



Flood Consequences Assessment and Drainage Strategy

Bridge Road North, Wrexham

Presented to Caelus Limited

Issued: July 2020

Delta-Simons Project No. 20-0948.01



Delta-Simons Environmental Consultants Limited
Head Office: 3 Henley Office Park, Doddington Road, Lincoln, LN6 3QR
Tel: 01522 882555 | www.deltasimons.com



Report Details

Client	Caelus Limited
Report Title	Flood Consequence Assessment and Drainage Strategy
Site Address	Bridge Road North, Wrexham
Project No.	20-0948.01
Delta-Simons Contact	Josh Rigby (Joshua.Rigby@deltasimons.com)

Quality Assurance

Issue No.	Status	Issue Date	Comments	Author	Technical Review	Authorised
1	Draft	10 th July 2020	-			
				Anoop Bains Consultant	Josh Rigby Associate	Josh Rigby Associate

About us

Delta-Simons is a trusted, multidisciplinary environmental consultancy, focused on delivering the best possible project outcomes for customers.

Specialising in Environment, Health & Safety and Sustainability, Delta-Simons provide support and advice within the property development, asset management, corporate and industrial markets. Operating from ten locations - Lincoln, Birmingham, Bristol, Dublin, Leeds, London, Manchester, Newcastle, Norwich, and Nottingham - we employ over 100 environmental professionals, bringing experience from across the private consultancy and public sector markets.

Delta-Simons is proud to be a founder member of the Inogen® Environmental Alliance, a global corporation providing multinational organisations with consistent, high quality and cost effective environmental, health, safety, energy, and sustainability solutions. Inogen assists multinational clients by resolving liabilities from the past, addressing today's requirements, and delivering solutions for the future. With more than 200 offices located on every continent, more than 6,430 staff worldwide, and projects completed in more than 120 countries, Inogen provides a single point of contact for diverse markets as Automotive, Chemical, Consumer Products & Retail, Financial, Food & Beverage, Healthcare, Insurance, Manufacturing, Non-Profit Organisations, Oil & Gas, Real Estate, Services Firms, Technology and Transportation, amongst others.

Reference of Terms

Canal Failure

Canal failure can include a breach or overtopping of a canal system due to the effects of a high intensity rainfall event or structural failure that is not associated with a rainfall event. Such failure can be very dangerous as it can involve the rapid release of large volumes of water at high velocity, however, it is typically limited to reaches of canal that are raised above the surrounding ground level on one or both side and where watercourses or other structures pass beneath the canal. The size and nature of canals themselves can also have a hydraulic control on the mechanisms of flooding associated with a failure, resulting in a rapid peak in flow followed by a gradual reduction as the flow becomes restricted by the capacity of the canal itself to rapidly pass flow to the breach or failure point.

Fluvial Flooding

Fluvial flooding typically occurs when a river's capacity is exceeded, and the excess water overtops the river banks. It can also occur when the watercourse has a high level downstream, perhaps due to structures or blockage, thus limiting conveyance. This creates a back-up of water which can overtop the banks. Typical flooding issues occur when the natural floodplain has been urbanised and the river has been confined.

Groundwater Flooding

Groundwater flooding is caused by the emergence of water from beneath the ground at either point or diffuse locations when the natural level of the water table rises above ground level. This can result in deep and long-lasting flooding of low-lying or below-ground infrastructure such as underpasses and basements. Groundwater flooding can cause significant damage to property, especially in urban areas, and can pose further risks to the environment and ground stability.

Reservoirs Failure

Reservoir failure can be a particularly dangerous form of flooding as it results in the sudden release of large volumes of water that can travel at high velocity. This can result in deep and widespread flooding, potentially resulting in significant damage. The likelihood of reservoir flooding occurring is generally extremely low given that all large reservoirs are managed in accordance with the Reservoirs Act 1975. Under the Reservoirs Act 1975, a large raised reservoir is defined as one that holds over 25,000 cubic metres of water above the level of the surrounding land. The EA's online reservoir inundation map illustrates the maximum flood extents that could potentially occur in the event of a reservoir failure.

Sewer Flooding

Flooding from sewers primarily occurs when flow entering a system exceeds available capacity or if the network capacity has been reduced through blockage or collapse. In the case of surface water sewers that discharge to watercourses, the same effect can be caused as a result of high water levels in the receiving watercourse. As a result, water can begin to surcharge the sewer network, emerging at ground level through gullies and manholes and potentially causing flooding to highways and properties. If this occurs flooding can represent a significant hazard to human health due to the potential for contaminants in flood water.

Surface Water Runoff

Surface water runoff is defined as water flowing over the ground that has not yet entered a drainage channel or similar. It usually occurs as a result of an intense period of rainfall which exceeds the infiltration capacity of the ground. Typically, runoff occurs on sloping land or where the ground surface is relatively impermeable. The ground can be impermeable either naturally due to the soil type or geology, or due to development which places impervious material over the ground surface (e.g. paving and roads).

Tidal Flooding

Tidal flooding is caused by high tides coinciding with a low-pressure storm system which raises sea and tidal water levels, overwhelming coastal and river defences. This may be made worse by gale force winds blowing the raised body of water up tidal river basins some distance from the coast, due to floodwater being forced up the tidal reaches of rivers and estuaries. Such flooding may become more frequent in future years due to rising sea levels.

Table of Contents

1.0	INTRODUCTION	1
1.1	Appointment	1
1.2	Project Understanding	1
1.3	Scope of Works	1
1.4	Sources of Information	2
1.5	Project Limitations	2
2.0	SITE DESCRIPTION	3
3.0	RELEVANT PLANNING POLICY AND GUIDANCE	6
3.1	Introduction	6
3.2	Assessment of Flood Risk	6
3.3	Planning Policy Wales	6
3.4	Local Policy	7
3.5	Consultation	8
4.0	ASSESSMENT OF FLOOD RISK	9
4.1	Tidal Flood Risk	9
4.2	Fluvial Flood Risk	9
4.3	Surface Water Flood Risk	10
4.4	Groundwater Flood Risk	11
4.5	Artificial Sources Flood Risk	11
4.6	Summary of Flood Risk	11
4.7	Mitigation	11
4.8	Residual Risks	12
4.9	Impact on Flood Risk Elsewhere	12
5.0	DRAINAGE STRATEGY	13
5.1	Introduction	13
5.2	Surface Water Drainage Hierarchy	13
5.3	Surface Water Discharge Location	14
5.4	Surface Water Runoff Calculations	14
5.5	Attenuation Storage	14
5.6	Sustainable Drainage Systems	14
5.7	Preferred Drainage Scheme	15
5.8	Event Exceedance	15
5.9	Surface Water Treatment	16
5.10	Maintenance	16
5.11	Foul Water Discharge	16
5.12	Other Considerations	16
6.0	TAN15 JUSTIFICATION TEST	17
6.1	Introduction	17
7.0	CONCLUSIONS AND RECOMMENDATIONS	18
7.1	Conclusions	18
7.2	Recommendations	18

Appendices

Appendix A	Limitations
Appendix B	Topographical Data
Appendix C	Indicative Development Plan
Appendix D	ReFH2 Runoff Rates
Appendix E	MicroDrainage Attenuation Calculations
Appendix F	Maintenance Schedules

1.0 Introduction

1.1 Appointment

- 1.1.1 Delta-Simons Environmental Consultants Limited (“Delta-Simons”) was instructed by Caelus Limited (the “Client”) to carry out a Flood Consequences Assessment (FCA) and Drainage Strategy (DS) for land south of Bridge Road North, Wrexham, LL13 9XT (the “Site”) to inform a planning application for a proposed gas to grid development.
- 1.1.2 The assessment considers potential flood risks from all sources and provides options for managing any Site-specific flood risks identified.

1.2 Project Understanding

- 1.2.1 The Site is shown to lie within Flood Zones 2 and 3 on the Natural Resources Wales’ (NRW) Flood Risk Map. Flood Zone 2 is defined as the extent of a flood from rivers with up to a 0.1% (1 in 1000) annual chance of flooding (Annual Exceedance Probability (AEP)). Flood Zone 3 is the extent of a flood from rivers with a 1% (1 in 100) AEP. On the NRW Development Advice Map the Site is shown to be partially located within Flood Zone C2 (areas of the floodplain without significant flood defence infrastructure) and Partially within Flood Zone B (areas known to have flooded in the past). The Client has therefore requested a FCA to support the planning application.
- 1.2.2 The aim of this report is to assess the potential flood risk to the Site, the impact of the proposed development on flood risk elsewhere, and the proposed measures which could be incorporated to mitigate the identified risk. This report has been prepared in accordance with the guidance contained in Planning Policy Wales (PPW) and Technical Advice Note 15 (TAN15): Development and Flood Risk.
- 1.2.3 New legislation (introduced with Schedule 3 of the Flood & Water Management Act) in Wales requires new development to have Sustainable Drainage Systems (SuDS) approval by the SuDS Approval Body (SAB) in conjunction with the planning process. Therefore, the Client has requested a DS to identify water management measures, including Sustainable Drainage Systems (SuDS), to provide surface water runoff reduction and treatment.

1.3 Scope of Works

- 1.3.1 The scope of works has been as follows for this FCA:
 - ▲ Assess flood risk from all sources using best available information including review of NRW data and mapping, topography, and historical records;
 - ▲ Assess previous relevant studies, local authority plans or strategies;
 - ▲ Advise on flood mitigation measures and residual risks;
 - ▲ Assess evacuation routes;
 - ▲ Advise on availability of flood warnings;
 - ▲ Identify whether the Site complies with the Justification Test;
 - ▲ Assess/conduct flood compensatory storage requirements; and
 - ▲ Prepare FCA report.
- 1.3.2 The suggested DS would include the following:
 - ▲ Review existing conditions including sewer plans, British Geological Survey information and topographical information;
 - ▲ Review Lead Local Flood Authority (LLFA) drainage policies;
 - ▲ Analyse existing and proposed impermeable areas;
 - ▲ Calculate existing runoff rates (excluding existing drainage system modelling);

- ▲ Assess method of surface water runoff disposal (soakaway / watercourse / sewer);
- ▲ Establish surface water discharge rate in consultation with the LLFA / sewerage provider;
- ▲ Estimate required attenuation volume using MicroDrainage or similar;
- ▲ Assess and advise on suitable forms of SuDS;
- ▲ Advise on drainage system maintenance measures;
- ▲ Advise on surface water treatment methods;
- ▲ Establish method of foul water drainage;
- ▲ Prepare concept drainage sketch (where development plan is available as dwg. format);
- ▲ Complete Drainage Proforma; and
- ▲ Prepare DS report.

1.3.3 This report considers the following national and local policies:

- ▲ Planning Policy Wales (PPW) (2018)¹;
- ▲ Technical Advice Note 15: development and flood risk (TAN15) (2004)²;
- ▲ CL-03-16 Flood Consequence Assessments: Climate change allowances.³; and
- ▲ Wrexham County Borough Council (WCBC) Unitary Development Plan (UDP).

1.4 Sources of Information

1.4.1 The following sources of information have been reviewed and assessed for the purpose of this FCA:

- ▲ NRW online flood maps⁴;
- ▲ British Geological Society (BGS) Interactive Map⁵;
- ▲ MAGIC Interactive Map⁶;
- ▲ WCBC Preliminary Flood Risk Assessment (2011 PFRA);
- ▲ EA River Dee Catchment Flood Management Plan (2010 CFMP);
- ▲ WCBC Local Flood Risk Management Strategy (2013 LFRMS);
- ▲ WCBC Flood Risk Management Plan 2016 - 2021 (2016 LFRMP); and
- ▲ WCBC Preliminary Flood Risk Assessment Addendum Report (2017 PFRA).

1.5 Project Limitations

1.5.1 It is possible that the data shown on the NRW Flood Map for Planning does not consider the implications of climate change. For Sites on the periphery of defended areas and or in close proximity to Flood Zone 3, further assessment may be required to more accurately determine the flood risk.

1.5.2 The wider Delta-Simons limitations are contained within Appendix A.

1 <https://gov.wales/sites/default/files/publications/2019-02/planning-policy-wales-edition-10.pdf>

2 <https://gov.wales/sites/default/files/publications/2018-09/tan15-development-flood-risk.pdf>

3 <https://gov.wales/climate-change-allowances-and-flood-consequence-assessments-cl-03-16>

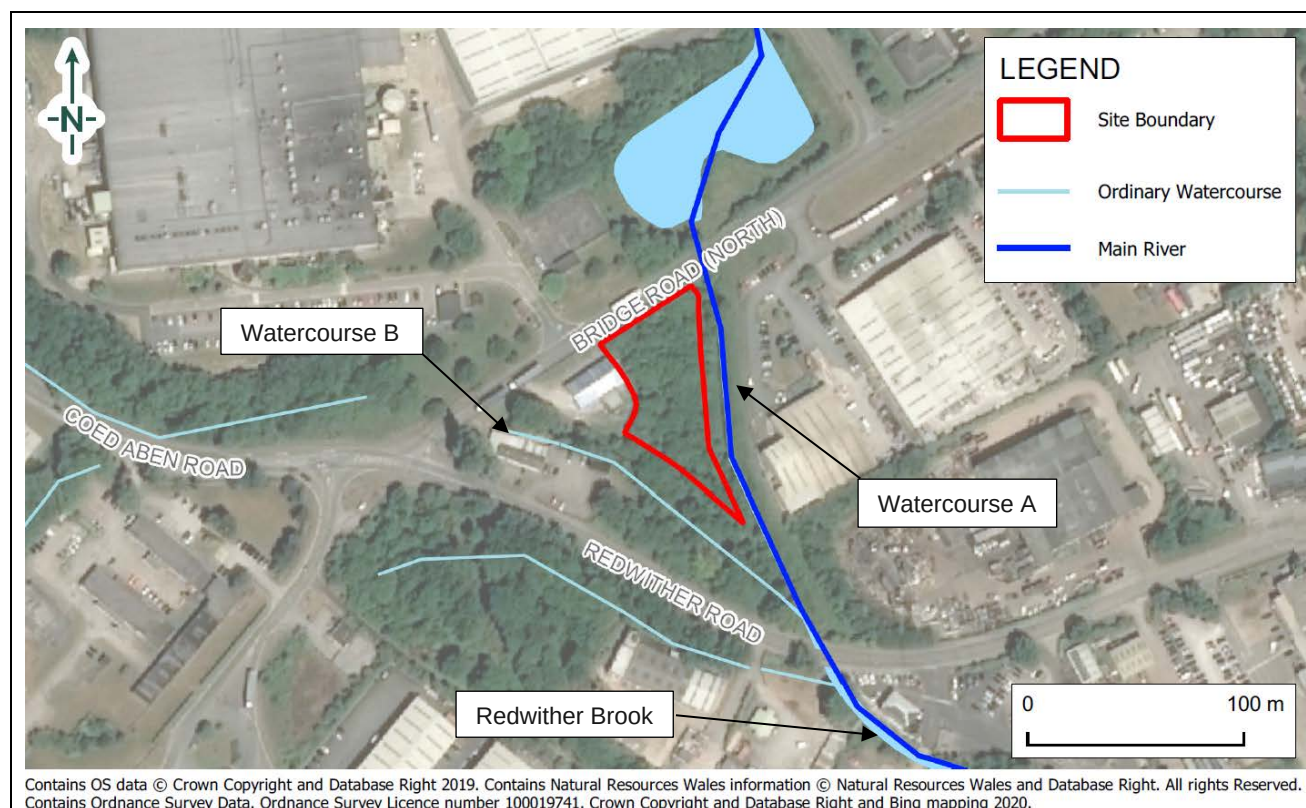
4 <https://gov.wales/climate-change-allowances-and-flood-consequence-assessments-cl-03-16>

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

6 <http://www.magic.gov.uk/>

2.0 Site Description

2.1.1 The aim of this section of the report is to outline key environmental information associated with the baseline environment.



