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Leitrim County Council

SLNCR Greenway

SLNCR Greenway GI Specification (RoI)

Reference: ARP-ERW-P3-SP-001

Issue 01 | 7 September 2026

Job number 284939-25

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Appendices

Short Description of Investigation

The Ground Investigation (GI) Works comprise of intrusive investigations to obtain geological, geotechnical, geo-environmental and hydrogeological information to support the design and development of the Sligo Leitrim Northern Counties (SLNCR) Greenway within Counties Sligo, Leitrim and Cavan. The Northern Ireland section of the scheme is excluded from this commission and will be procured separately.

The GI Works will be undertaken along the proposed Greenway corridor and at locations associated with proposed earthworks and structures. The outline scope of works comprises a combined geotechnical and geo-environmental intrusive investigation, incorporating trial pits, windowless sampling boreholes, cable percussion boreholes with rotary core follow-on, and a range of in situ probing and penetration testing (DCP, DPSH, CPT and SPT). These are supplemented by geophysical survey transects, peat probing, and the installation and monitoring of groundwater standpipes, together with associated geotechnical and geo-environmental sampling and laboratory testing.

The purpose of the GI is to obtain sufficient ground information on the geological, geotechnical, hydrogeological and geo-environmental conditions along the proposed route to inform the design of the final route, earthworks, pavements, drainage systems, structures and associated infrastructure. It will also identify any geotechnical, hydrogeological or geo-environmental constraints that may influence the design and construction of the project.

While future phases of ground investigation are not currently planned, in the event that gaps in the available information or unforeseen conditions are encountered on site then it may be necessary to carry out further phases of GI at a later date to supplement the available information and reduce construction risk. The currently proposed GI works are therefore considered to be Phase 1.

Specification

The Specification shall be Specification and Related Documents for Ground Investigation in Ireland, 2nd Edition, published by Engineers Ireland (2016) (EI SGI, 2016 including Errata Sheet Revision No.1, January 2019), with information, amendments and additions as described in the Schedules.

Schedule 1. Information and site-specific requirements

Schedule 2. Exploratory holes

Schedule 3. Investigation Supervisor's facilities

Schedule 4. Specification amendments

Schedule 5. Specification Additions.

Schedules

Schedule 1. Information and site-specific requirements

S1.1 Name of Contract

The Contract is to be called 'SLNCR Greenway Ground Investigation – Sligo, Leitrim & Cavan'

The Client's name and address are Leitrim County Council (LCC), Summerhaven House, Summerhill, Ck-on-Shannon, Co Leitrim N41 HW92

S1.2 Investigation Supervisor

The Investigation Supervisor is Cameron Kelly at address:

Arup, Bedford House, 3rd Floor, 16-22 Bedford Street, Belfast BT2 7FD.

Tel: +447501459041

Email: Cameron.Kelly@arup.com

Access to the site should be arranged through the landowner / occupier via the respective local authorities Project Liaison Officer (PLO). There is a dedicated PLO for County Sligo and a dedicated PLO for Counties Leitrim and Cavan.

S1.3 Description of site

The site comprises a linear corridor extending approximately 58 km between Carraroe, County Sligo and Blacklion, County Cavan, generally following the route of the former Sligo, Leitrim and Northern Counties Railway (SLNCR). The Corridor passes through/adjacent to the settlements of Ballysadare, Collooney, Ballintogher, Dromahair, Manorhamilton and Glenfarne.

The topography is varied along the route and comprises generally flat to gently undulating terrain associated with the former railway corridor, interspersed with embankments, cuttings, river valleys and floodplains. There are some locations where the Corridor deviates away from the former railway corridor due to various constraints and/or attractions.

The historic SLNCR did not remain in state ownership and much of the route has subsequently been incorporated into adjacent agricultural holdings, forestry, private property and other land uses. Portions of the former railway infrastructure remain in place, including embankments, cuttings and structures.

Access to the Site will be obtained at multiple locations along the linear route. The Contractor shall use only those access points and routes agreed with the relevant landowners or occupiers through the respective Project Liaison Office (PLO) and approved by the Investigation Supervisor.

The Contractor shall provide office and/or welfare facilities.

S1.4 Main works proposed and purpose of this contract

The proposed development comprises the construction of the SLNCR Greenway, a traffic free, shared walking and cycling route. The Greenway is being developed as an active travel corridor for pedestrians, cyclists and other non-motorised users and will utilise a combination of the former SLNCR alignment, existing roads, existing trails and agricultural lands.

The proposed land use is recreational and sustainable transport infrastructure together with associated ancillary infrastructure.

The proposed works are expected to comprise, but are not limited to:

- Construction of a traffic-free shared-use path for pedestrians, cyclists and other non-motorised users.
- Construction of a bound pavement structure comprising asphalt surfacing and associated pavement layers over new or improved formation.
- Upgrading and widening of existing paths and road corridors where required.

- Realigning of small sections of road to facilitate the greenway alignment.
- Earthworks including excavation, filling, regrading of existing ground, formation of cuttings and embankments, and stabilisation of existing railway earthworks. Note: the design has sought to maximise use of the existing SLNCR railway formation and follow existing ground levels in order to minimise earthworks, however, there are locations where earthworks will be required to achieve the required geometry and accessibility standards.
- Construction and improvement of drainage infrastructure, including culverts and attenuation measures.
- Construction, refurbishment or replacement of bridges, culverts, and retaining structures.
- Construction of new bridges, culverts, retaining structures, and/or boardwalks.
- Construction of road crossings, junction improvements and ancillary highway works.
- Provision of fencing, gates, signage, lighting (where appropriate), landscaping and environmental mitigation measures.

The purpose of the GI is to obtain sufficient ground information on the geological, geotechnical, hydrogeological and geo-environmental conditions along the proposed route to inform the environmental evaluation and design of the final route, earthworks, pavements, drainage systems, structures and associated infrastructure. It will also identify any geotechnical, hydrogeological or geo-environmental constraints that may influence the design and construction of the project.

The ground investigation that is the subject of this specification is the Phase 1 intrusive combined geo-environmental investigation of the site in the Republic of Ireland.

S1.5 Scope of investigation

The scope of the ground investigation is as follows:

- A pre-investigation walkover with the Ground Investigation Contractor to confirm positions of proposed exploratory holes and logistical considerations;
- 173No. Machine excavated trial pits to depth of 3m bgl (metres below ground level) or refusal, of which 131No. shall include handheld dynamic cone penetrometer tests (DCP) to a target depth of 3m bgl (metres below ground level) or refusal, adjacent to selected trial pit locations (See Schedule 2);
- 50No. Windowless sampling boreholes to a target depth of 8m bgl or refusal;
- 50No. Dynamic probing (super heavy) (DPSH) tests one adjacent to each windowless sampling borehole, to a target depth of 8 m bgl or refusal;
- 44No. Cone penetration tests (CPT) to a target depth of 20m bgl or rockhead/refusal to investigate the presence, extent and characteristics of expected peat deposits;
- 10No. Cable percussive boreholes to a nominal depth of 10 m bgl.
- 42No. Cable percussion boreholes to rockhead or refusal, with subsequent rotary core follow-on to a maximum depth of 30 m bgl, positioned adjacent to proposed structure abutments (structures with proposed spans greater than 5 m only);
- 26 No. Cable percussion boreholes to rockhead or refusal, with subsequent rotary core follow-on to a maximum depth of 15 m bgl, targeting areas of low resistivity within areas of potentially Karstified bedrock;
- 1No. Cable percussion boreholes to rockhead or refusal, with subsequent rotary core follow-on to a maximum depth of 30 m bgl, positioned adjacent to proposed retaining wall;
- Standard penetration testing within selected cable percussive and windowless sampling boreholes (See Schedule 2);

- Geophysical survey transects - total potential extent approximately 19km however allowance to be made for 25% of this = 4.75km. Geophysical surveys were specified to improve understanding of subsurface variability, bedrock levels, potential karst features, and engineering ground properties. Survey method and schedule to be confirmed in consultation with the specialist subcontractor;
- Peat probing to confirm the extent and depth of peat deposits (to assist in targeting subsequent CPTs);
- Installation of groundwater monitoring standpipes within selected boreholes (See Schedule 2);
- 3No. rounds of groundwater monitoring at fortnightly intervals from installed standpipes;
- Geotechnical sampling and testing including high quality UT100 samples and rotary core sub samples to facilitate laboratory testing;
- Geo-environmental sampling and testing to confirm the nature and extent of contamination in the soil;
- Screening of all geo-environmental soil samples with a PID monitor;
- Digital data in ags format including all laboratory testing results; and
- Factual report.

Refer to Schedule 2 and the Drawings for further details of scope of work to be undertaken at the site.

S1.6 Geology and ground conditions

A desktop review of the ground conditions is provided in the SLNCR Greenway Feasibility Report Reference: ARP-PDV-P1-R-003, Issue 1, 26 June 2023 (Section 4.3-4.6).

The following assessment of the geology of the site and ground conditions has been inferred from available information. No assurance is given to its accuracy.

Table 1 Ground Conditions

Stratum	Description	Thickness of Stratum (m)
Made Ground	Localised made ground associated with the historic SLNCR railway corridor, former station areas, embankments, cuttings and bridge approaches. Presence and extent unknown pending GI.	Unknown/varies
Alluvium	Alluvium is a general term for clay, silt, sand and gravel. It is the unconsolidated detrital material deposited by a river, stream or other body of running water as a sorted or semi-sorted sediment in the bed of the stream or on its floodplain or delta, or as a cone or fan at the base of a mountain slope.	Unknown/varies
Lacustrine Sediments	Sediments deposited in lakes as deltaic, lake-bottom and shoreline material. Typically, fine-grained (clay and silt), commonly laminated, and may include thin bands of organic material or sand; coarser bedload and suspended fines are introduced by inflowing streams, with evaporites locally significant under arid conditions.	Unknown/varies
Peat	A partially decomposed, semi-carbonised accumulation of vegetation formed under waterlogged, anaerobic (oxygen-poor) conditions, typically in bogs or swamps.	Unknown/varies
Glacial Till	Unsorted, unstratified glacial deposit laid down directly beneath a glacier without later reworking by meltwater. A heterogeneous mix of clay, sand, gravel and boulders of widely varying size and shape (a diamicton); also known as boulder clay.	Unknown/varies
Limestone	A carbonate sedimentary rock in which the dominant mineral is calcium carbonate. It forms mainly in warm, shallow, clear marine environments (typically <100 m deep) where carbonate production outpaces clastic input.	Unknown/varies

Stratum	Description	Thickness of Stratum (m)
	Karstified Limestone: Limestone that has been chemically dissolved by slightly acidic rainwater/groundwater, producing solution features such as widened joints and bedding planes, solution pipes, dissolution voids/conduits, caves and sinkholes. Void networks can allow rapid groundwater and pollutant movement.	
Shale	A fine-grained, fissile sedimentary rock composed predominantly (>50%) of mud-grade particles finer than ~0.032 mm; tends to split readily along bedding.	Unknown/varies
Sandstone	A clastic sedimentary rock composed dominantly of sand-sized grains, ~0.0625–2 mm, defined on grain/crystal size. Framework grains are mostly quartz and feldspar (with lithic fragments, mica and accessory minerals), bound by cement (silica, calcite or iron oxides) and/or a finer matrix.	Unknown/varies

The following assessment of the groundwater at the site has been inferred from available information. No assurance is given to its accuracy.

The bedrock beneath the corridor varies considerably along its length and falls into three broad Geological Survey Ireland (GSI) aquifer classifications. These are Regionally Important Aquifers (Karstified conduit, Rkc), Locally Important Aquifers (Lm and Ll) and Poor Aquifers (Pl). Their distribution along the route is set out below:

- Section 1 (Carraroe to Collooney). Predominantly underlain by the Slishwood Division Psammitic Paragneiss and Ballygawley Tonalitic Gneiss, both classified as Poor Aquifers (Pl) which are generally unproductive except for local zones. Localised areas are underlain by the Dartry Limestone, Twigspark, Abbeytown Limestone and Moy Sandstone formations.
- Section 2 (Collooney to Dromahair). Predominantly underlain by the Oakport Limestone Formation, a Regionally Important Aquifer (Karstified conduit, Rkc), along with Dargan Limestone (Rkc) and Lisgorman Shale (Ll).
- Section 3 (Dromahair to Manorhamilton). Predominantly underlain by the Bundoran Shale Formation, a Locally Important Aquifer (Ll), with areas of Oakport Limestone, Lisgorman Shale, Benbulben Shale and Mullaghmore Sandstone.
- Section 4 (Manorhamilton to Blacklion and Belcoo). Predominantly underlain by the Dartry Limestone and Mudbank Limestone, both Regionally Important Aquifers (Karstified conduit, Rkc), and the Carraun Shale Formation, a Poor Aquifer (Pl). Other formations include Benbulben Shale, Glencar Limestone, Bellavally Shale and Dergvone Shale.

No site-specific groundwater level monitoring has been undertaken to date and groundwater levels are therefore unproven. Groundwater is expected to be encountered within the superficial deposits (peat, alluvium and glacial till) and is anticipated to be shallow where the route lies within river floodplains and low-lying ground. Groundwater across the corridor is classified as 'Good Status', with groundwater vulnerability ranging from Low to Extreme, including areas mapped as 'Rock at or near Surface or Karst'. The more vulnerable (High to Extreme) conditions are associated with the karstified limestone and shallow rock areas. Karst features noted adjacent to the route include the Poulconaperry spring (Section 1), a cave west of Ballintogher (Section 2), two springs, a cave and a swallow hole adjacent to the N16 with a potential hydrological connection to Lough Macnean Upper (Section 4), and a spring south of Gardrum Road (Section 5). Historic groundwater flooding has been recorded near Dromahair and Manorhamilton (GSI ID 3442, Section 3).

Groundwater levels are to be established and monitored as part of this ground investigation.

S1.7 Schedule of drawing(s) and documents

Table 2 Summary of contract drawings

Drawing Number	Drawing Title
ARP-ERW-P3-DR-101 to ARP-ERW-P3-DR-135	Ground Investigation Location Plan
MKO-ENV-P3-DR-001 to MKO-ENV-P3-DR-035	Ecological Constraints
MKO-ENV-P3-DR-101 to MKO-ENV-P3-DR-135	Archaeological Constraints

S1.8 General requirements (Specification Section 3) - particular restrictions/relaxations

The exact sequence of ground investigation is to be organised with the Client prior to the commencement of works on site. Once an exploratory hole has commenced, it shall be completed continuously and without undue delay.

The Contractor shall ensure that methods of boring, drilling, sampling and excavation are suitable for the anticipated ground conditions in order to achieve the scheduled depths and the objectives of the investigation. If methods other than the ones specified in Schedule 2 are necessary to achieve the objectives of the investigation, the Contractor shall notify the Investigation Supervisor and seek approval with regards to any proposed changes to methodology.

Unhindered access is not available to all exploratory hole positions.

The Contractor shall visit the site to satisfy themselves as to the access to each of the proposed locations. By submitting a tender return, it is implied that the Contractor has carried out a site visit and satisfied themselves that all proposed exploratory holes are accessible. If the Contractor has any reservations regarding accessibility their tender return shall list their concerns.

A programme for the fieldwork, monitoring / sampling, laboratory testing and reporting shall be submitted to the Client for approval a minimum of 1 week prior to the commencement of works on site.

Portions of the GI are proposed within, or in close proximity to, Special Areas of Conservation (SACs) and/or located within floodplains. The Contractor shall allow for reasonable flexibility within the programme and sequencing of works to accommodate statutory approvals, environmental/seasonal constraints, and potential flood events. At the time of submission, Arup had not yet received MKO's ecological constraints drawings (see Schedule S1.7). These have been formally requested from MKO and will be issued to the Contractor when available.

Audited Land Drilling Operatives

All drilling operatives (Lead Drillers and Drillers) employed on the Contract shall be suitably qualified and experienced for the drilling techniques being undertaken and shall hold valid and current competency certification applicable to the work and specific drilling operation on which they are engaged. Evidence of competency and relevant training records shall be submitted to the Investigation Supervisor prior to commencement of the Works.

The aspects of this investigation related to contaminated land investigation are specified in Schedule 5, with details provided in the various Schedules below.

Method Statements

Method Statements for all elements of the works shall be submitted to the Investigation Supervisor for approval a minimum of 1 week prior to the commencement of works on site.

Standing time

The rates or sums in the Bill of Quantities and Schedule of Rates shall include for the standing time of equipment. The Investigation Supervisor shall be notified immediately that standing time starts to be incurred. The duration of standing time shall be agreed with the Investigation Supervisor.

