Weetwood
Development • Planning • Environment

LAND OFF ABER ROAD, FLINT,
FLINTSHIRE, CH6 5EX

FLOOD CONSEQUENCES AND DRAINAGE ASSESSMENT

Final Report v2.1
June 2023

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Report Title	**Land Off Aber Road, Flint, Flintshire, CH6 5EX** Flood Consequences and Drainage Assessment Final Report v2.1
Client	HMG (Aber Road) Limited
Date of issue	7 June 2023

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1 INTRODUCTION

1.1 Purpose of Report

Weetwood Services Ltd ('Weetwood') has been instructed by HMG (Aber Road) Limited to prepare a Flood Consequences and Drainage Assessment (FCDA) report to accompany a full planning application for the proposed redevelopment of land off Aber Road, Flint, Flintshire ("the site") for industrial use.

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	Provides background information relating to the development site
Section 3	Presents national and local flood risk and drainage planning policy
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	Presents an illustrative surface water drainage scheme
Section 7	Summarises how foul water flows from the development will be disposed
Section 8	Presents a summary of key findings and the recommendations

1.3 Relevant Documents

The assessment has been informed by the following documents:

- Strategic Flood Consequences Assessment, Flintshire County Council, July 2018
- Preliminary Flood Risk Assessment, Flintshire County Council, June 2011

2 SITE DETAILS AND PROPOSED DEVELOPMENT

2.1 Site Location

The approximately 0.7 ha site is located to the south-east of Aber Road at Ordnance Survey National Grid Reference SJ 239 734, as shown in **Figure 1**.

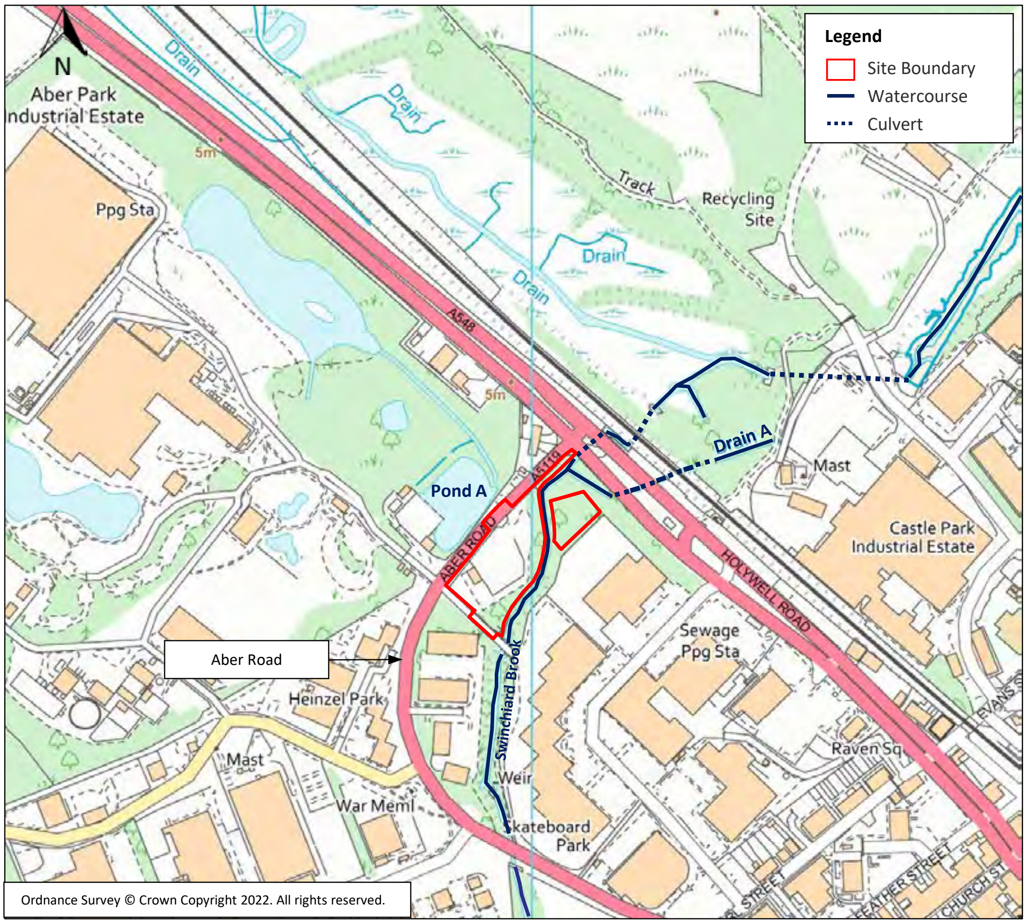


Figure 1: Site Location

2.2 Existing and Proposed Development

The site was previously occupied by a large industrial building (approximately 2,300 m^2), with associated infrastructure, hardstanding and car parking. The building has since been demolished and the current hardstanding area is being used as a hand car wash facility, with a small building (approximately 210 m^2) in the south-west. The existing site plan is provided in **Appendix A**.

The proposals comprise the construction of 6 commercial units with associated loading bays (equating to 2,173 m^2), car parking and landscaping. Access to the site will continue to be provided via Aber Road to the north, with an additional access provided to the south. The proposed site plan is provided in **Appendix B**.

Please note, the isolated parcel of land to the north-east of the site shown in is proposed as a flood storage area.

TAN15 classifies general industry development as Less Vulnerable to flood risk.

2.3 Waterbodies in the Vicinity of the Site

Swinchiard Brook flows in a northerly direction along the eastern boundary of the site, before being culverted under Holywell Road (A548) and ultimately outfalling into the River Dee. The River Dee is located approximately 500 m to the north-east of the site.

Drain A flows in a south-westerly direction to the east of the site before outfalling into Swinchiard Brook approximately 35 m north-east of the site.

Pond A is located approximately 23 m north-west of the site beyond Aber Road.

The River Dee is classified as a main river, whilst Swinchiard Brook is an ordinary watercourse.

2.4 Topographic Levels

A topographic survey of the site was undertaken by Powers and Tiltman Ltd in 2010 (**Appendix C**) and LiDAR data has been used to develop a digital terrain model of the site and surrounding area as illustrated in **Figure 2**.

Site levels are shown to be in the region of 6.1 - 8.0 m AOD falling in a northerly direction.

Levels along Aber Road, adjacent to the site, are shown to rise from 6.4 m AOD at the site entrance to 7.4 m AOD to the south-west. Levels on the road along the south-western boundary of the site are between 7.4 - 8.1 m AOD.

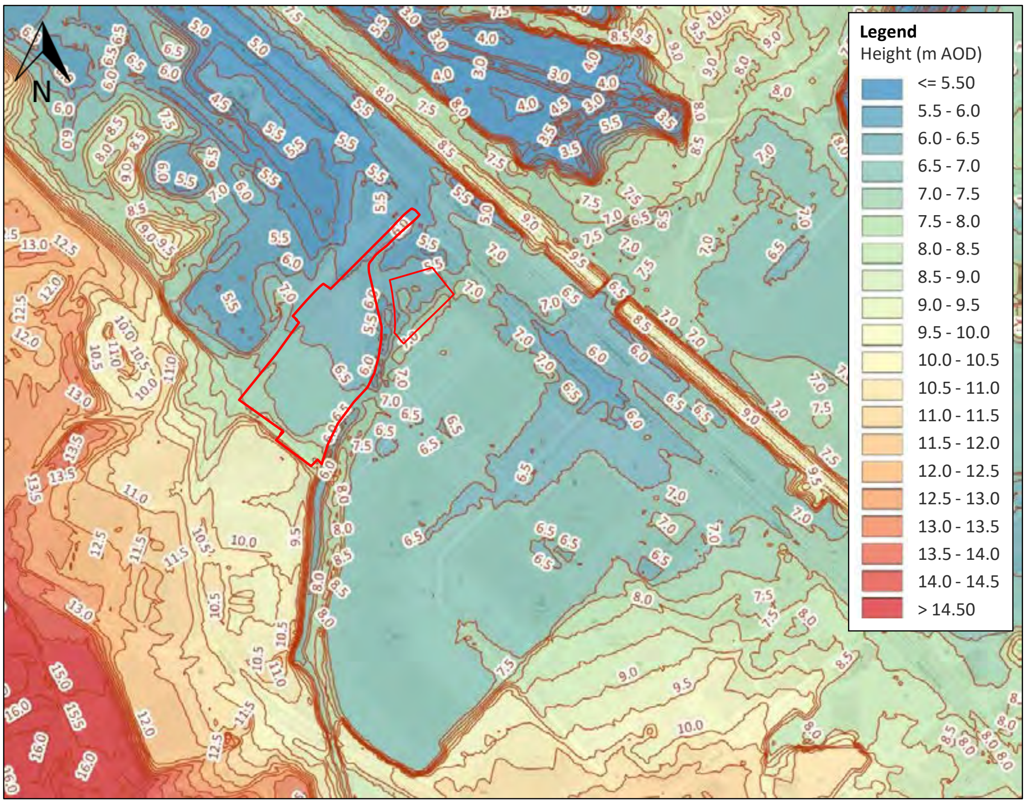


Figure 2: Digital Terrain Model from LiDAR Data

2.5 Ground Conditions

A geo-environmental assessment of the site was undertaken by Atkinson Peck Consulting Engineers in May 2008[1]. The site investigation comprised five boreholes. The assessment reported ground conditions to comprise made ground (gravels, ash, sands, silts, clays) to typical depths of 2.3 - 2.6 m bgl, underlain by soft to firm brown sandy clay extending to between 3.3 - 6.0 m bgl with gravel recorded in some boreholes. Groundwater was recorded in all boreholes at depths ranging between 1.2 - 1.4 m bgl.

According to the Soilscapes soils dataset produced by the Cranfield Soil and AgriFood Institute[2], soil conditions at the site and within the surrounding area are slowly permeable, seasonally wet, slightly acid but base-rich loamy and clayey soils..

British Geological Survey mapping of surface geology[3] indicates the underlying bedrock formation comprises of mudstone, siltstone and sandstone (Pennine Middle Coal Measures Formation), overlain by clay, silt and sands (Tidal Flat Deposits).

The British Geological Survey and Natural Resources Wales aquifer designation dataset[4] classifies the clay, silt and sands superficial deposits at the site as a Secondary Undifferentiated aquifer whilst the underlying mudstone, siltstone and sandstone bedrock is classified as a Secondary A aquifer.

According to the Natural Resources Wales database[5] the site is not shown to be located within a designated groundwater source protection zone.

1 Site Investigation Report, Atkinson Peck Consulting Engineers, May 2008 (Ref. KM/C14157)
2 www.landis.org.uk/soilscapes/
3 http://mapapps2.bgs.ac.uk/geoindex/home.html
4 Footnote 3
5 https://lle.gov.wales/catalogue/item/SourceProtectionZonesSPZMerged/?lang=en

3 PLANNING POLICY AND GUIDANCE

3.1 National Planning Policy and Guidance

Future Wales - the national Plan 2040 sets out the national development framework for Wales with a strategy for addressing key national priorities through the planning system, including sustaining and developing a vibrant economy, achieving decarbonisation and climate-resilience, developing strong ecosystems and improving the health and well-being of our communities.

Policy 8 - Flooding states that *"flood risk management that enables and supports sustainable strategic growth and regeneration in National and Regional Growth Areas will be supported. The Welsh Government will work with Flood Risk Management Authorities and developers to plan and invest in new and improved infrastructure, promoting nature-based solutions as a priority. Opportunities for multiple social, economic and environmental benefits must be maximised when investing in flood risk management infrastructure. It must be ensured that projects do not have adverse impacts on international and national statutory designated sites for nature conservation and the features for which they have been designated"*.

Planning Policy Wales (PPW) sets out government's planning policies for Wales and how these are expected to be applied. TAN15 provides technical guidance which supplements the policy within PPW and seeks to ensure that flood risk is taken into account at all stages in the planning process and is appropriately addressed.

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 developments which can be justified should be located in such areas.

In accordance with paragraph 6 of TAN15, development will only be justified if it can 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 PPW and meets the definition of previously developed land (PPW Figure 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.

National policy requires that planning applications for new development proposals should incorporate sustainable drainage systems (SuDS) to appropriate operational standards and with maintenance arrangements in place unless there is clear evidence that this would be inappropriate.

Statutory standards for sustainable drainage were published by Welsh Government in October 2018[6] in relation to the design, construction, operation and maintenance of sustainable drainage systems serving new developments of more than one house or where the construction area is equal to or greater than 100 m^2. These standards set out how surface water runoff generated during the present day 1 in 1, 1 in 30 and 1 in 100 annual exceedance probability (AEP) rainfall events and for events exceeding the present day 1 in 100 AEP event should be managed, how peak runoff rates should be restricted and how runoff volumes should

6 Statutory Standards for Sustainable Drainage Systems – designing, constructing, operating and maintaining surface water drainage systems (https://gov.wales/sites/default/files/publications/2019-06/statutory-national-standards-for-sustainable-drainage-systems.pdf)

be controlled. Approval is subsequently required from the SuDS Approval Body (SAB) before construction can commence.

3.2 Local Planning Policy and Guidance

The Flintshire Local Development Plan was adopted by Flintshire County Council in January 2023. The following policies are relevant in respect of flood risk and drainage:

Policy EN14; Flood Risk

In order to avoid the risk of flooding, development will not be permitted:

a) *in areas at risk of fluvial, pluvial, coastal and reservoir flooding, unless it can be demonstrated that the development can be justified in line with national guidance and is supported by a technical assessment that verifies that the new development is designed to alleviate the threat and consequences of flooding;*
b) *where it would lead to an increase in the risk of flooding on the site or elsewhere from fluvial, pluvial, coastal or increased surface water run-off from the site;*
c) *where it would have a detrimental effect on the integrity of existing flood risk management assets: or*
d) *where it would impede access to existing and proposed flood risk management assets for maintenance and emergency purposes.*

Policy EN15; Water Resources

Development affecting water resources will only be permitted if:

a) *it would not have a significant adverse impact on the capacity and flow of groundwater, surface water, or coastal water systems;*
b) *it would not pose an unacceptable risk to the quality of groundwater, surface water, or coastal water; and*
c) *it would have access to adequate water supply, sewerage and sewage treatment facilities which either already exist, or will be provided in time to serve the development, without detriment to existing abstractions, water quality, fisheries, amenity or nature conservation.*

3.3 Water Framework Directive

The Water Framework Directive (WFD) provides a legal framework for the protection, improvement and sustainable use of inland surface waters, groundwater, transitional waters, and coastal waters across Wales, and seeks to:

- Prevent deterioration in the status of aquatic ecosystems, protect them and improve the ecological condition of waters
- Achieve at least 'good' status for all waterbodies by 2015
- Promote the sustainable use of water as a natural resource
- Conserve habitats and species that depend directly on water
- Progressively reduce or phase out the release of individual pollutants or groups of pollutants that present a significant threat to the aquatic environment
- Progressively reduce the pollution of groundwater and prevent or limit the entry of pollutants; and
- Contribute to mitigating the effects of floods and droughts.

The WFD applies to any proposed development which has the potential to impact on a waterbody. Where this is the case, Natural Resources Wales may require evidence demonstrating that the proposed development does not compromise the aims of the WFD.

3.4 Environmental Permitting and Land Drainage Consent

Under the Environmental Permitting (England and Wales) Regulations 2016 an Environmental Permit for Flood Risk Activities[7] is required from Natural Resources Wales for any permanent or temporary works:

- In, over or under a designated main river
- Within 8 m of the top of bank of a designated main river or of the landward toe of a flood defence (16 m if it is a tidal main river or a sea defence).

In addition, any permanent or temporary works within the floodplain of a designated main river may also require an Environmental Permit for Flood Risk Activities. A permit is separate to and in addition to any planning permission granted.

Land drainage consent may be required from the lead local flood authority for work to an ordinary watercourse.

Undertaking activities controlled by local byelaws also requires the relevant consent.

[7] https://naturalresources.wales/permits-and-permissions/environmental-permits/?lang=enhttps://www.gov.uk/guidance/flood-risk-activities-environmental-permits

4 REVIEW OF FLOOD RISK

4.1 Historical Records of Flooding

The Natural Resources Wales historic flood outlines database[8] indicates that flooding in the north and east of the site occurred in 2000 as a result of the Swinchiard Brook channel capacity being exceeded. No details have been made available to confirm flood levels during that event.

4.2 Flood Zone Designation

Figure 1 of TAN15 defines 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 [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:
    - Zone C1: Areas of the floodplain which are developed and served by significant infrastructure, including flood defences
    - Zone C2: Areas of the floodplain without significant flood defence infrastructure

The development advice zones are shown on the Development Advice Map[9] and are defined by the predicted extent of the 1 in 1,000 (rivers and sea) AEP event (zone C) and British Geological Survey drift data (zone B).

The Development Advice Map (**Figure 3**) indicates that the majority of the site is located in zone C1 with an area in the south located in zone B.

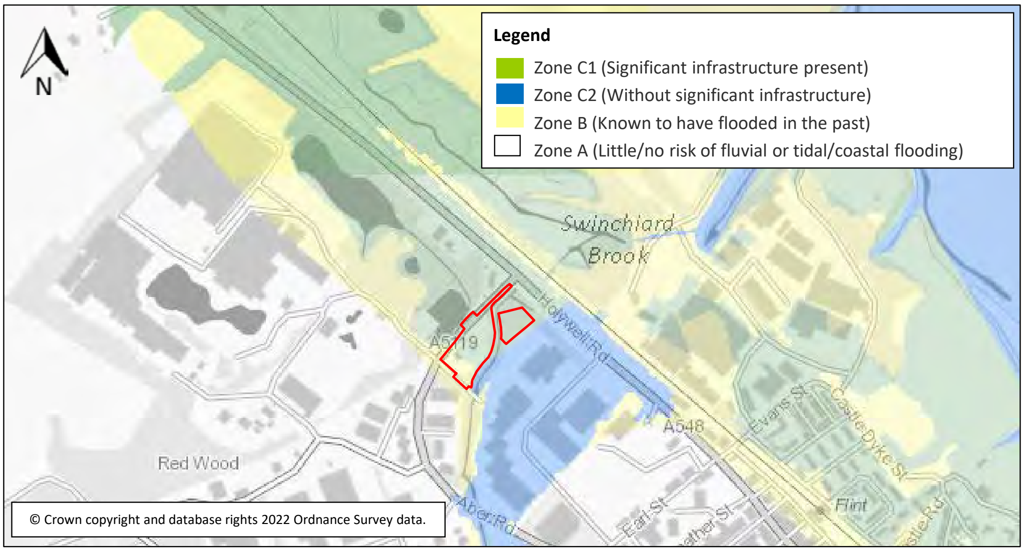


Figure 3: Development Advice Map
Source: Natural Resources Wales website; Accessed: June 2022

4.3 Flood Risk from the Sea (Tidal / Coastal)

The DataMapWales indicates the presence of several tidal/coastal flood defence assets within the vicinity of the site. The corresponding asset information is provided in **Table 1**.

[8] http://lle.gov.wales/catalogue/item/HistoricFl/?lang=en
[9] https://naturalresources.wales/evidence-and-data/maps/long-term-flood-risk/?lang=en

Table 1: Existing Tidal / Coastal Flood Defence Information

Object ID	Asset Description	Crest Level (m AOD)	Condition
609	High ground with sections of stone revetment	7.60*	Fair
489	Embankment with gabion basket frontage	6.52	Very Good
603	High ground - old industrial waste site	7.23	Very Good
556	Trapezoidal clay embankment with masonry revetment on the face in.	6.36	Poor

* Indicates where LiDAR has been utilised to inform estimated crest level where detailed information is not available

According to the Environment Agency's Coastal Flood Boundary Conditions for the UK: 2018 Update[10], the following modelled peak still tidal levels are expected adjacent to the site:

- 1 in 200 (2017) AEP event 6.42 m AOD
- 1 in 1,000 (2017) AEP event 6.63 m AOD

TAN15 requires an allowance for climate change to be made. Using the allowance set out in Welsh Government guidance[11] and a development lifetime of 75 years, this allowance has been calculated as 0.66 m (70th Percentile; 70P) and 0.90 m (95th Percentile; 95P) for the year 2097. It is noted that this should ideally be for the year 2098; however, the associated hydraulic modelling to assess flood risk from this source (as discussed below) was undertaken in 2022 and the additional year of climate change is considered to be negligible. The peak still tidal level for the 1 in 200 AEP event plus climate change (2097) is therefore estimated to be 7.08 m AOD (70P) and 7.32 m AOD (95P), whilst the 1 in 1,000 AEP event plus climate change (2097) is 7.29 m AOD (70P) and 7.53 m AOD (95P).

The Welsh Government climate change guidance is based on UK Climate Projections (UKCP18) data and states *"as a minimum, development proposals should be assessed against the relevant regional 70th percentile… to inform design levels. An assessment should also be made against the 95th percentile to inform mitigation measures, access and egress routes and emergency evacuation plans"*.

Overtopping and breach of the of the River Dee tidal/coastal flood defences was assessed by Natural Resources Wales as part of the Flint Point to Greenfield Initial Assessment Study (January 2015) utilising a 1D-2D Estry-TUFLOW hydraulic model, which includes the site. However, the tidal levels and climate change allowances utilised within the study are based on now superseded datasets/information.

In order to account for the latest peak still tidal levels and climate change allowances, overtopping and breach of the existing flood defences has subsequently been assessed by Weetwood as part of the River Dee (Tidal) Hydraulic Modelling Study (April 2023) (**Appendix D**) for the 1 in 200 and 1 in 1,000 AEP events plus climate change (2097 - 70P and 95P[12]).

The modelled overtopping and breach outputs are provided in **Figure 4** and **Figure 5** respectively.

Table 2 and **Table 3** summarise the maximum level, depth and velocity of floodwaters expected at the site during the aforementioned overtopping and breach scenarios.

The proposed access to the north of the site immediately off Aber Road is expected to flood during all modelled tidal events. However, the south-western boundary of the site which leads to Aber Road remains dry in all modelled tidal events.

[10] https://data.gov.uk/dataset/73834283-7dc4-488a-9583-a920072d9a9d/coastal-design-sea-levels-coastal-flood-boundary-extreme-sea-levels-2018

[11] Flood Consequences Assessments: Climate Change Allowances - https://gov.wales/sites/default/files/publications/2021-09/climate-change-allowances-and-flood-consequence-assessments_0.pdf

[12] The River Dee tidal model was initially run by Weetwood in December 2022, as such climate change was considered to the year 2097. Accounting for the additional increase to the year 2098 would result in a 0.012 m increase in peak still tidal levels, and as such is unlikely to have any material impact on modelled flood levels on site when compared to the year 2097.

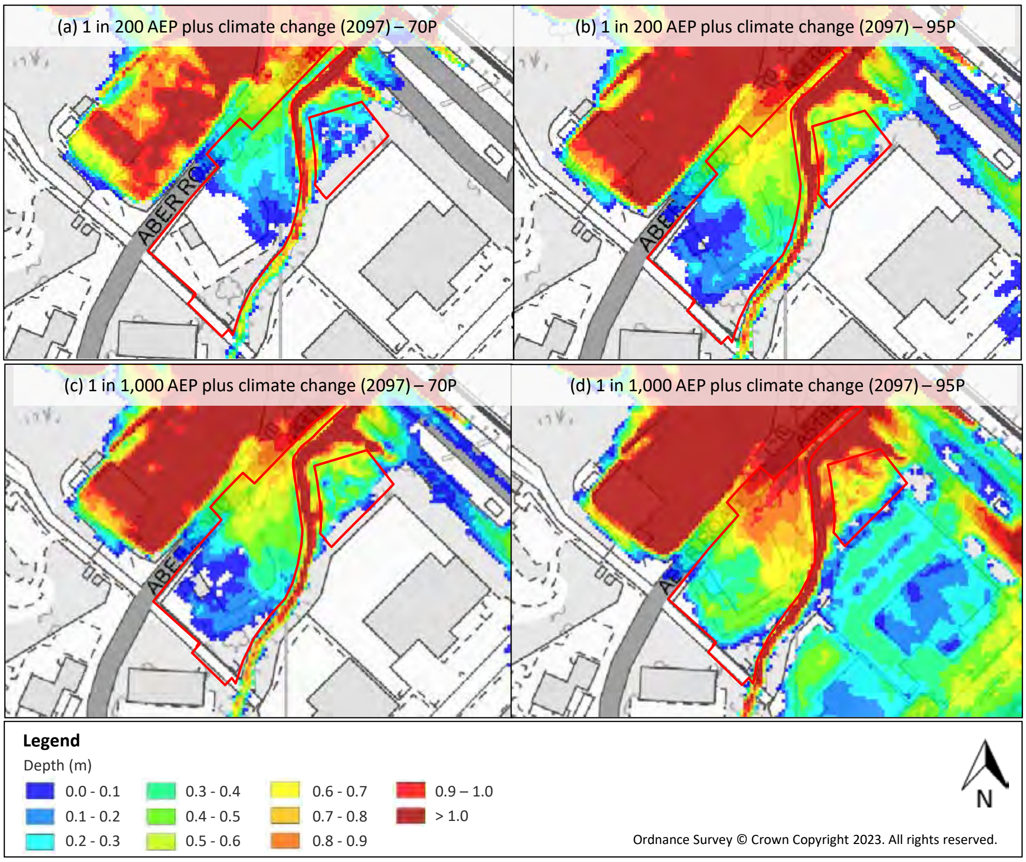


Figure 4: River Dee (Tidal) Modelled Flood Extents (Baseline) - Overtopping
Source: River Dee Hydraulic Modelling Study, Weetwood, April 2023

Table 2: Site Flood Information - Tidal Overtopping (Baseline)
Source: River Dee Hydraulic Modelling Study, Weetwood, April 2023

AEP Event	Max Level (m AOD)	Max Depth (m)		Max Velocity (m/s)	
		Highest	Mean	Highest	Mean
1 in 200 plus climate change (2097 - 70P)	6.56	0.55	0.21	0.62	0.06
1 in 1,000 plus climate change (2097 - 70P)	6.83	0.93	0.30	0.82	0.07
1 in 200 plus climate change (2097 - 95P)	6.86	0.96	0.32	0.85	0.08
1 in 1,000 plus climate change (2097 - 95P)	7.13	1.23	0.55	0.94	0.15

n.b. The above table ignores areas of land where no development is proposed, such as the proposed flood storage area.

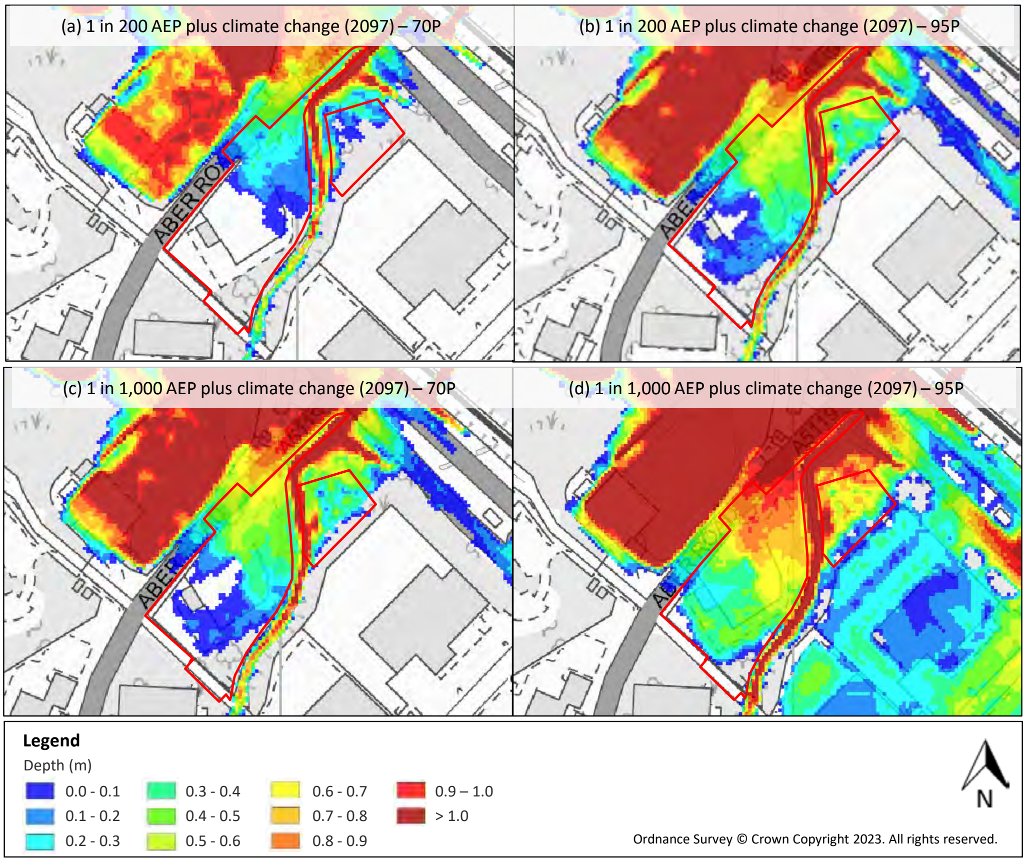


Figure 5: River Dee (Tidal) Modelled Flood Extents (Baseline) - Breach
Source: River Dee Hydraulic Modelling Study, Weetwood, April 2023

Table 3: Site Flood Information - Tidal Breach (Baseline)
Source: River Dee Hydraulic Modelling Study, Weetwood, April 2023

AEP Event	Max Level (m AOD)	Max Depth (m)		Max Velocity (m/s)	
		Highest	Mean	Highest	Mean
1 in 200 plus climate change (2097 - 70P)	6.51	0.51	0.18	0.60	0.05
1 in 1,000 plus climate change (2097 - 70P)	6.78	0.88	0.29	0.81	0.08
1 in 200 plus climate change (2097 - 95P)	6.82	0.91	0.30	0.83	0.08
1 in 1,000 plus climate change (2097 - 95P)	7.11	1.21	0.53	1.00	0.16

n.b. The above table ignores areas of land where no development is proposed, such as the proposed flood storage area.

4.4 Flood Risk from Rivers (Fluvial)

A 1D-2D Flood Modeller-TUFLOW hydraulic model of Swinchiard Brook has been developed by Weetwood as part of the Swinchiard Brook Hydraulic Modelling Study (June 2023) (**Appendix E**). This assesses the risk of flooding from Swinchiard Brook for the present day 1 in 100 and 1 in 1,000 AEP events, the 1 in 100 AEP event plus climate change (20% - central estimate[13]), and in order to future-proof the site the 1 in 1,000 AEP event plus climate change (20% - central estimate) has also been assessed. In addition, a 25% and 80% blockage of the downstream bridge structure, located underneath Holywell Road (A548) approximately 50 m north-east of the site, has been simulated for the present day 1 in 1,000 AEP event, the 1 in 100 AEP event plus climate change (20% and 45%) and the 1 in 1,000 AEP event plus climate change (20%).

During all modelled free flowing scenarios, floodwater enters the site via two mechanisms; a very shallow overland flow route from the south-western corner of the site, as well as directly from Swinchiard Brook overtopping its banks in the north of the site. It should be noted that the maximum flood level of circa. 7.40 m AOD indicated for most scenarios within

Table 4 accounts for the very shallow flow route in the south-western corner of the site where ground levels are higher and does not represent typical flood levels within the site for the respective scenarios.

When accounting for a blockage of the downstream bridge structure, flood depths within the site are not shown to significantly increase.

Shallow flooding of Aber Road is expected during all modelled fluvial events. In all modelled fluvial events up to the 1 in 1,000 AEP event plus climate change (20%) depths are not indicated to exceed 0.2 m to the north of the site and 0.1 m to the south-east of the site. In the 1 in 1,000 AEP event plus climate change (20%) flood depths up to 0.5 m may be expected in the north of the site; however depths are still expected to remain below 0.1 m in the south of the site. In all modelled events the access road along the south-western boundary of the site remains dry.

Table 4 summarises the maximum level, depth and velocity of floodwaters expected at the site during the aforementioned scenarios. The modelled free flowing and bridge blockage outputs are provided in **Figure 6** and **Figure 7** respectively.

[13] As detailed in Section 5.2 of **Appendix E**, the 1 in 100 AEP plus climate change (45% - upper end estimate) model run did not complete it's simulation. For the purposes of this assessment, this scenario is not considered to have any bearing on proposed flood mitigation measures given that the site will be mitigated against the more extreme blockage scenario.

Table 4: Site Flood Information (Baseline)

Source: Source: Swinchiard Brook Hydraulic Modelling Study, Weetwood, April 2023

Scenario	AEP Event	Max Level (m AOD)	Max Depth (m)		Max Velocity (m/s)	
			Highest	Mean	Highest	Mean
Overtopping	Present day 1 in 100	6.11 - 7.39	0.51	0.09	0.51	0.13
	1 in 100 +20% climate change	6.13 - 7.40	0.56	0.12	0.55	0.16
	Present day 1 in 1,000	6.13 - 7.40	0.62	0.16	0.77	0.19
	1 in 1,000 +20% climate change	6.32 - 7.40	0.66	0.19	0.88	0.23
Bridge Blockage (25%)	1 in 100 +20% climate change	6.19 - 7.40	0.58	0.14	0.69	0.17
	1 in 100 +45% climate change	6.19 - 7.40	0.61	0.15	0.78	0.19
	Present day 1 in 1,000	6.19 - 7.41	0.63	0.17	0.83	0.20
	1 in 1,000 +20% climate change	6.33 - 7.41	0.66	0.19	0.86	0.23
Bridge Blockage (80%)	1 in 100 +20% climate change	6.24 - 7.40	0.62	0.16	0.87	0.19
	1 in 100 +45% climate change	6.28 - 7.40	0.65	0.18	0.87	0.20
	Present day 1 in 1,000	6.32 - 7.41	0.67	0.19	0.88	0.21
	1 in 1,000 +20% climate change	6.33 - 7.41	0.71	0.21	0.89	0.23

n.b. The above table ignores areas of land where no development is proposed, such as the proposed flood storage area.

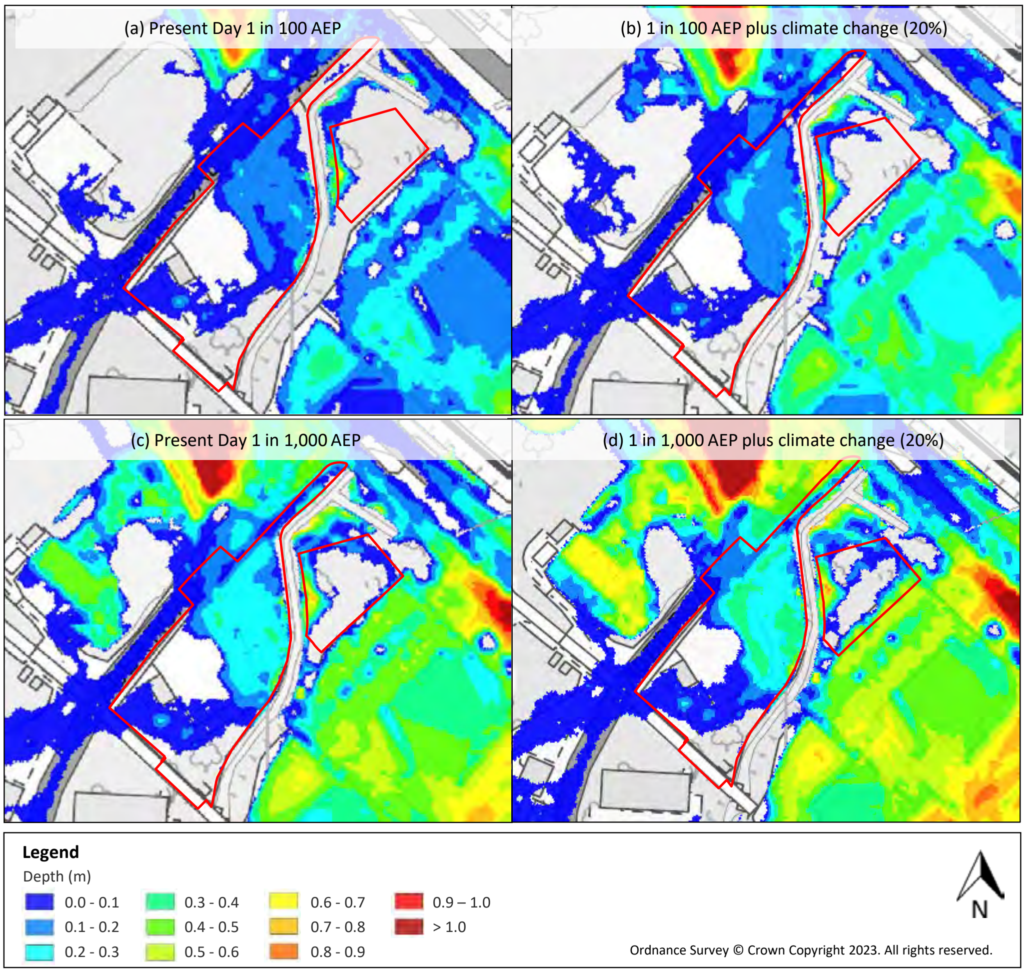


Figure 6: Swinchiard Brook Modelled Flood Extents (Baseline) - Free Flowing

Source: Source: Swinchiard Brook Hydraulic Modelling Study, Weetwood, April 2023

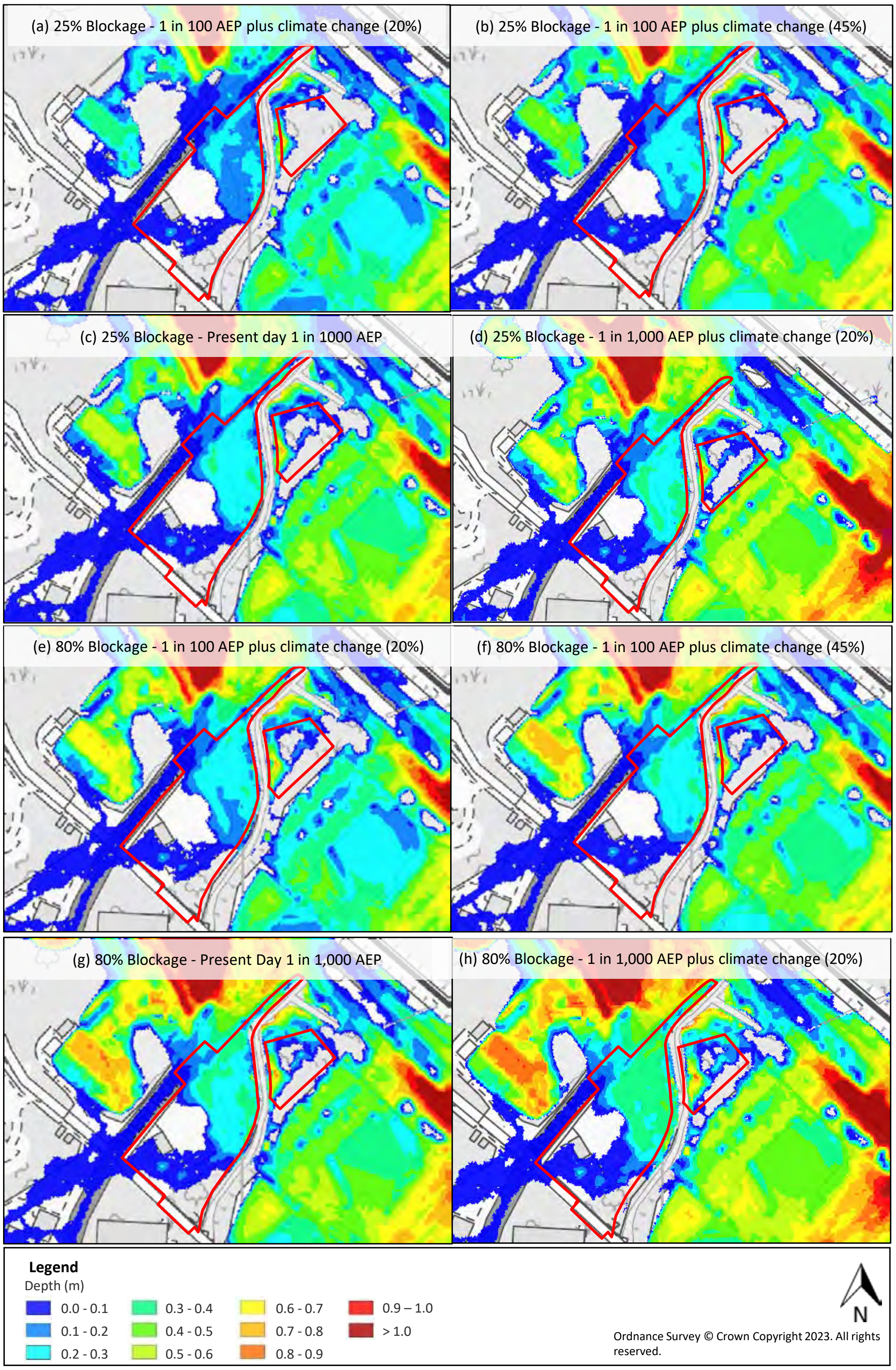
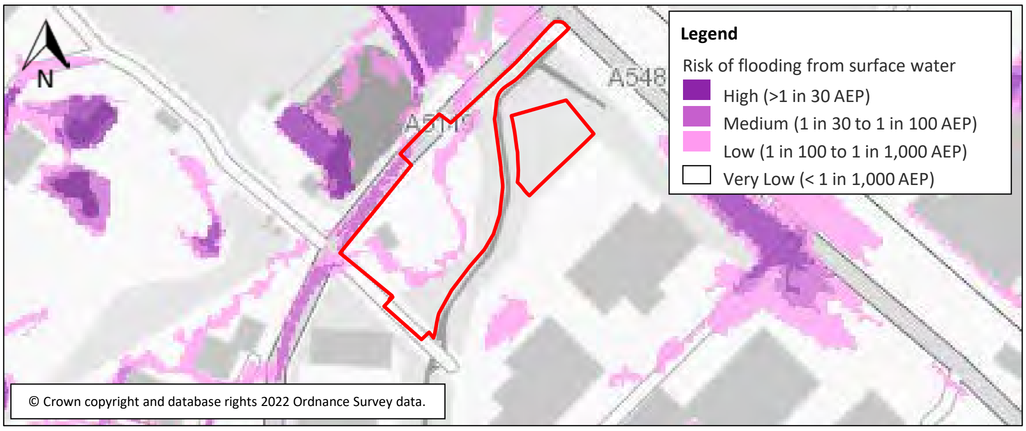


Figure 7: Swinchiard Brook Modelled Flood Extents (Baseline) - Bridge Blockage
Source: Swinchiard Brook Hydraulic Modelling Study, Weetwood, April 2023

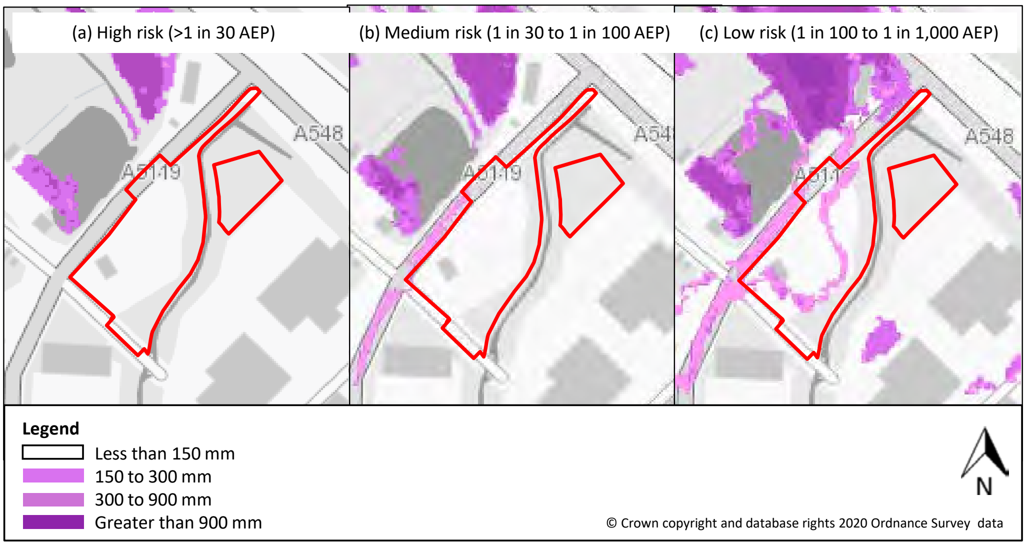
4.5 Flood Risk from Surface Water (Pluvial) and Small Watercourses

The Flood Risk from Surface Water and Small Watercourses map (**Figure 8**) indicates that the majority of the site is at a Very Low risk of flooding from surface water, with an area through the centre being at Low risk. The depth and velocity of floodwater at the site during the low risk event is typically not expected to exceed 0.3 m and 1 m/s respectively.

