Job name:	Goldsborough
Job No:	S10465
Note No:	TN002 Rev C
Date:	15/12/2017
Prepared by:	Sarah Longstaff
Subject:	Drainage Strategy

1 Introduction

1.1.1 jnpgroup were instructed by DH Land Strategy to provide additional information to support the planning application for a site known as Goldsborough (hereinafter referred to as 'the site'). This information is further that that provided in the jnpgroup Technical Note TN001 dated August 2017 which outlines options to drain the site. The additional information required was as follows:

- A more substantial flood risk assessment with reference to the 2015 floods;
- A preliminary drainage strategy;
- Outline measures to mitigate potential floods from within site and shield the existing neighbouring houses from flooded back gardens.

2 Flood Risk Assessment.

Rivers (Fluvial)

2.1.1 The site is approximately 800m east of the River Nidd which flows to the south. The EA Flood Map for Planning shows the site to lie in Flood Zone 1, areas at greater risk of fluvial flooding are not located close to the site. The risk of fluvial flooding is therefore considered to be low.

Coastal and Tidal Flood Risk

2.1.2 The site is located inland and is not near any tidally influenced watercourses; therefore, there is no risk of flooding from this source.

Surface Water Flood Risk (Overland Flows)

2.1.3 Surface water flooding occurs when the rainwater does not drain away through the normal drainage system or infiltrate the ground, but instead lies on or flows over the ground.

2.1.4 The EA produced a Risk of Flooding from Surface Water Map in December 2013. The maps were produced using 'direct rainfall' modelling. Although they take into account local drainage capacity, non-surface water influences such as rivers, seas or groundwater are not considered. The map is based on LIDAR topographic data which is not suitable for site specific assessment and therefore, where available, topographic survey data should be used to provide a more accurate understanding of potential flow paths.

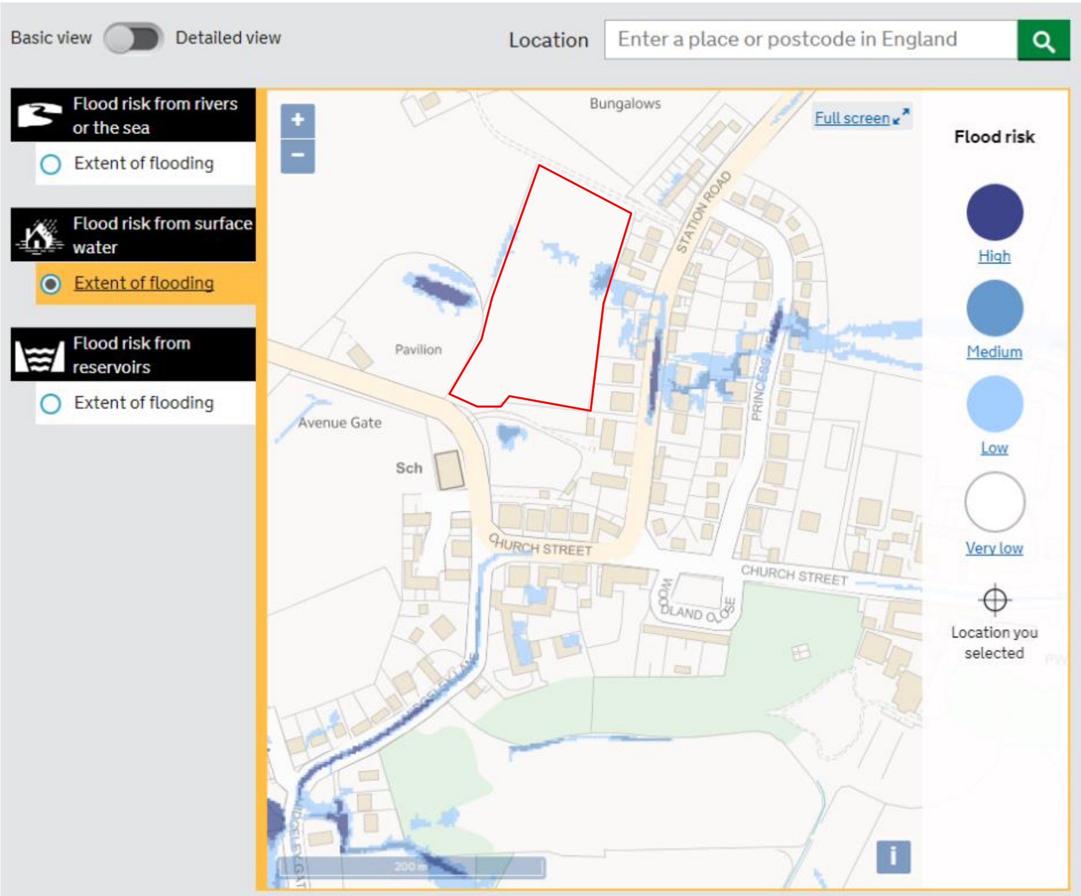
2.1.5 The map shows the entire country within four different risk categories, defined below in Table 1.

Table 1: EA Surface Water Flood Risk Categories

Risk Category	Definition
High	Each year, there is a chance of flooding of greater than 1 in 30 (3.3%)
Medium	Each year, there is a chance of flooding of between 1 in 30 (3.3%) and 1 in 100 (1%)
Low	Each year, there is a chance of flooding of between 1 in 100 (1%) and 1 in 1000 (0.1%)
Very Low	Each year, there is a chance of flooding of less than 1 in 1000 (0.1%)

2.1.6 An extract of the map, provided below in Figure , suggests that the site is at very low to medium risk from surface water flooding.

Figure 1: Environment Agency Flood Risk from Surface Water Map



2.1.7 The low to medium level surface water flooding risk appears to relate to an overland flow route from the higher ground to the west of the site, towards the houses to the east. There is also an area at high risk of surface water flooding close to the western site boundary within the cricket ground.

2.1.8 Photos taken following the heavy rainfall at the end of 2015 confirm that surface water flooding did occur in broadly the areas predicted by the EA modelling (Photo 1).

Photo 1: *Field to the west of the site looking south east with the cricket ground in the background.*

2.1.9 The predicted depth of flooding on site and in the cricket ground from the EA website is less than 300mm. For the areas at higher risk of flooding, the predicted velocity of the flood water is less than 0.25 m/s. For the areas at lower risk of flooding, some of the surface water flood velocities are in excess of 0.25 m/s, directed eastwards across the site towards the existing housing.

2.1.10 Since 2015 and the EA modelling exercise, land drains have been installed in the field bordering the north west side of the site by the farmer. These collect at a manhole on the western side of the site and discharge via a land drain to the north. This is understood to connect to surface watercourses to the north east of the site and has reduced the overland flow across the site.

2.1.11 The risk of surface water flooding is therefore considered low to medium.

Groundwater Flood Risk

2.1.12 Groundwater flooding occurs when the water table rises to the surface and is most likely to occur in low-lying areas underlain by permeable rocks. The site is mostly underlain by typically low permeability Till and is located towards the top of an interfluve. A review of the hydrogeological conditions in the area has been undertaken and is included in Appendix A. Groundwater levels are predicted to be well below ground and the risk of groundwater flooding is assessed as low.

Sewer/Drainage Flood Risk

2.1.13 Sewer flooding is often caused by excess surface water entering the drainage system and when there is insufficient sewer capacity to cope with this excess water, but also due to 'one off' events such as blockages.

2.1.14 In order to fulfil statutory commitments set by OFWAT (The Water Services Regulation Authority), water companies must maintain verifiable records of sewer flooding. This is achieved through DG5 registers that record flooding arising from public foul, combined or surface water sewers and identify where properties flooded internally or externally. In order to maintain customer's privacy, Yorkshire Water only supply this information on a postcode by postcode basis.

2.1.15 The data provided to the North West Yorkshire 2010 SFRA has been analysed and used to inform Critical Drainage Areas. Goldsborough is not listed as a Critical Drainage Area.

2.1.16 For these reasons, the risk of flooding from this source is considered to be low.

Reservoir Flood Risk

2.1.17 The EA has produced a Reservoir Flood Map, that shows that the site is at no risk at all from reservoir flooding.

Summary

2.1.18 The risk of flooding has been assessed as low from all sources apart from surface water. Mitigation measures to address this risk is outlined in the following sections.

3 Drainage Strategy

3.1.1 The National Standards for Sustainable Drainage Systems (Defra, 2011) state that the following options must be considered for disposal of surface water runoff in order of preference:

- Discharge to ground
- Discharge to a surface water body
- Discharge to a surface water sewer
- Discharge to a combined sewer

Discharge to Ground

3.1.2 The underlying geology is indicated to be superficial clay overlying limestone. Seven trial pits were constructed on the site, five on 15th August 2017 and a further two on 7th December 2017 and soakaway tests undertaken in six of the pits. Beneath a topsoil layer of 0.4m, superficial deposits were found in five of the trial pits to depths between 0.9m and in excess of 2.7m bgl (see Appendix B). The superficial deposits were variable but included clay and weathered bedrock mixed with clay. Limestone was present beneath the superficial deposits. In TP4 and TP6 in the centre of the western part of the site, the topsoil directly overlay the limestone. The locations of the trial pits and details of the strata are shown in Appendix B.

3.1.3 Infiltration testing was undertaken in six of the pits and the results are tabulated below.

Table 2: Infiltration test results

Location	Geology	Testing date	Infiltration rate (m/s)
TP4	Topsoil overlying limestone.	August 2017	2.4×10^{-4}
TP6		December 2017	4.9×10^{-5} 5.5×10^{-5} 7.6×10^{-5}
TP1	Topsoil overlying superficial deposits overlying limestone	August 2017	2.3×10^{-6}
TP2		August 2017	9.2×10^{-6}
TP3		August 2017	9.4×10^{-6}
TP7		December 2017	6.1×10^{-6}

3.1.4 In addition, water was left in TP6 and TP7 overnight to confirm that the water would drain completely away over time. Both pits emptied overnight.

3.1.5 Consideration has been given to the depth to the water table and a summary of the local hydrogeological regime is presented in Appendix A. The groundwater level is estimated to be at least 10m below ground level at the site when at a seasonal maximum.

3.1.6 Infiltration systems are therefore considered feasible if extended into the underlying limestone. Limited shallow infiltration should also be feasible into the overlying superficial deposits, for example for private driveways.

4 Preliminary Surface Water Drainage Design

4.1.1 Infiltration drainage will be adopted for the disposal of surface water across the site. In addition, measures will also be introduced to improve the risk of surface water from and to neighbouring sites.

4.1.2 Infiltration rates varied across the site, and probably reflect whether the test was undertaken in the superficial deposits or underlying limestone. The limestone underlies the site, so it could be anticipated that higher infiltration rates may be present across the site, albeit at depth in some parts of the site. Prior to the detailed drainage design, it is recommended that further testing is undertaken to determine whether improved infiltration can be achieved in the eastern part of the site at depth. Where possible, as much of the site as possible should be drained towards the west to maximise the greater infiltration rate found in this part of the site.

4.1.3 Four types of infiltration drainage will be used as discussed below. Reference should also be made to the schematic drainage layout shown in Appendix C.

1. Permeable paving.

4.1.4 Private driveways will be surfaced with permeable paving underlain by voided stone. Water falling onto these areas will drain to ground with the voided stone sub-base providing storage. The depth of the voided stone should be sufficient to allow storage up to a 1 in 200 year plus climate change storm. A provisional design has been undertaken based on these criteria which indicate that a pavement c. 0.45m deep would be required to provide the necessary storage (Appendix C).

