

ISG Construction Ltd

**Millwood School
New Classroom Block and Car Park**

Surface Water Management Report

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Preliminary Note

This report has been produced by Mark Symonds who has over 19 years' experience in infrastructure engineering (in particular surface water management design) and has qualifications including: BSc (Hons) Civil Engineering (2003); HND Civil Engineering Studies (2002); and OND Construction Studies (2000).

1. Introduction

Bradshaw Gass & Hope LLP have produced this surface water management report in support of an application for a new classroom block and car park at Millwood School, School Street, Bury, M26 3BW (hereafter referred to as the 'Site').

The report describes and demonstrates how the surface water run-off rate and volume from the Site will be managed to adhere to National and local planning policies, regulations, and relevant design guidance, which include:

- National Planning Policy Framework (NPPF), July 2021, Paragraphs 153-158 and 159-169;
- National Planning Practice Guidance (NPPG) ('Flood Risk and Coastal Change' section), released in March 2014 and updated in August 2022;
- National Standards for Sustainable Drainage Systems (SuDS) set out by the Department for Environment, Food & Rural Affairs (DEFRA) (2011);
- CIRIA (2010) Planning for SuDS – Making it Happen C687;
- CIRIA SuDS Manual C753 (2015);
- Non-Statutory Technical Standards for Sustainable Drainage Systems (March 2015);
- Bury Council Preliminary Flood Risk Assessment (May 2011);
- Bury, Rochdale and Oldham Strategic Flood Risk Assessment (November 2009);
- Greater Manchester Surface Water Management Plan (January 2012);
- Bury Council Local Plan - Topic Paper 6 – Flood Risk (October 2018).

Bury Metropolitan Borough Council (acting as Lead Local Flood Authority - LLFA), and United Utilities (local water company and sewerage undertaker), need to be satisfied that the design and drainage principles of the proposed development:

- will address the surface water management and risk of flooding within the site;
- will ensure that the drainage is managed and maintained for its lifetime to prevent flooding;
- will ensure that the development will not increase the risk of flooding to neighbouring land and property.

The report is formatted such that it identifies and references appropriate design parameters, shows by calculation how the proposed drainage strategy can meet the various requirements and ultimately controls, mitigates and reduces future flood risk both on and off site.

2. National Policies and Water Management Guidance

2.1. National Planning Policy Framework (NPPF) and National Planning Practice Guidance (NPPG)

The NPPF (July 2021) sets out the Government's planning policies for England and how these should be applied. It provides a framework within which locally prepared plans for housing and other development can be produced. This document is used to form this surface water management report, with particular attention to Paragraphs 153 to 158 Planning for Climate Change, and Paragraphs 159 to 169 Planning for Flood Risk.

NPPG, Paragraph 051 states that sustainable drainage systems (SuDS) are designed to control surface water run off close to where it falls and mimic natural drainage as closely as possible, where they provide opportunities to reduce the causes and impacts of flooding; remove pollutants from urban run-off at source; and to combine water management with green space with benefits for amenity, recreation, and wildlife.

Further to this NPPG, Paragraph 080 states that the aim should be to discharge surface run off as high up the following hierarchy of drainage options as reasonably practicable which (in order) are into the ground (infiltration); to a surface water body; to a surface water sewer, highway drain, or another drainage system; to a combined sewer.

2.2. Flood and Water Management Act

The Flood and Water Management Act (FWMA) received royal assent in April 2010, aiming to create a simpler and more effective means of managing flood risk and coastal erosion. The FWMA incorporates and implements some of the recommendations from the Pitt Review (2008), following the severe flooding that affected a large area of the UK in 2007.

The FWMA also places several new duties and responsibilities on LLFAs regarding the management of local flood risk, to: Develop, maintain, apply, and monitor a Local Flood Risk Management Strategy; Approve, adopt, and maintain Sustainable Drainage Systems (SuDS) (yet to be implemented); Establish and maintain a flood risk Asset Register; Investigate incidents of flooding (where appropriate) and publish the findings in a report; Ensure delivery of effective and joined up management of flood risk.

3. Site Setting and Description

3.1. Site Location

The Site is within the grounds of Millwood School, which is approximately 750m west of Radcliffe station. The Site is to the west of the existing school building, and is bound by the school playing fields to the north; School Street to the south; and Manchester, Bolton and Bury Canal to the west.

The address of the Site is Millwood School, School Street, Bury, M26 3BW, with the co-ordinates for the centre of the Site being E: 377845, N: 407110.

3.2. Existing Site and Topography

As detailed on the existing site / topographical survey plan in Appendix A, the Site currently, in a pre-development site mainly consists of the school playing fields with a small area of playground area to the north-east. As most of the development area is a playing field, it is deemed to be a greenfield site.

In terms of topography the Site is relatively flat, with the levels ranging from approximately 78.67m AOD to the centre to approximately 78.40m towards the southern boundary.

3.3. Proposed Development

The proposed site plan is shown in Appendix B, with a full description being stated by the Architect. In brief, and in relation to this surface water management report, the proposal is to build a new classroom block to the west, and a new car park area to the south of the existing school building. The new classroom block will have associated playground areas and pedestrian access areas around the perimeter.

3.4. Ground Conditions

A ground investigation report was issued by Sub Surface North-West Limited in July 2023 states that the Site consists of made ground over bands of sand and clay, with groundwater monitored as shallow as 1.38m bgl.

A ground investigation report was also issued by Atkins in February 2010, which also found the Site to consist of made ground over bands of sand and clay with groundwater monitored as shallow as 0.47m bgl. This report also states contamination of the made ground to depths of 600mm.

3.5. Waterbody / Rivers / Canals / Reservoirs

The nearest waterbodies to the site is the disused Manchester, Bolton, and Bury Canal, which is approximately 10m west of the Site boundary, and a culverted watercourse crossing over the canal and flowing in a southerly direction. There are no other no known waterbodies directly adjacent to the Site.

3.6. Public Sewers

As detailed on the United Utilities pre-development response and asset plan in Appendix D, there is a 150mm diameter surface water sewer to the south of the Site in School Street, that flows in a west to east direction.

3.7. Development Areas

The Site is currently undeveloped, and therefore the surface water from all the Site discharges off the Site at a greenfield rate.

The proposed classroom building, associated playground / footpaths, and car park, equate to an area of 2,710m² / 0.271 ha. Therefore, the post development surface water run-off area is **0.271 ha**.

4. Surface Water Management Principles

The surface water for the development areas of the site is to be managed so that it adheres to the current national regulations and local authority requirements.

4.1. Run-Off Destination

Surface water run-off is to discharge to one or more of the following in the order of priority shown:

- Discharge into the ground (infiltration);
- Discharge to a surface water body;
- Discharge to a surface water sewer, highway drain or other drain;
- Discharge to combined sewer.

4.2. The Management Train

A concept fundamental to implementing a successful SuDS scheme is the management train. This is a sequence of SuDS components that serve to reduce run-off rates and volumes and reduce pollution. The hierarchy of techniques that are to be used for the surface water management of the development are:

- Prevention - Prevention of run-off by good site design and reduction of impermeable areas;
- Source Control - Dealing with water where and when it falls (e.g. infiltration techniques);
- Site Control - Management of water in the local area (e.g. swales, detention basins);
- Regional Control - Management of run-off from sites (e.g. balancing ponds, wetlands).

4.3. Design Principles

The design principles for the surface water management of the development will be to:

- Ensure that people, property, and critical infrastructure are protected from flooding;
- Ensure that the development does not increase flood risk off site;
- Ensure that SuDS can be economically maintained for the development.

4.4. Peak Surface Water Flow

DEFRA Non-Statutory Technical Standards for Sustainable Drainage Systems states:

‘S2 For greenfield developments, the peak runoff rate from the development to any highway drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100-year rainfall event should never exceed the peak greenfield runoff rate for the same event’.

4.5. Volume Control

DEFRA Non-statutory technical standards for sustainable drainage systems states:

‘S4 Where reasonably practicable, for greenfield development, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100-year, 6-hour rainfall event should never exceed the greenfield runoff volume for the same event.

S6 Where it is not reasonably practicable to constrain the volume of runoff to any drain, sewer or surface water body in accordance with S4 above, the runoff volume must be discharged at a rate that does not adversely affect flood risk’.

4.6. Flood Risk within Development

National Non-statutory technical standards for sustainable drainage systems states:

***S7** The drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur on any part of the site for a 1 in 30-year rainfall event.*

***S8** The drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur during a 1 in 100-year rainfall event in any part of: a building (including a basement); or in any utility plant susceptible to water (e.g. pumping station or electricity substation) within the development.*

***S9** The design of the site must ensure that, so far as is reasonably practicable, flows resulting from rainfall in excess of a 1 in 100-year rainfall event are managed in exceedance routes that minimise the risks to people and property'.*

4.7. Pollution / Water Quality

The SuDS design for the development site will ensure that the quality of any receiving water body is not adversely affected and preferably enhanced in accordance with Ciria SuDS Manual C753, Chapter 4.

