Project

Car Park and Access Road
Thornbridge Hall, Baslow Road
Ashford-in-the-Water, DE45 1NZ

Title

Flood Risk Statement and
Surface Water Management Report

Project No

C14090

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B

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1. Introduction

Northern Structural Services have prepared this flood risk statement and surface water management report for a car park and access road at Thornbridge Hall, Baslow Road, Ashford-in-the-Water, which is in the local authority areas of Derbyshire County Council and Derbyshire Dales District Council.

The report provides evidence of the assessment of current flood risks to the development site and describes how the surface water run-off rate and volume from the post development site is proposed to be managed. National and local planning policy, regulations and relevant design guidance include:

- National Planning Policy Framework (NPPF) 2019 Paragraphs 149-150 and 155-165;
- National Planning Practice Guidance (NPPG);
- Principles of Sustainable drainage systems (SuDS) set out by DEFRA (2011);
- CIRIA (2010) Planning for SuDS;
- Ciria SuDS Manual C753 (2015);
- Non-Statutory Technical Standards for Sustainable Drainage Systems (March 2015);
- Derbyshire County Council Preliminary Flood Risk Assessment (May 2011);
- Derbyshire County Council Strategic Flood Risk Assessment (August 2012);
- Derbyshire County Council Local Flood Risk Management Strategy (July 2015);
- Derbyshire Dales District Council Preliminary Flood Risk Assessment (May 2011);
- Derbyshire Dales District Council Level 1 Strategic Flood Risk Assessment (June 2016);
- Derbyshire Dales District Council Adopted Local Plan (December 2017);
- Derbyshire Dales and High Peak Joint Core Strategy.

Derbyshire County Council and Derbyshire Dales District Council, acting as Lead Local Flood Authority (LLFA), and Severn Trent Water (local water company and sewerage undertaker) need to be satisfied that this report identifies and evaluates the various possible sources of flood risk to which the proposed site might be subjected to; that it identifies any mitigation, protection or compensation measures deemed necessary or feasible; ensures 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; and 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 / Local Policies and Water Management Guidance

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

The NPPF 2019 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 149 to 154 Planning for Climate Change, and Paragraphs 155 to 165 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 takes forward some of the proposals from three previous strategy documents published by the UK Government - Future Water (2008), Making Space for Water (2008) and the UK Government's response to the Sir Michael Pitt's Review of the summer 2007 floods. In doing so it gives the EA a strategic overview role for flood risk, and gives local authorities responsibility for preparing and putting in place strategies for managing flood risk from groundwater, surface water and ordinary watercourses in their areas.

2.3. Derbyshire Dales District Council Adopted Local Plan

Policy PD8: Flood Risk Management and Water Quality, states:

'The District Council will support development proposals that avoid areas of current or future flood risk and which do not increase the risk of flooding elsewhere, where this is viable and compatible with other polices aimed at achieving a sustainable pattern of development.

When considering planning applications, the District Council will have regard to the 'Humber Flood Risk Management Plan', the 'Humber River Basin Management Plan' and the Local Flood Risk Management Strategy, all relevant Catchment Flood Management Plans and the Local Flood Risk Management Strategy.

Development will be supported where it is demonstrated that there is no deterioration in ecological status in line with the Water Framework Directive, either directly through pollution of surface or groundwater or indirectly through pollution of surface or groundwater or indirectly through overloading of the sewerage system and Wastewater Treatment Works.

Management of flood risk will be achieved by only permitting development within areas at risk from flooding as defined by the Environment Agency if:

a) a sequential test as set out in the 'National Planning Practice Guidance' to the NPPF and in accordance with the updated 'Derbyshire Dales Strategic Flood Risk Assessment' demonstrates that this is the only site where the development can be located;

b) the development is on a site which has passed the sequential test but where flood risk still exists, the sequential approach has been used to locate the most vulnerable parts of the development in the areas of lowest flood risk;

c) where necessary an 'Exception Test' as set out in the 'National Planning Practice Guidance' to the NPPF demonstrates that the proposed development can be accommodated with an acceptable degree of safety;

d) a site specific flood risk assessment shows that the site is protected adequately from flooding, or the scheme *includes adequate flood defences or flood risk management measures and takes account of the predicted impact of climate change;*

e) it does not damage or inhibit access to watercourses for maintenance or existing flood defence and flood risk management structures or measures; and

f) it will not cause or worsen flooding on the site or elsewhere, and will reduce flood risk elsewhere where possible.

New developments shall incorporate appropriate Sustainable Drainage Measures (SuDs) in accordance with National Standards for Sustainable Drainage Systems. This should be informed by specific catchment and ground characteristics, and will require the early consideration of a wide range of issues relating to the management, long term adoption and maintenance of SuDs. In considering SuDs solutions, the need to protect ground water quality must be taken into account, especially where infiltration techniques are proposed. SuDs schemes will require the approval of the SuDS approval body for the area, where one exists.

Wherever possible SuDS will be expected to contribute towards wider sustainability considerations, including amenity, recreation, conservation of biodiversity and landscape character, making use of the role that trees, woodland and other green infrastructure can play in flood alleviation and water quality control.

For developments in areas with known surface water flooding issues, appropriate mitigation and construction methods will be required. Applications and proposals which relate specifically to reducing the risk of flooding (e.g. defence / alleviation work, retro-fitting of existing development, off site detention /retention basins for catchment wide interventions) will be encouraged.

New development in areas with known ground and surface water flooding issues will seek to provide betterment in flood storage and to remove obstructions to flood flow routes where appropriate'.

3. Site Setting and Description

3.1. Site Location

The new car park and access road is built within the Thornbridge Hall Estate, which is approximately 1.5km north of Ashford-in-the-Water village centre and approximately 1.5km south of Great Longstone village centre.

The full address of the site is Thornbridge Hall Estate, Baslow Road, Ashford-in-the-Water, DE45 1NZ, with the co-ordinates for the centre of the car parking being E: 419865, N: 370830.

3.2. New Car Park and Access Road Details

As detailed on the plans in Appendix A, the new car park is located 200m to the east of the Thornbridge Hall building, with the new access road being to the south of the car park, where it joins an existing road in the estate approximately 400m south of the Thornbridge Hall Building.

3.3. Existing Site and Topography

The area of the car park and access road consisted of grassed areas, with a dirt track to the south where the new access road meets the existing estate road. As the areas are currently undeveloped, the site is deemed to be a 'greenfield'.

In terms of topography, there is a general fall from north to south, with the high point of the car park being along the northern boundary at approximately 178.74m AOD, the low point of the car park being to the south-east where the car park meets the access road at approximately 169.45m AOD, and the low point of the access road being at the junction with Baslow Road (to the south) at approximately 149.68m AOD.

3.4. Ground Conditions

Full ground investigation and infiltration tests are yet to take place at the development site. However, data for the ground conditions can be sourced from the British Geological Survey (BGS) website, where it identifies the development site to have no superficial deposit, over bedrock consisting of Eyam Limestone Formation (limestone).

The BGS website also shows borehole log data within the same bedrock strata as the car park and access road (see Appendix B), which identify the strata of the ground to predominantly consist of clay over limestone and mudstone.

3.5. Waterbodies

The nearest waterbody is a lake / pond located to the south of the new access road junction with Baslow Road.

3.6. Existing Drainage / Sewers

Due to the rural and undeveloped area of the car park and access road, there are no known drainage networks.

3.7. Development Areas

The car park covers an area of approximately 3480m² / 0.348 ha, and the road is approximately 648m long, 5.60m wide equating to an area of approximately 3810m² / 0.381 ha.

Therefore, the surface water management area equates to approximately 7290m³ / 0.729 ha.

4. Potential Sources of Existing Flooding

4.1. Fluvial Flooding

Fluvial flooding is resulted from watercourses / rivers surcharging and flooding the surrounding areas.

4.2. Pluvial Flooding

'Pluvial' flooding is that which results from rainfall generated overland flow before the run-off enters any watercourse, drain or sewer. It is more often linked to high intensity rainfall events (typically more than 30mm per hour). However, it can also result from lower intensity rainfall or melting snow where the ground is saturated, frozen, developed or has low permeability. This results in overland flow and ponding in depressions in the topography. In urban areas 'pluvial' flows are likely to follow the routes of highways and other surface connectivity to low spots where flooding can occur. In some cases, it can deviate from this route into adjacent developments via dropped kerbs (either for access to driveways or disability access).

4.3. Groundwater Flooding

Groundwater flooding is caused by the emergence of water from sub-surface permeable strata. Fluctuations in the groundwater table can cause flooding should the table rise above the existing ground level. Groundwater flooding events tend to have long durations, lasting days, or weeks.

4.4. Flooding from Drains and Sewers

Flooding from drains and sewers is caused when the capacity of the drains and sewers is exceeded, and will result in flooding from the manholes.

4.5. Canals, Reservoirs and Other Artificial Sources

Flooding from canals, reservoirs and artificial sources is caused when the capacity of the sources is exceeded, or if there is an infrastructure failure.

5. Probability of Flooding

5.1. Fluvial Flooding

The fluvial flood zone map (Risk of Flooding from Rivers and Sea) on the EA website (see Figure 1 below) identifies that the all the car park and most of the access road lies within Flood Zone 1 - low probability of flooding (less than 1 in 1000 annual probability of river flooding in any year), with the junction of the new access road and existing estate road being in Flood Zone 2 – medium probability of flooding (land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding).

Figure 1 – EA Fluvial Flood Zone Map

The fluvial flood probability map on the EA website (see Figure 2 below) identifies that all the car park and most of the access road gas a better than very low probability of fluvial flooding, with the junction of the new access road and existing estate road having a low to medium probability of flooding.

As the flood probability has only increase for a small area near the road junctions, it is deemed that the risk of fluvial flooding for the new developed areas is low.

Figure 2 – EA Fluvial Flood Probability Map

5.2. Pluvial / Surface Water Flooding

The pluvial flood map on the EA website (see Figure 3 below) identifies that all the car park and access road has site has a very low and occasional low probability of pluvial flooding. Therefore, the risk of pluvial flooding is deemed to low.

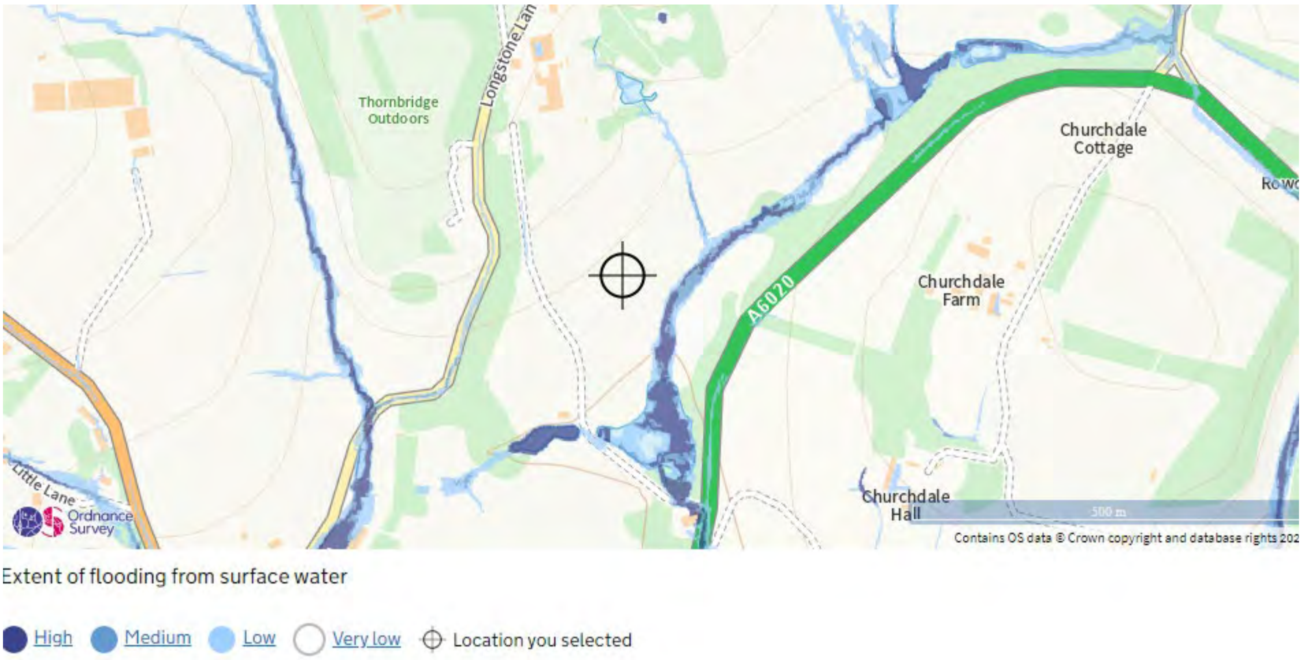


Figure 3 – EA Puvial / Surface Water Flood Probaility Map

5.3. Ground Water Flooding

There has been no known history of ground water flooding at the car park or access road location, and due to the development site being on a relatively steep gradient, ground water flooding is very unlikely.