2. Main site soakaway.

4.1.5 Run-off from the buildings and the site roads will be captured at source and drained via a soakaway located in public restricted area in the south west of the site, in the area where the highest infiltration was determined. The base of the soakaway will be at c. 4m bgl, in the underlying limestone. This elevation will also allow gravity drainage in the sewers discharging into the soakaway.

4.1.6 The soakaway has been oversized and will store water generated in a 1 in 200 year storm plus climate change. Calculations are included in Appendix C.

4.1.7 The catchment for this soakaway is the majority of the site and so will capture much of the overland flow across the site, directing it to an area with good infiltration capacity. This will provide betterment compared to the existing situation.

3. French drain

4.1.8 A French drain will be constructed between the site and the cricket pitch along the south western site boundary. This will be a stone filled trench containing a permeable pipe connected to the field drains to the west of the site. This will allow infiltration through the base and sides of the trench and will intercept some of the surface water flow which accumulates on the cricket pitch. Any excess flow will be directed towards the field drain. This should protect the development from the surface water flooding that occurs on the cricket pitch and permit infiltration and below ground storage of flood water on the cricket pitch providing betterment compared to the current situation.

4. Soakaways – eastern boundary

4.1.9 An area on the eastern side of the site is not within the catchment area of the main site soakaway. This area, which covers c. 1600 m^2 comprises landscaped areas where water should infiltrate directly into the ground. However, it is also known that there is currently an overland flow issue which impacts properties to the east of the site.

4.1.10 MircroDrainage has been used to assess whether the infiltration rate is sufficient in the superficial deposits to allow rainfall to infiltrate. A simulation was run using the full size of this area (simulated as a 40m by 40m area), the measured infiltration rate and assuming an infiltration blanket (to simulate the soil and superficial deposits) 0.75m thick. Rainfall for all events simulated would infiltrate in this area (see Appendix C).

4.1.11 Overland flow is known to be an issue across the site. Most of the site is drained towards the main soakaway in the western side of the site, which has been over-designed to accommodate additional flows. This in itself will reduce the volume of overland flow towards the eastern site boundary.

4.1.12 To provide additional infiltration capacity, smaller soakaways will be placed close to the eastern site boundary, in the gardens and beneath permeable paving of the proposed properties. A small stone filled trench and bund will also be formed along the boundary where possible such that any surface water running across the site which is not intercepted by the main site drainage or the permeable paving will be diverted to these trenches and then diverted to the small soakaways. The soakaways have been located such that they are 5m away from the proposed buildings and boundary. These measures will reduce the risk of surface water flooding the gardens of the properties to the east of the site, again providing betterment compared to the existing situation.

Maintenance

4.1.13 A maintenance plan will need to be prepared to outline the management of the potential permeable paving, soakaways, pipe networks and associated infrastructure (silt traps etc.).

Post-Development Water Quality Treatment

4.1.14 In line with the 2015 SuDS Manual (CIRIA C753), certain criteria should be applied to manage the quality of run-off to support and protect the natural environment effectively. Treatment design, wherever practicable, should be based on good practice, comprising the following principles:

- Manage surface water run-off close to source
- Treat surface water run-off on the surface
- Treat surface water run-off to remove a range of contaminants
- Minimise risk of sediment remobilisation
- Minimise impacts from accidental spills.

4.1.15 Managing pollution close to the source can help keep pollutant levels and accumulation rates low, essentially allowing natural treatment processes to be effective.

4.1.16 The proposed development comprises two types of land use; residential roofs and then individual property driveways/residential car parks/low traffic roads. These land uses are classified as having very low and low hazard pollution levels, respectively.

4.1.17 As per Table 4.3 of the 2015 SuDS Manual (C753), the minimum water quality management requirement for discharges to groundwater requires the Simplified Index Approach to be applied, which has replaced the previous requirement to provide 'treatment stages'. The Simplified Index Approach uses the following steps:

- Step 1: Allocate suitable pollution hazard indices for the proposed land use
- Step 2: Select SuDS with a total pollution mitigation index that equals or exceeds the pollution hazard index
- Step 3: Where the discharge is to be treated to protect groundwater, consider the need for a more precautionary approach.

4.1.18 ***Step 1***: Table 26.2 of the 2015 SuDS Manual (C753) sets out the required pollution hazard indices for various land uses. The pollution hazard indices for the total suspended solids (hereon referred to as TSS), metals and hydrocarbons is 0.2, 0.2 and 0.05, respectively, for residential roofs and 0.5, 0.4 and 0.4, respectively, for property driveways/residential car parks/low traffic roads. This table is provided in Table .

Table 3: Pollution Hazard Indices from 2015 SuDS Manual (C753)

TABLE 26.2 Pollution hazard indices for different land use classifications

Land use	Pollution hazard level	Total suspended solids (TSS)	Metals	Hydro-carbons
Residential roofs	Very low	0.2	0.2	0.05
Other roofs (typically commercial/ industrial roofs)	Low	0.3	0.2 (up to 0.8 where there is potential for metals to leach from the roof)	0.05
Individual property driveways, residential car parks, low traffic roads (eg cul de sacs, homezones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie < 300 traffic movements/day	Low	0.5	0.4	0.4
Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospitals, retail), all roads except low traffic roads and trunk roads/motorways[1]	Medium	0.7	0.6	0.7
Sites with heavy pollution (eg haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured; industrial sites; trunk roads and motorways[1]	High	0.8[2]	0.8[2]	0.9[2]

4.1.19 ***Step 2:*** The proposed drainage strategy utilises the following SuDS features (to be confirmed at detailed design stage):

- Infiltration devices;
- Permeable paving.

4.1.20 The indicative SuDS mitigation indices, provided in Table 26.4 of the 2015 SuDS Manual (C753) have been reviewed for the proposed features. This table is provided below in Table .

Table 4: Indicative SuDS Mitigation Indices from 2015 SuDS Manual (C753)

TABLE 26.4 Indicative SuDS mitigation indices for discharges to groundwater

Characteristics of the material overlying the proposed infiltration surface, through which the runoff percolates[1]	TSS	Metals	Hydrocarbons
A layer of dense vegetation underlain by a soil with good contaminant attenuation potential[2] of at least 300 mm in depth[3]	0.6[4]	0.5	0.6
A soil with good contaminant attenuation potential[2] of at least 300 mm in depth[3]	0.4[4]	0.3	0.3
Infiltration trench (where a suitable depth of filtration material is included that provides treatment, ie graded gravel with sufficient smaller particles but not single size coarse aggregate such as 20 mm gravel) underlain by a soil with good contaminant attenuation potential[2] of at least 300 mm in depth[3]	0.4[4]	0.4	0.4
Constructed permeable pavement (where a suitable filtration layer is included that provides treatment, and including a geotextile at the base separating the foundation from the subgrade) underlain by a soil with good contaminant attenuation potential[2] of at least 300 mm in depth[3]	0.7	0.6	0.7
Bioretention underlain by a soil with good contaminant attenuation potential[2] of at least 300 mm in depth[3]	0.8[4]	0.8	0.8
Proprietary treatment systems[5, 6]	These must demonstrate that they can address each of the contaminant types to acceptable levels for inflow concentrations relevant to the contributing drainage area.		

4.1.21 To deliver adequate treatment, the selected SuDS components should have a total pollution mitigation index (for each contaminant type) that equals or exceeds the pollution hazard index (for each contaminant type), as follows:

Total SuDS mitigation index ≥ pollution hazard index

(for each contaminant type) (for each contaminant type)

4.1.22 For each type of land-use, the pollution hazard indices, mitigation indices and concluding hazard have been outlined in Table to 7 below.

Table 5: Roof Space Water Quality Mitigation Summary

Residential Roofs				SuDS Manual Reference
	TSS	Metals	Hydrocarbons	
Pollution Hazard Index	0.2	0.2	0.05	Table 26.2
Mitigation Index (Infiltration Trench)	0.4	0.4	0.4	Table 26.4
Result	Total SuDS mitigation index ≥ pollution hazard index and therefore hazard is exceeded			

Table 6: Roads Water Quality Mitigation Summary

Low traffic roads				SuDS Manual Reference
	TSS	Metals	Hydrocarbons	
Pollution Hazard Index	0.5	0.4	0.4	Table 26.2
Mitigation Index (Infiltration Trench)	0.4	0.4	0.4	Table 26.4
Result	Total SuDS mitigation index ≥ pollution hazard index except for TSS			

4.1.23 Silt traps will be placed on the road gulleys which will reduce the level of total suspended solids entering the soakaway.

Table 7: Private Driveways Water Quality Mitigation Summary

Private driveways				SuDS Manual Reference
	TSS	Metals	Hydrocarbons	
Pollution Hazard Index	0.5	0.4	0.4	Table 26.2
Mitigation Index (Infiltration Trench)	0.7	0.6	0.7	Table 26.4
Result	Total SuDS mitigation index ≥ pollution hazard index and therefore hazard is exceeded			

4.1.24 Therefore, it can be concluded that the provision of permeable paving and soakaways mostly exceeds the required pollution mitigation indices and provides sufficient treatment as part of the surface water management train, in accordance with the 2015 SuDS Manual (CIRIA C753). The TSS derived from low traffic roads slightly exceeds the mitigation index and further mitigation will be provided in the form of silt traps on the gulleys.

4.1.25 Step 3: Given that the site is not located in a Source Protection Zone, and there is a considerable unsaturated zone in the underlying strata, it is not considered necessary to apply a more cautionary approach.

5 Conclusions

5.1.1 The risk of the site flooding is low from all sources apart from surface water. This risk can be mitigated by the site surface water drainage.

5.1.2 Infiltration testing has demonstrated that infiltration is a feasible option for the disposal of surface water.

5.1.3 A hydrogeological review has concluded that groundwater levels should be at least 10m bgl and there will therefore be sufficient unsaturated zone beneath the base of the soakaways.

5.1.4 Surface water from roofs and the site roads will be drained to a soakaway in the public restricted area in the south west of the site. This will be sized to store water from a 1 in 200 year flood plus climate change.

5.1.5 Private drives will be surfaced with permeable paving underlain by voided stone to allow direct infiltration into the underlying strata.

5.1.6 A French drain will be installed along the south western boundary to provide additional storage for the predicted surface water flooding on the cricket pitch and to prevent this impinging on the site.

5.1.7 A bund and soakaways will be placed where possible along the eastern site boundary to intercept surface water flowing from the site into neighbouring gardens to the east.

5.1.8 The construction of the infiltration systems, and the robust over-design of these, will reduce the level of surface water flooding both on and off site resulting in betterment of the surface water risk to the neighbouring properties.

Document Issue Record

Technical Note No	Rev	Date	Prepared	Reviewed	Approved
TN002	-	13.12.2017	SLL	KG	KG
TN002	A	15.12.2017	SLL	KG	KG
TN002	B	11.07.2018	HB	SLL	SLL
TN002	C	18.07.2017	SLL	KG	KG

List of Appendices

Appendix A **Hydrogeological Review**

Appendix B **Infiltration Testing Results**

Appendix C **Preliminary Drainage Design & Associated Calculations**

Appendix A

Hydrogeological Review

Job name:	Goldsborough
Job No:	S10465
Note No:	TN002
Date:	04/12/2017
Prepared by:	Sarah Longstaff
Subject:	Hydrogeological Assessment

1 Introduction

1.1.1 jnpgroup were instructed by DH Land Strategy to provide information to support a response to Harrogate Borough Council. The Council has commented on the proposed Drainage Assessment undertaken for the site (TN001-Rev B). This recommends that additional soakaway testing is undertaken and specifies that 'Industry guidance recommends that trial hole and infiltration testing should be undertaken at least four times overall, during different seasons'.

