

Ford Carpark Extension, Halewood

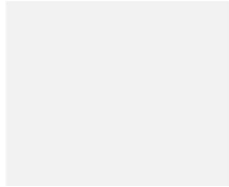
Drainage Strategy

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Contacts



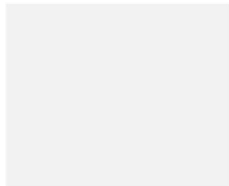
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Ford Car Park Extension Halewood

Drainage Strategy

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Contents

1 Introduction.....5

2 Existing Site and Description6

3 Proposed Development.....12

4 Planning Policy Requirements13

5 Surface Water Management Strategy15

6 Maintenance17

7 Conclusion21

Appendices

Appendix A

Appendix B

1 Introduction

1.1 Purpose Of Report

This report has been prepared by Arcadis Consulting (UK) Ltd for Ford Halewood Transmissions Ltd. The purpose of this report is to set out a viable surface water drainage strategy to support a proposed carpark extension located to the North of South Road, Halewood.

This report provides the findings of the Drainage Strategy for the provision of additional storage and car parking within the area known as Getrag.

2 Existing Site and Description

2.1 Location

The Ford Halewood car park site, or hereafter within this report named 'the site', is located approximately 15km West of Warrington and 12km Southeast of Liverpool town centres. The site is centred at National Grid reference 345251, 383898, near postcode L24 9PZ.

The 0.906ha Site is located on land to the North of Speke Boulevard and located to the East of the existing Ford Halewood car park. The proposed site is comprised currently of existing green space, with an access route from the existing car park running along the Northern face of the proposed site boundary.

An extract of Ordnance Survey Mapping, showing the site location is shown in **Figure 1** below.

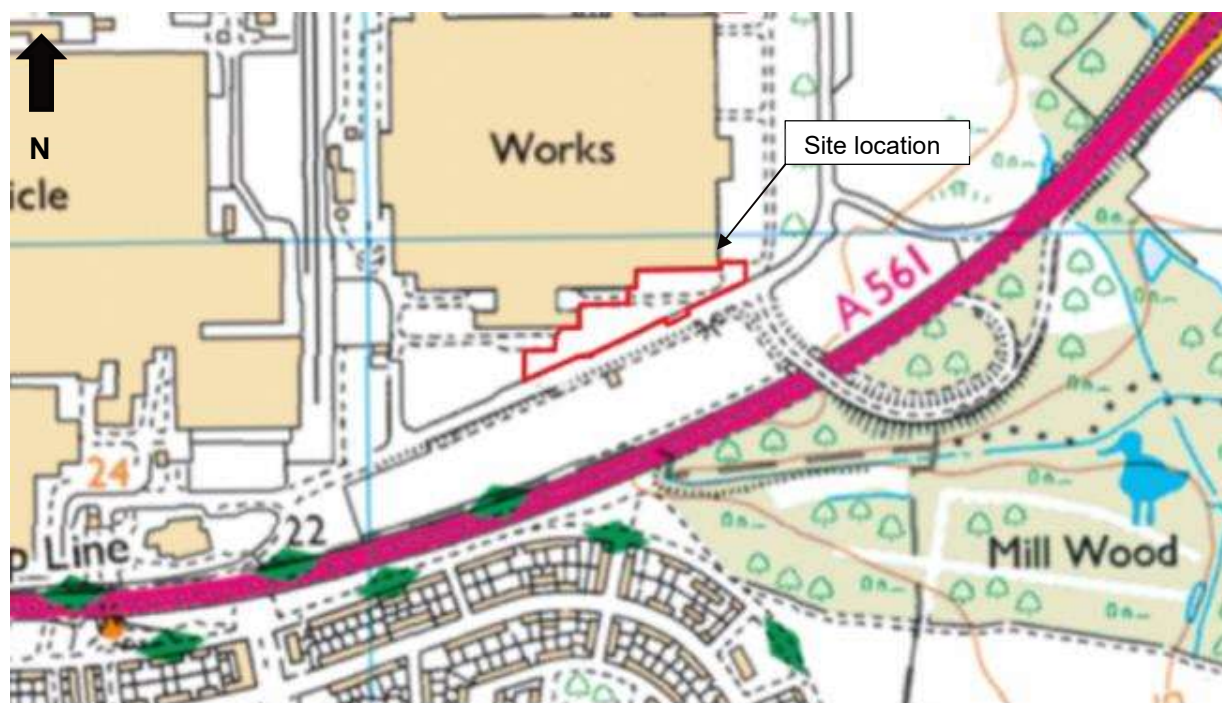


Figure 1 - Car Park Site Location (Ordnance Survey Mapping)

2.2 Site Topography

The site appears to be relatively flat with levels along the Northern Boundary of the Site ranging from approximately 21.1m to 21.6m AOD. On the Eastern Boundary, on the North Corner the level is 21.5m and the Southern corner 21.9m AOD. On the southern Boundary the levels fluctuate between 21.9 and 22.1m AOD, and along the western edge of the site between 21.4 and 22.1m AOD. The site tends to slope towards the building, South to North, with the higher levels located along the Southern Boundary of the site. There appears to be very little slope in the East-West plane.

2.3 Ground Conditions

From a review of the landscape classification displayed by Magic maps¹, the subsurface in the area of the site appears to be comprised of 'Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils'. This mapping is shown in **Figure 3** below.

