APPENDIX F

ENCIA 2013. SUMMARY ENVIRONMENTAL RISK REPORT OF CHURCH HILL (AREA F), NUTFIELD ROAD, REDHILL, SURREY. PREPARED FOR EVONIK DEGUSSA UK HOLDINGS LIMITED REPORT NUMBER 20096/6F, MAY 2013

APPENDIX F1

Report No. 20096/6F
Date: May 2013

SUMMARY ENVIRONMENTAL RISK REPORT

of

CHURCH HILL ('AREA F')

NUTFIELD ROAD, REDHILL, SURREY

Prepared for

Evonik Degussa UK Holdings Limited

LANDPLUS GmbH
Hedwigstr. 62
45131 Essen
Germany

Tel: +49 201 2448820
Fax: +49 201 2448811

Encia Regeneration Ltd
10 Church View
Knutsford
Cheshire
WA16 6DQ

Tel: +44 01565 652394
Fax: +44 0845 5190766

SUMMARY OF GEOENVIRONMENTAL RISKS
CHURCH HILL (AREA F)
NUTFIELD ROAD, REDHILL, SURREY

The study site is located off Nutfield Road, approximately 2.5km east of Redhill Town Centre (NGR TQ 301 509). The study site covers an area of approximately 103.6 hectares.

A series of ground investigations have been carried out by Landplus/Encia between October 2011 and May 2012 with associated post fieldwork monitoring. The findings of the above investigations have been presented to Reigate & Banstead Borough Council (RBBC), Tandridge District Council (TDC) and the Environment Agency (EA).

It was agreed that a series of 'summary environmental risk reports' be prepared for each part of the site to assist RBBC, TDC and the EA in their overall assessment of the site within the context of the contaminated land provisions of Part 2A of the Environmental Protection Act 1990 ('Part 2A').

This present report is therefore intended to present an overview and summary of the findings of the geoenvironmental investigations carried out in the **Church Hill** part of the site (referred to in previous Landplus/Encia reports as **'Area F'**).

A summary of environmental risks associated with the Church Hill area is presented below (Part 2A statutory guidance 'risk categories' used).

Summary of Environmental Risks – Church Hill (Area F)

Receptor		Pathway(s)	Source	Risk Category	Comments
Property	Livestock (Sheep)	Ingestion Dermal Contact	Soil contamination in near surface restoration soils	4	No contamination in excess of soil screening values noted
	Crops (Grass)	Vegetation uptake	Soil contamination in near surface restoration soils Landfill gas and VOCs	4	No phototoxic contamination in excess of soil screening values noted No significant landfill gas detected
	Buildings (off site)	Migration & accumulation	Landfill gas and VOCs	4	Putrescible materials absent in Area F with corresponding low landfill can concentrations. Landraise of waste materials at levels above nearby properties mitigates gas migration risk
	Buildings (future)	Migration & accumulation	Landfill gas and VOCs	3	Future residential/commercial development in north of Area F is a possibility but unlikely (greenbelt). Further assessment and gas protection measures would be anticipated
Humans	Tenants (Farmer Workers)	Ingestion Dermal Contact	Soil contamination in near surface restoration soils	4	No contamination in excess of soil screening values noted Farmer workers are adults with a relatively low exposure frequency and duration
	Informal Users (Walkers/ Children at play)	Ingestion Dermal Contact Inhalation	Soil contamination in near surface restoration soils. Soil contamination in near surface natural strata in woodland. Landfill gas and VOCs.	4	No contamination in excess of soil screening values noted in restoration soils. Arsenic US_{95} in excess of residential SGV (natural strata) - considered to be naturally occurring background concentrations. Localised marginally elevated BaP. However, elevated SO_4 in yellow clays are a potential irritant but site users will have a relatively low exposure frequency and duration and these materials are not present at surface.
	Anglers	Ingestion of fish Dermal contact (water)	Leachate migration to angling ponds located in Area D	4	Water quality in angling ponds below EQS values. No positive evidence for consumption of caught fish. Groundwater quality in Area C good when compared to rest of study site.
	Nearby Residents	Inhalation	Dusts, vapours and landfill gas	4	100% grass cover and lack of site traffic etc prevents generation of airborne dusts. No VOCs detected in Area F. Putrescible materials absent in Area F with corresponding low landfill can concentrations. Landraise of waste materials at levels above nearby properties mitigates gas migration risk
	Users of Country Park (sailing etc)	Ingestion (water) Dermal Contact (water)	Leachate migration to Mercer Country Park lake	4	Water quality in Mercer's lake below EQS values. Groundwater quality in Area F good when compared to rest of study site.
Controlled Waters	Off site Surface Water Bodies	Leachate generation and migration	Landfilled wastes and leachate	4	Landfilled wastes possess no basal containment and directly overlie relatively permeable strata. Groundwater flow to north and intersects waste mass which is in hydraulic continuity with surface water features to the north. Groundwater quality in Area E good when compared to rest of study site. Water quality in lakes below EQS.
	Principal Aquifers	Leachate generation and migration	Landfilled wastes and leachate	3	Landfilled wastes (Areas A, B, north of Area C, north of Area E and Area F possess no basal containment & directly overlie relatively permeable strata. Groundwater flow to north & intersects waste mass. Groundwater observed to be impacted by leachates directly beneath the site but no evidence of deterioration of water quality in nearby surface water features that are substantially groundwater fed. Dilution & dispersion of contaminants considered to be significant elements of natural attenuation. Site not located in groundwater SPZ & is not abstracted for potable supply locally.

Continued…

Receptor		Pathway(s)	Source	Risk Category	Comments
Ecosystems	On site Woodland	Vegetation uptake (flora) Ingestion (fauna) Dermal contact (fauna)	Soil contamination in made ground in woodland area and natural Strata	4	Arsenic US_{95} in excess of residential SGV in reworked made ground and natural strata - considered to be naturally occurring background concentrations. Elevated SO_4 in yellow silt/clays No sign of vegetative stress. Local soil types and chemical status has given rise to diverse habitats. Area F not a designated site (SSSI, SBI, LNR etc)
	Nature Reserve and Country Park (Aquatic)	Leachate generation and migration	Landfilled wastes and leachate	4	Aquatic ecosystems potentially at risk from migration of leachate within groundwater derived from landfilled wastes. Nearby ponds/lakes considered to be in hydraulic continuity with landfill leachate. However, water quality in nearby surface water features are below EQS. The distance of these features from the site suggest that dilution and dispersion of contaminants considered to be significant elements of natural attenuation

TABLE OF CONTENTS

APPENDICES

Appendix A **Drawings**

Drawing No.	Title	Size	Scale
20096/1	Site Location Plan	A4	NTS
20096/2	Site Areas Plan	A3	1:5000
20096/3	Existing Site Features	A3	1:5000
20096/F/4	LiDAR Topographical Survey – Church Hill Area	A3	1:4000
20096/F/5	Photograph Locations - Church Hill Area	A3	1:4000
20096/6	Surrounding Land Use/Environmental Setting	A3	NTS
20096/7	Historical Site Features	A3	1:5000
20096/F/8	Exploratory Hole Location Plan - Church Hill Area	A3	1:4000
20096/F/10	Approximate Depth of Fill Materials - Church Hill Area	A3	1:4000
20096/F/11	Approximate Groundwater Contours (December 2012)	A3	1:5000
20096/F/12	Landfill Gas Concentrations – Church Hill Area	A3	1:4000
20096/F/13	Conceptual Site Model – Church Hill Area	A3	NTS

Appendix B **Photographic Survey**

Appendix C **Aerial Photographs (1945-2009)**

Appendices D to F **Exploratory Hole Records (Church Hill Area)**

Appendix D	Windowless Sampler Boreholes WS35-WS43, WS230-WS235
Appendix E	Cable Percussion Boreholes BH25 – BH30
Appendix F	Trial Pits TP16-TP22, TP24-TP29

Appendix G **Summary of Groundwater Levels Measurements (October 2011-March 2013)**

Appendix H **Statistical Analysis of Soil Chemical Test Results - Church Hill Area**

Appendix I **Water Monitoring Report (Ref 20096/056 dated 31st January 2013)**

FOREWORD

This report has been prepared for the sole internal use and reliance of the Client named on page 1. This report shall not be relied upon or transferred to any other parties without the express written authorisation of LANDPLUS GmbH (Landplus) and Encia Regeneration Limited (Encia); such authorisation not to be unreasonably withheld. If any unauthorised third party comes into possession of this report, they rely on it at their peril and the authors owe them no duty of care and skill.

The report presents a summary of observations and factual data obtained during our site investigations, and provides an assessment of geoenvironmental issues with respect to information provided by the Client regarding the existing use of the site. Further advice should be sought from Landplus/Encia prior to development proposals.

The report should be read in its entirety, including all associated drawings and appendices. Landplus/Encia cannot be held responsible for any misinterpretations arising from the use of extracts that are taken out of context. However, it should be noted that in order to keep the number of sheets of paper in the hard copy to a minimum, some information (e.g. laboratory test certificates) is only included within the “electronic”, PDF Report on the accompanying CD.

The findings and opinions conveyed in this report (including review of any third party reports) are based on information obtained from a variety of sources as detailed within this report, and which Landplus/Encia believes are reliable. All reasonable care and skill has been applied in examining the information obtained. Nevertheless, Landplus/Encia cannot and does not guarantee the authenticity or reliability of the information it has relied upon.

The report represents the findings and opinions of experienced geo-environmental consultants. Landplus/Encia does not provide legal advice and the advice of lawyers may also be required.

Intrusive investigation can only investigate shallow ground beneath a small proportion of the total site area. It is possible therefore that the intrusive investigation undertaken by Encia, whilst fully appropriate, may not have encountered all significant subsurface conditions. Consequently, no liability can be accepted for conditions not revealed by the exploratory holes. Any opinion expressed as to the possible configuration of strata between or below exploratory holes is for guidance only and no responsibility is accepted as to its accuracy

It should be borne in mind that the timescale over which the investigations were undertaken may not allow the establishment of equilibrium groundwater levels. Particularly relevant in this context is that groundwater levels are susceptible to seasonal and other variations and may be higher during wetter periods than those encountered during this commission.

Where the report refers to the potential presence of invasive weeds such as Japanese Knotweed, or the presence of asbestos containing materials, it should be noted that the observations are for information only and should be verified by a suitably qualified expert.

LANDPLUS GmbH/Encia Regeneration Limited cannot be responsible for the consequences of changing practices, revisions to waste management legislation etc that may affect the viability of proposed remedial options.

Landplus/Encia reserve the right to amend their conclusions and recommendations in the light of further information that may become available.

SUMMARY ENVIRONMENTAL RISK REPORT

of

CHURCH HILL ('AREA F')

NUTFIELD ROAD, REDHILL, SURREY

1 INTRODUCTION

1.1 General

1.1.1 LANDPLUS GmbH/Encia Regeneration Limited (Landplus/Encia), were commissioned by Evonik Degussa UK Holdings Limited, to carry out geoenvironmental investigations of the former Park, North Cockley and Beechfield Landfills and adjoining land located off Nutfield Road, Redhill, Surrey.

1.1.2 The study site forms part of a wider landholding located across the United Kingdom that are also owned by Evonik Degussa UK Holdings Limited as a result of a number of corporate acquisitions over the years.

1.1.3 It is the intention of Evonik Industries AG to divest their current UK landholdings. In so doing, Evonik Industries AG required the assessment of the geoenvironmental condition associated with each site within their UK landholding, and any associated environmental liabilities and/or geotechnical/development constraints that may be present.

1.1.4 The Landplus/Encia investigations were carried out between September 2011 and May 2012 and have comprised the following principal works:

- Site walkovers and inspections.
- An assessment of the land use history.
- Determination of the site's environmental setting.
- An initial exploratory phase of intrusive ground investigation across the '**main body'** of the site comprising 29 No. trial pits, 43 No. windowless sampler boreholes and 33 No. cable percussive drilled boreholes.
- A supplementary exploratory phase of intrusive ground investigation within '**woodland areas'** comprising 35 No. windowless sampler boreholes.
- A supplementary phase of intrusive ground investigation within the north-western portion of the site near to '**Chilmead Farm'** comprising 11 No. windowless sampler boreholes and 6 No. cable percussive drilled boreholes.
- A programme of gas and groundwater/surface water monitoring between October 2011 and April 2013 (ongoing).

1.1.5 Evonik Degussa UK Holdings Limited and Landplus/Encia held an initial meeting on the 26th February 2013 with representatives of Reigate & Banstead Borough Council (RBBC), Tandridge District Council (TDC) and the Environment Agency (EA). During the meeting, the findings of the above investigations were discussed.

1.1.6 It was agreed at the above meeting that a series of 'summary environmental risk reports' be prepared for each part of the site to assist RBBC, TDC and the EA in their overall assessment of the site within the context of the contaminated land provisions of Part 2A of the Environmental Protection Act 1990 ('Part 2A').

1.1.7 This present report is therefore intended to present an overview and summary of the findings of the geoenvironmental investigations carried out in the **Church Hill** part of the site (referred to in previous Landplus/Encia reports as **'Area F'**).

1.1.8 Within this present report, salient information relating to ground and groundwater

conditions within the Church Hill area has been extracted from previous Landplus/Encia geoenvironmental reports and information re-presented. The investigation findings are discussed within the risk-based framework of Part 2A, with particular reference to the prevailing statutory guidance on contaminated land [1].

1.1.9 Similar 'summary environmental risk reports' have been prepared for the remaining parts of the study site, and which should be read in conjunction with this present report.

1.2 Previous Reports

1.2.1 The findings of the investigations noted in Section 1.1.4 have been presented in the following reports:

Table 1
Previous Geoenvironmental Reports Prepared by Landplus/Encia for the Study Site

Report No.	Report Date	Report Title	Comments
20096/1	Jan 2012	Exploratory Geoenvironmental Appraisal of Former Park, North Cockley and Beechfield Landfills, Nutfield Road, Redhill, Surrey	**'Main'** ground investigation across the main body of site. Establishment of principal monitoring wells
20096/2	April 2012	Exploratory Geoenvironmental Appraisal of Woodland Areas, Former Landfills, Redhill, Surrey	Investigation within '**woodland areas'** not investigation during the 'Main' investigation
20096/3	May 2012	Geoenvironmental Appraisal for a Landfill Gas Passive Venting Trench at the Former North Cockley Landfill, Nutfield Road, Redhill, Surrey	Supplementary detailed investigation in the north-western part of the site near to **Chilmead Farm/Chilmead Lane**. Establishment of additional monitoring wells.

1.2.2 In addition to the above reports, Landplus/Encia have prepared letter reports detailing the findings of the ongoing gas and groundwater/surface water monitoring programme.

1.2.3 For full details relating the findings of the previous investigations and subsequent monitoring programme, reference should be made to the above noted reports.

1.3 The Current/Proposed Development

1.3.1 No development is anticipated at the study site.

1.3.2 Under Part 2A, risks are required be considered only in relation to the current use of the land. "Current use" is defined as:

(a) The use which is being made of the land currently.
(b) Reasonably likely future uses of the land that would not require a new or amended grant of planning permission.
(c) Any temporary use to which the land is put, or is likely to be put, from time to time within the bounds of current planning permission.
(d) Likely informal use of the land, for example children playing on the land, whether authorised by the owners or occupiers, or not.
(e) In the case of agricultural land, the current agricultural use should not be taken to extend beyond the growing or rearing of the crops or animals which are habitually grown or reared on the land.

[1] *Environmental Protection Act 1990: Part 2A. Contaminated Land Statutory Guidance*. Department for Environment Food and Rural Affairs. April 2012

1.3.3 In assessing risks, receptors which are not likely to be present given the current use of the land or other land which might be affected have been disregarded.

1.4 Report Format and Limitations

1.4.1 The primary aims of the geoenvironmental investigated noted in Table 1 above were to identify salient geoenvironmental issues affecting the site to enable the Evonik Degussa UK Holdings Limited to consider environmental and other liabilities within the context of their wider UK landholding divestment programme.

1.4.2 Supplementary investigations may be required in order to further assess ground and groundwater conditions prevailing in some parts of the site and to further assist in the development of any remediation or restoration works, if required. Similar supplementary investigations may additionally be required if redevelopment is proposed in some parts of the site to satisfy the requirements of the Local Planning Authority.

1.4.3 To assist RBBC, TDC and the EA, references to the appropriate sections or appendices of the above noted reports are presented throughout this present report in **blue text**. These references are designed to direct the reader to the appropriate and salient sources of information contained within those reports listed in Table 1.

2 SITE DESCRIPTION

2.1 General

2.1.1 The location of the study site is shown on Drawing No. 20096/1 presented in Appendix A to this report. Site details are summarised in the Table 2 below.

Table 2
Summary Site Details

Detail	Remarks
Location	2.5 km east of Redhill Town Centre
NGR	TQ 301 509 (site centre)
Approximate Area	103.64 hectares
Known services	No statutory utilities are known to cross the site, but are anticipated to be present within surrounding roads. Extensive gas extraction and gas collection pipework is present within the former North Cockley Landfill area (Area B) of the site

2.1.2 The whole of the study site exists as a large and extensive area of open grassland as well as densely wooded areas located to the east of the town of Redhill, Surrey.

2.1.3 The study site is roughly semi-circular in shape and is bounded to the south by the A25 Nutfield Road, to the west by Cormongers Lane, to the north by Chilmead Lane and to the east by Church Hill/Nutfield Marsh Lane.

2.1.4 The site is known to have existed as a series of extensive contiguous former mineral extraction workings and which have subsequently been restored by landfilled wastes.

2.1.5 For descriptive purposes (largely based on historical land use), the site can be subdivided into the following areas, which are indicatively shown on Drawing No. 20096/2 in Appendix A.

- **Area A** - Former Park Quarry/Landfill (western site area)
- **Area B** - Former North Cockley Quarry/Landfill (central-western site area)
- **Area C** – Gore Meadow Quarry (central/southern site area)
- **Area D** – Former Sand Pit (northern site area)
- **Area E** – Former Beechfield Quarry/Landfill (central-eastern site area)
- **Area F** – Former Church Hill Quarry/Landfill (eastern site area)

2.1.6 Existing salient site features are presented on Drawing No. 20096/3 in Appendix A.

2.2 Site Features – Area F (Church Hill Area)

2.2.1 The Church Hill area is roughly triangular in shape and covers an area of approximately 17.4 hectares in the eastern portion of the study site and is bounded by Nutfield Marsh Road to the east.

2.2.2 Topographical information has been obtained in the form of a remote 'Light Detection and Ranging' ('LiDAR') survey. The 'LiDAR' topographical information for the Church Hill area is presented as Drawing No. 20096/F/4 in Appendix A.

2.2.3 A selection of photographs of the Church Hill area is presented in Appendix B, the location and orientation of which are presented on Drawing No. 20096/F/5 in Appendix A. A selection of aerial photographs is presented in Appendix C.

2.2.4 The majority of this part of the site exists as open grassland with isolated clusters of trees and is currently used for the grazing of sheep (Photographs 24, 25 and 27 in Appendix B).

2.2.5 In the south of the Church Hill area is located an area of dense woodland.

2.2.6 Ground levels increase steadily from north (90mAOD) to south (124mAOD) across the grassland area with steeper slopes existing along the eastern margins with ground levels decreasing down to the adjacent Nutfield Marsh Road to the east.

2.2.7 A steep wooded slope is present along the western margins with ground levels decreasing down ca 8-9m to the adjacent Beechfield Quarry area (Area E) to the west. The topography of this part of the site suggests possible substantial 'land raise' has taken place in the past.

2.2.8 The southern portion of the Church Hill area exists as dense, predominantly deciduous, woodland situated on steep northerly and westerly sloping slopes and covers an area of ca 4.4 hectares. At the crest of these slopes is a 1.3 hectare clearing containing rough grasses and self seeded trees situated at an elevation of ca 135mAD, representing the highest point of the study site (Photograph 26, Appendix B).

2.2.9 An area of hummocky ground, (inaccessible for investigation equipment), is present in the northern part of the woodland and a small collapsed concrete structure was observed adjacent to the footpath in this area.

2.2.10 Public footpaths cross the southern woodland area, which lead from Nutfield Marsh Road, and both traverse along the toe of the wooded slopes and additionally cross up and over the slopes and enter the above noted woodland clearing.

For descriptions of other parts of the site reference should be made to:

Report No. 20096/1 – Sections 2.3-2.7

Report No. 20096/2 – Section 2.2

2.3 Surrounding Land Use

2.3.1 The study site is understood to be located in the 'Adopted Greenbelt' and surrounding land uses are typically residential properties, waste management activities, agricultural (pasture) and recreational/amenity use.

2.3.2 The surrounding land uses near to the study site are depicted on Drawing No. 20096/6 in Appendix A.

2.3.3 Located to the west of the study site (to the west of Cormongers Lane) is a large operational landfill facility operated by Biffa Waste Services Limited. The northern and north-eastern portion of the Biffa Landfill area has not yet been landfilled, and extensive and deep excavations to ca. 45mAOD are present immediately to the northwest of the study site, within the base of which are collected waters. This landfill utilises engineered low permeability basal and sidewall mineral and artificial (geomembrane) liner systems and the landfill is operated on current waste management industry best practice operational means and is understood to possess active gas and leachate collection systems. Access to the Biffa landfill is via an access road off Cormongers Lane to the west of the study site opposite the former Park Quarry (Area A) part of the site.