Also, due to the ground consisting of clay layers (which has a very low permeability rate), above the limestone and mudstone, it is unlikely that ground water flooding will occur. Therefore, the probability of ground water flooding is deemed to be low.

5.4. Flooding from Drains and Sewers

There are no known drains and sewers near the site, and therefore probability of flooding is deemed to be low.

5.5. Canals, Reservoirs and Other Artificial Sources

There are no known canals, reservoirs or artificial sources near the new car park or access road, and therefore the probability of flooding from these sources is deemed to be low.

6. Surface Water Management Principles

The surface water for the development site is to be managed so that it adheres to the current regulations, and local authority requirements, as detailed in previous sections of this report.

6.1. National Planning Policy Framework (NPPF)

Paragraph 165 of NPPF – July 2018 states that:

Developments should incorporate sustainable drainage systems unless there is clear evidence that this would be inappropriate. The systems used should:

- take account of advice from the lead local flood authority;
- have appropriate proposed minimum operational standards;
- have maintenance arrangements in place to ensure an acceptable standard of operation for the lifetime of the development; and
- where possible, provide multifunctional benefits.

6.2. 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.

6.3. 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).

6.4. 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.

6.5. Peak Surface Water Flow

The surface water run-off from the developed areas of the site are to be reduced to as low as possible, with the aim to restrict the rates to the equivalent greenfield rates, where practical.

The practicality of reducing to the equivalent greenfield rate will depend on the flow control size / diameter. If the flow control opening / diameter is too small to achieve the greenfield rates, there will be an increased risk of blockage and subsequent flooding. Therefore, the flow control is to be sized appropriately to reduce the risk of blockage, but to reduce the surface water run-off rates from the post development site.

6.6. Volume Control

The aim is to ensure that the run-off volume from the developed site for the 1 in 100-year 6-hour rainfall does not exceed the pre-development run-off volume for the same event.

Should infiltration methods not be suitable, and it is not possible to achieve pre-development runoff volume, then it will be demonstrated that the increased volume will not increase flood risk on or off site.

6.7. Flood Risk

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

The drainage system will also be designed so that, unless an area is designed to hold and/or convey water, 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.

The design of the site will ensure that flows resulting from rainfall more than a 1 in 100-year rainfall event are managed in exceedance routes that avoid risk to people and property both on and off site.

6.8. Pollution

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.

6.9. 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 will be achieved by designing suitable ground exceedance or flood pathways, and run-off will be completely contained 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 100-year rainfall event are managed in exceedance routes that avoid risk to people and property both on and off site.

7. 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:

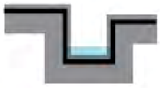
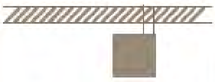
Run-Off Destination	Feasible	Description
Discharge to Ground	No	The BGS borehole log data, within the same superficial deposit and bedrock strata as the development, identifies the strata of the ground to predominantly consist of clay over limestone and mudstone. Clay is known to have exceptionally low or no infiltration value, and therefore due to this, the discharge of the surface water to ground is not feasible.
Discharge to Surface Water Body	**Yes**	The natural / greenfield surface water run-off from the undeveloped grassed areas currently follows the topography of the site and discharge to the existing lake / pond to the south. Therefore, it is proposed to discharge the surface water run-off from the car park and access road at the equivalent natural / greenfield rate to the lake / pond. This will ensure that the news car park and access road have no impact on flood risk to the existing lake / pond, or any area near to the estate.
Discharge to Surface Water Sewer	No	There are no known surface water sewers near the development site, and therefore discharge to a surface water sewer is not feasible.
Discharge to Highway Drain or Other	No	There are no known highway or other drains near the development site, and therefore discharge to a highway other drain is not feasible.
Discharge to Combined Water Sewer	No	There are no known combined water sewers near the development site, and therefore discharge to a combined water sewer is not feasible.

8. 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 maintenancce 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	Feasible Use	Description
Green Roofs	No	This is not feasible due to the development consisting of a new car park and access road only
Rainwater Harvesting	No	This is not feasible due to the development consisting of a new car park and access road only
Soakaway	No	The BGS data identifies the ground at the development site to predominantly consists of clay over sandstone. Clay is known to have exceptionally low or no infiltration value, and therefore the use of soakaways is not feasible.
Filter Strips	**Yes**	A filter drain can be formed along the southern boundary of the car park, and edge of the existing access road. The surface water run-off from the car park and road can discharge to the filter drain, where the water won't discharge to ground (due to the ground conditions stated previously), but will be conveyed to the existing drainage to the south of the site, and into the attenuation pond. The filter drain will reduce the surface water run-off from the car park and will act as a pollutant control.

Permeable Paving	No	The new car park has a relatively steep gradient (steeper than 1 in 20), and therefore the use of permeable paving sub-base for attenuation (not infiltration as stated previously) will not be feasible, due to only small areas of the sub-base being utilised.
Bioretention Area / Swale / Pond	**Yes**	There is an open grassed area to the south of the access road, which is at the low point of the site, and adjacent to the existing lake / pond. A new pond can be built in this area, where a pond can be built to attenuate the surface water run-off from the car park and access road. The pond will also act as a pollutant control, and add biodiversity to the development.
Hardscape Storage	No	The new car park and access road is built on a relatively steep gradient, and therefore hardscape storage will not be feasible.
Underground Storage	No	There is a requirement to prevent flooding for storm events up to the 1 in 30-year; and to suitable 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 site. The attenuation for both storm events can be accommodated within the pond, and therefore no requirements for below ground attenuation.

9. Development Greenfield Run-Off Rate and Volumes

To minimise the surface water run-off from the new development areas of the site, it is preferred that the post development surface water run-off be restricted to the equivalent greenfield run-off rate and volume for the post development area.

9.1. 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 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):

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

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

Area	=	50.00 ha
SAAR	=	950
Soil	=	0.300
Urban Factor	=	0.00
Region Number	=	4

Based on these variables, and the calculation results provided by the MicroDrainage computer software (Appendix C), the QBAR for a 50.00ha catchment area is:

$QBAR_{Rural}$ = 130.3 l/s

This figure is for the catchment area of 50.00 ha, and is to be reduced to reflect the surface water catchment area (0.729 ha) of the development site. Therefore, the QBAR (greenfield run-off) for development area has been calculated to be:

$QBAR_{Rural}$ = **1.90 l/s (2.61 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 4.

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_1	1.90 l/s	0.83	**1.6 l/s**
Q_{30}	1.90 l/s	1.99	**3.8 l/s**
Q_{100}	1.90 l/s	2.57	**4.9 l/s**

9.2. 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 Flood Estimation Handbook (FEH), with the results shown in Appendix C. The FEH data and variables used to calculate the greenfield run-off volume at the development site locations are as follows:

Site Location = GB 419950 370650 SK 19950 70650

C (1km) = -0.027

D1 (1km) = 0.373

D2(1km) = 0.461

D3 (1km) = 0.328

E (1km) = 0.303

F (1km) = 2.317

Areal Reduction Factor = 1.000

Area = 383.000 ha

SAAR = 958

CWI = 123.053

SPR Host = 24.120

URBTEXT = 0.00

Based on these variables, and the calculation results provided by the MicroDrainage computer software (Appendix C) the greenfield run-off volume for the overall catchment area at the site location is:

$Q_{100\ (6\text{-Hour})}$ = 67,936.748m³

This figure is for the catchment area of 383.000 ha, and is to be reduced to reflect the surface water catchment area of the development site which is 0.729 ha. Therefore, the greenfield run-off volume for the development site area has been calculated to be:

$Q_{100\ (6\text{-Hour})}$ = **129.31m³ (177.38m³/ha)**

10. Drainage Networks and Surface Water Management Calculation

10.1. Climate Change

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 (Table 2) summarised in Table 4 below.

Applies across all of England	Total change anticipated for the 2020's	Total change anticipated for the 2050's	Total change anticipated for the 2080's
Upper End	10%	20%	**40%**
Central	5%	10%	20%

It is anticipated the life span of the new car park I between 60- 80 years, and therefore will fall at least into the 2080's and will have rainfall intensity increase of 40%. This increase in rainfall is to be taken into consideration for the surface water management calculations, to ensure that the probability of flooding remains low.

10.2. Surface Water Network Calculations

The FEH data and variables used to calculate the required attenuation volumes at the development site are as follows:

SW Management Area = 0.729 ha

Site Location = GB 419950 370650 SK 19950 70650

C (1km) = -0.027

D1 (1km) = 0.373

D2(1km) = 0.461

D3 (1km) = 0.328

E (1km) = 0.303

F (1km) = 2.317

10.3. Surface Water Drainage Network Details

As shown on the below ground drainage layout drawing in Appendix D, the surface water run-off from the car park and access road will discharge via a filter drain system into an existing manhole to the south of the site.

Surface water from the existing manhole (taking run-off from car park and access road) will discharge to a new pond, through a flow control chamber and into the existing lake / pond, and through the new pond and flow control chamber, prior to discharge to the existing lake / pond.

This final surface water run-off destination for the car park and access road will replicate the natural / greenfield run-off destination of the pre-development areas.

10.4. Surface Water Run-Off Rate

For the surface water run-off from the development site to be at the greenfield run-off rate, they are to be restricted to 1.6 l/s for the 1 in 1-year storm event; 3.8 l/s for the 1 in 30-year storm event, and 4.9 l/s for the 1 in 100-year storm event including 40% rainfall intensity increase (climate change).

This is to adhere to Ciria document C753 – The SuDS Manual which states that: *'the flow controls / orifice design should be designed so that it has simplicity on operation, and has resistance to clogging, blocking or mechanical failure'.*

To achieve the equivalent greenfield run-off rates, it is proposed to use a complex flow control chamber, where a hydro-brake (minimum of 57mm) at the invert level of the chamber will restrict the surface water during 1-year storm event, and an orifice plate (minimum 54mm) set 1.200m higher in the chamber, will allow additional surface water flow from the chamber for the 30-year and 100-year + 40% climate change storm events.