Site Specific Health and Safety Plan

A Site-Specific Health and Safety Plan including risk assessments for all aspects of the works shall be submitted to the Investigation Supervisor for review and comment a minimum of 1 week prior to the commencement of works on site.

S1.8.1 Quality management system (QMS) (Clause 3.3)

The Contractor shall work to a quality management system established in accordance with IS EN ISO 9001, IS EN ISO 14001 and IS ISO 45001 (Clause 3.3). Details shall be provided to the Investigation Supervisor prior to the start of field work.

The Contractor shall provide details of their QMS to the Investigation Supervisor prior to the commencement of work on site together with a project specific Quality Plan.

S1.8.2 Professional attendance (Clause 3.5.2)

Full-time professional attendance on Site is required. The Contractor is responsible for providing their own supervision to ensure the requirements of the Specification are met (Clause 3.5.2).

CVs for all site staff the Contractor plans to use shall be provided to the Investigation Supervisor in advance of the site works.

The Contract's Manager shall be available to attend weekly meetings.

For the investigation of contaminated land, the Contractor shall provide an environmental scientist, geo-environmental engineer or geochemist with a minimum of five years' relevant experience.

For investigation on potentially asbestos-contaminated land, or in the event that asbestos is identified during the investigation, the Contractor shall ensure all staff on site at a minimum have received relevant asbestos awareness training. The guidelines and practices contained within the HSA document "Asbestos- containing Materials (ACMs) in Workplaces - Practical Guidelines on ACM Management and Abatement", 2013, shall be consulted.

Where asbestos is or is likely to be present on site, the Contractor shall consult an appropriately competent, qualified and accredited specialist organisation for advice on asbestos.

The Contractor and the specialist shall determine the nature of the work and, where necessary, shall provide sufficiently trained and competent staff during the site works as required by the relevant asbestos legislation and applicable code(s) of practice. If the investigation (or any part of the investigation) is licensable work, the Contractor shall ensure: that (i) the work is notified to the appropriate enforcing authority; and (ii) the relevant work is undertaken by a suitably qualified Asbestos Specialist.

The Contractor shall nominate a Project Supervisor for construction in accordance with the Safety, Health & Welfare at Work (Construction) Regulations 2013 and shall prepare a Safety & Health Plan for the project.

S1.8.3 Provision of ground practitioners and other personnel (Clauses 3.6.1 and 3.6.2)

The services of a specialist (Clause 3.6) are required for:

Ecologist: The Contractor shall appoint a suitably qualified ecologist to liaise with the Project Ecologist. Minimum qualification: degree in ecology or related discipline with a minimum of 5 years relevant field experience. In ecologically sensitive areas the Contractor's ecologist shall visit each site where ecological constraints have been identified and liaise with the Project ecologist in advance to agree access arrangements, final exploration locations and to ensure the works are undertaken in accordance with environmental constraints and agreed mitigation measures. The Contractor shall notify the Investigation Supervisor of such requirements in advance and keep the Investigation Supervisor informed of all communications, constraints, instructions or mitigation measures issued by the ecologist.

Archaeologist: The Contractor shall appoint a suitably qualified archaeologist to liaise with the Project Archaeologist. Minimum qualification: degree in ecology or related discipline with a minimum of 5 years

relevant field experience. In archeologically constraint areas the Contractor shall liaise with the Project archaeologist in advance to agree access arrangements, final exploration locations and to ensure the works are undertaken in accordance with environmental constraints and agreed mitigation measures. The Contractor shall notify the Investigation Supervisor of such requirements in advance and keep the Investigation Supervisor informed of all communications, constraints, instructions or mitigation measures issued by the archaeologist.

S1.8.4 Hazardous ground, land affected by contamination and notifiable and invasive weeds (Clauses 3.7.1 and 3.22)

The former railway corridor comprises approximately 40 km of historic railway ballast, embankment and associated made ground. Railway infrastructure is recognised as having the potential to contain contaminants associated with historical operational activities, including hydrocarbons, metals, PAHs and asbestos-containing materials within ballast and fill materials.

Outside the railway corridor, approximately 35 km of the route traverses a combination of farmland, settlements, paths and other areas with limited historical industrial activity. The scheme includes a number of structures where localised earthworks, construction activities and potential anthropogenic ground disturbances are anticipated.

Therefore the *Safe Intrusive Activities on Land Potentially Impacted by Contamination BDA (2024)* designation of the potential contaminated area is YELLOW.

With regards to asbestos in soil (AIS) or encountering asbestos containing material (ACM), the Contractor shall comply with the guidance and methods described in *Assessment and control of asbestos risk in soil, Part 1: Protection of personnel working on ground investigations and Part 2: Protection of personnel working in geotechnical and geoenvironmental laboratories (AGS, 2021*). The Contractor shall complete the required safety risk assessments set out in the guidance. The Contractor shall comply with CAR 2012 and CARSOIL™.

On potentially contaminated land, the Contractor shall comply with the safety requirements of *Protection of workers and the general public during the development of contaminated land* (HSE, 1991) and follow the safety guidance in Annex C of BS 10175 *Investigation of potentially contaminated sites - Code of practice* and in *Safe intrusive activities on land potentially impacted by contamination* (BDA, 2024). In addition, the following minimum requirements shall apply in addition to any other requirements stipulated in Schedule 1:

- Site personnel shall wear protective overalls, safety hat, safety boots, gloves and/or barrier cream and eye protection where appropriate. Any protective clothing and footwear shall be removed at the hygiene facilities before leaving the potentially contaminated land if necessary.
- Dust masks of suitable efficiency and artificial respiratory equipment shall be available on site for the duration of the site operations on potentially contaminated land should a particular risk of encountering asbestos be identified.
- Instructions for use of safety equipment shall be prominently displayed and at least one member of the Contractor's staff who is conversant with the use of the safety equipment shall be on site at all times during working hours.
- An adequate range of appropriate first aid facilities shall be provided.
- Adequate washing facilities shall be provided at the hygiene facilities.
- Activities that involve hand-mouth contact, such as eating and smoking, shall not be permitted on potentially contaminated land.
- No naked flames or other ignition sources shall be allowed on potentially contaminated land.
- Only suitably trained personnel shall be permitted to work in confined spaces or in excavations. The HSA document "Code of Practice for Working in Confined Spaces", May 2017, shall be adhered to strictly.

- The Contractor shall make adequate provision of both staff and equipment to undertake rescue should an incident occur. The Contractor shall inform the local hospital of the type of work in progress and the potential type of injuries.

The above-stated requirements are not exclusive and do not remove from the Contractor any obligations to conform to statute.

A summary of potentially hazardous ground and land affected by contamination and non-native invasive plant species at the site is provided below:

- Potentially hazardous ground may be associated with historical railway infrastructure, including embankments, cuttings, bridge abutments, retaining structures and areas of made ground of unknown composition and condition.
- No records of contaminated land were identified from the desk study; however, localised contamination associated with former railway operations, historic industrial activities, fuel storage, maintenance areas or made ground cannot be ruled out and should be considered during the ground investigation.
- Suitable habitat exists throughout much of the SLNCR corridor and ecological walkover surveys are proposed; therefore, the presence of non-native invasive plant species, including Japanese Knotweed and other invasive species, cannot be discounted until field surveys have been completed.

The Contractor shall liaise with the Client and local authority where the site is operating under a licence.

The requirements of Annex 9 – Ground investigation on potentially contaminated ground, shall be adhered to.

S1.8.5 Additional information on services shown on Contract drawings (Clause 3.7.2)

Available utilities and services information is provided in the information pack. This information is not necessarily up-to-date, complete or accurate and are provided for information only.

Information has not been received from all providers but will be added to the information pack when available. The design team will review the information and update GI locations based on the utility information if required.

It is the requirement of the contract that the Contractor liaises with the Client and all service providers directly, in advance of the works, to obtain the most reliable service information available.

S1.8.6 Known/suspected mine workings, mineral extractions, etc. (Clause 3.7.3)

No mine workings or mineral extraction sites are identified in the Stage 1 or 2 geological constraints assessment (ARP-ERW-P2-FN-001 and ARP-ERW-P2-FN-002). However, historic quarry locations were specifically excluded from that assessment. Consequently, former quarries, pits, associated spoil deposits and recorded or unrecorded workings cannot be ruled out from being encountered.

S1.8.7 Protected species, habitats, and designated areas (Clause 3.7.4)

The Site interacts with various designated ecological sites as outlined below:

- Unshin River SAC
- Lough Gill SAC
- Union Wood SAC
- Unshin River pNHA
- Lough Gill pNHA
- Union Wood pNHA
- Lough Macnean Upper pNHA

Ecological surveys have been completed and have identified the following ecological constraints within the Corridor.

- Annex 1 habitat including Molinia Meadow, Hydrophilous Tall Herb Swamp, Old Sessile Oak Woods, Alluvial Woodland, Lowland Hay Meadow
- A17 Habitats including dry heath and wet heath
- High Value Habitats including woodland, scrub land, species rich wet grassland and marsh
- Invasive Species including Rhododendron, Japanese knotweed, Giant hogweed, native and hybrid bluebells, Himalayan balsam, Spanish bluebell
- Badger Sets

All protected species and designated sites are shown on drawings MKO-ENV-P3-DR-001 to MKO-ENV-P3-035.

Appropriate Assessment (AA) screening is being undertaken concurrently with the tender process.

In channel works and/or works within Annex 1 habitats are not required.

Works within designated ecological sites shall not be within 10m of a watercourse.

Appropriate site-specific protection and mitigation measures shall be agreed between the Project ecologist and the Contractor's ecologist prior to commencing the Works within designated ecological sites.

The Contractor is responsible for the following:

- Reviewing all ecological information provided prior to commencing the Works and shall take account of ecological constraints when planning access arrangements, site compounds, plant movements and investigation activities;
- To avoid all works in areas of non-native invasive species;
- If an invasive species listed on the Third Schedule of the European Communities regulations[1] lists non-native invasive species that are subject to restrictions under Regulations 49 and 50 is identified or where potentially infested areas are encountered by the Contractor, works in vicinity shall immediately cease work and the Investigation Supervisor shall be notified. These areas will require fencing to restrict access until specialist have been appointed. The exclusion zone should be in accordance with TII guidance[2];
- Where required, an appropriate invasive species management plan (ISMP) should be implemented before relevant works begin again. The ISMP should be in accordance with TII guidance;
- Take the necessary measures to prevent the spread or dispersal of non-native invasive species. Where required these preventative measures shall be included in the Contractor's Method Statement and agreed with the Investigation Supervisor.

S1.8.8 Archaeological remains (Clause 3.7.5)

Archaeological and cultural heritage constraints have been identified during Phase 1 and 2 of the project, and the design has aimed to avoid archaeological sites where practical.

GI works may be undertaken in the vicinity of known or potential archaeological features. The locations of known archaeological constraints, recorded monuments and protected structures are identified on the drawings referenced in Schedule S1.7 and shall be reviewed by the Contractor prior to undertaking any intrusive works.

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[1] S.I. No. 477/2011 - European Communities (Birds and Natural Habitats) Regulations 2011 9 S.I. No. 477/2011 - European Communities (Birds and Natural Habitats) Regulations 2011. (irishstatutebook.ie))

[2] TII GE-ENV-01105 (2020) "The Management of Invasive Alien Plant Species on National Roads – Technical Guidance";

Coordination with the Project Archaeological Consultant will be required when planning works within the vicinity of known archaeological constraints and other sensitive heritage features. Additional restrictions or archaeological supervision may be required in certain locations.

In the event that previously unidentified archaeological remains, artefacts or features are encountered during the Works, all works in the affected area shall cease immediately and the Investigation Supervisor shall be notified. No further works shall be undertaken in the affected area until appropriate instructions have been provided by the Employer.

S1.8.9 Security of site (Clause 3.11)

The requirements of Clause 3.11 apply.

The Contractor is responsible for the security of the Contractor's equipment on site for the duration of the site works phase of the investigation.

S1.8.10 Traffic management measures (Clause 3.12)

The following pedestrian/traffic management requirements apply (Clause 3.12):

- The Contractor is required to provide and maintain adequate traffic and pedestrian safety and management measures to safeguard the public and site works during the execution of the works.
- The Contractor is responsible for liaising with all relevant stakeholders (i.e. Local Authority, Garda Síochána, and Emergency Services). The Contractor is responsible for determining the particular requirements of the relevant stakeholders to apply for, execute closures and the implementation of any such traffic management regimes as may be necessary to facilitate the execution of the Works.
- The Contractor shall provide and maintain access to all existing properties and facilities adjacent to the Works.
- The Contractor shall arrange their operations so that obstruction to traffic is minimised. Where any such obstruction is required for the satisfactory progress of the works, the Contractor shall consult with the Investigation Supervisor about the situation, in advance of commencing the work.
- The Contractor is responsible for obtaining and completing all licenses and permits for undertaking of access and permissions for the works. Confirmation of receipt of permission must be provided to the Investigation Supervisor in advance of the respective works.
- The traffic management plans shall comply with the requirements and/or recommendations:
  - Chapter 8 of the Traffic Signs Manual, Temporary Traffic Measures and Signs for Roadworks, Department of Transport, Tourism and Sport (2019); and
  - The Guidance for the Control and Management of Traffic at Road Works (Second Edition - 2010) prepared by the Local Government Management Services Board.
- The traffic management as set up on site shall be supervised on a full-time basis by a competent person with CSCS Signing, Lighting and Guarding (SLG) qualification or equivalent approved as a minimum.
- Five days, minimum, prior to the commencement of each traffic/pedestrian management phase of the Works, the Contractor shall submit the relevant detailed traffic management plans to the Investigation Supervisor.
- The Contractor shall be responsible for the maintenance of all traffic management.
- In the event of a traffic accident occurring adjacent to the works area, the Contractor shall immediately contact An Garda Síochána, the Investigation Supervisor and the relevant local authority where appropriate.

S1.8.11 Restricted working hours (Clause 3.13)

Work may take place on site between the hours of 8.00am and 5.00pm, Monday to Friday and 8.00am to 4.00pm on Saturday. Work outside these hours may take place only with the prior agreement of the Investigation Supervisor (Clause 3.13).

S1.8.12 Trainee site operatives (Clause 3.14.1)

Not permitted for lead driller.

S1.8.13 Contamination avoidance and/or aquifer protection measures required (Clauses 3.15.2 and 3.15.3)

All equipment shall be thoroughly cleaned before being used on site. Jet washing equipment shall be provided to wash down relevant equipment and tools before starting each exploratory hole. A clean stainless-steel trowel shall be used to collect soil samples for chemical testing and shall be cleaned between samples. When working on land affected by contamination (eg. Made ground) the Contractor shall clean equipment (including wheels) before leaving the site.

If significant contamination is encountered, sampling equipment and tools shall be cleaned between strata, particularly at the boundary between Made Ground and natural strata, in order to prevent cross contamination.

The Contractor may only use vegetable oil-based lubricants on any equipment that may make contact with ground or groundwater.

Aquifer protection as defined in Clause 3.15.3 is required.

The known aquifers requiring protection are detailed below:

- Aquifer 1: Slishwood Division Psammitic Paragneiss - Poor Aquifer (Pl)
- Aquifer 2: Ballygawley Tonalitic Gneiss - Poor Aquifer (Pl)
- Aquifer 3: Oakport Limestone Formation - Regionally Important Karstified Conduit Aquifer (Rkc)
- Aquifer 4: Dargan Limestone - Regionally Important Karstified Conduit Aquifer (Rkc)
- Aquifer 5: Dartry Limestone - Regionally Important Karstified Conduit Aquifer (Rkc)
- Aquifer 6: Mudbank Limestone - Regionally Important Karstified Conduit Aquifer (Rkc)
- Aquifer 7: Glencar Limestone - Regionally Important Karstified Conduit Aquifer (Rkc)
- Aquifer 8: Ballyshannon Limestone - Regionally Important Karstified Conduit Aquifer (Rkc)
- Aquifer 9: Bundoran Shale Formation - Locally Important Aquifer (Ll)
- Aquifer 10: Lisgorman Shale - Locally Important Aquifer (Ll)
- Aquifer 11: Moy Sandstone Formation - Locally Important Aquifer (Lm)
- Aquifer 12: Carraun Shale Formation - Poor Aquifer (Pl)

Aquifer protection measures shall be formed by the following steps:

a. boring or drilling (both with temporary casing) to a suitable depth into, but not penetrating through, a suitably low permeability layer;

b. forming a bentonite plug in the base of the hole, then pulling back the temporary casing to just below the top of the bentonite seal;

c. installing a secondary, smaller-diameter temporary casing through the seal to the depth required.

