



HBL ASSOCIATES
FLOOD RISK ASSESSMENT AND DRAINAGE STRATEGY
REPORT

For

BRIDGEWATER HOUSE, MANCHESTER

On Behalf Of

Watch This Space (Jembrana) Ltd

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Author	F. Gennard MEng CEng MICE
Signature	
Date	26.06.2022
Approved	A. Ben Ghalbon BEng (Hons), MSc]
Signature	
Date	26.06.2022

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HBL Associates
Brook House
Weybrook Road
Manchester
M19 2QD

Tel: +44 (0)161 432 9977

consultants@hbl.ltd

Table of Contents

1. Introduction	3
2. Information on the Existing Site and Proposed Development	4
Existing Site	4
Proposed Development	5
3. Assessment of Flood Risk	5
Natural Drainage	6
Artificial Drainage	8
4. Sequential Test	11
5. Storm Water Management	11
Control of Surface Water Run-off	11
Allowable Site Discharge	12
Proposed Attenuation Strategy	12
Summary	17
Design Example	18
Maintenance and remedial work	19
Foul Drainage	20
6. Summary	22
Appendix A – Topographical Survey	24
Appendix B – Proposed Development	25
Appendix C – Existing and Proposed Areas	26
Appendix D – Whole Site Attenuation	27
Appendix E – Extract from GI Report	28
Appendix F – Microdrainage Calculations	29
Appendix G – Microdrainage output for exceedance	30
Appendix H – Drainage Strategy Drawing	31
Appendix I – Sewer Records	32

1. Introduction

- 1.1. HBL Associates Limited was commissioned to carry out a Flood Risk Assessment for the apartment block at Bridgewater House, Manchester.
- 1.2. The report is to support a planning application and a drainage strategy has been submitted as part of these works.
- 1.3. As a result of Climate Change, the Government continues to place higher priority on the need to investigate the risks associated with flooding at all stages of the development. This is to reduce the potential for damage to property as well as loss of life. The PPG-Technical Guidance (PPG-TG) sets out how the issue of flooding is dealt with as well as the capacitation of flooding risk in terms of annual probability as detailed within Table 1.

Table 1: Flood Zones – PPG-TG Table 3

Flood Zones	Appropriate Use
Flood Zone 1 - Low Probability This zone comprises land having less than 1 in 1000 annual probability of river or sea flooding (<0.1%)	All uses of land are appropriate in this zone
Flood Zone 2 - Medium Probability This zone comprises land assessed as having between 1 in 100 and 1 in 1000 annual probability of river flooding (1%-0.1%) or between 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5%- 0.1%) in any year	The water-compatible, less vulnerable, and more vulnerable uses of land and essential infrastructure in Table D.2 are appropriate in this Zone Subject to the Sequential Test being applied, the highly vulnerable uses in Table D.2 are only appropriate in this zone if the Exception Test is passed
Flood Zone 3a - High Probability This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year	The water-compatible and less vulnerable uses of land in Table D.2 area appropriate in this zone. The highly vulnerable uses in Table D.2 should not be permitted in this zone. The more vulnerable and essential infrastructure uses in Table D.2 should only be permitted in this zone if the Exception Test is passed. Essential infrastructure permitted in this should be designed and constructed to remain operational and safe for users in time of flood.
Flood Zone 3b - Functional Floodplain This zone comprises land where water must flow or be stored in times of flood. SFRAs should identify this Flood Zone (land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1%) flood, or at another probability to be agreed between the LPA and the Environment Agency, including water conveyance routes)	Only the water-compatible uses and the essential infrastructure listed in Table D.2 that must be there should be permitted in this zone. It should be designed and constructed to: Remain operational and safe for users in times of flood. Result in no net loss of floodplain storage. Not impede water flows; and Not increase flood risk elsewhere. Essential infrastructure in this zone should pass the Exception Test.

Source: <http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/flood-zone-andflood-risktables/table-3-flood-risk-vulnerability-and-flood-zone-compatibility/>

- 1.4. In the preparation of this report, HBL Associates Limited has followed accepted procedure, however, given the residual risk associated with any prediction and the variability which can be experienced in flood conditions, we take no liability for and give no warranty against actual flooding of any property (client's or third party) or the consequence of the flooding in relation to the performance of this service. This report has been prepared as part of an outline planning application only and should not be relied upon or used for any other purpose.
- 1.5. Allowance for the effect of climate change will be made in accordance with government recommendations and statistical data available at the time of writing this report. These recommendations may become more onerous, and the statistical data revised, and we will not as part of this report make any predictions of how this may or may not change the outcome of this report. The reader should be aware that issues outside of HBL Limited's control may affect future flood risk and as such there may be a requirement for future works for which we accept no liability.

2. Information on the Existing Site and Proposed Development

Existing Site

Site Location

- 2.1. The site is located off the A56 Chester Road, Manchester. The nearest postcode is M15 4AX and it is centred on National Grid Reference (NGR) 383200E, 397343N.
- 2.2. A site location plan is shown in Figure 1 below.

Figure 1: Site Location Plan



Source: www.streetmap.co.uk/map

Site Description

- 2.3. The site is currently made up of an existing building and hardstanding with access being provided off Silvercroft Street to the south.
- 2.4. The site is bounded by the A56 Chester Road to the north, Great Jackson Street to the east, Silvercroft Street to the south and an unnamed road to the west.
- 2.5. A topographical survey for the existing car park has been undertaken and is included within Appendix A for reference. It shows that the site falls from south west to north east with a level of 32.448m AOD in the south western corner falling to 31.479m AOD in the north east.

Existing Site Drainage

- 2.6. Little information is available on existing site drainage, however, the topographical survey has identified a number of manholes which indicates that the site is served by an existing private drainage system.
- 2.7. Sewer records included in Appendix I show that there is a combined sewer of unknown diameter running along Silvercroft Street before connecting into a 375 x 500mm diameter sewer within Great Jackson Street which heads north towards Chester Road.

Existing Watercourse

- 2.8. There is no watercourse within the site boundary with the nearest being the Bridgewater Canal located approximately 110m to the north across the A56.
- 2.9. The nearest main river is the River Irwell which is located approximately 620m to the northwest.

Proposed Development

- 2.10. Drawings showing the proposed development are included in Appendix B for reference.
- 2.11. The development will consist of two apartment blocks, one constructed within the existing building which wraps around the northern and western boundary of the site and wrapping around the southeast corner. The two building will be separated by a central courtyard with gardens being provided to some of the ground floor apartments.

3. Assessment of Flood Risk

- 3.1. A summary of the flood risk both pre- and post-development is included within Table 2, with further information provided in the Sections below.

Table 2: Summary of sources and extent of flood risk

Potential Source of Flooding	Is there a flood risk to the development?	Does the development increase flood risk upstream?	Does the development increase the flood risk downstream?
Fluvial Flooding	No	No	No
Pluvial Flooding and Overland Flow	No	No	No
Ground Water Flooding	Yes	No	No
Adopted Drainage	Yes	No	No
Private Drainage	No	No	No
Highway Drainage	Yes	No	No
Reservoir Flooding	No	No	No
Development Drainage	No	No	No

Source: Flood Memorandum

Natural Drainage

Fluvial Flooding

- 3.2. With reference to the EA's indicative flood maps, it can be seen that the site is located within Flood Zone 1 an area with low risk of flooding.

Figure 2: Fluvial Flood Risk Map



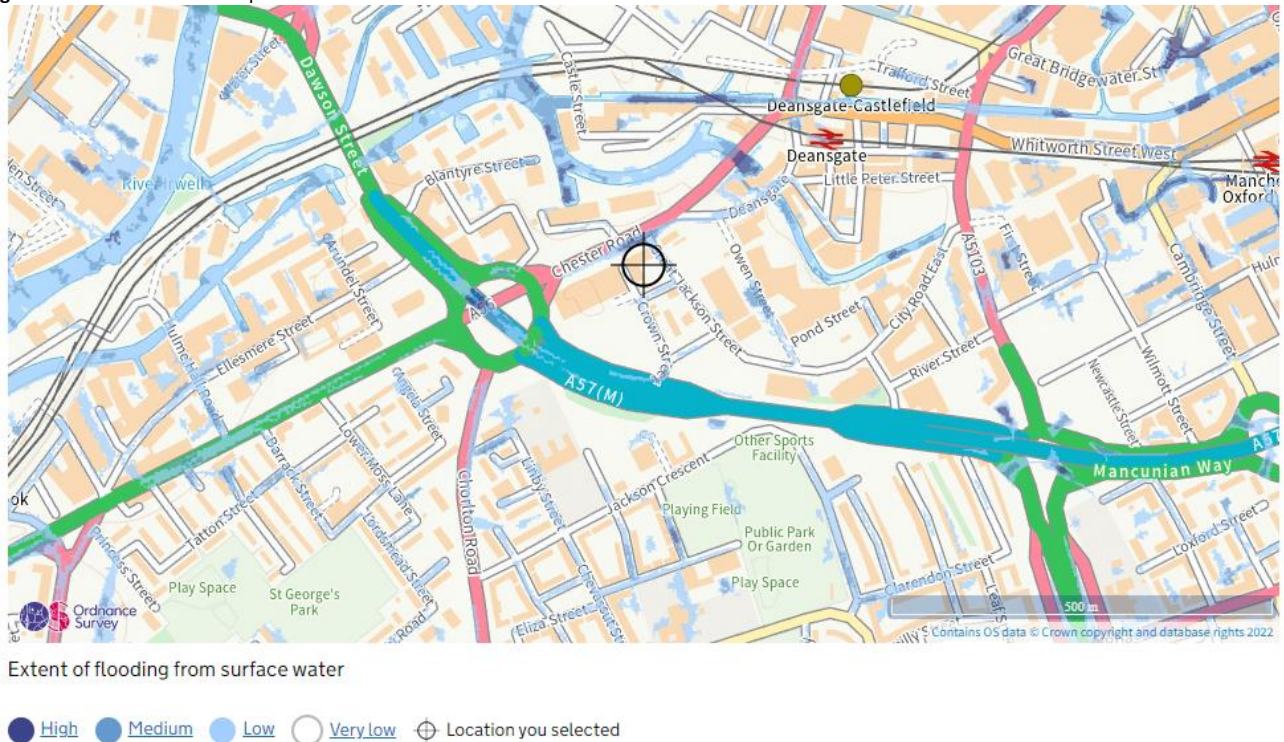
Source: <https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>

- 3.3. As such the risk of flooding to the site from watercourse and rivers is deemed to be low.

Pluvial Flooding and Overland Flow

- 3.4. With reference to the EA's online mapping, data related to the risk of potential surface water inundation or flooding is also provided. This shows that there is no risk of surface water flooding within the site boundary.

Figure 3: Pluvial Flood Risk Map



Source: <https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>

- 3.5. As there is no risk of surface water flooding in the area around the proposed development the risk of surface water flooding to the site is deemed to be low.

Ground Water Flooding

- 3.6. A Phase 1 ground investigation was undertaken in June 2022 with an extract relating to potential groundwater flooding provided in Appendix E.
- 3.7. It shows that the site is believed to have a moderate-high risk of flooding from groundwater as shown in Figure 4 below.

Figure 4: Ground Water Flood Mapping



Source: Phase 1 Ground Investigation Report

- 3.8. In addition, a Ground Investigation undertaken for a neighbouring site encountered groundwater between 23.3m AOD and 24.1m AOD. As the ground conditions do not differ significantly between the two sites it is not expected that the groundwater level will vary too much. Based on the topography on site this would mean groundwater would likely be struck about 7.5m below ground level.
- 3.9. An extract of this report is included in Appendix E.
- 3.10. The risk of flooding from groundwater is therefore currently deemed to be medium, however further investigation will be required in the form of an intrusive ground investigation as part of the next stage of design.

Climate Change

- 3.11. In accordance with the Government's PPG-TG document and as required by the Environment Agency, there should be no increase in the rate of surface water discharging from a new development above that of any previous development. The EA and Local Planning Authorities also actively encourage the reduction of stormwater discharge as a condition of approval for new developments.

In addition, all new drainage systems should be sized to accommodate the runoff generated from the 1 in 100-year rainfall event with a further allowance for climate change. Table 3 below shows the anticipated increase in rainfall intensities.

Table 3: Climate Change Allowance

Type	Applies across all of England	2015 to 2039	2040 to 2069	2070 to 2115
Rainfall	Upper End	10%	20%	40%
	Central	5%	10%	20%

Source: <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>

- 3.12. The development has a proposed design life of 75 years, which if constructed this year will be until 2096. For Rainfall, 20% climate change will be used for design, and 40% for checking.

Artificial Drainage

Adopted Drainage

- 3.13. Sewer Records have been obtained from United Utilities and are included within Appendix I.
- 3.14. From looking at the records it can be seen that there is a 375mm dia combined sewer running from west to east along Silvercroft Street which connects into a 375mm x 500mm combined sewer running from south to north along Great Jackson Street.
- 3.15. While Great Jackson Street follows the topography of the site, Silvercroft Street sits slightly higher with the natural failure route being towards the site boundary should the sewer become inundated.
- 3.16. As such, there is a minor risk of flooding from adopted assets.

Private Drainage System

- 3.17. There is limited information available about the existing private drainage system, however, from viewing the topographical survey, there appears to be an existing drainage network currently serving the site.

3.18. It is not proposed to increase the impermeable areas draining to this network, with most of the system being replaced as part of these works.

3.19. As such the risk of flooding from this source is deemed to be low.

Highway Drainage System

3.20. The site is currently bounded by the A56 to the north, Great Jackson Street to the east, Silvercroft Street to the south and an unnamed road to the west.

