

57 BRYN GLAS, RHOSLLANERCHRUGOG

FLOOD CONSEQUENCES ASSESSMENT

Final Report v1.0

June 2019

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Flood Consequences Assessment
Final Report v1.0

Client Dave Cottle Civil Engineering Ltd

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1 INTRODUCTION

1.1 PURPOSE OF REPORT

Weetwood Services Ltd ('Weetwood') has been instructed by Dave Cottle Civil Engineering Ltd to prepare a Flood Consequences Assessment (FCA) report for the proposed redevelopment of land at 57 Bryn Glas, Rhosllanerchrugog.

The assessment has been undertaken in accordance with the requirements of Technical Advice Note 15 (TAN15).

1.2 STRUCTURE OF THE REPORT

The report is structured as follows:

- Section 1** Introduction and report structure
- Section 2** Presents national and local flood risk and drainage planning policy
- Section 3** Provides background information relating to the development site, the development proposals, ground conditions and existing site access arrangements
- Section 4** Assesses the potential sources of flooding to the development site
- Section 5** Presents flood risk mitigation measures based on the findings of the assessment
- Section 6** Addresses the effect of the proposed development on surface water runoff and presents an illustrative surface water drainage scheme to ensure that surface water runoff is sustainably managed and flood risk is not increased elsewhere.
- Section 7** Presents a summary of key findings
- Section 8** Presents the recommendations

2 PLANNING POLICY AND GUIDANCE

2.1 NATIONAL PLANNING POLICY AND GUIDANCE

2.1.1 Technical Advice Note 15

The general approach of TAN15 is to set out a precautionary framework to guide planning decisions in areas at high risk of flooding. The overarching aim of the framework is, in order of preference, to:

- Direct new development away from those areas which are at a high risk of flooding.
- Where development has to be considered in high risk areas (i.e. Zone C) only those development which can be justified should be located in such areas.

2.1.1.1 Justification Test

In accordance with Paragraph 6 of TAN15 for the Justification Test to be passed it must be demonstrated that:

- i. Its location in Zone C is necessary to assist, or be part of, a local authority regeneration initiative or a local authority strategy required to sustain an existing settlement; **or**,
- ii. Its location in Zone C is necessary to contribute to key employment objectives supported by the local authority, and other key partners, to sustain an existing settlement or region;

and,

- iii. It concurs with the aims of Planning Policy Wales (PPW) and meets the definition of previously developed land (PPW Fig 2.1); and,
- iv. The potential consequences of a flooding event for the particular type of development have been considered, and in terms of the criteria contained in sections 5 and 7 and appendix 1 found to be acceptable.

2.1.1.2 Surface Water Drainage

TAN15 provides an overview of the requirements for the management of surface water to ensure that development does not increase flood risk at the site or elsewhere.

Paragraph 8.3 of TAN15 states that *"the aim should be for new development not to create additional run-off when compared with the undeveloped situation, and for redevelopment to reduce runoff where possible. It is accepted that there may be practical difficulties in achieving this aim"*.

2.1.2 Welsh Government

2.1.2.1 Climate Change Allowances for Planning, August 2016

A consultation letter¹ and supporting guidance note² issued by Welsh Government in August 2016 sets out allowances for climate change for use in FCAs submitted in support of planning applications.

¹ Welsh Government consultation letter 23 August, 2016 (Ref: CL-03-16)

When considering new development proposals, TAN15 states that it is necessary to take account of the potential impact of climate change over the lifetime of development. The Welsh Government guidance note states that *"residential development is assumed to have a lifetime of 100 years while a lifetime of 75 years is assumed for non-residential developments. To ensure future development can provide a safe and secure living and /or working environment throughout its lifetime, national planning policy requires proposals in areas of high flood risk to be accompanied by an assessment of flooding consequences to and from the development, taking into account the impacts of climate change"*.

The climate change allowances detailed within the Welsh Government guidance note are informed by latest available information on climate change projections and allowances are provided for different epochs (periods) of time over the next century.

The guidance note should be applied to planning applications (full, outline and reserved matters) submitted from 1 December 2016.

2.1.2.1 Statutory Standards for Sustainable Drainage Systems

For applications submitted from 7 January 2019, the Flood and Water Management Act 2010 (Schedule 3) requires new developments to include Sustainable Drainage Systems (SuDS) features that comply with national standards.

New developments of more than one dwelling or where the area covered by construction work equals or exceeds 100 m² require approval before construction can commence from the SuDS Approval Body (SAB) to ensure compliance with the SuDS standards.

The SAB will also be required to adopt the SuDS unless the scheme serves only a single property or is a publically maintained road to which Section 41 of the Highways Act 1980 applies.

The statutory standards are as follows:

Standard S1; Surface water runoff destination

- Priority Level 1: Surface water runoff is collected for use;
- Priority Level 2: Surface water runoff is infiltrated to ground;
- Priority Level 3: Surface water is discharged to a surface water body;
- Priority Level 4: Surface Water is discharged to surface water sewer, highway drain, or another drainage system;
- Priority Level 5: Surface water runoff is discharged to a combined sewer.

Standard S2; Surface water runoff hydraulic control

1. Surface water should be managed to prevent, so far as possible, any discharge from the site for the majority of rainfall events of less than 5 mm.
2. The surface water runoff rate for the 1:1 annual probability event (or agreed equivalent) should be controlled to help mitigate the negative impacts of the development runoff on the morphology and associated ecology of the receiving surface water bodies.
3. The surface water runoff (rate and volume) for the 1:100 annual probability event (or agreed equivalent) should be controlled to help mitigate negative impacts of the development on flood risk in the receiving water body.

² <https://gov.wales/docs/desh/publications/160831guidance-for-flood-consequence-assessments-climate-change-allowances-en.pdf>

4. The surface water runoff for events up to the 1:100 annual probability (or agreed equivalent) should be managed to protect people and property on and adjacent to the site from flooding from the drainage system.
5. The risks (both on site and off site) associated with the surface water runoff for events greater than the 1:100 annual probability should be considered. Where the consequences are excessive in terms of social disruption, damage or risk to life, mitigating proposals should be developed to reduce these impacts.
6. Drainage design proposals should be examined for the likelihood and consequences of any potential failure scenarios (e.g. structural failure or blockage), and the associated flood risks managed where possible.

Standard S3; Surface water quality management

Treatment for surface water runoff should be provided to prevent negative impacts on the receiving water quality and/or protect downstream drainage systems, including sewers.

Standard S4; Amenity

The design of surface water management systems should maximise amenity benefits.

Standard S5; Biodiversity

The design of the surface water management system should maximise biodiversity benefits.

Standard S6; Design of drainage or construction, operation and maintenance

1. All elements of the surface water drainage system should be designed so that they can be constructed easily, safely, cost-effective, in a timely manner, and with the aim of minimising the use of scarce resources and embedded carbon (energy).
2. All elements of the surface water drainage system should be designed to ensure maintain and operation can be undertaken (by the relevant responsible body) easily, safely, cost-effective, in a timely manner, and with the aim of minimising the use of scarce resources and embedded carbon (energy).
3. The surface water drainage system should be designed to ensure structural integrity of all elements under anticipated loading conditions over the design life of the development site, taking into account the requirement for reasonable levels of maintenance.

2.2 LOCAL PLANNING POLICY AND GUIDANCE

The Wrexham County Borough Council (WCBC) Unitary Development Plan (UDP) 1996 to 2011 expired at the end of 2015; however, this remains the adopted development plan for the county.

The Wrexham County Borough Council (WCBC) has submitted the Local Development plan (LDP) 2013-2028 to the Welsh Government. The LDP will replace the current Unitary Development plan, once adopted by Welsh Government.

The following policy is relevant in respects of flood risk:

Policy EC12 - Development and Flood Risk

Development (including the raising of land) within the defined flood plains will only be permitted if it:-

- a) Would not be subject to an unacceptable risk of flooding on-site; and/or
- b) Does not result in unacceptable risk of flooding on or off-site; and/or
- c) Does not adversely affect flood management or maintenance

WCBC is currently preparing a Local Development Plan (LDP) which will replace the current adopted UDP in spring 2019.

2.3 CONSENTS

An Environmental Permit for Flood Risk Activities may be required from the Natural Resources Wales (NRW) for work:

- In, under, over or near a main river (including where the river is in a culvert)
- On or near a flood defence on a main river
- In the flood plain of a main river
- On or near a sea defence

Further information can be found at <https://naturalresources.wales/apply-for-a-permit/flood-risk-activities/flood-risk-activity-permits-information/?lang=en>.

If the location of an activity is on any watercourse that lies within an Internal Drainage District (IDD) an application will need to be made to NRW for a Flood Risk Activity Permit.

Ordinary Watercourse Consent may be required from the lead local flood authority for work to an ordinary watercourse. Undertaking activities controlled by local Byelaws (made under the Water Resources Act 1991) also requires the relevant consent.

2.4 RELEVANT DOCUMENTS

The assessment has been informed by the following documents:

- Local Flood Risk Management Strategy (LFRMS), WCBC, April 2013
- Preliminary Flood Risk Assessment (PFRA), WCBC, November 2017

3 SITE DETAILS AND PROPOSED DEVELOPMENT

3.1 SITE LOCATION

The site is located at the end of Bryn Glas in Rhosllanerchrugog at Ordnance Survey National Grid Reference SJ 289 459, as shown in **Figure 1**. The site is approximately 0.39 hectares (ha) in area.

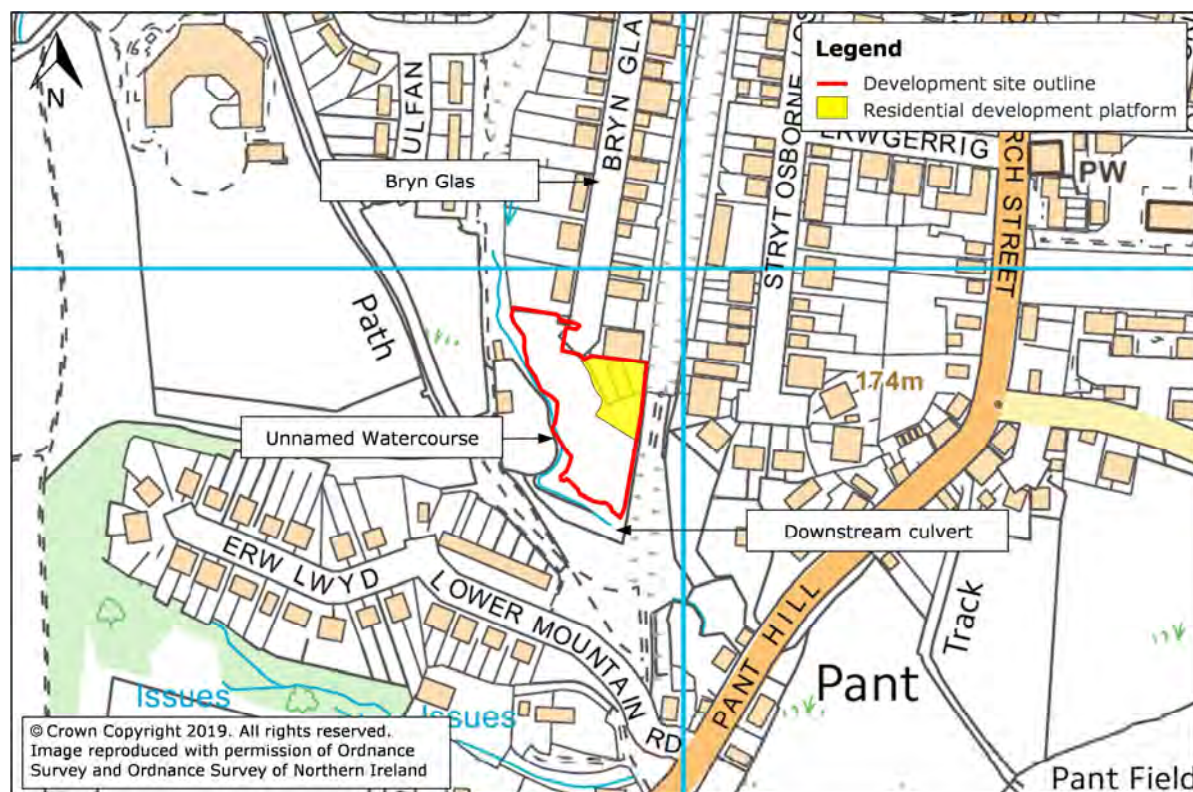


Figure 1: Site Location

3.2 EXISTING AND PROPOSED DEVELOPMENT

The majority of the existing site consists of undeveloped land, with an existing dwelling and associated hardstanding in the north-eastern corner.

The proposed development is for the construction of three residential dwellings, along with an access road, associated hardstanding and amenity areas (**Appendix A**).

The development will be restricted to the north-east corner of the site, as illustrated in **Figure 1**. It is understood the rest of the land within the application boundary will remain undeveloped.

TAN15 classifies residential development as 'highly vulnerable' land use³.

³ TAN15, Figure 2

3.3 WATERBODIES IN THE VICINITY OF THE SITE

There is an unnamed watercourse located adjacent to the site's western boundary; this flows in a predominantly southerly direction and is classified as an 'ordinary watercourse'.

The watercourse flows in open channel adjacent to the site, prior to entering a culvert adjacent to the site's southernmost point (**Figure 2**). The watercourse is also culverted upstream of the site, through the residential areas to the north.

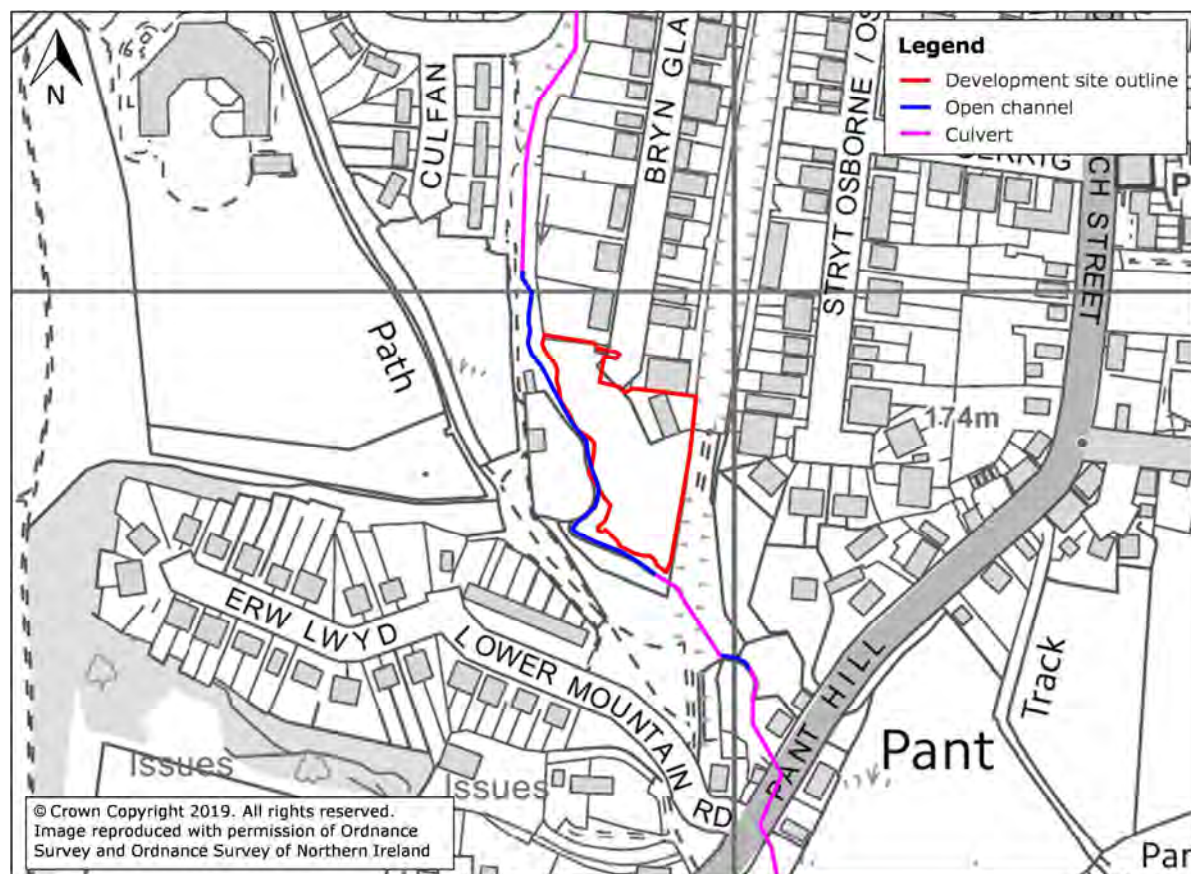


Figure 2: Ordinary Watercourse

3.4 GROUND CONDITIONS

According to the Soilsapes maps produced by the National Soils Research Institute⁴, soil conditions at the site and within the surrounding area are described as 'slightly acid loamy and clayey soils with impeded drainage'.

British Geological Survey (BGS) borehole records⁵ located approximately 30 m south-west of the site identifies layers of sandy clay, sand and gravel, and boulder clay.

BGS Surface Geology mapping⁶ indicates the underlying bedrock formation comprises 'Mudstone, Siltstone and Sandstone', which is overlain by 'Till, Devensian - Diamicton' superficial deposits.

⁴ Soilsapes www.landis.org.uk/soilsapes/

⁵ www.bgs.ac.uk/data/boreholescans/home.html, Ref: SJ24NE1122

The site is shown to be located within a Secondary A bedrock aquifer.

3.5 SITE LEVELS

LiDAR data has been utilised to develop a digital elevation model as illustrated in **Figure 3**.

Site levels are generally shown to be in the region of 158.8 to 170.0 metres Above Ordnance Datum (m AOD), with the greatest elevations being at the north east corner of the site and the lowest running parallel to the watercourse running left of the site.