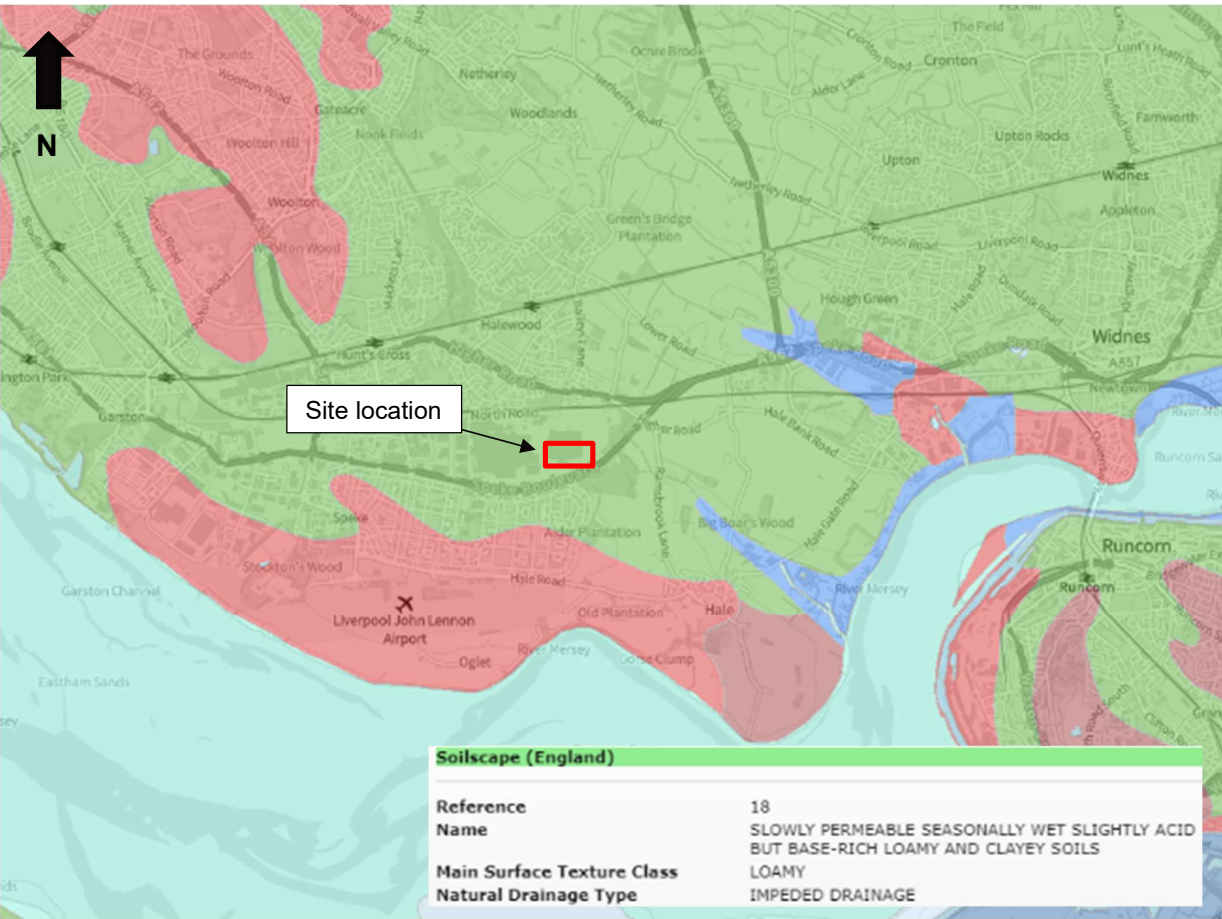


Figure 2 - Landscape Classification of site (Magic Map)

The British Geological Survey (BGS)² maps were also reviewed. Using the BGS he bedrock geology of the site is comprised of Kinnerton sandstone formations as shown below in **Figure 4** below.

¹ <https://magic.defra.gov.uk/magicmap.aspx>

² https://mapapps2.bgs.ac.uk/geoindex/home.html?layer=BGSBoreholes&_ga=2.55596587.1439428944.1678976392-1350448516.1678976392

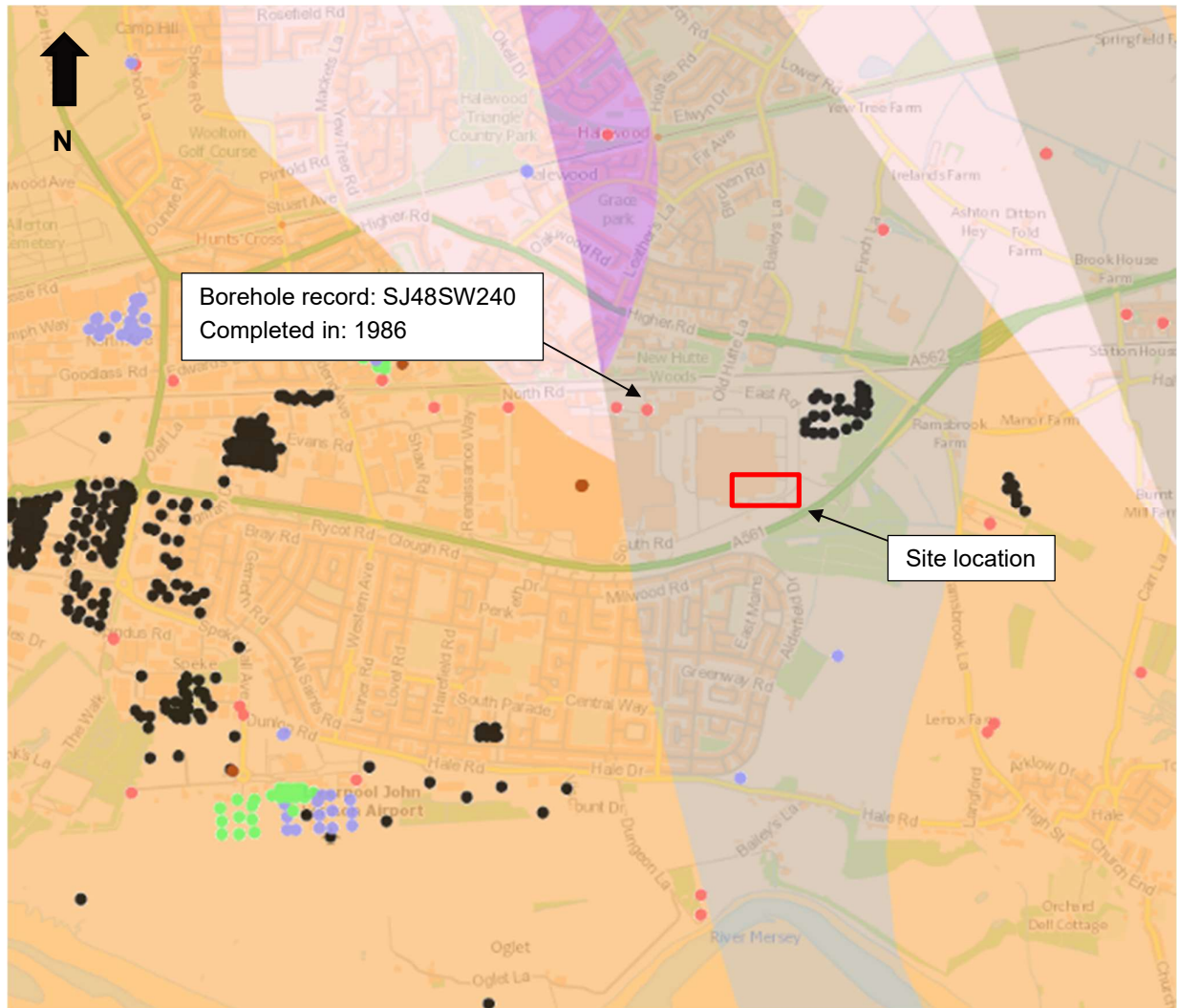


Figure 3 - Bedrock Geology of the site (BGS)

From the BGS maps, there were some existing borehole logs that were reviewed. The borehole reviewed was 800m away from the site with the following strata which corresponded to the superficial deposits and bedrock (as shown in **Figure 4**):

Soil layer	Depth
Brown CLAY with pebbles	0 - 36m
Red SANSTONE	36m+

Review of the Magic Maps, the site was also found to be located within a source protection zone (SPZ) 3: total catchment (**Figure 5**). SPZ3 is defined as³:

³ <https://www.gov.uk/guidance/groundwater-source-protection-zones-spzs>

“This is the area around a supply source within which all the groundwater ends up at the abstraction point. This is the point from where the water is taken. This could extend some distance from the source point.”

