

P e l l   F r i s c h m a n n

106240- ICN Framework- Longhurst Road

106240-PEF-HDG-01-TN-D-00001

Drainage Verification Report

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|                    |             |                                                                                                                                                  |             |                   |                |                 |
|--------------------|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------------|----------------|-----------------|
| <b>Report Ref.</b> |             | <b>106420-PEF-HDG-01-TN-D-00001</b>                                                                                                              |             |                   |                |                 |
| <b>File Path</b>   |             | P:\data\Manchester Office Projects\106000 to 106999\106240 - ICN Framework - Longhurst Road\01 - WIP\Documents\106420-PEF-HDG-01-TN-D-00001.docx |             |                   |                |                 |
| <b>Rev</b>         | <b>Suit</b> | <b>Description</b>                                                                                                                               | <b>Date</b> | <b>Originator</b> | <b>Checker</b> | <b>Approver</b> |
| P01                | S3          | SUITABLE FOR REVIEW                                                                                                                              | 06/02/26    | E.BLIZZARD        | S.AKRILL       | A.HALL          |
|                    |             |                                                                                                                                                  |             |                   |                |                 |
|                    |             |                                                                                                                                                  |             |                   |                |                 |
|                    |             |                                                                                                                                                  |             |                   |                |                 |

Ref. reference. Rev revision. Suit suitability.

**Prepared for**

**Great Places Housing Group**

Derwent Avenue  
Manchester  
M21 7QP

**Prepared by**

**Pell Frischmann**

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One St James Square  
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M2 6DN



Pell Frischmann

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- Appendix C Attenuation Tank Product Specification

# 1 Introduction

## 1.1 Project Background

Pell Frischmann have been commissioned by Great Places Housing Group to provide a surface water drainage Verification Report for the 9-block apartment development at Longhurst Road, Manchester. This report references as-built information provided to Pell Frischmann by Great Places Housing Group and is based on best practice guidance.

The surface water drainage strategy involved the discharge of the surface water flows into an existing United Utilities Combined Sewer which runs beneath Longhurst Road. A discharge rate into the watercourse of 5l/s was agreed by Manchester City Council. As such, the discharge rate has been limited to 5l/s. The surface water drainage network was designed based on the following assumptions/criteria:

- Housing unit roofs will drain into the indicated downpipes and into the private drainage network which discharges into highway adopted sewer.
- A Hydro-brake manhole is employed to limit flow rate into watercourse to 5l/s
- The proposed cellular attenuation tanks will allow for the storage of storm water runoff during peak events. This, including the oversized 0.675m diameter pipes, were designed to accommodate for the 1-in-30-year storm event. When simulated in MicroDrainage, there was no flooding in the 1 in 100yr +CC storm event.

## 1.2 Scope of this Verification Report

This report will cover the following content, based on Planning Condition 16 requirements for a verification report.

- An as-built survey of installed drainage infrastructure.
- Photo's of as-installed drainage.

## 2 As-Built Drainage Infrastructure Survey

### 2.1 Introduction and Scope of Survey

This survey aims to assess the installed drainage infrastructure using photographs provided by Great Places Housing Group. Manchester City Council requirements are to verify the installation of the Drainage and SuDS, confirmed by photographic evidence as outlined in Planning Condition 16. It will include a survey of installed drainage infrastructure, including:

- Surface water drainage.
- Highway gullies
- Installation of the attenuation tank.
- Under slab drainage.

### 2.2 As-Built Drawings

The following Final Construction drawings, as confirmed by the contractor, are included within Appendix A The drawings included are as listed below:

**Table 2.1: As-Built Drawings Register**

| PF Drawing Reference                          | Drawing Title                                            |
|-----------------------------------------------|----------------------------------------------------------|
| 106240-PEL-HDG-01-DR-D-0001                   | OUTLINE DRAINAGE PLAN - GREENFIELD                       |
| 106240-PEL-HDG-01-DR-D-0002                   | OUTLINE DRAINAGE PLAN - BROWNFIELD                       |
| 106240-PEL-HDG-01-DE-D-0001-0002              | S104 - SURFACE WATER, SW MANHOLE DETAILS                 |
| 106240-PEL-HDG-01-DE-D-0003-Foul MH details   | S104 FOUL WATER, MH DETAILS                              |
| 106240-PEL-HDG-01-DE-D-0004-HYDROBRAKE DETAIL | HYDROBRAKE DETAIL                                        |
| 106240-PEL-HDG-01-DR-D-1001                   | GENERAL ARRANGEMENT                                      |
| 106240-PEL-HDG-01-DR-D-1002                   | IMPERMEABLE AREAS PLAN                                   |
| 106240-PEL-HDG-01-DR-D-1003                   | LONGSECTIONS                                             |
| 106240-PEL-HDG-01-DR-D-1004                   | OVERLAND FLOW, ROUTING PLAN                              |
| 106240-PEL-HDG-01-DR-D-1005                   | PRIVATE DRAINAGE, GENERAL ARRANGEMENT                    |
| 106240-PEL-HDG-01-DR-D-1006                   | LAND DRAINAGE, GENERAL ARRANGEMENT                       |
| 106240-PEL-HDG-01-DR-D-1007                   | ATTENUATION, FOUNDATION PLAN                             |
| 106240-PEL-HDG-01-DR-D-1008                   | MANHOLE SCHEDULE                                         |
| 106240-PEL-HDG-01-DR-D-1009                   | LAND REGISTRY PLAN                                       |
| 106240-PEL-HDG-01-DR-D-1010                   | DRAINAGE, ATTENUATION TANK PLAN                          |
| 106240-PEL-HDG-01-DR-D-1011                   | TEMPORARY WORKS, SITE DRAINAGE PLAN, GENERAL ARRANGEMENT |
| 106240-PEL-HDG-01-SK-D-1001                   | DRAINAGE, AERIAL VIEW                                    |

### 2.3 Product Specifications

The product specifications for the relevant installed drainage infrastructure are included within the following Appendices:

**Table 2.2: Table of product specifications.**

| Drainage Element   | Product Specification                     | Appendix   |
|--------------------|-------------------------------------------|------------|
| Hydro-brake        | Hydro-brake Optimum (Hydro International) | Appendix B |
| Attenuation Crates | Polystorm-R (Polystorm)                   | Appendix C |

## 2.4 Photos of Installed Drainage



Photo 1: Excavation within Longhurst Road to expose existing UU combined sewer to install new connection.



Photo 2: Installation of new manhole within Longhurst Road where connection into existing UU combined sewer will be located.



Photo 3: Angled pipe connection into existing UU sewer within Longhurst Road.



Photo 4: Angled pipe connection into existing UU sewer within Longhurst Road.



Photo 5: Angled pipe connection into existing UU sewer within Longhurst Road.



Photo 6: Angled pipe connection at base of new manhole within Longhurst Road after installation of manhole ring.



**Photo 7: Angled pipe connection at base of new manhole within Longhurst Road after installation of manhole rings.**



**Photo 8: Concrete benching at base of new manhole within Longhurst Road after installation of manhole rings and new connection.**



**Photo 9: Installation of new manhole within Longhurst Road where connection into existing UU combined sewer will be located.**



**Photo 10: Finished ground and resurfacing surrounding new manhole connection into existing UU combined sewer within Longhurst Road.**



Photo 11: Casting of concrete manhole base along with first pre-cast manhole ring installation.



Photo 12: Casting of hydrobrake manhole benching ahead of hydrobrake installation.



**Photo 13: Installation of hydrobrake unit.**



**Photo 14: View of hydrobrake unit installed within manhole from cover slab.**



**Photo 15:** Installation of impermeable membrane over attenuation storage tank.



**Photo 16:** Installation of impermeable membrane over attenuation storage tank.



**Photo 17: Backfill of cover above attenuation tank.**



**Photo 18: Backfill of cover above attenuation tank.**



**Photo 19: Backfill of cover above attenuation tank.**



**Photo 20: Depth of backfill above attenuation tank.**



**Photo 21: Backfill of cover above attenuation tank.**



**Photo 22: Backfill of cover above attenuation tank.**

## Appendix A Drainage Drawings



- GENERAL NOTES
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- PROPOSED SURFACE WATER CARRIER PIPE
- PROPOSED FOUL WATER CARRIER PIPE
- PROPOSED DRAINAGE NOT TO BE ADOPTED
- STORAGE 1 IN 100 YEAR NOT TO BE ADOPTED
- PROPOSED SURFACE WATER LATERAL CONNECTION AND CHAMBER
- PROPOSED FOUL WATER LATERAL CONNECTION AND CHAMBER
- INDICATIVE LOCATION OF UNITED UTILITIES COMBINED SEWER
- EXISTING UNITED UTILITIES COMBINED SEWER MANHOLE

|     |                                  |     |     |     |          |
|-----|----------------------------------|-----|-----|-----|----------|
| C01 | CONSTRUCTION ISSUE               | PC  | AH  | AH  | 26.03.25 |
| P12 | MINOR UPDATES                    | PC  | RM  | RM  | 17.01.25 |
| P11 | UU LEGAL COMMENTS ADDRESSED      | PC  | RM  | RM  | 14.01.25 |
| P10 | ADDITIONAL UU COMMENTS ADDRESSED | PC  | AH  | AH  | 07.11.24 |
| P09 | LATEST UU COMMENTS ADDRESSED     | EP  | PC  | AH  | 18.10.24 |
| P08 | ADDITIONAL DETAILS ADDED         | PC  | LB  | AH  | 04.10.24 |
| P07 | ATTENUATION SPECIFICATION UPDATE | PC  | AH  | AH  | 19.09.24 |
| P06 | ADDITIONAL UU COMMENTS ADDRESSED | PC  | LB  | AH  | 13.09.24 |
| P05 | BOUNDARY ADDED                   | PC  | LB  | LB  | 22.08.24 |
| P04 | UU COMMENTS ADDRESSED            | PC  | AH  | AH  | 24.07.24 |
| P03 | LLFA COMMENTS ADDRESSED          | PC  | AH  | AH  | 24.05.24 |
| P02 | ADDITIONAL INFORMATION ADDED     | PC  | AH  | AH  | 20.03.24 |
| P01 | FIRST ISSUE                      | PC  | NB  | AH  | 06.11.23 |
| REV | DESCRIPTION                      | DRN | CHK | APP | DATE     |

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Project

LONGHURST ROAD

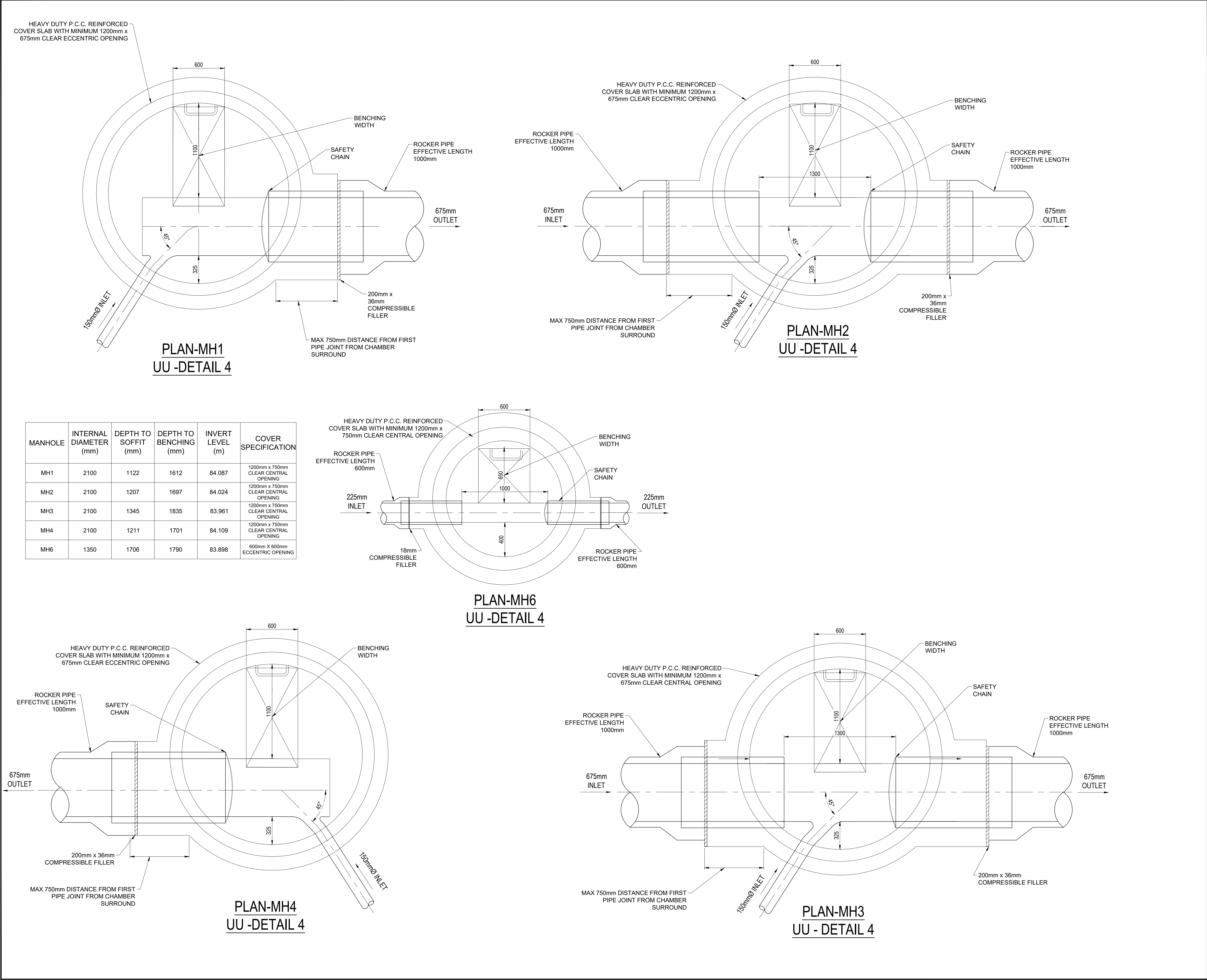
Drawing Title

S104  
DRAINAGE  
GENERAL ARRANGEMENT

|                |              |          |             |       |
|----------------|--------------|----------|-------------|-------|
| Drawing Status | CONSTRUCTION |          |             |       |
| Drawn          | Name         | Date     | Status Code | B01   |
| Designed       | P. CLARK     | 03.11.23 | Scale       | 1:200 |
| Eng Chk        | N. BANKS     | 06.11.23 | Revision    | C01   |
| Approved       | A. HALL      | 06.11.23 |             |       |

Drawing No.

