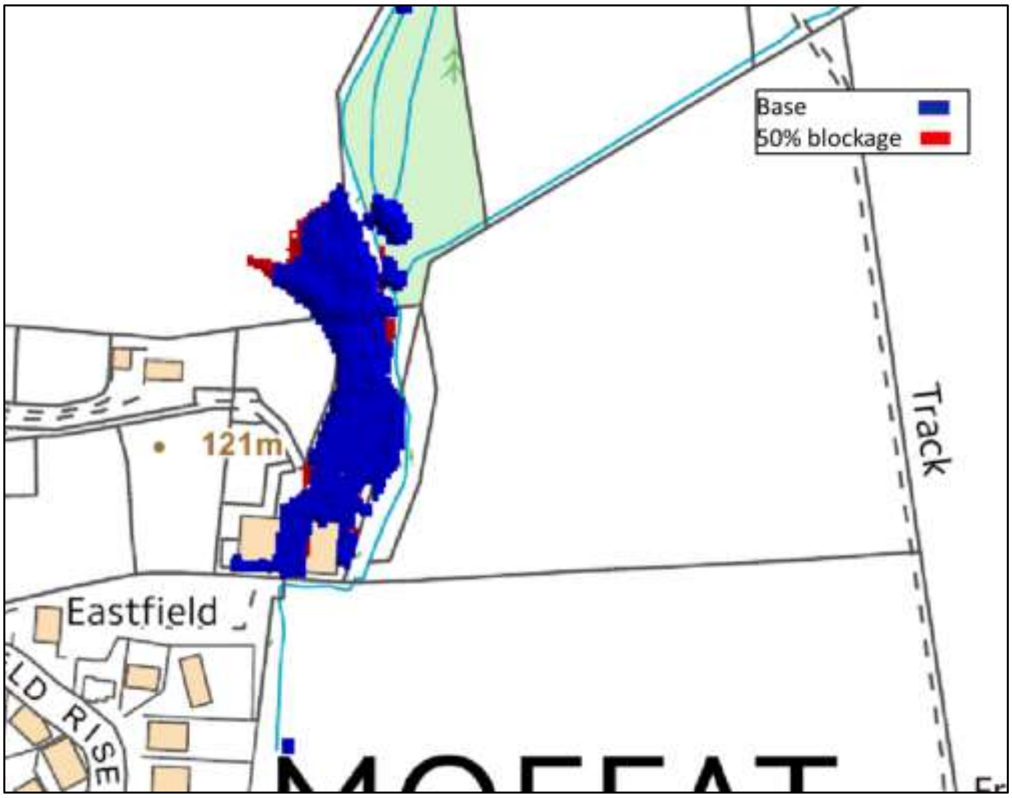
Figure 13: 200 year cross section results for Small Drain water gate field boundary – 3 - (50% blocked)



Crosslaw Burn

Structures 9 and 13 will be retained following the development of the site. A 50% blockage to the water gate structures has been applied to the model. In the vicinity of the structures, flood waters are predicted to overtop the channel and flood low lying land, see Figure 14 which shows the 200 year flood extent. By adding a 50% blockage to the water gates, flood levels increase by 0.32 m. The channel is situated in a deep hollow at this location therefore the flood extents do not significantly change. Built development is proposed on the east bank on ground which rises up to 116 m AOD, which is well out with the 200 year plus 50% blockage level and also out with flooding on the right bank.

Figure 14: Crosslaw 200 year base map vs. 200 year plus 50% blockage to retained water gates



6 Flood Risk Assessment

The flood risk assessment considers flooding from:

- Crosslaw Burn watercourse (along with contributing flood risk from neighbouring watercourses);
- Surface runoff from adjacent land;
- Groundwater;
- Site access; and
- Site drainage.

6.1 Risk of Flooding from Crosslaw, Small Drain and Frenchland Burn

The flood risk from the Crosslaw, Small Drain and Frenchland Burn was assessed using the Dumfries and Galloway Council Moffatt flood model, locally updated for this study, with linkage to the River Annan removed, and the addition of topographic survey data in the site. In addition, cross-sections of the Small Drain were surveyed and included in the model.

Analysis of the flood extent map shows that part of the proposed development site is predicted to be at fluvial flood risk. The predicted extent of inundation for the 1 in 200 year event and 1 in 1000 year event are shown in Figures 9 and 10. There is a large proportion of the site area which is free from flooding and situated out with the functional floodplain.

Any development should be located outwith the predicted 1 in 200 year floodplain, as shown in Figure 9; with any critical infrastructure ideally outside of the 1 in 1000 year floodplain or taking account of 1 in 1000 year flood levels when setting floor levels. The requirements for the critical infrastructure should be agreed with the local council and SEPA.

The sensitivity analyses undertaken (Section 5.2) shows that the site is sensitive to blockage of the A708 road bridge and associated 0.6m drain culvert. The A708 road level is a control on the floodwaters and therefore the overtopping level on this road should be used to further inform development levels. It is suggested that finished floor levels of development in the southern area of the site should be set no lower than 107.84 m AOD which is 1m above the 1000 year event.

The respective flood levels are detailed in Table 11.

Detailed flood management measures are provided in Section 7 below.

6.2 Risk of Flooding from Birnock Water

The Moffat Flood Study model results indicated that the channel has sufficient capacity to pass the 200 year flow event and flooding of the site was not predicted.

Flood management measures regarding blockage to bridge crossings are provided in Section 7.

6.3 Risk of Flooding from Surface Water

High ground rises to the north and east of the site; therefore, there is a relatively large catchment outside the site boundary that could generate runoff into the site. The A708 is embanked between the site and lower ground to the south; hence, the site would be at risk of surface water runoff from land to the north and east. This should be taken into account in the design of the site. Flood management measures are discussed in Section 7.

6.4 Risk of Flooding from Groundwater

There is no information on groundwater levels in the area at present. However, as the Crosslaw Burn runs through the site, groundwater levels are expected to be controlled by the water level in the channel and the hydraulic gradient of subsurface flows of the sloping land within the site. As the developed part of the site will sit at a higher level than the channel, the site is not considered to be at significant risk of groundwater flooding.

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 and SuDS measures will need to take account of ground water conditions.

6.5 Risk of Flooding from the Site Access

The proposed site access is from the A708 to the south of the site. The access points will be raised above the 200 year flood level, this is detailed in Section 7 below.

Ground levels fall south, away from the site; however, there is high ground to the east of the site therefore there is a limited risk of flood waters entering the site via the A708. Within the site, access roads will rise to the north reducing the risk of flood waters entering the built development. Any flows entering the site from the A708 should be intercepted by the site drainage and/or ground/road levels should be arranged so that any surface water ingress is diverted away from the proposed developments without affecting any properties.

Care would need to be taken in the design of site access points so that they do not act as flow pathways allowing excess surface water from the site to enter the road.

6.6 Risk of Flooding from the Site Drainage System

Design of the site drainage system is not part of this assessment. It is recommended that surface water is discharged to the Crosslaw Burn. Due to the A708 being elevated adjacent to the site, it is recommended that finished ground levels are suitably arranged so that, in the event of a blockage to the drainage system, flood waters can flow south to the adjacent watercourse without ponding within the site.

It is expected that the council would require surface water from the site to be attenuated to greenfield rates before discharge to the Crosslaw Burn. Appropriate discharge rates should be agreed with the council. Requirements for SuDS should also be discussed with the council, SEPA and Scottish Water.

7 Flood Risk Management

As described above, part of the proposed development site is predicted to be at risk of flooding from the Crosslaw and Frenchland Burns during a 200 year event. Flood risk management measures are described below. These are in addition to those discussed in Section 6, e.g., no development in 200 year floodplain.

7.1 Birnock Burn – Auldton Road bridge

The Birnock Water flows south close to the western boundary of the site, the channel measures approximately 10 m wide and 2.5 m deep. Close to the north western corner of the site the burn flows under Auldton Road via a single span concrete bridge. Bed levels at the bridge have been surveyed to be approximately 117.08 m AOD and the bridge soffit at 119.69 m AOD.

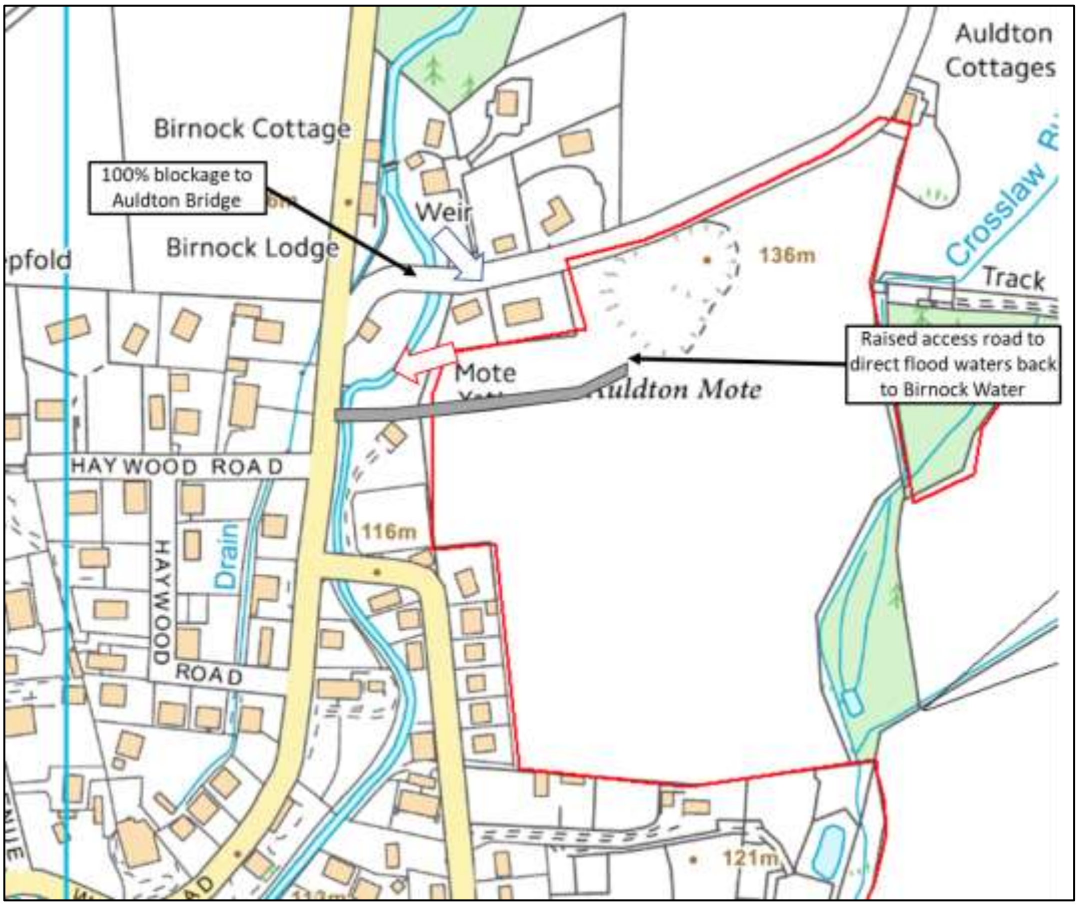
Results of the Moffat Flood study indicated that the site would not be at risk of flooding from the Birnock Water up to and including the 1000 year event. A bridge blockage of 20% was also applied to the Auldton Bridge for the 200 year event, which indicated that the site would not be at risk of flooding; therefore, this watercourse has not been included in this assessment to estimate the functional floodplain at the site.

The bridge is raised significantly above the channel and there have been no historical instances of flooding from the crossing in the past. The crossing is assessed to have a low likelihood of blockage. However, as part of flood mitigation measures for the site, an assessment of the 100% blockage was undertaken.

It is accepted that the above is an unlikely scenario, but it is recommended that the site is designed so that flood waters are able to flow through the site via an overland flow pathway. Discussions with the client indicated that this could be achieved as part of development of the access road within the northern area of the site. The burn has been modelled using 2D modelling to assess the risk of flooding to the site during a 100% blockage to the crossing; in addition, the proposed access road was modelled to be raised. Model results indicated that flood depths up to ~ 0.5 m could be expected upstream of the road. The road embankment was able to convey flood waters back to the channel based on a positive alignment of the road, see Figure 15.

This mitigation option would need to be discussed and agreed with the client and the local Council but the above shows that careful arrangement of road levels could mitigate against flooding.

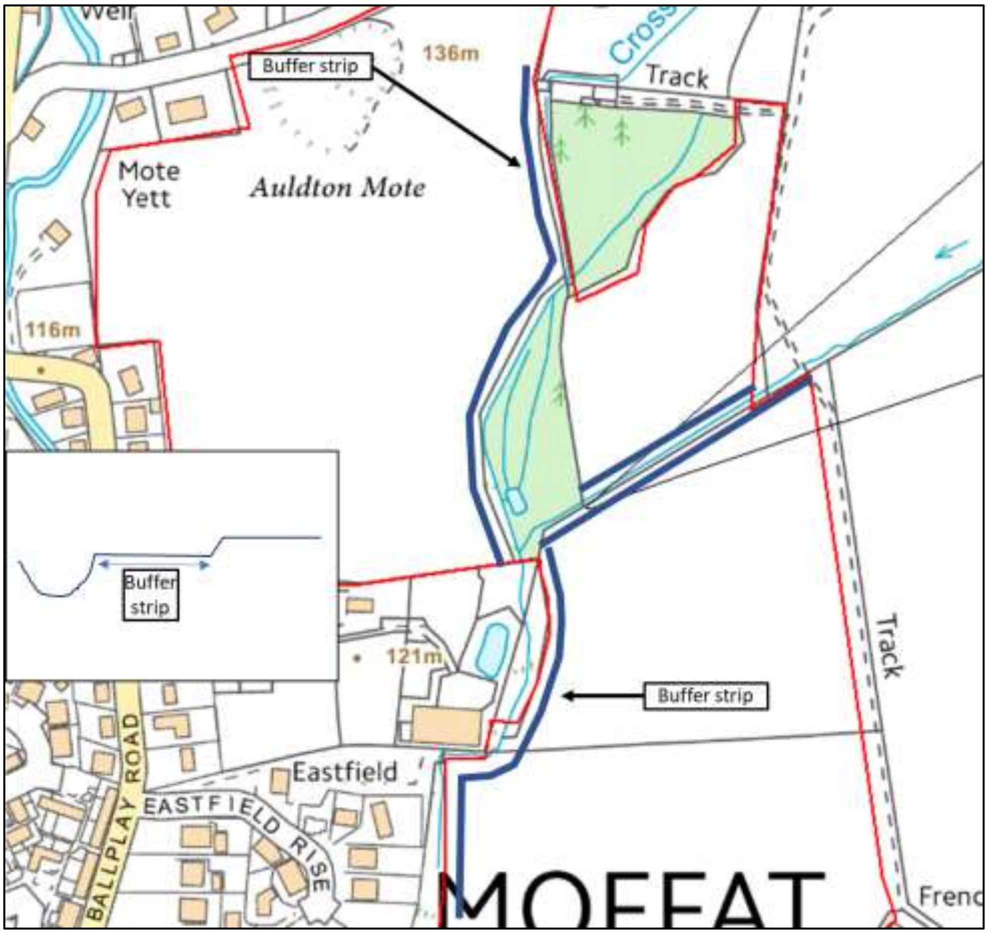
Figure 15: Birnock Water overland flow pathway (100% blockage) plus mitigation options



7.2 Crosslaw Burn/Small Drain – Various

It is recommended that a suitable buffer strip between the site and the channels are included in the site design. Ground levels should be arranged to rise up away from the channel so that any extreme (greater than the 200 year return period) flood waters leaving the main channel are contained within the buffer strip before returning to the channel, see Figure 16. Buffer strips of 5 m are normally requested by Local Authorities to allow for access for channel maintenance in any case.

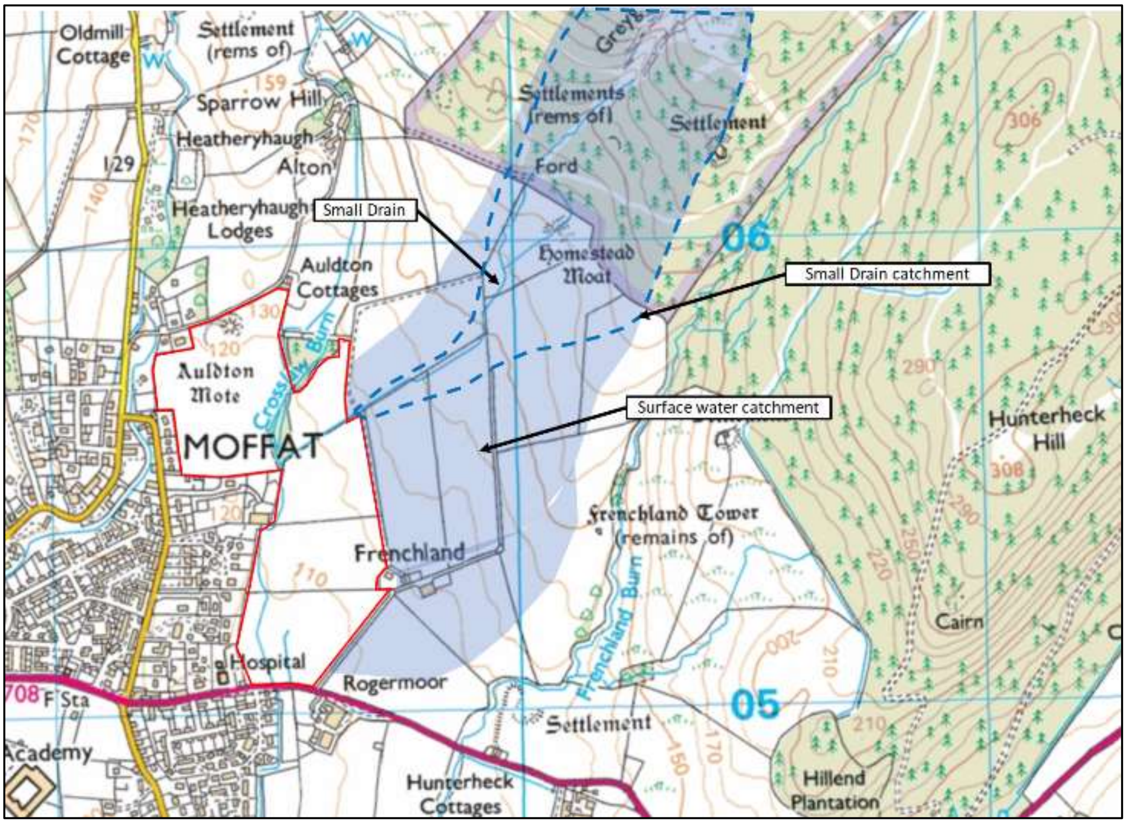
Figure 16: Buffer strip



7.3 Surface Water runoff

High ground rises to the north and east of the site. Ordnance Survey 1:25,000 scale maps show that the Small Drain would intercept surface water runoff within its natural catchment. The Frenchland Burn would also reduce the area able to runoff towards the site, see Figure 17. Therefore, the area freely able to drain to the site is relatively small.

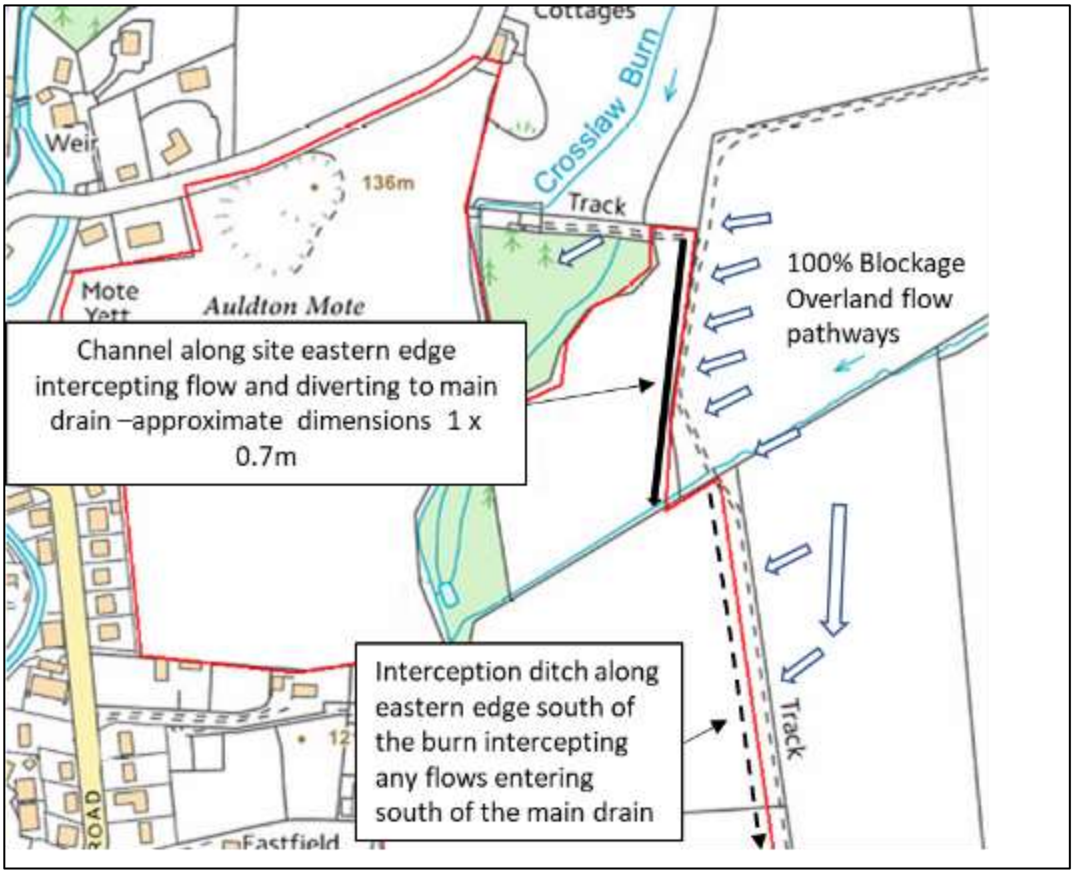
Figure 17: Surface water runoff catchment



However, it is noted that the Small Drain passes through a number of field boundaries which if blocked, would result in additional surface water able to flow overland towards the site. During such conditions, the site could be at risk of flooding from fluvial flows and general surface water runoff.