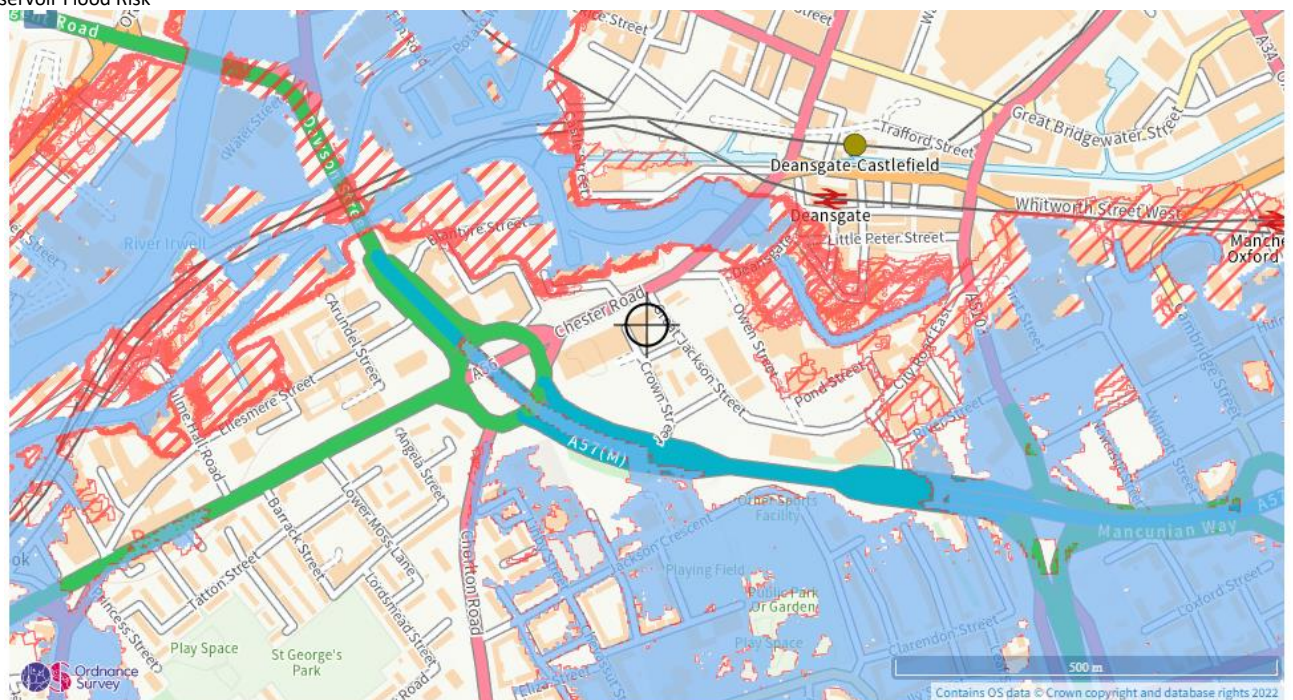
3.21. The topographical survey shows that Silvercroft Street currently sits higher than the proposed development, while elevation finder indicates that the A56 Chester Road and the unnamed access road sit slightly lower. It is assumed that Great Jackson Street will follow the topography of the site.

3.22. As Silvercroft Street sits slightly higher than the proposed development, there is a localised low spot at the current access point and the new apartment building will be located adjacent to the road, there is a slight risk of flooding from the highway should the system become inundated.

Reservoir Flooding

With reference to the EA's online mapping, data related to the risk of potential reservoir flooding is shown in Figure 5.

Figure 5: Reservoir Flood Risk



Maximum extent of flooding from reservoirs:

● when river levels are normal ■ when there is also flooding from rivers ⊕ Location you selected

Source: <https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>

3.23. The flood maps show that there is no risk of reservoir flooding to the site.

Development Drainage

3.24. As part of any development, it is necessary to provide a suitably designed storm water drainage system to collect, convey and attenuate any additional runoff that may be generated by the development itself. The net result is that there should be no increase in flood risk either downstream or to any neighbouring properties because of the scheme.

3.25. The current proposed layout for the site is included within Appendix B and shows that there will be an decrease in impermeable area as part of this development.

3.26. The total site is approximately 2133m² in area, with the existing impermeable areas being divided as follows:

- Building = 758m²
- Hardstanding = 1246m²

The remaining 129m² of area is predominantly vegetation and has been taken as permeable.

3.27. A quick estimate has been made using the Lloyd Davies Method and a rainfall intensity of 50mm/hr which found the proposed runoff to be approximately 23.2l/s.

3.28. By looking at the proposed layouts included in Appendix B the new areas can be broken down as follows:

- Proposed Building = 1353m²
- Proposed Hardstanding = 362m²

The remaining 418m² will be made up of gardens and public open space which has been taken as permeable.

3.29. This shows that there will be an overall reduction in impermeable area from this development.

3.30. An existing and proposed impermeable area drawing is included within Appendix C.

3.31. A development of this scale is likely to generate relatively large amounts of storm water runoff which will be discharged in accordance with the strategy outlined in Section 5.1.

3.32. The runoff will itself pose a risk to both the development site and the areas downstream of this point.

3.33. Foul flows are also likely to be increased, however, the risk of flooding from this source should be mitigated by ensuring that the system is properly designed and in the absence of any positive outfall an adequate operation and maintenance strategy developed to ensure adequate emptying of any tank system.

3.34. As part of the detailed design process consideration should also be given to the maintenance requirements of the drainage system and information relating to this included with any supporting information provided at handover.

3.35. As such it is not envisaged that the development itself will pose a flood risk.

4. Sequential Test

- 4.1. As the development site is shown to be wholly within Flood Zone 1 and outside the influence of any other local flood risk elements, in accordance with table 3 of the PPG it is concluded that the development is suitable for this location and the Sequential Test is deemed to have been passed.

5. Storm Water Management

Control of Surface Water Run-off

- 5.1. It should be acknowledged that the satisfactory collection, control, and discharge of storm water is now a principal planning and design consideration. This is reflected in recently implemented guidance and the National SuDS Standards.
- 5.2. Part H of the Building Regulations 2015 recommends that surface water run-off shall discharge to one of the following, listed in order of priority:
- An adequate soakaway or some other adequate infiltration system, or where that is not reasonably practicable;
 - A watercourse, or, where that is not reasonably practicable;
 - A surface water sewer.
- 5.3. It is necessary to identify the most appropriate method of controlling and discharging surface water. The design should seek to improve the local run-off profile by using systems that can either attenuate run-off and reduce peak flow rates or positively impact on the existing flood profile.

Infiltration Based Systems

- 5.4. From looking at the maps from the British Geological Society the bedrock geology around the proposed is sandstone with superficial deposits being listed as Glaciofluvial Sheet Deposits, Devensian - Sand and Gravel.
- 5.5. This was confirmed by the Phase 1 Ground Investigation which summarised the geology as follows:
- Superficial – Glaciofluvial sheet deposits, sands and gravels.
 - Bedrock – Sandstones of coarse-grained, typically well-cemented to fine-grained, less well-cemented.
- 5.6. As such it is anticipated that infiltration could be possible for this site, however, this will need to be confirmed via a series of soakaway tests prior to detailed design.

Watercourses

- 5.7. There are no watercourses within or close to the site boundary and as such for the purpose of this development this method of discharge has been discounted.

Adopted Sewers

- 5.8. Sewer records have been obtained from United Utilities and are included within Appendix I.

- 5.9. They show that there is a combined sewer of unknown diameter running from west to east along Silvercroft Street which connects into a 375mm x 500mm combined sewer running from south to north along Great Jackson Street.
- 5.10. While not confirmed, it is likely that the existing surface water connection is into one of these existing sewers.
- 5.11. As such it is envisaged that surface water generated from the proposed development will be discharged via an existing connection into one of these adopted assets.
- 5.12. For the purpose of this report it has been proposed that the connection will be into the sewer in Great Jackson Street.

Allowable Site Discharge

- 5.13. Based on the above, while it is likely that due to the anticipated ground conditions that some level of infiltration will be possible, in the absence of soakaway test results, a conservative design will be produced utilising a positive connection into the adopted asset within Great Jackson Street.
- 5.14. Based on the values in 3.3.5 the existing areas has been calculated to be approximately 2004m² while the proposed area is 1715m². This provides an overall reduction in impermeable area of 289m² which equates to approximately 14%.
- 5.15. Taking the above into account, and the requirement to limit any proposed discharge to as close to greenfield rates as possible, the allowable discharge rate for this development will be taken as 5l/s, although this will need to be confirmed following consultation with United Utilities.

Proposed Attenuation Strategy

- 5.16. When developing the site layout, the provision of adequately sized attenuation system to mitigate flood risk will need to be considered.
- 5.17. Based on the proposed impermeable areas taken from the current layouts included within Appendix B, the volume of attenuation required for the proposed development may be estimated by using design software.
- 5.18. Initially this assessment will be carried out assuming that all water will be attenuated into a single system, in this case a tank, as this will provide the total volume required to be attenuated on the site.
- 5.19. An assessment will then be undertaken to highlight how this design could be refined during detailed design to provide additional opportunities.

Calculation

- 5.20. In the first example it has been assumed that all water will flow into a single system, such as a tank, with a flow control device being used. Basing the calculations on the FSR characteristic the following input parameters can be used:
- M5-60 = 18.0mm
 - R = 0.360
 - Return Period = 1 in 100
 - Climate Change Factor = 20%

5.21. A summary of the results is included in Table 4 below.

Table 4: Preliminary Attenuation Calculations

	Proposed Impermeable Area (ha)	Anticipated Unrestricted Run- off (l/s)	Proposed Restricted Runoff Rate (l/s)	Approximate Attenuation Volume Required (1 in 100 +20) (m ³)
Whole site	0.172	23.2	5	55.7

5.22. This assessment is for the whole impermeable area discharging to a single system such as a Cellular Storage System with no infiltration. Undeveloped areas within the site boundary have not been considered as it is assumed that drainage of these areas will be as existing.

5.23. A copy of the Microdrainage calculations is included in Appendix D.

Water Quality

5.24. It is important to manage the quality of surface water runoff so that the receiving surface waters and/or groundwaters is protected. 'SuDS Manual' CIRIA report C753 states that for most developments a well-designed SuDS system can provide treatment and enable pollution removal through the following mechanisms:

- Pollution prevention: stopping contaminants becoming mixed with runoff.
- Interception: Preventing runoff and therefore the associated pollution load, for most small rainfall events.
- Treatment: implementing SuDS components (in series where required) that use a range of treatment processes to reduce contaminate levels in surface water runoff to an acceptable level.
- Maintenance and Remedial Works: to remove any pollutants that have been to maintain performance.

5.25. In accordance with Table 4.3 of CIRIA report C753 this development can be classed as having a low risk of pollution with the main sources of pollutants for this development being silt and debris from the roofs. As a result, the requirement for the discharge to surface water is the removal of silts. The above will need to be addressed prior to the next stage of design.

Available SuDS Overview

5.26. The most appropriate attenuation systems should ideally satisfy four main characteristics:

- Provide the required volume of storage while minimising the loss of developable land.
- Improve Water Quality
- Where possible provide opportunities to create additional amenity space.
- Where possible provide opportunities to promote biodiversity through the creation of new habitats.

5.27. Systems which best meet the above criteria are often referred to as Sustainable Drainage Systems (SuDS). SuDS aim to mimic the natural run off profile of the original catchment and the CIRIA SuDS Manual (C753) states that on new developments drainage systems should not just be designed to restrict the runoff but also ensure that the quality is improved.

5.28. To help identify the most appropriate systems, the manual in combination with EA Guidance sets out a hierarchy which has been summarised in Table 5 below for reference.

Table 5: SuDS Hierarchy

	SuDS Technique	Flood Reductions	Pollution Reductions	Landscape & Wildlife Benefit
Most Sustainable	Living Roofs	✓	✓	✓
↑	- Basins and Ponds - Constructed Wetlands - Balancing Ponds - Detention Basins - Retention Ponds	✓	✓	✓
	- Filter strips and swales - Infiltration devices - Soakaways - Infiltration trenches and basins	✓	✓	✓
↓	- Permeable surfaces and filter drains - Gravelled areas - Solid paving blocks - Porous pavements	✓	✓	
Least Sustainable	- Tanked Systems - Oversized pipes/tanks - Cellular Storage	✓		

Source: CIRIA SuDS Manual (C753)

5.29. Systems at the top of the hierarchy meet all the requirements set out in the points above and are generally considered the most sustainable option. It is, however, accepted that there are certain scenarios where some systems are more suitable than others and while at this preliminary stage it is not possible to identify what the most appropriate system will be, the following sections talk through each in turn and identifies their suitability for the project.

Living or Green Roofs

5.30. Although often only considered applicable for larger commercial roofs, there are opportunities to utilise living or green roofs on residential projects, particularly when located in large built-up areas. This can bring a range of benefits including:

- The absorption of heat from the sun.
- The absorption of CO₂
- Reducing the size of attenuation requirement as typically green roofs intercept up to 70% of the water that falls on them.
- The creation of additional habitats.
- Improvements to the aesthetics of a property.

5.31. If considered at the outset of the design of a unit, a green roof can be integrated within the provision of a roof terrace area to create additional living space, alternatively, a maintained roof can be installed that may require specialised access.

5.32. There are numerous systems available, and it is recommended that if these systems are being considered discussion with several suppliers is instigated as soon as possible.

5.33. For this development, while the use of a green roof would have the potential to bring additional benefits to the site, the fact the part of the development will be a retrofit inside an existing listed

building makes their use impractical for the main building. There could be opportunities however, to fit them onto any bin stores or other out buildings if these are included within later iterations of the design.

Ponds and Basins

- 5.34. Where space allows, ponds can be a great addition to a development as they enhance outdoor space. They also provide great water quality benefits as they promote biological action and stilling of sediments.
- 5.35. In rural settings basins can also create areas of open space that can enhance existing habitats for wildlife.
- 5.36. Both systems do, however, take up developable land and have residual maintenance and liability issues attached to their implementation.
- 5.37. Based on the proposed layout there is insufficient space to incorporate a pond or basin into the scheme.

Filter Strips and Swales

- 5.38. Swales and filter strips are often incorporated adjacent to roads and footpaths and can be used to collect water directly from linear features, or as a way of joining the dots between several larger features. If designed correctly they can also be used to attenuate and then discharge the flow to either a traditional system or a secondary SuDS device.
- 5.39. The use of these systems is more suited to linear applications such as roads as the typical cross section is relatively small and longer runs are required to provide attenuation volume.
- 5.40. Filter strips will be smaller in plan area than a swale although the swale can be landscaped to be incorporated into the verge of the carriageway, combining two functions.
- 5.41. Land take can be relatively small in comparison to other systems and both types perform well in improving water quality. They are also ideally suited for disposal of water via a secondary infiltration.
- 5.42. Due to the lack of linear features on this development there is limited opportunity to incorporate filter strips and swales as part of the drainage strategy for this development. As such they have not been considered further.

