PHASE II GEOENVIRONMENTAL INVESTIGATION ADDITION 4

CARPENTER PLC
SHAW LANE
GLOSSOP
SK13 9LE

Report Ref:
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December 2008

Prepared on Behalf of:

Carpenter Plc

By:

Clancy Consulting Ltd.
Dunham Court
2 Dunham Road
Altrincham
Cheshire
WA14 4NX

DISTRIBUTION:

1 copy	Mr. Bob Daughtry, Carpenter Plc.
1 copy	Mr. Gary Hart, Carpenters Plc.
1 copy	Mr. Des Yates, Clancy Consulting Ltd.

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Report Reference:	10/0008/R1/V1.0
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Date:	December 2008
Prepared for:	Carpenter Plc Dinting Lodge Industrial Estate Off Shaw Lane Glossop Derbyshire SK13 9LE
Prepared by:	Clancy Consulting Ltd. Dunham Court 2 Dunham Road Altrincham Cheshire WA14 4NX

Definition of Version Code:
D. Applied during initial drafting of the report before it has been reviewed.
C Applied after the report has been reviewed but before it has been approved by the Project Manager.
B. Applied after the Project Manager has approved the report ready for issue to the client.
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EXECUTIVE SUMMARY

It is understood that Carpenters Plc propose to extend operations at Shaw Lane, Glossop with the construction of a new building (Addition 4) and associated parking areas.

The proposed development area is currently used to access Addition 3 and will involve the removal of an area of woodland and ecology and re-profiling of the general landscape. The creation of the development platform for the Addition 4 building will require the excavation and reprofiling of a substantial quantity of material that forms an area of open space and woodland.

Clancy Consulting Plc was commissioned to undertake a Phase II GeoEnvironmental Investigation to assess ground conditions for foundation design purposes and to investigate any environmental and geotechnical issues (including slope stability) which may affect the proposed development of the Addition 4 area. The Phase II site investigation follows an earlier phase (Phase I) of site investigation work by Clancy Consulting. The additional Phase II site investigation was considered necessary after revising the design of the Addition 4 area and associated parking areas.

The Phase II site investigation works were undertaken by Clancy Consulting between 2nd September 2008 and 22nd September 2008 and comprised the drilling of eight cable percussion boreholes (BH201–BH208). The boreholes were all drilled within the area of open space and woodland areas, where ground levels rise sharply towards Dinting Road. BH208 was however drilled in the yard area of Addition 3, near to some fuel tanks.

All locations were designed to investigate potential sources of contamination associated with the current and historical land uses and to determine the below ground conditions for foundation design and to provide more geotechnical information to support an enhanced slope stability assessment.

The additional boreholes have provided further information on ground conditions within the wooded area and the open space area, where previously material has been deposited from construction activities for Addition 1 and Addition 2. Material from the former reservoir, which occupied the majority of the current works area, was placed in this area in 1992.

Logging of the soil samples has allowed for the classification of the superficial geology into several distinct horizons, which have been incorporated into a digital terrain model for the site and also been incorproated into a slope stability model. The geology of the area can be broadly classifed as;

Made Ground
Upper Clay
Sand
Lower Clay
Shale/Mudstone

The Made Ground consists of a mixture of soft to very soft organic clays, originating from the former reservoir area together with a granular mixture of ash and cinder, which probably originated from a boiler house on the site.

Chemical analysis of the soil samples indicates an absence of any significant risk to long term human health for the proposed land uses, including commercial and open space. At two locations the total inorganic arsenic was found to be in excess of residential with plant uptake standards (adopted for area of open space as no generic guidance exists for this land use) and at one location elevated hydrocarbons were found in the Addition 3 access area.

Groundwater quality has been measured and compared to conservative drinking water and environmental quality standards. There are minor exceedances of these standards however based upon the proposed land use and the prevailing geology it is not anticipated that any further investigation of ground water quality or remedial measures are required. The Environment Agency should however be consulted on the groundwater quality in order to determine the need for any further assessment.

Ground gas concentrations within the Addition 3 area are low, however within the area of the tipped former reservoir material, elevated methane and carbon dioxide concentrations have been recorded. The presence of elevated methane and carbon dioxide concentrations are most likely to be attributable to the organic nature of the former reservoir material, although there may be a minor component derived from deeper strata.

A probabilistic slope stability model has been used in order to generate an enhanced understanding of any potential failure mechanism and factors of safety in any newly developed slopes, as part of the development of Addition 4. A digital ground modelling software package has been used to generate a three dimensional model of the existing and proposed topography. The generated model incorporates a 1 in 3 gradient slope which has been used to generate a series of six cross sections along the new slope.

The three dimensional model incorporates the geology encountered within all of the boreholes, which have been simplified into several distinct units.

The slope stability model incorporates a number of variables in order to provide a probabilistic assessment. The variables include soil parameters such as shear strength, angle of internal friction, bulk density and the position of the water table. The existing and additional geotechnical testing has been statistically analysed for the various separate identifiable horizons. Assuming that the data is normally distributed, these have been input into the slope stability model in order to evaluate the probability of failure of each slope section.

The results from the slope stability modelling for total and effective stress conditions indicates an adequate factor of safety, even using a piezometric surface at the rockhead level. The high factors of safety can be attributed to the measured angle of friction which has been proven to be in the range of six to eight degrees, together with the level of rockhead. The rockhead level is higher in elevation than originally envisaged and this surface has not been considered by previous consultants.

The three dimensional model has determined there to be an excess of approximately 300,000m^3 of material from the 1 in 3 slope, 50% of which is Made Ground. This represents a worst case scenario as the high factors of safety could lead to a reduced excavation if the slope profile is steepened (particularly in rock).

Chemical testing of materials that are likely to be excavated including Made Ground, natural sands and clays have been classified in accordance with Environment Agency guidance and deemed to be not hazardous (can therefore be deposited in an inert or non-hazardous facility). Waste Acceptance Criteria testing suggests that most of the material can be deposited in an inert landfill facility, although further testing during the programme of earthworks will be required to support this designation.

Based on the finding from the Phase I and Phase II site investigations together with a review of previous studies the following recommendations can be made;

- The new slope adjacent to the Addition 4 area should be constructed at a gradient of 1 in 3 in the superficial materials, and subject to further assessment 1 in 1 (forty five degrees) within the rock profile. The new slope should be offset from the new structure and parking areas by a minimum of 5m.

- It is recommended that additional boreholes are drilled to “core” the rock horizon beneath the superficial materials to allow for laboratory geotechnical testing of the shear strength of intact rock samples. The sampling of rock in-situ is however difficult and it may be more prudent to examine exposures when they are excavated to observe discontinuity patterns and thereby revise the slope design. The rock exposed will be weathered with a postulated dip direction towards to the toe of the slope.

- Due to the potential for further deterioration of the weathered rock horizon it would be prudent to consider some means of protection of the slope, such as the application of a geotextile erosion control mat.

- Due to the overall height of slope it would be prudent to incorporate a 5m wide bench into the slope design, which would promote stability and also allow for collection of surface water and groundwater.

- As part of the design of the new slope an important consideration will be the collection of groundwater and surface water. It is recommended that the slopes incorporate crest, slope and toe drainage.

- Foundation loadings will need to be transferred to the shale strata by means of end bearing driven piles. It is however possible that vibro-stone columns may be acceptable subject to receipt of technical proposals and costings from suitable contractors.

- All relict foundations, beneath proposed new foundations, should be removed to a minimum depth of 2mbgl prior to construction of any new structures.

- Ground bearing slabs will be suitable for the new structure subject to proof-rolling of the formation layer and removal of any soft spots.

- The earthwork for the new structure will generate a large quantity of material suspected to be approximately 300,000m^3 of a mixture of Made Ground, sand, clay and shale. The Made Ground has been tested in accordance with Waste Acceptance Criteria test protocols and has been largely classified as being inert if taken to a landfill facility. Further compliance testing will be required over the duration of the earthworks contract to assess suitable destinations.

