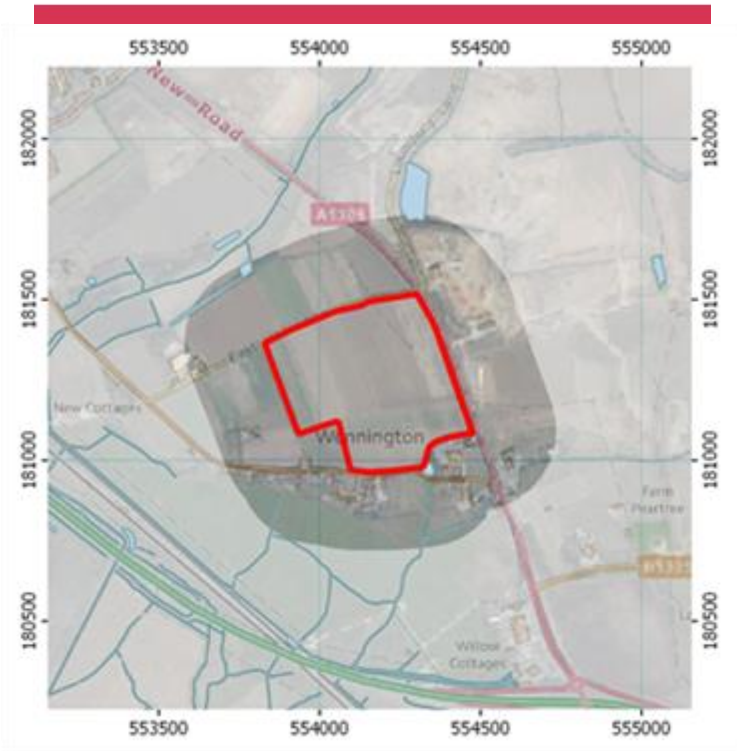

Wennington Quarry Proposed Landfill: Hydrogeological Risk Assessment

Wennington Quarry Proposed Landfill: Hydrogeological Risk Assessment

Prepared for

Ingrebourne Valley Ltd.
Cecil House
Harlow Common
Harlow
Essex
CM17 9HY

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Confidential
Prepared by
ESI Ltd

New Zealand House,160 Abbey Foregate, Shrewsbury, SY2 6FD, UK
Tel *+44(0)1743 276100* ***Fax*** *+44 (0)1743 248600* ***email*** *info@esinternational.com*

Wennington Quarry Proposed Landfill: Hydrogeological Risk Assessment

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Confidential
Prepared by
ESI Ltd

New Zealand House, 160 Abbey Foregate, Shrewsbury, SY2 6FD, UK
Tel *+44(0)1743 276100* ***Fax*** *+44 (0)1743 248600* ***email*** *info@esinternational.com*
Registered office: New Zealand House, 160 Abbey Foregate, Shrewsbury, SY2 6FD. Registered in England and Wales, number 3212832

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	Name	Signature
Author	Andrew Abbott	
Checked by	Kate Brady / Andrew Tait	
Reviewed by	Francis Crozier / Andrew Singleton	

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Confidential
Prepared by
ESI Ltd

New Zealand House,160 Abbey Foregate, Shrewsbury, SY2 6FD, UK
Tel *+44(0)1743 276100* ***Fax*** *+44 (0)1743 248600* ***email*** *info@esinternational.com*
Registered office: New Zealand House, 160 Abbey Foregate, Shrewsbury, SY2 6FD. Registered in England and Wales, number 3212832

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1 INTRODUCTION

1.1 Report context

Wennington Quarry (the Site) is owned by Ingrebourne Valley Ltd (IVL) and is a proposed quarry and landfill site for the winning and working of minerals followed by the restoration using suitable pre-treated imported inert materials to return the land to agricultural use.

This report is produced for IVL by ESI Ltd. (ESI) to support an application for an Environmental Permit.

This assessment is based on the data and information contained within the Environmental Setting and Site Design (ESSD) report which has been prepared for the permit application. The application is for a new landfill accepting inert waste only.

1.2 Conceptual hydrogeological site model

The proposed facility is to be a landfill site, and associated infrastructure, for the disposal of inert waste. Information on the Site location and surroundings are discussed in Section 2 of the ESSD report and shown on Drawing 66250D2.

Further details of the landfill design and site infrastructure are provided in the Site Operating Plan. The layout of the Site is shown on Drawing D-ESSD4.

An understanding of the key physical components of a soil and groundwater system must be accomplished prior to undertaking any risk assessment modelling for controlled waters. To simplify the complexity of observed soil and groundwater conditions and to identify the relevant flow and transport parameters, a conceptual site model has been prepared. The model accounts for both the physical ground conditions (including surface and subsurface conditions, natural geology and made ground) and the key hydrological inputs and outputs to and from the system.

The environmental site setting description and data presented in the ESSD report have been conceptualised into a set of potential source, pathway, receptor (S-P-R) linkages. These are described in this section, for the assessment of risk to controlled waters from the wastes deposited at the Site.

The hydrogeological conceptual model has been developed based upon the proposed site layout, construction and geo-environmental setting described in the ESSD. The model is not reliant on geological barriers and so is therefore conservative.

1.2.1 Water balance for the landfill

The various fluxes into and out of the landfill are estimated in the model using a water balance approach.

The model calculates the fluxes as described below:

- Rainwater will fall onto the landfill ground surface, where a proportion will infiltrate through the top of the landfill and the balance will run off. The remaining water will seep into the restoration soils where it will be subject to evaporation and use by plants (transpiration). These two processes are often jointly referred to as evapotranspiration.

  During the summer the evapotranspiration demand may be higher than rainfall, whereas during winter the rainfall may be greater than evapotranspiration. For this reason in summer all of the rainfall is usually accounted for, while during the winter months the excess water percolates downwards deeper into the soil zone, where lateral movement of this water is likely to occur due to local heterogeneity in the soil zone. This water, in combination with the surface runoff, will ultimately infiltrate the shallow superficial aquifer at the landfill perimeter. The remaining water will percolate into the waste.

- It is reported (Environment Agency, 2014) that the Thames region receives an average rainfall of 690 mm/a, with an average effective rainfall (HER) of 250 mm/a. In this conceptual model it is assumed that 250 mm/a of water is available for infiltration to the waste and runoff (either by surface runoff or lateral flow within the restoration soils). In reality, it is likely that a higher volume will be available with the additional water running off. As this water is used to dilute potential contaminants in the model, this results in a conservative assessment of risk.

