PROPOSED RESIDENTIAL DEVELOPMENT OFF BRAYS LANE, ROCHFORD, ESSEX

FLOOD RISK ASSESSMENT

MARCH 2011

REF: 1022/RE/02-10/01 REVISION B

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CONTRACT

Evans Rivers and Coastal Ltd has been commissioned by Strutt and Parker LLP through Andrew Martin Associates, to carry out Flood Risk Assessment for a proposed residential development off Brays Lane, Rochford, Essex.

QUALITY ASSURANCE, ENVIRONMENT AND HEALTH AND SAFETY

Evans Rivers and Coastal Ltd operates a Quality Assurance, Environmental, and Health and Safety Policy.

This project comprises various stages including data collection; hydrological and hydrogeological assessments; surface water drainage designs; and reporting. Quality will be maintained throughout the project by producing specific methodologies for each work stage. Quality will also be maintained by initiating internal quality procedures including the validation of third party deliverables; creation of an audit trail to record any changes made; and document control using a database and correspondence log file system.

To adhere to the Environmental Policy, data will be obtained and issued in electronic format and alternatively by post. Paper use will also be minimised by communicating via email or telephone where possible. Documents and drawings will be transferred in electronic format where possible and all waste paper will be recycled. Meetings away from the office of Evans Rivers and Coastal Ltd will be minimised to prevent unnecessary travel, however for those meetings deemed essential, public transport will be used in preference to car journeys.

The project will follow the commitment and objectives outlined in the Health and Safety Policy operated by Evans Rivers and Coastal Ltd. All employees will be equipped with suitable personal protective equipment prior to any site visits and a risk assessment will be completed and checked before any site visit. Other factors which have been taken into consideration are the wider safety of the public whilst operating on site, and the importance of safety when working close to a water source and highway. Any designs resulting from this project and directly created by Evans Rivers and Coastal Ltd will also take into account safety measures within a "designers risk assessment".

Report carried out by:

R W Evans

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Rupert Evans, BSc (Hons), MSc, CEnv, C.WEM, MCIWEM, FGS, AIEMA, MIEnvSc

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REGISTRATION OF AMENDMENTS

Revision and Date	Amendments	Revision Prepared By	Revision Approved By
A 19/05/2010	Paragraphs 2.2.1, 2.2.2, 3.1 amended.	Rupert Evans	Colin Taylor
A 19/05/2010	Sections 5 and 6 revised.	Rupert Evans	Colin Taylor
A 19/05/2010	Drawing Numbers 1022/RE/01-03 revised.	Rupert Evans	Colin Taylor
A 19/05/2010	Drawing Number 1022/RE/04 added.	Rupert Evans	Colin Taylor
A 19/05/2010	Drawing Number 010.036/03B added.	Rupert Evans	Colin Taylor
A 19/05/2010	Figure 2 and Table 1 changed.	Rupert Evans	Colin Taylor
B 28/02/2011	Changes to paragraph 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.2.1, 4.2.5	Rupert Evans	Colin Taylor
B 28/02/2011	Changes to Chapter 5 and 6	Rupert Evans	Colin Taylor
B 28/02/2011	Changes to Appendix B and D	Rupert Evans	Colin Taylor
B 28/02/2011	Drawing Numbers 1022/RE/01-03 revised	Rupert Evans	Colin Taylor
B 28/02/2011	Drawing Number 1022/RE/04 removed	Rupert Evans	Colin Taylor
B 28/02/2011	Changes to Table 1 and Figures 1, 2, 6, 7, 8	Rupert Evans	Colin Taylor

DISCLAIMER

This report has been written and produced for Strutt and Parker LLP. No responsibility is accepted to other parties for all or any part of this report. Any other parties relying upon this report without the written authorisation of Evans Rivers and Coastal Ltd do so at their own risk.

CONTENTS

1. INTRODUCTION

1.1 Project Scope

1.1.1 Evans Rivers and Coastal Ltd has been appointed by Strutt and Parker LLP to carry out a Flood Risk Assessment for a proposed residential development off Brays Lane, Rochford, Essex.

1.1.2 It is understood that this Flood Risk Assessment will be submitted to the Planning Authority and Environment Agency (Agency, hereafter) in support of a planning application. Specifically, this assessment intends to:

a) Consider all potential sources of flood risk including groundwater flooding and surface water runoff from the proposed development.

b) Determine the existing surface water drainage regime across the site using appropriate calculation methods and guidance.

c) Develop a surface water drainage strategy for the proposed site which considers flood risk to people and property up to the climate change enhanced 1 in 100 year storm event.

d) Use gathered data, such as relevant soil maps and borehole logs, to support any proposed strategies and conclusions.

e) Report findings and recommendations.

1.1.3 This assessment is carried out in accordance with the requirements of Planning Policy Statement 25 (PPS 25). Other key documents which have been consulted include the following:

- DEFRA/EA document entitled *Framework and guidance for assessing and managing flood risk for new development Phase 2 (FD2320/TR2)*, 2005;
- Woods-Ballard., et al. 2007. *The SUDS Manual, Report C697*. London: CIRIA.
- DCLG document entitled *PPS 25: Development and Flood Risk Practice Guide*, updated in 2009.
- DEFRA/Jacobs 2006. *Groundwater flooding records collation, monitoring and risk assessment (ref HA5)*.

1.1.4 PPS 25 and the Agency require that the effects of climate change over the next 100 years be considered in any assessment of flood risk for residential developments. When considering the impacts of climate change on rainfall intensity, PPS 25 advises that when designing surface water drainage systems for residential developments an allowance of 30% for climate change should be included for the next 100 years.

1.1.5 The guidance stipulated within the DEFRA/EA technical document entitled *Preliminary Rainfall Runoff Management for Developments*, Revision C, 2005 (as amended), indicates in Table 2.1 of the document that during the masterplan definition stage, a conceptual outline of SUDS components to be used together with the location of stormwater storage and outfalls is required.

2. SITE CHARACTERISTICS

2.1 Existing Site Characteristics and Location

2.1.1 The site is divided into two separate areas, located to the south of Brays Lane and to the east of Oxford Road, Rochford, Essex. The approximate Ordnance Survey (OS) grid reference for the site is 587162 192405 and the location of the site is shown on Figure 1. The site is within the administrative boundary of Rochford District Council.

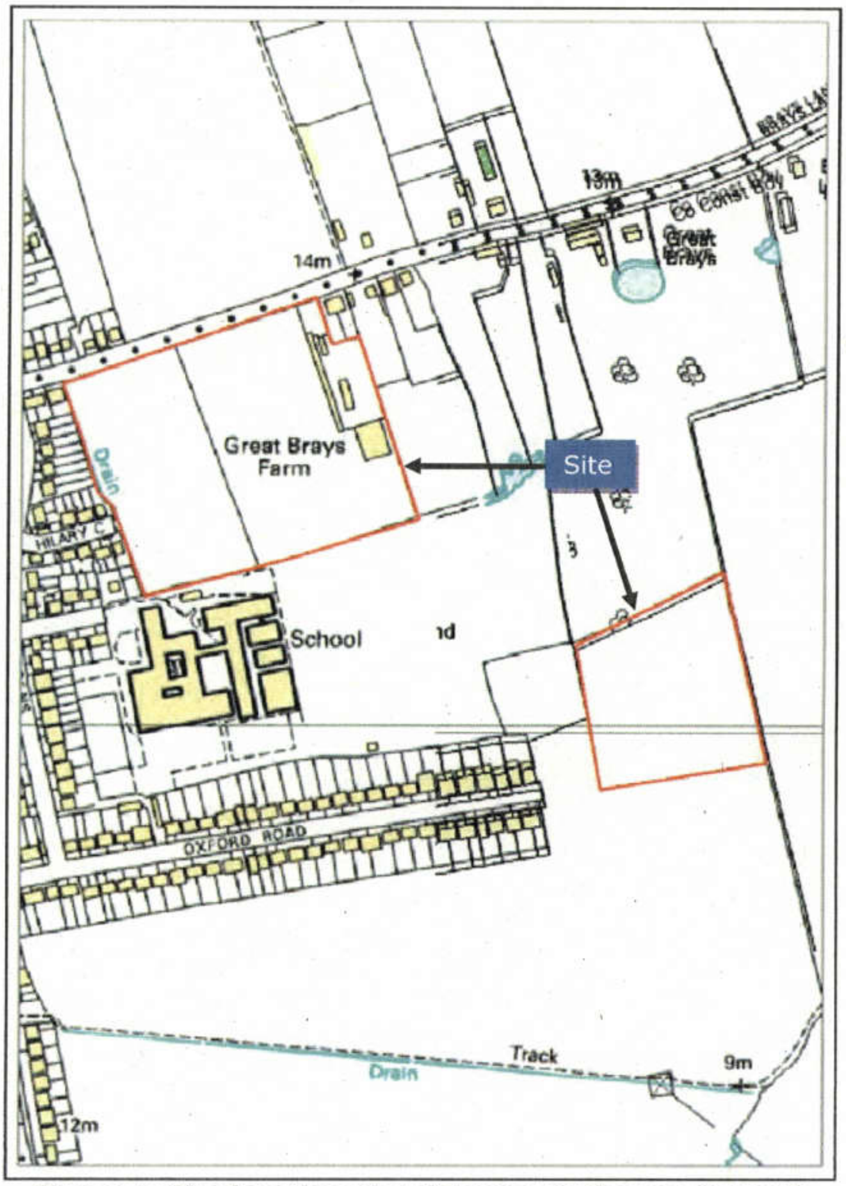


Figure 1: Site location plan (Source: Ordnance Survey)

2.1.2 Both site areas are approximately square in shape and cover a total area of approximately 5.35 ha and 2.2 ha respectively. The northern site is bounded by Brays Lane which runs in an east to west direction along its northern frontage. The site currently comprises rough pasture and stable buildings are located towards the eastern frontage of the site.

2.1.3 Man-made shallow drainage ditches run along the western and southern frontages of the northern site. Due to the presence of poorly draining soils beneath the site (see Section 4); it is thought that these ditches were originally excavated by the landowner to assist with land drainage.

2.1.4 The western frontage of the northern site is bounded by residential dwellings and back gardens. The south frontage of the site is bounded by The King Edmund School and associated playing fields. The eastern frontage of the site is bounded also by private land and cropped land. Access onto the site is currently achieved from Brays Lane. The southern site currently consists of, and is surrounded by, rough pasture.

2.1.5 A GPS topographical survey has been carried out by Randall Surveys LLP and can be seen on Drawing Numbers 11526/JD/1 and 11526/JD/2. The survey only covers the northern site and ground levels are in metres above Ordnance Datum (m AOD). By reviewing the topographical survey it can be seen that the existing levels across the site fall in a south east direction (i.e. from 15.14m AOD to 12.31m AOD) at an approximate gradient of 1:60.

2.1.6 The Environment Agency Indicative Floodplain Map shows that the site is located within the PPS 25 defined Zone 1, "Low Probability". PPS 25 states that all uses of land are appropriate in this zone.

2.2 Site Proposals

2.2.1 The site proposals have been developed by Andrew Martin Associates, and can be seen on Figure 2 and Drawing Number 010036/22A. It is the Client's current intention to develop the northern site with up to 100 residential units, access roads and parking areas together with open space. A bus turning and waiting area to serve the existing school is to be provided across part of the site. The southern site is intended to be used as permeable/grass playing fields.

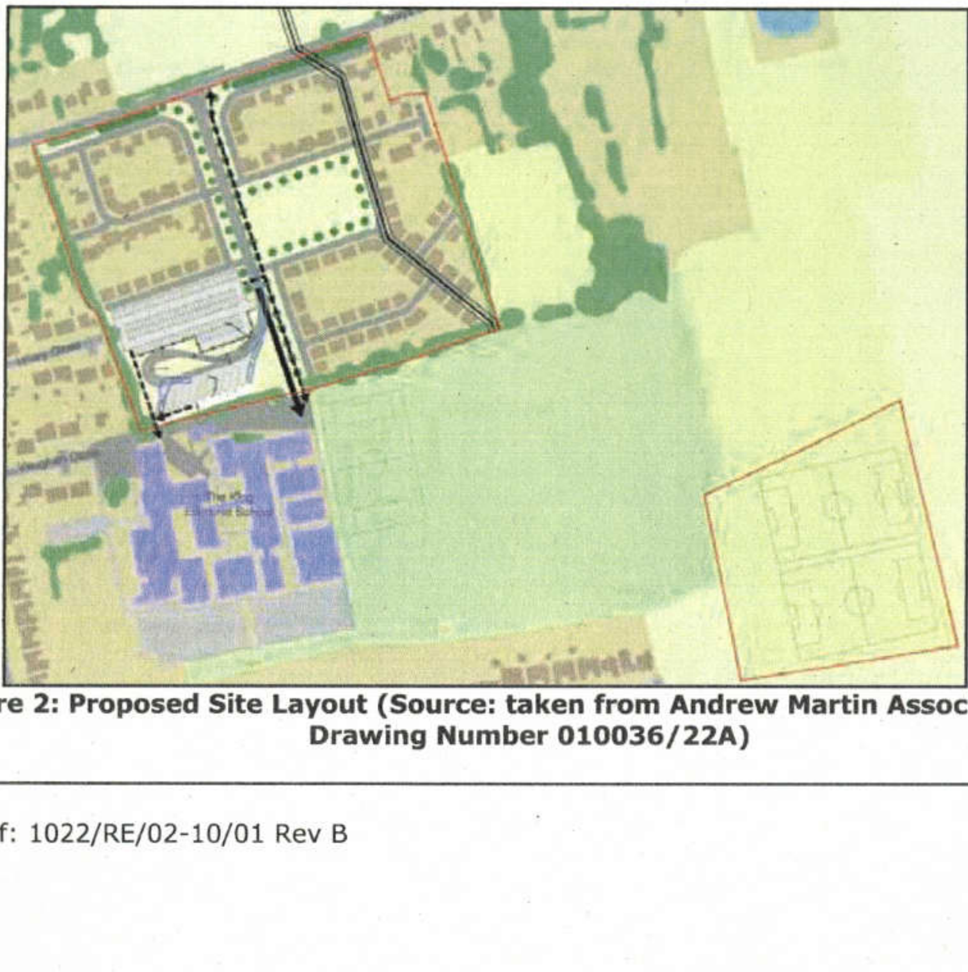


Figure 2: Proposed Site Layout (Source: taken from Andrew Martin Associates Drawing Number 010036/22A)

3. DATA COLLECTION

3.1 To assist with this report, the data collected included:

- Ordnance Survey 1:10,000 street view map (Evans Rivers and Coastal Ltd OS licence number 100049458) obtained from Andrew Martin Associates and Promap.
- Topographical survey of the site including spot levels and existing building footprints carried out by Randall Surveys LLP (Drawing Numbers 11526/JD/1 and 11526/JD/2).
- 1:250,000 *Soil Map of Eastern England* (Sheet 4) published by Cranfield University and Soil Survey of England and Wales 1983.
- 1:625,000 *Hydrogeological Map of England and Wales*, published in 1977 by the Institute of Geological Sciences (now the British Geological Survey).
- Borehole log records obtained from British Geological Survey's GeoRecords dataset.

3.2 All third party data used in this study has been checked and verified prior to use in accordance with Evans Rivers and Coastal Ltd Quality Assurance procedures.