- Any material that is excavated from the tipped area and used on site for land regrading operations will require the approval of the regulatory authorities. Further consultations with the regulatory authorities would determine whether the re-use of such material on site would require waste management licensing or an exemption to such licensing. Early consultations with the Environment Agency would be of benefit to all parties.

- Consultations with a local quarry operator suggest that they may be willing to accept surplus materials from the earthworks operation, subject to suitability testing. Contact should be made with the operator to determine the scope of testing and timescale for potential phasing of the receipt of materials.

TABLE OF CONTENTS

LIST OF FIGURES

APPENDICES

1.0 INTRODUCTION

1.1 Background

Clancy Consulting were commissioned by Carpenters Plc to conduct a Phase II Site investigation and slope stability assessment within an area that is being proposed to be developed in the near future as Addition 4.

The Phase II site investigation follows an earlier Phase I site investigation by Clancy Consulting which produced an overview of the ground conditions, together with an assessment of soil quality and overall stability of a proposed landform that will be generated to allow for the construction of a new building and associated parking areas.

The Phase II investigation aims to provide supplementary ground information and an enhanced slope stability assessment after a review and enlargement of the proposed building and reconfiguration of the parking areas. In particular further information was considered necessary within the existing wood which is to be removed to make way for the new building footprint.

The site is centred at NGR SK016949 and the site location is presented as Fig 10/0008/001, Appendix I and Fig 10/0008/002 shows the proposed development.

1.2 Terms of Reference

Clancy Consulting has been commissioned by Carpenters Plc, to undertake an addition GeoEnvironmental Investigation of the site in accordance with a proposal (10/0008/FF/MA/AKC) dated 14th April 2008.

The objectives of the investigation outlined within the proposal were as follows:

- Undertake site investigation works within the wooded area, area intended for deposition of the excess overburden material and near to the pond adjacent to Dinting Road.

- Refine the existing slope stability assessment (for short term undrained and long term effective stress conditions) using the existing and supplementary site investigation data to accommodate the development of a lorry park. A similar slope stability assessment would be made for the area intended to receive the excess overburden material generated from the removal of the wooded area.

- Assess the volume of material generated within the proposed earthworks and provide a three dimensional model of the new landforms.

- Assess the local market for acceptance of the excess overburden material at either an exempt, inert or non-hazardous landfill site or for sale as general construction fill. Enquiries would also be made with the local planning authority and Environment Agency on the potential sale of the excess overburden material as construction fill.

1.3 Limitations of the Study

Clancy Consulting Ltd. cannot be held responsible for any omissions, misrepresentation, errors or inaccuracies with the supplied third party report information.

The report is written in the context of an agreed scope of work and budget and should not be used in a different context. New information or improved practices and changes in legislation may require a reinterpretation of the report in whole or in part.

Clancy Consulting reserve the right to amend either conclusions or recommendations in light of any further information that may become available. The report is provided for the sole use of Carpenter Plc, for the objectives discussed previously only, and is confidential to them. It may not be relied upon by any other party without prior written consent of Clancy Consulting Ltd. Those using this information in subsequent assessments or evaluations do so at their own risk.

Recommendations within this report are also based on exploratory records and examination of samples and, where applicable, laboratory tests. No liability can be accepted for conditions not revealed by the boreholes particularly at intervening locations. Whilst every effort is made to ensure accuracy of data supplied, all opinions expressed as to the spatial distribution of strata between sampling locations is for guidance only and no responsibility is accepted as to its accuracy.

It should be noted that access for a drilling rig in the wooded area was restricted and only two locations could be accessed within this area.

At the time of writing of this report a topographical survey of the eastern sector of the site area was commissioned and underway. The area to be surveyed is likely to receive a substantial quantity of excess materials generated from the earthworks programme. This report does not address the ground conditions within this area or the stability of the proposed landform within this area.

2.0 PREVIOUS DESK STUDY

2.1 Previous Site Investigations and Assessment

A previous assessment of the stability of an extension of the works into the slope has been conducted by Exploration Associates in 1992 and this involved the drilling of several boreholes, a walk over survey and groundwater modelling.

The walkover over survey identified a number of land features of interest including areas of potential instability (*"sharp scarp")* where it is believed that some of the material from the former reservoir (beneath current works) was placed. The area of potential instability is described as an arcuate shaped land feature to the north of the lodge, which could represent the limit of a "classical circular slip feature".

The Environment Agency website shows the area of filling as a historic landfill site (Dinting Lodge) which was operated by E R Carpenter Plc between 31 December 1992 to March 1993.

Other noteworthy land features include a land drain from the pond situated adjacent to Dinting Road and several waterlogged areas which could represent springs or ephemeral watercourses.

3.0 SITE INVESTIGATION

3.1 Exploratory Fieldwork

Eight cable percussion boreholes were drilled between 2nd September and 22nd September 2008, (BH201 – BH208) to assess ground conditions at areas considered to require additional information after the initial site investigation work by Clancy Consulting. Additional boreholes were considered necessary after an amendment to the scale of the proposed extension and associated parking areas.

Boreholes were drilled further to the east in the area of open space to the north of the lodge and within the wooded area which is intended to be removed as part of a proposed large earthworks programme.

The aim of the boreholes was to provide additional information with respect to the level of rockhead, chemical quality of materials, provide additional groundwater level data and determine the geotechnical properties of surplus materials.

The borehole locations are illustrated in Fig No: 10/0008/003 located within Appendix I. Following drilling all boreholes were installed with two 19mm pipes to assess groundwater encountered, at both shallow and deep levels, with the exception of boreholes BH204, BH206A, BH207 and BH208, which were installed with a single 19mm pipe.

Soil samples destined for chemical testing were collected at regular intervals. Details of the strata encountered and the samples taken are listed in the borehole records in Appendix II.

All soils were logged in accordance with BS5930 (Code of Practice for Site Investigations) and BS EN ISO 14688-1:2002 “Geotechnical investigation and testing — Identification and classification of soil — Part 1: Identification and description” and BS EN ISO 14688-2:2004 “Geotechnical investigation and testing — Identification and classification of soil — Part 2: Principles for a classification”.

3.2 Summary of Site Investigation Observations

3.2.1 Ground Conditions

Ground conditions are broadly consistent across the site, with Made Ground underlain by clay, occasionally interbedded with sand overlying weathered shale. The Made Ground largely comprises of an organic soft to firm clay with mudstone/coal gravel and clinker/cinder. At CP104 and CP105 the Made Ground comprised of a granular mixture of boiler ash, bricks and limestone.

The materials encountered can be broadly subdivided into several horizons, some of which such as the sand horizon do not appear at all locations, i.e;

Made Ground
Upper Clay
Sand
Lower Clay
Weathered Shale

The surface comprised of grass or rough vegetation at all locations except CP101 – CP103 and BH208, within the main works area, which was tarmacadam.

The Made Ground comprised of clay with occasional sandy or gravelly clay with the exception of CP101 – CP103 and BH208 where the Made Ground consisted of a limestone sub-base over clayey gravel separated by two geotextile membranes.

A summary of the thickness of Made Ground and the depth to bedrock at each sampling location for both phases of site investigation is provided below, in Table 3.1.

Table 3.1
Summary of Made Ground Thickness and Depth to Bedrock

Location	Thickness of Made Ground (mbgl)	Depth to Shale Bedrock (mbgl)
CP101	0.70	3.10
CP102	0.70	1.50
CP103	0.70	5.00
CP104	4.70	8.80
CP105	3.10	9.70
CP106	1.75	11.70
BH201	4.00	17.9
BH202	4.50	14.9
BH203	3.90	15.3
BH204	2.90	11.2
BH205	4.80	10.7
BH206	2.60	Not determined
BH206A	3.50	11.8
BH207	5.50	8.0
BH208	0.50	6.3

Notes for Table 3.1
mbgl = metres below ground level.