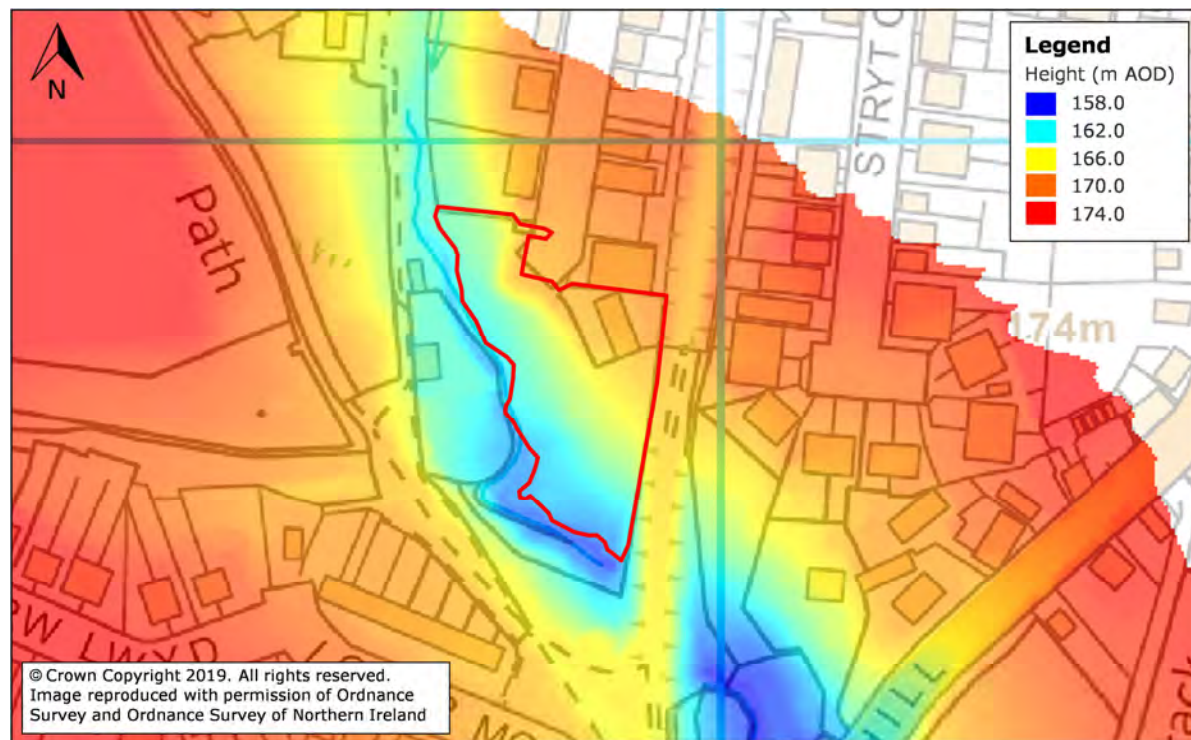


Figure 3: Digital Elevation Model

3.6 ACCESS AND EGRESS

Access and egress to the site is provided via Bryn Glas.

Levels along Bryn Glas are in the region of 168.7 to 171.4 m AOD.

⁶ <http://mapapps.bgs.ac.uk/geologyofbritain/home.html>

4 REVIEW OF FLOOD RISK

4.1 FLOOD ZONE DESIGNATION

Flood zones refer to the probability of river and sea flooding. TAN15 defines flood zones as follows:

- Zone A: Considered to be at little or no risk of fluvial or tidal/coastal flooding.
- Zone B: Areas known to have been flooded in the past evidenced by sedimentary deposits.
- Zone C: Based on [the Natural Resources Wales] flood outline, equal to or greater than 0.1% (river, tidal or coastal). Zone C is subdivided into the following two zones:
 - o Zone C1: Areas of the floodplain which are developed and served by significant infrastructure, including flood defences.
 - o Zone C2: Areas of the floodplain without significant flood defence infrastructure.

The flood zones are shown on the Development Advice Map. The zones do not account for possible future changes in flooding due to the impact of climate change or the presence of flood defences (although areas benefitting from flood defences may be indicated).

According to the Development Advice Map (**Figure 4**) the site is located in Zone A.

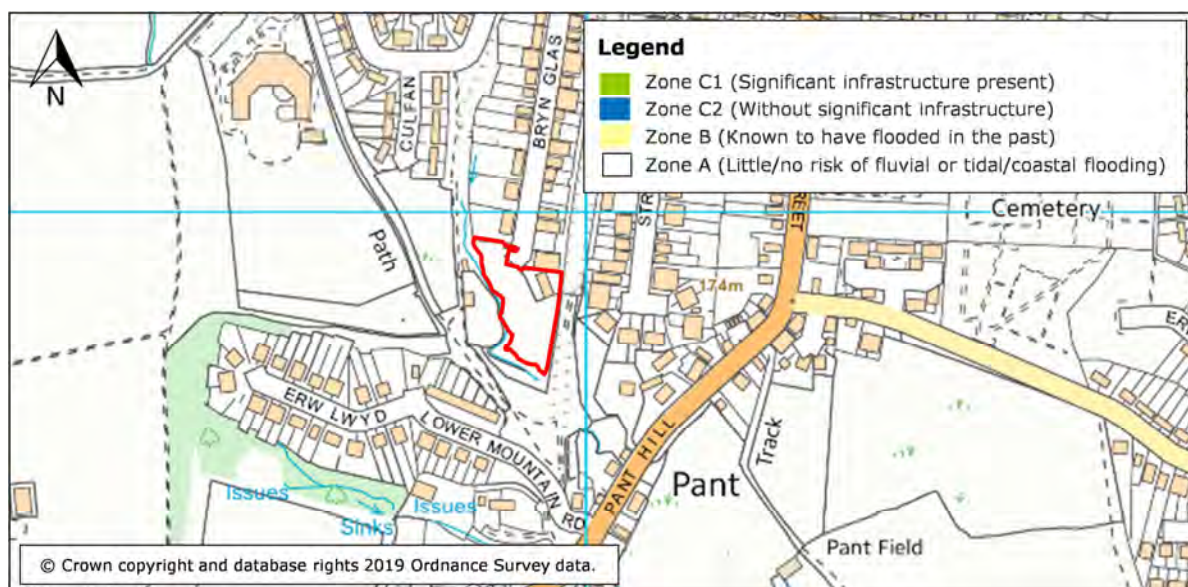


Figure 4: Development Advice Map
(Source: NRW website)

The Flood Risk Map (Rivers and Sea) (**Figure 5**) indicates that the site is located in the 1:1,000 annual probability flood outline, thereby supporting the site's Zone A designation.

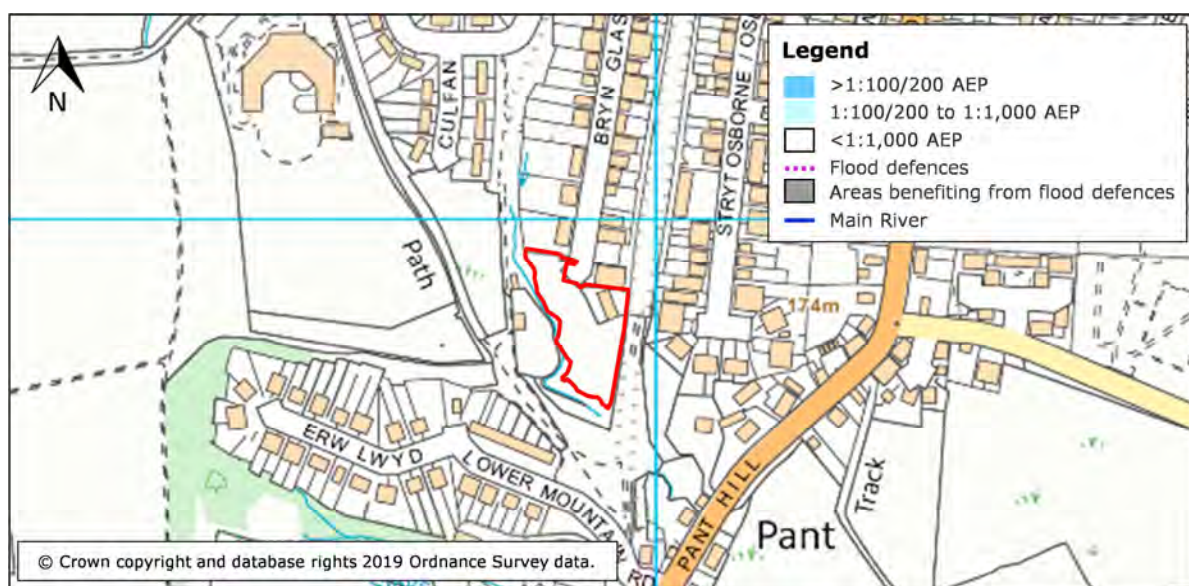


Figure 5: Flood Risk Map (Rivers and Sea)
(Source: NRW website)

4.2 HISTORICAL RECORDS OF FLOODING

According to NRW historic flood outlines⁷, there are no records of the site previously being affected by flooding.

4.3 FLUVIAL FLOOD RISK - UNNAMED WATERCOURSE

As discussed in **Section 3.3**, the unnamed watercourse is located at western boundary of the site.

However, the flood risk posed by the unnamed watercourse is not accurately represented on the NRW Flood Risk Map or on the Development Advice Map, due to its small catchment size.

In order to more accurately identify and assess the level of flood risk from the watercourses at the site a 1D-2D ESTRY-TUFLOW hydraulic model has been developed by Weetwood. Details of the hydraulic modelling study are provided in **Appendix B**.

4.3.1 Modelled Flood Levels - Baseline

The following events were modelled in order to establish the baseline scenario:

- 1:100 annual probability event
- 1:100 plus climate change (+CC) (20%) annual probability event
- 1:100 +CC (45%) annual probability event
- 1:1,000 annual probability event

Model output plots are provided in Annex D of **Appendix B**.

The modelled peak flood levels within the site boundary are provided in **Table 1**.

⁷ <http://lle.gov.wales/catalogue/item/HistoricFI/?lang=en>

Table 1: Modelled Flood Levels – Baseline

Annual Probability Event	Max Level (m AOD)
1:100	163.37
1:100 +CC (20%)	164.24
1:100 +CC (45%)	165.19
1:1,000	165.73

No flooding of the proposed residential platform, including the access road and gardens, or Bryn Glas would be expected in up to the 1:100 +CC (45%) annual probability event.

Some minor flooding of the south-western extremity of the residential platform area may be expected to a maximum depth of 0.32 m during the 1:1,000 annual probability flood event.

4.3.2 Structure Blockage

The Weetwood modelling study also assessed the impact of a 100% culvert blockage of the downstream culvert.

A 100% blockage of the culvert was modelled for the following events as a sensitivity assessment:

- 1:100 +CC (20%) annual probability event
- 1:1,000 annual probability event

Model output plots for the culvert blockage scenario are provided in Annex E of **Appendix B**.

Table 2 summarises the maximum flood level expected on site during the respective blockage scenarios.

Table 2: Modelled Flood Levels – Blockage

Annual Probability Event	Max Level (m AOD)
1:100+CC (20%) with 100% blockage	166.54
1:1,000 with 100% blockage	166.59

Some flooding of the southern extremity of residential platform area would be expected during the 1:100 +CC (20%) and 1:1,000 annual probability events with 100% blockage, with maximum flood depths of 1.13 and 1.18 m respectively.

No flooding of Bryn Glas would be expected during the aforementioned blockage events.

Flood risk to the southern section of the development platform will be addressed by the mitigation measure proposed in **Section 5**.

4.4 FLOOD RISK FROM SURFACE WATER

The Surface Water Flood Risk map (**Figure 6**) indicates that site is generally at 'very low' risk of flooding, with areas adjacent to western boundary of the site shown to be at a 'low' to 'medium' risk of flooding.

The Flood Risk from Surface Water map indicates that surface water flood depths at the site in the 'low' risk event may exceed 0.9 m. However, this assessment is believed to be reflective of the watercourse, rather than surface water flooding.

Irrespective, the residential development platform is shown to be at 'very low' risk of flooding.

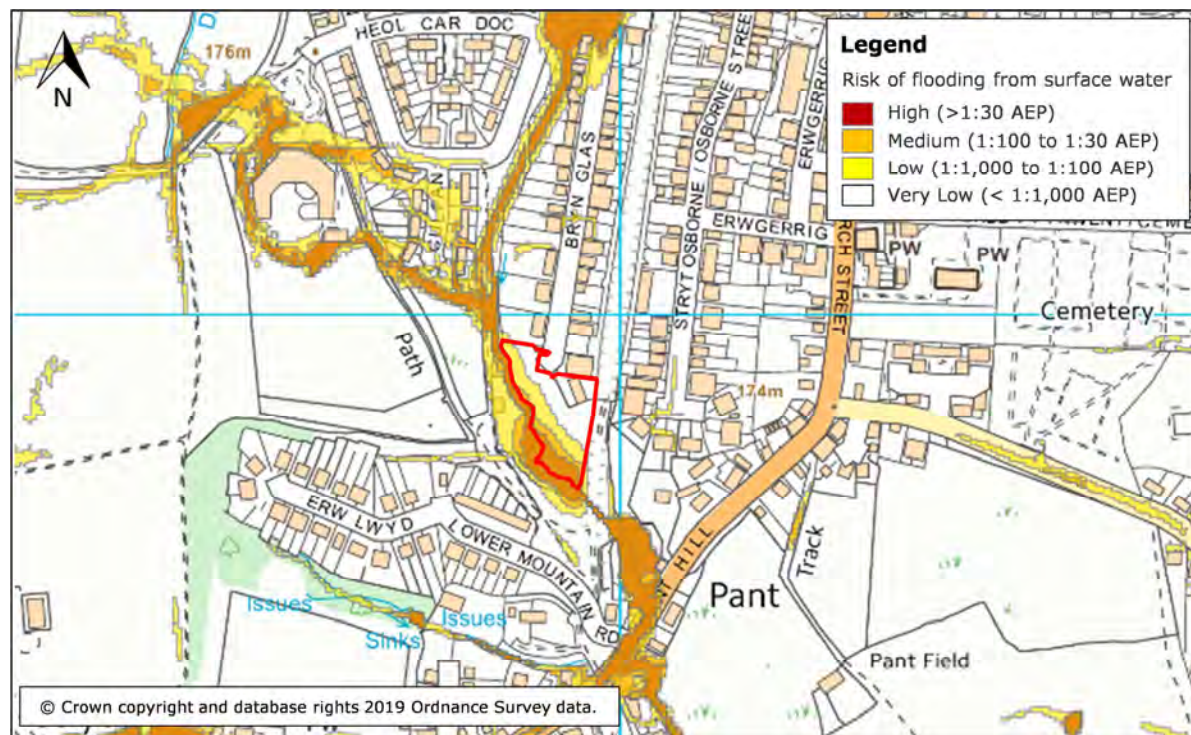


Figure 6: Surface Water Flood Risk
(Source: NRW website)

4.5 FLOOD RISK FROM RESERVOIRS, CANALS AND OTHER ARTIFICIAL SOURCES

There are no canals or other impounded waterbodies located within the immediate vicinity of the site. The Reservoir Flood Risk map indicates that the site is not at risk of flooding from such sources. The site is therefore not assessed to be at risk of flooding from reservoirs, canals or other artificial sources.

4.6 FLOOD RISK FROM GROUNDWATER

According to the BGS Groundwater Flooding Hazard map (**Figure 7**) the susceptibility to groundwater flooding is moderate.

In addition, the presence of the unnamed watercourse along the site's western boundary would be expected to convey elevated groundwater away from the site, reducing groundwater levels locally.

The residual risk of flooding from this source will be mitigated through the implementation of the measures proposed in **Section 5** of this report.

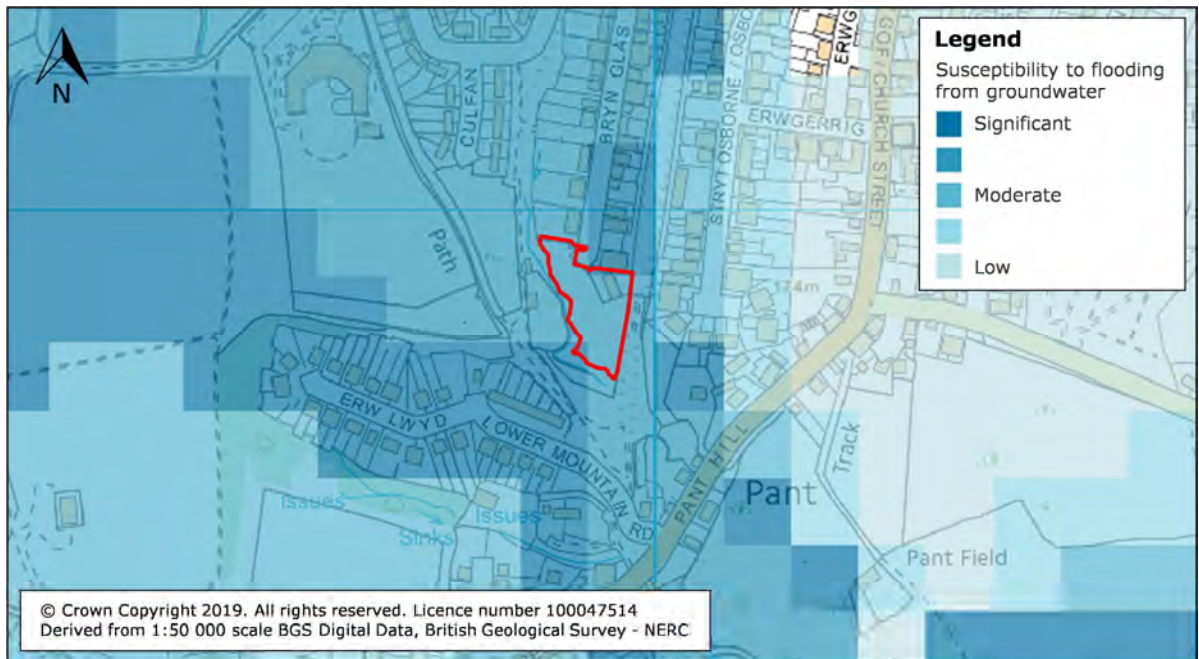


Figure 7: Groundwater Flooding Hazard Map
(Source: Findmaps)

5 FLOOD RISK MITIGATION MEASURES

The flood risk to the site from the unnamed watercourse and any residual risk of flooding from groundwater and surface will be mitigated through the implementation of the measures proposed within the following section of this report.