106240 - PEL - HDG - 01 - DR - D - 1001



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|-----|--------------------------|-----|-----|-----|------|----------|
| C01 | CONSTRUCTION ISSUE       | PC  | LB  | AH  | AH   | 26.03.25 |
| P05 | ADDITIONAL UU COMMENTS   | PC  | LB  | AH  | AH   | 15.11.24 |
| P04 | DETAILS UPDATED          | PC  | LB  | AH  | AH   | 04.10.24 |
| P03 | UU COMMENTS ADDRESSED    | PC  | LB  | AH  | AH   | 16.07.24 |
| P02 | ADDITIONAL DETAILS ADDED | PC  | LB  | AH  | AH   | 25.03.24 |
| P01 | FIRST ISSUE              | PC  | LB  | AH  | AH   | 02.11.23 |
| REV | DESCRIPTION              | DRN | CHK | APP | DATE |          |

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**greatplaces**  
HOUSING GROUP

Project

LONGHURST ROAD

Drawing Title

S104 - SURFACE WATER  
SW - MANHOLE DETAILS

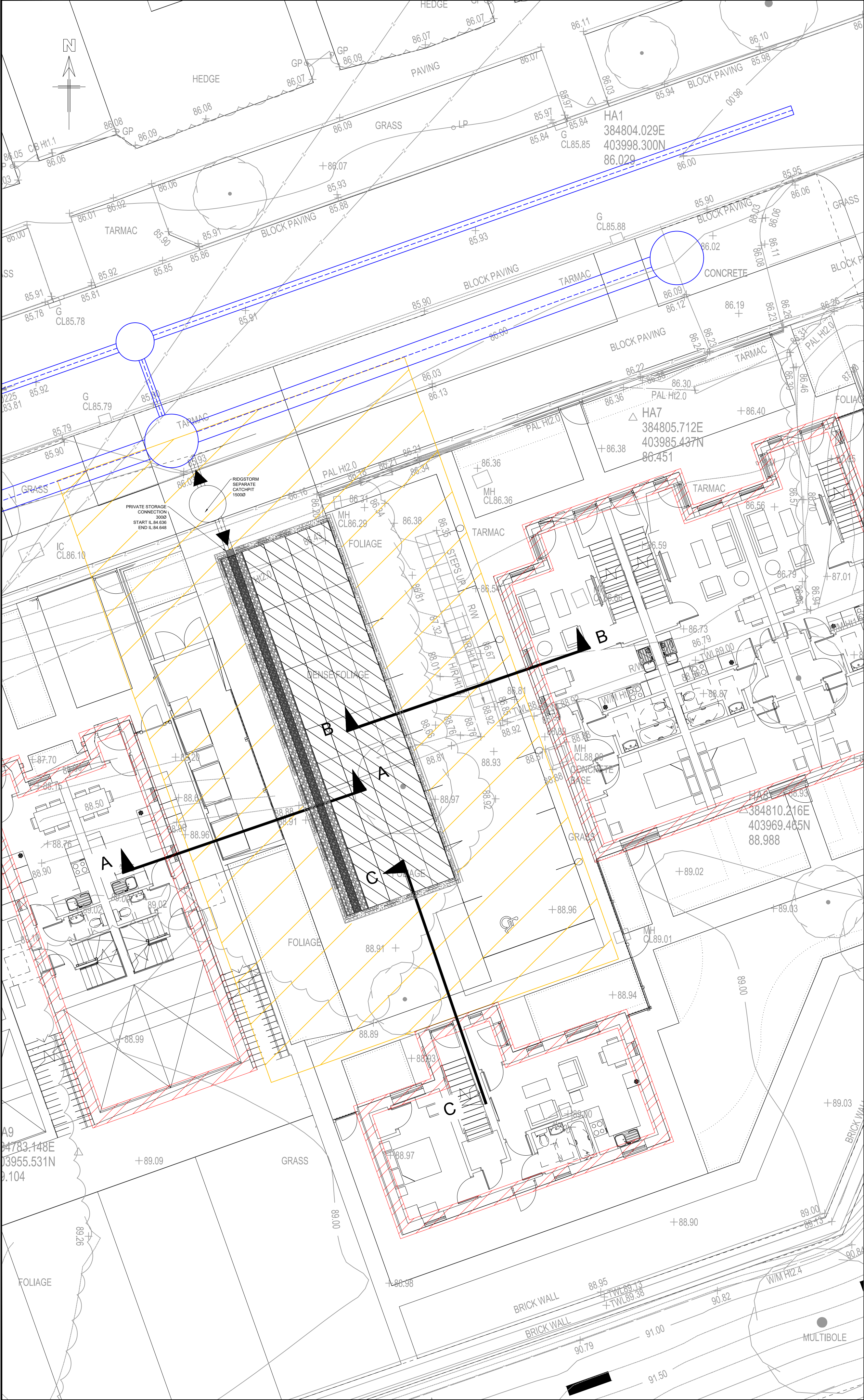
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CONSTRUCTION

|          | Name     | Date     | Status Code |
|----------|----------|----------|-------------|
| Drawn    | P. CLARK | 02.11.23 | B01         |
| Designed | P. CLARK | 02.11.23 | Scale       |
| Eng Chk  | N. BANKS | 02.11.23 | Revision    |
| Approved | A. HALL  | 02.11.23 | C01         |

Drawing No.

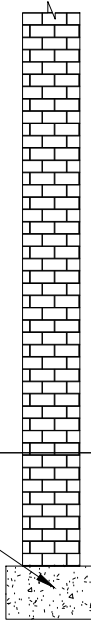
106240 - PEL - HDG - 01 - DE - D - 0002



**BLOCK 3**

FOR FOUNDATION  
PLAN SEE  
DRAWING  
106240-PEF-FD-XX-DR-S-10003

600mm WIDE BY  
350mm DEEP MASS  
CONCRETE  
FOUNDATIONS  
BLOCK 3



100MM THICK  
COURSE SAND  
OR NON-ANGULAR  
GRANULAR SURROUND

PIPEWORK CONNECTIONS TO MH MADE WITH PROPRIETARY  
FLANGE ADAPTORS AND GEO-MEMBRANE SEALED AS REQUIRED

**SECTION A-A**

1:50 SCALE

HEAT-SEALED  
POLYPROPYLENE  
GEO-MEMBRANE

100MM THICK  
COURSE SAND  
OR NON-ANGULAR  
GRANULAR SURROUND

1000X500X400 ATTENUATION  
UNITS WITH 95% VOID RATIO  
POLYSTORM-R OR SIMILAR  
APPROVED

PIPEWORK CONNECTIONS TO MH MADE WITH PROPRIETARY  
FLANGE ADAPTORS AND GEO-MEMBRANE SEALED AS REQUIRED

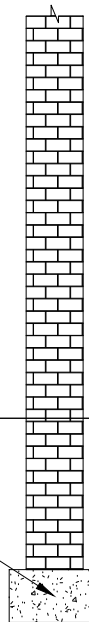
**SECTION B-B**

1:50 SCALE

**BLOCK 2**

FOR FOUNDATION  
PLAN SEE  
DRAWING  
106240-PEF-FD-XX-DR-S-10002

600mm WIDE BY  
350mm DEEP MASS  
CONCRETE  
FOUNDATIONS  
BLOCK 2

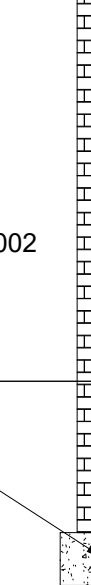


100MM THICK  
COURSE SAND  
OR NON-ANGULAR  
GRANULAR SURROUND

PIPEWORK CONNECTIONS TO MH MADE WITH PROPRIETARY  
FLANGE ADAPTORS AND GEO-MEMBRANE SEALED AS REQUIRED

**SECTION C-C**

1:50 SCALE



100MM THICK  
COURSE SAND  
OR NON-ANGULAR  
GRANULAR SURROUND

1000X500X400 ATTENUATION  
UNITS WITH 95% VOID RATIO  
POLYSTORM-R OR SIMILAR  
APPROVED

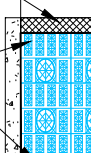
PIPEWORK CONNECTIONS TO MH MADE WITH PROPRIETARY  
FLANGE ADAPTORS AND GEO-MEMBRANE SEALED AS REQUIRED



HEAT-SEALED  
POLYPROPYLENE  
GEO-MEMBRANE

PROPOSED CAR PARK  
CONSTRUCTION WITH  
CONCRETE BASE

1000X500X400 ATTENUATION  
UNITS WITH 95% VOID RATIO  
POLYSTORM-R OR SIMILAR  
APPROVED

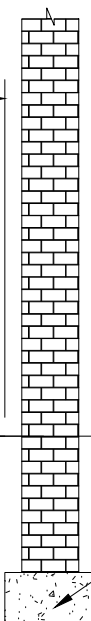


TANK DIMENSIONS AS PER DRAWINGS  
106240-PEL-HDG-01-DR-D-1001

**BLOCK 1**

FOR FOUNDATION  
PLAN SEE DRAWING  
106240-PEF-FD-XX-DR-S-10003

600mm WIDE BY  
350mm DEEP MASS  
CONCRETE  
FOUNDATIONS  
BLOCK 1



PROPOSED CAR PARK  
CONSTRUCTION WITH  
CONCRETE BASE

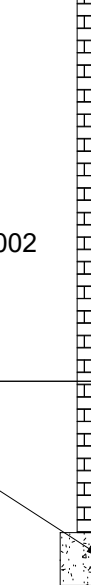
HEAT-SEALED  
POLYPROPYLENE  
GEO-MEMBRANE

1000X500X400 ATTENUATION  
UNITS WITH 95% VOID RATIO  
POLYSTORM-R OR SIMILAR  
APPROVED

PIPEWORK CONNECTIONS TO MH MADE WITH PROPRIETARY  
FLANGE ADAPTORS AND GEO-MEMBRANE SEALED AS REQUIRED

**SECTION B-B**

1:50 SCALE



100MM THICK  
COURSE SAND  
OR NON-ANGULAR  
GRANULAR SURROUND

1000X500X400 ATTENUATION  
UNITS WITH 95% VOID RATIO  
POLYSTORM-R OR SIMILAR  
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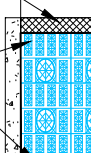
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FLANGE ADAPTORS AND GEO-MEMBRANE SEALED AS REQUIRED



HEAT-SEALED  
POLYPROPYLENE  
GEO-MEMBRANE

PROPOSED CAR PARK  
CONSTRUCTION WITH  
CONCRETE BASE

1000X500X400 ATTENUATION  
UNITS WITH 95% VOID RATIO  
POLYSTORM-R OR SIMILAR  
APPROVED



TANK DIMENSIONS AS PER DRAWINGS  
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- STORAGE 1 IN 100 YEAR NOT TO BE ADOPTED
- 5m EASEMENT
- MASS CONCRETE FOUNDATION

|     |                              |     |     |     |          |
|-----|------------------------------|-----|-----|-----|----------|
| C01 | CONSTRUCTION ISSUE           | PC  | AH  | AH  | 26.03.25 |
| P02 | ADDITIONAL INFORMATION ADDED | PC  | AH  | AH  | 11.12.24 |
| P01 | FIRST ISSUE                  | PC  | AH  | AH  | 24.05.24 |
| REV | DESCRIPTION                  | DRN | CHK | APP | DATE     |

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Architect/Client/Contractor

**greatplaces**  
HOUSING GROUP

Project

**LONGHURST ROAD**

Drawing Title

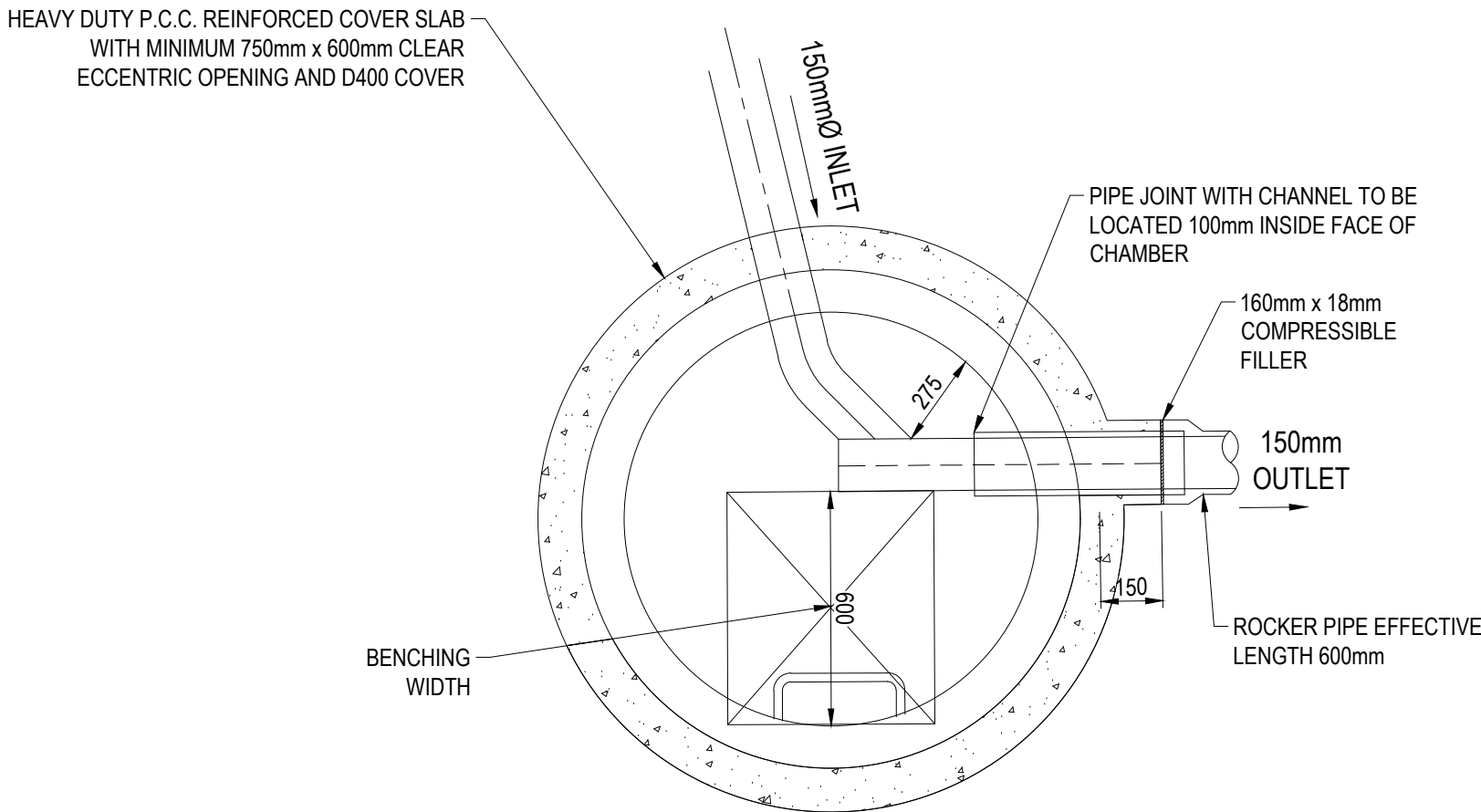
**S104  
ATTENUATION  
FOUNDATION PLAN**