4.8. Designing for Exceedance

The development site design will be such that when SuDS features fail or are exceeded, exceedance flows do not cause flooding of properties on or off site. This is achieved by completely containing the surface water within the drainage system (including areas designed to hold or convey water) for all events up to a 1 in 30-year event. The design of the site ensures that flows from rainfall more than a 1 in 30-year rainfall event are managed in exceedance routes that avoid risk to people and property both on and off site.

5. Surface Water Run-Off Destination

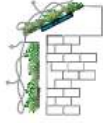
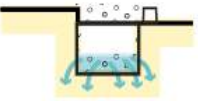
The destination of the surface water run-off from the post development site has been assessed against the prioritisation set by the Approved Document H (2010). The feasibility of the surface water run-off to the priority receptors are as follows:

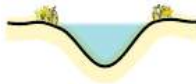
Run-Off Destination	Feasible	Description
Discharge to Ground	No	As stated in Section 3.4, two ground investigation reports state that the Site consists of made ground over bands of sand and clay, with groundwater monitored as shallow as 0.47m and 1.38m bgl. In accordance with CIRIA 753, soakaways are to be at least 1.0m above known groundwater levels, and therefore based on this the groundwater level is too shallow for soakaways to be viable. Also, soakaways cannot be built within contaminated land / made ground, and clay is known to have exceptionally low infiltration value.
Discharge to Surface Water Body	No	The Manchester, Bolton and Bury Canal is 10m north of the Site boundary. However, this canal is disused and therefore is not maintained, which may result in the blockage of any outfalls and subsequent flooding. Also, discharge to the canal will require the removal of the canal path and wall which is to be preserved. Therefore, excavation of these features to install new drainage will not be permitted by the Manchester, Bolton and Bury canal society. The culverted watercourse is believed to be at a relatively shallow depth (crossing over canal and at shallow depth to south of the Site), which will either mean a pumped discharge, which is not sustainable, or discharging 150m south of the site which is not feasible (crossing multiple 3rd party land).
Discharge to Surface Water Sewer	Yes	As the surface water cannot discharge to ground, and discharge to the canal is not feasible, the only alternative is to discharge to the 150mm surface water sewer south of the Site in School Street.
Discharge to Highway Drain or Other	No	There are no known highway or other drains near to the development site. Therefore, discharge to a highway or other drain is not feasible.
Discharge to Combined Water Sewer	No	There is a combined water sewer in School Street, but direct discharge to this is not required.

6. SuDS Feasibility

To reduce the surface water run-off to the greenfield rate, SuDS methods are to be introduced to the post development design.

SuDS methods as per the Sustainable Drainage System (SuDS) hierarchy, and the Non-Statutory Technical Standards for Sustainable Drainage Systems – March 2015, that can be used are detailed below:

	Description	Setting	Required area
 Green roofs	A planted soil layer is constructed on the roof of a building to create a living surface. Water is stored in the soil layer and absorbed by vegetation.	 Building	Building integrated.
 Rainwater harvesting	Rainwater is collected from the roof of a building or from other paved surfaces and stored in an overground or underground tank for treatment and reuse locally. Water could be used for toilet flushing and irrigation.	 Building	Water storage (underground or above ground).
 Soakaway	A soakaway is designed to allow water to quickly soak into permeable layers of soil. Constructed like a dry well, an underground pit is dug filled with gravel or rubble. Water can be piped to a soakaway where it will be stored and allowed to gradually seep into the ground.	 Open space	Dependant on runoff volumes and soils.
 Filter Strip	Filter strips are grassed or planted areas that runoff is allowed to run across to promote infiltration and cleansing.	 Open space	Minimum length 5 metres.
 Permeable paving	Paving which allows water to soak through. Can be in the form of paving blocks with gaps between solid blocks or porous paving where water filters through the block itself. Water can be stored in the sub-base beneath or allowed to infiltrate into ground below.	 Street/open space	Can typically drain double its area.
 Bioretention area	A vegetated area with gravel and sand layers below designed to channel, filter and cleanse water vertically. Water can infiltrate into the ground below or drain to a perforated pipe and be conveyed elsewhere. Bioretention systems can be integrated with tree-pits or gardens.	 Street/open space	Typically surface area is 5-10% of drained area with storage below.

	Description	Setting	Required area
 Swale	Swales are vegetated shallow depressions designed to convey and filter water. These can be 'wet' where water gathers above the surface, or 'dry' where water gathers in a gravel layer beneath. Can be lined or unlined to allow infiltration.	 Street/open space	Account for width to allow safe maintenance typically 2-3 metres wide.
 Hardscape storage	Hardscape water features can be used to store run-off above ground within a constructed container. Storage features can be integrated into public realm areas with a more urban character.	 Open space	Could be above or below ground and sized to storage need.
 Pond / Basin	Ponds can be used to store and treat water. 'Wet' ponds have a constant body of water and run-off is additional, while 'dry' ponds are empty during periods without rainfall. Ponds can be designed to allow infiltration into the ground or to store water for a period of time before discharge.	 Open space	Dependant on runoff volumes and soils.
 Wetland	Wetlands are shallow vegetated water bodies with a varying water level. Specially selected plant species are used to filter water. Water flows horizontally and is gradually treated before being discharged. Wetlands can be integrated with a natural or hardscape environment.	 Open space	Typically 5-15% of drainage area to provide good treatment.
 Underground storage	Water can be stored in tanks, gravel or plastic crates beneath the ground to provide attenuation.	 Open space	Dependant on runoff volumes and soils.

The feasibility of the above SuDS methods for the post developed site are summarised in the table below:

SuDS Method	Potential Use	Description
Green Roofs	No	The classroom block roof has not been structurally designed for a green roof, and therefore this isn't a feasible SuDS method.
Rainwater Harvesting	Yes	The Site is an extension of an existing school which is already connected to the water main system, and therefore rainwater harvesting for water re-use inside the school will not be practical. However, water butts can be placed at several rainwater pipe locations, where the water can be re-used for irrigation.
Soakaway	No	As stated in Sections 3.4 and 5, two ground investigation reports state that the Site consists of made ground over bands of sand and clay, with groundwater monitored as shallow as 0.47m and 1.38m bgl. In accordance with CIRIA 753, soakaways are to be at least 1.0m above known groundwater levels. Therefore, based on this the groundwater level is too shallow for soakaways to be viable.

		Also, soakaways cannot be built within contaminated land / made ground, and clay is known to have exceptionally low infiltration value.
Filter Strips	Yes	Filter strips in the form of 300x300mm granular trenches filled with 20mm no fines aggregate and housing a perforated pipe, can be formed in the existing grassed area along the footpaths. Surface water from the footpaths can discharge to the filter drain, won't discharge to ground, but will be conveyed to the main drainage network. The filter drain will reduce the surface water run-off rates and act as a pollutant control.
Permeable Surfacing	Yes	There is potential to have permeable surfacing within the playground areas around the perimeter of the new classroom block, and within the parking bays. The permeable surface will take the surface water run-off from the playground and car park, won't discharge the surface water to ground, but will be conveyed to the main drainage network via a perforated pipe and will act as a pollutant control. The granular material within the sub-base will be formed of 20mm granular material, which has a 30% void ratio, and can act as attenuation.
Bioretention Area / Swale / Pond	No	The Site will consist of the new classroom block, footpaths and playground areas only, with the grassed areas within the main Millwood School site remaining as recreational areas. Therefore, these are not a suitable SuDS method.
Raised Planters	Yes	Raised planters can be installed at rainwater down pipe locations, and will take the surface water run-off from the roof area. The surface water from the rainwater pipe will percolate through the raised planter prior to discharge to the main drainage network. The raised planter will also act as a pollutant control.
Underground Storage	Yes	The surface water run-off from the site will be restricted. Therefore, there will be a requirement to have underground storage for storm events up to 1 in 30-year; and to suitably sized so that the volume of water during the 1 in 100-year storm event is kept a minimum at surface level, where it can be contained on the site.

7. Development Greenfield Run-Off Rates

To minimise the surface water run-off from the new fire station site, it is preferred that the post development surface water run-off be restricted to the equivalent greenfield run-off rates and volume.

