



September 2015

HANSON CEMENT WORKS - PADESWOOD LANDFILL SITE

Landfill Closure Report

Submitted to:

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REPORT



Report Number 1419741.501/A.0

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Table of Contents

1.0	AREA OF THE SITE PROGRESSING IN TO DEFINITE CLOSURE	1
2.0	STABILITY OF WASTE.....	1
3.0	HYDROGEOLOGICAL RISK ASSESSMENT	2
4.0	SITE INFRASTRUCTURE	2
4.1	Leachate Infrastructure.....	2
4.2	Leachate Infrastructure Maintenance	3
4.3	Landfill Gas Infrastructure.....	3
4.4	Landfill Gas Infrastructure Maintenance	3
4.5	Groundwater Infrastructure	3
4.6	Groundwater Infrastructure Maintenance	4
4.7	Surface Water Infrastructure.....	4
4.8	Surface Water Infrastructure Maintenance	4
4.9	Cap Maintenance.....	4
5.0	MONITORING	4
5.1	Leachate Monitoring	4
5.2	Landfill Gas Monitoring	4
5.3	Groundwater Monitoring	4
5.4	Surface Water Monitoring	4
5.5	Restored Surface Monitoring	4
6.0	REPORTING.....	5
6.1	Significant Environmental Effects	5
7.0	HABITATS	5
7.1	Habitat Sites	5
8.0	REFERENCES.....	5



PADESWOOD LANDFILL CLOSURE REPORT

APPENDICES

DRAWINGS

Drawing 1: Site Map and Boundary

APPENDIX A

Stability Risk Assessment

APPENDIX B

Padeswood Landfill: Capping Geotechnical Assessment, Report reference 1051424262.515/B.0, Dated January 2012

APPENDIX C

Padeswood Landfill: Hydrogeological Risk Assessment, Report reference 1051424262.502/B.0, Dated December 2010

APPENDIX D

Padeswood Landfill: Toe Drain Infrastructure Testing Report, Report reference 13514240032.501/A.0, Dated March 2014

APPENDIX E

Leachate Monitoring Plan

APPENDIX F

Landfill Gas Monitoring Plan

APPENDIX G

Letter Responses to NRW

Golder – NRW Dated 4 March 2014: Interpretation Regarding Landfill Gas and Groundwater Quality

Golder – NRW Dated 5 December 2014: Response to NRW Queries Regarding Interpretation of Landfill Gas and Groundwater Quality.

APPENDIX H

Groundwater Monitoring Plan

(Superseded in part by this Closure Report)

APPENDIX I

Surface Water Monitoring Plan

APPENDIX J

Reporting of Significant Environmental Effects



BACKGROUND

Hanson Cement Limited (Hanson) has requested that Golder Associates (UK) Limited (Golder) prepare a Closure Report for Padeswood Landfill Site ('the Site') in accordance with Landfill Directive (Article 13) and the Environment Agency Regulatory Guidance LFD1 (2010). A previous Closure report was prepared in 2006 (Golder, 2006) and has since been the subject of discussions with Natural Resources Wales ('NRW'; formerly Environment Agency Wales). This updated Closure Report incorporates the outcomes of the discussions held, whilst detailing the current conditions at the Site and proposals for management of the Site during the post-closure and aftercare phase.

1.0 AREA OF THE SITE PROGRESSING IN TO DEFINITE CLOSURE

The Site was developed as a land raise and lies immediately south of the operational area of the Padeswood Cement Works (NGR SJ 291 620). The Works are situated approximately 5 km west of Mold, 12 km east of Chester and 12 km north of Wrexham, and about 1 km from Buckley, Penymynydd and Penyfford.

Padeswood Cement Works and Padeswood Landfill Site are surrounded by farmland on all sides. A tributary to Black Brook, understood to be referred to as Foundry Drain, is present outside of the eastern and southern boundaries of the landfill Site. To the north is the Padeswood Cement Works; to the east beyond Foundry Drain are open fields and a railway line; to the south beyond Foundry Drain is a disused railway line, footpaths and Black Brook; and to the west are open fields, a channelised ditch, Dyke Farm and Oak Tree Farm.

Limestone extracted from the local Cefn Mawr Quarry is used in the manufacture of cement at Padeswood Works. Waste and cement kiln dust (CKD) produced by the manufacturing process has been deposited at Padeswood Landfill since the opening of the cement works in 1949. Additionally to the predominant CKD waste deposited at the Site, visual observations of the Site prior to capping indicated the deposition of fine grained shale, with many broken bricks and occasional demolition wastes. As part of the Kiln 4 Project, the landfill was re-graded and ceased to accept waste in 2002.

The proposed area of Padeswood Landfill Site progressing to definite closure is demonstrated on Drawing 1 of this report.

2.0 STABILITY OF WASTE

The Site was developed as a land raise and is a domed feature with three distinctive side slopes facing the north, east and southwest. A Stability Risk Assessment ('SRA') was carried out for the Site in 2006 (Appendix A) which investigated the stability of the capping and restored surface of the waste. According to the SRA, the peak of the domed feature is at approximately 121 m AOD, with the base of the slopes varying from around 101 to 105 m AOD.

Gas pressures and waste settlement are expected to be negligible due to the nature of the waste and are therefore not expected to affect the stability of the capping system.

Site inspections in 2006 noted localised failures to the restoration soils.

Stability modelling as part of the 2006 SRA identified:

- The final slopes of the waste mass were stable, with safety factors in excess of 1.3;
- The capping system to the east and south of the landfill was considered to be stable when considering the risk of cover soil sliding and tensile failures in the GCL materials in all scenarios modelled. During the inspection carried out in 2006, no evidence of cover soil failure was identified in these areas; and



- The analysis undertaken for the north and west of the landfill indicated potential failure of the cover soils when little to no water pressure was applied. Localised failure was identified in these areas during the inspection carried out between 2006 and present, with the analyses confirming this.

Following the recommendations laid out in the 2006 SRA, a Capping Geotechnical Assessment was carried out in 2012 (Appendix B). The assessment comprised a field investigation (September 2011) into the condition of the restoration soils and Geosynthetic Clay Liner ('GCL'), with the results used to reassess the stability modelling carried out as part of the 2006 SRA. The following findings were reported in the geotechnical assessment report:

- The analyses indicated that tensile forces were not interpreted to develop within the GCL liner. Field observations during trial pitting also indicated that the GCL liner was intact with no signs of over-stressing beneath the restoration soils;
- Laboratory testing suggested that the interface shear strengths were greater than the values assumed during the previous 2006 SRA; and
- Additional modelling (which incorporated the site-specific interface shear strength testing) showed that whilst the eastern and southern areas of Site were still calculated to remain stable under various conditions, the western and northern areas still showed potential for failure when the PSR (Plane Strain Ratio) value reaches 0.5. This was again consistent with the location of the failures which had been observed in the restoration soils on Site.

Based on the findings of the site investigation and subsequent stability assessment, it is considered that it will be necessary to remediate the restoration soils on the northern and western capping slopes of Padeswood Landfill. It has been indicated from NRW that given that the findings at the time of the site investigations were that the GCL liner was intact and not over-stressed, the Site can progress in to formal closure prior to any subsequent works on restoration soil stability being completed.

The most recent topographic survey of the Site is presented in Drawing 515/1 of Appendix B.

3.0 HYDROGEOLOGICAL RISK ASSESSMENT

An updated hydrogeological risk assessment was prepared in December 2010 to support ongoing discussions regarding hydrogeological risk and define closure of the landfill. The risk assessment is attached in Appendix C of this report. The findings of the assessment indicated that the risk from the Site on the underlying Coal Measures aquifer and ultimately on the River Alyn were acceptable.

4.0 SITE INFRASTRUCTURE

4.1 Leachate Infrastructure

The Site is unlined, although it is understood that a head of leachate of less than 1 m is perched on the underlying Drift deposits.

Prior to capping of the Site the level of leachate within the landfill was higher than it currently is. At the time of capping leachate toe drains were installed in order to manage leachate head in the flanks of the waste to below ground level. These leachate toe drains were installed to feed into a concrete collection sump that has subsequently been identified to have been excavated into the Drift deposits. Leachate toe drain investigations have been conducted at the Site which have considered pumping trials and a consideration of invert levels. The reports from these investigations are provided in Appendix D. The findings of these reports identified that subsequent to capping of the Site leachate levels have fallen and as a consequence are lower than the toe drain. During pumping trials the toe drain pipework and manholes were pumped out and did not recharge. The pumped water was sampled and analysed and was not found to be representative of leachate and most likely to be rainwater that had collected in the drain. Leachate



generation rates are limited by the cap and given that leachate levels are below the toe drain it no longer has a function at the Site.

There are currently two locations where leachate can be monitored at the Site, L1 and L3. The proposed leachate monitoring borehole locations can be seen on Drawing 1.

Where possible, leachate level and quality will continue to be monitored as outlined in the Leachate Management Plan (Appendix E).

In May 2015 the depth to leachate was measured in leachate wells L1 and L3. Leachate well L1 is installed to the base of the landfill, the measured depth to base of the well was 8.24 m with a depth to leachate of 7.94 m hence indicating a perched head of leachate on the base of the landfill of 0.30 m. Leachate well L3 is installed through the base of the landfill in to a lens of sand and gravel 2.25 m beneath the landfill. It is considered that the response zone reflects the composition of leachate perched within this lens. The depth to the base of the well was 13.52 m with a depth to leachate of 9.52 m indicating a head of leachate within the waste of 1.75 m.

A sample of leachate was recovered from L3 which identified a concentration of ammoniacal nitrogen of 47.7 mg/l, chloride of 3,640 mg/l and a pH of 12.9.

4.2 Leachate Infrastructure Maintenance

Maintenance of the leachate monitoring infrastructure will be carried out as outlined in the Leachate Management Plan. The Leachate Management Plan has been included as Appendix E of this report.

4.3 Landfill Gas Infrastructure

An active gas control system is not required at the Site due to the predominantly inert waste types that were deposited, and therefore gas management is currently achieved by gas monitoring systems within the waste. Monitoring for landfill gas will be conducted on the in-waste monitoring boreholes L1 and L3, as outlined by the Landfill Gas Management Plan in Appendix F. The proposed landfill gas monitoring borehole locations can be seen on Drawing 1. An appraisal of the monitored gas composition is attached in Appendix G.

4.4 Landfill Gas Infrastructure Maintenance

In the event any of the in-waste monitoring boreholes are found to be defective, recommendations for remedial works will be proposed and conducted as outlined in the Landfill Gas Management Plan (Appendix F).

4.5 Groundwater Infrastructure

Due to the land raise design of the Site, there are no groundwater management systems required at the Site.

Shallow groundwater in the superficial deposits is thought to be perched at the interface between the superficial deposits and the underlying Coal Measure deposits, or within discontinuous lenses of sand and gravel. Deeper groundwater found in the Coal Measures locally is considered a Secondary A aquifer.

Groundwater elevations in the superficial deposits vary depending on the elevation of the lens of permeable material in which the groundwater is perched. The groundwater elevation in the superficial deposits is also dependant on other factors, such as the influence of the presence of surface waters in the limited areas where there is the potential for the coincidence of permeable lenses and the surface water course, and the influence of the underlying Coal Measures aquifer for which the elevation of groundwater is much lower. There is no distinct regional gradient for groundwater flow in the superficial deposits given the combined effect of each of these contributing factors. The vertical hydraulic gradient to the underlying Coal Measures aquifer is greater than lateral gradients generated in the superficial deposits. As part of Appendix H, an indication of the hydraulic gradient in the Coal Measures and lower superficial deposits is presented, which indicates that the gradient is in the direction of the south west. This would indicate that BH14 and GA4 are down gradient to the landfill.



Monitoring of both shallow and deep groundwater will be carried out in accordance with that outlined in the Groundwater Monitoring Plan (Appendix H). Groundwater monitoring locations can be seen on Drawing 1.

4.6 Groundwater Infrastructure Maintenance

Maintenance of the groundwater infrastructure will be carried out as outlined in the Groundwater Management Plan (Appendix H).

4.7 Surface Water Infrastructure

Appendix I – To be included following NRW response.

4.8 Surface Water Infrastructure Maintenance

Appendix I – To be included following NRW response.

4.9 Cap Maintenance

The SRA (Appendix A) indicates that the capping system comprises a 200 mm blinding layer of clay, overlain by a Bentofix 4900-1 Geosynthetic Clay Liner (GCL), which is in turn overlain by approximately 250 mm of protective clay. The protective clay is overlain by up to 750 mm of restoration soils in areas where tree planting was undertaken. The final layer of the restoration system comprised 150 mm of topsoil.

The restored surface will be monitored by a relevant person for visible indications of instability on a quarterly basis. The restoration soils will be checked for such issues as erosion or loss of stability. Any issues found will be flagged by relevant person and remedied as soon as logistically possible.

5.0 MONITORING

5.1 Leachate Monitoring

Leachate monitoring will be carried out as outlined in the Leachate Monitoring Plan (Appendix E).

5.2 Landfill Gas Monitoring

Landfill gas monitoring will be carried out as outlined in the Landfill Gas Monitoring Plan (Appendix F).

5.3 Groundwater Monitoring

Groundwater monitoring will be carried out as outlined in the Groundwater Monitoring Plan (Appendix H).

5.4 Surface Water Monitoring

Surface water monitoring will be carried out as outlined in the Surface Water Monitoring Plan (Appendix I).

5.5 Restored Surface Monitoring

The restoration soils will be inspected on a quarterly basis, and following heavy rainfall. The quality of the restoration soils will be checked for such issues as erosion or loss of stability. Any issues found will be flagged by the monitoring staff and remedied as soon as logistically possible.

Following a meeting with Tony Roberts on 27 March 2015, NRW have recommended that Site topographical surveys are carried out on a bi-annual basis for the first year following closure, with surveys to be carried out annually following that. The Site survey will be repeated in order to ascertain long-term trends in cap stability.



6.0 REPORTING

6.1 Significant Environmental Effects

The reporting of significant environmental effects will be carried out as per the landfill gas, leachate, groundwater and surface water management plans. A template for reporting of Significant Environmental Effects is provided in Appendix J.

7.0 HABITATS

7.1 Habitat Sites

A number of sensitive land uses have been identified within 10 km of the Site and these are summarised below:

- The Coal Measures Aquifer located beneath the Site is classified as a Secondary A Aquifer;
- The Site is located approximately 5 km to the west of an area along the River Dee which designated as a Surface Water Nitrate Vulnerable Zone (NVZ);
- The River Dee is also classified as a Site of Special Scientific Interest ('SSI');
- There are several other SSI's located within approximately 6 km of the Site; Coed Talon Marsh, Connah's Quay Ponds and Woodland, Buckley Claypits and Common and Maes y Grug.
- The Site is located approximately 2 km to the south of the Deeside and Buckley Newt Sites, which are considered Special Areas of Conservation ('SAC').
- The Site is located approximately 3 km to the northeast of designated "Less Favourable Areas" for farming;
- The nearest Ramsar site, Midland Meres and Mosses Phase 2 wetland, is located approximately 11 km to the southeast of the Site; and
- The nearest Special Protected Area (SPA) is the Dee Estuary, located approximately 10 km to the north of the Site.

Due to the nature of the waste, the risk to these sensitive areas is considered to be low. No Habitats assessment is required by the Specified Steps described in Schedule 1 of the original Closure Notice.

8.0 REFERENCES

Golder Associates (UK) Ltd, 2006. Castle Cement Ltd. Padeswood Landfill Site Closure Report. Report No. 06524211.500/A.0, May 2006.



Report Signature Page

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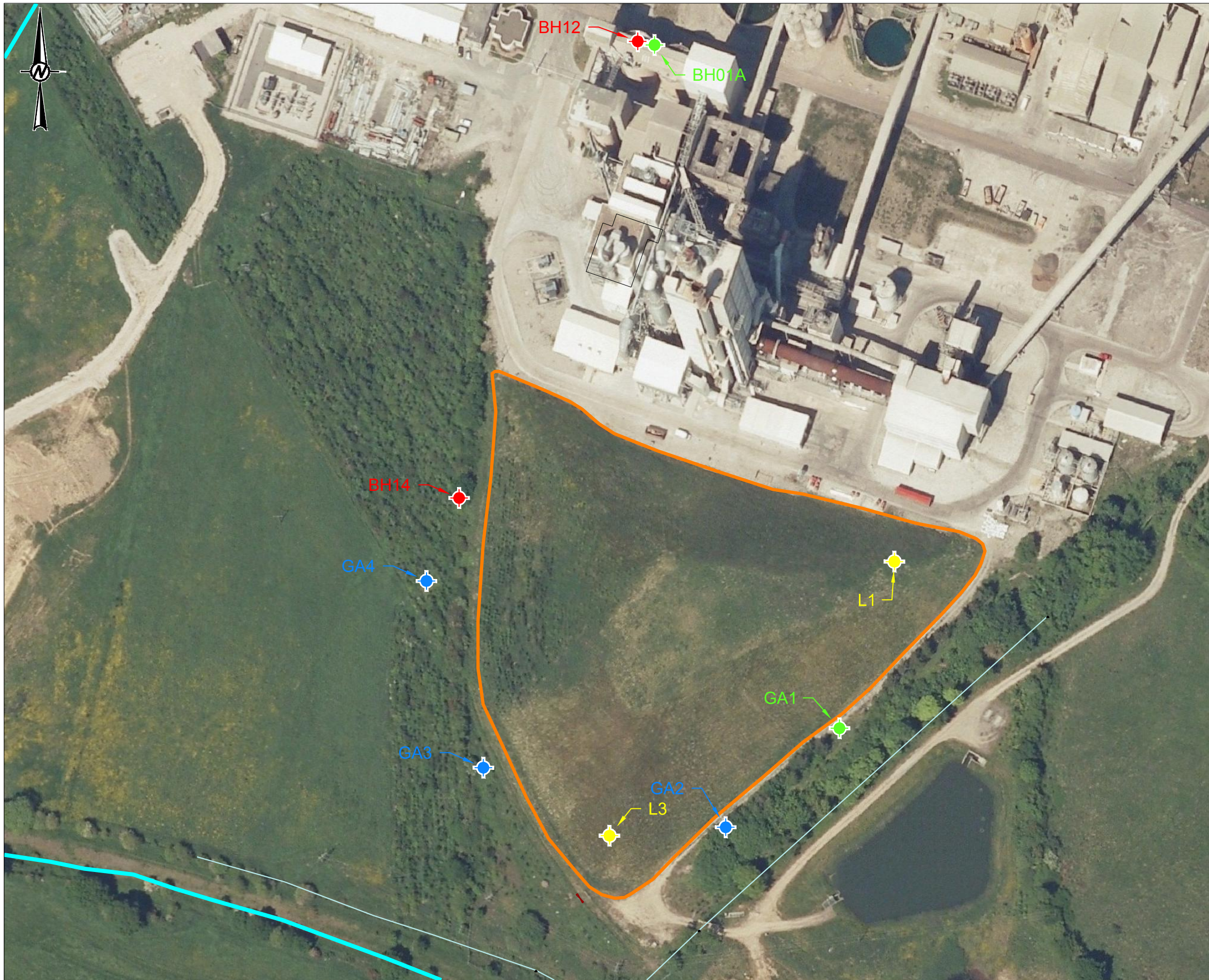
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DRAWINGS

Drawing 1: Site Map and Boundary

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LEGEND

- SITE OWNERSHIP BOUNDARY
- AREA OF SITE PROGRESSING TO CLOSURE
- GROUNDWATER MONITORING BOREHOLE (SHALLOW DRIFT)
- GROUNDWATER MONITORING BOREHOLE (DEEP DRIFT)
- GROUNDWATER MONITORING BOREHOLE (COAL MEASURES)
- LEACHATE MONITORING BOREHOLE
- STREAM

NOTES

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CONSULTANT



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PREPARED	ECS
DESIGN	SN
REVIEW	RJL
APPROVED	RJL

PROJECT
PADESWOOD LANDFILL SITE

TITLE
BOREHOLE LOCATION PLAN

PROJECT No.	CONTROL	Rev.	DRAWING
1419741.501	0001-CW-0001	A	1

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APPENDIX A

Stability Risk Assessment

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REPORT ON**APPENDIX 3****PADESWOOD LANDFILL SITE
STABILITY RISK ASSESSMENT**

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TABLE OF CONTENTS

SECTION	PAGE
1.0 INTRODUCTION.....	1
1.1 Report Context.....	1
1.1.1 Outline of the Installation	1
1.1.2 Site Setting and Previous Ground Investigations	2
1.1.2.1 General	2
1.1.2.2 Ground Conditions Proven.....	3
1.1.2.3 Groundwater and Leachate Conditions Proven.....	4
1.1.2.4 Records of Coal Mining Beneath the Site	4
1.1.3 Lifecycle Phases.....	5
1.2 Conceptual Stability Site Model.....	6
1.2.1 Final Waste Model.....	6
1.2.2 Restoration System Model.....	6
2.0 STABILITY RISK ASSESSMENT	8
2.1 Risk Screening	8
2.1.1 Final Waste Slopes Screening.....	8
2.1.2 Restoration System Screening	8
2.2 Data Summary	8
2.2.1 Waste Mass.....	8
2.2.2 Restoration System	9
2.2.3 Leachate Levels	9
2.3 Selection of Appropriate Factors of Safety	9
2.3.1 Factor of Safety for Final Waste Slopes.....	9
2.3.2 Factor of Safety for Restoration System	10
2.4 Justification for Modelling Approach and Software	10
2.5 Justification of Geotechnical Parameters Selected for Analyses	10
2.5.1 Parameters Selected for Final Waste Slopes Analyses	10
2.5.2 Parameters Selected for Restoration System Analyses	11
2.6 Analyses	11
2.6.1 Final Waste Slopes Analyses	11
2.6.2 Restoration System Analyses	12
2.7 Assessment	13
2.7.1 Final Waste Slopes Assessment.....	13
2.7.2 Restoration System Assessment	13
3.0 MONITORING AND RECOMMENDATIONS	14
3.1 Final Waste Slopes Monitoring.....	14
3.2 Restoration System Monitoring and Recommendations	14
4.0 REFERENCES.....	15

LIST OF TABLES

Table SRA1	Geological Sequence On-Site
Table SRA2	Summary of Site Investigations Carried out at Padeswood Works
Table SRA3	Summary of 2001 Site Investigation
Table SRA4	Summary of SPT 'N' Values in CKD at Coplow Quarry
Table SRA5	Summary of Laboratory Testing on CKD at Coplow Quarry
Table SRA6	Summary of Parameters Used in the Final Waste Slope Analyses
Table SRA7	Summary of Geosynthetic Parameters Used in the GCL Capping Analyses
Table SRA8	Summary of the Slope/W Runs for the Final Waste Slopes
Table SRA9	Summary of the GCL Capping Analyses

LIST OF DRAWINGS

Drawing SRA1	Padeswood Landfill in Relation to Old Mine Workings
Drawing SRA2	Topographic Survey of Capping System, and Location of Sections A-A, B-B, C-C and D-D

LIST OF APPENDICES

Appendix SRA1	Slope Stability Analyses
Appendix SRA2	Capping Stability Analyses

1.0 INTRODUCTION

1.1 Report Context

Castle Cement Ltd (Castle Cement) has requested Golder Associates (UK) Ltd (Golder) to carry out an assessment of geotechnical stability at Padeswood Landfill, located at the Padeswood Works, Flintshire. The assessment is made in relation to the requirements proceeding to *Definitive Closure* as described by the Landfill (England and Wales) Regulations 2002 (as amended).

The stability assessment has been prepared in accordance with the stability assessment methodology as outlined in the Environment Agency's guidance document released in March 2003 and entitled *Stability of Landfill Lining Systems: Report No. 2 Guidance* (Environment Agency, 2003).

The assistance of Castle Cement in the provision of data for this work is gratefully acknowledged. Golder has not independently verified any of the information supplied. Detailed design of the landfill capping system has not been undertaken and it should be noted that this report does not constitute a detailed design.

1.1.1 Outline of the Installation

The Site lies immediately south of the operational area of the Padeswood Cement Works (NGR SJ 291 620). The Works are situated approximately 5 km west of Mold, 12 km east of Chester and 12 km north of Wrexham, and about 1 km from Buckley, Penymynydd and Penyfford.

The Works is surrounded by farmland on all sides; the predominant land use is grazing though some arable farming also occurs. To the north of the Site is the Padeswood Cement Works; to the east are open fields and a railway line; to the south is a disused railway line, footpaths and Black Brook; and to the west are open fields, a channelised ditch, Dyke Farm and Oak Tree Farm.

Limestone used in the manufacture of cement is extracted from Cefn Mawr Quarry, located some 9 km from the Padeswood Works. Waste and cement kiln dust (CKD) produced by the manufacturing process has been deposited at Padeswood Landfill since the opening of the cement works in 1949. As part of the Kiln 4 Project, the landfill was re-graded and ceased to accept waste in 2002.

The Site has been developed as a landraise, and is a domed feature with three distinctive side slopes facing the north, east and southwest (see Drawing SRA2). The peak of the domed feature is at approximately 121 m AOD, with the base of the slopes varying from around 101 to 105 m AOD.

1.1.2 Site Setting and Previous Ground Investigations

1.1.2.1 General

The ground conditions at the site have been proven using a combination of published literature and ground investigation around the Site. Site investigation undertaken has comprised trial pits, shallow and deep boreholes and the installation of piezometers.

The regional geological setting beneath the Site has been established through review of the published geological map for the area (British Geological Survey, 1:50,000 scale, Sheet 108 Flint). The published stratigraphic sequence is indicated in Table SRA1.

Table SRA1: Geological Sequence On-Site

Age	Formation	Description	Depth (m)
Quaternary	Glacial Till (Boulder Clay)	Sandy silty clays with bands of sand and gravel	0 – 20.7 m
Carboniferous	Middle Coal Measures	Rhythmic sequences of seat earths, shales, sandstones, limestones and productive coal seams	Variable

The Glacial Till is typified by sandy silty clays with bands of sand and gravel. Glacial sands and gravel are present to the south of Site. The Middle Coal Measures comprise rhythmic sequences of seat earths, shales, sandstones, limestones and productive coal seams.

Several phases of site investigation have been carried out on behalf of Castle Cement in order to determine the local geological setting and for the installation of monitoring wells. The investigations are summarised in Table SRA2.

Table SRA2: Summary of Site Investigations Carried out at Padeswood Works

Date	Contractor	Site Investigation
1995	Gibb Environmental	Excavation of trial pits concentrated on the landfill area south of the current works and in an area to the east of the works used for coal stockpiling.
1998	Kennedy & Donkin	Excavation of trial pits.
1998	Castle Cement	Drilling of 6 boreholes.
1998/1999	Exploration Associates	Drilling of 13 boreholes in the area of the new Kiln 4, and towards the northern end of the landfill
January 2001	Foundation and Exploration Services Ltd	Drilling of 11 boreholes around the existing landfill
September 2004	Ground Restoration Ltd	Drilling of 5 boreholes around the proposed new development area for a landfill to the west of the existing landfill

1.1.2.2 Ground Conditions Proven

Previous Site Investigations

The site investigations that were concentrated around the landfill, as indicated in Table SRA2, have confirmed the presence of Glacial Till deposits, the observations are consistent with the Glacial Geology of the area as demonstrated by the geological map (Sheet 108 Flint).

Reference 4 indicates that Made Ground was encountered in all of the boreholes during the Exploration Associates site investigation of 1999, and in most of the trial pits in the Gibb Environmental site investigation of 1995, overlying the Glacial Till. The Made Ground comprised cement kiln dust (CKD), silty sand and clayey silt with gravel, brick, plastic, wood and concrete and fine to medium gravel sized particles of coal and shale. Some of the trial pits in the 1995 investigation were dug on the landfill, and as such terminated in the CKD waste. During the drilling of the leachate and groundwater monitoring boreholes a maximum of 6 m of waste was proven in the landfill at the time.

Site Investigation in 2001

A Site investigation was undertaken between January and February 2001. Foundation and Exploration Services Ltd under the supervision of Golder Associates drilled 11 boreholes. The purpose of this phase of site investigation was:

- To install a wider network of leachate monitoring points;
- To further characterise and determine the spatial variability of the Drift Deposits;
- To widen the network of boreholes within the shallow Drift Deposits; and
- To investigate the nature of the underlying Coal Measures Aquifer.

Details of the boreholes drilled at the Site during 2001 are summarised below.

Table SRA3: Summary of 2001 Site Investigation

<i>Borehole</i>	<i>Purpose</i>	<i>Drilling Method</i>	<i>Terminal Depth (m bgl)</i>	<i>Water Bearing?</i>
L1	Leachate Monitoring	Rotary – Fraste Rig	7.0	Leachate – yes
L2	Leachate Monitoring	Rotary – Fraste Rig	8.0	Leachate – yes
L3	Leachate Monitoring	Rotary – Fraste Rig	10.0	Leachate and groundwater
BH07	Drift Monitoring	Rotary – Fraste Rig	6.6	Dry
BH08	Backfilled	Rotary – Fraste Rig	6.1	Dry
BH09	Drift Monitoring	Rotary – Fraste Rig	5.0	Groundwater
BH10	Drift Monitoring	Rotary – Dando Rig	5.1	Dry
BH11	Coal Measures Aquifer monitoring	Rotary – Dando Rig	12.0	Groundwater
BH12	Coal Measures Aquifer monitoring	Rotary – Dando Rig	23.0	Groundwater
BH13	Coal Measures Aquifer monitoring	Rotary – Dando Rig	13.00	Groundwater
BH14	Coal Measures Aquifer monitoring	Rotary –Dando Rig	23.0	Groundwater

Borehole information from the Site investigation indicates the geology to consist of mudstones and sandstones of the Middle Carboniferous Coal Measures overlain by a sequence of Glacial Till and interbedded glacial sand and gravel lenses with a total thickness ranging between 10 to 14 m thick.

The Glacial Till, consistent with previous Site investigations, is comprised stiff orange brown sandy gravelly clay with layers and lenses of sands and gravels.

At the southern end of the landfill in the vicinity of Borehole L3 and BH07, approximately 3 m of Made Ground was penetrated. The origin of this Made Ground is unknown.

Site Investigation in 2004

The investigation undertaken in 2004 indicated the drift geology beneath a new proposed development to comprise firm to stiff brown typically sandy gravelly clay with interbedded layers of sand and gravel.

1.1.2.3 Groundwater and Leachate Conditions Proven

Inspection of the 1:100,000 Institute of Geological Sciences Hydrogeological Map of Clwyd and the Cheshire Basin confirms that the proposed development overlies rhythmic sequences of seat earths, shales, sandstones, coal and limestones (Middle Coal Measures) with a significant cover of undifferentiated Drift. The Coal Measures are collectively referred to as a minor aquifer, which may support abstractions of local importance. Some minor fissure flow may occur in the sandstones and limestones. The mine waters from coal measures are typically ferruginous and acidic although locally supplies of reasonable quality are obtainable.

Groundwater levels and groundwater quality are monitored at nine monitoring Boreholes BH01A, BH02A, BH03, BH04, BH05, BH06, BH01/02, BH02/02 and BH03/02.

Boreholes BH06, BH01/02 and BH2/02 are consistently dry or only with very small amounts of groundwater. The location of these boreholes is shown on Drawing 2 of the Closure Report.

Recent leachate level monitoring data is unavailable, as leachate levels are not monitored at present.

1.1.2.4 Records of Coal Mining Beneath the Site

The location of known coal workings is shown as Drawing SRA1. This is taken from a map of Hollins Coal Working produced by Padeswood Hall Colliery in 1902. According to coal mining records obtained from the Coal Authority, coal mining ended in 1901. The drawing indicates that recorded coal workings do not extend beneath the landfill.

Structural Geology

There are two geological faults in the vicinity of Site. One to the west trends north to south with a down throw to the west. A second fault exists to the east of the site also trending north to south. The Coal Authority records show no faults or lines of weakness in the area as affecting the Site stability.

1.1.3 Lifecycle Phases

The site is believed to have formerly been an open field and waste was deposited directly on the underlying top soil and boulder clay. The site is licensed to receive inert non toxic waste from cement manufacture and off-Site construction, off-cuts of ferrous metals, packaging materials, paper and plastics.

Historically, the site held a licence for the disposal of cement wastes, inert/non hazardous/non toxic construction and demolition wastes, non-hazardous and non-toxic waste. Visual observations prior to closure indicated that mainly fine grained shale and cement kiln dusts with many broken bricks and occasional demolition wastes had been deposited.

Padeswood was proposed to have a non-hazardous landfill classification upon submission of a Site Conditioning Plan by Castle Cement in 2002.

Upon closure, the site will continue to be regulated under its Waste Management Licence. Castle Cement will continue to maintain operational control of the Site to ensure that it does not cause any significant detrimental effects on the environment, harm to human health or detriment to amenity.

Groundwater Management

Groundwater management has not been required at the Site.

Leachate Management

Leachate management undertaken at the Site comprises drainage of leachate via a perimeter toe drain beneath the cap that directs leachate flow to a concrete sump at the southeast corner of the Site. The toe drain comprises a 250 mm diameter perforated pipe with filter gravel surround and GCL lining on the outer face and base of the drain only.

Leachate is removed from the sump and, where possible, re-introduced into the cement manufacturing process via a waste water holding tank located at Kiln 4. Alternatively, removal of leachate by tanker for treatment and disposal off-site remains the default operation and assists in the management of leachate at times when leachate cannot be returned to the cement manufacturing process.

Gas Management

The site has accepted primarily cement kiln dust waste and inert wastes for disposal, with only negligible quantities of biodegradable wastes; therefore, this waste mass is unlikely to produce significant quantities of landfill gas. Site-specific monitoring data completed as spike surveys prior to capping indicated negligible production and emissions of the bulk landfill gases methane and carbon dioxide. The inorganic nature of the waste and the confirmatory bulk gas monitoring data from the Site indicate that there is negligible risk from organic trace gas components normally associated with landfill gas.

It will not be possible to collect, treat or utilise landfill gas. The Site does not have an active landfill gas collection system.

1.2 Conceptual Stability Site Model

1.2.1 Final Waste Model

The site has accepted non-hazardous cement kiln dust (CKD) generated at Padeswood Cement Works, as well as fine grained shale, with many broken bricks and occasional demolition wastes.

The final waste slopes have typical gradients of around 1(v):3(h), though locally steepening to around 1v:2.5h. The waste has been built up as a landraise to form a domed profile with three distinctive sides, facing north, east and southwest (see Drawing SRA2).

1.2.2 Restoration System Model

The majority of the capping system, comprising a GCL cap, was constructed in 2004. The contractor for the works was Mowlem Plc, with Construction Quality Assurance (CQA) works being undertaken by CL Associates. Capping was not completed in 2004 as access was limited on the northern flank due to the construction of Kiln 4. As such, an interim CQA report for the works was submitted in November 2004 (Reference 5).

It is thought the remaining capping works, which included the northern flank of the landfill, was completed in 2005.

The interim CQA report (Reference 5) indicates that the capping system comprises a 200 mm blinding layer of clay, overlain by a Bentofix 4900-1 Geosynthetic Clay Liner (GCL), which is in turn overlain by approximately 250 mm of protective clay. The protective clay is overlain by up to 750 mm of restoration soils in areas where tree planting was undertaken. Although this area is not particularly well defined as no as-built drawings for the placement of the restoration soils is available, it is inferred from the CQA report that this was mainly along the western flank (see Drawing SRA2). The final layer of the restoration system comprised 150 mm of topsoil.

In addition, a leachate drainage system as described in Section 1.1.3 was constructed around the edges of the landfill.

Visual inspection of the cap in 2006 has noted the presence of superficial tension cracks and minor slumping on the northern and western slopes. This is subject to ongoing surveillance and monitoring by Castle Cement. The requirement for further investigation and remediation is discussed in Section 3.0.

2.0 STABILITY RISK ASSESSMENT

2.1 Risk Screening

2.1.1 Final Waste Slopes Screening

The stability of the steepest, longest and highest final waste slopes will be considered.

2.1.2 Restoration System Screening

The stability of the GCL cap and cover soils along steepest, longest and highest capped restoration profiles will be considered. In addition, the stability of the GCL cap and cover soils will be considered for the steepest slope where the thicker restoration soils were placed.

2.2 Data Summary

No site-specific shear strength testing of the materials used in the construction of the landfill capping system has been undertaken.

2.2.1 Waste Mass

Geotechnical data for analysis of the stability of the waste mass has been obtained from a Site investigation carried out by Golder at the Coplow Quarry, Ribblesdale Works, which is also a CKD landfill operated by Castle Cement. The Standard Penetration 'N' Values (SPT 'N' Values) obtained during the Site investigation are summarised in Table SRA4. The highest and lowest 'N' values have been disregarded as they are deemed not to be representative. In addition, a series of laboratory tests were carried out on undisturbed samples obtained during the Site investigation, the results of which are presented in Table SRA5.

Table SRA4: Summary of SPT 'N' Values in CKD at Coplow Quarry

	SPT 'N' Value (all values)	SPT 'N' Value (highest and lowest disregarded)
Lowest	6	10
Highest	34	17
Average	15	11
Number	6	4

Table SRA5: Summary of Laboratory Testing on CKD at Coplow Quarry

Parameter	Count	Range	Average
Moisture Content (%)	13	43 - 79	71
Clay Content (%)	2	14	14
Content of >Silt (%)	2	86	86
Effective Cohesion (kPa)	2	23 - 32	27.5
Friction Angle (Degrees)	2	35 - 37	36

The shear strength parameters obtained from testing on the CKD from Coplow Quarry indicate that the material is competent, with a high friction angle typical of a granular material. The high cohesion value is probably caused by the cementitious nature of the CKD.

In addition to the laboratory testing, observations of the behaviour of the CKD were made during the Site investigation. CKD has cementitious properties to add strength to the waste mass on exposure to moisture. Typically, as the landform is developed with the disposal of CKD, the surface of the fill crusts over and becomes hard before additional material is placed above. This effectively creates a number of reinforcing layers throughout the waste mass.

Additional material landfilled at Padeswood reportedly includes fine grained shale, with many broken bricks and occasional demolition wastes. It is considered that these materials will typically have a high friction angle.

2.2.2 Restoration System

Shear strength parameters for the analysis of the GCL cap have been obtained from a series of Golder *in-house* interface shear strength tests combined with Golder's *in-house* experience of interface shear strengths, as detailed in Appendix SRA2. The tensile strength of the GCL has been obtained from the manufacturers data sheet for the Bentofix NSP 4900-1, included as page 19 of Appendix SRA2.

2.2.3 Leachate Levels

Leachate levels at the site are not currently monitored. However, following correspondence with Castle Cement it is apparent that leachate has not been pumped from the Site for a number of months, and as the leachate is drained under gravity this may be interpreted that leachate levels are relatively low, at least at the perimeter. However, the monitoring will be reinstated as part of the Closure Report to determine leachate levels.

It is recommended that leachate level monitoring should be undertaken on a regular basis to verify the assumptions made in this analysis. Due to the lack of data, a sensitivity analysis on the effect of leachate levels has been undertaken.

2.3 Selection of Appropriate Factors of Safety

2.3.1 Factor of Safety for Final Waste Slopes

A minimum factor of safety of 1.3 against failure in the waste mass will be considered acceptable providing reasonably conservative parameters have been used.

2.3.2 Factor of Safety for Restoration System

A minimum factor of safety of 1.3 will be considered acceptable for overall stability providing reasonably conservative parameters have been used.

2.4 Justification for Modelling Approach and Software

The overall stability of the final waste profile has been assessed using the slope stability programme Slope/W. Circular failure surfaces were analysed using the Morgenstern-Price method. The stability and integrity of the capping system has been assessed using the method proposed by Jones & Dixon, 1998.

To summarise, stability assessments have been carried out to assess the following:

- **Stability of Final Waste Slopes**
Analyses of the steepest (Section A-A), longest (Section B-B) and highest (Section C-C) final waste slopes have been carried out for a range of circular failures (Morgenstern-Price method) using the Slope/W computer code. Leachate levels of 1 m, 2 m and 4 m above the base of the landfill have been modelled.
- **Stability of Restoration System**
The stability and integrity of the capping system has been carried out using four cross sections taken through the post-restoration contours. The stability of the cover soils has been assessed using the method proposed by Jones & Dixon (1998), utilising a finite slope length to assess the stability of the cover soils and the integrity of the geomembrane cap. The stability of the capping system has been assessed with dry and partially saturated restoration soils.

Methods of analysis are those described in the Agency Guidelines '*Stability of Landfill Lining Systems*' (Environment Agency, 2003). These represent best available techniques at the time of this report.

2.5 Justification of Geotechnical Parameters Selected for Analyses

This section describes the parameters used in the stability assessment. Values have been selected based on a combination of the available data, Golder's *in-house* experience and the technical literature. At all stages in the analyses, conservative parameters have been selected.

2.5.1 Parameters Selected for Final Waste Slopes Analyses

The material parameters used in the analysis of the final waste (Cement Kiln Dust) slopes are presented in Table SRA6. The parameters for the analysis of the waste slopes have been obtained from laboratory testing on samples from Coplow Quarry, *in-situ* testing at Coplow Quarry and Site observations. Relatively low cohesion values have been selected to provide a conservative analysis. The Glacial Till parameters have been obtained from a review of

available literature, with particular reference to CIRIA guide C504 'Engineering in glacial tills' in which a summary of the results of drained peak shear strength tests is presented.

Table SRA6: Summary of Parameters Used in the Final Waste Slope Analyses

Material	Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (degrees)
Cement Kiln Dust	18	5	35
Glacial Till	20	4	27

2.5.2 Parameters Selected for Restoration System Analyses

The material parameters used in the analyses of the GCL capping system are presented in Table SRA7, and justification for the parameters used is provided on Page 1 of Appendix SRA2.

Table SRA7: Summary of Geosynthetic Parameters Used in the GCL Capping Analyses

Material Interface	Cohesion (kPa)	Friction Angle (degrees)
Restoration soil/GCL	0	22
GCL/clay blinding layer	0	22

2.6 Analyses

Analyses has been undertaken on Sections A-A (Steepest), B-B (Longest), C-C (Highest) and D-D (Steepest with 750 mm restoration soils) from the survey undertaken of the completed cap (Drawing SRA2).

2.6.1 Final Waste Slopes Analyses

A summary of the Slope/W runs for the final waste slopes is presented in Table SRA8, and the output files are given in Appendix SRA1.

Table SRA8: Summary of the Slope/W Runs for the Final Waste Slopes

Ref.	Description	Factor of Safety
211_A-A_01	Steepest slope, circular failure through waste, dry	2.08
211_A-A_02	Steepest slope, circular failure through waste, leachate head = 1 m	2.04
211_A-A_03	Steepest slope, circular failure through waste, leachate head = 2 m	1.98
211_A-A_04	Steepest slope, circular failure through waste, leachate head = 4 m	1.62
211_A-A_05	Steepest slope, circular failure through waste and foundation, dry	1.94
211_A-A_06	Steepest slope, circular failure through waste and foundation, leachate head = 1 m	1.93
211_A-A_07	Steepest slope, circular failure through waste and foundation, leachate head = 2 m	1.89

Ref.	Description	Factor of Safety
211_A-A_08	Steepest slope, circular failure through waste and foundation, leachate head = 4 m	1.64
211_B-B_01	Longest slope, circular failure through waste, dry	4.34
211_B-B_02	Longest slope, circular failure through waste, leachate head = 1 m	4.10
211_B-B_03	Longest slope, circular failure through waste, leachate head = 2 m	3.32
211_B-B_04	Longest slope, circular failure through waste, leachate head = 4 m	2.84
211_B-B_05	Longest slope, circular failure through waste and foundation, dry	3.51
211_B-B_06	Longest slope, circular failure through waste and foundation, leachate head = 1 m	3.43
211_B-B_07	Longest slope, circular failure through waste and foundation, leachate head = 2 m	3.13
211_B-B_08	Longest slope, circular failure through waste and foundation, leachate head = 4 m	2.87
211_C-C_01	Highest slope, circular failure through waste, dry	2.32
211_C-C_02	Highest slope, circular failure through waste, leachate head = 1 m	2.25
211_C-C_03	Highest slope, circular failure through waste, leachate head = 2 m	2.07
211_C-C_04	Highest slope, circular failure through waste, leachate head = 4 m	1.81
211_C-C_05	Highest slope, circular failure through waste and foundation, dry	2.31
211_C-C_06	Highest slope, circular failure through waste and foundation, leachate head = 1 m	2.24
211_C-C_07	Highest slope, circular failure through waste and foundation, leachate head = 2 m	2.06
211_C-C_08	Highest slope, circular failure through waste and foundation, leachate head = 4 m	1.69

2.6.2 Restoration System Analyses

A summary of the factors of safety calculated for the GCL capping analyses are presented in Table SRA9, and the output files are given in Appendix SRA2.

Table SRA9: Summary of the GCL Capping Analyses

Description	Factor of Safety	
	Slippage of Cover Soil	Tensile Failure of GCL
Section A, Steepest Slope, PSR = 0	0.99	Infinite
Section A, Steepest Slope, PSR = 0.2	0.89	Infinite
Section B, Longest Slope, PSR = 0	2.65	Infinite
Section B, Longest Slope, PSR = 0.2	2.37	Infinite
Section C, Highest Slope, PSR = 0	1.52	Infinite
Section C, Highest Slope, PSR = 0.2	1.36	Infinite
Section D, 750 mm Restoration Soil, PSR = 0	1.12	Infinite
Section D, 750 mm Restoration Soil, PSR = 0.2	1.00	Infinite

PSR represents Parallel Submergence Ratio

2.7 Assessment

2.7.1 Final Waste Slopes Assessment

The analysis of the steepest, longest and highest waste slopes indicate a factor of safety above 1.3 for circular failure through the waste mass. It is also above 1.3 for failure through the waste mass and underlying glacial till even assuming a leachate level of 4 m above the base of the landfill. The final waste mass can therefore be considered stable.

2.7.2 Restoration System Assessment

The capping system analyses using the finite slope approach along Sections B-B and C-C indicated that the factors of safety are above 1.3 against cover soil sliding and tensile failures in the GCL materials in all scenarios modelled. During the inspection carried out in 2006, no evidence of cover soil failure was identified in these areas. The capping system can therefore be considered stable in these areas.

The analysis undertaken for Section A-A indicates potential failure of the cover soils when a no water pressure is applied, and for Section D-D the factor of safety is unity when a PSR of 0.2 is applied. Localised failure was identified in these areas during the inspection carried out in 2006, with the analyses confirming this.

Gas pressures and waste settlement are expected to be negligible due to the nature of the waste and are therefore not expected to affect the stability of the capping system.

3.0 MONITORING AND RECOMMENDATIONS

3.1 Final Waste Slopes Monitoring

It is not considered necessary to carry out site-specific shear strength testing on the waste. It is therefore suggested that the final waste slopes are visually monitored on a regular basis and following major rainfall events.

3.2 Restoration System Monitoring and Recommendations

Site-specific interface shear strength testing should be carried out to verify the values used in the analyses and it is recommended that the restoration slopes are visually monitored on a regular basis and following major rainfall events.

In addition, it is recommended that a hand-dug trial pit investigation is undertaken in the areas of localised cover soil failure on the cap to identify whether failure has occurred in the cover soils, or whether the integrity of the GCL has been compromised. Following the results of the trial pit investigation, recommendations can be made with respect to remediation measures to be undertaken.

4.0 REFERENCES

1. Environment Agency (2003). Stability of Landfill Lining Systems. R&D Technical Report P1 – 385/TR2.
2. Golder Associates (UK) Ltd (2001). Site Investigation Cefn Mawr Quarry, Flintshire. Ref. 00525559/B.0.
3. Jones, DRV & Dixon, N (1998). The stability of geosynthetic landfill lining systems. Geotechnical Engineering of Landfills, Thomas Telford, pp. 99-117.
4. Charles Haswell & Partners Ltd (2002). Proposals for the Restoration of Padeswood Landfill. Report No. 5013-649-02.
5. CL Associates (2004). Padeswood Capping and Restoration, CQA Interim Validation Report. Report No. 44026/1.

DRAWINGS

Padeswood Hall Colliery
Hollin Coal Workings, 1902

Existing Landfill

Proposed Development Area

Labels on map: Padeswood Hall Farm, Sports Ground, Pavilion, Works, Tanks, Ponds, ED Bdy, Path (um), Wot's Dyke, NORTH, WESTERN, MP .5, 1.22.

Handwritten note: This plan is a true working plan of completed up to the date of issue, and I certify, after inspection that

— *Boundary of old Mineworks area*



	<i>Project</i>
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Padeswood Landfill Closure Report

<i>Location</i>	
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Padeswood

<i>Title</i>	
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Padeswood Landfill in Relation to Mine Workings

Project No. 06524211

Engineer

Drawing No.

File No. 5225947

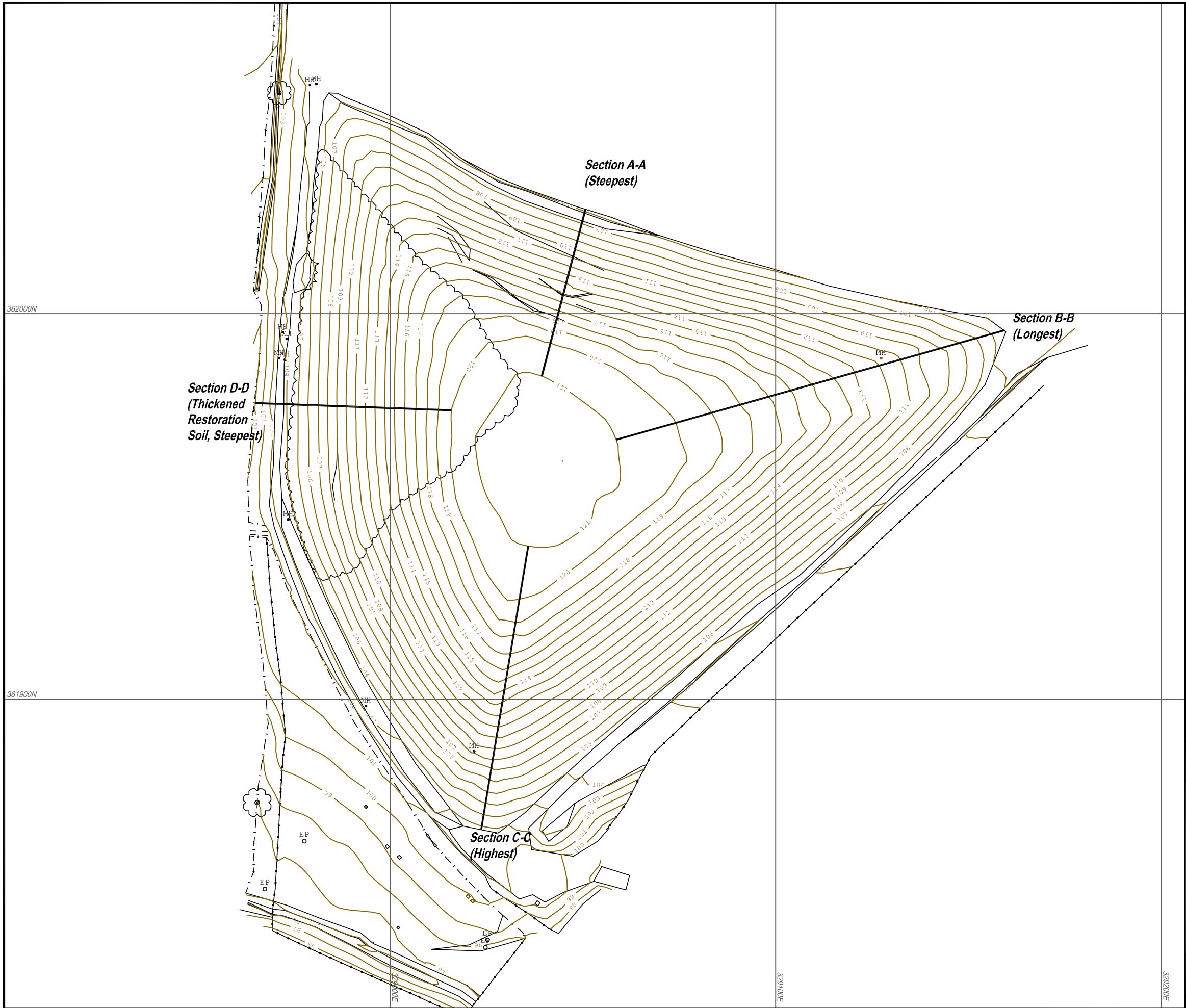
	<i>Reviewed by</i>

Created by C.B.

<i>Scale</i>	<i>Not to Scale</i>
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Date	19th May 2006
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Park Square
3160 Solihull Parkway
Birmingham Business Park
Birmingham
B37 7YN

Project <i>Padeswood Landfill Closure Report</i>		
Location <i>Padeswood</i>		
Title <i>Topographic Survey of Capping System and Location of Sections A-A, B-B, C-C and D-D</i>		
Project No. 06524211	Engineer	Drawing No. SRA2
File No. 5225948	Reviewed by	
Created by C.B.		
Scale 1:1000	Date 19th May 2006	



APPENDICES

APPENDIX SRA1
SLOPE STABILITY ANALYSES

APPENDIX SRA2
CAPPING STABILITY ANALYSES



PROJECT Padeswood Landfill Closure Report

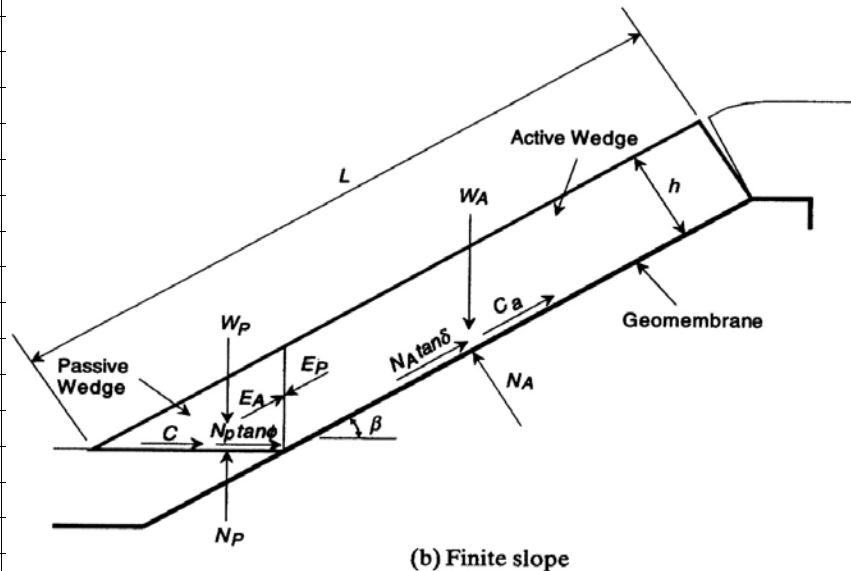
Job No.	06524211	Made By:	PE	Date:	17/05/2006
Ref.	Appendix SRA2	Checked:	DRVJ	Sheet:	2
	Stability of GCL cap	Reviewed:	DRVJ	of:	19

Stability of capping soils: GCL Cap (PSR = 0), Steepest slope (Section A-A)

Aim: To assess the stability of the capping soils and integrity of the GCL.

Approach: Use the approach proposed by Jones & Dixon, 1998.

Geometry:



Input Parameters

Cover soil unit weight (dry), γ_{dry}	19	kN/m ³
Cover soil unit weight (saturated), γ_{sat}	20	kN/m ³
Cover soil internal shear strength, ϕ	24	Deg.
Cover soil cohesion, c	0	kPa
Thickness of cover soil, h	0.40	m
Height of slope, H	15	m
Slope angle, β	22.6	Deg.
Geosynthetic interface shear strengths:		
Cover soil/GCL friction angle, δ_1	22	Deg.
Cover soil/GCL cohesion intercept, α_1	0	kPa
GCL/blinding layer friction angle, δ_2	22	Deg.
GCL/blinding layer cohesion intercept, α_2	0	kPa
Parallel submergence ratio, PSR	0	
Geosynthetic tensile strengths:		
GCL	12	kN/m

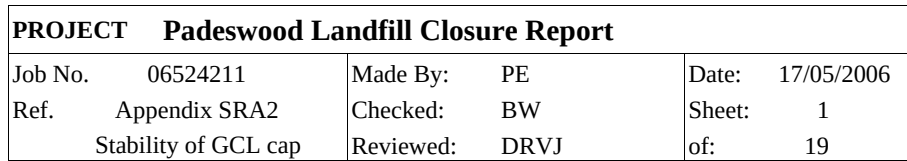
Justification of the interface shear strength parameters and tensile strengths are given on page 1.



PROJECT Padeswood Landfill Closure Report

Job No.	06524211	Made By:	PE	Date:	17/05/2006
Ref.	Appendix SRA2	Checked:	DRVJ	Sheet:	3
	Stability of GCL cap	Reviewed:	DRVJ	of:	19

1. Stability of Cover Soil																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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The stability of the GCL capping system has been assessed using the worst case cross sections taken through the steepest, highest and longest slopes of the actual post-settlement restoration levels as obtained from the most recent survey of the site.
In addition, analysis has been undertaken on the worst case slope in the planted area, where the restoration soil is thickest.

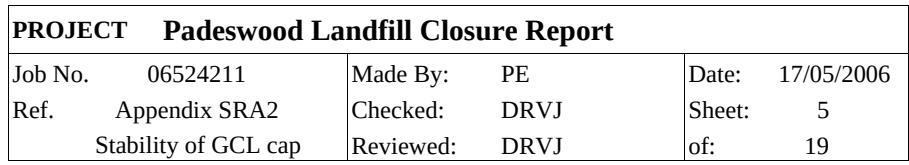
[illegible][illegible][illegible]

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|-----------------------------|---------------|---------|-------------|-----------|
| • GCL/clay blinding layer | $\alpha_{p'}$ | = 0 kPa | δ_p' | = 22 deg. |
| • GCL/clay protection layer | $\alpha_{p'}$ | = 0 kPa | δ_p' | = 22 deg. |

These values should be confirmed by site specific interface shear strength testing.

[illegible][illegible]

Justification of the interface shear strength parameters and tensile strengths are given on page 1.

[illegible]

Justification of the interface shear strength parameters and tensile strengths are given on page 1.