| CONSTRUCTION |          |          |             |              |
|--------------|----------|----------|-------------|--------------|
| Drawn        | Name     | Date     | Status Code |              |
|              | P. CLARK | 24.05.24 |             | <b>B01</b>   |
| Designed     | Name     | Date     | Scale       |              |
|              | P. CLARK | 24.05.24 |             | <b>1:200</b> |
| Eng Chk      | Name     | Date     | Revision    |              |
|              | A. HALL  | 24.05.24 |             | <b>C01</b>   |
| Approved     | Name     | Date     |             |              |
|              | A. HALL  | 24.05.24 |             |              |

Drawing No.

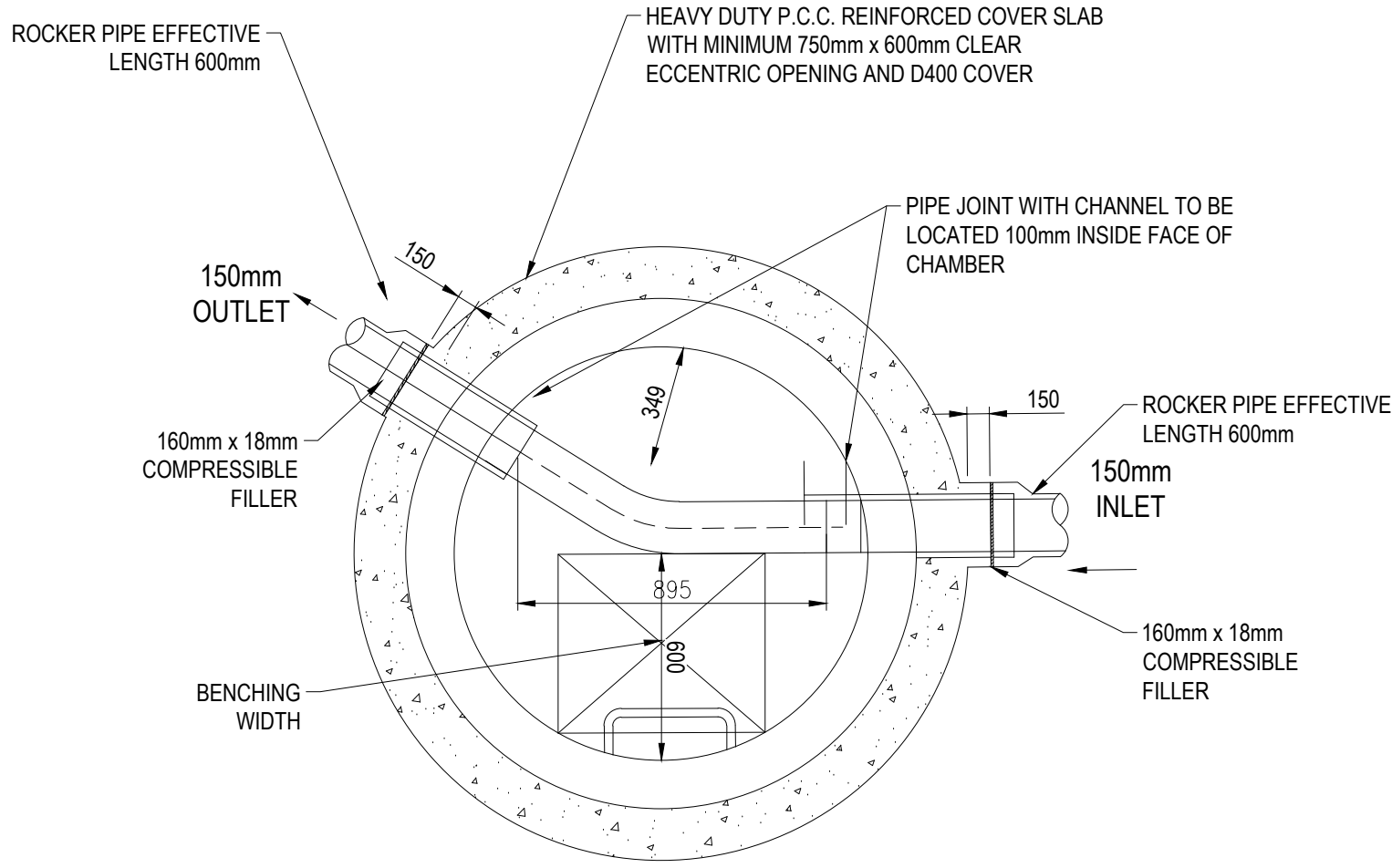
**106240 - PEL - HDG - 01 - DR - D - 1007**

| MANHOLE    | INTERNAL DIAMETER (mm) | DEPTH TO SOFFIT (mm) | DEPTH TO BENCHING (mm) | INVERT LEVEL (m) | COVER SPECIFICATION                          |
|------------|------------------------|----------------------|------------------------|------------------|----------------------------------------------|
| MH1        | 1200                   | 1553                 | 1738                   | 84.218           | 750 X 600mm CLEAR CENTRAL OPENING D400 COVER |
| MH2        | 1200                   | 1768                 | 1953                   | 84.030           | 750 X 600mm CLEAR CENTRAL OPENING D400 COVER |
| UU MANHOLE | 1350                   | 1612                 | 1122                   | 83.900           | 750 X 600mm CLEAR CENTRAL OPENING D400 COVER |



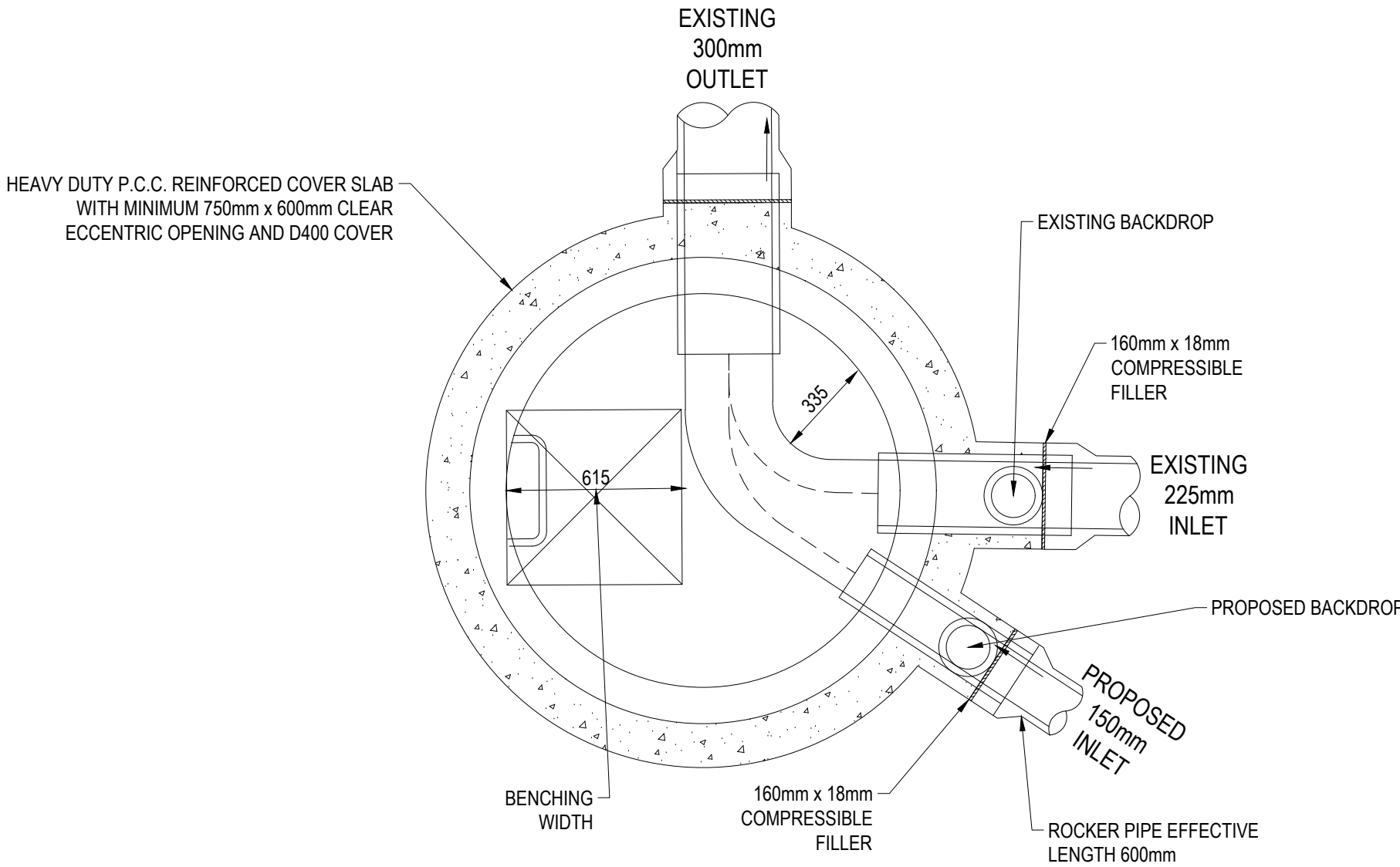
PLAN - FW-MH1  
UU DETAIL 1 MANHOLE TYPE 3  
SCALE 1:20

INTERNAL DIAMETER: 1200mm  
DEPTH TO SOFFIT: 1553mm  
DEPTH TO BENCHING: 1303mm



PLAN - FW-MH2  
UU DETAIL 1 MANHOLE TYPE 3  
SCALE 1:20

INTERNAL DIAMETER: 1200mm  
DEPTH TO SOFFIT: 1768mm  
DEPTH TO BENCHING: 1518mm



PLAN UU MANHOLE NO. 7900  
UU DETAIL 1 MANHOLE TYPE 1  
SCALE 1:20

INTERNAL DIAMETER: 1350mm  
DEPTH TO SOFFIT: 1122mm  
DEPTH TO BENCHING: 1612mm

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|-----|----------------------------------|-----|-----|-----|----------|
| C01 | CONSTRUCTION ISSUE               | PC  | AH  | AH  | 26.03.25 |
| P06 | MINOR COMMENTS                   | PC  | LB  | AH  | 20.11.24 |
| P05 | ADDITIONAL UU COMMENTS ADDRESSED | PC  | LB  | AH  | 15.11.24 |
| P04 | ADDITIONAL COMMENTS ADDED        | PC  | LB  | AH  | 07.10.24 |
| P03 | UU COMMENTS ADDRESSED            | PC  | AH  | AH  | 16.07.24 |
| P02 | ADDITIONAL UU COMMENTS ADDRESSED | PC  | LB  | AH  | 13.09.24 |
| P01 | FIRST ISSUE                      | EP  | LB  | AH  | 23.08.24 |
| REV | DESCRIPTION                      | DRN | CHK | APP | DATE     |

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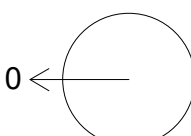
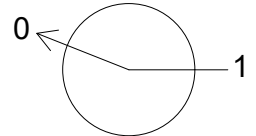
**greatplaces**  
HOUSING GROUP

Project  
**LONGHURST ROAD**

Drawing Title  
**S104 FOUL WATER  
MH DETAILS**

| CONSTRUCTION |            |          |             |  |
|--------------|------------|----------|-------------|--|
|              | Name       | Date     | Status Code |  |
| Drawn        | E.PHYTHIAN | 23.08.24 | B01         |  |
| Designed     | L.BOWLES   | 23.08.24 | AS SHOWN    |  |
| Eng Chk      | A.HALL     | 23.08.24 | Revision    |  |
| Approved     | A. HALL    | 23.08.24 | C01         |  |

Drawing No.  
**106240 - PEL - HDG - 01 - DE - D - 0003**

| Manhole Number |            | Cover Level     | Connections                                                                           | Pipe |       |         | Manhole Size | Types |         |       |
|----------------|------------|-----------------|---------------------------------------------------------------------------------------|------|-------|---------|--------------|-------|---------|-------|
| Coordinates    |            | Depth To Soffit |                                                                                       | Code |       | Inverts |              | Diams | Manhole | Cover |
| FW-MH1         |            | 85.921          |   |      |       |         |              | 1200  | B       | D400  |
| E.             | 384727.787 | 1.563           |                                                                                       |      |       |         |              |       |         |       |
| N.             | 403963.289 |                 |                                                                                       | 0    | 1.000 | 85.218  | 150          |       |         |       |
| FW-MH2         |            | 85.948          |  | 1    | 1.000 | 84.030  | 150          | 1200  | B       | D400  |
| E.             | 384718.902 | 1.768           |                                                                                       |      |       |         |              |       |         |       |
| N.             | 403960.234 |                 |                                                                                       | 0    | 1.001 | 84.030  | 150          |       |         |       |

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- G9. ALL MANHOLES HAVE CONCRETE SURROUNDS.

|     |                       |     |     |     |          |
|-----|-----------------------|-----|-----|-----|----------|
| C01 | CONSTRUCTION ISSUE    | PC  | AH  | AH  | 26.03.25 |
| P03 | UU COMMENTS ADDRESSED | PC  | LB  | AH  | 13.09.24 |
| P02 | UPDATED MH SCHEDULE   | LB  | AH  | AH  | 22.08.24 |
| P01 | FIRST ISSUE           | PC  | AH  | AH  | 24.07.24 |
| REV | DESCRIPTION           | DRN | CHK | APP | DATE     |

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Architect/Client/Contractor



Project

LONGHURST ROAD

Drawing Title

S104  
MANHOLE SCHEDULE

Drawing Status

CONSTRUCTION

|          | Name     | Date     | Status Code     |
|----------|----------|----------|-----------------|
| Drawn    | P. CLARK | 24.07.24 | B01             |
| Designed | P. CLARK | 24.07.24 | Scale<br>NTS    |
| Eng Chk  | A. HALL  | 24.07.24 | Revision<br>C01 |
| Approved | A. HALL  | 24.07.24 |                 |

Drawing No.

