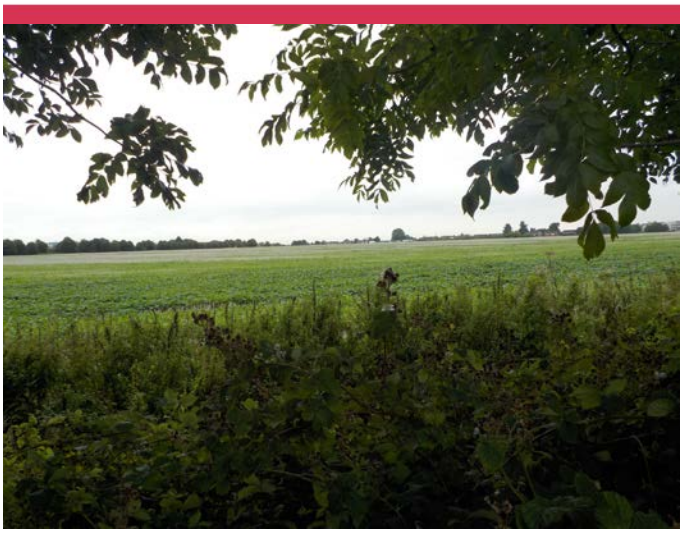

Langley Quarry Hydrogeological Risk Assessment

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Prepared for

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Langley Quarry Hydrogeological Risk Assessment

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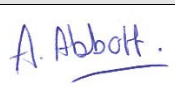
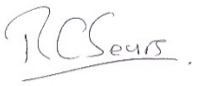
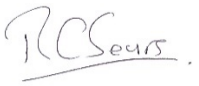
Author	Andrew Abbott	
Checked by	Robert Sears	
Reviewed by	Robert Sears	

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CONTENTS

1 INTRODUCTION 1

1.1 Report context 1

1.2 Conceptual Hydrogeological Site Model 1
1.2.1 Water balance for the landfill 1
1.2.2 Source 2
1.2.3 Pathways 2
1.2.4 Receptors 2

2 HYDROGEOLOGICAL RISK ASSESSMENT 4

2.1 The nature of the Hydrogeological Risk Assessment 4
2.1.1 General modelling approach 4

2.2 The proposed assessment scenarios 4
2.2.1 Lifecycle phases 4

2.3 The priority contaminants to be modelled 4

2.4 Review of technical precautions 7

2.5 Mathematical modelling 7
2.5.1 Justification of the modelling approach and software 7
2.5.2 General assumptions 7
2.5.3 Representation of the conceptual model 7
2.5.4 Spreadsheet modelling of source – pathway – receptor 8
2.5.5 Model parameterisation 11

2.6 Emissions to groundwater 14

2.7 Hydrogeological completion criteria 14

3 REQUISITE SURVEILLANCE 15

3.1 The risk-based monitoring plan 15
3.1.1 Leachate monitoring 15
3.1.2 Groundwater monitoring 15
3.1.3 Surface water monitoring 15

4 CONCLUSIONS 16

4.1 Compliance with the Environmental Permitting Regulations 2010 16

5 REFERENCES 17

FIGURES

Figure 2.1 Conceptual model plan view 9
Figure 2.2 Conceptual model cross section 10

TABLES

Table 2.1 Sources of information on leachate properties 5
Table 2.2 Inert landfill leachate data 6
Table 2.3 Landfill parameters 11
Table 2.4 Selected leachate parameters 11
Table 2.5 Hydrological parameters applied in the model 12
Table 2.6 Hydrogeological properties 12
Table 2.7 Pathway properties in the Lynch Hill Gravel and Horton Brook 13
Table 2.8 Environmental Assessment Levels 13
Table 2.9 Predicted concentrations in groundwater at the southern Site boundary 14
Table 2.10 Predicted concentrations adjacent to Horton Brook 14
Table 3.1 Proposed control levels and compliance limits 15

APPENDICES

Appendix A Electronic RAM model
Appendix B Time Series data for compliance parameters and locations

1 INTRODUCTION

1.1 Report context

Langley Quarry is a sand and gravel quarry owned and operated by CEMEX UK Operations Ltd (CEMEX). This report is produced for CEMEX by ESI Ltd to support an application for an Environmental Permit to restore the void with inert waste.

This assessment is based on the data and information contained within the Environmental Setting and Site Design (ESSD) report that has been prepared for the permit application.

1.2 Conceptual Hydrogeological Site Model

The facility is a landfill site, and associated infrastructure, for the disposal of inert waste. Information on the Site location and surroundings are discussed in Section 1 of the ESSD report and shown on Drawing Number CEM/A103725/LOC/01.

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 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, whilst 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, 2004) 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).

- The landfilled material is likely to be less permeable than the surrounding aquifer. 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 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.
- Any water running off the landfill surface will infiltrate the aquifer at the landfill perimeter and will act to dilute any contamination that migrates out the sides of the landfill.
- Due to the presence of nearby historical landfills, the landfill will be worked wet and no pumping will take place during the operational phase. Groundwater will therefore remain at its natural levels throughout the operational phase. The risk assessment considers the long term situation when landfilling has ceased and the site has been restored.

