McDonnell Cole

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Hydrogeological Risk Assessment Review for Colsterworth Landfill, Grantham, Lincolnshire

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1. Introduction

Lincwaste Limited, a company name of FCC Environment (FCC), operates Colsterworth Landfill under environmental permit EPR/BV1437IB. The Hydrogeological Risk Assessment (HRA) of the site is required to be reviewed every six years. The last HRA review was carried out by FCC in 2013. A further review is now required.

This report seeks to review the hydrogeological conditions of the site and whether there have been any significant changes in the last six years. The assessment will determine whether the site is still considered to be compliant with the Environmental Permitting Regulations. This review assesses the last 10 years of environmental monitoring data and information contained in the following reports:

- Golder: 2003 : Environmental Setting and Installation Design, report reference 03523307.005.
- Golder: 2003: Hydrogeological Risk Assessment, Colsterworth Landfill Site, report reference 03523307.501.
- Golder: 2007 : Colsterworth Landfill Site, Hydrogeological Risk Assessment Four Year Review, report reference 07514290190.501/A.1.
- ESI: 2014: Colsterworth Landfill: Review of Leachate Levels.

2. The Site

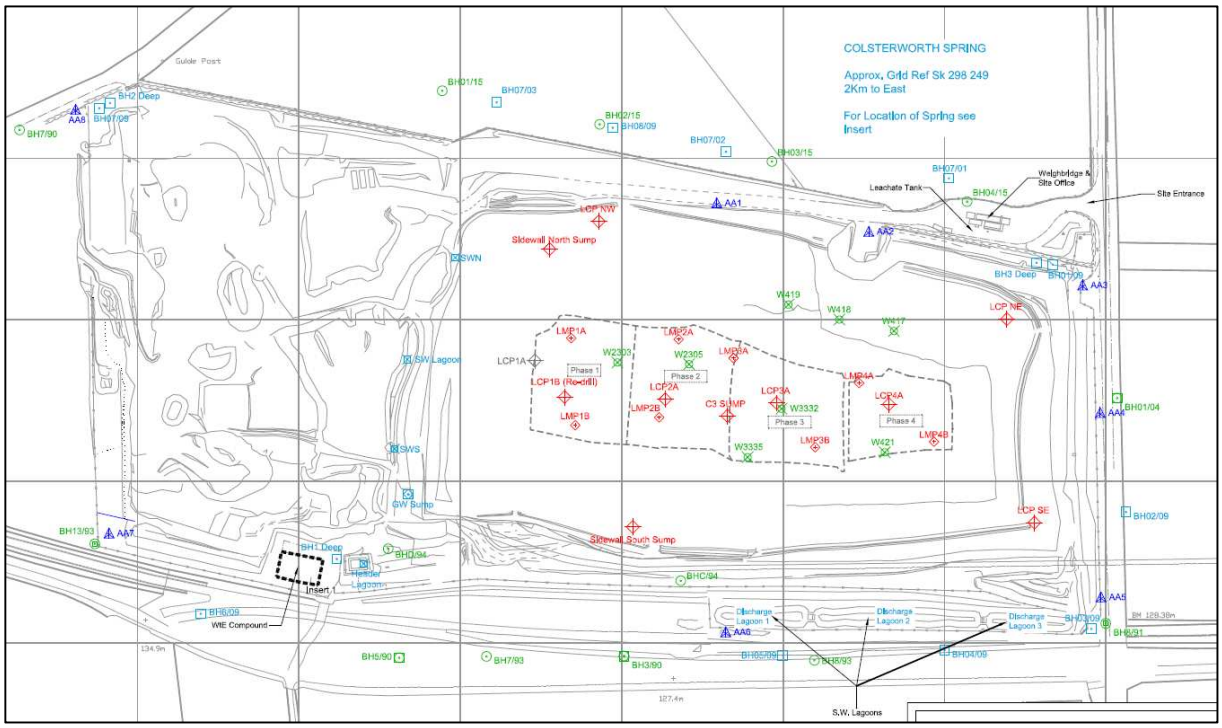
2.1. Location

Colsterworth Landfill is situated off Crabtree Road, Stainby, Grantham, Lincolnshire, NG33 5QT and can be located by National Grid Reference SK 905 244. The site is approximately 1km west of Colsterworth and 1km south of Skillington. Ground levels are at approximately 130m AOD. The topography rises gradually to the west-southwest. There is a fall of approximately 20m northwards to the Cringle Brook, just south of Skillington. The land falls more gently eastwards towards the River Witham at Colsterworth. The surrounding land use is mostly agricultural.

In 2003 the site was licensed to take household, commercial, industrial, contaminated soils and special waste. After 2004 it was permitted as a non-hazardous landfill. To the east Spencer's Field and to the northwest Clark's field are both restored quarry waste sites. It is also understood that the former railway cutting to the west has been landfilled.

An extract of the Environmental Monitoring Plan is presented as Figure 1 to show the general layout of the site.

Figure 1: Site Plan (taken from FCC Environmental Monitoring Plan reference 706M299B, Plan 4A, 2.8.19)



2.2. Environmental Setting

The site is located within a former iron works.

Table 1: Local Environmental Features

Receptor	Nature of feature	Distance from site
Residential/Work-Place/Amenity - Between 0 and 1000 m	Open farmland	
Habitats		
Habitats Directive sites	None within 2km	
CROW Act 2000 sites	None within 2km Closest= Sproxton Quarry	3.5km west
Other habitat sites	Deciduous woodland Semi-improved grassland	Southern boundary of site
Groundwater		
Aquifer	Lincolnshire Limestone Formation – Principal Aquifer Northampton Sand Formation - Secondary A Grantham Formation – Secondary Undifferentiated	
Groundwater protection zone	None on site SPZ3 2km east of site	

Receptor	Nature of feature	Distance from site
Groundwater abstractions	Understood to be none within 2km	
Nitrate vulnerable zone	Yes	
Surface Water		
Sensitivity of receiving water	River Witham is considered to be of good quality	
Direct runoff from site?	No	
Surface water abstractions	Cringle Brook	3km
Wells and springs		
Wells	None known within 1km	
Springs	Adjacent to Cringle Brook Adjacent to River Witham	700m north 2km east
Air quality management zone	No	
Flood zone	Flood zone 1 – low risk	

2.3. Site History

The site was initially worked as an ironstone quarry. Subsequent excavation of clay was undertaken to depths of 91m AOD. Landfilling began in 1995. In 2003 there was still active quarrying on site to the west. At this time active landfilling was taking place in Phase 4 and other phases were temporarily capped at approximately 120m AOD. By 2013 the filling of Phase 4 was almost complete and over tipping of other phases was being undertaken to levels around 130m AOD. The site ceased accepting waste in January 2019.

