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Drainage Strategy & Design

Crow Trees Farm
Chatburn

Pringle Homes Ltd

Ref: K39346.DS/003

Version	Date	Prepared By	Checked By	Approved By
Original	22 March 2024	[redacted]	[redacted]	[redacted]

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GLOSSARY OF TERMS

AEP	Annual Exceedance Probability
AOD	Above Ordnance Datum
BGL	Below Ground Level
BGS	British Geological Society
CC	Climate Change
LCC	Lancashire County Council
DSM	Digital Surface Model
DTM	Digital Terrain Model
EA	Environment Agency
FEH	Flood Estimation Handbook
FFL	Finished Floor Level
FRA	Flood Risk Assessment
GIS	Geographical Information System
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
NPPF	National Planning Policy Framework
OS	Ordnance Survey
RGP	RG Parkins & Partners Ltd
SFRA	Strategic Flood Risk Assessment
SuDS	Sustainable Drainage System
UU	United Utilities

1. INTRODUCTION

1.1 BACKGROUND

This report has been prepared by R. G. Parkins & Partners Ltd (RGP) for Pringle Homes Ltd in support of their proposals for a new residential development at Crow Trees Farm in Chatburn. The proposals include 39 no. residential dwellings, with associated access roads, driveways, landscaped and garden areas plus the conversion of the existing farmhouse and outbuildings. A full planning application has been approved at Planning Committee subject to the Section 106 Agreement (ref: Ribble Valley Borough Council, 3/2022/0966). Plots 1 – 37 will be affordable housing, owned and maintained by a Housing Association, MSV Housing. The redevelopment of the farmhouse and conversion of the barn will provide the additional 2no. private dwellings.

RGP has been appointed to undertake the detailed foul and surface water drainage strategy and design in accordance with the National Planning Policy Framework (NPPF) [1][2] to discharge pre-commencement conditions from the current planning application and fulfil the requirements of the Local Planning Authority, Lead Local Flood Authority and the Sewerage Undertaker.

The following report demonstrates that the proposed development will not adversely affect flood risk elsewhere.

1.2 PLANNING POLICY

The NPPF [1] and its Planning Practice Guidance[2] states "a site-specific flood risk assessment should be provided for all development in Flood Zones 2 and 3. In Flood Zone 1, an assessment should accompany all proposals involving: sites of 1 hectare or more; land which has been identified by the Environment Agency as having critical drainage problems; land identified in a strategic flood risk assessment as being at increased flood risk in the future; or land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use." Flood Risk Assessments are also required for all major developments in Flood Zone 1 in accordance with the Town and Country Planning Order 2015[3].

A separate Flood Risk Assessment and Outline Drainage Strategy has previously been prepared by Reford Consulting Engineers (dated September 2022)[4] and confirmed the site is in Flood Zone 1 and at very low risk of flooding from any other sources. As such, the following report will focus specifically on the proposed detailed drainage strategy and design requirements.

1.3 LLFA CONSULTATION RESPONSE

Lancashire County Council (LCC) Lead Local Flood Authority (LLFA) have formally responded to the Planning Application on 29/11/22 and 20/06/23. The proposed surface water drainage strategy and design is therefore based on the requirements of the LLFA taking into account the site constraints and outline drainage strategy proposed by Reford.

2. SITE CHARACTERISATION

2.1 SITE LOCATION

The proposed site is located to the south of Chatburn at National Grid Reference 376789E 443933N. The site location is shown in Figure 2.1.

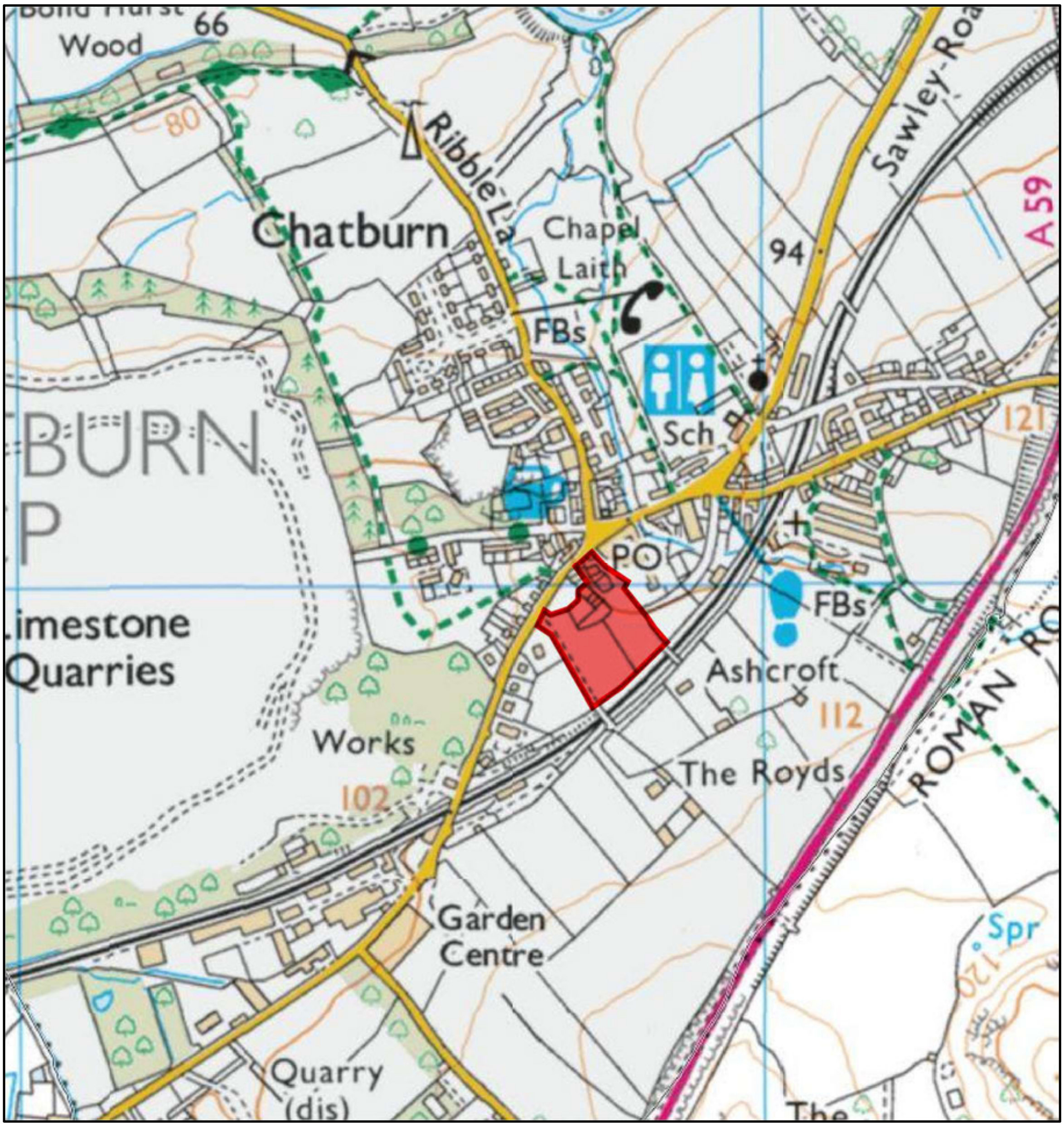

Figure 2.1 Site Location

2.2 SITE DESCRIPTION

The site covers a total area of 1.67 ha comprising 2no. fields and associated farm buildings and barns. The site is accessed via 2no. existing private access roads off Crow Trees Brow that runs along the northern boundary. A railway line and cutting run along the southern boundary. The site topography falls from the north-western corner with a max. level of c. 106mAOD to the northeastern corner, with a min. level of c. 98.2mAOD. A hedgerow separates the 2no. fields with several mature trees located within the site and along the boundaries.

2.3 GEOLOGY & HYDROGEOLOGY

A detailed Site Investigation & Ground Assessment Report has been prepared by BEK Geo-Environmental Consulting (ref: BEK-23-127-1 (Rev A), dated October 2023) [5], and confirmed that the recorded bedrock geology underlying the site is the "Chatburn Limestone Formation". There are no records of made ground or superficial deposits on-site. BEK confirmed that the site is unlikely to be affected by natural ground instability.

The bedrock strata is classified as a Secondary A aquifer and there is one groundwater abstraction located within 250m of the site.

Table 2.1 Site Geological Summary

Geological Unit	Classification	Description	Aquifer Classification
Drift	N/A	N/A	N/A
Solid	Chatburn Limestone Formation	Primarily Limestone	**Character:** Secondary A

2.4 HYDROLOGY

The nearest waterbody is Heys Brook which is located c. 80m north-east of the site. Heys Brook is designated as Main River by the Environmental Agency.

2.5 EXISTING SEWERS

The United Utilities sewer records indicate there is an existing 150mm dia. public combined sewer running down Crow Trees Brow in a north-east direction, passing close to the existing access to the farm. There is an existing UU manhole located part-way up Crow Trees Brow, which has been inspected and the depth to invert level confirmed as 1.69m below cover level. A second manhole is located downstream, near the farm access road, but is not shown on the UU records. This was lifted and was entirely full of silt. Further investigation was undertaken by UU, but they could not confirm whether this was part of the sewer network or not. As the upstream manhole was running freely, it was concluded that this downstream manhole was not part of the sewer network.

There is also a 180mm dia. UU rising main running back up Crow Trees Brow in a south-west direction that passes close to the existing private access road that runs down the western boundary.

For the existing farmhouse, farm access road, outbuilding and barns it has been confirmed via a drainage investigation that both surface water and foul water discharge into existing private combined drainage systems. These private systems run towards Crow Trees Brow and discharge into the existing public combined sewer. The existing drainage system within the farm access road has not been maintained and will be replaced as part of the redevelopment works. Foul and surface water associated with the existing farmhouse discharges into a manhole chamber in the northern corner of the site with a separate connection into the UU combined sewer. It is proposed that this existing connection will be re-used as part of the future redevelopment of the farmhouse.

2.6 GROUND CONDITIONS

A comprehensive ground investigation was undertaken on the site by BEK in October 2023 and their assessments and recommendations are detailed in their report [5]. At the request of RGP and Pringle Homes, BEK were instructed to return to site in November 2023 and undertake additional BRE 365 infiltration tests. Their results and assessment presented in their letter (ref: BEK/23127/231127/PRL, dated 27 November 2023) [6] which has confirmed that infiltration-based drainage is not considered viable at the site, due to the relatively impermeable superficial deposits.

A Ground Gas Risk Assessment Report (ref: BEK-23127-24-0124-PH, dated 24 January 2024) [7] has subsequently been prepared following the conclusion of BEK's programme of gas and groundwater monitoring.

In summary, the intrusive ground investigations have confirmed that the ground conditions typically comprise the following:

- Made Ground in 3no. locations to a max. depth of 0.5m.
- Black/brown silty clayey SAND (topsoil) varying in thickness from 0.2 – 0.4m in all locations.
- Superficial deposits of either brown silty clayey SAND or sandy gravelly CLAY in most locations.
- Organic peat in one location.
- Suspected bedrock encountered in most locations at depths ranging from 0.6 – 2.3m, comprising limestone, shale and sandstone.

Groundwater was not encountered during the site investigation. Subsequent monitoring has indicated groundwater at depths of 1.46 – 1.73m in two monitoring wells.

3. SURFACE WATER DRAINAGE STRATEGY & DESIGN

3.1 INTRODUCTION

The principal aim of the drainage strategy is to design the development to avoid, reduce and delay the discharge of rainfall to public sewers and watercourses in order to protect watercourses and reduce the risk of localised flooding, pollution and other environmental damage.

In order to satisfy these criteria this surface water runoff assessment and drainage design has been undertaken in accordance with the following reports and guidance documents:

- SuDS Manual, CIRIA Report C753, 2015 [8]
- Code of Practice for Surface Water Management, BS8582:2013, November 2013[9]
- Rainfall Runoff Management for Developments, Defra/EA, SC030219, October 2013[10]
- Designing for Exceedance in Urban Drainage – Good Practice, CIRIA Report C635, 2006[11]
- Flood Estimation Handbook (FEH)[12]
- Flood Studies Report (FSR), Volume 1, Hydrological Studies, 1993[13]
- Flood Studies Supplementary Report No 14 (FSSR14), Review of Regional Growth Curves, 1983[14]
- Flood Estimation for Small Catchments, Marshall & Bayliss, Institute of Hydrology, Report No. 124 (IoH 124), 1994[15]
- Non-statutory Technical Standards for Sustainable Drainage Systems (2015), DEFRA[16]
- Lancashire Sustainable Drainage Systems (SuDS) Pro-forma, Guidance for completing your proforma, Lancashire County Council, V6, November 2022[17]

The following drainage strategy is based on the latest site layout plan by Pringle Homes showing 37no. new affordable dwellings, farmhouse redevelopment, barn conversion and associated infrastructure and landscaping.

3.2 PREVIOUS APPROVED SURFACE WATER DRAINAGE STRATEGY

A Flood Risk Assessment and Drainage Strategy [4] was prepared by Reford Consulting Engineers Ltd on behalf of Pringle Homes in support of their Planning Application and has been approved by the LLFA, subject to pre-commencement Planning Conditions. The approved drainage strategy is based on a similar site layout plan and is summarised below:

a) Reford proposes that attenuated surface water drainage will discharge into the existing 150mm dia. public combined sewer located in Crow Trees Brow. Reford have calculated a pre-development Greenfield run-off rate, Q_{bar} of 10.6 lit/sec.

b) The proposed attenuation storage by Reford comprises 5no. below ground storage/attenuation areas (geocellular), which are 1.2m depth, equating to a total storage volume of c. 350m^3. The attenuation tanks were all to be located below the new access road and car parking areas to the front of Plots 25 – 37.

c) The Reford design uses default run-off coefficients of 0.75 (summer) and 0.84 (winter) in their hydraulic modelling.

d) Reford have applied a +10% urban creep in their catchment analysis and the total catchment area applied to their design is 0.623Ha (6,230m^2).

e) Reford have not included for any potential run-off from permeable areas (e.g. grass verges, POS, front/rear gardens) that may contribute to the drainage network in extreme storm events.

f) Surface water run-off from the proposed barn conversion is not included within the surface water storage calculations provided by Reford. The catchment areas associated with this new dwelling is located downstream of the proposed attenuation tanks and flow control chamber and would not be attenuated prior to discharge into the UU combined sewer.

g) The hydraulic design has been undertaken for the Q1, Q30, Q100 & Q100+50% CC critical storm events using the FSR rainfall methodology and demonstrated that no flooding would take place.

h) Treatment design has not been included within Reford's proposals, presumably since attenuated surface water will discharge into the UU combined sewer, rather than a surface water sewer or watercourse.

i) An outline foul water drainage design or plan has not been provided by Reford but assumes that a gravity connection into the existing UU combined sewer in Crow Trees Brow is feasible.

j) A detailed highways levels design has not been provided and Reford's proposed cover levels and invert levels for the surface water drainage manholes has been estimated from indicative finished floor levels provided by LMP Architects.