106240 - PEL - HDG - 01 - DR - D - 1008

## Appendix B Hydro-brake Product Specification

## Hydro-Brake® Optimum

### Vortex Flow Control

Inspired by nature and engineered to deliver the perfect curve, the Hydro-Brake® Optimum is the most advanced vortex flow control available. There is no equivalent to the Hydro-Brake® Optimum when it comes to delivering the best possible hydraulic performance with a passive flow control.

With a wide range of configurations and options available, the Hydro-Brake® Optimum is able to provide precision flow control to suit the vast majority of applications.



*Figure 1 - The Hydro-Brake® Optimum is designed and manufactured to deliver precise, repeatable flow control.*

### Precision Engineered Vortex Flow Controls

Each Hydro-Brake® Optimum is custom configured to suit the application and is manufactured under strict quality assurance procedures to deliver precise flow control to exacting requirements.

Every unit is backed by significant R&D investment to fine-tune the performance, meaning that the Hydro-Brake® Optimum is the only vortex flow control to have been independently certified by the BBA and WRc.



### Benefits

- Manufactured from high grade stainless steel.
- Future proof – adjustable or replaceable inlet plates available to alter flow rates post-installation.
- Configurations available to suit a wide variety of installations.
- Large cross sectional area at all heads.
- Simple installation.
- Self-activating.
- No moving parts or external power requirement.

### Versatile and Flexible

At Hydro International, we pride ourselves on providing solutions that meet your requirements, rather than providing a standard solution and asking you to compromise on your project needs.

The Hydro-Brake® Optimum offers designers options to precision-engineer a vortex flow control to:

- Minimise upstream storage volumes.
- Maximise internal (inlet & outlet) cross sectional areas to prevent blockages.
- Build-in a climate change factor to allow for future changes in flow rate.

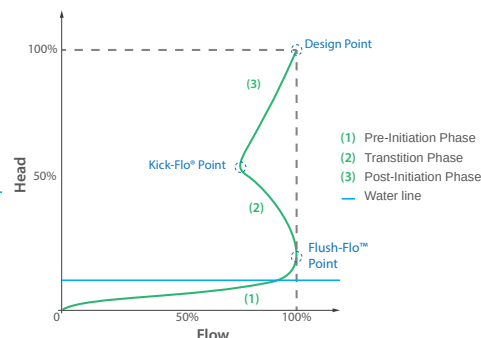
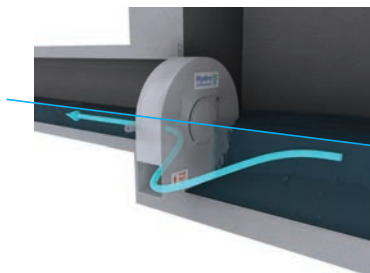
Furthermore, if you need to retrofit a flow control, our dedicated team of engineers can assist with providing a customised Hydro-Brake® Optimum suitable for installation into existing drainage infrastructure.

## Operating Principles

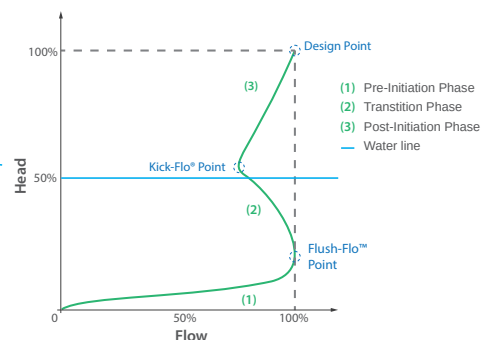
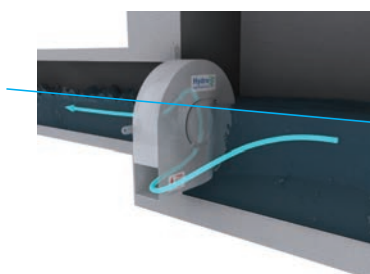
The hydraulic behaviour of the Hydro-Brake® Optimum is described by its hydraulic characteristic curve, which relates the discharge flow from the unit to the hydraulic head acting upon that unit.

The hydraulic characteristic curve consists of three distinct sections, each corresponding to a different governing flow control regime:

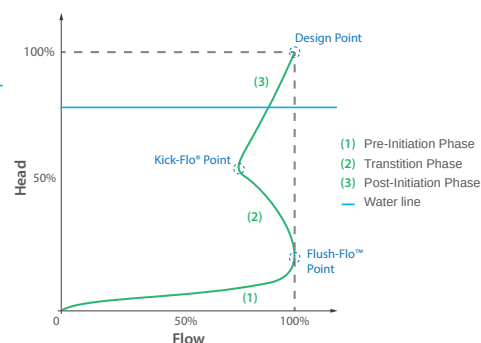
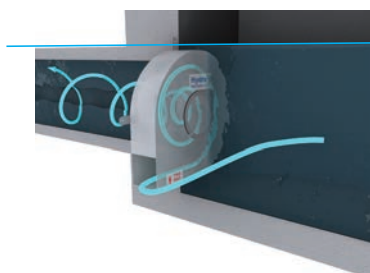
1. The pre-initiation phase – governed by orifice flow and defined on the characteristic curve as the region between the origin and the point at which the vortex begins to have a throttling effect (Flush-Flo™ point). In this region, the depth of water is below the soffit of the outlet orifice of the Hydro-Brake® Optimum.



2. The transition phase – governed by vortex formation and defined on the characteristic curve as the region between the Flush-Flo™ and the point at which the vortex has fully initiated (Kick-Flo® point). In this region the vortex will continually form and collapse. A trapped volume of air inside the Hydro-Brake® Optimum will exert a backpressure and cause the discharge rate to reduce even though the hydraulic head continues to increase.



3. The post-initiation phase – governed by stable vortex flow and defined on the characteristic curve as the region above the Kick-Flo® point. A stable vortex is formed and sustained. An air filled core at the centre of the vortex acts as a pseudo-physical flow restriction by reducing the cross sectional area available for the passage of water.



## Design Flexibility

It is possible for the Design Point to be achieved using a number of different flow control configurations, each with a different hydraulic response or characteristic curve.

An in-depth understanding of the flow regimes and interactions at each stage of the hydraulic characteristic curve allows custom configuration of the Hydro-Brake® Optimum to achieve the hydraulic profile best suited to the site requirements.

# Design Data

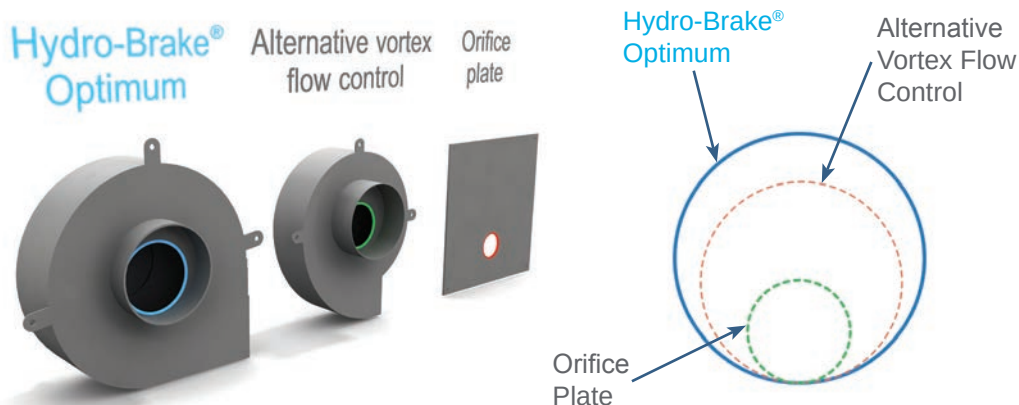
## Hydro-Brake® Optimum

### Vortex Flow Control

#### Resilience by Design

Hydro-Brake® Optimum has outlets (clearances) up to 20% larger than competitor products to minimise the risk of blockages. All units are fitted with a pivoting bypass door to enable full access to the internal chamber and the outlet structure in the event that a blockage does occur.

All Hydro-Brake® Optimum units can also be supplied with an adjustable or replaceable inlet to future-proof the device, allowing flows to be altered post-installation, to account for site expansion or climate change.



#### Expert Design Support Services

**Hydro International's professional engineers work with you to provide expert technical and aftersales support to ensure your projects meet exacting design requirements and deliver the very best hydraulic controls for your site.**

With over 35 years' experience of flow control knowledge and experience, Hydro International's design support team is available to advise on any aspect of water flow management, including detailed modelling of vortex flow controls and composite outlet structures.

**Call the Hydro-Brake® Hotline on: 01275 337937 or email [hydrobrake@hydro-int.com](mailto:hydrobrake@hydro-int.com)**

#### Hydro-Brake® Optimum Design Tool

Engineers have the flexibility to try out any number of flow control iterations and explore their impact on hydraulic performance.

The Hydro-Brake® Optimum Design Tool allows you to quickly and easily compare a number of different flow control options for your site to develop the most robust and sustainable drainage solution possible.

In just 3 simple steps you can obtain:

- Detailed dimensional drawings
- Hydraulic modelling data for direct import or copy/paste into commercial hydraulic modelling software



[www.hydrobrakeoptimum.com](http://www.hydrobrakeoptimum.com)

#### Full MicroDrainage® Compatibility

Engineers can carry out sizing and flow rate calculations and conduct hydraulic modelling of drainage networks containing Hydro-Brake® Optimum units using the industry-standard MicroDrainage® modelling software.

**XP**solutions



**Guides to modelling the Hydro-Brake® Optimum using the Hydro-Brake® Optimum Design Tool and MicroDrainage® are available for download at: [www.hydrobrakeoptimum.com](http://www.hydrobrakeoptimum.com)**

# Design Data

## Hydro-Brake® Optimum

### Vortex Flow Control

## Easy to Install

Hydro-Brake® Optimum has a range of mounting options for ease of installation or can be supplied ready fitted into a manhole chamber (with or without a weir wall) for simple plug-and-play installation. There are no set-up or commissioning requirements.



## The Hydro-Brake® Flow Control Series

As a brand leader for vortex flow controls for more than 30 years, Hydro International continues to set the standard in flow control management technologies.

At Hydro International, we pride ourselves on our engineering excellence and in developing a range of flow control solutions, we have invested in significant research & development to validate their performance.

### Hydro-Brake® Orifice



The low-cost option for unconstrained sites (shown with optional screen).

### Hydro-Brake® Optimum



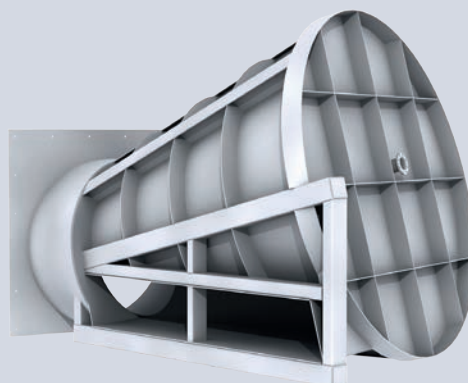
The vortex flow control with no equivalent, delivering Nature's Perfect Cuve with no moving parts and independently verified by the BBA and WRc.

### Hydro-Brake® Agile

Precision engineered flow control for highly constrained applications.



### Hydro-Brake® Flood Alleviation



The vortex controlled solution to watercourse flooding.

## Appendix C Attenuation Tank Product Specification

## Polystorm System - Recommended Installation Details

The information given in the following document has been provided to aid in the preliminary assessment of the Polystorm geocellular units' suitability for a proposed installation; however, a detailed site specific structural assessment should be undertaken before final design or construction activities commence.

It should be noted that this document is uncontrolled and updates will not be issued automatically. Polypipe reserves the right to change product specifications without prior notice.

### 1.0 Polystorm Unit Properties

The characteristic unit parameters detailed in Table 1 may be used for design purposes

#### 1.1 Characteristic Parameters, $X_k$

| Polystorm Unit                                     |          | Lite<br>(PSM2) | Standard<br>(PSM1) | -R<br>(PSM1A) | Xtra<br>(PSM3) | Deep<br>(PSM5) |
|----------------------------------------------------|----------|----------------|--------------------|---------------|----------------|----------------|
| Ultimate Compressive Strength [kN/m <sup>2</sup> ] | Vertical | 200            | 440                | 610           | 834            | 610            |
|                                                    | Lateral  | 40             | 63                 | 63            | 93             | 146            |
|                                                    |          |                |                    |               |                |                |
| Short Term Deflection [kN/m <sup>2</sup> per mm]   | Vertical | 43.0           | 83.0               | 60.0          | 97.8           | 74.8           |
|                                                    | Lateral  | 6.4            | 4.2                | 4.4           | 7.1            | 10.1           |

**Table 1** Characteristic Polystorm unit parameters

#### 1.2 Recommended Material Factor of Safety (FoS)

| Limit State          | Material, $\gamma_m$<br>(Cellular unit) |
|----------------------|-----------------------------------------|
| Ultimate (ULS)       | 2.75                                    |
| Serviceability (SLS) | 1.5                                     |

**Table 2** Recommended material FoS

Material factors of safety quoted in Table 2 have been based on the minimum recommendations within CIRIA C680 (RP782; 2008).

