THE RED HOUSE, DEE BANKS, CHESTER

FLOOD RISK AND DRAINAGE ASSESSMENT
FINAL REPORT V1.0

December 2020

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Report Title	**The Red House, Dee Banks, Chester** Flood Risk and Drainage Assessment Final Report v1.0
Client	Sterling Property CO. Limited
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1 INTRODUCTION

1.1 Purpose of Report

Weetwood Services Ltd ('Weetwood') has been instructed by Sterling Property CO. Limited to prepare a Flood Risk and Drainage Assessment (FRDA) report to accompany a detailed planning application for the proposed redevelopment of The Red House, Dee Banks, Chester.

The assessment has been undertaken in accordance with the requirements of the revised National Planning Policy Framework (NPPF) updated on 19 February 2019 and the National Planning Practice Guidance (NPPG) updated on 1 October 2019.

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, the development proposals, ground conditions, existing site access arrangements and the flood zone designation
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	Addresses the effect of the proposed development on surface water runoff and presents an illustrative surface water drainage scheme to ensure that surface water runoff is sustainably managed and flood risk is not increased elsewhere
Section 7	Presents a summary of key findings and the recommendations

1.3 Relevant Documents

The assessment has been informed by the following documents:

- Level 1 Strategic Flood Risk Assessment (SFRA), Cheshire West and Chester Council, March 2016
- Preliminary Flood Risk Assessment (PFRA), Cheshire West and Chester Council, November 2011
- Water Cycle Study (WCS), Cheshire West and Chester Council, June 2010

2 SITE DETAILS AND PROPOSED DEVELOPMENT

2.1 Site Location

The approximately 0.17 hectare (ha) site is located to the west of Dee Banks at Ordnance Survey National Grid Reference SJ 419 653, as shown in **Figure 1**.

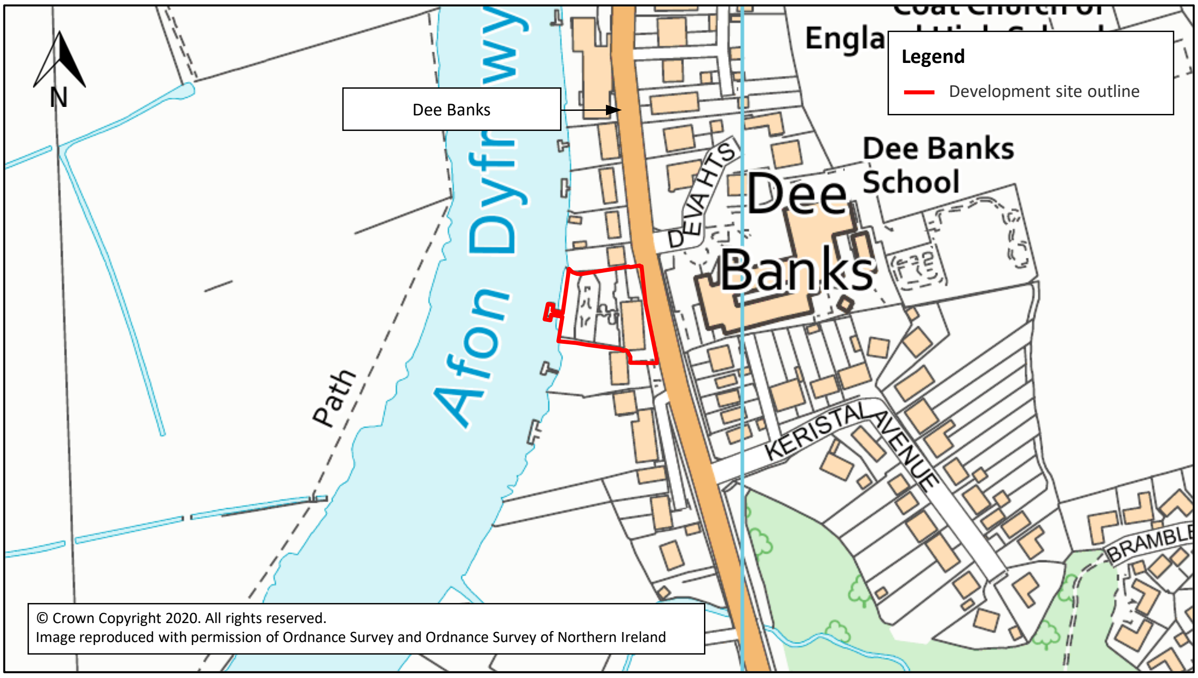


Figure 1: Site Location

2.2 Existing and Proposed Development

The site currently comprises of a restaurant and bar, along with a residential flat on the top floor of the existing building.

Proposals are for the demolition of the existing building and for the construction of nine new residential apartments with a communal basement parking facility, associated infrastructure and landscaping. Private garden terraces will be located off the west face of the building at levels of 11.18 m AOD to the north and 9.54 m AOD to the south (**Appendix A**).

The NPPG classifies residential development as More Vulnerable to flood risk.

2.3 Waterbodies in the Vicinity of the Site

The waterbodies within the vicinity of the site have been identified in **Figure 2**.

The River Dee is located adjacent to the western boundary of the site and flows in a northerly direction.

Caldy Brook is located approximately 130 metres (m) south of the site and flows in a westerly direction, outfalling into the River Dee.

Larger rivers and streams are usually designated as 'main river'; other rivers are called 'ordinary watercourses'. The main river map[1] shows which rivers in England are designated as 'main river'.

[1] https://environment.maps.arcgis.com/apps/webappviewer/index.html?id=17cd53dfc524433980cc333726a56386

The Environment Agency carries out maintenance, improvement and construction work on main rivers to manage flood risk. Lead local flood authorities, district councils and internal drainage boards carry out flood risk management work on ordinary watercourses.

According to the main river map (**Figure 2**) both the River Dee and Caldy Brook are classified as main river.

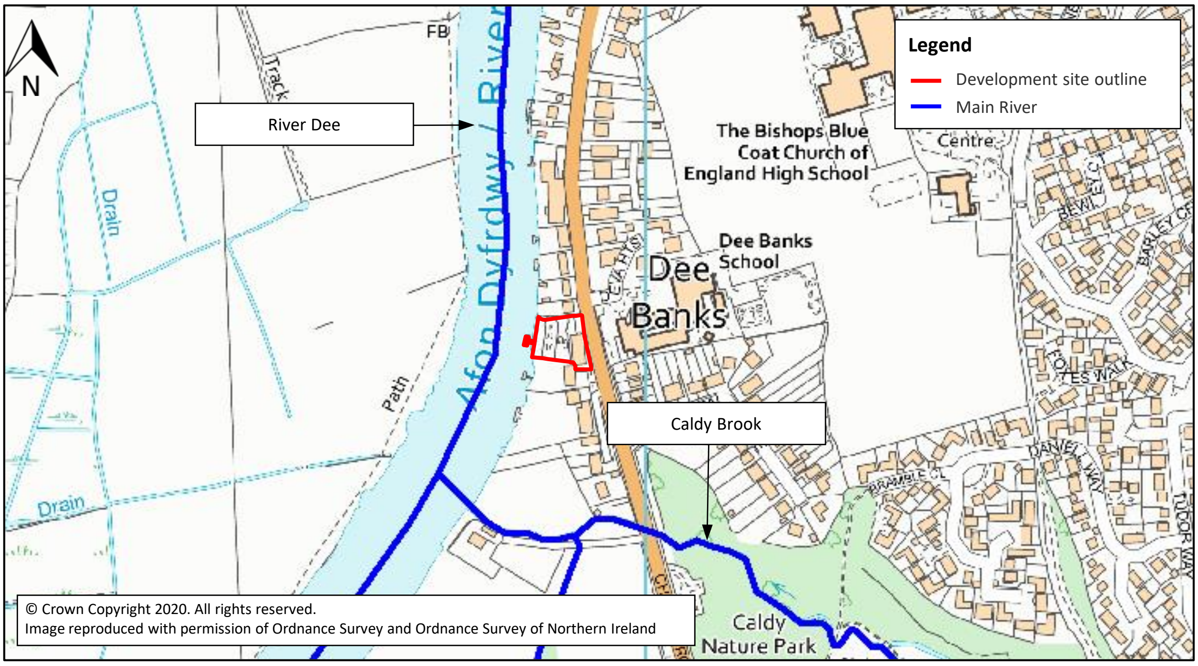


Figure 2: Location and Designation of Waterbodies
Source: gov.uk website; Accessed: 2 September 2020

2.4 Ground Conditions

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 described as '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 Chester Formation – Sandstone, Pebbly (gravelly), overlain by Till, Devensian – Diamicton superficial deposits.

According to the MAGIC website[4] the Till, Devensian - Diamicton superficial deposits at the site are classified as a Secondary (undifferentiated) aquifer whilst the underlying Chester Formation – Sandstone, Pebbly (gravelly) bedrock is classified as a Principal aquifer. A Principal aquifer is defined by its high level of water storage. They may support water supply and/or river base flow on a strategic scale. Whilst a Secondary (undifferentiated) aquifer has been assigned where it has not been possible to attribute either category A or B to a rock type.

The site is not shown to be located within a designated groundwater source protection zone.

2 www.landis.org.uk/soilscapes/
3 http://mapapps.bgs.ac.uk/geologyofbritain/home.html
4 https://magic.defra.gov.uk/MagicMap.aspx

2.5 Site Levels

A topographic survey of the site has been undertaken by Site Scan and is provided in **Appendix B**. This information has been utilised to develop a digital terrain model as illustrated in **Figure 3**.

Site levels generally fall from east to west, from approximately 16.0 Above Ordnance Datum (AOD) to 5.5 m AOD, towards the River Dee. Levels from the road to the end of the private garden terraces on site in the east are generally in the region of 6.69 to 15.74 m AOD.

Figure 3: Digital Terrain Model from Topographic Survey

2.6 Access and Egress

Access and egress is provided via Dee Banks to the east of the site. The topographic survey indicates that levels along Dee Banks are generally in the region of 14.42 to 16.28 m AOD within the vicinity of the site.

2.7 Flood Zone Designation

Flood zones refer to the probability of river and sea flooding. Table 1 of the NPPG defines flood zones as follows[5]:

- Flood zone 1: Low Probability. Land having a less than 1 in 1,000 annual probability of river or sea flooding
- Flood zone 2: Medium Probability. Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding
- Flood zone 3a: High Probability. Land having a 1 in 100 or greater annual probability of river flooding or a 1 in 200 or greater annual probability of sea flooding
- Flood zone 3b: Functional Floodplain. Land where water has to flow or be stored in times of flood.

The flood zones are shown on the Environment Agency Flood Map for Planning (Rivers and Sea)[6].

5 https://www.gov.uk/guidance/flood-risk-and-coastal-change#flood-zone-and-flood-risk-tables
6 https://flood-map-for-planning.service.gov.uk/

The flood zones shown on the flood map are defined by the predicted extent of flooding during the present day 1 in 100 (non-tidal rivers), 1 in 200 (tidal rivers and sea) and 1 in 1,000 (rivers and sea) annual exceedance probability (AEP) events. The zones do not take account of the possible impacts of climate change and consequent changes in the future probability of flooding.

Flood zone 3b (functional floodplain) is not separately distinguished on the Flood Map for Planning but is usually identified by local planning authorities in their SFRAs. The boundary of flood zone 3b is normally defined as land that would flood during the present day 1 in 20 AEP event, although definitions may vary particularly in some districts and in urban areas.

Where an area benefits from formal flood defences providing a minimum standard of protection, the defended area may be indicated as an area benefiting from flood defences. However, not all areas are shown as such, and unless specifically indicated, the Flood Map for Planning conservatively shows land at risk of flooding in the absence of flood defences.

The Flood Map for Planning (**Figure 4**) indicates the eastern part of the site is located in flood zone 1, whilst the western part is located in flood zone 2 and flood zone 3.

Appendix A, detailed map 124, of the Level 1 SFRA reaffirms the above flood zone designation (**Figure 5**). The majority of the site, including all proposed buildings, are located within flood zone 3a, with a small area to the west adjacent to the River Dee defined as flood zone 3b.

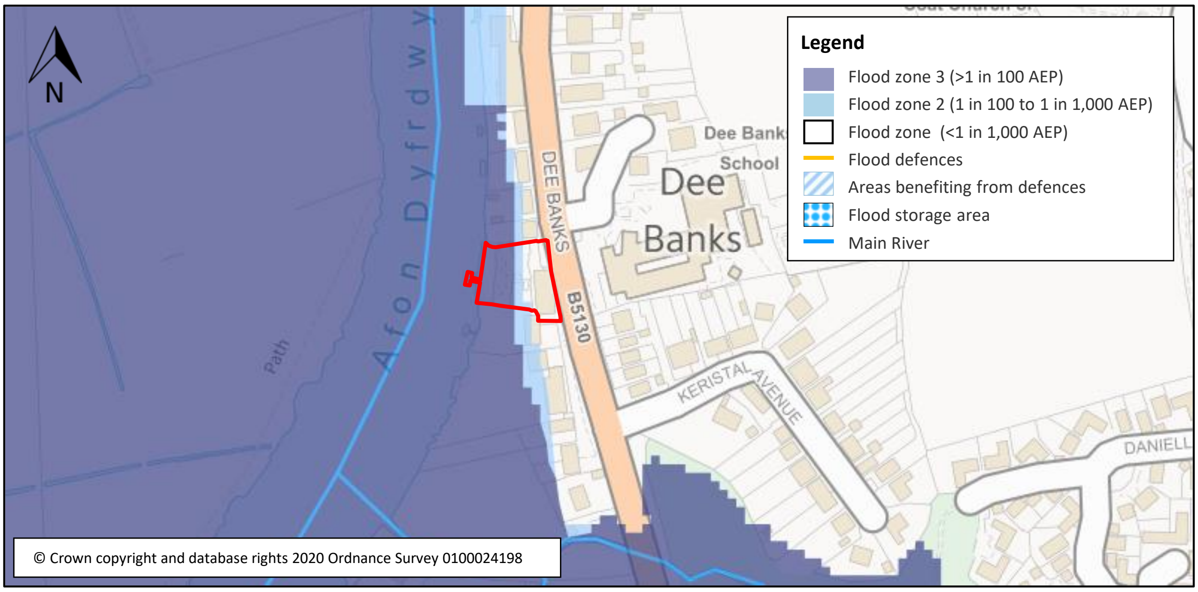


Figure 4: Flood Map for Planning
Source: gov.uk website; Accessed: 2 September 2020