To protect the site, it is recommended that this overland flow is intercepted and routed towards the Small Drain or Crosslaw Burn. A short HEC-RAS model was constructed to size an example channel based on a full blockage of the Small Drain. A cross section approximately 1 m wide by 0.7m deep with 1 in 2 side slopes would have capacity to pass the 200 year plus climate change flow with a 300 mm freeboard. As discussed, the catchment arriving at the site to the south of the Small Drain is limited by the Frenchland Burn, therefore flows arriving at this location should be captured and diverted towards the Crosslaw Burn, which replicates the situation at present, see Figure 18.

Figure 18: Overland flow mitigation



7.4 Site Access

SEPA acknowledge that compensatory storage proposals cannot be finalised, given the early stage in the process and that this will not be able to be determined until a detailed site layout has been provided.

The development will comprise residential development, which will include respite care housing and social housing. Moffat Hospital lies along the western boundary of the site and there is a need for local development to serve the Hospital residential care services. It is necessary that the development is located adjacent to the hospital buildings for operational requirements. Two access roads will link the development from the A708 and a pedestrian link is proposed through the Hospital boundary.

Based on SEPA guidance, access to the site should be "dry" and free from fluvial flooding. As a result, the proposed access route, which crosses part of the 200 year floodplain, is required to be raised and a crossing structure is required so that flood flow paths are not blocked.

SEPA guidance suggests that compensatory storage calculations should indicate that post-development storage is provided at the same elevation as the area removed for development. Such an approach is useful if the area lowered for compensatory storage is immediately adjacent to the floodplain to be raised for development. However, if the compensatory storage is any distance upstream and/or downstream of the development site, it is not the elevation of the storage provision that is important it is the time that the storage area is accessed by flood waters relative to flows in the river.

Outline design drawings provided by Asher Associates indicate that the proposed access roads could displace an area of up to 500 m^2 based on a water level of approximately 106.2 m AOD. This results in an average depth of approximately 350 mm and total volume of 175 m^3. It is recommended that such a volume is lowered in dry areas of land adjacent to the floodplain to displace the volume lost due to the raised access road. There is a large part of the site outside of the floodplain, where this volume can be provided.

In addition, culvert structures are required to allow flood waters entering the site from the east to pass under the road. Results from the 200 year event indicated that a flow of approximately 1.6 m^3/s could pass under the proposed eastern access; velocity results of the flow pathway do not exceed 1 m/s therefore, a culvert with a depth of 1 m and 2 m width would be sufficient to pass the 200 year flow. Culverts should also be constructed on the western road to allow flood waters to access the floodplain the west.

7.5 Finished Floor Levels

Due to the risk of blockage from field boundaries and the A708, Finished Floor Levels of properties defined as “critical infrastructure’/extra care units should be set at least 1 m above the 1000 year flood levels tabulated in Table 11. For highly vulnerable developments we would recommend that Finished Floor Levels are set 0.6 m above the 200 year plus climate change level.

In areas where overland flow pathways are proposed, ground levels should be arranged to contain flows with sufficient freeboard. Ground levels should be arranged so that flood waters drain away from properties and discourages surface water to pond within the site

8 Summary and Conclusions

This report describes a Flood Risk Assessment for a proposed development site on land north of the A708 in Moffat. The site is undeveloped, comprised of grass and scrub, measuring approximately 24 ha in area.

The Crosslaw Burn flows north to south through the site; in addition, the Frenchland Burn and the Birnock Water are located a short distance to the east and west of the site respectively. A Small Drain discharges into the Crosslaw Burn within the site

The proposed development will comprise of residential development, in the form of respite care housing and social housing. Moffat Hospital lies along the western boundary of the site and there is a need for local development to serve the Hospital residential care services. It is necessary that the development is located close to the hospital buildings for operational requirements.

The risk of flooding from all three watercourses was assessed using 1D/2D mathematical modelling based on surveyed cross-sectional data. Modelling indicated that parts of the proposed development site would be at risk of flooding during a 1 in 200 year event from the Crosslaw and Frenchland Burn.

Development is proposed outside the predicted functional floodplain. Flood mitigation measures are provided in detail in Sections 6 and 7. Finished Floor Level recommendations are also provided.

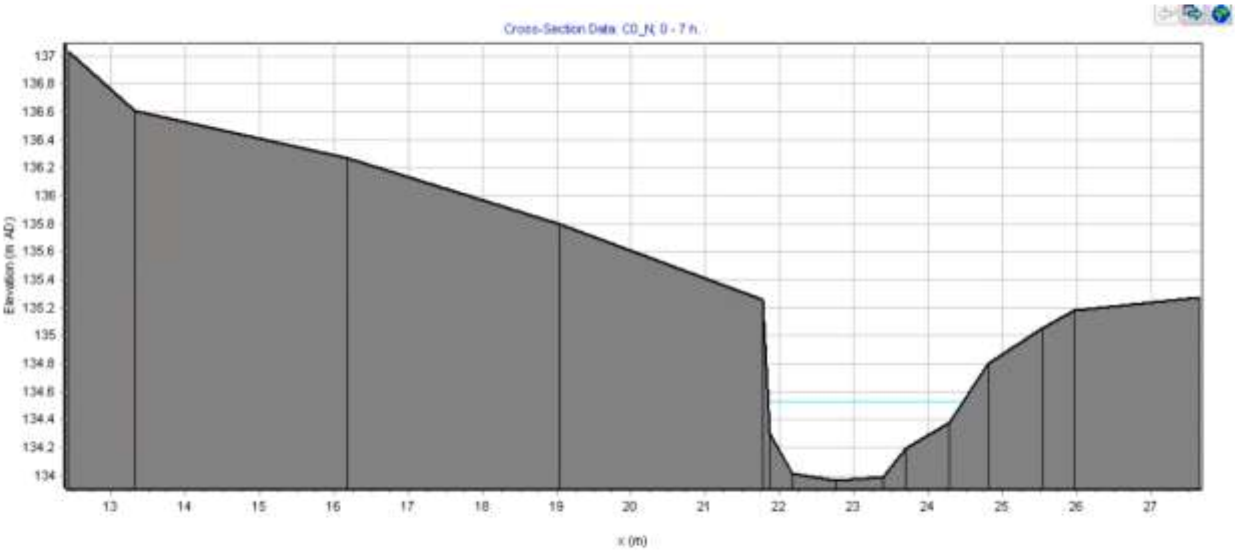
Design of site drainage system was not part of this commission and the requirements for SuDS should be discussed and agreed with Dumfries and Galloway Council.

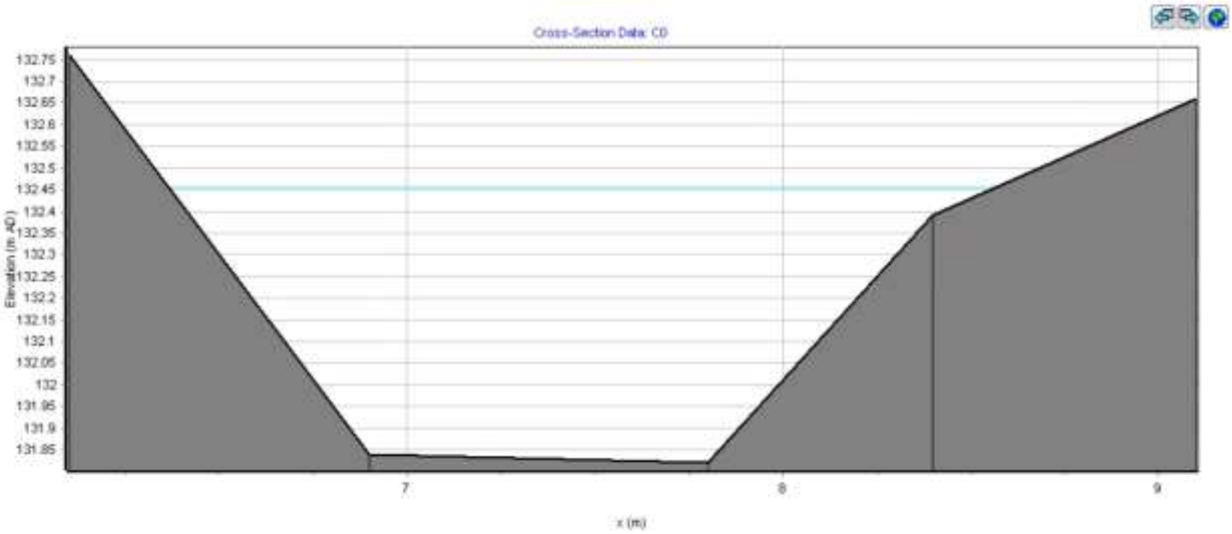
Irrespective of the conclusions above, it is good practice to design finished floor levels an appropriate height above surrounding ground levels and arrange finished ground levels sloping away from buildings. General ground levels should be finished in a way not to allow ponding of surface water within the site where it could increase the risk of flooding of buildings.

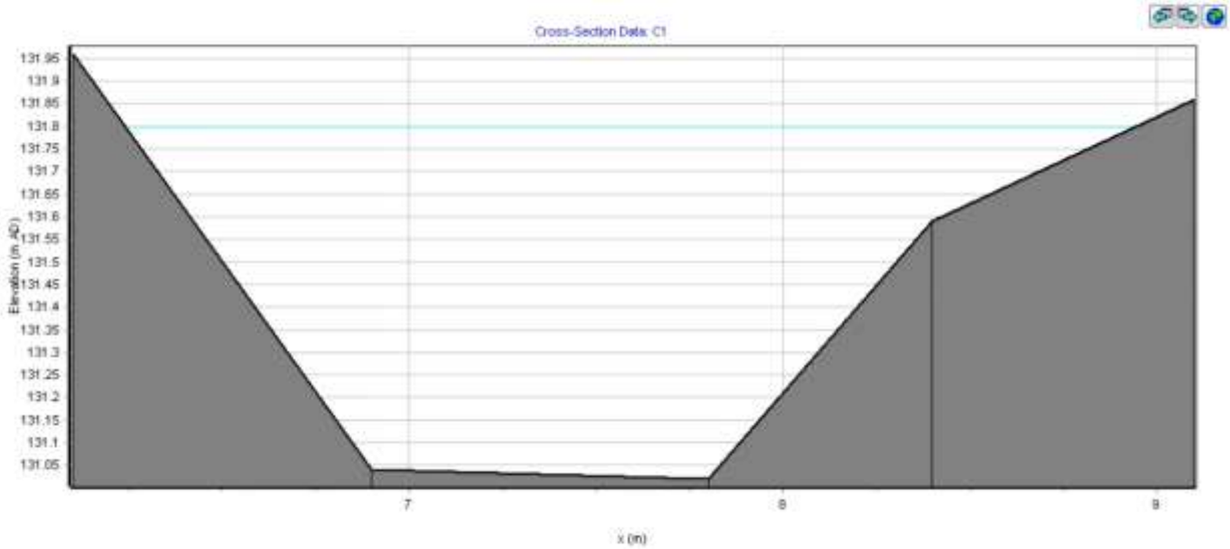
As with any design, maintenance is an important requirement for an effective drainage system. Regular maintenance programs need to be implemented for all components of the drainage system.

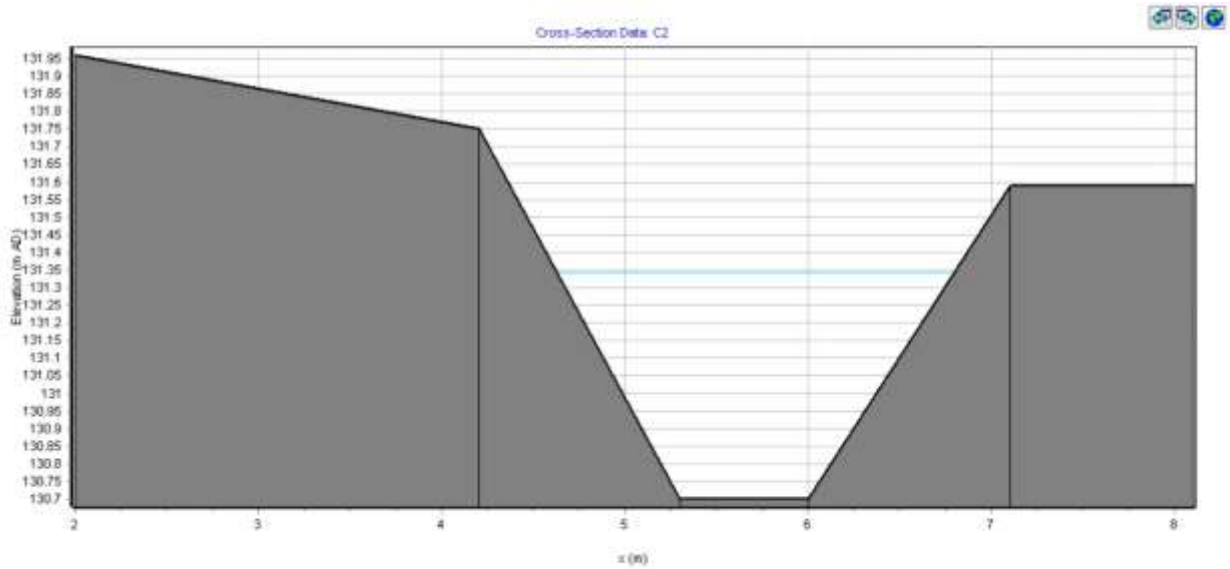
It should be noted that risk of flooding can be reduced but not totally eliminated, given the potential for events exceeding design conditions and the inherent uncertainty associated with estimating hydrological parameters for any given site.

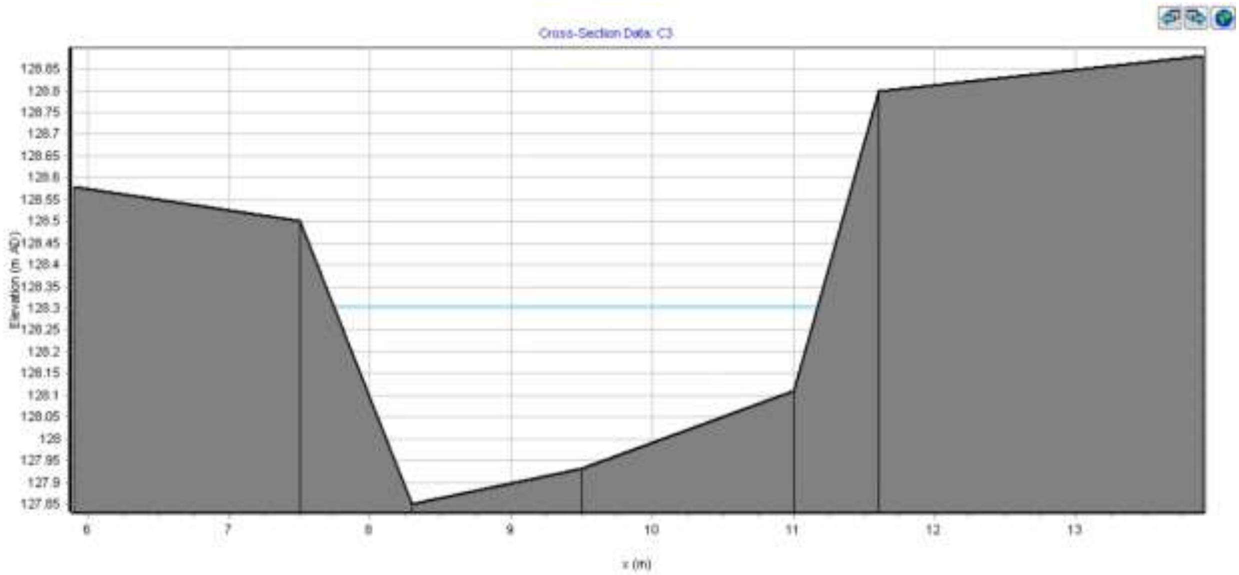
Appendix A – Crosslaw model cross sections






Cross-Section Data: C1
Elevation (m AD)
131.95
131.9
131.85
131.8
131.75
131.7
131.65
131.6
131.55
131.5
131.45
131.4
131.35
131.3
131.25
131.2
131.15
131.1
131.05
7
8
9
x (m)


Cross-Section Data: C2
Elevation (m AD)
131.95
131.9
131.85
131.8
131.75
131.7
131.65
131.6
131.55
131.5
131.45
131.4
131.35
131.3
131.25
131.2
131.15
131.1
131.05
131
130.95
130.9
130.85
130.8
130.75
130.7
2
3
4
5
6
7
8
x (m)


