

HS2

HS2 Assurance No.8 to NFU

Borrow Pit Review - Final

April 2019

OFFICIAL

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1 Introduction

1.1 Background

1.1.1 In May 2018, HS2 Ltd, on behalf of the Secretary of State for Transport, wrote to the National Farmers Union (NFU) to offer a number of assurances including one in relation to Borrow Pits – Assurance No.8, as follows:

1.1.2 *'Following the completion of preliminary Ground Investigation of the sites proposed under the Bill for development of Borrow Pits, but prior to the termination of proceedings on the Bill before the House of Commons Select Committee, the Promoter will publish a review of the extent of land likely to be required and in preparing the report the Promoter will consult with the NFU and those landowners on whose land the Borrow Pits are proposed to be developed.'*

1.1.3 The purpose of this report is to provide the review referenced in Assurance No. 8. This report was issued in February 2019 as a draft for consultation and was distributed to the NFU and those landowners on whose land the borrow pits are proposed to be developed as required by the assurance. At the time of final reporting, HS2 Ltd had not received any formal responses to the consultation draft. However, some of those consulted did include the issue in their petitions against Additional Provision 2 to the Bill.

1.2 Status of preliminary ground investigation data (April 2019)

1.2.1 The Borrow Pit Review (April 2019) is based on the draft preliminary ground investigation report that was available in January 2019. The final preliminary ground investigation report is due to be available in April 2019 and any changes to data will be reflected in updates to this review.

1.2.2 The preliminary ground investigation at the borrow pits and major cuttings is only the first stage of intrusive, and increasingly more complex, geotechnical investigations that will be undertaken during the development of the detailed design of HS2 Phase 2a; and the borrow pits and major cuttings preliminary ground investigation (PGI) is the second of four preliminary ground investigation work packages which will extend through to 2020.

1.2.3 Further detailed ground investigations will be undertaken between approximately 2020 and 2022 as the design is progressed through to final design by the Design & Build contractor(s) once they are appointed. As the design is developed and design changes are adopted, there may be changes in volumes of embankment material required and the availability of excavated material for use as borrow pit backfill. This could result in a change in the demand on the borrow pits and the way in which materials excavated from each borrow pit are used. These potential changes of demand could be a factor in the final overall borrow pit extents within the limits conferred by the Bill.

1.3 Description of contents

1.3.1 The report contains the following sections:

- Section 2 (and the supporting information in Appendix E) provides a description of each borrow pit (its extent, depth, and assumed quality of material in the absence of PGI), where the material extracted will be used and the source(s) of material that will be used to backfill each borrow pit. This section provides information on how the method of borrow pit operation will be approved and managed, including how the borrow pits might be screened to reduce visual and noise impacts during their operation;
- Section 3 (and the supporting information in Appendix F) describes how the assumptions on the HS2 Phase 2a scheme minerals requirements and excavated materials management strategy (the earthworks strategy) have changed during design in the absence of borrow pits and major cuttings specific ground investigation. It then goes on to describe the current assumptions on the HS2 Phase 2a scheme earthworks strategy (for AP2) informed by the PGI draft factual data;
- Section 4 provides an update on borrow pit specific information based on the findings of the PGI draft factual data and related studies that have been published as part of AP2; and explains how updates on hydrogeology will be reported. The supporting information in Appendix F includes a summary of the geology at each borrow pit; and
- Section 5 provides a discussion on borrow pit extents based on draft PGI results.

1.3.2 The report also includes a number of supporting appendices as follows:

- Appendix A – a glossary of terms and abbreviations;
- Appendix B – maps and plans showing the location and layout of the HS2 Phase 2a scheme borrow pits and the locations of the major cuttings. This appendix also provides the location of a potential alternative borrow pit (Borrow Pit X (BPX)), as proposed by a petitioner;
- Appendix C – describes how the PGI was designed and is being reported;
- Appendix D – provides a guide to the HS2 Phase 2a scheme earthworks;
- Appendix E – tables containing examples of AP2 borrow pit materials export destinations and import (backfill) sources; and
- Appendix F – a summary of geological information for each borrow pit.

2 Description, purpose and operation of borrow pits

2.1 Phase 2a scheme borrow pit description and purpose

Introduction

- 2.1.1 The HS2 Phase 2a scheme will require high quality aggregate (usually comprising sand and gravel) to construct railway embankments¹ and associated works². This material will be provided, in part, through excavation of cuttings³ and other works (for example, tunnels or balancing ponds) along the HS2 Phase 2a route, where the quality is appropriate. However, at some locations along the route there is anticipated to be a requirement to source additional high quality material for use in railway embankment construction and associated works.
- 2.1.2 The Bill provides for the acquisition of land for six borrow pits (as described in Table 1) to provide material to construct elements of the HS2 Phase 2a scheme, in particular railway embankments. The rationale for including borrow pits in the HS2 Phase 2a scheme is explained in Volume 1 of the main Environmental Statement⁴ (ES) Volume 1 Section 6.10 and Phase 2a Information Paper D12: Borrow Pits⁵. Volume 1 of the main ES describes in detail the use of borrow pits and Volume 5: Technical appendices Borrow pits restoration strategy, of the main ES, sets out the borrow pits restoration strategy (BPRS)⁶.
- 2.1.3 The locations of the borrow pits (and major cuttings) are shown in Figures A to D (Appendix B).

¹ The railway embankments for HS2 require a superior quality of fill compared to highway embankments and landscape earthworks due to the increased performance required to support the railway and minimise movements. This superior fill could be a granular material (sands and gravels); or it could be a clay or mudstone provided it meets the performance requirements.

² The materials extracted from the borrow pits are intended for constructing the railway embankments. However, if the properties are suitable, and sufficient quantities are available, there may be an opportunity for minerals extracted from the borrow pits to be used to make concrete or other cement bound materials for construction of the scheme.

³ The major cuttings are the six cuttings along the Phase 2a route where it is expected that the majority of the granular excavated material will be won, as follows: Brancote South Cutting; Hopton South Cutting; Hopton North Cutting; Swynnerton North Cutting; Hatton South Cutting; and Whitmore South Cutting.

⁴ HS2 Ltd (2017). High Speed Rail (West Midlands - Crewe) Environmental Statement, Volume 1: Introduction and methodology. Available online at: <https://www.gov.uk/government/publications/hs2-phase-2a-environmental-statement-volume-1-introduction-and-methodology>

⁵ HS2 Ltd (2017). HS2 Phase 2a construction information paper: Borrow pits. Available online at: <https://www.gov.uk/government/publications/construction-hs2-phase-2a-information-papers>

⁶ HS2 Ltd (2017), High Speed Two (HS2) Phase 2a (West Midlands – Crewe), Volume 5: Technical appendices, Borrow pits restoration strategy (CT-009-000). Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/627178/E30_CT_009_000_WEB.pdf

Table 1: HS2 Phase 2a scheme borrow pit naming convention and locations

Borrow Pit (BP) Reference	Approximate distance from Euston (km) - chainage	Community Area (CA)	Location name
Borrow Pit 1 (BP1)	189/189a	CA1	Kings Bromley South (east and west of route)
Borrow Pit 2 (BP2)	190	CA1	Kings Bromley North (adjacent to A515)
Borrow Pit 3 (BP3)	191	CA1	Kings Bromley North (adjacent to Shaw Lane)
Borrow Pit 4 (BP4)	193	CA1	Blithbury
Borrow Pit 5 (BP5)	235	CA4	West of Netherset Hey Farmhouse
Borrow Pit 6 (BP6)	241	CA5	North of Checkley Lane

2.1.4 Following the use of borrow pits to provide granular material, cohesive material (such as clays and mudstones) from the excavation of the Phase 2a route which is assessed not to be suitable for high speed railway embankment construction purposes will be used for highway embankments and landscape earthworks and as backfill to restore the borrow pits to original ground levels and to the original land use⁷. This presents a more sustainable option by reducing the need to move this material off-site and further helping to limit impacts on the local road network and communities.

Purpose of HS2 Phase 2a scheme borrow pits

2.1.5 The six HS2 Phase 2a borrow pits as proposed in the Bill are designed to provide granular engineering fill material for the following principal uses:

- construction of railway embankments and zones of high quality fill associated with bridges, viaducts and culverts; and
- fill to ground treatment areas under embankments and for ground treatments under the railway foundation layers at the base of cuttings.

2.1.6 In addition, borrow pits 1 (189/189a) and 3 (191) will also provide cohesive fill for landscape earthworks adjacent to Pyford North and South and Bourne embankments respectively.

2.1.7 The earthworks design for the HS2 Phase 2a scheme includes an assessment that, prior to the PGI, 35% of material excavated from borrow pits would not be acceptable as granular fill for construction of the HS2 Phase 2a scheme and would be stockpiled at

⁷ As set out in the BPRS described in Section 2.3 of this review.

each borrow pit and used as backfill during borrow pit restoration; and that 65% of the excavated material from the borrow pits would be acceptable as granular fill.

2.1.8 The materials movement analysis (without PGI) that was used to inform the Supplementary Environmental Statement 2 and Additional Provision 2 Environmental Statement (SES2 and AP2 ES), was based on the assumptions set out in Section 3.2. This analysis has been used to develop summary tables for each borrow pit (Appendix E).

2.1.9 As information becomes available from the PGI, this assessment will be reviewed and the volumes of material anticipated to be acceptable or unacceptable as granular fill will be adjusted accordingly and taken into account in future iterations of the materials movement analysis. Information from the contractor's draft PGI report that is available for borrow pits at the time of drafting of this report is provided in Sections 3.4 and 3.5, Section 4.2 and Appendix F.

Borrow Pit 1 (189/189a)

2.1.10 This borrow pit is located near Kings Bromley (at chainage⁸ 189) south-east and west (both sides) of the route in community area 1 (CA1) (see Figure F Appendix B). The borrow pit has a footprint area of up to 35ha. It is envisaged that it would be:

- used to provide construction materials for the Pyford North and Pyford South embankments (Appendix E Table 1); and
- backfilled with material unacceptable as granular fill, either stockpiled at the borrow pit during its excavation or imported from the Moreton cutting (Appendix E Table 2).

Borrow Pit 2 (190)

2.1.11 This borrow pit is located near Kings Bromley (at chainage 190) – adjacent to the A515 - in community area 1 (CA1) (see Figure G Appendix B). The borrow pit footprint area is up to 12ha. It is envisaged that it would be:

- used to provide construction materials for the Pyford North and Bourne embankments (Appendix E Table 3); and
- backfilled with material unacceptable as granular fill, either stockpiled at the borrow pit during its excavation or imported from the Brancote South Cutting (Appendix E Table 4).

⁸ Chainage (known as reference chainage) is referenced from Euston Station, which is 0+000, and the value presented is in metres. E.g. 192+000 refers to the point, 192,000m, or 192km, from Euston Station. The chainage has been used in the naming convention for each borrow pit.

Borrow Pit 3 (191)

2.1.12 This borrow pit is located near Kings Bromley (at chainage 191) – adjacent to Shaw Lane – in community area 1 (CA1) (see Figure G Appendix B). The borrow pit footprint area is up to 19ha. It is envisaged that it would be:

- used to provide construction materials for the Bourne embankment (Appendix E Table 5); and
- backfilled with material unacceptable as granular fill, either stockpiled at the borrow pit during its excavation or imported from the Hopton North cutting (Appendix E Table 6).

Borrow Pit 4 (193)

2.1.13 This borrow pit is located near Pipe Ridware (Blithbury) (at chainage 193), in community area 1 (CA1) (see Figure H Appendix B). The borrow pit footprint area is up to 20ha. It is envisaged that it would be used to provide construction materials for the following (Appendix E Table 7):

- railway embankments (Pipe Ridware, Stockwell Heath, Moreton North and South, and Trent South) and fill to ground treatment areas below them, where required;
- fill to ground treatment areas at the base of cuttings (Blithbury South, Central and North, Stockwell Heath, and Moreton); and
- zones of high quality granular fill associated with one viaduct, 12 bridges and an auto-transformer station.

2.1.14 It is envisaged that Borrow Pit 4 would be backfilled with material unacceptable as granular fill, either stockpiled at the borrow pit during its excavation or material excavated from and imported from the following locations (Appendix E Table 8):

- cuttings (Blithbury Central and North, Stockwell Heath and Moreton);
- foundation excavations for six bridges and a viaduct; and
- excavations for ground treatment under two embankments (Moreton South and North).

Borrow Pit 5 (235)

2.1.15 This borrow pit is located at Netherset Hey (chainage 235) in community area 4 (CA4) (see Figure I Appendix B). The borrow pit footprint area is up to 28ha. It is envisaged that it would be used to provide construction materials for the following (Appendix E Table 9):

- railway embankments (Meece, Lea South and North, Checkley South and North, Blakenhall Southbound Spur, Blakenhall Northbound Spur, Chorlton South and North) and fill to ground treatment areas below them, where required;
- fill to ground treatment areas at the base of cuttings (Whitmore North, Crewe South, Blakenhall Northbound Spur and Blakenhall); and

- zones of high quality granular fill associated with 10 bridges, the portals of Madeley tunnel, Bar Hill aqueduct, three viaducts and two auto-transformer stations.

2.1.16 It is envisaged that Borrow Pit 5 would be backfilled with material unacceptable as granular fill, either stockpiled at the borrow pit during its excavation or material excavated from and imported from the following locations (Appendix E Table 10):

- Cuttings (Yarlet South, Central and North, Madeley and Hopton North); and
- Madeley Tunnel.

Borrow Pit 6 (241)

2.1.17 This borrow pit is located at Checkley Lane (at chainage 241) in community area 5 (CA5) (see Figure J Appendix B). The borrow pit footprint area is up to 4oha. It is envisaged that this borrow pit would be used to provide construction materials for the following (Appendix E Table 11):

- railway embankments (Blakenhall Southbound Spur and Blakenhall Northbound Spur); and
- fill to ground treatment areas at the base of Crewe South cutting.

2.1.18 It is envisaged that Borrow Pit 6 would be backfilled with material unacceptable as granular fill, either stockpiled at the borrow pit during its excavation or material excavated from and imported from the following cuttings (Appendix E Table 12):

- Crewe South, Basford and Yarlet North.

2.1.19 As reported in the main ES, Volume 2 South Cheshire (CA5) Section 2.3, this borrow pit will be excavated to a depth of 1m above the existing groundwater level or an alternative method agreed with the relevant stakeholders to ensure that there will be no significant impact to the flow or quality of groundwater and surface water reaching Betley Mere SSSI⁹.

2.2 Petitioner proposed borrow pit – Borrow Pit X (between BP2 and BP3 – 190/191)

2.2.1 This site comprises three land parcels identified by a petitioner during the House of Commons (HoC) Select Committee hearings as a potential site for the extraction of construction materials (see Figure K Appendix B). The combined sites are approximately 9ha in area and all three lie outside of the area conferred by the Bill for the construction of the HS2 Phase 2a scheme (Bill limits).

2.2.2 The three areas that make up this potential borrow pit are as follows:

⁹ For further information reference should be made to the Habitats Regulations Assessment screening report for Midland Meres and Mosses Phase 1 Ramsar site addendum - Betley Mere Site of Special Scientific Interest component (EC-017-002) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/628037/E53_EC-017-002_WEB.pdf.

- Area 1 – approximately 7ha;
- Area 2 – approximately 0.6ha; and
- Area 3 – approximately 1.5ha.

2.2.3 The site has been investigated as part of the PGI and the draft data for this potential borrow pit has been provided in Section 3.4 and Appendix F.

2.2.4 Any borrow pit sites that would be located outside of Bill limits (e.g. Borrow Pit X) would not be authorised by the Bill. Therefore, such borrow pits would need to be subject to separate planning and environmental assessment in order to be consented by the local minerals planning authority, in the case of Borrow Pit X, this would be Staffordshire County Council (SCC). The requirement for further formal consent to be secured would create additional programme risk and uncertainty around gaining approval. An application process would typically take approximately 1 year and such an application (e.g. for Borrow pit X) would need to be submitted at least a year in advance of the borrow pit being required to provide construction materials e.g. submission by the end of 2019 / beginning of 2020 to allow operation to commence at the beginning of 2021.

2.2.5 Staffordshire County Council have provided the following guidance which is relevant to the submission of a planning application for Borrow Pit X:

- BPX would need to be the subject of a full planning application to the Mineral Planning Authority. There is no presumption in favour of the proposed site on the basis of any allocation made in the Minerals Local Plan (MLP) for Staffordshire (2015 - 2030)¹⁰;
- it would be necessary to justify the proposed alternative borrow pit site in terms of policy 1.6 of the MLP which states¹¹:

Proposals for any other sand and gravel sites (extensions / new sites) will only be supported where it has been demonstrated that the proposals would secure significant material planning benefits that outweigh any material planning objections.

- it is anticipated that a planning application for Borrow Pit X would need to address flood risk, ecological, hydrogeological, and public access issues¹² as well as impacts on local amenity as a consequence of noise, dust, visual and traffic impact. However, these constraints would be no more significant than for Borrow Pit 1 (190); and
- proposals would need to demonstrate that the excavations could be restored at the earliest opportunity and to a high standard¹³.

¹⁰ The new Minerals Local Plan for Staffordshire 2015 to 2030 Response to Inspector's Questions – Provision for Sand and Gravel.

¹¹ Material planning benefits could include proposals that are required as part of a major infrastructure project (refer to paragraph 7.11 of the MLP).

¹² Refer to policy 4 of the MLP. HS2 Ltd's own review concluded that an assessment of potential impacts on cultural heritage would also be required but also concluded that BPX would be no different to the impacts that would arise from Borrow Pit 2 (190) and Borrow Pit 3 (191).

¹³ Refer to policy 6 of the MLP.

- 2.2.6 In addition, the acquisition of land (including acquisition of mineral rights) outside Bill limits as would be required for a borrow pit such as Borrow Pit X, would not be authorised by the compulsory acquisition powers conferred by the Bill. Accordingly, the land required (including mineral rights) would need to be acquired by separate agreement with the relevant landowner.
- 2.2.7 The design would need to be developed in accordance with the relevant HS2 Technical Standards and taking account of HS2 Ltd’s environmental policies, which include the Design Policy and Sustainability Policy (which forms Annex 2 to the draft Code of Construction Practice (CoCP))¹⁴ and relevant HS2 Information Papers.

2.3 Borrow pit operation and restoration management

Introduction

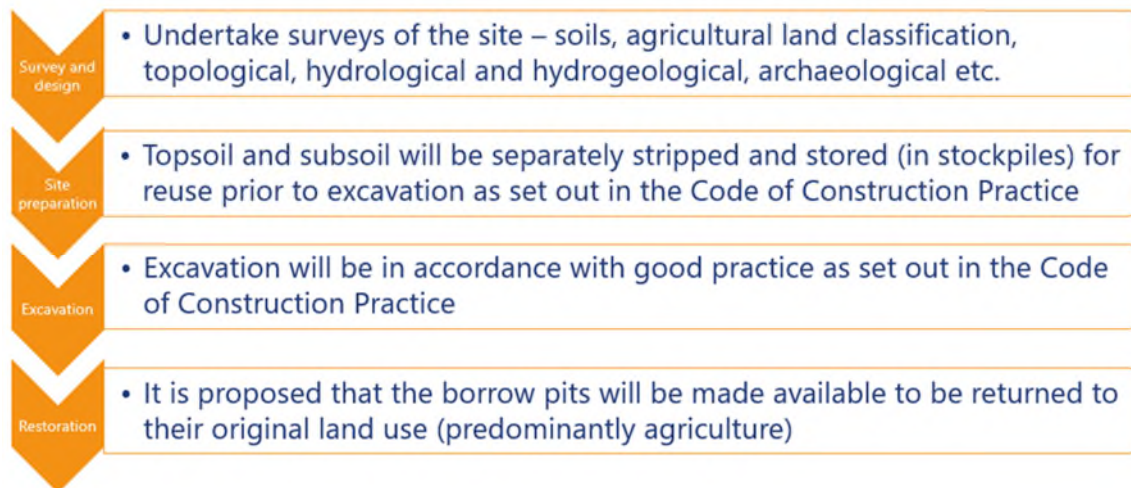
- 2.3.1 The excavation (operational) phase of the borrow pits is addressed in the Environmental Statement (ES) Volume 2: community area reports and will be bound by the commitments of the Environmental Minimum Requirements (EMR)¹⁵, including the draft CoCP.
- 2.3.2 Sections 4 and 5 of HS2 Phase 2a Information Paper D12: Borrow Pits, describe how the operation of borrow pits will be managed and Section 6 describes the restoration principles.
- 2.3.3 Section 3 of the Borrow Pit Restoration Strategy (BPRS) sets out the overarching objectives, design principles and environmental provisions that are central to the BPRS and the restoration principles are described in Section 5 of the BPRS.
- 2.3.4 Section 4 of the BPRS describes the borrow pit site preparation and excavation process, as summarised in Figure 1. The indicative sequence of borrow pit excavation, backfilling and restoration is also provided in the HS2 exhibit entitled Borrow Pit Standard Exhibit Pack P125 (May 2018)¹⁶.

¹⁴ HS2 Ltd (2017). *High Speed Rail (West Midlands - Crewe) Environmental Statement*, Volume 5: Technical appendices, draft Code of Construction Practice (CT-003-000). Available online at <https://www.gov.uk/government/publications/draft-code-of-construction-practice-for-hs2-phase-2a>.

¹⁵ The Secretary of State has published draft Environmental Minimum Requirements (EMRs), which set out the environmental and sustainability commitments that will be observed in the construction of HS2 Phase 2a. For more information on the EMRs, please see Information Paper E1: Control of Environmental Impacts.

¹⁶ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/705803/Section_O_-_Borrow_Pits.pdf.

Figure 1: Borrow pit preparation, operation and restoration process



- 2.3.5 Section 6 of the BPRS describes the role of the planning authority and other statutory bodies in the control of borrow pit operation and restoration design.
- 2.3.6 The BPRS provides a commitment that the land in the borrow pits will be made available to be returned to their original pre-construction ground level and land uses, which is predominantly agricultural, subject to individual land owner agreements.
- 2.3.7 The BPRS sets out a commitment to an aftercare period of five years following completion of restoration of each borrow pit. An extended period may apply where ecological mitigation has been provided, or for land restored to agriculture where this is agreed with landowners.
- 2.3.8 HS2's appointed contractor will be required to develop method statements for all aspects of borrow pit excavation (including dewatering), backfilling, restoration and aftercare. These method statements will be in accordance with the measures outlined within the draft CoCP and the principles contained in the BPRS. The contractor method statements will be subject to approval by HS2 Ltd and the relevant planning authority²⁷ and the excavation of bulk materials from borrow pits cannot commence unless the authority has approved a scheme for the restoration of the borrow pit site.
- 2.3.9 Schedule 32 to the Bill sets out the requirement for approval from the relevant body (either the Environment Agency or Lead Local Flood Authority), for works such as water abstraction and discharges, which may affect the water environment. Such works, which could affect the water environment, cannot commence until the relevant body is

²⁷ Under Schedule 17 (planning conditions) paragraph 7 to the Bill, the planning authority will need to approve the plans and specifications for the excavation of bulk materials from borrow pits.

satisfied that any impacts are properly understood and that any necessary mitigation and monitoring has been adopted¹⁸.

Draft Code of Construction Practice (CoCP)

- 2.3.10 Section 3.3 of the draft CoCP describes the approvals of construction arrangements conferred by the Bill. Section 6.2 of the draft CoCP sets out the measures that will be undertaken to reduce the impacts on agricultural, forestry and soil resources.
- 2.3.11 Section 16 of the draft CoCP sets out the measures that will be undertaken to manage surface water and groundwater impacts, including those on private water supplies. The nominated undertaker will require its contractors to undertake risk assessments as appropriate for excavation work and dewatering impacts on surface water, groundwater and abstractions. If this risk assessment confirms the potential for significant effects to occur on private water supplies, mitigation proposals will be developed and discussed with the owner, with a view to an alternative supply being provided.

Screening of borrow pits during construction

- 2.3.12 Temporary security fencing or hoardings (as appropriate) will be erected on land required for construction, which includes land identified for borrow pits. The type and construction of fences will depend on factors such as the level of security required, the need for acoustic screening and the degree of visual impact on residents or other relevant receptors.
- 2.3.13 When assessing the visual impact of construction activities associated with the borrow pits on nearby visual receptors (types of receptor include, but are not limited to; residential, recreational, transport routes), the following measures have been taken into account, which aim to avoid or reduce landscape and visual effects:
- avoidance of unnecessary tree and vegetation removal, and protection of existing trees; and
 - use of well-maintained hoardings and fencing.
- 2.3.14 The likely significant effects on visual receptors during construction are reported in Section 11.4, within the relevant community area report, Volume 2, of the Environmental Statement.
- 2.3.15 Section 5.6 of the draft CoCP describes how hoardings, fencing and screening will be applied during the construction phase. With particular relevance to borrow pits and the issue of visual screening and noise attenuation of borrow pit activities, the following will be applied:
- maintenance of adequate fencing and hoardings to an acceptable condition to prevent unwanted access to the construction site, to provide noise attenuation,

¹⁸ For more information see Information Paper E15: Water Resources, Flood Risk and Authorisation of Related Works.

screening, and site security where required. This will include the need to provide viewing points at relevant locations, if appropriate;

- use of different types of fencing, including hoardings used for noise control;
- retaining existing walls, fences, hedges and earth banks for the purpose of screening as far as reasonably practicable; and
- where hoarding is required, it will be 2.4m in height and will be raised to 3.6m (and possibly altered in form) to enhance acoustic performance for specific locations.

- 2.3.16 The final design of temporary fencing/hoarding that is suitable, in functional, acoustic, visual and landscape terms for that specific location, will be made by the nominated undertaker during the detailed design stage, and subject to the Environmental Minimum Requirements.
- 2.3.17 The Bill grants a deemed planning permission for the works it authorises. It also establishes a planning regime in Schedule 17 under which certain matters and details will need local planning authority approval. Works screening will be subject to planning approval.
- 2.3.18 Figure 2 provides an illustrative example of an unmitigated borrow pit operation. Figure 3 provides an illustrative example of this same view with open panel fencing (unmitigated) and the same fencing with an illustrative example of mitigation in the form of sheeting attached to the fence panels. site-specific arrangements for the fencing around borrow pits will be developed during the detailed design stage, and will require approval by the relevant planning authority.
- 2.3.19 Typically, borrow pit operation will include the stockpiling of material retained at the borrow pit for use during restoration. Where practicable, this material could be used to provide temporary earthwork bunds (potentially seeded) to screen the activities at the borrow pit sites as shown in Figure 4.
- 2.3.20 The inclusion of temporary earthworks for screening will form part of site-specific arrangements, which will be developed during the detailed design stage, and will require approval by the relevant planning authority.

Figure 2: Illustrative example of a typical borrow pit operation (unmitigated) (by permission of Highways England)



Figure 3: Illustrative example of borrow pit security fencing without mitigation (left) and with mitigation (right)



Figure 4: Illustrative example of typical borrow pit boundary soil stockpiling (seeded in the right hand image)



3 Earthworks strategy

3.1 Earthworks volumes, material types and uses

Introduction

- 3.1.1 The volumes, sources and destinations of material (the earthworks design) have been assessed and reported at specific stages of design development in the form of a series of earthworks strategies. Each iteration of the earthworks strategy has provided an assessment of earthworks and materials movement required to construct the Phase 2a scheme and has been based on assumptions about the potential volumes and quality of the excavated material from tunnels, major cuttings and borrow pits. The sources are interlinked in the strategy – i.e. if the volumes available from the major cuttings were to increase, the volumes required from the borrow pits would decrease and vice versa.
- 3.1.2 The earthworks strategy is, as assessed in the Supplementary Environmental Statement (SES)² and the Additional Provisions (AP)² Environmental Statement (ES), based on a design dated 23rd May 2018 prior to the commencement of the PGI.
- 3.1.3 Sections 3.2 and 3.3 provide tables which describe the assumptions that were made on the extent, depth and volume of borrow pits for the AP² revised earthworks design stage as follows:
- without PGI (Section 3.2); and
 - with draft PGI (Section 3.3)).
- 3.1.4 A description of earthworks materials quality classes (e.g. Class 1, Class 6 etc) that are referenced in Section 3 is provided in Appendix D.

3.2 AP² (without PGI)

Introduction

- 3.2.1 The main changes in the earthworks volumes between the original scheme earthworks design¹⁹ and the AP² revised scheme earthworks design are due to the following reasons:
- changes between the original scheme and AP¹ revised scheme earthworks design²⁰;
 - shortening of the Filly Brook Viaduct²¹ by increasing the lengths of the approach embankments;

¹⁹ 16th January 2017.

²⁰ 21st December 2017.

²¹ When the design was amended for the AP² revised scheme, the Filly Brook Viaduct was renamed as part of the Norton Bridge to Stone Railway Viaduct.

- changes in the cut and fill volumes and classes of materials required for the Infrastructure Maintenance Base – Rail (IMB-R) earthworks platform and Stone Headshunt;
- reductions in environmental mitigation and landscape earthworks at several locations along the route;
- changes between AP1 revised scheme design and AP2 revised scheme design²²;
 - vertical alignment changes in CA1, CA3, CA4 and CA5;
 - horizontal alignment changes in CA4, in particular a reduction of track spacing through Whitmore Wood and over the River Lea viaduct;
 - addition of ground treatment at the base of cuttings in clay and mudstone materials where required;
 - Whitmore Heath Tunnel was lengthened at its southern end and the cut and cover section of the tunnel was replaced with twin bored tunnels;
 - addition of several surplus reduction measures to minimise the earthworks surplus;
 - changes to the environmental mitigation earthworks in CA5;
 - changes of sizes of Auto Transformer Feeder Station (ATFS) and Auto Transformer Stations (ATS) especially in CA1; and
 - changes in the potential volumes of borrow pits due to more historical ground investigation data being made available, and inclusion of updated utilities and archaeological information.

AP2 earthworks design assumptions

3.2.2 In the absence of site-specific ground investigation information across the Phase 2a AP2 revised scheme²³, the volume of granular material that could be won from the cuttings and tunnels along the route and the volume of granular material required for railway embankments and associated works was estimated. It was anticipated that a total of 3.94 Mm³ of granular material could be excavated along the route, as summarised in Table 2. At this design stage, the increased volume of granular material anticipated to be excavated from the major cuttings (compared to previous design stages²⁴) is primarily due to the refinements and corrections to the analysis of materials quantities and movement that had been used for the main ES. Other changes in anticipated

²² 23rd May 2018.

²³ The AP2 revised scheme is the amended scheme for which powers will be sought under the Bill.

²⁴ The earthworks design that informed the deposit of the hybrid Bill (earthworks design dated 16th January 2017) the volume of granular material anticipated to be excavated from the major cuttings was 3.54Mm³ and at AP1 this was 3.72Mm³.

volumes are primarily due to changes in the vertical alignment in the AP2 revised scheme.

Table 2: Summary of anticipated sources of granular material along the route in earthworks design for SES2 and AP2 ES (2019) – without PGI

Location	Estimated volume of granular material to be excavated (Mm ³)
The six "major" cuttings (Brancote South, Hopton South, Hopton North, Swynnerton North, Hatton South and Whitmore South)	2.72
Madeley and Whitmore Tunnels	0.74
Other cuttings	0.48
Total	3.94

3.2.3 The volume of granular material estimated to be available from the cuttings and tunnels was less than that estimated to be required in the engineering works. The difference between the requirements for the permanent engineering earthworks and the predicted volumes available from the three sources (tunnels, cuttings and borrow pits) was then estimated.

3.2.4 The assessment of the earthworks volumes that have been used to inform the SES2 and AP2 ES are based on the same assumptions for the borrow pits as the earthworks design for the main ES (July 2017) except for:

- the depth of topsoil and subsoil was assessed in the main ES to be an average of 0.3 m and 0.5 m respectively, giving a total average depth of 0.8 m. In the AP2 revised scheme earthworks design, assessed in the SES2 and AP2 ES, it was assessed that topsoil and subsoil will be excavated and restored to an average depth of 0.25 m and 0.95 m respectively, giving a total average depth of 1.2 m to allow a full agricultural soil profile to be restored;
- the average depth to the base of mineral extraction in Borrow Pit 5, assessed in the SES2 and AP2 ES, was assumed to increase to 8.0 m below existing ground level²⁵;
- the average depth of mineral excavation at Borrow Pit 6 varied due to the requirement to keep it at least 1m above the groundwater level^{26,27};
- when estimating the volumes of material that can potentially be excavated from the borrow pits, allowances were made in the AP2 earthworks design for some existing utilities which would not be diverted and for some other proposed utility diversions within the borrow pit footprints. This affected borrow pits 1, 2, 3 and 6; and

²⁵ In the earthworks design assessed in the main ES, the average depth to the base of mineral extraction in Borrow Pit 5 was assumed to be 4.3 m below existing ground level. This was based on a geotechnical desk study of publicly available information but without any site-specific ground investigation.

²⁶ See Sections 3.4.1 to 3.4.6 of the HRA for Betley Mere
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/628037/E53_EC-017-002_WEB.pdf

²⁷ The July 2017 (main) ES assumes that the extraction of minerals at Borrow Pit 6 (241) is restricted to a depth of 1m above the groundwater level. However, the earthworks volumes for the main ES had been estimated before January 2017 and this change occurred after that date.

- there is an area of likely archaeology at Borrow Pit 3, which will be investigated/recorded and then removed prior to commencement of this part of the borrow pit excavation. There is a risk of delay to the construction programme in using this area and therefore a worst-case scenario excluding it was adopted for the AP2 earthworks volumes²⁸.

3.2.5 A comparison of the anticipated usage of the borrow pits in the earthworks designs for the original scheme (main ES (July 2017)) and the AP2 revised scheme (SES2 and AP2 ES) is given in Table 3²⁹.

Table 3: Comparison of Borrow Pit mineral resource / void estimates for main ES (2017) and for SES2 and AP2 ES (2019) – without ground investigation

Borrow Pit (BP) Ref	Estimated Area (ha)		Potential volume of Class 1 or Class 6 material (million cubic metres (Mm ³))		Proportion of borrow pit estimated to be used at Design Stage (%)	
	2017 ES design	2019 SES2 & AP2 design	2017 ES design	2019 SES2 and AP2 ES design	2017 ES design	2019 SES2 and AP2 ES design
BP1	35	34 ³⁰	0.70	0.60	27	27
BP2	12	12	0.24	0.20	100	41
BP3	19	14 ³¹	0.40	0.24	62	63
BP4	20	20	1.08	1.08	77	100
BP5	28	28	0.58	1.06	70	100
BP6	40	30 ³²	0.74	0.26	100	100

3.2.6 Further design development at AP2 has also identified the need to amend the designs of individual borrow pits. These changes require additional land to provide for pipes from the borrow pits to allow the recharge of groundwater³³; diversion of watercourses; and/or the reduction in the area of borrow pits to allow for utility works³⁴.

²⁸ Overall, the area of Borrow Pit 3 was reduced to 14 ha for the purpose of volume calculations but not for the topic assessments in the SES2 and AP2 ES as this area would be investigated as standard practice in accordance with the provisions of Cultural Heritage agreements.

²⁹ The potential volumes in Columns 4 and 5 of Table 3 assume 100% usage of the borrow pits.

³⁰ Reduced area of Borrow Pit 1 in calculations only is to allow for gas main diversion with 30 m exclusion zone on each side, across corner of borrow pit.

³¹ Area of 14 ha in Borrow Pit 3 was conservatively used for calculation of volumes only.

³² Due to utility diversion works.

³³ The requirement for this potential mitigation measure to be adopted will be confirmed by future updates of the hydrogeological model – see Section 4.3.

³⁴ Details of these changes and the consideration of the potential for significant environmental effects are reported in the AP2 Volume 2 community area (CA) reports for Fradley to Colton (CA1), Whitmore Heath to Madeley (CA4) and South Cheshire (CA5).
<https://www.gov.uk/government/collections/hs2-phase-2a-environmental-statement>

HS2 Phase 2a scheme requirements at AP2 (without PGI)

- 3.2.7 In the earthworks design for the Phase 2a AP2 revised scheme (without PGI), there is a requirement to source 4.44 M m³ of Class 1 and Class 6 material. This includes a requirement to source 0.59 M m³ of Class 6 Prepared Subgrade, which would need to be imported (as is also the case for the earthworks design for the original scheme, assessed in the main ES). Of the remaining Class 1 and Class 6 material required, 2.80 M m³ would be sourced from borrow pits. The borrow pits from Blithbury to the northern end of the Phase 2a route (i.e. Borrow Pit 4 (193), Borrow Pit 5 (235) and Borrow Pit 6 (241)) would all be fully used in this case and so the remainder of the Class 1 and Class 6 combined that would be required (1.05 Mm³) would need to be imported. This is discussed further in Sections 3.3 and 5.

3.3 AP2 with draft PGI data

Baseline assumptions

- 3.3.1 The underlying assumptions for the AP2 revised scheme earthworks design with draft PGI data are the same as those described in para 3.2.4 for the AP2 revised scheme without PGI except as discussed below.

Assumptions reviewed for AP2 with draft PGI data

- 3.3.2 As a result of the findings of the draft PGI at the borrow pits and major cuttings, the following assumptions and assessments were reviewed for the borrow pits:
- the ground and groundwater conditions;
 - the depth to the base of the mineral and the estimated average depth of excavation;
 - the average potential volume of mineral to be excavated;
 - the proportion of mineral that is estimated to be acceptable as granular fill; and
 - the potential void space available for backfilling.
- 3.3.3 The assumptions and assessments that were reviewed at the major cuttings were as follows:
- the ground and groundwater conditions;
 - the proportion of each cutting that is estimated to be sand/sandstone; and
 - the proportion of sand / sandstone in each cutting that is estimated to be acceptable as granular fill.

AP2 assumptions with draft PGI

Borrow pits

- 3.3.4 The principal results of the reassessments carried out for the borrow pits for the AP2 revised scheme earthworks design with draft PGI data are summarised below and in Table 4.

- 3.3.5 The average estimated depth of mineral extraction has increased at all of the borrow pits apart from the western part of Borrow Pit 1 (189a), where the ground conditions are variable. Based on the limited draft PGI information there, there appears to be little or no mineral that would be suitable to construct the scheme in the western corner and along the north-western side of this part of Borrow Pit 1. At this stage of the design, it is currently difficult to estimate the likely depth of mineral in the rest of this part of Borrow Pit 1 (189a) but there appears to be an increasing depth towards the eastern side.
- 3.3.6 Geotechnical interpretation of the draft PGI data has been undertaken and the percentage of mineral likely to be acceptable as granular material at each borrow pit has been estimated. In borrow pits 1, 2, 3 and 4 this percentage is estimated to be greater than the 65% previously assessed from desk study³⁵. However, at Borrow Pit 5, the estimated percentage of acceptable material is only slightly greater than assessed from desk study; and at Borrow Pit 6 it is less than assessed from desk study.
- 3.3.7 The estimated potential volumes of mineral (both granular and non-granular) in each borrow pit assuming 100% usage and excluding topsoil and subsoil have increased from the AP2 revised scheme earthworks design without PGI in all borrow pits, except for the western part of Borrow Pit 1 (189a), where the estimated potential volume has decreased.
- 3.3.8 At Borrow Pit 6 (241), the ground conditions are variable and the topography is undulating. A preliminary ground model has been developed based on interpretation of the draft PGI data. This model has been used to estimate the potential volumes of mineral in Table 4. There is considerable uncertainty in these volumes due to the wide spacing of the PGI exploratory holes and the complex ground conditions. There appears to be a substantial volume of silty or clayey sand above the groundwater table in this borrow pit which would not be classified as granular material in an 'as-dug' state. However, this material could potentially either be processed to produce granular material, or it may be possible to use it without processing in the lower parts of some of the railway embankments in CA4 or CA5.
- 3.3.9 The estimated potential volumes of granular material in each borrow pit assuming 100% usage and excluding topsoil and subsoil are also given in Table 4.
- 3.3.10 The equivalent information for the petitioner's proposed alternative borrow pit (Borrow Pit X (BPX)) is also included in Table 4.

Major cuttings

- 3.3.11 The principal results of the reassessments carried out for the major cuttings with the draft PGI data are summarised in Table 5 and below, as follows.

³⁵ This is because the draft PGI has confirmed that there is a higher percentage of granular materials and a lower percentage of non-granular materials in these borrow pits than assessed from desk study.

- 3.3.12 **Brancote South Cutting:** In the AP2 revised scheme earthworks design without PGI, a large part of this cutting was expected to be in sand/sandstone and it was expected to provide about 0.4 Mm³ of granular material. However, the draft PGI information indicates that there will be no sand/sandstone in this cutting and the cutting will all be in clay/mudstone. Investigations into the reasons for this anomaly identified that the historical GI information used for the previous interpretation was unreliable. As a result it is estimated that the amount of granular fill that can be sourced from this cutting will be reduced by about 0.4 Mm³.
- 3.3.13 **Hopton South and Hopton North Cuttings:** The draft PGI information indicates that there is a greater thickness of non-granular superficial materials at these two cuttings than was expected in the AP2 revised scheme earthworks design without PGI. As a result, it is estimated that the amount of granular fill that can be sourced from these cuttings will be reduced by about 0.1 Mm³.
- 3.3.14 **Swynnerton North, Hatton and Whitmore South Cuttings:** The draft PGI information indicates that there is a greater thickness of non-granular superficial materials at these cuttings than was expected in the AP2 revised scheme earthworks design without PGI. As a result, it is estimated that the amount of granular fill that can be sourced from these cuttings will be reduced by about 0.6 Mm³.
- 3.3.15 In summary, the draft PGI data indicates that a total of approximately 1.1 Mm³ less granular fill can be sourced from the major cuttings than had previously been estimated prior to the PGI. It is anticipated that more material would therefore need to be sourced from the borrow pits (principally Borrow Pit 2 and Borrow Pit 5) to provide additional granular material. In addition, these cuttings will generate about 1.1 Mm³ more non-granular material than was previously estimated prior to the PGI.
- 3.3.16 Future design development will need to consider the locations of suitable sources of granular material to take account of the reduced volumes available from the cuttings described in para 3.3.15. If considered feasible, the potential for borrow pits in community areas 1 and 4 (CA1 and CA4) to provide additional granular material required elsewhere on the route will need to take account of an updated earthworks volumes estimate and materials movement analysis. In addition, such an assessment will need to take account of the balance of engineering, environmental and construction requirements and cost, in accordance with the HS2 Phase 2a Environmental Minimum Requirements (EMR).

Table 4: Borrow Pit Resource / Void Estimates – AP2 revised scheme earthworks design without PGI and with draft PGI (HS2 Phase 2a scheme) and petitioner proposed borrow pit (BPX)

Borrow Pit (BP) Reference	Area (ha)	Assumed average depth of mineral extraction ³⁶ (m)		Estimated percentage of mineral acceptable as granular fill		Potential volume in borrow pit for 100% usage of borrow pit excluding topsoil and subsoil (million cubic metres (Mm ³))				
		AP2 earthworks design before PGI (m)	AP2 earthworks design with draft PGI (m)	AP2 earthworks design before PGI	AP2 earthworks design with draft PGI	All mineral (granular and non-granular) – AP2 earthworks design before PGI	All mineral (granular and non-granular) – AP2 earthworks design with draft PGI	Class 1 or Class 6 material – AP2 earthworks design before PGI	Class 1 or Class 6 material – AP2 earthworks design with draft PGI	Potential void available for backfill – AP2 earthworks design with draft PGI
BP1 (189)	24 *	4.1	7.3	65%	80%	0.67	1.35	0.44	1.08	1.08
BP1 (189a)	10 *	4.1	4.1	65%	80%	0.25	0.13	0.16	0.10	0.10
BP2 (190)	12	4.1	9.3 ³⁷	65%	90%	0.31	0.76	0.20	0.69	0.69
BP3 (191)	14**	4.3	5.0	65%	90%	0.37	0.45	0.24	0.41	0.41
BP4 (193)	20	11.1	12.8	65%	95%	1.65	1.85	1.08	1.76	1.76
BP5 (235)	28	8.0	11.0	65%	75%	1.63	2.19	1.06	1.64	1.64
BP6 (241)	23 ***	varies	varies	65%	20%	0.32	1.89	0.26	0.38 ³⁸	0.38
Totals						5.20	8.62	3.44	6.06	6.06
BPX	9	N/A	**** 6.5 ³⁹	N/A	**** 90%	N/A	**** 0.33	N/A	**** 0.30	**** 0.30

Notes – * Borrow Pit 1: area reduced due to likely 30m offset from proposed gas main diversion; **Borrow Pit 3: area reduced due to existing water main and archaeology area.