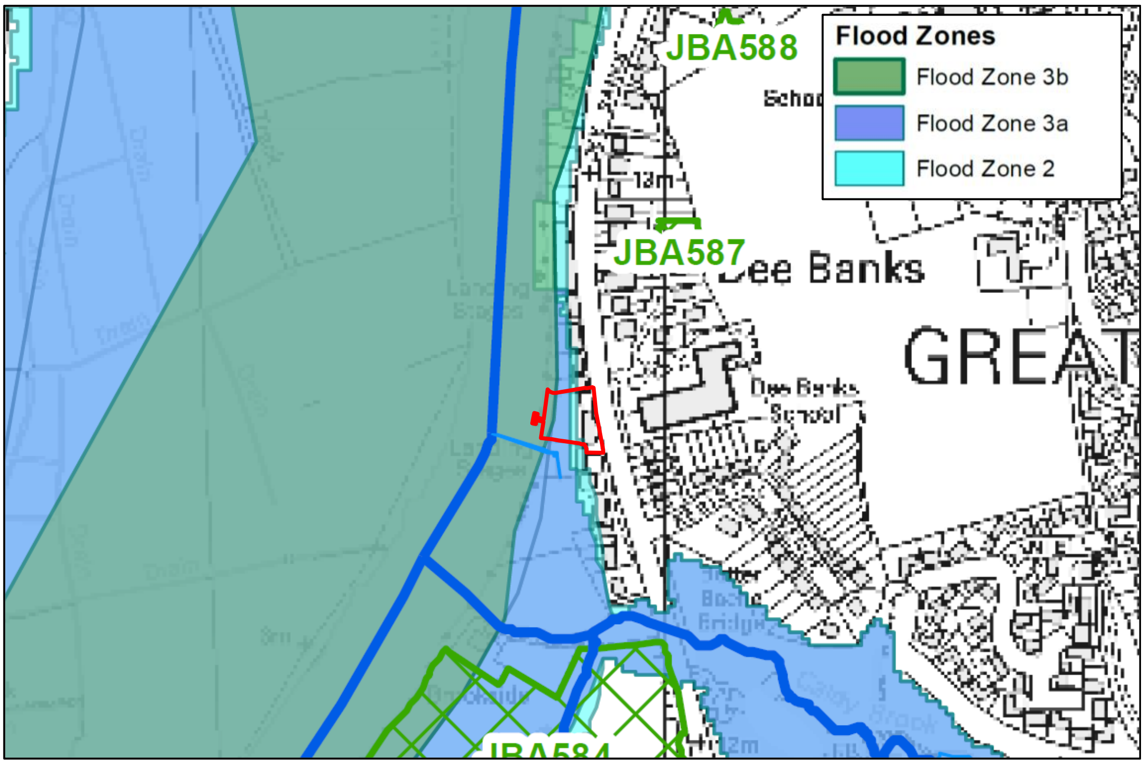


Figure 5: Flood Map from the Strategic Flood Risk Assessment
Source: Cheshire West and Chester Council SFRA, March 2016 – Appendix A, detailed map 124

3 PLANNING POLICY AND GUIDANCE

3.1 European Union Legislation

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 England, 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, the Environment Agency may require evidence demonstrating that the proposed development does not compromise the aims of the WFD.

3.2 National Planning Policy and Guidance

The NPPF sets out government's planning policies for England and how these are expected to be applied. The NPPF seeks to ensure that flood risk is taken into account at all stages in the planning process and is appropriately addressed.

Footnote 50 of the NPPF states that a site-specific flood risk assessment should be submitted for all development proposed in flood zone 2 and flood zone 3 whilst in flood zone 1, an assessment should accompany all proposals involving: sites of 1 ha or more; land identified as having critical drainage problems or as being at increased flood risk in future; or land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use.

NPPF paragraph 155 states that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk but accepts that where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere. The policy of seeking to direct development away from areas at highest risk of flooding is implemented through the application of the sequential test (NPPF paragraph 158).

Paragraph 159 of the NPPF states that if it is not possible for a development to be located in zones with a lower risk of flooding, taking into account wider sustainable development objectives, the exception test may have to be applied.

The need for the exception test will depend on the flood zone of the site and the vulnerability of the development proposed (as set out in NPPG Table 2 and 3).

NPPF paragraph 160 states that application of the exception test for development proposals at the application stage should be informed by a site-specific flood risk assessment. For the test to be passed it should be demonstrated that: the development would provide wider sustainability benefits to the community that outweigh the flood risk; and the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

NPPF Paragraph 161 states that both elements of the exception test should be satisfied for development to be permitted.

NPPF paragraph 163 states that development should only be allowed in areas at risk of flooding if it incorporates sustainable drainage systems (SuDS) unless there is clear evidence that this would be inappropriate. NPPF paragraph 165 states that applications for major developments should incorporate sustainable drainage systems to appropriate operational standards and with maintenance arrangements in place unless there is clear evidence that this would be inappropriate.

Non-statutory technical standards for sustainable drainage published by DEFRA in March 2015 set out how surface water runoff generated during the present day 1 in 30 and 1 in 100 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 be controlled.

3.3 Local Planning Policy and Guidance

3.3.1 Local Plan (Part One) Strategic Policies, Cheshire West and Chester Council, January 2015

The Cheshire West and Chester Council Local Plan (Part One) was adopted on 25 January 2015 with the purpose of providing the overall vision, strategic objectives, spatial strategy and strategic planning policies for the borough for the period up to 2030.

The following policy is relevant in respect of flood risk and drainage:

<u>Policy ENV 1; Flood Risk and Water Management</u>

The Local Plan will seek to reduce flood risk, promote water efficiency measures, and protect and enhance water quality through the following mechanisms:

- All development must follow the sequential approach to determining the suitability of land for development, directing new development to areas at the lowest risk of flooding and where necessary apply the exception test, as outlined in national planning policy.
- Developers will be required to demonstrate, where necessary, through an appropriate [FRA] at the planning application stage, that development proposals will not increase flood risk on site or elsewhere, and should seek to reduce the risk of flooding. New development will be required to include or contribute to flood mitigation, compensation and/or protection measures, where necessary, to manage flood risk associated with or caused by the development.
- Development proposals should comply with the [WFD] by contributing to the North West River Basin Management Plan and Dee River Basin Management Plan objectives, unless it can be demonstrated that this would not be technically feasible.
- The drainage of new development shall be designed to reduce surface water run-off rates to include the implementation of [SuDS] unless it can be demonstrated that it is not technically feasible or viable.
- Proposals within areas of infrastructure capacity and/or water supply constraint should demonstrate that there is adequate wastewater infrastructure and water supply capacity to serve the development or adequate provision can be made available.

3.3.2 Local Plan (Part Two) Land Allocations and Detailed Policies, Cheshire West and Chester Council, July 2019

The Cheshire West and Chester Council Local Plan (Part Two) was adopted on 18 July 2019, with the purpose of providing further detailed policies and land allocations which support the strategic objectives and policies set out in the Local Plan (Part One).

The following policies are relevant in respect of flood risk and drainage:

<u>Policy DM 40; Development and Flood Risk</u>

In line with Local Plan (Part One) policy ENV 1, flood risk must be avoided or reduced by:

- Locating development within areas of lower flood risk through the application of a borough-wide sequential test and then, where required, applying the exception test in line with the [NPPF]; and

- Ensuring development proposals in flood risk areas are actively managed and reduce flood risk by applying the sequential approach at site level.

Where a site specific [FRA] is required in line with the [NPPF], this will be expected to demonstrate whether a proposed development is likely to be affected by current or future flooding (including effects of climate change) from any source. Development proposals for sites that are at risk will only be supported where the site-specific [FRA] shows that:

- The effects of climate change have been taken into account;
- There is no loss in floodplain storage resulting from the development;
- The development will not increase flood risk elsewhere;
- There is no adverse effect on the operational functions of any existing flood defence infrastructure;
- Proposed resistance / resilience measures designed to deal with current and future risks are appropriate;
- Where applicable, appropriate [SuDS] techniques have been considered and are to be incorporated into the design of the site, in line with Local Plan (Part Two) policy DM 41; and
- The development will be safe and pass the exceptions test, if applicable.

A [FRA] will be required for development within a Critical Drainage Area (CDA) as notified by the Environment Agency. All development in a designated CDA will be required to incorporate measures to alleviate surface water flood risk through the layout and form of the development, including the appropriate application of SuDS to intercept and attenuate overland flow and drained water in line with Local Plan (Part Two) policy DM 41 and the Council's Draft SuDS Design and Technical Guidance.

Flood risk should be considered at an early stage in deciding the layout and design of a site to provide an opportunity to reduce flood risk within the development. Applicants will be required to provide schemes to reduce flood risk on individual sites through flood resilient design and on site flood risk management measures. It is essential that the scheme proposed does not create any additional flood risk outside the development in any part of the catchment, either upstream or downstream.

Existing structures and other features that help to reduce the risk of flooding or mitigate its impacts should be protected. Their loss, alteration or replacement will only be permitted where there would be no increase in flood risk.

Where appropriate, the Council may request that phasing of development should be carried out to avoid any cumulative impacts of flood risk.

Policy DM 41; Sustainable Drainage Systems (SuDS)

In line with Local Plan (Part One) policy ENV 1, proposals for major development will be required to incorporate [SuDS].

SuDS must be included in the early stages of the site design in order to incorporate appropriate SuDS within the development. SuDs schemes will be required to satisfy technical standards and design requirements having regard to the Council's Draft SuDS Design and Technical Guidance.

On greenfield sites, restrictions on surface water runoff from new development should be incorporated into the development at the planning stage and must mimic or improve upon greenfield rates. On brownfield sites, site runoff rates should be reduced to the greenfield rates wherever possible. Where this cannot be achieved a reduction of at least 30 per cent of the actual existing runoff must be provided, unless it can be demonstrated that this is unachievable or hydraulically impractical to do so.

Policy DM 43; Water quality, supply and treatment

In line with Local Plan (Part One) policies ENV 1, ENV 4 and SOC 5, development proposals will be supported where it can be demonstrated that the proposal will not cause unacceptable deterioration to water quality or have an unacceptable impact on water quantity (including drinking water supplies) or waste water infrastructure capacity by ensuring that:

- wastewater infrastructure already exists or can be provided in time to serve the development. Development should connect to the nearest point of adequate capacity.

The discharge of surface water to combined drainage systems will be regulated in accordance with requirements set by the relevant utility provider. The Council will support the development or expansion of infrastructure associated with water supply, surface water drainage and wastewater treatment facilities where proposals are consistent with other relevant development plan policies such as the development strategy (including development in the Green Belt), flood risk, contamination, health and wellbeing and protection of the natural and built environment.

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 the Environment Agency 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 or drainage board for work to an ordinary watercourse.

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

7 https://www.gov.uk/guidance/flood-risk-activities-environmental-permits

4 REVIEW OF FLOOD RISK

4.1 Sequential Test and Exception Test

As outlined in **Section 4.3**, the proposed buildings will be located outside the 1 in 1,000 plus climate change (20%) AEP flood extent. This will effectively locate all built development within flood zone 1 taking into account the lifetime of the development. As such the application of the sequential test and exception test is not deemed to be necessary; however, the proposals should still meet the requirements for site specific FRAs.

4.2 Historical Records of Flooding

The Environment Agency historic flood map[8] indicates that two historic flood events impacted the eastern boundary of the site, in January 1964 caused by the overtopping of defences and the other in November 2000 caused by the exceedance of the River Dee channel capacity (no raised defences).

It should be noted that none of the aforementioned historic flood events impacted the location of the existing or proposed building.

4.3 Fluvial Flood Risk

The River Dee flows in a northerly direction adjacent to the western boundary of the site. Caldy Brook is located approximately 130 m south of the site and outfalls into the River Dee.

The Environment Agency Spatial Flood Defences database indicates that flood defences are present along the River Dee (**Figure 6**) within the vicinity of the site, which comprise of high ground with a crest level of 5.01 m AOD. Flood defences are also present along Caldy Brook, comprising of high ground with crest levels ranging between 5.52 to 5.57 m AOD.

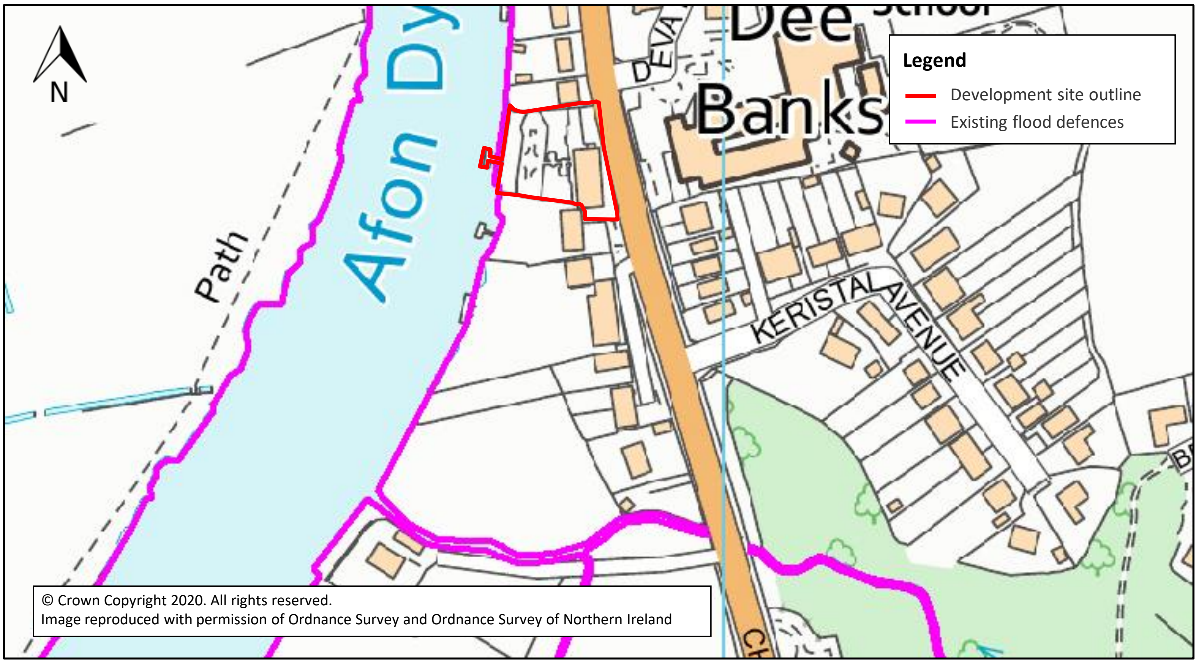


Figure 6: Existing Flood Defences

8 https://data.gov.uk/dataset/76292bec-7d8b-43e8-9c98-02734fd89c81/historic-flood-map

A 1D-2D Estry-TUFLOW hydraulic model of the River Dee was developed by Natural Resources Wales (formerly Environment Agency Wales) as part of River Dee Catchment Flood Management Plan, September 2008. This assesses the risk of flooding from the River Dee for the present day 1 in 100 and 1 in 1,000 AEP events and the 1 in 100 and 1 in 1,000 plus climate change (20%) AEP events.

Modelled flood outputs are provided in **Figure 7**. Only modelled flood depths have been made available from the Environment Agency, which are summarised in **Table 1**. However, it should be noted that the 2008 hydraulic model is very coarse, utilising a grid size of 50 m, which is evident by the large cell sizes of the modelled outputs below. Each cell will provide an average flood depth for the entire 50 m cell, which includes areas within the River Dee itself. As such, the flood depths presented below should not be considered to be representative of the flood depths expected at the site itself and the flood extents will be inaccurate.