1.2.2 Source

The installation is to be utilised for the disposal of inert waste only, as detailed in the ESSD report. Also, as detailed in the ESSD report (Paragraph 2.1.7), the total quantity of waste will be approximately 1,687,500 m³ (2.7 million 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 London Clay, which has a relatively 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.

1.2.3 Pathways

The following pathways have been considered:

- Flow from the landfill, through 10 m of aquifer to a receptor located at the site boundary.
- Flow from the landfill, through the 10 m stand-off of aquifer, to groundwater just before Horton Brook. No account is taken of dilution in surface water.

Groundwater flow within the Lynch Hill Gravel is considered to be from north to south and there may be local discharge to Horton Brook. Therefore, whilst any contaminant discharge along the northern boundary of the landfill would be subject to dilution in the receiving groundwater, the southern side is entirely within the shadow of the landfill. Thus the only dilution process applied within the model for contaminants discharging to groundwater is from the water running off within the restoration soils and the model ignores any additional dilution from up hydraulic gradient groundwater. Attenuation is also considered within the groundwater pathway.

1.2.4 Receptors

The potential receptors of contamination have been identified as follows (see also Section 3.6 of the ESSD):

- 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 material deposited at the Site. Any materials accidentally placed would be attenuated within the geological barrier (which the model does not rely upon). Assessment of hazardous substances has been qualitatively screened out of this risk assessment.
- Non-hazardous pollutants: groundwater at the southern Site boundary and adjacent to Horton Brook.

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 Lynch Hill Gravel, which is locally classified as a Principal Aquifer. Principal aquifers are highly permeable formations usually highly productive and able to support large abstractions for public water supply and other purposes. The Lynch Hill Gravel is underlain by the London Clay, which has a thickness of between 30 and 100 m.

The installation will be partially below and partially above the water table, and is to be utilised 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, 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 basal barrier will consist of the naturally present London Clay. The risk assessment presented here does not consider a sidewall 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 relatively low. However, it is recognised that the landfill is below the water table and within a principal aquifer. Therefore, in accordance with guidance from the Environment Agency[1] for an inert landfill site under these conditions, a simple quantitative risk assessment has been undertaken.

2.2 The proposed assessment scenarios

2.2.1 Lifecycle phases

As discussed in Section 4.1.1 of the ESSD report, no management of groundwater will take place at Langley Quarry landfill site. Therefore, no groundwater management has been considered in the Risk Assessment scenarios. 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.

There will be no difference in the water balance or contaminant transport mechanisms and processes between the operational and post closure phases. Therefore a single lifecycle phase is considered in the model.

2.3 The priority contaminants to be modelled

Data 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 study the leachate data from AEA (1991) were found to be most appropriate, as detailed in the following Table 2.1.

[1] https://www.gov.uk/guidance/landfill-developments-groundwater-risk-assessment-for-leachate

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, potassium and iron, 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 Table 2.2, 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 Riding Court Farm Landfill, 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 conservative inorganic substances 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

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 ESSD report.

These technical precautions, combined with pre-inspection of the waste, are considered sufficient for the facility to comply with the Environmental Permitting Regulations (2010).

2.5 Mathematical modelling

2.5.1 Justification of the modelling approach and software

The risk assessment has been undertaken using ESI's Risk Assessment Model (RAM) commercial software package (ESI, 2008).

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 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 filling of the site will take longer than this time, 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 probably be less permeable than the surrounding River Terrace Deposits of the Lynch Hill 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 Lynch Hill Gravel. Leachate will discharge through the sides of the waste. As the gravel will have been 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.

The site is taken to be a single source and has not been further sub-divided.

A maximum value of Q_{side} can be calculated 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 saturated 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 and attenuation is applied in the flow path from the waste mass to the receptor. Dilution occurs by runoff from the landfill between the edge of the waste disposal area and the receptor.

The distance to the down-hydraulic gradient Site boundary receptor in the south-west is considered to be 10 m. As a stand-off from Horton Brook of 10 m will also be applied, this is also taken as the travel distance between the waste and Horton Brook.

At the groundwater receptor, resultant concentrations are assessed against the DWS and at the Brook 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.

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.