2.3.4 Along the southern boundary of the study site are located a number of residential properties along Nutfield Road. A cemetery is also located to the south of the site (to the southwest of Gore Meadow (Area C)). Immediately to the south of the Beechfield Quarry area (Area E) are a number of residential properties located off Blacklands Meadow and Parkwood Road (accessed from Nutfield Road to the south). A sports ground is located to the southwest of the Church Hill area and further residential properties are located to the east of the sports ground to the south of the Church Hill

area.

2.3.5 To the south of Nutfield Road are located agricultural (pasture) fields and woodland, isolated residential and farm buildings and a hotel complex. The Nutfield Road is aligned east to west along a ridge and ground levels decease sharply to the south of Nutfield Road.

2.3.6 Immediately to the north of the study site are located isolated residential properties and converted farm buildings located off Chilmead Lane (Chilmead Farm) and Nutfield Marsh Road, a public house ('The Inn on the Pond') and a cricket ground. Beyond these is located a Country Park ('Mercers Country Park'), which comprises a large lake which is used for sailing and other water sports. Another large surface water body ('Spynes Mere Nature Reserve') is located 1.5km to the northeast of the study site.

2.3.7 Agricultural land and another large lake ('Glebe Lake') are located on land to the northeast of the study site. It is understood that this land to the east represents former (restored) mineral workings known as 'Glebe Quarry'. It is unknown whether the former Glebe Quarry has been landfilled with wastes.

2.3.8 Immediately to the east of the Church Hill area (off Nutfield Marsh Road) is located a row of terraced cottages ('Peytons Cottages') and other terraced, semi-detached and detached residential properties and a church and vicarage with pasture land beyond.

2.4 Site Operations

2.4.1 The study site substantially exists as open grassland and these areas are used for the grazing of sheep by a local tenant farmer, as well as for the grazing of horses in the south of Area C. The majority of the reminder of the study site is covered in dense woodland.

2.4.2 Landfill gas is commercial exploited for electricity generation in the North Cockley landfill (Area B) in the central-western part of the site.

2.4.3 A number of public footpaths cross the study site and it is apparent, based on observations made during the ground investigation works, that the open grassland areas of study site are commonly used by walkers, dog walkers and joggers (individuals and clubs). Within the Church Hill area, a network of public footpaths are present within the woodland and these appear to be frequently used by local residents for walking.

2.4.4 Two surface water ponds located in the north of the site in the former Sand Pit area (Area D) are used by a local angling club.

2.5 Site Designation

2.5.1 The Church Hill area is located within the administrative area of TDC, and is located within an area of Adopted Greenbelt

3 SITE HISTORY

3.1 Introduction

3.1.1 The whole of the study site is known to have had a history of extensive mineral extraction and subsequent quarry restoration by landfilled wastes.

3.1.2 Historical Ordnance Survey (OS) maps (1:10000 scale dating from 1869) have been obtained.

For Historical Ordnance Survey map extracts see:

Report No. 20096/1 - Appendix G

3.1.3 Drawing No. 20096/7 in Appendix A presents a summary of the principal historical features (as shown on historical OS maps) which have been present across the whole site.

3.1.4 An aerial photograph of the site obtained from *Google Earth*™ dating from 1945 is presented in Appendix C.

3.1.5 A previous desk study undertaken on behalf of Evonik Degussa UK Holdings Limited by Ford Consulting Group states*:*

> *"The original development applications (1947) to win Fullers Earth covered an area of some 400 hectares. It was reported that Fullers Earth deposits close to surface had been worked since at least 1872, with large scale excavations of Fullers' Earth deposits and overlying sands and sandstone occurring during the 1960s and 1970s over the majority of the area. It appears that from the late 1960s landfill operations consistently formed part of the overall workings, with infilling of a number of the sites."*

3.2 Area F – Church Hill

3.2.1 The historical OS plans show no development at the Church Hill Quarry in the 19th Century, with the exception of a small 'Fullers Earth Works' in the southeast of the area by 1895, in the vicinity of which, mineral extraction and/or waste disposal is shown to have slowly expanded in the south of this area of the site during the first half of the 20th Century (also see 1945 aerial photograph in Appendix C).

3.2.2 By 1955, an elongated quarry/refuse tip was present in the north of the Church Hill area which also extended on to the adjacent Beechfield Quarry area (Area E) to the west.

3.2.3 By 1970, the small Fullers Earth works and associated nearby mineral extraction are no longer shown in the south of the Church Hill area and woodland is shown in those areas where it is present today. However, a large 'refuse pit' is shown in the central portion of the Church Hill area extending onto the adjacent Beechfield Quarry area to the west. By 1976 the refuse pit is no longer shown and a spring and northerly flowing stream are present on the eastern margin of the site on the verge of Nutfield Marsh Road.

3.2.4 The Ford Consulting Group study indicates that mineral extraction was rather piecemeal in the Church Hill area with a number of discrete pits extending to possibly 16m depth that were interspersed with woodland.

3.2.5 It is reported that commercial and industrial wastes were potentially deposited in the Church Hill area as well as possibly some acidic sludges derived from the large 'Cockley (Fullers Earth) Works' (that was present to the west in the southern part of

Area B).

3.2.6 Land within the central and northern parts of the Church Hill area was apparently raised by some 10m above surrounding land as a domed landform (exact dates unknown, possibly 1970s).

For descriptions of the historical development of other parts of the site reference should be made to

Report No. 20096/1 – Sections 3.3-3.7

Report No. 20096/2 – Section 3.1

4 ENVIRONMENTAL SETTING

4.1 Geology

4.1.1 The British Geological Survey (BGS) map for the area (Sheet 286 1:50,000 scale) shows the site to be underlain by 'Lower Greensand' strata of the Lower Cretaceous period.

4.1.2 The southern half of the study site is indicated to be underlain by the Sandgate Beds formation. These strata are variable in nature and consist of sandstone, mudstone and sandy limestone, sand, silts and clays and, in the Nutfield area contain important lenses of Fullers Earth. The Fullers Earth deposits east of Redhill are the largest known in Great Britain and are of national significance. The BGS sheet indicatively shows the thickness of the Sandgate beds to be ca 25m. The Sandgate Beds are underlain by the Hythe Beds which comprise bands of sands, sandstone, limestone and chert.

4.1.3 The northern half of the site is shown to be underlain by strata of the Folkestone Beds of the Lower Greensand formation and which overlie the Sandgate Beds. The Folkestone Beds consist of loosely consolidated pure cross bedded quartzose silica sands, including deposits of clean, white silica sand as well as irregular bands of ferruginous sandstone ("carstone"). The thickness of the Folkestone Beds can extend to ca 80-100m, although in the vicinity of the site, the thickness of the Folkestone beds are likely to be little more than 5-20m in thickness.

4.1.4 The Hythe Beds, Sandgate Beds and Folkestone Beds are shown to dip to the north at ca 6^{o}.

4.1.5 With regard to Drift strata, these are shown to be largely absent in the vicinity of the site.

4.2 Hydrogeology

4.2.1 The Sandgate Beds which underlie the southern half of the study site are classified as a 'Secondary A' Aquifer.

4.2.2 The Folkestone Beds which underlie the northern half of the study site are classified as a 'Principal Aquifer', as are the Hythe Beds which underlie the Sandgate Beds.

4.2.3 The Drift deposits which are present to the north of the study site are classified as a 'Secondary A' aquifer.

4.2.4 The Lower Greensand Formation is comprised of two Principal aquifer units these being the Hythe Formation (consisting of fine-grained sands and sandstones) and the Folkestone Formation, a poorly consolidated, cross-bedded sand. These two aquifer units are separated by the Sandgate Formation which comprises poorly sorted sands clays, silts and sandstones.

4.2.5 Information held by the BGS indicates that, while piezometric data show the two Hythe and Folkestone Beds aquifer units to be hydraulically independent, the Sandgate Formation is not laterally persistent and may allow vertical leakage.

4.2.6 The Hythe Beds exhibit both fracture flow in cemented sandstones and intergranular flow through poorly consolidated sands.

4.2.7 The British Geological Survey notes that the Folkestone Beds are the only aquifer within the Thames Basin regarded as generally homogenous, containing intergranular flow only. Where intergranular flow dominates, transmissivity values are accordingly reduced. High storage, within the Folkestone Beds provides diffuse baseflow to rivers and a characteristic steady groundwater head with minimal seasonality. The hydraulic

conductivity of the Folkestone Beds is high and typically varies between $1x10^{-4}$ to 10m/day (mean 0.46m/day).

4.2.8 The study site is not located in a Groundwater Source Protection Zone. A Groundwater Protection Zone (Zone III) is however present ca 1-1.5km to the east and northeast relating to potable water supply boreholes located between 2 and 4km to the northeast.

4.2.9 Two licensed groundwater abstractions are present within 1km of the site. The nearest of these is located ca 400m to the south and relates to an abstraction used for general farming and domestic use abstracting via a borehole within the Hythe Beds (volume unknown). The next nearest groundwater abstraction is present ca 950m to the north which relates to abstraction from a lake (Mercers East Quarry) for mineral washing uses ($4800m^3$/day).

4.2.10 It is additionally understood that Biffa Waste Services possess groundwater abstractions within the landfill site immediately to the west of the Park Quarry/Landfill that locally dewater the Hythe Beds to enable the construction of waste containment cells.

4.2.11 Potable water abstractions are present ca 2+km to the northeast operated by Thames Water (Warwick Wold Pumping Station).

4.3 Quarrying

4.3.1 The whole of the study site and surrounding land has had a long history of mineral extraction.

4.3.2 Modest quarrying operations took place, predominantly in the south of the site, in the late 19th Century, although major mineral extraction across the remainder of the site would appear to have taken place in the 1960's and 1970's (see Drawing No. 20096/7 in Appendix A).

4.3.3 Information contained within the Ford Consulting Group study suggests that sand/sandstone as well as Fullers Earth deposits were extracted from various parts of the site and which may have extended to ca 73-74mAOD (ca. 40+m below existing) in the North Cockley area (Area B). The depth of excavations within the Church Hill area are not known , but are reported by the Ford Consulting Group Ltd to have potentially extended to 16m depth in the south of this area

4.3.4 To the north of the site are a series of large lakes which represent flooded former sand extraction pits and which are now used for amenity and nature reserve uses (see Drawing 20096/6 in Appendix A).

4.4 Hydrology

4.4.1 A number of surface water features are present on site, as shown on Drawing No. 20096/3 in Appendix A.

4.4.2 In the north of the study site (Area D), two un-restored sand extraction pits are present. The western of these two features contains surface water, whereas the eastern feature was observed to be largely dry between September 2011-November 2012 but contained waters from December 2012-March 2013 . Aerial photographs (Appendix C) also suggest that the eastern pond has periodically been dry over the years.

4.4.3 Within the south-western part of the North Cockley Quarry (Area B) is a small surface water pond. This pond would appear to have developed within a depression caused by the settlement of the underlying fill materials.

4.4.4 A number of land drains are present across the north of the study site at the toe of

slopes. Between September2011 and November 2012, these drains were observed to be dry.

4.4.5 To the north of the study site are a number of surface water drains. These features would appear to drain to the westerly flowing Redhill Brook which is located ca 350m to the northwest of the study site (see Drawing No. 20096/6 in Appendix A). Water filled former mineral extraction pits are present to the north and northeast of the site.

4.4.6 The water quality within the Redhill Brook would not appear to have been assessed by the Environment Agency and no river quality data exists for any water course within 1500m of the study site.

4.4.7 The study site is indicated to not be within a flood plain, however, areas susceptible to 1:1000 and 1:100 flood events (within the Redhill Brook) are present on land 200m to the northwest.

4.5 Landfills

4.5.1 The study site is known to have had a history of landfilling by wastes. Information relating to historical landfilling operations and their extents are summarised below:

Table 3
Summary on Former Landfilling on Site

Site Area	Name	License	Dates	Other information
A	Park Quarry	1978-79 licensed under 10/454, TA/8/LLC	1968-79	Operated by Greater London Council. DCI + inert + special wastes
B	North Cockley	Licensed under 10/468, TA/23	1981-91	Operated by Laporte and Waste Management Ltd. DCI + inert + sludge wastes <250,000tpa Gas extraction system still operational
C	Gore Meadow	Licensed under 40IADAAL	1979 onwards?	Difficult wastes. No further details. Landfilling in northern parts of Area C only
D	Sand Pit	No Details	Early 1970s?	Unknown. Possibly shallow wastes
E (and E1 + E2)	Beechfield Quarry	Licensed under 10/455, TA/9/LLC	1977-1994	Operated by Laporte and Waste Management Ltd. DCI +inert + sludge wastes in E1 and E2 >250,000tpa
F	Church Hill	No details	Unknown (pre 1977)	Details unknown. Possible waste disposal in early 20th Century around small Fullers Earth Works in the south.

DCI- Domestic, commercial and industrial wastes

4.5.2 Land to the west of the study site is an operational landfill facility licensed by the Environment to Biffa Waste Services (IPPC ref YP3490ES) for the disposal of commercial, household and industrial wastes. The site has been licensed to accept wastes since December 1989.

4.5.3 Environment Agency and BGS records additionally show the presence of an historical landfill site located immediately to the south of Areas A and B (to the south of Nutfield Road) – also see Drawing No. 20096/6 in Appendix A. This site, known as the 'Nutfield Priory Landfill Site' was operated under a number of waste disposal licenses by Reigate Borough Council. The site was licensed in July 1978 for the disposal of inert, commercial, industrial and domestic wastes, but would have been operational prior to this date.

4.5.4 Land to the east of Church Hill (to the east of Nutfield Marsh Road) was operated as an additional Fullers Earth mineral extraction site, known as Glebe Quarry. Flooded mineral workings ('Glebe Lake') are present to the northeast of the Church Hill area, although it is not known whether waste disposal (landfilling) operations took place in this area.

5 GROUND INVESTIGATION DESIGN

5.1.1 A series of preliminary conceptual site models were used as a basis for the design of an appropriate ground investigation, the scope of which is summarised below.

For a description of the Preliminary Conceptual Site Model, reference should be made to:

Report No. 20096/1 – Sections 5.1-5.3

Report No. 20096/2 – Sections 6.1-6.3

Table 4
Initial Ground Investigation Strategy

Exploratory Holes	Purpose
Cable Percussion Boreholes	To determine the general nature of soils underlying the site, including the: • nature, distribution and thickness of any made ground • nature, degree and extent of contamination • Determine geotechnical information from depth To install monitoring wells around and across the site in order to: • monitor for hazardous gas. • determine groundwater levels and assess flow direction. • retrieve representative groundwater samples to determine water quality.
Windowless Percussion Boreholes	To determine the nature of the shallow soils including the presence and nature of the restoration soils and any landfill cap overlying the waste materials and the nature, degree and extent of near surface contamination. To determine the nature of shallow soils and the degree and extent of near surface contamination within woodland areas
Mechanically Excavated Trial Pits	To determine the general nature of soils underlying selected areas of the site, as determined by the above noted exploratory holes, including the: • nature, distribution and thickness of any made ground • nature, degree and extent of contamination

5.1.2 The proposed cable percussion boreholes were proposed to be located within the centre of the anticipated areas of landfilled wastes to confirm the nature and depth of the landfilled wastes but also to establish a series of monitoring wells both within and around the boundary of the site.

5.1.3 A programme of windowless percussion boreholes were proposed to be drilled across the site on a ca 100-150m grid pattern to assess the presence and condition of near surface restoration soils and the presence of landfill capping materials. An additional programme of windowless percussion boreholes was performed within woodland areas as part of a second 'exploratory' investigation.

5.1.4 Mechanically excavated trial pits were proposed to be located in accessible areas to further assess ground conditions identified by the cable percussion and windowless percussion boreholes, possibly focussing on areas where no landfilled wastes are present.

5.1.5 Given the former extensive landfilling activities which have taken place on the study site, contamination was anticipated to be present in waste materials, restoration soils as well as groundwater underlying the wastes and perched leachates within the waste mass. The contamination was anticipated to be wide ranging, reflecting the types of materials deposited which are expected to have comprised commercial, industrial and putrescible domestic wastes, inert wastes and sludges as well as 'special and difficult' wastes such as tyres and bulky wastes and timbers.

6 FIELDWORK – CHURCH HILL AREA

6.1 Scope of Works

6.1.1 Ground investigation fieldwork within the Northern and central parts of the Church Hill area was supervised by Landplus/Encia between the 19th September and 7th October 2011.

6.1.2 'Supplementary' ground investigation fieldwork within the areas of Church Hill that are covered in woodland was supervised by Landplus/Encia on the 24th February 2012.

6.1.3 The fieldwork comprised the exploratory holes listed below.

Table 5
Scope of Ground Investigation Works

Technique	Exploratory holes	Final depth(s)	Remarks
Cable percussive boreholes (Grassland Area)	BH25 to BH30	14.3m to 14.8m	SPT Tests performed in selected boreholes Monitoring wells installed in all boreholes
Windowless percussion boreholes (Grassland Area)	WS35 to WS43	2.0 to 4.0m	Boreholes backfilled with bentonite seal and compacted arisings
Trial Pits (Grassland Area)	TP16 to TP22 TP24 to TP29	1.54 to 2.8m	Trial pit backfilled with and compacted arisings
Windowless percussion boreholes (Woodland Area)	WS230 to WS235	0.7 to 3.0m	Boreholes backfilled with compacted arisings

6.1.4 The logs for the exploratory holes located within the Church Hill area are presented in Appendices D and F to this Report. These logs include details of the:

- Samples taken
- Descriptions of the soil strata, and any groundwater encountered.
- Results of the in-situ testing
- The monitoring wells installed

6.1.5 The locations of the exploratory holes located within the Church Hill area are shown on Drawing No. 20096/F/8 presented in Appendix A.

7 GROUND CONDITIONS – CHURCH HILL AREA

7.1 General

7.1.1 A complete record of strata encountered beneath the Church Hill area is given on the various exploratory hole records, presented in Appendices D, E and F .

7.1.2 The ground conditions identified are complex and only a broad summary of the ground investigation is provided below. For specific detail on ground conditions encountered at each location, reference should be made to the specific exploratory hole records.

7.2 Made Ground – Near Surface Restorations Soils and Landfill Cap

7.2.1 No landfill capping soils were noted to be present within the Church Hill area *per se*. However, as noted in Section 7.3 below, the upper ca 2-3m of made ground soils present across much of the Church Hill area comprise soils of 'natural appearance' that resemble weathered Sandgate Beds strata (sandy gravelly clays) and which probably represent deposited/reworked overburden materials won from quarry operations within this and other parts of the study site that have been placed as restoration soil cover.

7.2.2 These near surface soils were observed to be overlain by a ca 0.25-0.4m thick immature topsoil. This topsoil would appear to be of the same materials as the underlying restoration soil materials but possesses an immature organic soil horizon formed over the years since the soils were placed, and possibly seeded with grass.

7.3 Made Ground – 'Inert Wastes'

7.3.1 Where waste/landfilled materials where encountered which contained small or no proportions of putrescible materials, these have been generally classified an 'Inert Waste'. This classification has been made for descriptive purposes only and does not represent potential contamination content.

7.3.2 In the Church Hill area the majority of exploratory holes encountered 'Inert' Waste materials.

7.3.3 The 'Inert' wastes were proved to much greater depth within the centre and south of the Church Hill area, where such materials were typically encountered to ca 10m depth.

7.3.4 The upper ca 2-3m of the made ground deposits in the Church Hill appeared 'natural' in nature and comprised a variable sequence of sandy gravelly clays and clayey gravelly sands. These materials probably represent soils placed above the wastes in this part of the site that were 'won' from the former mineral extraction operations and closely resemble the weathered Sandgate Beds strata in texture and composition.

7.3.5 In BH25 and BH26, the above noted soils overlie sandy gravelly clay at 3.8 and 3.3m depth within which a slight hydrocarbon odour was noted. In BH25, the 'Inert Wastes' were proven to 4.9m depth and in BH26 the 'Inert Wastes' were proven to 9.8m and also contained rare fragments of timber and glass.

7.3.6 In Boreholes BH27-BH30, and in some windowless sample boreholes (WS39, WS42, WS43), located in the southern half of the Church Hill area, horizons of very soft orange/yellow very clayey silt/very silty clay were encountered (as summarised in Table 6 below - see next page). This material was observed to possess unusual geotechnical properties with *in situ* Standard Penetration Test (SPT) 'N' Values of 0 or 1. This material has been interpreted as reworked/waste Fullers Earth material or 'acid sludge' materials derived from the former Cockley Fullers Earth Works that was

formerly located in the south of Area B. Similar yellow clay/silt materials were noted within 'depression features' (or former lagoons) within the adjacent Beechfield Quarry area (Area E) to the west (see Landplus/Encia Report No. 20096/6E).