Table 1: Modelled Flood Information Adjacent to Site (Baseline)

AEP Event	Depth (m)	
	Highest	Mean
Present day 1 in 100	0.46	0.41
1 in 100 plus climate change (20%)	0.76	0.72
Present day 1 in 1,000	0.92	0.83
1 in 1,000 plus climate change (20%)	1.07	0.98

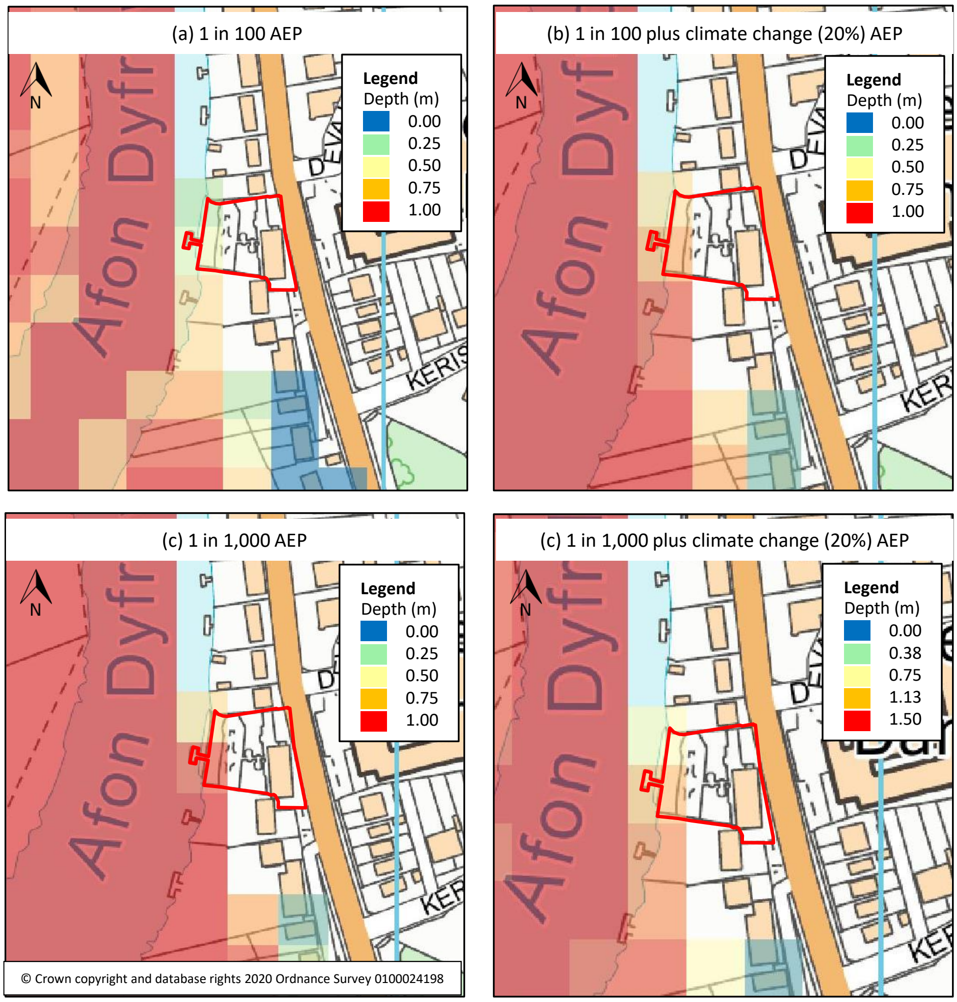


Figure 7: River Dee Modelled Flood Depths
Source: River Dee Catchment Flood Management Plan, Natural Resources Wales, September 2008

The Environment Agency have provided flood level data for the node located approximately 140 m south-west of the site (upstream) for the 1 in 100 AEP event, which is 6.99 m AOD. Utilising this flood level and the known increases in flood depth for other AEP events presented in **Table 1**, calculated flood levels of 7.29 and 7.45 m AOD are derived for the 1 in 100 plus climate change (20%) and 1 in 1,000 AEP events, respectively.

Given the sites partial flood zone 3 designation and the more vulnerable nature of the proposals a +25% and +45% increase in peak river flow for the 1 in 100 AEP event must be considered over the lifetime of the development to account for the likely impacts of climate change. A simple level-discharge relationship has been developed to estimate peak flood levels for the 1 in 100 plus climate change AEP events (25% and 45%), which are 7.37 and 7.67 m AOD respectively.

Based on the above flood levels and the topographic survey data in **Appendix B**, no flooding of the proposed building areas or access and egress is expected during any of the modelled flood events. Some flooding in western extent of the developable area may occur to depths of up to 0.56 m during the 1 in 100 plus climate change (25%) AEP event, in parts of the proposed garden terrace areas.

The Environment Agency has confirmed that no detailed hydraulic modelling information is available for Caldy Brook. In the absence of such information, the Flood Risk from Surface Water map (**Figure 8**) may be used as a reasonable proxy to assess the risk of flooding from this source. This indicates that the site is not expected to be at risk of flooding from Caldy Brook in up to a 1 in 1,000 AEP event.

4.4 Flood Risk from Surface Water

The Flood Risk from Surface Water map (**Figure 8**) indicates that the majority of the site is at 'very low' risk, with a small area of 'low' to 'medium' risk along the western boundary, associated with the River Dee.

The majority of Dee Banks is located at a 'very low' risk, with an area of 'high' risk associated with Caldy Brook to the south of the site.

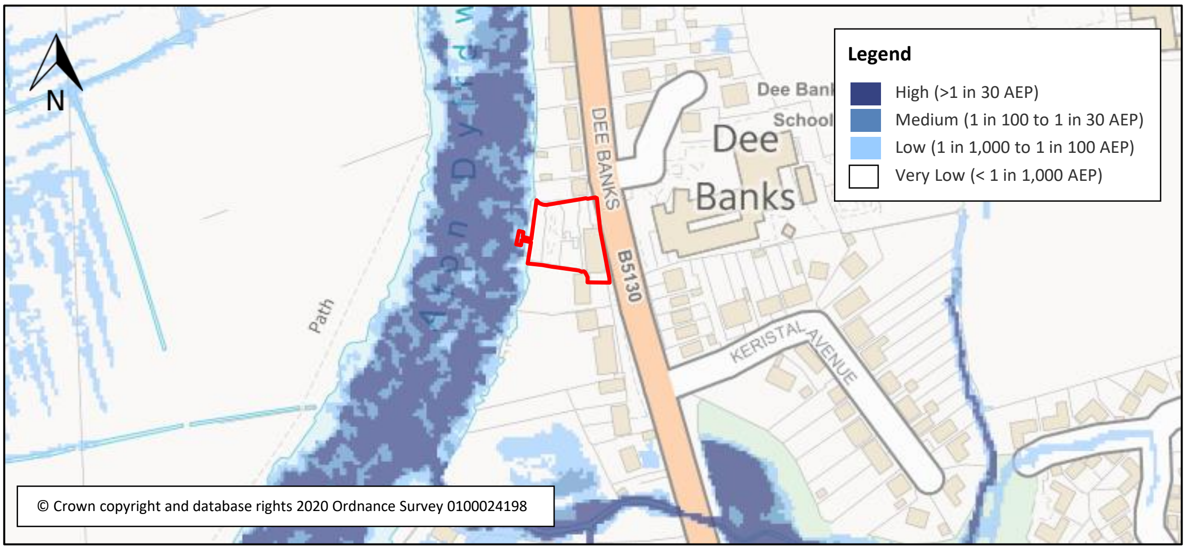


Figure 8: Flood Risk from Surface Water
Source: gov.uk website; Accessed: 2 September 2020

4.5 Flood Risk from Reservoirs, Canals and Other Artificial Sources

The Flood Risk from Reservoirs map (**Figure 9**) indicates that the western area of the site may be at residual risk from such sources, presumably from the failure of upstream reservoirs within the Dee catchment. However, all large reservoirs are regularly inspected by reservoir panel engineers with essential safety work carried out as required. As detailed on the gov.uk website, reservoir flooding is therefore extremely unlikely to occur.

There are no canals or other impounded waterbodies within the vicinity of the site.

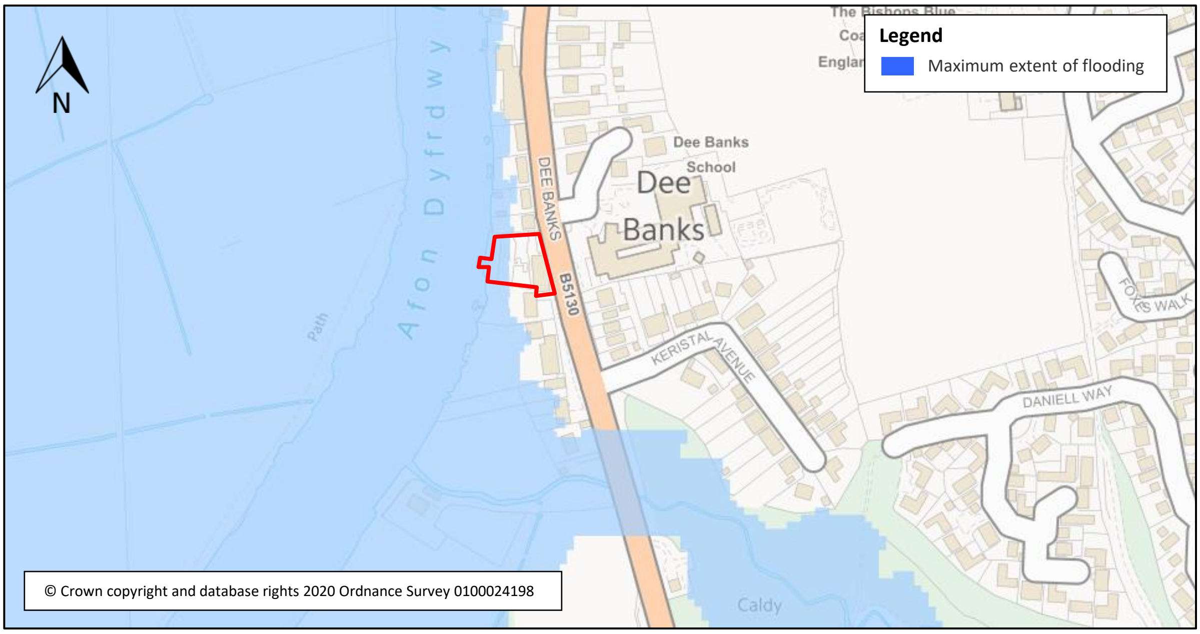


Figure 9: Flood Risk from Reservoirs
Source: gov.uk website; Accessed: 2 September 2020

4.6 Flood Risk from Groundwater

The British Geological Survey Groundwater Flooding Hazard map (**Figure 10**) indicates that the site is at a moderate to significant susceptibility to groundwater flooding. However, ground levels at the site fall steeply to the west, towards the River Dee and it is considered unlikely that emerging groundwater could accumulate to significant depths at the site itself.

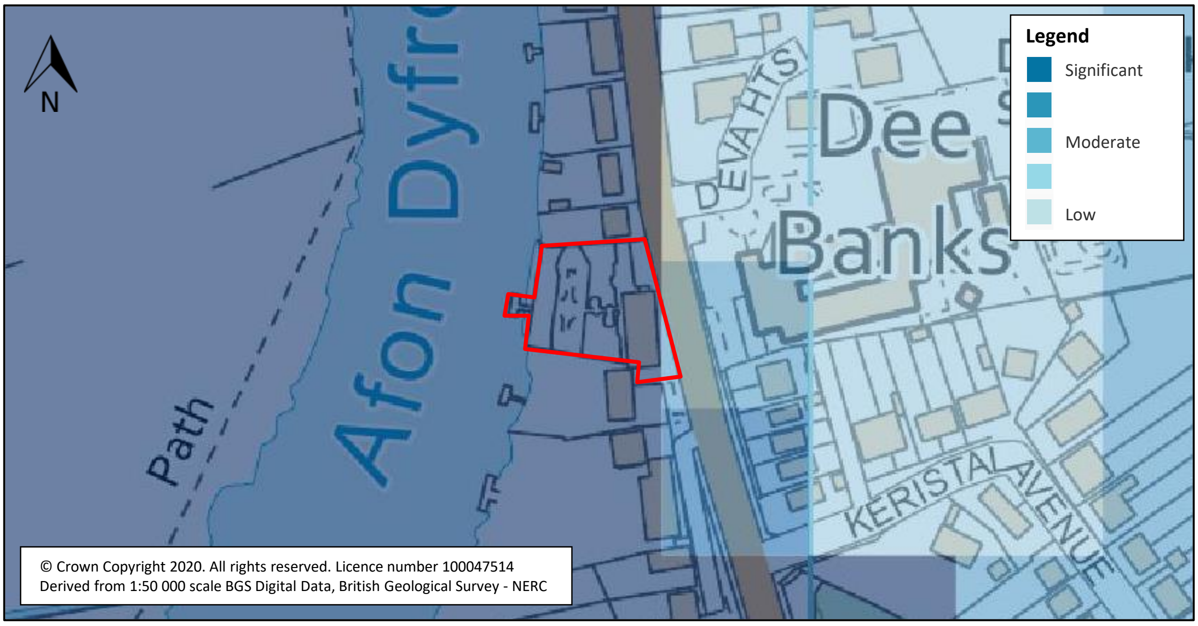


Figure 10: Groundwater Flooding Hazard Map
Source: Findmaps; Accessed: 2 September 2020

5 FLOOD RISK MITIGATION MEASURES

The risk of flooding to the proposed development from the River Dee and the residual risk of groundwater flooding will be mitigated through the implementation of the measures proposed within the following section of this report.

5.1 Finished Floor Levels

Ground floor finished floor levels should be set at a minimum of 7.97 m AOD. This provides a freeboard of 600 mm above the estimated flood level at the site during the 1 in 100 plus climate change (25%) AEP event (i.e. 7.37 m AOD). This also provides a freeboard of 300 mm above the estimated 1 in 100 plus climate change (45%) AEP event.

In accordance with Building Regulations Approved Document C[9], the ground floor finished floor levels of the buildings should be set at a minimum of 0.15 m above adjacent ground levels following reprofiling of the site.

This will, subject to the implementation of an appropriately designed surface water drainage scheme (**Section 6**), enable any potential overland flows to be conveyed safely across the site without affecting property in accordance with the approach promoted by government policy[10].

5.2 Basement

Proposals are to set the finished floor level of the basement at 5.63 m AOD, which is required to allow for car stackers.

The following mitigation measures are subsequently proposed for the basement:

- The basement should be appropriately tanked to prevent groundwater ingress
- The threshold level of access points to the basement should be set no lower than 7.97 m AOD
- The threshold level of ventilation intake should be set no lower than 7.97 m AOD

5.3 Flood Risk Elsewhere

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

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 100 AEP fluvial event. Whilst not specified by the NPPF, current national guidance recommends that this should generally be assessed considering the 'higher central' climate change allowance, which is +25% in this instance.