3.2.2 Observable Indications of Contamination

No visual or olfactory indication of mobile contamination was identified during the site investigation works.

3.2.3 In-Situ Standard Penetration Testing

In-situ standard penetration testing was undertaken (in accordance with BS EN ISO 22476-3:2005 “Geotechnical investigation and testing —Field testing —Part 3: Standard penetration test) in all of the Clancy Consulting boreholes.

3.3 Groundwater Monitoring and Sampling

Groundwater was encountered during the drilling at 2.5mbgl within BH202 rising to 2.0mbgl after 20 minutes and 4.5mbgl within BH204 which did not rise.

Dual installations were placed within CP105, BH201, BH202, BH203 and BH205 to allow for measurement of groundwater levels at shallow and deeper elevations within the Made Ground and shale horizons.

A monitoring visit was undertaken on 2nd October 2008 and the groundwater levels encountered are summarised below, in Table 3.2.

Table 3.2
Summary of Groundwater Level Monitoring Results on 2nd October 2008

Borehole Number	Water Level (mbgl)	Depth to Installation Base (mbgl)	Ground Level (mAOD)	Water Level (mAOD)	Response Zone (mbgl)	Horizon
CP101	1.45	3.35	125.5	124.05	3.1-4.00	Shale
CP102	1.03	1.98	125.5	124.47	1.55-3.00	Shale
CP103	0.4	5.23	125.5	125.10	4.0-6.4	Lower Clay/Shale
CP104	3.6	6.7	137.5	133.90	4.0-7.0	Made Ground/Lower Clay
CP105	0.7	3.15	137.2	136.50	2.6-3.15	Made Ground/Lower Clay
CP105	Dry	10.3	137.2	Dry	9.0-11.0	Lower Clay/Shale
CP106	Destroyed		143.35		3.4-5.0	Sand/Lower Clay
BH201	6.53	7.2	142.23	135.70	4.0-7.2	Upper Clay/Sand
BH201	Dry	8.00 -blocked	142.23	Dry/Blocked	14.0-19.5	Lower Clay
BH202	2.6	3.8	142.64	140.04	1.0-3.8	Made Ground
BH202	Dry	15.1	142.64	140.04	13.0-15.1	Lower Clay
BH203	Dry	7.82	147.50	Dry	2.50-7.82	Made Ground/Upper Clay/Lower Clay
BH203	Dry	15.5	147.50	Dry	13.0-15.5	Lower Clay
BH204	1.58	7.5	132.89	131.31	3.45-7.5	Lower Clay
BH205	Dry	4.1	146.5	Dry	1.0-4.1	Made Ground
BH205	10.95	11.2	146.5	135.55	8.0-11.2	Lower Clay
BH206A	Dry	12.1	149.09	Dry	9.0-12.1	Lower Clay
BH207	Dry	7.8	141.0	Dry	5.50-7.8	Lower Clay
BH208	0.74	6.55	120.33	119.59	3.00-6.55	Lower Clay

3.4 Ground Gas Monitoring

A ground gas monitoring survey was carried out on 2nd October 2008. Concentrations of methane, carbon dioxide and oxygen were measured using an infra red gas analyser (GA94) calibrated to a reference standard of methane (before and after each survey) and gas flow rates measured using an attached flow pod.

Gas measurements were recorded every 60 seconds up to 180 seconds at each location, over which point the peak and steady concentrations of methane and carbon dioxide, together with the lowest concentration of oxygen were recorded.

The results of the ground gas monitoring are presented in Table 3.3, below.

Table 3.3
Summary of Ground Gas Monitoring Results

Location	Date	Response Zone (mbgl)	Maximum Methane (% vol/vol)	Maximum Carbon Dioxide (% vol/vol)	Minimum Oxygen (% vol/vol)	Flow Rate (l/hr)	Atmospheric Pressure (mB)
CP101	10/10/2008	3.1-4.00	NA	NA	NA	NA	
CP102	10/10/2008	1.55-3.00	NA	NA	NA	NA	
CP103	10/10/2008	4.0-6.4	NA	NA	NA	NA	
CP104	02/10/2008	4.0-7.0	0.2	1.9	19.7	1.8	994
CP105	02/10/2008	2.6-3.15	0.1	0.8	19.7	0.3	994
CP105	02/10/2008	9.0-11.0	0.1	0.2	21.0	0.1	994
CP106	10/10/2008	3.4-5.0	DR	DR	DR	DR	
BH201	02/10/2008	4.0-7.2	**25.6**	***6.7***	1.2	1.6	982
BH201	10/10/2008	14.0-19.5	0.0	0.0	20.5	0.0	1005
BH202	02/10/2008	1.0-3.8	**25.2**	***13.8***	2.0	0.2	982
BH202	10/10/2008	13.0-15.1	0.1	0.3	20.7	1.3	1005
BH203	02/10/2008	2.50-7.82	**6.4**	***9.4***	1.6	4.9	981
BH203	02/10/2008	13.0-15.5	**8.5**	***7.9***	0.3	0.4	981
BH204	02/10/2008	3.45-7.5	0.1	0.1	18.7	0.2	994
BH205	10/10/2008	1.0-4.1	0.0	*3.3*	7.3	0.0	1004
BH205	10/10/2008	8.0-11.2	0.0	0.0	21.4	0.0	1004
BH206A	02/10/2008	9.0-12.1	0.0	0.2	21.0	0.1	981
BH207	10/10/2008	5.50-7.8	0.0	0.5	20.3	0.0	1005
BH208	10/10/2008	3.00-6.55	0.0	0.1	21.1	0.1	1007

Notes for Table 3.3

Carbon Dioxide concentrations greater than 5.0% vol/vol shown in ***bold and italics***.
Methane concentrations greater than 1% shown in **bold**.
DR = Destroyed.

3.5 Level Survey

The boreholes positions have been surveyed using a hand held Global Positioning Satellite system, with the elevations established from an earlier land survey.

Table 3.4, provides a summary of the ground elevations at each borehole.

Table 3.4
Summary of Borehole Elevations

Location	Elevation (mAOD)
BH201	142.23
BH202	142.64
BH203	147.5

Location	Elevation (mAOD)
BH204	132.89
BH205	146.5
BH206A	149.09
BH207	139.5
BH208	126.63

3.6 Laboratory Testing Programme

Based upon the former use of the site, thirteen soil samples were selected for a range of analytes including asbestos, metals, pH, sulphate and sulphide, cyanide, phenols, total organic carbon (TOC), total and speciated polycyclic aromatic hydrocarbons (PAH) and total petroleum hydrocarbons (TPH).

Four soil samples were also submitted for Waste Acceptance Criteria (WAC) testing.

The analytical work was undertaken by Derwentside Environmental Testing Services of Durham and the test certificates are provided within Appendix III.

A selection of geotechnical samples (see Appendix IV) were submitted to Professional Soils Lab for pH, soluble sulphate tests, particle size distribution (PSD), quick undrained triaxial and consolidation undrained triaxial tests.

4.0 CHEMICAL TESTING

4.1 Background and Reference Guidance

Laboratory testing of potential contaminants of concern has been performed on selected samples from material that is to be excavated and either removed offsite or retained on site.

As material is to be removed offsite, to either a landfill facility, or used as a construction/landscaping fill it is considered necessary to provide an overview of the chemical status of the material. Similarly if material, such as Made Ground is to be retained on site, in a landscaping area, then an assessment needs to be made of the potential impact on construction workers, the local ecology and end users.