- The landfilled material is likely to be less permeable than the surrounding Taplow Gravel. As low permeability London Clay lies beneath the landfill, it is likely there will be a 'doming' of water within the waste due to recharge to the waste and discharge at the sides. Water may cross the boundary of the landfill through the up and down gradient sides. Depending on the leachate level, this flux may be either into or out of the landfill. The direction and quantity of flow will be determined based on the relative head difference between the leachate in the landfill and groundwater in the surrounding aquifer.
- If the leachate head in the landfill rises above ground level then run-off will occur. This is not leachate overflowing from the landfill; rather it is excess recharge that is not able to infiltrate the waste. As such this water will be clean. The outflow from the landfill thus reaches a maximum value controlled by the hydraulic gradient between the landfill and the surrounding groundwater.
- If the leachate head in the landfill does not rise to ground level, then all the effective rainfall will be able to infiltrate the waste and the outflow from the landfill must balance the inflow. In this case, there is no run off from the landfill surface.
- The risk assessment considers the long-term situation when landfilling has ceased.

1.2.2 Source

The landfill is to be utilised for the disposal of inert waste only, as detailed in the ESSD report. The total quantity of waste will be approximately 1,400,000 m^3 (equivalent to approximately 2.5M tonnes).

The potential source of contamination is taken to be the inert waste deposited in the landfill. Infiltrating water will pass out of the sides of the landfill. It will not pass through the base of the landfill as this is located on the London Clay, which has a low permeability. Within the landfill, the final flow regime on completion of landfilling is likely to be a radial pattern with flow out of each side of the landfill.

As water flushes through the waste, the source term concentrations will decline at a rate governed by the infiltration flux.

As discussed in Section 2.3, the determinands that will be used to model contaminant transport are ammonium, chloride and nickel.

Given the approximately square shape of the Site it is not considered necessary to further divide the Site.

1.2.3 Pathways

The following pathways have been considered:

- Flow from the Site to groundwater in the Taplow Gravel at the site boundary.
- Flow directly from the waste into the on-site pond.

Groundwater in the Sand & Gravel is likely to flow towards the west and south west with a groundwater divide being present towards the north of the Application Area and with discharge to the Common Watercourse to the north and north west and discharge to the drainage ditch and streams to the south/south west. Leachate discharging from the landfill would be subject to dilution in the receiving groundwater and this process is applied within the model. Additionally, contaminants discharging to groundwater will be diluted from the water running off within the restoration soils.

Upon discharge to the proposed on-site pond, contaminants will be subject to dilution within the water body. The pond will act to infiltration runoff to ground with overflow during storm conditions to the network of small streams which flow in the direction of Rainham Marshes to the south.

1.2.4 Receptors

The potential receptors of contamination have been identified as follows:

- Hazardous substances: local groundwater and surface water at the Site boundary. No discernible concentrations of hazardous substances are likely to be present within the waste materials deposited at the Site.
- Non-hazardous pollutants: groundwater at the Site boundary and surface water in the on-Site pond, with dilution from runoff in the restoration soils applied within the pond.

2 HYDROGEOLOGICAL RISK ASSESSMENT

2.1 The nature of the Hydrogeological Risk Assessment

2.1.1 General modelling approach

The Site is located within the Taplow Gravel, which is locally classified by the Environment Agency as a Secondary A aquifer. These are aquifers which contain permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important part of base flow to rivers.

The Taplow Gravel is underlain by the London Clay, which is a silty clay between 1.0 m and 8.5 m thick locally. The London Clay is in turn underlain by the clay-dominated Lambeth Group, with its clay with beds of sand, pebbles and shells.

The landfill will be partly below the water table, and is for the disposal of inert waste only. The nature of the waste to be accepted is such that there will be no discernible concentrations of hazardous substances present within the landfill. For any hazardous substances accidentally accepted then the geological strata will act to attenuate them such that there is no discharge to controlled water.

An artificially enhanced geological barrier will be constructed on the sides of the landfill. The risk assessment presented here does not consider such a geological barrier and no reliance is made upon it in this assessment.

From the conceptual model discussed in Section 1.2 above it is considered that the hazard to controlled water posed by the landfill is low. Even though the London Clay is present beneath the Site, acting as a natural geological barrier, it is acknowledged that a Principal Aquifer is located beneath the Site in the form of the Chalk. Therefore, in accordance with guidance from the Environment Agency (2009) for an inert landfill site under these conditions, a simple quantitative risk assessment has been undertaken.

2.2 Proposed assessment scenarios

2.2.1 Lifecycle phases

As the landfill is for inert waste, a single lifecycle phase is considered. The model conservatively assumes that the Site is instantaneously filled and therefore the operational phase is not simulated. The model considers the post-completion phase and considers the leachate to have reached full strength.

As the landfill is inert, there will be no active leachate management and no managed phase will be considered in this risk assessment model.

As there is no cap or artificial sealing liner considered, there is no consideration of deterioration of these components by the risk model.

As the landfill is inert, no active leachate management and no managed phase will be considered in the risk assessment model.

There will be no difference in the water balance or contaminant transport mechanisms and processes between the operational and post-closure phases.

2.3 Priority contaminants to be modelled

Documents describing the properties of inert landfill leachate are generally scarce. In order to give a quantitative description of the source term a literature review has been undertaken. Data are available from five sources, namely AEA (1991), Norstrom *et al.* (1991), Long (1997), Jago (1996) and Shaw (1999). For the purposes of this risk assessment the leachate data from AEA (1991) were found to be the most appropriate, as detailed in the following Table 2.1.

Table 2.1 Sources of information on leachate properties

Description	Appropriate	Justification
AEA (1991)	Yes	A clear description of the waste types in the landfills is given and the data appear to relate to groundwater from within the site (i.e. that might be more representative of the leachate) rather than from boreholes outside the site.
Norstrom et al (1991)	No	The data apply to US inert landfills, which contain a significant proportion of vegetable matter.
Long (1997)	No	The focus of the report is on the data from upstream and downstream boreholes rather than on leachate from within the site.
Jago (1996)	No	The types of waste in each site are not described in any detail.
Shaw (1999)	No	The chemistry data is from boreholes at the site perimeter not from boreholes within the waste.

For the AEA sites, only one leachate sample was taken from each of the sites and the exact sampling position within each site is unknown. The AEA sites are described as accepting only demolition and inert wastes. However, the high values of ammonium in some of the sites suggest that other types of waste may be present. For this reason the average of all six sites has been calculated to estimate the source concentration for chloride and nickel, while the ammonium concentration has been estimated to be lower than the calculated average.

The leachate data from AEA (1991) are summarised in Table 2.2, where the limit of detection has been used to calculate the averages in case of non-detects. This conservative estimate affects mainly trace metals since they are often below detection limits.

Based on the conceptualisation of the source term (Section 1.2) and on the literature review information summarised in here, the priority contaminants selected for the risk assessment are ammonium, chloride and nickel.

Ammonium was chosen in case small quantities of wood or other biodegradable material are accidentally placed into the landfill. Although biodegradable material will not be deliberately disposed of at the Site, it is possible that some residual biodegradable material may be placed in the landfill. Therefore, it is possible that some degradation products, such as ammonium may be produced. The purpose of including ammonium in the risk model is to demonstrate that, even if it is present in the leachate, is does not pose a risk to groundwater. Chloride is a conservative inorganic substance that may be expected to reach receptors quickly. Nickel is a relatively mobile metal.

