GONDOLIN
Land & Water
Civil Engineering & Environmental Solutions

Lecropt Plot - Flood Risk Assessment

Proposed Residential Development

Flood Risk Assessment Report

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1. Introduction

1.1 Preamble

Gondolin Land and Water Ltd (Gondolin) has been appointed by Houghton Planning to prepare a Flood Risk Assessment (FRA) in support of a planning permission in principle (PPP) application for a proposed dwelling house at Land at Meadowlands Farm, Bridge of Allan, Stirling, FK9 4UE.

The site has been visited by an experienced Hydrologist to inform the assessment.

This report addresses any potential flood risk to the proposed development from all possible sources in accordance with best practice and Scottish Planning Policy (SPP).

1.2 Site & Development Context

The site is located on the opposite side of the minor road to the main farm buildings of Meadowlands Farm. The site is at an approximate National Grid Reference (NGR): NS 77840 97489 and currently comprises existing farm sheds / buildings. The surrounding landscape is predominantly agricultural fields with the M9 motorway located approximately 150m east of the site and a cottage located 80m north of the site.

The proposed development is for a single dwellinghouse with associated new access point from the adjacent minor road. The development will also comprise a driveway and associated soft landscaping.

A site location plan is included as Appendix A.

1.3 Topography

Review of the site topographic data indicates that the site has a maximum elevation of approximately 9.7mAOD along the north western boundary and a minimum of 8.8mAOD along the existing minor road to the southeast. Generally, the topography falls gently from northwest to southeast across the site.

1.4 Geology and Hydrogeology

1.4.1 Geology

1.4.1.1 Superficial

Review of the British Geological Survey (BGS) online geology maps[1] indicates that the underlying superficial deposits at the site comprise Raised Tidal Flat Deposits of Holocene Age consisting of silts and clays.

1.4.1.2 Bedrock

Review of the BGS online geology maps shows that the bedrock geology at site is the Arbuthnott-garvock Group comprising Sandstone with subordinate conglomerate, Siltstone and Mudstone.

1.4.2 Hydrogeology

Review of the Scotland Environment online map viewer[2] (references BGS data) indicates the site is underlain by a moderately productive bedrock aquifer with flows being virtually all through fractures and other discontinuities.

[1] British Geological Survey (2022) Natural Environment Research Council – online Geology of Britain Viewer, available at: https://mapapps.bgs.ac.uk/geologyofbritain/home.html (accessed on 30th June 2022)
[2] Scottish Government (2022) Scotland's Environment Web hub, available at: https://map.environment.gov.scot/sewebmap/ (accessed on 30th June 2022)

1.5 Local Hydrology and Existing Drainage Scheme

Review of the Flood Estimation Handbook (FEH) Web Service[3] and other available mapping shows the site is in the natural surface water catchment of a minor watercourse immediately adjacent to the site known as Bairn's Burn. The Bairn's Burn flows in a predominantly south eastern direction and runs adjacent to the minor road connecting the site to the M9 underpass to the A9 and the properties to the northwest. The Bairn's Burn is a tributary to the River Forth with their confluence being approximately 1.2km downstream of the site. The Bairn's Burn is predominantly an open watercourse within the vicinity of the site with the exception of three minor culverts, upstream, adjacent and downstream of the site.

Drawing FRA-001 included provides an overview of the existing hydrological conditions at the site and surrounding area.

A hydrological summary and catchment characteristics of the Bairn's Burn are shown in Table 1 below. The data shown is taken from the FEH Web Service and the catchment has been delineated from the NGR: NT 77850 97500, a point in the watercourse immediately adjacent to the site.

Table 1 Hydrological Summary

Waterbody Catchment	Area (km^2)	SAAR[1] (mm)	URBEXT[2] (%)	PROPWET[3]	SPRHOST[4] (%)	ALTBAR[5] (m)
Bairn's Burn	1.49	996	0.000	0.590	45.42	60

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

The FEH data indicates that the Bairn's Burn catchment experiences a moderate SAAR value for a Scottish catchment and that the catchment is completely rural.

2. Planning & Policy Context

2.1 Overview

This assessment has been completed in accordance with guidance presented within Scottish Planning Policy (SSP), the current National Planning Framework for Scotland 3 (NPF3) and taking cognisance of the Flood Risk Management (Scotland) Act 2009. NPF4 is currently only in draft format.

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

- Stirling Council (2020) Supplementary Guidance, Flood Risk Management and the Water Environment;
- British Standards Institution (2017) Assessing and Managing Flood Risk in Development – Code of Practice, Report BS-8533:2017;
- Scottish Environment Protection Agency (2019) Technical Flood Risk Guidance for Stakeholders (Reference: SS-NFR-P-002), v12, May 2019;
- Scottish Environment Protection Agency (2018) Flood Risk and Land Use Vulnerability Guidance (Reference: LUPS-GU24), Version 4, July 2018;
- Scottish Environment Protection Agency (2018) SEPA Development Plan Guidance Note 2a: Development Management Guidance: Flood Risk (Reference: LUPS-DM-GU2a), July 2018; and

[3] UK Centre for Ecology and Hydrology (2022) Flood Estimation handbook Web Service, available at: https://fehweb.ceh.ac.uk/ (accessed on 30th June 2022)

- Scottish Environment Protection Agency (2022) Climate Change Allowances for Flood Risk Assessment in Land Use Planning (Reference: LUPS-CC1), v2.

2.2 SEPA Flood Risk and Land Use Vulnerability Guidance

With reference to Table 1 (SEPA Land Use Vulnerability Classifications) of SEPA's Flood Risk and Land Use Vulnerability guidance document, the proposed residential development is classified as a *Highly Vulnerable Use* category.

With reference to Table 2 (SEPA Matrix of Flood Risk) of the guidance, the proposed *Highly Vulnerable* development is only suitable in little or no risk (less than 0.1% AEP) or low to medium risk (0.1% - 0.5% AEP) provided an FRA is undertaken if the risk is close to 0.5% AEP. Anything that is medium to high risk is classified as generally not suitable unless mitigating / exceptional circumstances apply.

The proposed flood design criteria for the development is that the Site is to be free from flood risk (from all sources) for up to and including the design 0.5% AEP event plus climate change event.

2.3 Scottish Planning Policy

This report has been prepared in accordance with Scottish Planning Policy (SPP) relating to Managing Flood Risk and Drainage, which states that 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;*
- *avoidance of increased surface water flooding through requirements for Sustainable Drainage Systems (SuDS) and minimising the area of impermeable surface; and,*
- *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."*

SPP presents a risk framework for planning decision making relating to flood risk. A summary of this risk framework is provided below:

SPP Flood Risk Framework
Little or No Risk – annual probability of coastal or watercourse flooding is less than 0.1% (1:1000 years): ➢ No constraints due to watercourse, tidal or coastal flooding.
Low to Medium Risk – annual probability of coastal or watercourse flooding is between 0.1% - 0.5% (1:1,000 – 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):

SPP Flood Risk Framework
➢ 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 runoff from adjacent areas.

The SPP Flood Risk Framework above uses the designations from SEPAs online indicative Flood Map to categorise the fluvial (and coastal) flood risk and these are defined as follows:

- **High Likelihood:** A flood event is likely to occur in the defined area on average once in every ten years (1:10) or a 10% AEP chance of happening in any one year;
- **Medium likelihood:** A flood event is likely to occur in the defined area on average once in every two hundred years (1:200) or a 0.5% AEP chance of happening in any one year; and
- **Low likelihood:** A flood event is likely to occur in the defined area on average once in every thousand years (1:1000) or a 0.1% AEP chance of happening in any one year.

3. Flood Risk Assessment

3.1 Screening Assessment of Potential Source of Flood Risk

3.1.1 Overview

There are a number of potential sources of flooding which should be evaluated in accordance with best practice and SPP such as:

- Flooding from rivers or fluvial flooding;

- Flooding from the sea or tidal / coastal flooding;
- Flooding from land;
- Flooding from groundwater;
- Flooding from sewers; and
- Flooding from reservoirs, canals, and other artificial sources.

The flood risk from each of these potential sources is discussed in the following sections and a 'screening assessment' is presented in Section 3.1.8 which confirms any potential flood risk sources requiring a more detailed analysis and specification of bespoke mitigation measures.

Flood 'risk' definitions within the screening exercise are based on a qualitative technical assessment taking into account the information reviewed, risk to site users and the Proposed Development itself.

3.1.2 Fluvial Flooding

Review of SEPA's Fluvial Flood Map indicates that the site is partially located within an area of low flood risk from the Bairn's Burn (taken as the 1:1,000yr event or 'Low Risk' classification as per Section 2.3).

Although the flood risk is shown to be low risk at the proposed site location and thus therefore suitable with respect to SEPA's Land Use Vulnerability guidance (see Section 2.2). Given that the objective of SEPA flood maps is to inform flood risk at a strategic community / regional level and the scale of mapping reflects this, it is not possible to accurately determine the extent of the flood risk at the site from a qualitative based review only. In addition, SEPA's Surface Water Flood Map (see Section 3.1.4 below), indicates a medium flood risk to the site location from surface water flooding linked to the Bairn's Burn.