As shown in the output calculation from the MicroDrainage computer software in Appendix E, if the hydro-brake opening is set at 57mm, with a design head of 1.20m, and a design flow of 1.60 l/s, and an orifice is set 1.200m above the hydro-brake with a 54mm opening, the maximum surface water run-off rates for each storm event will be as follows:

Strom	-	**Rate**	-	**Critical Storm Event**
Q_1	-	**1.5 l/s**	-	2880-minute winter storm duration
Q_{30}	-	**2.1 l/s**	-	2880-minute winter storm duration
Q_{100+CC}	-	**4.9 l/s**	-	2880-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	-	**QBAR**	-	**Post Dev**	-	**Difference**
Q_1	-	1.6 l/s	-	1.5l/s	-	Equivalent Greenfield
Q_{30}	-	3.8 l/s	-	2.1 l/s	-	0.55 x Greenfield / 45% Betterment
Q_{100+CC}	-	4.9 l/s	-	4.9 l/s	-	Equivalent Greenfield

The calculations show that the surface water run-off rates are equivalent to the 1-year and 100-year greenfield rates, and a 45% betterment of the equivalent 30-year greenfield rate. Therefore, the new development will not increase the probability of flooding to the existing lake / pond during extreme storm event including climate change, which is deemed to be acceptable.

10.5. Surface Water Run-Off Volume

The surface water run-off volumes for the post development site have also been calculated for 1 in 100-Year the 6-hour duration (Inc. 40% CC), where:

$Q_{100\ (6\text{-hour})}$	-	4.9 l/s x 60 x 60 x 6	-	105,840 litres	-	**105.84m³**

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

Greenfield Volume to Post Development Volume

Strom	-	**Greenfield**	-	**Post Dev**	-	**Difference**
Q_{100}	-	129.39m³	-	105.84m³	-	0.85 x Greenfield / 18% Betterment

The surface water run-off volume for the 100-year, 6-hour storm event is a less than the greenfield volume for the same storm event. Therefore, the restricted volume will not increase the probability of flooding to the existing lake / pond, during extreme storm event including climate change, which is deemed to be acceptable.

10.6. Surface Water Attenuation Calculations

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

Ciria SuDS Manual 2015, Paragraph 10.2.4 states that: *'Exceedance flows (i.e. flows in excess of those for which the system is designed) should be managed safely in above-ground space such that risks to people and property are acceptable'.*

And PPS25 Practice Guidance Paragraph 5.51 previously stated that: *'For events with a return-period in excess of 30 years, surface flooding of open spaces such as landscaped areas or car parks is acceptable for short periods, but the layout and landscaping of the site should aim to route water away from any vulnerable property, and avoid creating hazards to access and egress routes. No flooding of property should occur as a result of a one in 100-year storm event (including an appropriate allowance for climate change)'.*

The attenuation volume can be achieved within the attenuation pond within the communal area to the south-east of the site. As detailed in the surface water management calculations in Appendix G, and demonstrated on the surface water management layout in Appendix F, the required size / volume of the attenuation pond is as follows:

Attenuation Pond

Pond Outer Area	-	1165.00m²
Pond Base Area	-	900.00m²
Pond Depth	-	0.600m
Side Slope Gradient	-	1 in 3
Pond Volume	-	**619.50m³**

The calculations show that no flooding occurs from the attenuation pond for all storms up to and including the 100-year + 40% climate change event. Therefore, no flooding to the proposed building or buildings to the areas near the site will occur.

11. Maintenance Requirements

The extent of the drainage network and SuDS features for the development sites are shown on the below ground drainage layout drawings in Appendix D.

Maintenance and suitable management of all drainage aspects is required, to ensure that the SuDS methods are working affectively, and subsequently reducing the risk of flooding on the site.

The management and maintenance of the drainage networks; flow control chamber; filter drains; permeable paving; and attenuation pond will be by contractors appointed by the estate managers of Thornbridge Hall, where the works will become part of the existing maintenance regime for the whole site.

The management and maintenance fee will form part of the overall maintenance fee for the communal landscape areas and will be carried out as follows:

11.1. Drainage Networks

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

11.2. 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 tank and flow control chamber (where may cause risk performance)	Monthly
Where rainfall into tank and flow control manhole 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 upstream surface water network by jetting.	Annually or as required
Repair/check all inlets, outlets, and overflow pipes	As required
Inspect/check all inlets, outlets	Annually and after large storms

11.3. Filter Drain and Permeable Surfacing

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 catchment on surface of permeable surfacing and patio areas (where may cause risk performance)	Monthly
Check surface for blockage or silt, algae, or other matter by jetting	As required, but at least twice a year

11.4. Attenuation Pond

Operation	Frequency
Inspections to identify any areas not operating correctly; eroded areas, hydrocarbon pollution, blocked outlets, and silt accumulation. Record any areas that are ponding and where water is lying more than 48 hours.	Monthly
Collect and remove from the site all extraneous rubbish that is detrimental to the operation of the SUDS feature and appearance of the site, including paper, packaging materials, bottles, cans, and similar debris.	Monthly
Maintain grass within the specified range (50mm above specified design water depth). Ensure that the soil and grass does not become compacted. Do not cut during periods of drought or when ground conditions or grass are wet.	As required, but at least twice a year
Scarifying and spiking	As required
Reinstate design levels, repair eroded areas or damaged areas by returfing and reseeding.	As required
Seed or sod bare eroded areas.	As required

11.5. Linked and Further Maintenance and Maintenance Activities

The maintenance of the drainage network and SuDS features are to be linked with the wider site maintenance plan for the industrial estate.

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.

12. Surface Water Exceedance Design

If an extreme storm greater than the designed 1 in 100-year + 40% climate change were to occur, or the maintenance of the SuDS features is not carried out, flooding may occur from the network.

The flood water will follow the topography of the ground and will flow along the road and into the existing lake / pond. No properties will be in the flow path, and due to the new attenuation pond, the volume of discharge to the existing lake / pond will always be less than the pre-development state.

Therefore, the car park and access road will not increase the risk of flooding to any areas near the estate in any storm events.

13. 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.

13.1. Car Park Areas Pollutant Hazard

C753 Table 26.2 Pollution Hazard Level	=	Low
C753 Table 26.2 Pollution Hazard Index:		
Total Suspended Solid (TSS)	=	0.5
Metals	=	0.4
Hydrocarbons	=	0.4
Pollution Hazard Index	=	**1.30**

13.2. Dwelling Roof and Patio Areas Pollutant Mitigation

Mitigation Measures:

Filter Drain and Pond

Filter Drain Pollutant Mitigation Indices:

Total Suspended Solid (TSS)	=	0.7
Metals	=	0.7
Hydrocarbons	=	0.5
SuDS Mitigation Indices	=	**1.20**

13.3. Access Road Areas Pollutant Hazard

C753 Table 26.2 Pollution Hazard Level	=	Low
C753 Table 26.2 Pollution Hazard Index:		
Total Suspended Solid (TSS)	=	0.5
Metals	=	0.4
Hydrocarbons	=	0.4
Pollution Hazard Index	=	**1.30**

13.4. Access Road Areas Pollutant Mitigation

Mitigation Measures:

Attenuation Pond

Attenuation Pond Pollutant Mitigation Indices:

Total Suspended Solid (TSS)	=	0.7
Metals	=	0.7
Hydrocarbons	=	0.5
SuDS Mitigation Indices	=	**1.90**

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

14. Conclusion / Summary

14.1. Existing Flood Probability

All potential sources of flooding to the development site have assessed, and it is deemed that the probability of flooding from all existing sources is low.

14.2. SuDS Principles

All feasible SuDS methods, and surface water discharge destination have been assessed, with the feasible SuDS methods being filter drain systems; an attenuation pond; and a flow control, with the surface water destination being to a waterbody (existing lake / pond).

14.3. Peak Flow Control

The calculations show that the surface water run-off rates are equivalent to the 1-year and 100-year greenfield rates, and a 45% betterment of the equivalent 30-year greenfield rate. Therefore, the new development will not increase the probability of flooding to the existing lake / pond during extreme storm event including climate change, which is deemed to be acceptable.

14.4. Volume Control

The surface water run-off volume for the 100-year, 6-hour storm event is a less than the greenfield volume for the same storm event. Therefore, the restricted volume will not increase the probability of flooding to the existing lake / pond, during extreme storm event including climate change, which is deemed to be acceptable.

14.5. Flood Risk within the Development

The attenuation pond has been suitably sized so that no flooding occurs within the network during the 1 in 1-year; 1 in 30-year; and 1 in 100-year storm event + 40% climate change.

14.6. Management and Maintenance

The management and maintenance of the drainage networks; flow control chamber; filter drains; permeable paving; and attenuation pond will be by contractors appointed by the estate managers of Thornbridge Hall, where the works will become part of the existing maintenance regime for the whole site.

14.7. Surface Water Exceedance Design

If an extreme storm greater than the designed 1 in 100-year + 40% climate change were to occur, or the maintenance of the SuDS features is not carried out, flooding may occur from the network.

The flood water will follow the topography of the ground and will flow along the road and into the existing lake / pond. No properties will be in the flow path, and due to the new attenuation pond, the volume of discharge to the existing lake / pond will always be less than the pre-development state.

Therefore, the car park and access road will not increase the risk of flooding to any areas near the estate in any storm events.

14.8. 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.

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

Appendix A Car Park and Road Details

Key:

- Existing trees
- Existing parkland grassland
- Existing post & wire fence
- Existing bitmac surfaced access driveway and car park
- Public Footpath - Great Longstone - WD42 3/1
- Proposed native species tree and shrub planting
  - See schedule for species, specifications and quantities.
- Proposed individual trees
  - See schedule for species, specifications and quantities. Existing bitmac surface and sub base to be removed from identified car parking spaces to create soft area to plant new trees and to establish an area of wildflower grass.
- Proposed remodelled landform
- Proposed wildflower grassland
  - Landform slopes facing car park area to be seeded with Emorsgate EM2 Standard General Purpose Meadow Mix.
- Proposed parkland grassland
  - Landform slopes facing wider parkland to be seeded with appropriate pastoral grass seed mix.
- Proposed pedestrian access
  - Section of existing Public Footpath - Great Longstone WD42 3/1 linking the car park area with the entrance to the formal garden area and cafe at Thornbridge Hall to be upgraded with new surfacing. Surface to comprise 3m wide hoggin footpath set between timber boards using a no dig construction to ensure existing root protection area of adjacent trees remain undisturbed.

Planting Schedules:

Individual Tree Planting

SPECIES	SIZE/ SPEC	Quantity
Alnus cordata - Ac	EHS 18-20cm RB	1
Acer platanoides - Ap	EHS 18-20cm RB	4
Pinus sylvestris - Ps	EHS 18-20cm RB	3
Quercus petrea - Qp	EHS 18-20cm RB	2

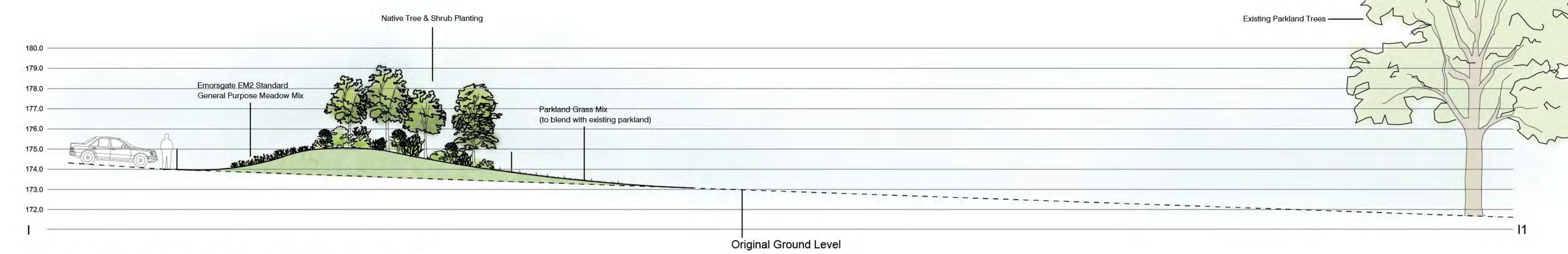
Individual Tree Planting
- Extra heavy standard rootballed 18-20cm trees to be pit planted and secured with a proprietary underground guying system. Area around tree to be seeded with wildflower mix.

