# Crimplesham Quarry Landfill - Environmental Permit

## Hydrogeological Risk Assessment

A110260

Mick George Limited
September 2020

Prepared on behalf of WYG Environment Planning Transport Limited

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# 1.0 Introduction

## 1.1 Report Context

1.1.1 This report presents the Hydrogeological Risk Assessment (HRA) for Crimplesham Quarry Landfill in support of an Environmental Permit Application for the site currently prepared by WYG Environment on behalf of Mick George Ltd (MGL).

1.1.2 The objectives of this document are to assess whether the proposed landfill operations, engineered containment, monitoring network and management controls fulfil the requirements of the Groundwater Regulations 2009 and Landfill Directive 1999 and ensure that the site is in compliance with the requirements of the Environmental Permitting Regulations, 2010.

1.1.3 Please refer to the various documents (ESSD, Operating Techniques, etc.) submitted as part of this application for detailed information on other aspects relating to the site.

## 1.2 Site Location

1.2.1 The application site forms part of the Crimplesham Quarry which is located approximately 855m east from the village of Crimplesham in Norfolk.

1.2.2 Crimplesham Quarry comprises two areas of land that are separated by a road (Main Road) that runs through the middle of the property. This application solely relates to the southern section of the quarry which is centred at approximate National Grid Reference (NGR) TF 66346 03464.

1.2.3 The proposed environmental permit boundary is shown on Drawing Number P2734 D3, Rev F.

1.2.4 The proposed regulated facility will occupy a surface area of approximately 12.5 hectares, located on a gentle slope with elevations of approx. 34mAOD along its northeast boundary (defined by the Main Road) and gradually falling away to approx. 24mAOD at the southwestern boundary defined by agricultural fields.

1.2.5 The nearest residential properties (as potential receptors in relation to the installation) are listed in Table 2 of the Environmental Risk Assessment report accompanying this application.

## 1.3 Brief Site History

### Historical and Proposed Development

1.3.1 With reference to historic maps dated from 1885 to 2009, the application site has largely comprised open agricultural land.

1.3.2 In May 2009, planning permission (reference C/2/2008/2006) was granted by Norfolk County Council (NCC) to allow the extraction and processing of sand and gravel to the south of the existing quarry site (i.e. the application site). Following mineral extraction, the planning permission allows the site to be restored back to agricultural land via landfilling of inert waste materials.

1.3.3 In December 2014, planning permission (reference C/2/2014/2018) was granted by NCC to vary two conditions of permission C/2/2008/2006. The first condition (Condition 3), relates to amendments to the previously approved Phasing Plans. The second condition (Condition 7) concerns amendments to the approved Plant Site Layout Plan. The alterations include an additional lagoon for use in the processing of mineral and the siting of a wheel cleaning facility in a different position to the approved plan.

1.3.4 In January 2016, planning permission (reference C/2/2015/2038) was granted by NCC to vary two conditions (2 and 30) of permission C/2/2014/2018 which relate to the Plant Site Layout and the Phasing Plans.

1.3.5 The proposed development entails the importation of inert waste to infill and restore the quarry void that will be created following mineral extraction activities. Works will be completed in accordance with the restoration scheme (Drawing Number P2734 D1, Rev G) which was originally approved under planning permission C/2/2008/2006 and has been incorporated in to the most recent planning permission (C/2/2015/2038).

## 1.4 Landfill Design Philosophy

### Basal Layer

1.4.1 Prior to the commencement of landfilling, a geological basal barrier will be engineered using imported clay or other imported material. The geological barrier will be constructed in compliance with the Environmental Permitting Regulations: Inert Waste Guidance 2010, which specifies a minimum geological barrier of 1m thickness and shall have an hydraulic conductivity with an average of $1x10^{-7}$m/s or 0.5m thick at an average of $5x10^{-8}$m/s (See Drawing Number

MGL-A110260-HYD-01).