Cross-Section Data: C3
Elevation (m AD)
128.85
128.8
128.75
128.7
128.65
128.6
128.55
128.5
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128.4
128.35
128.3
128.25
128.2
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7
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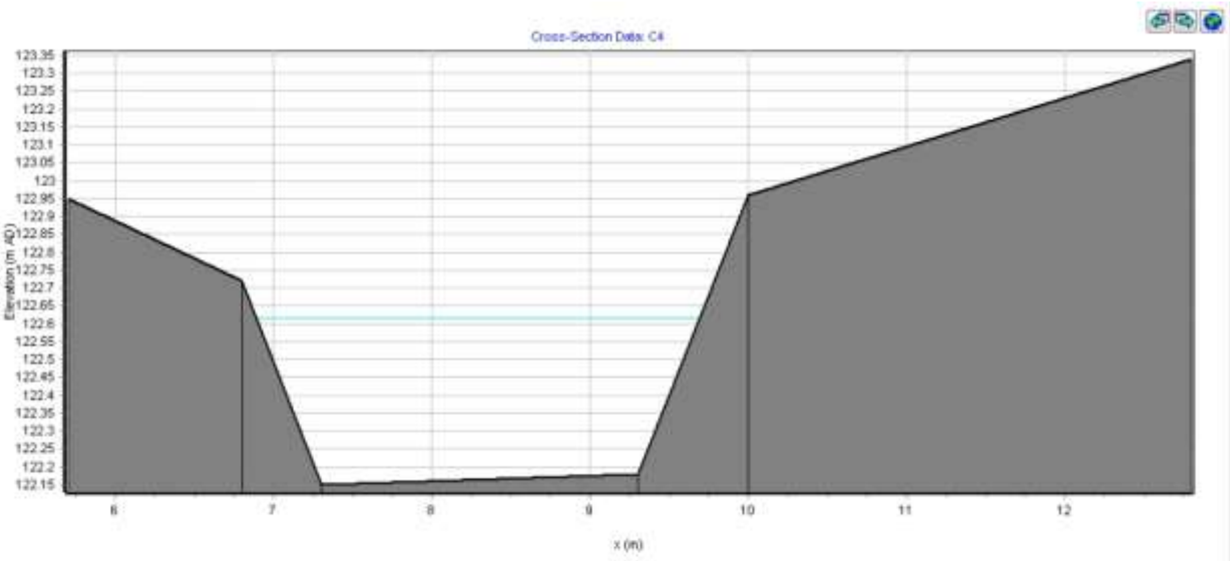
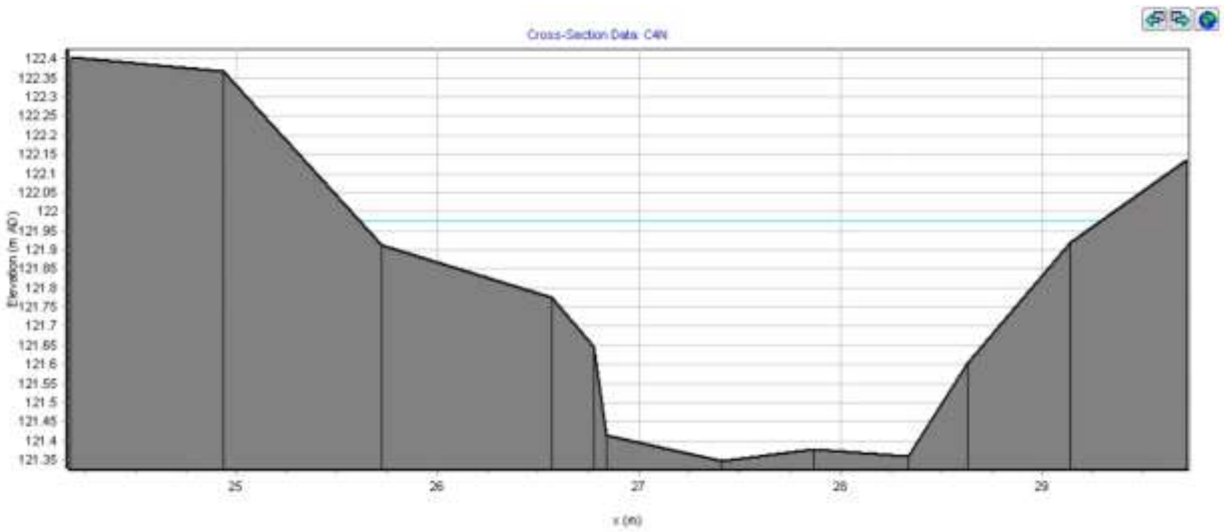
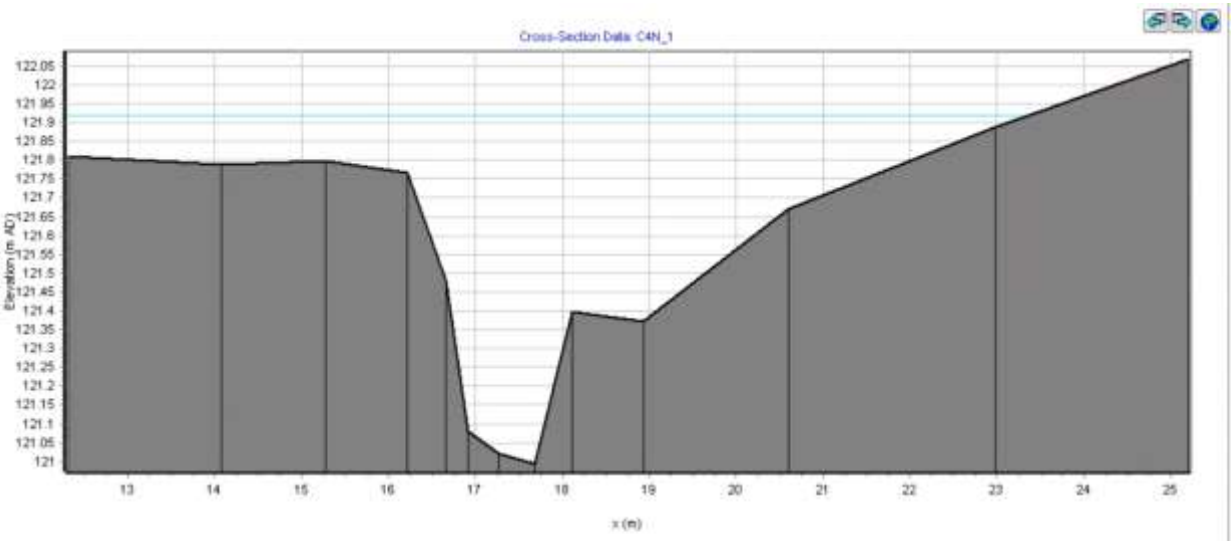
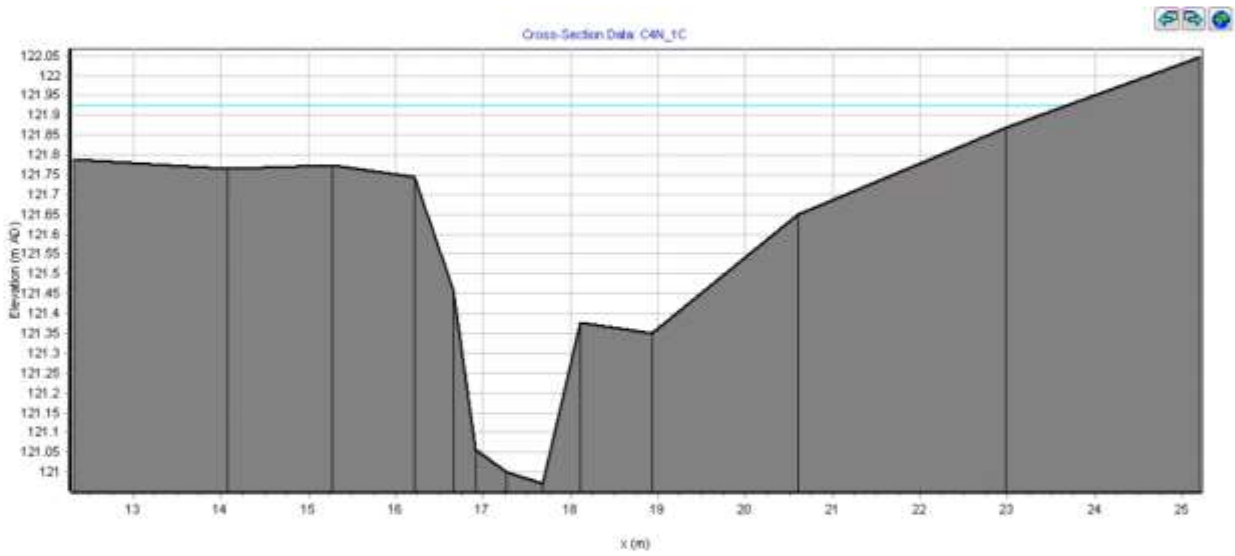
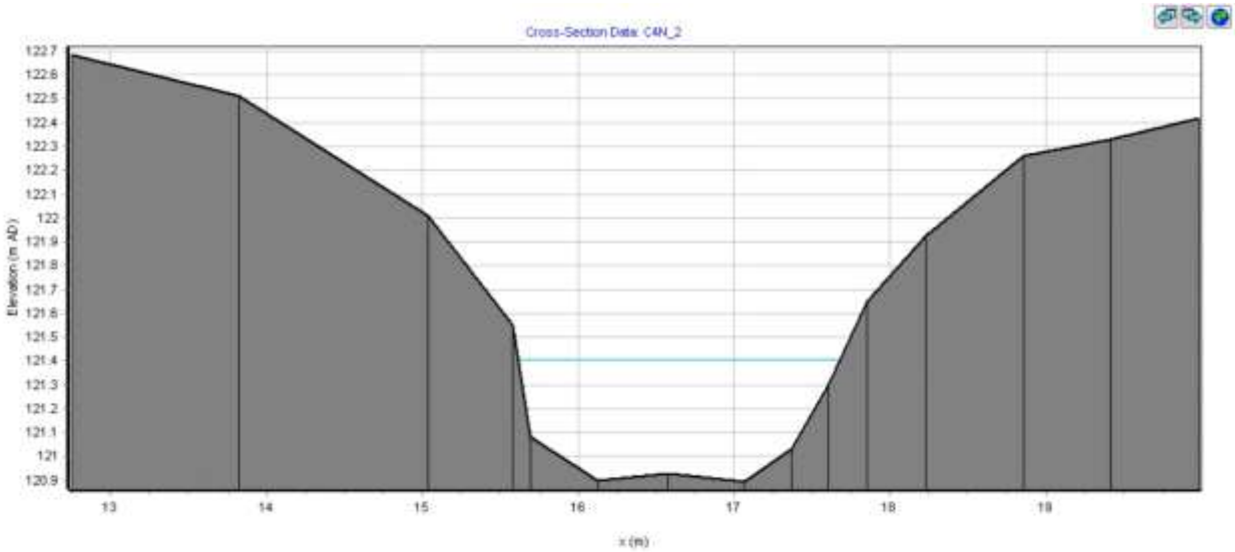
9
10
11
12
13
x (m)

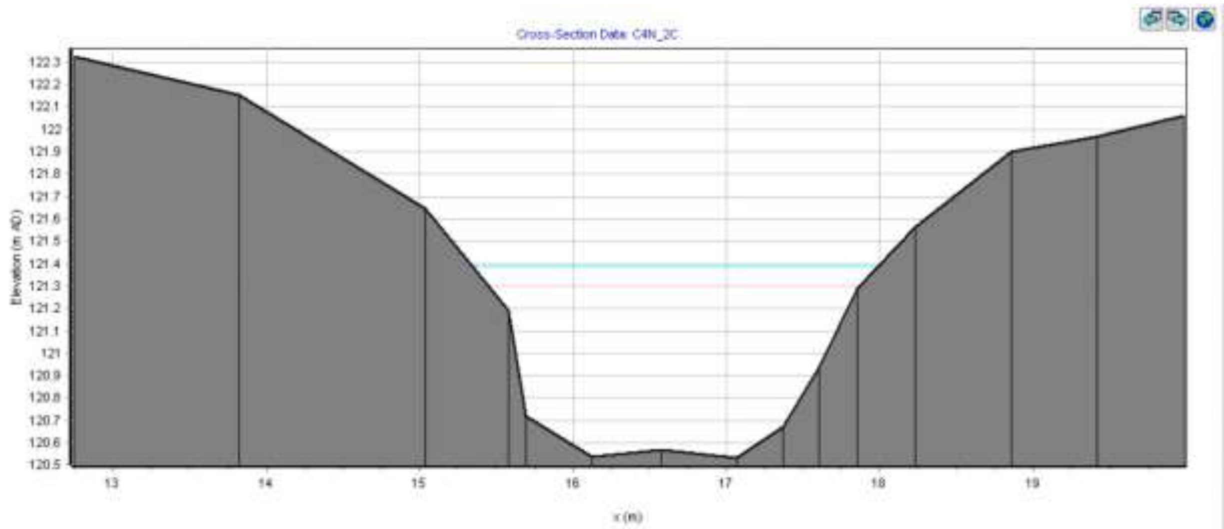

Cross-Section Data: C4
Elevation (m AD)
x (m)

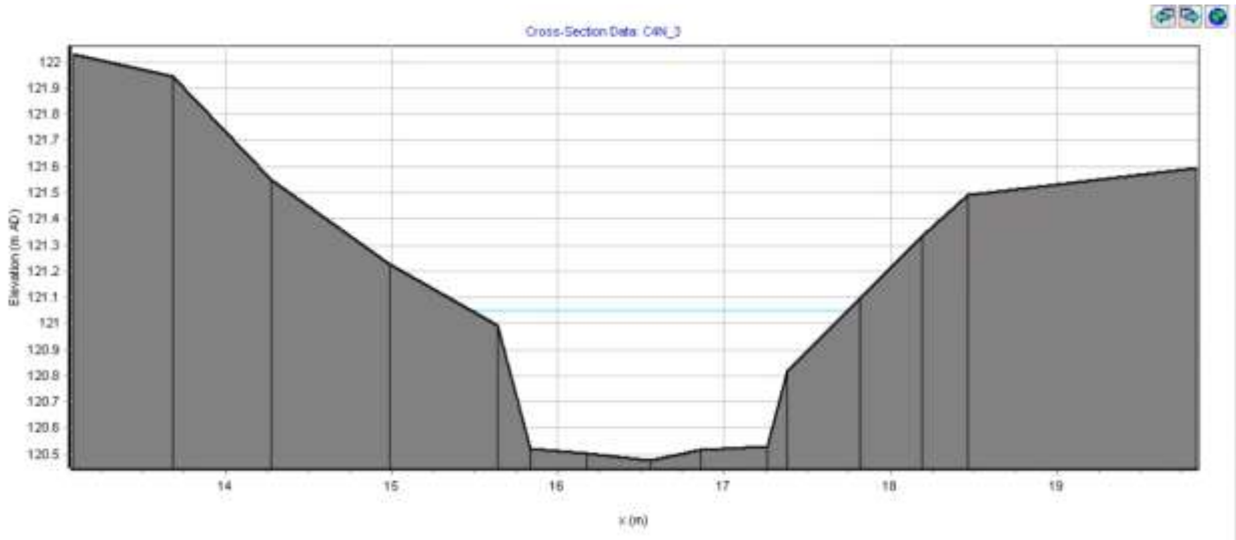

Cross-Section Data: C4N
Elevation (m AD)
x (m)

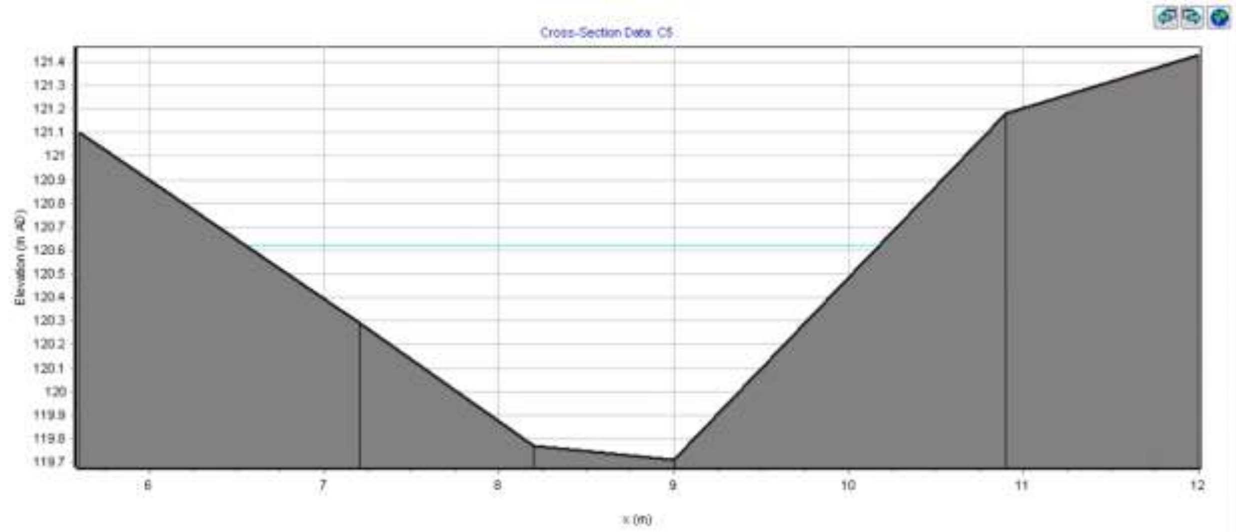

Cross-Section Data: C4N_1
Elevation (m AD)
x (m)

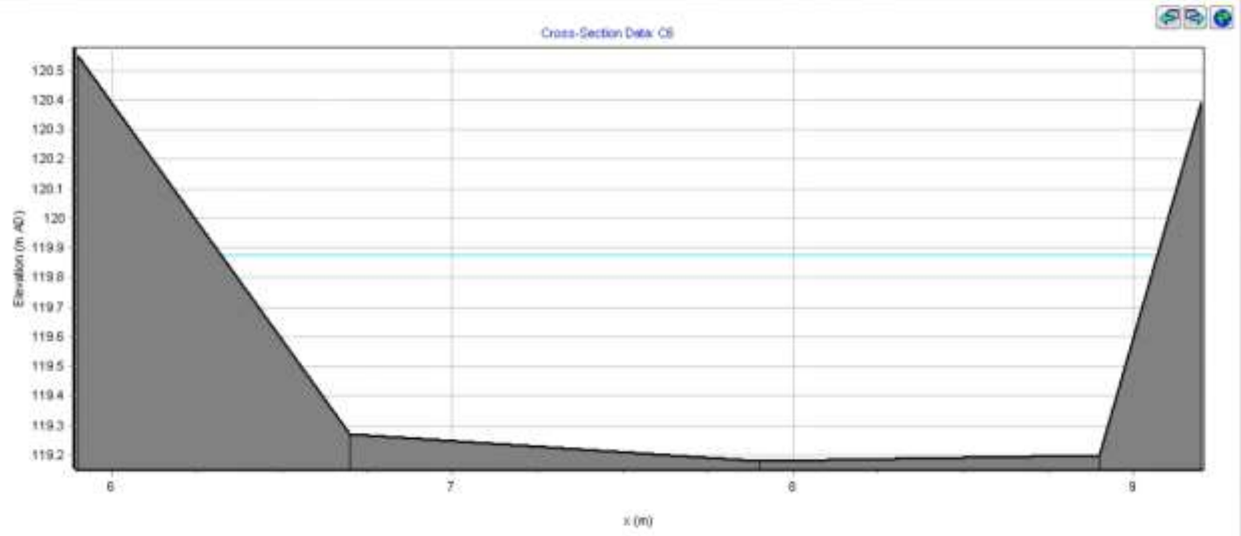

Cross-Section Data: C4N_1C
Elevation (m AD)
x (m)

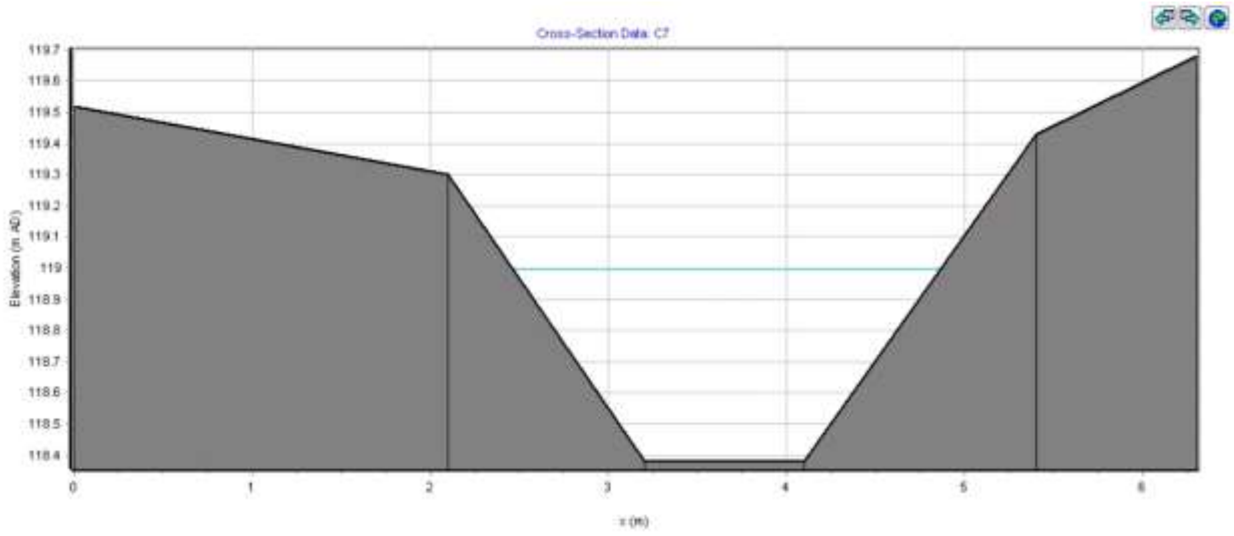

Cross-Section Data: C4N_2
Elevation (m AD)
x (m)

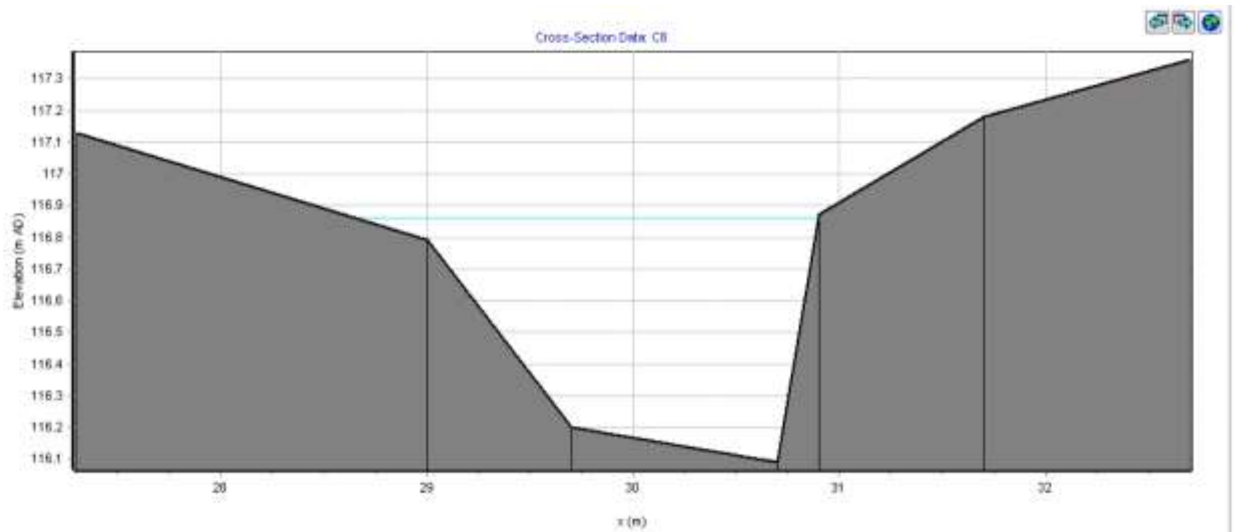

Cross-Section Data: C4N_2C
Elevation (m AD)
x (m)

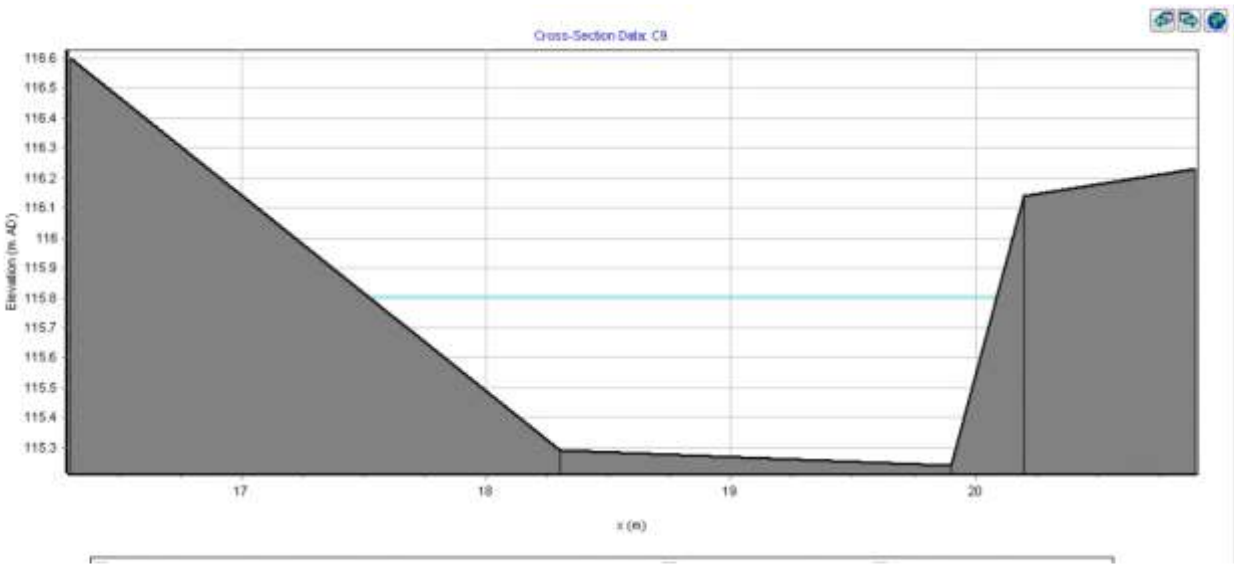

Cross-Section Data: C4N_3
Elevation (m AD)
x (m)

