AN APPLICATION FOR AN ENVIRONMENTAL PERMIT TO AUTHORISE THE DEPOSITION OF WASTE ON LAND AS A RECOVERY ACTIVITY FOR THE RESTORATION OF PHASES 3A, 3B, 4A, 4B, 5A, 5B, 6A, 6B, 6C AND 7 AT ARLEWAS QUARRY, ARLEWAS, STAFFORDSHIRE

STABILITY RISK ASSESSMENT

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CONTENTS

INTRODUCTION		1
1.2.1	Basal Sub-Grade Model	7
1.2.2	Side Slope Sub-Grade Model	7
1.2.3	Basal Attenuation Layer Model	7
1.2.4	Side Slope Attenuation Layer Model	8
1.2.5	Waste Mass Model	8
1.2.6	Capping System and Restoration Model	9
2	STABILITY RISK ASSESSMENT	10
2.1	Risk Screening	10
2.1.1	Basal Sub-Grade Screening	10
2.1.2	Side Slope Sub-Grade Screening	10
2.1.3	Basal Attenuation Layer Screening	10
2.1.4	Side Slope Attenuation Layer Screening	10
2.1.5	Waste Mass Screening	11
2.1.6	Capping System and Restoration Screening	11
2.2	Life Cycle Phases	11
2.3	Data Summary	11
2.4	Justification for Modelling Approach and Software	11
2.5	Justification for Geotechnical Parameters Selected for Analysis	12
2.5.1	Parameters Selected for Basal Sub-Grade Analysis	12
2.5.2	Parameters Selected for Side Slope Sub-Grade Analysis	12
2.5.3	Parameters Selected for Basal Attenuation Layer Analysis	12
2.5.4	Parameters Selected for Side Slope Attenuation Layer Analysis	12
2.5.5	Parameters Selected for Waste Mass Analysis	14
2.5.6	Parameters Selected for Capping System and Restoration Analysis	14
2.6	Selection of Appropriate Factors of Safety	14
2.6.1	Factor of Safety for Basal Sub-Grade	14
2.6.2	Factor of Safety for Side Slope Sub-Grade	14
2.6.3	Factor of Safety for Basal Attenuation Layer	14
2.6.4	Factor of Safety for Side Slope Attenuation Layer	14
2.6.5	Factor of Safety for Waste Mass	14
2.6.6	Factor of Safety for Capping System and Restoration	15
2.7	Analysis	15
2.7.1	Basal Sub-Grade Analysis	15
2.7.2	Side Slope Sub-Grade Analysis	15
2.7.3	Basal Attenuation Layer Analysis	15
2.7.4	Side Slope Attenuation Layer Analysis	15
2.7.5	Waste Mass Analysis	15
2.7.6	Capping System and Restoration Analysis	15
2.8	Assessment	16
2.8.1	Basal Sub-Grade Assessment	16
2.8.2	Side Slope Sub-Grade Assessment	16
2.8.3	Basal Attenuation Layer Assessment	16
2.8.4	Side Slope Attenuation Layer Assessment	16
2.8.5	Waste Mass Assessment	16
2.8.6	Capping System and Restoration Assessment	16
3	MONITORING	17
3.1	The risk based monitoring scheme	17
3.1.1	Basal Sub-Grade Monitoring	17

3.1.2 Side Slopes Sub-Grade Monitoring 17
3.1.3 Basal Attenuation Layer Monitoring 17
3.1.4 Side Slope Attenuation Layer Monitoring 18
3.1.5 Waste Mass Monitoring 18
3.1.6 Capping System and Restoration Monitoring 18
REFERENCES 19

TABLES

Table SRA 1 Geotechnical parameters used in the stability modelling

FIGURES

Figure SRA 1 Site location and layout (Drawing Reference TAR/AL/12-20/22164)

Figure SRA 2 Topographical survey of the site (Drawing Reference TAR/AL/12-20/22165)

Figure SRA 3 Proposed extracted profile (Drawing Reference TAR/AL/12-20/22166)

Figure SRA 4 Schematic drawing of the construction of the attenuation layer (Drawing Reference TAR/AL/12-20/22167)

APPENDICES

Appendix A Drawings showing the restored profile

Appendix B Results of the stability modelling

INTRODUCTION

1.1. Report Context

i) MJCA is commissioned by Tarmac Trading Limited (Tarmac) to prepare an application (the application) for a bespoke Environmental Permit (EP) for the deposition of inert waste on land as a recovery activity in order to restore Phases 3A, 3B, 4A, 4B, 5A, 5B, 6A, 6B, 6C and 7 at Alrewas Quarry, Croxall Road, Alrewas, Staffordshire. This report comprises the Stability Risk Assessment (SRA) to support the EP application. Throughout this application Phases 3A, 3B, 4A, 4B, 5A, 5B, 6A, 6B, 6C and 7 of Alrewas Quarry are referred to as the site. The extracted area will be restored with inert waste to agriculture, amenity and nature conservation.

ii) Mineral extraction activities are ongoing at the site. The site forms part of the wider Alrewas Quarry complex operated by Tarmac that have or is being restored using inert waste. The design and operation of the proposed recovery operation is consistent generally with the design and operations previously used at other Tarmac inert recovery sites.

iii) The structure of this SRA is based on a template produced by the Environment Agency entitled "Stability Risk Assessment Report Version 1" dated March 2010 (Reference 1). The SRA presents relevant aspects of the site setting and the proposed design of the recovery operations. A risk screening stage identifies which potential stability risks need further assessment. The further assessment methodology is explained and the geotechnical parameters and target factors of safety used are described. From the stability assessment it is concluded that the external side slope attenuation layer achieves an acceptable factor of safety.

Site Description

iv) The SRA is based on the conceptual model presented in the Environmental Setting and Site Design (ESSD) report dated November 2022 which is provided at Appendix F to the application. Details presented in the ESSD include:

- the site location,
- the environmental setting of the site,

- the site geology, hydrology and hydrogeology,
- the history of the site,
- the recovery site design,
- the potential contamination migration pathways and receptors, and
- the waste acceptance procedures to verify that waste material permitted under the site recovery permit only will be accepted at the site.

Site location

v) The site is centred approximately on National Grid Reference (NGR) SK 171 133 approximately 70m south east of the village of Alrewas and approximately 530m east of the village of Fradley at its closest point. With the exception of Phase 7 the site lies to the south south west of Phases 1 and 2 of Alrewas Quarry which are currently being restored to agriculture, amenity and nature conservation. Phases 1 and 2 are the subject of an existing inert waste landfill permit (Environmental Permit number EPR/EB3509GE). Phase 7 is located to the north east of Phases 1 and 2. A railway line runs along the western boundary of the site and is located approximately 10m west of the site at its closest point. The A38 dual carriageway runs generally parallel to the railway line and is approximately 40m west of the site at its closest point. The A513, which runs in a generally east west direction, separates Phases 1 and 7 to the north of the A513 from Phases 2 to 6 to the south of the A513. There are several other minor roads in the area of Phases 3 to 7 some of which separate and/or delineate the phases of operation. In addition to the properties in Alrewas and Fradley there are several residential properties and agricultural and commercial premises in the area of Phases 3 to 7 The site location is shown on Figure SRA 1.

Topography

vi) Topography survey data for the site and the immediate surrounds provided by Tarmac is presented on Figure SRA 2. Mineral extraction operations are ongoing at the site. Original ground levels at the site fall gently at a gradient of approximately 1v:100h from west to east, with local gradients of up to approximately 1v:30h. The original ground levels at the site fall from a high of approximately 61mAOD in the south west of Phase 4B to a low of approximately 52m AOD in the east of the mid-northern section of the site. In the areas where excavation has taken place the base of excavation is at an elevation of approximately 49m AOD.