**Side Slope Lining**

1.4.2 The quarry sides will be shaped using on site materials. Prior to the commencement of landfilling, a geological side slope barrier will be engineered using imported clay or inert materials. The geological side slope barrier will be constructed in compliance with the Environmental Permitting Regulations: Inert Waste Guidance 2010, which specifies a minimum of 1m thick geological barrier with average hydraulic conductivity of $1x10^{-7}$m/s or 0.5m thick at 5 x 10-8m/s (See Drawing Number MGL-A110260-HYD-01).

1.4.3 Leachate is generated by rainfall infiltrating through areas of open waste and also through areas of capped and restored waste. Due to the inert nature of the material to be imported, no leachate management or monitoring is proposed in line with current guidance.

**Capping**

1.4.4 In accordance with the requirements of the Landfill Directive, an engineered cap (clay or plastic) is not required. On completion of filling to final levels, the site will be capped with 1m of restoration soils comprising not less than 0.3m of topsoil.

**Restoration**

1.4.5 The application site is presently in agricultural use and it is the intention of MGL to restore the site back to agricultural land detailed in the approved restoration plan (Drawing Number P2734 D1, Rev G).

1.4.6 It is proposed that the original topsoil and subsoil material are stripped and retained on site thus providing temporary screening bunds. The restoration works that will follow the landfilling operations will re-use these stored materials.

1.4.7 All site-related engineering activities will be carried out under independent CQA supervision, following the submission and approval of a CQA plan.

## 1.5 Regulatory Context, Groundwater and Surface Water Protection

**Aquifer designation**

1.5.1 According to the Multi Agency Geographic Information for the Countryside (MAGIC) website, the application site overlies an unproductive aquifer – the Gault Formation (see section 4).

**Licensed and Unlicensed Abstractions**

1.5.2 Based on evidence from the MAGIC website, the site does not lie within a groundwater Source Protection Zone (SPZ) or public water supply (PWS).

1.5.3 To our knowledge there are no licensed surface water or groundwater abstractions in the area.

**Water Table**

1.5.4 The final working level has been proposed to be around 24mOAD. In the Hydrogeological conceptual model (Drawing Number MGL-A110260-HYD-01) the average maximum groundwater levels beneath the site are around 21mAOD therefore the base of the landfill will be located above the recorded groundwater levels. Hence, the installation is not described as sub-water table.

**Hydrology**

1.5.5 The nearest surface water feature to the site is an unnamed pond which is located approximately 415m south from the application site.

1.5.6 According to the Flood Map for Planning Service (FMPS), the application site is not situated in an area at risk of flooding.

# 2.0 Conceptual Hydrogeological Model

2.1.1 The conceptual hydrogeological model for the site is based on the source-pathway-receptor linkages and relies on the geological and hydrogeological information gathered during site investigations.

2.1.2 A schematic conceptual hydrogeological model (Cross section D-D' in Drawing number P2734 D1, Rev G) has been prepared as Drawing No. MGL-A110260-HYD-01. This model will be updated as the site develops and more information becomes available.

2.1.3 **Source**: potentially-contaminating leachate that could be generated by rainfall infiltration through the emplaced inert material and any moisture inherent to the inert material itself.

2.1.4 **Pathways**: to include the landfill liner system (base and sides), an unsaturated zone within the *in situ* geology, and a saturated zone below the groundwater table in which dilution and degradation processes may occur.

2.1.5 **Receptors**: the groundwater system beneath the site is considered to be the primary receptor. To our knowledge there are no secondary receptors in the form of licensed surface water abstractions.

2.1.6 A detailed discussion of the three components of the conceptual model is given in the sections below.

# 3.0 Conceptual Model: Source Term

3.1.1 The requirements of the Landfill Directive for the disposal of inert waste material do not necessitate the installation of a leachate management or monitoring system. Therefore, there will not be a discussion of a leachate source term component in this risk assessment process.

3.1.2 The proposed types of waste to be deposited into the landfill void are detailed in the Operating Techniques report accompanying this application.

3.1.3 However, a consideration is made for the potential of accepting waste that is not inert (e.g. potentially contaminated soil) or non-inert waste concealed within a load of waste that appears to be inert. The likelihood of any (or both) of these types of actions is predicted to be very low as strict source characterisation procedures will be applied to the loads being imported and visual inspection of each load will be undertaken prior to and during disposal.

