



Greencore Plc

**North Littlehampton Strategic Development Area
Littlehampton
West Sussex**

Drainage Strategy Report

10th February 2011



REPORT CONTROL

Document: Drainage Strategy Report

Project: North Littlehampton Strategic Development Area

Client: Greencore Plc

Job Number: A044029-3

File Origin: L:\000 3801 Highways Transportation and Development\A044029-A - Littlehampton Toddington\Reports\Toddington Park Drainage Strategy.doc

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Issue	Date	Status	Checked for Issue
1	13/02/2009	Issued in Draft	ECW
1A	03/09/2009	Issued in Draft	DS
2	19/11/2009	Issued	CT
3	01/12/2009	Issued	CT
4	21/12/2009	Issued	CT
5	10/02/2011	Issued	CT



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1 EXECUTIVE SUMMARY

- The 85 Ha Greenfield site is located predominantly on arable land with no evidence of contamination with several watercourses within its boundaries. The low lying, northern section of the site is known to lie within the flood plain. Consequently, due to the flood risk presented, this area will not be developed and will be maintained as an area of ecology. Inspection of the detailed topographical survey has shown that there is an area of similarly low lying land extending into the development area towards Toddington Lane. It is proposed that this area will not be developed but will also form part of the flood plain and maintained as an area of ecology.
- The site lies within a groundwater Source Protected Zone (SPZ). The groundwater body type is identified as 'Principle'.
- It is considered unlikely that any Sequential or Exception Testing undertaken as part of the Strategic Flood Risk Analysis (SFRA) would discourage development on this site as the built development is located away from the identified floodplain.
- The proposed built development is not subject to significant flood risk being located beyond the floodplain of the Black Ditch and any watercourse on site. However, there are areas of 'Green Corridor' located within the identified floodplain. It is proposed to utilise these green areas to convey and infiltrate surface water run off as appropriate.
- The EA have requested that SUDS be implemented in accordance with PPS25. The most suitable solution is to use a combination of infiltration drainage, attenuation in the form of swales and balancing pond supplemented by piped systems where appropriate.
- Restricted storm outfalls to the Black Ditch via suitable attenuation systems appear viable. Notwithstanding detailed design a series of attenuation systems/drainage ponds and swales located generally within the green areas of the Development can provide a total attenuation capacity of approximately 16,564m³.
- The proposed drainage system will control flood events as the discharge will be restricted to a rate which provides a betterment of the existing conditions.
- Historic sewer flooding has been identified and recorded in the Old Mead Road area which is adjacent to the site. This indicates the existing public sewer systems may be at or near capacity. The exact cause of this flooding is unknown.
- It is proposed to connect the developments foul drainage into the existing public sewer network south of the site via a new connection point to be confirmed with Southern Water. The associated construction of the new sewer system could coincide with the construction of the new bridge deck for the main access into the development.
- The recently constructed Ford Treatment Plant does have the capacity to accommodate the foul flows produced by the development. Improvement works may



be required at the existing pumping facility connecting Littlehampton to the treatment plant.

- Temporary package pumping stations and connections to existing foul sewers are possible options to accommodate the proposed construction phasings. It is recommended however that the development drains via new gravity sewers to a new adoptable pumping station and thereafter discharge via rising main direct to the Ford Sewage Treatment Works thus minimising abortive costs. It is anticipated that the Ford Sewage Treatment Works needs re-modelling to accommodate foul discharge from the proposed Development.

Recommendations/Future Works

- Undertake detailed foul and storm water drainage design
- Continue liaison with the EA to identify any additional parameters of outfalls
- Ongoing liaison with Southern Water to confirm details of existing public sewers and future works
- Undertake detailed topographical survey of the route of connection to the Ford Sewage Treatment works



2 INTRODUCTION

2.1 INSTRUCTION

WYG Engineering have been commissioned by Greencore Plc to evolve and develop a drainage strategy for the proposed development of the Toddington Park site at Toddington Lane, Littlehampton.

2.2 BRIEF

The Toddington Park site at Toddington Lane, North Littlehampton is currently being promoted for development by Greencore through the Arun District Local Development Framework. The proposed mixed use development is expected to include 1,460 houses and areas of employment and community facilities.

This report will set out the requirements for drainage of the site and recommend the preferred options for the provision of foul and surface water drainage to the site and the means of disposal from the site incorporating:

- Surface water management strategy and a conceptual drainage design
- Identification of key criteria affecting the design of the surface water drainage system
- Preliminary indications and descriptions of drainage components and requirements
- Estimate of foul discharge rates

This report is part of the documentation submitted in support of the Planning Application for the development.

The drainage and flood risk assessment (FRA) have been developed in parallel but the FRA undertaken by Peter Brett Associates is reported separately.



necessary flood storage and maximise the area of development, these are detailed in the Peter Brett Associates Flood Risk Assessment dated February 2011.