7.1. Greenfield Run-Off Rate

The Flood Estimation Handbook (FEH) is often used for the calculation of the greenfield run-off rate, however, relevant documents state that to calculate the greenfield run-off rates on small catchments less than 25km², the IH 124 QBAR equation (and the equation for the instantaneous time to peak for the unit hydrograph approach) is to be used.

The IH method is based on the Flood Studies Report (FSR) approach and is developed for use on catchments less than 25km². It yields the Mean Annual Maximum Flood (QBAR). This reference also recommends the use of Ciria C753 Table 24.2 to generate Growth Factors. These are used to convert QBAR to different return periods for different regions in the UK.

The input variables to establish QBAR are:

Return Period (years) Results based on a range of return periods and the specified RP;

Area Catchment Area (ha) which is adjusted to km² for use in the equation;

SAAR Average annual rainfall in mm (1941-1970) from FSR figure II.3.1;

Soil Procedure Volume 3. Soil classes 1 to 5 have Soil Index values of 0.15, 0.3, 0.4, 0.45 and 0.5 respectively;

Urban Proportion of area urbanised expressed as a decimal;

Region Number Region number of the catchment based on FSR Figure I.2.4.

QBAR(l/s)

The output variables to establish QBAR are calculated using the following formula (equation yields m³/s):

$$\text{QBAR} = 0.00108 \times \text{AREA}^{0.89} \times \text{SAAR}^{1.17} \times \text{SOIL}^{2.17}$$

The IH 124 Variables (taken from FSR) that are specific to this site are as follows:

Area = 50.00 ha (required area for calculation)

SAAR = 950

Soil = 0.450

Urban Factor = 0.00

Region Number = 10

The calculations in Appendix D show the rate for 50.00ha is 314.0 l/s, but is to be reduced to reflect the surface water catchment area (0.271 ha) of the development site. Therefore, the QBAR (greenfield run-off) for development area has been calculated to be:

$$\text{QBAR} = 1.70 \text{ l/s (6.28 l/s/ha)}$$

Ciria C753 Table 24.2 identifies the growth factors for each of the storm events, based on the known QBAR figure. The growth factors from the table vary depending on the site location. In this case hydrometric area (Region Number) is 10.

Based on the figures shown in the table, the growth factors, and the existing greenfield run-off rates for each of the storm events for the development areas of the site are as follows:

Storm Event	QBAR	Growth Factor (C753 Table 24.2)	Greenfield Run-off Rate
Q ₂	1.70 l/s	0.93	1.6 l/s
Q ₃₀	1.70 l/s	1.70	2.9 l/s
Q ₁₀₀	1.70 l/s	2.08	3.5 l/s

7.2. Greenfield Run-Off Volume

The greenfield run-off volume for the 100-year, 6-hour storm event has also been calculated in the MicroDrainage software using the data from the FEH 2013, with the results shown in Appendix D.

The FEH 2013 data and variables used to calculate the greenfield run-off volume at the Site location area as follows:

Site Location	=	GB 377929 407139 SD 77929 07139
Area	=	0.271 ha
SAAR	=	1054
CWI	=	123.486
SPR Host	=	47.000
URBTEXT	=	0.00

Based on these calculation results (Appendix D), the greenfield run-off volume for the surface water management area of the Site is:

Q ₁₀₀ (6-Hour)	=	91.42m ³ (337.34m ³ /ha)
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8. Below Ground Drainage Networks and Surface Water Management Calculations

8.1. Climate Change Allowance

The NPPF makes it a planning requirement to account for climate change in the proposed design. The recommended allowances are taken from the Environment Agency guidance summarised in Figure 1 below.

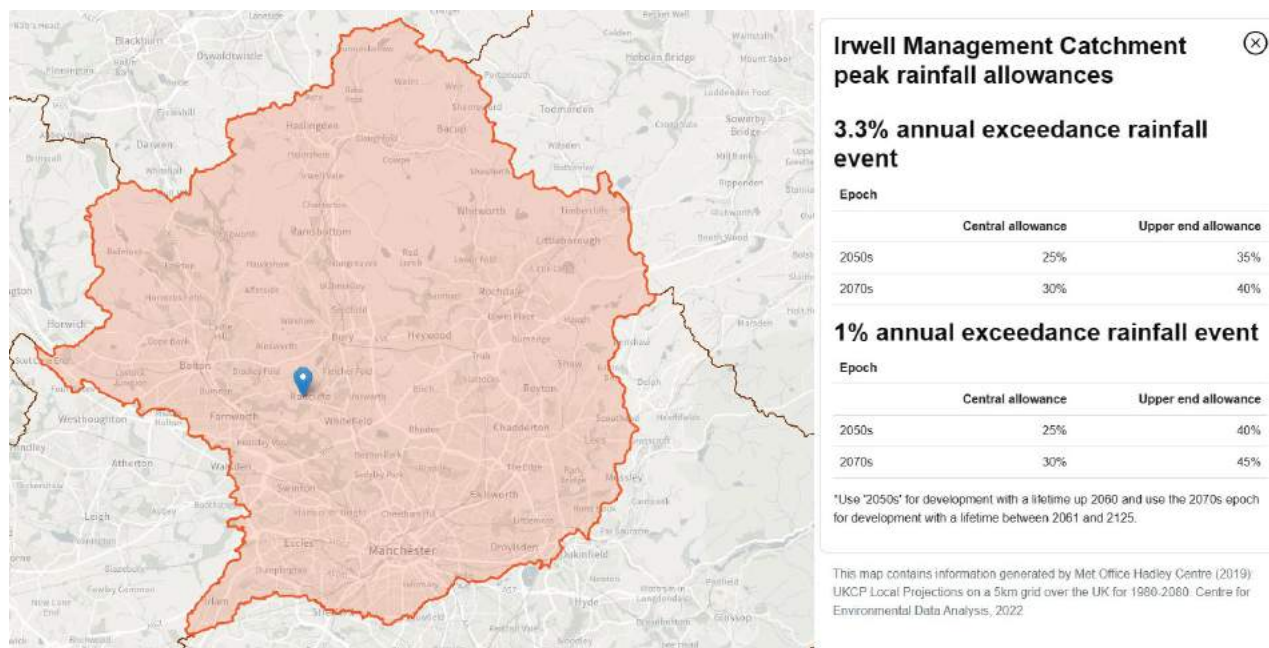


Figure 1 - Department for Environment Food & Rural Affairs – Climate Change Allowances

The lifetime of the extension is likely to be beyond 2061, and therefore the Epoch 2070's is to be used with Upper End Allowance. Therefore, the climate change allowance for the pre and post development surface water run-off will be **40%** and **45%** for the 30-year and 100-year storms, respectively.

8.2. Surface Water Network Calculations

The calculations to determine the post development surface water run-off rates are based on the surface water run-off area of 0.271 ha, and the rainfall data given by the FEH 2013.

8.3. Surface Water Drainage Network and Management

As shown on the below ground drainage layout drawing in Appendix E, the proposed surface water network will consist of 150mm diameter pipes, 460mm diameter inspection chambers, water butts, filter drains, permeable surfacing, raised planters, a flow control chamber containing a hydro-brake and orifice, a below ground attenuation tank in the form of cellular units.

The surface water run-off from the roof areas will discharge to the main drainage network via water butts and raised planters, and the surface water run-off from the external areas will discharge to the main drainage via filter drains and permeable surfacing.

The surface water network will flow to the south of the Site, where it will pass through the flow control chamber, prior to discharge to the 150mm diameter surface water sewer in School Street. The restricted surface water will surcharge the drainage network and will be attenuated within the cellular units and paving sub-base to prevent flooding.

8.4. Surface Water Run-Off Rate

For the surface water run-off from the Site to be at the greenfield run-off rate, they are to be restricted to 1.6 l/s for the 1 in 2-year storm event, 2.9 l/s for the 1 in 30-year storm event including 40% allowance, and 3.5 l/s for the 1 in 100-year storm event including 45% allowance.

To achieve the equivalent greenfield run-off rates, it is proposed to use a complex flow control chamber, where a hydro-brake at the invert level of the chamber will restrict the surface water during 1-year and 30-year storm event + 40% allowance, and an orifice plate set higher in the chamber, will allow additional surface water flow from the chamber during the 100-year storm event + 45% allowance.