Table 6
Summary of Exploratory Holes where
Orange/Yellow Very Clayey Silt/Clay
('Reworked Fullers Earth') was Encountered

Site Area	Exploratory Hole	Depth Encountered (mbgl)	Range of SPT 'N' Values
F	BH27	4.0 - 9.5	0 - 1
F	BH28	0.1 – 3.7 7.1 – 8.1	0 1
F	BH29	1.6 – 9.6	0 - 1
F	BH30	1.8 – 6.4	0
F	WS39	0.8 – 4.0+	1 blow for each 1m penetrated
F	WS42	1.1 – 1.4	1 blow for 0.3m penetration
F	WS43	1.3 – 3.0+	1 blow for each 1m penetrated
F	WS230	1.7 – 3.0+	
F	TP24	1.7 – 2.6+	
F	TP25	1.6 – 2.5+	
F	TP26	0.8 – 1.5	
F	TP27	1.4 – 1.8+	Contained bottles, jars and tin cans
F	TP29	0.6 - 2.0+	

7.3.7 A number of exploratory holes located within the centre and southern parts of Church Hill encountered ash and clinker materials and, in BH27, a 0.8m thick layer of concrete was encountered at the base of the 'Inert Wastes' at 10.2-11.0m depth.

7.3.8 The 'Inert Wastes' were observed to directly overlie natural strata and there was no evidence of any mineral or artificial low permeability basal liner to the wastes.

7.3.9 The approximate thickness of the made ground materials within the Church Hill area are presented in Drawing No. 20096/F/10 in Appendix A.

7.4 Made Ground – Woodland Areas

7.4.1 Made ground materials were observed to be absent in WS231-WS234 located in woodland to the north, south and east of the woodland clearing.

7.4.2 Made ground deposits were, however, encountered in WS42 and WS43 located within the centre of the woodland clearing as well as WS320 located in the west of the woodland area and WS235 located in the north of the woodland.

7.4.3 In WS42, topsoil materials were underlain by very stiff sandy gravelly clay (reworked natural strata) to 0.6m depth. A horizon of angular sandstone gravel was then encountered to 1.1m which was underlain by a band of very soft yellow silt to 1.4m depth (also see 7.3.6 above). The soft yellow silt was observed to be underlain by firm sandy clay with occasional fragments of rubber to 2.0+m depth.

7.4.4 In WS43, a similar upper sequence of made ground deposits was encountered but were underlain by 0.2 and 0.5m thick horizons of clayey sand and sand with entrained ash, clinker and brick. Firm yellow silt was penetrated from 1.3 to 3.0+m depth.

7.4.5 In WS230, the upper 1.0m of made ground comprised sandy clay with gravel of sandstone and brick fragments (reworked natural strata) underlain to 1.7m depth by ash and clinker deposits. These deposits were underlain to 3.0+ depth by soft yellow silty clay materials.

7.4.6 WS235 encountered ash and clinker deposits to 0.6m depth that were underlain by

brick and sandstone cobbles which prevented penetration to greater depth.

7.4.7 The distribution of made ground within the southern woodland areas of Church Hill possibly suggests the presence of a former infilled quarry centred on the clearing within the woodland area

7.5 Natural Ground

7.5.1 Natural ground encountered during the investigation within the Church Hill area comprised the following:

- Folkestone Beds
- Weathered/partially weathered Sandgate Beds

7.5.2 Made Ground strata were observed to be absent at the following location with natural strata exposed at surface (see Drawing No. 20096/F/10 in Appendix A):

- Woodland area (WS231-WS234)

Folkestone Beds

7.5.3 Folkestone Beds were encountered directly beneath the 'Inert' waste materials within exploratory holes located in the north of the Church Hill area, but were also observed to overlie the Sandgate Beds in the central part of Church Hill.

7.5.4 Boreholes BH25, BH26 and BH27 encountered medium dense to very dense yellow/orange brown silty fine to medium sand to depths of 15.4+, 18.3+ and 18.35+m depth respectively. Similar strata were also encountered directly beneath fill materials in BH29 and BH30 to 18.4 and 16.5m depth. In BH28, silty fine to medium sands were noted above Sandgate Beds clay deposits between 10.2 and 13.1m depth

Weathered/Partially Weathered Sandgate Beds

7.5.5 Weathered and partially weathered Sandgate Beds were encountered beneath the 'Inert' waste and made ground deposits across southern half of the Church Hill area.

7.5.6 These strata generally comprised a variable sequence of stiff sandy clay with variable sandstone gravel of sandstone.

7.5.7 Brown medium grained sandstone (BH28) strata were also encountered beneath the above noted weathered Sandgate beds at 13.1m depth

7.6 Groundwater

7.6.1 No groundwater was encountered in any of the exploratory holes during boring, with the exception of BH26 which encountered groundwater at 7.2m depth.

7.6.2 Groundwater levels recorded in the monitoring wells following the fieldwork period are presented in Appendix G and are summarised for the Church Hill area below (see Table 7).

7.6.3 Details of the monitoring well installations are shown on the respective borehole logs in Appendix E. It should be noted that particular care was employed with regard to the design of the monitoring wells so as to not create any 'preferential pathways' for contamination from waste materials to enter the underlying natural strata.

Table 7
Measured Groundwater Levels
(3rd October 2011– 12th March 2013)

Hole ID	Response Zone depth range (m) (& strata)	Groundwater Body	Range of water level (m bgl)
BH25	1.0-5.55 (Inert Waste)	Leachate	Dry – 5.50
BH26	1.0-9.0 (Inert Waste)	Leachate	3.66 – 2.70
BH27	1.0-9.0 (Inert Waste)	Leachate	6.95 – 6.10
BH28	1.0-10.0 (Inert Waste)	Leachate	Dry – 9.20
BH29	1.0-8.5 (Inert Waste)	Leachate	Dry – 5.52
BH30	1.0-6.0 (Inert Waste)	Leachate	5.0 – 3.05

Notes:
CDI – Commercial Domestic and Industrial Waste

7.6.4 Some boreholes within the Church Hill area have been dry throughout much the monitoring period, however a rise in water levels has been noticed across the whole site (in response a wetter than average 2012) and groundwater has been noted in all of the Church Hill boreholes in the most recent monitoring visits.

7.6.5 Drawing No. 20096/F/11 in Appendix A presents approximate groundwater contours recorded across the whole site (as observed in December 2012).

7.6.6 The monitoring data suggests that there is a continuous groundwater table across the whole of the study site.

7.6.7 Groundwater levels are in the order of 123mAOD in the south of the study site and decrease in a northerly direction to 75mAOD in the vicinity of Chilmead Lane in the north. The approximate hydraulic gradient across the site is relatively steep and is calculated to be approximately 0.053m/m.

7.6.8 The groundwater levels closely correlate with the level of surface water bodies located on and near to the study site, which indicates that these flooded former mineral extraction features are substantially groundwater fed.

7.6.9 The groundwater monitoring has shown that a natural water table is present within the natural Sandgate and Folkestone Bed strata but this same groundwater body intersects the waste mass within Areas A, B, E and F. No 'perched' leachate within the waste mass is discernable across the site and such waters within the waste would appear to represent a continuation of the 'natural' piezometric surface. A slight 'deflection' of the groundwater contours is, however, noted within the areas noted to possess a significant thickness of waste deposits (Areas B and F).

8 CONTAMINATION (ANALYSIS)

8.1 General

8.1.1 The site has had a history of extensive mineral extraction and the subsequent restoration of the quarry voids/land raise by the deposition of waste materials over a number of years.

8.1.2 The nature of the waste materials were expected to be variable and the chemical testing scheduled has been designed to reflect this variability and additionally consider the contamination related issues with respect to near surface restoration/landfill cap materials, the wastes themselves and the underlying and surrounding natural deposits.

8.2 Soils Testing Scheduled

8.2.1 A Landplus/Encia Engineer submitted test schedules (summarised in the Table 8 below) to a UKAS accredited laboratory.

Table 8
Summary of Soils Testing Scheduled (Whole Site)

Type of Sample	No. of Samples	Determinands
Near surface Restoration Soils and Landfill Cap	110	pH, total metals (arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc)
	27	Cyanide
	31	Asbestos (screen)
	35	Total and water soluble sulphate
	27	Leachable metals: arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc
	110	Speciated PAH
	6	3 Banded TPH (CRO/DRO/LRO split)
	2	Speciated VOC/SVOC
	1	Speciated PCBs and Pesticides
Made Ground (Woodland Areas)	32	pH, metals (arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc)
	10	Cyanide, total sulphate, water soluble sulphate
	9	Leachable metals: arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc
	32	Speciated PAH
	5	Monohydric phenol
	4	Calorific Value
	1	PCB
	8	Asbestos screen

Continued...

`... Continued

Type of Sample	No. of Samples	Determinands
Wastes ('Commercial, industrial and domestic' and 'Inert')	35	pH, total metals (arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc)
	16	Cyanide
	18	Asbestos (screen)
	25	Total and water soluble sulphate
	13	Leachable metals: arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc
	37	Speciated PAH
	15	Speciated BTEX
	14	Phenols
	24	Speciated TPH
	14	Speciated VOC/SVOC
	13	Speciated PCBs and Pesticides
Topsoil (Woodland areas)	6	pH, total metals (arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc)
	6	Speciated PAH
Natural Strata	57	pH, total metals (arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc)
	12	Cyanide
	5	Asbestos (screen)
	23	Total and water soluble sulphate
	3	Leachable metals: arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc
	54	Speciated PAH
	4	Speciated BTEX
	5	Phenols
	17	Speciated TPH
	9	Speciated VOC/SVOC
	3	Speciated PCBs and Pesticides

8.3 Soil / Waste Contamination Results (Church Hill Area)

For notes relating to the assessment of contamination data reference should be made to:

Report No. 20096/1 – Appendix A

For full laboratory test certificates of chemical tests performed on soils obtained from the Church Hill Area reference should be made to:

Report No. 20096/1 – Appendix L

Report No. 20096/2 – Appendix G

8.3.1 The results of the contamination tests performed on soils/wastes obtained from the Beechfield Quarry area are summarised in Tables 9, 10 and 11.

8.3.2 The test results have been classified by comparison of parameter concentrations with the current UK guidance threshold values for an end use including **'residential with gardens with plant uptake' and any use where plants are to be grown'**.

8.3.3 This end use is considered to be the most stringent with respect to published soil guidance values and represent the most sensitive of end uses. It should be noted that the current use of the site for informal public open space and animal grazing would likely dictate higher soil screening concentrations, however the most sensitive (residential) end use has been considered here to enable a 'worst case' assessment of the contamination data.

Inorganic Determinands

8.3.4 The results of the tests performed on soils from the Church Hill area for inorganic determinands are presented in Table 9.

Made Ground – Woodland Area

8.3.5 Of the 4 samples of woodland area made ground deposits tested for inorganic determinands, none could be classified as being 'contaminated' with respect to the determinands analysed (see Table 9).

Near Surface Restoration Soils

8.3.6 Of the 25 samples of near surface 'restoration soil materials' analysed for inorganic parameters, 7 of the samples could be classified as being 'contaminated' (see Table 9).

8.3.7 The inorganic contaminants detected in the Church Hill area near surface 'restoration soil' deposits in excess of soil screening values are as summarised below:

- **Arsenic** - Detected in excess of the residential end use soil guidance value of 32mg/kg in 4 samples of reworked/disturbed Sandgate Beds.
- **Total and Soluble Sulphate** – Detected in excess of the Building Research Establishment (BRE Special Digest 1) screening values of 2400mg/kg and 0.6g/l respectively in 2 samples of yellow silt/clay (Fullers Earth sludge) deposits (BH28 at 1.0m and WS29 at 2.0m) and in one sample of soil possessing quantities of ash and clinker materials (BH27 1.0m)

Table 9
Summary of Inorganic Contamination in Soils/Wastes
Church Hill (Area F)

Site Area	Hole ID & Sample Depth (m)	Material	Concentrations in mg/kg unless otherwise stated. Results are quoted to 1 decimal plac if <10, and whole numbers if >10. Trigger Level Concentrations are shown in brackets and assume residential with gardens end use														
			pH	As (32)$	Cd (10)$	Cr (130)$	Pb (450)$	Hg (170)$	Se (350)$	B (3)*	Cu (135)x♣	Ni (130)$	Zn (300)x♣	CN	Asbestos	Total SO_4 (2400)◊	Sol SO_4 (0.5g/l)◊
Made Ground - Woodland Area																	
F	WS230 - 0.1m	MG: Sandy Clay	7.5	8.8	<0.20	9.4	<2	<0.35	0.56	<4	24	21	31				
	WS230 - 1.8m	MG: Yellow Clay	7.7	21	0.62	5.9	36	<0.35	<0.35	<4	11	20	19				
	WS230 - 1.2m	MG: Ash & Clinker	5.5	17	0.43	47	6.6	<0.35	<0.35	4.9	<5	22	41	<2.5			
	WS235 - 0.2m	MG: Ash & Clinker	6.2	5.5	<0.20	9.4	<2	<0.35	<0.35	<4	15	32	14				
Surface/Near Surface Restoration Soils																	
F	WS35 0.50m	Restoration Soils	6.9	20	0.54	52	20	<0.35	<0.35	15	<5.0	26	33	<2.5	ND	<240	0.12
	WS35 1.50m	Restoration Soils	7.8	25	0.43	36	19	<0.35	<0.35	16	<5.0	42	65				
	WS36 0.40m	Restoration Soils	6.5	26	0.54	60	22	<0.35	<0.35	15	5.3	31	42	<2.5			
	WS37 0.30m	Restoration Soils	6.3	24	0.48	54	21	<0.35	0.36	10	26	26	57		ND	<240	<0.06
	WS38 0.30m	Restoration Soils	6.7	14	0.58	37	18	<0.35	<0.35	12	<5.0	22	39				
	WS38 1.50m	Restoration Soils	6.9	26	0.49	67	17	<0.35	<0.35	20	<5.0	43	50			<240	0.1
	WS39 0.60m	Restoration Soils	6.6	12	0.58	21	20	<0.35	<0.35	8.7	14	37	29	<2.5	ND		
	WS39 2.00m	Restoration Soils	7.9	12	0.80	11	34	<0.35	<0.35	9.3	18	18	160	<2.5		35000	0.88
	WS40 0.50m	Restoration Soils	7.7	50	0.62	9.6	18	<0.35	0.55	11	7.3	38	38	<2.5	ND		
	WS41 0.20m	Restoration Soils	6.7	34	0.66	45	32	<0.35	<0.35	11	5.4	29	50				
	WS41 1.50m	Restoration Soils	7.1	36	<0.20	66	12	<0.35	<0.35	14	5.1	48	59				
	WS42 0.50m	Restoration Soils	5.8	24	<0.20	47	18	<0.35	<0.35	9.1	8.6	30	51	<2.5	ND	260	<0.06
	WS43 0.50m	Restoration Soils	6.1	21	<0.20	36	14	<0.35	<0.35	7.3	7.2	29	42	<2.5	ND	<240	<0.06
	BH26 0.50m	Restoration Soils	7.3	26	<0.20	57	13	<0.35	<0.35	19	<5.0	44	61			<240	<0.06
	BH27 1.00m	Restoration Soils	7.6	26	<0.20	21	28	<0.35	<0.35	8.9	55	34	120			4800	1.3
	BH28 1.00m	Restoration Soils	7.6	14	<0.20	4.2	16	<0.35	<0.35	<4.0	<5.0	14	110	<2.5		61000	1.4
	BH29 0.50m	Restoration Soils	7.2	26	<0.20	93	<2.0	<0.35	<0.35	16	<5.0	34	34				
	BH30 0.50m	Restoration Soils	6.8	32	<0.20	50	18	<0.35	<0.35	7.2	<5.0	34	51			620	0.17
	TP17 2.00m	Restoration Soils	7.9	40	<0.20	30	3.5	<0.35	<0.35	<4.0	5.2	44	47			680	
	TP18 2.00m	Restoration Soils	8.0	29	<0.20	17	3.2	<0.35	<0.35	<4.0	6.3	36	45				
	TP19 2.20m	Restoration Soils	6.9	28	<0.20	110	3.6	<0.35	<0.35	<4.0	<5.0	32	39		ND	<240	0.23
	TP20 2.00m	Restoration Soils	7.2	28	<0.20	65	5.4	<0.35	<0.35	<4.0	<5.0	35	48			<240	<0.060
	TP21 1.50m	Restoration Soils	8.2	29	<0.20	6.8	4.2	<0.35	<0.35	<4.0	7.0	40	40				
	TP22 1.50m	Restoration Soils	7.9	28	<0.20	13	4.1	<0.35	<0.35	<4.0	<5.0	41	51		ND		
	TP25 1.50m	Restoration Soils	7.7	19	<0.20	31	58	<0.35	<0.35	<4.0	34	40	68		ND		
Waste Materials																	
F	BH26 5.00m	'Inert' Waste	8.1	20	0.48	34	310	<0.35	<0.35	12	41	25	130	7.2		1000	
	BH27 3.00m	'Inert' Waste	8.1	21	<0.20	26	25	<0.35	<0.35	8.9	10	29	130			69000	1.6
	BH28 5.00m	'Inert' Waste	7.4	30	<0.20	43	<2.0	<0.35	<0.35	13	<5.0	38	50				
	BH29 1.00m	'Inert' Waste	7.3	17	<0.20	47	<2.0	<0.35	<0.35	11	14	31	26			1800	0.07
	BH30 2.00m	R/W Fullers Earth	7.9	17	<0.20	6.2	34	<0.35	<0.35	5.3	9.9	29	190			41000	1.8
	TP24 2.00m	RW Fullers Earth	8.1	15	<0.20	4.8	25	<0.35	<0.35	<4.0	8.8	26	180			46000	1.5
	TP26 0.50m	'Inert' Waste	7.9	37	<0.20	6.4	18	<0.35	<0.35	<4.0	8.0	21	73			380	0.062
	TP26 1.00m	RW Fullers Earth	7.7	15	<0.20	3.8	28	<0.35	<0.35	<4.0	10	12	210		ND	38000	1.2
	TP27 0.50m	'Inert' Waste	6.7	26	<0.20	31	19	<0.35	<0.35	12	6.6	27	54		ND		
	TP28 0.30m	'Inert' Waste	6.7	29	<0.20	74	13	<0.35	<0.35	16	6.3	40	49				
	TP28 1.50m	'Inert' Waste	7.9	41	<0.20	13	11	<0.35	<0.35	8.1	9.1	26	33		ND		
	TP29 0.50	'Inert' Waste	6.6	4.0	<0.20	12	5.0	<0.35	<0.35	14	43	38	68		ND		
	TP29 1.50m	RW Fullers Earth	7.8	12	<0.20	4.2	24	<0.35	<0.35	7.1	10	18	130			45000	1.3
Natural Strata																	
F	BH26 10.00m	Natural	8.1	13	0.25	49	8.5	<0.35	<0.35	5.6	<5.0	9.7	10	<2.5		<0.24	
	BH28 12.00m	Natural	7.6	49	<0.20	27	4.3	<0.35	<0.35	15	<5.0	27	35			980	0.24
	BH29 10.00m	Natural	8.5	1.9	<0.20	6.0	<2.0	<0.35	<0.35	<4.0	<5.0	<1.0	8.2			<240	
	BH30 7.00m	Natural	8.4	2.1	<0.20	16	2.4	<0.35	<0.35	<4.0	<5.0	2.3	11			<240	0.076
	WS231 - 0.1m	Natural	5.5	51	1.6	64	<2	<0.35	<0.35	4.1	<5	59	68				
	WS232 - 0.1m	Natural	4.5	25	0.71	40	29	<0.35	<0.35	<4	<5	26	54				
	WS233 - 0.1m	Natural	4.6	58	1.7	18	7.2	<0.35	0.39	<4	5.8	45	59				
	WS233 - 1.5m	Natural	6	41	1.2	16	<2	<0.35	<0.35	<4	<5	48	46				

Key		Source of Guidance Trigger Level	
	Highlighted cells - value exeecds Tier 1 Screening Concentration	$	DEFRA and the EA Contaminated Land Exposure Assessment Model (CLEA)
	Blank cells - parameter not tested for	*	ICRCL Guidance Note 59/83 2nd Edition (1987) - Water Soluble Boron (Phytotoxic only)
ND	None Detected	◊	BRE Special Digenst 1 (2005) Concrete in Aggressive Ground
♣	Tier 1 Value is pH dependent	x	MAFF - The Soil Code (rev 1998). Most phytotoxic elements can pose a risk to human health if sufficient concentrations are present. However, plants represent the the most sensitive receptor and a Tier 1 value which is protective of flora is therefore also protective of human health

Waste Materials

8.3.8 Of the 13 samples of 'Inert waste' materials tested for inorganic, 7 of the samples could be classified as being 'contaminated' (see Table 9).

8.3.9 The inorganic contaminants detected in the Church Hill area 'Inert' Waste deposits in excess of soil screening values are as summarised below:

- **Arsenic** - Detected in excess of the residential end use soil guidance value of 32mg/kg in 2 samples (TP16 at 0.5m and TP28 at 1.5m).
- **Total and Soluble Sulphate** – Detected in excess of the Building Research Establishment (BRE Special Digest 1) screening values of 2400mg/kg and 0.6g/l respectively in 4 samples of yellow silt/clay (Fullers Earth sludge) deposits and in one sample of soil possessing quantities of ash and clinker materials (BH27 3.0m)

Natural Strata

8.3.10 Of the 8 samples of 'natural strata' analysed for inorganic parameters, 4 could be classified as being 'contaminated' (see Table 9).