PROJECT Padeswood Landfill Closure Report

Job No.	06524211	Made By:	PE	Date:	17/05/2006
Ref.	Appendix SRA2	Checked:	DRVJ	Sheet:	7
	Stability of GCL cap	Reviewed:	DRVJ	of:	19

1. Stability of Cover Soil																					
Calculated Parameters																					
Length of slope, L										104.585	m										
Thickness of water, h_w										0.000	m										
Weight of active wedge, W_A										784.791	kN/m										
Weight of passive wedge, W_p										10.054	kN/m										
Force from pore pressure perp. to slope, U_n										0.000	kN/m										
Force from pore pressure in interwedge surface, U_h										0.000	kN/m										
Force normal to active wedge, N_A										775.553	kN/m										
Vert pp on passive wedge, U_v										0.000	kN/m										
a										118.649											
b										-322.309											
c										21.343											
										Factor of Safety against cover soil sliding					2.65						
2. Integrity of Geosynthetic Clay Liner																					
Shear strength at upper surface										317.358	kN/m										
Mobilised shear stress at upper interface										119.822	kN/m										
Shear strength at lower interface										317.358	kN/m										
Tension developed in the geotextile										0.000	kN/m										
Tensile strength of the geotextile										12	kN/m										
										Factor of Safety against rupture					Infinite						

Justification of the interface shear strength parameters and tensile strengths are given on page 1.



PROJECT Padeswood Landfill Closure Report

Job No.	06524211	Made By:	PE	Date:	17/05/2006
Ref.	Appendix SRA2	Checked:	DRVJ	Sheet:	9
	Stability of GCL cap	Reviewed:	DRVJ	of:	19

1. Stability of Cover Soil																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																</
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PROJECT Padeswood Landfill Closure Report

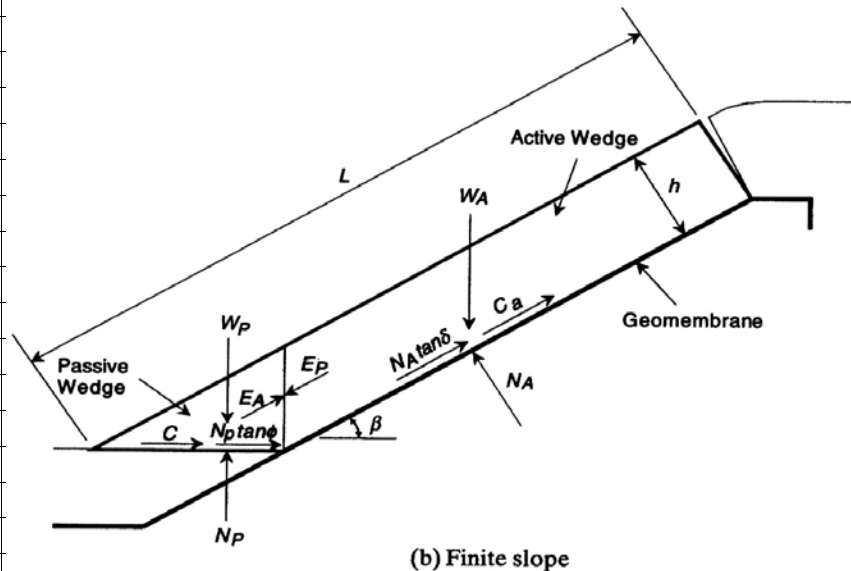
Job No.	06524211	Made By:	PE	Date:	17/05/2006
Ref.	Appendix SRA2	Checked:	DRVJ	Sheet:	10
	Stability of GCL cap	Reviewed:	DRVJ	of:	19

Stability of capping soils: GCL Cap (PSR = 0), Highest (corner) slope (Section C-C)

Aim: To assess the stability of the capping soils and integrity of the GCL.

Approach: Use the approach proposed by Jones & Dixon, 1998.

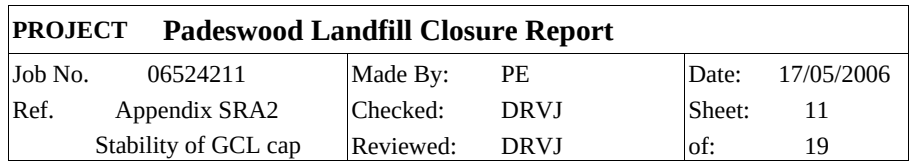
Geometry:



Input Parameters

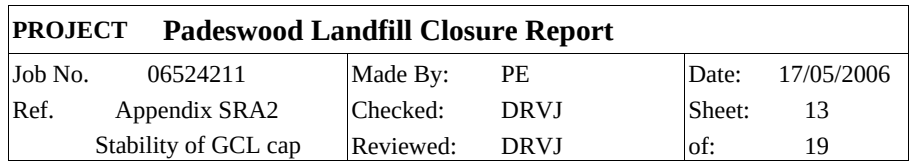
Cover soil unit weight (dry), γ_{dry}	19	kN/m ³
Cover soil unit weight (saturated), γ_{sat}	20	kN/m ³
Cover soil internal shear strength, ϕ	24	Deg.
Cover soil cohesion, c	0	kPa
Thickness of cover soil, h	0.40	m
Height of slope, H	20	m
Slope angle, β	15.1	Deg.
Geosynthetic interface shear strengths:		
Cover soil/GCL friction angle, δ_1	22	Deg.
Cover soil/GCL cohesion intercept, α_1	0	kPa
GCL/blinding layer friction angle, δ_2	22	Deg.
GCL/blinding layer cohesion intercept, α_2	0	kPa
Parallel submergence ratio, PSR	0	
Geosynthetic tensile strengths:		
GCL	12	kN/m

Justification of the interface shear strength parameters and tensile strengths are given on page 1.

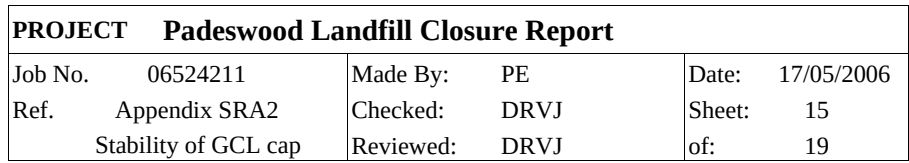


1. Stability of Cover Soil				
Calculated Parameters				
Length of slope, L	76.774	m		
Thickness of water, h_w	0.000	m		
Weight of active wedge, W_A	577.440	kN/m		
Weight of passive wedge, W_p	6.043	kN/m		
Force from pore pressure perp. to slope, U_n	0.000	kN/m		
Force from pore pressure in interwedge surface, U_h	0.000	kN/m		
Force normal to active wedge, N_A	557.502	kN/m		
Vert pp on passive wedge, U_v	0.000	kN/m		
a	145.232			
b	-237.606			
c	26.125			
Factor of Safety against cover soil sliding				1.52
2. Integrity of Geosynthetic Clay Liner				
Shear strength at upper surface	227.603	kN/m		
Mobilised shear stress at upper interface	149.985	kN/m		
Shear strength at lower interface	227.603	kN/m		
Tension developed in the geotextile	0.000	kN/m		
Tensile strength of the geotextile	12	kN/m		
Factor of Safety against rupture				Infinite
References:				
Jones, DRV & Dixon, N (1998)				
The stability of geosynthetic landfill lining systems, <i>Geotechnical Engineering of Landfills</i> ,				
Thomas Telford, pp. 99-117				

Justification of the interface shear strength parameters and tensile strengths are given on page 1.

[illegible]

Justification of the interface shear strength parameters and tensile strengths are given on page 1.

[illegible]

Justification of the interface shear strength parameters and tensile strengths are given on page 1.



PROJECT Padeswood Landfill Closure Report

Job No.	06524211	Made By:	PE	Date:	17/05/2006
Ref.	Appendix SRA2	Checked:	DRVJ	Sheet:	17
	Stability of GCL cap	Reviewed:	DRVJ	of:	19

1. Stability of Cover Soil																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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PROJECT Padeswood Landfill Closure Report

Job No.	06524211	Made By: PE	Date: 17/05/2006
Ref.	Appendix SRA3	Checked: BW	Sheet: 18
	Stability of GCL cap	Reviewed: DRVJ	of: 19

INTERFACE	CONDITIONS			SHEAR RATE in/min	NORMAL STRESS (kPa)	SHEAR STRESS		ANGLE		COHESION INTERCEPT	
	DRY	WET	HYD			PEAK (kPa)	RESIDUAL (kPa)	PEAK	RESIDUAL	PEAK (kPa)	RESIDUAL (kPa)
Reinforced Bentomat (woven-side) vs. Soil			X	1.0	119.7 239.4 359.1	64.7 157.2	47.5 112.7	21.1	15.2	18.4	15.0
GCL (Woven-side) vs. Cushioning Layer			X	1.0	3.4 6.9 13.8	4.1 8.3 19.0	4.0 7.6 19.0	53.2	52.7	-	-
GCL (Woven-side) vs. Cushioning Layer (PEAK RE-ANALYSIS)			X	1.0	3.4 6.9 13.8	3.8 8.3 16.1	4.0 7.6 19.0	49.6	52.7	-	-
GCL (Woven-side) vs. Cushioning Layer	X			1.0	3.4 6.9 13.8	4.1 7.5 12.4	4.0 7.4 12.4	38.4	38.7	-	-
CETCO Bentomat DN GCL (White Side) vs Soil (SF-SP-1)			X	1.0	143.6 287.3 574.6	58.3 107.3 222.3	110.1 158.1 82.0	21.0	17.0	0.7	0.0
Bentofix NWL GCL vs Structural Fill (AHP-2-2 G/H)			X	1.0	119.7 239.4 478.8	69.0 101.7 192.1	42.7 63.2 110.3	19.2	10.7	23.8	19.2
GCL (Bentomat ST-Woven side) vs. S-1 (Reddish Brown Clayey Silt)			X	1.0	206.8 413.7 620.5	104.8 189.6 266.8	81.4 142.7 196.5	21.4	15.6	24.8	24.8
GCL (Bentomat Woven-side) vs. Reddish Brown Clayey Silt			X	1.0	68.9 206.8 344.7	45.5 112.4 162.0	35.9 84.1 107.6	22.9	14.6	19.3	22.1
GCL (Bentomat Woven-side) vs. Red Clayey Silt			X	1.0	103.4	52.3	45.6				
GCL (Bentomat Woven-side) vs. Red Clayey Silt				1.0	3.4 6.9 34.5	2.4 4.4 24.5	1.6 2.8 14.5	35.3	22.7	0.0	0.1
GCL (Bentomat Woven-side) vs. Clay (LL-West)			X	1.0	4.8 9.6 14.4 23.9	4.5 8.6 14.4 14.9	7.4 11.4 17.7 17.2	28.6	27.2	3.4	6.7
GCL (Bentomat Woven-side) vs. Soil (Imported Soil)			X	1.0	9.6 14.4 23.9	7.7 10.1 17.4	8.4 9.9 18.7	34.7	36.8	0.7	0.4
GCL (Bentomat Woven-side) vs. Sand			X	1.0	9.6 14.4 23.9	6.7 11.1 18.3	7.4 13.0 18.4	36.0	27.4	0.0	0.1
40-mil HDPE Gundleal (GM-side) vs. Silty Clay				1.0	19.2 71.8 124.5	15.1 46.6 111.9	10.5 32.1 70.4	39.9	28.2	0.0	0.0
Bentofix (woven side) vs. Soil			X	1.0	68.9 206.8 344.7	44.8 109.6 162.0	32.4 41.4 40.7	23.0	1.7	17.9	31.7
Bentofix NW vs. Soil			X	1.0	4.8 9.6 23.9	3.6 6.0 13.3	3.9 7.5 15.2	26.7	29.9	1.2	1.5



APPENDIX B

**Padeswood Landfill: Capping Geotechnical Assessment,
Report reference 1051424262.515/B.0, Dated January 2012**



January 2012

PADESWOOD LANDFILL

Capping Geotechnical Assessment

Submitted to:
Hanson (UK) Ltd
Padeswood
Mold
Flintshire
CH7 4HB

REPORT



Report Number. 10514240262.515/B.0

Distribution:

Hanson (UK) Ltd - 1 copy (pdf)
Golder Associates (UK) Ltd - 1 copy





CAPPING GEOTECHNICAL ASSESSMENT



Table of Contents

1.0 INTRODUCTION.....	1
1.1 Site Description.....	1
1.2 Background.....	1
2.0 SITE INVESTIGATION	1
2.1 Procedure	1
2.2 Investigation.....	2
2.3 Laboratory Testing.....	2
3.0 STABILITY ASSESSMENT	3
3.1 Modelling Geometries.....	3
3.2 Interface Properties	3
3.3 Material Properties.....	3
3.4 Capping Slope Stability Analysis	4
3.5 Assessment	4
4.0 SUMMARY AND RECOMMENDATIONS.....	5
5.0 REFERENCES.....	5

TABLES

Table 515/1: Summary of Tested Interface Shear Strengths	3
Table 515/2: Summary of Cross Sections	3
Table 515/3: Summary of Interface Shear Strengths	3
Table 515/4: Summary of Material Properties	4
Table 515/5: Results of Finite Slope Analyses	4

APPENDICES

DRAWING

515/1: Location of Trial Pit and Stability Analysis Sections

APPENDIX 515/1

Trial Pit Records

APPENDIX 515/2

Trial Pit Photographs

APPENDIX 515/3

Laboratory Direct Shear Results

APPENDIX 515/4

Slope Stability Analyses



1.0 INTRODUCTION

Hanson (UK) Ltd (Hanson) has commissioned Golder Associates (UK) Ltd (Golder) to undertake a Geotechnical Assessment for the capping at Padeswood Landfill (the 'Site'). This report summarises the findings of a site investigation, presents the results of slope stability analyses and gives recommendations for potential remediation measures.

1.1 Site Description

The Site was previously owned by Castle Cement and has subsequently been acquired by Hanson. The landfill accepted non-hazardous cement kiln dust (CKD) generated at Padeswood Cement Works, as well as fine grained shale, with many broken bricks and occasional demolition waste. The final waste slopes have typical gradients of around 1v:3h, though locally steepening to around 1v:2.5h. The waste has been built up as a landraise to form a domed profile with three distinctive sides, facing north, east and southwest (Drawing 515/1).

The majority of the capping system, comprising a Geosynthetic Clay Liner (GCL) cap, was constructed in 2004. The contractor for the works was Mowlem Plc, with Construction Quality Assurance (CQA) works being undertaken by CL Associates. Capping was not completed in 2004 as access was limited on the northern flank due to the construction of Kiln 4. As such, an interim CQA report for the works was submitted in November 2004 (Reference 1).

It is thought the remaining capping works, which included the northern flank of the landfill, was completed in 2005.

The interim CQA report (Reference 1) indicates that the capping system comprises a 200 mm blinding layer of clay, overlain by a Bentofix NSP 4900 GCL, which is in turn overlain by approximately 250 mm of protective clay. The protective clay is overlain by up to 750 mm of restoration soils in areas where tree planting was undertaken. Although this area is not particularly well defined as no as-built drawings for the placement of the restoration soils is available, it is inferred from the CQA report that this was mainly along the western flank (Drawing 515/1). The final layer of the restoration system comprised 150 mm of topsoil.

1.2 Background

Golder prepared a closure report for the Site on behalf of Castle Cement in 2006, in which a Stability Risk Assessment (SRA) was produced (Reference 2). The stability assessment indicated that the capping slopes may be only marginally stable for the steepest areas. There were signs of restoration soil slippage along the northern and western slope. The 2006 SRA recommended that the site-specific interface shear strength testing be undertaken which would enable a more robust slope stability analysis to be carried out.

Golder carried out a site inspection/geotechnical appraisal for the landfill cap at Padeswood in September 2010. The main finding of the inspection is that the capping slopes may be too steep to ensure the stability and integrity of the capping system in the long-term. The underlying GCL may be over-stressed, particularly in the steepest area. An intrusive investigation was deemed necessary to assess the conditions of the GCL capping liner. It was proposed to excavate 6 trial pits across the Site. Golder prepared a detailed investigation procedure which was submitted to the Environment Agency (EA) on 9 May 2011 (Reference 3) and subsequently approved by the EA.

2.0 SITE INVESTIGATION

2.1 Procedure

Golder carried out the trial pitting investigation on 12 and 13 September 2011. The trial pitting investigation followed the proposed procedure which is detailed below:

- Prior to the excavation, the location of the trial pits should be agreed with the Site Engineer on-site;
- Remove the vegetation on the surface;



- The size of the trial pits should be 1 m by 1m;
- Although an excavator can be used, it should not be used within 150 mm of the top of the GCL. It is envisaged that for TP1 to TP4, the restoration soils are likely to be approximately 400 mm thick. For TP5 and TP6, the restoration soils are envisaged to be approximately 1.15 m thick;
- When reaching 150 mm above the GCL cap, hand excavation should be carried out to carefully expose the GCL;
- The condition of the GCL in each pit should be described and recorded by the Site Engineer. Photos should be taken for the exposed GCL. In particular, any sign of stretches of the GCL will be noted;
- If the GCL is deemed to be over-stressed, samples should be taken to send to laboratory for testing. It is recommended that tensile strength and permeability of the GCL samples should be tested.
- When the inspection is completed, the GCL liner should be repaired (if samples were taken) by patching with new material. Each trial pit should be backfilled with the excavated material;
- Site-specific interface shear strength testing should also be carried out using soil samples taken on-site. An updated capping stability risk assessment will be conducted using the updated interface shear strength parameters;
- An interpretative report will be produced which describe the results of the site investigation and make conclusions and recommendations.

2.2 Investigation

The 6 trial pits (TP1 to TP6) were excavated in accordance with the location plan given on Drawing 515/1. The logs for each trial pit are presented in Appendix 515/1. The main findings of the trial pitting investigation are summarised below:

- The restoration soils were mainly dry to damp, stiff to very stiff, moderate plasticity, slightly gravelly to gravelly CLAY (Plates 515/1 and 2). The thickness of the restoration soils varies in a range between 0.4 m and 1.0 m for different locations;
- The exposed GCL appeared to be intact and in a good condition, i.e. no signs of over-stressing and the bentonites are reasonably swelled (Plates 515/3 and 4);
- Samples of the restoration soils and the blinding layer were taken to the laboratory to conduct the site-specific interface shear strength testing; and
- All damages to the GCL liner were repaired in accordance with the standard procedure (Plates 515/5 and 6).

The photographs are included in Appendix 515/2.

2.3 Laboratory Testing

Laboratory testing was carried out to obtain the shear strengths for both the upper and lower interfaces of the capping system. Fresh GCL materials (Bentofix NSP 4900) were used in the testing. Soil samples taken from the restoration soils and blinding layer were used to test the upper and lower interfaces respectively. Three normal pressures (20 kPa, 40 kPa and 60 kPa) were used in the test for each interface. The test results are summarised in Table 515/1 and the laboratory sheets are presented in Appendix 515/3.



Table 515/1: Summary of Tested Interface Shear Strengths

Interface	Adhesion (kPa)		Friction Angle (Degree)	
	Peak	Residual*	Peak	Residual*
Upper (Restoration soils/GCL)	13.4	11.5	28.3	29.5
Lower (GCL/Blinding layer)	0.2	1.3	38.6	35.5

* Although these are reported as residual values, they relate to displacements of between 30 mm and 50 mm.

It can be seen that the interface shear strengths are greater than the values previously assumed in the 2006 SRA. In addition, the upper interface appears to have a higher adhesion and a lower friction angle compared with the figures for the lower interface.

3.0 STABILITY ASSESSMENT

The stability assessment has been carried out in accordance with the stability assessment methodology as outlined in the Environment Agency's guidance document released in March 2003 and entitled 'Stability of Landfill Lining Systems: Report No.2 Guidance, R&D Technical Report' (Reference 4).

3.1 Modelling Geometries

The 2006 SRA analysed the capping slopes using 4 cross sections (Section A to D), as shown in Drawing 515/1. The same cross sections have been selected and analysed in this assessment. The geometry for each cross section is summarised in Table 515/2. It is noted that the soil thickness has been corrected using the information obtained in the trial pitting investigation.

Table 515/2: Summary of Cross Sections

Cross Sections	Slope Angle (Degree)	Slope Height (m)	Soil Thickness (m)
Section A	22.6	15	1.0
Section B	8.8	16	0.6
Section C	15.1	20	0.6
Section D	20.8	19	1.0

3.2 Interface Properties

The interface shear strength parameters adopted in the current assessment are summarised in Table 515/3 together with the values previously assumed in the 2006 SRA. No adhesion values are used in the analysis despite the fact that they were reported in the laboratory testing results. Friction angles are chosen based on the testing results, which are greater than previously assumed values.

Table 515/3: Summary of Interface Shear Strengths

Interface		Adhesion (kPa)	Friction Angle (Degree)
Current Assessment	Upper (Restoration soils/GCL)	0	28
	Lower (GCL/Blinding layer)	0	35
2006 SRA	Upper (Restoration soils/GCL)	0	22
	Lower (GCL/Blinding layer)	0	22

3.3 Material Properties

The material properties of the restoration soils used in the 2006 SRA are presented in Table 515/4 below. Since the trial pitting investigation revealed that the restoration soils mainly comprise clay type of material, the shear strength parameters of the restoration soils have been slightly modified to reflecting the finding. The modified material properties used in the current assessment are presented in the table.



Table 515/4: Summary of Material Properties

Material	Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (Degree)
Restoration Soils (2006 SRA)	19	0	24
Restoration Soils (Current)	19	1	22

3.4 Capping Slope Stability Analysis

The finite slope approach has been adopted to analyse the stability of the restoration soils and assess the integrity of the underlying GCL liner at all four cross section locations. Parallel submerge ratio (PSR) has been used to assess the influence of the pore water pressure on the capping slope stability. Three scenarios, i.e. PSR=0, PSR=0.25 and PSR=0.5 have been considered in the analysis.

Results of the restoration soils stability and GCL integrity analyses are summarised in Table 515/5 below. The analysis sheets are presented in Appendix 515/4.

Table 515/5: Results of Finite Slope Analyses

Description	Water Levels	Factor of Safety	
		Slippage of Restoration Soils	Tensile Failure of GCL
Section A	PSR = 0	1.34	Infinite
	PSR = 0.25	1.17	Infinite
	PSR = 0.5	0.98	Infinite
Section B	PSR = 0	3.51	Infinite
	PSR = 0.25	3.06	Infinite
	PSR = 0.5	2.61	Infinite
Section C	PSR = 0	2.01	Infinite
	PSR = 0.25	1.75	Infinite
	PSR = 0.5	1.50	Infinite
Section D	PSR = 0	1.45	Infinite
	PSR = 0.25	1.26	Infinite
	PSR = 0.5	1.08	Infinite

3.5 Assessment

For Section A, the factor of safety calculated against soil slippage for the dry condition (PSR=0) is 1.34. When applying a PSR value of 0.25, the factor of safety reduces to 1.17, which is below the required 1.3. When the PSR value further increases to 0.5, i.e. half saturated condition, the factor of safety further reduces to 0.98. This is less than unity which indicates potential slippage failure of the restoration soils. The calculation is consistent with the localised failure that was identified in the northern area. No tensile forces have been calculated within the underlying GCL liner for all the three scenarios, which is confirmed by the findings of the trial pitting investigation.

For Sections B and C, the calculated factors of safety for different water levels are all above the required 1.3. Moreover, no tensile forces will be developed within the underlying GCL liner. This is considered satisfactory.

For Section D, the factor of safety calculated against soil slippage for the dry condition (PSR=0) is 1.45. When applying a PSR value of 0.25, the factor of safety reduces to 1.26. This is only marginally below the required 1.3 and therefore still considered satisfactory. When the PSR value further increases to 0.5, i.e. half saturated condition, the factor of safety further reduces to 1.08. This is not considered satisfactory.



4.0 SUMMARY AND RECOMMENDATIONS

A trial pitting investigation was carried out at Padeswood Landfill to assess the current condition of the GCL capping liner. The investigation suggests that the GCL liner is in a good condition. There is no sign of over-stressing of the GCL liner beneath the restoration soils. Soil samples were taken and interface shear strength testing was carried out. Stability assessment has been carried out using the results of the site-specific interface shear strength testing.

The stability assessment shows the restoration soil slopes in the northern and western areas may become unstable when the PSR value reaches 0.5, which is consistent with the presence of superficial tension cracks and minor slumping on the northern and western slopes. The analyses indicate no tensile forces will be developed within the GCL liner, which is confirmed by the trial pitting investigation.

Based on the findings of the site investigation and the follow-up stability assessment, it is considered necessary to remediate the northern and western capping slopes at Padeswood Landfill. Since the site investigation and stability assessment do not suggest that the GCL liner has been compromised, the remedial measures are envisaged to include scraping the vegetation off the surface and the placement of additional capping soils to make the restoration soil slopes shallower than the GCL capping slope, i.e. tapered slopes. The footprint required to extend the toe of the slope and thus reduce the overall slope angle will be subject to detailed design being carried out.

5.0 REFERENCES

- 1) CL Associates (2004). CQA Interim Validation Report, Padeswood Capping and Restoration, Ref: 44026/1, November 2004.
- 2) Golder Associates (UK) Ltd. (2006). Stability Risk Assessment, Padeswood Landfill Site, Ref: 06524211.503/A.0, May 2006.
- 3) Golder Associates (UK) Ltd. (2011). CQA Plan and Method Statements for Further Works at Padeswood and Pant-Y-Buarth Landfill Sites, Ref: 10514240262.510/511, 9 May 2011.
- 4) Dixon, N. & Jones, D.R.V. (2003). Stability of Landfill Lining Systems: Report No. 2, Guidance, R&D Technical Report P1 – 385/TR2, Environment Agency, January 2003.



Report Signature Page

GOLDER ASSOCIATES (UK) LTD



R Lansley
Project Manager



Dr DRV Jones
Reviewer

Date: 27 January 2012

Author: Dr B Zhang/RJL/DRVJ/jt

Company Registered in England No. 1125149

At Attenborough House, Browns Lane Business Park, Stanton-on-the-Wolds, Nottinghamshire NG12 5BL

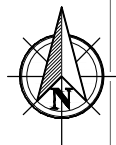
VAT No. 209 0084 92

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DRAWING

515/1: Location of Trial Pit and Stability Analysis Sections



362000N

361900N

Section D-D
(Thickened
Restoration
Soil, Steepest)

Section A-A
(Steepest)

Section B-B
(Longest)

Section C-C
(Highest)

Legend

 Geotechnical trail pit location

Notes

Client					Hanson (UK) Limited	
Project					Padeswood Landfill Site Capping Geotechnical Assessment	
Title					Location of Trial Pit and Stability Analysis Sections	
Created by		Requested by		Proj Manager	Reviewer	Date
AD		RL		BZ	DRVJ	26/01/12
File No.				Project No.		
5233672				10514240262		
Size		Scale		Status		
A3		1:1,000		Issue		
Drawing No.						Rev
515/1						-

1:1,000 



APPENDIX 515/1

Trial Pit Records



TEST PIT LOG

No. TP 1

TEMP 22°C WEATHER Sunny, dry, windy ENGINEER B. ZHANG OPERATOR T. Condren
EQUIPMENT SI excavator CONTRACTOR / DATE 12/09/2011
COORDINATES N / E / ELEV. / DATUM / JOB 10514240262
LOCATION Parkview Landfill TIME 10:00 - 11:00

LENGTH	
0.3m	Topsoil
0.9m	CLAY, stiff to very stiff, moderate plasticity, trace of gravels, brown, damp - MADE GROUND CAPPING SOIL
	GCL, trace of swelled bentonite, no sign of over-stressing
1.2m	BLINDING LAYER, clay, stiff to very stiff, moderate plasticity, trace of gravels, brown, damp
	END OF PIT

LITHOLOGIC DESCRIPTIONS AND EXCAVATION NOTES	

SPECIAL NOTES	
GCL liner was repaired using patch before backfilling.	

POCKET PENETROMETER		
DEPTH	STRENGTH	
SAMPLES		
ID	TYPE (NO.)	DEPTH
TP1	3	0.5m
TP1	3	1.0m
LEGEND		



TEST PIT LOG

No. TP 2

TEMP 22°C WEATHER Sunny, dry, windy ENGINEER B ZHANG OPERATOR T CONDREN
EQUIPMENT S + Excavator CONTRACTOR / DATE 12/09/2011
COORDINATES N / E / ELEV. / DATUM / JOB 10514242262
LOCATION PADESWOOD LANDFILL TIME 11:00 - 12:00

LENGTH	
0.3m	Topsoil
1.0m	Clay, stiff to very stiff, moderate plasticity, trace of gravels and cobbles, brown, damp, MADE GROUND CAPPING SOIL
1.3m	GCL, trace of swelled bentonite, no sign of over-stressing
	BLINDING LAYER - Clay, stiff to very stiff, moderate plasticity, trace of gravels, brown, damp
	END OF PIT

LITHOLOGIC DESCRIPTIONS AND EXCAVATION NOTES

SPECIAL NOTES	
GCL Liner was repair using patch before backfilling.	

POCKET PENETROMETER		
DEPTH	STRENGTH	
SAMPLES		
ID	TYPE (NO.)	DEPTH
TP2	3	0.5m
TP2	3	1.0m
LEGEND		



TEST PIT LOG

No. TP3

TEMP 22°C WEATHER Sunny, dry, windy ENGINEER B. ZHANG OPERATOR T. CONDREN
 EQUIPMENT 5t excavator CONTRACTOR DATE 12/09/2011
 COORDINATES N E ELEV. DATUM JOB 10514240262
 LOCATION Padeswood Landfill TIME 15:00 - 16:00

LENGTH		LITHOLOGIC DESCRIPTIONS AND EXCAVATION NOTES
DEPTH	0.2m Topsoil MADE-GROUND CAPPING SOIL, Gravelly Clay, Stiff to very stiff, moderate plasticity, dark brown, damp 0.6m GCL, trace of swelled bentonite, No signs of over-stressing 0.6m BLINDING LAYER, Clay, stiff to very stiff, trace of gravels, brown, damp END OF PIT	

SPECIAL NOTES		POCKET PENETROMETER													
GCL liner was repaired using patch before backfilling the pit.		DEPTH	STRENGTH												
SAMPLES <table border="1"> <thead> <tr> <th>ID</th> <th>TYPE (NO.)</th> <th>DEPTH</th> </tr> </thead> <tbody> <tr> <td>TP3</td> <td>3</td> <td>0.4m</td> </tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> </tbody> </table>		ID	TYPE (NO.)	DEPTH	TP3	3	0.4m							LEGEND	
		ID	TYPE (NO.)	DEPTH											
		TP3	3	0.4m											



TEST PIT LOG

No. TP 4

TEMP 22°C WEATHER Sunny, dry, windy ENGINEER B. ZHANG OPERATOR T. CONDREN
EQUIPMENT ST excavator CONTRACTOR / DATE 12/09/11
COORDINATES N / E / ELEV. / DATUM / JOB 1054240262
LOCATION Padeswood Landfill TIME 14:00 - 15:00

LENGTH	
0.2m	Topsol
0.5m	MADE GROUND CAPPING SOIL - Gravelly Clay. Stiff to very stiff, low - moderate plasticity, greyish brown, dry
0.5m	GCL. No signs of over-stressing.
0.5m	BLINDING LAYER, Clay, stiff to heavy stiff trace of graels, brown, dry
0.5m	END OF PIT

LITHOLOGIC DESCRIPTIONS AND EXCAVATION NOTES	

SPECIAL NOTES	
GCL liner was repaired using patch before backfilling the pit.	

POCKET PENETROMETER		
DEPTH	STRENGTH	
SAMPLES		
ID	TYPE (NO.)	DEPTH
TP4	3	0.4m
LEGEND		



TEST PIT LOG

No. TP6

TEMP 22°C WEATHER Sunny, dry, windy ENGINEER B ZHANG OPERATOR T CONDREN
 EQUIPMENT ST Excavator CONTRACTOR / DATE 12/09/2011
 COORDINATES N / E / ELEV. / DATUM / JOB 10514240262
 LOCATION PADESWOOD LANDFILL TIME 12:00 - 13:00

LENGTH		LITHOLOGIC DESCRIPTIONS AND EXCAVATION NOTES
DEPTH	DESCRIPTION	
0.3m	Topsoil	
1.0m	Gravelly clay, stiff to very stiff, low plasticity, gravels are fine to medium, brown, dry. -MADE GROUND CAPPING SOIL	
	GCL, trace of swelled bentonite, No signs of over-stressing	
1.0m	BLINDING LAYER, clay, stiff to very stiff, trace of gravels, brown, damp	
	END OF PIT	

SPECIAL NOTES		POCKET PENETROMETER	
GCL liner was repaired using patch before backfilling the pit		DEPTH	STRENGTH
SAMPLES		ID	TYPE (NO.) DEPTH
		TP6	3 0.5m
LEGEND			

Friday, September 09, 2011 - 10:45am
 FILE: C:\Documents and Settings\jguyen\Desktop\0839725815 Revised Test Pit Log.dwg TAB NAME \BLANK
 THE DRAWING HAS BEEN PREPARED BY GOLDBER ASSOCIATES INC. FOR USE BY THE CLIENT NAMED IN THE TITLE BLOCK SOLELY IN RESPECT OF THE CONSTRUCTION OPERATION AND MAINTENANCE OF THE FACILITY NAMED IN THE TITLE BLOCK. GOLDBER ASSOCIATES INC. SHALL NOT BE LIABLE FOR THE USE OF THIS DRAWING ON ANY OTHER FACILITY OR FOR ANY OTHER PURPOSES.



APPENDIX 515/2

Trial Pit Photographs



APPENDIX 515/2

Trial Pit Photographs



Plate 515/1: Restoration Soils 1



Plate 515/2: Restoration Soils 2



APPENDIX 515/2

Trial Pit Photographs



Plate 515/3: Exposed GCL 1



Plate 515/4: Exposed GCL 2



APPENDIX 515/2

Trial Pit Photographs



Plate 515/5: GCL Patch 1



Plate 515/6: GC Patch 2



APPENDIX 515/3

Laboratory Direct Shear Results

Direct Shear Test



062-11

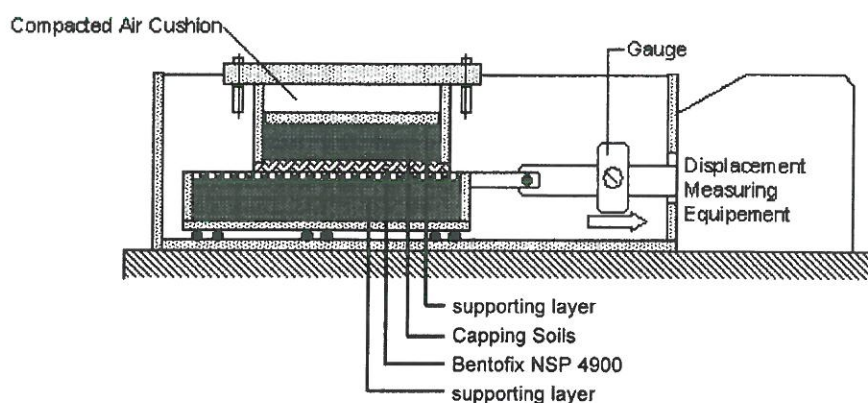
Padeswood, UK

Page 1 of 2

Test set-up: supporting layer
Capping Soils
Bentofix NSP 4900
supporting layer

Remarks: soil delivered in September 2011; water content by setup was 15%
enclosed pictures from the soil

In the direct shear test, the frictional behaviour of the test sample is determined using a standard shear box apparatus. The sample material is placed into the shear box and a uniform normal load is applied via compacted air cushion to the apparatus.

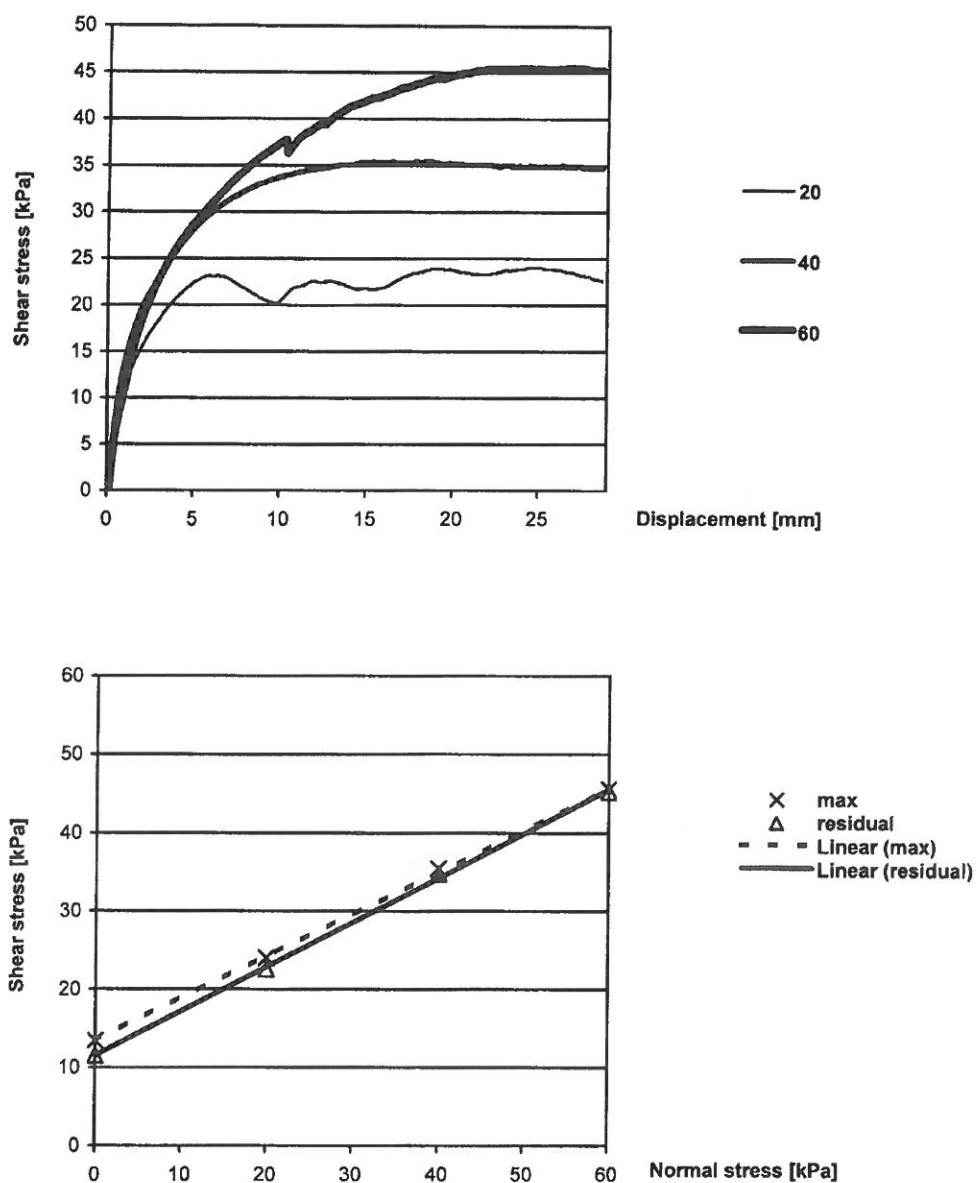


A shear force is induced by the displacement of the lower section of the shear box apparatus. The force is plotted against the displacement for different normal stress loading conditions.

Test:

Shear plane: Bentofix NSP 4900 (upper side) vs. Capping Soils
Area [cm²]: 900
Rate of strain [mm/h]: 2
Shear plane: without water
Consolidation: yes, without water

Normal stress [kPa]	20	40	60
Consolidation stress [kPa]	20	40	60
Time of consolidation [h]	12	12	12



Regression Line at $\tau_{\max}$: $13.44 + \sigma * \tan 28.32^\circ$

Regression Line at τ_{residual} : $11.52 + \sigma * \tan 29.54^\circ$

The use of the results and the appropriate application is the responsibility of the engineer and must take into consideration all aspects of the proposed construction and local soil conditions.

Espelkamp-Fiestel

28/11/2014

i.V. H. Ehrenberg

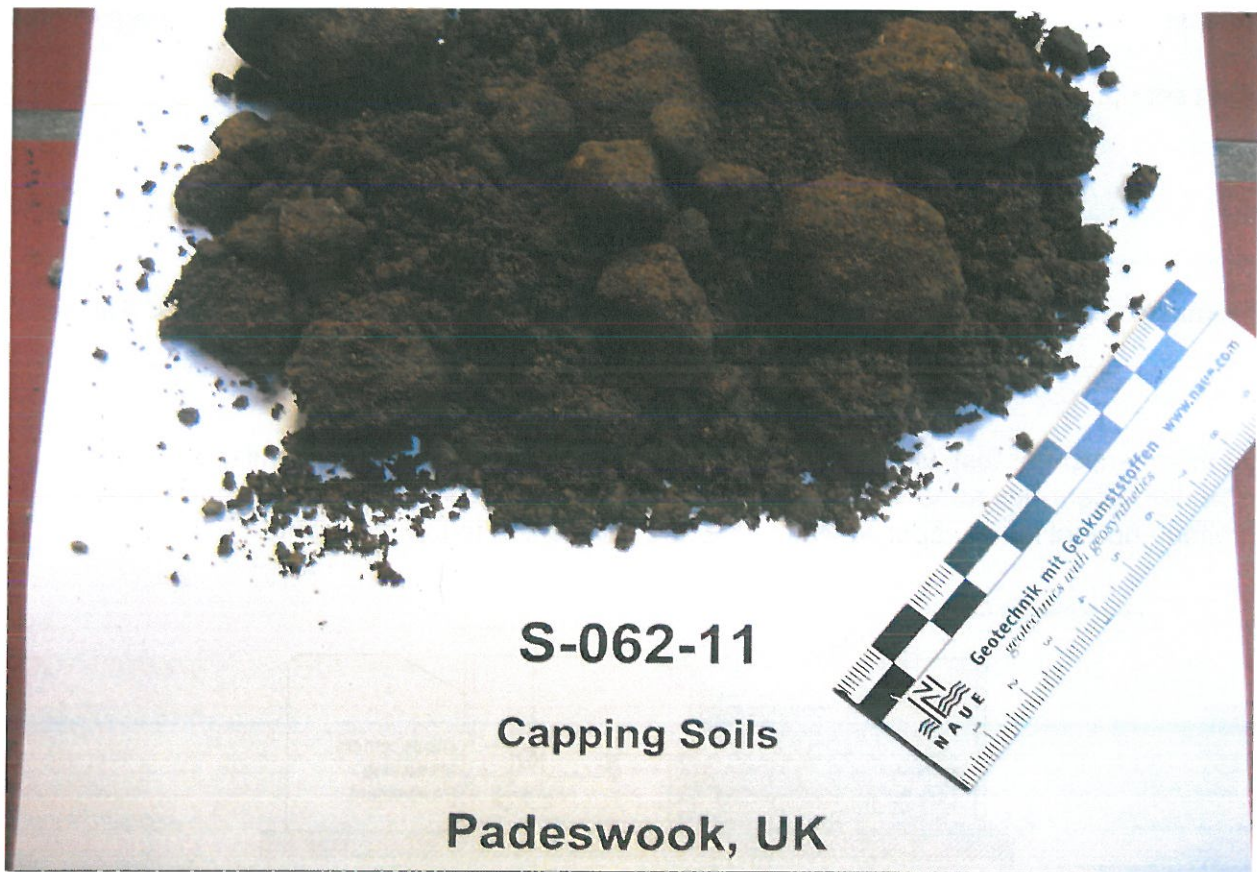
A. Polzin

i.A. A. Polzin

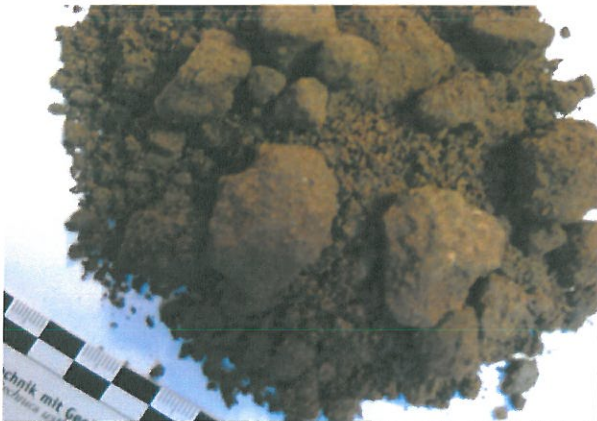
062-11

Padeswood, UK

Enclosure



picture 1



picture 2



picture 3

Direct Shear Test



061-11

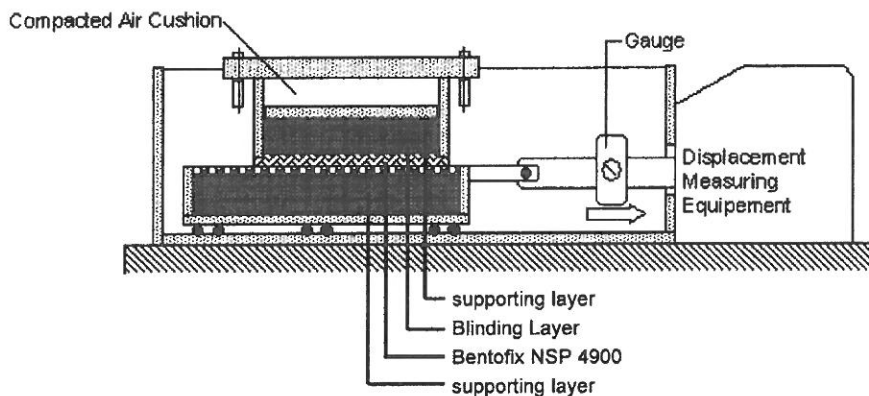
Padeswood, UK

Page 1 of 2

Test set-up: supporting layer
Blinding Layer
Bentofix NSP 4900
supporting layer

Remarks: soil delivered in September 2011; water content by setup was 1,5 %
enclosed pictures from the soil

In the direct shear test, the frictional behaviour of the test sample is determined using a standard shear box apparatus. The sample material is placed into the shear box and a uniform normal load is applied via compacted air cushion to the apparatus.

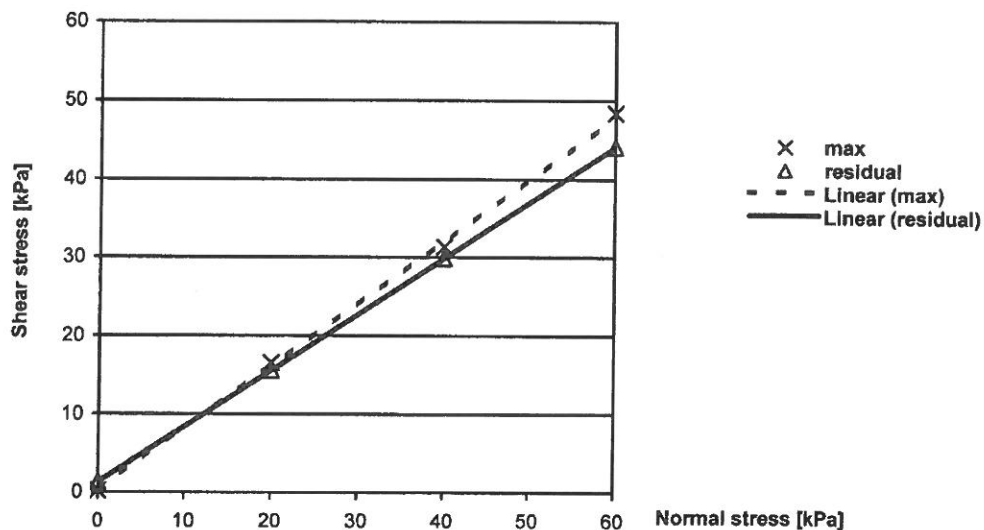
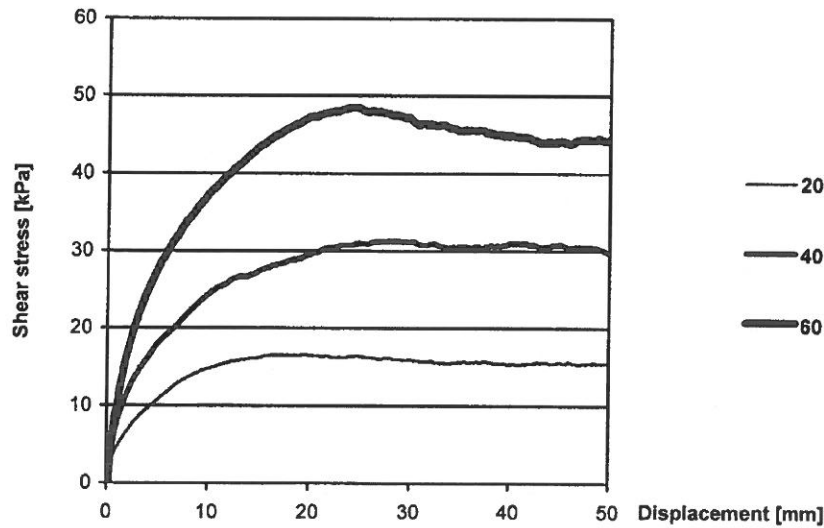


A shear force is induced by the displacement of the lower section of the shear box apparatus. The force is plotted against the displacement for different normal stress loading conditions.

Test:

Shear plane: Bentofix (bottom side) vs. Blinding Layer
Area [cm²]: 900
Rate of strain [mm/h]: 2
Shear plane: without water
Consolidation: yes, without water

Normal stress [kPa]	20	40	60
Consolidation stress [kPa]	20	40	60
Time of consolidation [h]	12	12	12



Regression Line at $\tau_{\max}$: $0.22 + \sigma * \tan 38.56^\circ$

Regression Line at τ_{residual} : $1.3 + \sigma * \tan 35.52^\circ$

The use of the results and the appropriate application is the responsibility of the engineer and must take into consideration all aspects of the proposed construction and local soil conditions.

Espelkamp-Fiestel

21/11/2011

i.V. H. Ehrenberg

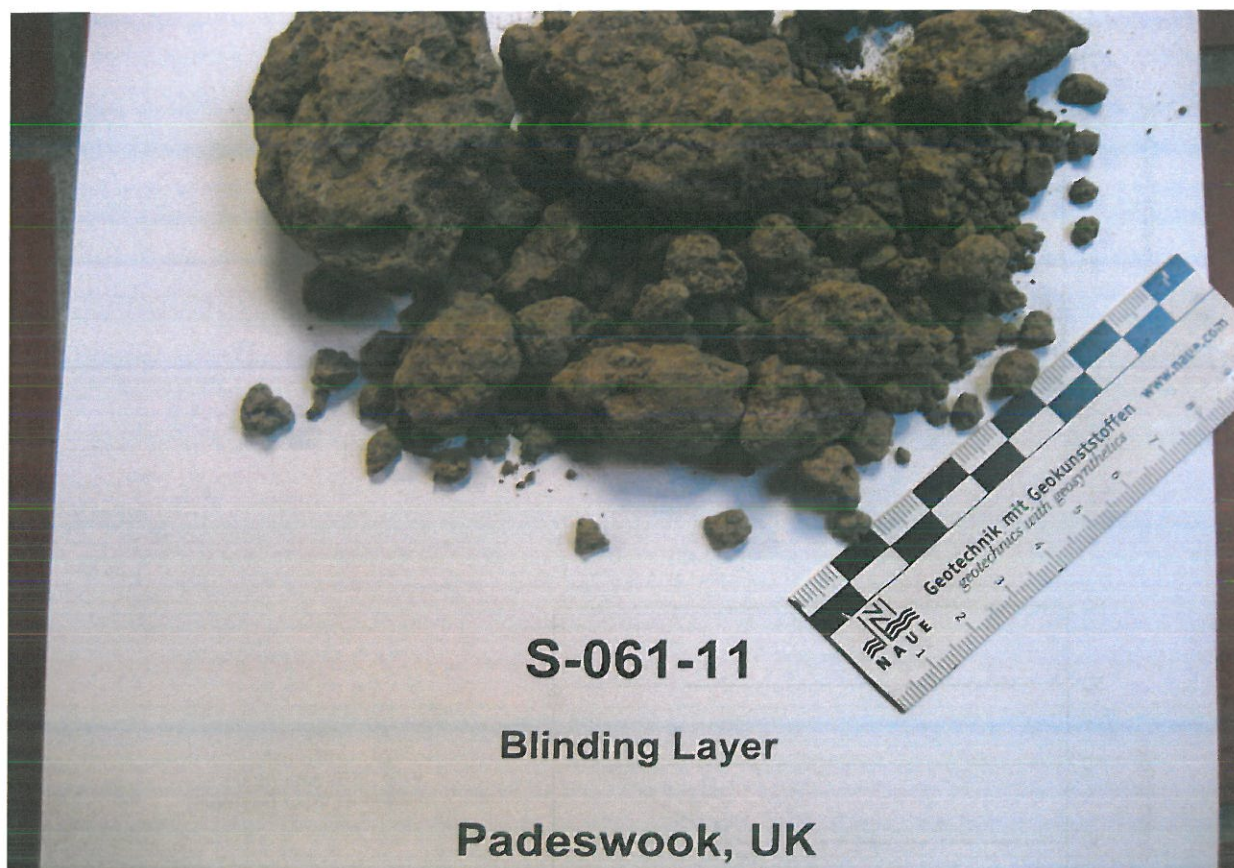
A. Polzin

i.A. A. Polzin

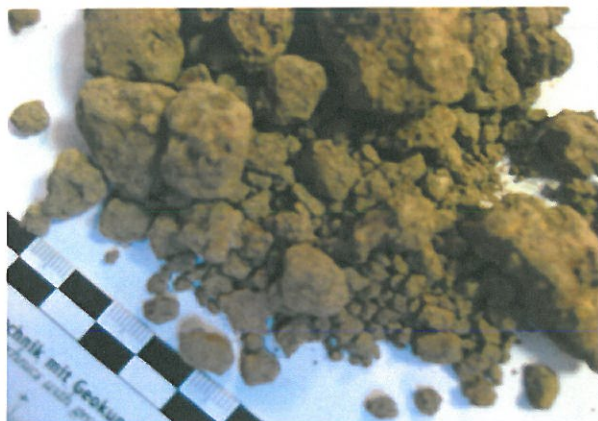
061-11

Padeswood, UK

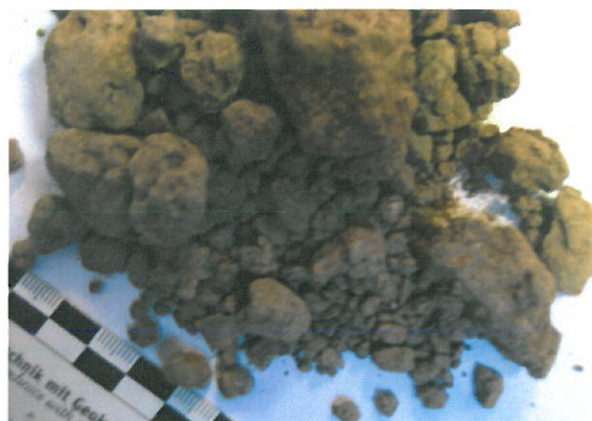
Enclosure



picture 1



picture 2



picture 3



APPENDIX 515/4

Slope Stability Analyses



PROJECT Padeswood Landfill Stability Risk Assessment

Job No. 10514240262
Ref. Appendix 515/4

Made By: BZ
Checked: DRVJ
Reviewed: DRVJ

Date: 06/01/2012
Sheet: 1
of: 26

INTRODUCTION

The stability of the cover soils and the integrity of the geosynthetic layers has been assessed for the capping system. Analysis has been carried out for the selected steepest and highest section.

Stability

The effect of a partially and fully saturated cover soil layer has been assessed using the method proposed by Jones & Dixon (1998). The normal operating conditions have been modelled using dry cover soils and the worst case conditions of fully saturated cover soils have been analysed. The water pressures acting on the system have been modelled using a Parallel Submergence Ratio (PSR). PSR = 0 for dry conditions, PSR = 0.25 and 0.5 for partially saturated conditions with seepage flow.

Integrity

The integrity of the geosynthetic liner have been assessed by considering the shear strength developed above and below the geosynthetic, and comparing this to the material strength.

Geosynthetic

Analyses has been carried out assuming the lining system comprises a GCL liner with 1.0 m of restoration soil.

The parameters used in the analysis have been derived from the site specific interface shear strength testing results. Based on this and our experience of geosynthetic interfaces, a conservative assessment of the interface shear strength parameters is:

•	Cover soils	/	GCL	$\alpha_p' =$	0	kPa	$\delta_p' =$	28	Deg.
•	GCL	/	Blinding layer	$\alpha_p' =$	0	kPa	$\delta_p' =$	35	Deg.

The tensile strength of the GCL has been taken from the GCL supplier's specification. A copy of the relevant data sheet is given in the reference page.