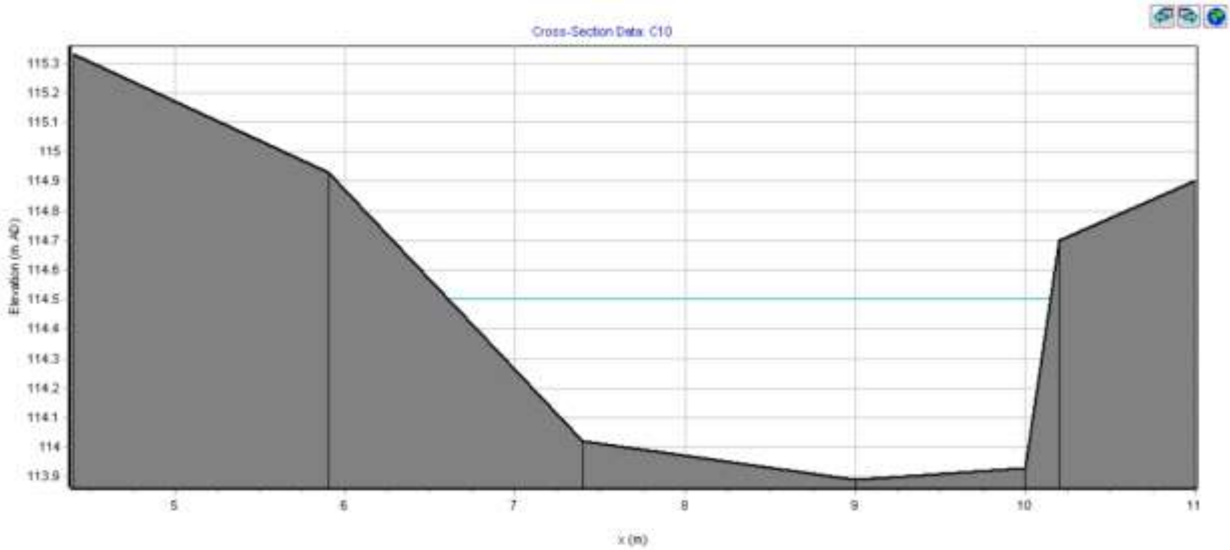

Cross-Section Data: C5
Elevation (m AD)
x (m)

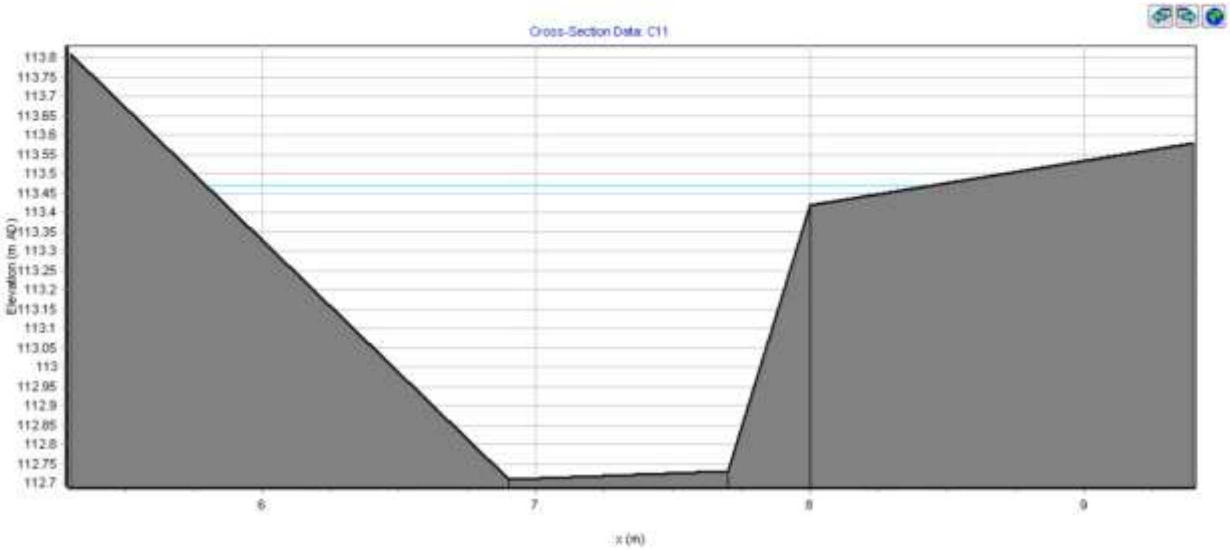

Cross-Section Data: C6
Elevation (m AD)
x (m)

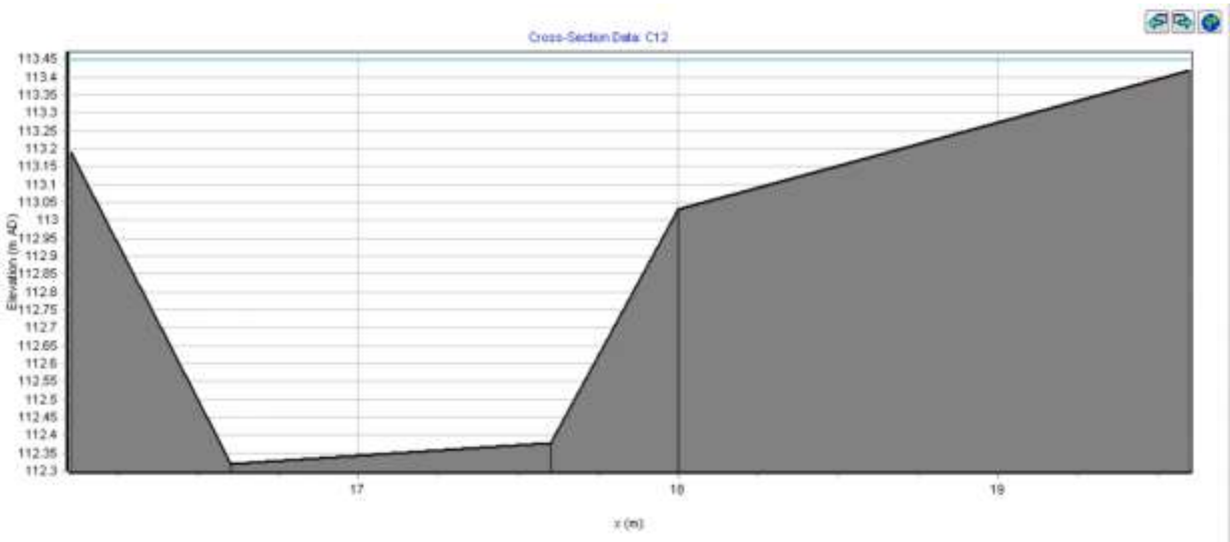

Cross-Section Data: C7
Elevation (m AD)
119.7
119.6
119.5
119.4
119.3
119.2
119.1
119
118.9
118.8
118.7
118.6
118.5
118.4
0
1
2
3
4
5
6
x (m)

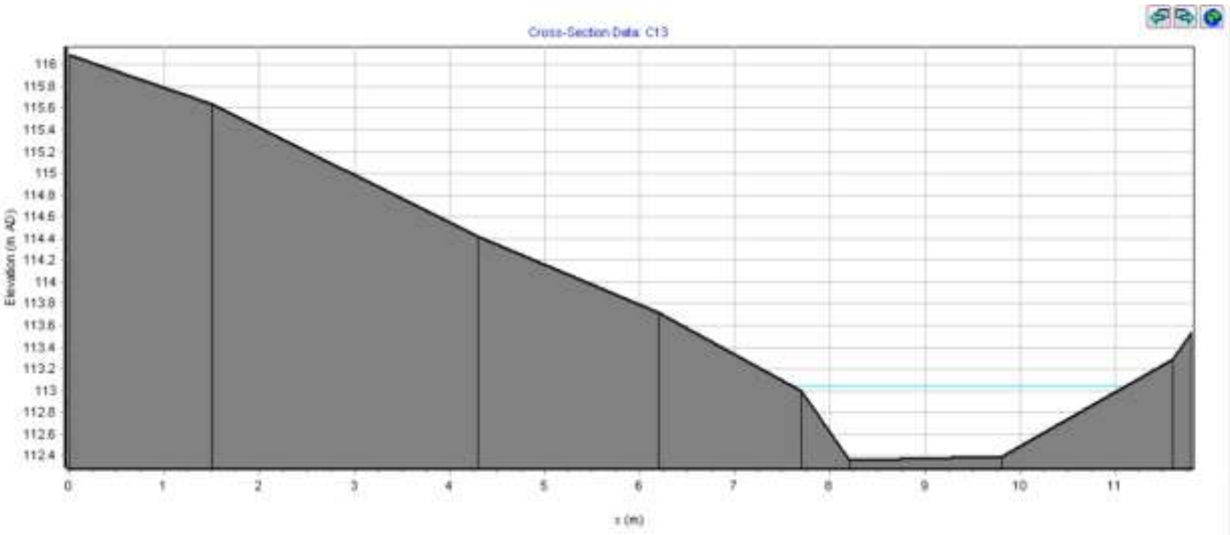

Cross-Section Data: C8
Elevation (m AD)
117.3
117.2
117.1
117
116.9
116.8
116.7
116.6
116.5
116.4
116.3
116.2
116.1
28
29
30
31
32
x (m)

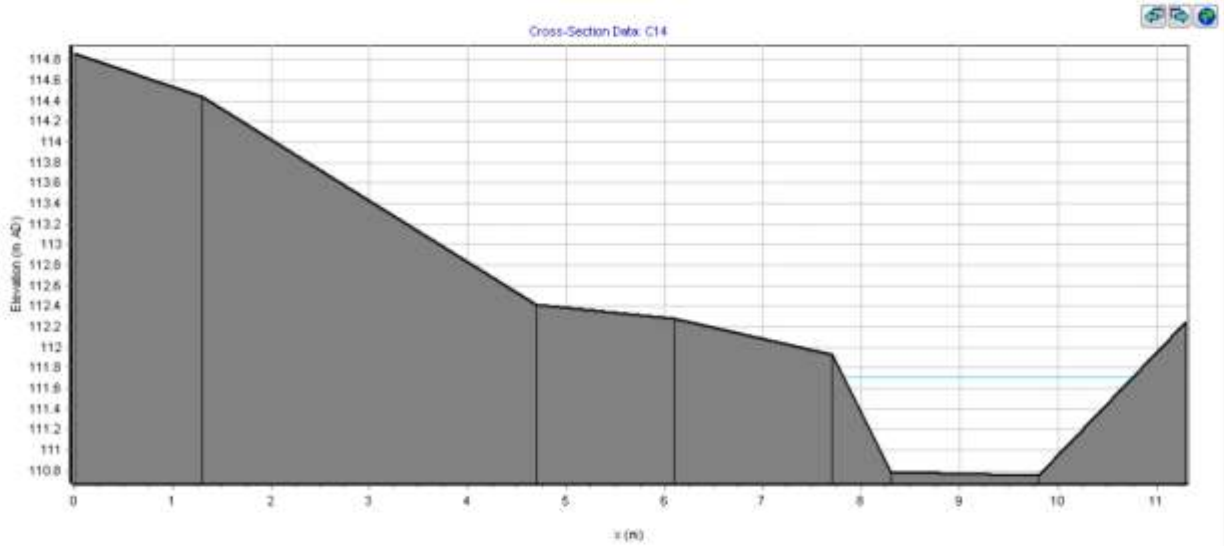

Cross-Section Data: C9
Elevation (m AD)
116.6
116.5
116.4
116.3
116.2
116.1
116
115.9
115.8
115.7
115.6
115.5
115.4
115.3
17
18
19
20
x (m)

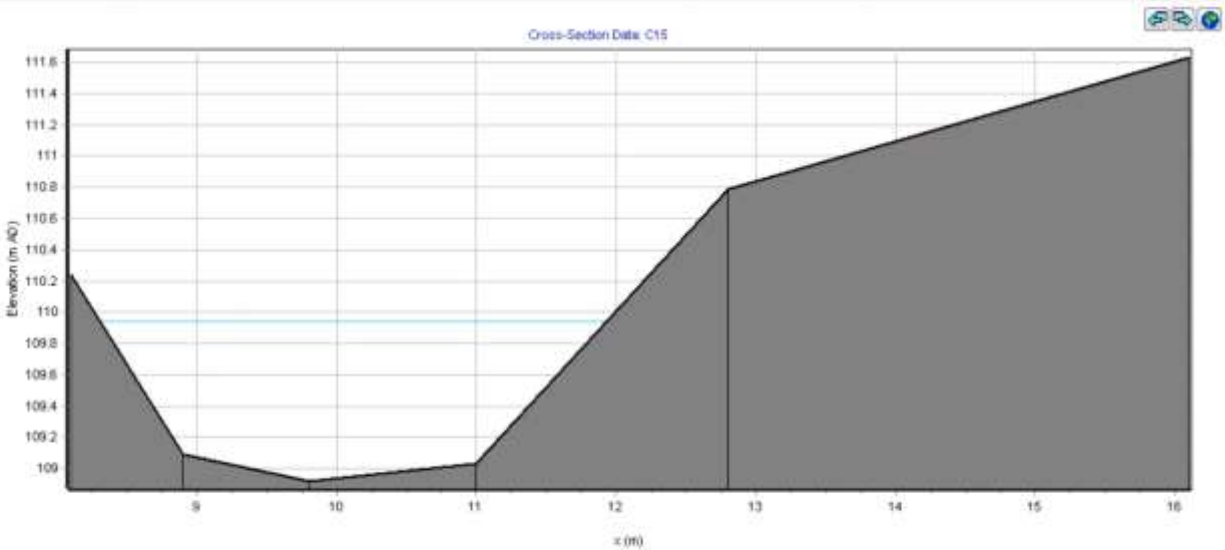

Cross-Section Data: C10
Elevation (m AD)
x (m)

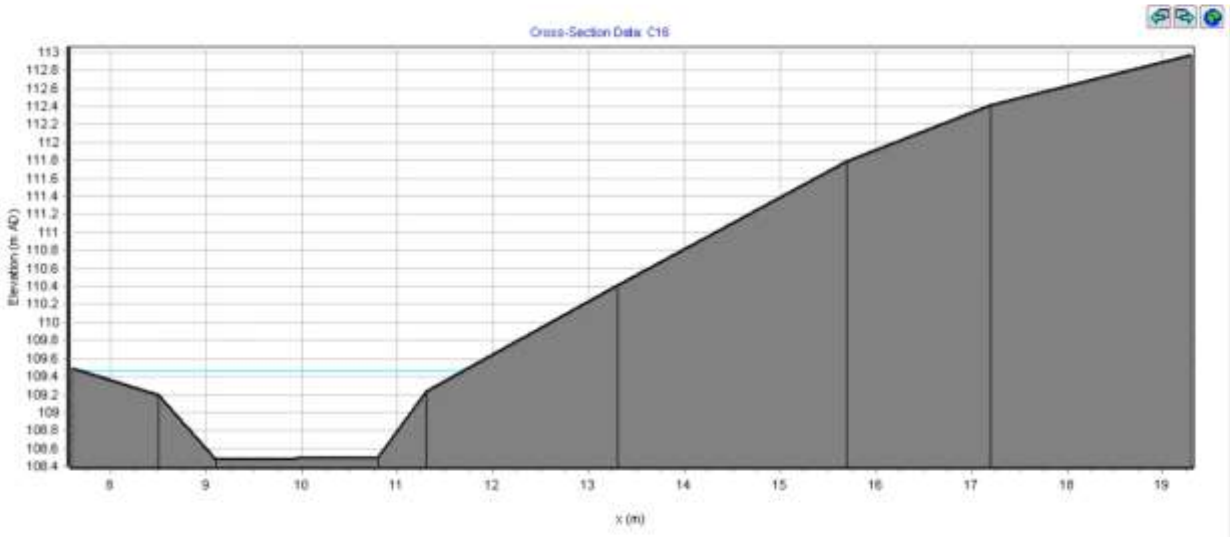

Cross-Section Data: C11
Elevation (m AD)
x (m)

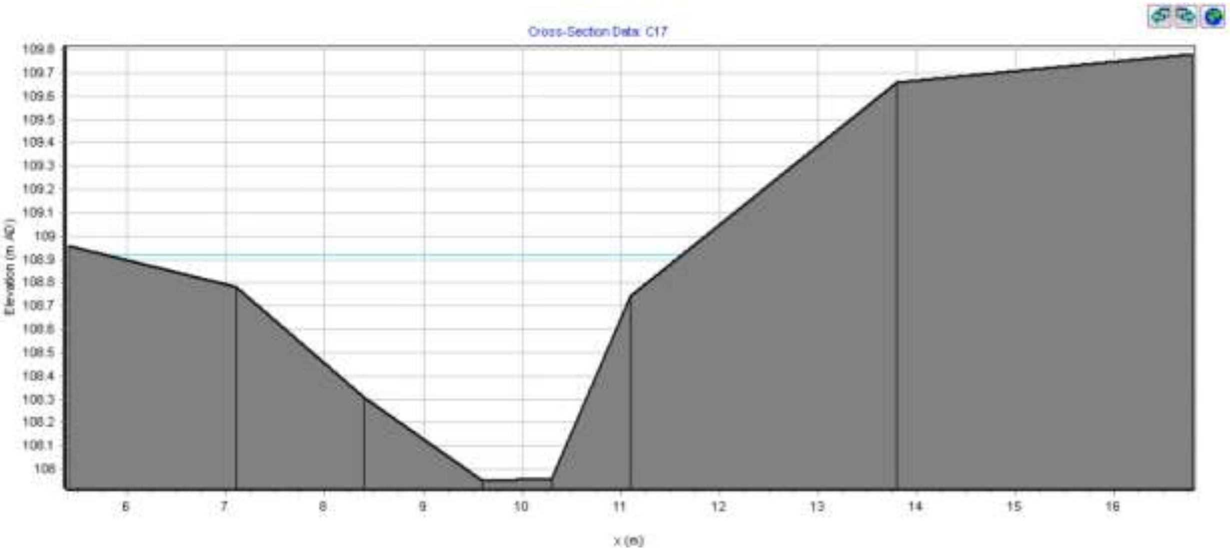

Cross-Section Data: C12
Elevation (m AD)
x (m)

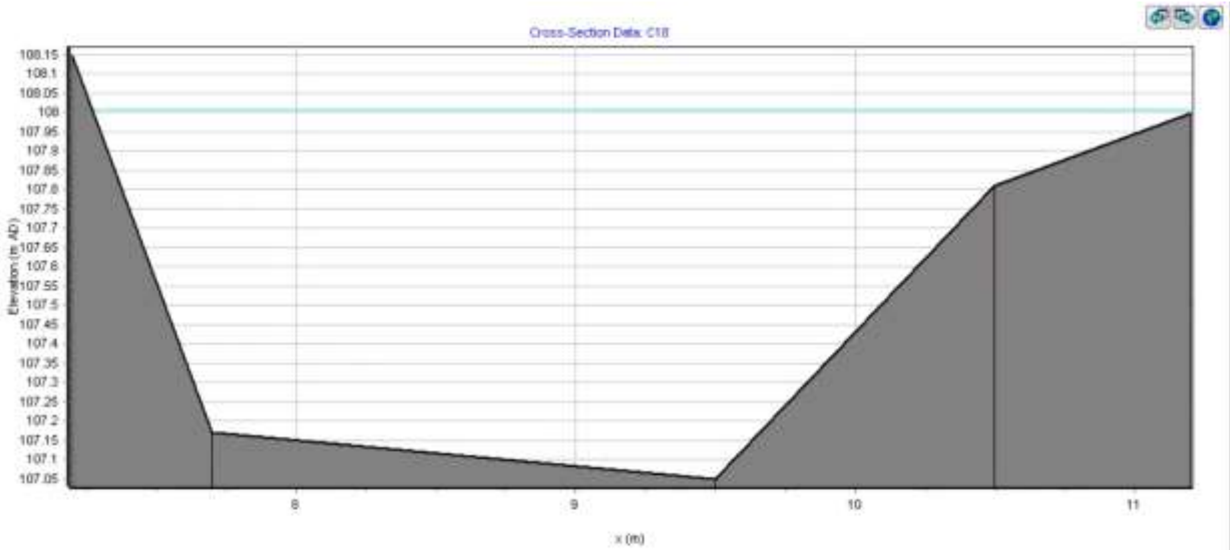

Cross-Section Data: C13
Elevation (m AD)
116
115.8
115.6
115.4
115.2
115
114.8
114.6
114.4
114.2
114
113.8
113.6
113.4
113.2
113
112.8
112.6
112.4
0 1 2 3 4 5 6 7 8 9 10 11
x (m)