4. GROUNDWATER FLOODING

4.1 Mechanisms for Groundwater Flooding

4.1.1 In order to assess the potential for groundwater flooding during higher return period rainfall events, the Jacobs/DEFRA report entitled *Strategy for Flood and Coastal Erosion Risk Management: Groundwater Flooding Scoping Study*, published in May 2004, was consulted, together with the guidance offered within the document entitled *Groundwater flooding records collation, monitoring and risk assessment (ref HA5)*, commissioned by DEFRA and carried out by Jacobs in 2006.

4.1.2 According to Cobby et al (2009), groundwater flooding can be defined as flooding caused by the emergence of water originating from subsurface permeable strata. The greatest risks of groundwater flooding are considered to be from either:

- a rise of groundwater in unconfined permeable strata, such as Chalk, after prolonged periods of extreme rainfall;
- a rise of groundwater in unconsolidated, permeable superficial deposits, which are in hydraulic continuity with local river water levels and where the hydraulic gradient of the water table is low.

4.1.3 As described above, it is widely accepted that groundwater flooding generally occurs from both permeable strata (e.g. Chalk) and superficial deposits (e.g. sands and gravels). In particular, unconfined water-bearing deposits (i.e. those with permeable soils above them) are susceptible to a rise in groundwater during prolonged, extreme rainfall and during periods of high recharge throughout autumn and winter. Antecedent conditions, such as, above average groundwater levels prior to the rainfall event, are also a contributing factor to a variation in the water table.

4.1.4 Groundwater flooding from Chalk aquifers, for example, mainly occurs when the surface of the Chalk is close to, or outcrops at the ground surface. The rise in the water table during prolonged and extreme rainfall can be significant, especially if the Chalk aquifer is unconfined and if the original water level in the aquifer is high. Flooding from such aquifers may occur within a few hours or days of the rainfall or up to a few weeks after.

4.1.5 The volume stored within the fissures of the Chalk is dependent on the relatively slow transportation of water through the fissures. These characteristics of the Chalk allow it to become susceptible to an increase in the volume of water stored and therefore potential increases in the water table into the unsaturated zone.

4.1.6 Permeable superficial deposits can also hold quantities of groundwater, although these tend to be insignificant compared to the stored quantities within consolidated aquifers. Unconsolidated deposits such as sand and gravels are sufficiently permeable to store water; however such deposits which yield a low quantity of water are commonly termed a non-aquifer.

4.1.7 It is common for groundwater flooding from water-bearing superficial deposits to occur within the vicinity of watercourses, as the water table is generally in hydraulic continuity with the water levels in the watercourse. Therefore, if the watercourse floodplain is flat and low-lying, the water table is likely to have a low hydraulic gradient and will rise to the equivalent water level within the watercourse (Figure 3). This, in turn, can cause the water table to breach the ground surface. This is more prominent in winter during which groundwater flooding often precedes fluvial flooding.

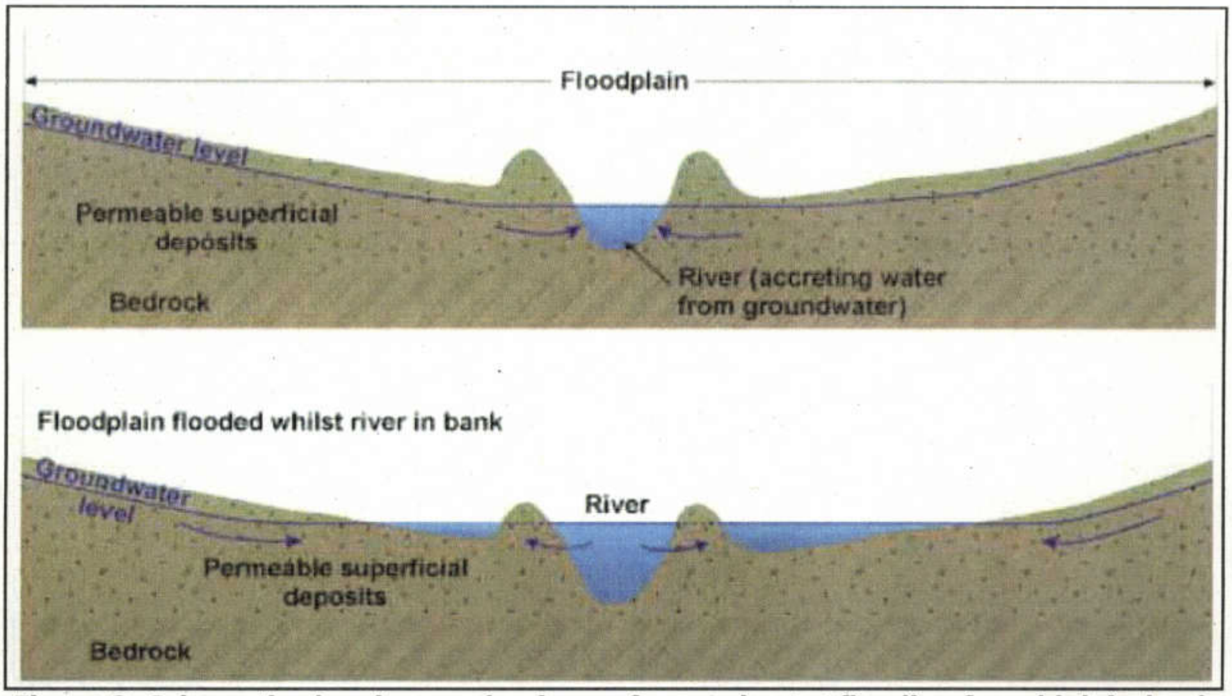


Figure 3: Schematic showing mechanisms of groundwater flooding from high in-bank water levels (Source: DEFRA Groundwater flooding records collation, monitoring and risk assessment (ref HA5))

4.1.8 Conversely, unconfined permeable deposits further up in the catchment are not generally in hydraulic continuity with a watercourse, and groundwater flooding across these areas occurs if the recharge in a particular area exceeds the local drainage capacity. In such instances, an increased flow from springs may be observed (especially at the junction between the permeable and impermeable deposits). During some extended periods of rainfall, when the local drainage capacity has been exceeded, the stored water in the permeable deposits increases thus leading to a significant rise in the water table.

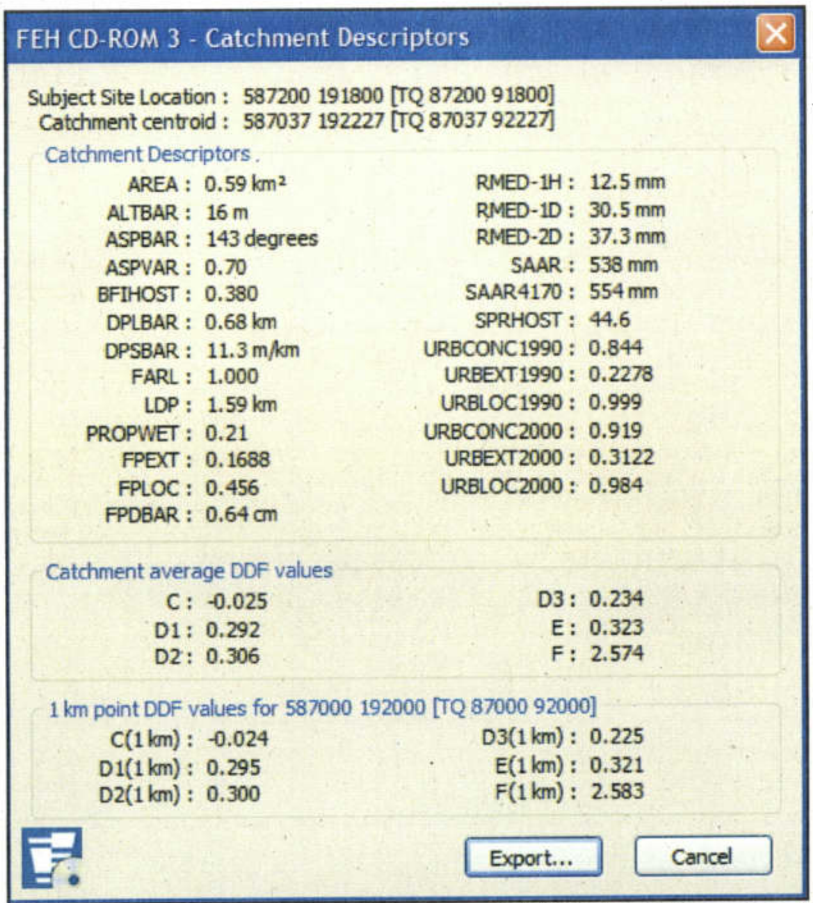
4.1.9 Similarly, deposits comprising a mixture of permeable and impermeable soils can lead to a presence of perched water. Perched water tables are located above less permeable deposits such as clay and are located within water-bearing soils such as sand and gravel. If perched water is unconfined then the potential for recharge and groundwater flooding can be high. If the perched water is confined by less permeable clay deposits, then the clay deposits will have a buffering effect on percolating surface water and thus the recharge potential and rise in the water table is low.

4.2 Soil and Geology at the Site

4.2.1 It can be seen from the various geological and hydrogeological data, listed in Section 3, that the soil types below the site are likely to comprise Eocene Superficial River Terrace deposits (i.e. slowly permeable, seasonally waterlogged, silty, sandy, gravelly, clay soils) underlain by thick Eocene London Clay.

4.2.2 The deposits across the site are likely to be slowly permeable due to the high proportion of clay soils present. This is supported by a Standard Percentage Runoff value (SPRHOST) of 44.63 (Figure 4), (i.e. 44.63 percent of all water falling across the site runs off leaving 55.37 percent to infiltrate). The information from the *Flood Studies Report*, 1975, together with Table 6 and equation 12 of the ADAS document entitled *Pipe Size Design for Field Drainage*, 1980, indicates that the soils across the site have a low

Winter Rain Acceptance Potential (WRAP) and high Winter Runoff Potential. This suggests further that the soils at the site are poorly drained and have a low infiltration capacity.



FEH CD-ROM 3 - Catchment Descriptors

Subject Site Location : 587200 191800 [TQ 87200 91800]
Catchment centroid : 587037 192227 [TQ 87037 92227]

Catchment Descriptors

AREA :	0.59 km²	RMED-1H :	12.5 mm
ALTBAR :	16 m	RMED-1D :	30.5 mm
ASPBAR :	143 degrees	RMED-2D :	37.3 mm
ASPVAR :	0.70	SAAR :	538 mm
BFIHOST :	0.380	SAAR4170 :	554 mm
DPLBAR :	0.68 km	SPRHOST :	44.6
DPSBAR :	11.3 m/km	URBCONC1990 :	0.844
FARL :	1.000	URBEXT1990 :	0.2278
LDP :	1.59 km	URBLOC1990 :	0.999
PROPWET :	0.21	URBCONC2000 :	0.919
FPEXT :	0.1688	URBEXT2000 :	0.3122
FPLOC :	0.456	URBLOC2000 :	0.984
FPDBAR :	0.64 cm		

Catchment average DDF values

C :	-0.025	D3 :	0.234
D1 :	0.292	E :	0.323
D2 :	0.306	F :	2.574

1 km point DDF values for 587000 192000 [TQ 87000 92000]

C(1 km) :	-0.024	D3(1 km) :	0.225
D1(1 km) :	0.295	E(1 km) :	0.321
D2(1 km) :	0.300	F(1 km) :	2.583

Export... Cancel

Figure 4: Catchment descriptors (Source: FEH CD-ROM Version 3, 2009)

4.2.3 In order to provide confirmation of the soil types below the site, two borehole logs have been obtained from the British Geological Society's GeoRecords dataset. The location of the boreholes can be seen on Figure 5 and the borehole logs can be seen in Appendix A.

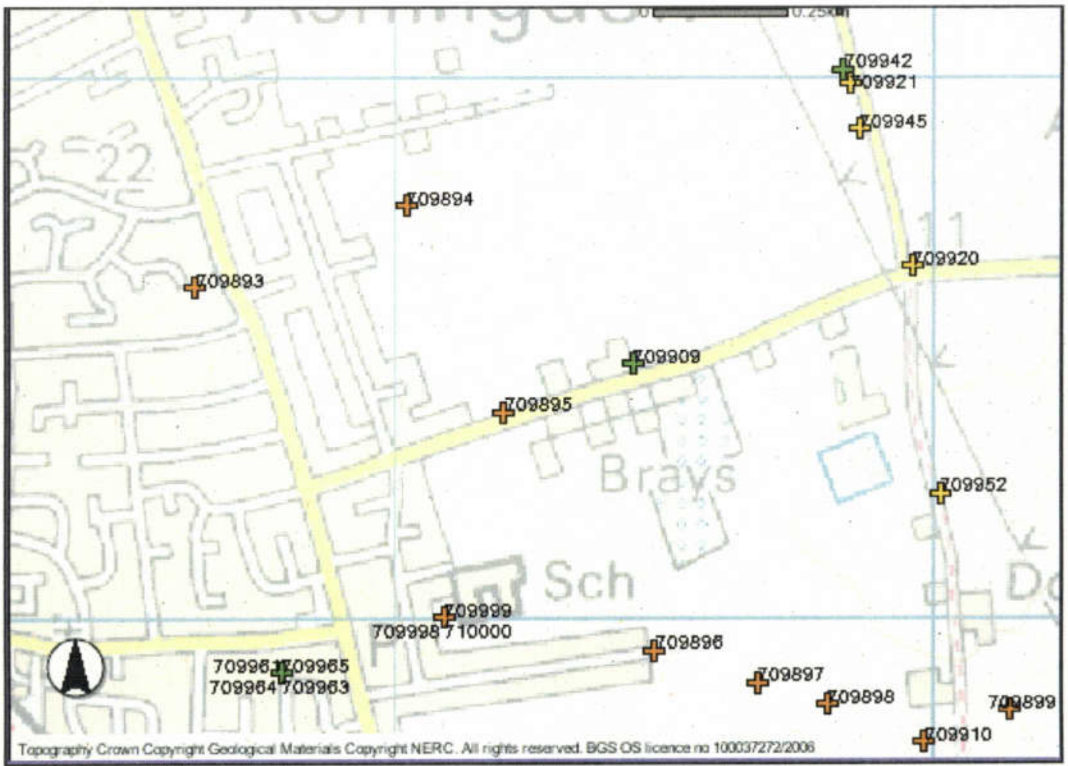


Figure 5: Borehole locations (Source: British Geological Society GeoRecords, 2010)

4.2.4 Borehole 709909 (also referenced as TQ89SE37 in Appendix A) is located approximately 200m to the east of the northern site and was drilled to a total depth of 12.3m below ground level (bgl). The information confirms that silty, sandy clays are present across this area up to 8.6m bgl. Sandy gravel horizons have been recorded below these deposits between 8.6m bgl and 12.10m bgl, below which, London Clay is the dominant soil type.

4.2.5 Borehole 709894 (also referenced as TQ89SE22 in Appendix A) is located to the north of the site and was drilled to a depth of 4m bgl. Similarly, silty, sandy clay with occasional gravels are present at this location.

4.2.6 By consulting the soil maps and hydrogeological maps, it is considered that the lithology recorded on the borehole logs is representative of the soil types across the site and wider area.