1.1.2 It is understood that further soakaway testing will be undertaken at the site, ideally over the next month, and this will be generally in accordance with BRE 365. The test will be repeated three time if feasible.

1.1.3 The requirement to undertake testing during different seasons is recommended in industry guidance. The sentiment behind this requirement is understood, in that to ensure that there is adequate freeboard beneath the base of a soakaway, the maximum elevation of the groundwater needs to be understood. This can be achieved by monitoring, which will introduce a delay in gathering information, so that seasonal maxima can be measured. Alternatively, a review of the local hydrogeology can be undertaken to assess the likely maximum groundwater level. This note presents an assessment of anticipated groundwater levels beneath the site.

2 Geology and Hydrogeology

2.1.1 The geology of the site was determined by reference to the 1:50,000 scale British Geological Survey (BGS) online GeoIndex Tool (http://mapapps2.bgs.ac.uk/geoindex/home.html).

2.1.2 There are no artificial or mass movement deposits beneath the site. There are two types of superficial deposits beneath the site. The north western part of the site is underlain by Devensian Glaciolacustrine Deposits which the BGS describe as clay. The north eastern and central part of the site are underlain by the Vale of York Formation (formerly known as Boulder Clay and Glacial Till). The bedrock beneath the site comprises the Brotherton Formation which the BGS describe as *'Limestone, dolomitic, grey with abundant Calcinema'* and was formerly known as the Magnesian Limestone. The area approximately 100m to the north of the site is underlain by the Roxby Formation which is a calcareous mudstone. The bedrock dips to the east in this area therefore the Roxby Formation overlies the Brotherton Formation and the site is located towards the top of the Brotherton Formation. There is a south west to north east trending fault across the northern part of the site but the Brotherton Formation subcrops on both sides of the fault on the site.

2.1.3 jnpgroup consulted online borehole records held by the BGS. There is a deep borehole used as a well located at Cockstone Hill Farm c. 300m to the north west. The well was constructed in 1995 at which point a pumping test was undertaken. The borehole penetrated brown clay to 3m, sand and gravel to 15.5m, brown limestone and marl to 48m and brown limestone to 68m. At the start of the pumping test, the rest water level was 14.47m below datum (usually near ground level) and declined to 15.28m after two days testing (tested in July 1995).

2.1.4 The five trial pits constructed on the site on August 2017 determined superficial deposits to depths between 0.9m and in excess of 2.7m bgl. Limestone was present beneath the superficial deposits. In TP4 in the centre of the western part of the site, the topsoil directly overlay the limestone.

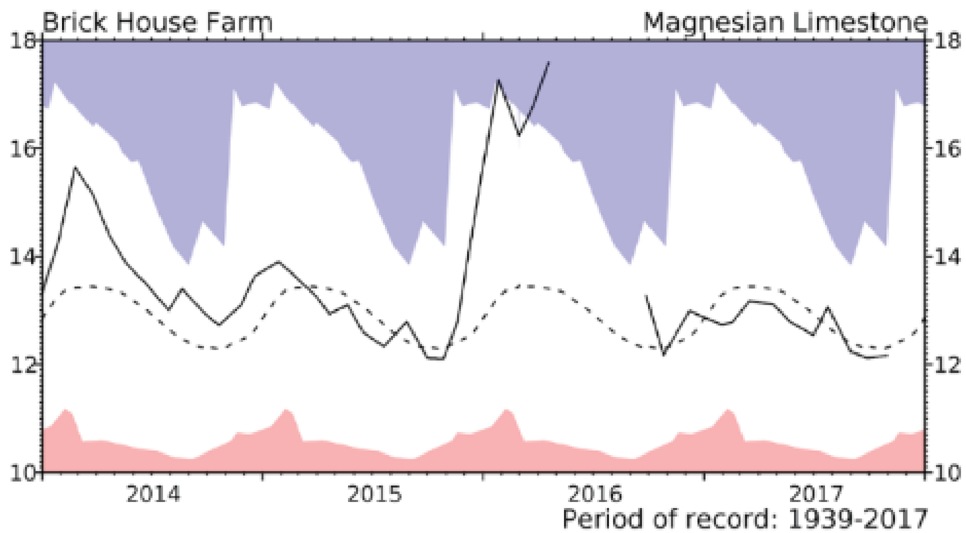
2.1.5 The elevation of the site is c. 46m to 49.5m above Ordnance datum (aOD) and the ground elevation at the borehole at Cockstone Hill Farm c. 50m aOD. The site is located towards the top of an interfluve with the River Nidd to the west. The River Nidd is at an elevation of 33m aOD to the west of the site.

2.1.6 The water table in unconfined aquifers is often a subdued replica of the topography. As the Brotherton Formation extends almost to the Nidd in the west, it could be anticipated that the groundwater flows from the site towards the river where it discharges into the river or superficial deposits in the river valley and contributes to the baseflow of the river.

2.1.7 Away from the river, the water table will rise and it is known that the water table was at least 10m below the ground level at the site when the pumping test was undertaken.

2.1.8 The water table will also vary seasonally. CEH monitor key boreholes across the country including a borehole in Wharfedale which penetrates the Magnesian Limestone, approximately 15km to the south east. The Brick House Farm borehole is located on an outcrop of the Brotherton Formation with the River Wharfe to the east. The elevation of the river is c. 7m aOD and the site is on the valley side at c. 53m aOD. The seasonal range in groundwater levels would be expected to be greater in such a scenario than at the site in Goldsborough. The hydrograph from the borehole shows that the seasonal maxima generally occur between January and February with the minima around September with a range of c. 1.5m.

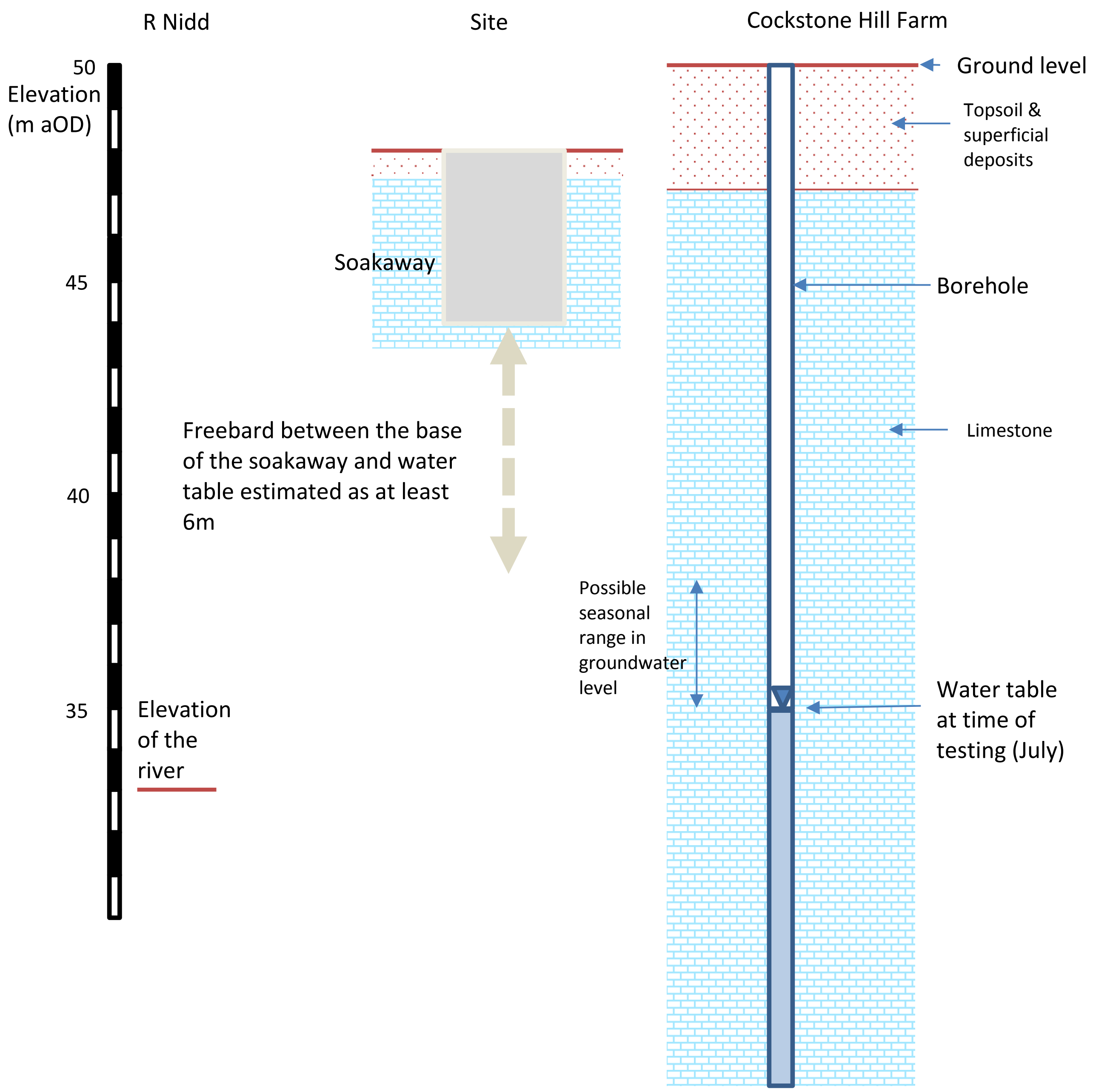
Figure 1: Magnesian Limestone Hydrograph



2.1.9 Collating this data, and allowing a greater variation is seasonal groundwater levels, it has been estimated that there will be at least 6m of unsaturated zone beneath the base of any soakaways at this site. This is 5m more than is generally required and this estimate has been made using conservative estimates. The data has been collated schematically as shown overleaf.

2.1.10 Seasonal measurement of groundwater levels is deemed unnecessary at the site and it concluded that there will be sufficient unsaturated zone beneath any soakaways that may be installed, subject to the findings of the further testing.