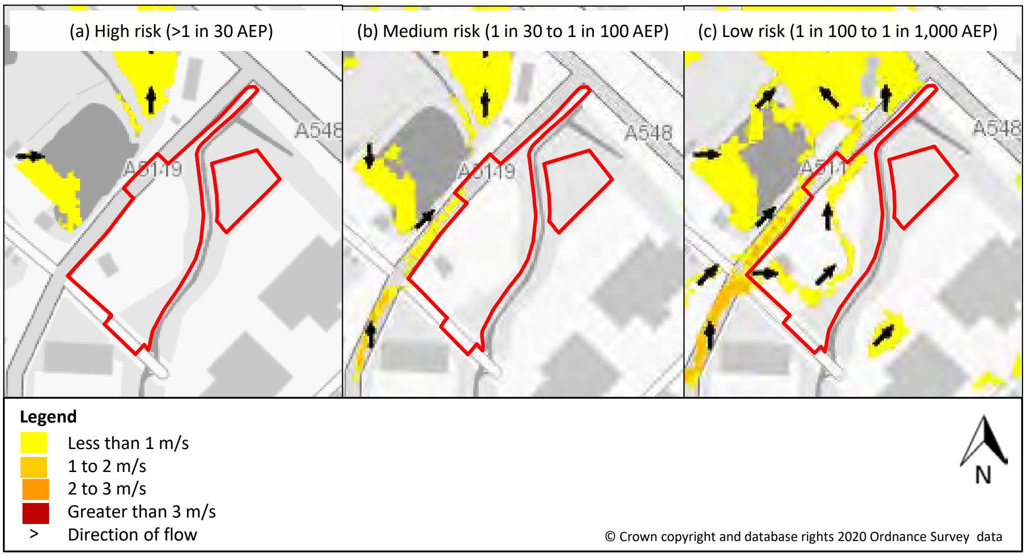
Aber Road is shown to be at a Low to Medium risk of flooding from surface water adjacent to the site; however, the extent of flooding is relatively confined, with depths and velocities typically not expected to exceed 0.3 m and 1 m/s respectively.



(a) Extent



(b) Depth



(c) Velocity

Figure 8: Flood Risk from Surface Water and Small Watercourses
Source: Natural Resources Wales website; Accessed: April 2023

4.6 Flood Risk from Reservoirs, Canals and Other Artificial Sources

As outlined in **Section 2.3**, Pond A is located approximately 23 m north-west of the site beyond Aber Road. LiDAR data indicates that ground levels fall northwards away from the pond and the site (as evidenced in **Figure 8**). As such this is not considered to pose a risk of flooding to the proposed development.

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.

4.7 Flood Risk from Groundwater

The JBA Groundwater Flood Risk Indicator map (not shown) indicates that the site and surrounding area are at a negligible risk of flooding in a 1 in 100 AEP groundwater flood event.

However, as detailed in **Section 2.5**, the site investigations undertaken by Atkinson Peck Consulting Engineers in May 2008 recorded groundwater in all boreholes at the site at depths ranging between 1.2 - 1.4 m bgl. As such there may be a residual risk of flooding from this source.

4.8 Justification Test

The proposals to develop 6 commercial units on the site should help contribute to key employment objectives within the local area. This meets part ii of the Justification Test.

The site is previously developed, meeting part iii of the test.

It should be noted that TAN15 states some flexibility in the application of the Justification Test 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.

This FCDA addresses part iv of the test.

5 FLOOD RISK MITIGATION MEASURES

The risk of flooding to the proposed development from all identified sources is assessed to be low, with the exception of the River Dee (tidal/coastal) and Swinchiard Brook (fluvial). The risk of flooding to the proposed development will be mitigated through the implementation of the measures proposed within the following section of this report.

Note, to inform the proposed mitigation measures, proposed scenario flood modelling has been undertaken in order to account for changes to flood levels (during fluvial flooding scenarios) on site as a result of reprofiling ground levels.

5.1 Finished Floor Levels

For Building A (**Appendix B**), finished floor levels should be set at a minimum of 7.13 m AOD. This is the flood level expected at the site during the modelled tidal 1 in 1,000 AEP overtopping event plus climate change (2097 - 95P) and provides a freeboard of 570 mm above the flood level expected at the site in a tidal 1 in 200 AEP overtopping event plus climate change (2097 - 70P). This finished floor level is also 360 mm above the modelled flood levels adjacent to Building A during the proposed scenario fluvial 1 in 1,000 AEP event plus (20%) climate change (i.e. the level of the shallow overland flow route once the site has been reprofiled).

For Building B (**Appendix B**), finished floor levels should be set slightly higher, at a minimum of 7.16 m AOD, to mitigate the very shallow overland flow route that enters the site during fluvial scenarios. The fluvial flood level within the vicinity of Building B is essentially very similar for all AEP events but the proposed finished floor level aims to keep the building dry during all modelled events.

In accordance with Building Regulations Approved Document C10, finished floor levels of buildings should be set at a minimum of 0.15 m above adjacent ground levels, sloping down from the buildings, following reprofiling of the site.

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

5.2 Development Platform

Ground levels on all ancillary areas are proposed to range from 6.50 to 8.05 m AOD falling in a north-westerly direction (refer to **Appendix F**). Given that flood levels during the tidal 1 in 200 AEP overtopping event plus climate change (2097 – 70P) are modelled to be 6.56 m AOD the proposed site would largely be dry with minor flooding of up 0.06 m around the entrance where ground levels are proposed to be lowest in order to tie in with existing highway levels. During the fluvial 1 in 100 AEP bridge blockage event plus climate change (20%) typical maximum flood depths of 0.06 m would be expected.

As outlined within the Natural Resources Wales Operational Guidance Note; Flooding to ancillary areas dated January 2018, flooding to areas intended for non-residential development should be avoided where possible.

However, where this is not possible to achieve, Natural Resources Wales state that it may not choose to object to a development where the developer has shown within the FCA that the risks are manageable and the anticipated flooding meets the criteria below. In this case, this would apply to both the tidal 1 in 200 plus climate change (2097) AEP event and the fluvial 1 in 100 AEP bridge blockage event plus climate change (20%) in order to comply with A1.14 of TAN15.

1. *All properties/buildings are designed to be flood free.*

   This will be achieved as above.

2. *Flood depths to 'ancillary areas' do not exceed 300 mm.*

   This will be achieved as above.

3. *The flood hazard rating is no greater than 'very low' in accordance with the established DEFRA FD2320*

hazard guidance. Flood hazard greater than this may result in an unacceptable risk (dependant on the type/location of the development proposal).

The flood Hazard Ratings within the proposed platform have been calculated to be 'very low' during all design events, even when assuming a conservative debris factor of 0.5 (which is unlikely for such shallow flooding).

4. *There is no risk of increased flooding elsewhere.*

   Refer to the **Section 5.5** below.

The proposed levels will also ensure that the proposed development complies with A1.15 of TAN15 during a tidal 1 in 1,000 AEP overtopping/breach event plus climate change (2097 - 70P) and fluvial 1 in 1,000 AEP bridge blockage event, as maximum flood depths on site are far less than 1 m.

5.3 Flood Plan

It is recommended that a Flood Warning and Evacuation Plan is prepared in consultation with Flintshire County Council emergency planning team. The site is included in a Natural Resources Wales flood alert and warning area. This provides the opportunity for the relevant response procedures set out in the plan to be invoked in response to receipt of a flood warning from Natural Resources Wales

5.4 Flood Risk Elsewhere

In accordance with A1.2 of TAN15 developers must ensure there will be no loss of flood flow or flood storage capacity for floods up to the severity of the 1 in 1,000 AEP event. Whilst not specified by TAN15, Natural Resources Wales generally recommends that this should be the case over the lifetime of development (i.e. should take into account climate change) and should consider breach and blockage where necessary.

Compensatory storage is generally not required for the loss of floodplain storage or conveyance during a tidally dominated event. However, in such instances where overtopping of defences is expected by tidal floodwaters, and the predicted water level is not an extension of the water level within the estuary then the developer should demonstrate no increase in flood risk.

In order to assess the impact on flood risk elsewhere, the development proposals have been incorporated within both the River Dee and Swinchiard Brook hydraulic models. Given that the mechanisms of flooding are different during fluvial and tidal scenarios, it was decided to incorporate the proposals into the respective models in slightly different ways. It was considered necessary to incorporate the proposed site levels (as detailed in **Section 5.2** and illustrated in **Appendix F**) accurately within the Swinchiard Brook hydraulic model owing to the overland flow entering the site from the south-west; whereas, a more simplistic and conservative approach was taken for tidal flood risk by raising the development platform arbitrarily high, which is considered to assess a worst case scenario in terms of displacing the tidal floodwater.

Compensatory flood storage has also been included within both hydraulic models and is provided in the form of an approximately 1,600 m^2 area to the east of the site (**Figure 9**), where ground levels have been set to 5.76 m AOD.

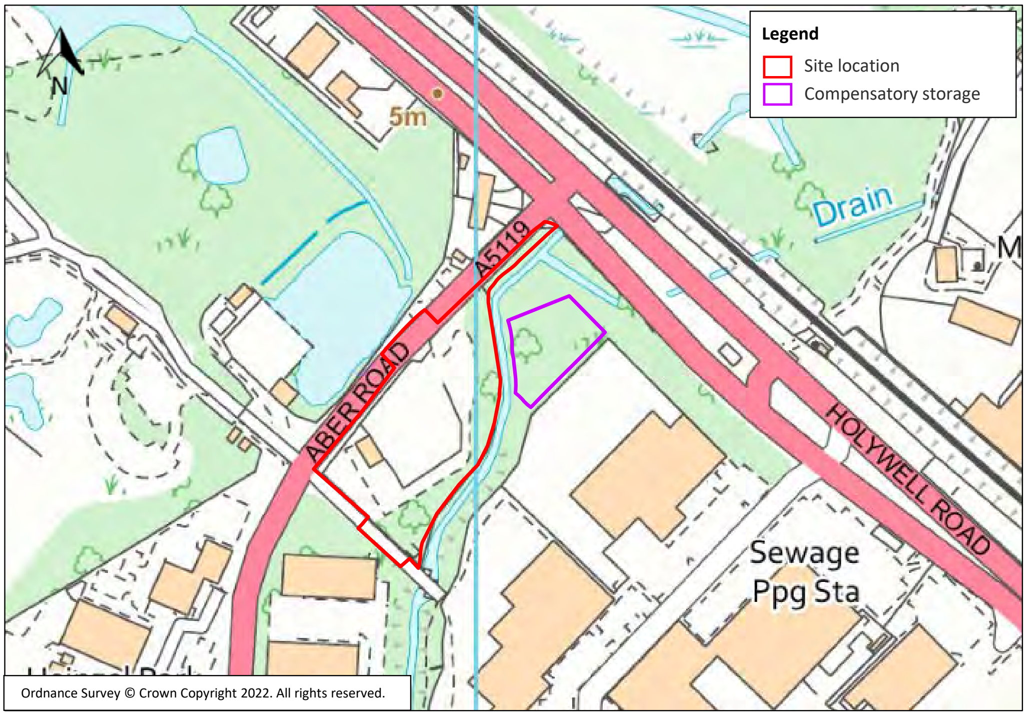


Figure 9: Location of Proposed Compensatory Storage

Model flood risk comparison plots are provided in **Appendix G** and indicate that during the tidal 1 in 200 and 1 in 1,000 AEP overtopping and breach events plus climate change (2097 - 70P) there is no increase in flood risk elsewhere.

During the fluvial 1 in 100 AEP event plus climate change (20%) and 1 in 1,000 AEP event plus climate change (20%), and all modelled bridge blockage scenarios, no significant increase in flood risk elsewhere is indicated by the modelling. For many of these scenarios, the hydraulic modelling study indicates that fluvial flooding is reduced to large adjacent areas of built development. Consequently, in some instances floodwater is slightly increased by less than 100 mm to some undeveloped woodland and marshy areas (primarily immediately to the north-east of the site and to the north-east of the railway); these areas are already shown to flood with typical maximum depths ranging from 1.12 to 1.60 m. Therefore, considering the depths of flooding that would ordinarily occur and the existing land use types in those areas, the increased flooding is considered to be immaterial, particularly when noting that in many scenarios this is at the expense of providing betterment to areas of existing built development. It is noted that there is shown to be a small area of increased flooding to a rear garden of some residential development 25 m to the north of the site during the 1 in 1,000 AEP event plus climate change including an 80% bridge blockage; however, this is indicated to be an 8 mm increase for what is a very extreme event only, and this area already floods to a typical maximum depth of 600 mm during this scenario. Moreover, this same area is either not shown to be adversely impacted during other modelled events, or reduced flood risk shown to the same area during the more-likely free-flowing scenarios.

Given the above, in the context of wide-scale flood risk betterment to existing built development at the expense of some relatively small increases in flooding primarily to woodland and marshy areas, on balance, the proposals are not considered to adversely impact flood risk elsewhere.

6 SURFACE WATER MANAGEMENT

The drainage assessment presented below was completed prior to the hydraulic modelling work set out within the previous sections of this report, while minor alterations to the site layout may have occurred, these have been considered and is not deemed to have altered the principles of this assessment.

6.1 Surface Water Drainage at the Existing Site

No on site drainage details are currently available, however, several inspection chambers and gullies are noted to be present on site (refer to **Appendix C**). Dŵr Cymru Welsh Water Public sewer records (**Appendix H**) indicate a 225 mm diameter surface water sewer flowing in a north-westerly direction within Aber Road, prior to discharging into Swinchiard Book, north of the site.

The site has a total area of 0.667 ha of which 0.207 ha currently comprises impermeable areas and 0.460 ha permeable areas.

The greenfield runoff rate for the site has been calculated using the ICP SUDS method within MicroDrainage. Runoff rates from existing impermeable areas have been calculated using the Modified Rational Method. Details of the input parameters and the output results are provided in **Appendix I** and **Appendix J** respectively**.**

The runoff rates from the existing site are presented in **Table 5**.

Table 5: Peak Runoff Rate - Existing Site

AEP of rainfall event	Permeable Runoff Rate 0.460 ha (l/s)	Impermeable Runoff Rate 0.207 ha (l/s)	Total (l/s)
1 in 1	2.3	15.4	17.7
QBAR / 1 in 2	2.6	19.9	22.5
1 in 30	4.6	37.6	42.2
1 in 100	5.7	48.4	54.1

6.2 Surface Water Drainage at the Redeveloped Site

6.2.1 Disposal of Surface Water (Standard S1)

In accordance with Welsh Government guidance[14], 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; To a combined sewer.

As part of the drainage strategy on site, a rainwater harvesting system could be considered to collect non-potable water for reuse where possible. However, the incorporation of rainwater harvesting systems will require pumped systems. In accordance with the principles of the Statutory Standards for SuDS, the use of pumping should be avoided where possible. Therefore, Priority Level 1 has been discounted as the primary method for disposal of surface water.

As detailed in **Section 2.4** 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 should be undertaken at the detailed design stage in accordance with the guidelines in BRE365[15].

In the event that infiltration is not a practicable method for the disposal of surface water (Priority Level 2), it is subsequently proposed to direct all runoff from the redeveloped site to Swinchiard Brook in accordance with Priority Level 3.

14 Footnote 6
15 BRE Digest 365 Soakaway Design, Building Research Establishment, 2016

6.2.2 Post Development Impermeable Area

The area of impermeable surfaces within the proposed development has been calculated to be 0.532 ha, based on the development proposals presented in **Appendix B**.

6.2.3 Peak Flow Control (Standard S2)

Paragraph G2.24 of the Statutory Standards for SuDS states that *'for previously developed sites, site runoff rates should be reduced to the greenfield rates wherever possible'* with betterment of at least 30% considered as a minimum requirement.

It is proposed to restrict surface water runoff to the greenfield QBAR rate of 3.0 l/s post development.

6.2.4 Volume Control (Standard S2)

Where reasonably practicable, for sites which have been previously developed, the runoff volume from the proposed development to any highway drain, sewer or surface water body in the 1 in 100 AEP, 6 hour rainfall event must be constrained to a value as close as is reasonably practicable to the greenfield runoff volume for the same event, but should never exceed the runoff volume from the development site prior to redevelopment for that event.

As outlined within the CIRIA SuDS Manual 2015 extra runoff volumes in extreme events may be managed by releasing all runoff (above the 1 in 1 AEP event) from the site at a maximum rate of 2 l/s/ha or QBAR, whichever is the higher value.

It is proposed to restrict peak discharge rates to the greenfield QBAR rate in up to the 1 in 100 AEP event, including an allowance for climate change. This will minimise the impact of the increase in the volume of surface water discharged from the site.

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 Network module of MicroDrainage (**Appendix K**). The required storage volume has been sized to store the 1 in 100 AEP rainfall event including a 30% increase in rainfall intensity to allow for climate change.

Assuming a peak discharge rate of 3.0 l/s, a total storage volume of 410.5 m^3 would be required. The storage volume could be accommodated within the pipe network, a filter drain, various locations of permeable pavement sub-bases and a geo-cellular storage tank, with an area of 975.0 m^2 and a depth of 0.4 m.

A preliminary surface water drainage layout is provided in **Appendix L**.

6.2.6 Exceedance Routes

Flows resulting from rainfall in excess of the 1 in 100 AEP rainfall event including an allowance for climate change will be managed in exceedance routes. It is assumed that as the development proposals progress, the design of the site would ensure flood flows are directed away from built development.

6.2.7 Water Quality and Pollution Control (Standard S3)

The CIRIA SuDS Manual[16] and Table G3.1 of the Statutory Standards for SuDS identifies commercial roofs and delivery areas as having a low to medium pollution hazard level. Table 26.2 of the CIRIA SuDS Manual 2015 indicates that the pollution hazard indices associated with commercial roofs and delivery areas for total suspended solids, hydrocarbons and metals are 0.30, 0.20 and 0.05 and 0.7, 0.6 and 0.7 respectively.

---

[16] Table 26.2

Table 26.3 of the CIRIA SuDS Manual indicates that the SuDS mitigation indices for filter drains and permeable paving for total suspended solids, hydrocarbons and metals are 0.4, 0.4 and 0.4 and 0.70, 0.60 and 0.70 respectively. The use of filter drains and permeable block paving will also help prevent debris from entering the surface water drainage system, reducing the risk of blockage.

In addition, a Class 1 bypass separator, along with catchpit manholes and silt traps in gullies/channels drains, will help prevent contaminants discharging into the downstream receptor.

6.2.8 Amenity and Biodiversity (Standard S4 and Standard S5)

The proposed layout includes landscaped areas/trees in a number of locations which will provide aesthetic benefits and interception of water surface, thus helping with volume control (via evapotranspiration).

It is generally recommended that native vegetation is used to maximise the biodiversity value of these areas. However, it may be valuable to include some non-native vegetation to support pollinators, such as butterflies and bees.

The implementation of soft landscaping will also help provide users of the site with health and wellbeing benefits.

6.2.9 Adoption and Maintenance of SuDS (Standard S6)

SuDS elements which serve one property will be the responsibility of the owner of the property.

SuDS elements which serve more than one property will be adopted and maintained by the SuDS Approving Body, in accordance with the Statutory Standards for SuDS.

An indicative maintenance schedule is presented in **Table 6**.

Table 6: Maintenance Requirements

Schedule	Required action	Frequency
Permeable Paving		
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.
Occasional maintenance	Stabilise and mow contributing and adjacent areas	As required
	Removal of weeds or management using glyphosphate 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
	Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance or a hazard to users, and replace lost jointing material	
	Rehabilitation of surface and upper substructure by remedial sweeping	Every 10 to 15 years or as required
Monitoring	Initial inspection	Monthly for three months after installation
	Inspect for evidence of poor operation and/or weed growth- if required, take remedial action	Three-monthly, 48h after large storms in first six months
	Inspect silt accumulation rates and establish appropriate brushing frequencies accumulation rates and establish appropriate removal frequencies	Annually

Schedule	Required action	Frequency
	Monitor inspection chambers	
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
Filter Drain		
Regular maintenance	Remove litter including leaf litter and debris from filter drain surface, access chambers and pre-treatment devices	Monthly (or as required)
	Inspect filter drain surface, inlet/outlet pipework and control systems for blockages, clogging, standing water and structural damage	Monthly
	Inspect pre-treatment systems, inlets and perforated pipework for silt accumulation, and establish appropriate silt removal frequencies	Six monthly
	Remove sediment from pre-treatment devices	Six monthly (or as required)
Occasional maintenance	Remove or control tree roots where they are encroaching the sides of the filter drain, using recommended methods (eg NJUG, 2007 or BS 3998:2010)	As required
	At locations with high pollution loads, remove surface geotextile and replace, and wash or replace overlying filter medium	Five yearly (or as required)
	Clear perforated pipework of blockages	As required
Flow Control Unit		
Routine maintenance	Remove litter and debris and inspect for sediment accumulation	Six Monthly
	Remove sediment from sump	As necessary – Indicated by system inspections
Remedial actions	Replace malfunctioning parts or structures	As required
Monitoring	Inspect for evidence of poor operation	Six Monthly
	Inspect flow control unit and establish appropriate replacement frequencies	Six Monthly
	Inspect sediment accumulation rates and establish appropriate removal frequencies	Monthly during first year of operation, then every six months

7 FOUL WATER MANAGEMENT

Dŵr Cymru Welsh Water Public sewer records (**Appendix H**) indicate that a 225 mm diameter public foul gravity sewer is present adjacent to the north-western site boundary, which feeds into a pumping station (Ref: 2848 Aber Road Flint).

It is proposed to discharge foul flows from the site to the final manhole of the 225 mm diameter public foul sewer before the pumping station (Ref: SJ23739450).

8 SUMMARY AND RECOMMENDATION

This report has been prepared on behalf of HMG (Aber Road) Limited and relates to the proposed redevelopment of land off Aber Road, Flint for industrial use.

According to the Development Advice Map the majority of the site is located within zone C1 with an area in the south located within zone B.

The risk of flooding to the proposed development from all identified sources is assessed to be low, with the exception of the River Dee (tidal/coastal) and Swinchiard Brook (fluvial).

The assessment demonstrates that the proposed development may be completed in line with planning policy subject to the following measures:

- Finished floor levels to be set at a minimum of 7.13 m AOD and 7.16 m AOD for building A and building B respectively, and at least 0.15 m above adjacent ground levels following any reprofiling of the site, with ground levels sloping down from the buildings.
- Levels of all ancillary areas to be set as illustrated on the plan provided in **Appendix E**
- Compensatory storage to be provided to the north-east of the site in the form of a 1,600 m^2 area of land lowered to a level of 5.76 m AOD.
- Flood Warning and Evacuation Plan to be developed in consultation with Flintshire County Council

The proposals are considered to contribute to key employment objectives within the local area, in addition, the site has been previously developed. The proposals are therefore considered to meet parts ii and iii of the justification test.

The proposed development is not expected to have a significant detrimental impact on flood risk elsewhere when compared to the existing situation, with overall reduced flooding shown to existing built development nearby.

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

It is proposed to discharge foul flows from the development to the existing 225 mm diameter public foul gravity sewer adjacent to the north-western site boundary.

APPENDIX A

Existing Site Plan

- ALL DIMENSIONS AND LEVELS ARE TO BE CHECKED ON SITE.
- ANY DISCREPANCIES ARE TO BE REPORTED TO CUBE ARCHITECTURE AND DESIGN BEFORE ANY WORK COMMENCES.
- THIS DRAWING SHALL NOT BE SCALED TO ASCERTAIN ANY DIMENSIONS. WORK TO FIGURED DIMS ONLY.
- THIS DRAWING SHALL NOT BE REPRODUCED WITHOUT EXPRESS WRITTEN PERMISSION FROM CUBE ARCHITECTURE AND DESIGN.
- TITLE OVERLAY DRAWINGS AND OWNERSHIP BOUNDARIES ARE PRODUCED USING ALL REASONABLE ENDEAVOURS. CUBE ARCHITECTURE AND DESIGN CANNOT BE RESPONSIBLE FOR THE ACCURACY OR SCALE DISCREPANCY OF BASE PLANS SUPPLIED TO THEM.

Rev	Description	Date	By

Status:
PLANNING

Client:
THE HOLLINS MURRAY GROUP

Contract:
PROPOSED INDUSTRIAL DEVELOPMENT
ABER ROAD
FLINT

Drawing:
EXISTING SITE PLAN

Drawing No:	Revision:	Scales:
AS786-02	-	1:200@A1
Drawn: DMR	Checked:	Date: MAY '23

CUBE architecture and design
www.cubearchitecture.net
commercial house
clarence avenue
trafford park
m17 1qs
tel: 0161 848 5893

DO NOT scale from this drawing.

APPENDIX B

Proposed Site Plan

- ALL DIMENSIONS AND LEVELS ARE TO BE CHECKED ON SITE.
- ANY DISCREPANCIES ARE TO BE REPORTED TO CUBE ARCHITECTURE AND DESIGN BEFORE ANY WORK COMMENCES.
- THIS DRAWING SHALL NOT BE SCALED TO ASCERTAIN ANY DIMENSIONS. WORK TO FIGURED DIMS ONLY.
- THIS DRAWING SHALL NOT BE REPRODUCED WITHOUT EXPRESS WRITTEN PERMISSION FROM CUBE ARCHITECTURE AND DESIGN.
- TITLE OVERLAY DRAWINGS AND OWNERSHIP BOUNDARIES ARE PRODUCED USING ALL REASONABLE ENDEAVOURS. CUBE ARCHITECTURE AND DESIGN CANNOT BE RESPONSIBLE FOR THE ACCURACY OR SCALE DISCREPANCY OF BASE PLANS SUPPLIED TO THEM.

0 2 4 6 8 10
Scale Bar @ 1:200 Metres

EXTERNAL FINISHES KEY

- Tarmacadam footpath surface course finish on suitable binder course and sub-base as per S.E. specification
- Reinforced concrete yard slab and/or road surface on a suitable binder course and sub-base as per S.E. specification. Build up to be suitable for HGV's, new road levels to match and feather in to existing at bellmouths.
- Denotes extent of Armco Barrier protection to exposed areas
- Proposed grass areas and planting to separate landscape consultant details / specifications to incorporate native species planting.
- Broxap Sheffield (or sim') cycle shelter with 4No. Sheffield cycle hoops root mounted to provide 8 cycles spaces.

Rev	Description	Date	By

Status:
PLANNING

Client:
THE HOLLINS MURRAY GROUP

Contract:
PROPOSED INDUSTRIAL DEVELOPMENT
ABER ROAD
FLINT

Drawing:
PROPOSED SITE PLAN

Drawing No:	Revision:	Scales:
AS786-03	-	1:200@A1
Drawn: DMR	Checked:	Date: MAY '23

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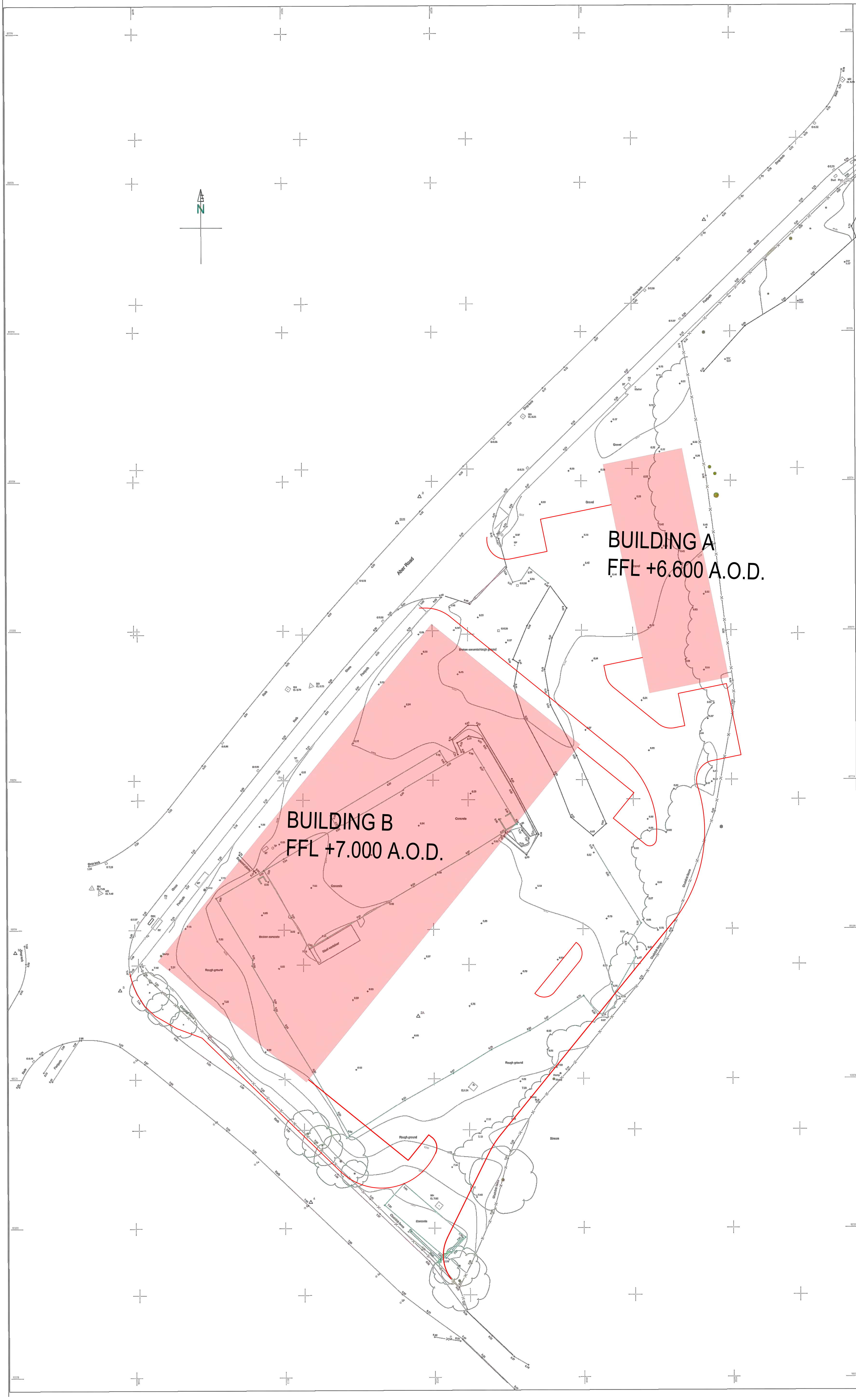
tel: 0161 848 5893

DO NOT scale from this drawing.

APPENDIX C

Topographic Survey



SURVEY STATIONS

Name	Easting	Northing	Height
1	1066.088	2112.610	6.002
2	1042.538	2070.873	6.554
2A	1042.298	1992.292	6.969
3	997.210	1988.293	7.576
3A	961.364	2001.093	8.056
4	1026.620	1954.138	7.901
SM1	1039.414	2066.888	6.614

NOTE

Local Grid

Levels related to OSBM situated on St Mary's Catholic Club, Coleshill Street.

OSBM value - 12.49m.

Amendments

	Date	Surveyor	Description of work
A	13/05/10	MDP	Rotated Survey to North
B	04/06/10	MD	Levels linked to OSBM

Meridian House
58/60 Hillside Road, Frodsham, Cheshire WA6 6AG
Tel: 01928 734473 Fax: 01928 735578
Email: mail@powerstiltman.co.uk
www.powerstiltman.co.uk

Land off Aber Road

Aber Park Industrial Estate, Flint

Topographic Survey

Client : Craig Foster Architects

Surveyed By : MD	Date : 30/04/10	Scale 1:200
Drawn By : MD	Drawing No : 6111/01	
Checked By : DG	Amendment : B	

APPENDIX D

River Dee (Tidal) Hydraulic Modelling Study Technical Note, May 2023

(5560/TN/Final/v1.0/2023-05-22)

Weetwood Services Ltd
info@weetwood.net

Aber Road, Flint

River Dee (Tidal) Hydraulic Modelling Study

Technical Note

Project ref:	5560 – Aber Road, Flint
Prepared by:	Flora Lockey MEnvSci, *Assistant Flood Risk Consultant*
Approved by:	Adam Edgerley BSc (Hons), *Director*
Date:	22 May 2023
Version:	Final v1.0

Summary of modelling study requirements	A modelling study has been undertaken to assess the existing tidal flood risk to the redevelopment site, whether the proposed redevelopment will be safe and whether flood risk elsewhere will be increased as a result of the proposals. The development site is located to the south-east of Aber Road at Ordnance Survey National Grid Reference SJ 239 734. Further details regarding the proposed redevelopment and site location are provided within the Weetwood Flood Consequences Assessment (FCA) report dated 21 April 2023.
Details of existing models	A copy of the River Dee model named “Panton Cop” has been provided by the Natural Resources Wales under licence. The Panton Cop model includes the site location and is herein referred to as the ‘supplied model’. It is understood the supplied model has been approved for use by the Natural Resources Wales. The supplied model files include the four scenarios: Do Nothing – Short Term, Do Nothing – Long Term, Do Minimum – Overtopping and Do Minimum – Breaches.
Model extent and details of any truncations	The model extent has not been changed from the supplied model.
Amendments to hydrology	The hydraulic modelling study requires 4 events to be assessed; 1 in 200 and 1 in 1,000 Annual Exceedance Probability (AEP) events, both with climate change applied up to the year 2097, based on both the 70th and 95th percentile scenarios (70P and 95P). The model inflow hydrology has been derived from an existing Natural Resources Wales 1D-2D Flood Modeller Pro-TUFLOW hydraulic model of the River Dee, which was most recently updated in 2020 as part of its ‘Flood Risk Assessment Wales’ update and ‘Tidal Dee Breaches’ assessment. That model does not represent the site within its 2D domain; however, the 1D domain of the model covers the River Dee section adjacent to the site. The 2020 hydraulic model utilises the latest available tidal levels from the Environment Agency’s Coastal Flood Boundary Conditions for the UK: 2018 Update, and it includes climate change up to the years 2095 and 2120 using the allowances set out in superseded Welsh Government guidance issued on 23 August 2016 (reference CL-03-16).

	Weetwood has updated the inflows at node Est_00000 (i.e. the mouth of the Estuary) to account for the latest guidance on climate change allowances issued by the Welsh Government on 27 September 2021. The guidance states *"as a minimum, development proposals should be assessed against the relevant regional 70th percentile… to inform design levels. An assessment should also be made against the 95th percentile to inform mitigation measures, access and egress routes and emergency evacuation plans."* Climate change allowances have been applied to the existing 1 in 200 and 1 in 1,000 AEP tidal inflow boundaries of the model to allow for 75 years of climate change, up to the year 2097 for the 70th percentile (70P) and 95th percentile (95P) scenarios (note, the modelling study was undertaken in 2022). Weetwood has then re-run the 2020 Natural Resources Wales model with the amended hydrology. Hydrographs have then been extracted from the amended Natural Resources Wales model outputs at node Est_20000, which is located adjacent to the Weetwood model domain, to create inflow hydrographs for the supplied model.
Amendments to existing model hydraulics	No amendments have been made to the supplied model hydraulics.
Design runs	The amended 'baseline' model has been run for the 1 in 200 and 1 in 1,000 plus climate change (2097) 70P and 95P AEP events. The model run number for the overtopping scenario is 5560_001_. The model has been run in TUFLOW version 2020-10-AC-iDP-w64, using the HPC solver. In addition to the overtopping scenario, a breach scenario has been assessed for the aforementioned AEP events, accounting for a 50 m wide breach of the existing River Dee Flood defences located approximately 1 km north of the site. This breach location was chosen in the supplied model informed by local flood history observed in December 2013. The model run number for the breach scenario is 5560_002_.
Suitability and accuracy of model for study site	The model has been reviewed, and with the amendments included in the model hydrology, it is considered suitable for site-specific modelling. The model cell size is 4 m which enables sufficient detail of the floodplain and flow routes around buildings. The stability of the model is good for the site location. There are 37 warning messages and 19 checks shown prior to the simulation during all model events. Most of these are a legacy of the supplied model and are not thought to impact the maximum results at the site. The minimum timestep (dt) mapped outputs indicate areas of instability, with areas where timesteps are smaller than 0.5 seconds potentially indicating an issue with the model. Generally, the minimum timestep is greater than 0.5 seconds with some exceptions within areas where deeper flooding is expected.
Sensitivity and calibration	The amendments undertaken to the supplied model are relatively minor. As such, sensitivity testing is not considered necessary.
Submitted files	To accompany this Technical Note, the following files can be provided to Natural Resources Wales if required: • The digital model files. • A modelling log detailing the model runs that have been undertaken. To submit the above files, we will require a "sharefile" link from Natural Resources Wales. If required, please can this be sent to Flora.Lockey@Weetwood.net

Weetwood
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Flood Risk Assessments
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APPENDIX E

Swinchiard Brook Hydraulic Modelling Study, June 2023

(5560/HMS/Final/v1.1/2023-06-07)

LAND OFF ABER ROAD, FLINT, FLINTSHIRE, CH6 5EX

SWINCHIARD BROOK HYDRAULIC MODELLING STUDY

Final Report v1.1
June 2023

Weetwood Services Ltd
info@weetwood.net
www.weetwood.net

Report Title	**Land off Aber Road, Flint, Flintshire, CH6 3EX** Swinchiard Brook Hydraulic Modelling Study Final Report v1.1
Client	HMG (Aber Road) Limited
Date of issue	7 June 2023

Prepared by	Flora Lockey MEnvSci *Assistant Flood Risk Consultant* Matthew Newbold BSc (Hons) MSc GradCIWEM *Graduate Flood Risk Consultant*
Checked and Approved by	Adam Edgerley BSc (Hons) *Director*

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1 INTRODUCTION

1.1 Purpose of Report

Weetwood Services Ltd ('Weetwood') has been instructed by HMG (Aber Road) Limited to undertake a hydraulic modelling study of Swinchiard Brook in order to identify and assess the level of flood risk from this source in association with a proposed redevelopment located at land off Aber Road, Flint.

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 model runs and results
Section 6 Describes the hydraulic model calibration and sensitivity assessment
Section 7 Presents a summary of key findings

2 SITE DETAILS AND PROPOSED DEVELOPMENT

2.1 Site Location and Description

The approximately 0.7 hectare (ha) site is located to the south-east of Aber Road at Ordnance Survey National Grid Reference SJ 239 734, as shown in **Figure 1**.

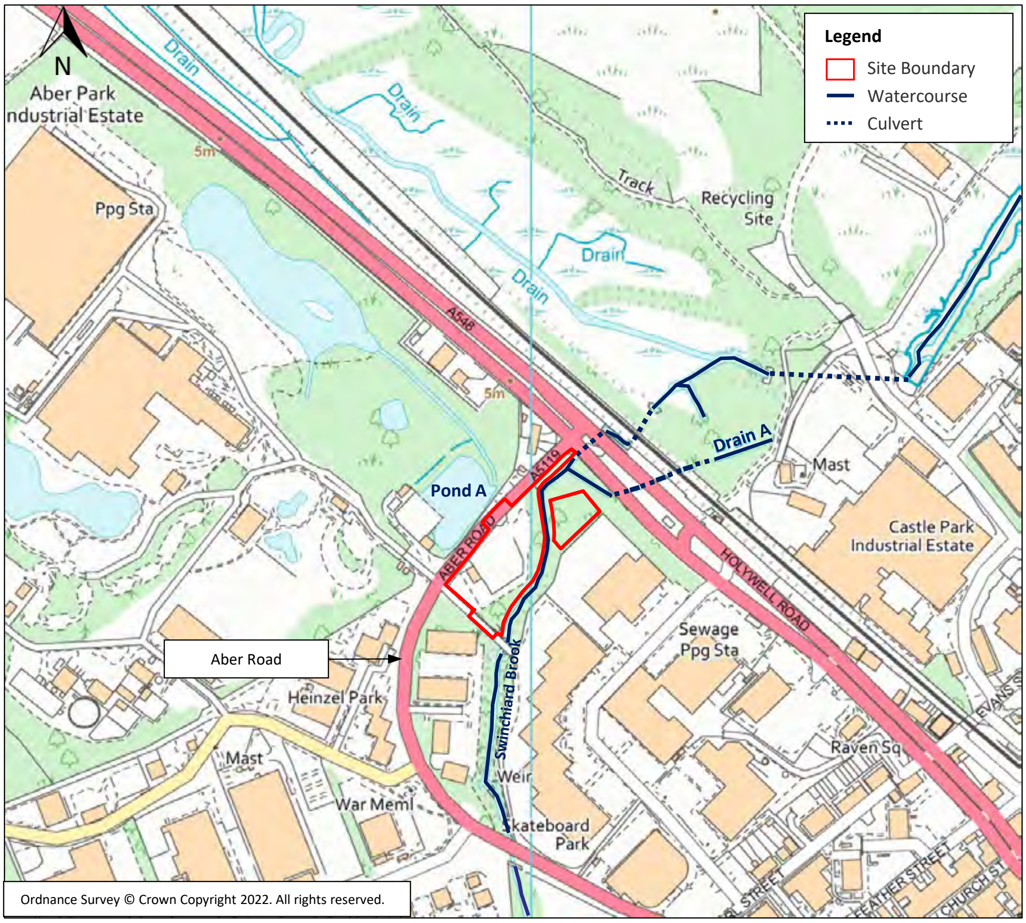


Figure 1: Location of Site and Surface Waterbodies

A topographic survey of the site was undertaken by Powers and Tiltman Ltd in 2010 and is provided in **Annex A**. Site levels are shown to be in the region of 6.1 - 8.0 m AOD falling in a northerly direction.

Levels along Aber Road, adjacent to the site, are shown to rise from 6.4 metres (m) Above Ordnance Datum (AOD) at the site entrance to 7.4 m AOD to the south-west. Levels along on the access road along the south-western boundary of the site are between 7.4 to 8.1 m AOD.

2.2 Waterbodies in the Vicinity of the Site

Swinchiard Brook flows in a northerly direction along the eastern boundary of the site, before being culverted under Holywell Road (A548) and ultimately outfalling into the River Dee (**Figure 1**).

A channel survey of Swinchiard Brook has been undertaken by Met Geo Environmental and is provided in **Annex B**.

2.3 Flood Zone Designation

Figure 1 of TAN15 defines 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 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:
    - Zone C1: Areas of the floodplain which are developed and served by significant infrastructure, including flood defences
    - Zone C2: Areas of the floodplain without significant flood defence infrastructure

The development advice zones are shown on the Development Advice Map[1] and are defined by the predicted extent of the 1 in 1,000 (sea and rivers) AEP event (zone C) and British Geological Survey drift data (zone B). The zones do not take account of the possible impacts of climate change and consequent changes in the future probability of flooding.

The Development Advice Map (**Figure 2**) indicates that the majority of the site is located in zone C1 with an area in the south located in zone B.