3.3 SURFACE WATER DISPOSAL

Surface water disposal has been considered in line with the hierarchy outlined in the SuDS Manual[8] and the Non-statutory Technical Standards for SuDS[16]. The approach considers infiltration drainage in preference to disposal to watercourse, in preference to discharge to sewer.

3.3.1 DISCHARGE TO GROUND

As discussed in Section 2.6, the in-situ ground investigation and permeability testing confirms that the underlying clay drift deposits are of low permeability. Relatively shallow groundwater has also been recorded across the site. As such, it is concluded that infiltration-based SuDS will not be a suitable method for the disposal of surface water.

3.3.2 DISCHARGE TO WATERCOURSE

As stated in the approved Drainage Strategy by Reford, the nearest watercourse is Heys Brook that passes through Chatburn approx. 100m to the east of the site. It was not deemed viable for surface water to discharge into this watercourse due to the works that would be required to install a new sewer down Crow Trees Brow and form a new discharge point into the watercourse.

3.3.3 DISCHARGE TO SURFACE WATER SEWER OR HIGHWAYS DRAIN

With reference to the UU public sewer records there are no existing surface water sewers in Chatburn. Likewise, there does not appear to be a separate highways drainage system and all nearby road gullies discharge into the UU combined sewer.

3.3.4 DISCHARGE TO COMBINED SEWER

As stated in the approved Drainage Strategy by Reford surface water will be restricted to the predevelopment Greenfield runoff rate (Q_{bar}) of 10.6 lit/sec via on-site attenuation and discharged into the UU public combined sewer located in Crow Trees Brow via the construction of a new manhole in the road.

The manhole immediately upstream of the proposed point of connection has been inspected on-site and has been confirmed to be free-flowing without any evidence of blockage or surcharge. The depth to invert level was measured as 1.69m. The sewer follows the steep road gradient of Crow Trees Brow to the north-east, crossing below Heys Brook and then running north.

The depth of the combined sewer at the proposed point of connection for the development will be at a significantly higher elevation than the downstream sewer and therefore would be at a very low risk of surcharge. As such, the point of connection onto the existing combined sewer is assumed to be free-flowing.

Further to this RGP have contacted the UU Wastewater Developer Services and have confirmed that the drainage principles established by Reford are acceptable to UU. As such, both foul and surface water drainage are permitted by UU to discharge to the existing combined sewer, with a max. pass forward flow of 10.6 lit/sec for surface water runoff associated with the new dwellings.

3.4 ASSESSMENT OF SITE AREAS

To support the exploration of options for site drainage, the spatial extent of different types of proposed land cover on the site have been measured. The total existing site area is 16,688m^2 (1.67ha).

A summary of the existing land uses within the development site is included in Table 3.1 below.

Table 3.1 Land Cover Areas for Existing Site

Land Cover	Area		Percentage of total site area
	m²	Ha	
Existing roof areas (e.g. house, barns & outbuildings)	438	0.044	2.6%
Farm access road	538	0.054	3.2%
Paved paths, walls & other hardstanding	350	0.035	2.1%
Private access road	410	0.041	2.5%
Gardens to farmhouse	3,765	0.377	22.6%
Undeveloped land and fields	11,187	1.119	67.0%

Table 3.2 below show the measured proposed development land cover areas for Plots 1 - 37. Note that an additional 10% urban creep is added onto the housing roof areas to allow for any future extensions (as discussed in Section 3.6.2).

Table 3.3 shows the measured site areas proposed for the renovation of the farmhouse and barn, plus associated new structures and access roads.

Table 3.2 Land Cover Areas for Proposed Development (Plots 1 – 37)

Land Cover	Area		Percentage of total site area
	m²	Ha	
Housing roofs	1,900	0.190	11.4%
10% urban creep on housing roofs	190	0.019	1.1%
Access road & footway	1,936	0.194	11.6%
Shared driveways & car parking	799	0.080	4.8%
Footpaths & patios	559	0.056	3.3%
Private drives	1,031	0.103	6.2%
Gardens, landscaping & POS	6,748	0.675	40.4%

Table 3.3 Land Cover Areas for Redeveloped Farmhouse & Proposed Barn Conversion

Land Cover	Area		Percentage of total site area
	m²	Ha	
Redeveloped farmhouse, outbuildings & garage roof areas	235	0.024	1.4%
Existing farm access road	538	0.054	3.2%
Existing paths, walls & other hardstanding	350	0.035	2.1%
Existing barn roof area for conversion	121	0.021	0.7%
New extension, outbuilding & garage to barn conversion	160	0.016	1.0%
New driveway to barn conversion	165	0.017	1.0%
New patio & paths to barn conversion	45	0.004	0.3%
Remaining gardens, landscaping & POS	1,911	0.191	11.5%

To develop the detailed drainage design, only certain surfaces and areas will be positively drained into the surface water drainage network and below ground attenuation storage tanks. Positively drained areas include roof areas, car parking, access roads, patios, footways and footpaths. All other areas (principally gardens, landscaping, POS) will have a permeable surface and will have no positive drainage. Table 3.4 summarises the balance of positively drained and undrained areas for Plots 1 – 37, and Table 3.5 provides a summary of the areas for the farmhouse & barn conversion.

Table 3.4 Summary of drained & undrained areas for surface water drainage system (Plots 1 - 37)

Land Cover	Area		Percentage of total site area
	m²	Ha	
Total Positively Drained Area	6,415	0.642	38.5%
Remaining Undrained Area	6,748	0.675	40.4%

Table 3.5 Summary of drained & undrained areas for farmhouse & barn conversion

Land Cover	Area		Percentage of total site area
	m²	Ha	
Existing Positively Drained Area	1,244	0.160	7.5%
Additional Positively Drained Area from barn conversion	370	0.037	2.2%
Remaining Undrained Area	1,922	0.192	11.5%

For Plots 1 – 37 it is proposed that runoff from all positively drained areas will be included within the catchment analysis for the new surface water drainage system (i.e. 6,415m^2) and will drain via a single large geocellular attenuation tank.

For the farmhouse and barn conversion, there will be an additional positively drained area compared to the existing condition. It is therefore proposed that new impermeable area associated with the barn conversion (i.e. 370m^2) will be positively drained into the new surface water drainage system via a separate geocellular attenuation tank.

A surface water drainage catchment plan is included in Appendix A for reference.

3.5 CONTRIBUTION OF RUNOFF FROM PERMEABLE AREAS

As per the requirements of the LLFA and as stated within their consultation response dated 29/11/22 the contribution of runoff from permeable areas (i.e. gardens, landscaping and POS) has been considered as part of the drainage design for the development. A detailed assessment of external levels has been undertaken by RGP confirming road and driveway gradients and finished floor levels for new dwellings. Gradients for gardens and landscaped areas has also been assessed. Details of the proposed levels and gradients are shown on RGP drawing K39346-01 included in Appendix A.

The majority of new rear gardens will fall towards the site boundaries where runoff would be intercepted by existing hedgerows and large mature trees (e.g. Plots 19 – 37). Likewise, in most cases landscaping to the front of dwellings either slopes towards the dwelling or towards areas of new tree and shrub planting. As such, interception and evapotranspiration will mitigate any significant runoff from permeable areas running directly onto the new access road and into the drainage system via gullies.

Elsewhere, the rear gardens of Plots 5 – 11 slope towards the rear gardens of Plots 13 – 18, with a new 1 – 1.4m high retaining wall located on the garden boundary line. The retaining wall will be finished with a raised parapet and timber fence to intercept any runoff and prevent it from cascading onto the gardens below.

In some areas, due to the existing topography, new private shared driveways are being raised above existing ground levels (e.g. driveway to Plots 15 – 18 and 25 – 26) with ground being battered down to tie back to existing levels. In these locations, runoff would be directed to the POS areas where large mature trees and hedgerows are being retained. In extreme wet weather, these areas will offer temporary interception storage of runoff from permeable areas, ensuring that runoff does not enter the new drainage system or downstream combined sewer.

Taking all these measures into consideration it is concluded that a significant proportion of permeable area will not contribute to the drainage network and as such should not be included within the catchment analysis. However, in recognition of the LLFA's request, the proposed drainage system will be designed with an enhanced factor of safety to store an additional 10% of runoff associated with permeable areas. As such, the total drained area associated with Plots 1 – 37 has been increased to 7,100m^2. A Surface Water Drainage Catchment Plan (ref: K39346-24) is included in Appendix A for reference.

3.6 SURFACE WATER DRAINAGE DESIGN PARAMETERS

The surface water drainage system has been designed on the following basis using the modified rational method and a generated rainfall profile.

3.6.1 CLIMATE CHANGE

Projections of future climate change indicate that more frequent short-duration, high intensity rainfall and more frequent periods of long-duration rainfall are likely to occur over the next few decades in the UK. These future changes will have implications for river flooding and for local flash flooding. These factors will lead to increased and new risks of flooding within the lifetime of planned developments.

The EA have provided a peak rainfall online map showing the anticipated changes in peak rainfall intensity across the UK. Climate change allowances are now provided on a catchment basis. The site falls within the Ribble Management Catchment. Table 3.6 outlines the EA guidance for this catchment, for the anticipated design life of the proposed development.

In line with current guidance and for conservative design, a 50% allowance shall be used within this assessment.

Table 3.6 Ribble Management Catchment Peak Rainfall Allowances (1.0% AEP)

Ribble (1.0% AEP)	Central Allowance (%)	Upper End Allowance (%)
2050s	25	40
2070s	35	**50**

3.6.2 URBAN CREEP

BS 8582:2013[9] outlines best practice with regard to Urban Creep. Although not a statutory requirement, future increase in impermeable area due to extensions and introduction of impervious positively drained areas has been considered. Typically, an uplift of 10% on impermeable areas associated with dwellings is considered appropriate. However, the LCC SuDS Guidance document[17] states that 10% urban creep should be added to the total impermeable site area. However, applying 10% urban creep to the main access road and footways is considered excessive since it is highly unlikely that these areas would change post-construction due to the limited space available for expansion.

Furthermore, the development proposals provide for a min. of 2no. car parking spaces for each dwelling and as such adequate car parking provision is made. Any future desire by residents to change landscaped gardens to additional car parking will require Planning Permission and approval from the Housing Association, MSV Housing, and is therefore considered unlikely to occur.

It is therefore proposed that the 10% urban creep allowance is only applied to the dwelling roof areas as stated in Table 3.2 and the catchment plan included in Appendix A. This equates to a total additional impermeable area of 190m^2 included with the drainage model. When taken into consideration alongside all the other factors of safety used within the design (e.g. additional +10% contribution from permeable areas) it can be concluded that this is a reasonable and proportionate allowance within the drainage design.

3.6.3 PERCENTAGE IMPERMEABILITY (PIMP)

The percentage impermeability (PIMP) for all impermeable areas is modelled as 100%. The entirety of the impermeable areas is to be positively drained into the network.

3.6.4 VOLUMETRIC RUNOFF COEFFICIENT (CV)

The volumetric runoff coefficient describes the volume of surface water which runs off an impermeable surface following losses due to infiltration, depression storage, initial wetting and evaporation. The coefficient is dimensionless. As per the LCC SuDS Guidance document[17] a runoff coefficient of 1 has been used in the surface water drainage design for all winter storm events. This is higher than the default industry standards and provides a further factor of safety within the hydraulic design (i.e. +16% increase in surface water run-off).

3.6.5 RAINFALL MODEL

The calculations use the REFH2 unit hydrograph methodology in line with best practice as outlined in the SuDS Manual[8]. The calculations use the most up to date available catchment descriptors (2013) provided by the Centre for Ecology and Hydrology Flood Estimation Handbook web service.

3.7 SURFACE WATER DRAINAGE DESIGN – PLOTS 1 - 37

In accordance with the principles established in the original drainage strategy approved as part of the Planning Permission all impermeable areas (+10% permeable areas) associated with Plots 1 – 37 will be positively drained into a new below ground surface water drainage pipe network.

The roof areas to all plots will be drained via conventional gutters, downpipes and below ground plot drainage with connections into the new surface water sewers.

Highways drainage will be positively drained via conventional road gullies with connections into the new surface water sewers.

Driveways and car parking areas will drain via conventional channel drains into plot drainage or new surface water sewers.

The surface water drainage network will generally to be located within the main access road and a minimum cover depth of 1.2 m shall be provided.

Detailed drainage plans are included in Appendix A for reference.

The hydraulic model has been analysed using Causeway FLOW and a copy of the analysis and model outputs for a range of storm events and durations is included in Appendix B for reference.

3.7.1 GEOCELLULAR ATTENUATION STORAGE

The pipe network will be located within the proposed new access road and will follow the road gradient towards the turning head area to the front of Plots 25 – 29 and discharge into a single geocellular attenuation tank. The tank dimensions will be 10m x 46m x 1.2m deep, thereby providing a total storage volume of 524.4m^3. It should be noted that the storage design provides 174.4m^3 of additional storage when compared to the original drainage proposal by Reford (see Section 3.2 (b)). This increased storage volume is a direct result of enhanced factors of safety associated with an increased total impermeable area, increased runoff coefficient, and +10% contribution from permeable areas.

Silt trap manholes are to be provided upstream of each inlet pipe into the attenuation tank, to minimise deposition of suspended solids into the tank.

The geocellular attenuation tank will be lined with an impermeable geomembrane to create a watertight structure. The geomembrane will be protected with a geotextile to ensure that it does not get damaged or punctured during or after installation.

The geocellular tank will also benefit from access turrets and inspection cells to facilitate future access and maintenance.

Drainage construction details are included in Appendix A for reference.

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3.7.2 FLOW CONTROL DEVICE

A Hydrobrake Optimum vortex type flow control device will limit discharge from the attenuation tank to a max. 10.4 lit/sec. The Hydro-brake design criteria will be as follows:

- Design Head = 1.2 m
- Design Flow = 10.4 lit/s
- Orifice diameter = 145 mm
- Unit Reference: MD-SHE-0145-1040-1200-1040

3.8 SURFACE WATER DRAINAGE DESIGN – REDEVLOPMENT OF FARMHOUSE & BARN CONVERSION

The existing farmhouse and associated impermeable areas currently drain into the existing UU combined sewer and it is proposed that the existing pipe connection is re-used as part of the redevelopment. There will be no additional impermeable area added as part of the farmhouse redevelopment.

