SITE LOCATED OFF GOODLASS ROAD, SPEKE

FLOOD RISK ASSESSMENT

Final Report v1.2

February 2011

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Report Title:	**Site Located off Goodlass Road, Speke** Flood Risk Assessment Final Report v1.2
Client:	Speke Business Park Limited
Date of Issue:	28 February 2011

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1 INTRODUCTION

Weetwood has been instructed by Speke Business Park Limited to undertake a Flood Risk Assessment (FRA) for the proposed redevelopment of a site located off Goodlass Road, Speke in accordance with the requirements of Planning Policy Statement 25 (PPS25): Development and Flood Risk.

In addition this report has been prepared in order to demonstrate compliance with Pol 5 (Flood Risk) of the *BRE Environmental and Sustainability Standard: BREEAM Industrial 2008 Assessor Manual*. Within the *BREEAM 2008 Industrial Assessor Manual* credits are awarded as follows for Pol 5:

Two credits

1. Where the assessed development is situated in a flood zone that is defined as having a low annual probability of flooding
2. A site specific FRA confirms that there is a low risk of flooding from all sources

One additional credit

3. Where attenuation measures are specified to ensure that the peak run-off rate from the site to the watercourse (natural or municipal) is no greater for the developed site than it is for the pre-development site
4. The capacity of the attenuation measures includes an allowance for climate change

1.1 SITE LOCATION

The site is located at Ordnance Survey National Grid Reference SJ 419 844 (**Figure 1**).

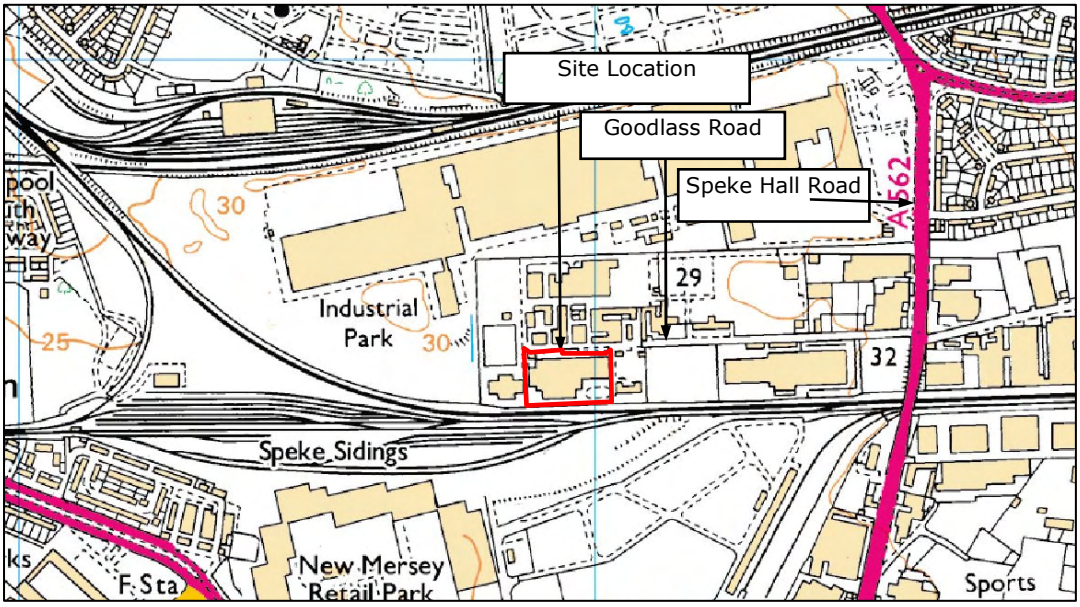


Image reproduced with permission of Ordnance Survey and Ordnance Survey of Northern Ireland

Figure 1: Site Location

1.2 EXISTING AND PROPOSED DEVELOPMENT

The site formerly comprised part of a paint and varnishing works. The buildings associated with the former paint and varnishing works have been demolished to allow for redevelopment. Currently, the site is comprised entirely of hardstanding areas.

Proposals are for the construction of four blocks of industrial units, associated car parking, and small landscaped areas. General industry is classified as *'less vulnerable'* development in Table D.2 of PPS25.

1.3 SITE LEVELS

A topographic survey of the site is provided in **Appendix B**. Site levels are in the region of 26.22 and 26.32 metres Above Ordnance Datum (m AOD).

1.4 ACCESS AND EGRESS

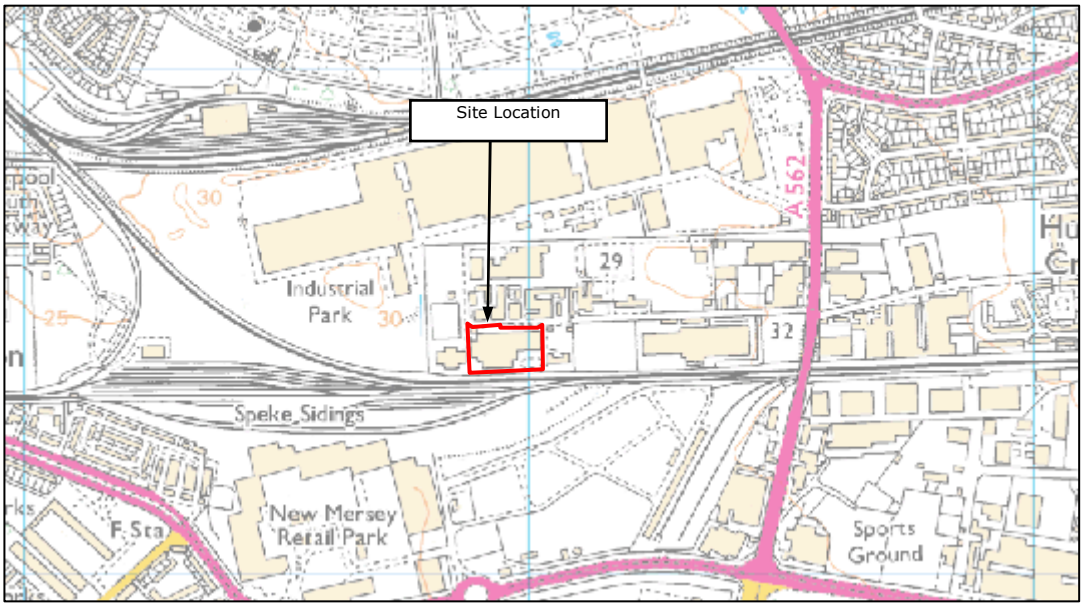
Access and egress for the site is provided directly off Goodlass Road, which leads in an easterly direction to Speke Hall Road.