Therefore, for the purposes of this Screening Assessment, it is considered the development is potentially at '**Low Medium Risk**' of flooding to the site from fluvial flooding and should be reviewed further - this is provided in Section 4 of the report.

3.1.3 Tidal/Coastal Flooding

The site is located sufficiently inland from the coast and sufficiently upgradient of the tidally influenced waters of the River Forth, thus is not subject to tidal or coastal flood risk and is designated as **'No Risk'** to the site.

Flooding from this source is therefore not considered further in the assessment.

3.1.4 Flooding from Land (Pluvial or Surface Water Flooding)

Review of SEPA's Surface Water Flood Map shows the site to be partially located in an area of low to medium flood risk. The extent of surface water flooding in the area is inherently related to the Bairn's Burn channel and immediate overbanks. Given that the site and immediate surroundings naturally drain to the Bairn's Burn, there are no additional sources of surface water flooding except from the watercourse itself which is assessed under fluvial flooding.

For the purposes of this Screening Assessment, it is considered the development is potentially at '**Low to Medium Risk**' of flooding to the site from surface water flooding and should be reviewed further in the context of fluvial flood risk from the Bairn's Burn - this is provided in Section 4 of the report.

3.1.5 Groundwater Flooding

Review of SEPA's Groundwater Flood Map indicates the site and the surrounding local area is not located within a groundwater flood risk area.

Taking the above into account it is considered that the site is at **'Low Risk'** of groundwater flooding and therefore flooding from this source is not considered further.

3.1.6 Flooding from Sewers / Drainage Systems

Given the rural nature of the development, no public sewers are located within the immediate vicinity.

Taking the above into account it is considered that there is **'No Risk'** of flooding to the site from sewers and drainage systems and therefore this source is not considered further in the assessment.

3.1.7 Flooding from Infrastructure Failure / Blockage

Review of SEPA's Reservoir Inundation Map indicates the site is located within the possible flood risk area from Loch Katrine. This shows the "*indicative area that may flood from an uncontrolled release of water from all possible dam failure scenarios*". SEPA states that reservoir inundation maps are indicative only and of a strategic nature, not suitable for property assessment and the maps do not relate to any particular probability of dam breach flooding.

There are no other known water infrastructure features at / in proximity to the site which would pose a material flood risk in the event of failure.

As such it is considered that the development site is at **'Low Risk'** of flooding from this sources.

3.1.8 Flood Risk Screening Assessment Review

A summary of the potential flood risk to the site from the sources reviewed is presented in Table 2 below.

This 'Screening Assessment' is used to identify if any sources of flood risk are required to be investigated in more detail i.e., a 'Technical' more detailed assessment which would include consideration / specification of bespoke flood mitigation measures for the site development.

Table 2 Flood Risk Screening Assessment

Potential Flood Source	Screening Assessment of Flood Risk at Site[1]	Requiring Further Consideration i.e. Technical Assessment?
Fluvial flooding	Low to Medium Risk	Yes
Tidal flooding	No Risk	No
Flooding from land	Low to Medium Risk	Yes
Groundwater flooding	Low Risk	No
Flooding from sewers / artificial drains	No Risk	No
Flooding due to infrastructure failure / blockage	Low Risk	No

Notes: [1]only Flood Risks designated as being 'medium' or 'high' warrant further investigation

The Screening Assessment confirms that there is a '**Low to Medium Risk'** of fluvial flooding at the site from the Bairn's Burn based on a qualitative review and a '**Low to Medium Risk'** of surface water flooding based on SEPA flood maps and attributed to the Bairn's Burn. As such a more detailed 'Technical Assessment' of flood risk is required for the Bairn's Burn and is duly addressed in Section 4.

All other potential sources of flooding are not applicable or insignificant and therefore not considered further.

3.2 Climate Change

3.2.1 Context

The most recent Climate Change (CC) projections published by The UK Climate Impacts Programme are presented in report 'UKCP18'. Central estimates published in UKCP18 indicate marked increases in winter rainfall and decrease in summer rainfall but with more intense storms under all CO2 emissions scenarios across the majority of the country.

A climate change allowance in drainage and flood risk assessment terms is a prediction of anticipated change in peak river flow, peak rainfall intensity and sea level rise caused by future climate change.

The allowances applied for sea level rise, peak river flow and peak rainfall intensity are determined by river basin regions across Scotland. SEPA have developed a web map[4] to allow any location in Scotland to be identified for its applicable river basin region and respective climate change uplift allowances.

3.2.2 Peak River flow

With reference to SEPA's online map service, the site is located within the Forth river basin region. The peak river flow allowance until 2100 for this region is a 56% uplift.

In accordance with SEPA climate change guidance, given the small catchment size of the Ross Burn (1.49km^2), peak rainfall intensity uplifts (see below) should be used instead of peak river flow uplifts.

3.2.3 Peak rainfall intensity

Using SEPA's online map service, the site is located within the Forth river basin region. The peak rainfall intensity allowance until 2100 for this region is a 39% uplift.

This increased rainfall intensity is appropriately factored into the flood risk assessment.

3.2.4 Sea Level Rise

Using SEPA's online map service, the site is located within the Forth river basin region. The cumulative sea level rise allowance until 2100 for this region is a 0.86m uplift.

This increase in predicted Sea Level rise will not increase the coastal flood risk to the site due to distance to the significant elevation differential.

4. Technical Flood Risk Assessment

4.1 Introduction

4.1.1 Context

The screening assessment outlined above concludes a **'Low to Medium Risk'** of flooding from fluvial sources and a '**Low to Medium Risk'** of surface water flooding (i.e. Pluvial flooding) both attributed to the Bairn's Burn. As such, a detailed technical assessment of fluvial flooding at the site has been undertaken which addresses both the Fluvial and Pluvial flood risks identified.

4.1.2 Fluvial Flood Risk Overview

The local hydrology described in Section 1.5 of this report highlighted the locality of the Bairn's Burn to the site. Given the proximity of the watercourse and presence of upstream and downstream culverts, there is a potential risk of high flows inundating the site as outlined in Section 3.1.2 previously.

SEPAs flood maps are not produced at a suitably accurate local scale to be relied upon for site specific assessments and thus a more detailed quantitative assessment has been undertaken to better understand the site specific risk.

The assessment of flood risk to the site has been undertaken via consideration of the following factors:

- Bairn's Burn channel capacity assessment
- Culvert capacity assessment
- Culvert blockage risk assessment

[4] SEPA Climate Change Allowances for Flood Risk Assessment in Land Use Planning: https://scottishepa.maps.arcgis.com/apps/webappviewer/index.html?id=2ddf84e295334f6b93bd0dbbb9ad7417

4.2 Bairn's Burn Peak Flow Assessment

To inform both the channel capacity and culvert capacity assessments, an estimate of the Bairn's Burn peak flow has been undertaken using catchment characteristics obtained from the FEH Web Service in combination with the industry standard Revitalised Flood Hydrograph V.2 (ReFH2) software.

Table 3 below presents the peak flow estimates for a range of return periods and the full ReFH2 analysis is presented in Appendix B. In accordance with SEPA guidance[5], the ReFH2 analysis is the most applicable for this application given that the catchment is small and ungauged.

Table 3 Bairn's Burn Peak Flow Summary

Return Period (years)	AEP (%)	Peak Flow (m^3/s)
2	50	0.64
10	10	1.12
30	3.3	1.47
100	1	1.97
200	0.5	2.32
200 +39% CC[1]	0.5 +39% CC	3.39

Notes: [1] Climate change uplift of 39% applied to peak rainfall intensity within ReFH2 software

As per Section 2.2 the flood design criteria for the site will be taken as 200-year plus climate change uplift estimate of **3.39m^3/s**.

4.3 Channel Capacity Assessment

4.3.1 Overview

An assessment of channel capacity within the Bairn's Burn at the site location has been undertaken to determine if the channel can convey the expected peak flow as estimated above. The channel capacity has been estimated using the open channel Manning's Equation and site survey information.

Drawing FRA-002 provides an overview of the assessment and its outcomes.

This assessment has been undertaken with no consideration of any constriction of flow from the upstream culvert and does not consider any backing up of flows from the culvert adjacent to the site. See Section 4.4 for further details.

4.3.2 Assessment

As indicated on Drawing FRA-002, the Bairn's Burn channel capacity assessment has been undertaken at surveyed cross-sections 02 – 09 via application of Manning's formulae for open channel flow.

The capacity calculations have been undertaken as an iterative process to determine the estimated water level for conveyance of the design flow at each cross-section. During the process, the available depth of the channel has been increased systematically until the respective cross-sectional area and wetted perimeter yields a capacity approximately equal to the design flow.

Table 4 below provides an overview of the measured parameters and estimated water level elevation for conveyance of the design flow at each cross-section.