At a Tier I stage the long term (chronic) human health toxicity of the soil has been assessed with reference to DEFRA/Environment Agency Contaminated Land Exposure Assessment (CLEA) Soil Guideline Values (SGV) for a residential (with no plant uptake scenario) using default parameters. Where Environment Agency generic guidance is absent, reference has been made to the Chartered Institute of Environmental Health (CIEH)/Land Quality Management (LQM) Generic Assessment Criteria (GAC) which are also based upon generic sandy soils and land uses.

The soil concentrations have been input into CAT-WASTE^{SOIL} a proprietary software package that allows for the classification of soils into either hazardous or non-hazardous waste.

CAT-WASTE^{SOIL} has been designed to cover the European Waste Catalogue code number 17 05 03 “soil and stones containing dangerous substances”.

The assessment of chemical data to determine the potential non-hazardous/hazardous status has been developed with adherence to the following:

- Environment Agency. Hazardous Waste, Interpretation of the definition and classification of hazardous waste. Technical Guidance WM2. Version 2.1 June 2003, ISBN:1 84432 130 4;
- The Hazardous Waste Directive, (HWD, Council Directive 91/689/EC);
- European Waste Catalogue, 2002 (EWC 2002, Commission Decision 2000/532/EC) as amended by Commission Decision 2001/118/EC, 2001/119/EC and Council Decision 2001/573/EC;
- List of Waste (England) Regulations 2005.
- Approved Supply List (Eighth Edition), 2002. ISBN: 0 7176 2368 8

The assessment system has not been biased to accommodate a particular type of site or industrial process as such it is intended to be an impartial assessment of all contaminated soils according to UK Regulations and published guidance.

The chemical test data indicates that all of the materials sampled are not hazardous.

It should be noted that from 30 October 2007 all non-hazardous waste needs to be pre-treated prior to landfilling.

4.2 Impact on End Users

Table 4.1 below provides a summary of the chemical testing data and comparison with a residential with plant uptake end scenario. A residential with no plant uptake scenario has been adopted as there are no Soil Guideline Values for open space areas.

Table 4.1
Summary of Chemical Testing

Potential Contaminant of Concern	Range of Values (mg/kg)	Assessment Criteria (mg/kg)	Source of Criterial	No of Exceeedances	Location of Exceedances & Depth (m)
Arsenic	<3 – 39 (23)	20	DEFRA/EA SGV's	2	CP104,0.0 BH207, 2.95
Chromium	<10 – 200 (23)	200	DEFRA/EA SGV's	0	
Mercury	0.1 – 0.23 (23)	15	DEFRA/EA SGV's	0	
Nickel	4.8 – 36 (23)	75	DEFRA/EA SGV's	0	
Selenium	<0.5 (23)	260	DEFRA/EA SGV's	0	
Lead	<10 – 98 (23)	450	DEFRA/EA SGV's	0	
Cadmium	<0.5 – 3.5 (23)	30	DEFRA/EA SGV's	0	
Phenol	<0.1 – 0.4 (23)	21900	DEFRA/EA SGV's	0	
Vanadium	4.1 – 80 (23)	150	CIEH 1% SOM	0	
Naphthalene	<0.01 – 2.1 (20)	6.94	CIEH 1% SOM	0	
Fluorene	< 0.01 – 0.44 (20)	2770	CIEH 1% SOM	0	
Benzo(a) pyrenre	<0.01 – 0.60 (20)	1.30	CIEH 1% SOM	0	
Dibenzo(a,h)anthracene	<0.01 – 0.9 (20)	1.30	CIEH 1% SOM	0	
TPH	<10 – 970 (23)	500	EA Inert Landfill WAC	1	CP101/0.1
Beryllium	<0.5 - 5.7 (23)	84.9	CIEH 1% SOM	0	
Copper	<5 – 220 (23)	2080	CIEH 1% SOM	0	
Zinc	<10 – 3600 (23)	8250	CIEH 1% SOM	0	
Asbestos	Absent (23)	Presence		0	
Total Cyanide	<1	20	Dutch Intervention Value	0	

Notes for Table 4.1

Value in brackets in Range of Values refers to total number of samples tested.

The above testing indicates an absence of any concentrations that would pose a risk to long term human health, for material that is retained on site, within an area of landscaping or open space. Elevated total arsenic was found at two locations in ashy Made Ground and it would be prudent to place this material if left on site beneath a cover of natural material to break any pollutant linkage and to promote the healthy growth of grass.

Elevated total petroleum hydrocarbons were found at CP101, although this concentration is likely to be related to a minor fuel spill. As part of the development of this area a surface scrape the material in this area should be performed to remove the impacted material.

Asbestos fibres were not found within any of the twenty three soil samples.

4.3 Waste Acceptance Criteria Testing

Waste Acceptance Criteria (WAC) testing has been conducted on seven samples in accordance with Environment Agency guidance WM2, Version 2, 2006. The WAC testing allows for a determination whether based on chemical concentrations a material can be deposited in a hazardous facility and if deemed to be non-hazardous in accordance with the output from CAT-WASTE*SOIL,* whether it can be tipped either at an inert or non-hazardous landfill facility.

Waste Acceptance Criteria are set out in the Landfill Directive (Directive 1999/31/EC on the landfilling of waste) and Council Decision 03/33/EC, as implemented by Schedule 10 of the Environmental Permitting (England and Wales) Regulations 2007.

The testing has been undertaken in accordance with BS EN 12457 (Parts 1 to 4):2002 Characterisation of Waste Leaching - Compliance test for leaching of granular waste materials and sludges.

Wastes can only be accepted at a landfill if they meet the relevant Waste Acceptance Criteria (WAC) for that type of landfill.

There are three different WAC for:

- Inert waste
- Non – hazardous waste
- Hazardous waste

Each WAC might include:

- A list of acceptable wastes which do not have to be tested; and/or
- Leaching limit values for a number of contaminants; and/or
- Limit values for other parameters.

The sample from CP104 at 2.0m in the Made Ground (ash/cinder granular horizon) proved an exceedance of the total organic carbon and loss on ignition criteria for hazardous waste. These two exceedances would imply that the material would require deposition in a hazardous landfill site; however the analytical results should be treated as suspicious.

The samples from BH201 at 2.45m, BH202 at 2.45m, BH203 at 1.65m, BH206 at 0.30m, CP105, 1.2m and CP106 1.0m all fulfilled the criteria of inert waste for all of the parameters.

It is therefore envisaged that most if not all of the Made Ground could be classified as inert waste with a minor proportion being non-hazardous. The non-hazardous component is envisaged to be the granular ash/cinder based material originating from a former boiler.

4.4 Ground Gas Assessment

The potential impact on the development from ground gases has been assessed with reference to standards and guidelines published in Assessing Risks Posed by Hazardous Ground Gases to Buildings, CIRIA C659, 2006 and BS8485, Code of Practice for the characterization and remediation from ground gas in affected developments, 2007.

The gas monitoring shows that BH201, BH202 and BH203 exhibit elevated methane and carbon dioxide together with positive flow rates. The source of the ground gas is likely to be from the tipped materials from the former reservoir area, although BH203 also proved elevated methane and carbon dioxide at depth (13.0m to 15.5m). The source of gas at depth could be from gas migrating from overlying strata or be from a deeper natural source.

The elevated ground gas concentrations are not considered to pose a risk to the development however they do serve to indicate that the tipped materials do have a biodegradable component and any material retained on site should incorporate a further ground gas monitoring regime with the possible implementation of a passive gas dissipation system.

4.5 Groundwater Quality Assessment

The concentration of potential contaminants of concern have been assessed in accordance with the Environment Agency "technical advice to third parties on Pollution of Controlled Water for PartIIa of the Environmental Protection Act 199, V2".

As the development area is close to surface water features Drinking Water Standards (Water Supply (Water Quality) Regulations 1989 & 2000) and Environmental Quality Standards have been used. Where the Drinking Water Standards have been used the maximum permissible concentrations have been utilised.