These priority contaminants are representative of different groups of contaminants, which exhibit similar behaviour and are indicative substances found in modern inert landfill leachates.

Table 2.2 Inert landfill leachate data

mg/l	Inert Landfill Sites						Overall average for six sites	EC Drinking water standards	Exceeded by average?	maximum of all samples**	minimum of all samples
	AEA 21	AEA 22	AEA 23a	AEA 23b	AEA 23c	AEA 27					
pH	8.81	7.83	7.7	8.5	7.92	7.82	8.10			8.81	7.7
COD	600	85	100	95	300		236.00			600	85
TOC	290	31	43	32	20	140	92.67			290	20
Phosphate	13	0.01	0.2	10.3	0.3	0.7	4.09			13	0.01
Chloride	(1700)	130	94	32	99	180	107	400	No	180	32
Sulphate	220	51	330	250	300	120	211.83	250	No	330	51
Nitrate	0.3	52	<0.1	0.5	<0.1	1.9	9.15	50	No	52	0.1
Ammonia as NH3	(95)	26	5.2	3.6	0.4	39	14.84	0.47*	Yes	39	0.4
Calcium	110	150	460	340	380	570	335	250	Yes	570	110
Copper	<0.1	<0.1	0.5	<0.1	<0.1	<0.1	0.17	3	No	0.5	0.1
Iron	1.2	1.5	380	1.8	5.4	30	7.98	0.2	Yes	30	1.2
Potassium	180	38	25	16	12	26	23.4	12	Yes	38	12
Magnesium	110	38	45	20	20	47	46.67	50	No	110	20
Manganese	0.3	0.3	3	1.2	2.6	2.1	1.58	0.05	Yes	3	0.3
Sodium		150	65	45	60	200	104.00	150	No	200	45
Lead	<1	<0.2	0.4	<0.2	<0.2	<0.2	0.37	0.05	Yes	1	0.2
Zinc	0.3	0.2	2.8	<0.1	<0.1	0.3	0.63	5	No	2.8	0.1

*equivalent to 0.5 mg/l as NH4 and 0.39 mg/l as N

NB Values in brackets are outliers and therefore not used for calculation of averages, maximum and minimum values.

Where concentrations are given as less than a value, then that value has been used to calculate the averages

2.4 Review of technical precautions

The nature of the waste is likely to be such that no discernible concentrations of hazardous substances are present within the landfill. Hazardous substances in tipped materials will be controlled by waste acceptance checks on the content of materials arriving at the landfill. Controls are based on the waste acceptance and control procedures defined in the Site Operating Plan. Furthermore, there will be control on the concentration of non-hazardous pollutants accepted at the Site as no wastes will be accepted that are not defined as inert and meet the maximum leachable concentration limits defined by the Landfill Directive as detailed in the waste acceptance procedure in the Site Operating Plan.

These technical precautions, combined with pre-inspection of the waste, are considered sufficient for the facility to comply with the Environmental Permitting Regulations (2016).

2.5 Mathematical modelling

2.5.1 Justification for the modelling approach and software

The risk assessment has been undertaken using ESI's Risk Assessment Model (RAM) commercial software package (ESI, 2000).

An electronic copy of the model is presented in Appendix A.

The RAM software package, together with a number of groundwater risk assessment tools, has been benchmarked by ESI for the Environment Agency (ESI, 2001). Additionally, the equations used in RAM have been verified by comparison between direct evaluation of an analytical solution and the semi-analytic transform approach applied for more complex pathways, and by comparison with published solutions used for verification as part of the nuclear waste industry code comparison exercise INTRACOIN (Robinson and Hodgkinson, 1986).

2.5.2 General assumptions

There are a number of general assumptions made which simplify the model:

- For the sake of simplicity and clarity the thickness of the waste body is averaged across the Site.
- It is assumed that the entire waste mass is present at the start of the simulation. As the risk assessment model predicts that the peak contaminant load will occur during the first few years, and since the filling of the Site will take longer than this time, then the actual source term will be smaller than that represented in the model, which thus represents a conservative approximation of the system.

2.5.3 Representation of the conceptual model

The waste source will be less permeable than the surrounding River Terrace Deposits of the Taplow Gravel. As such there will be a 'doming' of groundwater within the waste due to recharge infiltrating through the top of the waste. At the up-hydraulic gradient end of the site, the waste will act as a lower permeability barrier to groundwater flow, and groundwater will preferentially flow around the waste along the path of least hydraulic resistance within the permeable Taplow Gravel. Leachate will discharge through the sides of the waste. As the gravel will be worked to the top of the London Clay there will be no flow through the base of the landfill. The landfill water balance may be represented by the following equations:

$$Q_{eff\_rain} = Q_{side} + Q_{runoff}$$

Where;

Qeff_rain is the effective rainfall to the top surface of the Site,

Qside is the net leachate discharge flux through the sides of the waste and

Qrunoff is the excess infiltrating water that cannot be transported through the waste mass, which is of relatively low permeability and which runs off.

This water balance works on the simple assumption that the flux infiltrating the waste must balance the flux discharging from the water and therefore it is only necessary to estimate one of these components.

A maximum value of Q_{side} can be calculated for the Site as the flow through the waste mass, assuming a hydraulic gradient controlled by a maximum head equal to the maximum elevation of the landfill surface and the average groundwater head at the downstream margin; a hydraulic conductivity representative of the expected waste composition; the depth of the waste and the perimeter in contact with groundwater.

If this maximum value is greater than effective rainfall, then the flux out of the landfill is limited to effective rainfall and runoff from the landfill surface is set to 0. If the maximum value is less than effective rainfall, then the flux out of the landfill is set to the maximum value, the infiltration flux is also set to this maximum value and the difference between the effective rainfall and the infiltration flux is assumed to be runoff.

Dilution is applied in the flow path from the waste mass to both receptors. Dilution occurs by runoff from the landfill between the edge of the waste disposal area and the receptor. Dilution in groundwater is also applied to the aquifer receptor.

The distance to the down-hydraulic gradient Site boundary receptor in the south is considered to be a nominal 10 m (i.e. this is taken to be the distance from the edge of the waste to the edge of the Site ownership boundary. If the receptors identified above are shown by risk assessment to be at minimal risk of pollution, then the risk of contamination of the adjacent surface water courses to the south is also precluded.

At the groundwater receptor, resultant concentrations are assessed against the DWS and at the on-Site pond against the freshwater EQS.

Schematic diagrams of the hydrogeological conceptual models upon which the risk assessment is based are presented in Figure 2.1 and Figure 2.2.