Figure 2.1 Conceptual model plan view

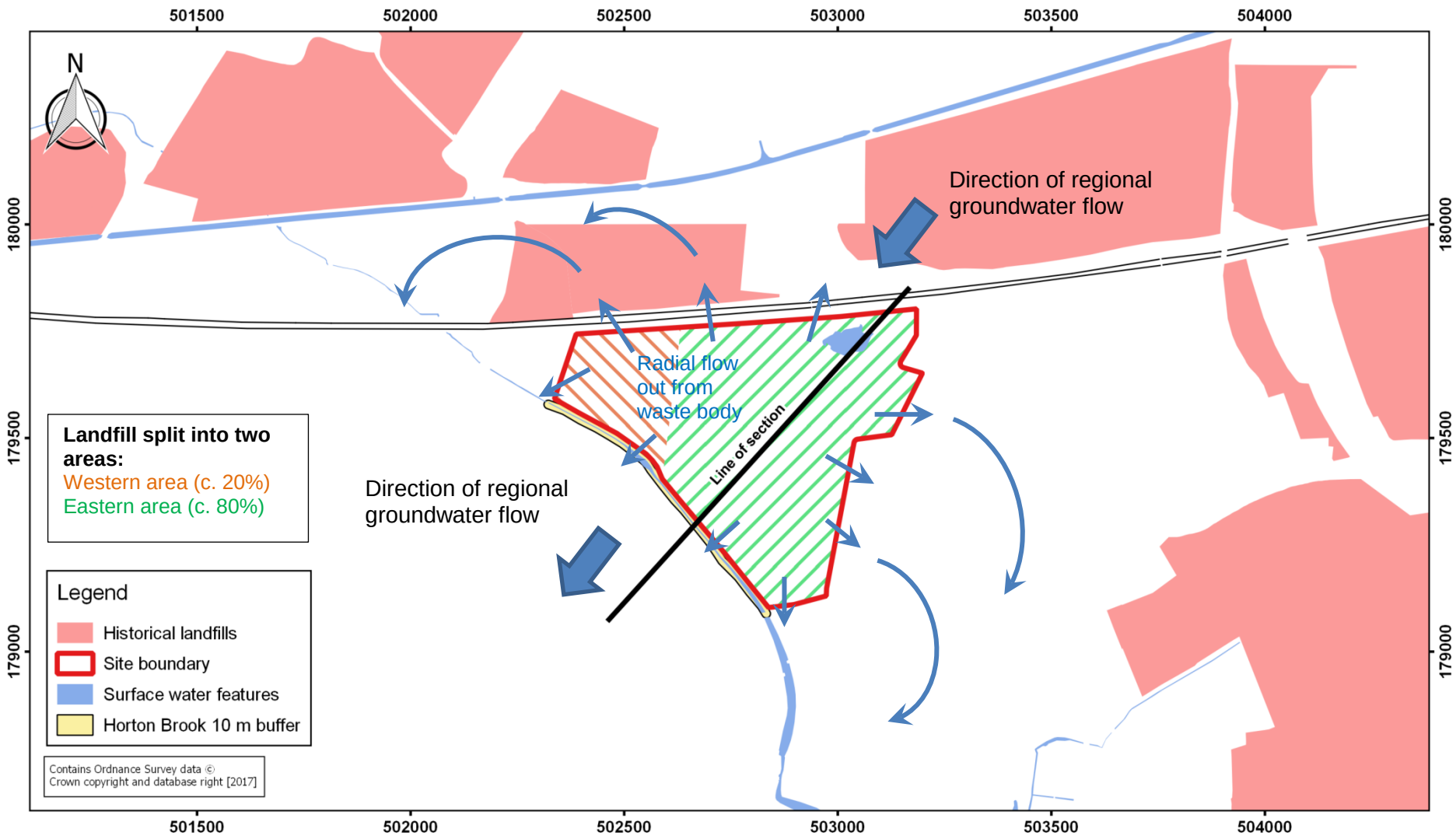
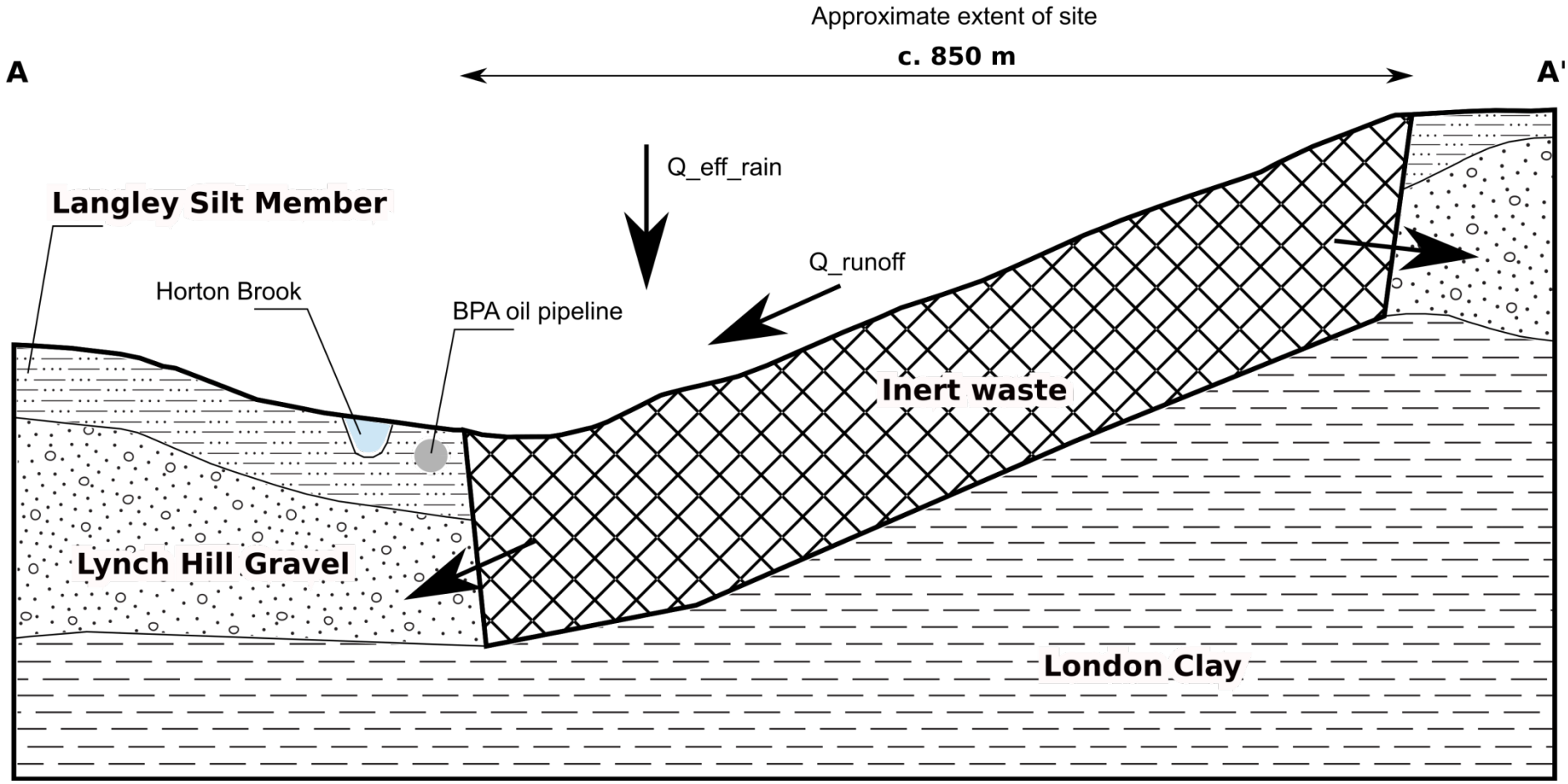


