

Docksway Disposal Site, Newport

Revision to the Hydrogeological Risk Assessment

On behalf of **Newport City Council**



Project Ref: 14739/155 | Rev: 00 | Date: April 2015



Document Control Sheet


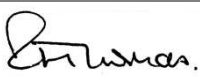
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Report Title: Revision to the Hydrogeological Risk Assessment

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Date: April 2015

	Name	Position	Signature	Date
Prepared by:	Kate Riley	Principal Engineer		30/04/15
Approved by:	Richard Thomas	LLP Director		30/04/15
For and on behalf of Peter Brett Associates LLP				

Revision	Date	Description	Prepared	Reviewed	Approved
00	Apr 2015	Issue – to support Permit Revision Application	VKR	RHT	RHT

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1 Introduction

1.1 Background

Docksway Disposal Site is a non hazardous waste disposal site located approximately 3km south of Newport City Centre, Gwent and is centred on National Grid Reference ST 305 853 (Figure 1). It is operated by Newport City Council, referred to hereafter as NCC.

The site is split into a northern half (Area 1) and a southern half (Area 2) as shown on Figure 1. Area 1 of the site has been used intermittently for waste disposal operations since 1939 and is now closed. There is no artificial engineered containment of potential contaminants at Area 1, and it operates as a 'dilute and disperse' landfill. Area 2 of the site has been operated under Environmental Permit (EPRDP3733BK) since 2005, and is engineered and constructed as a full containment landfill.

NCC are applying to vary the existing Environmental Permit (EP) to include a Stable Non Reactive Hazardous Waste (SNRHW) cell for the disposal of asbestos, and to increase the side slope angles and final restored height of the landfill across Area 2.

A Hydrogeological Risk Assessment (HRA) was carried out for Area 2 as part of the application for the existing EP, and this revision presents the findings of the additional LandSim modelling that has been undertaken with reference to the proposed changes. This report should be read in conjunction with the original HRA (Conceptual Model and Hydrogeological Risk Assessment for Area 2 - Landfill Extension, Reissue, April 2005)^[1].

1.2 Scope of Works

The scope of works for this revision comprises a review of the LandSim input parameters used in the original assessment, with reference to the proposed changes to the EP, and where appropriate, amendment of the input parameters and re-run of the modelling to identify any potential changes to the risk to groundwater from the proposed variation.

2 Site Description

2.1 Introduction

Each sub-section of the 'Site Description' section in the original HRA has been reviewed, and only areas that require amendment for the purpose of updating the HRA are presented herein.

2.2 Site History

The percentages of waste types accepted when the original HRA was produced were as follows;

- Domestic/household: 54%
- Commercial: 35%
- Inert: 11%

At the present time, NCC are redirecting all of their domestic/household waste to an Energy from Waste facility (Trident Park) in Cardiff, and therefore they have estimated that the percentages of waste types being accepted going forwards is likely to be as follows;

- Commercial/Industrial: 50%
- SNRHW: 10%
- Inert: 40%

2.3 Drainage

In Area 2, there are two developed cells within the permitted area and up to three additional cells that could be developed, as shown on Figure 2. Cell 1 has been partially filled and is part permanent and part temporarily capped. Cell 2 is the currently active cell and is part permanently capped. Both cells are full containment cells and therefore leachate is actively managed and kept separate from surface water.

Surface water in Area 2 is collected in perimeter ditches that encircle part of the Area 2 site boundary, and then discharged under consent to the River Ebbw.

It is not proposed to change the principal drainage mechanisms for either the ongoing non-hazardous waste disposal operations at the site, or the proposed asbestos disposal operations. The operating requirements of the Asbestos cell will limit the potential for surface water to be in contact with asbestos materials, as described in the asbestos operational and management plan (SNRHW – Construction and Operational Management Plan, NCC 2015)^[2].

2.4 Engineering Design Philosophy

The Engineering Design Philosophy for Area 2 is not fundamentally changed by the proposed changes to the EP. A minor change to the existing design of the Engineered Barrier System (EBS) is that there is no need for a load transfer blanket over the stabilised

alluvium that effectively separates the two clay barriers (one natural, one engineered). The load transfer blanket was previously included to provide a platform on top of which the clay liner could be constructed, and was not a requirement for the containment engineering. However the EBS options within LandSim do not allow a double clay barrier system without the internal drainage layer to be modelled and therefore the load transfer blanket remains as part of the model for the re-runs carried out as part of this assessment.

Additionally, it is proposed to use tyre bales instead of non-calcareous gravel as the drainage blanket for the next cell development in Area 2. The tyre bales provide a similar or better permeability over a greater depth than the aggregate that has previously been used (as described in TRL Ltd Published Project Report PPR080, Tyre Bales in Construction, 2006). Therefore the same permeability value has been used within the LandSim modelling re-runs, but the thickness has been increased appropriately.

3 Hydrology

3.1 Rainfall

Rainfall data used in the original HRA (for the period 1980 to 1991) has been compared to more recent data available on the Met Office website, for the period 1981 to 2010, and for the Usk weather station.

The recent data indicates a very similar average annual precipitation (1077mm) to the previous figure (1112mm). The rainfall data from the on-site weather station indicates that in 2014, 1054mm of rainfall was recorded at the site. Therefore the input parameters for rainfall and effective rainfall are not amended in the LandSim model for this revision because they can be considered to be the worst case values.

Similarly the effective rainfall and therefore infiltration for the site has been calculated as part of the water balance calculations (see below). These input parameters have not been amended in the water balance calculations for the non-hazardous waste cell because the original parameters are still considered to be conservative and the assumptions made regarding run off are considered to be appropriate. However, the SNRHW cell will only be opened one day at week for asbestos waste disposal, and at the end of the disposal day, the cell will be immediately covered with 1m of cover. Therefore the effective percolation and infiltration is adjusted to reflect this. Separate calculations have been carried out to include for varying the run-off coefficient for the SNRHW cell only, and the resultant effective percolation has been used in the water balance calculation.

3.2 Water Balance

Pre-restoration and post-restoration water balances have previously been undertaken for the developed cells in Area 2 at the site, on a cell by cell basis. As part of this addendum, pre-restoration and post-restoration water balances have been carried out for the next cell (Cell 3), to take account of changes required to the LandSim input parameters, such as percolation, rate of waste infilling, placement density of waste and absorptive capacity of the waste, as described below. The cell has been split into sub-cells to reflect the operational differences between the non-hazardous and the SNRHW cell. Cell 3A is the SNRHW cell and Cell 3B is the non-hazardous cell.

The percolation that was previously calculated (678mm) has been used in the water balance calculations for the non-hazardous cell, based on a runoff coefficient of zero (worst case assuming all effective rainfall available for infiltration) during the filling stages. However, for the SNRHW cell, due to the daily cover requirement, a runoff coefficient of 0.30 (70% infiltration) has been used for the water balance calculations. The SNRHW cell has been further sub-divided into four sub cells (3Aa, 3Ab, 3Ac, 3Ad) to reflect the operational procedures and programme for filling, as described in the construction and operational plan^[2].

The rate of waste infilling at Docksway has declined since the original assessment was carried out, and is still changing due to the operation of the Trident Park EfW facility at Cardiff. Therefore NCC has estimated that the rate of waste infilling is likely to be in the region of 45,000 tonnes per annum of non-hazardous waste and 10,000 tonnes per annum of asbestos materials (excluding daily cover) into the SNRHW cell. These values have been used as the LandSim input parameters for the modelling re-runs.

The types of waste and percentage inputs has also changed at Docksway (see Section 2.2) since the original assessment was carried out and therefore the emplacement density of the non hazardous waste has been increased to 1.2 tonne/m³ to reflect this, in accordance with the stability assessment (Revised Stability Assessment for Area 2 at Docksway Disposal Site, PBA, April 2015)^[3].

Guidance in Landfill site design recommends that the absorptive capacity of the waste is linked to the waste density. Therefore, in accordance with guidance given in 'Landfill Site Design' (EPA, 2000)⁴, the absorptive capacity of the waste has been changed (reduced) to 0.02m³/tonne, as appropriate for the amended waste density.

Except where described above, the water balance input parameters have remained the same as the original HRA^[1].

The full water balance calculation for Cell 3 is contained in Appendix 1. The results indicate that free liquid will be generated within the two sub cells because the absorptive capacity is not sufficient for the calculated infiltration. Within the non-hazardous cell the free liquid is categorised as leachate, whilst in the SNRHW cell, the liquid can be regarded as surface water because it is only in contact with the non biodegradable asbestos waste. Table 3.1 below presents the results of the water balance and the volumes of free liquid/leachate that have been calculated. Cell 3A has been subdivided into separate sub cells for the calculations, to reflect the proposed operational programme as described in the construction and operational plan for the proposed SNRHW cell^[2].

The leachate management and extraction system at the site is designed as a piped system and therefore any free leachate generated in the non hazardous cell will be extracted by pumping (direct to a tanker for off-site disposal) to maintain the leachate head at permitted levels. Free liquid generated in the SNRHW cell will be extracted separately and filtered through a sand filter (to remove any loose asbestos fibres) before being tested for asbestos fibres and subsequently discharged, as described in the construction and operational plan for the proposed SNRHW cell^[2].

Table 3.1: Cell 3 Water Balance Results

Cell	Absorptive Capacity (m ³)	Volume of Infiltration (m ³)	Free Liquid/Leachate
3Aa (SNRHW)	788	4433	Yes (3645 m ³)
3Ab (SNRHW)	788	4433	Yes (3645 m ³)
3Ac (SNRHW)	788	4433	Yes (3645 m ³)
3Ad (SNRHW)	788	4433	Yes (3645 m ³)
3B (Non-haz)	6348	50607	Yes (44259 m ³)

4 Conceptual Model

4.1 Leachate Chemistry

The original HRA identified six key potential contaminants that were used to predict the potential future concentrations in the Area 2 leachate, and therefore the potential risk to groundwater over time. As the scope of this revised assessment is to identify the change to this risk from the proposed EP changes, it is not considered appropriate to change the key potential contaminants, and therefore the six contaminants used in the LandSim modelling are as follows;

- Ammonia (Ammoniacal Nitrogen)
- Mercury
- Nickel
- Potassium
- Tributyltin chloride
- Xylene

The concentrations used in the original HRA have been compared against the actual concentrations measured in the Area 2 leachate, where available, to determine the appropriateness of the values used originally. Where direct comparison is available, the average measured concentrations of the contaminant are lower than the input values used in the original LandSim modelling. These input values were not amended for the re-runs carried out as part of this assessment, however, and can therefore be considered to be conservative.