#### 1.3 Design Parameters, $X_d$

$$X_d = X_k / \gamma_m$$

| Polystorm Unit                                     |          | Lite<br>(PSM2) | Standard<br>(PSM1) | -R<br>(PSM1A) | Xtra<br>(PSM3) | Deep<br>(PSM5) |
|----------------------------------------------------|----------|----------------|--------------------|---------------|----------------|----------------|
| Ultimate Compressive Strength [kN/m <sup>2</sup> ] | Vertical | 72.7           | 160                | 221.8         | 303.3          | 221.8          |
|                                                    | Lateral  | 14.5           | 22.9               | 22.9          | 33.8           | 53.0           |
|                                                    |          |                |                    |               |                |                |
| Short Term Deflection [kN/m <sup>2</sup> per mm]   | Vertical | 28.6           | 55.3               | 40.0          | 65.2           | 49.9           |
|                                                    | Lateral  | 4.2            | 2.8                | 2.9           | 4.7            | 6.7            |

**Table 3** Polystorm unit design parameters (based on Table 1 unit strengths and application of Table 2 material FoS)

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## 2.0 CIRIA Report C680 (2008; RP782) Parameters

### 2.1 Vehicle Loads

Table 4 summarises the vehicle loads suggested by Steve Wilson (2008) in CIRIA C680; 'Structural design of modular geocellular drainage tanks'; Table 4.2.

Vehicle load classifications have been based on DIN 1072, where relevant / available.

| Load Case |                                                                                                                          | Load Magnitude by Type      |               |                   | Tyre Footprint [m] |        |
|-----------|--------------------------------------------------------------------------------------------------------------------------|-----------------------------|---------------|-------------------|--------------------|--------|
| Ref       | Description                                                                                                              | UDL<br>[kN/m <sup>2</sup> ] | Point<br>[kN] | Dynamic<br>Factor | Width              | Length |
| NTA       | Small gardens or landscaped areas<br>(No vehicles)                                                                       | 0                           | 0             | 0                 | 0                  | 0      |
| LA        | Landscaped area<br>(Motorised mower)                                                                                     | 5                           | 1.4           | 1.0               | 0.150              | 0.150  |
| CP-R      | Driveway / Car parking<br>(Cars < 3,000 Kg GVW)<br>[DIN 1072 Class 3/3]                                                  | 5                           | 10            | 1.0               | 0.200              | 0.200  |
| CP-U      | Parking; no height restriction<br>(Cars & vans < 6,000 Kg GVW)<br>[DIN 1072 Class 6/6]                                   | 5                           | 20            | 1 – 1.25          | 0.200              | 0.200  |
| CP-LDV    | Parking; no height restriction<br>(Occasional LDV < 9,000 Kg GVW)<br>[DIN 1072 Class 9/9]                                | 5                           | 30            | 1 – 1.5           | 0.200              | 0.260  |
| LAR       | Parking & light access Rd<br>(GVW < 12,000 Kg)<br>[DIN 1072 Class 12/12]                                                 | 10                          | 40            | 1 – 1.5           | 0.200              | 0.300  |
| MEWS      | Rigid vehicle parking, Mews etc<br>(GVW < 16,000 Kg; eg. med rigid fire engine)<br>[DIN 1072 Class 16/16]                | 10                          | 50            | 1 – 1.5           | 0.200              | 0.400  |
| SER       | Rigid HGV parking, access or small<br>estate road<br>(GVW < 30,000 Kg; eg. rigid refuse lorry)<br>[DIN 1072 Class 30/30] | 10                          | 50            | 1 – 1.5           | 0.200              | 0.400  |
| LSR       | Low speed roads (< 15 mph)<br>(Articulated HGV < 60,000 Kg)<br>[DIN 1072 Class 60/30]                                    | 10                          | 100           | 1 – 2.0           | 0.200              | 0.600  |
| HA        | Full HA road loading<br>(GVW < 44,000 Kg)                                                                                | 10                          | 100           | 1.0               | 0.266              | 0.266  |

**Table 4** Recommended vehicle load classifications (CIRIA C680, Table 4.2)

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## 2.2 Partial Factors of Safety, $f_m$

Recommended permanent (dead) & transient (live) load partial FoS can vary according to the check being performed. Tables 7 to 9 are based on standardised load FoS (summarised in Table 5); which have been based on CIRIA C680 (RP782; 2008), Table 4.5.

Hydrostatic pressure has been assumed to act as a permanent load (highest credible water level). It should be noted that where the probable variability of an assumed ground water level is unknown, the associated hydrostatic pressures may be assumed to act as a variable load.

| Limit State          | Vertical Load                        |                                     | Lateral Load                            |                        |                                        |
|----------------------|--------------------------------------|-------------------------------------|-----------------------------------------|------------------------|----------------------------------------|
|                      | Permanent (Dead Load); $\gamma_{Gk}$ | Variable (Live Load); $\gamma_{qk}$ | Permanent (Dead Load); $\gamma_{Hk; G}$ | Hydrostatic $\gamma_u$ | Variable (Live Load); $\gamma_{Hk; q}$ |
| Ultimate (ULS)       | 1.4                                  | 1.6                                 | 1.35                                    |                        | 1.5                                    |
| Serviceability (SLS) | 1.0                                  | 1.0                                 | 1.0                                     |                        | 1.0                                    |

**Table 5** Recommended partial FoS [CIRIA C680 (RP782; 2008), Table 4.5; (lateral loads - Combination 1 in EN 1997-1)]

## 2.3 Typical Angle of Shearing Resistance

Table 6 is an abridged reproduction of the one given in Polypipe's Polystorm BBA certificate (N° 06/4297, Product Sheet 3; table 9); indicating a typical angle of friction which can be expected for a range of soil descriptions.

This information is provided to facilitate preliminary design; the ground conditions of a proposed installation should be confirmed prior to final design or the commencement of construction activities.

| Typical Soil Type<br>(Description)                                     | Soil Weight<br>[kN/m <sup>3</sup> ] | Angle of Friction<br>(Typical Shearing Resistance), $\phi$ |
|------------------------------------------------------------------------|-------------------------------------|------------------------------------------------------------|
| Stiff over consolidated Clay,<br>(e.g. London Clay)                    | 20                                  | 24°                                                        |
| Normally consolidated Silty Sandy Clay<br>(e.g. Alluvium, Made Ground) | 19                                  | 26°                                                        |
| Loose Sand and Gravel                                                  | 18                                  | 30°                                                        |
| Medium dense Sand and Gravel                                           | 19                                  | 34°                                                        |
| Dense Sand and Gravel                                                  | 20                                  | 38°                                                        |
|                                                                        |                                     | 40°                                                        |

**Table 6** Typical angle of friction for given soil description

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### 3.0 Maximum recommended burial depth (to cell invert)

| Angle of friction, $\phi$                                                                                                                                     | Soil Weight [kN/m³] | Vehicle Surcharge Load |       |       |       |       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------------|-------|-------|-------|-------|
|                                                                                                                                                               |                     | NTA                    |       |       |       |       |
| Unit                                                                                                                                                          |                     | PSM2 <sup>3)</sup>     | PSM1  | PSM1A | PSM3  | PSM5  |
| a) No groundwater present                                                                                                                                     |                     |                        |       |       |       |       |
| 24°                                                                                                                                                           | 20                  | 1.477                  | 2.211 | 2.211 | 3.074 | 4.862 |
| 26°                                                                                                                                                           | 19                  | 1.652                  | 2.487 | 2.487 | 3.481 | 5.500 |
| 28°                                                                                                                                                           |                     | 1.770                  | 2.673 | 2.673 | 3.756 | 5.933 |
| 29°                                                                                                                                                           |                     | 1.834                  | 2.774 | 2.774 | 3.904 | 6.165 |
| 30°                                                                                                                                                           | 18                  | 1.995                  | 3.028 | 3.028 | 4.280 | 6.754 |
| 32°                                                                                                                                                           | 19                  | 2.045                  | 3.106 | 3.106 | 4.396 | 6.936 |
| 33°                                                                                                                                                           |                     | 2.123                  | 3.229 | 3.229 | 4.577 | 7.221 |
| 34°                                                                                                                                                           |                     | 2.205                  | 3.359 | 3.359 | 4.768 | 7.521 |
| 36°                                                                                                                                                           | 20                  | 2.275                  | 3.468 | 3.468 | 4.929 | 7.773 |
| 38°                                                                                                                                                           |                     | 2.464                  | 3.766 | 3.766 | 5.370 | 8.465 |
| 40°                                                                                                                                                           |                     | 2.677                  | 4.102 | 4.102 | 5.865 | 9.242 |
| b) Groundwater assumed 1.0m below ground level                                                                                                                |                     |                        |       |       |       |       |
| 24°                                                                                                                                                           | 20                  | 1.364                  | 1.800 | 1.800 | 2.273 | 3.372 |
| 26°                                                                                                                                                           | 19                  | 1.448                  | 1.906 | 1.906 | 2.409 | 3.561 |
| 28°                                                                                                                                                           |                     | 1.495                  | 1.963 | 1.963 | 2.477 | 3.650 |
| 29°                                                                                                                                                           |                     | 1.518                  | 1.990 | 1.990 | 2.511 | 3.694 |
| 30°                                                                                                                                                           | 18                  | 1.576                  | 2.066 | 2.066 | 2.608 | 3.831 |
| 32°                                                                                                                                                           | 19                  | 1.586                  | 2.072 | 2.072 | 2.610 | 3.823 |
| 33°                                                                                                                                                           |                     | 1.608                  | 2.098 | 2.098 | 2.642 | 3.865 |
| 34°                                                                                                                                                           |                     | 1.630                  | 2.124 | 2.124 | 2.673 | 3.906 |
| 36°                                                                                                                                                           | 20                  | 1.643                  | 2.134 | 2.134 | 2.681 | 3.909 |
| 38°                                                                                                                                                           |                     | 1.686                  | 2.186 | 2.186 | 2.744 | 3.992 |
| 40°                                                                                                                                                           |                     | 1.727                  | 2.236 | 2.236 | 2.805 | 4.073 |
| Note                                                                                                                                                          |                     |                        |       |       |       |       |
| 1. Maximum burial depth recommendation has been based on the following expression:<br>$X_d = [K_a (q_k + G_k)] \cdot \gamma_H \cdot G_k + U_k \cdot \gamma_u$ |                     |                        |       |       |       |       |
| 2. Assumed density of water, $\gamma_w = 10.0 \text{ kN/m}^3$ .                                                                                               |                     |                        |       |       |       |       |

**Table 7** Summary of recommended maximum depth to invert [CIRIA C680 (2008) FoS and methodology]

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| Angle of friction, Ø                                                                                                                                              | Soil Weight [kN/m³] | Vehicle Surcharge Load                                                       |       |       |       |       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------------------------------------------------------------------|-------|-------|-------|-------|
|                                                                                                                                                                   |                     | LA<br>CP-R (GVW ≤ 3,000Kg)<br>CP-U (GVW ≤ 6,000Kg)<br>CP-LDV (GVW ≤ 9,000Kg) |       |       |       |       |
| Unit                                                                                                                                                              |                     | PSM2 <sup>3)</sup>                                                           | PSM1  | PSM1A | PSM3  | PSM5  |
| a) No groundwater present                                                                                                                                         |                     |                                                                              |       |       |       |       |
| 24°                                                                                                                                                               | 20                  | 1.227                                                                        | 1.961 | 1.961 | 2.824 | 4.612 |
| 26°                                                                                                                                                               | 19                  | 1.389                                                                        | 2.224 | 2.224 | 3.218 | 5.237 |
| 28°                                                                                                                                                               |                     | 1.507                                                                        | 2.410 | 2.410 | 3.493 | 5.669 |
| 29°                                                                                                                                                               |                     | 1.571                                                                        | 2.510 | 2.510 | 3.641 | 5.902 |
| 30°                                                                                                                                                               | 18                  | 1.717                                                                        | 2.750 | 2.750 | 4.002 | 6.476 |
| 32°                                                                                                                                                               | 19                  | 1.782                                                                        | 2.843 | 2.843 | 4.132 | 6.673 |
| 33°                                                                                                                                                               |                     | 1.860                                                                        | 2.966 | 2.966 | 4.314 | 6.957 |
| 34°                                                                                                                                                               |                     | 1.942                                                                        | 3.096 | 3.096 | 4.505 | 7.258 |
| 36°                                                                                                                                                               | 20                  | 2.025                                                                        | 3.218 | 3.218 | 4.679 | 7.523 |
| 38°                                                                                                                                                               |                     | 2.214                                                                        | 3.516 | 3.516 | 5.120 | 8.215 |
| 40°                                                                                                                                                               |                     | 2.427                                                                        | 3.852 | 3.852 | 5.615 | 8.992 |
| b) Groundwater assumed 1.0m below ground level                                                                                                                    |                     |                                                                              |       |       |       |       |
| 24°                                                                                                                                                               | 20                  | 1.216                                                                        | 1.652 | 1.652 | 2.125 | 3.224 |
| 26°                                                                                                                                                               | 19                  | 1.303                                                                        | 1.762 | 1.762 | 2.265 | 3.416 |
| 28°                                                                                                                                                               |                     | 1.359                                                                        | 1.826 | 1.826 | 2.341 | 3.514 |
| 29°                                                                                                                                                               |                     | 1.386                                                                        | 1.858 | 1.858 | 2.379 | 3.562 |
| 30°                                                                                                                                                               | 18                  | 1.445                                                                        | 1.934 | 1.934 | 2.477 | 3.699 |
| 32°                                                                                                                                                               | 19                  | 1.466                                                                        | 1.951 | 1.951 | 2.489 | 3.703 |
| 33°                                                                                                                                                               |                     | 1.492                                                                        | 1.981 | 1.981 | 2.525 | 3.748 |
| 34°                                                                                                                                                               |                     | 1.518                                                                        | 2.011 | 2.011 | 2.561 | 3.794 |
| 36°                                                                                                                                                               | 20                  | 1.540                                                                        | 2.031 | 2.031 | 2.578 | 3.806 |
| 38°                                                                                                                                                               |                     | 1.589                                                                        | 2.090 | 2.090 | 2.648 | 3.896 |
| 40°                                                                                                                                                               |                     | 1.638                                                                        | 2.147 | 2.147 | 2.716 | 3.983 |
| Note                                                                                                                                                              |                     |                                                                              |       |       |       |       |
| 1. Maximum burial depth recommendation has been based on the following expression:<br>$X_d = [K\alpha (q_k + G_k)] \cdot \gamma_H \cdot G_k + U_k \cdot \gamma_u$ |                     |                                                                              |       |       |       |       |
| 2. Assumed density of water, $\gamma_w = 10.0 \text{ kN/m}^3$                                                                                                     |                     |                                                                              |       |       |       |       |
| 3. Polystorm Lite is not recommended for regularly trafficked areas; depths given for reference only                                                              |                     |                                                                              |       |       |       |       |

