WMS

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May 2011

Polystorm & Polystorm Lite
Technical Guide

Water Management Solutions

Design, planning, specification and installation guidelines

Polypipe

Water Management Solutions

Modular Cell Systems

Design, planning, specification and installation guidelines

From the **technical specialists**, Polypipe Water Management Solutions. The Polystorm range of products and solutions for **attenuation and soakaway** applications.

This document describes the products from Polypipe Water Management Solutions for implementing a **stormwater management** system that meets the requirements for **Sustainable Drainage Systems** (SUDS).

Purpose of this document

This document provides full technical details on Polypipe WMS Polystorm products and explains how to:

- select products to provide the best solution for your specific stormwater requirements
- incorporate products into your project's design
- install products on-site

Other relevant documents from Polypipe WMS

- Ridgidrain/Ridgisewer and Polysewer Design and Installation Manuals
- Forms for specifying your requirements for Catchpits and Stormcheck chambers

Contents

Index - how this document is organised

The document is presented in clearly marked sections to help you navigate and find the information you require quickly and easily.

Section 1 - provides an overview of SUDS.

Section 2 - provides guidance on drainage design and helps you select which product to use for managing a site's stormwater run-off.

Section 3 - provides testing and certification information.

Section 4 & 5 - describe design protocol, installation and maintenance.

Section 6 - provides information on associated products.

Section 7 - shows project solutions.

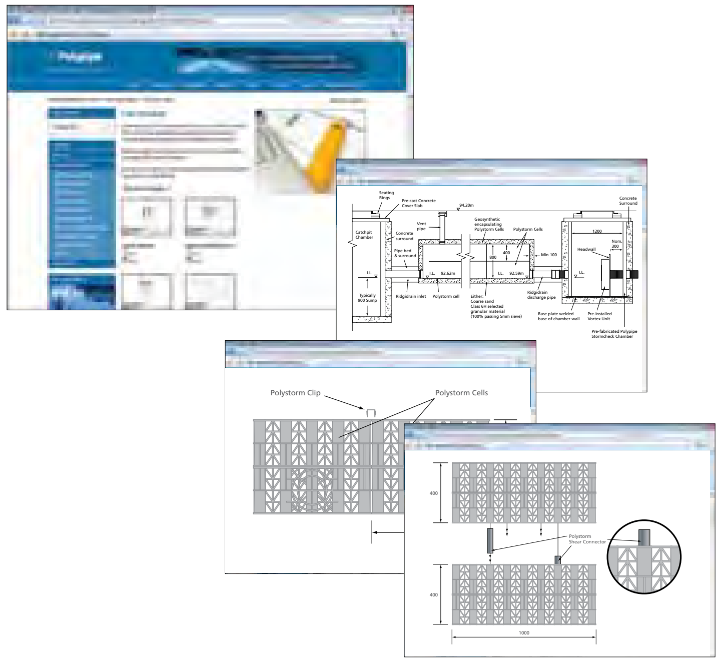
Section 8 - company overview.

Index - illustrations and tables

*** Please note:**

Illustrations shown within this publication are available as downloadable CAD drawings from

www.polypipewms.co.uk



1.0 Overview
Polypipe Water Management Solutions

Part of the overall Polypipe Civils business, the Polypipe Water Management Solutions (WMS) team includes some of the most talented Civil Engineers and Water Management Specialists within the industry to provide dedicated knowledge, support and technical expertise for a wide range of sustainable drainage systems (SUDS) and water management projects.

Today, the concept of sustainable water management is a major driver in the UK construction industry. Planning Policy Statement 25 (PPS25) requires local planning authorities to institute policies that enforce, wherever possible, the use of Sustainable Drainage Systems or SUDS. Combine this with the Floods and Water Management Act and it becomes obvious that specifying the correct sustainable drainage solution is vital.

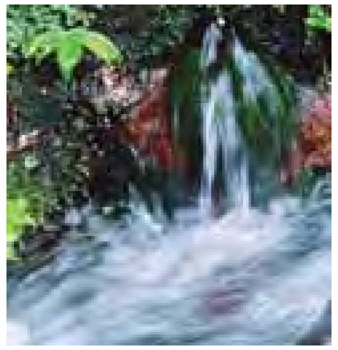
Polypipe WMS are totally dedicated to focusing on the legislative drivers and industry developments in order to provide innovative, future proof sustainable Water Management Solutions to our customers and the UK construction industry.

Overview

Contents

1.1 SUDS - sustainable drainage best practise and building regulations

Sustainable drainage systems are an alternative to the traditional approach of collecting stormwater in pipes and discharging it into treatment works or watercourses. SUDS best practice limits the flow of rainwater which runs off a site or is piped away, protects local watercourses from the contamination carried in surface run-off, encourages natural groundwater recharge (where appropriate) and reduces the likelihood of downstream flooding.



1.1.1 Building regulations

The Building Regulations Approved Document H3, Rainwater Drainage, which came into effect on 1st April 2002, prioritises drainage requirements. In short, it requires that rainwater from the roof of a building or from a paved area may either be gathered for re-use in a rainwater tank or be discharged into one of the following, listed in order:

(a) an adequate soakaway or some other adequate infiltration system; or, where that is not reasonably practical,

(b) a watercourse; or, where that is not reasonably practical,

(c) a sewer.

In other words, the traditionally preferred method of rainwater disposal, i.e. totally discharging to a sewer, may now only be considered after other forms of re-use or drainage have been considered.

1.1.2 SUDS Best Practice CIRIA C697

The SUDS Manual, published by CIRIA 2007 (CIRIA C697) defines that a sustainable urban drainage system should consider certain basic requirements, including:

- Run-off from a developed area should be no greater than the run-off prior to development
- Run-off from a developed area should not result in any down-grading of downstream watercourses or habitat
- Consideration should be given at the development feasibility stage to water resource management and control in the developed area
- Run-off should replicate as far as possible the natural response of the site to rainfall

SUDS best practice limits the flow of rainwater which runs off a site or is piped away, protects local watercourses from contamination carried in surface run-off, encourages natural groundwater recharge (where appropriate) and reduces the likelihood of downstream flooding.

1.1.3 The Code for Sustainable Homes

The Building Regulations also provide guidance on the construction of rainwater harvesting systems for the first time. The newly published Guidance Document entitled 'The Code for Sustainable Homes' indicates the Government's intentions to further drive developers towards building sustainable homes.

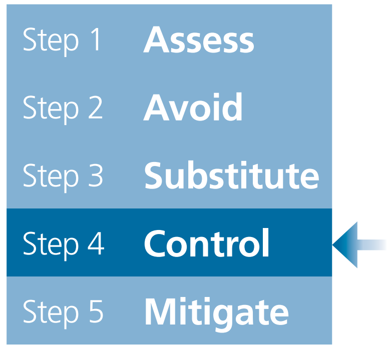
As well as covering energy efficiency, water usage and waste, the Code also proposes a minimum standard for surface water management. This minimum standard will require peak run-off rates or annual run-off volumes of surface water to be no more than the original conditions of the site.

The challenge each developer faces on both greenfield and brownfield developments is what to do with the excess run-off generated by a development which has to be retained in and around the site.

Polypipe WMS
provide the developer, both large and small, with flexible value engineered solutions which cater for almost any site conditions and restraints.

1.2 Drainage design - planning, cost effective techniques, site evaluation, adoption and future maintenance

Many authorities will expect planning applications, whether outline or detailed, to demonstrate how a more sustainable approach to drainage is to be incorporated into development proposals.



Step 4 requires planners to use SUDS as a form of control for surface water.

1.2.1 Key elements of Planning Policy Statement 25 (PPS25)

- Covers all types of flooding
- Flooding considered at all stages of the planning process
- Risk-based sequential approach
- Safe development of sustainable communities

1.2.2 Planning

Planning authorities will set a limit to the rate of stormwater flow from a site via sewers as a condition of planning consent. In recognition of this, Local Planners increasingly state that all applications should, in the first instance, aim to incorporate SUDS into development proposals. SUDS are also considered suitable for mitigating adverse impacts and supporting water conservation objectives.

1.2.3 Cost effective techniques

SUDS incorporate cost-effective techniques that are applicable to a wide range of schemes, from small developments to major residential, leisure, commercial or industrial operations with large roof spaces and large hardstanding areas. They can also be successfully retrofitted to existing developments. Planning policy guidance on development and flood risk emphasises the role of SUDS and introduces a general presumption that they will be used.

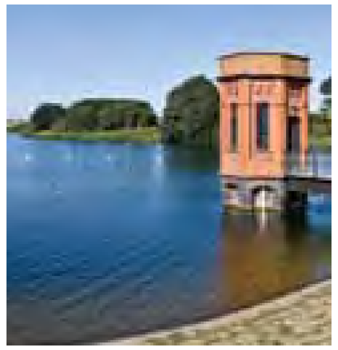
1.2.4 Site evaluation

As with other key considerations in the planning process - transport, landscape, heritage and nature conservation - incorporating SUDS needs to be considered early in the site evaluation and planning process, as well as at the detailed design stage.

1.2.5 Floods & Water Management Act

Sir Michael Pitt completed his independent review of the 2007 flooding emergency in June 2008, forming the catalyst for major legislative change. The report proposed 92 recommendations to improve UK surface water management and has called for significant investment from the Government in sustainable drainage techniques and flood management strategy.

The Floods and Water Management Act sets out a more joined-up approach to flood risk prevention and management and has been developed to implement the majority of the recommendations set out in the Pitt Review. It gives local authorities the lead role in managing local flood risk, as well as the responsibility for adopting and maintaining sustainable drainage schemes. This will then enable the Environment Agency to adopt a strategic overview role for all forms of flood risk, including groundwater and surface water.



1.2.6 Adoption and future maintenance

In the early stages of design, consideration should be given to the arrangements for adoption and future maintenance of the system. This is likely to influence the design just as much as technical considerations. For private, or non-adopted systems, maintenance will be the responsibility of the owner and future developments may be affected by covenants. For systems serving more than one residential property it is recommended that maintenance should be the responsibility of a publicly accountable body, which will often necessitate the payment of a commuted sum or a legal agreement, possibly backed by the deposit of a financial bond. The adopting organisation should approve the design before construction.

2.0 Polystorm modular cell system

attenuation and soakaway solutions

Average UK temperatures are expected to rise by up to 3/5°C by 2080, resulting in a dramatic change in the seasonal distribution of rainfall and subsequent weather patterns. The flooding witnessed during recent years is a clear indication that climate change is causing more frequent and extreme weather events and innovative solutions are required to cope with increased pressure on our existing drainage and water management networks.

Planning Policy Statement 25 - Development and flood risk

Planning Policy Statement 25 (PPS25) sets out Government policy on development and flood risk. Its aim is to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding and to direct development away from areas of highest risk. Where new development is exceptionally necessary in such areas, policy aims to make it safe, without increasing flood risk elsewhere and where possible, reducing flood risk overall.

Planning Policy Statement 25: Development and Flood Risk (PPS25), published in June 2008.

Polystorm modular solution

The Polystorm range of modular cells are designed to address the above legislation on minimising flood risk. The cells retain large volumes of water and fit together to create a modular underground water tank. The tank can then be modified to be either an attenuation or soakaway solution.

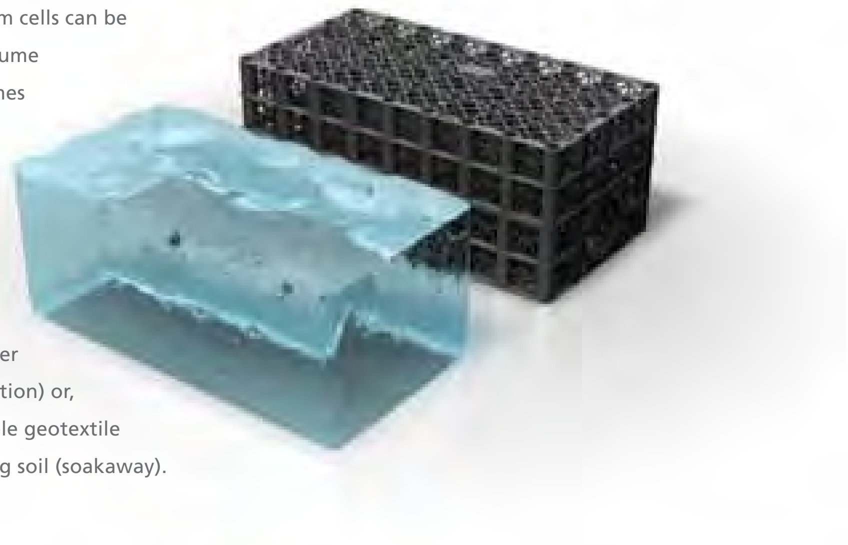
Products

Contents

2.1 Polystorm modular cell system - three types of Polystorm cells

2.1.1 The Polystorm principles

The Polystorm range of modular cell systems are designed with a 95% void ratio to retain large volumes of water run-off. The Polystorm cells can be designed and built to a specific size to a total void volume requirement dependent upon the water run-off volumes required on a particular project (i.e. car park, road or building). The Polystorm range of water storage cells are structurally strong, individual modular cells which can be built up to form a structure of any shape or size. The structure is wrapped in a non permeable, geomembrane which can receive rainwater collected from the roof gutter system or surface drains and either releases the water within set discharge limits (attenuation) or, where soil conditions allow, be wrapped in a permeable geotextile and slowly release the water back into the surface soil (soakaway).




Polystorm Lite 20T

BBA Polystorm Lite


Polystorm 40T

BBA Polystorm

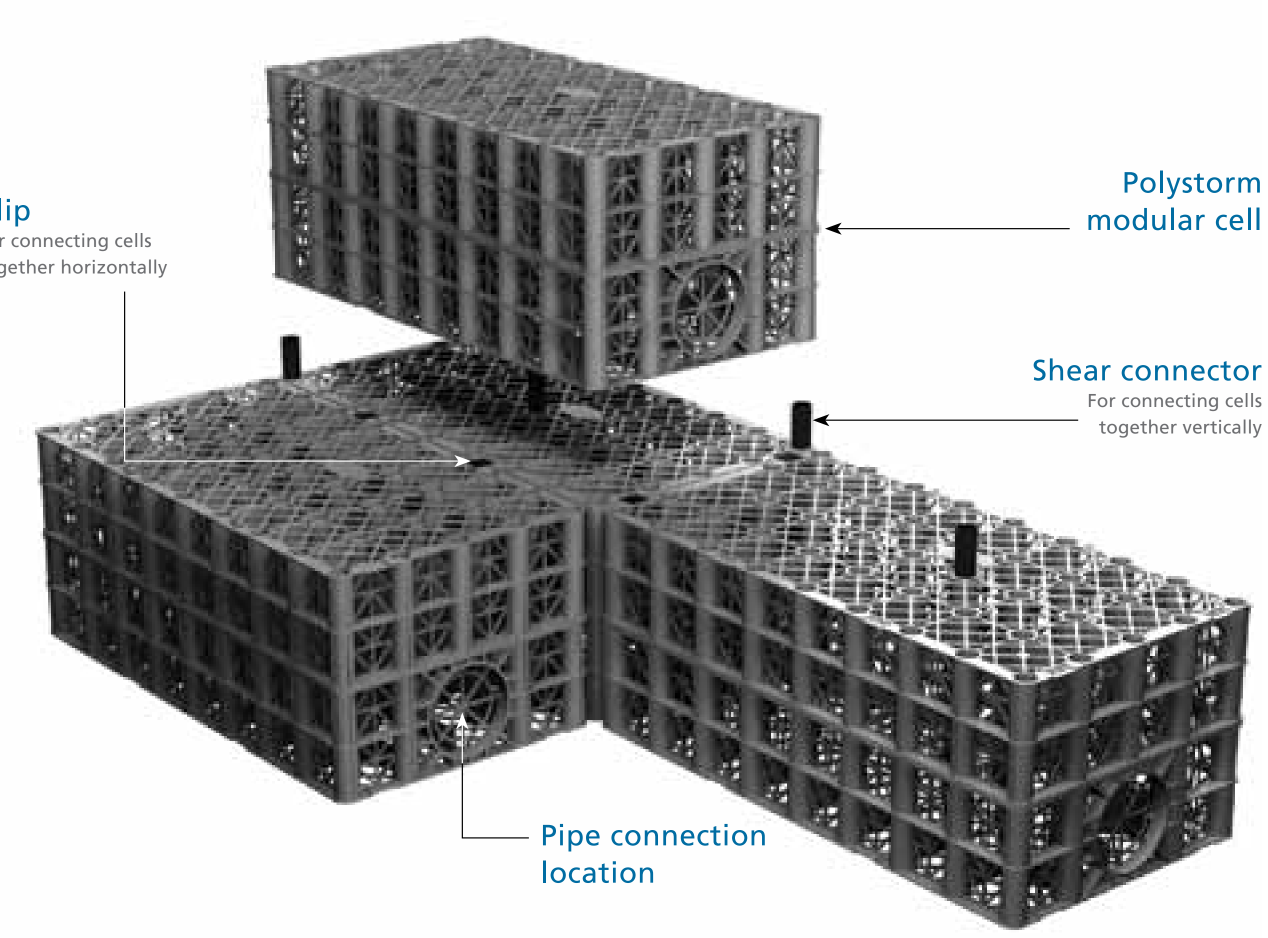
Key benefits

- **95% void ratio:** Providing greater water storage capacity and reduced excavation and disposal costs
- **Modular units:** Allow flexibility of shape - ideal for shallow excavation systems, narrow strips or use in restricted areas
- **Light weight yet robust:** Excellent Health and Safety and installation benefits
- **Easy to handle:** Unique rounded corners for ease of handling and reduces likelihood of punctures to membranes
- **Cost effective:** Especially when used as a hybrid, value engineered system
- **Recyclable:** 100% recyclable at the end of its useful life
- **Range:** Spans from 20 tonnes per square metre load bearing capacity up to a maximum of 80 tonnes per square metre load bearing capacity
- The range can be designed for non-trafficked, trafficked or heavy trafficked applications
- Suitable for both attenuation and soakaway systems
- 50 year design life
- BBA Approved
- Hybrid Solutions

There are three different types of Polystorm cells which are Polystorm Lite, Polystorm and Polystorm Xtra. Each Polystorm cell type has a different surface load specification.

- Polystorm Lite is designed for use in landscaped pedestrian or other non-loaded applications
- Polystorm is designed for use in light trafficked and loaded applications

The Polystorm Technical Manual is available to download at: www.polypipewms.co.uk/downloads



2.2 Polystorm Lite

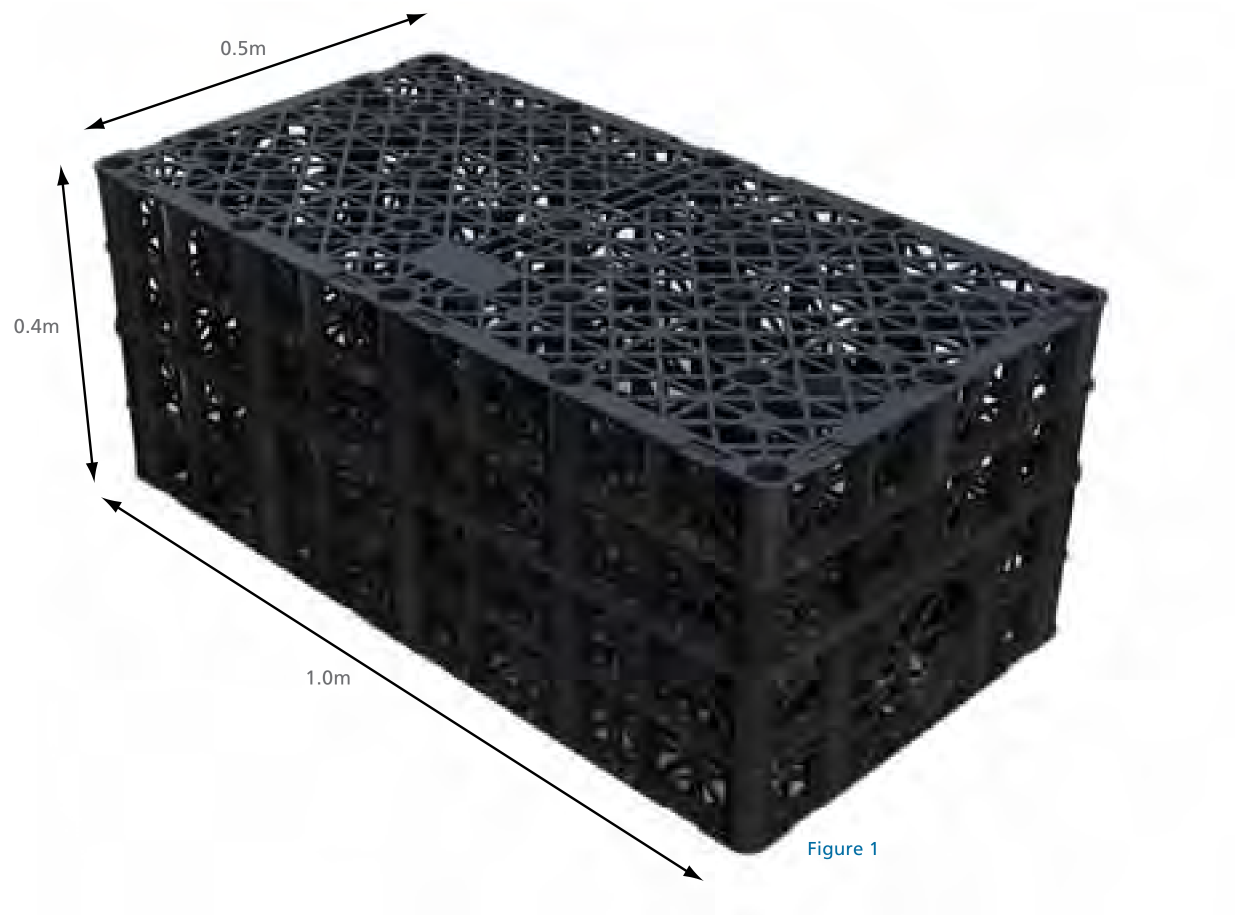


Figure 1

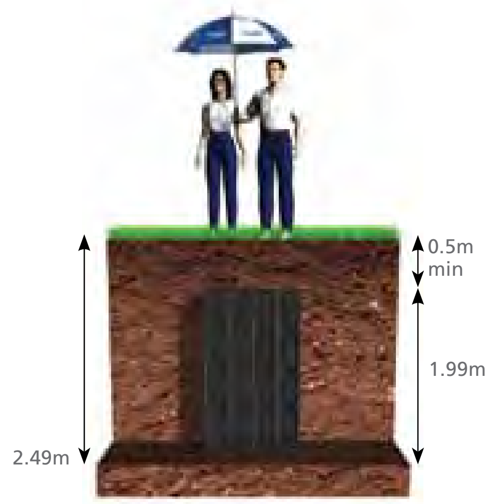


Figure 2

Polystorm Lite has been specifically designed for non-trafficked applications. With a 20 tonne per square metre compressive strength it will however take general maintenance vehicles such as grass cutters. Polystorm Lite can be used for both attenuation and soakaway applications. The modular structure receives rainwater collected from roofs or surface drains ready to release within a set drainage limit. Polystorm Lite can be used typically for landscaped areas, pedestrian or public open spaces such as underneath playgrounds.

