

Defence Estates

Roussillon Barracks, Chichester

Geotechnical Site Investigation

Final Factual Report
DE Project No. 12123/2

October 2007

Entec UK Limited

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Defence Estates
D Ops North – CST, EMG
St George's House
Kingston Road
Sutton Coldfield
West Midlands
B75 7RL

Main Contributors

Ross Muir
Ed Gilligan

Issued by

Ed Gilligan

Approved by

Dave Williams

Accepted by Task Officer

.....

Accepted by Project Sponsor

.....

Entec UK Limited

17 Angel Gate
City Road
London EC1V 2SH
England
Tel: +44 (0) 207 843 1400
Fax: +44 (0) 207 843 1410

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Executive Summary

Introduction and Terms of Reference

Entec UK Ltd (Entec) was commissioned by Defence Estates (DE) to undertake a Geotechnical Investigation of the Roussillon Barracks site. The purpose of the investigation is to provide outline factual geotechnical and topographical data to support disposal of the site.

Site Location, Description and History

Roussillon Barracks is located approximately one mile north of Chichester city centre in the county of West Sussex as shown in Figure 1 and lies off Broyle Road. It is centred on National Grid Reference SU 861 063.

The site covers an area of approximately 15 hectares. It was first developed during the Napoleonic Wars (1799 - 1815) and was acquired by the military in 1812. The site was used as a barracks by the Royal Sussex Regiment following its formation in 1881 and was further developed by the Royal Military Police as a training school from 1964.

More recent developments on the site include refurbishment of existing buildings and construction of additional accommodation buildings.

The site is underlain by Gravel Head Deposits which are thought to consist of variable gravels, sands, silts and clays. The hydrogeological map of the area indicates the site to be underlain by Brickearth and Coombe deposits which comprise silty loams, sands and clays.

The drift deposits are underlain by the Reading Beds comprising mottled clays with a basal bed of pebbles at depth. The southern end of the site is shown to be underlain by London Clay comprising bluish grey clay. The London Clay, if present is underlain by the Reading Beds. The Cretaceous Upper Chalk underlies the Reading Beds at depth.

The site is underlain by a Minor Aquifer comprising Gravel Head Deposits and the Reading Beds.

Environmental Setting

The site is underlain by Gravel Head Deposits which are thought to consist of variable gravels, sands, silts and clays. The hydrogeological map of the area indicates the site to be underlain by Brickearth and Coombe deposits which comprise silty loams, sands and clays.

The drift deposits are underlain by the Reading Beds comprising mottled clays with a basal bed of pebbles at depth. The southern end of the site is thought to be underlain by London Clay comprising bluish grey clay. The London Clay, if present is underlain by the Reading Beds. The Cretaceous Upper Chalk underlies the Reading Beds at depth.

Site Investigation and Ground Conditions

The site investigation works comprised drilling of 11 window sample boreholes, drilling of 13 cable percussion boreholes and excavation of 8 trial pits, with associated soil sampling and geotechnical testing, both in situ and laboratory based.

The geological sequence generally comprised the following:

- Topsoil;
- Made Ground;
- Drift (Gravel Head Deposits);
- Clay (Reading Beds/London Clay).

Made Ground

A variable thickness of Made Ground was encountered, generally consisting of reworked natural ground with a minor proportion of inert building waste (brick rubble, concrete, timber, metal fragments).

Natural Ground

The Made Ground, where present, was underlain by drift deposits of a relatively consistent thickness across the site (approximately 6m). The drift comprised variable gravels and clay gravels, sands and gravelly clays and clays. Generally, coarse clayey gravels up to 3.2m in thickness were underlain by gravelly sands up to 5.5m thick.

The drift deposits were underlain by Reading Beds over the majority of the site at relatively consistent depth of approximately 6 m bgl with the exception of the south west of the site where the drift deposits were underlain by London Clay with Reading Beds beneath. In this area of the site the Reading Beds were found at a depth of approximately 11 m to 15 m bgl.