8.3.11 The only contaminant was arsenic, detected in excess of the residential end use soil guidance value of 32mg/kg in the weathered Sandgate Beds sandy clay.

Asbestos

8.3.12 Thirteen samples of near surface soils and waste materials from across Area F have been screened for the presence of asbestos fibres (see Table 9).

8.3.13 None of the samples of recorded the presence of asbestos fibres.

Leachables

8.3.14 The results of the leachability testing have been compared against Freshwater Environmental Quality Standards (EQS) or UK Drinking Water Standards, where appropriate (see Table 10).

Table 10
Summary of Leachability in Soils/Wastes
Church Hill (Area F)

Site Area	Hole ID & Sample Depth (m)	Material	Leachate concentration in mg/l unless otherwise shown. Trigger Level Concentrations are shown in brackets									
			As (0.05)*	Cd (0.005)*	Cr (0.05)*	Cu (0.028)*	Pb (0.01)*	Hg (0.0001)*	Ni (0.05)*	Zn (0.008)*	Se (0.01)~	B (1)*
Made Ground - Woodland Area												
F	WS235 - 0.2m	MG: Ash & Clinker	<0.0014	<0.0006	<0.002	<0.009	<0.006	<0.0001	<0.003	<0.018	<0.0016	<0.230
Surface/Near Surface Restoration Soils												
F	WS35 1.50m	Restoration Soils	<0.0014	0.0009	<0.0007	0.001	<0.005	<0.0001	<0.002	<0.003	<0.0016	<0.12
	WS39 0.60m	Restoration Soils	<0.0014	0.0008	0.0013	0.004	<0.005	<0.0001	<0.002	0.003	<0.0016	0.14
	WS39 2.00m	Restoration Soils	<0.0014	0.0010	0.0011	0.001	<0.005	<0.0001	<0.002	0.008	<0.0016	<0.12
	WS42 0.50m	Restoration Soils	<0.0014	0.0006	0.0011	0.008	<0.005	<0.0001	<0.002	0.004	<0.0016	<0.12
	WS43 0.50m	Restoration Soils	<0.0014	<0.0006	0.0016	0.003	<0.005	<0.0001	<0.002	0.004	<0.0016	<0.12
	BH27 1.00m	Restoration Soils	<0.0014	0.0006	<0.005	<0.005	0.005	<0.0001	<0.002	0.008	<0.0016	<0.12
	BH29 0.50m	Restoration Soils	<0.0014	<0.0006	<0.005	0.013	<0.005	<0.0001	<0.002	<0.003	<0.0016	<0.12
	BH30 0.50m	Restoration Soils	<0.0014	<0.0006	<0.005	<0.005	<0.005	<0.0001	<0.002	0.009	<0.0016	<0.12
Waste Materials												
F	BH30 2.00m	RW Fullers Earth	<0.0014	<0.0006	<0.005	<0.005	<0.005	<0.0001	<0.002	0.010	<0.0016	<0.12

Key		Source of Guidance Trigger Level	
	Highlighted cells - value exeecds Tier 1 Screening Concentration	*	Freshwater Environmental Quality Standard
	Blank cells - parameter not tested for	~	Water Supply (Water Quality) Regulations 1989, as amended (UK Drinking Water Standards
ND	None Detected		

8.3.15 The leachability tests performed on 10 samples of made ground from the the Church Hill area gave results generally below the limit of laboratory detection for the inorganic determinands analysed.

8.3.16 Zinc possessed a leachable concentration marginally in excess of the most stringent freshwater EQS value of 0.008mg/l in three samples of near surface restoration soils and one sample of waste materials.

Organic Determinands

8.3.17 In the absence of published UK guidance values for many organic determinands, samples have additionally been classified by comparison with Encia risk-derived Tier 1 screening values with respect to a stringent 'residential end use scenario' to provide a 'worst case' assessment of the contamination data.

For Notes relating to Encia's risk-based Tier 1 screening values reference should be made to:

Report No. 20096/1 – Appendix A

8.3.18 The results of the chemical analysis for organic compounds on soils/wastes obtained from the Church Hill are summarised in Table 11.

Made Ground – Woodland Area

8.3.19 The test results indicate the concentration total PAH compounds and of benzo(a)pyrene (the most toxic of the PAH compounds) to be below the risk-based screening concentration of 1.6mg/kg in all the majority of samples of near surface made ground materials from the woodland areas within Area F.

8.3.20 Total phenols were not detected in excess of the limit of laboratory deection within two samples of ash and clinker made ground

Near Surface Restoration Soils

8.3.21 The test results indicate the concentration of benzo(a)pyrene (the most toxic of the PAH compounds) to be below the risk-based screening concentration of 1.6mg/kg in all of the samples of near surface restoration soil materials from Area F. However, marginally elevated total PAH was noted in 4 samples, but at concentrations <3.2mg/kg.

8.3.22 Concentrations of BTEX compounds, as well as total petroleum hydrocarbons, phenols, VOCs and SVOCs were not detected in excess of the limits of laboratory detection in the samples of near surface restoration soils materials.

'Inert' Waste Materials

8.3.23 The test results indicate the concentration of benzo(a)pyrene (the most toxic of the PAH compounds) to be below the risk-based screening concentration of 1.6mg/kg in all of the samples of 'Inert' waste materials from Area F. However, marginally elevated total PAH was noted in 3 samples, with the maximum total PAH concentration of 23mg/kg noted in the sample from BH26 at 5.0m.

8.3.24 Concentrations of BTEX compounds, as well as total petroleum hydrocarbons, phenols, VOCs and SVOCs were not detected in excess of the limits of laboratory detection in the samples of near surface restoration soils materials, with the exception of the sample from BH26 at 5.0m. This sample recorded the presence of GRO, DRO and LRO petroleum hydrocarbon compounds, but at concentrations below the respective risk-based screening concentrations of 0.3, 330 and 5000mg/kg.

Table 11
Summary of Organic Contamination in Soils/Wastes
Church Hill (Area F)

Site Area	Hole ID & Sample Depth (m)	Material	Concentrations in mg/kg unless otherwise stated. Results are quoted to 1 decimal plac if <10, and whole numbers if >10. Trigger Level Concentrations are shown in brackets and assume residential with gardens end use														
			TOC	Benzene	Toluene	Ethyl Benzene	Xylenes	Phenols	PAH		TPH - C_6 to C_{40}			VOC	SVOC	PCB	Pesticides + Herbicides
									Total	BaP	GRO C_6-C_{10}	DRO C_{10}-C_{20}	LRO C_{20}-C_{40}				
			%	(0.33)♣	(610)♠	(350)♠	(230)♠	(420)♠	(1.6)~◊	(1.6)~	(0.3)~◊	(330)~	(5000)~			(1.4~)	
Made Ground - Woodland Area																	
F	WS230 - 0.1m	MG: Sandy Clay							0.57	0.02							
	WS230 - 1.8m	MG: Yellow Clay							<0.10	<0.01							
	WS230 - 1.2m	MG: Ash & Clinker						<0.75	0.37	0.037							
	WS235 - 0.2m	MG: Ash & Clinker						<0.75	0.6	0.022							
Surface/Near Surface Restoration Soils and Landfill Cap																	
F	WS35 0.50m	Restoration Soils							0.14	0.012							
	WS35 1.50m	Restoration Soils							<0.10	<0.010							
	WS36 0.40m	Restoration Soils	0.77						0.10	0.011							
	WS37 0.30m	Restoration Soils							<0.10	<0.010							
	WS38 0.30m	Restoration Soils	1.2						<0.10	<0.010							
	WS38 1.50m	Restoration Soils							<0.10	<0.010							
	WS39 0.60m	Restoration Soils	13						0.26	0.013							
	WS39 2.00m	Restoration Soils							<0.10	<0.010							
	WS40 0.50m	Restoration Soils							<0.10	<0.010							
	WS41 0.20m	Restoration Soils	1.9						2.0	0.19							
	WS41 1.50m	Restoration Soils							0.10	0.013							
	WS42 0.50m	Restoration Soils	2.3						0.18	0.016							
	WS43 0.50m	Restoration Soils							<0.10	<0.010							
	BH26 0.50m	Restoration Soils							2.5	0.060							
	BH27 1.00m	Restoration Soils	0.75						0.81	<0.010							
	BH28 1.00m	Restoration Soils	0.45	<0.005	<0.005	<0.005	<0.005	<1	0.39	0.020	<50	<50	<50	ND	ND		
	BH29 0.50m	Restoration Soils							1.0	<0.010							
	BH30 0.50m	Restoration Soils	0.63						0.56	<0.010							
	TP17 2.00m	Restoration Soils							2.2	<0.010							
	TP18 2.00m	Restoration Soils							3.2	<0.010							
	TP19 2.20m	Restoration Soils							0.47	<0.010							
	TP20 2.00m	Restoration Soils	0.54						0.76	<0.010							
	TP21 1.50m	Restoration Soils							2.5	<0.010							
	TP22 1.50m	Restoration Soils							0.90	<0.010							
Waste Materials																	
F	BH26 5.00m	'Inert' Waste	1.5	<0.01	<0.01	<0.01	<0.01	<1	28	1.3	0.24	228	385	ND	ND		
	BH27 3.00m	'Inert' Waste							0.30	0.012	<50	<50	<50				
	BH28 5.00m	'Inert' Waste							0.67	<0.010							
	BH29 1.00m	'Inert Waste	17	<0.01	<0.01	<0.01	<0.01	<1	1.5	0.015	<0.1	<1	<5	ND	ND	<0.001	
	BH30 2.00m	R/W Fullers Earth							0.10	<0.010	<50	<50	<50				
	TP24 2.00m	RW Fullers Earth							0.21	0.018							
	TP25 1.50m	Restoration Soils							1.2	0.027	<50	<50	<50				
	TP26 0.50m	'Inert' Waste							1.2	0.082							
	TP26 1.00m	RW Fullers Earth							<0.10	<0.010							
	TP27 0.50m	'Inert' Waste							2.7	0.15	<50	<50	<50				
	TP28 0.30m	'Inert' Waste							0.88	<0.010							
	TP28 1.50m	'Inert' Waste							0.51	<0.010							
	TP29 0.50	'Inert' Waste							1.6	<0.010	<50	<50	<50				
	TP29 1.50m	RW Fullers Earth							<0.10	<0.010							
Natural Strata																	
F	BH26 10.00m	Natural	0.22	<0.01	<0.01	<0.01	<0.01	<1	0.13	<0.010	<0.1	<1	<5	ND	ND		
	BH28 12.00m	Natural							1.2	<0.010							
	BH29 10.00m	Natural							2.7	0.17							
	BH30 7.00m	Natural							2.2	0.14							
	WS231 - 0.1m	Natural							<0.10	<0.01							
	WS232 - 0.1m	Natural							0.58	0.039							
	WS233 - 0.1m	Natural							0.46	0.029							
	WS233 - 1.5m	Natural							<0.10	<0.01							

Key		Source of Guidance Trigger Level	
	Highlighted cells - value exeecds Tier 1 Screening Concentration	~	Encia risk-derived Tier 1 screening values - See General Notes 04 in Appendix A
	Blank cells - parameter not tested for	◊	Conservative value - assumes all PAH is BaP and all GRO is benzene
BaP	Benzo(a)Pyrene	♣	CLEA SGV is dependent on soil organic matter content. The Tier 1 values used here are the
ND	None Detected		most conservative and, in the event of exceedances, reference should be made to the TOC analysis

Natural Strata

8.3.25 Total PAH compounds were locally detected in natural strata directly underlying 'Inert' waste materials in BH29 and BH30 , although the concentrations of benzo(a)pyrene were detected below the risk-based screening concentration of 1.6mg/kg.

8.3.26 In natural strata directly underlying 'Inert' wastes in Area F (BH26) concentrations of total petroleum hydrocarbons (GRO (C_6-C_{10}), DRO (C_{10}-C_{20}) and LRO (C_{20}-C_{40})), VOCs and SVOCd were not detected in excess of laboratory detection limits.

8.4 Statistical Analysis of Soil Test Results (Church Hill Area)

8.4.1 Statistical analysis of the results of chemical tests performed on soils/wastes from Area C has been carried out in general accordance with the methods outlined in "*Guidance on Comparing Soil Contamination Data with a Critical Concentration*" CIEH\CL:AIRE (2008) and the results are summarised below.

8.4.2 The statistical calculation sheets are presented in Appendix H and is summarised in Table 12.

Table 12
Results of Statistical Analysis of Soil Contamination Data from Church Hill (Area F)

Soil Type	US_{95} Values for Contaminants that have yielded one or more exceedances of Threshold Value for a given made ground type (Threshold Value in Brackets - mg/kg)			
	Arsenic (32)	**Total PAH (1.6)**		
Near Surface Restoration Materials	29.97	1.12		
'Inert' Waste	26.97	1.23 (**6.24**)		
Natural Strata	**45.29**	**1.61**		

Notes: All Values are expressed as mg/kg

Values are bolded where the US95 value exceeds the relevant Tier 1 value.

Values in brackets are US95 values inclusive of any outliers.

8.4.3 The statistical analysis indicates that the upper 95th percentile bound values (US95) for arsenic within the restoration soil and 'Inert' waste made ground materials were below the soil guidance value for residential use of 32mg/kg. However, the US95 concentration for arsenic within the natural strata was in excess of the soil guidance value for residential use.

8.4.4 The US95 value for 'total' PAH was below tier 1 screening concentration of 1.6mg/kg in the samples near surface restoration soils materials.

8.4.5 The US95 value for 'total' PAH was in excess of the tier 1 screening concentration in the 'Inert' wastes, although this was dictated by a statistical outlier with respect to the concentration of PAH noted in BH26 at 5.0m (28mg/kg). Once this statistical outlier is removed, the US95 value for total PAH is below the tier 1 screening concentration.

8.4.6 The US95 value of total PAH in natural strata was marginally in excess of the of the tier 1 screening concentration, but this marginal exceedance was dictated by the marginally elevated concentrations of total PAH in the samples of natural strata obtained from beneath 'Inert' waste materials at depth. Near surface natural strat were observed to contain no elevated PAH concentrations.

8.5 Groundwater/Leachate and Surface Water Contamination Results

8.5.1 Groundwater Leachate samples have been obtained from the monitoring wells at the site at generally 3 monthly intervals between October 2011 and December 2012.

monitoring works are still ongoing.

8.5.2 The results of the chemical tests performed on groundwater/leachate samples obtained to date are presented in the form of a recent monitoring report (Encia letter ref 20096/056 dated 31st January 2013) which is presented in Appendix I.

8.5.3 It should be noted that, as some of the monitoring wells have been recorded to be dry throughout most of the monitoring programme, not all boreholes have been sampled for groundwater analysis within the Church Hill area.

8.5.4 The significance of the results has been assessed by comparison with Freshwater Environmental Quality Standards (EQS) or, where no EQS has been published, UK Drinking Water Standards (Water Supply (Water Quality) Regulations 1989, as amended).

8.5.5 The groundwater and leachate at the site has been shown to routinely possess concentrations of inorganic determinands in excess of Freshwater Environmental Quality Standards (EQS) concentrations (see Appendix I).

8.5.6 The groundwater and leachate at the study site is generally characterised by elevated concentrations of arsenic, chromium, lead, selenium, copper, nickel and zinc and ammoniacal nitrogen from Area A and Area B, as would be expected in landfill areas possessing putrescible wastes. However, the groundwater quality from Area F is generally characterised by lower concentrations of these determinands, albeit that concentrations of arsenic, selenium, chromium, lead, copper, zinc, nickel and ammoniacal-nitrogen have been detected to be in excess of freshwater EQS values, on occasion.

8.5.7 Elevated electrical conductivity, BOD, COD and ammoniacal nitrogen concentrations have also been detected during each sampling round, and are particularly elevated within the putrescible waste areas (Areas A and B), and have remained consistently elevated during the monitoring period. Elevated sulphate concentrations are characteristic of groundwaters within the Church Hill area from those boreholes which encountered horizons of the yellow very silty clay deposits.

8.5.8 Concentrations of mercury, cadmium, cyanide, nitrate and nitrite have generally been detected below their laboratory limits of detection and/or their respective Freshwater EQS/UK Drinking Water Standards in groundwaters/leachates, although elevated cadmium concentrations were noted in a number of boreholes in May 2012.

8.5.9 It is noteworthy that groundwater quality in BH1 which is located up hydraulic gradient of the wastes within the south of the Park Quarry/Landfill area (Area A) also possesses a poor quality, although it should be noted that this borehole is also located down hydraulic gradient from an adjacent (off site) area of landfilled wastes (Nutfield Priory Landfill).

8.5.10 Organic compounds (BTEX, TPH, VOC, SVOC, PCB and pesticides/herbicides) have not generally not been detected in groundwaters within Area F, although TPH and PAH compounds have been detected in BH26 (which recorded a hydrocarbon odour drilling drilling) in the early part of the monitoring programme, with such concentrations decreasing to below laboratory detection limits and/or EQS values.

8.5.11 BTEX compounds have generally not been detected in excess of their respective freshwater EQS in the groundwater/leachate across the remainder of the study site. However, xylenes have been detected in excess of the freshwater EQS value of 30ug/l in the leachate samples obtained from BH6 and BH15 drilled within putrescible wastes (in Area B) in all monitoring rounds up to a maximum concentration of 106ug/l (BH15, Round 3 – February 2012).

8.5.12 Gasoline, Diesel and Lubricating Oil Range Organic Petroleum Hydrocarbons (GRO C_6-

C_{10}, DRO C_{10}-C_{20} and LRO C_{20}-C_{40}) have been detected in excess of UK Drinking Water Standards in the majority of groundwater/leachate samples from within Area B as well as locally within Areas A and F. The highest recorded concentrations of total petroleum hydrocarbons have been detected in BH31 drilled within putrescible wastes within Area B (1457ug/l TPH C_6-C_{40} in Round 2).

8.5.13 VOCs have been detected in groundwater/leachate substantially across Area A (and Area B) at relatively low/trace concentrations (typically <10ug/l for each compound, were detected). 1,2,4-Trimethylbenzene was the most common contaminant and made up most of the VOC concentrations detected with chloroethane, vinyl chloride, chlorobenzene and iso-propylbenzene also being detected in groundwater/leachate in Area A and Area B.

8.5.14 With regard to SVOCs, 3,4-Methylphenol, Dibenzofuran and 2-methylnaphthalene were the most commonly detected contaminants and were detected at trace concentrations in boreholes located across Areas A and B in groundwater/leachate samples obtained early in the monitoring programme. No SVOC compounds were detected in any borehole during the monitoring carried out in late May 2012 and The only SVOC compound detected during the most recent monitoring Round 6 (December 2012) was diethylphthalate in upgradient BH1 in Area A (5.3ug/l)

8.5.15 Organo-chlorine and organo-phosphorus pesticides/herbicides have been detected at trace concentrations (generally <0.05ug/l) from those boreholes drilled through putrescible waste materials within the centre of Area A (BH14) and across Area B (BH6, BH7, BH15, BH16, BH17 and BH31). The pesticides/herbicides detected have been 'dichlobenil' and 1,2,4 trichlorobenzene but these have not generally detected in excess of UK drinking water quality standard concentrations.

8.5.16 PCBs have only been detected in excess of laboratory detection limits in the samples of leachate obtained from BH4 and BH14 (Area A) in the earliest 2 monitoring rounds (max. concentration 0.02ug/l – BH4, Round 1). No PCBs have been detected in any other borehole during any other monitoring round.

8.5.17 The quality of the surface waters has been determined to be good, with potential contaminants being detected at concentrations below freshwater Environmental Quality Standards with no evidence for landfill leachate being detected within the nearby surface water features. Slightly elevated concentrations of zinc and lead has been detected in some surface water features but this has been detected in ponds located to the east and some distance to the north of the site as well as in the nearby Angling Pond, and this could be a reflection of the natural local groundwater geochemistry or derived from other non-landfill sources. Similarly, trace concentrations of SVOC, pesticide and TPH compounds have periodically been detected in some surface water bodies, but this has been interpreted as being as a result of non-landfill sources or of natural origin.

9 HAZARDOUS GAS

9.1 General

9.1.1 The majority of the Church Hill area is known to have been land filled by wastes over a number of years.

9.1.2 Landfilling operations are considered to have initially taken place in the south of the Church Hill area, possibly as unlicensed operations in the early part or mid 20th Century within relatively small scale mineral extraction pits associated with a small scale Fullers Earth works that was also located in the south of the Church Hill area.

9.1.3 Late, more extensive landfilling would appear to have taken place as possibly unlicensed operations prior to 1977. Based on a review of topographic information, the disposal of wastes in the central and northern parts of the Church Hill area would appear to have been carried out as part of a general 'land raise' operation.

9.1.4 The wastes within the Church Hill area have been observed to be relatively deep, extending to ca 10m depth, although such wastes are predominantly 'inert' in nature possessing a high minerogenic content and very little degradable materials. Reworked natural weathered Sandgate strata are present to ca 2-3+m, depth at surface across most of the Church Hill area with ash and clinker materials present in the central and southern areas at greater depth. Yellow clay deposits, considered to be acidic sludges derived from Fullers Earth processing, are also present in the southern half of this part of the site.