5 Numerical Simulations

5.1 LandSim Inputs

Table 5.1 describes the inputs used for the LandSim modelling re-runs undertaken for this addendum risk assessment. Where the values have changed from the previous risk assessment, the text is in italics.

Table 5.1: LandSim Input Parameters

Parameter	Value	Distribution	Units	Justification
Effective rainfall	281, 531, 760	triangular	mm	Unchanged
Infiltration	239, 451, 646	triangular	mm	Unchanged
Design Cap infiltration	23 to 46	uniform	mm/yr	Unchanged
Waste porosity	0.02, 0.07, 0.2	triangular	fraction	Unchanged
<i>Waste density</i>	<i>1.2-1.5</i>	<i>uniform</i>	<i>kg/l</i>	<i>Based on stability assessment (PBA, 2015)</i>
<i>Final waste thickness</i>	<i>5, 20, 35</i>	<i>normal</i>	<i>m</i>	<i>Based on proposed changes to EP and the restoration contours</i>
Waste field capacity	0.4, 0.425, 0.45	triangular	fraction	Unchanged
No cells	5	single	-	Unchanged
<i>End of filling</i>	<i>30</i>	<i>single</i>	<i>yrs</i>	<i>2005 to 2035</i>
Total surface area of landfill	15.7	single	ha	Unchanged
End of managed phase (from start of filling)	70	single	yrs	Unchanged
Leachate head above cell bases	2.0	single	m	Unchanged
Leachate head above which surface break-out will occur	10	single	m	Unchanged
<u><i>Leachate Inventory</i></u>				
Ammonia	4.37, 723, 3640	triangular	mg/l	Unchanged
Mercury	3.94x10 ⁻⁵ , 8.91x10 ⁻⁵ , 0.00195	triangular	mg/l	Unchanged

Parameter	Value	Distribution	Units	Justification
Nickel	0.0083, 0.12, 2.21	triangular	mg/l	Unchanged
Potassium	7.55, 929, 3120	triangular	mg/l	Unchanged
Tributyltin chloride	1×10^{-7} , 1×10^{-5} , 1×10^{-4}	triangular	mg/l	Unchanged
Xylene	0.168, 0.034	normal	mg/l	Unchanged
<u>Engineered Barrier System – Double Clay Liner</u>				
Thickness of top clay liner	1.1, 1.2, 1.4	triangular	m	Unchanged
Thickness of bottom (cement stabilised) clay liner	1.9, 2.0, 2.5	triangular	m	Unchanged
Permeability of clay liners	1.0×10^{-10} , 5.0×10^{-10} , 1.0×10^{-9}	triangular	m/s	Unchanged
Dispersivity of clay liners	0.32	triangular	m	Unchanged
Thickness of internal drainage layer	0.3	triangular	m	Unchanged
Conductivity of drainage layer	10^{-4} to 10^{-6}	triangular	m/s	Unchanged
Base slope to sump	1 in 50	single		Unchanged
Diameter of sump	3	single	m	Unchanged
<u>Unsaturated Zone – Alluvial Clay</u>				
Unsat zone thickness	4, 0.4	normal	m	Unchanged
Unsat zone vertical conductivity	1×10^{-10} , 5×10^{-10} , 1×10^{-9}	triangular	ms^{-1}	Unchanged
Moisture content	0.478, 0.15	normal	fraction	Unchanged
Unsat zone density	1.65 to 2.0	uniform	kg/l	Unchanged
Dispersivity of Unsat zone	0.4	single	m	Unchanged
<u>Vertical Pathway – Alluvial Clay</u>				

Parameter	Value	Distribution	Units	Justification
Thickness of vertical pathway	1.5	single	m	Unchanged
Porosity of vertical pathway	0.41 to 0.69	uniform	fraction	Unchanged
Dispersivity of vertical pathway	0.15	single	m	Unchanged
<i>Aquifer Properties</i>				
Width of aquifer	500	single	m	Unchanged
Mixing zone thickness	6.12, 1.35	normal	m	Unchanged
Hydraulic conductivity	$1e^{-5}$, $5e^{-3}$, $1e^{-2}$	triangular	ms^{-1}	Unchanged
Hydraulic gradient	0.0034 to, 0.0065	triangular	fraction	Unchanged
Porosity	0.2 to 0.35	uniform	fraction	Unchanged
Longitudinal dispersivity	30	single	m	Unchanged
Transverse dispersivity	3	single	m	Unchanged
<i>Retardation Factors</i>				
Ammonia Kd	0.5 to 2	uniform	l/kg	Unchanged
Ammonia decay rate	10, 20, 50	triangular	years	Unchanged
Mercury Kd	450 to 3835	uniform	l/kg	Unchanged
Mercury half life	10^9	single	years	Unchanged
Nickel Kd	20 to 800	uniform	l/kg	Unchanged
Nickel half life	10^9	single	years	Unchanged
Potassium Kd	0	single	l/kg	Unchanged
Potassium half life	10^9	single	years	Unchanged
Potassium kappa constants	0.2919 (c) 0.0298 (m)	single	kg/l	Unchanged
Tributyltin chloride Kd	500 to 5000	uniform	l/kg	Unchanged
Tributyltin chloride half life	10^4	single	years	Unchanged

Parameter	Value	Distribution	Units	Justification
Tributyltin chloride kappa constants	-0.0862 (c) 0.0415 (m)	single	kg/l	Unchanged
Xylene Kd	8.9 to 10.5	uniform	l/kg	Unchanged
Xylene half life	1	single	years	Unchanged
Note: For normal distributions the mean value is given followed by the standard deviation. For triangular distributions the lowest value, expected value and highest value are given in that order.				

6 Results of the Revised Quantitative Risk Assessment

6.1 Percentiles and Confidence Limits

The results of the revised quantitative risk assessment have been discussed in terms of the 95th percentile (95%ile). The 95%ile is considered to be an appropriate conservative estimate of the risk that might arise as a result of uncertainty in the model inputs. It represents a result or value which has only been realised 5% of the time and there is therefore 95% confidence that the actual result or value will be less than the 95%ile value.

6.2 Predicted Leachate Heads

Figure 3 presents the expected leachate head in the Area 2 landfill as predicted by LandSim. For the present day the leachate head has been fixed within the LandSim model at 2.0m above the EBS, as this is the current permitted maximum leachate level in Area 2, and that will be maintained by pumping to tanker for removal and off-site disposal.

Figure 3 shows that when the managed phase of the landfill operation ends (70 years from the commencement of tipping), according to the 95%ile, the leachate will rise to no more than an average of 8.75m above the base of the EBS during the unmanaged phase.

Figure 4 indicates the predicted rate of leachate leakage from the base of the Area 2 landfill. The plot demonstrates how leakage from the base of the EBS will increase when leachate management via pumping ceases (70 years after commencement of tipping), for a period of about 5 years before the predicted rate decreases to 14,500 litres per day.

Surface breakout of leachate is not predicted to occur during the operational, managed or unmanaged phase according to the 95%ile value (Figure 5). This prediction is based on the assumption that leachate will breakout at the surface from the base of the sides of the landfill if the leachate reaches an average of 10m above the EBS of the landfill as a whole. It should be noted that the leachate levels within the waste will be higher where the waste thickness is greatest (i.e. beneath the centre of the tip) and lower closer to the edges of the landfill. The estimate of 10m to give surface breakout is an average value above the EBS. In reality leachate would probably reach higher than 10m above the EBS in the centre of the waste mass before any major breakout is observed at the edges.

Estimates of the amounts of leachate that will need to be pumped and extracted to maintain the permitted leachate head of 2m during the operational and managed phases are given in Figure 6. Once the cap has been completed on Area 2, the model predicts that based on the 95%ile value, 10,500 litres of leachate per day will need to be pumped during the managed phase.

6.3 Emissions to Groundwater – Hazardous (former List I) Substances

Figures 7, 8 and 9 indicate the LandSim predicted concentrations of the hazardous substances mercury, tributyltin chloride and xylene respectively at the base of the vertical pathway.

The figures demonstrate that none of these three substances are predicted to reach the base of the vertical pathway in 20,000 years.

6.4 Emissions to Groundwater – Non-hazardous (former List II) Substances

Figures 10 and 11 indicate the LandSim-predicted concentrations of the non-hazardous substances ammoniacal nitrogen and nickel at the base of the vertical pathway.

Figure 10 indicates that ammoniacal nitrogen will reach a maximum concentration of about 0.35 mg/l at the base of the vertical pathway after approximately 450 years (95%ile).

Figure 11 shows that nickel is not predicted to reach the base of the vertical pathway at discernible levels (95% ile) in 20,000 years.

6.5 Emissions to Groundwater – Potassium

Figure 12 indicates that potassium will reach a maximum concentration of approximately 225mg/l at the base of the vertical pathway after approximately 250 years (95%ile), thereafter reducing to <5 mg/l by 3000 years.

6.6 Control and Compliance Limits

There are currently eleven compliance monitoring wells with agreed compliance limits across Area 2, as reproduced in Table 6.1. The compliance limits are based on baseline concentrations plus a percentage.

Table 6.1 – Accepted Area 2 Groundwater PPC Permit Compliance Limits for Emissions to Groundwater

Monitoring Well	Benzene	Naphthalene	Xylene	Arsenic
	Compliance Limit ug/l	Compliance Limit ug/l	Compliance Limit ug/l	Compliance Limit ug/l
GW03_09	2	5	3	35
GW06_13	2	5	3	50
GW06_14a	2	5	3	25
GW06_34	2	5	3	65
GW06_36	2	5	3	30
GW06_37	2	5	3	60
GW06_39	2	5	3	50
GW07_40	2	5	3	35
GW09_31	13	5	3	80
GW09_32	3	5	3	30
GW09_35	2	5	3	50

Monitoring Well	Nickel		Potassium		Ammoniacal Nitrogen	
	Control Level	Compliance Limit	Control Level	Compliance Limit	Control Level	Compliance Limit
	ug/l	ug/l	mg/l	mg/l	mg/l	mg/l
GW03_09	8	10	160	180	30	35
GW06_13	12	14	100	110	30	35
GW06_14a	12	14	160	180	53	60
GW06_34	12	14	310	350	30	35
GW06_36	8	10	100	110	20	23
GW06_37	8	10	100	110	30	35
GW06_39	26.4	30	100	110	20	23
GW07_40	8	10	39.6	45	20	23
GW09_31	8	10	100	110	50	50
GW09_32	8	10	160	180	50	50
GW09_35	8	10	100	110	30	35

The maximum concentrations of Ammoniacal Nitrogen, Nickel, Potassium and Xylene recorded during the ongoing groundwater monitoring in Area 2 have been compared to the trigger levels in the original HRA assessment and the compliance limits in Table 6.1 above, and none have exceeded the trigger levels or compliance limits with two exceptions. There have been occasional exceedances of the compliance limits for Nickel in GW09_35 and GW07_40 during 2014.