S1.8.14 Maximum period for boring, pitting or trenching through hard material, hard stratum or obstruction (Clauses 2.8, 4.3 and 6.4)

The requirements of Clause 4.3 apply.

S1.8.15 Reinstatement requirements (Clause 3.16)

All reinstatements shall be to the requirements of Clause 3.16.

For public roads:

Guidelines for the Opening, Backfilling and Reinstatement of Openings in Public Roads, Department of Transport, April 2017.

In addition, for National Roads the following applies:

Requirements for the Reinstatement of Openings in National Roads (TII, CC-PAV-04007).

S1.8.16 Hygiene facilities required (Clauses 2.21 and 3.16.1)

If appropriate, arisings from exploratory holes shall be placed on heavy-gauge polyethylene sheeting and/or boards and covered in wet or windy weather so as to prevent the spread of contamination or placed in covered skips.

The Contractor shall provide hygiene and decontamination facilities appropriate for the colour designation stated in Schedule S1.8.4 in order to control risks to the health and safety of site operatives and site visitors.

The Contractor shall take account of the requirements of the Control of Asbestos Regulations 2012; AGS (2013) Site investigation asbestos risk assessment for the protection of site investigation and geotechnical laboratory personnel; and CIRIA C733 Asbestos in soil and made ground: a guide to understanding and managing risks.

The Contractor shall comply with the safety requirements of HSG 66 (1991) Protection of workers and the general public during the development of contaminated land.

The Contractor shall follow the safety guidance in CIRIA 132 (1996) A guide for safe working on contaminated sites and in Annex C of BS 10175 Investigation of potentially contaminated sites - Code of practice.

S1.8.17 Unavoidable damage to be reinstated by Contractor (Clause 3.16.1)

All unavoidable damage shall be reinstated by the Contractor.

Such reinstatement of damage shall be to the satisfaction of the Client.

S1.8.18 Accuracy of exploratory hole locations (Clauses 3.19 and 3.20)

The Contractor is responsible for setting-out each exploratory hole location and for surveying the as-built location of each exploratory hole.

The accuracies specified for setting out (Clause 3.19 and amended in Schedule 4) and levelling (Clause 3.20) are appropriate.

As-built positions shall be reported in Irish Transverse Mercator coordinates.

Levels shall be reported relative to Ordnance Datum.

S1.8.19 Photography requirements (Clause 3.25)

Photographs are required. The requirements of Clause 3.25 apply.

Attention is drawn to the requirement of Clause 3.25.2 that a JPG of each photograph be provided to the Investigation Supervisor for approval within 3 working days of the photography.

Hard copies of photographs are not required.

Photographs shall be provided for all cores, pits and trenches.

Photographs shall be provided of each location before commencing works and upon completion of reinstatement.

The original JPG of the images shall be provided as well as the photographs being incorporated into the relevant report.

S1.8.20 Document Control and Digital Management of the Works

Throughout the contract, all submissions, including risk assessments, method statements, health and safety documentation, programmes, look-ahead, requests for information, daily records, draft reports, final reports and payment applications shall be submitted through a document management system to be agreed with the Investigation Supervisor.

Access to a web-based Geographical Investigation System (GIS) will be provided to the Contractor for two staff; additional profiles may be agreed with the Investigation Supervisor. This GIS portal will present the GI locations and landowner details. The progress status of each location and its laboratory testing shall be updated on a weekly basis by the Contractor and shall be up to date at the time of the agreed progress meeting.

S1.8.21 Landowner engagement

Landowner engagement for the SLNCR Greenway project is managed by two dedicated Project Liaison Officers (PLOs), with one PLO responsible for County Sligo and one PLO responsible for Counties Leitrim and Cavan. The PLOs have been involved in the project since Phase 1 and have established relationships with landowners and occupiers throughout the corridor, including those affected by the proposed GI Works.

The Contractor should be aware that day-to-day liaison with landowners or occupiers may be required during the course of the works. Whilst the PLOs will provide support in agreeing access and managing stakeholder matters where required, they will not always be available to attend site visits or respond immediately to site-based queries. The Contractor shall therefore plan the works accordingly and maintain regular communication with the PLOs and Investigation Supervisor regarding any access or landowner issues that arise during the execution of the works.

A Landowner Engagement Management System (LEMS) has been compiled. Initial contact will be made by the PLOs notifying Landowners of the proposed works on their property (including a brief description of the works and images of what type of equipment will be used) a minimum of two weeks prior to commencement on site. The Contractor is responsible for the following as part of this process:

- The Contractor shall engage with the PLOs to outline the expected dates and times of the Works;
- Engage with the PLOs to plan and coordinate access arrangements;
- Respond to any technical queries regarding equipment, noise, area affected, etc;
- Record any correspondence with landowners and stakeholder including, but not limited to, letters, emails, phone conversations, site meetings. These shall be provided to the Investigation Supervisor and PLOs for inclusion within LEMS on a weekly basis;
- The Contractor shall notify the Investigation Supervisor and PLOs of any comments or complaints during the works;
- Follow up liaison to ensure reinstatement of the locations has been completed as required. Final reinstatement shall be agreed with the Investigation Supervisor;
- Attend weekly progress meetings with Designer and Client; and
- Provide a full summary of all works completed on each individual landowner’s property once works, and full reinstatement have been completed.

To allow for the above, specific landowner engagement items have been included in the pricing documents and on-site delays due to late engagement will be at the Contractors’ risk.

S1.8.22 Noise Restrictions

The Contractor shall take all reasonably practicable measures to minimise noise arising from the works, particularly in the vicinity of sensitive receptors including residential properties, schools, places of worship, offices and healthcare facilities. Plant and equipment shall be fitted with effective silencers and maintained in good working order.

Where instructed by the Project Manager or Investigation Supervisor, temporary acoustic screening shall be provided adjacent to sensitive receptors. Acoustic screening may comprise acoustic blankets, acoustic barriers or acoustic noise control liners fixed to Heras fencing (or similar approved system). Such measures shall remain in place for the duration of the relevant works.

S1.9 Percussion boring (Specification Section 4) particular restrictions/relaxations

S1.9.1 Permitted methods and restrictions (Clauses 4.1 to 4.4)

Cable percussion boring shall be used at the locations specified in Schedule 2. Any other proposed methods should be submitted to the Investigation Supervisor for approval.

The aim of the cable percussion drilling is:

- to obtain continuous high-quality soil samples that can be used for detailed logging and from which subsamples can be selected for geotechnical laboratory testing;
- to obtain soil samples for contamination analysis;
- to create suitable holes for in-situ testing, rotary core follow-on and gas and groundwater installation construction.

The minimum nominal casing diameter shall be 150 mm. At ground level before boring commences, the initial casing diameter shall be sufficiently large to ensure that the borehole can be completed to its scheduled depth.

A borehole remaining open overnight shall be covered. Before the first sample of the new day is taken the boring shall be advanced for at least 0.3 m.

If ‘blow back’ occurs, re-boring may be necessary to advance the borehole beyond the disturbed zone. The Investigation Supervisor shall be informed of such conditions and instruct the Contractor as to whether re-boring is required.

It is envisaged that cable percussion boring will be used. Any other proposed methods should be submitted to the Investigation Supervisor for approval. Any alternative proposed methods shall be detailed in the tender submission.

S1.9.2 Backfilling (Clause 4.5)

Backfilling of boreholes with soil arisings is not permitted (Clause 4.5).

All boreholes shall be backfilled with cement bentonite grout, following the requirements of Appendix I of the Specification (EI SGI, 2016), and Annex 3 (all parts), taking account of any requirements for the installation of instruments in the hole.

S1.9.3 Dynamic sampling (Clause 4.6)

Windowless dynamic sampling shall be carried out and reported in accordance with Annex 2.3 at the locations specified in Schedule 2.

SPT testing shall be carried out in all windowless sample holes at 1.5m intervals.

Where required in Schedule 2, the dynamic sampling equipment shall be sufficiently sized to allow installation of instrumentation specified in a dynamic sampling hole.

Where dynamic sampling and dynamic probing are completed alongside each other, a combined log showing the findings of both the dynamic sampling and dynamic probing results with depth shall be provided.

S1.10 Rotary Drilling (Specification Section 5) – particular restrictions/relaxations

Rotary drilling shall be used at the locations specified in Schedule 2.

S1.10.1 Augering requirements and restrictions (Clauses 5.1)

Not required.

S1.10.2 Particular rotary drilling techniques (Clause 5.2)

Core is required from all rotary drilling operations, unless explicitly stated as not being required in Schedule 2. Where core is not required, the diameter of the open hole will be adequate for the collection of core of the requisite diameter at greater depth.

The aim of the rotary drilling is:

- to obtain continuous high-quality samples of both soil and rock materials that can be used for detailed logging and from which subsamples can be selected for laboratory testing including compressibility and shear strength testing;
- To create suitable holes in which in-situ testing and groundwater monitoring installations can be undertaken.

The rotary drilling procedures shall be aimed at minimising the mechanical disturbance and the changes in water content and suction in the sample caused by the sampling process. Speed is of the essence in achieving this aim. It is essential that the sample is not left down the borehole (and hence in contact with the drilling fluid) for any longer than necessary. It is also essential that the sample is sealed against changes in water content as soon as possible after it has been removed from the ground.

S1.10.3 Drilling fluid type and collection (Clause 5.3)

The default drilling medium for rotary drilling shall comprise water. The use of alternatives e.g. air mist or non-toxic drilling mud additives (foam, biodegradable polymer mud, bentonite mud) whichever is the most appropriate to ensure maximum core recovery without affecting local groundwater supplies and preventing the migration of contaminated soil or water shall be subject to the agreement of the Investigation Supervisor and approval of the Client. The use of air flush in contaminated soil or mine workings shall be avoided.

Drilling fluid returns shall be collected or appropriately controlled.

The type of drilling fluid proposed by the Contractor shall be described in the method statement. The use of the term ‘mud’ in this specification shall be taken as referring to ‘drilling fluid’.

Off-site disposal of drilling fluids shall require the use of a suitably licensed contractor and may require prior laboratory testing.

Where air flush is used, the following methodology shall be used to prevent build-up of pressure within the core barrel:

- Prior to starting coring, the core barrel shall be cleaned with a power washer with particular attention to ensuring ‘pressure release valves’ are clear.
- On retrieving core barrel from the borehole following a core run, the barrel shall be washed, again with particular attention to ensuring these valves are clear of debris.
- No persons shall stand in front and in line with end of core barrel.
- The core barrel shall not be in line with any property, vehicles when opening.

- When working in the vicinity of any areas where public may access, or personnel or vehicles could be present, Heras fencing shall be installed around the works area, including in front of core barrel, at a suitable distance to prevent rebound of any material into the works area.

S1.10.4 Rotary core drilling equipment and core diameter (Clauses 5.4.1 and 5.4.2)

For locations comprising rotary follow-on drilling (refer to Schedule 2):

- Rotary drilling with core recovery shall be by the triple tube system (in which the innermost barrel comprises a one-piece cylindrical semi-rigid plastic liner of minimum 1mm wall thickness)

For locations comprising Geobor-S, including Geobor-S follow-on drilling (refer to Schedule 2):

- The equipment used shall be a core drilling system incorporating triple tube core barrels in which the innermost barrel comprises a one-piece cylindrical semi-rigid plastic liner of minimum 1mm wall thickness. The core diameter from rotary drilling shall be at least 102mm for soils or 95mm for rock. The equipment shall be capable of providing cores Quality Class 1 standard in accordance with IS EN 1997-2:2007 in soils and rocks.
- Subsampling of soils shall be undertaken **immediately** on site as per Annex 2.2.

Core recovery of less than 90% is not acceptable. If the measured core recovery is less than 90%, the subsequent core run shall be halved (subject to a minimum core run length of 0.5m).

If in the opinion of the Investigation Supervisor more than 90% recovery can be achieved, the Contractor, after consultation with the Investigation Supervisor, shall take measures to improve core recovery.

Core is required from all rotary drilling operations, unless explicitly stated otherwise in Schedule 2. Where core is not required at a particular depth, the diameter of the open hole shall be adequate for the collection of core of the requisite diameter at greater depth (Clause 5.5).

The types, sequence, depths and variations in consistency of each stratum shall be recorded as drilling proceeds, in daily records on a form approved in advance by the Investigation Supervisor.

The Contractor shall have on site a suitable range of bits and core springs that will allow the optimisation of clearance between the cut diameter of the core and the liner. The clearance shall be of the order of 1 mm for undisturbed sampling. The actual clearance shall be determined at the outset of the site work phase and shall be to the approval of the Investigation Supervisor.

S1.10.5 Core logging (Clause 5.4.6)

Core logging shall be in accordance with Clause 5.4.6.

The Contractor's site compound shall include all necessary facilities for core logging to be carried out on site.

Sections of rotary core remaining after removal of sub-samples for laboratory testing (see Schedule S1.10.6) shall be stored temporarily in suitable core boxes ready for inspection by the Investigation Supervisor.

Core boxes shall be new (i.e. previously unused). Unless otherwise instructed by the Investigation Supervisor, cores and core boxes will not be retained by the Employer.

Labels stating the name of Contract, hole number and core depths shall be securely affixed to both ends of each core box and to both the inside and outside of the box lid. Rigid core spacers shall be provided to fill sections where undisturbed samples have been taken and any zones of core loss.

Cores shall be placed in the core box either between the split pieces of core liner or between two close-fitting sections of plastic drainpipe. These shall be bound together to restrain the sample during transportation.

Suitable precautions shall be taken at all times by the Contractor to ensure that the core is not adversely affected by environmental conditions, including moisture, extremes of temperature, vibration and physical shock.

S1.10.6 Core sub-samples for laboratory testing (Clause 5.4.7)

Core sub-sampling is required. Sub sampling shall be taken ON SITE using wax within 2 hours of being removed from the borehole. The requirements for preparing and handling soil sub-samples from rotary cores are specified in Annex 2.2. A summary, in table format, shall be provided that includes time and date when core was drilled, and date of sub sampling.

Requirements for sub-sampling of cores for contamination testing purposes are specified in Schedule S1.12.12.

The Contractor's site compound shall include all necessary facilities for core sub sampling to be carried out on site.

S1.10.7 Address for delivery of selected cores (Clauses 5.4.8 and 5.4.9)

Not required.

S1.10.8 Rotary open-hole drilling general requirements (Clause 5.5.1)

It is envisaged that the rotary coring will occur following completion of cable percussive boring through the superficial deposits. However, the Contractor may undertake the rotary coring in advance of the cable percussive boreholes with the permission of the Investigation Supervisor. If permission is granted, the Contractor may use open hole drilling to progress through the superficial deposits, however, the Contractor may not bill for the cost associated with the open hole drilling.

S1.10.9 Rotary open-hole drilling for locating mineral seams, mine workings, etc. (Clause 5.5.2)

Not required.

S1.10.10 Open-hole resonance (sonic) drilling (Clause 5.6.1)

Not required.

S1.10.11 Resonance (sonic) drilling with sampling or continuous coring (Clause 5.6.2)

Not required.

S1.10.12 Backfilling (Clause 5.7)

Backfilling of drillholes with soil arisings is not permitted (Clause 5.7).

All drillholes shall be backfilled with cement bentonite grout in accordance with the requirements of Appendix I of the Specification (EI SGI, 2016), and Annex 3, taking account of any requirements for the installation of instruments in the hole.

S1.10.13 Core photographic requirements (Clause 5.8)

Schedule S1.8.19 applies.

Photographs of cores are required. The requirements of Clause 5.8 apply.

In addition, prior to photographing of any core:

- The core shall be cleaned free from drilling mud and drilling fluid;
- The core shall be 'dabbed' to a damp state ensuring that the core and features in the core are visible to the camera; and
- Any areas of assumed zones of core loss (AZCL) shall be clearly labelled.

S1.11 Pitting and trenching (Specification Section 6) – particular restrictions/relaxations

Sampling for geotechnical purposes from trial pits shall be in accordance with Clause 7.6.11.

S1.11.1 Indirect detection of buried services and inspection pits (Clauses 3.8.3 and 6.1)

The Contractor is responsible for undertaking all appropriate good practice measures for the identification and avoidance of underground services at each exploratory hole location, including but not limited to: review of documentary records; use of cable detection methods such as generator scanning and CAT (cable avoidance tool) scanning; and direct investigation.