Illustrative Site Layout Plan

Co-ordinates	Centred approximately at National Grid Reference (NGR) 338124, 349551.	Area (approx.)	0.28 ha
Site Location	The Site is located off Bridge Road North within Wrexham Industrial Estate, approximately 4.6 km east of Wrexham City centre and within the jurisdiction of Wrexham County Borough Council (WCBC).		
Existing Site Conditions	Online mapping (including Google Maps accessed 06/07/2020) shows that the Site comprises undeveloped greenfield land and is therefore considered to be 100% permeable. The surrounding land is largely for industrial / commercial use. The Site is bordered by Bridge Road North to the north, an unnamed watercourse to the east, another unnamed watercourse and a warehouse building to the west and to the south is the confluence of the two unnamed watercourse, forming Redwither Brook. Access to the Site is provided in the north from Bridge Road North.		
Topography	Topographic levels to metres Above Ordnance Datum (m AOD) have been derived from a 1 m resolution Environment Agency (EA) composite 'Light Detecting and Ranging' (LiDAR) Digital Terrain Model (DTM). A review of LiDAR ground elevation data shows that the Site slopes from approximately 26.08 m AOD in the north of the Site to approximately 24.93 m AOD in the south. A LiDAR extract is included in Appendix B.		

Hydrology	The Site is situated between two watercourses, the nearest watercourse is an unnamed Main River (responsibility of the NRW to maintain), located approximately 10 m to the east. The watercourse flows south and parallel to the eastern boundary of the Site and is referred to as Watercourse A within this report. Upstream of the Site, Watercourse A is shown to run parallel to Ash Road (South) before flowing into pond situated approximately 20 m north of the Site boundary and then flows as a culverted watercourse under Bridge Road North before entering the Site boundary. An Ordinary Watercourse (responsibility of the WCBC LLFA), referred to as Watercourse B is located approximately 15 m west of the Site. Watercourse B is shown to be culverted approximately 800 m north west of the Site at Erilas Lane and flows as a culverted watercourse through Wrexham Industrial estate. The brook resurfaces at Coed Aben Rd and flows south east, past the Site and merges with Watercourse A, approximately 20 m south of the Site boundary where it become Redwither Brook. The Redwither Brook continues to flow south east and eventually draining into the River Clywedog, approximately 500 m downstream. The Redwither Brook is shown to be culverted under Redwither Road, approximately 75 m downstream of the Site boundary. Other watercourses in the area include an unnamed Ordinary Watercourse located approximately 64 m south west of the Site and drains into Redwither Brook approximately 97 m downstream of the Site boundary.
Geology	The British Geological Survey (BGS) online mapping (1:50,000 scale) indicates that the Site is underlain by superficial deposits of Alluvium in the eastern and western extent of the Site generally comprising clay, silt, sand and gravel and Devensian Till in the central and northern areas. The superficial deposits are identified as being underlain by a bedrock consisting of mudstone, sandstone, and conglomerate from the Salop Formation. The geological mapping is available at a scale of 1:50,000 and as such may not be accurate on a Site-specific basis. The nearest available historical BGS borehole records (BGS Ref: SJ34NE142 and SJ34NE143) are located to the east of the Site, dated 1986 and taken to a depth of 6 m below ground level (bgl). The following generalised geology was recorded within the borehole logs: ▲ Made Ground was recorded from the surface to 1.00 m bgl (SJ34NE142) / 2.5 m bgl (SJ34NE143), generally comprising silty Clay with fragments of brick, coal, cinders and occasional gravel and rootlets within SJ34NE142 and fragments of ash, brick and occasional fine gravel within SJ34NE143. Topsoil was also noted near the surface at SJ34NE143; and ▲ Slightly silty clay deposits with occasional pockets of light brown silt generally underlain Made Ground within both logs to 6.00 m bgl. Groundwater was not recorded within the above logs however given the Sites close proximity to two watercourses the water table is anticipated to be shallow and perched groundwater may be present within Devensian Till deposits.
Hydrogeology	According to the EA's Aquifer Designation data, obtained from MAGIC Map's online mapping [accessed 06/07/2020], the superficial deposits are classified as Secondary A and Secondary Undifferentiated Aquifers. The underlying Bedrock Deposit is described as Secondary A Aquifer. Secondary A Aquifers are defined as 'permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers. Secondary Undifferentiated Aquifers are assigned in 'cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means

	that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type'. The EA's 'Source Protection Zones' data, obtained from MAGIC Map's online mapping [accessed 06072020], indicates that the Site is not located within a Groundwater Source Protection Zone.
Local Drainage	Public sewer records have been requested from Dŵr Cymru Welsh Water; a response is awaited. It is assumed that there are public surface water and / or foul water sewers located within the vicinity of the Site given the urbanised nature of the surrounding land.
Proposed Site Conditions	The proposed development is for a proposed gas to grid development comprising six gas engines, and associated, Radiators, Gas Kiosk, DNO Building located in the northern extent of the Site boundary, the external areas will largely comprise a permeable gravel surfacing, with access provided in the north from Bridge Road North via a gated entry. A proposed development plan is included in Appendix C. The proposed development will introduce hardstanding areas in the form of bases to support the energy production equipment. Hardstanding will comprise 481.00 m² or 17% of the total Site area (2,845 m²). The remaining permeable, soft landscaped and or permeable surfaced areas will occupy 2,364 m² or 83% of the total Site area. Proposed Hardstanding and soft landscaping have been estimated from the proposed development plan provided.

3.0 Relevant Planning Policy and Guidance

3.1 Introduction

- 3.1.1 The aim of this section of the report is to discuss the main aspects of the local and national planning policies that are relevant to any proposed development on the Site and relevant guidance and legislation.

3.2 Assessment of Flood Risk

- 3.2.1 The flood risk from fluvial (Main Rivers) and coastal flooding is assessed using the Welsh Government, TAN15, Development Advice Maps and the NRW 'Flood Map for Planning' (flood risk from rivers or the sea).

The Development Advice Maps define three development advice 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 Environment Agency extreme flood outline, equal to or greater than 0.1% (river, tidal or coastal) (i.e.: greater than 1 in 1,000 chance of flooding in any one year).

Zone C is divided into C1 and C2.

- ▲ C1 is areas of the floodplain which are developed and served by significant infrastructure, including flood defences.
- ▲ C2 is Areas of the floodplain without significant flood defence infrastructure.

- 3.2.2 The NRW 'Flood Map for Planning' defines three zones of different flood risk, the third of which is subdivided into two categories:

- ▲ Zone 1 "Low probability of flooding" – This zone comprises land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%);
- ▲ Zone 2 "Medium probability of flooding" – This zone comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year;
- ▲ Zone 3a "High probability of flooding" – This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year;
- ▲ Zone 3b "Functional floodplain" – A sub-part of Zone 3, this zone comprises land where water has to flow or be stored in times of flood. This zone is not normally included within the national Flood Map for Planning and is calculated where necessary using detailed hydraulic modelling.

3.3 Planning Policy Wales

Development Vulnerability Classification

- 3.3.1 Given the nature and scale of the development and given that the national grid will not be reliant on its power, the proposed industrial development is considered to be 'less vulnerable' development in accordance with Figure 2 of the Welsh Government's Technical Advice Note 15 – Development and Flood Risk (TAN15).
- 3.3.2 The NRW Development Advice Map indicates that the south western extent of the Site clips Zone B and the eastern periphery is shown to lie within Zone C2. TAN15 states that less vulnerable development can be considered in Flood Zone C2 subject to the application of the TAN15 Justification Test and satisfying specific TAN15 acceptability criteria. The specific TAN15 'acceptability criteria' are assessed in the following sections and detailed in Section 6.0.

- 3.3.3 From 7th January 2019, all new developments of more than 1 dwelling house or where the construction area is 100m² or more require Sustainable Drainage Systems (SuDS) for surface water. From this date onwards, SuDS on new developments must be designed and built in accordance with the Statutory SuDS Standards published by the Welsh Ministers and SuDS Schemes must be approved by the local authority acting in its SAB role, before construction work begins.

3.4 Local Policy

- 3.4.1 The WCBC Unitary Development Plan (UDP) adopted in February 2005 is the current development plan in place for the county and contains the following policies relating to flood risk and drainage:

Policy EC12 - Development and Flood Risk:

'Development (including the raising of land) within 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 an unacceptable risk of flooding on or off-site; and/or*
- c) does not adversely affect flood management or maintenance schemes*

...Development proposals within areas of flood risk are not only at risk of flooding but may also exacerbate existing or create new flooding problems on other land or property through reductions in floodplain storage capacity or by impeding flood flows. Flood alleviation measures can only reduce the risk of flooding and can never eliminate the risk. For these reasons, development within land at an unacceptable risk of flooding will not be permitted. Where detailed information in respect of flood risk is not available, developers will be required to carry out detailed technical investigations to evaluate the extent of the flood risk and ensure that no unacceptable development, including the raising of land, occurs within the flood risk area identified.

In exceptional circumstances, where the Council considers a development essential for the economic viability of the area, and it has been confirmed that there are no other sites capable of providing the necessary stimulus, the development will still only be permitted where the developer can conclusively demonstrate that appropriate and environmentally sympathetic flood protection and mitigation measures can be implemented. The Council will require developers to carry out and provide details of hydraulic investigations to properly determine the implications of the proposed development. Developers should be aware that the responsibility for, and costs of, carrying out of any investigation/mitigation works rests with themselves. Development will not be permitted to commence until any mitigation works required have been implemented to the satisfaction of the Council, and a formal agreement regarding the future maintenance of any flood protection/mitigation structures is in place.'

Policy EC13 – Surface Water Run-off

'Development which would result in an unacceptable adverse impact on the water environment due to additional surface water run-off will not be permitted.

...Wherever practicable surface water should be disposed of as close to the source as possible. Where potential risks are identified appropriate flow attenuation facilities or mitigation measures may be a pre-requisite for development. Consideration should be given to the use of softer engineering structures referred to as Sustainable Urban Drainage Systems (SUDS). SUDS is a concept that focuses decisions about drainage design, construction, and maintenance on the quality of the receiving environment and people. SUDS are physical structures built to receive surface water runoff. They typically include swales, ponds, infiltration basins and porous surfaces and should be considered as alternatives to conventional drainage where appropriate. The Environment Agency Wales can provide guidance on the design of SUDS and have produced a document entitled "Protecting the Quality of Our Environment, Sustainable Urban Drainage Systems - An Introduction". The Council will require the developer to demonstrate, both financially and practically, how the long term maintenance of any attenuation facilities or mitigation measures will be achieved'

3.5 Consultation

- 3.5.1 A pre-planning opinion and data request was submitted to the NRW and the LLFA in June 2020. A response is awaited.

4.0 Assessment of Flood Risk

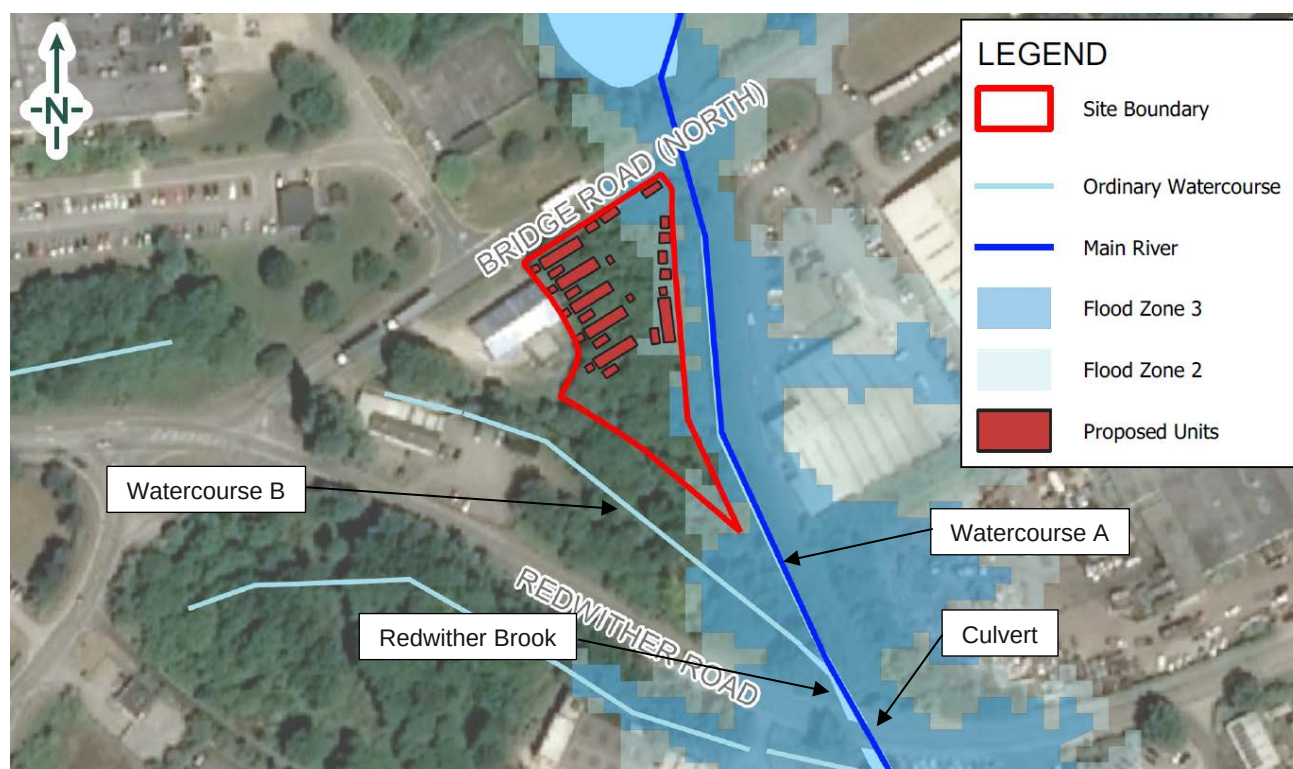
4.1 Tidal Flood Risk

- 4.1.1 The Site is situated in land at a minimum of 24.93 m AOD, significantly above sea level. Therefore, the risk of tidal flooding is considered **Low**.