For the new barn conversion, there will be an increased area of 370m^2 that will be positively drained into the downstream UU combined sewer and it is therefore proposed that a separate geocellular attenuation tank is provided to store and attenuate the additional run-off. The tank dimensions will be 3m x 12m x 1.2m deep, thereby providing a total storage volume of 41m^3.

A Hydrobrake Optimum vortex type flow control device will limit discharge from the attenuation tank to a max. 0.2 lit/sec. The Hydro-brake design criteria will be as follows:

- Design Head = 1.2 m
- Design Flow = 0.2 lit/s
- Orifice diameter = 19 mm
- Unit Reference: MD-SHE-0019-2000-1200-200

As such the total combined discharge of surface water from the development site will be 10.6 lit/sec, as per the original approved drainage strategy and UU's requirements.

3.9 DESIGNING FOR LOCAL DRAINAGE SYSTEM FAILURE

In accordance with the general principles discussed in CIRIA Report C635 – Designing for Exceedance in Urban Drainage[11] the proposed surface water drainage, where practical, should be designed to ensure there is no increased risk of flooding to the proposed dwellings on the site or elsewhere as a result of extreme rainfall, lack of maintenance, blockages or other causes. These measures are discussed below.

3.9.1 BLOCKAGE & EXCEEDANCE

Based on the existing topography and proposed highway levels and finished floor levels, overland flows will follow the site gradients as illustrated on the Surface Water Exceedance Plan included in Appendix A (ref: K39346-25).

In the unlikely case of exceedance or blockage of the drainage systems, pipes, manholes, silt traps or flow control chambers, flood flows would occur from the lowest manhole access covers or gullies located within the access roads and follow the proposed gradients as indicated towards the northern boundary and eventually spill onto the public open space and route through the existing farm access road and towards Crow Trees Brow.

Exceedance flows shall be retained on site within the drainage system as far as practical however for storms of a greater return period it may be necessary to pass forward more flow or spill flows, as would be the case under greenfield conditions. In the first instance this shall be achieved by passing forward more flow via the flow control chamber due to surcharge of the flow control device. Following this and should the freeboard within the drainage system be used, flow will spill onto the highway and follow the proposed gradients as discussed above.

3.9.2 SURFACE STORAGE & EXTERNAL LEVELS

The site levels have been designed to offer additional surface water storage volume and conveyance of flood water should the SuDS and associated upstream drainage system fail, flood or exceed capacity. Where appropriate, the kerb lines will have a 25 – 100mm high upstand to channel surface water runoff back into the drainage system within the proposed highway via the new gully network.

3.9.3 BUILDING LAYOUT & DETAIL

The finished floor levels to the new dwellings have been designed and situated to ensure that they are not at risk of flooding from overland flow. Threshold levels have been set 150mm above external paved areas, and external footpaths typically fall away from the thresholds, ensuring that any flood water runs away from, rather than towards the dwellings.

Due to existing topography Plots 1 – 4 are set at a lower level than the adjoining car parking area, but the FFL will be set 150mm above the perimeter footpaths. The car parking area will benefit from two lines of 150mm dia. channel drainage to intercept run-off, and in the event of exceedance, flood flow would follow the footpaths down the gable of Plot 4 and spill onto the rear garden.

3.9.4 DRAINAGE CONTINGENCY

The sustainable drainage system has been designed to store and attenuate a 100-year design storm including a 50% allowance for climate change and a run-off coefficient of 1. The drainage system will also provide capacity for lower probability (greater design storm events) which are not critical duration. An additional 10% contribution from permeable areas has also been included within the hydraulic design.

3.10 SURFACE WATER TREATMENT

The treatment of surface water is not a statutory requirement. Water quality remains a material consideration but there are no prescriptive standards to be imposed in terms of treatment train management. In the absence of a design standard, the SuDS manual has been used which outlines best practice.

Pollutants such as suspended solids, heavy metals and organic pollutants may be present in surface water runoff, the quantity and composition of the runoff is highly dependent upon site use. For housing developments, the pollutant load is very low. The SuDS Manual[8] outlines best practice with regards to treatment of surface water by SuDS components prior to discharge to the watercourse. However, as per the original drainage strategy approved as part of the Planning Permission, all attenuated surface water will discharge into the existing UU combined sewer and as such, enhanced treatment of surface water is not required. Nevertheless, a series of silt trap manholes and inspection chambers are proposed upstream of the main geocellular attenuation tank which will help to settle out suspended solids and other contaminants. The flow control manhole and upstream highways gullies will also benefits from sumps to assist with silt and contaminant retention.

3.11 OPERATIONS & MAINTENANCE RESPONSIBILITY

For Plots 1 – 37, both the main foul and surface water sewers and plot drainage will remain private and will be maintained by the Housing Association. The main access road will also remain private and will be maintained by the Housing Association.

All drainage associated with the farmhouse redevelopment and barn conversion will be private and will be the responsibility of the homeowners.

A SuDS Operations & Maintenance Plan has been prepared by RGP in support of the drainage proposals and details the requirements for future maintenance of the geocellular attenuation tanks.

4. FOUL WATER DRAINAGE STRATEGY

It is proposed that foul water from the development will drain via gravity towards the north, through the existing farm access road and into the existing UU combined sewer in Crow Trees Brow. UU have been consulted and have confirmed that foul water drainage will be permitted to discharge into their sewer system.

Foul water discharge calculations have been undertaken for the 39 no. dwellings, in accordance with the Design and Construction Guidance for Foul and Surface Water Sewers[18], as shown in Table 4.1.

Table 4.1 Peak Foul Flow Rates

Sewerage Sector Design & Construction Guidance Clause B3.1	
Peak Load based on Number of Dwellings, 39 no. units @ 4000 l/day	156,000
Peak Foul Flow Rate (l/s)	1.8

The estimated peak foul flow rate for the development is 1.8 lit/sec. For further details regarding the proposed foul water drainage layout refer to the drawings included in Appendix A.

5. CONCLUSIONS AND RECOMMENDATIONS

In consideration of the proposed Drainage Strategy for the development, the following conclusions and recommendations are made:

- Surface water drainage for Plots 1 – 37 shall be positively drained, stored and attenuated within a large geocellular attenuation tank prior to discharge at the Greenfield runoff QBAR (10.4 lit/sec) into the existing UU combined sewer in Crow Trees Brow. The tank will provide 524.4m^3 of storage.

- Surface water from the additional impermeable area associated with the new barn conversion shall be drained into a separate geocellular attenuation tank with flows limited to 0.2 lit/sec. The tank will provide 41m^3 of storage.

- The total attenuated surface water discharge rate into the UU combined sewer will be 10.6 lit/sec as per the original approved drainage strategy.

- The drainage system has been designed to convey and store the Q100 + 50% climate change storm event, with an additional allowance of 10% urban creep and 10% contribution from permeable areas.

- The new surface water drainage network will remain private and will be maintained by the Housing Association.

- Foul flows from the site shall drain by gravity to the existing UU combined sewer. UU have confirmed that this is acceptable.

- The site layout and drainage systems have been designed to ensure that there is no increased risk of flooding on or off site as a result of extreme rainfall, lack of maintenance, blockages or other causes. The measures that will be implemented comprise additional flow conveyance capacity on the access road and parking areas, a series of contingency and safety features for the surface water drainage system, and the careful design of building layouts and details.

- In addition to the above measures, a SuDS Operations & Maintenance Plan will be made available to the site owners detailing future maintenance requirements of all sustainable drainage systems.

6. REFERENCES

[1] Ministry of Housing, Communities and Local Government, National Planning Policy Framework, July 2018.

[2] Ministry of Housing, Communities and Local Government, Planning Practice Guidance to the National Planning Policy Framework, December 2022

[3] Defra/Environment Agency, The Town and Country Planning Order 2015, 2015 No.595, April 2015. January 2021

[4] Reford Consulting Engineers Ltd, Flood Risk Assessment And Drainage Strategy, September 2022

[5] BEK Geo-Environmental Consulting, Site Investigation & Ground Assessment, BEK-23127-1 (Rev A), October 2023

[6] BEK Geo-Environmental Consulting, BRE 365 Infiltration Testing, 27 November 2023

[7] BEK Geo-Environmental Consulting, Ground Gas Risk Assessment, 24 January 2024

[8] CIRIA, The SuDS Manual, Report C753, 2015.

[9] BS8582:2013, Code of Practice for Surface Water Management, November 2013.

[10] DEFRA/EA, Rainfall Runoff Management for Developments, SC030219, October 2013.

[11] CIRIA, Designing for Exceedance in Urban Drainage – Good Practice, Report C635, London, 2006.

[12] Centre for Ecology and Hydrology, Flood Estimation Handbook, Vols. 1 – 5 & FEH CD-ROM 3, 2009.

[13] Institute of Hydrology, Flood Studies Report, Volume 1, Hydrological Studies, 1993.

[14] Institute of Hydrology, Flood Studies Supplementary Report No 14 – Review of Regional Growth Curves, August 1983.

[15] Marshall & Bayliss, 1994. Flood Estimation for Small Catchments, Report No. 124 (IoH 124), Institute of Hydrology.

[16] Department for Environment, Food and Rural Affairs, Non-Statutory Technical Standards for Sustainable Drainage Systems, March 2015

[17] Lancashire County Council, Lancashire Sustainable Drainage Systems (SuDS) Pro-forma, Guidance for completing your proforma, V6, November 2022

[18] Water UK, Design and Construction Guidance for Foul & Surface Water Sewers Offered for Adoption Under the Code for Adoption Agreements for Water and Sewage Companies Operating Wholly or Mainly in England, Approved Version 2.1, 25 May 2021

APPENDIX A

DRAWINGS

Retaining Wall Key:

- Retaining Wall (0.45m to 1.4m high)
- Retaining Wall (0.8m to 1.15m high)
- PC Flag on edge/concrete gravel board (0.3m max. high)
- Masonry underbuild to dwelling (depth below FFL varies as indicated)

Rev	Description	Date	Revised by	Checked by	Approved

Issue Purpose: **Approval**

Do not scale from this drawing

R G PARKINS

Kendal | 01539 729393 Lancaster | 01524 32548

Client:	Pringle Homes	Scale @ A1: 1:250	First Issue: 19/03/24	Office of Origin: Kendal
Project:	Crow Trees Farm, Chatburn	Drawn by: JB	Checked by: TM	Approved: TM
Drawing Title:	Proposed Highway & External Levels Plan	Project No: K39346	Drawing No: 01	Rev: -
		BIM No: -		

Drainage Key

- Existing Combined Water Public Sewer
- 150Ø Foul Water Main Drainage
- 100Ø Foul Water Plot Drainage
- 225/300Ø Surface Water Main Drainage
- 100/150Ø Surface Water Plot Drainage
- 100/150Ø Surface Water Channel Drain
- 150Ø Highways Drainage

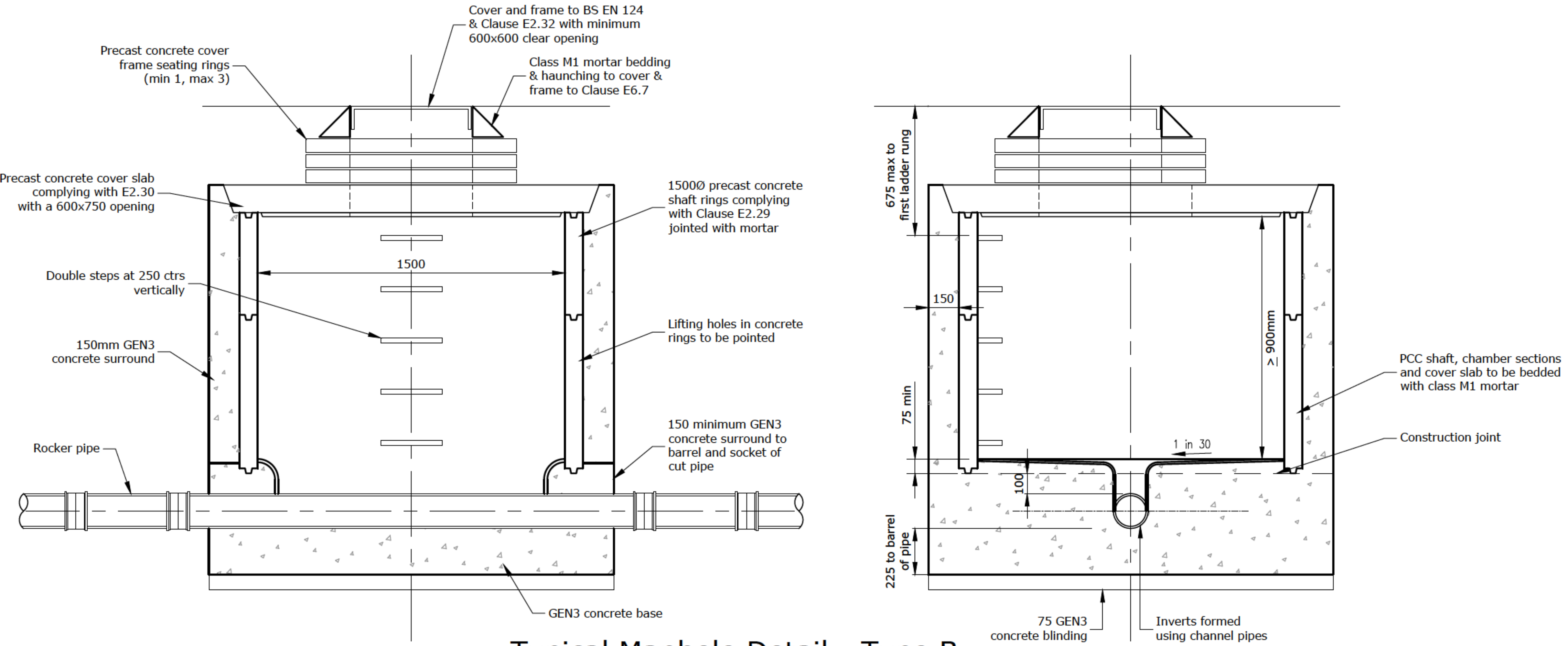
Rev	Description	Date	Revised by	Checked by	Approved