3.1.4 Any fuel tanks and oil drums used on the site and by sub-contractors will be stored in a containment bund capable of containing 110% of the total quantity of fuel present at any one time.

3.1.5 All fuel spillages from moving plant or machinery will be remediated immediately in a safe and controlled manner by ensuring spills kits are kept on site and checked daily.

3.1.6 In order to complete the proposed works at Crimplesham Inert Landfill Site, approximately 735,000$m^3$ of inert materials will be required in total. When using a bulk density conversion factor of 1.6 tonnes/$m^3$ this equates to approximately 1,176,000 tonnes of imported material.

# 4.0 Conceptual Model: Pathways

## 4.1 Geology

4.1.1 A round of drilling was undertaken to establish a network of monitoring boreholes encircling the site's boundary and dedicated to measuring groundwater levels and quality (See Drawing Number MGL-A110260-HYD-02).

4.1.2 A total of 7 no. combined gas and groundwater boreholes were installed around the site (Drawing Number MGL-A110260-HYD-02). In addition to providing basic geological and hydrogeological information these boreholes indicated the depths of exploitable minerals on the site.

4.1.3 According to the British Geological Survey's (BGS) 'Geology of Britain Viewer', the bedrock below the site comprises Chalk of the West Melbury Marly Chalk Formation. This was formed approximately 94 to 101 million years ago during the Cretaceous Period.

4.1.4 However, on closer inspection of the location and geological description obtained from the borehole logs, it would appear that the site lies on the edge of the lithological boundary between the Chalk and underlying Gault Formation where the Chalk formation would be at its shallowest and there is no evidence of limestone bands which would characterise the Chalk member as reported in the logs. It is also likely that the upper boundary of the Gault Formation is uneven and therefore the site would be located on an outlier which forms the bedrock beneath the site.

4.1.5 There are currently no superficial deposits recorded at the site as these will have been removed as a result of the approved extraction works. However, the drilling logs of Appendix A show that superficial deposits of varying thickness were encountered in several of the boreholes, comprising of sand and gravel material.

4.1.6 According to the results from the BGS' "Geology of Britain Viewer" there is no evidence of any mine activities (subsurface pathways) beneath the site.

**Hydrogeology: Aquifer Designation and Groundwater Vulnerability**

4.1.7 Although according to the MAGIC website the application site overlies a Principal Aquifer (the Chalk), it is concluded that in fact the geology is likely to be the Gault Formation which is classified as an unproductive aquifer unit.

4.1.8 The vulnerability potential of this lithological unit which will remain in situ below the basal layer

of the landfill is considered low due to the reported permeability of the strata intersected during drilling i.e. mostly clay (Appendix A).

**Groundwater Monitoring Boreholes**

Groundwater levels

4.1.9 The available groundwater data submitted by MGL were plotted on the hydrograph of Appendix A (raw level data also in this appendix). The following comments apply to the plotted data:-

- The highest water table level is recorded in borehole BHG in the north west of the site, whereas the lowest levels were measured in borehole BHC, located in the south eastern portion of the site. From these data the currently inferred groundwater flow direction through the site is roughly west north west to east south east; and
- The hydrograph shows in a number of the boreholes there is a regular rise and fall of the groundwater levels which can be associated to a natural rainfall cycle during the year, especially if groundwater levels are measured within boreholes intersecting the high permeability superficial deposits.

The latest groundwater data was used in deriving a groundwater flow map showing the inferred flow direction, as shown in Drawing Number MGL-A110260-HYD-02.

4.1.10 The inferred groundwater flow direction has allowed for the identification of the up- and down-gradient boreholes, namely:-

Up-gradient: BHA, BHF and BHG; and

Down-gradient: BHB, BHC, BHD and BHE.

Baseline Groundwater Quality

4.1.11 Groundwater quality data were obtained from the boreholes forming the current monitoring network (Drawing Number MGL-A110260-HYD-02) between October 2018 and June 2020.

