



Land off Goat Mill Road, Merthyr Tydfil

SuDS Design Report

For Sirius Planning Ltd

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Land off Goat Mill Road, Merthyr Tydfil

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1.0 INTRODUCTION

1.1 Background

This SuDS Design Report provides details of the method that will be used to discharge the surface water runoff in accordance with the six standards requiring evaluation as part of a SuDS Approval Body (SAB) application for the construction of a plastic recycling and processing facility at land off Goat Mill Road, Merthyr Tydfil.

It is recognised that consideration of flood issues should not be confined to the floodplain. The alteration of natural surface water flow patterns through developments can lead to problems elsewhere in the catchment, particularly flooding downstream. For example, replacing vegetated areas with roofs, roads and other paved areas can increase both the total and the peak flow of surface water runoff from the development site. Changes of land use on previously developed land can also have significant downstream impacts where the existing drainage system may not have sufficient capacity for the additional drainage.

1.2 Standards

This SuDS Design Report complies with the principles of SuDS presented in the 'Statutory Standards for Sustainable Drainage Systems – Designing, constructing, operating and maintaining surface water drainage systems'. The six standards that need to be met are as follows:

- S1 – Surface water runoff destination
- S2 – Surface water runoff hydraulic control
- S3 – Water Quality
- S4 – Amenity
- S5 – Biodiversity
- S6 – Designing drainage for construction, operation, maintenance and structural integrity

The report findings are based upon professional judgement and are summarised below with detailed recommendations provided at the end of the report. The report includes baseline data on flood risk from Natural Resources Wales, rainfall data from the Flood Estimation Handbook (FEH) and hydrogeological information from the British Geological Survey (BGS). The assessment will summarise and refer to these datasets in the text.

1.3 What are SuDS?

A Sustainable Drainage System (SuDS) is designed to replicate, as closely as possible, the natural drainage from the site (before development) to ensure that the flood risk downstream of the site does not increase as a result of the land being developed. SuDS can also significantly improve the quality of water leaving the site and can enhance the amenity and biodiversity that a site has to offer.

There are a range of SuDS options available to provide effective surface water management that intercept and store excess runoff. The standards set out appropriate design criteria based on four main parameters:

1. Runoff Destination (in order of preference)
 - a. To ground;
 - b. To surface water body;
 - c. To road drain or surface water sewer;
 - d. To combined sewer
2. Peak flow rate and volume (pre-and post-development)
3. Water Quality (based on potential hazards arising from development and sensitivity of the runoff destination)
4. Function (design; flood risk; operation and maintenance)

These parameters are then used to develop a drainage strategy based on the following six principles:

1. Manage surface runoff at source
2. Manage on the surface
3. Utilise public space and integrate into the drainage design
4. Effective operation and maintenance
5. Account for climate change and changes in impermeable area
6. Affordability

This report aims to identify the most practicable runoff destination and drainage parameters for the site. A surface water drainage assessment is presented with reference to the hydrological and hydrogeological context of the development.

1.4 Climate Change

Projections of future climate change, in the UK, indicate more frequent, short-duration, high intensity rainfall and more frequent periods of long duration rainfall. The recommended national precautionary sensitivity range for peak rainfall intensity is 30%.

1.5 SuDS Proposals

The SuDS proposals for the site can be summarised as follows:

- **Collect for Re-use:**
 - Rainwater harvesting system
- **Discharge to a Surface Water Body**
 - Attenuation storage in a surface water lagoon with a capacity of ~8000m³, 2.60m deep with 300mm silt allowance and 300mm freeboard with restricted discharge via a vortex flow device to watercourse.

1.6 Report Structure

This SuDS Design Report has the following report structure:

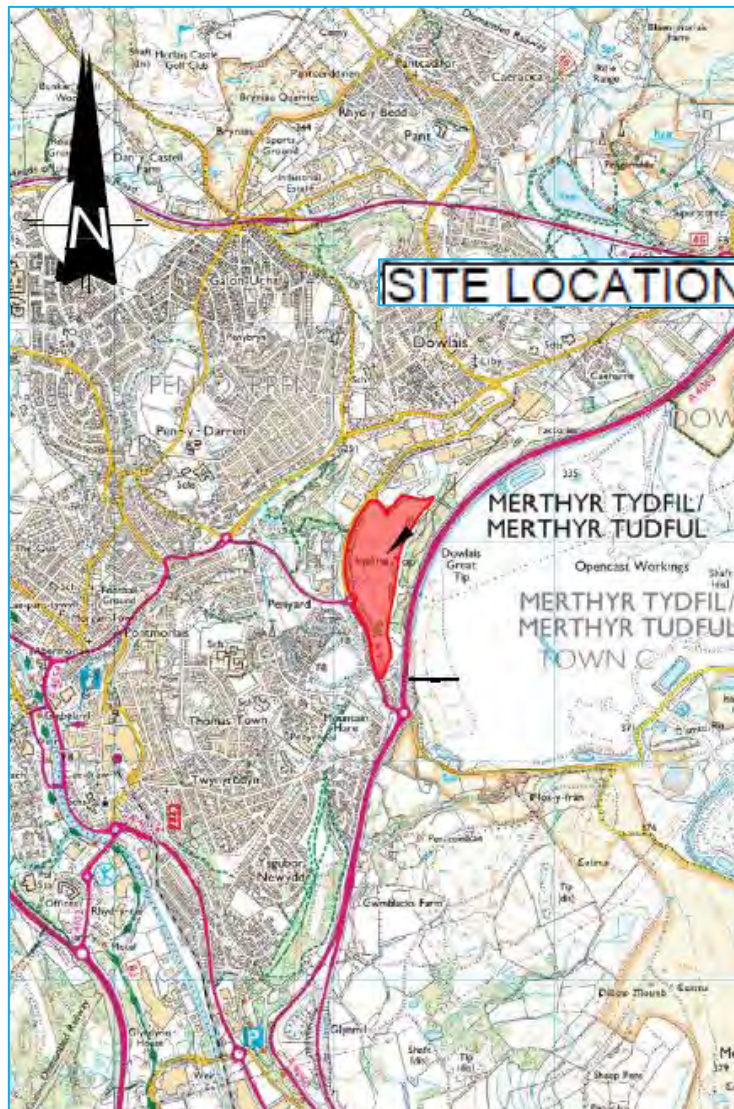
- Section 2 details the location & development description;

- Section 3 details standard S1 – surface water runoff destination;
- Section 4 outlines standard S2 – surface water runoff hydraulic control;
- Section 5 discusses standard S3 - water quality;
- Section 6 details standard S4 – amenity;
- Section 7 outlines standard S5 - biodiversity; and
- Section 8 discusses standard S6 – designing drainage for construction, operation, maintenance and structural integrity; and

2.0 LOCATION & DEVELOPMENT DESCRIPTION

2.1 Site Location

The site is located at land off Goat Mill Road, Merthyr Tydfil, CF47 0TJ. The National Grid Reference (NGR) for the site is 306200, 207000. (see Figure 1).



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Figure 1 - Site Location

2.2 Existing Development

The site currently consists of vacant land. The surfacing comprises mainly open sparsely grassed gravel, with a wooded margin along the western and eastern edges of the site. The eastern flank of the site forms the shoulder of an embankment carrying the A4060 dual carriageway.

2.3 Proposed Development

The proposals are for the erection of a plastic recycling and processing facility with associated office accommodation, external storage area, car parking and weigh bridge (see Appendix 1). The proposed site layout includes two large portal frame recycling buildings amongst hard-paved areas upon which baled plastic waste is to be stored. A surface water lagoon is also proposed in the south of the site. Wooded areas immediately east of Goat Mill Road, and to the west of the A4060 road are to remain undeveloped.

2.4 Ground Levels

A topographical survey of the site has been carried out (see Appendix 2). The site currently comprises a plateau in the western half, which slopes gently down from east to west, from circa 281-279 metres Above Ordnance Datum (mAOD), with an overall gradient of circa 1 in 90. The eastern part of the site forms the shoulder of an embankment supporting the A4060 road, up to circa 35m high, with a slope angle of circa 1 in 3.50.

2.5 Catchment Hydrology / Drainage

There is an unnamed surface watercourse along the northern site boundary, flowing to the west; there is a small concrete bridge spanning this giving access to the site. There are also drainage ditches along the base of the embankment to the A4060 road, which discharge into the surface watercourse to the north of the site, and a smaller watercourse, running to the west, within the site. These appear to convey surface water from the opencast mine to the east, below the A4060 road.

There is a second small concrete bridge spanning a watercourse within the south of the site. Appendix 3 shows the location of known watercourses within the vicinity of the site.

2.6 Ground Conditions

The British Geological Survey (BGS) Map indicates the site to be underlain by solid strata comprising the South Wales Lower Coal Measures Formation (SWLCMF) (Carboniferous age), described as 'Mudstone, siltstone and sandstone'.

Regarding the superficial deposits, the 1:10,560 and 1:50,000 scale geological mapping (produced prior to opencast mining) indicates that Boulder Clay is present in the central part of the site.

Published geological mapping shows, 'Made Ground, mainly spoil from coal and ironstone workings' covering much of the site. However, this is considered to be out of date, as it is known that a former ironworks slag heap was removed from the site and that the site is now underlain by made ground including opencast mine backfill, engineered fill and the embankment to the A4060 road.

Under the aquifer classification system developed by the Environment Agency, the superficial deposits are classified as a Secondary Undifferentiated Aquifer. Secondary Undifferentiated Aquifers are described by the Environment Agency as, 'assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type'.

The solid strata underlying the site are classified as a Secondary A Aquifer. Secondary A Aquifers are defined by the EA as, 'permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers'.

Information from the National Soil Resources Institute details the site area as being situated on slowly permeable seasonally wet acid loamy and clayey soils. The Flood Studies Report WRAP soil map

classification is Type 5: Soils of wet uplands - i) with peaty or humose surface horizons and impermeable layers at shallow depth; ii) deep raw peat associated with gentle upland slopes or basin sites; iii) bare rock cliffs and screes; iv) shallow permeable rocky soils on steep slopes.

2.7 Groundwater

There is one BGS borehole record within the site (BGS Ref. SO00NE72). The borehole record shows that groundwater is likely to be more than 1.50 metres Below Ground Level (mBGL) and the groundwater is not expected to be especially vulnerable to contamination. Water is likely to percolate through the unsaturated zone to the groundwater through fractures, a process which has little potential for contaminant removal and breakdown.

2.8 Source Protection Zone

The site is not located within an Environment Agency Source Protection Zone. SPZ's have been defined by the Environment Agency around major public water supplies with the intent to show the risk of contamination from any activities that might cause pollution in the area. Three zones are defined: SPZ 1 is the Inner Zone (highest risk); SPZ 2 is the Outer Zone (average risk); SPZ 3 is the Total Catchment (least risk).

2.9 Ground stability

Dissolution, sand liquefaction and landslides could be enhanced by SuDS infiltration and lead to unstable ground. Dissolution risk is low since the site does not appear to be directly underlain by chalk or other soluble rocks. Sand liquefaction risk is low since the site is not located on unconsolidated superficial sand deposits. Landslide risk is low since there are no records of landslides close to the site according to the BGS.

2.10 Permeability / Infiltration Rate

In determining the future surface runoff from the site, the potential of using infiltration devices has been considered. As no site geotechnical information on the permeability and infiltration rate at the site has been acquired at this stage it is not possible to comment definitively upon the suitability of infiltration-based systems. However, an overview of the general ground conditions may be used to gauge if there is potential for their application.

The general ground conditions suggest that the permeability and infiltration rate of the site will be low. However, the depth of Made Ground will reduce the permeability and infiltration rate further. It is also recommended that infiltration devices should not be located within 5m of any buildings or roads, or within 1m of groundwater, the availability of suitable locations on the site is very limited.

The ground conditions suggest infiltration techniques such as soakaways will not work and will not provide a suitable option at the site.

3.0 S1: SURFACE WATER RUNOFF DESTINATION

3.1 Opportunities for Discharge of Surface Water

As part of the SuDS Standards the management of runoff from developments should be prioritised as to the choice of discharge destination. The priority hierarchy is listed below:

- 1) Collect for re-use;
- 2) Infiltrate to ground;
- 3) Discharge to a surface water body;
- 4) Discharge to a surface water sewer / highway drain; and
- 5) Discharge to a combined sewer.

It is necessary to identify the most appropriate method of controlling and discharging surface water. The design should seek to improve the local runoff profile by using systems that can either attenuate runoff and reduce peak flow rates or positively impact on the existing surface water runoff.

3.2 Collect for Re-use

The development briefly comprises the erection of plastic recycling and processing facility with associated office accommodation, external storage area, car parking and weigh bridge (Appendix 1).

Being on an industrial facility there is no demand for domestic water uses, therefore BS 8515 will not apply. However, there will be rainwater harvesting incorporated into building 2 which contains the wash plant. As the detailed internal design of the buildings has not been finalised no further information is available at this stage but will be available at the SAB full application stage.

3.3 Discharge to Ground

The ground conditions show that infiltration SuDS techniques will not work and will not provide a suitable option for the discharge of surface water.

3.4 Discharge to Surface Water Body

Appendix 3 above details the watercourses in the vicinity of the site. There is a watercourse to the south of the site which flows to the west of the site which is culverted under the A4102 (see Figures 2, 3, 4 and 5).

It is proposed that the surface water runoff from the impermeable areas of the site will discharge to a new surface water lagoon to be located to the south of the site. The lagoon will have a capacity of ~8000m³, 2.60m deep with 300mm silt allowance and 300mm freeboard allowance.

There will be a diversion of the existing watercourse downstream of Morlais B off-site outfall as indicated on the SuDS Design Drawing (Appendix 4). It is considered that diverting the existing watercourse is a more sustainable option than taking the discharge from the Ffos y Fran area as the site would have to rely on the management of this upstream system which could potentially cause issues. This catchment area may be developed in future which by separating the flows from the site

and the existing outfall from the Ffos y Fran area would avoid any knock on effect on the sustainability of the current proposals. Therefore it will be possible to discharge surface water runoff into a water body.

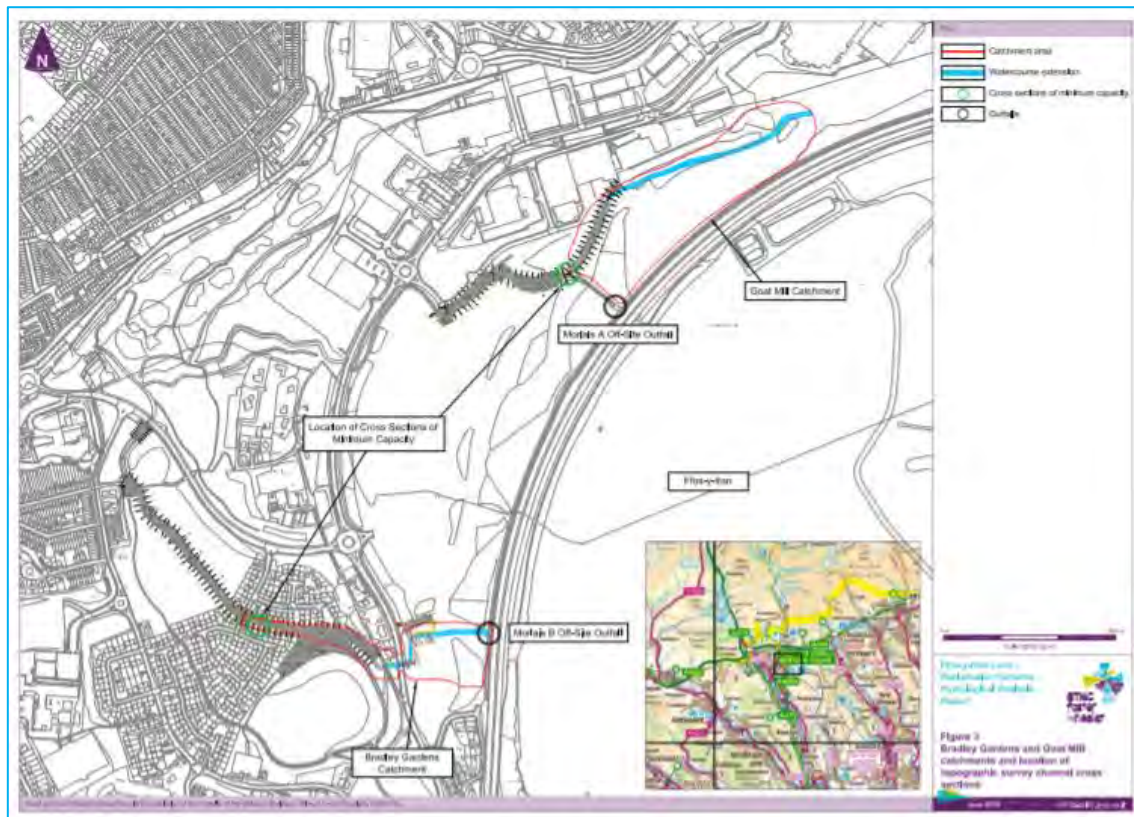


Figure 2 - Goat Mill Catchments



Figure 3 - Engineered channel immediately downstream of the Morlais B outfall



Figure 4 - Looking downstream immediately downstream of the road culvert in Bradley Gardens



Figure 5 - Looking upstream in the Bradley Gardens catchment watercourse at the smallest flow capacity cross section

3.5 Discharge to Road Drain or Surface Water Sewer

This option is not required.

3.6 Discharge to a Combined Sewer

This option is not required.

4.0 S2: SURFACE WATER RUNOFF HYDRAULIC CONTROL

4.1 Surface Water Runoff Rates

The proposed impermeable area of the site is 9.7449 hectares (ha). An estimation of surface water runoff is required to permit effective site surface water management and prevent any increase in flood risk to off-site receptors. In accordance with The SuDS Manual, the Greenfield runoff from the site has been calculated using the ReFH2 method. QMed (rural) has been calculated to be 166.30 litres/second (l/s) for the proposed impermeable area. Table 1 shows the ReFH2 method Greenfield runoff rates for the site (see Appendix 5).

Table 1 - ReFH2 method Greenfield Runoff Rates

Rainfall Event	Runoff Rate (l/s)
1	144.30
QMed (rural)	166.30
30	366.90
100	308.60

The 1 in 100 year 6 hour rainfall event has been calculated to have a rainfall intensity of 72.81mm, as calculated using the Flood Estimation Handbook 2013 (FEH2013) Catchment Descriptors for the site (see Appendix 6). Therefore, using the proposed impermeable area of 9.7449ha, the 1 in 100 year 6 hour rainfall event has a volume of 4916.06 m³ or 4,916,060 litres and the 1 in 100 year (+30%) 6 hour rainfall event has a volume of 6,390.88m³ or 6,390,878 litres (see Table 2). A 100% co-efficient of runoff has been assumed from the impermeable areas, this is a conservative estimate of the runoff.

Table 2 - 6 Hour Rainfall Calculations

Rainfall Event: 6 hours	Intensity (mm)	Volume	
		m ³	Litres
100	72.81	4916.06	4,916,060
100 (+30%)	94.65	6,390.88	6,390,878

These methods used for calculating the runoff complies with the SuDS Standards and assumes that the excess runoff associated with the proposed development (plus an allowance for future climate change) will need to be managed by the proposed SuDS Strategy.

4.2 SuDS

Current guidance promotes sustainable water management through the use of SuDS. SuDS measures should be used to control the surface water runoff from the proposed development site therefore, managing the flood risk to the site and surrounding areas from surface water runoff.

One of the aims of the SuDS Standards is to provide not only flood risk mitigation but also to maximise additional gains such as improvements in runoff quality and provision of amenity and biodiversity. Systems incorporating these features are often termed SuDS and it is the requirement of the SuDS Standards that these are considered as the primary means of collection, control and disposal for storm water as close to source as possible. A hierarchy of techniques is identified:

1. **Prevention** – the use of good site design and housekeeping measures on individual sites to prevent runoff and pollution (e.g. minimise areas of hard standing).

2. **Source Control** – control of runoff at or very near its source (such as the use of rainwater harvesting, permeable paving, soakaways and / or green roofs).
3. **Site Control** – management of water from several sub-catchments (including routing water from roofs and car parks to one / several large soakaways for the whole site, swales and / or infiltration trenches).
4. **Regional Control** – management of runoff from several sites, typically in a detention pond, basins, tanks and / or wetland.

It is generally accepted that the implementation of SuDS as opposed to conventional drainage systems, provides several benefits by:

- reducing peak flows to watercourses or sewers and potentially reducing the risk of flooding downstream;
- reducing the volumes and frequency of water flowing directly to watercourses or sewers from developed sites;
- improving water quality over conventional surface water sewers by removing pollutants from diffuse pollutant sources;
- reducing potable water demand through rainwater harvesting;
- improving amenity through the provision of public open spaces and wildlife habitat; and
- replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

The most appropriate attenuation system will need to satisfy three main characteristics, firstly, provide the required volume of storage, secondly, minimise the loss of developable land and thirdly, where possible provide local amenity.

The application of the SuDS Manual requires that the runoff from sites is not only restricted to meet the Greenfield runoff characteristics but also that SuDS systems are utilised to improve the quality of the runoff prior to outfall to watercourses. The SuDS Manual and the SuDS Standards guidance applies a sustainability hierarchy to the various types of SuDS systems, this is summarised in Table 3.

Systems at the top of the hierarchy provide a combination of attenuation, treatment and ecology and are deemed the most sustainable options. There are always specific scenarios where systems are more suitable than others and at this stage it is not possible to guide the development towards a particular strategy. The usual approach is to consider the 'SuDS train' where each of the above options are considered in turn until a suitable solution is found.