Borrow Pit 6 – area reduced due to proposed utilities diversions. * Borrow Pit X is not part of the HS2 Phase 2a scheme. N/A: not applicable.

³⁶ This is the average depth below ground level to the base of the mineral.

³⁷ Average depth of mineral in Borrow Pit 2 is based on six draft PGI boreholes and 12 historical boreholes, which gave consistent results in regard to the depth of the mineral. The reliability of third party data is discussed further for each borrow pit in Appendix F. The third party data was not always considered sufficiently reliable to use in the estimation of the average depth of mineral extraction.

³⁸ It is estimated that there is also approximately 0.6 Mm³ of silty or clayey sand (non-granular material) in Borrow Pit 6 which could potentially either be processed to produce granular material, or it may be possible to use it without processing in the lower parts of some of the railway embankments in CA4 or CA5 – see para 3.3.8 and Appendix D Figure L.

³⁹ Average depth of mineral in Borrow Pit X is based on six draft PGI boreholes and 17 historical boreholes, which gave consistent results in regard to the depth of the mineral. See also footnote 37 about reliability of third party data.

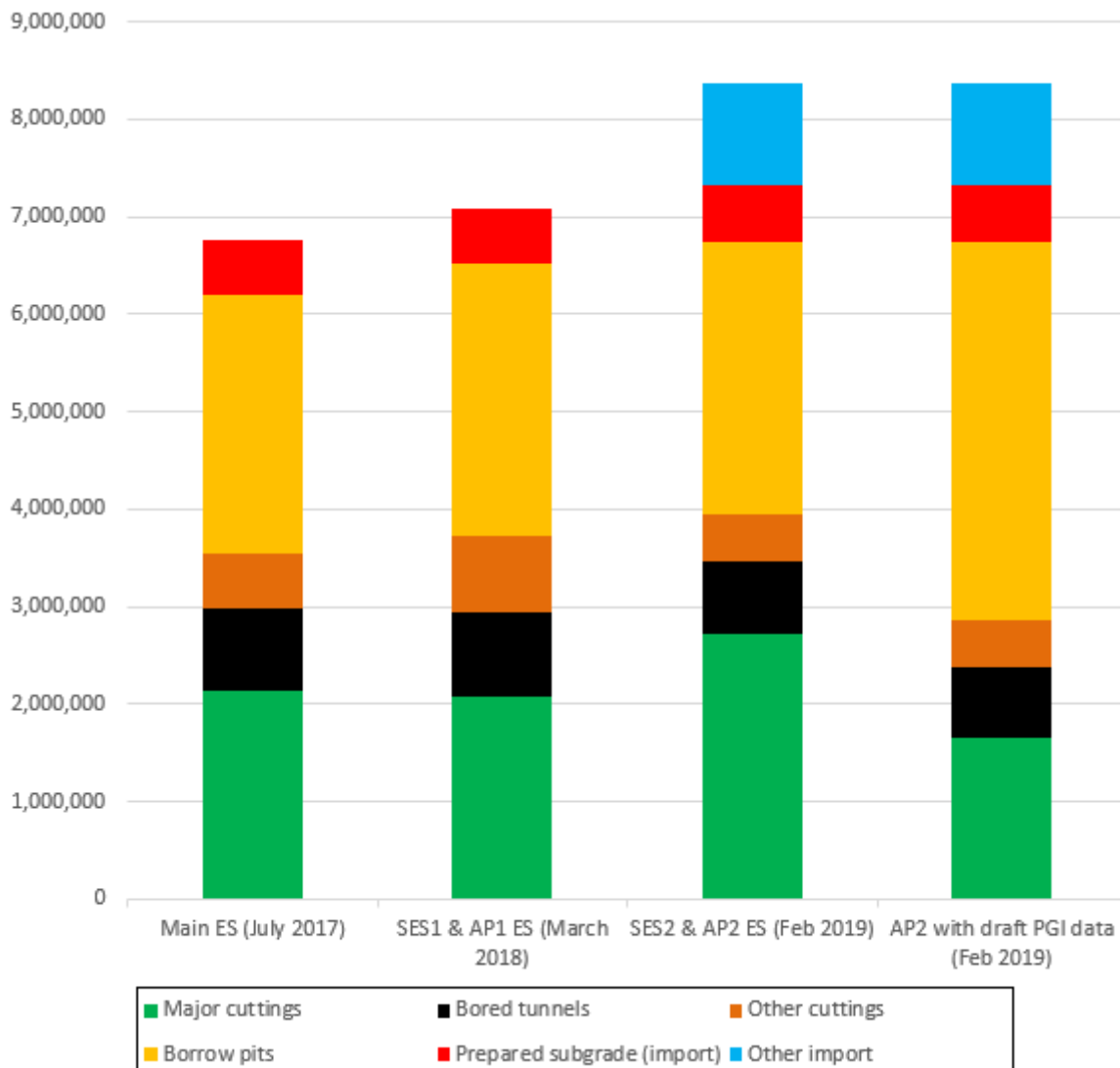
Table 5: January 2019 Excavation volumes and estimated acceptable proportions for granular fill for Major Cuttings – AP2 revised scheme earthworks design before PGI and with draft PGI

Cutting Location	Total volume of cutting at AP2 earthworks design (million cubic metres (Mm3))	Estimated percentage of cutting volume acceptable as granular fill		Estimated volume of Class 1 / 6 material in cutting excluding topsoil and subsoil (million cubic metres (Mm3))	
		AP2 earthworks design before PGI	AP2 earthworks design with draft PGI	Class 1 or Class 6 material – AP2 earthworks design before PGI	Class 1 or Class 6 material – AP2 earthworks design with draft PGI
Brancote South Cutting	0.84	46%	zero	0.40	zero
Hopton South Cutting	0.43	90%	75%	0.44	0.36
Hopton North Cutting	0.69	20%	15%	0.15	0.11
Swynnerton North Cutting	1.20	93%	73%	1.11	0.86
Hatton South Cutting	0.29	100%	39%	0.29	0.11
Whitmore South Cutting	0.34	100%	61%	0.34	0.21
Totals	<u>3.78</u>			<u>2.73</u>	<u>1.65</u>

3.4 Summary of granular material requirements at each design stage (without PGI and with draft PGI data (AP2 revised scheme only))

3.4.1 The estimated volumes of Class 1 / 6 granular material that were estimated could be won from the cuttings, tunnels and borrow pits at each design stage (without PGI) are illustrated graphically in Figure 5. This figure also provides updated estimates for the AP2 revised scheme with draft PGI data. The volumes for the major cuttings and borrow pits in Figure 5 assume that the difference in the pre-PGI and post-(draft) PGI estimated volumes from the major cuttings can be sourced from the borrow pits subject to the considerations discussed in para 3.3.16.

Figure 5: Sources and quantities (m³) of Class 1 / 6 granular material by design stage (without PGI and with draft PGI data for the AP2 revised scheme)



3.4.2

Figure 6 and Figure 7 provide graphical illustrations of the differences in the estimated potential volume of Class 1 / 6 granular material and the proportion required from each borrow pit for the original scheme and AP2 revised scheme earthworks design stages without PGI. These figures also illustrate the volumes that are imported as follows:

- green bar / prepared subgrade - which is imported and cannot be sourced from the borrow pits and cuttings for quality reasons; and
- purple bar / other import - material that is imported in the AP2 revised scheme earthworks design but could be potentially be sourced from borrow pits.

Figure 6: Borrow pit granular material volumes in design for original scheme without PGI

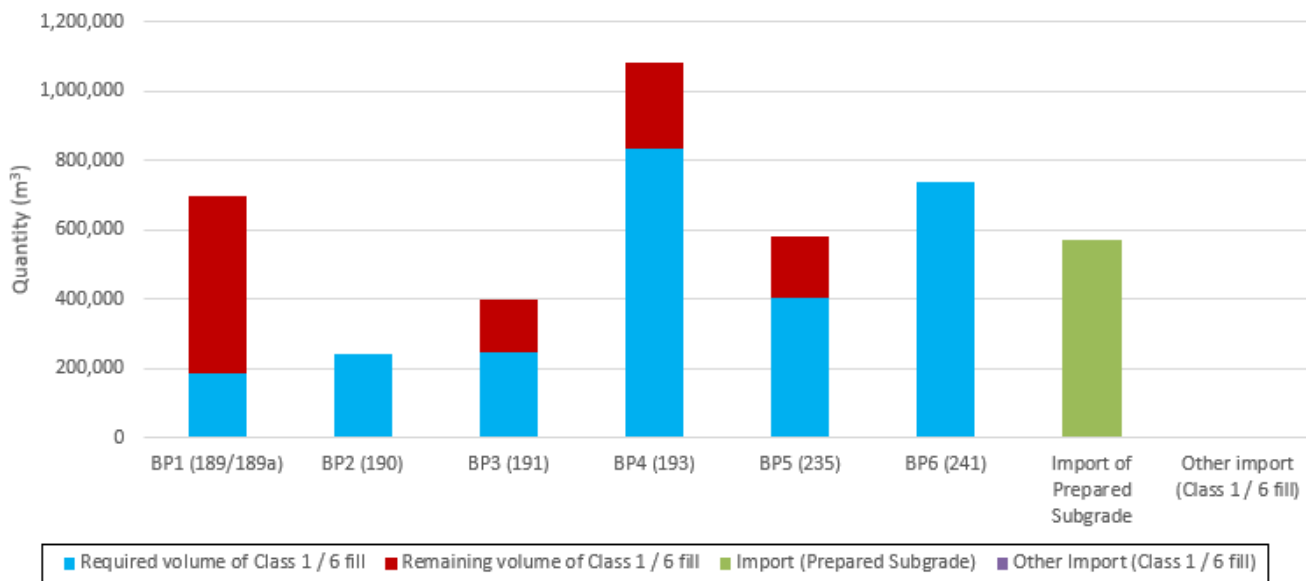
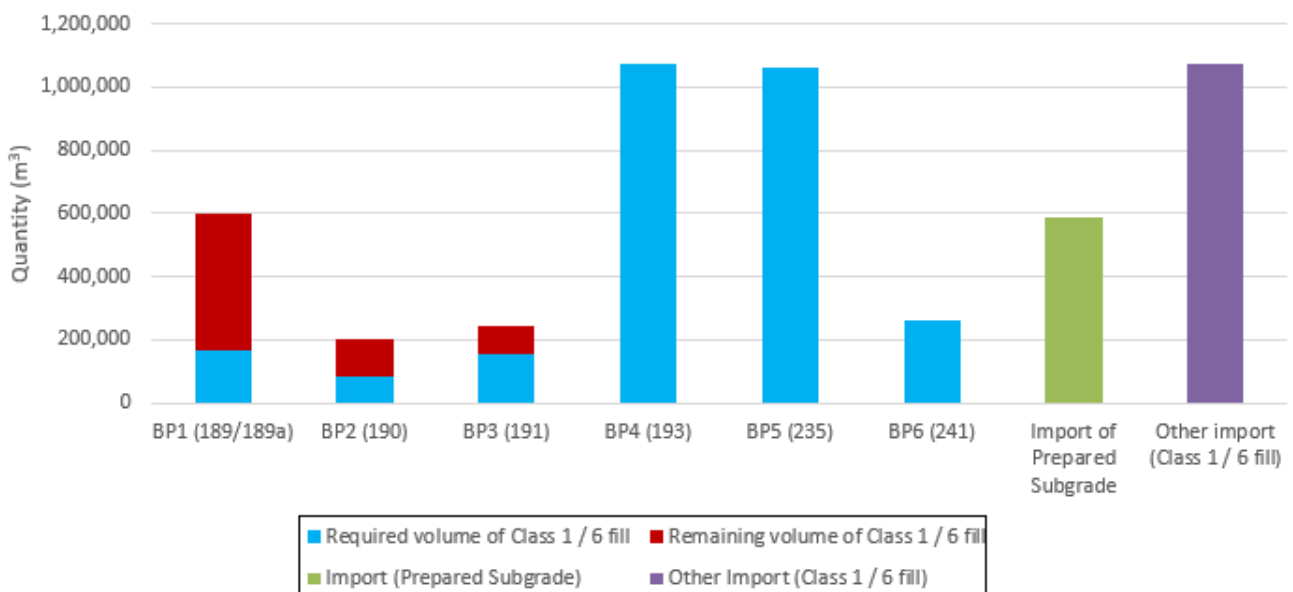
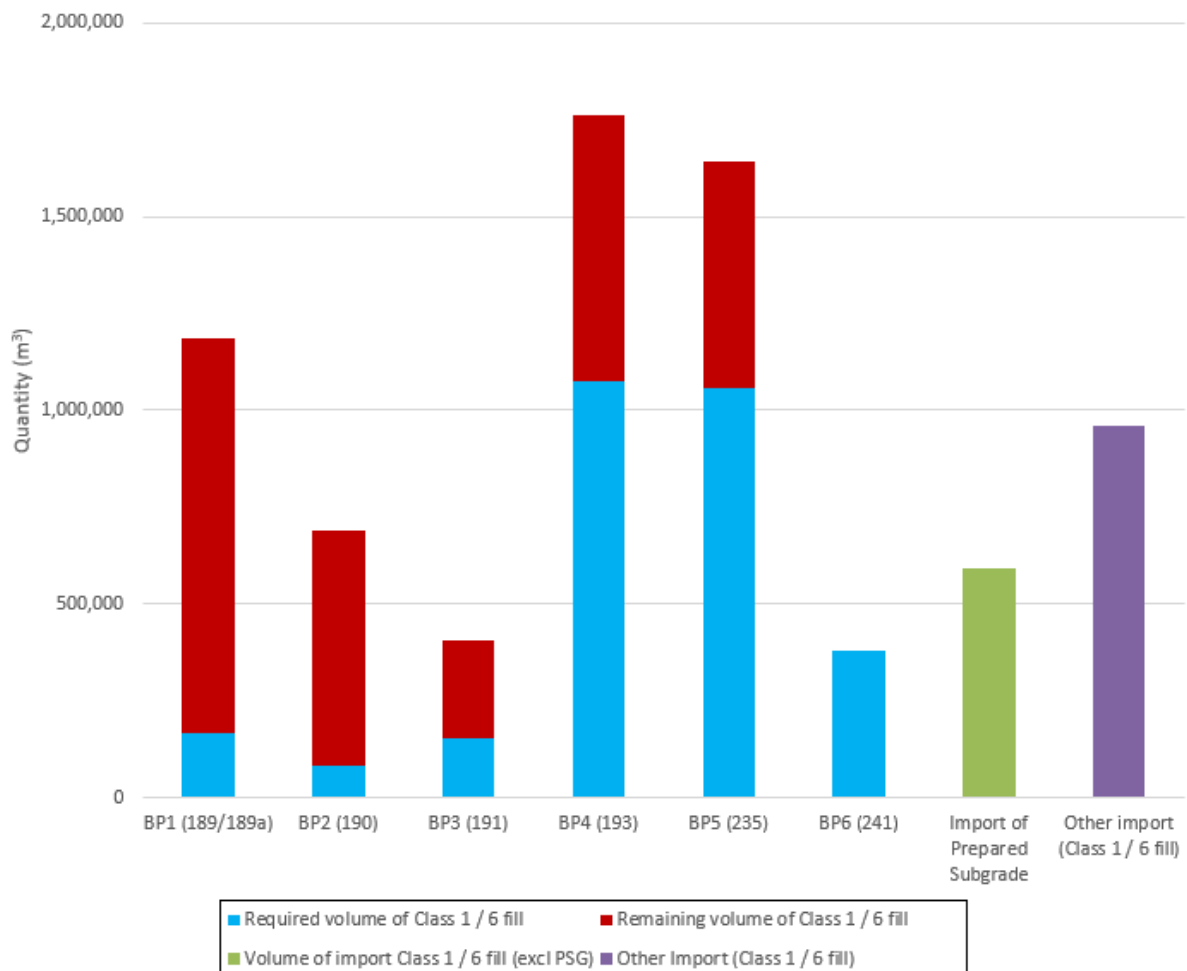


Figure 7: Borrow Pit granular material in design for the AP2 revised scheme without PGI



3.4.3 Figure 8 provides a graphical illustration of the estimated potential volume of Class 1 / 6 granular material and the proportion required from each borrow pit for the AP2 revised scheme earthworks design stage with draft PGI. No allowance is made for changes in granular material volumes from the major cuttings.

Figure 8: Borrow pit granular material in the AP2 revised scheme earthworks design with draft PGI data



3.4.4 Figure 9 and Figure 10 provide graphical illustrations of the Class 1 / 6 granular material estimates for the AP2 revised scheme earthworks design based on an interpretation of the results of the draft PGI. They illustrate the volume of granular material that can no longer be sourced from the major cuttings (yellow bar in Figure 9) and how this material might be sourced from borrow pits (Borrow Pit 2 and Borrow Pit 5 - yellow bar within the overall Borrow Pit 2 and Borrow Pit 5 capacity in Figure 10⁴⁰), subject to the considerations discussed in para 3.3.16. These charts do not take account of the potential changes in borrow pit extents discussed in Section 5.

⁴⁰ Figure 10 illustrates one way that changes in granular material volumes from major cuttings might be sourced from borrow pits as an alternative.

Figure 9: Borrow Pit granular material in the AP2 revised scheme earthworks design with draft PGI data

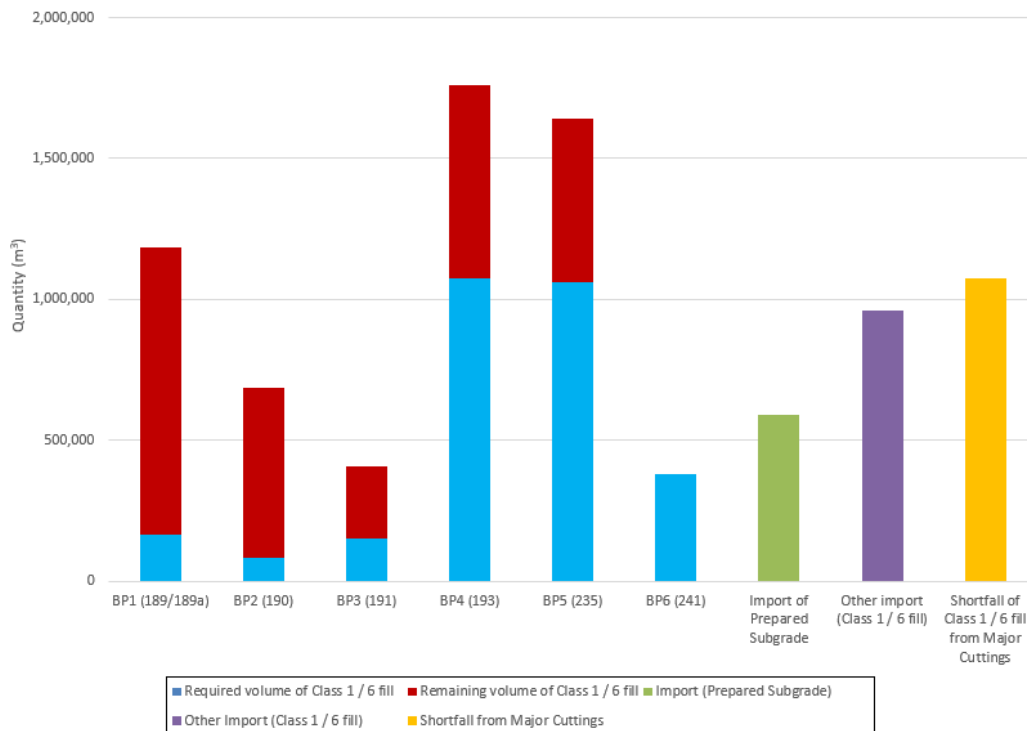
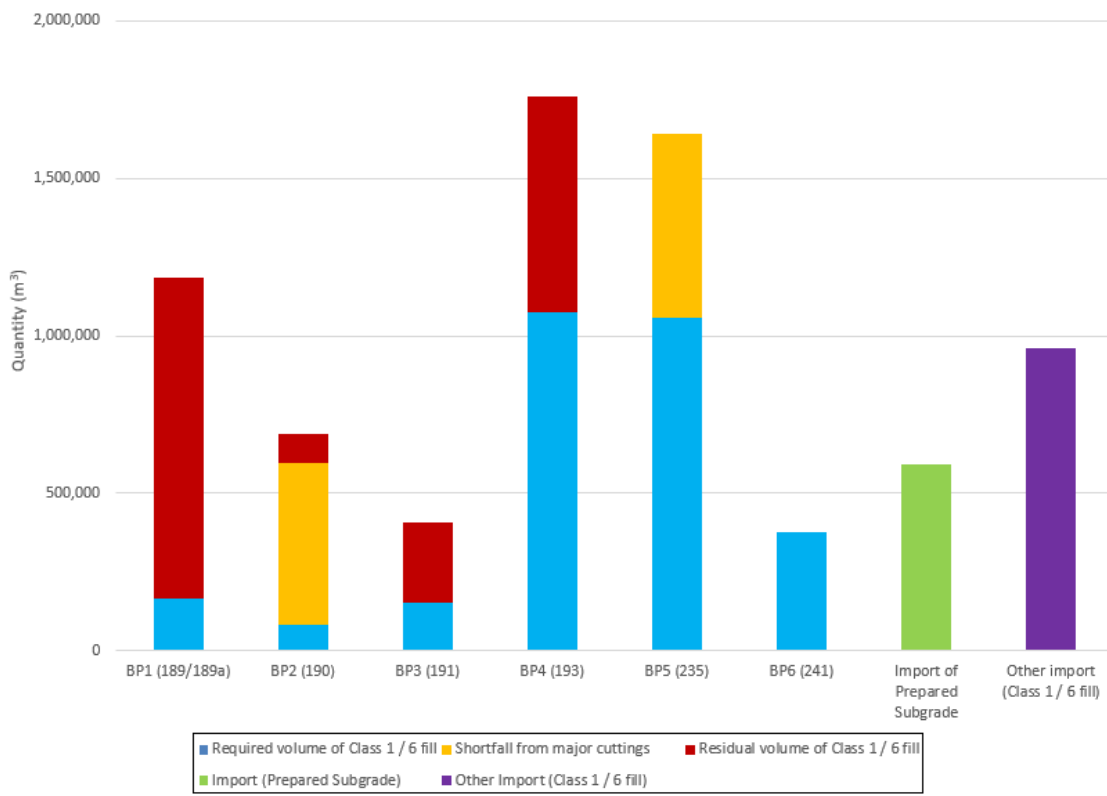


Figure 10: Borrow pit granular material in the AP2 revised scheme earthworks design with draft PGI data



3.5 Opportunities for further refinement of earthworks and materials movement

3.5.1 The earthworks design and materials movement analysis used as the basis for assessing the AP2 revised scheme are a reasonable 'worst case' for the environmental assessment reported in the SES2 and AP2 ES but do not include the findings of the preliminary ground investigation because the earthworks design and the materials movement analysis were prepared prior to the commencement of the PGI.

3.5.2 HS2 Ltd will continue to investigate opportunities for reducing the environmental effects arising from the earthworks and materials movements, including:

- reducing the extent and use of borrow pits, in line with assurances given to the National Farmers Union (NFU) and landowners;
- changing the design of engineering earthworks e.g. steepening earthworks slopes and reducing excavation volumes, where further ground investigation shows this to be feasible;
- the use of in-situ ground stabilisation, reducing the need to replace material that does not meet engineering requirements;
- the inclusion of additional or larger landscape earthworks, where these would improve mitigation screening of the railway from nearby communities; and
- examining opportunities to use surplus excavated material on land outside Bill limits. This could involve providing material e.g. for land restoration or flood defence schemes or the placement on land with the agreement of the owners.

3.5.3 These opportunities will be explored by HS2 Ltd and the contractors, in due course, taking account of the balance of engineering, environmental and construction requirements and cost, in accordance with the HS2 Phase 2a Environmental Minimum Requirements (EMR).

4 Geology and hydrogeology

4.1 Introduction

4.1.1 The information on the borrow pits and major cuttings in this review is a work in progress and is based on the draft information from the draft preliminary ground investigation (PGI) report. The draft borehole logs have been evaluated to provide draft geological cross sections for each borrow pit and an initial interpretation of the subsoil profile at each borrow pit and major cutting. This information has been used to prepare a draft information engagement pack for each borrow pit which is provided as Appendix F.

4.1.2 As at the end of January 2019, the PGI fieldwork had been completed at all of the relevant ground investigation work package locations. The laboratory testing had also been completed and the PGI contractor's draft factual report was received in January 2019. The final preliminary ground investigation report is due to be available in April 2019 and any changes to data will be reflected in updates to this review.

4.2 Geology

HS2 Phase 2a scheme and petitioner proposed borrow pits

4.2.1 Appendix F contains the following information:

- plans of the locations of exploratory holes for the PGI (and historical GI where appropriate);
- tables summarising the draft geological information for each borrow pit; and
- indicative draft geological cross-sections for each borrow pit. Where information from historical GI is considered to be reliable, this information has also been included in the plans and cross sections in Appendix F.1.

4.2.2 The proportion of the mineral that is suitable as granular fill to construct the HS2 Phase 2a revised scheme has been interpreted based on draft PGI data.

Major cuttings

- 4.2.3 The geology at the major cuttings is summarised in Section 3.3 (paras 3.3.11 to 3.3.14) Appendix B contains maps A to D which show the location of major cuttings.

4.3 Hydrogeology

- 4.3.1 The PGI was designed to provide detailed site-specific information on the permeability of the ground at each borrow pit location and also facilitated the monitoring of surface water and groundwater levels during pumping tests. The pumping tests were carried out with the objective of improving the understanding at each borrow pit of:

- the baseline groundwater and surface water feature water levels and water quality;
- the effect of pumping on groundwater and surface water levels and flows; and
- to provide information on ground permeability and hydraulic properties to refine previous assessments of impact (as reported in the SES2 and AP2 ES) and to aid future development of the design of mitigation options (if required).

- 4.3.2 The results of pumping tests, once verified, will be used to further develop the hydrogeological conceptual model of the borrow pit areas and inform numerical modelling during detailed design. This in turn will provide a refined representation of the potential construction dewatering radius of influence and allow more accurate prediction of potential impacts on water receptors.

- 4.3.3 The findings of the pumping tests and updated hydrogeological models for borrow pits will be reported separately and do not form part of the scope of this report because the models and model outputs do not directly impact on the extent of borrow pits.

4.4 Water features surveys

- 4.4.1 In August and September 2018, where access was possible, water feature walkover surveys were undertaken to assess groundwater and surface water features, including drainage channels, which might be affected by the excavation and dewatering of the borrow pits⁴¹. During the walkover surveys the surveyors took photographs and notes of features of interest, as well as water quality readings where necessary to identify potential connectivity between surface water and groundwater in the vicinity of the borrow pits.

- 4.4.2 These surveys, once complete, will allow an assessment to be made of the potential impacts of borrow pit dewatering on these water features based on the outputs from the updated hydrogeological models described in Section 4.3.

⁴¹ At the time of these surveys, access was not available at a number of locations and future surveys will be required to complete the surveys at these properties/farms.

5 Consideration of HS2 Phase 2a borrow pit extents with draft PGI

5.1 Introduction

- 5.1.1 Section 4 and Appendix F of this report provide updated information on the ground conditions that have been confirmed by the draft preliminary ground investigation (PGI) at each borrow pit.
- 5.1.2 Sections 5.2 to 5.7 provide a summary of potential reductions in the footprint of borrow pits taking into account the presence of potential live utilities or proposed utility diversions as well as the results of the draft PGI.
- 5.1.3 The materials extracted from the borrow pits are intended for constructing the railway embankments. However, if the properties are suitable, and sufficient quantities are available, there may be an opportunity for minerals extracted from the borrow pits to be used to make concrete or other cement bound materials for construction of the HS2 Phase 2a revised scheme.
- 5.1.4 As described in Section 3.3, it is estimated that, based on the draft PGI data, a total of approximately 1.1 Mm³ less granular fill can be sourced from the major cuttings than had previously been estimated prior to the PGI. Future design development will need to assess the potential feasibility of extracting additional granular material from borrow pits in CA1 and CA4 (principally Borrow Pit 2 and Borrow Pit 5)⁴².
- 5.1.5 Further interpretation will be undertaken when the PGI contractor's final factual report has been received.
- 5.1.6 The extent of all borrow pits will also be considered in more detail after detailed ground investigation and further analysis of the earthworks strategy have been undertaken during detailed design.

5.2 Borrow Pit 1 (189/189a)

- 5.2.1 In terms of potential changes to the extents of this borrow pit, there is a proposed utility diversion across the southern end of the borrow pit which is likely to reduce the footprint area of the borrow pit that is available for mineral extraction by approximately 1.2 ha (see areas A.1 and A.2 coloured red in Figure 11).
- 5.2.2 The coloured areas in Figure 11 represent the following:
- Area C (coloured purple) and Area D (coloured green (hatched) areas – approximately 3.6ha – are areas identified by the owner of Woodend Farm during

⁴² Where these borrow pits are not currently 100% utilised and it can be confirmed that the use of these borrow pits would not create new or different significant effects, in particular, on local roads and communities / other sensitive receptors.

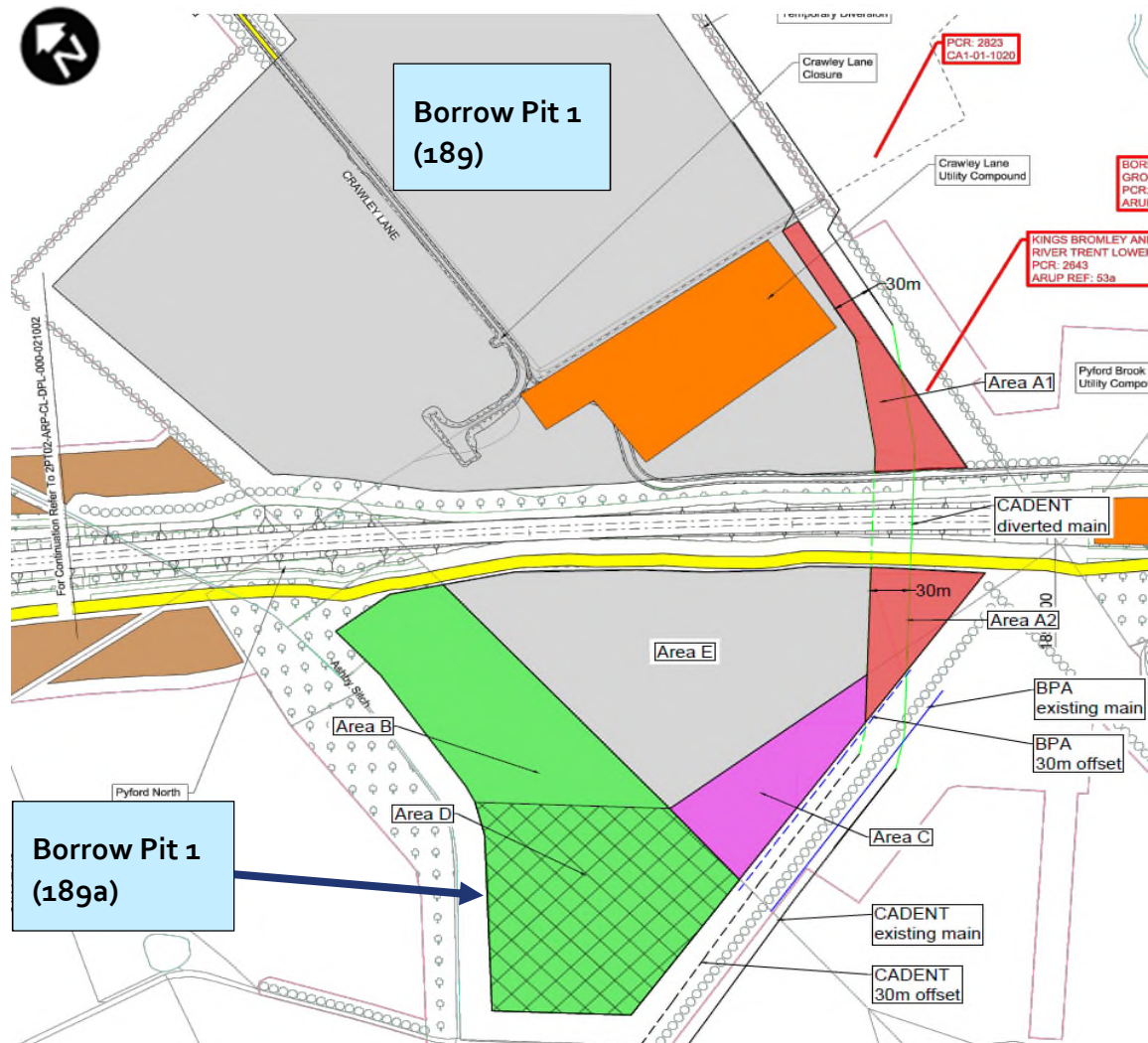
the 2018 Select Committee hearings as areas that they would wish to see removed from the HS2 Phase 2a scheme; and

- Area B (coloured green area (includes Area D) -approximately 4.8ha – is owned by Common Farm, this same landowner is also affected by borrow pit 2.

5.2.3 The draft PGI has confirmed that there is little or no available mineral that could be used to construct the HS2 Phase 2a scheme in Area B and D in the western part of Borrow Pit 1 (189a area).

5.2.4 The area that would be available for mineral extraction if the areas A.2, B, C and D were to be removed from borrow pit extraction area west of the route is approximately 4ha (out of 10ha for this part of Borrow Pit 1 (189a)). Based on the draft PGI, this residual area of Borrow Pit 1 (189a) (shown as Area E on Figure 11) would only provide approximately 0.10 Mm³ of mineral that would be acceptable as granular fill.

Figure 11: Borrow Pit 1 areas A to E.



5.2.1 The draft PGI has confirmed that the volumes of granular material available in the eastern part of Borrow Pit 1 (189) will be sufficient to construct the HS2 Phase 2a

scheme and that the western part of Borrow Pit 1 (189a) will no longer be required as part of Borrow Pit 1.

5.2.2 Areas A.1 and A.2 in Figure 11 would remain as part of the area required for temporary works for utility diversions.

5.3 Borrow Pit 2 (190)

5.3.1 In terms of potential changes to the footprint of this borrow pit, an existing water pipe runs across the northern part of the eastern boundary of the borrow pit. This will reduce the footprint of the borrow pit that is available for mineral extraction by approximately 0.3ha. Based on the PGI draft results, it is unlikely that the extent of the footprint of this borrow pit will be reduced at this stage of design.

5.3.2 Further consideration will be given to the use of this borrow pit to provide additional granular material as described in Section 3.4 and para 5.1.4 as well as the potential for this borrow pit to provide concrete or other cement bound materials for construction of the scheme as described in para 5.1.3 and para 5.1.4.

5.4 Borrow Pit 3 (191)

5.4.1 A study to assess the feasibility of removing the Bourne Embankment and replacing it with a viaduct has been completed which has allowed HS2 Ltd to better understand the advantages and disadvantages of replacing the embankment with viaduct. HS2 Ltd is in discussions with the directly affected tenants and landowners who have petitioned on this matter.

5.4.2 In the event that this change in design is adopted, Borrow Pit 3 would no longer be required for the construction of the Bourne embankment itself⁴³. However, the substitution of the embankment by a longer viaduct structure will increase the requirements for concrete or other cement bound materials at this location and there is potential for this borrow pit to provide this material locally to where it is required (i.e. as described in para 5.1.3). Nonetheless, it is likely that it would be possible to reduce the extent of the footprint of this borrow pit in order to minimise disruption to the farm holding and that the operational area could be confined to the south-eastern end of the borrow pit footprint.

5.4.3 In the event that the Bourne embankment is still required, potential changes to the extent of this borrow pit would be possible as follows as shown in Figure 12:

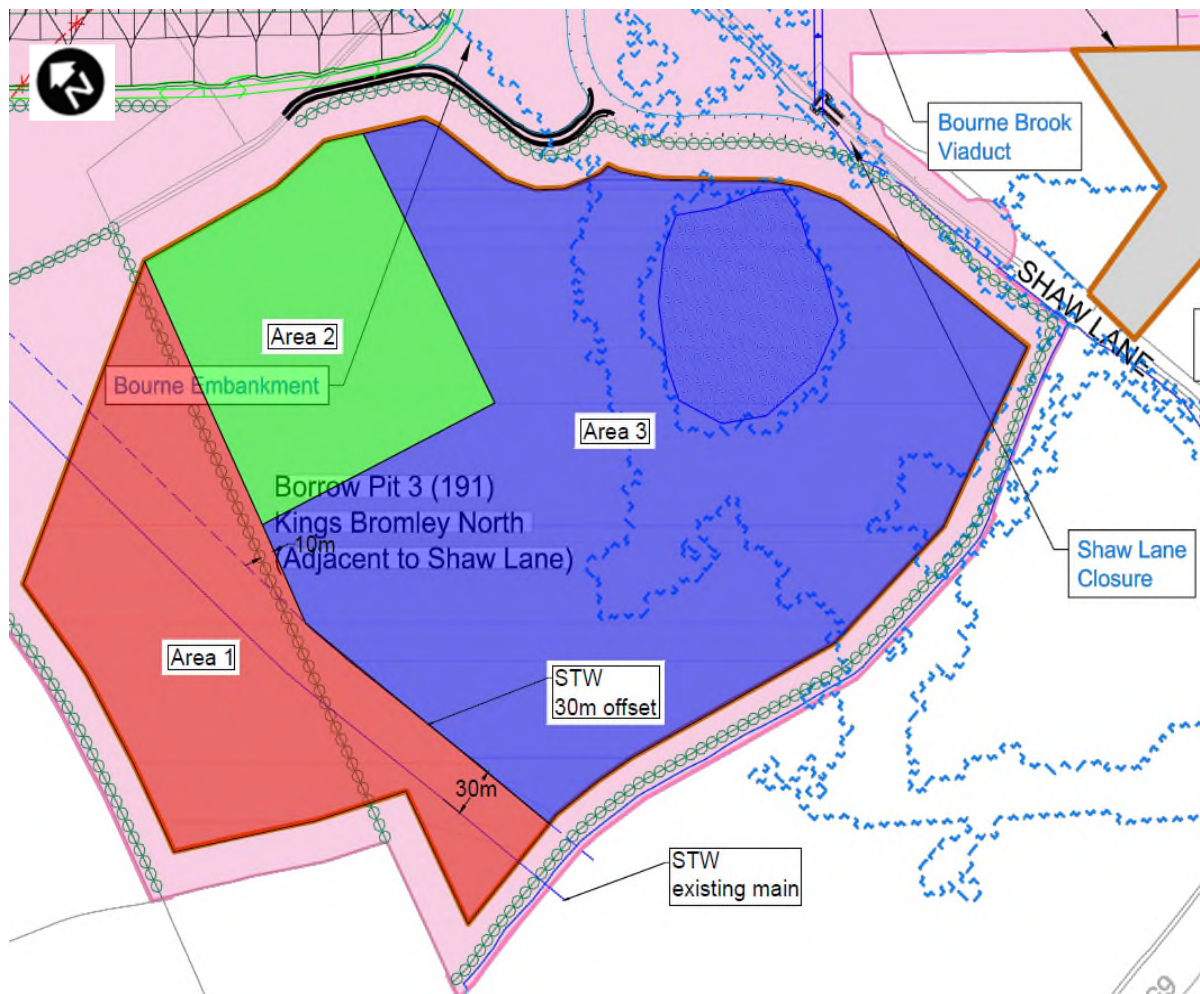
- an existing large diameter water main (owned by Severn Trent Water) runs through the western part of the borrow pit. This will reduce the footprint area of the borrow pit that is available for mineral extraction by approximately 4.5ha (Area 1); and

⁴³ A revised design at this location would also allow a reconfiguration of the layout of the precast yard and laydown area to be agreed with the landowner assuming that these could be relocated to part of the borrow pit area.

- a 3ha area within the existing borrow pit footprint could be used to accommodate the reconfiguration of the layout of the precast yard and laydown area (Area 2).

5.4.4 Overall the above changes would reduce the extent of the borrow pit footprint by approximately 7.5ha (out of a 19ha total original area) as shown in blue as Area 3 in Figure 12. During future design development there will be an opportunity to consider and, if necessary, avoid the most sensitive areas of potential archaeology at this borrow pit.

Figure 12: Borrow Pit 3 (191) reconfiguration



5.5 Borrow Pit 4 (193)

5.5.1 Based on the results of the draft PGI, reductions in the extent of this borrow pit are not proposed at this stage of design.

5.5.2 As part of this review it has been confirmed that it will be possible to accommodate the movement of cattle across Pipe Hall Farm during operation of this borrow pit. The details of this arrangement will be agreed with the landowner.

5.6 Borrow Pit 5 (235)

- 5.6.1 Based on the results of the draft PGI, reductions in the extent of this borrow pit are not proposed at this stage of design. This is due to the findings of the draft PGI at the cuttings, in particular, the Swynnerton North, Hatton South and Whitmore South Cuttings (see Section 3.3, paras 3.3.11 to 3.3.16). It is anticipated that additional material may need to be excavated from this borrow pit to make up the requirement to source suitable construction materials that will not be available from these cuttings.
- 5.6.2 Of relevance to future considerations on the extent of the footprint of this borrow pit, are the draft PGI results at selected PGI locations (see Appendix F) which indicate that there may be a small area of this borrow pit which will not yield mineral aggregates of a suitable quality for the HS2 Phase 2a scheme. The extent of this area, which is close to Netherset Hey Farmhouse, and the potential to reduce the extent of the borrow pit footprint, will be considered further when the PGI contractor's final factual report has been received.

