

TROSTRE LANDFILL SITE, LLANELLI

SITE CONDITION REPORT

OCTOBER 2011

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1.0 INTRODUCTION

ExCAL Limited was commissioned to carry out a site condition report on behalf of Carmarthenshire County Council (CCC) for a site in Trostre, Llanelli; *Land off Trostre Works Link Road*, NGR: 252799 199700.

This site condition report will accompany the surrender of the existing Inert Landfill Licence No. LLN/WD/007. The report is designed to summarise the information gathered in relation to the site over its operational and non-operational life to conclude whether the development has had a lasting impact upon the state of the environment.

This site condition report should be read in conjunction with the following reports found in Appendix D: -

- Preliminary Risk Assessment (PRA) (October 2009) including data supplied by CCC from Mott MacDonald's ground investigation. ExCAL Limited;
- Site Investigation Report (August 2010). ExCAL Limited;
- Monitoring Report (October 2011). ExCAL Limited.

All chemical testing results have been compiled and are presented in Appendix B.

All geotechnical logs (borehole, trial pit and dynamic probe) have been compiled and are presented in Appendix C.

2.0 SITE DETAILS

2.1 Site Location

The site is located approximately 300m east of Parc Trostre, near Cefncaeau, Llanelli, Carmarthenshire. The approximate centre of the site is location at NGR: 252799 199700. The site location is shown in Drawing 44-05-01.D02.

2.2 Site Description

A description of the site has been generated from a review of the existing information (Preliminary Risk Assessment (PRA) (October 2009), which is presented in Appendix D.

The site is surrounded by commercial and industrial land and is bisected by access roads and a roundabout. It is bounded to the south and west by mature trees and shrubs and to the north by shrubs and tall grasses. The access roads predominantly cover the western portion of the site. The area of the site to the west of the roads is elevated above the remainder of the site and comprises tall grasses and shrubs. The area east of the roads is surfaced with crushed aggregate and bunded with soil.

The nearest surface water is contained within a part culverted drainage trench, which runs parallel to the northern boundary of the site, passing beneath the roads and elevated ground to meet the River Dafen to the west.

Trostre Tin Plate Works exists approximately 100m to the south of the site and the A484 road passes northwest to southeast adjacent to the north-eastern boundary of the site.

Client supplied information on the contamination status of the site states that material obtained on-site and used for surface re-profiling is within the lower threshold concentration limits quoted in *Guidance for the disposal of contaminated soils*. This is evidenced in the Environment Agency letter dated 24 June 2002 (reference DJ/CL/SITE/Trostre). The site licence was issued on 2 March 1994 and the site ceased to accept waste on the 26 February 2000.

2.3 Site History

Analysis of the available historical maps provides a basis for the assessment of potential historic contamination through associated land-use. A summary of the history of the site is provided in Table 1 below.

Table 1 – Significant features, changes and developments on-site and in surrounding areas

Dates	Scale	Significant features, changes and developments	
		On site	Surrounding areas
1878 – 1901	1:1,250 1:10,560	& Undeveloped farmland with two water courses; one running southwest across the site to the River Dafen and another running through the centre of the site to a small pond on the southern site boundary.	Residential dwellings surround the site to the northeast, east, south and southwest – <i>Forest Villa</i> is adjacent to the eastern boundary of the site and <i>Maes ar Ddafen Fach</i> is 50m south. River Dafen bounds the site to the west. Access track west of the site. Surface water (pond) 100m south.
1901 – 1907	1:1,250 1:10,560	& No change.	Coal shaft 5m south and an air shaft 60m southeast.
1907 – 1916	1:1,250 1:10,560	& No change.	Coal shaft mapped as <i>Old Shaft (Coal)</i> indicating that it is now disused. 3no. additional buildings adjacent to south.
1916 – 1953	1:1,250 1:10,560	& No change.	Cefncaeau residential development 200m northeast. Works and electricity sub-station 110m south. Buildings adjacent to southeast.
1953 – 1969	1:1,250 1:2,500	& No change.	Buildings to southeast replaced by tennis courts, bowling green and pavilion. Works 110m south developed with additional buildings.
1969 – 1994	1:1,250 1:10,000	& No change.	Construction of A484 and access roads to north. Further development at Works 110m south. Garage and buildings 150m northwest.
1994 – 2000	N/A	Site used as an inert waste landfill (Licence No. LLN/WD/007)	Major development north and west including retail park, sports stadium (<i>Parc Y Scarlets</i>) and other commercial properties.
2000 – 2011	1:1,250 1:10,000	& Development of access roads and roundabout. Area east of access roads used as a car park. Concrete lined drainage ditch and watercourse running through centre of site redirected to join watercourse running southwest across site into River Dafen.	

2.3.1 Summary

The site remained undeveloped until 1994 when the land was used as an inert waste landfill. The landfill ceased to accept waste in 2000 and was subsequently used for infrastructure to surrounding developments. Notable developments in the surrounding areas include the presence of a coal shaft 5m south (1901 – 1907) and the Works 110m south (1916 – present) of the site boundary.