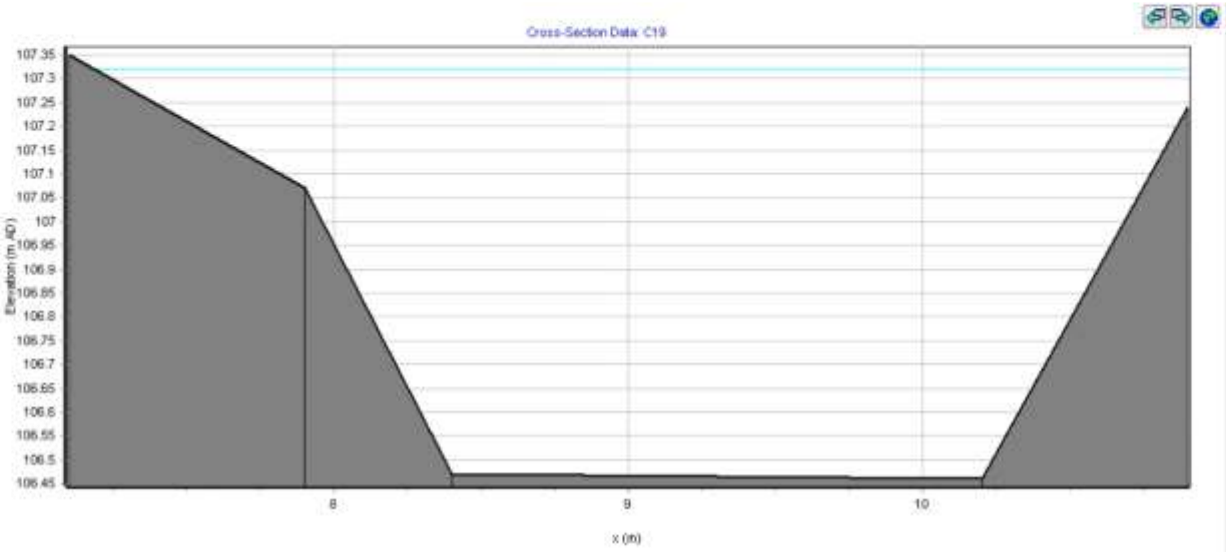

Cross-Section Data: C14
Elevation (m AD)
114.8
114.6
114.4
114.2
114
113.8
113.6
113.4
113.2
113
112.8
112.6
112.4
112.2
112
111.8
111.6
111.4
111.2
111
110.8
0 1 2 3 4 5 6 7 8 9 10 11
x (m)

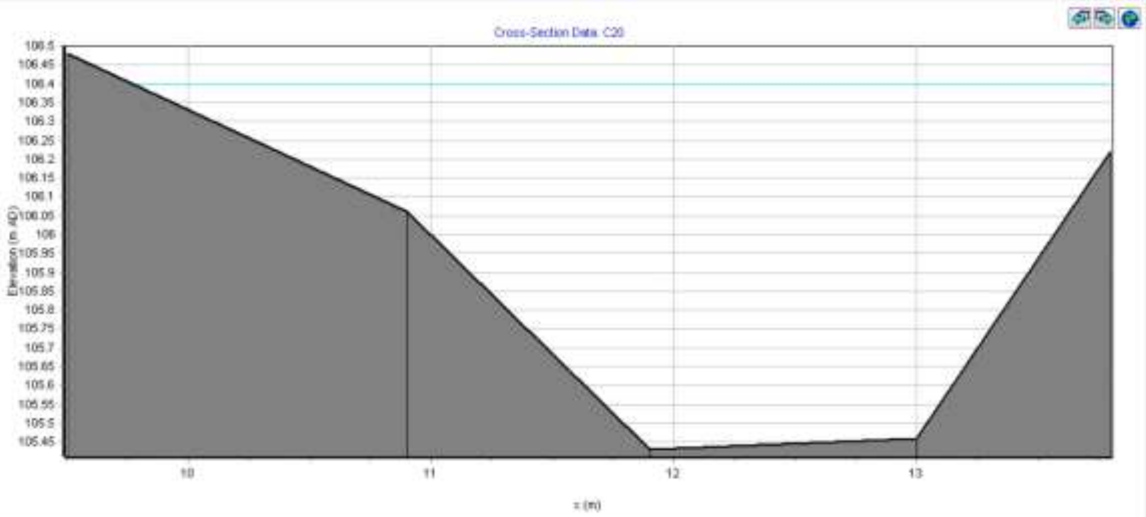

Cross-Section Data: C15
Elevation (m AD)
111.6
111.4
111.2
111
110.8
110.6
110.4
110.2
110
109.8
109.6
109.4
109.2
109
9 10 11 12 13 14 15 16
x (m)

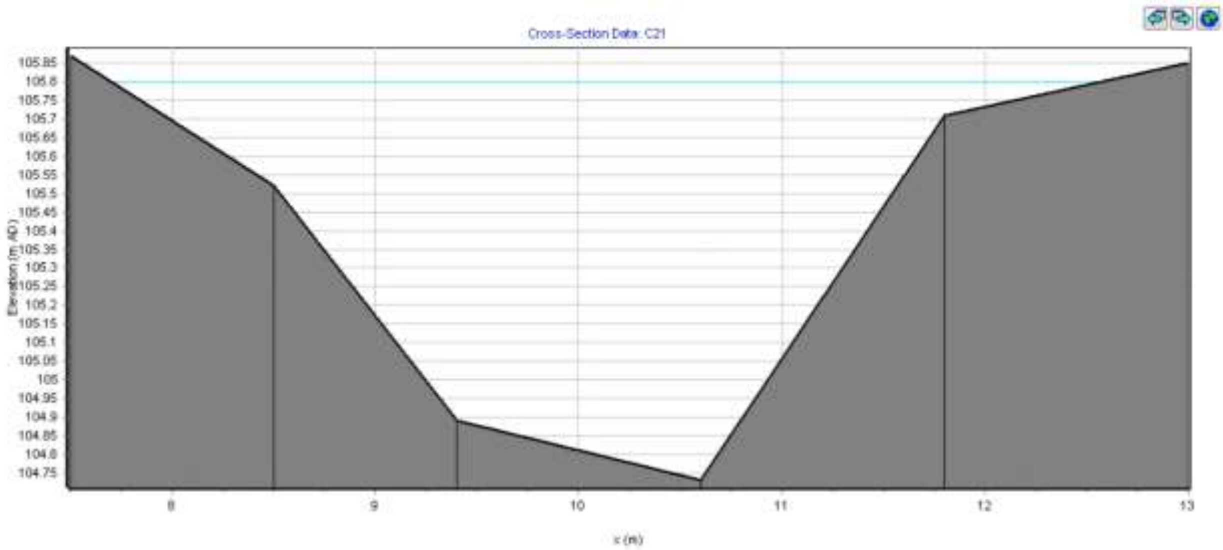

Cross-Section Data: C16
Elevation (m AD)
x (m)

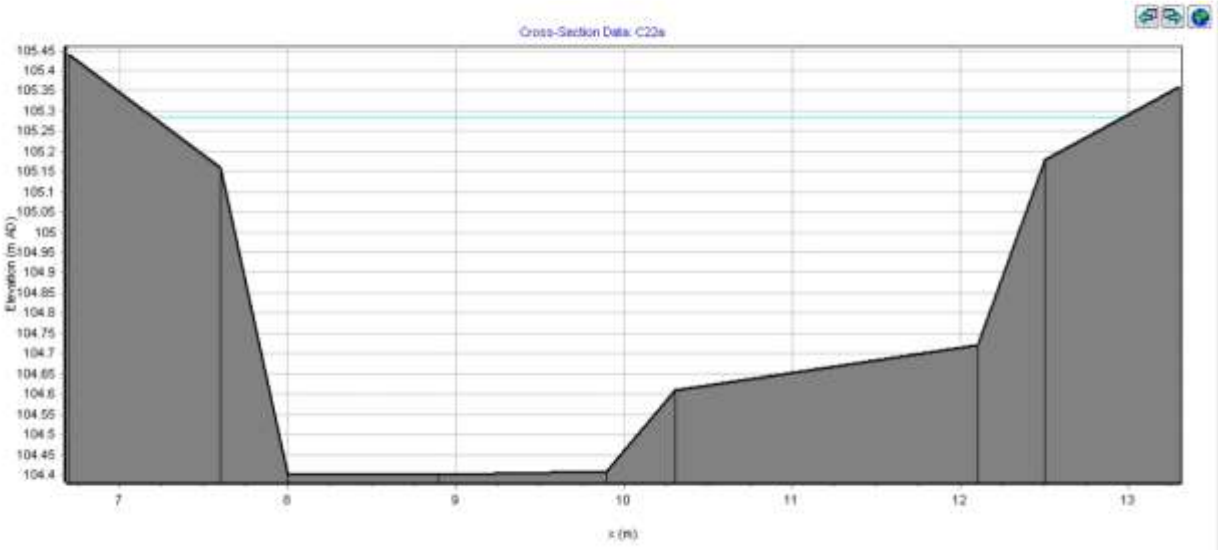

Cross-Section Data: C17
Elevation (m AD)
x (m)

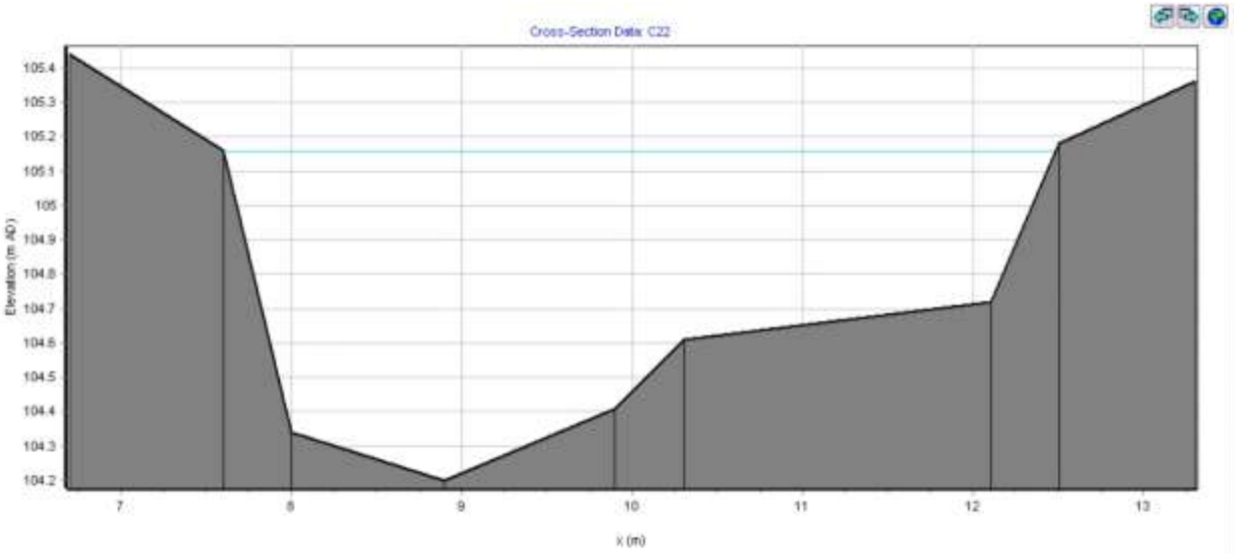

Cross-Section Data: C18
Elevation (m AD)
x (m)

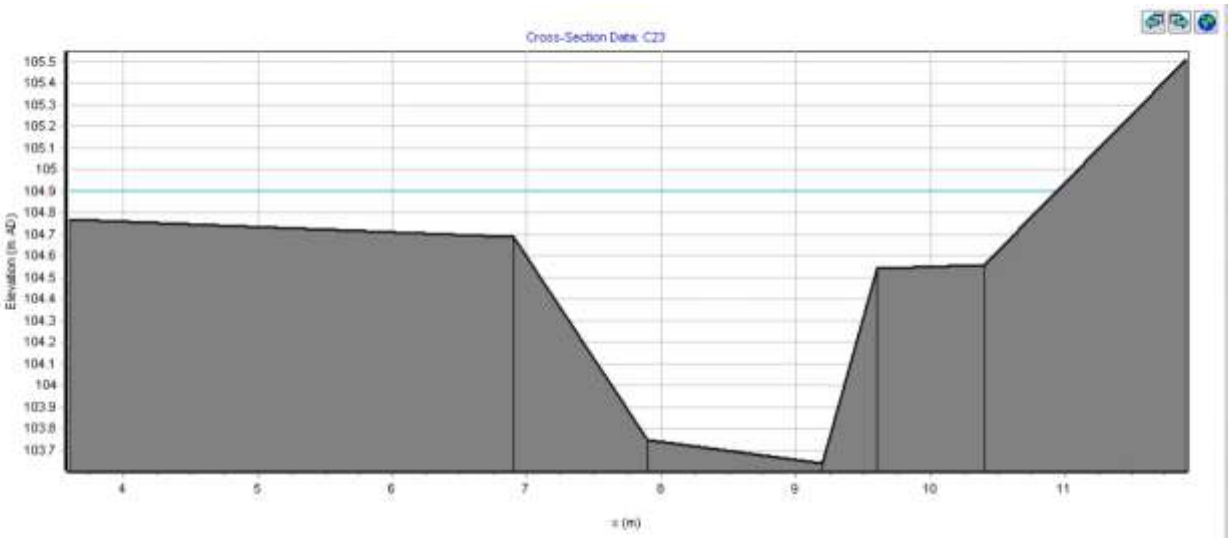

Cross-Section Data: C19
Elevation (m AD)
x (m)

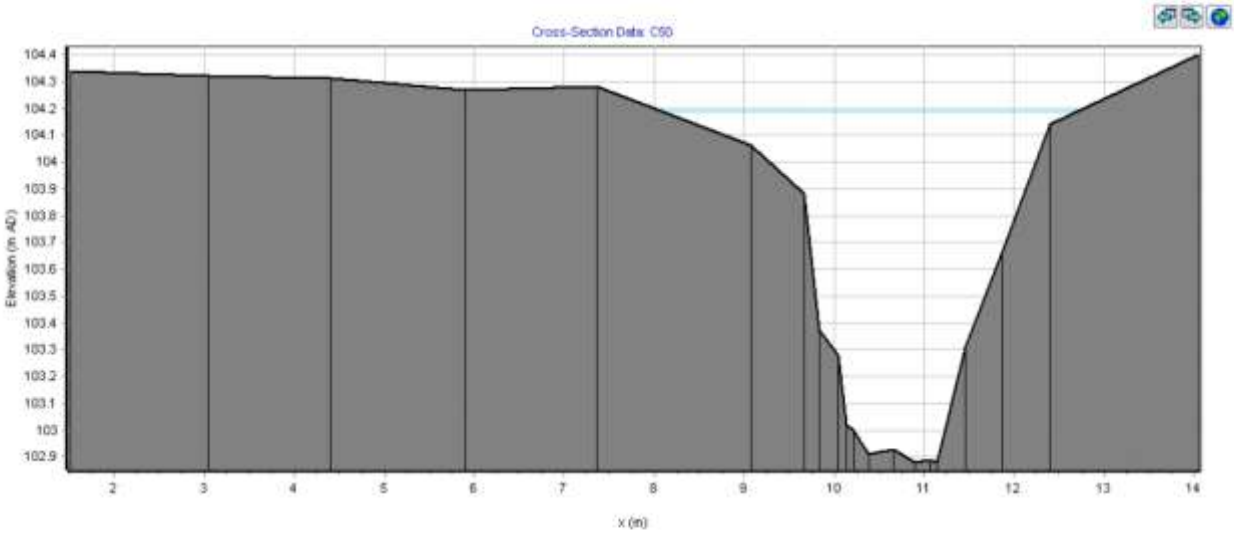

Cross-Section Data: C20
Elevation (m AD)
x (m)

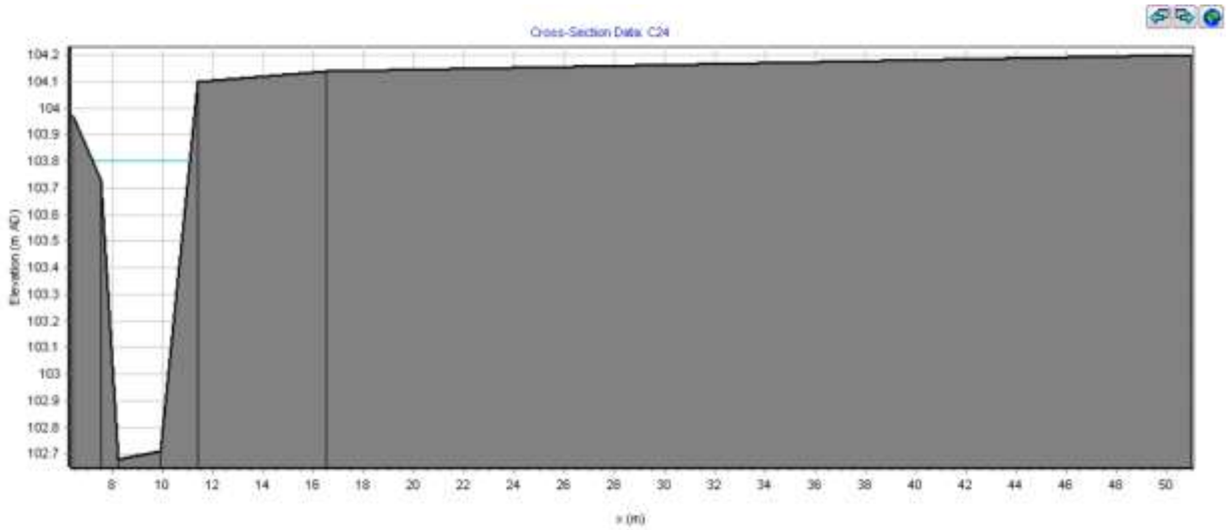

Cross-Section Data: C21
Elevation (m AD)
x (m)

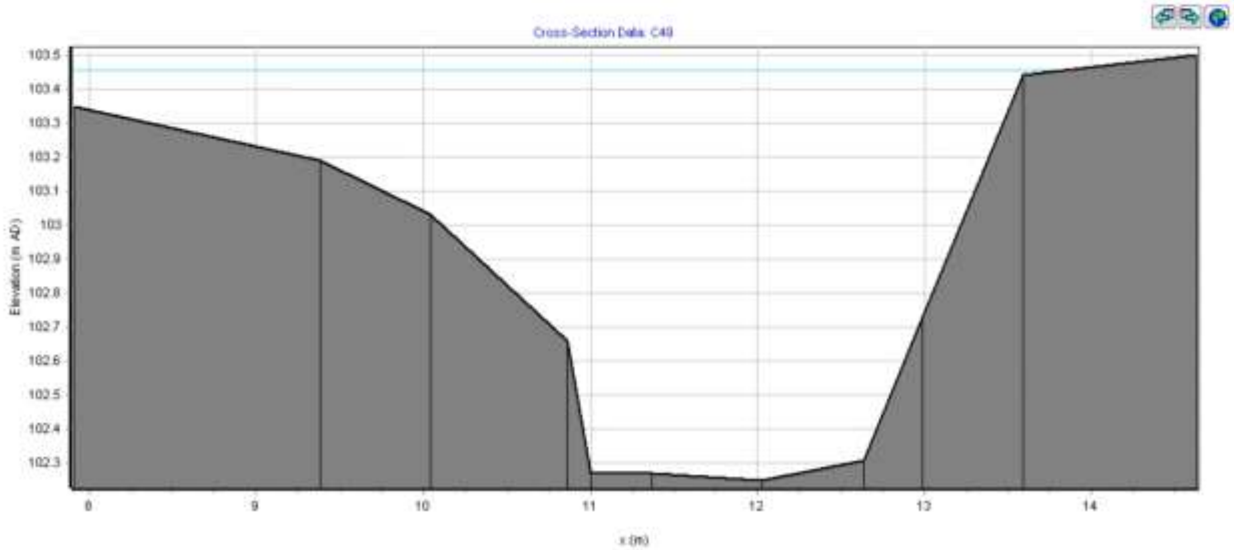

Cross-Section Data: C22a
Elevation (m AD)
x (m)