For the purposes of preliminary surface water drainage design, the proposed Development has been considered as three basic elements:

- Highways
- Buildings and hardstandings
- Soft landscaping and verges

The proposed Masterplan for the development is contained in Appendix A and identifies the constituent parts of the development. It should be understood that the identified areas of residential use, school use, and commercial use each carry an element of soft landscaping thus affecting the extent of each impermeable surfacing.

The impermeable areas attributed to each land use have been factored to reflect this as follows:

- Residential low density (30dph) 50% of area
- medium-low density (35dph) 60% of area
- medium-high density(50dph) 55% of area
- high density (80dph) 95% of area
- School 50% of area
- Other areas of development 90% of area

The area of the site can be broken down as follows:

- Total area of Development Site = 60Ha
- Total built Development Area = 37.7Ha

Consisting of:

- Residential Areas (of which) = 35.40Ha
 - High Density = 2.49Ha
 - Medium-high Density = 10.44Ha
 - Medium-low density = 12.97Ha
 - Low Density = 9.50Ha
- Employment/Business/Commercial = 1.3Ha
- Schools = 1.0Ha
- Green corridors (including allotments) = 22.3Ha

Note: Figures obtained using 'North Littlehampton – Residential Densities' Drawing No. GRL-007 issued by John Thompson & Partners dated 9 January 2011.

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The Arun SFRA was undertaken in accordance with the guidance contained in PPS25 and associated documents. Consideration was also given to additional guidance provided by the Environment Agency.

- so that an evidence based and risk based sequential approach can be adopted when making planning decisions in line with PPS25
- that is strategic in that it covers a wide spatial area and looks at flood risk today and in the future
- that supports sustainability appraisals of the LDF's
- that identifies what further investigations may be required in flood risk assessments for specific development proposals

Flood Zone 3b (the functional floodplain) comprises of land where water has to flow or be stored in times of flood. The flood defences along the River Arun remove much of flood zones 2 and 3a from the 'functional floodplain'. However, much of the floodplain for the Black Ditch is included within flood zone 3b.

Catchment Flood Management Plans (CFMP's) provide a large-scale assessment of the risks associated with river flooding. They present a policy framework to address the risks to people and the environment in a sustainable manner. In doing so, a CMFP is a high level document that forms part of the Department for Environment, Food and Rural Affairs (Defra) strategy for flood and coastal defence.

Coastal flood defence schemes are usually highly designed to withstand pressure from high water levels as well as erosive wind and wave action. Shoreline Management Plans (SMP's) outline policies and options for the management of coastlines and flood defence in Arun. Again, a CMFP is a high level document that forms part of the Department for Environment, Food and Rural Affairs (Defra) strategy for flood and coastal defence.

The proposed development site is identified and assessed within the SFRA in respect of the management of the flood risk associated with any development. The existing flood risk measures confirmed at the site include flood defences against river and sea flooding along the

The SFRA 'Assessment of sites of search' North Littlehampton is included in Appendix D of this report.

5.1 EXISTING FOUL WATER DRAINAGE

Investigations for this development have identified a number of sewer networks adjacent to the southern section of the site. The first of these is a 250mm rising main that heads south into the site and then east along the north of the site. South of the railway line on Toddington Lane there is a 225mm gravity sewer and to the west of the site there is a network of 150mm gravity sewers which also drain to the south.

The treatment plant at Ford has been recently constructed and replaces the previous methods of disposal. Southern Water have advised that the treatment plant was 'over designed' to provide spare capacity to service future developments within Littlehampton, such as that proposed at Toddington Park. As expected, Southern Water have previously confirmed there are no capacity issues affecting the current operation of this treatment plant.

No details are currently available of the internal layouts of all buildings. Consequently, typical values of foul discharge have been determined using figures based on the density of housing, proposed land use, size of site and / or anticipated site occupancy levels.

The table below estimates the peak foul flows generated by the residential and commercial areas of the development based on the design criteria in Sewers for Adoption 6th Edition.

Land Use	Development	SFA Criteria	Peak Design Flow
Residential	1460 units	4000 L/unit/day	67.59 L/s
Commercial	1.3 ha	1.35 L/s/ha ¹	1.755 L/s
TOTAL			69.35 L/s

Commercial development flows are based on a domestic flow element of 0.6 L/s/ha and a trade effluent flow element of 0.75 L/s/ha (total of 1.35 L/s/ha) in accordance with SFA 6th Edition.



For the purpose of this report, it has been assumed that the school identified on the Masterplan shall be a single form entry Primary School.

- This equates to (peak School effluent flow) of 4.66l/s.

Note: Number of teachers, pupils and facilities has been estimated using average occupancy figures. Estimated number of wastewater units in accordance with BS6465-1:2006 Sanitary Installations. Frequency factors and discharge rates of wastewater units in accordance with BS EN 752-4 Tables C.1 and C.2.