As shown in the output calculation from the MicroDrainage computer software in Appendix F, if the hydro-brake opening is set at 63mm, with a design head of 0.80m, and a design flow of 1.6 l/s (2-year greenfield rate), and an orifice is set 1.20m above the hydro-brake with a 36mm opening, the maximum surface water run-off rates for each storm event will be as follows:

Strom	-	Rate	-	Critical Storm Event
Q ₂	-	1.6 l/s	-	480-minute winter storm duration
Q _{30 + cc}	-	1.9 l/s	-	480-minute winter storm duration
Q _{100 + cc}	-	3.5 l/s	-	360-minute winter storm duration

A summary of the post development surface water run-off rates compared to the greenfield rates are as follows:

Greenfield Rate to Post Development Rate

Strom	-	Greenfield	-	Post Dev	-	Difference
Q ₂	-	1.6 l/s	-	1.6 l/s	-	Equivalent
Q _{30+ 40%}	-	2.9 l/s	-	1.9 l/s	-	34% Reduction
Q _{100 + 45%}	-	3.5 l/s	-	3.5 l/s	-	Equivalent

The results show that the post development run-off rates are equivalent to the 1-year and 100-year greenfield rates, and a 34% reduction of the 30-year greenfield rate.

Therefore, as the greenfield rates have not been exceeded, the discharge rates are deemed to be acceptable, as they meet the requirements set out in the SBC Surface Water Drainage Strategy Guidance and DEFRA Non-Statutory Technical Standards for Sustainable Drainage Systems – S2 (see Section 4.4).

8.5. Surface Water Run-Off Volume

The surface water run-off volumes for the post development site can be calculated for 1 in 100-Year the 6-hour duration (Inc. 45% allowance), based on the peak discharge rate of 2.8 l/s, where:

$$Q_{100 \text{ (6-hour)}} - 3.5 \text{ l/s} \times (60 \times 60 \times 6) - 75,600 \text{ litres} - \mathbf{75.60m^3}$$

A summary of the post development surface water run-off volume compared to the greenfield volumes are as follows:

Greenfield Volume to Post Development Volume

Strom	-	Greenfield	-	Post Dev	-	Difference
Q ₁₀₀	-	91.42m ³	-	75.60m ³	-	17% Reduction

The post development surface water run-off volume is a 17% reduction of the greenfield volume for the same storm event and duration.

Therefore, the discharge volume is deemed to be acceptable, as it meets the requirements set out in the DEFRA Non-Statutory Technical Standards for Sustainable Drainage Systems – S4 and S6 (see Section 4.5).

8.6. Surface Water Attenuation Calculations

As stated above, the post development run-off rates are restricted, there will be a requirement for surface water attenuation.

The attenuation structures / methods will be formed of a below ground attenuation tank in the form of cellular units, and the sub-base of the permeable surface systems in the playground and parking bays south and west of the Site, respectively. Note sub-base for other permeable surfacing not used for attenuation due to level difference.

As detailed in the MicroDrainage calculations (Appendix F) and surface water management layout (Appendix E) the attenuation volumes and details for the SuDS method are as follows:

Cellular Units

Attenuation Tank Length	-	26.00m
Attenuation Tank Width	-	4.50m
Attenuation Tank Area	-	117.00m ²
Attenuation Tank Depth	-	1.20m
Porosity	-	0.95
Attenuation Tank Volume	-	133.38m³
<i>Overall Tank Volume</i>	-	<i>140.40m³</i>

Permeable Paving

Total Paving / Sub-Base Area	-	409.00m ²
Sub-Base Depth	-	0.30m
Porosity	-	0.30
Attenuation Volume	-	36.81m³

The MicroDrainage calculations (Appendix F) show that with these SuDS methods and volumes, no flooding will occur for all storms up to and including the 100-year + 45% allowance.

Therefore, the attenuation volume is deemed to be acceptable, as they meet the requirements set out in the Non-Statutory Technical Standards for Sustainable Drainage Systems – S7 to S9 (see Section 4.6).

9. Maintenance Requirements

The management and maintenance of the surface water drainage networks and SuDS features will be undertaken by caretakers of the Millwood School site and will form part of the regular management and maintenance regime of the school. Details of the required maintenance and management of the drainage and SuDS are as follows:

9.1. Surface Water Drainage Network, Cellular Units and Flow Control Chamber

Operation	Frequency
Inspect and identify any areas that are not operating correctly, if required, take remedial actions	Monthly for 3 months, then six monthlies
Debris removal from manholes (where may cause risk performance)	Monthly
Where rainfall into network from above, check surface or filter for blockage or silt, algae, or other matter by jetting	As required, but at least twice a year
Remove sediment from pipework by jetting.	Annually or as required
Repair/check all inlets, outlets, and overflow pipes	As required
Inspect/check all inlets, outlets, and overflow pipes to ensure that they are in good condition and operating as designed	Annually and after large storms

9.2. Filter Drains, Permeable Surfacing and Raised Planters

Operation	Frequency
Inspect and identify any areas that are not operating correctly, if required, take remedial actions.	Monthly for 3 months, then six monthlies
Debris removal from on surface of filter drains, permeable surfacing and raised planters or near system (where may cause risk performance).	Monthly
Rainfall infiltration into filter drains, permeable surfacing and raised planters is ensured working effectively.	As required, but at least twice a year

9.3. Linked and Further Maintenance Activities

The maintenance of the drainage network and SuDS features are to be linked with the wider site maintenance for the new residential landscaped / garden areas. A log of all maintenance activities is to be kept and made available to the local planning authority (LPA) and / or the Lead Local Flood Authority (LLFA) on request.

10. Surface Water Design Exceedance

In the unlikely event of an extreme storm greater than 100-year + 45% allowance, or poor maintenance of the SuDS features and / or pipework, potential flooding of the drainage network could occur.

Flood water will follow the existing / proposed topography of the ground and will flow away from the new classroom block and existing school building towards the southern boundary and into School Street.

Surface water will not flow towards any other buildings / properties prior to discharging onto School Street. Water will be contained in School Street due to the road having a gradient towards the canal (flows in channels) and upstand kerbs.

11. Water Quality

The level of water treatment is to be assessed against the details set out in Ciria SuDS Manual C753. Chapter 26 sets out the Pollution Hazard Indices for different land classifications, and how to calculate that against the SuDS mitigation indices to show suitable levels of treatment.

11.1. Roof and External Areas Pollutant Hazard

C753 Table 26.2 Pollution Hazard Level = Low

C753 Table 26.2 Pollution Hazard Index:

Total Suspended Solid (TSS)	=	0.3
Metals	=	0.2
Hydrocarbons	=	0.05
Pollution Hazard Index	=	<u>0.55</u>

11.2. Roof and External Areas Pollutant Mitigation

Mitigation Measures:

Permeable Surfacing and Raised Planters

Lowest Mitigation Indices:

Total Suspended Solid (TSS)	=	0.7
Metals	=	0.6
Hydrocarbons	=	0.7
SuDS Mitigation Indices	=	<u>2.00</u>

The mitigation indices are greater than the pollution hazard index, and therefore suitable water quality is achieved.

12. Development Management and Construction Phase

All existing drainage networks within the development area are to be maintained during construction.

12.1. Construction Environment Management Plan

Full details of the construction environment management plan (CEMP) have to be confirmed by the chosen contractor. However, the CEMP will conform to the requirements of CIRIA 753 – The SuDS Manual – Chapter 31, and will include:

12.2. Construction Access

The main construction traffic will access the site from the south of the Site (School Street) and will ensure that traffic over the proposed cellular units will be avoided.

12.3. Sediments and Traps

Sediment basins and traps are to be installed before any major site earthworks take place, with further sediment traps and silt fences being installed as the earthworks progresses. This will keep sediment contained on site at appropriate locations.

12.4. Run-Off Control Measures

Run-off control measures are to be used in conjunction with sediment traps to divert water around planned earthworks areas to remove silt. Any surface water upstream of the site is to be diverted around the development areas, and to be discharged to the existing drainage system. The surface water run-off destination for the diverted surface water will continue as existing.

12.5. Main Surface Water Run-Off Systems

The main drainage network, cellular units and flow control chambers, and outfall to existing drainage network are to be built prior to any phase of construction of site. Surface water from each of the phased area is to discharge to the new drainage network, where the water is adequately restricted, and water quality maintained before discharging to the existing sewer network. Temporary inlet and outlet protection measures and appropriate silt traps are to be installed to prevent silt ingress into the main drainage network.

12.6. Clearing and Earthworks

Clearing and earthworks will only start when adequate erosion and sediment control measures are in place. Once the development areas are cleared, earthworks will follow immediately to ensure that the ground cover can be re-established quickly. Adjacent land to that being developed will be left undisturbed for as long as possible.

12.7. Surface Stabilisation Measures

Surface stabilisation measures will be applied to completed areas, channels ditches and other disturbed areas after the land is cleared and profiled. Permanent stabilisation measures will be installed as soon as possible after final profiling.

12.8. Construction of Permeable Surfacing

Construction of permeable paving is to be left to the later stages of construction. Unsuitable sediment is to be removed from surfacing prior to installation of sand binder layer and paving.