Geology

vii) A detailed description of the geology at the site is presented in the ESSD report. In summary, the geology of the site comprises superficial sand and gravel deposits underlain by Mercia Mudstone.

viii) Based on the British Geological Survey geological mapping the site is generally underlain by superficial deposits comprise Quaternary River Terrace Deposits and/or Glaciofluvial Sheet Deposits. The south west of Phase 7 and the west of Phase 6 is underlain by the Holme Pierrepoint Sand and Gravel Member of the Trent Valley Formation. BGS borehole and mineral exploration and groundwater monitoring boreholes drilled in the vicinity of the site record 0.2m to 0.5m thick sandy or clayey topsoil overlying sand and gravel deposits which vary in thickness across the site between 0.9m to 6.6m thick with the maximum proven base of the mineral at 7.0mbgl.

ix) The superficial deposits are underlain by mudstone comprising the Gunthorpe Member of the Triassic Mercia Mudstone Group. Information published by the British Geological Survey record the Mercia Mudstone as being between 70m to 90m thick in the region. BGS borehole logs from the vicinity of the site records the thickness of the Mercia Mudstone (Gunthorpe Member) of at least 33m and 39m.

Hydrogeology

x) A detailed description of the hydrogeology is provided in the ESSD report.

xi) The river terrace and glaciofluvial sheet deposits at the site are water bearing and are designated as a Secondary A aquifer containing permeable layers capable of supporting water supplies at a local rather than strategic level. Permeability tests carried out in the sand and gravel deposits at the site in 2015 yielded hydraulic conductivities of approximately 5.2 x 10^{-6}m/s and approximately 8.4 x 10^{-6}m/s.

xii) The Mercia Mudstone Group at the site is designated as a Secondary B aquifer containing predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. A permeability test was carried out in the mudstone during a site investigation in the vicinity of the site in 1988 and yielded a hydraulic conductivity of approximately 5 x 10^{-11}m/s.

xiii) Based on information available on the MAGIC website the site is not located within a groundwater Source Protection Zone (SPZ) for public drinking water supply.

Groundwater Flow

xiv) Based on topography and the groundwater levels recorded in the superficial deposits the direction of groundwater flow at and in the vicinity of the proposed extension generally is to the east towards the River Tame. Locally groundwater levels and the direction of groundwater flow may be influenced by dewatering at the existing quarry. In the northern part of Phase 6 there may be a north easterly component of groundwater flow due to dewatering in the currently permitted area the subject of Environmental Permit number EPR/EB3509GE. Groundwater levels recorded in boreholes installed in the superficial deposits at the site range from between approximately 53mAOD and 56mAOD in the west to between approximately 50mAOD and 53mAOD in the east.

General Site Design

xv) The site comprises 10 phases which will be worked progressively to recover the sand and gravel resources. Phases 6A, 6B, 6C and 7 are located in the northern area of the site, Phases 3A, 3B and 4A are located in the central area of the site and Phases 4B, 5A and 5B are located in the southern area of the site. Following sand and gravel extraction and prior to restoration the phases will continue to be dewatered so that the basal mudstones can be exposed. The phases will be progressively restored with inert waste with an external side slope attenuation layer constructed against the permeable sand and gravel deposits and keyed into the basal mudstone. The design of the quarry slopes, the proposed construction of the attenuation layer and subsequent recovery operations at the site are consistent generally with the operations undertaken within the Phases 1 and 2 of Alrewas Quarry which are operated under an existing inert waste landfill permit. Extraction of sand and gravel deposits has commenced in some phases at the site and the proposed extracted profile is shown on Figure SRA 3.

Quarry Base Design

xvi) The base of the mineral extraction at the site will be generally flat with the phases separated by unexcavated strips of in situ ground where several small roads and tracks which cross the site have been retained. The basal elevation of the excavated areas range between approximately 44mAOD and 58mAOD and are generally flat or fall gently to the south east with typical gradients of between approximately 1v:100h and 1v:50h, but locally increasing to approximately 1v:15h. The base of the extraction comprises the Mercia Mudstone (Gunthorpe Member).

xvii) Groundwater in the vicinity of the site is recorded in the overlying sand and gravel deposits and will be dewatered as necessary to facilitate the extraction and recovery operations. Dewatering will continue following the mineral extraction operations such that the waste will not be deposited directly into water. Groundwater has not been encountered in the Mercia Mudstone strata underlying the site.

Quarry Side Slope Design

xviii) The extracted profile is shown on Figure SRA 3. The external excavated slopes will be between 1.5m and 7m high with slope gradients of between 1v:1h and 1v:2h. The external side slopes will comprise the situ sand and gravel deposits and overlying soils. The stability, design, monitoring and maintenance of the excavations and slopes is the subject of separate ongoing geotechnical assessments as required by the Quarries Regulations 1999.

Attenuation layer

xix) The ESSD and HRA reports for the site specify that where a natural geological barrier equivalent to 1m of in situ material with a hydraulic conductivity no greater than 1×10^{-7} m/s is not present it is necessary to construct an equivalent attenuation layer.

xx) The base of the quarry comprises the Gunthorpe Member of the Mercia Mudstone Group. Based on lithological descriptions from borehole logs in the vicinity of the site it is considered that the Gunthorpe Member at the site comprises low permeability clay deposits which can be expected to form a natural geological barrier equivalent to 1m of in situ material with a hydraulic conductivity no greater than 1×10^{-7} m/s and it is not necessary to construct a basal attenuation layer.

xxi) Where an area of the Mercia Mudstone (Gunthorpe Member) forming the quarry base is determined through Construction Quality Assurance (CQA) procedures at the site to not form a natural geological barrier then a section of basal attenuation layer equivalent to 1m of in situ material with a hydraulic conductivity no greater than 1 x 10^{-7} m/s will be constructed locally over this area extending beyond it by 3m in all directions.

xxii) As the external side slopes of the excavation will comprise sand and gravel deposits and it is considered that the hydraulic conductivity of the sand and gravel deposits at the site is greater than 1 x 10^{-7} m/s, it will be necessary to construct a side slope attenuation layer equivalent to a natural geological barrier 1m thick with a hydraulic conductivity of no greater than 1 x 10^{-7} m/s against the external side slopes.

xxiii) The procedures for the selection, placement, and compaction of the materials used to form the attenuation layer will be agreed with the Environment Agency through the preparation and approval of a Construction Quality Assurance (CQA) Plan in accordance with Environment Agency guidance[1] to achieve a hydraulic conductivity of no greater than 1 x 10^{-7} m/s and a shear strength of no less than 40kPa.

xxiv) The external side slope attenuation layer will be constructed to a height of up to 7m and to a minimum thickness of 1m perpendicular to the face of the slope. Slopes will be constructed to achieve a maximum internal slope gradient no steeper than 1v:3h. Where required the basal attenuation layer will be constructed to a minimum thickness of 1m perpendicular to the base of the quarry. Schematic diagrams showing the construction design for the external side slope and basal attenuation layer are presented on Figure SRA 4.

xxv) The construction of the attenuation layer will be the subject of Construction Quality Assurance (CQA) as specified in the Environment Agency guidance[1].

xxvi) Filling against the attenuation layer will commence shortly after the construction of each lift of the external side slope attenuation layer or basal attenuation layer where applicable. Dewatering will continue during the construction of the attenuation layer and during waste placement as necessary.

[1] https://www.gov.uk/guidance/waste-recovery-engineering-create-a-construction-quality-plan

Restored Slope Design

xxvii) It is estimated that approximately 3.6 million m^3 of imported inert material will need to be placed in the excavated void to restore the site. The site will be restored to agriculture, amenity and nature conservation. The proposed restoration profile is shown on the drawings at Appendix SRA A.

1.2. Conceptual Stability Site Model (CSSM)

i) The principles of the site design as presented above have been used to define the individual slopes and materials which comprise each of the elements considered in the stability risk assessment.

1.2.1 Basal Sub-Grade Model

i) The base of the excavation will be generally flat with typical maximum gradients of 1v:100h. The base will be at an elevation of approximately 44mAOD to 58mAOD and will comprise the in situ low permeability Mercia Mudstone (Gunthorpe Member) which has a thickness of at least 33m. Groundwater has not been encountered in the Mercia Mudstone strata underlying the site.

1.2.2 Side Slope Sub-Grade Model

i) The external side slopes will comprise the in situ overburden and sand and gravel deposits. The external side slopes will be excavated at gradients of up to approximately 1v:1h and to a maximum depth of approximately 7m. Groundwater is present within the sand and gravel deposits and the deposits will be dewatered to facilitate mineral extraction and infilling. Site excavations and slopes will be subject to ongoing geotechnical assessment as required by the Quarries Regulations 1999.