Native Species Tree & Shrub Planting (NM1 & NM2)

SPECIES	SIZE/ SPEC	NM1 Area 662 m² 1no plants/sq m	NM2 Area 495 m² 1no plants/sq m
Betula pendula - 10%	60 - 90cm br transp	60	45
	10 - 12cm selected std	7	5
Betula pubescens - 10%	60 - 90cm br transp	60	45
	10 - 12cm selected std	7	5
Corylus avellana - 10%	60 - 90cm br transp	66	50
Crataegus monogyna - 20%	60 - 90cm br transp	132	99
Ilex aquifolium - 5%	3 litre container	33	25
Malus sylvestris - 5%	60 - 90cm br transp	33	25
Prunus padus - 7.5%	60 - 90cm br transp	45	34
	10 - 12cm selected std	5	4
Prunus spinosa - 5%	60 - 90cm br transp	33	25
Sorbus aucuparia - 7.5%	60 - 90cm br transp	45	34
	10 - 12cm selected std	5	4
Quercus petrea - 10%	60 - 90cm br transp	60	45
	10 - 12cm selected std	7	5
Quercus robur - 10%	60 - 90cm br transp	60	45
	10 - 12cm selected std	7	5

Native Tree & Shrub Planting
- Native tree and shrub whip plants to be protected from rabbits using appropriate proprietory flexible rabbit guards. Areas of new planting to be kept free of weeds during establishment using secured mulch matting. Bare root plants to be notch planted to depth of root collar in accordance with BS4428. Container grown plants to be planted to depth of original root collar in accordance with BS4428. All plants planted into mulch mats to be planted with appropriate long release fertiliser pellets (e.g. Osmocote Tel: 01282 873333), applied in accordance with the manufacturer's recommendations and directions.

Tree Stakes for Selected Standard Trees
- Stakes to be 65mm diameter tanalised softwood and pointed at one end. Top of stake to be 600mm above ground level and fixed to tree with 1 No suitable rubber tie and spacer. Stake to be firm in ground, position stake at time of planting.



Proposed Landform Section with Planting 1:200

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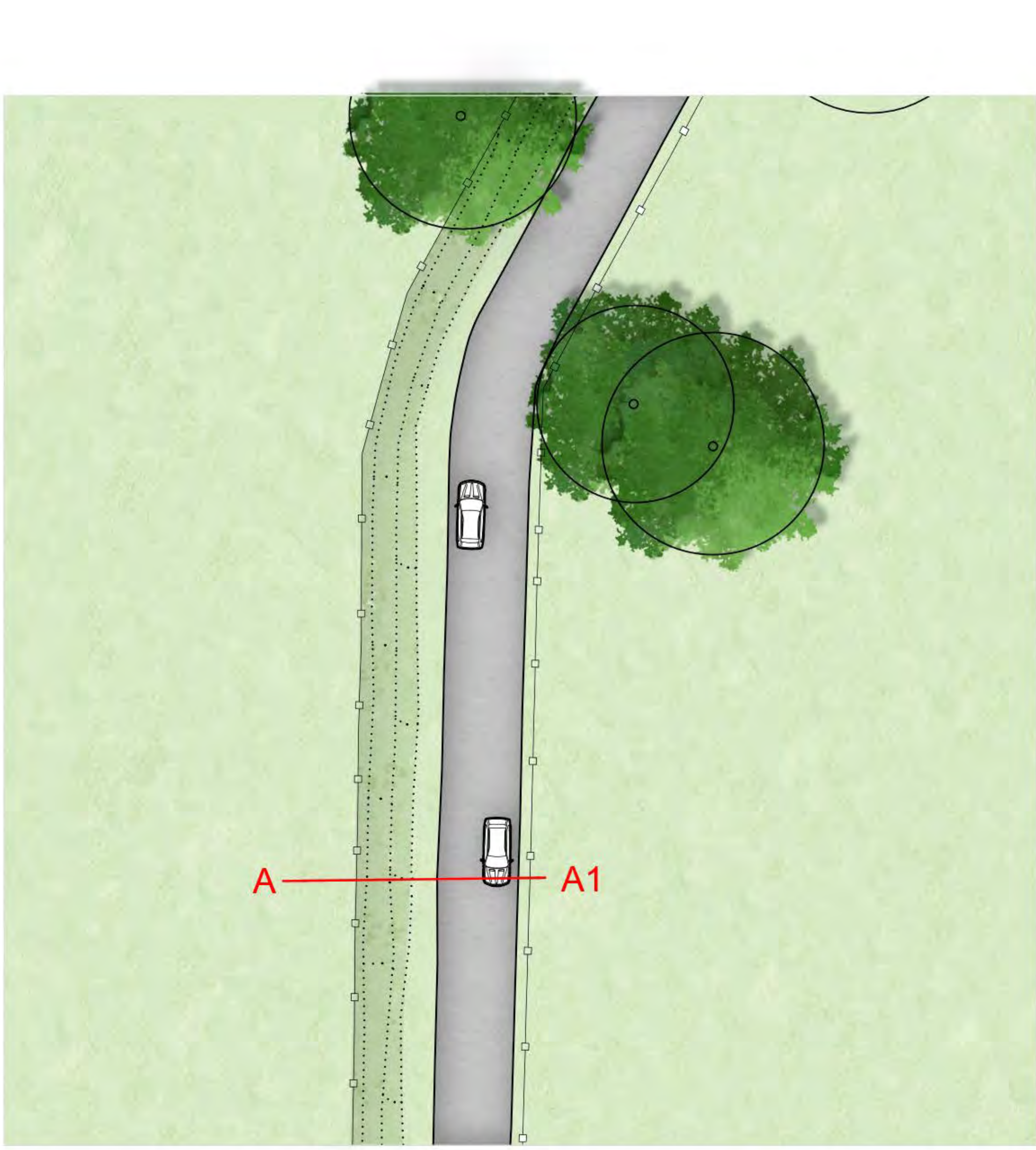
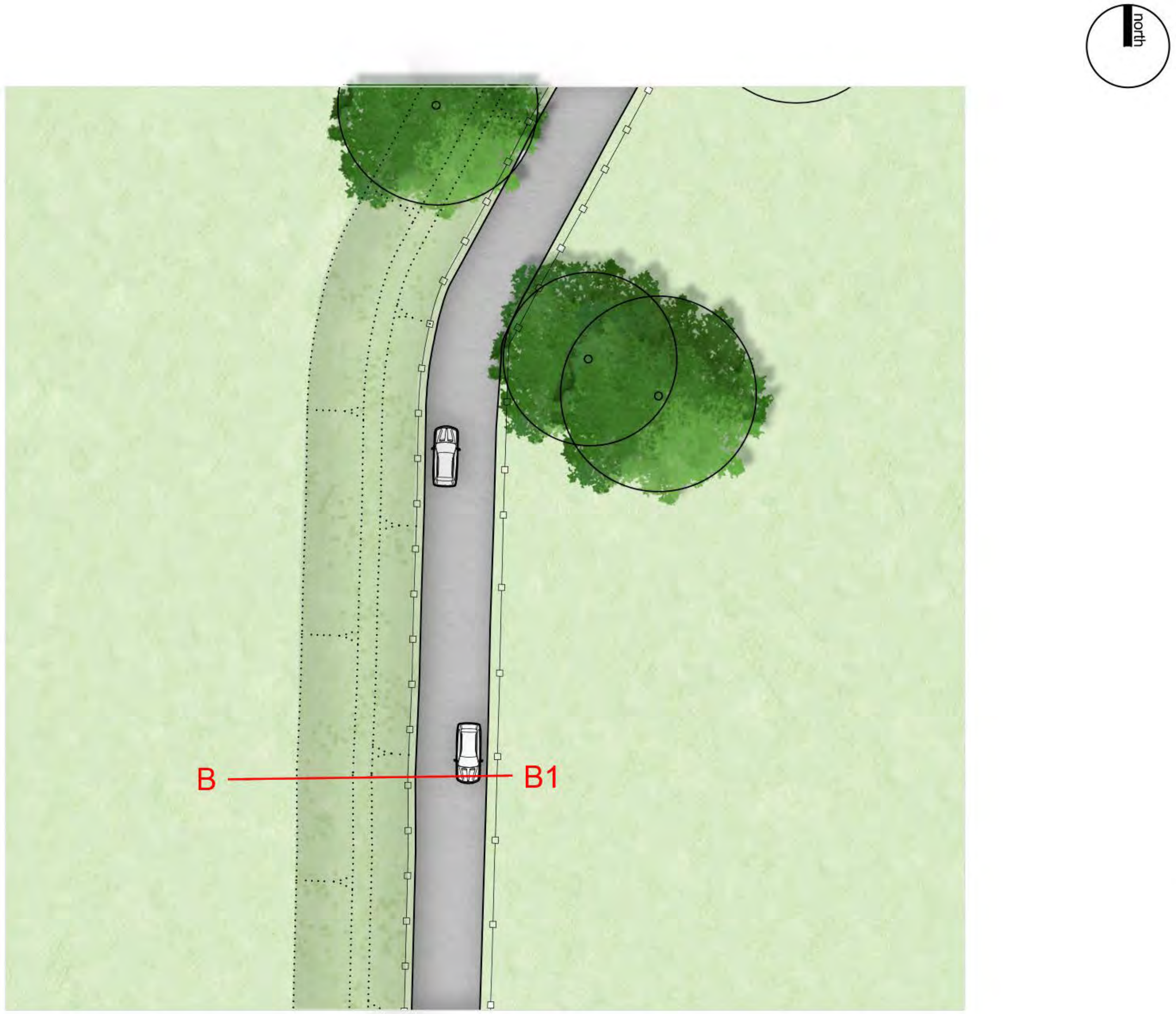
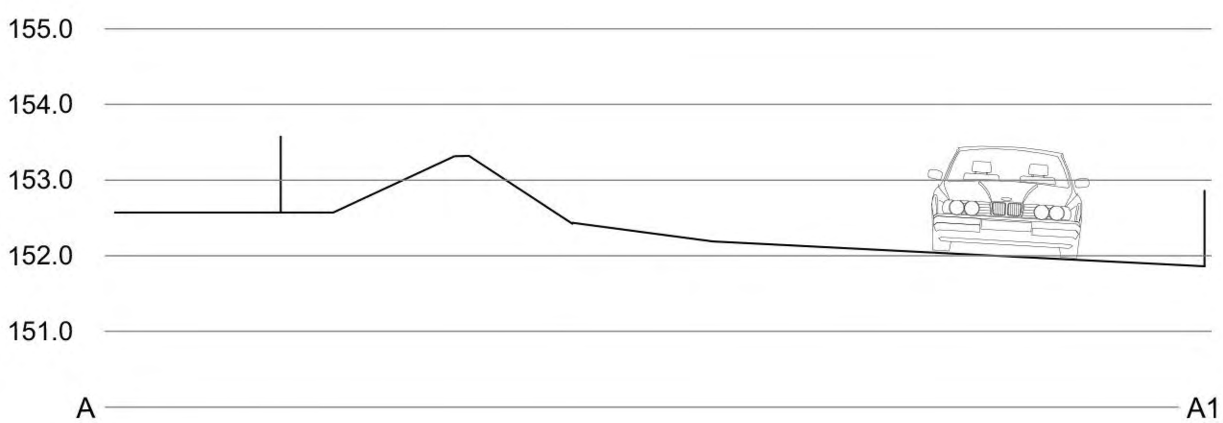
DWG NO. M3406-PA-02-V1
DWG TITLE. Car Park Landscape Layout Option 1
CLIENT. Jim & Emma Harrison
PROJECT TITLE. Thornbridge Hall, Bakewell
WORK STAGE. PLANNING
SCALE. 1:500@A2
DATE. 08.2021
DRAWN BY. HB
CHECKED BY. NF