4.1.12 The groundwater quality results for the indicator substances Ammoniacal Nitrogen (Amm. N), Chloride, Sulphate and Nickel are chosen to identify are potential contamination arising from the landfill due to their high mobility. The raw and plotted data to derive the time series chemographs are shown in Appendix B.

4.1.13 The following comments apply to these graphs and the raw data:-

Up-gradient boreholes

- Chloride average concentrations are all below 100mg/l for these up-gradient boreholes apart from one result in April 2020 in Borehole A. The trends are generally stable and linear with the exception of a reading taken in February 2019, which shows a clear spike associated only in these three boreholes and a single spike in Borehole A in April 2020. In the context of the remaining readings this is considered to be an anomalous reading.
- The Amm. N chemograph illustrates a similar peak in values from the February 2019 results as that recorded in the chloride data. Average concentrations are recorded between 0.99mg/l and 1.82mg/l, however these are skewed as a result of the noted peak in February 2019.
- The Sulphate chemograph illustrates a stable trend for these three boreholes with averages between 80mg/l and 116mg/l.
- The Nickel chemograph also shows a spike in readings in February 2019 but have averages between 1.2µg/l to 2.6µg/l.

Down gradient boreholes

- Average chloride concentrations are below 150mg/l, with distinct decreasing trends displayed by monitoring points BHB and BHC, although the values of these two boreholes plot in a range above the remainder of the down-gradient boreholes. A likely explanation for this evolution of their chemical characteristic could be the location relative to the road, where gritting takes place and infiltration of salty recharge could take place. The remaining down-gradient boreholes have mostly linear trends and grouped in a narrow range of concentrations.
- The Amm. N plot is also affected by the noted spurious (anomalous) behaviour of values from the February 2019 results. For the remainder of the monitoring points trends are mostly linear and stable and fall within a very narrow range of values. Average concentrations range between a minimum of 1.4mg/l and a maximum of 2.71mg/l, although these values are affected by the noted peak in the February concentrations.
- The Sulphate chemograph illustrates a low stable trend for Boreholes D and E with an average of 62mg/l. Whereas Boreholes B and C have higher trends with averages of 161mg/l and 218mg/l.
- The Nickel chemograph illustrates no results in Boreholes D and E whereas Boreholes B and C have trends with averages of 1.8µg/l to 2.1µg/l.

Long Term Hydrogeological Changes

4.1.14 Hydrogeological changes are expected within the Superficial Deposits as a result of the proposed extraction. These impacts are predicted as localised changes to recharge characteristics and flow directions; but would not affect resources within the underlaying Gault Formation. The impact of the proposed activity on recharge and flow direction are assessed as being minor, but long term, due to the localised nature of the development.

4.1.15 Any impacts in terms of both magnitude and duration that future climatic changes could bring about on the groundwater regime are too difficult to predict given the localised nature of the development.

# 5.0 Conceptual Model: Receptors

## 5.1 Current licensed/exempt groundwater or surface water abstractions

5.1.1 There are no licensed groundwater abstractions within a 1 km radius of the site.

5.1.2 Based on evidence from the MAGIC website, the site does not lie within the source protection zone (SPZ) of any public water supply.

5.1.3 Therefore, the remaining geological unit(s) i.e. the Gault Formation, is considered to be the principal receptor for this assessment.

## 5.2 Existing natural/induced discharges (e.g. springs/wetlands)

5.2.1 Groundwater flow direction appears to be north west to south east, down the topographic dip of the strata. There are no known springs emanating down-gradient of the area.

**Surface Water**

5.2.2 The site lies within the Wissey River catchment. This surface water feature is approximately 5Km south of the proposed permit boundary and due to its distance is not considered to be a potential receptor.

5.2.3 Any surface water generated by the restored landform will be conveyed into two existing ponds located to the south of the installation.

## 5.3 Sites of Ecological or Nature Conservation Significance

5.3.1 There are no Sites of Special Scientific Interest (SSSI) within 3km of the site.

# 6.0 Quantitative Hydrogeological Risk Assessment

## 6.1 The Nature of the Assessment

6.1.1 The proposed environmental permit application will be submitted for Crimplesham Quarry Inert Disposal Landfill in order to receive inert materials.