3.0 ENVIRONMENTAL SETTING

3.1 Sources of Information

ExCAL's PRA (October 2009) including data supplied by CCC from Mott MacDonald's ground investigation (2005) and GroundSure reports (GeoInsight and EnviroInsight) provides the basis for the information presented in this section. ExCAL's Site Investigation Report (August 2010) provides additional information.

3.2 Geology

Made Ground was encountered in all exploratory holes to a maximum proven depth of 8.90m below ground level (bgl). Typically, Made Ground comprised brick, concrete, ceramics, timber, metal, glass, coal, slag and coal tar.

The superficial geology of the western half of the site is Alluvium (Quaternary age) comprising clay, silt, sand and gravel. The superficial geology of the eastern half of the site is Devensian Till (Quaternary age) comprising a mixture (diamicton) of glacially derived materials. Silty clay was encountered at depths between 1.40m bgl and a maximum proven depth of 15.00m bgl.

The underlying bedrock is the Swansea Member (Carboniferous age), which is described in the British Geological Survey (BGS) Lexicon of Named Rock Units as comprising green-grey lithic arenites ("Pennant Sandstones") with thin mudstone/siltstone and seatearth interbeds and mainly thin coals. Bedrock was encountered and proven to a maximum depth of 50.00m bgl. Sandstone, mudstone and coal were encountered at various depths.

3.3 Hydrogeology

The Environment Agency (EA) website shows that the site is not located in a groundwater Source Protection Zone (SPZ).

The superficial deposits (Alluvium and Devensian Till) are shown by the EA website to be a Secondary (undifferentiated) aquifer. The bedrock (Swansea Member) is shown to be a Secondary 'A' aquifer.

A Secondary 'A' aquifer is defined as containing permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.

A Secondary (undifferentiated) aquifer is assigned in cases where it has not been possible to attribute either category 'A' or 'B' to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.

Catchment areas for source protection zones are located approximately 8km southwest of the site. There is no known groundwater abstraction located within 1km of the site.

3.4 Hydrology

The nearest surface water is an unnamed tributary of the Afon Dafen (River Dafen) crossing the site from northeast to southwest and joining the Afon Dafen immediately adjacent to the western boundary of the site. The source of the tributary is located approximately 100m north of the site and is culverted beneath recently constructed access roads and a roundabout.

The site is within 250m of a Zone 2 and Zone 3 floodplain. There is a groundwater flooding susceptibility within 50m of the site and the BGS confidence rating for this susceptibility area is moderately low.

3.5 Designated Environmentally Sensitive Sites

There are no environmentally sensitive sites within 500m of the site.

3.6 Condition of Land at Permit Issue

No baseline data exists for the site at the time of permit issue.

4.0 PERMITTED ACTIVITIES

Permitted activities are stipulated within the *Waste Disposal Site Licence* (Licence No. LLN/WD/007) issued on 2 March 1994 for the site described as *Land off Trostre Works Link Road, Trostre, Llanelli (Grid Reference SS5279999767)*. The licence relates only to the requirements of the Control of Pollution Act 1974 for the deposit of waste and the use of plant or equipment subject to the conditions set out within the licence.

The landfill ceased to accept waste on 26 February 2000.

4.1 Types of Waste

The types of controlled wastes accepted at the facility include only the following inert wastes: -

- Topsoil
- Subsoil
- Brickwork
- Stone
- Concrete
- Clay
- Sand
- Silica (excluding finely powdered waste)
- Glass.

4.2 Quantity of Waste

The total quantity of waste accepted daily should not have exceeded 50 tonnes.

4.3 Operations

Operations were to be in accordance with the Working Plan as agreed by the Disposal Authority.

All wastes were to be visually inspected to ensure they conformed to the types of controlled wastes accepted under the conditions of the licence. Any wastes not conforming should have been rejected as unsuitable for disposal.

No operations were to be conducted during the hours of darkness.

No material should have been burnt within the boundaries of the facility.

The depth of any layer of waste should not exceed 1.5m after initial compaction.

Waste would have been deposited in order to encourage surface water runoff from the working face.

No contaminated surface water was to be discharged / permitted to enter controlled waters.

No processing, sorting or re-excavation of waste was to take place without prior written agreement from the Disposal Authority.

Completed areas were to be graded and maintained as detailed in the Working Plan.

5.0 CHANGES TO THE ACTIVITY

No known changes to the activity have occurred.

6.0 MEASURES TAKEN TO PROTECT LAND

No operational records exist for the site.

7.0 POLLUTION INCIDENTS

GroundSure Reports indicate that there are no recorded pollution incidents within 250m of the site.

Historical map data does not indicate any former potentially contaminative land-use on site. Potential off-site sources of contamination include the coal shaft and Works to the south of the site.

7.0 DECOMISSIONING

No formal decommissioning has occurred at the site.

8.0 REFERENCE DATA

8.1 Introduction

No baseline or operational data exists for the site. A ground investigation was commissioned by Carmarthenshire County Council (CCC) and conducted by Mott MacDonald on 15 March 2005 the data from which has been supplied by CCC for this report.

A subsequent site investigation was commissioned by CCC and conducted by ExCAL Limited on 11 and 25 to 26 August 2010 to establish the nature of the waste deposited and provide a point of comparison for continued monitoring.