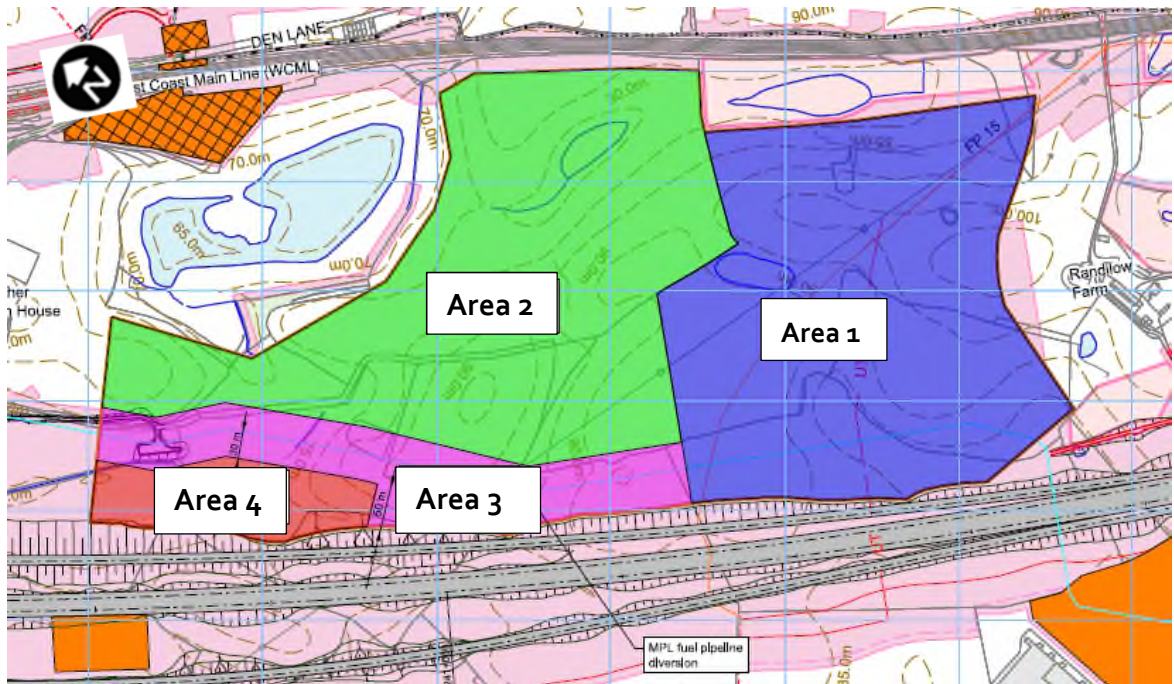
5.7 Borrow Pit 6 (241)

- 5.7.1 The geology of this borrow pit is variable and complex (see Appendix F and para 3.3.8).
- 5.7.2 Based on the draft PGI data, the areas of this borrow pit which are expected to yield most of the materials that would be suitable for construction of the HS2 Phase 2a scheme are shown indicatively as Areas 2 and 4 in Figure 13. This is based on the initial results of a ground model interpreted from the draft PGI information and will be confirmed on receipt of the PGI contractor's final factual report.
- 5.7.3 Borrow pit 6 can be broken down into the following areas:
- Area 1 (coloured blue in Figure 13 - approximately 16 ha) - the area least likely to yield materials suitable for construction of the scheme at the southern end of the borrow pit and the area closest to Randilow Farm;
 - Area 2 (coloured green in Figure 13 - approximately 17 ha) and Area 4 (coloured red in Figure 13 - approximately 2.2 ha) – the areas most likely to yield materials suitable for construction of the scheme in the northern and north-western parts of the borrow pit; and
 - Area 3 (coloured purple in Figure 13 - approximately 4.8 ha) – this is an area which is required for a utility diversion and would not be available as part of the operational borrow pit⁴⁴.
- 5.7.4 Areas 2 and 4 combined are approximately 19ha in area, slightly less than half of the original borrow pit extent. The draft PGI has confirmed that the volumes of granular material available Areas 2 and 4 will be sufficient to construct the HS2 Phase 2a revised

⁴⁴ This includes land owned by Grange Farm on the western side of the borrow pit.

scheme and that the southern part of Borrow Pit 6 (Area 1) and Area 3 will no longer be required as part of Borrow Pit 6.

Figure 13: Borrow Pit 6 (241)



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APPENDIX A

Glossary, terminology and abbreviations

HS2

Abbreviation, term or acronym	Definition
Aftercare	The ongoing management of a restored site to ensure that the restoration is established, is sustainable and delivers the proposed after use. It is usually used in the context of restoration of agricultural land.
Aquifer	A geological formation that is sufficiently porous and permeable to store and yield a significant quantity of water to a borehole, well or spring.
ATFS	Auto-transformer feeder station - permanent compounds located next to railway lines. They contain equipment that enables electrical power to be transferred between the National Grid network and the railway line.
ATS	Auto-transformer station - an installation that accommodates switchgear and associated equipment. Auto-transformer stations are located in the railway corridor at approximately 5km (3 mile) intervals. They allow the distance between auto-transformer feeder stations to be increased.
BGL	Below ground level
BGS	British Geological Survey
BH	Borehole
Borrow pits (BP)	Areas excavated to provide material for construction purposes.
Borrow Pits Restoration Strategy (BPRS)	The BPRS describes how the land in the borrow pits will be made available to be returned to their original land uses, which is predominantly agricultural, subject to individual land owner agreements.
Chainage	Chainage (known as reference chainage) is referenced from Euston Station, which is 0+000, and the value presented is in metres. E.g. 192+000 refers to the point, 192,000m, or 192km, from Euston Station. The chainage has been used in the naming convention for each borrow pit.
CL:AIRE	Contaminated Land: Applications in Real Environments is an independent not-for-profit organisation established in 1999 to stimulate the regeneration of contaminated land in the UK by raising awareness of, and confidence in, practical and sustainable remediation technologies.
Cohesive material	Soil for use as engineered fill with a content of fine material (ie material passing a 63 micron sieve) of greater than 15%, which has cohesive strength. The fine material is either silt, clay or a mixture of silt and clay.
CoCP	Code of Construction Practice
CP	Control point, a stage in the development of design.

Abbreviation, term or acronym	Definition
CPT	Cone penetration test (also referred to as a static cone penetration test), a test which is used to determine geotechnical properties of soils and to provide information on the profile of mineral deposits.
Constant rate test	The most common form of pumping test is the constant-rate pumping test in which a control well is pumped at a constant rate and water-level response (drawdown) is measured in one or more surrounding observation wells and optionally in the control well itself.
Cutting	A linear excavation of soil or rock to make way for a new railway or road. Cuttings help reduce the noise and/or visual impact of passing trains or road vehicles.
Detailed design	The process in which the finer details of the design of a proposed development are developed.
Earthworks	The removal or placement of soils and rocks such as in cuttings, embankments and environmental mitigation, including the in-situ improvement of soils/rocks to achieve desired properties.
Earthworks quantity estimate	The estimate of volumes, sources and destinations of material at a particular design control point which defines a particular earthworks design.
Earthworks strategy	An assessment of earthworks and materials movement required to construct the Phase 2a scheme. It is based on assessments of the volume and quality of the excavated material from cuttings, tunnels and borrow pits and will be refined as more information becomes available from the preliminary ground investigation (PGI).
Embankment	Artificially raised ground, commonly made of rock or compacted soil, on which a new railway or road is constructed.
Environmental Minimum Requirements (EMR)	EMR set out the environmental and sustainability commitments to be made by the Secretary of State for Transport that will be observed in the construction of the Phase 2a revised scheme.
Excavated material	Soil, rock and other material that has been removed from the ground during construction.
Granular material or aggregate	Sand, gravel or crushed rock that can be used for building and/or civil engineering purposes (e.g. to build railway embankments or to produce concrete).
Groundwater	All water that is below the surface of the ground and within the permanently saturated zone.
ha	Hectare (10,000 m ² area)
HGV	Heavy goods vehicle(s)
Hydrogeology	The nature, distribution and movement of groundwater in soils and rocks, including in aquifers.

Abbreviation, term or acronym	Definition
M	Million
m ³	Cubic metre
Mass haul movement plan (MHMP)	<p>A plan which describes how earthworks materials could be transported across the Phase 2a scheme. Each MHMP identifies one possible option of how the Phase 2a scheme could be constructed, based on the level of information available at that time and the assumptions made.</p> <p>The MHMP defines where the material excavated from each cutting, tunnel or borrow pit could be used, where the material used to construct the Phase 2a scheme could be sourced and how materials could be transported (and via what routes) to and from the various aspects of the Phase 2a scheme.</p>
MLP	Minerals local plan
Materials management plan (MMP)	A MMP is a mechanism by which those who are developing a site can comply with Environment Agency regulations for excavated ground materials.
MSA	Mineral safeguarding area
Nominated undertaker	The body or bodies appointed to implement the powers of the hybrid Bill to construct and maintain the Phase 2a scheme.
PGI	Preliminary ground investigation
Pump test and recovery test	<p>A pumping test consists of pumping groundwater from a well, usually at a constant rate, and measuring the change in water level (drawdown) in the pumping well and any nearby wells (observation wells) or surface water bodies during and after pumping. On completion of a pumping test the recovery in water levels is measured in surrounding observation wells and the pumping well (the recovery test).</p> <p>The pumping test is a practical method of estimating well performance, the zone of influence of the well and aquifer characteristics (e.g. the aquifer's ability to store and transmit water) as well as possible hydraulic connection to surface water and other groundwater abstractions.</p>
Restoration	The works delivered following completion of excavation, including regrading of excavations, the placement and preparation of soils, and landscape treatment.
SCC	Staffordshire County Council
SHW	(Department for Transport) Specification for Highway Works
Surplus excavated material	Excavated material becomes surplus if: its irrecoverable physical, chemical or biochemical quality prevents it from being used in the Phase 2a scheme; there is more material than

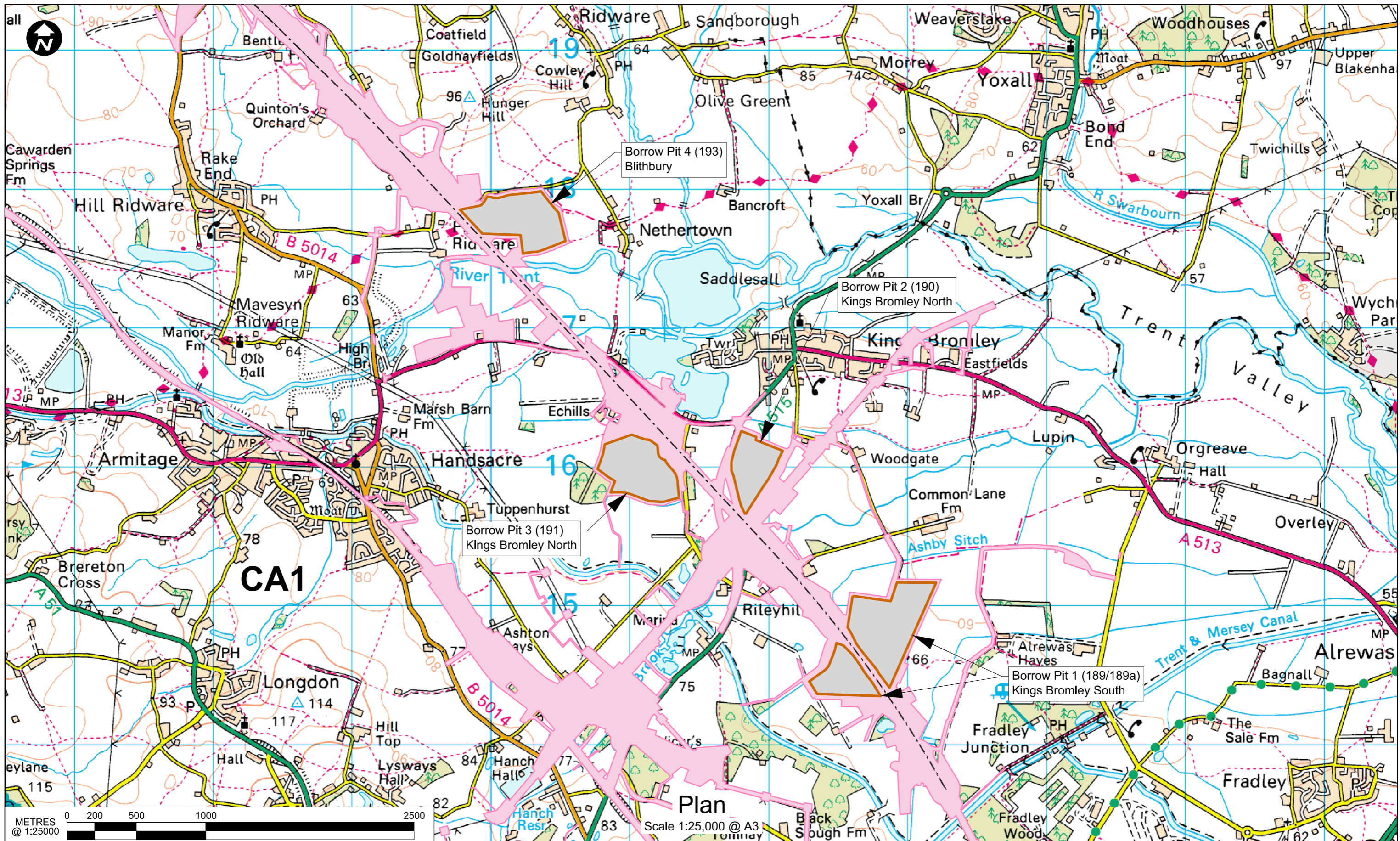
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Abbreviation, term or acronym	Definition
	required for the Phase 2a scheme or other permitted schemes; or the requirement for a type of material is too far away from the excavation point to make its use practicable.
T	Tonne
TP	Trial pit
Vehicle movement	A journey made by a vehicle that can either be a one-way or two-way trip.

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APPENDIX B

Borrow pit and cuttings Locations, borrow pit layouts



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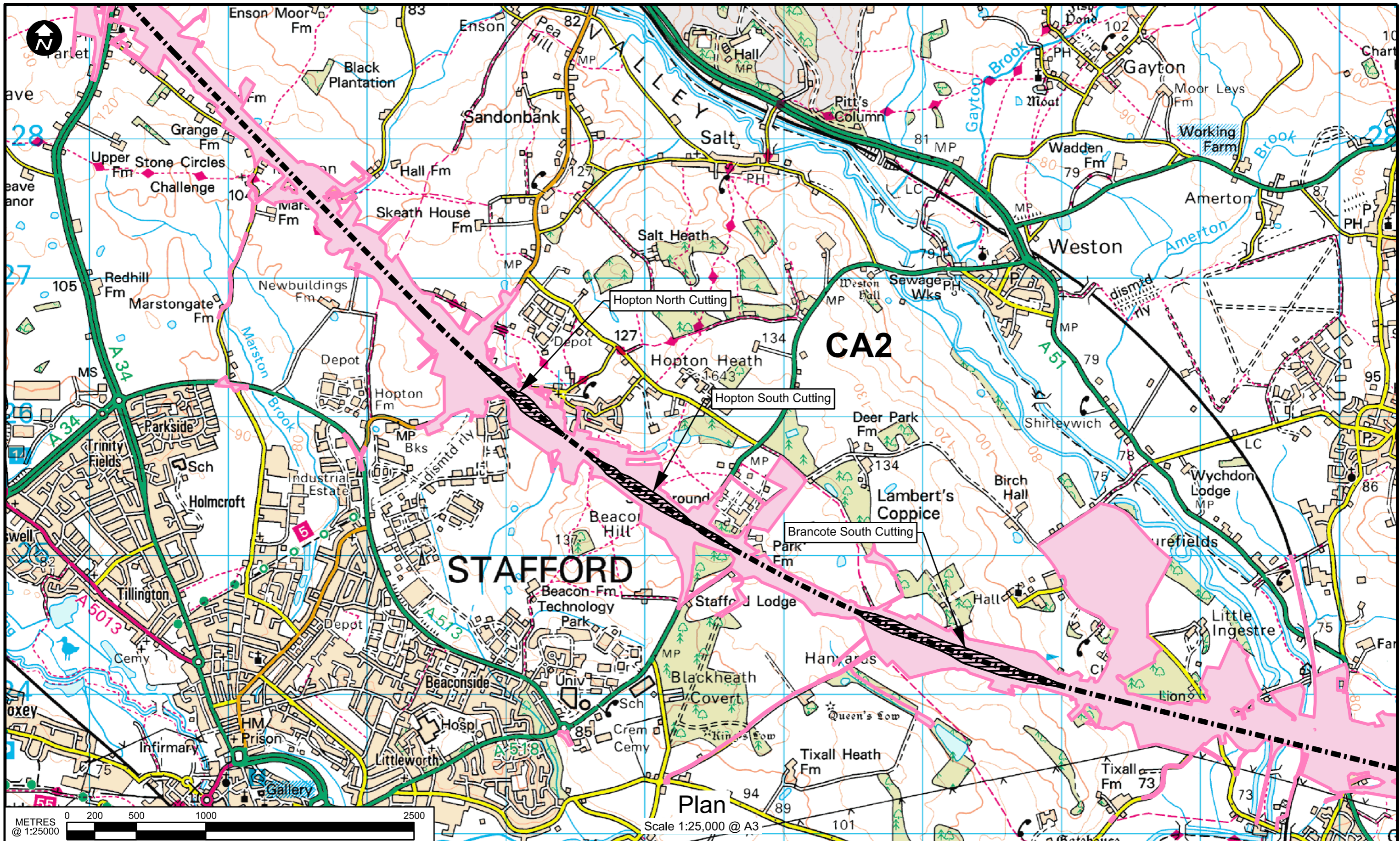
- Construction Area
- Borrow Pit
- HS2 Centreline
- Community Area Boundary

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Registration No. 06791686
Registered office:
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Birmingham, B4 6GA

Creator/Originator
Ove Arup & Partners International Ltd

Zone	Route Wide
Design Stage	Designs for Petition
Drawing Title	Figure A Location Plan for Borrow Pits and Major Cuttings

Project/Contract C861 Hybrid Bill Additional Provision 2 AP2		
Discipline/Function Petitions		
Drawn DS	Checked ACH	Approved TE
Date 16/01/2019	Scale 1:25000	Size A3
Drawing No. 2PT02-ARP-PT-DSK-000-000001		Rev. P00.1



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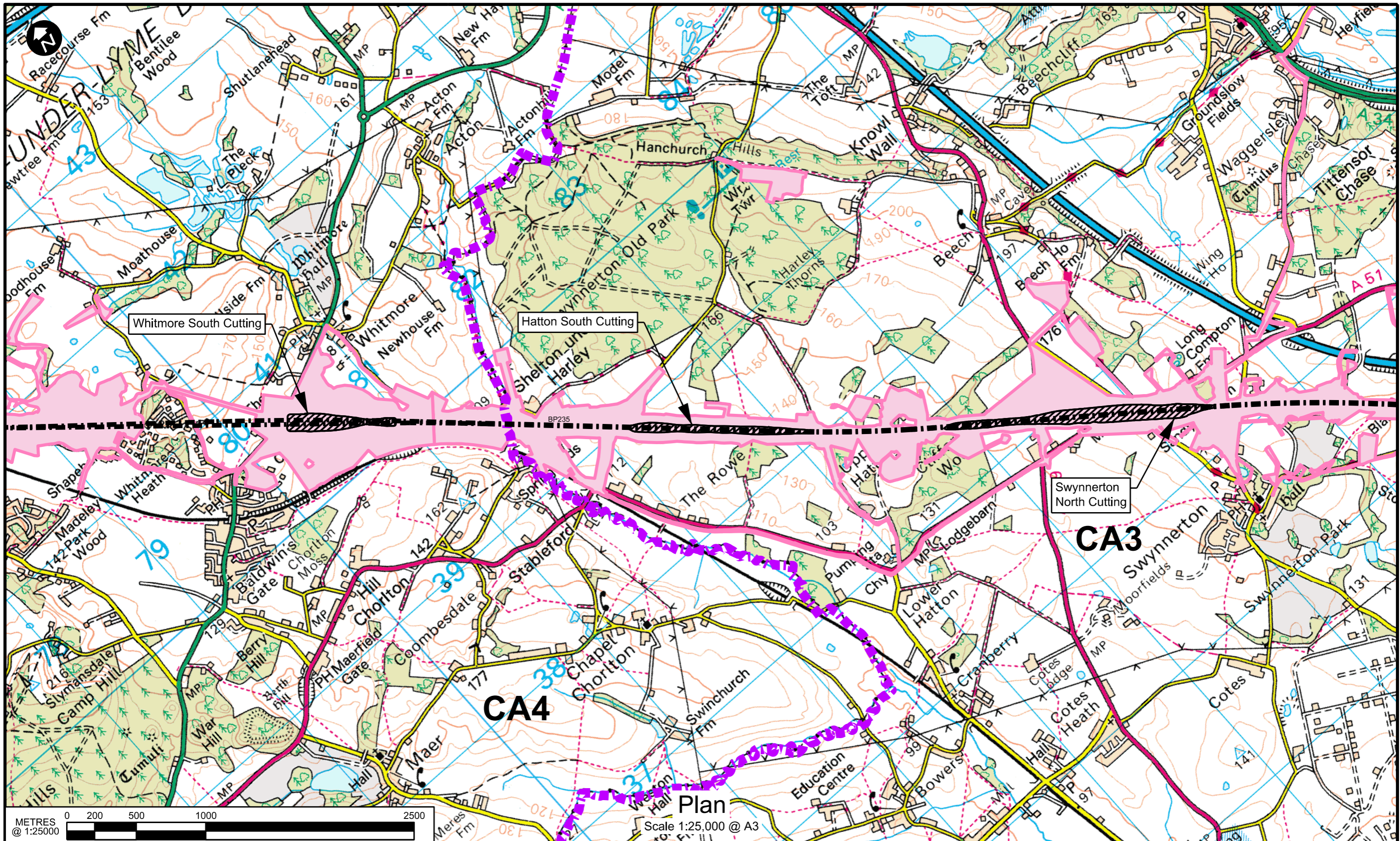


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Zone	Route Wide
Design Stage	Hybrid Bill - Draft Initial Preliminary Design
Drawing Title	Figure B Location Plan For Borrow Pits and Major Cuttings

Project/Contract	P2A Civils Design & Environmental Services		
Discipline/Function	Geotechnical		
Drawn	Checked	Approved	
DS	AC	TE	
Date	Scale	Size	
08/01/2018	1:25000	A3	
Drawing No.	Rev.		
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		4/04/2018	4/04/2018	

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Design Stage	Hybrid Bill - Draft Initial Preliminary Design
Drawing Title	Figure C Location Plan For Borrow Pits and Major Cuttings

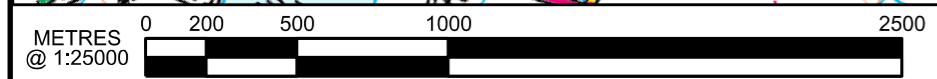
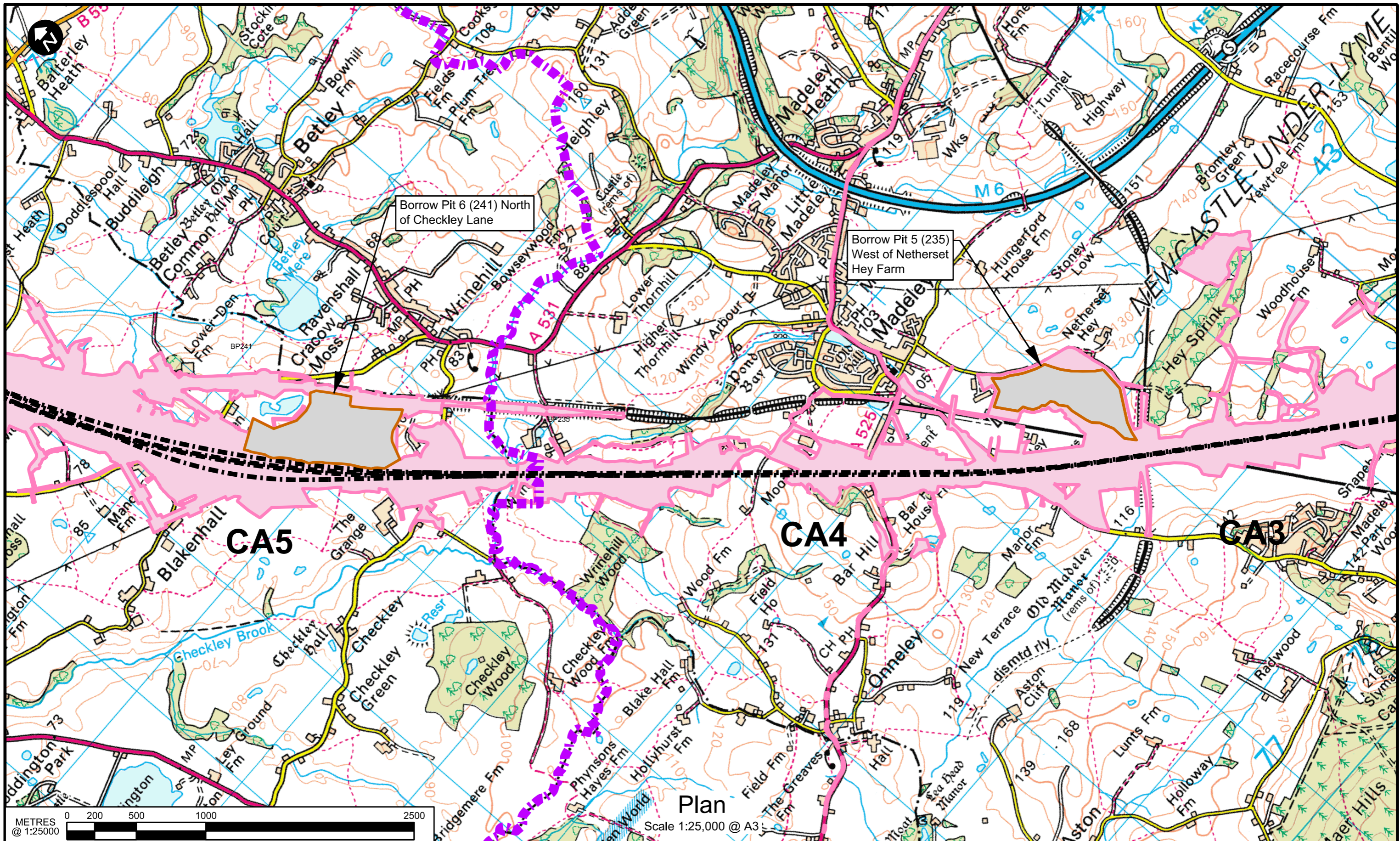
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Drawn	Checked	Approved	
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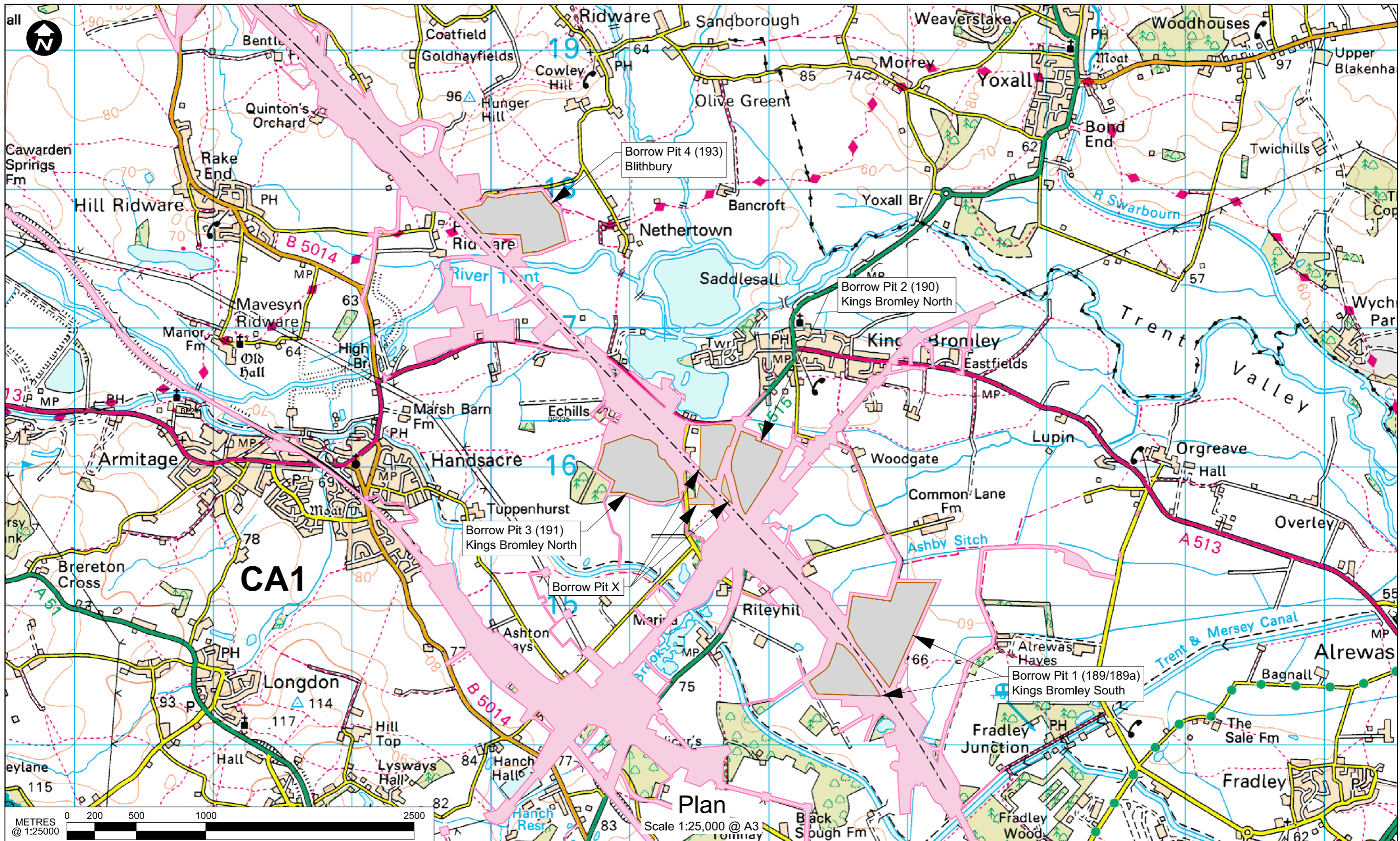


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Drawing Title	Figure D Location Plan For Borrow Pits and Major Cuttings

Project/Contract		P2A Civils Design & Environmental Services	
Discipline/Function		Geotechnical	
Drawn	Checked	Approved	
DS	AC	TE	
Date	Scale	Size	
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Drawing No.		Rev.	
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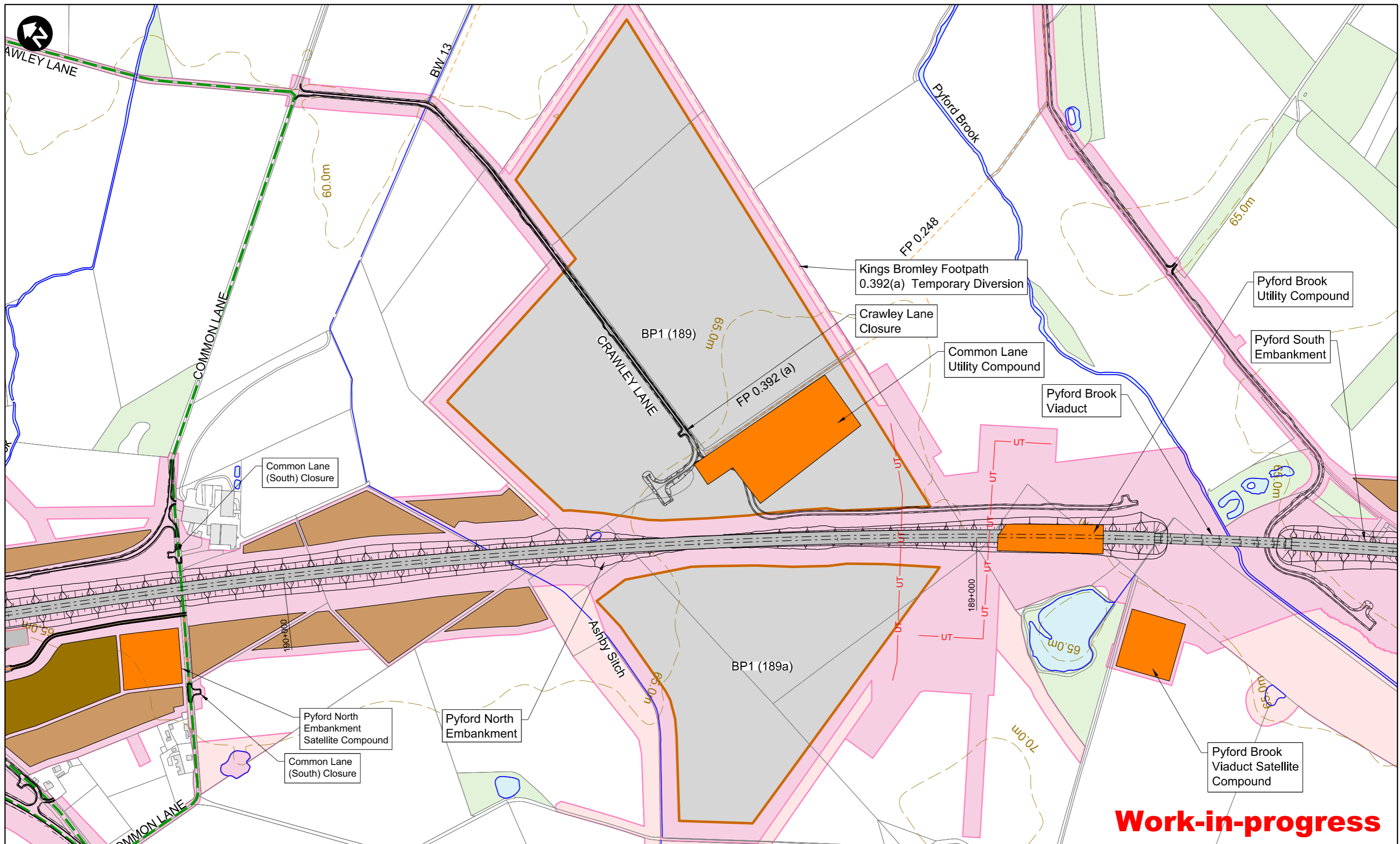
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Zone	Route Wide	Project/Contract	
Design Stage	Designs for Petition	C861 Hybrid Bill Additional Provision 2 AP2	
Drawing Title	Figure E Borrow Pit X	Discipline/Function Petitions	
	Alternative Borrow Pit Location	Drawn	Checked
		DS	ACH
		Approved	TE
		Date	Scale
		16/01/2019	1:25000
		Size	A3
		Drawing No.	Rev.
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Legends/Notes:

- Engineering earthworks
- Landscape earthworks
- Rail alignment
- Rail alignment formation
- Temporary Material Stockpile
- Indicative extent of Petitioner's land
- Construction Traffic Route

- Existing public right of way
- HS2 Access road
- Main Construction Compound
- Satellite Construction Compound
- Land potentially required during construction
- Extent of land potentially required during construction for mitigation planting

- Existing Inland Water
- Existing Woodland
- New, diverted or realigned PROW
- Stopped-up PROW
- Main Utility Work
- Haul Road

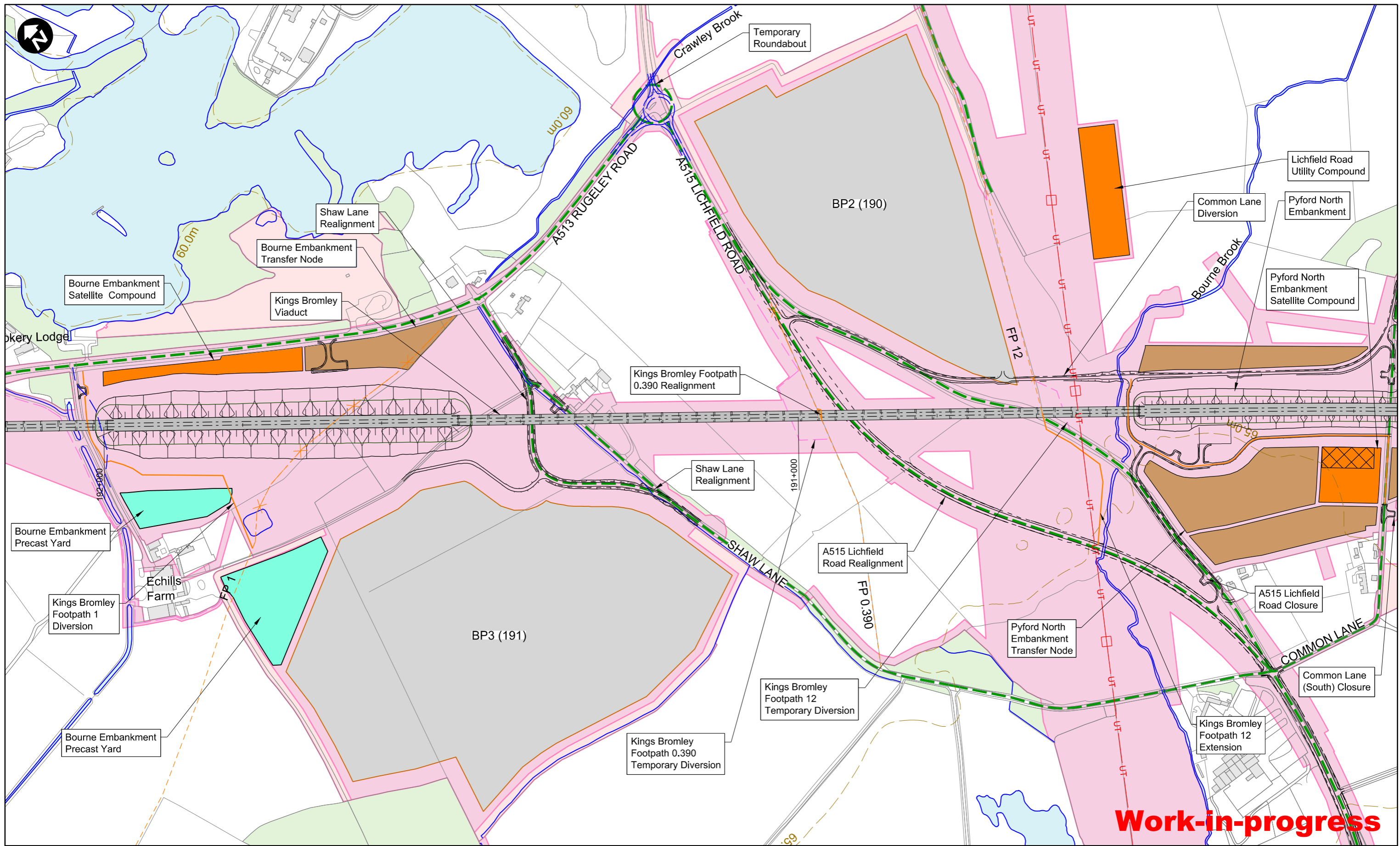
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Design Stage	Hybrid Bill - Draft Initial Preliminary Design	
Drawing Title	Figure F Borrow Pit 1 (189/189a)	

Project/Contract C861 Hybrid Bill Additional Provision 2 AP2		
Discipline/Function Petitions		
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Drawing No. 2PT02-ARP-PT-DSK-000-000006		Rev. P00.1



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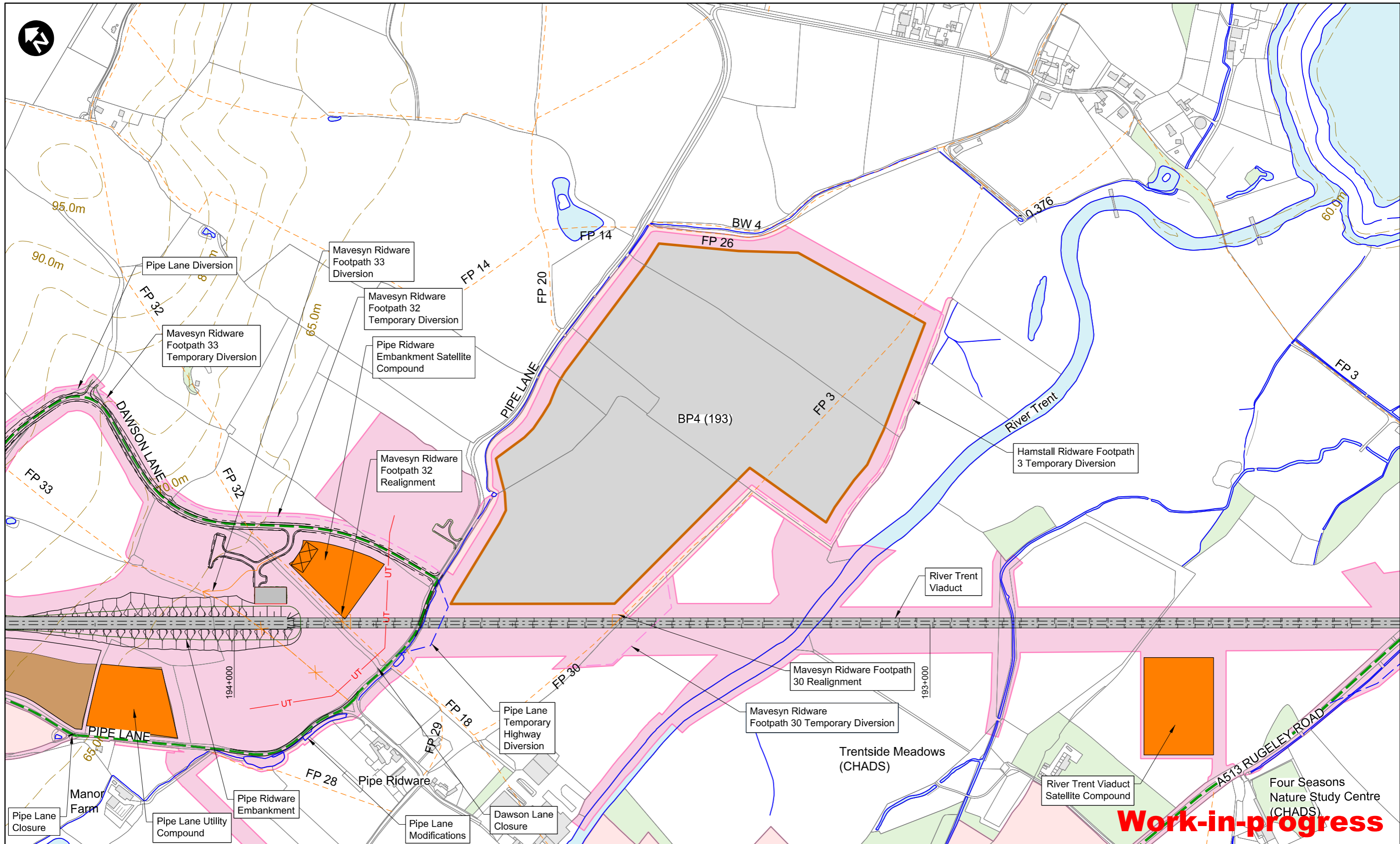
Legends/Notes:	
	Engineering earthworks
	Landscape earthworks
	Rail alignment
	Rail alignment formation
	Temporary Material Stockpile
	Indicative extent of Petitioner's land
	Construction Traffic Route
	Existing public right of way
	HS2 Access road
	Main Construction Compound
	Satellite Construction Compound
	Land potentially required during construction
	Extent of land potentially required during construction for mitigation planting
	Existing Inland Water
	Existing Woodland
	New, diverted or realigned PROW
	Stopped-up PROW
	Main Utility Work
	Haul Road

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Creator/Originator
 Ove Arup & Partners International Ltd

Zone	Route Wide
Design Stage	Hybrid Bill - Draft Initial Preliminary Design
Drawing Title	Figure G Borrow Pit 2 (190) and 3 (191)

Project/Contract C861 Hybrid Bill Additional Provision 2 AP2		
Discipline/Function Petitions		
Drawn DS	Checked AC	Approved TE
Date 21/01/2019	Scale 1:5000	Size A3
Drawing No. 2PT02-ARP-PT-DSK-000-000007		Rev. P00.1



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Legends/Notes:

- Engineering earthworks
- Landscape earthworks
- Rail alignment
- Rail alignment formation
- Temporary Material Stockpile
- Indicative extent of Petitioner's land
- Construction Traffic Route

- Existing public right of way
- HS2 Access road
- Main Construction Compound
- Satellite Construction Compound
- Land potentially required during construction
- Extent of land potentially required during construction for mitigation planting
- Existing Inland Water
- Existing Woodland
- New, diverted or realigned PROW
- Stopped-up PROW
- Main Utility Work
- Haul Road