3. Geology and Hydrogeology

3.1. Geology

The site is excavated in to rocks of Jurassic age, as summarised in Table 2. Strata dip at approximately 2 degrees to the east. There are reported to be faults to the north and south of the site, one crossing the southern boundary of the site, downthrowing the eastern side by approximately 4m. The upper 13 – 14 m of the quarry faces on the north and east of the site appear to be backfill form quarry workings.

Table 2: Geological Sequence

Geological Unit	Thickness	Description
Lincolnshire Limestone Formation	4 – 15m	Highly fractured oolitic and micritic limestones
Grantham Formation (Lower Estuarine Series)	1 – 11m absent from west of site	Weak to strong sandy clay, ironstone, limestone and sandstone. Site borehole information describes brown clay and green/blue shale.
Northampton Sand Formation (worked for iron content)	0 – 4.5m	Very strong ferruginous sandy limestone
Upper Lias Clay – Whitby Formation	60m	Dark blue grey mudstone
Marlstone Rock Formation	1 – 9 m	Ferruginous oolitic limestone and calcareous sandstone. Water- bearing.

3.2. Hydrogeology

3.2.1. General Properties

The Lincolnshire Limestone is the principal aquifer in this region. The Northampton Sand Formation is designated as a Secondary A aquifer. The Grantham Formation has been previously considered as an aquitard separating the Lincolnshire Limestone from the Northampton Sand. It is now designated as a Secondary Undifferentiated aquifer.

The site is not within a source protection zone, the closest being 2km to the east.

Groundwater flow is considered to be generally eastwards towards the River Witham. Tracer testing in the 1970s and 1990s has determined that Colsterworth landfill is in the catchment of springs along the River Witham.

3.2.2. Groundwater Management on Site

The base of the site rests in the Lias Clay, which confines the Marlstone Rock at substantial depth. The water-bearing units of the Northampton Sand and Lincolnshire Limestone, or their backfilled remains, form the upper walls of the site. A groundwater collector drain has been constructed around the periphery of the landfill to prevent groundwater entering the landfill. The original design had a 1 in 200 fall to a sump, maintained at 110.5m AOD, followed by a settlement lagoon and then gravity drainage to balancing ponds into a soakaway 800m east of the site.

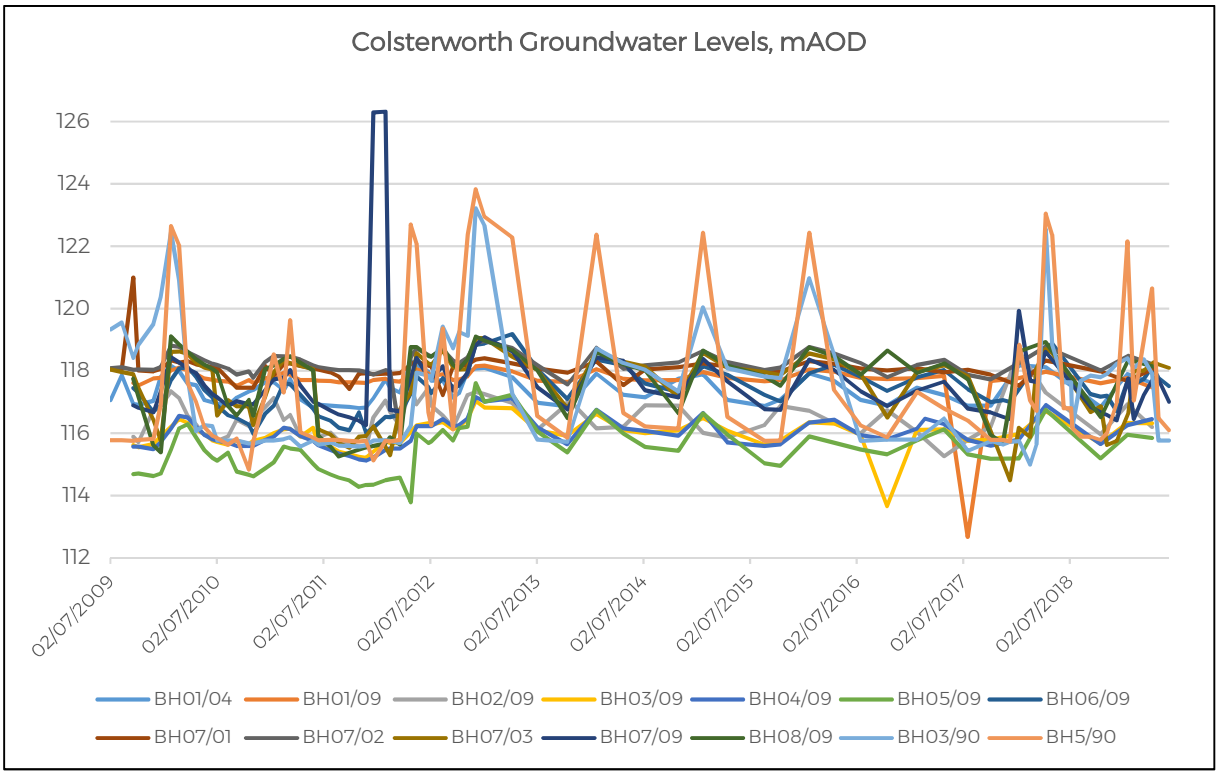
The 2007 HRA review considered that groundwater management only need continue to

maintain sidewall stability during filling. It is understood that some groundwater is still collected in a sump close to the surface water lagoon. From here it continues to be pumped through a series of lagoons before discharge off site towards the soakaway. Now that the site is fully capped the groundwater drainage requirements are being reviewed.

3.2.3. Groundwater Levels

Groundwater levels are presented in Figure 2. The boreholes which show the greatest fluctuation in groundwater levels are known to be screened in part through limestone: BH03/90 and BH05/90, on the southern boundary of the site. Boreholes on the northern boundary of the site are generally screened through the made ground of the quarry backfilling. Other boreholes are screened through Northampton Sand only: BH02/09, BH06/09 and BH07/09; or through both the Grantham Formation and Northampton Sand: BH04/09 and BH5/09.