Chemical analysis of soil and water samples have been compared to available guidelines; CLEA Soil Guideline Values (SGV's), LQM/CIEH Generic Assessment Criteria (GAC) and Environmental Quality Standards (EQS's). Tables 2 and 3 summarise the list of compiled values and sources of the guidelines used for comparison.

Table 2 – SGV's and GAC's for Soil

Contaminant	SGV / GAC
Cyanide (total) (mg/kg)	3.7 ^{*4}
Sulphide (mg/kg)	-
Organic matter (%)	-
Boron (hot water soluble) (mg/kg)	-
Sulphate (2:1 water soluble) as SO ₄ (g/L)	-
Sulphate (total) by BS1377 (HCl extract) (%)	-
Arsenic (mg/kg)	32 ^{*1}
Barium (mg/kg)	230 ^{*2}
Beryllium (mg/kg)	N/A
Cadmium (mg/kg)	1.8 ^{*3}
Chromium (mg/kg)	130 ^{*1}
Copper (mg/kg)	2,300 ^{*4}
Lead (mg/kg)	450 ^{*1}
Mercury (mg/kg)	8.0 ^{*3}
Nickel (mg/kg)	130 ^{*1}
Selenium (mg/kg)	120 ^{*3}
Vanadium (mg/kg)	-
Zinc (mg/kg)	3,800 ^{*3}
TPH (mg/kg)	-
pH	-
^{*1} CLEA Soil Guideline Value (SGV) – residential ^{*2} CLEA SGV – commercial ^{*3} CLEA SGV – allotments ^{*4} LQM & CIEH. 2009. <i>The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment (2nd Ed.)</i>	

Table 3 – EQS and GAC's for Water Samples

Determinand	EQS / GAC	Determinand	EQS / GAC
pH	6.5 – 10 ^{*2}	Anthracene	0.021 mg/l ^{*5}
Biological Oxygen Demand	<5 mg/l ^{*3}	Fluoranthene	0.23 mg/l ^{*5}
Chemical Oxygen Demand	30 mg/l ^{*3}	Pyrene	0.13 mg/l ^{*5}
Electrical Conductivity	N/A	Benzo[a]anthracene	0.0038 mg/l ^{*5}
Alkalinity	None	Chrysene	0.0020 mg/l ^{*5}
Chloride	250 mg/l ^{*2}	Benzo[b]fluoranthene	0.0020 mg/l ^{*5}
Ammoniacal Nitrogen	0.5 mg ^{*2} NH ₄ /l	Benzo[k]fluoranthene	0.0008 mg/l ^{*5}
Cyanide (total)	0.05 mg/l ^{*1}	Benzo[a]pyrene	0.0038 mg/l ^{*5}
Iron (dissolved)	2,000 µg/l ^{*1}	Dibenzo[a,h]anthracene	0.0006 mg/l ^{*5}
Iron (total)	2,000 µg/l ^{*1}	Indeno[1,2,3-cd]pyrene	0.0002 mg/l ^{*5}
Sulphide	N/A	Benzo[g,h,i]perylene	0.00026 mg/l ^{*5}
Total Organic Carbon	None	PCBs as Aroclor	None
Sulphate	250 mg/l ^{*1}	Catechols	None
Antimony	5 µg/l ^{*2}	Phenol	None
Arsenic (dissolved)	10 µg/l ^{*2}	Cresols	None
Arsenic	10 µg/l ^{*2}	Xylenols	None
Barium	100 µg/l ^{*1}	Naphthols	None
Beryllium	None	Trimethyl phenols	None
Boron	1,000 µg/l ^{*2}	2-sec-Butyl-4-6-dinitrophenol	None
Cadmium	5 µg/l ^{*1}	4-Chloro-3-methylphenol	None
Chromium (dissolved)	50 µg/l ^{*1}	2-Chlorophenol	None
Chromium (total)	50 µg/l ^{*1}	2,4-Dichlorophenol	None
Copper (dissolved)	50 µg/l ^{*1}	2,6-Dichlorophenol	None
Copper	50 µg/l ^{*1}	2,4-Dimethylphenol	None
Lead (dissolved)	50 µg/l ^{*1}	2,4-Dinitrophenol	None
Lead	50 µg/l ^{*1}	2-Methyl-4-6-dinitrophenol	None
Mercury	1 µg/l ^{*2}	2-Methylphenol	None
Nickel (dissolved)	20 µg/l ^{*2}	3-Methylphenol	None
Nickel	20 µg/l ^{*2}	4-Methylphenol	None
Selenium	10 µg/l ^{*1}	2-Nitrophenol	None
Antimony (dissolved)	5 µg/l ^{*2}	4-Nitrophenol	None
Antimony	5 µg/l ^{*2}	Pentachlorophenol	None
Vanadium (dissolved)	20 µg/l ^{*4}	Phenol	None
Vanadium	20 µg/l ^{*4}	2,3,4,5-Tetrachlorophenol	None
Zinc (dissolved)	3,000 µg/l ^{*1}	2,3,4,6-Tetrachlorophenol	None