Table 3 - Sustainability Hierarchy

Most Sustainable ↑ ↓ Least Sustainable	SuDS Technique	Flood Reduction	Pollution Reduction	Landscape & Wildlife
	Rainwater Harvesting	✓	✓	✓
	Green / Living Roofs	✓	✓	✓
	Basins and Ponds - Constructed wetlands - Balancing ponds - Detention basins - Retention ponds	✓	✓	✓
	Filter Strips and Swales	✓	✓	✓
	Infiltration Devices - Soakaways	✓	✓	✓
	Permeable Surfaces and Filter Drains - Gravelled areas - Solid paving blocks - Permeable paving	✓	✓	
	Tanked Systems - Over-sized pipes / tanks - Cellular storage	✓		

4.3 SuDS Design

The objective of this SuDS Design is to ensure that a sustainable drainage solution can be achieved which reduces the peak discharge rate to manage and reduce the flood risk posed by the surface water runoff from the site. The SuDS Design takes into account the following principles:

- No increase in the volume or runoff rate of surface water runoff from the site.
- No increase in flooding to people or property off-site as a result of the development.
- No surface water flooding of the site.
- The design takes into account a 30% increase in rainfall intensity due to climate change during the lifetime of the development.
- A 10% increase in impermeable areas due to urban creep.
- Maintain / improve surface water quality.
- Provide amenity and biodiversity benefits.

In line with adopting a 'management train' it is recommended that water is managed as close to source as possible. A hierarchical approach to surface water management has been adopted within this SuDS Design. This will reduce the size and cost of infrastructure further downstream and also shares the maintenance burden more equitably. The SuDS proposals for the site can be summarised as follows:

- **Collect for Re-use:**
 - rainwater harvesting system
- **Discharge to a Surface Water Body**

- Attenuation storage in a surface water lagoon with a capacity of $\sim 8000\text{m}^3$, 2.60m deep with 300mm silt allowance and 300mm freeboard with restricted discharge via a vortex flow device to watercourse.

The SuDS Design is shown in Appendix 4. This method will reduce peak flows, the volume of runoff, and slow down flows and will provide a suitable SuDS solution for this site. The adoption SuDS features for the site represents an enhancement from the current conditions as the current surface water runoff from the site is uncontrolled, untreated, unmanaged and unmitigated. The SuDS features will reduce the risk of flooding to the site and off-site locations.

In adopting these principles, it has been demonstrated that a scheme can be developed that does not increase the risk of flooding to adjacent properties and development further downstream.

4.4 Interception Storage

The rainwater harvesting system, landscaped areas and surface water lagoon will provide interception storage as per Table G2.1 of the SuDS Standards.

4.5 Morphological Protection / Flood Risk Mitigation of Receiving Surface Water Bodies

The provision of suitable storage on site to mitigate the flood risk resulting from the development of the site will be a key factor in the evolution of the site development layout. One of the aims of the SuDS Standards is to provide not only flood risk mitigation but also to maximise additional gains such as improvements in runoff quality and provision of amenity and biodiversity.

It is therefore proposed that rainwater harvesting, and a surface water lagoon with a restricted outfall to the watercourse to the south west of the site will be used. By restricting runoff rates to Greenfield runoff rates the receiving watercourse will be protected from erosion and the resulting morphological, ecological damage and increasing flood risk.

Runoff Rate Control

QMed (rural) has been calculated to be 166.30 litres/second. Using a flow control device and practical minimum pipe sizes it is not practical to control the discharge rate to below the Greenfield runoff rate of 166.30 litres/second. Therefore, a value of 166.30 litres/second has been used as the limiting discharge rate before discharge to the watercourse, for all events up to and including the 1 in 100 year (+30%) event.

Runoff Volume Control

The size of the surface water lagoon has been calculated such that the development has the capacity to accommodate the 1 in 100 year rainfall event including a 30% increase in rainfall intensity that is predicted to occur as a result of climate change. The proposed impermeable area of the site is $97,449\text{m}^2$. With a 10% increase in impermeable to account for urban creep the proposed impermeable area used within the calculations is $107,194\text{m}^2$. Consequently, all areas drained have been designed to accommodate a 100 year (+30% climate change) event.

Table 4 shows the volume of storage required for the proposed impermeable surfaces estimated using the MicroDrainage Software for the critical 1 in 100 year event with a 30% allowance for climate change (increase in peak rainfall) (see Appendix 7). A 100% co-efficient of runoff has been assumed from the impermeable areas, this is a conservative estimate of the runoff.

It is proposed that the impermeable areas of the site will be discharged to a surface water lagoon a minimum capacity of 7,742m³ before discharging off the site to the watercourse at a restricted runoff rate of 166.30 litres/second.

Table 4 – Surface Water Lagoon Storage Volumes

Return Period (years)	Limiting Discharge Rate (l/s)	Volume (m ³)
100 +30%	166.30	7,742.00

G2.28 of the SuDS Standards for Wales, 2018 states that “Ideally, the volumetric control of runoff should be demonstrated to meet greenfield runoff behaviour for all events and particularly those relevant for the mitigation of flood risk in the receiving watercourse. However, this would require the use of time series rainfall as part of a modelling exercise. Until this approach becomes standard industry practice, a simple method using the 1:100 year, 6 hour rainfall event is sufficient for design purposes, as it represents a suitable event for smaller watercourses that are most at risk from the effects of urban development. As designs for Interception will help control runoff volumes from smaller events, a single requirement for large events is considered a pragmatic solution.”

The Greenfield 1 in 100 year 6 hour rainfall event has been calculated to have a volume of 4916.06m³. Therefore, the surface water lagoon will have the capacity to store the 1 in 100 year 6 hour rainfall event. The site will adhere Greenfield runoff rates for all events up to and including the 1 in 100 year (+30%) rainfall event. Therefore, the surface water runoff from the developed site will be no greater than existing.

The remainder of the site that is not formally drained, i.e. landscaped areas, will be permeable (grass). The majority of rainwater falling on these areas will soak into the ground. Surface water runoff would be directed to the drainage system through channel drainage located through the contouring of the hardstanding areas.

Furthermore, betterment will be provided by the use of a rainwater harvesting system for process water. It is proposed to collect rainwater for use as process water from the proposed buildings. Further details will be provided at SAB full application stage.

4.6 Design Exceedance

Appendix 4 shows the exceedance routes. When considering residual risk, it is necessary to make predictions as to the impacts of a storm event that exceeds the design event or potential failure of the drainage system through the blockage of pipes, blockage of outlet structures and risk of impediments across flood routing paths.

The SuDS Design applies a safe and sustainable approach to discharging rainfall runoff from the site and this reduces the risk of flooding however, it is not possible to completely remove the risk. This section is therefore associated with the way the residual risk is managed.

As part of the SuDS Design it must be demonstrated that the flooding of property would not occur in the event of design exceedance or local drainage system failure. It is not economically viable or sustainable to build a drainage system that can accommodate the most extreme events. It is also very unlikely that a catastrophic failure would occur.

The SuDS features have been designed to accommodate the 1 in 100 year event plus climate change (+30%) including a 10% increase in the impermeable areas due to urban creep therefore, flooding will not occur for all events up to the 1 in 100 year (+30%) event. It should also be noted that additional storage is provided within the manholes, channel drainage as well the rainwater harvesting system which will provide betterment over and above the 1 in 100 year (+30%) event. Flow resulting from a

rainfall event in excess of the 1 in 100 year (+30%) event (exceedance event) will be managed to that minimise the risks to people and property.

A freeboard of 300mm will be provided above the temporary water level within the surface water lagoon, this will provide additional storage should an exceedance event occur. An exceedance flow route from the surface water lagoon to the watercourse will be installed to prevent overtopping. This will take the form of a simple channel with a 300mm freeboard. This will protect the embankment from structural damage and has been located to not put downstream people and property at risk.

The site rises from west to east; the proposed buildings will be located above and not in close proximity to the surface water lagoon so that any flows will not enter the proposed buildings ensuring any exceedance flooding would not affect the buildings. Boundary planting will also retard and allow infiltration of any surface water runoff. It is not considered that there is an increased risk to the buildings on the site or located adjacent to the site.

Consequently, the impact of an exceedance event or local drainage system is not considered to represent any significant flood hazard. The above manages and mitigates the flood risk from surface water runoff to the proposed properties from surface water runoff generated by the site development and to offsite locations as well the risk from surface water runoff generated offsite.

5.0 S3: WATER QUALITY

5.1 SuDS and Water Quality

According to the SuDS Standards (see Table 5), the proposed development is of medium hazard (industrial uses).

Table 5 - Level of hazard

Hazard	Source of Hazard
Low	Roof drainage
Medium	Residential, amenity, commercial, industrial uses including car parking spaces and roads
High	Areas used for handling and storage of chemicals and fuels, handling of storage and waste (incl. scrap-yards)

The proposed development has a 'high' pollution hazard level (see Table 6), as per Table 26.2 of the SuDS Manual.

Table 6 - Pollution Hazard Indices

Land Use	Pollution Hazard Level	Total Suspended Solids (TSS)	Metals	Hydrocarbons
Sites with heavy pollution (e.g. haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured; industrial sites, trunk roads and motorways	High	0.80	0.80	0.90

* Indices values range from 0-1.

To deliver adequate treatment, the SuDS features should have a total pollution mitigation index (for each contaminant type) that equals or exceeds the pollution hazard index (for each contaminant type). Water treatment will be provided via the SuDS components included throughout the drainage network.

Discharge through channel drainage and the surface water lagoon will not provide sufficient pollution mitigation. Table 7 shows the indicative SuDS pollution hazard indices as per Tables 26.3 and 26.4 the SuDS Manual. It is therefore considered that adequate water quality treatment cannot be provided via SuDS components alone.

Proprietary systems are sometimes used as part of the overall SuDS management train e.g., to protect a SuDS features from excess silt or oil contamination. Proprietary surface water treatment systems such as oil interceptors and vortex settlement chambers have historically been used and accepted as 'equivalent systems' to SuDS for use to treat runoff from a development. The Statutory standards for Sustainable Drainage Systems does indicate an indicative suitability of proprietary treatment systems as SuDS components within the management train where design performance can be demonstrated. The proposed development is a for constrained site where conventional additional SuDS features to those already proposed are not practicable. Given the constraints of the site, it is proposed that

proprietary systems to include silt traps and oil interceptors (see Table 7) will be used in addition to the proposed SuDS components to treat the surface water runoff to protect the surface water lagoon from excess silt or oil contamination to complete the SuDS management train and to reduce pollutants to acceptable levels prior to infiltration into the unsaturated zone.

Table 7 - Pollution Hazard Indices for Discharges to Surface Water

Type of Component	Description	TSS	Metals	Hydrocarbons
Hydro-Int Up-Flo filter**	Silt trap	0.80	0.70	0.80
Hydro-Int Downstream Defender**	Advanced Hydrodynamic Vortex Separator	0.25*	0.20*	0.40*
Attenuation pond (surface water lagoon)	N/a	0.35*	0.35*	0.25*
Total		>1.00	>1.00	>1.00

* a factor of 0.50 is used to account for the reduced performance of secondary components associated with already reduced inflow concentrations.

** Indices obtained from Hydro International (hydro-int.com.stormtrain)

The surface water runoff will first pass through a Hydro International Up-Flo Filter which catch and filter sediment and Hydro International Downstream Defender which is a vortex separator which will remove fine particles, oils and other floatable debris from the surface water runoff (see Appendix 8).

These proprietary surface water treatment systems are proposed as a last resort as no further treatment can be provided via the introduction of additional SuDS features on the Site due to the constraints of the Site.

The surface water lagoon will have a permanent pool of water. Each time it rains, the runoff entering the lagoon is detained and treated by settling out sediments and biological uptake until it is displaced by runoff from the next storm.

The design of the system will allow any silt and debris from the development an opportunity to settle. The surface water lagoon will naturally filter potentially suspended solids contained in the surface water runoff from any hardstanding. Treatment will be provided by the proprietary treatment systems and within the permanent pool in the surface water lagoon and attenuation storage will be provided above the permanent pool.

6.0 S4: AMENITY

6.1 Amenity Benefits

As the proposals are for a new plastic recycling and processing facility, the amenity benefits possible are limited. In accordance with the SuDS Manual, rainwater harvesting will provide an indirect amenity value by supporting the resilience of the development and the adjacent landscape to changes in climate and water resource availability by re-using water.

The tree planting and landscaped / grassed zones will help support flora and fauna for the benefit of the development community.

7.0 S5: BIODIVERSITY

7.1 Biodiversity Benefits

In accordance with the SuDS Manual, rainwater harvesting does not provide any inherent biodiversity value, but it will help to reduce flows on the downstream system. See Appendix 9 for the biodiversity improvement measures.

Planting will use a variety of native species of local provenance to ensure opportunities for biodiversity and sustain habitat within the development. Table 8 provides details of the native plants recommended by the SAB. The majority of trees are to be retained. Carrying out grass cuts, and removing from site will also improve biodiversity of landscaped areas.

Table 8 - List of Native Plants to be Used

Erect Marginal Plants	Low-growing Marginal / Aquatic Plants
Flowering-rush (<i>Butomus umbellatus</i>)	Amphibious bistort (<i>Persicaria amphibia</i>)
Gipsywort (<i>Lycopus europaeus</i>)	Brooklime (<i>Veronica beccabunga</i>)
Great water-dock (<i>Rumex hydrolapathum</i>)	Watercress (<i>Nasturtium officinale</i>)
Hemp Agrimony (<i>Eupatorium cannabinum</i>)	Floating sweet-grasses (<i>Glyceria</i> spp.)
Marsh Woundwort (<i>Stachys palustris</i>)	Marsh foxtail (<i>Alopecurus geniculatus</i>)
Pendulous sedge (<i>Carex pendula</i>)	Marsh marigold (<i>Caltha palustris</i>)
Purple loosestrife (<i>Lythrum salicaria</i>)	Meadowsweet (<i>Filipendula ulmaria</i>)
Rush (<i>Juncus</i> spp.)	Water forget-me-not (<i>Myosotis scorpiodes</i>)
Yellow iris (<i>Iris pseudacorus</i>)	Water mint (<i>Mentha aquatica</i>)

7.2 Surface Water Lagoon and Surrounding Area

A range of habitats will be created, with an aquatic benches for marginal planting and open water for deep water plants.

Importing plants can introduce diseases and invasive non-native species to the site. It is recommended that a pond edge wildflower mix (see Table 11 or <https://wildseed.co.uk/mixtures/view/13>), is sown in the areas surrounding permanent low water levels, following the completion of work and once water has reached a typical expected level. A wetland meadow mixture will be used in the rest of the lagoon (see Table 11 or <https://wildseed.co.uk/mixtures/view/9>).

To be of the greatest value to wildlife, public access will be limited as much as possible. Dogs in particular are detrimental to the wildlife in ponds/lagoons.

7.3 Scrub and Trees

An existing area of scrub and trees near the lagoon will provide important terrestrial habitat cover and act as a windbreak. Trees and scrub will attract a greater variety of insects and birds to the site, and will provide terrestrial habitat for amphibians.

Species should be native and of local provenance and could include; Guelder-rose *Viburnum opulus*, Crab Apple *Malus sylvestris*, Hawthorn *Crataegus monogyna*, Hazel *Corylus avellane* and Rowan *Sorbus aucuparia*.

7.4 Features

The land surrounding the lagoon will include features beneficial to wildlife. This will include log / deadwood piles, embankments and hibernacula. Hibernacula generally comprise mounds of timber or other material covered by turf to provide damp, sheltered habitat. If available, inert discarded bricks or rubble from the site can be used. Soil from excavating the lagoon can be used to create an embankment, which is particularly beneficial if sited near the lagoon edge. This will create habitat for reptile basking.

Arisings from trees or bushes that have been cut down could be used to create log / deadwood piles, which are beneficial to a range of species, particularly insects. Using recovered material is always preferential to importing material to the site for the construction of such features, as this increases the risk of spreading invasive non-native species and diseases.

8.0 S6: DESIGNING DRAINAGE FOR CONSTRUCTION, OPERATION, MAINTENANCE AND STRUCTURAL INTEGRITY

8.1 Maintenance Responsibility

The system will be maintained by the owner of the site who were required with appoint a maintenance contractor and will not be adopted by the SAB. An Operation and Maintenance Manual will be developed, the Operation and Maintenance Manual shall be passed on to subsequent future owners covered by the document. The maintenance will be the responsibility of the property owner as the SuDS features will serve a single private site.

8.2 Phasing

The surface water drainage scheme will be installed and fully operational before occupation of the site occurs.

8.3 Construction Phase Surface Water Impacts

The proposed development has the potential to introduce contaminants from the associated machinery, infrastructure, transportation, importation of constructions materials and maintenance and storage of plant equipment as discussed below:

Excavated Ground and Exposed Ground

Recently disturbed and vegetation free ground allows for relatively low velocity runoff to erode the surface. This leads to increased runoff and sedimentation of receiving waters, thereby increasing flood risk / potential impacts on water quality.

Stockpiles

Rainfall could lead to erosion of material should a stockpile be uncovered. This could lead to siltation of drainage or receiving watercourses and therefore an increase in flood risk / potential impact on water quality.

Oils and Hydrocarbons

The use of oils and hydrocarbons on construction sites provide a risk of leakages and spillages, leading to pollution incidents. This could affect the water quality in drainage / receiving watercourses and aquifers.

8.4 Construction Phase Surface Water Management Plan

The following Section provides detail on site drainage during the Construction Phase, this will reduce the potential for vehicle movement on wet ground, which can increase the potential for compaction. In summary, the withdrawn Pollution Prevention Guidance¹ (PPG) and Government guidance² states

¹ Pollution Prevention Guidelines PPG1: Understanding Your Environmental Responsibilities (July 2013).

Pollution Prevention Guidelines PPG6: Working at construction and demolition sites (March 2012).

Pollution Prevention Guidelines PPG7: The safe operation of refuelling facilities (July 2011).

Pollution Prevention Guidelines PPG8: Safe storage and disposal of used oils (February 2004).

Pollution Prevention Guidelines PPG13: Vehicle washing and cleaning (July 2007).

Pollution Prevention Guidelines PPG21: Incident Response Planning (March 2009).

Pollution Prevention Guidelines PPG22: Dealing with spills (April 2011).

² <https://www.gov.uk/guidance/storing-oil-at-a-home-or-business>, May 2015.

<https://www.gov.uk/guidance/manage-waste-on-land-guidance-for-land-managers>, May 2014.

that the following methods of surface water management should be put in place during the construction phase to ensure pollution, sediment and erosion control.

Excavated Ground and Exposed Ground

To limit the volume of runoff reaching the exposed ground, runoff diversion or interception devices / bunds can be placed upstream of exposed ground. To help control sediment in runoff from leaving the site or entering drainage, silt fences, bunds, hay bales or ditches can be placed downstream of exposed ground to intercept runoff.

Stockpiles

Soil stockpiles will be located away from any site drainage systems and measures to intercept runoff will be incorporated, such as a silt fence or small perimeter bunds around the base of the stockpiles. Concrete should also be stored to prevent release into drains.

Oils and Hydrocarbons

Simple measures can be taken to prevent oil and hydrocarbons becoming pollutants, such as:

- Maintenance of machinery and plant.
- Drip trays.
- Regular checking of machinery and plant for oil leaks.
- Correct storage facilities.
- Check for signs of wear and tear on tanks.
- Care with specific procedures when refuelling.
- Designated areas for refuelling.
- Emergency spill kit located near refuelling area.
- Regular emptying of bunds.
- Tanks located in secure areas to stop vandalism.

Ground Compaction

In order to minimise ground compaction, the following measures will be implemented:

- A temporary hardcore surface will be placed as the construction site access road (to be removed at the end of the Construction Phase).
- Vehicle movements on bare soil will be minimised.
- Vehicle movements on wet ground will be minimised.

The pollution, sediment and erosion control mitigation measures as detailed above will ensure that the effects on receptors during the construction phase are negligible.

8.5 Construction Requirements

Lagoon Management and Planting Scheme

As part of the proposed drainage plan for the site, a surface water lagoon will be created, within which will be a permanent water level. Where possible the lagoon has been designed avoiding the use of straight sides. Curves and edges are beneficial for creating a greater diversity of micro-habitats for plant and animal life. At least one section of the lagoon will be minimum of 0.60m deep (in typical conditions), to allow protection from winter freezing in deeper water.

The minimum lagoon design requirements are shown in Table 9. The lagoon will include some shallow, shelved areas. A range of heights will be incorporated, including shelves at approximately 0.10m and 0.40m in depth during typical conditions. If water levels are likely to fluctuate widely, shelves should be created at a wider range of depths to suit a range of conditions.

The inlet and outlet details are provided on the plans together with any necessary erosion control. The lagoon will have gradually sloping sides to allow wildlife access in and out and to allow marginal vegetation to flourish. If this is not possible in the entire lagoon, at least one quarter of the lagoon edge should be gradually sloping to create a 'beach' area.

The bottom and side slopes of the lagoon, including any benches, will be carefully prepared to ensure that they are structurally sound. Any embankments will be checked to ensure that they meet their design criteria. The preparation will also ensure that the lagoon will satisfactorily retain the surface water runoff without significant erosion damage.

Backfilling against inlet and outlet structures will be controlled to minimise settlement and erosion. The soils used to finish the side slopes of the lagoon above the retained level will be suitably fertile, porous and of sufficient depth to ensure healthy vegetation growth. An earth bund around the inflow and outflow pipes will help prevent silt and sediment being churned up in the lagoon during times of high flow.

Wildlife in the lagoon will benefit from it not being stocked with fish. It is therefore preferable that it is sited so that it will not be flooded from nearby rivers which could potentially bring fish into the waterbody, and the discharge pipe from river to the lagoon should be designed so fish cannot swim up it.

When landscaping and preparing the ground, avoid importing soil as this will have a higher nutrient content, which will wash into the lagoon, lowering water quality. Lower nutrient soil is also better for native wildflower species, whereas nutrient rich topsoil will encourage rapid weed growth. Imported soil also carries a risk of introducing disease and invasive non-native species.

Table 9 - Lagoon Design Requirements

Parameter	Design Requirements
Freeboard above temporary water level	300mm
Depth of permanent water	0.60m to 1.00m
Maximum side slopes	1 in 3
Maximum depth of aquatic bench below permanent water level	400mm
Maximum side slopes of safety bench	1 in 15
Width of safety bench	3.50

The lagoon will be designed for ease of maintenance and will contain several zones.:

1. Effective pre-treatment will be implemented via a sediment forebay.
2. The permanent pool that will remain throughout the year (less any evaporation and infiltration during extended periods of dry weather).
3. The temporary storage volume provides flood attenuation for the required events.
4. The shallow zone (aquatic bench) along the edge of the permanent pool to support wetland planting. This acts as a biological filter and provides ecology, amenity and safety benefits.