[5] SEPA, Flood modelling guidance for responsible authorities, Version 1.1

Table 4 Manning's Equation Summary

Parameter	Units	Cross-Section Value								Notes
		CS-02	CS-03	CS-04	CS-05	CS-06	CS-07	CS-08	CS-09	
Cross-Section Base Elevation	mAOD	8.201	7.860	7.646	7.810	7.777	7.845	7.718	7.684	Measured from AutoCAD using survey data
Cross-Section Bank Elevation	mAOD	9.830	9.594	9.610	9.497	9.355	8.863	8.797	8.901	Measured from AutoCAD using survey data (taken from right hand bank)
Water Level Elevation	mAOD	10.100	9.650	9.500	9.400	9.450	9.450	9.350	9.300	Determined through iterative process of capacity calculations to determine level at which channel capacity = peak flow
Area (A)	m^2	13.274	12.549	7.717	9.663	10.593	11.58	13.406	8.700	Measured from AutoCAD channel cross-section
Wetted Perimeter (P)	m	95.136	87.913	25.054	40.614	47.304	69.63	80.738	35.586	Measure from AutoCAD channel cross-section
Hydraulic Radius (R)	m	0.140	0.143	0.308	0.238	0.224	0.1663	0.1660	0.244	$R = \frac{A}{P}$
Slope (S)	-	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	Measured from AutoCAD using survey data (slope estimation of watercourse between cross-sections)
Manning's Coefficient (n)	-	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	Selected from site observations and published values
Velocity (V)	m/s	0.270	0.274	0.459	0.386	0.371	0.304	0.303	0.393	$V = \frac{R^{0.67} x\, S^{0.5}}{n}$
Channel Capacity (Q)	m^3/s	3.584	3.440	3.541	3.730	3.926	3.516	4.067	3.420	$Q = VA$ (all values marginally greater than estimated peak flow of 3.39m^3/s)

The above assessment shows that the design flow would result in out of bank flows up to an estimated elevation of 10.100mAOD (approximately 270mm above the respective measured bank height at the cross-section location). With reference to Drawing FRA-002, the estimated flood extents is shown to be predominantly out with the site boundary with the exception of the area around the minor road culvert adjacent to the site.

The estimated water level at each individual cross-section is greater than the maximum bank height surveyed on the opposite bank to the proposed development (refer to sections in Drawing FRA-002). As such the flood extent can be considered conservative as flood depths would further dissipate onto the opposite overbank. Additionally, the capacity assessments have been undertaken using a conservative approach, adopting the Manning's value of the channel extent (overgrown with brush) for the full extents despite the overbanks exhibiting a much lesser value due to it agricultural nature. Nevertheless, the estimated flood depths across the right hand overbank are generally shallow at less than 200mm.

The assessment has shown that although the Bairn's Burn channel is not capable of conveying the estimated peak flow, the out of bank flood extents are suitably distanced from and lower than the main development area where the dwelling shall be located. As such the risk with respect to the Bairn's Burn channel capacity is considered low.

4.4 Culvert Assessment

4.4.1 Overview

Three culverts have been identified within the vicinity of the site which have the potential to impact on flows within the Bairn's Burn. The culverts are located, immediately upstream (Culvert 1), adjacent (Culvert 2) and immediately downstream (Culvert 3) of the site. All three culverts are similarly sized in terms of diameter, ranging between 200 – 300mm. Culvert 1 is the longest culvert at approximately 36m in length and provides access to the adjacent cottage from the minor road. Culverts 2 and 3 are short sections (c.5m) providing flow conveyance beneath the minor road.

Additional culverts are present both upstream and downstream which have not be considered within the assessment as should these surcharge resulting floodwaters would immediately return to the corridor of the Bairn's Burn downstream following the existing topography.

Given the relatively small diameter of the culverts, it is apparent that they will not be capable of conveying the estimated design flow with the Bairn's Burn (approximate culvert capacity < 200 l/s). As such it is anticipated that the culverts will surcharge and overtop during the design event. Given that Culvert 1 is located most upstream and is the longest of the culverts, it is considered to be the main constraint within this section of the Bairn's Burn and its ability to convey flows. During a design event, Culvert 1 would cause flows within the watercourse to back-up before overtopping occurred and a reduction of flows would be observed downstream (i.e., adjacent to the site). However, as a conservative approach, Culvert 1's impact on flows has been disregarded and the potential backing-up and overtopping of Culvert 2 is assessed as a worst-case scenario with respect to the site.

Drawing FRA-003 provides an overview of the culvert assessments undertaken.

4.4.2 Backing Up / Overtopping Assessment

During the design event, Culvert 2 would quickly become surcharged (ignoring any reduction in flows from Culvert 1) and back-up along the watercourse until the water level reaches the elevation of the minor road above Culvert 1 at which point flood waters would overtop the culvert and continue downstream.

To assess the potential impact to the proposed development, the elevation at which the culvert would overtop has been determined. Review of the survey information indicates that the minimum level of the minor road above Culvert 2 is approximately 8.80mAOD. Once water levels reach this elevation the culvert would overtop and floods waters would continue downstream.

Drawing FRA-003 shows the anticipated flood extent with an assumed 650mm of water depth overtopping the minor road (equivalent to the estimated water level at CS-07 from Section 4.3.2). The flood extents from this overtopping scenario show that flood water would infill the lower lying areas

around the western and southern site extents. The estimated depths within the main site area are predominantly less than 200mm with the exception of local low spots.

This flood extent is considered to be a conservative estimate and worst-case. As previously discussed, no reduction in peak flow due to the constricting upstream Culvert 1 at the entry of Culvert 2 has been considered. In addition, the flood extents shown in Drawing FRA-003 does not consider the continuation of flows downstream once the culvert has been overtopped that would aid in reducing flood depths near to the site. Nevertheless, the conservative assessment indicates that the majority of the main site area will remain free from flooding during the design event and areas where flooding is shown to potentially occur will be shallow in depth at predominantly less than 200mm.

The assessment shows that any potential backing up or overtopping of Culvert 2 poses a low risk to the site.

4.4.3 Blockage Risk

Culverts have a potential to become blocked particularly during high flows when debris is swept into the channel and is unable to pass through a culvert entry. Blockages in culverts will result in a reduction in the culvert's capacity to convey the flow in the watercourse and thus result in backing up / overtopping of the structure at lower flows. The risk of blockages within the culverts in locality to the site is considered to be high given the culvert diameters. However, the impact of a blockage on any of the culverts would result in negligible changes to the estimated flood extents already determined in previous sections of this report due to the small diameter of the culverts and their respective limited conveyance capacity under full-flow conditions.

4.5 Flood Risk Conclusions / Proposed Flood Mitigation Measures

4.5.1 Overview

The assessments above confirm that there is a potential for out of bank flows within the Bairn's Burn to inundate parts of the site. The assessment shows that these extents are limited and predominantly at shallow depths of <200mm and as such the risk to the site from the Bairn's Burn is considered low.

The development is therefore suitable in flood risk planning terms subject to final positioning of the dwelling and setting of the finished floor levels (FFL).

4.5.2 Proposed Dwelling Location and Finished Floor Levels

Drawings FRA-002 and FRA-003 include an indicative location for the dwelling based on the outcomes of the assessments and subject to the final building footprint (to be confirmed at the detailed planning stages). This location is out with the flood extents of the design event (200 year plus climate change) and therefore suitably out with the functional flood plain of the Bairn's Burn (200 year event).

The assessment estimates that the water level in the vicinity of the proposed dwelling location for the design event would be 9.450mAOD (overtopping level and estimated water level at cross-section 06 and 07). In accordance with CIRIA Report C624 and SEPA's Technical Flood Risk Guidance, the FFL of the proposed dwelling is required to be +600mm above the design flood elevation. Therefore the proposed FFL is to be a minimum of 9.450mAOD + 600mm = **10.050mAOD**. As depicted on Drawings FRA-002 and FRA-003, the dwelling and part of the site boundary is afforded 'safe refuge' during the design flood events examine.

4.5.3 Flood Resilience Measures

The proposed development will be made flood resilient taking account of the following key guidance documents and the Scottish Building Regulations:

- CIRIA Report C790 – Guidance on the code of practice for property flood resilience (2020)
- RIBA – Retrofitting for Flood Resilience, A Guide to Building & Community Design
- Department for Communities and Local Government – Improving the flood performance of new buildings, Flood Resilient Construction (May 2007)

Full resilience and protection measures will be specified at Building Warrant application stages in consultation with a flood expert

5. Closure

Gondolin Land and Water Ltd (Gondolin) has been appointed by Houghton Planning to prepare a Flood Risk Assessment (FRA) in support of a planning permission in principle (PPP) application for a proposed dwelling house at Land at Meadowlands Farm, Bridge of Allan, Stirling, FK9 4UE.

In accordance with national planning policy and guidance, all potential sources of flooding to the site have been considered.