The Reading Beds were found to consist of stiff to very stiff red and grey mottled sandy clays. The London Clay is firm to stiff blue/grey slightly sandy clay, which in places was thickly laminated with silt with thin laminations of fine to medium sand.

Groundwater

Groundwater was encountered at the majority of locations across the site, within the drift deposits. Water levels were generally around 3 m bgl across the site. Seven boreholes were installed with groundwater monitoring apparatus and monitored daily, after completion, for the duration of the works. Gas monitoring was also carried out.

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1. Introduction

1.1 Terms of Reference

1.1.1 Background

Entec UK Ltd (Entec) was instructed to carry out a geotechnical site investigation at the Roussillon Barracks site in Chichester to provide factual geotechnical information to support disposal of the site.

1.1.2 Aims and Objectives

The objectives of the project are to undertake a Geotechnical Investigation of the Barracks site in order to inform prospective purchasers and assist disposal of the site. It is understood that a Phase Two LQA of the site has been carried out with an initial intrusive investigation having been carried out in February 2007 and additional investigation in July 2007. The following key objectives were identified for the investigation:

- Establish the spatial and vertical distribution of drift deposits across the site including review of limited existing site investigation data;
- Establish the outline engineering parameters of the materials present on site through a combination of engineering description, in-situ testing and laboratory testing;
- Factual reporting of the findings of the investigation;
- Archaeological Desk Study to inform on potential constraints to the proposed site investigation and future development of the site;
- Topographical Survey showing exploratory locations, trees covered by tree protection orders and other architectural features of note.

It is important to note that the purpose of the geotechnical investigation and testing is to provide outline engineering parameters and an indication of the spatial distribution of materials across the site. Further development-specific geotechnical investigation will still be required once the layout and structural loadings of any proposed development had been established to confirm local ground conditions and design parameters.

1.1.3 Future Site Use

It is understood that the site is to be sold off in stages. Initially, the southern area of the site is to be sold off for residential development with existing properties in the north of the site retained by Defence Estates (DE). The Green in the centre of the site is likely to remain largely undeveloped.

2. Site Setting

2.1 Site Location

Roussillon Barracks is located approximately one mile north of Chichester city centre in the county of West Sussex as shown in Figure 1 and lies off Broyle Road. It is centred on National Grid Reference SU 861 063.

2.2 Site Description

2.2.1 General

The site covers an area of approximately 15 hectares. It was first developed during the Napoleonic Wars (1799 - 1815) and was acquired by the military in 1812. The site has been used as a barracks by the Royal Sussex Regiment following its formation in 1881 and was further developed by the Royal Military Police as a training school from 1964. More recent developments on the site include refurbishment of existing buildings and construction of additional accommodation buildings.

The barracks comprise a mix of brick-built buildings of up to three storeys in height, most of which date to phases of building in the 1870s, 1930s and 1960-90s. In addition there is a large open grassed space (The Green) which was laid out as a parade ground in the nineteenth century.

The northern part of the site is largely occupied by Family Services Accommodation with associated play areas and the Officers Mess. To the south of these, and to either side of The Green are a range of administrative and mess buildings, with a large accommodation block (The Sandhurst Block) to the south of The Green.

South of the Sandhurst Block is a car park and motor maintenance area, whilst there is an assault course in the southwest corner of the site.

2.2.2 Site Boundaries

The majority of the site is bordered by roads, beyond which are residential properties. The south east of the site is directly bordered by residential properties.

2.2.3 Buried Services

The full range of services is present at the site, which is consistent with the development which is currently in place and the operational nature of the site. Full service plans were made available to Entec including electric, gas, water, foul sewer and telecoms. These were collated and made available to the site supervisor and contractors during the works and are presented in Annex D.

2.3 Site History

2.3.1 Historical Development

Full details of historical and more recent use of Roussillon Barracks are given in the Enviro Consulting Ltd Phase 2 LQA Report June 2007.