The system will be installed using safe construction methods, and the manufacturers' guidelines will be followed at all times.

8.6 Operation / Maintenance and Structural Integrity

The SuDS have been designed for easy maintenance to comprise:

- Regular day to day care – litter collection, regular gardening to control vegetation growth and checking inlets where water enters the SuDS feature.
- Occasional tasks – checking the SuDS feature and removing any silt that builds up in the SuDS feature.
- Remedial Work – repairing damage where necessary.

As far as is reasonably practicable the surface water drainage system has been designed so that the SuDS features can be constructed easily, safely, cost effectively and in a timely manner.

The surface water drainage scheme will be installed and fully operational before occupation of the site occurs. The surface water drainage scheme will be regularly maintained. The key maintenance requirements are regular inspection of silt traps, manholes, pipework and pre-treatment devices, with removal of sediment and debris as required.

The structural integrity of the drainage components will be designed to withstand the anticipated loading conditions over the design life of the development, accounting for reasonable levels of maintenance. The maintenance will be the responsibility of the property owner as the SuDS features will serve a single property.

8.7 SuDS Scheme Checklist

The following lists the SuDS components and extra features which are found on site.

- Rainwater harvesting for process water.
- Surface water lagoon will accept surface water runoff from impermeable areas.
- Manholes, inspection chambers and rodding eyes are used on bends or where pipes come together. They allow access and cleaning to the system if necessary.
- Inlet structures such as rainwater down pipes and drainage channels. They should be free from obstruction at all times to allow free flow through the drainage network.
- Below ground drainage pipes convey water into and out of the attenuation system. They should be free from obstruction at all times to allow free flow.

8.8 Sustainable Drainage Maintenance Specification

General Requirements

Table 10 details the general requirements.

Table 10 - General Requirements

General Requirements	
Maintenance activities comprise • Regular maintenance • Occasional tasks • Remedial work	Frequency
• Generally • Litter • Collect all litter or other debris and remove it from the site at each visit	Monthly

- Avoid use of weed killers and pesticides to prevent chemical pollution.
- Avoid de-icing agents wherever possible.
- Protect all below ground drainage through careful selection and placement of hard and soft landscaping.

Rainwater Harvesting

The rainwater harvesting system will be drained cleaned and de silted as part of its service schedule. Table 11 provides details of the maintenance requirements.

Table 11 - Rainwater Harvesting

Regular Maintenance	Frequency
• Inspection of the tanks for debris and sediment build-up, inlets / outlets / withdrawal devices, pumps, filters. • Cleaning of tank, inlets, outlets, withdrawal devices, filters and other debris. • Maintain vegetation to designed limits within the vicinity of the below tanked system to avoid damage to the system.	4 times a year
Remedial Work	Frequency
• Repair of damage to tanks. • Pump repairs.	As required
Monitoring	Frequency
• Inspect inlets, outlets and vents to ensure that they are in good condition and operating as designed.	4 times a year

Surface Water Lagoon

The surface water lagoon will be designed to provide attenuation and storage of surface water. Table 12 provides details of the maintenance requirements.

Table 12 - Surface Water Lagoon

General Requirements	Frequency
Litter removal.	As required
Grass cutting – public areas.	Monthly (during growing season)
Grass cutting – meadow grass.	Half yearly (spring, before nesting season, and autumn)
Inspect vegetation to lagoon edge and remove nuisance plants (for first 3 years).	Monthly (at start, then as required)
Hand cut submerged and emergent aquatic plants (at minimum of 0.10m above lagoon base. Include max 25% of lagoon surface).	Annually
Remove 25% of bank vegetation from water's edge to a minimum of 1 m above water level.	Annually
Tidy all dead growth before start of growing season.	Annually
Remove sediment from forebay.	1–5 years, or as required
Remove sediment from one quadrant of the main body of lagoon without sediment forebays.	2-10 years
Occasional Tasks	Frequency
Remove sediment from the main body of big lagoon when pool volume is reduced by 20%.	>25 years (usually)
Remedial Work	Frequency
Repair of erosion or other damage.	As Required
Aerate lagoon when signs of eutrophication are detected.	As Required
Realignment of damage.	As Required
Repair / rehabilitation of inlets, outlets and overflows.	As Required

Sediments excavated from the lagoon that receive runoff from roof / driveway areas are generally not toxic or hazardous material and can be safely disposed of by either land application or landfilling. However, consultation should take place with the environmental regulator to confirm appropriate protocols.

It will be acceptable to distribute the sediment on site if there is an appropriate safe and acceptable location to do so. If the lagoon is to be drawn down, care should be taken to prevent downstream discharge of sediments and anoxic water.

It should be ensured that in the first five years, while vegetation is establishing, certain plant growth is controlled, such as invasive plants, particularly Common Bulrush (*Typha latifolia*). As it is not desirable for all new ponds/lagoons to be bulrush dominated. After this period, ponds/lagoons can usually be allowed to develop naturally, recognising that, unless the margins are occasionally managed, they are likely to become dominated by trees and shrubs.

Eutrophication of SuDS ponds/lagoons can occur during the summer months. Eutrophication is best alleviated by controlling the nutrient source or providing a continuous baseflow to the pond/lagoon. Unless eutrophication is severe, aeration can be used as a stop-gap measure to save aquatic animal

species and reduce risks to receiving waters. However, the addition of barley straw bales, dredging or rendering the nutrients inactive by chemical means can also be successful.

Flow Control Device

A flow control device controls the flow of water leaving the site. Table 13 provides details of the maintenance requirements.

Table 13 - Flow Control Device

General Requirements	Frequency
Inspect and identify any areas that are not operating correctly and clear out any debris from chamber.	Monthly for first 3 months then every 6 months
Remedial Work	Frequency
Repair physical damage if necessary.	As required

Inlet Structures and Inspection Chambers

Inlet structures such as rainwater downpipes, road gullies and channel drains. They should be free from obstruction at all times to allow free flow through the SuDS system. Inspection chambers and rodding eyes are used on bends or where pipes come together. They allow access and cleaning to the system if necessary. Table 14 provides details of the maintenance requirements.

Table 14 - Inlet Structures and Inspection Chambers

Regular Maintenance	Frequency
Inlet Structures - Inspect rainwater downpipes, channel drains and road gullies, removing obstructions and silt, as necessary. Check there is no physical damage. - Strim vegetation 1m minimum surrounding structures and keep area free from silt and debris.	Monthly
Inspection Chambers Remove cover and inspect, ensuring that the water is flowing freely and that the exit route for water is unobstructed. Removed debris and silt.	Annually
Occasional Maintenance	Frequency
Check topsoil levels are 20mm above edges of chambers to avoid mower damage.	As required
Remedial Work	Frequency
Repair physical damage if necessary.	As required

Below Ground Drainage Pipes

Below ground drainage pipes convey water to the SuDS system. They should be free from obstruction at all times to allow free flow. Table 15 provides details of the maintenance requirements.

Table 15 - Below Ground Drainage Pipes

Regular Maintenance	Frequency
Inspect and identify any areas that are not operating correctly. If required, take remedial action.	Monthly for first 3 months then annually
Remove debris from the catchment surface (where it may cause risks to performance)	Monthly
Remove sediment from pre-treatment inlet structures and inspection chambers.	Annually or as required
Maintain vegetation to designed limits within vicinity of below ground drainage pipes and tanks to avoid damage to system.	Annually or as required
Remedial Works	Frequency
Repair physical damage if necessary.	As required
Monitoring	Frequency
Inspect all inlets, outlets, and vents to ensure that they are in good condition and operating as designed.	Annually
Survey inside of pipe runs for sediment build up and remove if necessary.	Every 5 years or as required

Overflow and Flood Routes

Overflows are overland across weirs, through gratings or within chambers and must be kept clear at all times to protect areas from flooding. They allow onward flow when part of the SuDS system is blocked.

Flood routes (exceedance routes) allow water volumes that exceed the capacity of the SuDS system to pass through or round the site without causing damage to property. These routes must be clear of obstructions at all times. Table 16 provides details of the maintenance requirements.

Table 16 - Overflow and Flood Routes

Regular Maintenance	Frequency
Overflow Jet pipes leading from overflow structures annually and check by running water through the overflow.	Monthly for first 3 months then annually
Remove debris from the catchment surface (where it may cause risks to performance)	Monthly
Flood Routes Make visual inspection. Check route is not blocked by new fences, walls, soil, or other rubbish. Remove as necessary.	Monthly
Remedial Works	Frequency
Overflow If overflow is not clear then dismantle structure and reassemble to design detail.	As required

8.9 Design Life

In order for any surface water drainage system to operate as originally intended, it is necessary to ensure that it is adequately maintained throughout its lifetime. Therefore, over the lifetime of a development there is strong possibility that the system could either fail or its performance be reduced if it is not correctly maintained.

During the routine inspections of any SuDS components it may become apparent that they have reached the end of their functional lifetime. In the interest of sustainability repairs should be the first-choice solution where practicable. If this is not the case, then it will be necessary to undertake complete replacement of the component in question.

When undertaking maintenance, repairs or replacement, all engineering drawings used in the design, construction and installation of the SuDS components should be referred to for construction and specification details. This will help to ensure satisfactory performance of each of the SuDS components.

8.10 Health and Safety

In order to comply with the Construction (Design and Management) Regulations (CDM) 2015, SuDS designers must assess all the foreseeable risks during the construction phase and during the ongoing maintenance of the schemes.

Contractors and those responsible for future maintenance will be made aware of the risks by the site owner, keeping a record of the key health and safety factors that will need to be managed during future ongoing maintenance works. During construction, the residual risks should be identified, and an action plan developed to deal with them appropriately.

All those responsible for maintenance should also take the appropriate health and safety precautions for all maintenance activities, this should additionally include lone working when relevant, and risk assessments should be undertaken for all activities.

8.11 Spillage – Emergency Action

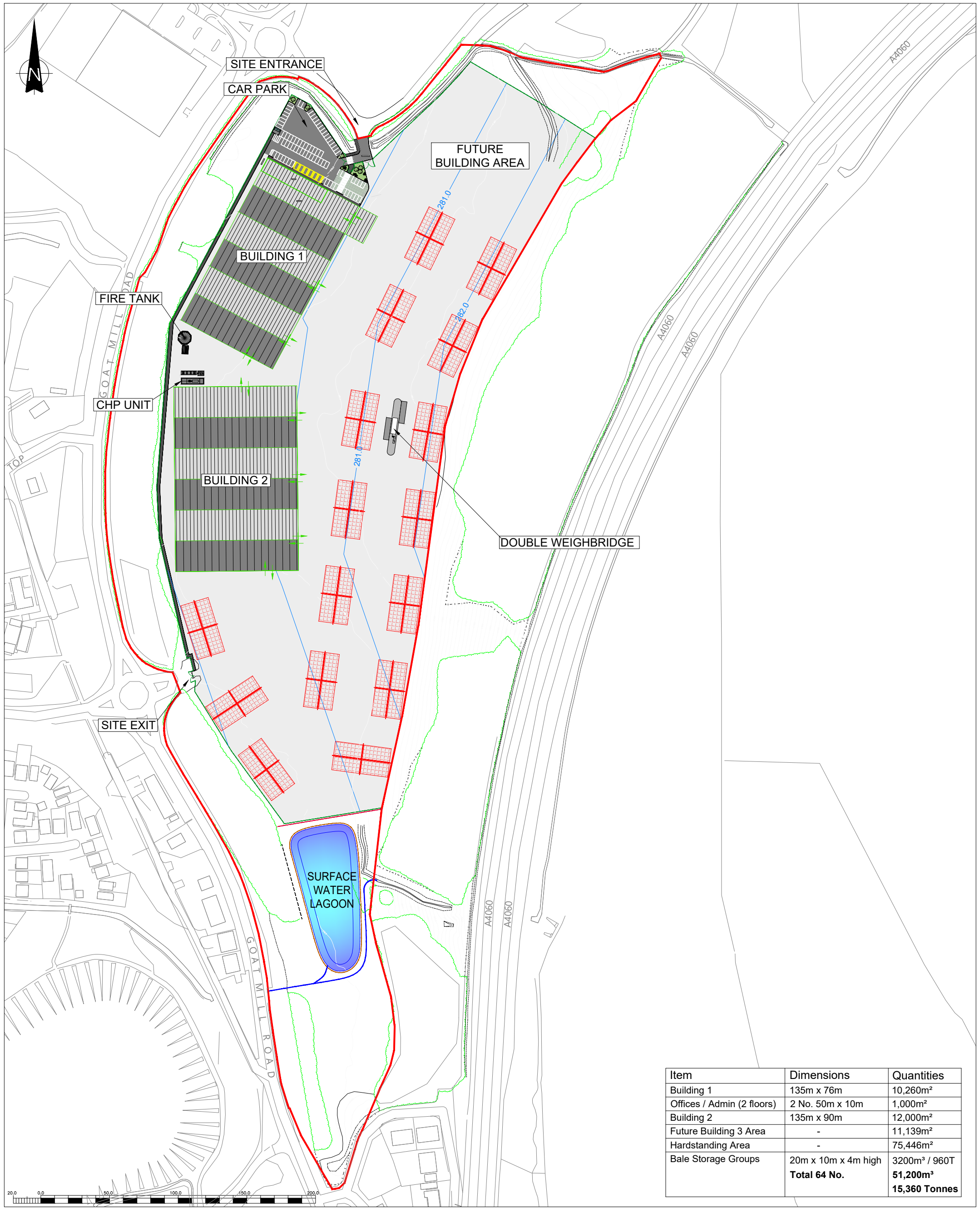
Most spillages on development are of compounds that do not pose a serious risk to the environment if they enter the drainage in a slow and controlled manner with time available for natural breakdown in a treatment system. Therefore, small spillages of oil, milk or other known organic substances should be removed where possible using soak mats as recommended by the Environment Agency, with residual spillage allowed to bioremediate in the drainage system.

In the event of a serious spillage, either by volume or of unknown or toxic compounds, then isolate the spillage with soil, turf or fabric and block outlet pipes from chamber(s) downstream of the spillage with a bung(s) (A bung for blocking pipes may be made by wrapping soil or turf in a plastic sheet or closely woven fabric).

Contact Natural Resources Wales immediately. Tel: 0300 065 3000.

APPENDICES

APPENDIX 1 – Development Proposals



Item	Dimensions	Quantities
Building 1	135m x 76m	10,260m ²
Offices / Admin (2 floors)	2 No. 50m x 10m	1,000m ²
Building 2	135m x 90m	12,000m ²
Future Building 3 Area	-	11,139m ²
Hardstanding Area	-	75,446m ²
Bale Storage Groups	20m x 10m x 4m high	3200m ³ / 960T
	Total 64 No.	51,200m³
		15,360 Tonnes



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JOB TITLE
GOAT MILL ROAD, MERTHYR

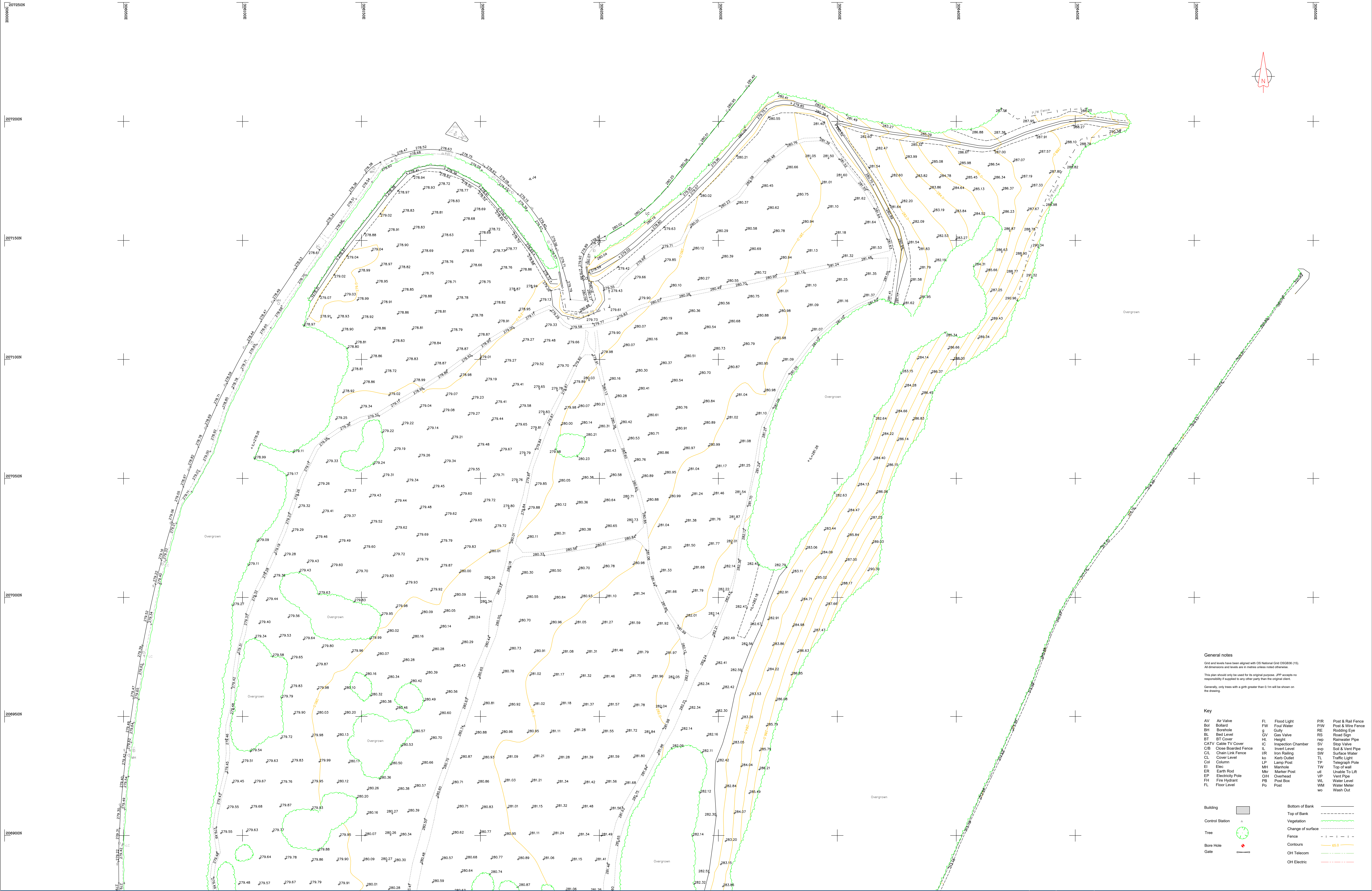
DRAWING TITLE
SITE LAYOUT

- KEY
- PLANNING APPLICATION BOUNDARY
 - PROPOSED DEVELOPMENT PLATFORM CONTOURS
 - PROPOSED PALADIN SECURITY FENCE
 - PROPOSED TIMBER CLOSE BOARDED FENCE
 - PROPOSED TIMBER POST AND RAIL FENCE
 - PROPOSED FOOTPATH
 - PROPOSED BALE STORAGE

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REV	DESCRIPTION	DATE	BY
S.T	13/1/2022	D.B	28/2/2022
SCALE	SHEET	DRAWING NUMBER	REVISION
1:2500	A3P	JAY1001/04/06	0

APPENDIX 2 – Topographical Survey



General notes

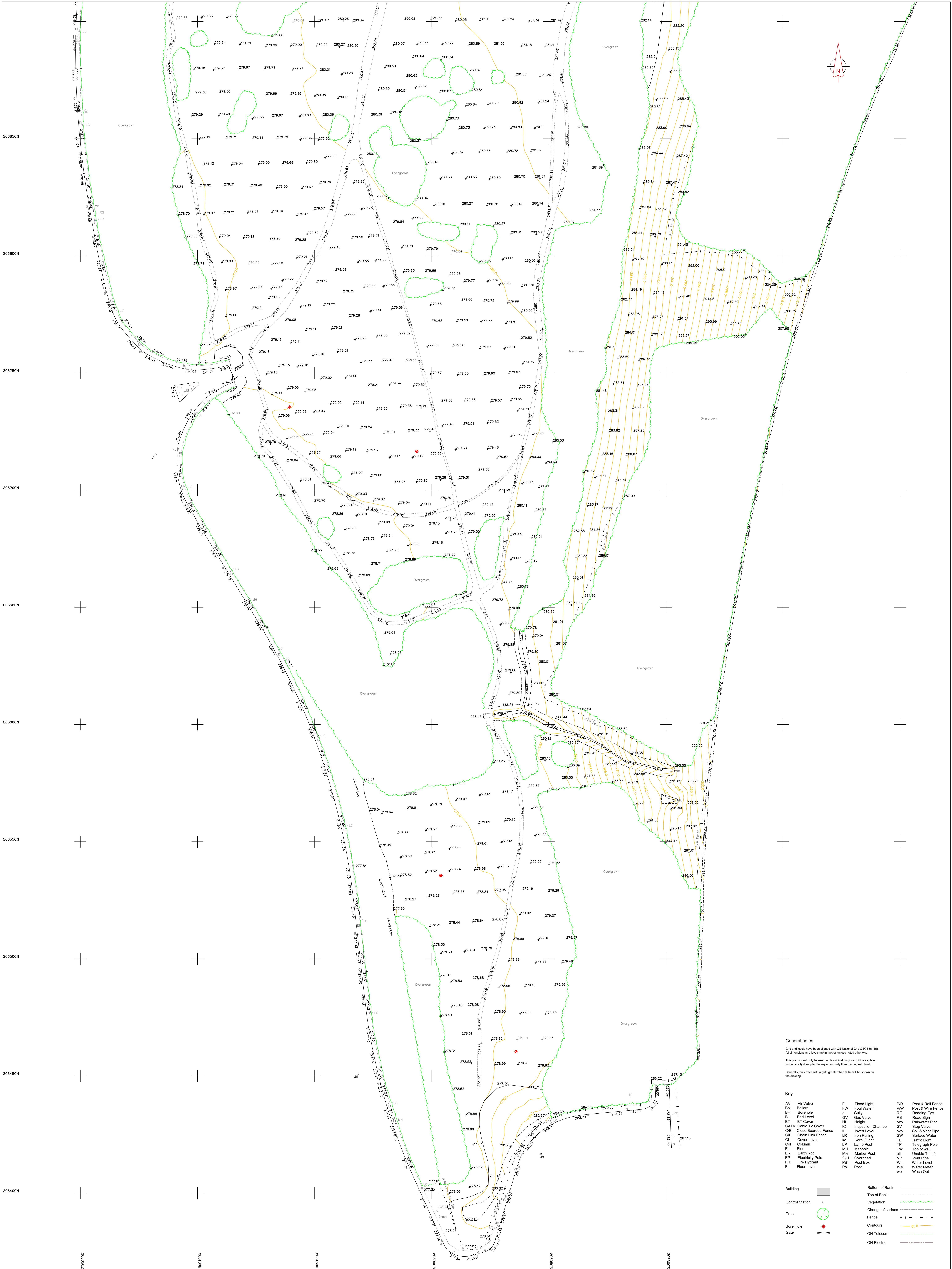
Grid and levels have been aligned with OS National Grid OSG308 (15).
All dimensions and levels are in metres unless noted otherwise.

