APPENDIX G

HYDROGEOLOGICAL RISK ASSESSMENT (HRA) (REPORT REFERENCE BRE/WL/RLW/2992/01/HRA)

AN APPLICATION FOR AN ENVIRONMENTAL PERMIT TO AUTHORISE THE DEPOSITION OF WASTE ON LAND AS A RECOVERY ACTIVITY FOR THE RESTORATION OF WILLINGTON LOCK QUARRY, ST NEOTS ROAD, BEDFORD TO AGRICULTURE AND NATURE CONSERVATION

APPENDIX G

HYDROGEOLOGICAL RISK ASSESSMENT REPORT (HRA)

Report reference: BRE/WL/SE/1729/01/HRA
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1. Introduction

1.1 MJCA is commissioned by Breedon Trading Limited (Breedon) to prepare a Hydrogeological Risk Assessment (HRA) as part of an application for a bespoke Environmental Permit (EP) for the deposition of waste on land as a recovery activity in order to restore Willington Lock Quarry, St Neots Road, near Bedford (the site) to agriculture and nature conservation. The site location and the Environmental Permit application boundary are shown in green on Figure ESSD 1 presented in the Environmental Setting and Site Design (ESSD) report. The ESSD report is presented at Appendix F of the application report.

1.2 The HRA is based on the conceptual site model presented in the ESSD report. Details of the environmental setting of the site, the geology, hydrology and hydrogeology, the site design, the history of the site, the potential contaminant migration pathways and the receptors are also described in the ESSD report. The acceptance at the site of inert waste materials only will be the subject of Waste Acceptance Procedures (WAP) which will be implemented through the externally certified Environmental Management System (EMS). The WAP and a summary of the EMS are presented in Appendices L and J of the application report respectively.

1.3 The structure of the HRA is based on a template produced by the Environment Agency entitled “Hydrogeological Risk Assessment Report” Version 1 dated March 2010. As the proposed development comprises a waste recovery activity rather than and landfill disposal operation and inert waste materials only will be accepted at the site there are sections of the template which are not relevant to this HRA report although the general structure has been followed.

2. Hydrogeological risk assessment

2.1 The hydrogeological risk assessment is undertaken based on the relevant guidance presented on the GOV.UK website[1]. Information on the geology, hydrology and hydrogeology of the site is presented in the ESSD report. The information is used in the ESSD report to identify the relationships between the source, pathways and the identified potential receptors.

2.2 The restoration works will include the deposit of restoration materials including imported inert waste materials and on site soils and overburden. The restoration of Willington Lock will necessitate the importation of approximately 447,000m^3 of inert restoration materials to restore the site to agriculture and nature conservation. The consented restoration scheme based on a high-pressure gas main which runs in a generally east west direction centrally though the site being retained is shown on drawing reference W16_LAN_022 Rev A a copy of which is presented at Appendix ESSD F of the ESSD report.

2.3 It is understood that Breedon consider that it is highly unlikely that the gas pipeline will be removed or relocated, although ultimately this is a decision which will be taken by Cadent who operate the pipeline. For the purpose of the HRA it is assumed that the gas pipeline will be removed and that if it is not removed a revised extraction profile will be provided once the required stand offs and excavation profiles along the pipeline route can be confirmed.

2.4 The waste materials that will be deposited at the site will comprise imported inert waste materials and on site soils and overburden. Precipitation infiltrating the restoration materials at the site may migrate to groundwater in the in situ River Terrace Deposits round the site, and when dewatering by the pumping of groundwater ceases, groundwater will be in contact with some of the materials placed at the site. Groundwater in the River Terrace Deposits is underlain by the unproductive strata of the Oxford Clay Formation which is in turn underlain by the Kellaways Formation which is in turn underlain by the Great Oolite group. The River Great Ouse is located adjacent to the north western boundary of the site and is likely

[1] https://www.gov.uk/guidance/waste-recovery-plans-and-permits accessed 1 October 2019

to be in hydraulic continuity with the groundwater in the River Terrace Deposits and is a potential receptor for the migration of contaminants present in the waste.

2.5 Based on the definition specified in Council Directive 1999/31/EC (reference 1) inert waste comprises:

> *"…waste that does not undergo any significant physical, chemical or biological transformations. Inert waste will not dissolve, burn or otherwise physically or chemically react, biodegradable or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm to health."*

2.6 The waste types that it is proposed will be accepted at the site are presented in Table ESSD 1 of the ESSD report presented at Appendix F to the application report. The waste types listed in Table ESSD 1 of the ESSD report are listed in the guidance[2] relevant to waste acceptance procedures for waste recovery on land as waste types which may not need to be tested except for classification purposes. The waste types that will be accepted at the site comprise a limited range of inert waste types only. On this basis it is considered that the waste does not comprise a contaminant source with the potential to have a significant detrimental effect on groundwater quality.

2.7 Furthermore, waste acceptance procedures will be in place to minimise the risk that unacceptable waste materials will be accepted at the site and procedures will be in place for the rejection of non-conforming loads. No wastes will be accepted from contaminated sites. Because robust waste acceptance procedures will be implemented the uncertainty with regard to the presence of contaminants in the waste deposited will be low.

2.8 As the restoration materials imported to the site will comprise inert waste only together with on site soils and overburden, the water that has percolated through the waste mass is highly unlikely to contain discernible concentrations of hazardous substances and on this basis the concentrations of hazardous substances in groundwater at a relevant compliance point located down hydraulic gradient of the site also will not be discernible. The inert waste and on site soils and overburden

2 https://www.gov.uk/government/publications/deposit-for-recovery-operators-environmental-permits/waste-acceptance-procedures-for-deposit-for-recovery

deposited at the site is highly unlikely to contain significant concentrations of non hazardous substances which could give rise to pollution of groundwater. Based on the hydrogeological setting, the waste types that will be accepted and the waste acceptance procedures it is concluded that there is a negligible risk of unacceptable impacts on groundwater or surface water quality.

2.9 The side slopes of the excavation will comprise superficial sand and gravel deposits and on this basis are likely to have a hydraulic conductivity greater than 1.0 x 10^{-7}m/s. Notwithstanding that it is concluded that there will be no unacceptable impacts on groundwater or surface water quality it is proposed on a precautionary basis to construct an attenuation layer round the perimeter of the site adjacent to the sidewalls of the excavation. The purpose of the attenuation layer is to provide additional confidence that the risk of unacceptable impacts on groundwater or surface water quality is negligible and to provide attenuation in the unlikely event that any non-compliant loads of waste are accepted at the site.

2.10 It is proposed that the thickness of the attenuation layer will be at least 1m and that suitable materials will be used such that the permeability of the attenuation layer separating the deposited waste from the in situ River Terrace deposits aquifer will be $1x10^{-7}$m/s or less. The Oxford Clay Formation underlying the site is considered to have a low hydraulic conductivity and is designated as unproductive strata by the EA. It is highly likely that the permeability of the in situ Oxford Clay Formation is less than $1x10^{-7}$m/s on which basis it is considered that no attenuation layer will be needed in the base of the site.

2.11 Based on the information reviewed it is considered that there is no history of potentially contaminative activities at the site which at the time of restoration will have been used only for mineral extraction activities. The three historical landfill sites recorded within a 2km radius of the site boundary are Darnells Field, White's, and Playing Fields Land adjacent to the Village Hall which are located to the south west of the site. Given the proximity of the off site landfills to the site and the location of the off site landfills up hydraulic gradient of the site and the assumed direction of groundwater flow it is considered that groundwater quality at the site could be affected by the areas of former landfill sites.

2.12 Notwithstanding that it is concluded based on the proposed use of inert waste only that there will be no significant risks to human health or to the environment from the proposed development and that waste acceptance procedures will be in place to minimise the risk that unacceptable waste materials are accepted, consideration has been given to the potential effect on groundwater quality of the possible acceptance of rogue loads and a quantitative rogue load risk assessment is presented in Section 3 of this report.

3. Quantitative hydrogeological rogue load risk assessment methodology

3.1 Notwithstanding that waste acceptance procedures will be in place to minimise the risk that unacceptable waste materials will be accepted at the site and procedures will be in place for the rejection of non-conforming loads, it is considered reasonable that consideration should be given in the HRA to the possibility, however remote, that non-conforming loads will be accepted and that the potential for such non-conforming loads to affect groundwater quality is considered. It is considered that such an assessment provides useful context for considering the suitability and proportionality of the proposed waste acceptance procedures and the procedures that will be in place for the rejection of non-conforming loads. It is in this context that consideration has been given to the potential effect on groundwater quality of the possible acceptance of rogue loads. A rogue load assessment provides an assessment of the magnitude of potential impacts on groundwater in the unlikely event that the procedures in place relating to the acceptance of waste are not adequate.

3.2 The methodology adopted in undertaking the quantitative hydrogeological rogue load risk assessment is explained in this section. Information on the input parameters used in the modelling is presented in Section 4. The results of the modelling and conclusions are presented in Section 5.

3.3 The quantitative hydrogeological rogue load assessment for the site has been undertaken using ConSim version 2.5 augmented by additional spreadsheet based calculation as necessary. ConSim is a quantitative groundwater modelling tool developed on behalf of the EA which uses the probabilistic Monte Carlo simulation technique to accommodate parameter uncertainty. The approach adopted to carry out the assessment is consistent generally with the EA Remedial Targets Methodology (reference 9). ConSim is used to calculate the concentrations of substances predicted at the edge of the imported materials and its associated attenuation layer which are used as an input parameter in the spreadsheet model which calculates the predicted concentration of contaminants in the sand and gravel aquifer at the compliance point taking into account immediate dilution in the aquifer. It is considered that the use of ConSim version 2.5 augmented by additional spreadsheet based calculations is reasonable and appropriate in this context. An electronic copy of the ConSim model for the site is presented at Appendix HRA A.

3.4 For the purpose of the modelling it is assumed that non-conforming loads potentially could be accepted at the site notwithstanding the waste acceptance and other procedures that will be in place. It is assumed that each rogue load will have a volume of 30m^3 which is approximately two to three times the capacity of a typical road going tipper lorry. It is assumed that rogue loads are placed in the waste mass at a distance of 9m from the down hydraulic gradient edge of the imported material which is 10m from in situ aquifer taking into account the sidewall attenuation layer. It is considered that this assumption is conservative as based on the dimensions of the site it is probable that if present the rogue loads would be likely to be placed a greater distance generally from the down hydraulic gradient edge of the imported material.

3.5 Following recovery of groundwater levels in the imported materials it is assumed that contaminants present in each rogue load will migrate through advection which is the migration of contaminants carried by groundwater flow and dispersion to the down hydraulic gradient edge of the imported materials, migrate through advection through the attenuation layer and then enter the groundwater in the sand and gravel superficial aquifer. Attenuation in the flow path from the location of the rogue load to the down hydraulic gradient edge of the imported material and in the attenuation layer is taken into account. The compliance point for hazardous substances is in groundwater at the down hydraulic gradient edge of attenuation layer following immediate dilution in the sand and gravel aquifer. Conservatively the same compliance point is assumed for non-hazardous pollutants.

3.6 Based on the available information on the groundwater flow regime at and in the vicinity of the site it is considered that groundwater migrating through the deposited waste could migrate down hydraulic gradient and discharge to the River Great Ouse. As it is likely that the hydraulic conductivity of the deposited waste will be lower than the hydraulic conductivity of the sand and gravel horizons in the River Terrace Deposits, groundwater flowing through the deposited waste will be diluted by groundwater flowing round the deposited waste and incident rainfall which runs off the restored landform and infiltrates the ground round the site.

3.7 Other than immediate dilution no attenuation of hazardous substances or of non-hazardous pollutants in the sand and gravel aquifer is taken into consideration. Because attenuation processes will act to reduce the concentrations of non-hazardous pollutants along the groundwater flow path prior to the groundwater reaching discrete receptors such as areas of groundwater discharge to surface watercourses or water features it is considered that this assumption is conservative. Dilution in the surface water features is also ignored.

3.8 Consistent with the deposition of the imported materials below the water table the source term in respect of the rogue loads has been modelled using simulation level 3a in ConSim which simulates direct groundwater contamination. A constant source term is assumed conservatively although over time physical and chemical processes will operate to reduce the concentrations of substances present in the rogue load. It is considered that this approach will result in a conservative assessment of the effects of the acceptance of rogue loads on groundwater receptors.

3.9 The concentrations of substances predicted at the edge of the attenuation layer calculated using the ConSim model are used as an input parameter in a spreadsheet based model which calculates the predicted concentration of contaminants in the sand and gravel aquifer at the compliance point taking into account immediate dilution in the aquifer. For each of the substances modelled environmental assessment limits (EALs) have been specified. To assess the magnitude of the potential impact on groundwater quality of the possible acceptance of rogue loads the predicted concentration of contaminants in the sand and gravel aquifer at the compliance point are compared with the EALs. The spreadsheet models are presented at Appendix HRA C.

3.10 The predicted concentration of contaminants in the sand and gravel aquifer at the compliance point following immediate dilution is calculated as follows:

$$C_{aq} = \frac{C_{mat} \times Q_{mat} + C_{bg} \times Q_{aq}}{Q_{mat} + Q_{aq}}$$

where:

C_{aq} is the predicted concentration in the aquifer (mg/l)

C_{mat} is the concentration predicted at the edge of the attenuation layer using the ConSim model output (mg/l)

Q_{mat} is the groundwater discharge from the imported materials (m^3/s) which is calculated based on the hydraulic conductivity of the imported materials multiplied by the assumed hydraulic gradient across the imported materials.