1.2.3 Basal Attenuation Layer Model

i) Where the Mercia Mudstone (Gunthorpe Member) of the basal sub-grade is considered to provide a suitable natural basal geological barrier no artificially constructed attenuation layer is necessary.

ii) Where the Mercia Mudstone (Gunthorpe Member) of the basal sub-grade is not considered to provide a suitable natural basal geological barrier a section of artificially constructed attenuation layer will be constructed over the unsuitable area to a minimum thickness of 1m perpendicular to the base of the quarry area extending beyond it by 3m in all directions.

iii) The basal attenuation layer will be constructed using Mercia Mudstone available at the site or imported from other sites. The Mercia Mudstone materials will be selected, placed and compacted to achieve a minimum undrained shear strength of 40kPa and a hydraulic conductivity of no greater than 1 x 10^{-7} m/s.

1.2.4 Side Slope Attenuation Layer Model

i) An external side slope attenuation layer will be constructed prior to the deposition of inert waste. Dewatering will continue during the construction of the attenuation layer to maintain groundwater levels below the base of the construction works. The external side slope attenuation layer will be constructed in lifts of up to 3m in height with internal slope gradients no steeper than 1v:3h and to a minimum thickness of 1m perpendicular to the side slopes of the excavation.

ii) The attenuation layer will be constructed using Mercia Mudstone available at the site or imported from other sites. The Mercia Mudstone materials will be selected, placed and compacted to achieve a minimum undrained shear strength of 40kPa and a hydraulic conductivity of no greater than 1 x 10^{-7} m/s.

1.2.5 Waste Mass Model

i) The inert waste materials will be placed generally in horizontal layers so that no significant internal slopes are formed during the recovery operations. The site will be worked progressively from Phase 3 (current working area) to Phase 7 as detailed in the Waste Recovery Plan (WRP). The upper surface of the waste mass will consist of placed suitable imported inert waste and on site soils and overburden to form the restored landform.

ii) Dewatering of the site will continue throughout the infilling operations to maintain groundwater levels below the base of the waste until the level of material placement is above natural groundwater level.

1.2.6 Capping System and Restoration Model

i) No capping system is proposed. The final restoration will consist of placed suitable imported inert waste and on site soils and overburden to form the restored landform. The restored profile will be gently undulating with localised areas of maximum gradients of approximately 1v:25h.

2 STABILITY RISK ASSESSMENT

2.1 Risk Screening

i) A risk screening of the CSSM is presented in this section of the SRA. The risk screening considers each element of the CSSM and assesses whether the component of each element needs further detailed assessment.

2.1.1 Basal Sub-Grade Screening

i) The basal sub-grade is formed in the natural in situ Mercia Mudstone (Gunthorpe Member). The basal profile will be generally flat with gradients of approximately 1v:100h falling gently from west to east, with local gradients of up to approximately 1v:30h. Groundwater has not been encountered in the Mercia Mudstone strata underlying the site. The excavations at the site are the subject of ongoing geotechnical assessment as required by the Quarries Regulations 1999. As a result it is unnecessary to undertake separate quantitative assessments of the basal sub-grade.

2.1.2 Side Slope Sub-Grade Screening

i) The side slopes excavations will be the subject of ongoing geotechnical assessment as required by the Quarries Regulations 1999. As a result it is unnecessary to undertake separate quantitative assessments of the side slope sub-grade.

2.1.3 Basal Attenuation Layer Screening

i) As sections of basal attenuation layer will be constructed on the generally flat base of the quarry to a minimum thickness of 1m and will be confined by waste placed over them it is not necessary to undertake a quantitative analysis of the short or long term stability of the basal attenuation layer.

ii) Where a section of basal attenuation layer may be constructed directly beneath the side slope attenuation layer the basal attenuation layer will be considered part of the side slope attenuating layer.

2.1.4 Side Slope Attenuation Layer Screening

i) As each lift of the external side slope attenuation layer will be constructed to an internal slope gradient of up to 1v:3h and up to a height of 3m it is appropriate to undertake a quantitative analysis of the short term stability of the external side slope attenuation layer to verify that a suitable factor of safety against slope failure is achieved.

ii) As in the long term the external side slope attenuation layer will be supported by inert materials placed against it, it is unnecessary to assess further the long term stability of the external side slope attenuation layer.

2.1.5 Waste Mass Screening

i) As the internal temporary slopes formed during the placement of waste will be generally horizontal with no significant slopes constructed and as dewatering will continue during the restoration to maintain groundwater levels at a depth sufficient to pose no significant risk it is unnecessary to undertake quantitative assessments of the waste mass.

2.1.6 Capping System and Restoration Screening

i) No capping system is proposed.

ii) As the restored landform will have slope gradients no greater than approximately 1v:25h it is considered unnecessary to undertake quantitative slope stability assessments of the site restoration.

2.2 Life Cycle Phases

i) The site will be excavated and infilled progressively. The critical phase in relation to stability will be during the construction of the side slope attenuation layer and the placement of supporting inert waste against the side slope attenuation layer, during which the areas of excavation and infilling will need to be dewatered until the level of waste has reached a level above the natural groundwater level.

2.3 Data Summary

i) The data used in the stability analysis and the data sources are presented in Table SRA 1.

2.4 Justification for Modelling Approach and Software

i) Based on the results of the risk screening a quantitative SRA has been undertaken to assess the short term stability of the side slope attenuation layer. All other elements have been assessed qualitatively in the risk screening as not needing further assessment.

ii) The stability risk assessment analyses have been undertaken in general accordance with conventional British Standard methodologies using global factors of safety rather than incorporating partial factors into the individual parameters describing the slopes, strengths and forces.

iii) Analysis of stability against rotational failure of the side slope attenuation layer is undertaken using the two dimensional limit equilibrium programme SLOPE/W. Slopes are analysed using the Spencer method. The Spencer method has been selected as it is one of the more mathematically robust limit equilibrium methods and considers the shear and the normal inter-slice forces together with moment and force equilibrium (Reference 2). It is considered that this method is more appropriate than simpler methods such as Bishop's Simplified Method or Janbu's Simplified Method.

2.5 Justification for Geotechnical Parameters Selected for Analysis

2.5.1 Parameters Selected for Basal Sub-Grade Analysis

i) No quantitative assessment of the basal sub-grade is necessary.

2.5.2 Parameters Selected for Side Slope Sub-Grade Analysis

i) No quantitative assessment of the side slope sub-grade is necessary.

2.5.3 Parameters Selected for Basal Attenuation Layer Analysis

i) No independent quantitative assessment of the basal attenuation layer is necessary as detailed in Section 2.1.3. Where a section of basal attenuation layer is constructed beneath or directly adjacent to the side slope attenuation layer it will be considered part of the side slope attenuating layer.

2.5.4 Parameters Selected for Side Slope Attenuation Layer Analysis

ii) The model represents the construction of the initial 3m lift of the external side slope attenuation layer against the excavated slope gradient shown on the worked out model such that:

a. The basal sub-grade of the site is a horizontal surface formed of Mercia Mudstone (Gunthorpe Member).

b. The external side slope sub-grade has a slope gradient of 1v:1h, a height of 3m and is formed of superficial sand and gravel deposits.

c. The initial lift of the external side slope attenuation layer has a slope gradient of 1v:3h and a height of 3m and is modelled as a wedge with a minimum horizontal thicknesses of 1.5m (to represent the minimum horizontal thickness necessary to maintain a minimum 1m perpendicular thickness).

d. Elevated groundwater levels and pressures are not included as dewatering will continue during the construction of the external side slope attenuation layer and during infilling until the level of the waste is above the natural groundwater level.

ii) The values for the geotechnical parameters used are based on specified values, site specific information and parameters published in Hoek and Bray (1981) (Reference 3).

a. As the attenuation layer will be constructed from site derived material or selected imported inert waste that will be placed and compacted to achieve a minimum undrained shear strength of 40kPa, a shear strength of 40kPa is used to represent the side slope attenuation layer material in the model. A unit weight of 17 kN/m^3 is used in the modelling based on the lowest values provided for stiff glacial clay by Hoek and Bray (Reference 3).

b. The superficial sand and gravel deposits of the external side slope sub-grade are modelled as having an angle of friction of 45°, an apparent cohesion of 0kPa and a unit weight of $19kN/m^3$. These values for the strength parameters are equivalent to the minimum needed for a drained granular material which has an angle of repose of 1v:1h. As stated in the description of the conceptual model the external side slopes at the site which will form the sub-grade are excavated in sand and gravel deposits at gradients of up to approximately 1v:1h. The unit weight of the sand and gravel is based on values provided for sand and gravel of mixed grain size by Hoek and Bray (Reference 3).

c. The Mercia Mudstone (Gunthorpe Member) bedrock underlying the superficial deposits is modelled as impenetrable bedrock.