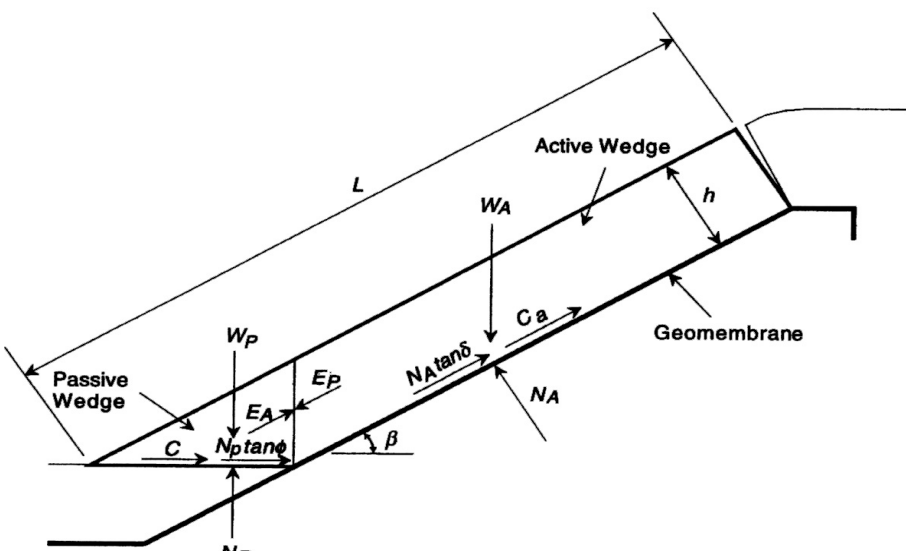


PROJECT Padeswood Landfill Stability Risk Assessment

Job No. 10514240262
Ref. Appendix 515/4

Made By: BZ
Checked: DRVJ
Reviewed: DRVJ

Date: 06/01/2012
Sheet: 2
of: 26

Section	A	PSR	=	0
Aim: To assess the stability and integrity of the geosynthetic capping system.				
Approach: Use the approach proposed by Jones & Dixon, 1998.				
Geometry:				
 (b) Finite slope				
Input Parameters				
Cover soils unit weight (dry), γ_{dry}	19	kN/m ³		
Cover soils unit weight (saturated), γ_{sat}	20	kN/m ³		
Cover soils internal shear strength, ϕ	22	Deg.		
Cover soils cohesion, c	1	kPa		
Thickness of cover soils, h	1	m		
Height of slope, H	15	m		
Slope angle, β	22.6	Deg.		
Geosynthetic interface shear strengths:				
Cover Soils/Geotextile friction angle, δ_1	28	Deg.		
Cover Soils/Geotextile cohesion intercept, α_1	0	kPa		
GCL/Blinding layer friction angle, δ_2	35	Deg.		
GCL/Blinding cohesion intercept, α_2	0	kPa		
Parallel submergence ratio, PSR	0			
Geosynthetic tensile strengths:				
GCL	12	kN/m		

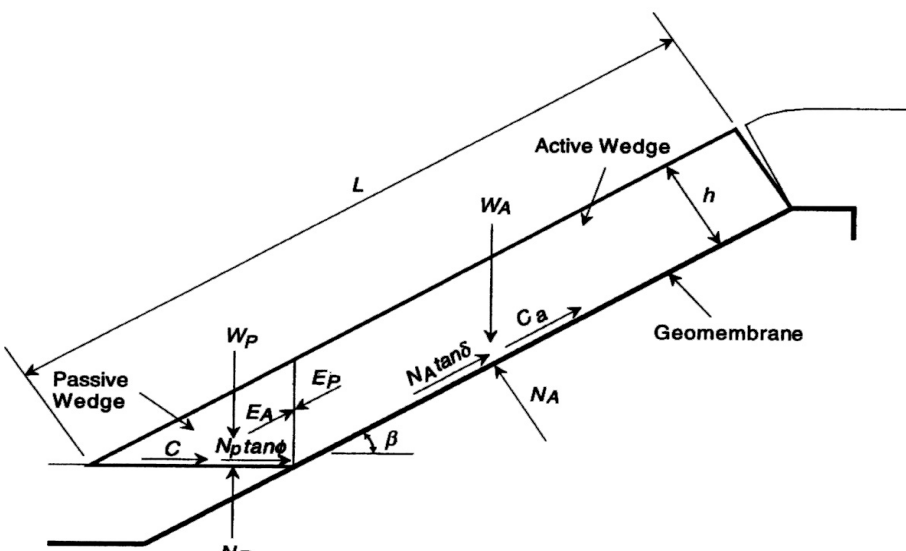


PROJECT Padeswood Landfill Stability Risk Assessment

Job No. 10514240262
Ref. Appendix 515/4

Made By: BZ
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Reviewed: DRVJ

Date: 06/01/2012
Sheet: 4
of: 26

Section	A	PSR =	0.25
Aim: To assess the stability and integrity of the geosynthetic capping system.			
Approach: Use the approach proposed by Jones & Dixon, 1998.			
Geometry:			
 (b) Finite slope			
Input Parameters			
Cover soils unit weight (dry), γ_{dry}	19	kN/m ³	
Cover soils unit weight (saturated), γ_{sat}	20	kN/m ³	
Cover soils internal shear strength, ϕ	22	Deg.	
Cover soils cohesion, c	1	kPa	
Thickness of cover soils, h	1	m	
Height of slope, H	15	m	
Slope angle, β	22.6	Deg.	
Geosynthetic interface shear strengths:			
Cover Soils/Geotextile friction angle, δ_1	28	Deg.	
Cover Soils/Geotextile cohesion intercept, α_1	0	kPa	
GCL/Blinding layer friction angle, δ_2	35	Deg.	
GCL/Blinding cohesion intercept, α_2	0	kPa	
Parallel submergence ratio, PSR	0.25		
Geosynthetic tensile strengths:			
GCL	12	kN/m	

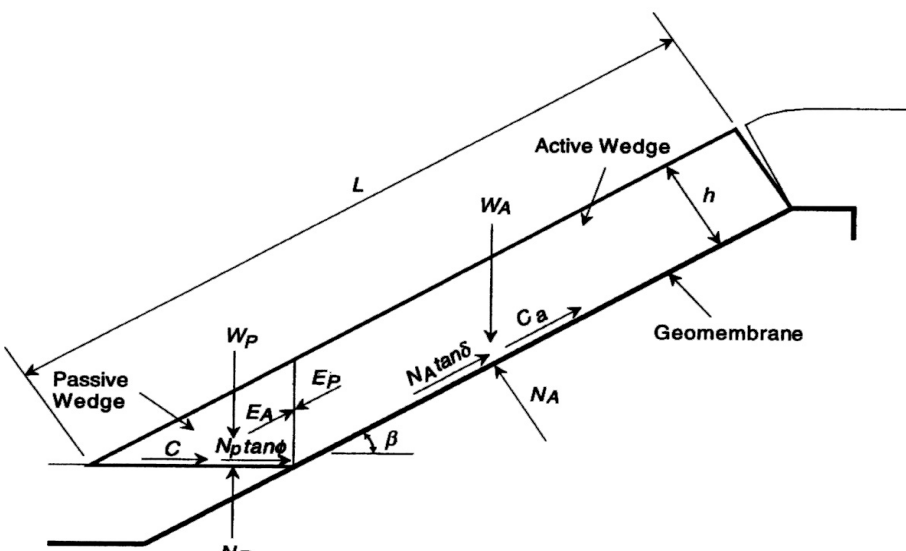


PROJECT Padeswood Landfill Stability Risk Assessment

Job No. 10514240262
Ref. Appendix 515/4

Made By: BZ
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Reviewed: DRVJ

Date: 06/01/2012
Sheet: 6
of: 26

Section	A	PSR =	0.5
Aim: To assess the stability and integrity of the geosynthetic capping system.			
Approach: Use the approach proposed by Jones & Dixon, 1998.			
Geometry:			
 (b) Finite slope			
Input Parameters			
Cover soils unit weight (dry), γ_{dry}	18	kN/m ³	
Cover soils unit weight (saturated), γ_{sat}	19	kN/m ³	
Cover soils internal shear strength, ϕ	22	Deg.	
Cover soils cohesion, c	1	kPa	
Thickness of cover soils, h	1	m	
Height of slope, H	15	m	
Slope angle, β	22.6	Deg.	
Geosynthetic interface shear strengths:			
Cover Soils/Geotextile friction angle, δ_1	28	Deg.	
Cover Soils/Geotextile cohesion intercept, α_1	0	kPa	
GCL/Blinding layer friction angle, δ_2	35	Deg.	
GCL/Blinding cohesion intercept, α_2	0	kPa	
Parallel submergence ratio, PSR	0.5		
Geosynthetic tensile strengths:			
GCL	12	kN/m	

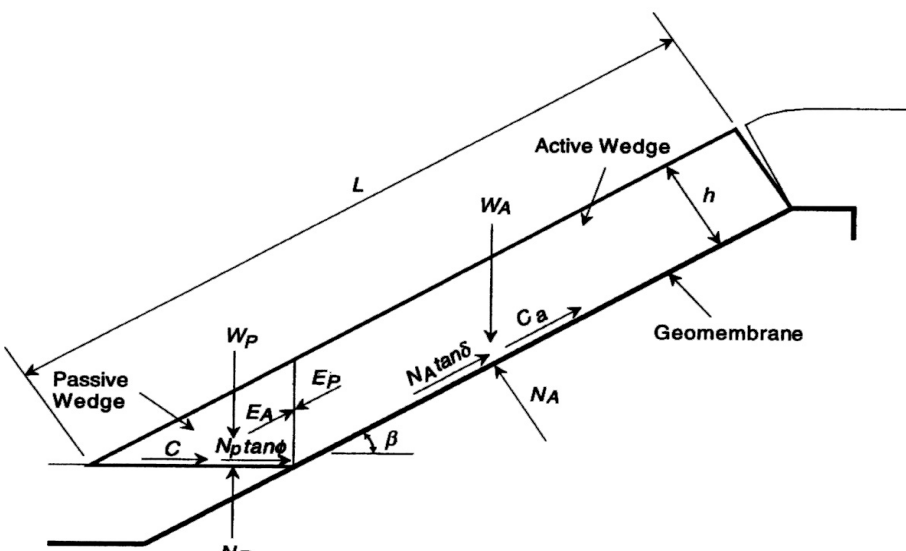


PROJECT Padeswood Landfill Stability Risk Assessment

Job No. 10514240262
Ref. Appendix 515/4

Made By: BZ
Checked: DRVJ
Reviewed: DRVJ

Date: 06/01/2012
Sheet: 8
of: 26

Section	B	PSR =	0
Aim: To assess the stability and integrity of the geosynthetic capping system.			
Approach: Use the approach proposed by Jones & Dixon, 1998.			
Geometry:			
 (b) Finite slope			
Input Parameters			
Cover soils unit weight (dry), γ_{dry}	19	kN/m ³	
Cover soils unit weight (saturated), γ_{sat}	20	kN/m ³	
Cover soils internal shear strength, ϕ	22	Deg.	
Cover soils cohesion, c	1	kPa	
Thickness of cover soils, h	0.6	m	
Height of slope, H	16	m	
Slope angle, β	8.8	Deg.	
Geosynthetic interface shear strengths:			
Cover Soils/Geotextile friction angle, δ_1	28	Deg.	
Cover Soils/Geotextile cohesion intercept, α_1	0	kPa	
GCL/Blinding layer friction angle, δ_2	35	Deg.	
GCL/Blinding cohesion intercept, α_2	0	kPa	
Parallel submergence ratio, PSR	0		
Geosynthetic tensile strengths:			
GCL	12	kN/m	

1. Stability of Cover Soils											
Calculated Parameters											
Length of slope, L								104.5848	m		
Thickness of water, h_w								0	m		
Weight of active wedge, W_A								1169.646	kN		
Weight of passive wedge, W_p								22.6213	kN		
Pore pressure perp. to slope, U_n								0	kN		
Pore pressure in interwedge surface, U_h								0	kN		
Force normal to active wedge, N_A								1155.877	kN		
Vert pp on passive wedge, U_v								0	kN		
a								176.8329			
b								-631.478			
c								37.98804			
Factor of Safety against cover soils sliding											3.51
2. Integrity of Geosynthetics											
(i) Geosynthetic Layer No.1											
Mobilised shear stress at upper interface								178.4918	kN		
Shear strength at lower interface								825.0072	kN		
Tension developed in the geosynthetic								0	kN		
Tensile strength of the geosynthetic								12	kN		
Factor of Safety against rupture											Infinite

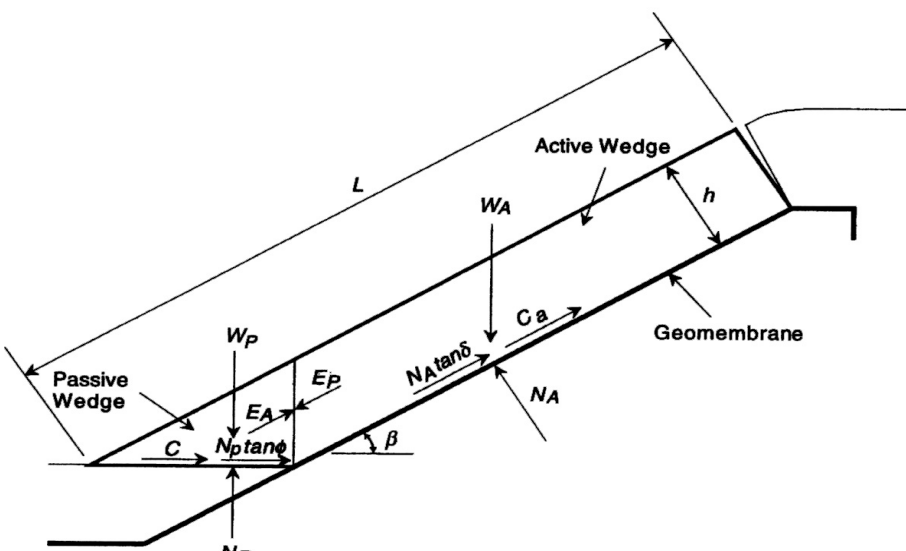


PROJECT Padeswood Landfill Stability Risk Assessment

Job No. 10514240262
Ref. Appendix 515/4

Made By: BZ
Checked: DRVJ
Reviewed: DRVJ

Date: 06/01/2012
Sheet: 10
of: 26

Section	B	PSR	=	0.25
Aim: To assess the stability and integrity of the geosynthetic capping system.				
Approach: Use the approach proposed by Jones & Dixon, 1998.				
Geometry:				
 (b) Finite slope				
Input Parameters				
Cover soils unit weight (dry), γ_{dry}		19	kN/m ³	
Cover soils unit weight (saturated), γ_{sat}		20	kN/m ³	
Cover soils internal shear strength, ϕ		22	Deg.	
Cover soils cohesion, c		1	kPa	
Thickness of cover soils, h		0.6	m	
Height of slope, H		16	m	
Slope angle, β		8.8	Deg.	
Geosynthetic interface shear strengths:				
Cover Soils/Geotextile friction angle, δ_1		28	Deg.	
Cover Soils/Geotextile cohesion intercept, α_1		0	kPa	
GCL/Blinding layer friction angle, δ_2		35	Deg.	
GCL/Blinding cohesion intercept, α_2		0	kPa	
Parallel submergence ratio, PSR		0.25		
Geosynthetic tensile strengths:				
GCL		12	kN/m	

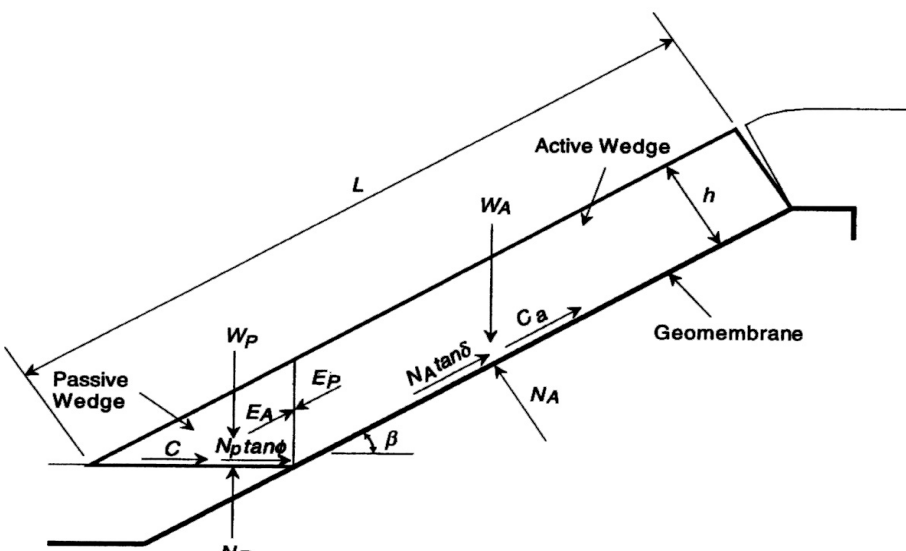


PROJECT Padeswood Landfill Stability Risk Assessment

Job No. 10514240262
Ref. Appendix 515/4

Made By: BZ
Checked: DRVJ
Reviewed: DRVJ

Date: 06/01/2012
Sheet: 12
of: 26

Section	B	PSR =	0.5
Aim: To assess the stability and integrity of the geosynthetic capping system.			
Approach: Use the approach proposed by Jones & Dixon, 1998.			
Geometry:			
 (b) Finite slope			
Input Parameters			
Cover soils unit weight (dry), γ_{dry}	19	kN/m ³	
Cover soils unit weight (saturated), γ_{sat}	20	kN/m ³	
Cover soils internal shear strength, ϕ	22	Deg.	
Cover soils cohesion, c	1	kPa	
Thickness of cover soils, h	0.6	m	
Height of slope, H	16	m	
Slope angle, β	8.8	Deg.	
Geosynthetic interface shear strengths:			
Cover Soils/Geotextile friction angle, δ_1	28	Deg.	
Cover Soils/Geotextile cohesion intercept, α_1	0	kPa	
GCL/Blinding layer friction angle, δ_2	35	Deg.	
GCL/Blinding cohesion intercept, α_2	0	kPa	
Parallel submergence ratio, PSR	0.5		
Geosynthetic tensile strengths:			
GCL	12	kN/m	

Infinite

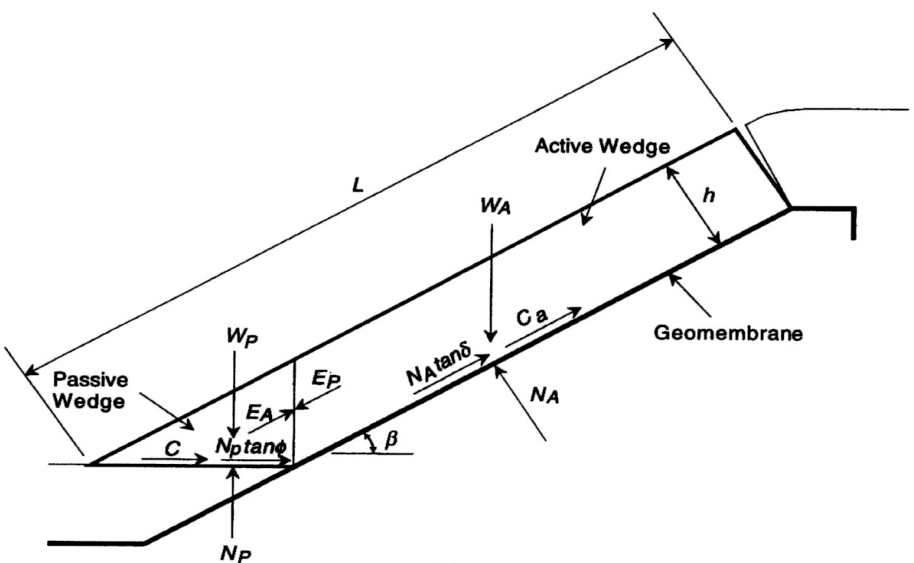


PROJECT Padeswood Landfill Stability Risk Assessment

Job No. 10514240262
Ref. Appendix 515/4

Made By: BZ
Checked: DRVJ
Reviewed: DRVJ

Date: 06/01/2012
Sheet: 14
of: 26

Section	C	PSR	=	0
Aim: To assess the stability and integrity of the geosynthetic capping system.				
Approach: Use the approach proposed by Jones & Dixon, 1998.				
Geometry:				
 (b) Finite slope				
Input Parameters				
Cover soils unit weight (dry), γ_{dry}	19	kN/m ³		
Cover soils unit weight (saturated), γ_{sat}	20	kN/m ³		
Cover soils internal shear strength, ϕ	22	Deg.		
Cover soils cohesion, c	1	kPa		
Thickness of cover soils, h	0.6	m		
Height of slope, H	20	m		
Slope angle, β	15.1	Deg.		
Geosynthetic interface shear strengths:				
Cover Soils/Geotextile friction angle, δ_1	28	Deg.		
Cover Soils/Geotextile cohesion intercept, α_1	0	kPa		
GCL/Blinding layer friction angle, δ_2	35	Deg.		
GCL/Blinding cohesion intercept, α_2	0	kPa		
Parallel submergence ratio, PSR	0			
Geosynthetic tensile strengths:				
GCL	12	kN/m		

Infinite



PROJECT Padeswood Landfill Stability Risk Assessment

Job No. 10514240262
Ref. Appendix 515/4

Made By: BZ
Checked: DRVJ
Reviewed: DRVJ

Date: 06/01/2012
Sheet: 16
of: 26

Section	C	PSR =	0.25
Aim: To assess the stability and integrity of the geosynthetic capping system.			
Approach: Use the approach proposed by Jones & Dixon, 1998.			
Geometry:			
(b) Finite slope			
Input Parameters			
Cover soils unit weight (dry), γ_{dry}	19	kN/m ³	
Cover soils unit weight (saturated), γ_{sat}	20	kN/m ³	
Cover soils internal shear strength, ϕ	22	Deg.	
Cover soils cohesion, c	1	kPa	
Thickness of cover soils, h	0.6	m	
Height of slope, H	20	m	
Slope angle, β	15.1	Deg.	
Geosynthetic interface shear strengths:			
Cover Soils/Geotextile friction angle, δ_1	28	Deg.	
Cover Soils/Geotextile cohesion intercept, α_1	0	kPa	
GCL/Blinding layer friction angle, δ_2	35	Deg.	
GCL/Blinding cohesion intercept, α_2	0	kPa	
Parallel submergence ratio, PSR	0.25		
Geosynthetic tensile strengths:			
GCL	12	kN/m	

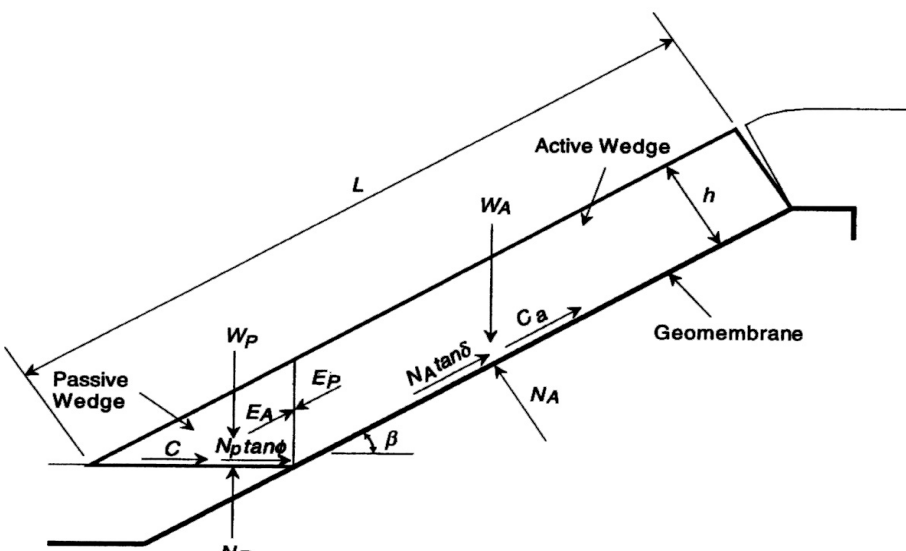


PROJECT Padeswood Landfill Stability Risk Assessment

Job No. 10514240262
Ref. Appendix 515/4

Made By: BZ
Checked: DRVJ
Reviewed: DRVJ

Date: 06/01/2012
Sheet: 18
of: 26

Section	C	PSR =	0.5
Aim: To assess the stability and integrity of the geosynthetic capping system.			
Approach: Use the approach proposed by Jones & Dixon, 1998.			
Geometry:			
 (b) Finite slope			
Input Parameters			
Cover soils unit weight (dry), γ_{dry}	19	kN/m ³	
Cover soils unit weight (saturated), γ_{sat}	20	kN/m ³	
Cover soils internal shear strength, ϕ	22	Deg.	
Cover soils cohesion, c	1	kPa	
Thickness of cover soils, h	0.6	m	
Height of slope, H	20	m	
Slope angle, β	15.1	Deg.	
Geosynthetic interface shear strengths:			
Cover Soils/Geotextile friction angle, δ_1	28	Deg.	
Cover Soils/Geotextile cohesion intercept, α_1	0	kPa	
GCL/Blinding layer friction angle, δ_2	35	Deg.	
GCL/Blinding cohesion intercept, α_2	0	kPa	
Parallel submergence ratio, PSR	0.5		
Geosynthetic tensile strengths:			
GCL	12	kN/m	

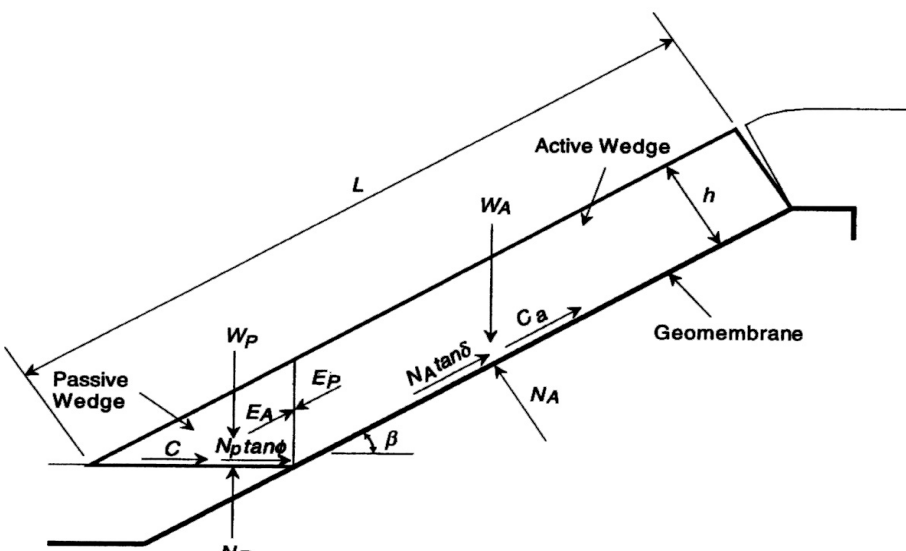


PROJECT Padeswood Landfill Stability Risk Assessment

Job No. 10514240262
Ref. Appendix 515/4

Made By: BZ
Checked: DRVJ
Reviewed: DRVJ

Date: 06/01/2012
Sheet: 20
of: 26

Section	D	PSR	=	0
Aim: To assess the stability and integrity of the geosynthetic capping system.				
Approach: Use the approach proposed by Jones & Dixon, 1998.				
Geometry:				
 (b) Finite slope				
Input Parameters				
Cover soils unit weight (dry), γ_{dry}	19	kN/m ³		
Cover soils unit weight (saturated), γ_{sat}	20	kN/m ³		
Cover soils internal shear strength, ϕ	22	Deg.		
Cover soils cohesion, c	1	kPa		
Thickness of cover soils, h	1	m		
Height of slope, H	19	m		
Slope angle, β	20.8	Deg.		
Geosynthetic interface shear strengths:				
Cover Soils/Geotextile friction angle, δ_1	28	Deg.		
Cover Soils/Geotextile cohesion intercept, α_1	0	kPa		
GCL/Blinding layer friction angle, δ_2	35	Deg.		
GCL/Blinding cohesion intercept, α_2	0	kPa		
Parallel submergence ratio, PSR	0			
Geosynthetic tensile strengths:				
GCL	12	kN/m		

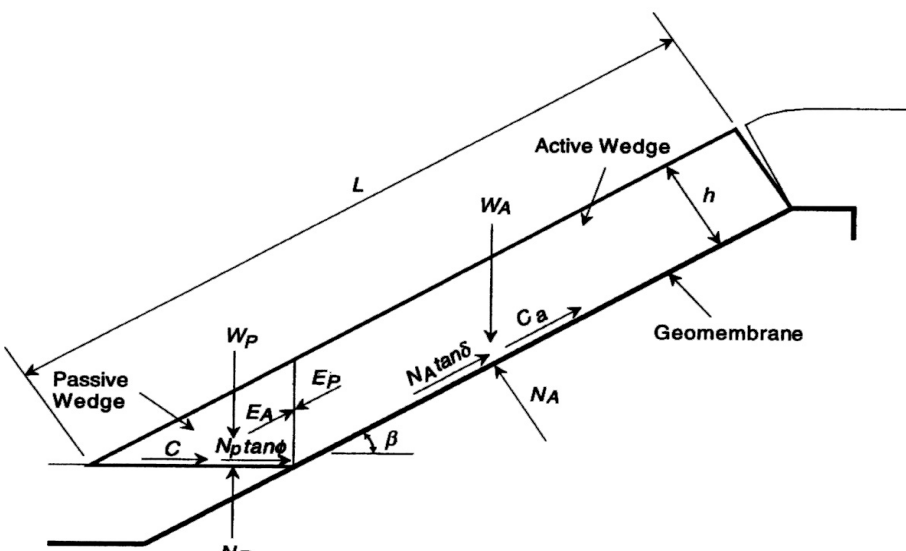


PROJECT Padeswood Landfill Stability Risk Assessment

Job No. 10514240262
Ref. Appendix 515/4

Made By: BZ
Checked: DRVJ
Reviewed: DRVJ

Date: 06/01/2012
Sheet: 22
of: 26

Section	D	PSR =	0.25
Aim: To assess the stability and integrity of the geosynthetic capping system.			
Approach: Use the approach proposed by Jones & Dixon, 1998.			
Geometry:			
 (b) Finite slope			
Input Parameters			
Cover soils unit weight (dry), γ_{dry}	19	kN/m ³	
Cover soils unit weight (saturated), γ_{sat}	20	kN/m ³	
Cover soils internal shear strength, ϕ	22	Deg.	
Cover soils cohesion, c	1	kPa	
Thickness of cover soils, h	1	m	
Height of slope, H	19	m	
Slope angle, β	20.8	Deg.	
Geosynthetic interface shear strengths:			
Cover Soils/Geotextile friction angle, δ_1	28	Deg.	
Cover Soils/Geotextile cohesion intercept, α_1	0	kPa	
GCL/Blinding layer friction angle, δ_2	35	Deg.	
GCL/Blinding cohesion intercept, α_2	0	kPa	
Parallel submergence ratio, PSR	0.25		
Geosynthetic tensile strengths:			
GCL	12	kN/m	

Infinite

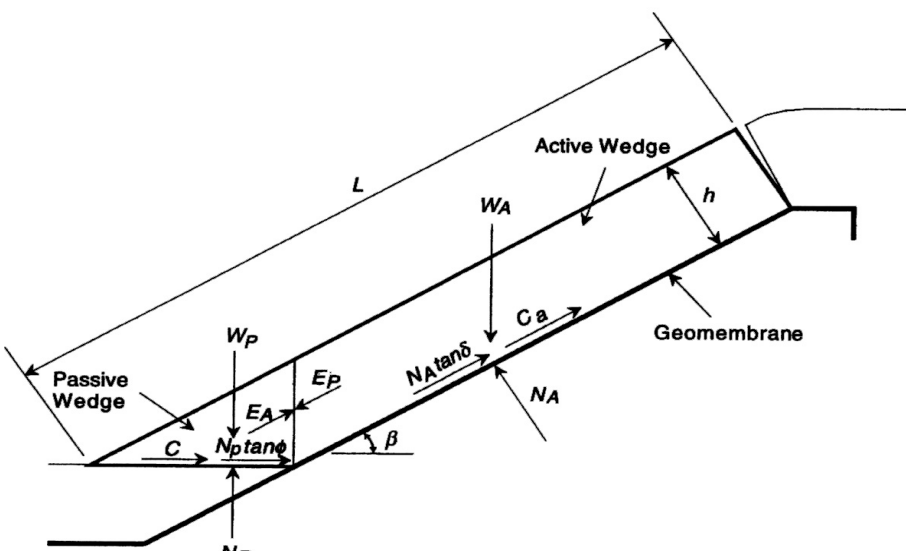


PROJECT Padeswood Landfill Stability Risk Assessment

Job No. 10514240262
Ref. Appendix 515/4

Made By: BZ
Checked: DRVJ
Reviewed: DRVJ

Date: 06/01/2012
Sheet: 24
of: 26

Section	D	PSR =	0.5
Aim: To assess the stability and integrity of the geosynthetic capping system.			
Approach: Use the approach proposed by Jones & Dixon, 1998.			
Geometry:			
 (b) Finite slope			
Input Parameters			
Cover soils unit weight (dry), γ_{dry}	19	kN/m ³	
Cover soils unit weight (saturated), γ_{sat}	20	kN/m ³	
Cover soils internal shear strength, ϕ	22	Deg.	
Cover soils cohesion, c	1	kPa	
Thickness of cover soils, h	1	m	
Height of slope, H	19	m	
Slope angle, β	20.8	Deg.	
Geosynthetic interface shear strengths:			
Cover Soils/Geotextile friction angle, δ_1	28	Deg.	
Cover Soils/Geotextile cohesion intercept, α_1	0	kPa	
GCL/Blinding layer friction angle, δ_2	35	Deg.	
GCL/Blinding cohesion intercept, α_2	0	kPa	
Parallel submergence ratio, PSR	0.5		
Geosynthetic tensile strengths:			
GCL	12	kN/m	

PROJECT Padeswood Landfill Stability Risk Assessment

Job No.	10514240262	Made By:	BZ	Date:	06/01/2012
Ref.	Appendix 515/4	Checked:	DRVJ	Sheet:	26
		Reviewed:	DRVJ	of:	26

Fibre-reinforced Geosynthetic Clay Liner (GCL)

Bentofix® NSP 4900



NAUE GmbH & Co. KG
Gewerbestrasse 2
32339 Espelkamp – Fiestel
Germany

Phone: +49 57 43 – 41 - 0
Fax: +49 57 43 – 41 - 240
info@naue.com www.naue.com

The following table lists properties of **Bentofix® NSP 4900**, a shear strength transmitting geosynthetic clay liner, continuously needle-punched through all components. Additional bentonite powder is impregnated into a 50 cm overlapping area on both longitudinal sides of the cover layer. The 30 cm longitudinal overlapping area is marked on the bottom side.

Property	Test method*	Unit	Values
Geotextile layers:			
Cover layer (polypropylene nonwoven):			
Mass per unit area	EN ISO 9864	g/m ²	220
Carrier layer (polypropylene woven):			
Mass per unit area	EN ISO 9864	g/m ²	110
Bentonite layer (sodium bentonite powder):			
Mass per unit area	EN 14196 (ρ_{TON})	g/m ²	4,670
Swell index	ASTM D 5890	ml/2g	24
Fluid Loss	ASTM D 5891	ml/2g	≤ 18
Water content	DIN 18121 / ISO 11465 (5hrs, 105 °C)	%	approx. 10
Geosynthetic Clay Liner:			
Mass per unit area	EN 14196 (ρ_{GBR-C})	g/m ²	5,000
Thickness	EN ISO 9863-1	mm	6.0
Max. tensile strength, md/cmd**	EN ISO 10319 / ASTM D 4595	kN/m	12.0 / 12.0
Elongation at break, md/cmd**	EN ISO 10319 / ASTM D 4595	%	10.0 / 6.0
Peel strength	ASTM D 6496	N/10 cm*** N/m	≥ 60 ≥ 360
Permeability / Hydraulic Conductivity	DIN 18130 / ASTM D 5887	m/s	2 x 10 ⁻¹¹
Index Flux	DIN 18130 / ASTM D 5887	(m ³ /m ²)/s	5 x 10 ⁻⁹
Roll dimensions:			
width x length, / diameter	-	m x m / m	4.85 x 40 / Ø 0.65

* = based on; **md = machine direction, cmd = cross machine direction; ***max. peak

The listed technical values are guiding values, achieved in our laboratories and/or independent testing institutes. Our products are subject to changes without prior notice.

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APPENDIX C

**Padeswood Landfill: Hydrogeological Risk Assessment,
Report reference 1051424262.502/B.0, Dated December 2010**



December 2010

CELEBRATING
50
YEARS
in 2010

HYDROGEOLOGICAL RISK ASSESSMENT REPORT

Padeswood Landfill Site

Submitted to:
Hanson (UK) Ltd
Padeswood Works
Mold
Flintshire
CH7 4HB

REPORT



A world of
capabilities
delivered locally

Report Number. 10514240262.502/B.0

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Table of Contents

1.0 INTRODUCTION.....	4
1.1 Objective.....	4
2.0 CONCEPTUAL HYDROGEOLOGICAL MODEL	4
2.1 Site Development	4
2.2 Source	4
2.2.1 Containment Engineering.....	4
2.2.2 Leachate Levels.....	5
2.2.3 Leachate Composition	5
2.3 Pathways	9
2.4 Receptor	10
2.4.1 Environmental Assessment Limits	10
3.0 HYDROGEOLOGICAL RISK ASSESSMENT	11
3.1 The Nature of the Hydrogeological Risk Assessment.....	11
3.2 The Proposed Assessment Scenarios.....	11
3.2.1 Vertical Leakage of Leachate through the Drift into the Coal Measures Aquifer	11
3.2.2 Accidents and their Consequences.....	12
3.3 The Priority Contaminants to be Modelled	12
3.4 Numerical Modelling	12
3.4.1 Justification for Modelling Approach and Software.....	12
3.4.2 Model Parameterisation	12
3.5 Emissions to Groundwater.....	14
3.5.1 Phases Constructed within the Middle Coal Measures Formation	14
3.6 Failure Scenario.....	15
3.6.1 Background.....	15
3.6.2 Assessment	15
3.7 Review of Technical Precautions.....	16
3.7.1 Capping.....	16
3.7.2 Leachate Drainage Systems	16
3.7.3 Leachate Head Control	17
3.7.4 Groundwater Management	17
3.8 Hydrogeological Completion Criteria	17



4.0	REQUISITE SURVEILLANCE	18
4.1	The Risk Based Monitoring Scheme.....	18
4.2	Leachate Level Monitoring.....	18
4.2.1	Leachate Level Compliance	18
4.3	Leachate Quality.....	19
4.4	Groundwater Level Monitoring.....	20
4.5	Groundwater Quality Monitoring	20
4.5.1	Groundwater Quality Compliance	21
4.6	Surface Water Quality Monitoring	21
4.6.1	Surface Water Quality Compliance	22
5.0	CONCLUSIONS.....	23
5.1	Compliance with the Landfill Directive 1999	23
5.2	Compliance with the Environmental Permitting (England & Wales) Regulations 2010	23
6.0	REFERENCES.....	24

TABLES

Table 1:	Summary of Leachate Composition from 'Leachate Sump'	5
Table 2:	Groundwater Quality Drift (2006 – 2010).....	10
Table 3:	Surface Water Quality Summary (2006 – 2010).....	11
Table 4:	Infiltration.....	12
Table 5:	Site Geometry	13
Table 6:	LandSim Source Term	13
Table 7:	Properties of the Unsaturated Zone	13
Table 8:	Aquifer Properties.....	14
Table 9:	Retardation Parameters, Unsaturated Zone and Aquifer	14
Table 10:	Time History Data from the Coal Measures at the Site Boundary (Normal Operating Conditions).....	15
Table 11:	Example Completion Criteria for Leachate	17
Table 12:	Leachate Monitoring Suite.....	19
Table 13:	Groundwater Monitoring Suite.....	20
Table 14:	Groundwater Trigger Concentrations	21
Table 15:	Proposed Action Plan in the Event of a Breached Groundwater Quality Trigger Concentration	21
Table 16:	Surface Water Monitoring Suite.....	21
Table 17:	Surface Water Trigger Concentrations	22
Table 18:	Proposed Action Plan in the Event of a Breached Surface Water Quality Trigger Concentration	23



DRAWINGS

Drawing 1: Site Location Plan
Drawing 2: Monitoring Location Plan

APPENDICES

Appendix 1: CL Associates CQA Capping Report
Appendix 2: Borehole Logs



1.0 INTRODUCTION

Hanson (UK) Ltd (Hanson) has requested that Golder Associates (UK) Ltd (Golder) prepare a series of documents to address Environment Agency queries regarding Padeswood Landfill Site, Padeswood Works, Mold, Flintshire, CH7 4HB (the Site).

1.1 Objective

The objective of this hydrogeological risk assessment report is to address the concerns of the Environment Agency that were provided to Hanson in a letter dated 16 August 2010. Where necessary recommendations are presented in this report for action to be taken by Hanson to mitigate any identified hydrogeological risks identified at Padeswood Landfill Site.

The assistance of Hanson in the provision of data for this work is gratefully acknowledged. Golder has not independently verified the information supplied.

2.0 CONCEPTUAL HYDROGEOLOGICAL MODEL

In the definition that has become accepted by the environmental and waste industries, there are three components to any site conceptual model:

- The *source* is the potentially contaminating components of the leachate that will be generated by precipitation infiltrating through the landfill waste;
- The *pathways* are any routes linking the source with the receptors including the underlying unsaturated geology in which degradation processes may occur; and
- The *receptors* are groundwater and surface water bodies that are connected to the source by the pathways, such as surface watercourses, local supply boreholes, or springs.

These three components are linked within a hydrogeological conceptual model for a site. Should either one of the source, pathway, or receptor be absent from the site setting, negligible risk will be posed to the groundwater and surface water environment.

2.1 Site Development

The Site lies immediately south of the operational area of the Padeswood Cement Works (NGR SJ 291 620). The Works are situated approximately 5 km east-southeast of Mold, 12 km west-southwest of Chester and 12 km north-northwest of Wrexham, and about 1 km from Buckley, Penymynydd and Penyfford. (Drawing 1)

To the north of the Site is the Padeswood Cement Works; to the east are open fields and a railway line; to the south is a disused railway line, footpaths and a tributary to Black Brook; and to the west are open fields, a channelised stream, Dyke Farm and Oak Tree Farm.

Limestone used in the manufacture of cement is extracted off-site and processed at Padeswood Works. Waste and cement kiln dust (CKD) produced by the manufacturing process has been deposited at Padeswood Landfill since the opening of the cement works in 1949. As part of the Kiln 4 Project, the landfill was re-graded and ceased to accept waste in 2002.

2.2 Source

2.2.1 Containment Engineering

The Site has no basal engineering. Waste has been deposited on top of the natural ground to a level of up to 6 m above ground level. The Site was capped in 2004 by the placement of a low permeability Geosynthetic Clay Liner (GCL) Cap.

It is understood from the Closure Report (Golder, 2006) that leachate is drained by a perimeter toe drain that was installed beneath the cap to direct flow towards the 'leachate sump'. The toe drain is reported by



Hanson to comprise a 250 mm diameter perforated pipe with filter gravel surround and GCL lining on the external side and base of the drain.

No reference to the construction of the toe drain is made in the CQA interim validation report (CL Associates, 2004) (Appendix 1) and consequently further details regarding the specification of the toe drain have not been identified.

The 'leachate sump' was inspected during a site visit on 20 September 2010. No evidence of inlets from toe drains were observed inside the sump, although it is noted that the sump is approximately 3 m deep, part filled with liquid and has perforations in the side wall to facilitate ground drainage.

It is considered that the 'leachate sump' was originally designed as a deep chamber excavated into the sand and gravel lenses beneath and adjacent to the Site to enable the abstraction of groundwater containing leachate.

2.2.2 Leachate Levels

It is stated in the Regulation 15 Risk Assessment Report (Golder 2001) that prior to capping, leachate was present at the Site with observed seepages of leachate from the flanks of the Site being collected in perimeter ditches and being pumped back into the Site.

It is reported on the borehole logs for Leachate Wells L1, L2 and L3 (Appendix 2) that at the time of drilling (January 2001), leachate was present approximately 1 m above the base of the Site. No recent data exists for L1, L2 and L3. Drawing 2 identifies the location of monitoring points.

The depth to water is reported for the 'leachate sump' although the ground elevation is not known for this location. The 'leachate sump' is located on the southeastern corner of the Site. Depths to water have been reported at between 0.67 m below ground level (m bGL) and 1.85 m bGL. The sump is believed to extend to a depth of approximately 3 m which could be below the base of the waste. Water levels may relate to the elevation of leachate in the southeastern corner of the Site, although due to the depth of the 'leachate sump' and its likely construction as a abstraction point for both leachate and potentially contaminated groundwater the water level in this installation may not give a true indication of leachate level in the Site.

2.2.3 Leachate Composition

A summary of the composition of leachate recovered from the 'leachate sump' is provided in Table 1. Also listed in Table 1 are the Environmental Quality Standard (EQS), Minimum Reporting Value (MRV), UK Drinking Water Standard (UKDWS) and the Waste Management Paper 26A (WMP26A) values for landfill completion criteria for those substances that are detected in leachate.

The parameters that exceed the completion criteria under WMP26A are pH and nitrite.

The substances that exceed the EQS are sulphate, ammoniacal nitrogen and chloride.

The only hazardous substance detected in the leachate is cadmium although at a concentration less than the Environment Agency MRV.

In Section 2.2.2 above, reference has been made to the 'leachate sump' acting as an abstraction of both leachate and underlying groundwater, consequently the leachate compositions reported may have been diluted to some degree by groundwater.

Table 1: Summary of Leachate Composition from 'Leachate Sump'

	Units	Min	Median	Max	EQS	MRV	UKDWS	WMP26A
Aluminium	mg/l	0.0193	0.12	0.72	N/A	N/A	0.2	2
Antimony	mg/l	<0.005	<0.005	<0.005	Not detected in leachate			
Arsenic	mg/l	0.00624	0.008	0.0125	0.05	N/A	0.01	0.5
Barium	mg/l	0.016	0.016	0.016	N/A	N/A	1	1
Beryllium	mg/l	<0.001	<0.001	<0.001	Not detected in leachate			
Boron	mg/l	0.031	0.031	0.031	2	N/A	1	
Cadmium	mg/l	<0.0001	0.000127	0.00028	0.005	0.001	0.005	0.05
Calcium	mg/l	3.66	14	42.62	N/A	N/A	250	1000



HRA REPORT: PADESWOOD LANDFILL SITE

	Units	Min	Median	Max	EQS	MRV	UKDWS	WMP26A
Chromium	mg/l	<0.001	0.01535	0.071	0.005-0.250	N/A	0.05	0.5
Cobalt	mg/l	<0.001	<0.001	<0.001	Not detected in leachate			
Copper	mg/l	0.002	0.00625	0.017	0.001-0.028	N/A	2	1
Cyanide, Free	mg/l	<0.01	<0.01	<0.01	Not detected in leachate			
Cyanide, Total	mg/l	<0.05	<0.05	<0.05	Not detected in leachate			
Dibutyl Tin*	mg/l	<0.00002	<0.00002	<0.00002	Not detected in leachate			
Iron	mg/l	<0.005	0.025	0.116	1	N/A	0.2	2
Lead	mg/l	<0.001	0.004	0.014	0.004-0.250	N/A	0.01	0.5
Magnesium	mg/l	0.451	5.37	7.3	N/A	N/A	50	500
Manganese	mg/l	0.001	0.002	0.00366	N/A	N/A	0.05	0.5
Mercury	mg/l	<0.00001	<0.00001	<0.00001	Not detected in leachate			
Molybdenum	mg/l	0.025	0.025	0.025	N/A	N/A	N/A	N/A
Nickel	mg/l	0.004	0.0167	0.0372	0.05-0.2	N/A	0.02	0.5
Phosphorus	mg/l	<0.01	<0.01	<0.01	Not detected in leachate			
Potassium	mg/l	39	635	1100	N/A	N/A	N/A	N/A
Selenium	mg/l	0.0164	0.0381	0.063	N/A	N/A	0.01	0.1
Silicon Dissolved	mg/l	3.31	3.31	3.31	N/A	N/A	N/A	N/A
Silver	mg/l	<0.001	<0.001	<0.001	Not detected in leachate			
Sodium	mg/l	23.3	62.5	90	170	N/A	200	1500
Tellurium	mg/l	<0.001	<0.001	<0.001	Not detected in leachate			
Thallium	mg/l	<0.001	<0.001	<0.001	Not detected in leachate			
Tin	mg/l	<0.001	<0.001	<0.001	Not detected in leachate			
Tributyl Tin*	mg/l	<0.00002	<0.00002	<0.00002	Not detected in leachate			
Triphenyl Tin*	mg/l	<0.00002	<0.00002	<0.00002	Not detected in leachate			
Titanium	mg/l	<0.001	<0.001	<0.001	Not detected in leachate			
Uranium	mg/l	0.002	0.002	0.002	N/A	N/A	N/A	N/A
Vanadium	mg/l	0.004	0.004	0.004	0.02-0.06	N/A	N/A	N/A
Zinc	mg/l	0.00253	0.046	0.219	0.008-0.5	N/A	5	1
Sulphate (soluble)	mg/l	185	490	720	400	N/A	250	2500
Total Alkalinity as CaCO3	mg/l	90	142.5	300	N/A	N/A	N/A	N/A
BOD	mg/l	<1	1	8	N/A	N/A	N/A	N/A
COD	mg/l	27	35.5	61	N/A	N/A	N/A	N/A
Conductivity (at 20 deg.C)	mS/cm	1.47	1.9	2.9	N/A	N/A	N/A	4
pH Value	pH units	7.88	8.71	11	N/A	N/A	N/A	6.5-8
Total Organic Carbon	mg/l	9	10	15	N/A	N/A	N/A	N/A
Total Suspended Solids	mg/l	<6	<10	21	N/A	N/A	N/A	N/A
Ammoniacal Nitrogen as N	mg/l	<0.2	0.25	2.9	0.015	N/A	0.39	3.9
Chloride	mg/l	47	205	958	250	N/A	250	2000
Fluoride	mg/l	<0.3	1.05	6.33	N/A	N/A	1.5	10
Nitrate as NO3	mg/l	0.724	10.2	33.2	N/A	N/A	50	500
Nitrite as NO2	mg/l	<0.05	<0.05	1.24	N/A	N/A	N/A	0.1
Phosphate (Ortho as PO4)	mg/l	<0.08	<0.08	<0.08	Not detected in leachate			
Total Oxidised Nitrogen as N	mg/l	0.253	2.2	7.5	N/A	N/A	N/A	N/A
Mineral Oil Aqueous	µg/l	<10	<10	<10	Not detected in leachate			
Aldrin	µg/l	<0.01	<0.01	<0.01	Not detected in leachate			
Alpha-BHC (Lindane)	µg/l	<0.01	<0.01	<0.01	Not detected in leachate			
Azinphos-ethyl	µg/l	<0.01	<0.01	<0.01	Not detected in leachate			
Azinphos-methyl	µg/l	<0.01	<0.01	<0.01	Not detected in leachate			
Beta-BHC (Lindane)	µg/l	<0.01	<0.01	<0.01	Not detected in leachate			
Carbophenothion	µg/l	<0.01	<0.01	<0.01	Not detected in leachate			
Chlorfenvinphos	µg/l	<0.01	<0.01	<0.01	Not detected in leachate			
Chlorothalonil	µg/l	<0.01	<0.01	<0.01	Not detected in leachate			
Chlorpyrifos	µg/l	<0.01	<0.01	<0.01	Not detected in leachate			
Chlorpyrifos methyl	µg/l	<0.01	<0.01	<0.01	Not detected in leachate			
cis-Chlordane	µg/l	<0.01	<0.01	<0.01	Not detected in leachate			
Diazinon	µg/l	<0.01	<0.01	<0.01	Not detected in leachate			
Dichlorvos	µg/l	<0.01	<0.01	<0.01	Not detected in leachate			
Diieldrin	µg/l	<0.01	<0.01	<0.01	Not detected in leachate			



HRA REPORT: PADESWOOD LANDFILL SITE

	Units	Min	Median	Max	EQS	MRV	UKDWS	WMP26A
Dimethoate	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Disulphoton	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Endosulphan I	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Endosulphan II	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Endosulphan sulphate	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Endrin	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Ethion	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Etrimphos	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Fenitrothion	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Fenthion	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Gamma-BHC (Lindane)	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Heptachlor	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Heptachlor Epoxide	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Hexachlorobenzene	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Isodrin	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Malathion	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Methyl Parathion	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Mevinphos	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
o,p'-DDE	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
o,p'-DDT	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
o,p'-Methoxychlor	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
o,p'-TDE (DDD)	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
p,p'-DDE	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
p,p'-DDT	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
p,p'-Methoxychlor	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
p,p'-TDE (DDD)	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Parathion	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Pendimethalin	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Permethrin I	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Permethrin II	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Phosalone	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Pirimiphos-methyl	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Propetamphos	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Quintozone (PCNB)	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Tecnazene	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Telodrin	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
trans-Chlordane	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Triadimefon	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Triallate	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Triazophos	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
Trifluralin	µg/l	<0.01	<0.01	<0.01		Not detected in leachate		
1,1,1,2-Tetrachloroethane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,1,1-Trichloroethane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,1,2,2-Tetrachloroethane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,1,2-Trichloroethane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,1-Dichloroethane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,1-Dichloroethene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,1-Dichloropropene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,2,3-Trichlorobenzene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,2,3-Trichloropropane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,2,4-Trichlorobenzene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,2,4-Trichlorobenzene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,2,4-Trimethylbenzene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,2-Dibromo-3-chloropropane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,2-Dibromoethane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,2-Dichlorobenzene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,2-Dichlorobenzene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,2-Dichloroethane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,2-Dichloropropane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,3,5-Trimethylbenzene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,3-Dichlorobenzene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		



HRA REPORT: PADESWOOD LANDFILL SITE

	Units	Min	Median	Max	EQS	MRV	UKDWS	WMP26A
1,3-Dichlorobenzene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,3-Dichloropropane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,4-Dichlorobenzene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
1,4-Dichlorobenzene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
2,2-Dichloropropane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
2,4,5-Trichlorophenol	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
2,4,6-Trichlorophenol	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
2,4-Dichlorophenol	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
2,4-Dimethylphenol	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
2,4-Dinitrotoluene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
2,6-Dinitrotoluene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
2-Chloronaphthalene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
2-Chlorophenol	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
2-Chlorotoluene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
2-Methylnaphthalene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
2-Methylphenol	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
2-Nitroaniline	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
2-Nitrophenol	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
3-Nitroaniline	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
4-Bromophenylphenylether	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
4-Chloro-3-methylphenol	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
4-Chloroaniline	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
4-Chlorophenylphenylether	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
4-Chlorotoluene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
4-Isopropyltoluene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
4-Methylphenol	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
4-Nitroaniline	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
4-Nitrophenol	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Acenaphthene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Acenaphthylene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Anthracene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Azobenzene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Benzene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Benzo(a)anthracene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Benzo(a)pyrene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Benzo(b)fluoranthene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Benzo(ghi)perylene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Benzo(k)fluoranthene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Bis(2-chloroethoxy)methane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Bis(2-chloroethyl)ether	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Bis(2-ethylhexyl) phthalate	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Bromobenzene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Bromochloromethane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Bromodichloromethane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Bromoform	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Bromomethane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Butylbenzyl phthalate	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Carbazole	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Carbon Disulphide	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Carbontetrachloride	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Chlorobenzene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Chloroethane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Chloroform	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Chloromethane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Chrysene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
cis-1-2-Dichloroethene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
cis-1-3-Dichloropropene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Dibenzo(a,h)anthracene	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Dibenzofuran	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Dibromochloromethane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		
Dibromomethane	µg/l	<1.0	<1.0	<1.0		Not detected in leachate		



HRA REPORT: PADESWOOD LANDFILL SITE

	Units	Min	Median	Max	EQS	MRV	UKDWS	WMP26A
Dichlorodifluoromethane	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Dichloromethane	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Diethyl phthalate	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Dimethyl phthalate	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Di-n-butyl phthalate	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Di-n-Octyl phthalate	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Ethylbenzene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Fluoranthene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Fluorene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Hexachlorobenzene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Hexachlorobutadiene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Hexachlorobutadiene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Hexachlorocyclopentadiene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Hexachloroethane	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Indeno(1,2,3-cd)pyrene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Isophorone	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Isopropylbenzene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Methyl Tertiary Butyl Ether	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Naphthalene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
n-Butylbenzene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Nitrobenzene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
N-nitrosodi-n-propylamine	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
o-Xylene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
p/m-Xylene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Pentachlorophenol	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Phenanthrene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Phenol	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Propylbenzene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Pyrene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
sec-Butylbenzene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Styrene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
tert-Butylbenzene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Tetrachloroethene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Toluene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
trans-1-2-Dichloroethene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
trans-1-3-Dichloropropene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Trichloroethene	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Trichlorofluoromethane	µg/l	<1.0	<1.0	<1.0				Not detected in leachate
Vinyl Chloride	µg/l	<1.0	<1.0	<1.0				Not detected in leachate

2.3 Pathways

Underlying the landfill are *in situ* superficial Drift deposits, these Drift deposits, comprise lenses of alluvial sand and gravel and Glacial Till, which comprises a sandy gravelly clay. The clay has a maximum thickness of 9 m in the north of the Site.

Some lenses of alluvial sand deposits contain perched groundwater and some are dry suggesting that they are discontinuous.

The Drift deposits overlie the Coal Measures which comprise interbedded sandstones and mudstones. The water table in the Coal Measures is below the interface with the Glacial Till.

Potential pathways include;

- Vertical migration of leachate through the Drift deposits and unsaturated Coal Measures to groundwater present in the Coal Measures; and
- Lateral migration of leachate through the Drift deposits or surface breakout towards the unnamed tributary to Black Brook. Whilst there is evidence to suggest that the lenses of alluvial sand and gravel



are discontinuous and the hydraulic gradient of the water table is relatively flat, there remains the possibility that leachate could impact a lens of gravel adjacent to the Site which could outcrop in the bed or bank of the adjacent unnamed tributary to Black Brook.

2.4 Receptor

The receptors for leachate from the Site comprise the following:

- Groundwater present in the underlying Coal Measures aquifer which is likely to contribute to baseflow of the River Alyn some 2 km downgradient; and
- An unnamed tributary to Black Brook adjacent to the eastern and southern boundaries of the Site.

2.4.1 Environmental Assessment Limits

The Drift deposits underlying the Site are designated by the Environment Agency as non water bearing 'unproductive strata' of low permeability, hence it is considered appropriate to define Environmental Assessment Limits (EALs) based on the background groundwater quality upgradient to the Site in boreholes located to the north of the Site. The EALs are required to ensure that if perched groundwater were to discharge to the unnamed tributary to Black Brook it does not raise concentrations of substances above the baseline criteria.

The EALs derived based on the background groundwater quality are presented in Table 2 below. The location of monitoring points is shown on Drawing 2. The use of background data to set quality EALs is consistent with the requirement that the Site would not impede future improvements in groundwater quality if the upgradient groundwater quality were to improve. EAL concentrations are derived for ammoniacal nitrogen, chloride and sulphate based on the substances present in the leachate above the EQS.

It is noted from Golder (2004) and the borehole logs that Boreholes BH04 and BH05 were drilled through fill at the edge of the landfill (1.6 m thick BH04 and 0.35 BH05) it is therefore considered likely that these boreholes are acting as a pathway for the migration of leachate in to the underlying lens of sand and gravel. It is therefore recommended that BH04 and BH05 be over drilled and backfilled with grout to prevent this from continuing. Monitoring of groundwater quality shall continue in BH01/02, BH02/02 and BH03/02 along the southern boundary.

No recent groundwater monitoring has been undertaken on the boreholes installed in the Coal Measures consequently EAL values cannot be set until a full 12 months of monitoring data is available.