Determinand	EQS / GAC	Determinand	EQS / GAC
Zinc	3,000 µg/l ^{*1}	2,3,5,6-Tetrachlorophenol	None
TPH (Aqueous Phase)	50 µg/l ^{*1}	2,3,4-Trichlorophenol	None
PAH (total EPA 16)	None	2,3,5-Trichlorophenol	None
Naphthalene	19 mg/l ^{*5}	2,3,6-Trichlorophenol	None
Acenaphthylene	4.2 mg/l ^{*5}	2,4,5-Trichlorophenol	None
Acenaphthene	3.2 mg/l ^{*5}	2,4,6-Trichlorophenol	None
Fluorene	1.9 mg/l ^{*5}	3,4,5-Trichlorophenol	None
Phenanthrene	0.53 mg/l ^{*5}		
*1 Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996 *2 Water Supply (Water Quality) Regulations 2000 *3 Council Directive concerning the quality required of surface water intended for the abstraction of drinking water in the Member States (Surface Water Directive) (Repealed) *4 Water Research Council (WRC). 1984. <i>Determination of pollutants in effluents: Proposed environmental quality standards for vanadium in water and associated materials.</i> *5 LQM & CIEH. 2009. <i>The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment (2nd Ed.)</i>			

8.2 Ground Investigation – 15 March 2005

This section summarises the factual data supplied by CCC and which is included in ExCAL's PRA (October 2009) (Appendix D) in relation to the ground investigation conducted by Mott MacDonald and compares contaminant concentrations to Soil Guideline Values (SGV's) and Environmental Quality Standards (EQS's) listed in Tables 2 and 3.

The results indicated elevated levels of naphthalene, indeno[1,2,3-cd]pyrene, barium and benzo[a]pyrene in soil samples (Table 4).

Table 4 – Samples exceeding SGV's / GAC's

Contaminant	SGV / GAC	TP230	TP231	TP230A
Barium (mg/kg)	230 ^{*2}			270
Naphthalene (mg/kg)	1.5 ^{*4}		2.3	
Indeno[1,2,3-cd]pyrene	3.2 ^{*4}	11		
Benzo[a]pyrene	0.83 ^{*4}		2.4	
*1 CLEA Soil Guideline Value (SGV) – residential *2 CLEA SGV – commercial *3 CLEA SGV – allotments *4 LQM & CIEH. 2009. <i>The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment (2nd Ed.)</i>				

The results indicated elevated levels of antimony, barium and selenium in groundwater samples (Table 5).

Table 5 – Samples exceeding EQS's / GAC's

Contaminant	EQS / GAC	TP222	TP223	TP231	SP3	SP4
Cyanide (total)	0.05 mg/l ^{*1}				0.65	0.57
Barium	100 µg/l ^{*1}	170 (8:1)	200 (8:1)			
Selenium	10 µg/l ^{*1}			26,000 (8:1)		
Antimony	5 µg/l ^{*2}	5.6 (2:1) 5.8 (8:1)	5.8 (2:1) 6.9 (8:1)	6.4 (2:1) 5.5 (8:1)		
*1 Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996						
*2 Water Supply (Water Quality) Regulations 2000						

The Environment Agency document *The surrender of permits for the permanent deposit of waste* (2010) states that, in order to achieve completion criteria, maximum concentration of methane in waste must be less than 1.5% by volume and the maximum concentration of carbon dioxide in waste must be less than 5% by volume throughout the entire waste body.

Monthly gas monitoring between May 2005 and October 2005 indicated consistently elevated levels of carbon dioxide (CO₂) and methane (CH₄) in BH213 and elevated levels of CO₂ in BH211.

8.3 ExCAL Site Investigation – August 2010

The site investigation comprised 6no. trial pits completed on 11th August 2010 and 4no. cable percussion boreholes completed between 25th and 26th August 2010.

The results of the soil sample analyses were compared to available CLEA Soil Guideline Values (SGV's) and LQM & CIEH Generic Assessment Criteria (GAC). Where no guideline values are available or analysis results are below chemical detection limits only the raw data is reported.

Table 6 – Comparison of analysis results with SGV's

Soil - 11 August 2010

Contaminant	SGV	TP1 1.50 m	TP1 3.50 m	TP2 1.50 m	TP2 3.50 m	TP3 0.50 m	TP3 2.50 m	TP4 1.50 m	TP4 2.50 m	TP5 1.50 m	TP5 2.50 m	TP6 0.50 m	TP6 3.50 m
Sulphide (mg/kg)	-	6.6	12	4.2	9.8	11	9.7	10	14	9.6	4.9	7.6	3.4
Organic matter (%)	-	21	14	11	16	24	14	10	13	8.8	1.6	8.1	9.5
Boron (hot water soluble) (mg/kg)	-	2.5	4.7	0.8	0.9	0.9	1.5	0.7	1.2	1.2	0.6	0.5	0.7
Sulphate (2:1 water soluble) as SO ₄ (g/L)	-	0.37	0.20	0.06	0.10	0.22	0.83	0.59	0.22	0.40	0.01	0.09	0.02
Sulphate (total) by BS1377 (HCl extract) (%)	-	0.11	0.03	0.04	0.05	0.09	0.21	0.14	0.09	0.12	0.02	0.07	0.07
Arsenic (mg/kg)	32 ^{*1}	31	28	24	17	<u>34</u>	<u>35</u>	24	30	23	10	10	<u>34</u>
Barium (mg/kg)	230 ^{*2}	190	<u>260</u>	140	120	<u>440</u>	<u>300</u>	<u>250</u>	210	140	40	110	81
Lead (mg/kg)	450 ^{*1}	200	180	98	90	340	<u>1200</u>	140	170	79	17	56	70
Vanadium (mg/kg)	-	18	41	19	15	28	26	14	28	52	21	9.2	29
TPH (mg/kg)	-	290	430	200	190	210	170	270	130	590	< 10	73	< 10
pH	-	8.3	8.2	8.1	8.2	8.0	9.4	7.8	8.0	8.2	6.8	7.8	6.8

All measurements in metres represent metres below ground level.