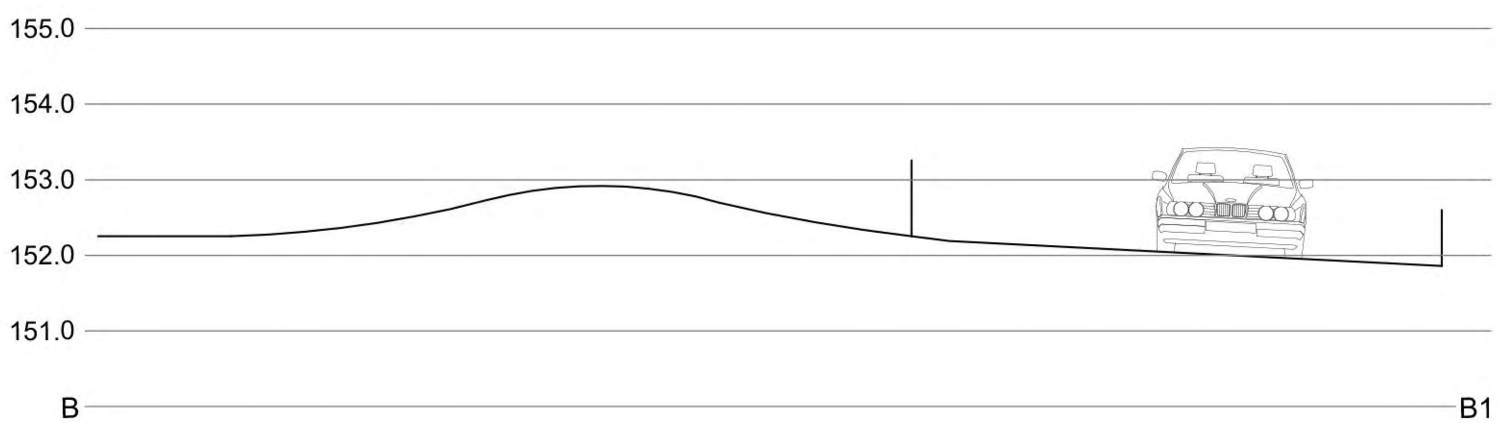
Existing Road Bund 1:500



Proposed Road Landform 1:500



Existing Bund Section A-A1 1:100



Proposed Landform Section B-B1 1:100

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DWG TITLE.
Driveway Bund Remediation

PROJECT TITLE.
Thornbridge Hall, Bakewell

DATE.
08.2021

DRAWN BY.
HB

CHECKED BY.
NF

DWG NO.
M3406-PA-05-V1

CLIENT.
Jim & Emma Harrison

WORK STAGE.
Planning

SCALE.
1:500@A3

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BARNES WALKER

Appendix B BGS Borehole Log Data

Chas. Boot Esq.,

1824 (?) — O.S. Grid Ref.

At Thornbridge Hall

Town or Village Great Longstone County Derbyshire Six-inch quarter sheet

Exact site Bakewell (A rough sketch-map or a tracing from a map is very desirable)

in parish of

Level of ground surface above sea-level (O.D.) ~~500~~ 610 ft. 186 (?) If well starts below ground surface, state how far ft.

Shaft ft., diameter ft. Bore ft. Diameter of bore: at top ins.; at bottom ins.

Details of permanent lining tubes (internal diameters preferred) 30' x 6". Top 7" b.s.
100' 2¾" x 5". Top level. 59' 4¼" x 5" at bottom. (perforated).

Water struck at depths of (feet) 50', 64', 133'6".

Rest-level of water below ~~above~~ top of well 32 feet. Suction at feet. Yield on hours'/days' test 667 gallons per hour (with pump of capacity g.p.h.); depressing water level to feet below top. Time of recovery hrs. Amount normally pumped daily g.p.h. for hours.

Quality (attach copy of analysis if available) Yes

Sunk by Le Grand S. & Co. for Mr. Date of well 21. 1. 37.

Information from Le Grand

(For Survey use only). GEOLOGICAL CLASSIFICATION.	NATURE OF STRATA (and any additional remarks).	THICKNESS Feet	THICKNESS Inches	DEPTH Feet	DEPTH Inches
	Broken shale	(0.15)	6	(0.15)	6
	Loam	3 (0.91)	-	3 (1.07)	6
	Loamy Clay and broken Limestone & Boulder Clay	6 (1.83)	-	9 (2.90)	6
	Hard bla ck shale (broken)	60 (18.44)	6	70 (21.34)	-
	Black shale with thin bands of Marl	52 (16.00)	6	122 (37.34)	6
	Blue Chert	3 (0.99)	3	125 (38.33)	9
	Hard Black Shale	1 (0.38)	3	127 (38.71)	-
	Broken Black Limestone	1 (0.30)	-	128 (39.01)	-
	Black shale	(0.23)	9	128 (39.24)	9
	Dark Limestone	1 (0.30)	-	129 (39.55)	9
	Black Shale	(0.23)	9	130 (39.78)	6
	Hard dark Limestone (open fissure between 133'6" - 135')	11 (3.51)	6	142 (43.28)	-

Letter from Estates Surveyor, City of Sheffield, Thornbridge Hall. dated 10.3.49

Site on DERBY 23 NE (W).

Analysis (attached) 1937 by County Public Health.

— purchased by Estates Dept of Sheffield Corp 1945

J. Snead (?)
10.3.49.

Sited [illegible]

For Survey use only

Date	G.S.M. Office	Site marked

GEOLOGICAL SURVEY AND MUSEUM.

6-inch Map Registered No.

SK 27 SW/26

RECORD OF SHAFT OR BORE FOR MINERALS

Name of Shaft or Bore given by Geological Survey: Bushey Cottage B.H.

Name and Number given by owner:

For whom made: I.G.S.

Town or Village: Great Longstone — County:

Exact site: (Attach a tracing from a map, or a sketch-map, if possible.)

Purpose for which made:

Ground Level at shaft/bore relative to O.D. — If not ground level give O.D. of beginning of shaft/bore

Made by: Messrs Foraky

Information from: examination of cores by A.P.A., T.J.C., & P.J.S.

Examined by:

Nat. Grid Reference: SK 2103 7142

1" N.S.Map No.	1" O.S.Map No.	Confidential or not
111		No

Date of sinking: 1972–3

Date received:

SPECIMEN NUMBERS AND ADDITIONAL NOTES

Specimens BLD 8583 – 8853 register 111 (10) p. 986
KR 180 – 232 " 111 (10) p 996 – (11) p. 998.

(For Survey use only) Geological Classification	Description of Strata	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
	Boulder clay: [partial recovery] stiff brown clay with limestone boulders < 0.17 metre and some chert	17.23		17.23	
	Mudstone, dark grey platy [broken]	3.67		20.90	
	Mudstone, dark hard calcareous with small brachiopods and *Sudeticeras*	0.10		21.00	
	Mudstone, dark grey with some bivalves	0.10		21.10	
	Mudstone, grey calcareous with *Lingula* and ?goniatite; pyrite specks and nodules at 25.00	4.20		25.30	
	Mudstone grey very calcareous; pyrite specks 25.80; calcite veinlets 27.20 – 27.42; goniatites, *Lingula* and shells in a 2.0 at 27.42; small nodules with pyrite 27.60; [dip 11° 27.60]	2.42		27.72	
	Mudstone, hard grey slightly calcareous with shell fragments; small phosphatic nodule with pyrite 27.85; rare shells at 27.90	0.28		28.00	
	Mudstone, grey hard calcareous	0.11		28.11	
	Mudstone, grey hard platy with shell fragments mainly calcareous; calcite veinlets below 28.20	0.22		28.33	
	Limestone grey argillaceous fine-grained; plant				

44410 3M 11/70 S&N Ltd. 3639

D STRATA LOG

Geological Classification (BGS only)	Description of strata	Thickness m	Depth m
	TOP SOIL	0-40	0-40
	BOULDER CLAY	2-60	3-00
	BLACK SHALE	15-00	18-00
	LIMESTONE	10-00	28-00
	NO RETURNS	52-00	80-00

(continue on separate page if necessary

Other comments (e.g. gas encountered, saline water intercepted, etc.)

FOR OFFICIAL USE ONLY

FILE .... CONSENT NO. .... NGS REF NO. ....

LIC NO. .... PURPOSE .... NRA REF NO. ....

DATE REC: COPY TO: ENTERED BY:

British Geological Survey

Appendix C Greenfield Run-Off Rates and Volume Calculations

IH 124 Mean Annual Flood

Input

Return Period (years)	1	Soil	0.300
Area (ha)	50.000	Urban	0.000
SAAR (mm)	950	Region Number	Region 4

Results	**l/s**
QBAR Rural	130.3
QBAR Urban	130.3
Q1 year	108.1
Q1 year	108.1
Q2 years	116.7
Q5 years	160.2
Q10 years	194.1
Q20 years	231.5
Q25 years	244.6
Q30 years	255.2
Q50 years	286.8
Q100 years	334.8
Q200 years	393.4
Q250 years	412.9
Q1000 years	541.9

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Greenfield Runoff Volume

FEH Data

Return Period (years)	100
Storm Duration (mins)	360
FEH Rainfall Version	1999
Site Location	GB 419950 370650 SK 19950 70650
C (1km)	-0.027
D1 (1km)	0.373
D2 (1km)	0.461
D3 (1km)	0.328
E (1km)	0.303
F (1km)	2.317
Areal Reduction Factor	1.00
Area (ha)	383.000
SAAR (mm)	958
CWI	123.053
SPR Host	24.120
URBEXT (USER)	0.0000