2 PLANNING POLICY STATEMENT 25 (PPS25)

The aim of PPS25 is to ensure that flood risk is taken into account at all stages in the planning process and is appropriately addressed.

2.1 ENVIRONMENT AGENCY FLOOD MAP

According to the Environment Agency (EA) flood map (**Figure 2**), the site is located in Flood Zone 1 (land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding in any year (< 0.1%)).



Flooding from rivers / sea without defences (1 in 100 yr) – **Flood Zone 3**
Extent of extreme flood (1 in 1000 yr) – **Flood Zone 2**

Environment Agency, 100026380, 2010

Figure 2: Environment Agency Flood Map

2.2 BREEAM CREDIT

Flood Zone 1 is defined in Table D.1 of PPS25 as having a low annual probability of flooding. Therefore, the proposed redevelopment demonstrates compliance with point 1 (as previously detailed) of Pol 5 (Flood Risk) of the *BREEAM 2008 Industrial Assessor Manual*.

2.3 STRATEGIC FLOOD RISK ASSESSMENT

A SFRA was published by Liverpool City Council in 2008. The SFRA has been reviewed and the information therein has been used to inform this FRA.

2.4 SEQUENTIAL TEST

The aim of the Sequential Test (as outlined in Annex D of PPS25 and Chapter 4 of the PPS25 Practice Guide) is to encourage preference to be given to locating new development in areas at the lowest probability of flooding (i.e. Flood Zone 1).

The proposed development site is situated within Flood Zone 1 and is therefore shown to satisfy the requirements of the Sequential Test.

2.5 DEVELOPMENT AND FLOOD RISK

Table D.1 of PPS25 states that for development proposals on sites in Flood Zone 1 comprising one hectare or above, the vulnerability to flooding from other sources and the effect of the new development on surface water run-off should be incorporated in a FRA. This information is also required to demonstrate compliance with Pol 5 (Flood Risk) of the *BREEAM 2008 Industrial Assessor Manual.*

Other potential sources of flooding are discussed in **Section 3** of this report. The effect of the new development on surface water run-off is addressed in **Section 4**.

3 FLOOD RISK

3.1 TIDAL FLOOD RISK - RIVER MERSEY

The River Mersey Estuary is located approximately 2.2km to the south of the proposed development site.

As shown in **Figure 2** the site is not shown to be at risk of flooding from this source.

3.2 HISTORICAL FLOOD RECORDS

The SFRA does not list any historic records of flooding at or in the vicinity of the site.

The British Hydrological Society (BHS) Chronology[1] does not list any records of flooding at this location.

3.3 GROUNDWATER FLOODING

Groundwater flooding generally occurs during intense, long-duration rainfall events, when infiltration of rainwater into the ground raises the level of the water table until it exceeds ground levels. It is most common in low-lying areas overlain by permeable soils and permeable geology, or in areas with a naturally high water table.

A geo-environmental investigation and assessment[2] has been prepared for the portion of land located immediately adjacent to the eastern boundary of the site. This report indicates that natural soil conditions (beneath the top soil) are generally comprised of '*brown or reddish brown, sandy, gravelly clay'* (glacial till). '*The clay was assessed as being soft or firm initially becoming stronger with depth'*. This suggests that the risk of groundwater flooding at the site would be low.

According to Section 5.59 of the SFRA '*groundwater flooding could be an issue in Liverpool as the water table is rising'.*

The EA Mersey Estuary Catchment Flood Management Plan (CFMP) states[3] '*groundwater levels are rising in Liverpool and the Wirral…but in general, there is no known documented evidence of surface flooding from groundwater in the Mersey Estuary CFMP area'*.

Any residual risk of groundwater flooding to the proposed buildings could be mitigated by raising finished floor levels above the levels of the immediately adjacent surrounding land.

[1] British Hydrological Society Chronology http://www.dundee.ac.uk/geography/cbhe/

[2] Results of a Phase ii Geo-Environmental Investigation and Assessment, Goodlass Road, Speke, February 2008

[3] EA Mersey Estuary Catchment Flood Management Plan Summary Report (December 2009)

3.4 SURFACE WATER FLOODING

Surface water flooding comprises ***pluvial flooding***, ***sewer flooding*** and flooding from ***highway drains and gullies***.

3.4.1 Pluvial Flooding

Pluvial flooding results from rainfall-generated overland flow, before the runoff enters any watercourse or sewer, or where the sewerage/drainage systems and watercourses are overwhelmed and therefore unable to accept surface water. Pluvial flooding is usually associated with high intensity rainfall events but may also occur with lower intensity rainfall where the ground is saturated, developed or otherwise has low permeability resulting in overland flow and ponding within depressions in the topography.

Section 3.38 of the SFRA confirms that *'there is limited information regarding surface water flooding in the catchment'*.

As previously noted, the site is currently comprised entirely of impermeable areas. Through the introduction of new landscaped (permeable) areas redevelopment of the site will reduce surface water runoff both at the site and in the surrounding areas. This will help minimise the likelihood of pluvial flooding; any residual risk to the proposed buildings could be mitigated by raising finished floor levels above the levels of the immediately adjacent surrounding land.

3.4.2 Sewer Flooding

Sewer flooding occurs when the capacity of underground sewerage systems is exceeded, resulting in flooding inside and outside of buildings. Normal discharge of sewers and drains through outfalls may be impeded by high water levels in receiving waters.

Table 10 of the SFRA identifies the number of properties within postcode areas which have experienced sewer flooding; no properties in the postcode area of the site (L24) are identified.

