Ms. Wong
Environment Agency
Aqua House,
20 Lionel St,
Birmingham
B3 1AQ

Friday 1 November 2024

Ref: K6036-GEO-LT-01

**RE: Maxey Quarry Extension Stability Risk Assessment**

Dear Ms Wong,

This letter sets out a stability risk assessment for the Maxey Quarry and has been carried out with due consideration of relevant Environment Agency guidance including Landfill operators: environmental permits ‘How to do a stability risk assessment: landfill sites for inert waste or deposit for recovery activities’[1].

## [1] Introduction to the SRA

The Maxey Quarry is being worked and will be restored in a phased manner with the site split into six Phases (1 to 6) with Phase 1 having been partially restored using imported materials. The base of the workings will extend to typical levels of approximately 3.5 to 4 mAOD. The western part of the quarry will be excavated to the base of the River Terrace Deposits (sand and gravel). In the eastern part, where the underlying clay thickens, some over-digging (excavation of the underlying clay) will take place to construct the irrigation lagoon and to allow for the development of the proposed restoration scheme. Due to the potential for basal heave, over-digging shall be controlled to mitigate against the risk of basal heave.

[1] https://www.gov.uk/guidance/landfill-operators-environmental-permits/how-to-do-a-stability-risk-assessment-landfill-sites-for-inert-waste-or-deposit-for-recovery-activities



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## [2] Contact Details

- Operator name: Tarmac Trading Limited
- Site name: Maxey Quarry Extension
- Site address: Maxey Quarry, High Street, Maxey, Peterborough, PE6 9EA
- Kourosh Azimi (BSc(Eng) MSc(Eng) MSc(Sci) / Associate Director – Geotechnics) Suite 104, Mere Grange Business Park, St Helens, WA9 5GG, United Kingdom Tel: +44 (0) 1925 291 111

## [3] Report Context

Environment Agency Guidance: How to do a stability risk assessment: landfill sites for inert waste or deposit for recovery activities, states:

> *Before you do a stability risk assessment you must:*
>
> - *create a conceptual site model*
> - *complete an environmental setting and site design report*
>
> *You only need to do a stability risk assessment if your conceptual site model confirms that you need one.*

A great majority of the Environment Agency's headings recommended for completing Stability Risk Assessments (SRA) [presented in the document entitled "*How to do a stability risk assessment: landfill sites for inert waste or deposit for recovery activities*", published 30 January 2020 and last updated 17 January 2024] do not apply to the proposed application. However, for completeness and following the EA's permitting officer's comments of 31 October 2024, the aforementioned format is adhered to in this document as far as practicable for relevant aspects.

The Guidance goes further to state:

> *You must include an entry in each section, even to confirm that a specific feature is not relevant to your site. The Environment Agency accepts that you may not need to complete some of the sections.*

As stated above, this assessment has been presented in terms of the relevant components. Notwithstanding this, cross references to the various non-applicable sections are summarised at the end of this document.



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## [4] Supporting Documents and Overview Summary

The conceptual site model for the site is presented with the application Hydrogeological Risk Assessment (HRA)[2] and Environmental Setting Site Design (ESSD)[3] document, along with accompanying cross-sections (Drawing K6036-01).

The site is an active quarry in which the northeast corner has been historically infilled with soil under an earlier exemption. The quarry requires the excavation of a superficial River Terrace Deposit (sand and gravel) unit which will expose the underlying bedrock. The bedrock comprises low permeability strata at subcrop (including the Cornbrash Limestone, a cemented limestone unit with regionally determined hydraulic conductivities in the order of $1x10^{-10}$m/s).

The quarry is being progressively dewatered (where necessary) as mineral workings progress to enable access to the mineral and relieve all pore pressures acting on the site base and sides.

The quarry is to be shaped primarily along the sides of the quarry with site derived overburden and interburden, with the basal works comprising the underlying strata.

The conceptual model does not call for an impermeable barrier system on the base of the site, as the *in-situ* material achieves the requirement for a natural geological barrier. This in any case of this classification of site is a chemical attenuation layer, directly intended to enable the throughflow of percolating waters. The side slopes are also to be placed “dry” and at a “safe slope” angle of less than 1:3, using suitable low permeability material and loading before site

## [5] Conceptual Site Stability Model

### [5.1] Geological Model

The underlying geological sequence is tabulated as Figure 1, which includes a tabular representation of the conceptual site geological model, also known as the ground model in the context of the SRA herein.