5.1 PROPOSED SITE LEVELS

5.1.1 Platform Levels

The platform level of the residential development (including ancillary areas) will be set at a minimum level of 166.59 m AOD, which is peak water level expected within the application boundary in the event of 1:1,000 annual probability event with 100% culvert blockage. As such, the proposed residential development platform will remain dry during all modelled events.

This ensures compliance of the proposed development with Section A1.14 of TAN15.

5.1.2 Finished Flood Levels

It is recommended that finished floor levels should be set at a minimum of 166.74 m AOD, providing a freeboard of 150 mm above the peak water level in the event of 1:1,000 annual probability event with 100% culvert blockage.

In accordance with Building Regulations Approved Document C, finished floor levels should also be set at a minimum of 0.15 m above adjacent ground levels following reprofiling of the site.

This will, subject to the implementation of an appropriately designed surface water drainage scheme (**Section 6**), enable any potential overland flows to be conveyed safely across the site without affecting property.

This ensures compliance of the proposed development with Section A1.15 of TAN15.

5.2 FLOOD RISK ELSEWHERE

Any proposal to modify ground levels should demonstrate that there is no increase in flood risk to the development itself, or to any existing buildings which are known to, or are likely to flood.

In accordance with A1.2 of TAN15 the consequences of the development on flood risk elsewhere should be assessed for up to the 1:1,000 annual probability event. It is understood that NRW seek to ensure that, where necessary, climate change and breach and blockage scenarios are considered for assessing the impact on flood risk elsewhere.

In order to quantify the impact on flood risk elsewhere, the development proposal detailed in **Section 5.1** have been incorporated within the Weetwood model and comparison plots have been produced showing the difference in flood depths between the baseline and proposed scenarios for the 1:100 +CC (20%) and 1:1,000 annual probability events, during the free-flowing and blockage scenarios (**Appendix C**).

These indicate that flood depths elsewhere remain unchanged post-development and therefore the development would not be expected to increase flood risk elsewhere.

5.3 ACCESS AND EGRESS

Dry access and egress to the site should be provided to the north via Bryn Glas under all flood scenarios.

6 SURFACE WATER MANAGEMENT

6.1 SURFACE WATER DRAINAGE AT THE EXISTING SITE

The majority of the site is currently permeable land. Based on existing topography, it is assumed surface water runs off towards the watercourse.

It is assumed that the existing dwelling on site is served by an existing drainage system.

6.1.1 Existing Runoff Rates

The site has a total area of 0.39 ha; however, for the purposes of this assessment the proposed developable area is taken as approximately 0.1 ha. This excludes the land which will remain undeveloped, which would be expected to continue to drain as existing.

The greenfield surface water runoff rates for the site, calculated using the ICP SUDS method within MicroDrainage are presented in **Table 3**. Details of the input parameters and the output results are provided in **Appendix D**.

Table 3: Greenfield Runoff Rate

Annual probability of rainfall event	Greenfield Runoff Rate (l/s/ha)	Greenfield Runoff Rate for 0.10 ha Site (l/s)
1:1	2.3	0.2
QBAR	2.6	0.3
1:30	4.5	0.5
1:100	5.6	0.6

Given that the details of the drainage system serving the existing dwelling are unknown, the existing impermeable areas have been discounted from this assessment to ensure a conservative approach. Existing brownfield rates may be confirmed at the detailed design stage.

6.2 SURFACE WATER DRAINAGE AT THE DEVELOPED SITE

6.2.1 Disposal of Surface Water

In accordance with Welsh Government guidance, surface water runoff should be disposed of according to the following hierarchy: Rainwater collected for use; Into the ground (infiltration); To a surface water body; To a surface water sewer or highway drain

As detailed in **Section 3.4** the site is underlain by soils with impeded drainage. As such the disposal of surface water via infiltration is unlikely to be feasible; however, infiltration tests have not been undertaken at this stage. Such tests could be undertaken at the detailed design stage. It is subsequently proposed to direct all runoff from the developed site to the watercourse.

6.2.2 Post Development Impermeable Area

The area of impermeable surfaces within the development has been estimated to be 0.06 ha, based on **Appendix A**.

6.2.3 Peak Flow Control

The runoff rates as outlined in **Table 3** will be achieved so far as is practicable; however, it is recognised that a flow control with a diameter of less than 100 mm and/or a design discharge rate of 5.0 l/s may pose a risk of blockage to the drainage system. As such a minimum discharge rate of 5.0 l/s may be used in accordance with national guidance⁸.

6.2.4 Volume Control

Where reasonably practicable, for greenfield sites, the runoff volume from the proposed development to any highway drain, sewer or surface water body in the 1:100 annual probability, 6 hour rainfall event should not exceed the greenfield runoff volume for the same event.

This is usually addressed by designing a Long Term Storage (LTS) facility within the site. However, as outlined within the CIRIA SuDS Manual 2015 an alternative approach to managing extra runoff volumes from extreme events is to release all runoff (above the 1:1 annual probability event) from the site at a maximum rate of 2 l/s/ha or QBAR, whichever is the higher value.

It is therefore proposed to restrict peak discharge rates to the greenfield QBAR rate recognising a minimum rate of 5.0 l/s would apply in up to the 1:100 annual probability event, including an allowance for climate change.

6.2.5 Attenuation Storage

Attenuation storage will be provided to restrict surface water runoff generated across roofs and hardstanding.

The attenuation storage facility has been modelled using the Detailed Design module of MicroDrainage Source Control (**Appendix E**). The required storage volume has been sized to store the 1:100 annual probability rainfall event including a 30% increase in rainfall intensity in order to allow for climate change.

Assuming a peak discharge rate of 5.0 l/s and a design depth of 0.8 m, a total storage volume of 11.9 m³ would be required.

The storage volume could be accommodated within detention basin, with an area of 16.0 m², a depth of 0.8 m, which would fill to a depth of 0.782 m affording a 0.018 m freeboard.

Additional SuDS features, such as rainwater harvesting, permeable paving and filter drains may be incorporated into the surface water drainage strategy at the detailed design stage.

It should be noted that the calculations assume that all storage is provided within the formal attenuation storage facility; with no storage being provided in the proposed pipe network. At the detailed design stage the network should be modelled with a drowned outfall, recognising the flood risk associated with the watercourse.

6.2.6 Indicative Surface Water Drainage Layout

An indicative surface water drainage layout is provided in Figure 8.

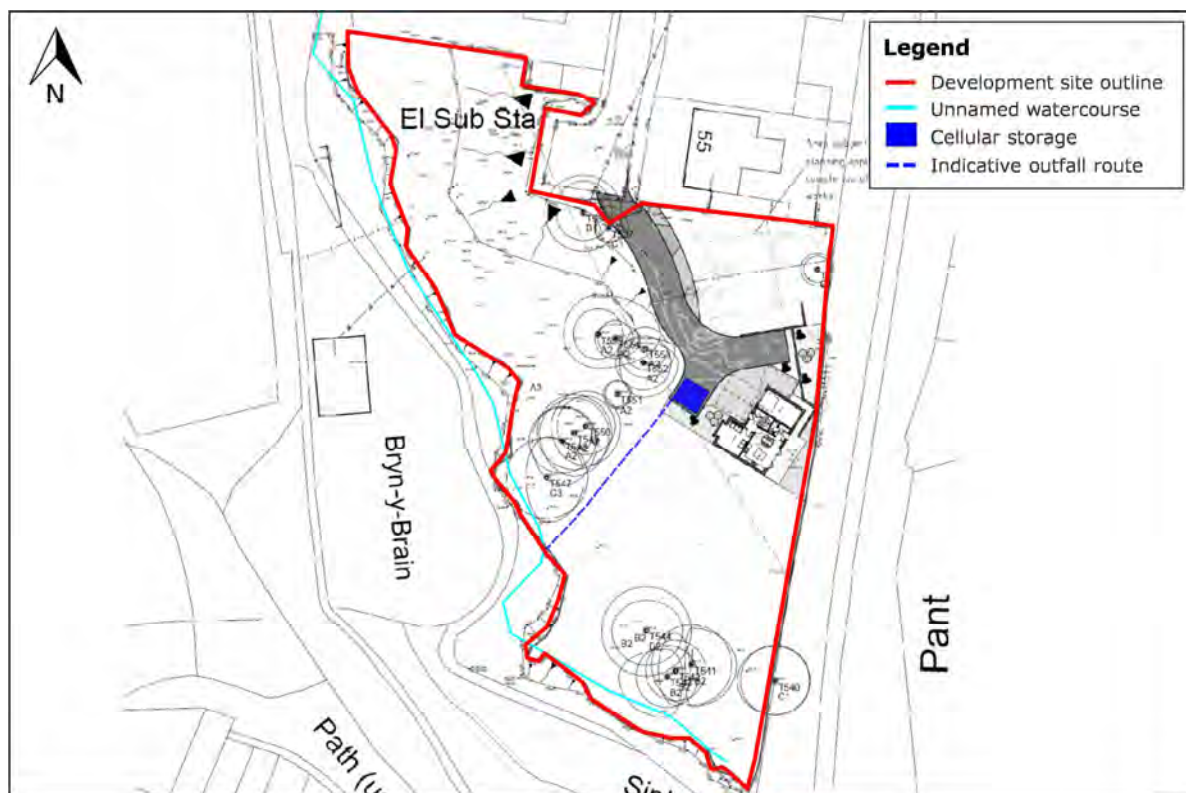


Figure 8: Indicative Surface Water Drainage Layout

6.2.7 Exceedance Routes

Flows resulting from rainfall in excess of the 1:100 annual probability rainfall event including an allowance for climate change would be expected to flow towards the watercourse, away from the proposed residential development.

6.2.8 Pollution Control

Detention basins can provide water quality benefits via the settlement of pollutants in still or slow moving water, adsorption by the soil, and biological activity. The potential for additional SuDS features to be utilised at the site would be investigated further at the detailed design stage.

6.2.9 Adoption and Maintenance of SuDS

The pipe network, designed to Sewers for Adoption (7th edition) standard, may be adopted by the sewerage undertaker.

SuDS in open spaces may be maintained by a management company.

An indicative maintenance schedule is presented in **Table 4**.

Table 4: Maintenance Requirements

Schedule	Required action	Frequency
Geo-cellular attenuation storage tank		
Regular maintenance	Inspect and identify any areas that are not operating correctly	Monthly for 3 months, then annually
	Remove debris from the catchment surface	Monthly
	Remove sediment from internal forebays	Annually, or as required
Remedial action	Repair inlet/outlet and vents	As required
Monitoring	Inspect catchpit manholes and note rate of sediment accumulation	Monthly in the first year and then annually
	Inspect inlet/outlet and vents to ensure that they are in good condition and operating as designed	Annually
	Survey inside of tank for sediment build-up and remove if necessary	Every 5 years, or as required

6.2.10 Summary

The purpose of this report is to demonstrate that a surface water drainage strategy is feasible for the site given the development proposals and the land available. The proposals provide the opportunity for the inclusion of SuDS elements, ensuring that there will be no increase in surface water runoff from the proposed development. The storage calculations may be refined at the detailed design stage and a final decision made on the types of storage to be provided.

7 SUMMARY

This report has been prepared on behalf of Dave Cottle Civil Engineering Ltd and relates to the proposed redevelopment of land at 57 Bryn Glas, Rhosllanerchrugog.

According to the Flood Risk Map (Rivers and Sea) the proposed development is located outside the 1:1,000 fluvial annual probability flood outline and is therefore defined by TAN15 as being situated within Zone A.

In order to more accurately identify and assess the level of flood risk from the watercourses at the site a 1D-2D ESTRY-TUFLOW hydraulic model has been developed by Weetwood.

No flooding of the proposed residential platform, including the access road and gardens, or Bryn Glas would be expected in up to the 1:100 +CC (45%) annual probability event. Some minor flooding of the south-western extremity of the residential platform area may be expected to a maximum depth of 0.32 m during the 1:1,000 annual probability flood event.

Some flooding of the southern extremity of residential platform area would be expected during the 1:100 +CC (20%) and 1:1,000 annual probability events with 100% blockage, with maximum flood depths of 1.13 and 1.18 m respectively.

The residential development platform is shown to be at 'very low' risk of flooding from surface water.

The site is not at risk of flooding from reservoirs, canals or other artificial sources.

There is a residual risk of flooding at the site from groundwater.

The platform level of the residential development (including ancillary areas) will be set at a minimum level of 166.59 m AOD, which is peak water level expected within the application boundary in the event of 1:1,000 annual probability event with 100% culvert blockage.

It is recommended that finished floor levels should be set at a minimum of 166.74 m AOD, providing a freeboard of 150 mm above the peak water level in the event of 1:1,000 annual probability event with 100% culvert blockage. In accordance with Building Regulations Approved Document C, finished floor levels should also be set at a minimum of 0.15 m above adjacent ground levels following reprofiling of the site.

This ensures that the proposed development will comply with Sections A1.14 and A1.15 of TAN15.

The proposal is not expected to impact flood risk elsewhere.

Dry access and egress to the site should be provided to the north of the site via Bryn Glas under all flood scenarios.

Surface water runoff from the developed site can be sustainably managed in accordance with planning policy.

8 RECOMMENDATIONS

This report has demonstrated that the proposed development may be completed in accordance with the requirements of planning policy subject to the following:

- Residential platform levels to be set at a minimum of 166.59 m AOD
- Finished floor levels to be set at a minimum of 166.74 m AOD
- The detailed drainage design to be submitted to and approved by the local planning authority prior to the commencement of development

APPENDIX A:

Development Proposals



Site Plan 1:500



Location Plan 1:1250

Landscaping

Soft

All garden areas to front and rear of dwellings to be laid to seed prior to completion, to provide a good quality grassed lawn.
Low level shrub planting to be used to complement lawn at the discretion of the occupier.

Hard

Adoptable roads to be constructed to an adoptable standard to local authority approval. Private driveways to be formed with tarmacadam finish to provide good quality surface for occupants to satisfaction of the Local Authority and client.

Pathways around dwellings to be formed with concrete paving slabs.
Paved areas to be laid with slight fall away from dwelling to discharge surface water.

Boundary Treatments.

Existing boundaries to remain as existing. Where areas of existing boundaries have deteriorated and new boundary's between plots contractor to install timber post and vertical timber board fencing to local authority approval.

Rev	Date	Detail	Initial
C	06/19	Level Amends	D.J.E.
B	06/19	Plot 4 removed from App	D.J.E.
A	04/19	Plot 1 & 2 removed from App	D.J.E.

Project:

Proposed residential development at
57 Bryn Glas
Rhos, Wrexham

Title:	Scale: (A2)
Site & Location Plan	1:500 & 1:1250

Drawn By: D.J. Edwards	Date: Oct 2018
Drawing No: C063/022	Sheet: 1 of 1

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APPENDIX B:

Hydraulic Modelling Study Report



57 BRYN GLAS, RHOSLLANERCHRUGOG

HYDRAULIC MODELLING STUDY

Final Report v1.0

June 2019

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Report Title: 57 Bryn Glas, Rhosllanerchrugog
Hydraulic Modelling Study
Final Report v1.0

Client: Dave Cottle Civil Engineering Ltd

Date of Issue: 5 June 2019

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This document has been prepared solely as a Hydraulic Modelling Study for Dave Cottle Civil Engineering Ltd. This report is confidential to Dave Cottle Civil Engineering Ltd and Weetwood Services Ltd accepts no responsibility or liability for any use that is made of this document other than by Dave Cottle Civil Engineering Ltd for the purposes for which it was originally commissioned and prepared.

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Annex C:	Digital Model Files
Annex D:	Model Results – Baseline
Annex E:	Model Results – Sensitivity

1 INTRODUCTION

1.1 PURPOSE OF REPORT

Weetwood Services Ltd ('Weetwood') has been instructed by Dave Cottle Civil Engineering Ltd to undertake a hydraulic modelling study of an unnamed watercourse in order to identify and assess the level of flood risk from this source in association with the proposed redevelopment of site at 57 Bryn Glas, Rhosllanerchrugog.

1.2 STRUCTURE OF THE REPORT

The report is structured as follows:

- Section 1** Introduction and report structure
- Section 2** Provides background information relating to the development site and the watercourse
- Section 3** Describes the derivation of flows for the watercourse
- Section 4** Describes the hydraulic model development process
- Section 5** Describes the hydraulic modelling runs and results
- Section 6** Describes the hydraulic model calibration and sensitivity assessment that has been undertaken
- Section 7** Presents a summary of key findings

2 SITE LOCATION AND WATERCOURSE DETAILS

2.1 SITE LOCATION AND DESCRIPTION

The site is located at the end of Bryn Glas, Rhosllanerchrugog at Ordnance Survey National Grid Reference SJ 289 459, as shown in **Figure 1**. The site is approximately 0.39 hectares (ha) in area.