The Contractor shall complete the works in accordance with

- The 'Code of Practice for Avoiding Danger from Underground Services, 2016'; and
- 'A Guide to Safety in Excavations, 2007' published by the Health and Safety Authority.

Calibration certificate for the cable avoidance tool shall be provided.

The Contractor shall excavate inspection pits of sufficient size for locating and avoiding of underground services (Clauses 3.8.3 and 6.1).

The use of inspection pits shall identify the positive presence or absence of services. Where services are suspected, known or found to be in close proximity to the proposed exploratory hole, the Contractor shall in the first instance relocate the hole to be clear of the services in consultation with the Investigation Supervisor. The revised location shall take into account statutory/required safe distances from services.

If the location of the exploratory hole cannot be moved it is recommended that, subject to consultation with and the agreement of the relevant utility, further inspection pits are put down to confirm the services and ensure that they will be unaffected by the investigation.

S1.11.2 Restrictions on plant or pitting/ trenching methods (Clauses 6.2 and 6.3)

The use of machine excavators is permitted at the locations specified in Schedule 2.

The following method of excavation shall be used, where the risk of below-ground services within or close to the plan area of machine-dug pits has not been eliminated.

A toothless bucket should be used, and the excavator operator instructed to dig slowly in thin layers (not more than 100 mm thick). The work should be closely supervised by an appropriately experienced ground practitioner, who should closely observe the bucket and ground conditions as the pit/trench proceeds.

On land affected by contamination, the excavation shall proceed in a series of shallow 0.2–0.3 m thick 'scrapes'. Arisings from distinctly different soil strata shall be stockpiled on separate polythene sheets.

S1.11.3 Entry of personnel (Clause 6.5)

No requirement for entry into excavations.

S1.11.4 Alternative pit and trench dimensions (Clause 6.7)

Trial pits and observation pits shall have the minimum dimensions specified in Clause 6.7.

S1.11.5 Abstracted groundwater from land affected by contamination (Clause 6.9)

On land affected by contamination, measures for the collection and temporary storage of pumped water (while testing and classification is being undertaken) shall be agreed in advance with the Investigation Supervisor.

S1.11.6 Backfilling (Clause 6.10)

For non-paved pits and trenches shall be backfilled using excavation plant in the manner specified in Clause 6.10.

For paved areas the method of backfilling as specified in Schedule 2 and clause S1.8.15 of this Specification.

Pits and trenches shall be permanently backfilled on the day of completion.

S1.11.7 Photographic requirements (Clause 6.12)

Schedule S1.8.19 applies.

Photographs are required of all pits, including inspection pits, and arisings therefrom. Where the faces in a pit differ in stratigraphic levels and/or strata, photographs of each face are required. The requirements of Clause 6.12 apply.

Each photograph of a pit or of pit arisings shall include details of the exploratory hole number and date, and include a visible colour scale, grey scale and length scale. The features being photographed shall reasonably fill the frame to show the details clearly.

Photographs shall be labelled with the location and include the direction, the photograph was taken.

S1.11.8 Artificial lighting (Clause 6.12.2)

Not required.

S1.11.9 Provision of pitting equipment and crew for Investigation Supervisor's use (Clause 6.13)

Not required.

S1.11.10 Slit trenches

Not required.

S1.11.11 Foundation Inspection pits

Not required.

S1.12 Sampling and monitoring during intrusive investigation (Specification Section 7) – particular restrictions/relaxations

S1.12.1 Address for delivery of selected geotechnical samples (Clause 7.6, 4.6.8)

Not required.

S1.12.2 Retention and disposal of geotechnical samples (Clause 7.6.2, 4.6.8)

The Investigation Supervisor shall be given notice of at least 1 week before the disposal of samples.

The requirements of Clause 4.6.8 and 7.6.2 are sufficient for storage of samples.

All geotechnical samples shall be removed from the vicinity of the exploratory holes at the end of each day's work and shall be protected from frost damage or excessive heat by being stored on or near the site in a structure that is under cover and is secure from interference. All geotechnical samples shall be removed from the site so as to reach the laboratory within 3 days of being taken.

All samples shall be disposed of in accordance with current waste legislation.

S1.12.3 Frequency of sampling for geotechnical purposes (Clauses 7.6.4-7.6.11)

The sampling and testing frequency shall be as stated in Clause 7.6.4 – 7.6.11 with the following additions:

Hand dug inspection pits:

- Ground level to 1.2mbgl: small and bulk disturbed samples shall be taken at every change in strata or every 0.5m with a minimum of 1 bulks and 2 disturbed samples.

Boreholes:

- In fine-grained (cohesive) soil, an SPT and disturbed sample shall follow every attempt to take an open tube sample
- in Made Ground and in coarse-grained (non-cohesive) soil and soil-like layers within the rock, bulk disturbed samples shall be taken at 1m depth intervals.

Trial pits:

- Small, disturbed samples shall be taken of the topsoil and at each change in soil type or consistency and between successive bulk disturbed samples;
- Bulk disturbed samples shall be taken at 1.0m depth intervals, with at least one large bulk disturbed sample for each soil type and be representative of the zone from which they have been taken; and
- Large bulk disturbed samples shall be taken at locations where granular strata is encountered. They shall be of sufficient size to allow large shear box testing of overburden material and ballast samples and be representative of the zone from which they have been taken. Refer to Schedule 2 for further details;

Windowless samples:

- Small disturbed samples shall be taken at each change in soil type or consistency;
- Bulk disturbed samples shall be taken at 1.0m depth intervals, with at least one bulk disturbed sample for each soil type and be representative of the zone from which they have been taken; and

Refer to S1.12.11 and Annex 9 for geo-environmental sampling.

S1.12.4 Open-tube and piston sample diameters (Clause 7.6.5)

All open tube samples shall be of the thin-walled type (denoted OS-T/W in EN ISO 22475-1). Open tube and piston samples shall have 100mm internal diameter (Clause 7.6.5). Sample tubes shall be made of steel or aluminium. Plastic lining tubes shall not be used in substitution for steel or aluminium sampling tubes. Soil samples shall be at least 300mm long.

Where thin walled samples refuse, for example due to high stiffness or gravel content, the Contractor may seek approval from the Investigation Supervisor to use thick-walled type open tube samples (denoted OSTK/W in EN ISO 22475-1). This shall only be acceptable if agreed in advance with the Investigation Supervisor.

S1.12.5 Retention of cutting shoe samples (Clause 7.6.5)

Cutting shoe samples shall be retained as small disturbed samples.

S1.12.6 Continuous and semi continuous sampling (Clause 7.6.12)

Not required.

S1.12.7 Groundwater level measurements during exploratory hole construction (Clause 7.7)

The requirements of Clause 7.7 apply.

S1.12.8 Special geotechnical sampling (Clause 7.8)

Requirements for 100mm-diameter thin-walled sampling are specified in Annex 2.1.

Requirements for sub-sampling from rotary cores are specified in Annex 2.2.

S1.12.9 Address for delivery of selected samples (Clause 7.9.2)

Not required.

S1.12.10 Retention and disposal of contamination (WAC) samples (Clause 7.9.3)

All untested samples and untested sample portions for analysis shall be retained for 28 days after submission of the approved final report.

Untested samples and untested sample portions for waste acceptance criteria (WAC) analysis shall be retained for 28 days after submission of the approved final report.

The Investigation Supervisor shall be given notice of at least 1 week before the disposal of samples.

All samples shall be disposed of in accordance with current waste legislation.

S1.12.11 Frequency of sampling (Clause 7.9.4)

The frequency of sampling for contamination sampling is specified in Annex 9 Section 9.5.

Additional sampling requirements are specified below:

- The first sample shall be taken from between ground surface (0m) and 0.3mbgl.
- Subsequent samples shall occur at approximately 1.0m intervals thereafter as required or every strata as appropriate.
- A sample shall be taken where colour, odour or consistency indicate a change in nature of the strata and from strata where any visual or olfactory evidence of contamination is observed.
- No samples for geo-environmental testing will be obtained from depths greater than 4mbgl, unless visual or olfactory evidence is observed, and/or exploratory locations remain within made ground at this depth.
- One sample of natural strata should be obtained from each exploratory location.

Samples for contamination testing shall be representative of the conditions encountered and shall not be collected at strata boundaries.

S1.12.12 Sampling method (Clause 7.9.5)

Solid and liquid samples for contamination testing shall be taken under the supervision of an environmental scientist meeting the requirements of Clause 2.3(c) of the Specification.

The size and type of samples and containers, method of sampling and time limitations for carrying out specific analyses shall be commensurate with the range of tests to be carried out as specified in Schedule 1.20.

The Contractor shall take all steps necessary to avoid cross contamination of sampling points.

The Contractor shall take samples which are representative of each of the materials encountered.

Solid Samples

Solid samples for the contamination ground investigation may be of any type covered by Clauses 7.6.5 to 7.6.9 inclusive of the Specification and may be taken from boreholes, trial pits and trenches, observation pits and trenches, as specified.

All samples for contamination/WAC testing shall be taken from discrete depths / locations. Under no circumstances shall material be mixed prior to sampling. Any mixing prior to sampling is non-compliant with this specification.

Sample tubes and split spoon samplers used for recovering material for contamination testing shall be washed with clean water immediately before use to minimise the potential for cross contamination.

Small disturbed samples shall be taken with clean stainless-steel hand tools and placed in rigid containers made of a material that is non-reactive with the likely contaminants. The containers shall be filled to the brim to effectively exclude air.

Solid samples shall be taken by the environmental scientist from the investigation position at the time of excavation. Sub-sampling from bags or from excavations left open for sampling is not permitted unless explicitly agreed in advance with the Investigation Supervisor.

Each sample suite collected for contamination testing shall comprise the following:

- Vial(s) for volatile hydrocarbon analysis;
- Amber glass jar(s) for hydrocarbon soil analysis. Depending on size, multiple jars may be required to achieve analysis; and
- Plastic tub(s) for inorganic, metals and WAC leachability soil analysis. Depending on size and soil type multiple tubs may be required to achieve analysis including leachability.

Depending on size and soil type multiple tubs may be required to achieve analysis including leachability.

Soil samples for VOC analysis shall be collected immediately after recovering the soil or exposing a fresh surface to minimise loses of volatile compounds.

The vial(s) for volatile hydrocarbon analysis shall be collected first, followed by the amber glass jar(s) and then the plastic tub(s)

The type and quantity of soil containers used for each sample suite shall be confirmed with the laboratory prior to the investigation to allow all the potential contaminants to be analysed as defined in Schedule S1.20. Following collection, environmental sub-samples shall be kept cool and dark in accordance with Section 8.6 of BS 10175.

For sub-sampling from rotary cores for environmental testing purposes, the relevant core shall be inspected and sub-sampled as soon after drilling as possible (and within a maximum of 12 hours of drilling). The core shall be kept in a cool, dry place until the environmental sub-samples have been collected from the core.

Labelling and protection samples

All sample storage, labelling, preservation (including temperature control and protection from light) and handling shall be in accordance with BS 10175 and in accordance with the recommendations of the relevant test laboratory.

Solid, liquid or gas samples suspected to be toxic or hazardous shall be tagged with a red label.

All samples shall immediately be placed in storage which is suitable to protect from extremes of temperature, such as:

- Laboratory supplied cool boxes, or contractor supplied containers that are agreed with the Investigation Supervisor in advance.
- In a structure that is under cover, not affected by extreme temperature and is secure from interference in accordance with Section 8.6 of BS 10175, agreed with the Investigation Supervisor in advance.

Transportation of samples, scheduling and test timeframes

- **All** testing shall be undertaken in accordance with the accredited laboratory **holding** times.
- All recovered samples shall be transported to the premises of the relevant test laboratory prior to scheduling and shall reach the laboratory within **3 days** of being sampled.
- The Investigation Supervisor shall be included on the Chain of Custody as an additional point of contact for the laboratory and receive documentation acknowledging sample receipt and estimated completion dates for the analyses.
- The Contractor shall provide each blank geo-environmental schedule, along with the relevant draft logs, to the Investigation Supervisor within **1 day** of the sampling for contamination testing.
- The Investigation Supervisor will schedule testing within **3 working days** following receipt of draft laboratory schedule, see clause S1.20.1 for details.
- See Clause 1.12.10 for sample disposal.

S1.12.13 Headspace testing (Clause 7.9.8)

All samples for contamination/WAC testing shall be screened by PID. The PID shall have a lamp characteristic rating of 10.6eV and shall include a moisture filter. The PID calibration records shall be provided by the Contractor. One headspace test shall be undertaken per representative sample location. The headspace test method shall be as defined in Clause 7.9.8. The results of headspace testing shall be included in the daily record, in addition to the requirements of Clause 13.2.

Samples for headspace testing shall not be subjected to direct sunlight and shall be tested as soon as possible after collection.

Headspace testing shall be carried out as follows:

- Half fill a suitable container (such as a sealable plastic freezer bag) with freshly collected sample and immediately seal the container in order to have approximately equal volumes of sample and air.
- In an environment above 0°C, allow a minimum of 20 minutes for headspace development by vigorously shaking the container at the beginning and end of the development.
- Check the PID is working and calibrate if necessary.
- Insert the instrument probe through the seal to about mid-depth of the headspace, taking care to avoid the uptake of water droplets or soil particles.
- Record the highest meter response. Erratic meter readings should be discounted.
- Record details of the sampling and testing, including comments on results which are inconsistent with visual/olfactory evidence of contamination.
- Record details of the ambient weather and temperature during the test.

S1.13 Probing and cone penetration testing (Specification Section 8) - particular restrictions/relaxations

S1.13.1 Type(s) and reporting of dynamic probing (Clauses 8.1.1 and 8.1.2)

Dynamic probing is required at the locations specified in Schedule 2 using both a hand-held dynamic probe and super heavy dynamic probe respectively. Dynamic probing shall be undertaken in accordance with IS EN ISO 22476-2.

Torque reading shall be undertaken at 1m intervals in accordance with IS EN ISO 22476-2.

A calibration certificate outlining the compliance of the probe with IS EN ISO 224476-2 shall be returned as part of the method statement. Only equipment with a current and relevant calibration certificate is permitted to be used on site.

Peat probing shall be undertaken using a Mackintosh Probe or approved equivalent within the areas identified for peat probing on the Drawings. Probes shall be advanced on a nominal 25 m grid across the extent of these areas. The spacing may be reduced at proposed structures, crossings, embankments and cuttings, and where peat thickness is observed to vary significantly on site. Confirmation shall be sought from the Investigation Supervisor prior to any reduction in spacing. The purpose of the probing is to determine peat thickness and the depth to underlying competent strata, and to confirm the extent of peat deposits.

Each probe shall be advanced vertically under hand pressure to refusal on competent underlying strata. The probe coordinates, depth of penetration (taken as peat thickness), nature of the material at refusal and a visual description of the peat encountered shall be recorded at each location. Results shall be recorded and reported in accordance with the project requirements, provided in a GIS-compatible digital format, and included in the Factual Report.

Hand auger peat coring shall be carried out adjacent to every other peat probe location. A log recording soil description with depth shall be prepared for each peat core location with peat descriptions following the extended Von Post Scale.

S1.13.2 Capacity and equipment requirements for cone penetration testing (Clause 8.2.1)

Cone penetration testing (CPT) is required as specified in Annex 5 at the locations specified in Schedule 2.

S1.13.3 Reporting of cone penetration testing parameters (Clause 8.2.4)

Reporting of CPT results and the CPT daily record shall be in accordance with Annex 5 and IS EN ISO 22476-1.

Interpretation of soil types from CPT results is not required.

S1.13.4 Seismic cone equipment requirements (Clause 8.3.1)

The requirements of Clause 8.3.1 apply.

S1.13.5 Interpretation of seismic cone tests (Clause 8.3.4)

The requirements of Clause 8.3.4 apply

S1.13.6 Other cone or specialist probes (Clause 8.4)

Not required

S1.14 Geophysical surveying (Specification Section 9) particular restrictions/relaxations

The Contractor shall familiarise themselves with access restrictions and surface ground conditions at the location of each survey before the beginning of the field works. Notification should be made to the investigation supervisor, prior to gaining access to the site.

A preliminary site examination shall be undertaken in conjunction with the investigation supervisor prior to commencement of the works, to determine the detailed location of proposed geophysical survey locations.

For the survey team, the successful Contractor shall provide full-time, on-site geophysicist(s) with experience in the methods employed. Where required, any additional operators provided on site by the Contractor shall be experienced in the system(s) to be used, and all labour and equipment necessary to prepare access and to carry out the work. The Contractor shall employ the most appropriate and effective techniques, plant and equipment to complete the work.