Figure 2: Groundwater Levels



The graph shows that some of the highest levels, except those in the limestone boreholes, are recorded in BH08/09 on the northern boundary of the site and some of the lowest are recorded in BH05/09 on the southern boundary. This correlates with findings in the 2003 ESID, giving the direction of groundwater flow to be generally to the southeast.

3.3. Hydrology

The site lies within the catchment of the River Witham to the east, which flows from south to north through Colsterworth. The Cringle Brook to the north is considered to be on the other side of a watershed local to the site. The River Witham and Cringle Brook converge approximately 4km north of Colsterworth. There is evidence of springs feeding both the River Witham at Colsterworth and the Cringle Brook north of the site.

There are currently three surface water discharge lagoons in the southeast of the site. The water quality of the most easterly, Discharge Lagoon 3, is controlled by emission limits in the environmental permit.

4. Review of Conceptual Hydrogeological Site Model

4.1. General

The 2003 HRA considered that there were two potential mechanisms for impact on the hydrogeological environment:

- Leakage through the site base and the thickness of Lias/Whitby Mudstone into the Marlstone Rock. This was assessed using Landsim.
- Leakage through the sidewall lining system, which could impact on the Northampton Sand, or Lincolnshire Limestone. This was assessed using Crystal Ball.

Basal leakage was assessed using a fixed 2m and a fixed 5m leachate head. A failure scenario was considered with a leachate head up to 25m. There was considered to be no discernible discharge of List I substances and limited risk of contamination by List II substances. Sidewall leakage used a 1m and a 2m head difference across the sidewall. Again, there was predicted to be no discernible discharge of List I substances and no risk from List II substances if the site remained hydraulically contained.

The 2007 HRA describes the work done since the original HRA on the design of the upper sidewall lining system. This now includes a 300mm thick leachate drainage layer inside the clay liner extending to below the top of the Lias Clay. This removes the potential for build-up of leachate against the sidewall lining. It is considered that the pathway to the Lincolnshire Limestone and Northampton Sand no longer exists.

The Marlstone Rock was still considered to be a receptor in 2007. However, boreholes put down in 2005 proved the thickness of overlying Lias Clay to be between 35 and 53m. On the basis of the proof of thickness and the consideration that the Marlstone Rock is a secondary

aquifer; it is not in a source protection zone and not discharging to a sensitive surface water receptor, it was determined that a simple risk assessment was now appropriate. With a 105mAOD leachate head (as required by the 2007 permit) over the approximately 95m AOD piezometric surface of the Marlstone Rock, this gave a lower head than originally modelled in Landsim (10m versus the 25m failure scenario). Therefore, it was deemed that if the original conclusion was that risks to the Marlstone Rock were limited to negligible this remained the case. It was recommended in the 2007 HRA that monitoring of the Marlstone Rock was no longer required.

4.2. Source

4.2.1. Leachate Level

The 2007 HRA discusses leachate levels in relation to a compliance level of 105m AOD. The 2013 HRA refers to proposals in the leachate management plan to reduce site leachate levels in a phased fashion. The targets were 110.5m AOD in January 2011, 108m AOD in January 2012 and 105m AOD in January 2013. Cells 2,3 and 4 were reported to be compliant at the time of the 2013 HRA. Cell 1 has a higher base than other cells, making it harder to achieve compliance.

In 2015 ESI reported that FCC received an enforcement notice from the Environment Agency (the Agency) dated 29 July 2014 which required the submission of a leachate monitoring and reduction plan. The ESI 2015 report undertook a review of leachate levels. It describes changes in leachate level monitoring, which was originally only undertaken in the Cell Sumps. These were progressively replaced with leachate collection points (LCP) and leachate monitoring points (LMP). From 2008 onwards it became necessary to pump from the leachate monitoring points. From 2013 pump suspension was put in place prior to monitoring levels in order to obtain more representative data. The data was reviewed in relation to the lowest level for the base of the Northampton Sand Formation, which was reported to be 113m AOD. It concluded that a revised leachate compliance level of 109m AOD was appropriate. This has now been agreed and is written into the current environmental permit.

Section 5 reviews leachate levels in relation to current compliance limit.

4.2.2. Leachate Quality

The original source term used in the 2003 HRA is given in the table below.

Table 3: Original Leachate Source Term

Contaminant		Concentration		
	Units	Minimum	Most likely	Maximum
Chloride	mg/l	1380	5120	13,300
Ammoniacal nitrogen	mg/l	872	1963	3480
Cadmium	mg/l	0.003	0.0065	0.01
Mecoprop	mg/l	0.0414	0.0699	0.0985

At the time of the 2003 HRA cadmium and mecoprop were considered to be hazardous substances. The Joint Agencies Groundwater Directive Advisory Group (JAGDAG) 2018 have since designated them as non-hazardous pollutants.

Section 5 reviews the current leachate quality and compares it to the original source term and the ranges determined in subsequent HRA reviews.

4.3. Pathways

4.3.1. Landfill Containment

The base of the landfill is excavated in to the Lias Clay. This has a natural permeability of less than 1 x 10-9 m/s and a thickness of more than 35 m. It, therefore, acts as both the artificial sealing liner and geological barrier.

The sidewalls above the level of the Lias Clay were graded to 1:1.5 and lined with a minimum thickness of 1m of reworked Lias Clay.

A groundwater collector drain has been installed around the entire perimeter of the landfill, comprising a 300mm gravel drainage blanket, placed between the natural strata and the sidewall lining system. The drain falls at a gradient of 1 in 200 to a sump at a level of 110.5 m AOD.

4.3.2. Basal Leakage

The investigations into the thickness of the Lias Clay directly below the site and the nature of the Marlstone Rock at greater depth, has lead to the agreement with the EA that there is no longer considered to be a significant pathway through the base of the landfill.

4.3.3. Sidewall Leakage

It is considered that the direct pathway of lateral leakage through the sidewall liner has been removed, as described above. In the event of perched leachate acting against the sidewall liner and drainage layer, the effects would be picked up via monitoring of the groundwater collector drain.