*1 CLEA Soil Guideline Value (SGV) – residential

*2 CLEA SGV – commercial

The Mean Value Tests indicate that the US₉₅ value for arsenic is 28.23 mg/kg, lead is 220.30 mg/kg and for barium is 244.67 mg/kg, therefore the site is below the SGV for arsenic and lead and above the SGV for barium.

Groundwater was sampled within TP2 and results of the analyses have been compared to EQS / GAC (see Table 3) as presented in Table 7.

Table 7 – Comparison of analysis results with EQS's

Water		11 August 2010
Contaminant	EQS	TP2 3.50m
Sulphide (mg/l)	None	<0.050
Total Organic Carbon (mg/l)	N/A	34
Barium (µg/l)	100 ^{*1}	180
All measurements in metres represent metres below ground level.		
*1 Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996		

8.3.1 Summary of Soil and Groundwater Contamination – 11 August 2010

Soil samples taken during the site investigation on 11th August 2010 indicated elevated levels of arsenic, barium and lead that may pose a risk to human health.

The groundwater sample taken during the site investigation on 11th August 2010 indicated elevated levels of barium that may pose a risk to human health.

8.4 Monitoring

Post site investigation monitoring included additional soil sampling and regular sampling of groundwater, surface water and ground gas.

8.4.1 Soil

Additional soil samples were obtained on 10th September 2010 and analysed. The results of the analyses have been compared to the SGV's / GAC's presented in Table 2. None of the samples indicated elevated levels of contaminants. The barium concentrations were anomalous for the type of waste deposited on the site.

Table 8 – Comparison of additional soil sample analysis with SGV's

Soil - 10 September 2010								
Contaminant	SGV	TP1 1.50m	TP2 1.50m	TP3 0.50m	TP3 2.50m	TP4 2.50m	TP5 1.50m	TP6 3.50m
Cyanide (total) (mg/kg)	3.7 ^{*4}	0.11	<0.05	<0.05	0.05	<0.05	<0.05	<0.05
Arsenic (mg/kg)	32 ^{*1}	5.7	<1	3.9	7.7	1.1	5.6	1.1
Barium (mg/kg)	230 ^{*2}	32	16	82	23	50	50	<5.0
Beryllium (mg/kg)	N/A	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cadmium (mg/kg)	1.8 ^{*3}	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Chromium (mg/kg)	130 ^{*1}	2.2	3.7	2.6	3.4	2.9	5.1	3.4
Copper (mg/kg)	2,300 ^{*4}	4	3.2	8	43	2.3	3.8	<1
Lead (mg/kg)	450 ^{*1}	<1	<1	<1	12	1.4	<1	<1
Mercury (mg/kg)	8.0 ^{*3}	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nickel (mg/kg)	130 ^{*1}	2.4	11	2.5	3.4	2.1	3.5	2
Selenium (mg/kg)	120 ^{*3}	3.2	<1	1.9	2.3	<1	1.4	<1
Vanadium (mg/kg)	-	2.2	<1	2.8	12	<1	12	<1

Zinc (mg/kg)	3,800 ^{*3}	<1	<1	<1	1.9	3.4	3.3	<1
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All measurements in metres represent metres below ground level.
*1 CLEA Soil Guideline Value (SGV) – residential
*2 CLEA SGV – commercial
*3 CLEA SGV – allotments
*4 LQM & CIEH, 2009. *The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment (2nd Ed.)*

8.4.2 Water

Monthly monitoring of groundwater and surface water was undertaken between September 2010 and August 2011.

The water samples have been analysed and compared to their relevant EQS / GAC (determinands without EQS's are listed as 'None') listed in table 3.

The surface water monitoring points were selected to provide background concentrations as well as the potential landfill contribution to surface waters (see Drawing No. 44-05-02.D02): -

- SW1 – surface waters that are likely to have originated onsite;
- SW2 – background concentrations from the River Dafen / Afon Dafen;
- SW3 – background concentrations for the unnamed tributary of the River Dafen / Afon Dafen.

The analysis indicates that values for biological oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen, total iron, mercury, sulphate and total petroleum hydrocarbons have exceeded guideline values at some point over the monitoring period. The majority of the inorganic determinands show an increasing trend throughout the monitoring period. Organic compound show a decreasing trend possibly indicating that natural attenuation of the pollutants could be occurring through natural biodegradation.

8.4.3 Gas

Monthly monitoring of gas was undertaken between September 2010 and August 2011 for methane (CH₄), carbon dioxide (CO₂) and oxygen (O₂). The results are presented in Table 10.