Figure 2: Collation of groundwater level data

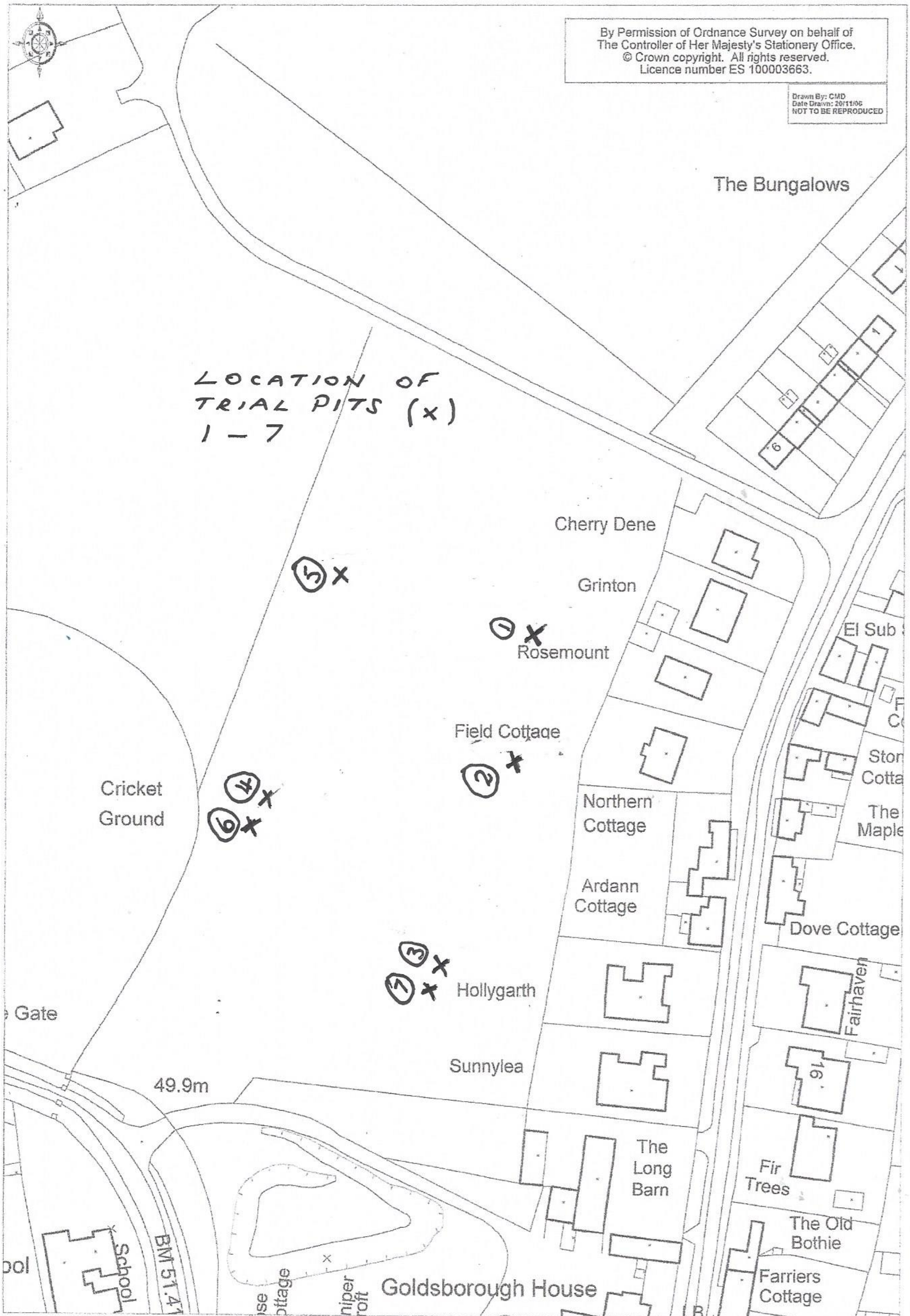


Document Issue Record

Technical Note No	Rev	Date	Prepared	Reviewed	Approved
TN002	-	04/12/2017	SLL	AS	AS

Appendix B

Infiltration Testing Results



This map was created by Lister Haigh Ltd

Trial Pit Lithology (client's description)

Top of strata (mm bgl)	Base of strata (mm bgl)	Description
Test Hole 1		
0	400	Loam topsoil
400	800	Compacted subsoil (sand & clay)
800	1800	Blue clay
1800	2700	Red clay mixed with limestone rock
Test Hole 2		
0	400	Loam topsoil
400	900	Subsoil salmon coloured limestone mix of clay & rock
900	1200	Limestone bed rock
Test Hole 3		
0	400	Loam Topsoil
400	900	Compacted sand & clay subsoil mix
900	1500	Red clay mixed with fragmented rock
1500	2000	Limestone bedrock
Test Hole 4		
0	400	Loam topsoil
400	1500	Limestone bedrock
Test Hole 5		
0	400	Loam topsoil
400	1600	Clay based subsoil
1600	2100	Compacted clay/ sand/ fragmented rock on to bedrock
Test Hole 6 (adjacent to TP4)		
0	400	Loam topsoil
400	3850	Limestone bedrock
Test Hole 7 (adjacent to TP3)		
0	400	Loam topsoil
400	900	Compacted sand and clay subsoil mix
900	1500	Red clay subsoil mix with rock fragments
1500	2800	Limestone bedrock

jnpgroup
Woodvale House
Woodvale Road
Brighouse
HD6 4AB
Tel 01484 400691
brighouse@jnpgroup.co.uk

john newton & partners
jnpgroup
Consulting Engineers

SOIL INFILTRATION TEST

Project:
Goldsborough

Project No:
S10465

Test Location: TP1 | Test No: 1 | Date: 15 Aug 2017

Water level during test

Time mins	Depth m bgl
0	0.86
6	0.88
16	0.9
20	0.92
40	0.93
80	0.98

Trial pit dimensions

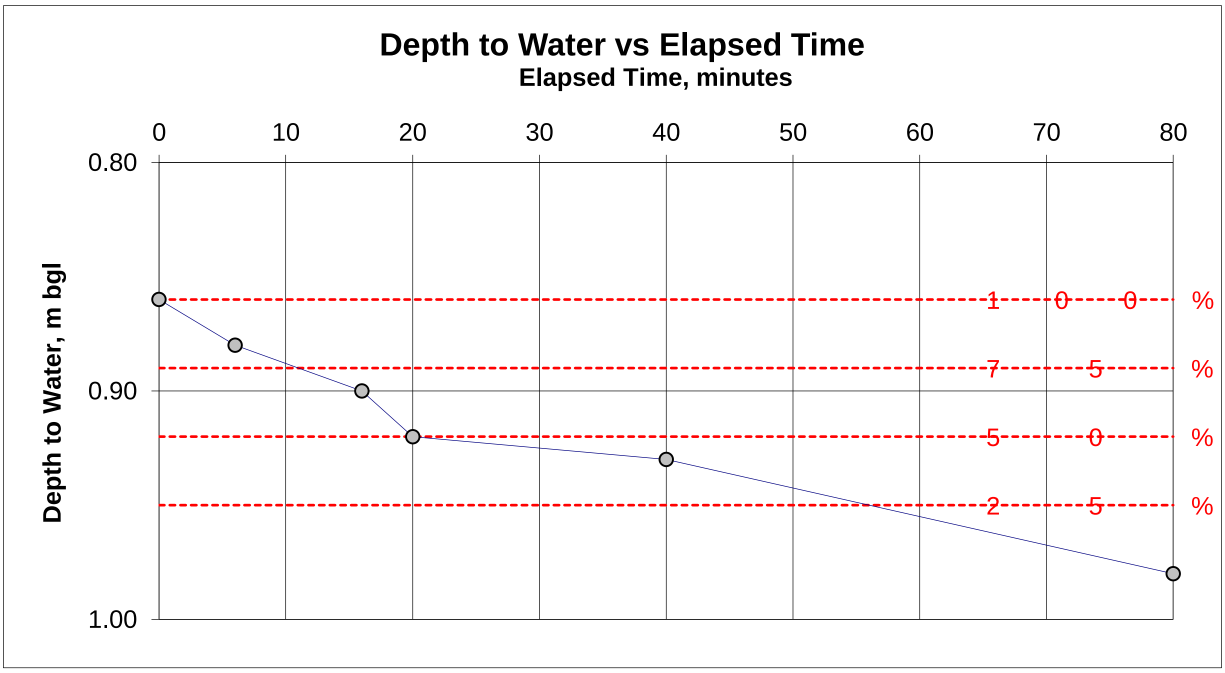
depth (m)	2.70
length (m)	1.30
width (m)	0.60

$$f = \frac{V_p}{\alpha_p \times t_p}$$

f = soil infiltration rate
Vp = volume of water from 75% to 25% effective depth
αp = Internal surface area at 50% effective depth
tp = time for the water level to fall from 75% to 25% effective depth

time at 75% effective depth (mins) 10
time at 25% effective depth (mins) 55
(from graph)

Calculated Soil Infiltration Rate = 2.3E-06 m/sec



jnpgroup
Woodvale House
Woodvale Road
Brighouse
HD6 4AB
Tel 01484 400691
brighouse@jnpgroup.co.uk

john newton & partners jnpgroup Consulting Engineers

SOIL INFILTRATION TEST

Project:
Goldsborough

Project No:
S10465

Test Location: TP2 | Test No: 1 | Date: 15 Aug 2017

Water level during test

Time mins	Depth m bgl
0	0.34
4	0.37
6	0.39
13	0.42
23	0.43
111	0.55
125	0.56
141	0.57
165	0.58

Trial pit dimensions

depth (m)	1.20
length (m)	1.60
width (m)	2.00

$$f = \frac{V_p}{\alpha_p \times t_p}$$

f = soil infiltration rate

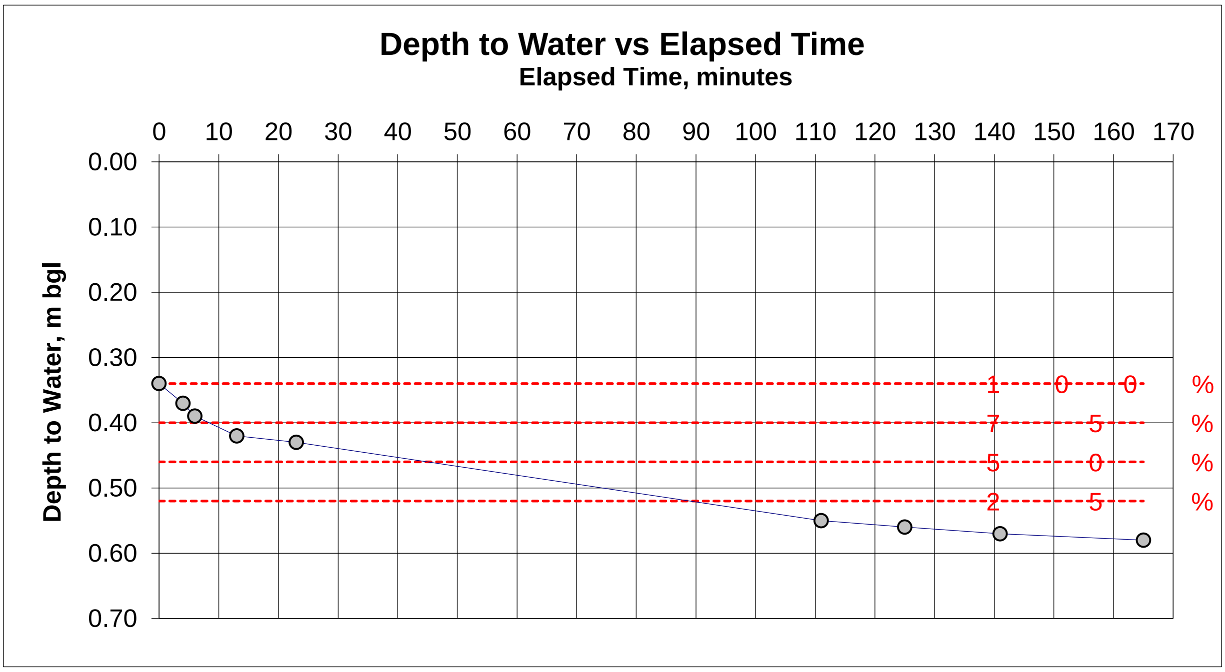
Vp = volume of water from 75% to 25% effective depth

αp = Internal surface area at 50% effective depth

tp = time for the water level to fall from 75% to 25% effective depth

time at 75% effective depth (mins) 8
time at 25% effective depth (mins) 90
(from graph)