Summary of Estimated Peak Foul Discharge for the Development:

- | | | |
|----------------|-------------------------|------------------|
| • School | for 1 single form entry | 4.66 l/s |
| • Residential | 1460 dwellings | 67.59 l/s |
| • Commercial | for 1.3 Ha | 1.76l/s |
| • Total | | 74.01 l/s |

Clearly, with an expected estimate peak flow of 74.01 L/s, the current drainage approach of cess pits and septic tanks will not be suitable to service the new development of the scale envisaged and a trunk foul drainage network will need to be provided for the development.

At this stage of the strategy, it is not possible to determine the exact location of connection to the adoptable sewer network as Southern Water are not able to provide capacity information about the existing system without a detailed analysis. It should be noted, however under current legislation, that Southern Water have a statutory obligation to provide a connection from the site to their public sewer via a requisition agreement. It is recommended that a full Hydraulic Capacity Assessment of the existing foul sewer systems in question is conducted to determine the exact maximum allowable discharge rate. In addition, this will allow analysis and consideration of any temporary connections into the existing system.

Inspection of the detailed topographic information was undertaken to assess ground levels. It is considered that there are no significant variations in ground level that imply difficulties for the provision of a straightforward and economical foul gravity drainage network within the site.

There are two potential routes have been identified in order to drain the site these being as follows:

1. To the west via Toddington Lane and Mill Lane to the existing system in Lyminster Road.
2. To the south via Toddington Lane to the existing system in Toddington Lane.

Whilst both routes present a feasible discharge route, both options also require the crossing of the main Chichester to Brighton railway line at the respective level crossings in Lyminster Road and Toddington Lane.

Option 1 will involve the installation of a considerable length of rising main and will cause disruption both within the existing housing development to the west of the site and to A284 Lyminster Road, one of the arterial routes to Littlehampton from the A27, whereas Option 2 will present minimal disruption during the installation of the rising main. On this basis it is considered that Option 2 be considered as the recommended route to drain the site, subject to Southern Water's confirmation of adequate capacity in the public sewer system in Toddington



Lane. If the existing system is at capacity, the requisition agreement will identify the extent of improvements required.

It is understood from inspection of the sewer records contained in Appendix B that the adoptable public sewer in Toddington Lane terminates south of the railway level crossing and does not cross into the site. Subsequently, it should be noted that any proposed connection or new sewer which crosses the railway will require permission. This can be a time consuming process and similar proposals have taken up to two years to resolve.

The drainage assessment report, dated June 2006 confirmed that based on the size and grade information available from Southern Water for the gravity sewers immediately south of the site in Toddington Lane general estimates can be made on their capacity. It is considered likely that the peak flow expected from the proposed development will exceed the capacity of this infrastructure. However, a connection may be possible further downstream, which may require the construction of a new sewer draining in parallel with the existing. Alternatively, Southern Water may require the existing sewers to be replaced and upsized to handle the existing flow and the new flows from the development.

The construction of the new gravity sewers, pumping stations and rising mains may be covered under a requisition agreement with Southern Water. This would mean that Southern Water would be responsible for the design and construction of the works and the client would pay the construction costs and any additional fees to Southern Water. A requisition agreement avoids any legal implications for the client caused by the infrastructure entering a third party's land and ensures Southern Water approval of the scheme.

Discussions have taken place with Southern Water who have suggested that the wastewater treatment plant in Ford has been designed with sufficient spare capacity to service the proposed development at Toddington Park. Further investigations and liaison with Southern Water will be required to determine whether it can operate adequately with the increased discharges. However, the pumping station which connects Littlehampton to the plant may need some works to provide additional capacity for the increase in flows from Toddington Park.

5.3 PROPOSED FOUL WATER DISPOSAL METHODS

As stated above, it is proposed that the foul water drainage from this site is routed into a requisitioned sewer draining to the existing adoptable sewer in Toddington Lane, this will be subject to capacity checks and approval by Southern Water.

Inspection of the topographical survey indicates that the site falls from the south to the north but is relatively flat from the east to the west. This topography of the site and the current Masterplan layout indicates that the site is split into 2 sections either side of a wetland area set aside for both flood relief and ecological uses. This configuration suggests that the site be drained by 2 foul water pumping stations, one located within the eastern residential area and the other within the commercial area to the west.

In order to allow the drainage elements to be constructed in accordance with the proposed phasing it is suggested that the eastern area is drained by gravity to a pumping station to the north of the site. This in turn is distributed via a rising main which connects and discharges to a gravity system in the west of the site. All the foul discharge is then distribute from the site via a single rising main into the requisitioned sewer in Toddington Lane. Any new connection into the public sewer system can be constructed in association with the new railway bridge to

Summary of Estimated Peak Foul discharge for individual stages (in relation to the proposed phasing):

Residential Phasings			
Phase No	no. of houses	% of overall	Foul discharge (l/s)
Phase 1	100	6.84	4.62
Phase 2	160	10.96	7.42
Phase 3	240	16.44	11.11
Phase 4	240	16.44	11.11
Phase 5	240	16.44	11.11
Phase 6	240	16.44	11.11
Phase 7	240	16.44	11.11
Total	1460	100	67.59

Note: Figures obtained using 'Draft Construction Programme' dated 11 January 2011.