4.3 Groundwater Flooding Potential at the Site

Chalk

4.3.1 Reference to the *Hydrogeological Map of England and Wales* and *Hydrogeological Map Southern East Anglia* indicates that the basement Chalk aquifer is located beneath the London Clay deposits at a greater depth. The phreatic water table of the Chalk below the site is estimated to be approximately at -60m AOD (i.e. at a minimum depth of 72.31m below the site).

4.3.2 The London Clay deposits have a low permeability and confine the underlying Chalk aquifer, which in turn, is having a buffering effect on percolating surface water. This causes the recharge potential of the aquifer to be reduced and also keeps the water table of the Chalk deep within the saturated zone. Therefore, the site is not considered to be at risk from flooding resulting from a rise in the water table within the Chalk.

4.3.3 It is considered that the effects of climate change also need to be considered in any assessment of groundwater flooding. The information provided by the UK Groundwater Forum suggests that during wetter winters the amount of groundwater recharge could increase and for areas with high water tables, this increase in groundwater recharge may result in more frequent groundwater flood events. Conversely, drier summers could reduce the moisture content of the soils leading to groundwater droughts and a decline in storage as harder and drier soil surfaces tend to promote runoff and evaporation rather than infiltration. The feature article entitled *Groundwater and Climate Change* from the March 2006 edition of the *Geoscientist* magazine, issued by The Geological Society of London, describes that climate change modelling results suggest that in Eastern England future drier summers will lead to a delay in the onset of recharge which may be compensated by greater winter recharge thus leading to an overall net increase in recharge over a given year. Even with greater winter recharge, it is unlikely that the site will be affected significantly by a rise in the Chalk water table as it remains confined and at depth.

Superficial Deposits

4.3.4 Localised perched water above the London Clay deposits has been observed at a depth of 8.2m bgl (5.4m AOD) in borehole 709909 (TQ89SE37) and at a depth of 2.9m bgl in borehole 709894 (TQ89SE22). The perched water is located within the more permeable sandy horizons; however the borehole logs confirm that these horizons are confined by less permeable clay deposits above them. The more permeable horizons, where perched water is being stored, form a non-aquifer as they tend to hold insignificant quantities of groundwater.

4.3.5 The base flow index (BFIHOST) value of 0.380, derived from the catchment descriptors shown on Figure 4, suggests a low propensity for flooding from high water table levels. The base flow index essentially proportions the flow within a watercourse which has been derived from the stored or slow release of groundwater. For example, high base flow values indicate that the flows are effectively groundwater fed. As the value drops, the catchment is likely to be dominated by surface water runoff/fluvial flooding. Therefore, the resultant low BFIHOST value suggests that the local drainage ditches and watercourses, receive most of their baseflow from overland runoff rather than from a groundwater source. This indicates that the perched water supply to these water bodies is limited.

4.3.6 The potential for perched water to rise within the unsaturated zone during periods of prolonged or heavy rainfall is low due to the presence of low permeability soils above it. The less permeable soils overlying the water-bearing deposits will be having a buffering effect on percolating surface water, thus reducing the recharge potential and keeping the water table at sufficient depth below the site.

4.3.7 Additionally, as the site is located across upper areas of the catchment, the hydraulic gradient of the water table will be steeper and not likely to be in hydraulic continuity with water levels in a watercourse. Therefore, this supports a lower risk of groundwater flooding at the site as the potential for groundwater to rise significantly is reduced.

4.3.8 Based on the evidence presented in this Section, there is likely to be no immediate risk to people and property, and there have been no recorded groundwater flood events across the area during 2002 to 2003, as indicated by the Jacobs Study.

4.3.9 Due to the sub-surface less permeable soil types, the site is however, likely to experience periodical water-logging and partial saturation, particularly after a rainfall event. Although this may be inconvenient for activities across the southern site, this should not be mistaken for groundwater flooding.

5. SURFACE WATER DRAINAGE AND SUDS

5.1 Existing Surface Water Drainage

5.1.1 As the southern site is intended to be kept as open space/playing fields, there will be no change in the surface water runoff regime across this area and therefore surface water drainage across this part of the site will not be discussed further in this Chapter.

5.1.2 It has been determined using the topographical survey that surface water runoff from the northern site occurs in a south east direction. Surface water runoff is also expected to contribute to the baseflow within the local drainage ditches. A proportion of rainfall falling across the existing site will also infiltrate into the soils of the site and this is denoted by the Standard Percentage Runoff (SPRHOST) catchment descriptor value of 44.6%.

5.1.3 As discussed within paragraph 2.1.2, the existing site is covered by agricultural land. In order to quantify the existing runoff rate from the site, the methodology outlined within the *Institute of Hydrology Report Number 124* (IoH 124) has been adopted. This document together with the guidance stipulated in the *Interim Code of Practice for Sustainable Drainage Systems*, compiled by the National SUDS Working Group in July 2004, suggests that an estimation of peak runoff rates from areas below 50 ha can be derived from the calculated mean annual flood flow, QBAR. For sites which are currently a greenfield, the peak flow rate for the site can be calculated by the IoH 124 method using QBAR which represents this greenfield runoff rate (GFR). The software also allows the user to enter the proportion of the site which is currently urbanised (i.e. 0.24 ha).

5.1.4 The ICPSUDS function within the Microdrainage software Version 12.5 can be used in order to determine the QBAR value as the application site area is below 50 ha in size (i.e. 5.35 ha). The SAAR value of 538mm for the site has been determined from the catchment descriptors shown on Figure 4. The soil value has been determined using the information from the Winter Rain Acceptance Potential (WRAP) map within the *Flood Studies Report*, 1975, together with Table 6 and equation 12 of the ADAS document entitled *Pipe Size Design for Field Drainage*, 1980. The resultant soil value of 0.45 was also checked for consistency with the digital geographical data within the Microdrainage software which also provides a soil value. The results can be seen on Figure 6.

Evans Rivers & Costal Limited		Page 1
PO Box 3494 Norwich Norfolk NR7 7PY	Brays Lane Rochford Rev B	Micro Drainage
Date 26/02/2011 File	Designed By RE Checked By	
Micro Drainage	Source Control W.12.5	

ICP SUDS Mean Annual Flood

Input

Return Period (years) [illegible] Soil 0.450
Area (ha) 5.350 Urban 0.045
SAAR (mm) 538 Region Number Region [illegible]

Results l/s

QBAR Rural 17.[illegible]
QBAR Urban 18.[illegible]

Q[illegible] years 16.7

Q1 year 16.[illegible]
Q30 years 41.[illegible]
Q100 years 5[illegible].0

Figure 6: Greenfield runoff rates for the existing site (Source: Microdrainage Version 12.5, 2010)

5.2 Soil Types and SUDS Suitability

5.2.1 Annex F of PPS 25 recommends the maximum practical use of Sustainable Drainage Systems (SUDS) within proposals for new sites. There is a general PPS 25 requirement that sustainable drainage systems (SUDS) be installed where appropriate, in order to limit the amount of surface water runoff entering drainage systems and to return surface water into the ground to follow its natural drainage path.

5.2.2 As described in Section 4, the soils below the site comprise slowly permeable silty, sandy, clay soils over London Clay deposits. Therefore, based on the guidance outlined within Table 4.7 of CIRIA 697 *The SUDS Manual*, it has been assumed that the soils beneath the site possess an overall infiltration rate of 1.3×10^{-7} m/s, which is considered to be appropriate for soils of this type.

5.2.3 The generally poor infiltration media below the site together with the presence of perched water may preclude the practical use of infiltration devices such as soakaways. For example, the design criteria outlined in *BRE Digest 365* for soakaways require that the soakaway discharges from full to half-volume within 24 hours, and this is unlikely to be achieved given the estimated infiltration rate. Additionally, the base of a soakaway is required to be a minimum of 1m above the water table, and this may not be achieved due to the presence of a variable perched water table below the site.

5.2.4 Other types of SUDS devices which could be used, and which do not rely on infiltration, are discussed further in this Chapter and include pervious surfaces, swales and detention basins.

5.2.5 The Environment Agency's website indicates that the site is not located within a Source Protection Zone associated with a groundwater abstraction point. Nevertheless, it is imperative that the pollution risk from any surface water soaking into the ground from hardstanding areas (which can carry pollutants such as oils and soap suds etc), is mitigated against to prevent soil and water contamination.

5.3 Pervious Surfaces

5.3.1 The driveways and other hardstanding areas such as car parking areas could be constructed using pervious surfaces. Surface water from the building roofs could then be drained onto these appropriately designed pervious surfaces. This approach is described further in CIRIA 582 entitled *Source control using constructed pervious surfaces.*

5.3.2 Pervious surfaces act as an effective way to store or infiltrate surface water and have also been shown to act as a filter and retainer for pollutants, in particular oil. This has been investigated and documented within the Quarterly Journal of Engineering Geology and Hydrogeology, Volume 37, November 2004, in which this approach can also be implemented when considering the protection of groundwater. CIRIA have reported that approximately 70-90 percent of hydrocarbons can be removed by this technique. Also there are cost reductions available with this approach as there is no requirement to install pipes and gullies.

Note: According to the DCLG document entitled *Guidance on the permeable surfacing of front gardens* published in September 2008, from the 1st of October 2008 new driveways or parking areas (>5 sq m) which allow uncontrolled runoff of surface water (i.e. are not constructed using permeable surfaces or use other infiltration/disposal media) will require planning permission.

5.3.3 The Tarmac Dry document entitled *Design Guidelines for porous/permeable pavements*, suggests that porous paving can permit a flow rate of up to 4500mm per hour. This coupled with a 30% porosity sub-base can provide for effective surface water control. Figures 7 and 8 illustrate the composition of a porous surface.

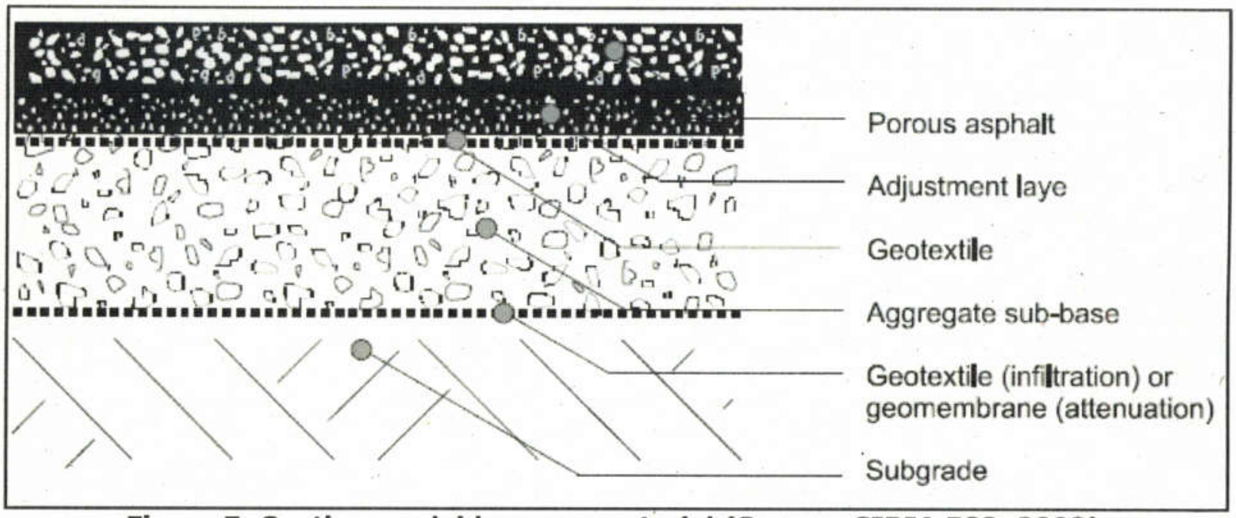


Figure 7: Continuous-laid porous material (Source: CIRIA 582, 2002)

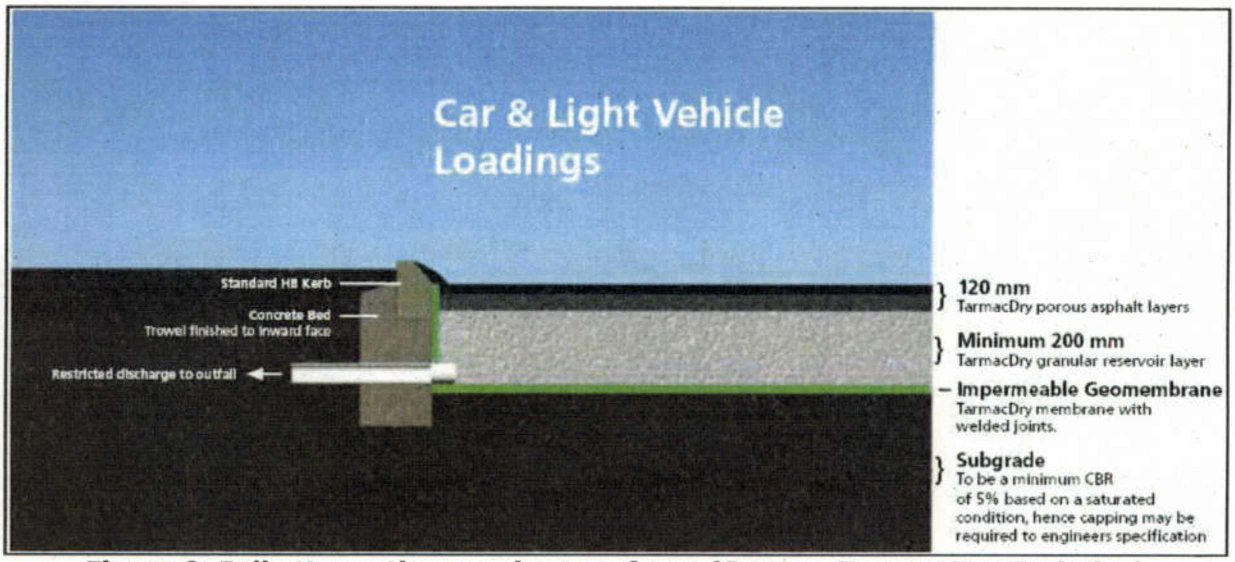


Figure 8: Full attenuation pervious surfaces (Source: Tarmac Dry Technical Information and Specifications)

5.3.4 Using the design criteria outlined within CIRIA 697 *The SUDS Manual* and CIRIA 582 *Source control using pervious surfaces*, the proposed hardstanding areas can be modelled as pervious surfaces within the Microdrainage software.

5.3.5 The system is assumed to be utilising full attenuation due to low permeable soils, therefore surface water will be temporarily stored within the pervious surface. A 110mm diameter outflow pipe will discharge surface water from the surface into either the main surface water sewer located beneath the access roads, or swales located along the side of the access roads.

5.3.6 In accordance with section 12.3.1 of CIRIA 697, a safety factor of 10 has been applied to the membrane percolation in the software to consider the gradual silting up effects of the concrete block paving joints. The model was run for the 1 in 100 year plus 30% climate change rainfall event and the DDF rainfall characteristics from the FEH CD-ROM Version 3 have also been entered into the software.

5.3.7 To provide an example of the performance of a typical pervious surface, a typical driveway (30 sq m) has been used, and an additional area of 80 sq m has been applied to represent the additional surface water draining across it from a typical dwelling roof area.

5.3.8 The results can be seen in Appendix B. The software has calculated the worst storm event to be 15 minute winter storm and there is no excess surface water residing on the surface of the driveway, with all surface water being stored and discharged by the pervious surface.