This plan should only be used for its original purpose. JPP accepts no responsibility if supplied to any other party than the original client.

Generally, only trees with a girth greater than 0.1m will be shown on the drawing.

Key					
AV	Air Valve	FL	Flood Light	PR	Post & Rail Fence
Bol	Bollard	FW	Foul Water	PW	Post & Wire Fence
BH	Borehole	G	Gully	RE	Rodding Eye
BL	Bird Level	GV	Gas Valve	RS	Road Sign
BT	BT Cover	HT	Height	RWP	Rainwater Pipe
CATV	Cable TV Cover	IC	Inspection Chamber	SV	Stop Valve
C/B	Close Boarded Fence	IL	Invert Level	SW	Soil & Vent Pipe
CL	Chain Link Fence	UR	Iron Railing	TL	Traffic Light
CL	Cover Level	K	Kent Outlet	TP	Telegraph Pole
Col	Column	L	Lamp Post	TP	Telegraph Pole
EL	Electric	MH	Manhole	TW	Top of Wall
ER	Earth Rod	MR	Manhole Post	U/L	Unable To Lift
EP	Electricity Pole	LP	Lamp Post	VP	Vent Pipe
PH	Fire Hydrant	PB	Post Box	WL	Water Level
FL	Floor Level	P	Post	WM	Water Meter

Building	Bottom of Bank
Control Station	Top of Bank
Tree	Vegetation
Bore Hole	Change of surface
Gate	Fence
	Contours
	OH Telecom
	OH Electric



General notes

Grid and levels have been aligned with OS National Grid OSG83 (15). All dimensions and levels are in metres unless noted otherwise.

This plan should only be used for its original purpose. JPP accepts no responsibility if applied to any other earth than the original client.

Generally, only trees with a girth greater than 0.1m will be shown on the drawing.

Key

AV	Air Valve	FL	Flood Light	P/R	Post & Rail Fence
Bol	Bollard	FW	Foul Water	P/W	Post & Wire Fence
BM	Bornhole	G	Gully	RE	Rodding Eye
BL	Bed Level	GV	Gas Valve	RS	Road Sign
BT	BT Cover	HL	Height	rwp	Rainwater Pipe
CATV	Cable TV Cover	IC	Inspection Chamber	SV	Stop Valve
C/B	Close Boarded Fence	IL	Invert Level	s/vp	Soil & Vent Pipe
CL	Chain Link Fence	IR	Iron Railing	SW	Surface Water
CL	Cover Level	ko	Keith Outlet	TL	Traffic Light
Col	Column	LP	Lamp Post	TP	Telegraph Pole
EI	Electric	MH	Manhole	TW	Top of wall
ER	Earth Rod	M/P	Marker Post	u/l	Unable To Lift
EP	Electricity Pole	O/H	Overhead	VP	Vent Pipe
FH	Fire Hydrant	PS	Post Box	WL	Water Level
FL	Floor Level	Po	Post	WM	Water Meter
				wo	Wash Out

Building

Control Station

Tree

Bore Hole

Gate

Bottom of Bank

Top of Bank

Vegetation

Change of surface

Fence

Contours

OH Telecom

OH Electric

APPENDIX 3 – Watercourses



1. Photo culvert pipe



2. Photo steel security point



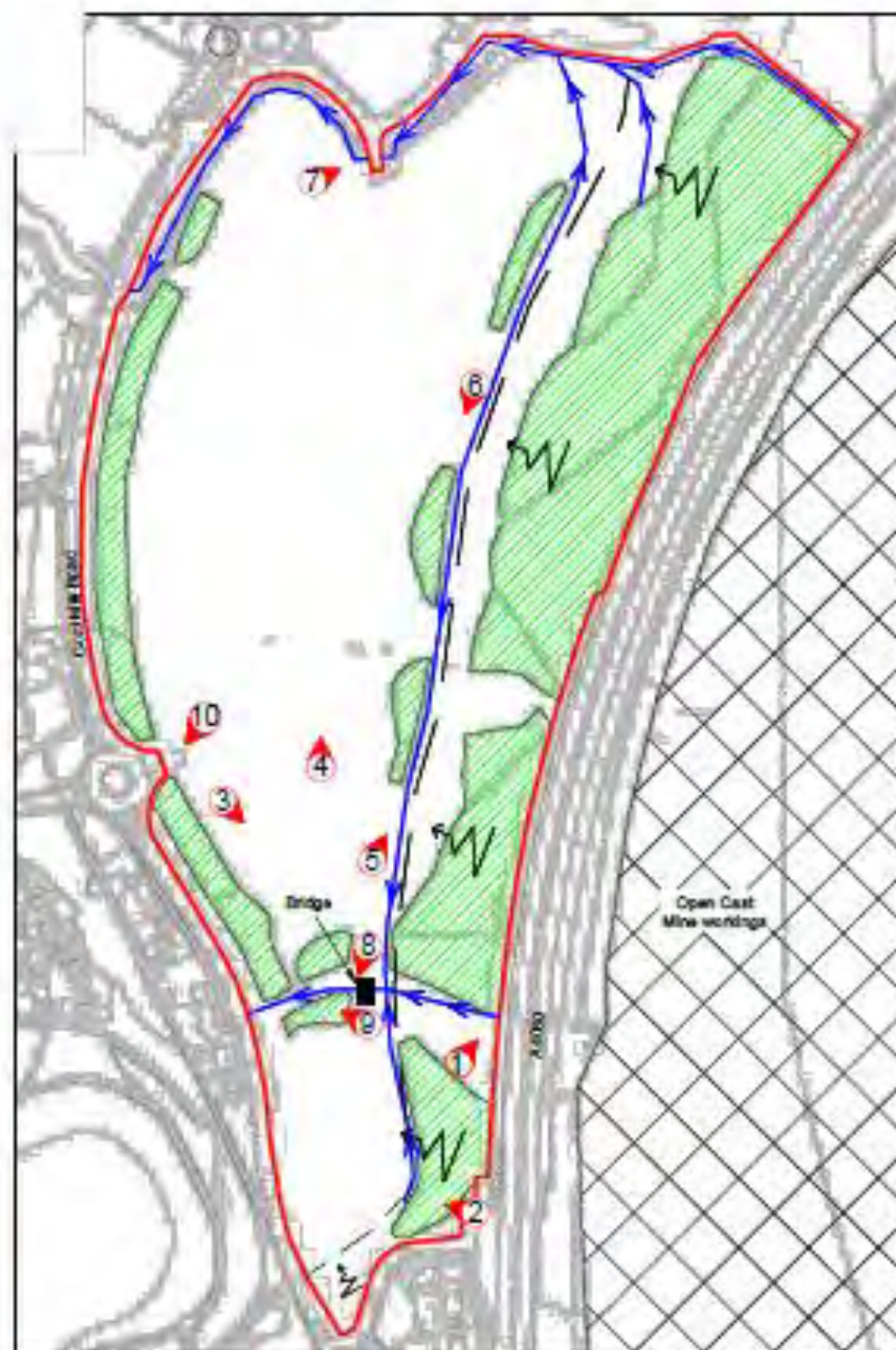
3. Landscape



4. Landscape



5. Landscape



6. Landscape



7. Photo bridge



8. Photo bridge

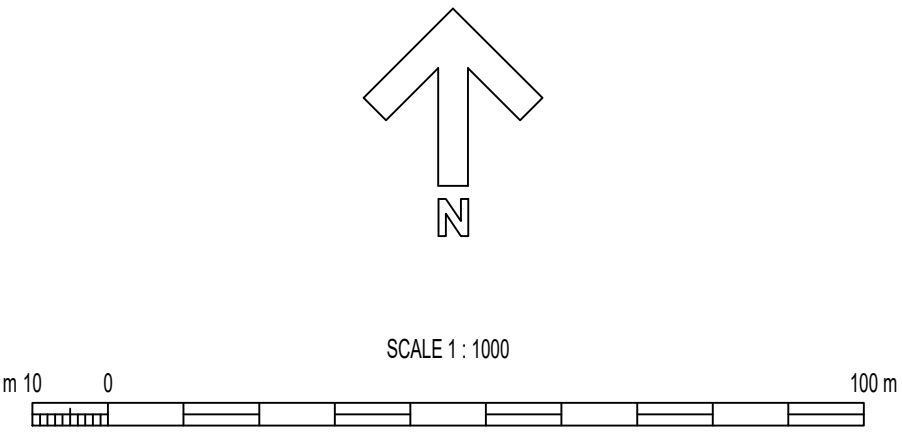
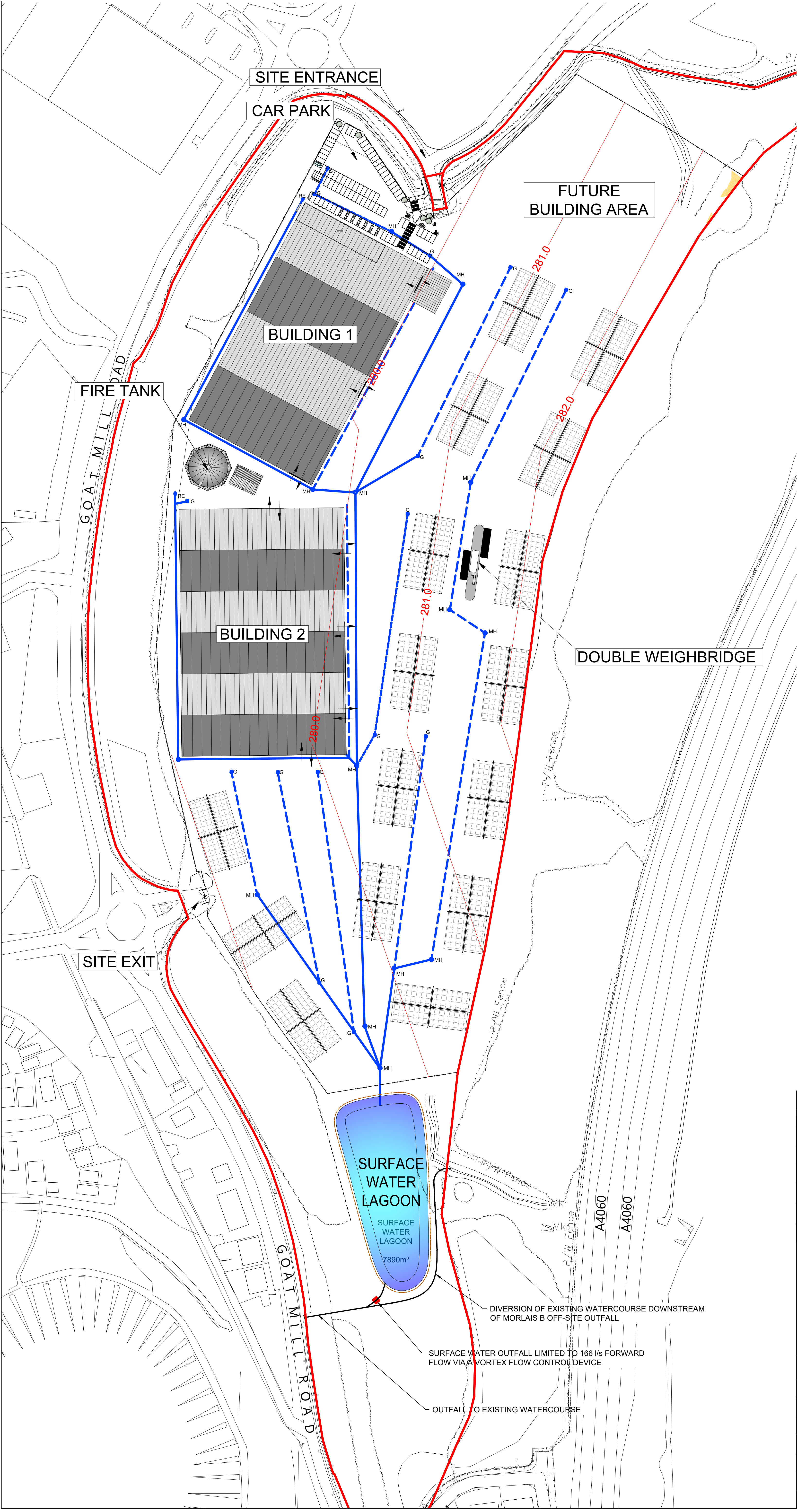


9. Photo stream



10. Photo stream

APPENDIX 4 – SuDS Design



- KEY**
- PLANNING APPLICATION BOUNDARY
 - PROPOSED DEVELOPMENT PLATFORM CONTOURS
 - PROPOSED PALADIN SECURITY FENCE
 - PROPOSED UNDERGROUND SURFACE WATER DRAINAGE
 - PROPOSED LINEAR DRAINAGE CHANNEL AND ASSOCIATED SUMP OUTLET
 - SURFACE WATER OUTFALL LIMITED TO 166 l/s FORWARD FLOW VIA A VORTEX FLOW CONTROL DEVICE
 - SWALE/LINEAR GRASSED CHANNEL
 - PROPOSED MANHOLE
 - PROPOSED GULLY

B	03.03.22	STORAGE BALES LAYOUT AMENDED. DRAINAGE UPDATED	AP
A	25.08.21	PROPOSED LAYOUT UPDATED & DRAINAGE AMENDED	AP
Rev.	Date:	Notes:	By:
KRS ENVIRONMENTAL TEL: 01484 437420 MOBILE: 07857264376 3 PRINCES SQUARE PRINCES STREET MONTGOMERY POWYS SY15 6PZ			
Job:	GOAT MILL ROAD, MERTHYR TYDFILL		
Client:	SIRIUS PLANNING		
Drawing Title:	PROPOSED SURFACE WATER DRAINAGE		
Date:	MARCH 2021		
Drawing No:	KRS.0297.021.01	revision:	B
Scale:	1:1000@A1		
Drawn:	AP		
Status:	FOR DISCUSSION		

APPENDIX 5 – ReFH2 Method Calculations

KRS Environmental Ltd		Page 1
3 Princes Square Princes Street, Montgomery Powys, Shrewsbury, SY15 6PZ		
Date 11/02/2021 21:26 File	Designed by Emma Checked by	
Innovyze		Source Control 2020.1
<u>ICP SUDS Mean Annual Flood</u> Input Return Period (years) 100 Soil 0.500 Area (ha) 9.745 Urban 0.000 SAAR (mm) 1600 Region Number Region 9 Results l/s QBAR Rural 141.5 QBAR Urban 141.5 Q100 years 308.6 Q1 year 124.6 Q30 years 249.6 Q100 years 308.6		
©1982-2020 Innovyze		

KRS Environmental Ltd		Page 1																																																												
3 Princes Square Princes Street, Montgomery Powys, Shrewsbury, SY15 6PZ																																																														
Date 11/02/2021 21:43 File	Designed by Emma Checked by																																																													
Innovyze		Source Control 2020.1																																																												
<u>ReFH2 Rural Runoff Peak Flows</u> Input <table> <tr> <td>Return Period (Years)</td> <td>2</td> </tr> <tr> <td>FEH Rainfall Version</td> <td>2013</td> </tr> <tr> <td>Site Location</td> <td>GB 306200 207000 SO 06200 07000</td> </tr> <tr> <td>Data Type</td> <td>Point</td> </tr> <tr> <td>Season</td> <td>Summer</td> </tr> <tr> <td>Country</td> <td>England/Wales/Northern Ireland</td> </tr> <tr> <td>Area (ha)</td> <td>9.745</td> </tr> <tr> <td>SAAR (mm)</td> <td>1446</td> </tr> <tr> <td>BFIHOST</td> <td>0.318</td> </tr> <tr> <td>FARL</td> <td>0.000</td> </tr> <tr> <td>SPRHOST</td> <td>0.000</td> </tr> <tr> <td>URBEXT (2000)</td> <td>0.0000</td> </tr> </table> Results <table> <thead> <tr> <th>Return Period (Years)</th> <th>Rural (l/s)</th> <th>Urban (l/s)</th> </tr> </thead> <tbody> <tr> <td>User</td> <td>166.3</td> <td>166.3</td> </tr> <tr> <td>Q1</td> <td>144.3</td> <td>144.3</td> </tr> <tr> <td>Q2</td> <td>166.3</td> <td>166.3</td> </tr> <tr> <td>Q5</td> <td>237.3</td> <td>237.3</td> </tr> <tr> <td>Q10</td> <td>286.8</td> <td>286.8</td> </tr> <tr> <td>Q30</td> <td>366.9</td> <td>366.9</td> </tr> <tr> <td>Q50</td> <td>406.6</td> <td>406.6</td> </tr> <tr> <td>Q75</td> <td>440.0</td> <td>440.0</td> </tr> <tr> <td>Q100</td> <td>465.4</td> <td>465.4</td> </tr> <tr> <td>Q200</td> <td>535.1</td> <td>535.1</td> </tr> <tr> <td>Q1000</td> <td>808.4</td> <td>808.4</td> </tr> </tbody> </table>			Return Period (Years)	2	FEH Rainfall Version	2013	Site Location	GB 306200 207000 SO 06200 07000	Data Type	Point	Season	Summer	Country	England/Wales/Northern Ireland	Area (ha)	9.745	SAAR (mm)	1446	BFIHOST	0.318	FARL	0.000	SPRHOST	0.000	URBEXT (2000)	0.0000	Return Period (Years)	Rural (l/s)	Urban (l/s)	User	166.3	166.3	Q1	144.3	144.3	Q2	166.3	166.3	Q5	237.3	237.3	Q10	286.8	286.8	Q30	366.9	366.9	Q50	406.6	406.6	Q75	440.0	440.0	Q100	465.4	465.4	Q200	535.1	535.1	Q1000	808.4	808.4
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APPENDIX 6 – Flood Estimation Handbook 2013 Rainfall Calculations

VERSION "FEH Web Version 1.0.0 exported at 21:45:27 GMT Thu 11-Feb-21

Parameters

Rainfall method FEH 2013

Calculation Design rainfall

Calculation For a point

Calculation Point GB 306200 207000 SO 06200 07000

Duration= 6 Hours

Fixed duration

Return period 100 Years

Annual maximum

A design rainfall of 72.81 mm was calculated.

This design rainfall has been calculated for a return period on the annual maximum scale.

The data in the following table have been computed using sliding durations.