Figure 2.1 Conceptual model plan view

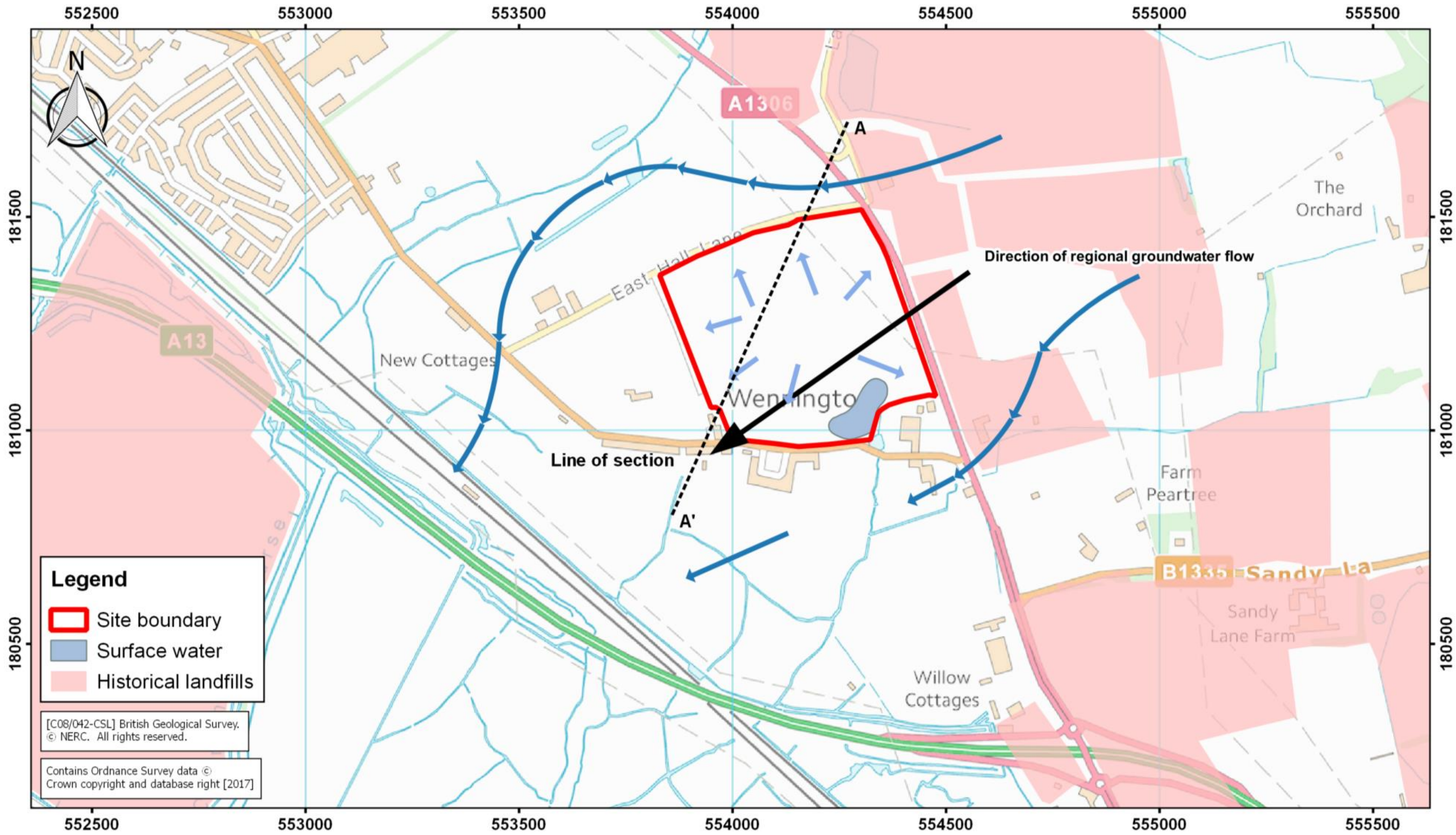
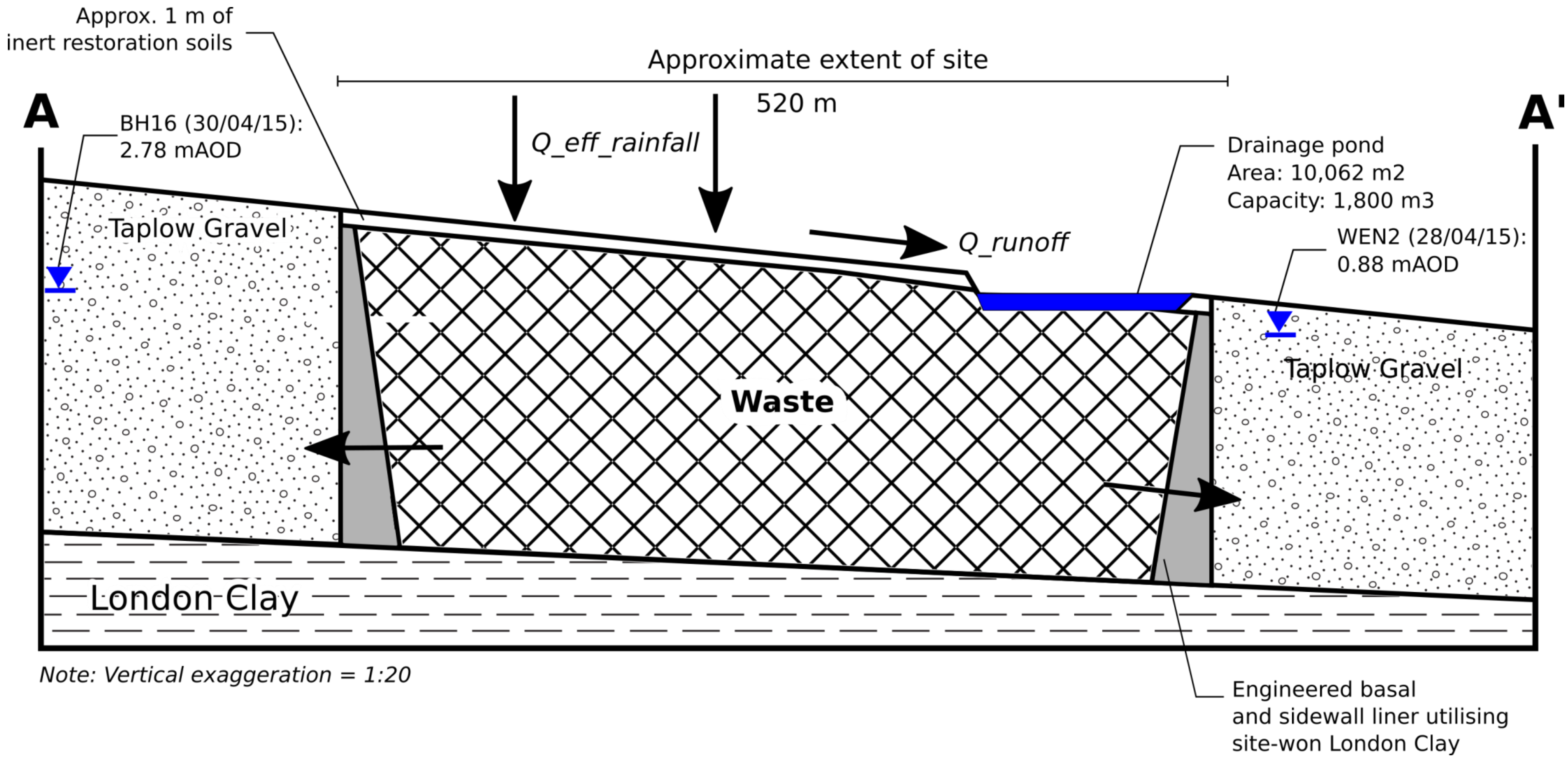