The Environment Agency (EA) document *The surrender of permits for the permanent deposit of waste* (2010) states that maximum concentration of methane in waste must be less than 1.5% by volume and the maximum concentration of carbon dioxide in waste must be less than 5% by volume throughout the entire waste body to achieve completion criteria. These concentrations must not be exceeded for at least two years in order for the landfill to comply with the completion criteria.

Table 9 – Monthly Gas Monitoring Results

Borehole Location	Date	O₂	CH₄	CO₂
1	September 2010	0.2	13	7
2		16.2	0	1.4
3		12.3	0	4.2
4		1.4	0	2.5
1	October 2010	1.7	10	5.2
2		18	0	1.7
3		2	47	9
4		1.2	0	5.1
1	November 2010	1.3	5	6
2		19.8	0	0.7
3		17.1	1	1.2
4		1.8	1.5	3.2
1	December 2010	1.4	1.3	5.2
2		19.7	0	0.1
3		10.8	1.4	2.3
4		4	0	4.2
1	January 2011	0.2	6	4
2		19.3	0	0.6
3		9.2	4.9	2.7
4		0.6	0	2.7
1	February 2011	0.7	5.3	3
2		18.4	0.1	1.1
3		13	2.2	1.7
4		3.2	0	2.7
1	March 2011	0.2	4.5	4.4
2		19.1	2.2	1.5
3		16	0	1.7
4		1.6	0	3.1
1	May 2011	0.4	5	7
2		16.6	0	2.9
3		14.4	0.8	2.7
4		0.8	0.5	3.1
1	April 2011	0.7	1	5
2		18.5	0	0.9
3		15.9	0.1	1.1
4		2	0.9	2.2
1	June 2011	0.4	5	7
2		16.6	0.6	2.9
3		14.4	0.8	2.7
4		0.8	0.5	3.1
1	July 2011	5.5	9	5
2		20.4	0	0.1
3		3.5	4.6	7
4		1.2	2.5	3.3
1	August 2011	0.4	4	3
2		20.2	2	1.1
3		15	0.5	2
4		2.2	0	2.4

With the exception of April 2011 gas results indicated that methane and / or carbon dioxide levels exceeded the requirements of the EA for the surrender of permits.

The ground investigation conducted by Mott MacDonald in 2005 proved the presence of coal beneath the site, which may provide a natural source of methane and carbon dioxide.

8.5 Summary of Contamination

8.5.1 Soil

Analysis has indicated elevated levels of naphthalene, Indeno[1,2,3-cd]pyrene and benzo[a]pyrene in samples from the ground investigation conducted in March 2005.

Analysis has indicated elevated levels of arsenic, barium and lead in samples obtained in August 2010. However, US₉₅ values show that the site is below the SGV for arsenic and lead. Subsequent samples obtained in September 2010 did not indicate elevated levels of any contaminants tested.

8.5.2 Water

Analysis has indicated elevated levels of antimony, cyanide (total), barium and selenium in groundwater and surface water samples from the ground investigation conducted by Mott MacDonald in March 2005.

The results of determinands exceeding EQS's / GAC's in surface water over the period September 2010 to August 2011 are summarised in the following table.

Table 10 – Summary of Surface Water Determinands Exceeding EQS's / GAC's

Determinand	EQS / GAC	Mean Concentration			
		SW1	SW2	SW3	All
Ammoniacal Nitrogen ^{*2}	0.5 mg NH ₄ /l	0.62	0.59	1.36	0.86
Iron (dissolved) ^{*1}	2,000 µg/l	220.00	228.75	182.50	210.00
Iron (total) ^{*1}	2,000 µg/l	742.50	731.25	898.75	790.83
Mercury ^{*2}	1 µg/l	1.47	0.75	0.82	1.01

*1 Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996
 *2 Water Supply (Water Quality) Regulations 2000

In the instances of ammoniacal nitrogen and dissolved iron the mean concentrations indicate that the surface waters entering the site (SW3 and SW2) have higher mean concentrations than surface waters from the site (SW1). However, mean concentrations of total iron and mercury are higher in SW1 than in both SW2 and SW3 suggesting that further monitoring / action is required.

Groundwater sampled during the site investigation in August 2010 indicated elevated levels of barium.

The results of determinands exceeding EQS's / GAC's in groundwater over the period September 2010 to July 2011 are summarised in Table 11.

Table 11 – Summary of Groundwater Determinands Exceeding EQS's / GAC's

Determinand	EQS / GAC	Mean Concentration
		BH3
Ammoniacal Nitrogen ^{*2}	0.5 mg NH ₄ /l	0.34
Iron (total) ^{*1}	2,000 µg/l	2,118
Mercury ^{*2}	1 µg/l	1.20
Total Petroleum Hydrocarbons (TPH) ^{*1}	50 µg/l	53.00
*1 Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996		
*2 Water Supply (Water Quality) Regulations 2000		

The majority of the inorganic determinands show an increasing trend throughout the monitoring period. Organic compounds show a decreasing trend possibly indicating that natural attenuation of the pollutants could be occurring through natural biodegradation.