Calculated Soil Infiltration Rate = 9.2E-06 m/sec



jnpgroup
Woodvale House
Woodvale Road
Brighouse
HD6 4AB
Tel 01484 400691
brighouse@jnpgroup.co.uk

john newton & partners
jnpgroup
Consulting Engineers

SOIL INFILTRATION TEST

Project:
Goldsborough

Project No:
S10465

Test Location: TP3 | Test No: 1 | Date: 15 Aug 2017

Water level during test

Time mins	Depth m bgl
0	0.67
5	0.7
14	0.74
31	0.81
75	0.9
93	0.94
105	0.95
130	0.98

Trial pit dimensions

depth (m)	2.00
length (m)	1.20
width (m)	1.40

$$f = \frac{V_p}{\alpha_p \times t_p}$$

f = soil infiltration rate

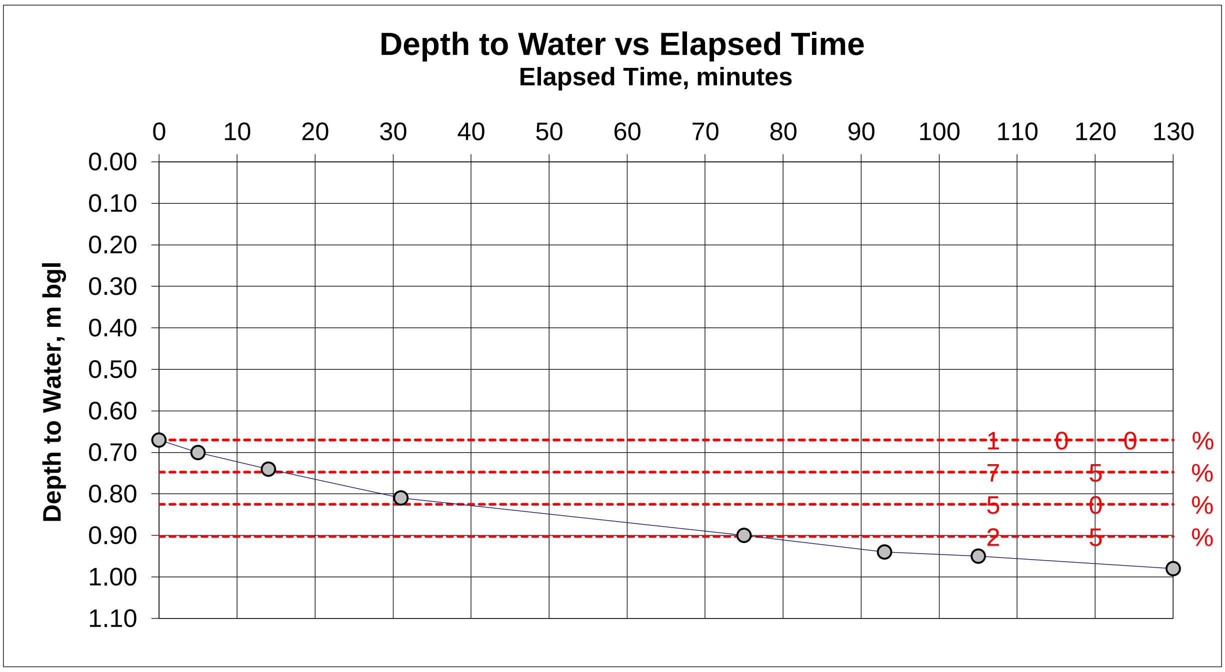
Vp = volume of water from 75% to 25% effective depth

αp = Internal surface area at 50% effective depth

tp = time for the water level to fall from 75% to 25% effective depth

time at 75% effective depth (mins) 16
time at 25% effective depth (mins) 75
(from graph)

Calculated Soil Infiltration Rate = 9.4E-06 m/sec



jnpgroup
Woodvale House
Woodvale Road
Brighouse
HD6 4AB
Tel 01484 400691
brighouse@jnpgroup.co.uk

john newton & partners jnpgroup Consulting Engineers

SOIL INFILTRATION TEST

Project:
Goldsborough

Project No:
S10465

Test Location: TP4 | Test No: 1 | Date: 15 Aug 2017

Water level during test

Time mins	Depth m bgl
0	0.64
25	1.5

Trial pit dimensions

depth (m)	1.50
length (m)	1.20
width (m)	1.10

$$f = \frac{V_p}{\alpha_p \times t_p}$$

f = soil infiltration rate

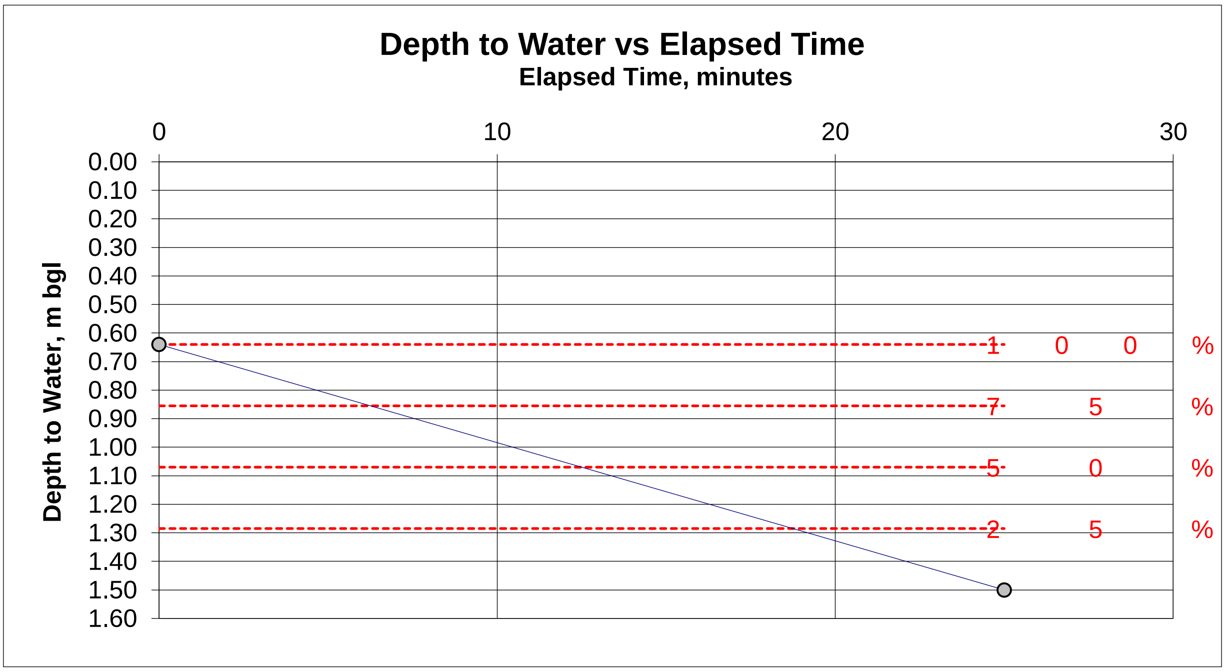
Vp = volume of water from 75% to 25% effective depth

αp = Internal surface area at 50% effective depth

tp = time for the water level to fall from 75% to 25% effective depth

time at 75% effective depth (mins)	6
time at 25% effective depth (mins)	18
(from graph)	

Calculated Soil Infiltration Rate = 2.4E-04 m/sec



jnpgroup
Woodvale House
Woodvale Road
Brighouse
HD6 4AB
Tel 01484 400691
brighouse@jnpgroup.co.uk

john newton & partners
jnpgroup
Consulting Engineers

SOIL INFILTRATION TEST

Project:
Goldsborough

Project No:
S10465

Test Location: TP6 | Test No: 5 | Date: 6th December 2017

Water level during test

Time mins	Depth m bgl
0	2.76
8	2.8
10	2.83
12	2.88
15	2.91
18	3.01
22	3.05
27	3.1
29	3.12
34	3.14
36	3.18
44	3.200
48	3.220
58	3.300
89	3.500

Trial pit dimensions

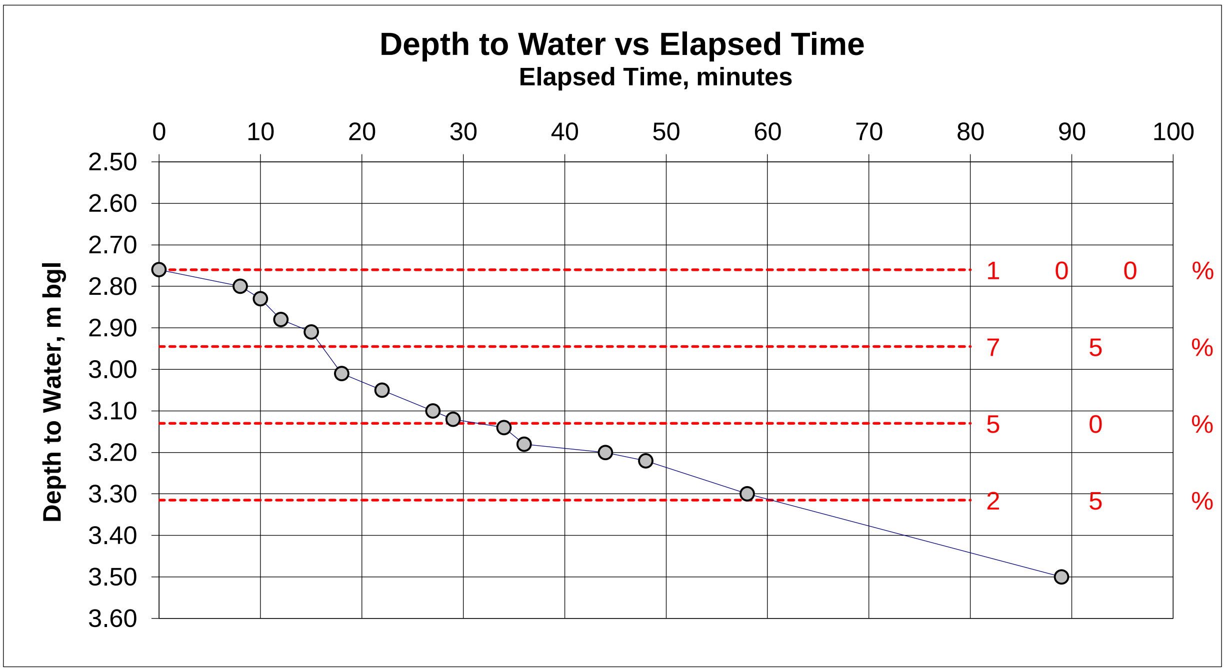
depth (m)	3.85
length (m)	2.80
width (m)	1.00

$$f = \frac{V_p}{\alpha_p \times t_p}$$

f = soil infiltration rate
Vp = volume of water from 75% to 25% effective depth
αp = Internal surface area at 50% effective depth
tp = time for the water level to fall from 75% to 25% effective depth

time at 75% effective depth (mins) 17
time at 25% effective depth (mins) 60
(from graph)