6.1.2 In line with current legislation, inert landfills could be subject to a quantitative risk assessment process if a reduction in the specification of the Landfill Directive, Annex 1 "geological barrier", would be considered and the receiving environment has been identified as being particularly sensitive.

6.1.3 In the case of the proposed geological barrier its specification, as set out in the Operating Techniques, will not be reduced therefore the receiving environment i.e. the limited areal extent of the underlying low permeability Gault Formation is not affected and therefore a quantitative risk assessment will not be undertaken.

6.1.4 In addition, the inert nature of the materials imported into the site has removed the first component of the Source-Pathway-Receptor linkage, therefore causing the sensitivity of the development to be considerably lowered.

6.1.5 In general, the likelihood of accidents happening is closely related to efficient site management and conscientious equipment and plant operators who will ensure lowering/minimising of risk through a robust implementation of site procedures included in the Operating Techniques document accompanying this application.

## 6.2 Environmental Assessment Limits (EALs)

6.2.1 Although the site will accept inert materials, a set of EALs will still be required to form part of the Environmental Permit, since this is defined as a value set at the down gradient Compliance Point boreholes BHC, calculated to be a maximum concentration allowable at that point in order to protect the identified potential principal receptor.

6.2.2 It is proposed to use the Agency's recognised statistical approach applied of the mean plus 3 x standard deviation for the chosen substances (Amm. N, Chloride, Sulphate, Nickel and Mercury) using the average values at the chosen compliance point BHC and shown in Table 1. See Appendix B for their statistical derivations.

6.2.3 As a Hazardous Substance Mercury has been chosen for being a highly mobile ion, and the EAL value has been set at the corresponding minimum reporting value (MRV).

**Table 1: Priority Substances and EALs**

| Determinants | MRV | Selected EALs |
|---|---|---|
| **Hazardous substance** | | |
| Mercury (µg/l) | 0.01 | 0.01 |
| **Non-hazardous pollutants** | | |
| Amm. N (mg/l) | | 4.38* |
| Chloride (mg/l) | | 223 |
| Sulphate (mg/l) | | 316 |
| Nickel (µg/l) | | 3.5 |

*The EAL value for Amm N has been derived by removing the anomalous reading recorded in Feb. 2019.

6.2.4 It is recommended these EALs be reviewed during the annual monitoring reporting procedure but also informally following each monitoring visit due to the specific environmental circumstances associated with this site.

# 7.0 Review of Technical Precautions

## 7.1 Review of Technical Precautions

7.1.1 A series of necessary technical precautions have been identified as part of this risk assessment, which will be reviewed during the life of the permit.

**Capping**

7.1.2 On completion of infilling to final waste levels, the installation will not require a capping system but the final landform will be restored with topsoil and subsoil materials recovered during the preparation phase of the site.

**Lining Design**

7.1.3 The base and side slopes will have an engineered containment system, which has been risk assessed on the basis of the proposed design and according to the waste stream to be imported.

7.1.4 Additional confidence in the robustness of these designs will be provided by the CQA supervision programme that will be implemented during the construction phases of each individual cell.

**Leachate Head Control, Drainage and Extraction Systems**

7.1.5 These operational controls will not be required as the installation is an inert landfill.

**Groundwater Management**

7.1.6 Given the difference in proposed basal level and current average groundwater elevations it is not expected to counteract any groundwater inflow. The operator, however, will ensure that any rainfall collected within the open void is managed as necessary. Site CQA supervision will also ensure that any potential heave encountered during construction works will be managed and that safe working conditions will be maintained.

**Surface Water Management**

7.1.7 A surface water management system will be installed around the southern perimeter of the site in the form of collection drains and any water generated will be conveyed into the existing seasonal ponds located down-gradient of these ditches.

# 8.0 Requisite Surveillance

## 8.1 The Risk-Based Monitoring Scheme

### Groundwater Monitoring

8.1.1 Groundwater level and chemical data are to be collected from the groundwater monitoring points shown in Drawing Number MGL-A110260-HYD-02.