6.1 EXISTING SURFACE WATER DISPOSAL

The two main ditches identified are the Toddington and Norway Ditch, which are assumed to be classified as 'main' watercourses. The Toddington Ditch is located to the central area of the site, connecting to the Black Ditch to the north. The Norway Ditch is located to the eastern extent of the site and appears to connect a pond to the south of the railway crossing to the Black Ditch to the north. For the purpose of the drainage strategy it is assumed that these watercourses currently discharge a proportion of the surface water run off produced within the site into the Black Ditch at an unrestricted rate.

6.2 PROPOSED SURFACE WATER DISPOSAL

The proposed development at Toddington Park was discussed with the Environment Agency and Arun District Council to obtain their comments and requirements for the future surface water drainage of the site.

6.2.1 ENVIRONMENT AGENCY REQUIREMENTS

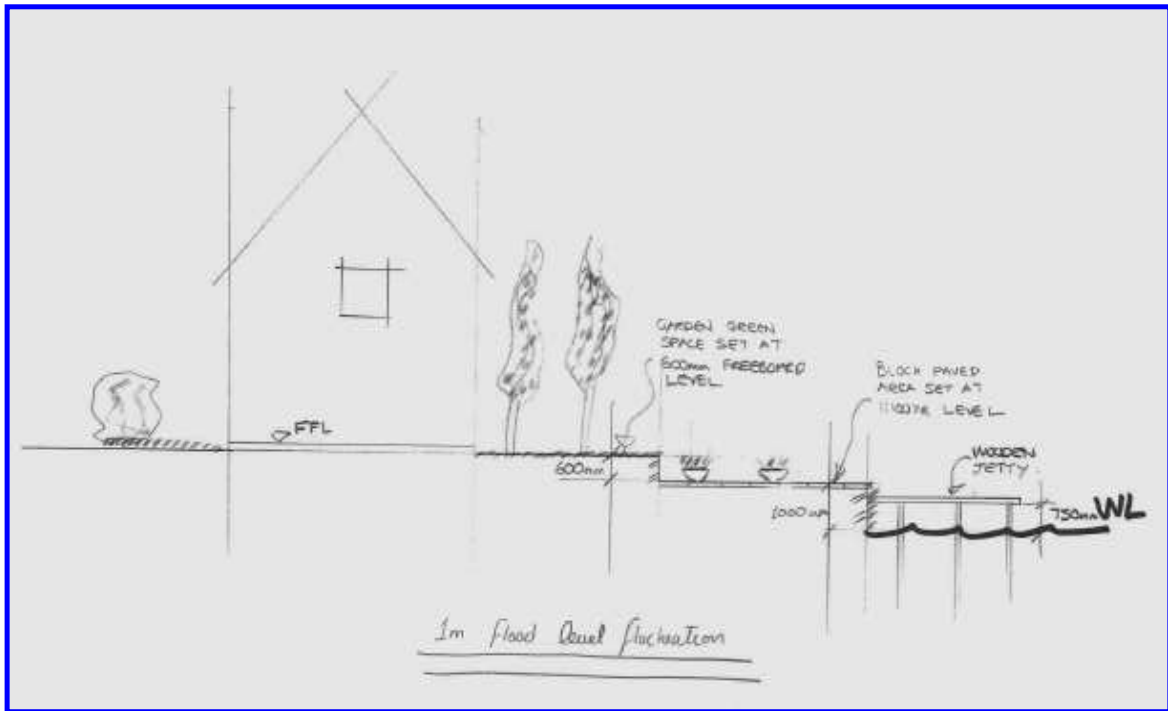
The Environment Agency will normally require that for all annual flow rate probabilities up to and including the 1 in 100 year event (plus an allowance of 20% for climate change), the developed rate of runoff shall not exceed the undeveloped (Greenfield) rate of runoff for the same event. The Environment Agency suggests that the Greenfield runoff rate be calculated in accordance with the guidance set out in the Institute of Hydrology Report No. 124 (IH124). The result of these calculations suggests that a Greenfield runoff rate of 7L/s/ha is appropriate for this development.

increased to suit the existing site conditions but care should be taken to prevent conflict between the pond and groundwater levels.

It would be beneficial to maximise the aesthetic potential of this balancing pond and create a focal point of the interaction between the pond and any adjacent properties. The associated levels would require careful consideration during the design to ensure that no flood risk is introduced.

A sketch indicating how this arrangement may look is shown below.