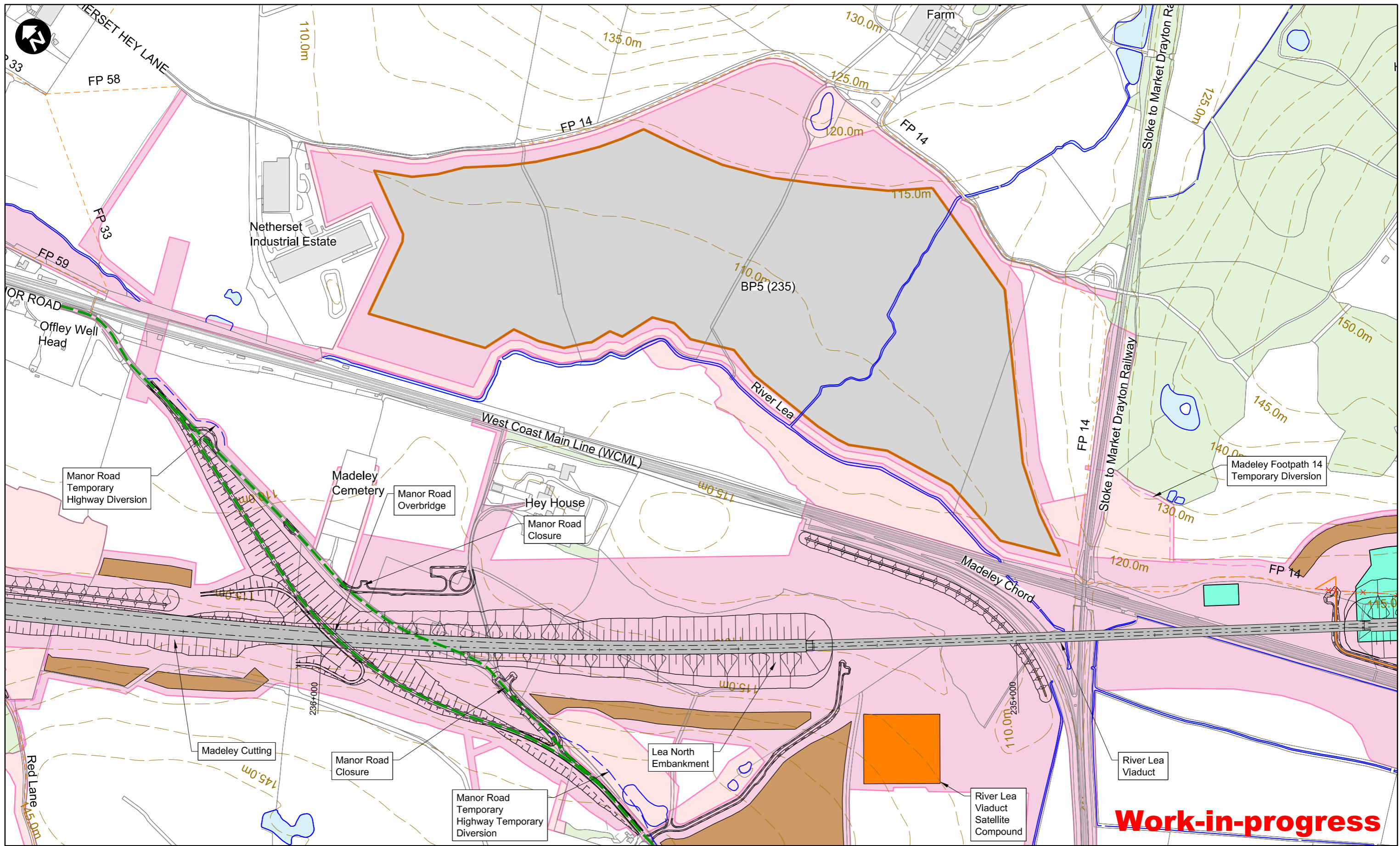
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Zone	Route Wide
Design Stage	Hybrid Bill - Draft Initial Preliminary Design
Drawing Title	Figure H Borrow Pit 4 (193)

Project/Contract		C861 Hybrid Bill Additional Provision 2 AP2	
Discipline/Function		Petitions	
Drawn	Checked	Approved	
DS	AC	TE	
Date	Scale	Size	
21/01/2019	1:5000	A3	
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- Existing Inland Water
- Existing Woodland
- New, diverted or realigned PROW
- Stopped-up PROW
- Main Utility Work
- Haul Road

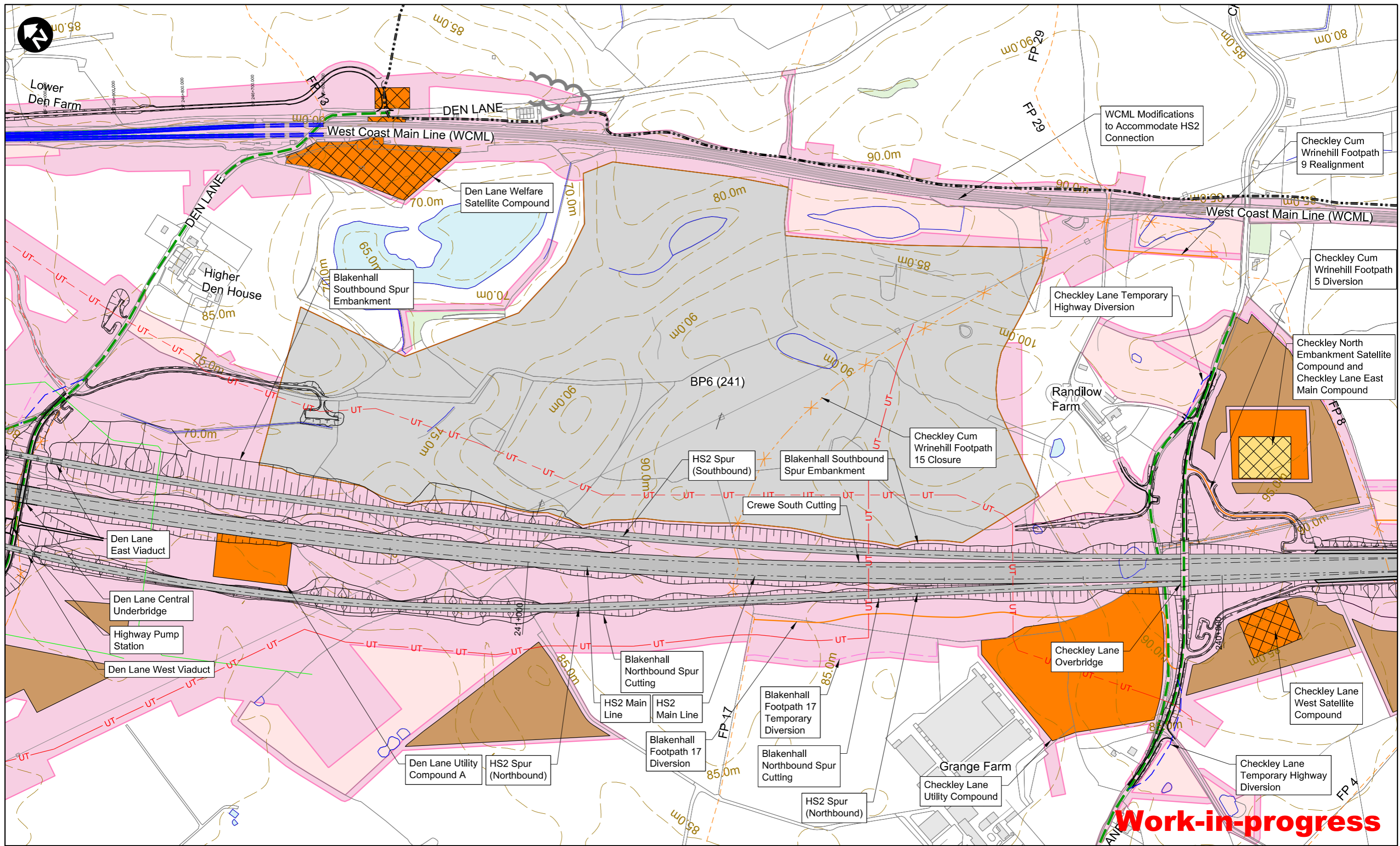
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Zone	Route Wide	
Design Stage	Hybrid Bill - Draft Initial Preliminary Design	
Drawing Title	Figure I Borrow Pit 5 (235)	

Project/Contract C861 Hybrid Bill Additional Provision 2 AP2		
Discipline/Function Petitions		
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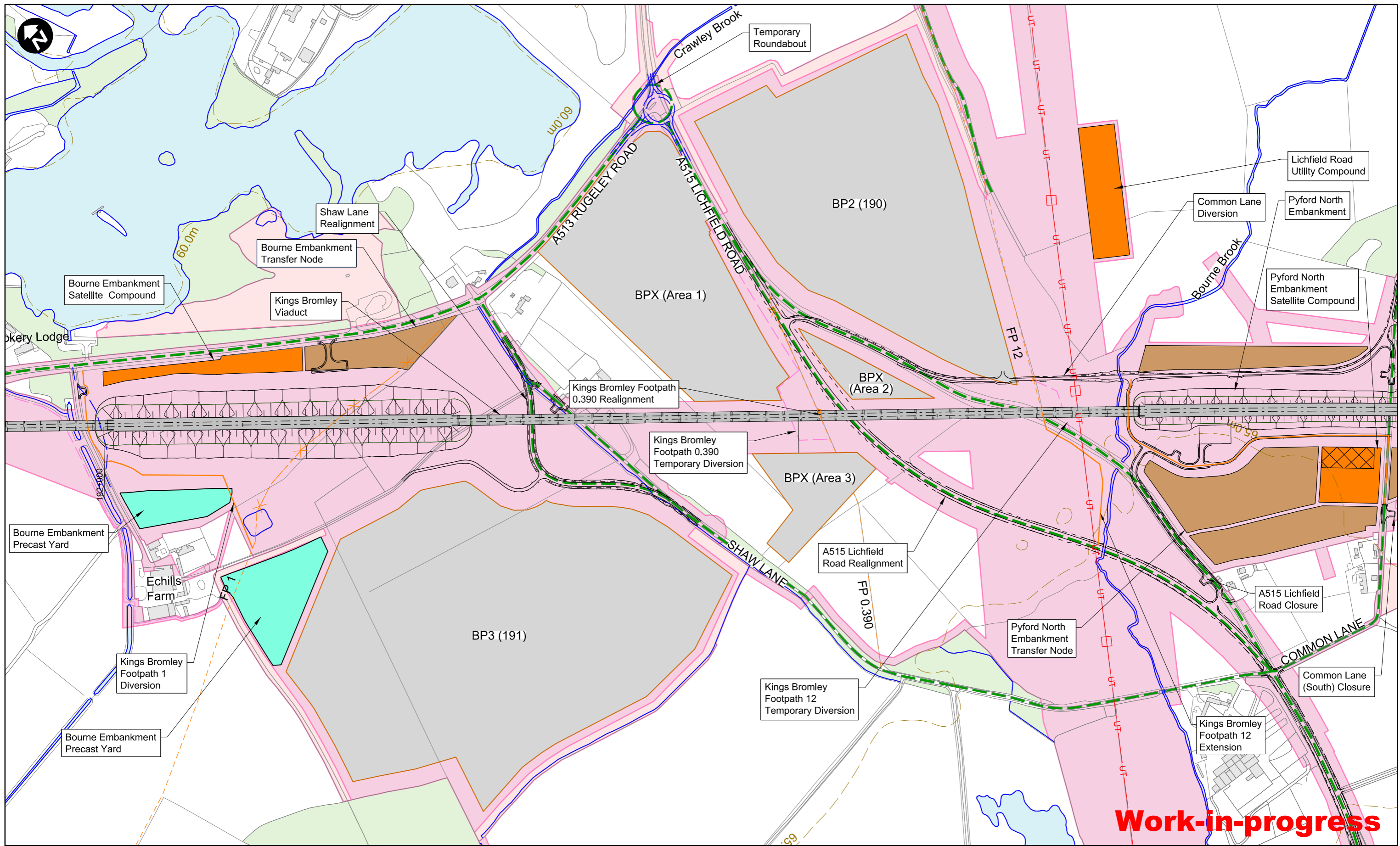
Legends/Notes:	
	Engineering earthworks
	Landscape earthworks
	Rail alignment
	Rail alignment formation
	Temporary Material Stockpile
	Indicative extent of Petitioner's land
	Construction Traffic Route
	Existing public right of way
	HS2 Access road
	Main Construction Compound
	Satellite Construction Compound
	Land potentially required during construction
	Extent of land potentially required during construction for mitigation planting
	Existing Inland Water
	Existing Woodland
	New, diverted or realigned PROW
	Stopped-up PROW
	Main Utility Work
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Zone	Route Wide
Design Stage	Hybrid Bill - Draft Initial Preliminary Design
Drawing Title	Figure J Borrow Pit 6 (241)

Project/Contract		C861 Hybrid Bill Additional Provision 2 AP2	
Discipline/Function		Petitions	
Drawn	Checked	Approved	
DS	AC	TE	
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21/01/2019	1:5000	A3	
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Zone	Route Wide
Design Stage	Hybrid Bill - Draft Initial Preliminary Design
Drawing Title	Figure K Borrow Pit X

Project/Contract C861 Hybrid Bill Additional Provision 2 AP2		
Discipline/Function Petitions		
Drawn DS	Checked AC	Approved TE
Date 21/01/2019	Scale 1:5000	Size A3
Drawing No. 2PT02-ARP-PT-DSK-000-000011		Rev. P00.1

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APPENDIX C

Design and reporting of borrow pit and cuttings preliminary ground investigation findings



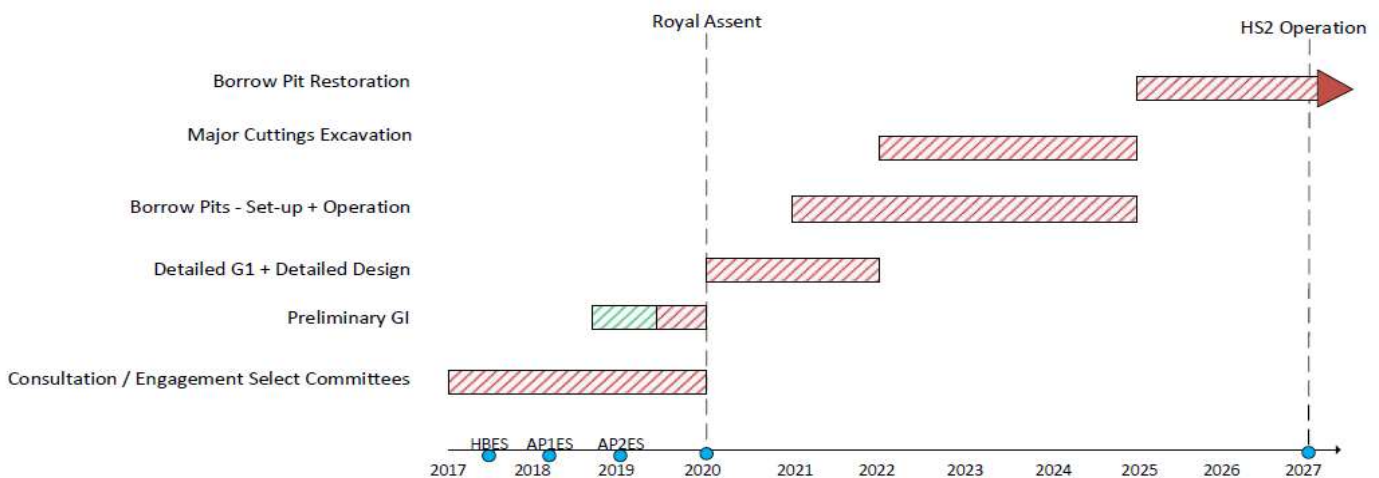
1 Design and reporting of preliminary ground investigation (PGI)

- 1.1.1 The earthworks strategy described in Section 3 is based on assumptions about the volumes and quality of the excavated material from borrow pits, cuttings and other associated works (e.g. tunnels, excavation of balancing ponds, excavation of flood compensation areas etc). The PGI has been designed to provide site-specific information, which will confirm or otherwise, these assumptions (but it is only preliminary and would be periodically updated during future design development).
- 1.1.2 The PGI for the borrow pits was scoped using geotechnical engineering judgement and experience to provide a level of site-specific information that was appropriate to the aims and objectives of a preliminary investigation as follows:
- ground conditions at each borrow pit, both in the mineral and the underlying bedrock, and particularly to ascertain whether there was sand and gravel present to the depths and over the full footprint assessed in the Phase 2a AP2 revised scheme earthworks design;
 - the engineering properties of the materials encountered in each borrow pit to enable preliminary estimates to be undertaken of the proportions of material acceptable for use as granular fill;
 - groundwater depths, how they vary seasonally, and especially whether the groundwater depth is as shallow as has been assessed in the Phase 2a AP2 revised scheme design; and
 - the hydrogeological conditions so that the feasibility of temporary dewatering of the five southernmost borrow pits can be determined and the likely effects of that on neighbouring receptors assessed.
- 1.1.3 The PGI fieldwork scope per borrow pit was typically six boreholes (BH), five static cone penetration tests (CPT) and 4 to 15 trial pits (TP) (dependent on the size of the borrow pit), together with a pumping test in each borrow pit where temporary dewatering was envisaged (see Table C.1). Groundwater monitoring standpipes or piezometers were installed in several of the boreholes in each borrow pit and will be monitored for a full cycle of seasons (12 months). Soil samples were recovered for laboratory testing.
- 1.1.4 The relationship between ground investigation and design, including the approximate timeframes for finalising the borrow pit design and the select committee / Hybrid bill process is shown indicatively in Figure. This schematic shows the timelines for the following elements, which are a small part of a much wider continuing process:
- overall programme of hybrid Bill submission (main, SES1 and AP1 ES and SES2 and AP2 ES) and Select Committee process;
 - preliminary ground investigation (PGI) and PGI reporting;

- the period for delivering the Assurance to NFU Borrow Pit Review (green hatching on Figure C.1);
- detailed GI, detailed design (e.g. including earthworks and borrow pit design);
- construction including cuttings, borrow pit excavation and backfilling, embankments and capping layers;
- borrow pit restoration;
- borrow pit aftercare and monitoring (this will be for a period of 5 years after restoration).

1.1.5 The level of confidence in the understanding of ground conditions and the availability of earthworks construction materials from the main sources along the route (i.e. major cuttings, tunnels and borrow pits) will increase as the ground investigation work packages are completed. Preliminary ground investigation (pre-Royal Assent) and detailed ground investigation (post-Royal Assent) will continue to inform the design of the Proposed Scheme including the detailed design of the extent of borrow pits and how they will be operated and restored.

Figure C.1: Ground investigation and design timeline



1.1.6 The PGI for borrow pits and major cuttings commenced on the 6th August 2018 and is due to be completed in April 2019.

1.1.7 The programme for the PGI for borrow pits and major cuttings is shown in Figure C.2. This figure also provides an indicative reporting programme with this draft report being published in February 2019 for consultation and a final report in April 2019. In the event that information from the PGI is not available at the time of final reporting, the final report will be updated accordingly. Information that becomes available between the circulation of the consultation draft and the final report would be communicated directly to the individual borrow pit landowners and the NFU during this interim period.

Figure C.2: Indicative programme for PGI for borrow pits and major cuttings and Assurance to NFU Borrow Pit Review reporting and engagement.

Activity	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19
PGI site work (BP and cuttings)									
PGI laboratory testing (BP and cuttings)									
PGI reporting (BP and cuttings)									
HS2 engagement and consultation									
Draft Assurance to NFU Borrow Pit Review									
Final Assurance to NFU Borrow Pit Review									

1.1.8 Table C.1 provides a summary of the completed borrow pit PGI.

1.1.9 During the HoC Select Committee hearings in 2018, a petitioner proposed an area for a potential borrow pit (BPX). The location of this potential borrow pit, which is outside the area conferred by the Bill, is shown in Figures E and K in Appendix B. Borrow Pit X was included in the PGI.

Table C.1: Details of completed preliminary ground investigations at each borrow pit site.

Borrow Pit (BP) Reference	Boreholes/Trial Pits /CPTs Undertaken	Groundwater Pumping Test Completed
BP1 (east of route (18g))	5 BHs, 5 TPs, 3 CPTs	1
BP1 (west of route (18ga))	1 BH, 3 TPs, 2 CPTs	Not applicable (n/a)– pump test for BP1 performed on BP1 area east of route
BPX - between BP2 and BP3	5 BHs, 6 TPs, 5 CPTs	n/a - sufficient hydrogeology information available from BP2 and BP3
BP2	6 BHs, 4 TPs, 5 CPTs	1
BP3	6 BHs, 8 TPs, 5 CPTs	1
BP4	6 BHs, 10 TPs, 5 CPTs	1
BP5	6 BHs, 10 TPs, 5 CPTs	1
BP6	7 BHs, 15 TPs, 5 CPTs	1

1.1.10 Preliminary investigations at the major cuttings were progressed alongside the preliminary investigations for the borrow pits as described in Table C.2.

Table C.2: Completed major cuttings preliminary ground investigations

Cutting Reference	Boreholes /Trial Pits Undertaken	Groundwater Pumping Test Completed
Brancote South Cutting	7 BHs, 3 TPs	Cancelled due to ground conditions encountered
Hopton South Cutting	4 BHs, 4 TPs	Not applicable (n/a)
Hopton North Cutting	2 BHs, 3 TPs	n/a
Swynnerton North Cutting	4 BHs, 5 TPs	n/a
Hatton South Cutting	4 BHs, 3 TPs	n/a
Whitmore South Cutting	3 BHs, 3 TPs	n/a

- 1.1.11 On completion of the major cuttings preliminary ground investigations this information was used to provide a preliminary update of the overall project minerals requirements and requirement to source granular materials in the Phase 2a AP2 revised scheme earthworks design as described in Section 3.
- 1.1.12 The preliminary ground investigation at the borrow pits and major cuttings is only the first stage of intrusive, and increasingly more complex, geotechnical investigations that will be undertaken during the development of the design of the HS2 Phase 2a scheme; and the borrow pits and major cuttings PGI is the second of four preliminary ground investigation work packages which will extend through to 2020.
- 1.1.13 Further detailed ground investigations will be undertaken between approximately 2020 and 2022 as the design is progressed through to final design by the Design & Build contractor(s) once they are appointed. As the design is developed and design changes are adopted, there may be changes in volumes of embankment material required and the availability of excavated material for use as borrow pit backfill. This could result in a change in the demand on the borrow pits and the way in which materials excavated from each borrow pit are used. These potential changes of demand could be a factor in the final overall borrow pit extents within the limits conferred by the Bill.

HS2

APPENDIX D

Guide to HS2 Phase 2a scheme earthworks

1 Guide to HS2 Phase 2a scheme earthworks

1.1 Introduction

- 1.1.1 Construction of HS2 will involve the formation of a route through the local undulating topography by the creation of cuttings, embankments and tunnels and the installation of bridges, viaducts and granular formations under the track.
- 1.1.2 Material excavated from cuttings along the line of the Phase 2a route and associated highway works will be used, where reasonably practicable, to construct embankments, noise bunds and landscape earthworks. The construction of cuttings and embankments will therefore be interdependent. In cases where the material generated from cuttings is granular it will be used to form railway embankments, where practicable in the same geographic part of the route. In cases where the material generated from cuttings is cohesive it will be used to form highway embankments, noise bunds, landscape earthworks and to backfill the borrow pits. Some of this material may be surplus to the project's requirements and would be disposed in local placement areas on site or disposed off-site.
- 1.1.3 Temporary stockpiling of excavated material may be required where it cannot be placed directly into its permanent location. Granular materials such as sands and gravels produced from excavations may need to be processed through crushing and/or screening, to ensure that the material is acceptable for use as drainage, selected fill, backfill to structures or capping material.
- 1.1.4 Where reasonably practicable, movement of construction material would be on designated temporary roads within the area of land required for construction (known as site haul routes), along the line of the Phase 2a route, or running parallel to it. Using haul routes will reduce the need for construction vehicles to use the existing public highway network, thereby reducing traffic related impacts on the road network and local communities.
- 1.1.5 The railway embankments for HS2 require a superior quality of fill compared to highway embankments, noise bunds and landscape earthworks due to the increased performance required to support the railway and minimise movements.
- 1.1.6 The construction material that is likely to be used in a typical HS2 railway embankment will comprise the following material types in order of quality (high to low – Class 6 being the highest quality) as shown in Figure L (and the accompanying notes):

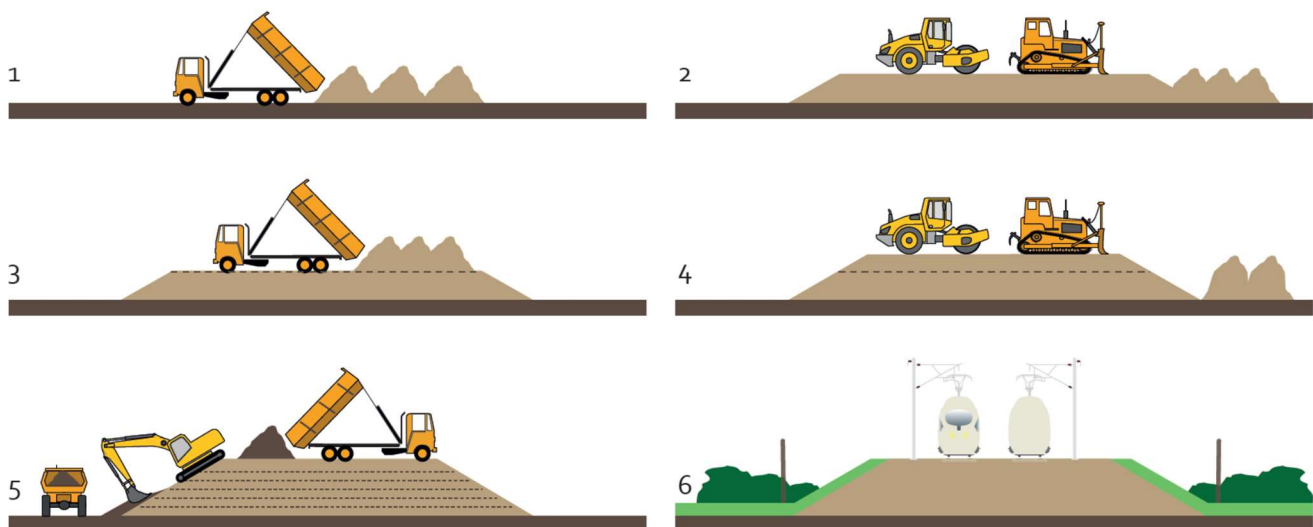
- Class 6 protection layer – high quality selected granular fill placed above the prepared subgrade (imported)¹;
- Class 6 for use as prepared sub-grade – high quality selected granular fill (imported)²;
- Class 6 for use other than as prepared protection layer/sub-grade – high quality selected granular fill (expected to be sourced from the major cuttings and/or borrow pits with some additional on-site processing); and
- Class 1 - good and normal quality granular fill (expected to be sourced from the major cuttings and/or borrow pits).

1.1.7 The other earthworks materials that are likely to be used in the construction of HS2 (see Section 1.7.7 above) are as follows:

- Class 2 / Class 4 – normal quality cohesive fill (clay or mudstone) (expected to be sourced from other cuttings along the route); and
- Topsoil (0.3m) and subsoil (0.5m) – for agricultural restoration. The topsoil and subsoil thicknesses to be excavated separately, stored and reinstated at the borrow pits are assumed to be 0.25m and 0.95m respectively.

1.1.8 Figure 1 provides an illustration of a generic construction sequence for an embankment.

Figure 1: Illustration of a generic construction sequence for an embankment



1.1.9 The route of HS2 Phase 2a is likely to encounter small volumes of other material types which would not be acceptable for use as a construction material without treatment as follows:

¹ Superior performance compared to Class 1 which is expected to be imported irrespective of whether or not borrow pits are used – typically 0.22m thick.

² As for the Class 6 protection layer but typically 0.5m thick.

- Class U1A – geotechnically unacceptable material which can be treated for use within the works; and
- Class U1B – chemically unacceptable non-hazardous material which can be treated for use within the works.

1.1.10 The route of HS2 Phase 2a is also likely to encounter very small volumes of Class U2 chemically unacceptable hazardous material which would need to be disposed off-site³.

1.2 Mass haul movement plans and earthworks material estimates

1.2.1 During preliminary design development prior to submission of the Bill, the volumes of earthworks materials were estimated⁴ and these were then used during the development of the materials movement analysis in order to plan the movement of materials across the HS2 Phase 2a scheme⁵. The volumes, sources and destinations of material which were assessed and reported in the main ES are particular to the materials movement analysis that was created at that stage of design from the earthworks quantities estimate for that design. A materials movement analysis identifies one possible solution of how the HS2 Phase 2a scheme could be constructed, based on the level of information available at that time and the assumptions made.

1.3 Earthworks and materials movement review – local placement opportunities

1.3.1 Since submission of the Bill, a route-wide review of the earthworks and movement of materials for Phase 2a has been carried out, taking into account design development and changes in construction assumptions, as part of the preparation of the SES2 and AP2 ES.

1.3.2 As part of the earthworks and materials movement review, the scope for local placement of surplus excavated material on land already required for the construction of the scheme was considered. Local placement will reduce the need for off-site road transport and disposal of surplus excavated materials and reduce the associated environmental impacts arising from HGV movements on the highway network.

1.3.3 Seventeen local placement areas have been identified across the Phase 2a route, applying appropriate environmental, engineering and construction criteria to select the most suitable sites. They vary between 0.7 ha and 8.5 ha in area and are generally capable of accommodating between 10,000 and 100,000 m³ of surplus excavated material.

³ Hazardous materials, if encountered, will not be acceptable for use on site and will be removed from site and disposed of via licensed disposal/treatment facilities.

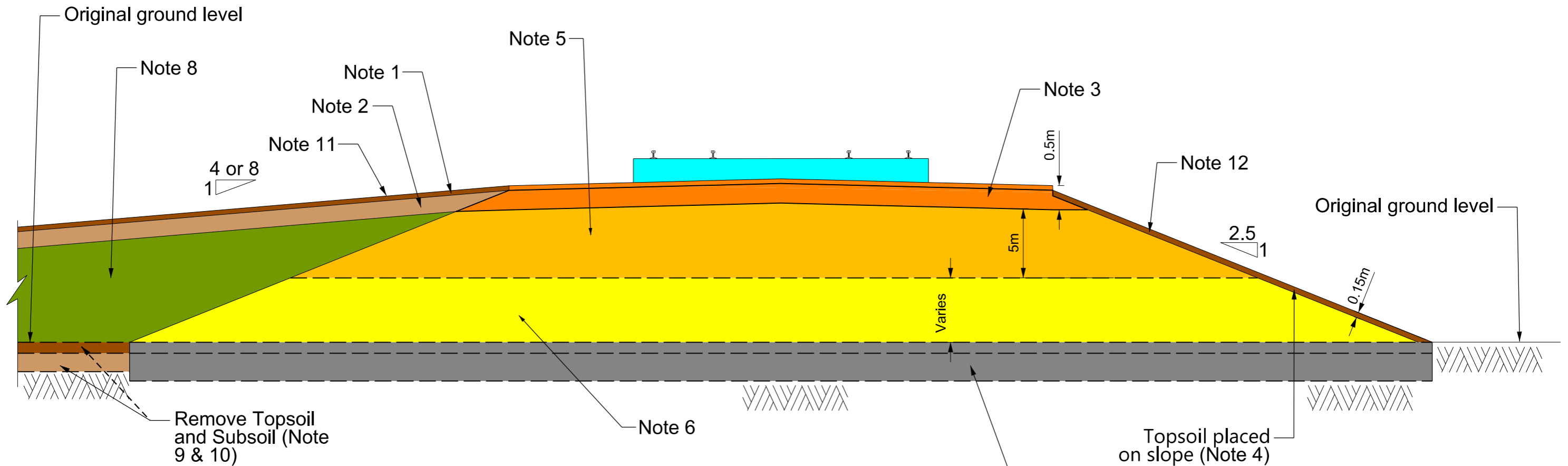
⁴ Earthworks quantities estimate.

⁵ Sources of materials (e.g. cuttings) and destinations e.g. the formation of embankments.

1.4 Materials management plan

- 1.4.1 Section 15 of Volume 3 of the main ES describes the design approach for waste and material resource management.
- 1.4.2 An integrated design approach has been developed that seeks to use excavated material to satisfy the necessary engineering and environmental mitigation earthworks requirements for the HS2 Phase 2a scheme including restoration of borrow pits. It seeks to minimise the quantity of surplus excavated material generated and minimise off-site disposal to landfill. This includes use of as much excavated topsoil and agricultural subsoil as close to the point of excavation as is reasonably practicable.
- 1.4.3 A Materials Management Plan will be drafted in accordance with the CL:AIRE Code of Practice⁶ in anticipation of implementing the integrated design approach. This will enable acceptable excavated material to be used as a resource within the construction of the HS2 Phase 2a scheme with the additional benefit of reducing the quantity of imported fill required.
- 1.4.4 For the excavated material that cannot be beneficially reused for the earthworks of the HS2 Phase 2a scheme, which would potentially be surplus, the nominated undertaker will, where regulation allows, seek to provide this excavated material for:
- use in other construction projects where opportunities arise at the time of construction;
 - use for restoration of mineral sites; and/or
 - disposal to off-site landfill.
- 1.4.5 This only applies to cases where the transportation of that material does not result in significant environmental effects.

⁶ CL:AIRE is an independent body that promotes sustainable remediation of contaminated land and groundwater. As part of its work, it has developed a Development Industry Code of Practice (CoP) to provide a clear, consistent and efficient process to enable the reuse of all types of excavated material (both inert and contaminated) without it being classified as a waste.



- Slab Track (Indicative)
- Class 6 (Imported Selected Granular Fill)
- Class 6 (Selected Granular Fill)
- Class 1/6 (Granular Fill)
- Class 1 (General Granular Fill)
- Class 4 (Landscape Fill)
- Topsoil
- Subsoil

DRAFT

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								Design Stage Designs for Petition	Discipline/Function Petitions		
								Drawing Title Figure L HS2 Embankment Schematic	Drawn DS	Checked SG	Approved DE
								Date 30/01/2019	Scale NTS	Size A3	
Rev	Description	Drawn	Checked	Con App	HS2 App	Scale with caution as distortion can occur.			Drawing No. 2PT02-ARP-PT-DSC-000-000012	Rev. P00.1	

Notes to Embankment Cross Section

1. Topsoil (0.3m thick).
2. Subsoil for agricultural restoration (minimum 0.5m thick).
3. Protection layer incorporates very high quality granular fill, 0.22m minimum thickness (Class 6). This is underlain by prepared subgrade 0.5m thick. Very high quality imported granular fill (Class 6).
4. Topsoil to be placed on earthworks slope (minimum 0.15m thick)
5. High quality engineering granular fill (Class 1 or Class 6). Or stabilised cohesive material (but it seems unlikely that the cohesive materials known to present on the site will be suitable for stabilising by adding materials such as cement or lime).
6. Lesser quality engineering fill (Class 1 granular or cohesive material). It seems likely that most of the cohesive materials known to be present on the site would need to be stabilised to provide the required stiffness and most of them would probably not be suitable for stabilising by adding materials such as cement or lime. A possible exception is some of the cohesive materials in the Crewe South area, eg from Borrow Pit 6, which either may be able to be used without stabilisation or probably would be suitable for stabilisation with lime or cement.
7. Remove soft material under the embankment (if it is encountered) and replace with high quality engineering granular fill (Class 6). Depth depends on extent of soft ground.
8. Normal quality cohesive engineering fill (Class 2 or Class 4).
9. Remove topsoil and subsoil and store separately for re-use on completed earthworks on the site.
10. Assumed topsoil thickness is 0.3m.
11. Side slope of land to be returned to agriculture could vary between 1V:4H and 1V:8H.
12. Side slope may vary following geotechnical investigation and detailed design analysis.

HS2

APPENDIX E

Borrow pits – materials movement tables

1 Borrow pit materials and materials movements

- 1.1.1 At each stage of design, an earthworks quantities estimate has been used to develop a materials movement analysis which identifies one possible solution of how the HS2 Phase 2a revised scheme could be constructed.
- 1.1.2 The materials movement analysis (without PGI) that was used to inform the SES2 and AP2 ES, was based on the assumptions set out in Section 3.2 and was developed prior to the commencement of the preliminary ground investigation (PGI)¹, based on an overall design dated 23rd May 2018. This analysis has been used to develop summary tables for each borrow pit which comprise:
- an example of the volumes of the types of materials that might be extracted, the potential number of resulting site haul or road haul 2-way vehicle movements and the possible destinations for that material ('materials out table'); and
 - a 'materials in table' which describes the potential sources of borrow pit backfill material and the resulting number of site haul or road haul 2-way vehicle movements involved.
- 1.1.3 These tables exclude the volumes of topsoil and subsoil which will be excavated separately from the borrow pit work area and stockpiled for reuse at each borrow pit during restoration.
- 1.1.4 The tables in this appendix (Tables 1 to 12) are based on a design dated 23rd May 2018 and are, therefore, not directly comparable to those provided previously as an exhibit during the House of Commons Select Committee hearings in 2018. This is because the tables provided in the HS2 exhibit, entitled Borrow Pit Standard Exhibit Pack P125², were generated from a specific materials movement analysis based on an earlier design dated 16th January 2017.

¹ PGI commenced in August 2018.

² https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/705803/Section_O_-_Borrow_Pits.pdf

Borrow Pit 1 (BP1 (18g/18ga))

Table 1: Materials out – destinations for excavated material and material movements

Source	Destination	Volume (m3)	Site Haul (2 way movements)	Road Haul (2 way movements)	Destination material use
BP1	Pyford North Embankment	175,000	10,300	0	Railway Embankment/ Selected Fill/ Landscaping
BP1	Pyford South Embankment	38,000	2,300	0	Railway Embankment/ Selected Fill/ Landscaping
BP1	Stockpile at borrow pit	42,000	0	0	Non-granular material stockpiled for use as backfill
	Total	255,000	12,600	0	

Table 2: Materials in – sources of backfill & material movements

Source	Destination	Volume (m3)	Site Haul (2 way movements)	Road Haul (2 way movements)	Destination material use
Moreton Cutting	BP1	213,000	25,000	25,000	Borrow Pit backfill
Stockpile at BP1	BP1	42,000	0	0	Non-granular material stockpiled for use as backfill
	Total	255,000	25,000	25,000	

Borrow Pit 2 (BP2 (190))

Table 3: Materials out – destinations for excavated material and material movements

Source	Destination	Volume (m3)	Site Haul (2 way movements)	Road Haul (2 way movements)	Destination material use
BP2	Pyford North Embankment	27,000	1,600	0	Railway Embankment/ Selected Fill
BP2	Bourne Embankment	60,000	3,500	0	Railway Embankment/ Selected Fill
BP2	Stockpile at borrow pit	40,000	0	0	Non-granular material stockpiled for use as backfill
	Total	127,000	5,100	0	

Table 4: Materials in – sources of backfill & material movements

Source	Destination	Volume (m3)	Site Haul (2 way movements)	Road Haul (2 way movements)	Destination material use
Brancote South Cutting	BP2	87,000	10,200	10,200	Borrow Pit Backfill
Stockpile at BP2	BP2	40,000	0	0	Non-granular material stockpiled for use as backfill
	Total	127,000	10,200	10,200	

Borrow Pit 3 (BP3 (191))

Table 5: Materials out – destinations for excavated material and material movements

Source	Destination	Volume (m3)	Site Haul (2 way movements)	Road Haul (2 way movements)	Destination material use
BP3	Bourne Embankment	222,000	13,100	0	Railway Embankment/ Selected Fill/ Landscaping
BP3	Stockpile at borrow pit	12,000	0	0	Non-granular material stockpiled for use as backfill
	Total	234,000	13,100	0	

Table 6: Materials in – sources of backfill & material movements

Source	Destination	Volume (m3)	Site Haul (2 way movements)	Road Haul (2 way movements)	Destination material use
Hopton North Cutting	BP3	222,000	26,200	26,200	Borrow Pit Backfill
Stockpile at BP3	BP3	12,000	0	0	Borrow Pit Backfill
	Total	234,000	26,200	26,200	

Borrow Pit 4 (BP4 (193))

Table 7: Materials out – destinations for excavated material and material movements

Source	Destination	Volume (m3)	Site Haul (2 way movements)	Road Haul (2 way movements)	Destination material use
BP4	Pipe Ridware Embankment	115,000	6,800	0	Railway Embankment/ Selected Fill
BP4	Blithbury South Cutting	2,000	200	0	Fill to ground treatment at base of cutting
BP4	Blithbury Central Cutting	93,000	5,500	0	Fill to ground treatment at base of cutting
BP4	Blithbury North Cutting	49,000	2,900	0	Fill to ground treatment at base of cutting
BP4	Stockwell Heath Embankment	209,000	12,300	0	Railway Embankment/ Selected Fill
BP4	Stockwell Heath Cutting	17,000	1,100	0	Fill to ground treatment at base of cutting
BP4	Moreton South Embankment	154,000	9,100	0	Railway Embankment/ Selected Fill
BP4	Moreton North Embankment	98,000	5,800	0	Railway Embankment/ Selected Fill
BP4	Moreton Cutting	34,000	2,000	0	Fill to ground treatment at base of cutting
BP4	Trent South Embankment	278,000	16,400	0	Railway Embankment/ Selected Fill
BP4	12 bridges, one viaduct and one auto-transformer station	27,000	2,400	0	Zones of high quality granular fill associated with bridges, viaduct and auto-transformer station
BP4	Stockpile at borrow pit	579,000	0	0	Non-granular material stockpiled for use as backfill
	Total	1,655,000	64,500	0	

Borrow Pit 4 (BP4 (193)) continued

Table 8: Materials in – sources of backfill & material movements

Source	Destination	Volume (m3)	Site Haul (2 way movements)	Road Haul (2 way movements)	Destination material use
Blythbury Central Cutting	BP4	31,000	1,900	0	Borrow Pit Backfill
Blythbury North Cutting	BP4	824,000	48,500	0	Borrow Pit Backfill
Stockwell Heath Cutting	BP4	58,000	3,400	0	Borrow Pit Backfill
Moreton South Embankment	BP4	9,000	600	0	Borrow Pit Backfill
Moreton North Embankment	BP4	16,000	1,000	0	Borrow Pit Backfill
Moreton Cutting	BP4	121,000	7,200	0	Borrow Pit Backfill
Foundation excavations for six bridges and one viaduct	BP4	18,000	1,500	0	Borrow Pit Backfill
Stockpile at BP4	BP4	579,000	0	0	Borrow Pit Backfill
	Total	1,655,000	64,100	0	

Borrow Pit 5 (BP5 (235))

Table 9: Materials out – destinations for excavated material and material movements

Source	Destination	Volume (m ³)	Site Haul (2 way movements)	Road Haul (2 way movements)	Destination material use
BP5	Meece Embankment	1,000	100	0	Railway Embankment/ Selected Fill
BP5	Whitmore North Cutting	1,000	100	0	Fill to ground treatment at base of cutting
BP5	Lea South Embankment	52,000	3,100	0	Railway Embankment/ Selected Fill
BP5	Lea North Embankment	54,000	3,200	0	Railway Embankment/ Selected Fill
BP5	Portals of Madeley Tunnel	19,000	1,200	0	Railway Embankment/ Selected Fill
BP5	Checkley South Embankment	105,000	6,200	0	Railway Embankment/ Selected Fill
BP5	Checkley North Embankment	87,000	5,200	0	Railway Embankment/ Selected Fill
BP5	Crewe South Cutting	162,000	9,600	0	Fill to ground treatment at base of cutting
BP5	Blakenhall Northbound Spur Cutting	53,000	3,100	0	Fill to ground treatment at base of cutting
BP5	Blakenhall Southbound Spur Embankment	306,000	18,000	0	Railway Embankment/ Selected Fill
BP5	Blakenhall Northbound Spur Embankment	23,000	1,400	0	Railway Embankment/ Selected Fill
BP5	Chorlton South Embankment	156,000	9,200	0	Railway Embankment/ Selected Fill
BP5	Chorlton North Embankment	18,000	1,100	0	Railway Embankment/ Selected Fill
BP5	Blakenhall Cutting	4,000	300	0	Fill to ground treatment at base of cutting
BP5	10 bridges, three viaducts, portals of Madeley Tunnel, one aqueduct and two auto-transformer stations	19,000	1,900	0	Zones of high quality granular fill associated with bridges, viaducts, auto-transformer stations, etc
BP5	Stockpile at borrow pit	570,000	0	0	Non-granular material stockpiled for use as backfill
	Total	1,630,000	63,700	0	

Borrow Pit 5 (BP5 (235)) continued

Table 10: Materials in – sources of backfill & material movements

Source	Destination	Volume (m3)	Site Haul (2 way movements)	Road Haul (2 way movements)	Destination material use
Yarlet South Cutting	BP5	519,000	61,100	61,100	Borrow Pit Backfill
Yarlet Central Cutting	BP5	125,000	14,700	14,700	Borrow Pit Backfill
Yarlet North Cutting	BP5	37,000	4,400	4,400	Borrow Pit Backfill
Madeley Cutting	BP5	112,000	6,600	0	Borrow Pit Backfill
Madeley Tunnel	BP5	231,000	13,600	0	Borrow Pit Backfill
Hopton North Cutting	BP5	36,000	4,300	4,300	Borrow Pit Backfill
Stockpile at BP5	BP5	570,000	0	0	Borrow Pit Backfill
	Total	1,630,000	104,700	84,500	

Borrow Pit 6 (BP6 (241))

Table 11: Materials out – destinations for excavated material and material movements

Source	Destination	Volume (m3)	Site Haul (2 way movements)	Road Haul (2 way movements)	Destination material use
BP6	Crewe South Cutting	81,000	4,800	0	Fill to ground treatment at base of cutting
BP6	Blakenhall Southbound Spur Embankment	58,000	3,500	0	Railway Embankment/ Selected Fill
BP6	Blakenhall Northbound Spur Embankment	124,000	7,300	0	Railway Embankment/ Selected Fill
BP6	Stockpile at borrow pit	141,000	0	0	Non-granular material stockpiled for use as backfill
	Total	404,000	15,600	0	

Table 12: Materials in – sources of backfill & material movements

Source	Destination	Volume (m3)	Site Haul (2 way movements)	Road Haul (2 way movements)	Destination material use
Yarlet North Cutting	BP6	244,000	28,800	28,800	Borrow Pit Backfill
Crewe South Cutting	BP6	3,000	200	0	Borrow Pit Backfill
Basford Cutting	BP6	16,000	1,000	0	Borrow Pit Backfill
Stockpile at BP6	BP6	141,000	0	0	Borrow Pit Backfill
	Total	404,000	30,000	28,800	

HS2

APPENDIX F

Draft preliminary ground investigation information

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APPENDIX F.1 – Borrow pit cross sections

1 Draft Preliminary Ground Investigation findings

1.1 Introduction, background and context

1.1.1 This document is based on the draft geotechnical and hydrogeological information from the Preliminary Ground Investigation (PGI). The draft borehole logs have been evaluated to provide draft geological cross sections and draft interpretation of the subsoil profile in the borrow pit areas.