C_{bg} is the background concentration of the contaminant in the sand and gravel aquifer (mg/l)

Q_{aq} is the groundwater flow in the sand and gravel aquifer (m^3/s) down hydraulic gradient of the site which is calculated based on the assumed hydraulic conductivity of the sand and gravel multiplied by the assumed hydraulic gradient across the imported materials. Dilution is assumed to occur in the aquifer down hydraulic gradient of the rogue load only. The approach to calculating groundwater flow is consistent generally with the approach to calculating the steady state dilution in the aquifer presented in the Environment Agency spreadsheet model “Contaminant Fluxes from Hydraulic Containment Landfills Worksheet Version 1.0”.

4. Model input parameters

4.1 The model input parameters have been entered as necessary using probability density functions to accommodate variations in data or uncertainty in data and to facilitate use of the Monte Carlo simulation technique. Where possible the input parameters are based on site specific data or other relevant sources. Where no site specific data are available professional judgement has been used to select appropriate parameter values based on relevant scientific literature. The model input parameters are presented in Tables HRA 1 to 3.

4.2 The materials imported to the site will comprise inert waste only and there is no expectation that the imported materials will contain discernible concentrations of hazardous substances or significant concentrations of non-hazardous pollutants. Nevertheless to carry out a quantitative assessment of the potential for rogue loads to affect groundwater quality it is necessary to establish a source term for the possible rogue loads. On this basis a representative set of substances was selected for the modelling of potential rogue loads based generally on the physical and chemical properties and behaviour in the environment of a wide range of substances and which has been agreed with the EA previously in respect of other sites.

4.3 It is considered that the hazardous substances mercury, toluene and naphthalene are representative of the general behaviour of substances in the categories heavy metals, light aromatic hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) respectively. Based on the available groundwater quality monitoring data mercury is typically recorded as below the analytical detection limit on which basis it is assumed that mercury is not present in groundwater at the site.

4.4 The selected non-hazardous pollutants comprise the metal zinc, together with sulphate and chloride. Chloride is selected for its conservative behaviour in groundwater as it does not sorb readily to aquifer materials, does not undergo biodegradation and forms common mineral compounds which are very soluble in natural waters. Sulphate is a non-hazardous substance which is ubiquitous in geological materials and natural waters. Zinc was selected as it is a non-hazardous metal which has the potential to be present in a rogue load in respect of the waste types specified in Table ESSD 1. The substances which comprise the source term in respect of the modelled rogue load together with the source concentrations are presented in Table HRA 1.

4.5 The use of inert waste acceptance criteria (WAC) limits as a basis for specifying a source term in respect of an activity which involves placing of inert waste in the ground is a standard risk assessment approach adopted in a range of hydrogeological settings where site specific information is not available. Although as described above procedures will be in place including robust waste acceptance procedures during deposition of waste at the site so that the quality of the restoration materials meets the necessary minimum standards for use at the site it is assumed generally that the source term for the rogue load assessment will comprise material in which the concentrations of the substances that will be modelled exceed significantly inert WAC limits where such are specified.

4.6 For the purpose of the rogue load assessment it is assumed conservatively that non-conforming loads with the hazardous substance mercury and the non-hazardous pollutants chloride, sulphate and zinc potentially could be accepted at the site at concentrations which exceed significantly the liquid to solid ratio 10 l/kg leaching limit values expressed in mg/l and the maximum concentration comprises three times the liquid to solid ratio 10 l/kg leaching limit values presented in the EU Commission document for inert WAC (reference 1) notwithstanding the waste acceptance and other procedures that will be in place. As the inert WAC limits for total organic substances are not converted readily to leachate concentrations for individual organic substances representative of the likely leachate concentrations generated by infiltration through the inert waste, leachate source concentrations for toluene and naphthalene are set based on literature values. The source concentrations in respect of the rogue loads for toluene and naphthalene are based conservatively on concentrations of these substances recorded in leachate at landfill sites accepting a range of non-hazardous and hazardous waste (reference 2). It is assumed conservatively that the concentrations of naphthalene and toluene in rogue loads will range between the respective maximum and three times the respective maximum leachate concentrations presented in reference 2. The input parameters relevant to attenuation in the flow path from the location of a rogue load to the down hydraulic gradient edge of attenuation layer are presented in Table HRA 2.

4.7 Consistent with Table HRA 3 it is assumed that the hydraulic conductivity of the imported materials will be approximately 1 x 10^{-7} m/s. The value is consistent with a typical literature value for an upper estimate of the hydraulic conductivity of clay. It is assumed that a rogue load is placed in the waste mass at a distance of 9m from the down hydraulic gradient edge of the waste mass or 10m from the in situ aquifer material taking into account the 1m thickness of the attenuation layer. For the purpose of the ConSim modelling the attenuation layer, which will have a hydraulic conductivity less than $1x10^{-7}$m/s, comprises part of the pathway separating the rogue load from the in situ aquifer material. It is not necessary to model the attenuation as a separate pathway in ConSim as the assumed hydraulic conductivity of the waste mass and the imported waste is consistent. The hydraulic gradient assumed for the sand and gravel aquifer pathway in the vicinity of the site is based on the available groundwater level monitoring data. It is assumed conservatively that the hydraulic gradient across the deposited waste at the site will be double the hydraulic gradient assumed for the sand and gravel aquifer. Infiltration to the waste mass is also taken into account in the ConSim models presented at Appendix HRA A.

4.8 For each of the substances modelled Environmental Assessment Limits (EALs) are proposed. The EALs comprise the concentrations of substances above which it is considered there may be a discernible discharge of hazardous substances to groundwater or pollution of groundwater by non-hazardous pollutants. The EALs for hazardous substances are set at their respective minimum reporting values (MRVs). The EALs for non-hazardous pollutants are set based on background groundwater quality where available and relevant water quality standards. As the background concentrations for chloride and sulphate are typically significantly lower than relevant water quality standards the EALs for these substances are set at concentrations intermediate between the average background concentrations recorded in the receiving groundwater and the relevant water quality standard. The EALs derived are substantially lower than the relevant water quality standards which are relevant at the receptor. For zinc the mean background concentration is slightly lower than the freshwater environmental quality standard (EQS) and the EQS has been exceeded on a number of occasions based on the background groundwater quality data. For zinc the EAL has been set at the EQS. The EALs for the substances modelled are presented in Table HRA 4. Background groundwater quality data used in the derivation of the EALs for chloride, sulphate and zinc is from the period November 2019 to October 2020 and the data are presented at Appendix ESSD J of the ESSD report.

5. Modelling results and conclusions

5.1 As stated above it is considered that there is no significant risk to groundwater quality from the deposition at the site of the waste types specified in the ESSD. The purpose of the quantitative risk assessment is to assess the effects of the possible acceptance at the site of rogue loads. The results of the quantitative rogue load assessment carried out using ConSim are presented in Table HRA 4. Electronic copies of the risk assessment models and results are presented at Appendix HRA B.

5.2 The results for the hazardous substances mercury, naphthalene and toluene show that the modelling peak 50th percentile and 95th percentile concentrations at the down hydraulic gradient edge of the attenuation layer are less than 1 x 10^{-9}mg/l. Based on the waste types that it is proposed will be accepted to the site it is considered highly unlikely that the organic hazardous substances toluene and naphthalene would be recorded in the imported waste and on this basis it is considered that there is a no reasonable basis for monitoring for and specifying compliance limits for toluene and naphthalene.

5.3 The results for the non-hazardous pollutants chloride, sulphate and zinc show that the modelled peak 50th percentile and 95th percentile groundwater concentrations at the non-hazardous pollutant compliance point following immediate dilution in the sand and gravel aquifer slightly increase the concentrations in groundwater when compared with the background concentrations. The concentrations calculated in the compliance point in the aquifer are lower than the relevant EALs.

5.4 It is considered that the assumptions on which the quantitative modelling is based are conservative. The receptor is groundwater in the sand and gravel aquifer external to the site. Whilst immediate dilution is taken into account at the down hydraulic gradient edge of the area of deposition of restoration materials at the down hydraulic gradient edge of the attenuation layer no account is taken of natural attenuation in the aquifer which will occur prior to groundwater reaching discrete down hydraulic gradient receptors such as groundwater abstractions or areas of groundwater discharge to surface watercourses.

5.5 The ConSim modelling is based on the assumption that a single rogue load will be present in discrete flow paths through the imported material. Based on the way that the dilution calculations are constituted and the results of the modelling it is considered unlikely that the presence of more than one rogue load would affect significantly the results of the modelling.

5.6 Based on the results of the assessment it is considered that there is no significant risk of discernible discharges of hazardous substances and that there will be no significant pollution by non-hazardous substances resulting from the acceptance of a rogue load at the site consistent with the modelled source term.

5.7 Based on the results of the risk assessment it is considered that the site will be compliant with The Environmental Permitting (England and Wales) Regulations 2016 with regard to the relevant provisions of the Directive 2006/118/EC of the European Parliament and of the Council on the protection of groundwater against pollution and deterioration (the 2006 Groundwater Directive).

6. Requisite surveillance

6.1 The scheme of operational groundwater quality and surface water monitoring is presented in Table ESSD 2 of the ESSD report. The groundwater and surface water monitoring locations are shown approximately on Figure ESSD 10. The proposed groundwater monitoring locations and determinands for which groundwater quality compliance and assessment limits should be set are presented in Table HRA 5. Consistent with Table HRA 5 interim groundwater quality compliance and assessment limits for groundwater at the down hydraulic gradient boreholes P22 and P41 have been calculated based on the available groundwater quality monitoring data.

6.2 The proposed surface water monitoring locations and determinands for which surface water quality compliance and assessment limits should be set are presented in Table HRA 6. Consistent with Table HRA 6 interim surface water quality compliance and assessment limits for downstream surface water monitoring location SWB have been calculated on based on data from surface water monitoring locations SW2 and SW4 located upstream in the River Great Ouse and Gadsey Brook, respectively. Monitoring is carried out at SW2 and SW4 in accordance with the Environmental Permit Number EPR/BB3207HL for Dairy Farm Landfill Site. It is proposed that revised surface water compliance and assessment limits will be submitted to the Environment Agency within two months of completion of the first year of monitoring the surface water at the site.

7. Conclusions

7.1 The restoration materials will comprise site soils and overburden and imported inert waste. The waste acceptance procedures that will be in place will minimise the risk that unacceptable waste materials are accepted. The waste types that will be accepted at the site comprise a limited range of inert waste types only. Based on the assessment of the waste types water which percolates through the waste mass will not contain discernible concentrations of hazardous substances and the concentrations of non-hazardous substances in groundwater at a relevant compliance point located down hydraulic gradient of the site will not be discernible. It is concluded that based on the waste types that will be accepted and the waste acceptance procedures which will be implemented there is a negligible risk of unacceptable impacts on groundwater or surface water quality and based on the HRA presented in this report it is considered that there is no significant risk from the proposed deposition of inert waste to groundwater quality in the vicinity of the site. Based on the environmental setting and the inert nature of the waste materials that will be deposited active long term site management will not be necessary in order to prevent long term groundwater pollution.

7.2 Waste acceptance procedures will be implemented to minimise the probability that non-inert wastes will be deposited at the site. It is considered that there will be no significant risk to groundwater beneath the site, surface water bodies in the vicinity of the site and groundwater and surface water abstractions in the vicinity of and down hydraulic gradient of the site.

8. References

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7. Kruseman, G. P. and de Ridder, N. A. 1994. Analysis and Evaluation of Pumping Test Data. Second Edition. International Institute for Land Reclamation and Improvement Publication 47.

8. SLR, 2017, Willington Lock Extension Application, Environmental Statement, Volume 1.

9. Environment Agency, 2006, Remedial Targets Methodology,

TABLES

Table HRA 1

Source term concentrations assumed in the ConSim rogue loads assessment model

Determinand	Environmental assessment limit (EAL) (mg/l)	EAL source [a]	Source term concentration (mg/l)	Probability density function
Hazardous substances				
Mercury	0.00001 [h]	MRV	0.001/0.003 [b]	Uniform
Toluene	0.004	MRV	1.287/3.861 [c]	Uniform
Naphthalene	0.00001 [d]	MRV	0.042/0.126 [c]	Uniform
Non-hazardous pollutants				
Zinc	0.014 [e]	EQS	0.4/1.2 [b]	Uniform
Chloride	154.9 [f]	UK DWS and BGC	80/240 [b]	Uniform
Sulphate	212.9 [g]	UK DWS and BGC	100/300 [b]	Uniform

Notes:

MRV Minimum reporting value;
EQS Environmental Quality Standard;
UK DWS UK Drinking Water Standard;
BGC Mean background groundwater concentration based on the available water quality monitoring data presented at Appendix ESSD J for the period November 2019 to October 2020

[a] The MRVs specified are consistent with MRVs specified at https://www.gov.uk/government/publications/values-for-groundwater-risk-assessments/hazardous-substances-to-groundwater-minimum-reporting-values unless stated otherwise.