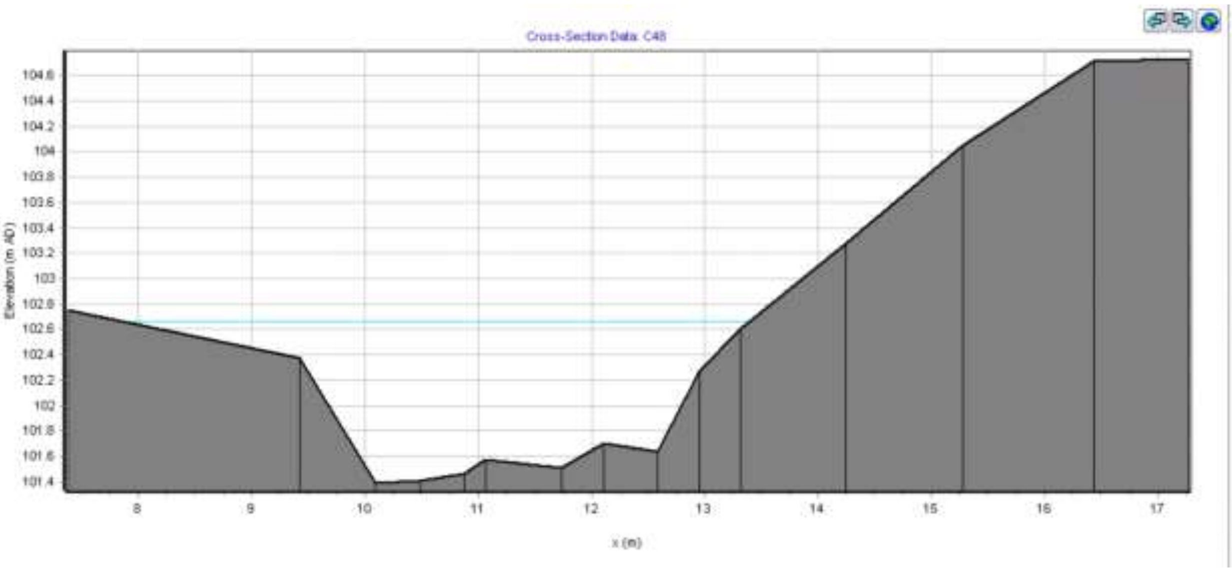

Cross-Section Data: C22
Elevation (m AD)
X (m)

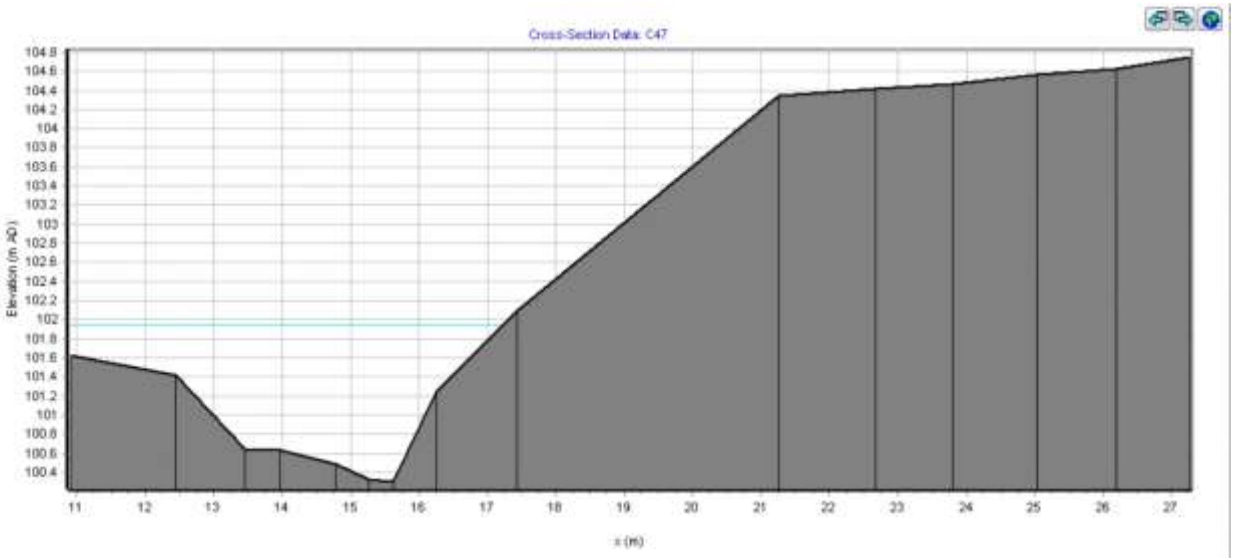

Cross-Section Data: C23
Elevation (m AD)
x (m)

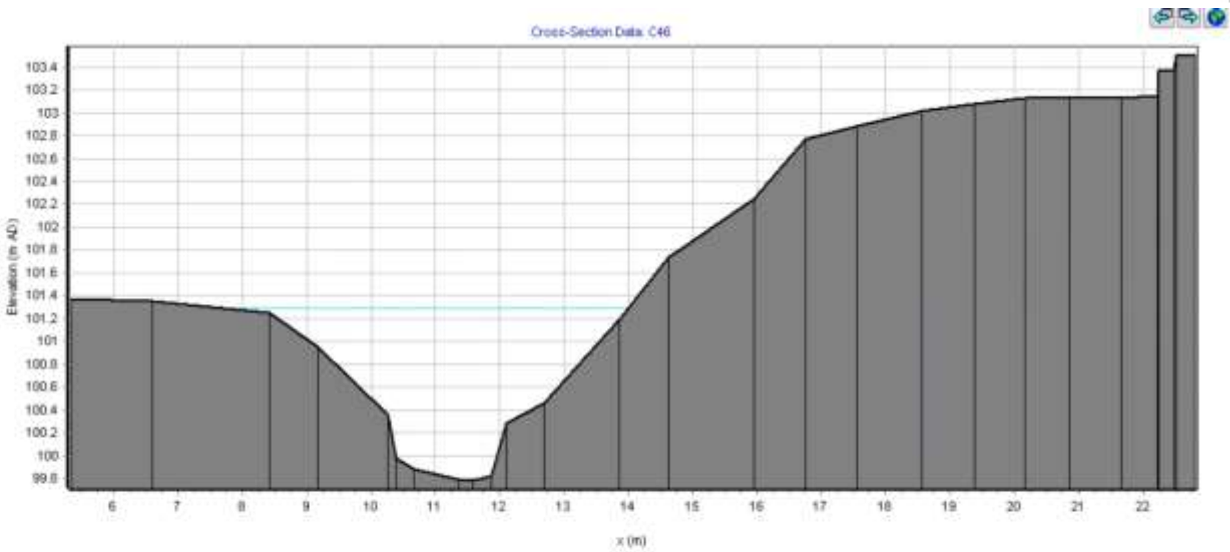

Cross-Section Data: C50
Elevation (m AD)
x (m)


Cross-Section Data: C24
Elevation (m AD)
x (m)

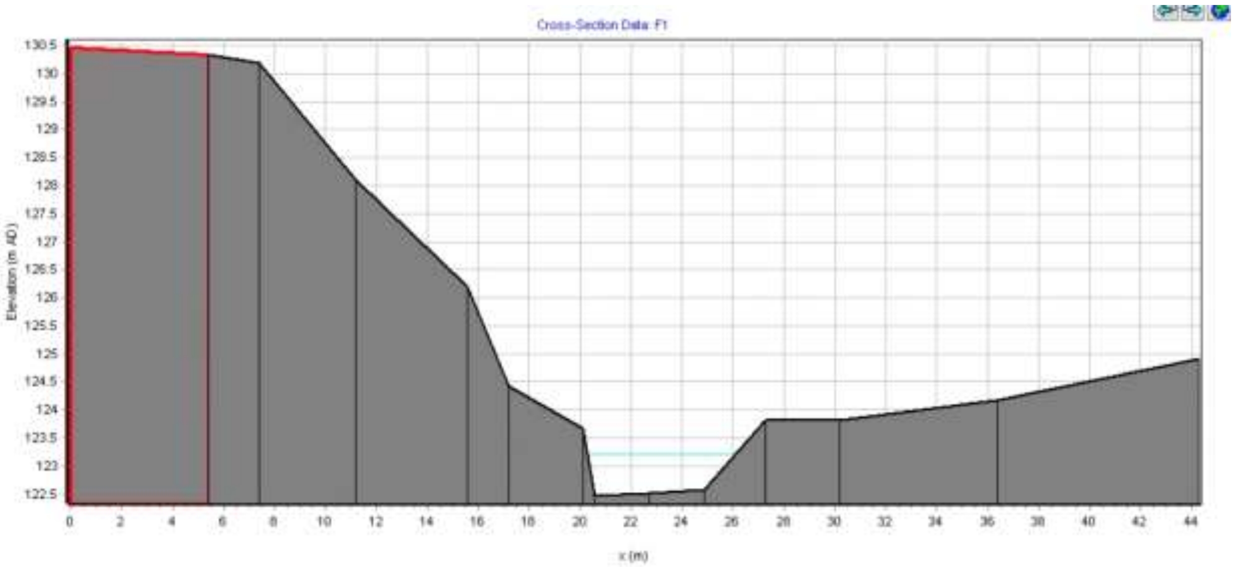

Cross-Section Data: C48
Elevation (m AD)
x (m)

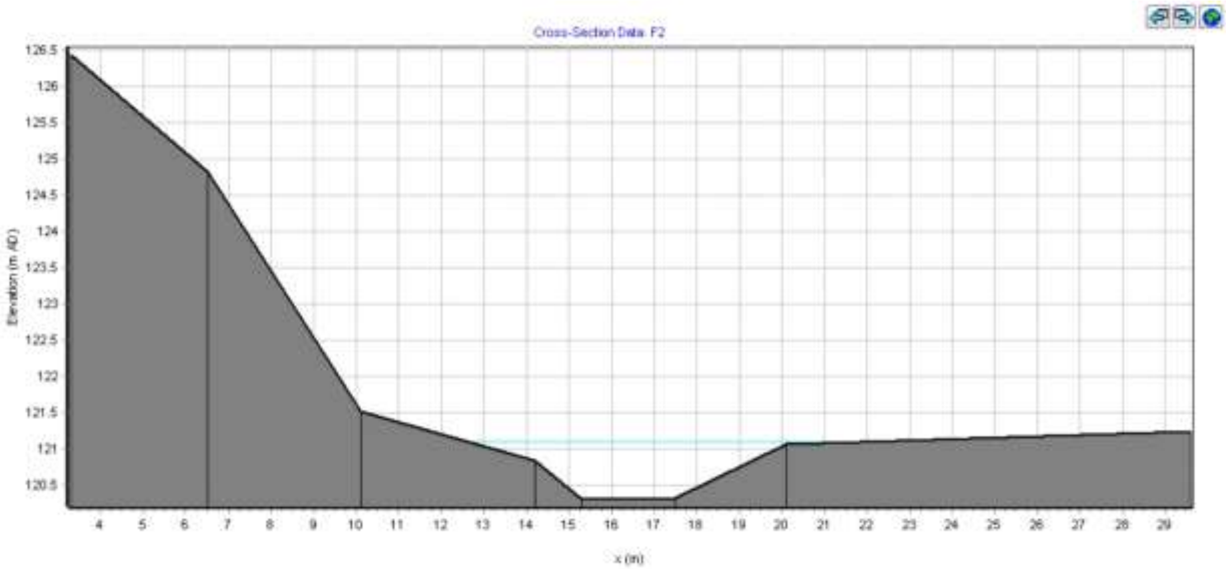

Cross-Section Data: C48
Elevation (m AD)
x (m)

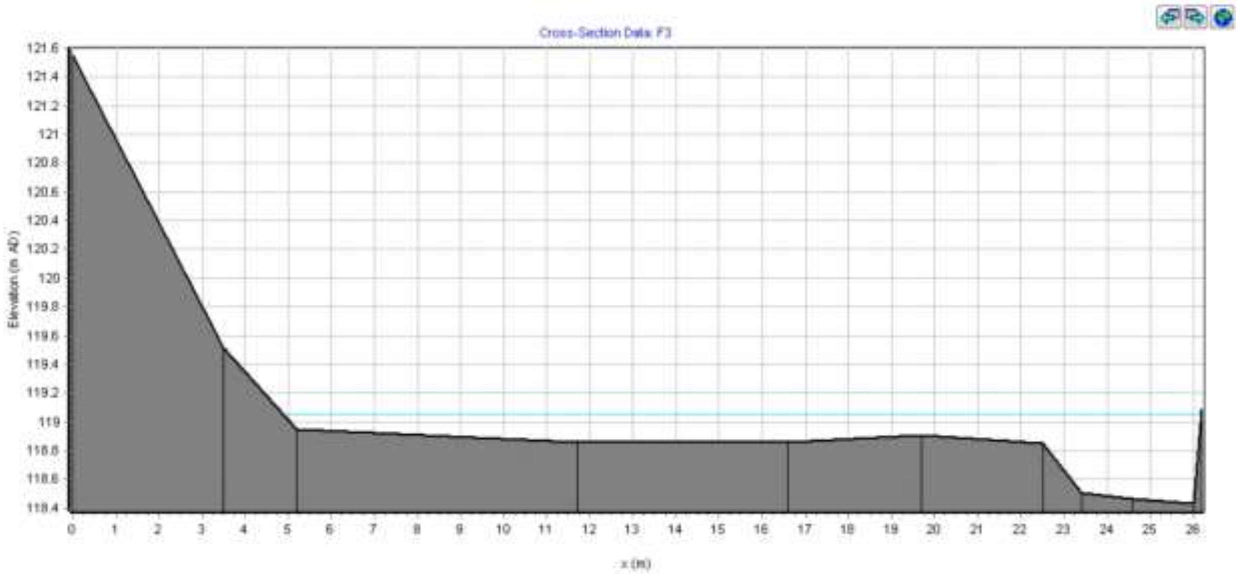

Cross-Section Data: C47
Elevation (m AD)
x (m)

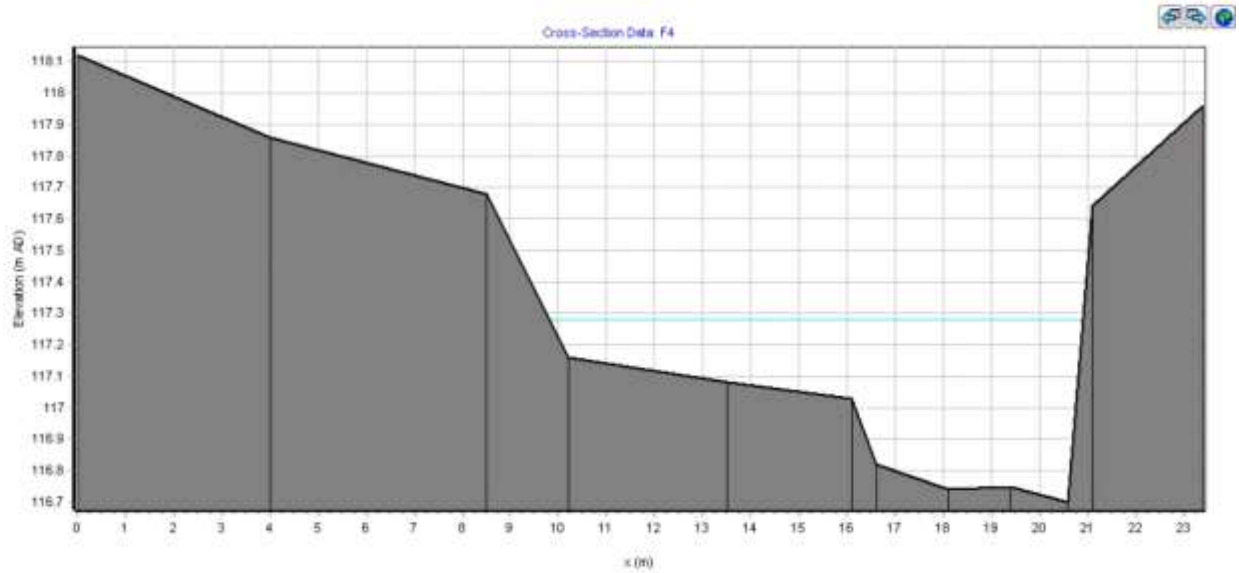

Cross-Section Data: C46
Elevation (m AD)
x (m)

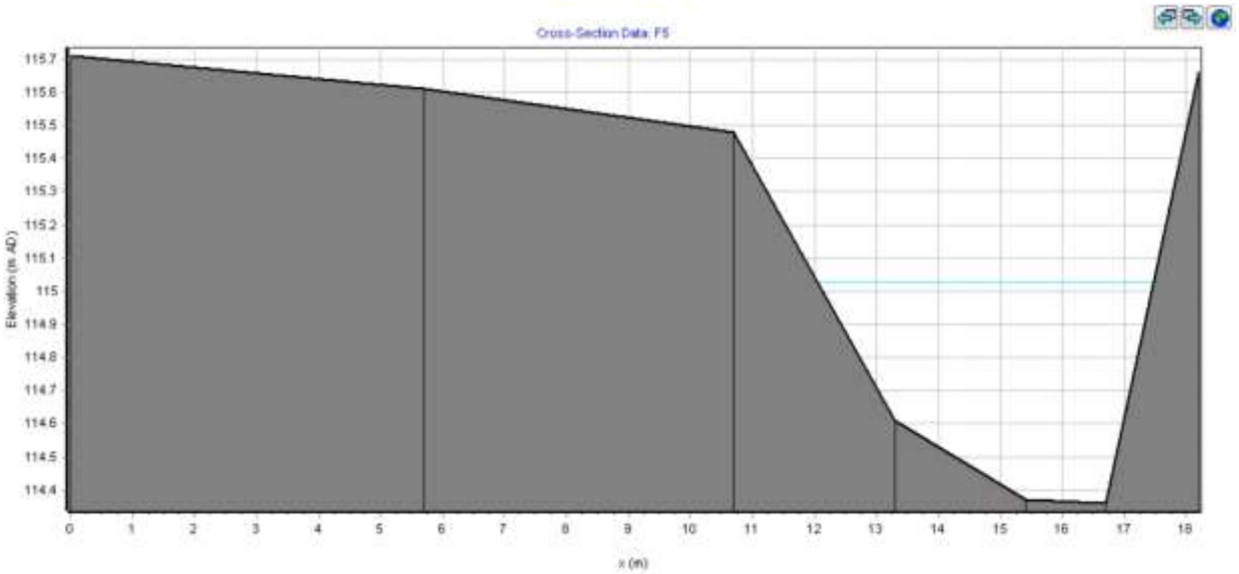
Appendix B – Frenchland model cross sections

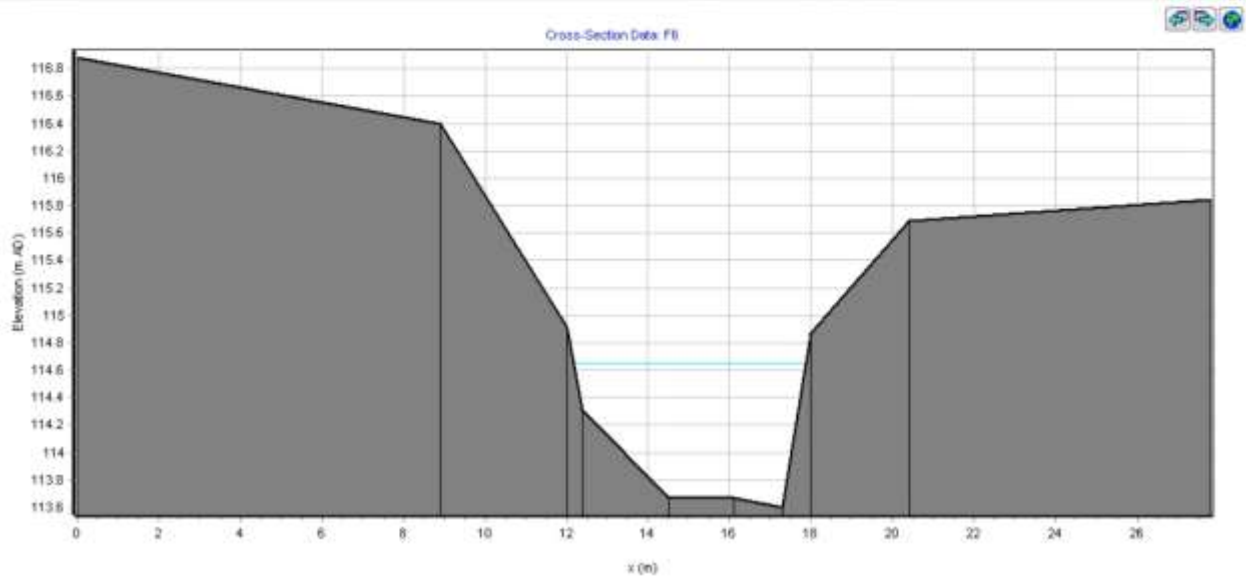


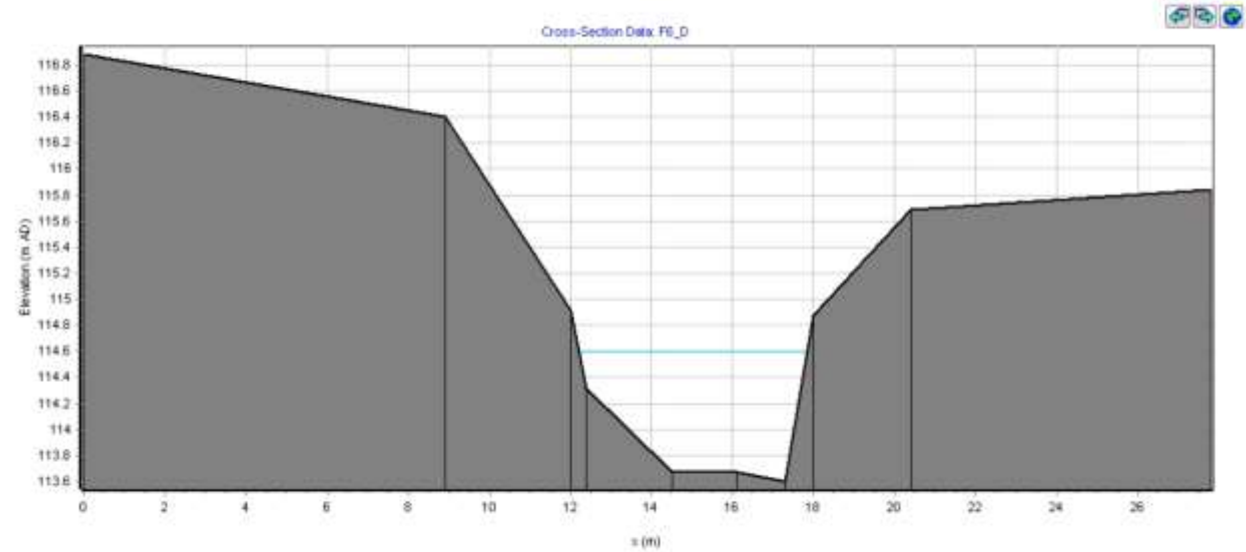


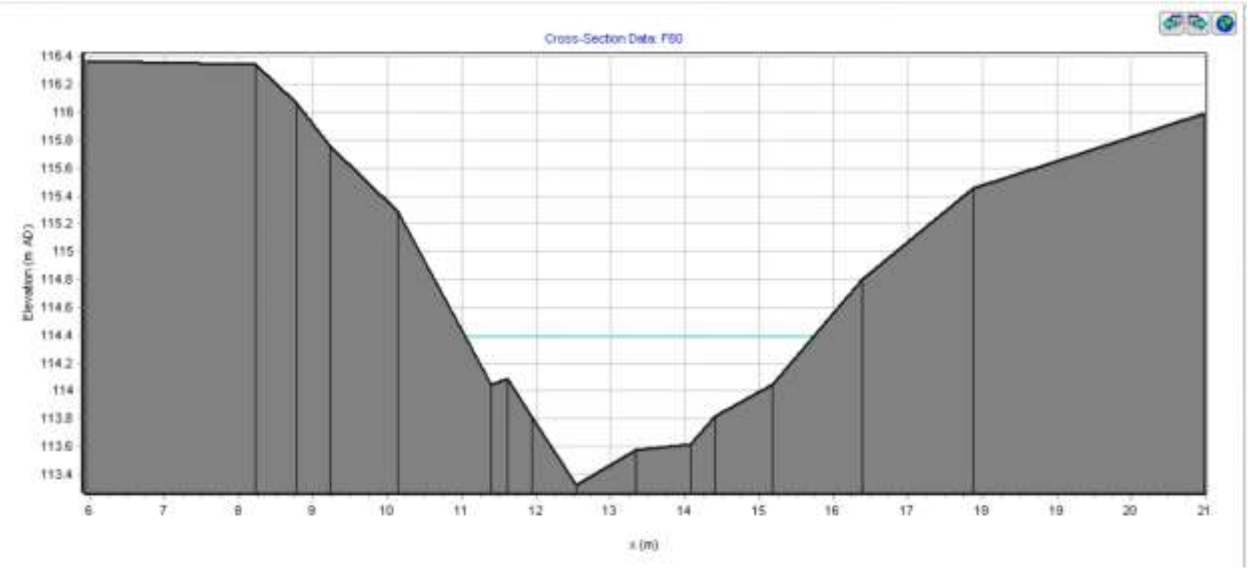

Cross-Section Data: F3
Elevation (m AD)
x (m)