Chichester is a city of Roman origin, which continued to be occupied during the Medieval period, and is therefore of high archaeological interest. Based on this, it appears that there is a potential for the presence of archaeological remains within the site, which could have implications for the completion of site investigation works and the eventual disposal of the site. To investigate this, a cultural heritage desk-based assessment was carried out. This is presented in Annex E.

2.4 Environmental Setting

2.4.1 Geology

The geology map of the area (1:50,000 Sheet 317 Drift Edition, Chichester) indicates that the site is underlain by Gravel Head Deposits which are likely to consist of variable gravels, sands, silts and clays. The hydrogeological map of the area indicates the site to be underlain by Brickearth and Coombe deposits which comprise silty loams, sands and clays.

The drift deposits are shown to be underlain by the Reading Beds comprising mottled clays although London Clay, which is a bluish grey clay with a basal bed of pebbles at depth, is shown to be present between the drift and the Reading Beds beneath the southern end of the site. The Cretaceous Upper Chalk underlies the Reading Beds at depth.

A reference in the Phase One LQA indicates that the drift deposits across the site range in thickness between 15 m and 22 m. The report also references a BGS borehole 370m to the west of the site which indicates the thickness of London Clay and Reading Beds over the Chalk to be 45m.

Recent investigations undertaken as part of a Phase 2 LQA included drilling of ten shallow window sample boreholes in localised areas of the site. These logs have been provided to Entec for information and indicate the following sequence of strata.

Made Ground ranging in thickness between 0.4 and 1.6m was encountered in all of the holes and comprised flint gravel and occasional brick and clinker. This material is underlain by gravel predominantly comprising flint. Sand was identified in a number of the holes at depths of between 2.2 m and 2.5m bgl and was identified as 'wet' indicating it may be water bearing. Window sample holes were not installed with standpipes.

2.4.2 Hydrogeology

Groundwater Vulnerability Map No 45 indicates that the site is underlain by a Minor Aquifer comprising Gravel Head Deposits and the Reading Beds.

2.4.3 Hydrology

The River Lavant lies 650m north east of the site and flows southwards into Chichester Harbour. The River Lavant is an ephemeral watercourse fed by springs during winter months.

2.4.4 Ecology

The nearest sensitive ecological receptor to the site is Brandy Hole Copse (A Local Nature Reserve). No Sites of Special of Scientific Interest (SSSIs), Special Areas of Conservation (SACs) or other designated sites of nature conservation interest are present within 1 km of the site.

2.5 Previous Investigations

2.5.1 Introduction

Two previous environmental investigations have been carried out at the site. Due to the geotechnical scope of the current phase of investigation, these reports are not reviewed in depth, but content relevant to the geotechnical aspects of the site are summarised below.

2.5.2 Enviros Aspinwall Phase 1 LQA - October 2001

Enviros Aspinwall conducted a Phase 1 LQA in October 2001. The following is a summary of the geology on the site as described in the above report;

Drift

Drift deposits 15 – 22m thick are thought to comprise Gravel Head Deposits consisting of gravels and loams. These deposits are thicker in the south. The hydrogeological map of the site describes the deposits underlying the site as drift deposits of Brickearth and Coomb Deposits (silty loam and clay).

Solid

Gravel Head Deposits are underlain by Reading Beds in the northern two thirds of the site and may be underlain by London Clay over Reading Beds in the south. At depth the Reading Beds are underlain by Cretaceous Upper Chalk.

The Reading Beds are described as mottled coloured clays with basal beds of pebbles, sand and ironstone concretions and may be up to 30m thick. The London Clay is described as comprising bluish sand and sandy loam with horizons of sandy ironstone.

2.5.3 Enviros Consulting Ltd Phase 2 LQA Report June 2007

The following is a summary of ground conditions encountered during the phase 2 intrusive investigation:

Hardstanding

Hardstanding, where present, was found to consist of concrete 0.15 to 0.2m thick or tarmac, 0.2m thick

Topsoil

Topsoil was found to consist of sandy, slightly gravelly clay with a thickness between 0.1 m and 0.3m. Two locations in the south of the site encountered buried topsoil at a depth of between 0.9 m and 0.95m below ground level (bgl).