United Utilities has confirmed that they do hold any records of sewer flooding at or in the immediate vicinity of the site.

The risk of flooding from sewers is therefore considered to be low.

3.4.3 Flooding from Highway Drains and Gullies

Table 8 of the SFRA records an incident of flooding in 2002 at Speke Road (between Speke Hall Road and Speke Retail Park), which is located approximately 550m to the south of the site.

There are no recorded incidents at or in the vicinity of the site and therefore the risk of flooding from highway drains and gullies is considered to be low.

3.5 BREEAM CREDIT

The above confirms that there is a low risk of flooding from all sources therefore demonstrating compliance with point 2 (as previously detailed) of Pol 5 (Flood Risk) of the *BREEAM 2008 Industrial Assessor Manual*.

4 MITIGATION MEASURES

4.1 FLOOD MITIGATION

In order to mitigate the residual risk from groundwater flooding and pluvial flooding finished floor levels should be set above the levels of the immediately adjacent surrounding land, by at least 150mm.

4.2 ACCESS AND EGRESS

As previously noted, access and egress for the site is provided directly off Goodlass Road, which leads in an easterly direction to Speke Hall Road. This route is shown to be located within Flood Zone 1 and will therefore provide dry access and egress to the site.

5 SURFACE WATER

5.1 REQUIREMENTS FOR SURFACE WATER DRAINAGE AT THE SITE

PPS25 recommends that surface water arising from the developed site should, as far as is practicable, be managed in a sustainable manner to mimic the surface water flows arising from the site prior to the proposed development.

Redevelopment of the site should be such that the peak flow rates of surface water leaving the developed site are no greater than the rates prior to development. Opportunities to reduce surface water runoff, and the associated flood risk, should also be identified and climate change taken into consideration.

Recognising the above, and the requirements of the EA[4], Building Regulations Approved Document H, the Code for Sustainable Homes Technical Guide (Category 4) and the requirement placed upon local planning authorities in PPS25 to promote the use of Sustainable Drainage Systems (SUDS), surface water runoff from the proposed site should demonstrate:

- no increase in existing flow rates discharged to watercourse/public sewer
- the use of SUDS as the preferred method of dealing with surface water
- how runoff up to the 1 in 100 year event plus an allowance for climate change will be dealt with without increasing flood risk elsewhere

5.2 SITE AREAS

The existing and proposed impermeable and permeable areas at the site are shown in **Table 1**. This indicates that the extent of impermeable area at the site will decrease by 0.04ha following redevelopment of the site.

Table 1: Site Areas

	Existing Site	Redeveloped Site
Impermeable Area (ha)	1.40	1.36
Permeable Area (ha)	0.00	0.04
TOTAL (ha)	1.40	1.40

5.3 SURFACE WATER RUNOFF FROM THE EXISTING SITE

The United Utilities (UU) public sewer records (**Appendix C**) indicate that there are a number of public sewers in the vicinity of the site. The nearest public sewer to the site is a 1372 x 2057 brick combined sewer which is located to the west of the site. Given that there are no watercourses in the immediate vicinity of the site, and that infiltration is not considered feasible (as detailed in Section 5.4.2.1), it is reasonable to assume that surface water runoff from the existing site discharges into the public brick combined sewer.

[4] Preliminary Rainfall Runoff Management for Developments, R&D Technical Report W5-074/A/TR/1 Revision C, 2005

5.3.1 Runoff from Existing Impermeable Surfaces

The Modified Rational Method[5] has been used to calculate the runoff from the impermeable surfaces at the existing site, as detailed in **Appendix D**. The flow rates calculated are shown in **Table 2**.

Table 2: Existing Runoff from Impermeable Areas

Return Period	Flow Rate for 1.4ha impermeable area (l/s)
1 in 2 year	225.4
1 in 30 year	421.6
1 in 100 year	538.2

5.4 SURFACE WATER RUNOFF FROM THE REDEVELOPED SITE

Table 1 indicates that impermeable areas at the site will decrease following redevelopment. The following sections describe how surface water runoff from the redeveloped site may be managed in line with the requirements of PPS25.

5.4.1 Surface Water Discharge Rate

Paragraph F10 of PPS25 states that the surface water drainage arrangements for any site should be such that the peak flow rates of surface water leaving a developed site are no greater than the rates prior to the proposed development.

It is proposed to limit runoff rates from the proposed impermeable areas to **421.6l/s**. This is the existing 1 in 30 year flow rate from the existing impermeable areas, as calculated in **Appendix D** and shown in **Table 2**. This restriction will ensure that rates of runoff from the site do not increase following redevelopment. The drainage system for the proposed site will be designed to manage flows in up to the 1 in 100 year event including an allowance for climate change.

5.4.2 Disposal of Surface Water

Building Regulations Approved Document Part H sets out a hierarchy of preferred methods for the disposal of surface water runoff. These are listed below in order of preference:

1. Disposal by infiltration
2. Disposal to a watercourse
3. Disposal to a public sewer[6]

5.4.2.1 Infiltration

According to the maps provided in '*The Wallingford Procedure*[7]' soil conditions at the site are generally impermeable.

[5] The Wallingford Procedure, Volume 4, 1981

[6] Building Regulations Approved Document H Section 3 page 45

[7] See footnote 4

As noted in Section 3.3 a geo-environmental investigation and assessment[8] has been prepared for the portion of land located immediately adjacent to the eastern boundary of the site. Recognising the soil conditions at the site, the report concludes that '*soakaway drainage will not be possible'*.

Recognising the above, infiltration methods are not considered suitable for the disposal of surface water from the site.

5.4.2.2 Discharge to Watercourse

As previously noted the River Mersey Estuary is located approximately 2.2km to the south of the proposed development site. It is therefore not considered feasible to discharge directly to the estuary.

5.4.2.3 Discharge to Sewer

PPS25 recommends that surface water arising from the redeveloped site should **mimic** the surface water flows arising from the site prior to the proposed redevelopment. Given that it is assumed that surface water runoff from the existing site currently discharges into the public combined brick sewer, it is proposed that surface water runoff from the redeveloped site will mimic the existing situation and continue to discharge into the public sewer system.