Table 2: Groundwater Quality Drift (2006 – 2010)

	Min	Median	Max	EQS	UKDWS
BH1A Background Monitoring Borehole					
Sulphate (mg/l)	66	94.5	149	400	250
Ammoniacal Nitrogen (mg/l)	<0.2	<0.2	0.5	0.021	0.39
Chloride (mg/l)	39	110	339	250	250
BH2A Background Monitoring Borehole					
Sulphate (mg/l)	170	274.5	600	400	250
Ammoniacal Nitrogen (mg/l)	<0.2	0.2	3.2	0.021	0.39
Chloride (mg/l)	70	99.5	290	250	250
Proposed EAL	EAL			Justification	
Sulphate (mg/l)	600			Based on background quality	
Ammoniacal Nitrogen (mg/l)	3.2			Based on background quality	
Chloride (mg/l)	339			Based on background quality	
BH4 Down Gradient Monitoring Borehole					
Sulphate (mg/l)	370	637.5	1120	400	250



	Min	Median	Max	EQS	UKDWS
Ammoniacal Nitrogen (mg/l)	6.5	14	44	0.021	0.39
Chloride (mg/l)	130	430	1092	250	250
BH5 Down Gradient Monitoring Borehole					
Sulphate (mg/l)	189	230	299	400	250
Ammoniacal Nitrogen (mg/l)	<0.2	1.2	8.5	0.021	0.39
Chloride (mg/l)	29	61	121	250	250
BH03/02 Down Gradient Monitoring Borehole					
Sulphate (mg/l)	280	375	593	400	250
Ammoniacal Nitrogen (mg/l)	<0.2	0.2	0.7	0.021	0.39
Chloride (mg/l)	54	120	259	250	250

The EALs for surface water quality of the unnamed tributary to Black Brook adjacent to the Site have been derived based on the EQS or upgradient water quality. (Table 2 below). EAL concentrations are derived for ammoniacal nitrogen, chloride and sulphate based on the substances present in the leachate above the EQS. The concentration of substances detected in the watercourse exceed the EAL at times. This is considered to relate to an operational issue with regard to capture of leachate from the toe drain and has been described elsewhere in this report. The surface water action plan will require the course of the unnamed tributary to Black Brook to be walked with electrical conductivity readings taken at 5 m intervals to identify where the additional loading of substances present in the leachate are entering the watercourse.

Table 3: Surface Water Quality Summary (2006 – 2010)

	Upstream			Down Stream			EQS	EAL	Justification
	Min	Median	Max	Min	Median	Max			
Sulphate (mg/l)	40	63	94	72	210	2,435	400	400	EQS
Ammoniacal Nitrogen as N (mg/l)	<0.2	<0.2	0.90	0.1	0.4	6.9	0.021	0.90	Upstream quality
Chloride (mg/l)	32	62	198	38	110	777	250	250	EQS

3.0 HYDROGEOLOGICAL RISK ASSESSMENT

3.1 The Nature of the Hydrogeological Risk Assessment

Golder has adopted a complex risk assessment methodology to assess the impact of Padeswood Landfill Site on the underlying Coal Measures aquifer. This approach recognises the leachate concentrations in the landfill and the aquifer status beneath the Site.

The impact of Padeswood Landfill Site on the perched groundwater present in the superficial deposits and ultimately the unnamed tributary to Black Brook will be considered using a generic quantitative approach as a failure scenario to consider options for leachate management.

3.2 The Proposed Assessment Scenarios

The different approaches to quantifying the risk associated with each regime are outlined in this section

3.2.1 Vertical Leakage of Leachate through the Drift into the Coal Measures Aquifer

Padeswood.sim has been used to model leakage as a function of time. This will span the operational and post operational periods. Leakage will be determined with respect to a fixed 1 m head of leachate. It will be



assumed that leachate levels are controlled to a fixed head of 1 m from 1949, when the Site opened to 2004 when it was capped. This assumption considers the typical head of leachate present from records before the Site was capped. The calculation will consider no leachate migration subsequent to capping as a conservative interpretation of the site management.

3.2.2 Accidents and their Consequences

In compliance with current regulations, operational control should be maintained until the Site can be demonstrated not to represent a risk to the environment, a period which would be anticipated to last for several decades after site closure.

The performance of leachate management systems at the Site is important to prevent surface breakout and mounding or leachate with the consequences being increased leakage to the underlying Coal Measures aquifer and lateral migration of leachate through the lenses of sand and gravel to the unnamed tributary to Black Brook.

A scoping calculation will be conducted to identify possible impacts that the site may have on the adjacent water course if the leachate management system was unable to manage migration of leachate and hence enable a discharge through the superficial deposits.

3.3 The Priority Contaminants to be Modelled

The source term for Padeswood Landfill Site has been defined based on the substances that were identified above the EQS in the leachate from routine monitoring at the Site between January 2006 and October 2010 and are ammoniacal nitrogen, chloride and sulphate.

3.4 Numerical Modelling

3.4.1 Justification for Modelling Approach and Software

The probabilistic software used for the assessment of the Site whereby the vertical leakage of leachate in to the Coal Measures Aquifer is considered is LandSim v2.5. This approach will allow the computer simulation of leakage through the base of each phase to be modelled on the basis of key landfill design parameters and its setting.

3.4.2 Model Parameterisation

Infiltration

Prior to capping, infiltration will occur directly to the open waste surface. The Site was capped with GCL and restoration soils in 2004. Table 4 presents the inputs used to represent the infiltration to the waste during the landfill's lifecycle.

Table 4: Infiltration

Parameter	Units	Distribution	Justification
<i>Pre-capping of cells</i>			
Infiltration to open waste	mm/yr	Normal (158, 15.8)	Consistent with Golder (2001).
<i>Cells capped and system performing as installed</i>			
Cap design infiltration	mm/yr	Normal (38, 3.8)	Consistent with Golder (2001).
Completion of capping	Year	2004	Year capped.



Site Geometry

Table 5 shows the cell geometry inputs that will be input to LandSim and are based on the survey data for the cap area.

Table 5: Site Geometry

Phase	Basal Area (Ha)	Top Area (Ha)	Number of Cells
Site	2.0	2.0	1

Source Term

The source term used is conservatively based on site-specific data the Site. The range of values considered are the minimum, median and maximum concentrations observed in BH04 which is a monitoring borehole screened through the waste. The concentrations observed in BH04 are higher than those observed from the 'leachate sump'. Table 6 specifies the range of concentrations considered for the Site.

Table 6: LandSim Source Term

Distribution	Contaminant	Min	Likely	Max
		mg/l		
Uniform	Ammoniacal Nitrogen	6.5	14	44
Uniform	Chloride	130	430	1,092
Uniform	Sulphate	370	637.5	1,120

Unsaturated Zone

The pathway for leachate to enter the Coal Measures aquifer is by vertical leakage through the unlined base of the landfill and vertical migration into the saturated sand and gravel lenses or through the underlying unsaturated Glacial Till towards the Coal Measures. It was demonstrated in the Regulation 15 Assessment (Golder, 2001) that there is limited vertical and lateral extent to the gravel lenses and consequently based on the low flow rates and greater vertical hydraulic gradient over lateral gradients that vertical migration through the unsaturated Glacial Till and Coal Measures would be the primary pathway towards groundwater. The LandSim model properties conservatively exclude the unsaturated component of the Coal Measures.

The properties of the unsaturated zone beneath the Site are summarised in Table 7.

Table 7: Properties of the Unsaturated Zone

Parameter	Units	Distribution	Min	Max	Justification
Hydraulic Properties					
Moisture content	Fr by volume	Uniform	0.1	0.2	Consistent with Golder (2001)
Density	Kg/l	Triangular	1.7	2.0	Consistent with Golder (2001)

Coal Measures Aquifer

Table 8 summarises the LandSim input parameters that will be used to represent the saturated Coal Measures Formation underlying the Site.



Table 8: Aquifer Properties

Parameter	Units	Distribution	Min	Likely	Max	Justification
Aquifer Geometry						
Pathway width taken from phase dimensions in the domain area window parallel to the inferred groundwater flow direction from data presented in Golder (2001).						
Hydraulic Properties						
Hydraulic Conductivity	m/s	Log uniform	1×10^{-6}		1×10^{-5}	Consistent with Golder (2001)
Hydraulic Gradient	-	Uniform	0.057		0.065	Consistent with Golder (2001)
Pathway porosity	Fr	Uniform	0.1		0.2	Consistent with Golder (2001)
Dispersion						
Longitudinal dispersivity	m	Uniform		200		1/10 th of pathway length.
Transverse dispersivity	m	Uniform		60		1/30 th of pathway length.

The pathway length which has been considered for this model has been taken as the distance to the River Alyn.

Retardation and Decay

It is considered that retardation will occur in the liner and the unsaturated zone and aquifer pathway. Table 9 summarises the expected range of data for each contaminant species considered in the LandSim model.

Table 9: Retardation Parameters, Unsaturated Zone and Aquifer

Contaminant	Units	Distribution	Min	Most Likely	Max	Justification
Kd						
Ammoniacal Nitrogen	l/Kg	Uniform	0.018		0.18	Environment Agency (2003).
Chloride	l/Kg		Unretarded			
Sulphate	l/Kg		Unretarded			

3.5 Emissions to Groundwater

3.5.1 Phases Constructed within the Middle Coal Measures Formation

The file Padeswood.sim was used to assess the concentration of chloride, ammoniacal nitrogen and sulphate in the aquifer at the site boundary and at the River Alyn. The results demonstrate that the peak impact occurred prior to capping the Site. For validation of the findings of the risk assessment model the 50th percentile concentrations are comparable to the concentrations observed in 2001 (Golder, 2001).

No EAL values have been set for the boreholes installed in the Coal Measures due to the lack of recent monitoring data. Once 12 months of monitoring data has been collected EAL values will be set to enable comparison of the findings of this assessment. It is noted that the predicted concentration of chloride and sulphate are both less than the UK DWS and EQS. The peak concentration of ammoniacal nitrogen exceeded the EQS and UKDWS however through retardation and dispersion in the unsaturated zone, source decline and capping of the Site to reduce leakage, the peak in the concentration of ammoniacal nitrogen was relatively short lived and groundwater quality is predicted to continue to improve.



It is also noted that the assessment has not considered decay of ammoniacal nitrogen or dilution by recharge between the site boundary and the River Alyn.

Table 10: Time History Data from the Coal Measures at the Site Boundary (Normal Operating Conditions)

	95% less than		50% less than	
	Year of Peak Impact	Peak Concentration (mg/l)	Year of Peak Impact	Peak Concentration (mg/l)
Chloride concentration at site boundary	1987	141	1978	60
Ammoniacal nitrogen concentration at site boundary	1992	5.7	1988	2.3
Sulphate concentration at site boundary	1984	210	1981	88
Chloride concentration prior to discharge to the River Alyn	2046	90	2049	32
Ammoniacal nitrogen concentration prior to discharge to the River Alyn	2178	2.9	2069	0.9
Sulphate concentration prior to discharge to the River Alyn	2093	141	2054	56

3.6 Failure Scenario

3.6.1 Background

As previously discussed, the Site was constructed without a formal lining system and without a means to manage leachate head. Prior to capping, leachate was allowed to seep from the flanks of the landfill to be collected in perimeter ditches. Subsequent to capping it is understood from the Closure Report (Golder, 2006) that leachate was drained by a perimeter toe drain that was installed beneath the cap to direct flow towards the 'leachate sump'. The toe drain reportedly comprises a 250 mm diameter perforated pipe with filter gravel surround and GCL lining on the external side and base of the drain.

No reference to the construction of the toe drain is made in the CQA interim validation report (CL Associates, 2004) and consequently further details regarding the specification of the toe drain have not been identified.

The 'leachate sump' was inspected during a site visit on 20 September 2010. No evidence of inlets from toe drains were observed inside the sump, although it is noted that the sump is approximately 3 m deep, part filled with liquid and has perforations in the side wall to facilitate ground drainage.

The water quality of the unnamed tributary to Black Brook adjacent to the Site deteriorates as it passes the Site. It has been inferred that it is possible that leachate may be escaping from the 'leachate sump' or toe drain to an underlying gravel lens that may be outcrop in the adjacent watercourse.

This failure scenario considers the possibility of leakage from the toe drain to ground either prior to, or at the 'leachate sump'. The generic quantitative assessment will consider the dilution of leachate from the perimeter drain to the unnamed tributary to Black Brook adjacent to the Site. The pathway connecting the source to the adjacent watercourse could be either through surface breakout or through groundwater seepages via a gravel lens coincident with both the watercourse and the location of leachate leakage.

3.6.2 Assessment

The Site has an area of approximately 20 Ha. Based on a cap infiltration rate of 38 mm/a, by water balance a volume of 760 m³ of leachate is generated each year.



The catchment of the unnamed tributary to Black Brook is 99 Ha. If an effective rainfall rate to the catchment of 158 mm/a is considered the flow rate of the watercourse is estimated to be in the order of 156,420 m³/a. This would provide a dilution factor over the year of 206.

The concentration of chloride in the leachate is reported up to 1,092 mg/l. Consequently if the volume of leachate generated from the Site over a year were to discharge to the adjacent watercourse due to failure of the leachate management system the additional loading of chloride would be in the order of 5 mg/l.

The concentration of ammoniacal nitrogen in the leachate is reported up to 44 mg/l. Consequently if the volume of leachate generated from the Site over a year were to discharge to the adjacent watercourse due to failure of the leachate management system the additional loading of ammoniacal nitrogen would be in the order of 0.2 mg/l.

The concentration of sulphate in the leachate is reported up to 1,120 mg/l. Consequently if the volume of leachate generated from the Site over a year were to discharge to the adjacent watercourse due to failure of the leachate management system the additional loading of sulphate would be in the order of 5 mg/l.

It is noted that the adjacent watercourse has a relatively small catchment and due to the relatively low permeability nature of the surface soils its flow will be relatively flashy, consequently the loading of substances will vary depending on the available flow for dilution.

3.7 Review of Technical Precautions

3.7.1 Capping

The permanent capping system comprises a low permeability GCL covered by a minimum thickness of 1 m of restoration soils. It is understood that there has been some slope failure in relation to the cap. If the GCL has become damaged, the infiltration rate to the Site could be increased and consequently the leachate generation rate would be greater. As part of a stability review, recommendations have been made for investigation and potential remedial options for the cap.

3.7.2 Leachate Drainage Systems

It is understood from the Closure Report (Golder, 2006) that leachate is drained by a perimeter toe drain that was installed beneath the cap to direct flow towards the leachate sump. The toe drain reportedly comprises a 250 mm diameter perforated pipe with filter gravel surround and GCL lining on the external side and base of the drain.

No reference to the construction of the toe drain is made in the CQA interim validation report (CL Associates, 2004) (Appendix 1) and consequently further details regarding the specification of the toe drain have not been identified.

The sump was inspected during a site visit on 20 September 2010. No evidence of inlets from toe drains were observed inside the sump, although it is noted that the sump is approximately 3 m deep, part filled with liquid and has perforations in the side wall to facilitate ground drainage.

It is considered that the sump was originally designed as a deep chamber excavated into the sand and gravel lenses beneath and adjacent to the site to enable the abstraction of groundwater containing leachate. The capture of leachate in this way is not considered to be effective or appropriate. In order to minimise the volumes of dilute leachate being generated and collected it is recommended that leachate is collected directly from the toe drain. As part of the geotechnical investigation works that are proposed in response to other Environment Agency queries it is recommended that information regarding the toe drain be collected to enable a design to facilitate its adaption to be submitted to the Environment Agency.

The information required to adapt the design of the toe drain will involve the excavation of the restoration soils and clay protection layer from above the GCL cap adjacent to the anchor trench at the site boundary. The GCL will be cut and the toe drain exposed. A surveyor will identify the elevation of the base of the toe drain to enable the fall of the drain to be identified. The GCL will be reinstated and patched and the GCL clay protection layer and restoration soils replaced following the works. The adaption design may include the



construction of 1 or more shallow sealed sumps at topographic low points in the toe drain to facilitate the collection of leachate from the drain directly.

Leachate may also be removed from within the waste by pumping leachate from the Monitoring Wells L1, L2 and L3. This targeted approach is proposed to enable the operator to manage the leachate at source and reduce the volume of water that is required to be disposed.

In order to collect and dispose of leachate from the Site it may be necessary to construct a leachate collection tank and connection to the mains sewer following agreement with the sewerage provider.

3.7.3 Leachate Head Control

Active Leachate head control will be undertaken in Padeswood Landfill Site to manage risks to groundwater and the adjacent watercourse within acceptable limits. This will be achieved by adapting the current leachate drainage and abstraction systems within the Site and by upgrading the facilities with the installation of further abstraction wells as necessary.

3.7.4 Groundwater Management

The Site is constructed above the water table; therefore groundwater management is not required.

3.8 Hydrogeological Completion Criteria

Completion relating to hydrogeological risks will have been achieved when there is no unacceptable risk of pollution from the landfill, i.e. when the Site can comply with the requirements of the Environmental Permitting (England & Wales) Regulations 2010 without the need for active management. Table 11 outlines an example of the completion criteria for landfill leachate whereby the site permit could be surrendered. This has been reproduced from Waste Management Paper 26A (DOE, 1993).

Example Completion Criteria for Leachate

Table 11: Example Completion Criteria for Leachate

Determinant	Concentration	
pH	6.5-8	
Conductivity	4000	μS/cm
Chloride	2000	mg/l Cl
Sulphate	2500	mg/l SO ₄
Calcium	1000	mg/l Ca
Magnesium	500	mg/l Mg
Sodium	1500	mg/l Na
Potassium	120	mg/l K
Aluminium	2	mg/l Al
Nitrate	500	mg/l NO ₃
Nitrite	1	mg/l NO ₂
Ammonia	5	mg/l NH ₄
Total organic carbon	10	mg/l C
Iron	2	mg/l Fe
Manganese	0.5	mg/l Mn
Copper	1	mg/l Cu
Zinc	1	mg/l Zn
Phosphorus	10	mg/l P ₂ O ₅
Fluoride	10	mg/l F



Determinant	Concentration	
Barium	1	mg/l Ba
Silver	0.1	mg/l Ag
Arsenic	0.5	mg/l As
Cadmium	0.05	mg/l Cd
Cyanides	0.5	mg/l CN
Chromium	0.5	mg/l Cr
Mercury	0.01	mg/l Hg
Nickel	0.5	mg/l Ni
Lead	0.5	mg/l Pb
Antimony	0.1	mg/l Sb
Selenium	0.1	mg/l Se
Mineral Oils	0.1	mg/l
Phenols	0.005	mg/l C ₆ H ₅ OH
Organochlorine compounds other than pesticides	0.01	mg/l
Pesticides	- individually	0.001 mg/l
	- collectively	0.005 mg/l
PAHs	0.002	mg/l

It is recommended that leachate concentrations and associated risks are reviewed during the site's aftercare period to determine/review when the completion criteria are likely to be met. Ultimately, source concentrations will decline sufficiently to allow a cessation of active controls at the Site.

4.0 REQUISITE SURVEILLANCE

4.1 The Risk Based Monitoring Scheme

The proposed monitoring regime includes leachate level, leachate quality, groundwater elevation, groundwater quality and surface water quality.

4.2 Leachate Level Monitoring

Providing Leachate Wells L1, L2 and L3 are serviceable subsequent to capping; leachate levels are considered to be adequately monitored by the existing monitoring infrastructure once ongoing monitoring recommences.

4.2.1 Leachate Level Compliance

Hanson proposes to manage leachate heads in the toe drain sumps to a Compliance Level of 1 m or less.

In the event that the Compliance Level for leachate head is breached, an action plan is proposed in order to ensure steps are taken to determine both the cause of the breached head and the impact it may have upon the identified receptors. A proposed action plan for the Site is below:

- Advise site management;
- Advise Environmental Manager of landfill operating company;
- Conduct trend analysis of leachate level for the previous 12 months;
- Confirm the status of the leachate extraction system;



- If the leachate pump has not been installed or is damaged action order of pump or repair respectively; and
- Follow notification provisions of the permit and undertake assessment where appropriate as agreed with the Agency.

4.3 Leachate Quality

Leachate quality will be monitored from Leachate Wells L1, L2 and L3 in accordance with the monitoring suite listed in Table 12.

Table 12: Leachate Monitoring Suite

Parameter	Quarterly
pH	●+
Temperature	●*
Electrical conductivity 20°C	●+
Ammoniacal nitrogen	●
Chloride	●
Sulphate	●
Alkalinity	●
COD	●
BOD	●
Nitrate (for TON)	●
Nitrite (for TON)	●
TOC	●
Sodium	●
Potassium	●
Calcium	●
Magnesium	●
Iron	●
Manganese	●
Copper	●
Chromium	●
Lead	●
Nickel	●
Zinc	●
Ionic balance	●
Former List I substances	Every 4 years prior to the HRA

Key:

- + Denotes field or laboratory measurements (subject to availability of field equipment, samples may be sent for laboratory analysis instead).
- * Denotes field only measurements



4.4 Groundwater Level Monitoring

On a quarterly basis all groundwater monitoring boreholes will be monitored for dip to groundwater and calculated elevation of groundwater. On an annual basis all groundwater monitoring boreholes will be monitored for dip to base.

4.5 Groundwater Quality Monitoring

Groundwater quality in the Drift deposits will continue to be monitored at Boreholes BH01A, BH02A, BH01/02, BH02/02 and BH03/02.

It is recommended that two additional boreholes are installed along the western site boundary and eastern site boundary to monitor the groundwater quality in the Drift.

It is recommended that the groundwater in the Coal Measures is monitored in BH12 (upgradient), BH13 and BH14 (downgradient).

It is recommended that BH04 and BH05 are decommissioned by over drilling and backfilling with grout because they provide a man-made subsurface pathway for the migration of leachate through the base of the Site to underlying sand and gravel lenses.

The location of proposed, existing and boreholes to be decommissioned are shown on Drawing 2.

Table 13 summarises the proposed groundwater monitoring regime at the Site.

Table 13: Groundwater Monitoring Suite

Parameter	Quarterly
pH	•+
Temperature	•*
Electrical conductivity 20°C	•+
Dissolved oxygen	•+
Ammoniacal nitrogen	•
Chloride	•
COD	•
BOD	•
TOC	•
Sulphate	•
Alkalinity	•
Nitrate (for TON)	•
Nitrite (for TON)	•
Sodium	•
Potassium	•
Calcium	•
Magnesium	•
Iron	•
Manganese	•
Copper	•
Chromium	•
Lead	•
Nickel	•



Parameter	Quarterly
Zinc	•
Ionic balance	•
Former List I substances present in the leachate	Every 4 years prior to review of the HRA.

Key:

+ denotes field or laboratory measurements (subject to availability of field equipment, samples may be sent for laboratory analysis instead);*denotes field only measurements.

4.5.1 Groundwater Quality Compliance

To monitor compliance with the Permit for the site groundwater Trigger levels are set for potentially polluting substances. Trigger concentrations have been set in Table 14 in line with EAL's based on baseline quality data for the Site. Trigger concentrations apply to BH01/02, BH02/02 and BH03/02.

Table 14: Groundwater Trigger Concentrations

Substance	Trigger	Justification
Sulphate (mg/l)	600	Based on background quality
Ammoniacal Nitrogen (mg/l)	3.2	Based on background quality
Chloride (mg/l)	339	Based on background quality

The action plan to follow in the event of an exceeded Trigger is outlined in Table 15.

Table 15: Proposed Action Plan in the Event of a Breached Groundwater Quality Trigger Concentration

Contingency Action

Advise site management.

Advise Environmental Manager of landfill operating company.

Confirm by repeat measurement within 1 day.

Conduct a trend analysis of 12 months of monitoring data to establish trends in the data.

Follow notification provisions of the Permit.

4.6 Surface Water Quality Monitoring

Surface Water quality in the adjacent watercourse, the unnamed tributary to Black Brook will continue to be monitored at up and downgradient locations to the Site.

Table 16 summarises the proposed groundwater monitoring regime at the Site.

Table 16: Surface Water Monitoring Suite

Parameter	Quarterly
pH	•+
Temperature	•*
Electrical conductivity 20°C	•+
Dissolved oxygen	•+
Ammoniacal nitrogen	•
Chloride	•



Parameter	Quarterly
COD	•
BOD	•
TOC	•
Sulphate	•
Alkalinity	•
Nitrate (for TON)	•
Nitrite (for TON)	•
Sodium	•
Potassium	•
Calcium	•
Magnesium	•
Iron	•
Manganese	•
Copper	•
Chromium	•
Lead	•
Nickel	•
Zinc	•
Ionic balance	•
Former List I substances present in the leachate	Every 4 years prior to review of the HRA.

Key:

+ denotes field or laboratory measurements (subject to availability of field equipment, samples may be sent for laboratory analysis instead);*denotes field only measurements.

4.6.1 Surface Water Quality Compliance

To monitor compliance with the Permit for the site groundwater Trigger levels are set for potentially polluting substances. Trigger concentrations have been set in Table 17 in line with EAL's based on baseline quality data for the Site. Trigger concentrations apply to the downgradient surface water monitoring location.

Table 17: Surface Water Trigger Concentrations

Substance	Trigger	Justification
Sulphate (mg/l)	400	EQS
Ammoniacal Nitrogen (mg/l)	0.90	Upstream quality
Chloride (mg/l)	250	EQS

The action plan to follow in the event of an exceeded Trigger is outlined in Table 18.



Table 18: Proposed Action Plan in the Event of a Breached Surface Water Quality Trigger Concentration

Contingency Action

Advise site management.

Advise Environmental Manager of landfill operating company.

Confirm by repeat measurement within 1 day.

Conduct a walkover survey of the watercourse from the downstream monitoring location to the upstream monitoring location with Electrical Conductivity readings taken every 5 m with a portable meter.

Conduct a trend analysis of 12 months of monitoring data to establish trends in the data.

Follow notification provisions of the Permit.

5.0 CONCLUSIONS

5.1 Compliance with the Landfill Directive 1999

The requirements of the Landfill Directive 1999 (99/31/EC) can be summarised as follows:

- The need to collect contaminated water and leachate;
- The compliance of the installation with the specified engineering standards; and
- The derivation of trigger levels for groundwater quality.

Management

Leachate is managed by extraction from the Site.

Trigger Levels for Groundwater Quality

Trigger levels for the substances considered in the leachate source term have been set.

In the event that the Trigger Criteria is breached then actions required by the Permit and Groundwater Management Plan will be implemented in order to ensure steps are taken to determine both the source of the substance and the magnitude of the impact it may have upon the receiving waters.

5.2 Compliance with the Environmental Permitting (England & Wales) Regulations 2010

The Environmental Permitting (England & Wales) Regulations 2010 state that hazardous substances should be prevented from polluting groundwater beneath a site and to limit discharge of non-hazardous substances as such as to prevent pollution. Non-hazardous substances are present within the leachate produced at Padeswood and during the lifecycle of the Site there is the potential for leachate to migrate to the surrounding water environment. Therefore the Environmental Permitting (England & Wales) Regulations 2010 are considered to apply to this site.

Essential and Technical Precautions

Given the scenarios considered, it has been demonstrated that the engineering safeguards and leachate drainage systems require further information to be collected in order to identify whether they are sufficient to control leachate head within the landfill.



Requisite Surveillance

The monitoring regime has been designed in consideration of the risk assessment, such that groundwater, and in particular its quality, will undergo the requisite surveillance. Therefore the monitoring regime is considered to be compliant with the Environmental Permitting (England & Wales) Regulations 2010.

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Report Signature Page

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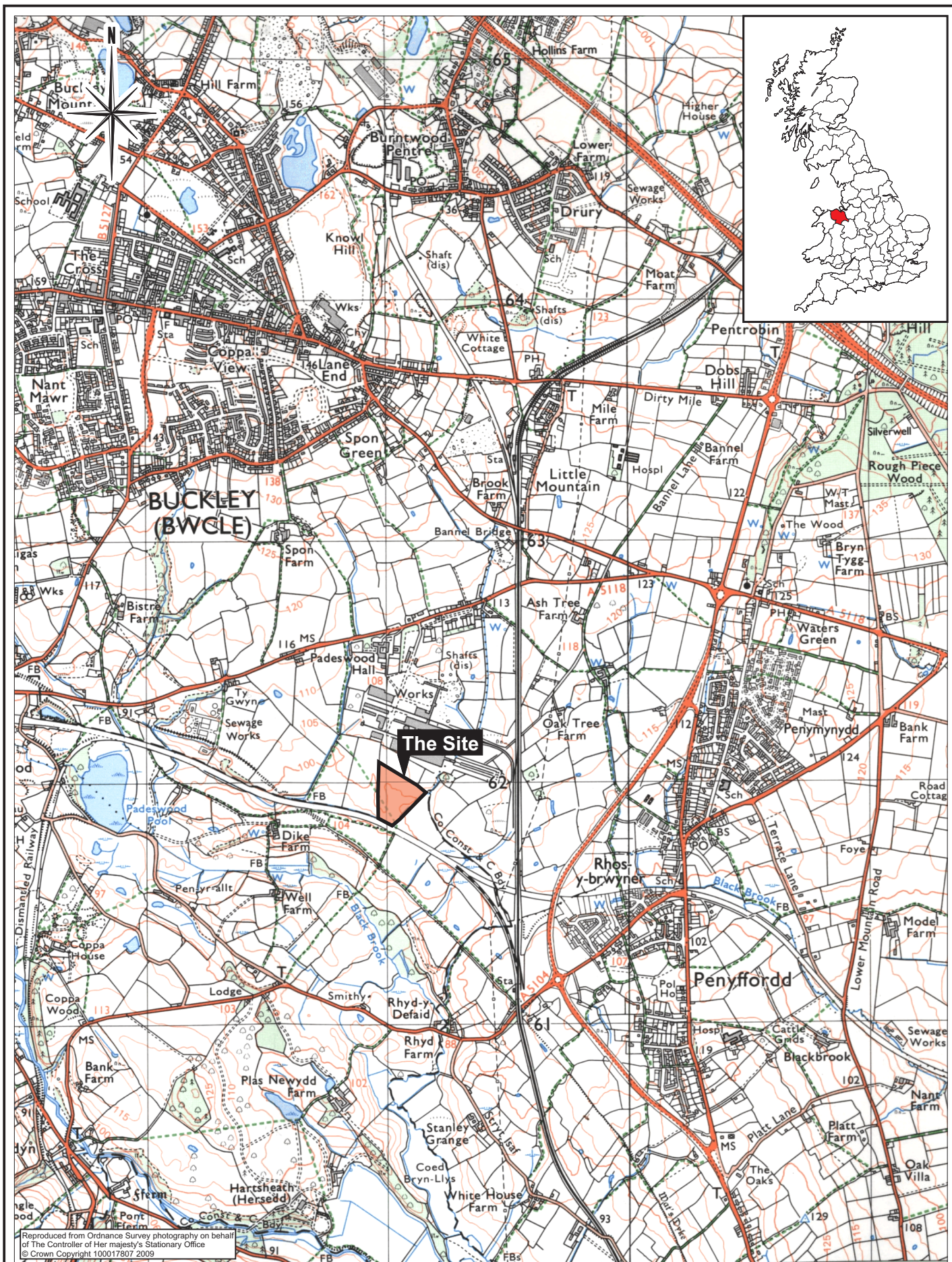
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DRAWINGS

Drawing 1 – Site Location Plan

Drawing 2 – Monitoring Location Plan



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	Project	Hydrogeological Risk Assessment Padeswood Landfill Site		File No.	5232731		Project No. 10514240262.502						
	Title	Site Location Plan		Size	A4	Scale	1:25,000		Status	Issue			
				Drawing No.			1						Rev



APPENDIX 1

CL Associates CQA Capping Report

**PADESWOOD CAPPING AND RESTORATION
CONSTRUCTION QUALITY ASSURANCE
INTERIM VALIDATION REPORT**

1 INTRODUCTION

In April 2004 CL Associates (CLA) were appointed by Mowlem plc to undertake certain works relating to the capping of Padeswood Landfill at Castle Cement Works, Padeswood, Flintshire (see Key Plan, Figure 1).

This document reports on the construction works and Quality Assurance monitoring carried out during the installation of the Geosynthetic Clay Liner (GCL) and associated protective clays and restoration soils. The results of any field and laboratory tests are presented and the report provides certification that the works have been carried out in accordance with the Construction Quality Assurance (CQA) Plan (Charles Haswell and Partners Ltd, Report Ref: 5013-649-02, January 2002). During construction, some works were undertaken that were different from the CQA Plan and where this has occurred it is explained in this report (see section 5). The CQA Plan was approved by the Agency in a letter dated 15 February 2004 (Ref: EAWML/37012) and a Site Inspection Report (Ref: 323235) was issued by the Environment Agency on 29/03/04.

CLA were commissioned to:

- a) supply a suitably qualified and experienced CQA Engineer to oversee the construction quality aspects of the project and to delegate responsibilities for CQA on site to a CQA Representative.
- b) Ensure material compliance is achieved in accordance with the CQA Plan Specification in UKAS approved geotechnical and chemical testing laboratories
- c) maintain records of the geosynthetic clay liner placement and testing data sufficient to provide a comprehensive CQA Validation Report.
- d) produce and submit a CQA Validation Report upon completion of the works.

The surface of the landfill was reprofiled in accordance with Drawing No. 5013-G011-01 (obtainable in the CQA Plan), by using fill material available on site. All objects greater than 200 mm in size were removed from the domed surface of the waste to reduce interference with the integrity of the cap and the surface was compacted with a low ground pressure bulldozer. Prior to any further works a co-ordinated level survey of the compacted surface of the waste was undertaken (see section 5.3).

2 CQA REPRESENTATIVE (CQAR) ATTENDANCE AND SUPERVISION

A full time Construction Quality Assurance Representative (CQAR) attended site for the duration of the capping works. Daily records were maintained by the CQAR and these are presented in Appendix A for information purposes. The capping works commenced on 30 April 2004 and terminated on 29 June 2004. Capping works were suspended between 25 May 2004 and 7 June 2004, due to restricted access to the northern flank of the waste mound.

3 CAPPING AND RESTORATION

3.1 General

The Geosynthetic Clay Liner (GCL) and associated protective layers and restoration soils were laid under the supervision of the CQAR. All materials and methods used during the works conformed with either the guidelines provided by the CQA Plan or the latest Environment Agency guidelines.

3.2 Capping and Restoration Design

The capping and restoration consisted of five layers of material as outlined in the CQA Plan. A basic description of each layer is provided in Table 1 below:

Table 1: Capping and Restoration Design – Layer Descriptions

Layer	Thickness	Material Classification / Description
Lower Protective Layer	200 mm $\pm$ 25 mm	• Class 2A (as described in Table 6/1 of SHW¹) • No angular particles • Continuously graded • Max particle size of 50 mm • Undrained shear strength 50kN/m²
Geosynthetic Clay Liner (GCL)	approximately 5 mm	• Reinforced GCL comprising calcium bentonite clay bonded between two needle punched geotextile layers
Upper Protective Layer	250 mm $\pm$ 25 mm	• Class 1A, 1B or 2A (as described in Table 6/1 of SHW¹) • No angular particles • Continuously graded • Max particle size of 50 mm • Undrained shear strength 50kN/m²
Subsoil / Restoration Soil	750 mm	• Class 1 or 2 (as described in Table 6/1 of SHW¹)
Topsoil	150 mm	• BS 3882 General Purpose Grade

¹ Highway Agency Specification for Highway Works 1991 (SHW)

3.3 Lower Protective Layer

The lower protective layer (subgrade) was laid under the supervision of the CQAR and comprised of resident clays (stockpiled on site) and imported clays. Two samples were taken from both the resident and imported clays and sent for chemical and geotechnical tests. The results, shown in Appendices C1 and C2 and discussed in Section 4 of this report, indicate that the clays conform with the CQA Plan.

In accordance with the CQA plan and the GCL manufacturers guidelines, the subgrade was initially compacted with a low ground pressure bulldozer and then smoothed using a vibratory roller (SP 2012) to form a uniform surface. Prior to GCL deployment, the surface of the subgrade was inspected to ensure it was free of any potentially damaging materials, such as debris, sharp objects or stones greater than or any sudden or abrupt changes in grade (greater than 100 mm in 5 m). Additionally, the subgrade was checked to ensure it was not excessively wet or softened by high moisture content. In situ shear strength tests were carried out at random intervals to ensure a minimum shear strength of 50 kN/m² had

been achieved (see Drawing 44026/1-3 and Appendix C4).

The CQAR provided full time supervision to ensure that the material was placed at a minimum depth of 200 mm. Depth checks were carried out at random intervals to provide further verification of the subgrade thickness, see Drawing 44026/1-2 and Appendix C3.

3.4 Geosynthetic Clay Liner

The Geosynthetic Clay Liner used for the capping was Bentofix NSP 4900-1 manufactured and supplied by Naue Fasertechnik GmbH & Co. The GCL was supplied in rolls 4.85 m wide by 40 m long.

3.4.1 Delivery and Storage

The delivery, storage and installation of the GCL was supervised by the CQAR and carried out in accordance with the CQA plan.

Two batches of GCL were initially delivered to the site on 19 April 2004 and an additional batch on 19 May 2004. The delivery and inspection record of the rolls is contained in Appendix B2 and the Quality Control Certificates provided by the manufacturer are included in Appendix B1. The GCL met the requirements set out in the CQA Plan.

Prior to installation, the GCL was stored in a designated area on the top of the mound. In order to protect the GCL from the weather, the rolls were stored off the ground, covered and the cover secured using sandbags.

The quality of the subgrade was inspected by the CQAR and upon compliance with the CQA Plan was certified as suitable to install GCL. Certificates of subgrade acceptance are provided in Appendix B3.

3.4.2 GCL Installation

Installation of the GCL was carried out in a regular fashion and was laid over the tip in one principal direction. The panels of GCL were installed in accordance with the manufacturer's recommendations. During deployment, the sheets of GCL were positioned above the slopes

using mobile plant equipment and pulled into position manually. The tops of the GCL panels were placed in an anchor trench 600 mm – 1000 mm deep, where necessary. At the base of the slopes, anchor trenches were used to secure the GCL and seal off the tip. The panel layout plan is shown in Drawing 44026/1-1 and the GCL Deployment and Seaming Records are given in Appendix B4.

The extent of overlap was 300 mm for adjacent sheets, and approximately 1000 mm for seams at the end of panels. At the ends of the panels, supplementary bentonite was applied in a continuous bead along the centre of the overlaps at a rate of 0.5 kg/m in accordance with the Environment Agency's guidance on the use of GCL in landfill engineering. Because of the bentonite impregnated into the outer longitudinal edges during manufacture, no extra bentonite was required for these joints. The seams were constructed to prevent potential run-off from entering the overlaps.

During unrolling and placement of the GCL, care was taken so that the GCL was not damaged, unduly stretched, folded or creased and did not bridge hollows. No mobile equipment of any kind was allowed on the GCL surface. Care was also taken to minimise the extent to which the GCL was dragged across the subgrade to avoid damage to the under surface. Only as much GCL was deployed as could be covered by the end of the working day. Prior to covering, each section of GCL was cleared of all equipment and debris and visually inspected for defects.

3.4.3 Repair Patching and Sealing Penetrations

Repairs and seals were carried out in accordance with the CQA Plan. Patches were obtained from fresh GCL rolls, cut to size and dry bentonite mastic was applied to the area prior to patching. An overlap of 300 mm was achieved around all of the area. Details of repairs are shown on the individual GCL Repair Plans, Appendix B5 and GCL Repair Record Sheets, Appendix B6.

3.4.4 Conformance Testing

Samples of GCL, cut at about 0.5 m in length across the full width of the roll, were taken to verify that the material met the typical requirements as set out in the Specification present in the CQA plan. The results are given in Appendix B7, and discussed in Section 4 of this

report.

3.5 Upper Protective Layer

The GCL was covered with a 250 mm layer of clay material which functioned as an upper protective layer for the GCL.

The placement of the upper protective clay layer was subject to full time supervision by the CQAR. The clays used originated from two locations on site and samples were taken from each source for chemical and geotechnical conformance tests. The results of these tests, discussed in Section 4 and shown in Appendices C1 and C2, show that the clay used conformed with the CQA Plan and Environment Agency guidance.

To comply with the CQA plan and to avoid damage to the GCL, the upper protective layer was placed on the slopes with a backacting excavator in one layer in a manner that prevented the clays from entering the GCL overlap zone. The clay was compacted with a low ground pressure bulldozer and a minimum thickness of 250 mm was maintained between the tracks of any construction plant and the GCL at all times.

During supervision, the CQAR ensured that the clay was placed at a minimum depth of 250 mm. Depth checks were carried out at random intervals to provide further verification of the protection layer's thickness, see Drawing 44026/1-2 and Appendix C3. In situ shear strength tests were also carried out at random intervals to ensure a minimum shear strength of 50 kN/m² had been achieved, see Drawing 44026/1-3 and Appendix C4.

3.6 Subsoil / Restoration Soil

Areas of 750 mm thick restoration soil, which will eventually function as tree planting zones, were placed over the landfill to comply with the profiles outlined by Colvin and Moggridge (Landscape Architects) in the CQA plan, shown on Drawing No. 811.42B. The placement of subsoil / restoration soil over the tip was supervised by the CQAR who ensured material placement was consistent with the practices detailed in the CQA plan.

The materials used as restoration soil were derived from stockpiles on site and samples were taken from each source for chemical and geotechnical conformance tests. The results

of these tests, shown in Appendices C1 and C2, indicate that the materials used conform with the CQA Plan and Environment Agency guidance.

To ensure a minimum depth of 750 mm was achieved, 'depth pegs' were placed outlining the area to be covered. The material was then filled to the appropriate depth. This was supervised by the CQAR.

3.7 Topsoil

The restored surface of the landfill was finally covered with a 150 mm deep layer of imported topsoil.

4 CONFORMANCE TESTING

4.1 Earthworks Materials

Any resident or imported materials that were used as GCL protective layers, subsoils or topsoils were subject to chemical and geotechnical analysis to ensure compliance with the requirements outlined in the CQA Plan. Testing for contamination and classification was initially intended to be carried out at an overall rate of approximately one test per 2400 m³. However, due to the variety in sources, and to ascertain the quality of material used, testing was carried out at a more regular frequency. Table 2 below outlines and explains the testing frequencies.

Table 2: Frequency of Sampling

Capping / Restoration Layer	Approx. Total Volume of Material Deployed (m ³)	No. of Samples Required by CQA Plan	No. of Samples Taken	Justification of Variation from Plan
Lower Protective Layer	3800	2	4	Change of source of onsite material
Upper Protective Layer	4750	2	2	N/A
Subsoil's / Restoration Soils	7800	3	3	N/A
Top Soils	2850	2	6	Material re-sampled because of various high chemical concentrations in original samples
All Layers	22080	9	15	N/A

4.2 Chemical Analysis of Earthworks Materials

Each sample taken was submitted to an independent UKAS accredited Chemical Testing Laboratory (TES Bretby) for conformance testing. All materials used during restoration were required to meet the specifications outlined in Table 3 and copies of the chemical analysis results are given in Appendix C1.

Table 3: Maximum permitted concentrations of chemical determinands in soils acceptable for use in restoration. Information taken from CQA Plan (Table 2.2).

Determinand	Lower Threshold Concentration (mg/kg air-dried sample)	Determinand	Lower Threshold Concentration (mg/kg air-dried sample)
pH	6 – 8	Nickel	70
Arsenic	10	Zinc	300
Cadmium	3	Cyanide (complex)	250
Chromium (total)	600	Cyanide (free)	25
Lead (total)	500	Sulphate (SO ₄)	2,000
Mercury	1	Sulphide	250
Selenium	3	Sulphur (free)	5,000
Boron	3	Phenol	5
Copper	130	Polyaromatic Hydrocarbons (screen)	50

4.2.1 Non Compliances

A number of samples did not comply with the requirements outlined in Table 3. The results of the non compliant samples were cross referenced with the latest Environment Agency guidelines and were deemed suitable for use by the CQAR and the CQA Engineer. The non compliances recorded are presented in Table 4 below.

Table 4: Non Compliances – Chemical Analysis

Determinand (max concentration - Table 3)	Sample No.	Result Recorded	Reason Permission for Use Granted
pH (8)	CA1 CA3 CA4 CA5 CA8 CA10 CA12	8.1 8.2 8.0 8.1 8.3 11.4 10.7	BS 3882:1994 Specification for Topsoil accepts a pH of 8.2 for normal grade soil. CA8, CA10 & CA12 are restoration soil samples and are not in contact with the atmosphere or humans.
Arsenic (10 mg/kg)	CA1 TS4 CA5 CA8 CA10 CA12 CA13 CA14 CA16	11.1 mg/kg 11.1 mg/kg 12.6 mg/kg 12.1 mg/kg 12.2 mg/kg 14.5 mg/kg 15.1 mg/kg 11.6 mg/kg 11 mg/kg	The Environment Agency's 'Soil Guideline Values for arsenic as a function of land-use' (2002) ¹ . Max. concentrations for Arsenic permitted are; - Residential with plant uptake land-use – 20 mg/kg - Commercial/ industrial land-use – 500 mg/kg Therefore the soil results are compliant within the Agency's guidelines.
Cadmium (3 mg/kg)	CA13	3.75 mg/kg	Sample proved to be an anomaly. Topsoil material re-tested 4 times and all other samples passed specification. Therefore sample can be argued not to represent topsoil quality.
Lead (500 mg/kg)	CA13	1302 mg/kg	Sample thought to be an anomaly.
Sulphate (2000 mg/kg)	CA13	3250 mg/kg	Sample thought to be an anomaly.
PAH (50 mg/kg)	CA13	63 mg/kg	Sample thought to be an anomaly.

¹ = DEFRA and Environment Agency : 2002 : Soil Guideline Values for Arsenic Contamination,

Report SGV 1, R and D Publication.

4.3 Geotechnical Analysis of Earthworks Materials

To positively classify the earthworks materials used, each sample taken was submitted to an independent UKAS accredited Geotechnical Testing Laboratory (Soil Mechanics, Doncaster) for conformance testing. Samples were subjected to Particle Size Distribution tests (PSD) to verify conformance with the Specifications outlined in the CQA Plan. All testing results were within the Specification. Table 5 summarises the specifications and copies of the geotechnical analysis results are given in Appendix C2.

Table 5: Specifications for Earthworks Material Classification

Layer	Classification (as described in Table 6/1 of SHW ¹)	Particle Size Distribution Required
Lower Protective Layer	Class 2A	• 100 % 125 mm • 80 – 100 % 2mm • 15- 100 % 63 microns
Upper Protective Layer	Class 1A	• 95 – 100 % 125 mm • < 15 % 63 microns
	Class 1B	• 100 % 125 mm • < 15 % 63 microns
	Or Class 2A	• 100 % 125 mm • 80 – 100 % 2 mm • 15- 100 % 63 microns
Subsoil / Restoration Soil	Class 1	• See above
	Or Class 2	• See above
Topsoil	BS 3882 General Purpose Grade	

¹ Highway Agency Specification for Highway Works 1991 (SHW)

4.4 Conformance Testing of GCL

Samples of GCL were taken and submitted to an independent UKAS accredited Geosynthetics Testing Laboratory (BTTG, Manchester) for conformance testing. The nature and frequency of testing carried out followed the guidelines outlined in the CQA Plan, and is summarised in Table 6. Copies of the test results are given in Appendix B7. All test results were compliant with the CQA Plan Specifications.

Table 6: Specification and Test Frequency for GCL (Information taken from CQA Plan)

Material Property	Test Method	Required Values	Routine Required (m ²)	Summary of Test Results	No. of Tests Required	No. of Tests Completed
Bentonite Fluid Loss	API 13A/13B	18ml max	5000	All Pass Specification	5	5
Bentonite Mass/Area	ASTM D 5361	9.5kg/m ²	5000	All Pass Specification	5	5
GCL Grab Strength	ASTM D 4632	400 N	500	All Pass Specification	48	45*

* further sampling to be undertaken to complete capping works

5 VARIATIONS FROM THE CQA PLAN

5.1 Separation Geotextile

The CQA requirements for a geotextile to separate landfill deposits from the lower protective layer of clay stated in the CQA plan was not undertaken during the installation of the cap. The geotextile barrier was deemed unnecessary due to the quality achieved in the finish to the surface of the waste. The reprofiling and compaction of the waste did not result in any protrusions of waste and a smooth surface was achieved (see photograph P1, Appendix F). The quality finish of the surface of waste was carefully scrutinized by the CQA Inspector for any protruding material before placement of the lower protective layer.

5.2 Geogrid

A stability analysis was undertaken in reviewing the necessity of a geogrid as a reinforcement soil. The preliminary stability analysis results produced a factor of safety of greater than 1.3, thus the requirement of a geogrid was deemed unnecessary. The results of the stability risk assessment are included in Appendix E.

5.3 Formation Survey

A formation / top of waste survey has not been provided to CL Associates to confirm the depth of the capping materials used on site. However, depth checks were regularly

undertaken by the CQA Representative on the both the lower and upper protective layer soils (see Appendix C3), thus demonstrating compliance for the protective soils with the CQA Plan.

A Coordinated Level Survey illustrating the levels of the cap restoration soils and the areas to be completed upon future commencement of the works can be found in Appendix D.

6 OUTSTANDING WORKS FOR COMPLETION

Part of the capping works on the northern flank were unable to be completed during the working time due to access restrictions incurred by the construction works for the Kiln 4 development at Padeswood. The total area of outstanding works is approximately 1100 m² and covers a length of 150 m, by 7.3 m width at the base of the northern flank on its eastern side. There is an approximate 3000 m² area upon the northern slope that requires the placement of restoration soils and topsoil. A small area of approximately 50m² on the north eastern corner of the mound awaits the installation of GCL. Completion of the works shall occur once access is available.

7 CONCLUSION

CL Associates can verify that the works associated with the capping and restoration of Padeswood Landfill followed the procedures set out in the CQA Plan and any variations are detailed, with explanations, in this report. All testing and quality assurance procedures were adhered to and the results obtained indicate conformance with the requirements set out in the CQA Plan, subject to the separate technical discussions within this report.

for CL Associates



Engineer



Associate



APPENDIX 2

Borehole Logs

Strata Record		Penetration Testing and Sampling												Groundwater Records						
Depth	Description	Depth From To	Type	1	2	3	4	5	6	N.B.W. EU	Sample Length	Casing Depth	Water Level	WATER ENCOUNTERED			PIEZOMETER/STANDPIPE			
6/1	Clay fill	1.0	D											Depth Struck	3.4		(Details on separate sheet)			
		2.0	D											Casing Depth	3m		Piezometer	From	To	
		3.0	D											Inflow			Tip			
2.20	firm brown	3.50	D											Depth 5 mins			Filter			
	sandy boulder	4.0	D											Depth 10 mins			Standpipe	From	To	
	clay	5.0	D											Depth 15 mins			Slotted Pipe	3m	6m	
		6.0	D											Depth 20 mins	3.4		Filter	3m	6m	
3.40	Brown sand & gravel													Cut off at	3.9		WATER ADDED			
														WATER LEVELS			Water Added	From	To	
														Depth	Casing	Time				
														Morning						
3.90	firm dark brown boulder clay													Evening			Borehole Kept Full			
														Other						
														FIELD RECORDS						
														Time (o'clock)		Depth (m)		Diameter (mm)	Borehole	Casing
														From	To	From	To	300		
																		250		
																		200		
																		150		
														Excavation Dimensions:			Backfill:			
														150mm						
6m	Borehole Complete / Incomplete											S/C		D	B	U	W	SITE		
Remarks :- Visitors, Instructions, Weather, etc Safety course (1/2 hr)				Q.A.				7								EASTLE CEMENT				
						Move	Drill	Stand	Break	Work	JOB No.		RIG TYPE							
						1	6m				128062		ISO							
						Crew		D. Munnally		DAY		Thurs.		DATE		12.3.98				
						Drillers Signature		R. C. Wood		Move From:-				BH No.		1				

Top copy to office, Green to Engineer, Blue to Client, Red to Driller

10000 Associates Cable Percussion Drilling Record

Data Record		Penetration Testing and Sampling										Groundwater Records									
Depth	Description	Depth		Type	2	3	4	5	6	7	8	9	10	11	12	WATER ENCOUNTERED			PIEZOMETER / STANDPIPE		
		From	To													1	2	3	1	2	3
G/L	Clay fill	1.0		D												Depth Struck			(Details on separate sheet)		
		2.0		D												Casing Depth			Piezometer	From	To
1m	firm light brown	3.0		D												Inflow			Tip		
	very sandy boulder	4.0		D												Depth 5 mins			Filter		
	clay	4.80		D												Depth 10 mins			Standpipe	From	To
		5.0		D												Depth 15 mins			Slotted Pipe	2m	7m
		6.0		D												Depth 20 mins			Filter	2m	7m
H-70	Brown sand & gravel	7.0		D												Cut off at			WATER ADDED		
																WATER LEVELS			Water Added	From	To
																Depth	Casing	Time			
5m	firm dark brown boulder clay															Morning			Borehole Kept Full		
																Evening					
																Other					
																FIELD RECORDS					
																Hard Stem / Chisel		Depth at end of shift			
																Time (o'clock)		Depth (m)	Diameter (mm)	Borehole	Casing
																From	To	From	To	300	
																				250	
																				200	
																				150	
																Excavation Dimensions:		Backfill:			
7m	Borehole Complete / incomplete															150mm					
Remarks :- Visitors, Instructions, Weather, etc					Q.A	S/C	D	B	U	W	SITE										
							8				CASTLE CEMENT										
						Move	Drill	Stand	Break	Work	JOB No.										
						1	7m				128062										
Top copy to office, Green to Engineer, Blue to Client, Red to Driller						Crew					DAY		DATE								
						D. munnelly					Thurs		12.3.98								
Drillers Signature					Move From:-					BH No.											
R. C. Wood					1					2											

Description		Depth (m)	Type	Borehole Logging and Sampling										Groundwater Records										
				1	2	3	4	5	6	7	8	9	10	11	12	Water Encountered		Piezometer/Standpipe						
0.00	BROWN CLAY FILL	0.50	D													Depth Struck	600	(Details on separate sheet)						
1.60	SOFT SILTY GREY CLAY FILL	1.60	D													Casing Depth	470	Piezometer	From	To				
3.10	CLAYEY ASH FILL	3.10	D													Inflow	S	Tip						
3.80	STIFF GREY CLAY FILL	4.80	D													Depth 5 mins	585	Filter						
4.80	BROWN CLAY FILL + WASTE	7.50	D													Depth 10 mins	580	Standpipe	From	To				
6.10	BROWN + GREY STIFF MOTTLED CLAY (NATURAL GROUND) TO 8.20m															Depth 15 mins	570	Slotted Pipe	1.00	8.20				
																Depth 20 mins	560	Filter	080	8.20				
																Cut off at	630	WATER ADDED						
																WATER LEVELS			From	To				
																Morning		Depth	Casing	Time				
																Evening								
																Other								
																FIELD RECORD								
																Time (o'clock)		Depth (m)		Diameter (mm)	Borehole	Casing		
																From	To	From	To	300				
																				250				
																				200				
																				150				
																Excavation Dimensions:		Backfill:						
																		STANDPIPE						
																Remarks :- Visitors, Instructions, Weather, etc								
																Q.A		S/C	D	B	U	W	SITE	
																		/	b	/	/	/	CASTLE CEMENT / PADESWOOD	
																Move		Drill	Stand	Break	Work	JOB No.		
																						1280b2		
																Crew		J. Fennell			DAY			
																		C. Robinson			THURSDAY			
																Drillers Signature		J. Fennell			Move From:-			
																		1/11/98			DEPOT			
																Exploration Associates		Cable Percussion Drill Record			BH No.			
																					3			

Top copy to office, Green to Engineer, Blue to Client, Red to Driller

Soil Record		Penetration testing and Sampling											Groundwater Records							
Description		Depth from	1	2	3	4	5	6	7	8	9	10	11	WATER ENCOUNTERED			PIEZOMETER / STANDPIPE			
0.00	Grass over a brown	0.40												Depth Struck			(Details on separate sheet)			
	CLAY FILL	1.20												Casing Depth			Piezometer	From	To	
0.40	Cement / blocks	2.00												Inflow			Tip			
1.60	Stiff brown boulder	2.70												Depth 5 mins			Filter			
	CLAY	3.70												Depth 10 mins			Standpipe	From	To	
2.60	dry dense sand +	4.80												Depth 15 mins			Slotted Pipe	100	650	
	GRAVEL, COBBLES	5.80												Depth 20 mins			Filter	080	650	
4.80	Stiff brown boulder	6.50												Cut off at			WATER ADDED			
	CLAY TO 6.50m													WATER LEVELS			Water Added	From	To	
														Depth	Casing	Time		Borehole Kept Full		
														Morning						
														Evening						
														Other						
														FIELD RECORDS						
														Hard Struck / Casing		Depth at end of shift				
														Time (o'clock)		Depth (m)	Diameter (mm)	Borehole	Casing	
														From	To	From	To	300		
																		250		
																		200		
																		150		
														Excavation Dimensions:			Backfill:			
																	STANDPIPE			
Remarks :- Visitors, Instructions, Weather, etc			Q.A		S/C	D	B	U	W	SITE				CASTLE CEMENT / RADESWOOD						
					Move	Drill	Stand	Break	Work	JOB No.				RIG TYPE						
										128062				SA/PIHCON						
										DAY				DATE						
										THURSDAY				12/13/98						
										Move From:				BH No.						
										b				4						
Top copy to office, Green to Engineer, Blue to Client, Red to Driller			Drillers Signature							Move From:										
Cable Parasite Daily Record																				

Soil Record		Penetration Testing and Sampling											Groundwater Records								
Depth	Description	Depth From To	Type	1	2	3	4	5	6	7	8	9	10	11	12	WATER ENCOUNTERED			PIEZOMETER / STANDPIPE		
G/L	Clay fill	0.50	D													Depth Struck			(Details on separate sheet)		
		1.50	D													Casing Depth			Piezometer	From	To
0.35	Soft-firm brown & grey mottled sandy clay	2.50	D													Inflow			Tip		
		3.00	D													Depth 5 mins			Filter		
		4.00	D													Depth 10 mins			Standpipe	From	To
		5.00	D													Depth 15 mins			Slotted Pipe	1.5	7.6
		6.00	D													Depth 20 mins			Filter	1.5	7.6
3m	Brown sand & gravel	7.00	D													Cut off at			WATER ADDED		
																WATER LEVELS			Water Added	From	To
																Depth	Casing	Time			
																Morning					
																Evening			Borehole Kept Full		
																Other					
5.60	firm dark brown boulder clay															FIELD RECORDS					
																Hard Struck / Churning			Depth at end of shift		
																Time (o'clock)	Depth (m)		Diameter (mm)	Borehole	Casing
																From	To	From	To	300	
																				250	
																				200	
																				150	
																Excavation Dimensions:			Backfill:		
7.60	Borehole Complete / Incomplete															150mm					
Remarks :- Visitors, Instructions, Weather, etc Winch rig off BH to dry ground (10A)				S/C	D	B	U	W	SITE												
					8				Castle Cement												
				Move	Drill	Stand	Break	Work	JOB No.												
				1	7.6				128062												
Top copy to office, Green to Engineer, Blue to Client, Red to Driller.				Crew				DAY			DATE										
				D. Munnally				Thurs			12-3-98										
Drillers Signature				Move From:				BH No.													
R. C. Wood				2				5													

Strat. Record

Penetration Testing and Sampling

Groundwater Records

Depth (m)	Description	Depth (m)	Notes	1	2	3	4	5	6	Inflow (m³)	Sample Location	Casing Depth (m)	Water Level (m)	WATER ENCOUNTERED			PIEZOMETER/STANDPIPE			
0.00	Grass over brown	0.50	D											Depth Struck	3.30		(Details on separate sheet)			
	CLAY TOP SOIL + FILL	0.80	D											Casing Depth	3.00		Piezometer	From	To	
0.80	SOFT BROWN / grey	2.60	D											Inflow	M		Tip			
	CLAY FILL	3.40	D											Depth 5 mins	3.05		Filter			
2.60	SOFT BROWN CLAY FILL	3.50	D											Depth 10 mins	2.90		Standpipe	From	To	
	+ WASTE	5.40	D											Depth 15 mins	2.90		Slotted Pipe	100	620	
3.20	CLAYEY SILTY SAND + GRAVEL	INSTALL 50mm WELL												Depth 20 mins	2.90		Filter	680	620	
3.50	STIFF BROWN + grey MOTTLED BOULDER CLAY	Cover												WATER LEVEL			Water Added	From	To	
		Concrete												Depth	Casing	Time				
5.60	Dry DENSE SAND + GRAVEL, COBBLES TO 6.20m	BENT SEAL												Morning				Borehole Kept Full		
														Evening						
														Other						
														FIELD RECORDS						
														Time of start / finishing			Depth at end of shift			
														Time (o'clock)		Depth (m)		Diameter (mm)	Borehole	Casing
														From	To	From	To	300		
																		250		
																		200		
																		150		
														Excavation Dimensions:			Backfill:			
														/			STANDPIPE			
														Borehole Complete / Incomplete						

* THREAD LEFT AT BASE TO EXTENT PIPE IF NEEDED.