Made Ground

Made Ground was encountered at all locations to a maximum depth of 1.6m bgl. The stratum was found to consist of slightly clayey, slightly sandy fine to coarse gravel. Enviro interpreted this to be reworked natural material. Occasional brick fragments were found at some locations.

Natural Strata

Immediately underlying hardstanding or topsoil, a layer of slightly silty, slightly sandy fine and medium gravel was encountered with a maximum thickness of 1.8m, interpreted as being Gravel Head Deposits.

In the centre of the site, a layer of slightly wet, silty fine and medium sand was encountered between 2.0m and 4.0m bgl. This was also interpreted to represent Gravel Head Deposits.

Groundwater

Groundwater was encountered at three locations in the centre of the site within the silty sand stratum.

3. Geotechnical Investigation

3.1 Scope of Works

The site investigation works comprised the drilling of 11 window sample boreholes, 13 cable percussion boreholes and excavation of 8 trial pits, with associated soil sampling and in-situ geotechnical tests. Site works were carried out by May Gurney with supervision from Entec. Supervision was also carried out by an engineer supplied by May Gurney. Site works were carried out between 9 and 19 July 2007. Exploratory locations were chosen to give a representative spread of geotechnical parameters across the site. Details of the scheduled laboratory based geotechnical tests are included in Annex A.

The site investigation target areas and investigation method as agreed with the Defence Estates team and the Quarter Master for the site prior to commencement are summarised in Table 3.1. Exploratory holes were assigned a unique identifier as shown on Figure 2 and exploratory hole logs are included in Annex B. Building and area numbers are shown on Figure 2a.

Ground gas and groundwater monitoring was carried out on a daily basis at selected boreholes commencing 24 hours after drilling. Groundwater levels and ground gas concentrations were measured on a daily basis.

Table 3.1 Site Investigation Targets Areas

| Exploration Identifier | Location |
|-------------------------------|---|
| BH1 | Grass verge near northwest perimeter fence north of tennis courts (Area No. 15) |
| BH2 | Adjacent to northern perimeter wall and Family Services Accommodation (FSA) |
| BH3 | Open land between Family Services Accommodation (FSA) and SOCO Training Area |
| BH4 | Gardens adjacent to officers mess (Building No. 3) |
| BH5 | Southeast corner of SOCO Training Area (Adjacent to Building No. 12) |
| BH6 | Front garden of officers accommodation |
| BH7 | West side of The Green (Area No. 70), adjacent to gatehouse |
| BH8 | Adjacent to NAAFI Junior Ranks Mess and Accommodation |
| BH9 | Adjacent to Advanced Training Wing (Building No. 67) |
| BH10 | Adjacent to southwest side of Sandhurst Block (Building No. 7) |
| BH12 | Centre of car park (Area No. 27) to front of Sergeants Mess (Building No. 11) |
| BH13 | South side of assault course (Area No. 14) |
| WS1 | Adjacent to tennis court (Area No. 15) |
| WS2 | West side of Family Services Accommodation (FSA) |

Table 3.1 (continued) Site Investigation Targets Areas

| Exploration Identifier | Location |
|-------------------------------|--|
| WS4 | Adjacent to northern perimeter wall and Family Services Accommodation (FSA) |
| WS5 | Northeast corner of site in Family Services Accommodation (FSA) garden |
| WS7 | Play area at front Family Services Accommodation (FSA) gardens |
| WS8 | Gardens at front of Officers Mess (Building No. 3) |
| WS9 | Adjacent and east of the Royal Military Police Head Quarters building |
| WS10 | Grass at northwest side of Sandhurst Block (Building No. 7) |
| WS11 | South of Indoor Firing Range (Building No. 9) at northeast of Parade Ground/car park |
| WS12 | East central side of Parade Ground/car park (Area No. 27) |
| TP1 | East of tennis courts (Area No. 15) |
| TP2 | North of Medical Centre (Building No. 2) |
| TP3 | Adjacent (south) to Chapel (Building No. 55) |
| TP4 | SOCO Training Area south of Lacard House (Building No. 12) |
| TP5 | Southeast corner of The Green (Area No. 70) |
| TP6 | East entrance of Sandhurst Block (Building No. 7) |
| TP7 | Gardens to south of Sergeants Mess (Building No. 11) |
| TP8 | Southeast corner of the site adjacent to former location of oil tanks |