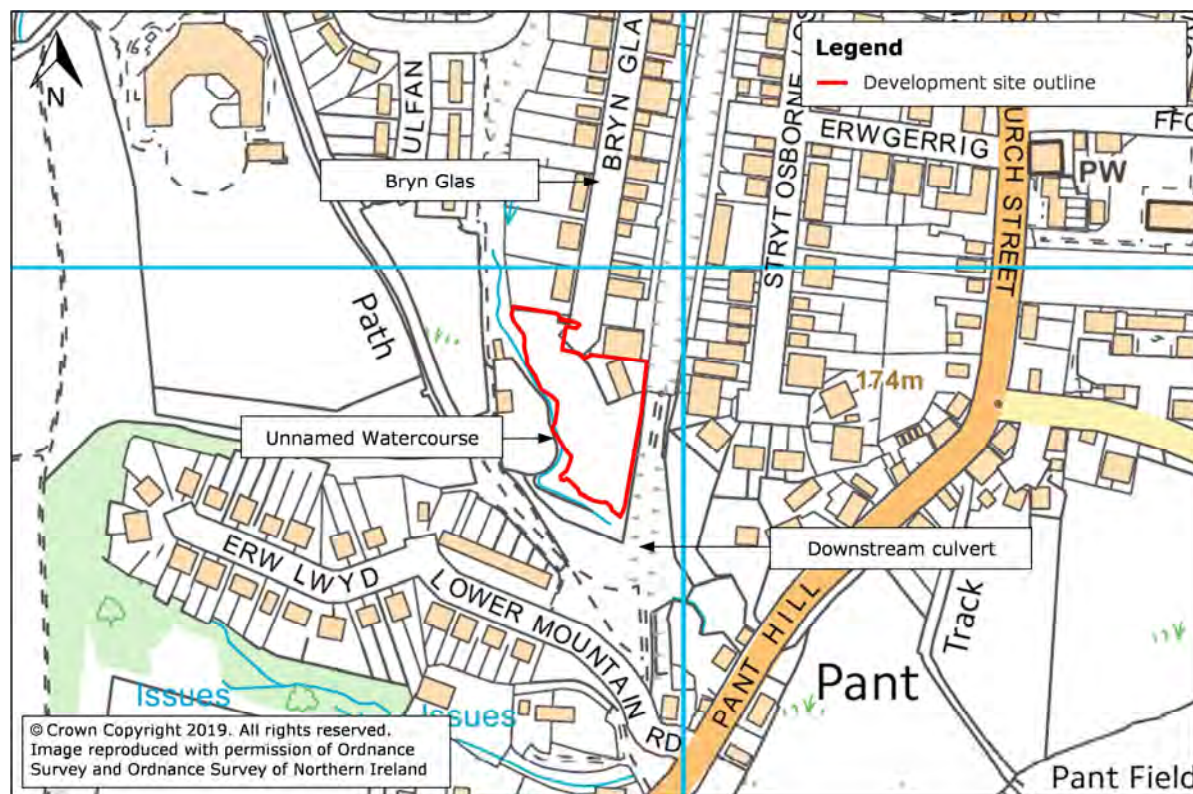


Figure 1: Site Location

2.2 WATERBODIES IN THE VICINITY OF THE SITE

There is an unnamed watercourse located adjacent to the site's western boundary; this flows in a predominantly southerly direction and is classified as an 'ordinary watercourse'. (Figure 1: Site Location **Figure 1**)

The watercourse flows in open channel adjacent to the site, prior to entering a culvert adjacent to the site's southernmost point. The watercourse is also culverted upstream of the site, through the residential areas to the north.

A channel survey has been undertaken by Malcolm Hughes Land Surveyors and is provided in **Annex A**.



(Photo looking upstream)

Figure 2: Photographs of unnamed Watercourse

2.3 FLOOD ZONE DESIGNATION

Flood zones refer to the probability of river and sea flooding. TAN15 defines flood zones as follows:

- Zone A: Considered to be at little or no risk of fluvial or tidal/coastal flooding.
- Zone B: Areas known to have been flooded in the past evidenced by sedimentary deposits.
- Zone C: Based on [the Natural Resources Wales] flood outline, equal to or greater than 0.1% (river, tidal or coastal). Zone C is subdivided into the following two zones:
 - o Zone C1: Areas of the floodplain which are developed and served by significant infrastructure, including flood defences.
 - o Zone C2: Areas of the floodplain without significant flood defence infrastructure.

The flood zones are shown on the Development Advice Map. The zones do not account for possible future changes in flooding due to the impact of climate change or the presence of flood defences (although areas benefitting from flood defences may be indicated).

2.3.1 Development Advice Map

According to the Development Advice Map (**Figure 3**) the site is located in Zone A.

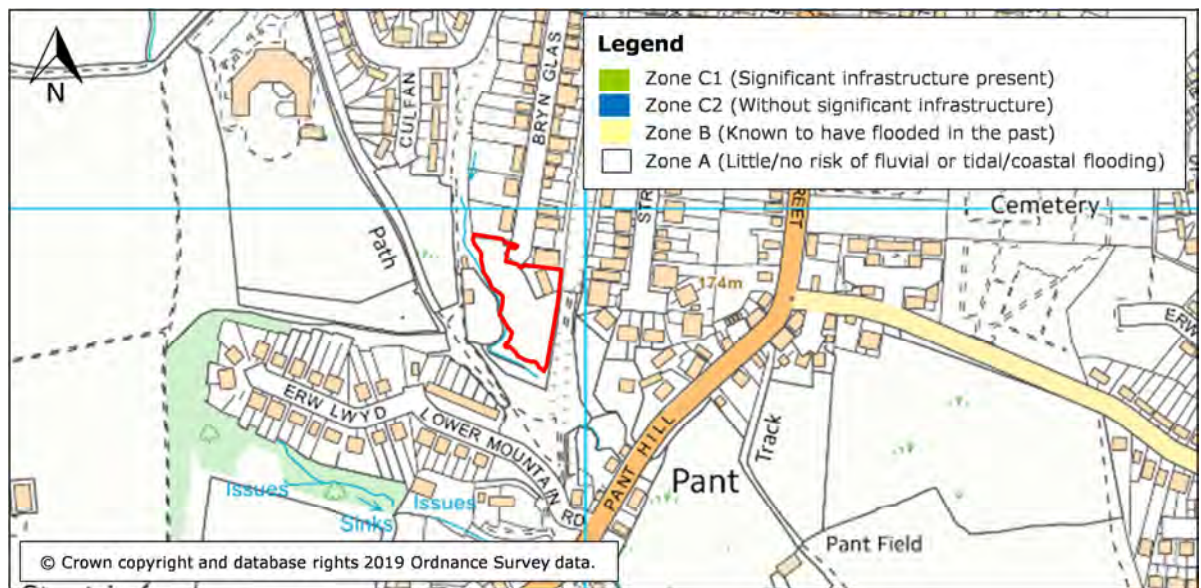


Figure 3: Development Advice Map
(Source: NRW website)

2.3.2 Natural Resources Wales Flood Risk Map

According to the Flood Risk Map () the site is located outside of the 1:1,000 annual probability flood outline, thereby supporting the sites Zone A designation.

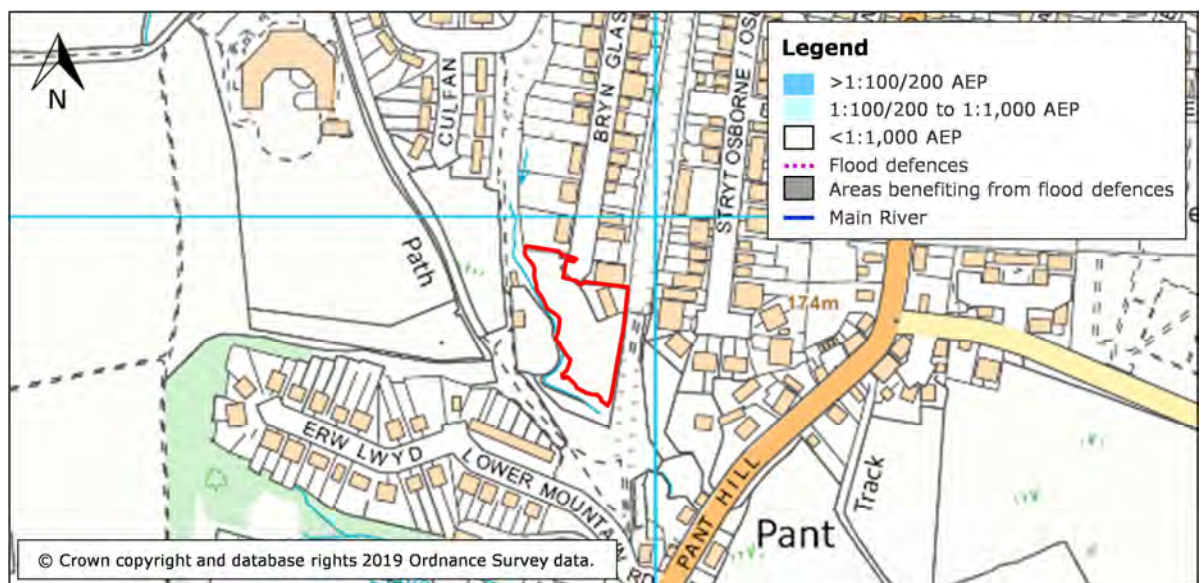


Figure 4: Flood Risk Map (Rivers and Sea)
(Source: NRW website)

2.4 FLUVIAL FLOOD RISK – UNNAMED WATERCOURSE

As discussed in **Section 2.2**, the unnamed watercourse is located along the western boundary of the site.

The flood risk posed by the unnamed watercourse is not accurately represented by the NRW Flood Risk Map or on the Development Advice Map. The watercourse is not expected to have been considered due to the small size of the catchment.

In order to more accurately identify and assess the level of flood risk from the watercourses at the site, a 1D-2D ESTRY-TUFLOW hydraulic model has been developed by Weetwood.

3 HYDROLOGY

3.1 CATCHMENT EXTENTS

The extent of the unnamed watercourse catchment has been derived using the Flood Estimation Handbook (FEH) Web Service (**Figure 5**) and was validated using Ordnance Survey (OS) mapping and LiDAR data. The catchment descriptors for the unnamed watercourse are presented by **Table 1**.

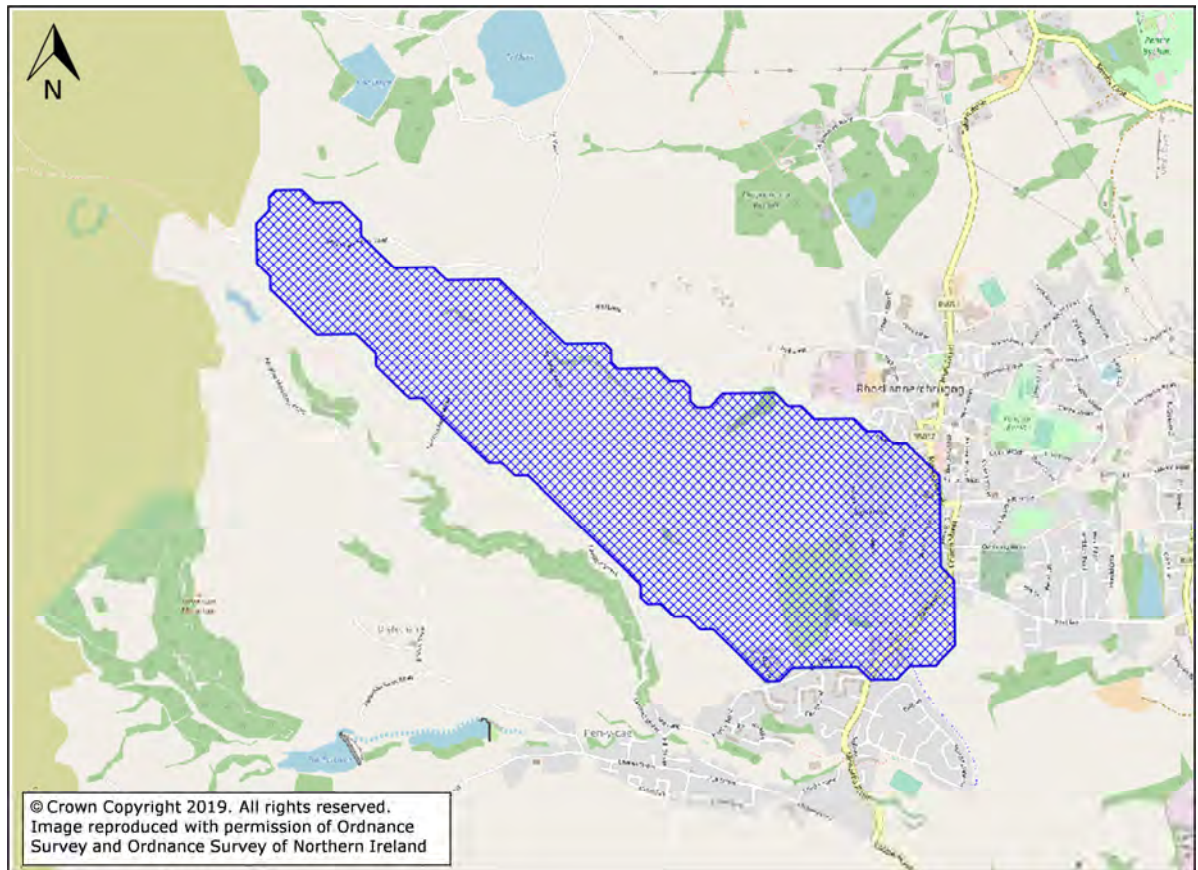


Figure 5: FEH Catchment Extents

Table 1: FEH Catchment Descriptors

Descriptor	Value	Descriptor	Value
OS NGR	329050 345650	LDP	3.87
AREA	1.92	RMED-1H	9.9
FARL	1	RMED-1D	35.9
PROPWET	0.51	RMED-2D	44.9
ALTBAR	215	SAAR	927
ASPBAR	108	SAAR4170	932
ASPVAR	0.71	SPRHOST	40.89
BFIHOST	0.403	URBCONC	0.77
DPLBAR	1.72	URBEXT	0.07
DPSBAR	57.3	URBLOC	0.37

3.2 APPROACH TO HYDROLOGICAL ANALYSIS

The FEH Statistical Method and Revitalised Flood Hydrograph Model v2.2 (ReFH2)¹ have been used to derive peak flows for the catchment.

3.2.1 FEH Statistical Method

The FEH Statistical Method for calculating peak flows uses gauged flow data from hydrologically similar catchments in the UK gauging station network. Flows calculated by the FEH Statistical Method may be considered more robust where a suitably homogeneous 'pooling group' of gauging stations similar to the study site can be identified.

The approach to calculating peak flows for given return periods using the FEH Statistical Method can be divided into two components:

- Estimating the index flood (QMED²)
- Estimating the flood growth curve (pooled analysis)

QMED is the median sized flood for a given catchment. The FEH recommends that data transfer from nearby gauged donor catchments should be used to calculate QMED wherever possible. QMED can be derived for ungauged catchments from catchment descriptors alone, or by adjusting the QMED value using a gauged 'donor' catchment to take into account differences between the donor catchment and the study catchment.

Most gauging stations record lengths are too short to allow for reliable estimation of long return-period floods. WINFAP-FEH allows for a pooled analysis, which draws together records from a group of hydrologically similar catchments into a pooling group.

The FEH Handbook recommends that 500 station years should be used, if possible, as this gives the best balance between a robust pooling group and enough data years to allow the determination of peak flows for extreme events.

The pooling group was generated in WINFAP-FEH v6.0, and catchment descriptors were used to assess whether the pooling group was acceptably homogenous and representative of the subject site.

A sufficiently representative pooling group could not be found due to the relatively high SAAR values (refer to **Annex B** for pooling group information). Nevertheless, peak flows estimated using the Generalised Logistic growth curve fitting are presented in **Table 2**.

3.2.2 ReFH2 Method

The ReFH2 method provides good definition of runoff contributions from small catchments and involves using 'catchment descriptors' to define:

- a) The duration of the critical rain storm for the catchment³.
- b) The rainfall for the critical storm duration with the required return period.
- c) The profile of the critical storm to apportion storm rainfall total.
- d) The shape of the unit hydrograph.

¹ Revitalised Flood Hydrograph Model ReFH2: Technical Guidance, Wallingford HydroSolutions Ltd, 2015

² To derive Qmed, a list of the maximum flow recorded in each year is drawn up. This is referred to as the Annual Maxima, or AMAX, series. Qmed is the median value in the AMAX series. As there is a 50% chance each year of the maximum flood being greater than Qmed, then Qmed is also analogous to the 1:2 annual probability flood.

³ In small, steep and urbanised catchments the duration will be shorter than in large, flat and undeveloped catchments

From these, the unit hydrograph and the profile storm are combined to produce the time against flow storm hydrograph from which a peak runoff rate can be determined.

The duration of the critical storm for the catchment was calculated using the catchment descriptors as approximately 4.45 hours. This duration was used with the catchment descriptors to calculate the design flood flows along the channel which are provided in **Table 2**.

Table 2: Peak Flow Estimates – Whole Catchment

Annual Probability	Peak Flow (m^3s^{-1})	
	FEH Statistical	ReFH2
QMED	1.24	1.28
1:100	3.33	4.29
1:1,000	-	6.95

The ReFH2 Method is shown to provide a more conservative estimate of peak flow rates and it was not possible to define a suitable representative pooling group using the FEH Statistical Method. As such, the ReFH2 Method flows will be used for the purpose of the hydraulic modelling study.

4 HYDRAULIC MODEL DEVELOPMENT

4.1 MODELLING APPROACH

In order to more accurately define the level of fluvial flood risk to the site posed by the unnamed watercourse, Weetwood has developed an ESTRY-TUFLOW hydraulic model.

The channels have been represented in 1D using ESTRY with the floodplain modelled in 2D using TUFLOW. The 1D and 2D model domains have been dynamically linked.

4.2 MODEL EXTENT

The upstream extent of the 1D domain is located approximately 545 m north-west of the development site at model node Rhos_1275. The downstream extent of the 1D domain is located approximately 340 m south-east of the development site at model node Rhos_0008.

The 2D domain extends across both the left and right floodplain of the unnamed watercourse as illustrated by **Figure 6**.