Figure 2.2 Conceptual cross-section of HRA model



2.5.4 Spreadsheet modelling of source – pathway – receptor

The modelling approach has been chosen to provide a robust and transparent assessment of risk using the source-pathway-receptor methodology.

In this approach, possible leachate migration pathways are identified from the conceptual model. The corresponding risk of groundwater contamination is evaluated by considering the three components in sequence, with the contaminant release from the source providing the input flux to the pathway and the contaminant flux from the pathway providing the contaminant load to the receptor.

The source of leachate in the landfill is modelled based on leachate concentrations considered likely for the given waste type.

2.5.5 Model parameterisation

Landfill dimensions

The proposed inert landfill represents the contaminant source to be considered in the risk assessment. An average depth of the landfill has been estimated from the base elevation of the gravel deposits and ground level. Table 2.3 presents the dimensions of the landfill as used in the model.

Table 2.3 Landfill parameters

Description	Value	Data Source
Total extent of waste	199,704 m^2	Calculated, based on presumption of a 10 m standoff on the inside of the site boundary.
Width of site parallel to groundwater flow	510 m	Calculated from GIS.
Length of site parallel to groundwater flow	520 m	Calculated from GIS.
Perimeter of site	1,850 m	Calculated from GIS.
Proportion of leachate that would freely drain from the landfill mass	30%	From Beavan (1996).
Hydraulic conductivity of the waste	1×10^{-7} m/s	Assumed conservative value for modern Landfill Directive compliant inert waste.
Hydraulic Gradient across waste	0.0095	Ground_level – Average groundwater level)/(Length/2)
Maximum leachate elevation	5.5 mAOD	Average proposed ground level
Landfill thickness	5.4 mAOD	Average base on depth of London Clay.

Source term concentrations

For the determinands indicated in Section 2.3 the source term concentration has been estimated as reported below.

The most likely value for the source term is defined by averaging the values for the sites given in Table 2.2. This applies to all determinands apart from ammonium (see Section 2.3). High ammonium concentrations in some of the AEA sites, in fact, suggest that other types of waste may be present within the sites. For this reason a more representative estimation of the concentration of this determinand has been reported in Table 2.4.

Table 2.4 Selected leachate parameters

Parameter	Value	Units	Justification
Concentration of NH_4 as N	1	mg/l	High ammonium concentrations in some of the AEA sites suggest that other types of waste may be present. For this reason a more representative estimation of the concentration of this determinand for modern landfill directive compliant waste has been selected.
Half-life of NH_4	1278 (gravel)	days	Mid value given in Buss et al., 2003
Partition coefficient of NH_4	0.4 (gravel)	l/kg	Mean values given by Buss et al., 2003.
Concentration of Cl-	107	mg/l	Average from Table 2.3.
Half-life of Cl-	No decay	days	
Partition coefficient of Cl-	0	l/kg	No retardation.
Concentration of Ni	0.12	mg/l	WAC percolation test value
Half life of Ni	No decay	days	
Partition coefficient of Ni	410	l/kg	Average of Landsim default.

Table 2.5 Hydrogeological properties

Parameter	Description	Value	Units	Justification
River Terrace Deposits (RTD)				
Hydraulic Conductivity	Corresponding central value of the unsaturated Taplow Gravel hydraulic conductivity in m/d (for information).	10	m/d	(Freeze & Cherry, 1979).
Effective porosity	Effective porosity of the Taplow Gravel.	0.2	m/d	Estimate for poorly sorted clayey, silty, sandy and gravels.
Dry bulk density of RTD	Density of Taplow Gravel used to calculate the mass of material available for sorption.	2080 (gravel)	m^3/kg	Based on specific gravity of Quartz (2.6) (Cox, Price and Harte, 1974) and a bulk porosity of 0.2.
Tortuosity of RTD	Tortuosity of the Taplow Gravel, only applies to diffusion.	5		Estimate.
Hydraulic gradient	Hydraulic gradient between BH03 and BH02, approx. 177 m apart.	0.00785	-	Site data
Groundwater level	Average at WEN01, 02, 03 and 04 in March 2016.	3.04	mAOD	Site data
Travel distance to groundwater receptor	Edge of site	10	m	Standoff length
Mixing width	Width of site perpendicular to GW flow	510	m	Measured
Mixing depth	Saturated thickness of Taplow Gravel	2.9	m	Average GW level – base of mineral

Table 2.6 Hydrological parameters

Parameter	Value	Units	Justification
Effective rainfall	250	mm/a	Based on Environment Agency (2004).
Infiltration factor	1	-	

Table 2.7 Environmental Assessment Levels

Description	Value	Units	Justification
NH4 as N	0.39	mg/l	DWS. No EQS so use DWS for pond receptor. Considered to be conservative because conversion of ammonia EQS value of 0.015 mg/l to ammoniacal nitrogen equates to 0.56 mg/l conservatively based on pH 8 and temperature of 15 ^oC
Chloride	250	mg/l	DWS and EQS
Nickel	0.004	mg/l	DWS and EQS

2.6 Emissions to groundwater

The deterministic model run produced the results presented below and summarised in Table 2.8 and Table 2.9.

For the pond and groundwater pathways, only 40% and 20% of runoff is conservatively applied to the runoff dilution calculations respectively. It is assumed that 95% of the leachate flux from the landfill enters groundwater with 5 % entering the pond, estimated based on the pond length and depth.

As some of the contaminant migration will have occurred before the Site is completely filled, the model predictions at one year are presented here as realistic maximum concentrations.

The tables shows that, following dilution, predicted concentrations at the receptors are well below the EALs.