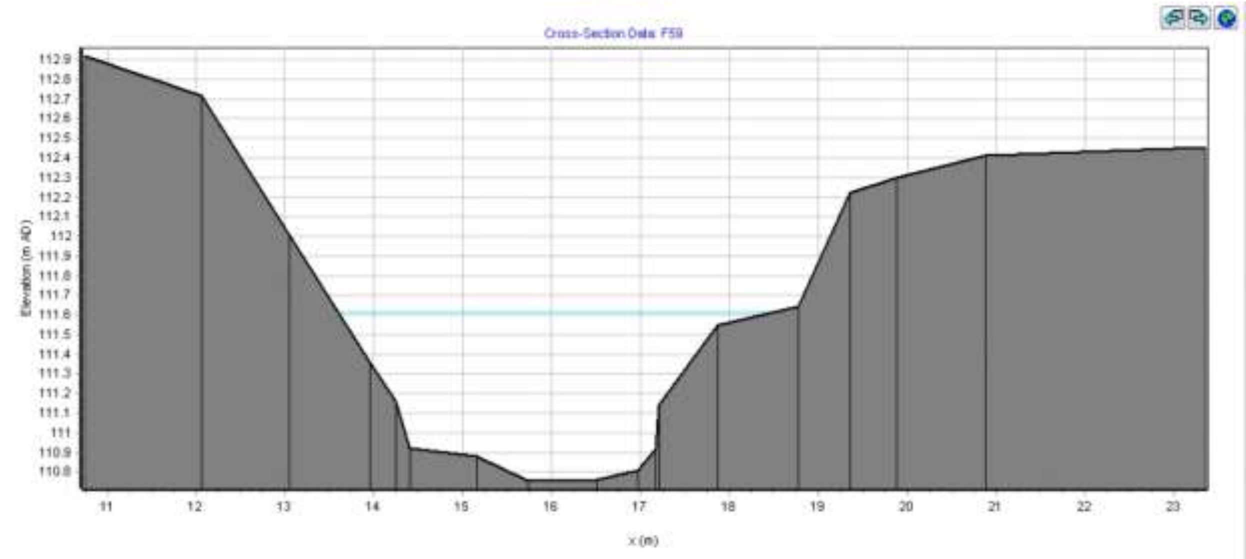

Cross-Section Data: F4
Elevation (m AD)
x (m)

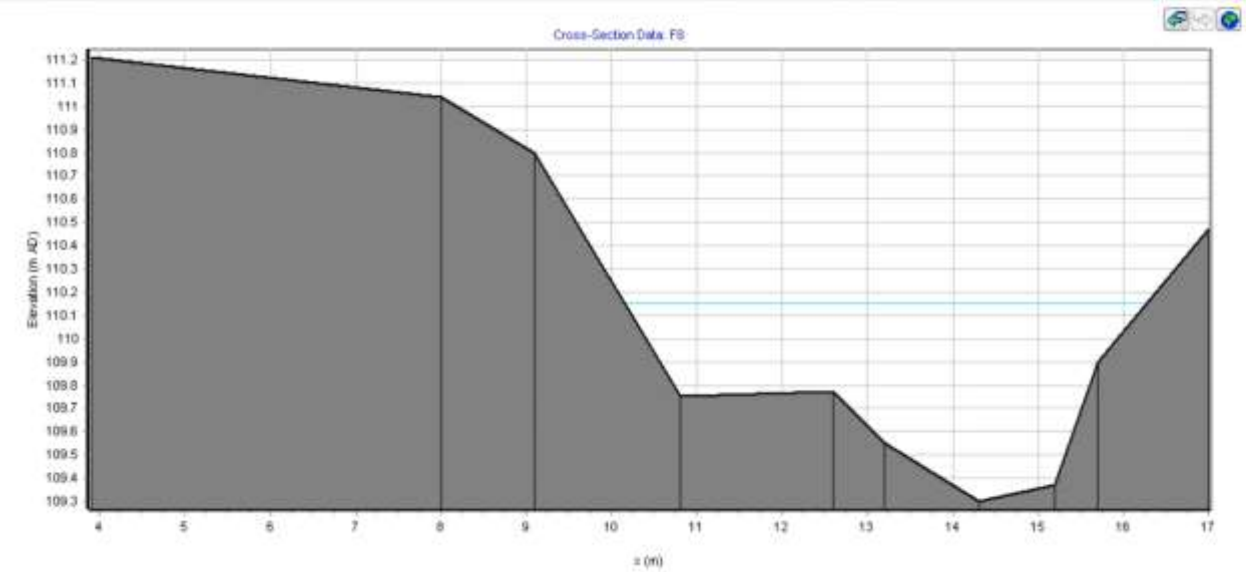

Cross-Section Data: F5
Elevation (m AD)
x (m)


Cross-Section Data: F6
Elevation (m AD)
x (m)


Cross-Section Data: F6_D
Elevation (m AD)
x (m)

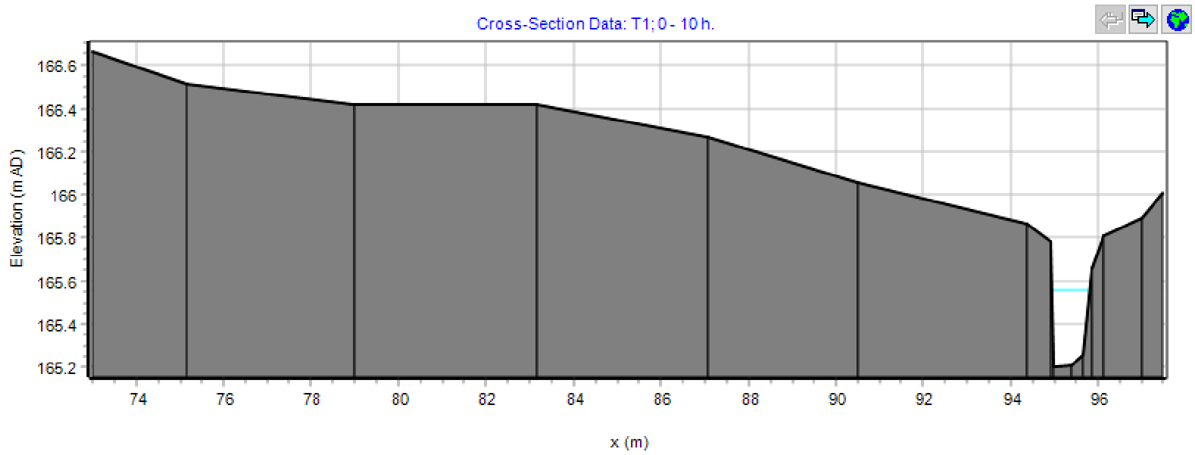

Cross-Section Data: F60
Elevation (m AD)
x (m)


Cross-Section Data: F59
Elevation (m AD)
x (m)

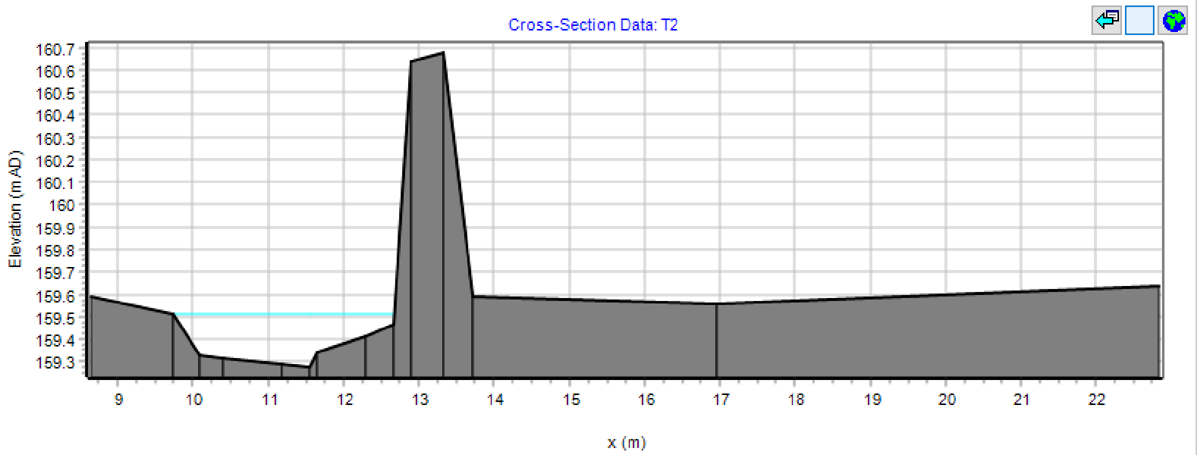

Cross-Section Data: F8
Elevation (m AD)
x (m)

Appendix C – Small Drain model cross sections

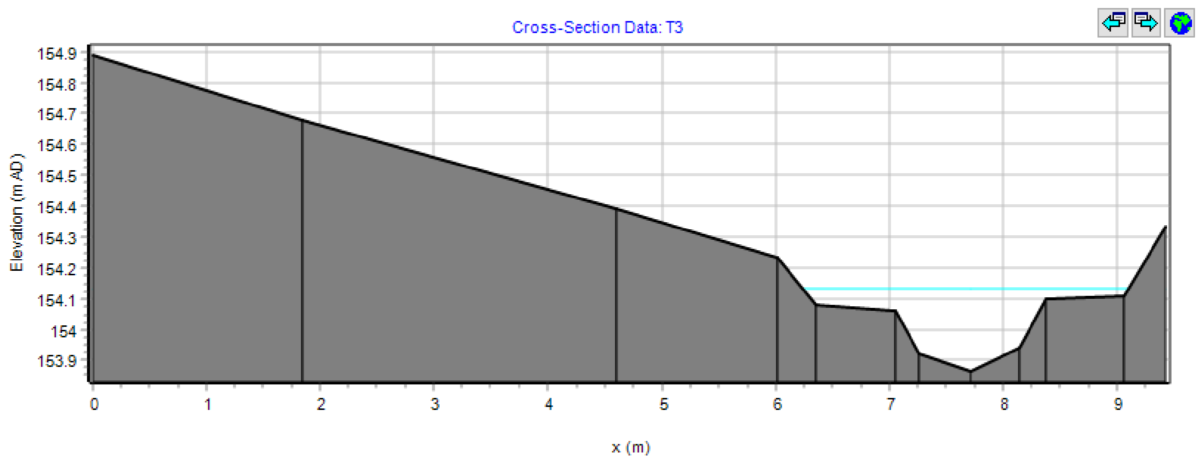
D1



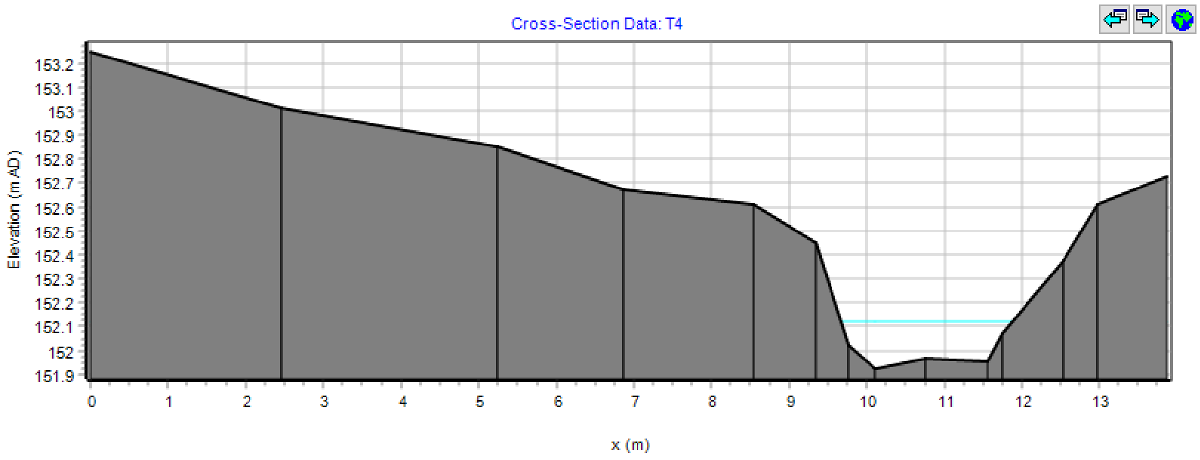
D2



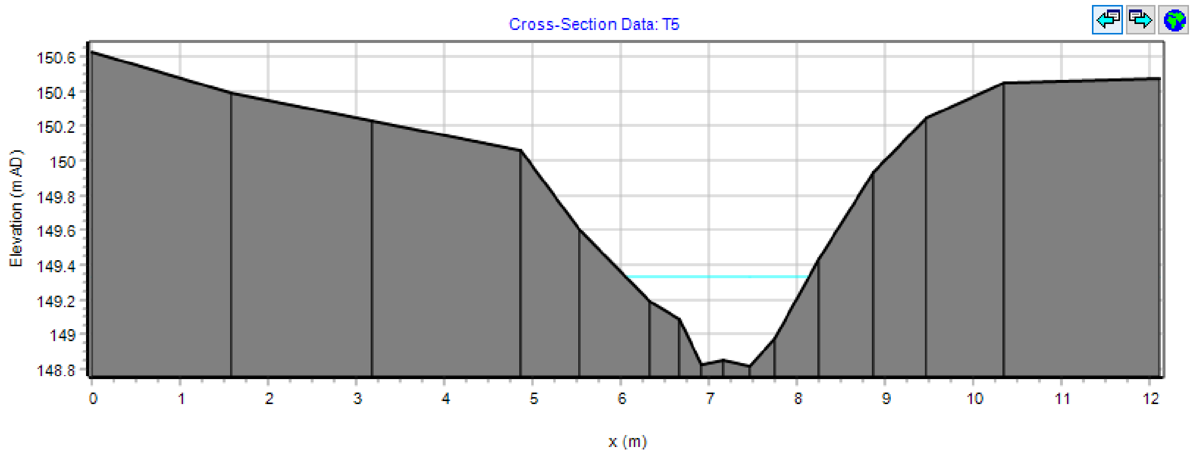
D3



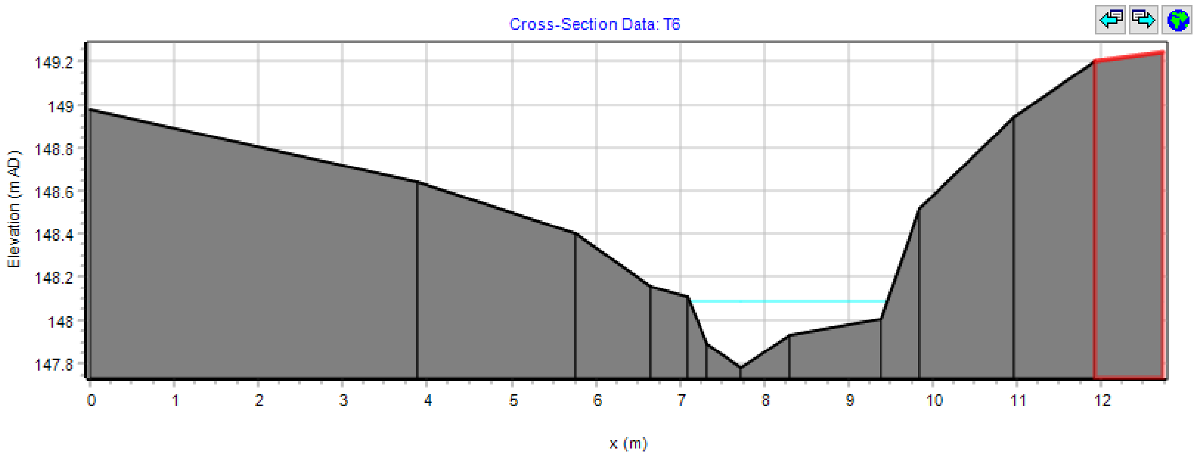
D4


Cross-Section Data: T4
Elevation (m AD)
153.2
153.1
153
152.9
152.8
152.7
152.6
152.5
152.4
152.3
152.2
152.1
152
151.9
0 1 2 3 4 5 6 7 8 9 10 11 12 13
x (m)

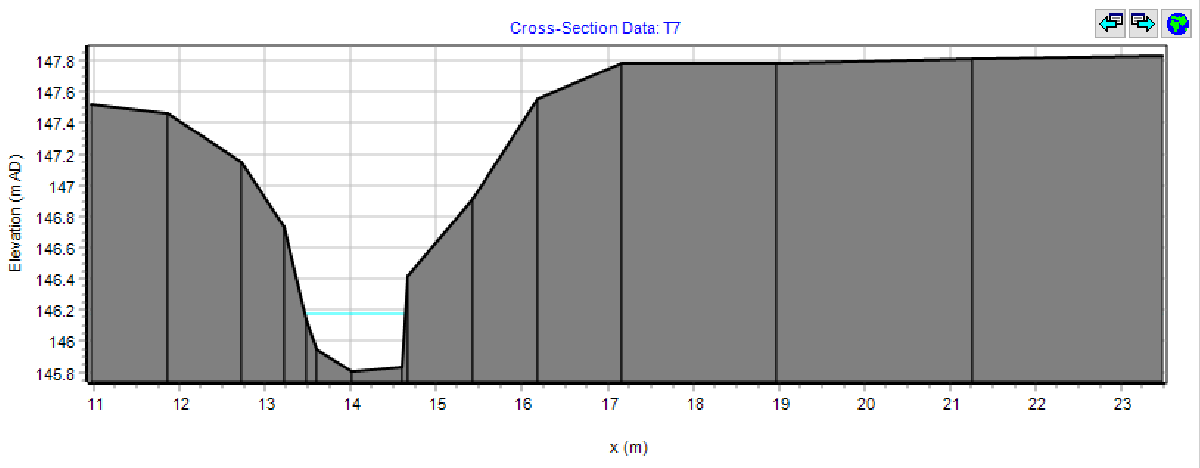
D5


Cross-Section Data: T5
Elevation (m AD)
150.6
150.4
150.2
150
149.8
149.6
149.4
149.2
149
148.8
0 1 2 3 4 5 6 7 8 9 10 11 12
x (m)