The Flood Risk Screening Assessment undertaken identified that further assessment was required to determine the flood risk to the site in respect to the fluvial flood source of the Bairn's Burn (which also serves are a proxy assessment for the surface water flood risk source also identified).

A channel capacity assessment was undertaken and has shown that although the Bairn's Burn channel is not capable of conveying the estimated peak flow, the out of bank flood extents are suitably distanced from and lower than the proposed development footprint / elevation.

A culvert capacity assessment was undertaken on the three culverts in the vicinity of the site. Review of the survey data indicates all three culverts are relatively small in diameter at only 200-300mm. It is therefore apparent that they will not be capable of conveying the estimated design flow with the Bairn's Burn (approximate culvert capacity < 200 l/s) and will surcharge and overtop.

An assessment has been carried out on the overtopping of Culvert 2 adjacent to the site. The assessment adopted a flood depth of 9.450mAOD overtopping Culvert 2, equivalent to a 650mm water depth flowing over the minor road based on the estimated design water level at CS-07. The flood extents from this overtopping scenario show that flood water would infill the lower lying areas around the western and southern site extents and predominantly shallow depths of less than 200mm (with the exception of local low spots).

This flood extent is considered to be a conservative estimate and worst-case as, no reduction in peak flow due to the constricting upstream Culvert 1 has been considered an the flood extents shown in Drawing FRA-003 does not consider the continuation of flows downstream once the culvert has been overtopped that would aid in reducing flood depths near to the site.

The risk of blockages was assessed within the culverts in locality to the site. The risk is considered to be high given the small culvert diameters, however, the impact of a blockage on any of the culverts would result in negligible changes to the estimated flood extents determined throughout the assessment due to the their limited conveyance capacity under full-flow conditions.

In summary, the assessments confirm that there is a potential for out of bank flows within the Bairn's Burn to inundate parts of the site. The assessment shows that these extents are limited and predominantly at shallow depths of less than 200mm and as such the risk to the site from the Bairn's Burn is considered low.

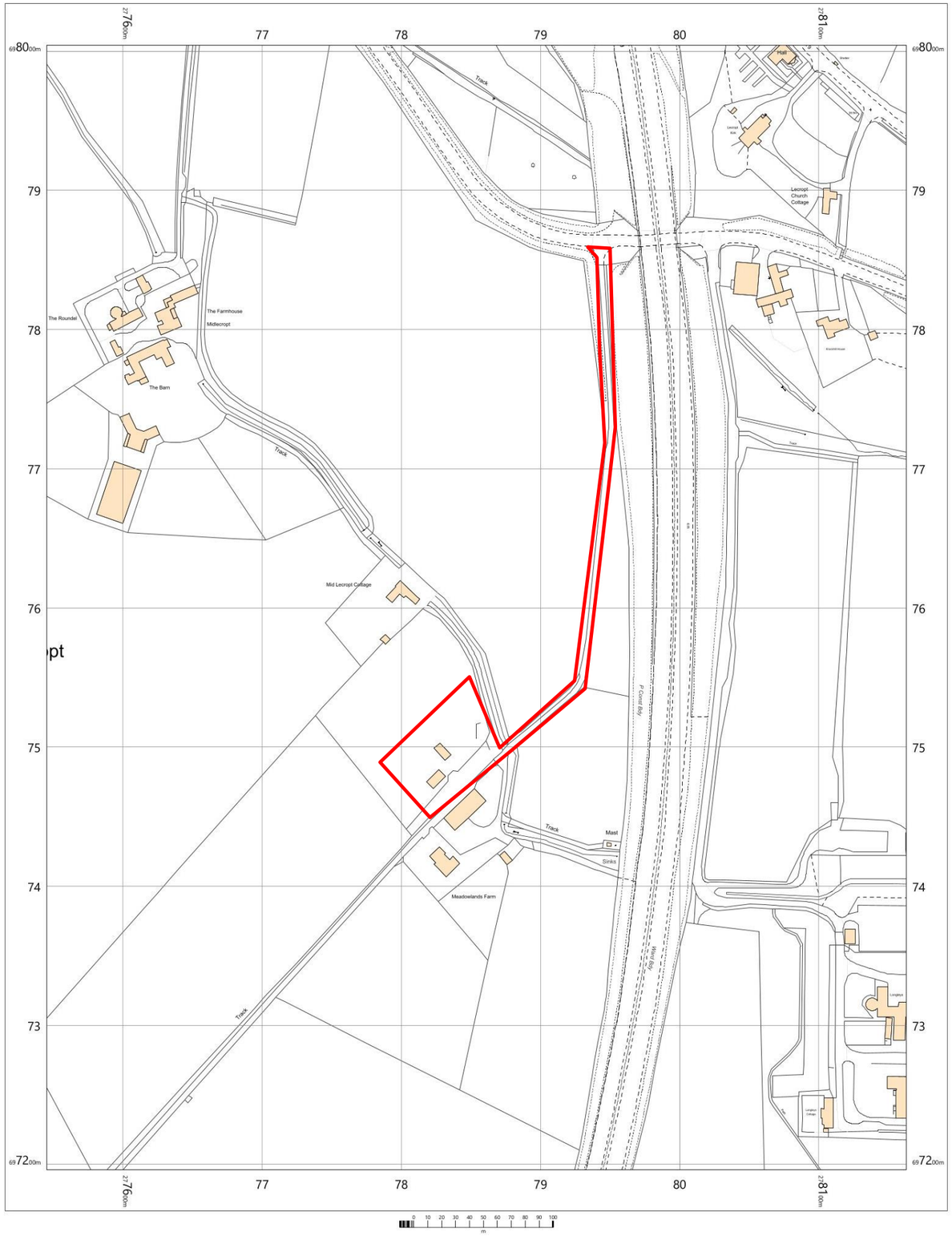
An indicative development footprint has been provided based on the outcomes of the assessments and subject to the final building footprint. This location is out with the flood extents of the design event (200 year plus climate change) and therefore suitably out with the functional flood plain of the Bairn's Burn (200 year event).

The assessment estimates that the water level in the vicinity of the proposed dwelling location for the design event would be 9.450mAOD (overtopping level and estimated water level at cross-section 06 and 07). In accordance with CIRIA Report C624, the FFL of the proposed dwelling is required to be +600mm above the design flood elevation. Therefore the proposed FFL is to be a minimum of 9.450mAOD + 600mm = **10.050mAOD**.

Taking all the above into account, it is considered that the proposed development is suitable, safe and sustainable in flood risk planning terms.

Appendix A

Site Location / Plot Plan



Legend

Site Boundary

Project: Lecropt	Client: Houghton Planning
Drawing Title: Plot Plan	
Scale 1:2500@A3	Date 26/06/2022
	Status: Planning
Drawn by: P Houghton	Checked by: P Houghton

t: 07780 117708 e: houghtonplanning.co.uk

HOUGHTON PLANNING

Appendix B

ReFH2 Analysis

UK Design Flood Estimation

Generated on Tuesday, July 12, 2022 5:57:14 PM by steph
Printed from the ReFH2 Flood Modelling software package, version 3.2.7650.24314

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

Site details Checksum: 23CB-3781

Site name: FEH_Catchment_Descriptors_277850_697500

Easting: 277850

Northing: 697500

Country: Scotland

Catchment Area (km²): 1.49

Using plot scale calculations: No

Model: 2.3

Site description: None

Model run: 200 year 1.39 CC

Summary of results

Rainfall - FEH 2013 model (mm):	88.65	Total runoff (ML):	34.86
Total Rainfall (mm):	62.83	Total flow (ML):	93.47
Peak Rainfall (mm):	12.25	Peak flow (m³/s):	3.39

Parameters

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

Rainfall parameters (Rainfall - FEH 2013 model)

Name	Value	User-defined?
Duration (hh:mm:ss)	03:15:00	No
Timestep (hh:mm:ss)	00:15:00	No
SCF (Seasonal correction factor)	0.73	No
ARF (Areal reduction factor)	0.97	No
Seasonality	Winter	No
Climate change factor	1.39	Yes

Loss model parameters

Name	Value	User-defined?
Cini (mm)	112.09	No
Cmax (mm)	384.74	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	1.59	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.05	No
BL (hr)	20.46	No
BR	1.68	No