Figure 6.1 Sketch of possible interface between houses– WYG 2009



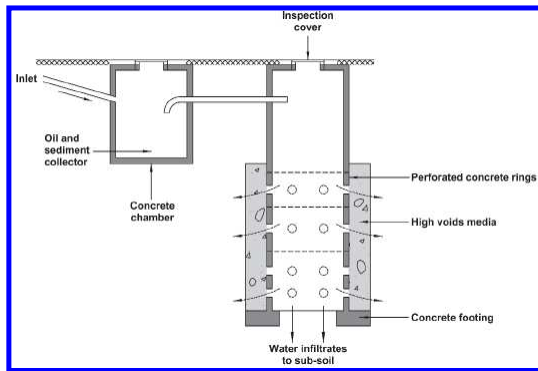
6.2.3 INFILTRATION

The Environment Agency has advised that the proposed development area lies on the Upper Chalk, a Major Aquifer under the Environment Agency's "Policy and Practice for the Protection of Groundwater". Due to the sensitivity of this site, the EA would seek to control any discharges to ground such as soakaways or infiltration trenches and have suggested that the local groundwater table is likely to be shallow.

While infiltration appears to be the most suitable option for the disposal of the majority of surface water run off, both Arun District Council and the EA have advised that it would be a requirement that groundwater level monitoring is undertaken to determine the seasonal fluctuation of the groundwater table.

An inspection of the site investigation report has revealed that the Upper Chalk is at a shallow depth which suggests that the use of infiltration drainage, in part may be appropriate for the disposal of surface water runoff. Possible infiltration devices that may be utilised are below-ground or surface structures which drain water directly into the ground such as soakaways, infiltration trenches, swales with infiltration and infiltration basins. These devices may be used at source or the run-off may be conveyed to the infiltration area in a pipe or swale.

Soakaways are the most common form of infiltration device in the UK and store rapid runoff from a development allowing it to infiltrate efficiently into the surrounding soil. Drainage from individual properties are often connected to underground rubble filled voids sited beneath lawns.



Where larger systems are required the structure tends to be constructed from pre formed rings up to a diameter of 2.5m. The hollow or high voids fill provides good storage capacity which allows the size of the structure to be minimised, reducing the overall attenuation requirements for a development. Soakaways also reduce the water volume which needs to be disposed by downstream drainage, also facilitating groundwater recharge. If ground conditions allow then a soakaway can be constructed as deep as 4m, limiting the depth means that the length must be increased which would form a trench soakaway. These are considered cost effective as they can be dug with readily available excavating equipment

- design to meet site drainage standards – generally 1 in 10 or 1 in 30 year event
- site infiltration rate assumed for design should be based on site investigations and include a safety factor
- appropriate pre treatment is required
- fill material should provide >30 per cent void space
- minimum 1m from groundwater table
- minimum 5m from foundations

- minimal land take
- groundwater recharge
- volume reduction and peak flow attenuation
- easy to construct and operate
- can be retrofitted

- removal of sediments
- monitoring performance (via observation well)

General assumptions:

- Soil infiltration rate = 12.5mm/hr (for chalk)
- Effective depth of storage
- Initial design using 2.5m diameter concrete ring units, placed in square pit of side length L, with a grain backfill of 30% free volume between rings and sides of pit
- Surface area drained is 100m²

Note: M10-15 refers the 5 year return storm period with a duration of 15 minutes.

Length of soakaway (m)	Storage (m ³)
5	18.257
10	52.007
20	187.00
50	1132.00

It should be noted that the detailed design of infiltration features should ensure that there is no conflict with the groundwater levels. As described above the groundwater survey obtained a variety of results which varied across the site.

SWALES

Swales provide effective pollutant removal by promoting low flow velocity, suspending the particulate load. In addition, roadside swales can be used in place of conventional gullies and drainage pipes. The swale channel is broad and shallow and covered by dense vegetation which is usually grass. This slows down drainage flows and traps pollutants. A swale can have check dams or berms installed across the flow path to increase settlement and infiltration.



Key design criteria:

- ### Advantages of swales:

- ### Key maintenance requirements of swales:

- litter/debris removal
- grass cutting and removal of cuttings

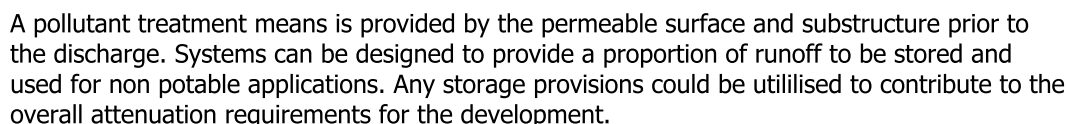
- Typical storage capacities of typical swales can be adjusted to accommodate the attenuation and flows in a specific area of the site. It is proposed that wherever possible the swales will form a feature within the green corridors of the development.



- Will infiltration be viable
- Depth of swale in relation to groundwater levels
- Side slopes of 1:4
- Width at base of 2m maximum
- Flow control devices installed eg check dams
- Length of swales

Additional sustainable drainage options for the development are possible and the following should be encouraged:

These devices have permeable surfaces to allow rainwater and runoff to infiltrate into permeable material placed below ground to store water prior to discharge into the underlying soil, reused or released to a watercourse or other drainage feature. These devices are suitable for both the residential and commercial developments but are most common in uses such as commercial car parking facilities.