Figure 2.2 Conceptual model cross section



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 volume of waste	1,687,500 m^3	Provided by WYG.
Waste area	339,065 m^2	Calculated from GIS.
Length of Site parallel to groundwater flow	660 m	Calculated from GIS.
Perimeter of Site	2,626 m	Calculated from GIS.
Saturated thickness of waste	3.66 m	Maximum saturated thickness of gravel deposits
Proportion of leachate that would freely drain from the landfill mass	30%	From Beavan (1996).
Hydraulic conductivity of the waste	1 x 10^{-7} m/s	Assumed conservative value for modern Landfill Directive compliant inert waste.
Ground Level	27.98 mAOD	Average current ground level and proposed restoration level.

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 2.2
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

Parameter	Value	Units	Justification
Half life of Ni	No decay	days	
Partition coefficient of Ni	410	l/kg	Average of Landsim default.

Hydrology

Table 2.5 Hydrological parameters applied in the model

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

Pathway definition

Table 2.7 lists the parameters required to define the three pathways that are conceptualised in the model (described in Section 1.2.3).

Table 2.6 Hydrogeological properties

Parameter	Description	Value	Units	Justification
River Terrace Deposits (RTD)				
Hydraulic conductivity	Hydraulic conductivity for sand & gravel	1	m/d	Value consistent with hydraulic gradient and recharge
Effective porosity	Effective porosity of the Lynch Hill Gravel	0.2	m/d	Estimate for poorly sorted clayey, silty, sandy gravel.
Dry bulk density of RTD	Density of Lynch Hill Gravel used to calculate the mass of material available for sorption	2120	m3/kg	Based on specific gravity of Quartz (2.65 g/cm^3) (Cox, Price & Harte, 1974) and a bulk porosity of 0.2.
Tortuosity of RTD	Tortuosity of Lynch Hill Gravel, only applies to diffusion	5	-	Estimate.
Hydraulic gradient	Hydraulic gradient between WOB05 and WOB01	0.010	-	Site-specific data.
Groundwater level	Average at WOB01, WOB02, WOB03, WOB04, WOB05 and WOB06 (Apr 2015 – Jul 2017)	27.2	mAOD	Site-specific data.
Travel distance to groundwater receptor	Typical distance from edge of waste to edge of Site	10	m	Nominal standoff.
Mixing depth	Saturated thickness of Lynch Hill Gravel	2.08	m	Average saturated thickness

Table 2.7 Pathway properties in the Lynch Hill Gravel and Horton Brook

Description	Value	Units	Justification
Proportion of flux from landfill going to groundwater	80%	-	Estimated based on area of north-western corner of Site
Proportion of flux from landfill going to brook	20%	-	Estimated based on area of eastern area of Site

Table 2.8 Environmental Assessment Levels

Description	Value	Units	Justification
NH4 as N	0.39	mg/l	DWS.
	0.3	mg/l	EQS based on average alkalinity of 139 mg/l for river <80 m and 'high' standard in Type 1, 2, 4 and 6 rivers (Environment Agency, 2011)
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 which are summarised in Table 2.9 and Table 2.10.

As the pathway distances to the two receptors are the same and the proportion of waste and run-off to each of the two receptors is also the same, the predicted concentrations at each receptor are also the same.