Urbanisation parameters

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

Time series data

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
00:00:00	1.118	0.000	0.327	0.000	0.052	0.052
00:15:00	1.731	0.000	0.513	0.004	0.051	0.056
00:30:00	2.672	0.000	0.808	0.020	0.051	0.071
00:45:00	4.104	0.000	1.276	0.053	0.051	0.104
01:00:00	6.259	0.000	2.031	0.114	0.052	0.166
01:15:00	9.406	0.000	3.244	0.218	0.055	0.273
01:30:00	12.251	0.000	4.569	0.393	0.060	0.453
01:45:00	9.406	0.000	3.773	0.669	0.070	0.739
02:00:00	6.259	0.000	2.638	1.040	0.087	1.127
02:15:00	4.104	0.000	1.785	1.474	0.112	1.585
02:30:00	2.672	0.000	1.186	1.929	0.145	2.074
02:45:00	1.731	0.000	0.778	2.364	0.187	2.551
03:00:00	1.118	0.000	0.507	2.732	0.237	2.968
03:15:00	0.000	0.000	0.000	2.972	0.292	3.264
03:30:00	0.000	0.000	0.000	3.039	0.350	3.389
03:45:00	0.000	0.000	0.000	2.959	0.407	3.366
04:00:00	0.000	0.000	0.000	2.779	0.461	3.239
04:15:00	0.000	0.000	0.000	2.536	0.509	3.045
04:30:00	0.000	0.000	0.000	2.262	0.552	2.814
04:45:00	0.000	0.000	0.000	1.982	0.589	2.570
05:00:00	0.000	0.000	0.000	1.720	0.619	2.340
05:15:00	0.000	0.000	0.000	1.492	0.644	2.136
05:30:00	0.000	0.000	0.000	1.288	0.665	1.953
05:45:00	0.000	0.000	0.000	1.101	0.681	1.782
06:00:00	0.000	0.000	0.000	0.927	0.694	1.621
06:15:00	0.000	0.000	0.000	0.764	0.703	1.467
06:30:00	0.000	0.000	0.000	0.610	0.708	1.318
06:45:00	0.000	0.000	0.000	0.466	0.710	1.176
07:00:00	0.000	0.000	0.000	0.333	0.710	1.043
07:15:00	0.000	0.000	0.000	0.219	0.707	0.926
07:30:00	0.000	0.000	0.000	0.134	0.702	0.836
07:45:00	0.000	0.000	0.000	0.077	0.696	0.772
08:00:00	0.000	0.000	0.000	0.040	0.688	0.729
08:15:00	0.000	0.000	0.000	0.019	0.681	0.699
08:30:00	0.000	0.000	0.000	0.007	0.673	0.679

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
08:45:00	0.000	0.000	0.000	0.001	0.665	0.666
09:00:00	0.000	0.000	0.000	0.000	0.656	0.656
09:15:00	0.000	0.000	0.000	0.000	0.649	0.649
09:30:00	0.000	0.000	0.000	0.000	0.641	0.641
09:45:00	0.000	0.000	0.000	0.000	0.633	0.633
10:00:00	0.000	0.000	0.000	0.000	0.625	0.625
10:15:00	0.000	0.000	0.000	0.000	0.618	0.618
10:30:00	0.000	0.000	0.000	0.000	0.610	0.610
10:45:00	0.000	0.000	0.000	0.000	0.603	0.603
11:00:00	0.000	0.000	0.000	0.000	0.595	0.595
11:15:00	0.000	0.000	0.000	0.000	0.588	0.588
11:30:00	0.000	0.000	0.000	0.000	0.581	0.581
11:45:00	0.000	0.000	0.000	0.000	0.574	0.574
12:00:00	0.000	0.000	0.000	0.000	0.567	0.567
12:15:00	0.000	0.000	0.000	0.000	0.560	0.560
12:30:00	0.000	0.000	0.000	0.000	0.553	0.553
12:45:00	0.000	0.000	0.000	0.000	0.547	0.547
13:00:00	0.000	0.000	0.000	0.000	0.540	0.540
13:15:00	0.000	0.000	0.000	0.000	0.533	0.533
13:30:00	0.000	0.000	0.000	0.000	0.527	0.527
13:45:00	0.000	0.000	0.000	0.000	0.520	0.520
14:00:00	0.000	0.000	0.000	0.000	0.514	0.514
14:15:00	0.000	0.000	0.000	0.000	0.508	0.508
14:30:00	0.000	0.000	0.000	0.000	0.502	0.502
14:45:00	0.000	0.000	0.000	0.000	0.496	0.496
15:00:00	0.000	0.000	0.000	0.000	0.490	0.490
15:15:00	0.000	0.000	0.000	0.000	0.484	0.484
15:30:00	0.000	0.000	0.000	0.000	0.478	0.478
15:45:00	0.000	0.000	0.000	0.000	0.472	0.472
16:00:00	0.000	0.000	0.000	0.000	0.466	0.466
16:15:00	0.000	0.000	0.000	0.000	0.461	0.461
16:30:00	0.000	0.000	0.000	0.000	0.455	0.455
16:45:00	0.000	0.000	0.000	0.000	0.450	0.450
17:00:00	0.000	0.000	0.000	0.000	0.444	0.444
17:15:00	0.000	0.000	0.000	0.000	0.439	0.439
17:30:00	0.000	0.000	0.000	0.000	0.433	0.433

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
17:45:00	0.000	0.000	0.000	0.000	0.428	0.428
18:00:00	0.000	0.000	0.000	0.000	0.423	0.423
18:15:00	0.000	0.000	0.000	0.000	0.418	0.418
18:30:00	0.000	0.000	0.000	0.000	0.413	0.413
18:45:00	0.000	0.000	0.000	0.000	0.408	0.408
19:00:00	0.000	0.000	0.000	0.000	0.403	0.403
19:15:00	0.000	0.000	0.000	0.000	0.398	0.398
19:30:00	0.000	0.000	0.000	0.000	0.393	0.393
19:45:00	0.000	0.000	0.000	0.000	0.388	0.388
20:00:00	0.000	0.000	0.000	0.000	0.383	0.383
20:15:00	0.000	0.000	0.000	0.000	0.379	0.379
20:30:00	0.000	0.000	0.000	0.000	0.374	0.374
20:45:00	0.000	0.000	0.000	0.000	0.370	0.370
21:00:00	0.000	0.000	0.000	0.000	0.365	0.365
21:15:00	0.000	0.000	0.000	0.000	0.361	0.361
21:30:00	0.000	0.000	0.000	0.000	0.356	0.356
21:45:00	0.000	0.000	0.000	0.000	0.352	0.352
22:00:00	0.000	0.000	0.000	0.000	0.348	0.348
22:15:00	0.000	0.000	0.000	0.000	0.344	0.344
22:30:00	0.000	0.000	0.000	0.000	0.339	0.339
22:45:00	0.000	0.000	0.000	0.000	0.335	0.335
23:00:00	0.000	0.000	0.000	0.000	0.331	0.331
23:15:00	0.000	0.000	0.000	0.000	0.327	0.327
23:30:00	0.000	0.000	0.000	0.000	0.323	0.323
23:45:00	0.000	0.000	0.000	0.000	0.319	0.319
24:00:00	0.000	0.000	0.000	0.000	0.315	0.315
24:15:00	0.000	0.000	0.000	0.000	0.312	0.312
24:30:00	0.000	0.000	0.000	0.000	0.308	0.308
24:45:00	0.000	0.000	0.000	0.000	0.304	0.304
25:00:00	0.000	0.000	0.000	0.000	0.300	0.300
25:15:00	0.000	0.000	0.000	0.000	0.297	0.297
25:30:00	0.000	0.000	0.000	0.000	0.293	0.293
25:45:00	0.000	0.000	0.000	0.000	0.290	0.290
26:00:00	0.000	0.000	0.000	0.000	0.286	0.286
26:15:00	0.000	0.000	0.000	0.000	0.283	0.283
26:30:00	0.000	0.000	0.000	0.000	0.279	0.279

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
26:45:00	0.000	0.000	0.000	0.000	0.276	0.276
27:00:00	0.000	0.000	0.000	0.000	0.272	0.272
27:15:00	0.000	0.000	0.000	0.000	0.269	0.269
27:30:00	0.000	0.000	0.000	0.000	0.266	0.266
27:45:00	0.000	0.000	0.000	0.000	0.263	0.263
28:00:00	0.000	0.000	0.000	0.000	0.259	0.259
28:15:00	0.000	0.000	0.000	0.000	0.256	0.256
28:30:00	0.000	0.000	0.000	0.000	0.253	0.253
28:45:00	0.000	0.000	0.000	0.000	0.250	0.250
29:00:00	0.000	0.000	0.000	0.000	0.247	0.247
29:15:00	0.000	0.000	0.000	0.000	0.244	0.244
29:30:00	0.000	0.000	0.000	0.000	0.241	0.241
29:45:00	0.000	0.000	0.000	0.000	0.238	0.238
30:00:00	0.000	0.000	0.000	0.000	0.235	0.235
30:15:00	0.000	0.000	0.000	0.000	0.232	0.232
30:30:00	0.000	0.000	0.000	0.000	0.230	0.230
30:45:00	0.000	0.000	0.000	0.000	0.227	0.227
31:00:00	0.000	0.000	0.000	0.000	0.224	0.224
31:15:00	0.000	0.000	0.000	0.000	0.221	0.221
31:30:00	0.000	0.000	0.000	0.000	0.219	0.219
31:45:00	0.000	0.000	0.000	0.000	0.216	0.216
32:00:00	0.000	0.000	0.000	0.000	0.213	0.213
32:15:00	0.000	0.000	0.000	0.000	0.211	0.211
32:30:00	0.000	0.000	0.000	0.000	0.208	0.208
32:45:00	0.000	0.000	0.000	0.000	0.206	0.206
33:00:00	0.000	0.000	0.000	0.000	0.203	0.203
33:15:00	0.000	0.000	0.000	0.000	0.201	0.201
33:30:00	0.000	0.000	0.000	0.000	0.198	0.198
33:45:00	0.000	0.000	0.000	0.000	0.196	0.196
34:00:00	0.000	0.000	0.000	0.000	0.193	0.193
34:15:00	0.000	0.000	0.000	0.000	0.191	0.191
34:30:00	0.000	0.000	0.000	0.000	0.189	0.189
34:45:00	0.000	0.000	0.000	0.000	0.187	0.187
35:00:00	0.000	0.000	0.000	0.000	0.184	0.184
35:15:00	0.000	0.000	0.000	0.000	0.182	0.182
35:30:00	0.000	0.000	0.000	0.000	0.180	0.180