7 Conclusions

In summary, the results and conclusions of the revised assessment are as follows;

- The revised model predicts marginally higher leachate heads on the EBS than the original HRA during the unmanaged phase and similar basal leakage rates.
- The revised model predicts no surface breakout, the same as the original HRA.
- The revised model predicts that none of the three hazardous (former List I) substances (mercury, tributyltin chloride or xylene) modelled as part of the original HRA will reach the base of the vertical pathway at discernible concentrations after 20,000 years.
- The revised model predicts that ammoniacal nitrogen will reach a concentration of 0.35 mg/l (much lower than the original HRA) at the base of the vertical pathway after approximately 450 years (95%ile), and that nickel is not predicted to reach the base of the vertical pathway at discernible levels (95% ile) in 20,000 years.
- The revised model predicts that potassium will reach a concentration of approximately 225mg/l at the base of the vertical pathway after approximately 250 years (95%ile), thereafter reducing to <5 mg/l by 2000 years. The higher value is within the range of background concentrations measured in many of the compliance monitoring wells in Area 2 and therefore not considered significant in terms of additional risk to groundwater.

The results of this revised risk assessment have identified that there is no significant additional risk to groundwater from the proposed variation to the existing Environmental Permit. This revision has demonstrated that many of the input parameters for the LandSim model and the water balance calculations are very conservative and therefore the output represents the worst case. In reality, the actual risk is likely to be less than predicted by the modelling.

8 REFERENCES

- [1] Peter Brett Associates. Conceptual Model and Hydrogeological Risk Assessment for Area 2 – Landfill Extension. Docksway Disposal Site, Newport. Report Re-issue to Address Schedule 4 Notice. April 2004.
- [2] Newport City Council. SNRHW Construction and Operational Plan. Docksway Disposal Site, Newport. March 2015.
- [3] Peter Brett Associates. Stability Assessment for Revised Landfill Layout. Docksway Disposal Site, Newport. March 2015.
- [4] Environmental Protection Agency. Landfill Site Design. 2000.

Figures



Site Grid Reference: ST 309 852

Client
NEWPORT CITY COUNCIL

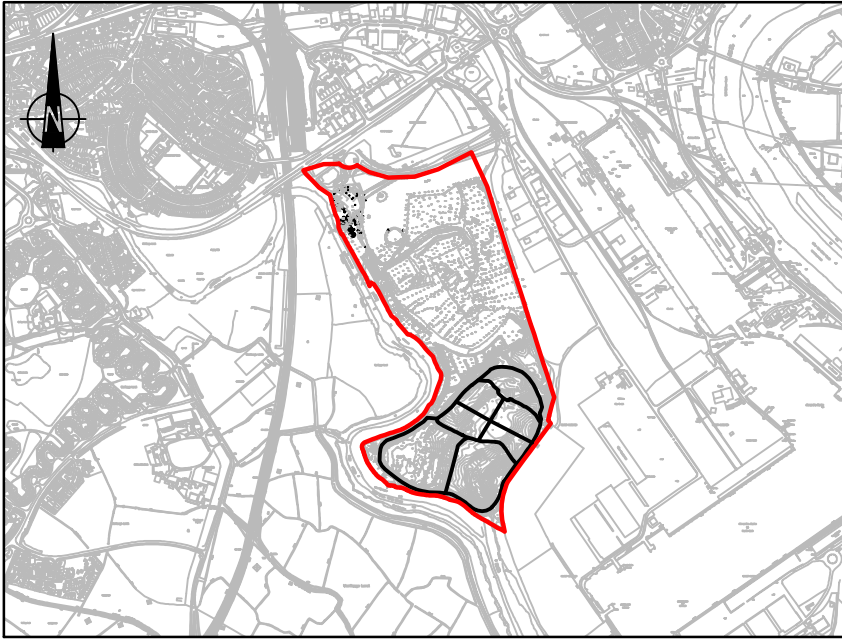
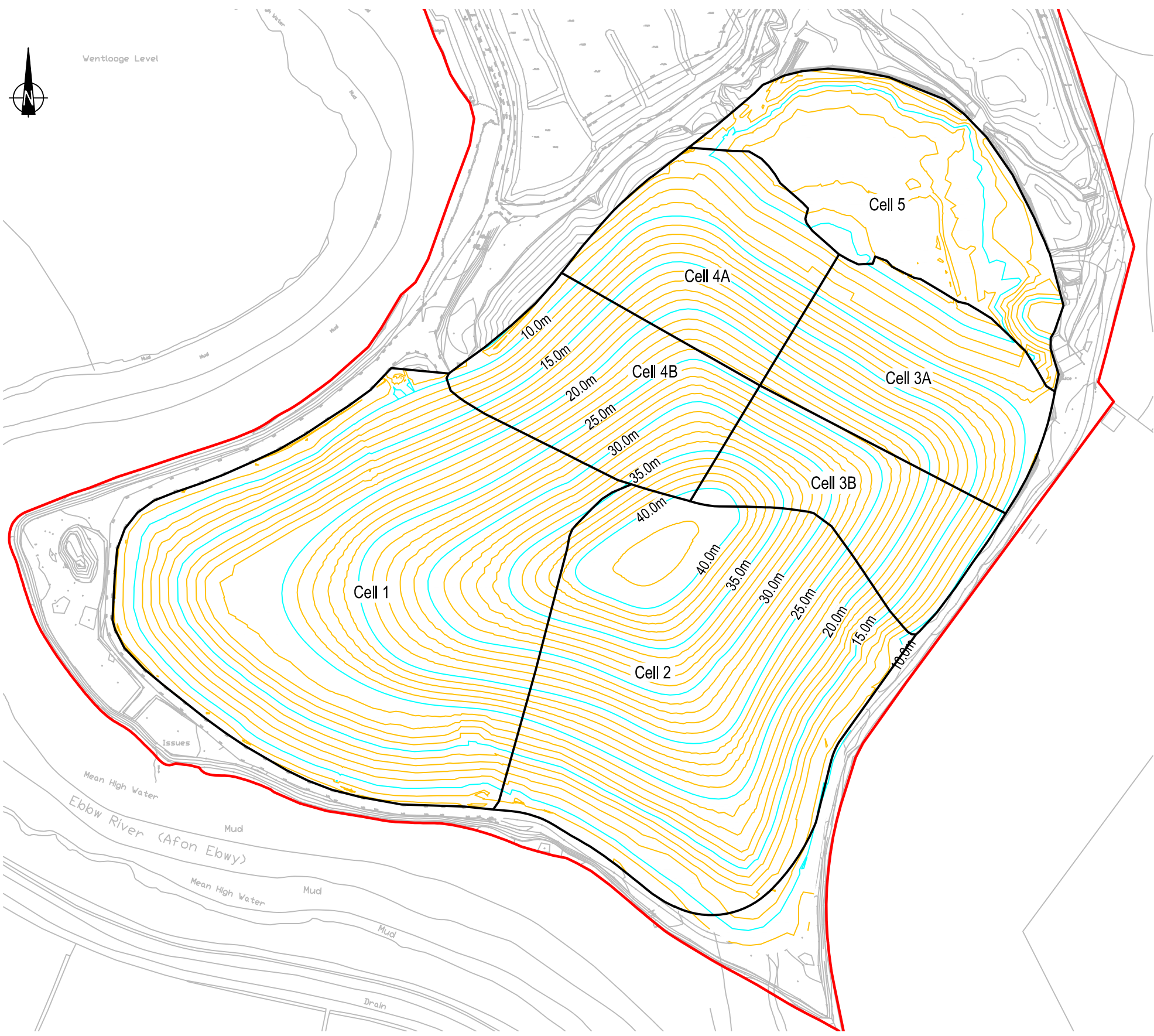
Contains Ordnance Survey data © Crown copyright and database right 2014.

**DOCKSWAY DISPOSAL SITE
 NEWPORT**

SITE LOCATION PLAN

Date	01.04.2015
A4 Scale	1:50 000
Drawn by	davco
Checked by	VKR
Revision	0

FIGURE 1



Client
NEWPORT CITY COUNCIL

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**DOCKSWAY DISPOSAL SITE
 AREA 2**

PRE SETTLEMENT RESTORATION CONTOURS

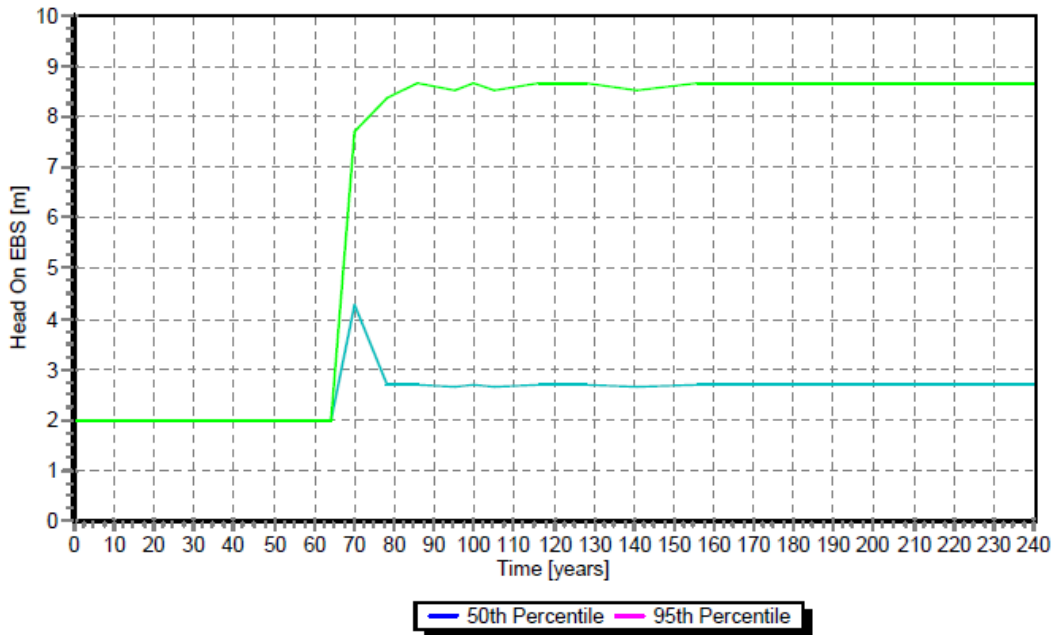
Date	30.03.2015
A3 Scale	1:5000
Drawn by	davco
Checked by	VKR
Figure Number	2

LandSim Version 2.5

Project Name: Docksway Area 2

Customer: Newport City Council

Results: Area 2, Head On EBS [m]



Area2-DrftD rerun waste density 1.2-1.5.sim

27/04/2015 08:35:18

Note: EBS denotes an abbreviation used by the LandSim model for engineered barrier system.