Designed for use in landscaped, pedestrian or other non-loaded applications with a load bearing capacity of:

20 tonnes

Technical specification overview	
Unit type	**Polystorm Lite**
Product code	PSM2*
Dimensions	1m x 0.5m x 0.4m high
Total volume	0.2m per cube
Unit weight	7kgs**
Cube storage volume	0.19m³ (190 litres)
Surface area	55% perforated
Compressive strength	Maximum 20 tonnes per sq metre
Maximum burial depth	2.5m***

* Each unit includes 4 clips and 2 shear connectors. Please note that brick bond connector may be required at additional cost.

** Pallet weight dependent upon order quantity and transport type.

*** In weak clay soil conditions the maximum burial depth is 1.5 metres. Polystorm Lite should not be installed below the water table.

Table 1

Polystorm Lite		
Description	**Code**	**Pack quantity**
Polystorm Lite cell 1000 x 500 x 400mm	PSM2	15
Polystorm Lite flow control unit	PSMFC160/30	1
Brick bond shear connector	PSMBBSC	30
Clips	PSMCLIP	60
Shear connector	PSMSC	30
EN1401 flange adaptor - 110mm	PSMFA110	1
Ridgidrain flange adaptor - 150mm	PSMFA150	1
EN1401 flange adaptor - 160mm	PSMFA160	1
Basic silt trap	PSMST160	1
Advanced silt trap - 15 litres/sec	PSMSTA160/15	1
Mini silt trap for Polystorm Lite	PSMST110	1
Cover & frame (round)	UG501	1
Cover & frame (square)	UG502	1
450mm silt trap lid & frame	UG512	1
460mm lockable plastic cover & frame	UG511	1
Polypropylene cover & frame	ICDC1	1
Chamber riser section	ICDR1	1
Silt trap sealing ring	UG488	1

Table 2

Note: Minimum cover and burial depths may vary depending on load and ground conditions. Please contact Polypipe WMS for further information. All grades of Polystorm units may be used in situations outside of those recommended above, through the use of the appropriate protective measures designed to reduce the imposed loading on the proposed Polystorm structures.

2.3 Polystorm

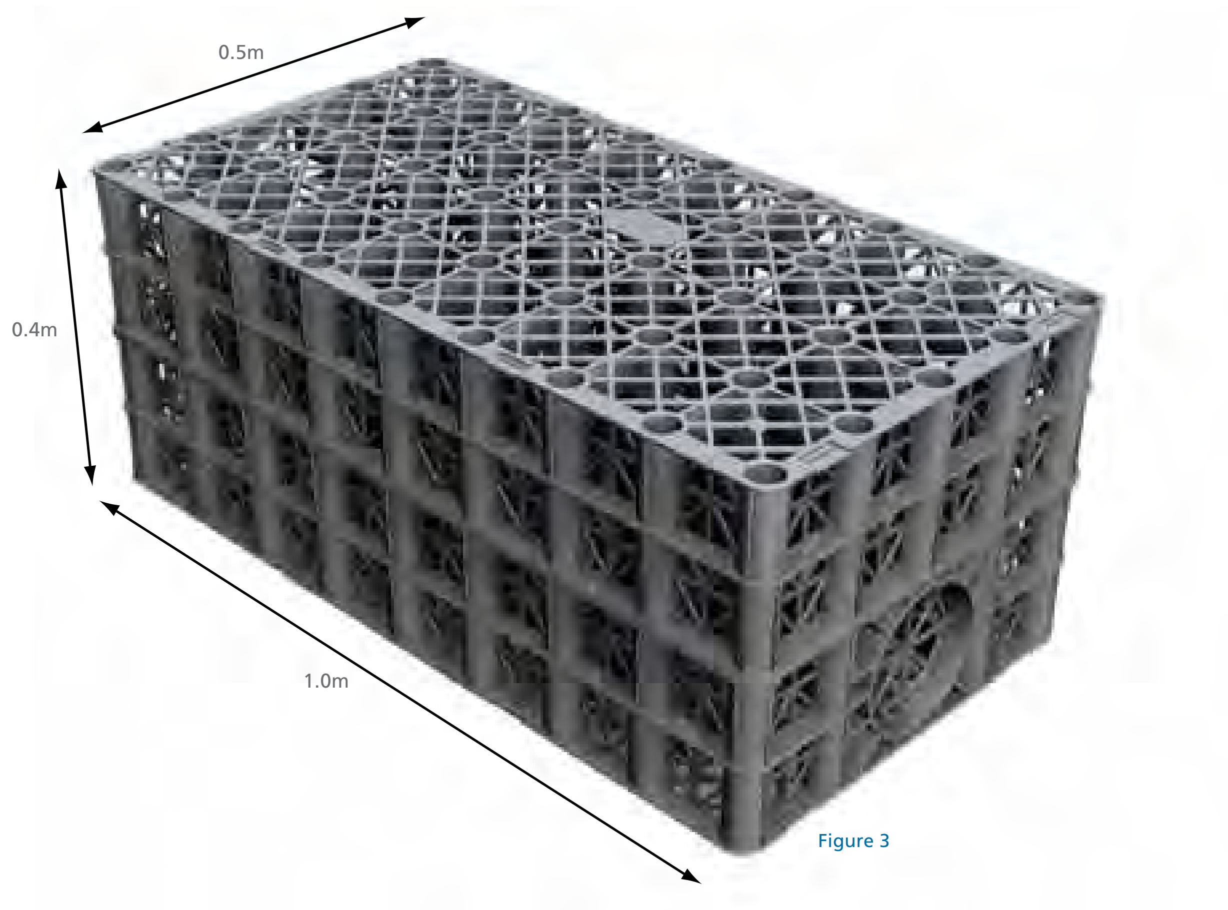


Figure 3

Designed for use in trafficked and loaded applications with a load bearing capacity of:

40 tonnes

Technical specification overview	
Unit type	**Polystorm**
Product code	PSM1*
Dimensions	1m x 0.5m x 0.4m high
Total volume	0.2m per cube
Unit weight	9kgs**
Cube storage volume	0.19m³ (190 litres)
Surface area	48% perforated
Compressive strength	Maximum 40 tonnes per sq metre
Maximum burial depth	3.7 metres***

* Each unit includes 4 clips and 2 shear connectors. Please note that brick bond connector may be required at additional cost.

** Pallet weight dependent upon order quantity and transport type.

*** In weak clay soil conditions the maximum burial depth is reduced, please consult Polypipe WMS Technical Team on 01509 615100.

Table 3

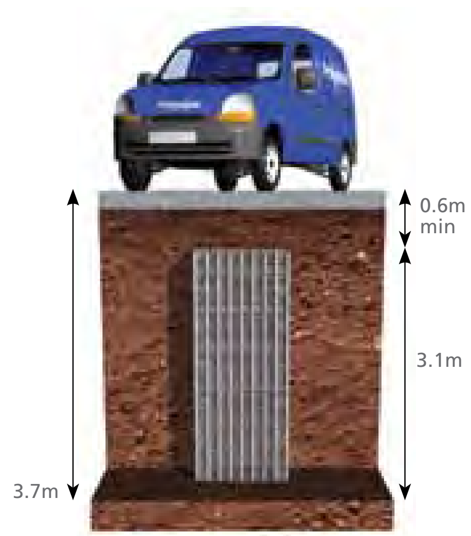


Figure 4

Polystorm features individual modular cells that can be built up to form a load-bearing tank structure of any shape or size to receive rainwater collected from the gutter system or surface drains ready to release within a set discharge limit. Polystorm has a 40 tonne per square metre compressive strength and is ideally suited for light trafficked and loaded applications. Polystorm can be used for both attenuation and soakaway applications and typically for housing developments, small car parks and light commercial developments.

Polystorm		
Description	**Code**	**Pack quantity**
Polystorm cell 1000 x 500 x 400mm	PSM1	15
Polystorm cell with 225mm connector	PSMCRD225	1
Polystorm cell with 300mm connector	PSMCRD300	1
Brick bond shear connector	PSMBBSC	30
Clips	PSMCLIP	60
Shear connector	PSMSC	30
EN1401 flange adaptor - 110mm	PSMFA110	1
Ridgidrain flange adaptor - 150mm	PSMFA150	1
EN1401 flange adaptor - 160mm	PSMFA160	1
Basic silt trap	PSMST160	1
Advanced silt trap - 15 litres/sec	PSMSTA160/15	1
Cover & frame (round)	UG501	1
Cover & frame (square)	UG502	1
450mm silt trap lid & frame	UG512	1
460mm lockable plastic cover & frame	UG511	1
Polypropylene cover & frame	ICDC1	1
Chamber riser section	ICDR1	1
Silt trap sealing ring	UG488	1

Table 4

Note: Minimum cover and burial depths may vary depending on load and ground conditions. Please contact Polypipe WMS for further information. All grades of Polystorm units may be used in situations outside of those recommended above, through the use of the appropriate protective measures designed to reduce the imposed loading on the proposed Polystorm structures.

2.4 Hybrid - Polystorm range of modular cells creating a cost-effective hybrid construction

The following illustrations indicate maximum burial depths for Polystorm Lite and Polystorm modular cell systems.

Polystorm Lite and Polystorm

POLYSTORM Lite
20 tonnes

Pedestrian

POLYSTORM
40 tonnes

Light Traffic

Figure 5

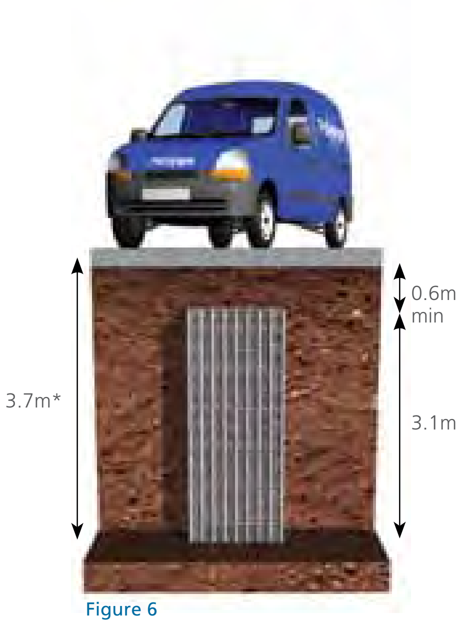


Figure 6

Note: * Based on ground conditions being dense sand and gravel.
Minimum cover and burial depths may vary depending on load and ground conditions.
Please contact Polypipe WMS for further information. All grades of Polystorm units may be used in situations outside of those recommended above, through the use of the appropriate protective measures, designed to reduce the imposed loading on the proposed Polystorm structures.

Hybrid Solution

VALUE ENGINEERED STRUCTURES

POLYSTORM Lite
POLYSTORM

Pedestrian

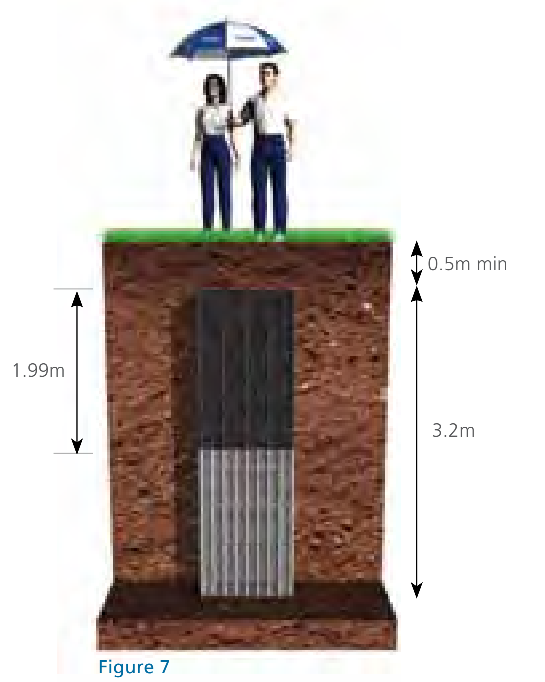


Figure 7

Value engineered structures

Polypipe are the only manufacturer who can offer a complete value engineered hybrid system utilising Polystorm Lite or Polystorm cells to create a bespoke solution based on the load requirements and burial depths for any given project.

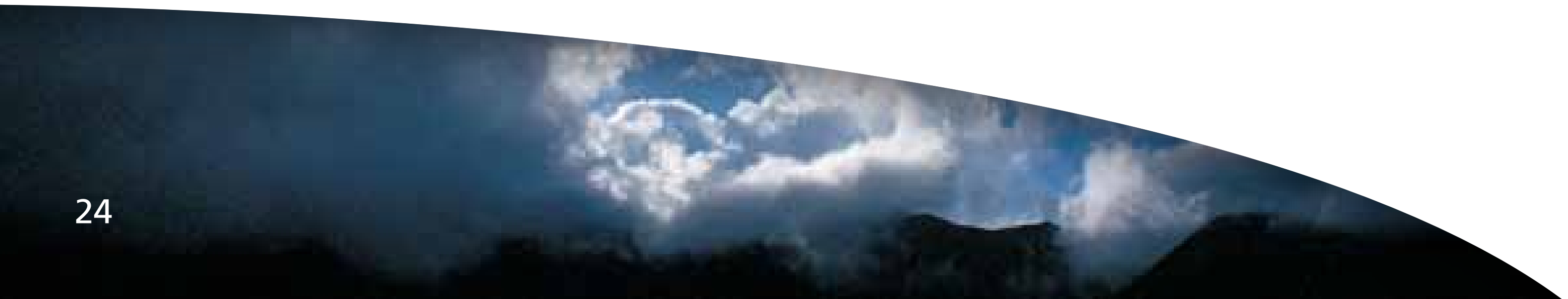
When integrated as a hybrid structure, a complete value engineered solution can be adopted for any given project. To reduce costs, it's possible to construct a hybrid tank, which contains all types of cells, the stronger Polystorm cells at the bottom and Polystorm Lite cells at the top. For further details contact Polypipe WMS technical support team. Refer to tables 8, 9 and 10 (page 39) for burial depths in different soil conditions.

3.0 Testing and certification - laboratory testing and protocol

At Polypipe WMS we pride ourselves on providing a consistently high level of product quality. All our products undergo stringent testing and quality control and where possible, are covered by third party certification. Our manufacturing processes are also accredited to ISO 9001:2008. There are two quality control labs in operation 12 hours a day.

Testing and certification

Contents



3.1 Testing and certification

As a manufacturer of plastic below-ground water management products, Polypipe WMS invests heavily in British Board of Agrément (BBA) approval and is a supporter of the criteria used to assess each product. By achieving BBA approval, Polypipe WMS can pass on to our customers confidence in the performance of all our products.

Figure 8 Compression test rig

Increasingly new products are being introduced within the UK water management markets with no independent approvals. This can create potential issues for product specifications unsupported by independent testing and assessment and may not correlate with the performance parameters of the product. BBA approved products offer our customers a safety net and further reassurances that the product will perform in-line with our claims when installed in accordance with the BBA certificate.

3.1.1 Laboratory testing

Laboratory testing to determine the structural performance of the Polystorm cells were carried out in accordance with the laboratory protocol provided by the British Board of Agrément (BBA) for products of this type. Direct compression tests were conducted at Polypipe's research and development laboratory in accordance with ISO 9001:2008 to determine the vertical and lateral strength of the Polystorm cells. Vertical creep tests were undertaken at the UKAS accredited Berry and Hayward laboratory.

3.1.2 Test protocol

Laboratory testing to determine the structural performance of the Polystorm cells has followed the protocol agreed with the British Board of Agrément (BBA). Direct loading tests were carried out on single cells. Individual cells were load tested until failure (i.e. the point at which they could not sustain further load).

Tests were carried out along two axes (Figure 9).

- Vertical compression test; with load applied down the y-axis, via a 300mm ø platen, at two positions (Figure 10)
- Vertical compression test; with load applied down the y-axis via a platen covering the full area of the cellular unit (0.5 x 1.0m)
- Lateral compression test; with load applied along the x-axis via a platen covering the full area of cellular unit (0.4 x 1.0m). A simultaneous restraining load, representing the vertical load that may be expected at the units recommended maximum burial depth, was also applied

Creep tests were carried out on single Polystorm cells for a minimum period of 90 days.

- Vertical creep test; with a constant load applied down the y-axis, via a 300mm ø platten at position (Figure 9). The applied test load was equivalent to 75% of the vertical compressive design load; with the design load calculated by applying an appropriate material factor of safety (2.75 recommended by CIRIA) to the lowest vertical compressive yield test result

Polystorm cell; direction of applied load and platen location

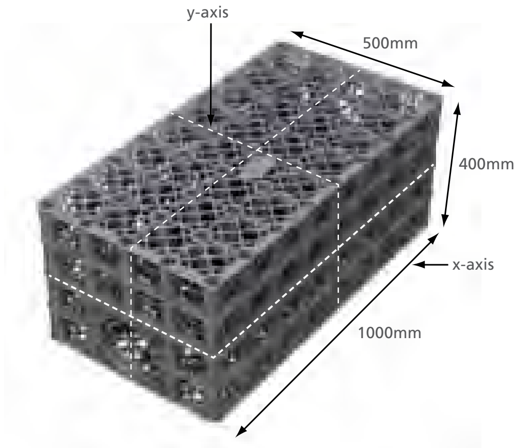


Figure 9 Unit axis; direction of applied load

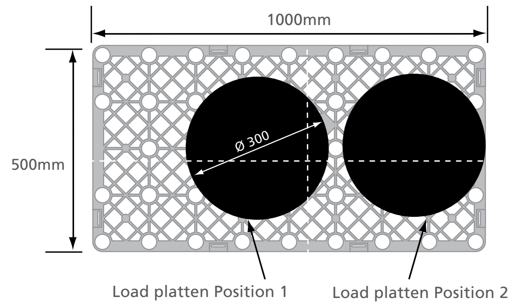


Figure 10 Position of load platens; point load resistance

Figure 11 Creep test rig

3.2 Summary of test results

3.2.1 Unit specifications

Figure 12 shows the dimensions of Polystorm Lite cells.

Figure 13 shows the dimensions of the Polystorm cells.

Table 5 shows the technical data for Polystorm Lite and Polystorm cells.