13. Conclusion / Summary

13.1. SuDS Principles and Discharge Destination

All feasible SuDS methods, and surface water discharge destination have been assessed, with the feasible SuDS methods being water butts, filter drains, permeable surfacing, raised planters, cellular units, and a flow control chamber, and the surface water destination being to a surface water sewer.

13.2. Peak Flow Control

The post development run-off rates are equivalent to the 1-year and 100-year greenfield rates, and a 34% reduction of the 30-year greenfield rate. Therefore, as the greenfield rates have not been exceeded, the discharge rates are deemed to be acceptable, as they meet the requirements set out in the SBC Surface Water Drainage Strategy Guidance and DEFRA Non-Statutory Technical Standards for Sustainable Drainage Systems – S2 (see Section 4.4).

13.3. Volume Control

The post development surface water run-off volume is a 17% reduction of the greenfield volume for the same storm event and duration. Therefore, the discharge volume is deemed to be acceptable, as it meets the requirements set out in the DEFRA Non-Statutory Technical Standards for Sustainable Drainage Systems – S4 and S6 (see Section 4.5).

13.4. Flood Risk within the Development

The below ground cellular unit structure and sub-base of the permeable surfacing will be suitably sized so that no flooding occurs for all storms up to and including the 100-year + 45% allowance event. Therefore, the attenuation volume is deemed to be acceptable, as they meet the requirements set out in the Non-Statutory Technical Standards for Sustainable Drainage Systems – S7 to S9 (see Section 4.6).

13.5. Maintenance

The management and maintenance of the surface water drainage networks and SuDS features will be undertaken by caretakers of the Millwood School site and will form part of the regular management and maintenance regime of the school.

13.6. Exceedance Event

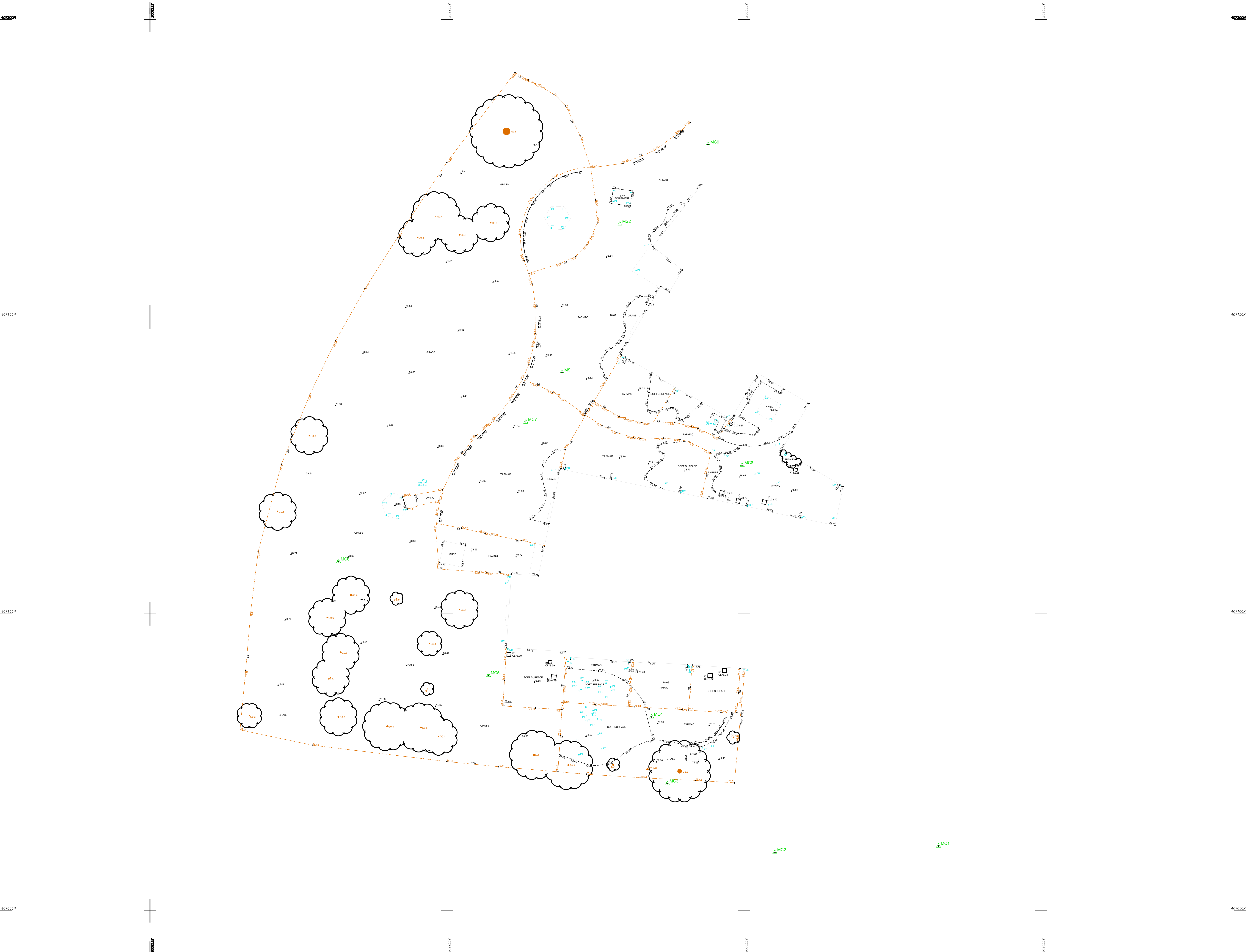
Flood water will follow the existing / proposed topography of the ground and will flow away from the new classroom block and existing school building towards the southern boundary and into School Street.

Surface water will not flow towards any other buildings / properties prior to discharging onto School Street. Water will be contained in School Street due to the road having a gradient towards the canal (flows in channels) and upstand kerbs.

13.7. Water Quality

The level of water treatment is to be assessed against the details set out in Ciria SuDS Manual C753. Chapter 26 sets out the Pollution Hazard Indices for different land classifications, and how to calculate that against the SuDS mitigation indices to show suitable levels of treatment. With the pollutant control chamber, the mitigation indices are greater than the pollution hazard index, and therefore suitable water quality is achieved.

Appendix A - Topographical Survey



The survey is plotted on a plane local Grid. Orientation to National Grid. All levels relate to Ordnance Datum, achieved using the OS National GPS Network.

Survey Control Markers established for Mapping purposes only and should not be used for Construction without the written approval of Survey Operations Ltd.

SURVEY STATIONS			
Name	Easting	Northing	Height
MC1	377632.74	407080.87	78.76
MC2	377605.90	407066.80	78.76
MC3	377657.68	407071.59	78.76
MC4	377654.45	407071.81	78.76
MC5	377658.87	407069.81	78.76
MC6	377631.72	407108.78	78.76
MC7	377653.58	407132.25	78.76
MC8	377659.49	407132.25	78.76
MC9	377653.58	407178.59	78.76
MC10	377666.36	407140.89	78.76
MS1	377678.11	407165.62	78.76

STANDARD REFERENCE & ABBREVIATIONS



Smith Street, Skelmersdale, Lancs. WN8 8LN
Tel: 01695 725662 Fax: 01695 51816
Email: mail@survops.co.uk - www.survops.co.uk