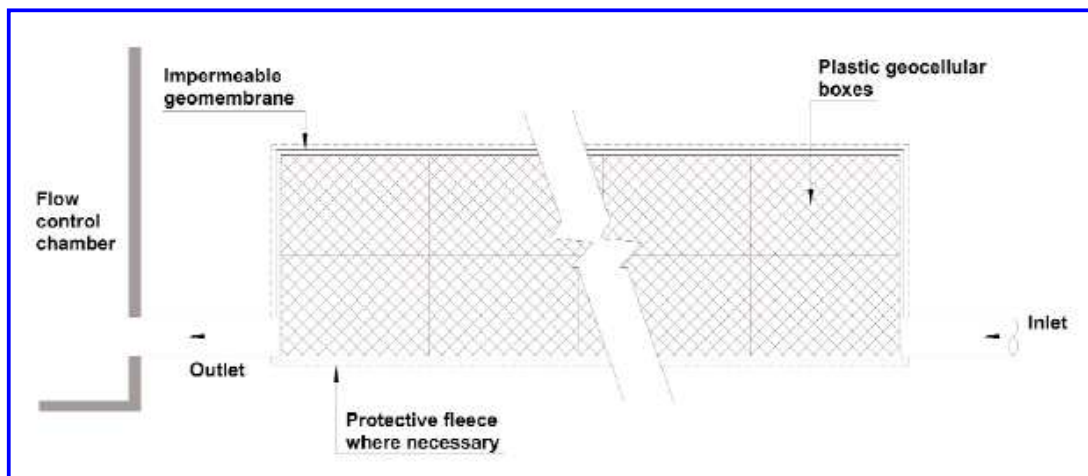


Geocellular modular systems can be tailored to suit specific site requirements. They are used to control and manage run off either as a soakaway or a storage tank. In addition, they can be used to store rainwater before recycling.

Traditionally, underground stone filled soakaways were used for infiltration, with the storage provided by constructing in situ concrete tanks. Recently developed geocellular systems are more efficient, versatile and easy to fit and have been designed to withstand a vehicular load which permits installation below roads and car parks.

Geocellular systems contribute to stormwater source control by:

- facilitating infiltration through the provision of a storage structure that is wrapped in a permeable geotextile membrane, allowing the stormwater to infiltrate into the underlying ground
- by creating storage volumes through the provision of a storage structure that is wrapped in an impermeable geotextile membrane, providing temporary storage. This is a suitable option where the ground conditions are not suited to infiltration.



Schematic of modular box system in storage/attenuation mode – Ciria Report C697

Geocellular systems can generally be used for any site which requires surface water drainage providing that the system provides the required hydraulic and structural elements. Geocellular systems offer considerable flexibility to the designer due to their nature.

The key design criteria for geocellular/modular systems are:

- standard storage design using limited discharges to determine storage volumes
- structural design to relevant standards for appropriate loads
- appropriate geotextile/geomembrane for wrapping

Considerations for using geocellular systems:

Most systems can be designed to manage stormwater from any size of drainage area. However, effective upstream treatment is crucial to limit pollutant and silt accumulation. It is recommended that the drained area is as small as practicable, which may require the use of several smaller tanks as opposed to one large one.

Modular systems are effective as the space above ground is maximised due to the underground siting.

Storage systems can be sited at most locations and site constraints will determine the location of the storage areas. Generally they should not be used on unstable ground until assessment has been made and the conditions determined.

When used for storage the tank requires an outlet connecting to the downstream drainage system or watercourse.

- Modular and flexible
- High void ratio providing high storage capacity
- Lightweight, easy to install and robust
- Can be installed beneath trafficked areas
- Long term physical and chemical stability

- No water quality treatment

- Regular inspection of silt traps, manholes pipework and pre-treatment devices
- Removal of sediment and debris as required

CONCLUSIONS



Appendices



Appendix A – Development Masterplan

TODDINGTON PARK, LITTLEHAMPTON



ARUN DISTRICT COUNCIL GU/381/18/D/09/11/





Appendix C - Proposed Drainage Strategy Plan

TODDINGTON PARK, LITTLEHAMPTON





Appendix D - Arun SFRA 'Assessment of sites of search'