SLOTTED 50mm PIPE

GRAVEL

6.20m

Borehole Complete / Incomplete

Remarks :- Visitors, Instructions, Weather, etc

Q.A

S/C D B U W
/ b / / /
Move Drill Stand Break Work

Crew J. Fennell
C. Robinson

Drillers Signature

SITE

CASTLE CEMENT / PAPERWOOD

JOB No.

RIG TYPE

128062

SA/PHCON

DAY

DATE

THURSDAY

12/3/98

Move From:

BH No.

3

6

Top copy to office, Green to Engineer, Blue to Client, Red to Driller

CABLE RECORD - Stand Daily Record



Project:
Padeswood Regulation 15 Site Investigation

Borehole No. **L1**
Sheet 1 of 1

Site: **Padeswood**

Client: **Castle Cement**

Project No. 00525426

Equipment & Methods:
Fraste Rig with Air Flush.

Drilled by: Foundation and Exploration Services
Date started: 25/01/2001 completed: 25/01/2001
Logged by: JD

Ground Level: 109.93 m aOD
Co-ordinates:
329122.00 E 361996.00 N

WATER	INSTALLATION / BACKFILL	HOLE DEPTH (m)	SAMPLES & TESTS				STRATA RECORD			
			Depth (m)	No.	Type	Test	Level (m aOD)	Legend	Depth Thickness (m)	Description
		1					109.13		(0.80) 0.80	Soft grey clayey soil containing hard black rounded particles approximately 0.5 cm across. Damp.
		2					107.73		(1.40) 2.20	Soft brown clay containing occasional plastic and brown paper. Damp.
		3					106.93		(0.80) 3.00	Soft dark grey clay. Wet.
		4					106.53		(0.90) 3.40	Firm grey brown clay. Damp.
		5					105.63		(0.60) 4.30	Firm to stiff fissile orange brown clay. Dry.
		6					105.23		(0.50) 4.70	Brown gravelly clay containing particles of iron oxide, carbon rich material and occasional red brick. Dry.
		7					104.63		(0.50) 5.30	Brown gravelly clay. Gravel is fine grained and well sorted. Dry.
		8					104.13		(0.50) 5.80	Brown-grey clay with occasional interspersed black organic deposits. Damp.
		9					103.93		(1.00) 6.00	Firm to stiff orange brown CLAY. Dry.
		10					102.93		(1.00) 7.00	Stiff orange brown gravelly CLAY. Gravel is rounded, well sorted and fine grained.
		11								End of Borehole at 7.00 m

Remarks: Borehole location is approximate.

Scale:
1:60



Project:
Padeswood Regulation 15 Site Investigation

Borehole No.
L2

Sheet 1 of 1

Site: **Padeswood**

Client: **Castle Cement**

Project No. 00525426

Equipment & Methods:
Fraste Rig with Air Flush.

Drilled by: Foundation and Exploration Services
Date started: 26/01/2001 completed: 26/01/2001
Logged by: JD

Ground Level: 109.01 m aOD
Co-ordinates:
329072.00 E 361950.00 N

WATER	INSTALLATION / BACKFILL	HOLE DEPTH (m)	SAMPLES & TESTS				STRATA RECORD			
			Depth (m)	No.	Type	Test	Level (m aOD)	Legend	Depth Thickness (m)	Description
		1					108.51		(0.50) 0.50	Soft dark grey clay. Dry.
		2					107.11 107.01 106.71 106.41		(1.40) 1.90 2.00 2.30 2.60	Soft to firm dark grey clay containing occasional fine angular fragments of red brick. Damp. Hard dry cement layer. Grey clay with fine gravel. moist to wet. Grey clay with fine well sorted angular gravel and occasional plant material. Dark grey gravelly clay with occasional fragments of paper and plastic. The gravel is fine grained and well sorted.
		3							(1.70)	
		4					104.71		4.30	Hard dry cement layer.
		5					104.01 103.71		(0.70) 5.00 5.30	
		6					103.21		(0.50) 5.80	Grey clay with plastic and paper fragments and occasional fragments of red brick. Soft to firm grey clay with occasional fine grey angular gravel.
		7					102.71 102.21		(0.50) 6.30 (0.50) 6.80	Soft to firm grey clay with a fine well sorted grey gravel. Firm grey gravelly clay containing fine grains of iron oxide and carbon rich material.
		8					101.51 101.21 101.01		(0.70) 7.50 7.80 8.00	Soft to firm gravelly clay containing timber. Gravel is fine to coarse and poorly sorted. Wet. Soft to firm brown grey clay. Soft to firm grey gravelly clay containing red brick fragments and occasional plant material.
		9								End of Borehole at 8.00 m
		10								
		11								

Remarks: Borehole location is approximate.

Scale:
1:60



Project:
Padeswood Regulation 15 Site Investigation

Borehole No. **L3**

Sheet 1 of 1

Site: **Padeswood**

Client: **Castle Cement**

Project No. 00525426

Equipment & Methods:
Fraste Rig with Air Flush

Drilled by: Foundation and Exploration Services
Date started: 26/01/2001 completed: 26/01/2001
Logged by: JD

Ground Level: 105.74 m aOD
Co-ordinates:
329029.00 E 361914.00 N

WATER	INSTALLATION / BACKFILL	HOLE DEPTH (m)	SAMPLES & TESTS				STRATA RECORD			
			Depth (m)	No.	Type	Test	Level (m aOD)	Legend	Depth Thickness (m)	Description
									(0.70)	Soft grey clay
							105.04		0.70	
							104.84		0.90	Soft clay with hard rounded coarse gravel of concrete.
		1					104.59		1.15	Grey consolidated spherical cement material approximately 1 to 2 cm across.
							104.34		1.40	Hard cement layer.
							104.24		1.50	Soft to firm brown clay layer.
									(1.10)	Grey clayey sand containing occasional fragments of paper and lagging.
		2								
							103.14		2.60	
							102.84		2.90	Medium dense fine to coarse grey gravel containing occasional red brick and paper fragments.
		3							(0.60)	Soft to firm brown grey gravelly clay with fine fragments of iron oxide and occasional fragments of timber and red brick. Dry to damp.
							102.24		3.50	
									(0.50)	Soft to firm grey gravelly clay with occasional red brick and wood fragments.
		4					101.74		4.00	
							101.64		4.10	Hard light grey cement layer. Dry.
							101.44		4.30	Soft to firm, black to brown grey gravelly clay containing fabric.
									(0.85)	Soft to firm, black to brown grey gravelly clay containing newspaper, cloth plastic and rubber. Dry.
		5					100.59		5.15	
									(1.00)	Soft to firm grey to black clay.
		6					99.59		6.15	
									(1.45)	Soft to firm grey clayey gravel containing occasional fragments of timber, plastic and red brick. Gravel is fine to coarse and angular. Wet.
		7								
							98.14		7.60	Medium dense grey SAND and GRAVEL. Sand is medium grained. Gravel is medium grained and well sorted. Wet.
		8							(2.55)	
		9								
		10					95.59		10.15	
										End of Borehole at 10.15 m
		11								

Remarks: Borehole location is approximate.

Scale:
1:60



Project:
Padeswood Regulation 15 Site Investigation

Borehole No. **BH7**

Sheet 1 of 1

Site: **Padeswood**

Client: **Castle Cement**

Project No. **00525426**

Equipment & Methods:
Fraste Rig with Air Flush.

Drilled by: **Foundation and Exploration Services**
Date started: **30/01/2001** completed: **30/01/2001**
Logged by: **JD**

Ground Level: **100.55 m aOD**
Co-ordinates:
329039.00 E 361892.00 N

WATER	INSTALLATION / BACKFILL	HOLE DEPTH (m)	SAMPLES & TESTS				STRATA RECORD			
			Depth (m)	No.	Type	Test	Level (m aOD)	Legend	Depth Thickness (m)	Description
							100.35		0.20	Soft brown clayey topsoil.
							99.95		0.60	Soft to firm grey clay containing angular cobbles of cement and fragments of red brick. Damp.
		1					99.35		1.20	Soft to firm brown grey clay with fragments of timber, concrete and black glassy slag.
							98.85		1.70	Firm brown grey clay containing fine angular grains of black glassy slag.
		2					98.25		2.30	Firm to stiff brown sandy gravelly clay. The gravel is fine to coarse grained and rounded to subangular. Damp.
							97.85		2.70	Firm to stiff brown grey clay.
		3					97.25		3.30	Soft grey clay containing grains of a blue crystalline material and fragments of plastic. Damp.
		4							(1.70)	Soft black clayey slurry. Wet.
		5					95.55		5.00	
							95.25		5.30	Soft to firm brown CLAY.
							94.95		5.60	Firm brown sandy gravelly CLAY. Dry.
		6					94.25		6.30	Orange brown medium grained and well sorted SAND. Dry.
							93.95		6.60	Medium dense orange brown SAND and GRAVEL. Damp.
		7								End of Borehole at 6.60 m
		8								
		9								
		10								
		11								

Remarks: 1. Hole backfilled.
2. Borehole location is approximate.

Scale:
1:60



Project:
Padeswood Regulation 15 Site Investigation

Borehole No. **BH8**

Sheet 1 of 1

Site: **Padeswood**

Client: **Castle Cement**

Project No. 00525426

Equipment & Methods:
Fraste Rig with Air Flush.

Drilled by: Foundation and Exploration Services
Date started: 31/01/2001 completed: 31/01/2001
Logged by: JD

Ground Level: N/A
Co-ordinates:
329007.00 E 361900.00 N

WATER	INSTALLATION / BACKFILL	HOLE DEPTH (m)	SAMPLES & TESTS				STRATA RECORD			
			Depth (m)	No.	Type	Test	Level (m aOD)	Legend	Depth Thickness (m)	Description
		1					-1.20		(1.20)	Soft to firm grey clay containing fabric and occasional fine angular fragments of red brick. Damp.
		2	1.50 - 3.00	01	B		-1.50		1.20	Firm to stiff orange brown sandy gravelly CLAY. Sand is fine to medium grained. Gravel is fine to medium grained and rounded to subangular.
		3					-3.50		(2.00)	Firm to stiff brown gravelly CLAY. Gravel is grey to light purple, fine to medium grained and rounded. Damp.
		4					-4.00		3.50	Medium dense orange brown clayey gravelly SAND. Dry
		5					-5.20		(0.50)	Medium dense orange brown SAND and GRAVEL. Medium sand and medium rounded to subangular gravel. Dry.
		6					-5.60		4.00	Medium dense brown SAND. Sand is medium to coarse grained. Damp.
		7					-6.10		(1.20)	Medium dense grey to light purple SAND and GRAVEL. Gravel is fine to medium grained and rounded to subangular. Dry.
		8							5.20	
		9							5.60	
		10							(0.50)	
		11							6.10	
										End of Borehole at 6.10 m

Remarks: Borehole location is approximate

Scale:
1:60



Project:
Padeswood Regulation 15 Site Investigation

Borehole No.
BH9

Sheet 1 of 1

Site: **Padeswood**

Client: **Castle Cement**

Project No. 00525426

Equipment & Methods:
Fraste Rig with Air Flush.

Drilled by: Foundation and Exploration Services
Date started: 01/02/2001 completed: 01/02/2001
Logged by: JD

Ground Level: 97.15 m aOD
Co-ordinates:
329010.00 E 361875.00 N

WATER	INSTALLATION / BACKFILL	HOLE DEPTH (m)	SAMPLES & TESTS				STRATA RECORD			
			Depth (m)	No.	Type	Test	Level (m aOD)	Legend	Depth Thickness (m)	Description
		1					96.95		0.20	Soft black topsoil. Damp.
							96.65		0.50	Soft brown sandy clayey soil. Damp.
									(0.70)	Soft brown sandy CLAY. Wet.
		2					95.95		1.20	Soft brown sandy CLAY. Damp.
							95.50		1.65	BOULDER
							95.15		2.00	Stiff blue grey CLAY. Dry.
		3					94.80		2.35	Medium dense dark brown SAND. Damp to moist.
							94.55		2.60	Soft to firm brown to grey clayey SAND. Wet.
							94.45		2.70	Stiff brown sandy CLAY. Damp.
		4	2.70 - 3.70	01	B				(0.70)	
							93.75		3.40	Soft to firm brown sandy gravelly CLAY. Gravel is medium grained and rounded to angular.
									(1.10)	
		5					92.65		4.50	Medium dense clayey GRAVEL. Wet.
							92.35		4.80	Soft to firm grey sandy gravelly CLAY. Gravel is rounded to subangular and medium grained. Wet.
							92.15		5.00	End of Borehole at 5.00 m
		6								
		7								
		8								
		9								
		10								
		11								

Remarks: Borehole location is approximate.

Scale:
1:60



Project:
Padeswood Regulation 15 Site Investigation

Borehole No. **BH10**

Sheet 1 of 1

Site: **Padeswood**

Client: **Castle Cement**

Project No. 00525426

Equipment & Methods:
Fraste Rig with Down the Hole Hammer and Air Flush.

Drilled by: Foundation and Exploration Services
Date started: 01/02/2001 completed: 01/02/2001
Logged by: JD

Ground Level: 97.56 m aOD
Co-ordinates:
329022.00 E 361863.00 N

WATER	INSTALLATION / BACKFILL	HOLE DEPTH (m)	SAMPLES & TESTS				STRATA RECORD			
			Depth (m)	No.	Type	Test	Level (m aOD)	Legend	Depth Thickness (m)	Description
		1	1.00	01	B		97.36 97.06		0.20 0.50	Soft brown to black TOPSOIL. Firm grey to black CLAY. Wet.
									(1.10)	Firm brown sandy CLAY.
		2	1.60 - 2.70	02	B		95.96 95.76		1.60 1.80	Firm orange brown sandy gravelly CLAY. Gravel is medium grained and well sorted. Dry.
									(1.40)	Stiff brown sandy gravelly CLAY. Dry.
		3					94.36		3.20	
		4	3.20 - 4.00	03	B				(1.60)	Medium dense brown SAND and GRAVEL. Sand is fine to medium grained. Gravel is fine to medium grained. Dry.
		5	4.80 - 5.10	04	B		92.76 92.46		4.80 5.10	Medium dense grey to light purple GRAVEL. Fine to medium grained and poorly sorted. Dry.
										End of Borehole at 5.10 m
		6								
		7								
		8								
		9								
		10								
		11								

Remarks: Borehole location is approximate.

Scale:
1:60



Project:
Padeswood Regulation 15 Site Investigation

Borehole No.
BH11

Sheet 1 of 2

Site: **Padeswood**

Client: **Castle Cement**

Project No. 00525426

Equipment & Methods:
Tractor Mounted Rotary Rig with Air Flush.

Drilled by: Foundation and Exploration Services
Date started: 05/02/2001 completed: 05/02/2001
Logged by: JD

Ground Level: 105.93 m aOD
Co-ordinates:
328992.00 E 362108.00 N

WATER	INSTALLATION / BACKFILL	HOLE DEPTH (m)	SAMPLES & TESTS				STRATA RECORD			
			Depth (m)	No.	Type	Test	Level (m aOD)	Legend	Depth Thickness (m)	Description
		1								Soft to firm grey clay. Damp.
		2							(3.00)	
		3					102.93		3.00	
		4							(1.70)	Stiff brown mottled black sandy gravelly clay.
		5	4.70 - 5.50	01	B		101.23		4.70	
		6					100.43		(0.80)	Soft to firm brown sandy gravelly CLAY. Gravel is medium grained and rounded.
		7	5.50 - 8.50	02	B				5.50	Soft to firm sandy CLAY. Damp.
		8							(3.00)	
		9					97.43		8.50	
		10							(3.50)	Soft to firm dark brown gravelly CLAY.
		11								
							93.93		12.00	

Continued on next sheet

Remarks: Borehole location is approximate.

Scale:
1:60



Project:
**Padeswood Regulation 15 Site
Investigation**

Borehole No. **BH11**

Sheet 2 of 2

Site: **Padeswood**

Client: **Castle Cement**

Project No. 00525426

Equipment & Methods:
Tractor Mounted Rotary Rig with Air Flush.

Drilled by: Foundation and Exploration Services
Date started: 05/02/2001 completed: 05/02/2001
Logged by: JD

Ground Level: 105.93 m aOD
Co-ordinates:
328992.00 E 362108.00 N

WATER	INSTALLATION / BACKFILL	HOLE DEPTH (m)	SAMPLES & TESTS				STRATA RECORD			
			Depth (m)	No.	Type	Test	Level (m aOD)	Legend	Depth Thickness (m)	Description
		13					93.93		12.00	Soft to firm dark brown gravelly CLAY.
		14	14.00	03	B		91.93		(2.00) 14.00	Soft to firm brown sandy gravelly CLAY.
		15								
		16								
		17								
		18								
		19								
		20								
		21								
		22								
		23								

Remarks: Borehole location is approximate.

Scale:
1:60



Project:
Padeswood Regulation 15 Site Investigation

Borehole No. **BH12**

Sheet 1 of 2

Site: **Padeswood**

Client: **Castle Cement**

Project No. 00525426

Equipment & Methods:
Tractor Mounted Rotary Rig with Air Flush

Drilled by: Foundation and Exploration Services
Date started: 06/02/2001 completed: 07/02/2001
Logged by: JD

Ground Level: 106.90 m aOD
Co-ordinates:
329052.00 E 362179.00 N

WATER	INSTALLATION / BACKFILL	HOLE DEPTH (m)	SAMPLES & TESTS				STRATA RECORD			
			Depth (m)	No.	Type	Test	Level (m aOD)	Legend	Depth Thickness (m)	Description
							106.80		0.10	Hardstanding with thin topsoil cover.
							106.60		0.30	Soft to firm brown clay. Damp.
									(0.65)	Stiff brown mottled grey clay containing bricks and timber.
		1					105.95		0.95	Stiff brown mottled grey clay containing angular fragments of red brick and black glassy slag.
		2							(2.35)	
		3					103.60		3.30	Stiff brown sandy CLAY with occasional fine gravel.
		4							(1.70)	
		5					101.90		5.00	Firm to stiff brown sandy gravelly CLAY. Gravel is fine grained
		6	5.50 - 7.00	01	B					
		7	7.00	02	B				(5.00)	
		8								
		9								
		10					96.90		10.00	Firm to stiff brown sandy gravelly CLAY.
		11							(4.00)	

Continued on next sheet

Remarks: Borehole location is approximate.

Scale:
1:60



Project:
Padeswood Regulation 15 Site Investigation

Borehole No. **BH12**

Sheet 2 of 2

Site: **Padeswood**

Client: **Castle Cement**

Project No. 00525426

Equipment & Methods:
Tractor Mounted Rotary Rig with Air Flush

Drilled by: Foundation and Exploration Services
Date started: 06/02/2001 completed: 07/02/2001
Logged by: JD

Ground Level: 106.90 m aOD
Co-ordinates:
329052.00 E 362179.00 N

WATER	INSTALLATION / BACKFILL	HOLE DEPTH (m)	SAMPLES & TESTS				STRATA RECORD			
			Depth (m)	No.	Type	Test	Level (m aOD)	Legend	Depth Thickness (m)	Description
		13							(4.00)	Firm to stiff brown sandy gravelly CLAY.
		14					92.90		14.00	Sandy MUDSTONE.
		15								
		16								
		17								
		18								
		19							(9.00)	
		20								
		21								
		22								
		23					83.90		23.00	End of Borehole at 23.00 m

Remarks: Borehole location is approximate.

Scale:
1:60



Project:
Padeswood Regulation 15 Site Investigation

Borehole No. **BH13**

Sheet 1 of 2

Site: **Padeswood**

Client: **Castle Cement**

Project No. 00525426

Equipment & Methods:
Tractor Mounted Rotary Rig with Air Flush.

Drilled by: Foundation and Exploration Services
Date started: 08/02/2001 completed: 12/02/2001
Logged by: JD

Ground Level: 99.47 m aOD
Co-ordinates:
329023.00 E 361887.00 N

WATER	INSTALLATION / BACKFILL	HOLE DEPTH (m)	SAMPLES & TESTS				STRATA RECORD			
			Depth (m)	No.	Type	Test	Level (m aOD)	Legend	Depth Thickness (m)	Description
		1					97.57		(1.90)	Stiff brown CLAY. Damp.
		2							1.90	
		3	1.90 - 3.90	01	B				(2.00)	Medium dense orange brown clayey sand and gravel. gravel is medium grained, angular and well sorted. Contains red brick and has a tarry odour. Damp.
		4					95.57		3.90	
		5	4.20 - 4.80	02	B		95.27		(0.60)	Soft to firm sandy gravelly clay. Wet.
		6	4.80 - 5.50	03	B		94.67		4.80	Stiff brown gravelly clay containing glassy black slag. Gravel is medium grained and rounded to angular. Dry.
		7					93.97		(0.70)	Stiff brown slightly sandy CLAY. Dry.
		8	5.50 - 7.10	04	B				5.50	
		9							(1.60)	Stiff brown sandy gravelly CLAY. Dry.
		10	7.10 - 9.40	05	B		92.37		7.10	
		11							(2.30)	Fine black organic SAND. Dry.
		12	9.40 - 10.00	06	B		90.07		9.40	
		13					89.47		(0.60)	Fine grey MUDSTONE. Dry.
		14	10.00 - 12.00	07	B				10.00	
		15							(2.00)	Medium dense dark brown SAND and GRAVEL. Gravel is medium grained and rounded to subangular.
		16					87.47		12.00	

Continued on next sheet

Remarks: Borehole location is approximate.

Scale:
1:60



Project:
Padeswood Regulation 15 Site Investigation

Borehole No. **BH13**

Sheet 2 of 2

Site: **Padeswood**

Client: **Castle Cement**

Project No. 00525426

Equipment & Methods:
Tractor Mounted Rotary Rig with Air Flush.

Drilled by: Foundation and Exploration Services
Date started: 08/02/2001 completed: 12/02/2001
Logged by: JD

Ground Level: 99.47 m aOD
Co-ordinates:
329023.00 E 361887.00 N

WATER	INSTALLATION / BACKFILL	HOLE DEPTH (m)	SAMPLES & TESTS				STRATA RECORD			
			Depth (m)	No.	Type	Test	Level (m aOD)	Legend	Depth Thickness (m)	Description
		12.00					87.47		12.00	Medium dense dark brown SAND and GRAVEL. Gravel is medium grained and rounded to subangular.
		13								Medium dense orange brown gravelly SAND. Sand is medium grained and well sorted.
		12.00 - 15.00	08	B					(3.00)	
		14								
		15					84.47		15.00	Medium dense orange medium grained SAND.
		15.00 - 17.00	09	B					(2.00)	
		16								
		17					82.47		17.00	End of Borehole at 17.00 m
		18								
		19								
		20								
		21								
		22								
		23								

Remarks: Borehole location is approximate.

Scale:
1:60



Project:
Padeswood Regulation 15 Site Investigation

Borehole No. **BH14**

Sheet 1 of 2

Site: **Padeswood**

Client: **Castle Cement**

Project No. 00525426

Equipment & Methods:
Truck Mounted Rotary Rig with Air Flush

Drilled by: Foundation and Exploration Services
Date started: 15/02/2001 completed: 16/02/2001
Logged by: JD

Ground Level: 102.78 m aOD
Co-ordinates:
328969.00 E 362011.00 N

WATER	INSTALLATION / BACKFILL	HOLE DEPTH (m)	SAMPLES & TESTS				STRATA RECORD			
			Depth (m)	No.	Type	Test	Level (m aOD)	Legend	Depth Thickness (m)	Description
		1								Stiff brown clay. Damp.
		2							(4.00)	
		3								
		4					98.78		4.00	
		5							(3.00)	Stiff brown gravelly CLAY. Gravel is fine to medium grained and rounded. Damp.
		6								
		7					95.78		7.00	
		8					94.78		(1.00)	Medium dense brown gravelly SAND. Gravel is medium grained and rounded. Damp.
		9							8.00	
		10							(5.00)	Stiff brown gravelly CLAY. Gravel is fine well sorted and angular. Damp.
		11								

Continued on next sheet

Remarks: Borehole location is approximate.

Scale:
1:60



Project:
Padeswood Regulation 15 Site Investigation

Borehole No. **BH14**

Sheet 2 of 2

Site: **Padeswood**

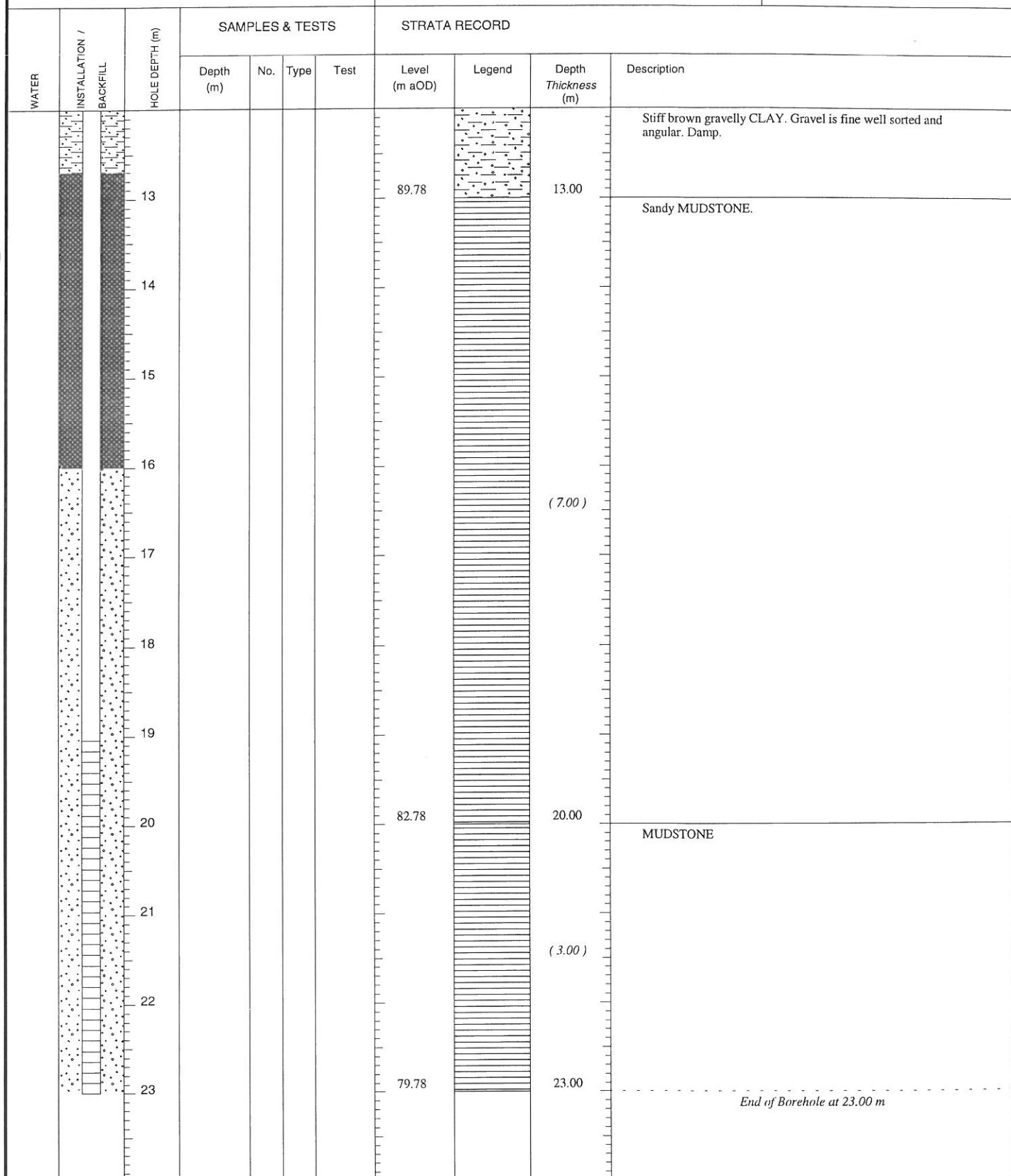
Client: **Castle Cement**

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Logged by: JD

Ground Level: 102.78 m aOD
Co-ordinates:
328969.00 E 362011.00 N



Remarks: Borehole location is approximate.

Scale:
1:60

At Golder Associates we strive to be the most respected global group of companies specialising in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organisational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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APPENDIX D

**Padeswood Landfill: Toe Drain Infrastructure Testing Report,
Report reference 13514240032.501/A.0, Dated March 2014**



March 2014

HANSON CEMENT WORKS - PADESWOOD LANDFILL

Toe Drain Infrastructure Testing Report

Submitted to:

Mr Matthew Uttley
Hanson (UK) Ltd
Ashby Road East
Shepshed
Loughborough
LE12 9BU

REPORT



Report Number 13514240032.501/A.0

Distribution:

Hanson UK Ltd - 2 copies
NRW - 1 copy
Golder Associates (UK) Ltd - 1 copy





Table of Contents

1.0 INTRODUCTION.....	1
1.1 Objectives.....	1
1.2 Background.....	1
2.0 METHODOLOGY.....	1
2.1 Pumping Test from TD1.....	2
2.1.1 Initial Set-Up	2
2.1.2 Pumping Test Procedure	2
2.1.3 Data Logger Procedure.....	2
2.1.4 Sampling Procedure.....	3
2.2 Pumping Test from TD2.....	3
2.2.1 Data Logger Procedure.....	3
2.2.2 Sampling Procedure.....	3
2.3 Leachate Level Monitoring (L3)	3
3.0 RESULTS	4
3.1 Toe Drain Water Elevations.....	4
3.2 Toe Drain Elevations	4
3.3 Leachate Well (L3) Water Elevations.....	4
3.4 Toe Drain Chemical Results.....	4
3.5 Leachate Chemical Results	4
4.0 DISCUSSION.....	5
4.1 Interpretation of Water and Leachate Analysis	5
4.2 Elevation of the Toe Drain	6
5.0 CONCLUSIONS.....	7
6.0 RECOMMENDATIONS.....	8

TABLES

Table 1: Chemical Analysis Results from TD1 and TD2.....	4
Table 2: Chemical Analysis for Monthly Monitoring of the Leachate Sump (S1).....	5
Table 3: Chemical Analysis of Leachate Wells L1, L2, and L3.....	5
Table 4: Leachate, Toe Drain, and Sump Ratios between Chloride and Ammoniacal Nitrogen.....	5



PADESWOOD CEMENT WORKS - TOE DRAIN INFRASTRUCTURE TESTING

APPENDICES

APPENDIX A

In Situ Testing Photographs

APPENDIX B

Laboratory Results



1.0 INTRODUCTION

Following an inspection of the leachate management infrastructure at Padeswood Cement Works Landfill (the Site) in June 2011 by Golder Associates (UK) Ltd (Golder), Golder was subsequently commissioned by Hanson (UK) Ltd (Hanson) in 2013 to undertake on-site testing of the leachate toe drain infrastructure at the landfill.

The Site is located approximately 5 km east-southeast of Mold, Flintshire, in North Wales.

This report is completed in-line with the Golder proposal 'Padeswood Landfill: Proposal for Consulting Support of Testing an On-site Strategy for the Management of Leachate', dated 23 January 2013 (Reference: P315240032/1/V.0).

1.1 Objectives

The objectives of the *in situ* testing and interpretive report are to:

- Conduct test pumping where waters are present in the toe drain to identify the physical functionality of the toe drain;
- Chemically assess the water contained within the toe drain;
- Interpret the chemical signature of the toe drain water to determine its likely source; and
- Determine the likely functionality of the toe drain within the observed context and conceptual understanding of the landfill, leachate, toe drain, and local groundwater conditions.

1.2 Background

Historically, leachate was managed at the Site through the dewatering of a concrete sump (S1) (shown in Drawing 1), which is approximately 3 m deep. The sump is assumed to be fed by two leachate toe drains; one extends partially along the eastern boundary of the landfill (subsequently named the 'eastern toe drain'); and the other is much longer and extends around the northern, western, and southwestern boundaries of the landfill (subsequently named the 'northern toe drain').

There is broad agreement between Hanson and the Environment Agency (EA) that the sump is not sufficiently isolated from perched groundwater present in lenses of sand and gravel in the Boulder Clay deposits that underlie the Site. As a consequence of this potential connection of the sump to perched groundwater, the water pumped from the sump is believed to comprise a mixture of leachate and groundwater and use of the sump ceased in 2010.

2.0 METHODOLOGY

The on-site test pumping was completed between 18 and 21 June 2013.

In order to assess the toe drain infrastructure independently of the sump, two manhole access locations directly upstream on each toe drain to the sump were chosen. TD1 drain chamber is located immediately upstream of the sump on the eastern arm of the landfill toe drain. TD2 drain chamber is located immediately upstream of the sump on the western and northern arm of the toe drain.

Within the vicinity of both toe-drain chambers, four new IBCs (holding up to 1,000 litres each) were placed and each drain had an individual diesel powered water pump. Connecting pipes were arranged between the drains, the pumps, and the IBCs to collect and retain the leachate recovered during the pumping tests.

The IBCs were emptied with the liquid taken off-site for appropriate disposal by a suitable waste-water tanker (Envirocare) when required throughout the duration of the Site works.

Throughout the test the weather remained dry, with only light rain falling on the last day.



2.1 Pumping Test from TD1

2.1.1 Initial Set-Up

TD1 is a cylindrical concrete chamber approximately 1.5 m diameter and 1.1 m deep. It is reached through a square metal manhole cover opening at the surface. On initial inspection the chamber was observed to have approximately 0.16 m depth of relatively clear water. Prior to undertaking an inspection of the pipework within the chamber, it was pumped out, resulting in approximately 200 L of water being removed.

Within the chamber there is an inlet pipe assumed to come from the arm of the toe drain, and an outlet pipe which appears to pass directly into the sump chamber (Photograph 1, Appendix A); located adjacent to TD1 (Drawing 1). The inlet pipe was approximately 0.8 m below the top of the chamber. Between the inlet and outlet pipe there is a valve (usually kept open), and what was understood to be a flow meter. However; when the pipes were inspected the flow meter was found to be a non-return valve (Photograph 2, Appendix A), which had been installed incorrectly, as it was allowing water from the sump to enter the toe drain, rather than letting the water from the toe drain flow through to the sump. Therefore, prior to this testing, no leachate from the eastern arm of the toe drain could have reached the sump chamber. It is understood that the non-return valve was fitted at the time the toe drain was completed and is unlikely to have been altered since.

The valve on the toe-drain side was closed, the non-return valve was removed, and a watertight blanking plate was fitted to the pipe coming from the sump chamber by a Hanson engineer (Photograph 3, Appendix A). This was fitted to prevent the potential for any water from the sump (S1) flowing back into TD1 chamber during the pumping test. At the time the blanking plate was fitted, the sump required continuous pumping to keep the water level below the pipe between the sump and TD1 chambers.

2.1.2 Pumping Test Procedure

The valve in TD1 was opened on 18 June 2013, and immediately a flow of water filled up the chamber to approximately 0.10 m depth before running dry. The water was clear with a slight brown/yellow staining. This water was pumped out so that the base of the TD1 chamber was mostly dry to allow further inflow from the toe-drain to be recorded accurately.

The inlet pipe from the toe drain remained dry throughout the pumping test completed between 18 and 21 June 2013.

On inspection of the chamber following each round of dewatering, it was observed that two areas of the concrete walls leaked and showed continuous seepages of water into the chamber (Photographs 4 and 5, Appendix A). The first area noted is where several cables exited the TD1 chamber close to the floor. Here the concrete is not flush with the surrounding wall concrete and appears to allow a relatively significant flow of water into the chamber. The second, slightly less significant, area of seepage is located on the opposite side of chamber to the first area.

No other inflow, including from the toe drain itself, was observed into TD1 except the two seepage areas throughout the duration of the test. During several tests, the chamber filled up to a maximum of between approximately 0.15 and 0.18 m depth. The water was removed from TD1 on several occasions, during which an average volume of between 215 L and 230 L was removed. On one occasion TD1 was allowed to refill overnight, after which approximately 280 L was recovered from the chamber on the following day.

It took approximately 20 minutes to fill TD1 chamber to the normal rest level of between 0.15 and 0.18 m depth.

2.1.3 Data Logger Procedure

A data logger was installed close to the floor of the chamber. However; due to the chamber refilling via the leaks in the side walls rather than from the toe drain pipe, the data obtained cannot be used to gain any further information on the toe drain system.



2.1.4 Sampling Procedure

Three water samples were obtained from TD1, on 18, 19 and 21 of June 2013. These were collected in clean suitable sample bottles, stored in a cool environment, and collected from site by UKAS accredited chemical testing laboratory ALcontrol Laboratories (ALcontrol). The samples were tested for ammoniacal nitrogen, arsenic, selenium, chloride, and pH as requested by Hanson, and the full results are presented in Appendix B.

2.2 Pumping Test from TD2

TD2 is a cylindrical drain chamber with a red plastic cylindrical liner from the surface to approximately 2.5 m depth which opens into a chamber (Photograph 6, Appendix A). Beneath the liner a chamber opens out and the dimensions are not visible from the surface; however, a Hanson engineer was able to access the drain base and described the chamber as being approximately 3.0 m by 3.0 m, with the total drain depth from ground level being approximately 3.68 m. On initial inspection the chamber contained black coloured water from a level approximately 0.8 m below ground level (m bGL). Prior to any works, this was pumped out and collected in the IBCs prior to appropriate disposal. Approximately 4.1 tonnes of liquid was removed from TD2.

There is an inlet pipe close to the top of the red access cylinder which remained dry throughout the pumping test completed between 18 and 21 June 2013. The inlet pipe is approximately 0.8 m bGL. The Hanson engineer did not identify any inlet or outlet in the base of the chamber.

An outlet pipe connecting TD2 to the sump (S1) was not observed either from the surface or from within the chamber. One outlet pipe was observed by the Hanson engineer (Photograph 7, Appendix A); however, from the direction it was pointing it is likely that this is an emergency overflow pipe which flows to an emergency valve (Photograph 8). On inspection, the valve was shut and there was no water contained within the chamber. If opened in an emergency, the flowing water would pass through the valve and out onto the ground surface to soak away.

Once emptied, TD2 did not significantly recharge during the duration of the pumping test, therefore no further pumping test interpretation could be undertaken on this arm of the toe drain.

The upgradient drains were inspected to identify if they were visibly blocked, and to assess if there was any flow towards TD2. Photographs presented on Drawing 1 show that the upgradient drains contained a small amount of liquid or were dry. Where there was liquid present a slow rate of flow was observed in the direction of TD2.

2.2.1 Data Logger Procedure

No data logger was installed in TD2 as there was insufficient inflow into the drain chamber.

2.2.2 Sampling Procedure

One water sample was obtained from TD2 on 20 June 2013. It was collected in clean suitable sample bottles, stored in a cool environment, and collected from site by UKAS accredited chemical testing laboratory ALcontrol Laboratories (ALcontrol). The samples were tested for ammoniacal nitrogen, arsenic, selenium, chloride, and pH as requested by Hanson, and the full results are presented in Appendix B.

2.3 Leachate Level Monitoring (L3)

Two leachate level readings were recorded in the leachate well closest to the toe drain sump (L3). These were monitored using a standard clean dip tape and the measurements were recorded to ground level and top of casing (the concrete/breeze block housing around the well).



3.0 RESULTS

3.1 Toe Drain Water Elevations

Water levels within TD1 and TD2 were manually measured throughout the testing period. The results have been averaged and show that TD1 generally remained at a water level that was 0.92 m bGL, which is approximately 99.19 m Above Ordnance Datum (m AOD). Once drained, water levels within TD2 did not rise.

3.2 Toe Drain Elevations

The elevation of the inlet pipe in TD1 is approximately 99.31 m AOD, and the elevation of the inlet pipe in TD2 is approximately 99.75 m AOD.

3.3 Leachate Well (L3) Water Elevations

The leachate level within well L3 was 9.52 m bGL, which is approximately 98.99 m AOD. This was measured prior to beginning the pumping test, and therefore is understood to represent the steady state leachate level within the landfill. Based on the elevation of the base of the waste reported in the borehole log for L3 this indicates that a head of leachate of 0.85 m exists in the base of the landfill.

3.4 Toe Drain Chemical Results

Table 1 presents the chemical analysis results from samples taken from TD1 and TD2 during the toe drain testing. Appendix B presents the complete laboratory results. Sample TD2 was taken prior to the testing commencing by ALcontrol staff under the instruction of Hanson. Samples taken from TD1 were taken from the water entering the chamber through the leaks and not from the toe drain inlet pipe as this remained dry throughout the test period.

Table 1: Chemical Analysis Results from TD1 and TD2

Sample ID	Date	Ammoniacal Nitrogen	Arsenic	Selenium	Chloride	pH
		mg/l	µg/l	µg/l	mg/l	
TD1/1	18/06/2013	25.30	86.80	302	1940	12.40
TD1/2	19/06/2013	31.10	72.10	233	1830	12.50
TD1/4	21/06/2013	26.00	64.20	216	1820	12.50
TD2/3	21/06/2013	1.49	5.03	1.78	27.5	7.90
TD2	05/06/2013	<0.30	2.00	1.77	7.4	8.03

The results from TD1 and TD2 show a good correlation between the samples taken from each toe drain.

3.5 Leachate Chemical Results

Table 2 presents a summary of the chemical analysis results from the previous three months of leachate sump (S1) monitoring that ALcontrol undertake for Hanson on a monthly (basic analysis suite) and quarterly (more comprehensive analysis suite) basis. Please note that the most recent available results are up to September 2013.



PADESWOOD CEMENT WORKS - TOE DRAIN INFRASTRUCTURE TESTING

Table 2: Chemical Analysis for Monthly Monitoring of the Leachate Sump (S1)

Sample ID	Date	Dissolved Oxygen	Electrical Conductivity	Temperature	Chloride	pH	Ammoniacal Nitrogen
		ppm	µS/cm	°C	mg/l		mg/l
S1	30/07/2013	36.6	2140	17.2	244	9.25	0.30
	20/08/2013	27.9	1870	16.1	228	9.08	1.01
	30/09/2013	19.4	1380	13.8	154	8.47	2.52

No monthly results from the leachate wells (e.g. L3) are available; however, results obtained in February 2001 are presented in Table 3 below.

Table 3: Chemical Analysis of Leachate Wells L1, L2, and L3

Borehole ID	Date	Ammoniacal Nitrogen	Chloride	pH	Electrical Conductivity
		mg/l	mg/l		µS/cm
L1	Feb-01	6.6	1215	8.56	10200
L2	Feb-01	7.5	1638	10.84	18800
L3	Feb-01	17.1	4257	12.91	41600

The exact date of the sampling is unknown; however it is understood to be approximately 6 February 2001

4.0 DISCUSSION

4.1 Interpretation of Water and Leachate Analysis

During the test pumping, samples of water from TD1 and TD2 were recovered to enable a comparison to be made with existing results for leachate composition from wells within the site and from the disused off-waste sump; S1 with the objective of identifying the source of water recovered from the toe train.

As the leachate wells are not regularly monitored, sample results obtained in February 2001 have been compared to the current samples from TD1 and TD2. Both chloride and ammoniacal nitrogen concentrations from samples taken from TD1 remained relatively stable throughout the testing period. Due to the lack of inflow, it was only possible to collect one sample from TD2. Example concentrations of two of the key contaminants in the leachate are listed in Table 4 with ratios between these two substances calculated to indicate the presence of different sources of leachate.

Table 4: Leachate, Toe Drain, and Sump Ratios between Chloride and Ammoniacal Nitrogen

Borehole/Chamber ID	Date of Sampling	Ammoniacal N	Chloride	Ratio Chloride : Ammoniacal N
S1	29/06/2010	4.00	278	70:1
S1	30/09/2013	0.30	178	600:1
L1	February 2001	6.6	1215	180:1
L2	February 2001	7.5	1638	220:1
L3	February 2001	17.1	4257	250:1
TD1/4	21/06/2013	26.00	1820	70:1
TD2/3	21/06/2013	1.49	27.5	12:1

Concentrations are in mg/l



Historic results for the composition of water from L3 have been included because L3 is a monitoring well located within the footprint of the south of the landfill. The screened interval of L3 is in a permeable lens of sand and gravel immediately beneath the waste and hence the composition of water from this well is indicative of the direct impact of the site at this location. The concentration of ammoniacal nitrogen and chloride indicate an impact from the site at this location or the presence of perched leachate beneath the waste. The ratio of ammoniacal nitrogen to chloride is unlike the other locations, however it is anticipated that the presence of ammoniacal nitrogen in the waste will be variable across the Site depending on the heterogeneity of the waste streams.

Two results from S1 have been included to provide a comparison to the other locations for periods when S1 was in active use and since it has ceased pumping. Concentrations of chloride and ammoniacal nitrogen have been identified in the seepages entering the side of the TD1 chamber and in S1 when in active use in 2010 that are indicative of the potential presence of leachate or leachate impacted water. Comparable chloride - ammoniacal nitrogen ratio results (70:1) between S1 when in active use in 2010 and the seepages through the sidewall of TD1 indicate a relationship between the water in the sump chamber (S1) and the water TD1. It is noted that the water taken from S1 was approximately 15 times more dilute than the seepages entering TD1. It is anticipated that this difference is through the abstraction from S1 also drawing in un-impacted water potentially connected to the sump via saturated lenses of permeable material in continuity with the adjacent watercourse. Based on this interpretation and the fact that the toe drains are not contributing to the sump, it is proposed that ceasing the abstraction from sump S1 was appropriate.

The sample obtained from TD2 is not indicative of leachate. The concentration of chloride is more indicative of surface run-off of rainwater. The observed water removed from TD2 was heavily stained and appeared to be stagnant hence it is inferred that the presence of a discernable concentration of ammoniacal nitrogen is an indication of biological processes occurring within the stagnant water present in the TD2 chamber. It is therefore inferred that the water present in the southern part of the western toe drain is infiltrated rainwater that has collected in the system over the intervening period since construction.

4.2 Elevation of the Toe Drain

The elevation of the inlet pipe into TD1 is at approximately 99.31 m AOD. The inlet pipe into TD2 is at approximately 99.75 m AOD. The leachate elevation recorded in L3 is 98.99 m AOD, which indicates that leachate within the waste may be below the toe drain by between 0.32 and 0.76 m. This indicates that in this corner of the Site, the toe drain lies above the rest leachate elevation.

It is understood that prior to capping the leachate elevation was much higher than it currently is and that leachate breakouts were occurring along the flanks of the Site. It is hence inferred that the toe drain was constructed at this time to manage the perimeter breakouts and since capping, the reduction of infiltration to the waste and subsequent reduction in leachate head, the toe drain has become redundant as a result of the elevation that it was installed.

The average elevation of groundwater in the Monitoring Boreholes GA2 to GA4 adjacent to the toe drain is between 86.35 and 90.34 m AOD and hence except where the potential for perched groundwater exists, the toe drain does not intersect groundwater and would not be able to be used to capture potentially contaminated groundwater.



5.0 CONCLUSIONS

Following an inspection of the leachate management infrastructure at the site in June 2011, Golder was commissioned by Hanson to undertake on-site testing of the leachate toe drain infrastructure at the landfill. The objectives were to physically assess the toe drain infrastructure by conducting test pumping on the eastern and northern arms of the toe drain separately. The pumping test and observations were completed between 18 and 21 June 2013.

In summary the following was observed throughout the duration of the test:

- TD1 –
 - The non-return valve had been installed the wrong way and was preventing water flowing from the toe drain into the sump (S1);
 - On removal of the non-return valve, fitting a blanking plate to S1 and opening the manual valve there was a small initial flow, no further inflow was observed into TD1 from the inlet pipe;
 - All flow into TD1 was observed to come from two areas in the concrete chamber walls from either perched leachate or groundwater;
 - The inlet pipe into TD1 is elevated approximately 0.32 m above the leachate elevation (measured in L3), which is likely to inhibit the flow of leachate into the toe drain;
 - The chemical signature of the water that flowed into TD1 is very similar to that observed in S1; and
 - The chemical signature indicates that the seepage water in TD1 is impacted by leachate that has been diluted by either perched groundwater or infiltration by a dilution factor of approximately 2.
- Sump S1 –
 - The sump did not appear to be hydraulically connected to either TD1 or TD2 by the pipework; and
 - From data collected in 2010 when S1 was actively dewatered a further 15 times dilution of the concentration of chloride and ammoniacal nitrogen observed in the TD1 seepages occurred. Based on this interpretation and the fact that the toe drains are not contributing to the sump, it is proposed that ceasing the abstraction from sump S1 was appropriate.
- TD2 –
 - Once the initial water had been pumped from TD2, no further inflow into the chamber was observed;
 - Following an inspection, it was observed that there was no outlet pipe towards S1. The observed outlet pipe exited towards a closed overflow valve;
 - The inlet pipe into TD2 is elevated approximately 0.76 m above the leachate elevation (as measured in L3), which is likely to inhibit the flow of leachate into the toe drain; and
 - The chemical signature of the water in TD2 is not comparable to either the leachate, or sump, therefore is likely that another influence is contributing, such as surface water run-off.



In conclusion, the toe drain was likely to have been installed as a temporary measure to prevent the surface breakout of leachate along the flanks of the landfill. This meant that the depth of installation was such that this could be achieved. Subsequent to capping of the site the leachate levels have fallen below the elevation of the toe drain. In places where there are perched leachate or groundwater present in isolated lenses of permeable material the toe drain may drain some leachate or impacted waters; however, the volumes are relatively small and are not able to be reliably managed. The toe drain is constructed above the rest elevation of groundwater within the boulder clay deposits and hence will not be able to capture groundwater that may be impacted from beneath the site.

It is not considered to be viable to re-engineer the existing toe drain given the elevation of the current drains.

6.0 RECOMMENDATIONS

It is recommended that the significance of these findings be considered in conjunction with the site hydrogeological risk assessment and the interpretative surface water and groundwater reports (Reference 13514240032.502).



Report Signature Page

GOLDER ASSOCIATES (UK) LTD

Emma Whitehead
Hydrogeologist

Richard Lansley
Senior Hydrogeologist

Date: 3 March 2014

Author: Emma Whitehead/RL/NW/sp

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APPENDIX A

In Situ Testing Photographs



APPENDIX A

In Situ Testing Photographs – Padeswood Landfill Toe Drain



Photograph 1: TD1 drain chamber with the non-return valve removed and the blanking plate fitted. The pipe at the top comes from the toe drain, and the pipe at the bottom goes to the sump (S1). The temporary pumping pipe is also visible from the surface.



Photograph 2: Non-return valve after removal from TD1 pipework. It was installed in a direction where flow was stopped from the toe drain and allowed from S1 to TD1.



APPENDIX A

In Situ Testing Photographs – Padeswood Landfill Toe Drain



Photograph 3: TD1 pipework showing the fitted blanking plate. This is fitted to stop and potential flows between S1 and TD1.



Photograph 4: Area of inflow into TD1. Several cables enter TD1 through the concrete (see the red circle), and it is this area that leaks water into TD1.



APPENDIX A

In Situ Testing Photographs – Padeswood Landfill Toe Drain



Photograph 5: Area of inflow into TD1. A vertical seam in the concrete ring chamber casing (see the red circle) appears to be poorly sealed and allows water to leak into TD1.

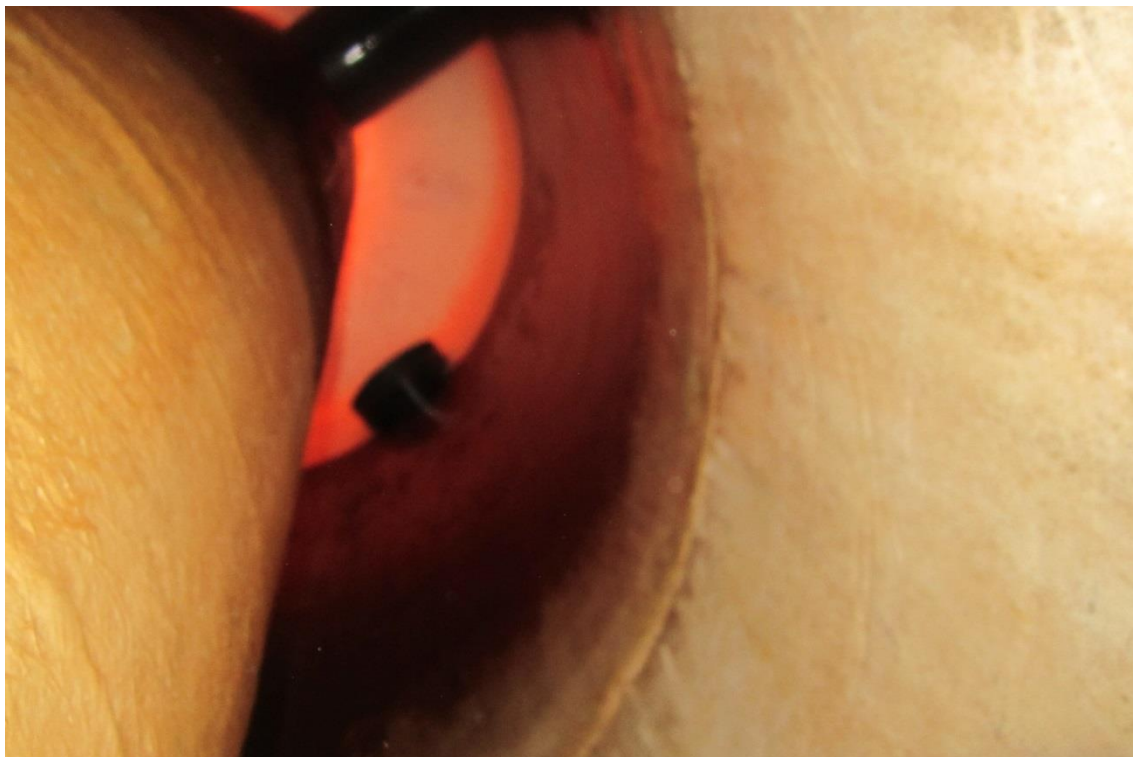


Photograph 6: TD2 following removal of the standing water. The water reached the level indicated on the wall of the chamber by the black coloured residue. The inlet pipe from the toe drain is observed towards the top photograph. No outlet pipe is visible from the ground surface.



APPENDIX A

In Situ Testing Photographs – Padeswood Landfill Toe Drain



Photograph 7: TD2 taken from the base of the chamber and looking up to the ground surface. The cylinder to the left of this photograph is the red tube in Photograph 6 from the outside. The inlet pipe can be seen at the very top of the photograph, and the assumed outlet pipe is noted towards the centre of the photograph.



Photograph 8: Emergency outflow pipe and valve from TD2. TD2 is located towards the bottom left of this photograph.



APPENDIX B

Laboratory Results



HANSON Cement
Padeswood
Mold
Flintshire
CH7 4HB

Attention: Victoria Smith

CERTIFICATE OF ANALYSIS

Date: 25 June 2013
Customer: H_CASCEM_MLD
Sample Delivery Group (SDG): 130620-1
Your Reference:
Location: Toe Drain
Report No: 230455

We received 2 samples on Wednesday June 19, 2013 and 2 of these samples were scheduled for analysis which was completed on Tuesday June 25, 2013. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

All chemical testing (unless subcontracted) is performed at ALcontrol Hawarden Laboratories.

Approved By:

Sonia McWhan

Operations Manager





SDG:	130620-1	Location:	Toe Drain	Order Number:	
Job:	H_CASCEM_MLD-27	Customer:	HANSON Cement	Report Number:	230455
Client Reference:		Attention:	Victoria Smith	Superseded Report:	

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
7618550	TD 1/1		0.00	18/06/2013
7618551	TD 1/2		0.00	19/06/2013

Only received samples which have had analysis scheduled will be shown on the following pages.



SDG:

Job:

Client Reference:

130620-1
H_CASCEM_MLD-27

Location:

Customer:

Attention:

Toe Drain
HANSON Cement
Victoria Smith

Order Number:

Report Number:

Superseded Report:

230455

LIQUID

Results Legend

X

Test

N

No Determination Possible

Lab Sample No(s)	7618550	7618551
Customer Sample Reference	TD 1/1	TD 1/2
AGS Reference		
Depth (m)	0.00	0.00
Container	500ml Plastic (ALE2)	HNO3 Filtered (ALE) H2SO4 (ALE244) 500ml Plastic (ALE2) HNO3 Filtered (ALE) H2SO4 (ALE244) 500ml Plastic (ALE2)

Ammoniacal Nitrogen	All	NDPs: 0 Tests: 2		X		X	
Anions by Kone (w)	All	NDPs: 0 Tests: 2	X		X		
Dissolved Metals by ICP-MS	All	NDPs: 0 Tests: 2			X		X
pH Value	All	NDPs: 0 Tests: 2	X		X		

Order Number:
Report Number: 230455
Superseded Report:

Page 4 of 7



SDG:	130620-1	Location:	Toe Drain	Order Number:	
Job:	H_CASCEM_MLD-27	Customer:	HANSON Cement	Report Number:	230455
Client Reference:		Attention:	Victoria Smith	Superseded Report:	

Table of Results - Appendix

Method No	Reference	Description	Wet/Dry Sample ¹	Surrogate Corrected
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TM184	EPA Methods 325.1 & 325.2,	The Determination of Anions in Aqueous Matrices using the Kone Spectrophotometric Analysers		
TM256	The measurement of Electrical Conductivity and the Laboratory determination of pH Value of Natural, Treated and Wastewaters. HMSO, 1978. ISBN 011 751428 4.	Determination of pH in Water and Leachate using the GLpH pH Meter		

¹ Applies to Solid samples only. DRY indicates samples have been dried at 35°C. NA = not applicable.