LANDSIM MODELLING RESULTS: PREDICTED HEAD OF LEACHATE ABOVE BASE OF AREA 2 BASAL LINER

Client

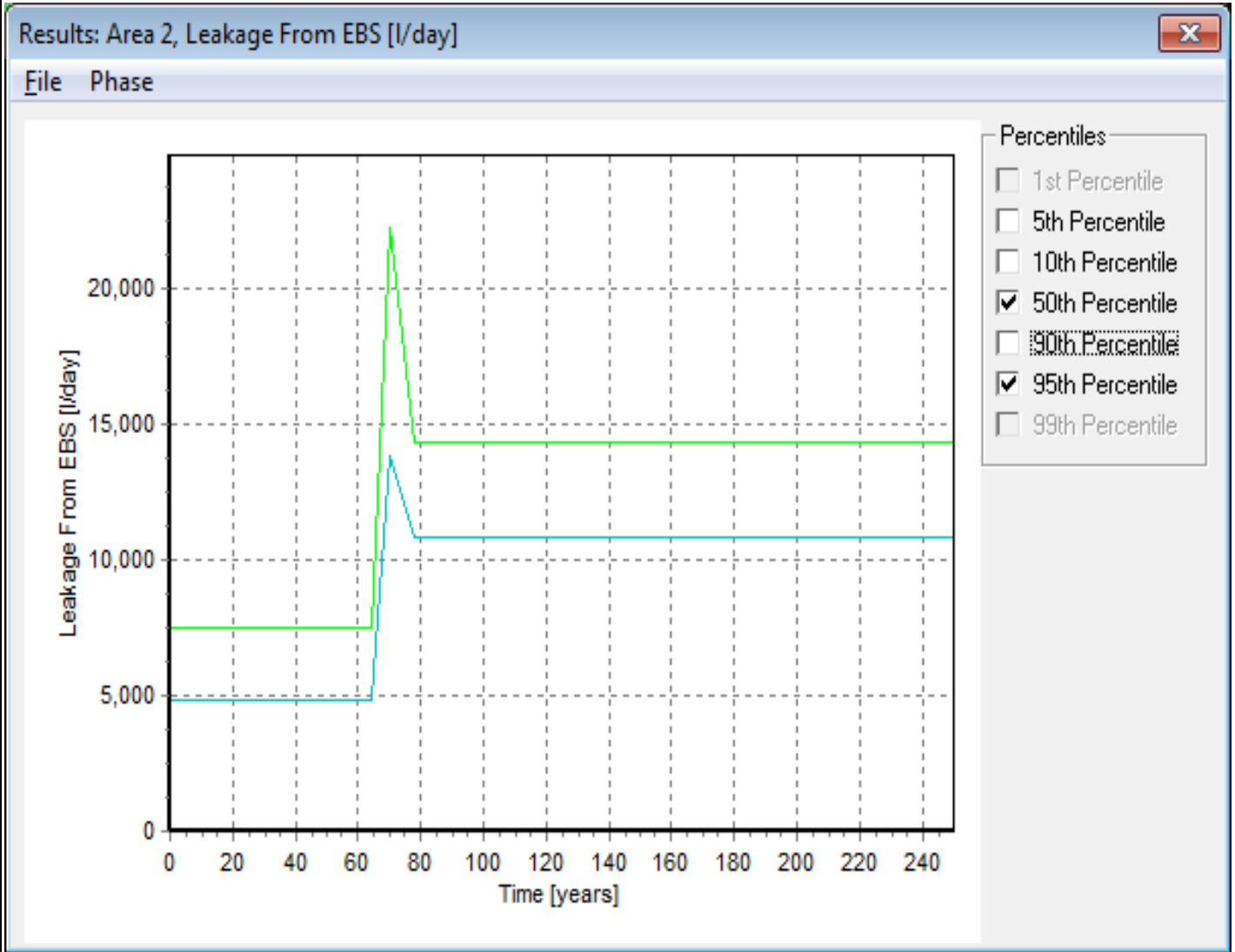


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Figure

3



Note: EBS denotes an abbreviation used by the LandSim model for engineered barrier system.

LANDSIM MODELLING RESULTS: PREDICTED LEAKAGE FROM THE ENGINEERED BARRIER SYSTEM

Client



Caversham Bridge House, Reading, RG1 8DN, Tel 0118 950 0761 Fax 0118 959 7498

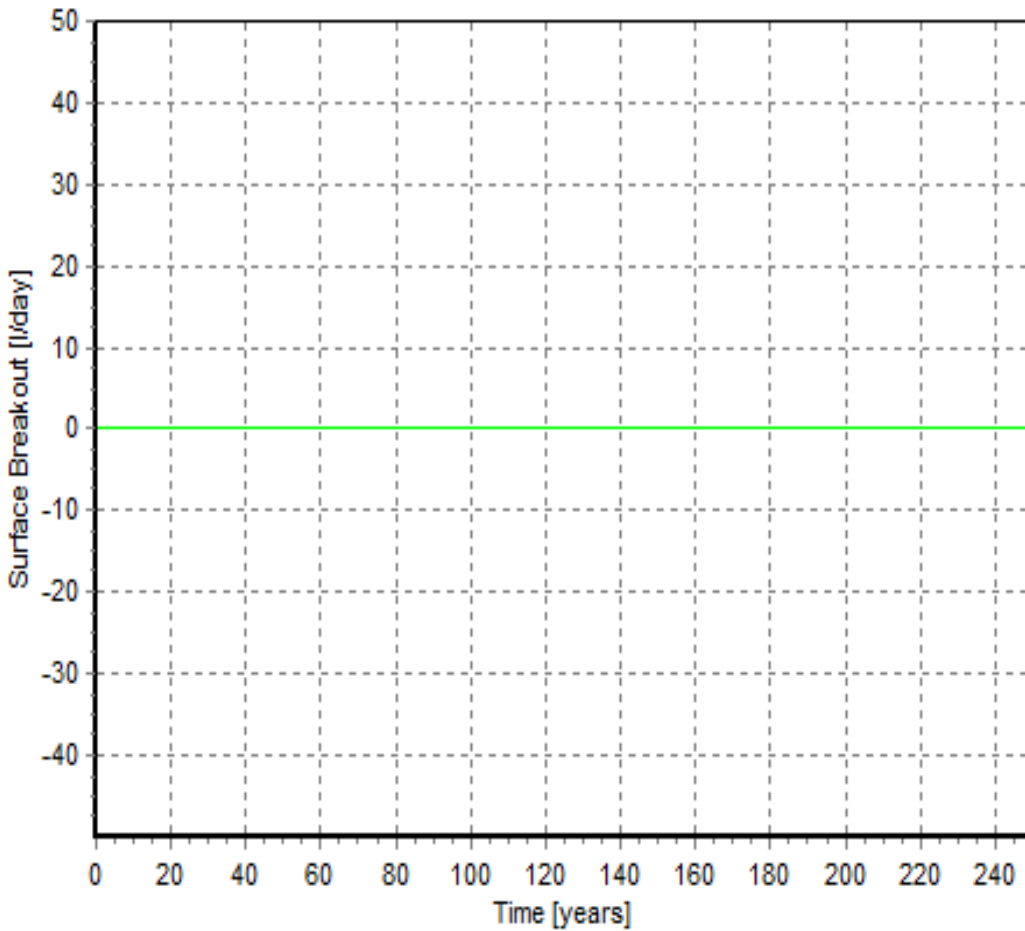
By	vkr	Rev	1
Date	Apr 15	Job	14739/155
Chkd	rht	File	n/a

Figure

4

Results: Area 2, Surface Breakout [l/day]

File Phase



Percentiles

- 1st Percentile
- 5th Percentile
- 10th Percentile
- 50th Percentile
- 90th Percentile
- 95th Percentile
- 99th Percentile