The survey and interpretation of data must be carried out by a suitably qualified Geophysicist with a Professional Accreditation (i.e. PGeo, CGeol, EurGeol or equivalent) in Geophysics.

The Contractor shall provide a detailed description of the proposed equipment, staff, field techniques and data processing method (including methods of data quality estimation and interpretation) and programme for the works for approval by the investigation supervisor prior to commencement of the work.

All works are to be carried out in accordance with a quality management system to be submitted to the Employer's Representative for approval before the commencement of the Works such as ISO 9001.

All fieldwork, data processing and interpretation shall be monitored by the Investigation Supervisor. The Investigation Supervisor reserves the right to carry out his or her own interpretation of the data.

Sufficient data processing shall be carried out in the field to be able to demonstrate that meaningful results are being achieved consistent with the stated objectives and to assess whether further geophysical surveying is required.

Additional requirements for geophysical testing are provided in Annex 13.

S1.14.1 Geophysical survey objectives (Clause 9.1.1)

The objectives of the geophysical survey are to:

- Determine variations in the stratigraphy profile across the site, in particular the presence and thickness of superficial deposits, the depth to bedrock and features indicative of Karstified dissolution features.
- Collect data on site specific stiffness parameters for soils.
- Collect data on excitability of rock.
- Collect data on rock voids.

S1.14.2 Requirement for competent geophysicist (Clause 9.1.1)

Where required, a qualified geophysicist shall design and advise the investigations in accordance with best practice, concentrating on recording quality and output requirements, including interpretation and digital data requirements. Survey planning and design shall be in accordance with:

- ASTM D6429-99 e1 (ASTM, 2011); and
- And ASTM D5753-05 (ASTM, 2010)

The geophysics site personnel shall have sufficient expertise and experience to provide preliminary advice on the results obtained from each geophysical test.

S1.14.3 Trial geophysical methods (Clause 9.1.1)

Refer to Annex 13.

S1.14.4 Types of geophysical methods required (Clause 9.1.1)

The contractor may recommend changes to the techniques, predetermined acquisition pattern or survey parameters, but no changes may be undertaken without the agreement of the investigation supervisor. The contractor is welcome to suggest alternatives at the tender stage for consideration by the investigation supervisor.

The proposed geophysical survey comprises of a combination of the following methods, to be discussed with the specialist contractor prior to works commencing:

- 2D Resistivity Survey
- Seismic Refraction
- Multi-Channel Analysis of Surface Wave (MASW)

2D Resistivity Survey

2D Resistivity surveys are required to determine:

- Overburden thickness
- Variations in the stratigraphy profile across the site and depth to competent bedrock if possible.
- Determination of overburden and bedrock type and variations
- The rock mass and engineering properties of the underlying strata

The equipment shall be capable of measuring the variation of resistivity of the ground with depth to a minimum of 30m along the specified lines. A multi-electrode cable system shall be used. The equipment shall be easily transportable and suitable for operation over a variety of types of terrain.

Seismic Refraction & MASW Profiling

The survey shall consist of measurement of refracted seismic waves and the shear wave velocity depth profile using the Multi-Channel Analysis of Surface Waves (MASW) method and calculation of the small strain shear modulus Gmax.

Methodology

To produce a stiffness profile of the subsurface using Surface waves the following basic procedure is followed:

- A point source (e.g. a hammer) shall be used to generate vertical ground motions.
- The ground motions shall be measured using low frequency geophones. Geophones shall be placed along a straight line directed toward the source. Note there are some areas of hardstanding.
- The maximum shot spacing should be 2m and the geophone spacing should be determined by the senior geophysicist on site.

- The geophones must have sufficient length to be introduced into the ground
- The ground motions shall be recorded using either a conventional seismograph, oscilloscope or spectrum analyser.
- A dispersion curve shall be produced from a spectral analysis of the data. The dispersion curve should show showing the variation of surface wave velocity with wavelength
- A subsurface profile of the variation of Surface wave and shear wave velocity with depth shall be determined.
- A stiffness-depth profile (shear modulus, G) shall be derived from elastic theory.

Data Processing

Preparation of the acquired multi-channel record: this involves converting the data file into the processing format.

Production of a dispersion curve from a spectral analysis of the data showing the variation of Raleigh wave phase velocity with wavelength. Confidence and accuracy of the dispersion curve shall be shown.
A subsurface profile of the variation of shear wave velocity with depth shall be determined.
Shear wave velocities shall be converted into shear modulus using the formula:

$$G = \frac{V_s^2 \times p}{1 \times 10^6}$$

where: G = Shear Modulus (MPa); Vs= Shear Wave Velocity (m/s); ρ = Density (kg/m^3)

Additional requirements for geophysical testing are provided in Annex 13.

S1.14.5 Information provided (Clause 9.2)

Refer to Annex 13.

S1.14.6 Horizontal data density (Clause 9.3)

Refer to Annex 13.

S1.14.7 Level datum (Clause 9.4)

The level datum to be used for the geophysical survey shall be Ordnance Datum.

S1.15 In situ testing (Specification Section 10) - particular restrictions/relaxations

S1.15.1 Tests in accordance with Irish, UK or European Standards (Clause 10.3)

Unless specified otherwise herein, in-situ testing and reporting shall be in accordance with the standards listed in Clause 10.3 as applicable, except where IS EN ISO 22476 has superseded the BS 1377 test method since publication of the Engineers Ireland Specification and related documents for ground investigation in Ireland. Any work undertaken to a British/Irish Standard shall conform to the latest version of the published standard.

A calibration certificate outlining the compliance of the equipment with IS EN ISO 224476 shall be returned as part of the method statement documents. Only equipment with a current and relevant calibration certificate is permitted to be used on site

S1.15.2 Hand penetrometer and hand vane for shear strength (Clause 10.4.1)

The following in-situ tests shall be undertaken in trial pits specified in Schedule 2:

Where possible, a set of three tests should be undertaken in close proximity within cohesive material. Tests shall be permitted from large block type bucket samples.

S1.15.3 Self-boring pressuremeter and high-pressure dilatometer testing and reporting (Clause 10.5.1)
Not required.

S1.15.4 Driven or push-in pressuremeter testing and reporting requirements (Clause 10.5.2)
Not required.

S1.15.5 Menard pressuremeter tests (Clause 10.5.3)
Not required.

S1.15.6 Soil infiltration test (Clause 10.6)
Not required.

S1.15.7 Special in situ testing and reporting requirements (Clause 10.7)
In-situ handheld dynamic cone penetrometer (DCP) and super heavy dynamic cone penetrometer (DPSH) testing is required at the locations specified in Schedule 2. Handheld DCP testing shall use the TRL Dynamic Cone Penetrometer with 8 kg hammer and drop height of 575mm.

The depth and frequency of testing shall be detailed by the Investigation Supervisor subject to the specific ground conditions encountered at each location.

S1.15.8 Interface probes (Clause 10.8)
Interface probe tests shall be used to determine the presence and thickness of dense non-aqueous phase liquids (DNAPLs) underlying groundwater or light non-aqueous phase liquids (LNAPLs) overlying the groundwater at the monitoring locations specified in Schedule 2, during the proposed groundwater monitoring rounds.

Interface probe measurements are required. During each monitoring round, the Contractor shall investigate the presence of NAPL (prior to any purging) using an interface probe. If NAPL is identified by the interface probing, the Contractor shall promptly notify the Investigation Supervisor with a view to agreeing with the Investigation Supervisor a suitable approach for the development of standpipes (Schedule S1.16.5) before undertaking such development. The requirements detailed in Schedule S1.17.3 apply.

At all installations so stated in Schedule 2 and at any installations where the presence of NAPL is identified, an interface probe shall be used to determine the following:

- LNAPL surface level;
- groundwater surface level;
- DNAPL surface level.

NAPL shall not be sampled where its measured thickness is less than 100 mm, unless directed otherwise by the Investigation Supervisor. When the measured thickness of NAPL exceeds 100 mm and/or where so directed by the Investigation Supervisor, NAPL shall be sampled using carefully inserted tubing to the midpoint of the NAPL layer. Pumping of NAPL for sample collection purposes shall be at a rate that does not cause mixing with groundwater.

S1.15.9 Contamination screening tests (Clause 10.9)
Field-based screening using portable test kits is not required.

S1.15.10 Metal detection (Clause 10.10)
Not required.

S1.15.11 Standard penetration testing (SPT)
SPT testing is required in cable percussive, windowless sampler boreholes specified in Schedule 2.

SPT testing shall be undertaken at 1.5m centres throughout the full depth of all cable percussion boreholes. The first SPT shall be made at the base of the inspection pit. A final SPT shall be carried out on termination of the cable percussion borehole.

A current calibration certificate must be provided as part of the method statement.

S1.16 Instrumentation (Section 11) - particular restrictions/relaxations

S1.16.1 Protective covers for installations (Clause 11.2)

Standpipe installation cover types shall be:

- flush with the ground surface in pavements,
- raised cover in all other areas on the site.
- avoid installations in roadways.

S1.16.2 Protective fencing (Clause 11.3)

Fence protection measures shall be implemented where raised covers are used in agricultural land, in accordance with Clause 11.3.

S1.16.3 Standpipe and standpipe piezometer installations (Clauses 11.4.1 and 11.4.2)

Groundwater observation wells and piezometer installations are required at the exploratory holes identified in Schedule 2.

The installation depths of groundwater instruments (including response zones as applicable) shall be specified by the Investigation Supervisor on receipt, from the Contractor, of the drillers logs summarising soil strata types, strata depths and groundwater (if any) encountered in the hole during drilling. This summary information shall be provided by the Contractor after the relevant strata have been penetrated and, where applicable, before the scheduled termination depth of the hole has been reached.

Should instrumentation become damaged during installation and/or operation the Contractor shall contact the Investigation Supervisor as soon as possible and within 24 hours. The Contractor shall try to repair or replace damaged instrumentation where possible. A re-drill may be required as advised by the Investigation Supervisor.

S1.16.4 Other piezometer installations (Clause 11.4.3)

Not required.

S1.16.5 Development of standpipes and standpipe piezometers (Clause 11.4.5)

Section S1.15.8 applies

Development of standpipes and standpipe piezometers is required at least one week prior to the first groundwater sampling round.

1. The date of borehole development shall be included with all groundwater monitoring results.
2. Development shall be undertaken by over-pumping as per IS ISO 14686.
3. Development of standpipes and standpipe piezometers is required at least one week prior to the first groundwater sampling, having left sufficient time for the bentonite seal to fully hydrate and the cement around the borehole headworks to cure.
4. Prior to well development arrangements should be made for the discharge of the water in accordance with relevant legislation.
5. Prior to or during development any residual drilling fluids, grout or debris should be cleaned off the well casing and headworks above ground level. This may be carried out with water from the well development.

6. Pumping should be undertaken at the maximum achievable rate without damaging the screen. The maximum achievable pumping rate comprises the maximum rate at which water can be pumped from the borehole whilst the water level in the borehole is not drawn down to below the level at which the pump can operate.
7. The pumping shall continue until the water discharged from the borehole appears to be reasonably free of suspended solids. The Investigation Supervisor should be contacted to satisfy that the well has been sufficiently developed.

S1.16.6 Ground gas standpipes (Clause 11.5, 12.6)

Not required.

S1.16.7 Inclinometer installations (Clause 11.6)

Not required.

S1.16.8 Slip indicators (Clause 11.7)

Not required.

S1.16.9 Extensometers and settlement gauges (Clause 11.8)

Not required.

S1.16.10 Settlement monuments (Clause 11.9)

Not required.

S1.16.11 Removal of installations (Clause 11.10)

No earlier than the end of the post-field work monitoring period, the installations so specified in Schedule 2 shall be drilled-out and backfilled such that no tubing or cavities remain in the ground. Specifically, within 30 days of receiving written notice from the Investigation Supervisor, the Contractor shall drill-out the specified installations to their full depths and shall backfill the drill holes with cement bentonite grout. The work shall follow the recommendations of the Environment Agency publication *Good practice for decommissioning redundant boreholes and wells*. The Contractor shall be responsible for arranging access to the site for the drill-out and backfilling work.

S1.16.12 Other instrumentation (Clause 11.11)

Not required.

S1.17 Installation monitoring and sampling (Specification Section 12) - particular restrictions/relaxations

S1.17.1 Groundwater level readings in installations (Clause 12.2)

Water levels in boreholes during boring/drilling shall be measured at the beginning and end of each shift and other rest periods (Clause 12.2). The time the water level is taken shall be recorded.

Groundwater monitoring data loggers shall have the following characteristics

a. minimum pressure range of 30m;
b. pressure accuracy +/- 0.05% FS; and
c. pressure resolution 0.02%FS.
d. Barro data loggers shall have the following characteristics
e. pressure accuracy +/- 0.5cmH2O;
f. pressure resolution 0.1cmH20.

Requirements for the frequency of monitoring of groundwater data from completed groundwater installations are as follows:

- after completion of the fieldwork period and until submission of the draft factual report, readings once per week from all installations

For post-fieldwork monitoring, in advance of each visit the Contractor shall give notice of at least 1 day to all occupiers of land on which groundwater monitoring installations are situated.

S1.17.2 Groundwater sampling from installations (Clause 12.3.1)

Groundwater sampling from completed installations is not required

S1.17.3 Purging/micro-purging (Clause 12.3.2)

Not required.

S1.17.4 Ground gas monitoring (Clause 12.4)

Not required.

S1.17.5 Sampling from ground gas installations (Clause 12.5)

Not required.

S1.17.6 Other monitoring (Clause 12.8)

Not required.

S1.17.7 Sampling and testing of surface water bodies (Clause 12.9)

Not required.

S1.18 Daily records (Specification Section 13) - particular restrictions/relaxations

S1.18.1 Information for daily records (Clause 13.1)

Unless otherwise instructed by the Investigation Supervisor, each set of daily records shall be emailed to the Investigation Supervisor (at email address(es) notified to the Contractor by the Investigation Supervisor) no later than midday following the day that is the subject of the daily records (Clause 13.1).

In addition to Item 11 of Clause 13.2, the Contractor shall provide any PID results obtained.

Grid north may be taken as magnetic north (Clause 13.2).

S1.18.2 Special in situ tests and instrumentation records (Clause 13.4)

Daily record reporting requirements for special in-situ testing (if any) and for instrumentation shall be as specified in the relevant section of Schedule 1 or the relevant Annex.

S1.19 Geotechnical laboratory testing (Specification Section 14) - particular restrictions/relaxations

S1.19.1 Investigation Supervisor or Contractor to schedule testing (Clause 14.1.1)

The Contractor is required to prepare a blank test schedule (Clause 14.1.1), giving on one axis the following information:

- Borehole number:
- Sample number:
- Sample type:
- Sample depth:

and on the other axis the following standard laboratory tests shall be listed:

- Water content:
- Atterberg Limits:
- Particular size distribution by dry sieving:
- Particular size distribution by wet sieving:
- Particular size distribution by pipette:
- Organic matter content:
- Sulphate and pH of water sample:
- Sulphate and pH of soil sample (water: soil extract)
- quick triaxial test on 100mm diameter specimen (leave space for cell pressure to be specified)
- Single stage consolidated isotopically undrained (CIU) compression triaxial testing;
- Oedometer (leave space for pressure range to be specified);
- Point load strength (rock samples);
- Uniaxial compressive strength (rock samples);
- Three blank columns for other tests.

These draft schedules sheets are to be submitted to the Investigation Supervisor with the preliminary logs, required under Clause 2.23.

S1.19.2 Tests required (Clause 14.1.2)

The following tests are required:

Laboratory testing quantities cannot be accurately predicted at tender stage before detailed ground conditions are known. An initial list of required testing is provided in S1.19.1

Single stage consolidated isotopically undrained (CIU) compression triaxial testing shall be undertaken in accordance with EN ISO 17892-9.

Theses shall be single stage ONLY. Multistage testing on the same sample is not permitted.

Samples that shall be initially consolidated to back to its mean in situ effective stress. This value shall be determined by the Investigation Supervisor.

A particle size distribution (sieve and hydrometer) and Atterberg limit test shall be carried out on each triaxial sample tested.