2.5.5 Parameters Selected for Waste Mass Analysis

i) No quantitative assessment of the waste mass is necessary.

2.5.6 Parameters Selected for Capping System and Restoration Analysis

i) No capping system is proposed as detailed in Section 1.2.6.

ii) No quantitative assessment of the site restoration is necessary.

2.6 Selection of Appropriate Factors of Safety

2.6.1 Factor of Safety for Basal Sub-Grade

i) Analysis of the stability of the basal sub grade is not necessary as detailed in Section 2.1.1.

2.6.2 Factor of Safety for Side Slope Sub-Grade

i) Analysis of the stability of the external side slope sub grade is not necessary as detailed in Section 2.1.2.

2.6.3 Factor of Safety for Basal Attenuation Layer

i) Analysis of the stability of a basal attenuation layer is not necessary as detailed in Section 2.1.3.

2.6.4 Factor of Safety for Side Slope Attenuation Layer

i) A factor of safety of 1.3 has been selected for the assessment of the external side slope attenuation layer as during a failure event of the side slope attenuation layer the failure will be contained within the site boundary, can be monitored and remediated, and would not extend outwards towards nearby buildings and infrastructure. This is consistent with Environment Agency guidance (Reference 4) and British Standards BS6031:2009 (Reference 5).

2.6.5 Factor of Safety for Waste Mass

i) Analysis of the waste mass is not necessary as detailed in Section 2.1.5.

2.6.6 Factor of Safety for Capping System and Restoration

i) Analysis of the capping system and restoration is not necessary is detailed in Section 2.1.6.

2.7 Analysis

i) This sub-section provides the results of the quantitative analysis where identified as needed as part of the risk screening.

2.7.1 Basal Sub-Grade Analysis

i) No analysis has been conducted on the basal sub-grade.

2.7.2 Side Slope Sub-Grade Analysis

i) No analysis has been conducted on the side slope sub-grade.

2.7.3 Basal Attenuation Layer Analysis

i) No analysis has been conducted on the basal attenuation layer.

2.7.4 Side Slope Attenuation Layer Analysis

i) The stability analysis of the 3m high external side slope attenuation layer with a minimum horizontal thickness of 1.5m with a slope gradient of 1v:3h onto the underlying Mercia Mudstone (Gunthorpe Member) yields a factor of safety of 6.050 which is above the target factor of safety of 1.3 and is therefore considered stable. The SLOPE/W plot of the assessment is presented at Appendix SRA B.

ii) Given the conservative selection of parameters, low risk due to slope failure and high factors of safety determined in the analysis no further sensitivity analysis has been undertaken.

2.7.5 Waste Mass Analysis

i) No analysis has been conducted on the waste mass.

2.7.6 Capping System and Restoration Analysis

i) No analysis has been conducted on the capping system and restoration.

2.8 Assessment

2.8.1 Basal Sub-Grade Assessment

i) Due to the shallow basal slopes, thickness and lack of recorded groundwater within the Mercia Mudstone (Gunthorpe Member) at the site it is considered that the basal sub-grade is stable and that there is no potential for basal heave at the site.

2.8.2 Side Slope Sub-Grade Assessment

i) The side slopes excavations at the site will be the subject of ongoing geotechnical assessment as required by the Quarries Regulations 1999. As a result it is unnecessary to undertake separate assessments of the side slope sub-grade.

2.8.3 Basal Attenuation Layer Assessment

i) No independent quantitative assessment of the basal attenuation layer is necessary as detailed in Section 2.1.3.

2.8.4 Side Slope Attenuation Layer Assessment

i) The stability of the external side slope attenuation layer has been analysed in the short term and the resulting lowest factor of the scenarios assessed is 6.050 which is above the target factor of safety of 1.3 and is therefore considered stable.

ii) In the long term the external side slope attenuation layer will be supported by inert waste placed against it and therefore is considered stable.

2.8.5 Waste Mass Assessment

i) As the internal temporary and final waste slopes will be generally horizontal and dewatering will continue during recovery operations to maintain groundwater levels below the level of waste, the waste mass is considered stable.

2.8.6 Capping System and Restoration Assessment

i) No capping system is proposed.

ii) As the restored landform will have slope gradients no greater than approximately 1v:25h it is considered that the restoration will be stable.

3 MONITORING

3.1 The risk based monitoring scheme

i) The results of the SRA show that all elements of the proposed site design, where assessed, are stable and where analysed achieve appropriate factors of safety.

ii) A weekly visual inspection of the exposed sub-grade, external side slope attenuation layer and the waste mass for signs of settlement or instability is appropriate for monitoring at the site. The results of the weekly inspections will be recorded in the site diary during the operation of the site. In the unlikely event that areas of concern are identified from the weekly inspection further assessment and remediation will be carried out as necessary.

iii) It will be necessary to monitor and control groundwater at the site during the extraction and filling works so that groundwater is dewatered in the sand and gravel deposits overlying the base of the quarry until placement of waste has reached a level above the natural groundwater level. A programme of groundwater monitoring is presented as part of Table ESSD 2 of the ESSD.

3.1.1 Basal Sub-Grade Monitoring

i) The basal sub-grade will be the subject of ongoing geotechnical assessment as required by the Quarries Regulations 1999.

3.1.2 Side Slopes Sub-Grade Monitoring

i) The side slopes excavations at the site will be the subject of ongoing geotechnical assessment as required by the Quarries Regulations 1999.

3.1.3 Basal Attenuation Layer Monitoring

i) The construction of a basal attenuation layer where required will be the subject of Construction Quality Assurance (CQA) to verify that it is constructed to a minimum perpendicular thickness of 1m and from materials which achieve a hydraulic conductivity of no greater than 1×10^{-7} m/s and a shear strength of no less than 40kPa. Prior to the construction of the attenuation layer a CQA Plan shall be prepared and agreed in accordance with Environment Agency guidance[1].

3.1.4 Side Slope Attenuation Layer Monitoring

i) The construction of the external side slope attenuation layer will be the subject of Construction Quality Assurance (CQA) to verify that it is constructed with maximum slope gradients of 1v:3h and to a minimum perpendicular thickness of 1m and from materials which achieve a hydraulic conductivity of no greater than 1×10^{-7} m/s and a shear strength of no less than 40kPa. Prior to the construction of the attenuation layer a CQA Plan shall be prepared and agreed in accordance with Environment Agency guidance[1].

ii) Placement of inert waste will commence shortly after construction of the attenuation layer to provide support to the side slope attenuation layer.

iii) The external side slope attenuation layer will be monitored for signs of instability by weekly visual inspections as detailed above.

3.1.5 Waste Mass Monitoring

i) The waste mass will be monitored for signs of settlement or instability by weekly visual inspections as detailed above.

3.1.6 Capping System and Restoration Monitoring

i) No capping system is necessary.

ii) The restoration will be monitored for signs of settlement or instability by weekly visual inspections as detailed above.

REFERENCES

1. Environmental Permitting (England and Wales) Regulations. ‘Information in support of an application for a landfill permit – Stability Risk Assessment Report’, Environment Agency, 2010

2. Slope Stability Modelling with Slope/W 2007 Version. An Engineering Methodology. Fourth Edition, February 2010. GEO-SLOPE International Ltd.