Issue Purpose:
Approval

Do not scale from this drawing

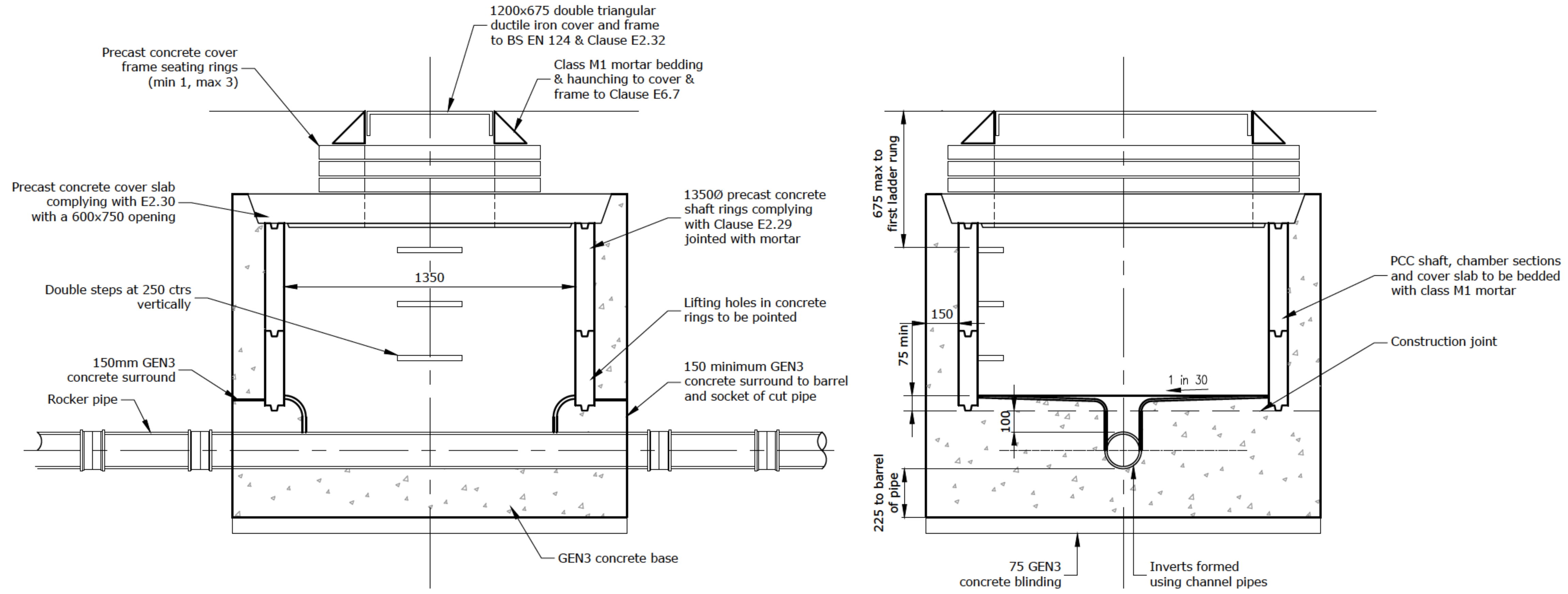
R G PARKINS
Kendal | 01539 729393 Lancaster | 01524 32548

Client: Pringle Homes	Scale @ A1: 1:250	First Issue: 21/03/24	Office of Origin: Kendal
Project: Crow Trees Farm, Chatburn	Drawn by: JB	Checked by: TM	Approved: TM
Drawing Title: Foul and Surface Water Drainage Plan	Project No: K39346	Drawing No: 20	Rev: -
	BIM No: -		



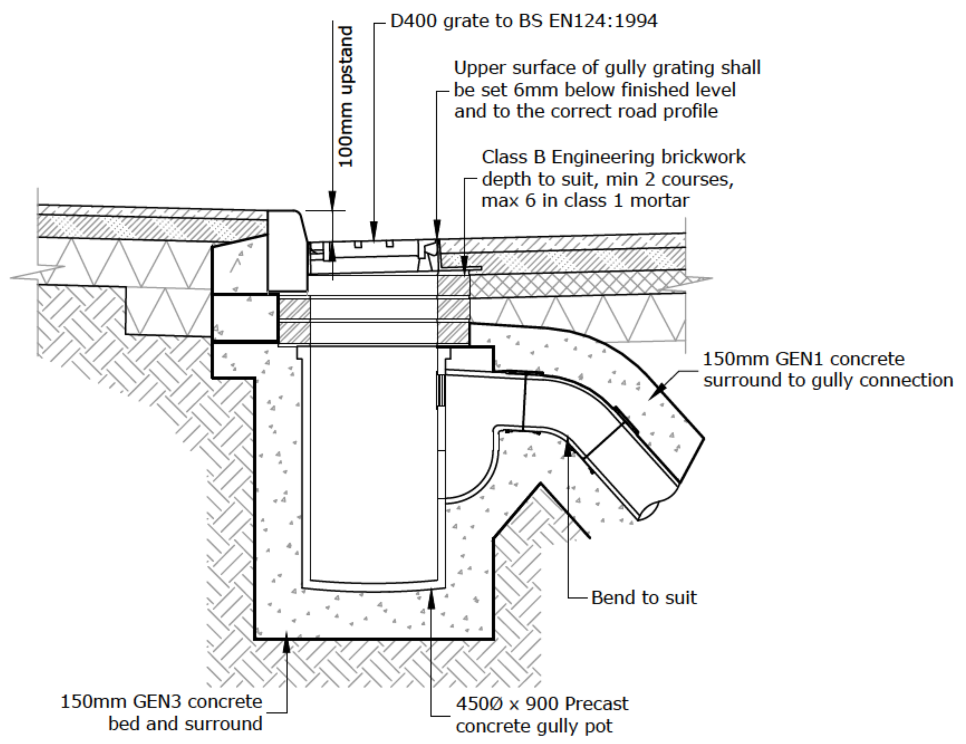
Typical Manhole Detail - Type B
Depth from Cover Level To Soffit
Of Pipe 1.5m to 3m (1500Ø)

Scale 1:20



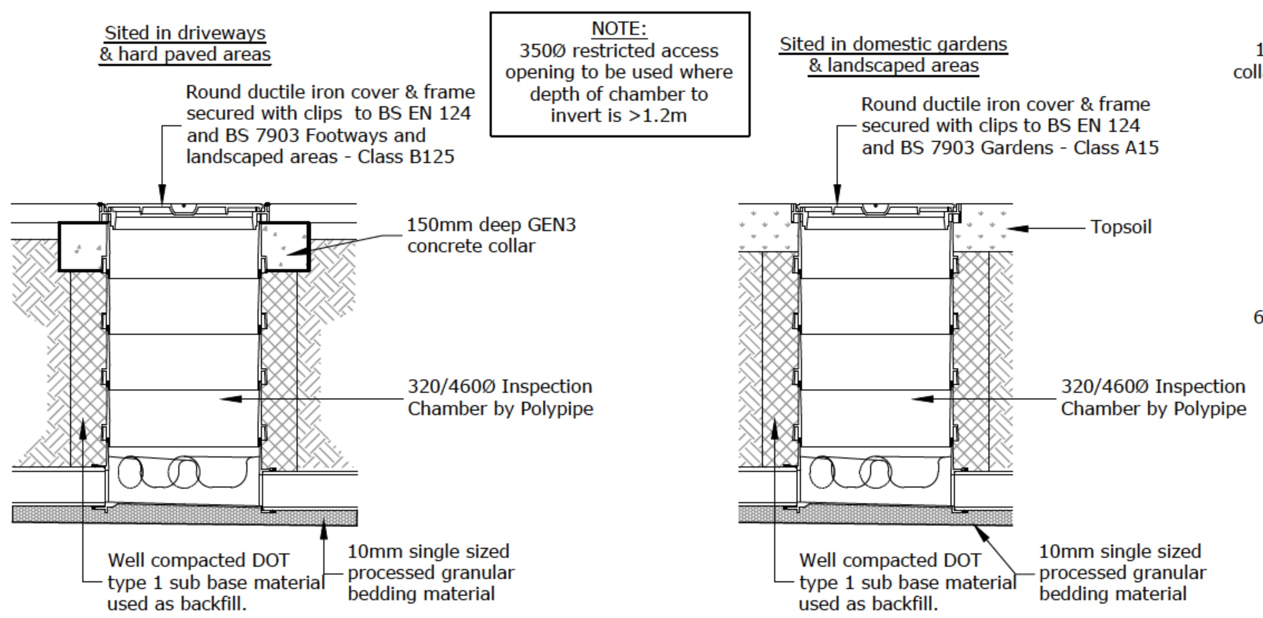
Typical Manhole Detail - Type C
Depth from Cover Level To Soffit
Of Pipe Less Than 1.5m (1350Ø)