4.4. Receptors

The key receptors are:

- the water quality of the Lincolnshire Limestone and Northampton Sand;
- the water quality of the site's surface water drainage system.

5. Hydrogeological Risk Assessment

5.1. Modelling

5.1.1. Justification for Modelling Approach and Software

The original risk assessments were carried out based on standard hydrogeological principles and were assessed probabilistically using Landsim for the basal leakage scenario and Crystal Ball for sidewall leakage. As it is now considered that there is no significant receptor from basal leakage, the Landsim model is no longer relevant.

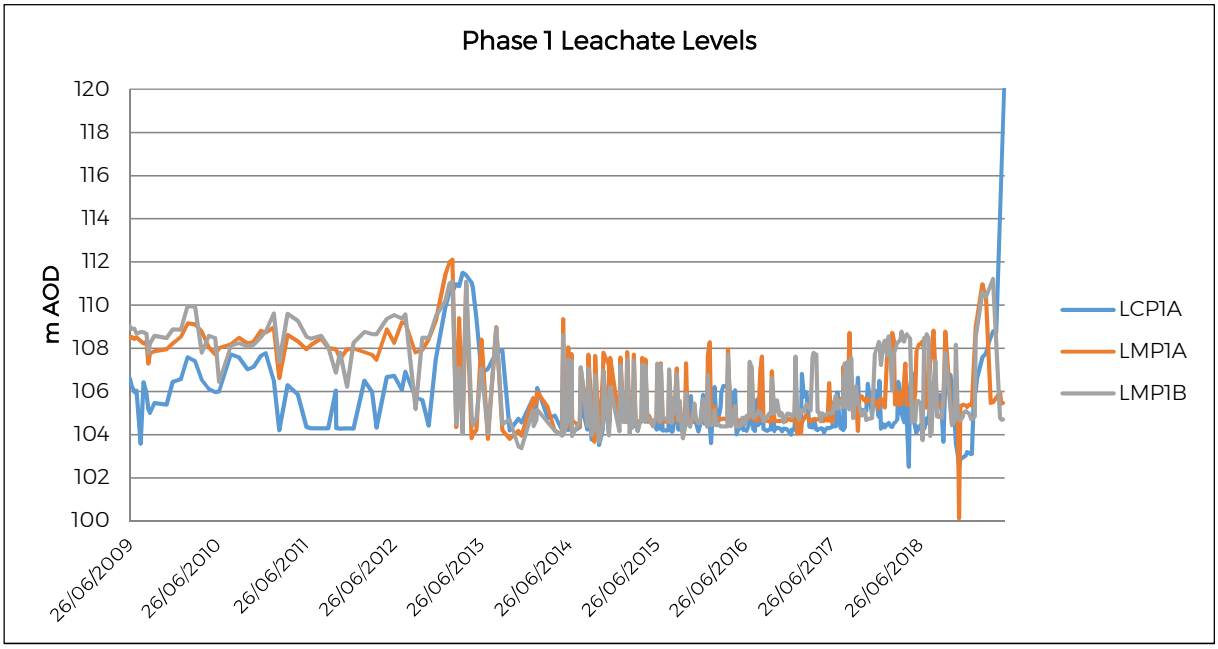
No new modelling has been undertaken since the original HRA. The current leachate levels and leachate quality are reviewed below to determine whether there has been substantial change and whether the original model parameters remain valid.

5.1.2. Model Parameterisation

5.1.2.1. LEACHATE LEVEL

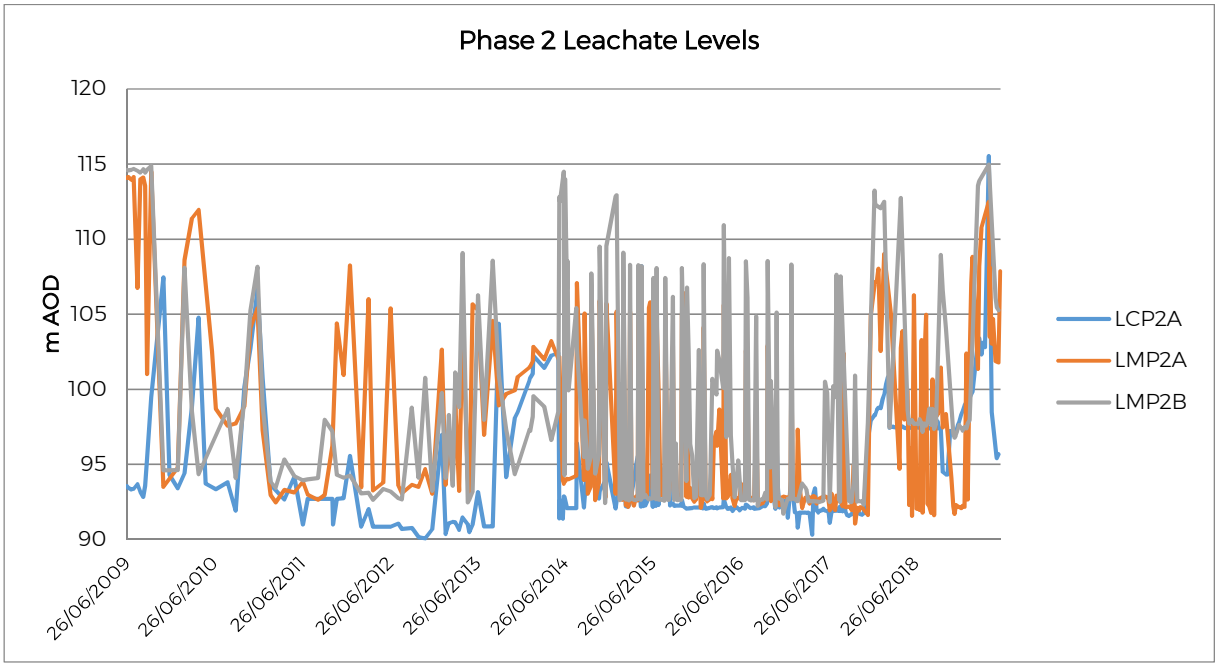
The leachate compliance level in the current environmental permit is 109m AOD. Figures 3 to 6 present the leachate levels for each of the four phases. Levels are generally compliant in all phases.

Figure 3: Leachate Levels Phase 1



The most recent data for LCP1A is reflective of collapse/breakage of the well. It has recently been replaced with LCP1B.