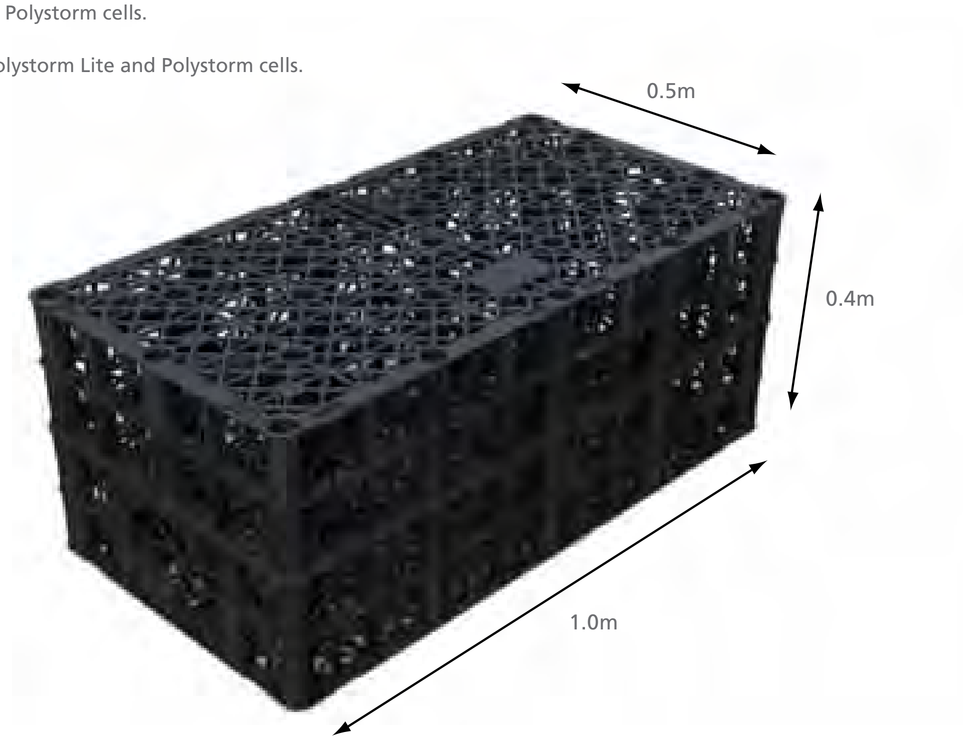


Figure 12 Dimensions of Polystorm Lite cell

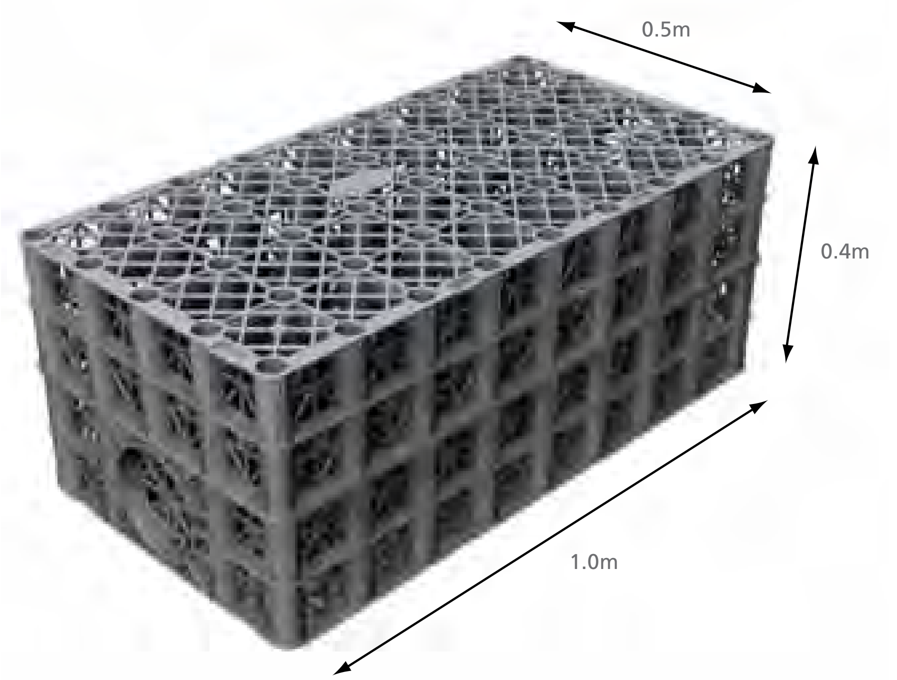


Figure 13 Dimensions of Polystorm cell

Technical data of Polystorm Lite and Polystorm cells		
	Polystorm Lite	Polystorm
Unit dimensions (nom) (mm)	1000 x 500 x 400	1000 x 500 x 400
Unit volume (nom) (m^3)	0.2	0.2
Storage volume (nom) (m^3)	0.19	0.19
Porosity (void ratio) (%)	95	95
Perforation of surface area (%)	55	48
Weight (kg)	7	9
Ultimate compressive strength at yield (kN/m^2)[1] : Vertical loading on top face	200	440
Lateral loading on side face	40	63
Short vertical loading on top side face (kN/m^2)	1 per 43	1 per 83
Estimated long-term deflection [2] (Ln) [3]	0.773	0.2796
Max burial depth (m)*	2.5m	3.7m

(1) = Applied load (2) = At up to 20 years @ 20°C @ 127kN/m² load (Polystorm) (3) = Time in hours
(2) = At up to 20 years @ 20°C @ 54kN/m² load (Polystorm Lite)
* Maximum burial depth dependant upon soil conditions, see page 39 for further details.

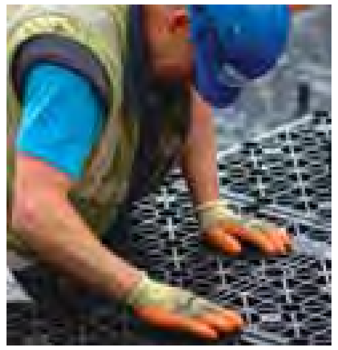
Table 5

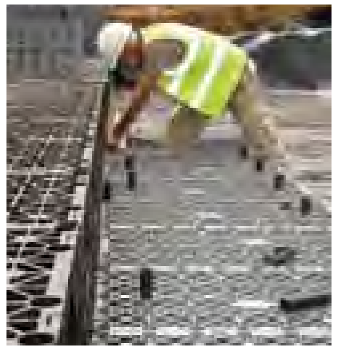
3.2.2 Durability

When installed in accordance with Polypipe WMS recommendations, the design life of Polystorm Lite and Polystorm cells exceeds 50 years. Please refer to BBA certificate.

3.2.3 Chemical resistance

Polystorm Lite and Polystorm cells are suitable for use in contact with chemicals likely to be found in rainwater. They are also resistant to all compounds occurring naturally in soils. For guidance on using Polystorm cells in contaminated ground, contact Polypipe WMS technical support team.

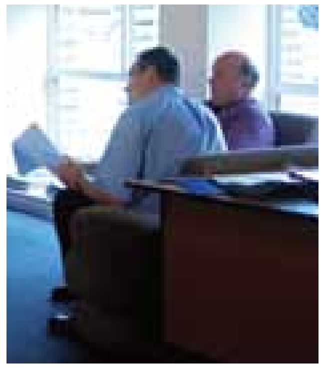




4.0 Design protocol

Polypipe WMS provide a full in-house design facility. Upon consultation our team of designers and technical advisors will guide you as to the best solution for your individual situation considering timescales and costs.





Design protocol

Contents

4.1 Detail design protocol

4.1.1 Structural design

4.1.1 Structural design

When designing plastic geocellular structure for soakaway or attenuation tanks care has to be taken to ensure the finished system is safe to carry the loads they will be subject to. The diagram below outlines a safe route to the design and installation of Polystorm modular stormwater tanks.

Figure 14

Listed below are the four main reasons for failure of the system:

1. Structural failure or collapse - when the structure cannot support the applied loads.
2. Excessive deflection or movement when vehicles passing over the tank cause movement and the surface above may crack or displace.
3. Creep - excessive movement or loss of strength over a period of time which can occur under a constant load.
4. Flotation: Constructing a tank below the groundwater table can create uplift.

4.1.2 Limit state design, 4.1.3 Industry standards, 4.1.4 Factors of safety

4.1.2 Limit state design

In the design of any load carrying system, there needs to be factors of safety to allow for any variation in either the applied load or cellular unit strength. Limit state design does not use a single overall factor of safety; the method looks at 'limit states' and applies partial factors of safety to the various design parameters depending on the consequences of the limit state being exceeded. In the case of Polystorm drainage tanks the two limit states to be considered are:

- **Ultimate limit state (ULS)**
  This is when the strength of the cell is exceeded by the applied loads and the tank collapses. This is obviously serious and the partial factors of safety used in this assessment are chosen to ensure there is a negligible risk of a collapse occurring.
- **Serviceability limit state (SLS)**
  This considers the operational behaviour of a tank to ensure that the installation remains serviceable. For the structural calculations this means that deflections are not excessive and do not cause damage to overlying surfaces (such as asphalt) or cause a significant reduction in the storage volume of the tank. The Polystorm Lite cell is recommended for use in landscaped areas, where deflections would have a negligible effect. SLS would therefore not play a significant role in Polystorm Lite structural design.

4.1.3 Industry standards

There are currently no design standards or guides specific to generic modular plastic stormwater tanks, with each manufacturer within the marketplace providing their own guidelines that tend to be specific to their own cells. However, a generic design method has been developed that can be applied to most types of cells, using basic structural design theory and relevant British Standards. In particular the loading on plastic tanks may be considered to be the same as a buried concrete or steel tank and so the loads and partial factors of safety for loads have been taken from the following:

1. **British Standards Institution (1997).** British Standard BS8110, Part 1: 1997; Structural use of concrete: Code of practice for design and construction. BSI
2. **British Standards Institution (1996).** British Standard BS 6399: Part 1: 1996: British Standard Loadings for Buildings. Part 1 Code of Practice for dead and imposed loads. BSI

The only available guidance relating to plastic materials in similar situations to buried cellular tanks is that for plastic geosynthetics in soil strengthening and reinforcement. The information in the following British Standard has been used as a guide to the choice of partial material factors used for the design:

1. **British Standards Institution (1995).** British Standard BS8006: 1995; Code of practice for strengthened/ reinforced soils and other fills. BSI

4.1.4 Factors of safety

To ensure that the risk of exceeding the limit states is minimal, factors of safety are applied to the cellular unit's ultimate compressive strength and to any applied loads; these are known as partial factors of safety.

4.1.5 Material factors

4.1.5 Material factors

The ultimate compressive strength of the Polystorm cells has been obtained from laboratory testing on samples. To take account of other factors such as variations due to manufacturing processes, variability and uncertainties in material strength (e.g. due to extrapolation of data), damage during installation and environmental effects, a design strength is derived by dividing the cell's characteristic strength by a material partial factor of safety (f_m), appropriate to the material and limit state. There is no guidance on the choice of material factors for plastic storage tanks.

Partial material factors of safety: Polystorm Lite & Polystorm	
Limit state	f_m
Ultimate limit state	2.75
Serviceability limit state	1.5

Table 6

The partial factor f_m is made up of several components:

f_{m11}

This is applied to the characteristic strength of Polystorm. It covers possible reductions in strength from the control test specimens and inaccuracies in the assessment of the resistance of a structural element resulting from modelling errors. For tightly controlled Polystorm production f_{m11} would normally be between 1.05 and 1.1. Because a limited number of compression tests have been undertaken on the Polystorm cells in addition to this property not being measured as part of the quality control program, a conservative value has been adopted. Compression tests were undertaken at points judged by inspection to be the weakest however the cell is a complex three dimensional structure, therefore an allowance must be made for this. In view of the preceding factors and the conservative choice of design parameters already undertaken, a value of f_{m11}= 1.20 has been adopted for the ULS and 1.1 for the SLS. This can be reviewed if the compressive strength is measured as part of the manufacturing quality control procedure.

f_{m12}

This is applied to take account of the extrapolation of creep test data. It is also used in the case of the Polystorm cells to allow for the absence of fatigue testing. A suggested value of f_{m12} is given by Ingoldv = Log (td/tt) where td = design life, tt is duration of creep test. This gives a value for the ULS, with a design life of 20 years, of f_{m12} = 1.9. Although the cells will be under compressive loads and appear to fail in compression at the internal columns, they are complex structures. Some of the elements will be acting in tension and when polypropylene is subject to creep under long term tensile loads it can lose strength over time. Therefore the values taken from reinforced earth applications are considered reasonable. For serviceability, which is not so critical, a value of 1.25 is adopted.

f_{m21}

This is applied to take account of damage during installation. The Polystorm cells are robust and not particularly susceptible to damage and therefore, in the absence of specific damaged strength testing, a factor of 1.1 for the ULS and 1.0 for the SLS has been used.

f_{m22}

This is applied to take account of environmental conditions. The polypropylene used in the manufacture of the Polystorm units is resistant to all contaminants that are naturally found in soil and rainwater. No specific test results are available and so a value of f_{m22} for both ULS and SLS of 1.1 has been adopted; which is the minimum value recommended for reinforced earth applications by Ingoldv. With the total value of $f_m = f_{m11} \times f_{m12} \times f_{m21} \times f_{m21}$

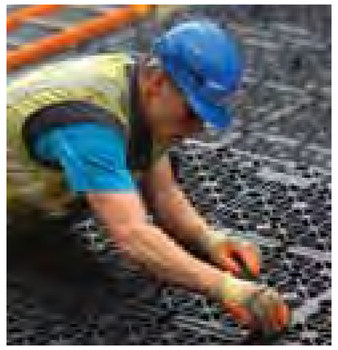
Therefore, for the following limit state, f_m will equate to:

Ultimate limit state: 1.2 x 1.9 x 1.1 x 1.1 = 2.75

Serviceability limit state: 1.1 x 1.25 x 1.0 x 1.1 = 1.5

The use of conservative factors also allows for synergistic effects (i.e. the combined effect of construction damage, environmental effects and lower than expected cell strength) that may result in a greater combined effect than the three factors acting individually. These factors are only applicable for temperate climate conditions such as in the UK. Although the strength of polypropylene varies with temperature, this will not be significant for installation in the UK where the temperature in the ground (at the typical depth of installation) remains between 0°C and 20°C with a mean value of around 10°C.

4.1.6 Applied loads and load factors



4.1.6 Applied loads and load factors

Loads that may be imposed on a cellular storage structure such as Polystorm, can be broken down into the following types:

- **Dead Loads**
  Permanent loads applied to the cells, including the weight of backfill material placed over the top and lateral (horizontal) earth and water pressure loads acting on the side of the system.
- **Live Loads**
  Loads due to pedestrian, vehicle and construction traffic that are not permanent. Traffic wheel loads are normally given as static loads, with a factor applied to allow for dynamic effects (a moving wheel will impose more force on the ground than a static one).

A design load is obtained by applying a partial factor of safety to the estimated characteristic load. This allows for unforeseen variations of loading and also the severity of the consequences of the limit state occurring. The loads on cellular units will be similar to loads applied in the design of structures using rigid materials such as concrete and therefore the partial safety factors for loads that are appropriate to the design of plastic storage systems are taken from British Standard BS 8110.

Partial factors of safety for applied loads			
Limit state	Imposed vertical dead load f_m	Imposed earth pressure dead load f_m	Imposed live load f_m
Ultimate limit state	1.40	1.40	1.60
Serviceability limit state (Polystorm only)	1.0	1.0	1.0

Table 7

Thermal expansion of the cells will be negligible because temperature variations that are likely to occur in the ground should not be significant. These loads are therefore not considered in this design.

4.2 Distributed loads

4.2.1 Example of calculation methods

The structural design of the cells needs to consider a number of different loads and their effects.

What load is applied to the tank?

1. Dead (permanent) loads such as the weight of soil placed over the top of the cells or long term stockpiles of containers or materials (anything that will be applying load for a lengthy period of time).
2. Surcharge loads. From stored materials or to allow for traffic.

How is this analysed?

The weight of the fill material is calculated from the depth of soil and its cell weight. The traffic loads that are typically used are: Car Parks - 2.5kPa. HGV Loading - 10kPa.

Example: 1.5m cover depth over the top of Polystorm - Car Park.

Design against collapse (ultimate limit state)

Weight of soil = 1.5m x 20kN/m3.

Partial factor of safety = 1.4.

Surcharge = 2.5 kPa, Partial factor of safety = 1.6.

Total design load = (1.5 x 20 x 1.4) + (2.5 x 1.6) = **46kPa**.

Polystorm ultimate compressive strength at yield = 440kPa.

Partial factor of safety = 2.75.

Design strength of Polystorm = 440/2.75 = **160kPa**.

Design strength is greater than factored loads so the design is ok.

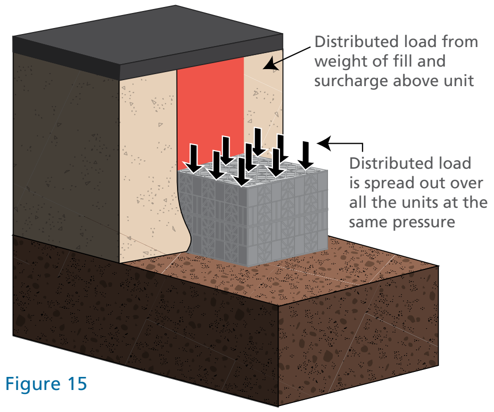


Figure 15

Check deflection (serviceability limit state)

Partial factor on load = 1.0.

Design load = (1.5 x 20 x 1.0) + (2.5 x 1.0) = **32.5kPa**.

Deflection of Polystorm = 1mm per 83kPa load.

Partial factor of safety = 1.5.

So elastic deflection of Polystorm = 32.5 x 1.5/83 = **0.6mm**.

Most of the deflection is due to the permanent load and so it will be acceptable.

Check creep (serviceability limit state)

Long term creep deflection = 0.2794Ln (design life in hours).

For a load less than 100kPa.

So if design life is 20 years

Creep = 0.2794 Ln (20 x 365 x 24) = **3.4mm**.

What load is applied to the tank?

3. Concentrated loads for example those from:
   - Wheels of cars or trucks
   - Container feet
   - Construction vehicles
   - Crane spreader plates or legs

How is this analysed?

The load from the wheel is spread out through the soil or pavement materials over the top of the tank. The heavier the load the greater the thickness of material that is required over the top of the tank. However there is a practical minimum of about 0.5m in most cases to avoid damage to the tank during installation and after construction.

Example:

Polystorm is to be used under a car park that may be occasionally crossed by delivery trucks or refuse collection lorries (maximum gross vehicle weight 31,000 kg). Polystorm is covered by 1.2m of Type 1 sub-base and asphalt pavement construction.

Design against collapse (ultimate limit state)

Load from wheel = 35kN.

Assume contact patch is 0.135m by 0.275m.

Trucks will be moving slowly but turning therefore dynamic factor = 1.5.

Cover depth of soil is 1.2m and assume a 26.6° load spread.

Contact area on top of tank is:

0.275 + 1.2 by 0.135 + 1.2 = 1.97m2.

Applied pressure from wheel is 35 x 1.5/1.97 = 26.6kPa.

Factor of safety = 1.6

and factored pressure = 26.6 x 1.6 = **42.6kPa**.

Pressure from soil is 1.2m x 20kN/m3 = 24kPa.

Factor of safety = 1.4

and factored pressure = 24 x 1.4 = **33.6kPa**.

Total pressure = 42.6 + 33.6 = 76.2kPa.

As in previous example design strength of Polystorm = 160Kpa and this is greater than the applied load and so it is acceptable.

4.3 Lateral loading - calculation example

4.3.1 Check deflection (serviceability limit state)

In this case we are interested in the continuous and repeated deflections under wheel loads only.

Partial factor on load = 1.0.

Applied pressure from wheel (above) is **26.6kPa**.

Design pressure = 26.6 x 1.0 = 26.6kPa.

Deflection of Polystorm = 1mm per 83kPa load.

Partial factor of safety = 1.5.

So elastic deflection of Polystorm = 26.6 x 1.5/83 = 0.5mm.

This will be repeated each time a wheel passes over the tank. This is acceptable for an asphalt pavement.

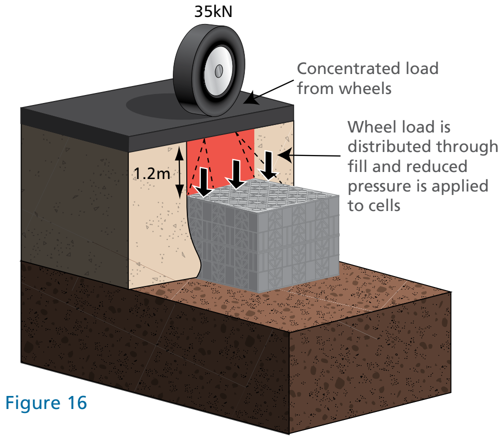


Figure 16

What load is applied to the tank?

4. Earth and groundwater pressure from the surrounding ground. Note that account must be taken of sloping ground, pre-existing shear planes and groundwater. If in doubt obtain expert advice from Polypipe WMS technical support team.

How is this analysed?

The earth pressure applied to the side of the tank by the soil and groundwater. The weaker the soil the greater the pressure it applies to the side of the tank. Water also applies pressure to the side of a tank. The calculations are based on standard earth pressure theory.