Chloride is predicted to break through and reach a maximum concentration by two years. Concentrations then start to decline as the source term declines. Ammoniacal nitrogen is retarded and degrades, so the peak concentration is slightly later at 10 years. Nickel is highly retarded and concentrations are still low, but rising after 1,000 years.

The tables show that concentrations are well below the respective EALs.

Table 2.9 Predicted concentrations in groundwater at the southern Site boundary

Parameter	Concentration (mg/l)	Time (years)	EAL (mg/l)
NH4 as N	5.063E-4	10	0.39
Chloride	9.046E-2	2	250
Nickel	4.46E-6	1,000	0.004

Table 2.10 Predicted concentrations adjacent to Horton Brook

Parameter	Concentration (mg/l)	Time (years)	EAL (mg/l)
NH4 as N	5.063E-4	1	0.3
Chloride	9.046E-2	1	250
Nickel	4.46E-6	200	0.004

2.7 Hydrogeological completion criteria

Although the Site will feature an engineered sidewall geological barrier, there will be no managed phase following the end of landfilling. 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 to 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 The risk-based monitoring plan

3.1.1 Leachate monitoring

The landfill has no leachate management system and therefore no leachate is assumed to collect during the operational and post-operational phases of landfilling. Therefore, no leachate management is proposed.

3.1.2 Groundwater monitoring

It is proposed that groundwater monitoring be carried out at the same six monitoring boreholes (WOB01 to WOB06). These monitoring boreholes cover both up-gradient (WOB04, WOB05 and WOB06), cross-gradient (WOB02 and WOB03) and down-gradient (WOB01) monitoring.

Calculation of appropriate control levels and compliance limits

Control levels and compliance limits have been set in Table 3.1 for ammoniacal nitrogen and chloride. 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. Time series charts with the proposed compliance limits are presented in Appendix B.

Water quality data collected at the selected monitoring points has been analysed and used to set control levels and compliance limits for WOB01 and WOB02. 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, whilst the compliance limit is set at the mean plus three standard deviations. The dataset is based on 28 results per monitoring well. The compliance limit for chloride in WOB02 has been manually adjusted to 135 mg/l to allow for a greater margin above the control level.

Table 3.1 Proposed control levels and compliance limits

Determinand	Unit	Control level		Compliance limit	
		WOB01	WOB02	WOB01	WOB02
NH4 as N	mg/l	2.15	13.9	2.87	16.4
Chloride	mg/l	59.6	104.7	73.8	135.0

The methodology which will be used to assess the Site against the control levels and compliance limits is detailed in the Site Monitoring Plan.

3.1.3 Surface water monitoring

Surface water monitoring is undertaken at SW2 (upstream) and SW1 (downstream). The monitoring locations are presented in the Site Monitoring Plan.

It is recommended to continue with the current surface water monitoring regime on Horton Brook.

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

4 CONCLUSIONS

4.1 Compliance with the Environmental Permitting Regulations 2010

The compliance of Langley Quarry Landfill with aspects of the Environmental Permitting Regulations (England and Wales) 2010, specific to the hydrogeology, is discussed in this HRA.

Protection to the groundwater environment will be provided by artificially established and natural geological barriers. There is cohesive material (London Clay) already present that will form the basal geological barrier and will provide sufficient protection to the underlying Chalk. Protection to shallow groundwater will be afforded by engineered sidewall geological barriers which will be constructed so as to conform with the requirements of the Landfill Directive. However, no reliance has been placed on these in the model, which is therefore much more conservative than the real-life scenario.

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 Lynch Hill Gravel) following the dilution of any leachate discharge from restoration soil runoff.

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

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, where available. 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.