4.2 Fluvial Flood Risk

- 4.2.1 The Site is situated at the confluence of two watercourses, an unnamed Main River (Watercourse A) flows parallel to the eastern Site boundary and an minor watercourse (Watercourse B) flows parallel to the western Site boundary. The watercourses are shown to merge approximately 20 m south of the Site becoming Redwither Brook, and continue to flow south east, eventually draining into the River Clywedog, approximately 500 m downstream.
- 4.2.2 The eastern extent of the Site is situated partially within Flood Zone 2 and shown clip Flood Zone 3 on the NRW 'Flood Map for Planning', shown as Figure 1 below. The Flood extent also closely matches that of the Flood Zone C2 extent on the NRW TAN15 Development Advice Mapping. No flood extents are shown to be associated with Redwither Brook, it is likely that no modelling has been undertaken for this watercourse as it is not a designated NRW Main River. Fluvial flooding could occur if either watercourse overtopped its banks during or following an extreme rainfall event. Flooding could also occur from a blockage at the inlet of the culvert located approximately 25 m south of the Site. In lieu of specific modelling data the NRW surface water flood map can provide a reasonable representation of the risk, this has been considered further in Section 4.3 below.

Figure 1: NRW Flood Map for Planning



- 4.2.3 The NRW 'Historical Flood Map' indicates that the Site has not been impacted by historic fluvial flooding and there is no indication within the 2017 PFRA of historic fluvial flooding impacting the Site.

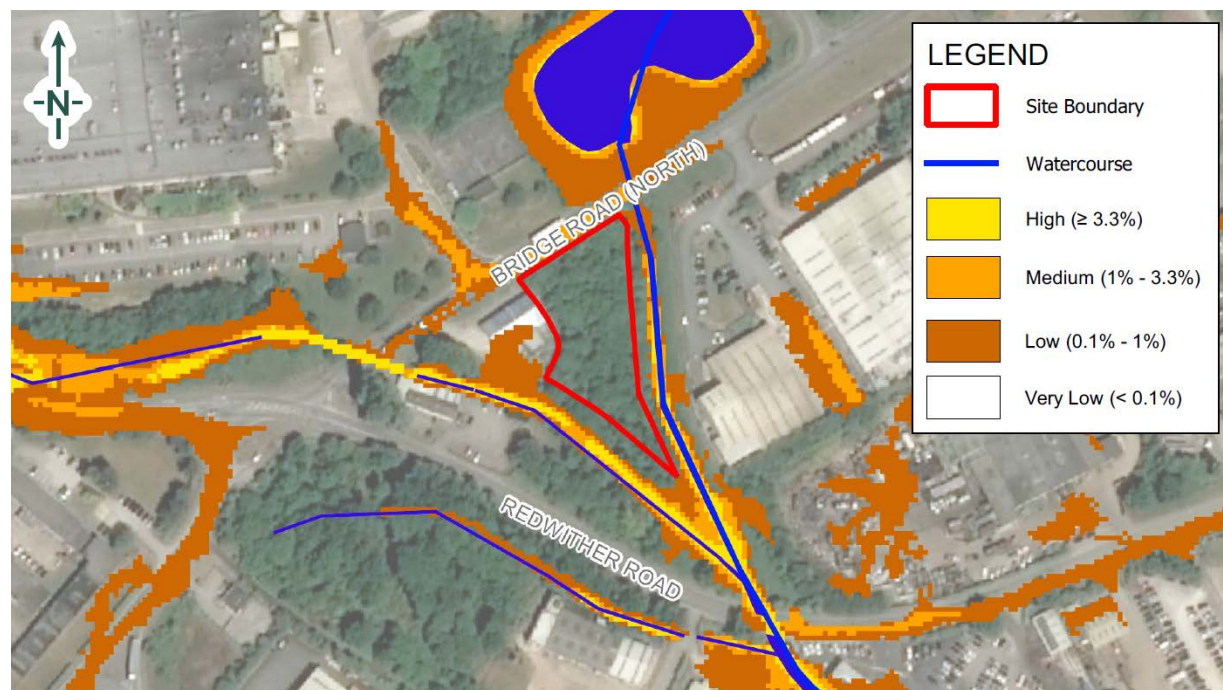
Estimated Flood Levels

- 4.2.4 Estimated flood levels for the nearby watercourses have been requested from NRW in July 2020, a response was not provided at the time of writing. Flood depth and the impact of climate change on fluvial flood extents will be assessed upon arrival of NRW Product Data.
- 4.2.5 Based on the above data, the Site is considered to be at **Moderate** risk from fluvial flooding. This can be reduced to **Low** following mitigation measures detailed in Section 4.7.

4.3 Surface Water Flood Risk

- 4.3.1 The NRW 'Flood Risk from Surface Water' map (Figure 2) indicates that the Site is at Very Low risk of surface water flooding, meaning it has a less than 0.1% AEP. There are areas of Medium (between a 3.3% and 1% AEP) and High (>3.3% AEP) surface water flood risk along the banks of nearby watercourses and within Bridge North Road.
- 4.3.2 Surface water flood extents along the banks of the watercourses represent out of channel flows during a rainfall event, the Site is not located within these extents therefore any surface water flooding associated with the adjacent watercourses is considered Low.
- 4.3.3 There are no distinct flow routes in the area shown to direct any potential surface water flooding towards the Site. A flow path is shown to form within an access road to the north of the Site, the flow path flows south onto Bridge Road North and then heads east towards Watercourse A. A review of LiDAR data (made available in Appendix B) shows that the northern extent of the Site is situated at a higher elevation than Bridge Road North. Any potential surface water flooding arising at Bridge Road North is unlikely to enter the Site boundary and instead be directed east and away from the Site, following the local topography.

Figure 2: NRW Flood Risk from Surface Water Map



© CNC/NRW and Centre for Ecology & Hydrology © NERC (CEH). Some features of this information are based on digital spatial data licensed from the Centre for Ecology & Hydrology © NERC (CEH). Defra, Met Office and DARD Rivers Agency © Crown copyright. © Cranfield University. © James Hutton Institute. Contains OS data © Crown copyright and database right 2015. Land & Property Services © Crown copyright and database right and Bing mapping 2020.

- 4.3.4 The NRW Flood Map indicates flood depths are expected to remain below 300 mm along Bridge Road North during the 1% AEP flood event. This is deemed to be passable by pedestrians and vehicles and therefore access and egress is considered achievable from the Site during the 1% AEP rainfall event. There are no records of surface water flooding at or in the immediate vicinity of the Site.

4.3.5 It can therefore be concluded that the Site is at **Low** risk of surface water flooding.

4.4 Groundwater Flood Risk

- 4.4.1 The geology underlying the Site has been detailed in Section 2.0 above. The Site is identified as being largely underlain by superficial deposits of Devensian Till in the central and northern regions and riverine deposits of alluvium along the eastern and western boundary associated with the adjacent watercourses. The superficial deposits are identified as being underlain by a bedrock consisting of mudstone, sandstone, and conglomerate from the Salop Formation.
- 4.4.2 BGS borehole logs advanced approximately 30 m east of the Site boundary encountered deposits of impermeable silty clay underlying Made Ground. Groundwater was not recorded within these logs however given the Site close proximity to two watercourses the water table is anticipated to be shallow and perched groundwater may be present within Devensian Till deposits. Groundwater levels generally correspond with river levels. As such groundwater flooding or saturated ground could occur during periods of prolonged high water levels within adjacent watercourses.
- 4.4.3 The 2016 FRMP and the 2017 PFRA identified no records of groundwater flooding within the County Borough.
- 4.4.4 Groundwater will likely be encountered during the constructional phase given that the water table is likely to be shallow underlying the Site. It is recommended to undertake works during drier summer months to avoid encountering groundwater and if groundwater is encountered, dewatering activities can be carried out to temporarily remove potential flood water.
- 4.4.5 It can therefore be concluded that the risk of groundwater flooding is **Low to Moderate**. This can be reduced to **Low** following mitigation measures detailed in Section 4.7.

4.5 Artificial Sources Flood Risk

Sewer Flooding

- 4.5.1 Sewer records have been requested from Dwr Cymr Welsh Water, a response is awaited. It is assumed that there are surface / foul sewers present within Bridge Road North given the urbanised surroundings. The sewer network is generally designed to accommodate the 1 in 30 year (3.3% AEP) frequent rainfall event, ensuring no flooding occurs above ground level for this return period.
- 4.5.2 The 2011 PFRA states that 'there were no records of properties affected by sewer flooding with significant consequences' in WCBC. There are no distinct flow routes in the area which would direct any potential flooding towards the Site.
- 4.5.3 It can therefore be concluded that the risk of sewer flooding is **Low**.

Reservoir and Canal Flooding

- 4.5.4 There are no canals within the vicinity of the Site and the Site, and its surroundings are not shown to lie within the extents of a reservoir breach or overtopping event on the NRW 'Flood Risk from Reservoirs' map. Therefore, the risk flooding associated with these sources is considered **Negligible**.
- 4.5.5 It can therefore be concluded that there is **Negligible to Low** risk of flooding from artificial sources.

4.6 Summary of Flood Risk

- 4.6.1 It can be concluded that fluvial and groundwater flooding are the main potential source of flood risk to the Site. The associated risk has been used to inform mitigation design as discussed further in this report.

4.7 Mitigation

- 4.7.1 The north eastern extent of the Site is identified to be at risk of fluvial flooding during the 1% AEP flood event and from groundwater flooding. Any equipment that is sensitive to water of finished floor levels should be raised as high as possible above surrounding ground levels.

Flood Warnings and Evacuation

- 4.7.2 Flood Alerts cover this area. Site operators and management should register to receive flood warnings. Flood Alerts is a free service that provides prior warning of a fluvial and tidal flood event. The site should not be manned when a flood alert is in place. Access to the site will be required relatively infrequently, typically by technicians for maintenance and inspection works. Such works can be scheduled as to avoid the site during times of flood.

4.8 Residual Risks

- 4.8.1 A residual risk is an exceedance event, such as the 1 in 1000 year (0.1% AEP) flood event that would overtop Watercourses A and B and potentially impact the Site. As the probability of a 1 in 1000 year flood event occurring is 0.1% in any given year, the probability is low and, therefore, no further mitigation beyond what is proposed is required.
- 4.8.2 In the event of an exceedance event occurring, the residual risk to people working within the Site can be managed through the implementation of an appropriate Site management plan, which recognises the residual risks and details what action is to be taken by staff in the event of a flood.

4.9 Impact on Flood Risk Elsewhere

- 4.9.1 The majority of the proposed units are located outside the extents of a fluvial flood extent and will not remove flood storage space from the floodplain. Two units in the north eastern extent of the Site occupying a total area of 23.0 m² are located within Flood Zone 3, resulting in a minor loss in flood storage area. The loss of floodplain as a result of the development is considered minimal and will have a negligible impact on flood risk elsewhere. In addition, land levelling activities upon development are likely to compensate for any floodplain displacement. This can be assessed in further detailed upon receipt of modelled flood data.
- 4.9.2 The proposed development will introduce impermeable area and therefore increase surface water run-off rates and volumes, a surface water drainage strategy outlining appropriate surface water removal from the development in line with local policy is provided in Section 5.0.
- 4.9.3 Based on the above, the impact of the proposed development on flood risk elsewhere is considered **Low and acceptable** from fluvial flood risk and all other sources of flooding.

5.0 Drainage Strategy

5.1 Introduction

- 5.1.1 The Site currently comprises undeveloped greenfield land which is not formally drained and is therefore considered to be 100% permeable.
- 5.1.2 The proposed development will introduce 471 m² of hardstanding in the form of buildings and power plant units. The increase in hardstanding area will result in an increase in surface water runoff rates and volumes. In order to satisfy Policy EC12 and EC13 within the WCBC Local Plan and to ensure the proposed development will not increase flood risk elsewhere, surface water discharge from the Site will be controlled.

5.2 Surface Water Drainage Hierarchy

- 5.2.1 Standard S1 of the Welsh Government: 'Recommended non-statutory standards for sustainable drainage (SuDS) in Wales' (2017) sets out the following hierarchy of drainage options:

- ▲ 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 runoff is discharged to a surface water body;
- ▲ Priority Level 4: Surface water runoff is discharged to a surface water sewer, highway drain, or another drainage system; and
- ▲ Priority Level 5: Surface water runoff is discharged to a combined sewer.

Priority Level 1: Surface Water Collected for Use

- 5.2.2 Given the nature of the proposals (unmanned, gas to energy facility) There is a limited foreseeable requirement for non-potable surface water at the Site.
- 5.2.3 It must be noted that section G1.6 of the 'Recommended non-statutory standards for sustainable drainage (SuDS) in Wales' states that; in most cases, rainwater harvesting alone will not be adequate to deal with the site drainage and provision will be required for an overflow to a Level 2 or lower priority runoff destination. As downstream provision of attenuation storage will be required to accommodate for rainwater harvesting system overflows, rainwater harvesting is not considered a cost-effective solution for managing surface water runoff as a whole.

Priority Level 2: Surface Water Infiltration

- 5.2.4 As described above, the Site is underlain by superficial deposits of Devensian Till and alluvium which overly Salop Formation bedrock comprising mudstone, sandstone, and conglomerate.
- 5.2.5 Impermeable deposits of silty clay were identified in BGS borehole records located approximately 50 m east of the Site boundary at depths of 1.00 / 2.50 m bgl. The presence of clay is not a suitable medium for infiltration due to its impermeable nature. In addition, groundwater is likely to be shallow given the proximity of the Site to nearby watercourses and perched groundwater may be present. Soakaways are not considered suitable in areas with a shallow or perched groundwater as a shallow water table can inhibit the soakaway system from operating appropriately and potentially increase surface water flood risk.
- 5.2.6 Given the underlying geology, it can be concluded that soakaways will not be suitable for the discharge of surface water runoff in this instance.

Priority Level 3: Surface Water Discharge to Watercourse

- 5.2.7 Where soakaways are not suitable a connection to watercourse is the next consideration.

- 5.2.8 The nearest watercourse is Watercourse A which is located approximately 10 m to the east and runs parallel to the eastern boundary. The land to the east of the Site is within Client ownership therefore a connection to this watercourse will not require crossing third party land. Discharge to this watercourse at a limited discharge rate appears to be feasible via a gravity fed connection.

Priority Level 4: Surface Water Discharge to Surface Water Sewer or Highway Drain

- 5.2.9 As described above, a connection to Watercourse A is feasible and therefore a connection to the public surface water sewer / Highway drain is not required.

Priority Level 5: Surface Water Discharge to a Combined Sewer

- 5.2.10 As described above, a connection to Watercourse A is feasible and therefore a connection to the public combined sewer is not required.

5.3 Surface Water Discharge Location

- 5.3.1 In this instance, the preferred strategy is to discharge surface water generated by the Site directly into the Watercourse flowing parallel to the eastern boundary of the Site. The outfall should be located to the south of the proposed units and where levels are lowest facilitating gravity fed discharge.