UU will need to be consulted at the detailed drainage design stage to confirm that the rate of surface water runoff to the public sewer system is acceptable.

5.4.3 SUDS Options and Storage Calculations

In order to restrict runoff rates from the proposed impermeable areas as set out in **Section 5.4.1**, attenuation storage will be provided.

The surface water storage facilities described in the following sections have been modelled using the *Detailed Design* module of MicroDrainage Source Control.

5.4.3.1 Storage Volume Calculation- Total Storage Volume

The required storage volume has been sized to store the 1 in 100 year storm event including a 20% increase in rainfall intensity in order to allow for climate change in accordance with Table B.2 of PPS25.

The parameters used in the storage calculation along with the MicroDrainage Source Control output results are shown in **Appendix E** which indicates that a storage volume of **129.2m^3** would be required. An orifice flow control device was used, achieving a flow rate of 420.8 l/s.

SUDS elements may be used to provide the required storage. Typical SUDS components include surface or subsurface storage (such as underground tank or oversized pipes) with flow limiting devices.

[8] Results of a Phase ii Geo-Environmental Investigation and Assessment, Goodlass Road, Speke, February 2008

5.4.4 Maintenance of SUDS

PPS25 requires that the ownership and responsibility for maintenance of SUDS elements should be clear. In the past local planning authorities and water companies have been reluctant to adopt SUDS. With no arrangements in place that require LPAs or water companies to adopt SUDS their maintenance has subsequently been the responsibility of the developer.

The Flood and Water Management Act (2010) received Royal Assent on 8 April 2010 but the ministerial order to commence that Act has not yet been made. Paragraph 17 of the Act imposes a duty on the approving body (generally a unitary, county or county borough local authority) to adopt and maintain any new drainage system which has been constructed in line with an approved drainage plan and which conforms with national policy and is defined as a *'sustainable drainage system'*. Prior to commencement of the Act, there may be a period of consultation to establish some national standards which can be applied by local authorities and developers to suit local conditions. The new approval system is unlikely to be in place until October 2011 at the earliest, and possibly not until April 2012.

In the meantime, options for maintenance of SUDS could include:

- SUDS elements within the curtilage of the site (e.g. tanks) will be the responsibility of the management company

5.4.5 Final Drainage Layout

The purpose of this FRA is to demonstrate that a surface water drainage strategy is feasible for the site given the development proposals and the land available. The site layout provides the opportunity for the inclusion of SUDS elements, ensuring that there will be no increase in surface water runoff from the proposed development.

In is important to note that a final decision on the types of storage to be provided will be made at the detailed drainage design stage.

5.5 BREEAM CREDITS

In order to restrict runoff rates from the proposed areas at the site following redevelopment, attenuation storage of 129.2m^3 is proposed and this includes a 20% allowance for climate change.

This therefore demonstrates compliance with points 3 and 4 (as previously detailed) of Pol 5 (Flood Risk) of the *BREEAM 2008 Industrial Assessor Manual*.

6 CONCLUSIONS

6.1 PLANNING POLICY STATEMENT 25 (PPS25)

There are proposals for the redevelopment of a site located off Goodlass Road, Speke. According to the EA flood map the proposed development site is located outside the 1 in 1,000 year flood outline and is therefore defined as being situated within Flood Zone 1.

The proposed development site, being located in Flood Zone 1, is shown to satisfy the requirements of the Sequential Test.

Any residual risk of groundwater flooding or pluvial flooding to the proposed buildings could be mitigated by raising finished floor levels to a minimum of 150mm above the levels of the immediately adjacent surrounding land.

Access and egress for the site is provided directly off Goodlass Road, which leads in an easterly direction to Speke Hall Road. This route is shown to be located within Flood Zone 1 and will therefore provide dry access and egress to the site.

Following redevelopment the overall impermeable areas at the site are expected to decrease. In accordance with Annex F of PPS25, surface water discharges should be no greater than those rates prior to development. A scheme for the provision and implementation of a surface water regulation system following the principles set out in this FRA should be submitted to and approved in writing by the LPA, prior to the commencement of development.

6.2 BREEAM INDUSTRIAL 2008 ASSESSOR MANUAL: POL 5 (FLOOD RISK)

This report has also been prepared in order to demonstrate compliance with Pol 5 (Flood Risk) of the *BRE Environmental and Sustainability Standard: BREEAM Industrial 2008 Assessor Manual.* Within the *BREEAM 2008 Industrial Assessor Manual* credits are awarded as follows for Pol 5:

Two credits

1. Where the assessed development is situated in a flood zone that is defined as having a low annual probability of flooding
2. A site specific FRA confirms that there is a low risk of flooding from all sources

The EA Flood Maps confirms that the site is located within Flood Zone 1 (i.e. low annual probability of flooding). This FRA confirms that there is a low risk of flooding from all sources. As such, the first two credits of Pol 5 may be awarded to the development.

One additional credit

3. Where attenuation measures are specified to ensure that the peak run-off rate from the site to the watercourse (natural or municipal) is no greater for the developed site than it is for the pre-development site
4. The capacity of the attenuation measures includes an allowance for climate change

In order to restrict runoff rates from the proposed areas at the site following redevelopment, attenuation storage of 129.2m^3 is proposed and this includes a 20% allowance for climate change. The one additional credit may therefore be awarded subject to the implementation of the drainage strategy as outlined within this report.

7 RECOMMENDATIONS

This FRA has demonstrated that the proposed development may be completed without conflicting with the requirements of PPS25 subject to the following:

- Finished floor levels to be set at a minimum of 150mm above adjacent ground levels
- The detailed drainage design, developed in accordance with the principles set down in this FRA, should be submitted to and approved by the local planning authority prior to the commencement of development
- The site has satisfied all criteria of the Pol 5 *BREEAM 2008 Industrial Assessors Manual* and as such should be awarded the maximum 3 credits

APPENDIX A: Proposed Site Layout

APPENDIX B: Topographic Survey

APPENDIX C: United Utilities Public Sewer Record

APPENDIX D: Modified Rational Method Calculation

The Modified Rational Method[9] has been used to calculate the runoff from the impermeable surfaces at the existing site.