The flood level during the 1 in 100 plus 25% climate change AEP event is assessed to be 7.37 m AOD. Based on the development proposals (**Appendix A**) and the topographic survey (**Appendix B**) most of the developable area will be located on land that would be expected to remain dry during the aforementioned event. However, some of the proposed private garden terraces are to be located on land below that flood level and are to be raised to levels of 9.54 and 11.18 m AOD.

Table 2 provides an assessment of the displacement of floodwater from raising the proposed private garden terraces during the 1 in 100 plus climate change (25%) AEP event. As shown, 81.1 m^3 of floodwater would be expected to be displaced as a result of the proposals.

9 Approved Document C - Site preparation and resistance to contaminants and moisture, 2004 edition (with 2010 and 2013 amendments)

10 Making Space for Water, Taking forward a new Government strategy for flood and coastal erosion risk management in England, March 2005, Dept for Environment, Food and Rural Affairs

Table 2: Floodwater Displacement

1 in 100 +CC (25%) Flood Level (m AOD)	Area of proposed garden terrace that is currently below the flood level (m^2)	Average existing ground level in the 144.8 m^2 area (m AOD)	Calculated average flood depth (m)	**Calculated floodwater displaced (m^3)**
7.37	144.8	6.81	0.56	**81.1**

5.3.1 Compensatory Storage

Given the size and steep nature of the site, it will not be feasible to provide level-for-level compensatory flood storage. Therefore, in this instance it is proposed to provide compensatory flood storage on a volume-for-volume basis.

The proposed compensatory storage area (**Figure 11**) will be located within the higher communal garden area. It is proposed to lower a 196 m^2 area of land by 0.41 m, providing 81.1 m^3 of floodplain storage.

Given the compensatory storage area has an existing average ground level of 6.64 m AOD, lowering by approximately 0.41 m will afford a new level of 6.23 m AOD for that area.

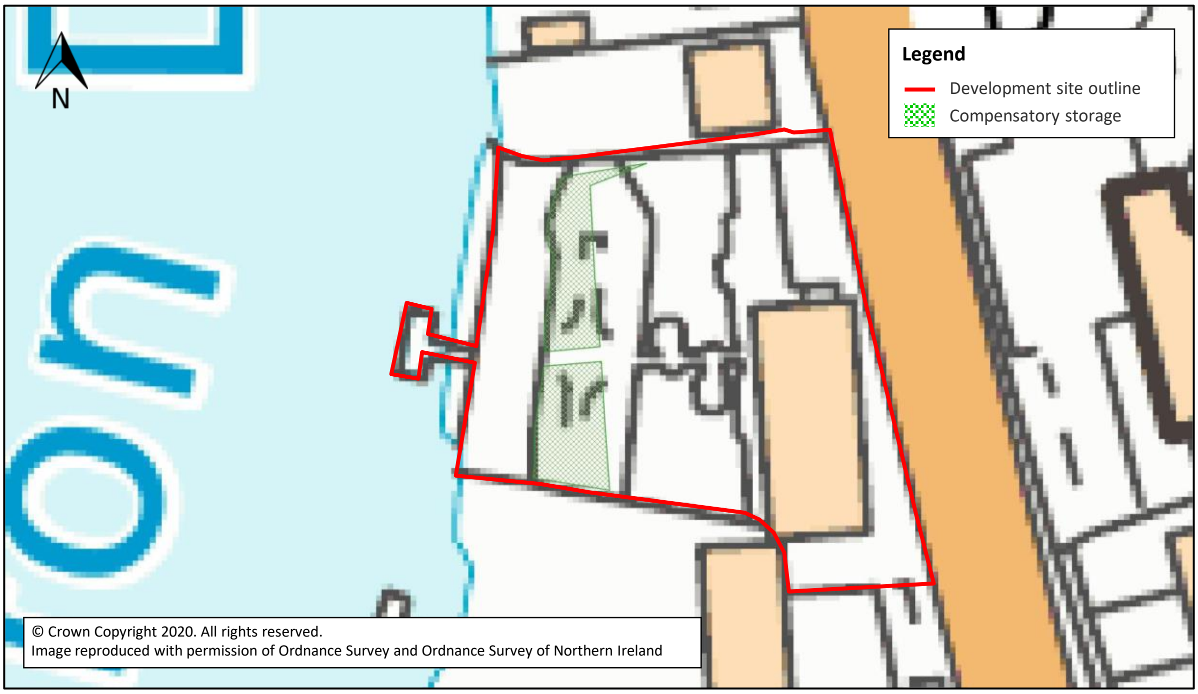


Figure 11: Proposed Compensatory Storage

5.4 Access and Egress

Dry access and egress may be provided via Dee Banks heading north in up to the 1 in 100 plus climate change (45%) AEP event.

The majority of Dee Banks is located at a 'very low' risk of surface water flooding.

6 SURFACE WATER MANAGEMENT

6.1 Surface Water Drainage at the Existing Site

The existing site has previously been developed. Therefore, it is likely that it is served by a formal surface water drainage system; however, no details of this system are currently available.

Based on ground levels surface water runoff from the existing site would naturally drain to the River Dee to the western boundary of the site.

An extract of the Dŵr Cymru Welsh Water public sewer record is provided in **Appendix C**. This indicates a 225 mm diameter public combined sewer located in Dee Banks to the east of the site.

Recognising the above, surface water runoff from the front of the existing building on site is considered to connect into the public combined sewer in Dee Banks. This is evidenced by downpipes at the front of the building on Dee Banks discharging surface water directly onto the footway. Based on ground levels, it is assumed that surface water runoff from the rear of the building, along with hardstanding areas to the rear, discharges either directly or indirectly to the River Dee.

6.1.1 Existing Runoff Rates

The site has a total area of 0.17 ha. Existing impermeable areas have been estimated to be 0.06 ha based on **Appendix B**.

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 D** and **Appendix E** respectively.

The runoff rates from the existing site are presented in **Table 3**.

Table 3: Peak Runoff Rate - Existing Site

AEP of rainfall event	Permeable Runoff Rate 0.11 ha (l/s)	Impermeable Runoff Rate 0.06 ha (l/s)	Total (l/s)
1 in 1	0.4	4.7	5.1
1 in 2	0.5	6.1	6.6
1 in 30	0.8	11.5	12.3
1 in 100	1.1	14.8	15.9

6.2 Surface Water Drainage at the Redeveloped Site

6.2.1 Disposal of Surface Water

In accordance with the NPPG[11], surface water runoff should be disposed of according to the following hierarchy: Into the ground (infiltration); To a surface water body; To a surface water sewer, highway drain, or another drainage system; To a combined sewer.

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[12].

11 Paragraph 080, Reference ID: 7-080-20150323
12 BRE Digest 365 Soakaway Design, Building Research Establishment, 2016

It is subsequently proposed to direct all runoff from the redeveloped site to the River Dee, located adjacent to the western boundary of the site.

6.2.2 Post Development Impermeable Area

The area of impermeable surfaces within the proposed development has been calculated to be 0.056 ha, based on **Appendix A**. A 10% allowance has been made for urban creep and so the post development impermeable area at the site is taken as 0.062 ha. The estimated impermeable area excludes minor hardstanding areas such as external footpaths and steps which are expected to drain to the soft landscaping and have a negligible impact on the proposed surface water regime at the site. There is therefore a slight reduction of impermeable area post development.

6.2.3 Peak Flow Control

It is proposed to restrict surface water runoff to the existing 1 in 1 AEP event rate, as outlined in **Table 3**, with a 30% betterment post development. It is therefore proposed to limit runoff from the redeveloped site to 3.6 l/s in up to the 1 in 100 AEP rainfall event including an allowance for climate change, providing betterment when compared to the existing situation.

6.2.4 Volume Control:

It is proposed to restrict peak discharge rates to the existing 1 in 1 AEP event rate with a 30% betterment in up to the 1 in 100 AEP rainfall 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 F**). The required storage volume has been sized to store the 1 in 100 AEP rainfall event including a 20% increase in rainfall intensity to allow for climate change in accordance with Environment Agency guidance[13].

Assuming a peak discharge rate of 3.6 l/s, a total storage volume of 13.4 m^3 would be required. The required surface water storage volume for the site may be provided in a geocellular attenuation storage tank and within the on site pipe network system.

The geocellular attenuation storage tank would have an area of 15 m^2 and a depth of 0.8 m. It would fill to a depth of 0.569 m providing a 0.231 m freeboard.

An area of permeable paving is also proposed adjacent to the site entrance. Surface water runoff will pass through an aggregate sub-base beneath the permeable surfacing. Runoff will then be directed into the proposed pipe network on site. The permeable paving structure is based upon an 80 mm thick block paving, 30 mm thick bedding aggregate and 320 mm thick granular sub-base with 30% porosity. The permeable paving will not provide any attenuation but will provide a level of treatment for the runoff.

Given that the site is at fluvial flood risk, the attenuation storage facility has also been modelled with a drowned outfall, using a water level of 7.67 m AOD and surcharge duration of 1440 minutes. As discussed in **Section 4.3**, this is the estimated flood level on site for the 1 in 100 plus climate change (45%) AEP event. The results provided in **Appendix G** show no flooding of the proposed surface water drainage system.

In accordance with Environment Agency guidance, a sensitivity analysis has been undertaken using a 40% increase in rainfall intensity in order to allow for uncertainty with respect to climate change (**Appendix H** and **Appendix I** (drowned outfall)).

[13] Flood Risk Assessments: climate change allowances (https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances)

The results indicate that the additional volume of surface water would be catered for within the freeboard of the geocellular attenuation storage tank and within the remaining capacity available within the on site pipe network . As such, no flooding of the drainage system would therefore be expected in the 1 in 100 AEP rainfall event including a 40% increase in rainfall intensity.

6.2.6 Preliminary Surface Water Drainage Layout

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

6.2.7 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 towards carriageways, with the site being profiled to ensure that flood flows are directed away from built development and ultimately towards the River Dee.

6.2.8 Water Quality and Pollution Control

The CIRIA SuDS Manual[14] and Table G3.1 of the Statutory Standards for SuDS identifies individual property driveways, roofs and low traffic roads as having a low pollution hazard level.

Table 26.2 of the CIRIA SuDS Manual 2015 indicates that the pollution hazard indices associated with such uses for total suspended solids, hydrocarbons and metals are 0.50, 0.40 and 0.40 respectively.

As discussed in **Section 6.2.5**, surface water runoff from trafficked areas will be treated within an aggregate sub-base beneath the proposed area of permeable paving. Runoff will be directed the proposed pipe network.

Table 26.3 of the CIRIA SuDS Manual 2015 indicates that the SuDS mitigation indices for permeable paving for total suspended solids, hydrocarbons and metals are 0.70, 0.60 and 0.70 respectively. As such, the proposed drainage system would incorporate adequate water quality treatment from trafficked areas through the treatment of surface water runoff at source.

In addition, trapped gullies and catchpit manholes provide quality treatment for the surface water and will help minimise the risk of siltation in the geocellular attenuation storage tank.

6.2.9 Adoption and Maintenance of SuDS

The pipe network and SuDS elements within the curtilage of the site are likely to remain private and will therefore be maintained by the landowner.

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

14 Table 26.2

Table 4: Maintenance Requirements

Schedule	Required action	Frequency
Flow Control Unit		
Routine maintenance	Remove litter and debris and inspect for sediment, oil and grease accumulation	Six Monthly
	Remove sediment, oil, grease and floatables	As necessary – Indicated by system inspections or immediately following significant spill
Remedial actions	Replace malfunctioning parts or structures	As required
Monitoring	Inspect for evidence of poor operation	Six Monthly
	Inspect sediment accumulation rates and establish appropriate removal frequencies	Monthly during first year of operation, then every six months
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
	Monitor inspection chambers	

Geocellular 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
	Inspect sediment accumulation rates and establish appropriate removal frequencies	Monthly during first year of operation, then every six months

7 SUMMARY AND RECOMMENDATIONS

This report has been prepared on behalf of Sterling Property CO. Limited and relates to the proposed redevelopment of The Red House, Dee Banks, Chester.

According to the Flood Map for Planning the eastern part of the site is located in flood zone 1, whilst the western part is located in flood zone 2 and flood zone 3.

The proposed buildings will be located outside the 1 in 1,000 plus climate change (20%) AEP flood extent, effectively locating all built development within flood zone 1 taking into account the lifetime of the development. As such the application of the sequential test and exception test is not deemed to be necessary; however, the proposals should still meet the requirements for site specific FRAs.

The River Dee is located adjacent to the western boundary of the site. Based on the calculated flood levels and the topographic survey data, no flooding of the proposed building areas or access and egress is expected during any of the modelled flood events. Some flooding in the western extent of the developable area may occur to depths of up to 0.56 m during the 1 in 100 plus climate change (25%) AEP event, in parts of the proposed garden terrace areas.

The Flood Risk from Surface Water map indicates that the site is not expected to be at risk of flooding from Caldy Brook.

The Flood Risk from Surface Water map indicates that the majority of the site is located at 'very low' risk, with a 'low' to 'medium' risk along the western boundary, associated with the River Dee.

The Flood Risk from Reservoirs map indicates that the west of the site may be at risk from such sources.

There may be a moderate to significant susceptibility to groundwater flooding at the site.