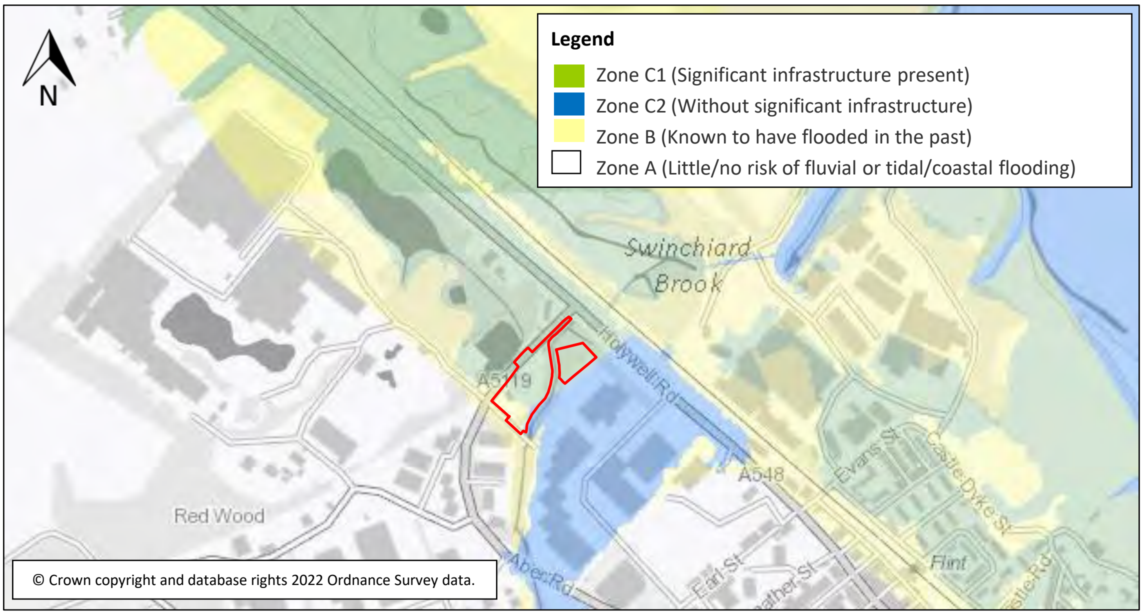


Figure 2: Development Advice Map
Source: Natural Resources Wales website; Accessed: June 2022

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

[1] https://naturalresources.wales/evidence-and-data/maps/long-term-flood-risk/?lang=en

3 HYDROLOGY

3.1 Requirement for Flood Estimation

Design flows are required for the present day 1 in 20, 1 in 100 and 1 in 1,000 Annual Exceedance Probability (AEP) events and the 1 in 100 AEP event including 20% and 45% increases in flow to allow for future climate change in accordance with the Welsh Government guidance updated in September 2021[2].

3.2 Methodology

The catchment delineation is shown in **Figure 3** with key catchment descriptors shown in **Table 1**. The methodology is detailed within the Flood Estimation Calculation Recorded presented in **Annex C.**

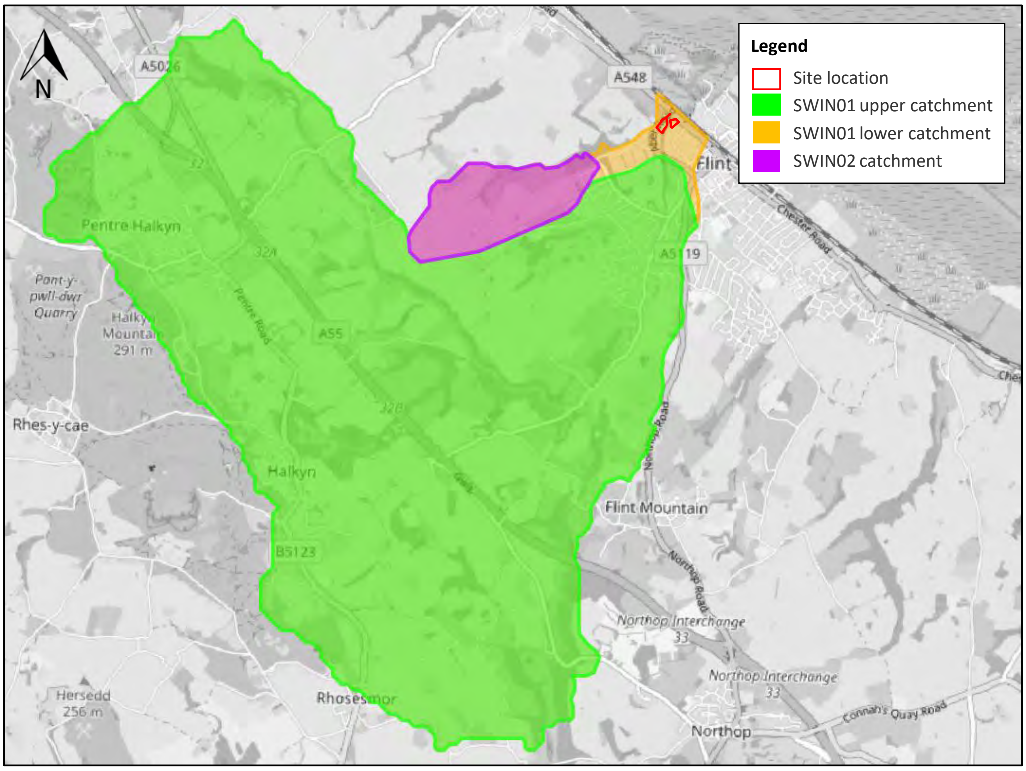


Figure 3: Catchment Delineation

Table 1: FEH Catchment Descriptors

LOCATION	FARL	PROPWET	BFIHOST19	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	URBEXT 2000	FPEXT
SWIN01-02	0.99	0.38	0.404	5.62	97.6	849	0.0504	0.0161

[2] https://www.gov.wales/sites/default/files/publications/2021-09/climate-change-allowances-and-flood-consequence-assessments_0

3.3 Final Choice of Method

Peak flow estimates up to the 1 in 100 AEP event have been derived using the Flood Estimation Handbook (FEH) Statistical Method. In order to determine flows for the 1 in 1,000 AEP event, ReFH2 has been used to calculate the ratio between the 1 in 100 and 1 in 1,000 AEP event flows, which has then been applied to scale the FEH 1 in 100 AEP event peak flow (i.e. the "Ratio Method").

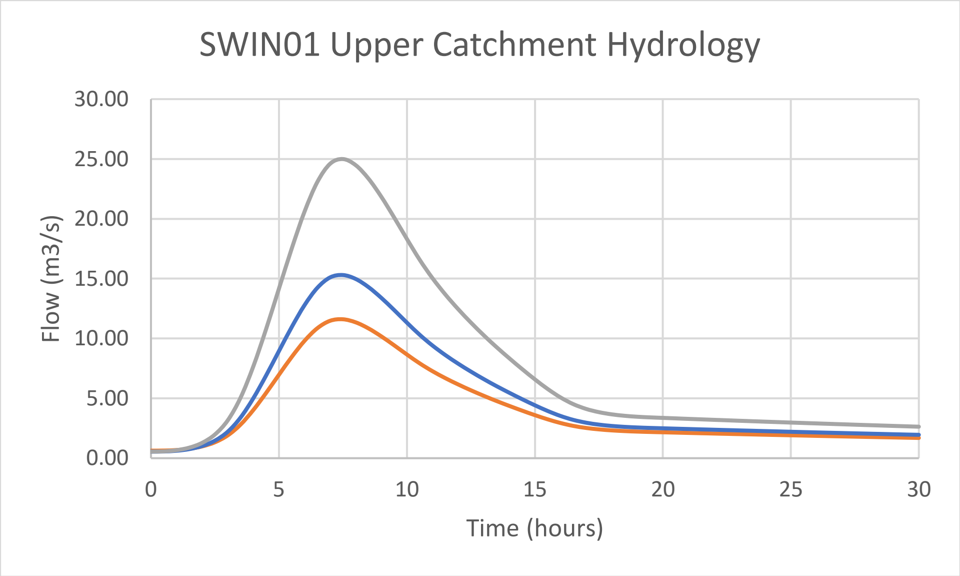
Flows for the SWIN01 sub-catchments and the SWIN02 catchment have been calculated by weighting the flows based on the areas of the sub-catchments.

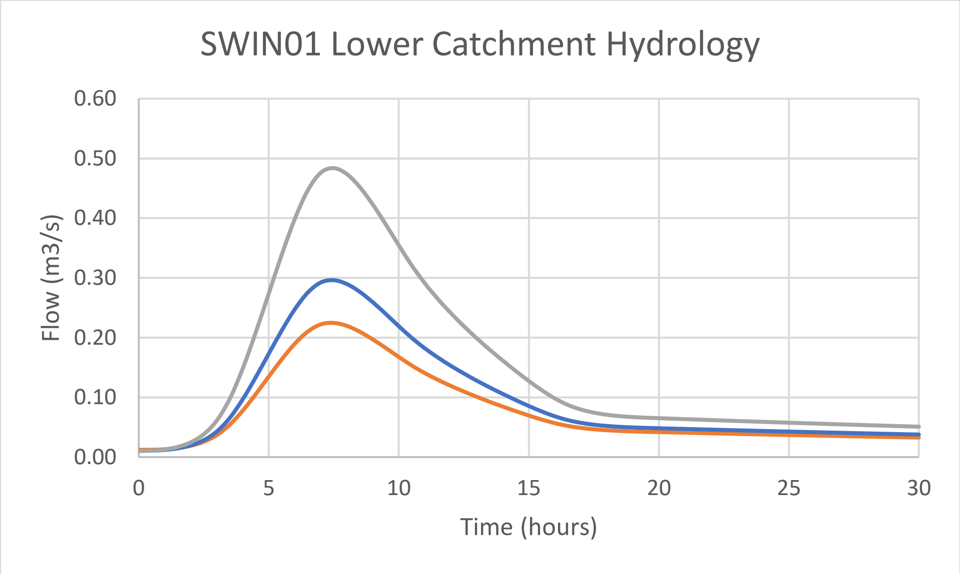
Flood hydrographs have been determined by the ReFH2 method.

3.4 Flows Applied to Hydraulic Model

The derived flows for each catchment have been input into the model as two point inflows at the upstream extent of Swinchiard Brook and the unnamed watercourse. The remaining flows for the lower part of the catchment were applied as lateral inflows to the lower reaches of Swinchiard Brook.

The hydrographs used within the model for Swinchiard Brook are shown in **Figure 4** and peak flow estimates for each sub-catchment are shown in **Table 2**.





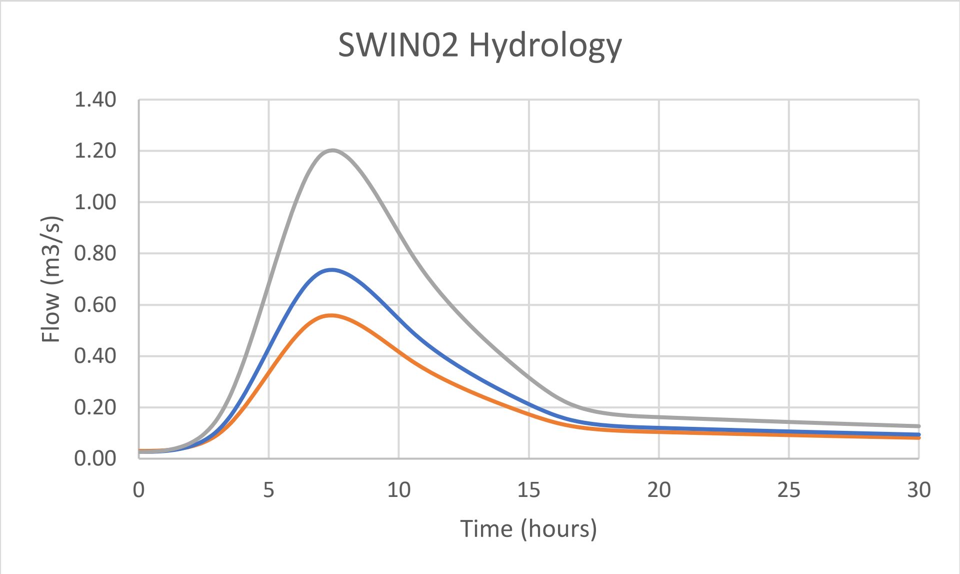


Figure 4: Flood Hydrographs

Table 2: Peak Flow Estimates

Location	Peak Flows (m3/s) for the following return periods				
	20	100	100 + 20% CC	100 + 45% CC	1000
SWIN01 Upper Catchment	11.61	15.30	18.36	22.19	24.99
SWIN01 Lower Catchment	0.22	0.30	0.36	0.43	0.48
SWIN02	0.56	0.74	0.88	1.07	1.20

4 HYDRAULIC MODEL DEVELOPMENT

4.1 Modelling Approach

In order to more accurately define the level of fluvial flood risk to the site from the Swinchiard Brook, Weetwood has developed an ESTRY-TUFLOW hydraulic model.

The Swinchiard Brook has been represented using a 1D ESTRY model. The floodplain has been modelled in 2D using TUFLOW. This has been dynamically linked to the 1D fluvial model.

4.2 Model Extent

The upstream extent of the 1D domain of Swinchiard Brook is located approximately 500 m south of the site (node label SWIN01_1105). The upstream extent of the south-western tributary is located 640 m south-west (node label SWIN03_0620). The downstream extent of the 1D domain is located approximately 250 m north-east of the site (node label SWIN01_0166).

The 2D domain extends across both the left and right floodplain between the entire modelled reach. The lateral extents of the 2D domain have been derived with reference to the topography and site location. The upstream and downstream extent of the 2D domain has been based on topography in order to have minimal influence on the assessed flood risk at the site.

Figure 5 illustrates the model extent.

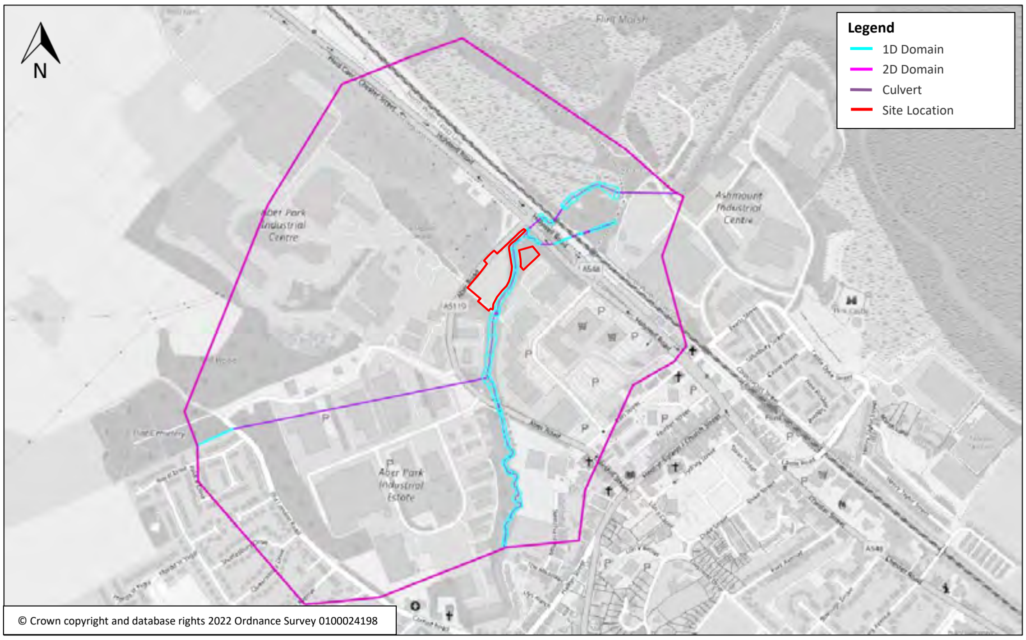


Figure 5: Model Extent

4.3 Topographic Development

In the 1D domain the channel topography is defined by cross-sections. The data collected during the channel survey (**Annex B**) 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 (**Section 4.3.1**).

The 2D domain topography is based upon filtered LiDAR data as shown in **Figure 6**.

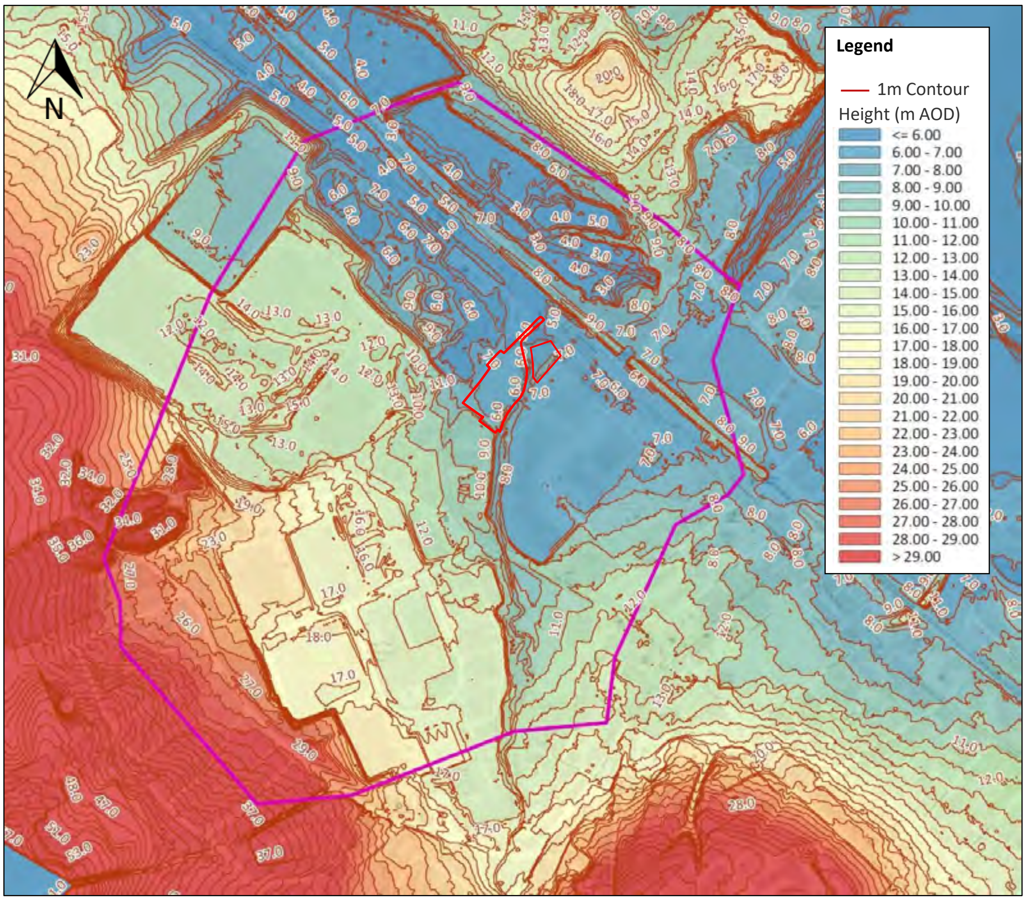


Figure 6: LiDAR

The LiDAR data was flown during February 2013 and is considered to be the most recent available data with a grid resolution of 2 m. The LiDAR data was validated against the survey data (**Annex A**) and is considered fit for purpose.

Whilst not ideal when using 2 m LiDAR, the grid size used for the 2D domain was chosen as 1 m given the small widths of some of the 1D channels. This grid sizing will also enable any flow paths between buildings/along roads to be modelled whilst still permitting reasonable model run times.

4.3.1 Structures - Channel

The structures that cross the channel are represented within the 1D domain. The location of these structures is shown in **Figure 7** with photographs of each structure and the Flood Modeller unit type provided **Figure 8**.

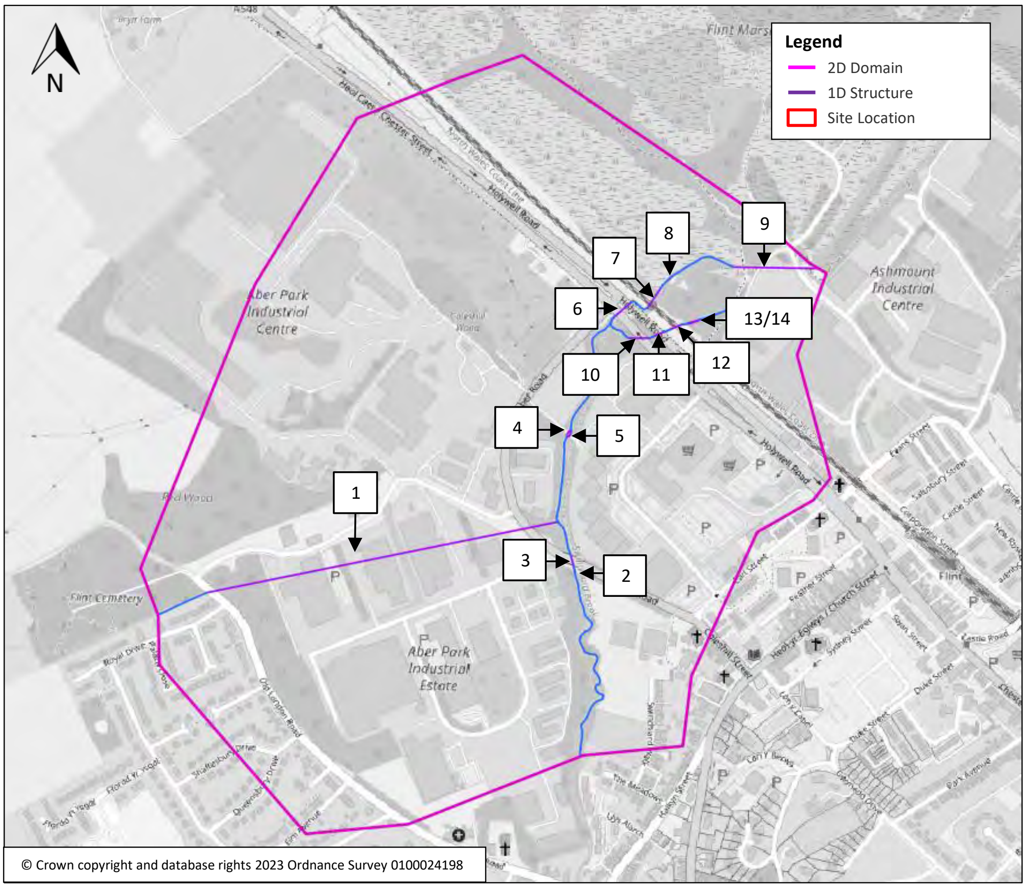


Figure 7: Location of Channel Structures in Modelled Reach

1. SWIN03_0539s
Estry Type: C

2. SWIN01_0779s
Estry Type: BBW

3. SWIN01_0769s
Estry Type: BBW

4. SWIN01_0568s1
FM Unit: RW

5. SWIN01_0568s2
Estry Type: R

6. SWIN01_0364s
Estry Type: R

7. SWIN01_0294s
Estry Type: BB

8. SWIN01_0240s (No image available)
Estry Type: WW

9. SWIN01_0131s
Estry Type: CU

10. SWIN01_0277s
Estry Type: R

11. SWIN02_0254s
Estry Type: RW

12. Swin02_0225s
Estry Type: BB

13. SWIN02_0196s1 & SWIN02_0196s2
Estry Type: C

Figure 8: 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_hxi' 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 Manning's n

The Manning's *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 Manning's *n* values.

The Manning's *n* values used in the model are shown in **Table 3**.

Table 3: Manning's *n* Values

Land Use		Manning's n Value
Channel	Clean, straight channel	0.030
	Clean, straight channel with stones and weeds	0.040 / 0.045

	Clean, straight channel with more stones and weeds	0.050
	Full Concrete Channel	0.013
Structures	Brick with Cement Mortar	0.015
	Trowel Finished Concrete	0.013
Floodplain	Short Grass	0.030
	Dense Trees and Shrubs	0.060
	Medium to Dense Brush	0.07
	Gardens	0.100
	Roads	0.25
	Hardstanding	0.035
	Waterbodies	0.025
	Buildings	0.500
	Woodland	0.100

4.6 Boundary Conditions

4.6.1 Input Boundaries

The input flow hydrographs are those outlined within **Section 3**.

Flows have been input into the upstream extent of the 1D model of Swinchiard Brook and Drain A using a 'QT' point and are read into TUFLOW using a '1d_bc_inflow' file. A lateral inflow has been applied along the downstream extent of Swinchiard Brook using 'QT' links, which have also been inputted into TUFLOW using a '1d_bc_inflow' file.

No flow has been input into Drain A (details presented in **Section 3**).

These have been input into the upstream extent of the 1D model at the locations shown in **Figure 9**.

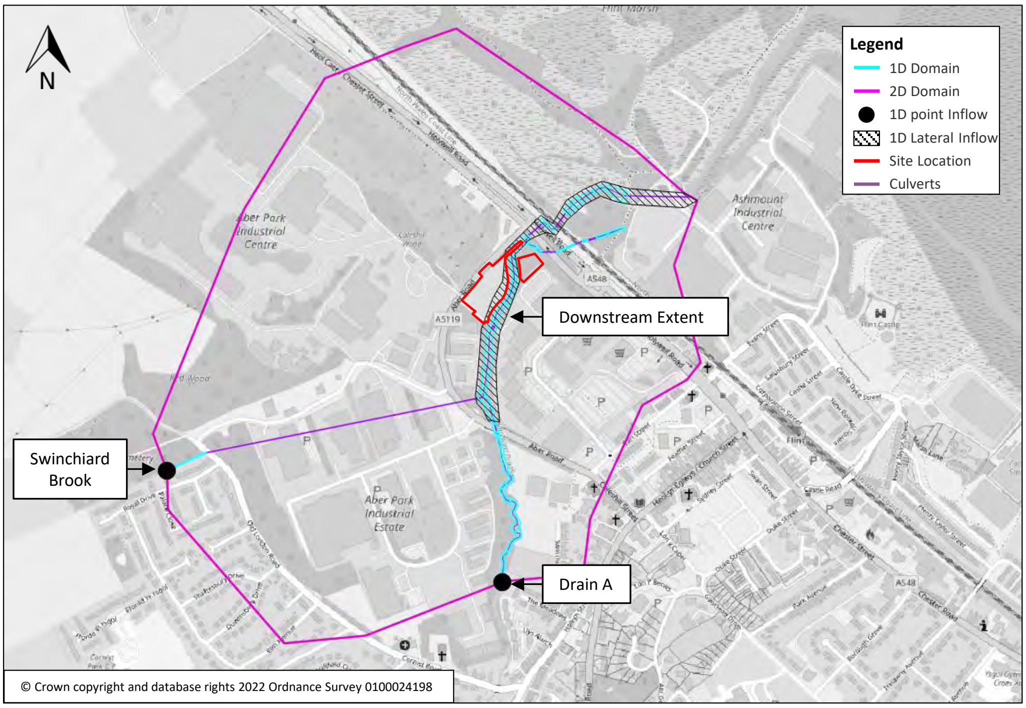


Figure 9: Input Boundaries

4.6.2 Downstream Boundaries

Given the model extents proximity to the River Dee (tidally influenced), the downstream boundary condition for the model has been derived from the Natural Resources Wales 2015 ESTRY_TUFLOW Model for the areas of Greenfield and Panton Cop (Greenfield_5_V2.0_2015) for the River Dee, using the mean high water spring plus an allowance for climate change.

4.7 Model Version and Simulation Information

The model was developed using TUFLOW build 2020-10-AD-iSP-w64 (HPC Solver).

Simulations for all design events were run with a 0.25 second timestep in the 1D Flood Modeller domain and a 0.5 second timestep in the 2D TUFLOW domain. Information on timestep and other variables can be seen in the *'*.tcf/.ecf'* files for each run and is recorded in the modelling logbook spreadsheet (*'5560 Modelling Logbook.xls'*) accompanying this report (see **Annex D**).

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 '*5560 Modelling Logbook.xls*' included within **Annex D** of this report.

Table 4: Model Runs

Scenario		Run Name	AEP Flood Event
Baseline		5560_026_Q0020	Present day 1 in 20
		5560_026_Q0100	Present day 1 in 100
		5560_026_Q1000	Present day 1 in 1,000
		5560_026_Q0100CC20	1 in 100 plus climate change (20%)
		5560_026_Q0100CC45	1 in 100 plus climate change (45%)
		5560_026_Q1000CC20	1 in 1,000 plus climate change (20%)
Sensitivity	Manning's n + 20%	5560_036_Q0100CC20	Manning's n + 20%
	Manning's n - 20%	5560_037_Q0100CC20	Manning's n - 20%
Blockage		5560_027_Q0100CC45	25% blockage of the A548 culvert
		5560_028_Q0100CC45	80% blockage of the A548 culvert

5.2 Model stability

Once the model has fully initialised, it is stable in both the 1D and 2D domains. The final cumulative Mass Error (ME) is between 0.01% and 0.09% during the baseline scenarios.

The HPC 'Not a Number' (NaN) value is zero for all modelled runs, indicating that no instabilities have occurred in the 2D domain. The HPC 'High Control Number' (HCN) value is also zero for all modelled runs.

There are a maximum 179 negative depths during the simulations; All of the negative depths occur early within the simulation and do not impact the maximum modelled results.

7 warning messages were indicated prior to simulation and a maximum of 335 were observed during. These relate to the aforementioned negative depths and associated instabilities that occur early within the simulation. These warnings have been checked accordingly and are considered acceptable.

The 1 in 100 AEP plus climate change (45%) baseline (free-flowing) scenario did not complete it's simulation, due to the aforementioned negative depths observed at the early stages on the simulation. For the purposes of this study, this scenario is not considered to have any bearing on proposed flood mitigation measures given that the site will be mitigated against the more extreme blockage scenario.

5.3 Model Results

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

The majority of flooding to the south-western half of the site is resultant of overland flow, entering at the south-western corner of the site from higher ground. In lower lying areas in the central and northern sections of the site, flooding occurs due to out of bank flow from Swinchiard Brook, which travels off site in a generally northern direction toward the A548.

Table 5 summarises the maximum depth and velocity of floodwaters expected at the site during the aforementioned events.

Table 5: Site Flood Information (Baseline)

Scenario	AEP Event	Max Level (m AOD)	Max Depth (m)		Max Velocity (m/s)	
			Highest	Mean	Highest	Mean
Overtopping	Present day 1 in 20	6.01 – 7.39*	0.45	0.05	0.31	0.07
	Present day 1 in 100	6.11 – 7.39*	0.51	0.09	0.51	0.13
	1 in 100 +20% climate change	6.13 – 7.40*	0.56	0.12	0.55	0.16
	Present day 1 in 1,000	6.13 – 7.40*	0.62	0.16	0.77	0.19
	1 in 1,000 +20% climate change	6.32 - 7.40*	0.66	0.19	0.88	0.23
Bridge Blockage (25%)	1 in 100 +20% climate change	6.19 – 7.40*	0.58	0.14	0.69	0.17
	1 in 100 +45% climate change	6.19 – 7.40*	0.61	0.15	0.78	0.19
	Present day 1 in 1,000	6.19 – 7.41*	0.63	0.17	0.83	0.20
	1 in 1,000 +20% climate change	6.33 – 7.41*	0.6	0.19	0.86	0.23
Bridge Blockage (80%)	1 in 100 +20% climate change	6.24 – 7.40*	0.62	0.16	0.87	0.19
	1 in 100 +45% climate change	6.28 – 7.40*	0.65	0.18	0.87	0.20
	Present day 1 in 1,000	6.32 – 7.41*	0.67	0.19	0.88	0.21
	1 in 1,000 +20% climate change	6.33 – 7.41 *	0.71	0.21	0.89	0.23

* highest levels relate to shallow overland flow from higher ground to the south-west.

6 MODEL CALIBRATION AND SENSITIVITY

6.1 Model Calibration

6.1.1 Known Historical Events

The Natural Resources Wales historic flood outlines database[3] indicates that flooding in the north and east of the site occurred in 2000 as a result of the Swinchiard Brook channel capacity being exceeded. No details have been made available to confirm flood levels during that event. As such, it has not been possible to calibrate the hydraulic model using historic flow/level data.

6.2 Model Sensitivity

6.2.1 Manning's n

Sensitivity testing has been carried out for the 1 in 100 plus climate change (20%) AEP event on the Manning's *n* coefficients by varying them by +/-20%.

Model output plots are provided in **Annex F**. 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 +0.03 and -0.07 m within the site and the flood extents were not significantly different.

Based on the above the model is not considered to be sensitive to changes in roughness coefficients.

6.2.2 Downstream Boundary

Given that the flood levels applied to the downstream boundary of the model have been taken from the modelled outputs of a Natural Resources Wales hydraulic model, no sensitivity testing is considered to be necessary for the downstream boundary of the model for this study.

6.2.3 Structure Blockage

Sensitivity testing has been carried out for the 1 in 100 plus climate change (20%) AEP event by applying a 25% and 80% blockage to the bridge located beneath the A548 (SWIN01_0364s), approximately 45 m downstream of the site.

Model output plots are provided in **Annex F**. The results indicate a 25% and 80% blockage would increase flood levels at the site by approximately 0.02 and 0.07 m respectively. Additional water backing up behind the structure is shown to flow north-west across Aber Road before being able to build up to significant depths at the site itself. Given this, the site is not considered to be sensitive to blockages of the A548 bridge.

6.3 Model Limitations and Assumptions

Study specific model limitations and assumptions include:

- The model has been prepared specifically for the application site and therefore should present the worst-case scenario for the site and may not accurately represent flood risk in other locations.
- Model calibration has not been undertaken due to limited data available.

[3] http://lle.gov.wales/catalogue/item/HistoricFl/?lang=en

7 SUMMARY

This report has been prepared on behalf of HMG (Aber Road) Limited and relates to the proposed redevelopment of the land off Aber Road, Flint.

The Development Advice Map indicates that the majority of the site is located in zone C1 with an area in the south located in zone B.

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

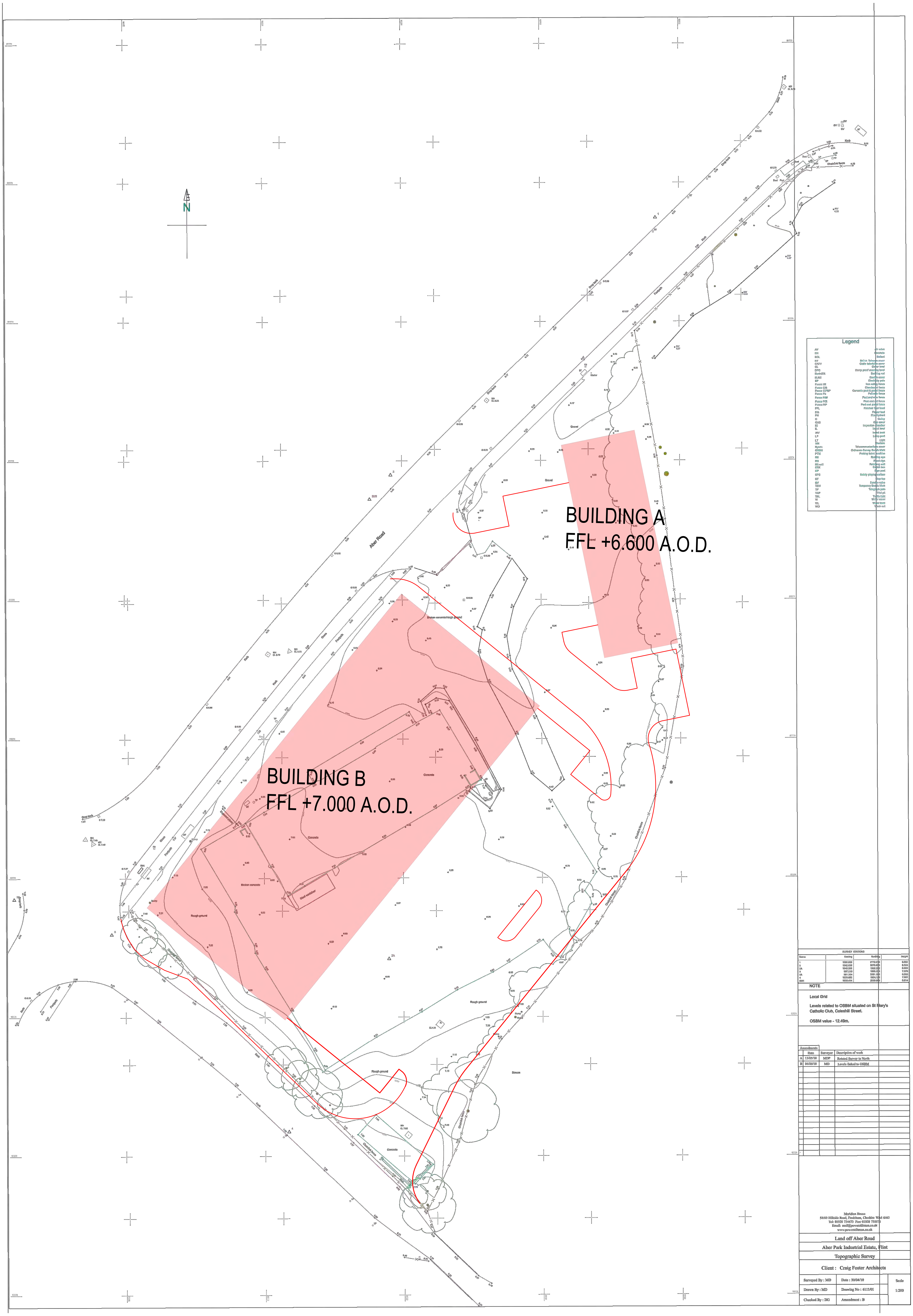
The model results indicate generally shallow flooding of the site from the south-west via overland flow from upstream, and flooding directly from overtopping of Swinchiard Brook in the eastern and northern portions of the site during all fluvial baseline AEP events assessed within this study.

The model is not considered to be sensitive to variations in Manning's n coefficients.

The site is not considered to be sensitive to blockages of the A548 bridge.

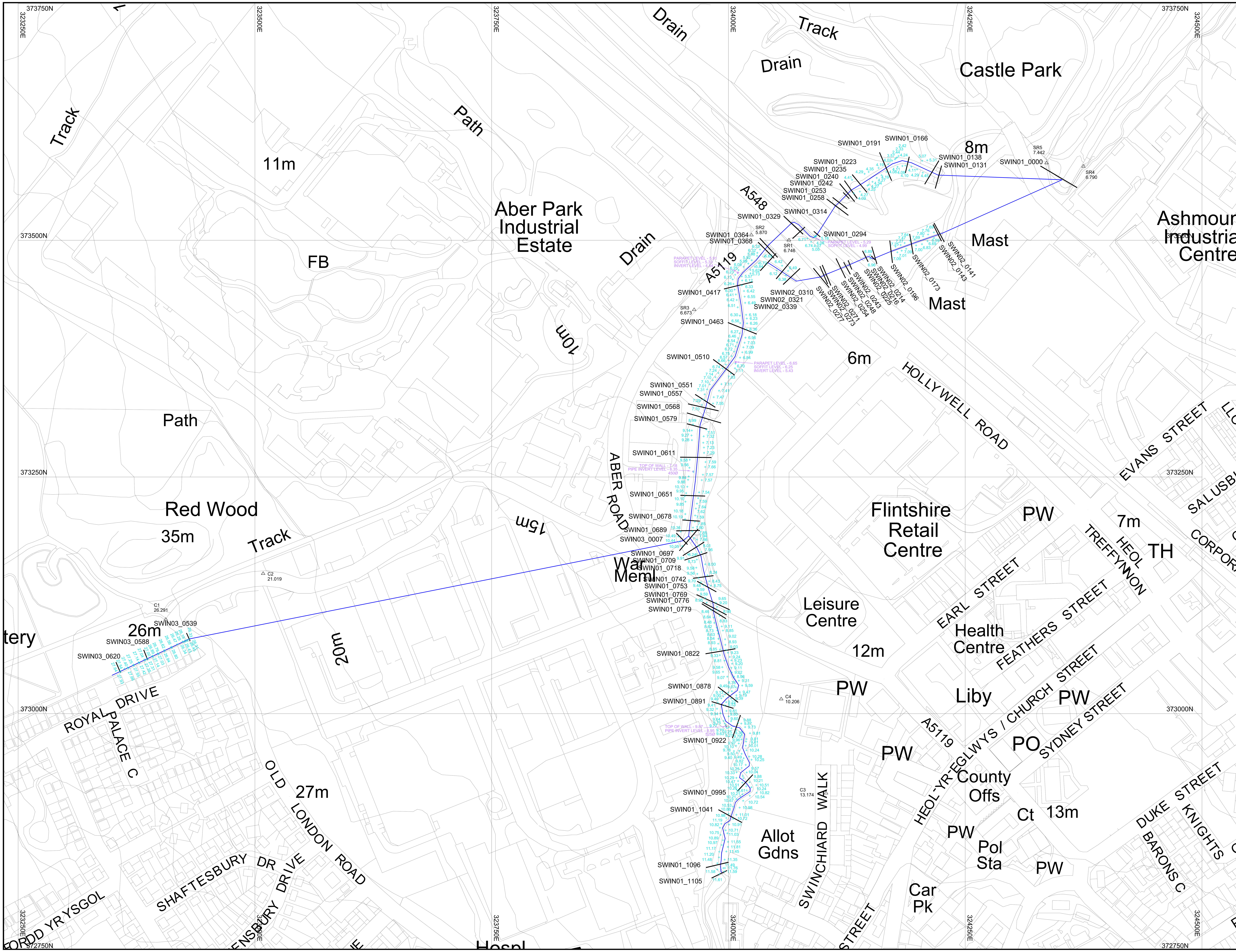
ANNEX A

Topographic Survey


N
Aber Road
BUILDING A
FFL +6.600 A.O.D.
BUILDING B
FFL +7.000 A.O.D.
Legend
SURVEY STATIONS
NOTE
Local Grid
Levels related to OSBM situated on St Mary's Catholic Club, Coleshill Street.
OSBM value - 12.49m.
Amendments
Date | Surveyor | Description of work
A | 13/05/10 | MDP | Rotated Survey to North
B | 04/06/10 | MD | Levels linked to OSBM
Meridian House
58/60 Hillside Road, Frodsham, Cheshire WA6 6AG
Land off Aber Road
Aber Park Industrial Estate, Flint
Topographic Survey
Client : Craig Foster Architects
Surveyed By : MD
Date : 30/04/10
Drawn By : MD
Drawing No : 6111/01
Checked By : DG
Amendment : B
Scale
1:200

ANNEX B

Channel Survey



Notes
This drawing and the information contained therein is Issued in confidence and is the copyright of Met Geo Environmental Limited. Disclosure of this information to Third Parties and unauthorised copying or replication of this data without approval is forbidden.

N

Grid : OS National Grid.
Using the OS GPS Network and applying OSTN15 transformation

Datum : OS Level Datum.
Using the OS GPS Network and applying OSGM15 National Geoid Model to obtain local area corrections.