**LANDSIM MODELLING RESULTS:
PREDICTED SURFACE BREAKOUT**

Client



Caversham Bridge House, Reading, RG1 8DN, Tel 0118 950 0761 Fax 0118 959 7498

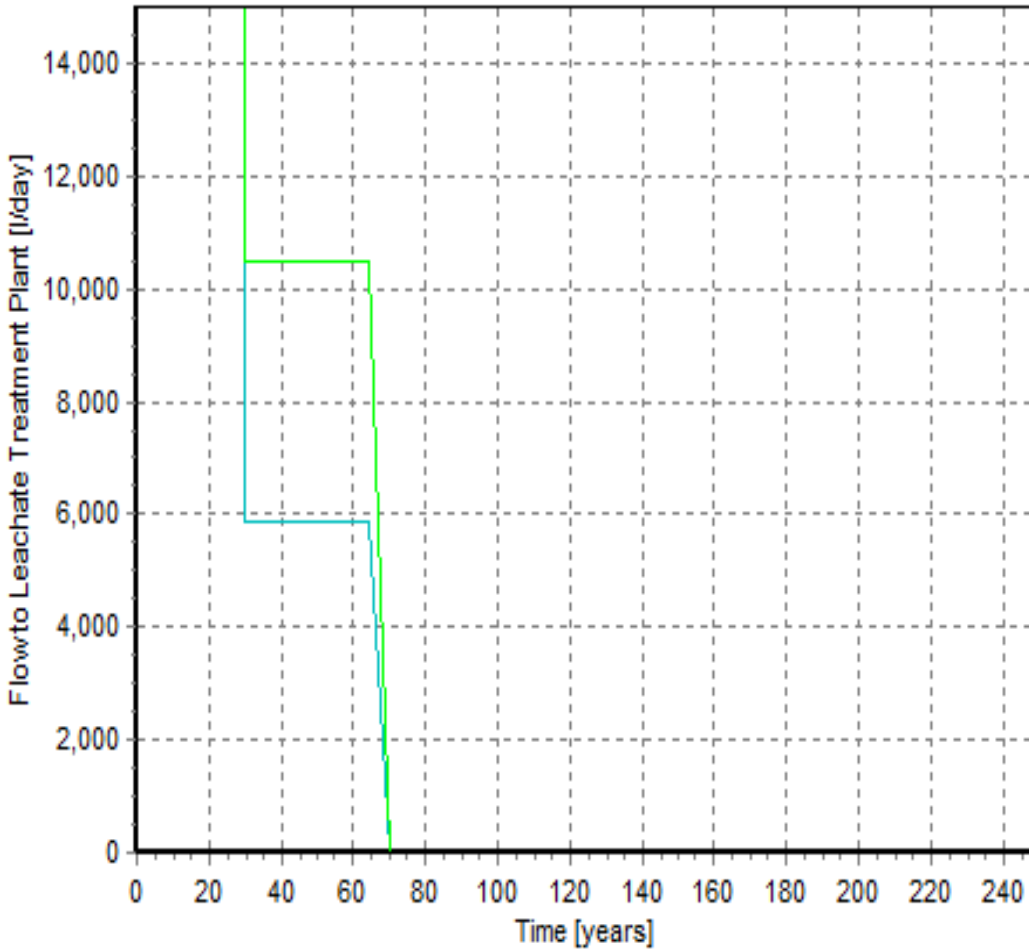
By	vkr	Rev	1
Date	Apr 15	Job	14739/155
Chkd	rht	File	n/a

Figure

5

Results: Area 2, Flow to Leachate Treatment Plant [l/day]

File Phase



Percentiles

- 1st Percentile
- 5th Percentile
- 10th Percentile
- 50th Percentile
- 90th Percentile
- 95th Percentile
- 99th Percentile

**LANDSIM MODELLING RESULTS:
PREDICTED LEACHATE FLOW**

Client



Caversham Bridge House, Reading, RG1 8DN, Tel 0118 950 0761 Fax 0118 959 7498

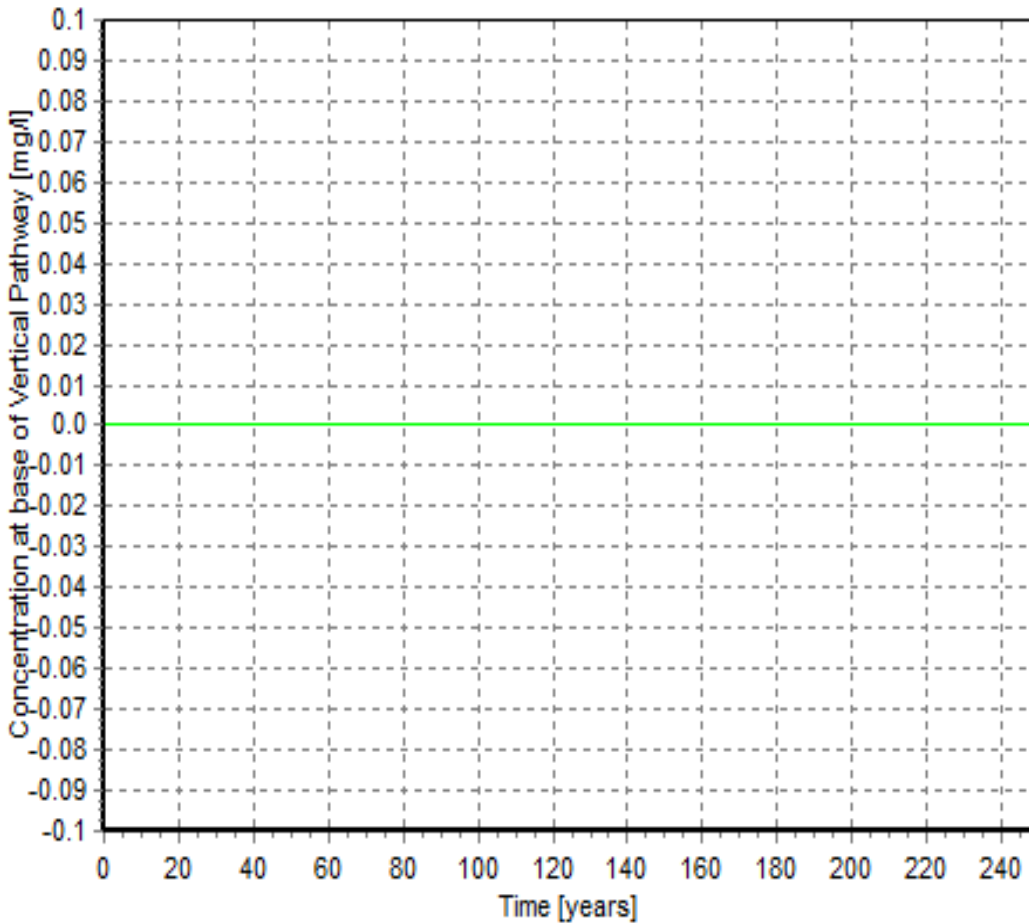
By	vk	Rev	1
Date	Apr 15	Job	14739/155
Chkd	rht	File	n/a

Figure

6

Results: Area 2, Mercury Concentration at base of Vertical Pathway [mg/l]

File Species Phase



Percentiles

- 1st Percentile
- 5th Percentile
- 10th Percentile
- 50th Percentile
- 90th Percentile
- 95th Percentile
- 99th Percentile

**LANDSIM MODELLING RESULTS:
PREDICTED MERCURY CONCENTRATION AT
BASE OF VERTICAL PATHWAY**

Client



Caversham Bridge House, Reading, RG1 8DN, Tel 0118 950 0761 Fax 0118 959 7498

By	vk	Rev	1
Date	Apr 15	Job	14739/155
Chkd	rht	File	n/a

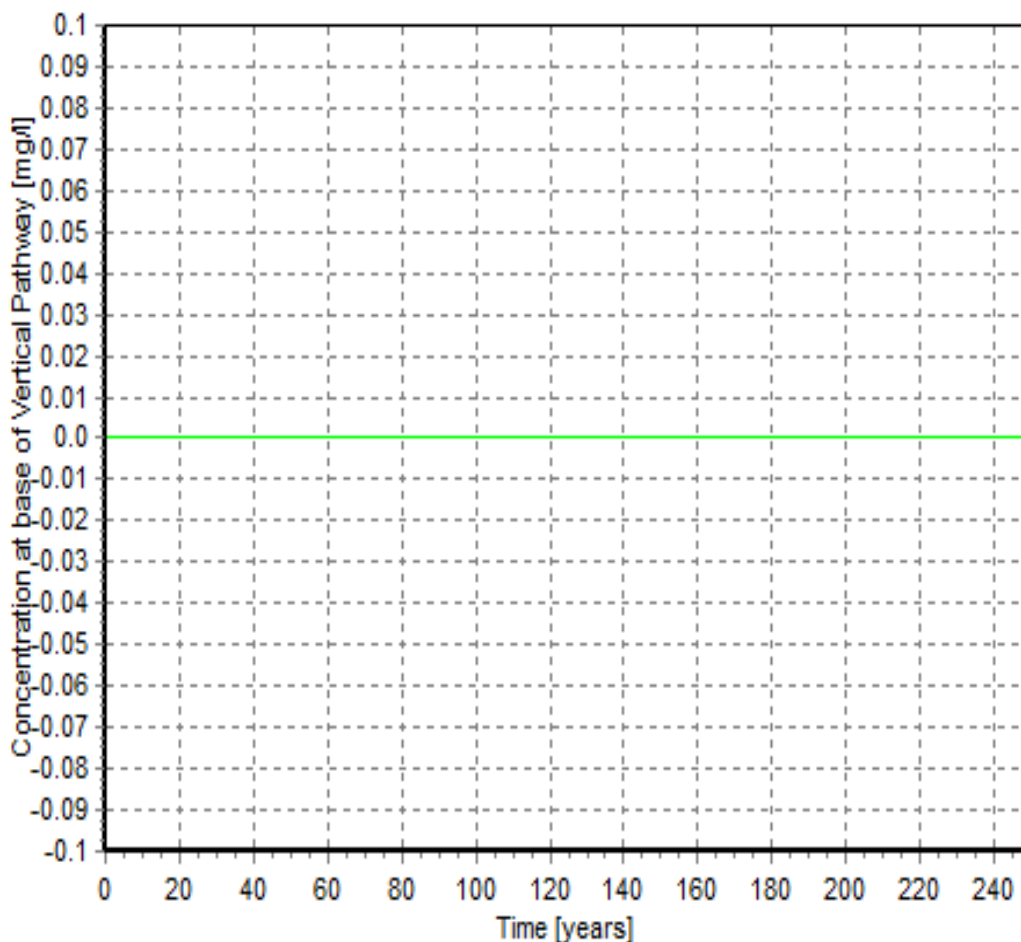
Figure

7

Results: Area 2, Tributyltin chloride Concentration at base of Vertical Pathway [mg/l]



File Species Phase



- Percentiles
- 1st Percentile
 - 5th Percentile
 - 10th Percentile
 - 50th Percentile
 - 90th Percentile
 - 95th Percentile
 - 99th Percentile