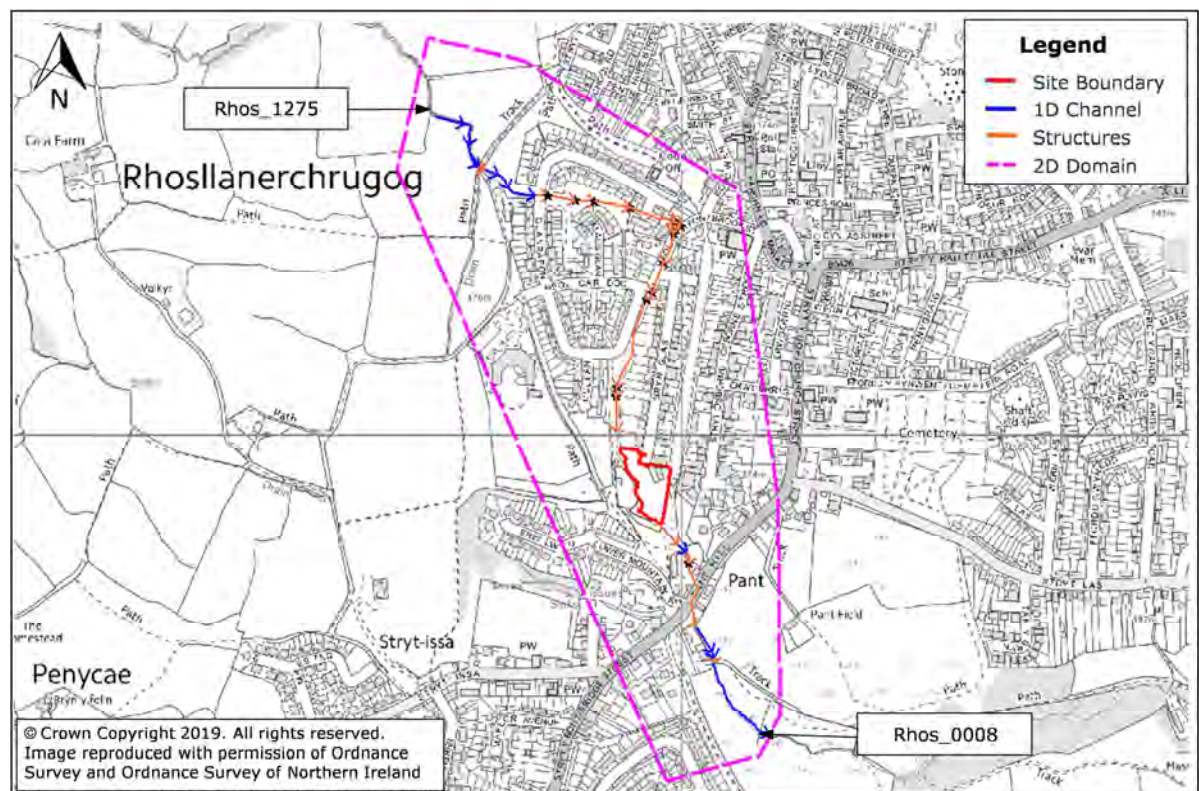


Figure 6: Model Extent

4.3 TOPOGRAPHIC DEVELOPMENT

In the 1D domain the channel topography is defined by cross-sections along the majority of the modelled reach. The data collected during the topographic survey (**Annex A**) has been used to define these channel cross-sections. The cross-sections are spaced at regular intervals with more detailed information collected around the structures (refer to **Section 4.3.1**).

The channel is located within a steep sided valley directly upstream and adjacent to the site. It was determined that the channel should be represented within the 2D domain in this location to stabilise the model and to ensure that flood extents could be properly defined.

The 2D domain topography is based upon filtered LiDAR data, where this information is available, as shown in **Figure 7**. The OS Terrain50 dataset, supplemented by topographic survey, has been used to define the topography in areas where LiDAR data is unavailable.

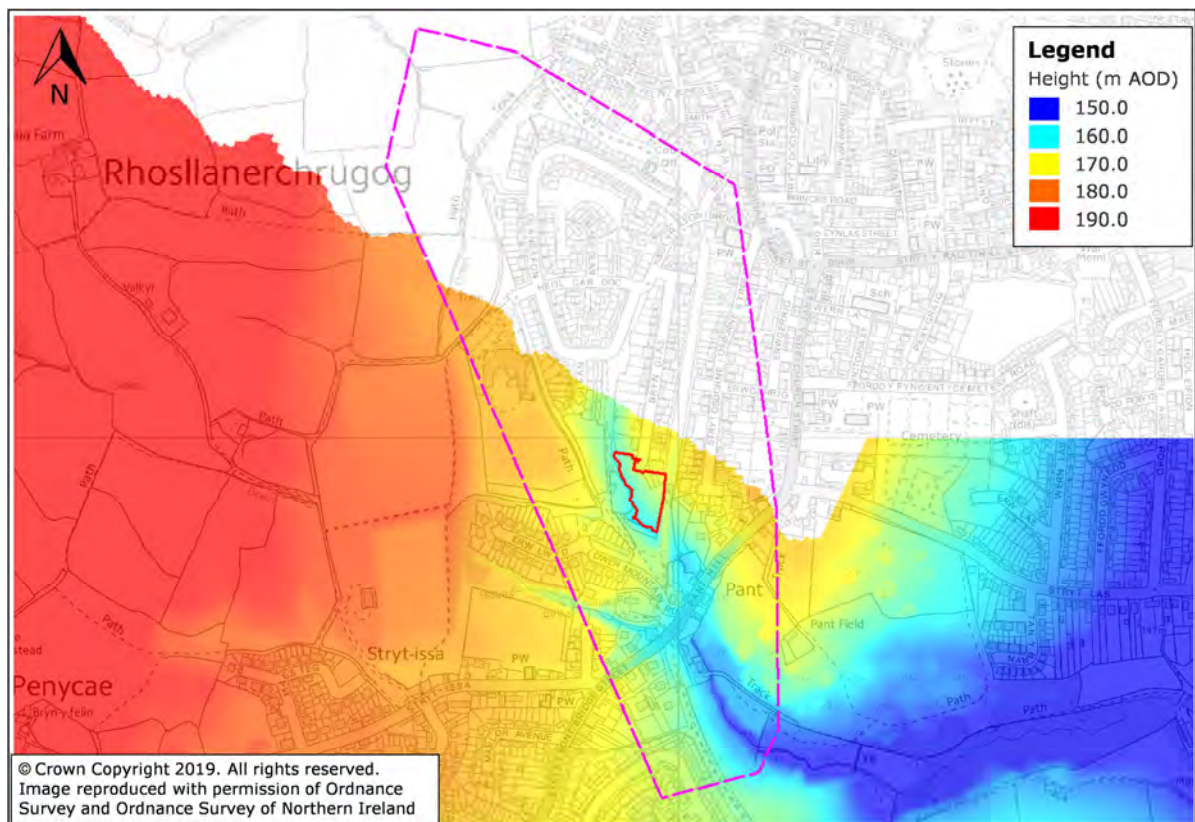


Figure 7: LiDAR

The above LiDAR data is the latest available composite digital terrain model (DTM) on the Lle Welsh Government website. It has a grid resolution of 1 m and is considered fit for purpose as it has been validated against the survey data.

The grid size used for the 2D domain was chosen as 2 m, thus enabling any flow paths between buildings/along roads to be modelled.

4.3.1 Structures - Channel

The structures along the watercourse are represented within the 1D domain. The location of these structures is shown in **Figure 8** with photographs of each structure and the ESTRY unit type provided in **Figure 9**.

It should be noted that structures 1, 2 and 4 have been represented using multiple conduits, with manhole losses automatically applied between conduits.

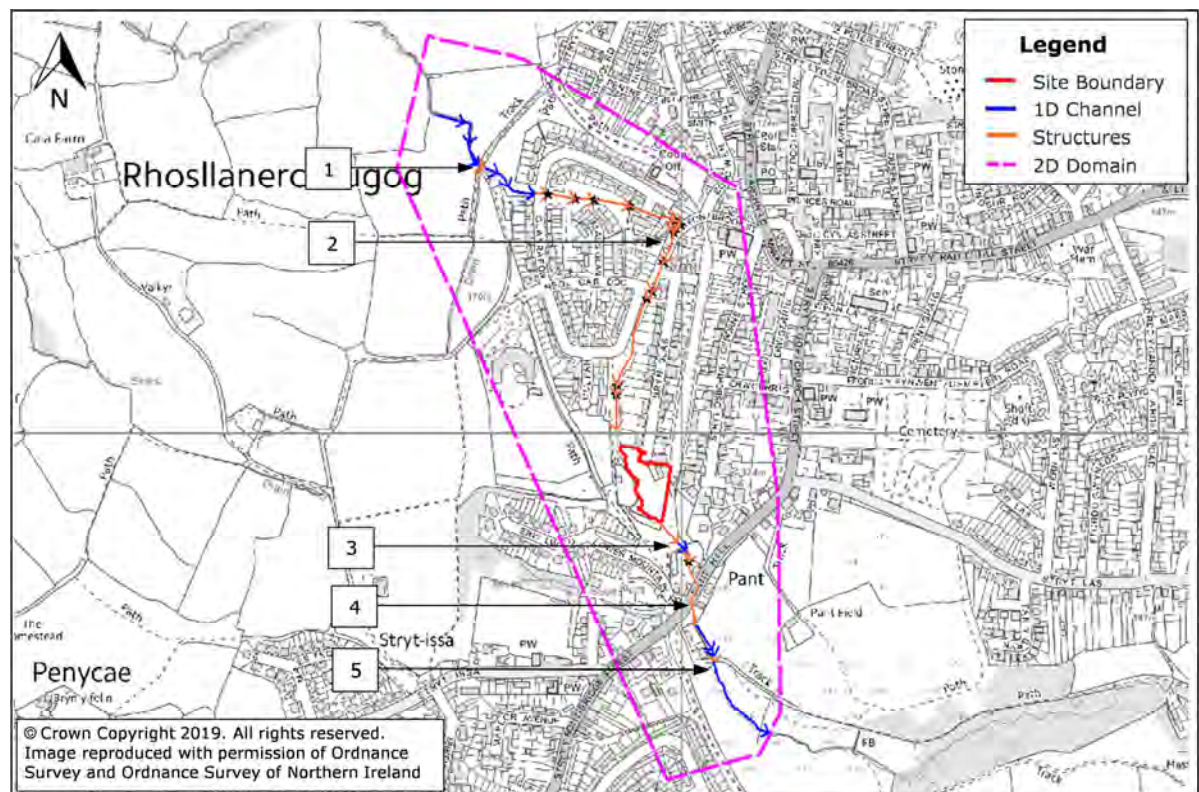
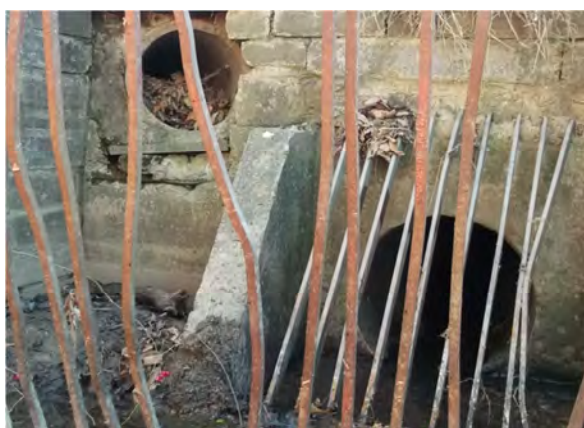


Figure 8: Location of Channel Structures in Modelled Reach



1. Double Culvert Inlet – Rhos_1158
ESTRY Unit: Circular Culverts



2. Culvert Inlet – Rhos_1059
ESTRY Unit: Circular Culvert



3. Culvert Inlet – Rhos_0362
ESTRY Unit: Circular Culvert



4. Triple Culvert Inlet – Rhos_0307
ESTRY Unit: Circular Culverts

Photo Unavailable

5. Bridge – Rhos_0144
ESTRY Unit: Bridge (B)

Figure 9: Photographs of Channel Structures in Modelled Reach

4.4 1D/2D LINKING

The 1D channel has been dynamically linked to the 2D domain. This has been carried out using 'HX' lines and 'CN' connectors within the '2d_bc_hx' layer in TUFLOW. Linking the two domains allows water to pass from the 1D domain to the 2D domain if water levels in the channel are higher than the floodplain. Conversely it allows water to pass into the 1D domain when water levels in the channel drop below floodplain levels.

4.5 MODEL COEFFICIENTS

4.5.1 Mannings n

The Mannings n values represent the 'roughness', or resistance to water flow due to friction, in both the river channel and the floodplain. Mapping data, aerial photography and several site visits were used to define the channel and land use types, which were then assigned Mannings n values.

The Mannings n values used in the model are shown in **Table 3**

Table 3: Mannings n Values

Land Use		Mannings n Value
Channel	Clean, straight channel with stones and weeds	0.035

Structures	Brick with Cement Mortar	0.015
	Corrugated Steel	0.025
	Float Finished Concrete	0.013 – 0.017
Floodplain	Long Grass	0.040
	Dense Trees and Shrubs	0.075
	Shrubs	0.050
	Gardens in built up areas	0.1
	Roads	0.025
	Buildings	0.500

4.6 BOUNDARY CONDITIONS

4.6.1 Input Boundaries

The input flow hydrographs are those outlined within **Section 3**. These have been input into the 1D model using a 'QT' boundary at model node 'Rhos_1275' (refer to **Figure 6**).

4.6.2 Downstream Boundaries

At the downstream extent of the 1D model, a 'HT' link is applied to node 'Rhos_0008' (refer to **Figure 6**). The downstream boundary is located significantly below site levels and will therefore not impact the assessment of flood risk at the site.

4.7 MODEL VERSION AND SIMULATION INFORMATION

The model was developed using TUFLOW build 2018-03-AB-iDP-w64.

Simulations for all design events were run with a 0.5 second timestep in both the 1D ESTRY domain and the 2D TUFLOW domain. Information on timestep and other variables can be seen in the '*.tcf' files for each run, and is recorded in the modelling logbook spreadsheet ('3494 Modelling Logbook.xls') accompanying this report (see **Annex C**).

5 MODEL RUNS AND RESULTS

5.1 MODEL RUNS

Table 4 details the model runs that have been undertaken in order to assess the flood risk at the existing site under the baseline scenario.

Full details are provided in the '3494 Modelling Logbook.xls' included within **Annex C** of this report.

Table 4: Model Runs - Baseline

Run Name	Flood Event (AEP)
3494_005_Q0100	1:100
3494_005_Q0100cc20	1:100+CC (20%)
3494_005_Q0100cc45	1:100+CC (45%)
3494_005_Q1000	1:1,000

5.2 MODEL RESULTS

Model output plots illustrating the maximum flood extents for all modelled events are provided in **Annex D**.

The baseline results indicate that for all modelled events, flooding of the site would be expected to occur. As shown in the model plots, deeper flooding expected to the western part of the site adjacent to the watercourse.

Table 5 summarises the maximum and average maximum flood level, depth and velocity of floodwaters expected on site during all modelled events.

Table 5: Modelled Flood Level, Depth & Velocity - Baseline

Annual Probability Event	Level (m AOD)		Depth (m)		Velocity (m/s)	
	Max	Ave Max	Max	Ave Max	Max	Ave Max
1:100	163.37	163.34	4.72	1.58	1.92	0.27
1:100+CC (20%)	164.24	164.23	5.61	2.04	1.97	0.23
1:100+CC (45%)	165.19	165.19	6.56	2.58	1.95	0.21
1:1,000	165.73	165.72	7.10	2.90	1.99	0.20

6 MODEL CALIBRATION AND SENSITIVITY

6.1 MODEL CALIBRATION

6.1.1 Known Historical Flood Events

The catchment is ungauged and there are no known historic flood events that have impacted the site and therefore it is not possible to calibrate the hydraulic model using historic data.

6.2 MODEL SENSITIVITY

6.2.1 Manning's n

Sensitivity testing has been carried out for the 1:100 +20CC annual probability event on the Manning's n coefficients by varying them by +/- 20%.

The results indicate that despite expected changes in velocity as a result of increasing Manning's n , peak water levels were generally not altered beyond + 30 mm. Reducing the roughness coefficients was not possible due to stability issues.

The model is therefore not considered to be sensitive to changes in roughness coefficients.

6.2.2 Downstream Boundary

Given that the downstream boundary of the model is located in an area where the channel invert is more than 10 m below the lowest channel invert level within the site, sensitivity testing on the downstream boundary should not be required as this is not likely to have any impact on flood risk at the site.

6.2.3 Structure Blockage

Sensitivity testing has been carried out for the 1:100+CC (20%) and 1:1,000 annual probability event for a 100% blockage of the culvert adjacent to the southern boundary of the site.

The model plots are available in **Annex E** illustrating the maximum flood extents for the above scenario.

The model results indicate that a blockage of the culvert exiting the site would result in a significant increase in water levels due to the presence of the raised embankment along the sites eastern boundary. Water levels are shown to increase to 166.54 m AOD and 166.59 m AOD in the 1:100+CC (20%) and 1:1,000 annual probability events respectively.

7 SUMMARY

Weetwood Services Ltd ('Weetwood') has been instructed by Dave Cottle Civil Engineering Ltd to undertake a hydraulic modelling study of an unnamed watercourse in order to identify and assess the level of flood risk from this source in association with the proposed redevelopment of a site at 57 Bryn Glas, Rhosllanerchrugog.

According to the Development Advice Map, the proposed development site is located in Flood Zone A. However, the risk of flooding from the unnamed watercourse is not expected to have been assessed owing to the small size of the catchment.

In order to more accurately identify and assess the level of flood risk from unnamed Watercourse in the vicinity of the site a 1D-2D ESTRY-TUFLOW hydraulic model has been developed.

The baseline results indicate during the 1:100, 1:100+CC (20%), 1:100+CC (45%) and 1:1,000 annual probability events flooding would be expected at the site.