Table 4.2
Summary of Groundwater Chemical Testing

Potential Contaminant of Concern	Assessment Criteria (µg/l)	Source	BH101 (1.54m)	BH102 (0.96m)	BH103 (0.58m)	BH104 (3.53m)
Arsenic	10	Water Supply Regs	2	1	<1	1
Boron	1000	Water Supply Regs	<20	<20	40	<20
Cadmium	5.0	Water Supply Regs	<0.5	<0.5	<0.5	<0.5
Mercury	1.0	Water Supply Regs	<0.05	<0.05	<0.05	<0.05
Nickel	20	Water Supply Regs	<1.5	2.8	<1.5	2.6
Selenium	10	Water Supply Regs	<1	1	<1	3

Potential Contaminant of Concern	Assessment Criteria (µg/l)	Source	BH101 (1.54m)	BH102 (0.96m)	BH103 (0.58m)	BH104 (3.53m)
Cyanide	50	Water Supply Regs	<0.05	<0.05	<0.05	<0.05
Sulphate	250000	Water Supply Regs	23	93	6	49
PAH(4)	0.1	Water Supply Regs	0.07	0.03	0.03	0.03
Benzo(a) pyrene	0.01	Water Supply Regs	**0.02**	<0.01	<0.01	<0.01
Chromium	5.0	EQS	**7**	4	5	**8**
Lead	25	Water Supply Regs	<0.5	13	<0.5	<0.5
Vanadium	20	EQS	2	2	1	2
Copper	2	Water Supply Regs	<1.6	<1.6	<1.6	<1.6
Zinc	8	EQS	<5	8	**14**	**10**
TPH	10	Water Supply Regs	**<50**	**<50**	**<50**	**70**

Notes for Table 4.2

Water Supply Regs = Water Supply (Water Quality) Regulations 1989 & 2000 and draft Private Water Supplies Regulations 2008.
PAH = Sum of benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, indeno(1,2,3-cd)pyrene.
In the case of TPH a withdrawn standard but normally adopted by the EA for assessment purposes.
Values in bold greater than assessment criteria.
All measured concentration units in µg/l.

The groundwater assessment indicates that there are minor exceedances of the standards for zinc, chromium, benzo(a)pyrene and total petroleum hydrocarbons. The exceedances are however not considered to be significant and do not require further investigation or assessment based on the existing and proposed land uses. It will however be necessary to consult with the Environment Agency on the need for any further ground investigation based on the existing dataset and development proposals.

6.0 ENGINEERING ASSESSMENT

6.1 Ground Conditions

The ground conditions within the area investigated as part of the Addition 4 area are uniform, with a varying mantle of Made Ground, underlain by glacial clays, sands and shales. The sequence encountered is similar to that found in previous site investigations.

Within the delivery area of the Addition 3 area three boreholes were drilled within the first phase of the Clancy consulting site investigation, to a maximum depth of 6.4m. The boreholes proved a thin sequence of Made Ground comprising of a sub-base with geotextile reinforcement underlain by clays and shale. The rockhead comprises of shale which was encountered at a depth of 3.10m, 1.5m and 0.70m in CP101, CP102 and CP103 respectively.

The boreholes (CP104, CP105, CP106, CP201- CP207) drilled in the open space area encountered a sequence of Made Ground underlain by clays and a shale horizon. Made Ground was found to a substantial thickness in CP104 and CP105, with the material in CP105 resembling boiler ash waste.

In-situ testing was performed within the boreholes, consisting of standard penetration testing (SPT's) and the undertaking of undisturbed sampling (U100's). Geotechnical laboratory testing was performed on selected samples from the boreholes.

6.2 Volume of Material, Disposal Options and Costs

The volume of excavated materials for a 1 in 3 slope profile (with a 5m wide mid level bench) has been calculated by the use of PDS software. The volumes should be treated with caution and are based on the mapping of the top of each horizon using triangulation.

Table 6.1 provides a summary of the volumes for the respective horizons.

Table 6.1
Summary of Volumes Generated to form 1 in 3 Slope

Horizon	Volume (m3)	Tonnage	Comments
Made Ground	153,368.60	303,669.82	
Upper Clay	ND		Not modelled separately
Sand	ND		Not modelled separately
Lower Clay	135,262.90	282,699.46	Volume includes Upper clay and Sand
Shale	20,536.90	54,217.41	
Total	309,168.40	640,586.69	

Notes for Table 6.1

ND = not determined
Tonnage estimate for Made Ground based on 10% bulking factor and 1.8tonnes/m^3
Tonnage estimate for Lower Clay based on 10% bulking factor and 1.9tonnes/m^3
Tonnage estimate for Shale based on 20% bulking factor and 2.2tonnes/m^3

An assessment of the disposal options for the excess material generated during the earthworks has highlighted the several options available, i.e;

a) Retain as much material as possible in the north eastern sector of the area of open space;

b) Take a proportion of the material particularly the Made Ground to a licenced landfill facility as inert waste, with a minor proportion as non-hazardous.

b) Take a proportion of the material particularly the virgin clays, sands and rock to a licenced inert landfill facility or exempted site;

c) Sell the virgin materials to the open market for use as construction fill;

c) Take some of the material to a nearby construction project or for the infilling of an excavation, such as Mouselow Quarry (200m south east of the site);

d) Use a proportion of the excess material to infill the lodge that is presently used as a supply of fire fighting water.

The nearest landfill site that is capable of accepting non hazardous waste (the Made Ground) is Arden Quarry, Oven Hill road, Birch Vale, High Peak Derbyshire, SK22 1BY which is operated by P Casey Enviro Plc. Current rates for tipping are in the order of £6.50/tonne, although from April 2009 the landfill tax rate will rise from £32/tonne to £40/tonne.

The lorry turnaround time to the Arden Landfill site is approximately 1.5hours and a lorry will be able to carry 9m^3, depending upon the material type. Assuming that the whole of the Made Ground is removed to the non-hazardous landfill site (based on 1 in 3 slopes) the lorry movements from the site would be 17,040. If 30 lorry movements can be accommodated within one working day, then 568 working days would be required.

The cost for haulage is estimated to be £50/lorry and therefore the cost for haulage would be approximately £852,000. The cost for the landfilling at Arden Landfill would be negotiable but could be £1,973,853 and £12,146,792 for landfill tax, i.e total of £14,972,645 (excl VAT, currently at 15%).

Should some of the material be retained on site then this will obviously offset the cost. If the material can be demonstrated to fully meet the criteria of inert waste it is possible that the material could be deposited in a lower category inert landfill site, which will attract a £2/tonne landfill tax rate. If the material can be demonstrated to be inert it may also be deposited at a licensing exempt site.

Table 6.2 (overleaf) provides a summary of nearby inert landfill sites that may be able to accept a substantial quantity of the Made Ground (if inert) and virgin materials.

Table 6.2
Summary of Inert Landfill Sites

Location	Site Name	Status	Operator
Hyde	Greenside Farm	Operational	NSR Plc
Hyde	Woodend Farm	Aftercare	Chartrange
Hyde	Pear Tree Farm	Partially revoked licence	Mr. Hanlon
Stalybridge	Tameside MBC	Closure	Tameside MBC
Stalybridge	Greenhollins Farm	Closure	Mr. Hopwood

6.3 Slope Stability Assessment Modelling Overview

A 2D Limit Equilibrium Slope Stability Analysis has been undertaken by the use of a proprietary software package Slide™ (Version 5.037) developed by Rocscience.

Slide V5.0 allows for parametric studies to determine the sensitivity of a slope's factor of safety to minor changes. This feature compares the effectiveness of remedial measures such as drainage or slope reinforcement changes. Results are plotted on a graph to show the relative influence of each variable.