9.1.5 Across the remainder of the (wooded) Chuch Hill area, made ground materials are either absent or, where present, substantially comprise reworked/disturbed weathered natural strata (Sandgate Beds) with inclusions of inert fractions such as sandstone gravel, brick and concrete, ash and clinker with yellow clay/silt materials also present.

9.1.6 To date, the monitoring wells across the site have been monitored on 15 occasions for and soil-gases.

9.1.7 A standard procedure was followed, in accordance with CIRIA C665 (2007) guidance:

- Ambient oxygen concentration
- Atmospheric temperature & pressure
- Methane, oxygen, hydrogen sulphide and carbon dioxide concentrations and flow rates using a Gas Data LMSx infra-red gas analyser.
- VOC concentrations using a calibrated photo-ionisation detector (PID).
- Standing water level using a dipmeter
- Ambient oxygen concentration (check for instrument drift)

9.2 Monitoring Results

9.2.1 The results of the monitoring within the Church Hill area completed to date are presented in Table 13. The results of the landfill gas monitoring are also presented in Drawing No. 20096/F/12 in Appendix A.

9.2.2 In the Church Hill area, landfill gas concentrations have been detected at relatively low concentrations.

9.2.3 Methane has either not been detected, or has been detected at low (<0.5%v/v) concentrations in all of the monitoring boreholes located within this part of the site (no methane has detected to date in BH25, BH28, BH29 and BH30).

Table 13
Summary of Gas Monitoring Results - Church Hill (Area F)

	Visit	Date	BH25	BH26	BH27	BH28	BH29	BH30	atm
Methane %v/v	1	03/10/2011	0.0	0.0	n/a	0.0	0.0	0.0	1006-1011
	2	06/10/2011	0.0	0.2	n/a	0.0	0.0	0.0	1000-1008
	3	25/10/2011	0.0	0.0	0.5	0.0	0.0	0.0	981-984
	4	09/11/2011	0.0	0.0	0.0	0.0	0.0	0.0	1004-1008
	5	21/11/2011	0.0	0.0	0.1	0.0	0.0	0.0	1005-1006
	6	05/12/2011	0.0	0.1	0.1	0.0	0.0	0.0	990-992
	7	21/02/2012	0.0	0.0	0.1	0.0	0.0	0.0	1018-1022
	8	02/04/2012	0.0	0.0	0.4	0.0	0.0	0.0	989-994
	9	02/05/2012	0.0	0.0	0.0	0.0	0.0	0.0	997-1011
	10	29/05/2012	0.0	0.0	0.0	0.0	0.0	0.0	1000-1010
	11	02/07/2012	0.0	0.2	0.2	0.0	0.0	0.0	980-985
	12	01/08/2012	0.0	0.0	0.0	0.0	0.0	0.0	994-1002
	13	10/09/2012						0.0	997-1001
	14	11/12/2012	0.0	0.0	0.0	0.0	0.0	0.0	1008-1016
	15	12/03/2013					0.0	0.0	995-998
		min	0.0	0.0	0.0	0.0	0.0	0.0	
		mean	0.0	0.0	0.1	0.0	0.0	0.0	
		max	0.0	0.2	0.5	0.0	0.0	0.0	

	Visit	Date	BH25	BH26	BH27	BH28	BH29	BH30	atm
Carbon Dioxide %v/v	1	03/10/2011	7.8	1.1	n/a	2.3	0.0	0.0	1006-1011
	2	06/10/2011	0.0	13.0	n/a	0.8	0.0	0.0	1000-1008
	3	25/10/2011	0.0	11.0	0.0	3.2	0.0	0.5	981-984
	4	09/11/2011	0.0	1.3	0.0	1.5	0.0	0.0	1004-1008
	5	21/11/2011	3.5	3.0	0.0	1.5	0.0	0.0	1005-1006
	6	05/12/2011	3.7	5.1	0.2	1.2	0.1	0.0	990-992
	7	21/02/2012	0.3	0.2	0.2	0.4	0.1	0.0	1018-1022
	8	02/04/2012	4.3	0.0	0.0	1.0	0.0	0.0	989-994
	9	02/05/2012	0.0	0.0	0.0	0.2	0.0	0.0	997-1011
	10	29/05/2012	0.0	0.0	0.1	0.1	0.0	0.3	1000-1010
	11	02/07/2012	0.5	0.8	0.2	0.1	0.1	0.4	980-985
	12	01/08/2012	6.0	0.9	1.4	0.5	0.3	1.2	994-1002
	13	10/09/2012						0.3	997-1001
	14	11/12/2012	0.0	0.0	1.1	2.1	0.3	0.3	1008-1016
	15	12/03/2013					0.1	0.1	995-998
		min	0.0	0.0	0.0	0.1	0.0	0.0	
		mean	2.0	2.8	0.3	1.1	0.1	0.2	
		max	7.8	13.0	1.4	3.2	0.3	1.2	

	Visit	Date	BH25	BH26	BH27	BH28	BH29	BH30	atm
Flow Rate l/hr	1	03/10/2011	2.6	-0.3	0.0	0.0	0.5	0.0	1006-1011
	2	06/10/2011	-5.0	0.3	0.0	-0.2	1.0	0.0	1000-1008
	3	25/10/2011	-3.7	-0.5	0.0	0.0	0.0	0.0	981-984
	4	09/11/2011	-1.7	-2.7	0.0	0.0	0.0	0.0	1004-1008
	5	21/11/2011	-2.4	0.0	0.0	0.0	0.0	0.0	1005-1006
	6	05/12/2011	0.8	0.0	0.0	0.0	0.0	0.0	990-992
	7	21/02/2012	0.1	-0.5	0.0	0.0	-0.2	-0.2	1018-1022
	8	02/04/2012	0.0	0.0	0.0	0.0	0.0	0.0	989-994
	9	02/05/2012	0.0	0.0	0.0	0.0	0.0	-0.3	997-1011
	10	29/05/2012	0.0	0.0	0.0	0.0	0.0	0.0	1000-1010
	11	02/07/2012	0.0	0.0	0.0	0.0	0.0	0.0	980-985
	12	01/08/2012	0.0	0.0	0.0	0.0	0.0	0.0	994-1002
	13	10/09/2012						0.0	997-1001
	14	11/12/2012	0.0	0.0	0.0	0.0	0.0	0.0	1008-1016
	15	12/03/2013					0.0	0.0	995-998
		min	-5.0	-2.7	0.0	-0.2	-0.2	-0.3	
		mean	-0.7	-0.3	0.0	0.0	0.1	0.0	
		max	2.6	0.3	0.0	0.0	1.0	0.0	

Atm - Atmospheric Pressure (mb)

9.2.4 Similarly, the boreholes in the Church Hill have not recorded the presence of carbon dioxide at significant concentrations, although in all carbon dioxide has periodically been detected.

9.2.5 In Boreholes BH27-BH30, carbon dioxide concentrations have typically been recorded at <1%v/v, although occasional concentrations of 1.1-3.2%v/v have been noted in BH27 and BH28.

9.2.6 Boreholes BH25 and BH26 have occasionally recorded the presence of more elevated concentrations of carbon dioxide, although these boreholes have also occasionally recorded no carbon dioxide.

9.2.7 The highest recorded carbon dioxide concentration has been in BH26 (13%v/v) and examination of the log for this exploratory hole indicates that some wood/timber fragments were encountered during the drilling of this borehole.

9.2.8 No detectable concentrations of hydrogen sulphide were recorded in any of the monitoring boreholes during the monitoring visits carried out to date.

9.2.9 No VOCs or hydrogen sulphide gas have were detected in any of the boreholes to date within the Church Hill area.

9.2.10 Positive gas flow rates have generally not been recorded in the Church Hill area. The highest gas flow rates of 2.6l/hr was recorded in BH25 in the first monitoring visit on the 3rd October 2011.

10 CONTAMINATION (ASSESSMENT)

10.1 Assessment of Contamination Test Results – Church Hill Area

10.1.1 The Church Hill area has had a relatively complex history of mineral extraction, industrial use and waste disposal.

10.1.2 In the latter half of the 19th Century and early 20th Century, the south of the area was used for the (relatively small scale) extraction of Fullers Earth and other minerals (sand/clay). These small pits/quarries would appear to have been infilled at a relatively early date (dates unknown). In the mid 20th Century, the northern and central parts of Church Hill, more extensive waste disposal operations would appear to have taken place, although such wastes would appear to have deposited as part of a wider 'land raise' operation to create a raised elongated domed landform.

10.1.3 Two lagoons are known to have been created in the adjacent Beechfield Quarry area (Area E) immediately to the west of the Church Hill area which are understood to have been used for the disposal of acid sludges derived from the commercial processing of Fullers Earth within the Cockley Fullers Earth Works that was formerly located in the south of Area B. The sludges (yellow very silty clay) would appear to have additionally been deposited within the central and southern parts of the Church Hill area.

Woodland Area Made Ground

10.1.4 Made ground materials present within the woodland areas substantially comprise reworked weathered Sandgate Bed natural strata (sandy gravelly clays) with variable minor inclusions of brick and concrete etc which overlie ash and clinker materials and yellow very silty clay sludges. These deposits would appear to be principally located within the existing 'woodland clearing' located within the woodland area in the south of the Church Hill area which would appear to represent a relatively small former quarry feature.

10.1.5 No inorganic or organic contamination has been noted in the made ground materials within the woodland, although chemical test results from other areas of the site suggest that the yellow very silty clay sludge materials contain elevated sulphate concentrations.

Waste Materials

10.1.6 The waste materials present across much of the Church Hill area can generally be classified as 'Inert' in nature. These wastes were observed to be present to depths of up to ca 10mbgl.

10.1.7 Such materials typically comprised soft to firm sandy gravelly clay with variable proportions of entrained ash/clinker, brick, concrete, and small quantities of timber. Horizons of the yellow very silty clay sludge deposits are also present within the waste materials in the southern parts of this part of the site

10.1.8 The investigation has found no evidence for the presence of a basal low permeability mineral leachate containment liner below the waste materials.

10.1.9 The 'Inert' wastes have been observed to possess locally elevated concentrations of arsenic and total PAH, but US95 concentrations are below screening concentrations for residential end use, however, the yellow very silty clay sludge deposits possess significantly elevated concentrations of sulphate. No significant TPH, VOC and SVOC contamination has been noted within the waste materials.

Near Surface Restoration Soils

10.1.10 The above noted waste materials have been observed to be overlain by a 2-3m thick covering of restoration soils.

10.1.11 The restoration soils overlying the wastes within the Church Hill area appear to be 'natural' in origin and probably represent re-deposited natural sandy clay/clayey sand strata (weathered Sandgate Beds) 'won' from previous mineral extraction operations on the study site.

10.1.12 The near surface restoration soil materials have been observed to be contain locally elevated concentrations of arsenic and total PAH but US95 concentrations are below screening concentrations for residential end use for these determinands.

Natural Strata

10.1.13 Natural soils are exposed at surface in some parts of the woodland parts of the Church Hill area where made ground is absent.

10.1.14 Natural soils were also encountered directly beneath the 'Inert' wastes and comprise weathered Sandgate Bed strata (clayey sands, sandy clays and sandstone) and Folkestone Beds (silty sands) in the northern parts of the area.

10.1.15 The natural soils possess widespread elevated arsenic concentrations which represent 'natural background' concentrations of mineral arsenic within the Cretaceous Greensand strata, and which is also reflected in the locally elevated arsenic concentrations detected in the reworked natural made ground materials used as restoration soils and the 'Inert wastes which largely comprise re-deposited 'site won' natural strata (see 10.1.9 and 10.1.12 above).

Groundwater

10.1.16 Groundwater monitoring across the whole of the study site suggests that a single groundwater body is present across the site, and the same patter of groundwater has been noted in the Church Hill area. The hydraulic gradient is aligned from south to north and the groundwater monitoring has shown that a natural water table is present within the natural Sandgate and Folkestone Bed strata but this same groundwater body intersects the waste mass within Areas A, B, E and F. The 'commercial, industrial and domestic' wastes within the Park Quarry (Area A) the North Cockley Landill (Area B) and the Inert Wastes within Areas E and F possess no basal containment liner and, as such, no widespread separate 'perched' body of groundwater/leachate is discernable in the waste mass.

10.1.17 The measured groundwater levels (see Appendix G and Drawing No. 20096/F/11 in Appendix A) closely match the water levels within on site and nearby surface water features (flooded mineral extraction pits). As such, these features would appear to be substantially fed by groundwater and are considered to by in hydraulic continuity with groundwater and leachate beneath the study site.

10.1.18 As would be expected, the quality of the groundwaters within the waste mass has been impacted by the presence of the landfilled wastes, although concentrations of both inorganic and organic contaminants are not excessive and considerably less than those which would be expected in a modern contained methanogenic landfill. The leachate (groundwater within the waste mass) is considered to be relatively dilute in nature and the waste mass is considered to have been subjected to 'flushing' of potential contaminants by a significant groundwater flux over some 30+ years.

10.1.19 The groundwater and leachate at the study site is generally characterised by elevated concentrations of arsenic, chromium, lead, selenium, copper, nickel and zinc and ammoniacal nitrogen, electrical conductivity, BOD, COD from Area A and Area B), as would be expected in landfill areas possessing putrescible wastes. Concentrations of

these determinands within groundwater in Area F are noted to be less than in other parts do the site, particularly in the later half of the monitoring programme carrued out to date.

10.1.20 Concentrations of mercury, cadmium, copper, cyanide, nitrate and nitrite have generally been detected below their laboratory limits of detection and/or their respective Freshwater EQS/UK Drinking Water Standards in groundwaters/leachates from across the remainder of the site.

10.1.21 With regard to organic compounds, these have not been detected in groundwater in Area F, with the exception of BH26, which recorded the presence of PAH and TPH compounds in the early part of the monitoring programme.

10.1.22 Across the remainder of the site BTEX, TPH and VOC and SVOC compounds have generally not been detected in excess of their respective freshwater EQS in the groundwater/leachate, although trace concentrations of TPH, VOCs and SVOCs have been detected on occasion in Areas A and B.

10.1.23 Organo-chlorine and organo-phosphorus pesticides/herbicides have been detected at trace concentrations (generally <0.05ug/l) from those boreholes drilled through putrescible waste materials within the centre of Area A (BH14). The pesticides/herbicides detected have been 'dichlobenil' and 1,2,4 trichlorobenzene but these have not generally detected in excess of UK drinking water quality standard concentrations.

10.1.24 PCBs have only been detected in excess of laboratory detection limits in the samples of leachate obtained from BH4 and BH14 (Area A) in the earliest 2 monitoring rounds (max. concentration 0.02ug/l – BH4, Round 1). No PCBs have been detected in any other borehole during any other monitoring round.

Surface Waters

10.1.25 The quality of the surface waters has been determined to good, with contaminants, for the most part, being detected at concentrations below freshwater Environmental Quality Standards with little or no evidence for landfill leachate being detected within them.

Landfill Gas

10.1.26 Methane has not been detected in the majority of monitoring boreholes in the Church Hill area and, where detected (BH26 and BH27), concentrations have periodically been <0.5%v/v. Carbon dioxide has also been detected at generally low concentrations, although in BH25 and BH26 maximum concentrations of 7.8 and 13.0%v/v were recorded

10.1.27 Gas flow rates have typically been negative or <1.0l/hr

10.2 Conceptual Ground Model

10.2.1 A Conceptual Site Model has been prepared in light of data obtained during the ground investigation, most notably with respect to the below ground strata and the presence of contamination.

10.2.2 The Conceptual Site Model, is presented as Drawing No. 20096/F/13 in Appendix A. The Conceptual Site Model is further discussed and described in Sections 10.3-10.5 below.

10.3 Environmental Setting & End Use

10.3.1 As discussed in Section 10.1 above, some contamination exists in the soils/wastes and groundwater beneath this site. In order to assess the significance of this contamination, consideration must be given to the site's environmental setting and the current use.

10.3.2 The Sandgate Beds which underlie the southern half of the study site are classified as a 'Secondary A' Aquifer.

10.3.3 The Folkestone Beds which underlie the northern half of the study site (present beneath the north of Beechfield Quarry) are classified as a 'Principal Aquifer', as are the Hythe Beds which underlie the Sandgate Beds.

10.3.4 The study site is not located in a Groundwater Source Protection Zone. A Groundwater Protection Zone (Zone III) is, however, present ca 1-1.5km to the east and northeast relating to potable water supply boreholes located between 2 and 4km to the northeast.

10.3.5 Surface water bodies are present to the north of Area F (in Area D) and on nearby land, principally in the form of flooded former mineral workings. The surface water features present in Area D are used by a local angling club.

10.3.6 To the north of the site, the flooded former mineral workings are used for leisure/amenity as part of the Mercer's Country Park (sailing, canoeing, bathing etc), and a nature reserve is also located further to the north.

10.3.7 A number of surface water drains/ditches are present on land to the north which flow into the westerly flowing Redhill Brook watercourse ca 350m to the northwest of the site.

10.3.8 The site is located in a designated greenbelt and low density residential housing is present around the perimeter of the site.

10.3.9 The woodland within the south of the Church Hill is not designated a SSSI, Site of Biological Importance or a Local Nature Reserve. However, the woodland is known to provide an important habitat for local woodland flora and fauna.

10.3.10 Overall, the site's environmental setting is considered to be of high sensitivity.

10.3.11 The north and central parts of Church Hill area is currently used for the grazing of sheep.

10.3.12 With respect to human health, although the Church Hill area is in private ownership, public (pedestrian) access onto and though this part of the site is possible via a number of designated public footpaths that are present within the southern (woodland) areas and observations made by Landplus/Encia suggests that local residents routinely this area for amenity/leisure purposes (for such uses as dog walking). These site uses are considered to be of low sensitivity. However, there is evidence that the woodland within the adjacent Beechfield Quarry area (Area E) are locally used by children for BMX cycle racing and potentially other forms of play – this use would be considered to be of high sensitivity.

10.3.13 No future use of the site has yet been considered and is likely to remain in woodland/pasture/sheep grazing uses for the foreseeable future. However, it is conceivable that the Church Hill area, along with the rest of the study site, could be used as an extension to the Mercer's Country Park with improved public access and amenity facilities.

10.3.14 The location of Church Hill within the Adopted Greenbelt would mean that any future development would be considered unlikely, although this could not be completely ruled

out, particularly within the extreme north of this part of the site, where waste materials are shallower or largely absent (in the adjacent Area D).

10.4 Pollutant Linkages

10.4.1 In terms of a proposed redevelopment of this site, plausible pollutant linkages can be summarised as follows.

Sources

10.4.2 Contaminant sources have been summarised in Section 10.1 above.

Pathways

10.4.3 Potential contaminant pathways include:

- Ingestion
- Dermal contact
- Inhalation of contaminated particulates/dusts
- Vegetative uptake
- Surface water run-off, including existing drainage ditches
- Downward infiltration of leachable/mobile contaminants to groundwater
- Off site lateral migration of groundwaters
- Off site migration of landfill gas

Receptors

10.4.4 Potential contaminant receptors include:

- Grazing livestock
- Informal users of the site (walkers/children at play)
- Anglers (angling ponds in the northeast in Area D)
- Nearby Residents
- Sailers/Bathers (Mercers County Park)
- Surface water bodies (flooded mineral extraction pits)
- Principal groundwater aquifer (Folkestone Beds/Hythe Beds)
- Possible future end users of the site (residents, country park users, employees)
- Woodland and aquatic ecosystems

10.5 Discussion

Livestock

10.5.1 Sheep livestock graze the northern/central parts of Church Hill. This livestock will come into contact and ingest potential contaminants in the near surface restoration soil materials.

10.5.2 No contamination has been noted in these materials. As such, it is considered that the near surface restoration soils presents a LOW RISK to existing grazing livestock.

Human Health – Informal Users of the Site

10.5.3 The woodland in the south of the Church Hill area is used by nearby (adult) residents for walking activities as well as children for an area to play. These site users could potentially come into contact with contaminants present in the near surface made ground materials (and natural strata) within the woodland areas.

10.5.4 The presence of naturally occurring arsenic contamination in near surface made ground soils and natural strata are present across this part of the site in excess of the

'residential end use' threshold concentration. PAH compounds are also locally present in these soils. The yellow lagoon silts have also been noted to contain elevated concentrations of sulphate.

10.5.5 These site users are expected to use the site relatively infrequently and for a limited duration, as such, critical ingestion, dermal contact and inhalation pathways are considered to be negligible.

10.5.6 Overall, the present condition of the Church Hill area presents a LOW RISK to informal site users, although the yellow silts could potentially cause irritation to skin and eyes if exposed for long duration. However, the human health implications of the elevated sulphate concentrations are considered to be minor.

10.5.7 The significant thickness and condition of the restoration soils present across the grassland areas of Church Hill also means that the likelihood of site users coming into direct contact with the underlying 'Inert' wastes is considered to be negligible. Inhalation exposure to VOCs etc, if present within the landfilled areas, is further reduced by the presence of a robust mineral soil cover.

Human Health - Anglers

10.5.8 A local angling club reportedly uses the flooded mineral extraction ponds in the north of the study site (in Area D).