5.3.9 To demonstrate the performance of the pervious surface which will form the large car park associated with the bus turning area, the software has also been used and the results can be seen in Appendix B. The software has calculated the worst storm event to be the 60 minute winter storm and the excess depth of surface water residing across the pervious surface is 0.105m.

5.3.10 Paragraph 5.25 of the DCLG document entitled *Development and Flood Risk: Consultation on a Practice Guide Companion to PPS 25* states that hardstanding areas used for temporary storage of surface water should not be flooded to depths in excess of 300mm. CIRIA 635 entitled *Designing for exceedance in urban drainage – good practice,* suggests that hardstanding areas should not be flooded to depths in excess of 200mm. Therefore, the excess storage depth of 105mm is lower than these thresholds and would not pose a risk to people and property during the higher return period events.

5.3.11 According to CIRIA 582, where pervious surfaces are intended to be used for surface storage, standard kerbing is sufficient to contain the surface water on the site.

5.4 Swales

5.4.1 Swales can receive surface water from access roads and pervious surfaces and convey this water from these areas to an attenuation feature.

5.4.2 Swales are a SUDS feature which can provide some cleansing of surface water, especially from the 'first flush'. CIRIA 609 entitled *Sustainable drainage systems*, states that between 80-90 percent of heavy metals can be removed when using swales. Swales can be used for primary treatment of surface water prior to re-entry into the drainage system.

5.4.3 CIRIA 697 and the HR Wallingford Report SR666 entitled *Use of SUDS in high density developments,* suggest that swales can reduce peak flows and provide some infiltration of surface water.

5.4.4 Swales are typically between 0.4m and 0.6m deep and have a base width of 0.5m to 2m. For safety, the side slopes should not be greater than 1:4. Figure 9 shows a cross section of a typical conveyance swale. Swales are generally located along the verge adjacent to the footway and the effective incorporation of swales heavily depends on the availability of space across the site. During the detailed design stage, the exact positioning of swales across the site may result in changes to the masterplan in order to ensure that there is sufficient space for these systems.

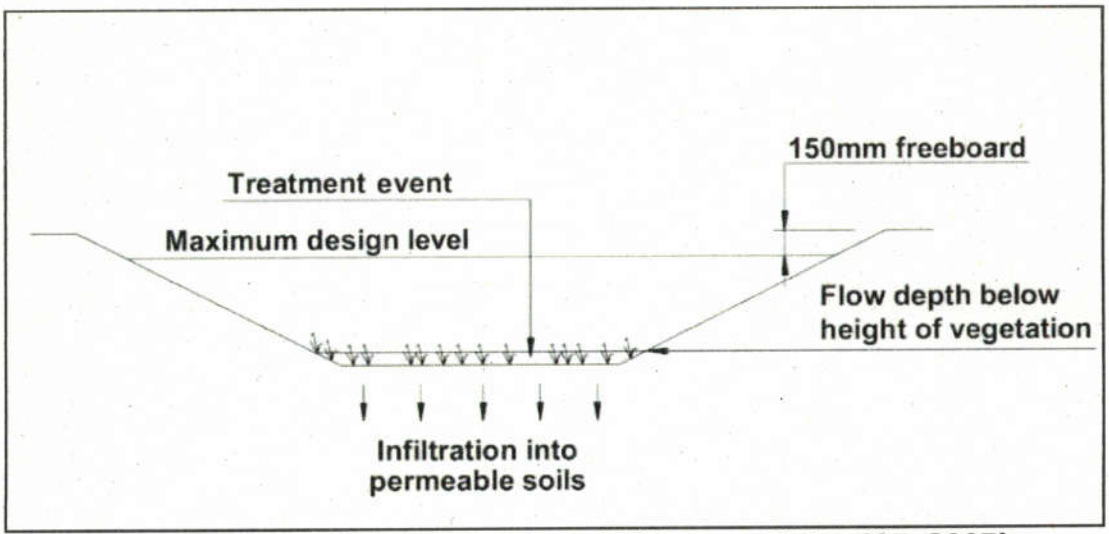


Figure 9: Standard conveyance swale (Source: CIRIA 697, 2007)

5.4.5 Swales will not be suitable across all areas of the proposed site due to the lack of available space. A pipe system independent of the swale network is also likely to be required to drain areas of the site where swales are not suitable due to the lack of available space.

5.5 Detention Basin

5.5.1 Surface water from all impermeable areas across the proposed site can be conveyed to a detention basin via swales or pipes. A dry detention basin is preferred to an attenuation basin to deter vandalism/trespassing and reduce the risks to vulnerable groups (i.e. children at nearby school).

5.5.2 Due to the development proposals across the site, the location of the detention basin is restricted to areas within the control of the Client outside of the site boundary. A site visit with the landowners on the 7th April 2010 confirmed whether the potential locations for the basin are feasible. These locations will need to be investigated further during the detailed design stage.

5.5.3 Three possible locations have been identified for the detention basin:

1) The first location is shown on Drawing Number 1022/RE/01B. The Anglian Water asset plans (Appendix C) indicate that there is a 525mm diameter surface water sewer running in a southerly direction past this location and it is proposed that, subject to an agreement with Anglian Water, a new pipe connection is made from the basin to the existing sewer, between manhole numbers 5752 and 5652, as this will allow for a positive discharge of attenuated flows from the basin. If Anglian Water will not accept an attenuated flow into the sewer, then attenuated flows from the basin could be discharged into the drainage ditch immediately to the south.

2) The second location is shown on Drawing Number 1022/RE/02B. As described above, the Anglian Water 525mm surface water sewer also flows in a southerly direction past this location. It is therefore proposed that attenuated flows from the basin will discharge into the sewer via a new connection between manholes 4953 and 4852.

3) The third location is shown on Drawing Number 1022/RE/03B. Surface water flows from the site would be directed to the basin which will be located adjacent to the existing fishing lake/reservoir. Attenuated flows would discharge into the drainage ditch located to the south of the existing lake which continues in an easterly direction.

5.5.4 Detention basins are vegetated depressions which are usually dry, except during and immediately after storm events. Some infiltration of surface water is likely to occur across the base of the basin and a restricted outflow allows the basin to fill and attenuate flows during storm events. Figure 10 shows a plan view of a typical detention basin.

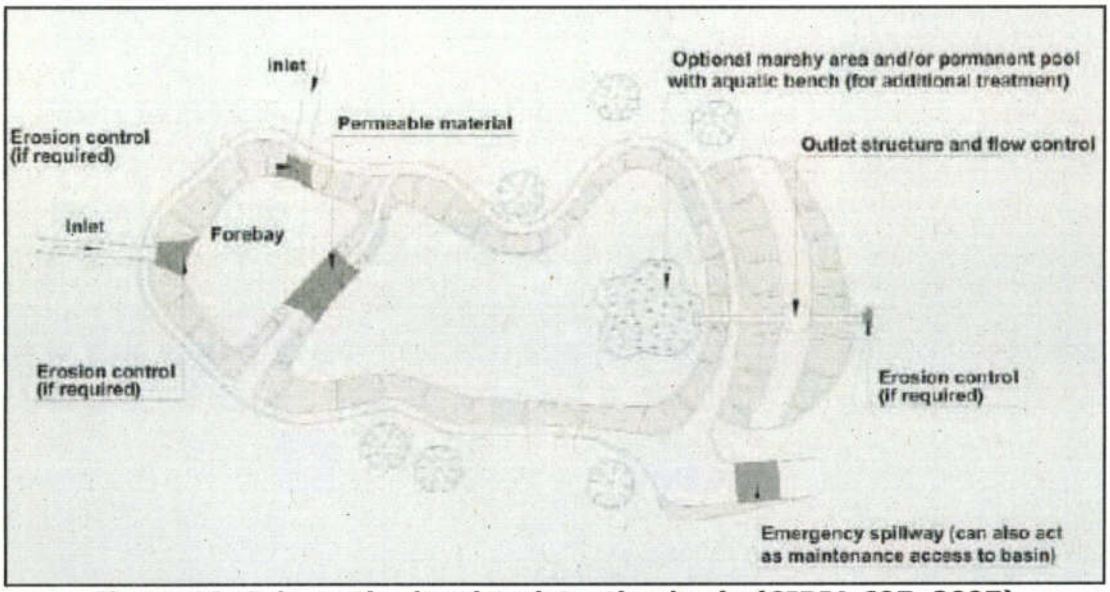


Figure 10: Schematic showing detention basin (CIRIA 697, 2007)

5.5.5 It is widely accepted that for a range of annual flow rate probabilities, up to and including the 1 in 100 year event, the developed rate of runoff from a site should be no greater than the existing rate of runoff for the same event.

5.5.6 CIRIA 697 and the *Interim Code of Practice for Sustainable Drainage Systems* suggest that it is important to match runoff volumes as well as runoff rates from a development with its greenfield equivalent. Without employing a wide range of infiltration systems, there will be an increased runoff volume from the site which could increase the volume of flood water within a receiving pipe network. Therefore, as recommended by Box 3.1 of CIRIA 697 and page 49 of the *Interim Code of Practice for Sustainable Drainage Systems*, it is preferable to limit the discharge from the attenuation feature during all return period events up to the 1 in 100 year event to the pre-development QBAR value or 2 l/s/ha, whichever is the greater.

5.5.7 By reviewing the greenfield runoff results shown on Figure 6, the corresponding greenfield runoff rate for QBAR is 18.8 l/s. Therefore, the maximum allowable discharge rate from the site equates to 18.8 l/s (QBAR being the largest flow rate).

5.5.8 In order to consider a worst-case scenario, it has been assumed that there is negligible infiltration of surface water into the soils from the pervious surfaces and swales, and that all surface water from hardstanding areas will eventually enter the detention basin.

5.5.9 By consulting the proposed site layout, the impermeable areas drainage to the basin is approximately 2.86 ha.

5.5.10 In order to quantify the volume of surface water needed to be stored within an detention basin up to the climate change enhanced 1 in 100 year storm event, the *Source Control – Tank or Pond* function within the Microdrainage software, Version 12.5, has been used together with the DDF rainfall characteristics from the FEH CD-ROM Version 3. The results are included within Appendix D and are summarised in Table 1.

Table 1: Detention basin storage calculations

Impermeable Area (ha)	Allowable Discharge Rate (l/s)	Storage volume during climate change 1 in 100 year storm event (cu m)	Area covered by detention basin (sq m)	Storage depth (m)	Total depth (m)
2.86	18.8	2342	3368	0.877	1.3

5.5.11 The CIRIA guidance suggests that for safety and maintenance reasons, the depth of the basin should not generally exceed 1.5m and the side slopes should have a maximum gradient of 1:4. A design freeboard allowance of at least 300mm should also be provided, and included within the total design depth.

5.6 Adoption

5.6.1 The maintenance of the pervious surfaces will be the responsibility of the home owner or alternatively a management company. Surface water pipes could be offered for adoption to Anglian Water, under Section 104 of the Water Industry Act 1991, or the Highways Authority, under Section 38 of the Highways Act 1980.

5.6.2 The swale network could also be offered to the aforementioned authorities, or alternatively the Local Authority could adopt these features under a Section 106 agreement of the Town and Country Planning Act 1990, or under The Community Infrastructure Levy (Planning Act 2008).

5.6.3 The detention basin could be adopted by the Local Authority or Highways Authority. If this is not preferable then such features can be adopted by a management company created by the developer as described above.

5.6.4 These arrangements will need to be confirmed prior to the detailed application, including detailed design carried out using appropriate computer modelling software. More detailed calculations demonstrating that the system has adequate capacity will also be required by Anglian Water for a Section 104 adoption application.

6. CONCLUSIONS

6.1 A review of the relevant guidance documents and various types of data collected at the site has enabled a full assessment of the flood risks to people and property to be quantified.

6.2 This assessment has investigated the possibility of groundwater flooding at the site and due to the nature of the soils at the site and catchment characteristics; it is considered that there will be a low risk to people and property during prolonged rainfall events.

6.3 An assessment of the practical use of sustainable drainage techniques has been carried out. As the soil types across the site are unlikely to support the effective use of deep infiltration devices such as soakaways, alternative methods of surface water disposal have been investigated:

- Surface water from driveways and roof areas across the proposed site could be drained via pervious surfaces. During the 1 in 100 year plus climate change event, there would be no excess surface water residing across the pervious surfaces.

- Pervious surfaces could be used to drain the waiting area associated with the bus turning area. During the climate change 1 in 100 year storm event the excess depth of surface water residing above the surface would be 105mm and would be managed and retained across this area by standard kerbing until capacity resumed.

- Surface water draining from access roads and pervious surfaces could be conveyed to the lower parts of the site via a swale and/or pipe network. This would allow for some infiltration and attenuation of surface water and would provide further cleansing of surface water, by removing some pollutants and suspended solids.

- The surface water conveyed by the swale or pipe network could discharge into an dry detention basin which would be designed up to the climate change enhanced 1 in 100 year event. Surface water flows and volumes would be attenuated and released into the Anglian Water system at a greenfield rate.

6.4 The pervious surfaces are likely to be privately adopted, however a management company could maintain the shared areas. The swales and detention basin could be adopted by the Local Authority, Highway Authority or maintained by a private management company. Any proposed surface water sewers across the site will need to be designed to adoptable standards if their maintenance is to be offered to Anglian Water.

6.5 It is recommended that the surface water drainage options described within this assessment are used to develop a more detailed surface water strategy during the detailed design stage. There may be a requirement for the masterplan and landscaping proposals to be revised in order to position the SUDS features more effectively.