Slide V5.0 gives users an objective measure of the risk of failure associated with a slope design to determine the probability of failure/reliability index for either the deterministic failure surface with the smallest factor of safety, or for the entire slope, using almost any input parameter as a random variable. It is particularly useful for determining material properties or groundwater conditions.

Slide V5.0 contains an integrated steady-state groundwater seepage analysis module, eliminating the need for multiple applications. Groundwater flows, pressures and gradients can be calculated using finite element analysis to test groundwater condition hypotheses using a variety of boundary conditions.

A series of six cross sections (see Fig 10/0008/004, 005 & 006, Appendix I) have been analysed within Slide with the input of the ground profile and soil parameters. The slope profile has been simplified to reflect ground conditions summarised within Table 6.1 with a granular Made Ground underlain by a Upper Clay horizon, Sand horizon, Lower Clay horizon and in turn a Shale horizon. The top of each horizon has been modelled by triangulation digital ground model with PDS developed by ESL Plc.

Slope stability modelling has been developed for a 1 in 3 gradient slope, incorporating a 5m wide bench. Undrained and drained soil parameters have been utilised for each condition to allow for an examination of the stability of the slopes shortly after condstuction and in the long term.

6.4 Slope Stability Input Soil Parameters

Soil parameters have been input into the model, based on total stress and effective stress testing by Clancy Consulting. The data has been statistically analysed to allow for a probabilistic and sensitivity assessment of the potential risk of slope failure for a differing cohesion, angle of friction, bulk density and water table elevation.

Tables 6.3 (below) provides a summary of the effective stress laboratory geotechnical testing conducted on material from within the area of interest with both phases of site investigation work.

Table 6.3
Summary of Drained (Effective Stress) Laboratory Testing

Source	Location	Depth (m)	Horizon	Effective Shear Strength (kN/m^2)	Effective Angle of Friction (Degrees)	Bulk Density (Mg/m^3)
Clancy	CP104	6.17	Lower Clay	16	20	2.06
Clancy	CP105	4.15	Lower Clay	18	22	2.16
Clancy	CP106	5.18	Lower Clay	18	23.5	2.15
Clancy	BH201	11.0	Lower Clay	8	26	2.11
Clancy	BH201	5.00	Upper Clay	17	27	2.18
Clancy	BH202	5.00	Upper Clay	8	27	2.20
Mean (Upper Clay)				**12.5**	**27**	**2.19**
Standard Deviation (Upper Clay)				**6.36**	**0.00**	**0.01**
Mean (Lower Clay)				**15.0**	**22.87**	**2.12**
Standard Deviation (Lower Clay)				**4.76**	**2.52**	**0.04**

A measured effective shear strength has been measured on retrieved samples ranging from $8kN/m^2$-$18kN/m^2$.

It should be noted that Strata Surveys used an effective shear strength of 1 kN/m^2 with an effective friction angle of 31 degrees, for their slope stability modelling.

Table 6.4 (overleaf) provides a summary of undrained (total stresses) shear strength of cohesive samples recovered from both phases of site investigation work by Clancy Consulting.

Table 6.4
Summary of Undrained (Total Stress) Laboratory Testing

Source	Location	Depth (m)	Horizon	Total Shear Strength (kN/m^2)	Angle of Friction (Degrees)	Bulk Density (Mg/m^3)
Clancy	CP101	1.20	Lower Clay	14	5.7	1.98
Clancy	CP101	3.00	Lower Clay	58	0	2.17
Clancy	CP102	1.20	Lower Clay	15	6.9	1.98
Clancy	CP103	1.20	Lower Clay	61	4.6	2.14
Clancy	CP103	3.00	Lower Clay	55	1.1	2.01
Clancy	CP106	10.5	Lower Clay	256	1.1	2.25
Clancy	BH201	1.50	Made Ground	30	5.7	1.99
Clancy	BH201	3.00	Made Ground	69	1.1	2.03
Clancy	BH201	8.00	Lower Clay	64	1.2	2.13
Clancy	BH201	14.40	Lower Clay	74	0.0	2.21
Clancy	BH202	1.20	Made Ground	19	3.5	1.99
Clancy	BH202	8.50m	Lower Clay	108.0	0.0	2.18
Clancy	BH202	14.50	Lower Clay	93.0	1.2	2.12
Clancy	BH203	1.20	Made Ground	15.0	2.3	2.05
Clancy	BH203	4.00	Upper Clay	34.0	0.0	1.96
Clancy	BH203	10.0	Lower Clay	86.0	0.0	2.24
Clancy	BH203	14.0	Lower Clay	100.0	0.0	2.21
Clancy	BH204	3.00	Lower Clay	63.0	1.1	2.12
Clancy	BH204	8.00	Lower Clay	54.0	1.1	2.16
Clancy	BH205	2.00	Made Ground	62.0	3.4	1.94
Clancy	BH205	8.00	Lower Clay	55.0	0.0	2.11
Clancy	BH206A	1.20	Made Ground	46.0	0.0	1.90
Clancy	BH206A	3.00	Made Ground	111.0	0.0	2.12
Clancy	BH206A	9.00	Lower Clay	96.0	0.0	2.14
Clancy	BH207	5.50	Lower Clay	61.0	2.3	2.14
Clancy	BH208	1.20	Lower Clay	56.0	2.3	2.18
Clancy	BH208	3.00	Lower Clay	82.0	2.3	2.17
Clancy	BH208	5.00	Lower Clay	45.0	0.0	1.91
Mean (Made Ground)				**50.29**	**2.29**	**2.13**
Standard Deviation (Made Ground)				**33.73**	**2.09**	**0.09**
Mean (Lower Clay)				**74.80**	**1.55**	**2.12**

Source	Location	Depth (m)	Horizon	Total Shear Strength (kN/m^2)	Angle of Friction (Degrees)	Bulk Density (Mg/m^3)
Standard Deviation (Lower Clay)				**49.30**	**2.01**	**0.09**

6.5 Slope Stability Model Settings

The slope stability modelling has been underkten on six different sections with the differing geology simplified to reflect the Made Ground, Upper Clay, Sand, Lower Clay and Shale horizons.

A composite slip surface has been modelled asssuming that the bedrock surface constitutes the base of the model. The Bishops simplified, Janbu corrected & simplified, Mortgensen Price, Fellenius, and Spencer limit equilibrium models have selected.

A probabilistic assessment has been conducted by use of three random variables, cohesion, friction angle and unit weight with normally distributed data. Table 6.3 and 6.4 provides a summary of the data for the three soil paramters.

For a normal distribution 99.7% of all samples sould fall within 3 standard deviation of the mean vlaue. The model requires the input of relative minimum and relative maximum (distance from mean) and normally these values are at least 3 times the standard deviation. Due to the variance in the data at 3 times the standard deviation the relative minimum and maximum are greater than the mean and theforefore canot be used in the modelling. Wherever the relative minimum or maximum exceeds the mean, the mean value has been used.

The Made Ground varies between two premoniant types a granular ash/cinder type probably representing residue from a former boiler and a soft to firm clay as a result of having originated from the former reservoir. For effective stresss slope stability modelling puroposes it has been assumed that Made Ground has the same probabilistic parameters as the Upper Clay. For undrained conditions there is sufficient information to justify the use of measured parameters for the Made Ground although this testing has been conducted on cohesive materials.

For undrained conditions the Upper Clay has been given the same probabilistic parameters as the Lower Clay.

Two separate water tables have been defined in the programme of groundwater monitoring within nested installations, with a water table in the sands and near to the rockhead level. A maximum and minimum water table has been assigned for the sand, as part of the slope stability assessment thereby making the water table one of the sensitivity assessment variables. The global minimum factor of safety is calculated for 50 equal increments between the miniumum and maximum water table boundaries.

A piezometric surface has been defined in the slope stability model at the interface of the Lower Clay horizon with the underlying rockhead. The introduction of a water table at this interface is considered to be a conservative assumption.