10.5.9 During the Landplus/Encia investigations and subsequent monitoring visits, no angling has been observed to have taken place and the type and number of fish present within these ponds are not known. Furthermore, it is not known whether fish caught in the ponds are consumed by the fishermen or whether the caught fish are returned to the waters. However, ad hoc barbequing equipment is present around the margins of the ponds which may suggest that some fish that are caught could, in fact, be consumed.

10.5.10 As noted in earlier sections of this report, the waters within the flooded mineral workings would appear to be in hydraulic continuity with groundwater and leachate within the study site, and there is a likelihood that waters within these ponds are, or could, become contaminated. As such, the ingestion of contaminated fish could be considered a plausible exposure pathway.

10.5.11 Chemical tests performed on waters within the Angling Pond(s) (see Appendix I) indicate that these surface waters to not be contaminated. As such, it is considered that the contamination to waters within the flooded (on site) mineral workings currently present a LOW RISK to anglers.

10.5.12 There is, however, the potential for contamination to manifest itself within these water bodies, and a programme of monitoring to assess the quality of these waters over a longer period of time is ongoing.

10.5.13 Should contamination be detected within the waters within the Angling Ponds, then Evonik Degussa UK Holdings Limited could easily implement with a cessation of fishing.

Human Health – Nearby Residents

10.5.14 Residential properties are located in immediately to the south, east and north of the Church Hill area.

10.5.15 Nearby residents may suffer the inhalation of volatile vapours derived from contaminated off site migrating leachates and nearby wastes with vapours having the potential to migrate through the relatively permeable Sandgate Bed and Folkestone Bed strata.

10.5.16 The chemical tests performed on groundwater/leachate from the Church Hill area

suggests that the groundwaters are not contaminated by oils and other volatile/less volatile hydrocarbons.

10.5.17 No significant concentrations of landfill gas have been detected in the Church Hill area which is reflective of the inert/minerogenic materials that have historically been deposited. Furthermore, these wastes would appear to have been deposited as part of a general 'land raise' operation across most of the Church Hill area meaning that any migration of landfill gas would be encourage to vent from the raised flanks of the waste landform, rather than to migrate too off site properties.

10.5.18 The above means that there is a LOW RISK to nearby residents in this part of the site with respect to gas migration/accumulation and inhalation pathways.

10.5.19 Gas migration within permeable (i.e. sandstone/sand) horizons towards nearby residential properties could potentially occur. As such, a continued programme of groundwater and gas monitoring is ongoing that will enable further assessments of the risk to these potential receptors.

Human Health - Sailers/Bathers

10.5.20 The Mercers Lake present to the north of the study site is part of the Mercers County Park and is used for the sailing of small boats. Bathing within the lake may also take place during the summer months.

10.5.21 The waters within the Mercers Lake are considered to be in hydraulic continuity with the groundwaters/leachate within the site and there is a likelihood that waters within this pond are, or could, become contaminated. As such, sailers/bathers may come into contact or ingest contaminated waters.

10.5.22 Chemical tests performed on waters within the Mercers Lake (see Appendix I) indicate that the surface waters are not contaminated, although trace concentrations of pesticides have been noted (October 2011). These pesticides are considered be derived from surface water runoff from adjacent agricultural land, and not from the study site.

10.5.23 It is considered that the contamination to waters within the Mercers Lake currently presents a LOW RISK to sailors/anglers.

10.5.24 There is, however, the potential for contamination to manifest itself within the Mercers Lake, and an extended programme of monitoring to assess the quality of these waters over a longer period of time is ongoing.

Surface Water Bodies

10.5.25 As noted above, nearby flooded mineral workings are in hydraulic continuity with, and are located down hydraulic gradient of, the groundwaters and leachates within the site.

10.5.26 There is therefore considered to be a plausible pollution pathway to these surface water receptors.

10.5.27 Existing data suggests that there is no significant contamination within these surface water bodies, although it is considered that there is a risk of contamination migrating to these features in the future.

10.5.28 Notwithstanding the above, the permeable nature of the underlying Folkestone/Sandgate Bed strata, combined with the observed groundwater hydraulic gradient beneath the site would suggest that the total groundwater flux and groundwater velocities beneath the site are high. Given the age of the landfilled materials, this would suggest that any contamination 'plume' in groundwater/leachates beneath the study site could potentially have reached the

surface water bodies to the north of the site by this time.

10.5.29 Given that no significant contamination has been detected in the surface water ponds as part of this study, overall there is considered to be a LOW/MODERATE RISK of contamination to nearby surface waters. However, a programme of monitoring to assess the quality of these waters over a longer period of time is ongoing.

Principal Aquifer

10.5.30 Information gathered as part of the investigations across the 'whole' of the study site suggests that the landfilled wastes and associated contaminated leachates are not contained by any engineered low permeability mineral containment liner. Indeed, the landfilled wastes have been deposited directly upon permeable sand and sandstone strata and the former landfilled areas have been designed on a 'dilute and disperse' basis.

10.5.31 The generation of leachate is, however, controlled to some extent by the presence of a good thickness of relatively low permeability mineral cap, and some parts of the site (Area B) possess a low permeability geomembrane capping system, albeit that the integrity of this geomembrane may be compromised by localised significant differential settlement and puncturing.

10.5.32 Contamination to underlying groundwater within the Principal Aquifer Folkestone Beds is therefore expected and this fact has been proven by the findings of this investigation.

10.5.33 As noted above, the total groundwater flux beneath the site is expected to be significantly high, therefore dilution and dispersion of any contaminated leachate is expected to be significant. This, combined with the fact that the site is not within a Groundwater Source Protection Zone and not in close proximity to potable groundwater abstractions, means that overall there is a LOW/MODERATE RISK to the principal aquifer.

10.5.34 The risk to groundwaters is being assessed by means of an extended groundwater monitoring programme.

Future Site End Users

10.5.35 No plans for any development of the site are currently put forward and the location of the site within a greenbelt means that any development would be unlikely.

10.5.36 However, there is a possibility that some development may be permitted in the extreme north of the Church Hill area, subject to planning status and permission.

10.5.37 The contamination noted within restoration and natural soils in this area and landfill gas concentrations would not necessarily preclude residential or commercial development, subject to further ground investigation, gas monitoring and risk assessment. Any future residential or commercial development within the north of Area D would present a LOW to MODERATE RISK as long as further assessment of ground conditions and appropriate and best practice development controls in the form of, for example, precautionary landfill gas exclusion measures are adopted

10.5.38 One potential future use of the site is the continued use of the site for public amenity and recreational use in the form of an extension to the nearby Country Park. This could take the form of enhanced footpaths and cycleways etc. Overall, the present condition of the Gore Meadow area presents a LOW RISK to future informal site users.

Ecology

10.5.39 Two potentially significant local ecosystems are present on site:

- Woodland fauna and flora (Church Hill woodland)
- Aquatic ecosystems (Fishing ponds in Area D and to the north of the study site)

10.5.40 With respect to woodland ecosystems, the contamination noted within Church Hill is in excess of the residential human health soil guidance value for arsenic (in natural strata). Phytotoxic contaminants (sulphate) has been noted at significant concentrations within the yellow silt/clay. However, the woodland vegetation appears healthy and varied, providing multiple woodland and scrub habitats for fauna. Overall, it is considered that the present condition of the Church Hill area presents a LOW RISK to woodland ecosystems.

10.5.41 Surface water quality within on site and nearby surface water features, as determined by the ongoing monitoring programme, is below stringent EQS values and, as such, aquatic ecosystems are not considered to currently be at risk from contaminated leachates/groundwaters within the study site.

11 SUMMARY OF ENVIRONMENTAL RISKS

11.1 General

11.1.1 The findings of the ground investigations and subsequent monitoring works carried out within the former Church Hill area are summarised in a 'risk-screening' format in line with the prevailing statutory guidance on contaminated land [2].

11.1.2 The Section 78A(2) of Part 2A of the Environmental Protection Act 1990 defines "contaminated land" as any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land that – (a) significant harm is being caused or there is a significant possibility of such harm being caused; or (b) significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused.

11.1.3 Section 78A(4) defines "Harm" as harm to the health of living organisms or other interference with the ecological systems of which they form part and, in the case of man, includes harm to his property.

11.1.4 Section 78A(9) defines "pollution of controlled waters" as the entry into controlled waters of any poisonous, noxious or polluting matter or any solid waste matter. The following types of pollution are considered to constitute "significant pollution of controlled waters":

(a) Pollution equivalent to "environmental damage" to surface water or groundwater as defined by The Environmental Damage (Prevention and Remediation) Regulations 2009, but which cannot be dealt with under those Regulations.

(b) Inputs resulting in deterioration of the quality of water abstracted, or intended to be used in the future, for human consumption such that additional treatment would be required to enable that use.

(c) A breach of a statutory surface water Environment Quality Standard, either directly or via a groundwater pathway.

(d) Input of a substance into groundwater resulting in a significant and sustained upward trend in concentration of contaminants (as defined in Article 2(3) of the Groundwater Daughter Directive (2006/118/EC).

11.1.5 With respect to **human health**, the following risk categories have been used in accordance with the 'Contaminated Land Statutory Guidance' (see next page):

[2] *Environmental Protection Act 1990: Part 2A. Contaminated Land Statutory Guidance*. Department for Environment Food and Rural Affairs. April 2012

Human Health-Related Risk Categories

Risk Category	Definition
1	A significant possibility of significant harm exists where the Local Authority considers there is an unacceptably high probability, supported by robust science based evidence, that significant harm would occur if no action is taken to stop it.
2	The land would be capable of being determined as contaminated land on grounds of significant possibility of significant harm to human health. There is a strong case for considering that the risks from the land are of sufficient concern, that the land poses a significant possibility of significant harm. The Local Authority considers on the basis of the available evidence that there is a strong case for taking action under Part 2A on a precautionary basis.
3	The land that the Local Authority considers would not be capable of being determined on grounds of significant possibility of significant harm to human health. Land where the risks are not low, but nonetheless the Local Authority considers that regulatory intervention under Part 2A is not warranted. This recognises that placing land in this Category would not stop others, such as the owner or occupier of the land, from taking action to reduce risks outside of the Part 2A regime if they choose.
4	The Local Authority considers that there is no risk that the land poses a significant possibility of significant harm, or that the level of risk posed is low: (a) Land where no relevant contaminant linkage has been established. (b) Land where there are only normal levels of contaminants in soil. (c) Land that has been excluded from the need for further inspection and assessment because contaminant levels do not exceed relevant generic assessment criteria. (d) Land where estimated levels of exposure to contaminants in soil are likely to form only a small proportion of what a receptor might be exposed to anyway through other sources of environmental exposure

11.1.6 With respect to **Controlled Waters**, the following risk categories have been used in accordance with the 'Contaminated Land Statutory Guidance':

Controlled Waters-Related Risk Categories

Risk Category	Definition
1	Land where the Local Authority considers that there is a strong and compelling case for considering that a significant possibility of significant pollution of controlled waters exists and that it is likely that high impact pollution (such as the pollution described in paragraph 11.1.4) would occur if nothing were done to stop it.
2	Land where the Local Authority considers that the strength of evidence to put the land into Category 1 does not exist; but nonetheless, on the basis of the available scientific evidence, the authority considers that the risks posed by the land are of sufficient concern that the land should be considered to pose a significant possibility of significant pollution of controlled waters on a precautionary basis
3	Land where the Local Authority considers that risks are such it is very unlikely that serious pollution would occur; or where there is a low likelihood that less serious types of significant pollution might occur and therefore regulatory intervention under Part 2A is not warranted.
4	Land where the Local Authority concludes that there is no risk, or that the level of risk posed is low. Where: (a) no contaminant linkage has been established in which controlled waters are the receptor in the linkage; or (b) The fact that substances are merely entering water and none of the conditions for considering that significant pollution is being caused (as set out in paragraph 11.1.4 above) are being met. (c) The fact that land is causing a discharge that is not discernible at a location immediately downstream or down-gradient of the land (when compared to upstream or up-gradient concentrations). (d) Substances entering water are in compliance with a discharge authorised under the Environmental Permitting Regulations.

11.1.7 With respect to **Ecosystems**, the following risk categories have been used (see next page):

Ecological Systems-Related Risk Categories

Risk Category	Definition
1	Land where the Local Authority considers that there is a strong and compelling case for considering that a significant possibility of significant harm to ecological systems exists, which results in: a) an irreversible adverse change, or in some other substantial adverse change, in the functioning of the ecological system within any substantial part of that location; or b) harm which significantly affects any species of special interest within that location and which endangers the long-term maintenance of the population of that species at that location.
2	The land would be capable of being determined as contaminated land on grounds of significant possibility of significant harm to ecological systems. There is a strong case for considering that the risks from the land are of sufficient concern, that the land poses a significant possibility of significant harm.
3	The land that the Local Authority considers would not be capable of being determined on grounds of significant possibility of significant harm to ecological systems. Land where the risks are not low, but nonetheless the Local Authority considers that regulatory intervention under Part 2A is not warranted. This recognises that placing land in this Category would not stop others, such as the owner or occupier of the land, from taking action to reduce risks outside of the Part 2A regime if they choose.
4	Land where the Local Authority concludes that there is no risk, or that the level of risk posed is low. Where: (a) Land where no relevant contaminant linkage has been established. (b) Land that has been excluded from the need for further inspection and assessment because contaminant levels do not exceed relevant generic assessment criteria etc.

11.1.8 With respect to **Property**, the following risk categories have been used:

Property-Related Risk Categories

Risk Category	Definition
1	Land where the Local Authority considers that there is a strong and compelling case for considering that a significant possibility of significant harm to property exists, which results in: a) a substantial diminution (>20%) in yield or other substantial loss in crop/livestock value resulting from death, disease or other physical damage. b) when a substantial proportion of the animals or crops are dead or otherwise no longer fit for their intended purpose. c) Structural failure, substantial damage or substantial interference with any right of occupation of a building when any part of the building ceases to be capable of being used for the purpose for which it is or was intended.
2	The land would be capable of being determined as contaminated land on grounds of significant possibility of significant harm to property. There is a strong case for considering that the risks from the land are of sufficient concern that the land poses a significant possibility of significant harm to property.
3	The land that the Local Authority considers would not be capable of being determined on grounds of significant possibility of significant harm to property Land where the risks are not low, but nonetheless the Local Authority considers that regulatory intervention under Part 2A is not warranted.
4	Land where the Local Authority concludes that there is no risk, or that the level of risk posed is low. Where: (a) Land where no relevant contaminant linkage has been established. (b) Land that has been excluded from the need for further inspection and assessment because contaminant levels do not exceed relevant generic assessment criteria etc.

11.2 Summary of Risks for the Church Hill Area

11.2.1 The following tables present a summary of the appropriate risk categories with respect to the appropriate source-pathway-receptors identified at Church Hill.

Table 14
Summary of Environmental Risks – Church Hill (Area F)

Receptor		Pathway(s)	Source	Risk Category	Comments
Property	Livestock (Sheep)	Ingestion Dermal Contact	Soil contamination in near surface restoration soils	4	No contamination in excess of soil screening values noted
	Crops (Grass)	Vegetation uptake	Soil contamination in near surface restoration soils Landfill gas and VOCs	4	No phototoxic contamination in excess of soil screening values noted No significant landfill gas detected
	Buildings (off site)	Migration & accumulation	Landfill gas and VOCs	4	Putrescible materials absent in Area F with corresponding low landfill can concentrations. Landraise of waste materials at levels above nearby properties mitigates gas migration risk
	Buildings (future)	Migration & accumulation	Landfill gas and VOCs	3	Future residential/commercial development in north of Area F is a possibility but unlikely (greenbelt). Further assessment and gas protection measures would be anticipated
Humans	Tenants (Farmer Workers)	Ingestion Dermal Contact	Soil contamination in near surface restoration soils	4	No contamination in excess of soil screening values noted Farmer workers are adults with a relatively low exposure frequency and duration
	Informal Users (Walkers/ Children at play)	Ingestion Dermal Contact Inhalation	Soil contamination in near surface restoration soils. Soil contamination in near surface natural strata in woodland. Landfill gas and VOCs.	4	No contamination in excess of soil screening values noted in restoration soils. Arsenic US_{95} in excess of residential SGV (natural strata) - considered to be naturally occurring background concentrations. Localised marginally elevated BaP. However, elevated SO_4 in yellow clays are a potential irritant but site users will have a relatively low exposure frequency and duration and these materials are not present at surface.
	Anglers	Ingestion of fish Dermal contact (water)	Leachate migration to angling ponds located in Area D	4	Water quality in angling ponds below EQS values. No positive evidence for consumption of caught fish. Groundwater quality in Area C good when compared to rest of study site.
	Nearby Residents	Inhalation	Dusts, vapours and landfill gas	4	100% grass cover and lack of site traffic etc prevents generation of airborne dusts. No VOCs detected in Area F. Putrescible materials absent in Area F with corresponding low landfill can concentrations. Landraise of waste materials at levels above nearby properties mitigates gas migration risk
	Users of Country Park (sailing etc)	Ingestion (water) Dermal Contact (water)	Leachate migration to Mercer Country Park lake	4	Water quality in Mercer's lake below EQS values. Groundwater quality in Area F good when compared to rest of study site.
Controlled Waters	Off site Surface Water Bodies	Leachate generation and migration	Landfilled wastes and leachate	4	Landfilled wastes possess no basal containment and directly overlie relatively permeable strata. Groundwater flow to north and intersects waste mass which is in hydraulic continuity with surface water features to the north. Groundwater quality in Area E good when compared to rest of study site. Water quality in lakes below EQS.
	Principal Aquifers	Leachate generation and migration	Landfilled wastes and leachate	3	Landfilled wastes (Areas A, B, north of Area C, north of Area E and Area F possess no basal containment & directly overlie relatively permeable strata. Groundwater flow to north & intersects waste mass. Groundwater observed to be impacted by leachates directly beneath the site but no evidence of deterioration of water quality in nearby surface water features that are substantially groundwater fed. Dilution & dispersion of contaminants considered to be significant elements of natural attenuation. Site not located in groundwater SPZ & is not abstracted for potable supply locally.

Continued...

Receptor		Pathway(s)	Source	Risk Category	Comments
Ecosystems	On site Woodland	Vegetation uptake (flora) Ingestion (fauna) Dermal contact (fauna)	Soil contamination in made ground in woodland area and natural Strata	4	Arsenic US_{95} in excess of residential SGV in reworked made ground and natural strata - considered to be naturally occurring background concentrations. Elevated SO_4 in yellow silt/clays No sign of vegetative stress. Local soil types and chemical status has given rise to diverse habitats. Area F not a designated site (SSSI, SBI, LNR etc)
	Nature Reserve and Country Park (Aquatic)	Leachate generation and migration	Landfilled wastes and leachate	4	Aquatic ecosystems potentially at risk from migration of leachate within groundwater derived from landfilled wastes. Nearby ponds/lakes considered to be in hydraulic continuity with landfill leachate. However, water quality in nearby surface water features are below EQS. The distance of these features from the site suggest that dilution and dispersion of contaminants considered to be significant elements of natural attenuation

11.3 Conclusions

11.3.1 The Church Hill area (Area F) exists as a large area of informal public open space in the private ownership of Evonik Degussa UK Holdings Limited. The southern part of the area exists as dense woodland with occasional clearings of shrubs and rough vegetation. The northern and central parts exist as grassland at levels higher than surrounding land which is currently used for the grazing of sheep. Public footpaths cross the woodland areas, that are used local residents for walking and the woodland would also appear to be used in some areas by children. Tenants regularly visit the northern part of the site to check on their grazing livestock.

11.3.2 Two flooded former mineral extraction pits are present ca 100-200m to the north/northwest of Area F (in Area D), which are used as fishing ponds and which are surrounded by dense woodland.

11.3.3 The Church Hill area is located within an area of Adopted Greenbelt. A country park and associated flooded former mineral workings (boating/sailing lake) is present to the north of the Evonik owned land. An area of former (restored) mineral workings (Glebe Quarry) is present to the east, although it is not known whether these workings have been infilled with wastes.

11.3.4 Historical maps suggest that the southern parts of the Church Hill area was used for 'ad hoc' and small scale Fullers Earth extraction in the late 19th and early 20th Centuries, and the quarries/pits infilled possibly around that time. It is, however, known that extensive mineral extraction took place across large parts of the study site in the second half of the 20th Century. These large mineral extraction pits were subsequently infilled with controlled wastes in the 1970s to the early 1990s. In the Church Hill area, the deposition of wastes would appear to have also taken place (pre-1977) but these materials would appear to have been deposited as part of a general 'land raise' to create an elongated domed landform.

11.3.5 The ground investigations identified the presence of relatively deep 'Inert' landfilled wastes to depths of up to ca 10m below existing ground levels in the central parts of Area F. These wastes were also observed to be predominantly minerogenic in nature with minor inert constituents (brick, concrete etc), ash and clinker deposits and contain little/no degradable fractions. A yellow very silty clay is president within the waste materials in the central/southern parts of Church Hill. These materials are considered to be reworked Fullers Earth acid sludges derived from a former large scale Fullers Earth Works that was once located in the south of Area B and such sluges have been noted in the adjacent Beechfield Quarry area (Area E) within two former 'lagoon' features.