Station Listing

Station	Easting	Northing	Level
SR1	324063.887	373500.136	6.746
SR2	324024.316	373505.474	5.870
SR3	323963.832	373426.644	6.673
SR4	324374.816	373578.083	6.790
SR5	324335.843	373581.602	7.442
C1	323405.882	373099.445	26.291
C2	323508.695	373147.976	21.019
C3	324103.122	372916.032	13.174
C4	324055.749	373015.415	10.206

Rev	Date	Drawn	Description	Check
-	--/--/----	--	--	--

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W: www.metgeoenvironmental.com

Client
WEETWOOD SERVICES LTD

Site
SWINCHIARD BROOK
FLINT, CH6 5EP

Title
KEYPLAN

Surveyed	RD, CC	Drawn	RD, CC
Check	KZ	Date	10/10/2022

Scale	Job No	Sheet Size	Rev
1:1250	P22-01289	A0	01

DWG Ref

Project Number	Origin	Zone	Level	Desc	Type	Role	Sheet
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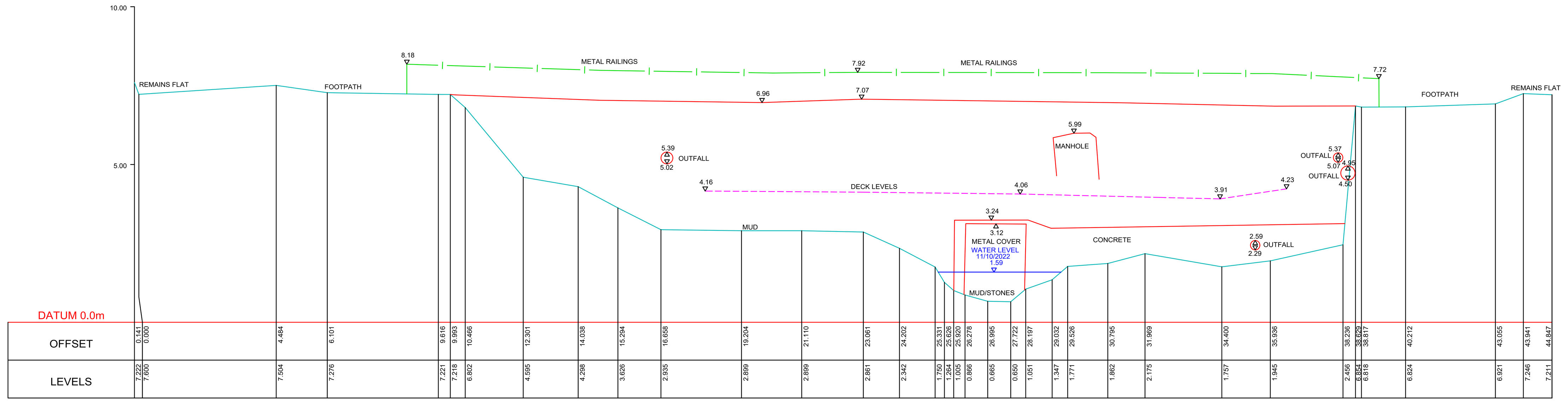
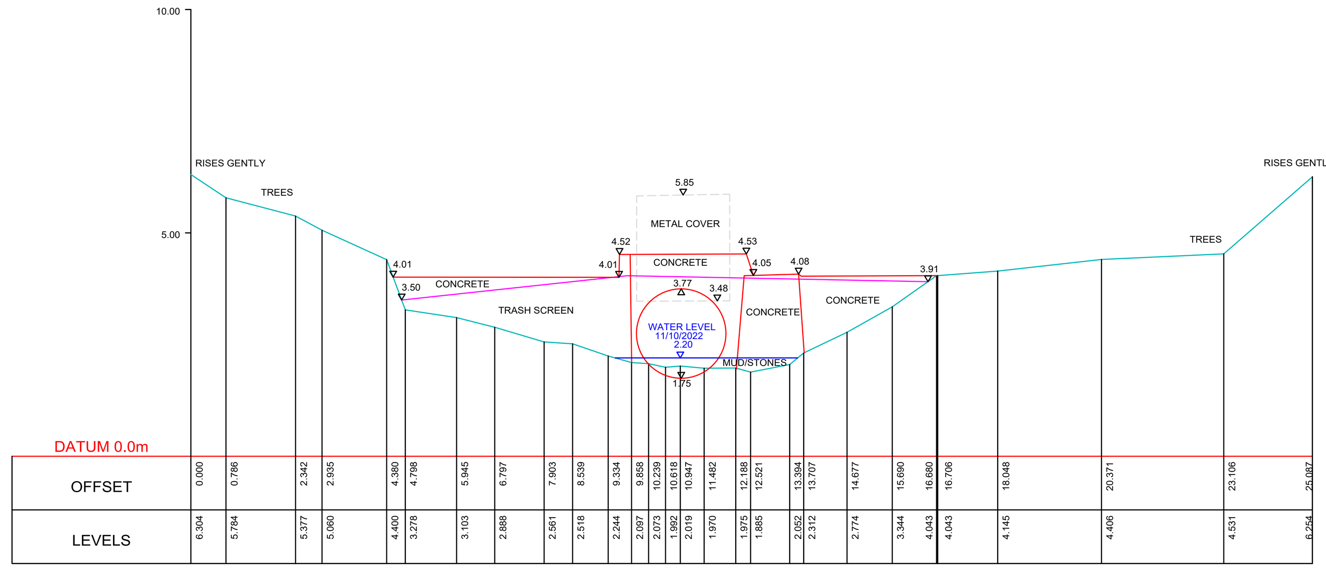
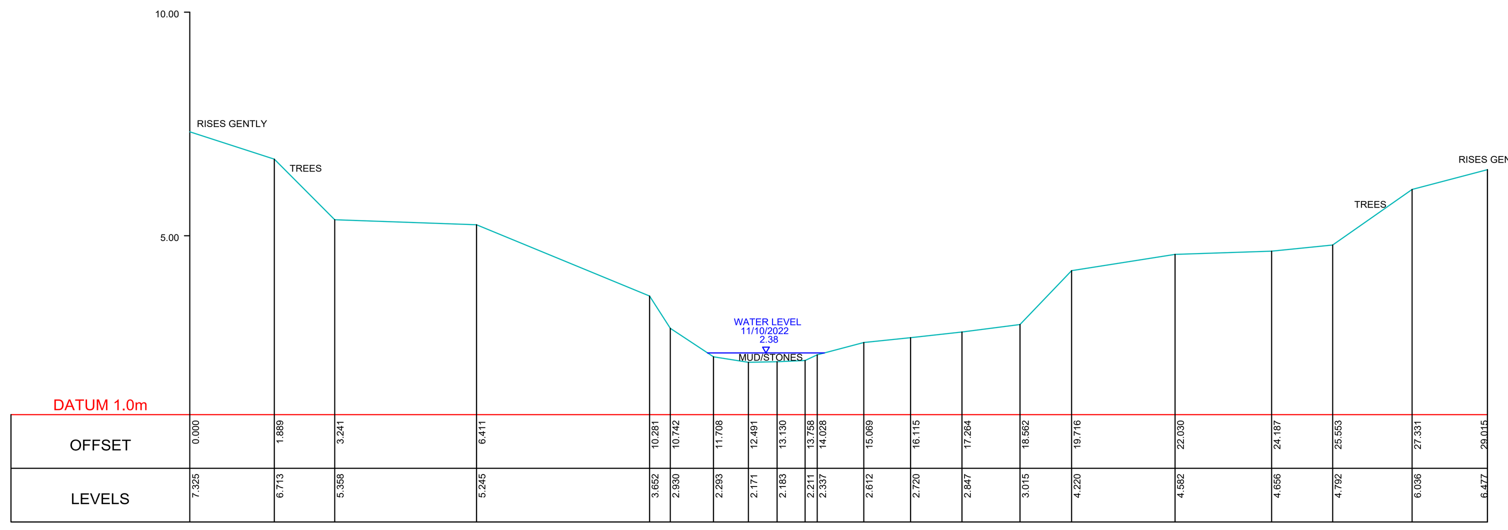


SWIN01_0000



SWIN01_0131



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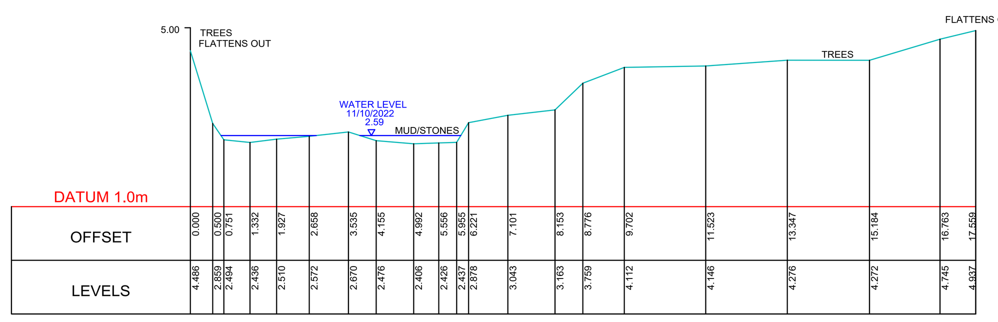

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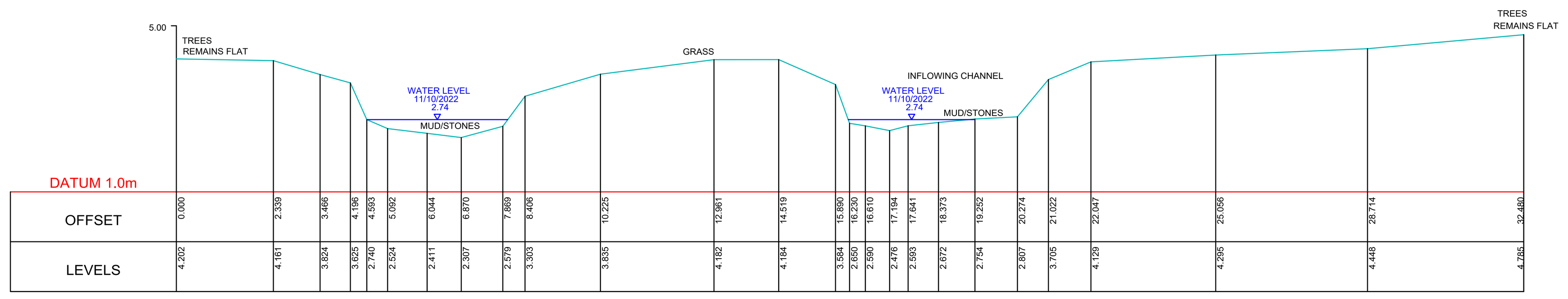

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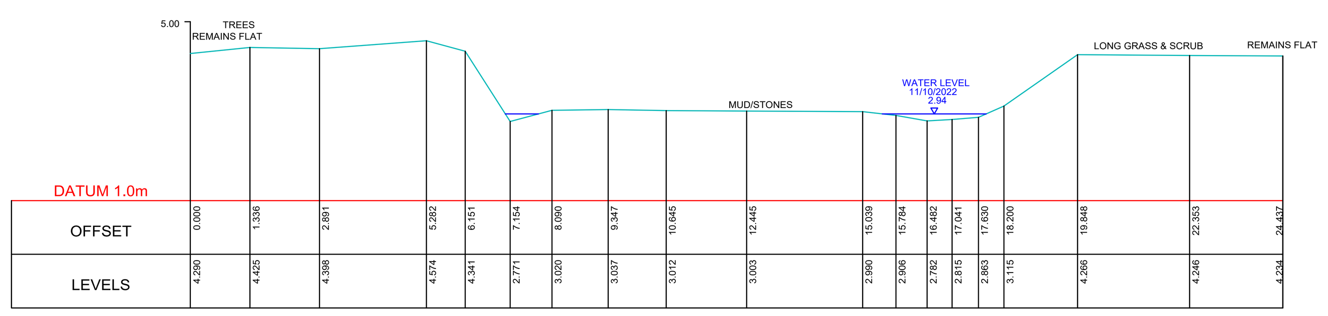

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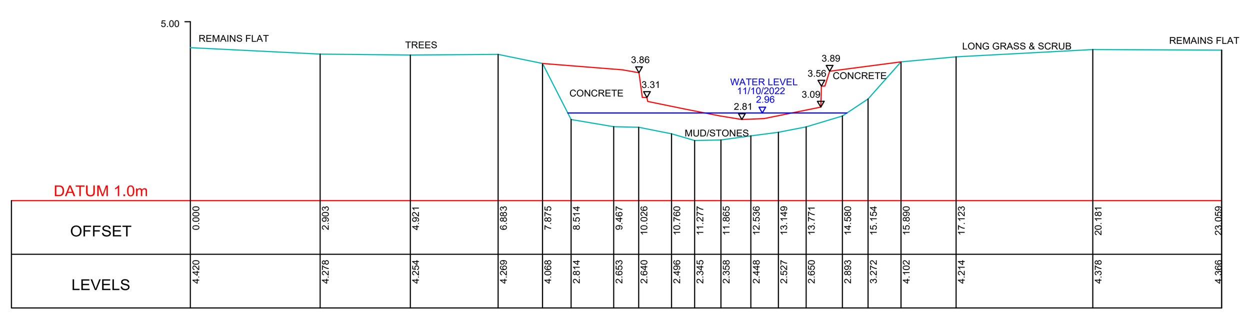

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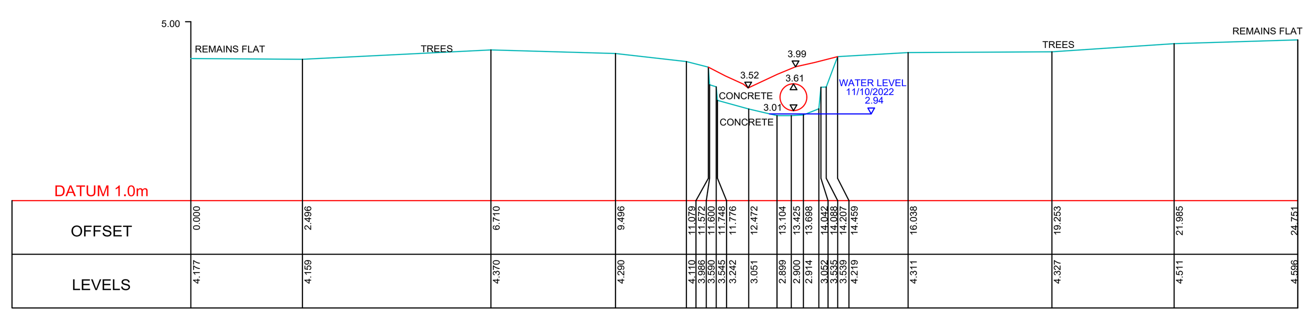

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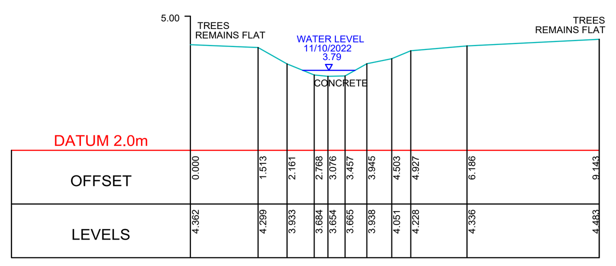

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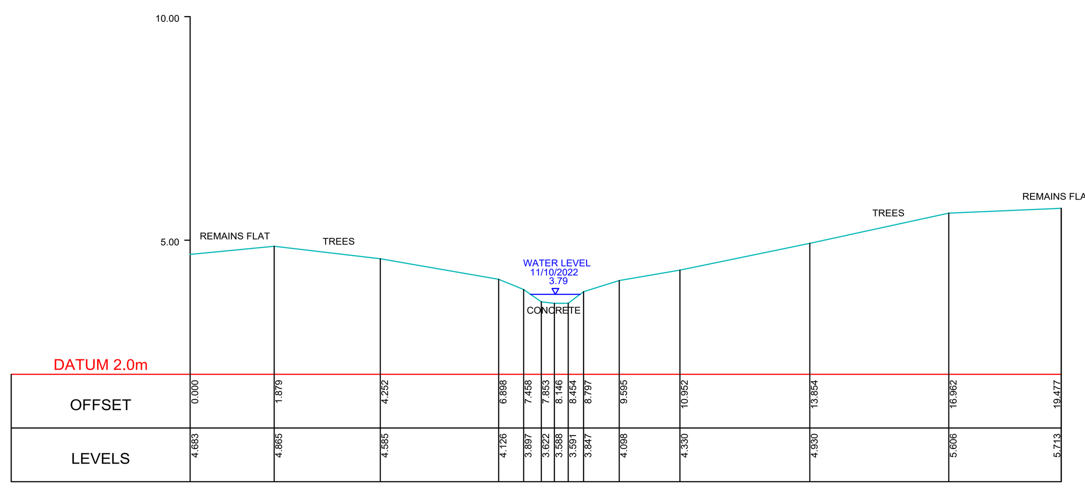

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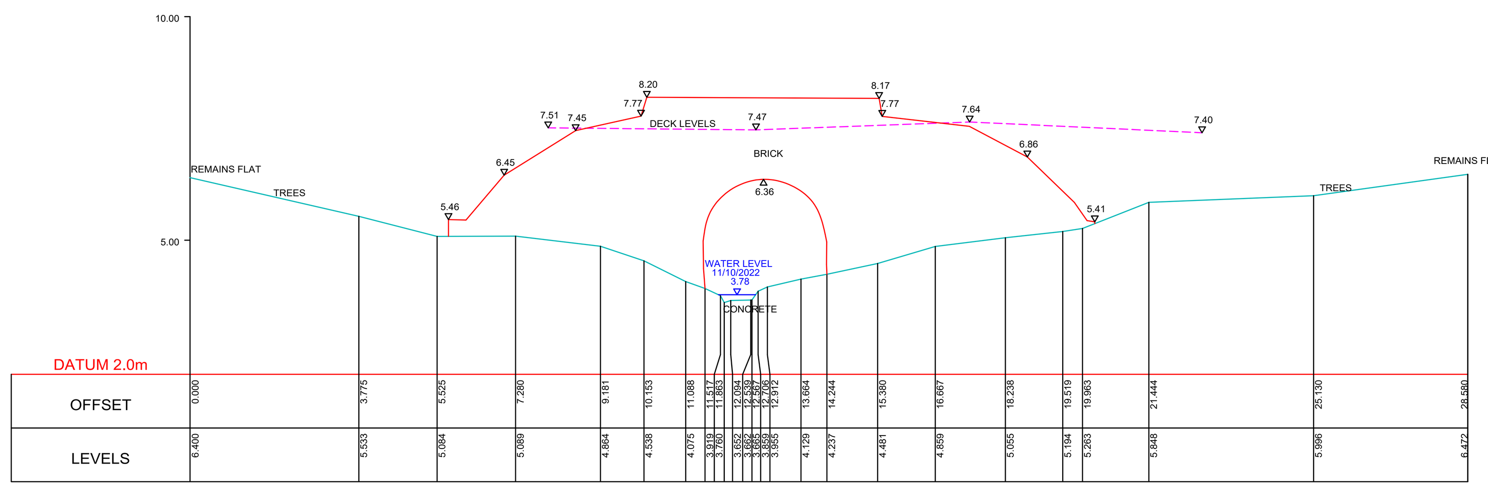

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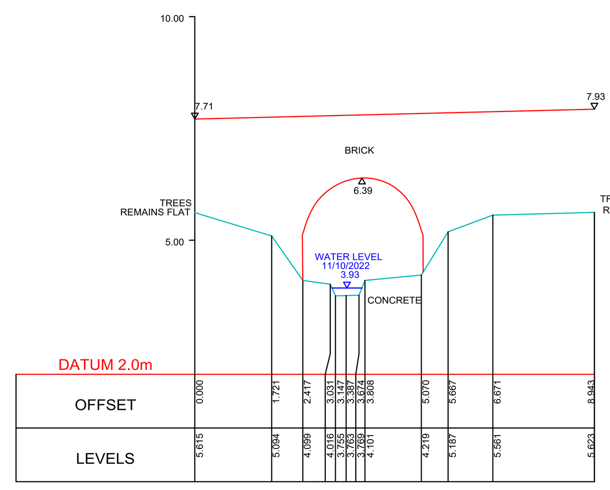

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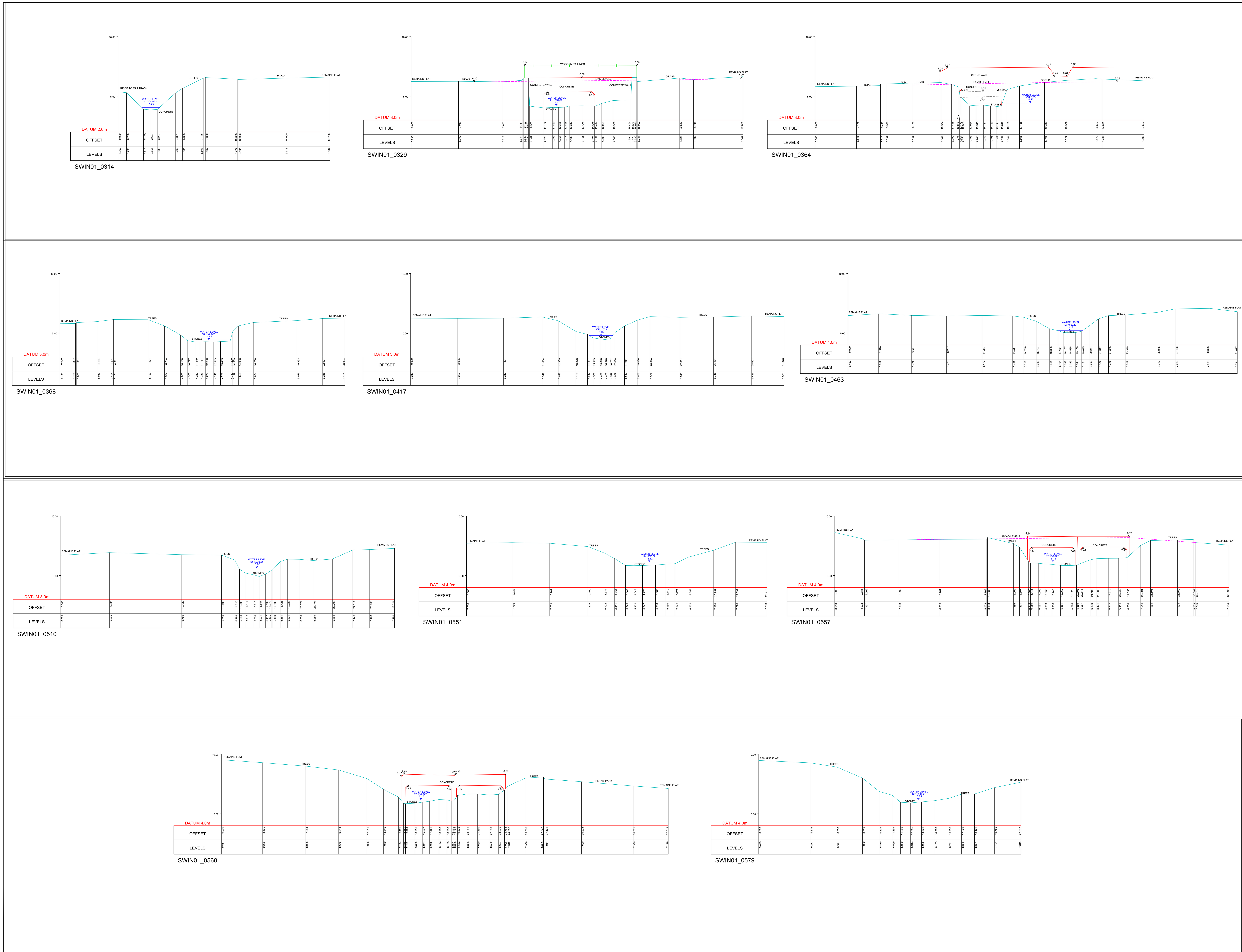

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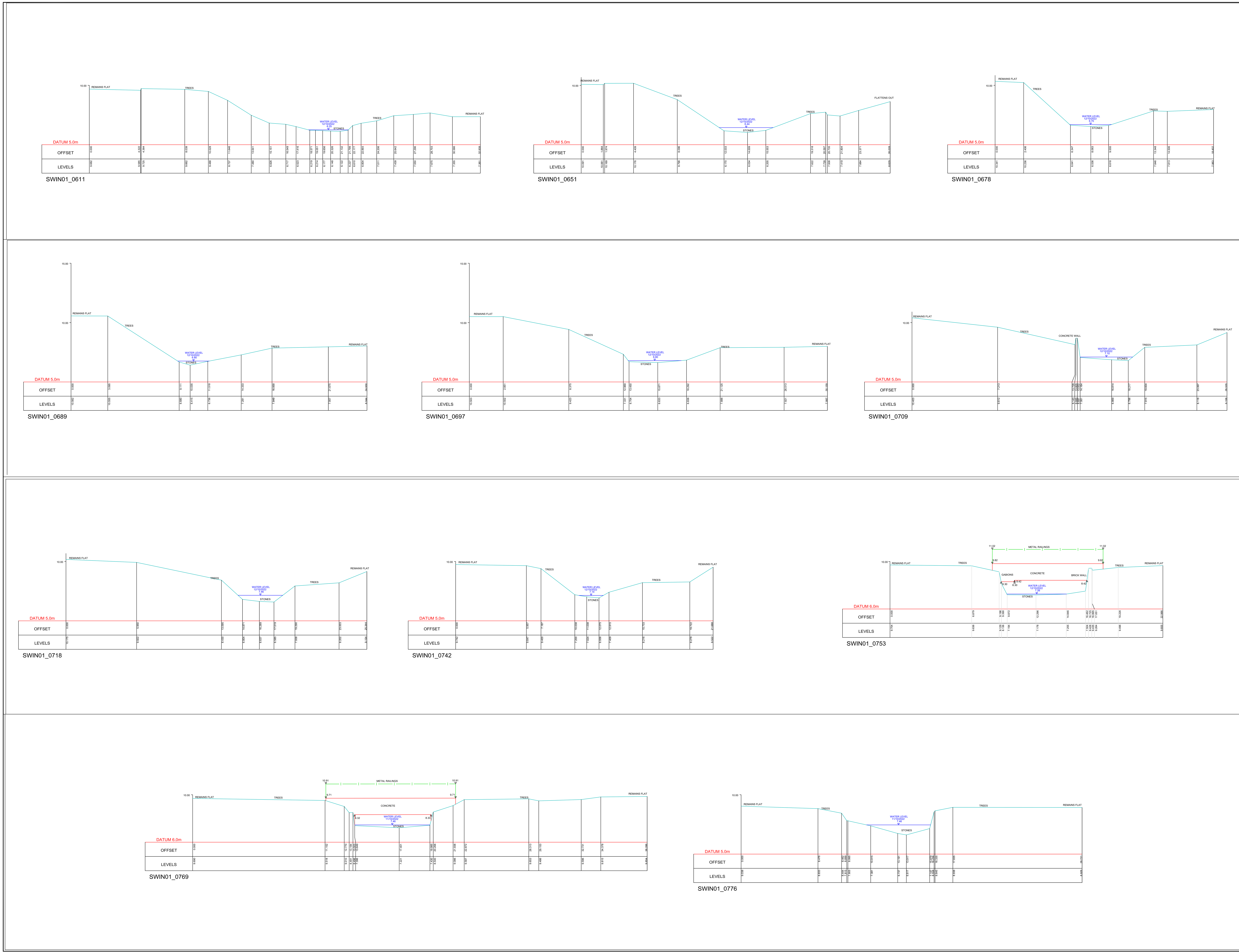

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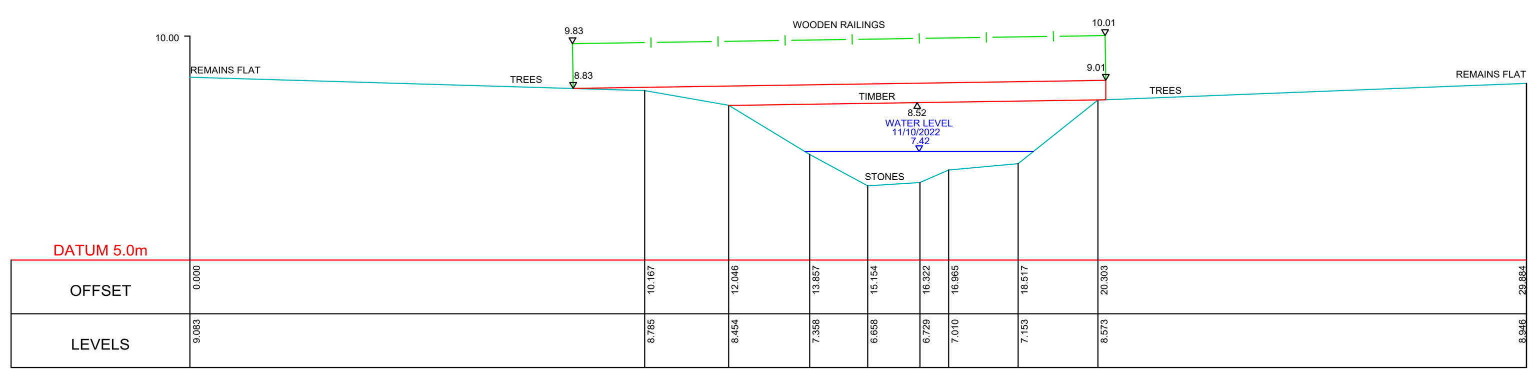

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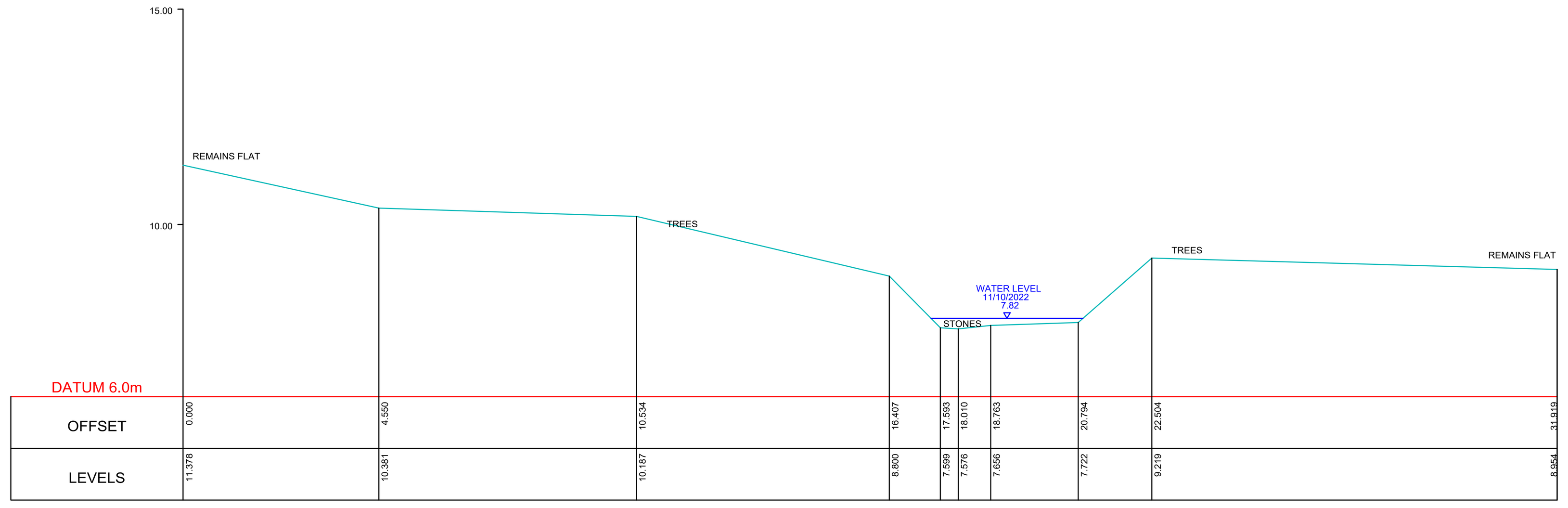

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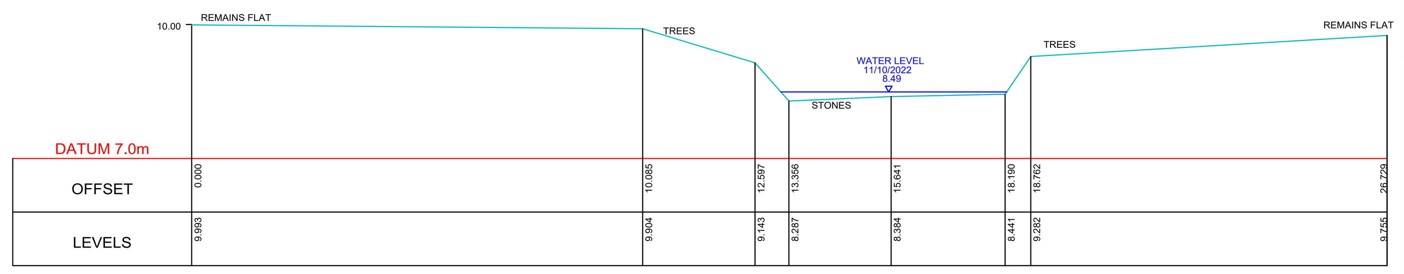

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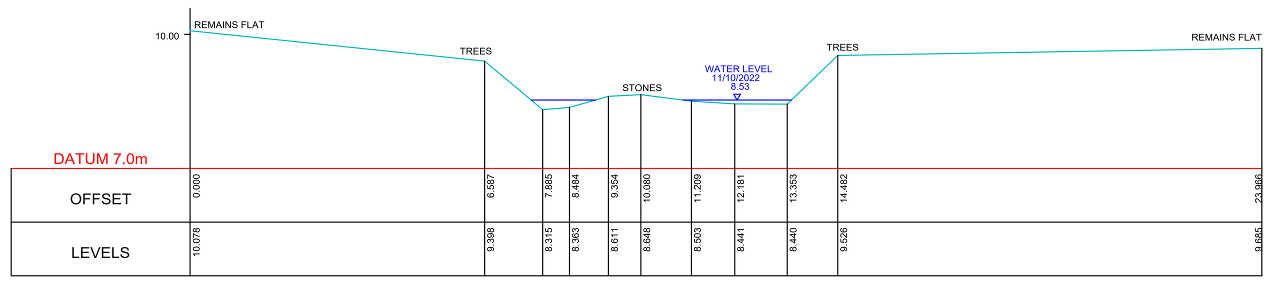

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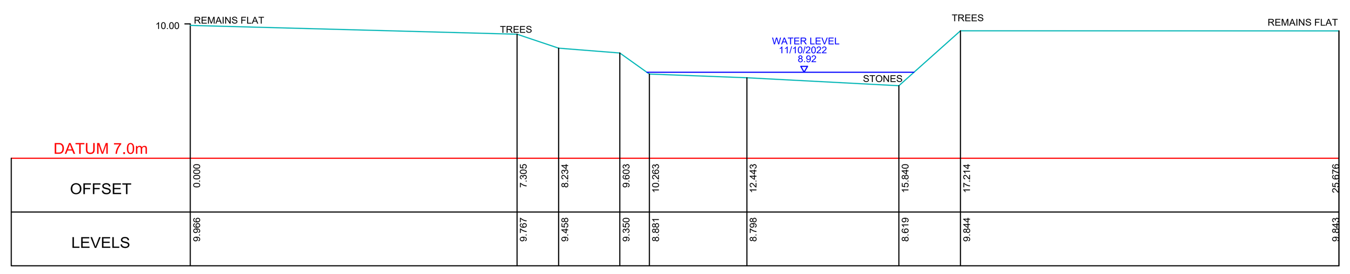

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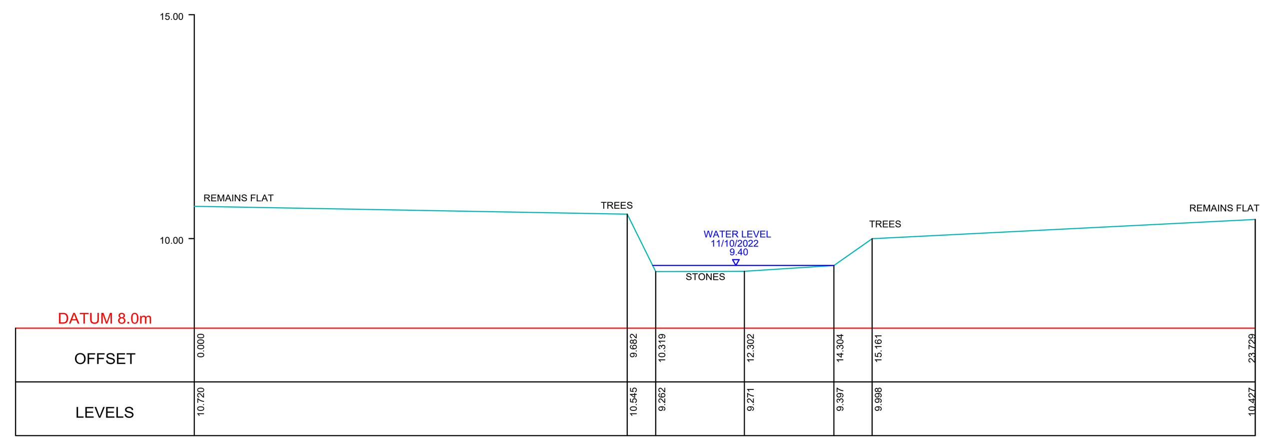

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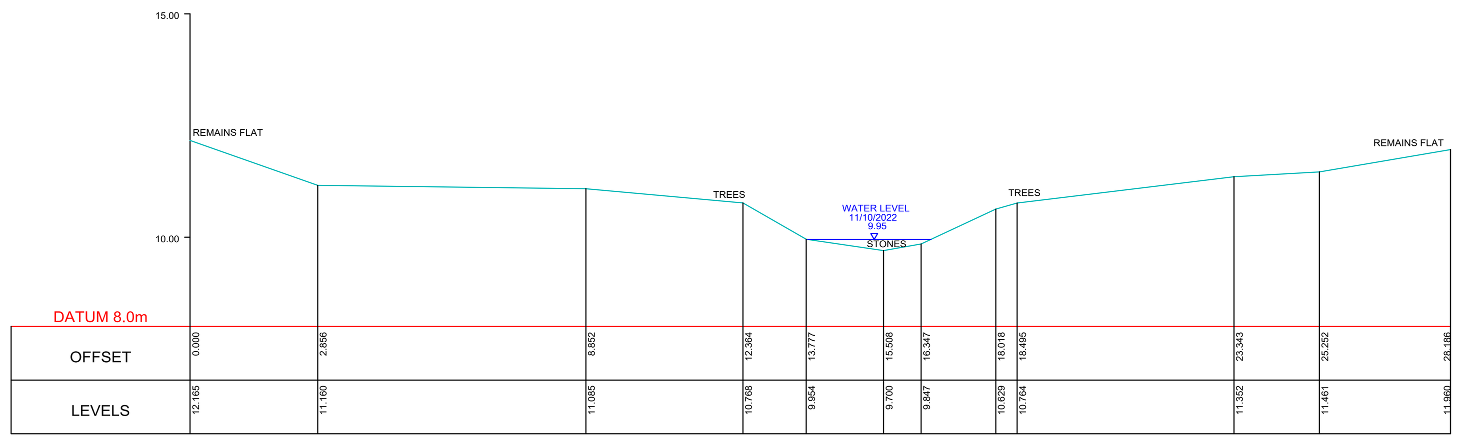

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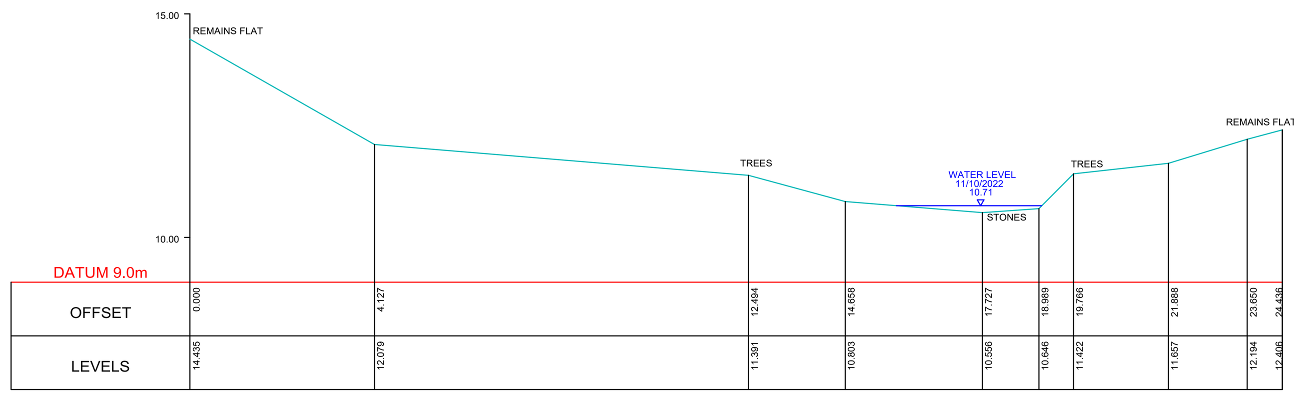

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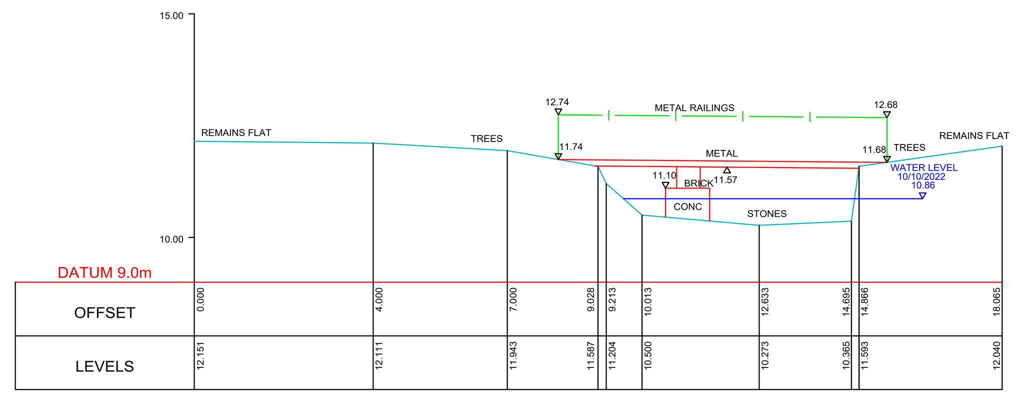

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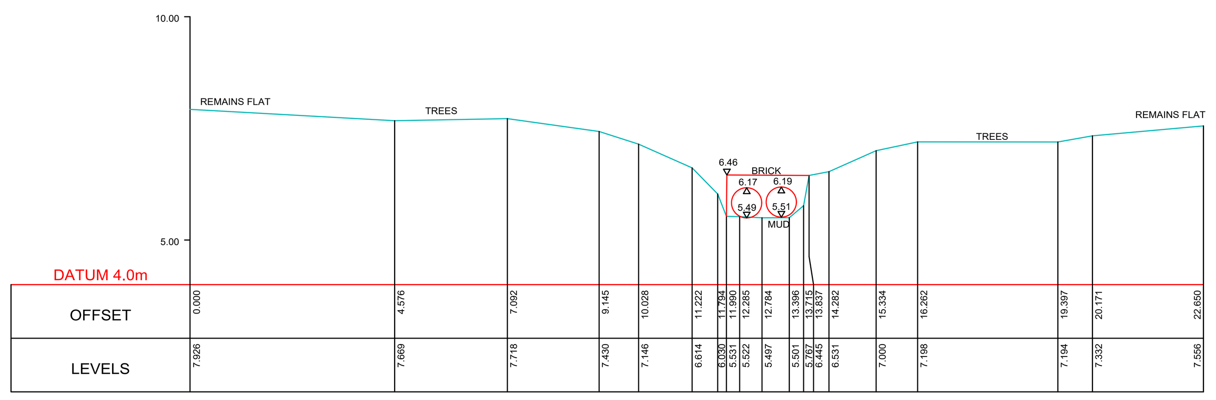