Reporting shall include:

- Photographs before and after testing
- Optional reporting as per clause 8.3 of EN ISO 17892-9

Incremental loading Oedometer test shall be undertaken in accordance with EN ISO 17892-5 and shall include all optional reporting as per clause 8.2

S1.19.3 Specifications for tests not covered by BS 1377 and options under BS 1377 (Clauses 14.2.1 and 14.4)

Unless specified otherwise herein, the version of any British Standard, including any published corrigenda, published by the BSI as at the issue date of this specification shall apply, except where BS EN ISO 17892 has superseded the BS 1377 test method since publication of the Engineers Ireland Specification and related documents for ground investigation in Ireland.

S1.19.4 INAB or UKAS accreditation to be adopted (Clause 14.3)

If the Irish National Accreditation Board (INAB) or the UK Accreditation Service (UKAS) offers an accreditation for a laboratory test for soil or rock, the test laboratory used by the Contractor shall hold the relevant INAB or UKAS (or an equivalent in a Member State of the European Community) accreditation for that test type.

In the event that the laboratory does not hold accreditation, the Contractor shall state this in their tender return.

S1.19.5 Rock testing requirements (Clause 14.5)

In addition to the requirements of Clause 14.5 of the Specification, the following requirements apply

The equipment, procedure and information to be submitted shall be as described in NF 904-430-1 (AFNOR, 2000) and ASTM D7625-10 (ASTM, 2010). The Contractor shall submit their proposed methodology for the review of the Investigation Supervisor prior to the start of the test.

The tests should be carried out on even “broken” surfaces, either rough (split using a hammer) or smooth (cut using a water-cooled diamond saw). It should be noted, however, that samples formatted using rough methods have a CAI of about 0.5 higher than samples with a smooth surface.

S1.19.6 Chemical testing for aggressive ground/groundwater for concrete (Clause 14.6)

Chemical testing to determine the Aggressive Chemical Environment for Concrete (ACEC) class of the ground shall be carried out in accordance with BRE Special Digest 1 'Concrete in Aggressive Ground' Part 1, Box C10.

A preliminary assessment of the anticipated ground conditions has been made, and on that basis, it is anticipated that the chemical geotechnical tests required will be those identified with a tick ✓in the following tables. This chemical geotechnical testing shall be additional to any geo-environmental testing carried out in accordance with Schedule S1.20, unless otherwise instructed by the Investigation Supervisor.

SCHEDULE 1.19.6: TEST SUITES (derived from BRE Special Digest SD1)

CHEMICAL TESTS ON POTENTIALLY AGGRESSIVE GROUND AND GROUNDWATER

Sample type	Determinand	Recommended test methods	Method specified
SUITE B – Greenfield site (pyrite present)			
SOIL	pH in 2.5:1 soil/water extract	BR 279 Electrometric method	
		BS 1377-3:1028+A1:2021 Section 9 Electrometric method	✓
	SO_4 in2:1 water/soil extract WS (g/l SO_4)	BR 279 Procedures for gravimetric method, cation exchange or ion chromatography.	
		BS 1377-3:2018+A1:2021, Section 5 Gravimetric or ion exchange methods. (Values determined as g/l SO3 should be multiplied by 1.2.)	
		TRL Report 447, Test 1 Sulfate extraction procedure as BS 1377-1, but ICP-AES used to determine sulfur in solution.	✓
	Acid soluble sulfate AS (% SO4)	BR 279 Gravimetric method	
		BS 1377-3, Section 5 Gravimetric methods. (Values determined as g/l SO3 should be multiplied by 1.2.)	
		TRL Report 447, Test 2 Preparation and extraction of sulfate as BS 1377-3, ICP-AES used to determine sulfur in solution.	✓
	Total sulfur TS (% S)	BR 279 Only Ignition in oxygen method recommended.	
		TRL Report 447, Test 4A Microwave digestion method.	
		TRL Report 447, Test 4B Ignition in oxygen method (e.g. with sulphur-carbon determinator).	✓
WATER	pH	BR 279 Electrometric method	
		BS 1377-3:2018+A1:2021, Section 9 Electrometric method	✓
	Soluble sulfate GWS (SO_4)	BR 279 Procedures for gravimetric method, cation exchange or ion chromatography.	
		BS 1377-3:2018+A1:2021, Section 5 Gravimetric or ion exchange methods. (Values determined as g/l SO3 should be multiplied by 1.2.)	✓
		Commercial test laboratory in-house procedure: Determination of sulfur by inductively coupled plasma atomic emission spectroscopy (ICP-AES)	
SUITE D – Brownfield site (pyrite present)			
SOIL	pH in 2.5:1 soil/water extract	BR 279 Electrometric method	
		BS 1377-3 Section 9 Electrometric method	✓
	SO_4 in 2:1 water/soil extract	BR 279 Procedures for gravimetric method, cation exchange or ion chromatography.	

Sample type	Determinand	Recommended test methods	Method specified
	WS (g/l SO4	BS 1377-3, Section 5 Gravimetric or ion exchange methods. (Values determined as g/l SO3 should be multiplied by 1.2.)	
		TRL Report 447, Test 1 Sulfate extraction procedure as BS 1377-1, but ICP-AES used to determine sulfur in solution.	✓
	Acid soluble sulfate AS (% SO4)	BR 279 Gravimetric method	
		BS 1377-3, Section 5 Gravimetric methods. (Values determined as g/l SO3 should be multiplied by 1.2.)	
		TRL Report 447, Test 2 Preparation and extraction of sulfate as BS 1377-3, ICP-AES used to determine sulfur in solution.	✓
	Total sulfur TS (% S)	BR 279 Only Ignition in oxygen method recommended.	
		TRL Report 447, Test 4A Microwave digestion method.	
		TRL Report 447, Test 4B Ignition in oxygen method (e.g. with sulphur-carbon determinator).	✓
	Soluble magnesium (g/l Mg)	BR 279 Atomic absorption spectrometry (AAS) method.	✓
		Commercial test lab in-house procedure Determination of magnesium in solution by ICP-AES.	✓
	Nitrate (g/l NO3)	BR 279	✓
	Chloride (g/l CI)	BR 279	
		BS 1377-3 Section 7	✓
WATER	pH	BR 279 Electrometric method	
		BS 1377-3 Section 9 Electrometric method	✓
	Soluble sulfate GWS (SO_4)	BR 279 Procedures for gravimetric method, cation exchange or ion chromatography.	
		BS 1377-3, Section 5 Gravimetric or ion exchange methods. (Values determined as g/l SO3 should be multiplied by 1.2.)	✓
		Commercial test lab in-house procedure determination of sulfur by inductively coupled plasma atomic emission spectroscopy (ICP-AES)	
	Soluble magnesium	BR 279 Atomic absorption spectrometry (AAS) method.	✓

Sample type	Determinand	Recommended test methods	Method specified
	(g/l Mg)	Commercial test lab in-house procedure Determination of magnesium in solution by ICP-AES.	
	Nitrate (g/l NO3)	BR 279	✓
	Chloride (g/l CI)	BR 279	
		BS 1377-3 Section 7	✓

S1.19.7 Laboratory testing on site (Clause 14.7)

No laboratory testing is to be carried out on site (Clause 14.7)

S1.19.8 Special laboratory testing (Clause 14.8)

Not required.

S1.20 Geo-environmental laboratory testing (Specification Section 15) - particular restrictions/relaxations

A targeted geoenvironmental sampling strategy has been developed in accordance with current contaminated land risk assessment guidance and industry good practice for linear infrastructure projects.

Historic Railway Corridor

The former railway corridor comprises approximately 40 km of historic railway ballast, embankment and associated made ground. Railway infrastructure is recognised as having the potential to contain contaminants associated with historical operational activities, including hydrocarbons, metals, PAHs and asbestos-containing materials within ballast and fill materials. Accordingly, geoenvironmental sampling is proposed at a frequency of one environmental investigation location per kilometre to provide representative coverage of the corridor.

General Route Sections

Outside the railway corridor, approximately 35 km of the route traverses a combination of farmland, settlements, paths and other areas with limited historical industrial activity. In these areas, contamination risk is considered significantly lower and geoenvironmental sampling will be targeted towards locations where made ground is encountered.

Based on anticipated ground conditions, made ground is expected to be present at roughly one-third of locations (approximately 60 locations). Where made ground is identified, samples will be collected.

Structure and Earthworks Locations

The scheme includes 21 structures where localised earthworks, construction activities and potential anthropogenic ground disturbances are anticipated. To adequately characterise soils at these higher-risk locations, geoenvironmental testing is proposed for all associated boreholes.

Sampling frequency should be undertaken in line with S1.12.3.

This risk-based approach concentrates sampling effort where contamination is most likely to occur while avoiding unnecessary testing within undisturbed natural soils and low-risk rural areas.

S1.20.1 Investigation Supervisor or Contractor to schedule testing (Clause 15.1)

Except where specified otherwise herein, the Investigation Supervisor will schedule the required geo-environmental tests.

The Contractor shall prepare a blank geo-environmental test schedule (Clause 15.1), listing on one axis the following information for each sample:

- Borehole number
- Sample number of each sample taken
- Sample type of the sample
- Sample depth of the sample

and on the other axis the following:

- All suites of chemical tests that are identified with quantities in the Bill of Quantities, with separate sheets provided for solid, liquid and gas samples.

Reference shall be made to Clause S1.12.12 for transportation and scheduling of samples requirements

S1.20.2 Accreditation required (Clause 15.2)

Chemical laboratory testing shall be carried out to EN ISO/IEC 17025 or the national equivalent. Laboratory testing on soil samples shall conform to the Environment Agency MCERTS (Monitoring Certification Scheme), where applicable. MCERTS is required for, but not limited to, the analytes listed in Annex A of the Environment Agency publication *Performance Standard for Laboratories Undertaking Chemical Testing of Soil*, Version 4, March 2012.

For asbestos, the method of asbestos analysis used shall be accredited the UK Accreditation Service (UKAS) or Irish National Accreditation Board INAB; the use of non-accredited methods for asbestos analysis is not permitted. The quality control schemes used by the asbestos analysis laboratory shall comply with Application of ISO/IEC 17025 for asbestos sampling and testing, HSA (2013) Asbestos containing materials (ACMs) in workplaces and HSE HSG 248 (Asbestos: the analyst's guide for sampling, analysis and clearance procedures).

S1.20.3 Chemical testing for contamination (Clause 15.3)

The chemical testing required for contamination are detailed in the following tables: Suite E and K.

Draft results of the chemical analysis shall be provided to the Investigation Supervisor not more than 24 hours after they are available from the laboratory. The draft results of the chemical analysis shall be provided in electronic format using non-write protected Microsoft Excel® spreadsheets.

Requirements for the final reporting of the results of the contamination ground investigation are specified in Schedule S1.21 of the Specification. Notwithstanding any requirements in Schedule S1.21 to provide contamination ground investigation data in digital format, the final results of the chemical analysis shall also be provided in electronic format using non-write protected Microsoft Excel® spreadsheets.

All test results for the contamination ground investigation shall be accompanied by an unambiguous description of sample preparation, extraction and analysis method used.

The Contractor shall provide the following additional details in the reporting for the contamination ground investigation (which shall be regarded as the data quality assessment report):

- The full analytical procedure for each parameter determined, including the detection limit and susceptibility to interference of the method and an appropriate reference to the method.

Details of the chain of custody between sampling and analysis, including the time between sampling and analysis, storage procedures, procedures for quantifying analytical errors including data quality assessments and quality management procedures.

SCHEDULE 1.20.3: TEST SUITES

CHEMICAL LABORATORY TESTING FOR CONTAMINATION

Suite E – Soils

Nominated test laboratory? *	
Required testing turnaround times? *	See clause S1.12.12

Suite E – Soils Chemical Laboratory Testing for Contamination (S1.20.3)			
Determinand	**Detection level [required]/[offered]**	**Test method [required]/[offered]**	**Accreditation [required]/[offered]**
Leachate Sample			
CEN Leachate Generation L/S 10: 1			
As	0.02mg/kg		
Ba	0.5mg/kg		
Cd	0.004mg/kg		
Cr	0.5mg/kg		
Cu	0.5mg/kg		
Hg	0.0005mg/kg		
Mo	0.05mg/kg		
Ni	0.1mg/kg		
Pb	0.5mg/kg		
Sb	0.05mg/kg		
Se	0.05mg/kg		
Zn	0.5mg/kg		
Chloride	10mg/kg		
Fluoride	0.1mg/kg		
Sulphate Soluble	30mg/kg		
Total Phenols by HPLC	0.1mg/kg		
Dissolved Organic Carbon	20mg/kg		
Total Dissolved Solids	500mg/kg		
Soil Sample – Total Pollutant Content			
pH	Unitless		
Asbestos Screen – confirmation of presence, quantification if present			
Total organic Carbon	0.10%		
PCB (7 congeners)	1ug/kg		

Suite E – Soils Chemical Laboratory Testing for Contamination (S1.20.3)			
Determinand	**Detection level [required]/[offered]**	**Test method [required]/[offered]**	**Accreditation [required]/[offered]**
TPHCWG with BTEX and MTBE by GC FID	1mg/kg		
Mineral Oil (C8-C40) By Calculation	1mg/kg		
PAH (Speciated 17) by GC MS, including Coronene	1ug/kg		
Loss on Ignition	0.1%		
Metals:			
As	Low Level		
Ba	Low level		
Cd	Low level		
Cr (III and VI speciated)	Low level		
Cu	Low level		
Hg	Low level		
Mo	Low level		
Sb	Low level		
Zn	Low level		
Ni	Low level		
Pb	Low level		
Se	Low level		

Suite K – Herbicides & Pesticides

Nominated test laboratory? *	
Required testing turnaround times? *	See clause S1.12.12

Suite K - Chemical Laboratory Testing for Contamination (S1.20.3)			
Determinand	**Detection level [required]/[offered]**	**Test method [required]/[offered]**	**Accreditation [required]/[offered]**
SUITE K12 – Soil samples herbicides			
Triazine herbicides	0.1 mg/kg	Note K12a	
Phenoxy Acid Herbicides	0.1mg/kg	Note K12b	
Carbamates and Uron Herbicides	0.1 mg/kg	Note K12c	
Pyrethroid Insecticides	0.1mg/kg	Note K12d	
SUITE K13 – Soil samples pesticides			
Organochlorine Pesticides	0.1 mg/kg	Note K13a	
Organophosphorus Pesticides	0.1mg/kg	Note K13b	

Note K12a

Atraton, Simazine, Prometon, Atrazine, Propazine, Terbuthylazine, Simetryn, Ametryn, Prometryn

Note K12b

Clopyralid, Picloram, Benazolin, Bentazone, Bromoxynil, 4- CPA, 2,4 – D, 2,4 –DB, Dicamba, Dichlorprop, Diclofop, Fenoprop, Flamprop, Flamprop – isopropyl, Ioxynil, MCPA, MCPB, Mecoprop,

PCP, 2,4,5 – T, 2,3,6 – TBA, Triclopyr

Note K12c

Carbendazim, Carbetamide, Bromacil, Cyanazine, Methabenzathiazuron, Carbaryl, Propham, Methiocarb, Monuron, Pirimicarb, Chlortoluron, Isoproturon, Monolinuron, Diuron, Linuron, Chlorbufam, Chlorpropham

Note K12d

Permethrin, Cyhalothrin, Cyfluthrin, Cypermethrin, Fenvalerate, Deltamethrin

Note K13a

Pentachloroethane ,Hexachloroethane, 1,3,5-trichlorobenzene, 1,2,4-trichlorobenzene, 1,2,3-trichlorobenzene, Hexachlorobutadiene, 1,2,4,5-tetrachlorobenzene, Dichlobenil, Pentachlorobenzene, Tecnazene, Trifluralin, alpha-HCH, Hexachlorobenzene, beta-HCH, gamma-HCH (lindane), Quintozene, Propyzamide, delta-HCH, Chlorothalonil, Triallate, Heptachlor, Aldrin, Triadimefon, Isodrin, Pendimethalin, Cis-Heptachlor Epoxide, gamma-Chlordane (trans), o,p-DDE, alpha-Endosulphan, alpha-Chlordane (cis), p,p-DDE, Dieldrin, o,p-TDE, Endrin, beta-Endosulphan, Iprodione, p,p-TDE, o,p-DDT, Propiconazole I, Endosulphan sulphate, p,p-DDT, Propiconazole II, o,p-Methoxychlor, Fluroxypyr, p,p-Methoxychlor, Permethrin I, Permethrin II

Note K13b

Dichlorvos, Mevinphos, Methacriphos, Heptenophos, Tributylphosphate, Sulfotep, Phorate, Dimethoate, Propetamphos, Fonofos, Diazinon, Phosphamidon I, Disulfoton, Phosphamidon II, Chlorpyriphos-methyl, Methyl-Parathion, Fenitrothion, Pirimiphos-methyl, Malathion, Fenthion, Chlorpyriphos, Parathion, Chlorfenvinphos, Ethion, Triazophos, Carbophenothion, Triphenylphosphate, Phosmet, EPN, Phosalone, Azinphos-methyl, Azinphos-ethyl, Coumaphos

S1.20.4 Waste characterisation (Clause 15.4)

Not required

S1.20.5 Waste Acceptance Criteria testing (Clause 15.5) (Testing Suites H and I)

Not required

S1.20.6 Laboratory testing (Clause 15.6)

Not required

S1.20.7 Special laboratory testing (Clause 15.7)

Not required.