[b] The minimum concentration comprises the liquid to solid ratio 10 l/kg leaching limit values expressed in mg/l and maximum concentration comprises three times the liquid to solid ratio 10 l/kg leaching limit values expressed in mg/l presented in the EU Commission document for inert WAC (reference 1)

[c] Concentrations are the maximum and three times the maximum concentrations respectively based on the maximum concentrations recorded in 63 leachate samples from a variety of waste types including municipal, mixed MSW and non-hazardous waste types and co-disposal sites (reference 2)

[d] Based on information provided by the Environment Agency National Laboratory Service that a typical MRV for naphthalene in clean groundwater is 0.01µg/l

[e] The EQS for zinc is 10.9µg/l of bioavailable zinc plus the ambient background concentration of the Great Ouse of 3.1µg/l as specified by the Environment Agency in The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 (a total of 14µg/l). Conservatively it is assumed that all the zinc is bioavailable. The mean background groundwater concentration of zinc is 8.4µg/l and the EQS has been exceeded on 12 out of 96 occasions. As the mean background concentration is close to the EQS the EAL is set at the EQS.

[f] The EAL is calculated as the midpoint between the mean background groundwater concentration of chloride at the site of 59.7mg/l and the UK DWS for chloride 250mg/l.

[g] The EAL is calculated as the midpoint between the mean background groundwater concentration of sulphate at the site of 175.8mg/l and the UK DWS for sulphate of 250mg/l.

[h] The MRV in respect of mercury is 0.00001mg/l. It is assumed that mercury is not present in groundwater at the site.

Table HRA 2

Input parameters used in the ConSim model relevant to attenuation in the flow path from the location of the rogue load to the down hydraulic gradient edge of the attenuation layer

Determinand	K_{oc} (ml/g) [1,2]			K_d (ml/g) [1]			Half-life (years) [1,3]	
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Maximum
Hazardous substances								
Mercury					3835.4			
Toluene	131		242				0.054	0.822
Naphthalene		1288					0.274	2.740
Non-hazardous pollutants								
Zinc					26			
Chloride					0			
Sulphate					0			

1 Parameters derived from ConSim suggested input parameters. Conservatively a K_d of zero is used for sulphate even though sulphate frequently undergoes chemical reactions during migration in the subsurface.
2 For organic substances K_{oc} values are used to calculate K_d.
3 For substances which biodegrade.

Table HRA 3

Physical input parameters used in the ConSim model

Parameter		Units	Minimum	Most likely	Maximum	Probability density function	Reference/Justification
Source parameters							
Size	Width	m		2.93		Single	Each individual rogue load is assumed to comprise a volume of 30m^3. Assuming that the thickness of the imported materials is approximately 3.5m the width and length of each individual rogue load is assumed as 2.93m.
	Length			2.93		Single	
Parameters relevant to contaminant migration in the waste mass							
Infiltration		mm/year		Mean: 66.0 Standard deviation: 6.00		Normal	Rainfall runoff and infiltration calculations have been undertaken consistent with a methodology developed by Thornthwaite and Mather (reference 3) and described in detail in Koerner and Daniel (reference 4) which take into account that the amount of runoff and infiltration will vary depending on the time of year. Runoff rates are calculated using a method published by the National Coal Board (reference 5) which takes into account slope gradient, vegetation type and soil type variations. Ground slope is a key determinant of runoff rate. The water balance approach is based on long term mean meteorological conditions published for the England South East and Central South area by the Met Office. The calculations are presented at Appendix HRA B. It is assumed that the standard deviation is 10% of the infiltration.
Waste porosity		Fraction		0.3		Single	The porosity assumed for inert waste in Hjelmar et al, 2001 (reference 6)
Waste dry density		kg/l		1.4		Single	Calculated assuming a waste bulk density of 1.7kg/l. It is assumed that the waste is fully saturated with a porosity of 0.3.
Effective porosity		Fraction		0.3		Single	The porosity assumed for inert waste in Hjelmar et al, 2001 (reference 6). It is assumed that the waste is fully saturated.
Hydraulic conductivity		m/s		1×10^{-7}		Single	It is assumed that the hydraulic conductivity of the waste mass is 1×10^{-7} m/s based on the upper estimate of the hydraulic conductivity of clay reported by Kruseman and de Ridder 1994 (reference 7).
Longitudinal dispersivity		m		1		Single	The length of the pathway is 10m. Consistent with the comments in the ConSim manual it is assumed that the longitudinal dispersivity is 10% of the pathway length. It is assumed that the transverse dispersivity is 30% of the longitudinal dispersivity.
Transverse dispersivity		m		0.3		Single	
Fraction of organic carbon (f_{oc})		Fraction	0.01		0.1	Uniform	Based on the range of values presented for clay in the ConSim Help file.
Thickness of the imported materials		m		3.5		Single	Approximate based on Figure ESSD 11 (drawing reference BRE/WL/02-20/21637).
Hydraulic gradient				5.2×10^{-3}			To account for the possibility that the hydraulic gradient in the waste mass will be greater than in the aquifer conservatively a hydraulic gradient of twice that in the aquifer has been used.
Travel distance to the edge of the imported materials (including the attenuation layer thickness)		m		10		Single	Conservatively it is assumed that rogue loads are placed in the waste mass at a distance of 10m only from the down hydraulic gradient edge of the attenuation layer.
Sand and gravel aquifer parameters							
Hydraulic gradient				2.6×10^{-3}		Single	The hydraulic gradient is calculated based on the indicative groundwater contours for January 2020 shown on Figure ESSD 13 (drawing reference BRE/WL/02-20/21621)
Hydraulic conductivity		m/s		3.65×10^{-5}		Single	Mean of the range of values reported for the River Terrace Deposits and Alluvium in the boreholes at the site (reference 8).

Table HRA 4
Results of the ConSim rogue loads assessment

Determinand	Background concentration (mg/l)	Maximum concentration (mg/l)				Environmental assessment limit (EAL) (mg/l)
		Concentration predicted at the edge of the attenuation layer using the ConSim model output		Concentration predicted in the sand and gravel aquifer [1]		
		50th percentile	95th percentile	50th percentile	95th percentile	
Toluene	NA	-	-	-	-	0.004
Naphthalene	NA	-	-	-	-	0.00001
Mercury	NA	-	-	-	-	0.00001
Chloride	59.7	128	159.6	60.1	60.2	154.9
Zinc	0.0084	0.349	0.509	0.0103	0.0111	0.014
Sulphate	175.8	263.5	301.1	176.3	176.5	212.9

Notes:
Probabilistic results from the risk assessment model are given as the 50th percentile which presents a 'most likely' assessment and the 95th percentile which represents a 'realistic worst case' assessment.
- Maximum concentration does not exceed 1 x 10^{-9} mg/l.
[1] The calculated groundwater concentration immediately down hydraulic gradient of the imported materials after allowing for immediate dilution in the groundwater.
NA No background groundwater quality data available.

Table HRA 5

Interim groundwater quality compliance and assessment limits

Criterion Objective To confirm that the deposition of inert waste at the site has no adverse effect on groundwater quality	
Measurement	Ammoniacal nitrogen, chloride, sulphate, lead and zinc
Frequency	Quarterly. To be reviewed annually. Compliance limits and control levels will be reviewed one year after the installation of the proposed additional groundwater monitoring boreholes.
Monitoring points	Groundwater monitoring borehole P22 and P41 located down hydraulic gradient of the site.
Compliance limits[1] for down hydraulic gradient groundwater monitoring boreholes	**Borehole P22** The concentration of ammoniacal nitrogen shall not exceed 0.040mg/l. The concentration of chloride shall not exceed 88.7mg/l. The concentration of sulphate shall not exceed 267.5mg/l. The concentration of lead shall not exceed 0.003mg/l. The concentration of zinc shall not exceed 0.0195mg/l. **Borehole P41** The concentration of ammoniacal nitrogen shall not exceed 0.040mg/l. The concentration of chloride shall not exceed 116.3mg/l. The concentration of sulphate shall not exceed 673.6mg/l. The concentration of lead shall not exceed 0.003mg/l. The concentration of zinc shall not exceed 0.172mg/l.
Assessment limits[2] for down hydraulic gradient groundwater monitoring boreholes	**Borehole P22** The concentration of ammoniacal nitrogen shall not exceed 0.031mg/l. The concentration of chloride shall not exceed 78.2mg/l. The concentration of sulphate shall not exceed 223.3mg/l. The concentration of lead shall not exceed 0.001mg/l. The concentration of zinc shall not exceed 0.0149mg/l. **Borehole P41** The concentration of ammoniacal nitrogen shall not exceed 0.031mg/l. The concentration of chloride shall not exceed 99.6mg/l. The concentration of sulphate shall not exceed 516.1mg/l. The concentration of lead shall not exceed 0.001mg/l. The concentration of zinc shall not exceed 0.12mg/l.
Assessment test	Concentrations exceed the assessment limit on three consecutive occasions.

Contingency action	**Response Time**
Advise the Environment Agency.	1 month
Increase the survey frequency to monthly.	1 month
Undertake investigation work to identify the source of the contaminants.	6 months

Report to the Environment Agency on the re-appraisal of risks and options for corrective measures.	12 months
If the risks are acceptable re-evaluate the assessment criteria. If the risks are unacceptable implement agreed corrective measures.	18 months 18 months

Notes:
[1] The compliance limits generally are set at the mean concentration recorded plus three standard deviations.
[2] The assessment limits generally are set at the mean concentration recorded plus two standard deviations.

Assessment and compliance limits for ammoniacal nitrogen at boreholes P22 and P41 have been calculated based on concentrations recorded in boreholes P11, P22, P41 and P45 between November 2019 and December 2020. As the variation in chloride and sulphate concentrations recorded in borehole P41 between November 2019 and December 2020 generally is greater than in the other boreholes the assessment and compliance limits for chloride and sulphate at borehole P41 have been calculated based on the concentrations recorded in borehole P41 only. Assessment and compliance limits for chloride at borehole P22 have been calculated based on concentrations recorded in boreholes P11, P22 and P45 between November 2019 and December 2020. As the variation in sulphate concentrations is slightly greater in borehole P22 than boreholes P11 and P45 assessment and compliance limits for sulphate at borehole P22 have been calculated based on concentrations recorded in borehole P22 only between November 2019 and December 2020. As lead was recorded above detection on three occasions only in boreholes P11, P22, P41 and P45 the assessment limit and compliance limits provisionally are set at the detection limit and the maximum concentration recorded respectively. Assessment and compliance limits for zinc at borehole P22 have been calculated based on concentrations recorded in borehole P22 only between November 2019 and December 2020 due to lower concentrations recorded in borehole P22 compared to boreholes P11, P41 and P45. Assessment and compliance limits for zinc at borehole P41 have been calculated based on concentrations recorded in boreholes P11, P41 and P45.

Table HRA 6

Interim surface water quality compliance and assessment limits

Criterion Objective To confirm that the deposition of inert waste at the site has no adverse effect on surface water quality	
Measurement	Ammoniacal nitrogen, chloride, sulphate, lead and zinc
Frequency	Monthly for a year (until 12 data sets have been collected) then reduced to quarterly. To be reviewed annually. Compliance limits and assessment limits will be reviewed within two months of the completion of the first year of monitoring the surface water quality at the site.
Monitoring points	Surface water monitoring location SWB located downstream of the site.
Compliance limits[1] for downstream monitoring locations	**SWB** The concentration of ammoniacal nitrogen shall not exceed 1.39mg/l. The concentration of chloride shall not exceed 150mg/l. The concentration of sulphate shall not exceed 166mg/l. The concentration of lead shall not exceed 0.001mg/l. The concentration of zinc shall not exceed 0.019mg/l.
Assessment limits[2] for downstream monitoring locations	**SWB** The concentration of ammoniacal nitrogen shall not exceed 0.98mg/l. The concentration of chloride shall not exceed 121mg/l. The concentration of sulphate shall not exceed 148mg/l. The concentration of lead shall not exceed 0.001mg/l. The concentration of zinc shall not exceed 0.014mg/l.
Assessment test	Concentrations exceed the assessment limit on three consecutive occasions.

Contingency action	**Response Time**
Advise the Environment Agency.	1 month
Increase the survey frequency to monthly.	1 month
Undertake investigation work to identify the source of the contaminants.	6 months
Report to the Environment Agency on the re-appraisal of risks and options for corrective measures.	12 months
If the risks are acceptable re-evaluate the assessment criteria. If the risks are unacceptable implement agreed corrective measures.	18 months 18 months

Notes:

[1] The compliance limits generally are set at the mean concentration recorded plus three standard deviations.

[2] The assessment limits generally are set at the mean concentration recorded plus two standard deviations.

Assessment and compliance limits for ammoniacal nitrogen, chloride and zinc at surface water monitoring location SWB have been calculated based on concentrations recorded at surface water monitoring locations SW2 and SW4 located upstream of the site in the River Great Ouse and Gadsey Brook, respectively between February 2014 and October 2020. As lead was not recorded above the detection limit at SW2 or SW4 the assessment limit and compliance limits provisionally are set at the detection limit. Assessment and compliance limits for sulphate have been calculated based on concentrations recorded at surface water monitoring location SW2 only between February 2014 and October 2020 as the sulphate concentrations recorded at SW4 were greater than those recorded at SW2.

APPENDICES

APPENDIX HRA A

CONSIM MODEL FOR THE SITE

APPENDIX HRA B

SPREADSHEET MODEL FOR INFILTRATION RATES FOR THE SITE

Source: https://www.metoffice.gov.uk/pub/data/weather/uk/climate/datasets/Rainfall/date/Midlands.txt

Midlands Rainfall (mm)
Areal series, starting from 1910
Allowances have been made for topographic, coastal and urban effects where relationships are found to exist.
Seasons: Winter=Dec-Feb, Spring=Mar-May, Summer=June-Aug, Autumn=Sept-Nov. (Winter: Year refers to Jan/Feb).
Values are ranked and displayed to 1 dp. Where values are equal, rankings are based in order of year descending.