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
35:45:00	0.000	0.000	0.000	0.000	0.178	0.178
36:00:00	0.000	0.000	0.000	0.000	0.175	0.175
36:15:00	0.000	0.000	0.000	0.000	0.173	0.173
36:30:00	0.000	0.000	0.000	0.000	0.171	0.171
36:45:00	0.000	0.000	0.000	0.000	0.169	0.169
37:00:00	0.000	0.000	0.000	0.000	0.167	0.167
37:15:00	0.000	0.000	0.000	0.000	0.165	0.165
37:30:00	0.000	0.000	0.000	0.000	0.163	0.163
37:45:00	0.000	0.000	0.000	0.000	0.161	0.161
38:00:00	0.000	0.000	0.000	0.000	0.159	0.159
38:15:00	0.000	0.000	0.000	0.000	0.157	0.157
38:30:00	0.000	0.000	0.000	0.000	0.155	0.155
38:45:00	0.000	0.000	0.000	0.000	0.153	0.153
39:00:00	0.000	0.000	0.000	0.000	0.152	0.152
39:15:00	0.000	0.000	0.000	0.000	0.150	0.150
39:30:00	0.000	0.000	0.000	0.000	0.148	0.148
39:45:00	0.000	0.000	0.000	0.000	0.146	0.146
40:00:00	0.000	0.000	0.000	0.000	0.144	0.144
40:15:00	0.000	0.000	0.000	0.000	0.143	0.143
40:30:00	0.000	0.000	0.000	0.000	0.141	0.141
40:45:00	0.000	0.000	0.000	0.000	0.139	0.139
41:00:00	0.000	0.000	0.000	0.000	0.137	0.137
41:15:00	0.000	0.000	0.000	0.000	0.136	0.136
41:30:00	0.000	0.000	0.000	0.000	0.134	0.134
41:45:00	0.000	0.000	0.000	0.000	0.132	0.132
42:00:00	0.000	0.000	0.000	0.000	0.131	0.131
42:15:00	0.000	0.000	0.000	0.000	0.129	0.129
42:30:00	0.000	0.000	0.000	0.000	0.128	0.128
42:45:00	0.000	0.000	0.000	0.000	0.126	0.126
43:00:00	0.000	0.000	0.000	0.000	0.125	0.125
43:15:00	0.000	0.000	0.000	0.000	0.123	0.123
43:30:00	0.000	0.000	0.000	0.000	0.122	0.122
43:45:00	0.000	0.000	0.000	0.000	0.120	0.120
44:00:00	0.000	0.000	0.000	0.000	0.119	0.119
44:15:00	0.000	0.000	0.000	0.000	0.117	0.117
44:30:00	0.000	0.000	0.000	0.000	0.116	0.116

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
44:45:00	0.000	0.000	0.000	0.000	0.114	0.114
45:00:00	0.000	0.000	0.000	0.000	0.113	0.113
45:15:00	0.000	0.000	0.000	0.000	0.112	0.112
45:30:00	0.000	0.000	0.000	0.000	0.110	0.110
45:45:00	0.000	0.000	0.000	0.000	0.109	0.109
46:00:00	0.000	0.000	0.000	0.000	0.108	0.108
46:15:00	0.000	0.000	0.000	0.000	0.106	0.106
46:30:00	0.000	0.000	0.000	0.000	0.105	0.105
46:45:00	0.000	0.000	0.000	0.000	0.104	0.104
47:00:00	0.000	0.000	0.000	0.000	0.102	0.102
47:15:00	0.000	0.000	0.000	0.000	0.101	0.101
47:30:00	0.000	0.000	0.000	0.000	0.100	0.100
47:45:00	0.000	0.000	0.000	0.000	0.099	0.099
48:00:00	0.000	0.000	0.000	0.000	0.098	0.098
48:15:00	0.000	0.000	0.000	0.000	0.096	0.096
48:30:00	0.000	0.000	0.000	0.000	0.095	0.095
48:45:00	0.000	0.000	0.000	0.000	0.094	0.094
49:00:00	0.000	0.000	0.000	0.000	0.093	0.093
49:15:00	0.000	0.000	0.000	0.000	0.092	0.092
49:30:00	0.000	0.000	0.000	0.000	0.091	0.091
49:45:00	0.000	0.000	0.000	0.000	0.090	0.090
50:00:00	0.000	0.000	0.000	0.000	0.089	0.089
50:15:00	0.000	0.000	0.000	0.000	0.087	0.087
50:30:00	0.000	0.000	0.000	0.000	0.086	0.086
50:45:00	0.000	0.000	0.000	0.000	0.085	0.085
51:00:00	0.000	0.000	0.000	0.000	0.084	0.084
51:15:00	0.000	0.000	0.000	0.000	0.083	0.083
51:30:00	0.000	0.000	0.000	0.000	0.082	0.082
51:45:00	0.000	0.000	0.000	0.000	0.081	0.081
52:00:00	0.000	0.000	0.000	0.000	0.080	0.080
52:15:00	0.000	0.000	0.000	0.000	0.079	0.079
52:30:00	0.000	0.000	0.000	0.000	0.078	0.078
52:45:00	0.000	0.000	0.000	0.000	0.077	0.077
53:00:00	0.000	0.000	0.000	0.000	0.076	0.076
53:15:00	0.000	0.000	0.000	0.000	0.076	0.076
53:30:00	0.000	0.000	0.000	0.000	0.075	0.075

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
53:45:00	0.000	0.000	0.000	0.000	0.074	0.074
54:00:00	0.000	0.000	0.000	0.000	0.073	0.073
54:15:00	0.000	0.000	0.000	0.000	0.072	0.072
54:30:00	0.000	0.000	0.000	0.000	0.071	0.071
54:45:00	0.000	0.000	0.000	0.000	0.070	0.070
55:00:00	0.000	0.000	0.000	0.000	0.069	0.069
55:15:00	0.000	0.000	0.000	0.000	0.068	0.068
55:30:00	0.000	0.000	0.000	0.000	0.068	0.068
55:45:00	0.000	0.000	0.000	0.000	0.067	0.067
56:00:00	0.000	0.000	0.000	0.000	0.066	0.066
56:15:00	0.000	0.000	0.000	0.000	0.065	0.065
56:30:00	0.000	0.000	0.000	0.000	0.064	0.064
56:45:00	0.000	0.000	0.000	0.000	0.064	0.064
57:00:00	0.000	0.000	0.000	0.000	0.063	0.063
57:15:00	0.000	0.000	0.000	0.000	0.062	0.062
57:30:00	0.000	0.000	0.000	0.000	0.061	0.061
57:45:00	0.000	0.000	0.000	0.000	0.061	0.061
58:00:00	0.000	0.000	0.000	0.000	0.060	0.060
58:15:00	0.000	0.000	0.000	0.000	0.059	0.059
58:30:00	0.000	0.000	0.000	0.000	0.058	0.058
58:45:00	0.000	0.000	0.000	0.000	0.058	0.058
59:00:00	0.000	0.000	0.000	0.000	0.057	0.057
59:15:00	0.000	0.000	0.000	0.000	0.056	0.056
59:30:00	0.000	0.000	0.000	0.000	0.056	0.056
59:45:00	0.000	0.000	0.000	0.000	0.055	0.055
60:00:00	0.000	0.000	0.000	0.000	0.054	0.054
60:15:00	0.000	0.000	0.000	0.000	0.054	0.054
60:30:00	0.000	0.000	0.000	0.000	0.053	0.053
60:45:00	0.000	0.000	0.000	0.000	0.052	0.052