3. Hoek and Bray “Rock Slope Engineering: Third Edition” 1981.

4. Environment Agency “Stability of Landfill Lining Systems: Report No. 2 Guidance” R&D Technical Report P1-385/TR2.

5. British Standard BS6031 – 2009, Code of practice for Earthworks.

TABLES

Table SRA 1

Geotechnical parameters used in the stability modelling

Material	Unit weight	Undrained parameters (short term)	Drained parameters (long term)
Side slope attenuation layer constructed from Mercia Mudstone available at the site or imported from other sites	γ = 17 kN/m^3 (1)	C_u = 40 kPa (2)	Not required
In situ sand and gravel deposits	γ = 19 kN/m^3 (1)	Not required	Ø' = 45° (3) c' = 0 kPa (3)
Mercia Mudstone (Gunthorpe Member)	Modelled as impenetrable bedrock		

Notes: γ Unit weight

Ø' Friction angle

c' Apparent cohesion

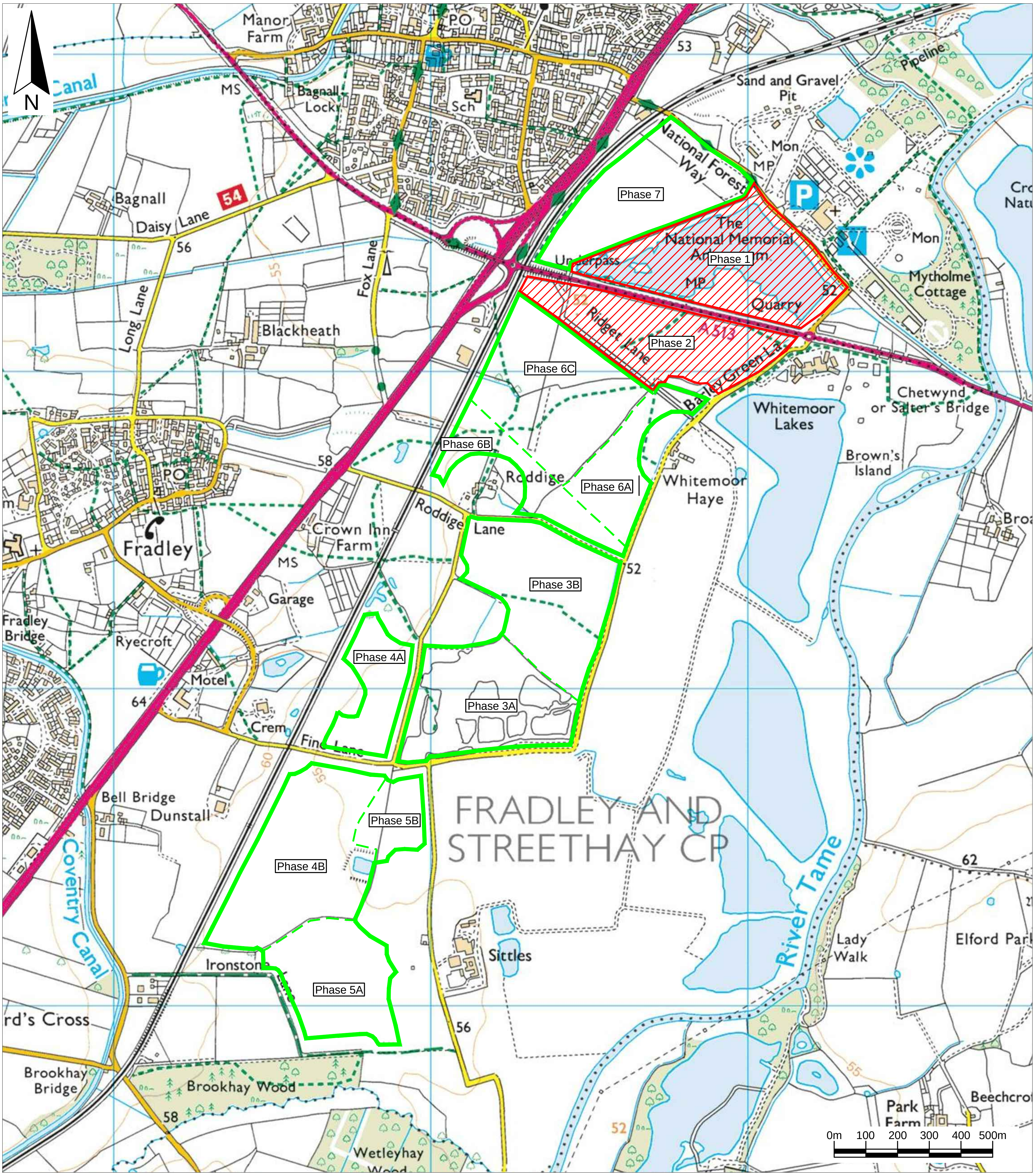
C_u Undrained shear strength

(1) Values based on conservative estimates taken from Hoek and Bray, "Rock Slope Engineering", 1981.

(2) Values based on minimum specified undrained shear strength.

(3) Value is conservatively based on minimum friction angle needed to achieve the 1v:1h excavated sand and gravel faces at the site.

FIGURES



Key / Notes

Environmental Permit boundary

Currently permitted area the subject of Environmental Permit number EPR/EB3509GE

Rev	Status	Drn	App	Chk	Date
	Final	JCR	JCR	GT	02/12/22

Site: ALREWAS QUARRY

Client: TARMAC A CRH COMPANY

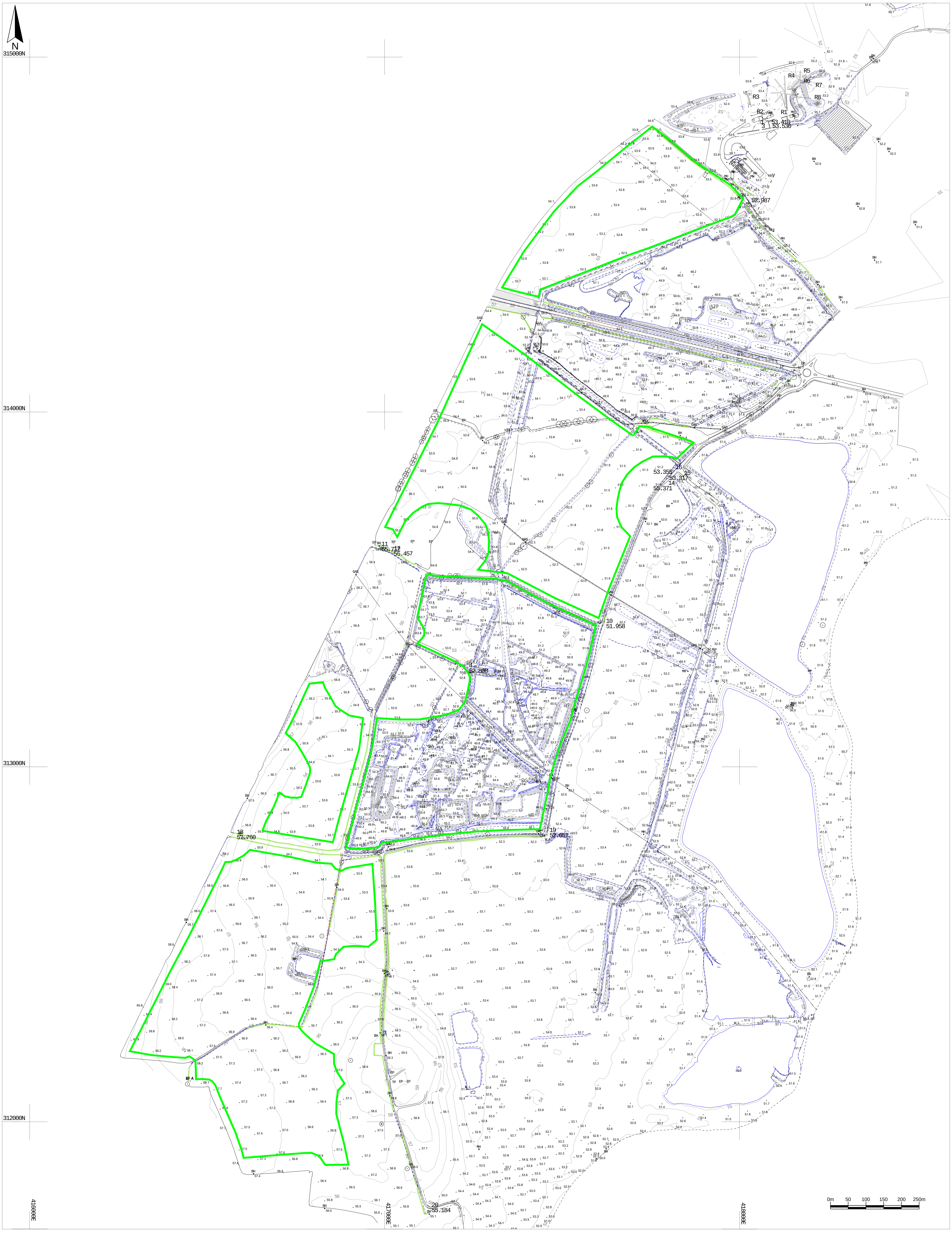
Title: Site location and layout

Figure SRA 1

Scale: 1:12,500@A3

Drawing Ref: TAR/AL/12-20/22164

MJCA
Technical advisers on environmental issues
Baddesley Colliery Offices, Main Road, Baxterley, Atherstone, Warwickshire, CV9 2LE.
Telephone : 01827 717891
Fax : 01827 718507