**LANDSIM MODELLING RESULTS:
PREDICTED TRIBUTYLTIN CHLORIDE
CONCENTRATION AT BASE OF VERTICAL
PATHWAY**

Client



Caversham Bridge House, Reading, RG1 8DN, Tel 0118 950 0761 Fax 0118 959 7498

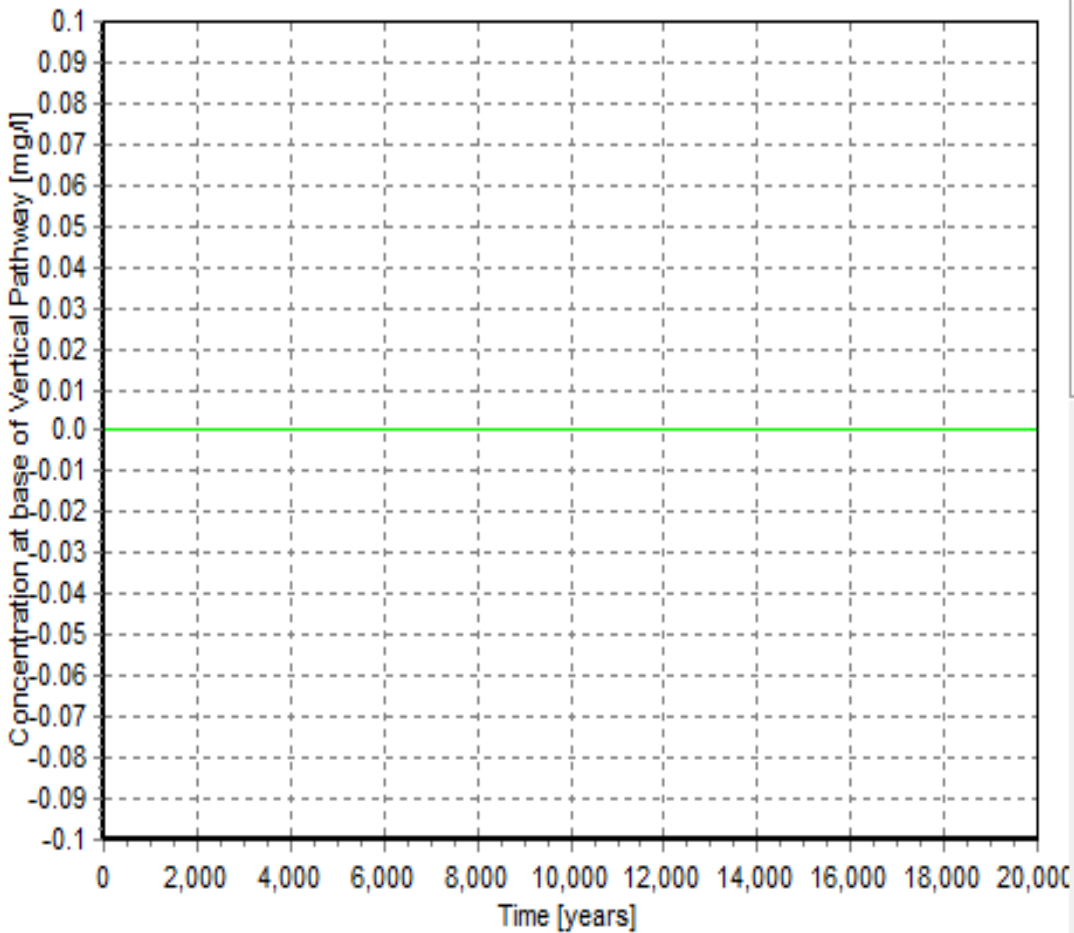
By	vkr	Rev	1
Date	Apr 15	Job	14739/155
Chkd	rht	File	n/a

Figure

8

Results: Area 2, Xylene Concentration at base of Vertical Pathway [mg/l]

File Species Phase



- Percentiles
- 1st Percentile
 - 5th Percentile
 - 10th Percentile
 - 50th Percentile
 - 90th Percentile
 - 95th Percentile
 - 99th Percentile

**LANDSIM MODELLING RESULTS:
PREDICTED XYLENE CONCENTRATION AT
BASE OF VERTICAL PATHWAY**

Client



Caversham Bridge House, Reading, RG1 8DN, Tel 0118 950 0761 Fax 0118 959 7498

By	vkr	Rev	1
Date	Apr 15	Job	14739/155
Chkd	rht	File	n/a

Figure

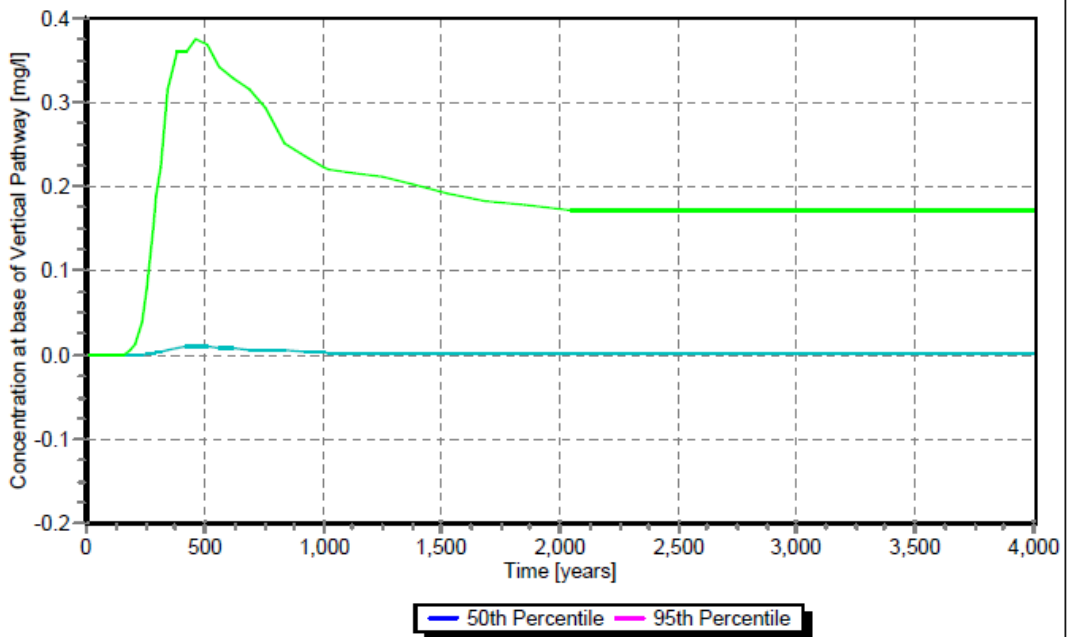
9

LandSim Version 2.5

Project Name: Docksway Area 2

Customer: Newport City Council

Results: Area 2, Ammoniacal_N Concentration at base of Vertical Pathway [mg/l]



\\Area2-DrftD rerun waste density 1.2-1.5.sim

27/04/2015 08:35:18

LANDSIM MODELLING RESULTS: PREDICTED AMMONIACAL NITROGEN CONCENTRATION AT BASE OF VERTICAL PATHWAY

Client



Caversham Bridge House, Reading, RG1 8DN, Tel 0118 950 0761 Fax 0118 959 7498

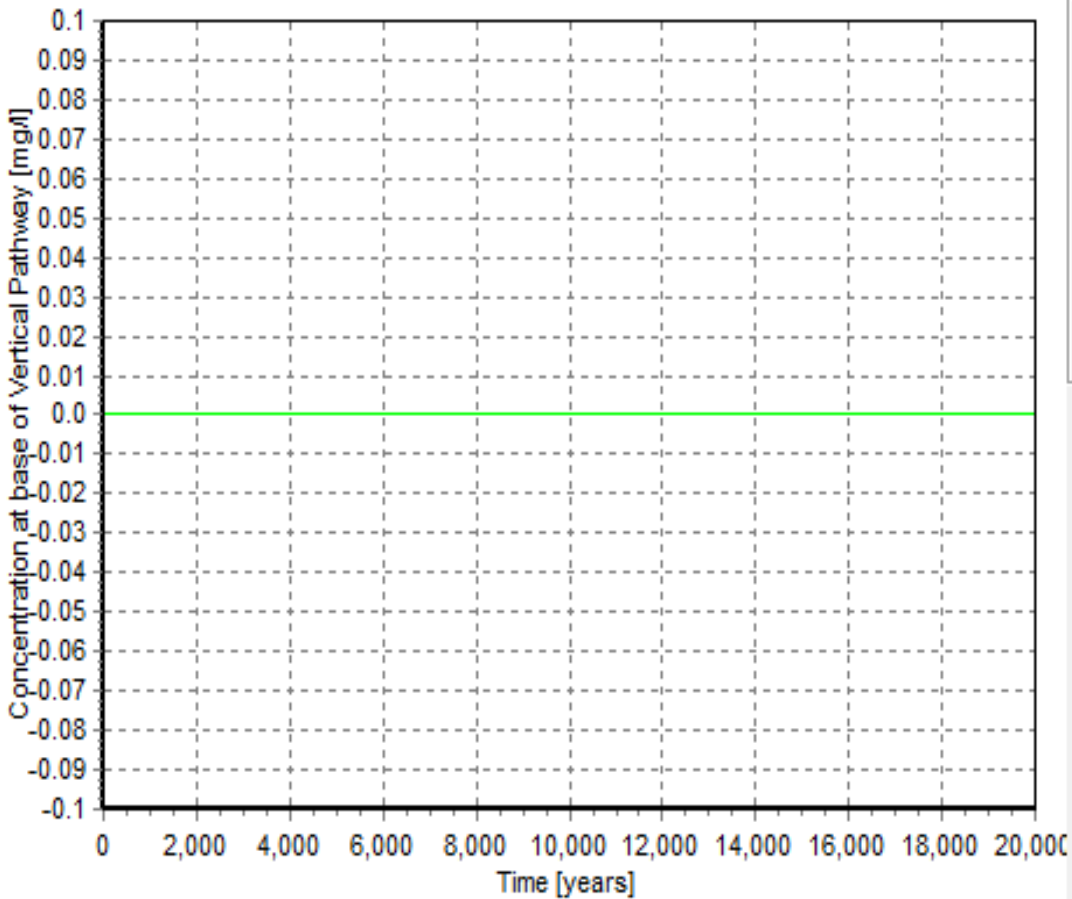
By	vkr	Rev	1
Date	Apr 15	Job	14739/155
Chkd	rht	File	n/a

Figure

10

Results: Area 2, Nickel Concentration at base of Vertical Pathway [mg/l]