3.1.1 In-situ Testing

In-situ testing comprised SPTs in cable percussive boreholes, CPTs in window sample boreholes and CBR test in four trial pits. The results of these tests are included on the borehole logs and presented in Annex C.

3.1.2 Laboratory Geotechnical Testing

Laboratory geotechnical testing was conducted by May Gurney through their UKAS accredited geotechnical laboratory Norfolk Partnership Laboratory. Quality assurance information is detailed with the results in Annex A.

Table 3.2 Summary of Laboratory Testing Undertaken

| Laboratory Test | Number Performed |
|------------------------|-------------------------|
| CBR | 7 |
| PSD | 23 |
| Moisture Content | 46 |

Table 3.2 (continued) Summary of Laboratory Testing Undertaken

| Laboratory Test | Number Performed |
|------------------------------------|-------------------------|
| Atterberg Limits | 39 |
| Undrained Triaxial | 18 |
| Organic Matter Content | 2 |
| Sulphate | 18 |
| pH | 18 |
| Oedometer 25,50, 100, 200, 400 kPA | 5 |
| Oedometer 12,25, 50, 100, 200 kPA | 1 |

4. Ground Conditions

4.1 Strata Encountered

4.1.1 General

The ground conditions encountered during the geotechnical investigation were consistent with those encountered during the previous Enviro Phase 2 investigation. The geological sequence generally comprised the following:

- Topsoil;
- Made Ground;
- Drift (Gravel Head Deposits);
- Clay (Reading Beds/London Clay).

Topsoil typically comprised dark brown gravely, slightly sandy clay. Made Ground was not encountered in all exploratory locations on the site. Made Ground was found to be absent at BH6, BH7, BH8, BH10, WS7 and WS11. Drift deposits were found across the whole site to depths of 5.2m to 8.0 m bgl. Reading Beds were generally found to underlie the drift with the exception of the southwest of the site where London Clay separates these deposits. This is broadly consistent with the published information.

4.1.2 Made Ground

A variable thickness of Made Ground was encountered across the site consisting on the whole of reworked natural ground with a minor proportion of inert building waste (brick rubble, concrete, timber and metal fragments). Two locations in the north of the site were found to have a considerable thickness of Made Ground compared with other locations on the site. WS4 (in the north of the site) encountered a buried wall or footings to a depth of 2.4m bgl. WS5 (in the northeast corner of the site) was found to have 1.6m of Made Ground containing brick, ash, shell and pottery.

4.1.3 Natural Ground

The Made Ground, where present, was underlain by drift deposits of a relatively consistent thickness across the site (approximately 6m). The drift comprised variable gravels and clay gravels, sands and gravely clays and clays. Generally, a layer of coarse clayey gravel up to 3.2m thick was underlain by gravely sands up to 5.5m thick.

The drift deposits were underlain by Reading Beds over the majority of the site at relatively a consistent depth of approximately 6 m bgl with the exception of the south west of the site where the drift deposits were underlain by London Clay followed by the Reading Beds. In this area of the site the Reading Beds were present at depths of approximately 11 m to 15 m bgl.

The Reading Beds were found to consist of stiff to very stiff red and grey mottled sandy clays. The London Clay is firm to stiff blue/grey slightly sandy clay; in places the clay was thickly laminated with silt with thin laminae of fine to medium sand.

4.2 Obstructions

Obstructions and former below ground structures were largely absent across the site. A concrete slab was encountered at TP3 at a depth of 1.5m bgl; this trial pit was ceased at this depth. The slab is likely to be footings for a wall that is indicated on an historical map from 1875 in the vicinity of TP3; there is no indication from the available historical maps that a building had been present at this location.