5.4 Surface Water Runoff Calculations

- 5.4.1 The existing greenfield runoff rates have been estimated using the Revitalised Flood Hydrograph Model (ReFH2) method, provided as Appendix D, and summarised in table 2 below. The existing 1 in 2 year event greenfield rate for the 0.28 ha development Site is 1.88 l/s.

Table 1: Existing Greenfield run-off rates

Return Period	Existing Greenfield Runoff Rate (l/s)
1 in 2 year (QMed)	1.88
1 in 10 year	3.57
1 in 30 year	5.08
1 in 100 year	7.25

- 5.4.2 Flows are proposed to discharge at the existing 1 in 2 year greenfield rate of 1.88 l/s. This flow rate will ensure that the risk to downstream receptors will not be exacerbated and for events above the 1 in 2 year rainfall event, betterment will be achieved.

5.5 Attenuation Storage

- 5.5.1 In order to achieve a discharge rate of 1.88 l/s, attenuation storage will be required. Storage estimates have been provided using MicroDrainage and are included in Appendix E. An estimated storage volume of 11 m³ will be required to accommodate the 1 in 30 year event and 17.7 m³ for the 1 in 100 year plus 20% Climate Change event. The storage estimates are based on a flow rate of 1.88 l/s, storage within a tank or pond structure, an impermeable drainage area of 471 m², a design head of 1.0 m and hydro brake flow control.
- 5.5.2 The attenuation volumes are provided for indicative purposes only and should be verified at the detailed design stage.

5.6 Sustainable Drainage Systems

- 5.6.1 Attenuation storage should be provided in the form of Sustainable Drainage Systems (SuDS) where practical. The following SuDS options have been considered:

Soakaways

- 5.6.2 As described above, the use of soakaways is not considered to be feasible given the impermeable strata and shallow / perched groundwater underlying the Site.

Swales, Detention Basins and Ponds

- 5.6.3 Sufficient space is available on Site to utilise a pond, basin, or swale as an above ground attenuation feature. In order to facilitate gravity drainage, attenuation features should be located at the lower southern extent of the Site.

Rainwater Harvesting

- 5.6.4 The attenuation benefits provided through the use of rainwater harvesting are considered to be limited and would only be realised when the tanks were not full. However, rainwater harvesting techniques could be incorporated within the final design.

Green Roofs

- 5.6.5 Green roofs are not identified on development plans. Given the nature of the proposed development, green roofs are not considered feasible. The benefits achieved through installing a green roof would be disproportionate to the significant ongoing maintenance and construction costs involved.

Porous / Permeable Paving / Surfaces

- 5.6.6 Permeable paving /surfaces could incorporate within external areas. Storage would be provided within the sub-grade material prior to controlled release to the receiving watercourse. Assuming a 0.3 m deep subgrade and a porosity of 30% a total porous area of 197 m² would be required to attenuate the full balance of storage required to attenuate the 1 in 100 + 20% CC storm.
- 5.6.7 The amount of storage offered by permeable paving is subject to sub-grade depth and Site gradient. The use of permeable paving should be considered at the detailed design stage.

Underground Attenuation Tanks

- 5.6.8 Storage could be provided within underground attenuation tanks or within oversized pipes. There is sufficient space for an underground tank to accommodate the full balance of storage, located within the southern extent, which is topographically lower than the remainder of the Site and where buildings are not proposed.

5.7 Preferred Drainage Scheme

- 5.7.1 As soakaways are not deemed feasible at the Site, surface water runoff will be discharged to Watercourse A located approximately 10 m to the east of the Site at a rate of 1.88 l/s. Surface water runoff up to the 1 in 100 year plus 20% climate change allowance event will be attenuated on Site. A total attenuation volume of 17.7 m³ will be required to achieve the discharge rate and will be provided in the form of porous paving or surfacing measuring a minimum of 197 m².
- 5.7.2 The proposed surface water drainage scheme will ensure no increase in runoff over the lifetime of the development / will create betterment over the existing drainage.

5.8 Event Exceedance

- 5.8.1 Storage will be provided for the 1 in 100 year plus 20% CC event. Storm events in excess of the 1 in 100 year plus 20% CC event should be permitted to produce temporary shallow depth flooding within low vulnerability external areas. The units will be set at a minimum of 150 mm above surrounding ground levels ensuring exceedance flooding will not affect site operations.

5.9 Surface Water Treatment

- 5.9.1 In accordance with the CIRIA C753 publication 'The SuDS Manual' (2015), other roofs have a 'low' pollution hazard level, with low traffic roads classified as having a 'low' pollution hazard level. Table 2 below shows the pollution hazard indices for each land use.

Table 2: Pollution Hazard Indices

Land Use	Pollution Hazard Level	Total Suspended Solids (TSS)	Metals	Hydrocarbons
Other Roofs (typically commercial/industrial roofs)	Low	0.5	0.2**	0.4
Commercial Yard and Delivery Areas	Medium	0.7	0.6	0.7

Table extract taken from the CIRIA C753 publication 'The SuDS Manual' – Table 26.2

* Indices values range from 0-1.

** up to 0.8 where there is potential for metals to leach from the roof

- 5.9.2 Where practical, runoff from roofs will be directed to permeable paving. Table 3 below demonstrates that permeable paving / surfaces provide sufficient treatment.

Table 3: SuDS Mitigation Indices

Type of SuDS	Mitigation Indices		
	Total Suspended Solids (TSS)	Metals	Hydrocarbons
Permeable Pavement	0.7	0.6	0.7

Table extract taken from the CIRIA C753 publication 'The SuDS Manual' – Table 26.3

- 5.9.3 It can be concluded that the inclusion permeable paving / surfaces will provide sufficient treatment. Where attenuation is provided in a below ground system (tank storage), treatment will need to be provided by a suitably sized separator.

5.10 Maintenance

- 5.10.1 Maintenance of communal drainage features such as permeable paving / surfacing or an attenuation tank will be the responsibility of the Site owner. Maintenance of shared surface water drainage systems can be arranged through appointment of a Site management company.
- 5.10.2 Maintenance schedules for an attenuation tank and permeable paving are included in Appendix F. Maintenance of the separator will be as per the manufacturer's guidance.

5.11 Foul Water Discharge

- 5.11.1 The proposed development plans suggest that the site will not be manned and there is no effluent produced, therefore, there will be no requirement for foul drainage onsite. Foul drainage is not considered further within this report.

5.12 Other Considerations

- 5.12.1 Maintenance access to Watercourse A and B should be retained. Maintenance access can be ensured by providing an 8 m buffer either side of the watercourse.

6.0 TAN15 Justification Test

6.1 Introduction

6.1.1 In accordance with TAN15, less vulnerable development will be justified in Flood Zone C2 if it can be demonstrated the following:

- i. Its location in Zone C is necessary to assist, or be part of, a local authority regeneration initiative or a local authority strategy 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, **or**

and,

- iii. It concurs with the aims of Planning Policy Wales (PPW) and meets the definition of previously development 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 [of TAN15] found to be acceptable.

6.1.2 The National Grid will not be reliant on this energy source. The proposed development will contribute to local energy security. Paragraph 6.1 of TAN 15 states; *'Much urban development in Wales has taken place alongside rivers and in the coastal plain. It is therefore inevitable, despite the overall aim to avoid flood risk areas, that some existing development will be vulnerable to flooding and fall within zone C. Some flexibility is necessary to enable the risks of flooding to be addressed whilst recognising the negative economic and social consequences if policy were to preclude investment in existing urban areas, and the benefits of reusing previously developed land. Further development in Manor Lane, Hawarden Flood Consequences Assessment & Drainage Strategy w10793-190604-FCA & Drainage Strategy.docx 19 such areas, whilst possibly benefiting from some protection, will not be free from risk and could in some cases exacerbate the consequences of a flood event for existing development and therefore a balanced judgement is required'*.

6.1.3 The acceptability of the consequences of a flooding event have been considered in this FCA. The development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall. It can be concluded that the development satisfies the criteria contained in sections 5 and 7 and appendix 1 of TAN15.

7.0 Conclusions and Recommendations

7.1 Conclusions

- 7.1.1 The proposed development is for a flexible power station, gas kiosk, DNO building and associated hardstanding and infrastructure.
- 7.1.2 The Welsh Government Development Advice Map shows that the site is located within Flood Zone C2 - areas of the floodplain without significant flood defence infrastructure.
- 7.1.3 Based on information available, the risk of flooding from all sources has been assessed and the flood risk to the site is considered to be low. However, there is a residual risk of flooding during extreme fluvial events when accounting for climate change or blockage scenarios. Any equipment that is sensitive to water should be raised above the 0.1% AEP plus climate change and blockage events, flood extents during these extreme events. The flood level will be determined following receipt of the NRW flood data for the Site.
- 7.1.4 The proposed development will introduce impermeable drainage area in the form of buildings and access. This will result in an increase in surface water runoff. In order to ensure the increase in surface water runoff will not increase flood risk elsewhere, flow control will be used, and attenuation provided on site to accommodate storm events up to and including the 1 in 100 year plus 20% climate change event.
- 7.1.5 All methods of surface water discharge have been assessed. As infiltration is not possible, discharge of surface water to Watercourse A at a rate of 1.88 l/s appears to be the most practical option and should be agreed with the LLFA.
- 7.1.6 Where a formal drainage system is proposed, attenuation storage will be required on site in order to restrict surface water discharge to 5 l/s. Attenuation can be provided within the sub-grade of permeable paving / surfacing or in the form of below ground attenuation storage.

7.2 Recommendations

Flood Risk

- ▲ Raise sensitive equipment above the 0.1% flood level.

Drainage Strategy

- ▲ Verify the attenuation volumes included in this report when undertaking detailed drainage design; and
- ▲ Make provision for porous surfacing.

Other

- ▲ Maintenance access to Watercourses A and B should be retained. Maintenance access can be ensured by providing an 8m buffer either side of the watercourse.

Appendix A – Limitations

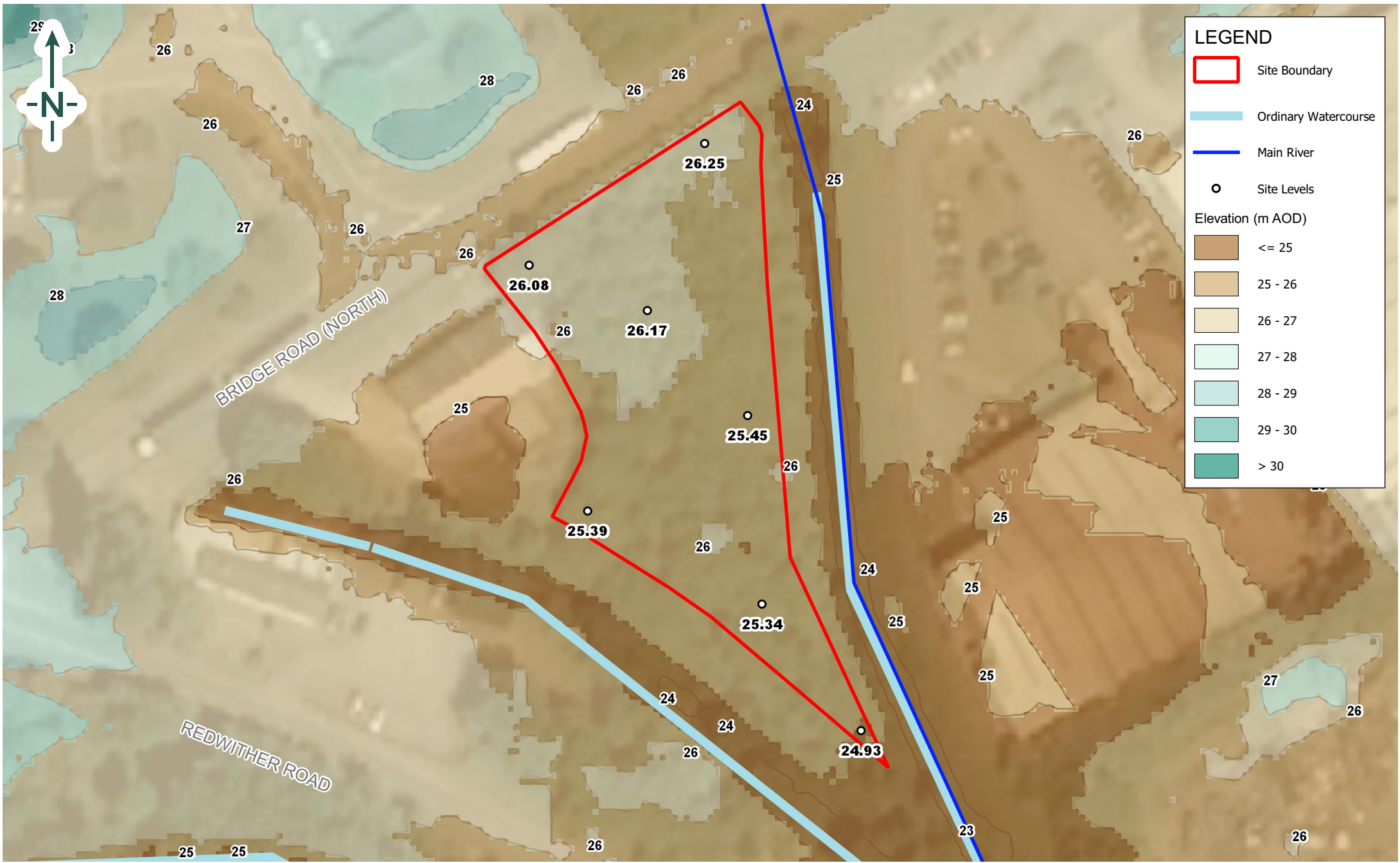
Limitations

The recommendations contained in this Report represent Delta-Simons professional opinions, based upon the information listed in the Report, exercising the duty of care required of an experienced Environmental Consultant. Delta-Simons does not warrant or guarantee that the Site is free of hazardous or potentially hazardous materials or conditions.

Delta-Simons obtained, reviewed, and evaluated information in preparing this Report from the Client and others. Delta-Simons conclusions, opinions and recommendations has been determined using this information. Delta-Simons does not warrant the accuracy of the information provided to it and will not be responsible for any opinions which Delta-Simons has expressed, or conclusions which it has reached in reliance upon information which is subsequently proven to be inaccurate.

This Report was prepared by Delta-Simons for the sole and exclusive use of the Client and for the specific purpose for which Delta-Simons was instructed. Nothing contained in this Report shall be construed to give any rights or benefits to anyone other than the Client and Delta-Simons, and all duties and responsibilities undertaken are for the sole and exclusive benefit of the Client and not for the benefit of any other party. In particular, Delta-Simons does not intend, without its written consent, for this Report to be disseminated to anyone other than the Client or to be used or relied upon by anyone other than the Client. Use of the Report by any other person is unauthorised and such use is at the sole risk of the user. Anyone using or relying upon this Report, other than the Client, agrees by virtue of its use to indemnify and hold harmless Delta-Simons from and against all claims, losses and damages (of whatsoever nature and howsoever or whensoever arising), arising out of or resulting from the performance of the work by the Consultant.