Example

The bottom of a modular tank is located 2.5m below ground level. The excavation is surrounded by medium dense sand and gravel with an angle of friction of 34°.

The groundwater is below the base of the tank.

Allow for a 10kN/m² surcharge.

To allow for load distribution on the side of the tank, the design uses the earth pressure at a depth of 0.25m above the base of the tank.

Therefore; Design depth = 2.5 – 0.25 = 2.25m.

For an angle of friction of 34° the coefficient of active earth pressure is 0.282.

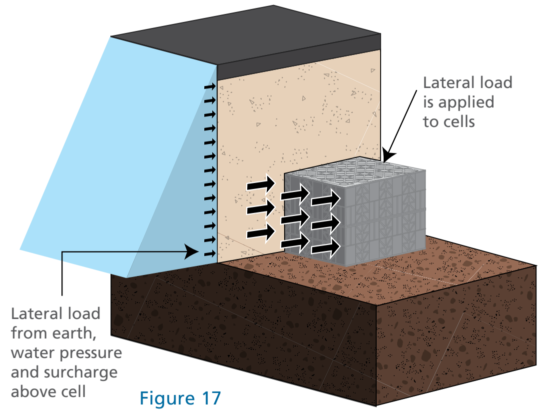


Figure 17

Design against collapse (ultimate limit state)

Partial factor of safety for earth pressure = 1.35.

Partial factor of safety for earth pressure = 1.5.

The applied pressure from the soil is given by;

Applied pressure =

0.282 x 2.25m x 20kN/m³ x 1.35 + 0.282 x 10kN/m³ x 1.5.

Applied pressure = **21.4kN/m²**.

Polystorm ultimate strength at yield for lateral loading = 63kN/m².

Material partial factor of safety = 2.75.

Design strength = 63/2.75 = **22.9kN/m²**.

This is greater than the applied load and so it is acceptable.

Deflections can be estimated using the same approach as for the vertical loads with a partial load factor of 1.0 in all cases.

Note: Where groundwater is present the submerged density must be used to calculate the earth pressure on the side of the tank from the soils below the groundwater table.

4.3 Lateral loading - calculation example

What load is applied to the tank?

5. Uplift pressure from groundwater of the tank is constructed below the groundwater table.

How is this analysed?

A tank is constructed 1m below the groundwater table and has a soil cover over the top of 0.8m.

Will uplift occur?

Design against floatation

Uplift pressure equals weight of water displaced by tank.

Partial factor safety on uplift force = 1.5.

Uplift pressure = 1 x 10 x 1.5 = **15kN/m²**.

Weight of soil resisting uplift

Partial factor of safety = 0.95.

Weight = 0.8 x 20 x 0.95 = **15.2kN/m²**.

The weight of soil is sufficient to present uplift.

Note: An assessment would need to be made of the risk of ground levels being reduced or groundwater levels rising after completion of construction.

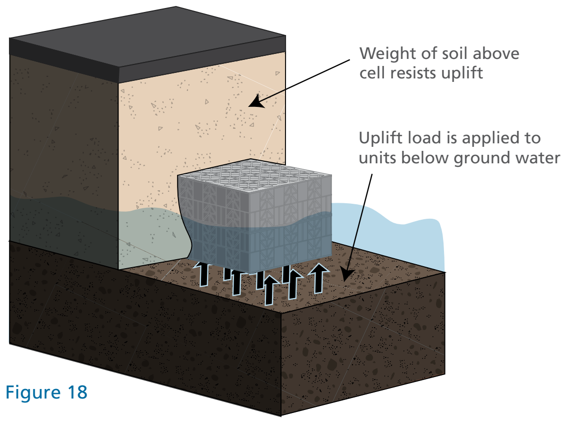


Figure 18

4.4 Maximum burial depths

4.4.1 Recommended maximum installation depths

Polystorm Lite and Polystorm cells can be buried to the maximum depths detailed below. Actual maximum burial depths will depend on soil conditions applicable, however in some circumstances both Polystorm Lite and Polystorm can be buried to greater depths when special measures are carried out. For examples of such measures please refer to page 40.

Polystorm Lite - maximum depth of installation (to base of cells) (m)

Typical soil type	Typical angle of shearing resistance ϕ	Without groundwater (below base of cells) normal case	With groundwater at 1m below ground level and units wrapped in geomembrane
		Non-trafficked	Non-trafficked
Stiff over consolidated clay e. g. London Clay	24	1.49	1.41
Normally consolidated silty sandy clay e.g. Alluviun, Made Ground	26	1.60	1.48
Loose sand and gravel	30	1.77	1.60
Medium dense sand and gravel	33	2.05	1.69
Dense sand and gravel	38	2.49	1.83

Table 8

Polystorm - maximum depth of installation (to base of cells) (m)

Typical soil type	Typical angle of shearing resistance ϕ	Without groundwater (below base of cells) normal case		With groundwater at 1m below ground level and units wrapped in geomembrane	
		Trafficked (cars only)	Non-trafficked	Trafficked (cars only)	Non-trafficked
Stiff over consolidated clay e. g. London Clay	24	2.1	2.2	1.5	1.6
Normally consolidated silty sandy clay e.g. Alluviun, Made Ground	26	2.3	2.4	1.5	1.6
Loose sand and gravel	30	2.5	2.7	1.6	1.7
Medium dense sand and gravel	33	3.0	3.1	1.7	1.7
Dense sand and gravel	38	3.7	3.8	1.8	1.8

Table 9

Polystorm Lite & Polystorm - minimum cover levels (to top of cells) (m)

Live load conditions	Field (Polystorm Lite & Polystorm)	Light trafficking (Polystorm only)	
		Car park with vehicle mass <2500kg	Car park with occasional vehicle mass >2500kg
Minimum cover depth required (m)	0.50	0.60	0.80

Table 10

Please note that the maximum burial depths above are based on the partial factors of safety derived during consultation with the British Board of Agrément (BBA) prior to the publication of CIRIA C680. The BBA has used higher partial factors of safety than CIRIA C680. For further information of the design method detailed in CIRIA C680 please contact our technical support team.

4.5 Special measures - relieving earth pressure for deeper installations

4.5.1 Special measures

The earth pressure at the design depth for the tank may exceed the lateral strength of Polystorm Lite and Polystorm cells (once it has been factored down). If this is the case there are a number of solutions:

1. Redesign the drainage system to make the invert of the tank shallower.
2. Place the cells in a stepped configurations where the tank gets wider from the base to the top (Figure 19).
3. Reinforce the lower part of the backfill with geogrids (Figure 20).
4. Use mass concrete backfill in the lower part of the backfill (Figure 21).

Reducing lateral pressure on a Polystorm Tank

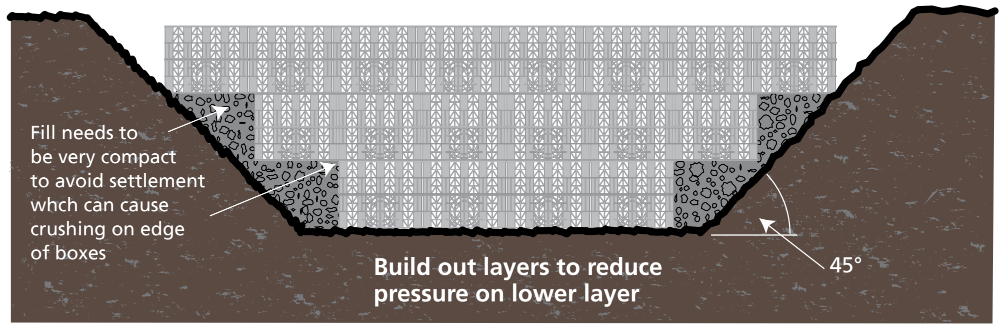


Figure 19

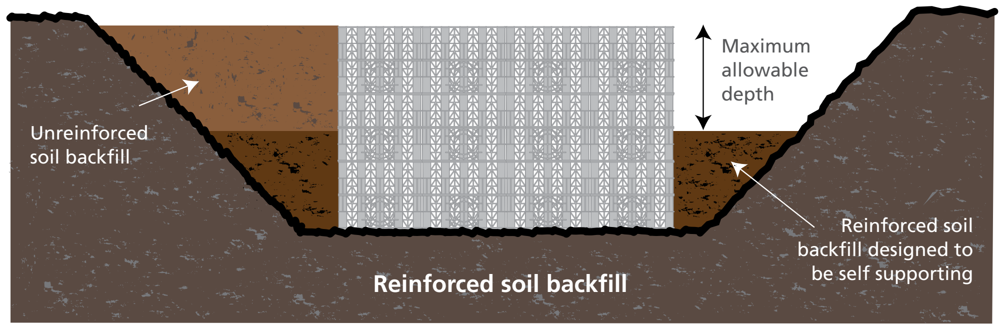


Figure 20

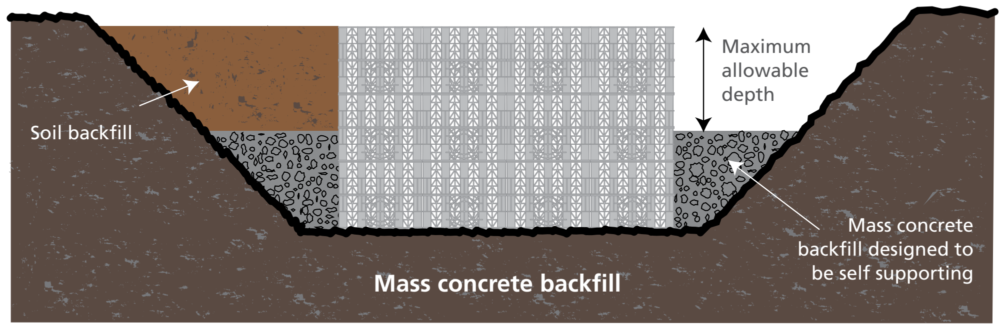


Figure 21

4.6 Hydraulic design

4.6.1 Hydraulic design

Hydraulic design calculations provide the storage volume required on any particular site that is required to reduce the speed, frequency and volume of rainfall run-off into rivers or sewers. The required volume depends on the site location, the size of the area being drained, the soil infiltration rate (for soakaways) or allowable discharge rate (for attenuations systems).

The design of SUDS should follow the requirements in the CIRIA Report C 697 The SUDS Manual.
This identifies three types of storage that are required:

- **Interception storage** - this is not actually storage - the aim is to reduce the frequency of run-off and prevent run-off from sites for rainfall events up to 5mm in order to simulate the behaviour of greenfield catchments more closely. This is achieved using infiltration or source control methods where evapotranspiration can reduce the volume of run-off.
- **Attenuation storage** - used to reduce the peak discharge rate from a site (i.e. how fast water flows off the site) and is used to store excess water where the rate of discharge is limited to greenfield run-off rates (or other agreed rate). It is designed to operate for a range of annual probabilities (typically 1 in 30 years and 1 in 100 years).
- **Long term storage** - used to reduce the additional volume of run-off caused by developments. Stores excess water that is the difference in total volume of run-off between the developed and greenfield site for a 1 in 100 year 6 hour rainfall event. Outflow from the long term storage should be to either infiltration or to a water course or sewer at 2 l/s/ha or less.

Polystorm can be used to provide attenuation, long term storage and can be designed into systems that provide interception storage (e.g. soakaways or below swales or infiltration basins). The SUDS manual also requires treatment of pollution in run-off and Polystorm can help these treatment systems work more effectively by controlling the flow of water through them (for example by providing attenuation storage upstream of a wetland). The exact design requirements for any site should be agreed with the Environment Agency.

4.6.2 Design of attenuation storage

The volume of Polystorm required for attenuation storage is typically calculated using drainage design software based on the Wallingford Procedure. The volume of temporary run-off storage required is shown in Figure 22 and is simply the difference between the volume of run-off that enters the tank during a design storm and the volume of water that is allowed to flow out in the same period (which is governed by the discharge rate allowed by the regulators). In this way Polystorm can be used to limit the peak rate of run-off from a site (usually to the greenfield run-off rate). The calculations are completed for a range of return periods and durations.

Attenuation storage volume

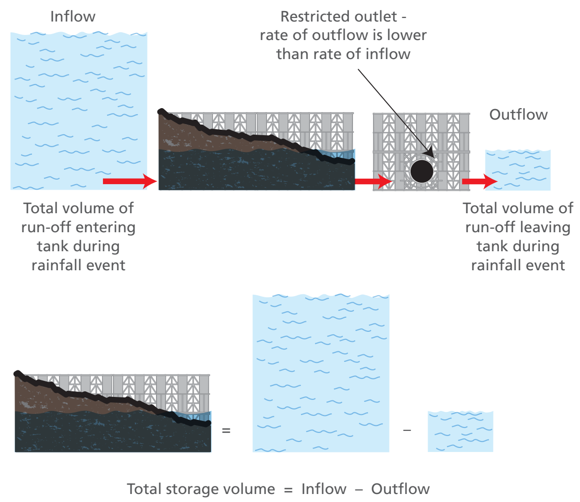


Figure 22

4.7 Hydrological rainfall

4.7.1 Hydrological rainfall zones for the UK

(HR Wallingford, Use of SUDS in high density developments, defining hydraulic performance criteria, Report SR 640, December 2003).

The table below can be used to size a Polystorm tank. The tables are based on the hydrological rainfall regions shown on the map.

The tables are based on the following assumptions:

- Storage is provided for development design events of 1 in 30 years, 1 in 100 years and 1 in 100 years plus 20% increase for climate change but the greenfield run-off rate is always considered to be 5 l/s/ha
- Time of entry and time of concentration within the drainage system is not considered
- 100% run-off is assumed

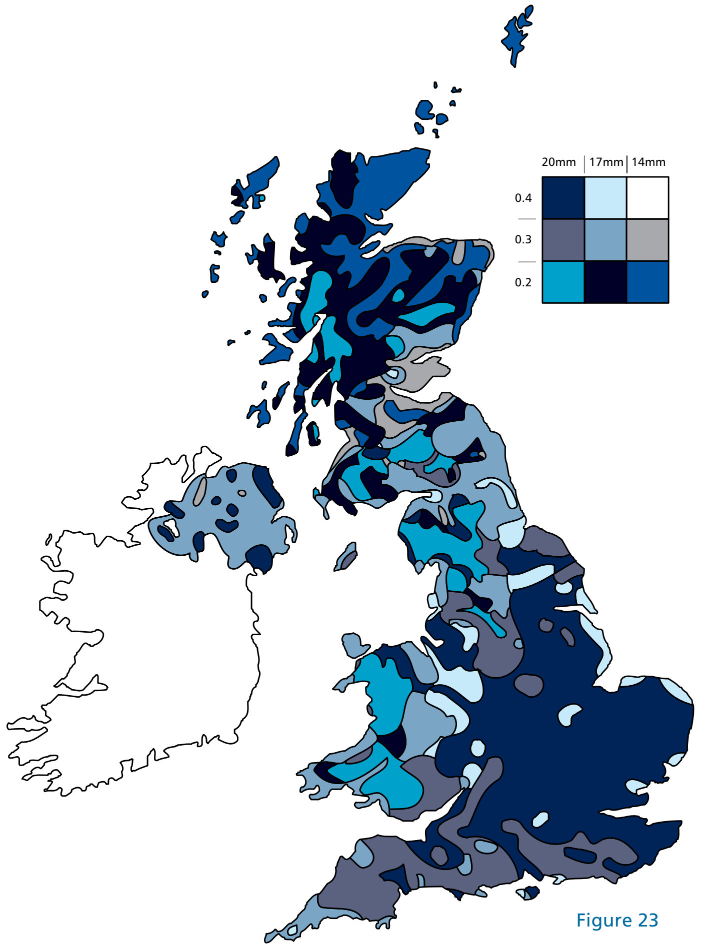


Figure 23

Required attenuation storage (m³ of storage per Ha of impermeable area)

	r	1 in 30 year design event	1 in 100 year event	1 in 100 year event plus 20% climate change
Ms-60 = 20mm	0.4	357	510	643
	0.3	413	583	749
	0.2	556	770	968
Ms-60 = 17mm	0.4	293	419	5.45
	0.3	335	483	631
	0.2	444	637	822
Ms-60 = 40mm	0.3	258	383	511
	0.2	335	500	665

Table 11

Note: Volumes include allowance for 95% void ratio of Polystorm.

Polystorm has a void ratio of 95% (i.e. for every 1m³ there is 0.95m³ of space available for water storage).

The volume of Polystorm required is therefore calculated by dividing the required storage volume by 0.95.

This factor is allowed for in the design table.

Example of Polystorm sizing for attenuation storage

Site in London has an impermeable area as follows:

1200m² roof area

1475m² car park and other areas

Therefore the total impermeable area = 2675m².

Assume the required return period for the drainage design is 1 in 100 years as agreed with the Environment Agency.

From Table 11 London is in the region where Ms-60=20mm ad r=0.4.

Therefore from the table the volume of the Polystorm tank required is 510m³/ha.

Required attenuation storage on this site

= 510 x 2675/10000 = 136.4m³.

Design of long term storage

Long term storage can be designed using the volumes in CIRIA C697 The SUDS manual and these are summarised in the table below.

Long term storage volumes (CIRA C697)

Soil type (from maps in Wallingford Procedure for Europe of Flood Studies Report)	Storage volume (m³/ha)
1	320
2	180
3	130
4	60
5	20

Table 12

The discharge rate for the long term storage is 2 l/s/ha or to infiltration (soakaway).

The long term storage is part of the attenuation storage but it is normally located in a separate tank that is restricted to an outflow of 2 l/s/ha. Alternatively one large tank can be fitted with an outlet control that achieves the different discharge criteria for the different storage volumes.

Example of Polystorm sizing for long term storage

As for the previous example consider a site in London which has an impermeable area as follows:

1200m² roof area

1475mm² car park and other areas

Therefore the total impermeable area = 2675m²

The attenuation storage is provided by Polystorm that has a volume of 86m³ and the flow out of this is restricted to 7 l/s/ha.

Assume the site is over Soil type 3.

From Table 12 the long term storage required is 130m³/ha

So required long term storage on this site

= 130 x 2675/10000 = 34.7m³

Redistribution of storage requirements gives:

Attenuation storage tank = 136.4 – 34.7

= 101.7m³ with an outflow of 1.2 l/s

Long term storage tank = 34.7m³ with an outflow of 0.4 l/s

4.7.2 Siltation

The drainage system upstream of Polystorm tanks should be designed so that silt and other debris is removed from the run-off and is prevented from entering the tank. This can be achieved using silt traps, permeable pavement or other methods. Polystorm can be used below basins and swales to provide underdrainage. This has the advantage of preventing silt entering the tank but also makes the swale more effective at removing pollution and makes it more aesthetically pleasing by keeping the base dry. If silt does enter the Polystorm tanks it may be difficult to remove. However after a site is completed the level of silt entering the tank is relatively small on most sites. It is simple to make an allowance for loss of storage due to siltation and the tank can be over designed by the amount (typically a 10% increase in tank size will deal with any siltation over a 50 year period). Off line tanks are less prone to siltation because the low flows (which contain most of the silt) bypass the tank. Soakaways are very prone to siltation if upstream treatment is not provided to remove silt. It is critical that silt from the construction site is not allowed to enter the Polystorm tank.