In the instances of ammoniacal nitrogen the mean concentration suggests that the groundwater is predominantly within the guidelines. Mean concentrations for total iron, mercury and TPH are above the guidelines, suggesting that further monitoring / action is required.

8.5.3 Gas

Elevated levels of carbon dioxide and methane were recorded in BH1 – BH4 throughout the monitoring period from September 2010 to August 2011.

9.0 ASSESSMENT OF RISK POSED BY SITE

9.1 Risk Assessment Methodology

'Contamination' is defined by BS 10175:2011 as the 'presence of a substance or agent, as a result of human activity, in, on or under land, which has the potential to cause harm [a measurable adverse effect on a receptor] or pollution.'

The Environmental Protection Act (EPA) 1990, Part IIA defines a site as 'contaminated land' if: -

- significant harm may occur to people, ecosystems or infrastructure;
- there is significant possibility that such harm could occur; or
- pollution of controlled waters is likely to, or does, occur.

'Controlled waters' are defined by BS 10175:2011 as 'inland freshwater, water contained in underground strata and any other coastal water between the limit of highest tide or the freshwater line to the three mile limit of territorial waters'.

Significant harm is regarded as significant in the following cases: -

- a) serious injury, chronic or toxic effect or death to humans;
- b) adverse or irreversible harm to ecosystems;
- c) substantial damage or failure of buildings;
- d) damage, disease or death of, or affecting, livestock or crops;
- e) pollution of controlled waters.

Contaminated land could therefore potentially affect the value or re-use of land and/or require measures that mitigate the risks in relation to a receptor.

The framework for risk assessment in the UK is provided by the DEFRA / EA Contaminated Land Report 11 (CLR 11) and is designed to be inline with the relevant UK legislation and policy including planning. The document prescribes a three stage assessment process to identify possible pollutant linkages (source-pathway-receptor) comprising: -

1. Preliminary Risk Assessment;
2. Generic Quantitative Risk Assessment; and
3. Detailed Quantitative Risk Assessment.

It may not be necessary to proceed beyond stage 1 or stage 2 as this will depend upon the outcome of the assessment at each stage. The conceptual model should be refined as more information becomes available.

CIRIA Report C552 provides a guide to good practice in contaminated land risk assessment. Risk is defined by CIRIA Report C552 as 'the probability that due to a hazard an adverse effect due to a hazard will occur under defined conditions'.

Thus risk estimation is based upon quantifying the magnitude of the potential consequence (effect) and probability of the risk occurring. The probability of a hazard

occurring is classified using the following terms and definitions derived from CIRIA Report C552: -

- High likelihood: a pollution linkage exists in combination with an event that either appears inevitable in the long-term or very likely in the short-term, or evidence exists of pollution or harm to a receptor;
- Likely: a pollution linkage exists and it is possible in the short-term or likely over the long-term that an event will occur;
- Low likelihood: a pollution linkage exists and it is not certain that in the long-term and even less likely in the short-term that an event will occur;
- Unlikely: a pollution linkage exists, but it is improbable than an event would occur even in the long-term.

The consequence, judged by severity, of an event is defined in CIRIA Report C552 as: -

- Severe: Short term (acute) risk to human health likely to result in 'significant harm' as defined by the Environment Protection Act 1990, Part IIA. Short-term risk of pollution of sensitive water resources. Catastrophic damage to buildings or property. Short term risk to an ecosystem or organism forming part of that ecosystem (note definition of ecosystem in 'Draft Circular on Contaminated Land', DETR 2000);
- Medium: Chronic damage to human health ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000), pollution of sensitive water resources, significant change in an ecosystem or organism forming part of that ecosystem (note definition of ecosystem in 'Draft Circular on Contaminated Land', DETR 2000);
- Mild: Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000). Damage to sensitive buildings, structures or the environment; and
- Minor: Harm, not necessarily significant, but that could result in financial loss or expenditure to resolve. Non-permanent human health effects easily prevented by use of personal protective clothing. Easily repairable damage to buildings, structures and services.

Consequence versus probability can then be used to define a category of risk as in the figure below.

		CONSEQUENCE			
		SEVERE	MEDIUM	MILD	MINOR
PROBABILITY	HIGHLY LIKELY	Very High	High	Moderate	Moderate / Low
	LIKELY	High	Moderate	Moderate / Low	Low
	LOW LIKELIHOOD	Moderate	Moderate / Low	Low	Very Low
	UNLIKELY	Moderate / Low	Low	Very Low	Very Low

9.2 Site Conceptual Model

A site conceptual model (SCM) based on the information presented in the proceeding sections has been developed (Table 12).

Table 12 – Site Conceptual Model

Potential source	Potential Pathway	Potential Receptor	Potential Probability & Consequence	Potential Risk	Comments
Soil contaminants (i.e. barium, naphthalene, indeno[1,2,3-cd]pyrene and benzo[a]pyrene)	Ingestion/ Dermal Contact	Future on-site users (residential / commercial)	Likely / Severe	High	Risk will change dependent on end-use
		Construction workers	Highly likely / Severe	Very high	Intrusive works are likely to result in contact with potential contaminants if incorrect PPE and Health & Safety measures are used
		Maintenance workers	Likely / Severe	High	
	Permeation	Subsurface plastic water pipes	Likely / Severe	High	If inappropriate pipes are laid within contaminated ground
	Leaching	Groundwater in Secondary A Aquifer/ surface watercourse	Highly likely / Medium	High	Exceedance of guidelines in background concentrations of contaminants in groundwater and surface water
	Root uptake	Soft landscaping on-site (e.g. phytotoxicity)	Likely / Mild	Moderate / Low	Risk will change dependent on end-use and degree of soft landscaping
Asbestos	Inhalation	Any	Unlikely / Severe	Moderate / Low	No asbestos found on site.