Duration h	Duration d	2 year rain	5 year rain	10 year rain	20 year rain	30 year rain	50 year rain	75 year rain	100 year rain
0.25	0.010417	6.04	9.52	11.93	14.15	15.43	17	18.35	19.36
0.5	0.020833	8.62	13.52	16.96	20.27	22.28	24.81	26.86	28.37
0.75	0.03125	10.37	16.36	20.49	24.62	27.16	30.29	32.82	34.69
1	0.041667	11.84	18.6	23.38	28.1	30.93	34.57	37.52	39.69
1.25	0.052083	13.5	20.74	25.84	30.8	33.77	37.6	40.72	43.02
1.5	0.0625	15.15	22.71	27.99	33.1	36.16	40.1	43.32	45.7
1.75	0.072917	16.75	24.54	29.93	35.13	38.26	42.27	45.56	48
2	0.083333	18.27	26.25	31.7	36.97	40.16	44.22	47.56	50.05
2.25	0.09375	19.59	27.81	33.37	38.77	42.01	46.15	49.57	52.11
2.5	0.104167	20.83	29.27	34.92	40.44	43.73	47.95	51.43	54.04
2.75	0.114583	22	30.65	36.38	42.01	45.35	49.64	53.18	55.84
3	0.125	23.11	31.95	37.76	43.5	46.88	51.23	54.84	57.54
3.25	0.135417	24.17	33.18	39.07	44.91	48.32	52.74	56.4	59.14
3.5	0.145833	25.18	34.35	40.32	46.24	49.7	54.17	57.88	60.67
3.75	0.15625	26.14	35.47	41.51	47.52	51.01	55.54	59.3	62.13
4	0.166667	27.07	36.54	42.64	48.74	52.26	56.84	60.66	63.52
4.25	0.177083	27.96	37.55	43.73	49.89	53.46	58.08	61.94	64.85
4.5	0.1875	28.81	38.51	44.78	50.99	54.6	59.27	63.18	66.12
4.75	0.197917	29.63	39.44	45.78	52.05	55.7	60.41	64.37	67.34
5	0.208333	30.43	40.33	46.75	53.07	56.75	61.51	65.51	68.52
5.25	0.21875	31.19	41.18	47.68	54.05	57.77	62.57	66.6	69.65
5.5	0.229167	31.93	42.01	48.58	54.99	58.76	63.59	67.66	70.74
5.75	0.239583	32.65	42.81	49.45	55.91	59.71	64.57	68.69	71.79
6	0.25	33.34	43.59	50.29	56.8	60.63	65.53	69.68	72.81
6.25	0.260417	34.01	44.34	51.1	57.65	61.51	66.45	70.63	73.79
6.5	0.270833	34.66	45.08	51.89	58.48	62.37	67.34	71.55	74.73
6.75	0.28125	35.29	45.79	52.66	59.29	63.2	68.21	72.45	75.64
7	0.291667	35.91	46.48	53.4	60.07	64.01	69.05	73.31	76.53
7.25	0.302083	36.5	47.15	54.12	60.83	64.8	69.86	74.16	77.4
7.5	0.3125	37.09	47.8	54.82	61.58	65.56	70.66	74.98	78.23
7.75	0.322917	37.65	48.44	55.5	62.3	66.31	71.43	75.78	79.05
8	0.333333	38.2	49.06	56.17	63	67.03	72.19	76.55	79.85
8.25	0.34375	38.74	49.66	56.82	63.69	67.74	72.93	77.31	80.62
8.5	0.354167	39.27	50.26	57.45	64.36	68.43	73.64	78.05	81.38
8.75	0.364583	39.78	50.83	58.07	65.01	69.11	74.35	78.78	82.12
9	0.375	40.28	51.4	58.68	65.65	69.77	75.03	79.49	82.84

9.25	0.385417	40.77	51.95	59.27	66.28	70.41	75.71	80.18	83.55
9.5	0.395833	41.26	52.49	59.85	66.89	71.05	76.36	80.85	84.24
9.75	0.40625	41.73	53.02	60.42	67.49	71.66	77.01	81.52	84.91
10	0.416667	42.19	53.54	60.97	68.08	72.27	77.64	82.17	85.57
10.25	0.427083	42.64	54.05	61.52	68.66	72.86	78.25	82.8	86.22
10.5	0.4375	43.08	54.55	62.05	69.22	73.45	78.86	83.43	86.86
10.75	0.447917	43.52	55.04	62.57	69.77	74.02	79.46	84.04	87.48
11	0.458333	43.94	55.52	63.09	70.32	74.58	80.04	84.64	88.1
11.25	0.46875	44.36	56	63.59	70.85	75.13	80.61	85.23	88.7
11.5	0.479167	44.77	56.46	64.09	71.38	75.67	81.18	85.81	89.29
11.75	0.489583	45.18	56.92	64.57	71.89	76.2	81.73	86.38	89.87
12	0.5	45.57	57.36	65.05	72.4	76.72	82.27	86.94	90.44
12.25	0.510417	45.96	57.8	65.51	72.89	77.23	82.8	87.48	90.99
12.5	0.520833	46.34	58.23	65.97	73.37	77.73	83.33	88.02	91.54
12.75	0.53125	46.71	58.65	66.42	73.85	78.22	83.84	88.55	92.08
13	0.541667	47.08	59.06	66.86	74.32	78.71	84.34	89.07	92.61
13.25	0.552083	47.44	59.47	67.3	74.78	79.18	84.84	89.58	93.13
13.5	0.5625	47.79	59.88	67.73	75.24	79.65	85.33	90.08	93.64
13.75	0.572917	48.14	60.27	68.15	75.68	80.12	85.82	90.58	94.15
14	0.583333	48.49	60.66	68.57	76.13	80.57	86.29	91.07	94.65
14.25	0.59375	48.83	61.05	68.98	76.56	81.02	86.76	91.56	95.15
14.5	0.604167	49.17	61.43	69.38	76.99	81.47	87.23	92.03	95.63
14.75	0.614583	49.5	61.8	69.78	77.42	81.91	87.69	92.5	96.11
15	0.625	49.82	62.17	70.18	77.84	82.34	88.14	92.97	96.59
15.25	0.635417	50.14	62.54	70.57	78.25	82.77	88.58	93.43	97.06
15.5	0.645833	50.46	62.9	70.95	78.66	83.19	89.03	93.88	97.52
15.75	0.65625	50.78	63.25	71.33	79.06	83.6	89.46	94.33	97.97
16	0.666667	51.09	63.6	71.71	79.46	84.02	89.89	94.77	98.43
16.25	0.677083	51.39	63.95	72.08	79.85	84.42	90.32	95.21	98.87
16.5	0.6875	51.69	64.29	72.44	80.24	84.83	90.74	95.65	99.31
16.75	0.697917	51.99	64.63	72.81	80.63	85.22	91.15	96.07	99.75
17	0.708333	52.29	64.97	73.16	81.01	85.62	91.56	96.5	100.18
17.25	0.71875	52.58	65.3	73.52	81.38	86.01	91.97	96.92	100.61
17.5	0.729167	52.87	65.63	73.87	81.76	86.39	92.37	97.33	101.03
17.75	0.739583	53.15	65.95	74.21	82.13	86.77	92.77	97.74	101.45
18	0.75	53.43	66.27	74.56	82.49	87.15	93.16	98.15	101.87
18.25	0.760417	53.71	66.59	74.89	82.85	87.52	93.55	98.55	102.28
18.5	0.770833	53.98	66.9	75.23	83.21	87.89	93.94	98.95	102.69
18.75	0.78125	54.25	67.21	75.56	83.56	88.26	94.32	99.34	103.09
19	0.791667	54.52	67.52	75.89	83.91	88.62	94.7	99.74	103.49
19.25	0.802083	54.79	67.82	76.22	84.26	88.98	95.08	100.13	103.89
19.5	0.8125	55.05	68.12	76.54	84.61	89.34	95.45	100.51	104.28
19.75	0.822917	55.31	68.42	76.86	84.95	89.69	95.82	100.89	104.67
20	0.833333	55.57	68.71	77.18	85.29	90.04	96.19	101.27	105.06
20.25	0.84375	55.82	69.01	77.49	85.62	90.39	96.55	101.65	105.45
20.5	0.854167	56.08	69.3	77.8	85.95	90.74	96.91	102.02	105.83
20.75	0.864583	56.33	69.58	78.11	86.28	91.08	97.27	102.39	106.2
21	0.875	56.58	69.87	78.42	86.61	91.42	97.62	102.75	106.58
21.25	0.885417	56.83	70.15	78.73	86.94	91.75	97.97	103.12	106.95
21.5	0.895833	57.07	70.43	79.03	87.26	92.09	98.32	103.48	107.32

21.75	0.90625	57.31	70.71	79.33	87.58	92.42	98.67	103.84	107.69
22	0.916667	57.55	70.99	79.62	87.9	92.75	99.01	104.19	108.05
22.25	0.927083	57.79	71.26	79.92	88.21	93.08	99.35	104.54	108.41
22.5	0.9375	58.03	71.54	80.21	88.52	93.4	99.69	104.89	108.77
22.75	0.947917	58.27	71.81	80.5	88.83	93.72	100.02	105.24	109.12
23	0.958333	58.5	72.07	80.79	89.14	94.04	100.36	105.58	109.48
23.25	0.96875	58.73	72.34	81.08	89.45	94.36	100.69	105.93	109.83
23.5	0.979167	58.96	72.6	81.36	89.75	94.67	101.02	106.27	110.17
23.75	0.989583	59.19	72.87	81.64	90.05	94.99	101.34	106.6	110.52
24	1	59.42	73.13	81.92	90.35	95.3	101.67	106.94	110.86
24.25	1.010417	59.64	73.38	82.2	90.65	95.6	101.99	107.27	111.2
24.5	1.020833	59.86	73.64	82.47	90.94	95.9	102.3	107.59	111.53
24.75	1.03125	60.08	73.89	82.75	91.23	96.21	102.62	107.92	111.86
25	1.041667	60.3	74.14	83.02	91.52	96.51	102.93	108.24	112.19
25.25	1.052083	60.51	74.39	83.29	91.81	96.8	103.24	108.56	112.52
25.5	1.0625	60.73	74.63	83.55	92.09	97.1	103.55	108.88	112.84
25.75	1.072917	60.94	74.88	83.82	92.38	97.39	103.85	109.19	113.16
26	1.083333	61.16	75.13	84.08	92.66	97.68	104.16	109.51	113.48
26.25	1.09375	61.37	75.37	84.35	92.94	97.97	104.46	109.82	113.8
26.5	1.104167	61.58	75.61	84.61	93.22	98.26	104.76	110.13	114.12
26.75	1.114583	61.79	75.85	84.87	93.5	98.55	105.06	110.44	114.43
27	1.125	62	76.09	85.12	93.77	98.84	105.36	110.75	114.75
27.25	1.135417	62.2	76.33	85.38	94.05	99.12	105.66	111.05	115.06
27.5	1.145833	62.41	76.56	85.64	94.32	99.4	105.95	111.36	115.37
27.75	1.15625	62.61	76.8	85.89	94.59	99.68	106.24	111.66	115.68
28	1.166667	62.82	77.03	86.14	94.86	99.96	106.54	111.96	115.98
28.25	1.177083	63.02	77.26	86.4	95.13	100.24	106.83	112.26	116.29
28.5	1.1875	63.22	77.49	86.65	95.4	100.52	107.12	112.56	116.59
28.75	1.197917	63.42	77.72	86.89	95.66	100.79	107.4	112.85	116.89
29	1.208333	63.62	77.95	87.14	95.93	101.07	107.69	113.15	117.19
29.25	1.21875	63.82	78.18	87.39	96.19	101.34	107.97	113.44	117.49
29.5	1.229167	64.01	78.41	87.63	96.45	101.61	108.26	113.73	117.79
29.75	1.239583	64.21	78.63	87.88	96.71	101.88	108.54	114.02	118.08
30	1.25	64.4	78.86	88.12	96.97	102.15	108.82	114.31	118.38
30.25	1.260417	64.6	79.08	88.36	97.23	102.42	109.1	114.6	118.67
30.5	1.270833	64.79	79.3	88.6	97.49	102.69	109.37	114.88	118.96
30.75	1.28125	64.98	79.53	88.84	97.74	102.95	109.65	115.17	119.25
31	1.291667	65.17	79.75	89.08	98	103.22	109.93	115.45	119.54
31.25	1.302083	65.36	79.97	89.32	98.25	103.48	110.2	115.74	119.83
31.5	1.3125	65.55	80.18	89.56	98.51	103.74	110.47	116.02	120.12
31.75	1.322917	65.74	80.4	89.79	98.76	104	110.75	116.3	120.4
32	1.333333	65.93	80.62	90.03	99.01	104.26	111.02	116.57	120.69
32.25	1.34375	66.12	80.83	90.26	99.26	104.52	111.29	116.85	120.97
32.5	1.354167	66.3	81.05	90.49	99.51	104.78	111.55	117.13	121.25
32.75	1.364583	66.49	81.26	90.72	99.75	105.03	111.82	117.4	121.53
33	1.375	66.67	81.47	90.95	100	105.29	112.09	117.68	121.81
33.25	1.385417	66.86	81.69	91.18	100.25	105.54	112.35	117.95	122.09
33.5	1.395833	67.04	81.9	91.41	100.49	105.8	112.62	118.22	122.36
33.75	1.40625	67.22	82.11	91.64	100.73	106.05	112.88	118.49	122.64
34	1.416667	67.4	82.32	91.87	100.98	106.3	113.14	118.76	122.91

34.25	1.427083	67.58	82.53	92.09	101.22	106.55	113.4	119.03	123.19
34.5	1.4375	67.76	82.73	92.32	101.46	106.8	113.66	119.3	123.46
34.75	1.447917	67.94	82.94	92.54	101.7	107.05	113.92	119.57	123.73
35	1.458333	68.12	83.15	92.77	101.94	107.3	114.18	119.83	124
35.25	1.46875	68.3	83.35	92.99	102.18	107.54	114.44	120.1	124.27
35.5	1.479167	68.48	83.56	93.21	102.41	107.79	114.69	120.36	124.54
35.75	1.489583	68.65	83.76	93.43	102.65	108.03	114.95	120.62	124.81
36	1.5	68.83	83.96	93.65	102.89	108.28	115.2	120.88	125.07
36.25	1.510417	69.01	84.17	93.87	103.12	108.52	115.46	121.14	125.34
36.5	1.520833	69.18	84.37	94.09	103.36	108.76	115.71	121.4	125.6
36.75	1.53125	69.35	84.57	94.31	103.59	109.01	115.96	121.66	125.87
37	1.541667	69.53	84.77	94.53	103.82	109.25	116.21	121.92	126.13
37.25	1.552083	69.7	84.97	94.75	104.05	109.49	116.46	122.18	126.39
37.5	1.5625	69.87	85.17	94.96	104.28	109.73	116.71	122.44	126.65
37.75	1.572917	70.04	85.37	95.18	104.51	109.96	116.96	122.69	126.91
38	1.583333	70.21	85.57	95.39	104.74	110.2	117.21	122.95	127.17
38.25	1.59375	70.39	85.76	95.61	104.97	110.44	117.45	123.2	127.43
38.5	1.604167	70.55	85.96	95.82	105.2	110.67	117.7	123.45	127.69
38.75	1.614583	70.72	86.15	96.03	105.43	110.91	117.94	123.7	127.94
39	1.625	70.89	86.35	96.24	105.65	111.14	118.19	123.96	128.2
39.25	1.635417	71.06	86.54	96.45	105.88	111.38	118.43	124.21	128.45
39.5	1.645833	71.23	86.74	96.67	106.11	111.61	118.68	124.46	128.71
39.75	1.65625	71.4	86.93	96.88	106.33	111.84	118.92	124.71	128.96
40	1.666667	71.56	87.12	97.08	106.55	112.08	119.16	124.95	129.21
40.25	1.677083	71.73	87.32	97.29	106.78	112.31	119.4	125.2	129.46
40.5	1.6875	71.89	87.51	97.5	107	112.54	119.64	125.45	129.72
40.75	1.697917	72.06	87.7	97.71	107.22	112.77	119.88	125.69	129.97
41	1.708333	72.22	87.89	97.92	107.44	113	120.12	125.94	130.22
41.25	1.71875	72.39	88.08	98.12	107.66	113.23	120.36	126.18	130.46
41.5	1.729167	72.55	88.27	98.33	107.88	113.45	120.59	126.43	130.71
41.75	1.739583	72.71	88.46	98.53	108.1	113.68	120.83	126.67	130.96
42	1.75	72.88	88.65	98.74	108.32	113.91	121.07	126.91	131.21
42.25	1.760417	73.04	88.83	98.94	108.54	114.13	121.3	127.16	131.45
42.5	1.770833	73.2	89.02	99.15	108.76	114.36	121.54	127.4	131.7
42.75	1.78125	73.36	89.21	99.35	108.97	114.58	121.77	127.64	131.94
43	1.791667	73.52	89.39	99.55	109.19	114.81	122	127.88	132.19
43.25	1.802083	73.68	89.58	99.75	109.41	115.03	122.24	128.12	132.43
43.5	1.8125	73.84	89.77	99.95	109.62	115.25	122.47	128.36	132.67
43.75	1.822917	74	89.95	100.15	109.84	115.48	122.7	128.59	132.91
44	1.833333	74.16	90.13	100.35	110.05	115.7	122.93	128.83	133.16
44.25	1.84375	74.32	90.32	100.55	110.27	115.92	123.16	129.07	133.4
44.5	1.854167	74.47	90.5	100.75	110.48	116.14	123.39	129.3	133.64
44.75	1.864583	74.63	90.68	100.95	110.69	116.36	123.62	129.54	133.88
45	1.875	74.79	90.87	101.15	110.9	116.58	123.85	129.78	134.11
45.25	1.885417	74.95	91.05	101.35	111.12	116.8	124.08	130.01	134.35
45.5	1.895833	75.1	91.23	101.55	111.33	117.02	124.31	130.24	134.59
45.75	1.90625	75.26	91.41	101.74	111.54	117.24	124.53	130.48	134.83
46	1.916667	75.41	91.59	101.94	111.75	117.45	124.76	130.71	135.06
46.25	1.927083	75.57	91.77	102.13	111.96	117.67	124.99	130.94	135.3
46.5	1.9375	75.72	91.95	102.33	112.17	117.89	125.21	131.17	135.54

46.75	1.947917	75.88	92.13	102.53	112.37	118.1	125.44	131.4	135.77
47	1.958333	76.03	92.31	102.72	112.58	118.32	125.66	131.64	136
47.25	1.96875	76.19	92.49	102.91	112.79	118.54	125.88	131.87	136.24
47.5	1.979167	76.34	92.67	103.11	113	118.75	126.11	132.09	136.47
47.75	1.989583	76.49	92.84	103.3	113.2	118.96	126.33	132.32	136.7
48	2	76.64	93.02	103.49	113.41	119.18	126.55	132.55	136.94
48.25	2.010417	76.8	93.2	103.69	113.62	119.39	126.78	132.78	137.17
48.5	2.020833	76.95	93.38	103.88	113.83	119.61	127	133.01	137.4
48.75	2.03125	77.1	93.56	104.08	114.03	119.82	127.22	133.24	137.63
49	2.041667	77.25	93.74	104.27	114.24	120.04	127.44	133.47	137.87
49.25	2.052083	77.41	93.91	104.46	114.45	120.25	127.67	133.7	138.1
49.5	2.0625	77.56	94.09	104.65	114.65	120.46	127.89	133.92	138.33
49.75	2.072917	77.71	94.27	104.84	114.86	120.68	128.11	134.15	138.56
50	2.083333	77.86	94.44	105.04	115.06	120.89	128.33	134.38	138.79
50.25	2.09375	78.01	94.62	105.23	115.27	121.1	128.55	134.6	139.02
50.5	2.104167	78.16	94.8	105.42	115.47	121.31	128.77	134.83	139.25
50.75	2.114583	78.31	94.97	105.61	115.68	121.52	128.99	135.05	139.48
51	2.125	78.46	95.15	105.8	115.88	121.73	129.21	135.28	139.7
51.25	2.135417	78.61	95.32	105.99	116.08	121.94	129.43	135.5	139.93
51.5	2.145833	78.76	95.5	106.18	116.29	122.15	129.64	135.72	140.16
51.75	2.15625	78.91	95.67	106.37	116.49	122.36	129.86	135.95	140.39
52	2.166667	79.06	95.84	106.56	116.69	122.57	130.08	136.17	140.61
52.25	2.177083	79.21	96.02	106.74	116.89	122.78	130.3	136.39	140.84
52.5	2.1875	79.35	96.19	106.93	117.09	122.99	130.51	136.62	141.06
52.75	2.197917	79.5	96.36	107.12	117.29	123.2	130.73	136.84	141.29
53	2.208333	79.65	96.54	107.31	117.49	123.4	130.94	137.06	141.51
53.25	2.21875	79.8	96.71	107.49	117.69	123.61	131.16	137.28	141.74
53.5	2.229167	79.94	96.88	107.68	117.89	123.82	131.37	137.5	141.96
53.75	2.239583	80.09	97.05	107.87	118.09	124.02	131.59	137.72	142.19
54	2.25	80.24	97.22	108.05	118.29	124.23	131.8	137.94	142.41
54.25	2.260417	80.38	97.39	108.24	118.49	124.44	132.02	138.16	142.63
54.5	2.270833	80.53	97.56	108.42	118.69	124.64	132.23	138.38	142.86
54.75	2.28125	80.67	97.73	108.61	118.89	124.85	132.44	138.6	143.08
55	2.291667	80.82	97.9	108.79	119.09	125.05	132.66	138.82	143.3
55.25	2.302083	80.96	98.07	108.98	119.29	125.26	132.87	139.03	143.52
55.5	2.3125	81.11	98.24	109.16	119.48	125.46	133.08	139.25	143.74
55.75	2.322917	81.25	98.41	109.35	119.68	125.67	133.29	139.47	143.96
56	2.333333	81.4	98.58	109.53	119.88	125.87	133.5	139.69	144.18
56.25	2.34375	81.54	98.75	109.71	120.07	126.07	133.72	139.9	144.4
56.5	2.354167	81.68	98.92	109.9	120.27	126.28	133.93	140.12	144.62
56.75	2.364583	81.83	99.09	110.08	120.46	126.48	134.14	140.34	144.84
57	2.375	81.97	99.26	110.26	120.66	126.68	134.35	140.55	145.06
57.25	2.385417	82.11	99.42	110.44	120.86	126.88	134.56	140.77	145.28
57.5	2.395833	82.26	99.59	110.63	121.05	127.08	134.77	140.98	145.5
57.75	2.40625	82.4	99.76	110.81	121.24	127.29	134.98	141.2	145.72
58	2.416667	82.54	99.93	110.99	121.44	127.49	135.19	141.41	145.93
58.25	2.427083	82.68	100.09	111.17	121.63	127.69	135.39	141.62	146.15
58.5	2.4375	82.83	100.26	111.35	121.83	127.89	135.6	141.84	146.37
58.75	2.447917	82.97	100.42	111.53	122.02	128.09	135.81	142.05	146.59
59	2.458333	83.11	100.59	111.71	122.21	128.29	136.02	142.26	146.8