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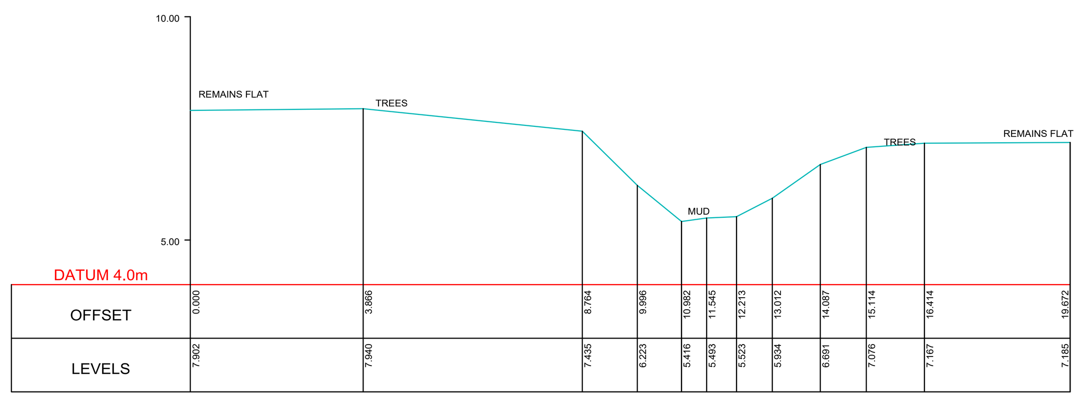

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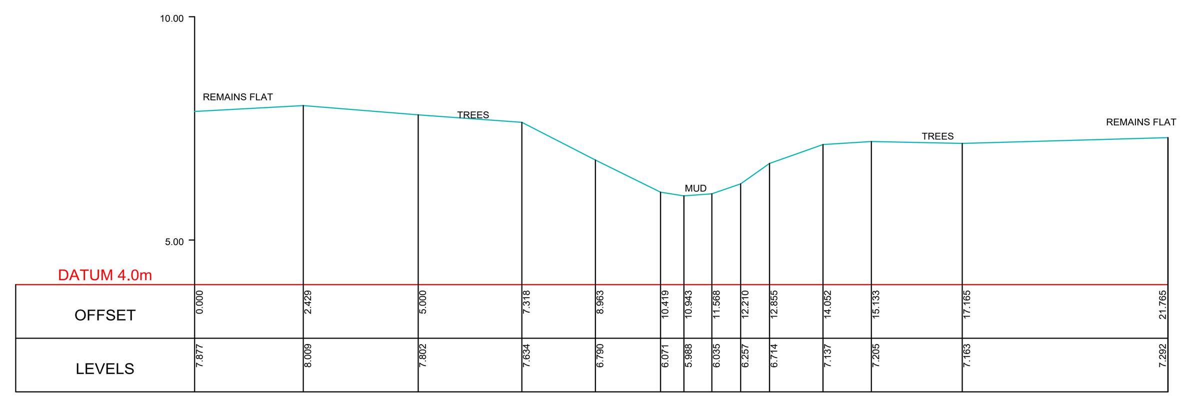

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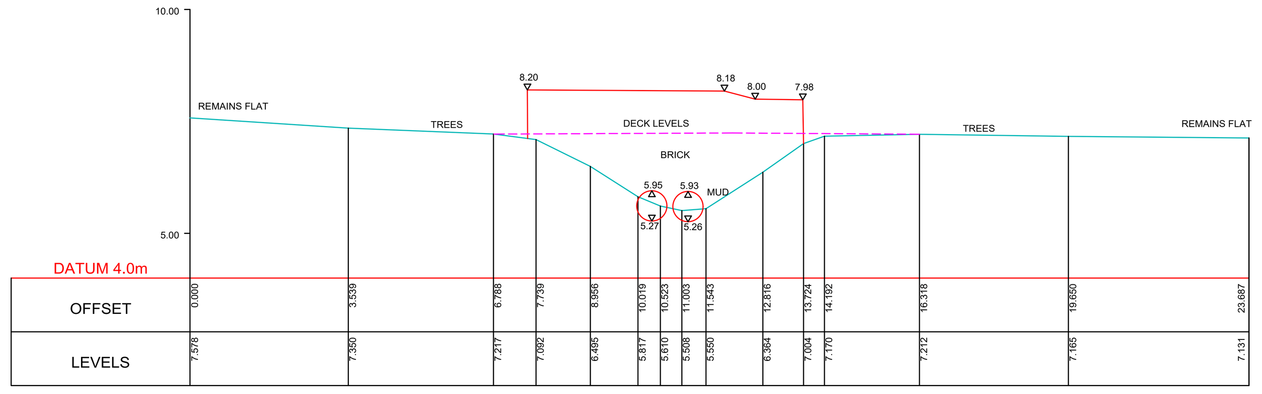

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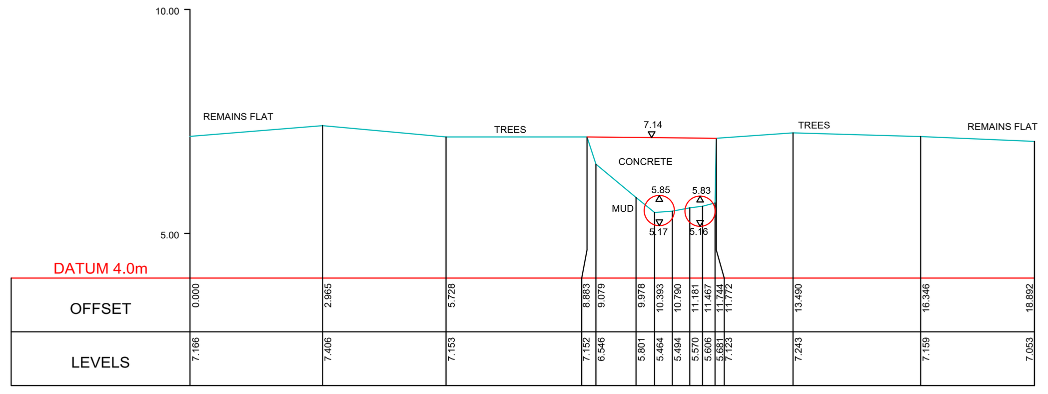

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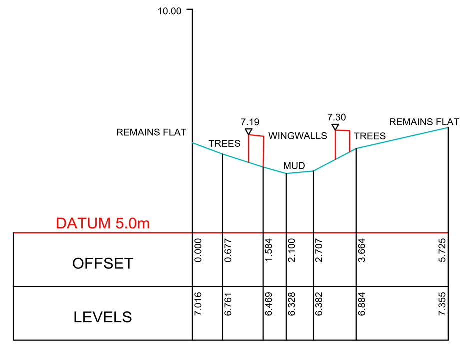

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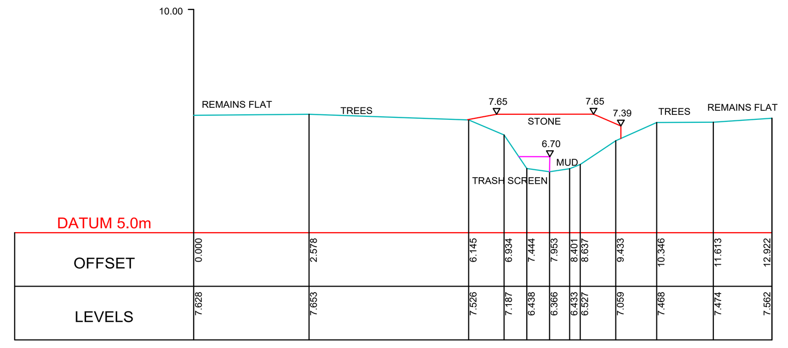

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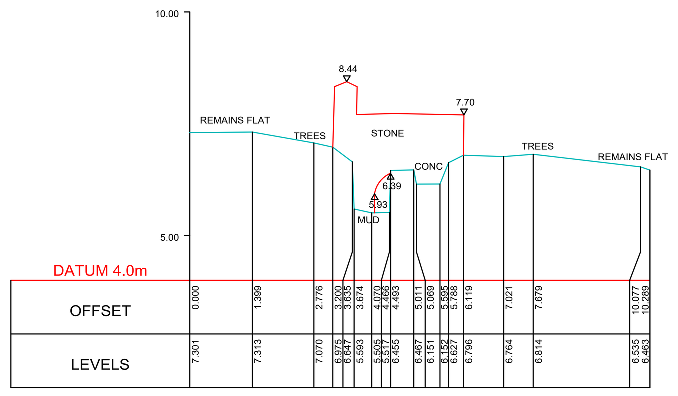

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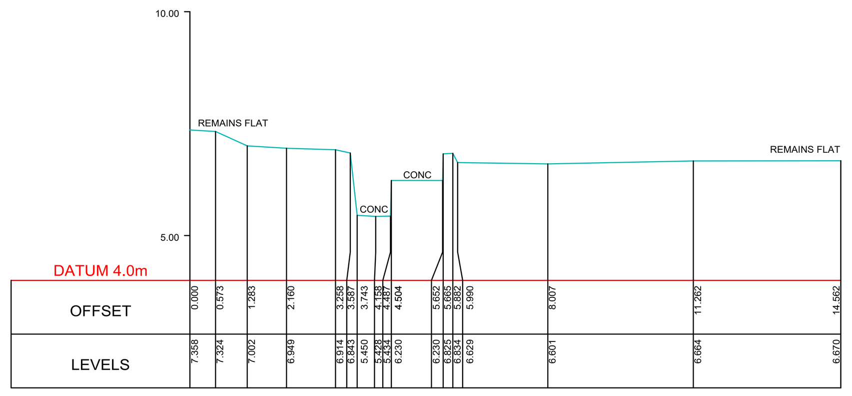

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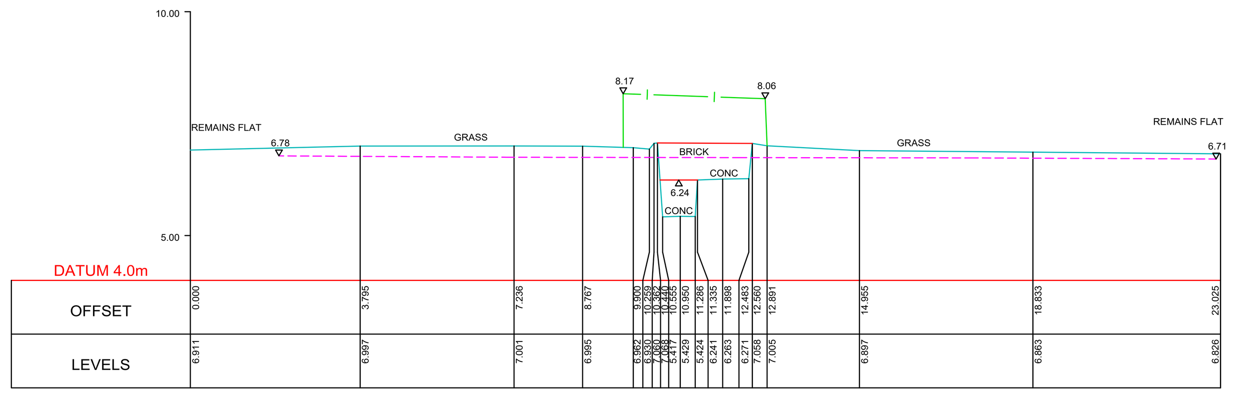

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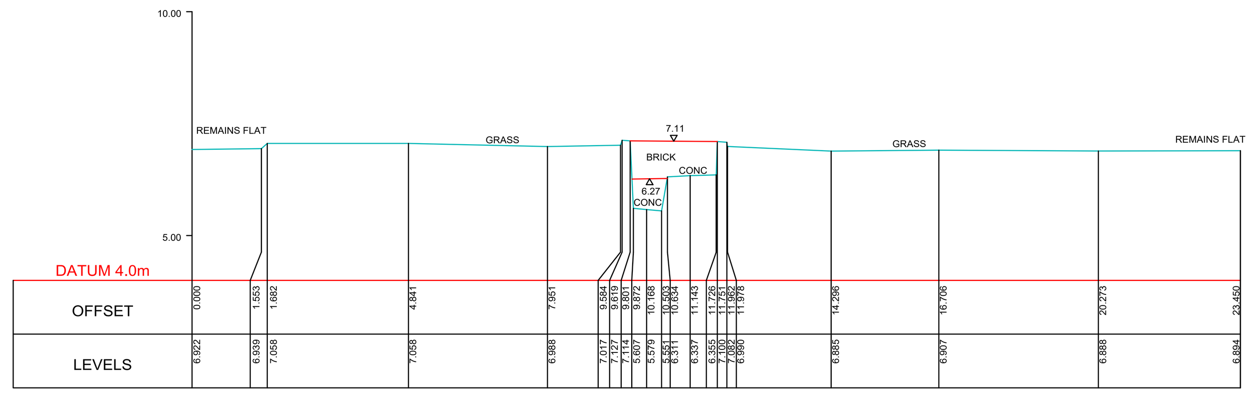

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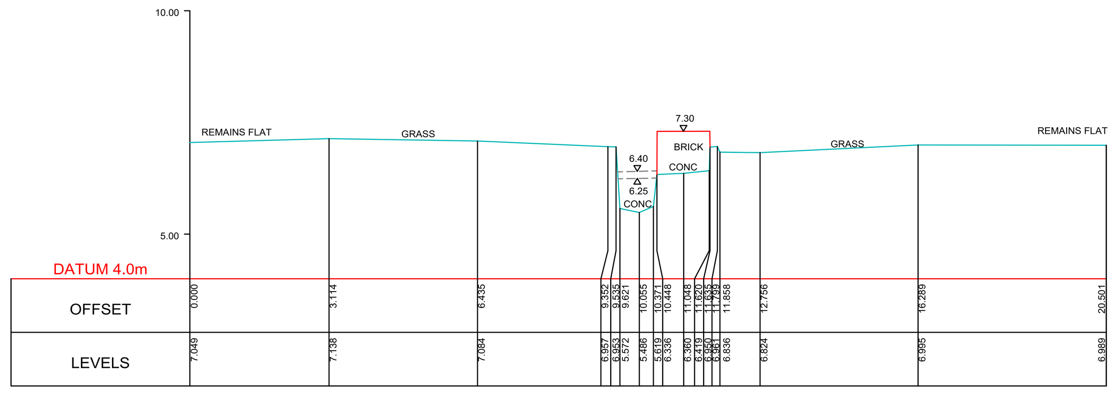

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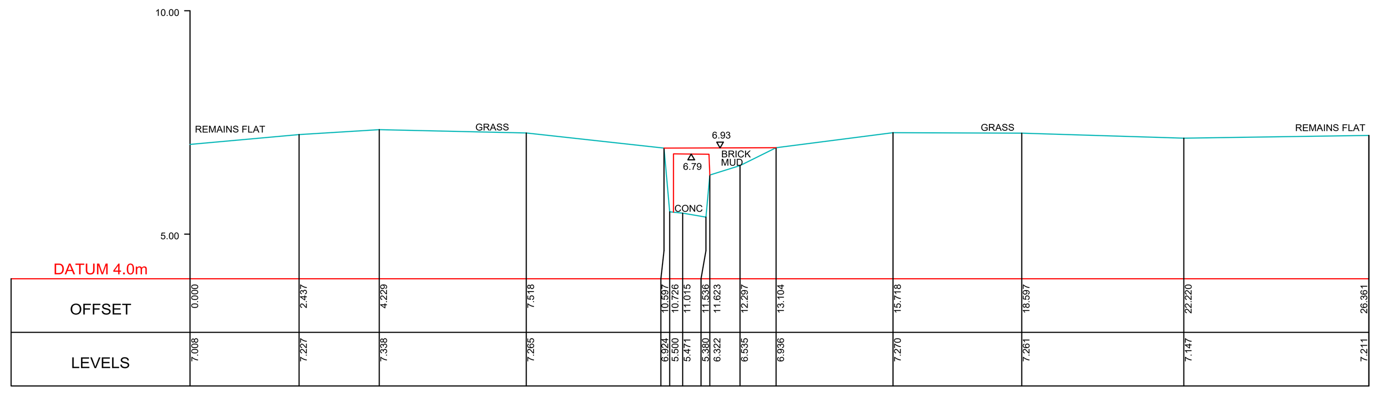

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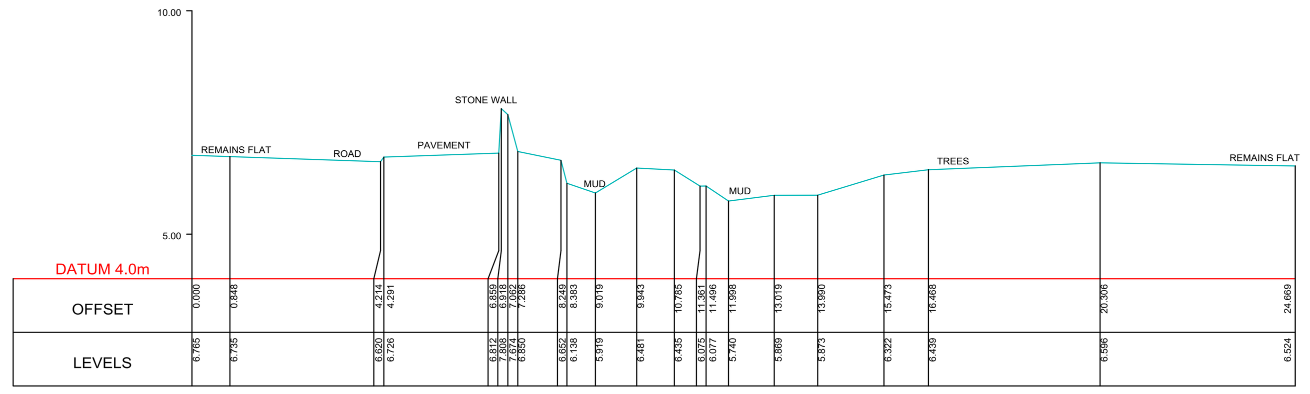

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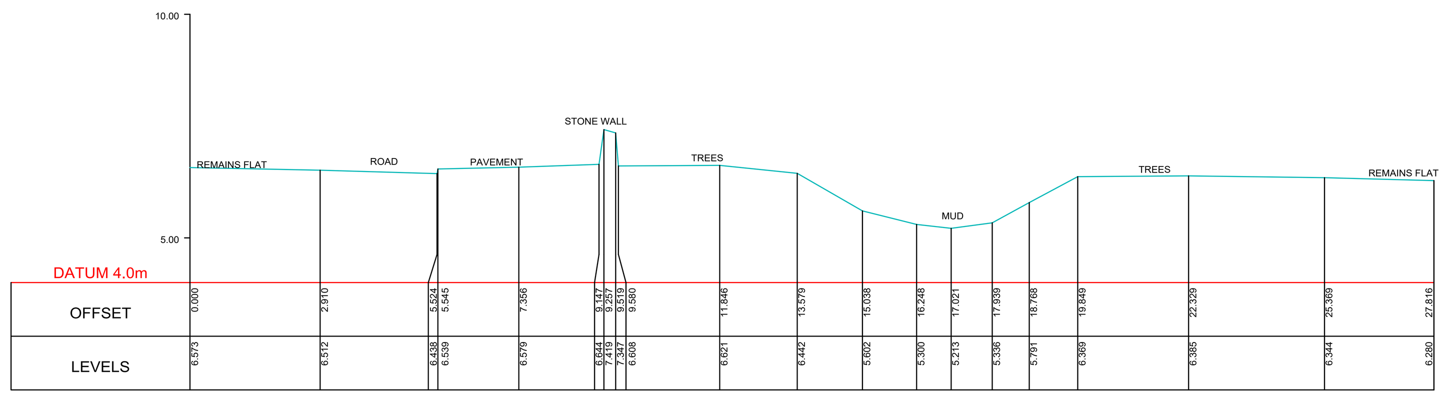

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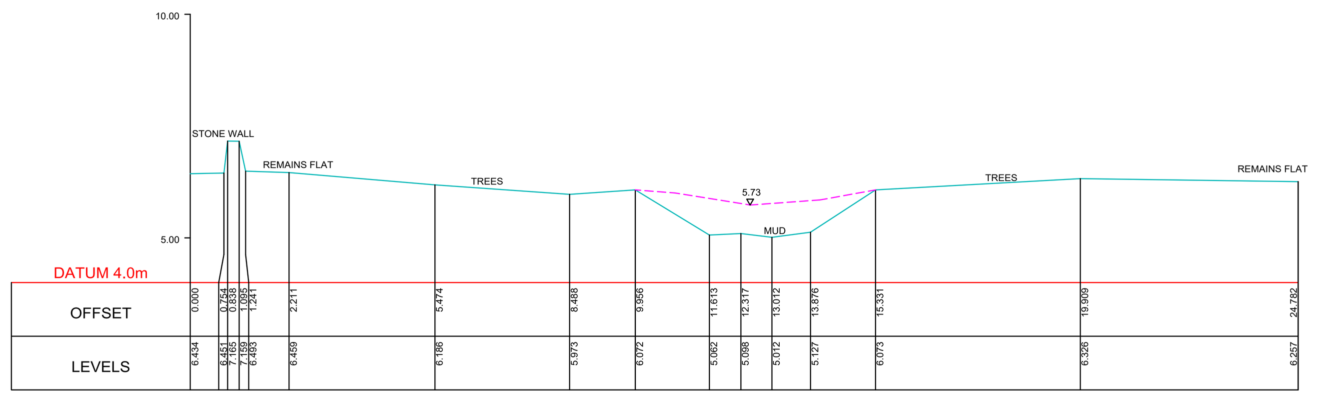

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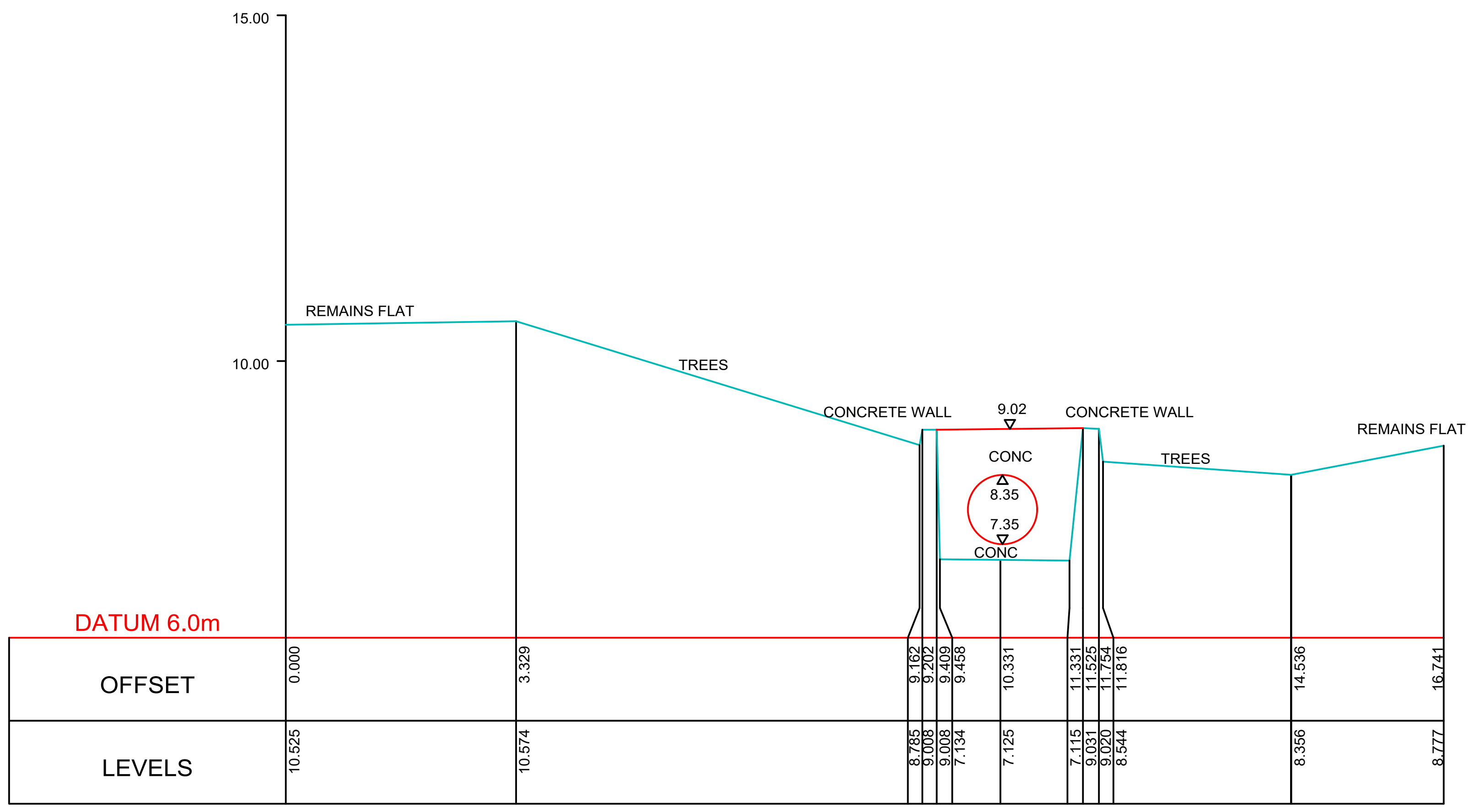

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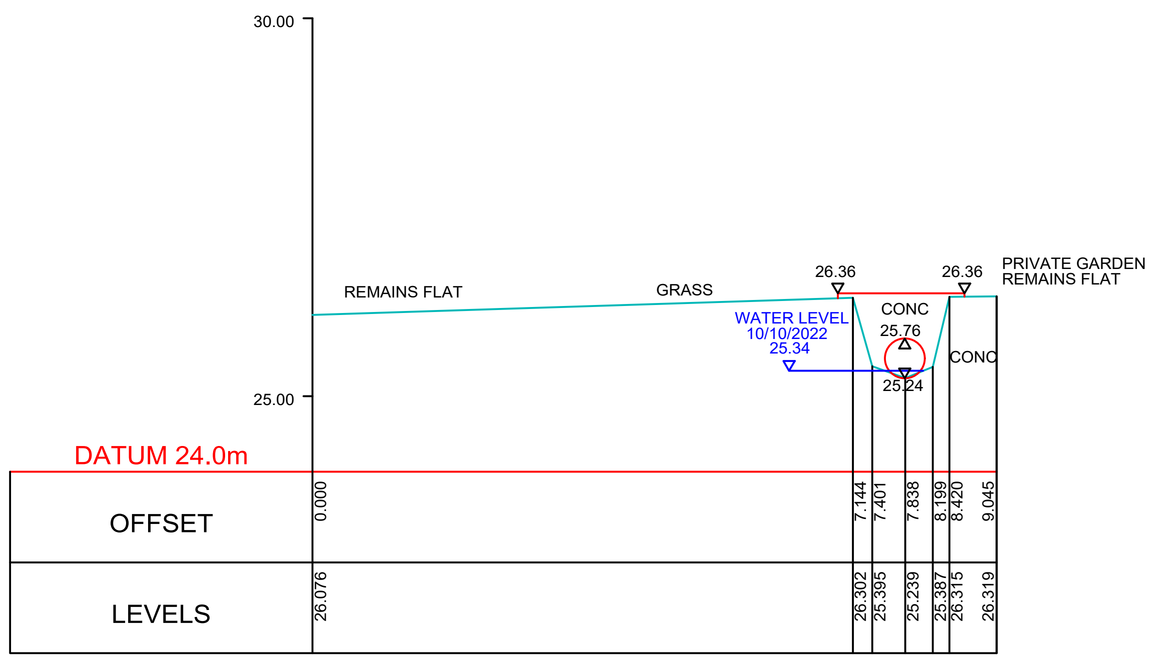

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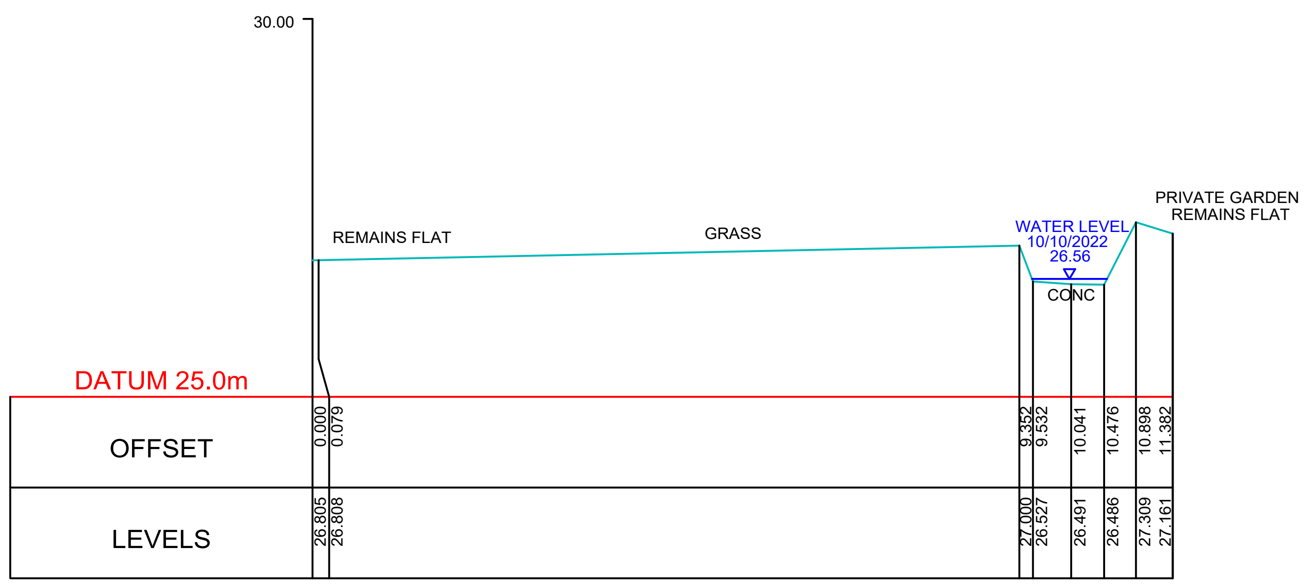

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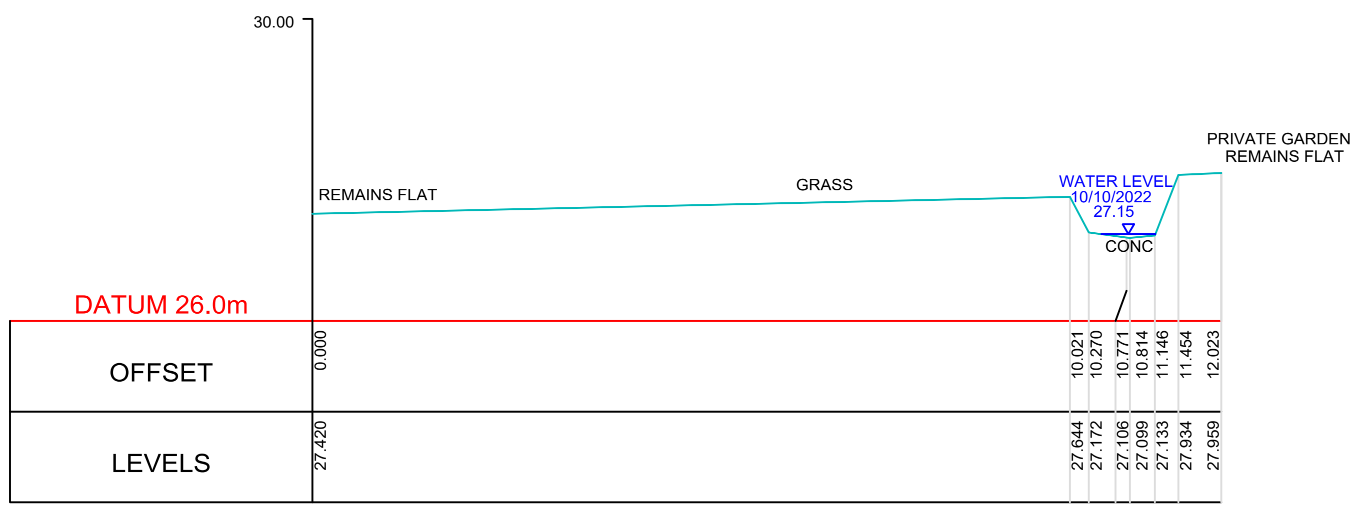

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ANNEX C

Weetwood Hydrological Assessment

Flood estimation report: Swinchiard Brook & Drain A - Land off Aber Road, Fint, Flintshire, CH6 5EX

Contents

Approval

Revision	Prepared by	Checked by	Date
1.0	Flora Lockey MEnvSci	James Aldridge BEng (Hons) MSc MCIWEM	14 April 2023

Abbreviations

AEP................................ annual exceedance probability

AM.................................. Annual Maximum

AREA .... Catchment area (km^2)

BFI .... Base Flow Index

BFIHOST .... Base Flow Index derived using the HOST soil classification

CPRE.............................. Council for the Protection of Rural England

FARL............................... FEH index of flood attenuation due to reservoirs and lakes

FEH................................. Flood Estimation Handbook

FSR................................. Flood Studies Report

HOST.............................. Hydrology of Soil Types

NRFA .... National River Flow Archive

OS.................................. Ordnance Survey

POT................................. Peaks Over a Threshold

QMED .... Median Annual Flood (with return period 2 years)

ReFH .... Revitalised Flood Hydrograph method

ReFH2 .... Revitalised Flood Hydrograph 2 method

SAAR .... Standard Average Annual Rainfall (mm)

SPR................................. Standard percentage runoff

SPRHOST .... Standard percentage runoff derived using the HOST soil classification

Tp(0) .... Time to peak of the instantaneous unit hydrograph

URBAN .... Flood Studies Report index of fractional urban extent

URBEXT1990 .... FEH index of fractional urban extent

URBEXT2000 .... Revised index of urban extent, measured differently from URBEXT1990

WINFAP-FEH .... Windows Frequency Analysis Package – used for FEH statistical method

1 SUMMARY OF ASSESSMENT

1.1 Summary

Catchment location	Flint, adjacent to the River Dee
Purpose of study and scope	To obtain the 20yr, 100yr and 1,000yr peak flows and hydrographs to use within a site specific hydraulic modelling study of Swinchiard Brook.
Key catchment features	Largely rural catchment with the lower reaches of the catchment within the urban area of Flint.
Flooding mechanisms	Fluvial
Gauged / ungauged	Unguaged
Final choice of method	FEH Statistical method
Key limitations / uncertainties in results	Unguaged catchment

1.2 Note on flood frequencies

The frequency of a flood can be quoted in terms of a return period, which is defined as the average time between years with at least one larger flood, or as an annual exceedance probability (AEP), which is the inverse of the return period.

The table below is provided to enable quick conversion between return periods and annual exceedance probabilities.

Annual exceedance probability (AEP) and related return period reference table

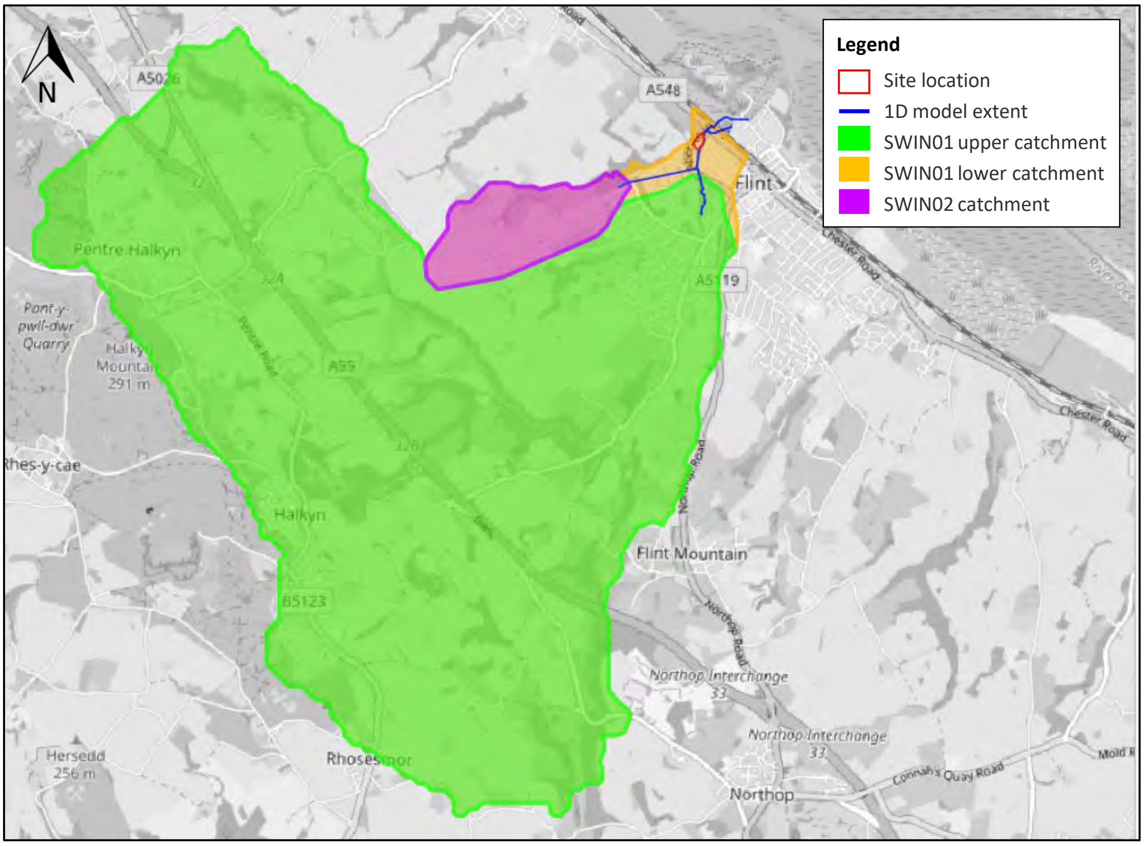
AEP (%)	50	20	10	5	3.33	2	1.33	1	0.5	0.1
AEP	0.5	0.2	0.1	0.05	0.033	0.02	0.0133	0.01	0.005	0.001
Return period (yr)	2	5	10	20	30	50	75	100	200	1,000

2 METHOD STATEMENT

2.1 Requirements for flood estimates

Overview	Weetwood Services Ltd ('Weetwood') has been instructed by HMG (Aber Road) Limited to identify and assess the level of flood risk from Swinchiard Brook to the proposed development site located at land off Aber Road, Flint. Peak flows and hydrographs are required as part of this study.The required design events are 20yr, 100yr (with and without allowances for climate change) and 1000yr. Flow estimations are required at the upstream and downstream extents of the model. This document details the work undertaken to derive the flow estimations that will be used within the hydraulic model of Swinchiard Brook.
Project scope	The scope of work includes a simple review of flood history, review of gauging station data (if available) and derivation of peak flows and hydrographs to be used within the hydraulic model.

2.2 The catchment



Description	The catchment is located on the western bank of the River Dee. The upper catchment is largely rural with heavily urbanised areas in the lower catchment. According to the Soilscapes soils dataset produced by the Cranfield Soil and AgriFood Institute[1], soil conditions within the upper catchment are largely freely draining, with some areas of slowly permeable seasonally wet loamy and clayey soils. In the lower catchment it is mostly areas of slowly permeable seasonally wet loamy and clayey soils.

1 www.landis.org.uk/soilscapes/

	British Geological Survey mapping of surface geology[2] indicates the underlying bedrock formation comprises mudstone, siltsone and sandstone and argillaceous rocks, interbedded.

2.3 Source of flood peak data

Source	NRFA peak flows dataset, Version 11, released September 2022. This contains data up to water year 2019-2020.

2.4 Other data available and how it has been obtained

Type of data	Data relevant to this study?	Data available?	Source of data	Details
Check flow gaugings	Yes	No		
Historical flood data	Yes	Yes	Natural Resources Wales historic flood outlines database[3]	Flooding occurred in the north and east of the site in 2000 as a result of the Swinchiard Brook channel capacity being exceeded. No details have been made available to confirm flood levels during the event.
Flow or river level data for events	Yes	No		
Rainfall data for events	No	No		
Potential evaporation data	No	No		
Results from previous studies	Yes	No		
Other data or information	No	No		

2.5 Hydrological understanding of catchment

Conceptual model	Swinchiard Brook flows in a predominantly easterly direction. Swinchiard Brook is culverted under Aber Road, Holywell Road and the North Wales Coast Line before outfalling into the tidal River Dee via a flapped outfall. Flooding at the proposed development site is likely to result from peak flows exceeding the channel capacity and/or the blockage of hydraulic structures.
Unusual catchment features	The catchment drains into the tidal River Dee via a flapped outfall. There are no other unusual features to take account of.

2.6 Initial choice of approach

Is FEH appropriate?	Yes
Initial choice of method(s) and reasons How will hydrograph shapes be derived if needed? Will the catchment be split into sub-catchments? If so, how?	FEH statistical method is the preferred approach for the estimation of flood frequency. ReFH2 being undertaken as a comparison and to derive flood hydrographs.

2 http://mapapps2.bgs.ac.uk/geoindex/home.html

3 http://lle.gov.wales/catalogue/item/HistoricFl/?lang=en

	The flows derived for the SWIN01 upper catchment and SWIN02 will be added to the upstream extent of the hydraulic model. Flows for the SWIN01 lower catchment will be laterally applied to Swinchiard Brook downstream of Aber Road to the confluence with the River Dee.
Software to be used (with version numbers)	FEH Web Service / WINFAP 5 / ReFH2.3

3 LOCATIONS WHERE FLOOD ESTIMATES REQUIRED

The table below lists the locations of subject sites. The site codes listed below are used in all subsequent tables to save space.

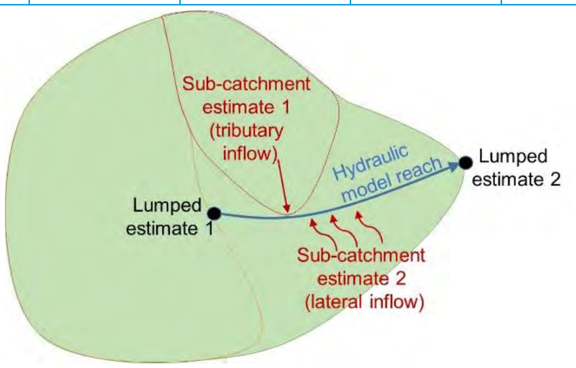
3.1 Summary of subject sites

Site code	Type of estimate L: lumped catchment S: Sub-catchment	Watercourse	Name or description of site	Easting	Northing	AREA on FEH CD-ROM (km^2)	Revised AREA if altered
SWIN01-02	L	Swinchiard Brook	Catchment located upstream of the North Wales Coast Line railway embankment SWIN01 upper = 17.05 km^2 SWIN01 lower = 0.33 km^2 SWIN02 = 0.82 km^2	324300	373550	18.47	n/a

Note: Lumped catchments (L) are complete catchments draining to points at which design flows are required.

Sub-catchments (S) are catchments or intervening areas that are being used as inputs to a semi-distributed model of the river system. There is no need to report any design flows for sub-catchments, as they are not relevant: the relevant result is the hydrograph that the sub-catchment is expected to contribute to a design flood event at a point further downstream in the river system. This will be recorded within the hydraulic model output files. However, catchment descriptors and ReFH model parameters should be recorded for sub-catchments so that the results can be reproduced.

The schematic diagram illustrates the distinction between lumped and sub-catchment estimates.