Appendix B – Topographical Data



LEGEND

- Site Boundary
- Ordinary Watercourse
- Main River
- Site Levels

Elevation (m AOD)

- <= 25
- 25 - 26
- 26 - 27
- 27 - 28
- 28 - 29
- 29 - 30
- > 30

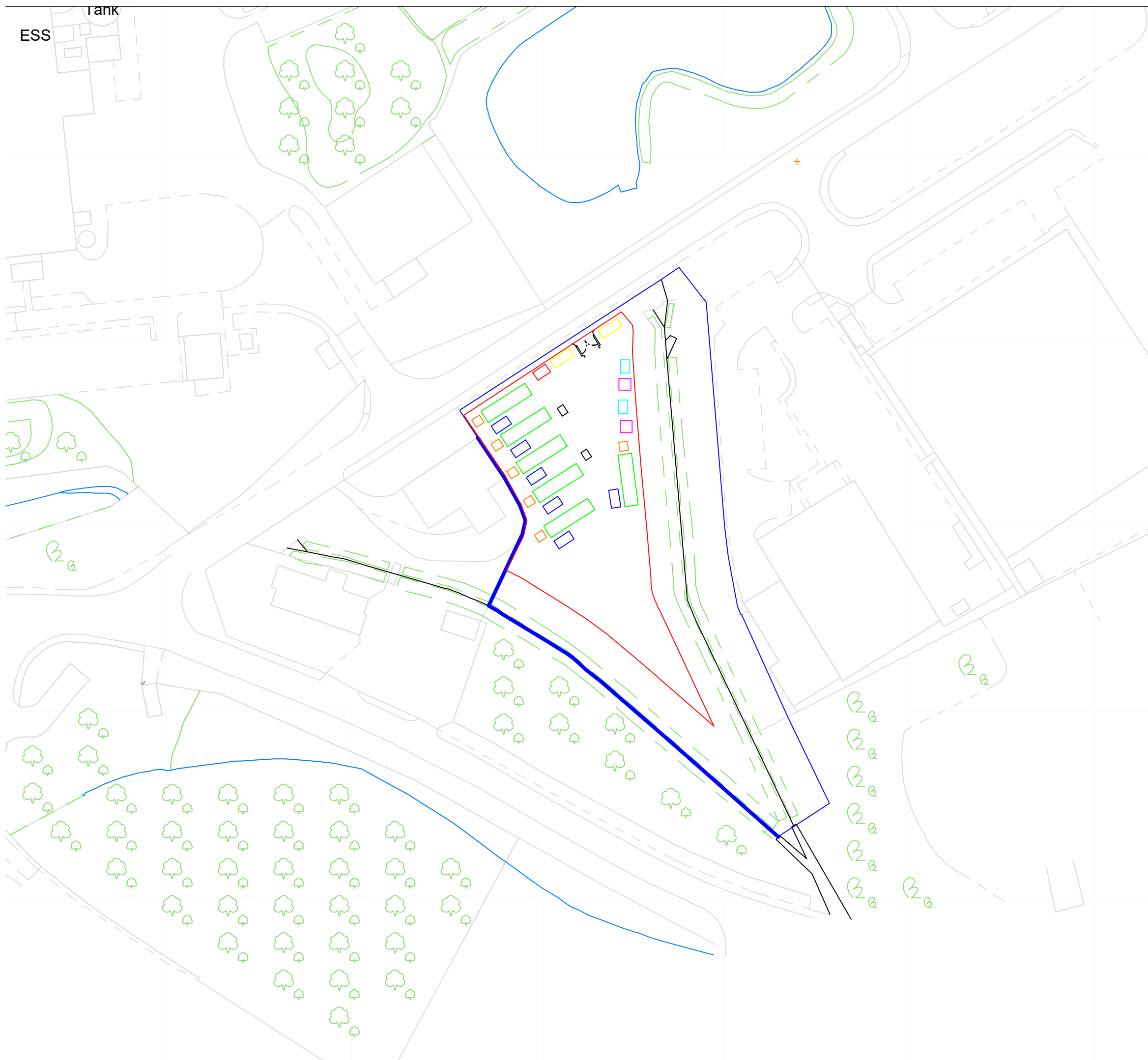
Service Layer Credits: Contains OS data © Crown Copyright and Database Right 2020 and © Environment Agency copyright and/or database right 2019 All rights reserved and Bing Mapping 2020.



TITLE:
LiDAR Plan
Bridge Road North, Wrexham

DRAWN BY: AB	SCALE (@A4): 1:800	PROJECT NO: 20-0948.01
CHECKED BY: JR	REVISION: -	FIGURE NO: B
DATE: 07 July 2020		

Appendix C – Indicative Development Plan





A

F

E

ASBESTOS SURVEYING, PROJECT MANAGEMENT,
HEALTH & SAFETY AND TRAINING

Rev	Date	Description
01	01/06/2020	Indicative site layout plan

Site

St Landholdings,
Bridge Road,
Wrexham

Client

Caelus Limited

Job Number

AQ109191

Drwg Title

Site Layout on 50m Grid

Date

01/06/2020

Scale

1:1 @ A3

Key

— Site Boundary
(Indicative Outline)

— Development Boundary
(Indicative Outline)

 Gate

 Gas Kiosk

 Radiators

 Gas Engine

 DND Building

 HV Client Building

 Amenity Cabin

 Oil Tanks

 Transformers

Appendix D – ReFH2 Runoff Calculations

Inputs	
BFI	0.364
Area	0.28 Ha

ReFH2 RUNOFF RATES*	
Return Period (Years)	As-rural Peak Flow (l/s)
1	1.624
2	1.884
5	2.807
10	3.569
30	5.083
50	5.941
75	6.692
100	7.259
200	8.708
1000	12.496

**Runoff Rates printed from the ReFH2 Flood Modelling software package*

Appendix E – MicroDrainage Attenuation Calculations

Delta-Simons						Page 1	
Suite 4A Portland Street Manchester, M1 3BE			1 in 30 yr Bridge Road, Wrexham				
Date 07/07/2020 File 1 IN 100 + 20% PROJ - N...			Designed by AC Checked by JR				
Innovyze			Source Control 2019.1				
<u>Summary of Results for 30 year Return Period (+20%)</u>							
Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	9.627	0.627	1.8	0.0	1.8	6.9	O K
30 min Summer	9.789	0.789	1.8	0.0	1.8	8.7	Flood Risk
60 min Summer	9.862	0.862	1.8	0.0	1.8	9.5	Flood Risk
120 min Summer	9.838	0.838	1.8	0.0	1.8	9.2	Flood Risk
180 min Summer	9.787	0.787	1.8	0.0	1.8	8.7	Flood Risk
240 min Summer	9.727	0.727	1.8	0.0	1.8	8.0	Flood Risk
360 min Summer	9.590	0.590	1.8	0.0	1.8	6.5	O K
480 min Summer	9.432	0.432	1.8	0.0	1.8	4.8	O K
600 min Summer	9.320	0.320	1.8	0.0	1.8	3.5	O K
720 min Summer	9.240	0.240	1.8	0.0	1.8	2.6	O K
960 min Summer	9.144	0.144	1.7	0.0	1.7	1.6	O K
1440 min Summer	9.078	0.078	1.4	0.0	1.4	0.9	O K
2160 min Summer	9.054	0.054	1.0	0.0	1.0	0.6	O K
2880 min Summer	9.044	0.044	0.8	0.0	0.8	0.5	O K
4320 min Summer	9.034	0.034	0.6	0.0	0.6	0.4	O K
5760 min Summer	9.029	0.029	0.4	0.0	0.4	0.3	O K
7200 min Summer	9.026	0.026	0.4	0.0	0.4	0.3	O K
8640 min Summer	9.024	0.024	0.3	0.0	0.3	0.3	O K
10080 min Summer	9.023	0.023	0.3	0.0	0.3	0.3	O K
15 min Winter	9.717	0.717	1.8	0.0	1.8	7.9	Flood Risk
30 min Winter	9.903	0.903	1.8	0.0	1.8	9.9	Flood Risk
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)		
15 min Summer	98.615	0.0	8.7	0.0	23		
30 min Summer	65.380	0.0	11.5	0.0	34		
60 min Summer	41.532	0.0	14.6	0.0	56		
120 min Summer	25.490	0.0	18.0	0.0	90		
180 min Summer	19.000	0.0	20.1	0.0	124		
240 min Summer	15.361	0.0	21.7	0.0	158		
360 min Summer	11.306	0.0	23.9	0.0	228		
480 min Summer	9.051	0.0	25.5	0.0	284		
600 min Summer	7.594	0.0	26.8	0.0	340		
720 min Summer	6.566	0.0	27.8	0.0	396		
960 min Summer	5.201	0.0	29.3	0.0	508		
1440 min Summer	3.721	0.0	31.5	0.0	736		
2160 min Summer	2.641	0.0	33.5	0.0	1100		
2880 min Summer	2.069	0.0	35.0	0.0	1468		
4320 min Summer	1.470	0.0	37.3	0.0	2200		
5760 min Summer	1.163	0.0	39.4	0.0	2896		
7200 min Summer	0.988	0.0	41.8	0.0	3632		
8640 min Summer	0.876	0.0	44.5	0.0	4304		
10080 min Summer	0.800	0.0	47.4	0.0	5024		
15 min Winter	98.615	0.0	9.7	0.0	23		
30 min Winter	65.380	0.0	12.9	0.0	35		
©1982-2019 Innovyze							