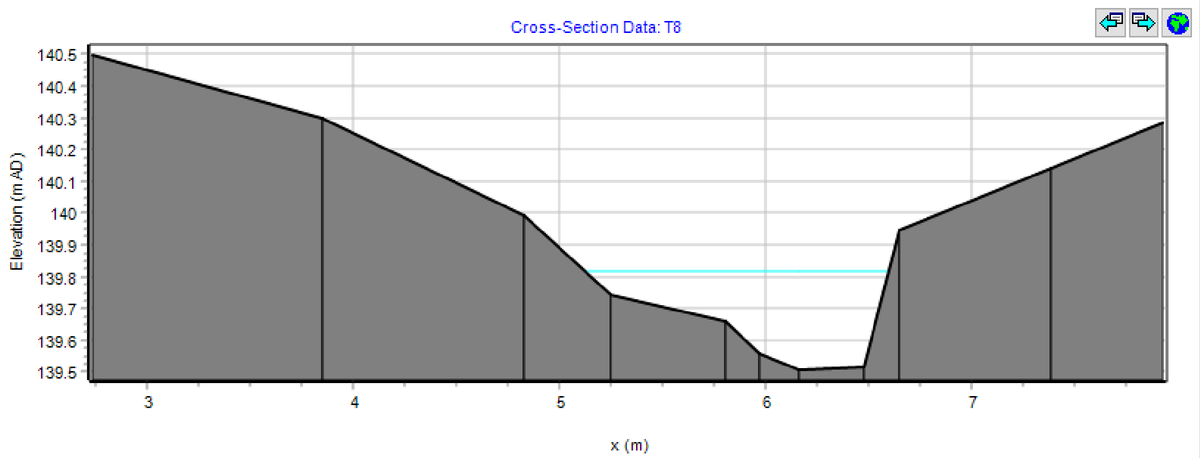
D6


Cross-Section Data: T6
Elevation (m AD)
149.2
149
148.8
148.6
148.4
148.2
148
147.8
0 1 2 3 4 5 6 7 8 9 10 11 12
x (m)

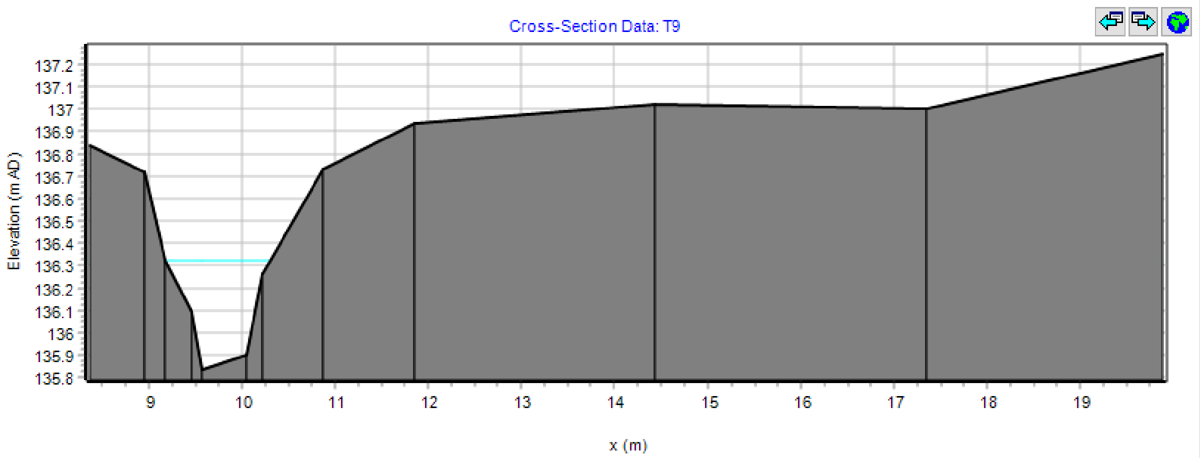
D7


Cross-Section Data: T7
Elevation (m AD)
147.8
147.6
147.4
147.2
147
146.8
146.6
146.4
146.2
146
145.8
11
12
13
14
15
16
17
18
19
20
21
22
23
x (m)

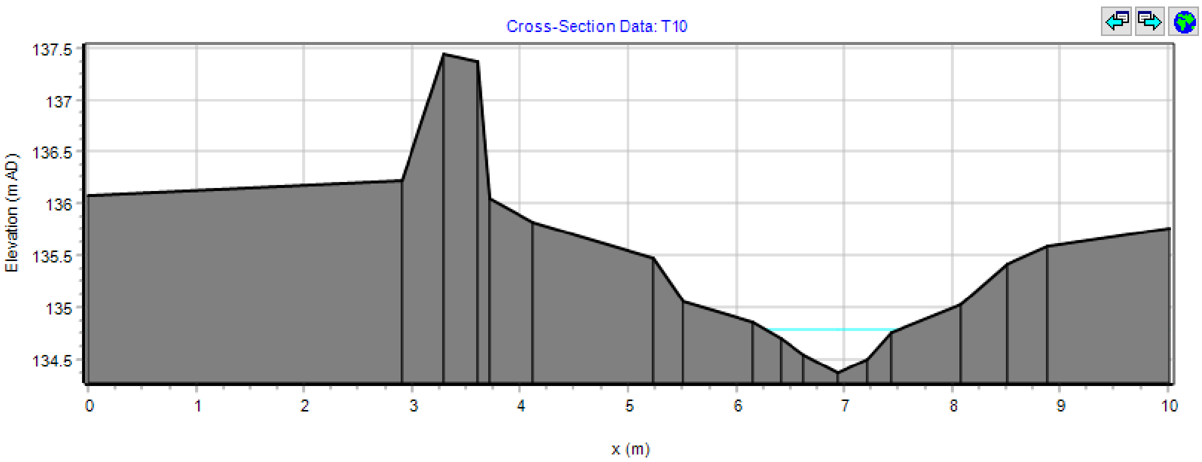
D8


Cross-Section Data: T8
Elevation (m AD)
140.5
140.4
140.3
140.2
140.1
140
139.9
139.8
139.7
139.6
139.5
3
4
5
6
7
x (m)

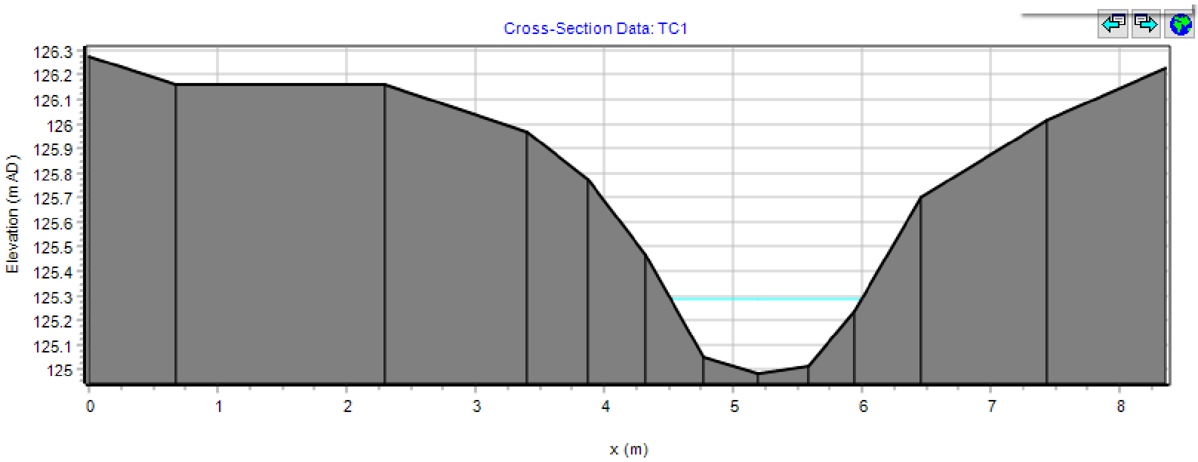
D9


Cross-Section Data: T9
Elevation (m AD)
137.2
137.1
137
136.9
136.8
136.7
136.6
136.5
136.4
136.3
136.2
136.1
136
135.9
135.8
9
10
11
12
13
14
15
16
17
18
19
x (m)

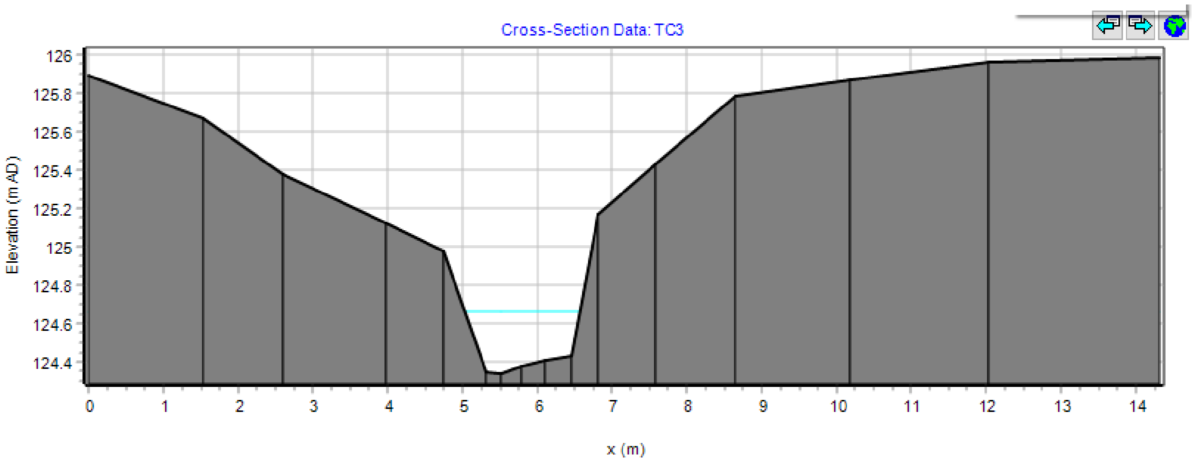
D10


Cross-Section Data: T10
Elevation (m AD)
137.5
137
136.5
136
135.5
135
134.5
0
1
2
3
4
5
6
7
8
9
10
x (m)

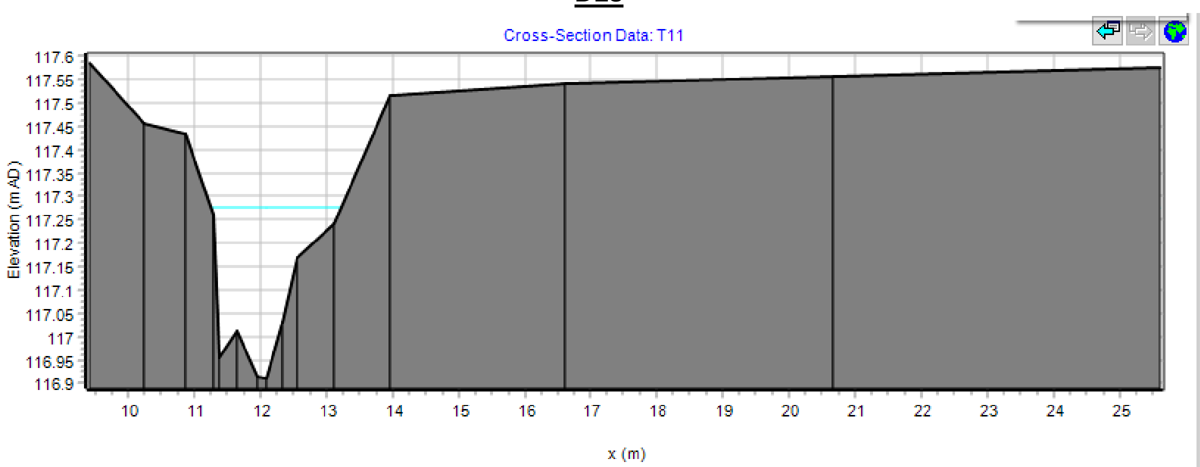
D11


Cross-Section Data: TC1
Elevation (m AD)
126.3
126.2
126.1
126
125.9
125.8
125.7
125.6
125.5
125.4
125.3
125.2
125.1
125
0
1
2
3
4
5
6
7
8
x (m)

D12


Cross-Section Data: TC3
Elevation (m AD)
126
125.8
125.6
125.4
125.2
125
124.8
124.6
124.4
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
x (m)

D13


Cross-Section Data: T11
Elevation (m AD)
117.6
117.55
117.5
117.45
117.4
117.35
117.3
117.25
117.2
117.15
117.1
117.05
117
116.95
116.9
10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
x (m)

Appendix D – SEPA Correspondence

Hello Callum,

Thank you for getting in touch, I hope the response to your e-mail below will help to outline our position.

To clarify, our last response was not an objection letter, due to the pre-planning status of the proposal. The purpose of the letter is to advise the likely response that would be given by SEPA if we had been consulted with the information submitted to date at the full planning stage. We acknowledge that we could phrase the response differently, e.g. by saying 'to ensure that SEPA does not object to or is able to support the full planning application we will require the submission of the following information…', however the outcome is the same with regards to our requirements at the detailed planning stage.

The information which will be required when we are formally consulted at a detailed planning stage will entail both the provision of standard technical information, in addition to demonstration that the site plan and compensatory proposals comply with SPP and SEPA's technical requirements to demonstrate appropriate flood mitigation and a neutral effect on flood risk.

We have previously agreed to a set of principles through the 'letter of comfort' and have also had a meeting to progress efforts to work closely with Kaya Consulting and Asher Associates to work towards a universally beneficial outcome.

In regards to the points outlined below, we are in agreement that the majority of these aspects appear to have already been progressed and can be overcome through a revision to the existing FRA. However, we have highlighted (in red) where we consider that further information will be required beyond that which has been proposed below. For instance, with regards to the water gate structures, cut-off drain and flood extent map queries.

Whilst we understand Kaya's reasoning that the water gate structures may be removed and the engineered cut-off drain can convey a design flow without blockage, we would at least need to understand the modelled response to flood risk from these sources (in channel restrictions and blockage e.g. from water gate downstream of confluence between small drain and Crosslaw Burn) as a sensitivity run, which may or may not be used to inform the functional floodplain. The same suggestion that in channel structures could be removed can apply in many cases. If appropriate written confirmation can be provided that explicitly states the water gate structures within this site will be removed, then we are willing to consider this information. The reason for this precautionary approach is due to the vulnerability increase on an undeveloped site and therefore requirement to improve understanding of flood risk from all sources and confidence that additional properties will not be at risk of flooding. Provision of this information may also help to identify potential flood mitigation actions such as in channel structures recommended for removal or floodplain avoidance, freeboard and site specific buffer strips.

We acknowledge that Kaya Consulting will not be able to finalise the proposed compensatory storage proposal, given the early stage in the process. Additionally, we accept that this will not be able to be determined until a detailed site layout has been provided. However, as highlighted in the letter of comfort, the principles with regards to complying with SEPA's technical advice on compensatory storage proposals and demonstrating a neutral or better effect will still need to be addressed when the planning application is formalised.

Thank you,
Leilla
From: Fotheringham, Brian <brian.fotheringham@Sepa.org.uk>
Sent: 29 May 2019 12:00
To: 'Callum Anderson' <Callum.anderson@kayaconsulting.co.uk>; Planning SW <planning.sw@sepa.org.uk>
Cc: Willy Milne <willy.milne@asherassociates.co.uk>; Yusuf Kaya <Yusuf.kaya@kayaconsulting.co.uk>; Farkhondeh, Leilla <leilla.farkhondeh@sepa.org.uk>
Subject: RE: Response to SEPA - PCS/164239

Hello Callum,

Thanks for your further email in respect of the development proposals at the Selkirk Road site in Moffat.

Our review of your initial email is ongoing and due to existing workload pressures it will be next week before we are in a position to provide you with an updated response. I recognise your offer to work with us to ensure the site design takes full cognisance of the flood risk issues at the site and you will note that I have cc'd your response to my colleague who is considering the content of your earlier email.

We will be in touch asap to discuss/advise on the next steps with this site.

Kind regards,
Brian

Brian Fotheringham
Senior Planning Officer
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Tel no 01698-839336
planning.sw@sepa.org.uk

From: Callum Anderson <Callum.anderson@kayaconsulting.co.uk>
Sent: 29 May 2019 11:34
To: Fotheringham, Brian <brian.fotheringham@Sepa.org.uk>; Planning SW <planning.sw@sepa.org.uk>
Cc: Willy Milne <willy.milne@asherassociates.co.uk>; Yusuf Kaya

<Yusuf.kaya@kayaconsulting.co.uk>
Subject: FW: Response to SEPA - PCS/164239

Hi Brian,

Following our response to the SEPA objection, we wanted to know if you require any additional information (aside from the technical model outputs)? We are trying to finalise the masterplan and it would be good to work with SEPA so that the objections can be addressed and the masterplan finalised.

Please do not hesitate to call through if you would like to discuss.

Kind regards,
Callum

From: Callum Anderson
Sent: 20 May 2019 16:44
To: planning.sw@sepa.org.uk
Cc: Yusuf Kaya <Yusuf.kaya@kayaconsulting.co.uk>
Subject: Response to SEPA - PCS/164239

Brian,

A draft flood risk assessment has been undertaken for the site at Selkirk Road, Moffat. SEPA have been consulted and have provided a pre-application response to our assessment.

We would like to respond to some of the points made in the objection, our response is on the basis that the development is at masterplan stage and detailed design such as detailed compensatory storage calculations would not be available at this stage of the development. We would ask that such items are agreed with SEPA in principle at this stage in the application process with finer details to be confirmed at a later stage.

Compliance to the points raised in the 'letter of comfort'
The engineer has taken on board all points requested to be addressed in the letter of comfort (i.e. bridge crossing to be designed to the appropriate level) and we have indicated in the report where they are addressed. It should be noted that the site is at masterplan stage so detailed calculations will be undertaken when finalising the detailed design etc.

Submission of outstanding FRA outputs e.g. modelled cross sections, long profile, velocities, FRA checklist, bridge blockage assessments and associated flood extents/levels
This can be provided as part of the final report for the application.

Justification on the change of flood estimation technique adopted for the Birnock Water
The Birnock Water flows were altered to tie into the Moffat Flood Study which has been passed to SEPA. The report indicates that the Birnock Water is not predicted to overtop during events up to the 1000 year. Therefore the small change in 200 year flow does not affect the site.

Demonstration of a credible blockage scenario is put forward and justified, in order to refine the floodplain extent associated with a blockage scenario of the Auldton Road bridge structure

Auldton Road bridge is a single span crossing raised significantly above the bed of the channel and there have been no historical instances of blockage in the past. The bridge does not provide a restriction on flows. Therefore based on SEPA guidance there is not a significant risk of blockage and flooding to the site. To be conservative we blocked the bridge by 100% to highlight a potential issue but this should not be confused with the standard likelihood of blockage. To be clearer we have re-run with a more likely blockage value (20%) and we note that overtopping of the bridge is not predicted. The impact of higher blockages will be discussed in the text only.

Update to Figure 11 to clearly illustrate the flood depths and extents associated with an appropriate bridge blockage scenario
We will report on a 20% blockage, as outlined above and update the figure.

A reasonable assessment of blockage to the culvert and water gate structures in addition to the floodplain extents and levels associated with blockage
The water gates are not permanent structures and could easily be removed at any time by the landowner. Flows in the watercourse are also impacted by small field culverts and gaps in dry stone walls. All of these could be removed and impractical to model. The approach taken in the report is to recommend the provision of a flow pathway between the site and the watercourse to route any excess flood waters along the edge of the site parallel to the watercourse. This appears a sensible approach to manage potential blockages, failures of walls or other impacts on the watercourse.

Clarification on the floodplain associated with the small drains
The small drain is comprised of a narrow, watercourse which has been diverted around and alongside field boundaries. The drain runs perpendicular to the natural slope of land and acts to intercept runoff from higher ground, similar to an interception ditch.

The drain passes through private land and a number of boundary walls. Mathematical modelling has shown that the channel has sufficient capacity to pass the 200 year flow, but there are potential impediments to flow along the channel, such as dry stone walls. It is not possible to model these features accurately. We believe our approach to managing this potential flood risk through the provision of a flow pathway between the site and the watercourse is practical and sensible. The SEPA response appears to indicate that SEPA would view any areas impacted by flood waters from the watercourse in the event of blockage to be functional floodplain. As the channel flows across the natural slope of land, this would imply that any land downslope of the channel could be floodplain. As many small man-influenced watercourses within Scotland cut across the slope, acting as cut-off drains, this would have a significant impact on development. We do not consider this to be a proportionate response given the rural nature of the site.

Submission of a combined flood risk map to show the flood extents associated with all sources of 'functional floodplain' including those separately assessed in Section 7 of the FRA. This will comprise the main watercourses (Crosslaw Burn, Birnock Water, Frenchland Burn) in addition to the small watercourses (drains, ditches) and blockage of key structures (Auldton Road Bridge, water gates, culverts)
As above

Demonstration of appropriate compensatory storage that complies with SEPA technical guidance and provides a neutral or better effect on flood risk
The site layout is at masterplan stage; therefore, detailed design of the access road has not been undertaken. The flood risk assessment has provided outline flood volumes. Given the size of the site, initial calculations have shown that the flood storage required for the road would be able to be achieved within the site. Detailed calculations would be provided at the detailed design stage.

Site layout and finished floor levels to demonstrate the highly vulnerable' and 'critical infrastructure' uses are appropriately sited and mitigated in relation to flood risk.
As outlined above the site is a masterplan stage therefore location of plots may change. Finished Floor Levels of properties have not yet been designed. However, recommendations regarding critical infrastructure have been addressed in the report (i.e. FFL'S raised at least 1 m above the 1000 year flood level).

Kind regards,
Callum