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

- Finished floor levels to be set at a minimum of 7.97 m AOD
- Finished floor levels to be set 0.15 m above adjacent ground levels
- The basement should be appropriately tanked
- The threshold level of access points to the basement should be set no lower than 7.97 m AOD
- The threshold level of ventilation intake should be set no lower than 7.97 m AOD
- The detailed drainage design to be submitted to and approved by the local planning authority prior to the commencement of development

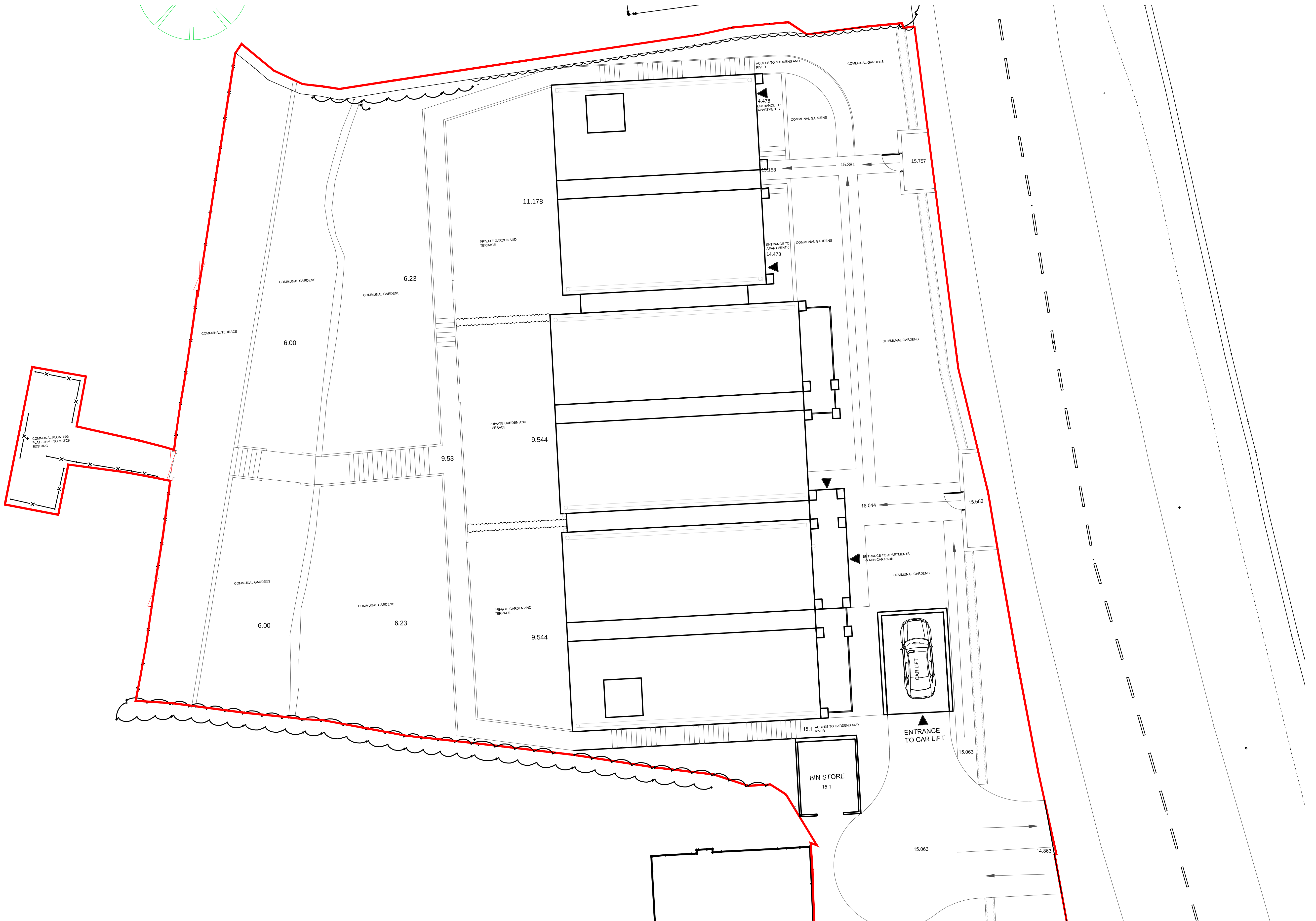
Construction of the proposed garden terrace areas may displace 81.1 m^3 of floodwater during a 1 in 100 plus climate change (25%) AEP event, which is proposed to be compensated for in the communal garden area in the west of the site by lowering a 196 m^2 area of land by approximately 0.41 m.

Dry access and egress is expected to be available via Dee Banks heading north.

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

APPENDIX A

Development Proposals



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STATUS KEY: SKE: SKETCH DESIGN PLA PLANNING TENDER TEN
CON CONSTRUCTION SUR SURVEY

REVISION / DESCRIPTION	DRAWN	CHECKED	DATE

REVISION / DESCRIPTION	DRAWN	CHECKED	DATE

REVISION / DESCRIPTION	DRAWN	CHECKED	DATE
P4 SITE PLAN WITH LEVELS	EP	CT	12/2020
P3 SITE PLAN WITH LEVELS	EP	CT	12/2020
P2 SITE PLAN WITH LEVELS	EP	CT	11/2020
P1 SITE PLANS	EP	CT	10/2020

RADM
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Telephone: 01244 350 628 Email:enquiries@radm.co.uk Website:www.radm.co.uk

PROJECT TITLE: The Red House, Dee Banks

JOB No: RA2004

DRAWING TITLE: Proposed Site Plan

DRAWING No: L(81)001

SCALE: 1:200 @A3 | DATE: OCT 2020 | STATUS: PL | REVISION: P4

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CON CONSTRUCTION SUR SURVEY

REVISION / DESCRIPTION	DRAWN	CHECKED	DATE

REVISION / DESCRIPTION	DRAWN	CHECKED	DATE

REVISION / DESCRIPTION	DRAWN	CHECKED	DATE
P3 SITE ELEVATION	EP	CT	12/2020
P2 SITE ELEVATION	EP	CT	11/2020
P1 SITE ELEVATION	EP	CT	10/2020

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PROJECT TITLE: The Red House, Dee Banks
JOB No: RA2004
DRAWING TITLE: Proposed River Elevation
DRAWING No: L(81)010
SCALE: 1:200 @A3
DATE: OCT 2020
STATUS: PL
REVISION: P3

STATUS KEY: SKE: SKETCH DESIGN PLA PLANNING TENDER TEN
CON CONSTRUCTION SUR SURVEY

REVISION / DESCRIPTION	DRAWN	CHECKED	DATE
P3 ELEVATIONS	EP	CT	12/2020
P2 ELEVATIONS	EP	CT	11/2020
P1 ELEVATIONS	EP	CT	10/2020

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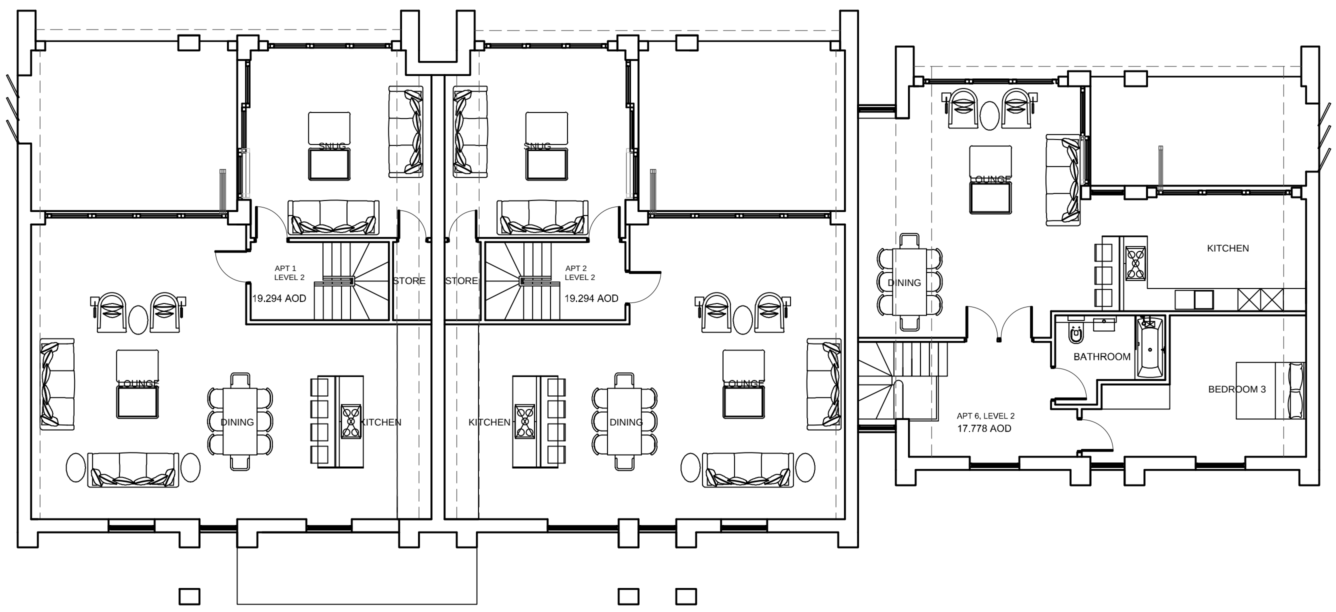
PROJECT TITLE: The Red House
JOB No: RA2004
DRAWING TITLE: Proposed Elevations
DRAWING No: L(91)010
SCALE: 1:200 @A3
DATE: OCT 2020
STATUS: PL
REVISION: P3

+1



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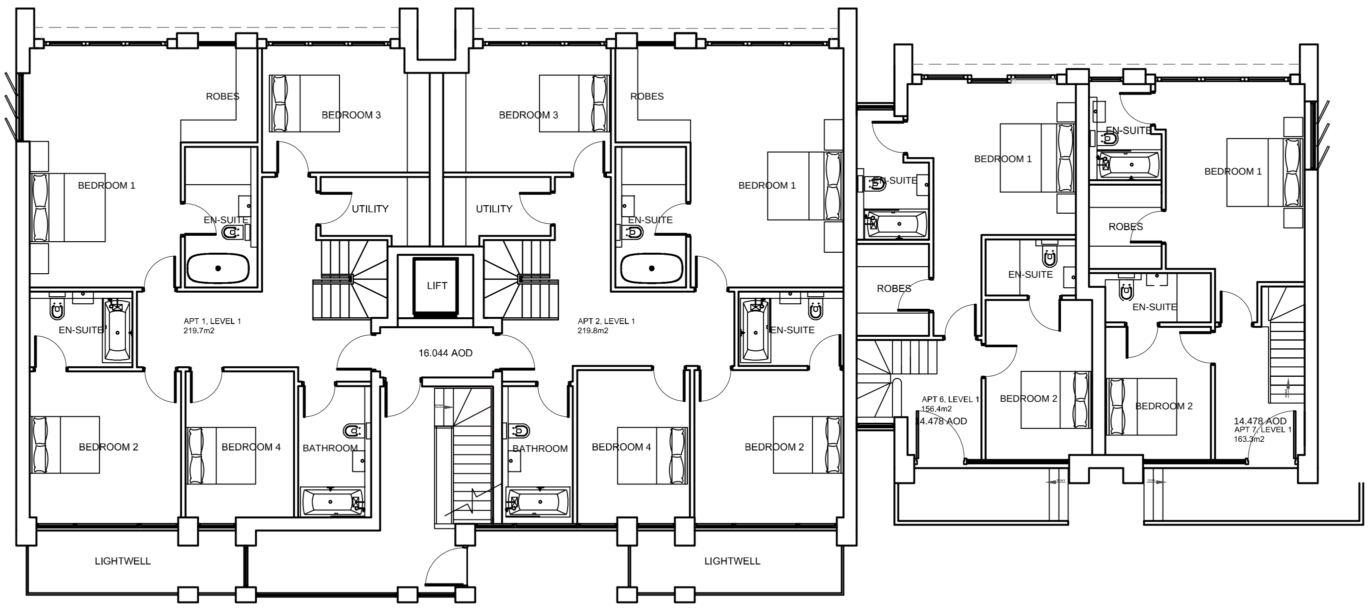

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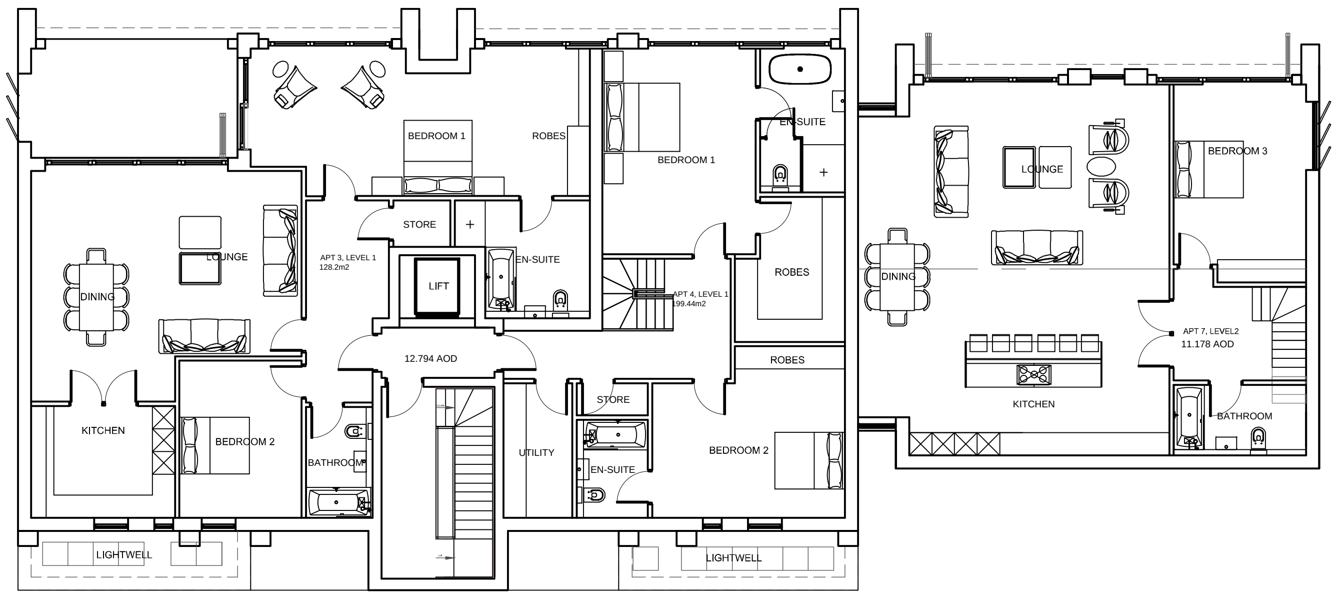

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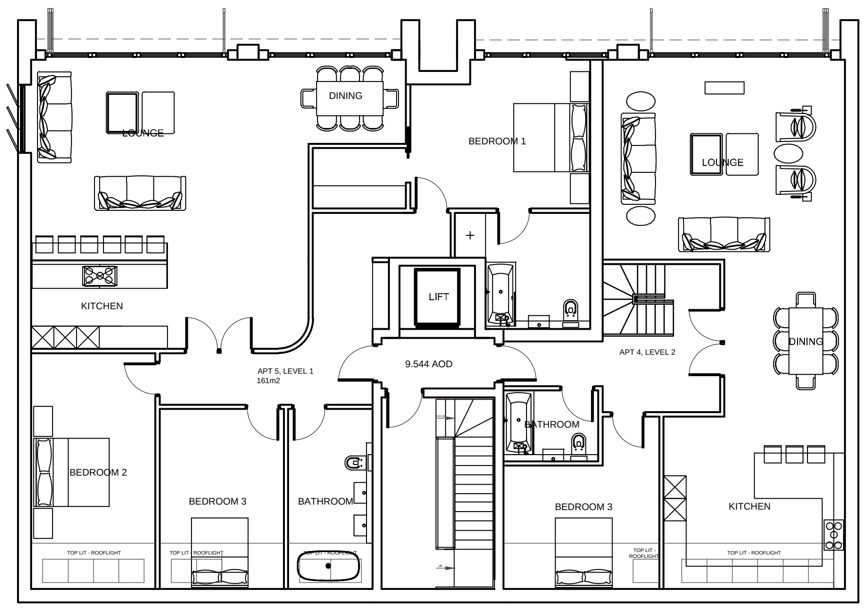