Delta-Simons		Page 2																																																																																																																																																																																																																																																												
Suite 4A Portland Street Manchester, M1 3BE	1 in 30 yr Bridge Road, Wrexham																																																																																																																																																																																																																																																													
Date 07/07/2020 File 1 IN 100 + 20% PROJ - N...	Designed by AC Checked by JR																																																																																																																																																																																																																																																													
Innovyze Source Control 2019.1																																																																																																																																																																																																																																																														
<u>Summary of Results for 30 year Return Period (+20%)</u> <table><tr><th>Storm Event</th><th>Max Level (m)</th><th>Max Depth (m)</th><th>Max Control (l/s)</th><th>Max Overflow (l/s)</th><th>Max Σ Outflow (l/s)</th><th>Max Volume (m³)</th><th>Status</th></tr><tr><td>60 min Winter</td><td>9.998</td><td>0.998</td><td>1.9</td><td>0.0</td><td>1.9</td><td>11.0</td><td>Flood Risk</td></tr><tr><td>120 min Winter</td><td>9.959</td><td>0.959</td><td>1.9</td><td>0.0</td><td>1.9</td><td>10.5</td><td>Flood Risk</td></tr><tr><td>180 min Winter</td><td>9.876</td><td>0.876</td><td>1.8</td><td>0.0</td><td>1.8</td><td>9.6</td><td>Flood Risk</td></tr><tr><td>240 min Winter</td><td>9.781</td><td>0.781</td><td>1.8</td><td>0.0</td><td>1.8</td><td>8.6</td><td>Flood Risk</td></tr><tr><td>360 min Winter</td><td>9.552</td><td>0.552</td><td>1.8</td><td>0.0</td><td>1.8</td><td>6.1</td><td>O K</td></tr><tr><td>480 min Winter</td><td>9.333</td><td>0.333</td><td>1.8</td><td>0.0</td><td>1.8</td><td>3.7</td><td>O K</td></tr><tr><td>600 min Winter</td><td>9.206</td><td>0.206</td><td>1.8</td><td>0.0</td><td>1.8</td><td>2.3</td><td>O K</td></tr><tr><td>720 min Winter</td><td>9.136</td><td>0.136</td><td>1.7</td><td>0.0</td><td>1.7</td><td>1.5</td><td>O K</td></tr><tr><td>960 min Winter</td><td>9.080</td><td>0.080</td><td>1.4</td><td>0.0</td><td>1.4</td><td>0.9</td><td>O K</td></tr><tr><td>1440 min Winter</td><td>9.055</td><td>0.055</td><td>1.0</td><td>0.0</td><td>1.0</td><td>0.6</td><td>O K</td></tr><tr><td>2160 min Winter</td><td>9.041</td><td>0.041</td><td>0.7</td><td>0.0</td><td>0.7</td><td>0.5</td><td>O K</td></tr><tr><td>2880 min Winter</td><td>9.035</td><td>0.035</td><td>0.6</td><td>0.0</td><td>0.6</td><td>0.4</td><td>O K</td></tr><tr><td>4320 min Winter</td><td>9.028</td><td>0.028</td><td>0.4</td><td>0.0</td><td>0.4</td><td>0.3</td><td>O K</td></tr><tr><td>5760 min Winter</td><td>9.024</td><td>0.024</td><td>0.3</td><td>0.0</td><td>0.3</td><td>0.3</td><td>O K</td></tr><tr><td>7200 min Winter</td><td>9.021</td><td>0.021</td><td>0.3</td><td>0.0</td><td>0.3</td><td>0.2</td><td>O K</td></tr><tr><td>8640 min Winter</td><td>9.020</td><td>0.020</td><td>0.3</td><td>0.0</td><td>0.3</td><td>0.2</td><td>O K</td></tr><tr><td>10080 min Winter</td><td>9.018</td><td>0.018</td><td>0.2</td><td>0.0</td><td>0.2</td><td>0.2</td><td>O K</td></tr></table> <table><tr><th>Storm Event</th><th>Rain (mm/hr)</th><th>Flooded Volume (m³)</th><th>Discharge Volume (m³)</th><th>Overflow Volume (m³)</th><th>Time-Peak (mins)</th></tr><tr><td>60 min Winter</td><td>41.532</td><td>0.0</td><td>16.4</td><td>0.0</td><td>58</td></tr><tr><td>120 min Winter</td><td>25.490</td><td>0.0</td><td>20.1</td><td>0.0</td><td>96</td></tr><tr><td>180 min Winter</td><td>19.000</td><td>0.0</td><td>22.5</td><td>0.0</td><td>134</td></tr><tr><td>240 min Winter</td><td>15.361</td><td>0.0</td><td>24.3</td><td>0.0</td><td>172</td></tr><tr><td>360 min Winter</td><td>11.306</td><td>0.0</td><td>26.8</td><td>0.0</td><td>242</td></tr><tr><td>480 min Winter</td><td>9.051</td><td>0.0</td><td>28.6</td><td>0.0</td><td>294</td></tr><tr><td>600 min Winter</td><td>7.594</td><td>0.0</td><td>30.0</td><td>0.0</td><td>344</td></tr><tr><td>720 min Winter</td><td>6.566</td><td>0.0</td><td>31.1</td><td>0.0</td><td>396</td></tr><tr><td>960 min Winter</td><td>5.201</td><td>0.0</td><td>32.8</td><td>0.0</td><td>498</td></tr><tr><td>1440 min Winter</td><td>3.721</td><td>0.0</td><td>35.3</td><td>0.0</td><td>738</td></tr><tr><td>2160 min Winter</td><td>2.641</td><td>0.0</td><td>37.5</td><td>0.0</td><td>1104</td></tr><tr><td>2880 min Winter</td><td>2.069</td><td>0.0</td><td>39.2</td><td>0.0</td><td>1428</td></tr><tr><td>4320 min Winter</td><td>1.470</td><td>0.0</td><td>41.8</td><td>0.0</td><td>2156</td></tr><tr><td>5760 min Winter</td><td>1.163</td><td>0.0</td><td>44.1</td><td>0.0</td><td>2896</td></tr><tr><td>7200 min Winter</td><td>0.988</td><td>0.0</td><td>46.8</td><td>0.0</td><td>3696</td></tr><tr><td>8640 min Winter</td><td>0.876</td><td>0.0</td><td>49.8</td><td>0.0</td><td>4416</td></tr><tr><td>10080 min Winter</td><td>0.800</td><td>0.0</td><td>53.1</td><td>0.0</td><td>5112</td></tr></table>			Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status	60 min Winter	9.998	0.998	1.9	0.0	1.9	11.0	Flood Risk	120 min Winter	9.959	0.959	1.9	0.0	1.9	10.5	Flood Risk	180 min Winter	9.876	0.876	1.8	0.0	1.8	9.6	Flood Risk	240 min Winter	9.781	0.781	1.8	0.0	1.8	8.6	Flood Risk	360 min Winter	9.552	0.552	1.8	0.0	1.8	6.1	O K	480 min Winter	9.333	0.333	1.8	0.0	1.8	3.7	O K	600 min Winter	9.206	0.206	1.8	0.0	1.8	2.3	O K	720 min Winter	9.136	0.136	1.7	0.0	1.7	1.5	O K	960 min Winter	9.080	0.080	1.4	0.0	1.4	0.9	O K	1440 min Winter	9.055	0.055	1.0	0.0	1.0	0.6	O K	2160 min Winter	9.041	0.041	0.7	0.0	0.7	0.5	O K	2880 min Winter	9.035	0.035	0.6	0.0	0.6	0.4	O K	4320 min Winter	9.028	0.028	0.4	0.0	0.4	0.3	O K	5760 min Winter	9.024	0.024	0.3	0.0	0.3	0.3	O K	7200 min Winter	9.021	0.021	0.3	0.0	0.3	0.2	O K	8640 min Winter	9.020	0.020	0.3	0.0	0.3	0.2	O K	10080 min Winter	9.018	0.018	0.2	0.0	0.2	0.2	O K	Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)	60 min Winter	41.532	0.0	16.4	0.0	58	120 min Winter	25.490	0.0	20.1	0.0	96	180 min Winter	19.000	0.0	22.5	0.0	134	240 min Winter	15.361	0.0	24.3	0.0	172	360 min Winter	11.306	0.0	26.8	0.0	242	480 min Winter	9.051	0.0	28.6	0.0	294	600 min Winter	7.594	0.0	30.0	0.0	344	720 min Winter	6.566	0.0	31.1	0.0	396	960 min Winter	5.201	0.0	32.8	0.0	498	1440 min Winter	3.721	0.0	35.3	0.0	738	2160 min Winter	2.641	0.0	37.5	0.0	1104	2880 min Winter	2.069	0.0	39.2	0.0	1428	4320 min Winter	1.470	0.0	41.8	0.0	2156	5760 min Winter	1.163	0.0	44.1	0.0	2896	7200 min Winter	0.988	0.0	46.8	0.0	3696	8640 min Winter	0.876	0.0	49.8	0.0	4416	10080 min Winter	0.800	0.0	53.1	0.0	5112
Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status																																																																																																																																																																																																																																																							
60 min Winter	9.998	0.998	1.9	0.0	1.9	11.0	Flood Risk																																																																																																																																																																																																																																																							
120 min Winter	9.959	0.959	1.9	0.0	1.9	10.5	Flood Risk																																																																																																																																																																																																																																																							
180 min Winter	9.876	0.876	1.8	0.0	1.8	9.6	Flood Risk																																																																																																																																																																																																																																																							
240 min Winter	9.781	0.781	1.8	0.0	1.8	8.6	Flood Risk																																																																																																																																																																																																																																																							
360 min Winter	9.552	0.552	1.8	0.0	1.8	6.1	O K																																																																																																																																																																																																																																																							
480 min Winter	9.333	0.333	1.8	0.0	1.8	3.7	O K																																																																																																																																																																																																																																																							
600 min Winter	9.206	0.206	1.8	0.0	1.8	2.3	O K																																																																																																																																																																																																																																																							
720 min Winter	9.136	0.136	1.7	0.0	1.7	1.5	O K																																																																																																																																																																																																																																																							
960 min Winter	9.080	0.080	1.4	0.0	1.4	0.9	O K																																																																																																																																																																																																																																																							
1440 min Winter	9.055	0.055	1.0	0.0	1.0	0.6	O K																																																																																																																																																																																																																																																							
2160 min Winter	9.041	0.041	0.7	0.0	0.7	0.5	O K																																																																																																																																																																																																																																																							
2880 min Winter	9.035	0.035	0.6	0.0	0.6	0.4	O K																																																																																																																																																																																																																																																							
4320 min Winter	9.028	0.028	0.4	0.0	0.4	0.3	O K																																																																																																																																																																																																																																																							
5760 min Winter	9.024	0.024	0.3	0.0	0.3	0.3	O K																																																																																																																																																																																																																																																							
7200 min Winter	9.021	0.021	0.3	0.0	0.3	0.2	O K																																																																																																																																																																																																																																																							
8640 min Winter	9.020	0.020	0.3	0.0	0.3	0.2	O K																																																																																																																																																																																																																																																							
10080 min Winter	9.018	0.018	0.2	0.0	0.2	0.2	O K																																																																																																																																																																																																																																																							
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)																																																																																																																																																																																																																																																									
60 min Winter	41.532	0.0	16.4	0.0	58																																																																																																																																																																																																																																																									
120 min Winter	25.490	0.0	20.1	0.0	96																																																																																																																																																																																																																																																									
180 min Winter	19.000	0.0	22.5	0.0	134																																																																																																																																																																																																																																																									
240 min Winter	15.361	0.0	24.3	0.0	172																																																																																																																																																																																																																																																									
360 min Winter	11.306	0.0	26.8	0.0	242																																																																																																																																																																																																																																																									
480 min Winter	9.051	0.0	28.6	0.0	294																																																																																																																																																																																																																																																									
600 min Winter	7.594	0.0	30.0	0.0	344																																																																																																																																																																																																																																																									
720 min Winter	6.566	0.0	31.1	0.0	396																																																																																																																																																																																																																																																									
960 min Winter	5.201	0.0	32.8	0.0	498																																																																																																																																																																																																																																																									
1440 min Winter	3.721	0.0	35.3	0.0	738																																																																																																																																																																																																																																																									
2160 min Winter	2.641	0.0	37.5	0.0	1104																																																																																																																																																																																																																																																									
2880 min Winter	2.069	0.0	39.2	0.0	1428																																																																																																																																																																																																																																																									
4320 min Winter	1.470	0.0	41.8	0.0	2156																																																																																																																																																																																																																																																									
5760 min Winter	1.163	0.0	44.1	0.0	2896																																																																																																																																																																																																																																																									
7200 min Winter	0.988	0.0	46.8	0.0	3696																																																																																																																																																																																																																																																									
8640 min Winter	0.876	0.0	49.8	0.0	4416																																																																																																																																																																																																																																																									
10080 min Winter	0.800	0.0	53.1	0.0	5112																																																																																																																																																																																																																																																									
©1982-2019 Innovyze																																																																																																																																																																																																																																																														

Delta-Simons		Page 4
Suite 4A Portland Street Manchester, M1 3BE	1 in 30 yr Bridge Road, Wrexham	
Date 07/07/2020 File 1 IN 100 + 20% PROJ - N...	Designed by AC Checked by JR	
Innovyze Source Control 2019.1		

Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

Invert Level (m) 9.000

Depth (m)	Area (m ²)	Depth (m)	Area (m ²)
0.000	11.0	1.000	11.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0065-1900-1000-1900
Design Head (m)	1.000
Design Flow (l/s)	1.9
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	65
Invert Level (m)	8.995
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	1.9
Flush-Flo™	0.286	1.8
Kick-Flo®	0.582	1.5
Mean Flow over Head Range	-	1.6

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

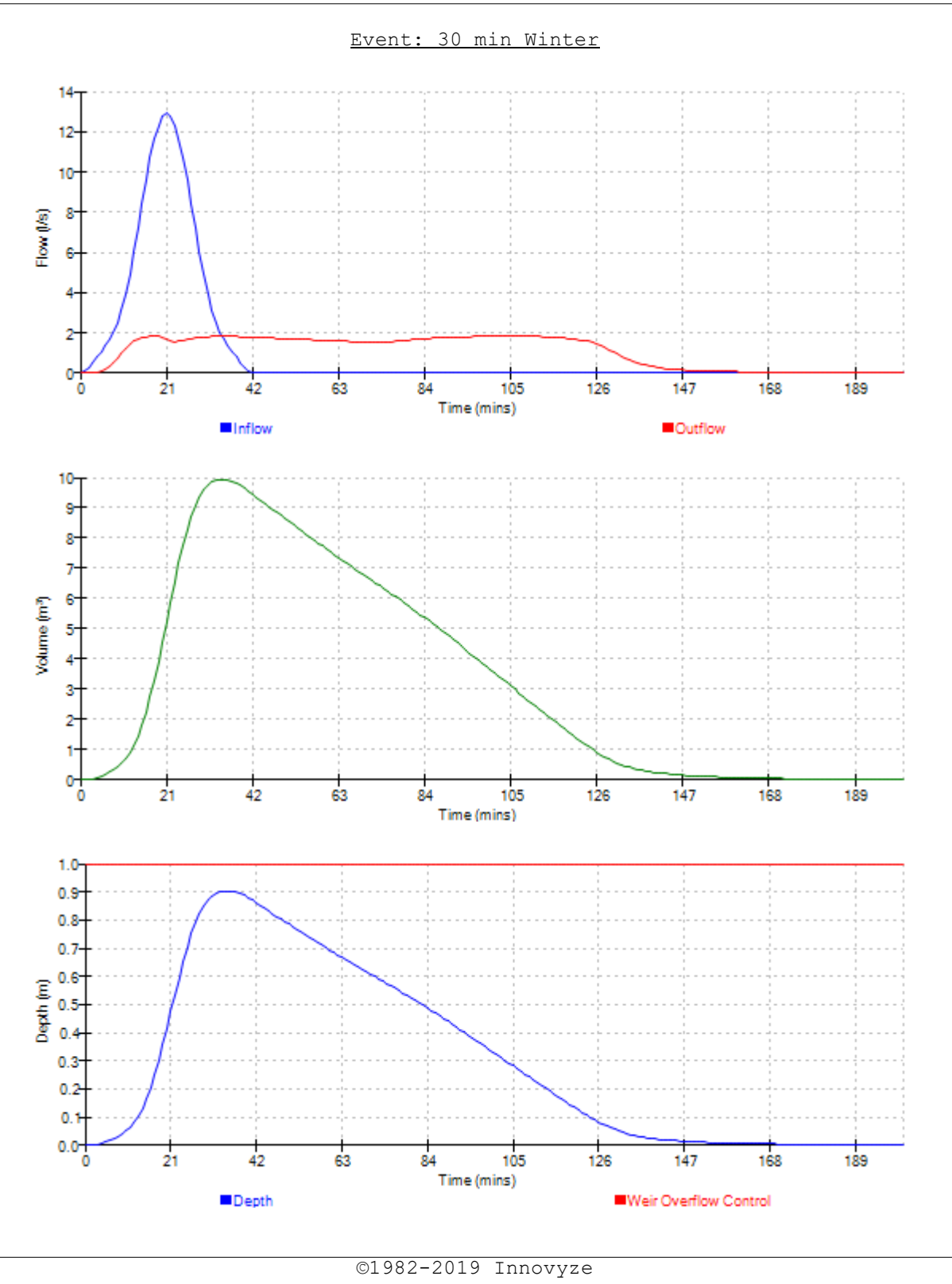
Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.5	1.200	2.1	3.000	3.1	7.000	4.7
0.200	1.8	1.400	2.2	3.500	3.4	7.500	4.8
0.300	1.8	1.600	2.4	4.000	3.6	8.000	5.0
0.400	1.8	1.800	2.5	4.500	3.8	8.500	5.1
0.500	1.7	2.000	2.6	5.000	4.0	9.000	5.3
0.600	1.5	2.200	2.7	5.500	4.2	9.500	5.4
0.800	1.7	2.400	2.8	6.000	4.3		
1.000	1.9	2.600	2.9	6.500	4.5		

Weir Overflow Control

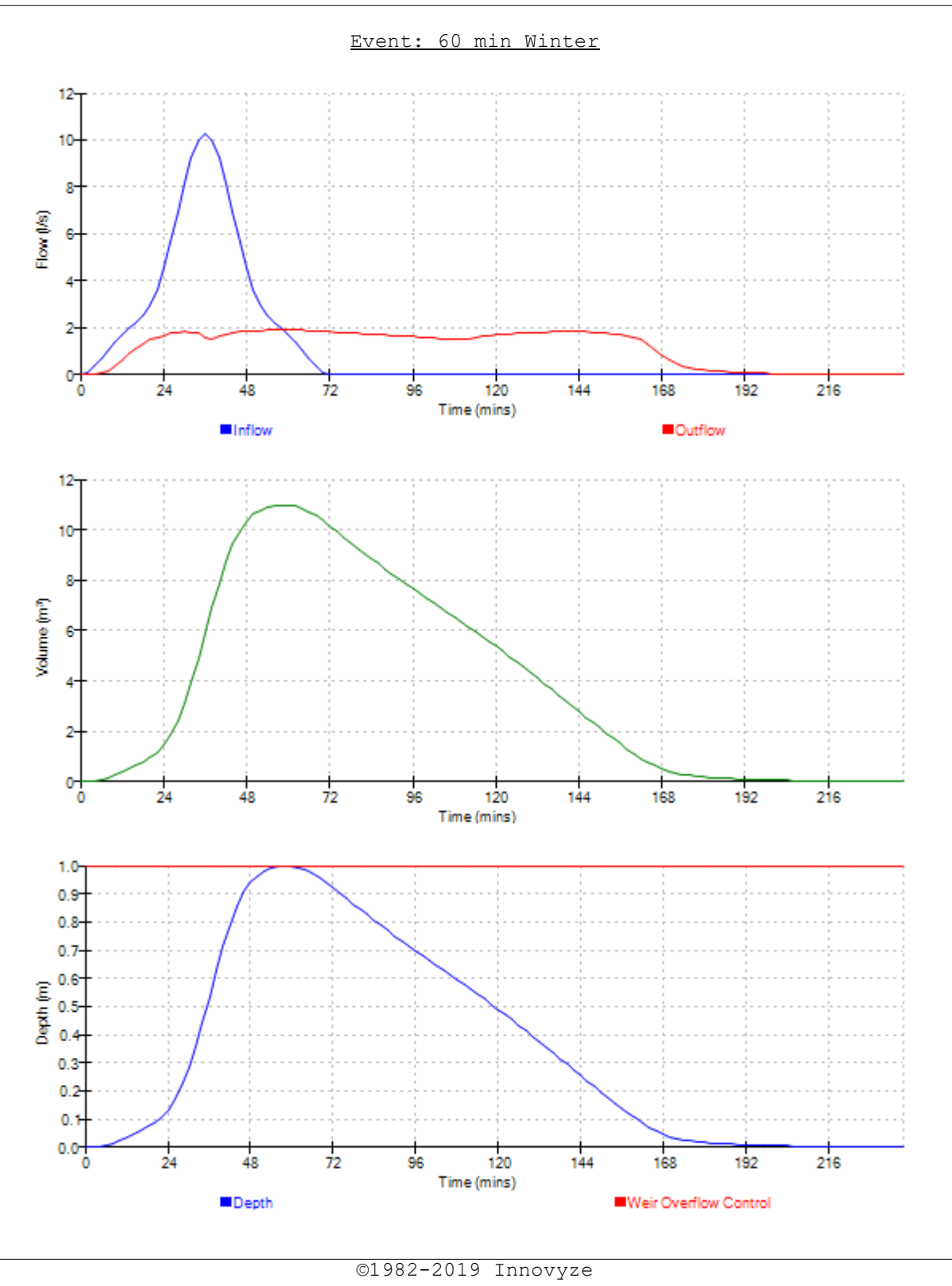
Discharge Coef 0.544 Width (m) 5.000 Invert Level (m) 10.000