1.1.2 As at April 2019, the PGI fieldwork and laboratory testing had been completed and the reporting was in progress. The interpretation will be confirmed when the PGI contractor's final report is received (April 2019).

1.1.3 The information contained in this document will be updated as necessary and will be included in an updated version of this report.

1.1.4 Each borrow pit is discussed separately and the following information has been provided:

- a site investigation exploratory hole location plan;
- a table which summarises the number of exploratory holes and provides a comparison of the average excavation depth based on the AP2 revised scheme earthworks design without PGI and with draft PGI data;
- a description of the geology and a table summarising the geological information obtained during the PGI based on the draft PGI data (explanatory notes are also provided); and
- indicative draft geological cross sections.

1.1.5 Exploratory hole location plans for the PGI (and historical GI where appropriate) and indicative draft geological cross sections are provided for each borrow pit in Appendix F.1. Each draft cross-section shows boreholes on both sides of the section line. A dimension at the top of each borehole "stick" shows the offset of the borehole from the section line. Negative dimensions indicate boreholes to one side of the line and positive dimensions indicate boreholes on the other side of the section line.

2 Geological summary Borrow Pit 1 (BP1)

2.1.1 Table A provides a summary of the number of PGI exploratory holes at Borrow Pit 1 and the average excavation depth assessed in the AP2 revised scheme earthworks design prior to the PGI and the post-draft PGI average mineral excavation depth. The estimated average depth with draft PGI data is based on the six PGI boreholes only.

Table A: Number of PGI exploratory holes and average borrow pit excavation depths for Borrow Pit 1

Borrow Pit Reference	BP1
No of exploratory holes for Borrow Pit in Preliminary Ground Investigation (PGI)	19 (including 6 boreholes)
Average excavation depth of Borrow Pit assumed in AP2 design prior to PGI (m below ground level (bgl))	4.1
Average excavation depth of Borrow Pit based on interpretation of draft PGI data (m bgl)	BP189: 7.3 BP189a: 4.1

2.1.2 The draft geological information for Borrow Pit 1 is summarised in Table B and in the indicative draft geological cross-sections in Appendix F.1.

2.1.3 Sand and gravel was encountered in five out of six of the PGI exploratory holes at this proposed borrow pit as anticipated in the AP2 design. On the basis of the draft PGI data, the depth to the base of the mineral was greater than the average depth of 4.1 m bgl assessed at AP2 revised scheme earthworks design stage prior to PGI in four of the six boreholes, all of which are in the eastern area of Borrow Pit 1, known as BP189. These were in the middle and north-eastern parts of the proposed borrow pit. However, in two of these boreholes the mineral contains bands of clayey material. In borehole ML189-CP124, on the northern side of BP189, only 2.4 m thickness of potential mineral was recorded, although this was all sand and gravel.

2.1.4 The draft PGI found that the depth to the base of the mineral in the western part of Borrow Pit 1 (known as BP189a) was either less than or similar to the average depth of 4.1 m bgl assessed at AP2 design stage prior to PGI. At one of the boreholes (ML189-CP113), which is at the south-western edge of BP189a, no useable potential mineral was recorded. Also, in trial pit ML189-TP117, which is at the north-eastern side of BP189a, no thickness of potential mineral was recorded.

2.1.5 The proportion of the mineral that is estimated to be suitable as granular fill for construction of HS2 Phase 2a is given in Table 4 in Section 3 of the report. This is based on the draft PGI data and may be subject to change when the PGI contractor's final report is received, as discussed in para 1.2.1 of this report.

Table B: Summary of draft geological information for Borrow Pit 1 (based on draft PGI data)

Borehole Reference No.	ML189-CP116	ML189-CP124	ML189-CP140	ML189-CP108	ML189-CP141	ML189-CP113
Final Depth (m bgl)	8.1	6.3	12.8	13.7	12.8	8.8
TOP SOIL depth (m bgl)	0.4	0.3	0.4	0.4	0.4	0.4
Thickness of subsoil which is to be excavated separately (excluding topsoil) (m)	0.8	0.9	0.8	0.8	0.8	0.8
MINERAL (depth to base) (m bgl)	6.9	3.6	10.7	11.6	11.8	None
BEDROCK (depth to top) (m bgl)	6.9	3.6	10.7	11.6	11.8	1.2
Groundwater depth (m bgl) ⁽¹⁾	1.2	1.5 ⁽³⁾	2.7 ⁽³⁾	2.7	2.7 ⁽³⁾	1.3 ⁽³⁾
POTENTIAL MINERAL THICKNESS in BH (m) ⁽²⁾	5.7	2.4	9.5	10.4	10.6	None
Potentially recoverable mineral thickness above water table (m)	None	0.3	1.5	1.5	1.5	None
Potentially recoverable mineral thickness below water table (m)	5.7	2.1	8.0	8.9	9.1	None
Type of material to be excavated	Sand and Gravel	Sand and Gravel	Sand and Gravel	Sand, Gravel and Clay	Sand, Gravel and Clay	Not applicable
Non granular content in BH (m) (see note 4)	None	None	None	2.2	3.8	Not applicable

2.1.6 Notes to Table B are as follows:

- Note (1) Water table varies in each borehole location;
- Note (2) Potential mineral thickness (excluding 1.2m thickness of topsoil plus subsoil which is to be excavated separately) but includes materials described in Note (4);
- Note (3) Highest groundwater recorded up to December 2018;
- Note (4) The 'potential mineral thickness' in Table 2 includes clayey layers in some boreholes as follows:
 - **ML189-CP108**: The 'potential mineral thickness' includes a 0.8 m thick layer of slightly gravelly CLAY (at depths of 4.7 to 5.5 m bgl) and also a 1.4 m thick layer of silty SAND (at depths of 5.5 to 6.9 m bgl); and
 - **ML189-CP141**: The 'potential mineral thickness' includes a 3.8 m thickness of sandy slightly gravelly CLAY (at depths of 4.4 to 8.2 m bgl).

3 Geological summary Borrow Pit 2 (BP2)

3.1.1 Table C provides a summary of the number of PGI exploratory holes at Borrow Pit 2 and the average excavation depth assessed in the AP2 revised scheme earthworks design prior to the PGI. The estimated average excavation depth of the borrow pit based on the draft PGI data is based on the six PGI boreholes and 12 historical boreholes, which gave consistent results in regard to depth of mineral.

Table C: Number of PGI exploratory holes and average borrow pit excavation depths for Borrow Pit 2

Borrow Pit Reference	BP2
No of exploratory holes for Borrow Pit in Preliminary Ground Investigation (PGI)	15 (including 6 boreholes)
Average excavation depth of Borrow Pit assumed in AP2 design prior to PGI (m bgl)	4.1
Average excavation depth of Borrow Pit based on interpretation of draft PGI data <i>and historical GI</i> (m bgl)	9.3

3.1.2 The draft geological information for Borrow Pit 2 is summarised in Table D and in the indicative draft geological cross-sections in Appendix F.1.

3.1.3 Sand and gravel was encountered in all of the PGI exploratory holes at this proposed borrow pit as anticipated in the AP2 revised scheme earthworks design prior to PGI. On the basis of the draft PGI data, in all six boreholes the depth to the base of the mineral was greater than the average depth of 4.1 m bgl assessed at AP2 revised scheme earthworks design stage prior to PGI. This greater depth to the base of the mineral is more evident in the northern part of the borrow pit area (i.e. in boreholes ML190-CP131, ML190-CP130 and ML191-CR105).

3.1.4 The proportion of the mineral that is estimated to be suitable as granular fill for construction of HS2 Phase 2a is given in Table 4 in Section 3 of the report. This is based on the draft PGI data and may be subject to change when the PGI contractor’s final report is received, as discussed in para 1.2.1 of this report.

Table D: Summary of draft geological information for Borrow Pit 2 (based on draft PGI data)

Borehole Reference No.	ML191-CR105	ML190-CP130	ML190-CP131	ML190-CP145	ML190-CP121	ML190-CP146
Final Depth (m bgl)	25.8 (CP then RC)	20.8 (CP then RC)	25.0 (CP then RC)	7.6 (CP only)	19.9 (CP then RC)	10.3 (CP only)
TOP SOIL depth (m bgl)	0.4	0.5	0.7	0.4	0.3	0.5
Thickness of subsoil which is to be excavated separately (excluding topsoil) (m)	0.8	0.7	0.5	0.8	0.9	0.7
MINERAL (depth to base) (m bgl)	13.8	10.1	11.5	6.7	8.4	7.3
BEDROCK (depth to top) (m bgl)	13.8	10.1	11.5	6.7	8.4	7.3
Groundwater depth (m bgl) ⁽¹⁾	2.0 ⁽³⁾	3.1 ⁽³⁾	3.1	3.5	4.1	1.8
POTENTIAL MINERAL THICKNESS in BH (m) ⁽²⁾	12.6	8.9	10.3	5.5	7.2	6.1
Potentially recoverable mineral thickness above water table (m)	0.8	1.9	1.9	2.3	2.9	0.6
Potentially recoverable mineral thickness below water table (m)	11.8	7.0	8.4	3.2	4.3	5.5
Type of material to be excavated	Sand and Gravel. Clay layer in lowest part of mineral.	Sand and Gravel. Clay layer in lowest part of mineral.	Sand and Gravel	Sand and Gravel	Sand and Gravel. Clay layer in lowest part of mineral.	Gravel
Non granular content in mineral BH (m) (see note 4)	0.6	0.7	None	None	0.8	None

- Notes to Table D: CP = Cable percussion, RC = rotary cored;
- Note (1) Water table varies in each borehole location;
- Note (2) Potential mineral thickness (excluding 1.2m thickness of topsoil plus subsoil which is to be excavated separately) but includes materials described in Note (4);
- Note (3) Value is from groundwater monitoring results up to October 2018;
- Note (4) The 'potential mineral thickness' in Table D includes clayey layers in some boreholes as follows:
 - ML191-CR105: The 'potential mineral thickness' includes a 0.6 m thick layer of slightly sandy gravelly CLAY (at depths from 13.2 to 13.8 m bgl);
 - ML190-CP130: The 'potential mineral thickness' includes a 0.7 m thick layer of sandy gravelly CLAY (at depths from 9.4 to 10.1 m bgl); and

- ML190-CP121: The 'potential mineral thickness' includes a 0.8 m thick layer of slightly sandy slightly gravelly CLAY (at depths from 7.6 to 8.4 m bgl).

4 Geological summary Borrow Pit 3 (BP3)

4.1.1 Table E provides a summary of the number of PGI exploratory holes at Borrow Pit 3 and the average excavation depth assessed in the AP2 revised scheme earthworks design prior to the PGI. The average excavation depth of the borrow pit based on the draft PGI data is based on six PGI boreholes and six historical boreholes, which gave consistent results in regard to depth of mineral.

Table E Number of PGI exploratory holes and average borrow pit excavation depths for Borrow Pit 3

Borrow Pit Reference	BP3
No of exploratory holes for Borrow Pit in Preliminary Ground Investigation (PGI)	19 (including 6 boreholes)
Average excavation depth of Borrow Pit assumed in AP2 design prior to PGI (m bgl)	4.3
Average excavation depth of Borrow Pit based on interpretation of draft PGI data <i>and historical GI</i> (m bgl)	5.0

4.1.2 The draft geological information for Borrow Pit 3 is summarised in Table F and in the indicative draft geological cross-sections in Appendix F.1.

4.1.3 Sand and gravel was encountered in all of the PGI exploratory holes at this borrow pit as anticipated in the AP2 revised scheme earthworks design. On the basis of the draft PGI data, in five out of the six boreholes the depth to the base of the mineral was only slightly greater than the average depth of 4.3 m bgl assessed at AP2 design stage prior to the PGI. The exception was borehole ML191-CR126, at the northern side of the proposed borrow pit, where the depth to the base of the mineral was 10.7 m bgl. In three of these boreholes the mineral contains bands of clayey material - see Table F and the indicative draft geological cross-sections in Appendix F.1.

4.1.4 The proportion of the mineral that is estimated to be suitable as granular fill for construction of HS2 Phase 2a is given in Table 4 in Section 3 of the report. This is based on the draft PGI data and may be subject to change when the PGI contractor's final report is received, as discussed in para 1.2.1 of this report.

Table F: Summary of draft geological information for Borrow Pit 3 (based on draft PGI data)

Borehole Reference No.	ML191-CP146	ML191-CP147	ML191-CR107	ML191-CR120	ML191-CR126	ML191-CR128
Final Depth (m bgl)	6.4	5.3	7.5	13.4	20.0	25.4
TOP SOIL depth (m bgl)	0.4	0.4	0.5	0.4	0.4	0.3
Thickness of subsoil which is to be excavated separately (excluding topsoil) (m)	0.8	0.8	0.7	0.8	0.8	0.9
MINERAL (depth to base) (m bgl)	4.8	4.8	5.0	4.5	10.7	5.7
BEDROCK (depth to top) (m bgl)	4.8	4.8	5.0	4.5	10.7	5.7
Groundwater depth (m bgl) ⁽¹⁾	1.5	1.4 ⁽³⁾	1.3 ⁽¹⁾	1.6 ⁽³⁾	2.0	1.7 ⁽³⁾
POTENTIAL MINERAL THICKNESS in BH (m) ⁽²⁾	3.6	3.6	3.8	3.3	9.5	4.5
Potentially recoverable mineral thickness above water table (m)	0.3	0.2	0.1	0.4	0.8	0.5
Potentially recoverable mineral thickness below water table (m)	3.3	3.4	3.7	2.9	8.7	4.0
Type of material to be excavated	Sand and Gravel	Sand, Gravel and Clay	Sand and Gravel	Sand and Gravel	Sand, Gravel and Clay	Sand, Gravel and Clay
Non granular content in BH (m) (see note 4)	None	0.2	None	None	0.7	0.5

4.1.5 Notes to Table F:

- Note (1) Water table varies in each borehole location;
- Note (2) Potential mineral thickness (excluding 1.2m thickness of topsoil plus subsoil which is to be excavated separately) but includes materials described in Note (4);
- Note (3) Value is from groundwater monitoring results up to December 2018;
- Note (4) The 'potential mineral thickness' in Table F includes clayey layers in some boreholes as follows:
 - **ML191-CP147:** The 'potential mineral thickness' includes a 0.2 m thick layer of sandy gravelly CLAY (at depths of 4.6 to 4.8 m bgl);
 - **ML191-CR126:** The 'potential mineral thickness' includes a 0.7 m thick layer of slightly sandy slightly gravelly CLAY (at depths of 8.8 to 9.5 m bgl); and
 - **ML191-CR128:** The 'potential mineral thickness' includes a 0.5 m thick layer of sandy gravelly CLAY (at depths of 5.2 to 5.7 m bgl).

5 Geological summary Borrow Pit 4 (BP4)

5.1.1 Table G provides a summary of the number of PGI exploratory holes at Borrow Pit 4 and the average excavation depth assessed in the AP2 revised scheme earthworks design prior to the PGI. The average excavation depth of the borrow pit based on the draft PGI results is based on six PGI boreholes and a historical borehole, which gave consistent results in regard to depth of mineral.

Table G Number of PGI exploratory holes and average borrow pit excavation depths for Borrow Pit 4

Borrow Pit Reference	BP4
No of exploratory holes for Borrow Pit in Preliminary Ground Investigation (PGI)	21 (including 6 boreholes)
Average excavation depth of Borrow Pit assumed in AP2 design prior to PGI (m bgl)	11.3
Average excavation depth of Borrow Pit based on interpretation of draft PGI data <i>and historical GI</i> (m bgl)	12.8

5.1.2 The draft geological information for Borrow Pit 4 is summarised in Table H and in the indicative draft geological cross-sections in Appendix F.1.

5.1.3 Sand and gravel was encountered in all six of the PGI exploratory holes at this borrow pit. This is as anticipated in the AP2 revised scheme earthworks design prior to the PGI. On the basis of the draft PGI data, in these boreholes, the depth to the base of the mineral was slightly greater than the average depth of 11.3 m bgl assessed at AP2 design stage prior to the PGI.

5.1.4 The proportion of the mineral that is estimated to be suitable as granular fill for construction of HS2 Phase 2a is given in Table 4 in Section 3 of the report. This is based on the draft PGI data and may be subject to change when the PGI contractor's final report is received, as discussed in para 1.2.1 of this report.

Table H: Summary of draft geological information for Borrow Pit 4 (based on draft PGI data)

Borehole Reference No.	ML193- CR107	ML193- CR125	ML193- CP115	ML193- CP116	ML193- CP138	ML193- CP139
Final Depth (m bgl)	24.9	25.3	9.8	13.6	16.5	16.1
TOP SOIL depth (m bgl)	0.4	0.4	None	0.4	0.4	0.4
Thickness of subsoil which is to be excavated separately (excluding topsoil) (m)	0.8	0.8	1.2	0.8	0.8	0.8
MINERAL (depth to base) (m bgl)	13.7	11.5	9.6	13.5	12.9	14.4
BEDROCK (depth to top) (m bgl)	13.7	11.5	9.6	13.5	12.9	14.4
Groundwater depth (m bgl) ⁽¹⁾	2.6	2.0	TBC ⁽³⁾	0.9	2.4	1.2
POTENTIAL MINERAL THICKNESS in BH (m) ⁽²⁾	12.5	10.3	8.4	12.3	11.7	13.2
Potentially recoverable mineral thickness above water table (m)	1.4	0.8	TBC ⁽³⁾	None	1.2	None
Potentially recoverable mineral thickness below water table (m)	11.1	9.5	TBC ⁽³⁾	12.3	10.5	13.2
Type of material to be excavated	Sand and Gravel	Sand and Gravel	Sand and Gravel	Sand and Gravel	Sand and Gravel	Sand and Gravel
Non granular content in BH (m) (see note 3)	None	None	None	None	None	None

5.1.5 Notes to Table H:

- Note (1) Water table varies in each borehole location;
- Note (2) Potential mineral thickness (excluding 1.2m thickness of topsoil plus subsoil which is to be excavated separately) but includes materials described in Note (3); and
- Note (3) There were no groundwater monitoring results in the draft PGI data for this borehole.

6 Geological summary Borrow Pit 5 (BP5)

6.1.1 Table I provides a summary of the number of PGI exploratory holes at Borrow Pit 5 and the average excavation depth assessed in the AP2 revised scheme earthworks design prior to the PGI. The average excavation depth of the borrow pit based on the draft PGI data is based on the six PGI boreholes only as the historical GI at this borrow pit was found to be unreliable.

Table I Number of PGI exploratory holes and average borrow pit excavation depths for Borrow Pit 5

Borrow Pit Reference	BP5
No of exploratory holes for Borrow Pit in Preliminary Ground Investigation (PGI)	21 (including 6 boreholes)
Average excavation depth of Borrow Pit assumed in AP2 design prior to PGI (m bgl)	8.0
Average excavation depth of Borrow Pit based on interpretation of draft PGI data (m bgl)	11.0

6.1.2 The draft geological information for Borrow Pit 5 is summarised in Table J and in the indicative draft geological cross-sections in Appendix F.1.

6.1.3 Sand and gravel was encountered in almost all of the PGI boreholes at this borrow pit as anticipated in the AP2 revised scheme earthworks design prior to the PGI. On the basis of the draft PGI data, in five out of the six boreholes, the depth to the base of the mineral was greater than the average depth of 8.0 m bgl assessed at AP2 design stage prior to the PGI. However in some boreholes this mineral contains bands of clayey material - see Table J and indicative draft geological cross-sections in Appendix F.1.

6.1.4 At one of the boreholes (ML235-CR107), which is at the north-eastern edge of the borrow pit, no mineral was found.

6.1.5 The proportion of the mineral that is estimated to be suitable as granular fill for construction of HS2 Phase 2a is given in Table 4 in Section of the report. This is based on the draft PGI data and may be subject to change when the PGI contractor's final report is received, as discussed in para 1.2.1 of this report.

Table J: Summary of draft geological information for Borrow Pit 5 (based on draft PGI data)

Borehole Reference No.	ML235-CR133	ML235-CR144	ML235-CR117	ML235-CR143	ML235-CR107	ML235-CR101
Final Depth (m bgl)	19.9 (CP then RC)	14.0 (CP only)	17.4 (CP only)	15.9 (CP only)	19.8 (CP then RC)	19.9 (CP then RC)
TOP SOIL depth (m bgl)	0.3	0.3	0.3	0.5	0.4	0.2
Thickness of subsoil which is to be excavated separately (excluding topsoil) (m)	0.9	0.9	0.9	0.7	0.8	1.0
MINERAL (depth to base) (m bgl)	9.5	13.9	14.6	13.4	None	14.6
BEDROCK (depth to top) (m bgl)	9.5	13.9	14.6	13.4	0.4	14.6
Groundwater depth (m bgl) ⁽¹⁾	3.8 ⁽³⁾	1.6 ⁽³⁾	1.6 ⁽³⁾	1.9 ⁽³⁾	2.2 ⁽³⁾	3.3 ⁽³⁾
POTENTIAL MINERAL THICKNESS in BH (m) ⁽²⁾	8.3	12.7	13.4	12.2	None	13.4
Potentially recoverable mineral thickness above water table (m)	2.6	0.4	0.4	0.7	None	2.1
Potentially recoverable mineral thickness below water table (m)	5.7	12.3	13.0	11.5	None	11.3
Type of material to be excavated	Sand, Gravel and Clay	Sand, Gravel and Clay	Sand, Gravel and Clay	Sand, Gravel and Clay	No Mineral	Sand, Gravel and Clay
Non granular content in BH (m) (see note 4)	2.4	3.9	1.9	2.6	Not applicable	0.6

6.1.6 Notes to Table J:

- CP = cable percussion, RC = rotary cored.
- Note (1) Water table varies in each borehole location.
- Note (2) Potential mineral thickness (excluding 1.2m thickness of topsoil plus subsoil which is to be excavated separately) but includes materials described in Note (4).
- Note (3) Value recorded in groundwater monitoring of piezometer or standpipe.
- Note (4) The 'potential mineral thickness' in Table J includes clayey layers in all boreholes as follows:
 - **ML235-CR133**: The 'potential mineral thickness' includes a 2.4 m thick band of slightly sandy slightly gravelly CLAY (at depths from 6.1 to 8.5 m bgl).
 - **ML235-CR144**: The 'potential mineral thickness' includes the following bands of clayey material:
 - (i) 0.8 m thickness of sandy silty CLAY (at depths from 1.2 to 2.0 m bgl);

- (ii) 1.1 m thickness of slightly gravelly sandy CLAY (at depths from 7.2 to 8.3 m bgl); and
 - (iii) 2.0 m thickness of slightly gravelly slightly sandy CLAY (at depths from 9.7 to 11.7 m bgl).
- **ML235-CR117**: The 'potential mineral thickness' includes the following bands of clayey material:
 - (i) 0.3 m thickness of sandy CLAY (at depths from 1.2 to 1.5 m bgl); and
 - (ii) 1.6 m thickness of slightly sandy CLAY (at depths from 7.6 to 9.2 m bgl).
- **ML235-CR143**: The 'potential mineral thickness' includes the following bands of clayey material:
 - (i) 1.9 m thickness of sandy slightly gravelly CLAY (at depths from 1.2 to 3.1 m bgl); and
 - (ii) 0.7 m thickness of sandy CLAY (at depths from 8.3 to 9.0 m bgl).
- **ML235-CR101**: The 'potential mineral thickness' includes a 0.6 m thick band of sandy CLAY (at depths from 1.2 to 1.8 m bgl).

7 Geological summary Borrow Pit 6 (BP6)

7.1.1 Table K provides a summary of the number of PGI exploratory holes at Borrow Pit 6 and the average excavation depth assessed in the AP2 revised scheme earthworks design prior to the PGI. The excavation depths of the borrow pit are based on the draft PGI data from the seven PGI boreholes only.

Table K Number of PGI exploratory holes and average borrow pit excavation depths for Borrow Pit 6

Borrow Pit Reference	BP6
No of exploratory holes for Borrow Pit in Preliminary Ground Investigation (PGI)	26 (including 7 boreholes)
Average excavation depth of Borrow Pit assumed in AP2 design prior to PGI (m bgl)	Estimated excavation depths in BP241 varied as excavation was required to be 1.0 m above the estimated groundwater level
Average excavation depth of Borrow Pit based on interpretation of draft PGI data (m bgl)	Estimated excavation depths in BP241 still vary as excavation is required to be 1.0 m above the estimated groundwater level

7.1.2 The draft geological information for Borrow Pit 6 is summarised in Table L and in the indicative draft geological cross-sections in Appendix F.1.

7.1.3 The topography of this proposed borrow pit undulates considerably and the ground levels vary from about 91 mAOD (in the south-western part of the borrow pit near the proposed route of HS2) down to about 74 mAOD (in the northern part of the borrow pit) near the WCML) before rising back to about 83 mAOD at the WCML (see draft geological cross-section A-A' in Appendix F.1). The topography north of the WCML then drops away northwards towards Betley Mere.

7.1.4 Seven boreholes were carried out for this borrow pit in the PGI. The AP2 revised scheme earthworks design anticipated that the bedrock would be at considerable depth. However, the draft PGI data suggests that the bedrock is deeper than interpreted in the AP2 design prior to PGI as none of the boreholes reached bedrock. Also, on the basis of the draft PGI data, only one of them (ML240-CP150) encountered groundwater during drilling.

7.1.5 On the basis of the draft PGI data, one of the boreholes (ML241-CP106) did not encounter any mineral. The other six boreholes encountered mineral to their full depth with variable thicknesses of clayey material. These boreholes all exhibit a sequence of sand and clay layers to depth, with gravel encountered in a few boreholes.

7.1.6 The proportion of the mineral that is estimated to be suitable as granular fill for construction of HS2 Phase 2a is given in Table 4 in Section 3 of the report. This is based on the draft PGI data and may be subject to change when the PGI contractor's final report is received, as discussed in para 1.2.1 of this report.

Table L: Summary of draft geological information for Borrow Pit 6 (based on draft PGI data)

Borehole Reference No.	ML241-CP106	ML240-CP116	ML240-CP127	ML240-CP128	ML240-CP132	ML240-CP150	ML240-CP151
Final Depth (m bgl)	10.5	30.0	15.2	27.6	20.5	22.0	20.9
TOP SOIL depth (m bgl)	0.2	0.5	0.4	0.4	0.2	0.5	0.3
Thickness of subsoil which is to be excavated separately (excluding topsoil) (m)	1.0	0.7	0.8	0.8	1.0	0.7	0.9
MINERAL (depth to base) (m bgl)	None	30.0+	15.2+	27.6+	20.5+	22.0+	20.9+
BEDROCK (depth to top) (m bgl)	Not reached	Not reached	Not reached	Not reached	Not reached	Not reached	Not reached
Groundwater depth (m bgl) ⁽¹⁾	2.1 ⁽³⁾	9.3 ⁽³⁾	3.5 ⁽³⁾	19.8 ⁽³⁾	Dry (> 18.5) ⁽³⁾	6.2 ⁽³⁾	8.2 ⁽³⁾
Groundwater level (m OD) ⁽¹⁾	71.7 ⁽³⁾	79.2 ⁽³⁾	72.4 ⁽³⁾	72.1 ⁽³⁾	< 72.4 ⁽³⁾	72.2 ⁽³⁾	79.3 ⁽³⁾
POTENTIALLY RECOVERABLE MINERAL THICKNESS TO 1.0m ABOVE WATER TABLE (m) ⁽²⁾	None	7.1	1.3	18.6	17.3	4.0	6.0
Potentially recoverable mineral thickness below 1.0m above water table (m)	None ⁽²⁾	None ⁽²⁾	None ⁽²⁾	None ⁽²⁾	None ⁽²⁾	None ⁽²⁾	None ⁽²⁾
Type of material to be excavated	Clay	Sand, silty sand and sandy clay	Silty and clayey sand	Silty sand, silt and clay	Silty sand and clay	Sand, clayey sand, gravel and silt	Sand and gravel, sandy clay and clayey sand
Non granular content in BH down to 1.0 m above water table (m) ⁽⁴⁾	Not applicable	6.4	1.3	18.6	9.7	1.0	3.6

7.1.7 Notes to Table L :

- Note (1) Water table varies in each borehole location;
- Note (2) HS2 Ltd has committed to only excavate this borrow pit to a depth of 1 m above the groundwater level. Therefore, the potential mineral thickness (excluding 1.2m thickness of topsoil plus subsoil which is to be excavated separately) is the thickness to that depth. It includes materials described in Note (4);
- Note (3) Highest groundwater recorded in monitoring up to December 2018;

- Note (4) The thicknesses of non-granular material in the 'potential mineral thickness' are from 1.2 mbgl to 1.0m above the highest groundwater level recorded in monitoring up to December 2018 and are summarised for each borehole below.

ML240-CP116: The 'potential mineral thickness' down to 1.0 m above the water table includes a 6.4 m thick layer of slightly sandy CLAY (at depths from 2.9 to 9.3 m bgl).

- **ML240-CP127:** The 'potential mineral thickness' down to 1.0 m above the water table includes a 1.3 m thick layer of silty or clayey SAND (at depths from 1.2 to 2.5 m bgl).

– **ML240-CP128**

The 'potential mineral thickness' down to 1.0 m above the water table includes:

- (i) a 0.7 m thick layer of slightly sandy CLAY (at depths from 1.2 to 1.9 m bgl);
- (ii) a 3.9 m thick layer of slightly gravelly clayey SAND (at depths from 1.9 to 4.8 m bgl);
- (iii) a 4.7 m thick layer of slightly sandy silty CLAY (at depths from 4.8 to 9.5 m bgl);
- (iv) a 7.5 m thick layer of silty SAND (at depths from 9.5 to 17.0 m bgl); and
- (v) a 2.8 m thick layer of sandy SILT (at depths from 17.0 to 19.8 m bgl).

– **ML240-CP132**

The 'potential mineral thickness' down to 1.0 m above the water table includes:

- (i) a 0.7 m thick layer of sandy slightly gravelly CLAY (at depths from 1.2 to 1.9 m bgl);
- (ii) a 4.6 m thick layer of silty SAND (at depths from 3.9 to 8.5 m bgl);
- (iii) a 1.4 m thick layer of sandy CLAY (at depths from 8.5 to 9.9 m bgl); and
- (iv) a 3.0 m thick layer of sandy slightly gravelly CLAY (at depths from 11.0 to 14.0 m bgl).

- **ML240-CP150:** The 'potential mineral thickness' down to 1.0 m above the water table includes a 1.0 m thick layer of clayey SILT (at depths from 4.0 to 5.0 m bgl)

ML240-CP151: The 'potential mineral thickness' down to 1.0 m above the water table includes a 1.6 m thick layer of clayey SAND (at depths from 1.4 to 3.0 m bgl) and a 2.0 m thick layer of slightly sandy CLAY (at depths from 3.0 to 5.0 m bgl).

8 Geological summary Borrow Pit X (between Borrow Pit 2 and Borrow Pit 3)

- 8.1.1 Table M provides a summary of the number of PGI exploratory holes at Borrow Pit X. This is a borrow pit proposed by a petitioner and it was not included in the AP2 revised scheme earthworks design prior to the PGI. The average excavation depth of the borrow pit based on the draft PGI data is based on five PGI boreholes and 17 historical boreholes, which gave consistent results in regard to depth of mineral.

Table M Number of PGI exploratory holes and average borrow pit excavation depths for Borrow Pit X

Borrow Pit Reference	BPX
No of exploratory holes for Borrow Pit in Preliminary Ground Investigation (PGI)	16 (including 5 boreholes)
Average excavation depth of Borrow Pit assumed in AP2 design prior to PGI (m bgl)	This borrow pit was not part of the AP2 design
Average excavation depth of Borrow Pit based on interpretation of draft PGI data <i>and historical GI</i> (m bgl)	6.5

- 8.1.2 The draft geological information for Borrow Pit X is summarised in Table N and in the indicative draft geological cross-sections in Appendix F.1.
- 8.1.3 Sand and gravel was encountered in all five of the PGI boreholes at this proposed borrow pit. On the basis of the draft PGI data in these boreholes, the depth to the base of the mineral is typically more than 5.5 m bgl and includes clayey layers in some boreholes.
- 8.1.4 The proportion of the mineral that is estimated to be suitable as granular fill for construction of Phase 2a (i.e. if this borrow pit were to be approved for use and operated) is given in Table 4 in Section 3 of the report. This is based on the draft PGI data and may be subject to change when the PGI contractor's final report is received, as discussed in para 1.2.1 of this report.

Table N: Summary of draft geological information for Borrow Pit X (based on draft PGI data)

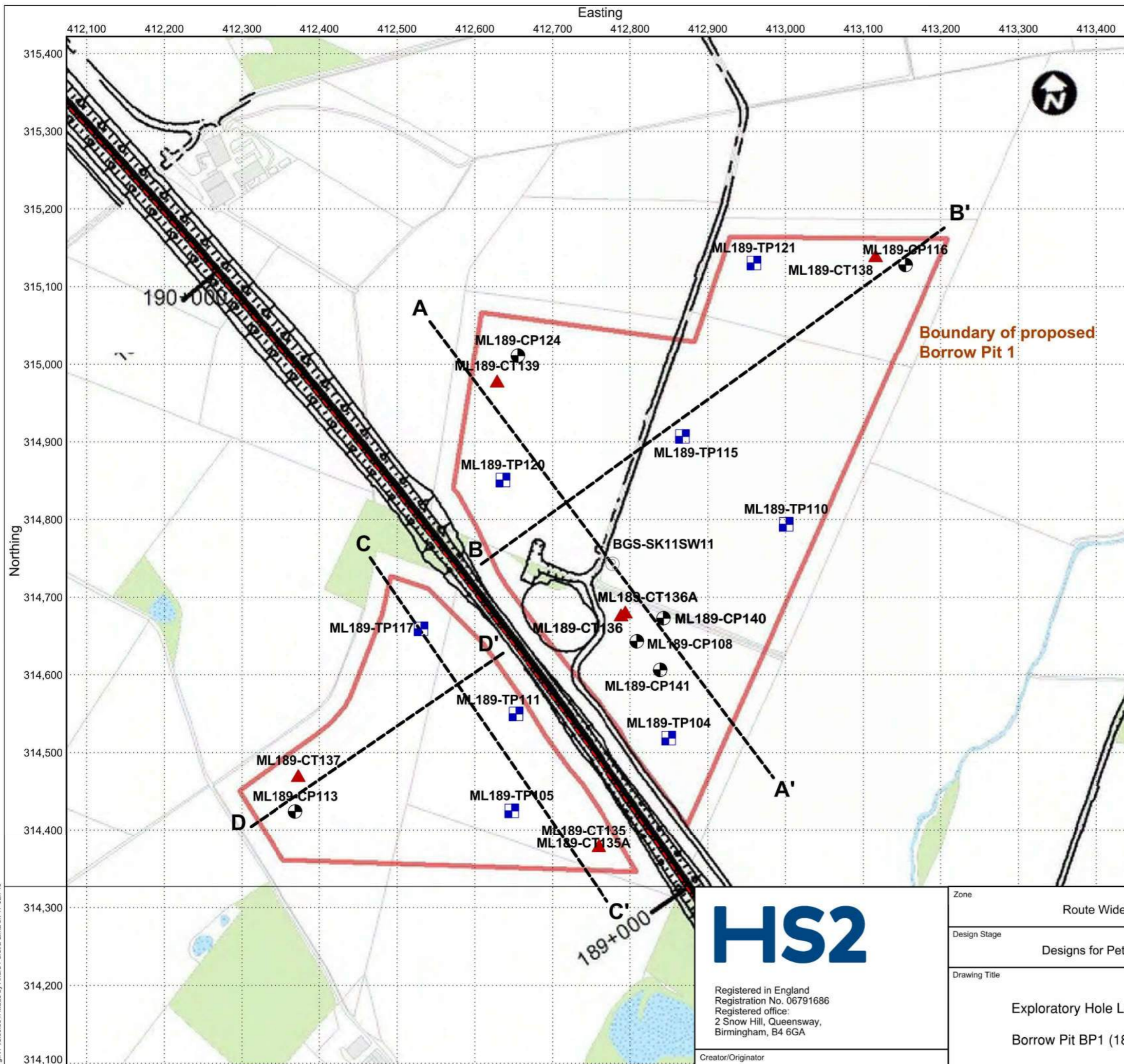
Borehole Reference No.	ML190-CP153	ML190-CP154	ML191-CP153	ML191-CP154	ML191-CP155
Final Depth (m bgl)	11.6	13.5	11.5	10.0	7.6
TOP SOIL depth (m bgl)	0.4	0.4	0.3	0.5	0.4
Thickness of subsoil which is to be excavated separately (excluding topsoil) (m)	0.8	0.8	0.9	0.7	0.8
MINERAL (depth to base) (m bgl)	7.1	10.1	11.0	8.8	6.7
BEDROCK (depth to top) (m bgl)	7.1	10.1	11.0	8.8	6.7
Groundwater depth (m bgl) ⁽¹⁾	3.2	3.4	2.8	1.9	2.8
POTENTIAL MINERAL THICKNESS in BH (m) ⁽²⁾	5.9	8.9	9.8	7.6	5.5
Potentially recoverable mineral thickness above water table (m)	2.0	2.2	1.6	0.7	1.6
Potentially recoverable mineral thickness below water table (m)	3.9	6.7	8.2	6.9	3.9
Type of material to be excavated	Sand and Gravel	Sand and Gravel. Clay layer in lowest part of mineral.	Sand and Gravel. Clay layer in lowest part of mineral.	Sand and Gravel. Clay layer in lowest part of mineral.	Sand and Gravel
Non granular content in BH (m) (see note 3)	None	3.0	4.6	1.0	None

Notes to Table N:

- Note (1) Water table varies in each borehole location.
- Note (2) Potential mineral thickness (excluding 1.2m thickness of topsoil plus subsoil which is to be excavated separately) but includes materials described in Note (4).
- Note (3) There were no groundwater monitoring results in the draft PGI data for this borrow pit (BPX).
- Note (4) The 'potential mineral thickness' in Table N includes clayey layers in some boreholes as follows:
 - **ML190-CP154:** The 'potential mineral thickness' includes a 3.0 m thick layer of slightly sandy gravelly CLAY (at depths from 7.1 to 10.1 m bgl);
 - **ML191-CP153:** The 'potential mineral thickness' includes a 4.6 m thick layer of sandy gravelly CLAY (at depths from 6.4 to 11.0 m bgl); and
 - **ML191-CP154:** The 'potential mineral thickness' includes a 1.0 m thick layer of slightly sandy slightly gravelly CLAY (at depths from 7.8 to 8.8 m bgl).