North Littlehampton

Map ref.	Littlehampton	
Site of interest	Existing nursery, north of railway	
Approx. NGR	503300, 103900	
Area (ha)	Unknown	
Type	Strategic greenfield site. Mixed land-use (residential and commercial)	
Former land-use	Nurseries	
Estimated design life	50 to 100 years	
Description of site	This site lies north of Littlehampton, adjacent to Black Ditch. The site is relatively flat, with lower ground levels adjacent to Black Ditch and in the centre of the site. Black Ditch is a tributary of the River Arun, which runs to the west. The site is located on chalk, overlain by sand and freely draining soils.	
Flood risk management policy	CFMP Policy: Take further action to reduce flood risk (now and/or in the future). SMP Policy: hold the line. Maintain or upgrade the level of protection provided by defences.	
Existing flood risk management at the site	Protected by river and sea flood defences along the River Arun. These include raised embankments estimated to protect against a flood with a 3.3% AEP. Parts of the site lie within river flood warning area F3C4.	
Sources of flood risk	Rivers	Mixed probability. Land immediately adjacent to Black Ditch is high probability (Flood Zone 3) and functional floodplain (Flood Zone 3b). Existing flood defences do not prevent flooding in this area for the 1% AEP event. Flood extents similar for the 2056 and 2106 climate change flood extents. Land to the south of the site is mostly low probability (Flood Zone 1) although the low lying area in the centre of the site is medium probability (Flood Zone 2). Extent of 1% AEP flood expected to increase for 2056 and 2106 climate change time horizons.
	Sea	Mixed probability. Land immediately adjacent to Black Ditch is high probability (Flood Zone 3). However existing flood defences prevent flooding. Land expected to be flooded in 2106 climate change time horizon. Land to the south of the site is mostly low probability (Flood Zone 1). Not expected to be flooded in 2056 or 2106 climate change time horizons.
	Land	Medium to high probability of flooding from land. Land adjacent to Black Ditch is relatively flat and crossed by many drainage channels therefore higher risk of surface water flooding. Higher land south of the site is at lesser risk. Recorded incidents of surface water flooding in the site and vicinity.
	Groundwater	High potential for groundwater flooding. Located in groundwater emergence zone (Defra 2004). However no recorded incidents of groundwater flooding.
	Sewers	Medium probability. Unlikely to be significant sewer infrastructure at the site. Some recorded incidents of sewer flooding in the vicinity.
	Artificial sources	Low risk – no artificial sources of flooding identified.
	Possible strategic solutions	Improvements to River Arun defences may increase level of protection from flooding from the sea into the future. Strategic solutions are unlikely to reduce groundwater flood risk. Site specific measures required.

TODDINGTON PARK, LITTLEHAMPTON



Assessment of sites of search

Map ref.	Littlehampton
Site of interest	Existing nursery, north of railway
Requirements of FRA	Full FRA required for areas within Flood Zone 3 (adjacent to Black Ditch). FRA will need to consider maintenance of defences and likely standard of protection provided in the future. Revisit flood zones to ensure suitably accurate for land-use planning. Assessment of management of surface water runoff is required for sites larger than 1ha. Surface water runoff will need to be maintained at existing levels. Flooding from land and groundwater flooding requires further investigation. Sequential approach recommended placing "more vulnerable" development on higher ground to the south of the area of search. Exception test will be required for "more vulnerable" development located in areas where probability of river, sea or groundwater flooding is considered "high". Only "water compatible" development is appropriate in Flood Zone 3b (according to PPS25 guidance).
Surface Water Management	Land west of the River Arun is generally greenfield therefore development of the site is likely to lead to increased runoff. Surface water runoff will need to be restricted to the existing rates. A strategic surface water management scheme may be feasible. Soils and geology information indicate the land is relatively permeable. Soakaways / infiltration may be effective and should be considered in preference to attenuation and storage of runoff. Land east of the river is generally developed therefore development is unlikely to significantly increase runoff. However development should seek to reduce runoff where possible. Restrictions on land availability may limit potential for large-scale storage / infiltration schemes. Source control measures (green roofs, permeable paving etc.) recommended.



Appendix E - WINDES Screenshots

TODDINGTON PARK, LITTLEHAMPTON



Development total: @30.051 Ha of hardstanding at a Brownfield run off rate of 8.27l/s

Quick Storage Estimate

Variables

FSR Rainfall: England and Wales

Return Period (years): 100

Region: England and Wales

Map: M5-60 (mm): 19.000

Ratio R: 0.350

Cv (Summer): 0.750

Cv (Winter): 0.840

Impermeable Area (ha): 30.051

Maximum Allowable Discharge (l/s): 469.3

Infiltration Coefficient (m/hr): 0.00000

Safety Factor: 2.0

Climate Change (%): 20

Analyse OK Cancel Help

Enter Climate Change between -100 and 600

Quick Storage Estimate

Results

Global Variables require approximate storage of between 11154 m³ and 16564 m³.

These values are estimates only and should not be used for design purposes.

Analyse OK Cancel Help

Enter Climate Change between -100 and 600

TODDINGTON PARK, LITTLEHAMPTON



Development total: @30.051Ha of hardstanding at a Greenfield run off rate of 7 l/s

Quick Storage Estimate

Micro Drainage

Variables

Results

Design

Overview 2D

Overview 3D

Vt

Results

Global Variables require approximate storage of between 13873 m³ and 20034 m³.
These values are estimates only and should not be used for design purposes.