Data are provisional from January 2018 and Winter 2018. Last updated 13/11/2020.

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	WIN	SPR	SUM	AUT	ANN	
1910	72.4	84.1	19.8	61.6	56	64.7	69.9	106.1	14.3	77.2	110.5	129.1	278	137.4	240.7	202	865.7	
1911	27.8	52.8	45.7	33	34.8	60.4	9.7	50.7	50.3	65.1	81.8	142.4	209.7	113.6	120.8	197.1	654.4	
1912	106.5	46.6	102.8	7.7	67.5	117.2	104.4	165	32.9	80.8	58.8	93.3	295.4	178	386.6	172.5	983.5	
1913	102.6	29.4	107.9	90.5	60.2	29.4	28	36.1	55.4	93	72.9	38.3	225.4	258.6	93.5	221.3	743.7	
1914	37.3	58.2	82.6	28.9	41.7	63.4	91.5	50.7	35	57	93.6	162.7	133.8	153.3	205.6	185.6	802.7	
1915	90.4	101.1	28.9	30.4	58.6	30.9	134.7	74	27.9	58.2	63.1	148.6	354.1	117.8	239.7	149.2	846.8	
1916	41.5	116.4	107.4	38.5	65.4	50.7	49.8	73.7	37.3	109	84.5	71.6	306.5	211.3	174.3	230.8	845.9	
1917	56.3	25.9	57.5	43.8	67.3	61.2	50.3	146	44.9	104.8	44.2	33.4	153.8	168.6	257.5	193.8	735.4	
1918	66	55.4	33.1	54.8	60	24.6	89	48.8	163.6	46.5	50.8	98.4	154.7	147.8	162.3	260.9	790.8	
1919	100.9	63.2	119.2	51.5	28.5	29.1	71.7	68.7	48.3	64.2	50.2	114.4	262.5	199.2	169.5	162.7	809.9	
1920	88.6	45.8	70.1	119	69.1	67.5	123.5	34.1	54.5	60	32.4	70.9	248.8	258.2	225.1	147	835.6	
1921	85.6	7.6	43	31.7	41.5	11.4	18.3	93.7	32.2	51.1	53.2	68.3	164.1	116.2	123.4	136.5	537.7	
1922	94.3	82.2	58.1	75	28.6	30.3	113.8	117.9	67.2	20.6	36.6	100.9	244.7	161.8	261.9	124.4	825.4	
1923	49.2	134.7	45.6	63.1	61.3	16.1	87.3	74.1	73.5	103.5	68.8	81.5	284.7	170	177.5	245.8	858.7	
1924	74.2	19.8	29.9	67	127.2	57.6	96.9	83.4	93.1	110.5	60.2	93.2	175.5	224.1	237.8	263.8	912.9	
1925	61.8	98.5	23.8	56.9	95.3	2.2	63.1	69.9	89.2	93.1	51.6	73	253.4	176	135.1	233.9	778.2	
1926	90	65	21.7	57.9	77.8	59	60.9	62.1	41	72.5	134.9	21.4	228	157.5	182	248.4	764.2	
1927	72.2	63.5	70.9	53.4	33.7	96.9	82.3	117.5	122.1	62	84.4	65.3	157.1	158	296.6	268.5	924.1	
1928	137	69.4	61.1	31.6	30.1	87	42	78.9	21.3	122	98.6	60.6	271.7	122.8	208	241.9	839.7	
1929	39.2	18.2	6.9	28.4	48.4	37.9	52.5	56.8	24.2	103.1	169.5	156.3	118	83.7	147.2	296.8	741.4	
1930	118.4	17.3	64.5	74	56.1	39.5	115.4	84.3	99.2	78	96	80.5	292	194.6	239.2	273.2	923.3	
1931	57.1	72	8.2	95	87.4	99.9	95.4	117.6	75.4	24.3	108.9	33.6	209.6	190.5	312.9	208.5	874.6	
1932	69.3	7.6	50.4	82.7	146.1	24.9	92	53.4	74.2	114.5	52.8	30.9	110.5	279.3	170.3	241.4	798.9	
1933	55.3	92	67.7	28.9	48.3	54.2	53.3	21.2	43.3	99.3	38.2	12.8	178.2	144.9	128.6	180.8	614.4	
1934	66.2	11.1	57.6	63.3	33.9	33	42.7	58.1	55.2	57.7	51.5	133.9	90.1	154.8	133.9	164.5	664.4	
1935	31.2	80.2	20.5	91.5	25.4	87.2	18.8	45.5	120.2	114.7	132.7	86.8	245.2	137.4	151.6	367.7	854.8	
1936	99.9	61.5	53	48	26.4	97.4	129.4	26.6	84.5	54.4	80.2	72.9	248.2	127.3	253.4	219	834.1	
1937	99.1	114.8	73.1	69.7	72.2	33.6	68.8	27.8	48.3	73.6	41.9	69.9	286.8	215	130.2	163.8	792.7	
1938	90	25.6	11.4	4.3	59.9	48.8	79.2	83.5	53.6	104.2	91.8	97.7	185.5	75.6	211.5	249.7	750.1	
1939	142.4	43.8	48.6	55.9	31.8	52.1	127.8	66.5	26.6	92.8	120.1	50	283.9	136.2	246.4	239.5	858.3	
1940	70.9	65.3	56.9	64.7	42.9	22	90.3	11.7	38	99.5	168.5	54.5	186.2	164.5	124	306	785.3	
1941	85.3	78.2	80.8	40	59.1	35	85.7	102.8	15.9	74.9	77	38.6	218.1	180	223.4	167.8	773.4	
1942	85.9	26.8	54	35.8	91.9	16.2	58.8	79.2	43.3	76.2	39	77.4	151.3	181.8	154.3	158.5	684.6	
1943	125.7	37.6	25.6	31.6	75.9	54.5	36.6	64.7	70.6	61.2	53.2	35.2	240.7	133.2	155.9	185	672.6	
1944	76.8	39.5	10.1	54.1	35.6	57.3	63.8	73.2	95.9	93	121.2	55.8	151.5	99.9	194.3	310.1	776.4	
1945	60.8	64.7	25.4	38.2	71.6	75.2	54.8	67.1	47.8	105.3	10.9	77.4	181.2	135.2	197.1	164.1	699.1	
1946	71.2	81.7	27.3	43.1	63.1	72.3	60.2	133.9	108.2	27.8	145.3	74.2	230.3	133.5	266.3	281.3	908.3	
1947	61.2	48.2	148	67.6	57.4	50.6	66.9	13.2	42.2	13.4	63.1	64.7	183.6	273	130.7	118.7	696.4	
1948	147.3	41.1	30.6	48.7	65.7	78.9	35.9	104.2	66.5	64	42.3	96.3	253.1	145.1	219.1	172.7	821.7	
1949	37.3	33.2	39.9	63.9	62.5	15.7	61.2	45	39.4	126.8	90.9	68.1	166.9	166.3	121.8	257.1	684	
1950	27.6	127.4	34	65.2	51	43.1	79.2	100	101.6	31.7	115.9	47	223.2	150.2	222.3	249.2	823.8	
1951	73.7	87.5	102.7	59.7	85	30.2	38.9	118.7	60.3	26.5	169.5	79.4	208.2	247.4	187.7	256.3	932.1	
1952	68.2	18.6	59.1	53.8	67.4	52.2	28.2	90.1	58.2	99.2	64.8	70.4	166.2	180.4	170.4	222.2	730.2	
1953	25.5	46	30.4	65.9	51.4	61.5	82.8	78.1	61.5	58.5	51.3	31	141.9	147.7	222.5	171.2	643.9	
1954	48.5	68.4	61.5	12.5	74.9	81.9	73.7	119.7	71.9	104	148.3	79	147.9	148.9	275.2	324.3	944.3	
1955	64.6	49.9	62.8	30	105.1	80.2	20.5	18.8	40.3	48.5	58.7	77.9	193.5	197.8	119.5	147.4	657.1	
1956	105.8	20	27.1	44.2	19	68.6	93.3	142.2	72.6	45.7	25.1	86.8	203.8	90.3	304.1	143.4	750.5	
1957	51.8	73.4	57.9	7.3	38.3	43.9	98.8	108.1	122.8	53.7	54.4	68.7	211.9	103.5	250.9	230.9	779.1	
1958	74.8	110.4	41.4	21	70.4	111.3	103.8	76.8	102.9	70.2	48.1	85.7	253.9	132.8	291.9	221.2	916.7	
1959	92.6	6.3	56.5	79.3	26.3	37.3	51.8	28.8	4	67.1	89.9	133.7	184.6	162.1	117.9	160.9	673.5	
1960	127.8	64.5	42.8	33.9	39	56.7	98.7	100.5	108.1	147.7	119.4	91.1	326	115.7	255.8	375.2	1030	
1961	88	58.2	11.1	98.2	31.4	34.8	64.5	69.7	60.9	81.5	47.3	88	237.2	140.7	169.1	189.7	733.6	
1962	84.1	31.4	32.4	67.3	59.2	13.6	50.9	110	89.9	26.4	50.3	56	203.5	158.8	174.4	166.6	671.3	
1963	27.2	21.2	82	63.8	42	79.4	47.3	79.6	62.2	48.9	128.2	19.7	104.4	187.8	206.2	239.3	701.5	
1964	23.2	26	87.6	54.6	48.9	69.6	50.5	43.6	24.1	42.4	39.9	80	68.9	191.1	163.7	106.4	590.4	
1965	80	14.9	67.4	54	54.6	66.1	92.1	54.2	134.6	25.7	86.6	150.3	174.9	176.1	212.4	247	880.6	
1966	43.2	112.5	33.8	96.5	67	74.2	68.5	98.5	45.4	106.3	69.6	94.8	306	197.2	241.1	221.3	910.2	
1967	44.3	76	49.1	35.6	138.8	33.3	48	68.2	81.8	143.3	56.4	64.5	215.2	223.5	149.4	281.5	839.3	
1968	71	36.3	48.6	63.2	78.9	76.4	110.5	57.9	128.3	71.5	69.3	59.2	171.8	190.7	244.9	269.1	871.1	
1969	74.7	64.9	68.5	56.5	125.2	45.3	58.2	76	34.7	14.4	103.9	71	198.9	250.2	179.6	153.1	793.6	
1970	87.3	72.6	57.9	81.5	21.5	44.5	60.2	85.7	47.6	44.1	147.5	36.9	230.9	160.9	190.4	239.2	787.4	
1971	91.1	29	56.8	56.3	45.3	85.8	41.6	108.7	24.9	70.4	72.9	33.9	157	158.4	236.1	168.1	716.6	
1972	86.1	64.2	73.2	54.1	68.1	67.7	55	35.8	44.7	30.9	75.8	94.2	184.2	195.5	158.5	151.5	750	
1973	37	36.4	21	65.3	75.4	67.6	99.3	49.9	59	46.9	42.7	52	167.5	161.7	216.7	148.6	652.4	
1974	96.4	83	39.5	10.2	33.6	61.8	69.8	81.8	113.9	71.9	95.6	56.7	231.5	83.2	213.3	281.4	814.1	
1975	87	27.6	72.9	59.5	36.3	15.4	61.5	43.5	72.3	27.6	48.6	45	171.3	168.7	120.4	148.6	597.3	
1976	53.1	34.3	38.8	16.3	64.3	17.4	25.6	31.2	144.2	122.2	50.5	80.8	132.4	119.4	74.1	316.9	678.5	
1977	83.2	141.5	58.8	49.1	45	95.9	16.7	92.4	30.1	48.5	86.5	77.1	305.4	152.9	205	165	824.7	
1978	91.4	57.4	62.6	42.8	38.8	61.1	76.7	61.9	52.2	14.2	45.6	149.2	225.9	144.2	199.7	112.1	753.9	
1979	68.2	54.2	110	64.4	115.3	29.8	26.1	82.2	32.7	58	71.1	138.5	271.6	289.7	138.1	161.8	850.5	
1980	67.1	83.2	89.5	15.6	29.4	111.8	60.5	91.4	61.3	110.6	72.4	57.9	288.8	134.6	263.7	244.3	850.8	
1981	52.7	53.2	130.5	63.7	81.1	38.1	35.7	54	127.7	90.8	54.6	78.4	163.8	275.3	127.7	273.1	860.5	
1982	60.6	33.4	94.2	24.7	32.6	134	28.5	83.3	71.2	73.6	96.5	76.6	172.5	151.6	245.8	241.3	809.2	
1983	80	30.3	55.3	107.7	111.6	21.9	44	27.4	89.3	64.8	42.6	94.9	186.8	274.6	93.3	196.6	769.6	
1984	114.2	51.8	55.6	8.7	58.7	44.8	18.3	62.3	104.3	74.4	127.1	54.4	260.9	123.1	125.5	305.7	774.7	
1985	55.6	28.5	50.1	61.5	72.3	95.4	62.2	85.9	28.9	46.4	66.3	101.7	138.6	183.8	243.5	141.6	754.8	
1986	108.1	16.7	65.6	82.8	79.7	37.3	42.9	115.4	17	77.4	95	113.2	226.4	228.2	195.5	189.4	851	
1987	24.1	45.2	76	61.1	41.2	112.5	56.4	60.7	54.2	134.1	64.5	44	182.5	178.2	229.7	252.7	774	
1988	124.1	53.6	87.4	34.9	52	45.9	120.6	71.5	47.3	68.5	39.2	36.2	221.7	174.2	238	155	781.2	
1989	34	67.6	67.9	91.5	25.4	55.1	42.8	45.7	35.9	82.9	50.4	127.8	137.8	184.8	143.5	169.1	726.8	
1990	107.2	112.6	20.3	32	17.7	60.9	28.6	37.8	42.8	91.2	47.5	85.6	347.7	69.9	127.4	181.5	684.3	
1991	75.9	49	59.7	63	11.4	80.5	71.8	21.2	55.6	54.2	77	42.3	210.5	134.1	173.5	186.8	661.6	
1992	58.9	33.5	69.2	56.1	59	45.8	87.6	119.3	83.3	74.5	114.4	64	134.7	184.2	252.7	272.2	865.6	
1993	87.4	9.9	17.3	83.3	77.3	64.7	77.8	44.7	101.4	75.5	60.8	132.7	161.3	177.9	187.3	237.7	832.9	
1994	95.8	67.7	72.4	57.1	56.6	25.4	42.2	55.8	113.7	70.8	75.8	109.5	296.3	186.1	123.5	260.3	843	
1995	131.2	87.8	54.2	21.4	47.7	14.9	30.1	8.3	97.6	38.2	65.2	77.2	328.5	123.2	53.3	201.1	673.8	
1996	45.2	67.1	38.8	48.1	44.3	29.7	37.1	68.9	23.1	65.5	95.4	55.3	189.5	131.2	135.7	184	618.4	
1997	12.2	89.6	24	27.4	75.7	119.6	47	86.1	28.2	59.2	88.2	76.4	157.1	127.1	252.6	175.6	733.6	
1998	95.4	17.6	84.4	117.1	23.9	119	40	46.6	81.8	140.6	60.6	70.6	189.5	225.4	205.6	283.1	897.6	
1999	114.8	43	67.9	70.2	62.6	76.3	21.9	99.6	104.5	79	47.7	117.5	228.4	200.8	197.8	231.3	905.1	
2000	37.6	78.1	32.5	137.9	73.2	42.3	55.1	56.4	115.3	145.1	144	116.7	233.2	243.6	153.8	404.5	1034.2	
2001	51.3	81.6	71.5	94	53.7	37.2	69.2	75.2	66.9	116	45.8	32.7	249.6	219.2	181.6	228.7	795	
2002	66.3	116.8	37.6	45.4	74.7	46.4	93.9	63.2	30.4	126.4	115.3	110.2	215.8	157.7	203.5	272.2	926.7	
2003	64.6	28.3	32.8	41.3	65.5	67.2	64.5	16.1	29.1	47.8	69.8	85.6	203.2	139.7	147.8	146.6	612.6	
2004	98	40.6	41.2	87.2	43	51.8	60.5	155.6	51.3	121.3	46.5	44	224.2	171.4	268	219.1	841.1	
2005	42.4	44.5	47.6	61.8	38.1	54.4	61.7	53.4	62.7	95.8	65.5	55.9	130.9	147.5	169.6	224.1	684	
2006	22.3	41.7	77.7	43.6	104.4	16.5	50.7	85.3	75.7	95.3	82.8	100.9	119.9	225.7	152.5	253.8	796.9	
2007	91.9	85	55.3	8.7	112.5	167	144.5	40.7	38.5	41.4	64.4	78	277.8	176.6	352.2	144.3	928.1	
2008	127	36.8	84.4	62.9	59.7	52.9	98.3	102.8	103.9	78.6	76.4	54.8	241.9	207	254.1	258.9	938.6	
2009	66.2	40.6	32.3	40.5	57	68.9	127.5	53.5	23.7	57.3	141	74	161.6	129.8	250	222	782.5	
2010	61.2	56.1	50.2	24.9	31.6	40.6	53.4	98.4	67.5	65	71.3	27.6	191.3	106.7	192.5	203.7	647.7	
2011	56.8	72.5	12	7.9	54	55.8	48.5	57.1	41.5	52.8	42.9	93.4	156.8	73.9	161.5	137.2	595.3	
2012	62.8	29	22.9	140.5	51.7	152.2	112.9	88.1	87.6	86.9	113.2	137.8	185.2	215.1	353.2	287.7	1085.5	
2013	64.2	45.5	65.2	21.9	78.7	36.3	67.4	53	44.9	133.1	58.8	89.7	247.4	165.8	156.6	236.8	758.6	
2014	148.6	108.8	47.4	46.1	102.9	51.7	48.7	102.6	13.7	85	92.8	72.8	347.1	196.4	202.9	191.5	921	
2015	75.4	41	52.4	23.3	79.3	37.6	65.9	80.3	41.7	57.2	107.5	120.8	189.1	155.1	183.8	206.4	782.4	
2016	98.7	69.9	82.6	62.1	54.7	100.8	35.1	64.7	58.7	28.3	96	33.9	289.4	199.4	200.6	183.1	785.6	
2017	59	55.9	66.7	16.3	55.9	66.2	79.9	68.1	84.6	46.3	55	87.8	148.8	138.9	214.2	185.9	741.8	
2018	82.6	37	105	79.3	55.7	11.5	30.8	55.5	61.2	54.2	62.6	92.8	207.4	240	97.8	178	728.1	
2019	32.3	38.5	83.4	36.1	42.6	122.4	78	77.7	105.9	125.1	122.9	86.2	163.5	162.1	278.1	353.8	950.9	Standard deviation
Mean	74.32909	56.21364	55.62545	53.61182	59.38818	57.87	65.56182	72.12636	63.98273	74.44364	77.95909	78.59182					788.2248	Mean
																	121%	Standard deviation as % of mean