Results

Percentage Runoff (%)	27.78
Greenfield Runoff Volume (m^3)	67936.748

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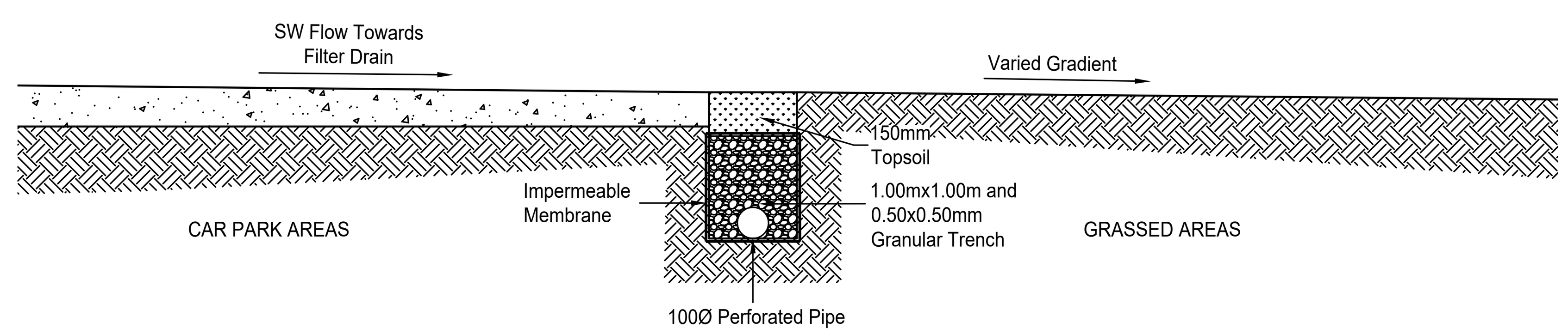
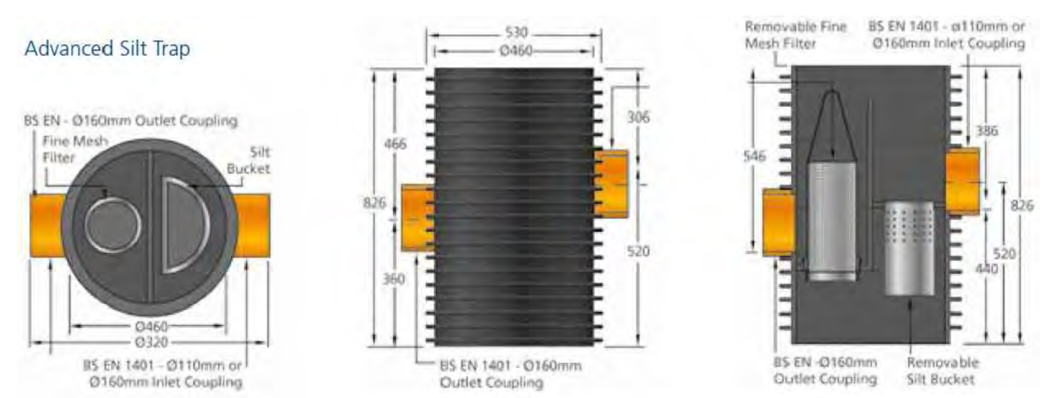
Appendix D Surface Water Management Layout and Details



Filter Drain Detail



PLANNING

NEW CAR PARK AND ACCESS ROAD
THORNBRIDGE HALL ESTATE

Scale:	1:200 @ A1
Drawn by:	MDS
Date:	Sep '21

Drawing No.: C 14090/31

SURFACE WATER
MANAGEMENT LAYOUT
SHEET 1 of 2

NORTHERN STRUCTURAL SERVICES
1, Prestbury Road
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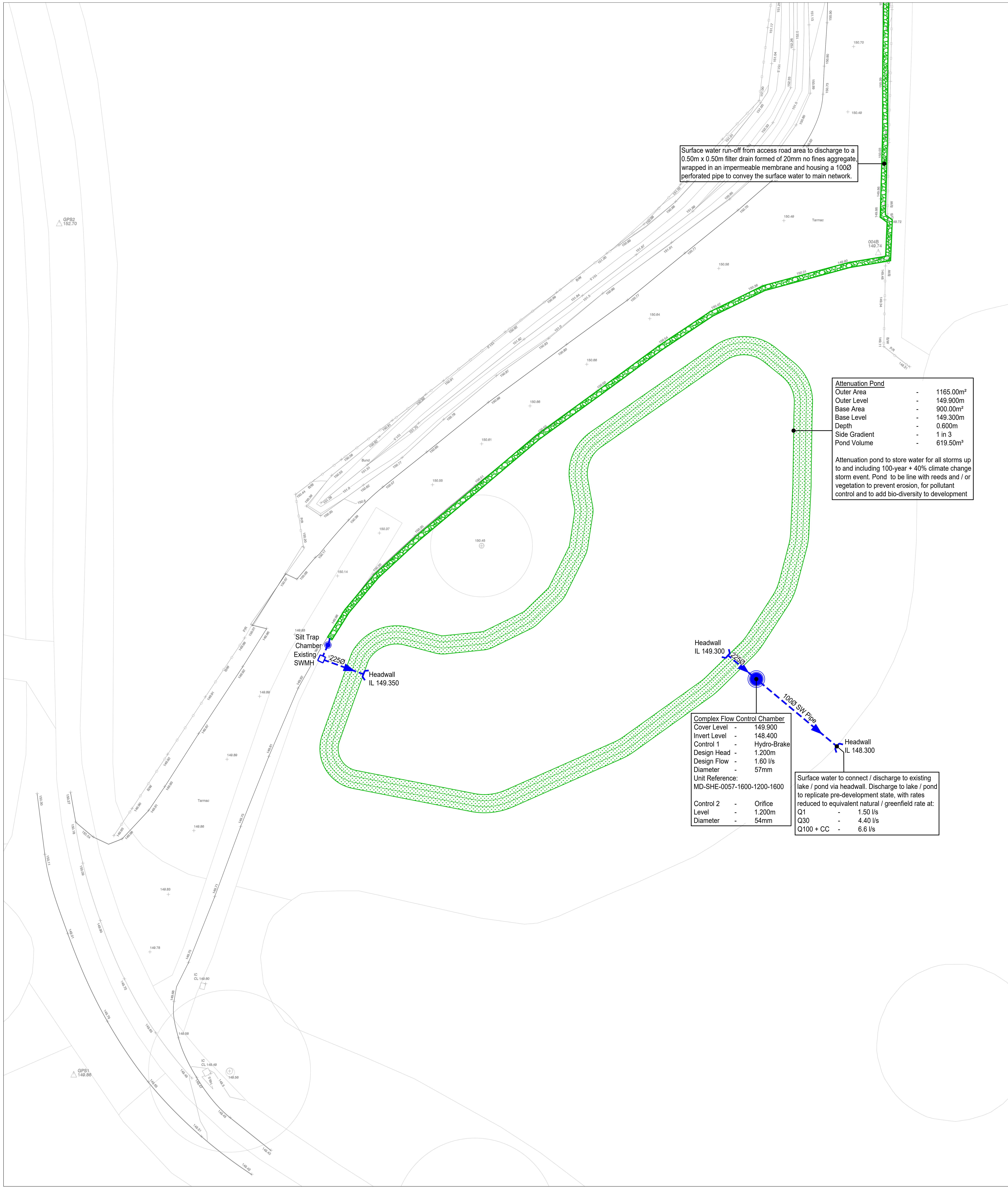
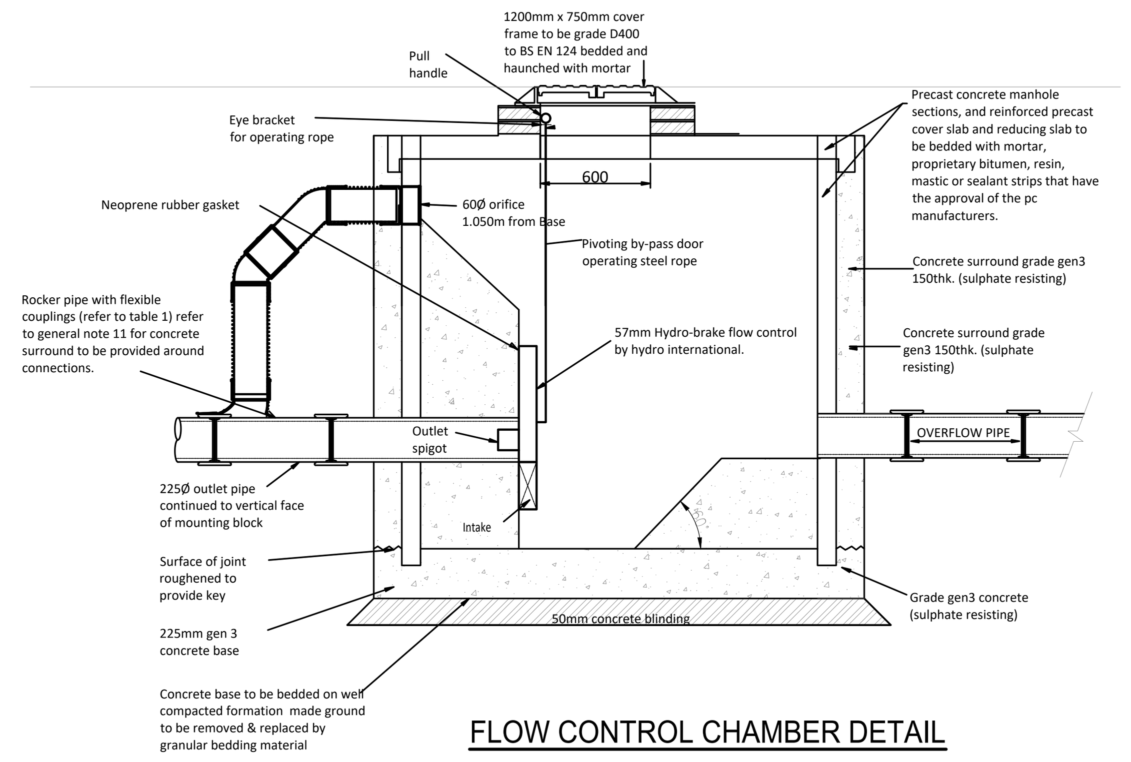
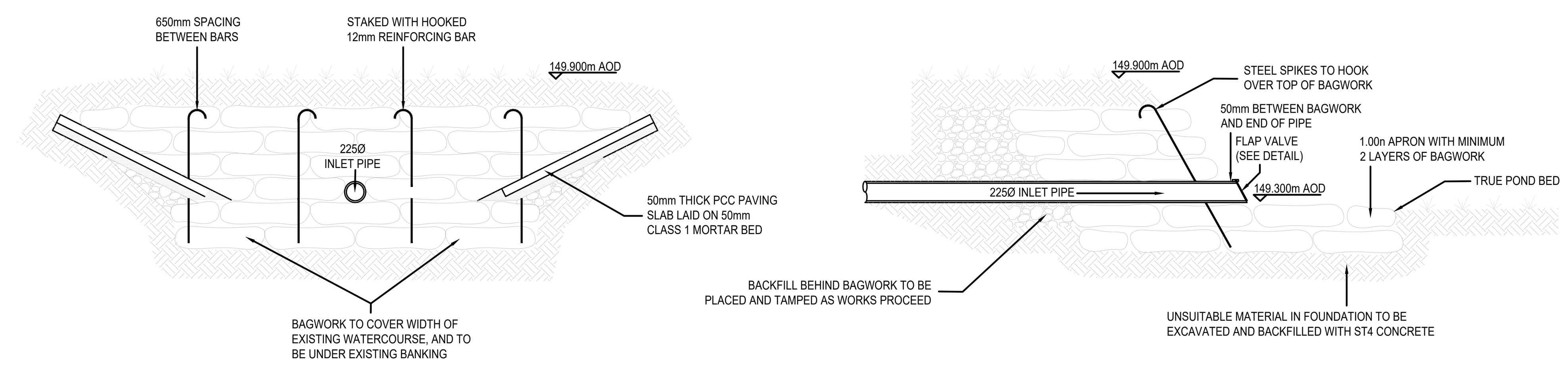
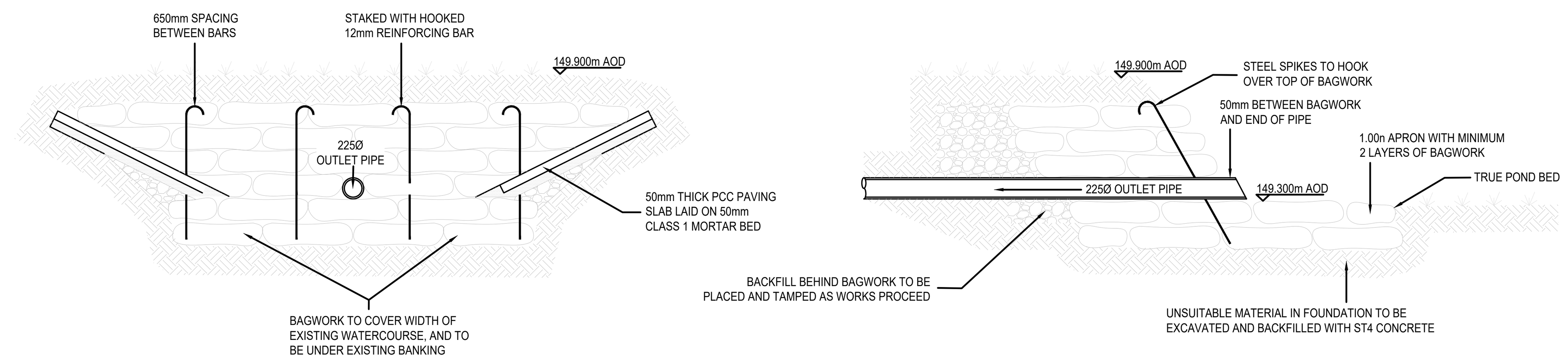