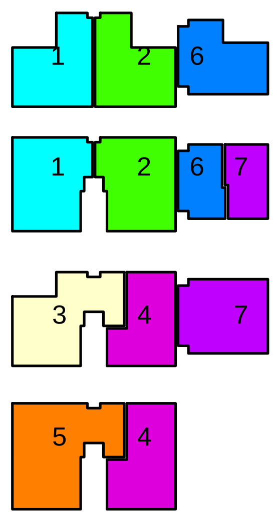

STATUS KEY: SKE SKETCH DESIGN PLA PLANNING TENDER TEN
CON CONSTRUCTION SUR SURVEY

REVISION / DESCRIPTION	DRAWN	CHECKED	DATE

REVISION / DESCRIPTION	DRAWN	CHECKED	DATE
P3 FLOOR PLANS	EP	CT	12/2020
P2 FLOOR PLANS	EP	CT	11/2020
P1 FLOOR PLANS	EP	CT	10/2020

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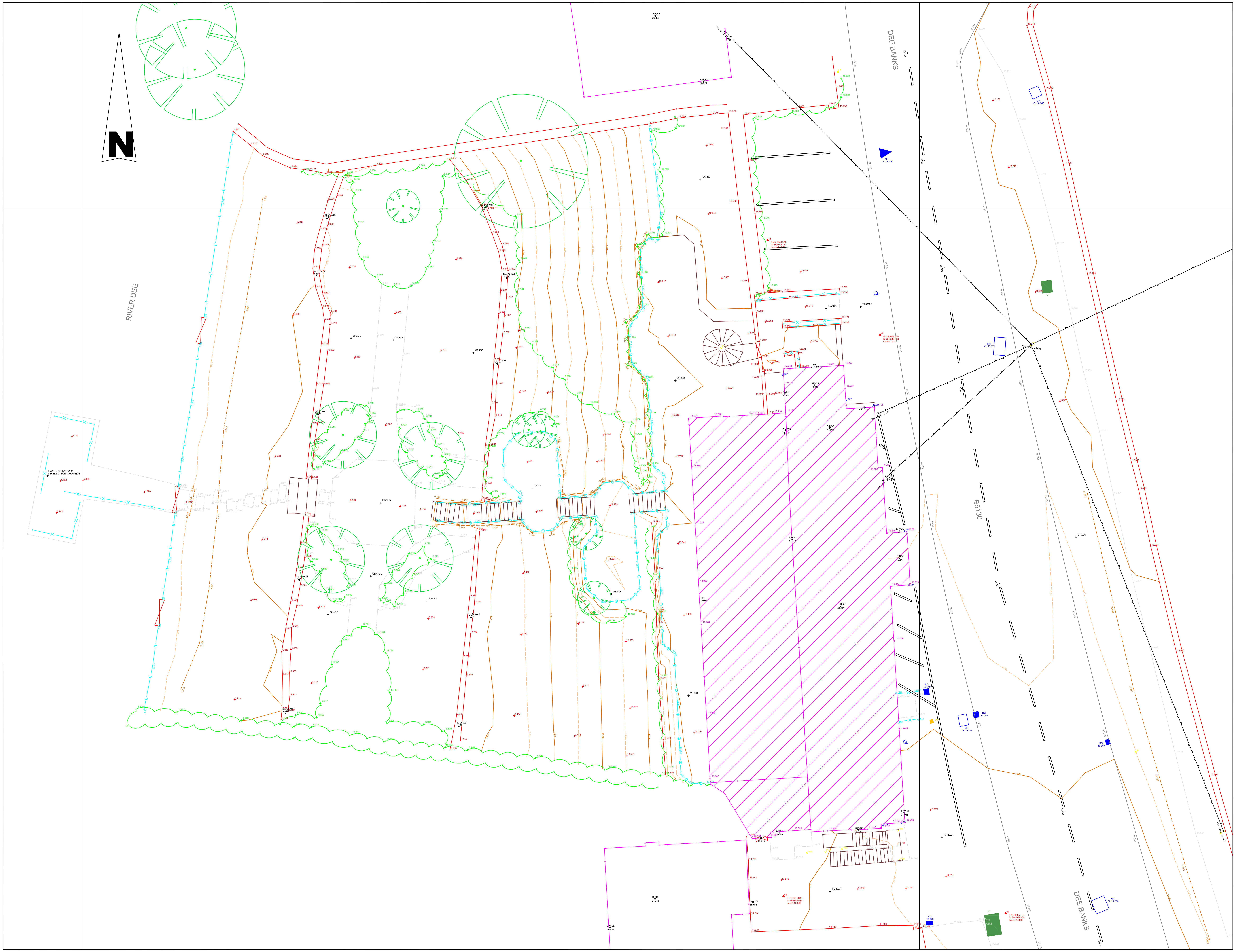
PROJECT TITLE: The Red House
JOB No: RA2004
DRAWING TITLE: Proposed Floor Plans
DRAWING No: L(91)001
SCALE: 1:200 @A3
DATE: OCT 2020
STATUS: SKE
REVISION: P3

APPENDIX B

Topographic Survey



KEY

LINETYPES

VERGE	CONCRETE EDGE
FENCE - CHAIN LINK	FOOTPATH
FENCE - METAL	TRACK
FENCE - WOODEN	BUILDING
FENCE - POST & RAIL	TREE
HEDGE	GATE
WALL	SURVEY STATION
BARRIER	EAVES
CHANNEL LINE	

UTILITY KEY

LINETYPES

BT BELOW GROUND	WATER BELOW GROUND
BT ABOVE GROUND	WATER ABOVE GROUND
BT ASSUMED ROUTE	WATER ASSUMED ROUTE
CATV BELOW GROUND	UNKNOWN BELOW GROUND
CATV ABOVE GROUND	UNKNOWN ABOVE GROUND
CATV ASSUMED ROUTE	GPR BELOW GROUND
COMMS BELOW GROUND	COMBINED WATER SEWER
COMMS ABOVE GROUND	ASSUMED COMBINED WATER SEWER ROUTE
COMMS ASSUMED ROUTE	FOUL WATER SEWER
GAS BELOW GROUND	ASSUMED FOUL WATER SEWER ROUTE
GAS ABOVE GROUND	STORM WATER SEWER
GAS ASSUMED ROUTE	ASSUMED STORM WATER SEWER ROUTE
ELECTRIC BELOW GROUND	REINSTATEMENT SCAR
ELECTRIC ABOVE GROUND	SURVEY BOUNDARY
ELECTRIC ASSUMED ROUTE	

ABBREVIATIONS

(AC)	ASSUMED CONNECTION	INT	INTERCEPTOR
A/G	ABOVE GROUND	KV	KILO VOLT
(AR)	ASSUMED ROUTE	LD	LOOP DETECTOR
ASB	ASBESTOS CEMENT	LH	LAMP HOLE
AV	AIR VALVE	LP	LAMP POST
BB	BELISHA BEACON	LV	LOW VOLTAGE
BD	BACK DROP	MK	MARKER
BL	BASE LEVEL	MH	MANHOLE
BO	BOLLARD	MT	METER
BOL	BOLLARD LIGHT	M/WELL	MONITORING WELL
BT	BRITISH TELECOM	O/H	OVERHEAD
CATV	CABLE TELEVISION	PE	POLYETHYLENE
CB	CONTROL BOX	PTG	PIPE TO GROUND
CI	CAST IRON	PVC	POLYVINYL CHLORIDE
CL	COVER LEVEL	TFR	TAKEN FROM RECORDS
CR	CABLE RISER	RE	RODDING EYE
CWS	COMBINED WATER SEWER	RED	REDUNDANT SERVICE
d	DEPTH OF SERVICE	RWP	RAIN WATER PIPE
DCH	DRAINAGE CHANNEL	SC	STOP COCK
DI	DUCTILE IRON	SI	SPUN IRON
DIS	DISUSED	SOF	SOFFIT
EOT	END OF TRACE	SP	SOIL PIPE
EP	ELECTRIC POLE	SWS	SURFACE WATER SEWER
ER	EARTH ROD	SV	STOP VALVE
FFP	FUEL TANK FILL POINT	TL	TRAFFIC LIGHT
FH	FIRE HYDRANT	TLC	TRAFFIC LIGHT COVER
FWS	FOUL WATER SEWER	TP	TELECOM POLE
GPR	GROUND PENETRATING RADAR	UTL	UNABLE TO LIFT
GR	GAS RISER	UTS	UNABLE TO SURVEY
GV	GAS VALVE	UTT	UNABLE TO TRACE
GY	GULLY	VC	VITRIFIED CLAY
HV	HIGH VOLTAGE	VP	VENT PIPE
IC	INSPECTION COVER	WL	WATER LEVEL
Id	INVERT DEPTH	WO	WASH OUT
IL	INVERT LEVEL	WR	WATER RISER

DISCLAIMER

Unless otherwise stated, all services shown on this plan have been surveyed using approved detectors and the connections between manholes, if not traced, are assumed to be direct.

No guarantee can be given that all services have been shown.
In ideal conditions the depth accuracies for the underground utilities located is +/- 10% of depth.

Utilities traced using GPR techniques show depths approximately from ground level to the top of the utility. Utilities traced using Electromagnetic techniques provide an estimated depth which is measured from ground level to the centre of the utility. Drainage and pipes traced using Sonde Electromagnetic techniques show depths at approximately the Invert Level.

Where services are shown as 'Taken From Records' on the drawing we are not liable for any loss that may arise due to a lack of accuracy in that guided information.

Due to BT's policy we are not permitted to lift their inspection chamber covers.

Reference should be made to the methodology used on site as detailed within the latest version of SiteScan Procedures for Utility Location Surveys.

SiteScan recommend that all excavations are to be carried out in accordance with HSG 47 (Avoiding Danger from Underground Services).

Plan accuracies of the order of + or - 150mm may be achieved but this figure will depend on the depth of the service below ground level. Where similar services run in close proximity, separation may be impossible. Successful tracing of non-metallic pipes may be limited.

Existing record information showing underground services is often incomplete and of doubtful accuracy. It should be regarded only as an indication and cannot be guaranteed.

NOTES

REV	AMENDMENT	DRAWN	CHECKED
A	INITIAL RELEASE	AL	NG

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SiteScan
Information to build on

CLIENT: RAY STALKER

PROJECT TITLE: THE RED HOUSE, CHESTER

DRAWING TITLE: TOPOGRAPHICAL SURVEY

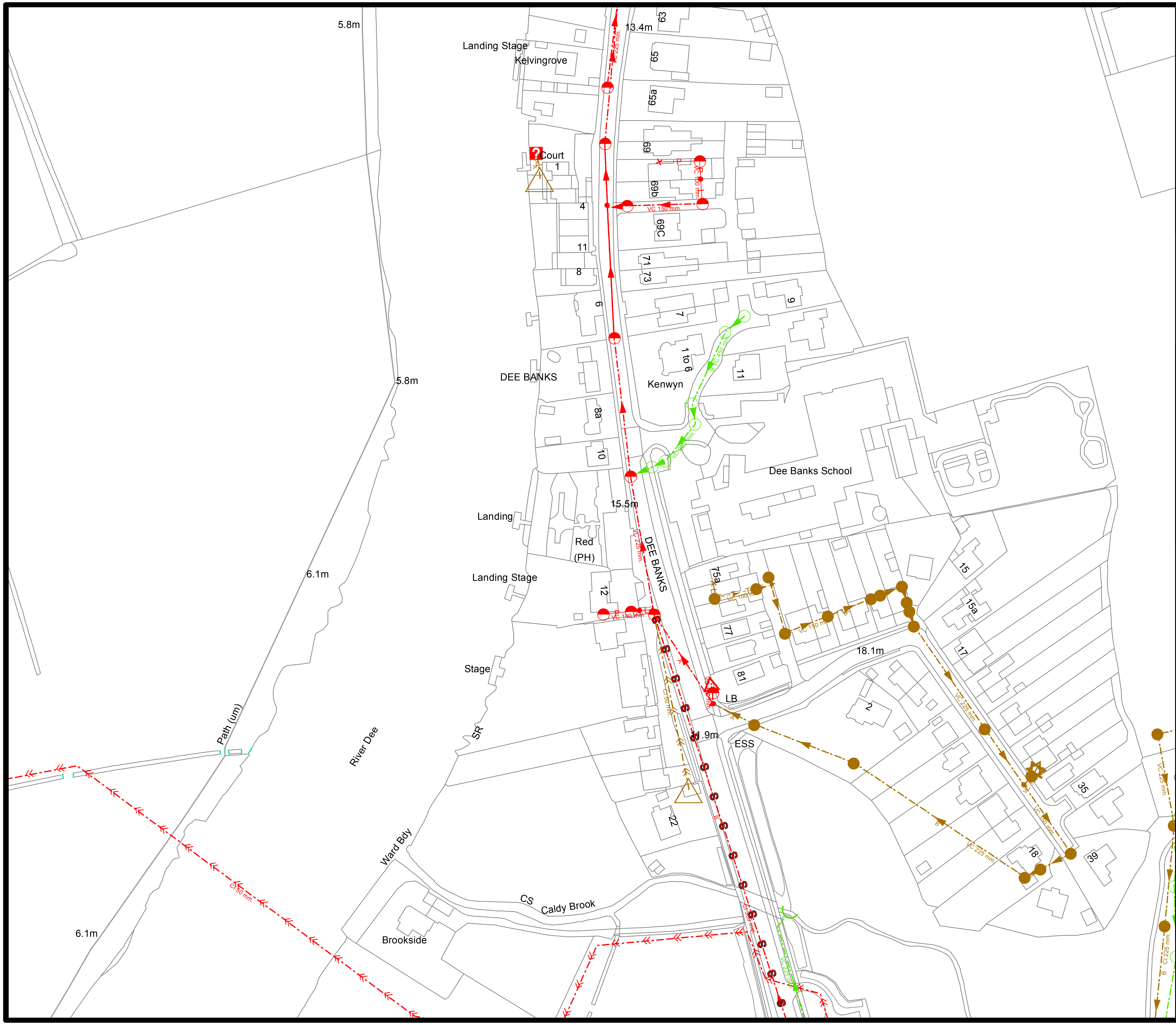
SCALE AT A1	DATE	GRID/DATUM
1:100 @ A1	13.06.19	OS

SURVEYED BY	DRAWN BY	APPROVED
AL	AL	NG

PROJECT No.	SHEET No.	REV
P19113	1/1	A

APPENDIX C

Dŵr Cymru Welsh Water Public Sewer Record



Dŵr Cymru
Welsh Water

Chester, Cheshire West

N
W E
S

LEGEND(Representative of most common features)

Waste network:

- Foul chamber
- Surface water chamber
- Combined chamber
- Combined sewer overflow
- Special purpose chamber
- Treatment works
- Pumping station
- Outfall
- Lamphole
- Storm Overflow
- Rising main
- Gravity sewer
- Private sewer
- Private sewer subject to Sect. 104 adoption agreement
- Private Sewer Transfer
- Lateral Drain
- Inspection Chamber

NB: Sewer symbol colour indicates the type.
RED - Combined
GREEN - Surface Water
BROWN - Foul
Purple - Former S24 sewers (for indicative purposes only)

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:	341932,365338
Map scale:	1:1500
Printed by:	Emma John
Printed on:	21 Oct 2020

APPENDIX D

Greenfield Runoff Calculations

ICP SUDS Mean Annual Flood

Input

Return Period (years)	100	Soil	0.450
Area (ha)	1.000	Urban	0.000
SAAR (mm)	700	Region Number	Region 9

Results	**l/s**
QBAR Rural	4.4
QBAR Urban	4.4
Q100 years	9.6
Q1 year	3.9
Q30 years	7.7
Q100 years	9.6

APPENDIX E

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[15].