Analyse

OK

Cancel

Help

Enter Maximum Allowable Discharge between 0.0 and 999999.0

IH124

IH 124 Input

Return Period (Years)

Area (ha)

SAAR (mm)

Soil

Growth Curve

Partly Urbanised Catchment (QBAR)

Urban

Region

Results

QBAR rural (l/s)

QBAR urban (l/s)

Return Period Flood

Region	QBAR (l/s)	Q (1 yrs) (l/s)	Q (1 yrs) (l/s)	Q (2 yrs) (l/s)	Q (5 yrs) (l/s)	Q (10 yrs) (l/s)	Q (20 yrs) (l/s)	Q (25 yrs) (l/s)	Q (30 yrs) (l/s)
Region 1	583.9	496.3	496.3	588.1	728.7	802.0	863.6	879.5	892.0
Region 2	583.9	508.0	508.0	584.8	715.3	785.0	850.2	867.0	880.3
Region 3	583.9	502.1	502.1	614.7	752.6	812.3	863.0	876.1	886.4
Region 4	583.9	484.6	484.6	588.8	748.0	825.9	891.0	907.8	921.2
Region 5	583.9	508.0	508.0	598.6	793.5	900.1	997.9	1023.1	1043.1
Region 6/Region 7	583.9	496.3	496.3	592.8	785.9	887.1	973.9	996.4	1014.1
Region 8	583.9	455.4	455.4	586.2	748.0	825.9	891.0	907.8	921.2
Region 9	583.9	513.8	513.8	599.8	731.0	794.8	845.5	858.6	868.9
Region 10	583.9	508.0	508.0	596.5	715.9	771.4	822.1	835.2	845.6
Ireland National	583.9	496.3	496.3	611.4	718.2	763.7	800.6	810.4	818.2
Ireland East	583.9	496.3	496.3	613.5	726.4	778.0	818.7	829.0	837.2
Ireland South	583.9	496.3	496.3	609.3	713.5	762.1	800.6	810.4	818.2
Ireland West	583.9	496.3	496.3	607.1	706.5	752.1	787.6	796.5	803.5

IH 124

ICP SUDS

ADAS 345

FEH

Enter Urban between 0.000 and 0.750

TODDINGTON PARK, LITTLEHAMPTON



Eastern Area. Max capacity of balancing pond: @4.1Ha of hardstanding at a Brownfield run off rate of 8.27 l/s

Quick Storage Estimate

Variables

Result

Design

Overview 2D

Overview 3D

Vt

Region

England & Wales

Cv (Summer)

0.750

Return Period (years)

100

Cv (Winter)

0.840

Map

M5-60 (mm)

19.0

Impermeable Area (ha)

4.1

Ratio R

0.350

Maximum Allowable Discharge (l/s)

33.907

Infil Coefficient (m/hr)

Safety Factor

2

Climate Change %

20

Apply

Done

Help

Quick Storage Estimate

Variables

Result

Design

Overview 2D

Overview 3D

Vt

Global Variables require approximate storage of between 1892 m³ and 2728 m³.

These values are estimates only and should not be used for design purposes.

Done

Help



Appendix F - Results of Groundwater Survey

TODDINGTON PARK, LITTLEHAMPTON



Area 1b	Standing water level (mbgl)	
Date	WS4	WS5
09 July 2008	4.77	-
12 February 2009	4.06	2.15
17 March 2009	4.84	2.78
17 April 2009	4.92	2.96
18 May 2009	4.92	2.99
22 June 2009	dry	-
20 July 2009	4.89	-
High	4.06	2.15
Low	4.92	2.99
Average	4.73	2.72

Area 1c	Standing water level (mbgl)	
Date	WS11	WS18
09 July 2008	2.93	2.79
12 February 2009	2.52	2.37
17 March 2009	-	3.13
17 April 2009	3.3	3.2
18 May 2009	3.31	3.21
22 June 2009	3.44	3.33
20 July 2009	3.33	3.22
High	2.52	2.37
Low	3.44	3.33
Average	3.14	3.04

Area 2	Standing water level (mbgl)
Date	WS2
09 July 2008	dry
12 February 2009	3.04
17 March 2009	dry
17 April 2009	dry
18 May 2009	dry
22 June 2009	dry
20 July 2009	dry
High	3.04
Low	3.04
Average	3.04

Area 3	Standing water level (mbgl)
Date	WS10
09 July 2008	-
12 February 2009	0.89
17 March 2009	-
17 April 2009	-
18 May 2009	1.62
22 June 2009	2.51
20 July 2009	1.63
High	0.89
Low	2.51
Average	1.66

Area 4	Standing water level (mbgl)			
Date	WS12	WS16	WS20	WS22
09 July 2008	-	3.2	-	-
12 February 2009	-	2.79	2.56	1.93
17 March 2009	-	3.1	-	-
17 April 2009	-	3.63	2.85	2.24
18 May 2009	-	3.67	dry	2.26
22 June 2009	-	3.8	dry	2.27
20 July 2009	-	3.68	dry	2.19
High	-	2.79	2.56	1.93
Low	-	3.8	2.85	2.27
Average	-	3.41	2.71	2.18

Results taken from WYG Engineering Ground Gas and Groundwater Monitoring Survey taken between July 2008 and July 2009



Appendix G - Preliminary Balancing Pond Design





Appendix H - Preliminary Indication of Swale Designs





Appendix I - Proposed Phasing of Foul Water Drainage