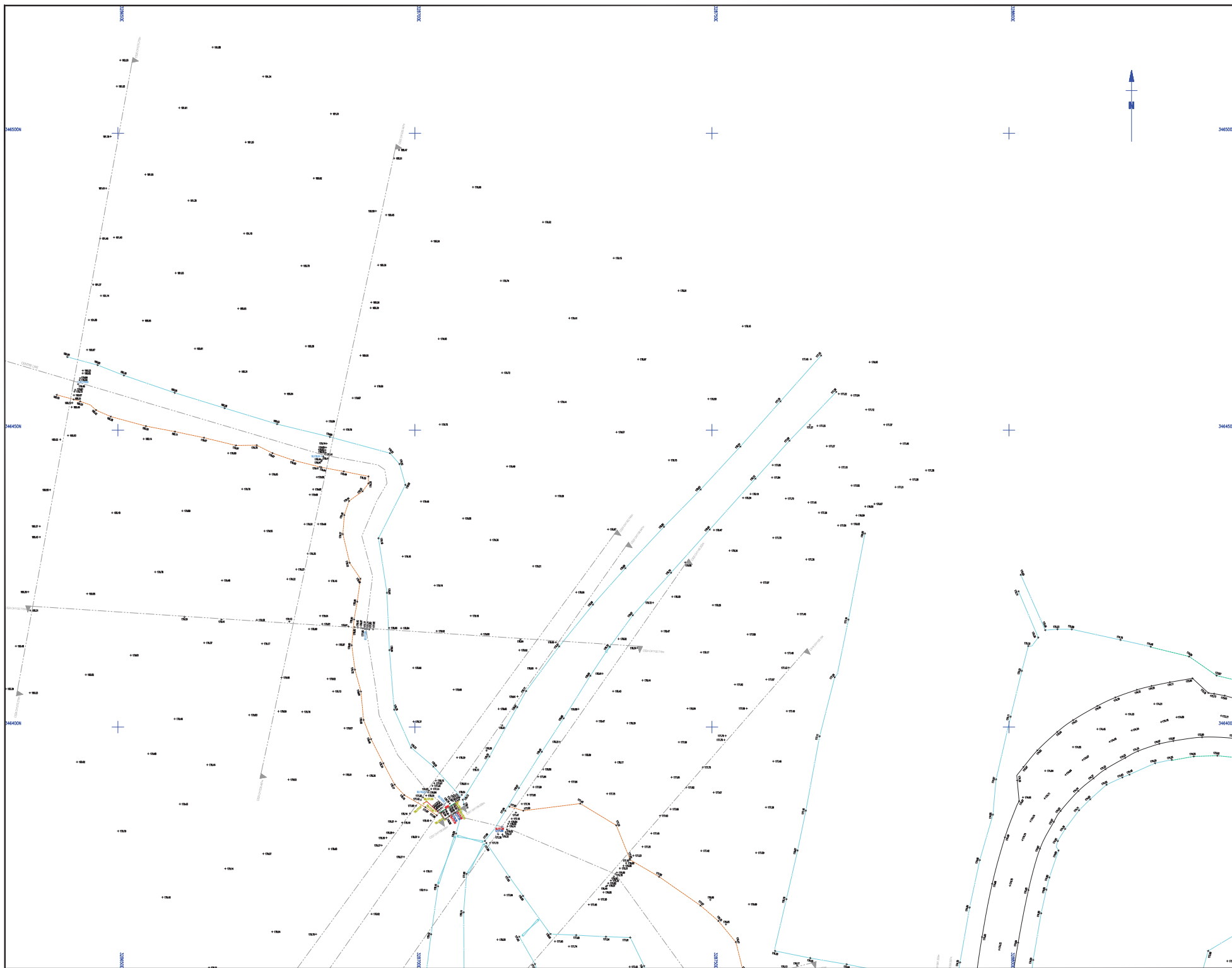
There are no recorded flood incidents at or within the vicinity of the site, the catchment is also ungauged. As such, it is not possible to calibrate the model in this instance.

The model sensitivity to Manning's n was tested by increasing the coefficient by + 20%. The results indicate that despite expected changes in velocity as a result of increasing Manning's n , peak water levels were generally not altered beyond + 30 mm. Reducing the roughness coefficients was not possible due to stability issues.

Sensitivity testing was also carried out for the 1:100+CC (20%) and 1:1,000 annual probability event for a 100% blockage of the culvert adjacent to the southern boundary of the site. A blockage of the culvert exiting the site would result in a significant increase in water levels due to the presence of the raised embankment along the sites eastern boundary. Water levels are shown to increase to 166.54 m AOD and 166.59 m AOD in the 1:100+CC (20%) and 1:1,000 annual probability events respectively.

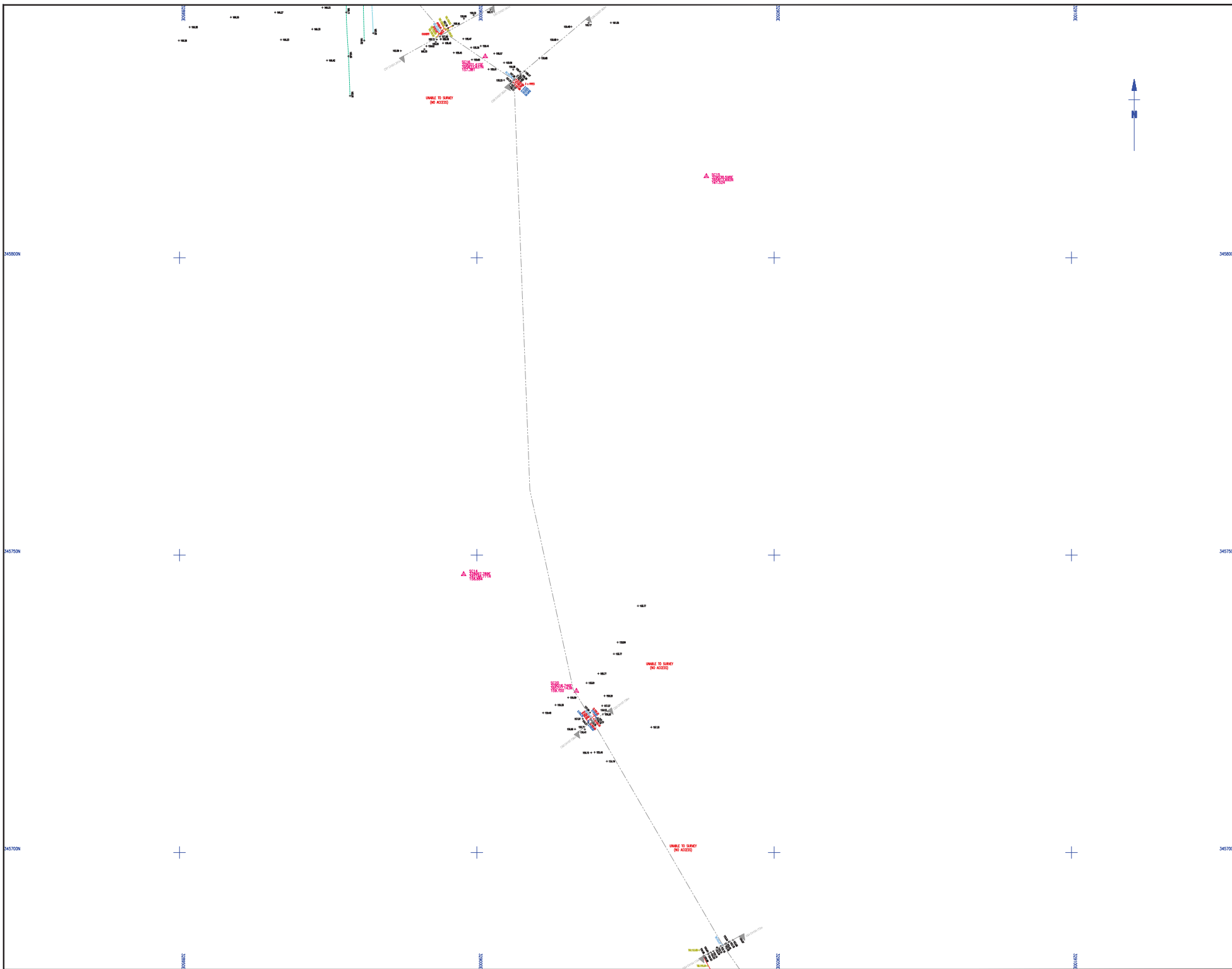
Annex A:

Topographic Survey

[illegible][illegible]

 MALCOLM HUGHES LAND SURVEYORS Chartered Land Surveyors 65 Cross Street, Manchester M2 7TF Tel: 0161 956 1265 www.mhsls.co.uk survey@mhsls.co.uk		
    		
Client WEETWOOD SUITE 1, PARK HOUSE BRONCROD BUSINESS PARK, WREXHAM RD, MOLD		
Project BRYN GLAS RHOSLANERCHUGOG LL14, 2DL		
Drawing Title TOPOGRAPHICAL SURVEY		
created AM	12/05/17	approved December 2016
checked BM	12/05/17	scale 1 : 200 (A4 Files)
1890/1/1		A





Survey Notes
Grid: Local Plane Metric related to National Grid at survey control BCP
Levels: CG datum from GNSD positioning using the National Grid
Metric (OSM2005)

Notes

Topographical Survey Legend

Scale: 1:200 (A0 Size)

Legend:

- Survey Points: Red and Blue symbols
- Contours: Brown lines
- Boundaries: Black lines
- Buildings: Black outlines
- Vegetation: Green areas
- Water: Blue areas
- Other features: Various symbols for fences, walls, etc.

Legend continued:

- Contours: 1:200 (A0 Size)
- Boundaries: 1:200 (A0 Size)
- Buildings: 1:200 (A0 Size)
- Vegetation: 1:200 (A0 Size)
- Water: 1:200 (A0 Size)
- Other features: 1:200 (A0 Size)

Sheet Index

Sheet	Date	Description
1	12/01/17	WREXHAM ROAD
2		
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MALCOLM HUGHES
LAND SURVEYORS
Chartered Land Surveyors
85 Green Street, Dale, Manchester
M20 7HF, Tel: 0161 955 1285
www.mhland.co.uk
survey@mh.co.uk

Client: WEETWOOD
SUITE 1, PARK HOUSE
BRONCOED BUSINESS PARK, WREXHAM RD, MOLD

Project: BRYN GLAS
RHOSLANERCHRUGOG
LL14, 2DL

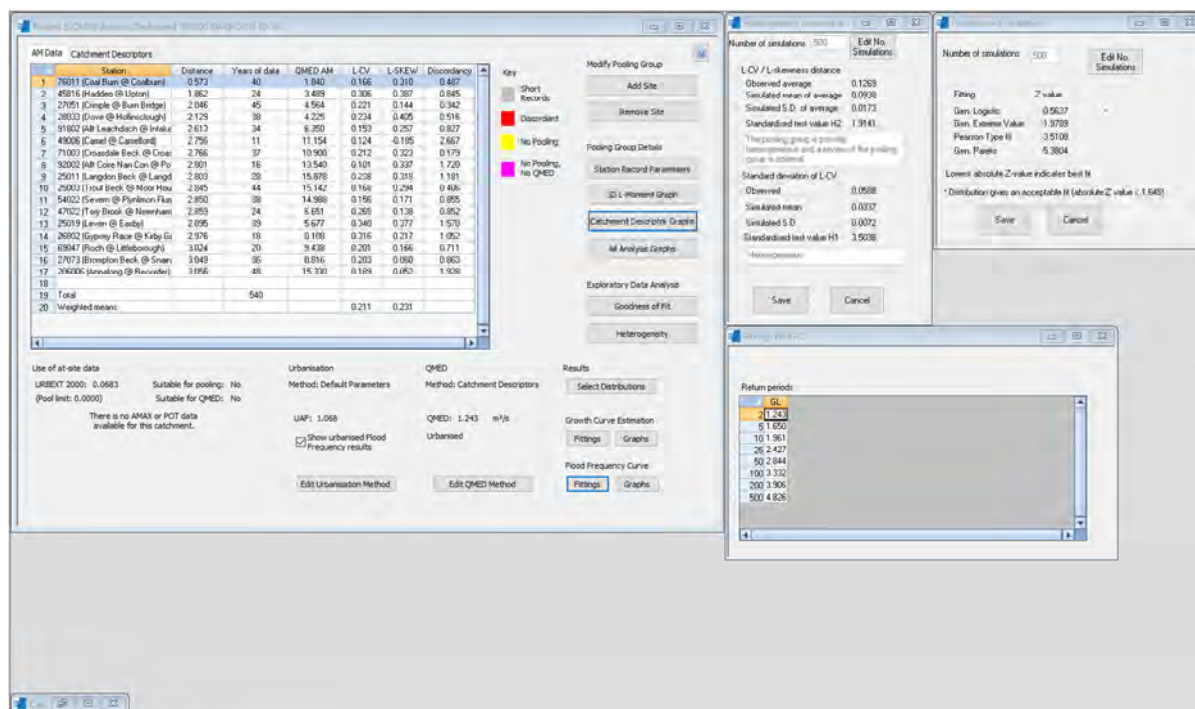
Drawing Title: TOPOGRAPHICAL SURVEY

Drawn By: AS 12/01/17
Checked By: BM 12/01/17
Scale: 1:200 (A0 Size)

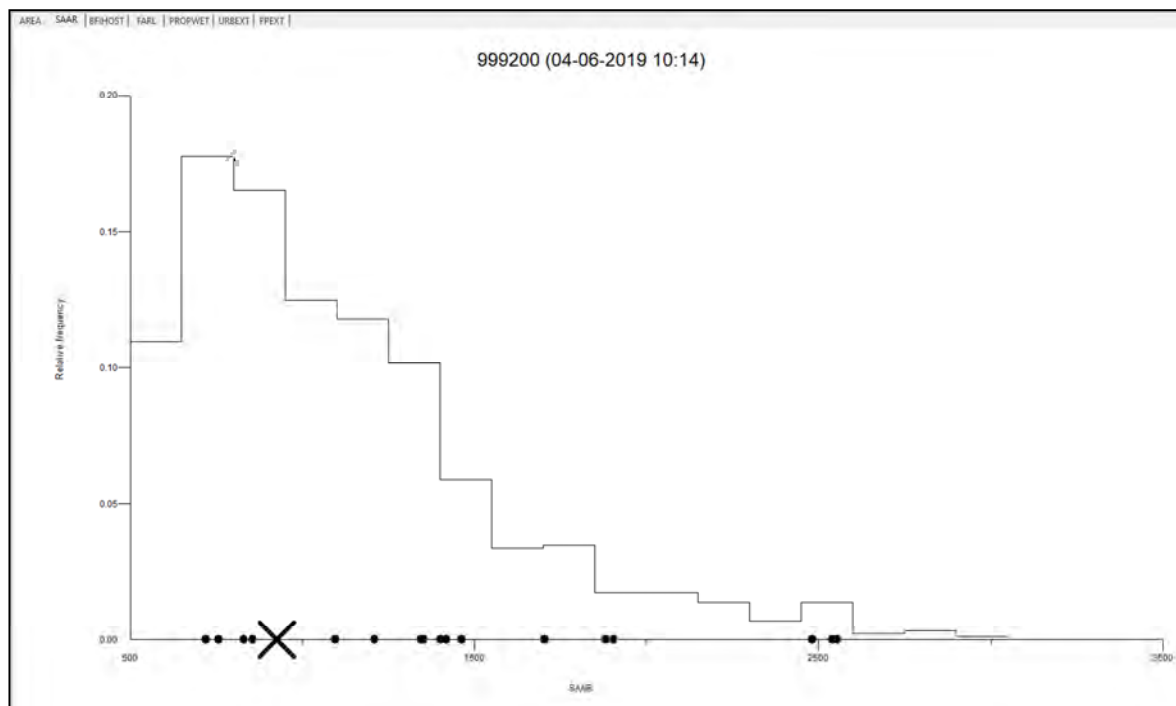
Sheet: 18901/8

Annex B:

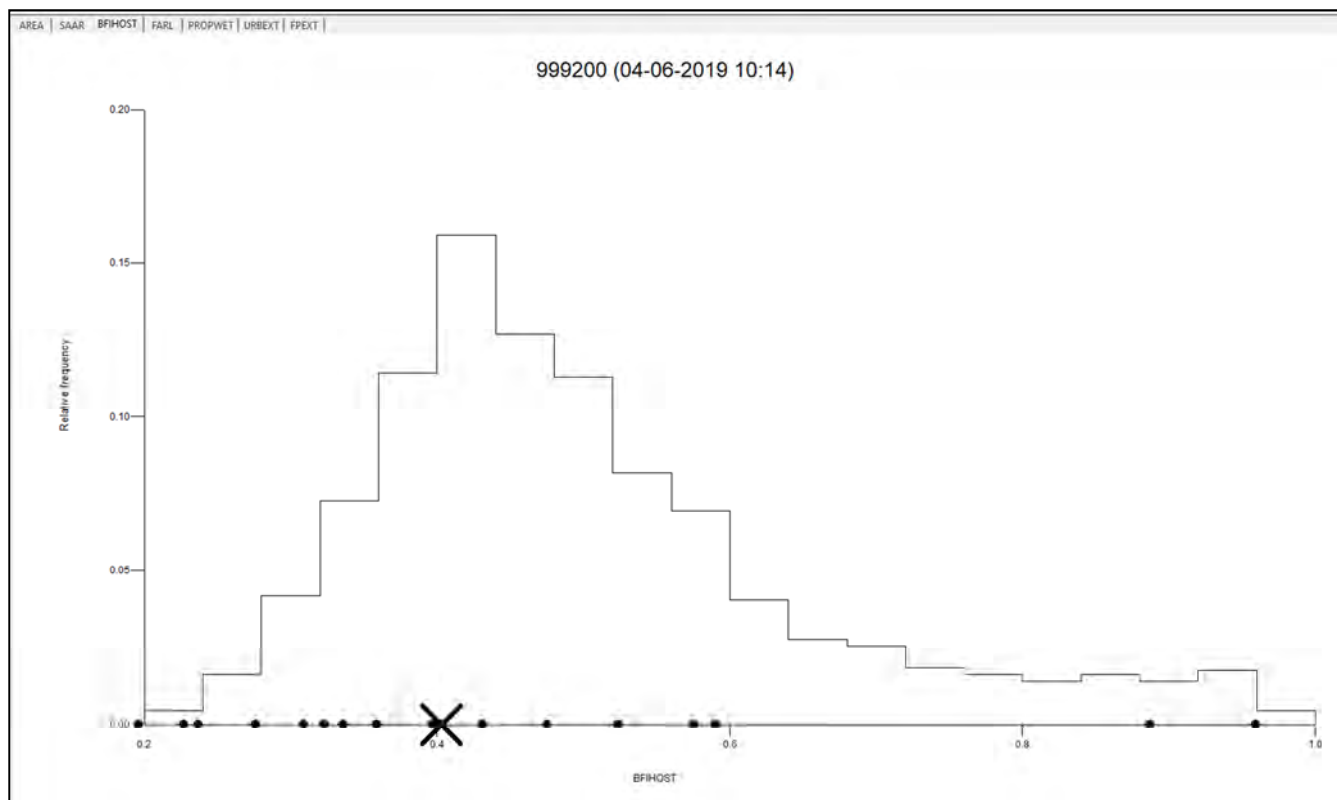
FEH Statistical Method - Pooling Group Details