Calculated Soil Infiltration Rate = 4.9E-05 m/sec



jnpgroup
Woodvale House
Woodvale Road
Brighouse
HD6 4AB
Tel 01484 400691
brighouse@jnpgroup.co.uk

john newton & partners
jnpgroup
Consulting Engineers

SOIL INFILTRATION TEST

Project:
Goldsborough

Project No:
S10465

Test Location: TP6 | Test No: 6 | Date: 6th December 2017

Water level during test

Time mins	Depth m bgl
0	2.65
5	2.75
8	2.8
18	2.96
22	3.01
36	3.12
57	3.26

Trial pit dimensions

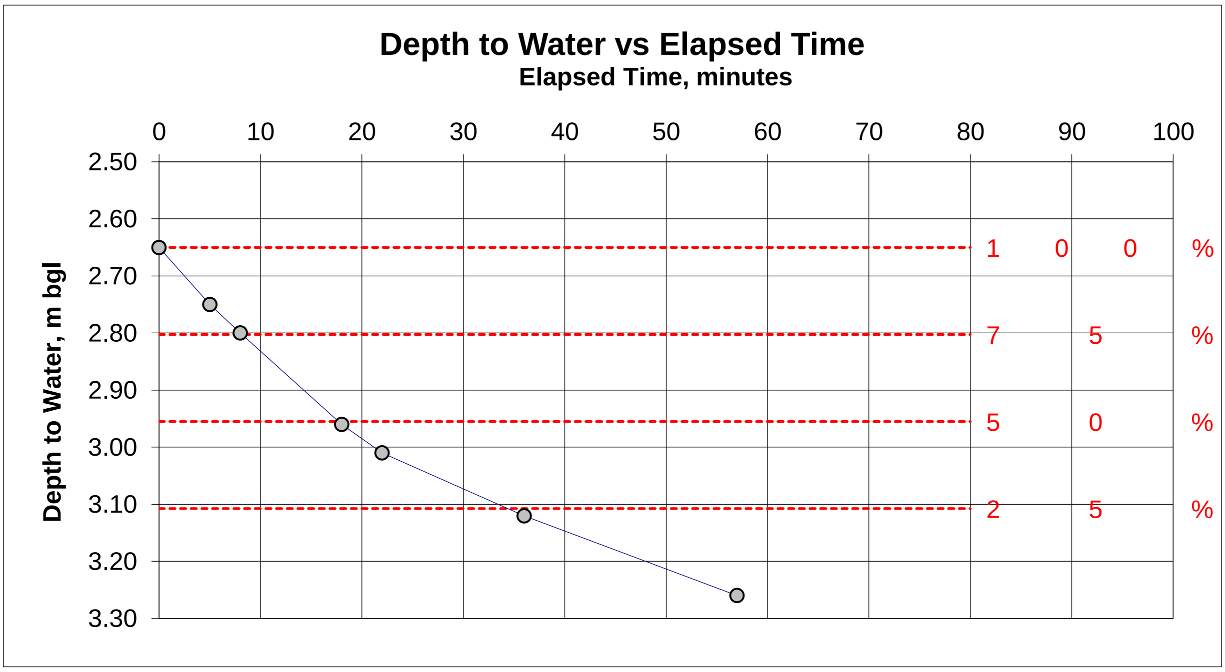
depth (m)	3.85
length (m)	2.80
width (m)	1.00

$$f = \frac{V_p}{\alpha_p \times t_p}$$

f = soil infiltration rate
Vp = volume of water from 75% to 25% effective depth
αp = Internal surface area at 50% effective depth
tp = time for the water level to fall from 75% to 25% effective depth

time at 75% effective depth (mins)	8
time at 25% effective depth (mins)	35
(from graph)	

Calculated Soil Infiltration Rate = 5.5E-05 m/sec



jnpgroup
Woodvale House
Woodvale Road
Brighouse
HD6 4AB
Tel 01484 400691
brighouse@jnpgroup.co.uk

john newton & partners
jnpgroup
Consulting Engineers

SOIL INFILTRATION TEST

Project:
Goldsborough

Project No:
S10465

Test Location: TP6 | Test No: 7 | Date: 7th December 2017

Water level during test

Time mins	Depth m bgl
0	2.31
5	2.49
12	2.68
21	2.83
36	3.04
46	3.11
51	3.16

Trial pit dimensions

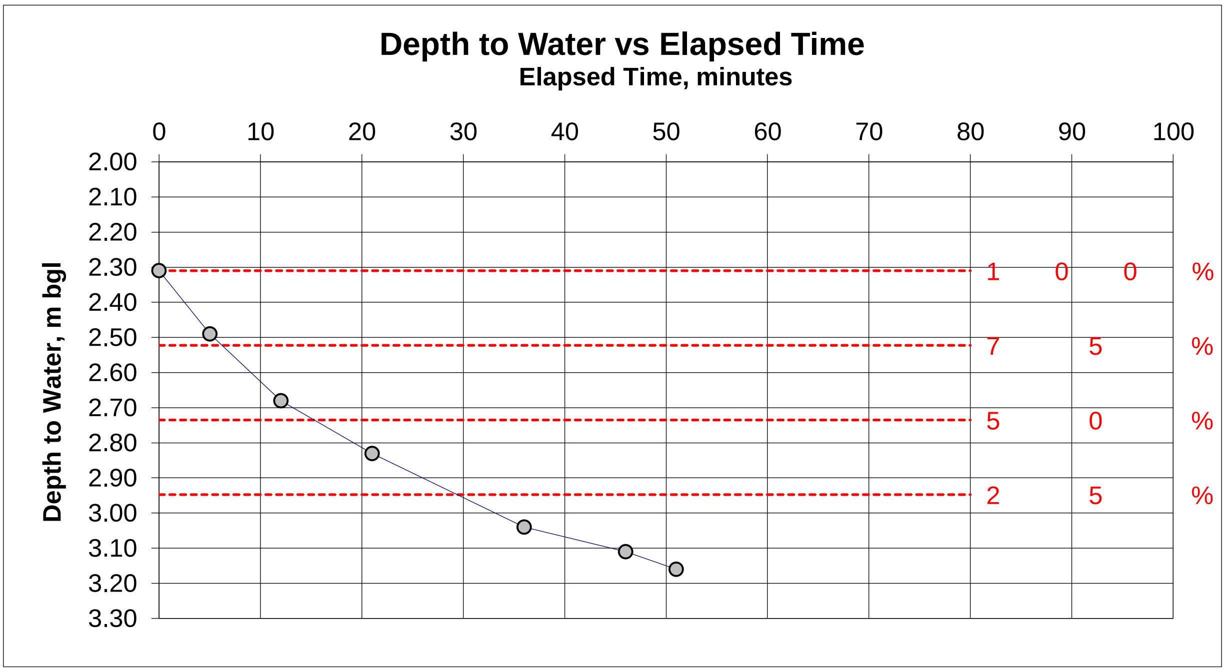
depth (m)	3.85
length (m)	2.80
width (m)	1.00

$$f = \frac{V_p}{\alpha_p \times t_p}$$

f = soil infiltration rate
Vp = volume of water from 75% to 25% effective depth
αp = Internal surface area at 50% effective depth
tp = time for the water level to fall from 75% to 25% effective depth

time at 75% effective depth (mins) 7
time at 25% effective depth (mins) 30
(from graph)

Calculated Soil Infiltration Rate = 7.6E-05 m/sec



jnpgroup
Woodvale House
Woodvale Road
Brighouse
HD6 4AB
Tel 01484 400691
brighouse@jnpgroup.co.uk

john newton & partners
jnpgroup
Consulting Engineers

SOIL INFILTRATION TEST

Project:
Goldsborough

Project No:
S10465

Test Location: TP7 | Test No: 8 | Date: 7th December 2017

Water level during test

Time mins	Depth m bgl
0	2.16
2	2.18
6	2.2
14	2.22
24	2.25
48	2.29
57	2.3
79	2.34

Trial pit dimensions

depth (m)	3.85
length (m)	2.80
width (m)	1.00

$$f = \frac{V_p}{\alpha_p \times t_p}$$

f = soil infiltration rate

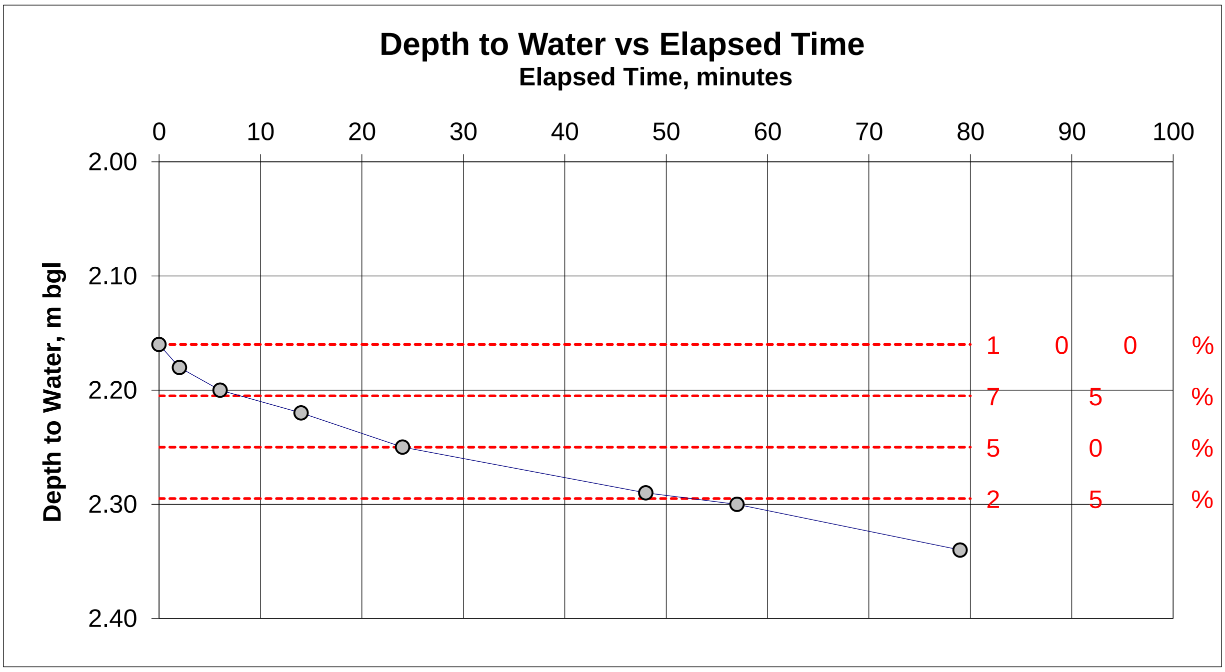
Vp = volume of water from 75% to 25% effective depth

αp = Internal surface area at 50% effective depth

tp = time for the water level to fall from 75% to 25% effective depth

time at 75% effective depth (mins) 7
time at 25% effective depth (mins) 53
(from graph)

Calculated Soil Infiltration Rate = 6.1E-06 m/sec



Appendix C

Preliminary Drainage Design & Associated Calculations

jnpgroup

Drainage Notes

1. All pipes to be 100mm diameter unless noted otherwise.
2. All surface water pipework beneath permeable paving to be perforated
3. Below ground drainage to be constructed in accordance with BS EN 752, BS EN 1610 & BS EN 12056-2 (current editions).
4. Foul & surface water drainage systems shall be tested to ensure the systems are laid & functioning correctly. Testing to be carried out with accordance with BS EN 1610.
5. No branch connections to be formed beneath the building footprint.
6. All 100/110mmØ foul water drains to have a minimum gradient of 1:40 unless a WC is connected in which case the minimum gradient is 1:80
7. Wider Site drainage strategy (Gateway 36 - Phase1) served by approved SuDS system comprising of enlarged drainage pond to north east.
8. Site surface water accommodated by SuDS system providing development doesn't exceed maximum impermeable area of 3975sqm

Notes:-

1. Where this drawing has been issued in electronic .dwg format it has been done so in good faith. jnpgroup do not take any responsibility for any inaccuracies in the electronic data, which should be checked against the paper (or .pdf) drawing issue. Any apparent discrepancies should be immediately reported to jnpgroup. The electronic .dwg file should not be assumed to be to scale and should not be used for 'overlaying', setting out or checking of any third party information. All dimensions should be taken from the paper (or .pdf) version of the drawing. Electronic drawings may contain third party information. jnpgroup take no responsibility for this information, which should be checked against the originators paper drawing(s).
2. All working dimensions to be checked on site.
3. Do not scale.
4. Any discrepancies between drawings of different scales, and between drawings and specification where appropriate to be notified to The Engineer for decision.
5. Copyright reserved. This drawing may only be used for The Client and location specified in the title block. It may not be copied or disclosed to any third party without the prior written consent of jnpgroup.
6. This drawing should only be used for construction if the drawing status is "Construction". jnpgroup take no responsibility for construction works undertaken to drawings which are not marked with this status.