Table 2.8 Predicted concentrations in groundwater at the Site boundary

Parameter	Concentration (mg/l)	Time (years)	EAL (mg/l)
NH4 as N	1.146E-01	1	0.39
Chloride	1.312E+01	1	250
Nickel	0.0	1	0.004

Table 2.9 Predicted concentrations at the on-site pond

Parameter	Concentration (mg/l)	Time (years)	EAL (mg/l)
NH4 as N	2.194E-02	1	0.39
Chloride	2.348E+00	1	250
Nickel	2.633E-03	1	0.004

2.7 Hydrogeological completion criteria

Given that there is no expected leachate generated at the site, there will be no managed phase following the end of landfilling except to confirm this assumption is true. During the operational phase the site monitoring data will be evaluated on an annual basis. The Hydrogeological Risk Assessment for the site will be reviewed in line with Environment Agency guidance. These reviews will help establish whether the landfill performance is as predicted by the site Hydrogeological Risk Assessment.

Following Site closure it is proposed to continue to monitor for five years in order to confirm that the site is performing as predicted by the site Hydrogeological Risk Assessment.

3 REQUISITE SURVEILLANCE

3.1 Risk-based monitoring plan

3.1.1 Leachate monitoring

The waste types for acceptance to the landfill will have negligible leaching potential and therefore no meaningful leachate is assumed to collect during the operational and post-operational phases of landfilling. For this reason, no leachate monitoring is proposed.

3.1.2 Groundwater monitoring

Groundwater in the Taplow Gravel aquifer will be monitored at the pre-existing borehole locations WEN01 through to WEN06 as shown on Drawing 66250D10 and Figure 3.1..

<u>Calculation of appropriate control levels and compliance limits</u>

Control and compliance levels have been set for ammoniacal nitrogen, chloride and nickel. Ammoniacal nitrogen is a common component of landfill leachates and is usually the non-hazardous pollutant present at the highest concentration relative to the UK DWS. Chloride is not retarded or degraded by any environmental processes and is thus a good choice as a conservative tracer. Nickel represents metals in groundwater.

Water quality data collected at the selected monitoring points has been analysed and used to set control and compliance limits for WEN02 and WEN03. Limits have only been set for these boreholes as setting limits for up-gradient boreholes, especially considering the proximity of other landfills in the area, is not considered to be appropriate. Control levels have been set at the mean plus two standard deviations, while the compliance is set at the mean plus three standard deviations.

Table 3.1 Proposed control levels and compliance limits

Determinand	Unit	Control level		Compliance limit	
		WEN02	WEN03	WEN02	WEN03
NH4 as N	mg/l	0.22	0.87	0.29	1.21
Chloride	mg/l	115	79	132	92
Nickel	mg/l	0.012	0.01	0.015	0.012

It is noted that the background nickel dataset only contains three valid results and therefore it is recommended that the control and compliance limits are reviewed for this determinand once more data has been collected.

For ammoniacal nitrogen and chloride ten results per borehole have been used to calculate the proposed action levels.

The methodology used to assess the Site against control levels and compliance limits is detailed in the Site Monitoring Plan, (ESI Report reference 66250R5).

3.1.3 Surface water monitoring

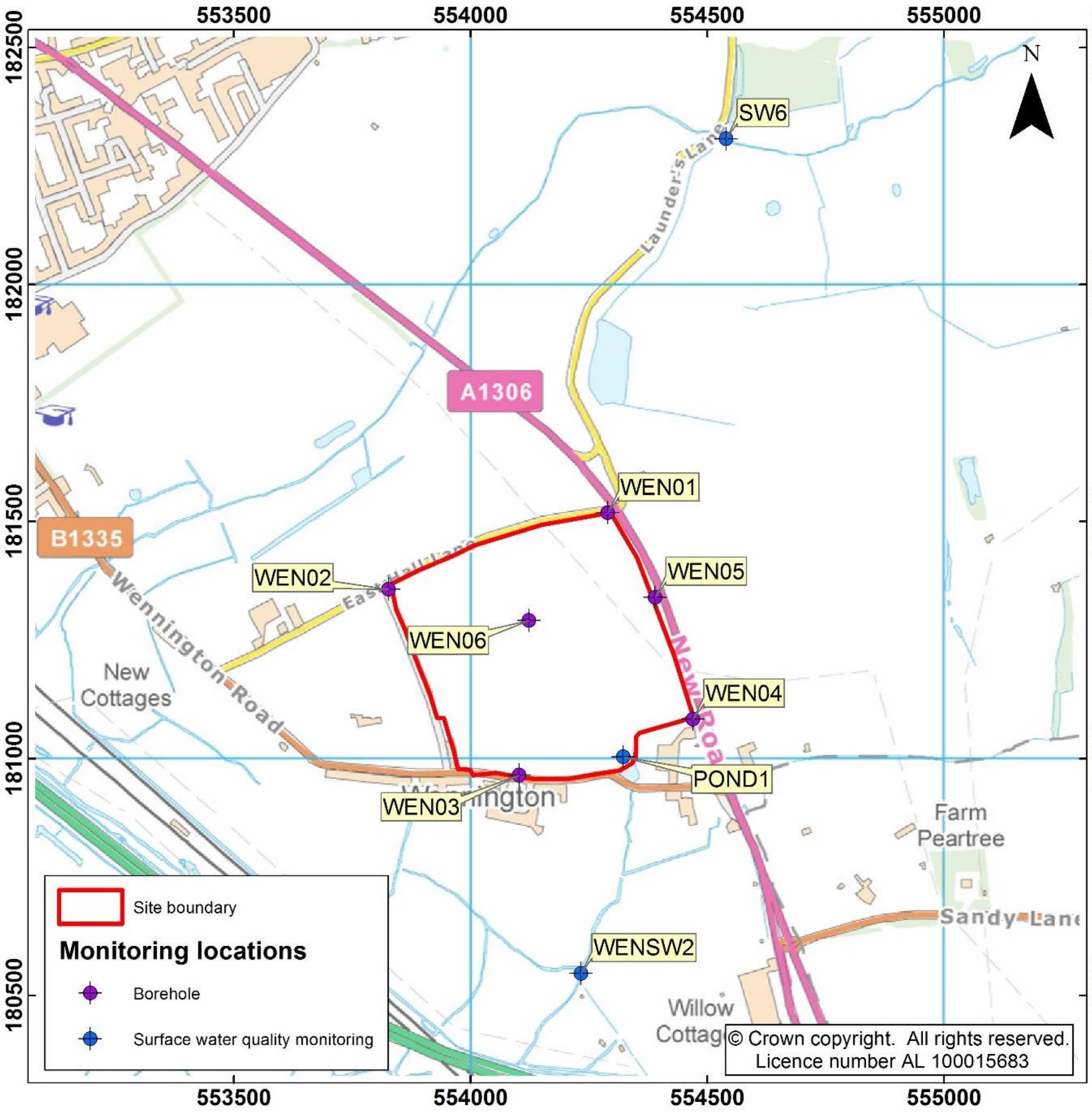
Surface water monitoring is recommended to be carried out at least one upstream and two downstream monitoring locations. The monitoring locations are presented in the Site Monitoring Plan and also in Figure 3.1.