Rain Gardens and tree pits

- 5.43. Rain gardens are designed to mimic the natural water retention of undeveloped land and reduce the volume of rainwater running off into drains from impervious areas. They also have the added benefit that they can treat low levels of pollution. For a residential setting these could take the form of either raised planters at the base of downpipes or shallow depressions with absorbent, yet free draining soil which are populated with plants that are able to withstand temporary flooding conditions.
- 5.44. This type of system not only has the advantage of meeting the requirements of SuDS but could also provide additional educational benefits for certain sites.
- 5.45. There could be opportunities to utilise some individual raingardens by disconnecting rainwater downpipes or within the vegetative areas surrounding the bin/bike store and mail areas. These could be incorporated into the planting regime and allow for additional amenity spaces to be created.
- 5.46. Tree Pits could also be used to break up the paving area and provide additional interest. This would have the added benefit of providing shade in the summer.

Permeable Paving

- 5.47. Where areas of paved hardstanding are proposed there are opportunities to make these permeable which can provide significant volumes of storage. These systems also encourage biological treatment of flow and extraction of oils and heavy metals from the run-off.
- 5.48. Compared to other SuDS components, land take is reduced as storage is located under hardstanding and access roads. However, maintenance is potentially a long-term issue and the possibility of the paving being damaged, dug up and not properly reinstated or not regularly swept could lead to compromising the future capacity of the system.
- 5.49. Unlike other SuDS systems, there is no specific amenity provided by permeable paving other than enabling other areas to be utilised for development rather than potentially sterilizing area with an easement for a sewer or stand-off for a basin.
- 5.50. These systems may be incorporated into normal car-parking areas and driveways but may not be suitable for areas accessed by larger vehicles. These systems can also work well with geo-cellular attenuation where attenuation volumes are large.
- 5.51. As part of this development there could be an opportunity to utilise permeable paving within the hardstand areas.

Cellular Storage

- 5.52. Large volumes of storage can be provided under grassed and lightly trafficked areas by using proprietary geo-cellular systems. This will maximise the developable area of the site.
- 5.53. There are no specific mechanisms within the system designed to treat flow, but extended detention times will allow sedimentation reducing the suspended solids within the discharge.
- 5.54. There is no creation of amenity by the installation of these types of systems, indeed by maintaining access to the system small areas may need to be reserved.
- 5.55. If the developable footprint is constrained then these systems may be advantageous, however, to ensure suitability it is recommended that the use of these systems is discussed with the maintaining body as they are not always preferred.
- 5.56. The installation of cellular storage requires significant excavation and therefore where space is not a critical issue other forms of attenuation should be considered. These systems will also require occasional maintenance to remove sediments which can be difficult depending on the design and access arrangements.

Tank or Culvert Storage

- 5.57. Hard engineered tank storage systems have traditionally been used for attenuation structures for the past decade and are often specified where large volumes of storage are required (>200m³) and available space is an issue.
- 5.58. These systems have no inherent water treatment properties except potential sedimentation of the attenuated flow and offer no additional amenity benefits. In some cases, the easement to the tank or culvert is such that a significant portion of land area is sterilized from development as are certain types of landscape planting.
- 5.59. There are also significant costs associated with these systems in production, transportation, and installation. However, once installed the long-term maintenance requirement of the system is relatively low.

- 5.60. With a proven record of successful installation, tanks and culverts are regularly adopted by water authorities across the country, albeit with a large associated easement that will sterilise that portion of the site. It should be noted however, that these systems will require occasional maintenance to remove sediments which can be difficult depending on the design and access arrangements.

Surface Storage

- 5.61. The use of roads, public areas and even landscaped areas as additional storage for an extreme rainfall event is becoming a widely accepted form of attenuation.
- 5.62. Water spilling from the drainage systems can be collected via roads and kerbs and channelled to lower lying areas where it would be stored until the capacity in the existing system returns.
- 5.63. These systems have the advantage of requiring little additional infrastructure merely detailing of the proposed roads and grassed areas.
- 5.64. As these systems will only be used in extreme events when the adopted drainage system is exceeded (>1 in 30 years), they provide a very efficient way of catering for these events rather than providing permanent capacity.
- 5.65. There is no inherent water treatment capability in this system nor any increase in amenity, however, the costs associated with this provision are relatively small.
- 5.66. While the final level strategy is still to be determined, there could be an opportunity to temporarily store water in localised pockets around the hardstanding. Consideration would need to be given however to ensure that this did not pose a flood risk to surrounding properties and that this only occurred during extreme circumstances.

Oversized Pipework

- 5.67. It is often possible to provide the required volume of storage within the existing collection pipework of the proposed system. This may be incorporated by using oversized pipework designed to act as inline storage.
- 5.68. As the diameter of larger pipes readily available is limited the applicability of these types of systems is more suited to <200m³ of attenuation. Above this volume, the length of pipe required is excessive and difficult to suitably fit into a normal site layout.
- 5.69. There is no intrinsic amenity provided using this system neither is there any specific level of run-off treatment over and above that of a standard pipe and gully system.
- 5.70. However, due to their traditional nature, the adoption of these types of systems by water companies is straightforward and does not require any specialist input. The pipes are generally available direct from suppliers with little or no lead time and the satisfactory long-term performance of these systems is well documented.
- 5.71. Due to the relatively small nature of the site, it is unlikely that sufficient lengths of pipework will be installed to make this a viable attenuation option. As such, this method has not been considered further as part of this design.

Summary

- 5.72. The application of a SuDS based system needs to be considered as the primary measures for dealing with surface water for any proposals, these systems are the only ones that provide the required level of treatment.

5.73. Due to the fairly constrained nature of the site and the extensive areas of hardstanding to be provided, it is currently proposed to use a combined permeable paving and geocellular attenuation tank system as the main form of attenuation as part of this development.

5.74. This would not only provide the required amount of attenuation but would also have added treatment benefits.

5.75. While the ground conditions mean that infiltration may be possible, there is a requirement for any soakaway to be located 5m from a building so as not to undermine the foundations. This would mean that any infiltration opportunities would be localised and to the centre of the site and as such a positive connection into the adopted assets located in Great Jackson Street would still be required.

5.76. Although not designed as part of these works, additional treatment, amenity and biodiversity benefits could be achieved through the incorporation of raingardens and tree pits. These could utilise the small areas of planting already proposed as part of the landscape strategy.

Design Example

5.77. To give some idea of the size of attenuation features that may be required and thus begin the process of integration, it is possible to provisionally size a typical feature at this stage based upon the assumptions discussed previously.

5.78. Due to the site layout and topographically it is currently proposed that attenuation for the building will be provided via a permeable paving system. In the absence of any soakaway tests, and due to the requirement for a 5m offset to be maintained from any building, for the purpose of the exercise it has been assumed that the system will discharge at 4l/s into the adopted asset located in Great Jackson Street.

5.79. A summary of the proposed attenuation systems is included within Table 6 below, with a full copy of the Microdrainage Calculations are included within Appendix F.

Table 6: Summary of attenuation size

Area	Area to be drained (m ²)	Attenuation Feature
Building and hardstanding	1715m ²	Permeable paving • Average Length = 24.3m • Average Width = 8.8m • Depth = 300mm • Slope = 1 in 50 (based on existing topo)

5.80. The calculations show that for the 1 in 100 plus 20% climate change scenario there will be 47.5m³ of flooding. As such a geocellular tank will need to be incorporated into the design with the following dimensions:

- Average Length = 10m
- Average Width = 2.5m
- Depth = 2.5m
- Assumed Porosity = 0.9

5.81. This combined system would provide sufficient attention for the 1 in 100 plus 20% climate change event.

5.82. A test for exceedance was also carried out for the 1 in 100 + 40CC event which also found that for the permeable paving 59.7m³ of flooding occurred. When the 56m³ of attenuation from the cellular storage system is subtracted this would result in 3.7m³ of flooding. If the hardstanding was used for temporary storage this would result in approximately 10mm of flooding across the site. While the proposed level strategy is still to be determined, it is recommended that a slight fall to the centre of the site is created to direct water away from the buildings and ensure that it does not leave the site.

5.83. Microdrainage outputs for Exceedance are included in Appendix G.

5.84. With reference to water quality, the simple index approach can be used to assess the that the pre-and post-treatment pollution index (Table 26.2 and 26.3 from the CIRIA SuDS Manual).

Table 7: Water Quality Assessment

Area	Pre-Treatment Pollution Index	Attenuation Feature	Mitigation Indices	Sufficient Treatment Provided
Residential Roof	- Total Suspended Solids = 0.2 - Metals = 0.2 - Hydrocarbons = 0.05	Permeable Paving	- Total Suspended Solids = 0.7 - Metals = 0.6 - Hydrocarbons = 0.7	Yes

Source: CIRIA SuDS Manual

5.85. As the mitigation is greater than the hazard, both systems would provide sufficient treatment.

5.86. A drainage strategy drawing has been included within Appendix H for reference.

Maintenance and remedial work

5.87. The CIRIA SuDS manual (C753) groups maintenance requirements into three categories:

- Regular maintenance;
- Occasional maintenance, and;
- Remedial maintenance.

5.88. Regular maintenance consists of the basic tasks that are carried out frequently and on a predictable schedule.

5.89. Occasional maintenance consists of tasks that are predictable but are not require a frequently as those falling under the regular maintenance.

5.90. Remedial maintenance is only required to rehabilitate the system when faults are identified during regular or occasional maintenance or pollution leads to contamination of the system.

Permeable Paving

5.91. Pervious pavements need to be regularly cleaned out of silt and other sediments to ensure that they continue to operate as designed. As part of the next stage of design, a detailed specification, including frequencies as well as adequate access provision will need to be confirmed prior to submission.

5.92. Table 8 taken from the CIRIA SuDS manual highlights typical activities which should be included as part of any operation and maintenance regimes of a permeable paving system.

Table 8: Typical operation and maintenance requirements for permeable paving system

Maintenance schedule	Required Action	Typical frequency
Regular Maintenance	Brushing and vacuuming	Once a year
Occasional Maintenance	Removal of weed or management using glyphosphate applied directly into the weeds by an applicator rather than spraying.	As required
Remedial Actions	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.	As required.
	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 actions	Three monthly, 48 hours after large storms in first six months
	Inspect silt accumulation rates and establish appropriate brushing frequencies.	Annually
	Monitor inspection chamber	Annually

Source: CIRIA SuDS Manual (C753)

Cellular Storage

5.93. Cellular Storage Units will require regular maintenance to ensure that they continue to operate efficiently and as designed.

5.94. Typical activities would include regular inspection of silt traps, manholes, pipework and any pre-treatment devices, with the removal of debris and silt as required.

Foul Drainage

Proposed Outfall and Strategy

5.95. Foul drainage from the site should be drained by an entirely separate system and it is currently proposed to connect into the 375mm diameter combined sewer on Great Jackson Street (see Appendix H for Drainage Strategy).

Foul Water Flow Rates

5.96. From reviewing the proposed layouts included in Appendix C the number of apartments can be broken down as shown in Table 9.

Table 9: Breakdown of Apartment Numbers

	Building A	Building B
Ground Floor	9	9
First Floor	8	8
Second Floor	0	8
Third Floor	0	8
Total	17	33

5.97. As the scheme is currently under development and the final internal layouts are still to be confirmed, the current system has been sized in accordance with the Design and Construction Guidance taking the peak flow rate as 4000 litres per dwelling per day (or 0.05l/s per dwelling).

5.98. Based in Table 9 above this would result in the following flow rates:

- Building A = 0.85l/s
- Building B = 1.65l/s

5.99. This could be accommodated within a 150mm dia. pipe at an average gradient of 1 in 50 which based on the Wavin Pipe Capacity Calculator would have a capacity of 22.213 l/s.

Adoption and Maintenance

5.100. It is currently envisaged that the foul drainage system would remain private until the point it connects into the adopted sewer in Silvercroft Street. An application will need to be completed during the detailed design stage.

5.101. To ensure the effective operation of any drainage system it is important to undertake some key activities as part of a regular maintenance strategy. These have been briefly summarised below:

- Periodic desilting of any catch pits, gully sumps and linear drainage systems which should as a minimum be emptied as follows:
 - On completion of the construction period.
 - Year 1
 - Year 3
 - Then every five years.
- Jetting and rodding of the pipework to ensure that there are no blockages.
- Remove of debris from the grates of gullies and channels.
- Desilting of the Hydro-Brake sumps and a check of the emergency drain down mechanism to ensure they stay in good working order. This should be completed as a minimum:
 - On completion of the construction period.
 - Year 1
 - Year 3
 - Then every five years.

5.102. It should be noted however that an annual inspection should take place with additional cleaning completed as required.

6. Summary

- 6.1. This flood risk assessment has been produced as part of an outline planning application for the proposed development of the Bridgewater Site into two Apartment Buildings.
- 6.2. From a review of the Environment Agency Flood Maps the site was found to be in Flood Zone 1.
- 6.3. No other sources of flooding were identified and as the works themselves will be the construction of a new residential development which will have a properly designed drainage system, it is not envisaged that there will be an increased risk of flooding because of the development.
- 6.4. At the time of writing while it is assumed infiltration may be possible, no soakaway tests have been carried out and the opportunity would be limited due to the requirement to maintain at least a 5m offset from any building foundations.
- 6.5. A provisional drainage strategy was produced using the source control module of Microdrainage and found that a combined permeable paving and cellular storage system could be used to attenuate surface water generated from the buildings themselves and associated hardstanding. In the absence of infiltration data, a discharge rate of 5l/s was used, which resulted in a permeable paving and cellular storage system with the following dimensions:

Permeable Paving

- Length = 24.3m
- Width = 8.8m
- Depth = 0.3m
- Slope = 1 in 50

Cellular Storage

- Average Length = 10m
- Average Width = 2.5m
- Depth = 2.5m
- Assumed Porosity = 0.9

- 6.6. This combined system would provide sufficient attenuation for the 1 in 100 plus 20% climate change event.
- 6.7. A test was run for the 1 in 100 plus 40% climate change event and found that there was 3.7m³. This would equate to approximately 10.2mm of flooding across the hardstanding and as such it is believed that this could be temporarily stored within the hardstanding before feeding back into the main drainage system.
- 6.8. The size of these systems could be further reduced using additional SuDS features such as raingardens and tree pits as part of the proposed landscape strategy. This will need to be explored further as part of the detailed design process.