Potential source	Potential Pathway	Potential Receptor	Potential Probability & Consequence	Potential Risk	Comments
Groundwater contaminants (i.e. barium, total iron, mercury and TPH)	Ingestion / Dermal Contact	Future on-site users (residents / commercial)	Likely / Severe	High	Risk will change dependent on end-use
		Adjacent commercial/residential land users	Likely / Medium	Moderate	Exceedances in background concentrations of contaminants
		Construction workers	Highly likely / Severe	Very high	Intrusive works are likely to result in contact with potential contaminants
		Maintenance workers	Likely / Severe	High	Intrusive works are likely to result in contact with potential contaminants
	Permeation	Subsurface plastic water pipes	Likely / Medium	Moderate	If unsuitable pipes are laid within contaminated ground
	Lateral Groundwater migration	Afon Dafen / River Dafen	Likely / Medium	Moderate	Higher concentrations of some contaminants in River Dafen than in groundwater and surface water
Ground gas (CO ₂ and CH ₄)	Inhalation / Explosion	Future on-site users (residents / commercial)	Likely / Severe	High	Gases present risks from asphyxiation, explosion and toxic effects. Gases are likely to accumulate in confined spaces presenting increased risk.
		Adjacent commercial/residential land users	Likely / Severe	High	
		Construction workers	Highly likely / Severe	Very high	
		Maintenance workers	Highly likely / Severe	Very high	

10.0 STATEMENT OF SITE CONDITION

Previous investigations have indicated that the site is underlain by Made Ground to a maximum proven depth of 8.90m below ground level (bgl). Superficial deposits comprising gravelly, silty clay were found beneath Made Ground to a maximum proven depth of 15.00m bgl. Bedrock was found from 6.50m bgl and comprised the following succession: -

- sandstone (6.50m – 20.00m bgl);
- mudstone and coal (20.00 – 30.00m bgl);
- sandstone (30.00m – 38.80m bgl);
- mudstone and coal (38.80m – 41.00m bgl);
- and sandstone (41.00 – 50.00m bgl).

Recent site investigations and monitoring have indicated elevated levels of barium, naphthalene, indeno[1,2,3-cd]pyrene and benzo[a]pyrene in Made Ground.

Groundwater seepages were recorded between 1.40m and 2.00m bgl during the ground investigation conducted by Mott MacDonald in 2005. Groundwater was encountered in the site investigation conducted by ExCAL Limited in 2010 in TP2 at 3.50m bgl and testing indicated elevated levels of barium.

Monitoring and analysis of groundwater has indicated that EQS's / GAC's for total iron, mercury and TPH have been exceeded. No background data exist.

Monitoring and analysis of surface water has indicated that EQS's / GAC's for total iron and mercury have been exceeded when compared to background surface water concentrations.

Monitoring of ground gas has indicated consistently elevated levels of methane and carbon dioxide. No background data exist.

A risk assessment for the site has indicated that significant pollutant linkages (source-pathway-receptor) exist on site that present moderate / low to very high risks to receptors and potential receptors. Contaminants from soil and water, which have been identified on site at elevated levels include;

- Mercury: toxic effects on both humans and wildlife and is bioaccumulative in the environment and exposure can occur as a result of dermal contact or ingestion through, for example consumption of fish from mercury contaminated surface waters.
- Barium: toxic effects on humans if ingested, but has a low tendency to bioaccumulate.
- Arsenic: often found naturally in soils, but it is carcinogenic to humans and toxic to humans and wildlife if ingested.

Risk management strategies can be employed to reduce the identified or potential risks by;

- Appropriate personal protective equipment for construction workers and site personnel will negate the health risks from contaminated land associated with construction, i.e. from soil and water contamination and ground gas.
- Use of specialised subsurface water supply pipes will prevent the permeation of organic contaminants.

Risks posed by soil and groundwater contaminants and ground gases should be investigated further. The following pollutant linkages have been proven for the site as seen by their presence at elevated levels in sources and receptors;

- Barium in groundwater, which is likely to have been leached from the soil. Sources of barium in soil have been found at depths of up to 3.50m below ground level.
- Iron, mercury and ammoniacal nitrogen in surface water, which is likely to have resulted from lateral migration of groundwater.

The increasing trend in concentration of the majority of inorganic determinands in groundwater and surface water may lead to exceedances in EQS's / GAC's of all inorganic determinands.

Based on the current data it is recommended that continued monitoring should be undertaken to investigate the apparent increasing trend in concentrations of inorganic determinands in water. Continued ground gas monitoring is also required as the site does not currently satisfy the requirements of the Environment Agency (EA) document *The surrender of permits for the permanent deposit of waste* (2010).

11.0 References

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