[2] Ayesa (2024) Hydrogeological Risk assessment Report K6036-R04
[3] Ayesa (2024) Environmental Setting and Site Design Report K6036-R03



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**Figure 1 - Conceptual Site Geological Model**

| Unit | Description | Thickness |
|---|---|---|
| Soils | Soils | Avg. 0.35m |
| *Quaternary*<br>Sand & Gravel | River Terrace – Very Gravelly Sand<br>Unconformity at base<br>**AQUIFER** | Avg. 3.3m |
| *Jurassic*<br>Kellaways Clay | Dark blueish grey, laminated stiff CLAY<br>Occasional <1mm shell fragments | 0m (in west)<br>to<br>7.8m |
| Cornbrash Limestone | Light blueish grey, fine-medium grained fossiliferous LIMESTONE<br>Disconformable sharp contact at base<br>**AQUIFER** | 0m (in west)<br>to<br>2.1m |
| Blisworth Clay | Grey and often mottled purple, green and/or yellow, very stiff CLAY<br>Occasional thin (<15cm) LIMESTONE bands and shelly horizons | 3.8m (in west)<br>to<br>7.7m |
| Blisworth Limestone | Light grey/white fossiliferous LIMESTONE<br>Abundant large (5cm) horizontally laminated oyster and brachiopod shells<br>Conformable / gradational contact at base<br>**AQUIFER** | 4.8m<br>to<br>4.9m |
| Rutland Formation | Dark blueish green, silty, laminated stiff CLAY / MUDSTONE<br>Gradational upper boundary<br>(base not proved) | 0.75m+ |

## [5.2] Local Hydrogeological Setting

A review of the borehole logs reported by Tarmac (Geotechnical Department) in 1998 shows water strikes in the River Terrace Deposits of sand and gravel at depths ranging between 1.5m and 2m below ground level. However, borehole logs by SLR which were all terminated in Blisworth Clay (2008) and the ones by ByrneLooby (2022) did not show any water strikes. The lack of water strikes in the latter sets of boreholes could most likely be due to the dewatering exercises undertaken by the quarry operator throughout the extraction work. These boreholes are included as **Appendix A** to this document.

**Appendix B** shows the groundwater level contours drawn based on the groundwater level monitoring data obtained from the boreholes with installations screened against the River Terrace Deposits (i.e. relatively shallow) and within the Cornbrash Limestone. The contours for both summer and winter times have been presented.



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### [5.3]  Restored Land Topography

The proposed scheme involves restoration of an operational sand and gravel quarry to form a topographical landscape sympathetic with the pre-quarrying ground levels. The restored scheme incorporate a series of wetland features for both ecological and flood attenuation purposes including its original agricultural land use, lowland meadow, and a series of ponds.

### [5.4]  Conceptual Stability Model

Basal Subgrade and Liner: The subgrade of the site is formed from the in-situ rock remaining when the excavation was completed. An engineered liner is not required.

Side Slope Subgrade and Liner: The subgrade of the site is formed from the in-situ rock remaining when the excavation was completed. An engineered liner is not required.

Capping Materials:  The proposals do include capping.

Waste Mass:  Details of geotechnical suitability with regards to the imported material is discussed within the Waste Acceptance Procedure (Ref. K6036-ENV-R005).

Pore fluid pressures, settlement and strains:  The stability risk associated with basal heave is considered within this report.

## [6] Stability Risk Items, Lifecycle Phases and Basal Stability

The final restored landform will follow the pre-quarrying topography and in such a topography the risk of global instability of the restored land will remain negligible. This is owing to the gentle gradients which make the restored land slopes geometry amenable to global stability.