6.6 Slope Stability Model Results

The previous slope stability work by Exploration Associates recommended that all existing slopes with an angle of less than twenty six degrees (1 in 3 gradient) should have adequate stability but that localised areas of steepened slope are unstable using the global design parameters, but can be shown to be stable if cohesion is introduced into the calculation. The report authors also stated that new slopes at an angle of twenty six degrees would have adequate stability if there is no piezometric pressure.

The previous work by Strata Surveys recommended that a nominal slope angle of 1 in 4 is used to avoid "surface sloughing due to water issuing from the sands and silts".

Table 6.5 (below) provides a summary of the global minimum factors of safety for a composite circular slip using the Bishops method.

Table 6.5
Summary of Slope Stability Modelling

Section	Profile	Stress Conditions	Minimum Global Factor of Safety	Probability of Failure/Reliability Index	Comments
1	New slope (1 in 3)	Total	22.9	0%/969.015	Minimum slip surface in rock
1	New slope (1 in 3)	Effective	12.6	0%/12.755	Minimum slip surface in Lower Clay
2	New slope (1 in 3)	Total	23.3	0%/202.949	Minimum slip surface in rock
2	New slope (1 in 3)	Effective	3.6	0%/50.794	Minimum slip surface in rock
3	New slope (1 in 3)	Total	10.1	0%/2.931	Minimum slip surface in sand
3	New slope (1 in 3)	Effective	2.5	0%/42.284	Minimum slip surface in rock
4	New slope (1 in 3)	Total	4.4	0%/3.678	Minimum slip surface in sand
4	New slope (1 in 3)	Effective	2.0	0%/84.645	Minimum slip surface in rock
5	New slope (1 in 3)	Total	14.4	0%/198.497	Minimum slip surface in rock
5	New slope (1 in 3)	Effective	2.3	0%/104.684	Minimum slip surface in rock

Section	Profile	Stress Conditions	Minimum Global Factor of Safety	Probability of Failure/Reliability Index	Comments
6	New slope (1 in 3)	Total	21.0	0.81%/1.806	Minimum slip surface in Lower Clay
6	New slope (1 in 3)	Effective	6.0	0%/4.801	Minimum slip surface in Lower Clay

Notes for Table 6.5

Probability of failure based on number of global minimum failure surfaces having factor of safety lower than 1.0 in 10,000 analyses by Monte Carlo sampling.

The Reliability Index represents the number of standard deviations which separate the MEAN Factor of Safety, from the critical Factor of Safety (= 1). The Reliability Index should be at least 3 or greater, to have reasonable assurance of a safe slope design.

The above results indicate that using undrained and effective stress conditions that the factor of safety against sliding for the existing situation are satisfactory (greater than 1.3) for a slope with a gradient of 1 vertical to 3 horizontal (nineteen degrees).

British Standard BS6031:1981 (Code of Practice for earthworks) recommend a factor of safety for first time slides of 1.2 where pre-existing slip surfaces exist.

The factors of safety are higher than in previous modelling exercises by Clancy Consulting and Exploration Associates/Strata Surveys due to the additional borehole data, which has proved the presence of a steeply inclined rockhead surface. The rockhead surface has been defined by the ground modelling software as intercepting the new slope at a mid-elevation point in Section 2 to Section 3. Previous modelling has not benefitted from the gain in strength from use of the weathered shale/mudstone horizon. The new model by Clancy Consulting also represents a substantial enhancement due to the use of a sophisticated probabilistic modelling and use of additional laboratory strength data.

The adequate factors of safety indicate that a steeper slope profile may be used particularly where the weathered rock is exposed. It is possible that a 1 in 1 slope (45 degrees) could be used subject to further assessment of the quality of the weathered rock. The additional assessment could take the form of additional geotechnical boreholes and subsequent geotechnical testing to determine effective stress parameters on cored intervals.

6.7 Material Properties

Geotechnical index and compaction testing has been performed on selected materials to assess the potential use of surplus materials on site.

The geotechnical testing (see Appendix III) has been performed on selected samples and the results are tabulated overleaf in Table 6.6.

Table 6.6
Summary of Geotechnical Testing

Location	Depth (m)	Horizon	Moisture Content (%)	Casagrande Classification	% Gravel/Sand/Silt/Clay	OMC %	MDD (Mg/m^3)
BH201	0.40	Made Ground	**20 (+9)**		13/40/27/20	11	1.94
BH201	1.95	Made Ground	22				
BH201	3.00	Made Ground	21	Intermediate			
BH201	3.50	Made Ground	29				
BH201	5.00	Upper Clay	26	High	5/72/13/10		
BH201	11.50	Lower clay	16				
BH201	14.40	Lower Clay	15	Intermediate			
BH202	0.30	Made Ground	17				
BH202	1.20	Made Ground	21				
BH202	1.65	Made Ground	22				
BH202	3.50	Made Ground	**22 (+12)**		6/41/30/23	10	1.92
BH202	5.00	Upper Clay	18	Low			
BH202	11.50	Lower Clay	13	Low			
BH203	1.00	Made Ground	19				
BH203	2.45	Made Ground	**23 (+8)**		13/49/22/16	15	1.84
BH203	3.45	Made Ground	23				
BH203	5.00	Upper Clay	20		5/32/37/26		
BH203	7.45	Lower Clay	9.4				
BH203	8.45	Lower Clay	10				
BH204	1.7	Made Ground	**19 (+8)**			11	1.97
BH205	2.5	Made Ground	**23 (+4)**	Not plastic	37/40/16/7	19	1.52
BH205	5.5	Sand	11				
BH205	10.7	Lower Clay	16				
BH206	2.7	Made Ground	**21 (+8)**		5/30/38/27	13	1.90
BH207	0.3	Made Ground	20				
BH207	1.2	Made Ground	21				
BH207	4	Made Ground	**26 (+8)**	Not plastic	53/29/15/3	18	1.58

Notes for Table 6.5

OMC = Optimum moisture content%
MDD = Maximum Dry Density Mg/m^3
Moisture content in bold greater than optimum moisture content. Value in brackets represents difference.

The compaction testing indicates that the natural moisture content within the Made Ground is greater than the optimum moisture content, in some cases by over 10%. The placement of any surplus material if placed in a controlled manner (and if required to be compacted) would require a period of initial drying, prior to placement.

6.8 Engineering Works

It is recommended that all new slopes are offset from the new building structure and parking areas by 5m, with the retention of all of the passive dewatering wells at the toe of the existing slope.

The new slopes should be designed to a gradient of 1 in 3 (eighteen degrees), possibly steeper, subject to further assessment. The slope should incorporate a herringbone pattern slope drainage system (with geotextile filtration system) to prevent erosion of the new slope faces, particularly where the sand horizon is exposed. A toe drain should also be incorporated into the design and the flows from the upper benched slope could be diverted along the mid-level bench.

To facilitate the construction of the new slope it is recommended that a bench of 5m width is incorporated into the overall slope. This will also promote stability and allow for the collection of groundwater and surface water run-off.

The earthworks will expose a sequence of Made Ground, sands, soft clays, firm to stiff clays and shale, which could be removed by large scaled scrapers. It is anticipated that the shales will be able to be “ripped” with an excavator without recourse to prior fragmentation. Where the sands are exposed the earthworks will be difficult particularly during periods of inclement weather and it may be necessary to use a face shovel rather than a scraper.

As it is intended to retain a substantial quantity (volume not determined yet) of material on site, subject to regulatory approval consideration will need to be made of the use of either trucks and excavators or scrapers.

Scrapers are advantageous earthmoving machines as they are independently capable of excavating, hauling, and placing material although neither as effective in excavating as the more specialised equipment such as hoes and shovels (or efficient as trucks in hauling and placing material) the fact that this one machine performs all three tasks makes it the equipment of choice when moving large quantities of material. Scrapers are especially economical when hauling is done off-roads and for distances between 150 metres to approximately 1000 metres.