Scale 1:20



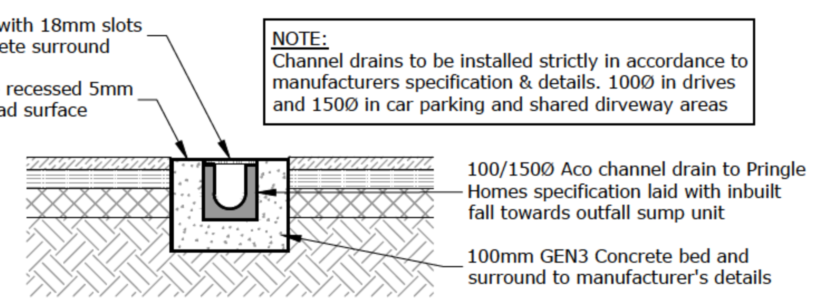
Typical PCC Road Gully Detail

Scale 1:20



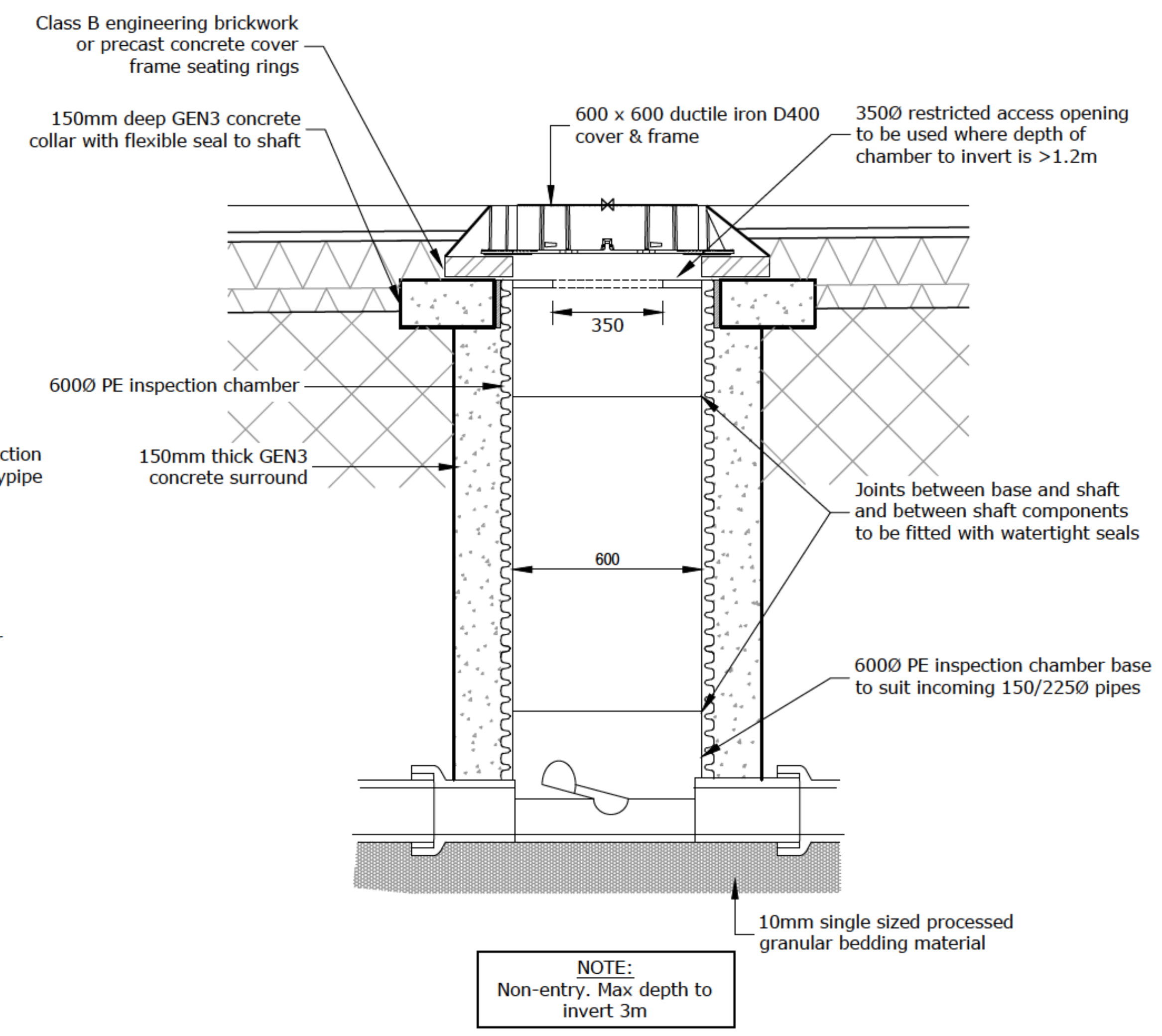
Typical Inspection Chamber Detail

Scale 1:20



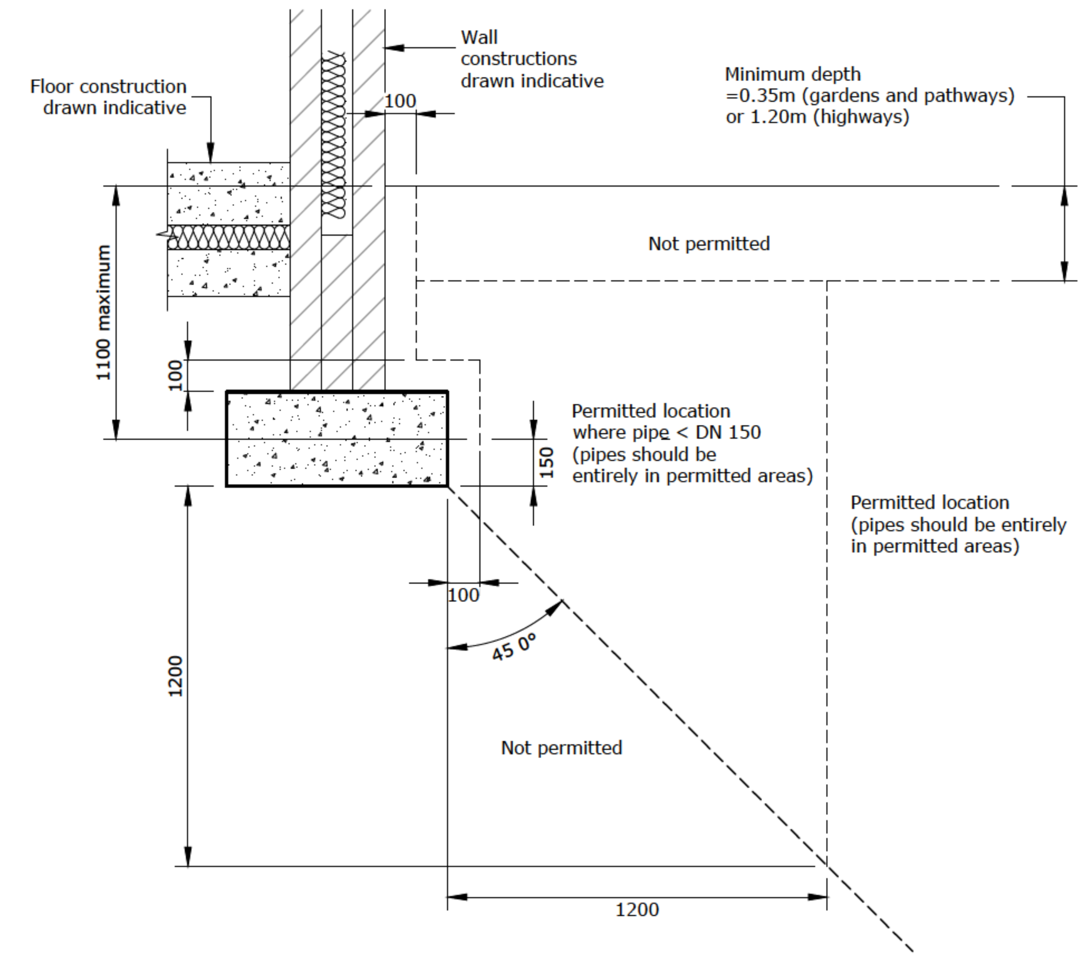
Typical Channel Drain Detail

scale 1:20



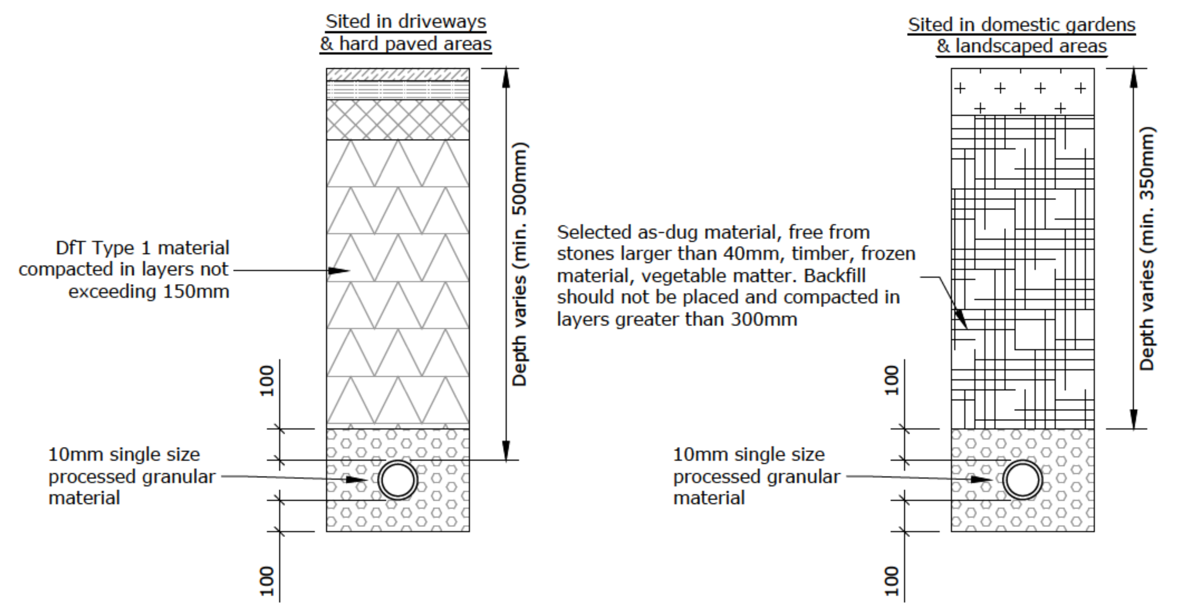
600Ø Inspection Chamber Detail

Scale 1:20



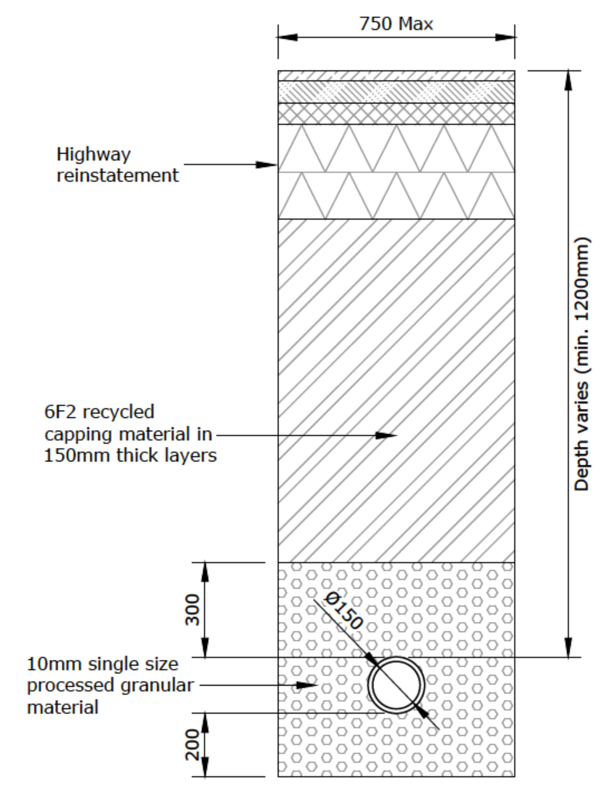
Permitted Location of Sewers and Lateral
Drains in Proximity to Buildings

Scale 1:20



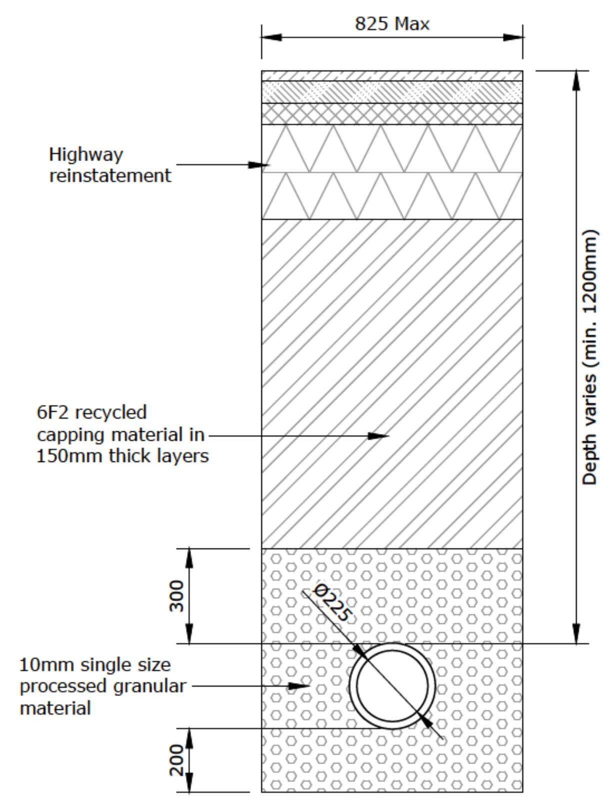
Pipe Bedding for 100Ø/150Ø/225Ø
Plot Drainage Pipes

scale 1:20



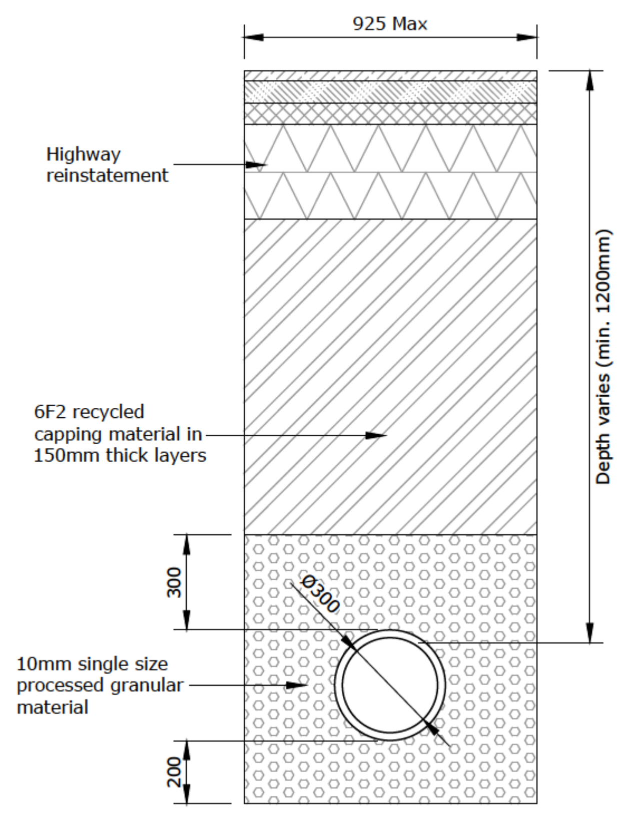
Type 7 Embedment Class S
for 150Ø Pipe
in Access Road

Scale 1:20



Type 7 Embedment Class S
for 225Ø Pipe
in Access Road

Scale 1:20



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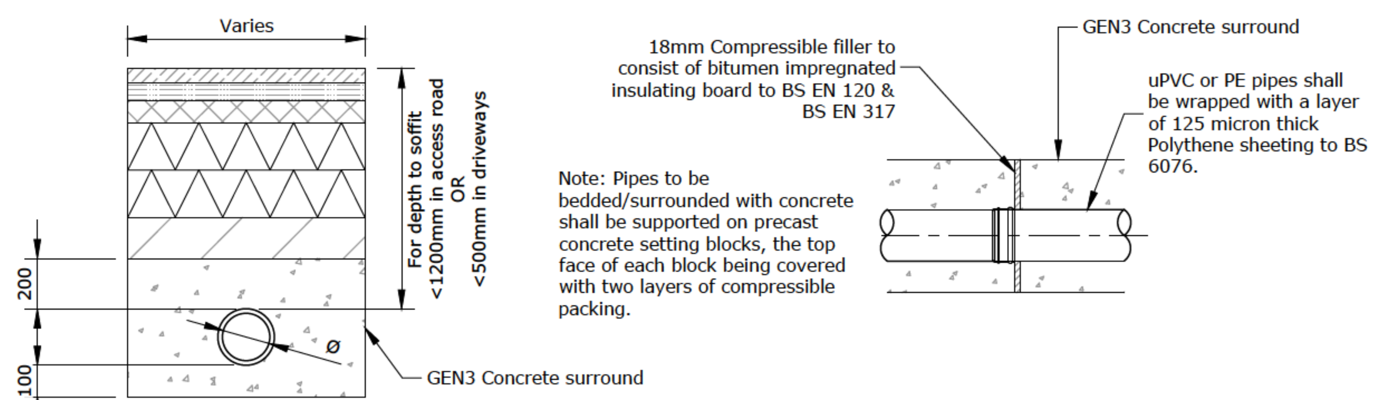
for 300Ø Pipe
in Access Road

Scale 1:20



Concrete surround
for Shallow Pipes

scale 1:20

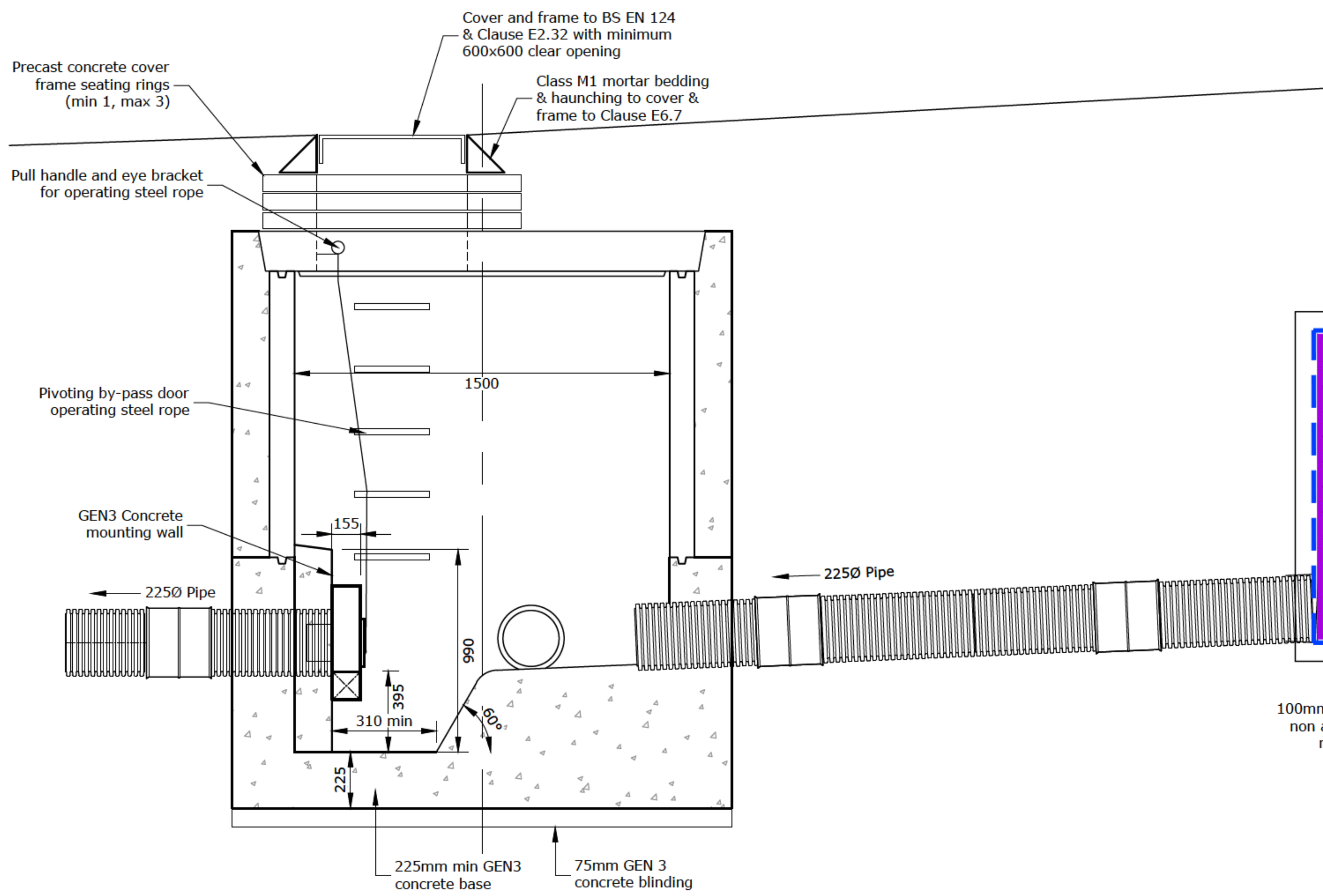
Rev	Description	Date	Revised by	Checked by	Approved