Health and Safety Note:
The details on this drawing have been prepared on the assumption that a competent contractor will be carrying out the works. If the contractor(s) considers that there is insufficient Health and Safety information on this drawing, this should immediately be brought to the attention of the designer.

KEY

- SITE BOUNDARY
- SW DRAIN/SEWER
- SW MANHOLE
- SW INSPECTION CHAMBER
- RODDING EYE
- GULLY
- EXISTING SEWER
- PROPOSED LAND DRAIN
- PROPOSED STONE TRENCH WITH BUND AND PERFORATED PIPE
- PROPOSED SOAKAWAY
- PROPOSED PERMEABLE PAVING

Rev.	Date	Amendment	By	Chk.
F	11.07.18	Rev A-D not issued. Minor amendments to road layout.	JK	HB

Status: Preliminary

john newton & partners
jnpgroup
Consulting Engineers
www.jnpgroup.co.uk
Chesham • Brighouse • Hartlepool • Leamington Spa • **Sheffield**
Tel: 0114 244 3500 E-mail: sheffield@jnpgroup.co.uk

Client: DH LAND STRATEGY

Job: GOLDSBOROUGH

Title: PRELIMINARY DRAINAGE PLAN

Scale	1:500 @ A1	Date	12.12.17

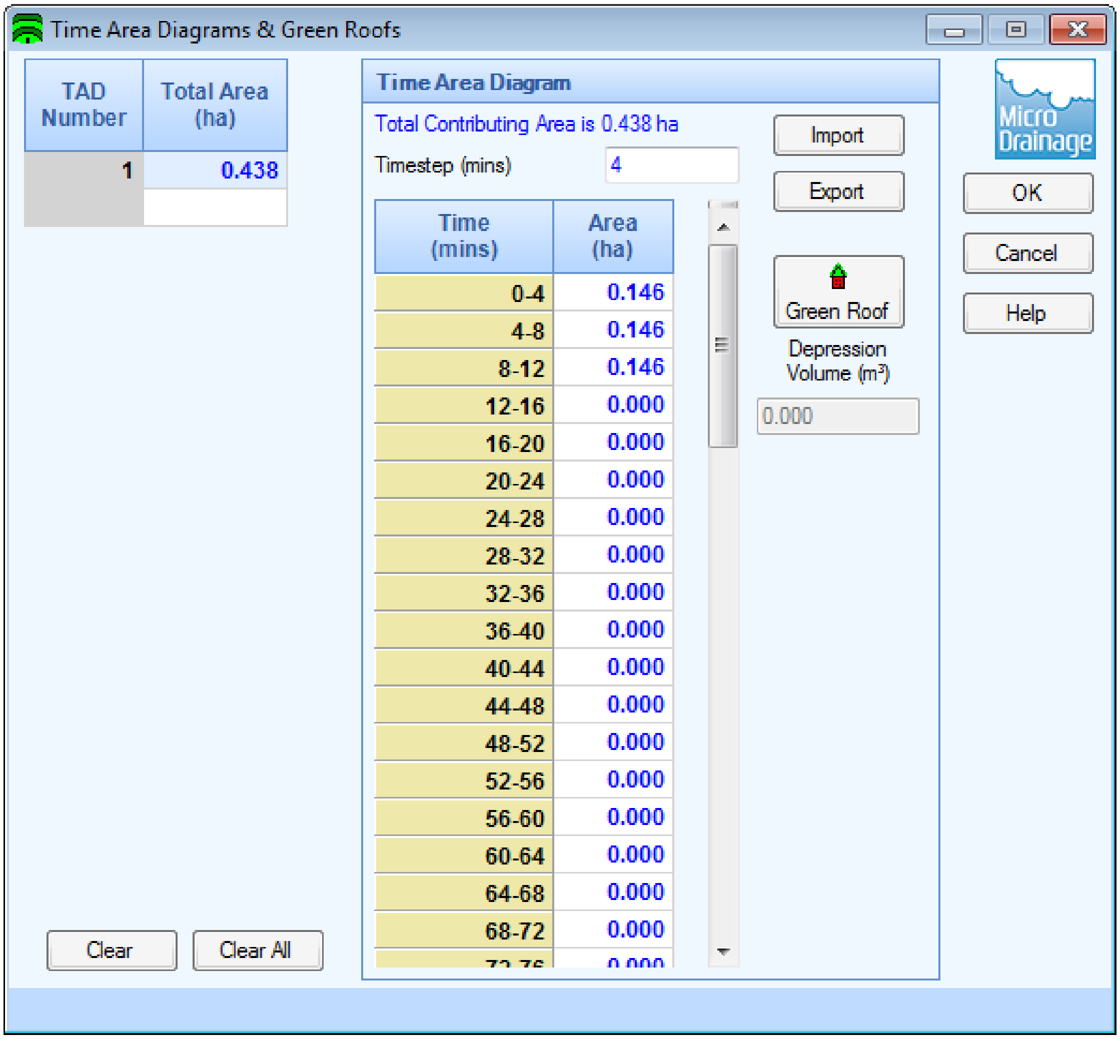
Drawn By	DAB	Eng. Check	SL	Tech. Check	

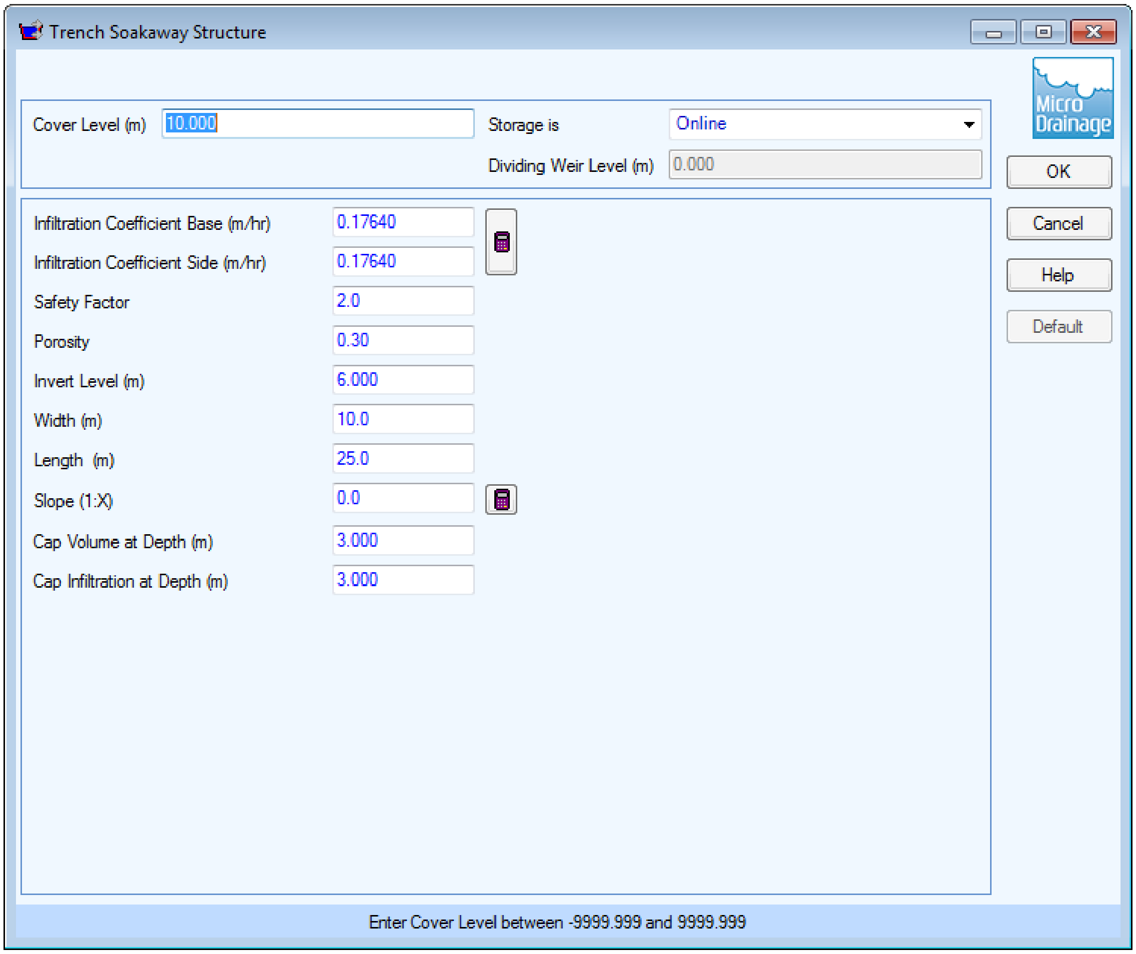
BMTRADA ISO 9001 — UKAS Quality Management 012 — CHAS Accredited Contractor — Constructionline Part of Capita plc — RISQS Audited Supplier No. 000026

HAZARD IDENTIFICATION BOX		
This table is provided to assist the Principal Contractor to fulfil their obligations under the CDM Regulations 2007		
Construction Hazard	Maintenance / Cleaning Hazard	Demolition / Adaption Hazard

Drawing No.: S10465-01 — Rev.: F

QA Ref: QD0190 Rev B


Time Area Diagrams & Green Roofs
TAD Number
Total Area (ha)
1
0.438
Clear
Clear All
Time Area Diagram
Total Contributing Area is 0.438 ha
Timestep (mins)
4
Time (mins)
Area (ha)
0-4 0.146
4-8 0.146
8-12 0.146
12-16 0.000
16-20 0.000
20-24 0.000
24-28 0.000
28-32 0.000
32-36 0.000
36-40 0.000
40-44 0.000
44-48 0.000
48-52 0.000
52-56 0.000
56-60 0.000
60-64 0.000
64-68 0.000
68-72 0.000
Import
Export
Green Roof
Depression Volume (m³)
0.000
Micro Drainage
OK
Cancel
Help


Trench Soakaway Structure
Cover Level (m)
10.000
Storage is
Online
Dividing Weir Level (m)
0.000
Micro Drainage
OK
Cancel
Help
Default
Infiltration Coefficient Base (m/hr)
0.17640
Infiltration Coefficient Side (m/hr)
0.17640
Safety Factor
2.0
Porosity
0.30
Invert Level (m)
6.000
Width (m)
10.0
Length (m)
25.0
Slope (1:X)
0.0
Cap Volume at Depth (m)
3.000
Cap Infiltration at Depth (m)
3.000
Enter Cover Level between -9999.999 and 9999.999

Summary of Results for 200 year Return Period (+40%)

Half Drain Time : 197 minutes.