Whilst the destination of the excess material is at this stage unclear it is possible that these materials could be retained on-site subject to approval from the regulatory authorities. It is possible that the material could be construed by the Environment Agency as waste material in accordance with the Waste Management Licensing Regulations and therefore possibly requiring some form of licensing exemption if retained on site.

Any surplus material retained on site in the north eastern sector of the open space would require careful consideration with respect to the final landform, i.e stability of material and the stability of the whole slope it is placed on. It would be prudent to place the material in a controlled manner in accordance with an engineering specification for the lower most horizons and if necessary for the whole material profile.

The stability of any new landform has not been assessed as part of this report but should be undertaken by drilling of further boreholes and assessing the soil mass and whole slope stability.

A drainage blanket should be placed beneath any retained material on site to allow for dissipation of pore pressures and to promote stability of the soil mass. It would be prudent to key (by benching) in the soil mass with the underlying soils.

6.9 Foundations

Ground conditions beneath the proposed Addition 4 footprint consist of a thin mantle of Made Ground and weak shales. Due to the anticipated foundation loadings and the variable thickness and strength of the strength materials it is recommended that all loadings are transferred to the shale horizon by piles.

Due to the high groundwater table it is recommended that driven piles are used as opposed to bored piles, due to the possible “necking” of bored piles.

This report together with anticipated foundation loadings should be provided to a specialist piling contractor for costing and technical proposals.

However it would also be beneficial to consult with a ground improvement contractor to consider the potential use of vibro-stone columns to accommodate the foundation and floor loadings.

The existing passive wells installed near to the existing toe of the slope should be retained beneath the ground floor slab.

A ground floor slab should be utilised subject to proof rolling of the formation layer and removal of any relict foundations and soft-spots within 2m influencing distance of the underside of the slab.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The Phase II site investigation has provided additional data to refine the previous Clancy Consulting slope stability assessment. The additional site investigation has proven to be very useful in defining the depth of rockhead across the proposed new slope area and has also allowed for additional strength test data to be acquired.

The level of rockhead across the proposed extension area varies substantially and is not as previously modelled. The outcrop of the rockhead is at a higher elevation in the proposed slope and therefore attributes a higher factor of safety against sliding, for the whole slope.

Measured soil concentrations have been compared against generic screening criteria for the protection of long term human health for a commercial end use and for open spaces. The concentrations do not pose a significant risk to the environment, construction workers or end users.

Ground gas concentrations with the tipped material on the slopes above the lodge have been determined to be elevated with respect to methane and carbon dioxide. The source of the ground gases is most likely to be attributed to the organic nature of the former reservoir material although there could be a minor natural component from deeper strata.

Concentrations of potential contaminants of concern in groundwater have been measured within four boreholes. Whilst there are some elevated concentrations, when contrasted with conservative drinking water and environmental quality standards the risk posed by the individual substances do not pose a significant risk to controlled waters, based on the prevailing geology and existing/proposed land uses.

An assessment of the waste classification of soils has been made by use of proprietary software that has been developed to accord with Environment Agency guidance documentation. Based on the soil concentrations from the two phases of site investigation the soils, and in particular the Made Ground, have been classified as not hazardous.

Waste Acceptance Criteria testing has determined that soils from seven boreholes could be deposited in an inert landfill facility or an exempted site. One of the samples exhibited elevated total organic content, above the hazardous waste classification, however this result should be treated as suspicious, pending further confirmatory testing.

A refined and enhanced probabilistic slope stability assessment has been undertaken by use of undrained and effective stress parameters using a simplified soil model for several distinct horizons, including the Made Ground, Upper Clay, Sand, Lower Clay and Shale. The probabilistic element comprises of variable normally distributed variables such as angle of friction, shear strength, bulk density and water table elevation. For the modelling two water tables have been incorporated, a shallow perched water table in the sand horizon and a piezometric surface along the rockhead/Lower Clay interface.

The stability of the proposed 1 in 3 slope profile along six sections lines has been made by use of Slide™ (Version 5.037) developed by Rocscience.

The resulting factors of safety against sliding for a 1 in 3 slope are all adequate with a probability of failure of <1% in all cases. Due to the high factors of safety it is possible that a steeper slope, particularly in the rock could be achievable, although at this stage this has not been modelled.

A three dimensional computer model of the development area has been created by Clancy Consulting allowing for the construction of section lines along the new slope profile and an assessment of the quantities of material generated. Based on a 1 in 3 slope profile there is estimated to be 300,000m^3 of excess material, of which 50% comprises of Made Ground.

Potential landfill sites, exempted sites and other sites that may receive the excess material have been investigated. Should the Made Ground require removal to a non-hazardous waste facility the haulage and landfill gate fees are likely to cost £15million. However it is possible that the quantity of material is likely to reduce if a revised slope profile is adopted and some of the material is allowed to be retained on site.

A local quarry operator (Wienerberger Ltd) has been contacted with respect to the receipt of virgin soils and has expressed a willingness to investigate the potential receipt of some material within the next phase of restoration work.

7.2 Recommendations

Based upon an assessment of previous and recent site investigation information Clancy Consulting recommend the following actions be implemented;

- The new slope adjacent to the Addition 4 area should be constructed at a gradient of 1 in 3 (eighteen degrees) in the superficial materials, and subject to further assessment 1 in 1 (forty five degrees) within the rock profile. The new slope should be offset from the new structure and parking areas by a minimum of 5m.

- It is recommended that additional boreholes are drilled to core the rock horizon beneath the superficial materials to allow for laboratory geotechnical testing of the shear strength of intact rock samples. The sampling of rock in-situ is however difficult and it may be more prudent to examine exposures when they are excavated to observe discontinuity patterns and thereby revise the slope design. The rock exposed will be weathered with a postulated dip direction towards to the toe of the slope.

- Due to the potential for further deterioration of the weathered rock horizon it would be prudent to consider some means of protection of the slope, such as the application of a geotextile erosion control mat.

- Due to the overall height of slope it would be prudent to incorporate a 5m wide bench into the slope design, which would promote stability and also allow for collection of surface water and groundwater.

- As part of the design of the new slope an important consideration will be the collection of groundwater and surface water. It is recommended that the slopes incorporate crest, slope and toe drainage.

- Foundation loadings will need to be transferred to the shale strata by means of end bearing driven piles. It is however possible that vibro-stone columns may be acceptable subject to receipt of technical proposals and costings from suitable contractors.

- All relict foundations, beneath proposed new foundations, should be removed to a minimum depth of 2mbgl prior to construction of any new structures.

- Ground bearing slabs will be suitable for the new structure subject to proof-rolling of the formation layer and removal of any soft spots.

- The earthwork for the new structure will generate a large quantity of material suspected to be approximately 300,000m^3 of a mixture of Made Ground, sand, clay and shale. The Made Ground has been tested in accordance with Waste Acceptance Criteria test protocols and has been largely classified as being inert if taken to a landfill facility. Further compliance testing will be required over the duration of the earthworks contract to assess suitable destinations.

- Any material that is excavated from the tipped area and used on site for land regrading operations will require the approval of the regulatory authorities. Further consultations with the regulatory authorities would determine whether the re-use of such material on site would require waste management licensing or an exemption to such licensing. Early consultations with the Environment Agency would be of benefit to all parties.

- Consultations with a local quarry operator suggest that they may be willing to accept surplus materials from the earthworks operation, subject to suitability testing. Contact should be made with the operator to determine the scope of testing and timescale for potential phasing of the receipt of materials.

APPENDIX I

Figures and Drawings

APPENDIX II

Borehole Logs

APPENDIX III

Geotechnical Testing Results

APPENDIX IV

Chemical Testing Results

APPENDIX V

Slope Stability Modelling Data & Output