7. BIBLIOGRAPHY

i. ADAS 1980. MAFF Report 5, *Pipe size design for field drainage.*

ii. Balmforth, D., et al. 2006. *Designing for exceedance in urban drainage – good practice, Report C635.* London: CIRIA.

iii. Bettess, R. 1996. *Infiltration drainage – Manual of good practice, Report C156.* London: CIRIA.

iv. BRE 1991. Digest 365. *Soakaway Design.*

v. British Geological Survey 2010. *Borehole Records 709909 and 709894.* GeoRecords.

vi. Communities and Local Government 2009. *Planning Policy Statement 25: Development and Flood Risk – Practice Guide.* HMSO.

vii. Communities and Local Government 2008a. *Guidance on the permeable surfacing of front gardens.* HMSO.

viii. Communities and Local Government 2007. *Improving the Flood Performance of New Buildings.* HMSO.

ix. Communities and Local Government 2006. *Planning Policy Statement 25: Development and Flood Risk.* HMSO.

x. DEFRA/EA 2005. *Framework and guidance for assessing and managing flood risk for new development, Phase 2, Flood and Coastal Defence R&D Programme, R&D Technical Report FD2320/TR2.* Water Research Council.

xi. DEFRA/EA 2005a. *Preliminary rainfall runoff management for developments, Flood and Coastal Defence R&D Programme, R&D Technical Report W5-074/A/TR/1*, Revision C. Water Research Council.

xii. DEFRA/Jacobs 2006. *Groundwater flooding records collation, monitoring and risk assessment (ref HA5).*

xiii. DEFRA/Jacobs 2004. *Strategy for Flood and Coastal Erosion Risk Management: Groundwater Flooding Scoping Study (LDS), Final Report, Volumes 1 and 2.*

xiv. Dickie et al. 2010. *Planning for SUDS – Making it happen.* *Report C687.* London: CIRIA

xv. DOE 1981. *The Wallingford Procedure: Design and Analysis of Urban Storm Drainage.* HR Wallingford.

xvi. DOE 1981a. *Modified Rational Method: The Wallingford Procedure.* HR Wallingford.

xvii. Environment Alliance 2006. *Pollution Prevention Guidelines 3: Use and design of oil separators in surface water drainage systems.*

xviii. Geological Society of London 2006. *Groundwater and Climate Change.* Geoscientist magazine, Volume 16, No 3.

xix. HR Wallingford 2005. *Use of SUDS in high density developments,* Report SR 666.

xx. HR Wallingford 2002. *Guide for the Drainage of Development Sites,* Report SR 574.

xxi. Hulme, M., Jenkins, G.J., Lu, X., Turnpenny, J.R., Mitchell, T.D., Jones, R.G., Lowe, J., Murphy, J.M., Hassell, D., Boorman, P., Mcdonald, R. and Hill, S. 2002 *Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report,* Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK. 120pp

xxii. Institute of Geological Sciences 1977. *Hydrogeological Map of England and Wales,* 1:625,000. NERC.

xxiii. Marshall, D.C.W. and Bayliss, A.C. 1994. *Flood Estimation for Small Catchments,* IH Report 124. Institute of Hydrology.

xxiv. Martin, P. *et al.* 2001. *Sustainable urban drainage systems - best practice guide, Report C523.* London: CIRIA.

xxv. Martin, P. *et al.* 2000. *Sustainable urban drainage systems - Design manual for England and Wales, Report C522.* London: CIRIA.

xxvi. National SUDS Working Group. 2004. *Interim Code of Practice for Sustainable Drainage Systems.*

xxvii. NERC 2009. *Flood Estimation Handbook* [CD-ROM], Version 3. Institute of Hydrology.

xxviii. NERC 1975. *Flood Studies Report (FSR).* Institute of Hydrology.

xxix. Newman, A.P. 2004. *Protecting groundwater with oil-retaining pervious pavements: historical perspectives, limitations and recent developments.* Quarterly Journal of Engineering Geology and Hydrogeology.

xxx. Pratt, C., Wilson, S., and Cooper, P. 2002. *Source control using constructed pervious surfaces; hydraulic, structural and water quality performance issues, Report C582.* London: CIRIA.

xxxi. Preene, M. et al 2000. *Groundwater control – design and practice, Report C515.* London: CIRIA.

xxxii. Reed, R., Faulkner, D. and Bayliss, A. 1999. *Flood Estimation Handbook (FEH),* 5 Volumes. Institute of Hydrology.

xxxiii. Soil Survey of England and Wales 1983. *Soil Map of Eastern England (Sheet 4),* 1:250,000. Cranfield University.

xxxiv. Tarmac (undated). *Design Guidelines for porous/permeable pavements.*

xxxv. Tarmac (undated). *Technical Information and Specifications.*

xxxvi. UK Groundwater Forum. *Groundwater Resources and Climate Change.* http://www.groundwateruk.org/Groundwater_resources_climate_change.aspx [accessed 01st March 2010]

xxxvii. Water UK 2006. *Sewers for Adoption 6th Edition, A design and construction guide for developers.* Water Research Council.

xxxviii. Wilson, S., Bray, R. and Cooper, P. 2004. *Sustainable Drainage Systems; hydraulic, structural and water quality advice, Report C609.* London: CIRIA.

xxxix. WinDes 2009. *Micro Drainage.* Version 12.5.

xl. Woods-Ballard., et al. 2007. *The SUDS Manual, Report C697.* London: CIRIA.

APPENDIX A – BOREHOLE LOG RECORDS

TQ 89 SE 37 8745 9247 Ashingdon, Essex. Block A

Surface level +13.6 m (+44.5 ft)
Water struck at +5.4 m (+17.5 ft)
Shell, 203 mm diameter
November 1972

Overburden 8.60 m
Mineral 3.50 m
Bedrock 0.20 m+

LOG

Geological Classification	Lithology	Thickness m	Depth m
Soil	Clayey silt	0.30	0.30
Head over brickearth	Clayey silt, light brown to yellowish brown with bluish greenish grey mottling. Race abundant from 1.30 m to 1.80 m. Scattered carbonaceous patches	4.10	4.40
Buried Channel Deposits	Clayey silt with fine sand, dark olive grey, becoming light olive grey with depth. Scattered carbonaceous patches present	4.20	8.60
	Sandy gravel Medium sand with fine to coarse gravel. Gravel composed of angular to subrounded flint and well rounded flint and quartzite. Gravel content increasing with depth	3.50	12.10
London Clay	Silty clay, stiff, medium olive grey	0.20+	12.30

GRADING

Mean for Deposit

See opposite

Bulk Samples Percentages

Depth below surface (m) From	To	Fines -1/16	+1/16-¼	Sand +¼-1	+1-4	Gravel +4-16	+16
9.8	12.1	6	4	49	7	21	13

103b TQ 89 SE/37
587450 192470

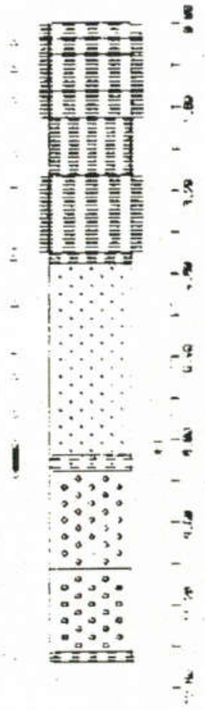
BOREHOLE LOG — I.G.S. REF. TQ8792 001 — FIELD STAFF REF. TQ89SE 37.

NATIONAL GRID REF. 587450 192470 — SURFACE LEVEL 13.60 M. OD.

DRILLED BY W&C FRENCH — DRILL TYPE SHELL&AUGER — DATE COMPLETED 24 NOV 1972

RECORDED BY R.ELLISON — FIRST WATER DEPTH 6.20M. — REST WATER DEPTH M.

STRATIGRAPHY	DESCRIPTION	THICKNESS	DEPTH	O.D.L.
TOPSOIL	CLAYEY, SILT.	0.30	0.30	13.30
HEAD	GRAVELLY(FINE AND MED), CLAYEY, SILT, FIRM, 5YR5/6 (LIGHT BROWN) MOTTLED 10YR5/2 (MEDIUM YELLOW BROWN),WEATHERED, CONTAINING FLINT, COMMON ROOTS (PRES.DAY)	0.30	0.60	13.00
BRICKEARTH	CLAYEY, SILT, STIFF, 10YR5/6 (MEDIUM YELLOW BROWN) MOTTLED 5B7/1 (LIGHT BLUISH GRAY),WEATHERED.	0.70	1.30	12.30
	CLAYEY, SILT, STIFF, 10YR5/4 (MODERATE YELLOW BROWN) MOTTLED 5B6/1 (MEDIUM BLUE),CONTAINING ABUNDANT RACE RARE CARBONACEOUS ROOTS	0.50	1.80	11.80
	SILTY, CLAY, STIFF, 10YR5/6 (MEDIUM YELLOW BROWN) MOTTLED 10G7/2 (PALE GREYISH GREEN),WEATHERED, CONTAINING SCATTERED RACE SCATTERED CARBONACEOUS MATERIAL	1.10	2.90	10.70
	CLAYEY, SILT, STIFF, 5YR5/6 (LIGHT BROWN) MOTTLED 5B7/2 (PALE BLUE),WEATHERED, CONTAINING SCATTERED CARBONACEOUS MATERIAL FISSURING, VERY HIGH. WITH SUBSIDIARY FINE SAND, 10YR6/6 (DARK YELLOWISH ORANGE) .	1.50	4.40	9.20
TERRACE DEPTS.	SILTY, CLAY, SOFT, 5P2/1 (DARK PURPLE), FRESH.	0.20	4.60	9.00
	SLIGHTLY CLAYEY, SILTY, FINE SAND, SOFT, 5Y3/1 (OLIVE GRAY) GRADING 5Y5/1 (LIGHT OLIVE GRAY),FRESH, CONTAINING SCATTERED CARBONACEOUS MATERIAL	3.70	8.30	5.30
	CLAYEY, FINE SAND, FIRM, 5Y5/1 (LIGHT OLIVE GRAY), FRESH.	0.30	8.60	5.00
	GRAVELLY(FINE), PREDOMINANTLY FINE TO COARSE SAND, VERY SOFT, 5Y6/1 (LIGHT OLIVE GRAY), CONTAINING ROUNDED TERTIARY FLINT, SUBANGULAR FLINT	1.90	10.50	3.10
	SANDY(COARSE), PREDOMINANTLY FINE TO COARSE GRAVEL. CONTAINING ROUNDED TERTIARY FLINT, SEPTARIAN NODULES	1.60	12.10	1.50
LONDON CLAY	SILTY, CLAY, STIFF, 5Y5/1 (LIGHT OLIVE GRAY), SLIGHTLY WEATHERED.	0.20	12.30	1.30



~~Temp borehole NO.~~ [illegible]

Borehole Reg No TQ 89 SE 37
Nat Grid Ref TQ ~~[illegible]~~ 8745, 9247
Locality CANEWDON
Surface level 13.6 m (44.6 ft) OD
Drilled by FRENCH I
Drill type SHELL
Hole diameter 8"
Depth(s) bailed 8.75m — 12.30m.
Date started 24-11-72
Date finished 24-11-72
Recorded by R.A. Ellison

Classification of deposit	Thickness m	Nature
WASTE	12.10m	mainly clayey silt and fine sand with 3.50m sand and gravel at base.
BEDROCK	0.2m.	London clay.

CONFIDENTIAL

Remarks

CONFIDENTIAL.

Explanation
Groundwater depth
▽ first encountered
▽ Morning water level
▽ Evening water level
Casing depth
Borehole depth
U4 sample
Fraction recovered
Spot disturbed sample
} Bulk sample
SPT Standard Penetration Test

Geological Classification	Description of Strata	Depth	Sampling	Sample Nos	Water Level	Drilling & casing progress
TOP SOIL	clayey silty soil.					
HEAD ✓ 30	Gravelly clayey silt. Gravel flints M+F grade. Firm. Mottled 5YR5/6, 10YR5/2. Weathered. Common modern roots	30	● 30 50	89SEGD1		
-60 clayey silt	clayey silt. Stiff. Mottled 10YR5/6, 5B7/1. weathered.	60	● 80 100	89SEGD2		
	brown / [illegible] y-br	1				
-1.30 clayey silt with race	clayey silt (less clay than above). Stiff. Mottled 10YR5/4, 5B6/1. Race ~~very common~~ abundant – white N9, soft → hard, occurs in irregular disseminated patches with some nodules. Rare carbonized rootlets.	1.30	● 140 160	89SEGD3		
-1.80 mainly clayey silt.	Silty clay. Stiff. Mottled 10YR5/6, 10G7/2. Scattered race nodules. Scattered carbonized plant remains. Weathered.	1.80 / 2	● 240 2.50	89SEGD4		
-2.90 clayey silt with sandy patches (Weathered)	Clayey silt. Stiff. Mottled, mainly 5YR5/6 and 5B7/2. Scattered carbonized plant remains. Some fine sandy patches 10YR8/6 Weathered	2.90 / 3	● 3.0 3.10	89SEGD5		
	4.20 Clayey silt. Mottled. 5YR5/6 and 5B7/2. Fissuring v. high.	4	● 4.20 4.30	89SEGD6		
4.40 purple silt	Clayey silt / silty clay. Soft. 5P2/1 (v. dark purple). Unweath.	4.40	● 4.40 4.50	89SEGD7		
4.60 Clayey silt / fine sand. (Unweathered)	4.60 clayey silt / fine sand. Soft. 5Y8/1. Scattered carbonized plant remains.	4.60 / 5	● 5.30 5.40	89SEGD8		
	6.20 silt / fine sand. Soft. 5Y4/1.	6	● 6.20 6.30	89SEGD9		
	6.70 Same as above.	7	● 6.70 6.80	89SEGD10		
	7.40 Same as above but slightly lighter – 5Y5/1	8	● 7.40 7.60	89SEGD11		

CONFIDENTIAL

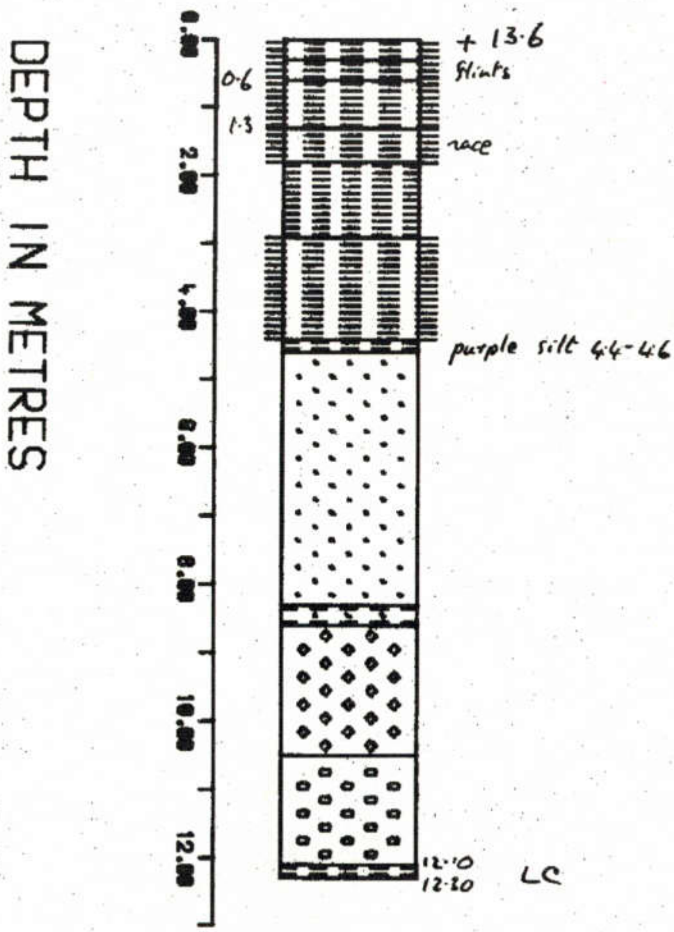
Borehole Reg No: TQ 89 SE/37 Sheet 2 of 2

Temp. borehole No: TQ89SEG

Geological classification	Description of Strata	Sampling	Sample Nos	Water level	Drilling and Casing progress
fine sand	8.0 Fine sand. Soft. 5Y5/1. Scattered carbonized root traces. (8.30)	8.0 8.20 8.30	89SEGD12	▽ 8.20	
oxidised layer 8.30–8.60	8.30 Clayey fine sand. Firm. 5Y5/1 (8.60)	8.75	89SEGU43		
ALLUVIUM (Unweathered) Mainly sands	8.60 FMC Sand + F gravel. Very soft 5Y6/1. 10% gravel. Rounded + sub ang. flints + tertiaries	8.60 9.80	89SEGD14		
	9.80 Coarse sand mainly. Abundant patina fragments.	9.80			
10.50 mainly gravel	10.50 FMC gravel (60%) + mainly C sand. Sub ang + sub round. Flint + tertiaries. 50% of flints are angular. London clay septaria present.		FB45		
12.10 LONDON CLAY. partly weathered	12.10 Silty clay. Stiff. 5Y5/1.	12.10 12.30	89SEGD15	DRY	24-11-72 12.0 / 12.30 24-11-72
	Borehole ended 12.30				