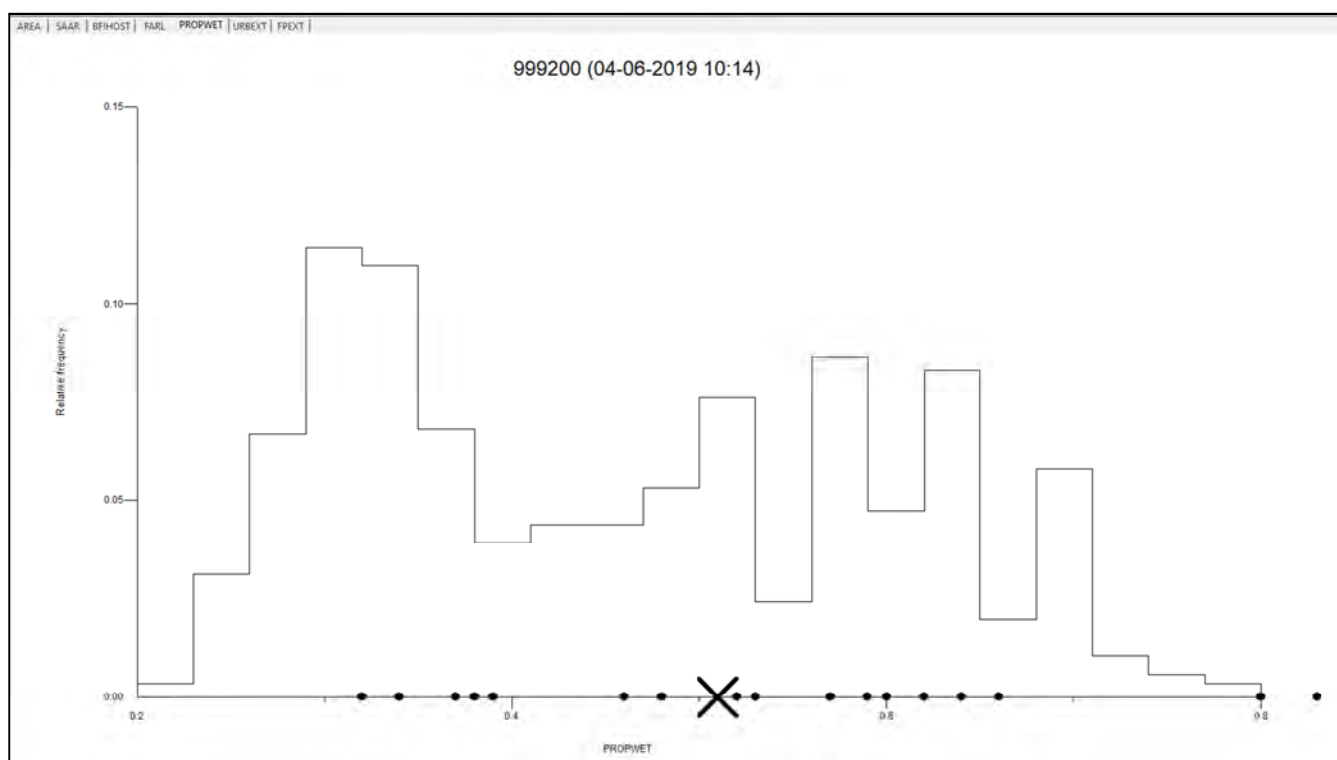
Pooling Group with Heterogeneity measures, Goodness of fit details and Fittings for Flood Frequency Curve



Catchment Descriptor Graph - SAAR



Catchment Descriptor Graph - BFIHOST



Catchment Descriptor Graph - PROPWET

Annex C:

Digital Model Files

Available upon request

Annex D:

Model Results - Baseline

Notes:

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KEY:

Site Location

Depth (metres)

0.00 to 0.25

0.25 to 0.50

0.50 to 0.75

0.75 to 1.00

1.00 to 1.25

1.25 to 1.50

1.50 to 1.75

1.75 to 2.00

2.00 to 2.25

2.25 to 2.50

> 2.50

Weetwood

Development • Planning • Environment

70 Cowcross Street
London
EC1M 6EJ

Tel: 0203 757 5444
Email: info@weetwood.net

Client:

Dave Cottle Civil Engineering Ltd

Project Title:

57 Bryn Glas, Rhosllanerchrugog

Drawing Title:

Baseline Scenario
1:100 AEP

Map Orientation:

N

W

E

S

Scale: 0 25 50 metres

Drawn:

DJ

Checked:

JA

Date:

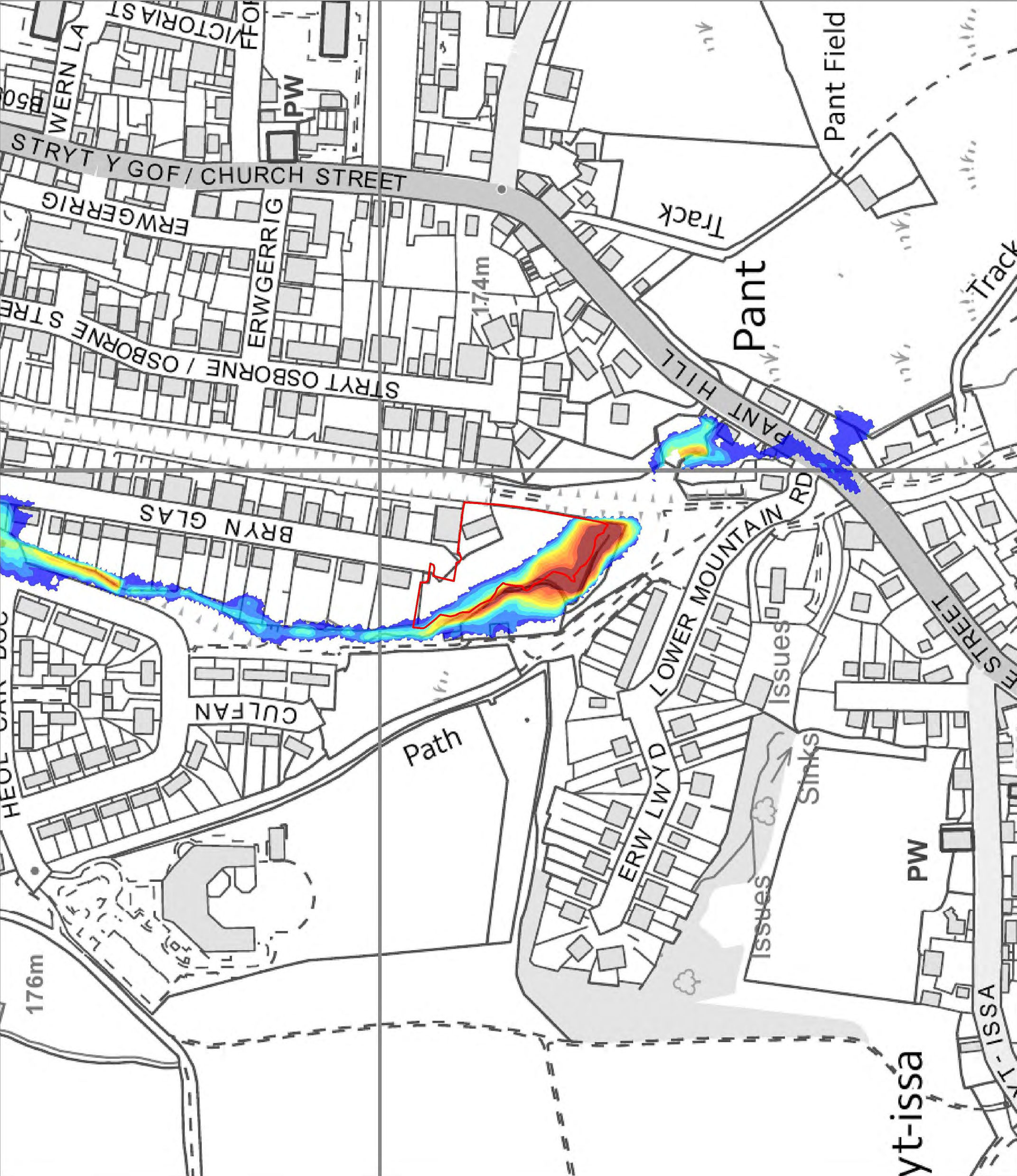
31 May 2019

Drawing No:

3494_005_Q0100_d

Rev:

A



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KEY:

Site Location

Depth (metres)

0.00 to 0.25

0.25 to 0.50

0.50 to 0.75

0.75 to 1.00

1.00 to 1.25

1.25 to 1.50

1.50 to 1.75

1.75 to 2.00

2.00 to 2.25

2.25 to 2.50

> 2.50

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Drawing Title:

Baseline Scenario
1:100+CC (20%) AEP

Map Orientation:

N

W

E

S

Scale: 0 25 50 metres

Drawn:

DJ

Checked:

JA

Date:

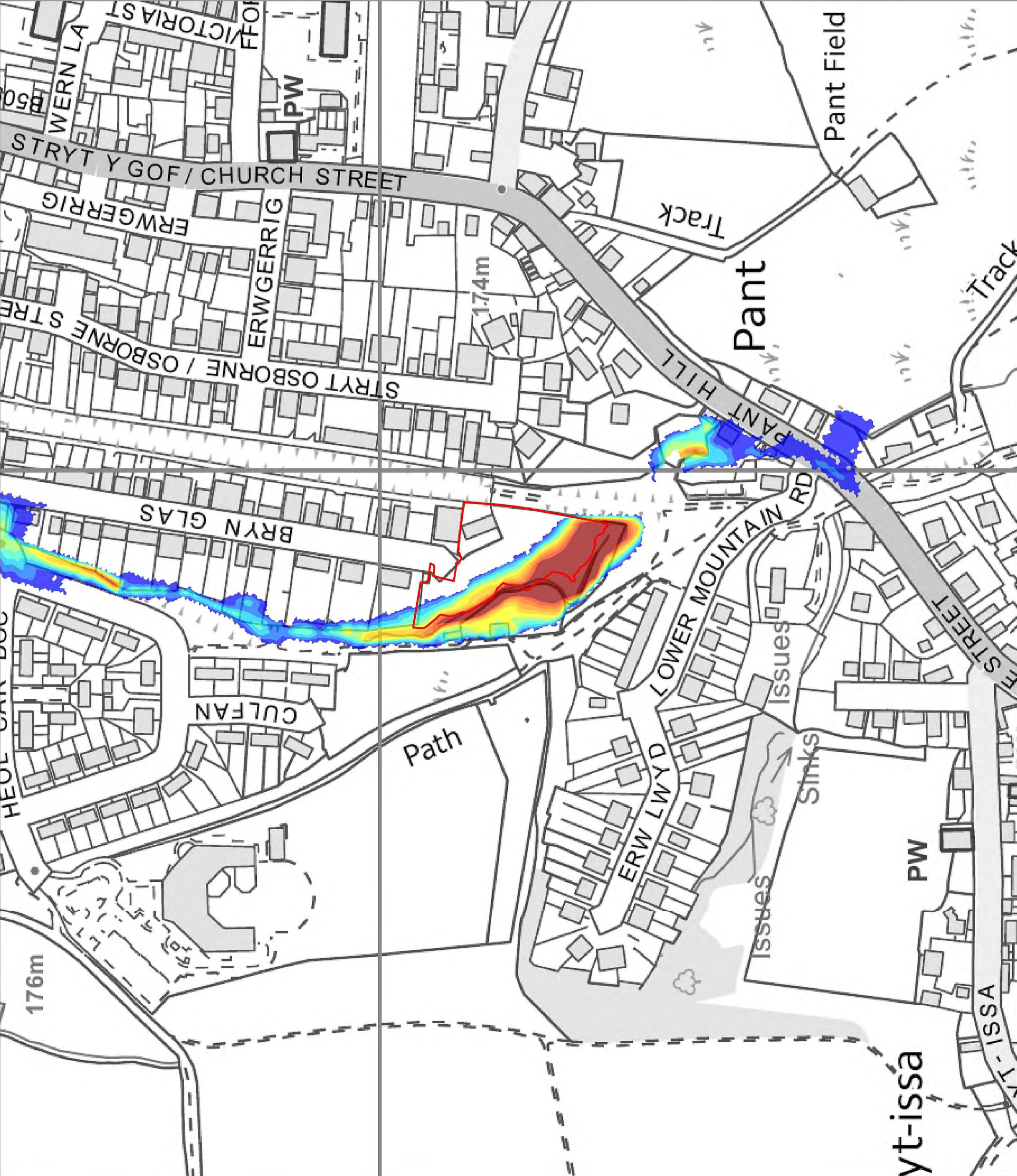
31 May 2019

Drawing No:

3494_005_Q0100cc20_d

Rev:

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KEY:

Site Location

Depth (metres)

0.00 to 0.25

0.25 to 0.50

0.50 to 0.75

0.75 to 1.00

1.00 to 1.25

1.25 to 1.50

1.50 to 1.75

1.75 to 2.00

2.00 to 2.25

2.25 to 2.50

> 2.50

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Client:

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Project Title:

57 Bryn Glas, Rhosllanerchrugog

Drawing Title:

Baseline Scenario
1:100+CC (45%) AEP

Map Orientation:

N

W

E

S

Scale: 0 25 50 metres

Drawn:

DJ

Checked:

JA

Date:

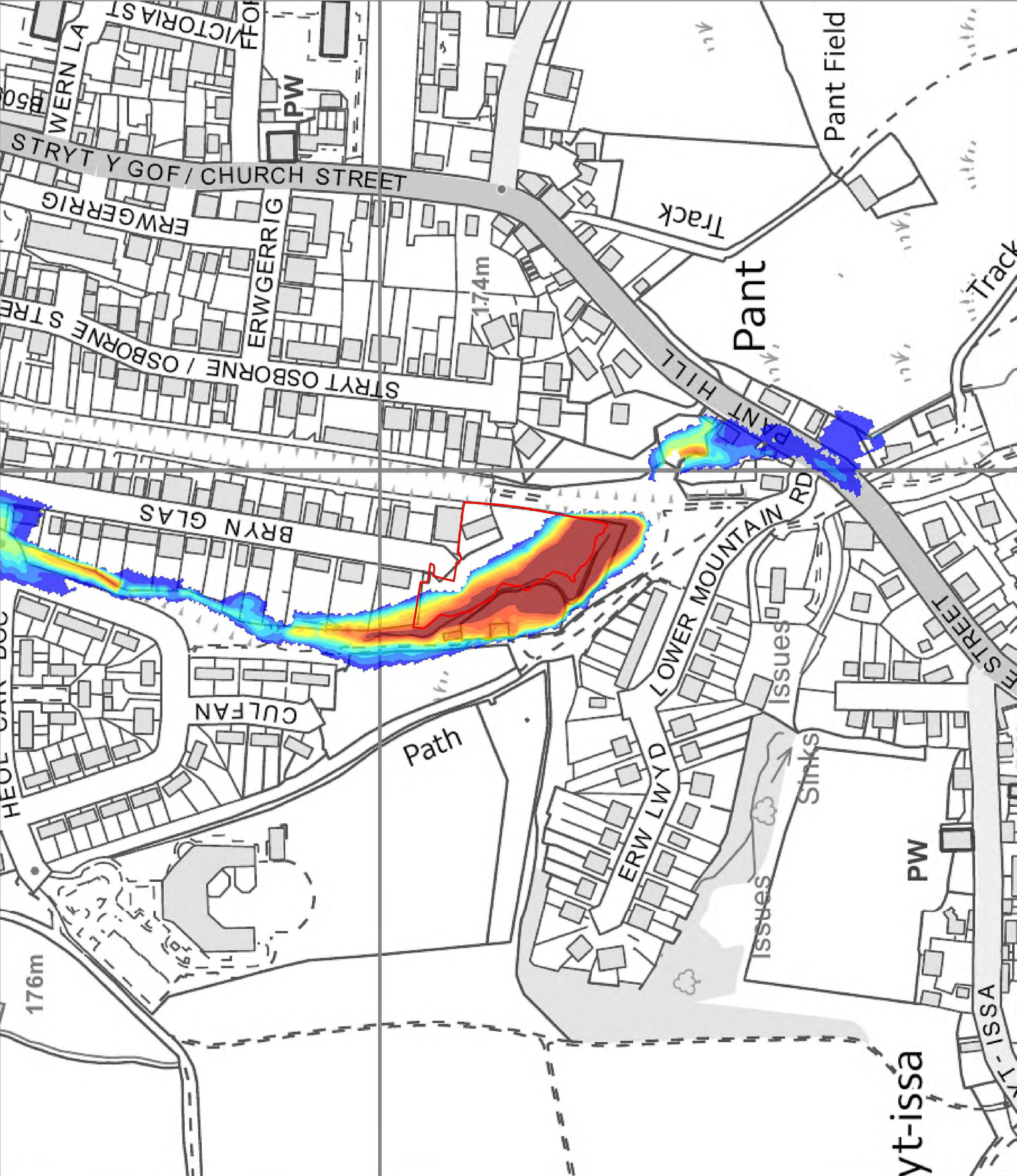
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KEY:

Site Location

Depth (metres)

0.00 to 0.25

0.25 to 0.50

0.50 to 0.75

0.75 to 1.00

1.00 to 1.25

1.25 to 1.50

1.50 to 1.75

1.75 to 2.00

2.00 to 2.25

2.25 to 2.50

> 2.50

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Project Title:

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Drawing Title:

Baseline Scenario
1:1,000 AEP

Map Orientation:

Scale: 0 25 50 metres

Drawn:

Checked:

Date:

DJ

JA

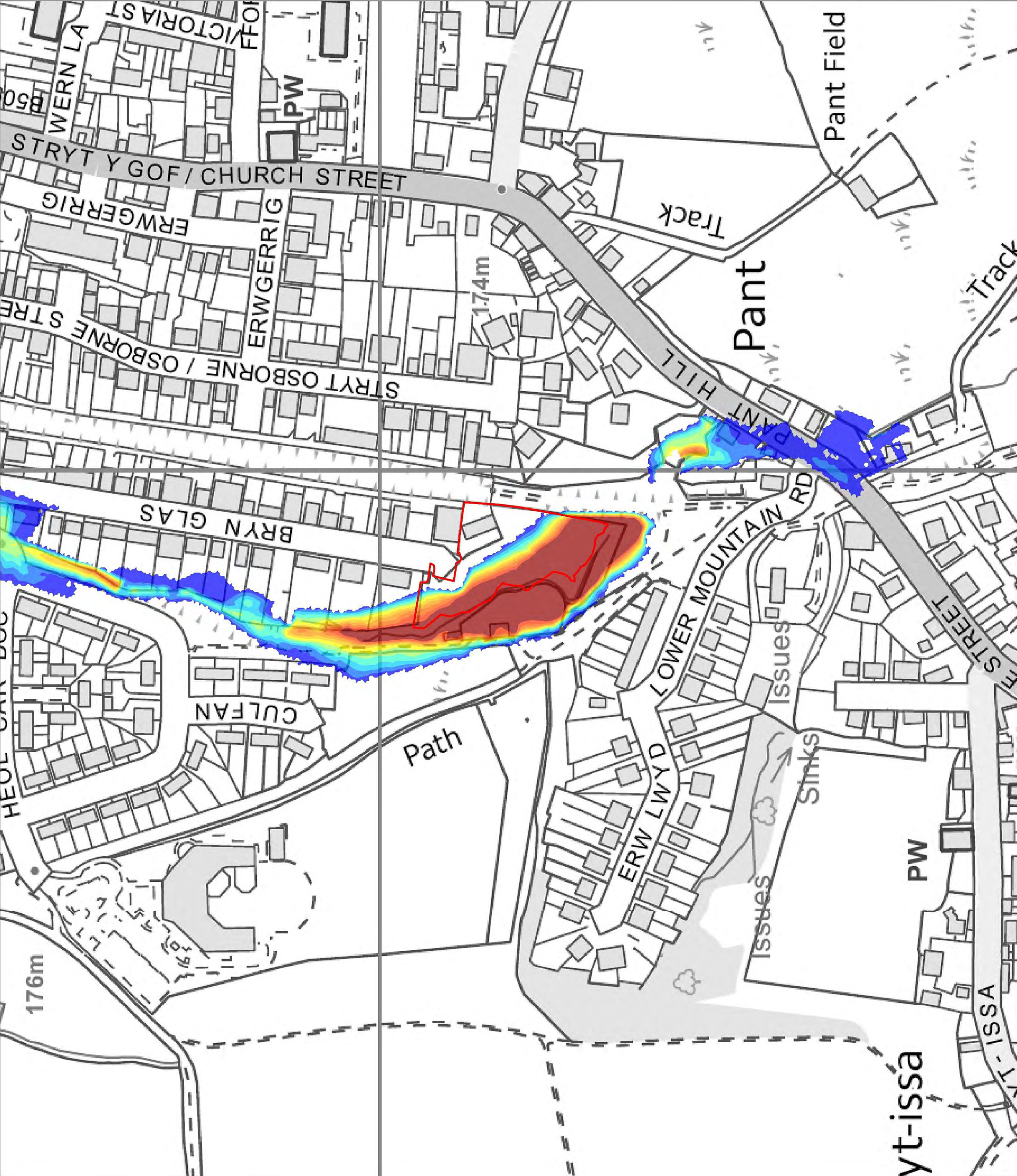
31 May 2019

Drawing No:

Rev:

3494_005_Q1000_d

A



Annex E:

Model Results - Sensitivity



Notes:

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KEY:

Site Location

Depth (metres)

	0.00 to 0.25
	0.25 to 0.50
	0.50 to 0.75
	0.75 to 1.00
	1.00 to 1.25
	1.25 to 1.50
	1.50 to 1.75
	1.75 to 2.00
	2.00 to 2.25
	2.25 to 2.50
	> 2.50

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Dave Cottle Civil Engineering Ltd

Project Title:
57 Bryn Glas, Rhosllanerchrugog

Drawing Title:
**Baseline Scenario - Blockage(100%)
1:100+CC (20%) AEP**

Map Orientation:

N
W
E
S

Scale:

02550

metres

Drawn: DJChecked: JADate: 31 May 2019

Drawing No: 3494_008_Q0100cc20_dRev: A



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KEY:

— Site Location

Depth (metres)

0.00 to 0.25
0.25 to 0.50
0.50 to 0.75
0.75 to 1.00
1.00 to 1.25
1.25 to 1.50
1.50 to 1.75
1.75 to 2.00
2.00 to 2.25
2.25 to 2.50
> 2.50

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Dave Cottle Civil Engineering Ltd

Project Title:

57 Bryn Glas, Rhosllanerchrugog

Drawing Title:

**Baseline Scenario - Blockage(100%)
1:1,000 AEP**

Map Orientation:

N
W
E
S

Scale: 0 25 50 metres

Drawn: DJ

Checked: JA

Date: 31 May 2019

Drawing No: 3494_008_Q1000_d

Rev: A

Delivering client focussed services

Flood Risk Assessments
Flood Consequences Assessments
Surface Water Drainage
Foul Water Drainage
Environmental Impact Assessments
River Realignment and Restoration
Water Framework Directive Assessments
Flood Defence Consent Applications
Sequential, Justification and Exception Tests
Utility Assessments
Expert Witness and Planning Appeals
Discharge of Planning Conditions

APPENDIX C:

Model Plots – Flood Risk Elsewhere

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KEY:

Site Location

Depth (metres)

Decrease ($\geq 5\text{mm}$)

No Change ($< 5\text{mm}$)

Increase ($\geq 5\text{mm}$)

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Tel: 0203 757 5444
Email: info@weetwood.net

Client:

Dave Cottle Civil Engineering Ltd

Project Title:

57 Bryn Glas, Rhosllanerchrugog

Drawing Title:

Flood Risk Elsewhere;
1:100+CC (20%) AEP

Map Orientation:

Scale: 0 25 50 metres

Drawn:

Checked:

Date:

DJ

JA

10 June 2019

Drawing No:

Rev:

3494_016-005_Q0100cc20_d

A



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KEY:

Site Location

Depth (metres)

Decrease ($\geq 5\text{mm}$)

No Change ($< 5\text{mm}$)

Increase ($\geq 5\text{mm}$)

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Client:

Dave Cottle Civil Engineering Ltd

Project Title:

57 Bryn Glas, Rhosllanerchrugog

Drawing Title:

Flood Risk Elsewhere;
1:1,000 AEP

Map Orientation:

Scale: 0 25 50 metres

Drawn:

Checked:

Date:

DJ

JA

10 June 2019

Drawing No:

Rev:

3494_016-005_Q1000_d

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KEY:

Site Location

Depth (metres)

Decrease ($\geq 5\text{mm}$)

No Change ($< 5\text{mm}$)

Increase ($\geq 5\text{mm}$)

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Tel: 0203 757 5444
Email: info@weetwood.net

Client:

Dave Cottle Civil Engineering Ltd

Project Title:

57 Bryn Glas, Rhosllanerchrugog

Drawing Title:

Flood Risk Elsewhere;
Blockage 100%
1:100+CC (20%) AEP

Map Orientation:

Scale: 0 25 50 metres

Drawn:

DJ

Checked:

JA

Date:

10 June 2019

Drawing No:

3494_017-008_Q0100cc20_d

Rev:

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KEY:

Site Location

Depth (metres)

Decrease ($\geq 5\text{mm}$)

No Change ($< 5\text{mm}$)

Increase ($\geq 5\text{mm}$)

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Tel: 0203 757 5444

Email: info@weetwood.net

Client:

Dave Cottle Civil Engineering Ltd

Project Title:

57 Bryn Glas, Rhosllanerchrugog

Drawing Title:

Flood Risk Elsewhere;
Blockage 100%
1:1,000 AEP

Map Orientation:

Scale: 0 25 50 metres

Drawn:

DJ

Checked:

JA

Date:

10 June 2019

Drawing No:

3494_017-008_Q1000_d

Rev:

A

The map displays the Bryn Glas area, including streets such as Wern La, Stryt Y Gof / Church Street, Erwgerrig, Stryt Osborne / Osborne Street, Bryn Glas, Culfan, Erw Lwyd, Lower Mountain, and Pant Field. A red outline indicates the site location. Flood risk contours are shown in green, with a depth of 174m marked. A path is also indicated. The map includes a scale bar (0 to 50 metres) and a north arrow. The map is oriented with North at the top.

APPENDIX D:

Greenfield Runoff Calculations

Weetwood		Page 1
Suite 1 Park House Broncoed Bus Park Wrexham Rd Mold		
Date 09/05/2019 15:06 File	Designed by LucyRaven Checked by	
Micro Drainage		Source Control 2018.1
<u>ICP SUDS Mean Annual Flood</u> Input Return Period (years) 100 Soil 0.300 Area (ha) 1.000 Urban 0.000 SAAR (mm) 938 Region Number Region 9 Results l/s QBAR Rural 2.6 QBAR Urban 2.6 Q100 years 5.6 Q1 year 2.3 Q30 years 4.5 Q100 years 5.6		
©1982-2018 Innovyze		

APPENDIX E:

Surface Water Attenuation - Storage Volume Calculation

Weetwood		Page 1					
Suite 1 Park House Broncoed Bus Park Wrexham Rd Mold							
Date 12/06/2019 12:13 File 2019-06-12 3494 Q0100cc...							
Designed by LucyRaven Checked by							
Micro Drainage		Source Control 2018.1					
Summary of Results for 100 year Return Period (+30%)							
Half Drain Time : 22 minutes.							
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.544	0.544	0.0	5.0	5.0	8.3	O K
30 min Summer	0.652	0.652	0.0	5.0	5.0	9.9	O K
60 min Summer	0.695	0.695	0.0	5.0	5.0	10.6	O K
120 min Summer	0.647	0.647	0.0	5.0	5.0	9.8	O K
180 min Summer	0.549	0.549	0.0	5.0	5.0	8.3	O K
240 min Summer	0.420	0.420	0.0	5.0	5.0	6.4	O K
360 min Summer	0.251	0.251	0.0	5.0	5.0	3.8	O K
480 min Summer	0.164	0.164	0.0	4.9	4.9	2.5	O K
600 min Summer	0.125	0.125	0.0	4.7	4.7	1.9	O K
720 min Summer	0.110	0.110	0.0	4.1	4.1	1.7	O K
960 min Summer	0.092	0.092	0.0	3.4	3.4	1.4	O K
1440 min Summer	0.075	0.075	0.0	2.5	2.5	1.1	O K
2160 min Summer	0.062	0.062	0.0	1.9	1.9	0.9	O K
2880 min Summer	0.055	0.055	0.0	1.5	1.5	0.8	O K
4320 min Summer	0.046	0.046	0.0	1.1	1.1	0.7	O K
5760 min Summer	0.041	0.041	0.0	0.9	0.9	0.6	O K
7200 min Summer	0.038	0.038	0.0	0.8	0.8	0.6	O K
8640 min Summer	0.035	0.035	0.0	0.7	0.7	0.5	O K
10080 min Summer	0.033	0.033	0.0	0.6	0.6	0.5	O K
15 min Winter	0.624	0.624	0.0	5.0	5.0	9.5	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)			
15 min Summer	101.613	0.0	11.4	16			
30 min Summer	70.732	0.0	15.9	25			
60 min Summer	47.182	0.0	21.2	42			
120 min Summer	30.391	0.0	27.3	78			
180 min Summer	23.098	0.0	31.2	112			
240 min Summer	18.837	0.0	33.9	140			
360 min Summer	14.109	0.0	38.1	196			
480 min Summer	11.478	0.0	41.3	252			
600 min Summer	9.770	0.0	44.0	308			
720 min Summer	8.559	0.0	46.2	368			
960 min Summer	6.937	0.0	49.9	490			
1440 min Summer	5.145	0.0	55.6	734			
2160 min Summer	3.805	0.0	61.6	1100			
2880 min Summer	3.066	0.0	66.2	1428			
4320 min Summer	2.257	0.0	73.1	2184			
5760 min Summer	1.819	0.0	78.6	2928			
7200 min Summer	1.539	0.0	83.1	3656			
8640 min Summer	1.343	0.0	87.0	4296			
10080 min Summer	1.197	0.0	90.5	5136			
15 min Winter	101.613	0.0	12.8	16			
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Weetwood		Page 2					
Suite 1 Park House Broncoed Bus Park Wrexham Rd Mold							
Date 12/06/2019 12:13 File 2019-06-12 3494 Q0100cc...							
Designed by LucyRaven Checked by							
Micro Drainage		Source Control 2018.1					
Summary of Results for 100 year Return Period (+30%)							
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max E Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	0.746	0.746	0.0	5.0	5.0	11.3	O K
60 min Winter	0.782	0.782	0.0	5.0	5.0	11.9	O K
120 min Winter	0.677	0.677	0.0	5.0	5.0	10.3	O K
180 min Winter	0.493	0.493	0.0	5.0	5.0	7.5	O K
240 min Winter	0.312	0.312	0.0	5.0	5.0	4.7	O K
360 min Winter	0.139	0.139	0.0	4.8	4.8	2.1	O K
480 min Winter	0.108	0.108	0.0	4.0	4.0	1.6	O K
600 min Winter	0.094	0.094	0.0	3.5	3.5	1.4	O K
720 min Winter	0.085	0.085	0.0	3.0	3.0	1.3	O K
960 min Winter	0.074	0.074	0.0	2.5	2.5	1.1	O K
1440 min Winter	0.061	0.061	0.0	1.8	1.8	0.9	O K
2160 min Winter	0.052	0.052	0.0	1.4	1.4	0.8	O K
2880 min Winter	0.046	0.046	0.0	1.1	1.1	0.7	O K
4320 min Winter	0.039	0.039	0.0	0.8	0.8	0.6	O K
5760 min Winter	0.035	0.035	0.0	0.7	0.7	0.5	O K
7200 min Winter	0.032	0.032	0.0	0.6	0.6	0.5	O K
8640 min Winter	0.029	0.029	0.0	0.5	0.5	0.4	O K
10080 min Winter	0.028	0.028	0.0	0.4	0.4	0.4	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)			
30 min Winter	70.732	0.0	17.8	27			
60 min Winter	47.182	0.0	23.8	46			
120 min Winter	30.391	0.0	30.6	84			
180 min Winter	23.098	0.0	34.9	118			
240 min Winter	18.837	0.0	38.0	144			
360 min Winter	14.109	0.0	42.7	194			
480 min Winter	11.478	0.0	46.3	248			
600 min Winter	9.770	0.0	49.2	308			
720 min Winter	8.559	0.0	51.8	364			
960 min Winter	6.937	0.0	55.9	482			
1440 min Winter	5.145	0.0	62.2	716			
2160 min Winter	3.805	0.0	69.0	1092			
2880 min Winter	3.066	0.0	74.2	1456			
4320 min Winter	2.257	0.0	81.9	2132			
5760 min Winter	1.819	0.0	88.0	2920			
7200 min Winter	1.539	0.0	93.1	3656			
8640 min Winter	1.343	0.0	97.5	4352			
10080 min Winter	1.197	0.0	101.3	5240			
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Weetwood		Page 3																																	
Suite 1 Park House Broncoed Bus Park Wrexham Rd Mold																																			
Date 12/06/2019 12:13 File 2019-06-12 3494 Q0100cc...	Designed by LucyRaven Checked by																																		
Micro Drainage Source Control 2018.1																																			
<u>Rainfall Details</u> <table> <tr> <td>Rainfall Model</td> <td>FSR</td> <td>Winter Storms</td> <td>Yes</td> </tr> <tr> <td>Return Period (years)</td> <td>100</td> <td>Cv (Summer)</td> <td>0.750</td> </tr> <tr> <td>Region</td> <td>England and Wales</td> <td>Cv (Winter)</td> <td>0.840</td> </tr> <tr> <td>M5-60 (mm)</td> <td>18.000</td> <td>Shortest Storm (mins)</td> <td>15</td> </tr> <tr> <td>Ratio R</td> <td>0.286</td> <td>Longest Storm (mins)</td> <td>10080</td> </tr> <tr> <td>Summer Storms</td> <td>Yes</td> <td>Climate Change %</td> <td>+30</td> </tr> </table> <u>Time Area Diagram</u> Total Area (ha) 0.060 <table> <tr> <th colspan="2">Time (mins)</th> <th>Area</th> </tr> <tr> <th>From:</th> <th>To:</th> <th>(ha)</th> </tr> <tr> <td>0</td> <td>4</td> <td>0.060</td> </tr> </table>			Rainfall Model	FSR	Winter Storms	Yes	Return Period (years)	100	Cv (Summer)	0.750	Region	England and Wales	Cv (Winter)	0.840	M5-60 (mm)	18.000	Shortest Storm (mins)	15	Ratio R	0.286	Longest Storm (mins)	10080	Summer Storms	Yes	Climate Change %	+30	Time (mins)		Area	From:	To:	(ha)	0	4	0.060
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