APPENDIX F.1

Borrow pit exploratory hole location plans and geological cross-sections



- Cable percussion borehole
- Trial pit
- ▲ Cone penetration test
- Unknown or unrecognised hole type

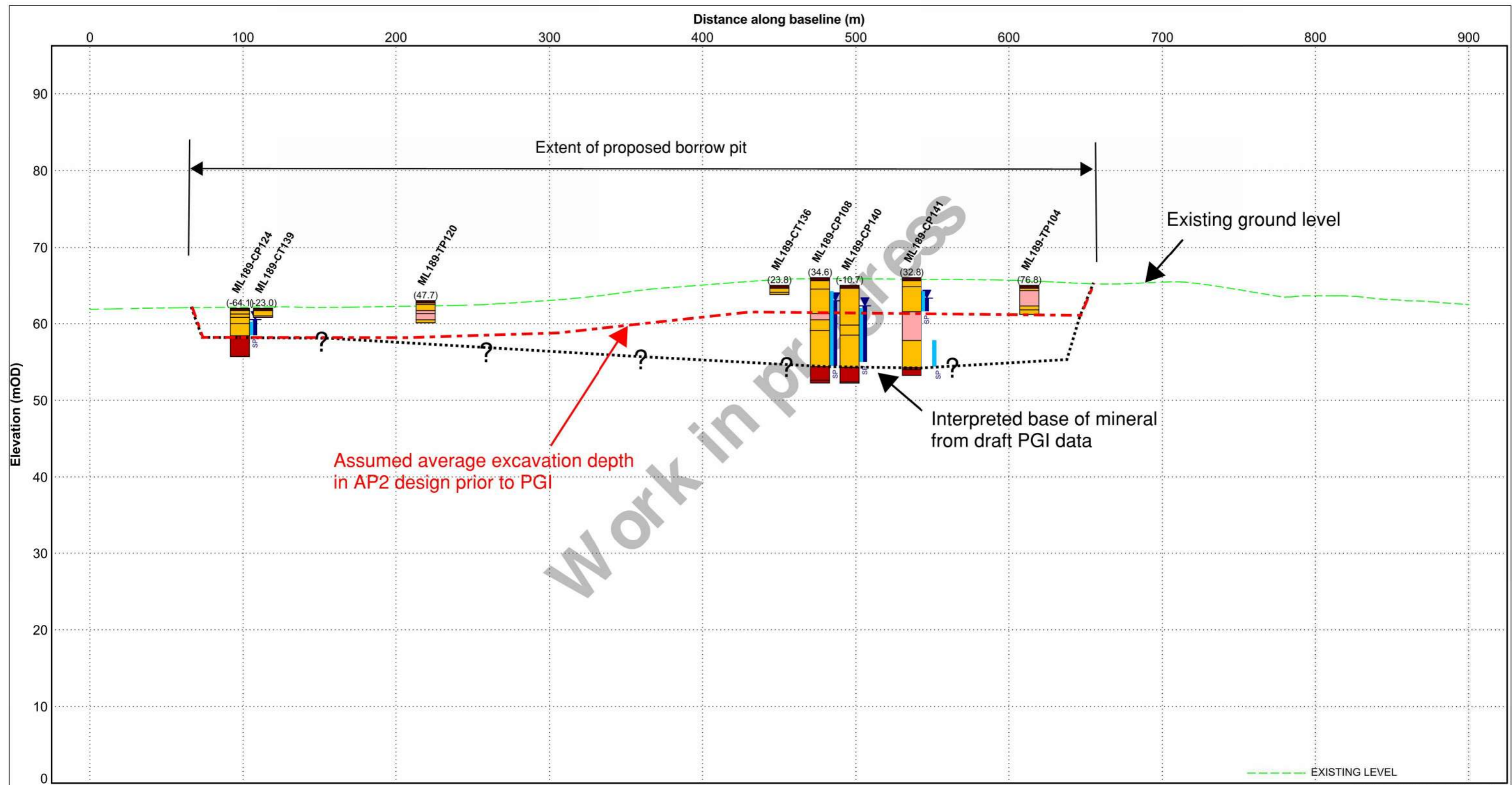
ARUP_gINT v8.30.004. Made by Andre Pereira-Lima on 17-Jan-19



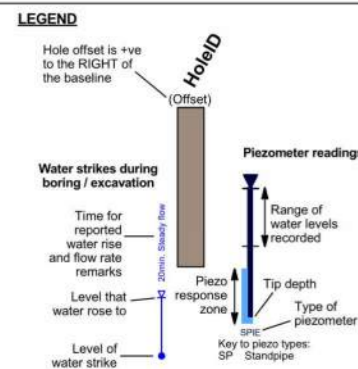
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 Birmingham, B4 6GA

Creator/Originator
 Ove Arup & Partners International Ltd

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Design Stage	Designs for Petition		Discipline/Function			
Drawing Title			Petitions			
			Drawn	Checked	Approved	
Exploratory Hole Locations Borrow Pit BP1 (189/189a)			APL, JN	AP		
			Date	Scale	Size	
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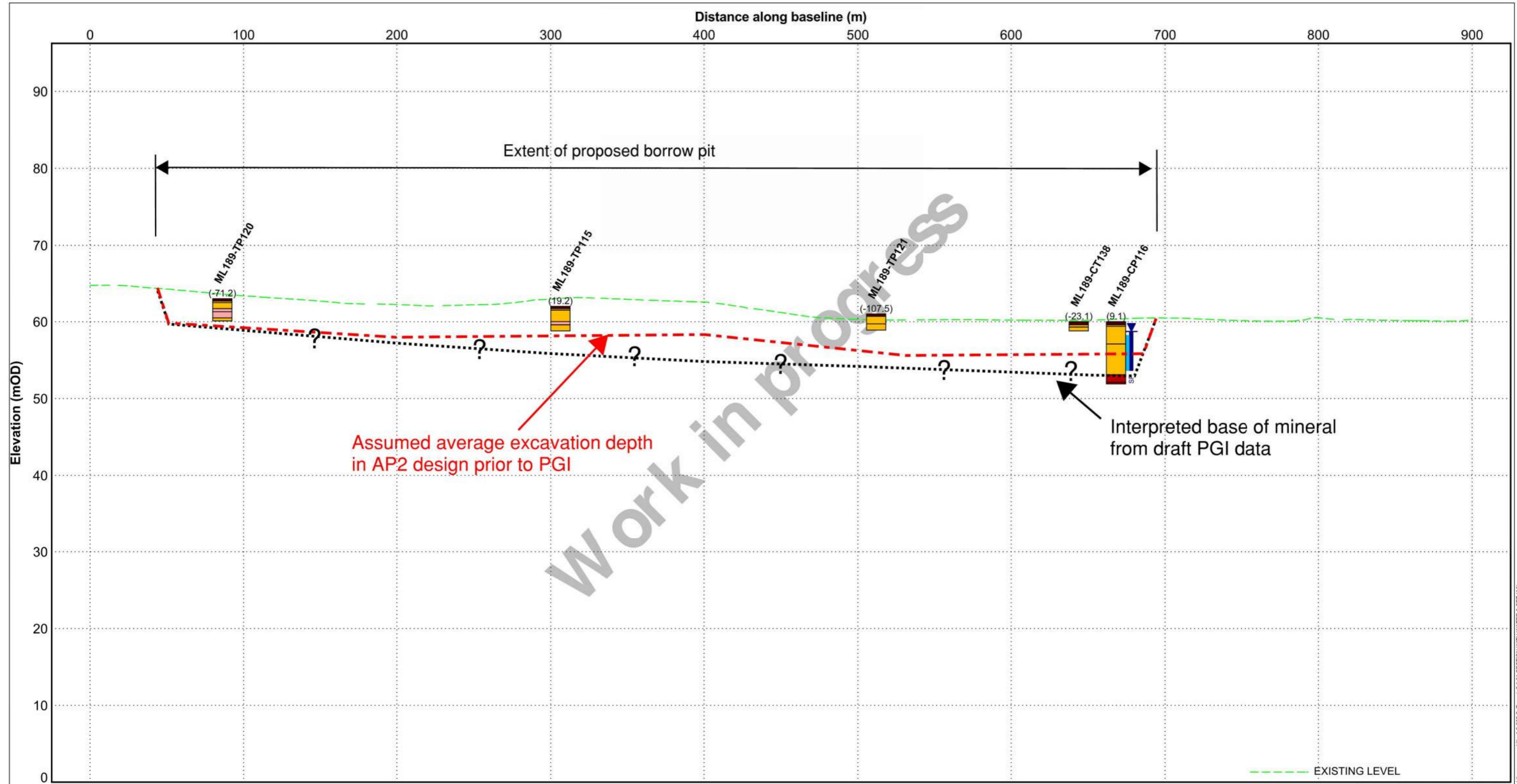
HS2

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Registration No. 06791686
Registered office:
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Birmingham, B4 6GA

Creator/Originator
Ove Arup & Partners International Ltd

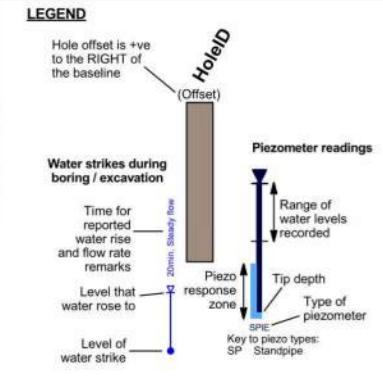
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	Borrow Pit BP1 (189)		Date 24/01/2019	Scale AS SHOWN	Size A1
Drawing No. 2PT02-ARP-PT-DSK-000-000038				Rev. P01	

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Data source: None (for holes) / Output: None (data not currently available)
Filter: None



SCALE 1:500V 1:2500H @ A3-L

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COLOUR LEGEND

Dark Brown	Top Soil [TOP]
Yellow	Sand/Gravel [SG]
Light Brown	Clay/Silt [CS]
Red	Mercia Mudstone Group (solid geology) [MMG]

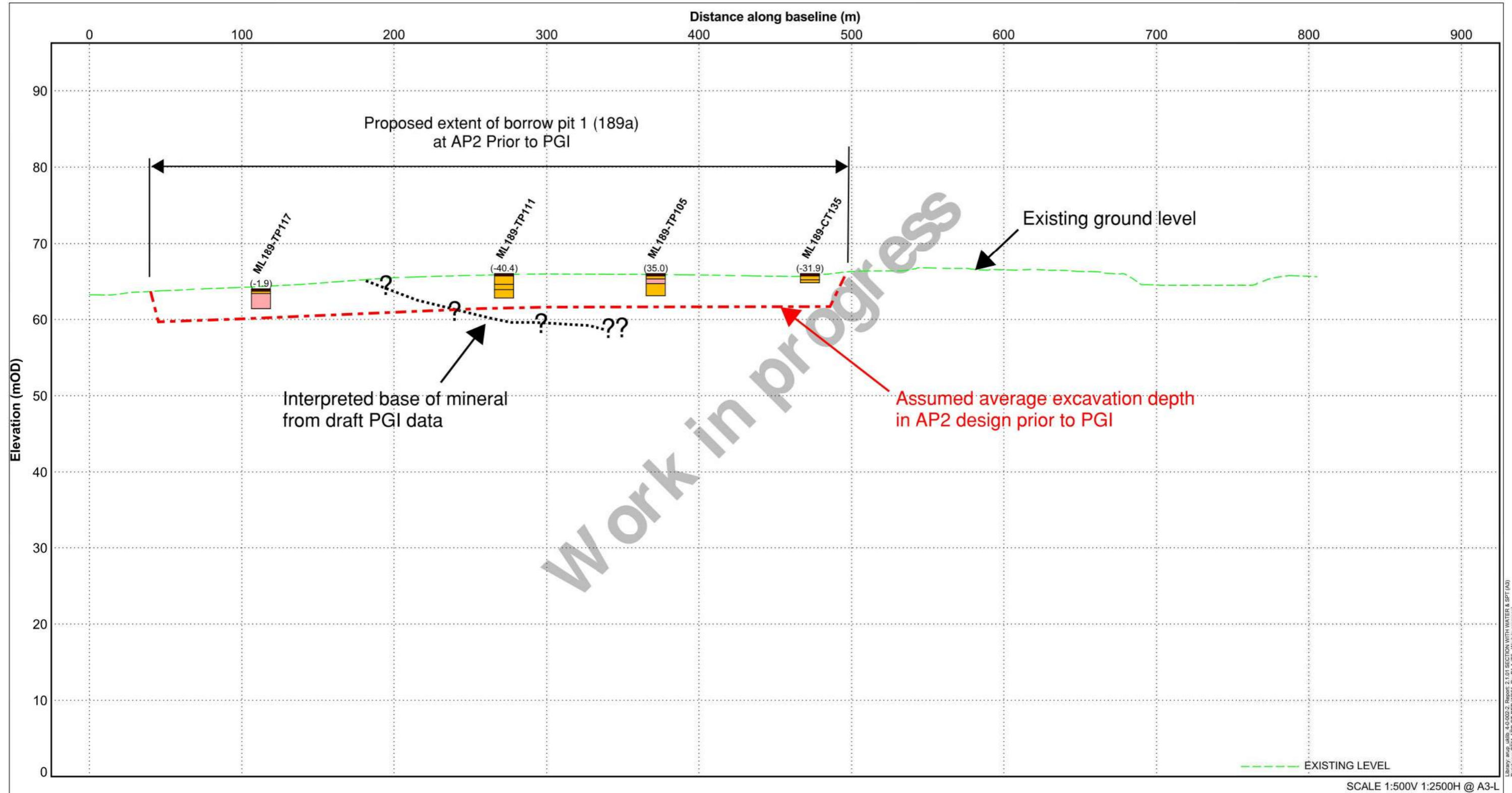
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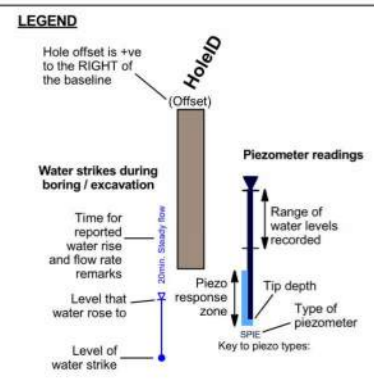
Creator/Originator
 Ove Arup & Partners International Ltd

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			APL, JN	AP				
Date	24/01/2019		Scale	AS SHOWN		Size		A1
Drawing No.	2PT02-ARP-PT-DSK-000-000039					Rev.		P01
Borrow Pit BP1 (189)								

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ARUP_gINT v8.30.004. Made by Andre Pereira-Lima on 17-Jan-19

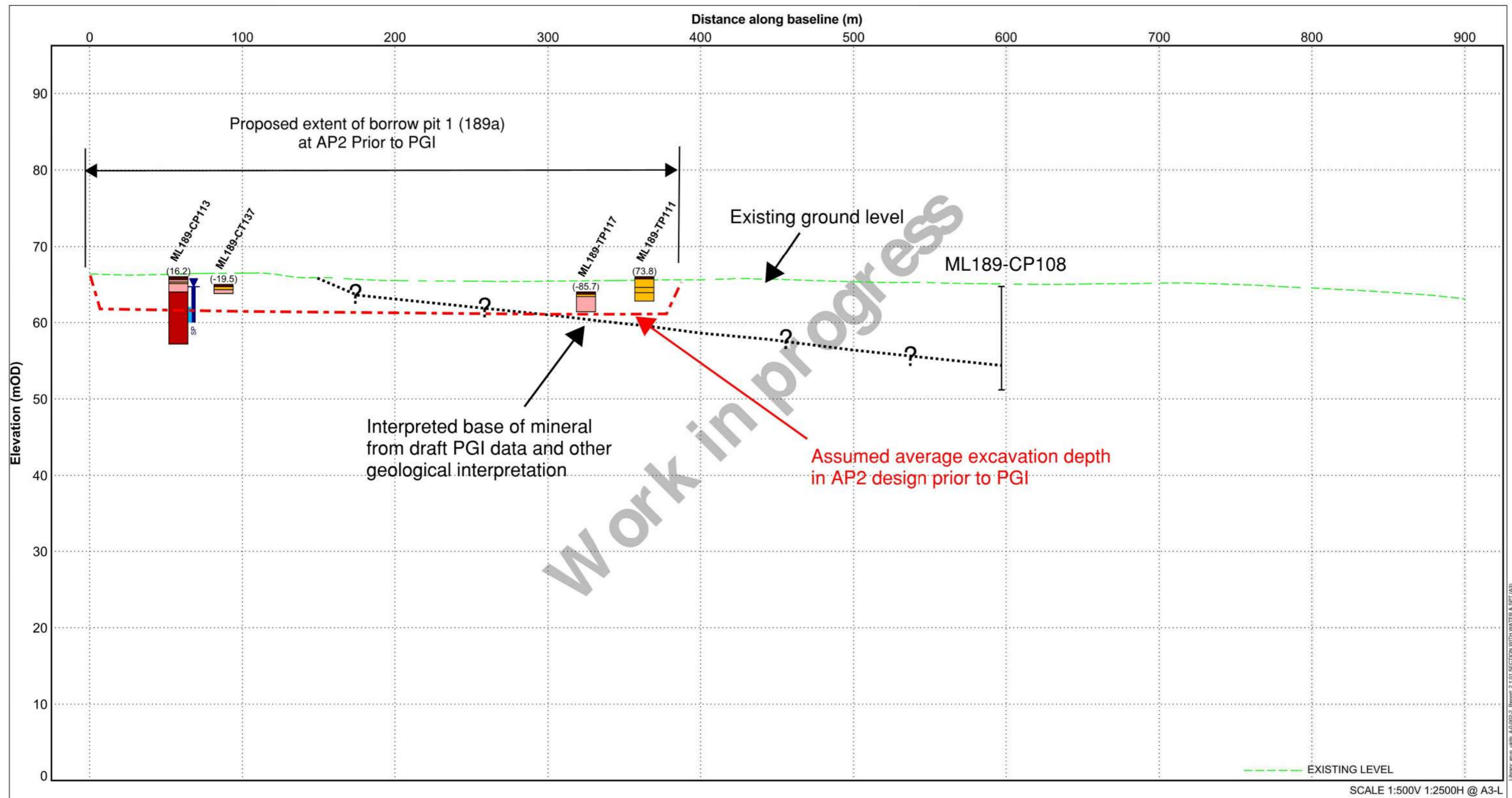


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 Birmingham, B4 6GA

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Zone	Route Wide		Project/Contract		C861 Hybrid Bill Additional Provision 2 AP2	
Design Stage	Designs for Petition		Discipline/Function		Petitions	
Drawing Title	Geological Cross Section		Drawn	Checked	Approved	
	C-C'		APL, JN	AP		
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ARUP_gINT_v8.30.004_Made by Andre Pereira-Lima on 17-Jan-19

LEGEND

HoleID (Offset)

Water strikes during boring / excavation

Time for reported water rise and flow rate remarks

Level that water rose to

Level of water strike

Piezometer readings

Range of water levels recorded

Tip depth

Type of piezometer

Key to piezo types: SP Standpipe

PLAN

COLOUR LEGEND

- Top Soil [TOP]
- Sand/Gravel [SG]
- Clay/Silt [CS]
- Mercia Mudstone Group (solid geology) [MMG]

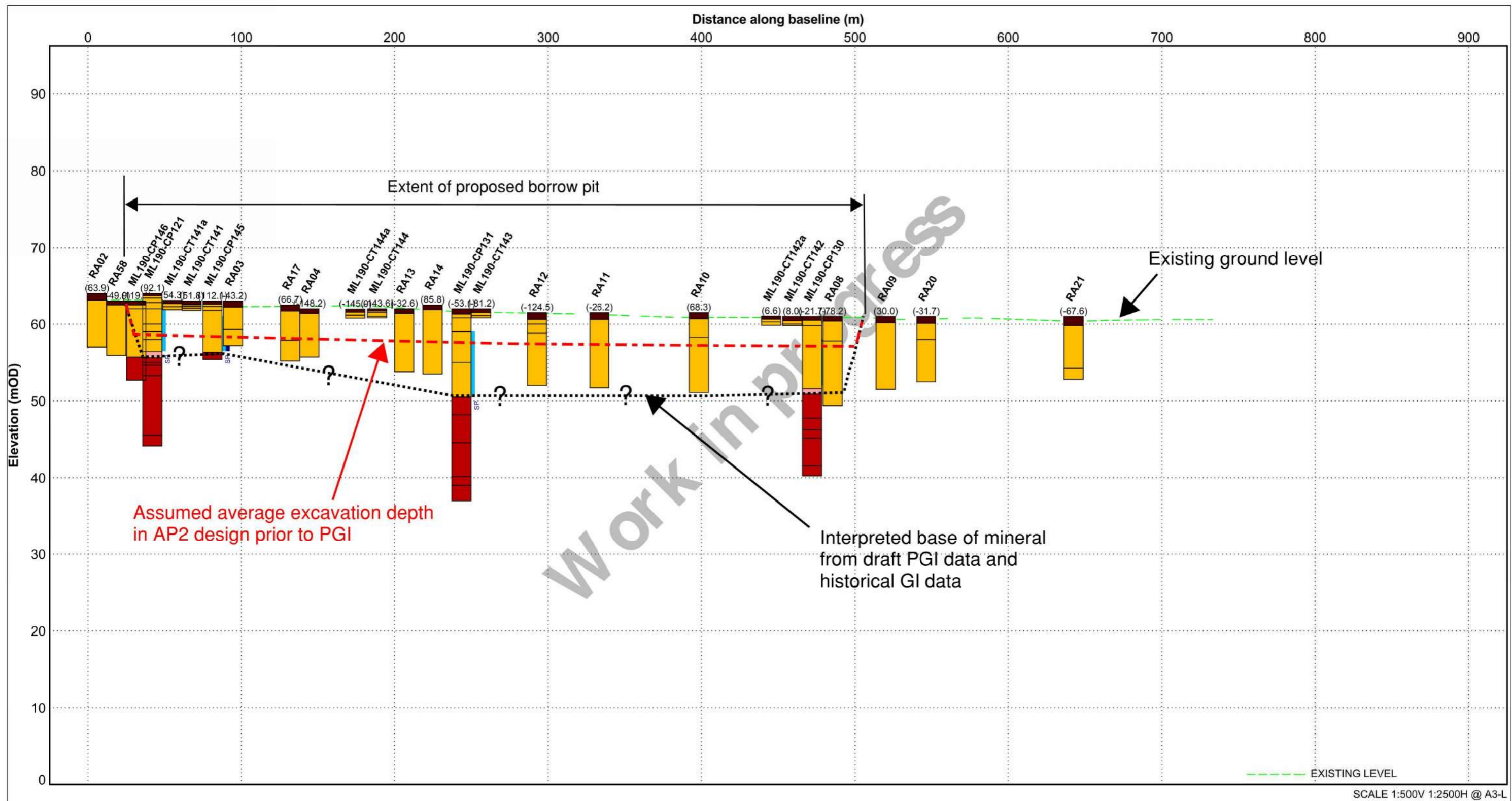
HS2

Registered in England
 Registration No. 06791686
 Registered office:
 2 Snow Hill, Queensway,
 Birmingham, B4 6GA

Creator/Organator
 Ove Arup & Partners International Ltd

Zone	Route Wide		
Design Stage	Designs for Petition		
Drawing Title	Geological Cross Section D-D' Borrow Pit BP1 (189a)		

Project/Contract			C861 Hybrid Bill Additional Provision 2 AP2		
Discipline/Function			Petitions		
Drawn	Checked	Approved			
APL, JN	AP				
Date	Scale	Size			
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Drawing No.		Rev.			
2PT02-ARP-PT-DSK-000-000041		P01			



ARUP_gINT_v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19

LEGEND

Hole/ID (Offset)

Water strikes during boring / excavation

Time for reported water rise and flow rate remarks

Level that water rose to

Level of water strike

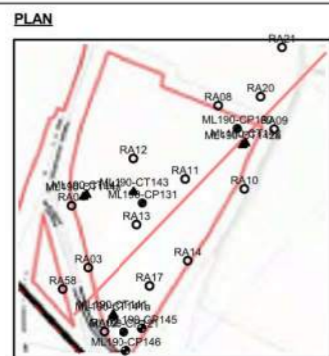
Piezometer readings

Range of water levels recorded

Tip depth

Type of piezometer

Key to piezo types: SP Standpipe



COLOUR LEGEND

- Top Soil [TOP]
- Sand/Gravel [SG]
- Clay/Silt [CS]
- Mercia Mudstone Group (solid geology) [MMG]

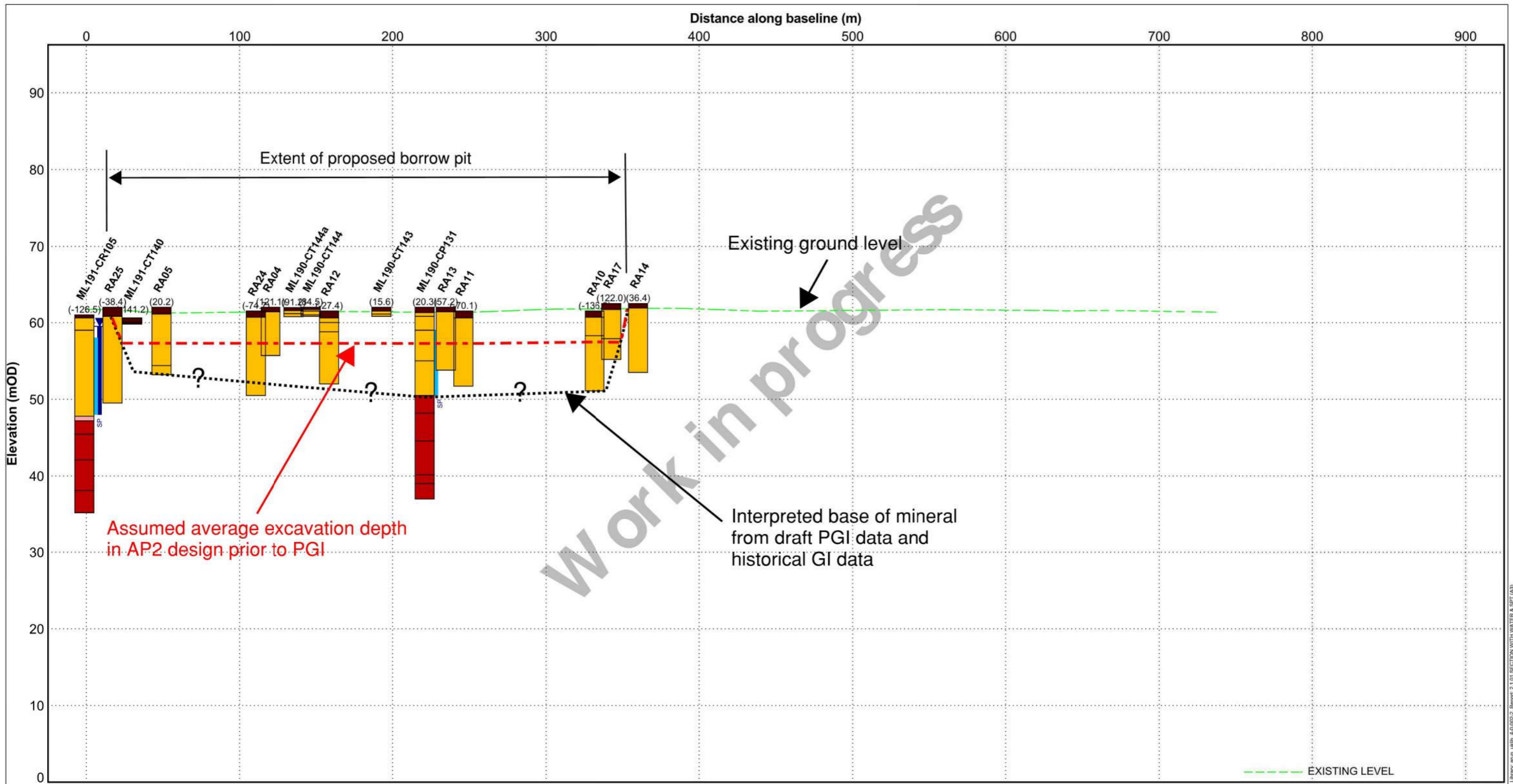
HS2

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 Registration No. 06791686
 Registered office:
 2 Snow Hill, Queensway,
 Birmingham, B4 6GA

Creator/Originator
 Ove Arup & Partners International Ltd

Zone	Route Wide		Project/Contract	C861 Hybrid Bill Additional Provision 2 AP2		
Design Stage	Designs for Petition		Discipline/Function	Petitions		
Drawing Title	Geological Cross Section		Drawn	Checked	Approved	
	A-A'		APL, JN	AP		
Drawing No.	Borrow Pit BP2 (190)		Date	Scale	Size	
			24/01/2019	AS SHOWN	A1	
			Drawing No.	Rev.		
			2PT02-ARP-PT-DSK-000-000043	P01		

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 Filter: None



SCALE 1:500V 1:2500H @ A3-L

Library: arup\gint\8.30.004 - Report: 2.0.01 SECTION WITH WATER & SPT (A3)
 Source: data table status of holes
 Database check status: Full check (A) = 0%, Partial/Selective check (B) = 0%, Minimum check (C) = 0%, Unchecked (U) = 63% of holes
 Filter: None

ARUP_gint v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19

LEGEND

Hole offset is +ve to the RIGHT of the baseline

Water strikes during boring / excavation

Time for reported water rise and flow rate remarks

Level that water rose to

Level of water strike

Hole ID

(Offset)

Piezometer readings

Range of water levels recorded

Tip depth

Type of piezometer

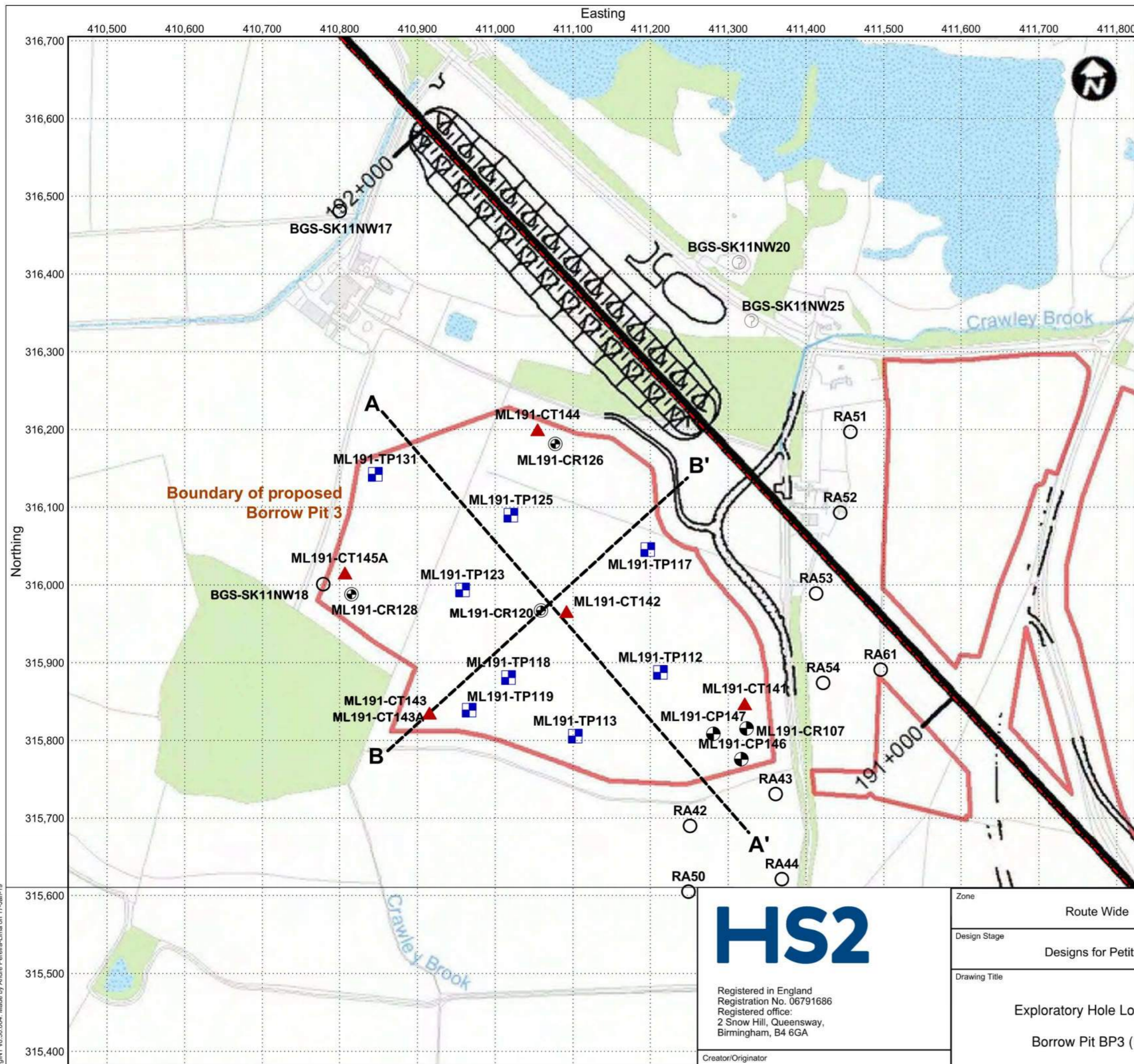
Key to piezo types: SP Standpipe

PLAN

COLOUR LEGEND

- Top Soil [TOP]
- Sand/Gravel [SG]
- Clay/Silt [CS]
- Mercia Mudstone Group (solid geology) [MMG]

<p>Registered in England Registration No. 06791686 Registered office: 2 Snow Hill, Queensway, Birmingham, B4 6GA</p> <p>Creator/Oriinator Ove Arup & Partners International Ltd</p>	Zone	Route Wide	Project/Contract		
	Design Stage	Designs for Petition	C861 Hybrid Bill Additional Provision 2 AP2		
	Drawing Title	Geological Cross Section B-B'	Discipline/Function		
		Borrow Pit BP2 (190)	Petitions		
		Drawn	Checked	Approved	
		APL, JN	AP		
		Date	Scale	Size	
		24/01/2019	AS SHOWN	A1	
		Drawing No.	Rev.		
		2PT02-ARP-PT-DSK-000-000044	P01		



- Cable percussion borehole
- ⊙ Cable percussion + rotary core follow on
- Borehole (unknown type)
- Trial pit
- ▲ Cone penetration test
- ⊙ Unknown or unrecognised hole type

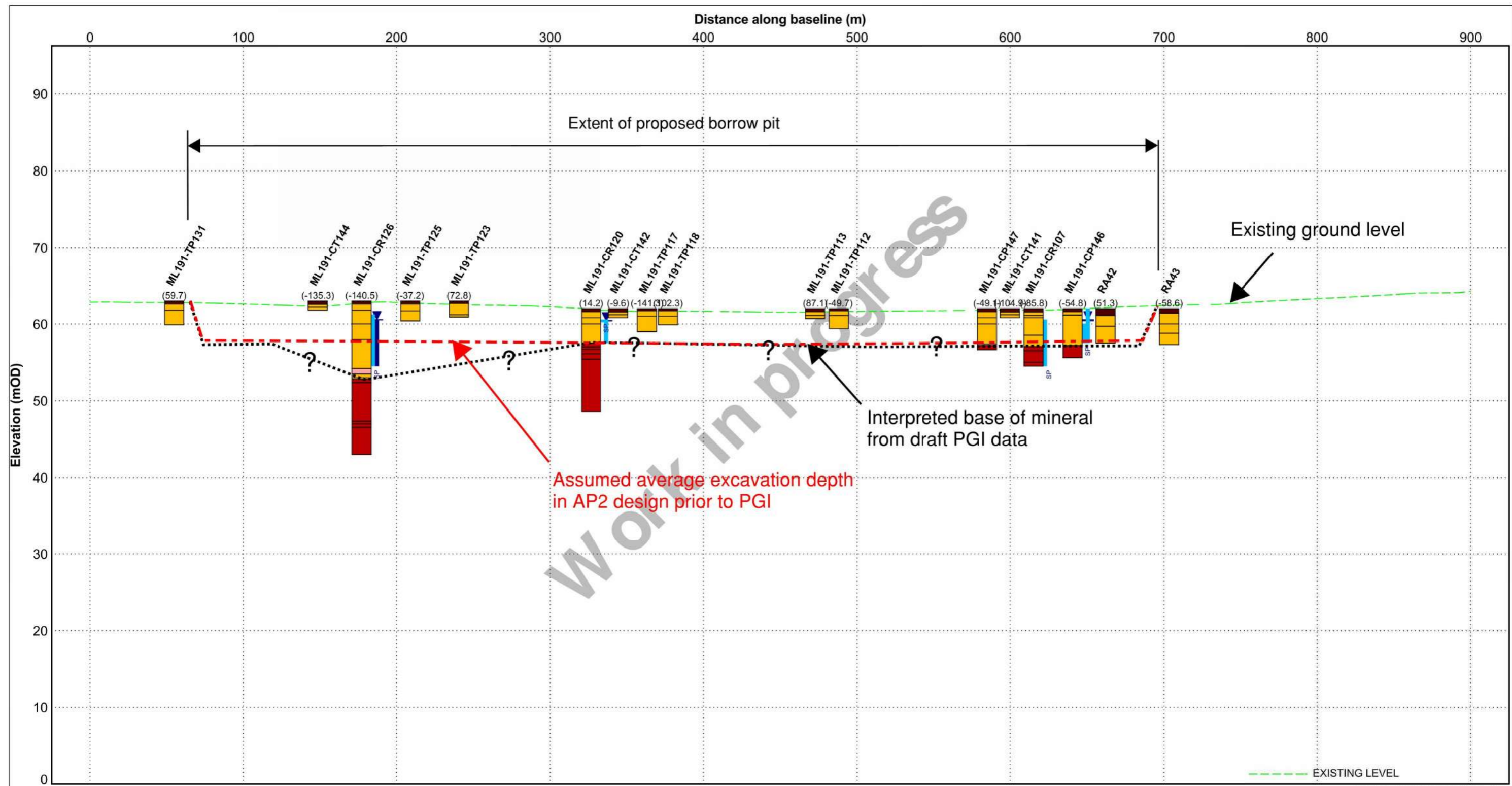
ARUP, gINT v8.30.004. Made by Andre Pereira-Lima on 17-Jan-19



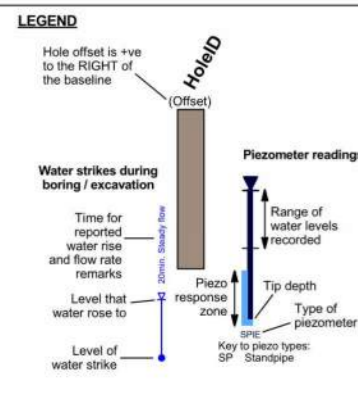
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Zone	Route Wide		Project/Contract	C861 Hybrid Bill Additional Provision 2 AP2	
Design Stage	Designs for Petition		Discipline/Function	Petitions	
Drawing Title	Drawn	Checked	Approved		
	APL, JN	AP			
Exploratory Hole Locations Borrow Pit BP3 (191)	Date	Scale	Size		
	24/01/2019	AS SHOWN	A1		
	Drawing No.	Rev.			
	2PT02-ARP-PT-DSK-000-000045	P01			



ARUP_gINT v8.30.004. Made by Andre Pereira-Lima on 17-Jan-19



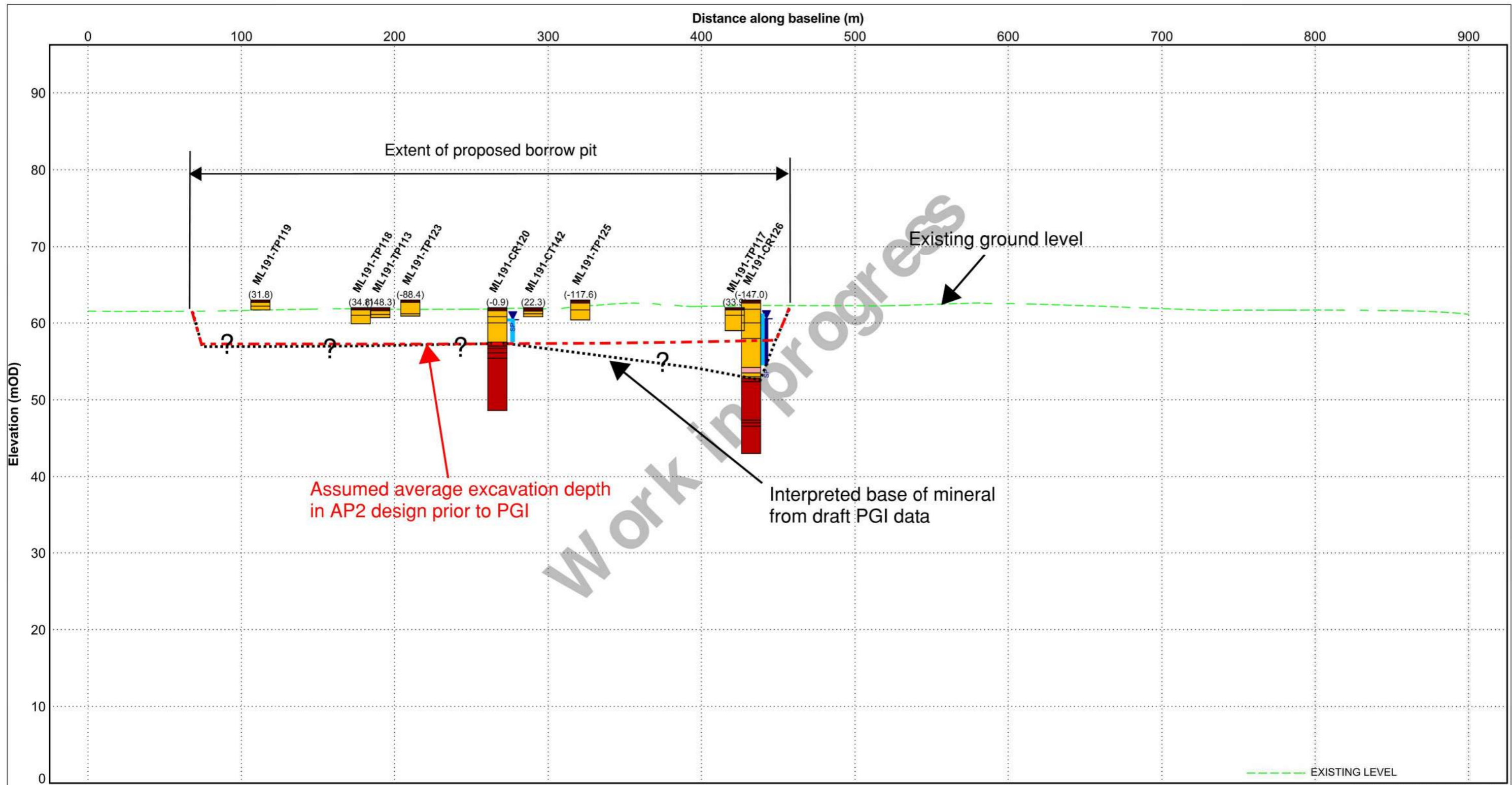
HS2

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Zone	Route Wide		Project/Contract		C861 Hybrid Bill Additional Provision 2 AP2	
Design Stage	Designs for Petition		Discipline/Function		Petitions	
Drawing Title	Geological Cross Section A-A'		Drawn	Checked	Approved	
			APL, JN	AP		
	Date	Scale	Size			
	24/01/2019	AS SHOWN	A1			
	Drawing No.	Rev.				
	2PT02-ARP-PT-DSK-000-000046	P01				

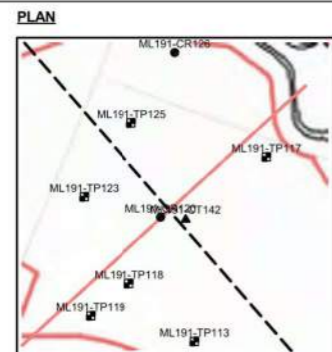
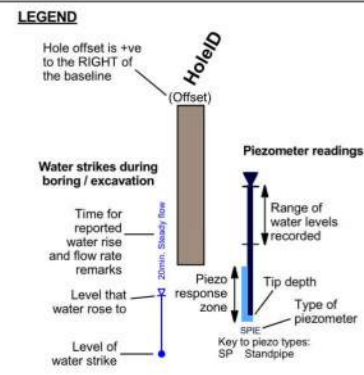
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 Filter: None



Library: arup; Path: C:\Users\andre.pereira.lima\Documents\2019\2019\SECTION WITH WATER & SPT (A3);
 Title: Section with water & SPT (A3);
 Author: andre.pereira.lima; Date: 2019-01-19 10:00:00; Version: 1.0; Scale: 1:2500H @ A3-L;
 Source data status: of holes; Database check status: Full check (A) = 0%; Partial/Selective check (B) = 0%; Minimum check (C) = 0%; Unchecked (U) = 0% of holes;
 Filter: None