Issue Purpose: Approval

Do not scale from this drawing

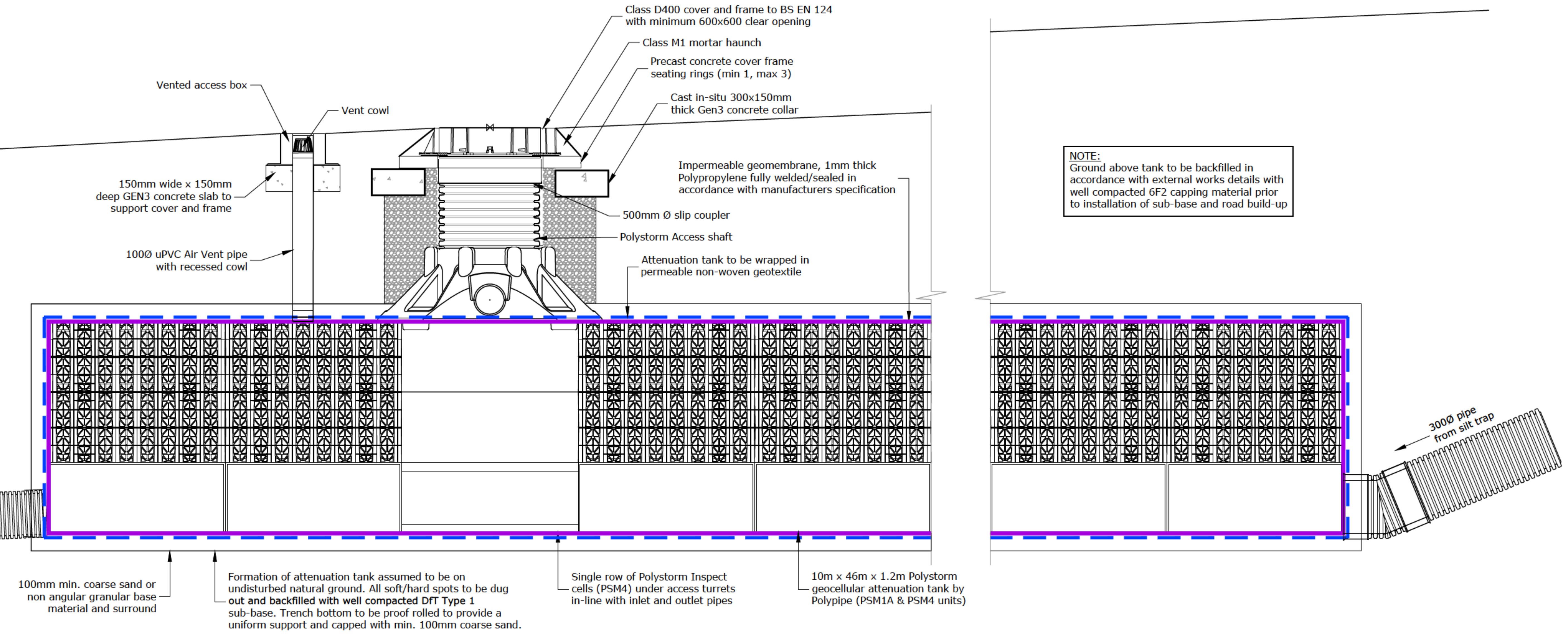
R G PARKINS
Kendal | 01539 729393 Lancaster | 01524 32548

Scale @ A1: 1:20	First Issue: 21/03/24	Office of Origin: Kendal	
Drawn by: JB	Checked by: TM	Approved: TM	
Client: Pringle Homes	Project No: K39346	Drawing No: 21	Rev: -
Project: Crow Trees Farm, Chatburn			
Drawing Title: Foul and Surface Water Drainage Construction Details - 1 of 2	BIM No: -		



S08 - Flow Control Chamber Section

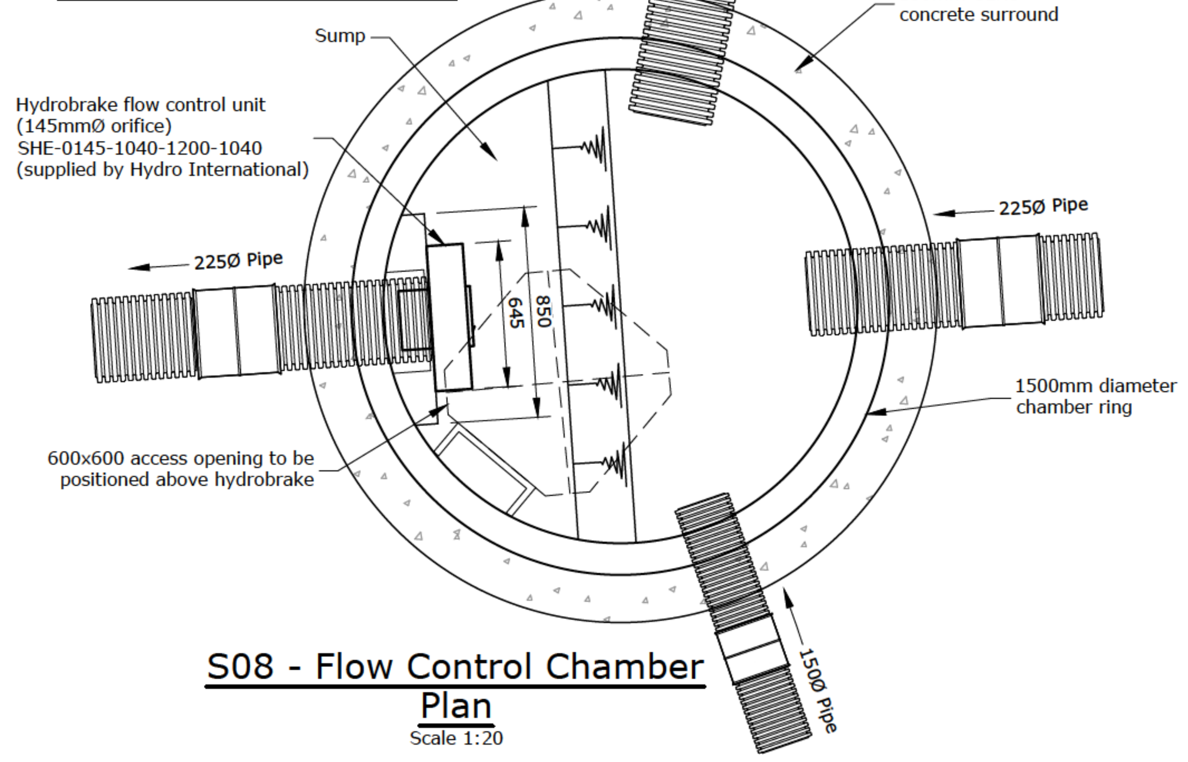
Scale 1:20



Section Through Geocellular Attenuation Tank 1 (Tank 2 similar)

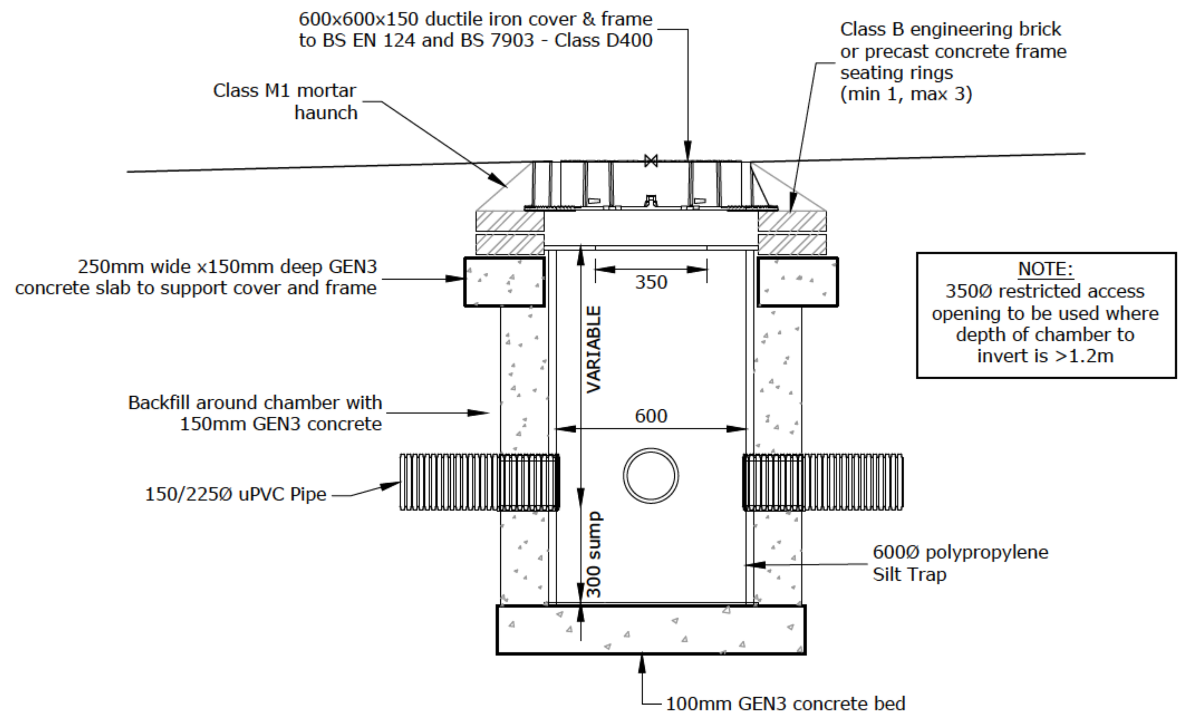
Scale 1:20

Hydro-brake optimum technical specification		
Control point	Head (m)	Flow (l/s)
Primary Design	1.200	10.400
Flush-Flo	0.355	10.396
Kick-Flo	0.778	8.486
Mean Flow		8.994