Key / Notes

Environmental Permit boundary	Foliage Line	Plant/structure
Top of bank	Hedge	Edge of Water
Bottom of bank	Tree	Contours (mAOD)
Fence	Road	Spot heights (mAOD)
Gate	Track	Borehole
	Pipe	
	Building	

Based on survey reference "A301 ALREWAS 2019-10-08 QU.LSS" provided by Sirius on 4 December 2019

Rev	Status	Drn	App	Chk	Date
	Final	JCR	JCR	GT	02/12/22

Site: ALREWAS QUARRY

Client: TARMAC A CRH COMPANY

Title: Topographical survey of the site

Figure SRA 2

Scale: 1:5,000@A1

Drawing Ref: TAR/AL/12-20/22165

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Warwickshire, CV9 2LE.
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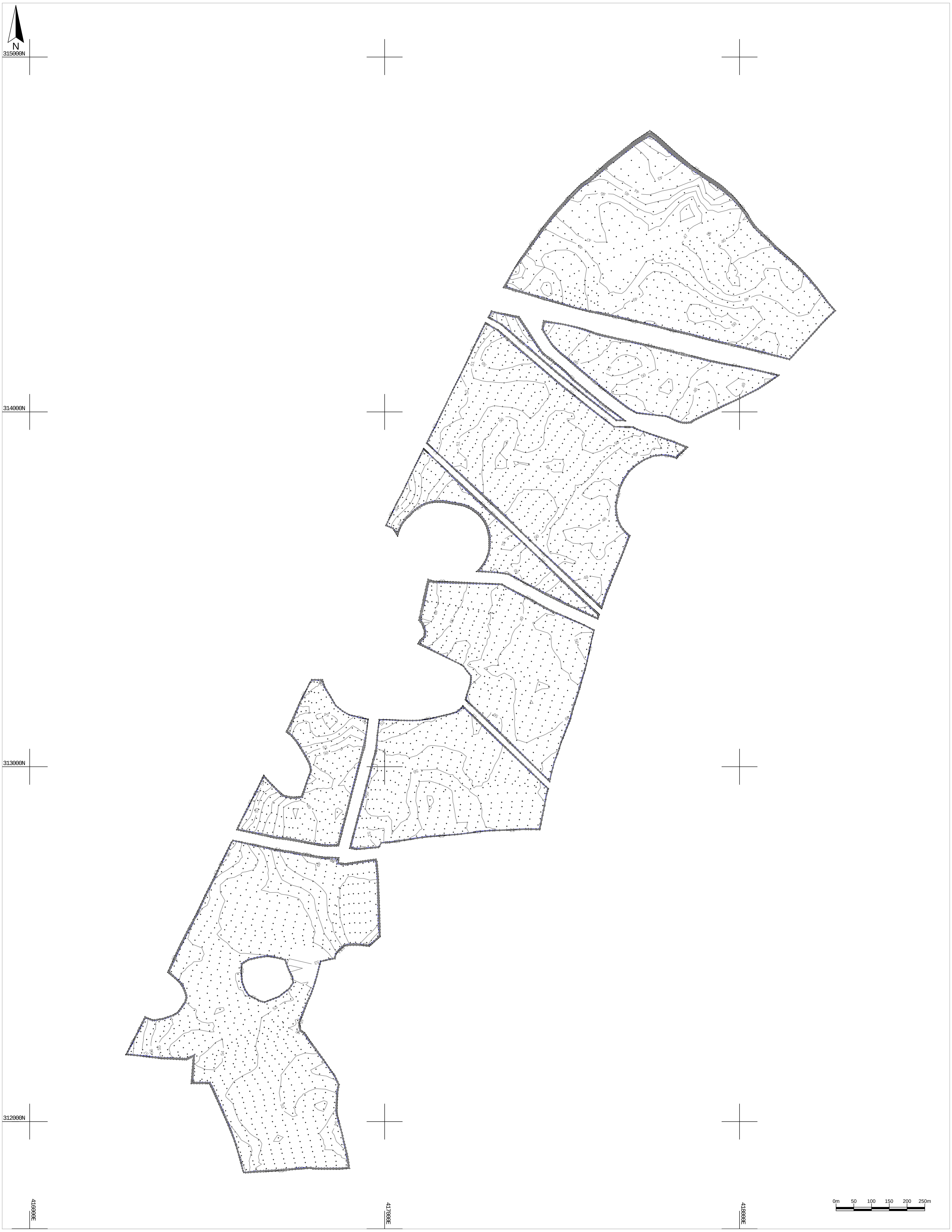

Key / Notes

—	Bottom of bank	—	Top of bank
—	Building	—	Track
— 52 —	Contours (mAOD)	—	Water
+	Level marker		
—I—	Fence		
	Hedge		
—	Kerb		

Based on survey reference "#5 BASE OF MINERAL EXTRACTION MODEL.LSS" provided by Sirius on 4 December 2019

Rev	Status	Drn	App	Chk	Date
	Final	JCR	JCR	GT	02/12/22

Site: ALREWAS QUARRY

Client: TARMAC A CRH COMPANY

Title: Proposed extracted profile

Figure SRA 3

Scale: 1:5,000@A1

Drawing Ref: TAR/AL/12-20/22166

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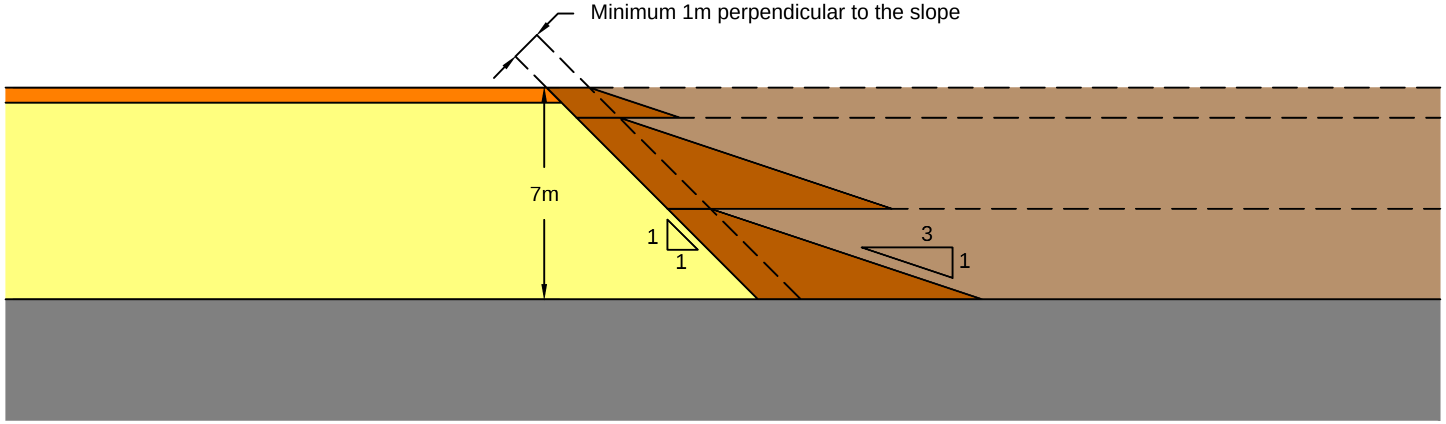
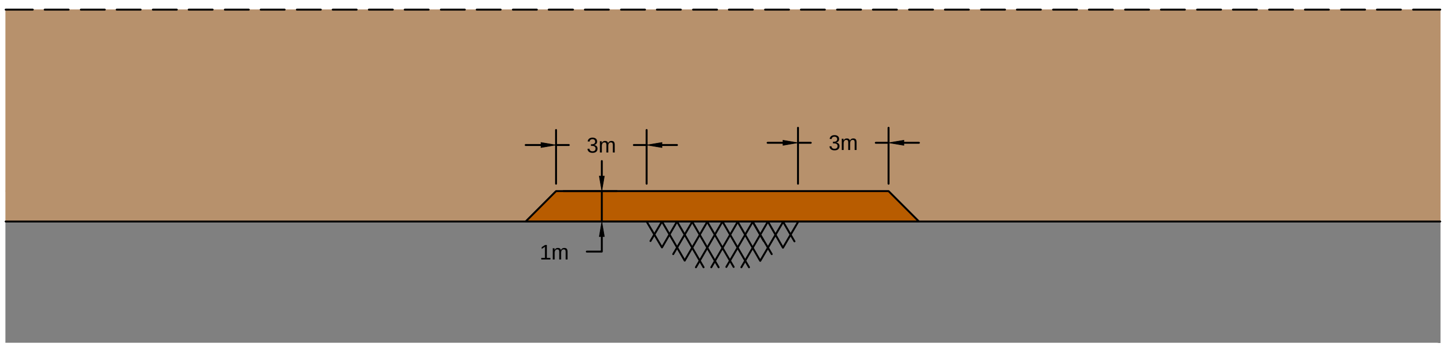
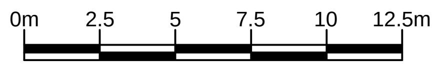
Side slope attenuation layer