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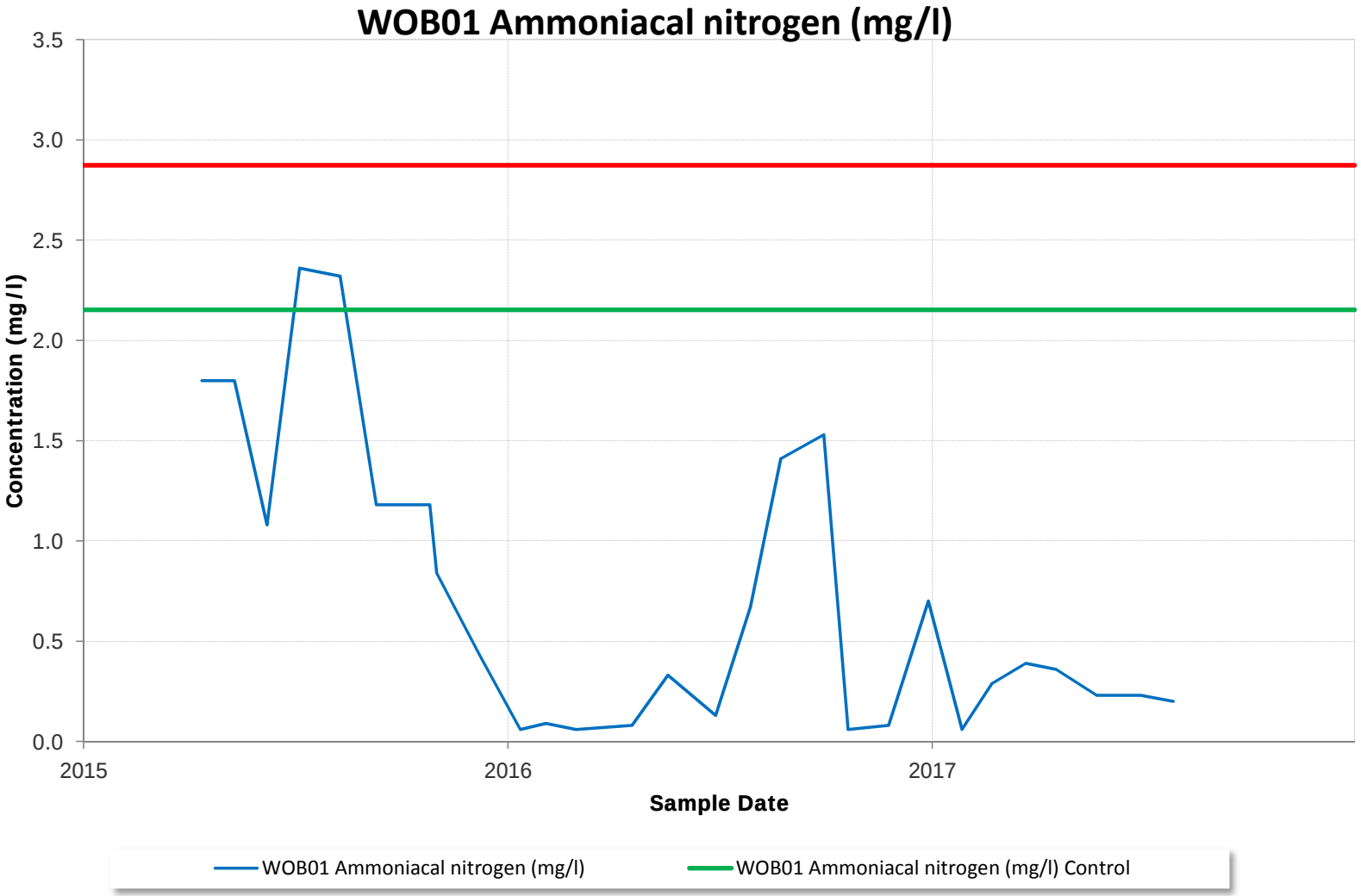
APPENDICES