11.3.6 No landfilled wastes have been observed to be present across much of the woodland area, although a central clearing within the woodland contains inert fill materials and probably represents a small former infilled quarry feature.

11.3.7 The 'Inert' wastes, where present, have been covered by a good quality substantial thickness (2-3m) of restoration soils. These materials visually appear to comprise natural weathered Sandgate Beds that would have been sourced from former quarrying operations within the study site.

11.3.8 The landfilled wastes would appear to have been deposited directly upon natural strata without the benefit of a basal or perimeter low permeability mineral engineered liner, and the landfill areas would appear to have been designed and operated on a 'dilute and disperse' basis.

11.3.9 Monitoring at the site suggests the presence of a continuous groundwater body beneath the site within natural strata and which intersects the landfilled waste mass. Groundwater flow directions are to the north and groundwater appears to be in hydraulic continuity with flooded mineral workings/ponds in the north and to the north of the study site.

11.3.10 No significant organic or inorganic contamination has been noted in the made ground, natural strata and near surface restoration soils materials across the Church Hill area. However, slightly elevated concentrations of arsenic (with respect to the most stringent 'residential end use' soil screening concentrations) has been noted within the natural strata and reworked natural made ground at naturally occurring concentrations typical of the Cretaceous Greensand strata. Locally elevated PAH concentrations have also been noted in the restorations spoils and inert wastes. Significantly elevated sulphate concentrations have been noted in the yellow lagoon silt/clays.

11.3.11 The waste materials across the whole of the study site possess variable contamination, although, in general terms, the waste in Area F would not appear to be significantly contaminated, and significant mobile contamination in the form of oils etc has not been encountered during the investigations.

11.3.12 The quality of groundwater within the monitoring boreholes located in the Church Hill area is relatively good when compared to the rest of the study site. Although some inorganic contamination is present in groundwater in excess of stringent EQS values, no organic contamination has been noted in the more recent groundwater samples and this is reflective of the 'Inert' waste that are present at these locations.

11.3.13 Across the remainder of the study site, the quality of the 'leachate' within the waste mass (e.g. in Areas A and B), although possessing inorganic and some organic contamination, can generally be regarded as being 'dilute' in nature when compared to leachate concentrations typically encountered in modern contained landfills and may also reflect the age of the wastes and the 'flushing effects' of groundwater over the intervening time. Groundwater beneath the waste materials contains varying degrees of inorganic and organic contamination.

11.3.14 There is currently no evidence of any contamination to on site or nearby off site surface water features which are used for fishing and sailing/amenity purposes respectively. This is possibly a result of the large groundwater dilution beneath the site and within these surface water ponds (which also receive a proportion of surface water flow). There is, however, the potential for groundwater/leachate contamination from within and beneath the site to migrate to nearby surface water features.

11.3.15 A direct 'pollution pathway' does, however, exist between the contaminated groundwater and leachates beneath the study site and the nearby surface water ponds. As such, further/ongoing groundwater and surface water monitoring is recommended.

11.3.16 A programme of gas monitoring has been carried out between October 2011 and Spring 2013 (still ongoing).

11.3.17 Methane has either not been detected, or has been detected at concentrations

<5%v/v across the Church Hill area. Similarly, carbon dioxide concentrations have been observed to low, although concentrations of 7.8-13.0%v/v have occasionally been detected in BH25 and BH26 in the northern portion of the Church Hill area, but gas flow rates have typically been <1l/hr. The risks associated with landfill gas migration to nearby properties is considered to be low given that the waste mass is generally present as a 'land raise' and higher than surrounding land.

11.3.18 Overall, given its current use and environmental setting, the contamination status of the Church Hill area means that this part of the site represents a low risk to property, human health and ecosystems. A low/moderate risk exists to controlled waters (aquifer) given the uncontained nature of the wastes present in the north and centre of this area (and elsewhere within the study site) and the observed groundwater regime. A low risk to off site properties exists with respect to landfill gas, although gas migration within permeable (i.e. sandstone) horizons towards nearby residential properties could potentially occur. As such, a continued programme of groundwater and gas monitoring is ongoing that will enable further assessments of the risk to these potential receptors.

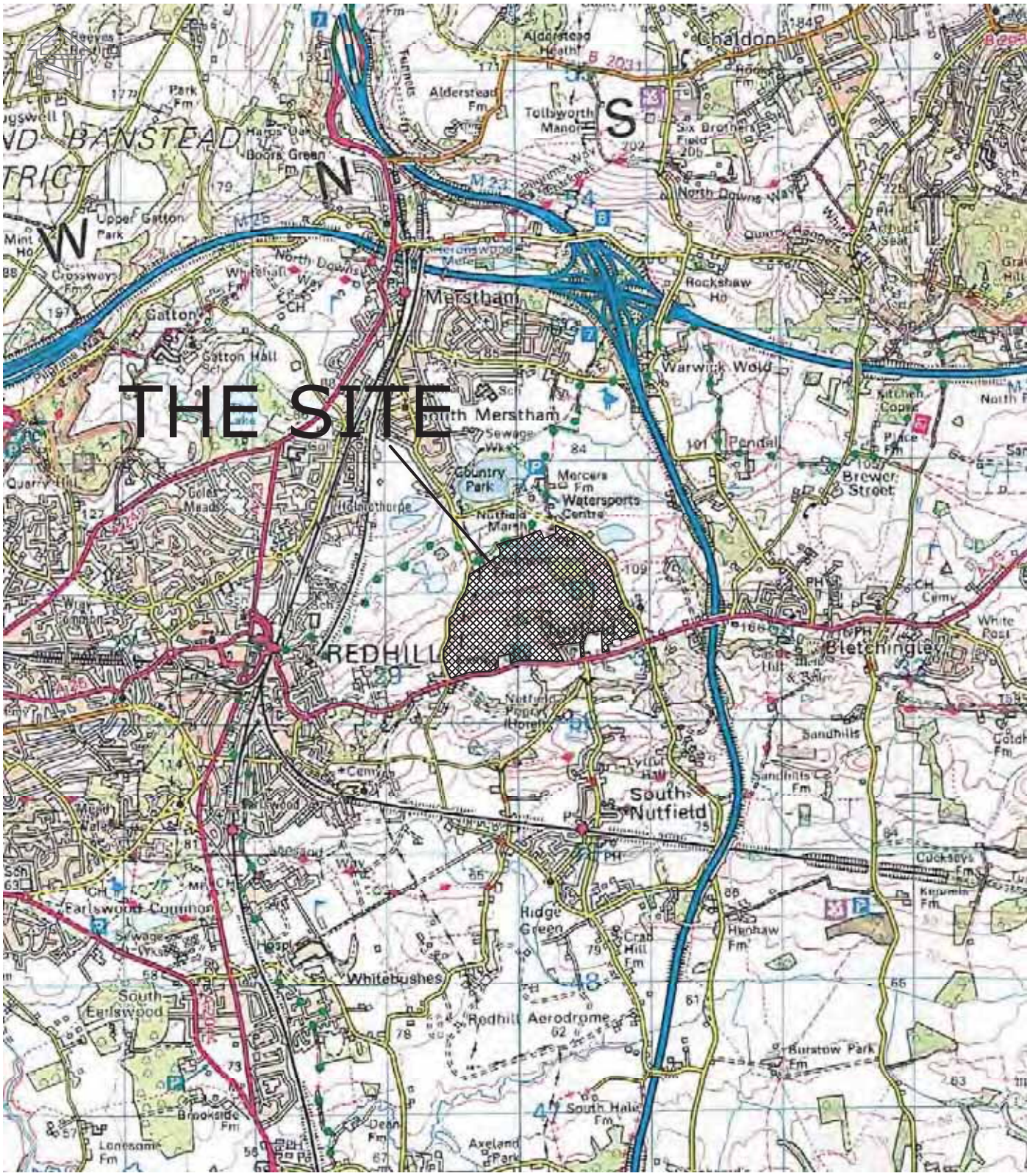
11.4 Recommendations

11.4.1 It is recommended the this present report be submitted to Tandridge District Council (TDC) to seek their acceptance of the contamination-related risks prevailing at the Beechfield Quarry area, which are summarised in Table 14 above.

11.4.2 It is further recommended that landfill gas and groundwater/leachate monitoring continues across the Church Hill area, the findings of which should be submitted to TDC on an annual basis to enable any revisions to the above presented environmental risk summary to be made. Landfill gas monitoring is currently carried out on a quarterly basis. Groundwater/leachate analysis is also currently carried out every 3 months for a 'reduced suite' of determinands with a full 'List I/II suite' of tests being undertaken every 12 months.

APPENDIX A

Drawings



ENCIA

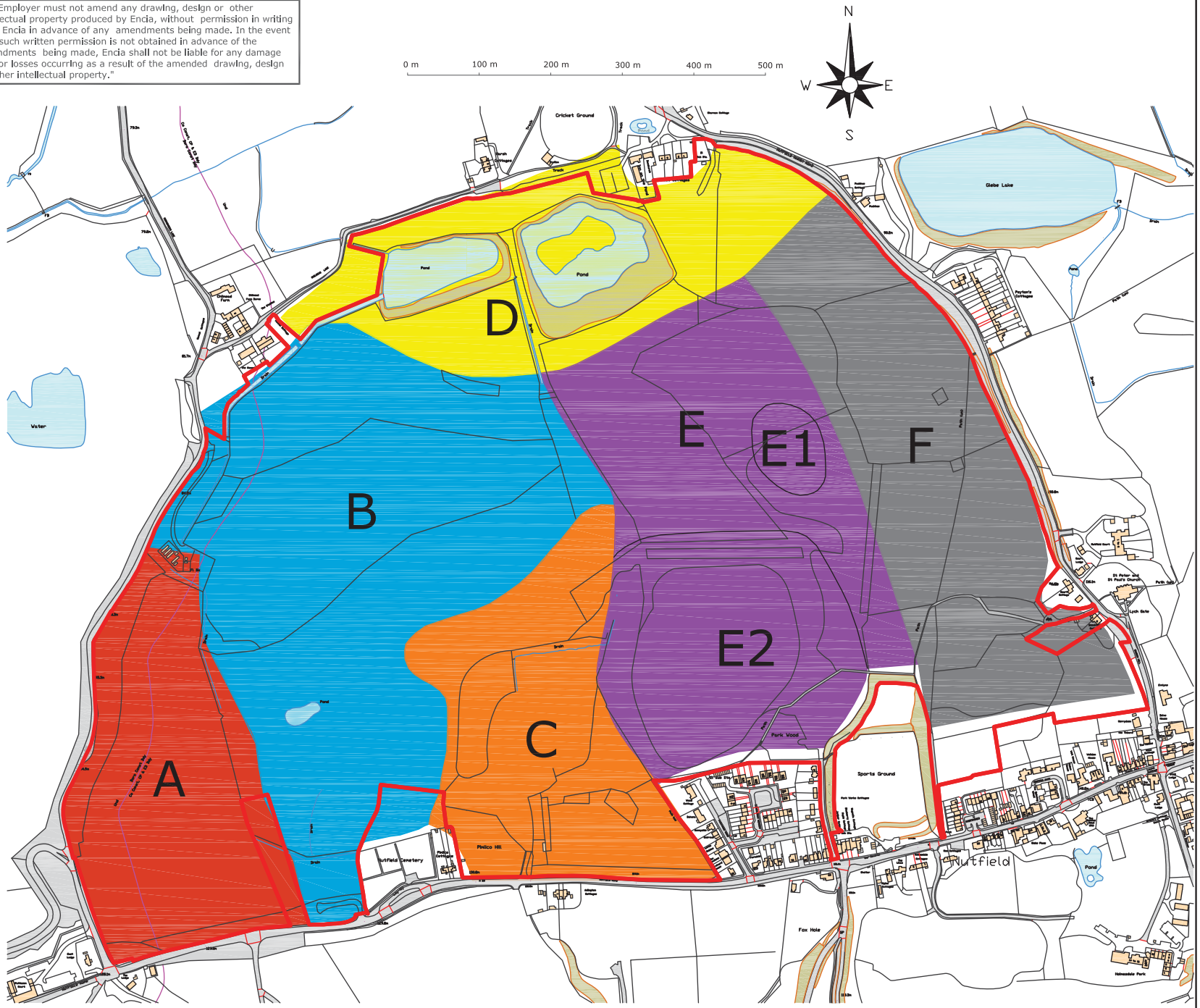
CLIENT: EVONIK DEGUSSA UK HOLDINGS LTD

JOB TITLE: FORMER LANDFILLS/QUARRIES, REDHILL, SURREY

DRAWING TITLE: SITE LOCATION PLAN

DRAWN BY	SIGNATURE	DATE	STATUS
KL		15/09/2011	FINAL

APPROVED	SIGNATURE	DATE	SCALE	DRG No.
AJA		15/09/2011	NTS	20096-1



KEY

A	PARK QUARRY
B	NORTH COCKLEY
C	GORE MEADOW
D	SAND PIT
E	BEECHFIELD QUARRY
F	CHURCH HILL

ENCIA
2 Regent Street Knutsford Cheshire WA16 6GR
T 01565 652394 F 0845 519 0766 LoCall 0845 519 0755
E info@encia.co.uk W encia.co.uk
Company No 6731047

CLIENT

EVONIK DEGUSSA UK HOLDINGS LTD

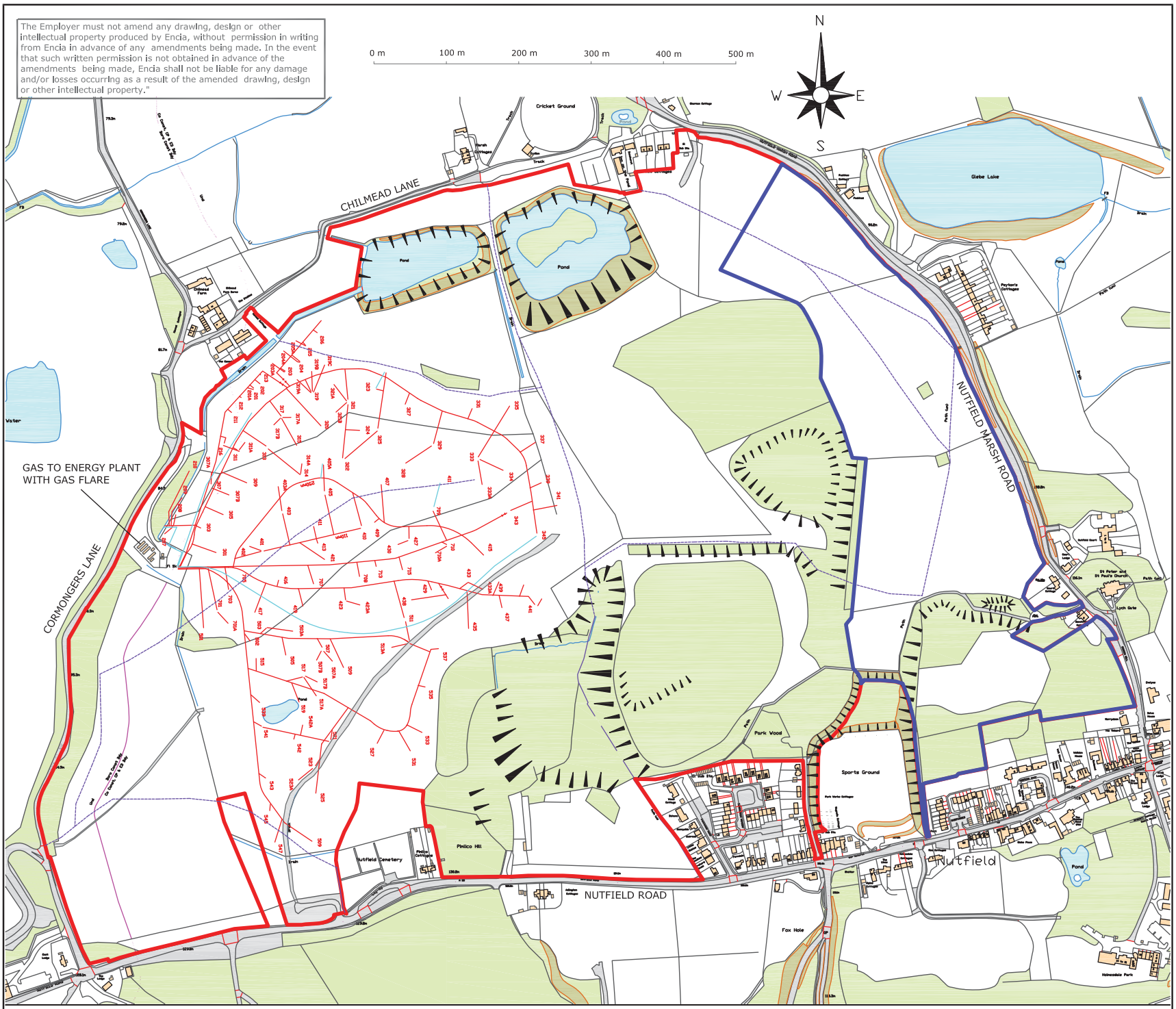
JOB TITLE

FORMER LANDFILL & QUARRIES
REDHILL, SURREY

DRAWING TITLE

SITE AREAS PLAN

STATUS	FINAL	
DRAWN BY: KL	SIGNATURE	DATE: 04/11/2011
APPROVED: AJA	SIGNATURE	DATE: 04/11/2011
SCALE: 1:5000@A3	DRG No.: 20096-2	



KEY

- WOODLAND
- SURFACE WATER
- HARDSTANDING
- 325 GAS EXTRACTION PIPELINE & WELL
- PUBLIC FOOTPATH
- CHURCH HILL AREA BOUNDARY
- STEEP SLOPE

ENCIA
2 Regent Street Knutsford Cheshire WA16 6GR
T 01565 652394 F 0845 519 0766 LoCall 0845 519 0755
E info@encia.co.uk W encia.co.uk
Company No 6723047

CLIENT

EVONIK DEGUSSA UK HOLDINGS LTD

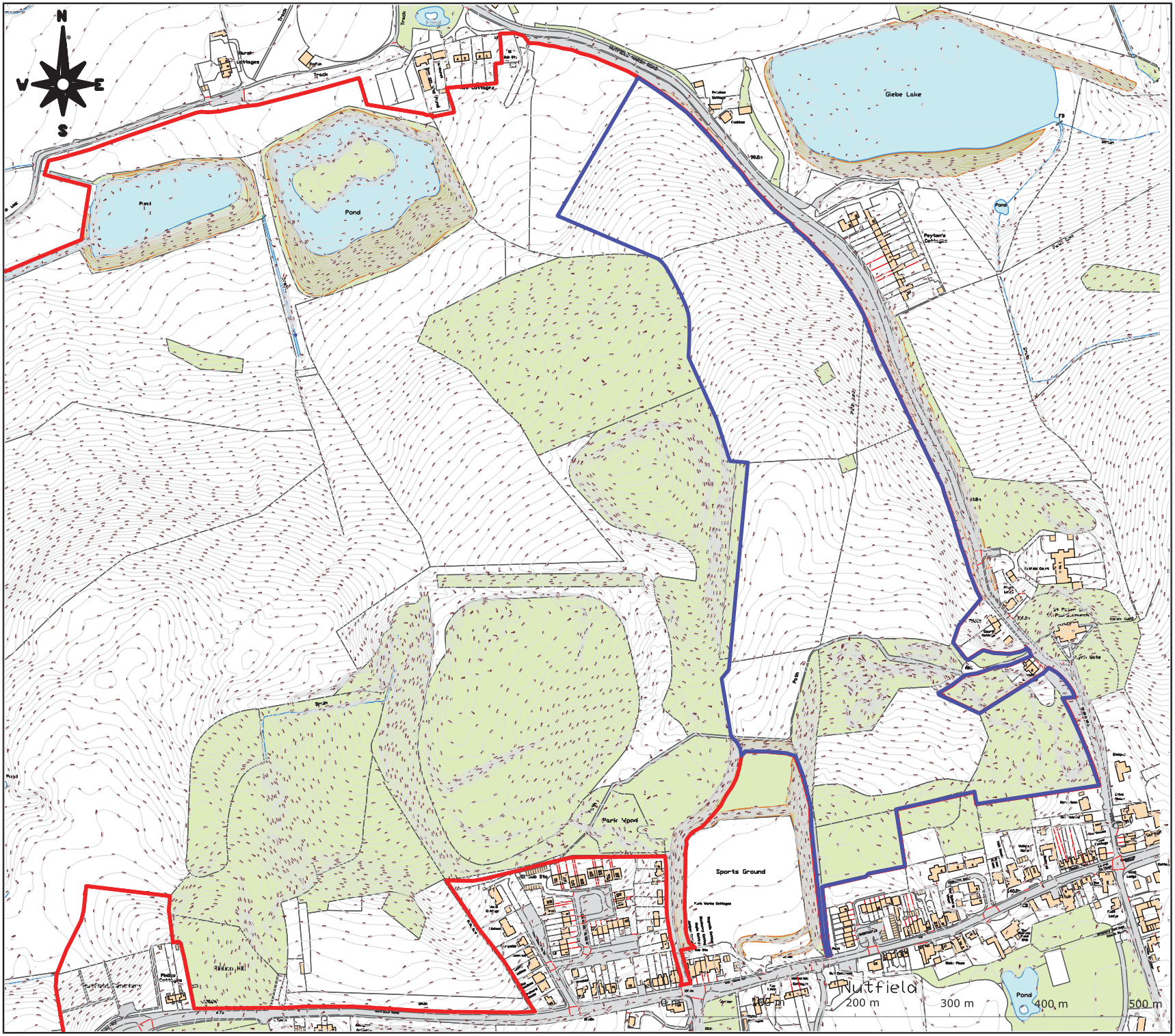
JOB TITLE

FORMER LANDFILLS/QUARRIES REDHILL, SURREY

DRAWING TITLE

EXISTING SITE FEATURES

STATUS	FINAL	
DRAWN BY	SIGNATURE	DATE
KL		15/11/2011
APPROVED	SIGNATURE	DATE
AJA		15/11/2011
SCALE		DRG No.
1:5000@A3		20096-3