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

M5-60 minute rainfall depth:	20 mm
Ratio of M5-60 to M5-2 day rainfall:	0.4
Average Annual Rainfall:	800 mm
Winter Rain Acceptance Potential/ Soil Type :	4 / 0.45
The Urban Catchment Wetness Index (UCWI) value:	85

A time of concentration of 8 minutes has been used comprising a time of entry of 4 minutes and a time of flow of 4 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 2 year, 1 in 30 year and 1 in 100 year return period events. The calculated rainfall intensities for these events are 55.6, 104.0, and 132.8 mm/hr respectively.

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

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

where:

C_v is the volumetric runoff coefficient = P_r/PIMP = 0.8
where P_r is Percentage Runoff and PIMP is Percentage Impermeable Area
C_r is the routing coefficient = 1.3
Impermeable Area = 1.4 ha

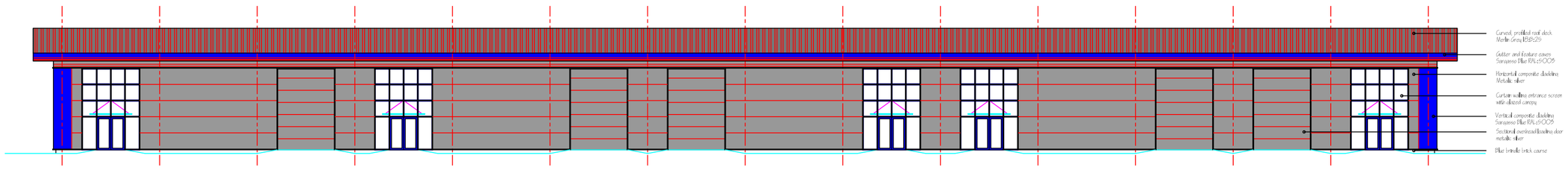
The flow rates for the impermeable areas at the existing site are shown in the table below.

Flow Rates for Impermeable Areas, Existing Site

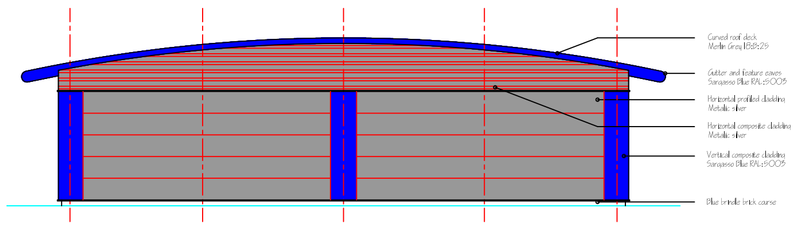
Return Period	Flow Rate for 1.4ha impermeable area (l/s)
1 in 2 year	225.4
1 in 30 year	421.6
1 in 100 year	538.2

[9] The Wallingford Procedure, Volume 4, 1981

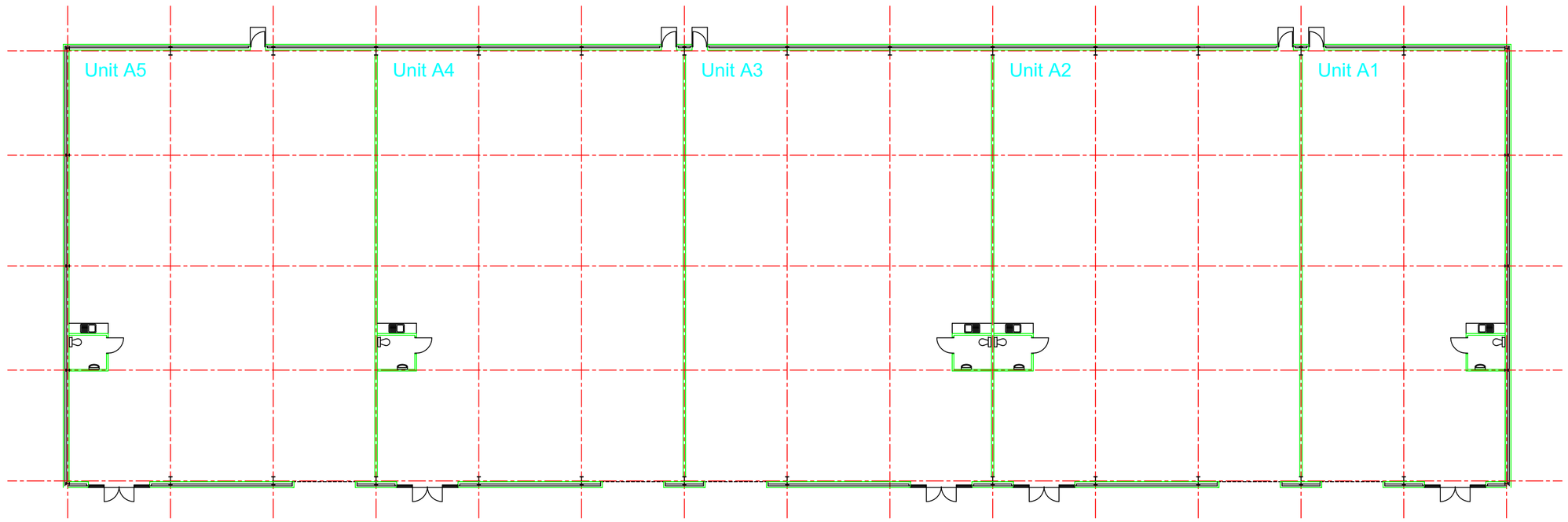
APPENDIX E: MicroDrainage Storage Volume Calculation



FRONT ELEVATION 1:200



GABLE ELEVATION 1:200



UNIT A FLOOR PLAN 1:200

ACCOMMODATION SCHEDULE

BLOCK A

A1	301sq.m.	3250sq.ft.
A2	455sq.m.	4900sq.ft.
A3	455sq.m.	4900sq.ft.
A4	455sq.m.	4900sq.ft.
A5	455sq.m.	4900sq.ft.
TOTAL	2121sq.m.	22850sq.ft.