File Species Phase



Percentiles

- 1st Percentile
- 5th Percentile
- 10th Percentile
- 50th Percentile
- 90th Percentile
- 95th Percentile
- 99th Percentile

**LANDSIM MODELLING RESULTS:
PREDICTED NICKEL CONCENTRATION AT
BASE OF VERTICAL PATHWAY**

Client

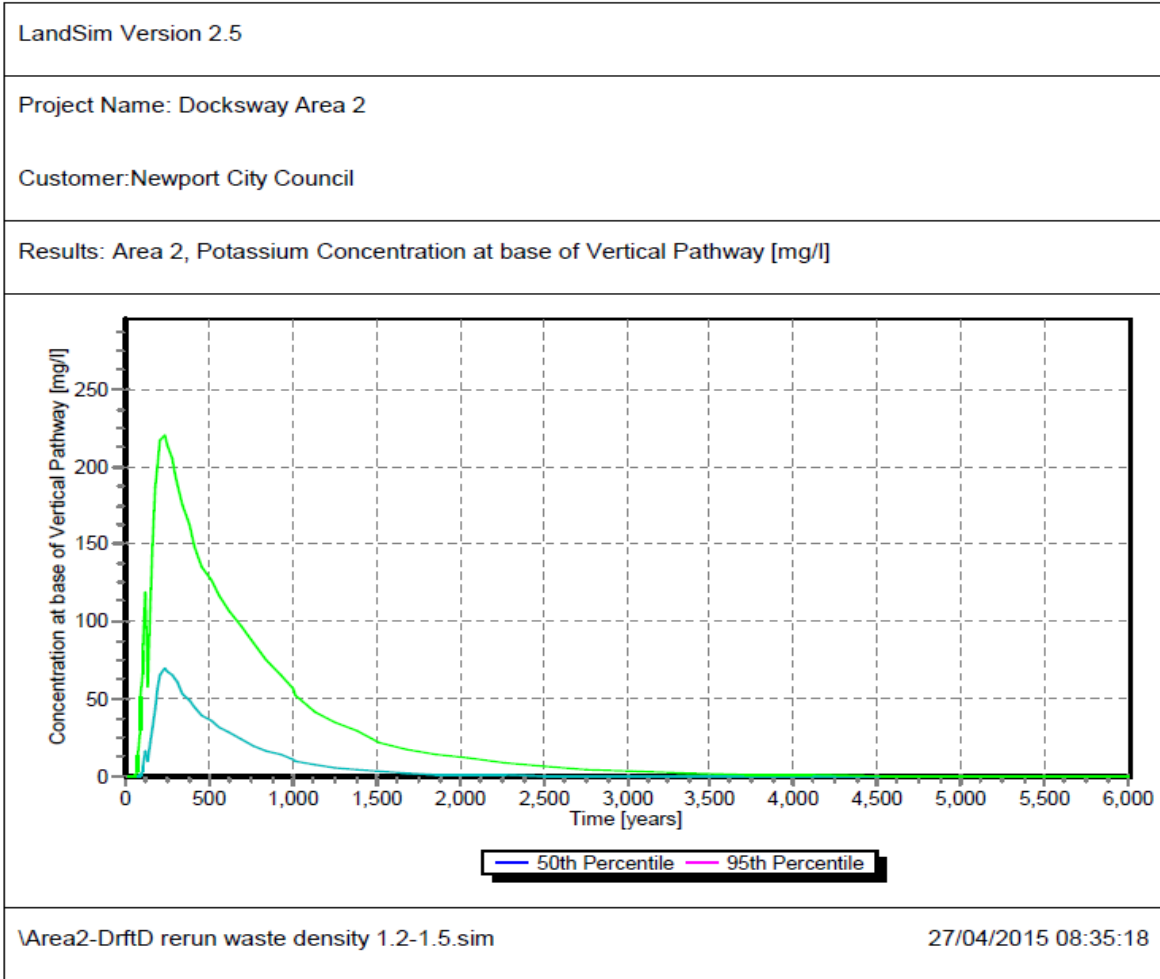


Caversham Bridge House, Reading, RG1 8DN, Tel 0118 950 0761 Fax 0118 959 7498



By	vkr	Rev	1
Date	Apr 15	Job	14739/155
Chkd	rht	File	n/a

Figure

11



**LANDSIM MODELLING RESULTS:
PREDICTED POTASSIUM CONCENTRATION
AT BASE OF VERTICAL PATHWAY**

Client		 Newport CITY COUNCIL CYNGOR DINAS Casnewydd	
Caversham Bridge House, Reading, RG1 8DN, Tel 0118 950 0761 Fax 0118 959 7498			
By	vkr	Rev	1
Date	Apr 15	Job	14739/155
Chkd	rht	File	n/a
			Figure 12

APPENDIX 1 Water Balance Calculations

Calculations



Water Balance Calculations											
Pre-Restoration - Non-Hazardous Sub-Cell											
Project Title	Docksway Disposal Site, Newport										
Project No	14739					By	vkr	Chkd	pj	Date	30/04/2015

Pre Restoration Water Balance - Infiltration Calculation - Non Hazardous sub-cell

PERC = Water percolation through daily cover to TOP of WASTE

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
Temperature (°C)	4.80	4.71	7.14	8.96	12.29	14.94	17.21	16.70	14.24	11.05	7.78	6.01	
It	0.94	0.91	1.72	2.42	3.90	5.25	6.50	6.21	4.88	3.32	1.95	1.32	39.32
TE	39.32	39.32	39.32	39.32	39.32	39.32	39.32	39.32	39.32	39.32	39.32	39.32	
a	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
PET	20.00	19.56	31.20	40.19	57.26	71.26	83.48	80.70	67.55	50.86	34.32	25.74	582.11
Adj Factor	0.74	0.78	1.02	1.15	1.33	1.36	1.37	1.25	1.06	0.92	0.76	0.70	
Adj PET	14.80	15.26	31.82	46.22	76.15	96.91	114.37	100.87	71.60	46.79	26.09	18.02	658.90
P (mm)	129.91	86.36	102.07	59.36	61.27	62.57	67.97	77.27	96.46	115.52	117.10	136.78	1112.639
C (r/o)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Ro (mm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
SR (mm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
IR (mm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
I	129.91	86.36	102.07	59.36	61.27	62.57	67.97	77.27	96.46	115.52	117.10	136.78	1112.64
I-Adj PET	115.11	71.10	70.25	13.14	-14.88	-34.34	-46.41	-23.61	24.86	68.74	91.01	118.76	453.74
NEG (I-Adj PET)	0.00	0.00	0.00	0.00	-14.88	-34.34	-46.41	-23.61	0.00	0.00	0.00	0.00	
Sum NEG (I-Adj PET)	0.00	0.00	0.00	0.00	-14.88	-49.22	-95.63	-119.24	0.00	0.00	0.00	0.00	
St	20	20	20	20	10	3	1	1	20	20	20	20	
dSt	0	0	0	0	-10	-7	-2	0	19	0	0	0	0
AET (mm)	11.10	11.44	23.87	34.66	35.64	34.78	34.98	38.63	35.80	35.09	19.56	13.51	329.08
PERC (mm)	118.81	74.92	78.21	24.69	0.00	0.00	0.00	38.63	41.66	80.43	97.54	123.27	678.16

- It = (T / 5)^{1.514}
- PET = 16(10/TE)²
- a = 0.00000675 (TE)³ - 0.0000771 (TE)² + 0.01792TE + 0.492 39
- TE = Annual Sum It
- Adj Factor = Values adjusted for Latitude 51 degress see table below
- P = Average Rainfall
- C = Runoff coefficient see table below
- Ro = P x C
- I = P + SR + IR - Ro
- SR = Surface runoff input to landfill
- IR = Irrigation input water
- NEG (I-Adj PET) = Lack of infiltration water needed for vegetation see table
- St = Soil Moisture storage at Field Capacity see table
- AET = Actual Evapotranspiration For dry months x 0.5 for wet months x 0.75 as no vegetation
- If NEG (I-Adj PET) = negative AET = I + |dSt|
- If NEG (I-Adj PET) = positive AET = Adj PET
- PERC = Percolation to TOP of capping layer
- If dSt = negative PERC = Zero
- If dSt = positive PERC = I - AET - dSt

Latitude	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
0	1.04	0.94	1.04	1.01	1.04	1.01	1.04	1.04	1.01	1.04	1.01	1.04
10	1.00	0.91	1.03	1.03	1.08	1.06	1.08	1.07	1.02	1.02	0.98	0.99
20	0.95	0.90	1.03	1.05	1.13	1.11	1.14	1.11	1.02	1.00	0.93	0.94
30	0.90	0.87	1.03	1.08	1.18	1.17	1.20	1.14	1.03	0.98	0.89	0.88
35	0.87	0.85	1.03	1.09	1.21	1.21	1.23	1.16	1.03	0.97	0.86	0.85
40	0.84	0.83	1.03	1.11	1.24	1.25	1.27	1.18	1.04	0.96	0.83	0.81
45	0.80	0.81	1.02	1.13	1.28	1.29	1.31	1.21	1.04	0.94	0.79	0.75
50	0.74	0.78	1.02	1.15	1.33	1.36	1.37	1.25	1.06	0.92	0.76	0.70

Runoff Coefficient after Salvato for leachate estimation (Lu et al 1985)

Surface condition	Slope (%)	Runoff Coefficient			
		Sandy Loam	Clay or Silt Loam	Clay	
Pasture or meadow (surface with cover crop)	0-2	flat	0.10	0.30	0.40
	5-10	rolling	0.16	0.36	0.55
	10-30	hilly	0.22	0.42	0.60
No vegetation (raw soil surface)	0-2	flat	0.30	0.50	0.60
	5-10	rolling	0.40	0.60	0.70
	10-30	hilly	0.52	0.72	0.82