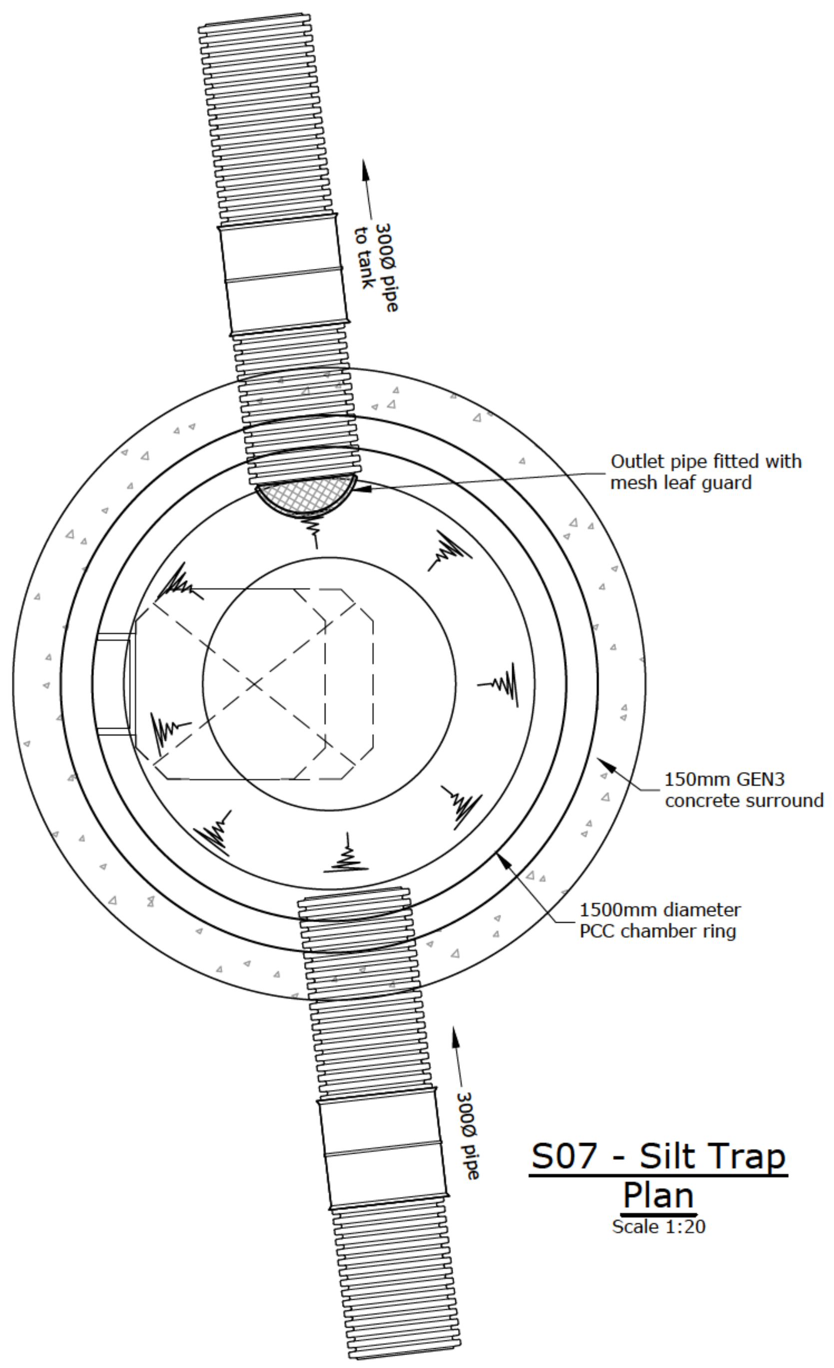
S08 - Flow Control Chamber Plan

Scale 1:20



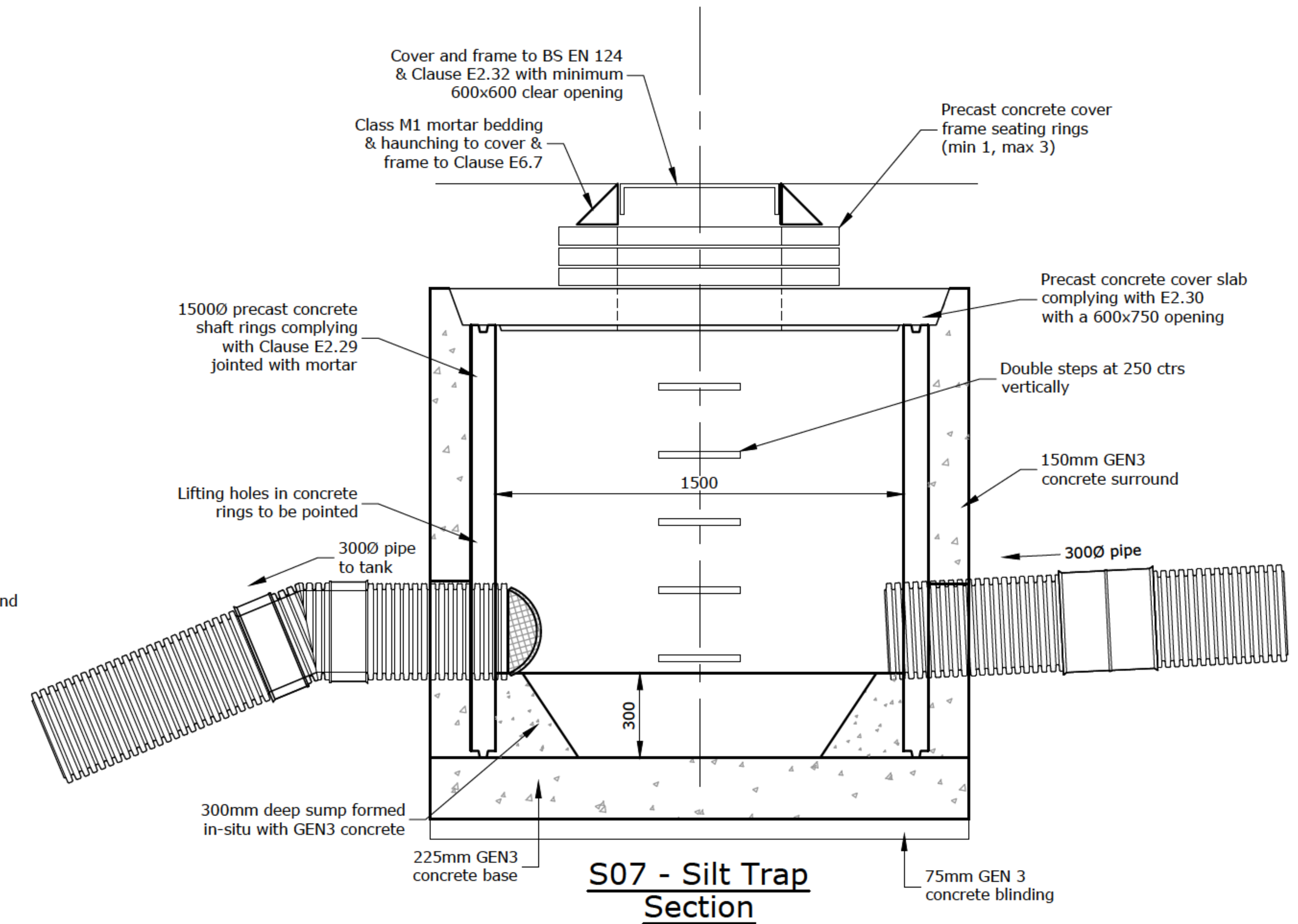
TYPICAL 600Ø SILT TRAP

scale 1:20



S07 - Silt Trap Plan

Scale 1:20



S07 - Silt Trap Section

Scale 1:20

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Kendal | 01539 729393 Lancaster | 01524 32548

Scale @ A1: 1:20	First Issue: 21/03/24	Office of Origin: Kendal	
Drawn by: JB	Checked by: TM	Approved: TM	
Project No: K39346	Drawing No: 22	Rev: -	
BIM No: -			

Client: Pringle Homes

Project: Crow Trees Farm, Chatburn

Drawing Title: Foul and Surface Water Drainage Construction Details - 2 of 2

Rev	Description	Date	Revised by	Checked by	Approved

Issue Purpose: Approval

Do not scale from this drawing

Manhole Schedule: Storm Network 1

Node	Easting (m)	Northing (m)	CL (m)	Depth to invert (m)	Depth to soffit (m)	Dia (mm)	Node Type	MH Type (DCG)	Cover Slab Opening	Cover Spec	Connections	Link	IL (m)	Dia (mm)	Link Type
S01	376722.908	443941.301	105.167	2.167	2.017	1200	Manhole	Type B	750 x 600	600 x 600 D400	1 0	Plot 1.000	103.000 103.000	150 150	Circ Circ
S02	376720.042	443933.832	105.222	2.472	2.172	1500	Manhole	Type B	750 x 600	600 x 600 D400	1 2 0	1.000 Gully 1.001	102.900 102.900 102.750	150 150 300	Circ Circ Circ
S03	376755.997	443873.772	103.833	1.783	1.483	1500	Manhole	Type C	1200 x 675	1200 x 675 D400	1 0	1.001 1.002	102.050 102.050	300 300	Circ Circ
S04	376779.410	443875.794	103.263	1.959	1.659	1500	Manhole	Type B	750 x 600	600 x 600 D400	1 2 0	1.002 Plot 1.003	101.304 101.454 101.304	300 150 300	Circ Circ Circ
S05	376795.881	443888.821	102.481	1.844	1.544	1500	Manhole	Type B	750 x 600	600 x 600 D400	1 2 0	1.003 Plot 1.004	100.637 100.787 100.637	300 150 300	Circ Circ Circ
S06	376801.513	443910.605	101.653	1.730	1.430	1500	Manhole	Type C	1200 x 675	1200 x 675 D400	1 2 0	1.004 Plot 1.005	99.923 99.998 99.923	300 225 300	Circ Circ Circ
S07 Silt Trap	376817.496	443922.627	101.117	1.828	1.528	1500	Manhole	Type B	750 x 600	600 x 600 D400	1	1.005 1.006	99.289 9 289	300 300	Circ i c
S08 Flow Control	376805.153	443961.507	100.132	2.158	1.933	1500	Manhole	Type B	750 x 600	600 x 600 D400	1 2 3 0	1.007 Plot Gully 1.008	97.974 97.974 98.049 97.974	225 225 150 225	Circ Circ Circ Circ
S09	376796.421	443974.387	99.234	1.742	1.517	1350	Manhole	Type B	750 x 600	600 x 600 D400	1	1.008 1.009	97.492 492	225	Circ
S10	376769.715	444000.212	99.374	2.104	1.879	1350	Manhole	Type B	750 x 600	600 x 600 D400	1 0	1.009 1.010	97.270 97.270	225 225	Circ Circ
S11	376753.275	444032.736	98.700	1.650	1.425	1350	Manhole	Type C	1200 x 675	1200 x 675 D400	1 0	1.010 Extg	97.050 97.050	225 150	Circ Circ

Manhole Schedule: Foul Network 1

Node	Easting (m)	Northing (m)	CL (m)	Depth to invert (m)	Depth to soffit (m)	Dia (mm)	Node Type	MH Type (DCG)	Cover Slab Opening	Cover Spec	Connections	Link	IL (m)	Dia (mm)	Link Type
F01	376778.698	443877.648	103.268	1.350	1.200	1350	Manhole	Type C	1200 x 675	1200 x 675 D400	1 0	Plot 1.000	101.918 101.918	150 150	Circ Circ
F02	376793.914	443889.027	102.557	1.350	1.200	1350	Manhole	Type C	1200 x 675	1200 x 675 D400	1 2 0	1.000 Plot 1.001	101.207 101.207 101.207	150 150 150	Circ Circ Circ
F03	376798.390	443909.544	101.790	1.350	1.200	1350	Manhole	Type C	1200 x 675	1200 x 675 D400	1 2 0	1.001 Plot 1.002	100.440 100.440 100.440	150 150 150	Circ Circ Circ
F04	376814.492	443924.531	101.233	1.350	1.200	1350	Manhole	Type C	1200 x 675	1200 x 675 D400	1 2 0	1.002 Plot 1.003	99.883 99.883 99.883	150 150 150	Circ Circ Circ
F05	376796.606	443956.456	99.833	1.350	1.200	1350	Manhole	Type C	1200 x 675	1200 x 675 D400	1 0	1.003 1.004	98.483 98.483	150 150	Circ Circ
F06	376802.101	443963.903	99.440	1.350	1.200	1350	Manhole	Type C	1200 x 675	1200 x 675 D400	1 2 0	1.004 Plot 1.005	98.090 98.140 98.090	150 100 150	Circ Circ Circ
F07	376796.268	443972.411	99.431	1.580	1.430	1350	Manhole	Type C	1200 x 675	1200 x 675 D400	1 0	1.005 1.006	97.851 97.851	150 150	Circ Circ
F08	376768.991	443998.454	99.407	1.808	1.658	1350	Manhole	Type B	750 x 600	600 x 600 D400	1 2 0	1.006 1.006 1.007	97.599 97.649 97.599	150 100 150	Circ Circ Circ
F09	376757.282	444022.219	99.266	1.844	1.694	1350	Manhole	Type B	750 x 600	600 x 600 D400	1 0	1.007 1.008	97.422 97.422	150 150	Circ Circ
F10	376750.634	444029.708	99.065	1.710	1.560	1350	Manhole	Type B	750 x 600	600 x 600 D400	1 0	1.008 Extg	97.355 97.355	150 150	Circ Circ

Pipeline Schedule: Storm Network 1

Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth	DS CL (m)	DS IL (m)	DS Depth	US Node	Dia (mm)	Node Type	DS Node	Dia (mm)	Node Type
1.000	8.000	80.0	150	Circular	105.167	103.000	2.017	105.222	102.900	2.172	1	1200	Manhole	2	1500	Manhole
1.001	70.000	100.0	300	Circular	105.222	102.750	2.172	103.833	102.050	1.483	2	1500	Manhole	3	1500	Manhole
1.002	23.500	31.5	300	Circular	103.833	102.050	1.483	103.263	101.304	1.659	3	1500	Manhole	4	1500	Manhole
1.003	21.000	31.5	300	Circular	103.263	101.304	1.659	102.481	100.637	1.544	4	1500	Manhole	5	1500	Manhole
1.004	22.500	31.5	300	Circular	102.481	100.637	1.544	101.653	99.923	1.430	5	1500	Manhole	6	1500	Manhole
1.005	20.000	31.5	300	Circular	101.653	99.923	1.430	101.117	98.289	1.528	6	1500	Manhole	7	1500	Manhole
1.006	3.369	2.9	300	Circular	101.117	98.289	1.528	101.033	98.135	2.598	7	1500	Manhole	Tank		
1.007	3.238	124.5	225	Circular	100.256	97.800	2.031	100.132	97.974	1.933	Tank		Junction	8	1500	Manhole
1.008	15.561	32.3	225	Circular	100.132	97.974	1.933	99.234	97.492	1.517	8	1500	Manhole	9	1350	Manhole
1.009	37.150	167.3	225		99.234	97.492	1.517	99.220	97.374	1.879	9	1350	Manhole	10	1350	
1.010	36.443	167.2	225	Circular	99.374	97.270	1.879	98.700	97.000	1.475	10	1350	Manhole	11	1350	Manhole

Pipeline Schedule: Foul Network 1

Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth	DS CL (m)	DS IL (m)	DS Depth	US Node	Dia (mm)	Node Type	DS Node	Dia (mm)	Node Type
1.000	19.000	26.7	150	Circular	103.268	101.918	1.200	102.557	101.207	1.200	1	1350	Manhole	2	1350	Manhole
1.001	21.000	27.4	150	Circular	102.557	101.207	1.200	101.790	100.440	1.200	2	1350	Manhole	3	1350	Manhole
1.002	21.997	39.5	150	Circular	101.790	100.440	1.200	101.233	99.883	1.200	3	1350	Manhole	4	1350	Manhole
1.003	36.594	26.1	150	Circular	101.233	99.883	1.200	99.833	98.483	1.200	4	1350	Manhole	5	1350	Manhole
1.004	9.255	23.5	150	Circular	99.833	98.483	1.200	99.440	98.090	1.200	5	1350	Manhole	6	1350	Manhole
1.005	10.316	43.2	150	Circular	99.440	98.090	1.200	99.431	97.851	1.430	6	1350	Manhole	7	1350	Manhole
1.006	37.713	149.7	150	Circular	99.431	97.851	1.430	99.407	97.599	1.658	7	1350	Manhole	8	1350	Manhole
1.007	26.493	149.7	150	Circular	99.407	97.599	1.658	99.266	97.422	1.694	8	1350	Manhole	9	1350	Manhole
1.008	10.014	149.5	150	Circular	99.266	97.422	1.694	99.065	97.355	1.560	9	1350	Manhole	10	1350	Manhole

Note:
Invert levels of connections into existing public sewer to be confirmed prior to construction.

Rev | Description | Date | Revised by | Checked by | Approved

Issue Purpose: Approval

Do not scale from this drawing

R G PARKINS
Kendal | 01539 729393 Lancaster | 01524 32548

Client: Pringle Homes
Project: Crow Trees Farm, Chatburn
Drawing Title: Foul and Surface Water Drainage Schedules

Scale @ A1: NTS | First Issue: 21/03/24 | Office of Origin: Kendal
Drawn by: JB | Checked by: TM | Approved: TM
Project No: K39346 | Drawing No: 23 | Rev: -
BIM No: -

Surface Water Drainage Contributing Areas Key

Scale 1:250

SW1.000	0.054 ha
SW1.001	0.085 ha
SW1.002	0.017 ha
SW1.003	0.110 ha
SW1.004	0.124 ha
SW1.005	0.132 ha
SW1.006	0.000 ha
SW1.007	0.178 ha
SW1.008	0.010 ha
SW1.009	0.000 ha
SW1.010	0.000 ha
SW2.000	0.000 ha
SW2.001	0.037 ha
Total Contributing Area	**0.747 ha**

Notes:

1. Additional 10% contributing area added to all new roof areas to account for potential future Urban Creep
2. Additional 10% area added to all contributing areas to account for potential runoff from permeable land areas

Rev	Description	Date	Revised by	Checked by	Approved

Issue Purpose: Approval

Do not scale from this drawing

R G PARKINS

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Client: Pringle Homes

Project: Crow Trees Farm, Chatburn

Drawing Title: Surface Water Drainage Catchment Plan

Scale @ A1: 1:250	First Issue: 21/03/24	Office of Origin: Kendal
Drawn by: JB	Checked by: TM	Approved: TM
Project No: K39346	Drawing No: 24	Rev: -
BIM No: -		

Rev	Description	Date	Revised by	Checked by	Approved

Issue Purpose: Approval

Do not scale from this drawing

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Scale @ A1: 1:250	First Issue: 21/03/24	Office of Origin: Kendal	
Drawn by: JB	Checked by: TM	Approved: TM	
Client: Pringle Homes	Project No: K39346	Drawing No: 25	Rev: -
Project: Crow Trees Farm, Chatburn			
Drawing Title: Surface Water Drainage Exceedance Plan	BIM No: -		