BLOCK B

B1	300sq.m.	3330sq.ft.
B2	300sq.m.	3330sq.ft.
B3	300sq.m.	3330sq.ft.
B4	300sq.m.	3330sq.ft.
TOTAL	1200sq.m.	13320sq.ft.

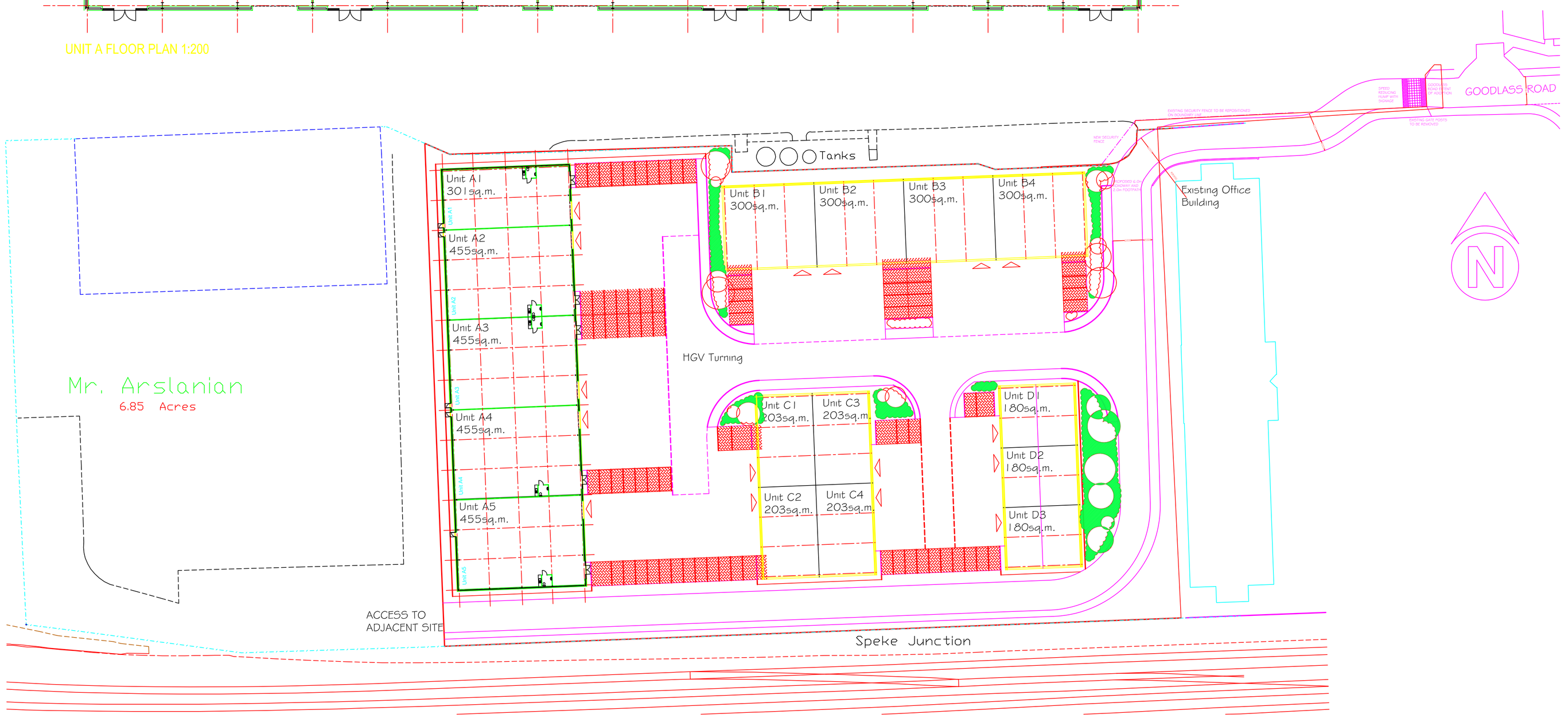
BLOCK C

C1	203sq.m.	2185sq.ft.
C2	203sq.m.	2185sq.ft.
C3	203sq.m.	2185sq.ft.
C4	203sq.m.	2185sq.ft.
TOTAL	812sq.m.	8740sq.ft.

BLOCK D

D1	180sq.m.	2000sq.ft.
D2	180sq.m.	2000sq.ft.
D3	180sq.m.	2000sq.ft.
TOTAL	540sq.m.	6000sq.ft
SITE TOTAL	4673sq.m.	50910sq.ft.

PARKING FOR 83 CARS 1 per 50sq.m.