**Table 8** Summary of recommended maximum depth to invert [CIRIA C680 (2008) FoS and methodology]

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| Angle of friction, Ø                                                                                                                                          | Soil Weight [kN/m³] | Vehicle Surcharge Load          |                                                                                                  |       |       |       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|---------------------------------|--------------------------------------------------------------------------------------------------|-------|-------|-------|
|                                                                                                                                                               |                     | LAR<br>MEWS<br>SER<br>LSR<br>HA | (GVW ≤ 12,000Kg)<br>(GVW ≤ 16,000Kg)<br>(GVW ≤ 30,000Kg)<br>(GVW ≤ 60,000Kg) &<br>(Full HA load) |       |       |       |
| Unit                                                                                                                                                          |                     | PSM2 <sup>3)</sup>              | PSM1                                                                                             | PSM1A | PSM3  | PSM5  |
| a) No groundwater present                                                                                                                                     |                     |                                 |                                                                                                  |       |       |       |
| 24°                                                                                                                                                           | 20                  | 0.977                           | 1.711                                                                                            | 1.711 | 2.574 | 4.362 |
| 26°                                                                                                                                                           | 19                  | 1.126                           | 1.961                                                                                            | 1.961 | 2.955 | 4.974 |
| 28°                                                                                                                                                           |                     | 1.244                           | 2.147                                                                                            | 2.147 | 3.230 | 5.406 |
| 29°                                                                                                                                                           |                     | 1.308                           | 2.247                                                                                            | 2.247 | 3.378 | 5.639 |
| 30°                                                                                                                                                           | 18                  | 1.440                           | 2.472                                                                                            | 2.472 | 3.724 | 6.198 |
| 32°                                                                                                                                                           | 19                  | 1.519                           | 2.580                                                                                            | 2.580 | 3.869 | 6.410 |
| 33°                                                                                                                                                           |                     | 1.597                           | 2.703                                                                                            | 2.703 | 4.051 | 6.694 |
| 34°                                                                                                                                                           |                     | 1.679                           | 2.832                                                                                            | 2.832 | 4.242 | 6.994 |
| 36°                                                                                                                                                           | 20                  | 1.775                           | 2.968                                                                                            | 2.968 | 4.429 | 7.273 |
| 38°                                                                                                                                                           |                     | 1.964                           | 3.266                                                                                            | 3.266 | 4.870 | 7.965 |
| 40°                                                                                                                                                           |                     | 2.177                           | 3.602                                                                                            | 3.602 | 5.365 | 8.742 |
| b) Groundwater assumed 1.0m below ground level                                                                                                                |                     |                                 |                                                                                                  |       |       |       |
| 24°                                                                                                                                                           | 20                  | 0.977                           | 1.503                                                                                            | 1.503 | 1.977 | 3.076 |
| 26°                                                                                                                                                           | 19                  | 1.126                           | 1.617                                                                                            | 1.617 | 2.120 | 3.272 |
| 28°                                                                                                                                                           |                     | 1.222                           | 1.690                                                                                            | 1.690 | 2.205 | 3.377 |
| 29°                                                                                                                                                           |                     | 1.254                           | 1.726                                                                                            | 1.726 | 2.247 | 3.430 |
| 30°                                                                                                                                                           | 18                  | 1.313                           | 1.802                                                                                            | 1.802 | 2.345 | 3.567 |
| 32°                                                                                                                                                           | 19                  | 1.346                           | 1.831                                                                                            | 1.831 | 2.369 | 3.582 |
| 33°                                                                                                                                                           |                     | 1.375                           | 1.865                                                                                            | 1.865 | 2.409 | 3.632 |
| 34°                                                                                                                                                           |                     | 1.405                           | 1.899                                                                                            | 1.899 | 2.448 | 3.681 |
| 36°                                                                                                                                                           | 20                  | 1.437                           | 1.928                                                                                            | 1.928 | 2.475 | 3.703 |
| 38°                                                                                                                                                           |                     | 1.493                           | 1.994                                                                                            | 1.994 | 2.552 | 3.800 |
| 40°                                                                                                                                                           |                     | 1.549                           | 2.058                                                                                            | 2.058 | 2.626 | 3.894 |
| Note                                                                                                                                                          |                     |                                 |                                                                                                  |       |       |       |
| 1. Maximum burial depth recommendation has been based on the following expression:<br>$X_d = [K_a (q_k + G_k)] \cdot \gamma_H \cdot G_k + U_k \cdot \gamma_u$ |                     |                                 |                                                                                                  |       |       |       |
| 2. Assumed density of water, $\gamma_w = 10.0 \text{ kN/m}^3$                                                                                                 |                     |                                 |                                                                                                  |       |       |       |
| 3. Polystorm Lite is not recommended for regularly trafficked areas; depths given for reference only                                                          |                     |                                 |                                                                                                  |       |       |       |

**Table 9** Summary of recommended maximum depth to invert  
[CIRIA C680 (2008) FoS and methodology]

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#### 4.0 Maximum recommended cover depth, above Polystorm structure

The maximum recommended cover depth detailed in the table 8 below, is based on the load used during the reference creep test only.

It should be noted that the maximum depth to structure invert is typically dictated by the Polystorm unit lateral compressive strength, rather than the vertical creep test load (ultimate limit state check; where the UDL is the dominant vehicle load model).

| Surcharge Load Type |       | No Traffic                           |        |        | Car Park<br>(≤ 9,000 kg; CP-LDV) |        |        | Road<br>(≤ 66,000 kg; LSR) |        |        |
|---------------------|-------|--------------------------------------|--------|--------|----------------------------------|--------|--------|----------------------------|--------|--------|
| Polystorm Unit      |       | Soil Density; γ <sub>s</sub> [kN/m²] |        |        |                                  |        |        |                            |        |        |
| Ref                 | Code  | 20                                   | 19     | 18     | 20                               | 19     | 18     | 20                         | 19     | 18     |
| Lite                | PSM2  | 2.597                                | 2.734  | 2.886  | 2.312                            | 2.433  | 2.569  | 2.026                      | 2.133  | 2.251  |
| Standard            | PSM1  | 5.714                                | 6.015  | 6.349  | 5.429                            | 5.714  | 6.032  | 5.143                      | 5.414  | 5.714  |
| -R                  | PSM1A | 7.922                                | 8.339  | 8.802  | 7.636                            | 8.038  | 8.485  | 7.351                      | 7.738  | 8.167  |
| Xtra                | PSM3  | 10.831                               | 11.401 | 12.035 | 10.545                           | 11.100 | 11.717 | 10.260                     | 10.800 | 11.400 |
| Deep                | PSM5  | 7.922                                | 8.339  | 8.802  | 7.636                            | 8.038  | 8.485  | 7.351                      | 7.738  | 8.167  |

**Table 10** Minimum cover depths recommended for stated vehicle load classification (CIRIA C680 FoS and methodology, assuming 1 in 2 load distribution)

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## 5.0 Minimum recommended cover depth above Polystorm structure

| Polystorm Unit                  | Surcharge Load Type                       | NTA          | LA           | CP-R<br>(≤ 3,000 Kg) | CP-U<br>(≤ 6,000 Kg) |              | CP-LDV<br>(≤ 9,000 Kg) |              | LAR<br>(≤ 12,000 Kg) |              |
|---------------------------------|-------------------------------------------|--------------|--------------|----------------------|----------------------|--------------|------------------------|--------------|----------------------|--------------|
|                                 | Unfactored Load @ GL [kN/m <sup>2</sup> ] | N/A          | 62           | 250                  | 500                  | 625          | 577                    | 865          | 667                  | 1000         |
|                                 | Inc. Dynamic Load Factor                  |              | 1            | 1                    | 1                    | 1.25         | 1                      | 1.5          | 1                    | 1.5          |
|                                 | Assumed load distribution [1 in]          |              | 2            | 2                    | 2                    |              | 2                      |              | 2                    |              |
| <b>Polystorm</b><br>(PSM1)      | ULS                                       | -            | N/A          | 0.120                | 0.258                | 0.314        | 0.335                  | 0.471        | 0.408                | 0.568        |
|                                 | SLS (0.5mm vertical deflection)           | -            | 0.075        | 0.401                | 0.650                | 0.841        | 0.812                  | 1.046        | 0.953                | 1.223        |
|                                 | SLS (1.0mm vertical deflection)           | -            | 0.009        | 0.225                | 0.401                | 0.536        | 0.507                  | 0.672        | 0.602                | 0.793        |
|                                 | <b>Recommended</b>                        | <b>0.500</b> | <b>0.500</b> | <b>0.500</b>         | <b>0.500</b>         | <b>0.540</b> | <b>0.510</b>           | <b>1.050</b> | <b>0.605</b>         | <b>1.225</b> |
| <b>Polystorm-R</b><br>(PSM1A)   | ULS                                       | -            | N/A          | 0.073                | 0.148                | 0.186        | 0.223                  | 0.340        | 0.300                | 0.458        |
|                                 | SLS (0.5mm vertical deflection)           | -            | 0.115        | 0.507                | 0.800                | 1.025        | 0.995                  | 1.270        | 1.165                | 1.483        |
|                                 | SLS (1.0mm vertical deflection)           | -            | 0.037        | 0.300                | 0.507                | 0.666        | 0.637                  | 0.831        | 0.751                | 0.976        |
|                                 | <b>Recommended</b>                        | <b>0.500</b> | <b>0.500</b> | <b>0.500</b>         | <b>0.510</b>         | <b>0.670</b> | <b>0.640</b>           | <b>1.270</b> | <b>0.755</b>         | <b>1.485</b> |
| <b>Polystorm Xtra</b><br>(PSM3) | ULS                                       | -            | N/A          | 0.030                | 0.127                | 0.166        | 0.172                  | 0.264        | 0.217                | 0.323        |
|                                 | SLS (0.5mm vertical deflection)           | -            | 0.057        | 0.354                | 0.583                | 0.759        | 0.730                  | 0.945        | 0.859                | 1.108        |
|                                 | SLS (1.0mm vertical deflection)           | -            | 0.003        | 0.192                | 0.354                | 0.478        | 0.449                  | 0.601        | 0.535                | 0.711        |
|                                 | <b>Recommended</b>                        | <b>0.500</b> | <b>0.500</b> | <b>0.500</b>         | <b>0.500</b>         | <b>0.500</b> | <b>0.500</b>           | <b>0.945</b> | <b>0.535</b>         | <b>1.110</b> |
| <b>Polystorm Deep</b><br>(PSM5) | ULS                                       | -            | N/A          | 0.070                | 0.184                | 0.231        | 0.243                  | 0.354        | 0.300                | 0.428        |
|                                 | SLS (0.5mm vertical deflection)           | -            | 0.087        | 0.433                | 0.696                | 0.897        | 0.867                  | 1.114        | 1.018                | 1.302        |
|                                 | SLS (1.0mm vertical deflection)           | -            | 0.018        | 0.248                | 0.433                | 0.576        | 0.546                  | 0.720        | 0.647                | 0.848        |
|                                 | <b>Recommended</b>                        | <b>0.500</b> | <b>0.500</b> | <b>0.500</b>         | <b>0.500</b>         | <b>0.580</b> | <b>0.550</b>           | <b>1.115</b> | <b>0.650</b>         | <b>1.305</b> |

**Table 11** Minimum cover depths recommended for stated vehicle load classification (CIRIA C680 FoS and methodology, assuming 1 in 2 load distribution)