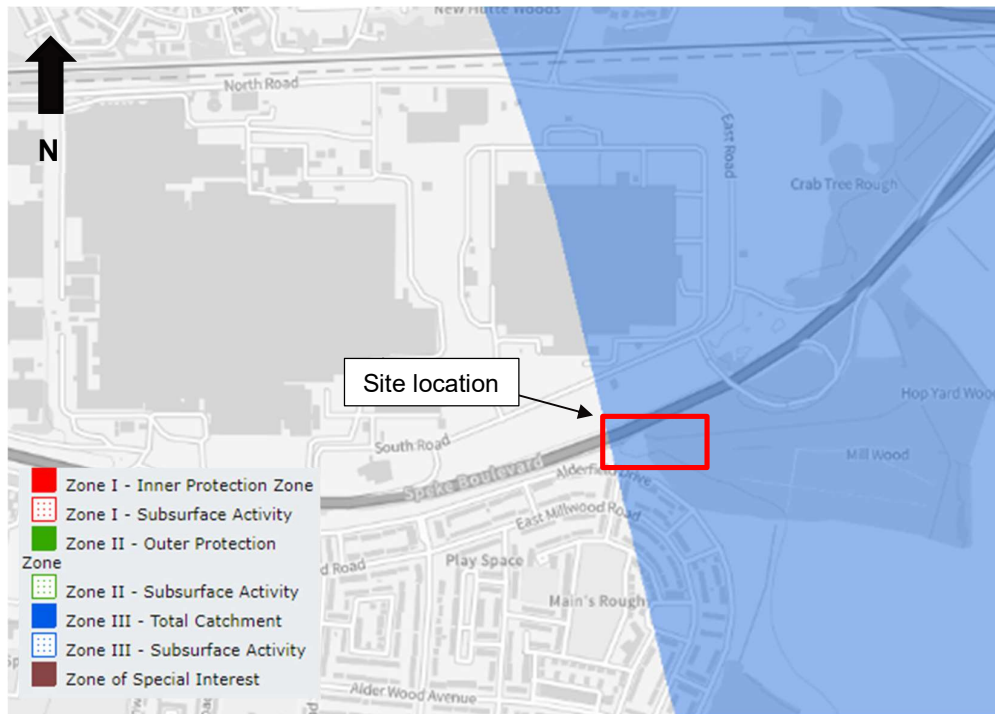


Figure 4 – Source protection zones (Magic Maps)

2.4 Existing Watercourses

There are no watercourse or waterbodies within the site boundary. The closest watercourses are a watercourse located 200m away across the A561 and another located 410m away to the east of the site. These are shown in Figure 6.

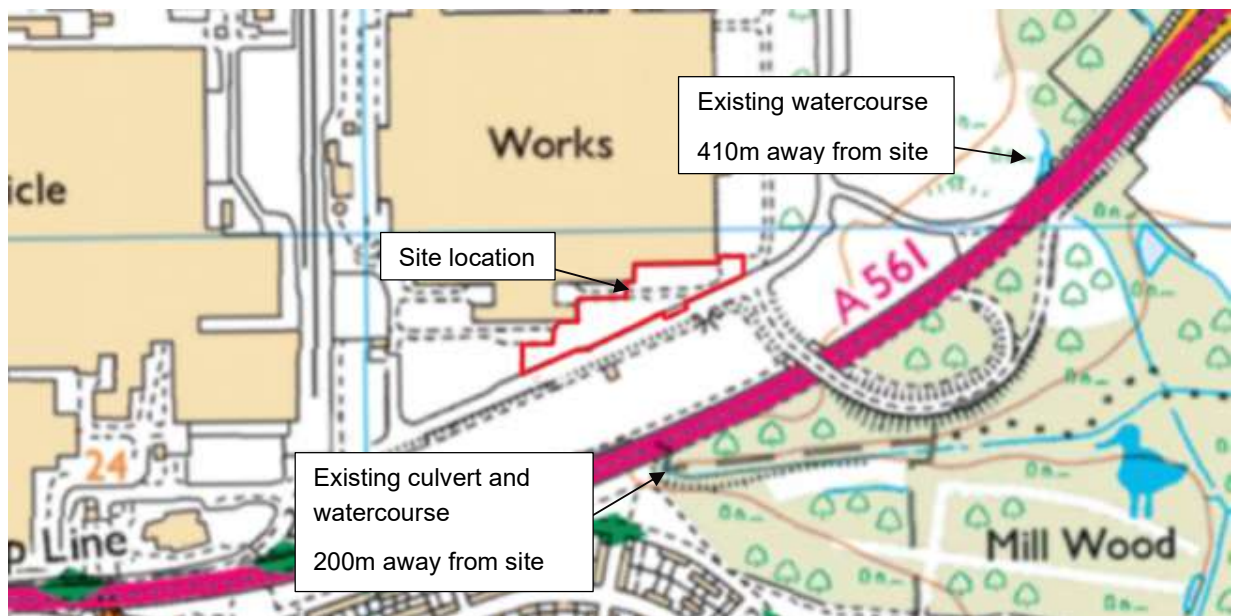


Figure 5 – Existing watercourses

2.5 Existing Flood risk

From flood risk maps for rivers and sea provided by the Environment Agency⁴, the site is in a zone with very little to no flood risks (**Figure 7**). The site is located within Flood Zone 1 with a chance of flooding associated with 'very-low' risk' is an annual chance of less than 0.1%.

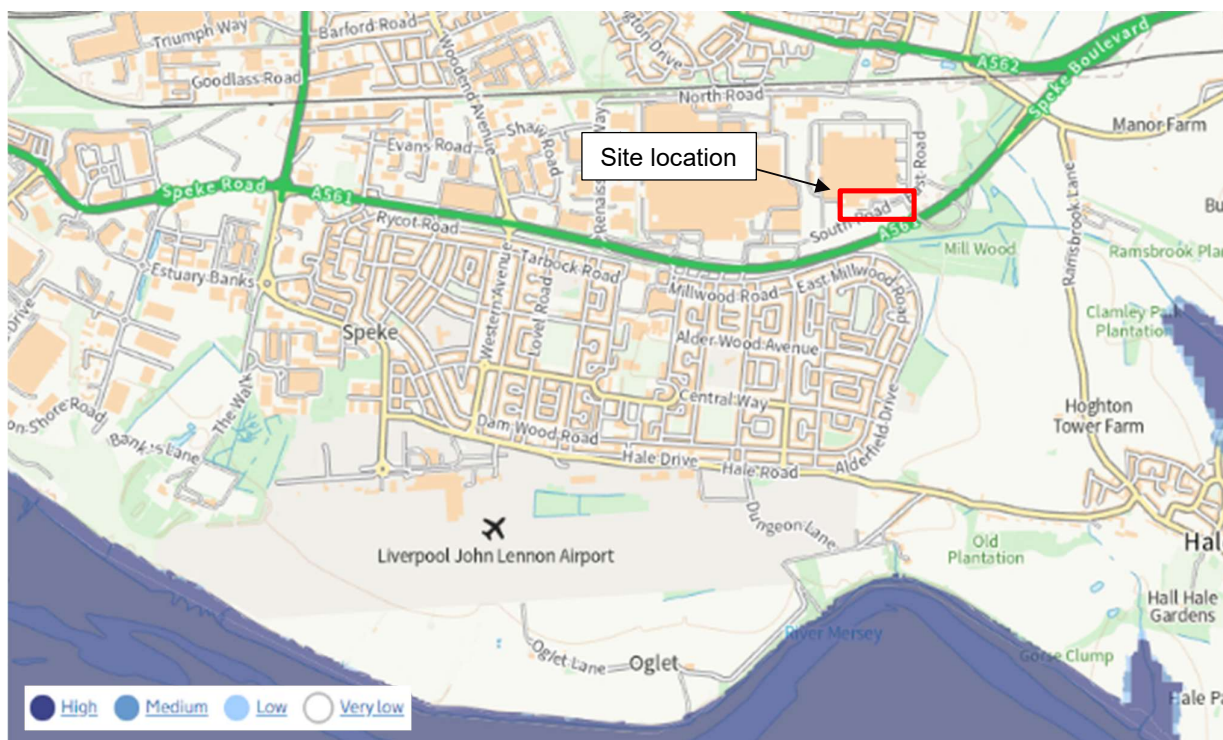


Figure 6 - Environment Agency - Flood risk map for Rivers and Sea

From the surface water flood risk maps (**Figure 8**), it can be seen that there are areas of land within the site with a 'high risk' of surface water flooding. It should be noted that these are only pockets of land which is subject to these risks (potential ponding due to depressions).