- 6.9. In comparison the foul flows are likely to be increased, however, the risk of flooding from this source should be mitigated by ensuring that the system is properly designed and appropriate approvals from the water authority obtained prior to connection into the adopted sewer.
- 6.10. Based on provisional foul flow rates from the Design and Construction Guidance, it is anticipated that a 150mm dia pipe at a 1 in 50 gradient will have sufficient capacity to accommodate the proposed flows. This will need to be confirmed as part of the detailed design process.

Appendix A – Topographical Survey



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DO NOT SCALE FROM THIS DRAWING. ALL DIMENSIONS TO BE CHECKED ON SITE

- Key**
- Building
 - Spot Level
 - Bank Bottom
 - Bank Top
 - Kurb
 - Wall
 - Contour 65.0

Notes:

Site	
Bridgewater House	
Drawing title	
Topographic Survey	
Scale	
1:250	
Drawn By	Date
GG	16/11/2021
Drawing Number	
BH-TS-002-A	

George Gordon
4 Greencoats Yard
Blackhall Road
Kendal
Cumbria
LA9 4XA
t: 07786923502
e: ggordon05@mail.com



Appendix B – Proposed Development

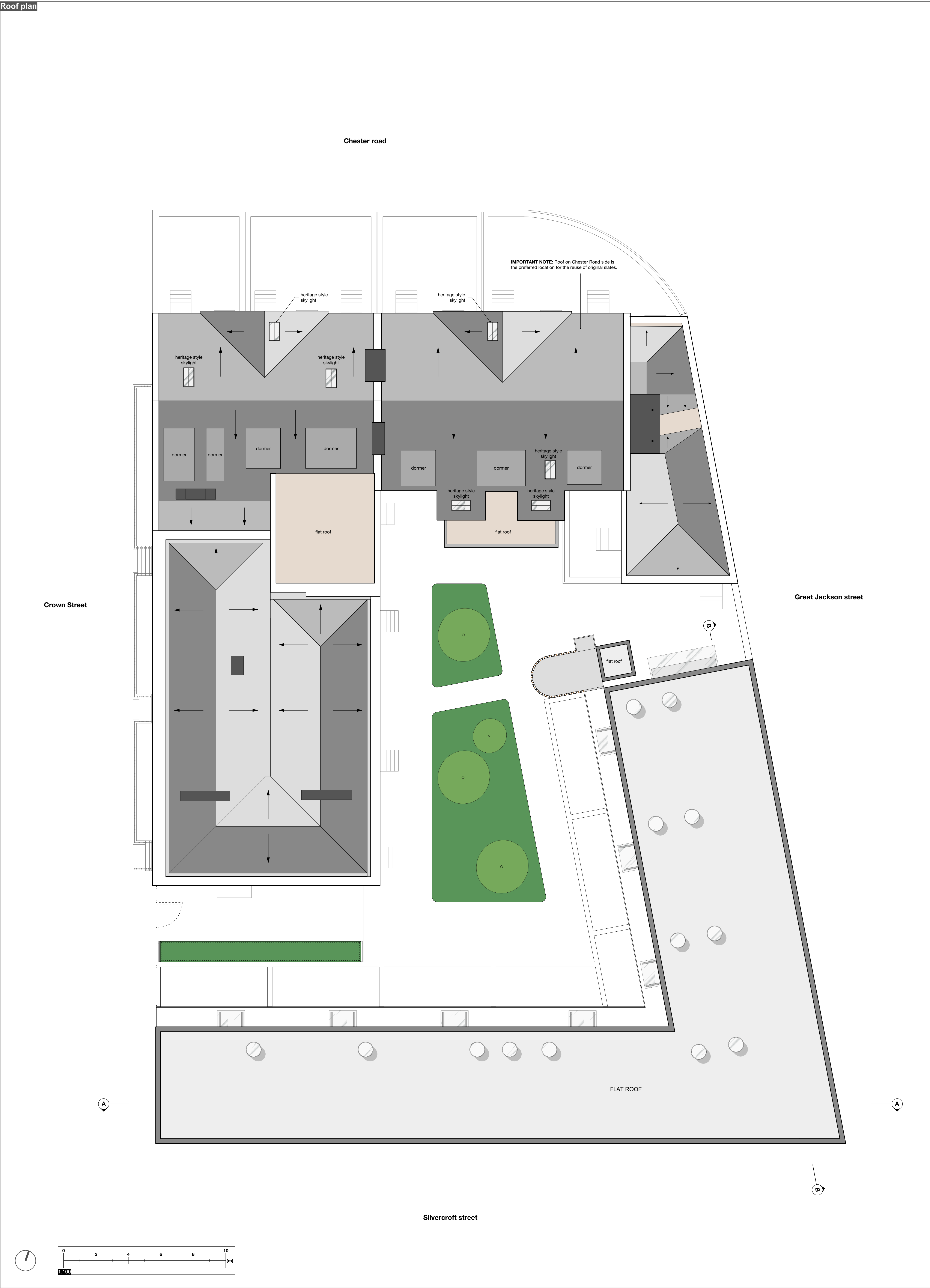




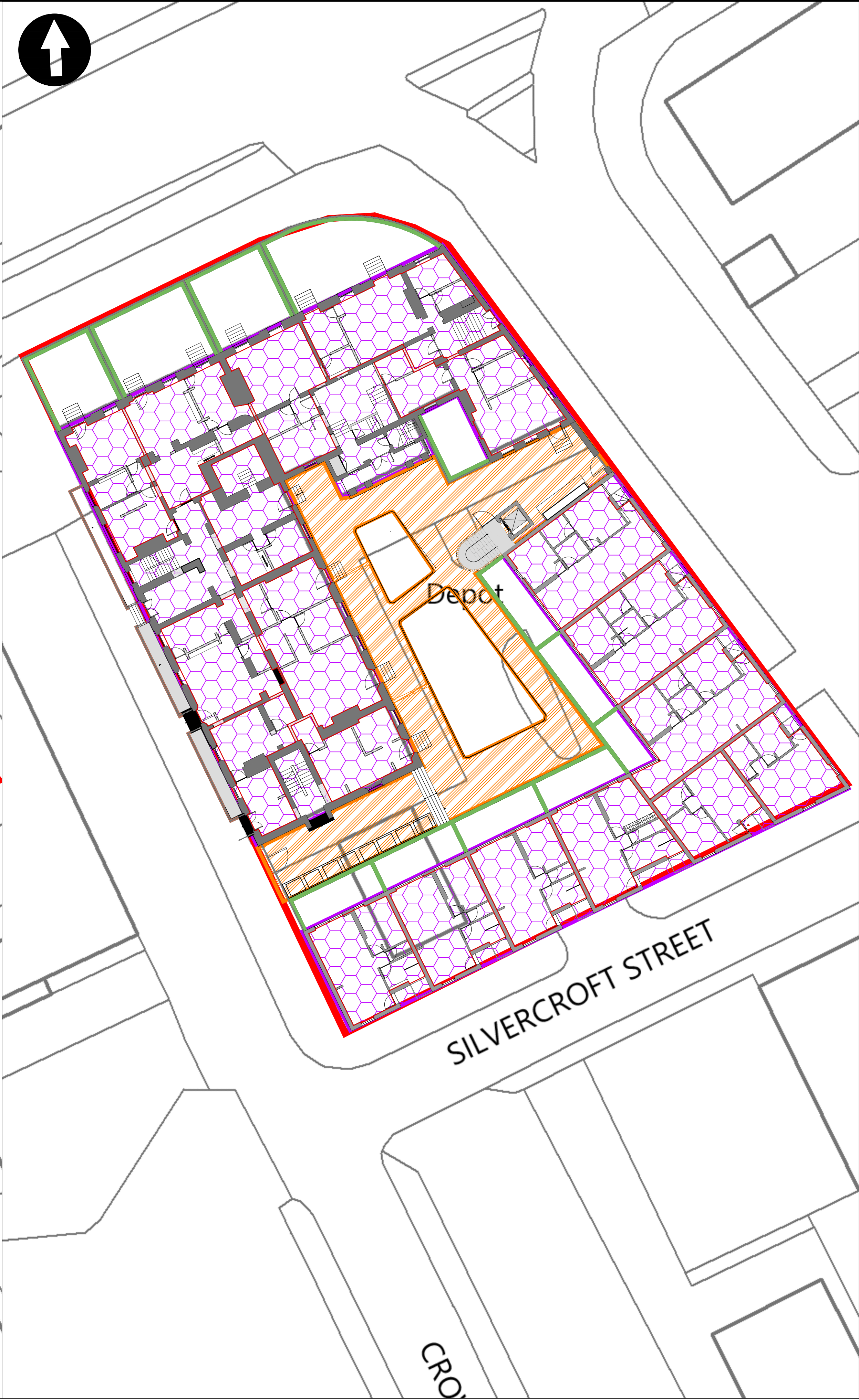
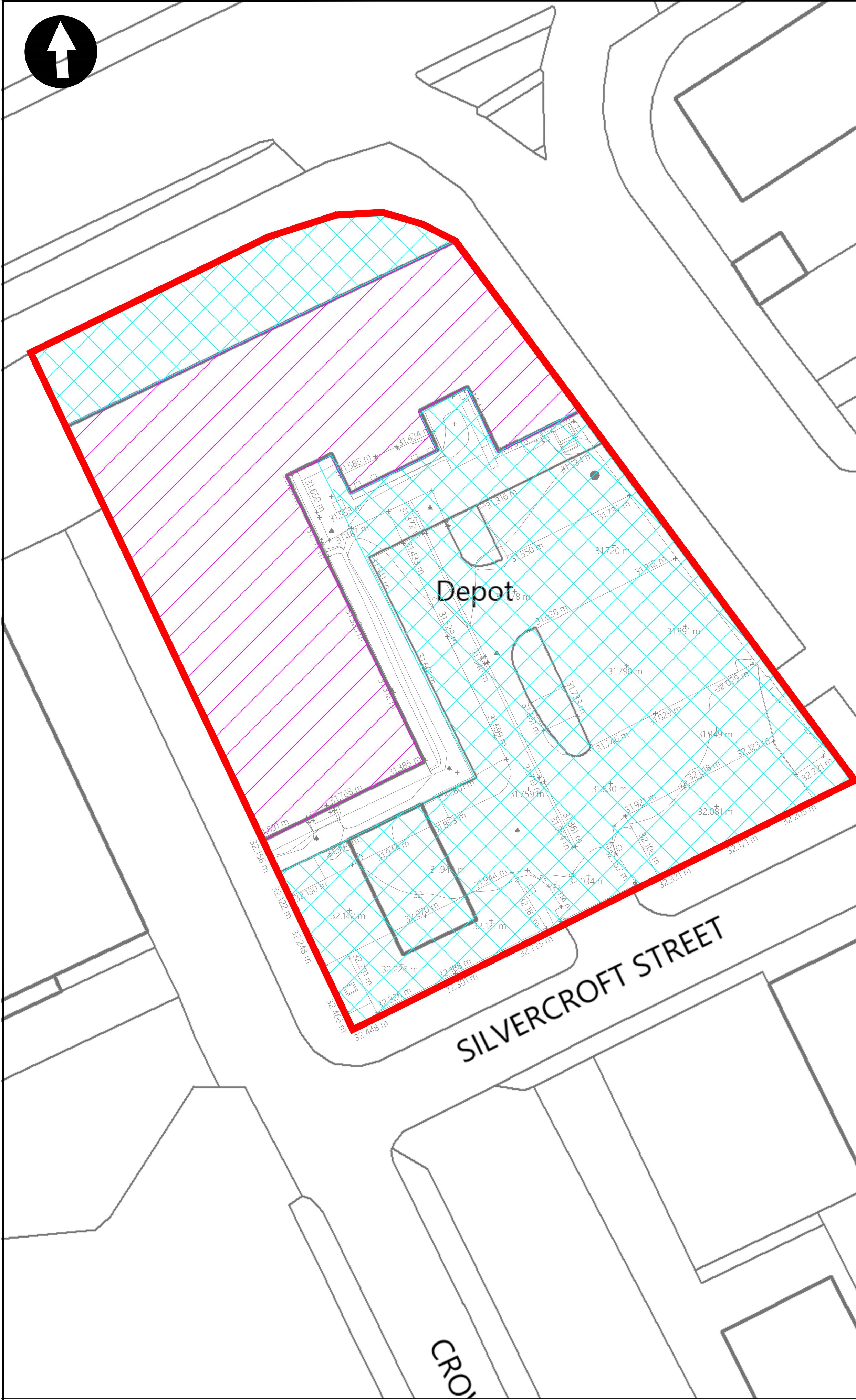


Do not scale from this drawing.

All dimensions are to be checked on site prior to commencing works on site. Discrepancy found between information given on this drawing and that given elsewhere or recorded on site shall be notified immediately to the project architect in writing.



Appendix C – Existing and Proposed Areas



DO NOT SCALE FROM THIS DRAWING

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER HBL DRAWINGS ISSUED FOR THIS PROJECT

KEY

- Site Boundary
- Existing Building = 758m²
- Existing Hardstanding = 1246m²
- Proposed Building = 1353m²
- Proposed Hardstanding = 362m²

REFERENCE DRAWINGS

Wherever possible, risk is designed out during the design process. Where this is not possible, the risk will be minimised and any significant residual risk will be noted and indicated by a hazard warning triangle.