TQ 89 SE 37

TQ89SE37 - TQ8792 1



TQ/89SE/22

THE CEMENTATION Co. Ltd.
SOIL MECHANICS SECTION

BOREHOLE No. 14

CONTRACT	[illegible] Main, [illegible] Sewer	REPORT No.	6908/[illegible]
[illegible] for	[illegible] Rural District Council	Ground Level	
Address	Rochford, Essex	Boring Commenced	17.8.[illegible]
		Boring Completed	[illegible]
Type and Dia. of Boring	Shell and auger [illegible] diameter casing		

Water Strikes		Water Levels Recorded During Boring						
[illegible]"	Hole Depth	14'0"						
	Casing Depth	10'0"						
	Water Level	9'6"						

Remarks

Description	Depth	Legend	Ref. No.	Type	Depth	N blows ft
Topsoil	0'6" (0·15m)					
[illegible] brown fissured silty clay			5836	J	[illegible]"	
			5837	U	[illegible]"–4'[illegible]"	
	4'0" (1·22m)		5838	J	4'0"	
Brown claybound gravel						
	7'0" (2·13m)					
[illegible] brown fissured silty clay with occasional grey-blue mottling and traces of sand			5839	J	7'3"	
			5840	U	7'[illegible]"	
	(3·35m) 11'0"		5841	J	11'0"	
[illegible] brown silty and sandy clay	12'0" (3·66m)					
Brown clayey sand			5842	U	12'[illegible]"–14'0"	
	14'0" (4·27m)		5844	W	([illegible]'0")	

Scale 1 inch [illegible]

APPENDIX B – CALCULATIONS FOR PERVIOUS SURFACES

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 2 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m^3)	Status
15 min Summer	0.189	0.189	0.0	9.3	9.3	1.4	O K
30 min Summer	0.154	0.154	0.0	7.8	7.8	1.0	O K
60 min Summer	0.120	0.120	0.0	5.5	5.5	0.7	O K
120 min Summer	0.091	0.091	0.0	3.5	3.5	0.5	O K
180 min Summer	0.075	0.075	0.0	2.6	2.6	0.3	O K
240 min Summer	0.065	0.065	0.0	2.1	2.1	0.2	O K
360 min Summer	0.056	0.056	0.0	1.6	1.6	0.2	O K
480 min Summer	0.051	0.051	0.0	1.2	1.2	0.2	O K
600 min Summer	0.046	0.046	0.0	1.0	1.0	0.1	O K
720 min Summer	0.043	0.043	0.0	0.9	0.9	0.1	O K
960 min Summer	0.038	0.038	0.0	0.7	0.7	0.1	O K
1440 min Summer	0.032	0.032	0.0	0.5	0.5	0.1	O K
2160 min Summer	0.027	0.027	0.0	0.4	0.4	0.0	O K
2880 min Summer	0.024	0.024	0.0	0.3	0.3	0.0	O K
4320 min Summer	0.020	0.020	0.0	0.2	0.2	0.0	O K
5760 min Summer	0.018	0.018	0.0	0.2	0.2	0.0	O K
7200 min Summer	0.016	0.016	0.0	0.1	0.1	0.0	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	233.318	11
30 min Summer	132.583	19
60 min Summer	75.340	34
120 min Summer	42.812	64
180 min Summer	30.760	94
240 min Summer	24.328	124
360 min Summer	17.479	184
480 min Summer	13.824	246
600 min Summer	11.525	306
720 min Summer	9.932	362
960 min Summer	7.867	480
1440 min Summer	5.664	728
2160 min Summer	4.078	1092
2880 min Summer	3.230	1448
4320 min Summer	2.255	2164
5760 min Summer	1.748	2856
7200 min Summer	1.435	3584

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	0.014	0.014	0.0	0.1	0.1	0.0	O K
10080 min Summer	0.013	0.013	0.0	0.1	0.1	0.0	O K
15 min Winter	0.196	0.196	0.0	9.5	9.5	1.4	O K
30 min Winter	0.146	0.146	0.0	7.3	7.3	1.0	O K
60 min Winter	0.108	0.108	0.0	4.6	4.6	0.6	O K
120 min Winter	0.077	0.077	0.0	2.7	2.7	0.3	O K
180 min Winter	0.063	0.063	0.0	2.0	2.0	0.2	O K
240 min Winter	0.056	0.056	0.0	1.6	1.6	0.2	O K
360 min Winter	0.049	0.049	0.0	1.1	1.1	0.1	O K
480 min Winter	0.043	0.043	0.0	0.9	0.9	0.1	O K
600 min Winter	0.039	0.039	0.0	0.7	0.7	0.1	O K
720 min Winter	0.036	0.036	0.0	0.7	0.7	0.1	O K
960 min Winter	0.032	0.032	0.0	0.5	0.5	0.1	O K
1440 min Winter	0.027	0.027	0.0	0.4	0.4	0.0	O K
2160 min Winter	0.023	0.023	0.0	0.3	0.3	0.0	O K
2880 min Winter	0.020	0.020	0.0	0.2	0.2	0.0	O K
4320 min Winter	0.017	0.017	0.0	0.2	0.2	0.0	O K
5760 min Winter	0.015	0.015	0.0	0.1	0.1	0.0	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
8640 min Summer	1.221	4352
10080 min Summer	1.065	5112
15 min Winter	233.318	11
30 min Winter	132.583	19
60 min Winter	75.340	34
120 min Winter	42.812	64
180 min Winter	30.760	94
240 min Winter	24.328	124
360 min Winter	17.479	186
480 min Winter	13.824	240
600 min Winter	11.525	310
720 min Winter	9.932	366
960 min Winter	7.867	484
1440 min Winter	5.664	716
2160 min Winter	4.078	1076
2880 min Winter	3.230	1460
4320 min Winter	2.255	2108
5760 min Winter	1.748	2936

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
7200 min Winter	0.013	0.013	0.0	0.1	0.1	0.0	O K
8640 min Winter	0.012	0.012	0.0	0.1	0.1	0.0	O K
10080 min Winter	0.011	0.011	0.0	0.1	0.1	0.0	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
7200 min Winter	1.435	3552
8640 min Winter	1.221	4184
10080 min Winter	1.065	4976

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	GB 587200 191800 TQ 87200 91800
C (1km)	-0.024
D1 (1km)	0.295
D2 (1km)	0.300
D3 (1km)	0.225
E (1km)	0.321
F (1km)	2.583
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+30

Time / Area Diagram

Total Area (ha) 0.011

Time (mins)	**Area (ha)**
0-4	0.011

Model Details

Storage is Online Cover Level (m) 0.320

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000
Membrane Percolation (mm/hr)	450
Max Percolation (l/s)	3.8
Safety Factor	2.0
Porosity	0.30
Invert Level (m)	0.000
Width (m)	5.5
Length (m)	5.5
Slope (1:X)	70.0
Depression Storage (mm)	5
Evaporation (mm/day)	3
Cap Volume Depth (m)	0.000

Orifice Outflow Control

Diameter (m) 0.110 Invert Level (m) 0.000
Discharge Coefficient 0.600

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 96 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.392	0.392	0.0	14.7	14.7	127.0	FLOOD
30 min Summer	0.402	0.402	0.0	14.9	14.9	139.2	FLOOD
60 min Summer	0.407	0.407	0.0	15.0	15.0	144.9	FLOOD
120 min Summer	0.403	0.403	0.0	14.9	14.9	139.6	FLOOD
180 min Summer	0.397	0.397	0.0	14.8	14.8	132.6	FLOOD
240 min Summer	0.391	0.391	0.0	14.6	14.6	125.0	FLOOD
360 min Summer	0.378	0.378	0.0	14.4	14.4	109.8	FLOOD
480 min Summer	0.367	0.367	0.0	14.1	14.1	95.9	FLOOD
600 min Summer	0.357	0.357	0.0	13.9	13.9	83.5	FLOOD
720 min Summer	0.348	0.348	0.0	13.7	13.7	72.5	FLOOD
960 min Summer	0.334	0.334	0.0	13.3	13.3	54.5	FLOOD
1440 min Summer	0.297	0.297	0.0	12.4	12.4	32.5	Flood Risk
2160 min Summer	0.221	0.221	0.0	10.3	10.3	17.9	O K
2880 min Summer	0.174	0.174	0.0	8.7	8.7	11.2	O K
4320 min Summer	0.132	0.132	0.0	6.3	6.3	6.4	O K
5760 min Summer	0.112	0.112	0.0	4.9	4.9	4.6	O K
7200 min Summer	0.099	0.099	0.0	4.0	4.0	3.6	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	233.318	18
30 min Summer	132.583	32
60 min Summer	75.340	60
120 min Summer	42.812	96
180 min Summer	30.760	128
240 min Summer	24.328	162
360 min Summer	17.479	230
480 min Summer	13.824	296
600 min Summer	11.525	360
720 min Summer	9.932	422
960 min Summer	7.867	540
1440 min Summer	5.664	768
2160 min Summer	4.078	1124
2880 min Summer	3.230	1472
4320 min Summer	2.255	2200
5760 min Summer	1.748	2936
7200 min Summer	1.435	3672

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	0.090	0.090	0.0	3.4	3.4	3.0	O K
10080 min Summer	0.082	0.082	0.0	2.9	2.9	2.4	O K
15 min Winter	0.407	0.407	0.0	15.0	15.0	144.9	FLOOD
30 min Winter	0.419	0.419	0.0	15.2	15.2	159.4	FLOOD
60 min Winter	0.425	0.425	0.0	15.4	15.4	167.4	FLOOD
120 min Winter	0.420	0.420	0.0	15.3	15.3	161.3	FLOOD
180 min Winter	0.413	0.413	0.0	15.1	15.1	152.0	FLOOD
240 min Winter	0.404	0.404	0.0	14.9	14.9	141.4	FLOOD
360 min Winter	0.386	0.386	0.0	14.5	14.5	119.3	FLOOD
480 min Winter	0.370	0.370	0.0	14.2	14.2	98.9	FLOOD
600 min Winter	0.355	0.355	0.0	13.8	13.8	80.7	FLOOD
720 min Winter	0.342	0.342	0.0	13.5	13.5	65.1	FLOOD
960 min Winter	0.323	0.323	0.0	13.1	13.1	41.4	FLOOD
1440 min Winter	0.237	0.237	0.0	10.8	10.8	20.7	O K
2160 min Winter	0.160	0.160	0.0	8.2	8.2	9.5	O K
2880 min Winter	0.136	0.136	0.0	6.6	6.6	6.7	O K
4320 min Winter	0.107	0.107	0.0	4.6	4.6	4.2	O K
5760 min Winter	0.092	0.092	0.0	3.5	3.5	3.1	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
8640 min Summer	1.221	4312
10080 min Summer	1.065	5120
15 min Winter	233.318	18
30 min Winter	132.583	32
60 min Winter	75.340	60
120 min Winter	42.812	110
180 min Winter	30.760	138
240 min Winter	24.328	176
360 min Winter	17.479	248
480 min Winter	13.824	318
600 min Winter	11.525	384
720 min Winter	9.932	444
960 min Winter	7.867	558
1440 min Winter	5.664	780
2160 min Winter	4.078	1120
2880 min Winter	3.230	1464
4320 min Winter	2.255	2188
5760 min Winter	1.748	2928

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m^3)	Status
7200 min Winter	0.080	0.080	0.0	2.8	2.8	2.3	O K
8640 min Winter	0.071	0.071	0.0	2.4	2.4	1.9	O K
10080 min Winter	0.065	0.065	0.0	2.1	2.1	1.5	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
7200 min Winter	1.435	3672
8640 min Winter	1.221	4360
10080 min Winter	1.065	5032

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	GB 587200 191800 TQ 87200 91800
C (1km)	-0.024
D1 (1km)	0.295
D2 (1km)	0.300
D3 (1km)	0.225
E (1km)	0.321
F (1km)	2.583
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+30

Time / Area Diagram

Total Area (ha) 0.350

Time (mins)	Area (ha)
0-4	0.350

Model Details

Storage is Online Cover Level (m) 0.320

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000
Membrane Percolation (mm/hr)	450
Max Percolation (l/s)	402.5
Safety Factor	2.0
Porosity	0.30
Invert Level (m)	0.000
Width (m)	35.0
Length (m)	92.0
Slope (1:X)	70.0
Depression Storage (mm)	5
Evaporation (mm/day)	3
Cap Volume Depth (m)	0.000

Orifice Outflow Control

Diameter (m) 0.110 Invert Level (m) 0.000
Discharge Coefficient 0.600

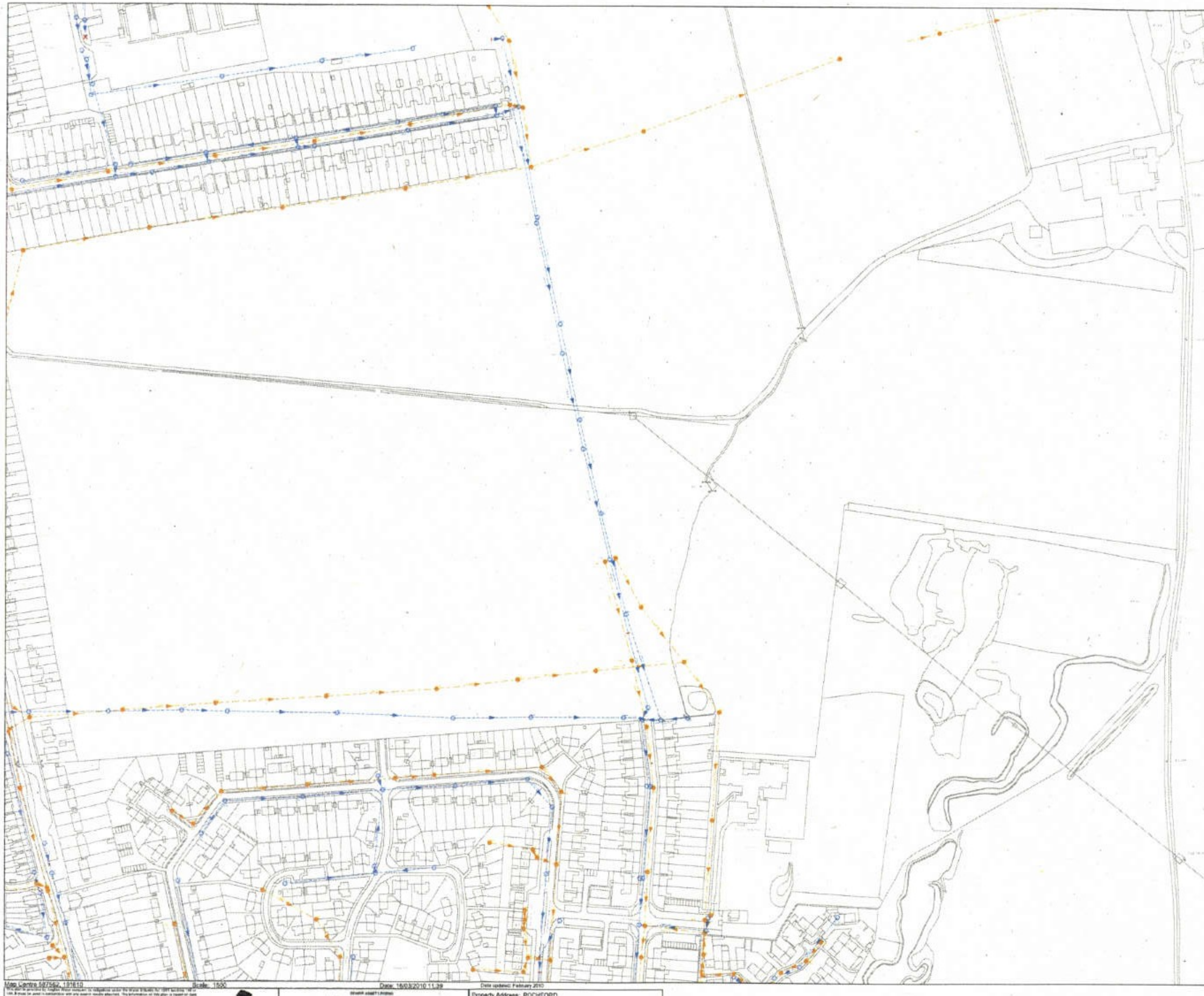
APPENDIX C – ANGLIAN WATER ASSET PLANS

Origin				Downstream Sewer		
Manhole Number	Cover Level (m AOD)	Depth to Invert (m)	Upstream Invert Level (m AOD)	Length (m)	Downstream Invert Level (m AOD)	Downstream Manhole Number
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Origin				Downstream Sewer		
Manhole Number	Cover Level (m AOD)	Depth to Invert (m)	Upstream Invert Level (m AOD)	Length (m)	Downstream Invert Level (m AOD)	Downstream Manhole Number
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Property Address: SITE AT, BRAYS LANE, ROCHFORD