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	1.49	No
ALTBAR	60	No
ASPBAR	159	No
ASPVAR	0.25	No
BFIHOST	0.47	No
BFIHOST19	0.45	No
DPLBAR (km)	1.63	No
DPSBAR (mkm^{-1})	75.8	No
FARL	1	No
LDP	3.32	No
PROPWET (mm)	0.59	No
RMED1H	8.9	No
RMED1D	34.1	No
RMED2D	47.8	No
SAAR (mm)	996	No
SAAR4170 (mm)	989	No
SPRHOST	45.42	No
Urbext2000	0	No
Urbext1990	0	No
URBCONC	0	No
URBLOC	0	No
DDF parameter C	-0.02	No
DDF parameter D1	0.43	No
DDF parameter D2	0.39	No
DDF parameter D3	0.35	No
DDF parameter E	0.24	No
DDF parameter F	2.29	No
DDF parameter C (1km grid value)	-0.02	No
DDF parameter D1 (1km grid value)	0.43	No
DDF parameter D2 (1km grid value)	0.4	No
DDF parameter D3 (1km grid value)	0.34	No
DDF parameter E (1km grid value)	0.24	No
DDF parameter F (1km grid value)	2.29	No

Drawings

BAIRN'S BURN

CS-01

CS-01'

CULVERT 1
250mm Ø PIPE

CS-02

CS-02'

CS-03

CS-03'

CS-04

CS-04'

CS-05

CS-05'

CS-06

CS-06'

CS-07

CS-07'

CS-08

CS-08'

CS-09

CS-09'

CULVERT 2
200mm Ø PIPE

CULVERT BENEATH M9
(NOT PART OF ASSESSMENT)

CS-10

CS-10'

CS-11

CS-11'

CS-12

CS-12'

CS-13

CS-13'

CS-14

CS-14'

CS-15

CS-15'

CULVERT 3
300mm Ø PIPE

BAIRN'S BURN

N

NOTES

1. SURVEY DATA TAKEN FROM ASPECT SURVEYS DRAWING 'A8016' DATED 9TH MARCH 2022.

LEGEND

- SITE BOUNDARY
- BAIRN'S BURN
- SURVEYED CHANNEL SECTIONS
- CULVERT
- OVERLAND FLOW ROUTE

REV	DATE	DESCRIPTION	BY	CHK
00	07/22	INITIAL ISSUE	SD	ZR

CLIENT:
HOUGHTON PLANNING

PROJECT:
LECROPT PLOT FRA

DRAWING TITLE:
EXISTING HYDROLOGICAL OVERVIEW

SCALE:
1:750@ A2

DATE:
JULY 2022

DRAWING NUMBER:
FRA-001

REV:
00

DRAWING STATUS:
PLANNING PERMISSION IN PRINCIPLE

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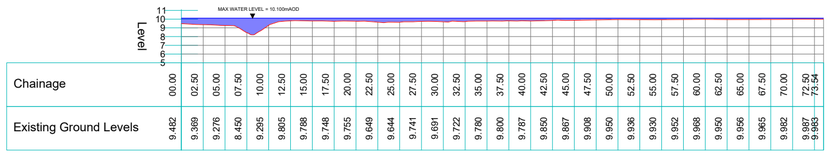
Registered Company No. SC706920

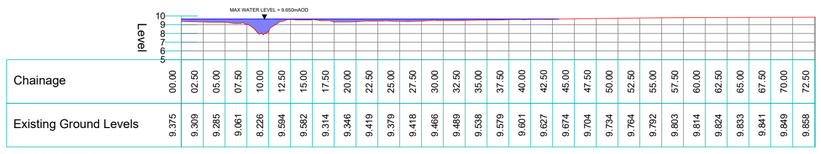
GONDOLIN Land & Water

FRA-001_Lecropt Plot_Existing Hydrological Overview.dwg



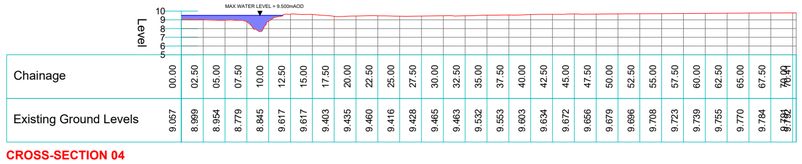
Chainage	00.00	02.50	05.00	07.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00	32.50	35.00	37.50	40.00	42.50	45.00	47.50	50.00	52.50	55.00	57.50	60.00	62.50	65.00	67.50	70.00	72.50
Existing Ground Levels	9.482	9.369	9.276	8.450	9.295	9.805	9.788	9.748	9.755	9.649	9.644	9.741	9.691	9.722	9.780	9.800	9.787	9.850	9.867	9.908	9.950	9.936	9.930	9.952	9.968	9.950	9.956	9.965	9.962	9.987

CROSS-SECTION 02



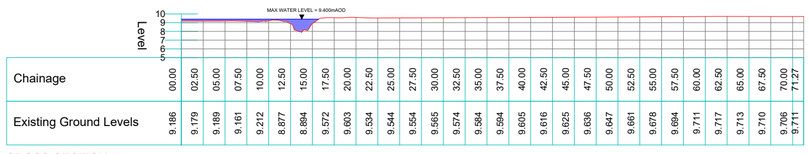
Chainage	00.00	02.50	05.00	07.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00	32.50	35.00	37.50	40.00	42.50	45.00	47.50	50.00	52.50	55.00	57.50	60.00	62.50	65.00	67.50	70.00	72.50
Existing Ground Levels	9.375	9.309	9.285	9.061	8.226	9.594	9.582	9.314	9.346	9.419	9.379	9.418	9.466	9.489	9.538	9.579	9.601	9.627	9.674	9.704	9.734	9.764	9.792	9.803	9.814	9.824	9.833	9.841	9.849	9.858

CROSS-SECTION 03



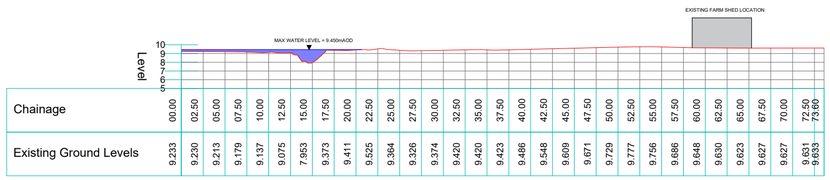
Chainage	00.00	02.50	05.00	07.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00	32.50	35.00	37.50	40.00	42.50	45.00	47.50	50.00	52.50	55.00	57.50	60.00	62.50	65.00	67.50	70.00	70.00
Existing Ground Levels	9.057	8.999	8.954	8.779	8.845	9.617	9.617	9.403	9.435	9.460	9.416	9.428	9.465	9.463	9.532	9.553	9.603	9.634	9.672	9.656	9.679	9.696	9.708	9.723	9.739	9.755	9.770	9.784	9.781	9.781

CROSS-SECTION 04



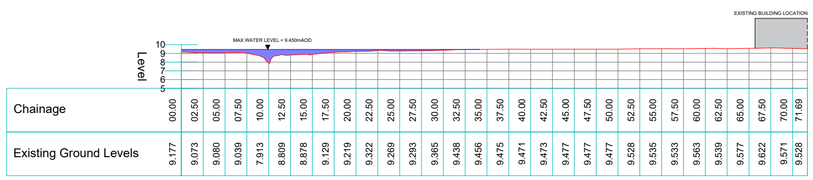
Chainage	00.00	02.50	05.00	07.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00	32.50	35.00	37.50	40.00	42.50	45.00	47.50	50.00	52.50	55.00	57.50	60.00	62.50	65.00	67.50	70.00	71.27
Existing Ground Levels	9.186	9.179	9.189	9.161	9.212	8.877	8.894	9.572	9.603	9.534	9.544	9.554	9.565	9.574	9.584	9.594	9.605	9.616	9.625	9.636	9.647	9.661	9.678	9.694	9.711	9.717	9.713	9.710	9.706	9.711

CROSS-SECTION 05



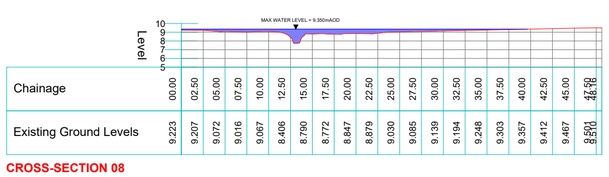
Chainage	00.00	02.50	05.00	07.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00	32.50	35.00	37.50	40.00	42.50	45.00	47.50	50.00	52.50	55.00	57.50	60.00	62.50	65.00	67.50	70.00	72.50
Existing Ground Levels	9.233	9.230	9.213	9.179	9.137	9.075	7.953	9.373	9.411	9.525	9.364	9.326	9.374	9.420	9.420	9.423	9.486	9.548	9.609	9.671	9.729	9.777	9.756	9.686	9.648	9.630	9.623	9.627	9.627	9.631