Basal attenuation layer section





Key / Notes

- Overburden
- Sand and gravel
- Mercia Mudstone (Gunthorpe Member)
- Unsuitable area of basal sub-grade
- Attenuation layer
- Inert recovery materials

Rev	Status	Drn	App	Chk	Date
	Final	JCR	JCR	GT	02/12/22

Site
KETTLEBY QUARRY

Client
BREEDON

Title
Schematic drawing of the construction of the attenuation layer

Figure SRA 4

Scale 1:250@A4

Drawing Ref
TAR/AL/12-20/22167

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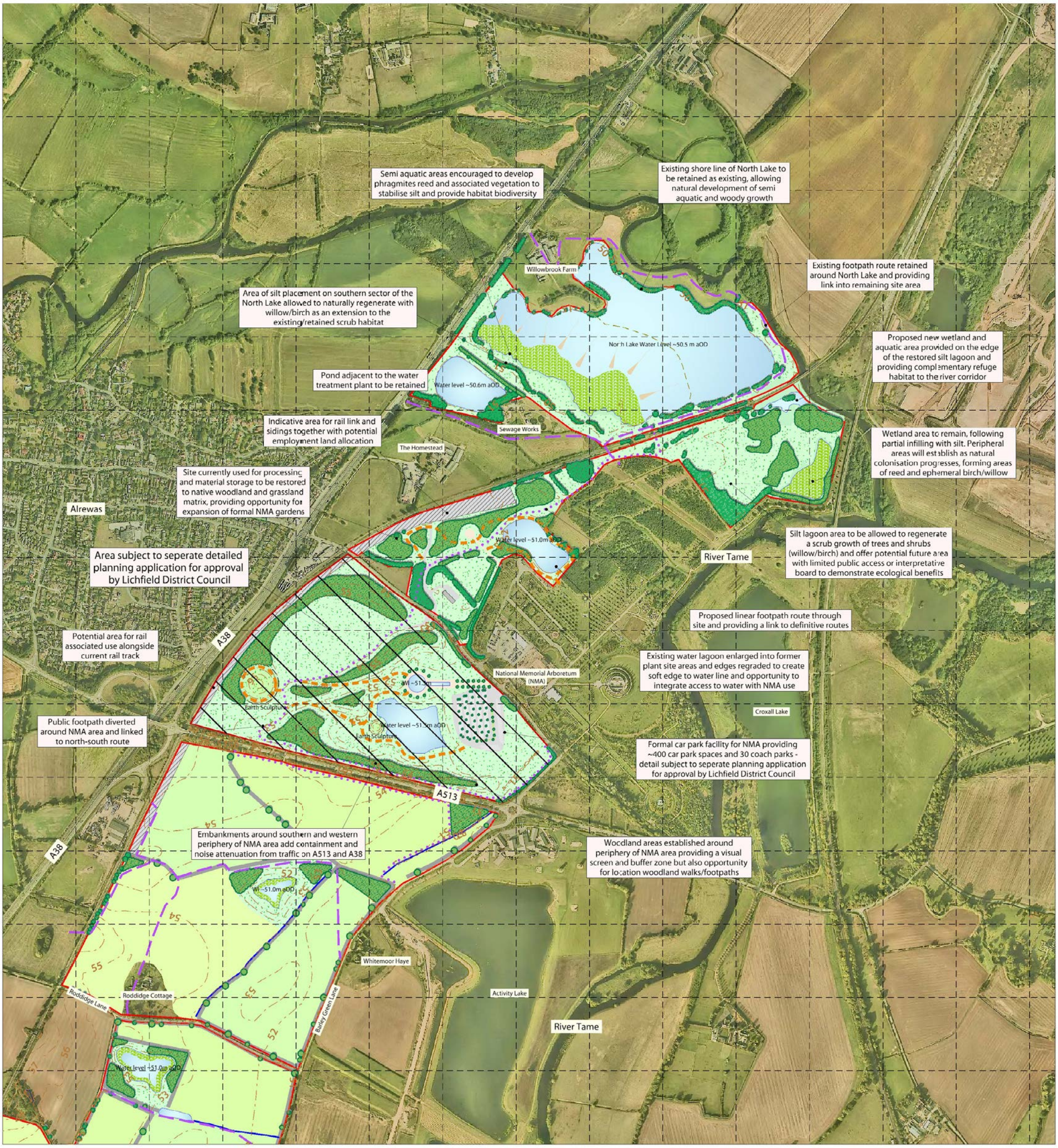
APPENDICES

APPENDIX A

DRAWINGS SHOWING THE RESTORED PROFILE



Legend

- Planning Application Boundary
- Grassland
- Agriculture
- 50 — Restoration Contours (m aOD)
- Existing Woodland Retained
- Proposed Woodland
- Proposed Individual Parkland Trees (may include ornamental species)
- Existing Hedgerow & Hedgerow Trees / Proposed Hedgerow & Hedgerow Trees
- Open Water
- Reedbed
- Marginal Wetland and Semi Aquatic Vegetation
- Drainage Ditches within Agricultural Areas
- Car Parking Area
- Potential Area for Sidings/ Rail Uses
- Main Pedestrian Paths into Parkland Area
- Illustrative Routes of Footpaths Providing Links within Parkland Area
- Linear Footpath Providing Link between Parkland Area and Wider Public Network
- Reinstated/Definitive Public Footpath
- Area subject to seperate detailed planning application for approval by Lichfield District Council