59.25	2.46875	83.25	100.76	111.89	122.41	128.49	136.23	142.48	147.02
59.5	2.479167	83.39	100.92	112.07	122.6	128.69	136.43	142.69	147.23
59.75	2.489583	83.53	101.09	112.25	122.79	128.89	136.64	142.9	147.45
60	2.5	83.67	101.25	112.43	122.98	129.09	136.85	143.11	147.66
60.25	2.510417	83.81	101.42	112.61	123.18	129.28	137.05	143.33	147.88
60.5	2.520833	83.95	101.58	112.79	123.37	129.48	137.26	143.54	148.09
60.75	2.53125	84.09	101.75	112.97	123.56	129.68	137.46	143.75	148.31
61	2.541667	84.23	101.91	113.15	123.75	129.88	137.67	143.96	148.52
61.25	2.552083	84.37	102.07	113.32	123.94	130.08	137.87	144.17	148.74
61.5	2.5625	84.51	102.24	113.5	124.13	130.27	138.08	144.38	148.95
61.75	2.572917	84.65	102.4	113.68	124.32	130.47	138.28	144.59	149.16
62	2.583333	84.79	102.56	113.86	124.51	130.67	138.49	144.8	149.38
62.25	2.59375	84.93	102.73	114.03	124.7	130.86	138.69	145.01	149.59
62.5	2.604167	85.07	102.89	114.21	124.89	131.06	138.9	145.22	149.8
62.75	2.614583	85.2	103.05	114.39	125.08	131.26	139.1	145.43	150.01
63	2.625	85.34	103.21	114.56	125.27	131.45	139.3	145.63	150.22
63.25	2.635417	85.48	103.38	114.74	125.46	131.65	139.51	145.84	150.44
63.5	2.645833	85.62	103.54	114.92	125.65	131.84	139.71	146.05	150.65
63.75	2.65625	85.76	103.7	115.09	125.84	132.04	139.91	146.26	150.86
64	2.666667	85.89	103.86	115.27	126.02	132.23	140.11	146.47	151.07
64.25	2.677083	86.03	104.02	115.44	126.21	132.43	140.32	146.67	151.28
64.5	2.6875	86.17	104.18	115.62	126.4	132.62	140.52	146.88	151.49
64.75	2.697917	86.3	104.34	115.79	126.59	132.81	140.72	147.09	151.7
65	2.708333	86.44	104.51	115.97	126.77	133.01	140.92	147.29	151.91
65.25	2.71875	86.58	104.67	116.14	126.96	133.2	141.12	147.5	152.12
65.5	2.729167	86.71	104.83	116.32	127.15	133.4	141.32	147.71	152.33
65.75	2.739583	86.85	104.99	116.49	127.33	133.59	141.52	147.91	152.54
66	2.75	86.99	105.15	116.66	127.52	133.78	141.72	148.12	152.75
66.25	2.760417	87.12	105.31	116.84	127.71	133.97	141.92	148.32	152.95
66.5	2.770833	87.26	105.46	117.01	127.89	134.17	142.12	148.53	153.16
66.75	2.78125	87.39	105.62	117.18	128.08	134.36	142.32	148.73	153.37
67	2.791667	87.53	105.78	117.36	128.26	134.55	142.52	148.94	153.58
67.25	2.802083	87.66	105.94	117.53	128.45	134.74	142.72	149.14	153.79
67.5	2.8125	87.8	106.1	117.7	128.63	134.93	142.92	149.34	153.99
67.75	2.822917	87.93	106.26	117.87	128.82	135.13	143.12	149.55	154.2
68	2.833333	88.07	106.42	118.05	129	135.32	143.32	149.75	154.41
68.25	2.84375	88.2	106.58	118.22	129.19	135.51	143.52	149.96	154.61
68.5	2.854167	88.34	106.73	118.39	129.37	135.7	143.71	150.16	154.82
68.75	2.864583	88.47	106.89	118.56	129.56	135.89	143.91	150.36	155.03
69	2.875	88.6	107.05	118.73	129.74	136.08	144.11	150.56	155.23
69.25	2.885417	88.74	107.21	118.9	129.92	136.27	144.31	150.77	155.44
69.5	2.895833	88.87	107.36	119.08	130.11	136.46	144.5	150.97	155.64
69.75	2.90625	89	107.52	119.25	130.29	136.65	144.7	151.17	155.85
70	2.916667	89.14	107.68	119.42	130.47	136.84	144.9	151.37	156.05
70.25	2.927083	89.27	107.83	119.59	130.66	137.03	145.1	151.58	156.26
70.5	2.9375	89.4	107.99	119.76	130.84	137.22	145.29	151.78	156.46
70.75	2.947917	89.54	108.15	119.93	131.02	137.41	145.49	151.98	156.67
71	2.958333	89.67	108.3	120.1	131.21	137.6	145.68	152.18	156.87
71.25	2.96875	89.8	108.46	120.27	131.39	137.78	145.88	152.38	157.08
71.5	2.979167	89.93	108.62	120.44	131.57	137.97	146.08	152.58	157.28

71.75	2.989583	90.07	108.77	120.61	131.75	138.16	146.27	152.78	157.48
72	3	90.2	108.93	120.78	131.93	138.35	146.47	152.98	157.69
72.25	3.010417	90.33	109.08	120.95	132.11	138.54	146.66	153.18	157.89
72.5	3.020833	90.46	109.24	121.11	132.3	138.73	146.86	153.38	158.09
72.75	3.03125	90.59	109.39	121.28	132.48	138.91	147.05	153.58	158.3
73	3.041667	90.72	109.55	121.45	132.66	139.1	147.25	153.78	158.5
73.25	3.052083	90.86	109.7	121.62	132.84	139.29	147.44	153.98	158.7
73.5	3.0625	90.99	109.86	121.79	133.02	139.47	147.63	154.18	158.9
73.75	3.072917	91.12	110.01	121.96	133.2	139.66	147.83	154.38	159.11
74	3.083333	91.25	110.17	122.13	133.38	139.85	148.02	154.58	159.31
74.25	3.09375	91.38	110.32	122.29	133.56	140.03	148.22	154.78	159.51
74.5	3.104167	91.51	110.48	122.46	133.74	140.22	148.41	154.98	159.71
74.75	3.114583	91.64	110.63	122.63	133.92	140.41	148.6	155.17	159.91
75	3.125	91.77	110.78	122.8	134.1	140.59	148.8	155.37	160.11
75.25	3.135417	91.9	110.94	122.96	134.28	140.78	148.99	155.57	160.32
75.5	3.145833	92.03	111.09	123.13	134.46	140.96	149.18	155.77	160.52
75.75	3.15625	92.16	111.24	123.3	134.64	141.15	149.37	155.97	160.72
76	3.166667	92.29	111.4	123.46	134.82	141.34	149.57	156.16	160.92
76.25	3.177083	92.42	111.55	123.63	135	141.52	149.76	156.36	161.12
76.5	3.1875	92.55	111.7	123.8	135.18	141.71	149.95	156.56	161.32
76.75	3.197917	92.68	111.86	123.96	135.35	141.89	150.14	156.75	161.52
77	3.208333	92.81	112.01	124.13	135.53	142.08	150.34	156.95	161.72
77.25	3.21875	92.94	112.16	124.3	135.71	142.26	150.53	157.15	161.92
77.5	3.229167	93.07	112.31	124.46	135.89	142.44	150.72	157.34	162.12
77.75	3.239583	93.2	112.47	124.63	136.07	142.63	150.91	157.54	162.32
78	3.25	93.33	112.62	124.79	136.24	142.81	151.1	157.74	162.52
78.25	3.260417	93.46	112.77	124.96	136.42	143	151.29	157.93	162.71
78.5	3.270833	93.59	112.92	125.12	136.6	143.18	151.48	158.13	162.91
78.75	3.28125	93.71	113.07	125.29	136.78	143.36	151.67	158.32	163.11
79	3.291667	93.84	113.23	125.46	136.95	143.55	151.87	158.52	163.31
79.25	3.302083	93.97	113.38	125.62	137.13	143.73	152.06	158.72	163.51
79.5	3.3125	94.1	113.53	125.79	137.31	143.92	152.25	158.91	163.71
79.75	3.322917	94.23	113.68	125.95	137.49	144.1	152.44	159.11	163.91
80	3.333333	94.36	113.83	126.11	137.66	144.28	152.63	159.3	164.1
80.25	3.34375	94.48	113.98	126.28	137.84	144.46	152.82	159.5	164.3
80.5	3.354167	94.61	114.13	126.44	138.02	144.65	153.01	159.69	164.5
80.75	3.364583	94.74	114.28	126.61	138.19	144.83	153.2	159.88	164.7
81	3.375	94.87	114.44	126.77	138.37	145.01	153.39	160.08	164.89
81.25	3.385417	94.99	114.59	126.94	138.54	145.19	153.57	160.27	165.09
81.5	3.395833	95.12	114.74	127.1	138.72	145.38	153.76	160.47	165.29
81.75	3.40625	95.25	114.89	127.26	138.9	145.56	153.95	160.66	165.49
82	3.416667	95.38	115.04	127.43	139.07	145.74	154.14	160.86	165.68
82.25	3.427083	95.5	115.19	127.59	139.25	145.92	154.33	161.05	165.88
82.5	3.4375	95.63	115.34	127.75	139.42	146.1	154.52	161.24	166.08
82.75	3.447917	95.76	115.49	127.92	139.6	146.29	154.71	161.44	166.27
83	3.458333	95.88	115.64	128.08	139.77	146.47	154.9	161.63	166.47
83.25	3.46875	96.01	115.79	128.24	139.95	146.65	155.08	161.82	166.67
83.5	3.479167	96.14	115.94	128.41	140.12	146.83	155.27	162.02	166.86
83.75	3.489583	96.26	116.09	128.57	140.3	147.01	155.46	162.21	167.06
84	3.5	96.39	116.23	128.73	140.47	147.19	155.65	162.4	167.25

84.25	3.510417	96.52	116.38	128.89	140.65	147.37	155.84	162.59	167.45
84.5	3.520833	96.64	116.53	129.06	140.82	147.55	156.02	162.79	167.64
84.75	3.53125	96.77	116.68	129.22	141	147.73	156.21	162.98	167.84
85	3.541667	96.89	116.83	129.38	141.17	147.91	156.4	163.17	168.04
85.25	3.552083	97.02	116.98	129.54	141.34	148.09	156.59	163.36	168.23
85.5	3.5625	97.14	117.13	129.71	141.52	148.27	156.77	163.55	168.43
85.75	3.572917	97.27	117.28	129.87	141.69	148.45	156.96	163.75	168.62
86	3.583333	97.4	117.43	130.03	141.87	148.63	157.15	163.94	168.82
86.25	3.59375	97.52	117.57	130.19	142.04	148.81	157.33	164.13	169.01
86.5	3.604167	97.65	117.72	130.35	142.21	148.99	157.52	164.32	169.2
86.75	3.614583	97.77	117.87	130.51	142.39	149.17	157.71	164.51	169.4
87	3.625	97.9	118.02	130.67	142.56	149.35	157.89	164.7	169.59
87.25	3.635417	98.02	118.17	130.84	142.73	149.53	158.08	164.9	169.79
87.5	3.645833	98.15	118.31	131	142.91	149.71	158.27	165.09	169.98
87.75	3.65625	98.27	118.46	131.16	143.08	149.89	158.45	165.28	170.18
88	3.666667	98.4	118.61	131.32	143.25	150.07	158.64	165.47	170.37
88.25	3.677083	98.52	118.76	131.48	143.42	150.25	158.82	165.66	170.56
88.5	3.6875	98.65	118.9	131.64	143.6	150.43	159.01	165.85	170.76
88.75	3.697917	98.77	119.05	131.8	143.77	150.61	159.2	166.04	170.95
89	3.708333	98.9	119.2	131.96	143.94	150.79	159.38	166.23	171.14
89.25	3.71875	99.02	119.35	132.12	144.11	150.96	159.57	166.42	171.34
89.5	3.729167	99.14	119.49	132.28	144.29	151.14	159.75	166.61	171.53
89.75	3.739583	99.27	119.64	132.44	144.46	151.32	159.94	166.8	171.72
90	3.75	99.39	119.79	132.6	144.63	151.5	160.12	166.99	171.92
90.25	3.760417	99.52	119.93	132.76	144.8	151.68	160.31	167.18	172.11
90.5	3.770833	99.64	120.08	132.92	144.98	151.86	160.49	167.37	172.3
90.75	3.78125	99.77	120.23	133.08	145.15	152.03	160.68	167.56	172.5
91	3.791667	99.89	120.37	133.24	145.32	152.21	160.86	167.75	172.69
91.25	3.802083	100.01	120.52	133.4	145.49	152.39	161.05	167.94	172.88
91.5	3.8125	100.14	120.67	133.56	145.66	152.57	161.23	168.13	173.07
91.75	3.822917	100.26	120.81	133.72	145.83	152.74	161.42	168.32	173.27
92	3.833333	100.38	120.96	133.88	146	152.92	161.6	168.51	173.46
92.25	3.84375	100.51	121.11	134.04	146.18	153.1	161.79	168.7	173.65
92.5	3.854167	100.63	121.25	134.2	146.35	153.28	161.97	168.89	173.84
92.75	3.864583	100.75	121.4	134.36	146.52	153.45	162.15	169.08	174.03
93	3.875	100.88	121.54	134.52	146.69	153.63	162.34	169.26	174.23
93.25	3.885417	101	121.69	134.68	146.86	153.81	162.52	169.45	174.42
93.5	3.895833	101.12	121.84	134.84	147.03	153.99	162.71	169.64	174.61
93.75	3.90625	101.25	121.98	135	147.2	154.16	162.89	169.83	174.8
94	3.916667	101.37	122.13	135.15	147.37	154.34	163.07	170.02	174.99
94.25	3.927083	101.49	122.27	135.31	147.54	154.52	163.26	170.21	175.18
94.5	3.9375	101.61	122.42	135.47	147.71	154.69	163.44	170.4	175.38
94.75	3.947917	101.74	122.56	135.63	147.88	154.87	163.62	170.58	175.57
95	3.958333	101.86	122.71	135.79	148.05	155.05	163.81	170.77	175.76
95.25	3.96875	101.98	122.85	135.95	148.22	155.22	163.99	170.96	175.95
95.5	3.979167	102.11	123	136.11	148.39	155.4	164.17	171.15	176.14
95.75	3.989583	102.23	123.14	136.26	148.56	155.57	164.36	171.34	176.33
96	4	102.35	123.29	136.42	148.73	155.75	164.54	171.52	176.52

150 year r: 200 year r: 500 year r: 1000 year 10000 year rainfall (mm)

20.78	21.87	25.98	30.21	55.94
30.61	32.31	38.67	45.41	85.95
37.54	39.68	47.64	56.08	107.33
42.94	45.4	54.64	64.38	123.55
46.45	49.06	59.01	69.67	131.59
49.25	51.97	62.44	73.84	137.33
51.65	54.44	65.35	77.35	141.88
53.78	56.64	67.93	80.43	145.71
55.95	58.91	70.61	83.57	149.6
57.98	61.03	73.09	86.46	153.1
59.88	63	75.42	89.13	156.29
61.66	64.87	77.6	91.62	159.22
63.35	66.62	79.65	93.95	161.92
64.96	68.29	81.58	96.14	164.44
66.48	69.87	83.42	98.19	166.79
67.94	71.38	85.16	100.13	168.99
69.31	72.79	86.77	101.91	171.06
70.62	74.13	88.3	103.6	173.02
71.88	75.41	89.77	105.2	174.87
73.09	76.65	91.17	106.74	176.64
74.25	77.83	92.51	108.2	178.32
75.37	78.97	93.8	109.61	179.92
76.45	80.08	95.04	110.95	181.46
77.49	81.14	96.23	112.25	182.93
78.5	82.17	97.38	113.51	184.35
79.47	83.16	98.49	114.73	185.71
80.41	84.13	99.56	115.9	187.02
81.33	85.06	100.6	117.04	188.29
82.22	85.97	101.61	118.14	189.51
83.08	86.86	102.59	119.2	190.69
83.92	87.72	103.54	120.24	191.84
84.74	88.56	104.46	121.25	192.95
85.54	89.38	105.36	122.23	194.03
86.32	90.18	106.24	123.18	195.08
87.08	90.96	107.09	124.1	196.1
87.83	91.72	107.92	125.01	197.09

88.56	92.47	108.73	125.89	198.06
89.27	93.2	109.53	126.75	199
89.97	93.91	110.3	127.59	199.92
90.65	94.61	111.06	128.41	200.81
91.32	95.3	111.81	129.21	201.69
91.97	95.97	112.53	130	202.54
92.62	96.63	113.25	130.76	203.38
93.25	97.28	113.94	131.52	204.19
93.87	97.91	114.63	132.25	204.99
94.48	98.54	115.3	132.97	205.77
95.08	99.15	115.96	133.68	206.54
95.67	99.76	116.61	134.37	207.29
96.24	100.35	117.24	135.05	208.03
96.81	100.93	117.86	135.71	208.75
97.36	101.5	118.47	136.37	209.46
97.91	102.06	119.07	137.01	210.15
98.45	102.61	119.66	137.64	210.84
98.98	103.16	120.24	138.26	211.51
99.51	103.7	120.81	138.86	212.17
100.03	104.23	121.38	139.46	212.81
100.54	104.75	121.93	140.05	213.45
101.04	105.27	122.48	140.63	214.08
101.54	105.78	123.02	141.2	214.69
102.03	106.28	123.55	141.76	215.3
102.51	106.78	124.07	142.31	215.9
102.99	107.27	124.59	142.85	216.49
103.46	107.75	125.1	143.39	217.06
103.93	108.23	125.6	143.92	217.64
104.39	108.7	126.1	144.44	218.2
104.85	109.17	126.59	144.95	218.75
105.3	109.63	127.08	145.45	219.3
105.75	110.09	127.56	145.95	219.84
106.19	110.54	128.03	146.44	220.37
106.63	110.99	128.5	146.93	220.89
107.06	111.43	128.96	147.41	221.41
107.49	111.87	129.42	147.88	221.92
107.91	112.3	129.87	148.34	222.42
108.33	112.73	130.32	148.8	222.92
108.75	113.16	130.76	149.25	223.41
109.17	113.58	131.2	149.7	223.9
109.58	113.99	131.64	150.14	224.38
109.98	114.41	132.07	150.57	224.85
110.39	114.82	132.49	151	225.32
110.78	115.22	132.91	151.43	225.78
111.18	115.63	133.33	151.85	226.24
111.57	116.02	133.75	152.27	226.69
111.96	116.42	134.16	152.68	227.14
112.35	116.81	134.56	153.09	227.58
112.73	117.2	134.97	153.49	228.02
113.11	117.59	135.36	153.89	228.45

113.49	117.97	135.76	154.29	228.88
113.86	118.35	136.15	154.68	229.3
114.24	118.73	136.54	155.07	229.72
114.6	119.1	136.93	155.45	230.13
114.97	119.47	137.31	155.83	230.54
115.33	119.84	137.69	156.21	230.95
115.69	120.21	138.06	156.58	231.35
116.05	120.57	138.44	156.95	231.75
116.41	120.93	138.81	157.32	232.14
116.76	121.29	139.18	157.68	232.53
117.1	121.63	139.53	158.04	232.92
117.45	121.98	139.89	158.38	233.3
117.78	122.32	140.24	158.73	233.68
118.12	122.67	140.58	159.07	234.06
118.46	123.01	140.93	159.41	234.43
118.79	123.34	141.27	159.75	234.8
119.12	123.68	141.61	160.09	235.17
119.45	124.01	141.95	160.42	235.53
119.77	124.34	142.29	160.75	235.89
120.1	124.67	142.62	161.08	236.25
120.42	125	142.96	161.4	236.6
120.74	125.32	143.29	161.73	236.95
121.06	125.64	143.61	162.05	237.3
121.38	125.97	143.94	162.36	237.64
121.69	126.29	144.26	162.68	237.98
122.01	126.6	144.58	163	238.32
122.32	126.92	144.9	163.31	238.65
122.63	127.23	145.22	163.62	238.99
122.94	127.55	145.54	163.93	239.32
123.24	127.86	145.85	164.23	239.64
123.55	128.17	146.17	164.54	239.97
123.85	128.47	146.48	164.84	240.29
124.15	128.78	146.79	165.14	240.61
124.46	129.08	147.09	165.44	240.93
124.75	129.39	147.4	165.74	241.24
125.05	129.69	147.7	166.03	241.55
125.35	129.99	148.01	166.33	241.86
125.64	130.29	148.31	166.62	242.17
125.94	130.58	148.61	166.91	242.48
126.23	130.88	148.91	167.2	242.78
126.52	131.18	149.2	167.48	243.08
126.81	131.47	149.5	167.77	243.38
127.1	131.76	149.79	168.05	243.68
127.39	132.05	150.08	168.34	243.97
127.67	132.34	150.37	168.62	244.26
127.96	132.63	150.66	168.9	244.55
128.24	132.92	150.95	169.18	244.84
128.52	133.2	151.24	169.45	245.13
128.81	133.49	151.53	169.73	245.41
129.09	133.77	151.81	170	245.69

129.36	134.05	152.09	170.28	245.97
129.64	134.33	152.38	170.55	246.25
129.92	134.61	152.66	170.82	246.53
130.19	134.89	152.94	171.09	246.8
130.47	135.17	153.22	171.36	247.07
130.74	135.45	153.49	171.62	247.34
131.02	135.72	153.77	171.89	247.61
131.29	136	154.04	172.15	247.88
131.56	136.27	154.32	172.42	248.15
131.83	136.55	154.59	172.68	248.41
132.1	136.82	154.86	172.94	248.67
132.36	137.09	155.13	173.2	248.93
132.63	137.36	155.4	173.46	249.19
132.9	137.63	155.67	173.71	249.45
133.16	137.89	155.94	173.97	249.71
133.43	138.16	156.21	174.23	249.96
133.69	138.43	156.47	174.48	250.21
133.95	138.69	156.74	174.73	250.46
134.21	138.96	157	174.99	250.71
134.47	139.22	157.26	175.24	250.96
134.73	139.48	157.53	175.49	251.21
134.99	139.75	157.79	175.74	251.45
135.25	140.01	158.05	175.99	251.7
135.51	140.27	158.31	176.23	251.94
135.76	140.53	158.57	176.48	252.18
136.02	140.78	158.82	176.73	252.42
136.28	141.04	159.08	176.97	252.66
136.53	141.3	159.34	177.21	252.89
136.78	141.56	159.59	177.46	253.13
137.04	141.81	159.84	177.7	253.36
137.29	142.07	160.1	177.94	253.59
137.54	142.32	160.35	178.18	253.83
137.79	142.57	160.6	178.42	254.06
138.04	142.82	160.85	178.66	254.28
138.29	143.08	161.1	178.9	254.51
138.54	143.33	161.35	179.13	254.74
138.78	143.58	161.6	179.37	254.96
139.03	143.83	161.85	179.61	255.19
139.28	144.08	162.1	179.84	255.41
139.52	144.32	162.34	180.08	255.63
139.77	144.57	162.59	180.31	255.85
140.01	144.82	162.84	180.54	256.07
140.26	145.07	163.08	180.77	256.29
140.5	145.31	163.32	181	256.51
140.74	145.56	163.57	181.23	256.72
140.98	145.8	163.81	181.46	256.94
141.23	146.04	164.05	181.69	257.15
141.47	146.29	164.29	181.92	257.36
141.71	146.53	164.53	182.15	257.57
141.95	146.77	164.77	182.38	257.78