⁴ <https://check-long-term-flood-risk.service.gov.uk/map>

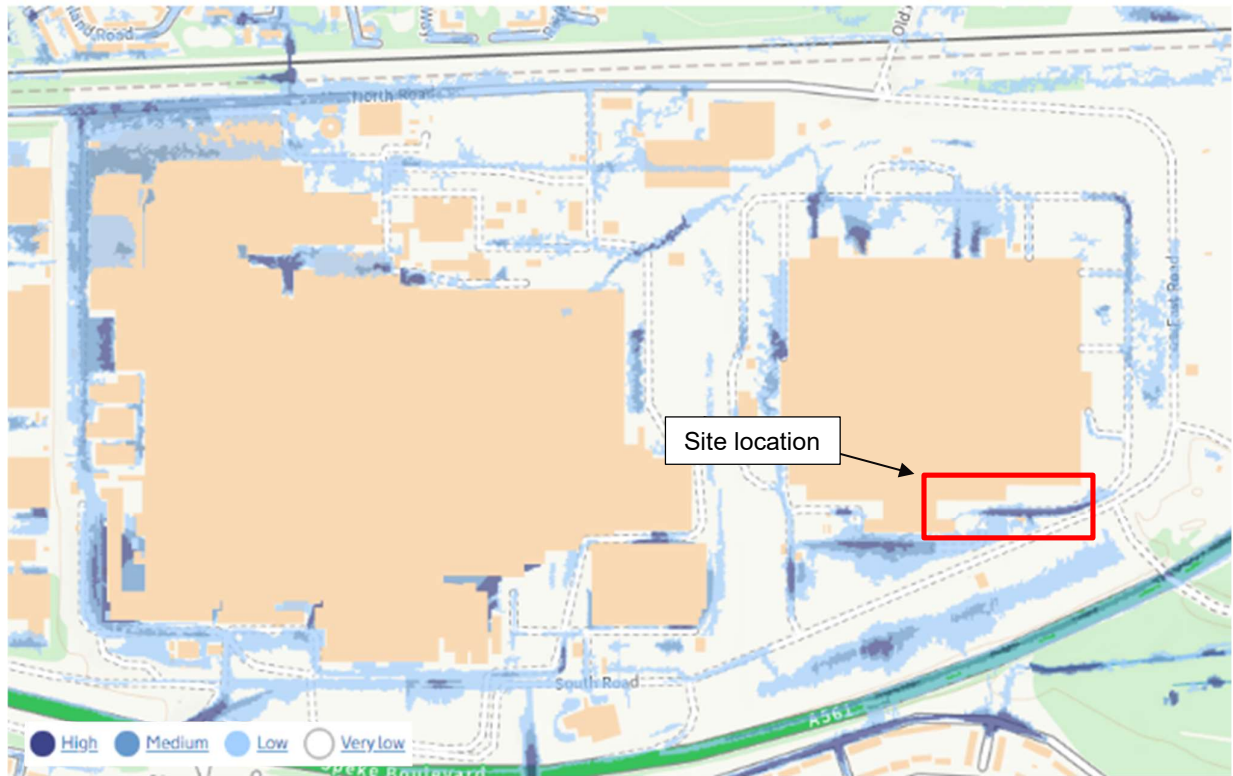


Figure 7 - Environment Agency – Flood risk from surface water

2.6 Existing Sewers

There are existing private drainage networks within the site boundary for both surface water and foul.

There is a private surface water kerb drain, which begins at the centre of the site and heads Southwest towards the western site boundary, adjacent to the previously developed carpark. Before leaving the site on the Western edge of the proposed site, the runoff within this surface water drain flows into an existing 150mm diameter surface water pipe network. There is also a separate surface water pipe which enters the site on the Northern corner of the Westernmost edge of the proposed site boundary. This 225mm diameter pipe then leaves the site along the North edge of the site, where outside of the sit boundary it connects into the same network as the pipe previously described. In the North-eastern region of the site there is an existing surface water land drain, which begins just South of the Northern boundary and leaves the site on the Northern boundary. Running through the site is a large 1676mm diameter private surface water pipe, which is assumed to service the local industrial areas, which flows from the Northwest to the Southeast, entering the site along the Northern Boundary and then exiting on the Southern Boundary.

There are also a number of private foul drains located within the site extents. Flowing into the site from the Westernmost boundary is a 530mm foul pipe, which flows Northeast where it connects to a series of other foul sewers at the centre of the proposed site. Entering from the Easternmost point of the site boundary is a 230mm diameter foul pipe which connections into the other foul pipes at the point previously mentioned. A third 230mm diameter pipe enters from the north of the site and once again connects at the same point as previously stated. All three of these pipes connect into a 530mm foul pipe, which then leaves the site along the South boundary and away from the site.

All the existing sewers located within the proposed site boundary are private and are indicated on the Drainage Strategy Plan along with existing ground levels for context within **Appendix B**.

3 Proposed Development

The proposed development is the construction of an extension to the existing car park in Halewood. The proposed development site is shown in **Figure 9**.



Figure 8 - -Proposed Development Site

Comparison between the existing and proposed site impermeable and permeable areas in relation to the total site area (0.906ha) are provided below:

	Impermeable area	Permeable area
Existing (0.906ha)	Existing access route from the existing car park 0.189ha	Existing green space 0.717ha
Proposed (0.906ha)	Existing access route from the existing car park (including proposed car park extension) 0.770ha	Existing green space (remainder) and proposed green space 0.136ha

As can be seen from the table above there is a significant increase in impermeable area between the existing and the proposed site due to the nature of the proposed site (car park).

4 Planning Policy Requirements

The proposed surface water drainage strategy serving the proposed site was completed adhering and following the below guidance documents:

4.1 National Planning Policy framework (NPPF)

The National Planning Policy framework (NPPF) specifies that surface water arising from a 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. Opportunities to reduce the flood risk to the site itself and elsewhere, taking climate change into account, should be investigated.

The NPPF requires that surface water drainage systems should cope with events that exceed the design capacity of the system. Any rainfall event with intensity in excess of that of the design capacity of the development surface water drainage network may result in temporary above ground flooding, potentially giving rise to overland flows. This excess water should be safely stored or conveyed from the site without adverse impacts to the development proposals, adjacent existing development or downstream.

The NPPF require that surface water drainage systems provided for the new development site should be designed to retain all runoff for events up to the 1 in 100 year rainfall event, with an appropriate allowance for climate change. This is to prevent downstream flooding.

4.2 NPPF Planning Practice Guidance

The Flood Risk and Coastal Change category of the Planning Practice Guidance which accompanies the NPPF states that the aim should be to discharge surface runoff as high up the following hierarchy of drainage options as reasonably practicable:

1. into the ground (infiltration);
2. to a surface water body;
3. to a surface water sewer, highway drain, or another drainage system;
4. to a combined sewer.