8.1.2 The parameters to be sampled and monitoring frequency to be included in the Environmental Permit are presented in Table 2 below. These requirements are considered adequate in providing an ongoing characterisation of the groundwater conditions.

**Table 2: Groundwater Determinants and Sampling Frequency**

| Quarterly | Annually |
|---|---|
| Levels, pH, Chloride, Alkalinity<br>Amm N, Sulphate, Sodium,<br>Potassium, Iron, Manganese, Cadmium<br>Chromium, Copper, Calcium,<br>Nickel, Lead, Zinc, Electrical conductivity, Magnesium | *To include quarterly suites plus:*<br><br>Hazardous substances |

### Surface Water

8.1.3 Surface water run-off will be controlled and conveyed in accordance to the agreed SWMP. Sampling will be undertaken at two chosen discharge points.

8.1.4 The frequency and sampling suite to be implemented for the characterisation of surface water quality is presented in Table 3.

**Table 3: Surface Water Determinants and Sampling Frequency**

| Quarterly |
|---|
| pH, Chloride, Amm N, Sulphate, Nickel, Electrical conductivity |

## 8.2 Compliance Limits

8.2.1 Compliance limits are set for down-gradient borehole BHC.

8.2.2 The limits for non-hazardous pollutants have been calculated following a statistical protocol outlined in Section 6.2.3 (see data sheet in Appendix B). These compliance limits are to be applied to the chosen down gradient borehole BHC.

8.2.3 For hazardous substance Mercury, the relevant MRV was chosen as the compliance limit. Table 4 contains these new sets of levels, which will be included in the newly issued EP.

**Table 4: Groundwater Compliance Limits**

| Determinands | Compliance limits |
|---|---|
| Ammoniacal Nitrogen (mg/l) | 4.38 |
| Chloride (mg/l) | 223 |
| Sulphate (mg/l) | 316 |
| Nickel (µg/l) | 3.5 |
| Mercury (µg/l) | 0.01 |

## 8.3 Contingency Action Plan

8.3.1 An annual review of the proposed compliance limits should be carried out and any alterations in the compliance levels discussed and agreed with the EA.

8.3.2 Where the site monitoring programme identifies an increase in groundwater determinants that could lead to a breach, then a series of contingency actions will be required. Suggested contingency actions, which will need to be agreed with the Environment Agency, are presented in Table 5.

**Table 5: Suggested Contingency Actions**

| Appropriate Contingency Action | Timescale |
|---|---|
| Advise Site Management | Immediately |
| Advise Operator's Environmental Manager | 1 Week |
| Advise Environment Agency | 1 Week |
| Confirm by repeat sampling and analysis | 1 Month |
| Review existing monitoring information | 1 Month |
| Review site management/operations, implement actions to prevent future failure of a compliance level | 3 Months |
| Review assumptions in conceptual site model | 3 Months |
| Review existing HRA Compliance Levels | 6 Months |
| Consult EA about need for corrective action | 6 Months |

# 9.0 Conclusions

9.0.1 The proposed engineered containment for the proposed inert landfill at Crimplesham Quarry complies with the Landfill Directive.

9.0.2 Surface water runoff is to be controlled within a proposed set of perimeter ditches located to the south of the landform and gravity released to seasonal ponds down-gradient of the development.

9.0.3 The proposed installation will comply with current engineering design, materials, specifications and CQA protocols applicable to current landfill containment best practices.

9.0.4 An independent CQA procedure will be carried out for all aspects of the basal and sidewall lining construction. This ensures that the liner meets the required engineering standards and thus complies with the Landfill Directive and will not have an impact on the groundwater system.

9.1.5 Compliance limits for groundwater have been derived.

9.0.6 The requirements of the Groundwater Regulations, 2016, have been satisfied by the inclusion of requisite surveillance of the groundwater quality to be carried out regularly as discussed in Section 6.

# Drawings

# Appendix A

Drilling logs, Groundwater Levels Data and Plot

# Appendix B

Groundwater Quality Data and Plots