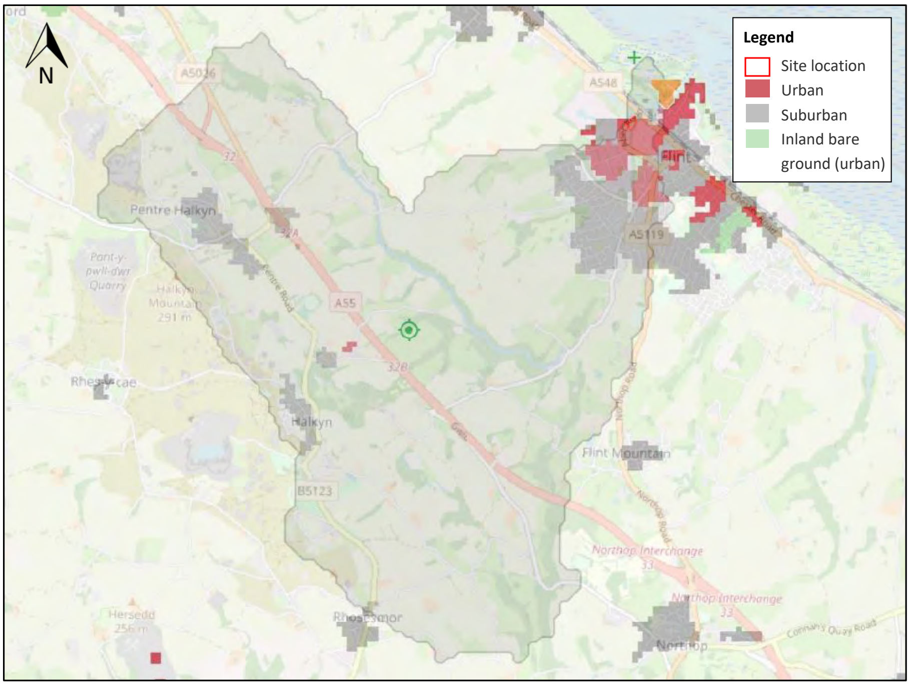


3.2 Important catchment descriptors at each subject site (incorporating any changes made)

Site code	FARL	PROPWET	BFIHOST19	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	URBEXT 2000	FPEXT
SWIN01-02	0.99	0.38	0.404	5.62	97.6	849	0.0504	0.0161

3.3 Checking catchment descriptors

Record how catchment boundary was checked and describe any changes	The catchment extents have been derived using the Flood Estimation Handbook (FEH) Web Service and were validated using Ordnance Survey (OS) mapping and LiDAR data. Changes to the catchement extent have been made however recognising the minimal effect this made compared to the size of the catchment the FEH CD-ROM catchment extent has been used to derive the flows.
Record how other catchment descriptors were checked and describe any changes.	A review of BGS surface geology mapping suggests that the BFIHOST parameter is appropriate.

Source of URBEXT	URBEXT2000 
Method for updating of URBEXT	FEH urbanisation layer has been compared with current OS mapping/aerial photography and is considered acceptable. No updates have been undertaken.

4 STATISTICAL METHOD

4.1 Application of Statistical method

What is the purpose of applying this method?	Derivation of peak flows.

4.2 Overview of estimation of QMED at each subject site

Site code	QMED (rural) from CDs (m^3/s)	Final method	Data transfer					Urban adjust-ment factor UAF	Final estimate of QMED (m^3/s)
			NRFA numbers for donor sites used (see 4.3)	Distance between centroids d_{ij} (km)	Moderated QMED adjustment factor, $(A/B)^a$	If more than one donor			
						Weight	Weighted ave. adjustment		
SWIN01 -02	6.311	DT	66005	22.96	1.655[a]			1.06745	5.809

Are the values of QMED spatially consistent?		n/a
Method used for urban adjustment for subject and donor sites		WINFAP v5
Parameters used for WINFAP v5 urban adjustment if applicable		
Impervious fraction for built-up areas, IF	Percentage runoff for impervious surfaces, PR_{imp}	Method for calculating fractional urban cover, URBAN
0.4	70%	URBEXT2000

Notes

Methods: AM – Annual maxima; POT – Peaks over threshold; DT – Data transfer (with urban adjustment); CD – Catchment descriptors alone (with urban adjustment); BCW – Catchment descriptors and bankfull channel width (add details); LF – Low flow statistics (add details).

The QMED adjustment factor A/B for each donor site is moderated using the power term, a, which is a function of the distance between the centroids of the subject catchment and the donor catchment. The final estimate of QMED is $(A/B)^a$ times the initial (rural) estimate from catchment descriptors.

Important note on urban adjustment

The method used to adjust QMED for urbanisation published in Kjeldsen (2010) in which PRUAF is calculated from BFIHOST is not correctly applied in WINFAP-FEH v3.0.003. Significant differences occur only on urban catchments that are highly permeable. This is discussed in Wallingford HydroSolutions (2016)**Error! Bookmark not defined.**.

4.3 Search for donor sites for QMED (if applicable)

Comment on potential donor sites	The gauging station on the River Clwyd at Ruthin Weir (66005) was chosen as a donor site. It is the nearest gugaing station that is hydrologically similar.

4.4 Donor sites chosen and QMED adjustment factors

NRFA no.	Method (AM or POT)	Adjustment for climatic variation?	QMED from flow data (A)	QMED from catchment descriptors (B)	Adjustment ratio (A/B)
66005	AM	No	17.210	28.487	0.604

4.5 Derivation of pooling groups

Site code from whose descriptors group was derived	Subject site treated as gauged?	Changes made to default pooling group, with reasons	Weighted average L-moments

Site code from whose descriptors group was derived	Subject site treated as gauged?	Changes made to default pooling group, with reasons	Weighted average L-moments
SWIN01-02	No	Stations removed from pooling group: 28058 (Henmore Brook @ Ashbourne) – negative L-Skew The final pooling group has 18 stations with a 511 year record. Heterogeneity test statistic = 1.6131	Parameters: L-CV: 0.257 L-SKEW: 0.212
Note: Pooling groups were derived using the procedures from Science Report SC050050 (2008).			

4.6 Derivation of flood growth curves at subject sites

Site code	Method	Distribution used and reason for choice	Note any urban adjustment or permeable adjustment	Parameters of distribution	Growth factor for 100-year return period / 1% AEP
SWIN01-02	P	P3 – Recommended distribution with the best fit	WINFAP v5	Location: 0.279 Scale: 0.340 Shape: 2.441	2.812
Notes Methods: SS – Single site; P – Pooled; ESS – Enhanced single site; J – Joint analysis Urban adjustments are all carried out using the method of Kjeldsen (2010). Growth curves were derived using the procedures from Science Report SC050050 (2008).					

Distribution	Growth Curve for the following return periods (in years)								
	2	5	10	30	50	100	200	500	1000
GEV	1	1.463	1.789	2.311	2.563	2.916	3.283	3.794	4.201
P3	1	1.494	1.823	2.308	2.524	2.812	3.093	3.459	3.731

4.7 Flood estimates from the statistical method

Site code	Flood peak (m^3/s) for the following return periods (in years)								
	2	5	10	20	50	100	200	500	1000
SWIN01-02	5.809	8.681	10.589	12.389	14.665	16.334	17.970	20.093	21.676

6 REVITALISED FLOOD HYDROGRAPH 2 (REFH2) METHOD

6.1 Application of ReFH2 method

What is the purpose of applying this method?	For providing a comparison for peak flow estimates and to derive hydrograph shapes.

6.2 Parameters for ReFH2 model

Site code	Method	Tp_{rural} (hours)	Tp_{urban} scaling factor	C_{max} (mm)	PR_{imp}	BL (hours)	BR
SWIN01-02	CD	3.62	0.75	310.94	0.7	40.61	1.43
Brief description of any flood event analysis carried out							
Methods: OPT: Optimisation, BR: Baseflow recession fitting, CD: Catchment descriptors, DT: Data transfer (give details)							

6.3 Design events for ReFH2 method: Lumped catchments

Site code	Urban or rural	Season of design event (summer or winter)	Storm duration (hours)
SWIN01-02	Urban	Winter	6.5

6.4 Flood estimates from the ReFH2 method

Site code	Flood peak (m^3/s) for the following return periods (in years)			
	2	20	100	1,000
SWIN01-02	6.51	13.17	19.86	32.45

7 DISCUSSION AND SUMMARY OF RESULTS

7.1 Comparison of results from different methods

Site code	Ratio of peak flow to FEH Statistical peak	
	Return period 2 years / 50% AEP	Return period 100 years / 1% AEP
	ReFH2	ReFH2
SWIN01-02	1.12	1.13

7.2 Final choice of method

Choice of method and reasons	The final choice of method is the FEH Statistical Method, which is the preferred approach. The hydrograph shape will be derived from ReFH2.
How will the flows be applied to a hydraulic model?	The flows derived for site code SWIN01-02 will be area weighted. Flows will be applied as two point inflows at the upstream extent of Swinchiard Brook (SWIN01 upper) and the unnamed watercourse (SWIN02). The flows derived for the downstream extent of to Swinchiard Brook (SWIN01 lower) will be applied as a lateral inflow to Swinchiard Brook downstream of Aber Road to the confluence with the River Dee.

7.3 Assumptions, limitations and uncertainty

List the main assumptions made (specific to this study)	FEH catchment boundary/descriptors are accurate, QMED estimate and growth curve accurately reflects the subject catchment. No transfer of water in or out of the catchment via the sewer network.
Discuss any particular limitations	FEH Statistical method not suitable for estimating 0.1% AEP flows, which have been scaled based upon ReFH2 peak flows.
Comment on the suitability of the results for future studies	The model has been specifically built to assess flood risk to the development site. Therefore, it may not be suitable for assessing flood risk within other parts of the catchment.
Give any other comments on the study	None.

7.4 Checks

Are the results consistent, for example at confluences?	n/a
What do the results imply regarding the return periods / frequency of floods during the period of record?	n/a
What is the range of 100-year / 1% AEP growth factors? Is this realistic?	The 100 year growth factor is 2.812, which is considered realistic.
If 1000-year / 0.1% AEP flows have been derived, what is the range of ratios for 1000-year / 0.1% AEP flow over 100-year / 1% AEP flow?	The ratio between ReFH2 1% and 0.1% AEP event flows is 1.63.
How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred.	n/a
Are the results compatible with the longer-term flood history?	No flows or return period have provided for the 2000 flood event, thererofre no comparison could be made.

Describe any other checks on the results	None.

7.5 Final results

Site code	Flood peak (m^3/s) for the following return periods (in years)			
	2	20	100	1,000
SWIN01 upper catchment	5.44	11.61	15.30	24.99
SWIN01 lower catchment	0.11	0.22	0.30	0.48
SWIN02	0.26	0.56	0.74	1.20

If flood hydrographs are needed for the next stage of the study, where are they provided? (e.g. give filename of spreadsheet, hydraulic model, or reference to table below)	Hydrographs are provided in the Hydraulic Modeling Study Report

8 ANNEX

Winfap 5 report

UK Design Flood Estimation

Summary of ESS/Pooled Estimation Analysis using the Flood Estimation Handbook Statistical Method

Date of creation:	19-01-2023 13:34:00
Software:	WINFAP Version: 5.0.8181 (30330)
Peak Flow dataset:	Peak Flow Dataset 11.0.0
Supplementary data used:	No

Site details

Site number:	592599455
Site name:	FEH_Catchment_Descriptors_324300_373550_v4_0_0
Site location:	SJ 24300 73550
Easting:	324300
Northing:	373550
Catchment area:	18.20 km²
SAAR:	849 mm
BFIHOST19:	0.404
FPEXT:	0.016
FARL:	0.990
URBEXT2000:	0.0504

Analysis settings

At-site data

At-site data present:	No

Urbanisation settings

User defined:	Yes
Urban area:	1.44 km²
PRimp:	70.00%
Impervious Factor:	0.400
UAF:	1.06745

Growth curve settings

Distance Measure Method:	Small catchment
Pooling group URBEXT2000 Threshold:	0.030
Deurbanise Pooling Group L-moments:	Yes

QMED settings

Use at-site data:	No
Method:	Donor Station(s)

Growth curve data and results

Pooling Group

Station	Distance	Years of data	QMED AM	L-CV Observed	L-CV Deurbanised	L-SKEW Observed	L-SKEW Deurbanised	Discordancy
25019 (Leven @ Easby)	0.162	43	5.677	0.334	**0.335**	0.373	**0.372**	0.819
26016* (Gypsey Race @ Kirby Grindalythe)	0.346	21	0.106	0.258	**0.258**	0.314	**0.314**	0.971
27010 (Hodge Beck @ Bransdale Weir)	0.432	41	9.420	0.224	**0.224**	0.293	**0.293**	1.492
44008* (South Winterbourne @ Winterbourne Steepleton)	0.510	23	0.624	0.344	**0.344**	0.238	**0.237**	0.779
41020 (Bevern Stream @ Clappers Bridge)	0.542	52	13.780	0.201	**0.203**	0.166	**0.164**	0.941
7011 (Black Burn @ Pluscarden Abbey)	0.566	9	5.205	0.491	**0.491**	0.521	**0.521**	3.632
26017* (Ings Beck @ South Newbald)	0.571	21	0.522	0.203	**0.205**	0.054	**0.053**	0.642
49005 (Bolingey Stream @ Bolingey Cocks Bridge)	0.600	11	5.777	0.262	**0.263**	0.207	**0.206**	2.545
27051 (Crimple @ Burn Bridge)	0.634	49	4.564	0.217	**0.218**	0.143	**0.142**	0.158
26014* (Water Forlornes @ Driffield)	0.654	19	0.623	0.251	**0.252**	0.188	**0.187**	0.150
44013* (Piddle @ Little Puddle)	0.687	18	1.854	0.299	**0.300**	0.181	**0.180**	0.448
24007 (Browney @ Lanchester)	0.733	15	10.981	0.222	**0.222**	0.212	**0.211**	0.910
9006 (Deskford Burn @ Cullen)	0.758	11	21.783	0.290	**0.290**	0.139	**0.139**	0.698
53017 (Boyd @ Bitton)	0.774	48	13.908	0.240	**0.242**	0.081	**0.079**	0.877
27073* (Brompton Beck @ Snainton Ings)	0.797	39	0.844	0.189	**0.190**	0.046	**0.045**	0.694
44011 (Asker @ Bridport East Bridge)	0.813	26	15.958	0.225	**0.227**	0.172	**0.169**	0.181
44003 (Asker @ Bridport)	0.813	14	12.354	0.224	**0.226**	0.170	**0.168**	1.744
41022 (Lod @ Halfway Bridge)	0.838	51	15.900	0.295	**0.297**	0.183	**0.181**	0.321
Total		**511**						

Short records   Discordant   No Pooling   No Pooling, no QMED

Pooling Group Rejected Stations

Station	Distance	Years of data	QMED AM	L-CV Observed	L-CV Deurbanised	L-SKEW Observed	L-SKEW Deurbanised
28058 (Henmore Brook @ Ashbourne)	0.612	13	10.600	0.145	0.147	-0.046	-0.049

Growth curve L-moments

Rural L-CV:	0.265	Urban L-CV:	0.257
Rural L-Skewness:	0.203	Urban L-Skewness:	0.212

Rural fitted parameters

Distribution	Location	Scale	Shape	H	Bound
GL	1.000	0.270	-0.203		-0.332
GEV	0.852	0.401	-0.051		-7.022
P3	0.221	0.335	2.651		0.221
KAP3	0.925	0.328	-0.134	-0.400	-1.517

Urban fitted parameters

Distribution	Location	Scale	Shape	H	Bound
GL	1.000	0.261	-0.212		-0.233
GEV	0.857	0.385	-0.064		-5.135
P3	0.279	0.340	2.441		0.279
KAP3	0.928	0.315	-0.145	-0.400	-1.245

Goodness of fit

GL: 3.8374
GEV: 1.5935 *
P3: 0.2028 *
GP: -3.4538
KAP3: 3.0239

** Distribution gives an acceptable fit (absolute Z value < 1.645)*

Heterogeneity

Standardised test value H2: 1.6131

The pooling group is possibly heterogeneous and a review of the pooling group is optional.

Standardised growth curves

Rural

Return period	GL	GEV	P3	KAP3
2	1.000	1.000	1.000	1.000
5	1.433	1.477	1.506	1.452
10	1.749	1.808	1.839	1.777
20	2.090	2.138	2.152	2.117
25	2.208	2.246	2.250	2.231
30	2.307	2.334	2.329	2.327
50	2.604	2.584	2.546	2.605
75	2.860	2.786	2.716	2.838
100	3.054	2.932	2.835	3.011
200	3.570	3.291	3.117	3.455
500	4.371	3.785	3.482	4.108
1000	5.083	4.174	3.754	4.657

Urban

Return period	GL	GEV	P3	KAP3
2	1.000	1.000	1.000	1.000
5	1.421	1.463	1.494	1.439
10	1.731	1.789	1.823	1.758
20	2.068	2.116	2.132	2.094
25	2.184	2.223	2.229	2.208
30	2.283	2.311	2.308	2.303
50	2.579	2.563	2.524	2.581
75	2.836	2.768	2.693	2.816
100	3.031	2.916	2.812	2.991
200	3.551	3.283	3.093	3.441
500	4.364	3.794	3.459	4.110
1000	5.093	4.201	3.731	4.677

QMED data and results

Donor selection criteria

Only sites suitable for QMED:	Yes
URBEXT2000:	<0.030
Donor adjusted FSE:	1.409
No. of donors:	1

Donor stations

Station	Distance	URBEXT	Use QMED obs deurbanised	QMED obs	QMED deurbanised	QMED CDs urban	QMED CDs rural	Centroid X	Centroid Y	Area	SAAR	BFIHOST19	FARL	Years of data	QMED suitability	Pooling suitability	Weight
*FEH_Catchment_Descriptors_324300_373550_v4_0_0 @ SJ 24300 73550)		0.050						321825	371375	18.200	849	0.404	0.990				
66005 (Clwyd @ Ruthin Weir)	22.96	0.005	Yes	17.210	**17.110**	28.487	28.487	309817	351811	96.392	958	0.471	0.995	45	Yes	Yes	0.291

Unused Donor stations

Station	Distance	URBEXT	Use QMED obs deurbanised	QMED obs	QMED deurbanised	QMED CDs urban	QMED CDs rural	Centroid X	Centroid Y	Area	SAAR	BFIHOST19	FARL	Years of data	QMED suitability	Pooling suitability	Weight
66004 (Wheeler @ Bodfari)	6.68	0.004	Yes	3.699	**3.680**	9.282	9.282	315144	371478	62.905	863	0.613	0.975	47	Yes	No	0.424
67008 (Alyn @ Pont-y-Capel)	12.37	0.029	Yes	21.740	**20.963**	42.347	42.347	323013	359066	225.653	917	0.542	0.990	56	Yes	Yes	0.361
67009 (Alyn @ Rhydymwyn)	13.88	0.002	Yes	8.780	**8.763**	20.850	20.850	319020	357784	81.595	968	0.527	0.990	65	Yes	Yes	0.349
66001 (Clwyd @ Pont-y-Cambwll)	16.53	0.006	Yes	51.309	**50.938**	69.930	69.930	309230	360665	404.558	910	0.539	0.993	46	Yes	No	0.331
68020 (Gowy @ Bridge Trafford)	30.40	0.017	Yes	15.458	**15.141**	17.819	17.819	351376	364257	148.657	729	0.541	0.994	42	Yes	No	0.250
66002 (Elwy @ Pant yr Onen)	30.91	0.001	Yes	65.600	**65.546**	82.732	82.732	291474	365507	218.510	1145	0.433	0.979	12	Yes	No	0.248
66006 (Elwy @ Pont-y-Gwyddel)	32.03	0.001	Yes	74.400	**74.332**	79.962	79.962	290505	364668	191.355	1185	0.425	0.980	47	Yes	Yes	0.242
67006 (Alwen @ Druid)	33.35	0.001	Yes	78.140	**78.102**	72.129	72.129	296642	349518	185.480	1305	0.392	0.897	61	Yes	No	0.236
67005 (Ceiriog @ Brynkinalt Weir)	35.53	0.001	Yes	30.000	**29.962**	58.390	58.390	317500	336107	111.718	1198	0.403	1.000	24	Yes	No	0.226

QMED

Rural: 5.442 m^3/s
Urban: 5.809 m^3/s

Flood Frequency Curve

Rural Flood Frequency Curve

Return period	GL (m^3/s)	GEV (m^3/s)	P3 (m^3/s)	KAP3 (m^3/s)
2	5.442	5.442	5.442	5.442
5	7.799	8.039	8.196	7.903
10	9.518	9.842	10.009	9.673
20	11.374	11.638	11.711	11.521
25	12.014	12.222	12.243	12.143
30	12.556	12.702	12.673	12.662
50	14.170	14.063	13.858	14.176
75	15.565	15.164	14.780	15.446
100	16.623	15.957	15.427	16.387
200	19.430	17.912	16.962	18.803
500	23.789	20.601	18.952	22.355
1000	27.665	22.717	20.433	25.344

Urban Flood Frequency Curve

Return period	GL (m^3/s)	GEV (m^3/s)	P3 (m^3/s)	KAP3 (m^3/s)
2	5.809	5.809	5.809	5.809
5	8.254	8.499	8.681	8.360
10	10.055	10.391	10.589	10.214
20	12.012	12.293	12.389	12.166
25	12.690	12.915	12.952	12.826
30	13.264	13.428	13.408	13.378
50	14.982	14.889	14.665	14.996
75	16.473	16.078	15.646	16.359
100	17.606	16.939	16.334	17.374
200	20.629	19.075	17.970	19.992
500	25.355	22.043	20.093	23.874
1000	29.586	24.404	21.676	27.170

ReFH2 1 in 100 year report

UK Design Flood Estimation

Generated on Thursday, January 19, 2023 12:20:57 PM by ModellingMold
Printed from the ReFH2 Flood Modelling software package, version 3.3.8355.27598

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

Site details

Checksum: 842C-0812

Site name: FEH_Catchment_Descriptors_324300_373550_v4_0_0

Easting: 324300

Northing: 373550

Country: England, Wales or Northern Ireland

Catchment Area (km²): 18.47

Using plot scale calculations: No

Model: 2.3

Site description: None

Model run: 100 year

Summary of results

Rainfall - FEH 2013 model (mm):	75.76	Total runoff (ML):	446.11
Total Rainfall (mm):	53.55	Total flow (ML):	988.91
		Peak flow (m³/s):	19.86
Peak Rainfall (mm):	10.44		

Parameters

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

Rainfall parameters (Rainfall - FEH 2013 model)

Name	Value	User-defined?
Duration (hh:mm:ss)	06:30:00	No
Timestep (hh:mm:ss)	00:30:00	No
SCF (Seasonal correction factor)	0.75	No
ARF (Areal reduction factor)	0.95	No
Seasonality	Winter	No

Loss model parameters

Name	Value	User-defined?
Cini (mm)	109.66	No
Cmax (mm)	310.94	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	3.62	No
Up	0.65	No

Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.74	No
BL (hr)	40.61	No
BR	1.28	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	1.46	No
Urbext 2000	0.05	No
Impervious runoff factor	0.7	No
Imperviousness factor	0.4	No
Tp scaling factor	0.75	No
Depression storage depth (mm)	0.5	No
Exporting drained area (km^2)	0.00	Yes
Sewer capacity (m^3/s)	0.00	Yes

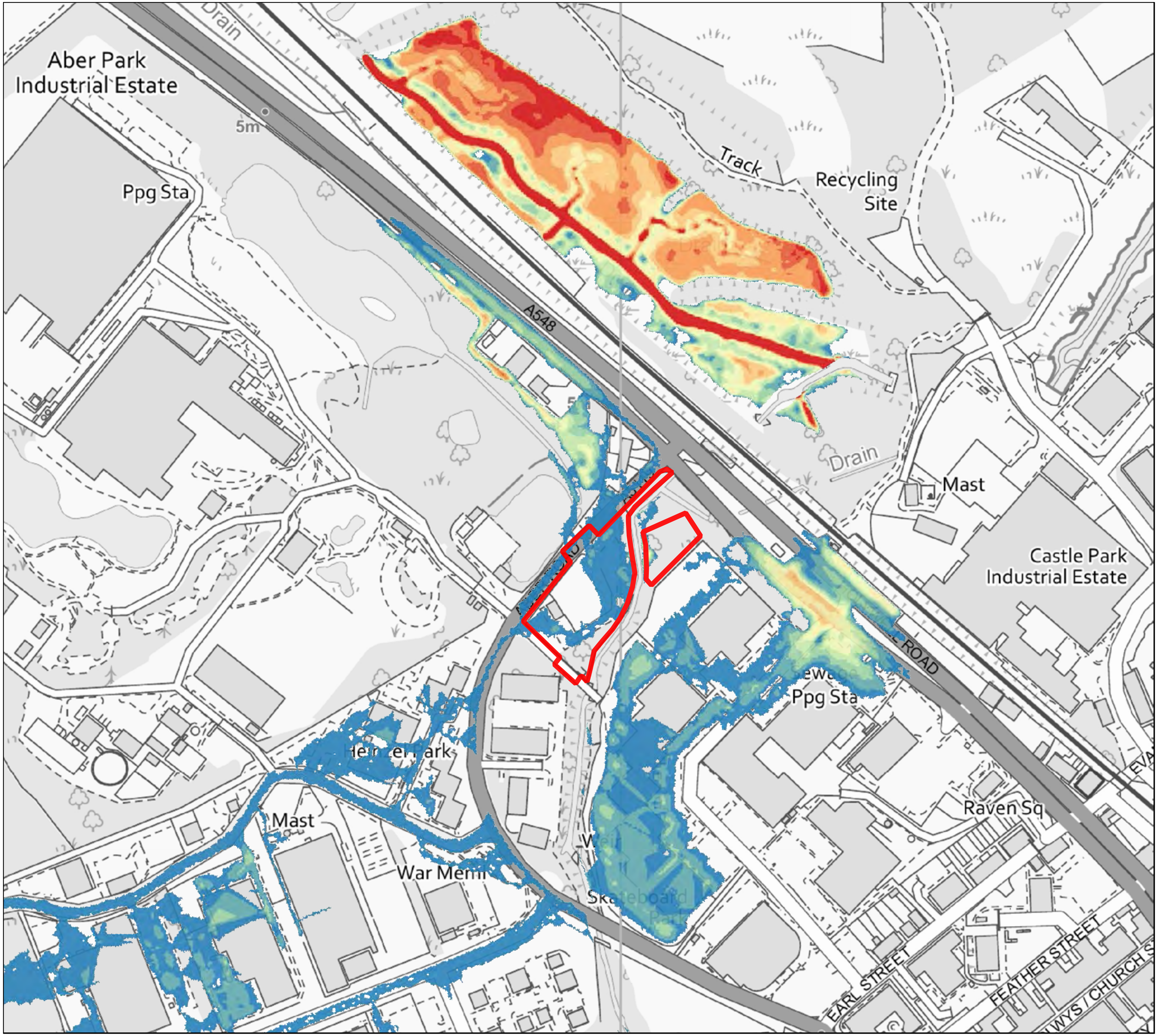
ANNEX D

Digital Model Files

Available on request

ANNEX E

Model Results - Baseline



Notes:

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Legend

Site Location

Depth (m)

- < 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 0.6
- 0.7
- 0.8
- 0.9
- > 1.0

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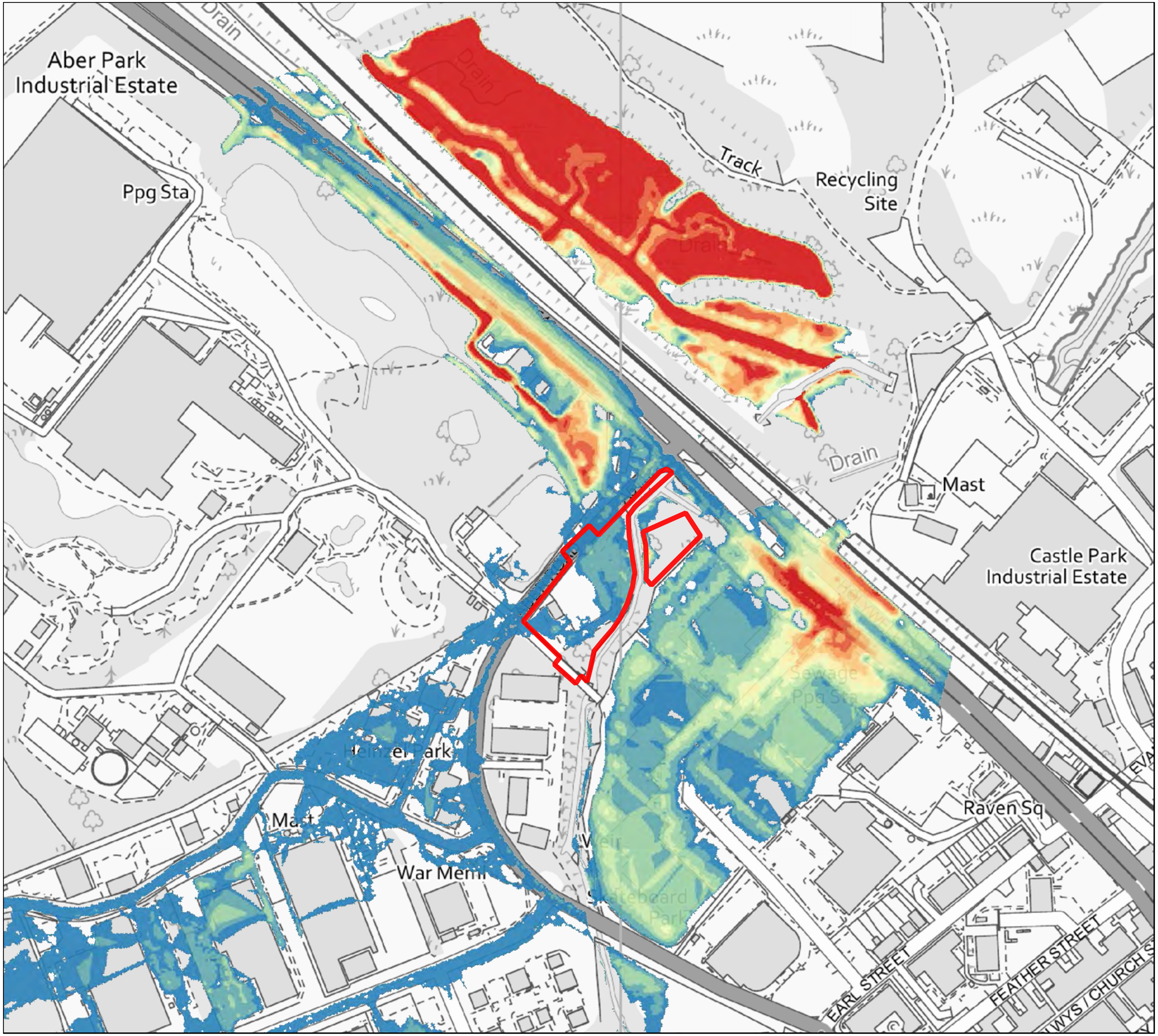
Client:	**HMG (Aber Road) Limited**
Project Title:	**Aber Road, Flint**
Drawing Title:	**Fluvial Baseline Scenario - Maximum Flood Depth; 1 in 20 AEP event**
Map Orientation:	Scale: 0 14 28 42 56 70 m
Drawn: MN	Checked: AE
Date:	5 June 2023
Project No: 5560	Drawing No: 5560_026_Q0020_d
Rev:	A



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Legend

Site Location

Depth (m)

- < 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 0.6
- 0.7
- 0.8
- 0.9
- > 1.0

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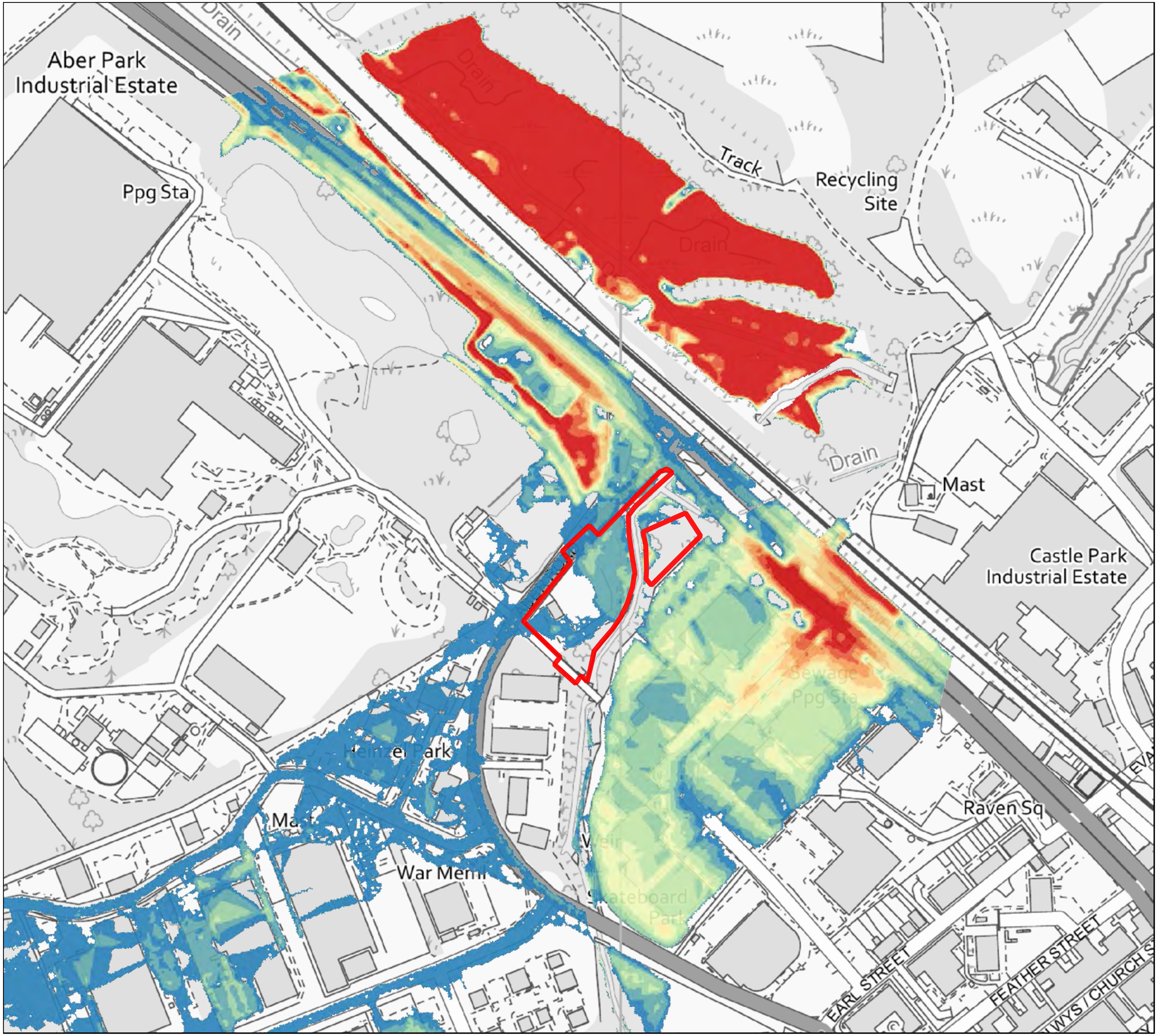
Project Title:	**Aber Road, Flint**
Drawing Title:	**Fluvial Baseline Scenario - Maximum Flood Depth; 1 in 100 AEP event**
Map Orientation:	
Scale:	0 14 28 42 56 70 m
Drawn:	MN
Checked:	AE
Date:	5 June 2023
Project No:	5560
Drawing No:	5560_026_Q0100_d
Rev:	A



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Legend

Site Location

Depth (m)

- < 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 0.6
- 0.7
- 0.8
- 0.9
- > 1.0

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Project Title: **Aber Road, Flint**

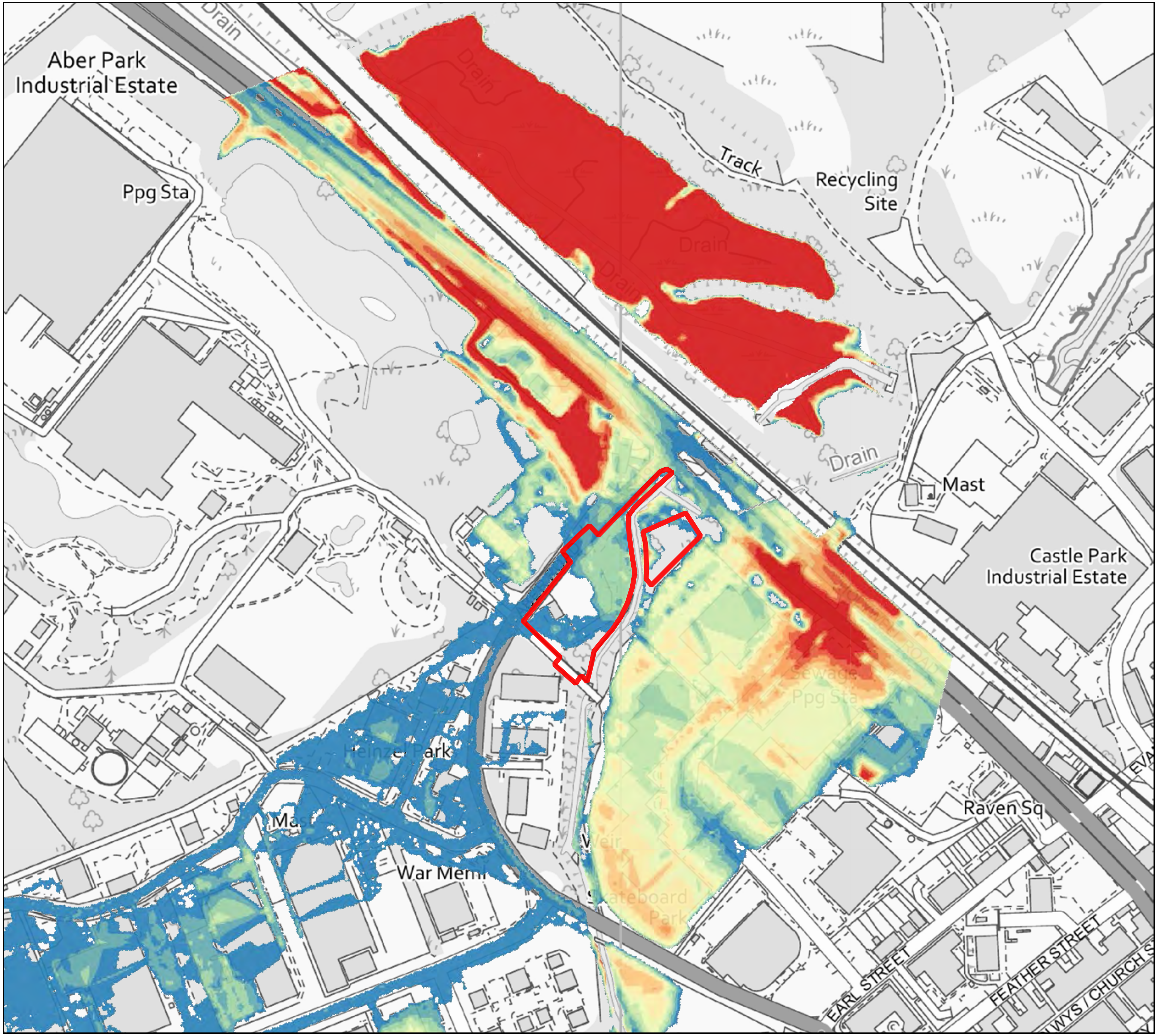
Drawing Title: **Fluvial Baseline Scenario - Maximum Flood Depth; 1 in 100 plus climate change (20%) AEP event**

Map Orientation:

Scale: 0 14 28 42 56 70 m

Drawn:	Checked:	Date:
MN	AE	5 June 2023

Project No:	Drawing No:	Rev:
5560	5560_026_Q0100CC20_d	A



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Legend

Site Location

Depth (m)

- < 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 0.6
- 0.7
- 0.8
- 0.9
- > 1.0

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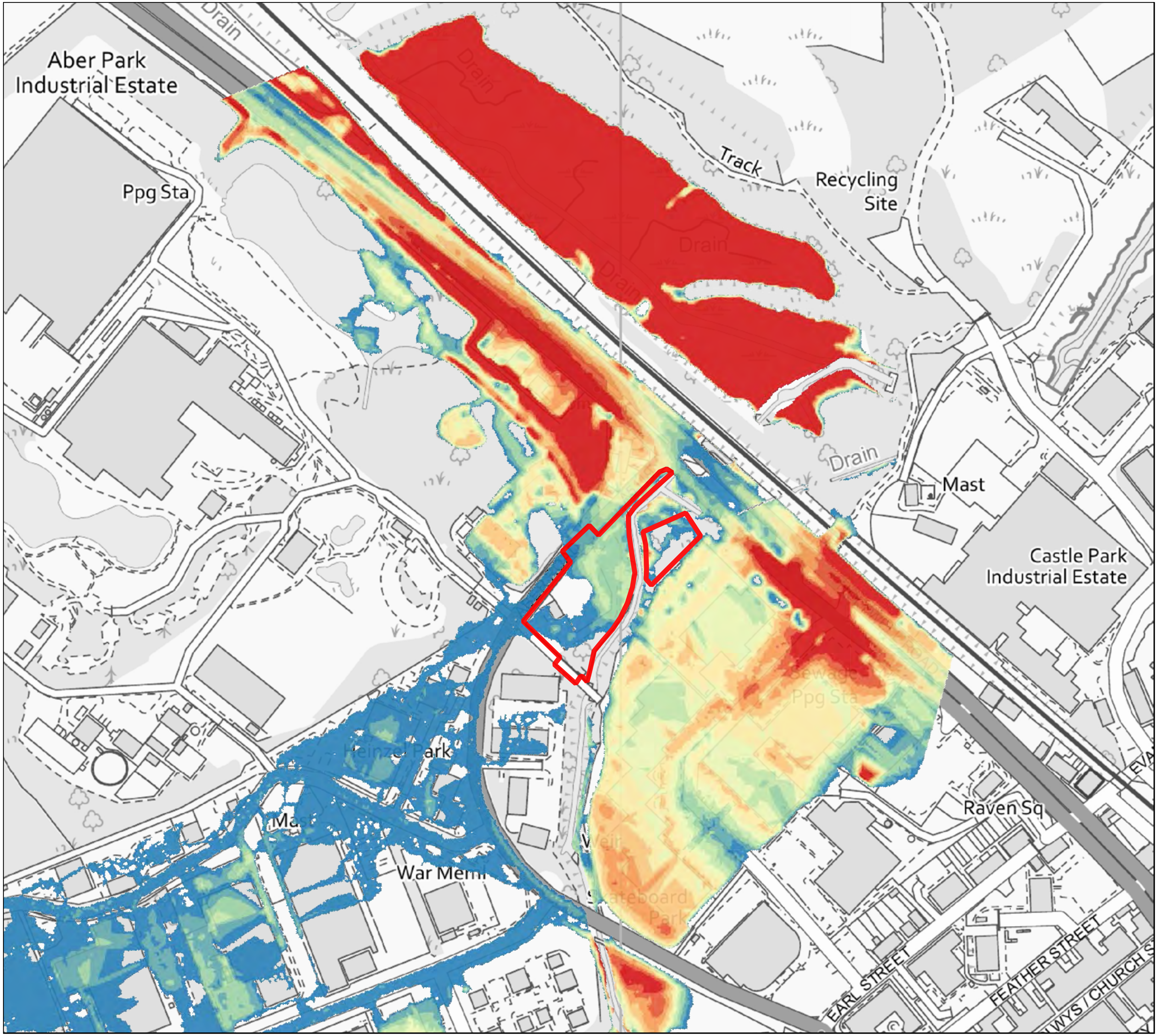
Drawing Title:
Fluvial Baseline Scenario - Maximum Flood Depth; 1 in 1000 AEP event

Map Orientation:	Scale: 0 14 28 42 56 70 m

Drawn:	Checked:	Date:
MN	AE	5 June 2023

Project No:	Drawing No:	Rev:
5560	5560_026_Q1000_d	A



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Legend

Site Location

Depth (m)

- < 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 0.6
- 0.7
- 0.8
- 0.9
- > 1.0

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Drawing Title: **Fluvial Baseline Scenario - Maximum Flood Depth; 1 in 1000 plus climate change (20%) AEP event**

Map Orientation:

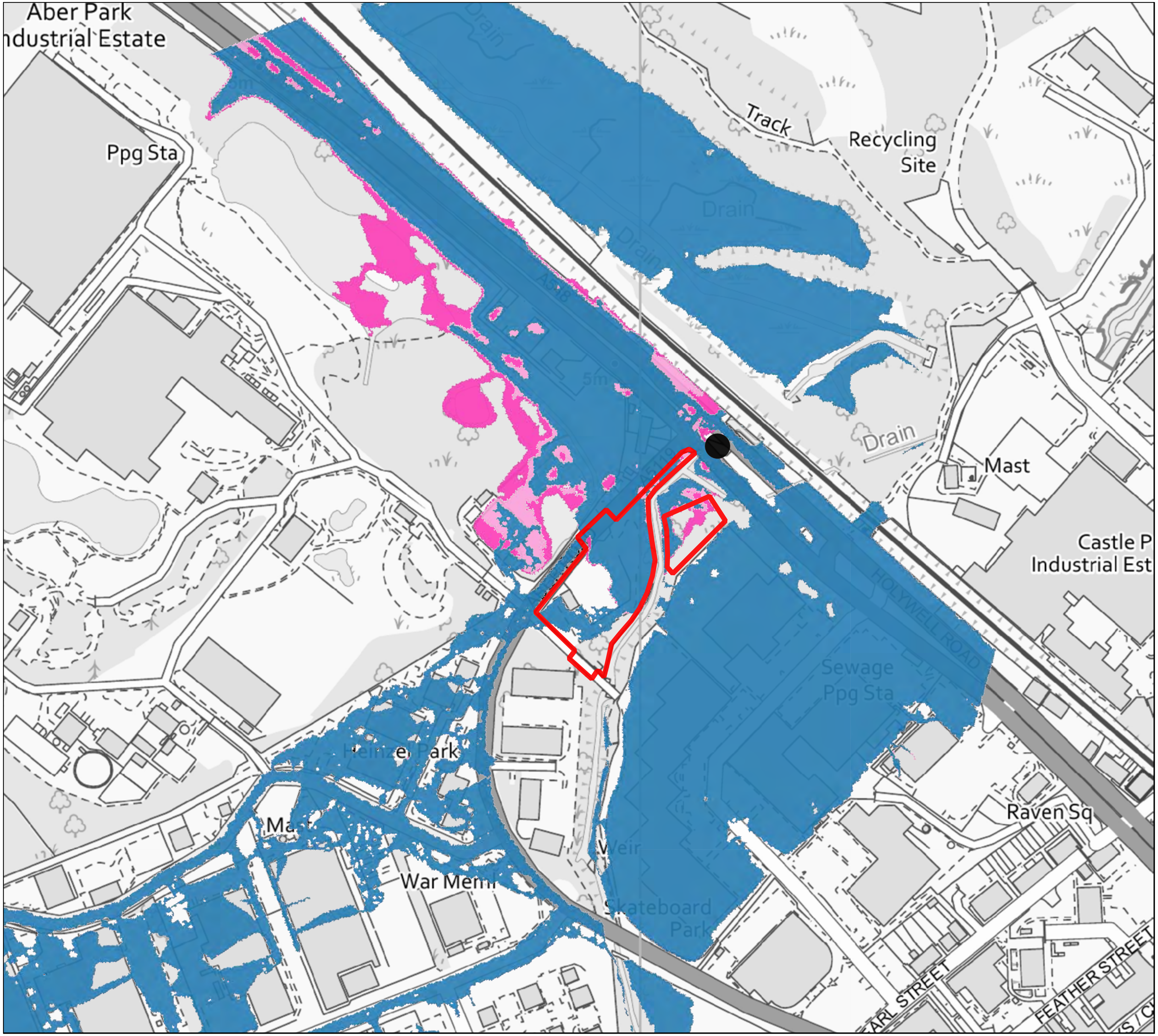
Scale: 0 14 28 42 56 70 m

Drawn:	Checked:	Date:
MN	AE	5 June 2023

Project No:	Drawing No:	Rev:
5560	5560_026_Q1000CC20_d	A

ANNEX F

Model Results - Sensitivity



Notes:

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Legend

- Site Location
- Structure Blockage Location
- Baseline Scenario
- 25% Blockage
- 80% Blockage

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Project Title: **Aber Road, Flint**

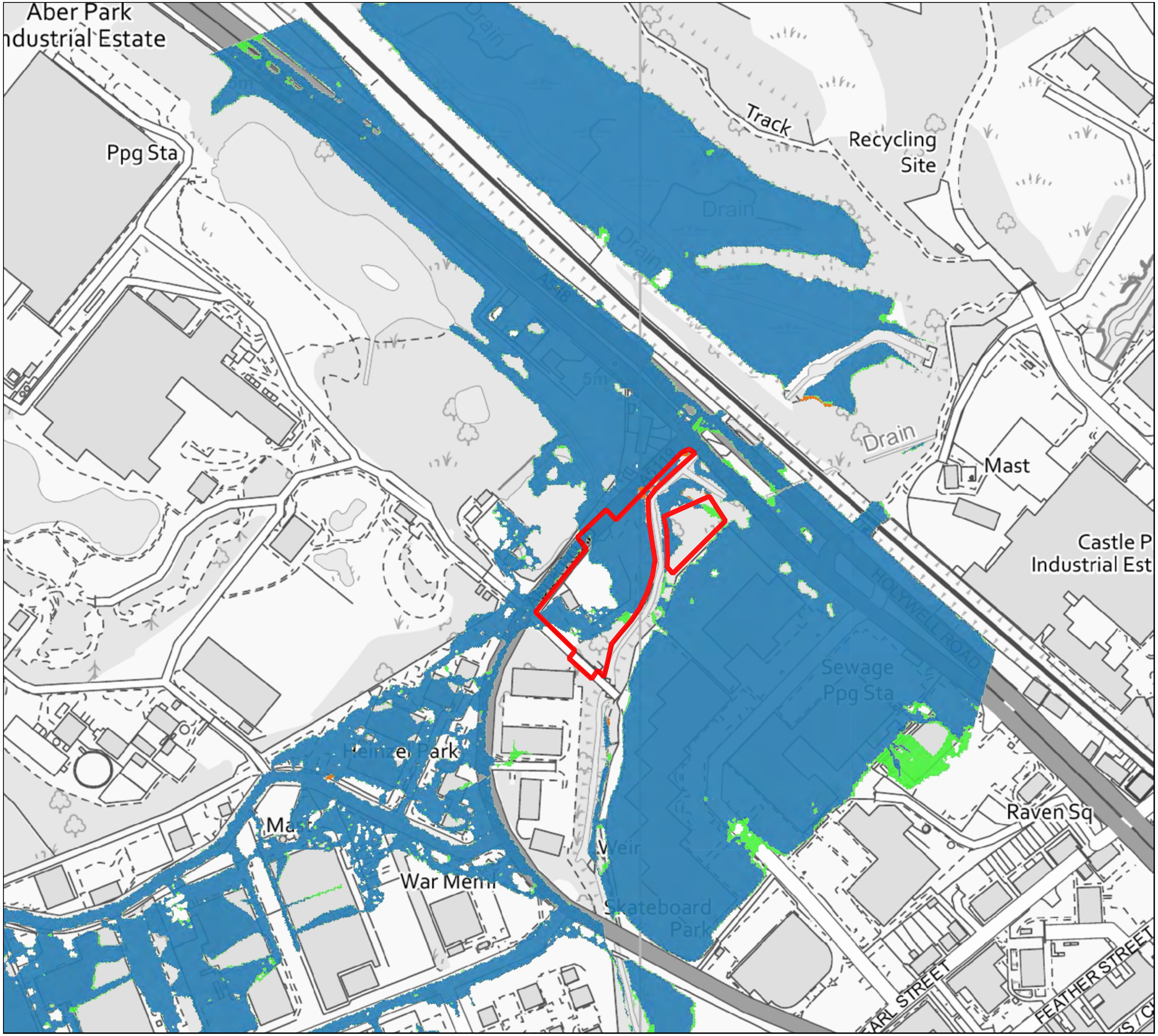
Drawing Title: **Blockage Scenario - Maximum Flood Extent; 1 in 100 plus climate change (20%) AEP event**

Map Orientation:

Scale: 0 14 28 42 56 70 m

Drawn:	Checked:	Date:
MN	AE	5 June 2023

Project No:	Drawing No:	Rev:
5560	5560_027_028_Q0100CC20	A



Notes:

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Legend

- Site Location
- Baseline Scenario
- Increased Mannings 'n' 20%
- Reduced Mannings 'n' 20%

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Client: **HMG (Aber Road) Limited**

Project Title: **Aber Road, Flint**

Drawing Title: **Sensitivty Scenario - Mannings 'n'; 1 in 100 plus climate change (20%) AEP event**

Map Orientation:

Scale: 0 14 28 42 56 70 m

Drawn:	Checked:	Date:
MN	AE	5 June 2023

Project No:	Drawing No:	Rev:
5560	5560_036_037_Q0100CC20	A

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

www.weetwood.net

APPENDIX F

Preliminary Proposed Site Levels

- ALL DIMENSIONS AND LEVELS ARE TO BE CHECKED ON SITE.
- ANY DISCREPANCIES ARE TO BE REPORTED TO CUBE ARCHITECTURE AND DESIGN BEFORE ANY WORK COMMENCES.
- THIS DRAWING SHALL NOT BE SCALED TO ASCERTAIN ANY DIMENSIONS. WORK TO FIGURED DIMS ONLY.
- THIS DRAWING SHALL NOT BE REPRODUCED WITHOUT EXPRESS WRITTEN PERMISSION FROM CUBE ARCHITECTURE AND DESIGN.
- TITLE OVERLAY DRAWINGS AND OWNERSHIP BOUNDARIES ARE PRODUCED USING ALL REASONABLE ENDEAVOURS. CUBE ARCHITECTURE AND DESIGN CANNOT BE RESPONSIBLE FOR THE ACCURACY OR SCALE DISCREPANCY OF BASE PLANS SUPPLIED TO THEM.

Scale Bar @ 1:200 0 2 4 6 8 10 Metres

Rev	Description	Date	By

Status:
PLANNING

Client:
THE HOLLINS MURRAY GROUP

Contract:
PROPOSED INDUSTRIAL DEVELOPMENT
ABER ROAD
FLINT

Drawing:
PROPOSED SITE PLAN

Drawing No:	Revision:	Scales:
AS786-03	-	1:200@A1
Drawn:	Checked:	Date:
DMR		MAR '22

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www.cubearchitecture.net

commercial house
clarence avenue
trafford park
m17 1qs
tel: 0161 848 5893

DO NOT scale from this drawing.

APPENDIX G

Flood Risk Comparison Plots

Notes:

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Legend

Site Location

Changes in flood depth (m)

- Reduction < 0.3
- Reduction 0.3 to 0.1
- Reduction 0.1 to 0.005
- Reduction 0.03 to 0.005
- No Change
- Increase 0.005 to 0.03
- Increase 0.03 to 0.1
- Increase 0.1 to 0.3
- Increase > 0.3

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Client: **HMG (Aber Road) Limited**

Project Title: **Aber Road, Flint**

Drawing Title: **Proposed Scenario (Tidal Overtopping) - Comparison Plot; 1 in 200 AEP event plus climate change (2097 - 70P)**

Map Orientation:

Scale: 0 75 150 225 m

Drawn:	Checked:	Date:
MN	AE	5 June 2023

Project No:	Drawing No:	Rev:
5560	5560_004-001_Q0200_2097_70P_d	A

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Legend

Site Location

Changes in flood depth (m)

- Reduction < 0.3
- Reduction 0.3 to 0.1
- Reduction 0.1 to 0.005
- Reduction 0.03 to 0.005
- No Change
- Increase 0.005 to 0.03
- Increase 0.03 to 0.1
- Increase 0.1 to 0.3
- Increase > 0.3

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Project Title:	**Aber Road, Flint**
Drawing Title:	**Proposed Scenario (Tidal Overtopping) - Comparison Plot; 1 in 1000 AEP event plus climate change (2097 - 70P)**
Map Orientation:	Scale: 0 75 150 225 m
Drawn: MN	Checked: AE
Date:	5 June 2023
Project No: 5560	Drawing No: 5560_004-001_Q1000_2097_70P_d
Rev:	A

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Legend

- Site Location
- Breach Location

Changes in flood depth (m)

- Reduction < 0.3
- Reduction 0.3 to 0.1
- Reduction 0.1 to 0.005
- Reduction 0.03 to 0.005
- No Change
- Increase 0.005 to 0.03
- Increase 0.03 to 0.1
- Increase 0.1 to 0.3
- Increase > 0.3

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Project Title:
Aber Road, Flint

Drawing Title:
Proposed Scenario (Tidal Breach) - Comparison Plot; 1 in 200 AEP event plus climate change (2097 - 70P)

Map Orientation:	Scale: 0 75 150 225 m

Drawn:	Checked:	Date:
MN	AE	5 June 2023

Project No:	Drawing No:	Rev:
5560	5560_004-002_Q0200_2097_70P_d	A

Notes:

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Legend

- Site Location
- Breach Location

Changes in flood depth (m)

- Reduction < 0.3
- Reduction 0.3 to 0.1
- Reduction 0.1 to 0.005
- Reduction 0.03 to 0.005
- No Change
- Increase 0.005 to 0.03
- Increase 0.03 to 0.1
- Increase 0.1 to 0.3
- Increase > 0.3

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Project Title:
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Drawing Title:
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Map Orientation:	Scale: 0 75 150 225 m

Drawn:	Checked:	Date:
MN	AE	5 June 2023

Project No:	Drawing No:	Rev:
5560	5560_004-002_Q1000_2097_70P_d	A

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Site Location

Changes in flood depth (m)

- Reduction < 0.3
- Reduction 0.3 to 0.1
- Reduction 0.1 to 0.005
- Reduction 0.03 to 0.005
- No Change
- Increase 0.005 to 0.03
- Increase 0.03 to 0.1
- Increase 0.1 to 0.3
- Increase > 0.3

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Project Title:
Aber Road, Flint

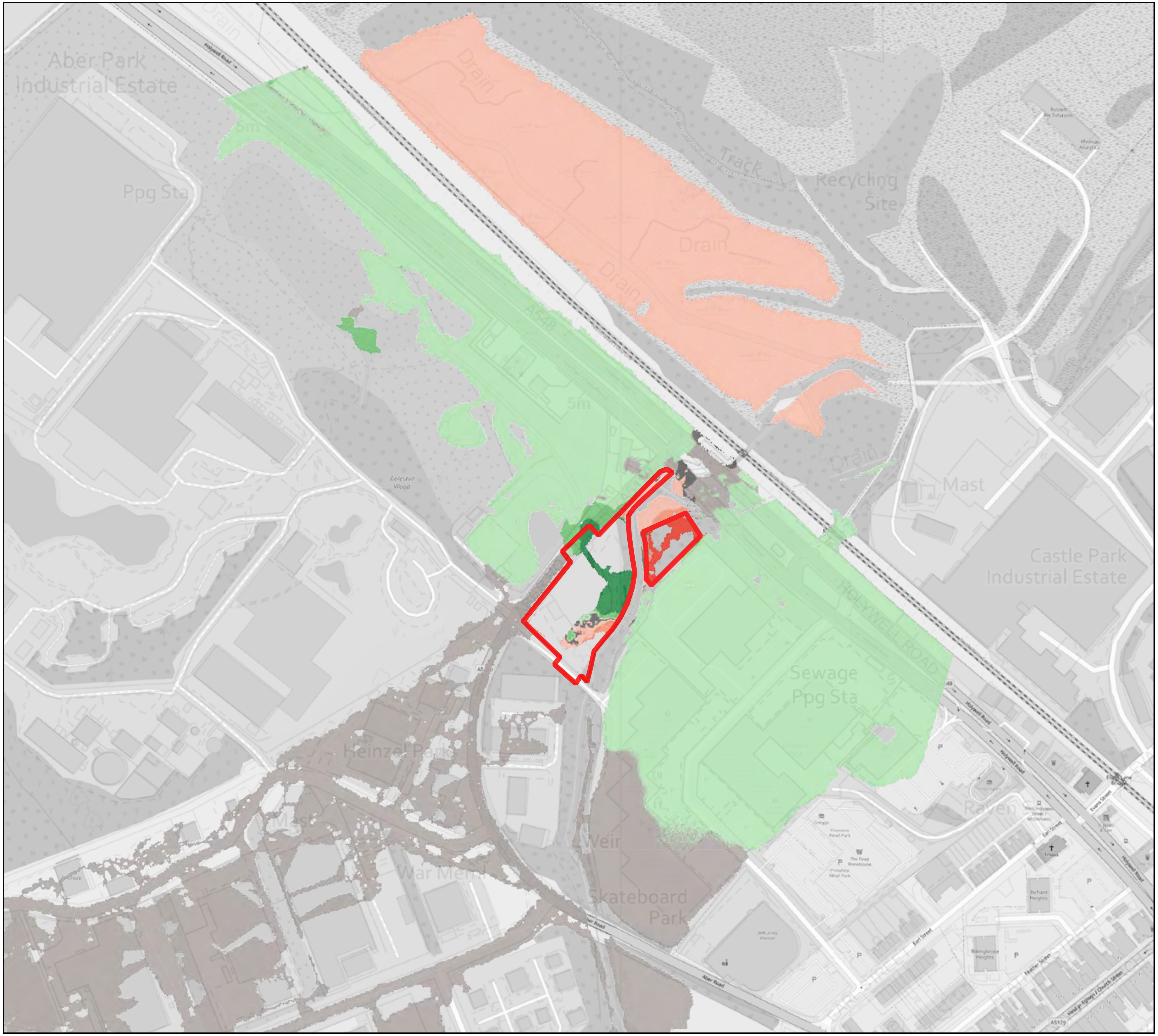
Drawing Title:
Proposed Scenario (Baseline) - Comparison Plot;
1 in 100 plus climate change (20%) AEP event

Map Orientation:

Scale: 0 14 28 42 56 70 m

Drawn:	Checked:	Date:
MN	AE	5 June 2023

Project No:	Drawing No:	Rev:
5560	5560_033-026_Q0100CC20_d	A



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Legend

- Site Location
- Changes in flood depth (m)
  - Reduction < 0.3
  - Reduction 0.3 to 0.1
  - Reduction 0.1 to 0.005
  - Reduction 0.03 to 0.005
  - No Change
  - Increase 0.005 to 0.03
  - Increase 0.03 to 0.1
  - Increase 0.1 to 0.3
  - Increase > 0.3

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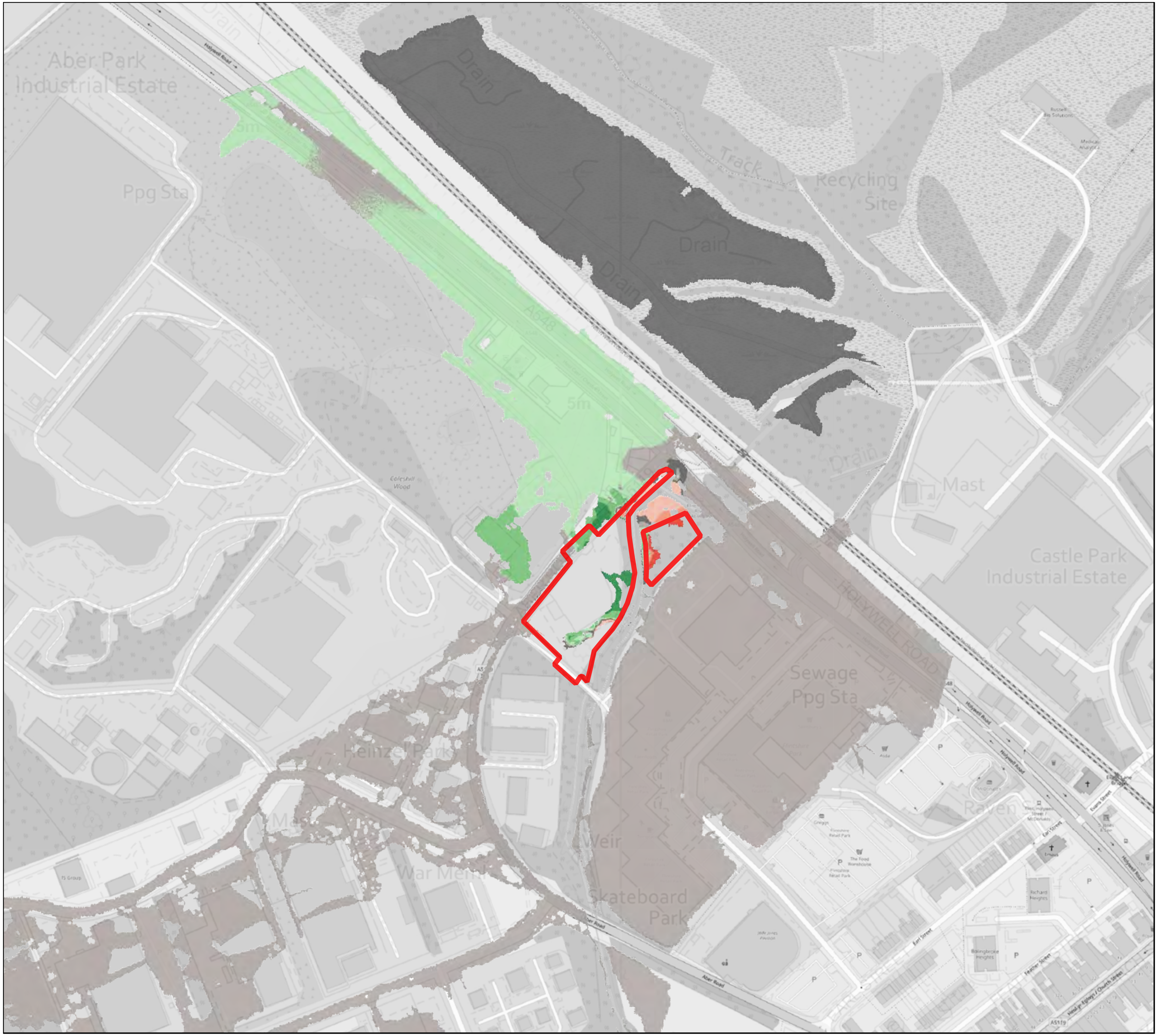
Drawn:	Checked:	Date:
MN	AE	5 June 2023

Project No:	Drawing No:	Rev:
5560	5560_033-026_Q1000CC20_d	A



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Site Location

Changes in flood depth (m)

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- Reduction 0.3 to 0.1
- Reduction 0.1 to 0.005
- Reduction 0.03 to 0.005
- No Change
- Increase 0.005 to 0.03
- Increase 0.03 to 0.1
- Increase 0.1 to 0.3
- Increase > 0.3

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Project Title: **Aber Road, Flint**

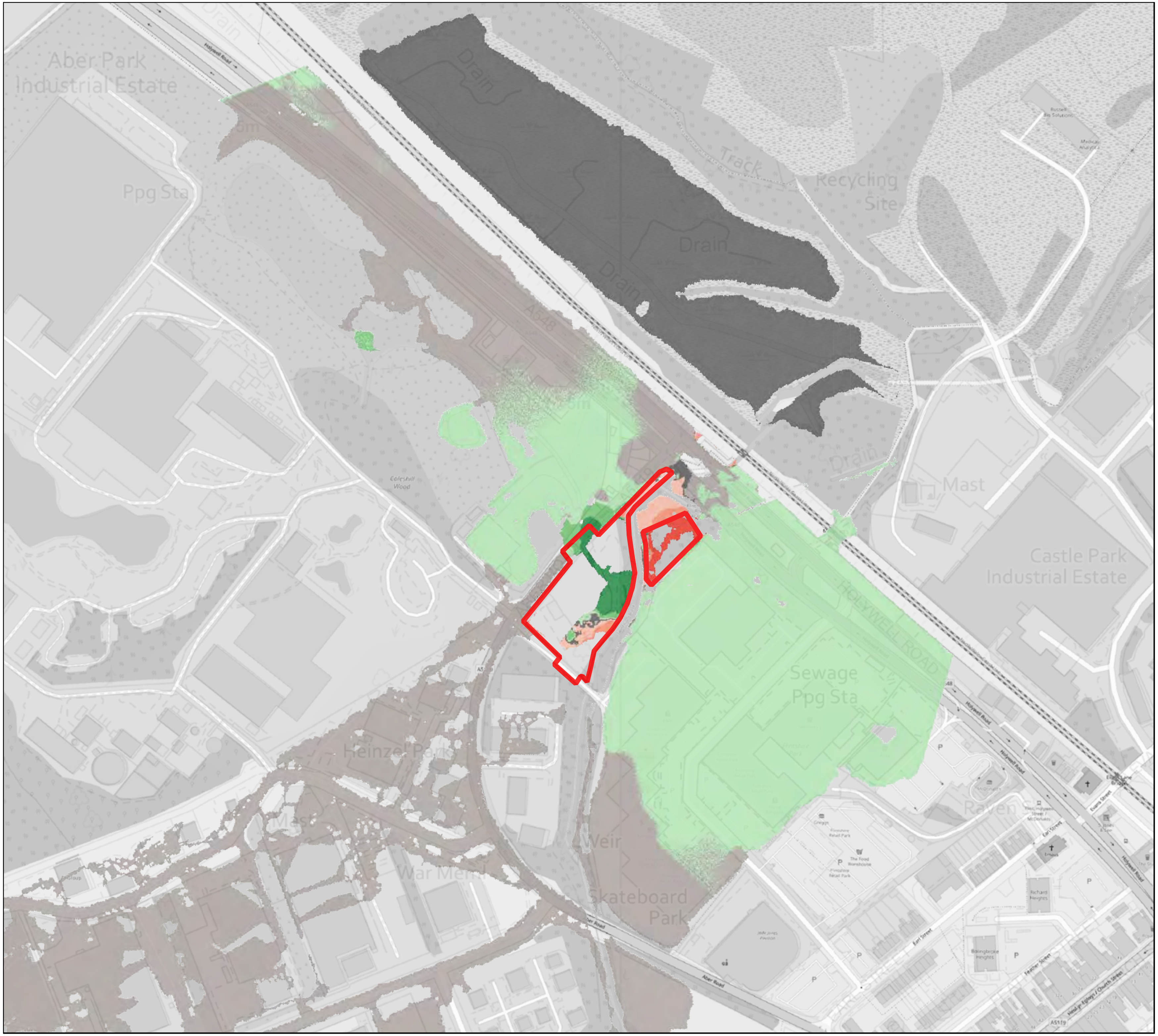
Drawing Title: **Proposed Scenario (25% Blockage) - Comparison Plot; 1 in 100 plus climate change (20%) AEP event**

Map Orientation:

Scale: 0 14 28 42 56 70 m

Drawn:	Checked:	Date:
MN	AE	5 June 2023

Project No:	Drawing No:	Rev:
5560	5560_034-027_Q100CC20_d	A



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Legend

Site Location

Changes in flood depth (m)

- Reduction < 0.3
- Reduction 0.3 to 0.1
- Reduction 0.1 to 0.005
- Reduction 0.03 to 0.005
- No Change
- Increase 0.005 to 0.03
- Increase 0.03 to 0.1
- Increase 0.1 to 0.3
- Increase > 0.3

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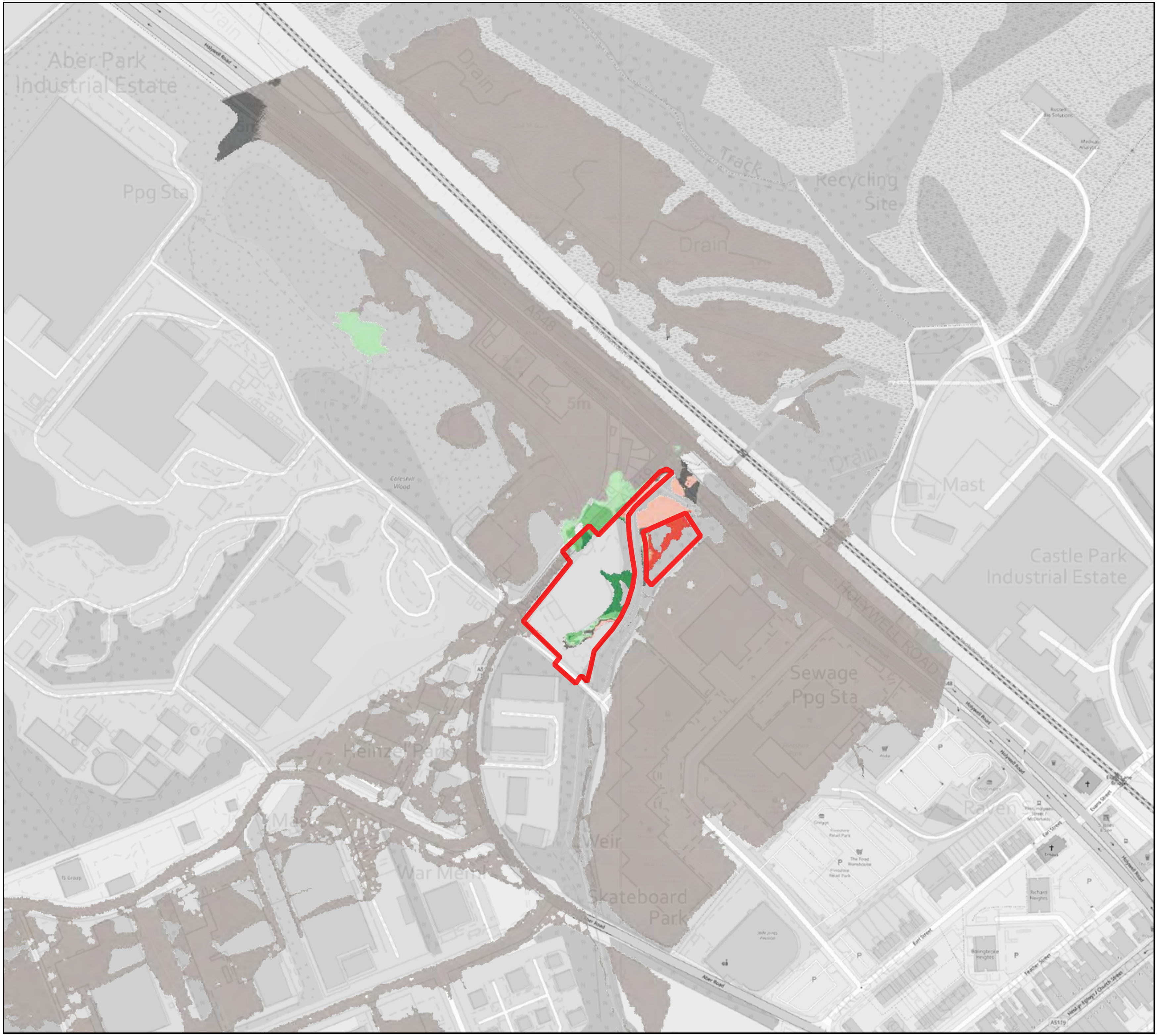
Project Title: **Aber Road, Flint**

Drawing Title: **Proposed Scenario (25% Blockage) - Comparison Plot; 1 in 1000 plus climate change (20%) AEP event**

Map Orientation:	Scale: 0 14 28 42 56 70 m	
Drawn: MN	Checked: AE	Date: 5 June 2023
Project No: 5560	Drawing No: 5560_034-027_Q1000CC20_d	Rev: A



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Legend

Site Location

Changes in flood depth (m)

- Reduction < 0.3
- Reduction 0.3 to 0.1
- Reduction 0.1 to 0.005
- Reduction 0.03 to 0.005
- No Change
- Increase 0.005 to 0.03
- Increase 0.03 to 0.1
- Increase 0.1 to 0.3
- Increase > 0.3

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Project Title: **Aber Road, Flint**

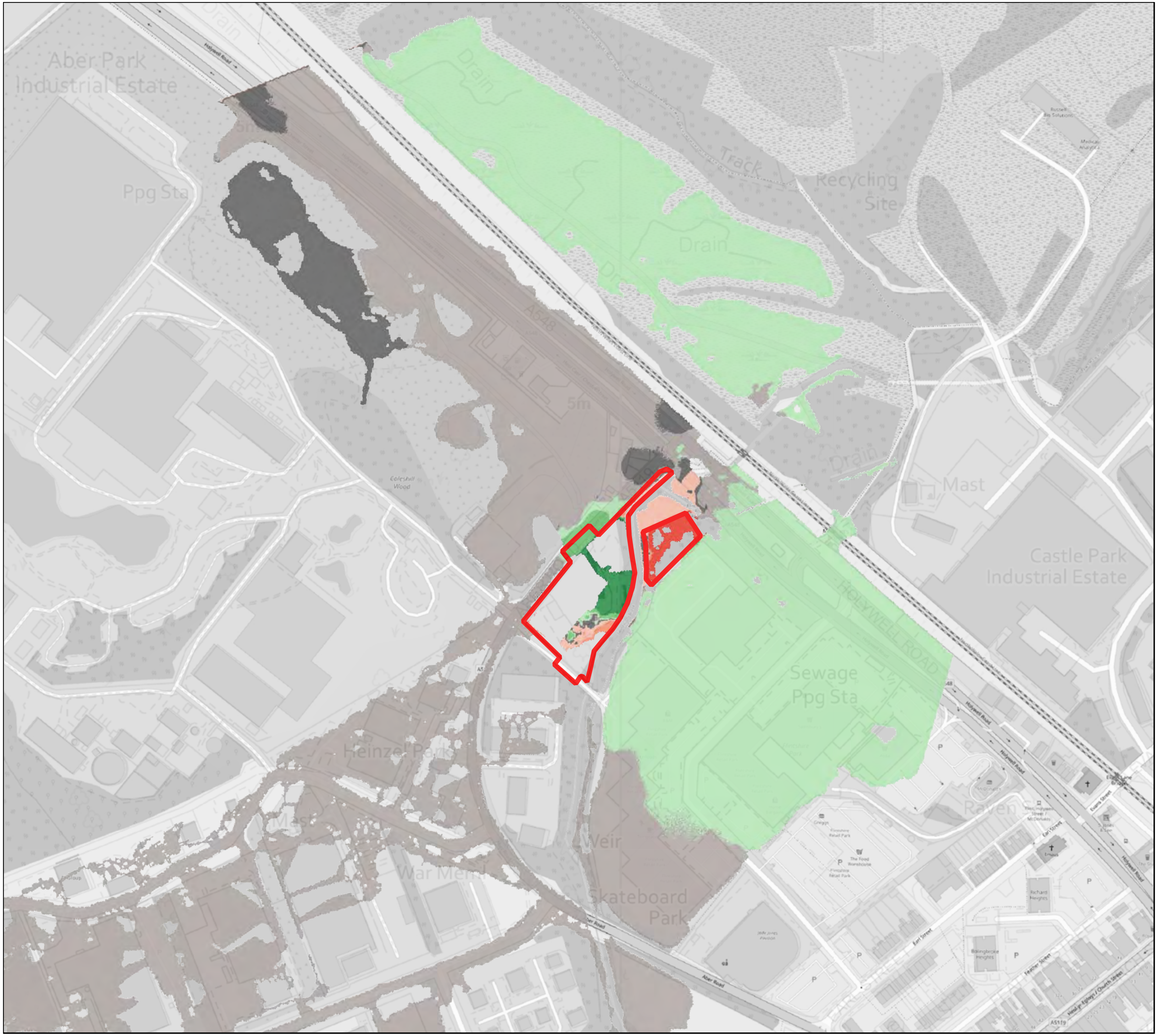
Drawing Title: **Proposed Scenario (80% Blockage) - Comparison Plot; 1 in 100 plus climate change (20%) AEP event**

Map Orientation:

Scale: 0 14 28 42 56 70 m

Drawn:	Checked:	Date:
MN	AE	5 June 2023

Project No:	Drawing No:	Rev:
5560	5560_035-028_Q100CC20_d	A



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Legend

- Site Location

Changes in flood depth (m)

- Reduction < 0.3
- Reduction 0.3 to 0.1
- Reduction 0.1 to 0.005
- Reduction 0.03 to 0.005
- No Change
- Increase 0.005 to 0.03
- Increase 0.03 to 0.1
- Increase 0.1 to 0.3
- Increase > 0.3

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Project Title: **Aber Road, Flint**

Drawing Title: **Proposed Scenario (80% Blockage) - Comparison Plot; 1 in 1000 plus climate change (20%) AEP event**

Map Orientation:

Scale: 0 14 28 42 56 70 m

Drawn:	Checked:	Date:
MN	AE	5 June 2023

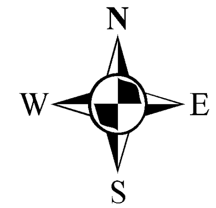
Project No:	Drawing No:	Rev:
5560	5560_035-028_Q1000CC20_d	A

APPENDIX H

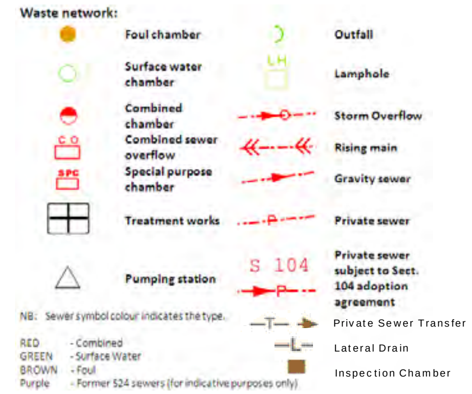
Dŵr Cymru Welsh Water Public Sewer Record

Dŵr Cymru Welsh Water

Aber Road Flint Flintshire



LEGEND(Representative of most common features)



Notes:

Whilst every reasonable effort has been taken to correctly record the pipe material of DCWW assets, there is a possibility that in some cases pipe material (other than Asbestos Cement or Pitch Fibre) may be found to be asbestos cement (AC) or Pitch Fibre (PF) . It is therefore advisable that the possible presence of AC or PF pipes be anticipated and considered as part of any risk assessment prior to excavation

Dŵr Cymru Cyfyngedig ('the Company') gives this information as to the position of its underground apparatus by way of general guidance only and on the strict understanding that it is based on the best information available and no warranty as to its correctness is relied upon in the event of excavations or other works made in the vicinity of the company's apparatus. The onus of locating apparatus before carrying out any excavations rests entirely on you. The information which is supplied by the Company, is done so in accordance with statutory requirements of sections 198 and 199 of the Water Industry Act 1991 which is based upon the best Information available and, in particular, but without prejudice to the generality of the foregoing, it should be noted that the records that are available to the Company may not disclose the existence of a water main, service pipe, sewer, lateral drain or disposal main and any associated apparatus laid before 1 September 1989, or, if they do, the particulars thereof including their position underground may not be accurate. It must be understood that the furnishing of this information is entirely without prejudice to the provision of the New Roads and Street Works Act 1991 and the Company's right to be compensated for any damage to its apparatus.

Service pipes are not generally shown but their presence should be anticipated.

EXACT LOCATIONS OF ALL APPARATUS TO BE DETERMINED ON SITE.

Map Ref:	324074,373405
Map scale:	1:1250
Printed by:	Zara Howells
Printed on:	20 Apr 2022

APPENDIX I

Greenfield Runoff Calculations

ICP SUDS Mean Annual Flood

Input

Return Period (years)	1	SAAR (mm)	869	Urban	0.000
Area (ha)	1.000	Soil	0.450	Region Number	Region 9

Results	**l/s**
QBAR Rural	5.7
QBAR Urban	5.7
Q1 year	5.0
Q1 year	5.0
Q30 years	10.0
Q100 years	12.3

APPENDIX J

Peak Runoff Rate from Existing Site

The peak discharge rates of surface water runoff from the impermeable areas at the site have been calculated based on the Modified Rational Method[17].

The following parameters have been obtained from the maps in Volume 3 of the Wallingford Procedure:

M5-60 minute rainfall depth:	18 mm
Ratio of M5-60 to M5-2 day rainfall:	0.35
Average Annual Rainfall:	869 mm
Winter Rain Acceptance Potential/ Soil Type :	0.45
The Urban Catchment Wetness Index (UCWI) value:	94.4

A time of concentration of 15 minutes has been used comprising a time of entry of 5 minutes and a time of flow of 10 minutes.

A rainfall estimation calculation has been carried out to convert the M5-60 minute rainfall to the 5-minute duration rainfall for the 1 in 1 and 1 in 100 annual exceedance probability (AEP) rainfall events. The calculated rainfall intensities for these events are 27.0 and 84.9 mm/hr respectively.