4.3 Strategic Flood Risk Assessment (SFRA)

A Level 2 Strategic Flood Risk Assessment (SFRA) was published by the Knowsley Council in 2012. The document advises that all new developments are to include appropriate SuDS techniques to manage surface water runoff from development based on the hierarchal approach found in Part H of the Building Regulations (2000). Developments, where feasible should aim to achieve Greenfield runoff rates, and as a minimum demonstrate a 50% reduction in runoff from the existing situation or Brownfield development. All new development across the Borough is to include at least one 'at source' SuDS measure. Where no 'at source' SuDS measure is proposed, provide evidence to show that such measures are not feasible as a result of existing ground conditions.

Development layouts should consider the effects of 'exceedance' of the drainage system during the 1 in 100-year return period plus climate change event, including overland flow routes and storage of surface water in appropriate areas within the site layout.

4.4 Knowsley Council Sustainable Drainage Guide

The Knowsley Council published their own Sustainable Drainage & Surface Water Management guide in August 2016. The document describes various types of SuDS features in a similar manner to the SuDS Manual, and also contains general guidance on Safety in Design (particularly around open water features) and maintenance requirements.

The document states that “the discharge point for surface water should follow the hierarchy set out in paragraph 80 of section 10 of the Planning Practice Guidance. Again, where preferential discharge points set out in the hierarchy cannot be achieved applicants must provide a robust justification, with acceptable evidence, as to why”.

Peak flow control: If the site is classed as greenfield, the flow rates from the development are to be limited to the equivalent pre-development greenfield runoff rates for all rainfall events up to and including the 1 in 100-year event (plus appropriate climate change allowance).

Volume control: For greenfield developments the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100-year, 6-hour rainfall event should never exceed the greenfield runoff volume for the same event. Given that infiltration methods are not feasible it is therefore proposed to limit peak flows to Q_{bar} as it is the rate that does not adversely affect flood risk.

4.5 Knowsley SuDS Proforma

In conjunction with the drainage strategy, the Knowsley SuDS pro-forma needs to be completed. This pro-forma is a requirement of the Planning Validation Checklist. The proforma provides a good basis for consideration of how surface water from a development will be managed sustainably under current and future conditions.

5 Surface Water Management Strategy

5.1 Proposed Surface Water Discharge Arrangements

In accordance with the discharge hierarchy as set out within the CIRIA SuDS Manual (C753) and Building Regulations Part H, surface water runoff should discharge to the following in order of priority:

1. into the ground (infiltration);
2. to a surface water body (watercourse);
3. to a surface water sewer, highway drain, or another drainage system;
4. to a combined sewer.

At present, there appears to be no existing SuDS features located within the site and surface water drainage is reliant upon various drainage channels both through the site and in the access road to the East.

As discussed in **Section 2.3**, based on the subsurface classification of the site (CLAY) it is unlikely for infiltration to be a reliable discharge mechanism for the surface runoff falling upon the carpark regions. The site is also located within a SPZ area and no information was available regarding groundwater levels. Due to the nature of the development, carpark, with higher levels of contamination, infiltration was not deemed an appropriate discharge method.

There are also no watercourses within the site boundary or in close proximity to connect to as discussed in **Section 2.4**.

There are a number of existing surface water sewers located in the site as discussed in **Section 2.6**. Following the discharge hierarchy, the surface water drainage system will connect and discharge to the existing surface water sewer.

5.2 Proposed Discharge Rates

The exiting greenfield runoff rates for the site was calculated using the HR Wallingford greenfield runoff rate estimation tool.

Based on the location of the site, the soil type, which in this case was classified as 'soil type 4' by using the Wallingford procedure. The standard percentage runoff for the site was assumed as 0.47. The calculated greenfield runoff rates for the 0.906ha site are provided in the table below:

Return Period Storm Event (n)	Greenfield runoff rate (l/s) – 0.906ha
1	3.9
Q _{BAR}	4.5
30	7.7
100	9.4

The outflow from the site should be limited to Q_{bar} and attenuation should be provided to ensure water is discharged safely. This is to ensure the proposed discharge volumes will be no greater than existing volumes for all corresponding storm events.

Controlling low flows by means of orifice/vortex can lead to the risk of blockages if the orifice is small. The flow control was designed with a minimum discharge in mind for the flow control and as recommended by the manufacturer of 2 L/s as a best practice minimum discharge rate.

5.3 SuDS Strategy

The proposed Surface Water Drainage Strategy layout is included in **Appendix A**.

The drainage system has been designed to mimic a greenfield situation as closely as practicably possible. SuDS are water sensitive drainage systems which mimic natural catchment processes to manage urban runoff.

The car park will be drained via a positive drainage system consisting of trapped linear channels, pipework, catchpits and light liquid separator connecting to cellular storage tank to maintain the drainage of the carpark development. The surfaced water discharged from the site it to be limited via the use of vortex flow control. A new outfall connection will be made to the existing site drainage as shown on the Drainage Strategy Plan in **Appendix A**. This connection will be subject to a Section 106 notification with United Utilities.

Space at ground level within the development site is limited; therefore, a below ground solution is proposed. Attenuation storage will be provided within cellular storage and controlled by means of a vortex flow control.

The Microdrainage modelling output can be found in **Appendix B**. The surface water system was designed to prevent flooding in any part of the site for the critical duration, up to the 1:100-year return storm event, including an allowance of 40% for climate change. This was to prevent downstream flooding.

The SuDS features and proposed storage volumes were designed to provide a level of service to ensure this criterion is met and to ensure that surface water in excess of this event was discharged safely away from the building to a suitable drainage feature via overland flow paths along exceedance routes.

5.4 Water quality

Pollution control measures was also included to minimise the risk of contamination or pollution entering the receiving sewer from surface water runoff from the development.

The onsite surface water drainage system was designed to comply with the requirements of the SuDS treatment train as laid out by CIRIA 753. A review has been undertaken of the suitability of various SuDS treatments for the site conditions. All surface runoff from the site is discharged into trapped linear drainage channels. These drainage channels feed into the cellular storage system via a catchpit, through a flow control device and an alarmed separator and into the private surface water drainage network.

The proposed SuDS components will also provide the filtration of runoff by means of traps and catchpits to intercept silt and a light liquid separator to collect any oil/petroleum leaks thus alleviating potential water quality issues in the runoff.

6 Maintenance

6.1 SuDS Maintenance Schedule

The maintenance of drainage and SuDS features is vital ensuring that they work as efficiently as they set out to do. Maintenance activities can be broadly defined as:

- Regular maintenance – basic tasks carried out regularly
- Occasional maintenance – tasks that are required periodically but on a much less frequent basis
- Remedial maintenance – tasks required when a fault needs rectifying and often includes unforeseen events

This section highlights the maintenance requirements for the proposed drainage system and components as set out in the SuDS manual. During construction the contractor will be responsible for the maintenance of the drainage system. Upon completion of the construction work that responsibility would pass to the landowner and/or its appointed agent to look after the drainage assets.

This section will be subject to review following detailed design.