Customer: EVANS RIVERS AND COSTAL



Map Centre 587562, 191610 Scale: 1500 Date: 16/03/2010 11:39 Date updated: February 2010

Geodesys
Asset Information Team
Geodesys
PO Box 466
Huntingdon
PE29 6YN

Property Address: ROCHFORD

Customer: EVANS RIVERS AND COSTAL

Title: A803277(1) (Caroline Jefferies)

Origin		Downstream sewer				
Manhole Number	Cover Level (m AOD)	Depth to Invert (m)	Upstream Invert Level (m AOD)	Length (m)	Downstream Invert Level (m AOD)	Downstream Manhole Number
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

APPENDIX D – CALCULATIONS FOR DETENTION BASIN

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.492	0.492	18.9	1239.8	O K
30 min Summer	0.551	0.551	18.9	1401.6	O K
60 min Summer	0.614	0.614	18.9	1577.2	O K
120 min Summer	0.679	0.679	18.9	1758.9	O K
180 min Summer	0.714	0.714	18.9	1861.5	O K
240 min Summer	0.738	0.738	18.9	1928.7	O K
360 min Summer	0.765	0.765	18.9	2007.5	O K
480 min Summer	0.778	0.778	18.9	2045.5	O K
600 min Summer	0.783	0.783	18.9	2060.1	O K
720 min Summer	0.782	0.782	18.9	2059.7	O K
960 min Summer	0.775	0.775	18.9	2036.4	O K
1440 min Summer	0.755	0.755	18.9	1980.3	O K
2160 min Summer	0.722	0.722	18.9	1884.5	O K
2880 min Summer	0.686	0.686	18.9	1779.2	O K
4320 min Summer	0.584	0.584	18.9	1491.2	O K
5760 min Summer	0.485	0.485	18.9	1220.7	O K
7200 min Summer	0.396	0.396	18.9	983.9	O K
8640 min Summer	0.334	0.334	18.9	822.3	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	233.318	19
30 min Summer	132.583	34
60 min Summer	75.340	64
120 min Summer	42.812	124
180 min Summer	30.760	182
240 min Summer	24.328	242
360 min Summer	17.479	362
480 min Summer	13.824	482
600 min Summer	11.525	600
720 min Summer	9.932	720
960 min Summer	7.867	894
1440 min Summer	5.664	1124
2160 min Summer	4.078	1512
2880 min Summer	3.230	1928
4320 min Summer	2.255	2724
5760 min Summer	1.748	3464
7200 min Summer	1.435	4112
8640 min Summer	1.221	4760

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Summer	0.294	0.294	18.6	719.2	O K
15 min Winter	0.547	0.547	18.9	1389.7	O K
30 min Winter	0.612	0.612	18.9	1571.5	O K
60 min Winter	0.682	0.682	18.9	1768.7	O K
120 min Winter	0.754	0.754	18.9	1975.1	O K
180 min Winter	0.794	0.794	18.9	2092.5	O K
240 min Winter	0.820	0.820	18.9	2169.8	O K
360 min Winter	0.851	0.851	18.9	2263.6	O K
480 min Winter	0.867	0.867	18.9	2312.2	O K
600 min Winter	0.875	0.875	18.9	2335.4	O K
720 min Winter	0.877	0.877	18.9	2342.1	O K
960 min Winter	0.873	0.873	18.9	2328.7	O K
1440 min Winter	0.844	0.844	18.9	2243.3	O K
2160 min Winter	0.801	0.801	18.9	2114.8	O K
2880 min Winter	0.750	0.750	18.9	1964.6	O K
4320 min Winter	0.606	0.606	18.9	1554.8	O K
5760 min Winter	0.454	0.454	18.9	1138.2	O K
7200 min Winter	0.336	0.336	18.9	826.0	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
10080 min Summer	1.065	5440
15 min Winter	233.318	19
30 min Winter	132.583	33
60 min Winter	75.340	64
120 min Winter	42.812	122
180 min Winter	30.760	180
240 min Winter	24.328	240
360 min Winter	17.479	356
480 min Winter	13.824	472
600 min Winter	11.525	584
720 min Winter	9.932	698
960 min Winter	7.867	914
1440 min Winter	5.664	1182
2160 min Winter	4.078	1624
2880 min Winter	3.230	2080
4320 min Winter	2.255	2944
5760 min Winter	1.748	3688
7200 min Winter	1.435	4248

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m^3)	Status
8640 min Winter	0.277	0.277	18.1	676.2	O K
10080 min Winter	0.244	0.244	16.6	593.0	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
8640 min Winter	1.221	4840
10080 min Winter	1.065	5448

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	GB 587200 191800 TQ 87200 91800
C (1km)	-0.024
D1 (1km)	0.295
D2 (1km)	0.300
D3 (1km)	0.225
E (1km)	0.321
F (1km)	2.583
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+30

Time / Area Diagram

Total Area (ha) 2.860

Time (mins)	**Area (ha)**
0-4	2.860

Model Details

Storage is Online Cover Level (m) 1.300

Tank or Pond Structure

Invert Level (m) 0.000

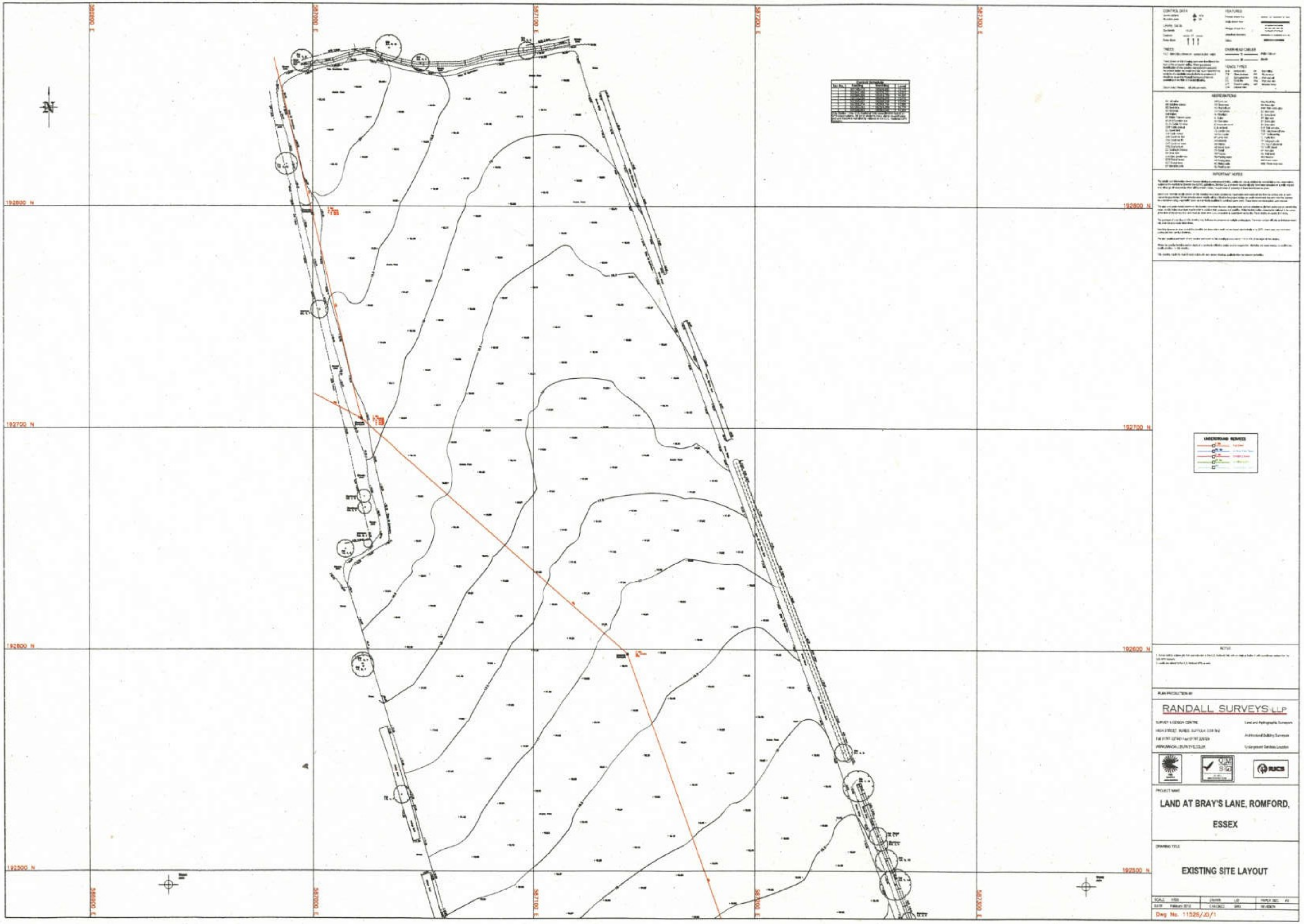
Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	2337.0	0.700	2871.0	1.400	3368.0	2.100	3368.0
0.100	2411.0	0.800	2951.0	1.500	3368.0	2.200	3368.0
0.200	2485.0	0.900	3033.0	1.600	3368.0	2.300	3368.0
0.300	2560.0	1.000	3115.0	1.700	3368.0	2.400	3368.0
0.400	2636.0	1.100	3198.0	1.800	3368.0	2.500	3368.0
0.500	2714.0	1.200	3282.0	1.900	3368.0		
0.600	2792.0	1.300	3368.0	2.000	3368.0		

Hydro-Brake® Outflow Control

Design Head (m) 1.000 Hydro-Brake® Type Md4 Invert Level (m) 0.000
Design Flow (l/s) 18.8 Diameter (mm) 155

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.9	1.600	23.7	5.000	41.9
0.200	13.2	1.800	25.1	5.500	43.9
0.300	18.7	2.000	26.5	6.000	45.9
0.400	17.8	2.200	27.8	6.500	47.7
0.500	16.0	2.400	29.0	7.000	49.5
0.600	15.6	2.600	30.2	7.500	51.3
0.800	16.9	3.000	32.4	8.000	53.0
1.000	18.7	3.500	35.0	8.500	54.6
1.200	20.5	4.000	37.4	9.000	56.2
1.400	22.2	4.500	39.7	9.500	57.7

DRAWINGS



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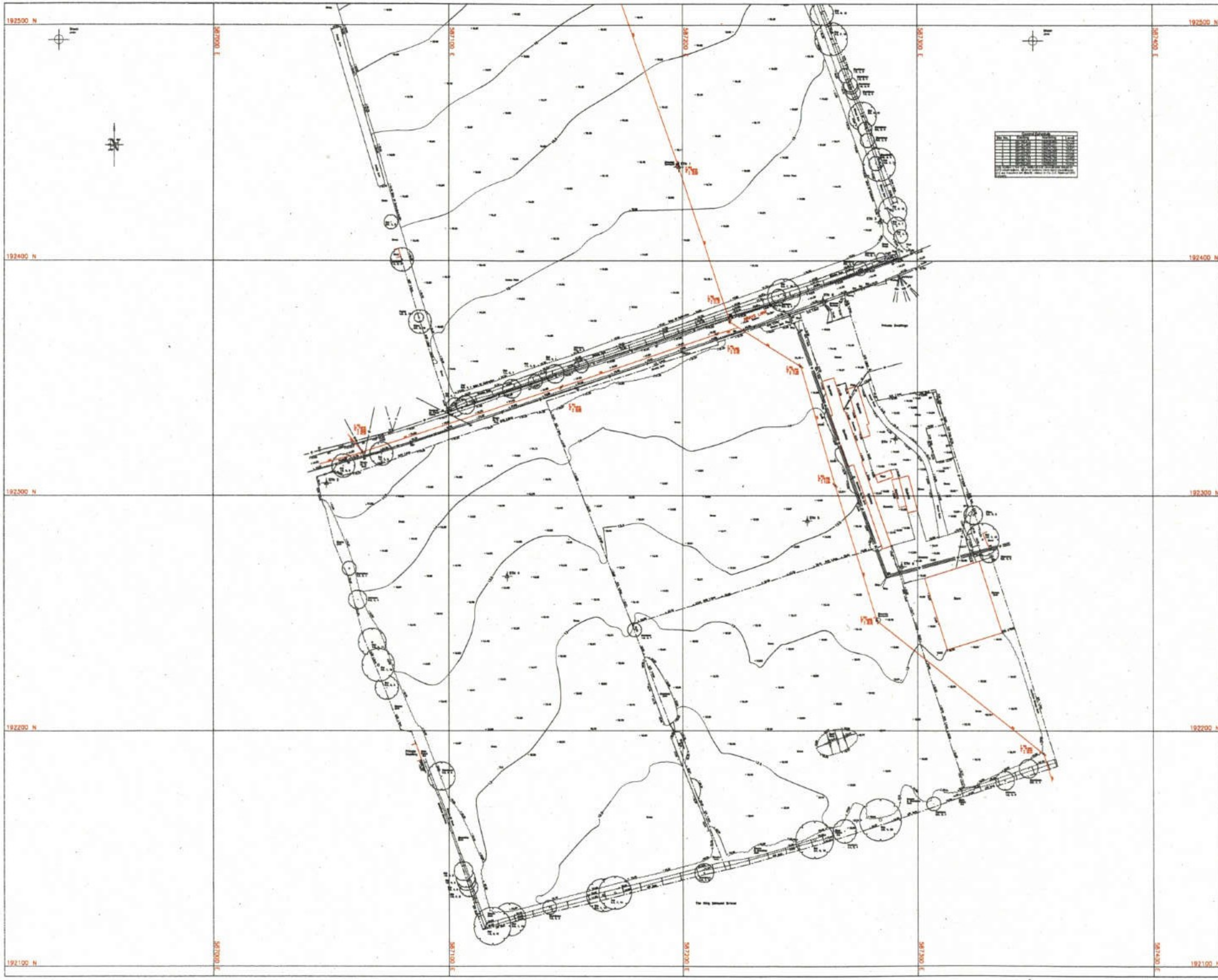