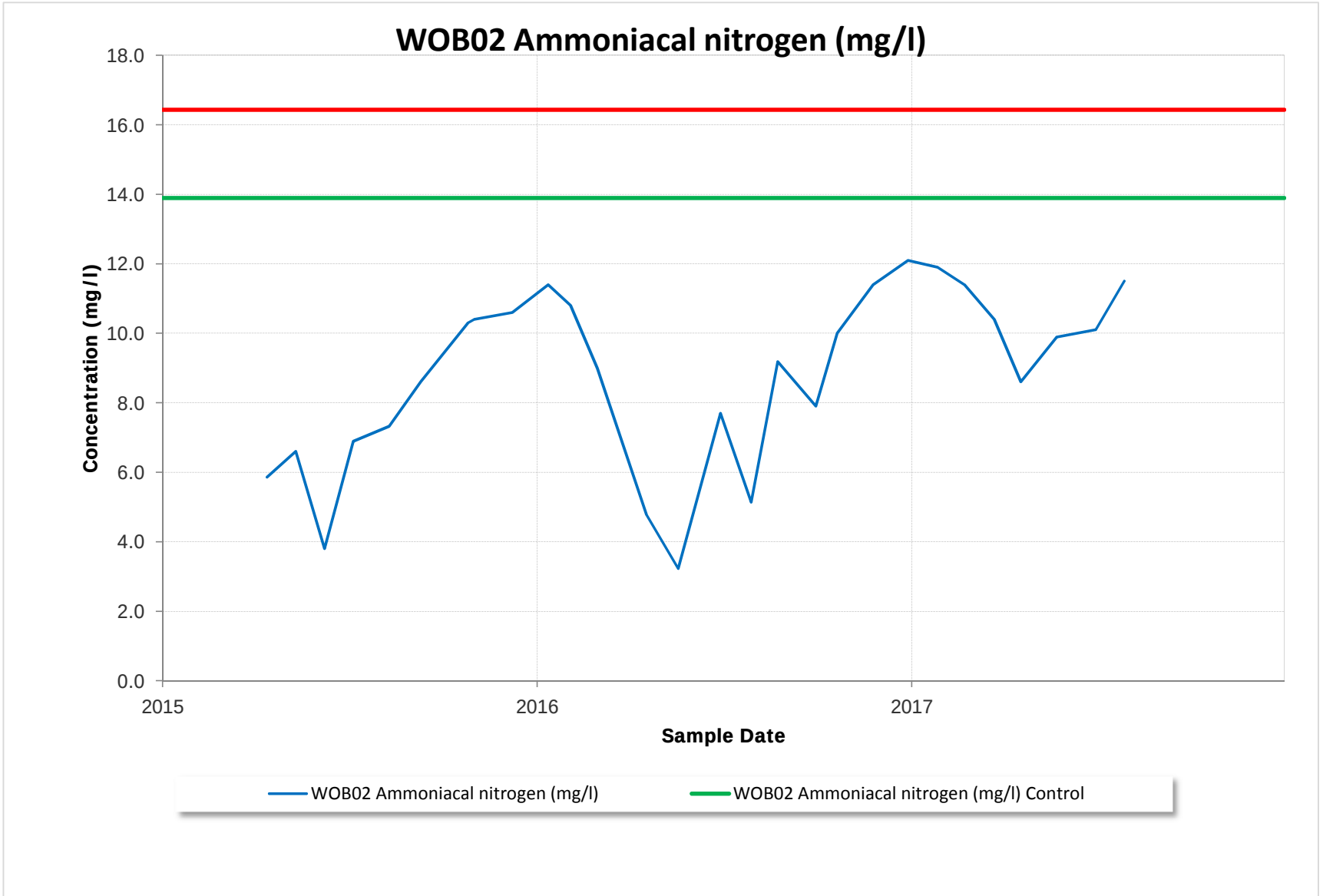
APPENDIX A

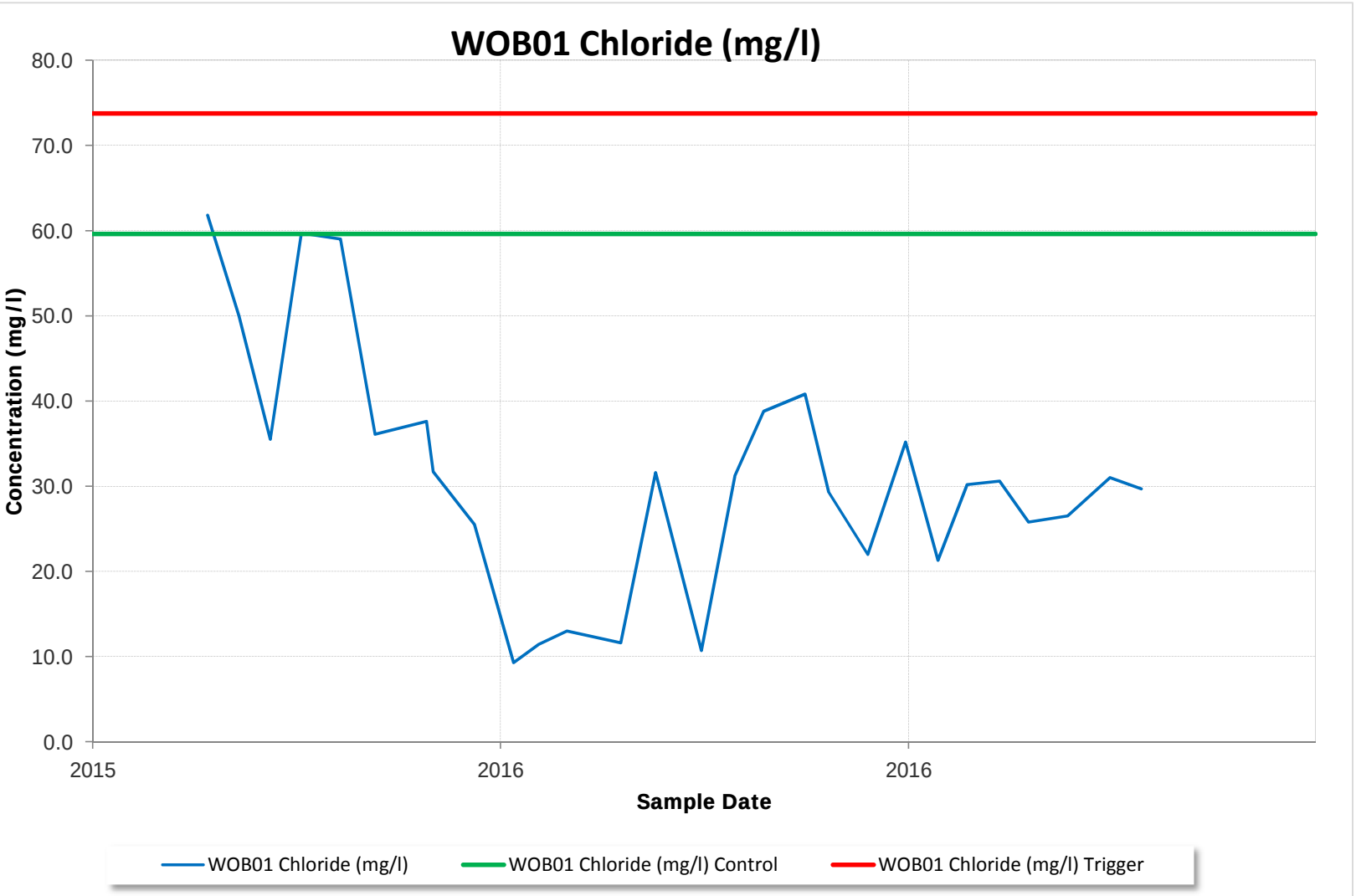
Electronic RAM model

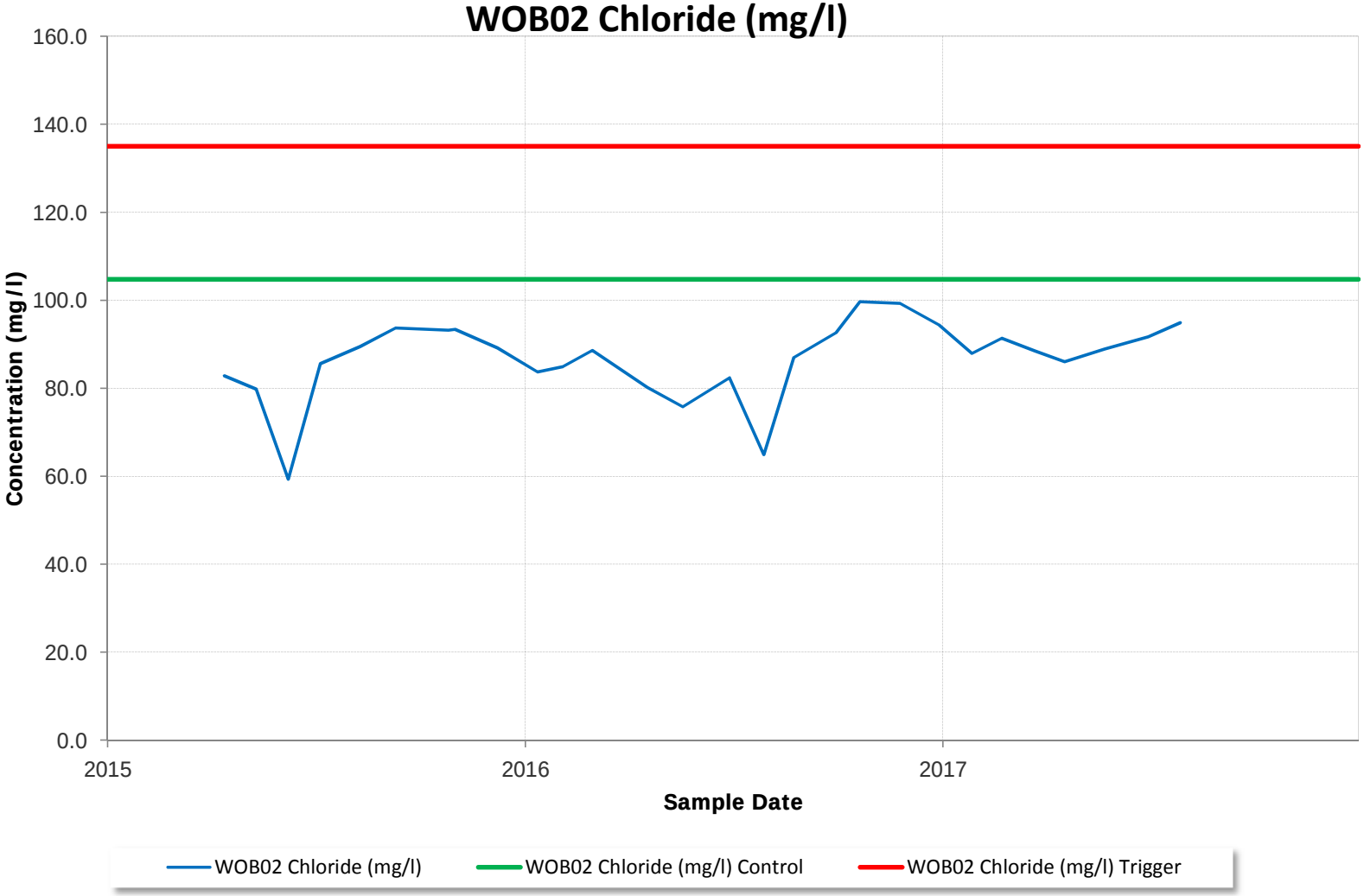
APPENDIX B

Time Series data for compliance parameters and locations


WOB01 Ammoniacal nitrogen (mg/l)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Concentration (mg/l)
2015
2016
2017
Sample Date
WOB01 Ammoniacal nitrogen (mg/l)
WOB01 Ammoniacal nitrogen (mg/l) Control


WOB02 Ammoniacal nitrogen (mg/l)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Concentration (mg/l)
2015
2016
2017
Sample Date
WOB02 Ammoniacal nitrogen (mg/l)
WOB02 Ammoniacal nitrogen (mg/l) Control


WOB01 Chloride (mg/l)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Concentration (mg/l)
2015
2016
2016
Sample Date
WOB01 Chloride (mg/l)
WOB01 Chloride (mg/l) Control
WOB01 Chloride (mg/l) Trigger


WOB02 Chloride (mg/l)
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Concentration (mg/l)
2015
2016
2017
Sample Date
WOB02 Chloride (mg/l)
WOB02 Chloride (mg/l) Control
WOB02 Chloride (mg/l) Trigger