6.1.1 Attenuation Storage Tanks

Attenuation storage tanks – Operation and maintenance requirements		
<u>Maintenance Schedule</u>	<u>Required Action</u>	<u>Frequency</u>
Regular Maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action	Monthly for 3 months, then annually
	Remove debris from the catchment surface (where it may cause risks to performance)	Monthly
	For systems where rainfall infiltrates into the tank from above, check surface of filter for blockage by sediment, algae, or other matter; remove and replace surface infiltration medium as necessary	Annually
	Remove sediment from pre-treatment structures and/ or internal forebays	Annually, or as required
Remedial actions	Repair/rehabilitate inlets, outlet, overflows, and vents	As required
Monitoring	Inspect/ check all inlets, outlets, vents, and overflows to ensure that they are in good condition and operating as designed	Annually
	Survey inside of tank for sediment build-up and remove if necessary	Every 5 years or as required

8.1.2 Flow Control

Vortex Separator – Operation and maintenance requirements		
<u>Maintenance Schedule</u>	<u>Required Action</u>	<u>Frequency</u>
Routine Maintenance	Remove litter, debris and inspect for sediment, oil and grease accumulation	Six monthly
	Remove sediment, oil, grease and floatable	As necessary – indicated by system inspections or immediately following significant spill.
Remedial Actions	Replace malfunctioning parts of structures	As required
Monitoring	Inspect for evidence of poor operation	Six monthly
	Inspect sediment accumulation rates and establish appropriate removal frequencies	Monthly during the first half year of operation, then every six months
Refer to manufacturer's requirements for detailed specification and frequencies for the required maintenance		

8.1.3 Other Drainage

Other Drainage Items – Operation and maintenance requirements			
Owner/ occupier Appointed Management Company	Feature	Maintenance	Frequency
	Private Drains	Inspection	CCTV survey every 5-10 years
		Regular Maintenance.	Jet clean system fully every 5-10 years. (Recommend prior to CCTV drainage survey is).
		Remedial/ Occasional Maintenance.	Carry our remedial works as identified in CCTV survey.
		Remove sediment from pre-treatment structures and/ or internal forebays	Annually, or as required
	Manholes and gratings	Manholes covers checked for operation/damage – seating's re-greased or replaced as required. Check for blockages and or damage to invert channel/inlets – jetting pipe runs if blocked, any damage to be repaired. All access ladders & other associated ironworks to be checked for corrosion & fixings to be checked for deterioration. To be repaired or replaced dependant of extent of damage.	Annually
	Catchpits	Remove silt and debris as necessary to prevent build up & base jetted clean.	Annually
	Gully/ Drainage channels	Inspection.	Quarterly.
		Regular Maintenance.	Remove silt and debris as necessary to prevent build up.
		Channel run to be jetted through between access points. Any channel grates to be inspected for damage & replaced as necessary	Every 6 months, or as required
Proprietary treatment systems will be maintained by the owner / occupier appointed management company			

6.2 SuDS Construction

The construction of SuDS usually only requires the use of standard civil engineering construction and landscaping operations, such as excavation, filling, grading, top soiling, seeding, planting etc. These operations are specified in various standard construction documents, such as the Civil Engineering Specification for the Water Industry (CESWI). Detailed guidance on the construction related issues for SuDS is available in the SuDS Manual (CIRIA C753 2015)

Water contaminated with silt must not be allowed to enter drains as it may cause pollution. All parts of the drainage system must be protected from construction runoff to prevent silt clogging the system and causing pollution downstream. Measures to prevent this include soil stabilisation, early construction of sediment management basins, channelling runoff away from surface water drains, and erosion prevention measures.

After the end of the construction period and prior to handover to the site owner/operator:

- Subsoil that has been compacted during construction activities should be broken up prior to the re-application of topsoil to garden areas and other areas of public open space to reinstate the natural infiltration performance of the ground.
- Checks must be made for blockages or partial blockages of orifices or pipe systems.
- Any silt deposited during the construction must be completely removed.
- Soils must be stabilised and protected from erosion whilst planting becomes established..

7 Conclusion

This report has set out the principles for a viable drainage strategy for the disposal of both surface water and foul flows from the development.

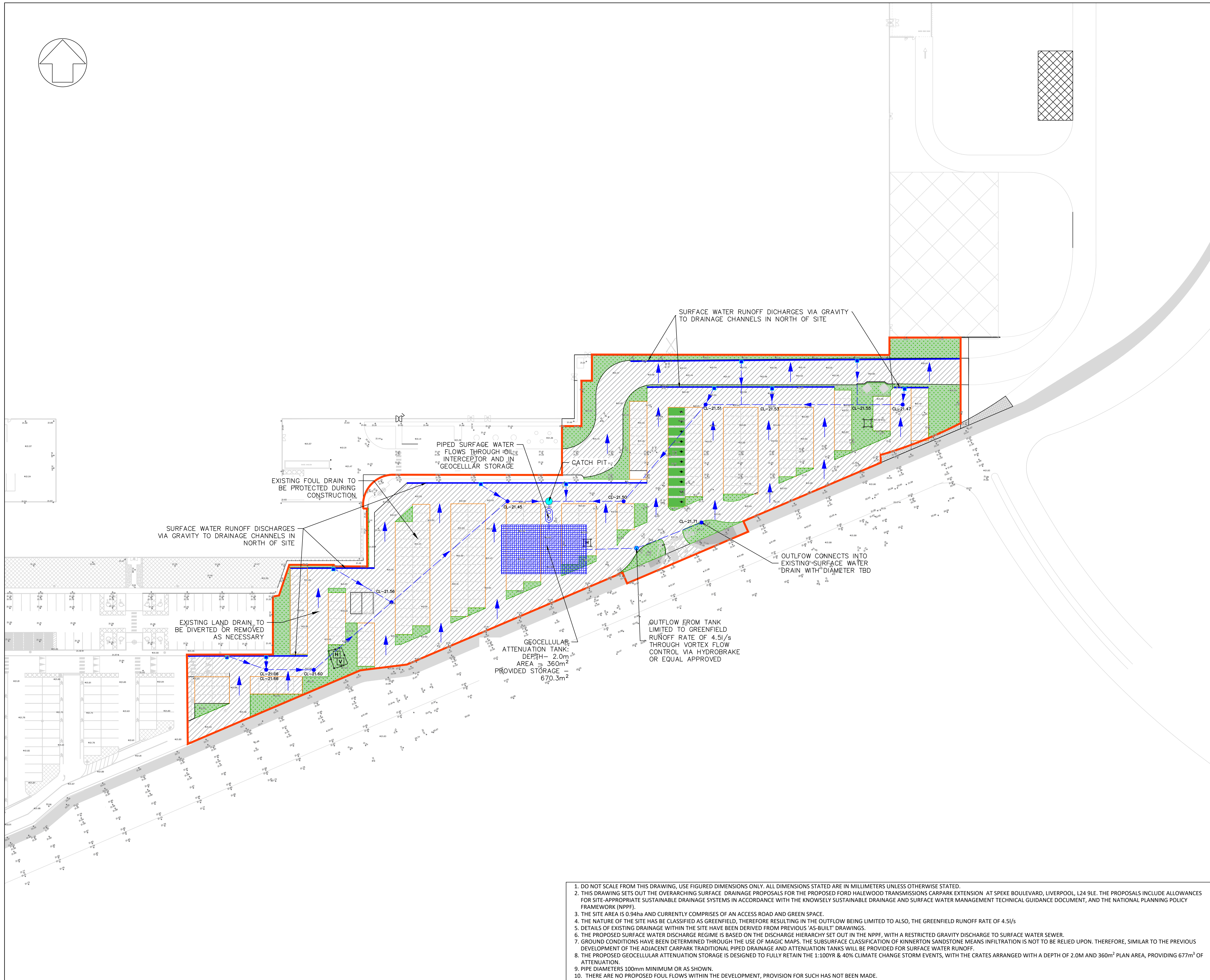
The key design principles are:

- The site is within Flood Zone 1 and therefore at minimal risk of flooding.
- Limiting surface water runoff to Qbar will ensure a discharge rate that doesn't adversely affect flood risk.
- Use of sustainable drainage systems to manage and attenuate the increase in surface water runoff onsite, for up to and including the 1 in 100-year rainfall event (including an allowance for climate change)
- Manage surface water runoff in exceedance events along safe corridors.
- Pollution control measures are also be included to minimise the risk of contamination or pollution entering the receiving surface water sewer from surface water runoff from the development.
- The proposed development consists of an extension to the existing ford Halewood carpark.
- A Section 106 notification with United Utilities will be required for an indirect connection to the public sewer.