Storm Event	Rain (mm/hr)	Time to Vol Peak (mins)	Max Water Level (m)	Max Depth (m)	Flooded Volume (m³)	Max Filtration (l/s)	Σ Max Outflow (l/s)	Maximum Volume (m³)	Status
60 min Summer	63.278	66	8.357	2.357	0.0	10.2	10.2	176.8	O K
120 min Summer	38.739	122	8.591	2.591	0.0	10.6	10.6	194.3	O K
180 min Summer	28.627	160	8.590	2.590	0.0	10.6	10.6	194.3	O K
240 min Summer	22.930	190	8.537	2.537	0.0	10.5	10.5	190.3	O K
360 min Summer	16.673	258	8.396	2.396	0.0	10.2	10.2	179.7	O K
480 min Summer	13.307	326	8.273	2.273	0.0	10.0	10.0	170.5	O K
600 min Summer	11.161	396	8.160	2.160	0.0	9.8	9.8	162.0	O K
720 min Summer	9.663	464	8.052	2.052	0.0	9.6	9.6	153.9	O K
960 min Summer	7.689	598	7.847	1.847	0.0	9.3	9.3	138.5	O K
1440 min Summer	5.561	862	7.484	1.484	0.0	8.7	8.7	111.3	O K
2160 min Summer	4.013	1240	7.046	1.046	0.0	7.9	7.9	78.5	O K
2880 min Summer	3.180	1596	6.712	0.712	0.0	7.3	7.3	53.4	O K
4320 min Summer	2.286	2296	6.274	0.274	0.0	6.6	6.6	20.5	O K
5760 min Summer	1.807	2944	6.069	0.069	0.0	6.2	6.2	5.2	O K
7200 min Summer	1.504	3664	6.044	0.044	0.0	5.4	5.4	3.3	O K
8640 min Summer	1.294	4400	6.037	0.037	0.0	4.6	4.6	2.8	O K
10080 min Summer	1.139	5112	6.033	0.033	0.0	4.1	4.1	2.5	O K
15 min Winter	149.283	25	7.693	1.693	0.0	9.0	9.0	127.0	O K
30 min Winter	99.619	38	8.214	2.214	0.0	9.9	9.9	166.1	O K
60 min Winter	63.278	66	8.683	2.683	0.0	10.7	10.7	201.2	O K
120 min Winter	38.739	120	8.988	2.988	0.0	11.2	11.2	224.1	O K
180 min Winter	28.627	174	10.000	4.000	1.0	11.3	11.3	226.0	FLOOD
240 min Winter	22.930	200	8.948	2.948	0.0	11.2	11.2	221.1	O K
360 min Winter	16.673	276	8.781	2.781	0.0	10.9	10.9	208.6	O K
480 min Winter	13.307	352	8.597	2.597	0.0	10.6	10.6	194.8	O K
600 min Winter	11.161	428	8.431	2.431	0.0	10.3	10.3	182.4	O K
720 min Winter	9.663	500	8.271	2.271	0.0	10.0	10.0	170.3	O K
960 min Winter	7.689	644	7.969	1.969	0.0	9.5	9.5	147.7	O K
1440 min Winter	5.561	916	7.448	1.448	0.0	8.6	8.6	108.6	O K
2160 min Winter	4.013	1300	6.852	0.852	0.0	7.6	7.6	63.9	O K
2880 min Winter	3.180	1648	6.425	0.425	0.0	6.9	6.9	31.9	O K
4320 min Winter	2.286	2152	6.048	0.048	0.0	5.9	5.9	3.6	O K
5760 min Winter	1.807	2904	6.038	0.038	0.0	4.7	4.7	2.8	O K
7200 min Winter	1.504	3648	6.032	0.032	0.0	3.9	3.9	2.4	O K
8640 min Winter	1.294	4280	6.027	0.027	0.0	3.4	3.4	2.0	O K
10080 min Winter	1.139	5048	6.024	0.024	0.0	3.0	3.0	1.8	O K

Flood of 1.0 m^3 can be adequately accommodated in the sewer.

MicroDrainage Output for infiltration into soft landscaping areas in the eastern side of the site

Summary of Results for 200 year Return Period (+40%)

Half Drain Time : 4874 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	9.342	0.092	0.3	45.1	O K
30 min Summer	9.373	0.123	0.3	60.0	O K
60 min Summer	9.406	0.156	0.3	76.0	O K
120 min Summer	9.440	0.190	0.3	92.5	O K
180 min Summer	9.459	0.209	0.3	101.9	O K
240 min Summer	9.472	0.222	0.3	108.2	O K
360 min Summer	9.490	0.240	0.3	116.7	O K
480 min Summer	9.502	0.252	0.3	122.9	O K
600 min Summer	9.512	0.262	0.3	127.5	O K
720 min Summer	9.519	0.269	0.3	131.1	O K
960 min Summer	9.530	0.280	0.3	136.3	O K
1440 min Summer	9.542	0.292	0.3	142.3	O K
2160 min Summer	9.549	0.299	0.3	145.7	O K
2880 min Summer	9.549	0.299	0.3	145.6	O K
4320 min Summer	9.540	0.290	0.3	141.1	O K
5760 min Summer	9.529	0.279	0.3	136.1	O K
7200 min Summer	9.519	0.269	0.3	131.2	O K
8640 min Summer	9.509	0.259	0.3	126.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	149.283	0.0	27
30 min Summer	99.619	0.0	42
60 min Summer	63.278	0.0	72
120 min Summer	38.739	0.0	132
180 min Summer	28.627	0.0	190
240 min Summer	22.930	0.0	250
360 min Summer	16.673	0.0	370
480 min Summer	13.307	0.0	490
600 min Summer	11.161	0.0	610
720 min Summer	9.663	0.0	728
960 min Summer	7.689	0.0	968
1440 min Summer	5.561	0.0	1446
2160 min Summer	4.013	0.0	2164
2880 min Summer	3.180	0.0	2880
4320 min Summer	2.286	0.0	3852
5760 min Summer	1.807	0.0	4560
7200 min Summer	1.504	0.0	5264
8640 min Summer	1.294	0.0	6056

Summary of Results for 200 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
10080 min Summer	9.500	0.250	0.3	121.6	O K
15 min Winter	9.354	0.104	0.3	50.5	O K
30 min Winter	9.388	0.138	0.3	67.3	O K
60 min Winter	9.425	0.175	0.3	85.2	O K
120 min Winter	9.463	0.213	0.3	103.8	O K
180 min Winter	9.485	0.235	0.3	114.4	O K
240 min Winter	9.499	0.249	0.3	121.5	O K
360 min Winter	9.519	0.269	0.3	131.2	O K
480 min Winter	9.534	0.284	0.3	138.3	O K
600 min Winter	9.545	0.295	0.3	143.6	O K
720 min Winter	9.553	0.303	0.3	147.9	O K
960 min Winter	9.566	0.316	0.3	154.1	O K
1440 min Winter	9.582	0.332	0.3	161.6	O K
2160 min Winter	9.592	0.342	0.3	166.5	O K
2880 min Winter	9.594	0.344	0.3	167.7	O K
4320 min Winter	9.588	0.338	0.3	164.5	O K
5760 min Winter	9.574	0.324	0.3	157.9	O K
7200 min Winter	9.561	0.311	0.3	151.4	O K
8640 min Winter	9.548	0.298	0.3	145.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
10080 min Summer	1.139	0.0	6864
15 min Winter	149.283	0.0	27
30 min Winter	99.619	0.0	41
60 min Winter	63.278	0.0	70
120 min Winter	38.739	0.0	130
180 min Winter	28.627	0.0	188
240 min Winter	22.930	0.0	248
360 min Winter	16.673	0.0	366
480 min Winter	13.307	0.0	484
600 min Winter	11.161	0.0	602
720 min Winter	9.663	0.0	720
960 min Winter	7.689	0.0	954
1440 min Winter	5.561	0.0	1422
2160 min Winter	4.013	0.0	2120
2880 min Winter	3.180	0.0	2800
4320 min Winter	2.286	0.0	4112
5760 min Winter	1.807	0.0	5304
7200 min Winter	1.504	0.0	5688
8640 min Winter	1.294	0.0	6576

Summary of Results for 200 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
10080 min Winter	9.534	0.284	0.3	138.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
10080 min Winter	1.139	0.0	7464

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	200	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.100	Shortest Storm (mins)	15
Ratio R	0.377	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.162

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.054	4	8	0.054	8	12	0.054

Model Details

Storage is Online Cover Level (m) 10.000

Infiltration Blanket Structure

Infiltration Coefficient Base (m/hr)	0.00828	Diameter/Width (m)	40.3
Safety Factor	13.0	Length (m)	40.3
Porosity	0.30	Cap Volume Depth (m)	0.750
Invert Level (m)	9.250		

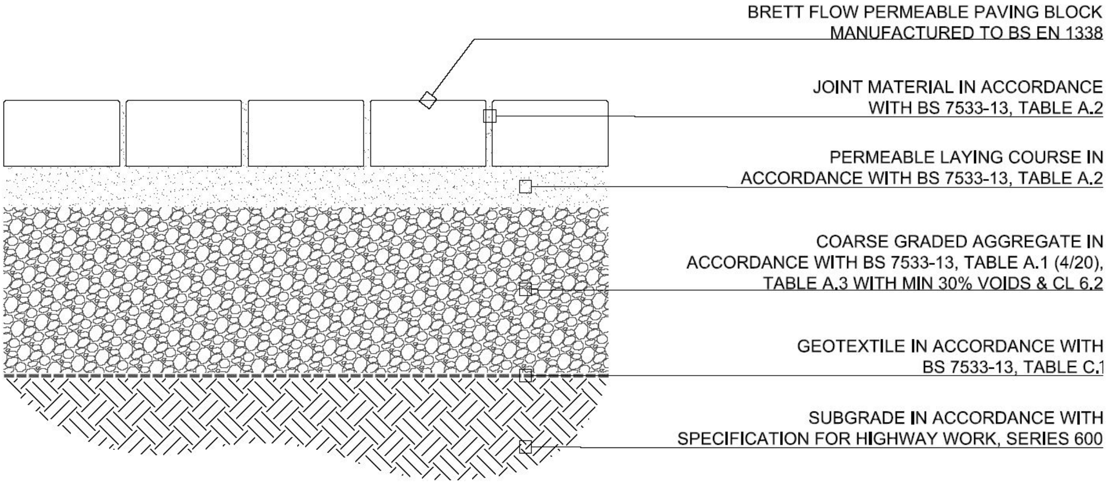
} = 1624m2 > 0.162ha

Suggested Pavement Solution

Permeable Pavement Design Suggestion

Alpha Flow	60 mm
Laying Course	50 mm
Coarse Graded Aggregate	250 mm
Lower Geotextile	Yes

System A



Summary of pavement requirements

Depth needed for Structural design	250 mm
Depth needed for hydraulic design	190 mm
Is there spare hydraulic capacity	Yes
Spare hydraulic depth	60 mm
Additional catchment area to fully ultilise spare hydraulic storage capacity	327 m²

Summary of hydraulic requirements

Available hydraulic storage	75,820 litres
Hydraulic storage require	57,320 litres
Spare hydraulic storage	18,500 litres
Half empty time	3.36 hours

Notes

The above calculations were based upon a level site.