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| Polystorm Unit                  | Surcharge Load Type                       | MEWs<br>(≤ 16,000 Kg) |              | SER<br>(≤ 30,000 Kg) |              | LSR<br>(≤ 60,000 Kg) |              | HA           |
|---------------------------------|-------------------------------------------|-----------------------|--------------|----------------------|--------------|----------------------|--------------|--------------|
|                                 | Unfactored Load @ GL [kN/m <sup>2</sup> ] | 625                   | 938          | 625                  | 938          | 625                  | 938          | 625          |
|                                 | Inc. Dynamic Load Factor                  | 1                     | 1.5          | 1.0                  | 1.5          | 1                    | 1.5          | 1.0          |
|                                 | Assumed load distribution [1 in]          | 2                     |              | 2                    |              | 2                    |              | 2            |
| <b>Polystorm</b><br>(PSM1)      | ULS                                       | 0.443                 | 0.623        | 0.443                | 0.623        | 0.684                | 1.204        | 0.814        |
|                                 | SLS (0.5mm vertical deflection)           | 1.048                 | 1.349        | 1.048                | 1.349        | 1.512                | 1.937        | 1.635        |
|                                 | SLS (1.0mm vertical deflection)           | 0.656                 | 0.869        | 0.656                | 0.869        | 0.959                | 1.259        | 1.078        |
|                                 | <b>Recommended</b>                        | <b>1.050</b>          | <b>1.350</b> | <b>1.050</b>         | <b>1.350</b> | <b>1.515</b>         | <b>1.940</b> | <b>1.635</b> |
| <b>Polystorm-R</b><br>(PSM1A)   | ULS                                       | 0.321                 | 0.465        | 0.321                | 0.465        | 0.500                | 0.890        | 0.619        |
|                                 | SLS (0.5mm vertical deflection)           | 1.284                 | 1.639        | 1.284                | 1.639        | 1.845                | 2.346        | 1.970        |
|                                 | SLS (1.0mm vertical deflection)           | 0.822                 | 1.073        | 0.822                | 1.073        | 1.194                | 1.547        | 1.315        |
|                                 | <b>Recommended</b>                        | <b>1.285</b>          | <b>1.640</b> | <b>1.285</b>         | <b>1.640</b> | <b>1.845</b>         | <b>2.350</b> | <b>1.970</b> |
| <b>Polystorm Xtra</b><br>(PSM3) | ULS                                       | 0.229                 | 0.347        | 0.229                | 0.347        | 0.366                | 0.680        | 0.477        |
|                                 | SLS (0.5mm vertical deflection)           | 0.942                 | 1.220        | 0.942                | 1.220        | 1.363                | 1.754        | 1.485        |
|                                 | SLS (1.0mm vertical deflection)           | 0.581                 | 0.777        | 0.581                | 0.777        | 0.854                | 1.130        | 0.972        |
|                                 | <b>Recommended</b>                        | <b>0.945</b>          | <b>1.220</b> | <b>0.945</b>         | <b>1.220</b> | <b>1.365</b>         | <b>1.755</b> | <b>1.485</b> |
| <b>Polystorm Deep</b><br>(PSM5) | ULS                                       | 0.321                 | 0.465        | 0.321                | 0.465        | 0.500                | 0.890        | 0.619        |
|                                 | SLS (0.5mm vertical deflection)           | 1.120                 | 1.437        | 1.120                | 1.437        | 1.613                | 2.061        | 1.737        |
|                                 | SLS (1.0mm vertical deflection)           | 0.706                 | 0.930        | 0.706                | 0.930        | 1.030                | 1.346        | 1.150        |
|                                 | <b>Recommended</b>                        | <b>1.120</b>          | <b>1.440</b> | <b>1.120</b>         | <b>1.440</b> | <b>1.615</b>         | <b>2.065</b> | <b>1.740</b> |

**Table 12** Minimum cover depths recommended for stated vehicle load classification (CIRIA C680 FoS and methodology, assuming 1 in 2 load distribution)

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# Appendix A Indicative Maximum Recommended Depth to Unit Invert

| Angle of friction, Ø                                                                                                                                                                                           | Soil Weight [kN/m³] | Vehicle Surcharge Load |       |       |       |       |                                                                              |       |       |       |       |                                                                                                                      |       |       |       |       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------------|-------|-------|-------|-------|------------------------------------------------------------------------------|-------|-------|-------|-------|----------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|
|                                                                                                                                                                                                                |                     | NTA                    |       |       |       |       | LA<br>CP-R (GVW ≤ 3,000Kg)<br>CP-U (GVW ≤ 6,000Kg)<br>CP-LDV (GVW ≤ 9,000Kg) |       |       |       |       | LAR (GVW ≤ 12,000Kg)<br>MEWS (GVW ≤ 16,000Kg)<br>SER (GVW ≤ 30,000Kg)<br>LSR (GVW ≤ 60,000Kg) &<br>HA (Full HA load) |       |       |       |       |
| Unit                                                                                                                                                                                                           |                     | PSM2 <sup>3)</sup>     | PSM1  | PSM1A | PSM3  | PSM5  | PSM2 <sup>3)</sup>                                                           | PSM1  | PSM1A | PSM3  | PSM5  | PSM2 <sup>3)</sup>                                                                                                   | PSM1  | PSM1A | PSM3  | PSM5  |
| a) No groundwater present                                                                                                                                                                                      |                     |                        |       |       |       |       |                                                                              |       |       |       |       |                                                                                                                      |       |       |       |       |
| 24°                                                                                                                                                                                                            | 20                  | 1.477                  | 2.211 | 2.211 | 3.074 | 4.862 | 1.227                                                                        | 1.961 | 1.961 | 2.824 | 4.612 | 0.977                                                                                                                | 1.711 | 1.711 | 2.574 | 4.362 |
| 26°                                                                                                                                                                                                            | 19                  | 1.652                  | 2.487 | 2.487 | 3.481 | 5.500 | 1.389                                                                        | 2.224 | 2.224 | 3.218 | 5.237 | 1.126                                                                                                                | 1.961 | 1.961 | 2.955 | 4.974 |
| 28°                                                                                                                                                                                                            |                     | 1.770                  | 2.673 | 2.673 | 3.756 | 5.933 | 1.507                                                                        | 2.410 | 2.410 | 3.493 | 5.669 | 1.244                                                                                                                | 2.147 | 2.147 | 3.230 | 5.406 |
| 29°                                                                                                                                                                                                            |                     | 1.834                  | 2.774 | 2.774 | 3.904 | 6.165 | 1.571                                                                        | 2.510 | 2.510 | 3.641 | 5.902 | 1.308                                                                                                                | 2.247 | 2.247 | 3.378 | 5.639 |
| 30°                                                                                                                                                                                                            | 18                  | 1.995                  | 3.028 | 3.028 | 4.280 | 6.754 | 1.717                                                                        | 2.750 | 2.750 | 4.002 | 6.476 | 1.440                                                                                                                | 2.472 | 2.472 | 3.724 | 6.198 |
| 32°                                                                                                                                                                                                            | 19                  | 2.045                  | 3.106 | 3.106 | 4.396 | 6.936 | 1.782                                                                        | 2.843 | 2.843 | 4.132 | 6.673 | 1.519                                                                                                                | 2.580 | 2.580 | 3.869 | 6.410 |
| 33°                                                                                                                                                                                                            |                     | 2.123                  | 3.229 | 3.229 | 4.577 | 7.221 | 1.860                                                                        | 2.966 | 2.966 | 4.314 | 6.957 | 1.597                                                                                                                | 2.703 | 2.703 | 4.051 | 6.694 |
| 34°                                                                                                                                                                                                            |                     | 2.205                  | 3.359 | 3.359 | 4.768 | 7.521 | 1.942                                                                        | 3.096 | 3.096 | 4.505 | 7.258 | 1.679                                                                                                                | 2.832 | 2.832 | 4.242 | 6.994 |
| 36°                                                                                                                                                                                                            | 20                  | 2.275                  | 3.468 | 3.468 | 4.929 | 7.773 | 2.025                                                                        | 3.218 | 3.218 | 4.679 | 7.523 | 1.775                                                                                                                | 2.968 | 2.968 | 4.429 | 7.273 |
| 38°                                                                                                                                                                                                            |                     | 2.464                  | 3.766 | 3.766 | 5.370 | 8.465 | 2.214                                                                        | 3.516 | 3.516 | 5.120 | 8.215 | 1.964                                                                                                                | 3.266 | 3.266 | 4.870 | 7.965 |
| 40°                                                                                                                                                                                                            |                     | 2.677                  | 4.102 | 4.102 | 5.865 | 9.242 | 2.427                                                                        | 3.852 | 3.852 | 5.615 | 8.992 | 2.177                                                                                                                | 3.602 | 3.602 | 5.365 | 8.742 |
| b) Groundwater assumed 1.0m below ground level                                                                                                                                                                 |                     |                        |       |       |       |       |                                                                              |       |       |       |       |                                                                                                                      |       |       |       |       |
| 24°                                                                                                                                                                                                            | 20                  | 1.364                  | 1.800 | 1.800 | 2.273 | 3.372 | 1.216                                                                        | 1.652 | 1.652 | 2.125 | 3.224 | 0.977                                                                                                                | 1.503 | 1.503 | 1.977 | 3.076 |
| 26°                                                                                                                                                                                                            | 19                  | 1.448                  | 1.906 | 1.906 | 2.409 | 3.561 | 1.303                                                                        | 1.762 | 1.762 | 2.265 | 3.416 | 1.126                                                                                                                | 1.617 | 1.617 | 2.120 | 3.272 |
| 28°                                                                                                                                                                                                            |                     | 1.495                  | 1.963 | 1.963 | 2.477 | 3.650 | 1.359                                                                        | 1.826 | 1.826 | 2.341 | 3.514 | 1.222                                                                                                                | 1.690 | 1.690 | 2.205 | 3.377 |
| 29°                                                                                                                                                                                                            |                     | 1.518                  | 1.990 | 1.990 | 2.511 | 3.694 | 1.386                                                                        | 1.858 | 1.858 | 2.379 | 3.562 | 1.254                                                                                                                | 1.726 | 1.726 | 2.247 | 3.430 |
| 30°                                                                                                                                                                                                            | 18                  | 1.576                  | 2.066 | 2.066 | 2.608 | 3.831 | 1.445                                                                        | 1.934 | 1.934 | 2.477 | 3.699 | 1.313                                                                                                                | 1.802 | 1.802 | 2.345 | 3.567 |
| 32°                                                                                                                                                                                                            | 19                  | 1.586                  | 2.072 | 2.072 | 2.610 | 3.823 | 1.466                                                                        | 1.951 | 1.951 | 2.489 | 3.703 | 1.346                                                                                                                | 1.831 | 1.831 | 2.369 | 3.582 |
| 33°                                                                                                                                                                                                            |                     | 1.608                  | 2.098 | 2.098 | 2.642 | 3.865 | 1.492                                                                        | 1.981 | 1.981 | 2.525 | 3.748 | 1.375                                                                                                                | 1.865 | 1.865 | 2.409 | 3.632 |
| 34°                                                                                                                                                                                                            |                     | 1.630                  | 2.124 | 2.124 | 2.673 | 3.906 | 1.518                                                                        | 2.011 | 2.011 | 2.561 | 3.794 | 1.405                                                                                                                | 1.899 | 1.899 | 2.448 | 3.681 |
| 36°                                                                                                                                                                                                            | 20                  | 1.643                  | 2.134 | 2.134 | 2.681 | 3.909 | 1.540                                                                        | 2.031 | 2.031 | 2.578 | 3.806 | 1.437                                                                                                                | 1.928 | 1.928 | 2.475 | 3.703 |
| 38°                                                                                                                                                                                                            |                     | 1.686                  | 2.186 | 2.186 | 2.744 | 3.992 | 1.589                                                                        | 2.090 | 2.090 | 2.648 | 3.896 | 1.493                                                                                                                | 1.994 | 1.994 | 2.552 | 3.800 |
| 40°                                                                                                                                                                                                            |                     | 1.727                  | 2.236 | 2.236 | 2.805 | 4.073 | 1.638                                                                        | 2.147 | 2.147 | 2.716 | 3.983 | 1.549                                                                                                                | 2.058 | 2.058 | 2.626 | 3.894 |
| Note                                                                                                                                                                                                           |                     |                        |       |       |       |       |                                                                              |       |       |       |       |                                                                                                                      |       |       |       |       |
| 1. Maximum burial depth recommendation has been based on the following expression: X <sub>d</sub> = [Ka (q <sub>k</sub> + G <sub>k</sub> )]. γ <sub>H</sub> ; G <sub>k</sub> + U <sub>k</sub> . γ <sub>u</sub> |                     |                        |       |       |       |       |                                                                              |       |       |       |       |                                                                                                                      |       |       |       |       |
| 2. Assumed density of water, γ <sub>w</sub> = 10.0 kN/m³.                                                                                                                                                      |                     |                        |       |       |       |       |                                                                              |       |       |       |       |                                                                                                                      |       |       |       |       |
| 3. Polystorm Lite is not recommended for regularly trafficked areas; depths given for reference only                                                                                                           |                     |                        |       |       |       |       |                                                                              |       |       |       |       |                                                                                                                      |       |       |       |       |

**Table 13** Summary of indicative maximum recommended cover depth, for stated vehicle load classification (CIRIA C680 FoS and methodology, assuming 1 in 2 load distribution)

## Appendix B1 Indicative Recommended Maximum Cover Depth Above Unit(s)

| Polystorm Unit                                    |       | Surcharge Load Type |        |        |                                  |        |        |                            |        |        |
|---------------------------------------------------|-------|---------------------|--------|--------|----------------------------------|--------|--------|----------------------------|--------|--------|
|                                                   |       | No Traffic          |        |        | Car Park<br>(≤ 9,000 kg; CP-LDV) |        |        | Road<br>(≤ 66,000 kg; LSR) |        |        |
|                                                   |       |                     |        |        |                                  |        |        |                            |        |        |
| Soil Density; γ <sub>s</sub> [kN/m <sup>2</sup> ] |       |                     |        |        |                                  |        |        |                            |        |        |
| Ref                                               | Code  | 20                  | 19     | 18     | 20                               | 19     | 18     | 20                         | 19     | 18     |
| Polystorm Lite                                    | PSM2  | 2.597               | 2.734  | 2.886  | N/A                              |        |        | N/A                        |        |        |
| Polystorm                                         | PSM1  | 5.714               | 6.015  | 6.349  | 5.429                            | 5.714  | 6.032  | 5.143                      | 5.414  | 5.714  |
| Polystorm -R                                      | PSM1A | 7.922               | 8.339  | 8.802  | 7.636                            | 8.038  | 8.485  | 7.351                      | 7.738  | 8.167  |
| Polystorm Xtra                                    | PSM3  | 10.831              | 11.401 | 12.035 | 10.545                           | 11.100 | 11.717 | 10.260                     | 10.800 | 11.400 |
| Polystorm Deep                                    | PSM5  | 7.922               | 8.339  | 8.802  | 7.636                            | 8.038  | 8.485  | 7.351                      | 7.738  | 8.167  |

**Table 14** Maximum recommended cover depth for stated vehicle load classification (CIRIA C680 FoS and methodology, assuming 1 in 2 load distribution)