The flow rate as given by the Modified Rational Method is:

$$Q=2.78 \times C_v \times C_r \times \text{rainfall intensity} \times \text{impermeable area}$$

where:

C_v is the volumetric runoff coefficient = P_r/PIMP = 0.7618
where P_r is Percentage Runoff and PIMP is Percentage Impermeable Area
C_r is the routing coefficient = 1.3
Impermeable Area = 0.207 ha

The peak discharges of surface runoff from impermeable areas of the existing site are shown in the table below:

AEP of rainfall event	Peak discharge for 0.207 ha impermeable area (l/s)
1 in 1	15.4
1 in 2	19.9
1 in 30	37.6
1 in 100	48.4

[17] The Wallingford Procedure, Volume 4, 1981

APPENDIX K

Surface Water Attenuation - Storage Volume Calculation

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - England and Wales

Return Period (years)	2	PIMP (%)	100
M5-60 (mm)	18.000	Add Flow / Climate Change (%)	0
Ratio R	0.352	Minimum Backdrop Height (m)	0.000
Maximum Rainfall (mm/hr)	50	Maximum Backdrop Height (m)	0.000
Maximum Time of Concentration (mins)	30	Min Design Depth for Optimisation (m)	0.000
Foul Sewage (l/s/ha)	0.000	Min Vel for Auto Design only (m/s)	1.00
Volumetric Runoff Coeff.	0.750	Min Slope for Optimisation (1:X)	500

Designed with Level Soffits

Time Area Diagram for Storm

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.366	4-8	0.166

Total Area Contributing (ha) = 0.532

Total Pipe Volume (m³) = 12.514

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
S1.000	60.000	0.250	240.0	0.159	5.00	0.0	0.600	o	300	Pipe/Conduit	🔒
S1.001	17.707	0.100	177.1	0.034	0.00	0.0	0.600	o	300	Pipe/Conduit	🔓
S2.000	33.423	0.150	222.8	0.035	5.00	0.0	0.600	o	300	Pipe/Conduit	🔒

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
S1.000	50.00	5.99	5.450	0.159	0.0	0.0	0.0	1.01	71.4	21.5
S1.001	50.00	6.24	5.200	0.193	0.0	0.0	0.0	1.18	83.3	26.1
S2.000	50.00	5.53	5.300	0.035	0.0	0.0	0.0	1.05	74.2	4.7

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
S3.000	40.000	0.200	200.0	0.081	5.00	0.0	0.600	o	300	Pipe/Conduit	🔒
S2.001	5.548	0.050	111.0	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	🔓
S4.000	8.201	0.200	41.0	0.194	5.00	0.0	0.600	o	300	Pipe/Conduit	🔒
S1.002	3.000	0.050	60.0	0.016	0.00	0.0	0.600	o	300	Pipe/Conduit	🔓
S1.003	6.374	0.050	127.5	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	🔓
S1.004	2.780	0.050	55.6	0.013	0.00	0.0	0.600	o	300	Pipe/Conduit	🔓

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
S3.000	50.00	5.60	5.350	0.081	0.0	0.0	0.0	1.11	78.3	11.0
S2.001	50.00	5.66	5.150	0.116	0.0	0.0	0.0	1.49	105.5	15.7
S4.000	50.00	5.06	5.300	0.194	0.0	0.0	0.0	2.46	174.1	26.3
S1.002	50.00	6.26	5.100	0.519	0.0	0.0	0.0	2.03	143.7	70.3
S1.003	50.00	6.34	4.950	0.519	0.0	0.0	0.0	1.39	98.3	70.3
S1.004	50.00	6.36	4.900	0.532	0.0	0.0	0.0	2.11	149.4	72.0

Manhole Schedules for Storm

MH Name	MH CL (m)	MH Depth (m)	MH Connection	MH Diam.,L*W (mm)	PN	Pipe Out Invert Level (m)	Diameter (mm)	PN	Pipes In Invert Level (m)	Diameter (mm)	Backdrop (mm)
S8	6.950	1.500	Open Manhole	1200	S1.000	5.450	300				
S7-TANK	6.700	1.500	Open Manhole	1500	S1.001	5.200	300	S1.000	5.200	300	
S6	6.550	1.250	Open Manhole	1200	S2.000	5.300	300				
S5	6.600	1.250	Open Manhole	1200	S3.000	5.350	300				
S4	6.600	1.450	Open Manhole	1200	S2.001	5.150	300	S2.000	5.150	300	
								S3.000	5.150	300	
S3A	6.600	1.300	Open Manhole	1200	S4.000	5.300	300				
S3	6.600	1.500	Open Manhole	1200	S1.002	5.100	300	S1.001	5.100	300	
								S2.001	5.100	300	
								S4.000	5.100	300	
S2-BS	6.600	1.650	Open Manhole	600	S1.003	4.950	300	S1.002	5.050	300	100
S1-FC	6.600	1.700	Open Manhole	1500	S1.004	4.900	300	S1.003	4.900	300	
S-OUTFALL	6.600	1.750	Open Manhole	0		OUTFALL		S1.004	4.850	300	

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
S8	1026.364	1980.832	1026.364	1980.832	Required	
S7-TANK	1064.120	2027.463	1064.120	2027.463	Required	
S6	1050.153	2058.853	1050.153	2058.853	Required	
S5	1068.108	2077.009	1068.108	2077.009	Required	
S4	1076.128	2037.822	1076.128	2037.822	Required	
S3A	1085.349	2027.903	1085.349	2027.903	Required	

Manhole Schedules for Storm

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
S3	1080.440	2034.330	1080.440	2034.330	Required	
S2-BS	1083.380	2034.932	1083.380	2034.932	Required	
S1-FC	1089.624	2036.210	1089.624	2036.210	Required	
S-OUTFALL	1092.347	2036.767			No Entry	

PIPELINE SCHEDULES for Storm

Upstream Manhole

PN	Hyd Sect	Diam (mm)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
S1.000	o	300	S8	6.950	5.450	1.200	Open Manhole	1200
S1.001	o	300	S7-TANK	6.700	5.200	1.200	Open Manhole	1500
S2.000	o	300	S6	6.550	5.300	0.950	Open Manhole	1200
S3.000	o	300	S5	6.600	5.350	0.950	Open Manhole	1200
S2.001	o	300	S4	6.600	5.150	1.150	Open Manhole	1200
S4.000	o	300	S3A	6.600	5.300	1.000	Open Manhole	1200
S1.002	o	300	S3	6.600	5.100	1.200	Open Manhole	1200
S1.003	o	300	S2-BS	6.600	4.950	1.350	Open Manhole	600
S1.004	o	300	S1-FC	6.600	4.900	1.400	Open Manhole	1500

Downstream Manhole

PN	Length (m)	Slope (1:X)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
S1.000	60.000	240.0	S7-TANK	6.700	5.200	1.200	Open Manhole	1500
S1.001	17.707	177.1	S3	6.600	5.100	1.200	Open Manhole	1200
S2.000	33.423	222.8	S4	6.600	5.150	1.150	Open Manhole	1200
S3.000	40.000	200.0	S4	6.600	5.150	1.150	Open Manhole	1200
S2.001	5.548	111.0	S3	6.600	5.100	1.200	Open Manhole	1200
S4.000	8.201	41.0	S3	6.600	5.100	1.200	Open Manhole	1200
S1.002	3.000	60.0	S2-BS	6.600	5.050	1.250	Open Manhole	600
S1.003	6.374	127.5	S1-FC	6.600	4.900	1.400	Open Manhole	1500
S1.004	2.780	55.6	S-OUTFALL	6.600	4.850	1.450	Open Manhole	0

Area Summary for Storm

Pipe Number	PIMP Type	PIMP Name	PIMP (%)	Gross Area (ha)	Imp. Area (ha)	Pipe Total (ha)
1.000	-	-	100	0.159	0.159	0.159
1.001	-	-	100	0.034	0.034	0.034
2.000	-	-	100	0.035	0.035	0.035
3.000	-	-	100	0.081	0.081	0.081
2.001	-	-	100	0.000	0.000	0.000
4.000	-	-	100	0.194	0.194	0.194
1.002	-	-	100	0.016	0.016	0.016
1.003	-	-	100	0.000	0.000	0.000
1.004	-	-	100	0.013	0.013	0.013
				Total	Total	Total
				0.532	0.532	0.532

Surcharged Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
S1.004	S-OUTFALL	6.600	4.850	0.000	0	0

Datum (m) 0.000 Offset (mins) 0

Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)
1	6.210	19	6.210	37	6.210	55	6.210	73	6.210	91	6.210	109	6.210
2	6.210	20	6.210	38	6.210	56	6.210	74	6.210	92	6.210	110	6.210
3	6.210	21	6.210	39	6.210	57	6.210	75	6.210	93	6.210	111	6.210
4	6.210	22	6.210	40	6.210	58	6.210	76	6.210	94	6.210	112	6.210
5	6.210	23	6.210	41	6.210	59	6.210	77	6.210	95	6.210	113	6.210
6	6.210	24	6.210	42	6.210	60	6.210	78	6.210	96	6.210	114	6.210
7	6.210	25	6.210	43	6.210	61	6.210	79	6.210	97	6.210	115	6.210
8	6.210	26	6.210	44	6.210	62	6.210	80	6.210	98	6.210	116	6.210
9	6.210	27	6.210	45	6.210	63	6.210	81	6.210	99	6.210	117	6.210
10	6.210	28	6.210	46	6.210	64	6.210	82	6.210	100	6.210	118	6.210
11	6.210	29	6.210	47	6.210	65	6.210	83	6.210	101	6.210	119	6.210
12	6.210	30	6.210	48	6.210	66	6.210	84	6.210	102	6.210	120	6.210
13	6.210	31	6.210	49	6.210	67	6.210	85	6.210	103	6.210	121	6.210
14	6.210	32	6.210	50	6.210	68	6.210	86	6.210	104	6.210	122	6.210
15	6.210	33	6.210	51	6.210	69	6.210	87	6.210	105	6.210	123	6.210
16	6.210	34	6.210	52	6.210	70	6.210	88	6.210	106	6.210	124	6.210
17	6.210	35	6.210	53	6.210	71	6.210	89	6.210	107	6.210	125	6.210
18	6.210	36	6.210	54	6.210	72	6.210	90	6.210	108	6.210	126	6.210

Surcharged Outfall Details for Storm

Time (mins)	**Depth (m)**	**Time (mins)**	**Depth (m)**	**Time (mins)**	**Depth (m)**	**Time (mins)**	**Depth (m)**	**Time (mins)**	**Depth (m)**	**Time (mins)**	**Depth (m)**	**Time (mins)**	**Depth (m)**
127	6.210	171	6.210	215	6.210	259	6.210	303	6.210	347	6.210	391	6.210
128	6.210	172	6.210	216	6.210	260	6.210	304	6.210	348	6.210	392	6.210
129	6.210	173	6.210	217	6.210	261	6.210	305	6.210	349	6.210	393	6.210
130	6.210	174	6.210	218	6.210	262	6.210	306	6.210	350	6.210	394	6.210
131	6.210	175	6.210	219	6.210	263	6.210	307	6.210	351	6.210	395	6.210
132	6.210	176	6.210	220	6.210	264	6.210	308	6.210	352	6.210	396	6.210
133	6.210	177	6.210	221	6.210	265	6.210	309	6.210	353	6.210	397	6.210
134	6.210	178	6.210	222	6.210	266	6.210	310	6.210	354	6.210	398	6.210
135	6.210	179	6.210	223	6.210	267	6.210	311	6.210	355	6.210	399	6.210
136	6.210	180	6.210	224	6.210	268	6.210	312	6.210	356	6.210	400	6.210
137	6.210	181	6.210	225	6.210	269	6.210	313	6.210	357	6.210	401	6.210
138	6.210	182	6.210	226	6.210	270	6.210	314	6.210	358	6.210	402	6.210
139	6.210	183	6.210	227	6.210	271	6.210	315	6.210	359	6.210	403	6.210
140	6.210	184	6.210	228	6.210	272	6.210	316	6.210	360	6.210	404	6.210
141	6.210	185	6.210	229	6.210	273	6.210	317	6.210	361	6.210	405	6.210
142	6.210	186	6.210	230	6.210	274	6.210	318	6.210	362	6.210	406	6.210
143	6.210	187	6.210	231	6.210	275	6.210	319	6.210	363	6.210	407	6.210
144	6.210	188	6.210	232	6.210	276	6.210	320	6.210	364	6.210	408	6.210
145	6.210	189	6.210	233	6.210	277	6.210	321	6.210	365	6.210	409	6.210
146	6.210	190	6.210	234	6.210	278	6.210	322	6.210	366	6.210	410	6.210
147	6.210	191	6.210	235	6.210	279	6.210	323	6.210	367	6.210	411	6.210
148	6.210	192	6.210	236	6.210	280	6.210	324	6.210	368	6.210	412	6.210
149	6.210	193	6.210	237	6.210	281	6.210	325	6.210	369	6.210	413	6.210
150	6.210	194	6.210	238	6.210	282	6.210	326	6.210	370	6.210	414	6.210
151	6.210	195	6.210	239	6.210	283	6.210	327	6.210	371	6.210	415	6.210
152	6.210	196	6.210	240	6.210	284	6.210	328	6.210	372	6.210	416	6.210
153	6.210	197	6.210	241	6.210	285	6.210	329	6.210	373	6.210	417	6.210
154	6.210	198	6.210	242	6.210	286	6.210	330	6.210	374	6.210	418	6.210
155	6.210	199	6.210	243	6.210	287	6.210	331	6.210	375	6.210	419	6.210
156	6.210	200	6.210	244	6.210	288	6.210	332	6.210	376	6.210	420	6.210
157	6.210	201	6.210	245	6.210	289	6.210	333	6.210	377	6.210	421	6.210
158	6.210	202	6.210	246	6.210	290	6.210	334	6.210	378	6.210	422	6.210
159	6.210	203	6.210	247	6.210	291	6.210	335	6.210	379	6.210	423	6.210
160	6.210	204	6.210	248	6.210	292	6.210	336	6.210	380	6.210	424	6.210
161	6.210	205	6.210	249	6.210	293	6.210	337	6.210	381	6.210	425	6.210
162	6.210	206	6.210	250	6.210	294	6.210	338	6.210	382	6.210	426	6.210
163	6.210	207	6.210	251	6.210	295	6.210	339	6.210	383	6.210	427	6.210
164	6.210	208	6.210	252	6.210	296	6.210	340	6.210	384	6.210	428	6.210
165	6.210	209	6.210	253	6.210	297	6.210	341	6.210	385	6.210	429	6.210
166	6.210	210	6.210	254	6.210	298	6.210	342	6.210	386	6.210	430	6.210
167	6.210	211	6.210	255	6.210	299	6.210	343	6.210	387	6.210	431	6.210
168	6.210	212	6.210	256	6.210	300	6.210	344	6.210	388	6.210	432	6.210
169	6.210	213	6.210	257	6.210	301	6.210	345	6.210	389	6.210	433	6.210
170	6.210	214	6.210	258	6.210	302	6.210	346	6.210	390	6.210	434	6.210

Surcharged Outfall Details for Storm

Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)
435	6.210	479	6.210	523	6.210	567	6.210	611	6.210	655	6.210	699	6.210
436	6.210	480	6.210	524	6.210	568	6.210	612	6.210	656	6.210	700	6.210
437	6.210	481	6.210	525	6.210	569	6.210	613	6.210	657	6.210	701	6.210
438	6.210	482	6.210	526	6.210	570	6.210	614	6.210	658	6.210	702	6.210
439	6.210	483	6.210	527	6.210	571	6.210	615	6.210	659	6.210	703	6.210
440	6.210	484	6.210	528	6.210	572	6.210	616	6.210	660	6.210	704	6.210
441	6.210	485	6.210	529	6.210	573	6.210	617	6.210	661	6.210	705	6.210
442	6.210	486	6.210	530	6.210	574	6.210	618	6.210	662	6.210	706	6.210
443	6.210	487	6.210	531	6.210	575	6.210	619	6.210	663	6.210	707	6.210
444	6.210	488	6.210	532	6.210	576	6.210	620	6.210	664	6.210	708	6.210
445	6.210	489	6.210	533	6.210	577	6.210	621	6.210	665	6.210	709	6.210
446	6.210	490	6.210	534	6.210	578	6.210	622	6.210	666	6.210	710	6.210
447	6.210	491	6.210	535	6.210	579	6.210	623	6.210	667	6.210	711	6.210
448	6.210	492	6.210	536	6.210	580	6.210	624	6.210	668	6.210	712	6.210
449	6.210	493	6.210	537	6.210	581	6.210	625	6.210	669	6.210	713	6.210
450	6.210	494	6.210	538	6.210	582	6.210	626	6.210	670	6.210	714	6.210
451	6.210	495	6.210	539	6.210	583	6.210	627	6.210	671	6.210	715	6.210
452	6.210	496	6.210	540	6.210	584	6.210	628	6.210	672	6.210	716	6.210
453	6.210	497	6.210	541	6.210	585	6.210	629	6.210	673	6.210	717	6.210
454	6.210	498	6.210	542	6.210	586	6.210	630	6.210	674	6.210	718	6.210
455	6.210	499	6.210	543	6.210	587	6.210	631	6.210	675	6.210	719	6.210
456	6.210	500	6.210	544	6.210	588	6.210	632	6.210	676	6.210	720	6.210
457	6.210	501	6.210	545	6.210	589	6.210	633	6.210	677	6.210	721	6.210
458	6.210	502	6.210	546	6.210	590	6.210	634	6.210	678	6.210	722	6.210
459	6.210	503	6.210	547	6.210	591	6.210	635	6.210	679	6.210	723	6.210
460	6.210	504	6.210	548	6.210	592	6.210	636	6.210	680	6.210	724	6.210
461	6.210	505	6.210	549	6.210	593	6.210	637	6.210	681	6.210	725	6.210
462	6.210	506	6.210	550	6.210	594	6.210	638	6.210	682	6.210	726	6.210
463	6.210	507	6.210	551	6.210	595	6.210	639	6.210	683	6.210	727	6.210
464	6.210	508	6.210	552	6.210	596	6.210	640	6.210	684	6.210	728	6.210
465	6.210	509	6.210	553	6.210	597	6.210	641	6.210	685	6.210	729	6.210
466	6.210	510	6.210	554	6.210	598	6.210	642	6.210	686	6.210	730	6.210
467	6.210	511	6.210	555	6.210	599	6.210	643	6.210	687	6.210	731	6.210
468	6.210	512	6.210	556	6.210	600	6.210	644	6.210	688	6.210	732	6.210
469	6.210	513	6.210	557	6.210	601	6.210	645	6.210	689	6.210	733	6.210
470	6.210	514	6.210	558	6.210	602	6.210	646	6.210	690	6.210	734	6.210
471	6.210	515	6.210	559	6.210	603	6.210	647	6.210	691	6.210	735	6.210
472	6.210	516	6.210	560	6.210	604	6.210	648	6.210	692	6.210	736	6.210
473	6.210	517	6.210	561	6.210	605	6.210	649	6.210	693	6.210	737	6.210
474	6.210	518	6.210	562	6.210	606	6.210	650	6.210	694	6.210	738	6.210
475	6.210	519	6.210	563	6.210	607	6.210	651	6.210	695	6.210	739	6.210
476	6.210	520	6.210	564	6.210	608	6.210	652	6.210	696	6.210	740	6.210
477	6.210	521	6.210	565	6.210	609	6.210	653	6.210	697	6.210	741	6.210
478	6.210	522	6.210	566	6.210	610	6.210	654	6.210	698	6.210	742	6.210

Surcharged Outfall Details for Storm

Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)
743	6.210	787	6.210	831	6.210	875	6.210	919	6.210	963	6.210	1007	6.210
744	6.210	788	6.210	832	6.210	876	6.210	920	6.210	964	6.210	1008	6.210
745	6.210	789	6.210	833	6.210	877	6.210	921	6.210	965	6.210	1009	6.210
746	6.210	790	6.210	834	6.210	878	6.210	922	6.210	966	6.210	1010	6.210
747	6.210	791	6.210	835	6.210	879	6.210	923	6.210	967	6.210	1011	6.210
748	6.210	792	6.210	836	6.210	880	6.210	924	6.210	968	6.210	1012	6.210
749	6.210	793	6.210	837	6.210	881	6.210	925	6.210	969	6.210	1013	6.210
750	6.210	794	6.210	838	6.210	882	6.210	926	6.210	970	6.210	1014	6.210
751	6.210	795	6.210	839	6.210	883	6.210	927	6.210	971	6.210	1015	6.210
752	6.210	796	6.210	840	6.210	884	6.210	928	6.210	972	6.210	1016	6.210
753	6.210	797	6.210	841	6.210	885	6.210	929	6.210	973	6.210	1017	6.210
754	6.210	798	6.210	842	6.210	886	6.210	930	6.210	974	6.210	1018	6.210
755	6.210	799	6.210	843	6.210	887	6.210	931	6.210	975	6.210	1019	6.210
756	6.210	800	6.210	844	6.210	888	6.210	932	6.210	976	6.210	1020	6.210
757	6.210	801	6.210	845	6.210	889	6.210	933	6.210	977	6.210	1021	6.210
758	6.210	802	6.210	846	6.210	890	6.210	934	6.210	978	6.210	1022	6.210
759	6.210	803	6.210	847	6.210	891	6.210	935	6.210	979	6.210	1023	6.210
760	6.210	804	6.210	848	6.210	892	6.210	936	6.210	980	6.210	1024	6.210
761	6.210	805	6.210	849	6.210	893	6.210	937	6.210	981	6.210	1025	6.210
762	6.210	806	6.210	850	6.210	894	6.210	938	6.210	982	6.210	1026	6.210
763	6.210	807	6.210	851	6.210	895	6.210	939	6.210	983	6.210	1027	6.210
764	6.210	808	6.210	852	6.210	896	6.210	940	6.210	984	6.210	1028	6.210
765	6.210	809	6.210	853	6.210	897	6.210	941	6.210	985	6.210	1029	6.210
766	6.210	810	6.210	854	6.210	898	6.210	942	6.210	986	6.210	1030	6.210
767	6.210	811	6.210	855	6.210	899	6.210	943	6.210	987	6.210	1031	6.210
768	6.210	812	6.210	856	6.210	900	6.210	944	6.210	988	6.210	1032	6.210
769	6.210	813	6.210	857	6.210	901	6.210	945	6.210	989	6.210	1033	6.210
770	6.210	814	6.210	858	6.210	902	6.210	946	6.210	990	6.210	1034	6.210
771	6.210	815	6.210	859	6.210	903	6.210	947	6.210	991	6.210	1035	6.210
772	6.210	816	6.210	860	6.210	904	6.210	948	6.210	992	6.210	1036	6.210
773	6.210	817	6.210	861	6.210	905	6.210	949	6.210	993	6.210	1037	6.210
774	6.210	818	6.210	862	6.210	906	6.210	950	6.210	994	6.210	1038	6.210
775	6.210	819	6.210	863	6.210	907	6.210	951	6.210	995	6.210	1039	6.210
776	6.210	820	6.210	864	6.210	908	6.210	952	6.210	996	6.210	1040	6.210
777	6.210	821	6.210	865	6.210	909	6.210	953	6.210	997	6.210	1041	6.210
778	6.210	822	6.210	866	6.210	910	6.210	954	6.210	998	6.210	1042	6.210
779	6.210	823	6.210	867	6.210	911	6.210	955	6.210	999	6.210	1043	6.210
780	6.210	824	6.210	868	6.210	912	6.210	956	6.210	1000	6.210	1044	6.210
781	6.210	825	6.210	869	6.210	913	6.210	957	6.210	1001	6.210	1045	6.210
782	6.210	826	6.210	870	6.210	914	6.210	958	6.210	1002	6.210	1046	6.210
783	6.210	827	6.210	871	6.210	915	6.210	959	6.210	1003	6.210	1047	6.210
784	6.210	828	6.210	872	6.210	916	6.210	960	6.210	1004	6.210	1048	6.210
785	6.210	829	6.210	873	6.210	917	6.210	961	6.210	1005	6.210	1049	6.210
786	6.210	830	6.210	874	6.210	918	6.210	962	6.210	1006	6.210	1050	6.210

Surcharged Outfall Details for Storm

Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)
1051	6.210	1095	6.210	1139	6.210	1183	6.210	1227	6.210	1271	6.210	1315	6.210
1052	6.210	1096	6.210	1140	6.210	1184	6.210	1228	6.210	1272	6.210	1316	6.210
1053	6.210	1097	6.210	1141	6.210	1185	6.210	1229	6.210	1273	6.210	1317	6.210
1054	6.210	1098	6.210	1142	6.210	1186	6.210	1230	6.210	1274	6.210	1318	6.210
1055	6.210	1099	6.210	1143	6.210	1187	6.210	1231	6.210	1275	6.210	1319	6.210
1056	6.210	1100	6.210	1144	6.210	1188	6.210	1232	6.210	1276	6.210	1320	6.210
1057	6.210	1101	6.210	1145	6.210	1189	6.210	1233	6.210	1277	6.210	1321	6.210
1058	6.210	1102	6.210	1146	6.210	1190	6.210	1234	6.210	1278	6.210	1322	6.210
1059	6.210	1103	6.210	1147	6.210	1191	6.210	1235	6.210	1279	6.210	1323	6.210
1060	6.210	1104	6.210	1148	6.210	1192	6.210	1236	6.210	1280	6.210	1324	6.210
1061	6.210	1105	6.210	1149	6.210	1193	6.210	1237	6.210	1281	6.210	1325	6.210
1062	6.210	1106	6.210	1150	6.210	1194	6.210	1238	6.210	1282	6.210	1326	6.210
1063	6.210	1107	6.210	1151	6.210	1195	6.210	1239	6.210	1283	6.210	1327	6.210
1064	6.210	1108	6.210	1152	6.210	1196	6.210	1240	6.210	1284	6.210	1328	6.210
1065	6.210	1109	6.210	1153	6.210	1197	6.210	1241	6.210	1285	6.210	1329	6.210
1066	6.210	1110	6.210	1154	6.210	1198	6.210	1242	6.210	1286	6.210	1330	6.210
1067	6.210	1111	6.210	1155	6.210	1199	6.210	1243	6.210	1287	6.210	1331	6.210
1068	6.210	1112	6.210	1156	6.210	1200	6.210	1244	6.210	1288	6.210	1332	6.210
1069	6.210	1113	6.210	1157	6.210	1201	6.210	1245	6.210	1289	6.210	1333	6.210
1070	6.210	1114	6.210	1158	6.210	1202	6.210	1246	6.210	1290	6.210	1334	6.210
1071	6.210	1115	6.210	1159	6.210	1203	6.210	1247	6.210	1291	6.210	1335	6.210
1072	6.210	1116	6.210	1160	6.210	1204	6.210	1248	6.210	1292	6.210	1336	6.210
1073	6.210	1117	6.210	1161	6.210	1205	6.210	1249	6.210	1293	6.210	1337	6.210
1074	6.210	1118	6.210	1162	6.210	1206	6.210	1250	6.210	1294	6.210	1338	6.210
1075	6.210	1119	6.210	1163	6.210	1207	6.210	1251	6.210	1295	6.210	1339	6.210
1076	6.210	1120	6.210	1164	6.210	1208	6.210	1252	6.210	1296	6.210	1340	6.210
1077	6.210	1121	6.210	1165	6.210	1209	6.210	1253	6.210	1297	6.210	1341	6.210
1078	6.210	1122	6.210	1166	6.210	1210	6.210	1254	6.210	1298	6.210	1342	6.210
1079	6.210	1123	6.210	1167	6.210	1211	6.210	1255	6.210	1299	6.210	1343	6.210
1080	6.210	1124	6.210	1168	6.210	1212	6.210	1256	6.210	1300	6.210	1344	6.210
1081	6.210	1125	6.210	1169	6.210	1213	6.210	1257	6.210	1301	6.210	1345	6.210
1082	6.210	1126	6.210	1170	6.210	1214	6.210	1258	6.210	1302	6.210	1346	6.210
1083	6.210	1127	6.210	1171	6.210	1215	6.210	1259	6.210	1303	6.210	1347	6.210
1084	6.210	1128	6.210	1172	6.210	1216	6.210	1260	6.210	1304	6.210	1348	6.210
1085	6.210	1129	6.210	1173	6.210	1217	6.210	1261	6.210	1305	6.210	1349	6.210
1086	6.210	1130	6.210	1174	6.210	1218	6.210	1262	6.210	1306	6.210	1350	6.210
1087	6.210	1131	6.210	1175	6.210	1219	6.210	1263	6.210	1307	6.210	1351	6.210
1088	6.210	1132	6.210	1176	6.210	1220	6.210	1264	6.210	1308	6.210	1352	6.210
1089	6.210	1133	6.210	1177	6.210	1221	6.210	1265	6.210	1309	6.210	1353	6.210
1090	6.210	1134	6.210	1178	6.210	1222	6.210	1266	6.210	1310	6.210	1354	6.210
1091	6.210	1135	6.210	1179	6.210	1223	6.210	1267	6.210	1311	6.210	1355	6.210
1092	6.210	1136	6.210	1180	6.210	1224	6.210	1268	6.210	1312	6.210	1356	6.210
1093	6.210	1137	6.210	1181	6.210	1225	6.210	1269	6.210	1313	6.210	1357	6.210
1094	6.210	1138	6.210	1182	6.210	1226	6.210	1270	6.210	1314	6.210	1358	6.210

Surcharged Outfall Details for Storm

Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)
1359	6.210	1371	6.210	1383	6.210	1395	6.210	1407	6.210	1419	6.210	1431	6.210
1360	6.210	1372	6.210	1384	6.210	1396	6.210	1408	6.210	1420	6.210	1432	6.210
1361	6.210	1373	6.210	1385	6.210	1397	6.210	1409	6.210	1421	6.210	1433	6.210
1362	6.210	1374	6.210	1386	6.210	1398	6.210	1410	6.210	1422	6.210	1434	6.210
1363	6.210	1375	6.210	1387	6.210	1399	6.210	1411	6.210	1423	6.210	1435	6.210
1364	6.210	1376	6.210	1388	6.210	1400	6.210	1412	6.210	1424	6.210	1436	6.210
1365	6.210	1377	6.210	1389	6.210	1401	6.210	1413	6.210	1425	6.210	1437	6.210
1366	6.210	1378	6.210	1390	6.210	1402	6.210	1414	6.210	1426	6.210	1438	6.210
1367	6.210	1379	6.210	1391	6.210	1403	6.210	1415	6.210	1427	6.210	1439	6.210
1368	6.210	1380	6.210	1392	6.210	1404	6.210	1416	6.210	1428	6.210	1440	6.210
1369	6.210	1381	6.210	1393	6.210	1405	6.210	1417	6.210	1429	6.210		
1370	6.210	1382	6.210	1394	6.210	1406	6.210	1418	6.210	1430	6.210		

Simulation Criteria for Storm

Volumetric Runoff Coeff	0.750	Additional Flow - % of Total Flow	0.000
Areal Reduction Factor	1.000	MADD Factor * 10m³/ha Storage	2.000
Hot Start (mins)	0	Inlet Coeffiecient	0.800
Hot Start Level (mm)	0	Flow per Person per Day (l/per/day)	0.000
Manhole Headloss Coeff (Global)	0.500	Run Time (mins)	60
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	1

Number of Input Hydrographs	0	Number of Offline Controls	0	Number of Time/Area Diagrams	0
Number of Online Controls	1	Number of Storage Structures	4	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FSR	Profile Type	Summer
Return Period (years)	2	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Storm Duration (mins)	30
Ratio R	0.352		

Online Controls for Storm

Hydro-Brake® Optimum Manhole: S1-FC, DS/PN: S1.004, Volume (m³): 3.4

Unit Reference	MD-SHE-0075-3000-1500-3000
Design Head (m)	1.500
Design Flow (l/s)	3.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	75
Invert Level (m)	4.900
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.500	3.0	Kick-Flo®	0.671	2.1
Flush-Flo™	0.329	2.6	Mean Flow over Head Range	-	2.4

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	2.1	1.200	2.7	3.000	4.1	7.000	6.1
0.200	2.5	1.400	2.9	3.500	4.4	7.500	6.3
0.300	2.6	1.600	3.1	4.000	4.7	8.000	6.5
0.400	2.6	1.800	3.3	4.500	5.0	8.500	6.7
0.500	2.5	2.000	3.4	5.000	5.2	9.000	6.9
0.600	2.3	2.200	3.6	5.500	5.5	9.500	7.1
0.800	2.2	2.400	3.7	6.000	5.7		
1.000	2.5	2.600	3.9	6.500	5.9		

Storage Structures for Storm

Porous Car Park Manhole: S8, DS/PN: S1.000

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	26.3
Membrane Percolation (mm/hr)	1000	Length (m)	10.0
Max Percolation (l/s)	73.1	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	6.500	Cap Volume Depth (m)	0.320

Complex Manhole: S7-TANK, DS/PN: S1.001

Cellular Storage

Invert Level (m)	5.200	Safety Factor	2.0
Infiltration Coefficient Base (m/hr)	0.00000	Porosity	0.95
Infiltration Coefficient Side (m/hr)	0.00000		

Depth (m)	**Area (m²)**	**Inf. Area (m²)**	**Depth (m)**	**Area (m²)**	**Inf. Area (m²)**
0.000	975.0	0.0	0.401	0.0	0.0
0.400	975.0	0.0			

Porous Car Park

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.0
Membrane Percolation (mm/hr)	1000	Length (m)	10.0
Max Percolation (l/s)	13.9	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	6.250	Cap Volume Depth (m)	0.320

Porous Car Park Manhole: S5, DS/PN: S3.000

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	8.8
Membrane Percolation (mm/hr)	1000	Length (m)	10.0
Max Percolation (l/s)	24.4	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	6.150	Cap Volume Depth (m)	0.320

Porous Car Park Manhole: S1-FC, DS/PN: S1.004

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	3.8
Membrane Percolation (mm/hr)	1000	Length (m)	10.0
Max Percolation (l/s)	10.6	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	6.150	Cap Volume Depth (m)	0.320

Volume Summary (Static)

Length Calculations based on True Length

Pipe Number	**USMH Name**	**Manhole Volume (m³)**	**Pipe Volume (m³)**	**Storage Structure Volume (m³)**	**Total Volume (m³)**
S1.000	S8	1.696	4.146	25.248	31.090
S1.001	S7-TANK	2.651	1.156	375.609	379.416
S2.000	S6	1.414	2.278	0.000	3.691
S3.000	S5	1.414	2.743	8.448	12.604
S2.001	S4	1.640	0.307	0.000	1.947
S4.000	S3A	1.470	0.495	0.000	1.965
S1.002	S3	1.696	0.148	0.000	1.845
S1.003	S2-BS	0.467	0.376	0.000	0.843
S1.004	S1-FC	3.004	0.143	3.648	6.796
Total		15.452	11.793	412.953	440.197

1 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor 1.000 Additional Flow - % of Total Flow 0.000
Hot Start (mins) 0 MADD Factor * 10m³/ha Storage 2.000
Hot Start Level (mm) 0 Inlet Coeffiecient 0.800
Manhole Headloss Coeff (Global) 0.500 Flow per Person per Day (l/per/day) 0.000
Foul Sewage per hectare (l/s) 0.000

Number of Input Hydrographs 0 Number of Offline Controls 0 Number of Time/Area Diagrams 0
Number of Online Controls 1 Number of Storage Structures 4 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR Ratio R 0.352
Region England and Wales Cv (Summer) 0.750
M5-60 (mm) 18.000 Cv (Winter) 0.840

Margin for Flood Risk Warning (mm) 300.0
Analysis Timestep 2.5 Second Increment (Extended)
DTS Status OFF
DVD Status ON
Inertia Status ON

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440
Return Period(s) (years) 1, 30, 100
Climate Change (%) 0, 0, 30

WARNING: Half Drain Time has not been calculated as the structure is too full.

PN	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.
S1.000	S8	15 minute 1 year Winter I+0%	6.950	5.558	-0.192	0.000	0.28
S1.001	S7-TANK	1440 minute 1 year Winter I+0%	6.700	5.345	-0.155	0.000	0.04
S2.000	S6	30 minute 1 year Winter I+0%	6.550	5.526	-0.074	0.000	0.04
S3.000	S5	30 minute 1 year Winter I+0%	6.600	5.532	-0.118	0.000	0.09
S2.001	S4	30 minute 1 year Winter I+0%	6.600	5.523	0.073	0.000	0.15
S4.000	S3A	30 minute 1 year Winter I+0%	6.600	5.527	-0.073	0.000	0.14
S1.002	S3	30 minute 1 year Winter I+0%	6.600	5.518	0.118	0.000	0.07
S1.003	S2-BS	30 minute 1 year Summer I+0%	6.600	5.519	0.269	0.000	0.05
S1.004	S1-FC	30 minute 1 year Summer I+0%	6.600	5.521	0.321	0.000	0.00

1 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Overflow (l/s)	Maximum Vol (m³)	Maximum Velocity (m/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status
S1.000	S8		0.117	0.8	6	19.0	OK
S1.001	S7-TANK		134.726	0.5	455	2.7	OK
S2.000	S6		0.250	0.5		2.6	OK
S3.000	S5		0.200	0.6	13	6.6	OK
S2.001	S4		4.869	0.3		9.5	SURCHARGED
S4.000	S3A		0.251	1.1		15.7	OK
S1.002	S3		2.399	0.5		4.4	SURCHARGED
S1.003	S2-BS		0.308	0.4		3.1	SURCHARGED
S1.004	S1-FC		1.464	0.0		0.0	SURCHARGED

30 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor 1.000 Additional Flow - % of Total Flow 0.000
Hot Start (mins) 0 MADD Factor * 10m³/ha Storage 2.000
Hot Start Level (mm) 0 Inlet Coeffiecient 0.800
Manhole Headloss Coeff (Global) 0.500 Flow per Person per Day (l/per/day) 0.000
Foul Sewage per hectare (l/s) 0.000

Number of Input Hydrographs 0 Number of Offline Controls 0 Number of Time/Area Diagrams 0
Number of Online Controls 1 Number of Storage Structures 4 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR Ratio R 0.352
Region England and Wales Cv (Summer) 0.750
M5-60 (mm) 18.000 Cv (Winter) 0.840

Margin for Flood Risk Warning (mm) 300.0
Analysis Timestep 2.5 Second Increment (Extended)
DTS Status OFF
DVD Status ON
Inertia Status ON

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440
Return Period(s) (years) 1, 30, 100
Climate Change (%) 0, 0, 30

WARNING: Half Drain Time has not been calculated as the structure is too full.

PN	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.
S1.000	S8	15 minute 30 year Winter I+0%	6.950	5.634	-0.116	0.000	0.68
S1.001	S7-TANK	1440 minute 30 year Winter I+0%	6.700	5.498	-0.002	0.000	0.05
S2.000	S6	15 minute 30 year Winter I+0%	6.550	5.765	0.165	0.000	0.14
S3.000	S5	15 minute 30 year Summer I+0%	6.600	5.794	0.144	0.000	0.29
S2.001	S4	15 minute 30 year Winter I+0%	6.600	5.753	0.303	0.000	0.51
S4.000	S3A	15 minute 30 year Summer I+0%	6.600	5.810	0.210	0.000	0.46
S1.002	S3	15 minute 30 year Winter I+0%	6.600	5.672	0.272	0.000	0.14
S1.003	S2-BS	15 minute 30 year Winter I+0%	6.600	5.688	0.438	0.000	0.13
S1.004	S1-FC	30 minute 30 year Summer I+0%	6.600	5.702	0.502	0.000	0.00

30 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Overflow (l/s)	Maximum Vol (m³)	Maximum Velocity (m/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status
S1.000	S8		0.203	1.0	6	46.3	OK
S1.001	S7-TANK		278.766	0.2	989	3.6	OK
S2.000	S6		0.520	0.6		9.2	SURCHARGED
S3.000	S5		0.497	0.7	5	20.8	SURCHARGED
S2.001	S4		5.697	0.4		31.1	SURCHARGED
S4.000	S3A		0.571	1.2		51.3	SURCHARGED
S1.002	S3		2.599	0.6		8.7	SURCHARGED
S1.003	S2-BS		0.356	0.5		7.8	SURCHARGED
S1.004	S1-FC		1.785	0.0		0.0	SURCHARGED

100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor 1.000 Additional Flow - % of Total Flow 0.000
Hot Start (mins) 0 MADD Factor * 10m³/ha Storage 2.000
Hot Start Level (mm) 0 Inlet Coeffiecient 0.800
Manhole Headloss Coeff (Global) 0.500 Flow per Person per Day (l/per/day) 0.000
Foul Sewage per hectare (l/s) 0.000

Number of Input Hydrographs 0 Number of Offline Controls 0 Number of Time/Area Diagrams 0
Number of Online Controls 1 Number of Storage Structures 4 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR Ratio R 0.352
Region England and Wales Cv (Summer) 0.750
M5-60 (mm) 18.000 Cv (Winter) 0.840

Margin for Flood Risk Warning (mm) 300.0
Analysis Timestep 2.5 Second Increment (Extended)
DTS Status OFF
DVD Status ON
Inertia Status ON

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440
Return Period(s) (years) 1, 30, 100
Climate Change (%) 0, 0, 30

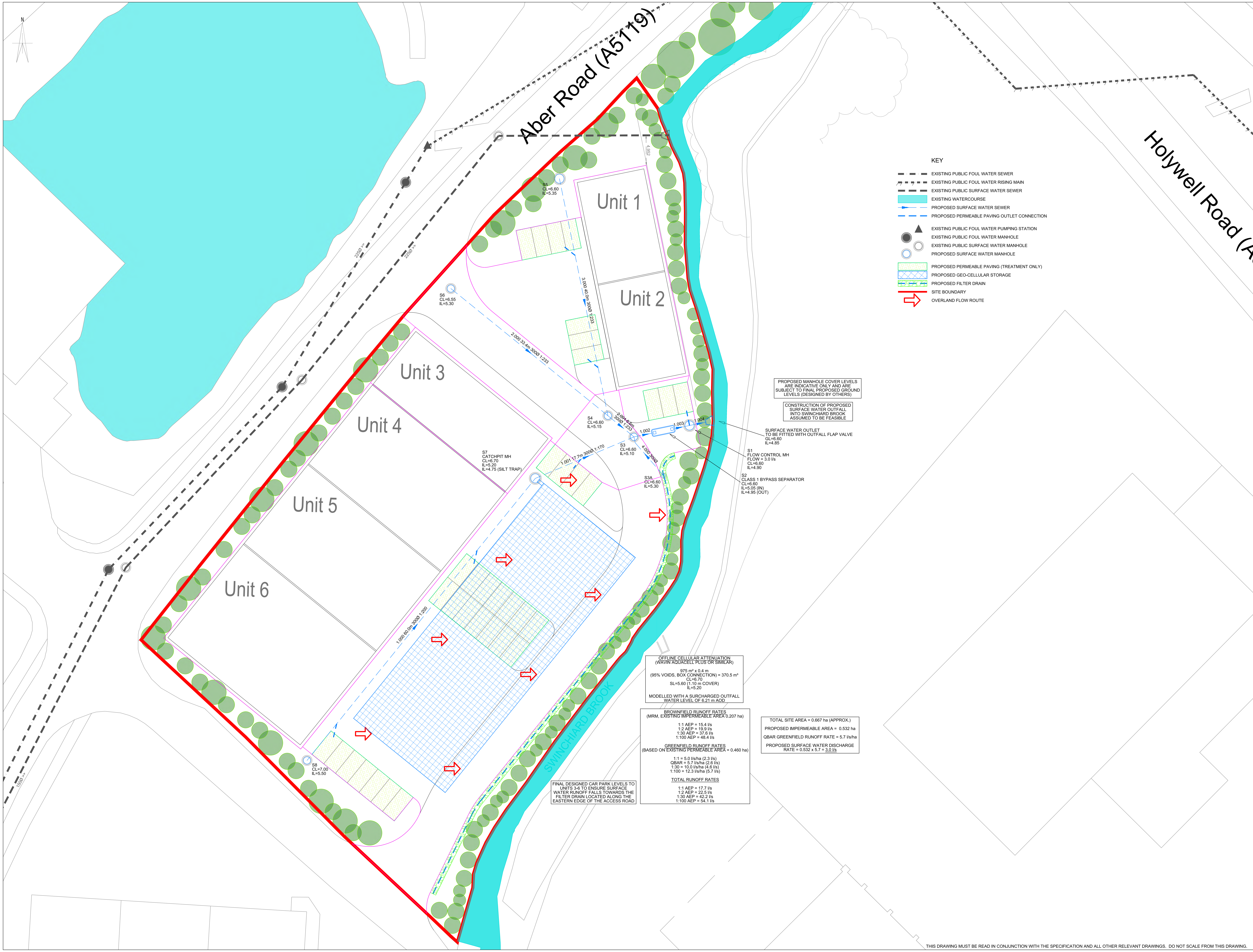
PN	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.
S1.000	S8	1440 minute 100 year Winter I+30%	6.950	6.459	0.709	0.000	0.06
S1.001	S7-TANK	1440 minute 100 year Winter I+30%	6.700	6.458	0.958	0.000	0.08
S2.000	S6	1440 minute 100 year Winter I+30%	6.550	6.457	0.857	0.000	0.01
S3.000	S5	1440 minute 100 year Winter I+30%	6.600	6.457	0.807	0.000	0.03
S2.001	S4	1440 minute 100 year Winter I+30%	6.600	6.457	1.007	0.000	0.09
S4.000	S3A	1440 minute 100 year Winter I+30%	6.600	6.458	0.858	0.000	0.05
S1.002	S3	1440 minute 100 year Winter I+30%	6.600	6.457	1.057	0.000	0.15
S1.003	S2-BS	1440 minute 100 year Winter I+30%	6.600	6.456	1.206	0.000	0.13
S1.004	S1-FC	1440 minute 100 year Winter I+30%	6.600	6.455	1.255	0.000	0.05

100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Overflow (l/s)	Maximum Vol (m³)	Maximum Velocity (m/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status
S1.000	S8		1.136	0.6	356	4.2	SURCHARGED
S1.001	S7-TANK		380.288	0.1		5.7	FLOOD RISK
S2.000	S6		1.303	0.2		1.0	FLOOD RISK
S3.000	S5		9.361	0.4	280	2.2	FLOOD RISK
S2.001	S4		6.493	0.1		5.5	FLOOD RISK
S4.000	S3A		1.304	0.7		6.0	FLOOD RISK
S1.002	S3		3.488	0.3		9.3	FLOOD RISK
S1.003	S2-BS		0.573	0.2		8.0	FLOOD RISK
S1.004	S1-FC		6.596	0.8	311	3.0	FLOOD RISK

APPENDIX L

Preliminary Surface Water Drainage Layout



NOTES

1. THIS DRAWING TO BE READ IN CONJUNCTION WITH ALL RELEVANT WEETWOOD DRAWINGS.
2. PROPOSED SITE LAYOUT TAKEN FROM CUBE ARCHITECTURE AND DESIGN'S 'PROPOSED SITE PLAN' DRAWING (REF: AS786-SK01, FEB 2022).
3. EXISTING LEVEL INFORMATION TAKEN FROM POWERS TILTMAN 'TOPOGRAPHIC SURVEY' (REF: 6111/01, APR 2010).

REV	DATE	DESCRIPTION	DRAWN	CHECK
P1	21.06.22	INITIAL ISSUE	TB	-

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Client
CLIENT NAME

Drawing Status: PRELIMINARY	Date: JUN 2022
	Scale (A0): 1:200
Project: ABER ROAD FLINT	Drawn: TB
	Checked: -
	Project No: 5560
Title: PROPOSED SURFACE WATER DRAINAGE LAYOUT	Drawing No: 104
	Revision: P1