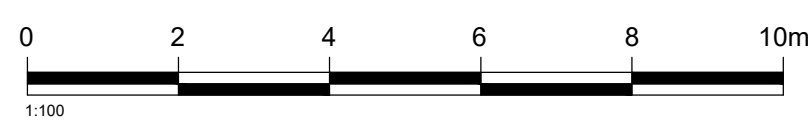
Client
ISG Construction Limited

Scale(s)	1:200	Surveyor	MC
Date	Jul 23	Drawn	OKS
Job Number	23E292	Checked	TP

Sheet Size & Dwg Number & Revision



Appendix B - Proposed Site Plan



 Tarmac
208 Sq.m

 Soft Surfacing
405 Sq.m

B G
& H

**Architects
Consulting Engineers
Quantity Surveyors**

21 Silverwell Street
Bolton
BL1 1PR
t: 01204 525321
email@tgbhbolton.co.uk
www.tgbhbolton.co.uk



Appendix C - United Utilities Asset Plan

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

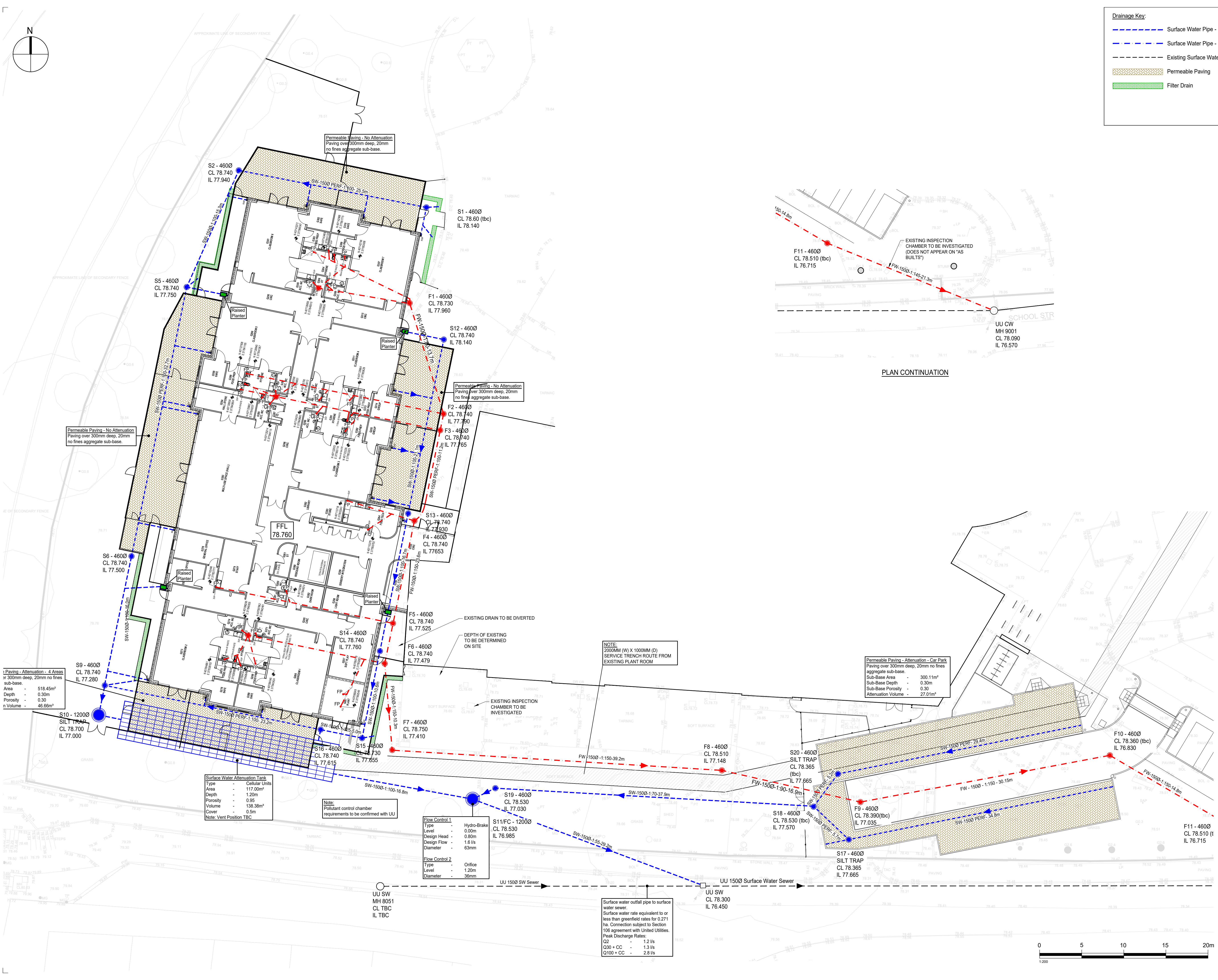
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Appendix D - Greenfield SW Run-Off Rates and Volume Calculations

Flo Consult UK Ltd		Page 1
4 Market Square Old Amersham Buckinghamshire, HP7 0DQ	Millwood School Greenfield Run-Off Rate Calculation	
Date 15/08/2023	Designed by MDS	
File	Checked by MDS	
Innovyze	Source Control 2020.1.3	
IH 124 Mean Annual Flood Input Return Period (years)2Soil0.450 Area (ha) 50.000Urban0.000 SAAR (mm)950Region NumberRegion 10 Results1/s QBAR Rural314.0 QBAR Urban314.0 Q2 years292.4 Q1 year273.2 Q2 years292.4 Q5 years373.6 Q10 years433.3 Q20 years493.7 Q25 years514.9 Q30 years532.4 Q50 years580.9 Q100 years653.1 Q200 years741.0 Q250 years769.3 Q1000 years954.5		
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Flo Consult UK Ltd		Page 1																										
4 Market Square	Millwood School																											
Old Amersham	Greenfield Run-Off																											
Buckinghamshire, HP7 0DQ	Volume Calculation																											
Date 05/02/2024	Designed by MDS																											
File	Checked by MDS																											
Innovyze		Source Control 2020.1.3																										
<u>Greenfield Runoff Volume</u> FEH Data <table> <tr> <td>Return Period (years)</td> <td>100</td> </tr> <tr> <td>Storm Duration (mins)</td> <td>360</td> </tr> <tr> <td>FEH Rainfall Version</td> <td>2013</td> </tr> <tr> <td>Site Location</td> <td>GB 377929 407139 SD 77929 07139</td> </tr> <tr> <td>Data Type</td> <td>Point</td> </tr> <tr> <td>Areal Reduction Factor</td> <td>1.00</td> </tr> <tr> <td>Area (ha)</td> <td>0.271</td> </tr> <tr> <td>SAAR (mm)</td> <td>1054</td> </tr> <tr> <td>CWI</td> <td>123.486</td> </tr> <tr> <td>SPR Host</td> <td>47.000</td> </tr> <tr> <td>URBEXT (1990)</td> <td>0.0000</td> </tr> </table> Results <table> <tr> <td>Percentage Runoff (%)</td> <td>51.04</td> </tr> <tr> <td>Greenfield Runoff Volume (m³)</td> <td>91.419</td> </tr> </table>			Return Period (years)	100	Storm Duration (mins)	360	FEH Rainfall Version	2013	Site Location	GB 377929 407139 SD 77929 07139	Data Type	Point	Areal Reduction Factor	1.00	Area (ha)	0.271	SAAR (mm)	1054	CWI	123.486	SPR Host	47.000	URBEXT (1990)	0.0000	Percentage Runoff (%)	51.04	Greenfield Runoff Volume (m³)	91.419
Return Period (years)	100																											
Storm Duration (mins)	360																											
FEH Rainfall Version	2013																											
Site Location	GB 377929 407139 SD 77929 07139																											
Data Type	Point																											
Areal Reduction Factor	1.00																											
Area (ha)	0.271																											
SAAR (mm)	1054																											
CWI	123.486																											
SPR Host	47.000																											
URBEXT (1990)	0.0000																											
Percentage Runoff (%)	51.04																											
Greenfield Runoff Volume (m³)	91.419																											
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Appendix E - Below Ground Drainage Layout and Details



Drainage Key:

- Surface Water Pipe - Solid
- Surface Water Pipe - Perforated
- Existing Surface Water Sewer
- Permeable Paving
- Filter Drain

status

PRELIMINARY

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The originator shall have no responsibility for any liability, loss, cost, damage or expense arising from or relating to any use of this document other than for its intended purpose on this project.

This drawing shall be read in conjunction with all other relevant drawings, specifications and associated documentation. Any discrepancies, errors or omissions are to be reported to the originator before proceeding with work.

All dimensions are to be checked on site by the contractor prior to proceeding with any work.

Hazard Identification

ref	hazard	date

client

ISG CONSTRUCTION LTD

project

MILLWOOD SCHOOL
NEW CLASSROOM BLOCK

drawing

BELOW GROUND DRAINAGE
LAYOUT

drawn by BH **date** 08.02.24

checked by **date**

scale 1:200 **A1**

dwg no MSE-BGH-XX-XX-DR-C-1061 **rev** 2

Appendix F- Surface Water Management Calculations

Flo Consult UK Ltd		Page 1	
4 Market Square Old Amersham Buckinghamshire, HP7 0DQ		Millwood School Surface Water Management Calculations	
Date 06/02/2024		Designed by MDS	
File Millwood Extension - SW ...		Checked by MDS	
Innovyze		Source Control 2020.1.3	

Summary of Results for 2 year Return Period

Half Drain Time : 202 minutes.