APPENDIX B

CALCULATIONS

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Easting (m)	Northing (m)	Depth (m)
1	0.054	5.00	105.167	1200	376722.908	443941.301	2.167
2	0.085	5.00	105.222	1500	376720.042	443933.832	2.472
3	0.017	5.00	103.833	1500	376755.997	443873.772	1.783
4	0.110	5.00	103.263	1500	376779.410	443875.794	1.959
5	0.124	5.00	102.481	1500	376795.881	443888.821	1.844
6	0.132	5.00	101.653	1500	376801.513	443910.605	1.730
7			101.117	1500	376817.496	443922.627	1.828
7_OUT	0.021	15.00	101.033		376820.225	443924.602	2.918
IC	0.157	5.00	100.385	600	376810.175	443960.626	1.135
IC_OUT			100.250		376807.804	443958.818	2.135
Outlet		5.00	100.256		376806.904	443958.783	2.256
8	0.010	5.00	100.132	1500	376805.153	443961.507	2.158
9			99.234	1350	376796.421	443974.387	1.742
Junction			99.220		376783.068	443987.300	1.839
10			99.374	1350	376769.715	444000.212	2.104
11			98.700	1350	376753.275	444032.736	1.648
Barns	0.037	5.00	100.248	450	376768.951	443973.702	1.350
Barns_Inlet			100.104		376769.655	443974.414	2.562
Outlet_2		5.00	99.630		376778.097	443982.943	2.130
12			99.549	1350	376779.155	443984.006	2.059

Links (Input)

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
1.000	1	2	8.000	0.600	103.000	102.900	0.100	80.0	150	5.12	50.0
1.001	2	3	70.000	0.600	102.750	102.050	0.700	100.0	300	5.86	50.0
1.002	3	4	23.500	0.600	102.050	101.304	0.746	31.5	300	6.00	50.0
1.003	4	5	21.000	0.600	101.304	100.637	0.667	31.5	300	6.12	50.0
1.004	5	6	22.500	0.600	100.637	99.923	0.714	31.5	300	6.26	50.0
1.005	6	7	20.000	0.600	99.923	99.289	0.634	31.5	300	6.38	50.0
1.006	7	7_OUT	3.369	0.600	99.289	98.135	1.154	2.9	300	6.38	50.0
1.007	Outlet	8	3.238	0.600	98.000	97.974	0.026	124.5	225	5.05	50.0
1.008	8	9	15.561	0.600	97.974	97.492	0.482	32.3	225	5.16	50.0
1.009	9	Junction	18.575	0.600	97.492	97.381	0.111	167.3	225	5.47	50.0
1.0091	Junction	10	18.575	0.600	97.381	97.270	0.111	167.3	225	5.77	50.0
1.010	10	11	36.443	0.600	97.270	97.052	0.218	167.2	225	6.38	50.0
2.000	Outlet_2	12	1.500	0.600	97.500	97.490	0.010	150.0	150	5.03	50.0
2.001	12	Junction	5.115	0.600	97.490	97.456	0.034	150.4	150	5.13	50.0
5.000	Barns	Barns_Inlet	1.001	0.600	98.898	98.346	0.552	1.8	150	5.00	50.0
4.000	IC	IC_OUT	2.982	0.600	99.250	98.847	0.403	7.4	225	5.01	50.0

Simulation Settings

Rainfall Methodology	FEH-22	Analysis Speed	Detailed	Additional Storage (m³/ha)	0.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	1.000	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
2	0	0	0
30	0	0	0
100	50	0	0

Node 8 Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	97.974	Product Number	CTL-SHE-0145-1040-1200-1040
Design Depth (m)	1.200	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	10.4	Min Node Diameter (mm)	1200

Node 12 Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	✓	Sump Available	✓
Invert Level (m)	97.490	Product Number	CTL-SHE-0019-2000-1200-2000
Design Depth (m)	1.200	Min Outlet Diameter (m)	0.075
Design Flow (l/s)	0.2	Min Node Diameter (mm)	1200

Node Outlet Flow through Pond Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Porosity	0.95	Main Channel Length (m)	46.000
Side Inf Coefficient (m/hr)	0.00000	Invert Level (m)	98.000	Main Channel Slope (1:X)	400.0
Safety Factor	2.0	Time to half empty (mins)		Main Channel n	0.030

Inlets

7_OUT | IC_OUT

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	460.0	0.0	1.199	460.0	0.0	1.200	0.0	0.0

Node Outlet 2 Flow through Pond Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Porosity	0.95	Main Channel Length (m)	17.000
Side Inf Coefficient (m/hr)	0.00000	Invert Level (m)	97.500	Main Channel Slope (1:X)	400.0
Safety Factor	2.0	Time to half empty (mins)		Main Channel n	0.030

Inlets

Barns_Inlet

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	36.0	0.0	1.199	36.0	0.0	1.200	0.0	0.0

Results for 2 year Critical Storm Duration. Lowest mass balance: 99.28%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute summer	1	10	103.070	0.070	7.8	0.0791	0.0000	OK
15 minute summer	2	10	102.840	0.090	20.0	0.1585	0.0000	OK
15 minute summer	3	11	102.117	0.067	22.0	0.1184	0.0000	OK
15 minute summer	4	11	101.393	0.089	37.2	0.1571	0.0000	OK
15 minute summer	5	11	100.745	0.108	54.6	0.1900	0.0000	OK
15 minute summer	6	11	100.071	0.148	73.2	0.2616	0.0000	OK
15 minute summer	7	11	99.365	0.076	73.4	0.1334	0.0000	OK
360 minute summer	7_OUT	232	98.280	0.165	26.6	0.0000	0.0000	OK
15 minute summer	IC	10	99.307	0.057	22.8	0.0161	0.0000	OK
360 minute summer	IC_OUT	232	98.279	0.164	8.3	0.0000	0.0000	OK
360 minute summer	Outlet	232	98.277	0.277	21.8	0.0000	0.0000	SURCHARGED
360 minute summer	8	232	98.275	0.301	10.2	0.5325	0.0000	SURCHARGED
360 minute summer	9	232	97.570	0.078	10.2	0.1121	0.0000	OK
360 minute summer	Junction	232	97.460	0.079	10.3	0.0000	0.0000	OK
360 minute summer	10	232	97.349	0.079	10.3	0.1130	0.0000	OK
360 minute summer	11	232	97.129	0.077	10.3	0.0000	0.0000	OK
15 minute summer	Barns	10	98.921	0.023	5.4	0.0036	0.0000	OK
1440 minute winter	Barns_Inlet	1080	97.792	0.249	0.5	0.0000	0.0000	OK
1440 minute winter	Outlet_2	1080	97.793	0.292	0.3	0.0000	0.0000	SURCHARGED
1440 minute winter	12	1080	97.793	0.302	0.2	0.4329	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Discharge Vol (m³)
15 minute summer	1	1.000	2	7.7	1.007	
15 minute summer	2	1.001	3	19.6	1.354	
15 minute summer	3	1.002	4	22.0	1.519	
15 minute summer	4	1.003	5	37.4	1.867	
15 minute summer	5	1.004	6	54.8	1.917	
15 minute summer	6	1.005	7	73.4	3.072	
15 minute summer	7	1.006	7_OUT	73.5	5.781	
360 minute summer	7_OUT	Flow through pond	Outlet	21.8	0.054	
15 minute summer	IC	4.000	IC_OUT	22.8	3.076	
360 minute summer	IC_OUT	Flow through pond	Outlet	21.8	0.054	
360 minute summer	Outlet	1.007	8	10.1	0.353	
360 minute summer	8	1.008	9	10.2	1.088	
360 minute summer	9	1.009	Junction	10.2	0.826	
360 minute summer	Junction	1.0091	10	10.3	0.830	
360 minute summer	10	1.010	11	10.3	0.842	194.2
15 minute summer	Barns	5.000	Barns_Inlet	5.4	3.557	
1440 minute winter	Barns_Inlet	Flow through pond	Outlet_2	0.3	0.009	
1440 minute winter	Outlet_2	2.000	12	0.2	0.069	
1440 minute winter	12	Hydro-Brake®	Junction	0.1		

Results for 30 year Critical Storm Duration. Lowest mass balance: 99.28%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute summer	1	10	103.132	0.132	18.8	0.1495	0.0000	OK
15 minute summer	2	10	102.895	0.145	48.2	0.2567	0.0000	OK
15 minute summer	3	11	102.155	0.105	53.3	0.1859	0.0000	OK
15 minute summer	4	10	101.452	0.148	90.7	0.2611	0.0000	OK
15 minute summer	5	11	100.839	0.202	133.1	0.3567	0.0000	OK
15 minute summer	6	11	100.323	0.400	177.7	0.7073	0.0000	SURCHARGED
15 minute summer	7	11	99.414	0.125	174.5	0.2215	0.0000	OK
360 minute winter	7_OUT	280	98.575	0.460	33.9	0.0000	0.0000	OK
15 minute summer	IC	10	99.344	0.094	54.9	0.0267	0.0000	OK
240 minute winter	IC_OUT	220	98.575	0.460	13.0	0.0000	0.0000	OK
360 minute winter	Outlet	280	98.573	0.573	26.8	0.0000	0.0000	SURCHARGED
360 minute winter	8	280	98.571	0.597	10.5	1.0545	0.0000	SURCHARGED
960 minute winter	9	795	97.571	0.079	10.4	0.1134	0.0000	OK
720 minute winter	Junction	705	97.461	0.080	10.5	0.0000	0.0000	OK
720 minute winter	10	705	97.350	0.080	10.5	0.1145	0.0000	OK
720 minute winter	11	705	97.130	0.078	10.5	0.0000	0.0000	OK
15 minute summer	Barns	10	98.934	0.036	13.0	0.0058	0.0000	OK
1440 minute winter	Barns_Inlet	1350	98.081	0.539	0.9	0.0000	0.0000	OK
1440 minute winter	Outlet_2	1350	98.082	0.582	0.5	0.0000	0.0000	SURCHARGED
1440 minute winter	12	1350	98.082	0.592	0.2	0.8466	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Discharge Vol (m³)
15 minute summer	1	1.000	2	18.6	1.200	
15 minute summer	2	1.001	3	47.5	1.714	
15 minute summer	3	1.002	4	53.2	1.898	
15 minute summer	4	1.003	5	90.4	2.191	
15 minute summer	5	1.004	6	131.8	2.159	
15 minute summer	6	1.005	7	174.5	3.428	
15 minute summer	7	1.006	7_OUT	174.4	7.055	
360 minute winter	7_OUT	Flow through pond	Outlet	26.8	0.065	
15 minute summer	IC	4.000	IC_OUT	54.8	3.810	
240 minute winter	IC_OUT	Flow through pond	Outlet	33.6	0.077	
360 minute winter	Outlet	1.007	8	10.4	0.368	
360 minute winter	8	1.008	9	10.4	1.094	
960 minute winter	9	1.009	Junction	10.4	0.830	
720 minute winter	Junction	1.0091	10	10.5	0.835	
720 minute winter	10	1.010	11	10.5	0.848	457.9
15 minute summer	Barns	5.000	Barns_Inlet	13.0	4.455	
1440 minute winter	Barns_Inlet	Flow through pond	Outlet_2	0.5	0.009	
1440 minute winter	Outlet_2	2.000	12	0.2	0.052	
1440 minute winter	12	Hydro-Brake®	Junction	0.1		

Results for 100 year +50% CC Critical Storm Duration. Lowest mass balance: 99.28%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
30 minute summer	1	20	103.478	0.478	34.1	0.5401	0.0000	SURCHARGED
30 minute summer	2	20	103.218	0.468	87.8	0.8271	0.0000	SURCHARGED
30 minute summer	3	20	102.903	0.853	96.1	1.5064	0.0000	SURCHARGED
30 minute summer	4	19	102.748	1.444	141.3	2.5522	0.0000	SURCHARGED
30 minute summer	5	19	102.367	1.730	200.1	3.0561	0.0000	FLOOD RISK
30 minute summer	6	19	101.418	1.494	274.2	2.6407	0.0000	FLOOD RISK
30 minute summer	7	20	99.453	0.164	272.7	0.2897	0.0000	OK
480 minute winter	7_OUT	448	99.237	1.122	50.3	0.0000	0.0000	OK
15 minute summer	IC	10	99.392	0.142	102.6	0.0403	0.0000	OK
480 minute winter	IC_OUT	448	99.236	1.121	14.6	0.0000	0.0000	OK
480 minute winter	Outlet	448	99.235	1.235	36.8	0.0000	0.0000	SURCHARGED
480 minute winter	8	448	99.233	1.259	10.6	2.2249	0.0000	SURCHARGED
480 minute winter	9	456	97.571	0.079	10.4	0.1136	0.0000	OK
480 minute winter	Junction	456	97.461	0.080	10.6	0.0000	0.0000	OK
480 minute winter	10	456	97.350	0.080	10.6	0.1149	0.0000	OK
480 minute winter	11	456	97.130	0.078	10.6	0.0000	0.0000	OK
15 minute summer	Barns	10	98.950	0.052	24.2	0.0083	0.0000	OK
2880 minute winter	Barns_Inlet	2220	98.741	1.199	1.0	0.0000	0.0000	OK
2880 minute winter	Outlet_2	2220	98.742	1.242	0.6	0.0000	0.0000	SURCHARGED
2880 minute winter	12	2220	98.742	1.252	0.2	1.7909	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Discharge Vol (m³)
30 minute summer	1	1.000	2	34.0	1.931	
30 minute summer	2	1.001	3	85.6	1.882	
30 minute summer	3	1.002	4	99.5	1.843	
30 minute summer	4	1.003	5	140.0	2.104	
30 minute summer	5	1.004	6	199.6	2.835	
30 minute summer	6	1.005	7	272.7	4.402	
30 minute summer	7	1.006	7_OUT	272.6	6.814	
480 minute winter	7_OUT	Flow through pond	Outlet	36.8	0.073	
15 minute summer	IC	4.000	IC_OUT	102.5	4.346	
480 minute winter	IC_OUT	Flow through pond	Outlet	36.8	0.073	
480 minute winter	Outlet	1.007	8	10.3	0.315	
480 minute winter	8	1.008	9	10.4	1.095	
480 minute winter	9	1.009	Junction	10.4	0.830	
480 minute winter	Junction	1.0091	10	10.6	0.837	
480 minute winter	10	1.010	11	10.6	0.849	386.0
15 minute summer	Barns	5.000	Barns_Inlet	24.2	5.147	
2880 minute winter	Barns_Inlet	Flow through pond	Outlet_2	0.6	0.011	
2880 minute winter	Outlet_2	2.000	12	0.2	0.108	
2880 minute winter	12	Hydro-Brake®	Junction	0.2		