Typical silt trap

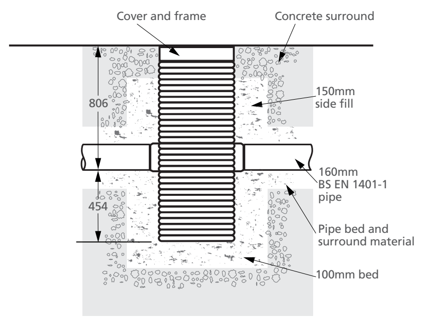


Figure 24

4.8 Soakaway design

4.8.1 Percolation test for designing a soakaway system

This percolation test follows the procedures laid out by the BRE Digest 365

Step 1 - Dig a trial hole

- The base of the trial hole should be approximately the same depth as anticipated in the full size soakaway
- Overall excavation depth is typically: 1.5m-2.5m for areas <100m²
- The test hole should be typically 0.3m-1m wide and 1m-3m long (make a record of the test hole dimensions)

Step 2 - Fill the hole with water

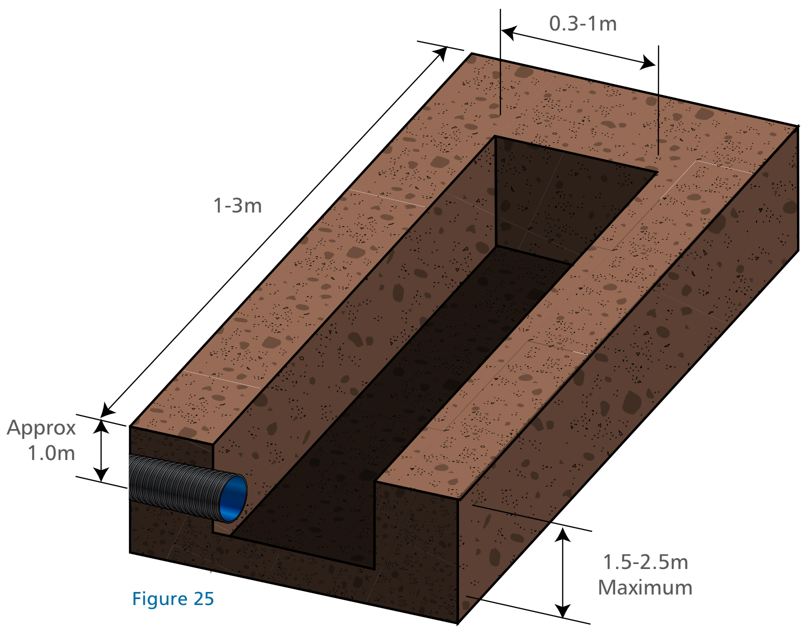


Figure 25

- Fill trial hole with water - this needs to be done rapidly to mimic a real storm event
- Record the time taken for the water level to fall within the trial hole from 75% to 25% full
- Repeat 3 times, allowing the trial hole to drain between tests
- Best practice for soakaways longer than 25m is to perform a second percolation test at a different location to that of the 1st test site

Step 3 - The results - Soil infiltration rate

$$f = \frac{V_{(p75-25)}}{a_{(p50)} \times t_{(p75-25)}}$$

$V_{(p75-25)}$ = Volume of the hole from 25% to 75% depth

$a_{(p50)}$ = Internal surface area of the hole up to 50% of the depth and including the base area

$t_{(p75-25)}$ = The time for the hole to drain from 75% to 25% full in seconds

- Contact the Polypipe WMS technical support team and advise them of the dimensions of the test hole and lowest timed result (in minutes)
- Polypipe WMS will take this data and estimate the soakaway size required

Worked example

Invert of the discharge drain - 1.0m below the surface. When cleaned and trimmed the test hole was 2.51m deep, 2.40m long and 0.60m wide.

An effective storage depth of 1.5m therefore adopted.

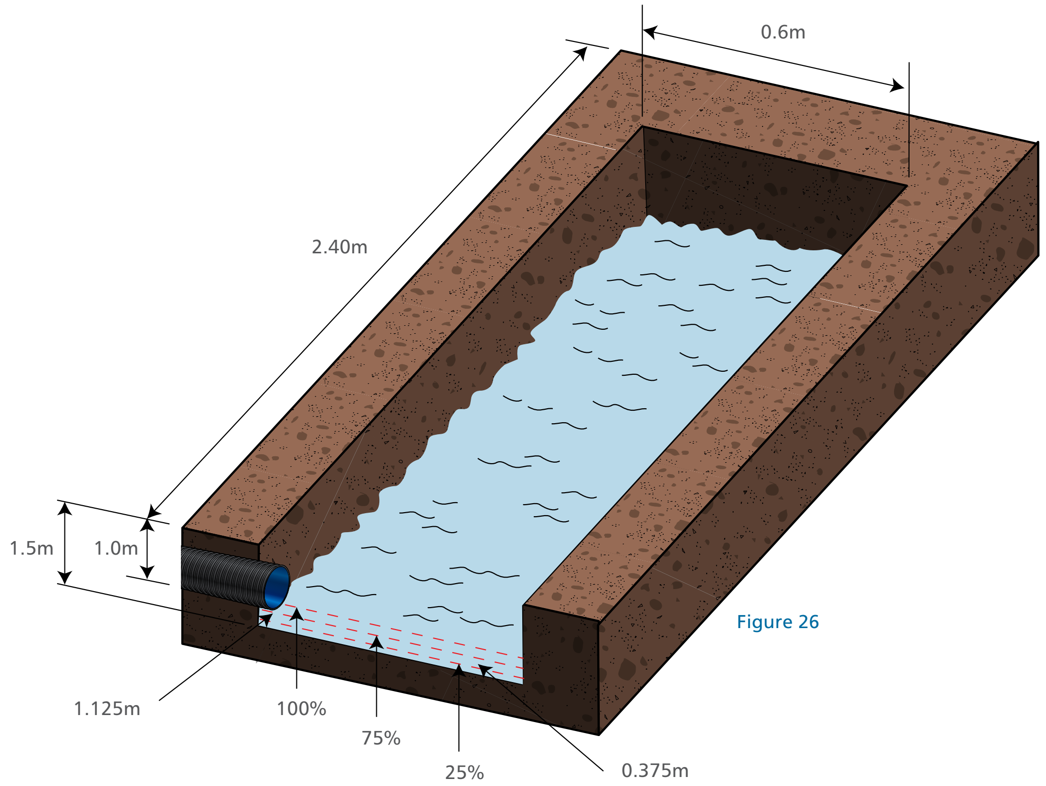


Figure 26

Test hole volume between 75% and 25% effective depth:

$V_{(p75-25)}$ = 2.40 x 0.60 x (1.125 - 0.375) = 1.08m3

Test hole depth at 75% and 25%

The mean surface area through which outflow occurs, taken to be the hole sides at 50% effective depth, including the base of the pit:

$a_{(p50)}$ = 0.75[2(2.40 + 0.6)] + (2.4 x 0.6) = 0.75(6) + 1.44 = 5.94m2

The time taken for water to drain from 75% to 25% full:

$t_{(p75-25)}$ = 102 - 11 = 91 minutes

Number of minutes to drain from 75% to 25% depth

Soil Infiltration rate $\frac{1.08}{5.94 \times (91 \times 60)}$ = 3.33 x 10-5 m/sec

4.8 Soakaway design

4.8.2 Infiltration

Calculation principles

There are two approaches, either of which may be adopted: the Construction Industry Research and Information Association (CIRIA) Report 156 Infiltration Drainage - Manual of Good Practice or BRE Digest 365 Soakaway Design.

A simplified approximate approach can be used on a very small site (i.e. a single house development) where detailed site infiltration rate information may not be required nor available (see table below). Approved document H3 (refer to 1.1, page 10) allows a storage volume equal to the area to be drained multiplied by 10mm for areas up to 25m². Beyond this size, design should be carried out in accordance with BS EN 752-4 : 1998 or BRE Digest 365. BS EN 752-4 : 1998 suggests a storage volume equal to 20mm multiplied by the area to be drained.

Guidance on soakaway for single house development (1)

Number of units	Storage volume (m^3)	Max area to be drained (m^2)
1	0.19	19.0 (2)
2	0.38	25.0 (2)
3	0.57	28.5 (3)
4	0.76	38.0 (3)
5	0.95	47.5 (3)
6	1.14	57.0 (3)

Table 13

(1) When doubt exists over suitability of ground for infiltration permeability figures should be derived by test (see BRE Digest 365).

(2) In accordance with Approved Document H3 (refer to 1.1 page 10).

(3) In accordance with BS EN 752-4 : 1998, Clause NG 2.4.

When the BRE or CIRIA approach is used, the design volumes and areas for trench or cuboid type installations can be found from Tables 14 and 15.

Volumetric data per linear metre for one cell (0.5m) wide trench configuration

Number of cells high	Storage volume (m^3)	Side areas (m^2)	Base area (m^2)
1	0.19	0.8	0.5
2	0.38	1.6	0.5
3	0.57	2.4	0.5

Table 14

Volumetric data for 3D usage - two cells high

Cells long (1m side)	2 wide (0.5m side)			4 wide (0.5m side)			8 wide (0.5m side)		
	Vol m^3	Side m^2	Base m^2	Vol m^3	Side m^2	Base m^2	Vol m^3	Side m^2	Base m^2
1	0.76	3.2	1.0	1.52	4.8	2.0	3.04	8.0	4.0
2	1.52	4.8	2.0	3.04	6.4	4.0	6.08	9.6	8.0
4	3.04	8.0	4.0	60.8	9.6	8.0	12.16	12.8	16.0
8	6.08	14.4	8.0	12.16	16.0	16.0	24.32	19.2	32.0
10	7.60	17.6	10.0	15.20	19.2	20.0	30.40	22.4	40.0
100	76.00	161.6	100.0	152.00	163.2	200.0	304.00	166.4	400.0

Table 15

Concrete ring converter

Table 16 enables the conversion of a specified nominal diameter pre-cast concrete ring soakaway volume into the equivalent number of Polystorm Lite and Polystorm cells.

Concrete Ring conversion

Depth of soakaway	900	1050	1200	1300	1500	1800
0.25	1	2	2	2	3	4
0.50	2	3	4	4	5	7
0.75	3	4	5	6	8	11
1.00	4	5	7	8	10	14
1.25	5	6	8	10	12	17
1.50	6	8	10	12	15	21
1.75	7	9	11	14	17	24
2.00	7	10	13	16	20	27
2.25	8	10	13	16	20	29
2.50	8	11	14	18	22	31
2.75	9	12	16	20	24	34
3.00	11	14	18	21	28	41

Table 16

4.9 General layouts - typical arrangement of Polystorm structures and manifolds

Typical arrangement

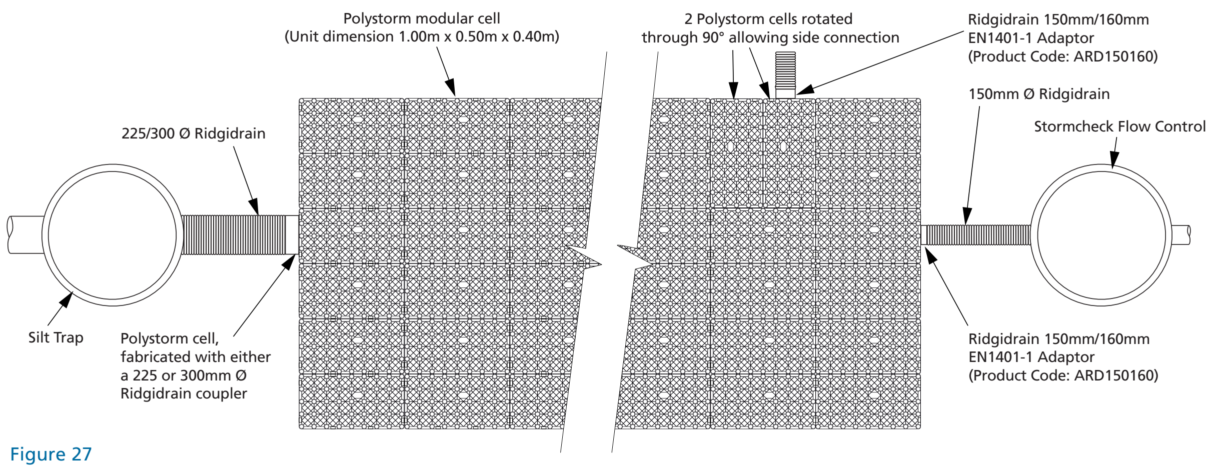


Figure 27

Cross section view of typical arrangement

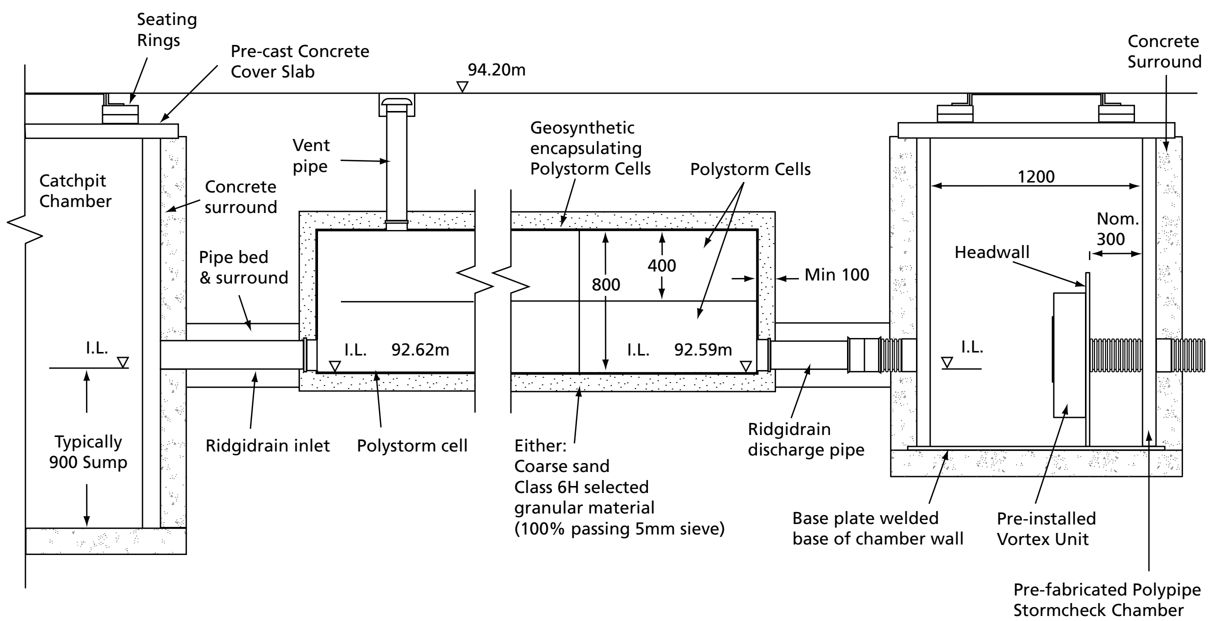


Figure 28

Example of offline solution

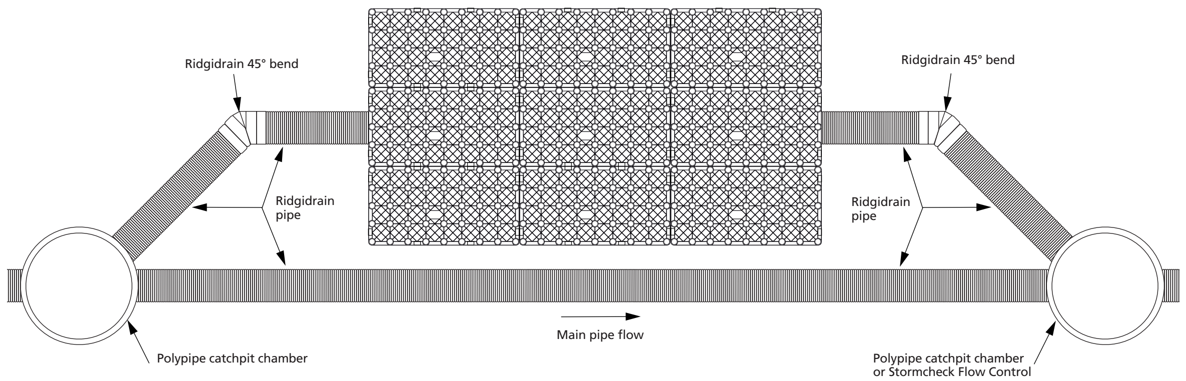


Figure 29

Example of offline solution

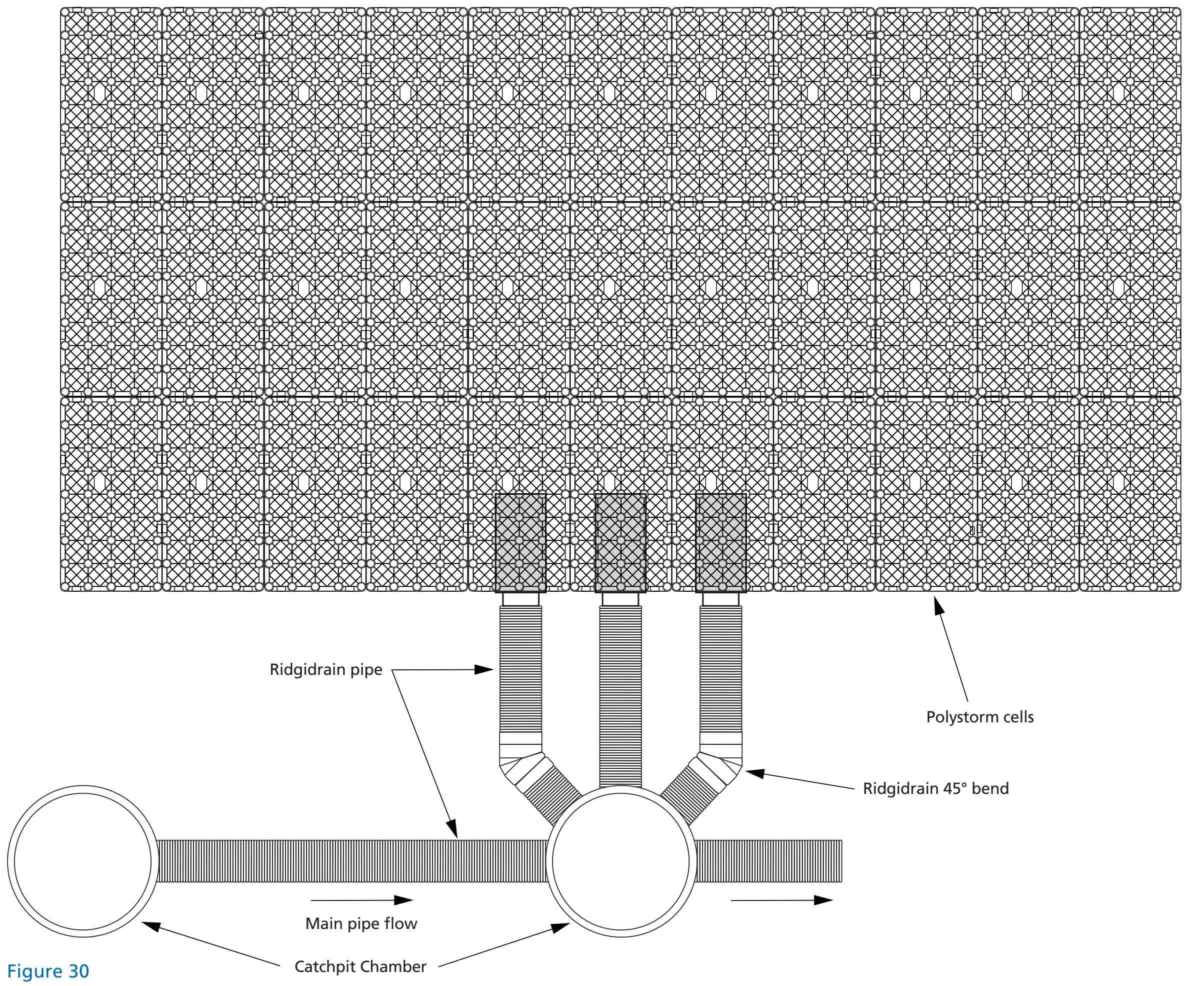


Figure 30

Please visit **www.polypipewms.co.uk** for downloadable Auto CAD files of all Polystorm Structures and manifold details.

5.0 Installation -
for attenuation and soakaway systems

The following section outlines site best practice for the installation of Polystorm Lite and Polystorm

Installation

Contents

5.1 Installation - health and safety

5.1.1 Health and safety

Under the Construction (Design and Management) Regulations 2007, unless they are a domestic client, all parties involved in construction or building work have legal duties. These include:

Clients

- Check competence and resources of all appointees
- Ensure there are suitable management arrangements for the project welfare facilities
- Allow sufficient time and resources for all stages
- Provide pre-construction information to designers and contractors

Designers

- Eliminate hazards and reduce risks during design
- Provide information about remaining risks

Contractors

- Plan, manage and monitor own work and that of workers
- Check competence of all their appointees and workers
- Train own employees
- Provide information to their workers
- Comply with the specific requirements in Part 4 of the Regulations
- Ensure there are adequate welfare facilities for workers

It should be noted that additional legal duties are imposed where construction work is notifiable.

All installation activities should be carried out observing the requirements of The Health and Safety at Work Etc. Act 1974; and The Management of Health and Safety at Work Regulations 1999.

Polystorm Benefits for CDM Compliance

Storage applications using Polystorm Water Management Systems are actually beneficial to CDM compliance. This is because the system avoids or reduces several risks associated with the construction of traditional storage tanks which can involve deep excavations and construction of large engineered structures. Specific advantages of Polystorm in this respect are:

- Individual Polystorm components are lightweight - making it easier for individual lifting of Polystorm cells
- Installation of Polystorm is quick - so open excavation time is minimised and high numbers of manpower and machinery is reduced

5.1.2 Risk assessment

Contractors are required to submit a method statement which includes a methodology for installation and risk assessment for the work to be carried out.