SDG:	130620-1	Location:	Toe Drain	Order Number:	
Job:	H_CASCEM_MLD-27	Customer:	HANSON Cement	Report Number:	230455
Client Reference:		Attention:	Victoria Smith	Superseded Report:	

Test Completion Dates

Lab Sample No(s)	7618550	7618551
Customer Sample Ref.	TD 1/1	TD 1/2
AGS Ref.		
Depth	0.00	0.00
Type	LIQUID	LIQUID

Ammoniacal Nitrogen	21-Jun-2013	21-Jun-2013
Anions by Kone (w)	25-Jun-2013	25-Jun-2013
Dissolved Metals by ICP-MS	21-Jun-2013	21-Jun-2013
pH Value	20-Jun-2013	20-Jun-2013



CERTIFICATE OF ANALYSIS

SDG:	130620-1	Location:	Toe Drain	Order Number:	
Job:	H_CASCEM_MLD-27	Customer:	HANSON Cement	Report Number:	230455
Client Reference:		Attention:	Victoria Smith	Superseded Report:	

Appendix
General

1. Results are expressed on a dry weight basis (dried at 35°C) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICS and SVOC TICS.
2. Samples will be run in duplicate upon request, but an additional charge may be incurred.
3. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 2 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALcontrol Laboratories reserve the right to charge for samples received and stored but not analysed.
4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.
5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.
6. When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as "Not detected". If no asbestos fibre types are found all will be reported as "Not detected" and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible. The quantity of asbestos present is not determined unless specifically requested.
7. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.
8. If appropriate preserved bottles are not received preservation will take place on receipt. However, the integrity of the data may be compromised.
9. NDP -No determination possible due to insufficient/unsuitable sample.
10. Metals in water are performed on a filtered sample, and therefore represent dissolved metals -total metals must be requested separately.
11. Results relate only to the items tested.
12. LODs for wet tests reported on a dry weight basis are not corrected for moisture content.
13. **Surrogate recoveries** -Most of our organic methods include surrogates, the recovery of which is monitored and reported. For EPH, MO, PAH, GRO and VOCs on soils the result is not surrogate corrected, but a percentage recovery is quoted. Acceptable limits for most organic methods are 70 -130 %.
14. **Product analyses** -Organic analyses on products can only be semi-quantitative due to the matrix effects and high dilution factors employed.
15. Phenols monohydric by HPLC include phenol, cresols (2-Methylphenol, 3-Methylphenol and 4-Methylphenol) and Xylenols (2,3 Dimethylphenol, 2,4 Dimethylphenol, 2,5 Dimethylphenol, 2,6 Dimethylphenol, 3,4 Dimethylphenol, 3,5 Dimethylphenol).
16. Total of 5 speciated phenols by HPLC includes Phenol, 2,3,5-Trimethyl Phenol, 2-Isopropylphenol, Cresols and Xylenols (as detailed in 15).
17. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.
18. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.
19. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

20. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.
21. For all leachate preparations (NRA, DIN, TCLP, BSEN 12457-1, 2, 3) volatile loss may occur, as we do not employ zero headspace extraction.
22. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill /made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.
23. Analysis and identification of specific compounds using GCFID is by retention time only, and we routinely calibrate and quantify for benzene, toluene, ethylbenzenes and xylenes (BTEX). For total volatiles in the C5-C12 range, the total area of the chromatogram is integrated and expressed as ug/kg or ug/l. Although this analysis is commonly used for the quantification of gasoline range organics (GRO), the system will also detect other compounds such as chlorinated solvents, and this may lead to a falsely high result with respect to hydrocarbons only. It is not possible to specifically identify these non-hydrocarbons, as standards are not routinely run for any other compounds, and for more definitive identification, volatiles by GCMS should be utilised.

Sample Deviations

1	Container with Headspace provided for volatiles analysis
2	Incorrect container received
3	Deviation from method
4	Holding time exceeded before sample received
§	Sampled on date not provided
♦	Sample holding time exceeded in laboratory
@	Sample holding time exceeded due to sampled on date
&	Sample Holding Time exceeded - Late arrival of instructions.

Asbestos

Identification of Asbestos in Bulk Materials & Soils

The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using Alcontrol Laboratories (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

The results for identification of asbestos in soils are obtained from a homogenised sub sample which has been examined to determine the presence of asbestos fibres using Alcontrol Laboratories (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

Asbestos Type	Common Name
Chrysotile	White Asbestos
Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than :
-
Trace -Where only one or two asbestos fibres were identified.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.



HANSON Cement
Padeswood
Mold
Flintshire
CH7 4HB

Attention: Victoria Smith

CERTIFICATE OF ANALYSIS

Date: 28 June 2013
Customer: H_CASCEM_MLD
Sample Delivery Group (SDG): 130621-149
Your Reference:
Location: Toe Drain
Report No: 230968

We received 2 samples on Friday June 21, 2013 and 2 of these samples were scheduled for analysis which was completed on Friday June 28, 2013. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

All chemical testing (unless subcontracted) is performed at ALcontrol Hawarden Laboratories.

Approved By:

Sonia McWhan

Operations Manager





CERTIFICATE OF ANALYSIS

Validated

SDG:	130621-149	Location:	Toe Drain	Order Number:	
Job:	H_CASCEM_MLD-27	Customer:	HANSON Cement	Report Number:	230968
Client Reference:		Attention:	Victoria Smith	Superseded Report:	

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
7635031	TD1/4			21/06/2013
7635030	TD2/3			20/06/2013

Only received samples which have had analysis scheduled will be shown on the following pages.



CERTIFICATE OF ANALYSIS

SDG: 130621-149

Job: H_CASCEM_MLD-27

Client Reference:

Location: Toe Drain

Customer: HANSON Cement

Attention: Victoria Smith

Order Number:

Report Number: 230968

Superseded Report:

LIQUID

Results Legend

X

 Test

N

 No Determination Possible

Lab Sample No(s)		7635030	7635031
Customer Sample Reference		TD/2/3	TD1/4
AGS Reference			
Depth (m)			
Container		HNO3 Filtered (ALE) H2SO4 (ALE244) 500ml Plastic (ALE2) HNO3 Filtered (ALE) H2SO4 (ALE244) 500ml Plastic (ALE2)	
All	NDPs: 0 Tests: 2		X
All	NDPs: 0 Tests: 2	X	
All	NDPs: 0 Tests: 2		X
All	NDPs: 0 Tests: 2	X	

Order Number:
Report Number: 230968
Superseded Report:

Page 4 of 7



SDG:	130621-149	Location:	Toe Drain	Order Number:	
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Test Completion Dates

Lab Sample No(s)	7635031	7635030
Customer Sample Ref.	TD1/4	TD2/3
AGS Ref.		
Depth		
Type	LIQUID	LIQUID

Ammoniacal Nitrogen	26-Jun-2013	26-Jun-2013
Anions by Kone (w)	28-Jun-2013	28-Jun-2013
Dissolved Metals by ICP-MS	27-Jun-2013	27-Jun-2013
pH Value	25-Jun-2013	25-Jun-2013



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Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than :
-
Trace -Where only one or two asbestos fibres were identified.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

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T: [+44] (0) 115 937 1111**





APPENDIX E

Leachate Monitoring Plan



September 2015

HANSON CEMENT WORKS - PADESWOOD LANDFILL SITE

Appendix E - Leachate Monitoring Plan

Submitted to:
Mr Matthew Uttley
Hanson (UK) Ltd
Ashby Road East
Shepshed
Loughborough
LE12 9BU

REPORT



Report Number 1419741.502/A.0

Distribution:

Hanson (UK) Ltd - 1 copy (pdf)
NRW - 1 copy (pdf)
Golder Associates (UK) Ltd - 1 copy





Table of Contents

1.0	LEACHATE MONITORING PLAN.....	1
1.1	Report Context.....	1
1.2	Leachate Generation and Management	1
1.3	Leachate Monitoring	2
1.3.1	Leachate Monitoring Infrastructure.....	2
1.3.2	Leachate Monitoring Programme	2
1.3.2.1	Leachate Level Monitoring.....	2
1.3.2.2	Leachate Quality Monitoring	2
1.4	Leachate Compliance Levels.....	3
1.5	Quality Assurance of Leachate Monitoring and Sampling	3
1.6	Making and Submission of Records	4

TABLES

Table LMP1: Leachate Quality Monitoring Suite	2
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1.0 LEACHATE MONITORING PLAN

1.1 Report Context

This report details the Leachate Monitoring Plan to be implemented at Hanson (UK) Limited's (Hanson) Padeswood Landfill Site (the Site).

1.2 Leachate Generation and Management

Leachate at the Site is formed by percolation of infiltrating water through the capping system and waste mass. The leachate will potentially contain chemical species including non-hazardous and hazardous substances. Description of the leachate source term is provided in the Hydrogeological Risk Assessment (Golder, 2010) in Appendix C of the Closure Report and The Toe Drain Infrastructure Testing Report (Golder, 2014) in Appendix D of the Closure Report.

The Site is unlined although it is understood that leachate is perched on the underlying Drift deposits and could migrate vertically to the underlying Coal Measures aquifer or laterally via discrete gravel lenses within the Drift where present.

Prior to capping of the Site, the level of leachate within the landfill was higher than it currently is. At the time of capping leachate toe drains were installed in order to manage leachate head in the flanks of the waste to below ground level. Historically, leachate was managed at the Site through the dewatering of a concrete sump, which is assumed to be fed by these leachate toe drains; one extending partially along the eastern boundary of the landfill (subsequently named the 'eastern toe drain'); and another drain extending around the northern, western, and south-western boundaries of the landfill (subsequently named the 'northern toe drain').

Leachate toe drain investigations have been conducted at the Site which have considered pumping trials and a consideration of invert levels. The reports from these investigations are provided in Appendix D of the Closure Report. The findings of these reports identified that subsequent to capping of the Site leachate levels have fallen and as a consequence are lower than the toe drain. During pumping trials the toe drain pipework and manholes were pumped out and did not recharge. The pumped water was sampled and analysed and was not found to be representative of leachate and most likely to be rainwater that had collected in the drain. Leachate generation rates are limited by the cap and given that leachate levels are below the toe drain it no longer has a function at the Site.

There was broad agreement between Hanson and Natural Resources Wales (NRW) that the sump is not sufficiently isolated from perched groundwater present in lenses of sand and gravel in the Boulder Clay deposits that underlie the Site. As a consequence of this potential connection of the sump to perched groundwater, the water pumped from the sump was believed to comprise a mixture of leachate and groundwater and use of the sump ceased in 2010. There is therefore no active management of leachate at the Site currently. Although the toe drains are above the leachate level, the discharge to the sump has been blocked off.

In May 2015 the depth to leachate was measured in leachate wells L1 and L3. Leachate well L1 is installed to the base of the landfill, the measured depth to base of the well was 8.24 m with a depth to leachate of 7.94 m hence indicating a perched head of leachate on the base of the landfill of 0.30 m. Leachate well L3 is installed through the base of the landfill in to a lens of sand and gravel 2.25 m beneath the landfill. It is considered that the response zone reflects the composition of leachate perched within this lens. The depth to the base of the well was 13.52 m with a depth to leachate of 9.52 m indicating a head of leachate within the waste of 1.75 m.

A sample of leachate was recovered from L3 which identified a concentration of ammoniacal nitrogen of 47.7 mg/l, chloride of 3,640 mg/l and a pH of 12.9.



1.3 Leachate Monitoring

1.3.1 Leachate Monitoring Infrastructure

There are currently two operational leachate monitoring wells at the Site; L1 and L3. The locations of the leachate monitoring wells are shown on Drawing 1 of the Closure Report.

Toe drains will not be monitored due to the aforementioned reasons in Section 1.2.

1.3.2 Leachate Monitoring Programme

1.3.2.1 Leachate Level Monitoring

Following closure, it is recommended that both L1 and L3 are monitored annually for the presence of leachate.

Where present, depth to leachate measured from ground level and leachate head above the (assumed) base of the borehole will be determined to an accuracy of 0.01 m. The depth to leachate will be measured using an electronic dip tape, which will be lowered down the borehole until the instrument sounds. The graduation on the tape will be read to give the depth at which the instrument starts to sound. If the borehole is identified to be dry this will be reported in the place of a leachate dip result and the depth of the borehole will be recorded.

1.3.2.2 Leachate Quality Monitoring

If leachate is found to be present in either of the leachate monitoring boreholes, and a sample can be recovered, the leachate quality suite of analysis (Table LMP1) will be conducted on the recovered sample. Leachate quality monitoring and analysis will be conducted on an annual basis.

Table LMP1: Leachate Quality Monitoring Suite

Parameter	Units	Annually	Six-Yearly ¹
pH ²	pH Units	✓	
Temperature ³	°C	✓	
Electrical conductivity ²	µS/cm	✓	
Dissolved Oxygen ²	mg/l	✓	
Alkalinity	mg/l	✓	
Ammoniacal Nitrogen	mg/l	✓	
Nitrate (for TON)	mg/l	✓	
Nitrite (for TON)	mg/l	✓	
Calcium	mg/l	✓	
Chloride	mg/l	✓	
Potassium	mg/l	✓	
Sodium	mg/l	✓	
Sulphate	mg/l	✓	
Chromium	µg/l	✓	
Copper	µg/l	✓	
Iron	µg/l	✓	
Lead	µg/l	✓	
Magnesium	mg/l	✓	
Manganese	µg/l	✓	
Nickel	µg/l	✓	



Parameter	Units	Annually	Six-Yearly ¹
Zinc	µg/l	✓	
COD	mg/l	✓	
BOD	mg/l	✓	
TOC	mg/l	✓	
Ionic balance	%	✓	
Hazardous Substances Suite	-		✓

¹ Samples to be taken prior to six-yearly HRA review.

² Measurement to be taken in the field using an appropriate water quality test kit, such as a YSI multiprobe, or to be analysed for at the laboratory.

³ Measurement to be taken only in the field, using an appropriate water quality test kit, such as a YSI multiprobe.

1.4 Leachate Compliance Levels

No leachate compliance levels are required as the leachate head in the landfill is not controlled and, given that the Site is unlined, is not required to be controlled in order to minimise leakage from the Site.

1.5 Quality Assurance of Leachate Monitoring and Sampling

Samples from monitoring well L3 will be collected using an electric or inertial pump. Monitoring well L3 will be purged by at least 3 well volumes prior to sampling, or, if pumped dry they will be allowed to refill and will then be sampled.

Due to the low volumes of leachate observed at monitoring well L1 previously, it is recommended that leachate samples are collected using a disposable bailer without purging.

Appropriate protective equipment will be worn when handling leachate.

Water samples collected for the purpose of analysis for dissolved metals will either be field filtered and placed in a pre-acidified bottle or will be placed in an empty bottle and filtered at the laboratory prior to analysis.

Samples will be received by the laboratory within a timescale that is appropriate to the holding time for the analysis required. The laboratory should routinely report QA data relating to the samples condition and whether samples were received within the analysis holding time.

Samples that are stored overnight will either be stored in a refrigerator or cool box. All samples will be analysed at a laboratory under UKAS accreditation which operates externally verified quality control procedures and checks on analytical work. These include spiked samples, blanks etc. Because of the large batches of samples that are processed by such laboratories, the QA/QC checks implemented are efficient in identifying any quality control failures.

During each monitoring round for leachate, groundwater and surface water, a duplicate water sample will be taken at one location in order to quality assure the repeatability of laboratory analysis.

Staff appropriately trained in environmental monitoring procedures and who are familiar with the equipment and its limitations will undertake sampling. Technical personnel have a relevant scientific background to HND or BSc level (or equivalent). All monitoring staff undergo a period of job training and in addition external courses are used to supplement internal training. The sampling personnel detailed above will validate results.

The range of determinands detailed above includes an ionic balance for all samples taken for the full range of determinands at annual intervals. Leachate samples that attain an ionic balance within +5% will be



deemed satisfactory. Where the ionic balance falls outside this range, the laboratory will be requested to repeat the analysis or to investigate the results provided for errors.

1.6 Making and Submission of Records

Records will be kept of determinands analysed, date of sampling, sampler, results, units and any repeat analysis or laboratory comment, or internal assessment, on the validity of the results.

A copy of the results of sampling and analysis, including laboratory certificates, will be forwarded to the Environment Agency on an annual basis.



Report Signature Page

GOLDER ASSOCIATES (UK) LTD

Sofia Nazaruk
Hydrogeologist

Richard Lansley
Senior Hydrogeologist

Date: 3 September 2015

Author: Sofia Nazaruk/RJL/xx

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APPENDIX F

Landfill Gas Monitoring Plan



September 2015

HANSON CEMENT WORKS - PADESWOOD LANDFILL SITE

Appendix F - Landfill Gas Monitoring Plan

Submitted to:
Mr Matthew Uttley
Hanson (UK) Ltd
Ashby Road East
Shepshed
Loughborough
LE12 9BU

REPORT



Report Number 1419741.503/A.0

Distribution:

Hanson (UK) Ltd - 1 copy (pdf)
NRW - 1 copy (pdf)
Golder Associates (UK) Ltd - 1 copy





Table of Contents

1.0	LANDFILL GAS MONITORING PLAN	1
1.1	Report Context.....	1
1.2	Landfill Gas Generation and Management	1
1.3	Landfill Gas Monitoring	2
1.3.1	Monitoring Network	2
1.3.2	Construction Quality Assurance of New and Replacement Monitoring Points	2
1.3.3	Maintenance of Landfill Gas Monitoring Points	2
1.4	Landfill Gas Monitoring Plan	3
1.4.1	Monitoring Programme and Trigger Levels	3
1.4.2	Action Plan Following Breach of a Trigger Level.....	3
1.5	Quality Assurance of Landfill Gas Monitoring	4
1.5.1	Monitoring Personnel	4
1.5.2	Monitoring Procedures	4
1.6	Making and Submission of Records	4
 TABLES		
	Table LGMP1: Landfill Gas Monitoring Schedule.....	3
	Table LGMP2: Landfill Gas Monitoring Schedule.....	3
	Table LGMP3: Action Plan in the Event of a Breached Trigger Level	3



1.0 LANDFILL GAS MONITORING PLAN

1.1 Report Context

This report details the Landfill Gas Monitoring Plan to be implemented at Hanson (UK) Limited's (Hanson) Padeswood Landfill Site (the Site).

1.2 Landfill Gas Generation and Management

The Site has accepted primarily cement kiln dust waste and inert wastes for disposal, with only negligible quantities of biodegradable wastes; therefore, the waste mass is unlikely to produce significant quantities of landfill gas.

The composition of gases monitored from within boreholes L1 and L3 have been routinely reported. As the NRW have identified, there have been no breaches of Trigger Levels for methane or carbon dioxide. Padeswood Landfill has been present for over 50 years and the waste streams cannot be confirmed to have been exclusively Cement Kiln Dust (CKD), hence, the objective of monitoring is to identify if organic wastes are present and generating landfill gas. The absence of carbon dioxide and methane is likely to be an indication of the predominantly inorganic nature of the waste materials, and the absence of any cellulosic degradable material.

It is noted that low levels of oxygen and an absence of carbon dioxide is observed from the monitoring data. Environment Agency funded research (Environment Agency, 2007. EA Science Report P1-516/2b – Investigation and Quantification of Gas Produced from Landfilling of Inorganic Wastes) reports that oxygen can be removed in inorganic waste disposal sites and the nitrogen (balance gas) concentration can increase above that in ambient air. This was ascribed to two possible causes:

- 1) There is no flow of gas in the emplaced waste and oxygen or its reaction (chemical or microbial) products are converted into either a solid or liquid phase. For example, oxygen removal may or may not result in carbon dioxide generation, but if carbon dioxide is generated, it is also removed from the gas phase.
- 2) There is a net influx of gas into the landfill and as oxygen and carbon dioxide are progressively removed from the gas, the relative concentration of nitrogen increases.

For this Site, it is considered most likely that scenario 1 applies. The observed low oxygen composition of the gas monitored relates to possible oxidation reactions with one of the constituents present within the CKD or other materials co-disposed with it.

It is noted that no differential pressure has been observed during monitoring indicating that migration of ground gas is unlikely.

Given the potential for low oxygen environments to be generated in the landfill, it is recommended that this is considered by Hanson prior to accessing any manholes or chambers adjacent to the landfill and appropriate confined space procedures put in place.

Previous monitoring of in-waste monitoring wells L1 and L3 has not identified any breaches of the Trigger Levels set for methane and carbon dioxide (1.0 and 1.5 % v/v respectively) and thus indicates negligible production and emissions of the bulk landfill gases methane and carbon dioxide. The inorganic nature of the waste and the confirmatory bulk gas monitoring data from the Site indicate that there is negligible risk from organic trace gas components normally associated with landfill gas.

An active gas control system is not appropriate for the Site due to the predominantly inert waste types that were deposited, and therefore gas management is currently achieved by gas monitoring systems within the waste.



1.3 Landfill Gas Monitoring

1.3.1 Monitoring Network

There are currently two in-waste boreholes available for the monitoring of landfill gas at the Site; L1 and L3.

Due to the above ground nature of the landfill and non-biodegradable nature of the waste, no external gas monitoring is proposed until such a time as landfill gas is identified in the in-waste monitoring boreholes.

The locations of the in-waste monitoring boreholes are shown in Drawing 1 of the Closure Report.

1.3.2 Construction Quality Assurance of New and Replacement Monitoring Points

If required, installation of new or replacement landfill gas monitoring boreholes will be undertaken in accordance with the following Construction Quality Assurance (CQA) programme which covers the elements of the design and installation.

Gas monitoring boreholes shall be drilled and recorded in accordance with BS 5930 Code of Practice for Site Investigations. Borehole logs and as-built installation details shall be forwarded to the NRW and shall provide the following information:

- Labelling of the borehole;
- Date of drilling/installation;
- Geological strata descriptions;
- Groundwater or leachate level (and any perched groundwater or leachate levels);
- Design of the borehole if more than one type is being used on the Site;
- Depth of borehole (metres) and level of the bottom of the borehole in metres Above Ordnance Datum (m AOD);
- The surveyed height of the top of the borehole in metres above ordnance datum, and the surveyed ground level at the point if it differs; and
- The National Grid Reference of the boreholes (ten figures).

A CQA validation report will be provided which includes the above details and borehole construction detail drawings. All boreholes will be surveyed to Ordnance Datum. The CQA validation report will be submitted to the NRW within three months of completion.

Following installation, all gas monitoring boreholes will be levelled to Ordnance Datum, and an elevation reference mark permanently placed on the point. Where any monitoring well is extended or repaired the well will be resurveyed within one month and, where necessary, any monitoring results obtained in the intervening period will be corrected according to the revised level.

1.3.3 Maintenance of Landfill Gas Monitoring Points

Landfill gas monitoring boreholes will be maintained in a condition that allows them to fulfil their required purpose. Boreholes will be inspected for damage each time that they are monitored or sampled. Any damage noted will be repaired prior to the next monitoring round. Where a borehole is damaged such that it requires replacement, a replacement borehole will be drilled within one month subject to availability of drilling contractor, weather conditions and access to the location, and in any event, within no later than six months.

Details of inspections of monitoring boreholes, remedial actions undertaken or replacement boreholes installed will be recorded to include relevant dates of inspections and remedial works and details of who carried out the inspection or works.



1.4 Landfill Gas Monitoring Plan

1.4.1 Monitoring Programme and Trigger Levels

In-waste Boreholes L1 and L3 will be monitored for landfill gases in accordance with the schedule in Table LGMP1.

Table LGMP1: Landfill Gas Monitoring Schedule

Parameter	Units	Bi-Annual Monitoring
Relative Pressure	mbar	✓
Barometric Pressure	mbar	✓
Whether pressure is rising or falling	Rising/Falling	✓
Flow (Peak and Stable)	L/s	✓
CH ₄ (Peak and Stable)	% v/v	✓
CO ₂ (Peak and Stable)	% v/v	✓
O ₂ (Peak and Stable)	% v/v	✓
CO	ppm v/v	✓
H ₂ S	ppm v/v	✓

In-waste boreholes will be monitored bi-annually for a minimum of two years in order to identify if any landfill gases are being produced by the waste. The monitoring frequency will then be reassessed with the potential for surrender considered at this point.

Should consistently increasing trends in the concentration of methane or carbon dioxide be observed within the in-waste monitoring boreholes, a consideration of the potential for lateral migration of landfill gas will be made based on the relative pressure and peak flow data collected. If it is concluded that there is the potential for lateral migration of landfill gas based on the monitoring data, a number of the existing monitoring wells on the perimeter of the waste mass will also be monitored in line with Table LGMP1.

1.4.2 Action Plan Following Breach of a Trigger Level

In waste landfill gas monitoring boreholes are not subject to Trigger Level assessments, however if perimeter landfill gas monitoring is required, they will be subject to the following Trigger Levels and Action Plan.

Table LGMP2: Landfill Gas Monitoring Schedule

Parameter	Units	Trigger Level
CH ₄ (Peak and Stable)	% v/v	1
CO ₂ (Peak and Stable)	% v/v	1.5

Following the breach of a trigger level in a perimeter landfill gas monitoring borehole (if subsequently installed) on two consecutive occasions, the following steps shall be taken to determine both the cause of the breached concentrations and the impact it may have upon the identified receptors in the event of a breach of trigger level. The proposed action plan for the Site is summarised in Table LGMP3.

Table LGMP3: Action Plan in the Event of a Breached Trigger Level

Contingency Action

Advise site management, environmental manager of landfill operating company and NRW.

Repeat monitoring of the borehole to confirm the breach. The second monitoring results will be obtained within two weeks. If this also exceeds the trigger level, monitoring will occur monthly for a further three months. The results of the re-monitoring will be forwarded to NRW.



Contingency Action

Existing monitoring information will be reviewed to establish the presence of any trends or patterns inclusive of considering relative pressure and peak flow data. An inspection will be carried out to determine whether there has been any unusual activity or occurrence on the Site that could account for the increase in the parameter exceeding the trigger level. If the data review or site inspections indicate the landfill is the cause of the breach, actions will be implemented to prevent future failure.

The assumptions incorporated into the conceptual site model will be reviewed, along with the existing trigger levels.

If the results from the monthly monitoring show no indications of decline over the three to four month period, the relative pressure and peak flow data indicate the potential for lateral migration of landfill gas, and the evidence indicates that the Site is the most likely cause of the increase in levels, then the proposals for the implementation of additional monitoring measures shall be submitted to NRW.

1.5 Quality Assurance of Landfill Gas Monitoring

1.5.1 Monitoring Personnel

Sampling will be undertaken by staff appropriately trained in environmental monitoring procedures, and who are familiar with the equipment and its limitations. Technical personnel have a relevant scientific background to HND or BSc level (or equivalent). All monitoring staff undergo a period of job training and in addition external courses are used to supplement internal training. Results will be validated by the sampling personnel detailed above.

Calibration and servicing of equipment will be undertaken, and will be maintained, in accordance with manufacturer specifications and QA procedures.

1.5.2 Monitoring Procedures

Monitoring of landfill gases will be carried out using a portable infrared gas analyser (GA2000+ or similar).

Before taking gas measurements, the equipment will be switched on and the methane and carbon dioxide readings allowed to zero whilst drawing clean air away from any potential sources of venting landfill gas. All monitoring will be undertaken by connecting the tubing from the instrument directly to the borehole sampling tap. Once connected, the gas tap will be opened and gas will be drawn through the analyser until a stable reading is obtained. The results will then be logged and the instrument will be purged, allowing the methane and carbon dioxide to zero, before the next borehole is sampled.

Gas measurements will be taken prior to the removal of the gas tap, as may be required as part of any leachate monitoring, as outlined in the Leachate Monitoring Plan (Appendix E of the Closure Report).

1.6 Making and Submission of Records

Records will be kept of parameters and sampling points analysed, date of monitoring, who the monitoring round was carried out by, results, units and any repeat monitoring or internal assessment on the validity of the results.

A copy of the landfill gas monitoring results and basal dip measurements, calculated to metres above Ordnance Datum, will be forwarded to the NRW on an annual basis.



Report Signature Page

GOLDER ASSOCIATES (UK) LTD

Sofia Nazaruk
Hydrogeologist

Richard Lansley
Senior Hydrogeologist

Date: 3 September 2015

Author: Sofia Nazaruk/RJL/cr

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APPENDIX G

Letter Responses to NRW

Golder – NRW Dated 4 March 2014: Interpretation Regarding Landfill Gas and Groundwater Quality

Golder – NRW Dated 5 December 2014: Response to NRW Queries Regarding Interpretation of Landfill Gas and Groundwater Quality.

4 March 2014

Project No. 13514240032.502/A.0

Ms Victoria Smith
Hanson (UK) Limited
Padeswood
Mold
Flintshire
CH7 4HB

PADESWOOD LANDFILL: INTERPRETATION REGARDING LANDFILL GAS AND GROUNDWATER QUALITY

Dear Victoria

We are pleased to submit to you an interpretation of gas and groundwater quality monitoring data from Padeswood Landfill Site landfill to address Natural Resources Wales (NRW) queries.

BACKGROUND

Following receipt of a Compliance Assessment Report (CAR) from the NRW dated 12 August 2013, you have requested that we prepare an interpretation of landfill gas and groundwater quality monitoring data at Padeswood Landfill Site (the Site).

CAR Item e2) Emissions: Landfill Gas

NRW Query: There were no breaches of trigger levels during the monitoring period; however, there are low levels of oxygen. The low oxygen may indicate chemical reactions happening within the waste.

The composition of gases monitored from within boreholes L1 and L3 have been routinely reported. As the NRW have identified, there have been no breaches of Trigger Levels for methane or carbon dioxide. Padeswood Landfill has been present for over 50 years and the waste streams cannot be confirmed to have been exclusively Cement Kiln Dust (CKD), hence, the objective of monitoring is to identify if organic wastes are present and generating landfill gas. The absence of carbon dioxide and methane is likely to be an indication of the predominantly inorganic nature of the waste materials, and the absence of any cellulosic degradable material.

It is noted that low levels of oxygen and an absence of carbon dioxide is observed from the monitoring data. Environment Agency funded research (Environment Agency, 2007. EA Science Report P1-516/2b – Investigation and Quantification of Gas Produced from Landfilling of Inorganic Wastes) reports that oxygen can be removed in inorganic waste disposal sites and the nitrogen (balance gas) concentration can increase above that in ambient air. This was ascribed to two possible causes:

- 1) There is no flow of gas in the emplaced waste and oxygen or its reaction (chemical or microbial) products are converted into either a solid or liquid phase. For example, oxygen removal may or may not result in carbon dioxide generation, but if carbon dioxide is generated, it is also removed from the gas phase.
- 2) There is a net influx of gas into the landfill and as oxygen and carbon dioxide are progressively removed from the gas, the relative concentration of nitrogen increases.

For this Site, it is considered most likely that scenario 1 applies. The observed low oxygen composition of the gas monitored relates to possible oxidation reactions with one of the constituents present within the CKD or other materials co-disposed with it.

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It is noted that no differential pressure has been observed during monitoring indicating that migration of ground gas is unlikely.

Given the potential for low oxygen environments to be generated in the landfill, it is recommended that this is considered by Hanson prior to accessing any manholes or chambers adjacent to the landfill and appropriate confined space procedures put in place.

A collation of landfill gas monitoring results is attached in Appendix A.

CAR Item e2) Emissions: Groundwater

NRW Query: Please clarify which boreholes are considered to be downgradient and therefore subject to the interim control levels proposed in Golder Associates letter of 3 June 2011. It would appear that the new drift boreholes GA1 and GA4 are being impacted by leachate.

From the most recent Hydrogeological Risk Assessment for the Site the following is reproduced:

Underlying the landfill are *in situ* superficial Drift deposits, these Drift deposits, comprise lenses of alluvial sand and gravel and Glacial Till, which comprises sandy gravelly clay. The clay has a maximum thickness of 9 m in the north of the Site.

Some lenses of alluvial sand deposits contain perched groundwater and some are dry suggesting that they are discontinuous.

The Drift deposits overly the Coal Measures which comprise interbedded sandstones and mudstones. The water table in the Coal Measures is below the interface with the Glacial Till.

Potential pathways include;

- Vertical migration of leachate through the Drift deposits and unsaturated Coal Measures to groundwater present in the Coal Measures; and
- Lateral migration of leachate through the Drift deposits or surface breakout towards the unnamed tributary to Black Brook. Whilst there is evidence to suggest that the lenses of alluvial sand and gravel are discontinuous and the hydraulic gradient of the water table is relatively flat, there remains the possibility that leachate could impact a lens of gravel adjacent to the Site which could outcrop in the bed or bank of the adjacent unnamed tributary to Black Brook.

The Drift deposits are not designated as a groundwater resource; the underlying Coal Measures are designated by the Environment Agency as a Secondary A Aquifer. Historically, monitoring at the Site has been focussed on the Drift deposits due to the potential connection with the adjacent watercourse as outlined in the reproduced text above. The objective of setting Trigger Levels in the Drift monitoring boreholes was to consider potential impacts on the adjacent watercourse.

Groundwater hydrographs from the monitoring boreholes BH1A, BH2A, BH03/02, BH4, BH5, GA1, GA2, GA3 and GA4 covering a period of 2 years are presented in Figure 1 below. From the data presented it is identified that there are no discernable trends in the data with the exception of BH5 and GA4. The variation in groundwater elevation in BH5 appears to be seasonal with insufficient water present to enable sampling during the drier part of the season. The elevation of groundwater in GA4 peaked during the winter of 2011/2012 but declined during 2012 and has been consistent with the elevation of groundwater in GA3 since. It is unclear what the cause for elevated groundwater heads at this time was.

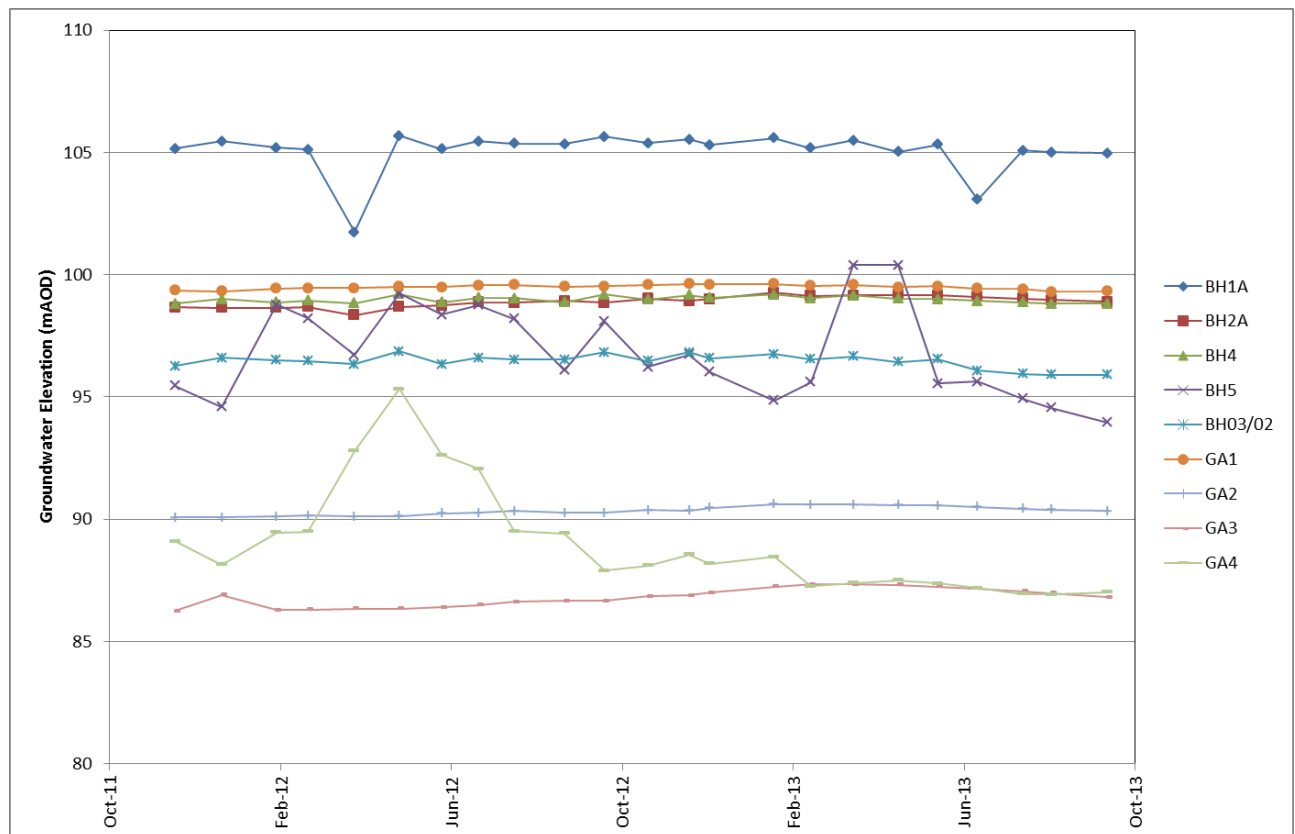


Figure 1: Drift Groundwater Elevation Hydrograph

There is approximately a 20 m range in the elevation of groundwater observed within the Drift deposits. This observation is consistent with the interpretation of the conceptual model reproduced above whereby rather than there being a steep consistent hydraulic gradient across the Site, the groundwater present in the Drift is perched in isolated lenses of more permeable deposits separated by less permeable clay deposits. The presence of perched water in the Drift is dependent on the presence of a lens of more permeable material and the presence of infiltration whether from precipitation, leakage of leachate or proximity to the adjacent watercourse. The composition of the water present within these lenses will be indicative of the infiltration source or the unsaturated pathway that the infiltration has followed.

Groundwater elevation contour maps for April and September 2013 are presented on Drawings 502/1 and 502/2. Whilst there is not a consistent gradient of groundwater within the Drift and that the groundwater present is perched in isolated lenses, the map presentation is useful to identify those areas where the groundwater is above the elevation of the adjacent watercourse, similar to the elevation of the adjacent watercourse and below the watercourse.

From the data presented on Drawings 502/1 and 502/2 it is inferred that the elevation of groundwater in the Drift has the following patterns:

- The elevation of groundwater at GA1 is broadly co-incident with an interpolation of the elevation of the bed of the adjacent watercourse. From Figure 1 the elevation of groundwater in GA1 is observed to be relatively constant at between 99.31 and 99.63 mAOD, this elevation is also broadly co-incident with the elevation of the base of the overlying Madeground. It is proposed that infiltration either through the landfill or through the Made Ground between the Site and GA1 is collecting on the surface of the underlying boulder clay. It is also proposed that borehole GA1 is acting as a sump for this perched water;
- Boreholes BH4, BH5 (seasonally) and BH03/02 have elevations of groundwater above or co-incident with the bed of the adjacent watercourse indicating that there is the potential for perched groundwater at these locations to discharge to the watercourse; and

- The observed elevation of groundwater in boreholes GA2, GA3 and GA4 are lower than the elevation of the adjacent watercourse. All were installed directly above the interface between the Drift and the underlying Coal Measures as no water strike was observed during drilling. GA2 and GA3 were installed in a band of sand that sits directly on the Coal Measures and GA4 is installed in sand and boulder clay directly above the Coal Measures.

In these cases where the elevation of groundwater is below the elevation of the adjacent watercourse the pathway for migration of groundwater would ultimately be downwards to the underlying Coal Measures as outlined in the extract from the HRA above. The objective of setting Trigger Levels in the Drift monitoring boreholes was to monitor perched water that could impact the adjacent watercourse. Therefore Trigger Levels should only be compared to groundwater quality monitoring data obtained for Drift boreholes that monitor groundwater that is above the elevation of the bed of the watercourse. Hence the Trigger Levels identified to be protective of the watercourse should not apply to GA2, GA3 and GA4.

Time-series graphs of groundwater quality are presented in Figure 2 below for two years from October 2011 to September 2013. As NRW have agreed that BH4 is located in waste and that its inclusion in the monitoring scheme was to provide a data overlap with the new boreholes it is proposed that this borehole is removed from the monitoring scheme and will not be considered further in this interpretation.

In the data presented with regard to the compliance substances and associated interim Trigger Levels considered, the following exceedances are identified;

- pH: Typically the reported pH for samples from boreholes are within the 6 to 8.6 range. There is an isolated exceedance that was identified at all locations (including remote upgradient locations) and hence this is considered to be an anomaly in the data set. The pH observed at BH5 is routinely reported above the interim Trigger Level of 8.6 with values as high as 11.83 identified. It is noted that an interpretation of the borehole logs for BH4 near to BH5 has identified the potential for CKD to be present outside of the capped area of the landfill. It is therefore possible that the perched water present in BH5 is influenced by infiltration through the uncapped CKD in this area. Elevated pH values in BH5 may also relate to the presence of crushed limestone or discarded cement;
- Ammoniacal nitrogen: Ammoniacal nitrogen has been identified in the leachate source term. Elevated concentrations of ammoniacal nitrogen have been identified in GA4 and BH5 in the past; however, a long-term declining trend in the concentration of ammoniacal nitrogen is identified at these locations. The concentration of ammoniacal nitrogen is elevated up to a maximum of 38.9 mg/l in samples from GA1, as identified above it is considered likely that GA1 is acting as a sump to collect infiltration collecting on the top of the Drift, Boulder Clay deposits and that this infiltration may have passed through source areas comprising the adjacent landfill or Madeground between the landfill and GA1; and
- Concentrations of sulphate and chloride have routinely been elevated above the respective interim Trigger Levels in GA1 and GA4. The presence of a number of compliance substances at elevated concentrations indicates that GA1 and GA4 are influenced by leachate or by infiltration that has passed through unsaturated waste either inside or outside of the capped area and collected within the perched lenses of water monitored by these installations.

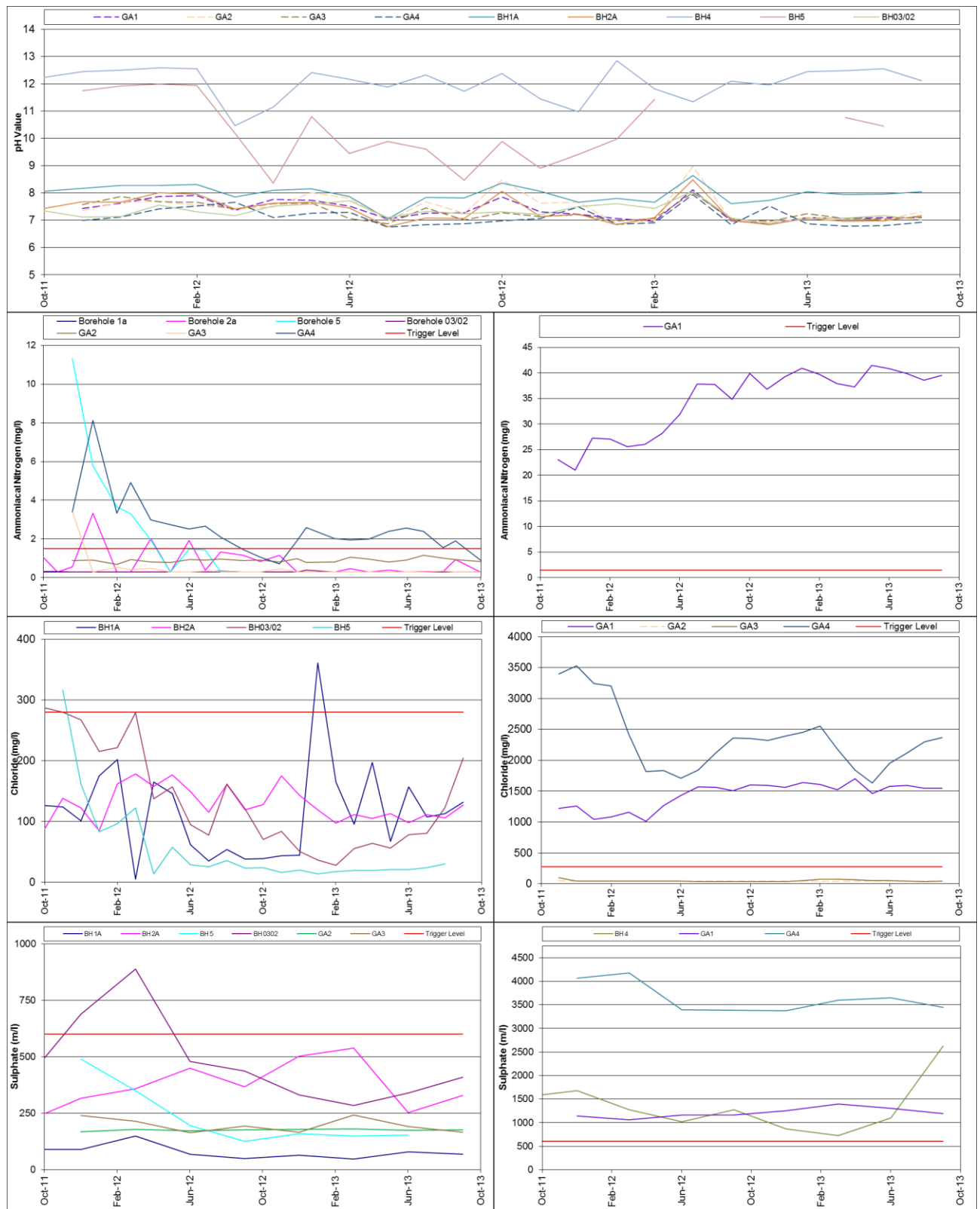


Figure 2: Time-Series Graphs of Compliance Substances

Based on the interpretation of water levels with respect to the conceptual model it is identified that the presence of perched water on the interface between the Drift and the Coal Measures is expected and that the presence of substances also present in the leachate is also expected. Water levels in GA2, GA3 and GA4 conform to this Conceptual Site Model and as they are below the elevation of the bed of the adjacent

watercourse the presence of elevated concentrations of substances identified at these locations is not a risk to the quality of the watercourse.

Based on the interpretation of the water elevations observed in GA1 and BH5, it is interpreted that the water present is perched at an elevation that may discharge to the watercourse if a continuous permeable connecting pathway exists between the two. The landfill has been capped and as such the rate of infiltration to the waste and subsequently through the base of the waste has been limited. The water present in the perched lenses monitored by GA1 and BH5 is not subject to lateral inflow of upgradient groundwater to dilute the infiltration of impacted waters and hence the composition of the water present reflects the source concentration from which it derives. There is the possibility that the source of contamination is not the capped waste and is infiltration of rainfall or cap runoff through uncapped waste or contaminated Made Ground however this cannot be confirmed.

The watercourse adjacent to the Site comprises an un-named land drain serving the surrounding land. The objective of monitoring this watercourse is to identify whether the Site is having a discernable impact on the quality of the watercourse before it discharges in to Black Brook, which is a tributary to the River Alyn.

The following amendments to the monitoring scheme are proposed following these interpretations:

- It is proposed that as the depth to groundwater in GA2, GA3 and GA4 confirms that the elevation of water is below the bed of the adjacent watercourse at these locations, sampling and analysis of samples is not required;
- In the light of breaches of the interim Trigger Levels at BH5 and GA1; it is proposed that the adjacent water course is monitored adjacent to the locations (as shown on Drawing 502/3);
- It is noted that NRW's objective is for there to be no discernible impact from the Site prior to discharge to the River Alyn. The ultimate objective of this monitoring programme is to monitor for an impact down gradient to the Hanson landholding which is upstream from the confluence to Black Brook which in turn is upstream to the River Alyn (as shown on Drawing 502/3); and
- As the watercourse is a land drainage feature it should only be sampled if it is flowing; an on-Site test by the monitoring technician should be conducted to confirm the absence of flow and hence the decision of not sampling.

CONCLUSIONS AND RECOMMENDATIONS

The following is a summary of the findings of this interpretative letter report:

Landfill Gas Monitoring Data

- Monitoring data for landfill gas reports the absence of carbon dioxide and methane which indicate the predominantly inorganic nature of the waste materials, and the absence of any cellulosic degradable material;
- Low levels of oxygen and an absence of carbon dioxide are observed from the monitoring data. Environment Agency funded research presents that oxygen can be removed from inorganic waste disposal sites and the nitrogen (balance gas) concentration can increase above that in ambient air; and
- The observed low oxygen composition of the gas monitored relates to possible oxidation reactions with one of the constituents present within the CKD or other materials co-disposed with it.

Groundwater Monitoring Data

- The Hydrogeological Conceptual Model for the Site identifies two pathways exist as outlined previously:
 - Seepage of infiltration from the waste through the Drift deposits into the Coal Measures below; and
 - Seepage of infiltration from the waste into isolated permeable lenses within the Drift deposits with the potential for lateral migration.

- Groundwater within the Drift is either perched in discrete isolated lenses of permeable deposits or perched on the interface with the underlying Coal Measures;
- The interpretation of the elevation of groundwater in the monitoring installation identifies areas of the Site where both pathways exist. In boreholes GA2, GA3 and GA4, the perched water monitored in these installations is below the adjacent surface water features and that the active pathway for migration is downward in to the Coal Measures. In boreholes GA1 and BH5 the perched water monitored is at or above the elevation of the adjacent watercourse and there is the potential for the water to migrate towards these;
- Monitoring data for compliance substances identify that the concentration of one or more of the compliance substances are elevated above the interim Trigger Levels at boreholes GA1, GA4 and BH5;
- The objective of the monitoring of the Drift was to consider the potential upgradient impact of contaminants in the Drift prior to potential discharge to the adjacent watercourse. As the elevation of water in GA2, GA3 and GA4 is below the elevation of the bed of the watercourse these do not need to be monitored further;
- In the light of breaches of the interim Trigger Levels at BH5 and GA1; it is proposed that the adjacent water course is monitored adjacent to the locations (as shown on Drawing 502/3);
- It is noted that NRW's objective is for there to be no discernible impact from the Site prior to discharge to the River Alyn. The ultimate objective of this monitoring programme is to monitor for an impact downgradient to the Hanson landholding which is upstream from the confluence to Black Brook which in turn is upstream to the River Alyn (as shown on Drawing 502/3); and
- As the watercourse is a land drainage feature it should only be sampled if it is flowing; an on-Site test by the monitoring technician should be conducted to confirm the absence of flow and hence the decision of not sampling.

We trust that the information presented in this letter report in line with your current needs. If you have any queries please do not hesitate to contact us. We look forward to hearing from you.

Yours sincerely

GOLDER ASSOCIATES (UK) LTD



Richard Lansley
Senior Hydrogeologist



Gareth Digges La Touche
Associate

RJL/GDLT/ab

Attachments: Drawings: 502/1 Drift Groundwater Elevation April 2013
502/2 Drift Groundwater Elevation September 2013
502/3 Proposed Surface Water Monitoring Locations

Appendix A: Landfill Gas Monitoring Results

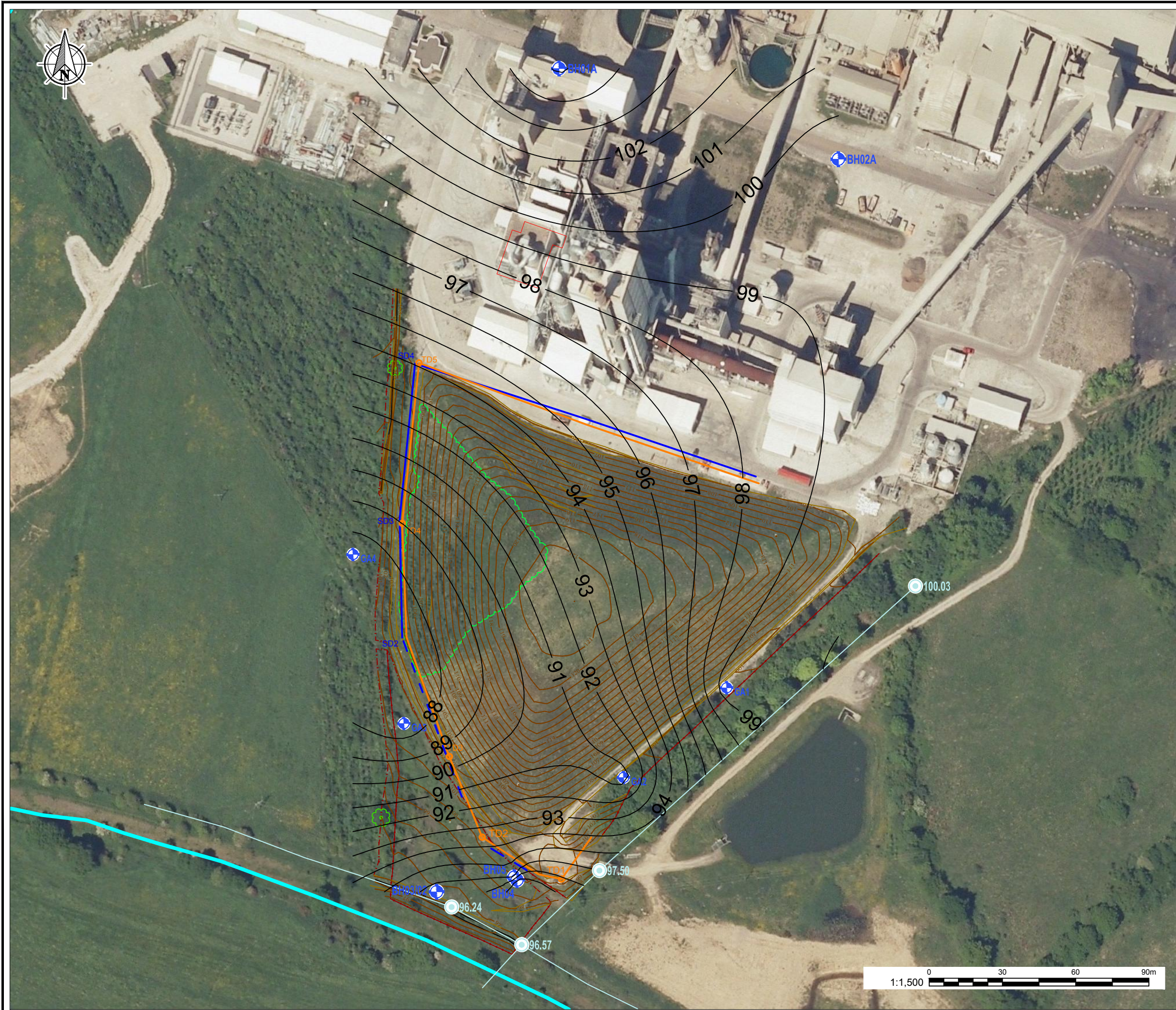


DRAWINGS

502/1 Drift Groundwater Elevation April 2013

502/2 Drift Groundwater Elevation September 2013

502/3 Proposed Surface Water Monitoring Locations



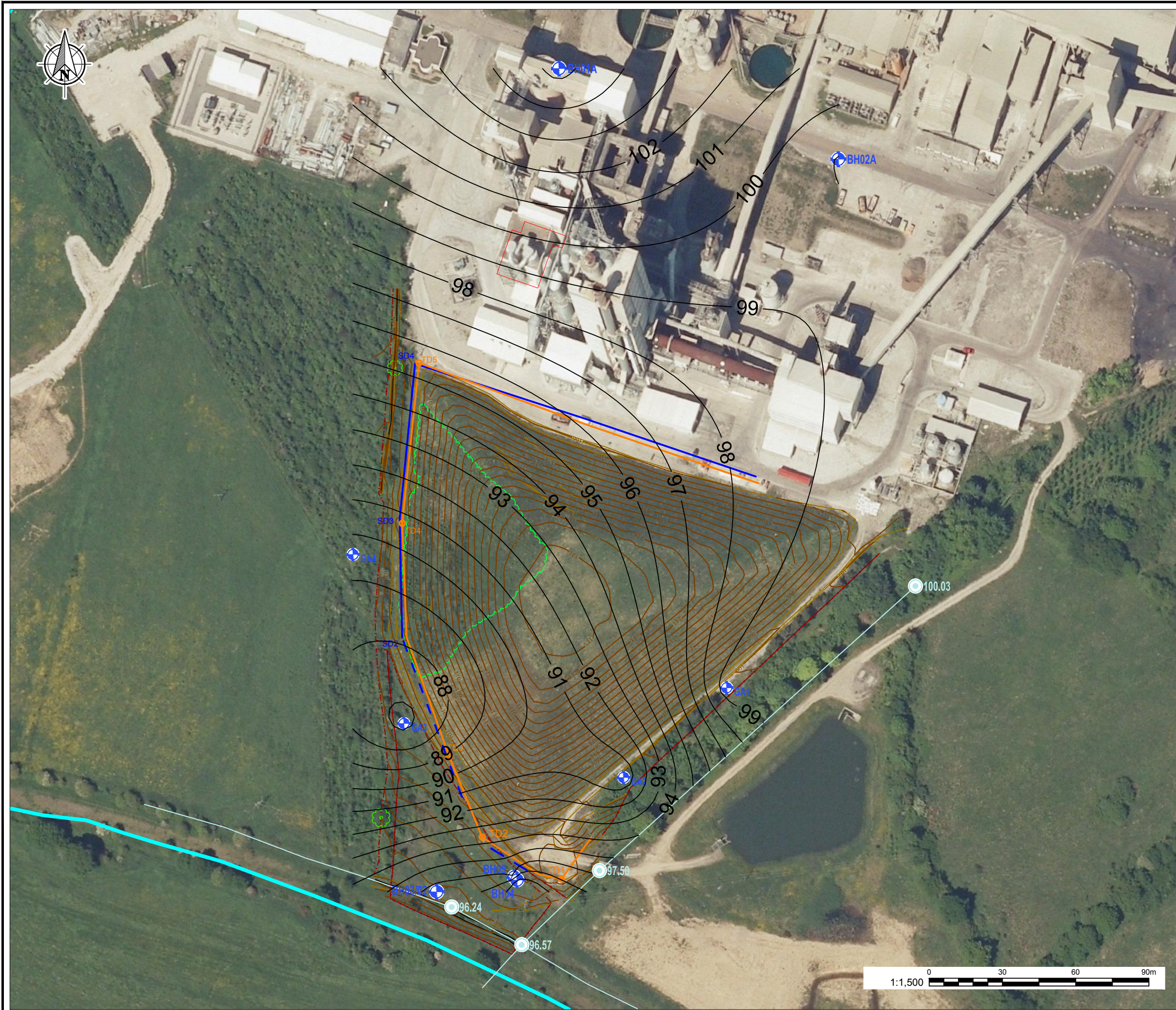
Legend

- Groundwater elevations (m AOD)
- Site ownership boundary
- Drift groundwater monitoring location
- Stream bed elevation survey locations
- Surface water drain
- Leachate toe drain
- Stream

Notes

- Surrounding survey information produced from Ordnance Survey digital data, survey scale 1:10,000, (c) Crown Copyright 2002. Licence No.AL813842.
- Aerial photograph bought from emapsite.com with covering license.