NOT FOR CONSTRUCTION

P02	26.06.2022	FEG	FOR PLANNING	AP	ABG
P01	27.05.2022	FEG	FOR PLANNING	AP	ABG
REV.	DATE	DRAWN	DESCRIPTION	CHKD	APPRD
STATUS DESCRIPTION				STATUS	
FOR PLANNING				S2	

Brook House
Weybrook Road,
Manchester M19 2QD
+44 (0)161 432 9977 | www.hbl.ltd
Consulting Civil & Structural Engineers

PROJECT	BRIDGEWATER HOUSE MANCHESTER
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DRAWING TITLE	EXISTING AND PROPOSED IMPERMEABLE AREAS
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CLIENT	THIS IS THE SPACE
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HBL REF. 9757	DATE 27.05.2022	SCALE(S) 1:200	A1
DRAWN FEG	CHECKED AP	APPROVED ABG	
DRAWING No. 9757-HBL-XX-XX-DR-D-0500			REV. P02

Appendix D – Whole Site Attenuation

Rennard Consulting Limited					Page 1
Ebenezer House Ryecroft Newcastle ST5 2BE		Bridgewater House Whole Site Attenuation 1 in 100 + 20CC			
Date 26/06/2022 15:39 File WHOLE SITE AREA - REV 3....		Designed by F.Gennard Checked by			
Innovyze		Source Control 2020.1.3			
<u>Summary of Results for 100 year Return Period (+20%)</u>					
Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	9.650	0.150	5.0	30.0	O K
30 min Summer	9.692	0.192	5.0	38.5	O K
60 min Summer	9.727	0.227	5.0	45.3	Flood Risk
120 min Summer	9.746	0.246	5.0	49.2	Flood Risk
180 min Summer	9.749	0.249	5.0	49.7	Flood Risk
240 min Summer	9.745	0.245	5.0	48.9	Flood Risk
360 min Summer	9.728	0.228	5.0	45.6	Flood Risk
480 min Summer	9.710	0.210	5.0	42.0	Flood Risk
600 min Summer	9.692	0.192	5.0	38.4	O K
720 min Summer	9.675	0.175	5.0	35.1	O K
960 min Summer	9.648	0.148	5.0	29.6	O K
1440 min Summer	9.617	0.117	4.6	23.3	O K
2160 min Summer	9.595	0.095	3.7	19.1	O K
2880 min Summer	9.583	0.083	3.1	16.6	O K
4320 min Summer	9.569	0.069	2.3	13.9	O K
5760 min Summer	9.561	0.061	1.9	12.2	O K
7200 min Summer	9.555	0.055	1.6	11.1	O K
8640 min Summer	9.551	0.051	1.4	10.2	O K
10080 min Summer	9.548	0.048	1.2	9.6	O K
15 min Winter	9.669	0.169	5.0	33.9	O K
30 min Winter	9.718	0.218	5.0	43.6	Flood Risk
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)	
15 min Summer	101.668	0.0	32.0	17	
30 min Summer	68.068	0.0	43.1	32	
60 min Summer	43.553	0.0	55.8	60	
120 min Summer	26.973	0.0	69.2	94	
180 min Summer	20.113	0.0	77.4	128	
240 min Summer	16.234	0.0	83.3	162	
360 min Summer	11.899	0.0	91.7	228	
480 min Summer	9.551	0.0	98.1	294	
600 min Summer	8.047	0.0	103.3	358	
720 min Summer	6.993	0.0	107.8	420	
960 min Summer	5.598	0.0	115.0	538	
1440 min Summer	4.083	0.0	125.7	766	
2160 min Summer	2.973	0.0	137.8	1124	
2880 min Summer	2.371	0.0	146.4	1476	
4320 min Summer	1.720	0.0	159.1	2204	
5760 min Summer	1.368	0.0	169.3	2936	
7200 min Summer	1.145	0.0	177.0	3672	
8640 min Summer	0.989	0.0	183.5	4408	
10080 min Summer	0.874	0.0	188.9	5136	
15 min Winter	101.668	0.0	35.9	17	
30 min Winter	68.068	0.0	48.4	31	
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Ebenezer House Ryecroft Newcastle ST5 2BE		Bridgewater House Whole Site Attenuation 1 in 100 + 20CC			
Date 26/06/2022 15:39 File WHOLE SITE AREA - REV 3....		Designed by F.Gennard Checked by			
Innovyze		Source Control 2020.1.3			
<u>Summary of Results for 100 year Return Period (+20%)</u>					
Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	9.759	0.259	5.0	51.7	Flood Risk
120 min Winter	9.778	0.278	5.0	55.7	Flood Risk
180 min Winter	9.779	0.279	5.0	55.7	Flood Risk
240 min Winter	9.770	0.270	5.0	54.0	Flood Risk
360 min Winter	9.742	0.242	5.0	48.4	Flood Risk
480 min Winter	9.713	0.213	5.0	42.5	Flood Risk
600 min Winter	9.685	0.185	5.0	36.9	O K
720 min Winter	9.660	0.160	5.0	32.1	O K
960 min Winter	9.626	0.126	4.9	25.2	O K
1440 min Winter	9.599	0.099	3.9	19.9	O K
2160 min Winter	9.581	0.081	2.9	16.1	O K
2880 min Winter	9.570	0.070	2.4	14.0	O K
4320 min Winter	9.558	0.058	1.7	11.7	O K
5760 min Winter	9.551	0.051	1.4	10.3	O K
7200 min Winter	9.547	0.047	1.2	9.3	O K
8640 min Winter	9.543	0.043	1.0	8.6	O K
10080 min Winter	9.540	0.040	0.9	8.0	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)	
60 min Winter	43.553	0.0	62.5	60	
120 min Winter	26.973	0.0	77.5	102	
180 min Winter	20.113	0.0	86.8	138	
240 min Winter	16.234	0.0	93.4	176	
360 min Winter	11.899	0.0	102.7	248	
480 min Winter	9.551	0.0	109.9	316	
600 min Winter	8.047	0.0	115.8	380	
720 min Winter	6.993	0.0	120.8	438	
960 min Winter	5.598	0.0	128.9	540	
1440 min Winter	4.083	0.0	140.9	778	
2160 min Winter	2.973	0.0	154.3	1128	
2880 min Winter	2.371	0.0	164.0	1500	
4320 min Winter	1.720	0.0	178.3	2208	
5760 min Winter	1.368	0.0	189.6	2944	
7200 min Winter	1.145	0.0	198.3	3632	
8640 min Winter	0.989	0.0	205.5	4384	
10080 min Winter	0.874	0.0	211.6	5232	
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Ebenezer House Ryecroft Newcastle ST5 2BE	Bridgewater House Whole Site Attenuation 1 in 100 + 20CC	
Date 26/06/2022 15:39 File WHOLE SITE AREA - REV 3....	Designed by F.Gennard Checked by	
Innovyze	Source Control 2020.1.3	

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)	18.000	Shortest Storm (mins)	15
Ratio R	0.360	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.172

Time (mins)		Area
From:	To:	(ha)
0	4	0.172

Rennard Consulting Limited		Page 4
Ebenezer House Ryecroft Newcastle ST5 2BE	Bridgewater House Whole Site Attenuation 1 in 100 + 20CC	
Date 26/06/2022 15:39 File WHOLE SITE AREA - REV 3....	Designed by F.Gennard Checked by	
Innovyze	Source Control 2020.1.3	

Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

Invert Level (m) 9.500

Depth (m)	Area (m ²)	Depth (m)	Area (m ²)
0.000	200.0	0.500	200.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0113-5000-0500-5000
Design Head (m)	0.500
Design Flow (l/s)	5.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	113
Invert Level (m)	9.500
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

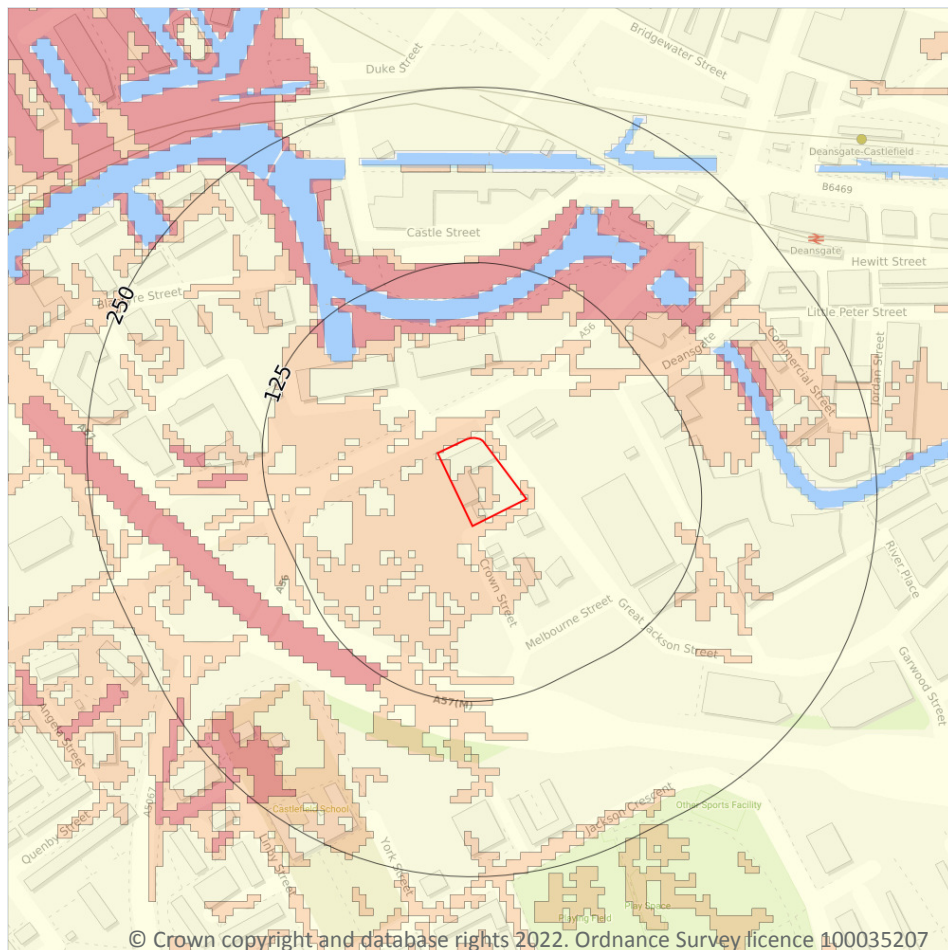
Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.500	5.0
Flush-Flo™	0.179	5.0
Kick-Flo®	0.372	4.4
Mean Flow over Head Range	-	4.1

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	3.9	1.200	7.5	3.000	11.6	7.000	17.4
0.200	5.0	1.400	8.1	3.500	12.5	7.500	18.1
0.300	4.8	1.600	8.6	4.000	13.3	8.000	18.7
0.400	4.5	1.800	9.1	4.500	14.1	8.500	19.2
0.500	5.0	2.000	9.6	5.000	14.8	9.000	19.8
0.600	5.4	2.200	10.0	5.500	15.4	9.500	20.3
0.800	6.2	2.400	10.4	6.000	16.1		
1.000	6.9	2.600	10.8	6.500	16.8		

Appendix E – Extract from GI Report

9 Groundwater flooding



— Site Outline
Search buffers in metres (m)

- High
- Moderate - High
- Moderate
- Low
- Negligible

9.1 Groundwater flooding

Highest risk on site

Moderate-High

Highest risk within 50m

Moderate-High

Groundwater flooding is caused by unusually high groundwater levels. It occurs when the water table rises above the ground surface or within underground structures such as basements or cellars. Groundwater flooding tends to exhibit a longer duration than surface water flooding, possibly lasting for weeks or months, and as a result it can cause significant damage to property. This risk assessment is based on a 1 in 100 year return period and a 5m Digital Terrain Model (DTM).

Features are displayed on the Groundwater flooding map on **page 95**

This data is sourced from Ambiantal Risk Analytics.

8. Groundwater

Groundwater was encountered in the Sandstone Bedrock at levels between 23.1 mAOD to 23.7 mAOD during the course of the fieldwork. The groundwater conditions entered on the exploratory hole logs are those observed at the time of the drilling operations and the water level may not have reached equilibrium with the surrounding water level prior to the record being taken.

Standing groundwater levels will be subject to seasonal variation or changes in local drainage conditions and could be higher at certain times of the year particularly after periods of heavy rainfall.

Subsequent monitoring of groundwater levels spanning a period from November 2017 to January 2018 in the standpipe installations at BH1, BH4 and BH6, confirm the groundwater levels to range between 23.3 mAOD to 24.1 mAOD in the sandstone bedrock. The readings obtained are considered to be generally representative of the steady state groundwater levels across the site. Elsewhere, localised pockets of perched water were encountered within the superficial geology during the fieldwork in particular in the area of BH6 where significant granular deposits of sandy gravels and cobbles were encountered.

Table 8.0 Groundwater observation summary showing the lowest and highest levels recorded during the fieldwork and the subsequent monitoring period.

	During Fieldwork	During Monitoring Period
Lowest observed Level (mAOD)	23.1	23.0
Highest observed Level (mAOD)	23.7	24.2

The results from the monitoring of groundwater levels across the site have been used to plot the groundwater flow regime plan which forms appendix A2 to this report. The flow regime confirms the groundwater flow hydraulic grade is relatively level. However, the highest observed (worst case) groundwater conditions indicate a gradual fall from north east to south west generally away from the River Medlock which is situated to the east of the site.

Table 8.1 Fluctuation of lowest and highest groundwater levels during monitoring period.