SITE LAYOUT PLAN 1:500

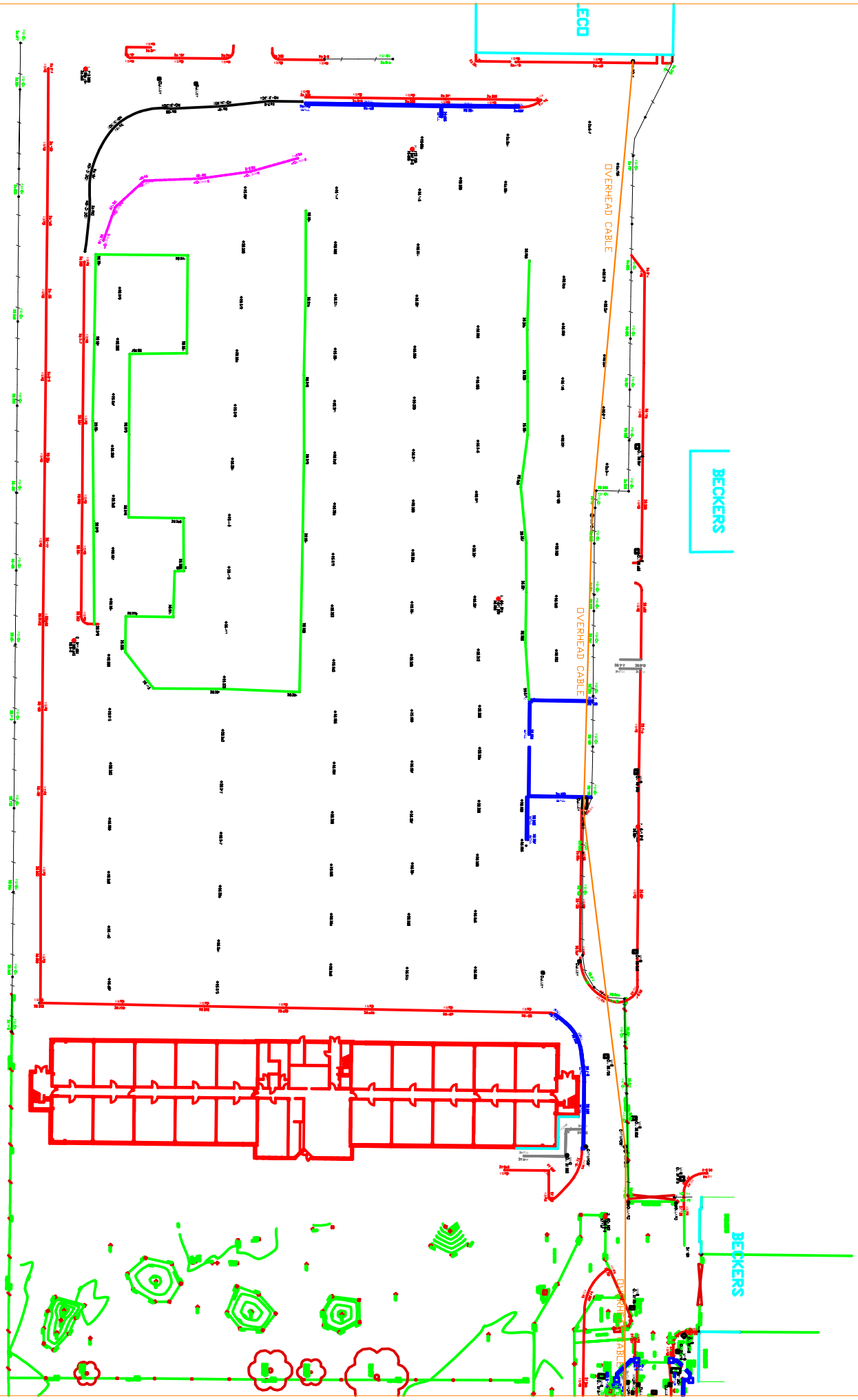
PROPOSED INDUSTRIAL UNITS
GOODLASS ROAD
SPEKE

SITE LAYOUT PLAN

Scale: 1:500+200 Date: Sept 2010 No. 3000/07A

CRAVEN DESIGN partnership
Architectural Services
Ribble Court, 1 Mead Way
Shuttleworth Mead
Business Park
Padiham, Burnley
Tel: 01282 779665
Fax: 01282 777591
Email: tech@cravendesign.co.uk

THIS DRAWING MUST NOT BE SCALED, ONLY WRITTEN DIMENSIONS MUST BE USE.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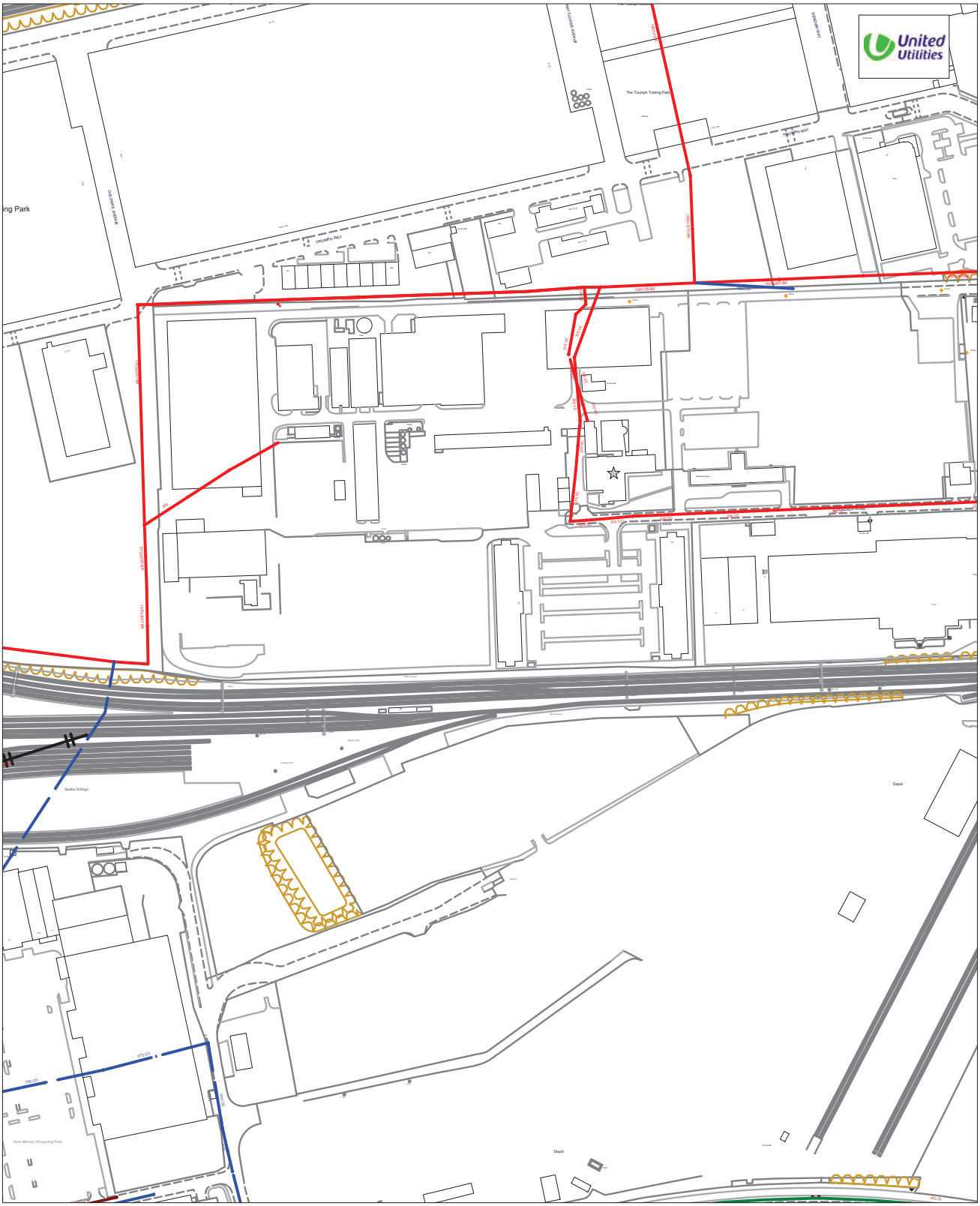