Client					Hanson (UK) Limited				
Project					Padeswood Landfill Response to NRW CAR				
Title					Drift Groundwater Elevation April 2013				
Created by	AD	Requested by	RL	Proj Manager	NW	Reviewer	GDLT	Date	03/01/14
File No.					Project No.				
5235201					13514240032.502				
Size	A3	Scale	1:1,500	Status	Report Issue				
Drawing No.					502/1				Rev
									-



Legend

- Groundwater elevations (m AOD)
- Site ownership boundary
- Drift groundwater monitoring location
- Stream bed elevation survey locations
- Surface water drain
- Leachate toe drain
- Stream

Notes

1. Surrounding survey information produced from Ordnance Survey digital data, survey scale 1:10,000, (c) Crown Copyright 2002. Licence No.AL813842.

2. Aerial photograph bought from emapsite.com with covering license.

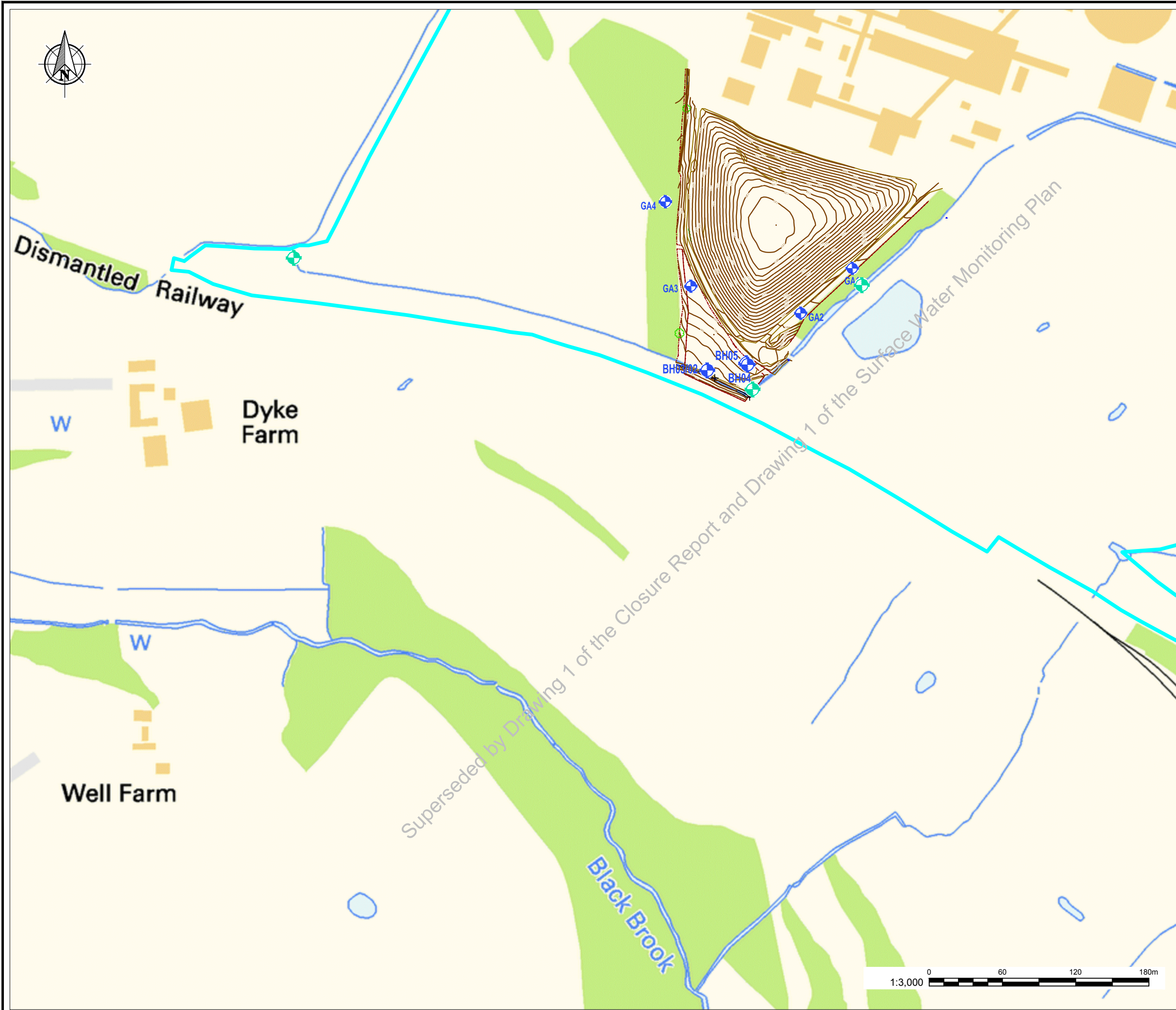
Client				
Hanson (UK) Limited				
Project				
Padeswood Landfill Response to NRW CAR				
Title				
Drift Groundwater Elevation September 2013				
Created by	Requested by	Proj Manager	Reviewer	Date
AD	RL	NW	GDLT	03/01/14
File No.		Project No.		
5235202		13514240032.502		
Size	Scale	Status		
A3	1:1,500	Report Issue		
Drawing No.				Rev
502/2				-



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Legend

- Groundwater elevations (m AOD)
- Site ownership boundary
- Drift groundwater monitoring location
- Proposed Surface water monitoring location

Notes

1. Surrounding survey information produced from Ordnance Survey digital data, survey scale 1:10,000, (c) Crown Copyright 2002. Licence No.AL813842.

Client					Hanson (UK) Limited
Project					Padeswood Landfill Response to NRW CAR
Title					Proposed Surface Water Monitoring Locations
Created by	Requested by	Proj Manager	Reviewer	Date	
AD	RL	NW	GDLT	03/03/14	
File No.		Project No.			
5235316		13514240032.502			
Size	Scale	Status			
A3	1:3,000	Report Issue			
Drawing No.					Rev
502/3					-



APPENDIX A

Landfill Gas Monitoring Results



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 31/01/11 (10:55) **BOREHOLE IDENTITY:** L3

MONITORED BY: SG **AMBIENT TEMP(°C):** 1.2

FLOW (l/h): Max -0.2 Min -0.4 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (m): 9.62 **UPSTAND (cm):** N/A

TIP DEPTH (m): 13.5 **US/IP DIFFERENCE (cm):** N/A

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
0	<0.1	<0.1	20.2	<1	<1	1008
1	<0.1	<0.1	19.1	<1	<1	1008
2	<0.1	<0.1	18.7	<1	<1	1008
3	<0.1	<0.1	18.7	<1	<1	1008
4	<0.1	<0.1	18.6	<1	<1	1008
5	<0.1	<0.1	18.2	<1	<1	1008

Weather: - Overcast, dry underfoot, light wind

Odour : - None

Comments:- Gas tap fitted to borehole and left for 30mins before recording the gas readings above.

For this reason the readings above may not be representative of the gasses being emitted from this well.

The gas tap was left in situ for the next round of monitoring.

Depth measurements were recorded from the top of the internal pipe and not from ground level.



ALcontrol Geochem

PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 23/02/11 (16:15) **BOREHOLE IDENTITY:** L3

MONITORED BY: SG **AMBIENT TEMP(°C):** 9

FLOW (l/h): Max +0.4 Min +0.1 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 8.87 **UPSTAND (cm):** 93

TIP DEPTH (m): 12.77 **US/IP DIFFERENCE (cm):** 20

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.6	<1	<1	1003
1	<0.1	<0.1	13.4	<1	1	1003
2	<0.1	<0.1	13.3	<1	1	1003
3	<0.1	<0.1	13.3	<1	2	1003
4	<0.1	<0.1	13.4	<1	1	1003
5	<0.1	<0.1	13.7	<1	2	1003

Weather: - Overcast, dry underfoot, light wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 31/03/11 (15:30) **BOREHOLE IDENTITY:** L3

MONITORED BY: SG **AMBIENT TEMP(°C):** 12.2

FLOW (l/h): Max -0.2 Min -0.5 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 8.69 **UPSTAND (cm):** 93

TIP DEPTH (m): 12.77 **US/IP DIFFERENCE (cm):** 20

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.2	<1	<1	992
1	<0.1	<0.1	13.0	<1	<1	992
2	0.1	<0.1	12.7	<1	<1	992
3	0.2	<0.1	12.5	<1	<1	992
4	0.2	<0.1	12.4	<1	<1	992
5	<0.1	<0.1	12.5	<1	<1	992

Weather: - Overcast, dry underfoot, strong wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 26/04/11 (11:40) **BOREHOLE IDENTITY:** L3

MONITORED BY: SG **AMBIENT TEMP(°C):** 13.4

FLOW (l/h): Max +0.2 Min +0.0 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 8.74 **UPSTAND (cm):** 93

TIP DEPTH (m): 12.77 **US/IP DIFFERENCE (cm):** 20

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.2	<1	<1	1016
1	<0.1	<0.1	15.8	<1	<1	1016
2	<0.1	<0.1	15.6	<1	<1	1016
3	<0.1	<0.1	15.6	<1	<1	1016
4	<0.1	<0.1	15.8	<1	<1	1016
5	<0.1	<0.1	16.2	<1	<1	1016

Weather: - Overcast, light rain, dry underfoot, light wind

Odour : - None

Comments:- Single valve gas tap present.



ALcontrol Laboratories

PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 26/05/11 (15:15) **BOREHOLE IDENTITY:** L3

MONITORED BY: SG **AMBIENT TEMP(°C):** 14.4

FLOW (l/h): Max +0.6 Min +0.3 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 8.81 **UPSTAND (cm):** 93

TIP DEPTH (m): 12.77 **US/IP DIFFERENCE (cm):** 20

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.1	<1	<1	993
1	<0.1	<0.1	17.6	<1	<1	993
2	<0.1	<0.1	17.4	<1	<1	993
3	<0.1	<0.1	17.4	<1	<1	993
4	<0.1	<0.1	17.5	<1	<1	993
5	<0.1	<0.1	17.4	<1	<1	993

Weather: - Overcast, light rain, wet underfoot, strong wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 01/08/11 (14:15) BOREHOLE IDENTITY: L1

MONITORED BY: SG AMBIENT TEMP (°C):17.8

FLOW (l/h): Max +0.2 Min -0.0 DIFFERENTIAL PRESSURE (mb): 0.0

DEPTH TO WATER (mbgl): 7.67 UPSTAND (cm): 65

TIP DEPTH (mbgl): 7.94 US/IP DIFFERENCE (cm): 33

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	19.8	<1	<1	1000
1	<0.1	<0.1	10.6	<1	1	1000
2	<0.1	<0.1	10.5	<1	2	1000
3	<0.1	<0.1	10.3	<1	2	1000
4	<0.1	<0.1	10.2	<1	2	1000
5	<0.1	<0.1	10.1	<1	3	1000

Weather: - Overcast, light rain, wet underfoot, light wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 30/08/11 (13:48) **BOREHOLE IDENTITY:** L1

MONITORED BY: SG **AMBIENT TEMP (°C):**15.8

FLOW (l/h): Max +0.1 Min -0.1 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 7.89 **UPSTAND (cm):** 65

TIP DEPTH (mbgl): 7.94 **US/IP DIFFERENCE (cm):** 33

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.1	<1	<1	1005
1	<0.1	<0.1	3.2	<1	<1	1005
2	<0.1	<0.1	1.6	<1	1	1005
3	<0.1	<0.1	1.6	<1	<1	1005
4	<0.1	<0.1	1.5	<1	<1	1005
5	<0.1	<0.1	1.5	<1	<1	1005

Weather: - Overcast, light rain, wet underfoot, light wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 28/09/11 (15:30) **BOREHOLE IDENTITY:** L1

MONITORED BY: SG **AMBIENT TEMP (°C):** 23.8

FLOW (l/h): Max +0.1 Min +0.0 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 7.68 **UPSTAND (cm):** 65

TIP DEPTH (mbgl): 7.94 **US/IP DIFFERENCE (cm):** 33

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.5	<1	<1	1011
1	<0.1	<0.1	3.6	<1	<1	1011
2	<0.1	<0.1	3.2	<1	<1	1011
3	<0.1	<0.1	3.1	<1	<1	1011
4	<0.1	<0.1	3.0	<1	<1	1011
5	<0.1	<0.1	2.8	<1	<1	1011

Weather: - Clear, dry underfoot, light wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 24/10/11 (11:25) **BOREHOLE IDENTITY:** L1

MONITORED BY: SG **AMBIENT TEMP (°C):** 14.4

FLOW (l/h): Max +0.3 Min +0.1 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 7.67 **UPSTAND (cm):** 65

TIP DEPTH (mbgl): 7.94 **US/IP DIFFERENCE (cm):** 33

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.7	<1	<1	979
1	<0.1	<0.1	2.0	<1	<1	979
2	<0.1	<0.1	1.7	<1	<1	979
3	<0.1	<0.1	1.4	<1	<1	979
4	<0.1	<0.1	1.3	<1	<1	979
5	<0.1	<0.1	1.3	<1	<1	979

Weather: - Overcast, dry underfoot, light wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 18/11/11 (13:10) **BOREHOLE IDENTITY:** L1

MONITORED BY: SG **AMBIENT TEMP (°C):** 12.4

FLOW (l/h): Max +0.2 Min +0.0 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 7.69 **UPSTAND (cm):** 65

TIP DEPTH (mbgl): 7.94 **US/IP DIFFERENCE (cm):** 33

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.5	<1	<1	999
1	<0.1	<0.1	2.1	<1	<1	999
2	<0.1	<0.1	2.0	<1	<1	999
3	<0.1	<0.1	1.9	<1	<1	999
4	<0.1	<0.1	1.8	<1	<1	999
5	<0.1	<0.1	1.8	<1	<1	999

Weather: - Overcast, dry underfoot, light wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 22/12/11 (09:30) **BOREHOLE IDENTITY:** L1

MONITORED BY: SG **AMBIENT TEMP (°C):** 10.3

FLOW (l/h): Max +0.2 Min -0.1 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 7.68 **UPSTAND (cm):** 65

TIP DEPTH (mbgl): 7.94 **US/IP DIFFERENCE (cm):** 33

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.6	<1	<1	1010
1	<0.1	<0.1	3.1	<1	<1	1010
2	<0.1	<0.1	2.8	<1	<1	1010
3	<0.1	<0.1	2.8	<1	<1	1010
4	<0.1	<0.1	2.7	<1	<1	1010
5	<0.1	<0.1	2.7	<1	<1	1010

Weather: - Clear, wet underfoot, light wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 31/01/12 (11:00) **BOREHOLE IDENTITY:** L1

MONITORED BY: SG **AMBIENT TEMP (°C):** 2.2

FLOW (l/h): Max +0.1 Min -0.1 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 7.48 **UPSTAND (cm):** 65

TIP DEPTH (mbgl): 7.94 **US/IP DIFFERENCE (cm):** 33

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.4	<1	<1	1013
1	<0.1	<0.1	1.5	<1	<1	1013
2	<0.1	<0.1	0.7	<1	<1	1013
3	<0.1	<0.1	0.7	<1	<1	1013
4	<0.1	<0.1	0.6	<1	<1	1013
5	<0.1	<0.1	0.6	<1	<1	1013

Weather: - Overcast, frozen underfoot, no wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 28/03/12 (15:30) **BOREHOLE IDENTITY:** L1

MONITORED BY: SG **AMBIENT TEMP (°C):** 22.1

FLOW (l/h): Max +0.2 Min +0.1 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 7.64 **UPSTAND (cm):** 65

TIP DEPTH (mbgl): 7.94 **US/IP DIFFERENCE (cm):** 33

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.4	<1	<1	1019
1	<0.1	<0.1	2.5	<1	<1	1019
2	<0.1	<0.1	2.4	<1	<1	1019
3	<0.1	<0.1	2.3	<1	<1	1019
4	<0.1	<0.1	2.2	<1	<1	1019
5	<0.1	<0.1	2.1	<1	<1	1019

Weather: - Clear, dry underfoot, no wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 30/04/12 (14:50) **BOREHOLE IDENTITY:** L1

MONITORED BY: SG **AMBIENT TEMP (°C):** 15.9

FLOW (l/h): Max +0.1 Min -0.1 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 7.40 **UPSTAND (cm):** 65

TIP DEPTH (mbgl): 7.94 **US/IP DIFFERENCE (cm):** 33

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.2	<1	<1	1000
1	<0.1	<0.1	2.5	<1	<1	1000
2	<0.1	<0.1	2.1	<1	<1	1000
3	<0.1	<0.1	2.3	<1	<1	1000
4	<0.1	<0.1	2.1	<1	<1	1000
5	<0.1	<0.1	2.1	<1	<1	1000

Weather: - Clear spells, wet underfoot, light wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 31/05/12 (11:20) **BOREHOLE IDENTITY:** L1

MONITORED BY: SG **AMBIENT TEMP (°C):** 18.0

FLOW (l/h): Max +0.1 Min -0.1 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 7.64 **UPSTAND (cm):** 65

TIP DEPTH (mbgl): 7.94 **US/IP DIFFERENCE (cm):** 33

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.7	<1	<1	10007
1	<0.1	<0.1	5.7	<1	<1	1007
2	<0.1	<0.1	5.6	<1	<1	1007
3	0.1	<0.1	5.3	<1	2	1007
4	0.3	<0.1	5.1	<1	2	1007
5	0.3	<0.1	4.8	<1	<1	1007

Weather: - Overcast, rain, wet underfoot, light wind

Odour : - None

Comments:- Single valve gas tap present.



ALcontrol Geochem

PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 27/06/12 (15:10) **BOREHOLE IDENTITY:** L1

MONITORED BY: SG **AMBIENT TEMP (°C):** 20.2

FLOW (l/h): Max +0.1 Min -0.1 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 7.48 **UPSTAND (cm):** 65

TIP DEPTH (mbgl): 7.94 **US/IP DIFFERENCE (cm):** 33

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.5	<1	<1	1003
1	<0.1	<0.1	2.7	<1	<1	1003
2	<0.1	<0.1	2.5	<1	<1	1003
3	0.1	<0.1	2.4	<1	<1	1003
4	<0.1	<0.1	2.1	<1	<1	1003
5	<0.1	<0.1	2.0	<1	<1	1003

Weather: - Clear spells, dry underfoot, light wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 23/07/12 (14:50) **BOREHOLE IDENTITY:** L1

MONITORED BY: SG **AMBIENT TEMP (°C):** 22.9

FLOW (l/h): Max +0.2 Min -0.1 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 7.48 **UPSTAND (cm):** 65

TIP DEPTH (mbgl): 7.94 **US/IP DIFFERENCE (cm):** 33

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.6	<1	<1	1008
1	<0.1	<0.1	2.6	<1	<1	1008
2	0.1	<0.1	2.3	<1	<1	1008
3	<0.1	<0.1	2.2	<1	<1	1008
4	0.1	<0.1	2.1	<1	<1	1008
5	0.1	<0.1	1.9	<1	<1	1008

Weather: - Clear spells, dry underfoot, light wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 29/08/12 (11:50) **BOREHOLE IDENTITY:** L1

MONITORED BY: SG **AMBIENT TEMP (°C):** 18.6

FLOW (l/h): Max +0.1 Min -0.1 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 7.64 **UPSTAND (cm):** 65

TIP DEPTH (mbgl): 7.94 **US/IP DIFFERENCE (cm):** 33

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.6	<1	<1	994
1	<0.1	<0.1	1.1	<1	<1	994
2	<0.1	<0.1	1.0	<1	<1	994
3	<0.1	<0.1	0.7	<1	<1	994
4	0.1	<0.1	0.7	<1	<1	994
5	0.1	<0.1	0.7	<1	<1	994

Weather: - Overcast, wet underfoot, light wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 27/09/12 (14:30) **BOREHOLE IDENTITY:** L1

MONITORED BY: SG **AMBIENT TEMP (°C):** 15.2

FLOW (l/h): Max +0.1 Min -0.1 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 7.43 **UPSTAND (cm):** 65

TIP DEPTH (mbgl): 7.94 **US/IP DIFFERENCE (cm):** 33

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.7	<1	<1	996
1	<0.1	<0.1	2.2	<1	<1	996
2	<0.1	<0.1	1.0	<1	<1	996
3	<0.1	<0.1	0.7	<1	<1	996
4	<0.1	<0.1	0.7	<1	<1	996
5	<0.1	<0.1	0.6	<1	<1	996

Weather: - Overcast, wet underfoot, light wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 29/10/12 (14:20) **BOREHOLE IDENTITY:** L1

MONITORED BY: SG **AMBIENT TEMP (°C):** 12.8

FLOW (l/h): Max +0.2 Min +0.0 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 7.55 **UPSTAND (cm):** 65

TIP DEPTH (mbgl): 7.94 **US/IP DIFFERENCE (cm):** 33

BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.6	<1	<1	994
1	<0.1	<0.1	0.5	<1	<1	994
2	<0.1	<0.1	0.1	<1	<1	994
3	<0.1	<0.1	0.2	<1	<1	994
4	<0.1	<0.1	0.1	<1	<1	994
5	<0.1	<0.1	0.1	<1	<1	994

Weather: - Clear spells, damp underfoot, light wind

Odour : - None

Comments:- Single valve gas tap present.



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PADESWOOD BOREHOLES GAS MONITORING DATA

DATE/TIME: 28/12/12 (13:50) **BOREHOLE IDENTITY:** L1

MONITORED BY: GW **AMBIENT TEMP (°C):** 11.6

FLOW (l/h): Max +0.1 Min +0.0 **DIFFERENTIAL PRESSURE (mb):** 0.0

DEPTH TO WATER (mbgl): 7.41 **UPSTAND (cm):** 65

TIP DEPTH (mbgl): 7.94 **US/IP DIFFERENCE (cm):** 33

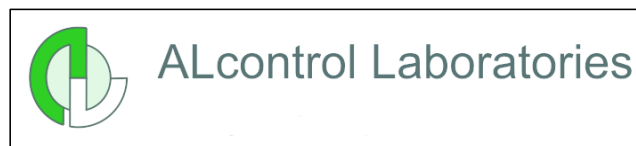
BOREHOLE ID (cm): 5

Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)
Standard	5.0	5.0	6.0	-	-	-
Observed	5.0	5.0	6.0	-	-	-
Ambient	<0.1	<0.1	20.2	<1	<1	994
1	<0.1	<0.1	0.1	<1	<1	994
2	<0.1	<0.1	0.1	<1	<1	994
3	<0.1	<0.1	<0.1	<1	<1	994
4	<0.1	<0.1	<0.1	<1	<1	994
5	<0.1	<0.1	<0.1	<1	<1	994

Weather: - Overcast, wet underfoot, slight wind

Odour : - None

Comments:- Single valve gas tap present.



GAS MONITORING RESULTS

Date and Time: 29/01/2013 14:40

Borehole Identity: L1

Ambient Temp (°C): 13.1

Monitored by: SG

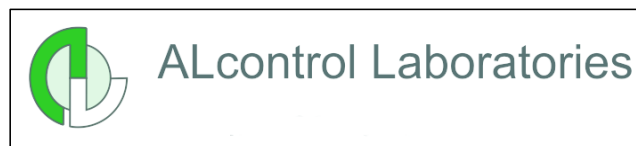
Weather: Overcast, wet underfoot, moderate wind

Comments: Single valve gas tap present

Tip Depth (mbgl)	Depth to Water (mbgl)	Standpipe ID (mm)	Upstand/Internal pipe Difference (cm)
7.94	7.45	50	33

Flow	Max: +0.2	Min: -0.0					
Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)	VOC (PID ppm)
*Standard	5.0	5.0	6.0	-	-	-	-
*Observed	5.0	5.0	6.0	-	-	-	-
**Ambient	<0.1	<0.1	20.4	<1	<1	978	N/A
1 (60)	<0.1	<0.1	0.1	<1	<1	978	N/A
2 (120)	<0.1	<0.1	<0.1	<1	<1	978	N/A
3 (180)	<0.1	<0.1	<0.1	<1	<1	978	N/A
4 (240)	<0.1	<0.1	<0.1	<1	<1	978	N/A
5 (300)	<0.1	<0.1	<0.1	<1	<1	978	N/A
6 (360)							
7 (420)							
8 (480)							
9 (540)							
10 (600)							
PEAK READINGS	<0.1	<0.1					

*Standard and observed refers to calibration results recorded using calibration gas from a cylinder containing specified concentrations



GAS MONITORING RESULTS

Date and Time: 25/02/2013 15:05

Borehole Identity: L1

Ambient Temp (°C): 5.1

Monitored by: SG

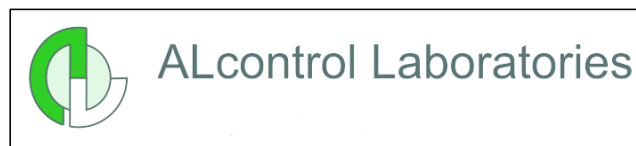
Weather: Overcast, dry underfoot, light wind

Comments: Single valve gas tap present

Tip Depth (mbgl)	Depth to Water (mbgl)	Standpipe ID (mm)	Upstand/Internal pipe Difference (cm)
7.94	7.56	50	33

Flow	Max: +0.1	Min: -0.1					
Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)	VOC (PID ppm)
*Standard	5.0	5.0	6.0	-	-	-	-
*Observed	5.0	5.0	6.0	-	-	-	-
**Ambient	<0.1	<0.1	20.4	<1	<1	1017	N/A
1 (60)	<0.1	<0.1	0.6	<1	<1	1017	N/A
2 (120)	<0.1	<0.1	<0.1	<1	<1	1017	N/A
3 (180)	<0.1	<0.1	<0.1	<1	<1	1017	N/A
4 (240)	<0.1	<0.1	<0.1	<1	<1	1017	N/A
5 (300)	<0.1	<0.1	<0.1	<1	<1	1017	N/A
6 (360)							
7 (420)							
8 (480)							
9 (540)							
10 (600)							
PEAK READINGS	<0.1	<0.1					

*Standard and observed refers to calibration results recorded using calibration gas from a cylinder containing specified concentrations



GAS MONITORING RESULTS

Date and Time: 28/03/2013 13:10

Borehole Identity: L1

Ambient Temp (°C): 3.8

Monitored by: SG

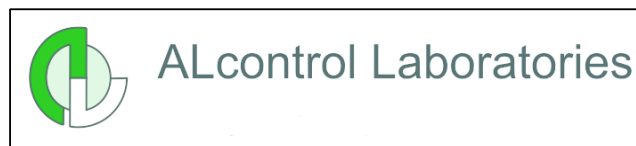
Weather: Overcast, snow underfoot, light wind

Comments: Single valve gas tap present

Tip Depth (mbgl)	Depth to Water (mbgl)	Standpipe ID (mm)	Height of Upstand (cm)	Upstand/Internal pipe Difference (cm)
7.94	7.51	50	65	33

Flow	Max: +0.1	Min: -0.1					
Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)	VOC (PID ppm)
*Standard	5.0	5.0	6.0	-	-	-	-
*Observed	5.0	5.0	6.0	-	-	-	-
**Ambient	<0.1	<0.1	20.1	<1	<1	1000	N/A
1 (60)	<0.1	<0.1	1.4	<1	<1	1000	N/A
2 (120)	<0.1	<0.1	0.5	<1	<1	1000	N/A
3 (180)	<0.1	<0.1	0.3	<1	<1	1000	N/A
4 (240)	<0.1	<0.1	0.3	<1	<1	1000	N/A
5 (300)	<0.1	<0.1	0.1	<1	<1	1000	N/A
6 (360)							
7 (420)							
8 (480)							
9 (540)							
10 (600)							
PEAK READINGS	<0.1	<0.1					

*Standard and observed refers to calibration results recorded using calibration gas from a cylinder containing specified concentrations



GAS MONITORING RESULTS

Date and Time: 30/04/2013 15:15

Borehole Identity: L1

Ambient Temp (°C): 14.4

Monitored by: SG

Weather: Clear spells, dry underfoot, light wind

Comments: Single valve gas tap present

Tip Depth (mbgl)	Depth to Water (mbgl)	Standpipe ID (mm)	Height of Upstand (cm)	Upstand/Internal pipe Difference (cm)
7.94	7.62	50	65	33

Flow	Max: +0.3	Min: +0.1					
Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)	VOC (PID ppm)
*Standard	5.0	5.0	6.0	-	-	-	-
*Observed	5.0	5.0	6.0	-	-	-	-
**Ambient	<0.1	<0.1	20.4	<1	<1	1011	N/A
1 (60)	<0.1	<0.1	3.6	<1	<1	1011	N/A
2 (120)	<0.1	<0.1	3.4	<1	<1	1011	N/A
3 (180)	<0.1	<0.1	3.3	<1	<1	1011	N/A
4 (240)	<0.1	<0.1	3.1	<1	<1	1011	N/A
5 (300)	<0.1	<0.1	3.1	<1	<1	1011	N/A
6 (360)							
7 (420)							
8 (480)							
9 (540)							
10 (600)							
PEAK READINGS	<0.1	<0.1					

*Standard and observed refers to calibration results recorded using calibration gas from a cylinder containing specified concentrations



GAS MONITORING RESULTS

Date and Time: 29/05/2013 14:05

Borehole Identity: L1

Ambient Temp (°C): 14.7

Monitored by: SG

Weather: Overcast, dry underfoot, light wind

Comments: Single valve gas tap present

Tip Depth (mbgl)	Depth to Water (mbgl)	Standpipe ID (mm)	Height of Upstand (cm)	Upstand/Internal pipe Difference (cm)
7.94	7.61	50	65	33

Flow	Max: +0.1	Min: -0.1					
Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)	VOC (PID ppm)
*Standard	5.0	5.0	6.0	-	-	-	-
*Observed	5.0	5.0	6.0	-	-	-	-
**Ambient	<0.1	<0.1	20.5	<1	<1	994	N/A
1 (60)	<0.1	<0.1	3.8	<1	<1	994	N/A
2 (120)	<0.1	<0.1	3.3	<1	<1	994	N/A
3 (180)	<0.1	<0.1	3.1	<1	<1	994	N/A
4 (240)	<0.1	<0.1	3	<1	<1	994	N/A
5 (300)	<0.1	<0.1	3	<1	<1	994	N/A
6 (360)							
7 (420)							
8 (480)							
9 (540)							
10 (600)							
PEAK READINGS	<0.1	<0.1					

*Standard and observed refers to calibration results recorded using calibration gas from a cylinder containing specified concentrations



GAS MONITORING RESULTS

Date and Time: 27/06/2013 14:50

Borehole Identity: L1

Ambient Temp (°C): 16.2

Monitored by: SG

Weather: Overcast, rain, wet underfoot, light wind

Comments: Single valve gas tap present

Tip Depth (mbgl)	Depth to Water (mbgl)	Standpipe ID (mm)	Height of Upstand (cm)	Upstand/Internal pipe Difference (cm)
7.94	7.64	50	65	33

Flow	Max: +0.1	Min: -0.2					
Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)	VOC (PID ppm)
*Standard	5.0	5.0	6.0	-	-	-	-
*Observed	5.0	5.0	6.0	-	-	-	-
**Ambient	<0.1	<0.1	20.6	<1	<1	1012	N/A
1 (60)	<0.1	<0.1	3.4	<1	<1	1012	N/A
2 (120)	<0.1	<0.1	3.1	<1	<1	1012	N/A
3 (180)	<0.1	<0.1	3	<1	<1	1012	N/A
4 (240)	<0.1	<0.1	3.2	<1	<1	1012	N/A
5 (300)	<0.1	<0.1	3.1	<1	<1	1012	N/A
6 (360)							
7 (420)							
8 (480)							
9 (540)							
10 (600)							
PEAK READINGS	<0.1	<0.1					

*Standard and observed refers to calibration results recorded using calibration gas from a cylinder containing specified concentrations



GAS MONITORING RESULTS

Date and Time: 30/07/2013 14:20

Borehole Identity: L1

Ambient Temp (°C): 20.4

Monitored by: SG

Weather: Overcast, damp underfoot, light wind

Comments: Single valve gas tap present

Tip Depth (mbgl)	Depth to Water (mbgl)	Standpipe ID (mm)	Height of Upstand (cm)	Upstand/Internal pipe Difference (cm)
7.94	7.64	50	65	33

Flow	Max: +0.1	Min: -0.1					
Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)	VOC (PID ppm)
*Standard	5.0	5.0	6.0	-	-	-	-
*Observed	5.0	5.0	6.0	-	-	-	-
**Ambient	<0.1	<0.1	20.6	<1	<1	996	N/A
1 (60)	<0.1	<0.1	12.4	<1	<1	996	N/A
2 (120)	<0.1	<0.1	12.1	<1	<1	996	N/A
3 (180)	<0.1	<0.1	12.1	<1	<1	996	N/A
4 (240)	<0.1	<0.1	11.9	<1	<1	996	N/A
5 (300)	<0.1	<0.1	11.8	<1	<1	996	N/A
6 (360)							
7 (420)							
8 (480)							
9 (540)							
10 (600)							
PEAK READINGS	<0.1	<0.1					

*Standard and observed refers to calibration results recorded using calibration gas from a cylinder containing specified concentrations



GAS MONITORING RESULTS

Date and Time: 19/08/2013 14:45

Borehole Identity: L1

Ambient Temp (°C): 18.8

Monitored by: SG

Weather: Overcast, dry underfoot, light wind

Comments: Single valve gas tap present

Tip Depth (mbgl)	Depth to Water (mbgl)	Standpipe ID (mm)	Height of Upstand (cm)	Upstand/Internal pipe Difference (cm)
7.94	7.64	50	65	33

Flow	Max: -0.0	Min: -0.1					
Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)	VOC (PID ppm)
*Standard	5.0	5.0	6.0	-	-	-	-
*Observed	5.0	5.0	6.0	-	-	-	-
**Ambient	<0.1	<0.1	20.5	<1	<1	1008	N/A
1 (60)	<0.1	<0.1	5.3	<1	<1	1008	N/A
2 (120)	<0.1	<0.1	4.9	<1	<1	1008	N/A
3 (180)	<0.1	<0.1	4.9	<1	<1	1008	N/A
4 (240)	<0.1	<0.1	4.8	<1	<1	1008	N/A
5 (300)	<0.1	<0.1	4.6	<1	<1	1008	N/A
6 (360)							
7 (420)							
8 (480)							
9 (540)							
10 (600)							
PEAK READINGS	<0.1	<0.1					

*Standard and observed refers to calibration results recorded using calibration gas from a cylinder containing specified concentrations



GAS MONITORING RESULTS

Date and Time: 30/09/2013 14:50

Borehole Identity: L1

Ambient Temp (°C): 20.1

Monitored by: SG

Weather: Overcast, dry underfoot, light wind

Comments: Single valve gas tap present

Tip Depth (mbgl)	Depth to Water (mbgl)	Standpipe ID (mm)	Height of Upstand (cm)	Upstand/Internal pipe Difference (cm)
7.94	7.65	50	65	33

Flow	Max: +0.0	Min: -0.1					
Time (min)	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Pressure (mb)	VOC (PID ppm)
*Standard	5.0	5.0	6.0	-	-	-	-
*Observed	5.0	5.0	6.0	-	-	-	-
**Ambient	<0.1	<0.1	20.5	<1	<1	993	N/A
1 (60)	<0.1	<0.1	2.8	<1	<1	993	N/A
2 (120)	<0.1	<0.1	2.3	<1	<1	993	N/A
3 (180)	<0.1	<0.1	2.2	<1	<1	993	N/A
4 (240)	<0.1	<0.1	2.1	<1	<1	993	N/A
5 (300)	<0.1	<0.1	1.8	<1	<1	993	N/A
6 (360)							
7 (420)							
8 (480)							
9 (540)							
10 (600)							
PEAK READINGS	<0.1	<0.1					

*Standard and observed refers to calibration results recorded using calibration gas from a cylinder containing specified concentrations

5 December 2014

Project No. 13514240032.503/B.0

Ms Victoria Smith
Hanson (UK) Limited
Padeswood
Mold
Flintshire
CH7 4HB

PADESWOOD LANDFILL: RESPONSE TO NRW QUERIES REGARDING INTERPRETATION OF LANDFILL GAS AND GROUNDWATER QUALITY

Dear Victoria

We are pleased to submit to you a response to the Natural Resources Wales (NRW) queries regarding the interpretation of gas and groundwater quality monitoring data from Padeswood Landfill Site (the Site).

BACKGROUND

Following receipt of a review of submissions regarding the Padeswood Works Landfill: Interpretation Regarding Landfill Gas and Groundwater Quality (Reference 13514240032.502/A.0); and Toe Drain Infrastructure Testing Report (Reference 13514240032.501/A.0) by the NRW a letter of queries were returned dated 13 June 2014. The letter comprises a response to these queries.

Letter Item 1: Landfill Gas

NRW Query: We note the comments regarding the low levels of oxygen being related to possible oxidation reactions with one of the constituents present within the CKD or other material co-disposed with it. We recommend that gas monitoring of the in-waste monitoring locations should continue for the time being.

Acceptance of the conceptual understanding with regard to landfill gas is noted. We confirm that gas monitoring of the in-waste monitoring locations will continue with review once the Site enters Definite Closure.

Letter Item 2: Groundwater

NRW Query: It is stated in the letter that GA1 is acting like a sump, but a sump for what, water level or water quality? This borehole (from the two contour plots) has the highest water level elevation (excluding BH1A – not marked on map, but included in Figure 1), implying that it is upgradient. We accept that the water levels are similar to the surface water level at this location, which potentially indicates that GA1 is hydraulically connected to the surface water, Please explain the reasoning behind this borehole acting as a sump – where does the water drain to?

The borehole log for GA1 is attached in Annex 1 to this letter. When GA1 was drilled a minor water strike was observed at the interface between the Made Ground and the underlying Boulder Clay at a depth of 6 m. No water strikes were identified in the Boulder Clay to a total depth of 10.36 m. On installation a long screen was installed co-incident with the Boulder Clay deposits with the gravel pack extending to a point broadly coincident with the interface between the Made Ground and the Boulder Clay. The elevation of the interface between the Made Ground and the Boulder Clay is reported in the borehole log to be 99.29 m the elevation of water within the borehole is reported to be between 0.02 m and 0.34 m above this. The interpretation that was presented in the previous submission stated the following:

- *The elevation of groundwater at GA1 is broadly co-incident with an interpolation of the elevation of the bed of the adjacent watercourse. From Figure 1 the elevation of groundwater in GA1 is observed to be relatively constant at between 99.31 and 99.63 mAOD, this elevation is also broadly co-incident with the elevation of*

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the base of the overlying Madeground. It is proposed that infiltration either through the landfill or through the Made Ground between the Site and GA1 is collecting on the surface of the underlying boulder clay. It is also proposed that borehole GA1 is acting as a sump for this perched water.

To clarify the point made; the water present in GA1 is interpreted to derive from infiltration through the Made Ground deposits. At the base of the Made Ground it is interpreted that a small quantity of water (0.02 m to 0.34 m) is perched on the underlying Boulder Clay. The source of this water is considered to either derive from the infiltration of runoff from the cap to the Made Ground which may contain small quantities of demolition waste or CKD, or; that a small quantity of leachate could be migrating from the unlined landfill through the Made Ground and is perched on the surface of the Boulder Clay. The reference to a sump is that GA1 is drilled in to the Boulder Clay which is a low permeability formation. From the superficial quantity of water present in the base of the Made Ground the borehole has collected with quantities of water which cannot escape and hence the borehole acts as a sump for superficial quantities of water that otherwise would be perched on the interface between the Made Ground and the Boulder Clay in saturated thicknesses that would not be able to be sampled.

It is proposed that the sampling methodology at this location comprises the purging of three well volumes from GA1 or until it is dry. If the borehole does not recharge within 30 minutes to sufficiently allow a representative sample to be taken it should be recorded as dry. This approach will ensure that results for the samples taken are representative of the conditions within either the Made Ground or Drift (Boulder Clay in this case) deposits and not of stagnant water that has collected in a man-made sump.

NRW Query: From Figure 2, GA1 and GA4 exceed the interim trigger levels for ammoniacal nitrogen, chloride and sulphate by a considerable amount for chloride and sulphate (orders of magnitude). GA1 is adjacent to the watercourse on the eastern flank and GA4 is on the western flank, downgradient of the site and below the bed level of the water courses. If GA4 has elevated contamination from the landfill and not adjacent to a watercourse (into which it could discharge as inferred at GA1) where is the contamination going – off site, on the pathway to deeper groundwater?

From the letter response the following points are restated:

From the most recent Hydrogeological Risk Assessment for the Site the following is reproduced:

Underlying the landfill are *in situ* superficial Drift deposits, these Drift deposits, comprise lenses of alluvial sand and gravel and Glacial Till, which comprises sandy gravelly clay. The clay has a maximum thickness of 9 m in the north of the Site.

Some lenses of alluvial sand deposits contain perched groundwater and some are dry suggesting that they are discontinuous.

The Drift deposits overly the Coal Measures which comprise interbedded sandstones and mudstones. The water table in the Coal Measures is below the interface with the Glacial Till.

Potential pathways include;

- Vertical migration of leachate through the Drift deposits and unsaturated Coal Measures to groundwater present in the Coal Measures; and
- Lateral migration of leachate through the Drift deposits or surface breakout towards the unnamed tributary to Black Brook. Whilst there is evidence to suggest that the lenses of alluvial sand and gravel are discontinuous and the hydraulic gradient of the water table is relatively flat, there remains the possibility that leachate could impact a lens of gravel adjacent to the Site which could outcrop in the bed or bank of the adjacent unnamed tributary to Black Brook.

At GA4 the water present in the Drift deposits is not designated as a groundwater resource and the underlying Coal Measures are designated by the Environment Agency as a Secondary A Aquifer.

The objective of setting Trigger Levels in the Drift monitoring boreholes was to consider potential impacts on the adjacent watercourse. Given that the elevation of water in GA4 is below the adjacent watercourse the pathway to the watercourse does not exist at this location.

The water identified in GA4 comprises part of the vertical pathway between the base of the Site and the Coal Measures Secondary A Aquifer in advance of infiltration to and dispersion in the Coal Measures aquifer underflow. It is expected that the concentration of substances that are not attenuated in the vertical pathway would be comparable to the composition of basal leakage from the Site. This is consistent with the observations at GA4 and hence consistent with the conceptual model for the Site.

The risk assessment findings indicate that once the vertical infiltration is reaches the Secondary A Aquifer and is dispersed in the aquifer underflow that the impact of the substances either at the Site boundary or down gradient surface water receptors would be acceptable.

NRW Query: We note that water levels within GA2, GA3 and GA4 are up to 15 mbgl below the watercourse elevation, inferring that they are hydraulically disconnected from the surface water. And we note the comment that these plots are based on perched water levels within the drift deposits. However, with GA3 and GA4 being downgradient of the landfill, we recommend that sampling is maintained especially as GA4 is known to exceed the interim trigger levels.

The objective at the time of installation of GA2, GA3 and GA4 was to characterise the composition of groundwater upgradient to the watercourses. At the time of drilling no water strikes were identified at shallow depths (i.e. between the elevation of the ground level and the elevation of the watercourse) and hence the boreholes progressed to a depth of either a deeper water strike within the Drift or were terminated at the interface with the Coal Measures.

The objective of these boreholes was to prove the presence of a shallow watertable that potentially could be a pathway for migration of leachate from the landfill to the adjacent watercourse and if so the composition of this groundwater. At GA2, GA3 and GA4 the conclusion from the site investigation was that there was not a lateral pathway at these locations for the migration of leachate from the Site and hence the vertical migration conceptual model in these areas remained valid.

As stated above the water present in GA2, GA3 and GA4 is pore water that has collected in the superficial deposits that are not a groundwater resource in advance of vertical infiltration in to the underlying Coal Measures Secondary A Aquifer. The composition of this pore water hence reflects the composition of leakage from the Site. Given that the locations have been used to validate the conceptual model and the conceptual model states that the composition of pore water in these locations in advance of infiltration in to the Aquifer would reflect the composition of leakage from the Site there is little value in continuing to monitor these locations.

In terms of monitoring, Drift boreholes should only be sampled when the groundwater elevation is above the elevation of the adjacent watercourse. Monitoring of boreholes in the Coal Measures should continue as proposed in the HRA.

Letter Item 3: Surface Water

NRW Query: We accept the additional surface water sampling due to the sampling exceeding interim trigger levels in GA1 and BH5, both of which are located next to the water courses. We also note the comment about only being able to sample this water course when there is flow within them – how often is there no water flowing in these water courses? What will be the frequency of sampling? Could the sampling be timed when flows are present after heavy rainfall, this might need observation of the water course on a regular basis and for the sampling frequency to be on an “as and when” basis.

It is accepted that this is a reasonable approach with regard to sampling of flowing surface waters in order to gather relevant and meaningful data with regard to the composition of water discharging through the watercourse adjacent to the Site. The site management will either retain sample bottles on site or engage the monitoring contractor so that four samples are recovered from the surface water monitoring locations on an annual basis while the watercourse is flowing. A gap of at least 2 months will be maintained between each monitoring round to ensure that the samples are representative of different times of year.

Letter Item 4: Toe Drain Infrastructure Testing Report

NRW Query: It would have been useful for a schematic drawing/plan of the toe drain infrastructure, in particular a cross section showing all the manhole chambers with the various inlets and outlets elevations and to include the seeps observed in the concrete rings. This would help with determining the flow directions of the toe drain and then allow for comparison with leachate head levels in leachate wells and

groundwater monitoring boreholes. There is a mention of drawing 1, but this was not included in the report.

There is no mention of decommissioning the infrastructure (i.e. removing it) within the report. It is assumed that this would be too onerous to do such works now that the site has been capped. Can they propose some decommissioning of the toe drain as it is now acting as a pathway for future pollution?

The basal elevation of leachate monitored in leachate well L3 is below the invert level of the toe drain infrastructure. This means that subsequent to capping the reduction of infiltration to the waste has resulted in the leachate level falling below the toe drain and the toe drain becoming obsolete.

Seeps of perched water were identified in the vicinity of TD1 at a depth of 0.92 below ground level. The elevation of this seepage is above the basal level of leachate in the site. The interpretation of the composition of the seeps entering TD1 were that it is similar to the composition of perched waters present in the adjacent sump and comprised a lens of perched groundwater that may have been influenced by infiltration either through the landfill or through the Made Ground between the Site and TD1.

Section 4.2 of the report details the relationship between leachate, the toe drain and groundwater in detail.

A copy of Drawing 1 is attached in Annex 2 of this letter.

Given that the toe drain is above the elevation of leachate it does not form a pathway for the migration of leachate. As part of the test pumping works a blanking plate was fitted to prevent flow in the toe drain from the eastern boundary of the Site.

Test pumping completed during June was found to be dry, but has the toe drain and sumps been inspected during winter during the heavy rainfall – what is the situation like then?

During test pumping the water in TD2 was sampled and pumped out. The composition of the water was not representative of leachate from the Site and was concluded to be representative of infiltrated surface water that had collected in the chamber. It is likely that the chamber of TD2 will continue to collect water as it infiltrates the ground however as leachate is below this location this is not relevant to the management of the Site.

Closing

We trust that the information presented in this letter report in line with your current needs. If you have any queries please do not hesitate to contact us. We look forward to hearing from you.

Yours sincerely

GOLDER ASSOCIATES (UK) LTD



Richard Lansley
Senior Hydrogeologist

RJL/GDLT/cr



Gareth Digges La Touche
Associate

Attachments: Annex 1: Borehole Logs
Annex 2: Drawing 1

ANNEX 1

Borehole Logs



Client :

Hanson (UK) Ltd

Hole No.

GA1

Site : Padeswood Landfill Site

Project : Padeswood Landfill Site Investigation

Project No : 10514240262

Equipment & Methods : Fraste Multidrill ML/Hollow Stem Augers

Contractor : CCGI

Date Started : 28/09/2011

Completed : 03/10/2011

Logged by : RB

Ground Level (mAOD) : 105.29

Co-ordinates : E 329107.0 N 361926.4

STRATA RECORD

WATER/ PROGRESS	INSTALLATION /BACKFILL	STRATA RECORD			
		Level (mAOD)	Legend	Depth (Thickness) m	Description
		105.19		0.10	Loose, dry, dark brown, clayey SILT with subangular limestone, gravel, brick and grass roots (MADE GROUND).
		104.89		0.40	Loose, dry, dark brown SILTY CLAY with pockets of light grey/brown medium sand, gravel, red brick, mudstone fragments and slag/coal. One whole red brick present (MADE GROUND).
				(0.80)	Loose, dry, dark brown medium grained SAND with with subangular gravel (MADE GROUND).
		104.09		1.20	
				(4.80)	Loose, moist, dark brown/black clayey SILT with much subangular, medium gravel and occasional brick fragments (MADE GROUND).
		99.29		6.00	
				(4.36)	Very soft, wet, brown/grey CLAY with a little subangular fine gravel. Boulder encountered at 7.2 m (BOULDER CLAY).

Remarks :

Checked By:
RL

Scale 1:50

GAUK BASIC(NO SAMPLES)
April 2008



Client :

Hanson (UK) Ltd

Hole No.

GA1

Site : Padeswood Landfill Site

Project : Padeswood Landfill Site Investigation

Project No : 10514240262

Equipment & Methods : Fraste Multidrill ML/Hollow Stem Augers

Contractor : CCGI

Date Started : 28/09/2011

Completed : 03/10/2011

Logged by : RB

Ground Level (mAOD) : 105.29

Co-ordinates : E 329107.0 N 361926.4

STRATA RECORD

WATER/
PROGRESS

INSTALLATION
/BACKFILL

Level
(mAOD)

Legend

Depth
(Thickness)
m

Description

94.93

10.36

Very soft, wet, brown/grey CLAY with a little subangular fine gravel. Boulder encountered at 7.2 m (BOULDER CLAY).

End of Hole at 10.36m

Remarks :

Checked By:
RL

Scale 1:50

GAJK BASIC(NO SAMPLES)
April 2008



Client :

Hanson (UK) Ltd

Hole No.

GA2

Site : Padeswood Landfill Site

Project : Padeswood Landfill Site Investigation

Project No : 10514240262

Equipment & Methods : Fraste Multidrill ML/Rotary Core with polymer

Contractor : CCGI

Date Started : 04/10/2011

Completed : 12/11/2011

Logged by : RL/RB

Ground Level (mAOD) : 104.58

Co-ordinates : E 329064.8 N 361889.7

STRATA RECORD

WATER/ PROGRESS	INSTALLATION /BACKFILL	Level (mAOD)	Legend	Depth (Thickness) m	Description
		103.78		(0.80) 0.80	Loose, dry, light grey/brown, clayey SILT with occasional subangular limestone (MADE GROUND).
		103.38		(0.40) 1.20	Loose, dry, light brown, clayey SILT with occasional subangular limestone (MADE GROUND).
		101.78		(1.60) 2.80	Concrete boulder (augers pulled to remove tangled rebar)
		100.58		(1.20) 4.00	Loose, soft, damp, dark brown, clayey SILT with some subangular limestone.
		97.08		(3.50) 7.50	Loose, soft, damp, dark brown clayey SILT.
				(2.89)	Very stiff, dry, brown/orange CLAY with pockets of light brown medium sand, subrounded sandstone, coal, subangular limestone cobbles. Black laminations throughout, with occasional subangular mudstone fragments.

Remarks :

Checked By:
RL

Scale 1:50

GAJK BASIC(NO SAMPLES)
April 2008



Client :

Hanson (UK) Ltd

Hole No.

GA2

Site : Padeswood Landfill Site

Project : Padeswood Landfill Site Investigation

Project No : 10514240262

Equipment & Methods : Fraste Multidrill ML/Rotary Core with polymer

Contractor : CCGI

Date Started : 04/10/2011

Completed : 12/11/2011

Logged by : RL/RB

Ground Level (mAOD) : 104.58

Co-ordinates : E 329064.8 N 361889.7

STRATA RECORD

WATER/ PROGRESS	INSTALLATION /BACKFILL	STRATA RECORD			
		Level (mAOD)	Legend	Depth (Thickness) m	Description
		94.19		10.39	Very stiff, dry, brown/orange CLAY with pockets of light brown medium sand, subrounded sandstone, coal, subangular limestone cobbles. Black laminations throughout, with occasional subangular mudstone fragments.
				(2.30)	Very stiff, dry, grey, CLAY with some cobbles (limestone) and gravel. Limestone is subangular (max ~100 mm size) and gravel is subrounded. Coal is present plus red/purple mudstone and occasional yellow/light brown sandstone pockets. Grades to orange colour close to the interface with the sand below.
		91.89		12.69	
				(1.11)	Loose, moist, brown, medium SAND.
		90.78		13.80	
				(2.90)	Loose, moist, orange/red, medium SAND with a little, subangular gravel (fine to medium) and 1 x 60 mm cobbles, subangular quartz fragments ~ 10 mm.
		87.88		16.70	
		87.78		16.80	Light brown/yellow with grey laminations, weathered MUDSTONE (clayey matrix with a little coal)
				(0.60)	Light blue/grey and reddish brown, fine MUDSTONE, weak (COAL MEASURES).
		87.18		17.40	
		86.98		17.60	Light brown/yellow, fine grained SANDSTONE (COAL MEASURES)
					End of Hole at 17.60m

Remarks :

Checked By:
RL

Scale 1:50

GAJK BASIC(NO SAMPLES)
April 2008



Client :

Hanson (UK) Ltd

Hole No.

GA3

Site : Padeswood Landfill Site

Project : Padeswood Landfill Site Investigation

Project No : 10514240262

Equipment & Methods : Fraste Multidrill ML/Hollow Stem Augers (0-8.1m), Rotary water flush (8.1-19.65m), Rotary Core (19.65-20.3m)

Contractor : CCGI

Date Started : 04/10/2011

Completed : 11/10/2011

Logged by : RL/RB

Ground Level (mAOD) : 101.59

Co-ordinates : E 328974.9 N 361911.7

STRATA RECORD

WATER/ PROGRESS	INSTALLATION /BACKFILL	Level (mAOD)	Legend	Depth (Thickness) m	Description
		101.29		0.30	Loose, dry, light brown, clayey SILT with occasional subrounded sandstone and silt stone cobbles (MADE GROUND).
		101.19		0.40	Firm, dry, brown, mottled orange sandy CLAY with angular gravel sized coal fragments (MADE GROUND).
				(0.80)	Loose, dry, brown mottled orange SAND with occasional subangular - subrounded medium gravel.
		100.39		1.20	
				(1.80)	Soft, damp, orange brown silty sandy CLAY with occasional subangular - subrounded medium gravel.
		98.59		3.00	
				(3.70)	Soft, damp, brown sandy clayey SILT with occasional subangular-subrounded medium gravel.
		94.89		6.70	
				(1.30)	Firm, damp, dark brown clayey SILT with many coarse subrounded - rounded gravel. Cobbles of sandstone and siltstone.
		93.59		8.00	
		93.49		8.10	Loose, damp, orange brown clayey SAND.
				(0.90)	Firm, damp, dark brown sandy CLAY with many coarse rounded gravel.
		92.59		9.00	
				(1.50)	Few returns, evidence of silt and sand in cuttings

Remarks :

Checked By:
RL

Scale 1:50

GAUK BASIC(NO SAMPLES)
April 2008



Client :

Hanson (UK) Ltd

Hole No.

GA3

Site : Padeswood Landfill Site

Project : Padeswood Landfill Site Investigation

Project No : 10514240262

Equipment & Methods : Fraste Multidrill ML/Hollow Stem Augers (0-8.1m), Rotary water flush (8.1-19.65m), Rotary Core (19.65-20.3m)

Contractor : CCGI

Date Started : 04/10/2011

Completed : 11/10/2011

Logged by : RL/RB

Ground Level (mAOD) : 101.59

Co-ordinates : E 328974.9 N 361911.7

STRATA RECORD

WATER/ PROGRESS	INSTALLATION /BACKFILL	Level (mAOD)	Legend	Depth (Thickness) m	Description
		91.09		10.50	Few returns, evidence of silt and sand in cuttings
				(1.30)	SAND
		89.79		11.80	Medium grained, loose, light brown/brown SAND with occasional patches of brown/grey clay. Cobbles of hard limestone.
				(6.20)	
		83.59		18.00	Brown/orange/red, slightly clayey medium to fine SAND.
				(1.65)	
		81.94		19.65	Grey, fine MUDSTONE, weathered, moderately weak. Frequent coal, purple mudstone, rounded to subangular sandstone and limestone cobbles.
				(0.65)	

Remarks :

Checked By:
RL

Scale 1:50

GAJK BASIC(NO SAMPLES)
April 2008



Client :

Hanson (UK) Ltd

Hole No.

GA3

Site : Padeswood Landfill Site

Project : Padeswood Landfill Site Investigation

Project No : 10514240262

Equipment & Methods : Fraste Multidrill ML/Hollow Stem Augers (0-8.1m), Rotary water flush (8.1-19.65m), Rotary Core (19.65-20.3m)

Contractor : CCGI

Date Started : 04/10/2011

Completed : 11/10/2011

Logged by : RL/RB

Ground Level (mAOD) : 101.59

Co-ordinates : E 328974.9 N 361911.7

STRATA RECORD

WATER/
PROGRESS

INSTALLATION
/BACKFILL

Level
(mAOD)

Legend

Depth
(Thickness)
m

Description

81.29

20.30

End of Hole at 20.30m

Remarks :

Checked By:
RL

Scale 1:50

GAJK BASIC(NO SAMPLES)
April 2008



Client :

Hanson (UK) Ltd

Hole No.

GA4

Site : Padeswood Landfill Site

Project : Padeswood Landfill Site Investigation

Project No : 10514240262

Equipment & Methods : Fraste Multidrill ML/Hollow Stem Augers (0-16m), Rotary Core (16-18.6m)

Contractor : CCGI

Date Started : 03/10/2011

Completed : 14/10/2011

Logged by : RL

Ground Level (mAOD) : 99.68

Co-ordinates : E 328954.0 N 361980.9

STRATA RECORD

WATER/ PROGRESS	INSTALLATION /BACKFILL	STRATA RECORD			
		Level (mAOD)	Legend	Depth (Thickness) m	Description
		99.28		(0.40) 0.40	Soft, damp, dark grey/brown silty clay with many grass rootlets.
		98.98		0.70	Loose, damp, orange brown clayey SAND with occasional subrounded fine to medium gravel.
		98.88		0.80	Loose, wet, orange brown, clayey SAND with occasional subrounded fine to medium gravel.
		98.58		1.10	Soft, wet, light grey CLAY.
				(4.00)	Loose, wet-damp, light brown, SANDY CLAY with occasional subrounded fine to medium gravel.
		94.58		5.10	Soft to firm, damp, grey brown CLAY with rare subrounded to rounded coarse gravel.
				(2.90)	Soft, moist, grey, CLAY.
		91.68		8.00	Soft, moist, grey, CLAY.
				(1.50)	Loose, dry, medium orange brown SAND.
		90.18		9.50	Loose, dry, medium orange brown SAND.