## Appendix B2 Indicative Recommended Minimum Cover Depth Above Unit(s)

| Polystorm Unit           | Surcharge Load Type              | NTA   | LA    | CP-R<br>(≤ 3,000 Kg) | CP-U<br>(≤ 6,000 Kg) |       | CP-LDV<br>(≤ 9,000 Kg) |       | LAR<br>(≤ 12,000 Kg) |       | MEWs<br>(≤ 16,000 Kg) |       | SER<br>(≤ 30,000 Kg) |       | LSR<br>(≤ 60,000 Kg) |       | HA    |
|--------------------------|----------------------------------|-------|-------|----------------------|----------------------|-------|------------------------|-------|----------------------|-------|-----------------------|-------|----------------------|-------|----------------------|-------|-------|
|                          | Unfactored Load @ GL [kN/m²]     | N/A   | 62    | 250                  | 500                  | 625   | 577                    | 625   | 938                  | 625   | 625                   | 625   | 938                  | 625   | 865                  | 667   | 625   |
|                          | Inc. Dynamic Load Factor         |       | 1     | 1                    | 1                    | 1.25  | 1                      | 1     | 1.5                  | 1.0   | 1.0                   | 1     | 1.5                  | 1.0   | 1.5                  | 1     | 1.0   |
|                          | Assumed load distribution [1 in] |       | 2     | 2                    | 2                    |       | 2                      |       | 2                    |       | 2                     |       | 2                    |       | 2                    |       | 2     |
| Polystorm<br>(PSM1)      | ULS                              | -     | N/A   | 0.120                | 0.258                | 0.314 | 0.335                  | 0.471 | 0.408                | 0.568 | 0.443                 | 0.623 | 0.443                | 0.623 | 0.684                | 1.204 | 0.814 |
|                          | SLS (0.5mm vertical deflection)  | -     | 0.075 | 0.401                | 0.650                | 0.841 | 0.812                  | 1.046 | 0.953                | 1.223 | 1.048                 | 1.349 | 1.048                | 1.349 | 1.512                | 1.937 | 1.635 |
|                          | SLS (1.0mm vertical deflection)  | -     | 0.009 | 0.225                | 0.401                | 0.536 | 0.507                  | 0.672 | 0.602                | 0.793 | 0.656                 | 0.869 | 0.656                | 0.869 | 0.959                | 1.259 | 1.078 |
|                          | Recommended                      | 0.500 | 0.500 | 0.500                | 0.500                | 0.540 | 0.510                  | 1.050 | 0.605                | 1.225 | 1.050                 | 1.350 | 1.050                | 1.350 | 1.515                | 1.940 | 1.635 |
| Polystorm-R<br>(PSM1A)   | ULS                              | -     | N/A   | 0.073                | 0.148                | 0.186 | 0.223                  | 0.340 | 0.300                | 0.458 | 0.321                 | 0.465 | 0.321                | 0.465 | 0.500                | 0.890 | 0.619 |
|                          | SLS (0.5mm vertical deflection)  | -     | 0.115 | 0.507                | 0.800                | 1.025 | 0.995                  | 1.270 | 1.165                | 1.483 | 1.284                 | 1.639 | 1.284                | 1.639 | 1.845                | 2.346 | 1.970 |
|                          | SLS (1.0mm vertical deflection)  | -     | 0.037 | 0.300                | 0.507                | 0.666 | 0.637                  | 0.831 | 0.751                | 0.976 | 0.822                 | 1.073 | 0.822                | 1.073 | 1.194                | 1.547 | 1.315 |
|                          | Recommended                      | 0.500 | 0.500 | 0.500                | 0.510                | 0.670 | 0.640                  | 1.270 | 0.755                | 1.485 | 1.285                 | 1.640 | 1.285                | 1.640 | 1.845                | 2.350 | 1.970 |
| Polystorm Xtra<br>(PSM3) | ULS                              | -     | N/A   | 0.030                | 0.127                | 0.166 | 0.172                  | 0.264 | 0.217                | 0.323 | 0.229                 | 0.347 | 0.229                | 0.347 | 0.366                | 0.680 | 0.477 |
|                          | SLS (0.5mm vertical deflection)  | -     | 0.057 | 0.354                | 0.583                | 0.759 | 0.730                  | 0.945 | 0.859                | 1.108 | 0.942                 | 1.220 | 0.942                | 1.220 | 1.363                | 1.754 | 1.485 |
|                          | SLS (1.0mm vertical deflection)  | -     | 0.003 | 0.192                | 0.354                | 0.478 | 0.449                  | 0.601 | 0.535                | 0.711 | 0.581                 | 0.777 | 0.581                | 0.777 | 0.854                | 1.130 | 0.972 |
|                          | Recommended                      | 0.500 | 0.500 | 0.500                | 0.500                | 0.500 | 0.500                  | 0.945 | 0.535                | 1.110 | 0.945                 | 1.220 | 0.945                | 1.220 | 1.365                | 1.755 | 1.485 |
| Polystorm Deep<br>(PSM5) | ULS                              | -     | N/A   | 0.070                | 0.184                | 0.231 | 0.243                  | 0.354 | 0.300                | 0.428 | 0.321                 | 0.465 | 0.321                | 0.465 | 0.500                | 0.890 | 0.619 |
|                          | SLS (0.5mm vertical deflection)  | -     | 0.087 | 0.433                | 0.696                | 0.897 | 0.867                  | 1.114 | 1.018                | 1.302 | 1.120                 | 1.437 | 1.120                | 1.437 | 1.613                | 2.061 | 1.737 |
|                          | SLS (1.0mm vertical deflection)  | -     | 0.018 | 0.248                | 0.433                | 0.576 | 0.546                  | 0.720 | 0.647                | 0.848 | 0.706                 | 0.930 | 0.706                | 0.930 | 1.030                | 1.346 | 1.150 |
|                          | Recommended                      | 0.500 | 0.500 | 0.500                | 0.500                | 0.580 | 0.550                  | 1.115 | 0.650                | 1.305 | 1.120                 | 1.440 | 1.120                | 1.440 | 1.615                | 2.065 | 1.740 |

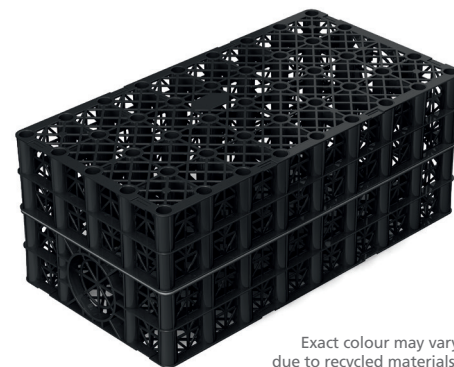
**Table 15** Minimum recommended cover depth for stated vehicle load classification (CIRIA C680 FoS and methodology, assuming 1 in 2 load distribution)

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Product code: PSM1A

The Polystorm-R modular cell is ideally suited for loaded applications at greater depths, such as housing, commercial and infrastructure projects and has a compressive strength of up to 61 tonnes/m<sup>2</sup>. It offers all the proven performance of the Polystorm cell, with the added benefits of being manufactured from over 90% recycled material content.

Wherever performance criteria and standards allow, we will always maximise the sustainability of our products by using post consumer plastics in their manufacture. By sourcing and carefully controlling the quality of the recycled material we use our precision injection moulding. Therefore we are able to guarantee consistent quality in our recycled plastic, giving you the confidence and the performance levels you expect from the market leader.



Exact colour may vary due to recycled materials.

## Applications

The Polystorm-R modular cells are combined to form a structure that receives rainwater collected from roofs of surface drains. The rainwater is then either attenuated by the structure, when wrapped in an impermeable membrane, or infiltrated by the structure, when wrapped in a permeable geotextile.

## Key Benefits

- Made from specially selected and controlled recycled materials
- Environmentally friendly, sustainable solution
- Has undergone stringent testing to ensure product performance
- Compressive strength of 61 tonnes/m<sup>2</sup>
- Ideal for retention, attenuation and infiltration applications with a suitable geomembrane or geotextile
- Designed for trafficked and loaded applications
- BBA approved
- Visual and maintenance access can be achieved when used in conjunction with Polystorm Access & Inspect
- Allow flexibility of shape – ideal for shallow excavation systems, narrow strips or use in restricted areas
- Can be used as part of a value engineered hybrid system with Polystorm, Polystorm Lite and Polystorm Xtra
- Integrated inlet and outlet
- 3D flow throughout the structure
- 95% void ratio
- Light in weight yet robust – excellent Health & Safety and installation benefits
- 100% recyclable
- 60 years creep limited life expectancy

### ELEMENT

### VALUE

#### PHYSICAL PROPERTIES

|                     |                                 |
|---------------------|---------------------------------|
| Length              | 1m                              |
| Width               | 0.5m                            |
| Depth               | 0.4m                            |
| Total volume        | 0.2m <sup>3</sup>               |
| Unit weight         | 9kg                             |
| Unit storage volume | 0.19m <sup>3</sup> (190 litres) |
| Void ratio          | 95%                             |

#### SHORT TERM COMPRESSIVE STRENGTH

|          |                                 |
|----------|---------------------------------|
| Vertical | Maximum 610 kN/m <sup>2</sup> * |
| Lateral  | Maximum 63 kN/m <sup>2</sup> *  |

#### SHORT TERM DEFLECTION

|          |                              |
|----------|------------------------------|
| Vertical | 60 kN/m <sup>2</sup> per mm  |
| Lateral  | 4.4 kN/m <sup>2</sup> per mm |

Note: Polystorm-R is ideal for use in trafficked and pedestrian applications subject to a structural design check and suitable installation conditions

Each unit includes 4 Clips and 2 Shear Connectors.

\* Compressive strength at yield, maximum recommended value for design purposes.



### RECOMMENDED MAXIMUM DEPTH OF INSTALLATION (to cell invert) [m]

| TYPICAL SOIL TYPE                                                    | TYPICAL ANGLE OF SHEAR RESISTANCE | SOIL WEIGHT kN/m <sup>3</sup> | WITHOUT GROUNDWATER<br>(below base of cells)<br>NORMAL CASE |                                  | WITH GROUNDWATER AT 1M<br>BELOW GROUND LEVEL AND UNITS<br>WRAPPED IN GEOMEMBRANE |                                  |
|----------------------------------------------------------------------|-----------------------------------|-------------------------------|-------------------------------------------------------------|----------------------------------|----------------------------------------------------------------------------------|----------------------------------|
|                                                                      |                                   |                               | Pedestrian                                                  | Trafficked (cars)<br><3000kg GVW | Pedestrian                                                                       | Trafficked (cars)<br><3000kg GVW |
| Stiff over consolidated clay<br>e.g. London clay                     | 24                                | 20.0                          | 2.2                                                         | 1.9                              | 1.8                                                                              | 1.6                              |
| Normally consolidated silty sandy<br>clay e.g. alluvium, made ground | 26                                | 19.0                          | 2.4                                                         | 2.2                              | 1.9                                                                              | 1.7                              |
| Loose sand and gravel                                                | 30                                | 18.0                          | 3.0                                                         | 2.7                              | 2.0                                                                              | 1.9                              |
| Medium dense sand and gravel                                         | 33                                | 19.0                          | 3.2                                                         | 2.9                              | 2.0                                                                              | 1.9                              |
| Dense sand and gravel                                                | 38                                | 20.0                          | 3.7                                                         | 3.5                              | 2.1                                                                              | 2.0                              |

Note:

1) Stated depths based on the calculation methodology detailed within CIRIA C680 (2008)

2) Assuming water density = 10.0kN/m<sup>3</sup>

3) Assumed ultimate limit state (ULS) partial factor of safety applied to: Material = 2.75 Lateral pressure = 1.35

### Durability

Wherever allowable we maximise the sustainability of our product by using post-consumer plastics in their manufacture. By carefully sourcing and controlling the quality of the recycled material we are able to guarantee the consistency of our recycled products. The polymer material used in the manufacture of the Polystorm-R unit has an adequate resistance to attack from the type and quantities of chemicals that may be expected to naturally occur in uncontaminated soils and rainwater run-off. When installed in accordance with our recommendations, it is expected that the Polystorm-R unit will have a design life in excess of 60 years\*. The installer of a proposed geocellular structure should ensure that an appropriate design check has been undertaken, in accordance with the recommended methodology and factors of safety given in CIRIA C680 (2008), Structural Design of Modular Geocellular Drainage Tanks, prior to the commencement of construction activities.

\* Derived from long term extrapolated creep testing

### Notes

1. Unless stated, all values are nominal and may vary within normal production tolerances.
2. The characteristic unit parameters stated have been based on Polypipe BBA certificate N° 06/4297, sheet 3.
3. Polypipe reserve the right to change product specifications without prior notice.
4. This document is uncontrolled and updates will not be issued automatically.

### RECOMMENDED MINIMUM COVER LEVELS [m]

| LIVE LOAD CONDITIONS             | PEDESTRIAN | LIGHT TRAFFICKED                |                 |
|----------------------------------|------------|---------------------------------|-----------------|
|                                  |            | Car park with vehicle mass <GVW |                 |
| Minimum cover depth required (m) | 0.50       | <3000kg<br>0.50                 | <9000kg<br>0.65 |

Note

1) Stated depths based on the calculation methodology detailed within CIRIA C680 (2008)

2) Assumed serviceability limit state (SLS) partial factor of safety applied to: Material = 1.5 Live load = 1.0 Dead load = 1.0

3) Shallower minimum burial depths may be applicable subject to an assessment of the specific site conditions. For further details please consult our Technical Team on 01509 615100.

### Technical Support

Detailed guidance and assistance is available.

For further information, please contact our Technical Team

on **+44 (0) 1509 615100** or email [civils@polypipe.com](mailto:civils@polypipe.com)

or visit [www.polypipe.com/civils-technical-hub](http://www.polypipe.com/civils-technical-hub)

### Polystorm-R Modular Cell can be utilised in these SuDS techniques

| TECHNIQUES       |              |       |                |             |                                         |                                |                              |              |        |               |                  |                  |               |
|------------------|--------------|-------|----------------|-------------|-----------------------------------------|--------------------------------|------------------------------|--------------|--------|---------------|------------------|------------------|---------------|
| Blue-Green roofs | Podium Decks | Trees | Sports Pitches | Cycle Paths | Permeable Paving<br>(sub base & podium) | Bioretention &<br>Rain Gardens | Attenuation<br>Storage Tanks | Infiltration | Swales | Filter Drains | Detention Basins | Ponds & Wetlands | Filter Strips |
|                  |              |       | ✓              |             |                                         | ✓                              | ✓                            | ✓            | ✓      | ✓             | ✓                | ✓                |               |

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