Figure 4: Leachate Levels Phase 2



There have been some exceedances in Phase 2 since 2017, however, the average from 2017 to present is as follows: LCP2A – 95.7m AOD; LMP2A – 96.84m AOD; LMP2B – 98.38m AOD.

Figure 5: Phase 3 Leachate Levels

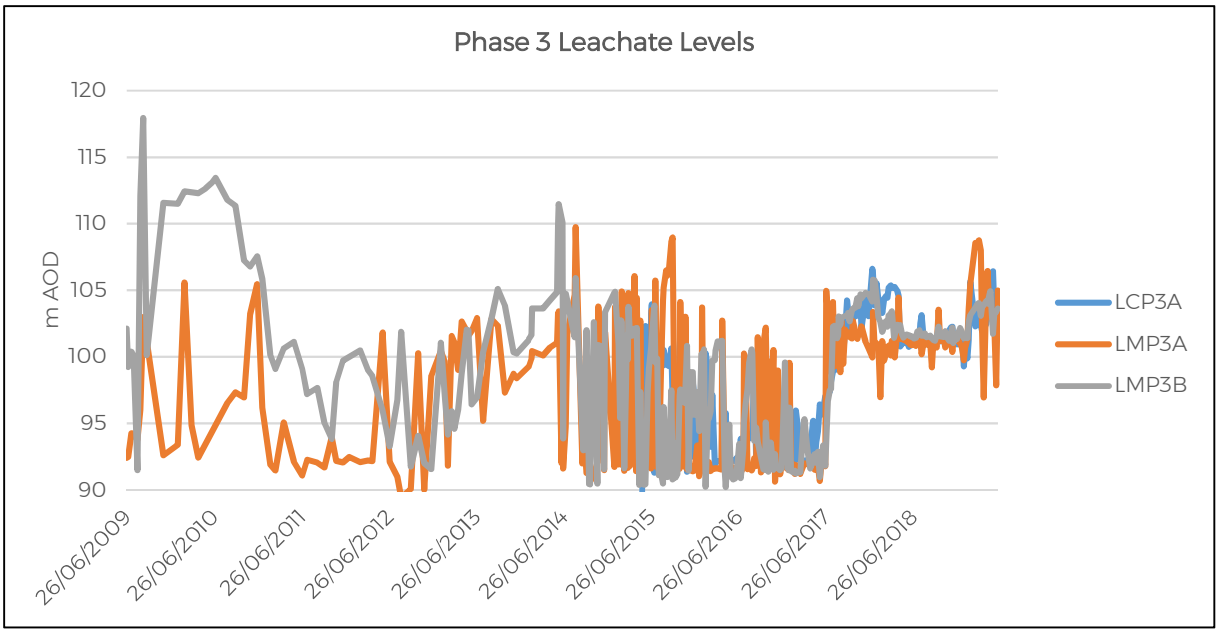
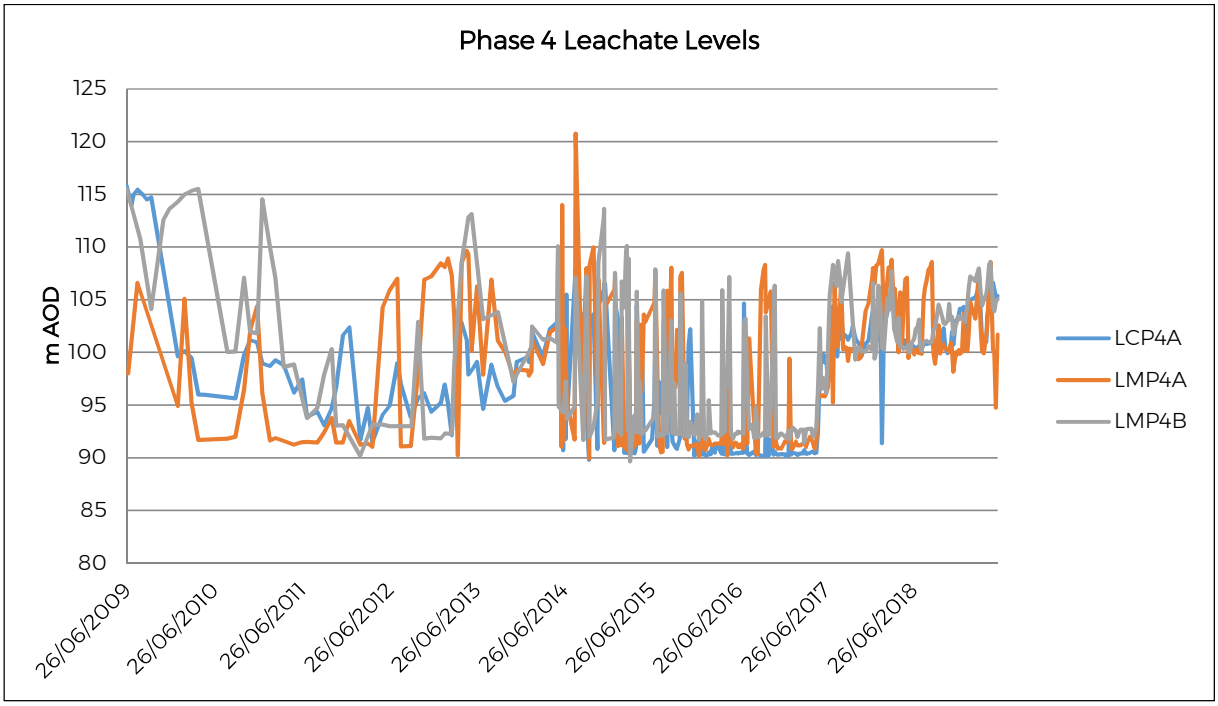


Figure 6: Phase 4 Leachate Levels



5.1.2.2. LEACHATE QUALITY

The former List I substances/hazardous substances were taken to be cadmium and mecoprop. Concentrations from the last 10 years of data are reported in Table 4.