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Date 18/02/2011

Extract From Map of Public Sewers

Site off Goodless Road, Liverpool

Red or Brown - Foul Sewers

Blue - Surface Water Sewers

Legend

- Abandoned Sewer
- Public Sewer
- Highway Drain
- Private Sewer
- Pumping Main
- Section 104 Sewer

Refer to colour guide for content of pipe

The position of underground apparatus shown on this plan is approximate only and is given in accordance with the best information currently available. The actual positions may be different from those shown on the plan and private pipes sewers or drains may not be recorded. United Utilities will not accept any liability for any damage caused by the actual positions being different from those shown.

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.904	0.904	393.3	116.8	O K
30 min Summer	0.926	0.926	399.8	119.6	O K
60 min Summer	0.786	0.786	356.8	101.6	O K
120 min Summer	0.610	0.610	272.8	78.8	O K
180 min Summer	0.519	0.519	214.2	67.0	O K
240 min Summer	0.460	0.460	176.7	59.4	O K
360 min Summer	0.387	0.387	132.1	50.0	O K
480 min Summer	0.334	0.334	107.2	43.1	O K
600 min Summer	0.298	0.298	91.0	38.5	O K
720 min Summer	0.275	0.275	79.5	35.5	O K
960 min Summer	0.248	0.248	63.7	32.1	O K
1440 min Summer	0.216	0.216	46.0	27.9	O K
2160 min Summer	0.179	0.179	33.3	23.1	O K
2880 min Summer	0.159	0.159	26.3	20.6	O K
4320 min Summer	0.135	0.135	19.0	17.4	O K
5760 min Summer	0.119	0.119	15.0	15.3	O K
7200 min Summer	0.109	0.109	12.5	14.0	O K
8640 min Summer	0.102	0.102	10.8	13.1	O K
10080 min Summer	0.095	0.095	9.5	12.2	O K
15 min Winter	1.000	1.000	420.8	129.2	O K
30 min Winter	0.956	0.956	408.6	123.5	O K
60 min Winter	0.724	0.724	335.7	93.5	O K
120 min Winter	0.535	0.535	224.8	69.2	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	118.417	15
30 min Summer	77.747	22
60 min Summer	48.611	38
120 min Summer	29.354	66
180 min Summer	21.556	96
240 min Summer	17.210	128
360 min Summer	12.501	188
480 min Summer	9.962	248
600 min Summer	8.347	308
720 min Summer	7.221	368
960 min Summer	5.740	488
1440 min Summer	4.148	734
2160 min Summer	2.992	1100
2880 min Summer	2.371	1468
4320 min Summer	1.705	2156
5760 min Summer	1.348	2936
7200 min Summer	1.123	3584
8640 min Summer	0.967	4352
10080 min Summer	0.852	5088
15 min Winter	118.417	15
30 min Winter	77.747	22
60 min Winter	48.611	38
120 min Winter	29.354	68

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
180 min Winter	0.447	0.447	168.7	57.7	O K
240 min Winter	0.393	0.393	135.8	50.8	O K
360 min Winter	0.316	0.316	99.3	40.8	O K
480 min Winter	0.275	0.275	79.5	35.5	O K
600 min Winter	0.254	0.254	67.0	32.8	O K
720 min Winter	0.239	0.239	58.1	30.8	O K
960 min Winter	0.216	0.216	46.0	27.9	O K
1440 min Winter	0.179	0.179	33.3	23.2	O K
2160 min Winter	0.153	0.153	24.0	19.7	O K
2880 min Winter	0.135	0.135	19.1	17.4	O K
4320 min Winter	0.114	0.114	13.8	14.7	O K
5760 min Winter	0.102	0.102	10.9	13.2	O K
7200 min Winter	0.092	0.092	9.0	11.9	O K
8640 min Winter	0.085	0.085	7.8	11.0	O K
10080 min Winter	0.080	0.080	6.9	10.3	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
180 min Winter	21.556	98
240 min Winter	17.210	128
360 min Winter	12.501	188
480 min Winter	9.962	248
600 min Winter	8.347	308
720 min Winter	7.221	366
960 min Winter	5.740	490
1440 min Winter	4.148	734
2160 min Winter	2.992	1096
2880 min Winter	2.371	1472
4320 min Winter	1.705	2196
5760 min Winter	1.348	2872
7200 min Winter	1.123	3672
8640 min Winter	0.967	4400
10080 min Winter	0.852	5112

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time / Area Diagram

Total Area (ha) 1.360

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.680	4-8	0.680

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	129.2	2.800	129.2	5.600	129.2	8.400	129.2
0.400	129.2	3.200	129.2	6.000	129.2	8.800	129.2
0.800	129.2	3.600	129.2	6.400	129.2	9.200	129.2
1.200	129.2	4.000	129.2	6.800	129.2	9.600	129.2
1.600	129.2	4.400	129.2	7.200	129.2	10.000	129.2
2.000	129.2	4.800	129.2	7.600	129.2		
2.400	129.2	5.200	129.2	8.000	129.2		

Orifice Outflow Control

Diameter (m) 0.481 Discharge Coefficient 0.600 Invert Level (m) 0.000