Through the use of drainage channels, gullies, catchpit, cellular storage and light liquid separators, the proposed development will discharge surface water flows, preventing flooding within the site and downstream, and provide water quality treatment. The proposed strategy therefore achieves the aims and objectives of both local and national planning policies.

Appendix A

Drainage Strategy Plan



LEGEND:

- | | |
|---|---|
|  | EXISTING SURFACE WATER PIPE |
|  | EXISTING FOUL DRAIN |
|  | EXISTING FOUL MANHOLE |
|  | EXISTING SURFACE WATER MANHOLE |
|  | PROPOSED DRAINAGE CHANNEL |
|  | PROPOSED SURFACE WATER PIPE |
|  | PROPOSED SURFACE WATER INSPECTION CHAMBER |
|  | CATCH PIT |
|  | OIL INTERCEPTOR |
|  | VORTEX FLOW CONTROL |
|  | TRAPPED OUTLETS |
|  | OVERLAND FLOW PATHS |
|  | GEOCELLULAR ATTENUATION CRATE |
|  | GREEN AREAS |
|  | HARDSTANDING AREAS |
|  | PARKING AREAS |
|  | EV PARKING AREAS |
|  | SITE BOUNDARY |

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Rev	Date	Description	Drawn	Check	Approved

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Carpark Extension

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Proposed Drainage Strategy

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Checked	D.OGDEN	Signed	Date 15 MAR 2023
Approved	M.DAVIES	Signed	Date 15 MAR 2023
Scale:	1:500	Datum:	AOD
Original Size:	A1	Grid:	OS
Suitability Code:	S0	Project Number:	10603362

Suitability Description:

WORK IN PROGRESS

NOT TO BE USED FOR CONSTRUCTION

Drawing Number: 10603362-ARC-SW-XX-DR-CE-0001	Revision: P01
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Appendix B

Drainage Calculations

Arcadis SSC Europe B.V		Page 1
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Date 15/03/2023 11:31 File Carpark Extension 14_03_...	Designed by allenb7729 Checked by	
XP SolutionsSource Control 2020.1.3		
ICP SUDS Mean Annual Flood Input Return Period (years)100Soil0.450 Area (ha)0.886Urban0.000 SAAR (mm)759Region NumberRegion 10 Results1/s QBAR Rural4.3 QBAR Urban4.3 Q100 years8.9 Q1 year3.7 Q30 years7.3 Q100 years8.9		
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Arcadis SSC Europe B.V		Page 4
P.O. Box 161 AD Arnhem 6800 Netherlands		
Date 15/03/2023 11:33 File Carpark Extension 14_03_...	Designed by allenb7729 Checked by	
XP Solutions Source Control 2020.1.3		

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	1999
Site Location	GB 345300 383750 SJ 45300 83750
C (1km)	-0.024
D1 (1km)	0.303
D2 (1km)	0.355
D3 (1km)	0.324
E (1km)	0.288
F (1km)	2.493
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.932

Time (mins)	Area	Time (mins)	Area
From:	To: (ha)	From:	To: (ha)
0	4 0.466	4	8 0.466

Time Area Diagram

Total Area (ha) 0.000

Time (mins)	Area
From:	To: (ha)
0	4 0.000

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Arcadis SSC Europe B.V		Page 5																																																																																																												
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Model Details Storage is Online Cover Level (m) 3.000 Cellular Storage Structure Invert Level (m) 0.000 Safety Factor 10.0 Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95 Infiltration Coefficient Side (m/hr) 0.00000 <table><tr><th>Depth (m)</th><th>Area (m²)</th><th>Inf. Area (m²)</th><th>Depth (m)</th><th>Area (m²)</th><th>Inf. Area (m²)</th></tr><tr><td>0.000</td><td>360.0</td><td>0.0</td><td>2.001</td><td>0.0</td><td>0.0</td></tr><tr><td>2.000</td><td>360.0</td><td>0.0</td><td>3.000</td><td>0.0</td><td>0.0</td></tr></table> Hydro-Brake® Optimum Outflow Control Unit Reference MD-SHE-0085-4300-2000-4300 Design Head (m) 2.000 Design Flow (l/s) 4.3 Flush-Flo™ Calculated Objective Minimise upstream storage Application Surface Sump Available Yes Diameter (mm) 85 Invert Level (m) 0.000 Minimum Outlet Pipe Diameter (mm) 100 Suggested Manhole Diameter (mm) 1200 <table><tr><th>Control Points</th><th>Head (m)</th><th>Flow (l/s)</th><th>Control Points</th><th>Head (m)</th><th>Flow (l/s)</th></tr><tr><td>Design Point (Calculated)</td><td>2.000</td><td>4.3</td><td>Kick-Flo®</td><td>0.756</td><td>2.7</td></tr><tr><td>Flush-Flo™</td><td>0.371</td><td>3.4</td><td>Mean Flow over Head Range</td><td>-</td><td>3.3</td></tr></table> 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 <table><tr><th>Depth (m)</th><th>Flow (l/s)</th><th>Depth (m)</th><th>Flow (l/s)</th><th>Depth (m)</th><th>Flow (l/s)</th><th>Depth (m)</th><th>Flow (l/s)</th></tr><tr><td>0.100</td><td>2.5</td><td>1.200</td><td>3.4</td><td>3.000</td><td>5.2</td><td>7.000</td><td>7.7</td></tr><tr><td>0.200</td><td>3.2</td><td>1.400</td><td>3.6</td><td>3.500</td><td>5.6</td><td>7.500</td><td>8.0</td></tr><tr><td>0.300</td><td>3.4</td><td>1.600</td><td>3.9</td><td>4.000</td><td>5.9</td><td>8.000</td><td>8.2</td></tr><tr><td>0.400</td><td>3.4</td><td>1.800</td><td>4.1</td><td>4.500</td><td>6.3</td><td>8.500</td><td>8.5</td></tr><tr><td>0.500</td><td>3.4</td><td>2.000</td><td>4.3</td><td>5.000</td><td>6.6</td><td>9.000</td><td>8.7</td></tr><tr><td>0.600</td><td>3.2</td><td>2.200</td><td>4.5</td><td>5.500</td><td>6.9</td><td>9.500</td><td>8.9</td></tr><tr><td>0.800</td><td>2.8</td><td>2.400</td><td>4.7</td><td>6.000</td><td>7.2</td><td></td><td></td></tr><tr><td>1.000</td><td>3.1</td><td>2.600</td><td>4.8</td><td>6.500</td><td>7.5</td><td></td><td></td></tr></table>			Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	0.000	360.0	0.0	2.001	0.0	0.0	2.000	360.0	0.0	3.000	0.0	0.0	Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)	Design Point (Calculated)	2.000	4.3	Kick-Flo®	0.756	2.7	Flush-Flo™	0.371	3.4	Mean Flow over Head Range	-	3.3	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	0.100	2.5	1.200	3.4	3.000	5.2	7.000	7.7	0.200	3.2	1.400	3.6	3.500	5.6	7.500	8.0	0.300	3.4	1.600	3.9	4.000	5.9	8.000	8.2	0.400	3.4	1.800	4.1	4.500	6.3	8.500	8.5	0.500	3.4	2.000	4.3	5.000	6.6	9.000	8.7	0.600	3.2	2.200	4.5	5.500	6.9	9.500	8.9	0.800	2.8	2.400	4.7	6.000	7.2			1.000	3.1	2.600	4.8	6.500	7.5		
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Arcadis SSC Europe B.V		Page 1
P.O. Box 161 AD Arnhem 6800 Netherlands	Ford Halewood Car Park Ext	
Date 16/03/2023 17:30 File Car Park Extension 100y...	Designed by ogdend4224 Checked by B Allen	
XP Solutions	Network 2019.1	