PLAN PRODUCTION BY

RANDALL SURVEYS LLP

PROJECT NAME

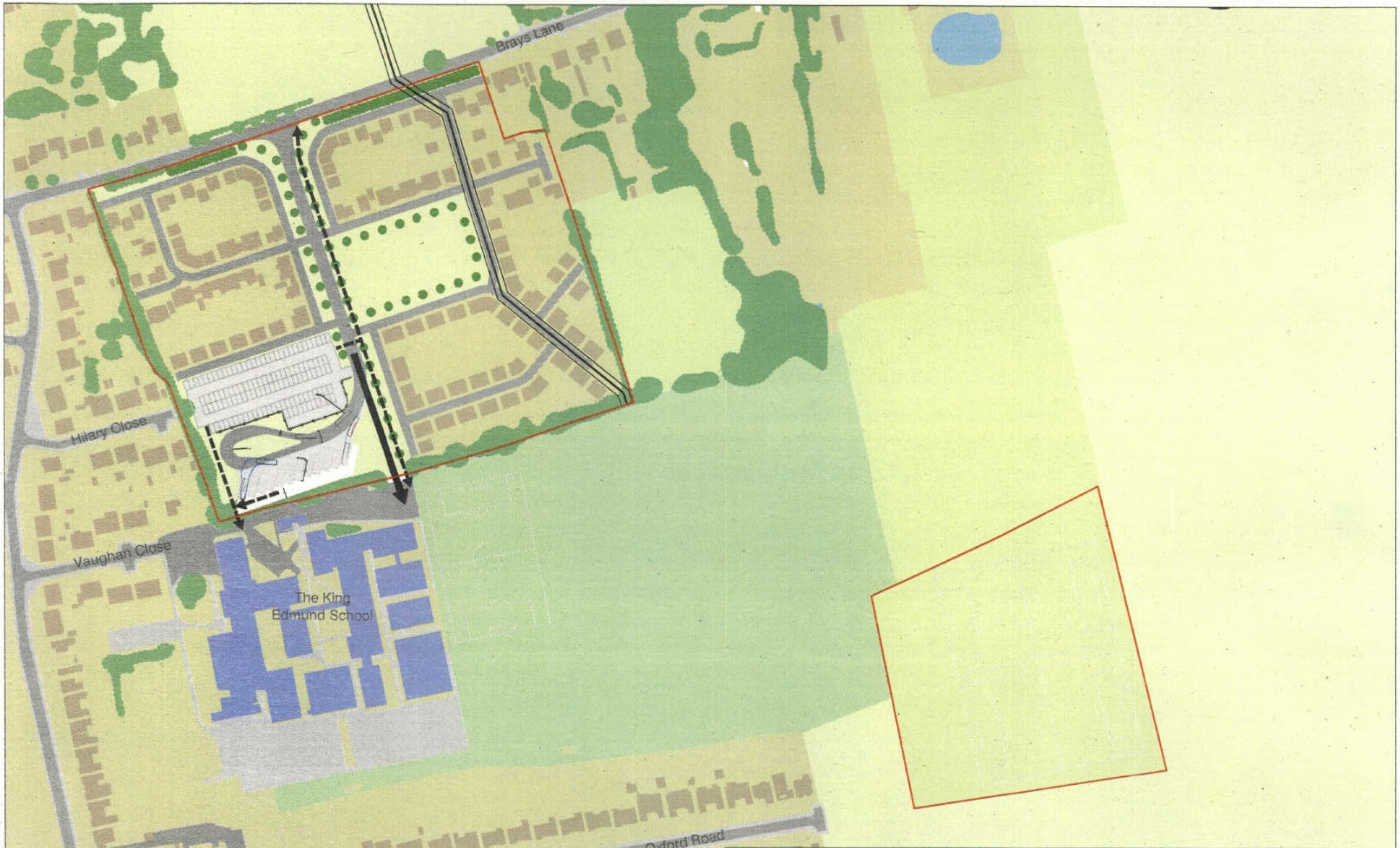
LAND AT BRAY'S LANE, ROMFORD,

ESSEX

DRAWING TITLE

EXISTING SITE LAYOUT

Dwg No. 11526/J0/2



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Chartered Town Planners
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Urban Designers
Landscape Designers

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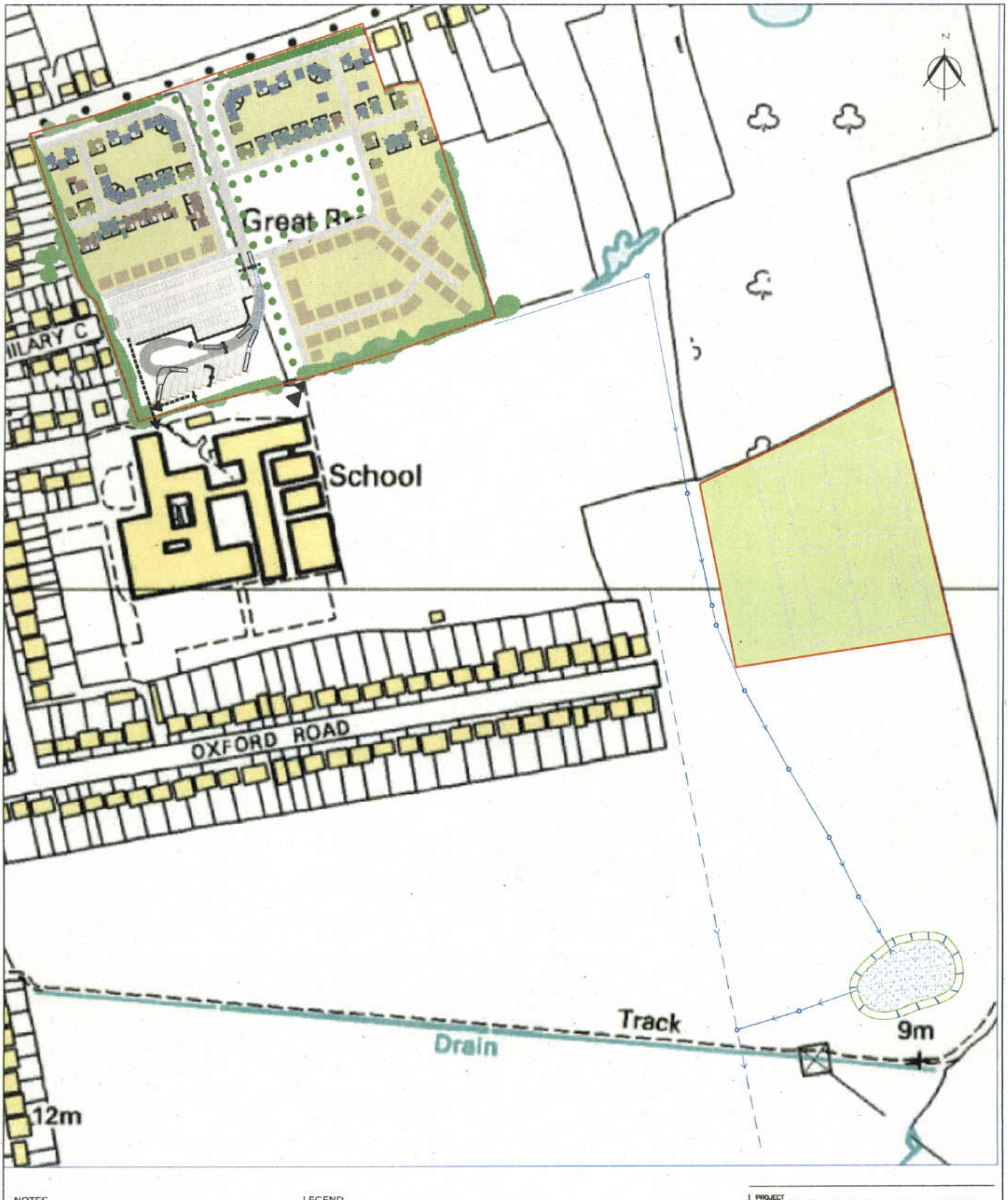
Drawn by	C.H.
Approved by	E.W.
Revision Detail/Date	Rev. A: reduction in bus reversing space, drop-off moved south and parking layout enhanced (R.J.M. 10/02/11).
Title	Illustrative Masterplan Land south of Brays Lane, Rochford
Scale	1:2000 @ A3
Date	27/01/11
Drawing Number	010036/22A

This drawing should not be scaled from for construction purposes.

Z:\CURRENT YEAR - 2010\2010\010036 ROCHFORD\NUMBERED DRAWINGS\010036 21A_22A_23



NOTES

STRATEGY SUBJECT TO CHANGE DURING MORE DETAILED DRAINAGE ASSESSMENT AS PART OF DETAILED DESIGN STAGE.

LOCATION OF DETENTION BASIN AND ROUTE OF SEWERS APPROXIMATE AND WILL REQUIRE CONFIRMATION AT A LATER STAGE.

DRAWING CANNOT BE RELIED ON FOR CONSTRUCTION PURPOSES.

SITE LAYOUT PROVIDED BY ANDREW MARTIN ASSOCIATES.

LEGEND

DETENTION BASIN DRAINING IMPERMEABLE SURFACES (AT 1.3m DEEP COVERING 3368sq m AND STORING UP TO 2342 cu m DURING CLIMATE CHANGE 1 IN 100 YEAR EVENT)

PROPOSED OFF-SITE SURFACE WATER SEWER TO TRANSPORT SURFACE WATER FLOWS TO BASIN (ROUTE TO BE CONFIRMED)

SITE BOUNDARY

EXISTING PUBLIC SURFACE WATER SEWER

DESIGNED	DRAWN	SCALE	DATE
RE	RE	1:2500	28/02/2011
DRAWING NUMBER		REVISION	DRAWING STATUS
1022/RE/01B		B	FINAL

PROJECT
PROPOSED DEVELOPMENT OFF BRAYS LANE ROCHFORD

DRAWING TITLE
PROPOSED SUDS STRATEGY - OPTION 1

CLIENT
STRUTT AND PARKER LLP

EVANS Rivers and Coastal

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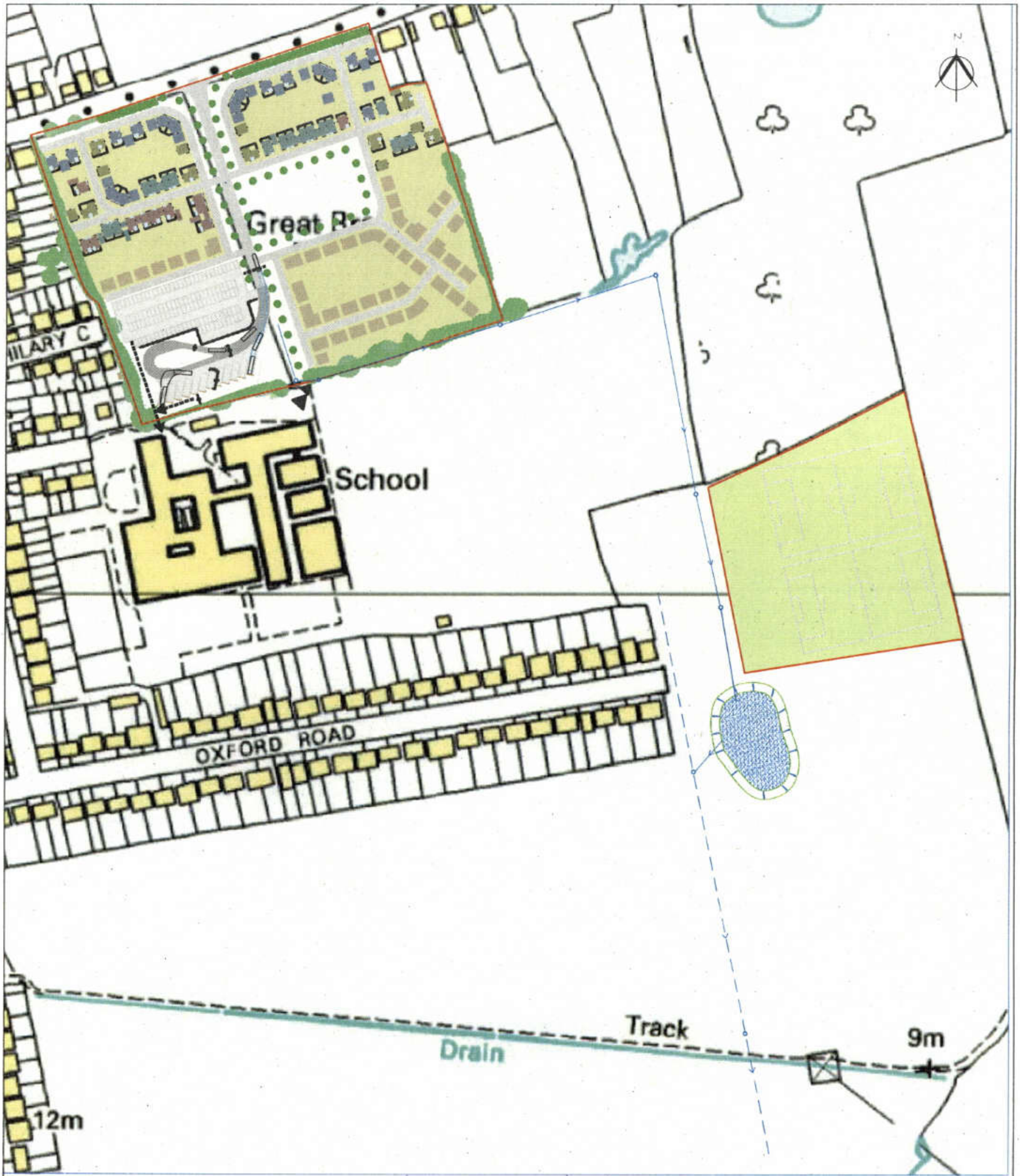
ORIGINAL SHEET SIZE A3V



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LEGEND

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PROPOSED OFF-SITE SURFACE WATER SEWER TO TRANSPORT SURFACE WATER FLOWS TO BASIN (ROUTE TO BE CONFIRMED)

SITE BOUNDARY

EXISTING PUBLIC SURFACE WATER SEWER

PROJECT
PROPOSED DEVELOPMENT OFF BRAYS LANE ROCHFORD

DRAWING TITLE
PROPOSED SUDS STRATEGY - OPTION 2

CLIENT
STRUTT AND PARKER LLP

EVANS
Rivers and Coastal

DESIGNED	DRAWN	SCALE	DATE
RE	RE	1:2500	28/02/2011
DRAWING NUMBER		REVISION	DRAWING STATUS
1022/RE/02B		B	FINAL

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LEGEND

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SITE BOUNDARY

DESIGNED	DRAWN	SCALE	DATE
RE	RE	1:2500	28/02/2011
DRAWING NUMBER		REVISION	DRAWING STATUS
1022/RE/03B		B	FINAL

PROJECT
PROPOSED DEVELOPMENT OFF BRAYS LANE ROCHFORD

DRAWING TITLE
PROPOSED SUDS STRATEGY - OPTION 3

CLIENT
STRUTT AND PARKER LLP

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ORIGINAL SHEET SIZE A3V

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