Table 4: Leachate quality: Cadmium and mecoprop

		LCP1A	LCP2A	LCP3A	Cell 3 Sump	LCP4A
Cadmium	n	39	39	10	23	29
	Min	< 0.0003	< 0.0003	<0.001	< 0.0003	0.0018
	Mean	0.0014	0.0022	0.0021	0.0031	0.0018
	Max	0.015	0.024	0.0063	0.03	0.0018
Mecoprop	n	10	10	3	6	7
	Min	<1	<10	64.6	<10.00	<10.00
	Mean	37.3	65.8	116.9	42.9	59.1
	Max	81.6	154	188	146	214

The maximum concentration of cadmium in 2003 was 0.01mg/l. This remains consistent with three of the five leachate monitoring points. Current mean values are all below the most likely value of 0.0065mg/l used in 2003. The maximum concentration of mecoprop was 98.5mg/l in 2003. Maximum concentrations have doubled approximately in most cells. The most likely value of 0.0699mg/l used in 2003 is, however, higher than the mean in the current dataset. Original modelled concentrations are considered to remain valid.

The former List II/non-hazardous pollutants previously assessed are presented in Table 5 relative to the last 10 years of data.

BOD

Median values in LCP1A and LCP4A are consistent with previous HRAs. Median values in LCP2A and Cell 3 Sump are approximately double previous values.

Chloride

In all cells the chloride concentrations have fallen since the previous HRA. In Cell 1 the median value is significantly lower than in the original HRA.

COD

For COD the median values in LCP1A and LCP2A have decreased relative to the previous HRA. In Cell 3 Sump and LCP4A the median values are comparable to the previous HRA.

Ammoniacal Nitrogen

In all cells the median value is lower than the previous HRA and in most cells the maximum values is also lower than the previous HRA

pH

No significant changes in the ranges of pH values has been observed

Table 5: Leachate Quality, Non-hazardous Pollutants

		LCP1A*				LCP2A*				Cell 3 Sump				LCP4A		
		HRA1	HRA2	HRA3	Recent	HRA1	HRA2	HRA3	Recent	HRA1	HRA2	HRA3	Recent	HRA2	HRA3	Recent
BOD	n	4	14	20	38	1	10	19	29	6	11	28	15	10	15	37
	5%ile	-	75	26	108	-	55	43	726	-	184	286	3822	307	407	1367
	median	150	211	223	171	2550	1130	2560	4070	450	14700	4370	20900	6265	2150	5310
	95%ile	-	2441	430	381	-	11855	6039	36080	-	19150	6910	52958	25010	4511	9222
Chloride	n	8	36	39	48	4	27	35	47	6	28	30	30	26	40	37
	5%ile	-	3085	3460	3377	-	834	2600	2152	-	2285	2171	2576	3100	2071	2290
	median	11500	9475	7820	5725	2385	1710	5540	3500	1475	3135	3470	3140	4065	3570	3360
	95%ile	-	13975	12080	10520	-	3837	7745	6084	-	10572	4755	3706	7693	4859	4460
COD	n	4	15	20	40	1	10	19	40	6	11	27	24	10	15	29
	5%ile	-	1499	1596	2548	-	613	6501	6460	-	2126	23908	21725	3191	23129	17240
	median	5525	1710	4280	3650	7700	5110	20000	16300	2900	25500	34000	37900	16250	36000	36000
	95%ile	-	10724	7008	5105	-	25862	31397	27385	-	37310	48416	44325	34550	49877	50700
Amm - N	n	8	36	39	48	4	27	34	47	6	28	30	29	26	25	37
	5%ile	-	600	1135	711.85	-	482	1904	1820	-	838	2768	3160	880	5490	1366.6
	median	1660	1895	1940	1790	3310	1490	4740	3800	920	3320	4350	4000	3945	6800	5310
	95%ile	-	3055	2734	2465	-	5440	6800	6650	-	5660	6140	5500	7168	8074	9222
pH	n	8	35	38	47	4	27	32	46	6	28	30	29	25	24	36
	5%ile	-	7.6	7.6	7.5	-	7.73	8.05	8.2	-	7.6	7.95	8.24	7.5	7.99	8.18
	median	7.55	7.9	7.9	7.8	8	8.3	8.4	8.4	7.75	8.3	8.3	8.35	8.3	8.4	8.30
	95%ile	-	8.2	8.26	8.3	-	8.5	8.82	8.9	-	8.7	8.67	8.67	8.4	8.86	8.75

The data suggests a general decrease in leachate concentration. Figures 7 and 8 present graphs of ammoniacal nitrogen and chloride to illustrate this point.