5.1.3 Site guidance

Good Practice Guide

The following are good practice principles for the handling and storage of all Polystorm cells on-site:

- Store units away from direct sources of heat including sunlight for excessive periods
- Place packs of cells on level ground: DO NOT stack filled pallets on-site
- Store loose individual cells NO MORE THAN 5 cells high
- Ensure a well positioned and secure stand for platform issued to remove the top layer of Polystorm cells from the pallet
- Although Polystorm cells contain an inhibitor giving ultra violet resistance for up to 6 months, avoid prolonged storage in direct sunlight
- DO NOT store cells near fuel bowsers, fuel tanks or any other solvents
- Although Polystorm cells are very robust and resistant to damage when handled normally, store in locations where impacts from vehicles and site plant will be avoided
- Ensure Polystorm cells are kept clean at all times
- Broken/cracked cells should not be installed. Broken/ cracked cells should be recycled wherever possible
- Individual Polystorm Lite cells weigh 7kg and Polystorm 9kg so they can normally be safely lifted on-site in accordance with current manual handling regulations
- Avoid walking on the geosynthetic membrane to reduce risk of puncturing or tearing the textile
- Care must be taken when placing the cells into the excavation
- Install 1st layer of cells to minimise walking on the geomembrane textile

5.1.4 Floatation

When placed below the ground water table as an attenuation system (i.e. wrapped in a geomembrane) there is a risk that the buoyancy of a tank may cause it to float. This can be prevented by placing a sufficient weight of soil on top of the tank to counteract the upward forces. Our Technical Team can assist with groundwater calculations. Please contact Polypipe WMS technical support team. Also see section 4.

5.1.5 Excavation and preparation

Excavate to the required plan dimensions and level, ensuring that the excavation orientation will allow easy installation of connecting pipework. Consideration should be given to maintaining construction plant access for reinstating around the installed Polystorm cells. Ensure that the ground bearing capacity at the formation level is sufficient for the proposed operational loads. The base of the excavation should be smooth and level, free of large or sharp stones and soft spots to avoid punctures or tears of the geomembrane. Any soft spots should be excavated and replaced with suitable compacted granular material. Place and compact a minimum 100mm thick layer of bedding material (typically coarse sand). If required, line the base and sides of the excavation with a protective geotextile before placement of the impermeable geomembrane. Excavation should be carried out in accordance with BS6031, paying particular attention to safety procedures.

5.1.6 Handling and installation

All materials used should be checked before and after installation for any damage such as punctures or tears to the membrane. The type of geosynthetic material used to encapsulate the Polystorm cells will determine the installation requirements. Please note the following information is generic and advice from the geosynthetic manufacturer should be sought to ensure that the appropriate protective measures are taken to comply with any proprietary requirements.

Impermeable geomembrane		
Physical properties		
Thickness	Min 0.75 to 1.0mm	ASTM D5199
Density	900kg/m^3	ASTM D1505
Mechanical properties		
Tensile strength, at yield	Min 1600N/m^3	ASTM D4885
Elongation at break	>500%	ASTM D4885
Puncture resistance	Min 170N	ASTM D4833
Tear resistance	Min 67N	ASTM D1004 Die C
Impact resistance	Min 15 Joules	ASTM 3998 mod
Stress crack resistance	Min 200 hrs	ASTM D5391 (SP=-NCTL)
Permeability coefficient	Max 2.0 x 10-12	ASTM D
pH	Resistant to all naturally occurring soil acids and alkalis	
Chemical/biological resistance	Resistance to all substances found to naturally occur in soils and rainwater. Detailed information would need to be provided to geomembrane manufacturer in instances of contaminated land.	

Table 17

5.1 Health and safety

Clip Connectors

Polypipe clips connect horizontally adjacent units.

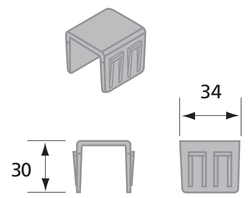


Figure 31

Shear Connector

Vertical connections are formed with the Polypipe shear connector.

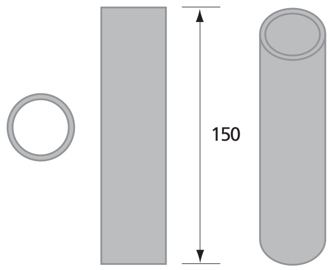


Figure 32

Before cells are installed a geomembrane should be laid over the subgrade level. Positioning of sheeting is undertaken by machinery or hand. After unrolling the sheeting, its position is adjusted so that a suitable overlap is achieved for the welding process. Before welding, the sheet must be checked for any damage including punctures or tears. If damage has occurred re-patch the damaged area with additional geomembrane material and weld over damaged area. Ensure the damaged area is overlapped by a minimum of 400mm. Joint each sheet of geomembrane together according to the suppliers' recommendations.

5.1.7 Polystorm cell installation

Before proceeding with the installation please ensure you carefully read and understand the Good Practise Guidelines stated earlier in the document.
Ensure cells are arranged so that they are in the correct alignment with the adjoining pipework. Wherever possible, minimise the amount of walking on the geomembrane to reduce the chances of punctures or tears to the material by laying the first layer of cells.

5.1.8 Connecting Polystorm cells

Place the Polystorm cells on the geomembrane in accordance with the construction drawings. Ensure the Polystorm cells are abut and the corners align with each other. During installation, Polystorm cells should be securely connected using clips and shear connectors. Clips and shear connectors are supplied in sealed polythene bags of 60 and 30.

Location of points for clips and shears

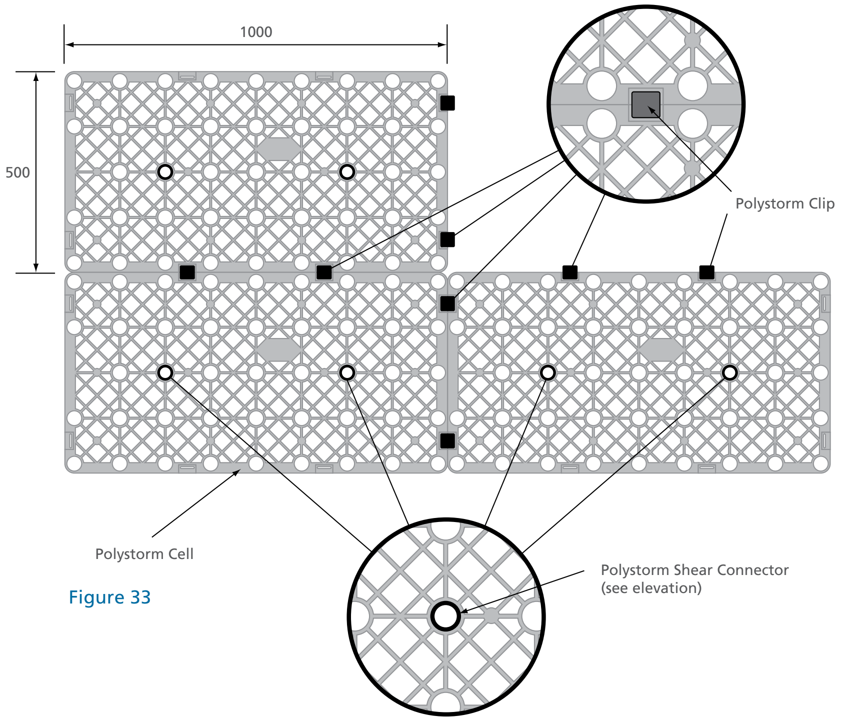


Figure 33

Shear connector installation

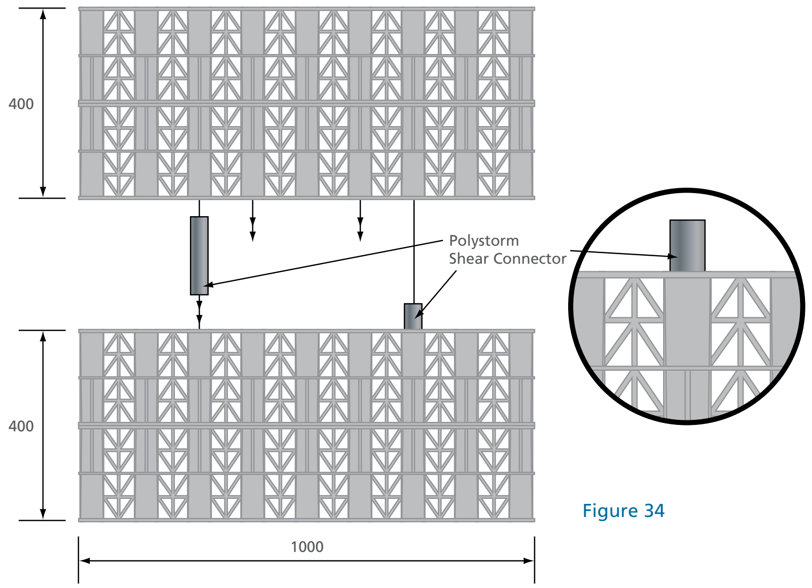


Figure 34

Insert shear connectors into Polystorm cell as shown. Ensure the shear connector is fully inserted before mounting the Polystorm cell.

5.1.9 Clip connector installation

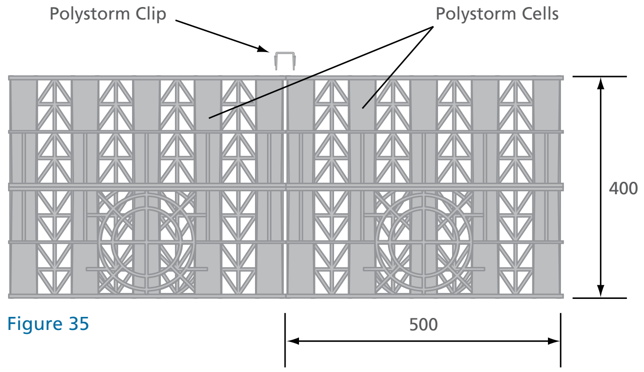
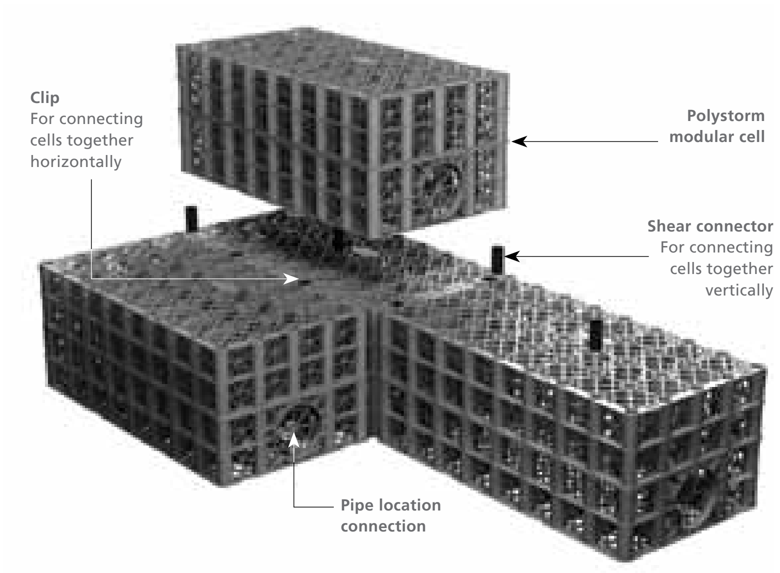
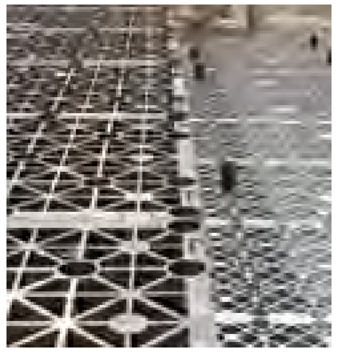


Figure 35

Polystorm cells are adjacently connected by clipping the two units together.





5.2 Connections

5.2.1 Types of connections 160mm – 300mm (direct to cells)

160mm EN 1401-1 pipes connect directly into the convenient knock-out incorporated in the end of each cell.

Connection to 110mm EN 1401-1 pipes or other products is accommodated through the use of standard Polypipe adapters.

Polystorm cells are also available with either a 225mm or 300mm fabricated Ridgidrain pipe connection.

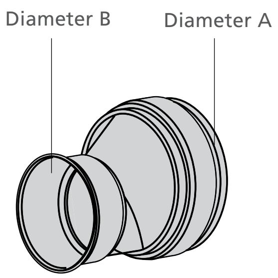


Figure 36
160/110mm invert level reducer

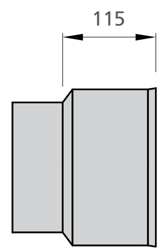


Figure 37
160mm diameter adaptor

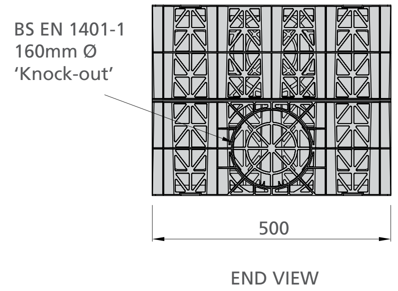


Figure 38
Polystorm cell 160mm diameter knockout

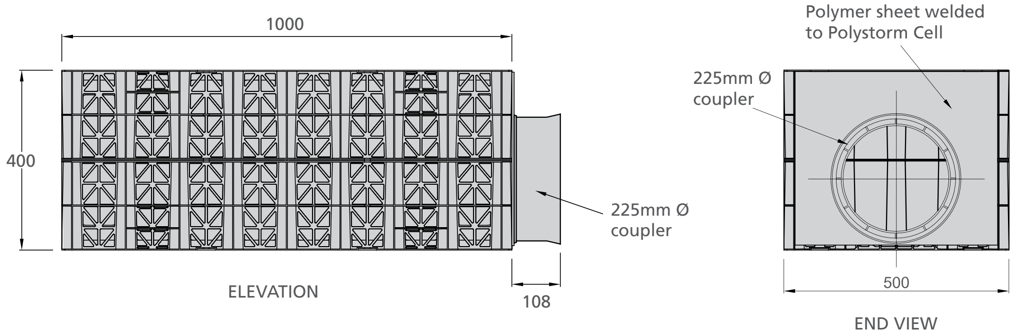


Figure 39 Fabricated Polystorm cell allowing 225mm diameter pipe connection

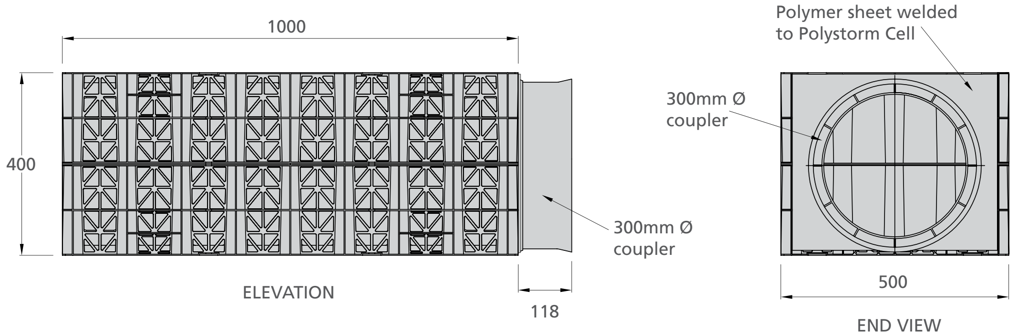


Figure 40 Fabricated Polystorm cell allowing 300mm diameter pipe connection

5.2.2 Types of connections 450mm – 600mm (direct to cells)

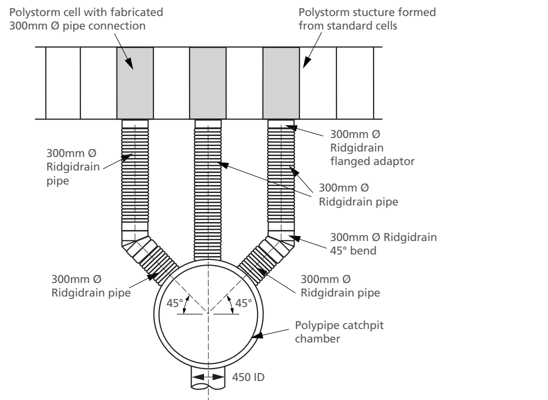


Figure 41 Typical Polystorm 450mm inlet manifold detail

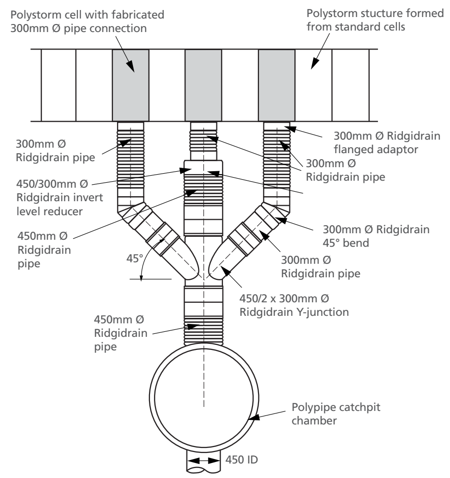


Figure 42
Typical Polystorm 450mm inlet manifold detail

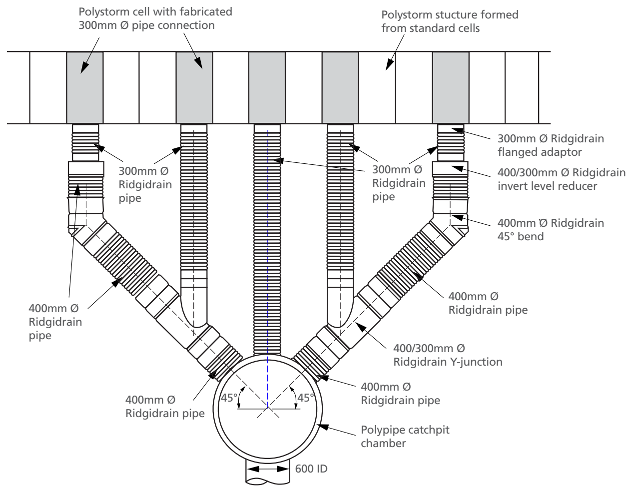


Figure 43 Typical Polystorm manifold detail

Note: For inlets larger than 600mm please contact Polypipe WMS technical team. Please also visit **www.polypipewms.co.uk** for downloadable Auto CAD files of the illustrations on this page.

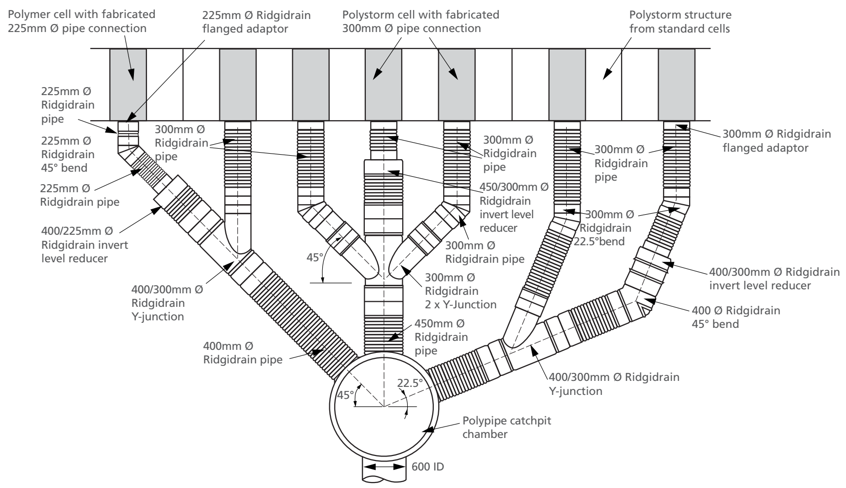


Figure 44 Typical Polystorm 600mm inlet manifold detail

5.3 Ventilation

Every attenuation tank requires at least one vent to avoid stagnant water. An infiltration tank does not need a vent. Large attenuation tanks need a vent for every 7500m² of drained catchment area. The illustrations below show a vertical vent pipe with a cowl (SCV40) and a horizontal vent pipe that connects to a catchpit.

5.3.1 Air vent connection and installation

Polystorm attenuation structures will require ventilation to ensure maximum hydraulic performance and avoid placing additional stress on the encapsulating geomembrane. Ensure vents are protected from damage during construction. Attach a 110/160mm flange adapter to a Polystorm cell from the top layer using cable ties on all four corners of the adaptor base and seal geomembrane around the flange, the same way as making an inlet or outlet connection and seal. Insert a 110/160mm dia vertical vent pipe into the flange and make connection. Large attenuation tanks need a vent for every 7500m² of drained catchment area. A vent has a minimum size of 100mm diameter.

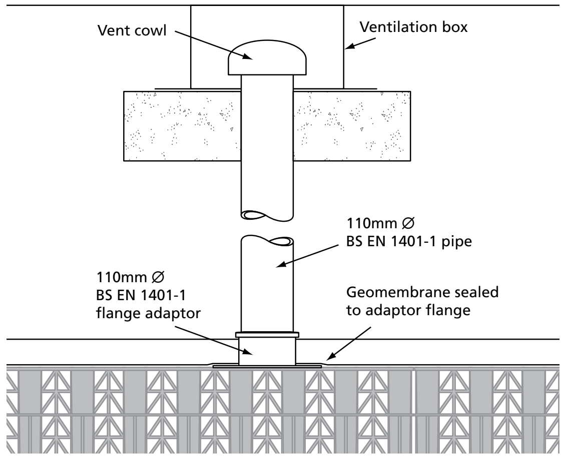


Figure 45 Vertical vent pipe with cowl

An alternative vertical vent pipe detail is available. Please call the Polypipe WMS technical support team.