Despite no water strikes being recorded in the aforementioned ground investigations by SLR and ByrneLooby (now Ayesa), the piezometric levels demonstrated in **Appendix B** indicate that uplift seepage forces on base of ‘unloaded’ excavations which would not benefit from the buttressing / surcharging effect of the imported fill material is the only conceivable geotechnical risk factor in the context of the proposed site restoration. In other words, all other potential stability risks such as excavations sidewall failure should be (and understood to have been until now) mitigated against as operational risk items in that they are / have been controlled by measures such as dewatering, safe excavations in the River Terrace Deposits by adopting safe angles for the sidewalls (i.e. 1v:3h or gentler), phased extraction, and the like.



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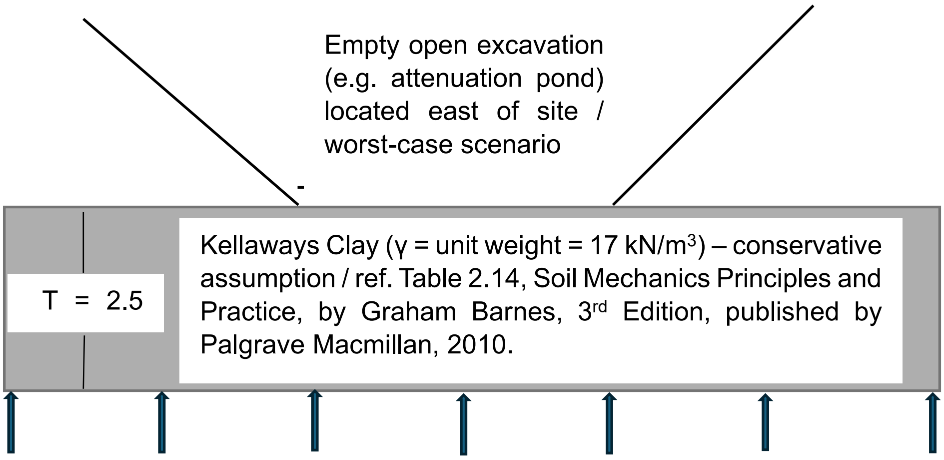
## [7] Basal Heave Calculation

Based on the information provided in this document, a cautious and simplified seepage uplift estimation indicates that so long as at least 2.5m thickness of the Kellaways Clays remains unexcavated in the unloaded features with permanent open excavations east of the site (e.g. proposed restoration pond), the risk of basal heave in such features will be very low. **Table 1** shows that the thickness of the Kellaways Clays east of the site can reach to as high as 7.8m (also consult ByrneLooby logs BH22/02 and BH22/03a included in **Appendix A**). With the base of workings typically not being below 3.5mAOD, the risk of basal heave as the result of seepage uplift forces on the base of permanently open excavations in the proposed restoration scheme is assessed to be very low.

**Figure 2** and the associated seepage calculations demonstrate that even under the conservative scenario where 2.5m thickness of Kellaways Clay is left at the base of an open excavation such as that of the proposed restoration pond, the safety margin against basal heave will still remain acceptable.

**Figure 2 – Seepage Uplift (Basal Heave) Model**




H = 7 m piezometric 'head' from the underlying Cornbrash Limestone or deeper aquifers is assumed to apply on the base of clay (also consult **Appendix B**)

Destabilising pressure = Uplift pressure on the base due to seepage = $P = i \times \gamma_w = [\delta H] \div T = [(7\ \text{m} - 0\ \text{m}) \div 2.5\ \text{m}] \times 9.8\ \text{kN/m}^3 = 27.44\ \text{kPa}$

Stabilising pressure = Normal (downward) stress due to the Kellaways Clay 'self-weight' = $N = \gamma \times T = 17\ \text{kN/m}^3 \times 2.5\ \text{m} = 42.50\ \text{kPa}$



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Applying the partial safety factors in line with the principles of 'Hydraulic Failure' of soils in Eurocode 7 (Tables A15 and A16 in National UK Annex) will result:

Factored [Unfavourable] Action = $P_{(\text{partially factored and EC-7 Compliant})}$ = 1.0 × 27.44 kPa = 27.44 kPa

Factored [Favourable] Action = $N_{(\text{partially factored and EC-7 Compliant})}$ = 0.9 × 42.50 kPa = 38.25 kPa

Therefore, Degree of Utilisation (DoU) in line with the principles of EC7:

DoU = $P_{(\text{partially factored and EC-7 Compliant})} \div N_{(\text{partially factored and EC-7 Compliant})}$ = 27.44 kPa ÷ 38.25 kPa = 71.74 % which is well below 100% (i.e. safe).