Figure 7: Ammoniacal Nitrogen in Leachate

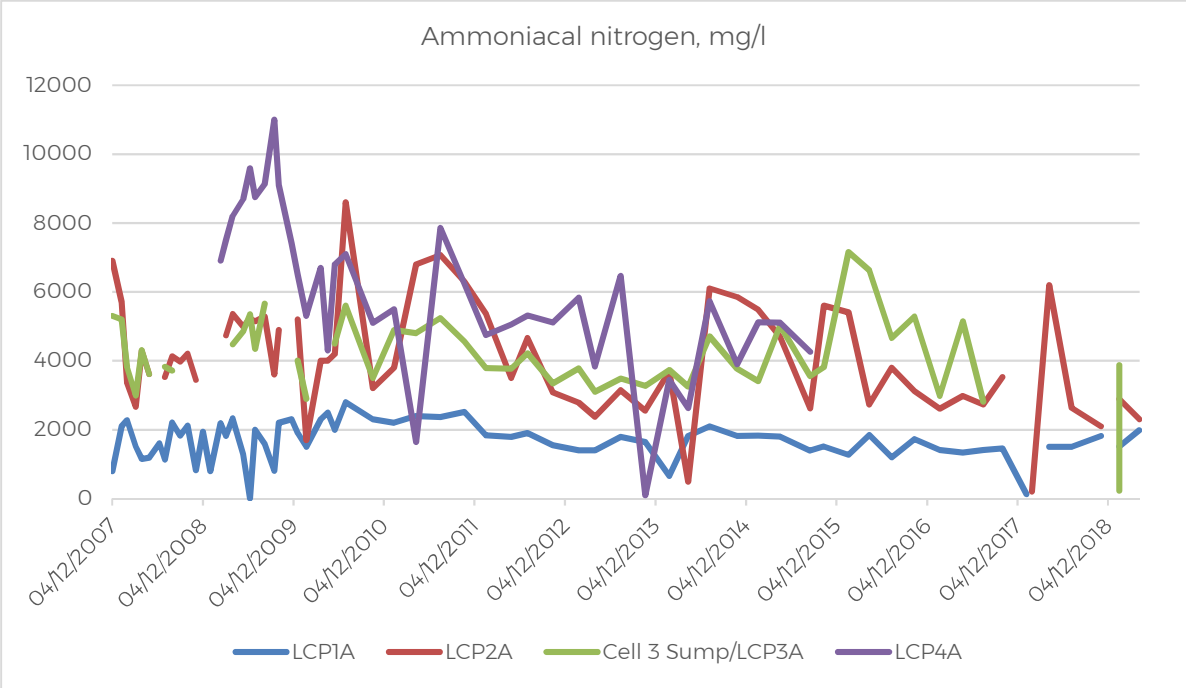
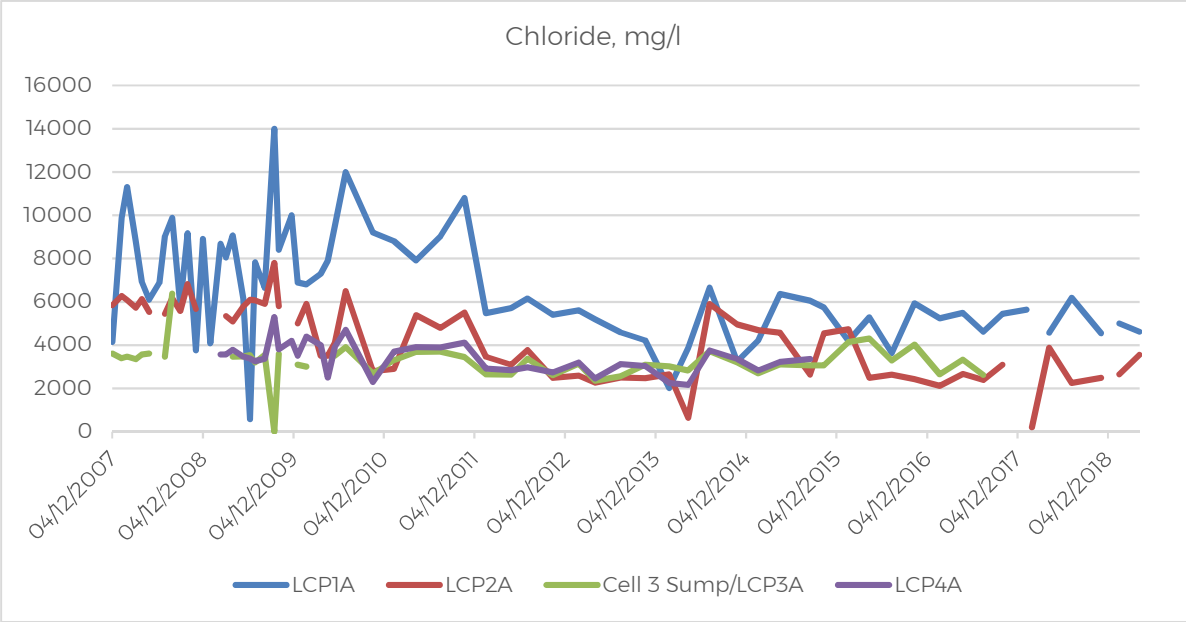


Figure 8: Chloride in Leachate



5.2. Emissions to Groundwater

The environmental permit contains emission limits for the following groundwater boreholes:

BH01/04, BH02/09, BH03/09, BH04/09, BH05/09, BH03/90

All boreholes have an emission limit of 0.39mg/l for ammoniacal nitrogen and a limit of 0.001mg/l for cadmium. The general emission limit for chloride is 150mg/l, however, in BH02/90 it is 615 mg/l. The limits for mecoprop vary between 0.1 and 1.12 ug/l. Data for the last 10 years is presented in the tables below.

Table 6: Cadmium in Groundwater (mg/l)

	BH01/04	BH01/09	BH02/09	BH03/09	BH04/09	BH05/09	BH06/09	BH07/01	BH07/02
n	64	65	65	64	65	65	64	63	67
>LOD	3	2	2	1	1	1	4	7	2
Max	0.0002	0.000148	0.0002	0.0003	0.0002	0.0001	0.0003	0.000597	0.000227
	BH07/03	BH07/09	BH08/09	BH01/90	BH03/90	BH13/93	BH05/90	BH08/91	BH09/91
n	57	63	59	0	65	0	60	0	0
>LOD	4	1	6	0	2	0	1	0	0
Max	0.000304	0.0002	0.0003		0.0002		0.0003		

Table 6 indicates that concentrations of cadmium remain very low and there have been no exceedances of emission limits.

Table 7: Mecoprop in Groundwater (ug/l)

	BH01/04	BH01/09	BH02/09	BH03/09	BH04/09	BH05/09	BH06/09	BH07/01	BH07/02
n	40	40	41	39	40	40	39	40	42
>LOD	3	2	3	3	2	4	29	7	4
Max	0.2	0.05	7.7	0.13	0.95	0.29	5.91	0.23	0.22
	BH07/03	BH07/09	BH08/09	BH01/90	BH03/90	BH13/93	BH05/90	BH08/91	BH09/91
n	37	41	39	0	40	0	37	0	0
>LOD	1	1	4	0	5	0	2	0	0
Max	0.03	0.21	0.44		0.20		0.11		

BH01/04 – there have only been three readings above the limit of detection (LOD) in 10 years. The value of 0.2ug/l was recorded in 2009. There have been no exceedances of the LOD since 2014.
BH02/09 - there have only been three readings above the limit of detection (LOD) in 10 years. The concentration of 7.7ug/l was recorded in 2009. There was a slight exceedance of the emission limit in July 2018, but this was an isolated incident and has not been repeated since.

BH03/09, BH04/09, BH05/09, BH03/90 – There have been no exceedances of the emission limit in 10 years.