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FEH Rainfall Model	
Return Period (years)	100
FEH Rainfall Version	1999
Site Location GB 345300 383750 SJ 45300 83750	
C (1km)	-0.024
D1 (1km)	0.303
D2 (1km)	0.355
D3 (1km)	0.324
E (1km)	0.288
F (1km)	2.493
Maximum Rainfall (mm/hr)	150
Maximum Time of Concentration (mins)	30
Foul Sewage (l/s/ha)	0.000
Volumetric Runoff Coeff.	0.750
PIMP (%)	100
Add Flow / Climate Change (%)	40
Minimum Backdrop Height (m)	0.200
Maximum Backdrop Height (m)	1.500
Min Design Depth for Optimisation (m)	0.900
Min Vel for Auto Design only (m/s)	1.00
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	0.297	4-8	0.464

Total Area Contributing (ha) = 0.761

Total Pipe Volume (m³) = 52.730

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 Coefficient 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 Storage Structures 1
Number of Online Controls 1	Number of Time/Area Diagrams 0
Number of Offline Controls 0	Number of Real Time Controls 0

Arcadis SSC Europe B.V		Page 2
P.O. Box 161 AD Arnhem 6800 Netherlands	Ford Halewood Car Park Ext	
Date 16/03/2023 17:30 File Car Park Extension 100y...	Designed by ogdend4224 Checked by B Allen	
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Simulation Criteria for Storm

Synthetic Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	1999
Site Location	GB 345300 383750 SJ 45300 83750
C (1km)	-0.024
D1 (1km)	0.303
D2 (1km)	0.355
D3 (1km)	0.324
E (1km)	0.288
F (1km)	2.493
Summer Storms	Yes
Winter Storms	No
Cv (Summer)	0.750
Cv (Winter)	0.840
Storm Duration (mins)	30

Arcadis SSC Europe B.V		Page 3
P.O. Box 161 AD Arnhem 6800 Netherlands	Ford Halewood Car Park Ext	
Date 16/03/2023 17:30 File Car Park Extension 100y...	Designed by ogdend4224 Checked by B Allen	
XP Solutions	Network 2019.1	

Online Controls for Storm

Hydro-Brake® Optimum Manhole: S9, DS/PN: S1.005, Volume (m³): 16.0

Unit Reference	MD-SHE-0082-4000-2000-4000
Design Head (m)	2.000
Design Flow (l/s)	4.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	82
Invert Level (m)	19.244
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.000	4.0
Flush-Flo™	0.356	3.1
Kick-Flo®	0.729	2.5
Mean Flow over Head Range	-	3.1

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	2.4	1.200	3.2	3.000	4.8	7.000	7.2
0.200	3.0	1.400	3.4	3.500	5.2	7.500	7.4
0.300	3.1	1.600	3.6	4.000	5.5	8.000	7.7
0.400	3.1	1.800	3.8	4.500	5.8	8.500	7.9
0.500	3.1	2.000	4.0	5.000	6.1	9.000	8.1
0.600	2.9	2.200	4.2	5.500	6.4	9.500	8.3
0.800	2.6	2.400	4.3	6.000	6.7		
1.000	2.9	2.600	4.5	6.500	6.9		

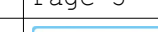
Arcadis SSC Europe B.V		Page 4
P.O. Box 161 AD Arnhem 6800 Netherlands	Ford Halewood Car Park Ext	
Date 16/03/2023 17:30 File Car Park Extension 100y...	Designed by ogdend4224 Checked by B Allen	
XP Solutions	Network 2019.1	

Storage Structures for Storm

Tank or Pond Manhole: S9, DS/PN: S1.005

Invert Level (m) 19.244

Depth (m)	Area (m ²)	Depth (m)	Area (m ²)	Depth (m)	Area (m ²)	Depth (m)	Area (m ²)
0.000	360.0	1.000	360.0	2.000	360.0	2.001	0.0

Arcadis SSC Europe B.V		Page 5
P.O. Box 161 AD Arnhem 6800 Netherlands	Ford Halewood Car Park Ext	
Date 16/03/2023 17:30 File Car Park Extension 100y...	Designed by ogdend4224 Checked by B Allen	
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Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

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

Synthetic Rainfall Details

```
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, 180, 240, 360, 480, 600, 720, 960, 1440, 2160, 2880, 4320, 5760, 7200, 8640, 10080
Return Period(s) (years)	1, 30, 100
Climate Change (%)	0, 0, 40

									Water
	US/MH		Return	Climate	First (X)	First (Y)	First (Z)	Overflow	Level
PN	Name	Storm	Period	Change	Surcharge	Flood	Overflow	Act.	(m)
S1.000	S1	15 Winter	100	+40%	100/15 Summer				21.304
S1.001	S2	1440 Winter	100	+40%	100/15 Summer				20.608
S1.002	S3	960 Winter	100	+40%	100/15 Summer				20.607
S2.000	S4	15 Winter	100	+40%	100/15 Summer				21.303
S2.001	S5	15 Winter	100	+40%	100/15 Summer				21.151
S2.002	S6	15 Winter	100	+40%	100/15 Summer				20.631
S1.003	S7	1440 Winter	100	+40%	100/15 Summer				20.608
S1.004	S8	1440 Winter	100	+40%	100/15 Summer				20.607
S1.005	S9	1440 Winter	100	+40%	1/240 Winter				20.608

Arcadis SSC Europe B.V		Page 6
P.O. Box 161 AD Arnhem 6800 Netherlands	Ford Halewood Car Park Ext	
Date 16/03/2023 17:30 File Car Park Extension 100y...	Designed by ogdend4224 Checked by B Allen	
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Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Surcharged Flooded		Flow / Overflow		Pipe Flow	Status	Level Exceeded
		Depth (m)	Volume (m³)	Cap.	(l/s)	(l/s)		
S1.000	S1	0.359	0.000	1.01		210.7	FLOOD RISK	
S1.001	S2	0.373	0.000	0.04		10.4	SURCHARGED	
S1.002	S3	0.616	0.000	0.07		16.3	SURCHARGED	
S2.000	S4	0.318	0.000	1.04		47.1	SURCHARGED	
S2.001	S5	0.303	0.000	1.21		82.8	SURCHARGED	
S2.002	S6	0.089	0.000	2.33		274.2	SURCHARGED	
S1.003	S7	0.706	0.000	0.11		21.3	SURCHARGED	
S1.004	S8	0.723	0.000	0.08		21.1	SURCHARGED	
S1.005	S9	1.139	0.000	0.27		3.3	SURCHARGED	



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