Monitoring Point Ref	Lowest (mAOD)	Highest (mAOD)	Fluctuation/Range (m)
BH1	23.6	24.2	0.6
BH4	23.0	23.7	0.7
BH6	23.5	23.6	0.1

397400

397350

397300

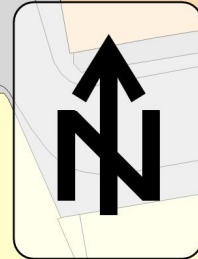
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383100

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383200

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GeoAssist Limited
Civil, Environmental & Geotechnical
Telephone: +44 (0) 161 480 8885 e-mail : info@geoassist.co.uk

A2 Groundwater

Site Name	Crown Street - Zone 1
Location	Silvercroft Street, Manchester
GeoAssist Ref	5890CRK
Client	DQ Developments Ltd
	1st Floor, NQ Building 47 Bengal Street Ancoats Manchester M4 6BB
Planning Consultant	
NGR (centre of site)	383130,397300
Production Date	Jan 18
Survey Method	
Surveyor	Others
Status	Final v1.00
Base Survey	OSGB36



Appendix F – Microdrainage Calculations

Rennard Consulting Limited							Page 1																																																																																																																																																																																																																																																																																	
Ebenezer House Ryecroft Newcastle ST5 2BE			Bridgewater House Permeable Paving Design 1 in 100 + 20CC																																																																																																																																																																																																																																																																																					
Date 26/06/2022 15:46 File permeable paving (300mm ...			Designed by F.Gennard Checked by																																																																																																																																																																																																																																																																																					
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<u>Summary of Results for 100 year Return Period (+20%)</u> Half Drain Time : 89 minutes. <table><tr><th>Storm Event</th><th>Max Level (m)</th><th>Max Depth (m)</th><th>Max Infiltration (l/s)</th><th>Max Control (l/s)</th><th>Max E Outflow (l/s)</th><th>Max Volume (m³)</th><th>Status</th></tr><tr><td>15 min Summer</td><td>10.021</td><td>0.321</td><td>0.0</td><td>5.0</td><td>5.0</td><td>27.7</td><td>FLOOD</td></tr><tr><td>30 min Summer</td><td>10.028</td><td>0.328</td><td>0.0</td><td>5.0</td><td>5.0</td><td>35.2</td><td>FLOOD</td></tr><tr><td>60 min Summer</td><td>10.033</td><td>0.333</td><td>0.0</td><td>5.0</td><td>5.0</td><td>39.9</td><td>FLOOD</td></tr><tr><td>120 min Summer</td><td>10.033</td><td>0.333</td><td>0.0</td><td>5.0</td><td>5.0</td><td>40.1</td><td>FLOOD</td></tr><tr><td>180 min Summer</td><td>10.031</td><td>0.331</td><td>0.0</td><td>5.0</td><td>5.0</td><td>38.7</td><td>FLOOD</td></tr><tr><td>240 min Summer</td><td>10.030</td><td>0.330</td><td>0.0</td><td>5.0</td><td>5.0</td><td>36.7</td><td>FLOOD</td></tr><tr><td>360 min Summer</td><td>10.025</td><td>0.325</td><td>0.0</td><td>5.0</td><td>5.0</td><td>32.1</td><td>FLOOD</td></tr><tr><td>480 min Summer</td><td>10.021</td><td>0.321</td><td>0.0</td><td>5.0</td><td>5.0</td><td>27.7</td><td>FLOOD</td></tr><tr><td>600 min Summer</td><td>10.017</td><td>0.317</td><td>0.0</td><td>5.0</td><td>5.0</td><td>23.4</td><td>FLOOD</td></tr><tr><td>720 min Summer</td><td>10.013</td><td>0.313</td><td>0.0</td><td>5.0</td><td>5.0</td><td>19.4</td><td>FLOOD</td></tr><tr><td>960 min Summer</td><td>10.006</td><td>0.306</td><td>0.0</td><td>5.0</td><td>5.0</td><td>12.6</td><td>FLOOD</td></tr><tr><td>1440 min Summer</td><td>9.918</td><td>0.218</td><td>0.0</td><td>5.0</td><td>5.0</td><td>3.1</td><td>Flood Risk</td></tr><tr><td>2160 min Summer</td><td>9.806</td><td>0.106</td><td>0.0</td><td>4.3</td><td>4.3</td><td>0.7</td><td>Flood Risk</td></tr><tr><td>2880 min Summer</td><td>9.788</td><td>0.088</td><td>0.0</td><td>3.4</td><td>3.4</td><td>0.5</td><td>Flood Risk</td></tr><tr><td>4320 min Summer</td><td>9.772</td><td>0.072</td><td>0.0</td><td>2.5</td><td>2.5</td><td>0.3</td><td>Flood Risk</td></tr><tr><td>5760 min Summer</td><td>9.763</td><td>0.063</td><td>0.0</td><td>2.0</td><td>2.0</td><td>0.3</td><td>Flood Risk</td></tr><tr><td>7200 min Summer</td><td>9.757</td><td>0.057</td><td>0.0</td><td>1.7</td><td>1.7</td><td>0.2</td><td>Flood Risk</td></tr><tr><td>8640 min Summer</td><td>9.752</td><td>0.052</td><td>0.0</td><td>1.4</td><td>1.4</td><td>0.2</td><td>Flood Risk</td></tr><tr><td>10080 min Summer</td><td>9.749</td><td>0.049</td><td>0.0</td><td>1.3</td><td>1.3</td><td>0.2</td><td>Flood Risk</td></tr><tr><td>15 min Winter</td><td>10.025</td><td>0.325</td><td>0.0</td><td>5.0</td><td>5.0</td><td>31.7</td><td>FLOOD</td></tr></table> <table><tr><th>Storm Event</th><th>Rain (mm/hr)</th><th>Flooded Volume (m³)</th><th>Discharge Volume (m³)</th><th>Time-Peak (mins)</th></tr><tr><td>15 min Summer</td><td>101.668</td><td>21.0</td><td>32.4</td><td>18</td></tr><tr><td>30 min Summer</td><td>68.068</td><td>28.1</td><td>43.7</td><td>32</td></tr><tr><td>60 min Summer</td><td>43.553</td><td>32.7</td><td>56.2</td><td>60</td></tr><tr><td>120 min Summer</td><td>26.973</td><td>32.8</td><td>69.9</td><td>96</td></tr><tr><td>180 min Summer</td><td>20.113</td><td>31.5</td><td>78.3</td><td>128</td></tr><tr><td>240 min Summer</td><td>16.234</td><td>29.6</td><td>84.3</td><td>164</td></tr><tr><td>360 min Summer</td><td>11.899</td><td>25.2</td><td>92.8</td><td>230</td></tr><tr><td>480 min Summer</td><td>9.551</td><td>20.9</td><td>99.3</td><td>298</td></tr><tr><td>600 min Summer</td><td>8.047</td><td>16.8</td><td>104.6</td><td>362</td></tr><tr><td>720 min Summer</td><td>6.993</td><td>13.0</td><td>109.1</td><td>426</td></tr><tr><td>960 min Summer</td><td>5.598</td><td>6.4</td><td>116.4</td><td>542</td></tr><tr><td>1440 min Summer</td><td>4.083</td><td>0.0</td><td>127.3</td><td>754</td></tr><tr><td>2160 min Summer</td><td>2.973</td><td>0.0</td><td>138.9</td><td>1096</td></tr><tr><td>2880 min Summer</td><td>2.371</td><td>0.0</td><td>147.5</td><td>1460</td></tr><tr><td>4320 min Summer</td><td>1.720</td><td>0.0</td><td>160.1</td><td>2192</td></tr><tr><td>5760 min Summer</td><td>1.368</td><td>0.0</td><td>169.4</td><td>2920</td></tr><tr><td>7200 min Summer</td><td>1.145</td><td>0.0</td><td>176.7</td><td>3664</td></tr><tr><td>8640 min Summer</td><td>0.989</td><td>0.0</td><td>182.7</td><td>4272</td></tr><tr><td>10080 min Summer</td><td>0.874</td><td>0.0</td><td>187.9</td><td>5088</td></tr><tr><td>15 min Winter</td><td>101.668</td><td>24.7</td><td>36.4</td><td>18</td></tr></table>								Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max E Outflow (l/s)	Max Volume (m³)	Status	15 min Summer	10.021	0.321	0.0	5.0	5.0	27.7	FLOOD	30 min Summer	10.028	0.328	0.0	5.0	5.0	35.2	FLOOD	60 min Summer	10.033	0.333	0.0	5.0	5.0	39.9	FLOOD	120 min Summer	10.033	0.333	0.0	5.0	5.0	40.1	FLOOD	180 min Summer	10.031	0.331	0.0	5.0	5.0	38.7	FLOOD	240 min Summer	10.030	0.330	0.0	5.0	5.0	36.7	FLOOD	360 min Summer	10.025	0.325	0.0	5.0	5.0	32.1	FLOOD	480 min Summer	10.021	0.321	0.0	5.0	5.0	27.7	FLOOD	600 min Summer	10.017	0.317	0.0	5.0	5.0	23.4	FLOOD	720 min Summer	10.013	0.313	0.0	5.0	5.0	19.4	FLOOD	960 min Summer	10.006	0.306	0.0	5.0	5.0	12.6	FLOOD	1440 min Summer	9.918	0.218	0.0	5.0	5.0	3.1	Flood Risk	2160 min Summer	9.806	0.106	0.0	4.3	4.3	0.7	Flood Risk	2880 min Summer	9.788	0.088	0.0	3.4	3.4	0.5	Flood Risk	4320 min Summer	9.772	0.072	0.0	2.5	2.5	0.3	Flood Risk	5760 min Summer	9.763	0.063	0.0	2.0	2.0	0.3	Flood Risk	7200 min Summer	9.757	0.057	0.0	1.7	1.7	0.2	Flood Risk	8640 min Summer	9.752	0.052	0.0	1.4	1.4	0.2	Flood Risk	10080 min Summer	9.749	0.049	0.0	1.3	1.3	0.2	Flood Risk	15 min Winter	10.025	0.325	0.0	5.0	5.0	31.7	FLOOD	Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)	15 min Summer	101.668	21.0	32.4	18	30 min Summer	68.068	28.1	43.7	32	60 min Summer	43.553	32.7	56.2	60	120 min Summer	26.973	32.8	69.9	96	180 min Summer	20.113	31.5	78.3	128	240 min Summer	16.234	29.6	84.3	164	360 min Summer	11.899	25.2	92.8	230	480 min Summer	9.551	20.9	99.3	298	600 min Summer	8.047	16.8	104.6	362	720 min Summer	6.993	13.0	109.1	426	960 min Summer	5.598	6.4	116.4	542	1440 min Summer	4.083	0.0	127.3	754	2160 min Summer	2.973	0.0	138.9	1096	2880 min Summer	2.371	0.0	147.5	1460	4320 min Summer	1.720	0.0	160.1	2192	5760 min Summer	1.368	0.0	169.4	2920	7200 min Summer	1.145	0.0	176.7	3664	8640 min Summer	0.989	0.0	182.7	4272	10080 min Summer	0.874	0.0	187.9	5088	15 min Winter	101.668	24.7	36.4	18
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max E Outflow (l/s)	Max Volume (m³)	Status																																																																																																																																																																																																																																																																																	
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Ebenezer House Ryecroft Newcastle ST5 2BE	Bridgewater House Permeable Paving Design 1 in 100 + 20CC	
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Innovyze	Source Control 2020.1.3	

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

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	10.033	0.333	0.0	5.0	5.0	40.6	FLOOD
60 min Winter	10.039	0.339	0.0	5.0	5.0	47.0	FLOOD
120 min Winter	10.040	0.340	0.0	5.0	5.0	47.5	FLOOD
180 min Winter	10.038	0.338	0.0	5.0	5.0	45.3	FLOOD
240 min Winter	10.035	0.335	0.0	5.0	5.0	42.3	FLOOD
360 min Winter	10.028	0.328	0.0	5.0	5.0	35.1	FLOOD
480 min Winter	10.021	0.321	0.0	5.0	5.0	28.1	FLOOD
600 min Winter	10.015	0.315	0.0	5.0	5.0	21.5	FLOOD
720 min Winter	10.009	0.309	0.0	5.0	5.0	15.6	FLOOD
960 min Winter	9.995	0.295	0.0	5.0	5.0	5.7	Flood Risk
1440 min Winter	9.805	0.105	0.0	4.2	4.2	0.7	Flood Risk
2160 min Winter	9.783	0.083	0.0	3.1	3.1	0.5	Flood Risk
2880 min Winter	9.772	0.072	0.0	2.5	2.5	0.3	Flood Risk
4320 min Winter	9.759	0.059	0.0	1.8	1.8	0.2	Flood Risk
5760 min Winter	9.752	0.052	0.0	1.4	1.4	0.2	Flood Risk
7200 min Winter	9.747	0.047	0.0	1.2	1.2	0.1	Flood Risk
8640 min Winter	9.744	0.044	0.0	1.0	1.0	0.1	Flood Risk
10080 min Winter	9.741	0.041	0.0	0.9	0.9	0.1	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	68.068	33.3	49.1	32
60 min Winter	43.553	39.5	63.1	60
120 min Winter	26.973	40.0	78.4	110
180 min Winter	20.113	37.9	87.8	140
240 min Winter	16.234	35.0	94.6	178
360 min Winter	11.899	28.0	104.1	250
480 min Winter	9.551	21.3	111.4	320
600 min Winter	8.047	15.0	117.4	386
720 min Winter	6.993	9.3	122.4	448
960 min Winter	5.598	0.0	130.6	560
1440 min Winter	4.083	0.0	142.8	730
2160 min Winter	2.973	0.0	155.8	1092
2880 min Winter	2.371	0.0	165.5	1428
4320 min Winter	1.720	0.0	179.7	2168
5760 min Winter	1.368	0.0	190.1	2912
7200 min Winter	1.145	0.0	198.4	3592
8640 min Winter	0.989	0.0	205.2	4336
10080 min Winter	0.874	0.0	211.1	5064

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Ebenezer House Ryecroft Newcastle ST5 2BE	Bridgewater House Permeable Paving Design 1 in 100 + 20CC	
Date 26/06/2022 15:46 File permeable paving (300mm ...	Designed by F.Gennard Checked by	
Innovyze	Source Control 2020.1.3	

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)	18.000	Shortest Storm (mins)	15
Ratio R	0.360	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.176

Time (mins) From: To:	Area (ha)	Time (mins) From: To:	Area (ha)	Time (mins) From: To:	Area (ha)	Time (mins) From: To:	Area (ha)
0 4	0.172	32 36	0.000	64 68	0.000	96 100	0.000
4 8	0.001	36 40	0.000	68 72	0.000	100 104	0.000
8 12	0.001	40 44	0.000	72 76	0.000	104 108	0.000
12 16	0.000	44 48	0.000	76 80	0.000	108 112	0.000
16 20	0.000	48 52	0.000	80 84	0.000	112 116	0.000
20 24	0.000	52 56	0.000	84 88	0.000	116 120	0.000
24 28	0.000	56 60	0.000	88 92	0.000		
28 32	0.000	60 64	0.000	92 96	0.000		

Rennard Consulting Limited		Page 4
Ebenezer House Ryecroft Newcastle ST5 2BE	Bridgewater House Permeable Paving Design 1 in 100 + 20CC	
Date 26/06/2022 15:46 File permeable paving (300mm ...	Designed by F.Gennard Checked by	
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Model Details