Source: https://www.metoffice.gov.uk/pub/data/weather/uk/climate/datasets/Tmean/date/Midlands.txt

Midlands Mean Temperature (Degrees C)
Areal series, starting from 1910
Allowances have been made for topographic, coastal and urban effects where relationships are found to exist.
Seasons: Winter=Dec-Feb, Spring=Mar-May, Summer=June-Aug, Autumn=Sept-Nov. (Winter: Year refers to Jan/Feb).
Monthly values are ranked and displayed to 1 dp and seasonal/annual values to 2 dp. Where values are equal, rankings are based in order of year descending.
Data are provisional from January 2018 and Winter 2018. Last updated 05/11/2019.

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	WIN	SPR	SUM	AUT	ANN
1910	2.8	4.4	5.4	6.7	10.7	14.3	13.8	14.7	12.1	10.1	2.6	5.7	3.42	7.61	14.27	8.28	8.64
1911	3.1	4.2	4.5	7.1	12.3	14	17.7	17.9	13.5	8.8	5.4	5.5	4.34	8.01	16.54	9.21	9.53
1912	2.7	4.6	6.6	8.2	11.4	13.3	15.5	12.4	10.6	7.6	5.6	6	4.22	8.78	13.74	7.95	8.74
1913	3.5	4	5.5	7.4	11	13.7	14.2	14.8	13.6	10.3	7.5	4.3	4.54	7.96	14.25	10.47	9.18
1914	2.9	6.1	5.6	9.2	10	14	15.5	15.6	12.7	9.8	6	3.9	4.39	8.24	15.05	9.53	9.29
1915	3.4	3.5	4.6	7.2	10.3	13.7	14	14.8	12.8	8.4	2.5	4.6	3.62	7.35	14.18	7.89	8.34
1916	6.8	3	2.7	7.7	10.9	11.1	14.8	16	12.4	10	5.9	1.2	4.85	7.1	14.01	9.47	8.58
1917	0.9	0.3	2.5	4.9	12.1	14.4	15.5	15	13.6	7	7.5	1.7	0.84	6.52	14.99	9.32	7.99
1918	3.2	5.8	5.3	6.3	12.3	12.6	15.1	15.7	11.5	8.7	4.7	6.3	3.51	8.01	14.46	8.29	8.99
1919	2.1	0.8	2.9	6.6	12.7	13.7	13.5	15.3	12.2	6.8	2.7	4.8	3.17	7.4	14.2	7.22	7.9
1920	4.5	5.2	6.6	7.6	11.2	13.7	13.6	13.1	12.3	9.8	6.1	3.7	4.83	8.49	13.46	9.37	8.95
1921	6.6	4.1	6.8	7.7	10.8	14	17.9	15	13.6	12.3	3.9	5.8	4.82	8.43	15.65	9.97	9.93
1922	2.9	3.7	4	5	12.3	13.2	13	12.8	11.6	7.7	5.1	5	4.14	7.13	12.99	8.14	8.06
1923	5	4.8	5.9	7	8.7	12	17.1	14.6	11.8	9	2.6	3	4.95	7.21	14.57	7.83	8.49
1924	3.8	2.6	3.4	6.6	11	13.4	14.8	13.5	12.9	9.5	6.4	6.1	3.16	7	13.9	9.59	8.69
1925	4.5	4.5	4.4	6.9	11.1	14.3	16.5	15.1	10.9	9.9	3.1	2.1	5.07	7.48	15.33	7.98	8.65
1926	3.7	6.1	5.8	8.6	9.4	13	16.3	15.8	13.9	7.4	5.2	3.6	3.91	7.94	15.05	8.83	9.09
1927	3.9	3.4	6.7	7.5	10.4	11.8	15	15.1	11.9	9.8	5.4	1.1	3.67	8.2	13.99	9.08	8.55
1928	4.5	5.1	5.5	7.6	10	12.3	15.8	14.8	12.1	9.5	7	2.7	3.54	7.7	14.33	9.53	8.92
1929	1	-0.6	5.8	6.1	10.6	12.6	15.5	14.7	14.9	9	6	5	1.07	7.49	14.28	9.94	8.43
1930	4.9	1.9	4.6	7.6	10	14.6	14.6	15.3	13	9.8	5.6	3.6	4.01	7.41	14.83	9.49	8.85
1931	2.6	3.2	3.4	7.1	10.6	13.9	14.9	13.7	11.2	8.1	7	4.7	3.16	7.01	14.15	8.77	8.38
1932	5.5	2.6	4.1	6.1	9.6	13.3	15.6	16.7	12.5	8.1	6	4.9	4.29	6.58	15.2	8.84	8.76
1933	1.7	3.5	6.7	8.4	11.5	14.8	17.3	17.1	14.5	9.5	5.1	1	3.36	8.87	16.42	9.7	9.29
1934	3.6	3.3	4.3	7.3	10.8	14.4	17.7	14.7	13.9	9.8	5.6	7.2	2.61	7.46	15.6	9.78	9.42
1935	4.1	5.3	6	7.5	9.3	14.5	16.8	16.3	13	8.9	6.1	2.3	5.53	7.6	15.91	9.31	9.19
1936	2.8	1.6	6.3	5.7	10.6	13.9	14.6	15.5	13.9	8.8	4.9	4.6	2.23	7.56	14.67	9.18	8.62
1937	4.4	4.8	2.7	8.4	11.4	13.4	15.5	16.2	12.7	9.6	4.5	2.3	4.58	7.49	15.05	8.96	8.84
1938	5.2	4.4	8.6	6.9	10	13.8	14.5	15.3	13	9.7	8.5	3.6	3.94	8.53	14.52	10.39	9.48
1939	3.5	4.9	5.2	8	10.6	13.4	14.7	15.8	13.6	7.5	7.8	2.6	3.94	7.94	14.65	9.61	8.98
1940	-2.1	1.5	5.5	7.9	11.9	15.8	14.5	15	12.2	9	6.1	3.3	0.65	8.43	15.08	9.09	8.39
1941	-0.3	2.7	4.4	5.9	8.5	14.5	16.9	14.1	13.9	9.8	5.8	4.9	1.88	6.26	15.17	9.83	8.45
1942	0.2	-0.5	4.3	8.5	10.5	14	14.9	15.9	13.1	9.9	4.6	6.1	1.61	7.75	14.9	9.22	8.51
1943	4.2	5.4	6.1	10.1	11.3	13.8	15.8	15.4	12.6	9.9	5.6	3	5.22	9.15	14.99	9.38	9.45
1944	5.3	2.8	4.7	9.5	10.7	12.8	15.8	16.4	11.9	8.7	5.7	3	3.74	8.27	15	8.74	8.95
1945	-0.1	6.6	7.5	9.5	11.5	13.9	16.1	15.2	13.5	11.1	6.6	4.4	3.03	9.5	15.08	10.44	9.67
1946	2.3	5.5	4.6	9.3	9.7	12.4	15.8	14	13.3	9.2	7.5	2.4	4.02	7.87	14.08	10.01	8.85
1947	1.4	-2.6	2.9	8	12.7	15	16.4	17.9	14.4	10.1	6.5	4.6	0.48	7.84	16.46	10.31	9
1948	4.8	4	7.7	8.3	10.6	12.9	15.1	14.4	13.4	9.4	6.6	4.9	4.5	8.89	14.15	9.79	9.37
1949	4.8	5	4.3	9.5	10.5	14.5	16.9	16.3	15.7	11.1	5.9	5.1	4.91	8.09	15.9	10.91	9.99
1950	3.6	4.8	6.9	6.9	10.3	15.6	15.4	15.1	12.4	9.1	5	0.6	4.49	8.08	15.35	8.86	8.83
1951	3.2	3	3.5	6.3	9.2	13.1	15.7	14.3	13.6	8.9	7.7	4.8	2.23	6.32	14.39	10.04	8.64
1952	2.2	2.8	6.1	9	12.6	13.7	16.2	15.5	10.3	8.4	3.5	2.5	3.26	9.24	15.14	7.42	8.59
1953	2.9	3.7	5.1	6.7	12.1	13.5	15	15.6	13.3	9	7.8	6.3	3	7.98	14.71	10.02	9.28
1954	2.3	2	5.2	7	10.6	12.8	13.6	14	12.2	11.4	6.2	6	3.56	7.6	13.48	9.98	8.65
1955	1.9	0.6	2.6	8.9	8.9	13.1	17	17.5	13.7	8.8	6.4	5	2.9	6.78	15.87	9.62	8.73
1956	3	-0.9	5.5	6.1	11.2	12.5	15.3	13	13.6	8.8	5.4	5	2.44	7.6	13.59	9.3	8.24
1957	4.8	4.5	8.5	8.1	9.7	14.6	15.9	14.8	12	10.2	5.7	3.7	4.79	8.8	15.09	9.29	9.41
1958	2.8	4.2	3.1	6.8	10.7	13.2	15.4	15.3	14.4	10.1	5.8	4	3.55	6.88	14.65	10.11	8.84
1959	1	3.8	6.6	8.9	11.9	14.6	16.8	16.8	14.4	11.9	6.2	5.2	2.88	9.15	16.09	10.83	9.88
1960	3.4	3.3	5.6	8.4	12.2	15.6	14.6	14.4	12.5	9.5	6.5	3.4	3.99	8.72	14.85	9.5	9.13
1961	2.9	6.3	7.7	9.3	10.2	13.9	14.5	14.9	14.5	10.1	5.4	1.5	4.12	9.04	14.44	10.02	9.27
1962	3.7	3.9	2.1	7	9.5	13	14.2	13.8	12.1	9.7	4.7	1.1	2.99	6.19	13.7	8.88	7.93
1963	-2.8	-1.6	5.2	7.9	9.9	14.3	14.5	13.6	12.4	10.2	7.3	2	-1.09	7.67	14.11	9.97	7.78
1964	2.5	3.8	3.5	8.1	12.6	13.1	15.4	14.9	13.5	8	6.9	2.6	2.74	8.07	14.52	9.43	8.76
1965	2.8	2.7	4.6	7.6	10.9	13.9	13.4	14.3	11.8	10.2	3.9	3.9	2.69	7.7	13.84	8.63	8.35
1966	2.1	5	5.9	6.5	10.5	14.7	14.3	14.2	13.2	9.5	4.8	4.7	3.62	7.63	14.4	9.17	8.81
1967	3.8	4.7	6.6	7.2	9.6	13.7	16.4	15.2	13	10.2	4.7	3.5	4.41	7.84	15.08	9.33	9.09
1968	3.8	1.3	5.9	7.6	9.2	14.3	14.4	15	13.3	12	5.8	2.4	2.89	7.59	14.57	10.36	8.76
1969	4.9	0.1	2.6	6.9	10.6	13.2	16.4	15.7	13.1	12.2	4.7	2.7	2.56	6.72	15.14	10.04	8.67
1970	3.1	2.4	3.1	6.2	12.4	15.6	14.7	15.4	13.9	10	7.1	3.6	2.76	7.24	15.26	10.34	9
1971	3.8	4	4.6	7.1	10.8	11.8	16.5	15.1	13.7	10.7	5.5	5.9	3.8	7.51	14.49	9.96	9.16
1972	3.2	3.7	5.9	7.8	9.9	11.2	14.9	14.5	11.1	9.8	5.9	4.9	4.29	7.88	13.59	8.94	8.6
1973	3.9	3.9	5.6	6.5	10.8	14.4	15.2	16	13.8	8.5	5.4	4.4	4.25	7.67	15.18	9.22	9.07