SCALE 1:500V 1:2500H @ A3-L

ARUP_gint v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19

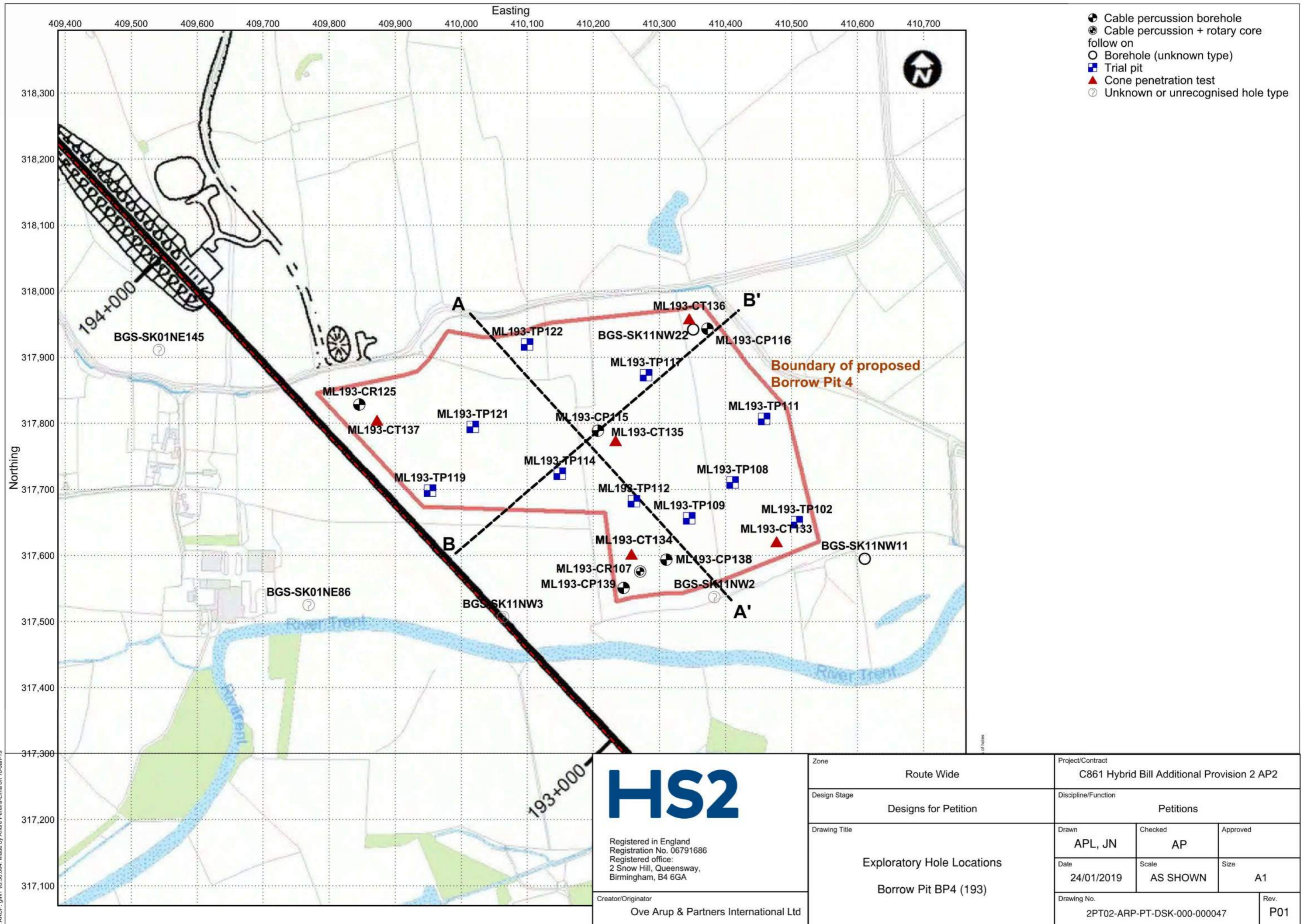


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Zone	Route Wide		Project/Contract		C861 Hybrid Bill Additional Provision 2 AP2			
Design Stage	Designs for Petition		Discipline/Function				Petitions	
Drawing Title	Geological Cross Section		Drawn	Checked	Approved			
			APL, JN	AP				
B-B'	Borrow Pit BP3 (191)		Date	Scale	Size			
			24/01/2019	AS SHOWN	A1			
Drawing No.			Rev.					
2PT02-ARP-PT-DSK-000-000046			P01					



- ⊕ Cable percussion borehole
- ⊗ Cable percussion + rotary core follow on
- Borehole (unknown type)
- Trial pit
- ▲ Cone penetration test
- ⊙ Unknown or unrecognised hole type

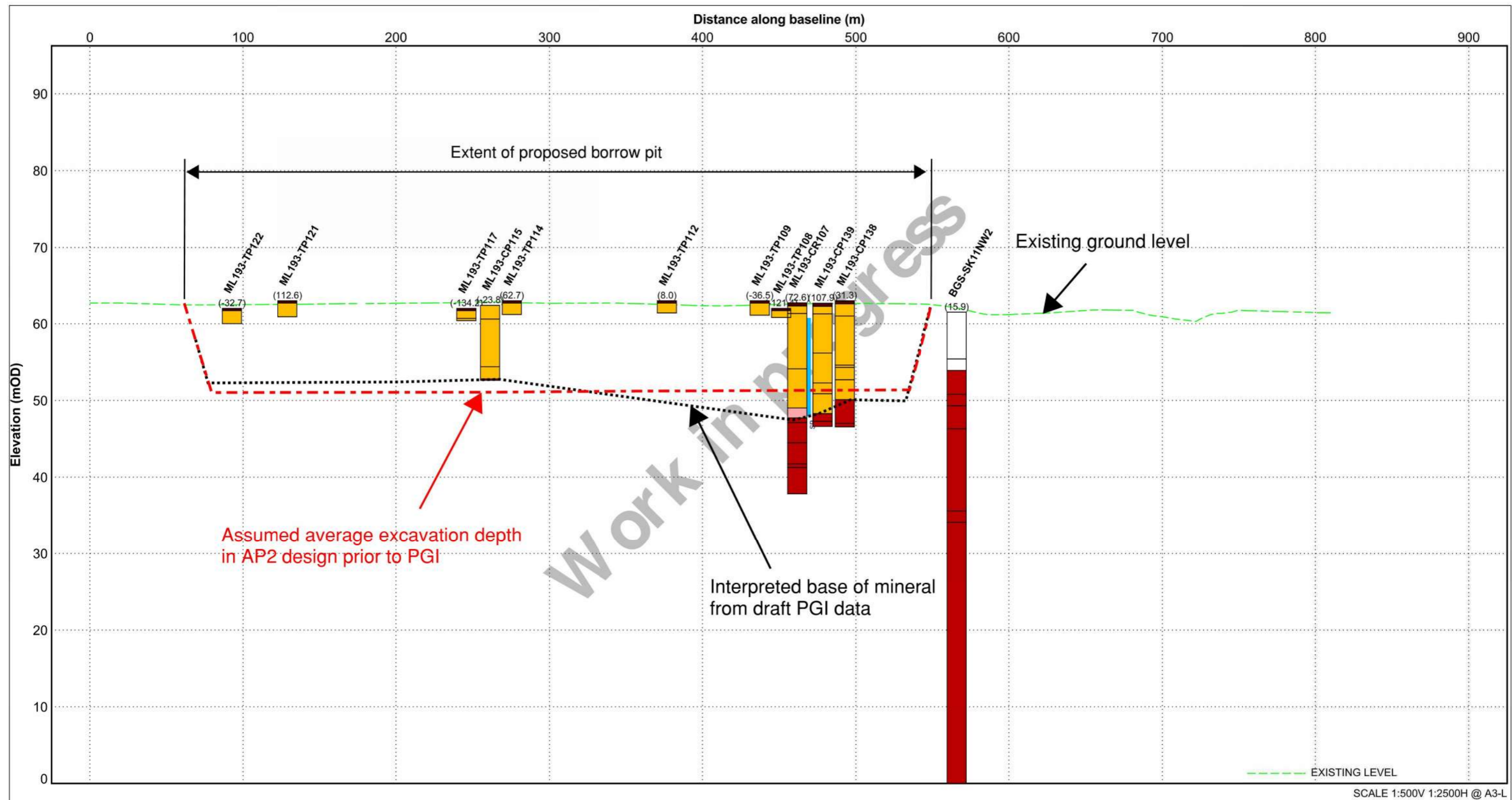
ARUP_gINT v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19



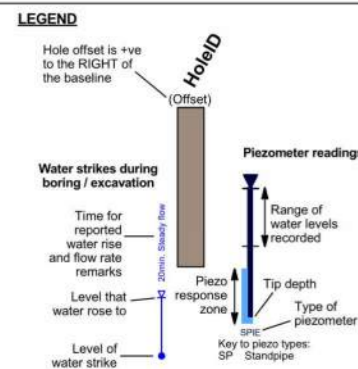
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Zone	Route Wide		Project/Contract C861 Hybrid Bill Additional Provision 2 AP2		
Design Stage	Designs for Petition		Discipline/Function Petitions		
Drawing Title Exploratory Hole Locations Borrow Pit BP4 (193)	Drawn	Checked	Approved		
	APL, JN	AP			
	Date	Scale	Size		
	24/01/2019	AS SHOWN	A1		
	Drawing No.		Rev.		
	2PT02-ARP-PT-DSK-000-000047		P01		



ARUP_gINT_v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19



COLOUR LEGEND

Top Soil [TOP]
Sand/Gravel [SG]
Clay/Silt [CS]
Mercia Mudstone Group (solid geology) [MMG]

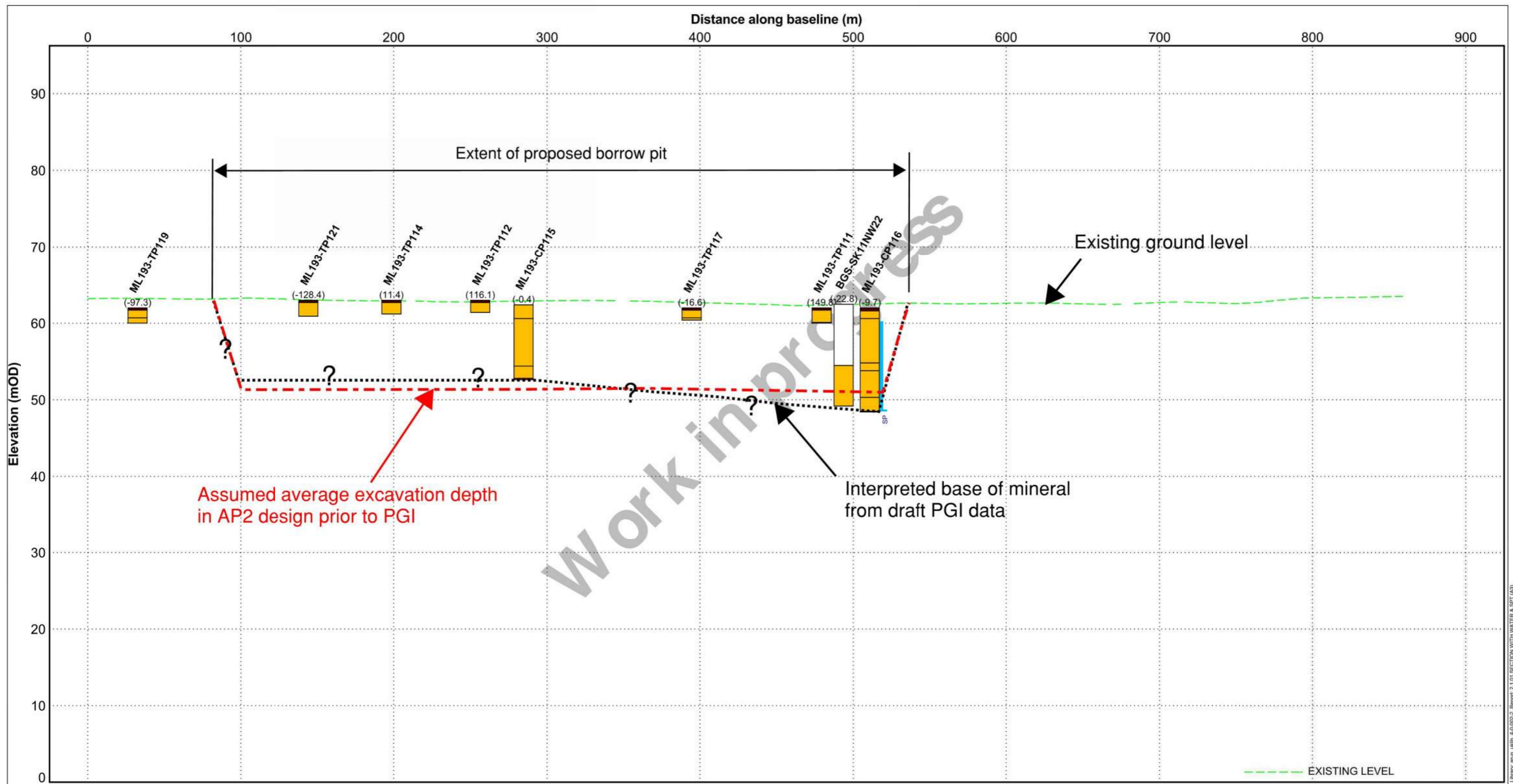
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Zone	Route Wide		Project/Contract		C861 Hybrid Bill Additional Provision 2 AP2	
Design Stage	Designs for Petition		Discipline/Function		Petitions	
Drawing Title	Geological Cross Section		Drawn	Checked	Approved	
	A-A'		APL, JN	AP		
Borrow Pit BP4 (193)	Date	Scale	Size			
	24/01/2019	AS SHOWN	A1			
Drawing No.			Rev.			
2PT02-ARP-PT-DSK-000-000048			P01			

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 Source data status: of holes
 Database check status: Full check (A) = 0%, Partial/selective check (B) = 0%, Minimum check (C) = 0%, Unchecked (U) = 0% of holes
 Date of last check: 18-Jan-2019
 Filter: None



SCALE 1:500V 1:2500H @ A3-L

ARUP_gINT v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19

LEGEND

HoleID (Offset)

Water strikes during boring / excavation

Time for reported water rise and flow rate remarks

Level that water rose to

Level of water strike

Piezometer readings

Range of water levels recorded

Tip depth

Type of piezometer

Key to piezo types: SP Standspipe

COLOUR LEGEND

- Top Soil [TOP]
- Sand/Gravel [SG]
- Mercia Mudstone Group (solid geology) [MMG]

PLAN

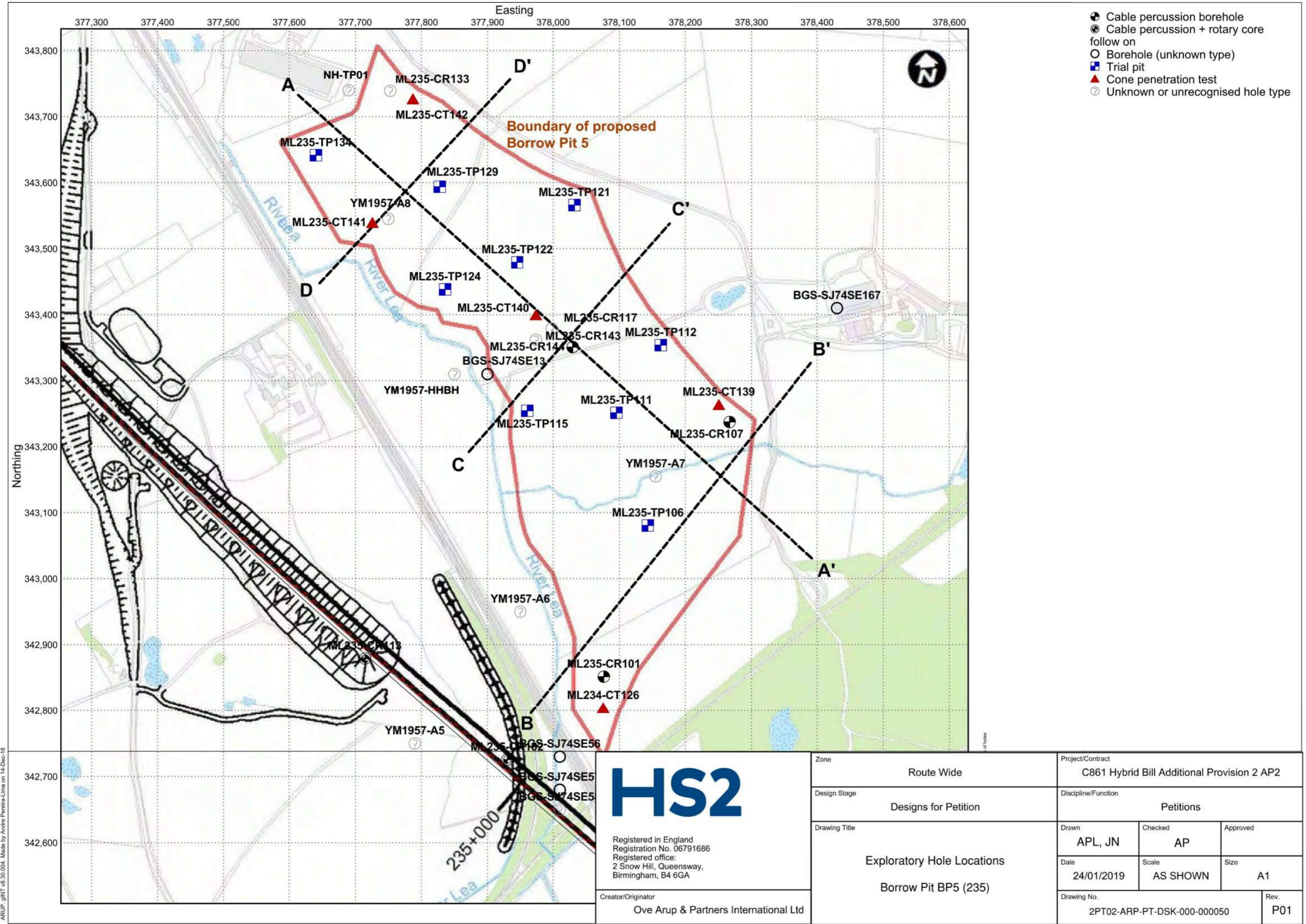
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Creator/Originator
Ove Arup & Partners International Ltd

Zone	Route Wide		Project/Contract	C861 Hybrid Bill Additional Provision 2 AP2		
Design Stage	Designs for Petition		Discipline/Function	Petitions		
Drawing Title	Geological Cross Section		Drawn	Checked	Approved	
	B-B'		APL, JN	AP		
	Borrow Pit BP4 (193)		Date	Scale	Size	
			24/01/2019	AS SHOWN	A1	
			Drawing No.	Rev.		
			2PT02-ARP-PT-DSK-000-000049	P01		

Library: arup\shared\GIS\Projects\2019\2019 SECTION WITH WATER & SPT (A3)
 Source: data from Ove Arup & Partners International (Ove Arup & Partners International)
 Source data status: Full check (A) = 0%, Partial/Selective check (B) = 0%, Minimum check (C) = 0%, Unchecked (U) = 0% of holes
 Database check status: Full check (A) = 0%, Partial/Selective check (B) = 0%, Minimum check (C) = 0%, Unchecked (U) = 0% of holes
 Filter: None



- Cable percussion borehole
- ⊙ Cable percussion + rotary core follow on
- Borehole (unknown type)
- Trial pit
- ▲ Cone penetration test
- ⊗ Unknown or unrecognised hole type

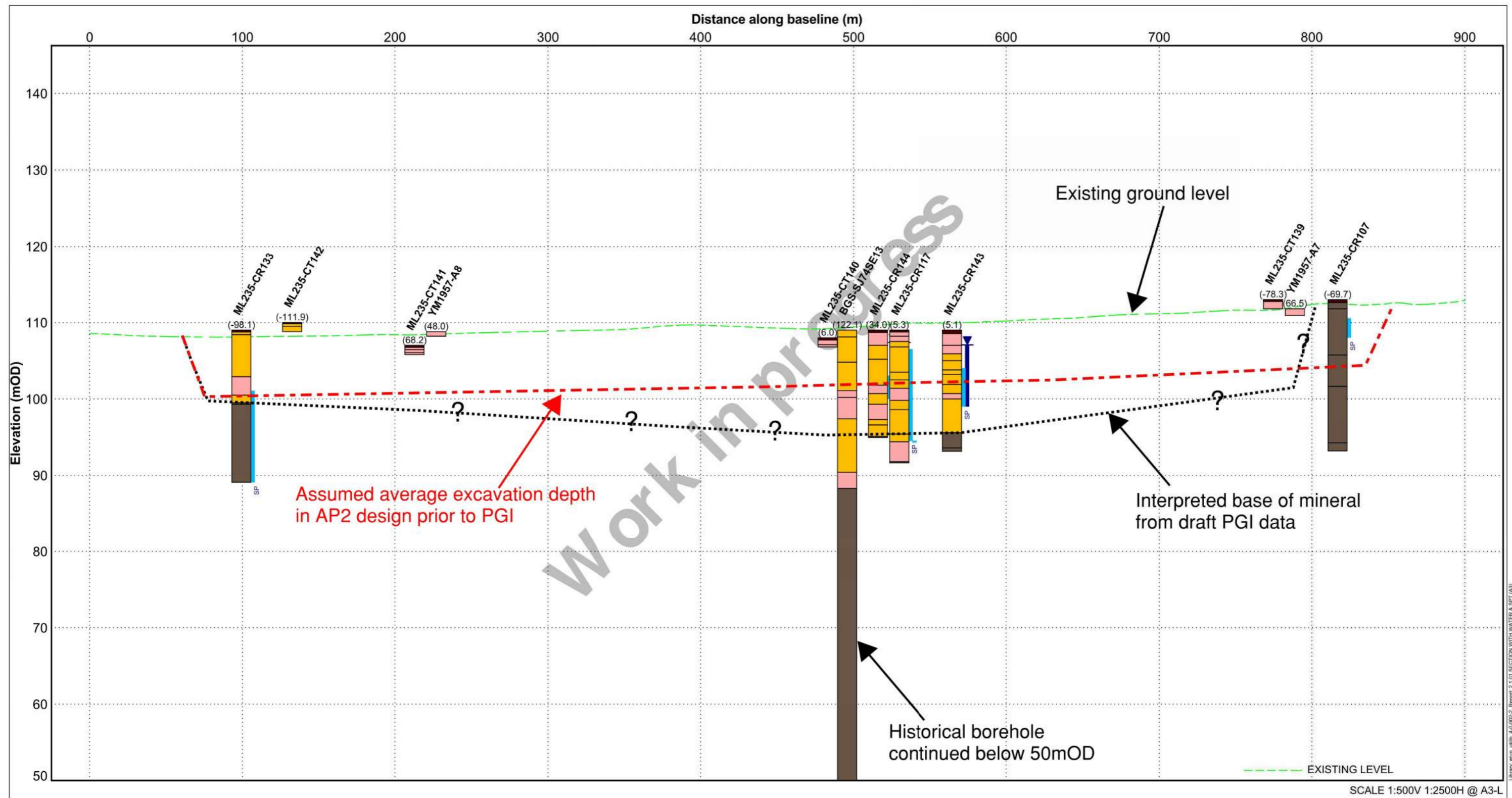
ARUP, gINT v8.30.004, Made by Andre Pereira-Lima on 14-Dec-18



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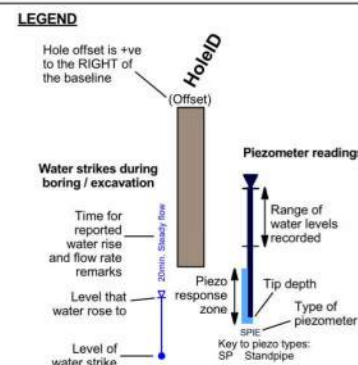
Creator/Originator
 Ove Arup & Partners International Ltd

Zone	Route Wide		Project/Contract		C861 Hybrid Bill Additional Provision 2 AP2	
Design Stage	Designs for Petition		Discipline/Function		Petitions	
Drawing Title	Drawn	Checked	Approved			
	APL, JN	AP				
Exploratory Hole Locations Borrow Pit BP5 (235)	Date	Scale	Size			
	24/01/2019	AS SHOWN	A1			
	Drawing No.				Rev.	
	2PT02-ARP-PT-DSK-000-000050				P01	



SCALE 1:500V 1:2500H @ A3-L

ARUP_gINT v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19



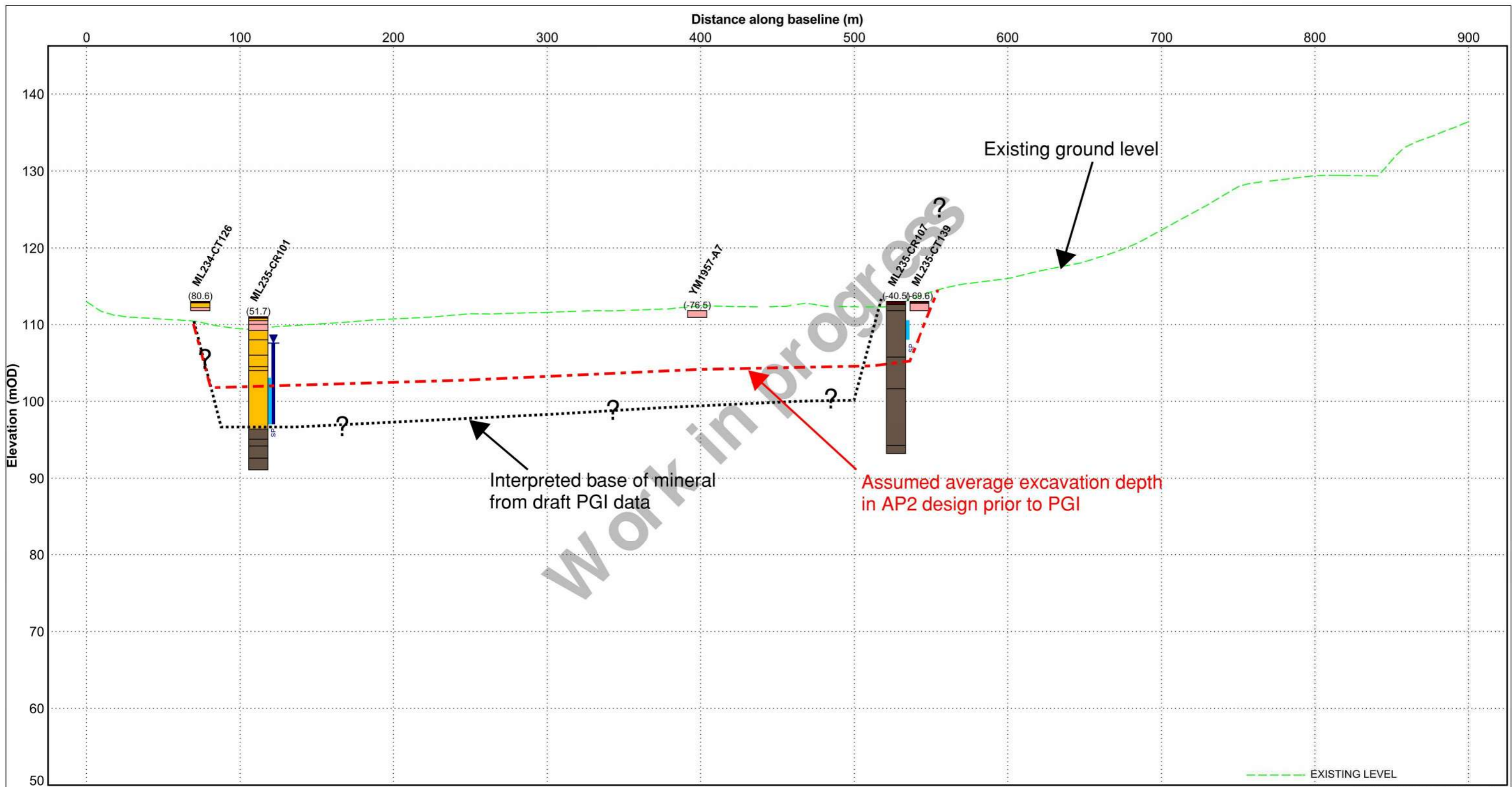
HS2

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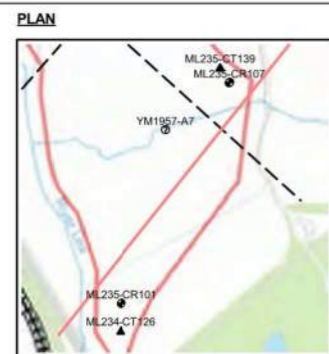
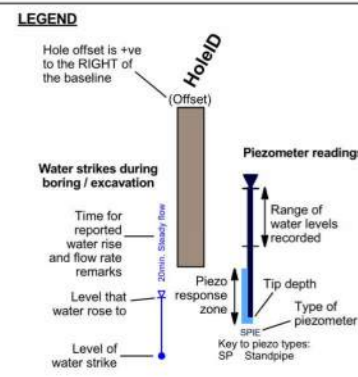
Creator/Originator
Ove Arup & Partners International Ltd

Zone	Route Wide		Project/Contract		C861 Hybrid Bill Additional Provision 2 AP2			
Design Stage	Designs for Petition		Discipline/Function				Petitions	
Drawing Title	Geological Cross Section A-A'		Drawn	Checked	Approved			
			APL, JN	AP				
	Date	Scale	Size					
	24/01/2019	AS SHOWN	A1					
Drawing No.	2PT02-ARP-PT-DSK-000-000051				Rev.		P01	

Library: arup\GIS\Projects\2019\2019-01-SECTION WITH WATER & SPT (A3)
 Drawing: 2PT02-ARP-PT-DSK-000-000051 - Rev. 1.1 (2019-01-19)
 Source data status: of holes
 Database check status: Full check (A) = 0%, Partial/Selective check (B) = 0%, Minimum check (C) = 0%, Unchecked (U) = 8% of holes
 Date of last update: 18-Jan-2019 10:50:00 AM
 Filter: None



ARUP_gINT v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19



- COLOUR LEGEND**
- Top Soil [TOP]
 - Sand/Gravel [SG]
 - Clay/Silt [CS]
 - Carboniferous Warwickshire Group (solid geology) [WAWK]

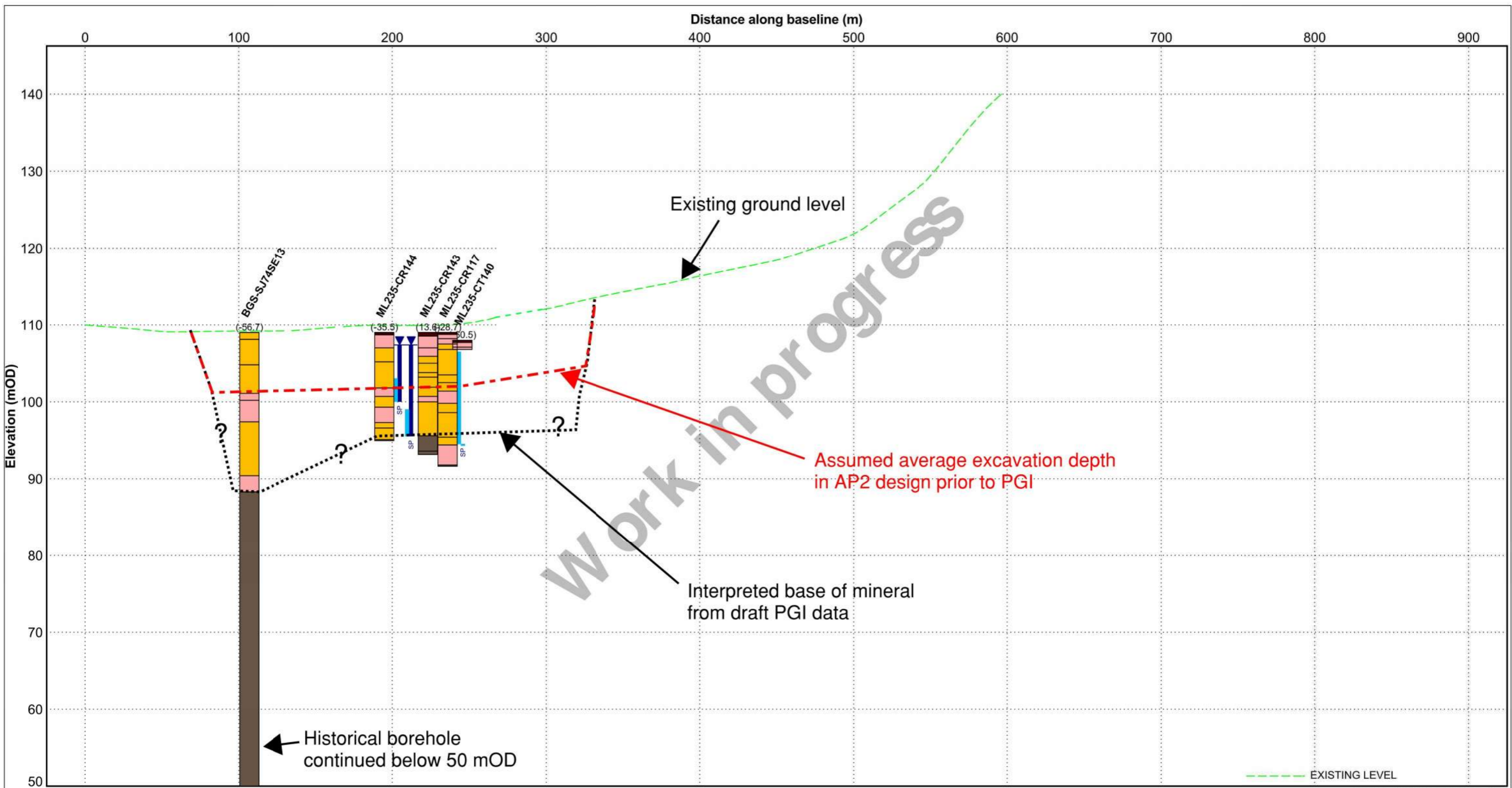
HS2

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Creator/Originator
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Zone	Route Wide		Project/Contract C861 Hybrid Bill Additional Provision 2 AP2	
Design Stage	Designs for Petition		Discipline/Function Petitions	
Drawing Title Geological Cross Section B-B' Borrow Pit BP5 (235)	Drawn	Checked	Approved	
	APL, JN	AP		
	Date 24/01/2019	Scale AS SHOWN	Size A1	
Drawing No.	2PT02-ARP-PT-DSK-000-000052		Rev. P01	

Library: arup/hs2/HS2/2019/2019/SECTION WITH WATER & SPT (A3)
 Drawing: 2PT02-ARP-PT-DSK-000-000052 - Rev. 1.1 (2019-01-24)
 Source data status: of holes
 Database check status: Full check (A) = 0%, Partial/Selective check (B) = 0%, Minimum check (C) = 0%, Unchecked (U) = 0% of holes
 Filter: None



SCALE 1:500V 1:2500H @ A3-L

ARUP_gINT v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19

LEGEND

Hole/ID (Offset)

Water strikes during boring / excavation

Time for reported water rise and flow rate remarks

Level that water rose to

Level of water strike

Piezometer readings

Range of water levels recorded

Tip depth

Type of piezometer

Key to piezo types: SP Standpipe



COLOUR LEGEND

- Top Soil [TOP]
- Sand/Gravel [SG]
- Clay/Silt [CS]
- Carboniferous Warwickshire Group (solid geology) [WAWK]

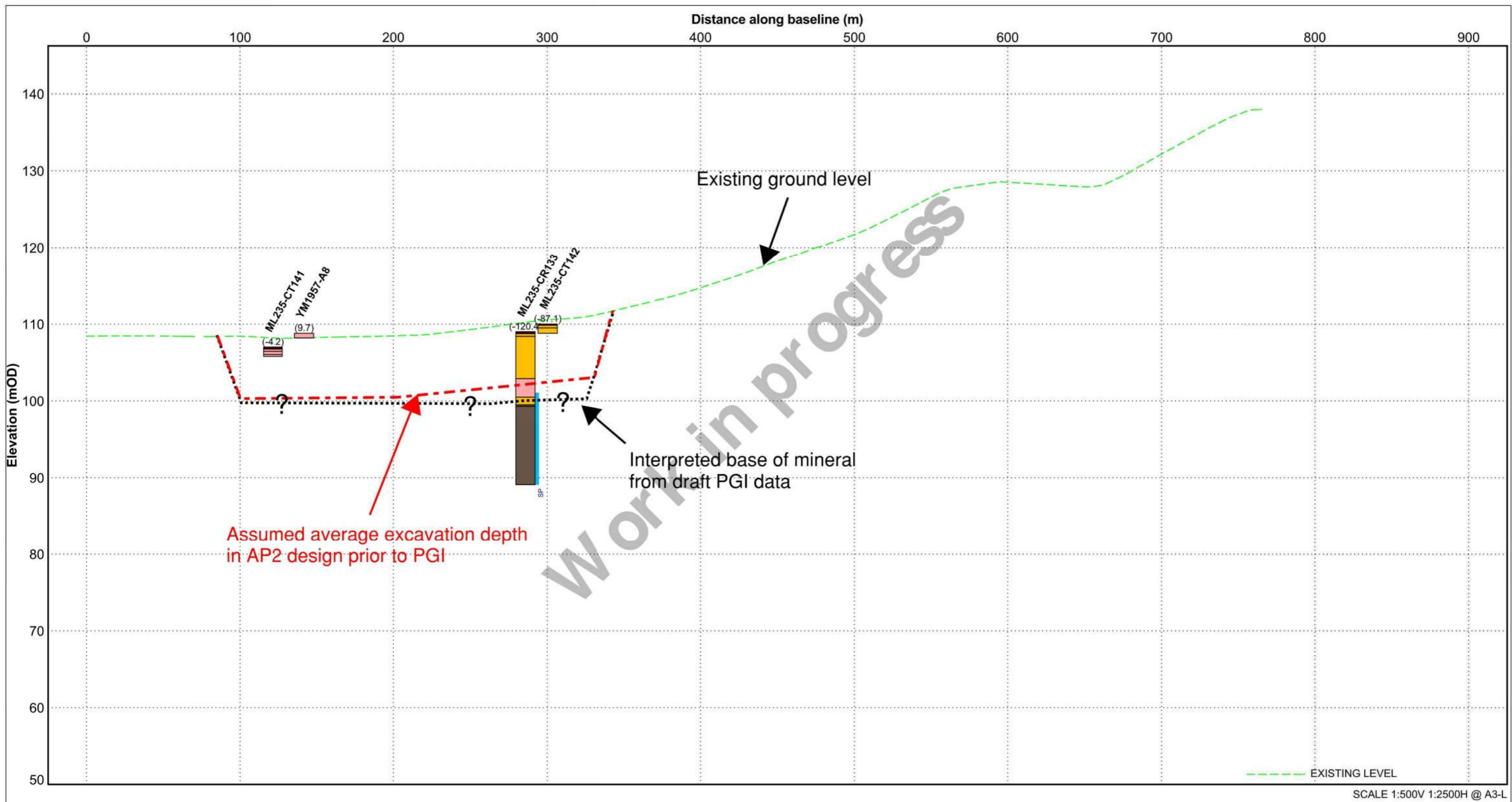


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Zone	Route Wide		Project/Contract		C861 Hybrid Bill Additional Provision 2 AP2	
Design Stage	Designs for Petition		Discipline/Function		Petitions	
Drawing Title	Geological Cross Section C-C'		Drawn	Checked	Approved	
			APL, JN	AP		
	Date	Scale	Size			
	24/01/2019	AS SHOWN	A1			
	Drawing No.	Rev.				
	2PT02-ARP-PT-DSK-000-000053	P01				
	Borrow Pit BP5 (235)					

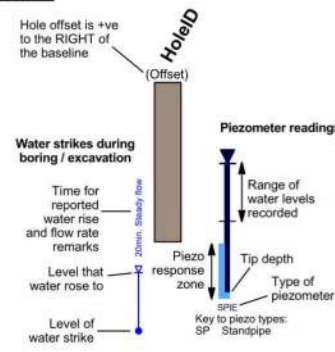
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 Drawing Title: Geological Cross Section C-C' (Petitions)
 Source data status: of holes
 Database check status: Full check (A) = 0%, Partial/selective check (B) = 0%, Minimum check (C) = 0%, Unchecked (U) = 17% of holes
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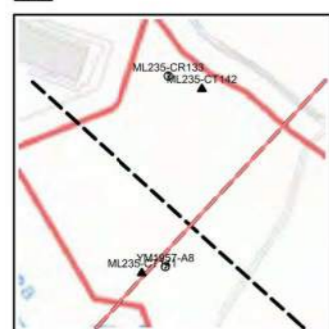
SCALE 1:500V 1:2500H @ A3-L

ARUP_gINT v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19

LEGEND



PLAN



COLOUR LEGEND

- Top Soil [TOP]
- Sand/Gravel [SG]
- Clay/Silt [CS]
- Carboniferous Warwickshire Group (solid geology) [WAWK]

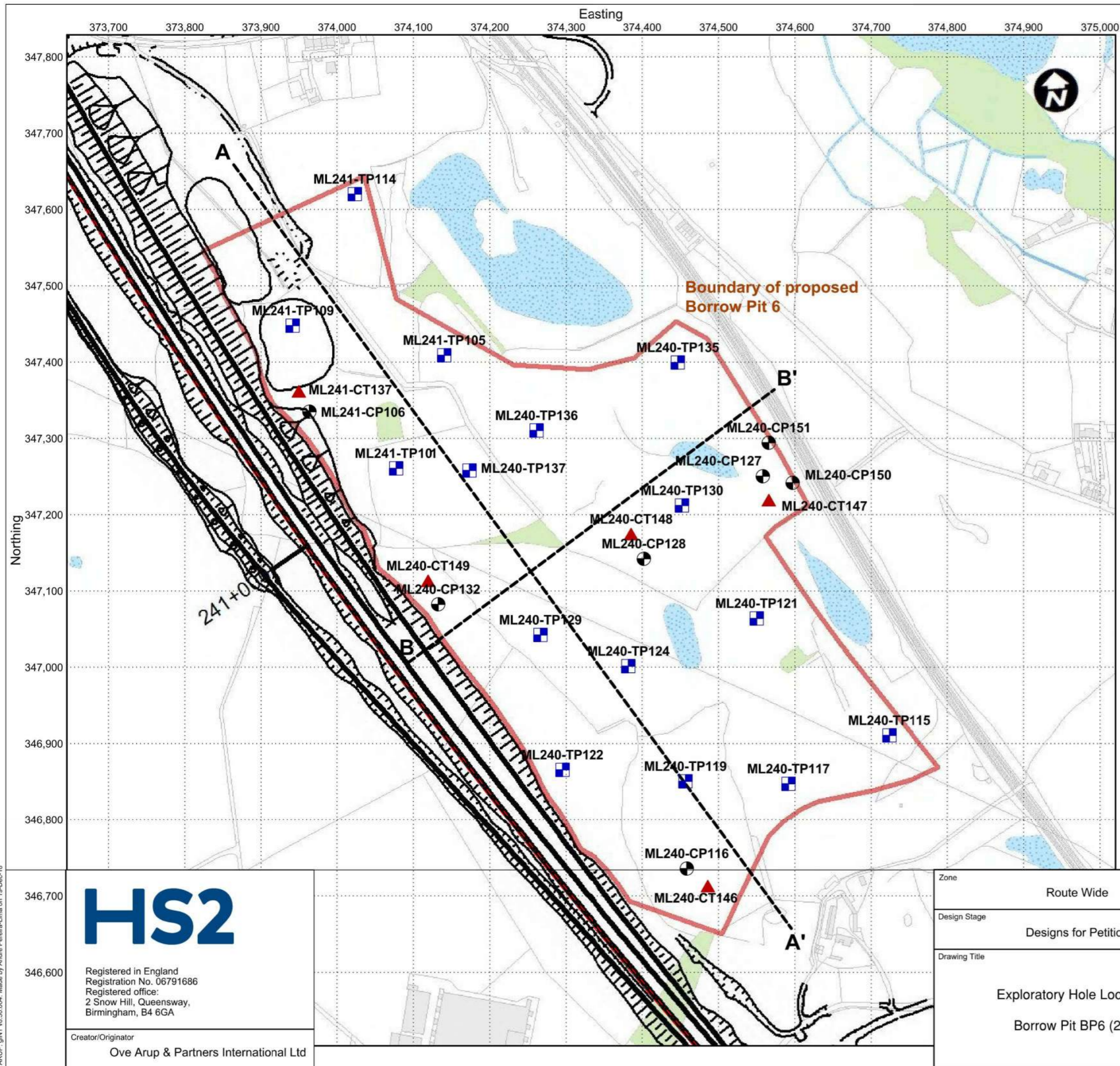


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Zone	Route Wide		Project/Contract C861 Hybrid Bill Additional Provision 2 AP2		
Design Stage	Designs for Petition		Discipline/Function Petitions		
Drawing Title	Geological Cross Section		Drawn	Checked	Approved
	D-D'		APL, JN	AP	
		Borrow Pit BP5 (235)	Date	Scale	Size
			24/01/2019	AS SHOWN	A1
			Drawing No.		Rev.
			2PT02-ARP-PT-DSK-000-000054		P01