CROSS-SECTION 06



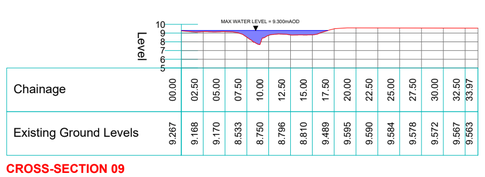
Chainage	00.00	02.50	05.00	07.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00	32.50	35.00	37.50	40.00	42.50	45.00	47.50	50.00	52.50	55.00	57.50	60.00	62.50	65.00	67.50	70.00	71.69
Existing Ground Levels	9.177	9.073	9.080	9.039	7.913	8.809	8.878	9.129	9.219	9.322	9.269	9.293	9.365	9.438	9.456	9.475	9.471	9.473	9.477	9.477	9.477	9.528	9.535	9.533	9.563	9.539	9.577	9.622	9.571	9.528

CROSS-SECTION 07



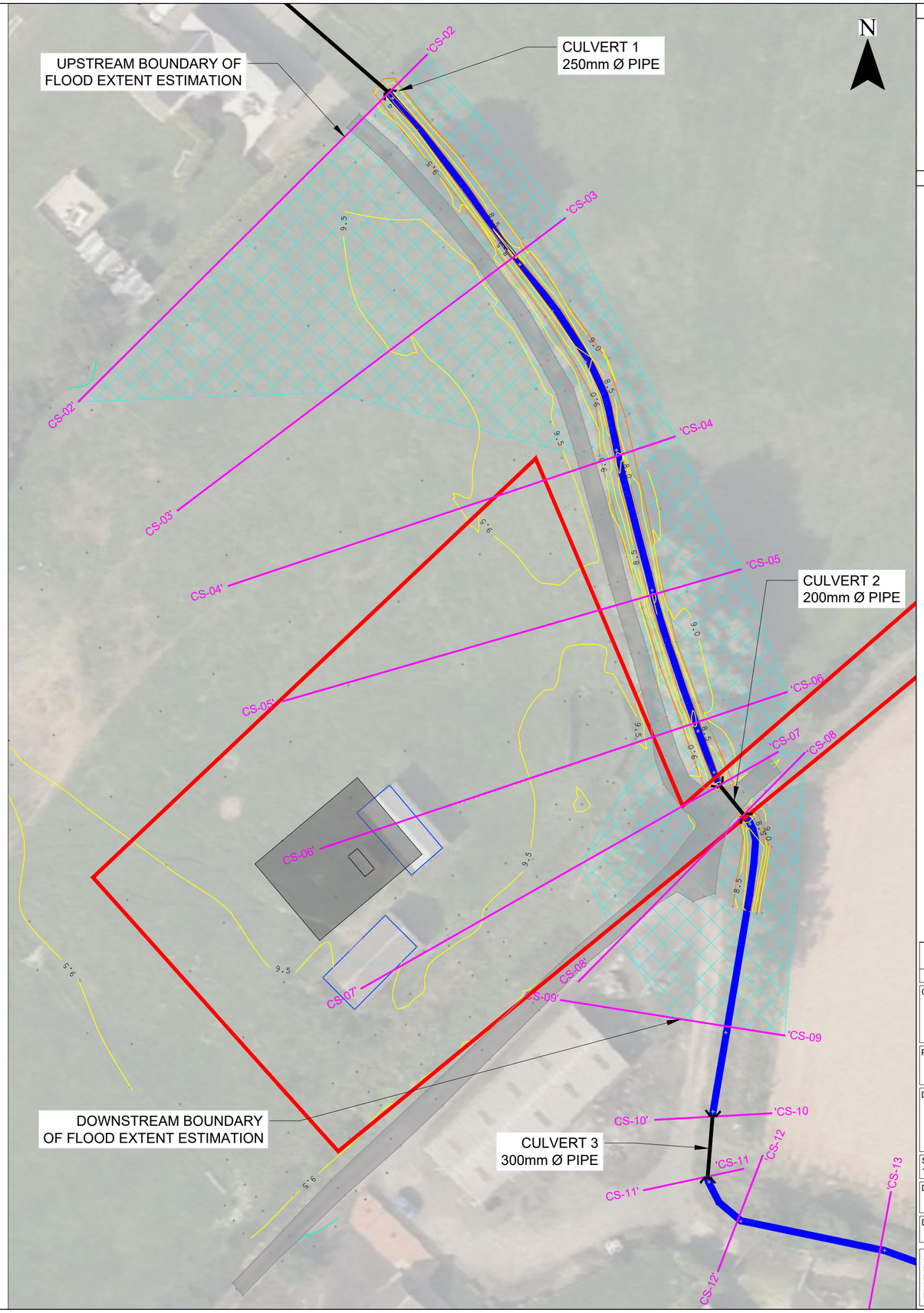
Chainage	00.00	02.50	05.00	07.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00	32.50	35.00	37.50	40.00	42.50	45.00	47.50
Existing Ground Levels	9.223	9.207	9.072	9.016	9.067	8.406	8.790	8.772	8.847	8.879	9.030	9.086	9.139	9.194	9.248	9.303	9.357	9.412	9.467	9.501

CROSS-SECTION 08



Chainage	00.00	02.50	05.00	07.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00	32.50	33.97
Existing Ground Levels	9.267	9.168	9.170	8.533	8.750	8.796	8.810	9.489	9.595	9.590	9.584	9.578	9.572	9.567	9.563

CROSS-SECTION 09



NOTES

1. SURVEY DATA TAKEN FROM ASPECT SURVEYS DRAWING 'A8016' DATED 9TH MARCH 2022.
2. DEVELOPMENT FOOTPRINT IS INDICATIVE AND BASED ON OUTCOMES OF FLOOD RISK ASSESSMENT. FINAL FOOTPRINT SUBJECT TO FINAL HOUSE LAYOUT.

LEGEND

- SITE BOUNDARY
- BAIRN'S BURN
- INDICATIVE DEVELOPMENT FOOTPRINT
- SURVEYED CHANNEL SECTIONS
- CULVERT
- 1-200 YEAR PLUS 39% CLIMATE CHANGE FLOOD EXTENTS (ESTIMATED FROM CHANNEL CAPACITY CALCULATIONS)

REV	DATE	DESCRIPTION	BY	CHK
00	07/22	INITIAL ISSUE	SD	ZR

CLIENT: HOUGHTON PLANNING

PROJECT: LECROPT PLOT FRA

DRAWING TITLE: **FLUVIAL FLOODING ASSESSMENT**

SCALE: 1:500 @ A2

DATE: JULY 2022

DRAWING NUMBER: **FRA-002**

REV: **00**

DRAWING STATUS: PLANNING PERMISSION IN PRINCIPLE

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EH6 5DL
T: +44 (0)7895 221230
Registered Company No. SC706920

GONDOLIN Land & Water

FRA-002_Lecropt Plot_Fluvial Flood Risk.dwg

CULVERT 1
250mm Ø PIPE

FLOOD EXTENT BASED ON OVERTOPPING OF CULVERT 2 AND DISREGARDING ANY REDUCTION OF FLOWS DUE TO UPSTREAM CULVERT 1. MODELLED WATER LEVEL = 9.450mAOD.

FLOOD DEPTHS WITHIN MAIN SITE AREA PREDOMINANTLY LESS THE 200mm (WITH EXCEPTION OF LOCAL LOW SPOTS)

CULVERT 2
200mm Ø PIPE

FLOOD EXTENT DOWNSTREAM NOT SHOWN DUE TO SURVEY EXTENTS

CULVERT 3
300mm Ø PIPE

N

NOTES

1. SURVEY DATA TAKEN FROM ASPECT SURVEYS DRAWING 'A8016' DATED 9TH MARCH 2022.
2. DEVELOPMENT FOOTPRINT IS INDICATIVE AND BASED ON OUTCOMES OF FLOOD RISK ASSESSMENT. FINAL FOOTPRINT SUBJECT TO FINAL HOUSE LAYOUT.

LEGEND

- SITE BOUNDARY
- BAIRN'S BURN
- INDICATIVE DEVELOPMENT FOOTPRINT
- SURVEYED CHANNEL SECTIONS
- CULVERT
- ESTIMATED FLOOD EXTENTS FOR DESIGN EVENT AND OVERTOPPING OF CULVERT 2

REV	DATE	DESCRIPTION	BY	CHK
00	07/22	INITIAL ISSUE	SD	ZR

CLIENT: HOUGHTON PLANNING

PROJECT: LECROPT PLOT FRA

DRAWING TITLE: **CULVERT FLOODING ASSESSMENT**

SCALE: 1:500 @ A2

DATE: JULY 2022

DRAWING NUMBER: **FRA-003**

REV: **00**

DRAWING STATUS: PLANNING PERMISSION IN PRINCIPLE

GONDOLIN LAND & WATER LTD
EDINBURGH
EH6 5DL
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Registered Company No. SC706920

FRA-003_Lecropt Plot_Culvert Flooding Assessment.dwg

GONDOLIN
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Civil Engineering and Environmental Solutions

Gondolin Land and Water Ltd is a small, client friendly environmental and engineering consultancy business based in Scotland with coverage throughout the UK.

Registered Address:

35/1 Balfour Street, Edinburgh, EH6 5DL, UK

Registered Company No.

SC706920

Sectors:

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