SURVEY INFORMATION BASED ON AN ENVIRONMENT AGENCY REMOTE LIGHT DETECTION AND RANGING (LIDAR) SURVEY

SURVEY DATE UNKNOWN

VERTICAL ACCURACY +/- 150mm

HORIZONTAL RESOLUTION 1000mm

CHURCH HILL AREA BOUNDARY

ENCIA
2 Regent Street Knutsford Cheshire WA16 6GR
T 01565 652394 F 0845 519 0766 toCall 0845 519 0755
E info@encia.co.uk W encia.co.uk
Company No 6731047

CLIENT

EVONIK DEGUSSA UK HOLDINGS LTD

JOB TITLE

FORMER LANDFILLS/QUARRIES REDHILL, SURREY

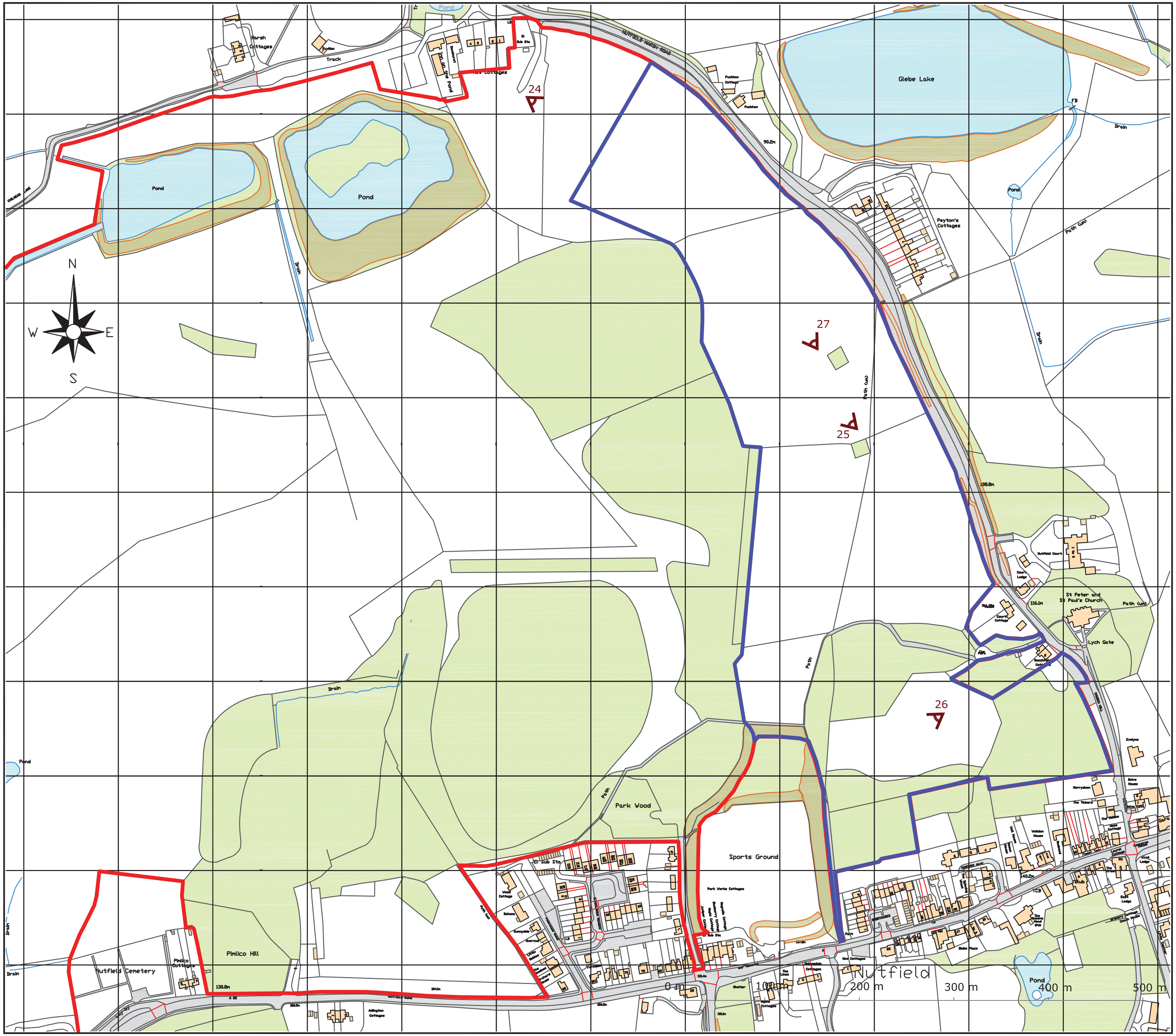
DRAWING TITLE

LIDAR TOPOGRAPHICAL SURVEY - CHURCH HILL

STATUS: FINAL

DRAWN BY	SIGNATURE	DATE
KL		22/05/2013
APPROVED	SIGNATURE	DATE
AJA		22/05/2013

SCALE	DRG No.
1:4000@A3	20096-F-4



KEY

SITE BOUNDARY

CHURCH HILL AREA BOUNDARY

F1 PHOTOGRAPH LOCATION AND NUMBER

ENCIA

2 Regent Street Knutsford Cheshire WA16 6GR

T 01565 652394 F 0845 519 0766 LoCall 0845 519 0755

E info@encia.co.uk W encia.co.uk

CLIENT

EVONIK DEGUSSA UK HOLDINGS LTD

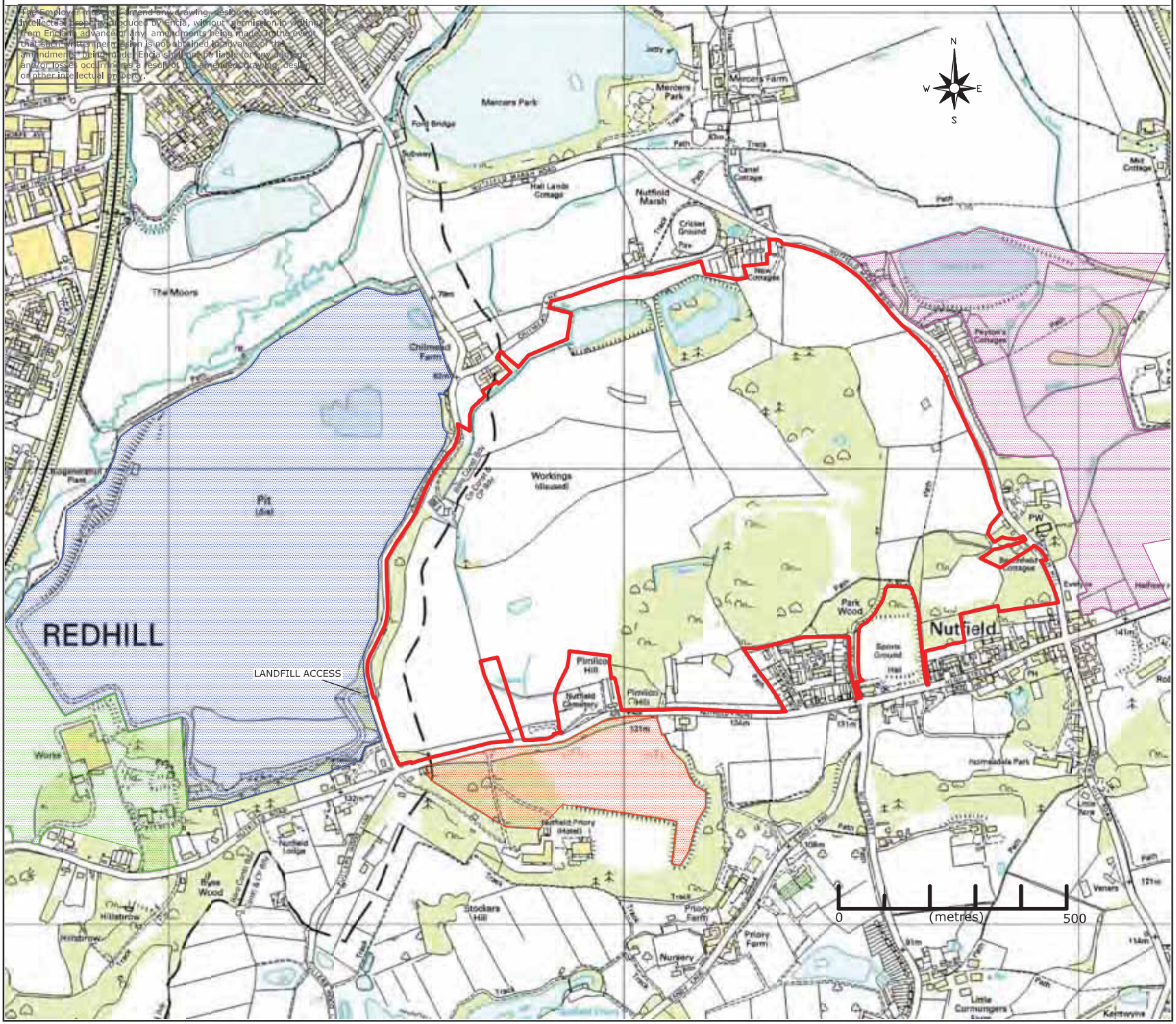
JOB TITLE

FORMER LANDFILLS/QUARRIES REDHILL, SURREY

DRAWING TITLE

PHOTOGRAPH LOCATIONS - CHURCH HILL AREA

STATUS		
FINAL		
DRAWN BY: AJA	SIGNATURE	DATE: 22/05/2013
APPROVED: KL	SIGNATURE	DATE: 22/05/2013
SCALE: 1:4000@A3	DRG No. 20096-E-5	



KEY

- BIFFA LANDILL SITE
- GLEBE QUARRY
- NUTFIELD PRIORY LANDFILL
- COPYHOLD WORKS
- SURFACE WATER
- SITE BOUNDARY

ENCIA
2 Regent Street Knutsford Cheshire WA16 6GR
T 01565 652394 F 0845 519 0766 toCall 0845 519 0755
E info@encia.co.uk W encia.co.uk
Company No 6733047

CLIENT

EVONIK DEGUSSA UK HOLDINGS LTD

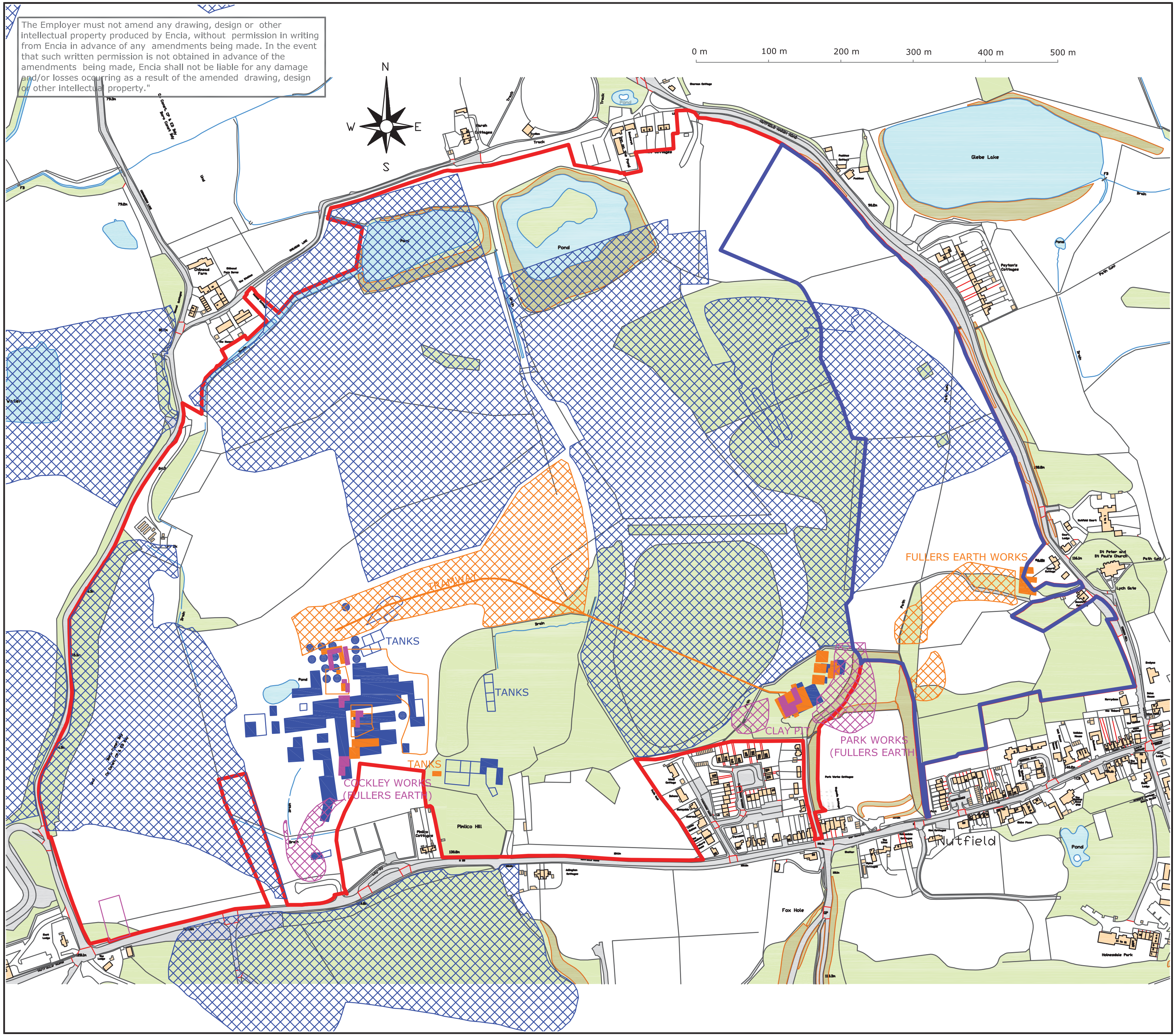
JOB TITLE

FORMER LANDFILLS/QUARRIES REDHILL, SURREY

DRAWING TITLE

SURROUNDING LAND USE / ENVIRONMENTAL SETTING

STATUS	FINAL	
DRAWN BY: KL	SIGNATURE:	DATE: 17/11/2011
APPROVED: AJA	SIGNATURE:	DATE: 17/11/2011
SCALE: AS_SHOWN	DRG No.: 20096-6	



KEY

- EXTENT OF MINERAL EXTRACTION/ REFUSE TIPPING ON 1975 MAP
- EXTENT OF MINERAL EXTRACTION/ REFUSE TIPPING ON 1934 MAP
- EXTENT OF MINERAL EXTRACTION/ REFUSE TIPPING ON 1871 MAP
- BUILDING SHOWN ON 1975 MAP
- BUILDING SHOWN ON 1934 MAP
- BUILDING SHOWN ON 1871 MAP
- CHURCH HILL AREA BOUNDARY

ENCIA
2 Regent Street Knutsford Cheshire WA16 6GR
T 01565 652394 F 0845 519 0766 loCall 0845 519 0755
E info@encia.co.uk W encia.co.uk

CLIENT
EVONIK DEGUSSA UK HOLDINGS LTD

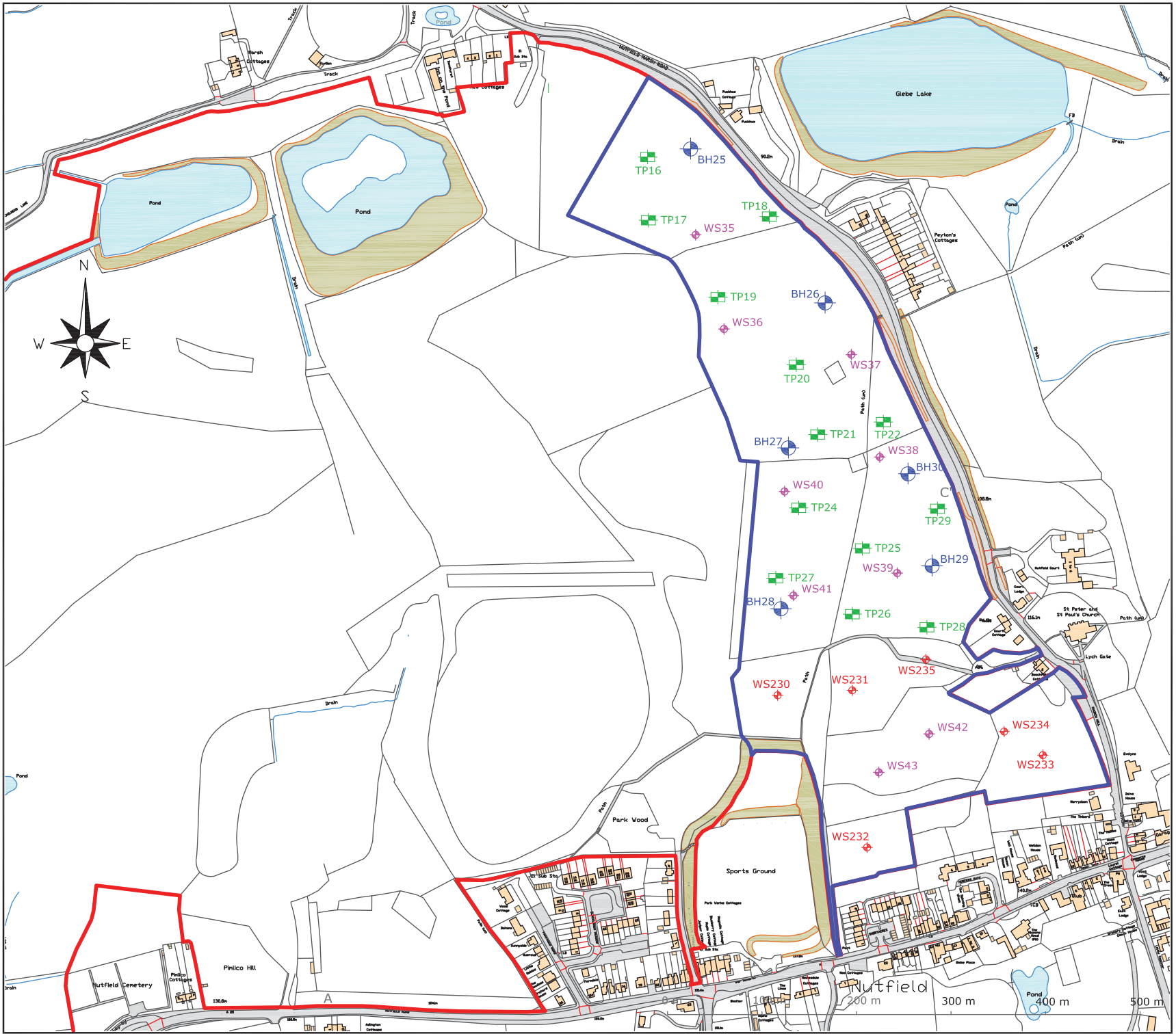
JOB TITLE
FORMER LANDFILLS/QUARRIES REDHILL, SURREY

DRAWING TITLE
HISTORICAL SITE FEATURES

STATUS
FINAL

DRAWN BY	SIGNATURE	DATE
KL		28/11/2011
APPROVED	SIGNATURE	DATE
AJA		28/11/2011

SCALE	DRG No.
1:5000@A3	20096-7



The Employer must not amend any drawing, design or other Intellectual property produced by Encia, without permission in writing from Encia in advance of any amendments being made. In the event that such written permission is not obtained in advance of the amendments being made, Encia shall not be liable for any damage and/or losses occurring as a result of the amended drawing, design or other Intellectual property."

ENCIA
2 Regent Street Knutsford Cheshire WA16 6GR
T 01565 652394 F 0845 519 0766 LoCall 0845 519 0755
E info@encia.co.uk W encia.co.uk
Company No 6723047

CLIENT

EVONIK DEGUSSA UK HOLDINGS LTD

JOB TITLE

WOODLAND AREA
FORMER LANDFILLS/QUARRIES
REDHILL, SURREY

DRAWING TITLE

EXPLORATORY HOLE LOCATION PLAN - CHURCH HILL AREA

STATUS		
FINAL		
DRAWN BY: KL	SIGNATURE:	DATE: 22/05/2013
APPROVED: AJA	SIGNATURE:	DATE: 22/05/2013
SCALE: 1:4000@A3	DRG No.: 20096-F-8	