PleydellSmithyman

psl ref: M13.116(t).D.005-01

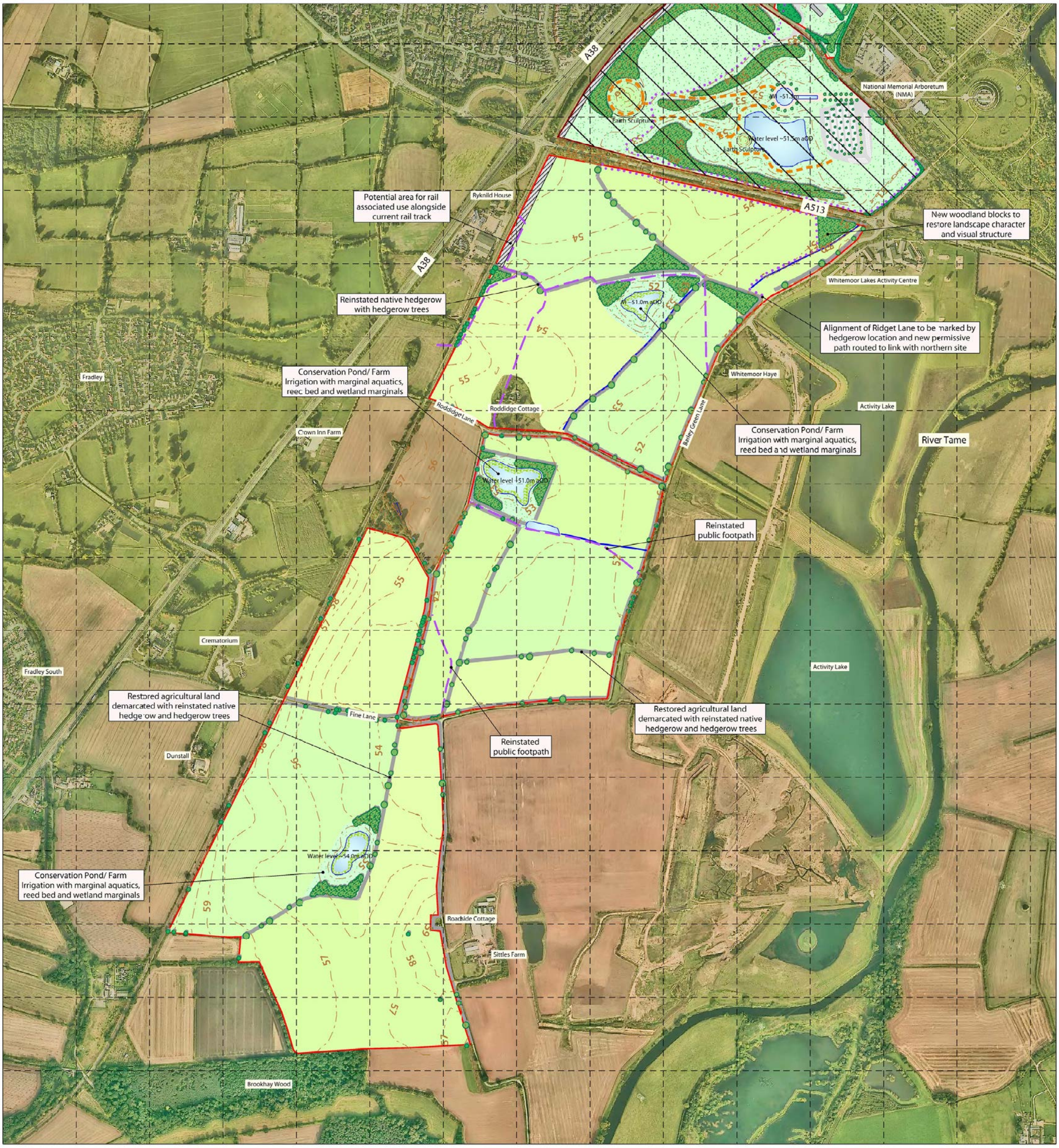
TARMAC
A CRH COMPANY

Site Name:
A301 - Alrewas Quarry

Drawing Name:
Southern Extension Restoration Plan (North)

Drawn By:	Scale @ A3:
C. Barrett	1:10,000
Date:	**Drawing Number:**
July 2019	A301-0079-05

N



Legend

- Planning Application Boundary
- Grassland
- Agriculture
- 50 — Restoration Contours (m aOD)
- Existing Woodland Retained
- Proposed Woodland
- Proposed Individual Parkland Trees (may include ornamental species)
- Existing Hedgerow & Hedgerow Trees / Proposed Hedgerow & Hedgerow Trees
- Open Water
- Reedbed
- Marginal Wetland and Semi Aquatic Vegetation
- Drainage Ditches within Agricultural Areas
- Car Parking Area
- Potential Area for Sidings/ Rail Uses
- Main Pedestrian Paths into Parkland Area
- Illustrative Routes of Footpaths Providing Links within Parkland Area
- Linear Footpath Providing Link between Parkland Area and Wider Public Network
- Reinstated/Definitive Public Footpath
- Area subject to seperate detailed planning application for approval by Lichfield District Council

PleydellSmithyman

psl ref: M13.116(t).D.005-02

TARMAC
A CRH COMPANY

Site Name:
A301 - Alrewas Quarry

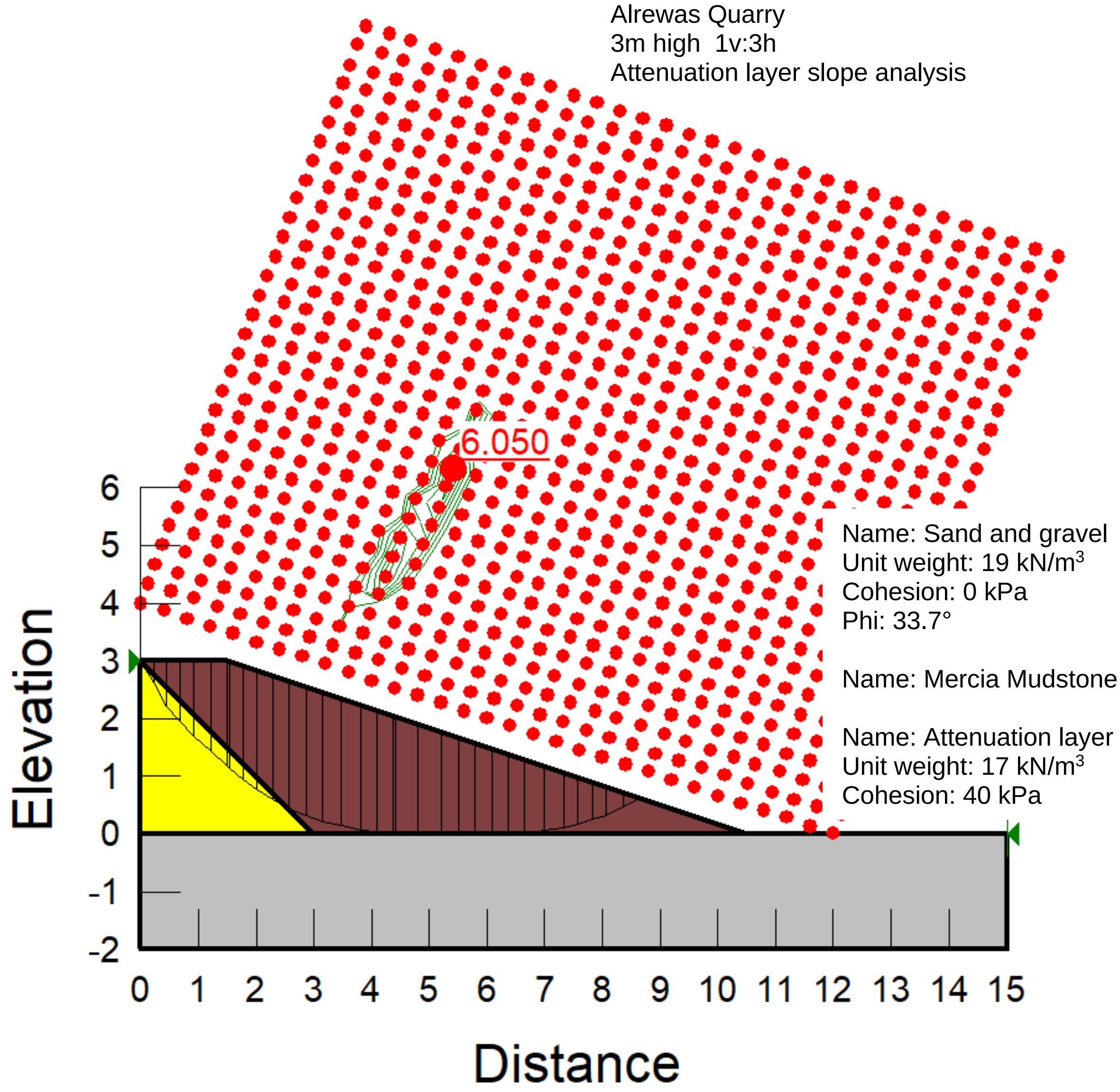
Drawing Name:
Southern Extension
Restoration Plan (South)

Drawn By:	Scale @ A3:
C. Barrett	1:10,000
Date:	Drawing Number:
July 2019	A301-0079-06

N

APPENDIX B

RESULTS OF THE STABILITY MODELLING



Alrewas Quarry
3m high 1v:3h
Attenuation layer slope analysis
6.050
Name: Sand and gravel
Unit weight: 19 kN/m3
Cohesion: 0 kPa
Phi: 33.7°
Name: Mercia Mudstone
Name: Attenuation layer
Unit weight: 17 kN/m3
Cohesion: 40 kPa
Elevation
Distance