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	77.021	0.121	0.0	1.5	1.5	13.4	O K
30 min Summer	77.061	0.161	0.0	1.6	1.6	17.9	O K
60 min Summer	77.100	0.200	0.0	1.6	1.6	22.2	O K
120 min Summer	77.152	0.252	0.0	1.6	1.6	28.0	O K
180 min Summer	77.174	0.274	0.0	1.6	1.6	30.5	O K
240 min Summer	77.187	0.287	0.0	1.6	1.6	31.9	O K
360 min Summer	77.199	0.299	0.0	1.6	1.6	33.3	O K
480 min Summer	77.203	0.303	0.0	1.6	1.6	33.7	O K
600 min Summer	77.201	0.301	0.0	1.6	1.6	33.5	O K
720 min Summer	77.197	0.297	0.0	1.6	1.6	33.0	O K
960 min Summer	77.185	0.285	0.0	1.6	1.6	31.6	O K
1440 min Summer	77.155	0.255	0.0	1.6	1.6	28.3	O K
2160 min Summer	77.113	0.213	0.0	1.6	1.6	23.7	O K
2880 min Summer	77.079	0.179	0.0	1.6	1.6	19.9	O K
4320 min Summer	77.032	0.132	0.0	1.5	1.5	14.6	O K
5760 min Summer	77.003	0.103	0.0	1.4	1.4	11.5	O K
7200 min Summer	76.987	0.087	0.0	1.4	1.4	9.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	33.314	0.0	14.5	31
30 min Summer	21.881	0.0	19.8	43
60 min Summer	13.869	0.0	25.9	68
120 min Summer	9.221	0.0	35.1	122
180 min Summer	7.128	0.0	41.1	164
240 min Summer	5.911	0.0	45.6	198
360 min Summer	4.527	0.0	52.6	266
480 min Summer	3.737	0.0	58.1	336
600 min Summer	3.218	0.0	62.6	406
720 min Summer	2.848	0.0	66.6	474
960 min Summer	2.349	0.0	73.3	612
1440 min Summer	1.795	0.0	84.0	876
2160 min Summer	1.380	0.0	97.0	1252
2880 min Summer	1.150	0.0	107.6	1616
4320 min Summer	0.895	0.0	125.0	2332
5760 min Summer	0.753	0.0	140.0	3008
7200 min Summer	0.661	0.0	152.9	3688

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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ	Millwood School Surface Water Management Calculations	
Date 06/02/2024	Designed by MDS	
File Millwood Extension - SW ...	Checked by MDS	
Innovyze		Source Control 2020.1.3

Rainfall Details

Rainfall Model	FEH
Return Period (years)	2
FEH Rainfall Version	2013
Site Location	GB 377929 407139 SD 77929 07139
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.271

Time (mins)	Area	Time (mins)	Area	Time (mins)	Area
From:	To:	From:	To:	From:	To:
0	4 0.055	8	12 0.054	16	20 0.054
4	8 0.054	12	16 0.054		

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Flo Consult UK Ltd		Page 5
4 Market Square Old Amersham Buckinghamshire, HP7 0DQ	Millwood School Surface Water Management Calculations	
Date	Designed by MDS	
File Millwood Extension - SW ...	Checked by MDS	
Innovyze		Source Control 2020.1.3

Model Details

Storage is Online Cover Level (m) 78.600

Complex Structure

Cellular Storage

Invert Level (m) 76.900 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m ²)	Inf. Area (m ²)	Depth (m)	Area (m ²)	Inf. Area (m ²)
0.000	117.0	0.0	2.600	0.0	0.0
0.200	117.0	0.0	2.800	0.0	0.0
0.400	117.0	0.0	3.000	0.0	0.0
0.600	117.0	0.0	3.200	0.0	0.0
0.800	117.0	0.0	3.400	0.0	0.0
1.000	117.0	0.0	3.600	0.0	0.0
1.200	117.0	0.0	3.800	0.0	0.0
1.400	0.0	0.0	4.000	0.0	0.0
1.600	0.0	0.0	4.200	0.0	0.0
1.800	0.0	0.0	4.400	0.0	0.0
2.000	0.0	0.0	4.600	0.0	0.0
2.200	0.0	0.0	4.800	0.0	0.0
2.400	0.0	0.0	5.000	0.0	0.0

Porous Car Park

Infiltration Coefficient Base (m/hr) 0.00000 Width (m) 5.0
Membrane Percolation (mm/hr) 1000 Length (m) 81.8
Max Percolation (l/s) 113.6 Slope (1:X) 0.0
Safety Factor 2.0 Depression Storage (mm) 5
Porosity 0.30 Evaporation (mm/day) 3
Invert Level (m) 78.100 Cap Volume Depth (m) 0.300

Complex Outflow Control

Hydro-Brake® Optimum

Unit Reference MD-SHE-0063-1600-0800-1600
Design Head (m) 0.800
Design Flow (l/s) 1.6
Flush-Flo™ Calculated

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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ	Millwood School Surface Water Management Calculations	
Date Millwood Extension - SW ...	Designed by MDS Checked by MDS	
Innovyze Source Control 2020.1.3		

Hydro-Brake® Optimum

Objective Minimise upstream storage

Application Surface

Sump Available Yes

Diameter (mm) 63

Invert Level (m) 76.900

Minimum Outlet Pipe Diameter (mm) 75

Suggested Manhole Diameter (mm) 1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.800	1.6	Kick-Flo®	0.508	1.3
Flush-Flo™	0.246	1.6	Mean Flow over Head Range	-	1.4

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.4	1.200	1.9	3.000	2.9	7.000	4.3
0.200	1.6	1.400	2.1	3.500	3.1	7.500	4.5
0.300	1.6	1.600	2.2	4.000	3.3	8.000	4.6
0.400	1.5	1.800	2.3	4.500	3.5	8.500	4.8
0.500	1.3	2.000	2.4	5.000	3.7	9.000	4.9
0.600	1.4	2.200	2.5	5.500	3.9	9.500	5.0
0.800	1.6	2.400	2.6	6.000	4.0		
1.000	1.8	2.600	2.7	6.500	4.2		

Orifice

Diameter (m) 0.037 Discharge Coefficient 0.600 Invert Level (m) 78.100

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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ		Millwood School Surface Water Management Calculations	
Date		Designed by MDS	
File Millwood Extension - SW ...		Checked by MDS	
Innovyze		Source Control 2020.1.3	

Summary of Results for 30 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
8640 min Summer	77.367	0.467	0.0	1.6	1.6	51.9	O K
10080 min Summer	77.285	0.385	0.0	1.6	1.6	42.7	O K
15 min Winter	77.402	0.502	0.0	1.6	1.6	55.8	O K
30 min Winter	77.577	0.677	0.0	1.6	1.6	75.3	O K
60 min Winter	77.762	0.862	0.0	1.7	1.7	95.8	O K
120 min Winter	77.898	0.998	0.0	1.8	1.8	111.0	O K
180 min Winter	77.972	1.072	0.0	1.8	1.8	119.2	O K
240 min Winter	78.017	1.117	0.0	1.9	1.9	124.2	O K
360 min Winter	78.062	1.162	0.0	1.9	1.9	129.2	O K
480 min Winter	78.078	1.178	0.0	1.9	1.9	130.9	O K
600 min Winter	78.076	1.176	0.0	1.9	1.9	130.8	O K
720 min Winter	78.065	1.165	0.0	1.9	1.9	129.5	O K
960 min Winter	78.039	1.139	0.0	1.9	1.9	126.5	O K
1440 min Winter	77.977	1.077	0.0	1.8	1.8	119.7	O K
2160 min Winter	77.884	0.984	0.0	1.8	1.8	109.4	O K
2880 min Winter	77.798	0.898	0.0	1.7	1.7	99.8	O K
4320 min Winter	77.640	0.740	0.0	1.6	1.6	82.3	O K
5760 min Winter	77.493	0.593	0.0	1.6	1.6	65.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.226	0.0	349.3	5008
10080 min Summer	1.120	0.0	371.6	5648
15 min Winter	105.537	0.0	57.5	34
30 min Winter	70.662	0.0	77.6	48
60 min Winter	45.321	0.0	100.8	76
120 min Winter	27.047	0.0	120.7	132
180 min Winter	19.964	0.0	133.8	188
240 min Winter	16.080	0.0	143.8	244
360 min Winter	11.835	0.0	158.9	358
480 min Winter	9.534	0.0	170.7	468
600 min Winter	8.061	0.0	180.5	574
720 min Winter	7.025	0.0	188.7	668
960 min Winter	5.640	0.0	201.9	756
1440 min Winter	4.154	0.0	222.5	1068
2160 min Winter	3.089	0.0	249.1	1524
2880 min Winter	2.519	0.0	270.5	1968
4320 min Winter	1.908	0.0	306.6	2828
5760 min Winter	1.580	0.0	338.2	3704

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	30
FEH Rainfall Version	2013
Site Location	GB 377929 407139 SD 77929 07139
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.271

Time (mins)	Area	Time (mins)	Area	Time (mins)	Area
From:	To:	From:	To:	From:	To:
0	4 0.055	8	12 0.054	16	20 0.054
4	8 0.054	12	16 0.054		