S1.21 Reporting (Specification Section 16) - particular restrictions/relaxations

S1.21.1 Form of exploratory hole logs (Clauses 16.1 and 16.2.1)

Where various methods of drilling are used to form a hole the form of the exploratory hole log shall be so as to present a continuous log e.g., cable percussive with rotary follow on shall be presented on one record. This shall also apply to a follow-on rotary undertaken within 1.5m of the initial cable percussion hole

S1.21.2 Information on exploratory hole logs (Clause 16.2.2)

The requirements of Clause 16.2.2 apply.

Exploratory hole locations shall be reported in Irish Transverse Mercator coordinates and relative to Ordnance Datum (Clause 16.2.2).

Soil and rock shall be described in accordance with I.S. EN ISO 14688-1, I.S. EN ISO 14688-2, I.S. EN ISO 14689-1 and BS 5930 by a Ground Practitioner as per Clause 2.3(c) of the Specification. Particular care shall be taken to describe the type and frequency of anthropogenic materials in Made Ground materials. Reference should be made to the AGS document, "Description of Anthropogenic Materials – A Practitioners Guide", 2018.

For rock strata, fracture spacings shall be reported.

S1.21.3 Variations to final digital data supply requirements (Clause 16.5.1)

Digital data of all fieldwork, monitoring and laboratory data (including contamination testing) are required (Clause 16.5).

The final digital data shall be issued at the same time as the final report.

Digital data shall be provided in AGS4 format (as specified in Association of Geotechnical and Geo-environmental Specialists *Electronic transfer of geotechnical and geo-environmental data* Version 4 and in the guidance documents and standard abbreviations published by AGS on www.ags.org.uk) and in accordance with the requirements specified in Annex 12 and Schedules S1.21.3 and S1.21.4.

In addition to .xls and .pdf formats, the Contractor shall provide geoenvironmental laboratory data from a laboratory certified to provide hwol format data.

All geoenvironmental (soil, water and gas) laboratory reports shall be provided in ESDAT format (ELDF)[3] to the Investigation Supervisor. Additionally, the Contractor's laboratory shall submit the geoenvironmental laboratory reports to "*ESdat_UK+arup_ie@ESdatLabSync.net*" and shall ensure these are validated and any errors resolved.

S1.21.4 Preliminary digital data (Clause 16.5.3)

Preliminary digital data are required. Requirements for preliminary digital data are specified in Annex 12 and Schedules S1.21.3 and S1.21.4.

S1.21.5 Type(s) of report required (Clause 16.6)

A Ground Investigation Factual Report is required. Specific requirements for the report are detailed in Schedule S1.21.8.

No hard copy of the draft report is required.

S1.21.6 Electronic report requirements (Clause 16.6.3)

The Ground Investigation Report, in both the draft version and final version, shall be presented in electronic format as a single collated file that includes text, exploratory hole records, laboratory test data, in-situ test data, all photographs and location plans. It shall be compiled as a bookmarked, non-copy protected, digitally-searchable portable document file (pdf).

The geo-environmental data shall be presented both in pdf format (within the Ground Investigation Report) and in spreadsheet format (Microsoft Excel® or equivalent). The spreadsheet shall present the data collated by type of test.

S1.21.7 Format and contents of Desk Study Report (Clause 16.7)

Not required.

S1.21.8 Contents of Ground Investigation Report (or specified part thereof) (Clause 16.8)

The part of the Ground Investigation Report prepared by the Contractor (termed herein the 'report' or the 'Ground Investigation Report') shall comprise only the factual reporting from the ground investigation (Clause 16.6 and Clause 16.8). No interpretation and evaluation of geotechnical information (as defined in Section 3.4.3 of IS EN 1997-1) is required from the Contractor.

The Ground Investigation Report shall conform to BS 5930 Section 10 and, as applicable, also to BS 10175 and BS 8576.

No additional information is required in the factual report (Clause 16.8).

S1.21.9 Contents of Geotechnical Interpretative or Design Report (or specified part thereof) (Clauses 16.9 and 16.10)

Not required.

S1.21.10 Times for supply of electronic information (Clause 16.11.1)

Requirements for the timing of the supply of electronic information (including draft logs, monitoring data, laboratory test schedules) are specified in the relevant Schedules herein.

The requirements for the timing of the supply of digital data are specified in Schedules S1.21.3 and S1.21.4.]

Attention is drawn to the Specification requirement for sequential numbering of data transmittals.

S1.21.11 Electronic information transmission media (Clause 16.11.2)

Electronic information including digital data (if any) shall be transmitted using a secure non-public electronic transmission system, which shall be subject to the approval of the Investigation Supervisor. Where hyperlinks to access/download electronic information are provided via email, the Contractor shall send each email notification to the Investigation Supervisor and also to any other email recipients named by the Investigation Supervisor.

In addition, CD(s) containing the final report in electronic format (see Schedule S1.21.6) and the digital data (if any) shall be provided with each hard copy of the final report (see Schedule S1.21.5). The CD(s) shall be affixed to each hard copy using a suitable wallet or envelope.

S1.21.12 Report approval (Clause 16.12)

The draft report shall be provided as an electronic file to the Investigation Supervisor for approval.

S1.22 Designer's risk assessment

The following table (overleaf) presents a risk assessment prepared by the designer of the ground investigation for the scope of ground investigation work presented in this Specification. The table does not include generic risks that would typically be encountered in any ground investigation at any site. The table focuses on risks that are particular to the planned scope of work at this site.

S1.23 Particular requirements relating to archaeology

Refer to S.1.8.3 & S1.8.8.

S1.22 Designer's risk assessment for the ground investigation (at the issue date of this document).

ARUP	Hazard Identification and Risk Assessment (Including Particular Risks & Other Significant Risks)	**Job Number**	284939-25
		Document Reference	ARP-ERW-P3-SP-001

Project	SLNCR Greenway	**Design Issue or Element**	Ground Investigation

Stage	**Scheme Stage**			**Pre-Tender Stage**			**Other (Pre-Construction Stage)**		
	Name	Hand Initial	Date	Name	Hand Initial	Date	Name	Hand Initial	Date
Designer	-	-	-	Cameron Kelly	CK	04/09/2026			
Project Manager	-	-	-	Emma Haggan					

Likelihood of Hazard occurring
L = Low (Seldom)
M = Medium (Reasonably Likely)
H = High (Certain/Nearly certain)

Severity of Harm
L = Minor Injury/Illness
M = Injury/Illness causing short term disability
H = Fatality or major injury/illness causing long term disability

Risk Assessment
L = Low Risk (No action)
M = Medium Risk (Action required unless good reason not to)
H = High Risk (Action required e.g. Design Change)

Refer to Arup Health & Safety Designer's Handbook
Detailed Design Project Flowchart for guidance on
form sign off and issue to PSDP.

Risk Table	*Severity*		
Likelihood	H	M	L
H	H	H	M
M	H	M	L
L	M	L	L

No.	Hazard	Design Mitigation measures	Other Possible Mitigation Measures (including measures by Contractor on site)	Residual Risk Assessment following mitigation measures		
				Likelihood	Severity	Risk Rating
1	Risk of accident involving existing buried services, including electricity, gas, water, telecommunications, drainage and other unrecorded services.	Available utility information has been reviewed and exploratory locations should be adjusted where known services or statutory stand off zones affect the proposed position. The design recognises that utility records may be incomplete or inaccurate. **HOLD POINT: Prior to the commencement of site works the Contractor, Project Manager and Investigation Supervisors shall liaise and agree on GI locations regarding interfaces with buried services and overhead lines.**	• Obtain current records from all relevant utility providers before works commence. • Walk over and scan every exploratory location using appropriate locating equipment, with calibrated equipment and a competent operator. • Excavate inspection pits to confirm the presence or absence of services before intrusive work. Relocate locations where safe clearance cannot be achieved. • Repeat the service avoidance process at every revised location and brief all personnel on emergency procedures.	L	H	M

No.	Hazard	Design Mitigation measures	Other Possible Mitigation Measures (including measures by Contractor on site)	Residual Risk Assessment following mitigation measures		
				Likelihood	Severity	Risk Rating
2	Overhead electricity and telecommunications services creating a risk of contact by drilling rigs, excavators, CPT rigs or raised equipment during set up and movement between locations.	Exploratory locations should be positioned away from overhead services where reasonably practicable. The linear nature of the works means plant access routes must also be considered.	• Assess every exploratory location and access route before mobilisation. • Identify overhead services in the location specific RAMS and comply with utility owner requirements and applicable safe clearances. • Use goalposts, height restrictions, a banksman and plant with suitable height limits where required. • Lower masts and booms before movement. If safe clearance cannot be maintained, stop work and agree an alternative location or method with the Investigation Supervisor.	L	H	M
3	Collision between GI plant or operatives and moving vehicles on public roads, at road crossings, on access tracks or while entering and leaving work areas.	The investigation layout uses multiple access points along the corridor. Locations should be adjusted where practicable to provide sufficient room for safe access, set up and traffic management.	• Prepare and implement location specific traffic management in accordance with the GI Specification and relevant approvals. • Provide safe plant access and egress, clear visibility, trained traffic management operatives and a banksman where required. • Use signs, barriers, cones, temporary lane control or closures as appropriate. • Maintain access for properties, emergency services and other road users.	L	H	M
4	Interaction with pedestrians, cyclists, landowners, agricultural workers and other members of the public within or adjacent to work areas.	Where practicable, exploratory locations should minimise conflict with publicly accessible routes and occupied land. Residual interfaces remain because the route crosses roads, settlements, farms and existing trails.	• Segregate work areas using suitable barriers or fencing and provide clear warning signs. • Provide safe pedestrian and cycle diversions where required. • Coordinate access with the Project Liaison Officers, landowners and occupiers before work starts. • Do not leave open holes, trip hazards, plant or materials unsecured. Maintain tidy work areas.	L	H	M
5	Unauthorised access to work areas, open holes, installations, plant or stored materials during working hours or when areas are unattended.	The dispersed linear work sites cannot be fully secured through design. Work should be planned so excavations are backfilled promptly and unattended hazards are minimised.	• Secure each active work area and control visitors. • Backfill trial pits on the day of excavation. Securely cover and fence any borehole or installation that remains open. • Protect completed monitoring installations against interference by people, livestock and vehicles. • Maintain emergency access and remove or secure plant, fuel and hazardous materials when unattended.	L	H	M
6	Person or plant falling into a trial pit or excavation, collapse of excavation sides, or trapping and burial of personnel.	No personnel entry into excavations is required. Trial pits are limited to the scheduled depth and are to be backfilled on completion of logging, sampling and testing.	• Do not permit personnel to enter excavations. • Keep plant, spoil and materials clear of excavation edges and avoid surcharge loading. • Use suitable battering, support or temporary works where ground or groundwater conditions require it. • Provide barriers and maintain visual contact with the excavator operator. Backfill pits on the day of completion.	L	H	M
7	Inadequate backfilling or reinstatement causing subsidence, trip hazards, vehicle damage, livestock injury or deterioration of roads and access tracks.	The Specification requires reinstatement of exploratory locations and unavoidable damage, with boreholes grouted and pits permanently backfilled.	• Use appropriate backfill materials and compact trial pits in controlled layers. • Reinstate paved surfaces, verges, agricultural land, fences, gates and drainage to the agreed standard. • Inspect and record completed reinstatement and rectify settlement or damage. • Agree final reinstatement with the Investigation Supervisor and relevant landowner or authority.	L	H	M

No.	Hazard	Design Mitigation measures	Other Possible Mitigation Measures (including measures by Contractor on site)	Residual Risk Assessment following mitigation measures		
				Likelihood	Severity	Risk Rating
8	Exposure to contaminated soil, groundwater, drilling fluid, vapours or hazardous biological material, including material associated with former railway use, made ground, agricultural land and animal waste.	The corridor has been designated YELLOW for potentially contaminated land. Geoenvironmental investigation, representative sampling and contamination controls are specified.	• Prepare contamination specific RAMS and brief staff on indicators such as staining, odour, unusual fill and free product. • Provide appropriate PPE, hygiene and decontamination facilities. Prohibit eating and smoking in affected work areas. • Control arisings, pumped water and drilling returns to prevent exposure and environmental release. • Stop affected work and notify the Investigation Supervisor if unexpected or significant contamination is encountered.	L	H	M
9	Exposure to asbestos containing material within made ground or former railway related fill.	Asbestos screening is included within the geoenvironmental testing requirements and asbestos specific guidance is referenced in the Specification.	• Provide asbestos awareness training and complete an asbestos risk assessment before intrusive work in potentially affected ground. • Avoid dust generation and use suitable PPE and respiratory protective equipment where the risk assessment requires it. • Stop work, isolate the area and notify the Investigation Supervisor if suspected asbestos is encountered. • Use an appropriately competent and accredited specialist where further assessment or licensed work is required.	L	H	M
10	Contraction of leptospirosis or other illness through contact with water, wet ground, soil, animal urine or droppings.	The route includes agricultural land, watercourses, floodplains and wet ground where biological exposure cannot be eliminated through design.	• Cover cuts and abrasions, wear waterproof gloves and suitable clothing, and avoid hand to mouth contact. • Provide washing facilities and antiseptic hand cleanser. Wash before eating, drinking or smoking and after work. • Brief personnel on symptoms and the need to obtain prompt medical advice following suspected exposure.	L	H	M
11	Ground gas, vapours or oxygen deficient conditions arising from made ground, peat, contamination, voids or enclosed excavations, with potential for illness, fire or explosion.	Personnel entry into excavations is not required. The Specification identifies potential gas and vapour sources and includes monitoring requirements where applicable.	• Assess gas and vapour risks in RAMS. Use calibrated monitoring equipment where required. • Control ignition sources and do not use air flush in contaminated soils or made ground. • Stop work and withdraw personnel if gas, vapour, odour, pressure or oxygen concerns are indicated. Notify the Investigation Supervisor. • Provide ventilation, exclusion zones and suitable PPE where justified by the assessment.	L	H	M
12	Soft ground, peat, alluvium or saturated ground causing loss of vehicle mobility, plant instability, bogging, overturning or harm to personnel.	The investigation targets areas of peat and soft superficial deposits. Locations may be moved where this does not compromise the investigation objectives.	• Complete a location specific ground bearing assessment before moving or setting up plant. • Use suitable low ground pressure plant, bog mats or a designed working platform where required. • Keep plant level and within manufacturer limits. Use a banksman during difficult access and set up. • Stop work and agree relocation where a stable platform or safe access cannot be achieved.	L	H	M
13	Sloping terrain, existing cuttings, embankments and bridge approaches causing slips, falls, runaway plant, overturning or instability during access and set up.	Exploratory locations should be adjusted to flatter ground where practicable while maintaining the investigation objective.	• Assess gradients, edge distances, access routes and ground conditions before mobilisation. • Use suitable tracked plant, restraint, benching or a designed working platform where required. • Maintain exclusion zones from slope crests, toes and unprotected edges. • Stop work and agree relocation where safe access or stable set up cannot be achieved.	L	H	M