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

M5-60 minute rainfall depth:	18.0 mm
Ratio of M5-60 to M5-2 day rainfall:	0.38
Average Annual Rainfall:	700 mm
Winter Rain Acceptance Potential/ Soil Type :	0.45/4
The Urban Catchment Wetness Index (UCWI) value:	70.0

A time of concentration of 15.0 minutes has been used.

A rainfall estimation calculation has been carried out to convert the M5-60 minute rainfall to the 15-minute duration rainfall for the 1 in 1, 1 in 2, 1 in 30 and 1 in 100 annual exceedance probability (AEP) rainfall events. The calculated rainfall intensities for these events are 27.5, 35.6, 67.3 and 86.6 mm/hr respectively.

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

$Q=2.78 \times C_v \times C_r \times$ rainfall intensity x impermeable area

<u>where:</u>

C_v is the volumetric runoff coefficient = P_r/PIMP = 0.79
where P_r is Percentage Runoff and PIMP is Percentage Impermeable Area
C_r is the routing coefficient = 1.3
Impermeable Area = 0.06 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 0.06 ha impermeable area (l/s)
1 in 1	4.7
1 in 2	6.1
1 in 30	11.5
1 in 100	14.8

[15] The Wallingford Procedure, Volume 4, 1981

APPENDIX F

MicroDrainage Calculations

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	0.380	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	0.036	4-8	0.026

Total Area Contributing (ha) = 0.062

Total Pipe Volume (m³) = 1.306

Network Design Table for Storm

« - Indicates pipe capacity < flow

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	8.558	0.850	10.1	0.013	5.00	0.0	0.600	o	150	Pipe/Conduit	🔒
S1.001	8.711	0.860	10.1	0.000	0.00	0.0	0.600	o	150	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	5.04	12.320	0.013	0.0	0.0	0.0	3.19	56.4	1.8
S1.001	50.00	5.09	9.610	0.013	0.0	0.0	0.0	3.18	56.3	1.8

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
S1.002	5.895	0.590	10.0	0.018	0.00	0.0	0.600	o	150	Pipe/Conduit	
S2.000	11.889	0.120	99.1	0.007	5.00	0.0	0.600	o	150	Pipe/Conduit	
S2.001	2.840	0.270	10.5	0.024	0.00	0.0	0.600	o	150	Pipe/Conduit	
S2.002	12.851	0.000	0.0	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit	
S2.003	3.636	0.350	10.4	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit	
S1.003	19.500	0.310	62.9	0.000	0.00	0.0	0.600	o	150	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)
S1.002	50.00	5.12	8.240	0.031	0.0	0.0	0.0	3.21	56.7	4.2
S2.000	50.00	5.20	10.330	0.007	0.0	0.0	0.0	1.01	17.8	0.9
S2.001	50.00	5.21	9.170	0.031	0.0	0.0	0.0	3.12	55.2	4.2
S2.002	50.00	7.52	8.000	0.031	0.0	0.0	0.0	0.09	1.6«	4.2
S2.003	50.00	7.54	8.000	0.031	0.0	0.0	0.0	3.14	55.6	4.2
S1.003	50.00	7.80	5.410	0.062	0.0	0.0	0.0	1.27	22.4	8.4

Manhole Schedules for Storm

MH Name	MH CL (m)	MH Depth (m)	MH Connection	MH Diam.,L*W (mm)	Pipe Out PN	Pipe Out Invert Level (m)	Pipe Out Diameter (mm)	Pipes In PN	Pipes In Invert Level (m)	Pipes In Diameter (mm)	Backdrop (mm)
S5	15.080	2.760	Open Manhole	450	S1.000	12.320	150				
S4	12.320	2.710	Open Manhole	450	S1.001	9.610	150	S1.000	11.470	150	1860
S3	9.600	1.360	Open Manhole	450	S1.002	8.240	150	S1.001	8.750	150	510
S2D	11.180	0.850	Open Manhole	450	S2.000	10.330	150				
S2C	11.180	2.010	Open Manhole	1200	S2.001	9.170	150	S2.000	10.210	150	1040
S2B - GEOCELL	9.540	1.540	Open Manhole	1200	S2.002	8.000	150	S2.001	8.900	150	900
S2A	9.540	1.540	Open Manhole	1200	S2.003	8.000	150	S2.002	8.000	150	
S2	9.540	4.130	Open Manhole	1200	S1.003	5.410	150	S1.002	7.650	150	2240
								S2.003	7.650	150	2240
S1-HW	5.400	0.300	Open Manhole	0		OUTFALL		S1.003	5.100	150	

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
S5	1724570.127	-250902.149	1724570.127	-250902.149	Required	
S4	1724561.585	-250902.676	1724561.585	-250902.676	Required	
S3	1724552.886	-250903.146	1724552.886	-250903.146	Required	
S2D	1724550.829	-250868.042	1724550.829	-250868.042	Required	
S2C	1724547.894	-250879.563	1724547.894	-250879.563	Required	
S2B - GEOCELL	1724548.034	-250882.400	1724548.034	-250882.400	Required	
S2A	1724548.691	-250895.234	1724548.691	-250895.234	Required	

Manhole Schedules for Storm

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
S2	1724548.831	-250898.867	1724548.831	-250898.867	Required	
S1-HW	1724529.348	-250899.687			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	150	S5	15.080	12.320	2.610	Open Manhole	450
S1.001	o	150	S4	12.320	9.610	2.560	Open Manhole	450
S1.002	o	150	S3	9.600	8.240	1.210	Open Manhole	450
S2.000	o	150	S2D	11.180	10.330	0.700	Open Manhole	450
S2.001	o	150	S2C	11.180	9.170	1.860	Open Manhole	1200
S2.002	o	150	S2B - GEOCELL	9.540	8.000	1.390	Open Manhole	1200
S2.003	o	150	S2A	9.540	8.000	1.390	Open Manhole	1200
S1.003	o	150	S2	9.540	5.410	3.980	Open Manhole	1200

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	8.558	10.1	S4	12.320	11.470	0.700	Open Manhole	450
S1.001	8.711	10.1	S3	9.600	8.750	0.700	Open Manhole	450
S1.002	5.895	10.0	S2	9.540	7.650	1.740	Open Manhole	1200
S2.000	11.889	99.1	S2C	11.180	10.210	0.820	Open Manhole	1200
S2.001	2.840	10.5	S2B - GEOCELL	9.540	8.900	0.490	Open Manhole	1200
S2.002	12.851	0.0	S2A	9.540	8.000	1.390	Open Manhole	1200
S2.003	3.636	10.4	S2	9.540	7.650	1.740	Open Manhole	1200
S1.003	19.500	62.9	S1-HW	5.400	5.100	0.150	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	0.013	0.013	0.013
1.001	-	-	100	0.000	0.000	0.000
1.002	-	-	100	0.018	0.018	0.018
2.000	-	-	100	0.007	0.007	0.007
2.001	-	-	100	0.024	0.024	0.024
2.002	-	-	100	0.000	0.000	0.000
2.003	-	-	100	0.000	0.000	0.000
1.003	-	-	100	0.000	0.000	0.000
				Total	Total	Total
				0.062	0.062	0.062

Free Flowing Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
S1.003	S1-HW	5.400	5.100	0.000	0	0

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 2 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	0.380		

Online Controls for Storm

Hydro-Brake® Optimum Manhole: S2, DS/PN: S1.003, Volume (m^3): 4.8

Unit Reference	MD-SHE-0069-3600-3100-3600
Design Head (m)	3.100
Design Flow (l/s)	3.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	69
Invert Level (m)	5.410
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)	3.100	3.6	Kick-Flo®	0.621	1.7
Flush-Flo™	0.305	2.1	Mean Flow over Head Range	-	2.6

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.8	1.200	2.3	3.000	3.5	7.000	5.3
0.200	2.1	1.400	2.5	3.500	3.8	7.500	5.4
0.300	2.1	1.600	2.6	4.000	4.0	8.000	5.6
0.400	2.1	1.800	2.8	4.500	4.3	8.500	5.8
0.500	2.0	2.000	2.9	5.000	4.5	9.000	5.9
0.600	1.8	2.200	3.1	5.500	4.7	9.500	6.1
0.800	1.9	2.400	3.2	6.000	4.9		
1.000	2.1	2.600	3.3	6.500	5.1		

Storage Structures for Storm

Porous Car Park Manhole: S5, DS/PN: S1.000

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	8.3
Membrane Percolation (mm/hr)	1000	Length (m)	10.0
Max Percolation (l/s)	23.1	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	14.650	Cap Volume Depth (m)	0.320

Cellular Storage Manhole: S2B - GEOCELL, DS/PN: S2.002

Invert Level (m)	8.000	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	15.0	0.0	0.801	0.0	0.0
0.800	15.0	0.0			

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	S5	0.439	0.143	7.968	8.550
S1.001	S4	0.431	0.146	0.000	0.577
S1.002	S3	0.216	0.090	0.000	0.306
S2.000	S2D	0.135	0.196	0.000	0.331
S2.001	S2C	2.273	0.029	0.000	2.302
S2.002	S2B - GEOCELL	1.742	0.206	11.405	13.352
S2.003	S2A	1.742	0.043	0.000	1.785
S1.003	S2	4.671	0.334	0.000	5.005
Total		11.649	1.186	19.373	32.208

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 2 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model	FSR	M5-60 (mm)	18.000	Cv (Summer)	0.750
Region	England and Wales	Ratio R	0.380	Cv (Winter)	0.840

Margin for Flood Risk Warning (mm)	300.0	DVD Status	OFF
Analysis Timestep	Fine	Inertia Status	OFF
DTS Status	ON		

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	1, 30, 100
Climate Change (%)	0, 0, 20

PN	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)
S1.000	S5	30 minute 1 year Summer I+0%	15.080	12.339	-0.131	0.000	0.03	
S1.001	S4	15 minute 1 year Summer I+0%	12.320	9.627	-0.133	0.000	0.03	
S1.002	S3	15 minute 1 year Summer I+0%	9.600	8.266	-0.124	0.000	0.06	
S2.000	S2D	15 minute 1 year Winter I+0%	11.180	10.352	-0.128	0.000	0.05	
S2.001	S2C	15 minute 1 year Winter I+0%	11.180	9.202	-0.118	0.000	0.10	
S2.002	S2B - GEOCELL	30 minute 1 year Winter I+0%	9.540	8.066	-0.084	0.000	0.40	
S2.003	S2A	30 minute 1 year Winter I+0%	9.540	8.023	-0.127	0.000	0.06	
S1.003	S2	30 minute 1 year Winter I+0%	9.540	6.455	0.895	0.000	0.10	

PN	US/MH Name	Maximum Vol (m³)	Maximum Velocity (m/s)	Pipe Flow (l/s)	Status
S1.000	S5	0.002	1.4	1.4	OK
S1.001	S4	0.002	1.3	1.3	OK
S1.002	S3	0.003	1.6	2.8	OK
S2.000	S2D	0.003	0.5	0.9	OK

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

PN	US/MH Name	Maximum Vol (m³)	Maximum Velocity (m/s)	Pipe Flow (l/s)	Status
S2.001	S2C	0.031	1.2	3.3	OK
S2.002	S2B - GEOCELL	1.011	0.3	2.0	OK
S2.003	S2A	0.041	1.2	2.0	OK
S1.003	S2	1.177	0.8	2.2	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 2 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR M5-60 (mm) 18.000 Cv (Summer) 0.750
Region England and Wales Ratio R 0.380 Cv (Winter) 0.840

Margin for Flood Risk Warning (mm) 300.0 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 1, 30, 100
Climate Change (%) 0, 0, 20

PN	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)
S1.000	S5	15 minute 30 year Winter I+0%	15.080	12.348	-0.122	0.000	0.08	
S1.001	S4	15 minute 30 year Winter I+0%	12.320	9.638	-0.122	0.000	0.08	
S1.002	S3	15 minute 30 year Winter I+0%	9.600	8.286	-0.104	0.000	0.20	
S2.000	S2D	15 minute 30 year Winter I+0%	11.180	10.366	-0.114	0.000	0.13	
S2.001	S2C	15 minute 30 year Winter I+0%	11.180	9.226	-0.094	0.000	0.30	
S2.002	S2B - GEOCELL	60 minute 30 year Winter I+0%	9.540	8.218	0.068	0.000	0.76	
S2.003	S2A	60 minute 30 year Winter I+0%	9.540	8.212	0.062	0.000	0.10	
S1.003	S2	60 minute 30 year Winter I+0%	9.540	8.210	2.650	0.000	0.16	

PN	US/MH Name	Maximum Vol (m³)	Maximum Velocity (m/s)	Pipe Flow (l/s)	Status
S1.000	S5	0.004	1.7	3.9	OK
S1.001	S4	0.004	1.7	3.9	OK
S1.002	S3	0.007	2.1	9.6	OK
S2.000	S2D	0.005	0.7	2.1	OK

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

PN	US/MH Name	Maximum Vol (m³)	Maximum Velocity (m/s)	Pipe Flow (l/s)	Status
S2.001	S2C	0.058	1.6	9.8	OK
S2.002	S2B - GEOCELL	3.349	0.3	3.8	SURCHARGED
S2.003	S2A	0.440	1.4	3.8	SURCHARGED
S1.003	S2	3.276	0.9	3.4	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 2 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR M5-60 (mm) 18.000 Cv (Summer) 0.750
Region England and Wales Ratio R 0.380 Cv (Winter) 0.840

Margin for Flood Risk Warning (mm) 300.0 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 1, 30, 100
Climate Change (%) 0, 0, 20

PN	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)
S1.000	S5	15 minute 100 year Winter I+20%	15.080	12.355	-0.115	0.000	0.12	
S1.001	S4	15 minute 100 year Winter I+20%	12.320	9.645	-0.115	0.000	0.12	
S1.002	S3	60 minute 100 year Winter I+20%	9.600	8.565	0.175	0.000	0.16	
S2.000	S2D	15 minute 100 year Winter I+20%	11.180	10.376	-0.104	0.000	0.20	
S2.001	S2C	15 minute 100 year Winter I+20%	11.180	9.242	-0.078	0.000	0.47	
S2.002	S2B - GEOCELL	60 minute 100 year Winter I+20%	9.540	8.569	0.419	0.000	0.87	
S2.003	S2A	60 minute 100 year Winter I+20%	9.540	8.562	0.412	0.000	0.10	
S1.003	S2	60 minute 100 year Winter I+20%	9.540	8.560	3.000	0.000	0.17	