142.18	147.01	165.01	182.6	257.99
142.42	147.25	165.25	182.83	258.2
142.66	147.49	165.49	183.05	258.41
142.9	147.73	165.73	183.28	258.61
143.13	147.97	165.96	183.5	258.82
143.37	148.21	166.2	183.72	259.02
143.61	148.45	166.43	183.94	259.2
143.85	148.69	166.67	184.16	259.38
144.08	148.93	166.9	184.38	259.56
144.32	149.17	167.14	184.6	259.73
144.55	149.41	167.37	184.82	259.91
144.79	149.64	167.6	185.03	260.09
145.02	149.88	167.84	185.25	260.26
145.26	150.12	168.07	185.46	260.43
145.49	150.35	168.3	185.68	260.61
145.72	150.59	168.53	185.9	260.78
145.96	150.82	168.76	186.11	260.95
146.19	151.06	168.99	186.32	261.12
146.42	151.29	169.22	186.54	261.29
146.65	151.52	169.45	186.75	261.46
146.88	151.76	169.68	186.96	261.63
147.12	151.99	169.91	187.18	261.8
147.35	152.22	170.14	187.39	261.97
147.58	152.45	170.36	187.6	262.14
147.8	152.68	170.59	187.81	262.31
148.03	152.92	170.82	188.02	262.47
148.26	153.15	171.04	188.23	262.64
148.49	153.38	171.27	188.44	262.8
148.72	153.61	171.49	188.65	262.97
148.95	153.83	171.72	188.86	263.13
149.17	154.06	171.94	189.07	263.3
149.4	154.29	172.17	189.28	263.46
149.63	154.52	172.39	189.48	263.62
149.85	154.75	172.62	189.69	263.79
150.08	154.98	172.84	189.9	263.95
150.3	155.2	173.06	190.11	264.11
150.53	155.43	173.28	190.31	264.27
150.75	155.66	173.51	190.52	264.43
150.98	155.88	173.73	190.72	264.59
151.2	156.11	173.95	190.93	264.75
151.42	156.33	174.17	191.13	264.91
151.65	156.56	174.39	191.34	265.07
151.87	156.78	174.61	191.54	265.23
152.09	157.01	174.83	191.75	265.38
152.31	157.23	175.05	191.95	265.54
152.53	157.45	175.27	192.15	265.7
152.76	157.68	175.49	192.36	265.85
152.98	157.9	175.71	192.56	266.01
153.2	158.12	175.93	192.76	266.17
153.42	158.34	176.14	192.97	266.32

153.64	158.57	176.36	193.17	266.48
153.86	158.79	176.58	193.37	266.63
154.08	159.01	176.8	193.57	266.79
154.3	159.23	177.01	193.77	266.94
154.52	159.45	177.23	193.97	267.09
154.73	159.67	177.44	194.17	267.24
154.95	159.89	177.66	194.37	267.4
155.17	160.11	177.88	194.57	267.55
155.39	160.33	178.09	194.77	267.7
155.61	160.55	178.31	194.97	267.85
155.82	160.77	178.52	195.17	268
156.04	160.99	178.73	195.37	268.15
156.26	161.21	178.95	195.57	268.31
156.47	161.42	179.16	195.76	268.46
156.69	161.64	179.38	195.96	268.6
156.9	161.86	179.59	196.16	268.75
157.12	162.08	179.8	196.36	268.9
157.33	162.29	180.01	196.55	269.05
157.55	162.51	180.23	196.75	269.2
157.76	162.73	180.44	196.95	269.35
157.98	162.94	180.65	197.14	269.5
158.19	163.16	180.86	197.34	269.64
158.41	163.37	181.07	197.53	269.79
158.62	163.59	181.28	197.73	269.94
158.83	163.8	181.49	197.93	270.08
159.05	164.02	181.71	198.12	270.23
159.26	164.23	181.92	198.32	270.38
159.47	164.45	182.13	198.51	270.52
159.68	164.66	182.34	198.71	270.67
159.9	164.88	182.55	198.9	270.81
160.11	165.09	182.75	199.09	270.96
160.32	165.3	182.96	199.29	271.1
160.53	165.52	183.17	199.48	271.25
160.74	165.73	183.38	199.67	271.39
160.95	165.94	183.59	199.87	271.53
161.16	166.15	183.8	200.06	271.68
161.37	166.37	184.01	200.25	271.82
161.58	166.58	184.21	200.45	271.96
161.79	166.79	184.42	200.64	272.11
162	167	184.63	200.83	272.25
162.21	167.21	184.84	201.02	272.39
162.42	167.42	185.04	201.21	272.53
162.63	167.63	185.25	201.41	272.68
162.84	167.84	185.46	201.6	272.82
163.05	168.05	185.66	201.79	272.96
163.26	168.26	185.87	201.98	273.1
163.46	168.47	186.07	202.17	273.24
163.67	168.68	186.28	202.36	273.38
163.88	168.89	186.49	202.55	273.52
164.09	169.1	186.69	202.74	273.66

164.3	169.31	186.9	202.93	273.8
164.5	169.52	187.1	203.12	273.94
164.71	169.73	187.31	203.31	274.08
164.92	169.94	187.51	203.5	274.22
165.12	170.15	187.72	203.69	274.36
165.33	170.36	187.92	203.88	274.5
165.54	170.56	188.12	204.07	274.64
165.74	170.77	188.33	204.26	274.78
165.95	170.98	188.53	204.45	274.91
166.15	171.19	188.73	204.64	275.05
166.36	171.39	188.94	204.83	275.19
166.56	171.6	189.14	205.01	275.33
166.77	171.81	189.34	205.2	275.46
166.98	172.01	189.55	205.39	275.6
167.18	172.22	189.75	205.58	275.74
167.38	172.43	189.95	205.77	275.88
167.59	172.63	190.15	205.95	276.01
167.79	172.84	190.36	206.14	276.15
168	173.04	190.56	206.33	276.29
168.2	173.25	190.76	206.52	276.42
168.41	173.46	190.96	206.7	276.56
168.61	173.66	191.16	206.89	276.69
168.81	173.87	191.37	207.08	276.83
169.02	174.07	191.57	207.27	276.97
169.22	174.28	191.77	207.45	277.1
169.42	174.48	191.97	207.64	277.24
169.62	174.68	192.17	207.83	277.37
169.83	174.89	192.37	208.01	277.51
170.03	175.09	192.57	208.2	277.64
170.23	175.3	192.77	208.38	277.78
170.43	175.5	192.97	208.57	277.91
170.64	175.7	193.17	208.76	278.05
170.84	175.91	193.37	208.94	278.18
171.04	176.11	193.57	209.13	278.31
171.24	176.32	193.77	209.31	278.45
171.44	176.52	193.97	209.5	278.58
171.64	176.72	194.17	209.68	278.72
171.84	176.92	194.37	209.87	278.85
172.05	177.13	194.57	210.05	278.98
172.25	177.33	194.77	210.24	279.12
172.45	177.53	194.97	210.42	279.25
172.65	177.73	195.17	210.61	279.38
172.85	177.94	195.36	210.79	279.51
173.05	178.14	195.56	210.98	279.65
173.25	178.34	195.76	211.16	279.78
173.45	178.54	195.96	211.35	279.91
173.65	178.74	196.16	211.53	280.04
173.85	178.94	196.36	211.72	280.18
174.05	179.15	196.55	211.9	280.31
174.25	179.35	196.75	212.08	280.44

174.45	179.55	196.95	212.27	280.57
174.65	179.75	197.15	212.45	280.71
174.85	179.95	197.35	212.64	280.84
175.04	180.15	197.54	212.82	280.97
175.24	180.35	197.74	213	281.1
175.44	180.55	197.94	213.19	281.23
175.64	180.75	198.14	213.37	281.36
175.84	180.95	198.33	213.55	281.49
176.04	181.15	198.53	213.74	281.62
176.24	181.35	198.73	213.92	281.76
176.43	181.55	198.92	214.1	281.89
176.63	181.75	199.12	214.29	282.02
176.83	181.95	199.32	214.47	282.15
177.03	182.15	199.51	214.65	282.28
177.23	182.35	199.71	214.84	282.41
177.42	182.55	199.91	215.02	282.54
177.62	182.75	200.1	215.2	282.67
177.82	182.95	200.3	215.38	282.8
178.01	183.15	200.49	215.57	282.93
178.21	183.35	200.69	215.75	283.06
178.41	183.54	200.89	215.93	283.19
178.61	183.74	201.08	216.12	283.32
178.8	183.94	201.28	216.3	283.45
179	184.14	201.47	216.48	283.58
179.2	184.34	201.67	216.66	283.71
179.39	184.54	201.86	216.85	283.84
179.59	184.73	202.06	217.03	283.97
179.79	184.93	202.25	217.21	284.1
179.98	185.13	202.45	217.39	284.23
180.18	185.33	202.64	217.57	284.36
180.37	185.53	202.84	217.76	284.49
180.57	185.72	203.03	217.94	284.62
180.77	185.92	203.23	218.12	284.75
180.96	186.12	203.42	218.3	284.87
181.16	186.32	203.62	218.48	285
181.35	186.51	203.81	218.67	285.13
181.55	186.71	204.01	218.85	285.26
181.74	186.91	204.2	219.03	285.39
181.94	187.11	204.4	219.21	285.52
182.13	187.3	204.59	219.39	285.65
182.33	187.5	204.79	219.57	285.78
182.52	187.7	204.98	219.76	285.91
182.72	187.89	205.17	219.94	286.03
182.91	188.09	205.37	220.12	286.16
183.11	188.29	205.56	220.3	286.29
183.3	188.48	205.76	220.48	286.42
183.5	188.68	205.95	220.66	286.55
183.69	188.87	206.15	220.85	286.68

APPENDIX 7 – Attenuation Storage Calculations

KRS Environmental Ltd					Page 1
3 Princes Square Princes Street, Montgomery Powys, Shrewsbury, SY15 6PZ		Land off Goat Mill Methyr Tydfil			
Date 25/08/2021 19:57 File STORAGE CALCS.SRCX		Designed by Emma Serjeant Checked by Keelan Serjeant			
Innovyze		Source Control 2020.1			
Summary of Results for 100 year Return Period (+30%)					
Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	268.262	0.862	165.7	2528.5	O K
30 min Summer	268.616	1.216	165.7	3691.3	O K
60 min Summer	269.008	1.608	165.7	5075.4	O K
120 min Summer	269.292	1.892	165.7	6137.0	O K
180 min Summer	269.452	2.052	165.7	6756.7	O K
240 min Summer	269.551	2.151	165.7	7148.4	O K
360 min Summer	269.648	2.248	165.7	7542.3	O K
480 min Summer	269.683	2.283	165.7	7686.3	O K
600 min Summer	269.697	2.297	165.7	7741.8	O K
720 min Summer	269.697	2.297	165.7	7741.6	O K
960 min Summer	269.674	2.274	165.7	7646.2	O K
1440 min Summer	269.592	2.192	165.7	7316.4	O K
2160 min Summer	269.442	2.042	165.7	6717.3	O K
2880 min Summer	269.282	1.882	165.7	6098.2	O K
4320 min Summer	268.932	1.532	165.7	4798.9	O K
5760 min Summer	268.659	1.259	165.7	3840.5	O K
7200 min Summer	268.461	1.061	165.7	3172.9	O K
8640 min Summer	268.310	0.910	165.7	2681.8	O K
10080 min Summer	268.198	0.798	165.5	2324.7	O K
15 min Winter	268.262	0.862	165.7	2528.5	O K
30 min Winter	268.616	1.216	165.7	3692.7	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)	
15 min Summer	100.654	0.0	2623.5	26	
30 min Summer	73.768	0.0	3871.4	40	
60 min Summer	51.594	0.0	5491.7	70	
120 min Summer	32.533	0.0	6932.7	128	
180 min Summer	24.932	0.0	7973.2	186	
240 min Summer	20.645	0.0	8805.2	244	
360 min Summer	15.775	0.0	10095.3	360	
480 min Summer	12.975	0.0	11072.1	416	
600 min Summer	11.125	0.0	11866.5	480	
720 min Summer	9.797	0.0	12540.3	544	
960 min Summer	7.997	0.0	13645.1	680	
1440 min Summer	6.005	0.0	15354.6	960	
2160 min Summer	4.516	0.0	17402.7	1380	
2880 min Summer	3.709	0.0	19051.9	1792	
4320 min Summer	2.847	0.0	21916.9	2552	
5760 min Summer	2.390	0.0	24584.4	3280	
7200 min Summer	2.114	0.0	27172.5	3968	
8640 min Summer	1.927	0.0	29711.9	4672	
10080 min Summer	1.792	0.0	32219.5	5352	
15 min Winter	100.654	0.0	2623.5	27	
30 min Winter	73.768	0.0	3871.4	40	
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KRS Environmental Ltd					Page 2
3 Princes Square Princes Street, Montgomery Powys, Shrewsbury, SY15 6PZ		Land off Goat Mill Methyr Tydfil			
Date 25/08/2021 19:57 File STORAGE CALCS.SRCX		Designed by Emma Serjeant Checked by Keelan Serjeant			
Innovyze		Source Control 2020.1			
<u>Summary of Results for 100 year Return Period (+30%)</u>					
Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	269.009	1.609	165.7	5076.1	O K
120 min Winter	269.293	1.893	165.7	6138.0	O K
180 min Winter	269.454	2.054	165.7	6764.8	O K
240 min Winter	269.555	2.155	165.7	7165.5	O K
360 min Winter	269.658	2.258	165.7	7582.4	O K
480 min Winter	269.687	2.287	165.7	7701.5	O K
600 min Winter	269.687	2.287	165.7	7700.6	O K
720 min Winter	269.679	2.279	165.7	7667.2	O K
960 min Winter	269.629	2.229	165.7	7464.9	O K
1440 min Winter	269.475	2.075	165.7	6848.0	O K
2160 min Winter	269.166	1.766	165.7	5659.0	O K
2880 min Winter	268.830	1.430	165.7	4434.1	O K
4320 min Winter	268.313	0.913	165.7	2691.8	O K
5760 min Winter	268.005	0.605	162.3	1730.1	O K
7200 min Winter	267.862	0.462	155.6	1300.7	O K
8640 min Winter	267.824	0.424	143.8	1189.2	O K
10080 min Winter	267.800	0.400	134.3	1118.4	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)	
60 min Winter	51.594	0.0	5491.8	68	
120 min Winter	32.533	0.0	6932.7	126	
180 min Winter	24.932	0.0	7973.3	182	
240 min Winter	20.645	0.0	8805.2	238	
360 min Winter	15.775	0.0	10095.3	350	
480 min Winter	12.975	0.0	11072.3	452	
600 min Winter	11.125	0.0	11866.7	490	
720 min Winter	9.797	0.0	12540.5	566	
960 min Winter	7.997	0.0	13645.7	722	
1440 min Winter	6.005	0.0	15356.9	1032	
2160 min Winter	4.516	0.0	17403.3	1476	
2880 min Winter	3.709	0.0	19052.7	1848	
4320 min Winter	2.847	0.0	21919.3	2552	
5760 min Winter	2.390	0.0	24584.7	3176	
7200 min Winter	2.114	0.0	27173.0	3752	
8640 min Winter	1.927	0.0	29713.2	4416	
10080 min Winter	1.792	0.0	32224.4	5144	
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KRS Environmental Ltd		Page 3
3 Princes Square Princes Street, Montgomery Powys, Shrewsbury, SY15 6PZ	Land off Goat Mill Methyr Tydfil	
Date 25/08/2021 19:57 File STORAGE CALCS.SRCX	Designed by Emma Serjeant Checked by Keelan Serjeant	
Innovyze Source Control 2020.1		

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 306200 207000 SO 06200 07000
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	1.000
Cv (Winter)	1.000
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+30

Time Area Diagram

Total Area (ha) 10.720

Time (mins)	Area	Time (mins)	Area	Time (mins)	Area	Time (mins)	Area
From:	To:	From:	To:	From:	To:	From:	To:
0	4	4	8	8	12	12	16
	3.248		3.248		3.248		0.975

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KRS Environmental Ltd		Page 4																																																																																																																					
3 Princes Square Princes Street, Montgomery Powys, Shrewsbury, SY15 6PZ	Land off Goat Mill Methyr Tydfil																																																																																																																						
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Model Details Storage is Online Cover Level (m) 270.000 Tank or Pond Structure Invert Level (m) 267.400 <table><thead><tr><th>Depth (m)</th><th>Area (m²)</th><th>Depth (m)</th><th>Area (m²)</th></tr></thead><tbody><tr><td>0.000</td><td>2687.6</td><td>2.600</td><td>4312.2</td></tr></tbody></table> Hydro-Brake® Optimum Outflow Control <table><tbody><tr><td>Unit Reference</td><td>MD-SHE-0468-1663-2600-1663</td></tr><tr><td>Design Head (m)</td><td>2.600</td></tr><tr><td>Design Flow (l/s)</td><td>166.3</td></tr><tr><td>Flush-Flo™</td><td>Calculated</td></tr><tr><td>Objective</td><td>Minimise upstream storage</td></tr><tr><td>Application</td><td>Surface</td></tr><tr><td>Sump Available</td><td>Yes</td></tr><tr><td>Diameter (mm)</td><td>468</td></tr><tr><td>Invert Level (m)</td><td>267.400</td></tr><tr><td>Minimum Outlet Pipe Diameter (mm)</td><td>500</td></tr><tr><td>Suggested Manhole Diameter (mm)</td><td>Site Specific Design (Contact Hydro International)</td></tr></tbody></table> <table><thead><tr><th>Control Points</th><th>Head (m)</th><th>Flow (l/s)</th></tr></thead><tbody><tr><td>Design Point (Calculated)</td><td>2.600</td><td>166.0</td></tr><tr><td>Flush-Flo™</td><td>0.853</td><td>165.7</td></tr><tr><td>Kick-Flo®</td><td>1.817</td><td>139.4</td></tr><tr><td>Mean Flow over Head Range</td><td>-</td><td>140.9</td></tr></tbody></table> The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated <table><thead><tr><th>Depth (m)</th><th>Flow (l/s)</th><th>Depth (m)</th><th>Flow (l/s)</th><th>Depth (m)</th><th>Flow (l/s)</th><th>Depth (m)</th><th>Flow (l/s)</th></tr></thead><tbody><tr><td>0.100</td><td>12.1</td><td>1.200</td><td>162.7</td><td>3.000</td><td>178.0</td><td>7.000</td><td>269.4</td></tr><tr><td>0.200</td><td>44.2</td><td>1.400</td><td>159.1</td><td>3.500</td><td>191.9</td><td>7.500</td><td>278.7</td></tr><tr><td>0.300</td><td>88.6</td><td>1.600</td><td>153.0</td><td>4.000</td><td>204.8</td><td>8.000</td><td>287.6</td></tr><tr><td>0.400</td><td>134.4</td><td>1.800</td><td>141.0</td><td>4.500</td><td>217.0</td><td>8.500</td><td>296.3</td></tr><tr><td>0.500</td><td>157.9</td><td>2.000</td><td>146.0</td><td>5.000</td><td>228.4</td><td>9.000</td><td>304.8</td></tr><tr><td>0.600</td><td>162.1</td><td>2.200</td><td>153.0</td><td>5.500</td><td>239.4</td><td>9.500</td><td>313.0</td></tr><tr><td>0.800</td><td>165.5</td><td>2.400</td><td>159.6</td><td>6.000</td><td>249.8</td><td></td><td></td></tr><tr><td>1.000</td><td>165.0</td><td>2.600</td><td>166.0</td><td>6.500</td><td>259.8</td><td></td><td></td></tr></tbody></table>			Depth (m)	Area (m²)	Depth (m)	Area (m²)	0.000	2687.6	2.600	4312.2	Unit Reference	MD-SHE-0468-1663-2600-1663	Design Head (m)	2.600	Design Flow (l/s)	166.3	Flush-Flo™	Calculated	Objective	Minimise upstream storage	Application	Surface	Sump Available	Yes	Diameter (mm)	468	Invert Level (m)	267.400	Minimum Outlet Pipe Diameter (mm)	500	Suggested Manhole Diameter (mm)	Site Specific Design (Contact Hydro International)	Control Points	Head (m)	Flow (l/s)	Design Point (Calculated)	2.600	166.0	Flush-Flo™	0.853	165.7	Kick-Flo®	1.817	139.4	Mean Flow over Head Range	-	140.9	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	0.100	12.1	1.200	162.7	3.000	178.0	7.000	269.4	0.200	44.2	1.400	159.1	3.500	191.9	7.500	278.7	0.300	88.6	1.600	153.0	4.000	204.8	8.000	287.6	0.400	134.4	1.800	141.0	4.500	217.0	8.500	296.3	0.500	157.9	2.000	146.0	5.000	228.4	9.000	304.8	0.600	162.1	2.200	153.0	5.500	239.4	9.500	313.0	0.800	165.5	2.400	159.6	6.000	249.8			1.000	165.0	2.600	166.0	6.500	259.8		
Depth (m)	Area (m²)	Depth (m)	Area (m²)																																																																																																																				
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Kick-Flo®	1.817	139.4																																																																																																																					
Mean Flow over Head Range	-	140.9																																																																																																																					
Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)																																																																																																																
0.100	12.1	1.200	162.7	3.000	178.0	7.000	269.4																																																																																																																
0.200	44.2	1.400	159.1	3.500	191.9	7.500	278.7																																																																																																																
0.300	88.6	1.600	153.0	4.000	204.8	8.000	287.6																																																																																																																
0.400	134.4	1.800	141.0	4.500	217.0	8.500	296.3																																																																																																																
0.500	157.9	2.000	146.0	5.000	228.4	9.000	304.8																																																																																																																
0.600	162.1	2.200	153.0	5.500	239.4	9.500	313.0																																																																																																																
0.800	165.5	2.400	159.6	6.000	249.8																																																																																																																		
1.000	165.0	2.600	166.0	6.500	259.8																																																																																																																		
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APPENDIX 8 – Proprietary Treatment Information

Downstream Defender® Advanced Hydrodynamic Vortex Separator

The Downstream Defender® is an advanced hydrodynamic vortex separator for the effective and reliable removal of fine particles, oils and other floatable debris from surface water runoff.

Its innovative design delivers high efficiency across a wide range of flows in a much smaller footprint than conventional or other swirl-type devices and it is the perfect choice for any catchment likely to convey high quantities of contamination.

1. Access for removal of floatables and sediments.
2. Inlet pipe.
3. Inlet chute.
4. Centre shaft.
5. Dip plate.
6. Centre cone.
7. Benching skirt.
8. Floatables and oil storage.
9. Isolated sediment storage zone.
10. Outlet pipe.