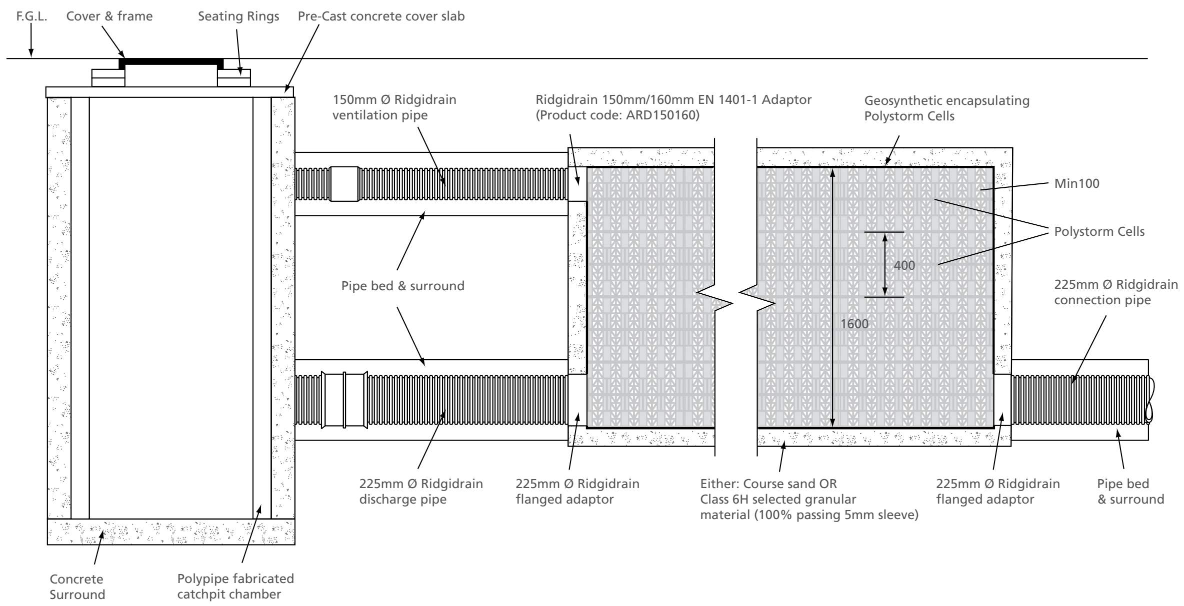


Figure 46 Horizontal vent pipe

5.3.2 Inlet and outlet connections and installations

A flange adapter is attached at both the inlet and outlet points as this gives a flat surface for the membrane to be attached to. The flange adaptor will require a hole punching in each corner of the base. Ensure the flange adaptor is fastened securely to the cell using cable ties. Once the adaptor has been secured, insert the pipe and seal connection.

5.3.3 Sealing and testing connections

All pipes entering and leaving the structure must be sealed in accordance to the contractor's method statement. Ensure the geomembrane around all connection areas are clean and free from moisture before sealing. All sealing equipment should be tested at the start of each day to ensure consistency is maintained throughout the installation of the structure. The inlet and outlet connections need a bung inserted into the hole to prevent siltation and water entering the structure whilst installation is carried out. Once the connections have been sealed, testing should be carried out to check for leaks. This procedure should be carried out in accordance to the contractor's method statement. All testing equipment should be tested at the start of each day.

For advice on procedures for testing joints refer to CIRIA SP 124 – Barriers, liners and cover systems for containment and control of land contamination.

5.3.4 Encasing geotextile

Complete the geosynthetic encapsulation of the entire Polystorm structure, forming joints where appropriate. Re-examine the geomembrane and/or geotextiles for damage and joint integrity. Avoid walking on the geosynthetic as this may cause punctures or tears to the material. The equipment used to form joints must be tested at the start of each day to ensure consistency is maintained throughout the process. For advice on procedures for testing joints refer to CIRIA SP 124 – barriers, liners and cover systems for containment and control of land contamination.

5.3.5 Lateral backfilling

Backfill around the sides of the encapsulated units, forming a 100mm thick layer of coarse sand or Class 6H selected granular material immediately adjacent to the cells. Where required, remaining excavated areas around the units should be backfilled with Class 6N or 6P selected granular material, in accordance with MCHW, Volume 1, or similarly approved specification.

5.3 Ventilation

5.3.6 Cover backfilling

Backfill around the sides of the encapsulated cells, forming a 100mm thick layer of coarse sand or Class 6H selected granular material immediately adjacent to the cells. Where required, remaining excavated areas around the units should be backfilled with Class 6N or 6P selected granular material, in accordance with MCHW, Volume 1 or similarly approved specification. Final backfilling of the installation and surfacing is dependent on the expected operational loads. (NB Compaction plant over and immediately adjacent to the Polystorm cells shall not exceed 2300 kg/m width). Above the wrapped Polystorm cells, place and lightly compact a minimum 100mm thick layer of either coarse sand or Class 6H selected granular material (with 100% passing the 5mm sieve), in accordance with MCHW, Volume 1, Series 600.

5.3.7 Field conditions (e.g. landscaped areas)

The backfill material that lies within 300mm above the Polystorm cells should be free from particles exceeding 40mm in diameter, in accordance with Class 8 material to Series 600, Volume 1, MCHW. Final backfilling up to finished ground level may be achieved using selected as-dug material. Backfill material should be placed and compacted in layers no greater than 300mm, or in compliance with the approved specification.

5.3.8 Lightly trafficked (e.g. restricted access car park)

Backfill with Class 1 or 2 material in accordance with MCHW, Volume 1, Series 600. Backfill material should be placed and compacted in layers not greater than 150mm. Where the Polystorm cells are installed beneath a paved area, the pavement sub-base may form part of the backfill material provided that minimum cover depths are maintained. Complete pavement construction or landscaping over the Polystorm system.

5.3.9 Heavy trafficked (e.g. roads used by HGV's)

Contact Polypipe WMS technical support team for further information and guidance.

5.3.10 Inspection

After installation and prior to handover, any silt collection chambers or control manholes should be examined to ensure they are free from debris. All chambers and manholes require the insertion of bungs at the inlet and outlet to prevent siltation during construction. Bungs should then be removed at commissioning.

5.4 Typical installation procedure - soakaway

5.4.1 Excavation and preparation

Place and compact a 100mm thick bedding layer of either coarse sand or Class 6H selected granular material (with 100% passing the 5mm sieve), in accordance with the Manual of Contract Documents for Highway Works (MCHW), Volume 1, Series 600. Install the permeable geotextiles, forming joints in accordance with the manufacturer's recommendations, making an allowance for the connecting pipework or adapters.

5.4.2 Geotextile layer (permeable)

The type of geosynthetic material used to encapsulate the Polystorm cells will determine the installation requirements. Please note the following information is generic and advice from the geosynthetic manufacturer should be sought to ensure that the appropriate protective measures are taken to comply with any proprietary requirements.

Permeable geotextile		
Physical properties		
Material	Typically Polypropylene/Polyethylene	
Mass	Min 125g/m^2	EN 965
Mechanical properties		
CBR puncture resistance	Min 1500N	EN ISO 12236
Peak tensile strength	Min 8kN/m^2	EN ISO 10319
Hydraulic properties		
Water flow rate normal to plane	Min 100 l/m_2 .s (@ 50mm Head)	EN ISO 11058
Pore size O90	Typically 100 µm	EN ISO 12956
pH	Resistant to all naturally occurring soil acids and alkalis	
Chemical/biological resistance	Resistance to all substances found to naturally occur in soils and rainwater. Detailed information would need to be provided to geosynthetic manufacturer in instances of contaminated land.	

Table 18

All joints should be sealed, using proprietary methods recommended by the manufacturer. Please refer to CIRIA SP 124 – Barriers, liners and cover systems for containment and control of land contamination, for advice on seam testing procedures. Before the cells are installed the geotextile should be laid over the subgrade level. The sheet of geotextile should be large enough such that it can overlap over the edge of the modules by 200mm.

5.4 Typical installation procedure
- soakaway

5.4.3 Polystorm cell installation

Place the Polystorm cells on the geotextile in accordance with the construction drawings and Polypipe connection details. Ensure cells are arranged so that they are in the correct alignment with the adjoining pipework (see pages 54 & 55).

5.4.4 Shear connection

Vertical connections are formed with the Polypipe shear connector (see pages 54 & 55).

5.4.5 Clip connectors

Polypipe clips connect horizontally adjacent cells (see pages 54 & 55).

5.4.6 Polystorm cell connections

Pipe Connections
160mm EN 1401-1 pipes connect directly into the convenient knock-out incorporated in the end of each cell. Connection to 110mm EN 1401-1 pipes or other products is accommodated through the use of standard Polypipe adapters. Polystorm cells are also available with either a 225mm or 300mm fabricated Ridgidrain pipe connection (see pages 56 & 57).

5.4.7 Encasing geotextile

Complete the geosynthetic encapsulation of the entire Polystorm structure, forming joints where appropriate. Re-examine the geomembrane and/or geotextile for damage and joint integrity.

5.4.8 Lateral backfilling

Backfill around the sides of the encapsulated cells, forming a 100mm thick layer of coarse sand or Class 6H selected granular material immediately adjacent to the cells. Where required, remaining excavated areas around the cells should be backfilled with Class 6N or 6P selected granular material, in accordance with MCHW, Volume 1, or similarly approved specification.

5.4.9 Cover backfilling

Backfill around the sides of the encapsulated cells, forming a 100mm thick layer of coarse sand or Class 6H selected granular material immediately adjacent to the cells.

Where required, remaining excavated areas around the cells should be backfilled with Class 6N or 6P selected granular material, in accordance with MCHW, Volume 1, or similarly approved specification.

Above the wrapped Polystorm cells, place and lightly compact a minimum 100mm thick layer of either coarse sand or Class 6H selected granular material (with 100% passing the 5mm sieve), in accordance with MCHW, Volume 1, Series 600.

Final backfilling of the installation and surfacing is dependent on the expected operational loads. (NB Compaction plant over and immediately adjacent to the Polystorm cells shall not exceed 2300 kg/m width).

5.4.10 Field conditions (e.g. landscaped areas)

The backfill material that lies within 300mm above the Polystorm cells should be free from particles exceeding 40mm in diameter, in accordance with Class 8 material to Series 600, Volume 1, MCHW. Final backfilling up to finished ground level may be achieved using selected as-dug material. Backfill material should be placed and compacted in layers no greater than 300mm, or in compliance with the approved specification.

5.4.11 Lightly trafficked (e.g. restricted access car park)

Backfill with Class 1 or 2 material in accordance with MCHW, Volume 1, Series 600. Backfill material should be placed and compacted in layers not greater than 150mm. Where the Polystorm cells are installed beneath a paved area, the pavement sub-base may form part of the backfill material provided that minimum cover depths are maintained. Complete pavement construction or landscaping over the Polystorm system.

5.4.12 Inspection

After installation and prior to handover, any silt collection chambers or control manholes should be examined to ensure they are free from debris or contamination.

5.5 Maintenance

5.5.1 Maintenance

The customer is responsible for maintenance
For soakaways to individual houses, the only necessary maintenance of the system is to keep gullies clear of debris such as leaves. For large installations or where the receiving waters are environmentally sensitive, a system of regular inspections should be established to prevent siltation of the system which, if allowed to develop, would reduce effectiveness. They should also be inspected after every major storm event.

It is recommended that a silt trap is incorporated into the pipework at the inlet to the tank (see Figure 47) there must be a maintenance plan that ensures regular cleaning of the trap to ensure correct performance.

Note: To download Auto CAD drawings and BBA certificates please visit www.polypipewms.co.uk.

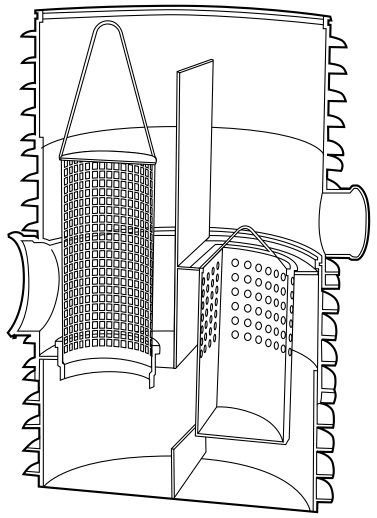


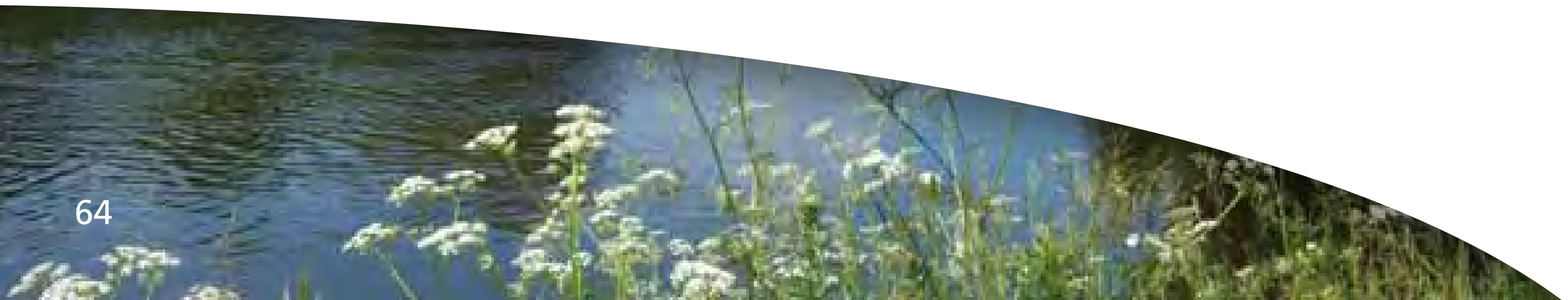
Figure 47

6.0 Associated products

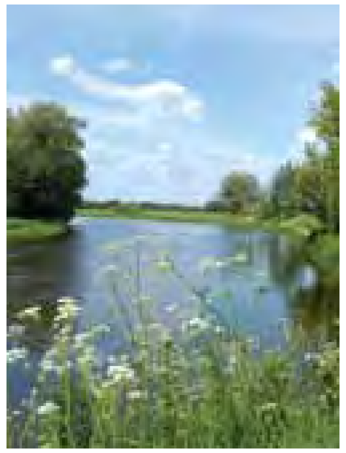
A full range of complementary products including stormwater treatment filters, catchpits and flow controls, alongside bespoke solutions from our dedicated in-house Fabrications team.

Associated products

Contents



6.1 Stormcheck



One aim of Sustainable Drainage Systems is to mimic greenfield run-off rates from developed sites. One way of achieving this aim is by stormwater storage and attenuation. The Stormcheck chamber allows precise control of site discharge rates and when combined with our storage systems provides an industry recognised flow attenuation system.

6.1.1 Stormcheck vortex flow control chamber

The Stormcheck vortex flow control chamber comprises of a pre-fabricated plastic chamber, in a range of diameters, with integral vortex flow control device.

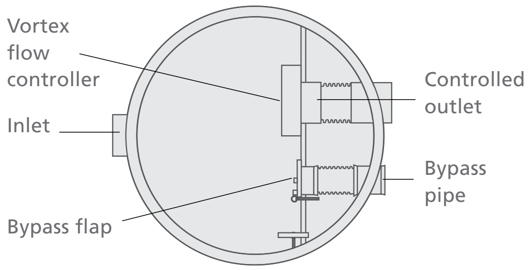


Figure 48 Manual bypass design

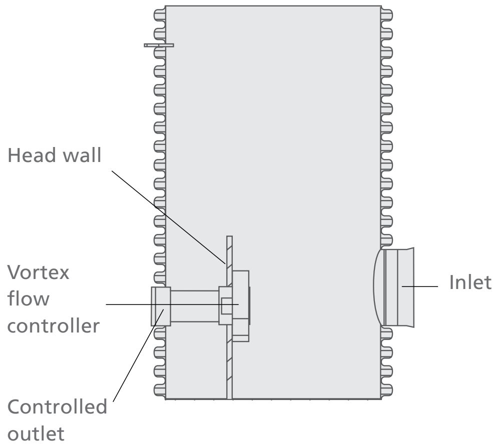


Figure 49 Auto bypass design

6.1.2 Chamber types

Non-bypass chamber for sites where discharge rates must be guaranteed and not exceeded.

6.1.3 Manual bypass design

Offers a bypass to the flow control device which is manually operated from the surface. The activation of the bypass system opens a door in the head wall allowing water in the chamber to drain down via the bypass pipe.

6.1.4 Auto bypass design

Stormcheck chambers with automatic bypass systems are also available, please contact the Polypipe WMS Technical support team.

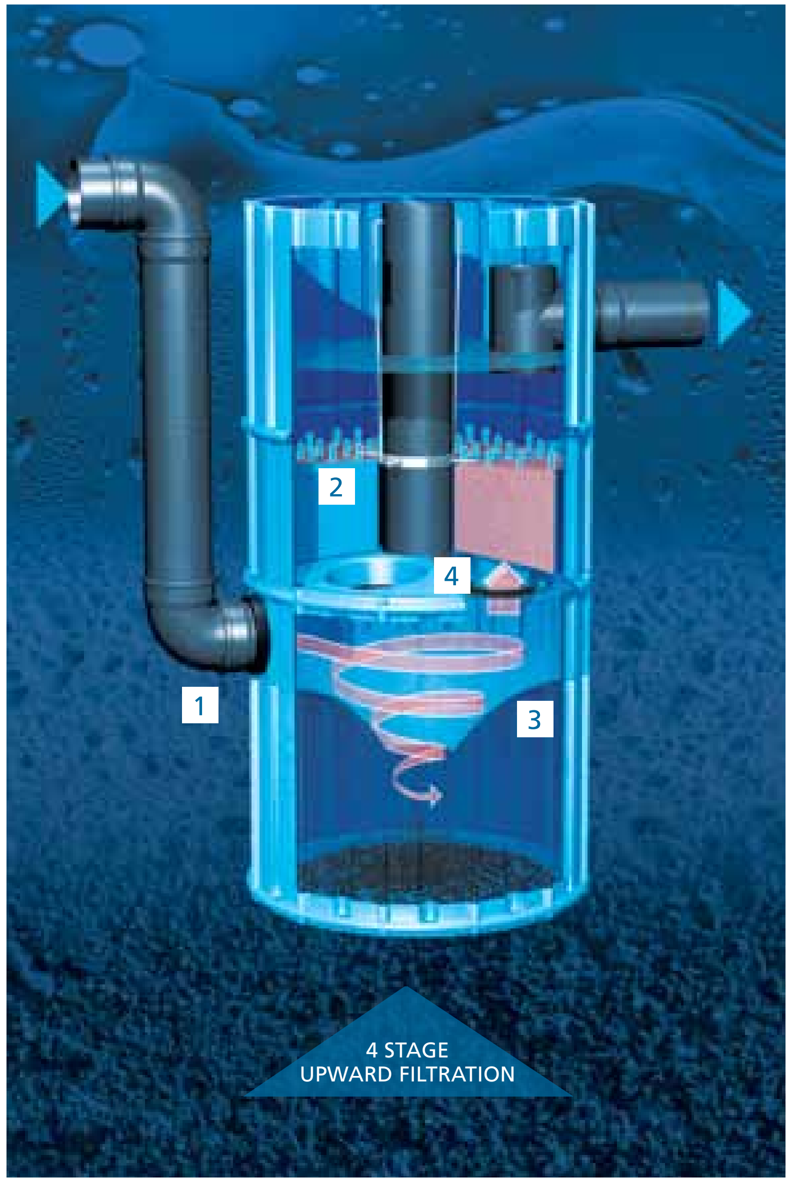
6.1.5 Key benefits

A complete system will include the following items:

- A sealed chamber produced in our dedicated fabrications department, built to exacting specifications and delivered to site ready to be installed
- The factory fitted vortex flow control device saves the time and expense of on-site construction
- Vortex flow control devices are widely recognised as being the most hydraulically efficient means of flow regulation. The unique design utilising no moving parts which means they are virtually maintenance free
- Stormcheck chambers are manufactured with an integral sump for silt catchment and an optional drain down system to ease maintenance and silt removal
- The Stormcheck chamber can be integrated with any Polypipe SUDS Solution and the market leading Ridgidrain ADS System

6.2 Storm-X4 - stormwater treatment system for roof and surface water run-off

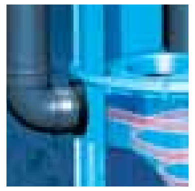
The use of the Storm-X4 advanced four stage filtration system can dramatically improve the quality of the surface water entering the receiving water course, improving biodiversity and aiding with compliance of the Water Framework Directive.