©1982-2019 Innovyze

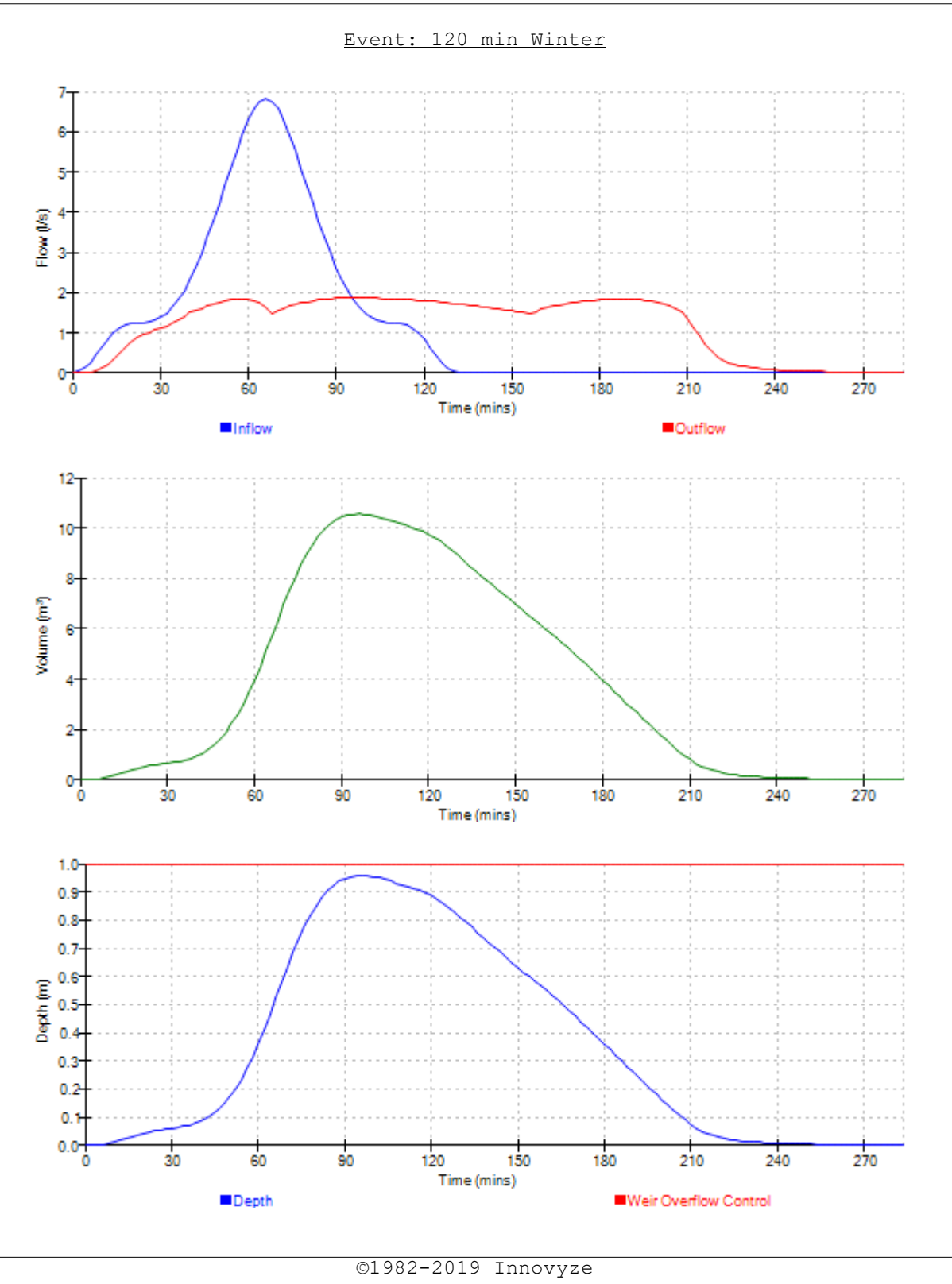
Delta-Simons		Page 5
Suite 4A Portland Street Manchester, M1 3BE	1 in 30 yr Bridge Road, Wrexham	
Date 07/07/2020 File 1 IN 100 + 20% PROJ - N...	Designed by AC Checked by JR	
Innovyze	Source Control 2019.1	



Delta-Simons		Page 6
Suite 4A Portland Street Manchester, M1 3BE	1 in 30 yr Bridge Road, Wrexham	
Date 07/07/2020 File 1 IN 100 + 20% PROJ - N...	Designed by AC Checked by JR	
Innovyze	Source Control 2019.1	



Delta-Simons		Page 7
Suite 4A Portland Street Manchester, M1 3BE	1 in 30 yr Bridge Road, Wrexham	
Date 07/07/2020 File 1 IN 100 + 20% PROJ - N...	Designed by AC Checked by JR	
Innovyze	Source Control 2019.1	



Delta-Simons						Page 1	
Suite 4A Portland Street Manchester, M1 3BE			1 in 100 yr Bridge Road, Wrexham				
Date 07/07/2020 File 1 IN 100 + 20% PROJ - N...			Designed by AC Checked by JR				
Innovyze			Source Control 2019.1				
<u>Summary of Results for 100 year Return Period (+20%)</u>							
Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	9.570	0.570	1.8	0.0	1.8	10.3	O K
30 min Summer	9.739	0.739	1.8	0.0	1.8	13.3	Flood Risk
60 min Summer	9.857	0.857	1.8	0.0	1.8	15.4	Flood Risk
120 min Summer	9.847	0.847	1.8	0.0	1.8	15.2	Flood Risk
180 min Summer	9.803	0.803	1.8	0.0	1.8	14.5	Flood Risk
240 min Summer	9.754	0.754	1.8	0.0	1.8	13.6	Flood Risk
360 min Summer	9.652	0.652	1.8	0.0	1.8	11.7	O K
480 min Summer	9.534	0.534	1.8	0.0	1.8	9.6	O K
600 min Summer	9.427	0.427	1.8	0.0	1.8	7.7	O K
720 min Summer	9.342	0.342	1.8	0.0	1.8	6.2	O K
960 min Summer	9.222	0.222	1.8	0.0	1.8	4.0	O K
1440 min Summer	9.110	0.110	1.6	0.0	1.6	2.0	O K
2160 min Summer	9.067	0.067	1.2	0.0	1.2	1.2	O K
2880 min Summer	9.052	0.052	1.0	0.0	1.0	0.9	O K
4320 min Summer	9.040	0.040	0.7	0.0	0.7	0.7	O K
5760 min Summer	9.033	0.033	0.5	0.0	0.5	0.6	O K
7200 min Summer	9.030	0.030	0.5	0.0	0.5	0.5	O K
8640 min Summer	9.027	0.027	0.4	0.0	0.4	0.5	O K
10080 min Summer	9.026	0.026	0.4	0.0	0.4	0.5	O K
15 min Winter	9.650	0.650	1.8	0.0	1.8	11.7	O K
30 min Winter	9.842	0.842	1.8	0.0	1.8	15.2	Flood Risk
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)		
15 min Summer	137.442	0.0	12.1	0.0	24		
30 min Summer	92.014	0.0	16.2	0.0	36		
60 min Summer	59.091	0.0	20.8	0.0	62		
120 min Summer	35.507	0.0	25.0	0.0	98		
180 min Summer	26.021	0.0	27.5	0.0	132		
240 min Summer	20.770	0.0	29.3	0.0	166		
360 min Summer	15.023	0.0	31.8	0.0	236		
480 min Summer	11.884	0.0	33.5	0.0	300		
600 min Summer	9.882	0.0	34.8	0.0	358		
720 min Summer	8.485	0.0	35.9	0.0	416		
960 min Summer	6.651	0.0	37.5	0.0	528		
1440 min Summer	4.694	0.0	39.7	0.0	752		
2160 min Summer	3.289	0.0	41.7	0.0	1104		
2880 min Summer	2.553	0.0	43.2	0.0	1468		
4320 min Summer	1.786	0.0	45.3	0.0	2192		
5760 min Summer	1.397	0.0	47.3	0.0	2888		
7200 min Summer	1.177	0.0	49.8	0.0	3656		
8640 min Summer	1.037	0.0	52.6	0.0	4376		
10080 min Summer	0.944	0.0	55.9	0.0	5072		
15 min Winter	137.442	0.0	13.6	0.0	24		
30 min Winter	92.014	0.0	18.2	0.0	36		
©1982-2019 Innovyze							

Delta-Simons		Page 2					
Suite 4A Portland Street Manchester, M1 3BE	1 in 100 yr Bridge Road, Wrexham						
Date 07/07/2020 File 1 IN 100 + 20% PROJ - N...	Designed by AC Checked by JR						
Innovyze Source Control 2019.1							
<u>Summary of Results for 100 year Return Period (+20%)</u>							
Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Outflow (l/s)	Max Volume (m³)	Status
60 min Winter	9.986	0.986	1.9	0.0	1.9	17.7	Flood Risk
120 min Winter	9.978	0.978	1.9	0.0	1.9	17.6	Flood Risk
180 min Winter	9.919	0.919	1.8	0.0	1.8	16.5	Flood Risk
240 min Winter	9.848	0.848	1.8	0.0	1.8	15.3	Flood Risk
360 min Winter	9.698	0.698	1.8	0.0	1.8	12.6	O K
480 min Winter	9.517	0.517	1.8	0.0	1.8	9.3	O K
600 min Winter	9.364	0.364	1.8	0.0	1.8	6.5	O K
720 min Winter	9.255	0.255	1.8	0.0	1.8	4.6	O K
960 min Winter	9.135	0.135	1.7	0.0	1.7	2.4	O K
1440 min Winter	9.070	0.070	1.3	0.0	1.3	1.3	O K
2160 min Winter	9.049	0.049	0.9	0.0	0.9	0.9	O K
2880 min Winter	9.040	0.040	0.7	0.0	0.7	0.7	O K
4320 min Winter	9.032	0.032	0.5	0.0	0.5	0.6	O K
5760 min Winter	9.027	0.027	0.4	0.0	0.4	0.5	O K
7200 min Winter	9.024	0.024	0.3	0.0	0.3	0.4	O K
8640 min Winter	9.022	0.022	0.3	0.0	0.3	0.4	O K
10080 min Winter	9.021	0.021	0.3	0.0	0.3	0.4	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)		
60 min Winter	59.091	0.0	23.3	0.0	62		
120 min Winter	35.507	0.0	28.0	0.0	104		
180 min Winter	26.021	0.0	30.8	0.0	140		
240 min Winter	20.770	0.0	32.8	0.0	180		
360 min Winter	15.023	0.0	35.6	0.0	254		
480 min Winter	11.884	0.0	37.5	0.0	322		
600 min Winter	9.882	0.0	39.0	0.0	376		
720 min Winter	8.485	0.0	40.2	0.0	428		
960 min Winter	6.651	0.0	42.0	0.0	530		
1440 min Winter	4.694	0.0	44.5	0.0	742		
2160 min Winter	3.289	0.0	46.7	0.0	1092		
2880 min Winter	2.553	0.0	48.4	0.0	1472		
4320 min Winter	1.786	0.0	50.8	0.0	2200		
5760 min Winter	1.397	0.0	52.9	0.0	2904		
7200 min Winter	1.177	0.0	55.8	0.0	3656		
8640 min Winter	1.037	0.0	59.0	0.0	4304		
10080 min Winter	0.944	0.0	62.6	0.0	5080		
©1982-2019 Innovyze							

Delta-Simons		Page 3
Suite 4A Portland Street Manchester, M1 3BE	1 in 100 yr Bridge Road, Wrexham	
Date 07/07/2020 File 1 IN 100 + 20% PROJ - N...	Designed by AC Checked by JR	
Innovyze Source Control 2019.1		

Delta-Simons		Page 4
Suite 4A Portland Street Manchester, M1 3BE	1 in 100 yr Bridge Road, Wrexham	
Date 07/07/2020 File 1 IN 100 + 20% PROJ - N...	Designed by AC Checked by JR	
Innovyze Source Control 2019.1		

Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

Invert Level (m) 9.000

Depth (m)	Area (m ²)	Depth (m)	Area (m ²)
0.000	18.0	1.000	18.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0065-1900-1000-1900
Design Head (m)	1.000
Design Flow (l/s)	1.9
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	65
Invert Level (m)	8.995
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	1.9
Flush-Flo™	0.286	1.8
Kick-Flo®	0.582	1.5
Mean Flow over Head Range	-	1.6