1974	5.2	4.9	4.9	7.2	10.3	13.1	14.6	14.5	11.4	7.1	6	7.3	4.83	7.49	14.07	8.17	8.91
1975	6.1	3.7	4.2	7.9	9.2	14	16.8	18.2	12.7	9.3	5.5	4.6	5.79	7.08	16.35	9.16	9.38
1976	5.1	3.9	4.1	7.4	11.3	16.4	17.8	16.8	12.7	9.8	5.3	1.3	4.56	7.61	17.01	9.28	9.35
1977	2	4.3	6.3	6.6	9.8	11.7	15.3	14.7	12.6	10.9	5.7	5.4	2.46	7.55	13.9	9.73	8.79
1978	2.6	1.8	6.2	5.8	10.9	13	14.3	14.5	13.5	11.2	7.7	3.2	3.34	7.64	13.95	10.81	8.77
1979	-0.9	0.5	4	7.2	9.4	13.5	15.7	14.4	12.7	10.5	6.1	5.1	0.91	6.86	14.54	9.78	8.22
1980	1.6	5.1	4.1	8.2	10.4	13.4	14	15.3	14.2	8.3	5.9	5	3.91	7.55	14.25	9.45	8.79
1981	4.1	2.3	7.3	7.1	10.8	12.9	15.2	15.8	14	7.7	7	-0.5	3.86	8.42	14.66	9.55	8.68
1982	2	4.3	5.5	8.1	10.9	15	16	15.3	13.7	9.5	7.2	3.7	1.82	8.18	15.43	10.15	9.28
1983	6	1	5.9	6.2	9.7	13.7	18.9	16.8	13.1	9.8	6.9	5.1	3.67	7.28	16.5	9.94	9.5
1984	3	2.8	4.2	7.5	9.3	14	16.2	17.1	13.2	10.5	7.4	4.6	3.65	7.01	15.81	10.35	9.17
1985	0.3	1.6	4.1	7.8	10.2	11.9	15.7	14.2	14.1	10.5	3.4	5.8	2.18	7.39	13.95	9.36	8.35
1986	2.8	-1.8	4.5	5.3	10.7	14.1	15.4	13.1	10.8	10.2	7.1	5.5	2.38	6.86	14.2	9.37	8.21
1987	0.3	3.2	3.6	9.8	9.5	12.3	15.4	15.2	13.1	9	6	5.1	2.95	7.61	14.33	9.36	8.56
1988	4.7	4.3	5.8	7.6	11.2	13.9	14.3	14.8	12.7	9.9	4.6	6.9	4.72	8.23	14.35	9.08	9.26
1989	5.6	5.4	6.9	5.9	12.5	14.1	17.6	16.1	14.1	11.1	5.8	4.4	5.99	8.47	15.93	10.34	9.99
1990	6	6.9	7.9	7.5	12.1	13.2	16.4	17.8	12.7	11.4	6.3	3.9	5.76	9.17	15.85	10.13	10.21
1991	2.6	1.2	7.4	7.4	10.5	11.6	17	16.6	14.2	9.6	6.1	4.1	2.6	8.45	15.1	9.96	9.07
1992	3	5.1	6.9	8.3	13	15.3	15.8	14.9	12.8	7.1	6.8	3	4.05	9.38	15.36	8.88	9.34
1993	5.2	4.3	6.1	8.9	10.9	14.5	14.8	14	11.8	7.7	4.1	4.8	4.17	8.63	14.42	7.85	8.94
1994	4.6	2.5	7.2	7.7	10	14.1	17.6	15.4	12.1	9.4	9.4	5.8	4.03	8.32	15.72	10.31	9.71
1995	4.1	5.9	4.9	8.5	11.2	13.7	18.2	18.5	13.1	12.4	7.1	1.7	5.23	8.21	16.83	10.85	9.96
1996	3.6	2	3.8	8.1	8.6	13.9	16.1	16.2	13	10.9	5.2	2.4	2.46	6.83	15.41	9.74	8.68
1997	1.9	6.2	7.9	8.5	10.9	13.6	16.3	18.5	13.6	9.5	7.9	5.3	3.39	9.11	16.17	10.33	10.03
1998	4.6	7	7.5	7.3	12.5	13.8	15.1	15.5	14.3	10	5.4	4.9	5.59	9.12	14.81	9.89	9.84
1999	5.1	4.7	6.9	9	12.6	13.4	17.3	15.8	15.2	10.2	7.2	4.1	4.92	9.5	15.51	10.86	10.16
2000	4.5	5.6	7	7.4	11.5	14.7	14.9	16.3	14.3	9.8	6.4	5	4.72	8.67	15.29	10.18	9.8
2001	2.7	4	4.6	7.2	12	13.8	16.7	16.5	12.9	12.9	6.9	3	3.89	7.97	15.71	10.93	9.48
2002	5	6.5	7.1	8.9	11.5	14	15.6	16.7	13.9	9.4	7.9	5.1	4.77	9.16	15.44	10.39	10.15
2003	4.1	3.4	7.1	9.3	11.7	15.7	17.1	17.8	14	8.7	7.6	4.4	4.23	9.36	16.88	10.09	10.11
2004	4.8	5	6.2	9.2	11.8	15.1	15.5	17.2	14.4	10.1	7.2	5.1	4.7	9.08	15.94	10.56	10.15
2005	5.6	3.9	6.8	8.6	11	15.2	16.4	16	14.8	12.6	5.7	4.1	4.9	8.81	15.87	11.07	10.1
2006	3.9	3.4	4.5	8.3	12	15.9	19.5	15.9	16.3	12.4	7.6	6	3.81	8.24	17.1	12.11	10.51
2007	6.6	5.5	6.8	10.9	11.5	14.8	15	15.4	13.6	10.5	6.9	4.5	6.05	9.72	15.08	10.38	10.21
2008	6.2	4.9	5.7	7.6	12.9	13.9	16.1	16.1	13.2	9.4	6.6	3.3	5.21	8.75	15.4	9.71	9.67
2009	2.7	3.8	6.7	9.6	11.7	14.5	15.9	16.4	13.9	11	8.1	2.6	3.23	9.33	15.61	11	9.77
2010	1	2.4	5.8	8.7	10.7	15.1	16.9	15.1	13.5	9.9	4.7	-1	1.99	8.41	15.72	9.39	8.61
2011	3.4	6.1	6.5	11.6	11.9	13.7	15.2	15.4	14.9	12.2	8.9	5.5	2.74	10	14.79	12.01	10.46
2012	5.1	3.7	8	6.9	11.5	13.3	15.3	16.3	12.6	9	6.1	4.2	4.79	8.82	14.98	9.23	9.36
2013	3.1	2.7	2.2	7.2	10.2	13.5	18.2	16.7	13.5	12	5.9	5.9	3.35	6.51	16.18	10.49	9.3
2014	5.1	5.7	7.3	9.8	12	15	17.5	14.8	14.7	11.9	7.9	4.8	5.58	9.72	15.76	11.5	10.58
2015	4	3.7	6.1	9	10.6	13.9	15.6	15.8	12.3	10.6	9	9.3	4.21	8.55	15.1	10.62	10.02
2016	5	4.6	5.3	7.2	12	14.9	16.6	16.8	15.7	10.4	5.4	5.6	6.32	8.2	16.11	10.47	9.98
2017	3.6	5.7	8.3	8.7	12.9	15.8	16.6	15.4	13.3	12	6.5	4.4	4.95	9.96	15.94	10.6	10.29
2018	4.8	2.5	4.4	9.4	13	15.9	19	16.6	13.5	10.2	7.6	6.4	3.96	8.96	17.19	10.45	10.34
2019	3.6	6.4	7.6	8.7	11	14	17.4	17	14	9.6	5.9	5.3	5.44	9.11	16.16	9.82	10.07
Mean	3.412727	3.600909	5.440909	7.738182	10.90545	13.82636	15.76364	15.46364	13.17	9.77	6.030909	4.148182					

Parameter	January	February	March	April	May	June	July	August	September	October	November	December	Total	Comments/justification
Average monthly temperature [^oC]	3.4	3.6	5.4	7.7	10.9	13.8	15.8	15.5	13.2	9.8	6.0	4.1		Mean monthly temperature for the Midlands (Met Office)
Monthly heat index [H_m]	0.6	0.6	1.1	1.9	3.3	4.7	5.7	5.5	4.3	2.8	1.3	0.8	32.55	Koerner and Daniel, 1997. Eqn 4.7.
Unadjusted daily potential evapotranspiration [UPET], mm	0.56	0.59	0.89	1.28	1.81	2.31	2.64	2.59	2.20	1.62	0.99	0.68		Koerner and Daniel, 1997. Eqn 4.8
Possible monthly duration of sunlight [N]	22.2	23.4	30.6	34.5	39.9	40.8	41.1	37.5	31.8	27.6	22.8	21.0		Koerner and Daniel, 1997. Table 4.3, NB: use 50deg poleward of 50deg
Potential evapotranspiration [PET], mm	12.3	13.7	27.4	44.1	72.3	94.2	108.4	97.0	69.9	44.7	22.6	14.2	620.97	PET= UPET x N
Precipitation [P], mm	74.3	56.2	55.6	53.6	59.4	57.9	65.6	72.1	64.0	74.4	78.0	78.6	789.70	Mean monthly rainfall for the Midlands (Met Office)
Runoff coefficient [C]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Runoff [R], mm	38.7	29.2	28.9	27.9	30.9	30.1	34.1	37.5	33.3	38.7	40.5	40.9	410.65	R = P x C
Infiltration [IN], mm	35.7	27.0	26.7	25.7	28.5	27.8	31.5	34.6	30.7	35.7	37.4	37.7	379.06	IN = P - R
IN - PET, mm	23.3	13.2	-0.7	-18.4	-43.8	-66.4	-76.9	-62.4	-39.1	-9.0	14.8	23.5		
Accumulated water loss [WL], mm	0.0	0.0	-0.7	-19.0	-62.9	-129.3	-206.2	-268.6	-307.7	-316.8	-316.8	-316.8		WL = Sum of neg * IN - PETs
Water stored (WS), mm	75.0	75.0	74.3	58.0	40.7	29.7	25.6	31.4	43.4	66.1	75.0	75.0		
Change in water storage [CWS], mm	0.0	0.0	-0.7	-16.3	-17.4	-11.0	-4.1	5.8	12.0	22.7	8.9	0.0		
Actual evapotranspiration [AET], in	12.3	13.7	27.4	42.0	45.9	38.8	35.5	28.8	18.7	13.0	22.6	14.2	313.09	
Percolation [PERC], mm	23.3	13.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	23.5	65.97	
Check [CK], mm	74.3	56.2	55.6	53.6	59.4	57.9	65.6	72.1	64.0	74.4	78.0	78.6	789.70	
Percolation rate [FLUX], m/s	9.0E-09	5.1E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-09	9.1E-09		