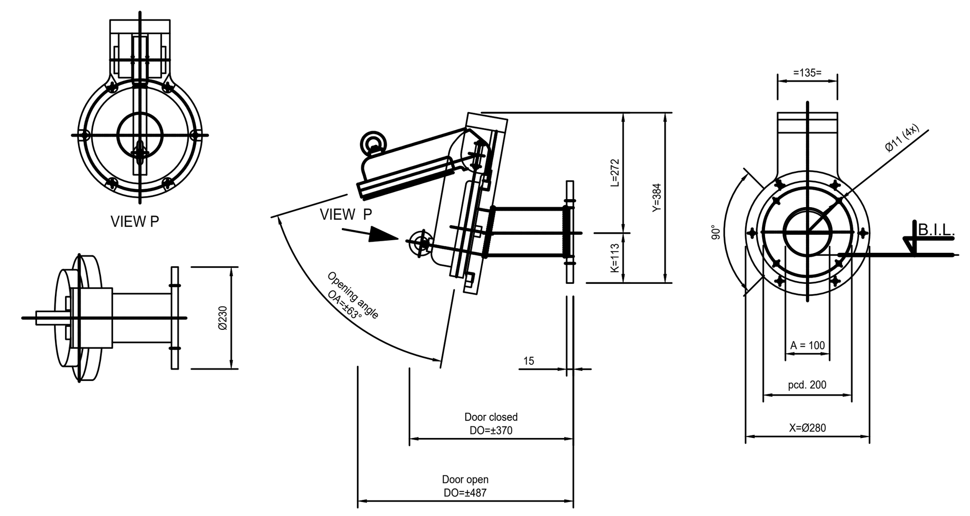
FLOW CONTROL CHAMBER DETAIL



INLET TO POND DETAIL



OUTLET FROM POND DETAIL



NON-RETURN FLAP VALVE

PLANNING

NEW CAR PARK AND ACCESS ROAD
THORNBRIDGE HALL ESTATE

Scale:	1:200 @ A1
Drawn by:	MDS
Date:	Sep '21

Drawing No.: C 14090/32

SURFACE WATER
MANAGEMENT LAYOUT
SHEET 2 of 2

NORTHERN STRUCTURAL SERVICES

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Appendix E Surface Water Management Calculations

Summary of Results for 1 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	149.334	0.034	1.4	30.9	O K
30 min Summer	149.343	0.043	1.4	39.4	O K
60 min Summer	149.354	0.054	1.4	49.6	O K
120 min Summer	149.367	0.067	1.4	61.0	O K
180 min Summer	149.374	0.074	1.5	67.7	O K
240 min Summer	149.379	0.079	1.5	72.1	O K
360 min Summer	149.384	0.084	1.5	77.1	O K
480 min Summer	149.386	0.086	1.5	79.3	O K
600 min Summer	149.388	0.088	1.5	80.7	O K
720 min Summer	149.389	0.089	1.5	81.9	O K
960 min Summer	149.394	0.094	1.5	86.7	O K
1440 min Summer	149.401	0.101	1.5	93.4	O K
2160 min Summer	149.407	0.107	1.5	98.9	O K
2880 min Summer	149.410	0.110	1.5	101.4	O K
4320 min Summer	149.399	0.099	1.5	91.6	O K
5760 min Summer	149.388	0.088	1.5	80.8	O K
7200 min Summer	149.376	0.076	1.5	70.0	O K
8640 min Summer	149.365	0.065	1.4	59.7	O K
10080 min Summer	149.355	0.055	1.4	50.1	O K
15 min Winter	149.338	0.038	1.4	34.9	O K
30 min Winter	149.349	0.049	1.4	44.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	24.196	0.0	32.6	26
30 min Summer	15.668	0.0	42.3	40
60 min Summer	10.145	0.0	55.1	68
120 min Summer	6.569	0.0	71.4	126
180 min Summer	5.095	0.0	83.2	186
240 min Summer	4.254	0.0	92.6	244
360 min Summer	3.299	0.0	107.8	362
480 min Summer	2.754	0.0	120.0	458
600 min Summer	2.395	0.0	130.5	518
720 min Summer	2.136	0.0	139.7	584
960 min Summer	1.829	0.0	159.6	726
1440 min Summer	1.470	0.0	192.4	1014
2160 min Summer	1.182	0.0	232.1	1452
2880 min Summer	1.012	0.0	265.2	1876
4320 min Summer	0.770	0.0	302.8	2688
5760 min Summer	0.635	0.0	332.7	3512
7200 min Summer	0.547	0.0	358.0	4256
8640 min Summer	0.484	0.0	380.2	5016
10080 min Summer	0.436	0.0	400.2	5752
15 min Winter	24.196	0.0	36.6	26
30 min Winter	15.668	0.0	47.5	40

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Summary of Results for 1 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	149.362	0.062	1.4	56.4	O K
120 min Winter	149.376	0.076	1.5	69.9	O K
180 min Winter	149.385	0.085	1.5	78.2	O K
240 min Winter	149.391	0.091	1.5	83.8	O K
360 min Winter	149.399	0.099	1.5	91.0	O K
480 min Winter	149.403	0.103	1.5	95.0	O K
600 min Winter	149.405	0.105	1.5	97.1	O K
720 min Winter	149.406	0.106	1.5	98.1	O K
960 min Winter	149.411	0.111	1.5	102.6	O K
1440 min Winter	149.419	0.119	1.5	109.7	O K
2160 min Winter	149.423	0.123	1.5	114.1	O K
2880 min Winter	149.424	0.124	1.5	114.4	O K
4320 min Winter	149.405	0.105	1.5	96.7	O K
5760 min Winter	149.385	0.085	1.5	78.4	O K
7200 min Winter	149.367	0.067	1.4	60.9	O K
8640 min Winter	149.349	0.049	1.4	45.0	O K
10080 min Winter	149.334	0.034	1.4	30.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	10.145	0.0	61.6	68
120 min Winter	6.569	0.0	80.0	124
180 min Winter	5.095	0.0	93.1	182
240 min Winter	4.254	0.0	103.8	240
360 min Winter	3.299	0.0	120.8	354
480 min Winter	2.754	0.0	134.4	464
600 min Winter	2.395	0.0	146.2	572
720 min Winter	2.136	0.0	156.5	674
960 min Winter	1.829	0.0	178.7	778
1440 min Winter	1.470	0.0	215.5	1098
2160 min Winter	1.182	0.0	260.0	1580
2880 min Winter	1.012	0.0	296.8	2048
4320 min Winter	0.770	0.0	339.3	2904
5760 min Winter	0.635	0.0	372.8	3752
7200 min Winter	0.547	0.0	401.1	4536
8640 min Winter	0.484	0.0	425.8	5272
10080 min Winter	0.436	0.0	448.2	5952

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	1
FEH Rainfall Version	1999
Site Location	GB 419950 370650 SK 19950 70650
C (1km)	-0.027
D1 (1km)	0.373
D2 (1km)	0.461
D3 (1km)	0.328
E (1km)	0.303
F (1km)	2.317
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) 0.729

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.243	4	8	0.243	8	12	0.243

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Model Details

Storage is Online Cover Level (m) 149.900

Tank or Pond Structure

Invert Level (m) 149.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	900.0	1.400	0.0	2.800	0.0	4.200	0.0
0.200	985.0	1.600	0.0	3.000	0.0	4.400	0.0
0.400	1075.0	1.800	0.0	3.200	0.0	4.600	0.0
0.600	1165.0	2.000	0.0	3.400	0.0	4.800	0.0
0.800	0.0	2.200	0.0	3.600	0.0	5.000	0.0
1.000	0.0	2.400	0.0	3.800	0.0		
1.200	0.0	2.600	0.0	4.000	0.0		

Complex Outflow Control

Hydro-Brake® Optimum

Unit Reference	MD-SHE-0057-1600-1200-1600
Design Head (m)	1.200
Design Flow (l/s)	1.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	57
Invert Level (m)	148.400
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	1.6
Flush-Flo™	0.253	1.3
Kick-Flo®	0.511	1.1
Mean Flow over Head Range	-	1.3

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	1.2	0.600	1.2	1.600	1.8	2.600	2.3
0.200	1.3	0.800	1.3	1.800	1.9	3.000	2.4
0.300	1.3	1.000	1.5	2.000	2.0	3.500	2.6
0.400	1.3	1.200	1.6	2.200	2.1	4.000	2.8
0.500	1.1	1.400	1.7	2.400	2.2	4.500	2.9

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Hydro-Brake® Optimum

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
5.000	3.1	6.500	3.5	8.000	3.8	9.500	4.2
5.500	3.2	7.000	3.6	8.500	3.9		
6.000	3.4	7.500	3.7	9.000	4.1		

Orifice

Diameter (m) 0.054 Discharge Coefficient 0.600 Invert Level (m) 149.600

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Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	149.411	0.111	1.5	102.4	O K
30 min Summer	149.433	0.133	1.5	123.6	O K
60 min Summer	149.459	0.159	1.5	148.4	O K
120 min Summer	149.488	0.188	1.5	176.6	O K
180 min Summer	149.506	0.206	1.5	194.0	O K
240 min Summer	149.518	0.218	1.5	206.5	O K
360 min Summer	149.535	0.235	1.6	223.5	O K
480 min Summer	149.546	0.246	1.6	234.4	O K
600 min Summer	149.553	0.253	1.6	241.7	O K
720 min Summer	149.558	0.258	1.6	246.6	O K
960 min Summer	149.572	0.272	1.6	260.0	O K
1440 min Summer	149.584	0.284	1.6	273.0	O K
2160 min Summer	149.592	0.292	1.6	281.3	O K
2880 min Summer	149.598	0.298	1.6	286.8	O K
4320 min Summer	149.581	0.281	1.6	269.3	O K
5760 min Summer	149.564	0.264	1.6	252.4	O K
7200 min Summer	149.547	0.247	1.6	235.7	O K
8640 min Summer	149.531	0.231	1.6	219.1	O K
10080 min Summer	149.515	0.215	1.5	202.9	O K
15 min Winter	149.424	0.124	1.5	114.9	O K
30 min Winter	149.449	0.149	1.5	139.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	76.579	0.0	104.2	27
30 min Summer	46.543	0.0	125.3	41
60 min Summer	28.288	0.0	154.1	70
120 min Summer	17.193	0.0	187.5	130
180 min Summer	12.848	0.0	210.3	190
240 min Summer	10.450	0.0	228.1	248
360 min Summer	7.809	0.0	255.8	368
480 min Summer	6.351	0.0	257.7	486
600 min Summer	5.410	0.0	258.9	604
720 min Summer	4.746	0.0	259.7	724
960 min Summer	3.959	0.0	261.4	962
1440 min Summer	3.066	0.0	262.7	1378
2160 min Summer	2.375	0.0	467.1	1760
2880 min Summer	1.981	0.0	509.0	2164
4320 min Summer	1.453	0.0	482.0	2980
5760 min Summer	1.167	0.0	612.1	3808
7200 min Summer	0.984	0.0	645.4	4616
8640 min Summer	0.856	0.0	673.5	5448
10080 min Summer	0.761	0.0	698.7	6248
15 min Winter	76.579	0.0	116.7	26
30 min Winter	46.543	0.0	126.2	41