Existing monitoring points at SW1 and SW3 monitor surface water drainage ditches at the Moor Hall Farm landfill, whilst SW2 monitors at an on-site pond at the same site (see locations in Drawing 66250D10). None of these locations are considered to be appropriate for up-gradient monitoring of Wennington Landfill, as these locations are likely to be being impacted by the up-gradient landfill. Instead it is proposed to adopt SW6 as the up-gradient surface water monitoring location as this is considered to be most representative of up-stream quality.

Down-gradient location 'WENSW2', located in the drainage feature to the south of the Site which flows in the direction of Rainham Marshes should be monitored to assess down gradient surface water quality, as well as the proposed on-site pond (Pond 1).

No control levels or compliance limits are proposed for surface water quality monitoring.

Figure 3.1 Proposed monitoring locations



4 CONCLUSIONS

4.1 Compliance with the Environmental Permitting Regulations 2016

The compliance of Wennington Landfill, with aspects of the Environmental Permitting Regulations (England and Wales) 2016 specific to the hydrogeology, is discussed in this HRA. No account is taken of other aspects such as gas migration or stability assessments.

The facility will be protected from the groundwater environment by natural geological barriers. There is cohesive material (London Clay) already present that will form the basal geological barrier and will provide sufficient protection of the underlying Chalk. Protection to shallow groundwater will be afforded by engineered sidewall geological barriers which will be constructed so as to conform to the Landfill Directive.

An on-Site pond will be constructed to assist with drainage in the southern part of the Site. The pond will allow the discharge water to recharge back into the sand and gravel, with an overflow discharge to the ditch to the south which feeds Wennington Marsh.

A conceptual site model has been developed for the facility and its surrounding environment. On the basis of the conceptual site model, a quantitative hydrogeological risk assessment has been undertaken. Given the inert nature of the waste, a simple model has been developed that considers the risk to shallow groundwater (within the Taplow Gravel) following the dilution of any leachate discharge from restoration soil runoff and dilution within groundwater.

The model does not predict any discernible impact to groundwater. The risk to the underlying Chalk has been qualitatively screened out from the assessment on the basis of the site geometry and geological barriers.

The model results show very little impact from the Site. As some of the contaminant migration will have occurred before the Site is filled, the model predictions at one year are presented as realistic maximum concentrations.

As required by the Landfill Directive, requisite monitoring for groundwater and surface water is proposed. Control levels and compliance limits for down-hydraulic gradient groundwater monitoring wells have been derived based on the background concentrations. Site monitoring data will be compared to these levels and limits to provide an early warning if the groundwater starts to deteriorate, allowing sufficient time to take remedial action prior to compliance limits being exceeded. It is not proposed to set compliance limits for surface water monitoring.

5 REFERENCES

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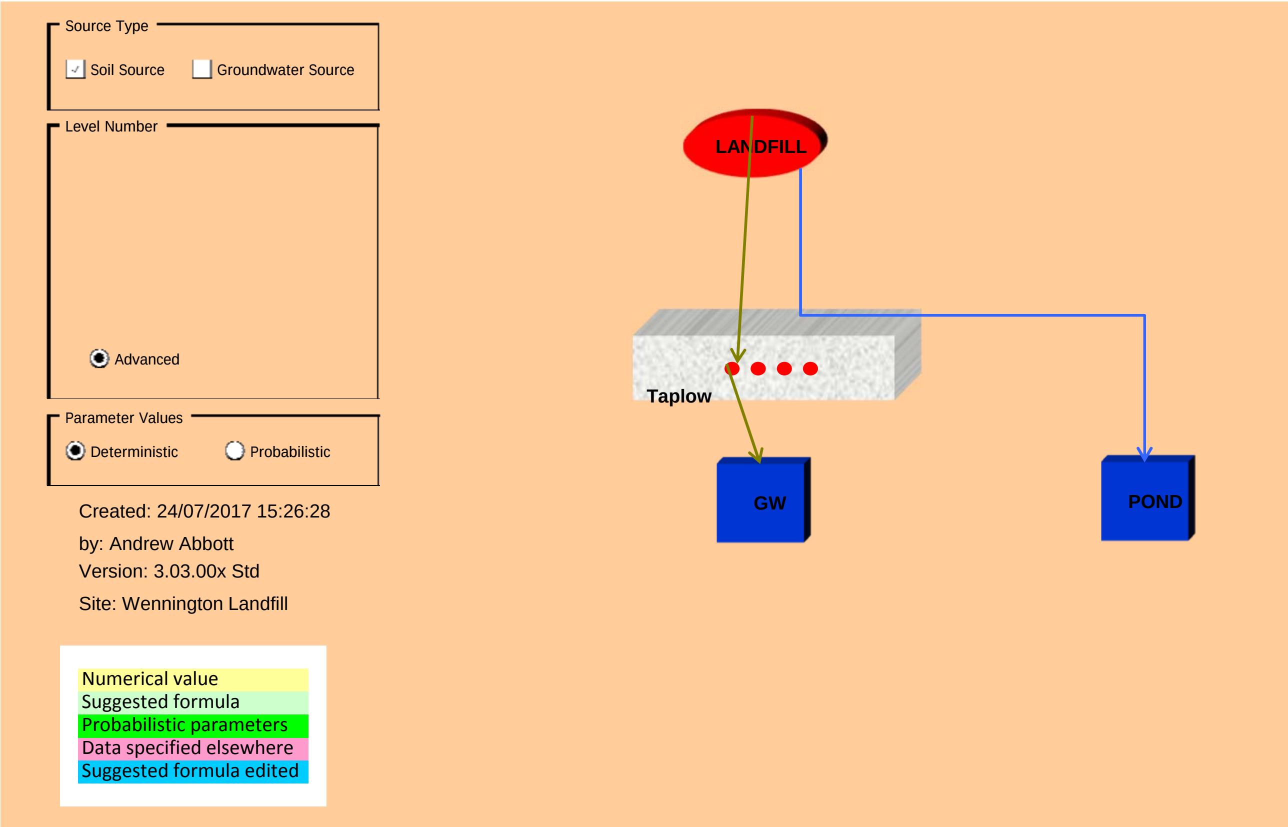
APPENDICES

APPENDIX A

Electronic copy of RAM model


Source Type
Soil Source
Groundwater Source
Level Number
Advanced
Parameter Values
Deterministic
Probabilistic
Created: 24/07/2017 15:26:28
by: Andrew Abbott
Version: 3.03.00x Std
Site: Wennington Landfill
Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited
LANDFILL
Taplow
GW
POND

CONTAMINANT INFORMATION

			Species1	Species2	Species3
Source determinand names		3	Ammoniac	Chloride	Nickel

Receptor Target Concentrations

	Name	Values in mg/L		
Quality Standard 1	DWS	0.39	250	0.02
Quality Standard 2	EQS	0.39	250	0.004
Quality Standard 3	EAL			
Quality Standard 4				