		Ground slope:	0.005	Based on an approximate fall of 3.5m across the restored phase over a distance of approximately 760m.
Runoff coefficient (NCB, 1982)	**0.52**	Vegetation type:	**Cultivated**	
		Soil type:	**Clay loam**	
Root zone depth, mm	200.0	Lowest maximum root zone depth specified in Koerner and Daniel, 1997 paragraph 4.4.1.12		
Volumetric water content at field capacity (θ)	0.375	Clay loam (Koerner and Daniel, 1997 table 4.5)		
Maximum water storage capacity, mm	75.0	Start water storage calculation on a month where water stored is known or can be calculated (e.g. after winter when there is no soil moisture deficit		

	Annual	Percentage of precipitation
Precipitation, mm	789.7	100.0
Runoff, mm	410.6	52.0
Actual evapotranspiration, mm	313.1	39.6
Percolation, mm	66.0	8.4
Ratio of runoff to percolation	6.2	

References

Koerner, R. M. and Daniel, D. E. 1997. Final covers for solid waste landfills and abandoned dumps. American Society of Civil Engineers, Virginia and Thomas Telford, London. (Reference 4
National Coal Board (NCB) document entitled "Technical Management of Water in the Coal Mining Industry " dated 1982. (Reference 5

APPENDIX HRA C

SPREADSHEET MODEL FOR THE SITE TO CALCULATE THE PREDICTED CONCENTRATIONS AT THE COMPLIANCE POINT IN THE AQUIFER

Determinand	Maximum concentration (mg/l)				Environmental assessment limit (EAL) (mg/l)	Assumed background concentrations (mg/l)
	Concentration predicted at the edge of the attenuation layer using the ConSim model output		Concentration predicted in the compliance point in the aquifer			
	50th percentile	95th percentile	50th percentile	95th percentile		
Toluene	-	-	-	-	4.00E-03	0
Naphthalene	-	-	-	-	0.00001	0
Mercury	-	-	-	-	0.00001	0
Chloride	128	159.6	60.1	60.2	154.9	59.7
Zinc	0.349	0.509	0.0103	0.0111	0.014	0.0084
Sulphate	263.5	301.1	176.3	176.5	212.9	175.8

$$C_{aq} = \frac{C_{mat} \times Q_{mat} + C_{bg} \times Q_{aq}}{Q_{mat} + Q_{aq}}$$

Where C_aq is the concentration in the aquifer (mg/l)
Where Qmat = Kmat x i_mat x (w_rogue x thickness_waste)
Where Qaq = K_aq x i_aq x (width_waste x thickness_waste)

K_mat is the hydraulic conductivity of the imported materials (m/s)	materials K	1.00E-07	m/s
K_aq is the hydraulic conductivity of the sand and gravel aquifer (m/s)	aquifer K	3.65E-05	m/s
i_aq is the hydraulic gradient within the sand and gravel aquifer (m/m)	aquifer i	2.60E-03	
i_mat is the hydraulic gradient within the imported materials and attenuation layer (m/r	materials i	5.20E-03	
w_rogue is the width of the rogue load (m)		2.93	
w_waste is the width of the waste (m)		2.93	
thickness_waste is the thickness of the waste (m)		3.5	

C_bg is the background concentration in the sand and gravel aquifer (mg/l)
C_mat is the concentration predicted at the edge of the imported materials and associated attenuation layer using the ConSim model output.

APPENDIX HRA D

CALCULATED COMPLIANCE AND ASSESSMENT LIMITS FOR THE SITE

Ammoniacal nitrogen

Date	S2	S4	
07/02/2014		0.04	
03/10/2014	0.11	0.4	
20/11/2014	0.4	0.04	
19/12/2014	0.06	0.3	
26/01/2015	0.03		
27/02/2015	0.02	0.05	
30/03/2015		0.08	
22/04/2015	0.12	0.12	
22/05/2015	0.3	0.14	
25/06/2015	0.11		
24/07/2015	0.09		
27/08/2015	0.09	0.03	
24/09/2015	0.06	0.04	
28/10/2015	0.06	0.04	
30/11/2015	0.16	0.05	
11/12/2015	0.1		
31/03/2016	0.02	0.02	
21/04/2016	0.04	0.01	
12/05/2016	0.03		
18/07/2016	0.06	0.3	
15/11/2016		0.01	
08/12/2016	2.1	1.1	
19/01/2017	0.4	2.8	
23/05/2017	0.09	0.07	
14/06/2017	0.02	0.03	
19/07/2017	0.05	0.04	
17/08/2017	0.09	0.08	
21/09/2017		0.01	
11/10/2017		0.01	
23/11/2017	0.09	1.1	
14/12/2017	0.05	0.04	
09/01/2018	0.05	0.06	
22/02/2018	0.03		
12/03/2018	0.1	0.07	
22/05/2018	0.03	0.01	
13/06/2018	0.01	0.01	
17/07/2018	0.01		
22/08/2018		0.01	
13/11/2018	0.01	0.02	
11/12/2018	0.03		
12/02/2019	0.07	0.02	
15/05/2019	0.05	0.04	
20/08/2019	0.06	0.06	
13/11/2019	0.06	0.06	
26/02/2020	0.05	0.03	
14/05/2020	0.2	0.06	
15/07/2020	0.04	0.01	
07/10/2020	0.11	0.04	**SW2 & SW4**
Minimum	0.01	0.01	0.01
Maximum	2.1	2.8	2.8
Mean	0.134762	0.18625	0.159878049
Standard deviation (STDEV)	0.32318	0.488481	0.41039726
Mean + 1*STDEV	0.457942	0.674731	0.570275309
Mean + 1.5*STDEV	0.619531	0.918972	0.775473939
Mean + 2*STDEV	0.781121	1.163212	0.980672568
Mean + 3*STDEV	1.104301	1.651693	1.391069828

Notes

Units: **mg/l**

Concentrations recorded below the analytical detection limit are set at the detection limit.

Value considered a possible outlier or the detection limit is elevated hence excluded.

Analytical result reported as below the analytical detection limit.

Proposed interim assessment limit

Proposed interim compliance limit

Chloride

Date	S2	S4	
07/02/2014		37	
20/11/2014	108	73	
19/12/2014	70	74	
26/01/2015	66		
27/02/2015	86		
22/04/2015		113	
22/05/2015	58	76	
25/06/2015	63		
24/07/2015	76	102	
28/10/2015	33	50	
30/11/2015	56	76	
11/12/2015	64		
31/03/2016	45	41	
21/04/2016	62	46	
12/05/2016	55		
20/06/2016		97	
18/07/2016	21	24	
08/12/2016	34	61	
19/01/2017	46	57	
23/05/2017	31	23.7	
14/06/2017	31	32	
19/07/2017	38	38	
17/08/2017	47	48	
21/09/2017		46	
23/11/2017	71	69	
14/12/2017	96	127	
09/01/2018	86	96	
22/02/2018	108		
12/03/2018	109	122	
22/05/2018	35	33	
13/06/2018	36	41	
17/07/2018	37		
13/11/2018	41	38	
11/12/2018	42	40	
12/02/2019	62	60	
15/05/2019	110	97	
20/08/2019	124	107	
13/11/2019	41	54	
26/02/2020	44	52	
14/05/2020	76	75	
15/07/2020	97	117	
07/10/2020	30	20	**SW2 & SW4**
Minimum	21	20	20
Maximum	124	127	127
Mean	61.44737	64.64857	62.98219178
Standard deviation (STDEV)	27.51088	30.63848	28.89311405
Mean + 1*STDEV	88.95825	95.28706	91.87530583
Mean + 1.5*STDEV	102.7137	110.6063	106.3218629
Mean + 2*STDEV	116.4691	125.9255	120.7684199
Mean + 3*STDEV	143.98	156.564	149.6615339

Notes

Units: **mg/l**

Concentrations recorded below the analytical detection limit are set at the detection limit.

Value considered a possible outlier or the detection limit is elevated hence excluded.

Analytical result reported as below the analytical detection limit.

Proposed interim assessment limit

Proposed interim compliance limit

Lead

Date	S2	S4
07/02/2014		0.001
20/11/2014	0.001	0.001
19/12/2014	0.001	0.001
26/01/2015	0.001	
22/04/2015		0.001
22/05/2015	0.001	0.001
25/06/2015	0.001	
28/10/2015	0.001	0.001
30/11/2015	0.001	0.001
31/03/2016	0.001	0.001
21/04/2016	0.001	0.001
12/05/2016	0.001	
20/06/2016		0.001
19/07/2017	0.001	0.001
17/08/2017	0.001	0.001
11/10/2017		0.001
14/12/2017	0.001	0.001
09/01/2018	0.001	0.001
22/02/2018	0.001	
13/06/2018	0.001	0.001
17/07/2018	0.001	
13/11/2018	0.001	0.001
11/12/2018	0.001	0.001
12/02/2019	0.001	0.001
20/08/2019	0.001	0.001
13/11/2019	0.001	0.001
26/02/2020	0.001	0.001
14/05/2020	0.001	0.001
15/07/2020	0.001	0.001
07/10/2020	0.001	0.001
Minimum	0.001	0.001
Maximum	0.001	0.001
Mean	0.001	0.001
Standard deviation (STDEV)	6.63E-19	6.64E-19
Mean + 1*STDEV	0.001	0.001
Mean + 1.5*STDEV	0.001	0.001
Mean + 2*STDEV	0.001	0.001
Mean + 3*STDEV	0.001	0.001

Notes

Units: **mg/l**

Concentrations recorded below the analytical detection limit are set at the detection limit.

Value considered a possible outlier or the detection limit is elevated hence excluded.

Analytical result reported as below the analytical detection limit.

Proposed interim assessment limit

Proposed interim compliance limit

Sulphate

Date	S2	S4	
24/07/2015	115	140	
27/08/2015	117	135	
24/09/2015	114	132	
28/10/2015	115	121	
30/11/2015	127	111	
11/12/2015	103	120	
21/01/2016	151	110	
11/02/2016	97	114	
31/03/2016	140	124	
21/04/2016	120	145	
12/05/2016	81.8	174	
20/06/2016	67.2	104	
18/07/2016	105	179	
25/08/2016	111	114	
12/09/2016	97.4	208	
06/10/2016	109	246	
15/11/2016	125	180	
08/12/2016	117	203	
19/01/2017	155	262	
23/02/2017	93	277	
16/03/2017	94	284	
12/04/2017	97	285	
23/05/2017	87	332	
17/08/2017	93	394	
23/11/2017	118	263	
22/02/2018	104	301	
22/05/2018	112	407	
17/07/2018	122	404	
22/08/2018	130	358	
16/10/2018	122	329	
12/02/2019	106	394	
15/05/2019	124	128	
20/08/2019	125	129	
13/11/2019	93	143	
26/02/2020	91	109	
14/05/2020	111	124	
15/07/2020	116	115	
07/10/2020	76	109	**SW2 & SW4**
Minimum	67.2	104	67.2
Maximum	155	407	407
Mean	110.0368	205.4474	157.742105
Standard deviation (STDEV)	18.75791	100.878	86.602878
Mean + 1*STDEV	128.7948	306.3253	244.344983
Mean + 1.5*STDEV	138.1737	356.7643	287.646422
Mean + 2*STDEV	147.5527	407.2033	330.947861
Mean + 3*STDEV	166.3106	508.0812	417.550739

Notes

Units: **mg/l**

Concentrations recorded below the analytical detection limit are set at the detection limit.

Value considered a possible outlier or the detection limit is elevated hence excluded.

Analytical result reported as below the analytical detection limit.