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

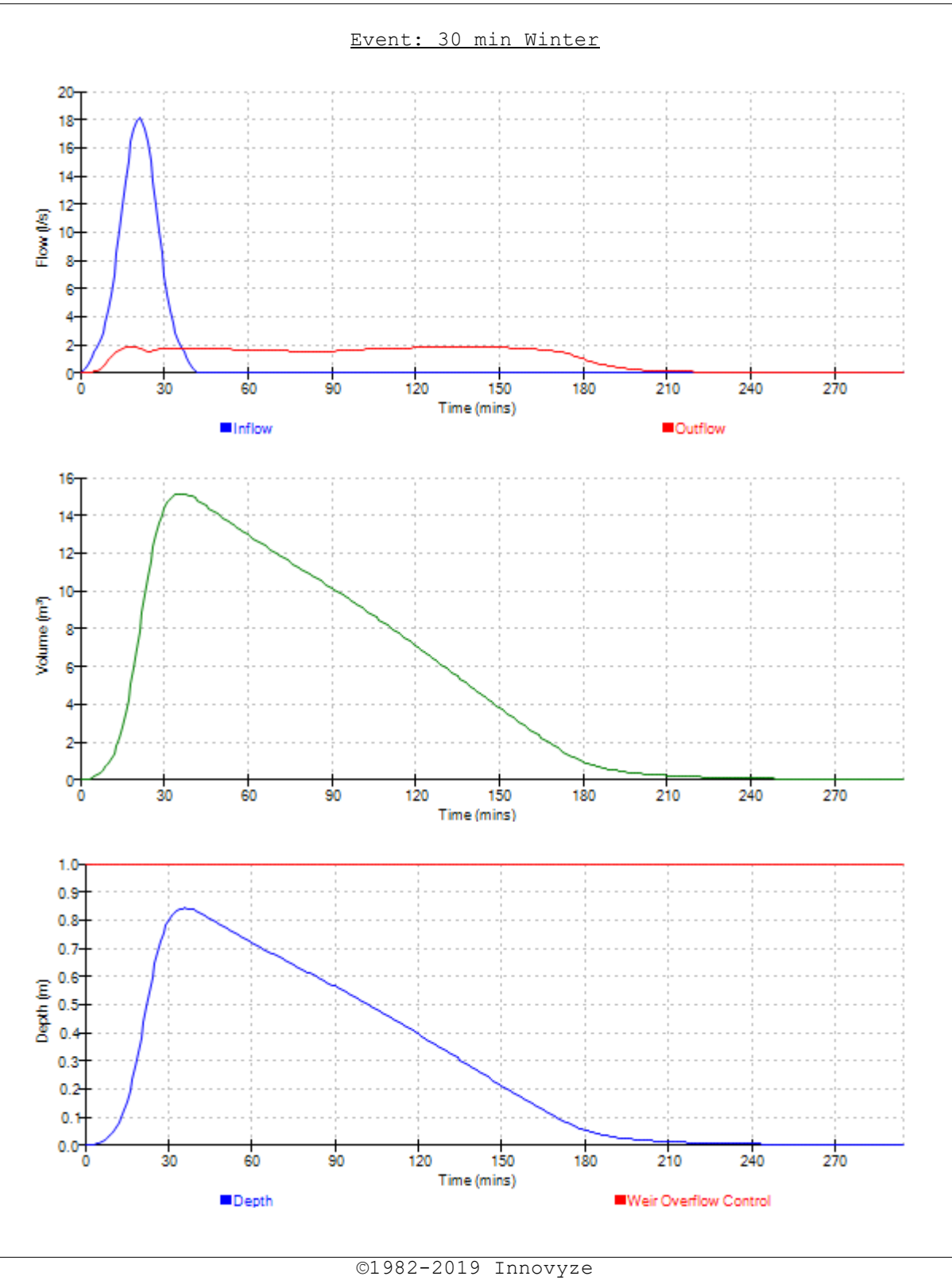
Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.5	1.200	2.1	3.000	3.1	7.000	4.7
0.200	1.8	1.400	2.2	3.500	3.4	7.500	4.8
0.300	1.8	1.600	2.4	4.000	3.6	8.000	5.0
0.400	1.8	1.800	2.5	4.500	3.8	8.500	5.1
0.500	1.7	2.000	2.6	5.000	4.0	9.000	5.3
0.600	1.5	2.200	2.7	5.500	4.2	9.500	5.4
0.800	1.7	2.400	2.8	6.000	4.3		
1.000	1.9	2.600	2.9	6.500	4.5		

Weir Overflow Control

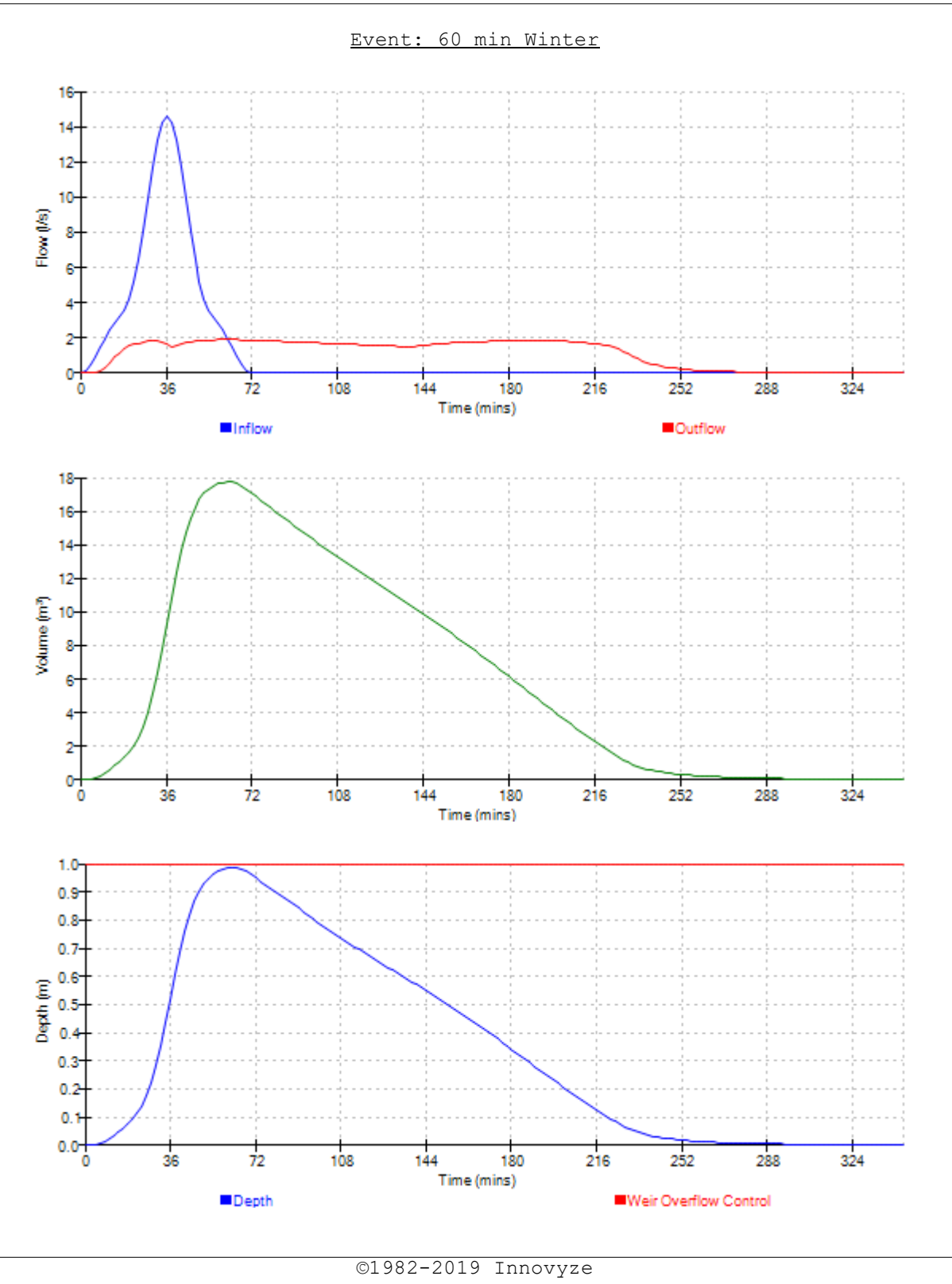
Discharge Coef 0.544 Width (m) 5.000 Invert Level (m) 10.000

©1982-2019 Innovyze

Delta-Simons		Page 5
Suite 4A Portland Street Manchester, M1 3BE	1 in 100 yr Bridge Road, Wrexham	
Date 07/07/2020 File 1 IN 100 + 20% PROJ - N...	Designed by AC Checked by JR	
Innovyze	Source Control 2019.1	

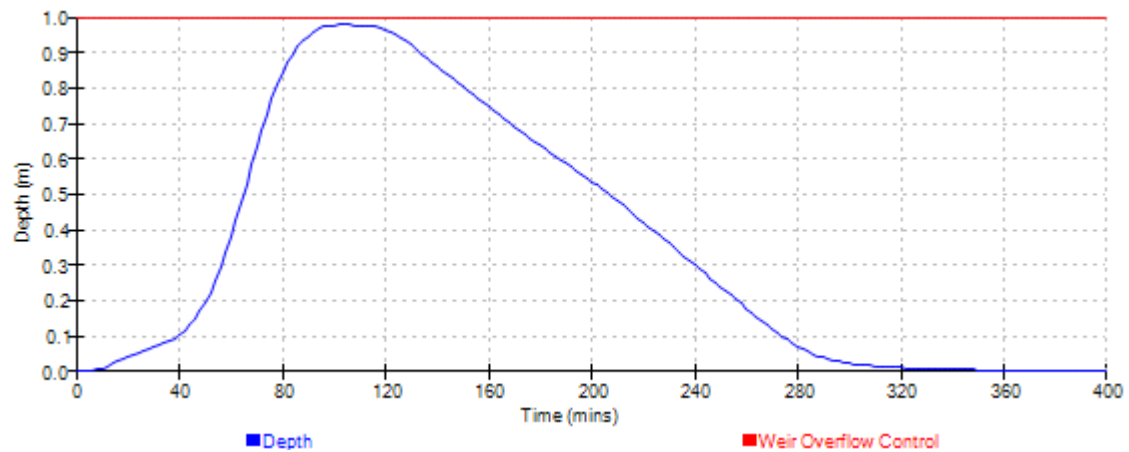
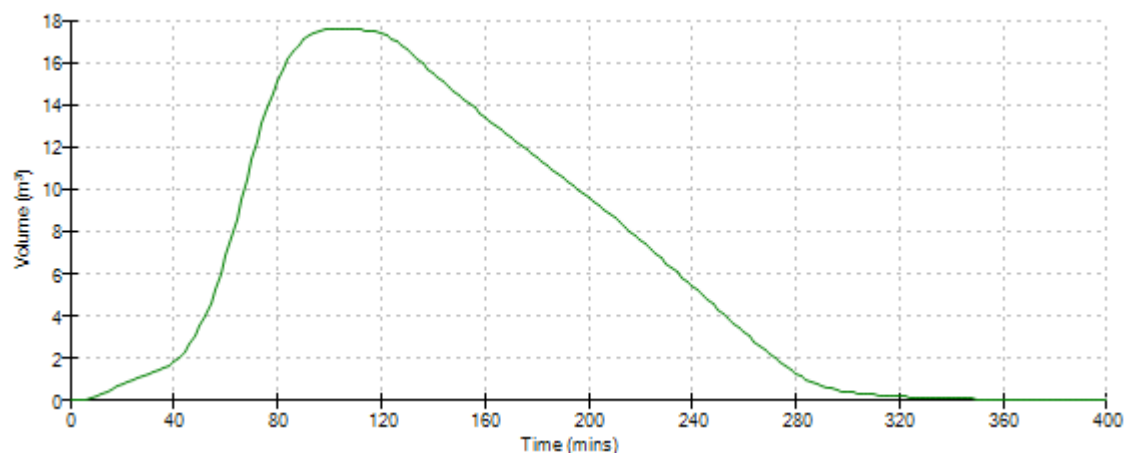
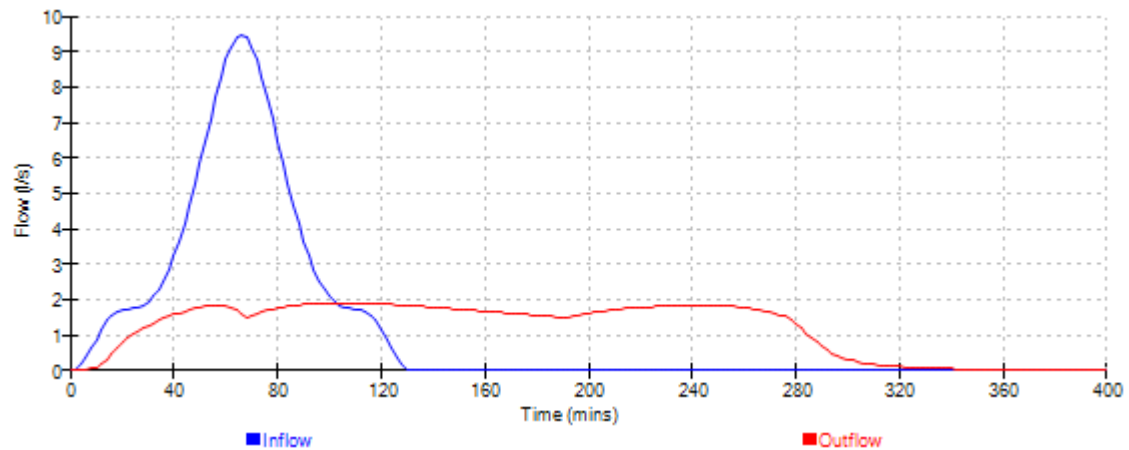


Delta-Simons		Page 6
Suite 4A Portland Street Manchester, M1 3BE	1 in 100 yr Bridge Road, Wrexham	
Date 07/07/2020 File 1 IN 100 + 20% PROJ - N...	Designed by AC Checked by JR	
Innovyze	Source Control 2019.1	



Delta-Simons		Page 7
Suite 4A Portland Street Manchester, M1 3BE	1 in 100 yr Bridge Road, Wrexham	
Date 07/07/2020 File 1 IN 100 + 20% PROJ - N...	Designed by AC Checked by JR	
Innovyze	Source Control 2019.1	

Event: 120 min Winter



Appendix F – Maintenance Schedules

Attenuation Storage Tank Maintenance Schedule

Maintenance Schedule	Required Action	Typical Frequency
Regular maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action	Monthly for 3 months, then annually
	Remove debris from the catchment surface (where it may cause risks to performance)	Monthly
	For systems where rainfall infiltrates into the tank from above, check surface of filter for blockage by sediment, algae, or other matter; remove and replace surface infiltration medium as necessary	Annually
	Remove sediment from pre-treatment structures and/ or internal forebays	Annually, or as required
Remedial actions	Repair/rehabilitate inlets, outlet, overflows, and vents	As required
Monitoring	Inspect/check all inlets, outlets, vents, and overflows 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

Ref. Table 21.3, CIRIA C753 'The SuDS Manual'

Permeable Paving Maintenance Schedule

Maintenance Schedule	Required Action	Typical Frequency
Regular maintenance	Brushing and vacuuming (standard cosmetic sweep over whole surface)	Once a year, after autumn leaf fall, or reduced frequency as required, based on Site-specific observations of clogging or manufacturer's recommendations – pay particular attention to areas where water runs onto pervious surface from adjacent impermeable areas as this area is most likely to collect the most sediment
Occasional maintenance	Stabilise and move contributing and adjacent areas	As required
	Removal of weeds or management using glyphosate applied directly into the weeds by an applicator rather than spraying	As required – once per year on less frequently used pavements
Remedial actions	Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50mm of the level of the paving	As required
	Rehabilitation of surface and upper substructure by remedial sweeping	Every 10 to 15 years or as required (if infiltration performance is reduced due to significant clogging)
Monitoring	Inspect for evidence of poor operation and / or weed growth – if required, take remedial action	Three-monthly, 48hr after large storms in first six months
	Inspect silt accumulation rates and establish appropriate brushing frequencies	Annually
	Monitor inspection chambers	Annually

Ref. Table 20.15, CIRIA C753 'The SuDS Manual'