PN	US/MH Name	Maximum Vol (m³)	Maximum Velocity (m/s)	Pipe Flow (l/s)	Status
S1.000	S5	0.005	2.0	6.1	OK
S1.001	S4	0.005	2.0	6.0	OK
S1.002	S3	0.051	2.0	7.5	SURCHARGED
S2.000	S2D	0.006	0.7	3.3	OK

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

PN	US/MH Name	Maximum Vol (m³)	Maximum Velocity (m/s)	Pipe Flow (l/s)	Status
S2.001	S2C	0.076	1.8	15.2	OK
S2.002	S2B - GEOCELL	8.748	0.3	4.4	SURCHARGED
S2.003	S2A	0.836	1.3	3.7	SURCHARGED
S1.003	S2	3.689	0.9	3.6	SURCHARGED

APPENDIX G

MicroDrainage Calculations (Drowned Outfall)

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 2 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR M5-60 (mm) 18.000 Cv (Summer) 0.750
Region England and Wales Ratio R 0.380 Cv (Winter) 0.840

Margin for Flood Risk Warning (mm) 300.0 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 1, 30, 100
Climate Change (%) 0, 0, 20

PN	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.
S1.000	S5	15 minute 100 year Winter I+20%	15.080	12.355	-0.115	0.000	0.12
S1.001	S4	15 minute 100 year Winter I+20%	12.320	9.645	-0.115	0.000	0.12
S1.002	S3	120 minute 100 year Winter I+20%	9.600	8.829	0.439	0.000	0.10
S2.000	S2D	15 minute 100 year Winter I+20%	11.180	10.376	-0.104	0.000	0.20
S2.001	S2C	15 minute 100 year Winter I+20%	11.180	9.242	-0.078	0.000	0.47
S2.002	S2B - GEOCELL	120 minute 100 year Winter I+20%	9.540	8.833	0.683	0.000	0.36
S2.003	S2A	120 minute 100 year Winter I+20%	9.540	8.828	0.678	0.000	0.05
S1.003	S2	120 minute 100 year Winter I+20%	9.540	8.826	3.266	0.000	0.11

PN	US/MH Name	Overflow (l/s)	Maximum Vol (m³)	Maximum Velocity (m/s)	Pipe Flow (l/s)	Status
S1.000	S5		0.005	2.0	6.1	OK
S1.001	S4		0.005	2.0	6.0	OK
S1.002	S3		0.096	1.6	4.6	SURCHARGED
S2.000	S2D		0.006	0.7	3.3	OK

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)	Pipe Flow (l/s)	Status
S2.001	S2C		0.076	1.8	15.2	OK
S2.002	S2B - GEOCELL		12.341	0.3	1.8	SURCHARGED
S2.003	S2A		1.137	1.1	2.0	SURCHARGED
S1.003	S2		3.991	0.1	2.3	SURCHARGED

APPENDIX H

MicroDrainage Calculations- Sensitivity

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 2 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR M5-60 (mm) 18.000 Cv (Summer) 0.750
Region England and Wales Ratio R 0.380 Cv (Winter) 0.840

Margin for Flood Risk Warning (mm) 300.0 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 1, 30, 100
Climate Change (%) 0, 0, 40

PN	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)
S1.000	S5	15 minute 100 year Winter I+40%	15.080	12.358	-0.112	0.000	0.14	
S1.001	S4	15 minute 100 year Winter I+40%	12.320	9.648	-0.112	0.000	0.14	
S1.002	S3	60 minute 100 year Winter I+40%	9.600	8.735	0.345	0.000	0.18	
S2.000	S2D	15 minute 100 year Winter I+40%	11.180	10.379	-0.101	0.000	0.24	
S2.001	S2C	15 minute 100 year Winter I+40%	11.180	9.249	-0.071	0.000	0.54	
S2.002	S2B - GEOCELL	60 minute 100 year Winter I+40%	9.540	8.739	0.589	0.000	0.83	
S2.003	S2A	60 minute 100 year Winter I+40%	9.540	8.733	0.583	0.000	0.11	
S1.003	S2	60 minute 100 year Winter I+40%	9.540	8.730	3.170	0.000	0.18	

PN	US/MH Name	Maximum Vol (m³)	Maximum Velocity (m/s)	Pipe Flow (l/s)	Status
S1.000	S5	0.005	2.1	7.1	OK
S1.001	S4	0.005	2.0	7.0	OK
S1.002	S3	0.078	2.0	8.6	SURCHARGED
S2.000	S2D	0.007	0.8	3.8	OK

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

PN	US/MH Name	Maximum Vol (m³)	Maximum Velocity (m/s)	Pipe Flow (l/s)	Status
S2.001	S2C	0.084	1.9	17.7	OK
S2.002	S2B - GEOCELL	11.369	0.3	4.2	SURCHARGED
S2.003	S2A	1.029	1.4	4.0	SURCHARGED
S1.003	S2	3.882	0.9	3.7	SURCHARGED

APPENDIX I

MicroDrainage Calculations- Sensitivity (Drowned Outfall)

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 2 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR M5-60 (mm) 18.000 Cv (Summer) 0.750
Region England and Wales Ratio R 0.380 Cv (Winter) 0.840

Margin for Flood Risk Warning (mm) 300.0 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 1, 30, 100
Climate Change (%) 0, 0, 40

PN	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.
S1.000	S5	15 minute 100 year Winter I+40%	15.080	12.358	-0.112	0.000	0.14
S1.001	S4	15 minute 100 year Winter I+40%	12.320	9.648	-0.112	0.000	0.14
S1.002	S3	120 minute 100 year Winter I+40%	9.600	9.499	1.109	0.000	0.11
S2.000	S2D	15 minute 100 year Winter I+40%	11.180	10.379	-0.101	0.000	0.24
S2.001	S2C	120 minute 100 year Winter I+40%	11.180	9.505	0.185	0.000	0.17
S2.002	S2B - GEOCELL	120 minute 100 year Winter I+40%	9.540	9.503	1.353	0.000	0.46
S2.003	S2A	120 minute 100 year Winter I+40%	9.540	9.497	1.347	0.000	0.05
S1.003	S2	120 minute 100 year Winter I+40%	9.540	9.495	3.935	0.000	0.13

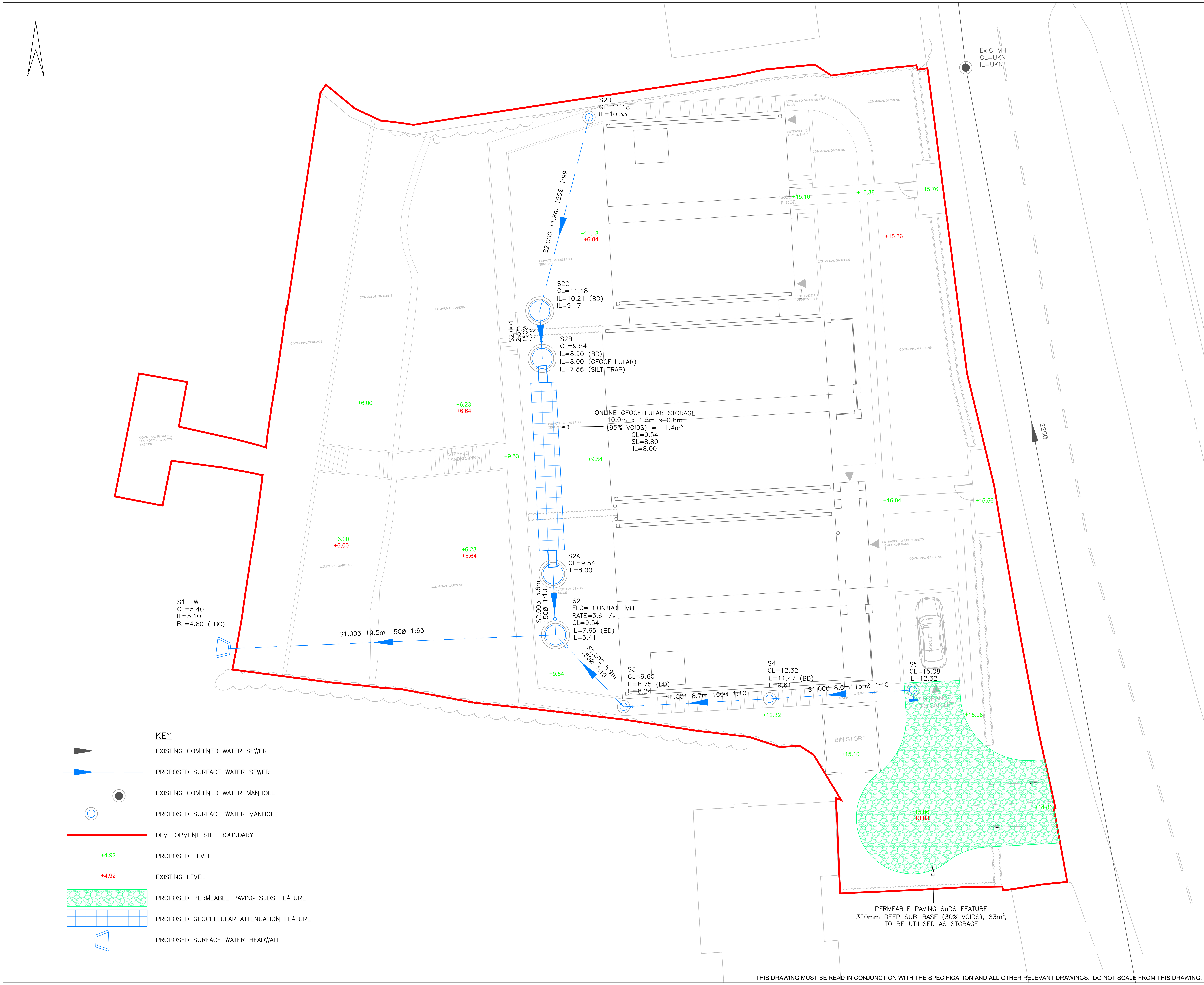
PN	US/MH Name	Overflow (l/s)	Maximum Vol (m³)	Maximum Velocity (m/s)	Pipe Flow (l/s)	Status
S1.000	S5		0.005	2.1	7.1	OK
S1.001	S4		0.005	2.0	7.0	OK
S1.002	S3		0.313	1.6	5.3	FLOOD RISK
S2.000	S2D		0.007	0.8	3.8	OK

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)	Pipe Flow (l/s)	Status
S2.001	S2C		0.373	1.4	5.6	SURCHARGED
S2.002	S2B - GEOCELL		13.128	0.2	2.3	FLOOD RISK
S2.003	S2A		1.894	1.1	2.0	FLOOD RISK
S1.003	S2		4.747	0.2	2.8	FLOOD RISK

APPENDIX J

Preliminary Surface Water Drainage Layout



KEY

- EXISTING COMBINED WATER SEWER
- PROPOSED SURFACE WATER SEWER
- EXISTING COMBINED WATER MANHOLE
- PROPOSED SURFACE WATER MANHOLE
- DEVELOPMENT SITE BOUNDARY
- +4.92 PROPOSED LEVEL
- +4.92 EXISTING LEVEL
- PROPOSED PERMEABLE PAVING SuDS FEATURE
- PROPOSED GEOCELLULAR ATTENUATION FEATURE
- PROPOSED SURFACE WATER HEADWALL

NOTES

1. THIS DRAWING TO BE READ IN CONJUNCTION WITH ALL RELEVANT WEETWOOD DRAWINGS.

DRAINAGE NOTES

1. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.
2. ALL LEVELS IN METRES.
3. ALL PROPOSED DRAINAGE TO BE MINIMUM 100Ø UNLESS NOTED OTHERWISE.
4. MINIMUM GRADIENTS:
   4.1. 150Ø SURFACE WATER = 1:100
5. ALL CONNECTING PIPES TO ADOPTABLE DRAINAGE TO BE MINIMUM 150Ø.
6. ALL HIGHWAY GULLY CONNECTIONS TO BE MINIMUM 150Ø.
7. ALL RAINWATER PIPES MUST BE FITTED WITH A RODDABLE ACCESS ABOVE GROUND.
8. ALL PRIVATE DRAINAGE TO BE INSTALLED IN ACCORDANCE WITH PART H OF THE BUILDING REGULATIONS AND BS EN 752 & 12056.
9. PRIVATE DRAINAGE TO BE UPVC PIPES WITH GRP OR UPVC INSPECTION CHAMBERS. SYSTEM DESIGN & CONSTRUCTION TO CONFORM WITH MANUFACTURER'S INSTRUCTIONS & "GOOD PRACTICE GUIDE".
10. PROPOSED SITE LAYOUT TAKEN FROM RADM ARCHITECTS LTD 'PROPOSED SITE PLAN' DRAWING (REF: RA2004, L(81)001, REV P4, DEC 2020).
12. EXISTING DRAINAGE INFORMATION TAKEN FROM DWR CYMRU WELSH WATER SEWER RECORD EXTRACT (REF: PLS0025987, OCT 2020).
13. EXISTING SITE LEVELS TAKEN FROM SITESCAN LTD 'TOPOGRAPHIC SURVEY' DRAWING (REF: P19113, REV A, JUNE 2019).
14. PROPOSED SITE LEVELS TAKEN FROM FROM RADM ARCHITECTS LTD 'PROPOSED SITE PLAN' DRAWING (REF: RA2004, L(81)001, REV P4, DEC 2020).
15. ALL EXISTING ON-SITE SURFACE WATER DRAINAGE APPARATUS TO BE ABANDONED AND REMOVED BEFORE THE IMPLEMENTATION OF THE PROPOSED SURFACE WATER DRAINAGE SYSTEM.
16. SURFACE WATER TO DISCHARGE TO THE RIVER DEE LOCATED TO THE WEST OF THE DEVELOPMENT SITE IN AT A RESTRICTED RATE OF 3.6l/s, SUBJECT TO APPROVAL BY THE ENVIRONMENT AGENCY.
15. SUB-BASE THICKNESS TO PERMEABLE PAVING SuDS FEATURES IS DESIGNED FOR WATER QUALITY. NO STRUCTURAL DESIGN ANALYSIS FOR VEHICLE LOADING HAS BEEN CARRIED OUT.
16. RETAINING WALL DESIGNS (BY OTHERS) TO CONSIDER THE SURFACE WATER DRAINAGE DESIGN PREPARED BY WEETWOOD, IF APPLICABLE.

Rev	Date	Description	Drawn	Check
P1	17-12-20	Issued for Information	OA	GW

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Client: STERLING PROPERTY CO. LTD

Drawing Status: PRELIMINARY

Project: THE RED HOUSE, DEE BANKS, CHESTER

Title: PROPOSED DRAINAGE LAYOUT

Date: DEC 2020
Scale (A1): 1:100
Drawn: OA
Checked: TB
Project No: 4902
Drawing No: C100
Revision: P1

THIS DRAWING MUST BE READ IN CONJUNCTION WITH THE SPECIFICATION AND ALL OTHER RELEVANT DRAWINGS. DO NOT SCALE FROM THIS DRAWING.

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