In other words, the Over-Design Factor (ODF), again in line with the definitions of EC7 is calculated as

ODF = $N_{(\text{partially factored and EC-7 Compliant})} \div P_{(\text{partially factored and EC-7 Compliant})}$ = 1.394

The ODF is well above the minimum acceptable value of 1.00, hence the risk of 'Hydraulic Failure' (or 'Basal Heave' due to seepage) is acceptable.

## [8] Concluding Remarks

The Maxey Quarry is being worked and will be restored in a phased manner. Since the proposed scheme involves restoration of an operational sand and gravel quarry to form a topographical landscape sympathetic with the pre-quarrying ground levels, the risk of global instability of the restored land will remain negligible. In other words, uplift seepage forces on base of 'unloaded' excavations which would not benefit from the buttressing / surcharging effect of the imported fill material is the only conceivable geotechnical risk factor in the context of the proposed site restoration. This is a geotechnical risk known as 'Hydraulic Failure' in Eurocode 7. All other potential stability risk items established in the Environment Agency's guidelines recommended for completing Stability Risk Assessments (SRA) [presented in the document entitled "*How to do a stability risk assessment: landfill sites for inert waste or deposit for recovery activities*", published 30 January 2020 and last updated 17 January 2024] do not apply to the proposed application. For example, items such as excavations sidewall failure should be (and understood to have been until now) mitigated against as operational risk items in that they are / have been controlled by measures such as dewatering, safe excavations in the River Terrace Deposits by adopting safe angles for the sidewalls (i.e. 1v:3h or gentler), phased extraction, and the like.

Based on the site conceptual geological (i.e. ground) model and the information presented in this document in regards the site local hydrogeological setting, a 'Basal Heave' model was developed. Eurocode 7 (EC-7) compliant calculations in this context indicated



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acceptable Over-Design Factors with a satisfactory safety margin, despite the conservative assumptions made in developing the model.

# [9] Rationalisation Cross References between Assessment with Guidance Components

## [9.1] 1) Introduction

As per Section 1 of this report

## [9.2] 2) Contact Details and Report Context

AS per Section 2) Contact details and 3) Report Context of this report

## [9.3] 3) Conceptual Site Model

As per Section 5 of this report

## [9.4] 4) Stability Risk Assessment

As per Section 6 and 7 of this report

## [9.5] 5) Lifecycle Phases

The site has two lifecycle phases, namely initial quarrying then restoration with soil forming materials under a recovery permit.

Safe slope angles are being created as part of the quarrying works, which are ongoing, during the application process.

## [9.6] 6) Data Summary

The data utilised is explained throughout this document with specific reference in Section 6 and 7.



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## [9.7] 7) Justification for modelling approach and software

As per Section 6 and 7 of this report

## [9.8] 8) Justification of geotechnical parameters selected for analysis

Parameters are Eurocode 7 (EC7) default parameterisation for the material types. The relevant literature is provided as Appendix C.

## [9.9] 9) Select appropriate factors of safety

Parameters are Eurocode 7 (EC7) default parameterisation for the material types. The relevant literature is provided as Appendix C.

## [9.10] 10) Sensitivity analysis

As per Section 6 and 7 of this report

## [9.11] 11) Assessment

As per Section 6 and 7 of this report

## [9.12] 12) Monitoring

No monitoring is proposed.

## [9.13] 13) Conclusion

As per Section 8 of this report



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## [10] Closure

For queries about this document, please contact the undersigned.
Yours sincerely

For Ayesa,
*Kourosh Azimi*

Kourosh Azimi
$BSc_{(Eng)}$ $MSc_{(Eng)}$ $MSc_{(Sci)}$
Associate Director - Geotechnics

**Appendices**

**Appendix A: Borehole Records**

**Appendix B: Groundwater contours**

**Appendix C: Literature and Guidance**



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# Appendix A

# Borehole Records

**Appendix B**

**Groundwater Contours**

## Appendix C

## Literature and Guidance