Table 8: Ammoniacal Nitrogen in Groundwater (mg/l)

	BH01/04	BH01/09	BH02/09	BH03/09	BH04/09	BH05/09	BH06/09	BH07/01	BH07/02
n	67	66	67	65	65	66	65	61	67
>LOD	50	47	46	42	33	35	52	53	49
Min	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mean	0.065	0.057	0.235	0.127	0.047	0.139	0.417	0.126	0.071
Max	0.6	0.7	6.1	4.4	1.000	5.77	4.17	0.851	0.500
	BH07/03	BH07/09	BH08/09	BH01/90	BH03/90	BH13/93	BH05/90	BH08/91	BH09/91
n	56	62	59	1	67	2	62	1	0
>LOD	44	31	39	0	36	1	41	1	0
Min	<0.01	<0.01	<0.01	<0.04	<0.01	<0.04	<0.01	0.08	
Mean	0.078	0.074	0.090		0.153	0.045	0.086	0.08	
Max	0.500	1.1	0.60	<0.04	2.9	0.05	0.7	0.08	

The data for ammoniacal nitrogen shows that for those boreholes with emission limits the mean value has remained below the emission limit for 10 years. The maximum recorded value for each has exceeded 0.39mg/l. However, this is due to isolated events as described below.

- BH01/04 – there have only been two exceedances of the emission limit in 2009 and 2011.
- BH02/09 – there have been isolated exceedances in 2009 and 2016. In October 2017 a value of 5.3mg/l was recorded. This had reduced to 0.5mg/l on the subsequent monitoring round and is now at, or below 0.01mg/l.
- BH03/09 – there was an isolated exceedance in 2012. All other results have been below the emission limit.
- BH04/09 - there have only been two exceedances of the emission limit in 2009 and 2016.
- BH05/09 – there have been three exceedances and these occurred twice in 2009 and once in 2011.
- BH03/90 – there have been five exceedances of the limit in 10 years, but none since 2013.

In summary, there have been isolated exceedances of limits, but current groundwater quality data is compliant with the environmental permit.

Table 9: Chloride in Groundwater (mg/l)

	BH01/04	BH01/09	BH02/09	BH03/09	BH04/09	BH05/09	BH06/09	BH07/01	BH07/02
n	67	66	66	65	66	66	65	62	67
>LOD	66	66	66	65	66	66	65	62	67
Min	<5	42	26	42	33	12	21	17	47
Mean	17.9	350.6	265.6	53.3	50.6	31.9	46.1	33.8	137.1
Max	99	890	623	97	120	53	130	178	270
	BH07/03	BH07/09	BH08/09	BH01/90	BH03/90	BH13/93	BH05/90	BH08/91	BH09/91
n	56	62	59	1	68	2	62	1	0
>LOD	56	62	59	1	68	2	61	1	0
Min	12	22	19	54	15	24	<5	160	
Mean	29.0	32.9	89.3	54.0	41.6	24.0	20.5	160	
Max	122	46	210	54	150	24	39	160	

There has been no exceedance of the 150mg/l emission limit in boreholes BH01/04, BH03/09, BH04/09, BH05/09 and BH03/90. Table 9 indicates that the 615mg/l limit for BH02/90 has been exceeded, however, a review of the data shoes that this related to one event in 2013. Chloride concentrations in groundwater are considered to be compliant with the environmental permit.

5.3. Emissions to Surface Water

The environmental permit has emission limits for the quality of water in Discharge Lagoon 3. Flow is limited to 50 l/s. FCC engineering state that the design and specification of Lagoon 3 overflow pipe is such that the permit limit for flow cannot be exceeded. The permit states there should be no visible oils and greases. The limit for suspended solids is 30 mg/l and ammoniacal nitrogen 1 mg/l.

The data for suspended solids shows exceedances in 2011 and 2013 and a slight exceedance in 2016, but none since. There have been no recorded incidences of visible oils and grease. There were several exceedances of the ammoniacal nitrogen limit in 2010, then again in 2012 and the early part of 2013. There have been no recorded exceedances since 2016. Chloride concentrations are 60mg/l on average. This data indicates there is no significant impact of the landfill on surface water quality.

5.4. Review of Technical Precautions

The placement of the sidewall leachate drainage blanket directly over the sidewall liner is considered to break the pathway for leachate migration laterally in to the Northampton Sand and Lincolnshire Limestone. Leachate has been generally maintained below the level of these two aquifers. If there were issues concerning perched leachate acting across the

sidewall liner, it would be expected that this would give rise to a deterioration in surface water quality, as monitored in Discharge Lagoon 3, or in the downgradient groundwater boreholes. This has not been proven to be the case and therefore, it is considered that the current technical precautions are functioning as intended.

6. Requisite Surveillance

6.1. Monitoring Objectives

There are no current improvement conditions in the environmental permit that relate to the hydrogeological condition of the site. The 2013 HRA review documents how each of the previous improvement conditions have been addressed.

6.2. Monitoring Frequency and Determinands

Table S3.1 of the environmental permit defines the leachate level monitoring requirements as monthly. The site now has a fully engineered cap and therefore, the monitoring requirements for non-operation cells apply. It is requested that the monitoring and reporting frequency is reduced to quarterly.

There are no other proposed changes to the current monitoring regime for groundwater, surface water, or leachate. Water quality data has been found to be compliant with emission limit values and leachate levels have been found to generally comply with the limit of 109m AOD. Therefore, no changes to these controls are required.

7. Summary and Conclusions

A review of the leachate quality data has determined that concentrations of the key determinands: ammonical nitrogen and chloride are declining and are generally lower than modelled in the original HRA.

Basal leakage to the Marlstone Rock at depth below the Lias Clay is no longer considered a significant pathway and therefore, the Marlstone Rock is no longer considered a receptor.

The pathway for sidewall seepage into the Northampton Sand and Lincolnshire Limestone is considered to be broken due to the placement of a leachate drainage layer directly onto the sidewall. Monitoring of surface water quality and the quality of groundwater in downgradient boreholes indicates that there have been no recent events giving rise to pollution by non-hazardous substances, or the former hazardous substances cadmium and mecoprop. Current groundwater and surface water monitoring data remains compliant with the environmental permit.

REFERENCES

1. Golder: 2003 : Environmental Setting and Installation Design. Colsterworth Landfill, report reference 03523307.005.
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3. Golder: 2007: Hydrogeological Risk Assessment Review. Colsterworth Landfill, report reference 07514290190.501/A.1.
4. FCC: 2013: Hydrogeological Risk Assessment Review. Colsterworth Landfill.
5. ESI: 2015: Colsterworth Landfill: Review of Leachate Levels. Report reference 62858R1Rev2.

McDonnell Cole

36 Dunster Road
West Bridgford
Nottingham
NG2 6JE.