4.3 Groundwater

The Enviro Phase 1 LQA Desk Study indicated that groundwater was present in the north of the site at approximately 20m below ground level and at 25m below the ground level in the south. With reference to the geological map of the area this would result in the presence of groundwater in the Gravel Head Deposits in the north of the site and the London Clay and Reading Beds in the south of the site. The Phase 1 LQA reported that the thickness of the London Clay is unlikely to result in the formation of an effective aquiclude above the Chalk aquifer.

The Enviro Phase 2 LQA investigation confirmed the presence of shallow groundwater, typically at approximately 2.5m depth. Groundwater was found in three of the window samples drilled during this investigation; WS6 in the east of the site; WS7, also in the east of the site and WS9 in the west of the site.

During the current geotechnical investigation, groundwater was encountered at twenty three of the exploratory locations, primarily within sand and gravels in the drift deposits. A summary of groundwater observations is presented in Table 4.1. No groundwater was encountered within the Reading Beds or London Clay formations; as a result all boreholes were screened within the Drift deposits.

Table 4.1 Groundwater Observations

| Location | Groundwater Strike (m bgl) | Groundwater Rising Level (m bgl) | Strata | Comments |
|----------|----------------------------|----------------------------------|----------------|--------------------------------------|
| BH1 | 4.5 | - | Drift deposits | Installed for groundwater monitoring |
| BH2 | 2.92 | - | Drift deposits | Installed for groundwater monitoring |
| BH3 | 3.0 | 2.9 | Drift deposits | |
| BH4 | 4.5 | - | Drift deposits | |
| BH5 | 4.3 | - | Drift deposits | Installed for groundwater monitoring |
| BH6 | 3.0 | 2.8 | Drift deposits | |

Table 4.1 (continued) Groundwater Observations

| Location | Groundwater Strike (m bgl) | Groundwater Rising Level (m bgl) | Strata | Comments |
|----------|----------------------------|----------------------------------|----------------|---|
| BH7 | - | - | Drift deposits | Very slight seepage, installed for groundwater monitoring |
| BH8 | 3.0 | 2.9 | Drift deposits | |
| BH9 | 4.4 | 4.10 | Drift deposits | |
| BH10 | 3.5 | 3.3 | Drift deposits | |
| BH11 | 2.85 | - | Drift deposits | Installed for groundwater monitoring |
| BH12 | 4.4 | 3.6 | Drift deposits | Installed for groundwater monitoring |
| BH13 | 3.28 | - | Drift deposits | Installed for groundwater monitoring |
| WS1 | 2.5 | 2.8 | Drift deposits | |
| WS2 | 3.0 | 2.8 | Drift deposits | |
| WS4 | 3.0 | 2.9 | Drift deposits | |
| WS5 | 3.0 | - | Drift deposits | |
| WS7 | 3.0 | 2.9 | Drift deposits | |
| WS8 | 3.0 | 2.8 | Drift deposits | |
| WS9 | 3.5 | 3.1 | Drift deposits | |
| WS10 | 3.0 | 2.7 | Drift deposits | |
| WS11 | 3.2 | - | Drift deposits | |
| WS13 | 3.0 | 2.7 | Drift deposits | |
| TP5 | 2.8 | - | Drift deposits | |
| TP6 | 3.0 | - | Drift deposits | |
| TP7 | 2.9 | - | Drift deposits | |

During the course of the geotechnical investigation, gas and groundwater levels were monitored in selected boreholes, daily, commencing 24 hours after drilling. The results are presented in Annex C. Flow rates ranged from -0.2 to 0.8 litres/h although most boreholes showed non detectable flow. Methane was not detected in any of the monitored boreholes; Carbon dioxide concentrations ranged from 0 to 2.9%. Most boreholes showed low concentrations of carbon dioxide although concentrations were slightly elevated in BH13 (2.3-2.9%). Barometric pressure was relatively constant during the monitoring period in the range of 1010-1014mB.

Figures