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Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	149.478	0.178	1.5	167.1	O K
120 min Winter	149.511	0.211	1.5	199.4	O K
180 min Winter	149.531	0.231	1.6	219.7	O K
240 min Winter	149.546	0.246	1.6	234.4	O K
360 min Winter	149.566	0.266	1.6	254.9	O K
480 min Winter	149.580	0.280	1.6	268.6	O K
600 min Winter	149.589	0.289	1.6	278.3	O K
720 min Winter	149.596	0.296	1.6	285.2	O K
960 min Winter	149.613	0.313	1.7	303.0	Flood Risk
1440 min Winter	149.630	0.330	1.9	319.8	Flood Risk
2160 min Winter	149.637	0.337	2.1	327.3	Flood Risk
2880 min Winter	149.640	0.340	2.1	330.5	Flood Risk
4320 min Winter	149.622	0.322	1.8	311.6	Flood Risk
5760 min Winter	149.599	0.299	1.6	288.5	O K
7200 min Winter	149.574	0.274	1.6	262.1	O K
8640 min Winter	149.548	0.248	1.6	236.1	O K
10080 min Winter	149.523	0.223	1.6	210.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	28.288	0.0	172.9	70
120 min Winter	17.193	0.0	210.1	128
180 min Winter	12.848	0.0	235.5	186
240 min Winter	10.450	0.0	255.4	244
360 min Winter	7.809	0.0	259.0	360
480 min Winter	6.351	0.0	260.6	478
600 min Winter	5.410	0.0	261.7	594
720 min Winter	4.746	0.0	262.5	708
960 min Winter	3.959	0.0	264.5	936
1440 min Winter	3.066	0.0	271.2	1362
2160 min Winter	2.375	0.0	523.1	1696
2880 min Winter	1.981	0.0	539.7	2164
4320 min Winter	1.453	0.0	503.8	3160
5760 min Winter	1.167	0.0	685.6	4144
7200 min Winter	0.984	0.0	722.8	5040
8640 min Winter	0.856	0.0	754.5	5880
10080 min Winter	0.761	0.0	782.8	6752

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	30
FEH Rainfall Version	1999
Site Location	GB 419950 370650 SK 19950 70650
C (1km)	-0.027
D1 (1km)	0.373
D2 (1km)	0.461
D3 (1km)	0.328
E (1km)	0.303
F (1km)	2.317
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) 0.729

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.243	4	8	0.243	8	12	0.243

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Model Details

Storage is Online Cover Level (m) 149.900

Tank or Pond Structure

Invert Level (m) 149.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	900.0	1.400	0.0	2.800	0.0	4.200	0.0
0.200	985.0	1.600	0.0	3.000	0.0	4.400	0.0
0.400	1075.0	1.800	0.0	3.200	0.0	4.600	0.0
0.600	1165.0	2.000	0.0	3.400	0.0	4.800	0.0
0.800	0.0	2.200	0.0	3.600	0.0	5.000	0.0
1.000	0.0	2.400	0.0	3.800	0.0		
1.200	0.0	2.600	0.0	4.000	0.0		

Complex Outflow Control

Hydro-Brake® Optimum

Unit Reference	MD-SHE-0057-1600-1200-1600
Design Head (m)	1.200
Design Flow (l/s)	1.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	57
Invert Level (m)	148.400
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	1.6
Flush-Flo™	0.253	1.3
Kick-Flo®	0.511	1.1
Mean Flow over Head Range	-	1.3

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	1.2	0.600	1.2	1.600	1.8	2.600	2.3
0.200	1.3	0.800	1.3	1.800	1.9	3.000	2.4
0.300	1.3	1.000	1.5	2.000	2.0	3.500	2.6
0.400	1.3	1.200	1.6	2.200	2.1	4.000	2.8
0.500	1.1	1.400	1.7	2.400	2.2	4.500	2.9

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Hydro-Brake® Optimum

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
5.000	3.1	6.500	3.5	8.000	3.8	9.500	4.2
5.500	3.2	7.000	3.6	8.500	3.9		
6.000	3.4	7.500	3.7	9.000	4.1		

Orifice

Diameter (m) 0.054 Discharge Coefficient 0.600 Invert Level (m) 149.600

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	149.531	0.231	1.6	219.3	O K
30 min Summer	149.571	0.271	1.6	259.7	O K
60 min Summer	149.617	0.317	1.7	306.5	Flood Risk
120 min Summer	149.666	0.366	2.7	358.0	Flood Risk
180 min Summer	149.695	0.395	3.2	388.6	Flood Risk
240 min Summer	149.715	0.415	3.5	410.0	Flood Risk
360 min Summer	149.740	0.440	3.7	438.0	Flood Risk
480 min Summer	149.756	0.456	3.9	455.0	Flood Risk
600 min Summer	149.765	0.465	4.0	465.3	Flood Risk
720 min Summer	149.771	0.471	4.0	471.3	Flood Risk
960 min Summer	149.787	0.487	4.1	489.4	Flood Risk
1440 min Summer	149.809	0.509	4.3	514.1	Flood Risk
2160 min Summer	149.827	0.527	4.4	534.0	Flood Risk
2880 min Summer	149.833	0.533	4.5	541.5	Flood Risk
4320 min Summer	149.801	0.501	4.3	505.3	Flood Risk
5760 min Summer	149.775	0.475	4.0	475.8	Flood Risk
7200 min Summer	149.753	0.453	3.8	451.5	Flood Risk
8640 min Summer	149.734	0.434	3.7	431.0	Flood Risk
10080 min Summer	149.718	0.418	3.5	413.3	Flood Risk
15 min Winter	149.558	0.258	1.6	245.9	O K
30 min Winter	149.602	0.302	1.6	291.3	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	162.180	0.0	130.7	27
30 min Summer	96.352	0.0	132.9	42
60 min Summer	57.244	0.0	264.0	72
120 min Summer	34.009	0.0	282.5	130
180 min Summer	25.079	0.0	301.8	188
240 min Summer	20.205	0.0	317.5	248
360 min Summer	14.900	0.0	342.0	366
480 min Summer	12.004	0.0	360.7	484
600 min Summer	10.151	0.0	375.8	602
720 min Summer	8.852	0.0	388.2	720
960 min Summer	7.314	0.0	418.8	864
1440 min Summer	5.590	0.0	464.4	1110
2160 min Summer	4.272	0.0	775.9	1500
2880 min Summer	3.530	0.0	810.7	1928
4320 min Summer	2.556	0.0	802.9	2764
5760 min Summer	2.033	0.0	1066.3	3576
7200 min Summer	1.702	0.0	1116.2	4392
8640 min Summer	1.472	0.0	1158.0	5192
10080 min Summer	1.302	0.0	1130.7	5952
15 min Winter	162.180	0.0	132.2	27
30 min Winter	96.352	0.0	134.6	41

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	149.652	0.352	2.4	343.5	Flood Risk
120 min Winter	149.706	0.406	3.4	401.0	Flood Risk
180 min Winter	149.739	0.439	3.7	436.2	Flood Risk
240 min Winter	149.761	0.461	3.9	460.9	Flood Risk
360 min Winter	149.791	0.491	4.2	494.0	Flood Risk
480 min Winter	149.809	0.509	4.3	514.6	Flood Risk
600 min Winter	149.821	0.521	4.4	528.0	Flood Risk
720 min Winter	149.829	0.529	4.5	536.6	Flood Risk
960 min Winter	149.849	0.549	4.6	559.8	Flood Risk
1440 min Winter	149.872	0.572	4.8	585.6	Flood Risk
2160 min Winter	149.890	0.590	4.9	606.2	Flood Risk
2880 min Winter	149.894	0.594	4.9	610.9	Flood Risk
4320 min Winter	149.852	0.552	4.6	563.1	Flood Risk
5760 min Winter	149.813	0.513	4.3	518.1	Flood Risk
7200 min Winter	149.780	0.480	4.1	481.4	Flood Risk
8640 min Winter	149.753	0.453	3.8	452.3	Flood Risk
10080 min Winter	149.731	0.431	3.6	427.7	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	57.244	0.0	274.8	70
120 min Winter	34.009	0.0	306.9	128
180 min Winter	25.079	0.0	331.1	186
240 min Winter	20.205	0.0	350.2	244
360 min Winter	14.900	0.0	379.7	358
480 min Winter	12.004	0.0	402.2	474
600 min Winter	10.151	0.0	420.3	586
720 min Winter	8.852	0.0	435.3	698
960 min Winter	7.314	0.0	472.0	912
1440 min Winter	5.590	0.0	527.0	1142
2160 min Winter	4.272	0.0	852.2	1604
2880 min Winter	3.530	0.0	895.8	2056
4320 min Winter	2.556	0.0	897.5	2944
5760 min Winter	2.033	0.0	1194.6	3808
7200 min Winter	1.702	0.0	1250.4	4616
8640 min Winter	1.472	0.0	1297.1	5448
10080 min Winter	1.302	0.0	1245.5	6256

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	1999
Site Location	GB 419950 370650 SK 19950 70650
C (1km)	-0.027
D1 (1km)	0.373
D2 (1km)	0.461
D3 (1km)	0.328
E (1km)	0.303
F (1km)	2.317
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) 0.729

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.243	4	8	0.243	8	12	0.243

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Model Details

Storage is Online Cover Level (m) 149.900

Tank or Pond Structure

Invert Level (m) 149.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	900.0	1.400	0.0	2.800	0.0	4.200	0.0
0.200	985.0	1.600	0.0	3.000	0.0	4.400	0.0
0.400	1075.0	1.800	0.0	3.200	0.0	4.600	0.0
0.600	1165.0	2.000	0.0	3.400	0.0	4.800	0.0
0.800	0.0	2.200	0.0	3.600	0.0	5.000	0.0
1.000	0.0	2.400	0.0	3.800	0.0		
1.200	0.0	2.600	0.0	4.000	0.0		

Complex Outflow Control

Hydro-Brake® Optimum

Unit Reference	MD-SHE-0057-1600-1200-1600
Design Head (m)	1.200
Design Flow (l/s)	1.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	57
Invert Level (m)	148.400
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	1.6
Flush-Flo™	0.253	1.3
Kick-Flo®	0.511	1.1
Mean Flow over Head Range	-	1.3

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	1.2	0.600	1.2	1.600	1.8	2.600	2.3
0.200	1.3	0.800	1.3	1.800	1.9	3.000	2.4
0.300	1.3	1.000	1.5	2.000	2.0	3.500	2.6
0.400	1.3	1.200	1.6	2.200	2.1	4.000	2.8
0.500	1.1	1.400	1.7	2.400	2.2	4.500	2.9

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Hydro-Brake® Optimum

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
5.000	3.1	6.500	3.5	8.000	3.8	9.500	4.2
5.500	3.2	7.000	3.6	8.500	3.9		
6.000	3.4	7.500	3.7	9.000	4.1		

Orifice

Diameter (m) 0.054 Discharge Coefficient 0.600 Invert Level (m) 149.600

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