6.2.1 Function principles

1. Contaminated surface water run-off is fed into the basal section of the filter. The angled inlet generates a radial flow pattern.
2. The hydrodynamic separator converts the radial flow to generate particle sedimentation to remove heavy debris and silt from the contaminated water. The sediment is then retained in a silt trap chamber below the separator for easy maintenance and access.
3. The filter element is housed in the central section of the Storm-X4. The filter element is specifically designed for traffic, heavy traffic or roof applications and filters out fine materials in an up-flow process. Dissolved materials are absorbed by the filter, which will need to be replaced every two years on average.
4. Situated above the filter element is an oil retention unit which removes the remaining contaminants from the surface water run-off. The clean water then flows via the outlet to the soakaway or watercourse.

1.



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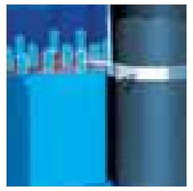
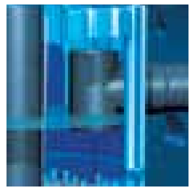


3.

4.



6.2.2 Stormwater treatment

Storm-X4 is capable of cleaning surface water run-off from roofs, car parks and the most polluted roads, even in heavily trafficked areas. Storm-X4 has been designed to remove heavy particles, silt and nutrients and heavy metals such as copper, zinc and cadmium from the surface water to provide an environmentally sound solution which benefits the natural watercourse and increases biodiversity.

6.2.3 Improved surface water quality

Storm-X4 minimises pollution of the natural watercourse and enables clean surface water run-off to be discharged from site. In line with new legislation and guidelines such as the Water Framework Directive, Storm-X4 offers a regulatory compliant solution for dealing with the issues of water quality. With the support, technical expertise and knowledge of Polypipe WMS, developers can be confident that a long-term, affordable, sustainable solution can be designed.

6.2.4 Source control

By using Storm-X4 developers can improve water quality even before discharge from site by treating surface run-off as close to its source as possible. Once it has passed through the Storm-X4 filter and used in conjunction with attenuation and flow control devices from Polypipe WMS, water run-off can be discharged from site at an agreed rate, reducing the risk of downstream flooding.

6.2 Storm-X4 - stormwater treatment system for roof and surface water run-off

6.2.5 Low maintenance

The advanced four stage filtration system within Storm-X4 utilises no moving parts, providing a low maintenance solution for all surface water run-off applications. The filters within the unit only need to be replaced on average every two years, providing an easily maintainable solution on-site.

6.2.6 Easy to install

Polypipe WMS can supply Storm-X4 as a standalone unit, or housed within a bespoke plastic chamber. When housed within a chamber, the units are constructed off-site and delivered to site ready to install, making installation quicker, safer and easier with a much lower development footprint.

6.2.7 Storm-X4 1000 traffic

- Surface water filter complying with DIN 1989-2 Type A
- For drained traffic areas to 500m²
- Connections: at DN150 or DN200
- 4 Filter Elements:
  Material, Filter, Substrate, Traffic
  Weight per element: 16kg

6.2.8 Storm-X4 1000 heavy traffic

- Surface water filter complying with DIN 1989-2 Type A
- For drained traffic areas to 500m²
- Connections: at DN150 or DN200
- 4 Filter Elements:
  Material, Filter, Substrate, Heavy Traffic
  Weight per element: 32kg

6.2.9 Storm-X4 1000 roof

- Surface water filter complying with DIN 1989-2 Type A
- For drained roof areas to 1000m²
- Connections: at DN150 or DN200
- 4 Filter Elements:
  Material, Filter, Substrate, Roof
  Weight per element: 16kg

This table shows capabilities of Storm-X4 to reduce chemical pollutants.

Parameter	Unit	Main road, distributor		Aims of LAWA[a]	Drinking water[b]	Seepage[c]	Storm-X4
		From	To	Permissible limit	Permissible limit	Control value	Aim[e]
Physio-chemical parameters				90-percentile			
El. cond.	(µS/cm)	110	2400	–	2500	–	<1500
pH	(-)	6.4	7.9	–	6.5 - 9.5	–	7.0 - 9.5
Nutrients							
P tot	(mg/L)	0.23	0.34	–	–	–	0.10
NH4	(mg/L)	0.5	2.3	–	0.5	–	0.3
NO3	(mg/L)	0.0	16.0	–	50.0	–	–
Heavy metals							
Cd	(µg/L)	0.3	13.0	1.0	5.0	5.0	<1.0
Zn	(µg/L)	120	2.000	500	–	500	<500
Cu	(µg/L)	97	104	20	2000	50	<50[d]
Pb	(µg/L)	11	525	50	10	25	<25[d]
Ni	(µg/L)	4	70	50	20	50	<20
Cr	(µg/L)	6	50	50	50	50	<20
Organic substances							
PAH (EPA)	(µg/L)	0.2	17.1	–	0.1 (6 Subst.)	0.2	<0.2
MOTH	(mg/L)	0.1	6.5	–	–	0.2	<0.2

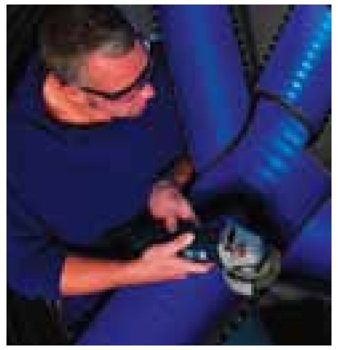
a. Aims of the German Working Group on water issues of the Federal States and the Federal Government (LAWA) for surface water usage as potable drinking water (1998).
b. Permissible limit of the German Drinking Water Ordinance (2001).
c. Control value for seepage of the German Federal Soil Protection Act an Ordinance (1999) according to §8 1,2.
d. For copper and lead roofs a second treatment step is necessary.
e. The aims of the system refer to average annual loads.

Critical parameter, treatment necessary	
Treatment may be necessary, not generally	
Non critical parameter	

Table 19

6.3 Fabrications

Polypipe WMS is in the unique position of being able to offer its customers bespoke fabrications from its highly skilled in-house Fabrications team.



Due to the variety of solutions available from Polypipe WMS, the fabrications department has become an integral part of the company. Whether you need a bend with a specialist angle or a complex chamber. Polypipe WMS are able to design and manufacture products to exact customer specifications. As well as delivering the products to site as a complete unit, ready for installation.

Having an in-house fabrication facility means we can respond quickly to customers needs. Liasing directly with the customer, through our own team of WMS specialists enables us to design and manufacture bespoke specialist fabrications to specific customer requirements. Examples of which can be seen in the following section. Due to the bespoke nature of these products, it is impossible to demonstrate every permutation available. For assistance please contact our sales department on 01509 615100.

6.3.1 Key benefits

- Design and manufacture of bespoke fabrications
- Purpose built 30,000 square metres fabrications facility
- All fabrications are constructed off-site and delivered as a complete unit
- Reduced Health and Safety risks in handling, storage and installation
- Increased versatility
- Strong yet light weight nature of plastic pipes enables a reduction of on-site plant requirements
- All Polypipe WMS fabricators are fully trained by The Welders Institute

TWI

6.3.2 The range

The range of products available is from standard applications to one-off bespoke solutions covering:

- Catchpits
- Surface water and sewer manholes manufactured to adoptable standards
- Rainwater harvesting tanks for both commercial and residential applications
- Sediment and leaf filters pre-fabricated within chambers
- Full range of fittings and accessories

6.3.3 Technical information online

The Polypipe WMS website, available at www.polypipewms.co.uk includes comprehensive technical information and installation guides, CAD drawings and BBA certificate downloads for the full Polystorm Modular Cell range. The ease of navigation and clear, concise information presented on the site has been designed to offer users more detailed and relevant information when looking to specify Polystorm products. Also included within the homepage is a product search facility to give easy and direct access to the information available on the site.

7.0 Project solutions

We have considerable project experience in sustainable drainage projects, providing tailor made solutions for our customers' requirements.

Project solutions

Contents

7.1 Polystorm - for commercial development Lytham St. Annes

Two stormwater management systems were supplied by Polypipe WMS within 12 months of one another on adjoining sites in Lytham St. Annes - a BMW garage and a Vauxhall Chevrolet and SAAB dealership.

Working closely alongside contractor James West Ltd and consultant Atkinson Peck, who specified the drainage on-site, Polypipe WMS supplied several cubic metres of Polystorm cells to provide an attenuation unit for absorbing vast quantities of rainwater. The Polystorm cells were also installed on the area surrounding the new car storage point, as this provided easy access to the large outfall drain and would further reduce the possibility of water logging on-site. 200 metres of Polysewer and 4000 metres of general purpose duct were also supplied alongside 400 metres of 150mm and 375 metres of Ridgidrain pipe.

7.2 Polystorm Lite - for new school development

A Polystorm Lite attenuation solution was implemented by Galliford Try on the development of a primary school in Heywood, Greater Manchester.

The project, at the New Central Heywood Primary School was part of a development to accommodate the integration of three local schools into one site. Over 1100 Polystorm Lite cells, along with the Stormcheck Vortex Flow Control Chamber were installed on the site to provide an integrated, robust and durable attenuation tank system. Once locked together, the cell structure was wrapped in a geotextile membrane to prevent silt migration. With a capacity of 350,000 litres and with a discharge rate set to ten litres per second, the Polystorm Lite cells were selected to provide the most effective SUDS solution for the long-term future of the development.

7.3 Hybrid drainage system
- for Knight Build site

Over 14,000 cells of Polystorm Lite and Polystorm were installed on the Knight Build site as part of a bespoke hybrid SUDS attenuation solution.

The site, a former private school which has been developed into apartments, consisted of various constraints meaning that the cells needed to be installed on a slope. The solution was a hybrid modular system containing both Polystorm Lite and Polystorm cells which accommodated the differing burial depths resulting in 2,700m³ of capacity.

Over 1800 metres of Ridgidrain pipes were supplied to facilitate the transportation of drainage water to and from the tank structure. Whilst Polystorm Lite, Polystorm and Ridgidrain can all be used effectively as standalone solutions, it was the ability of the products to be integrated together which offered Knight Build the most viable solution.

7.3 Hybrid drainage system
- for RAF Northolt project

A bespoke hybrid drainage system for the RAF Northolt Ministry of Defence site in Cambridgeshire, utilising both its Polystorm Lite and Polystorm modular cell solutions.

Approximately 3000 Polystorm Lite and Polystorm cells have been installed on-site to provide an attenuation solution to cope with surface water run-off from both hard standing and roof areas. The original project specification was changed from a concrete box culvert due to issues with rising material costs and concerns over the performance of the product in times of high-flow water run-off. However, a solution was needed that was capable of storing the required water capacity whilst accommodating difficult site constraints.
The modular construction of Polystorm Lite and Polystorm allows the cells to be connected together to form almost any shape and storage capacity.

8.0 The company - ground breaking technology, innovative products and total solutions

Polypipe is one of Europe's largest and fastest growing manufacturers of piping systems for the residential, commercial and infrastructure sectors. Polypipe is now the UK's leading manufacturer of cable protection, drainage, sewerage and water management systems for the UK construction industry.

The company

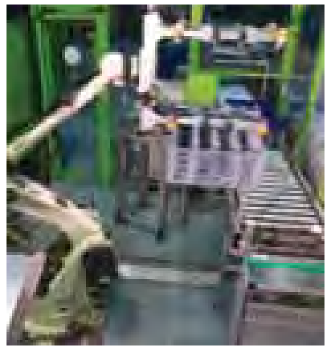
Contents

8.1 Manufacturing - breadth and strength

8.1.1 Manufacturing facilities

There are two manufacturing sites in the UK, in Loughborough and Horncastle with an operations site in Glasgow. Polypipe has undergone a continuous programme of investment in manufacturing over recent years to further enhance its market leading position.

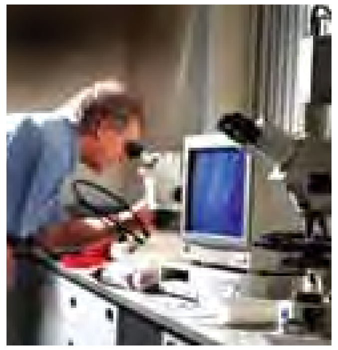
Operating from sites in Loughborough, Horncastle and Glasgow, Polypipe Civils employs over 300 people, with 35 production lines producing over 20 different product ranges consisting in excess of 1600 individual line items. With investment levels of £11m in 2006/07 Polypipe Civils prides itself in having the most extensive manufacturing capabilities in its sector.



8.1.2 Polystorm range

The use of modular cell systems has risen dramatically in recent years as consulting engineers, contractors and developers seek to manage surface water run-off on developed sites. In order to meet this growing demand and offer improved service levels and shorter lead times to its customers, Polypipe has made a further commitment to extend its production capacity. This includes a 12,000 sq.ft. extension to the Horncastle production line with 4 new injection lines and a fully automated 6 axis robot system.

8.2 Innovation, research & development - our continuous commitment



8.2.1 Innovation

Polypipe has dedicated research and development facilities setting the highest standard in the industry. In the last six years there has been extensive investment in laboratory facilities including the independent UKAS accredited Berry & Hayward laboratory. Our laboratories allow product development and certification testing to be undertaken in-house therefore shortening time to market and maximising product benefits for our customers.

8.2.2 Quality control

Polypipe take pride in providing a consistently high level of product quality with the most advanced and diverse range including accreditation from BSI to ISO 9001 : 2008. There are 2 quality control laboratories in action 24 hours a day and a fully equipped modern materials laboratory for development and analysis.

8.3 Health & safety and environmental policies

8.3.1 Polypipe health and safety policy

The Health and Safety of employees is an integral part of Polypipe's business activities. Health and Safety is a responsibility and statutory duty that each and every employee and visitor to our sites must share. To enable this, it is our intent that responsibility for Health and Safety be accepted and effectively carried out at all levels within our organisation.

All Polypipe companies shall, as far as possible, ensure that:

- We provide a safe working environment for our employees, where hazard and risk are effectively assessed and eliminated or adequately controlled
- We use suitable and sufficient controls to ensure that non-employees who may be affected by our activities are not exposed to risks to their Health and Safety
- We meet or exceed all current legislation and regulation relating to Health and Safety
- We clearly define and communicate organisational responsibilities for the management of Health and Safety
- Employee involvement in matters relating to Health and Safety is actively encouraged
- Adequate information, instruction and training are provided to all employees
- We properly investigate accidents and cases of work-related ill health
- We monitor and review Health and Safety performance using appropriate measures and methods
- There are good working relationships with regulatory authorities, neighbours, customers, suppliers and stakeholders on Health and Safety

8.3.2 Polypipe environmental policy

Polypipe Civils operates an Environmental Management System which complies with the requirements of ISO14001. At Polypipe we consider the positive management of the potential environmental impact of our activities as an integral part of our business undertaking. It is our intent to minimise the lasting impact of our operations on the environment and to take account of sustainability in our product design and applications.
The manufacture of these products consumes both raw materials and energy and Polypipe therefore has introduced proactive sustainability policies to manage both their usage and environmental impacts.

The Group shall ensure, as far as possible, that:

- We meet or exceed all current legislation and regulation relating to the environment
- We clearly define and communicate organisational responsibilities for the management of environmental protection
- Employee involvement in matters relating to the environment is actively encouraged
- Adequate information, instruction and training are provided to all employees
- We properly investigate environmental incidents
- We monitor and review performance using appropriate measures and methods
- We optimise the use of water and utilities
- There are good working relationships with regulatory authorities, neighbours, customers, suppliers and stakeholders on Environmental matters, energy management and Conservation Policy

8.4 Environmental commitments
- sustainability is not just a pipe dream

8.4.1 Sustainability is not just a pipe dream
Sustainability is not just about making products from recycled material, or helping to reduce energy consumption, there are many more elements to consider. Polypipe Civils makes a conscious effort to ensure as much is being done to help the external environment as possible. Products supplied to the market by Polypipe Civils are manufactured with sustainability in mind, making sure we provide sustainable solutions for generations to come. We constantly evaluate our systems and procedures so that the whole process of production is as sustainable as possible from material use through to product application.

8.4.2 Recycled product
Using recycled product is imperative and for the past 15 years it has been our policy to use as much recycled material as possible, either from other industries or post consumer waste. To this end Polypipe Civils use over 45% recycled material in the production of our pipes, which allows us to maintain the exacting standards of quality and durability that we strive to obtain and help to protect the environment.

8.4.3 100% Recyclable
As our products are manufactured in plastic, they are 100% recyclable at the end of their useful life, creating a sustainable path back into reuse.

8.4.4 Lowering energy consumption
Investing in new machinery has been key to the whole Polypipe Group and we have strived to ensure that our energy consumption has been addressed to make our new machinery more energy efficient.
An excellent example of this is the replacement of 17 injection moulding machines at a manufacturing site in 2006. The new machines saved between 18-20% in energy consumption over the outgoing machinery.

8.4 Sustainable - materials

8.4.5 Using less transport
Utilising our own transport fleet, Polypipe Civils ensure that the number of vehicles delivering product to site is kept to a minimum. For example, 1km of 450mm plastic drainage pipes will only require 3 deliveries, compared to concrete pipes which would require 12 deliveries. Not only will this benefit the environment but it also minimises the risk of on-site traffic related accidents, providing further Health and Safety benefits on-site.

8.4.6 Reducing our fuel usage
Our transport network plays a significant role in reducing our fuel consumption and as part of this, we have made sure that our vehicles run on bio-diesel. Polypipe Civils has also adopted the use of low rolling resistance tyres saving 5% on fuel. We also limit our vehicles to 54mph as opposed to the standard 56mph to save a further 5% on fuel.

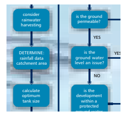
8.4.7 Recovering site waste
In the distribution of some products, Polypipe Civils use wooden pallets. In order to help reduce on-site waste and reduce consumption we have introduced a collection scheme, whereby we collect any pallet or strapping used on our products. Collection of pallets and strapping is easy and hassle-free and can be arranged by telephone.

8.4.8 Helping our communities
Polypipe Civils is committed to supporting our communities as much as possible. Whether it be supplying a local childrens hospice with decorations for their gardens, sponsoring youth sports teams and associations or holding one of the largest sailing regattas in the UK which brings the whole construction industry together to raise money for various charities. Sustainability is about the whole environment and Polypipe Civils takes pride in helping to create a sustainable environment wherever possible.

8.5 Support information
- www.polypipewms.co.uk

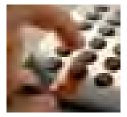
8.5.1 Website

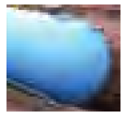
The Polypipe WMS website provides an overview, key benefits and a technical summary of each product supported by product and technical literature downloads. The next level of information is to provide the design engineer or contractor with more detail and guidance when specifying. CAD downloads are available in both PDF and DWG format plus specification clauses, assessment forms and BBA certificates. Legislative guidance from the Water Framework Directive, to the Code for Sustainable Homes is available plus Design Manuals from CIRIA, the BRE and much more. With FAQ's on Rainstream, Ridgistorm-XL and an 'Ask the Experts' section, the website is a comprehensive and essential source of water management information.


Selection and Design

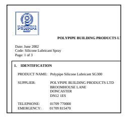

BBA Certificates


CAD Drawings

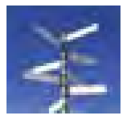

Calculation Tools


Installation Guides


Assessment Forms


Health and Safety


Specification Clauses


Legislative Guidance


FAQ's

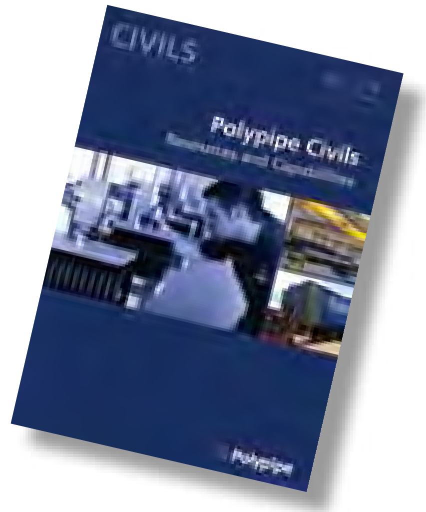

Ask the Experts

8.5 Support information
- literature

A range of specific product literature is also available from Polypipe WMS each with further details and support information. The literature is also available on the Polypipe WMS website (www.polypipewms.co.uk) as PDF downloads.

8.5.2 Product literature

To request a printed piece of product literature please contact Polypipe WMS on 01509 217671 or visit www.polypipewms.co.uk and click into choice of product, then 'Request brochure' which takes you to a simple request form. Complete the form before you submit your brochure request then click onto the 'Submit Request' panel.



8.5.3 Resources and Capabilities brochure

To know more about Polypipe WMS and Polypipe Civils there is the Polypipe Civils Resources and Capabilities brochure. The brochure encapsulates the company's investments and achievements made over recent years which is testimony to the leading position that Polypipe Civils and WMS currently has in the marketplace. There is information of additional products and solutions from Polypipe Civils with an overview of proven case studies and market sectors.


Bespoke Fabrications Brochure


Polypipe Civils Product and System Selector


Water Management Solutions Product and System Selector

WMS

Polypipe Water Management Solutions
Modular Cells Technical Guide

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