Generic Contaminant Properties

Contaminants_Organic_Carbon_Water_Partition_Coefficient_Koc	**L/kg**	0	0	0
Contaminants_Free_Water_Diffusion_Coefficient	**m2/s**			

HYDROGEOLOGICAL UNITS

Hydrogeological Units		Taplow
Hydrogeology_Unit_Thickness	m	
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)	
Hydrogeology_Hydraulic_Conductivity	m/s	0.000115741
Hydrogeology_Head	m	
Hydrogeology_Hydraulic_Gradient	[-]	0.007846154
Hydrogeology_Porosity	[-]	0.2
Hydrogeology_Velocity	m/s	4.5406E-06
Hydrogeology_Tortuosity	[-]	5

ATTENUATION PARAMETERS

Hydrogeological Units		Taplow	Sidewall

General properties

Attenuation_Dry_bulk_density	kg/m3	2080	
Attenuation_Fraction_organic_carbon	[-]		

Contaminant specific parameters

Ammoniacal nitrogen

Attenuation_Partition_Coefficient_Kd_Species_1	L/kg	0.4	
Attenuation_Retardation_Species_1	[-]	5.16	
Attenuation_Half_Life_Species_1	days	1277.5	
Attenuation_Decay_Coefficient_Species_1	1/s	6.27987E-09	

Chloride

Attenuation_Partition_Coefficient_Kd_Species_2	L/kg	0	
Attenuation_Retardation_Species_2	[-]	1	
Attenuation_Half_Life_Species_2	days	No Decay	
Attenuation_Decay_Coefficient_Species_2	1/s	0	

Nickel

Attenuation_Partition_Coefficient_Kd_Species_3	L/kg	410	
Attenuation_Retardation_Species_3	[-]	4265	
Attenuation_Half_Life_Species_3	days	No Decay	
Attenuation_Decay_Coefficient_Species_3	1/s	0	

WATER BALANCE

User defined

Enter your own calculations for the water balance
Carry fluxes and velocities over onto the Pathway sheet

Landfill dimensions

Estimated fill area with 10m buffer	199704	m2	*Calculated from GIS*
Landfill dimensions			
Width	510	m	*Calculated from GIS*
Length	520	m	*Calculated from GIS*
Perimeter	1,850	m	*Calculated from GIS*
Levels			
Ground level of site	5.5	mAOD	*Average from application plans*
Base of landfill	0.100	mAOD	*Average - estimate - from GL - landfill thickness*
Landfill thickness	5.400	m	*Based on average depth to top of London Clay - 1m*
Average groundwater levels	3.04	mAOD	*GWLs range from c. 3.5 mAOD to 2mAOD in NW and osuth*
Saturated thickness			
Saturated thickness of waste	5.400	m	*Does this work with negative numbers?*
Hydraulic gradients			
i_liner	2.46		
Hydraulic_gradient	0.009461538		
Gradient WEN01 to WEN03	0.007846154		
Saturated perimeter			
Saturated_perimeter_area	9990	m2	
K_Waste	1.00E-07	m/s	
K_liner	1.00E-08	m/s	*Assumed for landfill-directive compliant inert waste*
t_liner	5.00E+00	m	
Q_Path	2.46E-04		*This is only applicable for no presence of clay sidewall*
	6.14385E-05		
Q_Path to groundwater	2.33E-04		0.95 of GW disc
Q_path to pond	1.23E-05		0.05 of GW disc
	2.46E-04		
	9.45208E-06		
Distance between WEN01 and WEN03	585	m	
March 2016 GWLS			
WEN01	5.55	mAOD	
WEN03	0.96	mAOD	

Rainfall data

Effective rainfall	250	mm/a	*EA (2004) data, see ESID 3.1*
Infiltration factor	1	-	*No flow through base, so rainfall - whatever comes out the sides*
Q_inf	1.58E-03	m3/s	*Q_infiltration*
Q_ER_Total	1.58E-03	m3/s	

Diluting flux

Q_runoff	1.34E-03	m3/s
Q_runoff	1.34E-03	m3/s

PATHWAY SUMMARY

Path 1	Section 1		Section 2	
Path 1 Type		Source		Receptor
Path 1 Name		**LANDFILL**		**POND**
Path 1 Process		Declining source		Monitoring Borehole
Path 1 Standards			Target Standard	EQS
Path 1 Parameter1	**Q_managed [m3/s]**	0.000E+00		
Path 1 Parameter2	**Managed time [years]**	0.000E+00		
Path 1 Parameter3	**Q_path [m3/s]**	1.229E-05		
Path 1 Parameter4	**Q_decline [m3/s]**	2.458E-04		
Path 1 Parameter5				
Path 1 Parameter6			**Q_dilute [m3/s]**	5.345E-04

Path 2	Section 1		Section 2		Section 3	
Path 2 Type		Source		Unit		Receptor
Path 2 Name		**LANDFILL**		**Taplow: Node 1**		**GW**
Path 2 Process		Declining source		ADRD (1D) + Dilution		Monitoring Borehole
Path 2 Standards					Target Standard	DWS
Path 2 Parameter1	**Q_managed [m3/s]**	0.000E+00	**Velocity [m/s]**	4.541E-06		
Path 2 Parameter2	**Managed time [years]**	0.000E+00	**Dispersivity [m]**	1.0		
Path 2 Parameter3	**Q_path [m3/s]**	2.335E-04	**Travel Distance [m]**	10.0		
Path 2 Parameter4	**Q_decline [m3/s]**	2.458E-04	**Mixing Depth [m]**	2.9		
Path 2 Parameter5			**Mixing Width [m]**	510.0		
Path 2 Parameter6			**Q_Dilute [m3/s]**	1.629E-03	**Q_dilute [m3/s]**	0.000E+00

SIMULATION PARAMETERS

Monte Carlo Analysis with Crystal Ball

Reported Percentile	95
Number of simulations	10000

☐ Stop on calculation error

☐ Use same sequence of random numbers

Minimise while running:

◉ Nothing

○ All Spreadsheets (faster)

○ Microsoft Excel (fastest)

Named Constants

s_per_year	31557600
s_per_day	86400

Laplace Transform Solution Parameters

sigma	0
nu	1
nsum	16
omega	11

Reporting Options

Number of timeslices for breakthrough curves 10

The timeslices specified on the results sheets are saved below.

Path1 timeslices in years

TS_Path1_Spec1	TS_Path1_Spec2	TS_Path1_Spec3
1	1	1
2	2	2
5	5	5
10	10	10
15	15	15
20	20	20
50	50	50
60	60	60
80	80	80
100	100	100

Path2 timeslices in years

TS_Path2_Spec1	TS_Path2_Spec2	TS_Path2_Spec3
1	1	1
2	2	2
5	5	5
10	10	10
15	15	15
20	20	20
70	70	70
80	80	80
90	90	90
100	100	100