Remarks :

Checked By:
RL

Scale 1:50

GAUK BASIC(NO SAMPLES)
April 2008



Client :

Hanson (UK) Ltd

Hole No.

GA4

Site : Padeswood Landfill Site

Project : Padeswood Landfill Site Investigation

Project No : 10514240262

Equipment & Methods : Fraste Multidrill ML/Hollow Stem Augers (0-16m), Rotary Core (16-18.6m)

Contractor : CCGI

Date Started : 03/10/2011

Completed : 14/10/2011

Logged by : RL

Ground Level (mAOD) : 99.68

Co-ordinates : E 328954.0 N 361980.9

STRATA RECORD

WATER/ PROGRESS	INSTALLATION /BACKFILL	STRATA RECORD			
		Level (mAOD)	Legend	Depth (Thickness) m	Description
				(3.80)	Loose, dry, medium orange brown SAND.
		86.38		13.30	
				(1.25)	Loose, damp, medium, light orange brown SAND with rare subrounded fine to medium gravel.
		85.13		14.55	
				(3.65)	Very soft, dry, grey, CLAY with some gravel to subrounded cobbles of limestone, siltstone and sandstone, and angular fragments (fine gravel sized) of coal (BOULDER CLAY).
		81.48		18.20	
		81.08		(0.40) 18.60	Light grey/blue, fine, fresh MUDSTONE, weak to moderately weak (COAL MEASURES).
					End of Hole at 18.60m

Remarks :

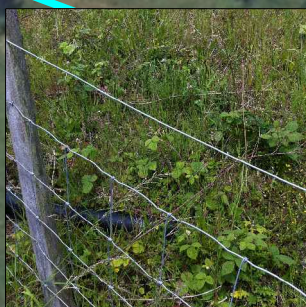
Checked By:
RL

Scale 1:50

GAUK BASIC(NO SAMPLES)
April 2008

ANNEX 2

Drawing 1



Legend

- Site ownership boundary
- Leachate extraction location
- Drift groundwater monitoring location
- Gas and leachate monitoring location
- Drift groundwater monitoring location
- Coal Measures groundwater monitoring location
- TD2 Emergency Overflow Valve
- Trail pit location
- Surface water drain
- Leachate toe drain
- Stream

Notes

- Surrounding survey information produced from Ordnance Survey digital data, survey scale 1:10,000, (c) Crown Copyright 2002. Licence No.AL813842.
- Aerial photograph bought from emapsite.com with covering license.

Client		Hanson (UK) Limited			
Project		Padeswood Landfill Toe Drain Infrastructure Testing Report			
Title		Surveyed Leachate and Surface Water Drains			
Created by	Requested by	Proj Manager	Reviewer	Date	
JW	EW	RJL	RJL	20/09/13	
File No.		Project No.			
585445		13514240032			
Size	Scale	Status		Report Issue	
A3	1:1,000				
Drawing No.				Rev	
1				-	



APPENDIX H

**Groundwater Monitoring Plan
(Superseded in part by this Closure Report)**



September 2015

HANSON CEMENT WORKS - PADESWOOD LANDFILL SITE

Appendix H - Groundwater Monitoring Plan

Submitted to:
Mr Matthew Uttley
Hanson (UK) Ltd
Ashby Road East
Shepshed
Loughborough
LE12 9BU

REPORT



Report Number 1419741.504/A.0

Distribution:

Hanson (UK) Ltd - 1 copy (pdf)
NRW - 1 copy (pdf)
Golder Associates (UK) Ltd - 1 copy





Table of Contents

1.0	GROUNDWATER MONITORING PLAN	1
1.1	Report Context.....	1
1.2	Summary of Conceptual Understanding for Groundwater Flow.....	1
1.3	Groundwater Management	1
1.4	Groundwater Monitoring	1
1.4.1	Monitoring Network	1
1.4.2	Construction Quality Assurance of New and Replacement Monitoring Points	2
1.4.3	Maintenance of Groundwater Monitoring Points	3
1.5	Groundwater Monitoring Plan	3
1.5.1	Monitoring Programme.....	3
1.5.2	Groundwater Level Monitoring	4
1.5.3	Groundwater Quality Assessment.....	4
1.5.4	Action Plan Following Breach of a Trigger Level.....	4
1.6	Quality Assurance of Groundwater Monitoring and Sampling	5
1.6.1	Monitoring Personnel	5
1.6.2	Monitoring Procedures	5
1.6.2.1	Water Level Monitoring.....	5
1.6.2.2	Sampling.....	5
1.7	Making and Submission of Records	6

TABLES

Table GWMP1: Groundwater Monitoring Network.	1
Table GWMP2: Groundwater Monitoring Suite	3
Table GWMP3: Trigger Levels for Groundwater Quality	4
Table GWMP4: Action Plan in the Event of a Breached Trigger Level.....	5

APPENDICES

ANNEX A

Historical Groundwater Elevation



1.0 GROUNDWATER MONITORING PLAN

1.1 Report Context

This report details the Groundwater Monitoring Plan to be implemented at Hanson (UK) Limited's (Hanson) Padeswood Landfill Site (the Site).

1.2 Summary of Conceptual Understanding for Groundwater Flow

Underlying the footprint of the landfill are *in situ* superficial Drift deposits, these Drift deposits, comprise lenses of alluvial sand and gravel and Glacial Till, which comprises a sandy gravelly clay. The clay has a maximum thickness of 9 m in the north of the Site.

Some lenses of alluvial sand deposits contain perched groundwater and some are dry suggesting that they are discontinuous.

The Drift deposits overly the Coal Measures which comprise interbedded sandstones and mudstones.

As detailed in the 2010 Hydrogeological Risk Assessment for the Site ('HRA'; Appendix C of the Closure Report), the potential pathways for any determinands detected in the waste is considered to include;

- Vertical migration of leachate through the Drift deposits and unsaturated Coal Measures to groundwater present in the Coal Measures Aquifer (Secondary A). The Coal Measures are also likely to contribute to the baseflow of the River Alyn, located 2 km in the perceived downgradient (south west direction) of the Site; and
- Lateral migration of leachate through the Drift deposits or surface breakout towards the Foundry Drain to the east of the Site. Whilst there is evidence to suggest that the lenses of alluvial sand and gravel are discontinuous and no consistent hydraulic gradient of the water table exists, there remains the possibility that leachate could impact a lens of gravel adjacent to the Site which could outcrop in the bed or bank of the adjacent Foundry Drain.

Further information on the conceptual understanding for groundwater flow and the potential receptors of contamination can be found in the HRA.

1.3 Groundwater Management

No groundwater management systems are in place at the Site. Given the conceptual model presented in the HRA; there is no requirement for active groundwater management at the Site.

1.4 Groundwater Monitoring

1.4.1 Monitoring Network

Following discussions with Natural Resources Wales ('NRW') on 27 March 2015, for the purpose of monitoring potential impacts of the Site upon both the groundwater of the Coal Measures, and the surface waters of the Foundry Drain, it is proposed that the following boreholes are monitored:

Table GWMP1: Groundwater Monitoring Network.

Screened Geology	Boreholes
Up gradient Drift Deposits (Shallow)	BH1A
Down gradient Drift Deposits (Shallow)	GA1
Up Gradient Drift Deposits (Deep)	GA2
Down Gradient Drift Deposits (Deep)	GA3, GA4
Up Gradient Coal Measures	BH12
Down Gradient Coal Measures	BH14*

*Borehole inclusion subject to access improvement works



Borehole BH1A is considered to be representative of perched groundwater within the shallow superficial deposits which are unaffected by the Site.

As discussed in the December 2014 letter response to NRW queries (Appendix G of the Closure Report), GA1 is not considered to be directly representative of groundwater elevation or groundwater quality within the superficial deposits, nor the elevation of surface water within the adjacent watercourse. The small quantities of water identified in borehole GA1 is thought to originate from either; infiltration of surface water runoff from the cap through the made ground; or a small quantity of leachate which is migrating from the unlined landfill and perching on the surface of the Boulder Clay. The quantity of water identified in borehole GA1 should be considered as a reflection of recent rainfall events and is subject to the rate of infiltration from the made ground to the lower permeability superficial deposits below. There is no direct hydraulic connection to the adjacent watercourse assumed for borehole GA1. Following discussions with NRW on 27 March 2015, borehole GA1 will continue to be monitored.

Boreholes GA2, GA3 and GA4 are screened at the base of the superficial deposits, just above the interface with the Coal Measures. As discussed in the letter responses to NRW (Appendix G of the Closure Report), the water found in boreholes GA2, GA3 and GA4 are interpreted as pore water that has collected in the superficial deposits in advance of vertical infiltration into the underlying Coal Measures aquifer. The composition of this pore water is hence a reflection of the composition of leakage from the Site and by monitoring these boreholes installed at the interface of the superficial deposits and the Coal Measures can provide an indication of the water quality entering the Coal Measures aquifer.

Due to the discontinuous nature of the shallow Drift deposits, it is not possible to adequately determine the groundwater flow direction locally to the Site. However based on historic monitoring data for BH12, BH13 and BH14 in the Coal Measures or deep Drift and GA2m GA3 and GA4 in the deep Drift it is indicated that groundwater flows towards the south west in the deep Drift and Coal Measures deposits towards the River Alyn. Upon improvement of access to BH14, a broad hydraulic gradient between GA2 to GA4 and BH12 and BH14 will be established. Boreholes BH12 and BH14 are screened within the Coal Measures and thus groundwater samples obtained from boreholes are directly representative of groundwater quality within the Coal Measures aquifer up and downgradient to the Site respectively.

The locations of the groundwater monitoring boreholes are shown in Drawing 1 of the Closure Report. The historic groundwater elevation in the Coal Measures is presented in Annex 1 of this report.

1.4.2 Construction Quality Assurance of New and Replacement Monitoring Points

If required, installation of new or replacement groundwater monitoring boreholes will be undertaken in accordance with the following Construction Quality Assurance (CQA) programme which covers the elements of the design and installation.

Groundwater monitoring boreholes shall be drilled and recorded in accordance with BS 5930 Code of Practice for Site Investigations. Borehole logs and as-built installation details shall be forwarded to the NRW and shall provide the following information:

- Labelling of the borehole;
- Date of drilling/installation;
- Geological strata descriptions;
- Groundwater level (and any perched water levels);
- Design of the borehole if more than one type is being used on the Site;
- Depth of borehole (metres) and level of the bottom of the borehole in metres Above Ordnance Datum (m AOD);



- The surveyed height of the top of the borehole in metres above ordnance datum, and the surveyed ground level at the point if it differs; and
- The National Grid Reference of the boreholes (ten figures).

A CQA validation report will be provided which includes the above details and borehole construction detail drawings. All boreholes will be surveyed to Ordnance Datum. The CQA validation report will be submitted to the NRW within three months of completion.

Following installation, all groundwater monitoring boreholes will be levelled to Ordnance Datum, and an elevation reference mark permanently placed on the point. Where any monitoring well is extended or repaired the well will be resurveyed within one month and, where necessary, any monitoring results obtained in the intervening period will be corrected according to the revised level.

1.4.3 Maintenance of Groundwater Monitoring Points

Groundwater monitoring boreholes will be maintained in a condition that allows them to fulfil their required purpose. Boreholes will be inspected for damage each time that they are monitored or sampled. Any damage noted will be repaired prior to the next monitoring round. Where a borehole is damaged such that it requires replacement, a replacement borehole will be drilled before the next monitoring round, subject to availability of drilling contractor, weather conditions and access to the location, and in any event, within no later than six months.

Details of inspections of monitoring boreholes, remedial actions undertaken or replacement boreholes installed will be recorded to include relevant dates of inspections and remedial works and details of who carried out the inspection or works.

1.5 Groundwater Monitoring Plan

1.5.1 Monitoring Programme

Boreholes BH1A, BH12, BH14, GA1, GA2, GA3 and GA4 will be sampled in accordance with the schedule in GWMP2 in order to obtain data regarding groundwater quality.

Table GWMP2: Groundwater Monitoring Suite

Parameter	Units	Bi-Annually	Six-Yearly ¹
pH ²	pH Units	✓	
Temperature ³	°C	✓	
Electrical Conductivity ²	µS/cm	✓	
Dissolved Oxygen ²	mg/l	✓	
Alkalinity	mg/l	✓	
Ammoniacal Nitrogen	mg/l	✓	
Nitrate (for TON)	mg/l	✓	
Nitrite (for TON)	mg/l	✓	
Calcium	mg/l	✓	
Chloride	mg/l	✓	
Potassium	mg/l	✓	
Sodium	mg/l	✓	
Sulphate	mg/l	✓	
Chromium (dissolved)	µg/l	✓	
Copper (dissolved)	µg/l	✓	



PADESWOOD LANDFILL - GROUNDWATER MONITORING PLAN

Parameter	Units	Bi-Annually	Six-Yearly ¹
Iron (dissolved)	µg/l	✓	
Lead (dissolved)	µg/l	✓	
Magnesium (dissolved)	mg/l	✓	
Manganese (dissolved)	µg/l	✓	
Nickel (dissolved)	µg/l	✓	
Zinc (dissolved)	µg/l	✓	
Chemical Oxygen Demand	mg/l	✓	
Biological Oxygen Demand	mg/l	✓	
Total Organic Carbon	mg/l	✓	
Ionic balance	%	✓	
Hazardous Substances Identified in Leachate	-		✓

¹ Samples to be taken prior to six-yearly HRA review.

² Measurement to be taken in the field using an appropriate water quality test kit, such as a YSI multiprobe, or to be analysed for at the laboratory.

³ Measurement to be taken only in the field, using an appropriate water quality test kit, such as a YSI multiprobe.

As detailed in the Leachate Management Plan for the Site (Appendix E of the Closure Report), leachate will be screened for a suite of hazardous substances prior to each 6 yearly HRA review. Should any hazardous substances be identified in the leachate, these substances will also be analysed for in addition to the bi-annual analytical suite shown in Table GWMP2.

1.5.2 Groundwater Level Monitoring

As a minimum, groundwater levels in all boreholes will be measured bi-annually, and prior to any additional sampling not identified in Table GWMP 2. Groundwater levels will be measured to an accuracy of 0.01 m as metres below ground level, and will be calculated as a groundwater level in metres above Ordnance Datum, and will be reported along with date of measurement.

1.5.3 Groundwater Quality Assessment

Where appropriate, groundwater quality in the downgradient borehole screened within the Coal Measures BH14 will be assessed against the groundwater quality assessment criteria as outlined in Table GWMP3 below. Trigger concentrations have been set in GWMP3 in line with EAL's based on baseline quality data for the Site.

Table GWMP3: Trigger Levels for Groundwater Quality

Determinand	Units	Trigger Level Concentration	Justification
Ammoniacal Nitrogen	mg/l	TBC based on 12 months of monitoring data collected for BH12, BH14, GA2, GA3 and GA4 to be prepared as part of 6 yearly HRA review in 2016	Based on background quality
Chloride	mg/l		Based on background quality
Sulphate	mg/l		Based on background quality

1.5.4 Action Plan Following Breach of a Trigger Level

Following the breach of the trigger level, the following steps shall be taken to determine both the cause of the breached concentrations and the impact it may have upon the identified receptors in the event of a breach of trigger level. The proposed action plan for the Site is summarised in Table GWMP4.



Table GWMP4: Action Plan in the Event of a Breached Trigger Level

Contingency Action

Advise site management, environmental manager of landfill operating company and the NRW.

Repeat sampling and analysis of the borehole to confirm the breach. The second analysis results will be obtained within three weeks; if this also exceeds the control concentration, re-sampling will occur monthly for a further three months. The results of the re-sampling will be forwarded to the NRW.

Existing monitoring information will be reviewed to establish the presence of any trends or patterns. An inspection will be carried out to determine whether there has been any unusual activity or occurrence on the Site that could account for the increase in the parameter exceeding the control concentration. If the data review or site inspections indicate the landfill is the cause of the breach, actions will be implemented to prevent future failure.

The assumptions incorporated into the conceptual site model will be reviewed, along with the existing hydrogeological risk assessment, and trigger levels.

If the laboratory results from the monthly monitoring show no indications of decline over the four month period, and the evidence indicates that the Site is the most likely cause of the increase in levels, then the proposals for the implementation of mitigation measures shall be submitted to the NRW.

1.6 Quality Assurance of Groundwater Monitoring and Sampling

1.6.1 Monitoring Personnel

Sampling will be undertaken by staff appropriately trained in environmental monitoring procedures, and who are familiar with the equipment and its limitations. Technical personnel have a relevant scientific background to HND or BSc level (or equivalent). All monitoring staff undergo a period of job training and in addition external courses are used to supplement internal training. Results will be validated by the sampling personnel detailed above.

1.6.2 Monitoring Procedures

1.6.2.1 Water Level Monitoring

Before bailing or pumping the sample, the water level will be measured using the electronic dip tape which will be lowered down the borehole until the electronic bleeper sounds. The graduation on the tape will be read to give the depth at which the bleeper starts to sound. Measurement will be taken from the top level of the borehole headworks and ground level, and recorded to the nearest 0.01 m. These readings will then be converted to a level in m AOD.

1.6.2.2 Sampling

It is proposed that groundwater is sampled in one of two ways:

- With a Waterra pump; or
- With a bailer.

Where water samples are pumped using the Waterra system the following procedure will be adhered to:

- Wells have been equipped with the Waterra sampling system. Boreholes will be pumped until three times the cased well volume of water has been drawn out and the pH and conductivity of discharge has attained a stable value, as determined using suitable hand held portable equipment, or flow through cell;
- The required volume to be pumped will be calculated having first measured the water level inside the well and having dipped the bottom of the well, or taken the corresponding value obtained from the borehole drilling and construction logs. (Periodically, the bottom level of the wells obtained from dipping



will be compared with the corresponding value obtained from the borehole drilling and construction logs. This will be used to determine whether the wells have silted up and to decide on the need for any borehole maintenance);

- Boreholes will then be pumped until three times the cased well volume of water has been drawn out and a pumped sample taken for analysis. However, in low permeability strata, where recharge rates to the borehole are low, purging three well volumes may be impractical; and
- If the borehole is dewatered, a sample will be collected once water levels have recovered sufficiently to provide an adequate sample volume.

Sampling will normally be undertaken by pumped means, but where difficulties arise or pumps are unavailable, bailed samples will be taken from individual wells.

Where bailed samples are taken, a disposable bailer will be used to bail the borehole without purging the borehole.

The field determinands which are measured are pH, conductivity and temperature. The final values obtained are recorded when samples are taken and will be reported with the laboratory results subsequently obtained for the remaining determinands.

Water samples collected for the purpose of analysis for dissolved metals will either be field filtered and placed in a pre-acidified bottle or will be placed in an empty bottle and filtered at the laboratory prior to analysis.

Samples will be collected in bottles, and using preservatives where required, supplied by the laboratory and appropriate to the analysis to be undertaken.

All samples taken will be labelled with time and date of sampling, sampling locations and any other relevant information. Alternatively bar coded sample bottles may be used which detail in bar coded form the above information and additionally details of analysis required.

Samples will be received by the laboratory within a timescale that is appropriate to the holding time for the analysis required. The laboratory routinely report QA data relating to the samples condition and whether samples were received within the analysis holding time.

Samples that are stored overnight will either be stored in a refrigerator or cool box. All samples will be analysed at a laboratory under UKAS accreditation which operates externally verified quality control procedures and checks on analytical work. These include spiked samples, blanks etc. Due to the large batches of samples that are processed by such laboratories, the QA/QC checks implemented are efficient in identifying any quality control failures.

During each monitoring round for leachate and groundwater, a duplicate sample will be taken at one location in order to quality assure the repeatability of laboratory analysis.

1.7 Making and Submission of Records

Records will be kept of determinands and sampling points analysed, date of sampling, sampler, results, units and any repeat analysis or laboratory comment, or internal assessment, on the validity of the results.

A copy of the results of sampling and analysis of groundwater and levels measured for groundwater, calculated to metres above Ordnance Datum, will be forwarded to the NRW on an annual basis.



Report Signature Page

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ANNEX A

Historical Groundwater Elevation

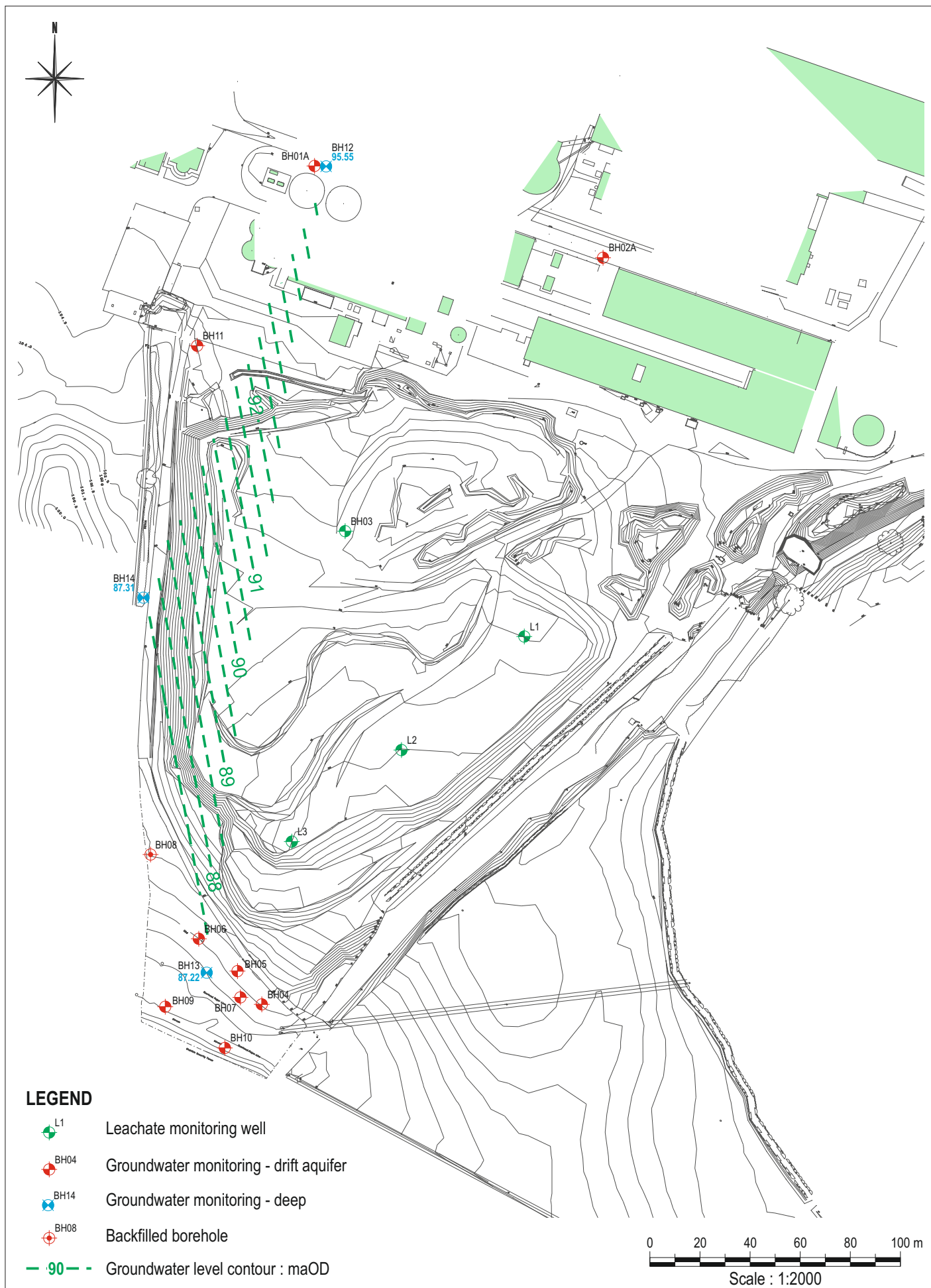


Figure 5:
Groundwater Elevation in the Coal Measures
Padeswood Works Landfill Site

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APPENDIX I

Surface Water Monitoring Plan



September 2015

HANSON CEMENT WORKS - PADESWOOD LANDFILL SITE

Appendix I - Surface Water Monitoring Plan

Submitted to:
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REPORT



Report Number 1419741.505/B.0

Distribution:

Hanson (UK) Ltd.- 1 copy (pdf)
NRW - 1 copy (pdf)
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Table of Contents

1.0	SURFACE WATER MONITORING PLAN.....	1
1.1	Report Context.....	1
1.2	Surface Water Management and Maintenance	1
1.3	Surface Water Monitoring	1
1.3.1	On-Site Surface Water Monitoring Points	1
1.3.2	Downstream NRW Surface Water Monitoring Points	1
1.3.3	Summary of Local Surface Water Quality	1
1.3.4	Surface Water Monitoring Schedule.....	2
1.3.5	Action Plan Following Breach of a Trigger Level.....	3
1.4	Quality Assurance of Surface Water Monitoring	4
1.4.1	Monitoring Personnel	4
1.4.2	Monitoring Procedures	4
1.5	Making and Submission of Records	4
2.0	REFERENCES.....	4
 TABLES		
	Table SWMP1: Groundwater Monitoring Suite.....	2
	Table SWMP2: Surface Water Quality Trigger Levels	3
	Table SWMP3: Action Plan in the Event of a Breached Trigger Level	3
 APPENDICES		
DRAWINGS		
ANNEX A		
Surface Water Monitoring Data		



1.0 SURFACE WATER MONITORING PLAN

1.1 Report Context

This report details the Surface Water Monitoring Plan to be implemented at Hanson (UK) Ltd's (Hanson) Padeswood Landfill Site (the Site).

1.2 Surface Water Management and Maintenance

The surface water management system has been designed to function independently by gravity drainage. However, the system may require simple maintenance from time to time. The surface water management system will be inspected bi-annually to ensure that the system is not damaged or its effectiveness impaired. The need for such maintenance will become evident during routine site inspections, action will be taken to clear any blockages or impediments to flow, such as fallen vegetation, encountered during Site inspections.

Maintenance will include the clearance of growing or fallen vegetation, the making good of any damage caused by agricultural activities or by burrowing animals and the removal of any accumulations of sediment which may reduce the carrying capacity of the system. The details of any remedial actions that are taken in order to remedy problems apparent in the drainage system will be entered in the Site diary.

1.3 Surface Water Monitoring

1.3.1 On-Site Surface Water Monitoring Points

'Foundry Drain', a tributary to Black Brook, flows along the eastern and southern boundary of the Site and is designated a Controlled Water by Natural Resources Wales ('NRW'). There are three surface water locations along Foundry drain where surface water quality is monitored by Hanson: 'Surface Water Upstream'; 'Surface Water Downstream', and 'Upstream of Trade Effluent'.

Water from the Lagoon also flows into Foundry Drain, so another location, 'Outlet from Lagoon' is monitored periodically under the Environmental Permit for the adjacent cement works. The Lagoon Outlet monitoring point (formerly known as the Trade Effluent Monitoring Point) is located between the upstream and downstream monitoring points.

All surface water monitoring locations are displayed on Drawing I-1 of this Plan.

1.3.2 Downstream NRW Surface Water Monitoring Points

Additionally to the on-site monitoring points discussed above, the NRW monitors surface water quality downstream of the Site at locations 'SPT837' and 'SPT839', also displayed on Drawing I-1 of this Plan.

'SPT837' is located on Bistre Brook prior to its confluence with Black brook. It should be noted that the Bistre Brook catchment includes both surface water from the watercourse downstream of the nearby Sewage Works and Foundry Drain downstream of Site. 'SPT839' is located downstream of the confluence of Bistre Brook with Black Brook.

1.3.3 Summary of Local Surface Water Quality

Appendix G of the Closure Report details communications with the NRW where the potential for small amounts of perched groundwater to migrate into the surface waters of Foundry Drain is discussed. The Hydrogeological Risk Assessment for the site (Appendix H of the Closure Report) identifies ammoniacal nitrogen, chloride and sulphate as the source term contaminants within leachate.

There is observed to be little to no flow within Foundry Drain during summer months, and thus it is considered that when elevated concentrations of contaminants are present in Foundry Drain adjacent to the site during the summer, Foundry Drain is not flowing.

The NRW has provided surface water quality data from locations 'SPT837' and 'SPT839'. This data is provided as Annex A of this Plan. A review of the NRW surface water quality data shows that only on isolated occasions are the source term contaminants present within the downstream monitoring data in



PADESWOOD LANDFILL - SURFACE WATER MONITORING PLAN

elevated concentrations, although there is no evidence to suggest that this derives from the site or from adjacent land users such as agricultural or sewage treatment.

1.3.4 Surface Water Monitoring Schedule

Surface water monitoring locations 'Surface Water Upstream', 'Surface Water Downstream', and 'Upstream of Trade Effluent' will be monitored in accordance with the schedule in Table SWMP1.

Table SWMP1: Groundwater Monitoring Suite

Parameter	Units	Quarterly ^{1,2}	Six-Yearly ³
pH ⁴	pH Units	✓	
Temperature ⁵	°C	✓	
Electrical Conductivity ⁴	µS/cm	✓	
Dissolved Oxygen ⁴	mg/l	✓	
Alkalinity	mg/l	✓	
Ammoniacal Nitrogen	mg/l	✓	
Nitrate (for TON)	mg/l	✓	
Nitrite (for TON)	mg/l	✓	
Calcium	mg/l	✓	
Chloride	mg/l	✓	
Potassium	mg/l	✓	
Sodium	mg/l	✓	
Sulphate	mg/l	✓	
Chromium (dissolved)	µg/l	✓	
Copper (dissolved)	µg/l	✓	
Iron (dissolved)	µg/l	✓	
Lead (dissolved)	µg/l	✓	
Magnesium (dissolved)	mg/l	✓	
Manganese (dissolved)	µg/l	✓	
Nickel (dissolved)	µg/l	✓	
Zinc (dissolved)	µg/l	✓	
Chemical Oxygen Demand (COD)	mg/l	✓	
Biological Oxygen Demand (BOD)	mg/l	✓	
Total Organic Carbon	mg/l	✓	
Ionic balance	%	✓	
Hazardous Substances Identified in Leachate	-		✓

¹ To be reviewed following first year.

² Subject to 'flowing' conditions following rainfall events, as discussed below.

³ Samples to be taken prior to six-yearly HRA review.

⁴ Measurement to be taken in the field using an appropriate water quality test kit, such as a YSI multiprobe, or to be analysed for at the laboratory.

⁵ Measurement to be taken only in the field, using an appropriate water quality test kit, such as a YSI multiprobe.



Following discussions with the NRW (Appendix G of Closure Report), samples will only be taken from surface water monitoring locations when they are observed to be flowing e.g. following rainfall events. Determination of adequate flow will be made by the sampling engineer. A minimum of two months will be left between each monitoring round to ensure that the samples are representative of different times of the year.

During the first year of closure, four samples will be obtained from each surface water monitoring location per annum. A review of monitoring data will be made after the first year, with a view to reducing monitoring frequency to bi-annually.

1.3.5 Action Plan Following Breach of a Trigger Level

Surface water quality at locations 'Surface Water Upstream', 'Surface Water Downstream', and 'Upstream of Trade Effluent' will be subject to assessment against the following water quality assessment criteria:

Table SWMP2: Surface Water Quality Trigger Levels

Determinand	Units	Trigger Level Concentration	Justification
Ammoniacal Nitrogen as N	mg/l	0.62	Upstream Quality*
Chloride	mg/l	250	Freshwater EQS
Sulphate	mg/l	400	Freshwater EQS

**95th percentile of concentrations observed July 2014 to July 2015. Less than detect values assumed at limit of detection.*

Trigger concentrations have been set in Table SWMP2 in line with EAL's based on baseline quality data for the Site. Trigger concentrations apply to the downgradient surface water monitoring location.

Following the breach of a trigger level at any of the surface water monitoring locations on two consecutive occasions, the following steps shall be taken to determine both the cause of the breached concentrations and the impact it may have upon the identified receptors in the event of a breach of trigger level. The proposed action plan for the Site is summarised in Table SWMP3.

Table SWMP3: Action Plan in the Event of a Breached Trigger Level

Contingency Action

Advise site management, environmental manager of landfill operating company and NRW.

Repeat monitoring of the borehole to confirm the breach. The second monitoring results will be obtained within two weeks. If this also exceeds the trigger level, monitoring will occur monthly for a further three months. The results of the re-monitoring will be forwarded to NRW.

Existing monitoring information will be reviewed to establish the presence of any trends or patterns inclusive of considering relative pressure and peak flow data. An inspection will be carried out to determine whether there has been any unusual activity or occurrence on the Site that could account for the increase in the parameter exceeding the trigger level. If the data review or site inspections indicate the landfill is the cause of the breach, actions will be implemented to prevent future failure.

The assumptions incorporated into the conceptual site model will be reviewed, along with the existing trigger levels.

If the results from the monthly monitoring show no indications of decline over the three to four month period, the relative pressure and peak flow data indicate the potential for lateral migration of landfill gas, and the evidence indicates that the Site is the most likely cause of the increase in levels, then the proposals for the implementation of additional monitoring measures shall be submitted to NRW.



1.4 Quality Assurance of Surface Water Monitoring

1.4.1 Monitoring Personnel

Sampling will be undertaken by staff appropriately trained in environmental monitoring procedures, and who are familiar with the equipment and its limitations. Technical personnel have a relevant scientific background to HND or BSc level (or equivalent). All monitoring staff undergo a period of job training and in addition external courses are used to supplement internal training. Results will be validated by the sampling personnel detailed above.

Calibration and servicing of equipment will be undertaken, and will be maintained, in accordance with manufacturer specifications and QA procedures.

1.4.2 Monitoring Procedures

An assessment will be made by the engineer as to whether the monitoring location is flowing. Should adequate flow be observed, then sampling will occur.

The appropriate sample bottle will be half filled by submerging it in the water at the sampling point. The bottle will then be filled to the top and an air tight cap fitted so excluding any air bubbles from the bottle.

Samples will be collected in bottles supplied by the laboratory and appropriate to the analysis to be undertaken. Bottles will normally be one litre PET, filled so as to exclude all air, and fitted with an air tight cap.

All samples taken will be labelled with time and date of sampling, sampling locations and any other relevant information. Alternatively bar coded sample bottles may be used which detail in bar coded form the above information and additionally details of analysis required.

Samples will be received by the laboratory within a timescale that is appropriate to the holding time for the analysis required. The laboratory routinely report QA data relating to the samples condition and whether samples were received within the analysis holding time.

Samples that are stored overnight will either be stored in a refrigerator or cool box. All samples will be analysed at a laboratory under UKAS accreditation which operates externally verified quality control procedures and checks on analytical work. These include spiked samples, blanks etc. Because of the large batches of samples that are processed by such laboratories, the QA/QC checks implemented are efficient in identifying any quality control failures.

During each monitoring round for leachate, groundwater and surface water, a duplicate sample will be taken at one location in order to quality assure the repeatability of laboratory analysis.

Results will be validated by the sampling personnel detailed above.

1.5 Making and Submission of Records

Records will be kept on-site of determinands and sampling points analysed, date of sampling, sampler, results, units and any repeat analysis or laboratory comment, or internal assessment, on the validity of the results.

A copy of the results of sampling and analysis of surface water will be forwarded to the NRW on an annual basis.

2.0 REFERENCES

Golder Associates (UK) Ltd, 2014. Padeswood Landfill: Response to NRW Queries Regarding Interpretation of Gas and Groundwater Quality. Report number: 13514240032.503/A.0. December 2014.



Report Signature Page

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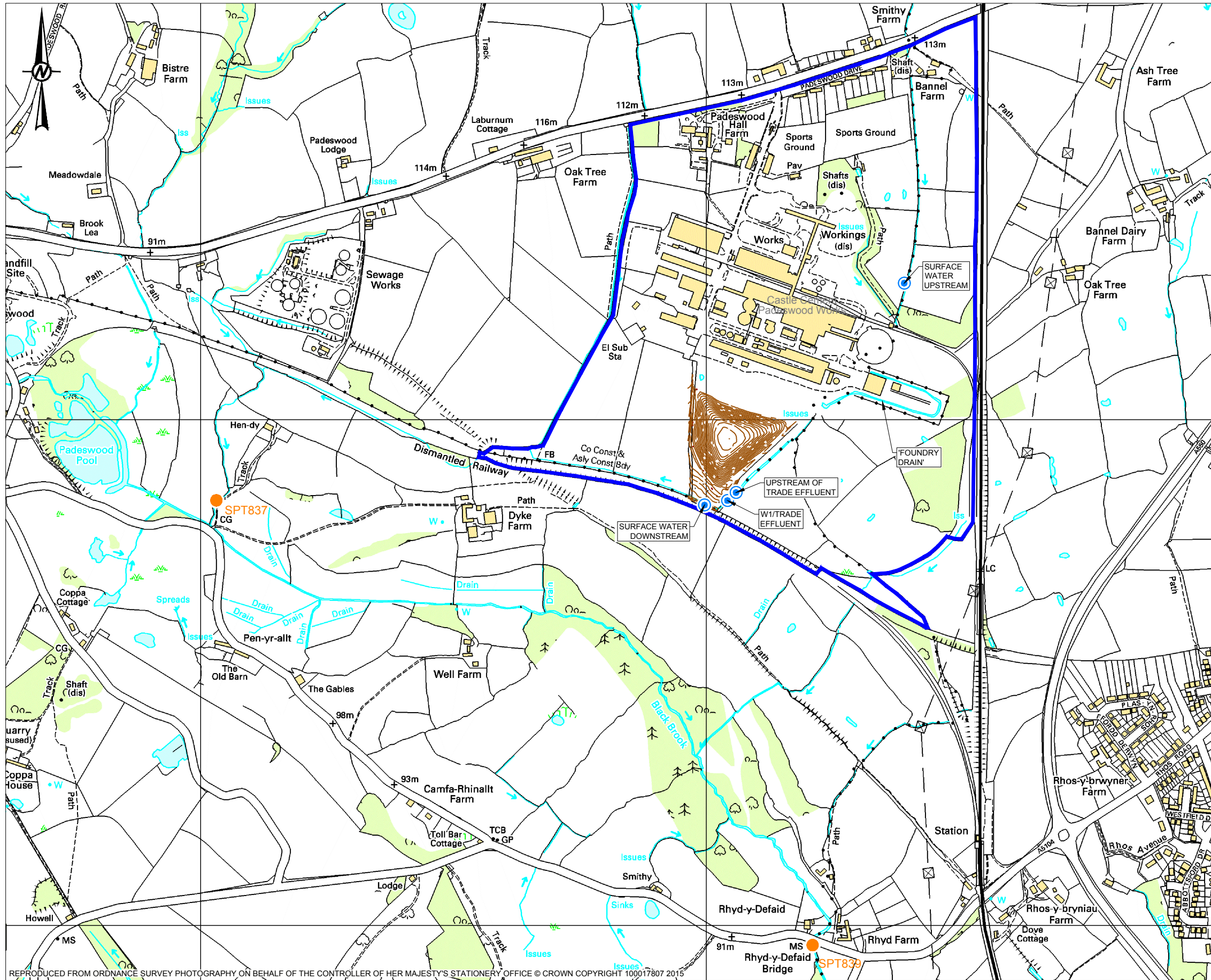
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DRAWINGS



LEGEND

- SITE OWNERSHIP BOUNDARY
- EXISTING SURFACE WATER MONITORING LOCATIONS
- NRW MONITORING LOCATIONS

0 200 400
1:8,000 METRES

CLIENT
HANSON (UK) LTD

CONSULTANT
Golder Associates

YYYY-MM-DD
2015-08-11

PREPARED
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DESIGN
SN

REVIEW
R.JL

APPROVED
R.JL

PROJECT
PADESWOOD LANDFILL SITE

TITLE
SURFACE WATER MONITORING LOCATION PLAN

PROJECT No.
1419741

CONTROL
0001-CW-0002

Rev.
A

DRAWING
I-1

Path:\work\1419741\main\1419741_CADD_GIS_Graphics\Hanson_UK_Ltd\padeswood\09_PROJECTS\1419741_Padeswood Landfill Site\02_PRODUCTION\DWG - File Name: 1419741-0001-CW-0002.dwg

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ISO A3



ANNEX A

Surface Water Monitoring Data

WIMS Result Data Extract for Sampling Point 837 BISTRE BROOK U/S BLACK BROOK - SJ2803061840

Samples taken between 01/01/2005 and 15/07/2015 for Sampling Purpose *

Note - Statistics have not been included as results contain character-base result qualifiers. Values highlighted at (<- 3 * Standard deviation)

Spt Ref	Date Taken	Time Taken	Purpose	0002 Cond @ 20C (uS/cm)	0076 Temp Water (CEL)	0077 Cond @ 25C (uS/cm)	0085 BOD ATU (mg/l)	0092 COD as O2 (mg/l)	0111 Ammonia(N) (mg/l)	0116 N Oxidised (mg/l)	0117 Nitrate-N (mg/l)	0118 Nitrite-N (mg/l)	0135 Sld Sus@105C (mg/l)	0172 Chloride Ion (mg/l)	0180 Orthophosph (mg/l)	0182 SK02 Rv (mg/l)	3267 Type of Flow (Coded)	7274 HHM Ident. (UNITLESS)	7868 NO FLOW/SAMP (Coded)	7887 CHLOROPHYLL (ug/l)	7888 CHLOR A (ug/l)	9901 O Diss %sat (%)	9924 Oxygen Diss (mg/l)
837	06/Jan/2005	1240	PI	592	8.41	1.1	16.3	0.62	0.92	9.88	0.95	6	48.7	1.76	4.59	7.9	79				86.1	10.08	
837	10/Feb/2005	1000	PI	893	7.23	4.7	63	1.69	4.129	4	132	42	4.89	1.17	4.09	12.9	62				81.2	9.77	
837	15/Mar/2005	1230	PI	932	7.77	1.09	26	1.78	3.77	3.72	048	7	121	247	3.13	12.1	60				103	12.22	
837	20/Apr/2005	1050	PI	488	7.64	6.6	83	.46	2.15	2.1	.05	35	36.57		2.85	4.77	74			5.36	90.7	10.82	
837	12/May/2005	1315	PI		10.88			049	2.88	2.82	056		288	4.23	4.23	3.34	79			11.8	93.4	10.09	
837	10/Jun/2005	1425	PI		13.75			084	1.1	1.08	027		18	4.71	4.71	54	54				84.6	8.75	
837	28/Jul/2005	1325	PI		13.42			1.44	1.52	1.4	117		414	7.56	7.56	83	83				70.9	7.38	
837	12/Aug/2005	0955	PI																				
837	16/Sep/2005	1225	PI		12.24			<.03	2.51	2.42	092			18	13.86	0	60				90.5	9.68	
837	18/Oct/2005	1305	PI		11.53			.691	<.2	1.87	013			438	8.21	2.9	74				72.1	7.84	
837	17/Nov/2005	0955	PI		5.02			.069	3.01	2.87	144			261	7.99	83	83				89.2	11.37	
837	14/Dec/2005	1000	PI		6.8			.255	3.91	3.8	107			117	11.1	74	74				93.7	11.42	
837	20/Jan/2006	1300	PI		6.43			.067	4.7	4.66	042			214	9.66	2.4	88				93.4	11.49	
837	15/Feb/2006	0955	PI		5.91			.495	2.69	2.62	073			349	7.01	74	74				88.8	11.06	
837	14/Mar/2006	1030	PI		4.38			.201	3.39	3.34	054			275	5.12	74	74				92.4	11.98	
837	19/Apr/2006	1300	PI		1.32			1.57	5.85	5.7	154			4.57	4.57	98	98				93.3	10.68	
837	12/May/2006	1005	PI		12.96			.082	2.58	2.55	032			227	6.76	7.71	88				99.4	10.46	
837	12/Jun/2006	1350	PI		16.74			<.03	.67	.666	<.004			206	6.61	60	60				78.4	7.6	
837	11/Jul/2006	0940	MU																				
837	11/Aug/2006	1310	MU																				
837	06/Sep/2006	1350	MU		17.01			<.03	1.37	1.33	04			348	15.6		60				52.2	5.03	
837	24/Oct/2006	1005	MU		9.85			<.03	9.27	9.25	022			257	12.2	62	62				79.3	8.97	
837	15/Nov/2006	1005	MU		9.88			<.03	4.36	4.36	06			423	12.5	61	61				85.3	9.62	
837	07/Dec/2006	1305	MU		8.01			1.05	6.38	6.3	082			473	9.83	63.8	62				86.1	10.18	
837	26/Jan/2007	1120	MU		5.82			.258	5.47	5.43	043			092	10.7	88	88				93	11.62	
837	15/Feb/2007	1005	MU		5.47			.243	2.79	2.79	062			133	12.6	88	88				101	12.77	
837	16/Mar/2007	1029	MU		6.22			<.03	1.64	1.61	03			033	9.3	107	107				97.9	12.1	
837	17/Apr/2007	1103	MU		10.29			<.03	1.03	1.02	0075			078	3.78	60	60				108	12.08	
837	14/May/2007	1114	MU		11.14			.245	21.4	21.2	156			159	10.2	107	107				94.8	10.4	
837	18/Jun/2007	1131	MU		14.59			14.59	4.33	4.33	0958			082	15.6	61	61				88.4	8.97	
837	05/Jul/2007	1055	MU		13.94			.095	2.73	2.61	122			188	12.4	83	83				95.2	9.8	
837	21/Aug/2007	1124	MU		13.43		<.1	.041	2.02	2	0156		23.4	57.3	1.76	97	97				88.9	9.25	
837	13/Sep/2007	1212	MU		14.02			123	1.3	41	.76		744	108	187	97	97				79.9	8.2	
837	12/Oct/2007	1429	MU		13.05		<.1	.043	.78	.774	0063		14.2	84.1	184	11.8	88				82.3	8.63	
837	12/Nov/2007	1134	MU		6.14			.133	5.49	5.43	0582		3.4	51.8	226	11.3	95				93.9	11.62	
837	03/Dec/2007	1133	MU		7.11			.532	1.9	1.9	067		20.6	30	163	9.8	83				109	13.13	
837	25/Jan/2008	1042	MU		6.91		<.1	.163	3.13	3.09	0415		8.1	49.2	136	10.8	95				106	12.85	
837	13/Feb/2008	1045	MU		4			.913	2.2	2.49	121		21.6	71.9	10.3	88	88				102	13.32	
837	06/Mar/2008	1229	MU		7.47			1180	10.8	45	<.03		1.43	32.9	13	8.86	95				112	13.35	
837	28/Apr/2008	1045	MU		8.94			778	3.4	54	.105		2.29	53.4	215	8.35	83				104	12.06	
837	12/May/2008	1015	MU		13.5			1050	1.89	1.89	0152		18.4	78.4	9.17	4.5	78				103	10.67	
837	16/Jun/2008	1100	MU		11.45			1660	2.1	33	.155		.91	0397	6.5	158	90				85.4	9.28	
837	11/Jul/2008	0955	MU		13.67			850	1.2	37	.046		4.7	4.68	016	5.7	134				86	8.9	
837	01/Sep/2008	1112	MU															0					
837	26/Sep/2008	0959	MU		10.9			1012	<.1	23	.037		1.66	1.66	<.004	<.3	81.2				6.3	90.1	9.93
837	03/Nov/2008	1320	MU		7.99			727	1.9	37	.73		1.66	1.61	0534	6.7	193				7.3	92.7	11
837	26/Nov/2008	1004	MU		7.69			1063	1.5	30	.063		1.67	1.61	0278	6.3	141				11.2	95.6	11.4
837	15/Dec/2008	1255	MU		5.77			683	2	18	.391		5.64	5.64	104	46.5	701				1.5	82.6	10.3
837	07/Jan/2009	1415	MU		1.08			1314	1.7	25	.083		2.74	2.73	0076	14	14				1.4	94	13.3
837																							

WIMS Result Data Extract for Sampling Point 839 BLACK BROOK AT RHYD-Y-DEFAID - SJ2921060960

Samples taken between 01/01/2005 and 15/07/2015 for Sampling Purpose *

Sgt Ref		Date Taken	Time	Value	Purpose	0051 pH (PHUNITS)	0055 Cond @ 25C (uS/cm)	0059 Temp Water (C/L)	0077 Cond @ 25C (uS/cm)	0085 BOD ATU (mg/l)	0082 COD as O2 (mg/l)	0111 Ammonia-N (mg/l)	0116 N Oxidised (mg/l)	0119 Nitrite-N (mg/l)	0118 Nitrate-N (mg/l)	0119 NH4 un-ion (mg/l)	0165 Silicic Acid (mg/l)	0162 Alky pH 4.3 (mg/l)	0172 Chloride Ion (mg/l)	0180 Orthophosph (mg/l)	0185 Silicic Ry (mg/l)	0182 Phosphate (mg/l)	0211 Potassium-K (mg/l)	6480 Cu Filtered (ug/l)	6485 Zinc-as 21 (ug/l)	7274 HM1 Item (UNITLESS)	7484 NITROGENP (UNITLESS)	7687 CHLOROPHYLL (ug/l)	7688 CHLOR A (ug/l)	8001 O Diss Head (%)	8024 Oxygen Diss (mg/l)	
839	05Jan2005	1300	NU	7.79		607	7.95			9	16.5		124	8.79	8.79	043		00121	6	53.6	1.32		2.57		9.65		79		6.07		84.2	9.96
839	10Feb2005	1055	NU	7.86		650	8.21			4.2	21		153	15.3	15.3	12	00134	22	72.5	1.47		4.45		0.75		107		67		10.15		
839	15Mar2005	1345	NU	7.79		779	9.29			0.72	19		125	12.5	12.5	027		00076	9	71.7	1.69		3.83		12.7		60		6.09		11.02	
839	20Apr2005	1155	NU	7.57		696	8.21			440			2.91	3.24	3.24	068		00456	18		32.63		4.19		11		74		9.57		10.3	
839	12May2005	1300	NU	7.9			11.10						< 0.03	7.99	7.95	038		<00048					1.18		2.52		79		11.54			
839	10Jun2005	1415	NU	7.81			10.03						0.044	7.88	7.92	087		00075				0.01	4.32		2.79		54		92.6		9.41	
839	28Jul2005	1425	NU	7.87			12.9						3.09	9.65	4.22	143	0377					6.94	1.34		6.84		83		9.96		10.8	
839	12Aug2005	1050	NU	7.43			15.65						0.083	10.41	10.3	088		00083				2.57	3.52		9.85		60		66.1		6.56	
839	16Sep2005	1325	NU	7.54			12.2						< 0.03	12.2	12.2	051		00072				13.24	9.35		10.47		60		67.3		7.19	
839	18Oct2005	1415	NU	7.86			12.3						1.46	7.52	7.41	111	0023					1.39	2.69		6.66		69		7.47			
839	17Nov2005	1100	NU	7.8			6.22						0.097	5.65	5.6	053		00085				7.51	2.95		6.66		83		63.8		10.36	
839	14Dec2005	1100	NU	7.64			7.63						2.97	5.57	5.5	073		0119				8.02	1.35		5.4		95		88.2		9.36	
839	20Jan2006	1405	NU	7.78			7.78						0.041	9.6	9.55	055		00037				6.9	10.7		3.22		13		88		10.19	
839	15Feb2006	1105	MS	7.85			6.0						61.4	4.64	4.5	159	00418					1.36	7.31		2.93		74		8.82			
839	14Mar2006	1125	NU	7.69			5.5						826	4.74	4.71	035		00034				6.996	5.27		3.82		74		86.1		10.84	
839	19Apr2006	1205	NU	7.88			12.24						1.24	5.95	5.9	031		011				1.07	2.94		16.6		86		9.83			
839	12May2006	1100	NU	7.67			18						0.066	6.17	6.1	071		00092				5.51	22.8		2.6		87		85.1		8.96	
839	12Jun2006	1305	NU	7.51			17.37						367	12.28	12.1	138		00078				1.25	5.01		4.55		60		67		6.41	
839	11Jul2006	1045	NU	7.63			15.6						0.066	1.8		055		00078				0.5	15.5		14.8		61		70.1		6.96	
839	11Aug2006	1440	NU	7.83			14.71						< 0.03	12.4	12.2	152		< 00033				1.66	12		2.6		81		11.9		8.25	
839	06Sep2006	1235	NU	7.85			17.03						0.09	8.78	8.65	13	00032					1.16	10.7		3.2		60		54.3		5.23	
839	24Oct2006	1100	NU	7.44			10.89						< 0.03	11.8	11.7	122		< 0006				2.22	10.4		3.8		95		67.7		7.39	
839	15Nov2006	1245	NU	8.08			11.33						0.09	8.09	8.5	073		0119				4.68	19.8		5.5		87		88.2		10.31	
839	07Dec2006	1250	NU	8.09			8.45						324	3.53	3.5	029		00021				2.95	4.5		21.9		95		87.3		10.39	
839	18Jan2007	1315	MS	7.62			7.75						446	5.98	5.87	107		00035				1.07	15.3		3		107		98.1		11.64	
839	16Mar2007	1010	MS	7.74		667	6.75						< 0.03	5.76	5.71	055		< 00024				232	12.3		3.8		98		10.99			
839	17Apr2007	1525	MS	8.02		653	11.79						0.08	14.8	14.8	037		0014				10.2	10.2		3.8		62		107		11.09	
839	14May2007	1535	MS	7.55		608	7.05						0.06	1.4	7.29	054		00034				6.7	6.8		6.7		95		7.64			
839	09Jun2007	1145	MS	7.68			13.87						583	4.94	4.94	056		00108				531	9.95		3.3		72		72.6		7.48	
839	31Jul2007	1115	MS	7.81			12.67						0.08	5.09	5.03	053		00141				241	39.8		4.43		88		9.32			
839	06Aug2007	1410	MS	7.73			16.19						117	8.57	8.5	073		00184				10.2	21.7		10.7		107		81.5		7.97	
839	13Sep2007	1445	MS	7.65			15.16						0.06	13.3	13.2	067		0008				198	44.5		2.15		103		9.31			
839	09Oct2007	1425	MS	7.47			13.74						8.3	12.4	12.1	291		011				125	46.2		2.66		95		67.8		7.01	
839	12Nov2007	1455	MS	7.82			625						119	8.84	8.6	045		00121				9.4	19.5		9.72		87		82.4		9.74	
839	03Dec2007	1400	MS	7.35			470						6	15.6	15.3	073		00382				138	61		93.4		62		93.7		12.05	
839	30Jan2008	1425	MS	7.67			12.2						10.9	9.22	9.2	102		00086				159	11.7		8.9		62		10.56			
839	13Feb2008	1400	MS	7.55			7.05						0.94	8.96	8.94	028		00098				16.2	1.15		9.53		90		96.4		11.66	
839	21Mar2008	1325	MS	7.84			8.66						0.69	5.91	5.39	053		00079				178	38.8		3.3		90		91.1		10.99	
839	26Apr2008	1305	MS	7.57			6.11						0.62	7.8	7.6	025		00064				29	1.62		8.18		73		86.1		9.56	
839	09May2008	0930	MS	7.51			12.03						0.86	6.46	6.41	046		00148				217	42.4		8.3		95		77.2		8.29	
839	16Jun2008	1410	MS	7.88			16.1						0.93	7.88	7.88	016		00176				14.27	175		10.4		87		93.8		9.82	
839	11Jul2008	1025	MS	7.91			14.51						1.37	6.38	6.27	109		00113				178	1.11		3.3		11		75		7.62	
839	01Sep2008	1440	MS	7.87			16.1						0.5	12	12	037		00168				159	15.8		14.8		88		74.8			
839	26Sep2008	0930	MS	7.12			11.91						1.3	10.1	10	056		00034				8.5	1.94		41		93		14.2		8.85	
839	03Nov2008	1040	MS	7.81			643						134	5.35	5.32	031		0014				135	42.8		9.13		10.2		84.5		9.92	
839	26Nov2008	1455	MS	7.72			625						0.63	6.39	6.17	018		00047				23	8.4		9.35		87		87.1		10.1	
839	15Dec2008	1410	MS	7.56			5.52						1.7	5.91	5.81	104		00179				205	44.5		6.63		95		91.4		11.5	
839	06Jan2009	1423	MS	7.63			2.1						1.17	6.32	6.27	177		00132				127	5.4		23.8		94		10.3			
839	05Feb2009	1411	MS	7.55			1451						7.69	7.68	7.58	066		00031				149	272		1.16		4.4		80.6		10.4	
839	03Mar2009	1220	MS	7.7			7.67						2.92	7.8	7.55	111		00072				47.7	1.27		9.1		4		82.5		9.83	
839	14Apr2009	1240	MS	7.57			12.40						11.7	8.24	8.24	055		00067				15.7	4.2		7.79		12		105.7			
839	21May2009	0930	MS	7.66			13.52						1.8	20	13.5	035		00305				10.9	22		3.3		95		88.9		9.23	
839	19Jun2009	0900	MS	7.49			14.35						14.7	14.7	14.7	044		00104				149	15.2		10.8		95		79.9		8.4	
839	17Jul2009	1524	MS	7.51			15.06						8.3	6.7	6.35	104		0116				93	32.2		63</							

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APPENDIX J

Reporting of Significant Environmental Effects



PADESWOOD LANDFILL CLOSURE REPORT

Part A

Permit Number
Name of operator
Location of Facility
Time and date of the detection

(a) Notification requirements for any malfunction, breakdown or failure of equipment or techniques, accident, or emission of a substance not controlled by an emission limit which has caused, is causing or may cause significant pollution

To be notified within 24 hours of detection

Date and time of the event
Reference or description of the location of the event
Description of where any release into the environment took place
Substances(s) potentially released
Best estimate of the quantity or rate of release of substances
Measures taken, or intended to be taken, to stop any emission
Description of the failure or accident.

(b) Notification requirements for the breach of a limit

To be notified within 24 hours of detection unless otherwise specified below

Emission point reference/ source
Parameter(s)
Limit
Measured value and uncertainty
Date and time of monitoring
Measures taken, or intended to be taken, to stop the emission



PADESWOOD LANDFILL CLOSURE REPORT

(c) Notification requirements for the detection of any significant adverse environmental effect

To be notified within 24 hours of detection

Description of where the effect on the environment was detected
Substances(s) detected
Concentrations of substances detected
Date of monitoring/sampling

Part B - to be submitted as soon as practicable

Any more accurate information on the matters for notification under Part A.
Measures taken, or intended to be taken, to prevent a recurrence of the incident
Measures taken, or intended to be taken, to rectify, limit or prevent any pollution of the environment which has been or may be caused by the emission
The dates of any unauthorised emissions from the facility in the preceding 24 months.

Name*

Post

Signature

Date

* authorised to sign on behalf of the operator

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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