Storage is Online Cover Level (m) 10.000

Porous Car Park Structure

Infiltration Coefficient Base (m/hr) 0.00000
 Membrane Percolation (mm/hr) 1000
 Max Percolation (l/s) 59.4
 Safety Factor 2.0
 Porosity 0.30
 Invert Level (m) 9.700
 Width (m) 8.8
 Length (m) 24.3
 Slope (1:X) 50.0
 Depression Storage (mm) 5
 Evaporation (mm/day) 3
 Membrane Depth (m) 0

Hydro-Brake® Optimum Outflow Control

Unit Reference MD-SHE-0114-5000-0350-5000
 Design Head (m) 0.350
 Design Flow (l/s) 5.0
 Flush-Flo™ Calculated
 Objective Minimise upstream storage
 Application Surface
 Sump Available Yes
 Diameter (mm) 114
 Invert Level (m) 9.700
 Minimum Outlet Pipe Diameter (mm) 150
 Suggested Manhole Diameter (mm) 1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.350	5.0
Flush-Flo™	0.166	5.0
Kick-Flo®	0.283	4.5
Mean Flow over Head Range	-	3.9

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	4.0	1.000	8.2	2.400	12.3	5.500	18.4
0.200	5.0	1.200	8.9	2.600	12.8	6.000	19.3
0.300	4.7	1.400	9.6	3.000	13.7	6.500	20.1
0.400	5.3	1.600	10.2	3.500	14.8	7.000	20.8
0.500	5.9	1.800	10.8	4.000	15.7	7.500	21.6
0.600	6.4	2.000	11.3	4.500	16.7	8.000	22.3
0.800	7.3	2.200	11.8	5.000	17.6	8.500	23.0

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Ebenezer House Ryecroft Newcastle ST5 2BE		Bridgewater House Permeable Paving Design 1 in 100 + 20CC																	
Date 26/06/2022 15:46		Designed by F.Gennard																	
File permeable paving (300mm ...		Checked by																	
Innovyze		Source Control 2020.1.3																	
<u>Hydro-Brake® Optimum Outflow Control</u> <table><tr><td>Depth (m)</td><td>Flow (l/s)</td><td>Depth (m)</td><td>Flow (l/s)</td><td>Depth (m)</td><td>Flow (l/s)</td><td>Depth (m)</td><td>Flow (l/s)</td></tr><tr><td>9.000</td><td>23.6</td><td>9.500</td><td>24.3</td><td></td><td></td><td></td><td></td></tr></table>				Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	9.000	23.6	9.500	24.3				
Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)												
9.000	23.6	9.500	24.3																
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Appendix G – Microdrainage output for exceedance

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Ebenezer House Ryecroft Newcastle ST5 2BE			Bridgewater House Permeable Paving Design 1 in 100 + 40CC																																																																																																																																																																																																																																																																																					
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<u>Summary of Results for 100 year Return Period (+40%)</u> Half Drain Time : 112 minutes. <table><tr><th>Storm Event</th><th>Max Level (m)</th><th>Max Depth (m)</th><th>Max Infiltration (l/s)</th><th>Max Control (l/s)</th><th>Max E Outflow (l/s)</th><th>Max Volume (m³)</th><th>Status</th></tr><tr><td>15 min Summer</td><td>10.026</td><td>0.326</td><td>0.0</td><td>5.0</td><td>5.0</td><td>33.1</td><td>FLOOD</td></tr><tr><td>30 min Summer</td><td>10.035</td><td>0.335</td><td>0.0</td><td>5.0</td><td>5.0</td><td>42.4</td><td>FLOOD</td></tr><tr><td>60 min Summer</td><td>10.041</td><td>0.341</td><td>0.0</td><td>5.0</td><td>5.0</td><td>49.0</td><td>FLOOD</td></tr><tr><td>120 min Summer</td><td>10.042</td><td>0.342</td><td>0.0</td><td>5.0</td><td>5.0</td><td>50.0</td><td>FLOOD</td></tr><tr><td>180 min Summer</td><td>10.041</td><td>0.341</td><td>0.0</td><td>5.0</td><td>5.0</td><td>48.6</td><td>FLOOD</td></tr><tr><td>240 min Summer</td><td>10.039</td><td>0.339</td><td>0.0</td><td>5.0</td><td>5.0</td><td>46.8</td><td>FLOOD</td></tr><tr><td>360 min Summer</td><td>10.035</td><td>0.335</td><td>0.0</td><td>5.0</td><td>5.0</td><td>42.1</td><td>FLOOD</td></tr><tr><td>480 min Summer</td><td>10.030</td><td>0.330</td><td>0.0</td><td>5.0</td><td>5.0</td><td>37.6</td><td>FLOOD</td></tr><tr><td>600 min Summer</td><td>10.026</td><td>0.326</td><td>0.0</td><td>5.0</td><td>5.0</td><td>33.1</td><td>FLOOD</td></tr><tr><td>720 min Summer</td><td>10.022</td><td>0.322</td><td>0.0</td><td>5.0</td><td>5.0</td><td>28.8</td><td>FLOOD</td></tr><tr><td>960 min Summer</td><td>10.015</td><td>0.315</td><td>0.0</td><td>5.0</td><td>5.0</td><td>21.0</td><td>FLOOD</td></tr><tr><td>1440 min Summer</td><td>10.003</td><td>0.303</td><td>0.0</td><td>5.0</td><td>5.0</td><td>9.3</td><td>FLOOD</td></tr><tr><td>2160 min Summer</td><td>9.826</td><td>0.126</td><td>0.0</td><td>4.9</td><td>4.9</td><td>1.1</td><td>Flood Risk</td></tr><tr><td>2880 min Summer</td><td>9.800</td><td>0.100</td><td>0.0</td><td>4.0</td><td>4.0</td><td>0.7</td><td>Flood Risk</td></tr><tr><td>4320 min Summer</td><td>9.779</td><td>0.079</td><td>0.0</td><td>2.9</td><td>2.9</td><td>0.4</td><td>Flood Risk</td></tr><tr><td>5760 min Summer</td><td>9.769</td><td>0.069</td><td>0.0</td><td>2.3</td><td>2.3</td><td>0.3</td><td>Flood Risk</td></tr><tr><td>7200 min Summer</td><td>9.762</td><td>0.062</td><td>0.0</td><td>1.9</td><td>1.9</td><td>0.3</td><td>Flood Risk</td></tr><tr><td>8640 min Summer</td><td>9.757</td><td>0.057</td><td>0.0</td><td>1.7</td><td>1.7</td><td>0.2</td><td>Flood Risk</td></tr><tr><td>10080 min Summer</td><td>9.753</td><td>0.053</td><td>0.0</td><td>1.5</td><td>1.5</td><td>0.2</td><td>Flood Risk</td></tr><tr><td>15 min Winter</td><td>10.031</td><td>0.331</td><td>0.0</td><td>5.0</td><td>5.0</td><td>37.7</td><td>FLOOD</td></tr></table> <table><tr><th>Storm Event</th><th>Rain (mm/hr)</th><th>Flooded Volume (m³)</th><th>Discharge Volume (m³)</th><th>Time-Peak (mins)</th></tr><tr><td>15 min Summer</td><td>118.613</td><td>26.1</td><td>37.9</td><td>18</td></tr><tr><td>30 min Summer</td><td>79.413</td><td>35.0</td><td>51.2</td><td>32</td></tr><tr><td>60 min Summer</td><td>50.812</td><td>41.4</td><td>65.8</td><td>60</td></tr><tr><td>120 min Summer</td><td>31.468</td><td>42.4</td><td>81.7</td><td>102</td></tr><tr><td>180 min Summer</td><td>23.466</td><td>41.1</td><td>91.5</td><td>134</td></tr><tr><td>240 min Summer</td><td>18.940</td><td>39.3</td><td>98.6</td><td>168</td></tr><tr><td>360 min Summer</td><td>13.882</td><td>34.8</td><td>108.4</td><td>236</td></tr><tr><td>480 min Summer</td><td>11.143</td><td>30.4</td><td>116.1</td><td>304</td></tr><tr><td>600 min Summer</td><td>9.389</td><td>26.1</td><td>122.3</td><td>370</td></tr><tr><td>720 min Summer</td><td>8.158</td><td>22.0</td><td>127.5</td><td>434</td></tr><tr><td>960 min Summer</td><td>6.531</td><td>14.5</td><td>136.1</td><td>558</td></tr><tr><td>1440 min Summer</td><td>4.764</td><td>3.2</td><td>148.9</td><td>792</td></tr><tr><td>2160 min Summer</td><td>3.468</td><td>0.0</td><td>162.4</td><td>1100</td></tr><tr><td>2880 min Summer</td><td>2.766</td><td>0.0</td><td>172.5</td><td>1460</td></tr><tr><td>4320 min Summer</td><td>2.007</td><td>0.0</td><td>187.3</td><td>2168</td></tr><tr><td>5760 min Summer</td><td>1.596</td><td>0.0</td><td>198.2</td><td>2936</td></tr><tr><td>7200 min Summer</td><td>1.336</td><td>0.0</td><td>206.8</td><td>3544</td></tr><tr><td>8640 min Summer</td><td>1.154</td><td>0.0</td><td>214.0</td><td>4400</td></tr><tr><td>10080 min Summer</td><td>1.020</td><td>0.0</td><td>220.1</td><td>5112</td></tr><tr><td>15 min Winter</td><td>118.613</td><td>30.5</td><td>42.6</td><td>18</td></tr></table>								Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max E Outflow (l/s)	Max Volume (m³)	Status	15 min Summer	10.026	0.326	0.0	5.0	5.0	33.1	FLOOD	30 min Summer	10.035	0.335	0.0	5.0	5.0	42.4	FLOOD	60 min Summer	10.041	0.341	0.0	5.0	5.0	49.0	FLOOD	120 min Summer	10.042	0.342	0.0	5.0	5.0	50.0	FLOOD	180 min Summer	10.041	0.341	0.0	5.0	5.0	48.6	FLOOD	240 min Summer	10.039	0.339	0.0	5.0	5.0	46.8	FLOOD	360 min Summer	10.035	0.335	0.0	5.0	5.0	42.1	FLOOD	480 min Summer	10.030	0.330	0.0	5.0	5.0	37.6	FLOOD	600 min Summer	10.026	0.326	0.0	5.0	5.0	33.1	FLOOD	720 min Summer	10.022	0.322	0.0	5.0	5.0	28.8	FLOOD	960 min Summer	10.015	0.315	0.0	5.0	5.0	21.0	FLOOD	1440 min Summer	10.003	0.303	0.0	5.0	5.0	9.3	FLOOD	2160 min Summer	9.826	0.126	0.0	4.9	4.9	1.1	Flood Risk	2880 min Summer	9.800	0.100	0.0	4.0	4.0	0.7	Flood Risk	4320 min Summer	9.779	0.079	0.0	2.9	2.9	0.4	Flood Risk	5760 min Summer	9.769	0.069	0.0	2.3	2.3	0.3	Flood Risk	7200 min Summer	9.762	0.062	0.0	1.9	1.9	0.3	Flood Risk	8640 min Summer	9.757	0.057	0.0	1.7	1.7	0.2	Flood Risk	10080 min Summer	9.753	0.053	0.0	1.5	1.5	0.2	Flood Risk	15 min Winter	10.031	0.331	0.0	5.0	5.0	37.7	FLOOD	Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)	15 min Summer	118.613	26.1	37.9	18	30 min Summer	79.413	35.0	51.2	32	60 min Summer	50.812	41.4	65.8	60	120 min Summer	31.468	42.4	81.7	102	180 min Summer	23.466	41.1	91.5	134	240 min Summer	18.940	39.3	98.6	168	360 min Summer	13.882	34.8	108.4	236	480 min Summer	11.143	30.4	116.1	304	600 min Summer	9.389	26.1	122.3	370	720 min Summer	8.158	22.0	127.5	434	960 min Summer	6.531	14.5	136.1	558	1440 min Summer	4.764	3.2	148.9	792	2160 min Summer	3.468	0.0	162.4	1100	2880 min Summer	2.766	0.0	172.5	1460	4320 min Summer	2.007	0.0	187.3	2168	5760 min Summer	1.596	0.0	198.2	2936	7200 min Summer	1.336	0.0	206.8	3544	8640 min Summer	1.154	0.0	214.0	4400	10080 min Summer	1.020	0.0	220.1	5112	15 min Winter	118.613	30.5	42.6	18
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max E Outflow (l/s)	Max Volume (m³)	Status																																																																																																																																																																																																																																																																																	
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2160 min Summer	9.826	0.126	0.0	4.9	4.9	1.1	Flood Risk																																																																																																																																																																																																																																																																																	
2880 min Summer	9.800	0.100	0.0	4.0	4.0	0.7	Flood Risk																																																																																																																																																																																																																																																																																	
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5760 min Summer	9.769	0.069	0.0	2.3	2.3	0.3	Flood Risk																																																																																																																																																																																																																																																																																	
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15 min Winter	10.031	0.331	0.0	5.0	5.0	37.7	FLOOD																																																																																																																																																																																																																																																																																	
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240 min Summer	18.940	39.3	98.6	168																																																																																																																																																																																																																																																																																				
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600 min Summer	9.389	26.1	122.3	370																																																																																																																																																																																																																																																																																				
720 min Summer	8.158	22.0	127.5	434																																																																																																																																																																																																																																																																																				
960 min Summer	6.531	14.5	136.1	558																																																																																																																																																																																																																																																																																				
1440 min Summer	4.764	3.2	148.9	792																																																																																																																																																																																																																																																																																				
2160 min Summer	3.468	0.0	162.4	1100																																																																																																																																																																																																																																																																																				
2880 min Summer	2.766	0.0	172.5	1460																																																																																																																																																																																																																																																																																				
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Rennard Consulting Limited		Page 2
Ebenezer House Ryecroft Newcastle ST5 2BE	Bridgewater House Permeable Paving Design 1 in 100 + 40CC	
Date 26/06/2022 16:56 File permeable paving (300mm ...	Designed by F.Gennard Checked by	
Innovyze	Source Control 2020.1.3	