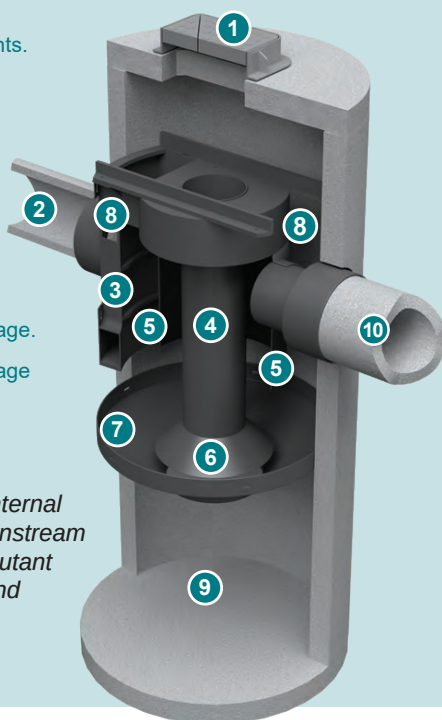


Figure 1 - The unique internal components of the Downstream Defender® enhance pollutant removal performance and prevent wash out.

Unique Flow Modifying Components

The Downstream Defender® consists of a choice of concrete or HDPE chamber with unique flow modifying internal components. It is these internal components that differentiate the Downstream Defender® from catchpits, sedimentation basins or sedimentation sumps. They facilitate advanced hydrodynamic vortex separation by reducing turbulence, lengthening the flow path to increase chamber residence time and introducing shear planes.

The internal components also ensure that the pollutant storage zones are isolated and protected from high flows that could cause pollutant re-entrainment or wash out.

Compared to devices that have poorly designed internal components, the Downstream Defender® captures and retains more of the annual pollutant load.

Watch a short video showing the Downstream Defender® components and operation at:

<http://www.hydro-int.com/en-gb/products/downstream-defender-0>



Repeatable, Reliable Performance

The Downstream Defender® delivers high removal of pollutants through advanced, hydrodynamic separation across a wide range of flows. The device has a proven track record of tackling an assortment of pollutants including:

Sediment (or Total Suspended Solids)



The Downstream Defender® is a highly effective sediment/TSS removal device. It can be sized in a number of ways to suit the application and level of protection required (see Table 1). **SuDS Mitigation Index = 0.5.**

Gross Pollutants



100% removal of floatable debris, such as food wrappers, Styrofoam cups and drinks cartons

Liquid Hydrocarbons



Effective spill containment device that meets the BS EN 858-1:2002 Class I and Class II effluent targets at low flow rates. Note these systems are not considered oil separators according to the BS EN 858-1 and must not be used in applications where full certification is required. **SuDS Mitigation Index = 0.8.**

Sediment Bound Hydrocarbons (including Polycyclic Aromatic Hydrocarbons - PAHs)



PAHs have low solubility in water and are readily adsorbed onto sediment particles. Effective removal of sediment particles will also ensure the removal of many PAHs.

Sediment Bound Heavy Metals and Nutrients

Heavy Metals

Nutrients

As an efficient device for removal of fine sediment, the Downstream Defender® is also effective for the removal of sediment bound pollutants. **SuDS Mitigation Index (Metals) = 0.4.**

Design Data

Downstream Defender®

Advanced Hydrodynamic Vortex Separator

No Risk of Pollutant Wash Out

The Downstream Defender® has been specially designed to isolate the pollutant storage zones and is proven to prevent pollutant wash out.

Sizing

The Downstream Defender® can be sized for different treatment goals and objectives.

For design purposes, the selected model's Treatment Flow Rate should be greater than or equal to the site's Water Quality Flow Rate.

The hydraulic capacity of the selected model should be considered with respect to the peak discharge flow rate from the site.

Model Diameter (m)	Treatment Flow Rate - Fine (l/s) ^(a)	Treatment Flow Rate - Coarse (l/s) ^(b)	Hydraulic Capacity (l/s) ^(c)	Minimum Oil Storage Capacity (l)	Minimum Sediment Storage Capacity (m³) ^(e)	Maximum Headloss at Treatment Flow Rate - Coarse (mm)
1.2	30	38	120	270	0.38	150
1.8	69	85	270	1300	1.04	225
2.55	138	171	542	2450	3.23	300
3.0	190	237	750	4550	3.81	375

Notes:

- a) Treatment Flow Rate - Fine is based on an annualised removal efficiency of >50% of all particles up to 1000 microns with a mass-median particle size (D_{50}) of 75 microns and a specific gravity of 2.65.
- b) Treatment Flow Rate - Coarse is based on an annualised removal efficiency of >80% of all particles between 50 and 1000 microns with a mass-median particle size (D_{50}) of 146 microns and a specific gravity of 2.65.
- c) Maximum flow rate that can pass through the chamber with a maximum headloss of 500mm.
- d) Alternative sizing based on different sediment grades available on request.
- e) Additional sediment storage capacity can be provided to extend maintenance intervals if required.

Table 1 - Downstream Defender® design information.

Expert Design Service

Hydro International's professional engineers are on hand to provide free support with the correct sizing and selection of the Downstream Defender® within each drainage design.

We can also provide estimated maintenance intervals, whole life cost estimates and predicted pollutant removal performance.

Call the StormTrain® Hotline on: 01275 337955 or email stormtrain@hydro-int.com

Design Data

Downstream Defender®

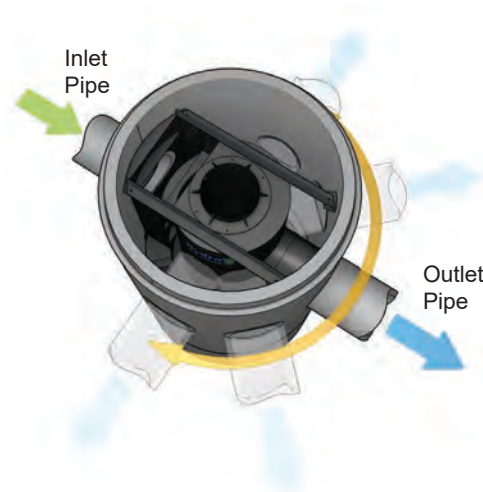
Advanced Hydrodynamic Vortex Separator

Setting Out

The Downstream Defender® can accommodate a change in pipe direction to suit site specific requirements. Combined with the high rate internal bypass, this helps to avoid the need for additional manholes on site. Head loss across the chamber is kept to a minimum (see Table 1). The inlet and outlet pipes should be sized in accordance with Table 2 (opposite), and a minimum of 90 degrees between inlet and outlet is required.

Inlet and outlet pipe connections are at the same invert level.

Additional manhole sections can be provided to extend the chamber to meet site cover and invert levels or provide additional pollutant storage where required.



Easy to Install

The Downstream Defender® is delivered to site as a near finished manhole with internal components already installed. Installation is therefore similar to any other manhole installation on site. Full installation guidelines are available.

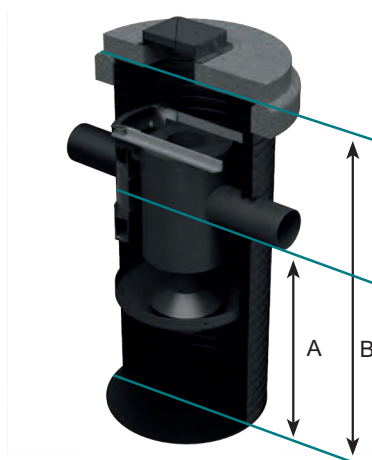
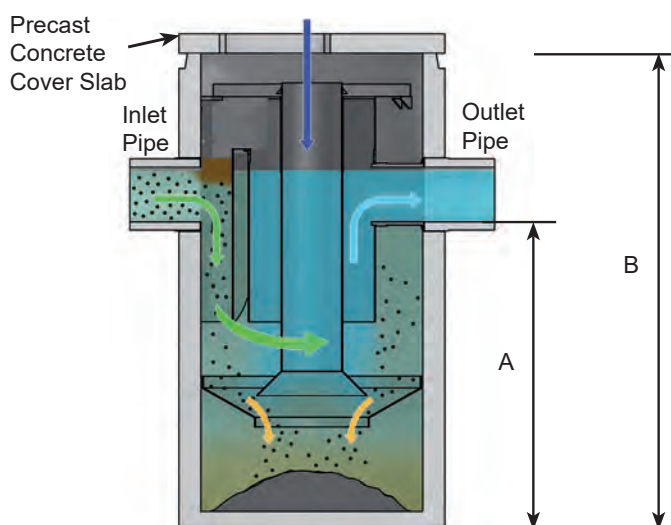
We can provide structural concrete systems for simple plug-and-play installation or choice of lightweight single and twin wall plastic chambers.

Easy to Maintain

Maintenance of the Downstream Defender® is simple, safe and cost-effective. Maintenance is carried out from the surface, using a standard vacuum tanker and personnel are not required to enter the device.

With a large capacity to store sediments and oils (see Table 1), and with a proven ability to prevent wash out, maintenance intervals can be years rather than months - depending on site conditions. The unit can also be fitted with a [Hydro-Logic™ Smart Monitoring](#) system to alert the site operator when maintenance is required and provide peace of mind that the unit is operating normally at other times.

Additional pollutant storage can be built into the chamber to extend maintenance intervals if required.



Dimensions and Weights

General arrangement drawings of all units are available for download from:
<http://www.hydro-int.com/en-gb/products/downstream-defender-0>

Model	Material	Chamber Diameter - Internal (mm)	Chamber Diameter - External (mm)	Inlet and Outlet ID (mm)	Depth to invert (m) (A) ⁽¹⁾	Chamber Depth (m) (B) ⁽²⁾	Max Component Lift Weight (kg)
PQL1320.1000	Concrete	1200	1460	300	1.92	2.80	2500
PQL1320.1030	Concrete	1800	2160	450	2.51	4.05	8000
PQL1320.1060	Concrete	2550	2850	600	2.84	4.95	9500
PQL1320.1090	Concrete	3000	3350	750	3.10	5.20	14000
PQL1320.1020	HDPE Single Wall	1200	1360	300	1.41	2.20	200
PQL1320.1050	HDPE Single Wall	1800	1950	450	2.11	3.41	400
PQL1320.1080	HDPE Single Wall	2550	2770	600	2.94	4.78	900
PQL1320.1110	HDPE Single Wall	3000	3220	750	3.13	5.3	1300
PQL1320.1025	HDPE Twin Wall	1200	1500	300	1.57	2.25	400
PQL1320.1055	HDPE Twin Wall	1800	2200	450	2.33	3.80	700

Notes:
1) Minimum depth to invert shown. Depth to invert can be increased if required.
2) Minimum chamber depth shown. Additional sediment storage capacity or increased depth to invert can be provided if required.

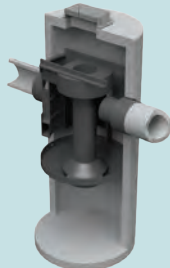
Table 2 - Downstream Defender® unit types, dimensions and weights.

The Hydro StormTrain® Series of Surface Water Treatment Devices

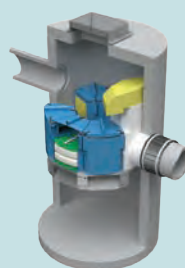
The Downstream Defender® is one of the Hydro StormTrain® Series of surface water treatment devices. Each device delivers proven, measurable and repeatable surface water treatment performance. Each can be used independently to meet the specific needs of a site or combined to form a management train. They can be used alongside natural SuDS features to protect, enable or enhance them.



First Defense®
Vortex Separator



Downstream Defender®
Advanced Hydrodynamic
Vortex Separator



Up-Flo™ Filter
Fluidised Bed Up Flow
Filtration System



Hydro Biofilter™
Biofiltration System

The Up-Flo™ Filter is an innovative surface water filtration technology that delivers a high performance multi-stage treatment train within a single device. The Up-Flo™ Filter combines sedimentation and screening with fluidised bed filtration technology to deliver high levels of performance.

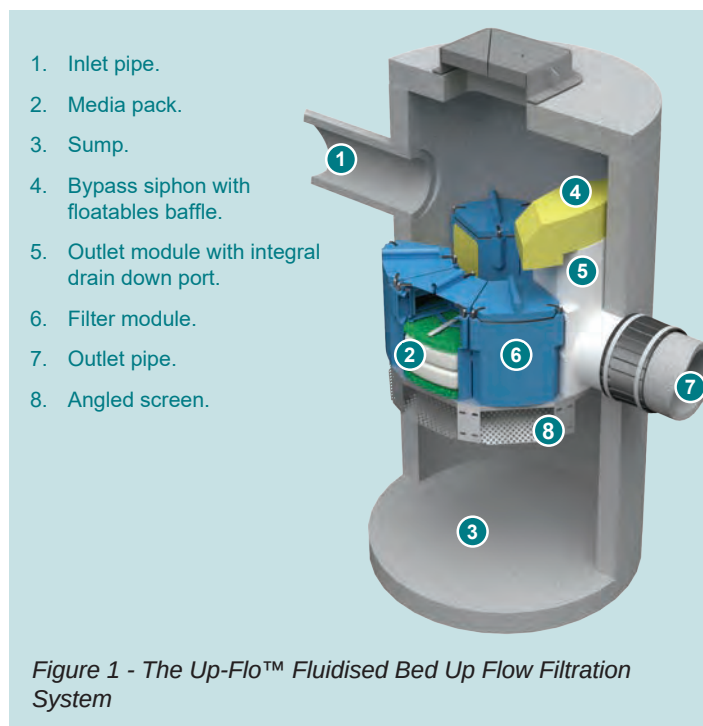


Figure 1 - The Up-Flo™ Fluidised Bed Up Flow Filtration System

Components and Filter Media

The Up-Flo™ Filter packs a 4-5 stage treatment train into a single device that can be fitted into a standard manhole. Settleable solids are collected in the chamber sump, whilst floatable material gathers in the central chamber.

An angled 4 mm perforated screen prevents coarse material from reaching the filter media. The media itself can be tailored to target specific pollutant groups and, where required, promote reactive filtration. The fluidised bed technology prevents blinding, clogging and compaction of the media surface, whilst ensuring that no wormholes can form to short-circuit the treatment process.

Filter media options include:

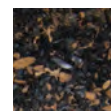
Filter Sand:

A good all-round media to target sediment and sediment-bound pollutants.



CPZ™ Mix:

An engineered media to promote reactive filtration for enhanced treatment of metals, nutrients and organics.



Watch a short video showing the Up-Flo™ Filter operation at:

<http://www.hydro-int.com/uk/products/flo-filter>

Repeatable, Reliable Performance

The Up-Flo™ Filter combines multiple sequential treatment processes to deliver sedimentation, screening and filtration all in one compact unit to remove a wide variety of pollutants including:

Very Fine Particles



Greater than 80% removal of fine sand and silt particles to a mass-median particle size of 22 µm.

See Technical Abstract: Performance Verification of Sediment Removal with Sil-Co-Sil 106 for your media of choice.

Gross Pollutants



Inclusion of the angled screen and protected bypass syphon effectively removes gross pollutants, including litter and leaf debris.

Liquid and Sediment Bound Hydrocarbons



Removal of various forms of hydrocarbons, including polycyclic aromatic hydrocarbons (PAHs).

Heavy Metals



Greater than 70% removal of metals commonly found in surface water runoff.

See Technical Abstract: Field Evaluation of Metals Removal.

Nutrients



Greater than 70% removal of phosphorus and other nutrients.

See Technical Abstract: Field Evaluation of Phosphorus Removal.

Design Data

Up-Flo™ Filter

Fluidised Bed Up Flow Filtration System

Sizing

The modular design of the Up-Flo™ Filter ensures that project specific treatment goals are easily met. Intended for intercepting pollutants at or close to source, the modular components are standardised for installation into a standard 1.2 m diameter manhole. For larger catchment areas, custom built vaults can be created to accommodate additional filter modules.

For design purposes, the selected number of modules required should be such that the total Treatment Flow Rate is greater or equal to the site's Water Quality Flow Rate.

The hydraulic capacity of the system should be considered with respect to the peak discharge flow rate from the site or pipe full flow rate.

Model	Chamber Size (m)	Number of Filter Modules	Treatment Flow Rate (l/s) ^{a)}	Hydraulic Capacity (l/s) ^{b)}	Operating Head (mm) ^{c)}	Oil Storage Capacity (l)	Sediment Storage Capacity (m³)
Manhole	1.2 m diameter	1-6	1.3 - 7.8	170	750	190	0.7
Vault	Site specific	7-19	7.8 - 24.7	170	750	Site specific	Site specific

Notes:

- a) Treatment flow rates based on >80% removal of Sil-Co-Sil 106 fine sand and silt ($D_{50} = 22 \mu\text{m}$).
- b) Maximum flow rate that can pass through the chamber without surcharge to the upstream network.
- c) Driving head for filter media.

Table 1 - Up-Flo™ Filter design information.



Expert Design Service

Hydro's professional engineers are on hand to provide free support with the correct sizing and application of the Up-Flo™ Filter within in each drainage design.

We can also provide estimated maintenance intervals, whole life cost estimates and predicted pollutant removal performance.

Call the StormTrain® Hotline on: 01275 337955 or email stormtrain@hydro-int.com

Design Data

Up-Flo™ Filter

Fluidised Bed Up Flow Filtration System

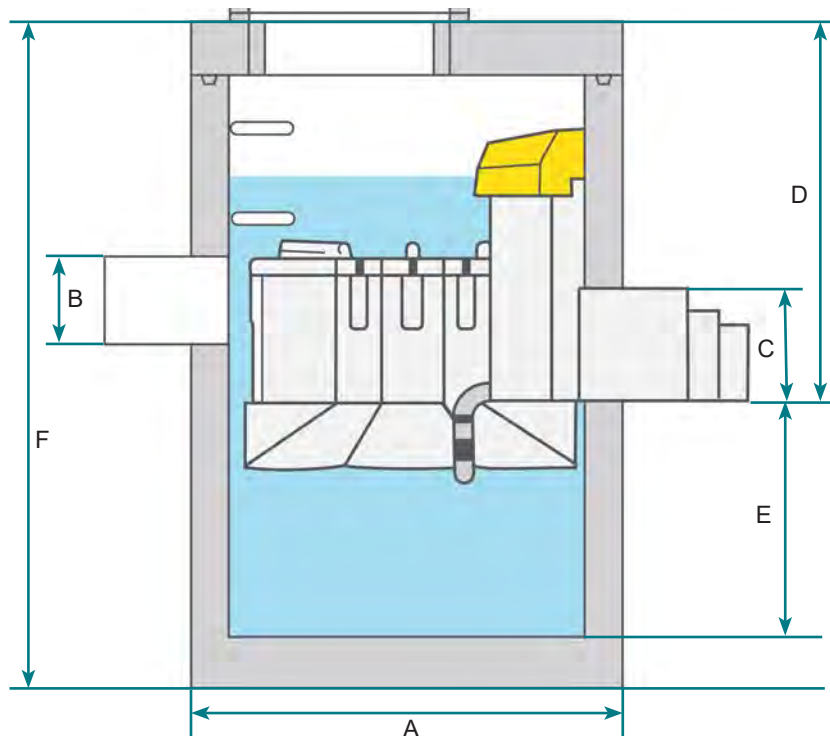
Easy Installation for Trouble-free Construction

The Up-Flo™ Filter is typically delivered to site as a pre-cast concrete manhole, complete with innovative manhole sealing system and internal components already installed. Installation is therefore similar to any other manhole installation on site.

The relative position of the filter modules and the inlet / outlet pipes can be adjusted to suit site conditions.

The outlet adapter allows a variety of different outlet pipe sizes to be easily connected (see Table 2).

Full installation guidelines are available.



Dimensions and Weights

The dimensions in Table 2 are given as a guide for standard manhole configurations. Vault configurations are site specific.

Detailed general arrangement drawings are available for download from <http://www.hydro-int.com/uk/products/flo-filter>

Unit	External Diameter of Unit (mm) (A)	Inlet Pipe Diameter (mm) ^{c)} (B)	Outlet Pipe Diameter (mm) ^{c)} (C)	Depth (m)			Lift Weight (t)
				Depth to Outlet Invert (m BGL) (D)	Sump Depth (m) (E)	Component Depth ^{a)} (m) (F)	
1.2 m Sealed Manhole System with HD Cover Slab	1460	300	225-375	1.150	1.100	2.560	n/a
HD Cover Slab ^{b)}						0.230	0.60
Base Section						1.145	1.85
Top Section						1.330	1.60

Notes:

- Base and Top Section component depths are shown as the total height during transportation / before assembly on site. The total depth is the depth of the assembled unit.
- Cover slabs are heavy duty, suited for highways loading and are supplied with one or two access openings for maintenance.
- Stub pipes are provided.

Table 2 - Up-Flo™ Filter dimensions and weights.

Design Data

Up-Flo™ Filter

Fluidised Bed Up Flow Filtration System

Simple and Cost-effective Maintenance

The gentle and effective action of the Up-Flo™ Filter ensures the filtration media have a much longer life than comparable media filters, so maintenance is infrequent, cost-effective and simple, with just three easy steps:

- 1) Floatable debris and litter is skimmed from the water surface.
- 2) Sediment collected in the sump is removed with a standard vacuum tanker.
- 3) Filter media packs are exchanged with no specialist lifting or handling equipment required.

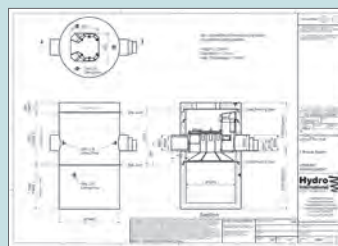
Up-Flo™ Filter Technical Guidance



Case Studies



Installation and
Maintenance Guidelines



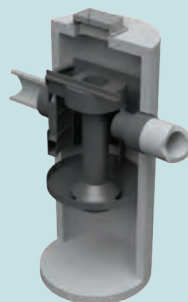
General Arrangement Drawings

The Hydro StormTrain® Series of Surface Water Treatment Devices

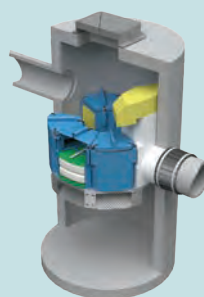
The Up-Flo™ Filter is one of the Hydro StormTrain® Series of surface water treatment devices. Each device delivers proven, measureable and repeatable surface water treatment performance. Each can be used independently to meet the specific needs of a site or combined to form a management train. They can be used alongside natural SuDS features to protect, enable or enhance them.



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Fluidised Bed Up Flow
Filtration System



Hydro Biofilter™
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Patent: www.hydro-int.com/patents

APPENDIX 9 – Amenity, Biodiversity and Landscape Plan



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