Library: arup\projects\00236 - HS2 - Report 21.01 SECTION WITH WATER & SPT (A3)
 Drawing: 21.01 SECTION WITH WATER & SPT (A3) - Rev. 1.1 (SP - Work in progress)
 Source data status: of holes
 Database check status: Full check (A) - 0%
 Database check (C) - 0%
 Minimum check (C) - 0%
 Unchecked (U) - 0% of holes
 Filter: None



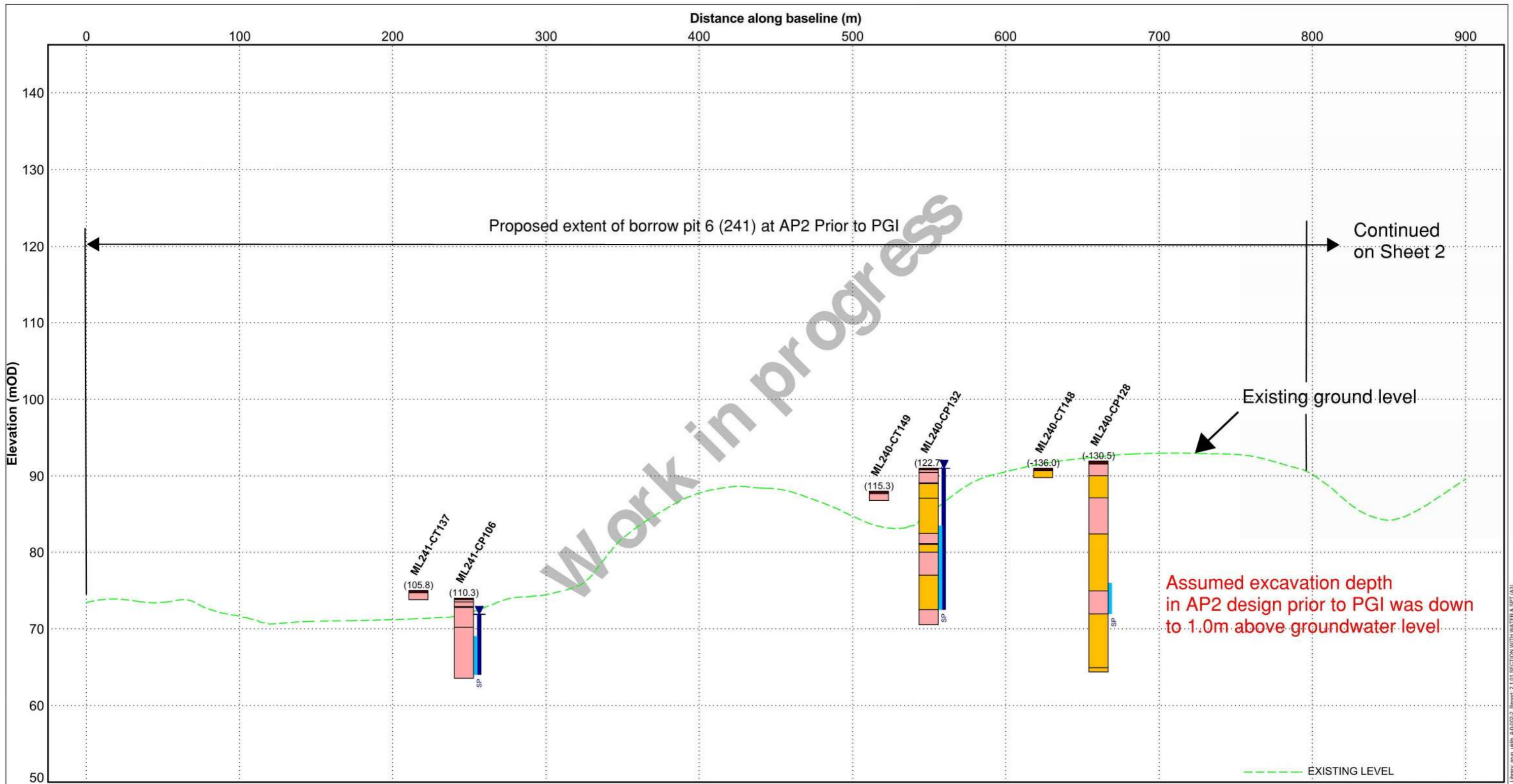
- Cable percussion borehole
- Trial pit
- ▲ Cone penetration test

HS2

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Creator/Originator
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Zone	Route Wide		Project/Contract	C861 Hybrid Bill Additional Provision 2 AP2	
Design Stage	Designs for Petition		Discipline/Function	Petitions	
Drawing Title	Drawn	Checked	Approved		
	APL, JN	AP			
	Date	Scale	Size		
	24/01/2019	AS SHOWN	A1		
	Exploratory Hole Locations Borrow Pit BP6 (241)		Drawing No.	Rev.	
			2PT02-ARP-PT-DSK-000-000055	P01	



SCALE 1:500V 1:2500H @ A3-L

Library: arup\GIS\Projects\2019\2401 SECTION WITH WATER & SPT (A3)
 Drawing: 2401-PT-DSK-000-000056-PT-1 (1 of 2) (SP - Work in Progress)
 Source data status: of holes
 Database check status: Full check (A) = 0% Partial/Selective check (B) = 0% Minimum check (C) = 0% Unchecked (U) = 0% of holes
 Date of last check: 18-Jan-19
 Filter: None

ARUP_gINT v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19

LEGEND

Hole offset is +ve to the RIGHT of the baseline

Water strikes during boring / excavation

Time for reported water rise and flow rate remarks

Level that water rose to

Level of water strike

20mm Standpipe

Piezometer readings

Range of water levels recorded

Tip depth

Type of piezometer

Key to piezo types: SP Standpipe

PLAN

COLOUR LEGEND

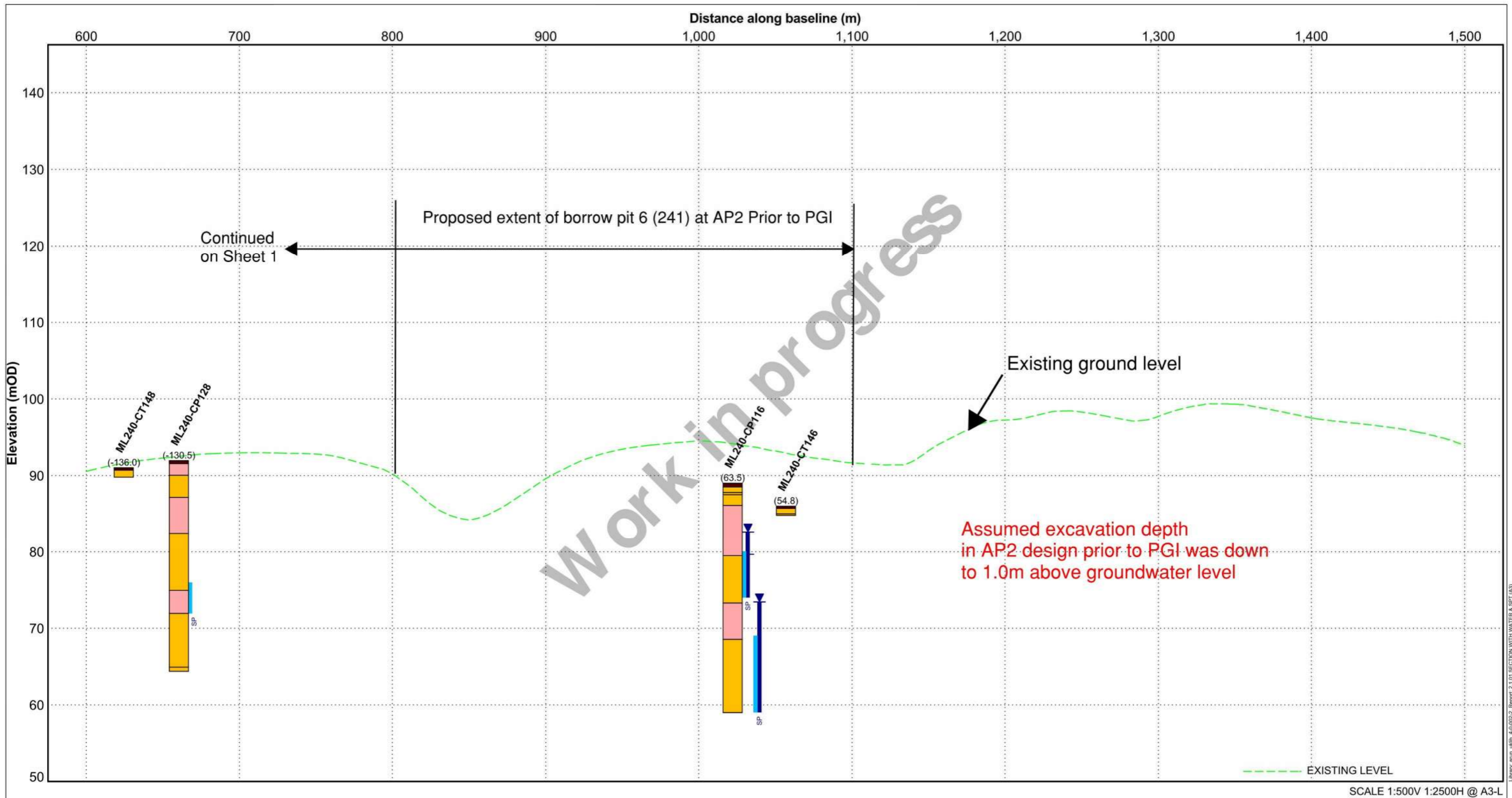
- Top Soil [TOP]
- Sand/Gravel [SG]
- Clay/Silt [CS]

HS2

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Registration No. 06791686
Registered office:
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Birmingham, B4 6GA

Creator/Originator
Ove Arup & Partners International Ltd

Zone	Route Wide	Project/Contract		
Design Stage	Designs for Petition	C861 Hybrid Bill Additional Provision 2 AP2		
Drawing Title	Geological Cross Section	Discipline/Function		
	A-A' (1 of 2)	Petitions		
	Borrow Pit BP6 (241)	Drawn	Checked	Approved
		APL, JN	AP	
		Date	Scale	Size
		24/01/2019	AS SHOWN	A1
		Drawing No.	Rev.	
		2PT02-ARP-PT-DSK-000-000056	P01	



Library and data sources: Report 21.01 SECTION WITH WATER & SPT (A3)
 Source: 21.01 SECTION WITH WATER & SPT (A3) - 21.01 (2019-10-14)
 Source data status: Full check (A) = 0%, Partial/Selective check (B) = 0%, Minimum check (C) = 0%, Unchecked (U) = 0% of holes
 Database check status: Full check (A) = 0%, Partial/Selective check (B) = 0%, Minimum check (C) = 0%, Unchecked (U) = 0% of holes
 Filter: None

ARUP_gINT v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19

LEGEND

Hole/Id (Offset)

Water strikes during boring / excavation

Time for reported water rise and flow rate remarks

Level that water rose to

Level of water strike

Piezometer readings

Range of water levels recorded

Tip depth

Type of piezometer

Key to piezo types: SP Standpipe

COLOUR LEGEND

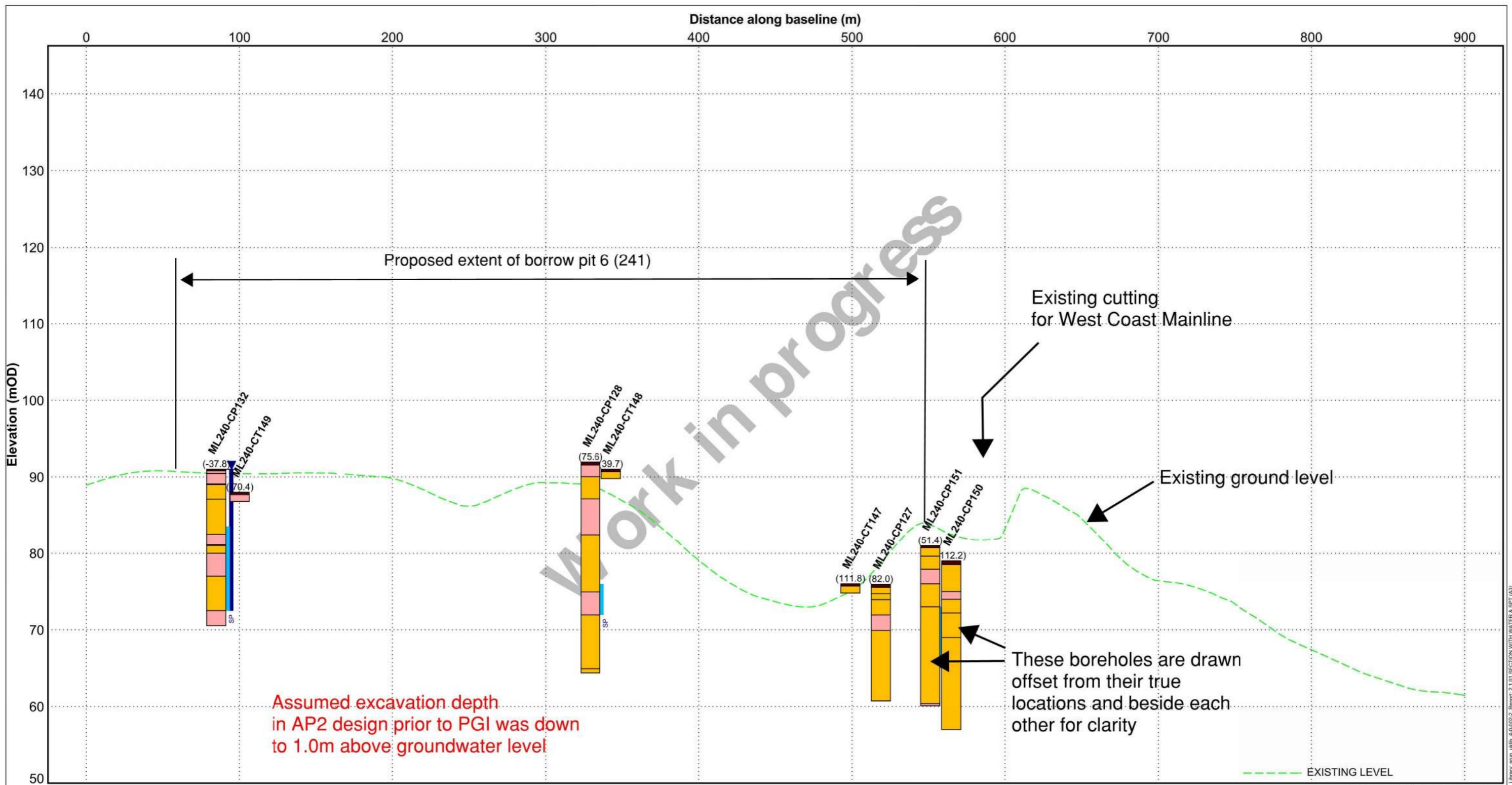
- Top Soil [TOP]
- Sand/Gravel [SG]
- Clay/Silt [CS]

PLAN

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 Registration No. 06791686
 Registered office:
 2 Snow Hill, Queensway,
 Birmingham, B4 6GA

Creator/Originator
 Ove Arup & Partners International Ltd

Zone	Route Wide	Project/Contract		
Design Stage	Designs for Petition	C861 Hybrid Bill Additional Provision 2 AP2		
Drawing Title	Geological Cross Section A-A' (2 of 2) Borrow Pit BP6 (241)	Discipline/Function		
		Petitions		
		Drawn	Checked	Approved
		APL, JN	AP	
		Date	Scale	Size
		24/01/2019	AS SHOWN	A1
		Drawing No.	Rev.	
		2PT02-ARP-PT-DSK-000-000057	P01	



SCALE 1:500V 1:2500H @ A3-L

Library: arup\uk\GIS\Projects\2019\2401 SECTION WITH WATER & SPT (A3)
 Drawing: 2401 SECTION WITH WATER & SPT (A3) - 1:500V 1:2500H @ A3-L
 Source data status: of holes
 Database check status: Full check (A) = 0%, Partial/Selective check (B) = 0%, Minimum check (C) = 0%, Unchecked (U) = 0% of holes
 Filter: None

ARUP_gINT v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19

LEGEND

Hole offset is +ve to the RIGHT of the baseline (Offset)

Water strikes during boring / excavation

Time for reported water rise and flow rate remarks

Level that water rose to

Level of water strike

20mm Standpipe

Piezometer readings

Range of water levels recorded

Tip depth

Type of piezometer

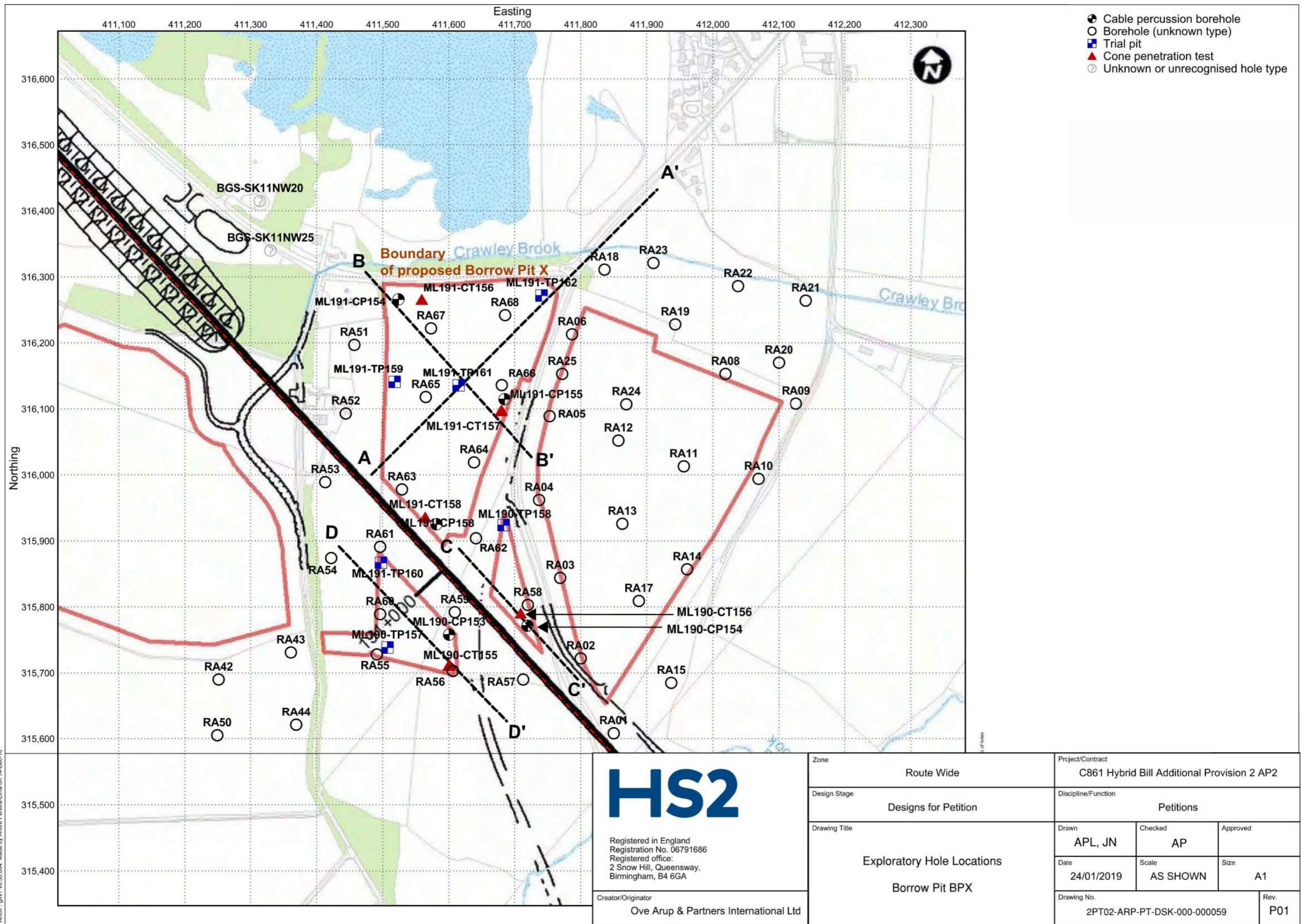
Key to piezo types: SP Standpipe

PLAN

COLOUR LEGEND

- Top Soil [TOP]
- Sand/Gravel [SG]
- Clay/Silt [CS]

<p>Registered in England Registration No. 06791686 Registered office: 2 Snow Hill, Queensway, Birmingham, B4 6GA</p> <p>Creator/Originator Ove Arup & Partners International Ltd</p>	Zone	Route Wide	Project/Contract C861 Hybrid Bill Additional Provision 2 AP2			
	Design Stage	Designs for Petition	Discipline/Function Petitions			
	Drawing Title	Geological Cross Section B-B' Borrow Pit BP6 (241)	Drawn APL, JN	Checked AP	Approved	
			Date 24/01/2019	Scale AS SHOWN	Size A1	
		Drawing No. 2PT02-ARP-PT-DSK-000-000058	Rev. P01			



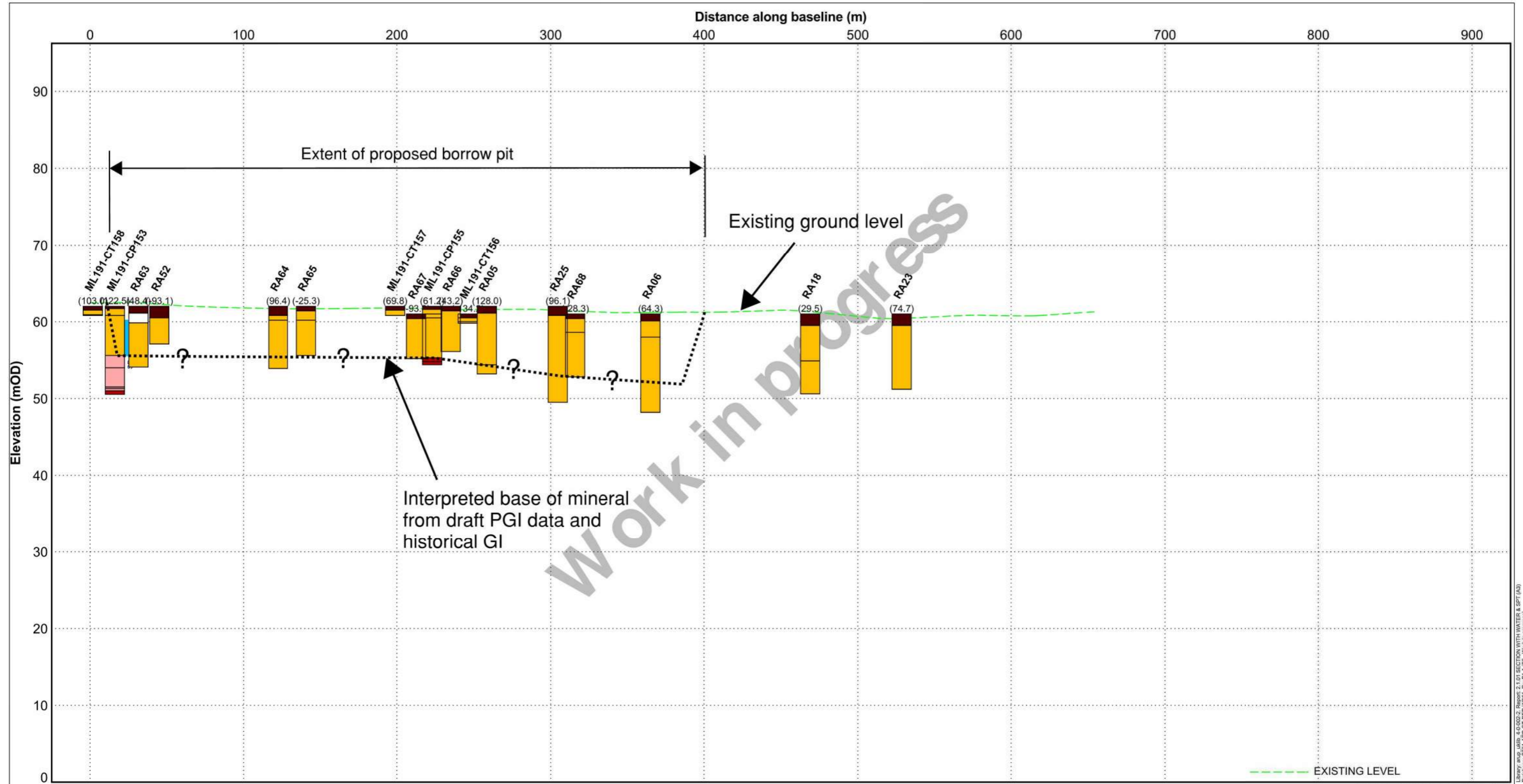
ARUP_gINT v8.30.004. Made by Andre Pereira-Lima on 14-Dec-18



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Creator/Originator
 Ove Arup & Partners International Ltd

Zone	Route Wide		Project/Contract		C861 Hybrid Bill Additional Provision 2 AP2			
Design Stage	Designs for Petition		Discipline/Function				Petitions	
Drawing Title	Exploratory Hole Locations Borrow Pit BPX		Drawn	Checked	Approved			
			APL, JN	AP				
			Date	Scale	Size			
		24/01/2019	AS SHOWN	A1				
Drawing No.			2PT02-ARP-PT-DSK-000-000059			Rev.	P01	



SCALE 1:500V 1:2500H @ A3-L

ARUP_gINT_v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19

LEGEND

Hole/ID (Offset)

Water strikes during boring / excavation

Time for reported water rise and flow rate remarks

Level that water rose to

Level of water strike

Piezometer readings

Range of water levels recorded

Tip depth

Type of piezometer

Key to piezo types: SP Standpipe

PLAN

COLOUR LEGEND

- Top Soil [TOP]
- Sand/Gravel [SG]
- Clay/Silt [CS]
- Mercia Mudstone Group (solid geology) [MMG]

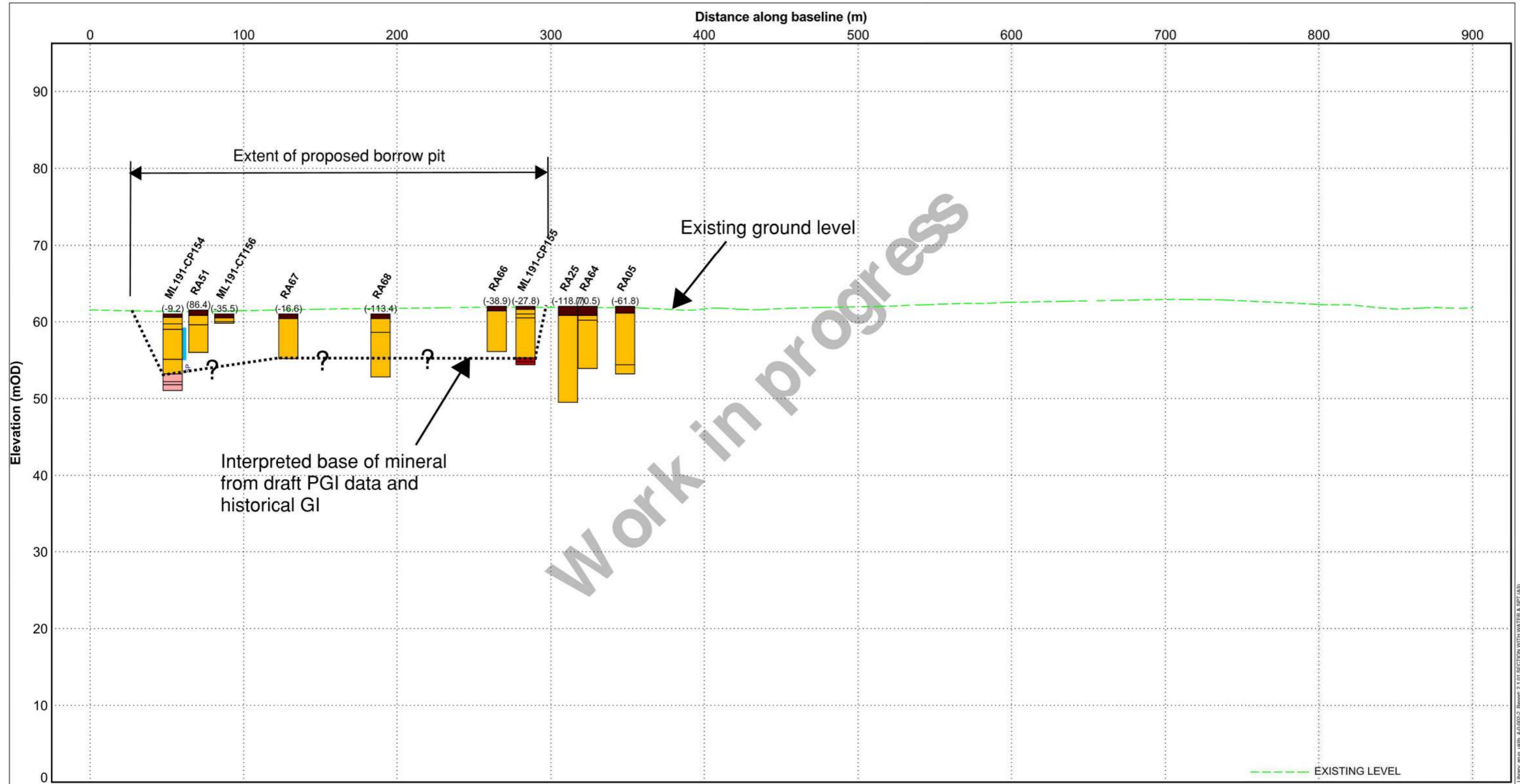
HS2

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Registered office:
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Birmingham, B4 6GA

Creator/Originator
Ove Arup & Partners International Ltd

Zone	Route Wide		Project/Contract		C861 Hybrid Bill Additional Provision 2 AP2	
Design Stage	Designs for Petition		Discipline/Function		Petitions	
Drawing Title	Geological Cross Section		Drawn	Checked	Approved	
	A-A'		APL, JN	AP	A1	
	Date	Scale	Size			
	24/01/2019	AS SHOWN	A1			
	Drawing No.	Rev.				
	2PT02-ARP-PT-DSK-000-000060	P01				

Library: arup/hs2/002/2/Report/2/01/SECTION WITH WATER & SPT (A3)
 Drawing: 2PT02-ARP-PT-DSK-000-000060 - Sheet 1.1 (2P - Water in progress)
 Source data status: of holes
 Database check status: Full check (A) = 0%, Partial/selective check (B) = 0%, Minimum check (C) = 0%, Unchecked (U) = 67% of holes
 Date of last update: 18-Jan-2019 11:43:57
 Output: Report (Data not currently available)
 Filter: None



SCALE 1:500V 1:2500H @ A3-L

ARUP_gINT v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19

LEGEND

HoleID (Offset)

Water strikes during boring / excavation

Time for reported water rise and flow rate remarks

Level that water rose to

Level of water strike

Piezometer readings

Range of water levels recorded

Tip depth

Type of piezometer

Key to piezo types: SP Standpipe

PLAN

COLOUR LEGEND

- Top Soil [TOP]
- Sand/Gravel [SG]
- Clay/Silt [CS]
- Mercia Mudstone Group (solid geology) [MMG]

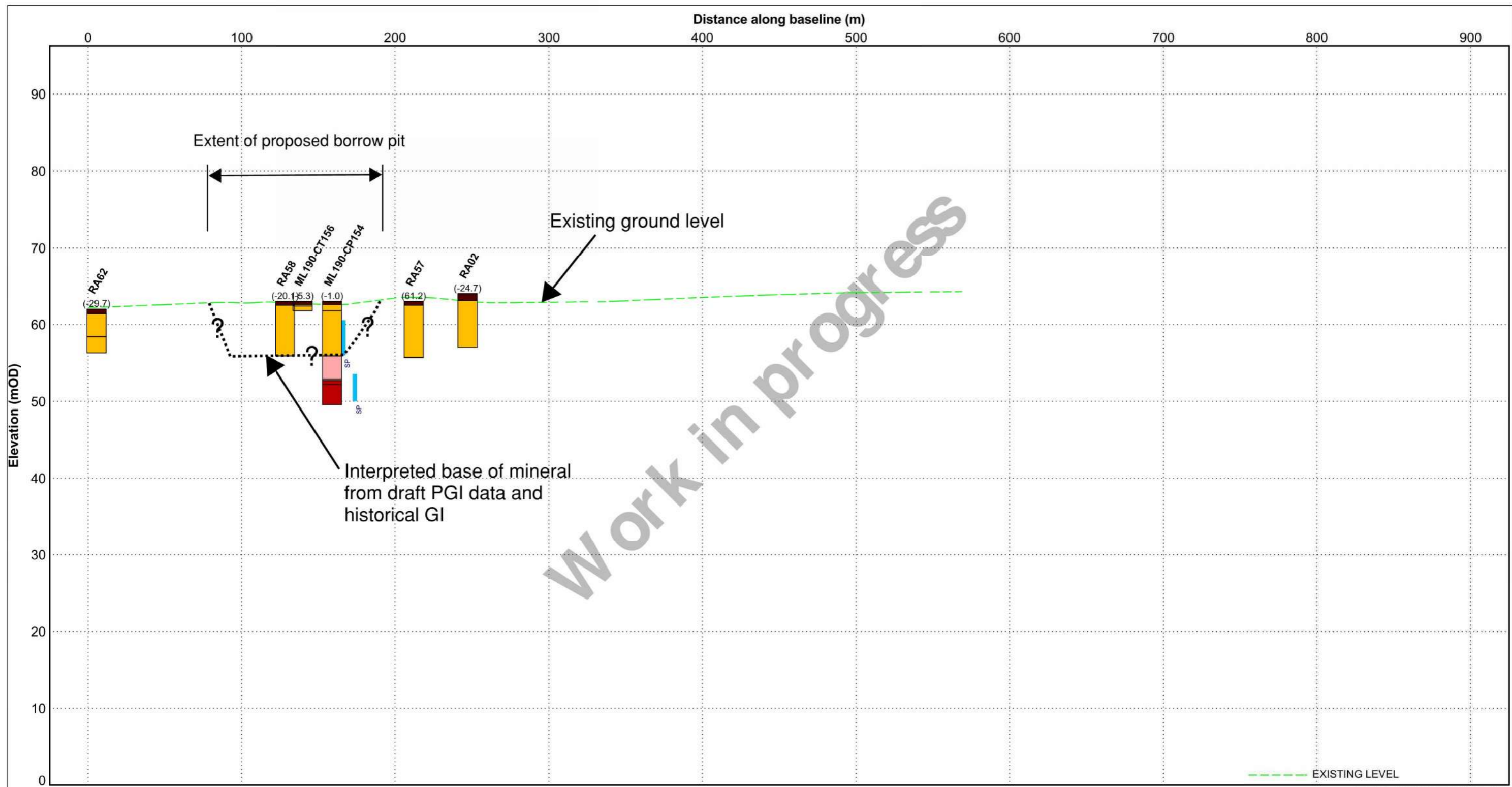
HS2

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Creator/Originator
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Zone	Route Wide		Project/Contract	C861 Hybrid Bill Additional Provision 2 AP2	
Design Stage	Designs for Petition		Discipline/Function	Petitions	
Drawing Title	Drawn	Checked	Approved		
	APL, JN	AP			
Geological Cross Section B-B' Borrow Pit BPX	Date	Scale	Size		
	24/01/2019	AS SHOWN	A1		
	Drawing No.	Rev.			
	2PT02-ARP-PT-DSK-000-000061	P01			

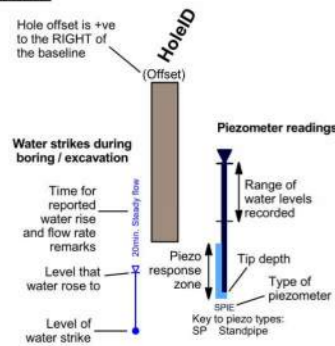
Library and data source: Report 21.01 SECTION WITH WATER & SPT (A3)
Source: Data from Ove Arup & Partners International (Ove Arup & Partners International)
Source data status: Full check (A) = 0%, Partial/Selective check (B) = 0%, Minimum check (C) = 0%, Unchecked (U) = 64% of holes
Database check status: Full check (A) = 0%, Partial/Selective check (B) = 0%, Minimum check (C) = 0%, Unchecked (U) = 64% of holes
Filter: None



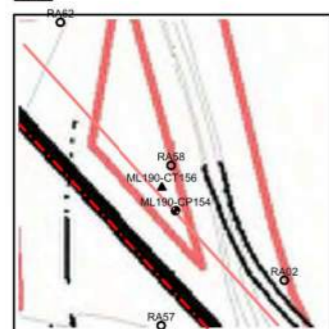
Library and data source: Report 21.01 SECTION WITH WATER & SPT (A3)
 Source data status: Full check (A) = 0%
 Database check status: Full check (A) = 0%
 Minimum check (C) = 0%
 Unchecked (U) = 57% of holes
 Filter: None

ARUP_gINT v8.30.004. Made by Andre Pereira-Lima on 18-Jan-19

LEGEND



PLAN



COLOUR LEGEND

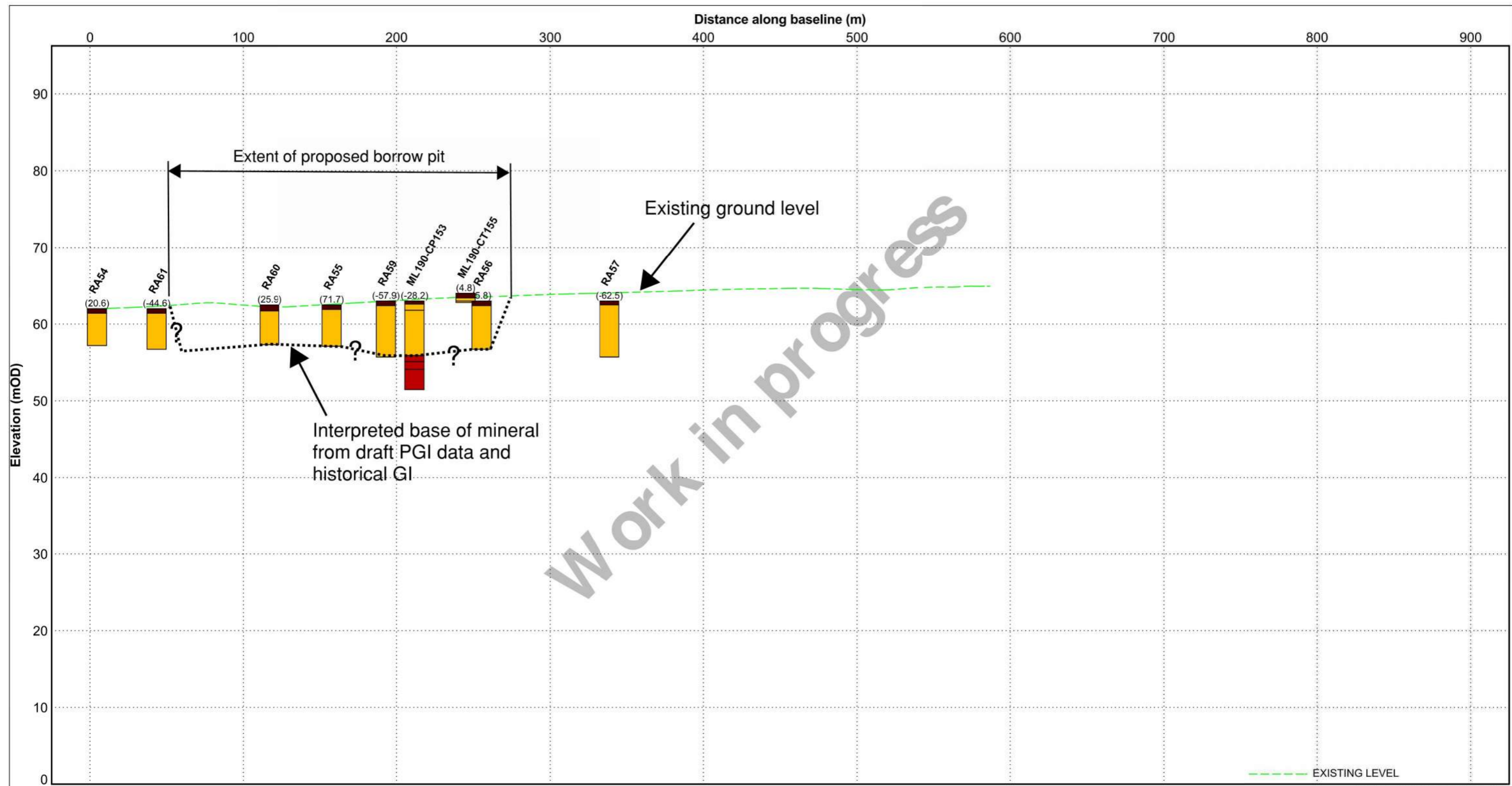
- Top Soil [TOP]
- Sand/Gravel [SG]
- Clay/Silt [CS]
- Mercia Mudstone Group (solid geology) [MMG]

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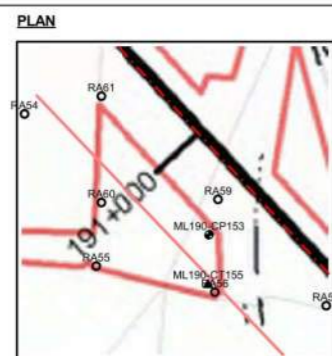
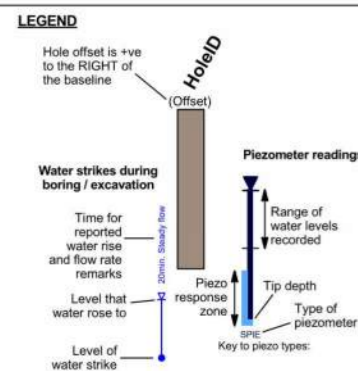
Creator/Originator
 Ove Arup & Partners International Ltd

Zone	Route Wide		Project/Contract C861 Hybrid Bill Additional Provision 2 AP2		
Design Stage	Designs for Petition		Discipline/Function Petitions		
Drawing Title	Geological Cross Section C-C'		Drawn	Checked	Approved
			APL, JN	AP	
	Date	Scale	Size		
	24/01/2019	AS SHOWN	A1		
	Drawing No. 2PT02-ARP-PT-DSK-000-000062			Rev. P01	



SCALE 1:500V 1:2500H @ A3-L

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Creator/Originator
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Zone	Route Wide		Project/Contract		C861 Hybrid Bill Additional Provision 2 AP2			
Design Stage	Designs for Petition		Discipline/Function				Petitions	
Drawing Title	Geological Cross Section D-D'		Drawn	Checked	Approved			
			APL, JN	AP				
	Date	Scale	Size					
	24/01/2019	AS SHOWN	A1					
	Drawing No.	Rev.						
	2PT02-ARP-PT-DSK-000-000063	P01						

Library: arup\GIS\Projects\2019\2019 SECTION WITH WATER & SPT (A3)
Drawing: 2019-01-24 10:00:00 - 2019-01-24 10:00:00
Source data status: Full check (A) = 0%
Database check status: Full check (A) = 0%
Filter: None