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	10.041	0.341	0.0	5.0	5.0	48.7	FLOOD
60 min Winter	10.049	0.349	0.0	5.0	5.0	57.3	FLOOD
120 min Winter	10.052	0.352	0.0	5.0	5.0	59.7	FLOOD
180 min Winter	10.049	0.349	0.0	5.0	5.0	57.4	FLOOD
240 min Winter	10.047	0.347	0.0	5.0	5.0	54.6	FLOOD
360 min Winter	10.040	0.340	0.0	5.0	5.0	47.4	FLOOD
480 min Winter	10.033	0.333	0.0	5.0	5.0	40.2	FLOOD
600 min Winter	10.026	0.326	0.0	5.0	5.0	33.3	FLOOD
720 min Winter	10.020	0.320	0.0	5.0	5.0	26.7	FLOOD
960 min Winter	10.009	0.309	0.0	5.0	5.0	15.2	FLOOD
1440 min Winter	9.823	0.123	0.0	4.9	4.9	1.0	Flood Risk
2160 min Winter	9.792	0.092	0.0	3.6	3.6	0.6	Flood Risk
2880 min Winter	9.779	0.079	0.0	2.9	2.9	0.4	Flood Risk
4320 min Winter	9.765	0.065	0.0	2.1	2.1	0.3	Flood Risk
5760 min Winter	9.757	0.057	0.0	1.7	1.7	0.2	Flood Risk
7200 min Winter	9.751	0.051	0.0	1.4	1.4	0.2	Flood Risk
8640 min Winter	9.747	0.047	0.0	1.2	1.2	0.1	Flood Risk
10080 min Winter	9.744	0.044	0.0	1.1	1.1	0.1	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	79.413	41.1	57.4	32
60 min Winter	50.812	49.4	73.8	60
120 min Winter	31.468	51.7	91.7	114
180 min Winter	23.466	49.5	102.7	144
240 min Winter	18.940	46.8	110.5	182
360 min Winter	13.882	39.9	121.6	256
480 min Winter	11.143	33.0	130.2	328
600 min Winter	9.389	26.3	137.1	398
720 min Winter	8.158	20.0	143.0	462
960 min Winter	6.531	8.9	152.6	586
1440 min Winter	4.764	0.0	166.9	736
2160 min Winter	3.468	0.0	182.1	1076
2880 min Winter	2.766	0.0	193.5	1460
4320 min Winter	2.007	0.0	210.1	2164
5760 min Winter	1.596	0.0	222.4	2840
7200 min Winter	1.336	0.0	232.2	3600
8640 min Winter	1.154	0.0	240.3	4392
10080 min Winter	1.020	0.0	247.2	5152

Rennard Consulting Limited		Page 3
Ebenezer House Ryecroft Newcastle ST5 2BE	Bridgewater House Permeable Paving Design 1 in 100 + 40CC	
Date 26/06/2022 16:56 File permeable paving (300mm ...	Designed by F.Gennard Checked by	
Innovyze	Source Control 2020.1.3	

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)	18.000	Shortest Storm (mins)	15
Ratio R	0.360	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.176

Time (mins) From: To:	Area (ha)	Time (mins) From: To:	Area (ha)	Time (mins) From: To:	Area (ha)	Time (mins) From: To:	Area (ha)
0 4	0.172	32 36	0.000	64 68	0.000	96 100	0.000
4 8	0.001	36 40	0.000	68 72	0.000	100 104	0.000
8 12	0.001	40 44	0.000	72 76	0.000	104 108	0.000
12 16	0.000	44 48	0.000	76 80	0.000	108 112	0.000
16 20	0.000	48 52	0.000	80 84	0.000	112 116	0.000
20 24	0.000	52 56	0.000	84 88	0.000	116 120	0.000
24 28	0.000	56 60	0.000	88 92	0.000		
28 32	0.000	60 64	0.000	92 96	0.000		

Rennard Consulting Limited		Page 4
Ebenezer House Ryecroft Newcastle ST5 2BE	Bridgewater House Permeable Paving Design 1 in 100 + 40CC	
Date 26/06/2022 16:56	Designed by F.Gennard	
File permeable paving (300mm ...	Checked by	
Innovyze	Source Control 2020.1.3	

Model Details

Storage is Online Cover Level (m) 10.000

Porous Car Park Structure

Infiltration Coefficient Base (m/hr) 0.00000
 Membrane Percolation (mm/hr) 1000
 Max Percolation (l/s) 59.4
 Safety Factor 2.0
 Porosity 0.30
 Invert Level (m) 9.700
 Width (m) 8.8
 Length (m) 24.3
 Slope (1:X) 50.0
 Depression Storage (mm) 5
 Evaporation (mm/day) 3
 Membrane Depth (m) 0

Hydro-Brake® Optimum Outflow Control

Unit Reference MD-SHE-0114-5000-0350-5000
 Design Head (m) 0.350
 Design Flow (l/s) 5.0
 Flush-Flo™ Calculated
 Objective Minimise upstream storage
 Application Surface
 Sump Available Yes
 Diameter (mm) 114
 Invert Level (m) 9.700
 Minimum Outlet Pipe Diameter (mm) 150
 Suggested Manhole Diameter (mm) 1200

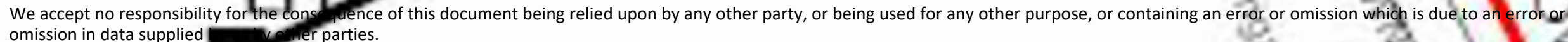
Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.350	5.0
Flush-Flo™	0.166	5.0
Kick-Flo®	0.283	4.5
Mean Flow over Head Range	-	3.9

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	4.0	1.000	8.2	2.400	12.3	5.500	18.4
0.200	5.0	1.200	8.9	2.600	12.8	6.000	19.3
0.300	4.7	1.400	9.6	3.000	13.7	6.500	20.1
0.400	5.3	1.600	10.2	3.500	14.8	7.000	20.8
0.500	5.9	1.800	10.8	4.000	15.7	7.500	21.6
0.600	6.4	2.000	11.3	4.500	16.7	8.000	22.3
0.800	7.3	2.200	11.8	5.000	17.6	8.500	23.0

Rennard Consulting Limited			Page 5																
Ebenezer House Ryecroft Newcastle ST5 2BE		Bridgewater House Permeable Paving Design 1 in 100 + 40CC																	
Date 26/06/2022 16:56		Designed by F.Gennard																	
File permeable paving (300mm ...		Checked by																	
Innovyze		Source Control 2020.1.3																	
<u>Hydro-Brake® Optimum Outflow Control</u> <table><tr><td>Depth (m)</td><td>Flow (l/s)</td><td>Depth (m)</td><td>Flow (l/s)</td><td>Depth (m)</td><td>Flow (l/s)</td><td>Depth (m)</td><td>Flow (l/s)</td></tr><tr><td>9.000</td><td>23.6</td><td>9.500</td><td>24.3</td><td></td><td></td><td></td><td></td></tr></table>				Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	9.000	23.6	9.500	24.3				
Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)												
9.000	23.6	9.500	24.3																
©1982-2020 Innovyze																			

Appendix H – Drainage Strategy Drawing



DRAWING No.	REV.
9757-HBL-XX-XX-DR-D-0502	P02

Appendix I – Sewer Records

Faye Gennard

8
Oakwood Road,
Leek,
ST13 8LW

FAO:

How to contact us:

**United Utilities Water Limited
Property Searches
Haweswater House
Lingley Mere Business Park
Great Sankey
Warrington
WA5 3LP**

Telephone: 0370 7510101

E-mail: propertysearches@uuplc.co.uk

**Your Ref: Bridgewater House
Our Ref: UUPS-ORD-399269
Date: 01/06/2022**

Dear Sirs

Location: Silvercroft Street

I acknowledge with thanks your request dated 26/05/2022 for information on the location of our services.

Please find enclosed plans showing the approximate position of United Utilities' apparatus known to be in the vicinity of this site.

The enclosed plans are being provided to you subject to the United Utilities terms and conditions for both the wastewater and water distribution plans which are shown attached.

If you are planning works anywhere in the North West, please read United Utilities' access statement before you start work to check how it will affect our network. <http://www.unitedutilities.com/work-near-asset.aspx>.

I trust the above meets with your requirements and look forward to hearing from you should you need anything further.

If you have any queries regarding this matter please [contact us](#).

Yours Faithfully,



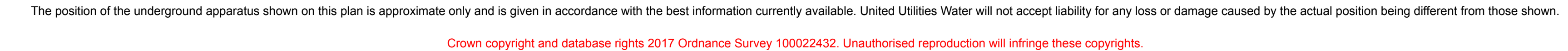
Karen McCormack
Property Searches Manager

TERMS AND CONDITIONS - WASTEWATER AND WATER DISTRIBUTION PLANS

These provisions apply to the public sewerage, water distribution and telemetry systems (including sewers which are the subject of an agreement under Section 104 of the Water Industry Act 1991 and mains installed in accordance with the agreement for the self construction of water mains) (UUWL apparatus) of United Utilities Water Limited "(UUWL)".

TERMS AND CONDITIONS:

- This Map and any information supplied with it is issued subject to the provisions contained below, to the exclusion of all others and no party relies upon any representation, warranty, collateral contract or other assurance of any person (whether party to this agreement or not) that is not set out in this agreement or the documents referred to in it.
- This Map and any information supplied with it is provided for general guidance only and no representation, undertaking or warranty as to its accuracy, completeness or being up to date is given or implied.
- In particular, the position and depth of any UUWL apparatus shown on the Map are approximate only. UUWL strongly recommends that a comprehensive survey is undertaken in addition to reviewing this Map to determine and ensure the precise location of any UUWL apparatus. The exact location, positions and depths should be obtained by excavation trial holes.
- The location and position of private drains, private sewers and service pipes to properties are not normally shown on this Map but their presence must be anticipated and accounted for and you are strongly advised to carry out your own further enquiries and investigations in order to locate the same.
- The position and depth of UUWL apparatus is subject to change and therefore this Map is issued subject to any removal or change in location of the same. The onus is entirely upon you to confirm whether any changes to the Map have been made subsequent to issue and prior to any works being carried out.
- This Map and any information shown on it or provided with it must not be relied upon in the event of any development, construction or other works (including but not limited to any excavations) in the vicinity of UUWL apparatus or for the purpose of determining the suitability of a point of connection to the sewerage or other distribution systems.
- No person or legal entity, including any company shall be relieved from any liability howsoever and whensoever arising for any damage caused to UUWL apparatus by reason of the actual position and/or depths of UUWL apparatus being different from those shown on the Map and any information supplied with it.
- If any provision contained herein is or becomes legally invalid or unenforceable, it will be taken to be severed from the remaining provisions which shall be unaffected and continue in full force and effect.
- This agreement shall be governed by English law and all parties submit to the exclusive jurisdiction of the English courts, save that nothing will prevent UUWL from bringing proceedings in any other competent jurisdiction, whether concurrently or otherwise.



No.	Description of work	Unit	Rate	Amount	Total
1	General services	sq. ft.	1.00	100.00	100.00
2	Painting	sq. ft.	2.00	200.00	200.00
3	Plumbing	hr.	15.00	150.00	150.00
4	Electric	hr.	20.00	200.00	200.00
5	Roofing	sq. ft.	3.00	300.00	300.00
6	HVAC	hr.	25.00	250.00	250.00
7	Landscaping	hr.	10.00	100.00	100.00
8	Security	hr.	12.00	120.00	120.00
9	Cleaning	hr.	8.00	80.00	80.00
10	Maintenance	hr.	10.00	100.00	100.00
11	Transportation	hr.	15.00	150.00	150.00
12	Insurance	hr.	10.00	100.00	100.00
13	Legal	hr.	20.00	200.00	200.00
14	Marketing	hr.	15.00	150.00	150.00
15	IT	hr.	10.00	100.00	100.00
16	Food & Beverage	hr.	10.00	100.00	100.00
17	Entertainment	hr.	15.00	150.00	150.00
18	Travel	hr.	10.00	100.00	100.00
19	Miscellaneous	hr.	10.00	100.00	100.00
20	Total	Total	Total	Total	Total

LEGEND

Abandoned

Foul

Surface Water

Combined

Public Sewer

Private Sewer

Section 104

Rising Main

Sludge Main

Overflow

Water Course

Highway Drain

All point assets follow the standard colour convention:

red - combined

blue - surface water

brown - foul

purple - overflow

●

Manhole

⬮

Head of System

➤

Extent of Survey

⬮

Rodding Eye

●

Inlet

⬮

Discharge Point

⬮

Vortex

⬮

Penstock

⬮

Washout Chamber

⬮

Valve

⬮

Air Valve

⬮

Non Return Valve

⬮

Soakaway

⬮

Gully

⬮

Cascade

⬮

Flow Meter

⬮

Hatch Box

⬮

Oil Interceptor

⬮

Summit

⬮

Drop Shaft

⬮

Orifice Plate

★

Side Entry Manhole

○

Outfall

▢

Screen Chamber

⬮

Inspection Chamber

⬮

Bifurcation Chamber

⬮

Lamp Hole

⬮

T Junction / Saddle

⬮

Catchpit

⬮

Valve Chamber

⬮

Vent Column

⬮

Vortex Chamber

⬮

Penstock Chamber

□

Network Storage Tank

□

Sewer Overflow

⌘

Ww Treatment Works

▲

Ww Pumping Station

⬮

Septic Tank

⬮

Control Kiosk

▽

Change of Characteristic

MANHOLE FUNCTION

FO	Foul
SW	Surface Water
CO	Combined
OV	Overflow

SEWER SHAPE

CI	Circular	TR	Trapezoidal
EG	Egg	AR	Arch
OV	Oval	BA	Barrel
FT	Flat Top	HO	HorseShoe
RE	Rectangular	UN	Unspecified
SQ	Square		

SEWER MATERIAL

AC	Asbestos Cement
BR	Brick
PE	Polyethylene
RP	Reinforced Plastic Matrix
CO	Concrete
CSB	Concrete Segment Bolted
CSU	Concrete Segment Unbolted
CC	Concrete Box Culverted
PSC	Plastic / Steel Composite
GRC	Glass Reinforced Plastic
DI	Ductile Iron
PVC	Polyvinyl Chloride
CI	Cast Iron
SI	Spun Iron
ST	Steel
VC	Vitrified Clay
PP	Polypropylene
PF	Pitch Fibre
MAC	Masonry, Coursed
MAR	Masonry, Random
U	Unspecified

Address or Site Reference:

Silvercroft Street,

Scale: 1:1250

Date: 01/06/2022

Sheet: 1 of 1

Printed by: Property Searches

SEWER RECORDS

United Utilities

Water for the North West