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Model Details

Storage is Online Cover Level (m) 78.600

Complex Structure

Cellular Storage

Invert Level (m) 76.900 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m ²)	Inf. Area (m ²)	Depth (m)	Area (m ²)	Inf. Area (m ²)
0.000	117.0	0.0	2.600	0.0	0.0
0.200	117.0	0.0	2.800	0.0	0.0
0.400	117.0	0.0	3.000	0.0	0.0
0.600	117.0	0.0	3.200	0.0	0.0
0.800	117.0	0.0	3.400	0.0	0.0
1.000	117.0	0.0	3.600	0.0	0.0
1.200	117.0	0.0	3.800	0.0	0.0
1.400	0.0	0.0	4.000	0.0	0.0
1.600	0.0	0.0	4.200	0.0	0.0
1.800	0.0	0.0	4.400	0.0	0.0
2.000	0.0	0.0	4.600	0.0	0.0
2.200	0.0	0.0	4.800	0.0	0.0
2.400	0.0	0.0	5.000	0.0	0.0

Porous Car Park

Infiltration Coefficient Base (m/hr) 0.00000 Width (m) 5.0
Membrane Percolation (mm/hr) 1000 Length (m) 81.8
Max Percolation (l/s) 113.6 Slope (1:X) 0.0
Safety Factor 2.0 Depression Storage (mm) 5
Porosity 0.30 Evaporation (mm/day) 3
Invert Level (m) 78.100 Cap Volume Depth (m) 0.300

Complex Outflow Control

Hydro-Brake® Optimum

Unit Reference MD-SHE-0063-1600-0800-1600
Design Head (m) 0.800
Design Flow (l/s) 1.6
Flush-Flo™ Calculated

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Summary of Results for 100 year Return Period (+45%)

Half Drain Time : 569 minutes.

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	77.519	0.619	0.0	1.6	1.6	68.8	O K
30 min Summer	77.741	0.841	0.0	1.6	1.6	93.5	O K
60 min Summer	77.977	1.077	0.0	1.8	1.8	119.7	O K
120 min Summer	78.117	1.217	0.0	2.0	2.0	137.3	O K
180 min Summer	78.161	1.261	0.0	2.6	2.6	145.8	O K
240 min Summer	78.188	1.288	0.0	2.7	2.7	150.3	O K
360 min Summer	78.209	1.309	0.0	2.9	2.9	153.4	O K
480 min Summer	78.209	1.309	0.0	2.9	2.9	153.5	O K
600 min Summer	78.207	1.307	0.0	2.8	2.8	153.1	O K
720 min Summer	78.202	1.302	0.0	2.8	2.8	152.4	O K
960 min Summer	78.188	1.288	0.0	2.7	2.7	150.3	O K
1440 min Summer	78.159	1.259	0.0	2.5	2.5	145.4	O K
2160 min Summer	78.127	1.227	0.0	2.1	2.1	139.2	O K
2880 min Summer	78.095	1.195	0.0	1.9	1.9	132.9	O K
4320 min Summer	77.987	1.087	0.0	1.8	1.8	120.8	O K
5760 min Summer	77.894	0.994	0.0	1.8	1.8	110.5	O K
7200 min Summer	77.812	0.912	0.0	1.7	1.7	101.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	143.989	0.0	70.5	34
30 min Summer	97.296	0.0	95.8	48
60 min Summer	62.801	0.0	125.2	76
120 min Summer	37.082	0.0	148.2	134
180 min Summer	27.208	0.0	163.3	190
240 min Summer	21.825	0.0	174.8	246
360 min Summer	15.974	0.0	192.0	360
480 min Summer	12.790	0.0	205.0	422
600 min Summer	10.759	0.0	215.6	484
720 min Summer	9.339	0.0	224.5	548
960 min Summer	7.464	0.0	239.0	684
1440 min Summer	5.447	0.0	260.0	970
2160 min Summer	4.003	0.0	288.9	1416
2880 min Summer	3.238	0.0	311.2	1852
4320 min Summer	2.430	0.0	349.4	2680
5760 min Summer	2.000	0.0	383.1	3472
7200 min Summer	1.727	0.0	413.0	4264

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Summary of Results for 100 year Return Period (+45%)

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
8640 min Summer	77.739	0.839	0.0	1.6	1.6	93.3	O K
10080 min Summer	77.677	0.777	0.0	1.6	1.6	86.3	O K
15 min Winter	77.598	0.698	0.0	1.6	1.6	77.6	O K
30 min Winter	77.847	0.947	0.0	1.7	1.7	105.2	O K
60 min Winter	78.106	1.206	0.0	1.9	1.9	134.8	O K
120 min Winter	78.212	1.312	0.0	2.9	2.9	153.9	O K
180 min Winter	78.284	1.384	0.0	3.2	3.2	163.4	O K
240 min Winter	78.327	1.427	0.0	3.4	3.4	168.7	Flood Risk
360 min Winter	78.360	1.460	0.0	3.5	3.5	172.7	Flood Risk
480 min Winter	78.360	1.460	0.0	3.5	3.5	172.7	Flood Risk
600 min Winter	78.358	1.458	0.0	3.5	3.5	172.5	Flood Risk
720 min Winter	78.352	1.452	0.0	3.5	3.5	171.7	Flood Risk
960 min Winter	78.328	1.428	0.0	3.4	3.4	168.7	Flood Risk
1440 min Winter	78.265	1.365	0.0	3.1	3.1	161.0	O K
2160 min Winter	78.192	1.292	0.0	2.8	2.8	151.0	O K
2880 min Winter	78.148	1.248	0.0	2.4	2.4	143.4	O K
4320 min Winter	78.047	1.147	0.0	1.9	1.9	127.5	O K
5760 min Winter	77.897	0.997	0.0	1.8	1.8	110.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.540	0.0	441.1	5032
10080 min Summer	1.402	0.0	467.9	5856
15 min Winter	143.989	0.0	79.1	34
30 min Winter	97.296	0.0	107.3	48
60 min Winter	62.801	0.0	140.5	76
120 min Winter	37.082	0.0	166.3	130
180 min Winter	27.208	0.0	183.2	186
240 min Winter	21.825	0.0	196.0	242
360 min Winter	15.974	0.0	215.3	350
480 min Winter	12.790	0.0	229.9	444
600 min Winter	10.759	0.0	241.7	480
720 min Winter	9.339	0.0	251.7	556
960 min Winter	7.464	0.0	268.0	712
1440 min Winter	5.447	0.0	290.6	1020
2160 min Winter	4.003	0.0	324.0	1472
2880 min Winter	3.238	0.0	349.1	1932
4320 min Winter	2.430	0.0	392.0	2864
5760 min Winter	2.000	0.0	430.0	3704

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 377929 407139 SD 77929 07139
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+45

Time Area Diagram

Total Area (ha) 0.271

Time (mins)	Area	Time (mins)	Area	Time (mins)	Area
From:	To:	From:	To:	From:	To:
0	4 0.055	8	12 0.054	16	20 0.054
4	8 0.054	12	16 0.054		

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Model Details

Storage is Online Cover Level (m) 78.600

Complex Structure

Cellular Storage

Invert Level (m) 76.900 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m ²)	Inf. Area (m ²)	Depth (m)	Area (m ²)	Inf. Area (m ²)
0.000	117.0	0.0	2.600	0.0	0.0
0.200	117.0	0.0	2.800	0.0	0.0
0.400	117.0	0.0	3.000	0.0	0.0
0.600	117.0	0.0	3.200	0.0	0.0
0.800	117.0	0.0	3.400	0.0	0.0
1.000	117.0	0.0	3.600	0.0	0.0
1.200	117.0	0.0	3.800	0.0	0.0
1.400	0.0	0.0	4.000	0.0	0.0
1.600	0.0	0.0	4.200	0.0	0.0
1.800	0.0	0.0	4.400	0.0	0.0
2.000	0.0	0.0	4.600	0.0	0.0
2.200	0.0	0.0	4.800	0.0	0.0
2.400	0.0	0.0	5.000	0.0	0.0

Porous Car Park

Infiltration Coefficient Base (m/hr) 0.00000 Width (m) 5.0
Membrane Percolation (mm/hr) 1000 Length (m) 81.8
Max Percolation (l/s) 113.6 Slope (1:X) 0.0
Safety Factor 2.0 Depression Storage (mm) 5
Porosity 0.30 Evaporation (mm/day) 3
Invert Level (m) 78.100 Cap Volume Depth (m) 0.300

Complex Outflow Control

Hydro-Brake® Optimum

Unit Reference MD-SHE-0063-1600-0800-1600
Design Head (m) 0.800
Design Flow (l/s) 1.6
Flush-Flo™ Calculated

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