Soil Moisture retention after Potential Evapotranspiration has occurred

Sum NEG (I-Adj PET)	St									
	25	50	75	100	125	150	200	250	300	
0	25	50	75	100	125	150	200	250	300	
10	16	41	65	90	115	140	190	240	290	
20	10	33	57	81	106	131	181	231	280	
30	7	27	50	74	98	122	172	222	271	
40	4	21	43	66	90	114	163	213	262	
50	3	17	38	60	83	107	155	204	254	
60	2	14	33	54	76	100	148	196	245	
70	1	11	28	49	70	93	140	188	237	
80	1	9	25	44	65	87	133	181	229	
90	1	7	22	40	60	82	127	174	222	
100		6	19	36	55	76	120	167	214	
150		2	10	22	37	54	94	136	181	
200			5	13	24	39	73	111	153	
250			2	8	16	28	56	91	130	
300			1	5	11	20	44	74	109	
350				3	7	14	34	61	92	
400				2	5	10	26	50	78	
450				1	3	7	20	41	66	
500				1	2	5	16	33	56	
600					1	3	10	22	40	
700						1	6	15	28	
800						1	4	10	20	
1000							1	4	10	

Calculations



Water Balance Calculations											
Pre-Restoration - SNRHW Sub-Cell											
Project Title	Docksway Disposal Site, Newport										
Project No	14739					By	vkr	Chkd	pj	Date	30/04/2015

PERC = Water percolation through daily cover to TOP of WASTE

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
Temperature (°C)	4.80	4.71	7.14	8.96	12.29	14.94	17.21	16.70	14.24	11.05	7.78	6.01	
It	0.94	0.91	1.72	2.42	3.90	5.25	6.50	6.21	4.88	3.32	1.95	1.32	39.32
TE	39.32	39.32	39.32	39.32	39.32	39.32	39.32	39.32	39.32	39.32	39.32	39.32	
a	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
PET	20.00	19.56	31.20	40.19	57.26	71.26	83.48	80.70	67.55	50.86	34.32	25.74	582.11
Adj Factor	0.74	0.78	1.02	1.15	1.33	1.36	1.37	1.25	1.06	0.92	0.76	0.70	
Adj PET	14.80	15.26	31.82	46.22	76.15	96.91	114.37	100.87	71.60	46.79	26.09	18.02	658.90
P (mm)	129.91	86.36	102.07	59.36	61.27	62.57	67.97	77.27	96.46	115.52	117.10	136.78	1112.639
C (r/o)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	
Ro (mm)	38.97	25.91	30.62	17.81	18.38	18.77	20.39	23.18	28.94	34.66	35.13	41.04	333.7917
SR (mm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
IR (mm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
I	90.94	60.45	71.45	41.55	42.89	43.80	47.58	54.09	67.52	80.87	81.97	95.75	778.85
I-Adj PET	76.14	45.19	39.63	-4.67	-33.26	-53.11	-66.80	-46.79	-4.08	34.08	55.88	77.73	119.95
NEG (I-Adj PET)	0.00	0.00	0.00	-4.67	-33.26	-53.11	-66.80	-46.79	-4.08	0.00	0.00	0.00	
Sum NEG (I-Adj PET)	0.00	0.00	0.00	-4.67	-37.93	-91.04	-157.84	-204.63	-208.70	0.00	0.00	0.00	
St	20	20	20	20	10	3	1	20	20	20	20	20	
dSt	0	0	0	0	-10	-7	-2	0	19	0	0	0	0
AET (mm)	11.10	11.44	23.87	31.16	26.45	25.40	24.79	27.04	24.26	35.09	19.56	13.51	273.68
PERC (mm)	79.84	49.01	47.58	10.39	0.00	0.00	0.00	27.04	24.26	45.78	62.41	82.23	428.54

$It = (T / 5)^{1.514}$
 $PET = 16(10/TE)^a$
 $a = 0.00000675 (TE)^3 - 0.0000771 (TE)^2 + 0.01792TE + 0.49239$
 TE = Annual Sum It
 Adj Factor = Values adjusted for Latitude 51 degree see table below
 P = Average Rainfall
 C = Runoff coefficient see table below
 Ro = P x C
 I = P + SR + IR - Ro
 SR = Surface runoff input to landfill
 IR = Irrigation input water
 NEG (I-Adj PET) = Lack of infiltration water needed for vegetation see table
 St = Soil Moisture storage at Field Capacity see table
 AET = Actual Evapotranspiration For dry months x 0.5 for wet months x 0.75 as no vegetation
 If NEG (I-Adj PET) = negative AET = I + |dSt|
 If NEG (I-Adj PET) = positive AET = Adj PET
 PERC = Percolation to TOP of capping layer
 If dSt = negative PERC = Zero
 If dSt = positive PERC = I - AET - dSt

Latitude	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
0	1.04	0.94	1.04	1.01	1.04	1.01	1.04	1.04	1.01	1.04	1.01	1.04
10	1.00	0.91	1.03	1.03	1.08	1.06	1.08	1.07	1.02	1.02	0.98	0.99
20	0.95	0.90	1.03	1.05	1.13	1.11	1.14	1.11	1.02	1.00	0.93	0.94
30	0.90	0.87	1.03	1.08	1.18	1.17	1.20	1.14	1.03	0.98	0.89	0.88
35	0.87	0.85	1.03	1.09	1.21	1.21	1.23	1.16	1.03	0.97	0.86	0.85
40	0.84	0.83	1.03	1.11	1.24	1.25	1.27	1.18	1.04	0.96	0.83	0.81
45	0.80	0.81	1.02	1.13	1.28	1.29	1.31	1.21	1.04	0.94	0.79	0.75
50	0.74	0.78	1.02	1.15	1.33	1.36	1.37	1.25	1.06	0.92	0.76	0.70

Surface condition	Runoff Coefficient		
	Slope (%)	Sandy Loam	Clay or Silt Loam
Pasture or meadow (surface with cover crop)	0-2 flat	0.10	0.30
	5-10 rolling	0.16	0.36
	10-30 hilly	0.22	0.42
No vegetation (raw soil surface)	0-2 flat	0.30	0.50
	5-10 rolling	0.40	0.60
	10-30 hilly	0.52	0.72

Sum NEG (I-Adj PET)	St								
	25	50	75	100	125	150	200	250	300
0	25	50	75	100	125	150	200	250	300
10	16	41	65	90	115	140	190	240	290
20	10	33	57	81	106	131	181	231	280
30	7	27	50	74	98	122	172	222	271
40	4	21	43	66	90	114	163	213	262
50	3	17	38	60	83	107	155	204	254
60	2	14	33	54	76	100	148	196	245
70	1	11	28	49	70	93	140	188	237
80	1	9	25	44	65	87	133	181	229
90	1	7	22	40	60	82	127	174	222
100	6	19	36	55	76	120	167	214	
150	2	10	22	37	54	94	136	181	
200	1	5	13	24	39	73	111	153	
250		2	8	16	28	56	91	130	
300		1	5	11	20	44	74	109	
350			3	7	14	34	61	92	
400			2	5	10	26	50	78	
450			1	3	7	20	41	66	
500			1	2	5	16	33	56	
600				1	3	10	22	40	
700					1	6	15	28	
800					1	4	10	20	
1000						1	4	10	

Calculations



Water Balance Calculations												
Pre-Restoration - SNRHW Sub-Cell												
Project Title	Docksway Disposal Site, Newport											
Project No	14739					By	vkr	Chkd	pj	Date	30/04/2015	

Newport City Council																
Docksway Landfill Permit Revision March 2015. Phase 2 - Cell 3A (SNRHW)																
Water Balance Calculations																
Cell No	Lined Area (m ²)	Available Airspace (m ³)	Infilling Rates (Years)	Filling year start	Filling Rate (m ³ /annum)	Rainfall p.a. (m)	Rainfall during filling (m)	Incident ppt for each Cell (m ³)	% Infiltration	Volume of Infiltration/Cell (m ³)	Implacement Density of Waste (t/m ³)	Absorptive Capacity of Refuse m ³	Tonnes of Waste/Cell (t)	Absorptive Capacity of each Cell (m ³)	Free Liquid	Liquid Volume
3Aa	2626	26260	3.94	0.00	6667	1.11	4.382	11508	39%	4433	1.5	0.02	39390	788	yes	3645
3Ab	2626	26260	3.94	3.00	6667	1.11	4.382	11508	39%	4433	1.5	0.02	39390	788	yes	3645
3Ac	2626	26260	3.94	6.00	6667	1.11	4.382	11508	39%	4433	1.5	0.02	39390	788	yes	3645
3Ad	2626	26260	3.94	9.00	6667	1.11	4.382	11508	39%	4433	1.5	0.02	39390	788	yes	3645

Notes	1	Input Rates see table below	
	2	Rainfall	1112.64 mm/annum
		Effective Percolation	428.54 mm/annum
		Infiltration	39%
3	Implacement Density of Waste	1.5 t/m ³	
4	Absorptive Capacity	0.02 m ³ /tonne	

Year	Input Rate		Year	Input Rate	
	t/annum	m ³ /annum		t/annum	m ³ /annum
1	10000	6667	10	10000	6667
2	10000	6667			
3	10000	6667			
4	10000	6667			
5	10000	6667			
6	10000	6667			
7	10000	6667			
8	10000	6667			
9	10000	6667			

Calculations



Water Balance Calculations

Pre-Restoration - Non-Hazardous Sub-Cell

Project Title	Docksway Disposal Site, Newport										
Project No	14739				By	vkr	Chkd	pj	Date	30/04/2015	

Newport City Council

Docksway Landfill Permit Revision March 2015. Phase 2 - Cell 3B (Non-Haz)

Water Balance Calculations

Cell No	Lined Area (m ²)	Available Airspace (m ³)	Infilling Rates (Years)	Filling year start	Filling Rate (m ³ /annum)	Rainfall p.a. (m)	Rainfall during filling (m)	Incident ppt for each Cell (m ³)	% Infiltration	Volume of Infiltration/Cell (m ³)	Implacement Density of Waste (t/m ³)	Absorptive Capacity of Refuse m3	Tonnes of Waste/Cell (t)	Absorptive Capacity of each Cell (m ³)	Free Leachate	Leachate Volume
3B	10580	264500	7.05	0.00	37500	1.11	7.848	83030	61%	50607	1.2	0.02	317400	6348	yes	44259

Notes

- 1 Input Rates see table below
- 2 Rainfall 1112.64 mm/annum
Effective Percolation 678.16 mm/annum
Infiltration 61%
- 3 Implacement Density of Waste 1.2 t/m³
- 4 Absorptive Capacity 0.02 m³/tonne

Year	Input Rate	
	t/annum	m ³ /annum
1	45000	37500
2	45000	37500
3	45000	37500
4	45000	37500
5	45000	37500
6	45000	37500
7	45000	37500