Proposed interim assessment limit

Proposed interim compliance limit

Zinc

Date	S2	S4	
07/02/2014		0.002	
20/11/2014	0.002	0.007	
19/12/2014	0.002	0.011	
26/01/2015	0.002		
27/02/2015	0.003		
22/05/2015	0.006	0.006	
25/06/2015	0.005		
24/07/2015	0.003	0.003	
28/10/2015	0.002	0.003	
30/11/2015	0.004	0.009	
11/12/2015	0.002		
31/03/2016	0.002	0.002	
21/04/2016	0.002	0.002	
12/05/2016	0.002		
20/06/2016		0.002	
18/07/2016	0.004	0.002	
08/12/2016	0.011	0.004	
19/01/2017	0.016	0.007	
23/05/2017	0.003	0.003	
14/06/2017	0.003	0.002	
19/07/2017	0.002	0.002	
17/08/2017	0.002	0.002	
21/09/2017		0.002	
11/10/2017		0.002	
23/11/2017	0.002	0.002	
14/12/2017	0.002	0.002	
09/01/2018	0.002	0.006	
22/02/2018	0.002		
12/03/2018	0.004	0.002	
22/05/2018	0.002	0.002	
13/06/2018	0.031	0.003	
17/07/2018	0.002		
13/11/2018	0.007	0.006	
11/12/2018	0.008	0.005	
12/02/2019	0.027	0.004	
15/05/2019	0.007	0.002	
20/08/2019	0.006	0.002	
13/11/2019	0.002	0.002	
26/02/2020	0.002	0.002	
14/05/2020	0.006	0.002	
15/07/2020	0.007	0.002	
07/10/2020	0.003	0.002	**SW2 & SW4**
Minimum	0.002	0.002	0.002
Maximum	0.031	0.011	0.031
Mean	0.005263	0.0034	0.00436986
Standard deviation (STDEV)	0.006417	0.002303	0.00495397
Mean + 1*STDEV	0.01168	0.005703	0.00932384
Mean + 1.5*STDEV	0.014888	0.006855	0.01180082
Mean + 2*STDEV	0.018096	0.008007	0.01427781
Mean + 3*STDEV	0.024513	0.01031	0.01923178

Notes

Units: **mg/l**

Concentrations recorded below the analytical detection limit are set at the detection limit.

Value considered a possible outlier or the detection limit is elevated hence excluded.

Analytical result reported as below the analytical detection limit.

Proposed interim assessment limit

Proposed interim compliance limit

Trigger Ammoniacal Nitrogen as N

Date	P11	P22	P41	P45	
13/11/2019	0.01	0.01	0.01	0.01	
19/11/2019	0.01	0.01	0.01	0.01	
25/11/2019	0.01	0.01	0.01	0.01	
05/12/2019	0.04	0.02	0.01	0.03	
10/12/2019	0.01	0.01	0.01	0.01	
17/12/2019	0.01	0.01	0.01	0.01	
07/01/2020	0.01	0.01	0.01	0.01	
14/01/2020	0.01	0.01	0.01	0.01	
23/01/2020	0.01	0.01	0.01	0.01	
28/01/2020	0.01	0.01	0.01	0.02	
04/02/2020	0.01	0.01	0.01	0.01	
13/02/2020	0.01	0.01	0.01	0.01	
25/02/2020	0.01	0.01	0.01	0.01	
05/03/2020	0.01	0.01	0.01	0.01	
18/03/2020	0.01	0.03	0.03	0.01	
31/03/2020	0.01	0.01	0.01	0.01	
14/04/2020	0.01	0.01	0.01	0.01	
28/04/2020	0.01	0.01	0.01	0.01	
12/05/2020	0.01	0.01	0.01	0.01	
09/06/2020	0.01	0.01	0.01	0.01	
08/07/2020	0.03	0.02	0.02	0.01	
05/08/2020	0.03	0.03	0.04	0.08	
08/09/2020	0.01	0.01	0.01	0.01	
07/10/2020	0.01	0.01	0.01	0.01	
10/11/2020	0.01	0.01	0.01	0.01	
08/12/2020	0.01	0.01	0.01	0.01	**P11, P22, P41, P45**
Minimum	0.01	0.01	0.01	0.01	0.01
Maximum	0.04	0.03	0.04	0.08	0.08
Mean	0.012692	0.012308	0.012308	0.013846	0.012788462
Standard deviation (STDEV)	0.007776	0.00587	0.007104	0.014164	0.009185968
Mean + 1*STDEV	0.020468	0.018178	0.019411	0.02801	0.021974429
Mean + 1.5*STDEV	0.024356	0.021113	0.022963	0.035092	0.026567413
Mean + 2*STDEV	0.028244	0.024048	0.026515	0.042174	0.031160397
Mean + 3*STDEV	0.036019	0.029919	0.033619	0.056338	0.040346364

Notes

Units: **mg/l**

Concentrations recorded below the analytical detection limit are set at the detection limit.

Value considered a possible outlier or the detection limit is elevated hence excluded.

Analytical result reported as below the analytical detection limit.

Proposed interim assessment limit

Proposed interim compliance limit

Trigger Chloride as Cl

Date	P11	P22	P41	P45	
13/11/2019	57	60	66	49	
19/11/2019	48	65	103	60	
25/11/2019	48	74	53	62	
05/12/2019	47	73	48	62	
10/12/2019	48	69	49	62	
17/12/2019	47	68	51	63	
07/01/2020	48	83	69	60	
14/01/2020	48	79	72	58	
23/01/2020	47	81	74	56	
28/01/2020	46	75	78	54	
04/02/2020	47	72	74	53	
13/02/2020	47	67	68	52	
25/02/2020	47	70	68	55	
05/03/2020	47	71	70	52	
18/03/2020	46	70	71	50	
31/03/2020	44	67	66	50	
14/04/2020	45	68	64	53	
28/04/2020	42	65	60	52	
12/05/2020	42	66	58	56	
09/06/2020	43	68	58	59	
08/07/2020	42	65	54	57	
05/08/2020	43	65	53	56	
08/09/2020	44	65	54	55	
07/10/2020	43	64	125	60	
10/11/2020	44	63	58	64	
08/12/2020	47	63	59	63	**P11, P22, P45**
Minimum	42	60	48	49	42
Maximum	57	83	125	64	83
Mean	46.03846	69.07692	66.26923	56.65385	57.25641026
Standard deviation (STDEV)	3.078711	5.691559	16.68426	4.533805	10.49110433
Mean + 1*STDEV	49.11717	74.76848	82.95349	61.18765	67.74751459
Mean + 1.5*STDEV	50.65653	77.61426	91.29562	63.45455	72.99306675
Mean + 2*STDEV	52.19588	80.46004	99.63776	65.72146	78.23861892
Mean + 3*STDEV	55.27459	86.1516	116.322	70.25526	88.72972325

Notes

Units: **mg/l**

Concentrations recorded below the analytical detection limit are set at the detection limit.

Value considered a possible outlier or the detection limit is elevated hence excluded.

Analytical result reported as below the analytical detection limit.

Proposed interim assessment limit

Proposed interim compliance limit

Trigger Lead as Pb (Dissolved)

Date	P11	P22	P41	P45	
13/11/2019	0.001	0.001	0.001	0.001	
19/11/2019	0.001	0.003	0.001	0.001	
25/11/2019	0.001	0.001	0.001	0.001	
05/12/2019	0.001	0.001	0.001	0.001	
10/12/2019	0.001	0.001	0.001	0.001	
17/12/2019	0.001	0.001	0.001	0.001	
07/01/2020	0.001	0.001	0.001	0.001	
14/01/2020	0.001	0.001	0.001	0.001	
23/01/2020	0.001	0.001	0.001	0.001	
28/01/2020	0.001	0.001	0.001	0.001	
04/02/2020	0.001	0.001	0.001	0.001	
13/02/2020	0.001	0.001	0.001	0.001	
25/02/2020	0.001	0.001	0.001	0.001	
05/03/2020	0.001	0.001	0.001	0.001	
18/03/2020	0.001	0.001	0.001	0.001	
31/03/2020	0.001	0.001	0.001	0.001	
14/04/2020	0.001	0.001	0.001	0.001	
28/04/2020	0.001	0.001	0.001	0.001	
12/05/2020	0.001	0.001	0.001	0.001	
09/06/2020	0.001	0.001	0.001	0.001	
08/07/2020	0.001	0.001	0.001	0.001	
05/08/2020	0.001	0.001	0.001	0.001	
08/09/2020	0.001	0.001	0.001	0.001	
07/10/2020	0.001	0.001	0.001	0.001	
10/11/2020	0.001	0.001	0.001	0.001	
08/12/2020	0.001	0.001	0.001	0.001	**P11, P22, P41, P45**
Minimum	0.001	0.001	0.001	0.001	0.001
Maximum	0.001	0.003	0.001	0.001	0.003
Mean	0.001	0.001077	0.001	0.001	0.001019231
Standard deviation (STDEV)	6.63404E-19	0.000392	6.63404E-19	6.63404E-19	0.000196116
Mean + 1*STDEV	0.001	0.001469	0.001	0.001	0.001215347
Mean + 1.5*STDEV	0.001	0.001665	0.001	0.001	0.001313405
Mean + 2*STDEV	0.001	0.001861	0.001	0.001	0.001411463
Mean + 3*STDEV	0.001	0.002254	0.001	0.001	0.001607579

Notes

Units: **mg/l**

Concentrations recorded below the analytical detection limit are set at the detection limit.

Value considered a possible outlier or the detection limit is elevated hence excluded.

Analytical result reported as below the analytical detection limit.

Proposed interim assessment limit

Proposed interim compliance limit

Trigger Total Sulphur as SO4

Date	P11	P22	P41	P45
13/11/2019	260	95	199	164
19/11/2019	234	90	703	153
25/11/2019	225	167	133	145
05/12/2019	185	163	107	126
10/12/2019	175	134	108	140
17/12/2019	155	97	143	124
07/01/2020	157	252	167	141
14/01/2020	141	200	169	130
23/01/2020	122	224	194	128
28/01/2020	117	183	208	125
04/02/2020	118	181	205	121
13/02/2020	114	136	181	117
25/02/2020	119	144	175	116
05/03/2020	106	142	181	103
18/03/2020	117	155	198	102
31/03/2020	116	122	182	101
14/04/2020	109	111	174	106
28/04/2020	124	110	159	2280
12/05/2020	122	101	141	111
09/06/2020	136	98	138	110
08/07/2020	125	97	121	98
05/08/2020	152	101	122	115
08/09/2020	155	101	120	109
07/10/2020	155	95	747	102
10/11/2020	136	100	128	103
08/12/2020	131	108	123	113
Minimum	106	90	107	98
Maximum	260	252	747	164
Mean	146.3846	134.8846	201	120.12
Standard deviation (STDEV)	40.17669	44.21251	157.5327	17.56018
Mean + 1*STDEV	186.5613	179.0971	358.5327	137.6802
Mean + 1.5*STDEV	206.6496	201.2034	437.2991	146.4603
Mean + 2*STDEV	226.738	223.3096	516.0655	155.2404
Mean + 3*STDEV	266.9147	267.5221	673.5982	172.8005

Notes

Units: **mg/l**

Concentrations recorded below the analytical detection limit are set at the detection limit.

Value considered a possible outlier hence excluded.

Analytical result reported as below the analytical detection limit.

Proposed interim assessment limit

Proposed interim compliance limit

Trigger Zinc as Zn (Dissolved)

Date	P11	P22	P41	P45	
13/11/2019	0.002	0.002	0.002	0.003	
19/11/2019	0.042	0.022	0.031	0.002	
25/11/2019	0.004	0.005	0.019	0.019	
05/12/2019	0.007	0.01	0.003	0.002	
10/12/2019	0.005	0.011	0.003	0.002	
17/12/2019	0.004	0.005	0.003	0.002	
07/01/2020	0.017	0.006	0.004	0.002	
14/01/2020	0.009	0.009	0.004	0.004	
23/01/2020	0.005	0.003	0.002	0.002	
28/01/2020	0.006	0.005	0.002	0.002	
04/02/2020	0.008	0.009	0.005	0.015	
13/02/2020	0.009	0.007	0.002	0.003	
25/02/2020	0.011	0.002	0.004	0.002	
05/03/2020	0.007	0.003	0.003	0.002	
18/03/2020	0.004	0.003	0.002	0.002	
31/03/2020	0.004	0.005	0.114	0.002	
14/04/2020	0.003	0.004	0.065	0.059	
28/04/2020	0.002	0.002	0.003	0.006	
12/05/2020	0.002	0.002	0.002	0.002	
09/06/2020	0.032	0.003	0.053	0.002	
08/07/2020	0.002	0.005	0.002	0.002	
05/08/2020	0.002	0.002	0.002	0.002	
08/09/2020	0.002	0.005	0.002	0.002	
07/10/2020	0.002	0.004	0.002	0.003	
10/11/2020	0.005	0.002	0.002	0.002	
08/12/2020	0.414	0.014	0.103	0.124	**P11, P41, P45**
Minimum	0.002	0.002	0.002	0.002	0.002
Maximum	0.414	0.022	0.114	0.124	0.414
Mean	0.023462	0.005769	0.016885	0.010385	0.016910256
Standard deviation (STDEV)	0.080204	0.004581	0.031439	0.025912	0.051539718
Mean + 1*STDEV	0.103666	0.01035	0.048324	0.036297	0.068449974
Mean + 1.5*STDEV	0.143768	0.012641	0.064043	0.049253	0.094219833
Mean + 2*STDEV	0.18387	0.014931	0.079763	0.062209	0.119989692
Mean + 3*STDEV	0.264075	0.019512	0.111202	0.088121	0.171529409

Notes

Units: **mg/l**

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Analytical result reported as below the analytical detection limit.

Proposed interim assessment limit

Proposed interim compliance limit