No.	Hazard	Design Mitigation measures	Other Possible Mitigation Measures (including measures by Contractor on site)	Residual Risk Assessment following mitigation measures		
				Likelihood	Severity	Risk Rating
14	Peat slope or earthwork instability triggered by plant loading, excavation, drilling, water movement or vibration, causing injury, equipment loss or environmental harm.	Peat probing and investigation locations should minimise concentrated loading and avoid visibly unstable areas where practicable.	• Review available peat and slope information and inspect for cracking, bulging, seepage or previous movement before work. • Minimise plant loading, excavation volume, vibration and water discharge on or above peat slopes. • Establish escape routes and exclusion zones. Stop work immediately if movement or warning signs are observed. • Agree specialist assessment, alternative access or relocation with the Investigation Supervisor where instability is suspected.	L	H	M
15	Shallow groundwater, flooding or rapidly changing water levels causing excavation collapse, loss of ground, plant instability or persons becoming trapped.	The route includes floodplains and areas where shallow groundwater is anticipated. Works sequencing is required to remain flexible for flood events.	• Check weather and flood conditions before work and suspend activities where safe access, egress or stability may be affected. • Use suitable excavation support, battering, pumping controls and plant positioning. • Do not permit personnel entry into excavations. Provide an emergency response plan for inundation. • Store fuels and materials outside flood prone areas where practicable.	L	H	M
16	Working adjacent to rivers, streams, drains, culverts, wetlands or other water bodies, with risk of drowning, bank collapse or environmental pollution.	Exploratory positions should maintain a safe stand off from water and unstable banks where practicable. Watercourse and wetland constraints remain along the corridor.	• Undertake a location specific water safety assessment and establish rescue arrangements. • Confirm bank and working platform stability and maintain a suitable stand off from edges. • Provide personal flotation equipment where the assessment requires it, with suitable access and egress. • Prevent discharge of drilling fluids, grout, silt, fuel or contaminated water. Provide spill response equipment and inspect plant for leaks.	L	H	M
17	Karstified limestone, cavities, swallow holes, dissolution features or unrecorded voids causing sudden loss of support, collapse, loss of flush or instability.	Targeted geophysics and boreholes are included to investigate potentially karstified areas. The hazard cannot be fully eliminated because void locations and geometry are uncertain.	• Brief drilling crews on areas of potential karst. Monitor penetration, flush returns and ground response continuously. • Stop work following sudden loss of flush, unexpected voids, settlement, ground cracking or gas emissions. Establish an exclusion zone and notify the Investigation Supervisor. • Use suitable casing, controlled drilling methods and plant positioning. Do not discharge fluids into suspected karst features. • Reassess and relocate or revise the method before work resumes.	L	H	M
18	Former quarries, pits, spoil, infilled ground or recorded or unrecorded workings causing voids, loose fill, contamination or ground instability.	No mine workings or mineral extraction sites were identified in the Stage 1 or Stage 2 assessments, but historic quarries were excluded and cannot be ruled out without further review.	• Review current desk study information and complete the pre investigation walkover for evidence of pits, spoil, entrances, hollows or settlement. • Brief crews to report unexpected voids, loss of flush, loose fill, gas or ground movement. • Stop work, secure the area and notify the Investigation Supervisor where suspected workings or unstable infill are encountered. • Relocate or revise the investigation method following risk reassessment.	L	H	M
19	Instability or damage to existing railway embankments, cuttings, bridge abutments, retaining structures, culverts, walls or other ageing infrastructure due to plant loading or intrusive works.	Locations at structures and earthworks should be positioned to obtain the required information while avoiding unnecessary loading close to edges, foundations and visibly defective areas.	• Inspect the work area and available structural information before mobilisation. • Maintain appropriate stand offs from edges, walls, abutments, culverts and foundations. Do not surcharge structures or slopes with plant or spoil. • Use smaller plant, alternative access or relocation where bearing capacity, condition or geometry is uncertain. • Stop work and notify the Investigation Supervisor if movement, cracking, distress or unexpected voiding is observed.	L	H	M

No.	Hazard	Design Mitigation measures	Other Possible Mitigation Measures (including measures by Contractor on site)	Residual Risk Assessment following mitigation measures		
				Likelihood	Severity	Risk Rating
20	Protected species, designated sites, sensitive habitats and non native invasive plants being harmed or spread by GI access, plant movement or intrusive works.	Ecological constraints drawings and specialist attendance are specified. The works programme must remain flexible to accommodate approvals, surveys and ecological restrictions.	• Review ecological information before accessing each location and comply with the Ecological Clerk of Works instructions. • Use approved access routes and exclusion zones. Clean plant where required and do not work within invasive species areas unless an approved management plan is in place. • Stop work and notify the Investigation Supervisor if protected species, nests, setts or unexpected invasive plants are encountered. • Prevent fuel, silt, drilling fluid and grout entering designated habitats or watercourses.	L	H	M
21	Damage to known or previously unidentified archaeological remains, recorded monuments, protected structures or railway heritage features.	Known constraints are shown on the archaeological drawings and archaeological specialist attendance is specified where required.	• Review archaeological information before work and coordinate sensitive locations with the Project Archaeological Consultant. • Comply with exclusion zones, permits, monitoring and archaeological supervision requirements. • Stop work immediately if artefacts, structures, deposits or other potential remains are encountered. Protect the area and notify the Investigation Supervisor.	L	H	M
22	Noise, vibration, flying debris, high pressure drilling fluids or ejected material causing injury or disturbance, particularly during rotary drilling, breaking, SPT, dynamic probing and geophysical work.	The Specification includes noise controls and specific precautions for opening core barrels when air flush is used. Work near sensitive receptors should be planned to minimise effects.	• Use maintained equipment, guards, silencers and suitable eye, hearing and body protection. • Establish exclusion zones around rigs, hammers, moving rods and core barrels. No person is to stand in line with the end of a pressurised core barrel. • Control drilling fluid returns and depressurise equipment before opening or maintenance. • Use temporary acoustic screening where instructed and coordinate noisy work with landowners and sensitive receptors.	L	H	M
23	Manual handling, lifting operations, rotating equipment, moving rods and heavy samples causing crush, entanglement or musculoskeletal injury.	The specified methods use standard GI equipment that can be safely operated by competent personnel with suitable mechanical assistance.	• Prepare lifting plans where required and use certified lifting accessories, mechanical aids and team lifts. • Keep personnel clear of suspended loads, rotating rods and pinch points. Fit and maintain guards and emergency stops. • Use competent operators and a banksman for plant movements and lifting operations. • Provide task specific training and suitable gloves, footwear and other PPE.	L	H	M
24	Unsafe storage, handling or refuelling of plant, fuel, oils, gas cylinders, chemicals, samples and contaminated arisings causing fire, spill, exposure or unauthorised access.	The works are dispersed across private land and public interfaces. Storage at each location should be minimised and suitable compounds used where required.	• Store fuel, chemicals and cylinders securely, upright where applicable, with segregation and secondary containment. • Refuel in controlled areas away from drains, watercourses and sensitive habitats. Provide spill kits and trained responders. • Label, secure and transport samples and hazardous arisings in suitable containers. • Remove waste using authorised routes and do not leave hazardous materials unattended.	L	H	M
25	Slips, trips and falls arising from uneven ground, vegetation, mud, hoses, rods, cables, temporary fencing, excavations and poor lighting.	The route includes varied terrain and cannot be made uniformly level through design. Work areas should be kept as compact and orderly as practicable.	• Maintain good housekeeping and defined walkways. Route hoses and cables to avoid access routes or protect them with suitable covers. • Provide suitable footwear and task lighting. Suspend work where visibility is inadequate. • Remove spoil, waste and unused equipment promptly and reinstate trip hazards.	L	M	L
26	Adverse weather, poor light, heat, cold, wind, lightning or lone and remote working causing injury, delayed rescue or loss of control of plant.	The programme is required to remain flexible for weather and flood events across the long, dispersed corridor.	• Monitor forecasts and define stop work criteria for wind, lightning, flooding, heat, cold and visibility. • Provide suitable clothing, lighting, communications, welfare and first aid. • Use check in arrangements and avoid lone working for intrusive activities or remote locations. • Confirm location details and emergency access for each work site.	L	H	M

No.	Hazard	Design Mitigation measures	Other Possible Mitigation Measures (including measures by Contractor on site)	Residual Risk Assessment following mitigation measures		
				Likelihood	Severity	Risk Rating
27	Vehicle load, width, height or access restrictions at existing bridges, culverts, access tracks or other structures may prevent safe access by GI vehicles and plant.	Available information on bridges, culverts and proposed access routes should be reviewed against the dimensions and operating weight of the proposed GI plant. Alternative access or smaller plant should be considered where restrictions are identified.	Contractor to complete a route and access assessment before mobilisation. Confirm vehicle and plant weights, dimensions and axle loads against posted or notified restrictions. Identify alternative access routes or use smaller plant where restrictions would be exceeded. Obtain approval from the relevant road, bridge or land authority where required. Do not cross any structure where its capacity or suitability has not been confirmed.	L	M	L
28	Restricted sightlines for road users approaching roadside exploratory locations, site access points or locations where GI plant enters or leaves the public road.	Exploratory locations and access points should be selected to provide suitable visibility where reasonably practicable. Locations should be moved where available sightlines would prevent safe traffic management or plant access.	Contractor to assess sightlines at each roadside location and access point before mobilisation. Provide suitable advance warning signs, traffic control, temporary speed restrictions or stop and go arrangements where required. Use vehicle mounted warning beacons and a banksman during plant access and egress. Schedule works outside peak traffic periods where practicable.	L	H	M
29	Risk of injury to operatives due to proximity to moving, reversing, slewing or operating plant and equipment.	Exploratory locations should provide sufficient space for plant set up, operation and segregation of personnel where reasonably practicable. Smaller plant or an alternative location should be considered where space is restricted.	Establish plant exclusion zones and clearly defined pedestrian routes. Use a trained banksman during reversing, tracking and slewing operations. Prevent personnel entering plant blind spots or standing within the operating radius of rigs and excavators. Operators are to stop plant movement where visual contact with the banksman is lost.	L	H	M

Schedule 2. Exploratory Holes

Provisional locations of exploratory holes are shown in the Drawings. The actual location of each exploratory hole shall be agreed between the Contractor and Investigation Supervisor taking account of relevant constraints including, but not limited to, access and location of services.

Table 3 Schedule 2 Exploratory Holes

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
COUNTY SLIGO								
BH101	CP + RC	15	568996.55	832848.10	n/a	SPT, GWL	Hardstanding/asphalt	GEO, ENV**
BH102	CP + RC	15	568783.86	832106.35	n/a	SPT	Hardstanding/asphalt	GEO, ENV**
BH103	CP + RC	15	568312.03	831483.53	n/a	SPT, GWL	Hardstanding	GEO, ENV**
BH104	CP + RC	15	567753.31	830915.43	n/a	SPT	Topsoil	GEO, ENV**
BH105	CP + RC	15	567653.60	830764.88	n/a	SPT, GWL	Topsoil	GEO, ENV**
BH106	CP + RC	15	567569.38	830601.03	n/a	SPT	Topsoil	GEO, ENV**
BH107	CP + RC	15	567492.79	830445.02	n/a	SPT, GWL	Topsoil	GEO, ENV**
BH108	CP + RC	15	567435.06	830226.78	n/a	SPT	Topsoil	GEO, ENV**
BH109	CP + RC	15	567272.38	829066.43	n/a	SPT, GWL	Topsoil	GEO, ENV**
BH110	CP + RC	30	568543.99	826915.90	n/a	SPT, GWL	Existing bridge abutment	GEO, ENV**, GBS
BH111	CP + RC	30	568546.82	826885.83	n/a	SPT	Existing bridge abutment	GEO, ENV**, GBS
BH112	CP + RC	15	568411.25	826538.51	n/a	SPT, GWL	Topsoil	GEO, ENV**

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
BH113	CP + RC	30	569830.96	826780.97	n/a	SPT, GWL	Existing railway embankment	GEO, ENV**, GBS
BH114	CP + RC	30	569851.89	826784.98	n/a	SPT	Existing railway embankment	GEO, ENV**, GBS
BH115	CP + RC	15	570669.37	826903.16	n/a	SPT	Topsoil	GEO, ENV**
BH116	CP + RC	15	571188.24	827073.44	n/a	SPT, GWL	Topsoil	GEO, ENV**
BH117	CP + RC	15	571852.01	827273.26	n/a	SPT	Topsoil	GEO, ENV**
BH118	CP + RC	30	572506.79	827438.49	n/a	SPT, GWL	Existing railway embankment	GEO, ENV**, GBS
BH119	CP + RC	30	572538.55	827446.64	n/a	SPT	Existing railway embankment	GEO, ENV**, GBS
BH120	CP + RC	30	573390.63	827606.53	n/a	SPT, GWL	Existing railway embankment	GEO, ENV**, GBS
BH121	CP + RC	30	573402.32	827606.81	n/a	SPT	Existing railway embankment	GEO, ENV**, GBS
BH122	CP + RC	30	573697.50	827613.64	n/a	SPT, GWL	Existing railway embankment	GEO, ENV**, GBS
BH123	CP + RC	30	573707.86	827613.87	n/a	SPT	Existing railway embankment	GEO, ENV**, GBS
BH124	CP + RC	15	575291.24	827563.05	n/a	SPT, GWL	Topsoil	GEO, ENV**
BH125	CP + RC	15	576055.96	827383.24	n/a	SPT	Topsoil	GEO, ENV**
CP101	CP	10	567323.10	830106.29	n/a	SPT, GWL	Topsoil	GEO, ENV**
CP102	CP	10	567344.14	830030.68	n/a	SPT	Topsoil	GEO, ENV**
CP103	CP	10	567304.30	829921.91	n/a	SPT, GWL	Topsoil	GEO, ENV**

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
CP104	CP	10	567293.28	829817.71	n/a	SPT	Topsoil	GEO, ENV**
CP105	CP	10	567318.50	829749.89	n/a	SPT, GWL	Topsoil	GEO, ENV**
CP106	CP	10	567371.17	829544.79	n/a	SPT	Topsoil	GEO, ENV**
CP107	CP	10	567346.36	829464.58	n/a	SPT, GWL	Topsoil	GEO, ENV**
CP108	CP	10	570973.83	827024.17	n/a	SPT	Topsoil	GEO, ENV**
CP109	CP	10	572335.00	827385.65	n/a	SPT	Topsoil	GEO, ENV**
CP110	CP	10	574993.89	827592.18	n/a	SPT, GWL	Topsoil	GEO, ENV**
CPT101	CPTU	20	568385.01	831560.35	n/a	n/a	Topsoil	
CPT102	CPTU	20	568245.12	831416.55	n/a	n/a	Topsoil	
CPT103	CPTU	20	568177.36	831347.01	n/a	n/a	Topsoil	
CPT104	CPTU	20	568114.19	831274.64	n/a	n/a	Topsoil	
CPT105	CPTU	20	568044.81	831196.08	n/a	n/a	Topsoil	
CPT106	CPTU	20	567983.80	831128.95	n/a	n/a	Topsoil	
CPT107	CPTU	20	567912.92	831071.41	n/a	n/a	Topsoil	
CPT108	CPTU	20	567843.50	831009.49	n/a	n/a	Topsoil	
CPT109	CPTU	20	567701.55	830850.19	n/a	n/a	Topsoil	
CPT110	CPTU	20	567612.80	830693.54	n/a	n/a	Topsoil	
CPT111	CPTU	20	567540.94	830510.42	n/a	n/a	Topsoil	
CPT112	CPTU	20	567484.12	830343.64	n/a	n/a	Topsoil	

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
CPT113	CPTU	20	569025.77	826606.62	n/a	n/a	Topsoil	
CPT114	CPTU	20	572319.94	827338.72	n/a	n/a	Topsoil	
CPT115	CPTU	20	573774.29	827627.74	n/a	n/a	Topsoil	
CPT116	CPTU	20	573871.75	827635.09	n/a	n/a	Topsoil	
CPT117	CPTU	20	573962.99	827628.82	n/a	n/a	Topsoil	
CPT118	CPTU	20	574057.50	827615.66	n/a	n/a	Topsoil	
CPT119	CPTU	20	575947.43	827443.22	n/a	n/a	Topsoil	
CPT120	CPTU	20	576165.35	827379.70	n/a	n/a	Topsoil	
CPT121	CPTU	20	576274.31	827369.66	n/a	n/a	Topsoil	
CPT122	CPTU	20	576378.43	827467.80	n/a	n/a	Topsoil	
CPT123	CPTU	20	576443.75	827492.40	n/a	n/a	Topsoil	
CPT124	CPTU	20	576510.36	827523.41	n/a	n/a	Topsoil	
DPSH101	DPSH	8	575804.71	827518.62	n/a	n/a	Topsoil	
DPSH102	DPSH	8	576909.37	827719.98	n/a	n/a	Topsoil	
TP101	TP + DP	3	568954.33	832668.68	n/a	HV	Hardstanding/asphalt	GEO, ENV
TP102	TP + DP	3	568916.26	832470.94	n/a	HV	Hardstanding/asphalt	GEO
TP103	TP + DP	3	568879.72	832281.51	n/a	HV	Hardstanding/asphalt	GEO, ENV
TP104	TP + DP	3	568635.70	831967.66	n/a	HV	Hardstanding/asphalt	GEO
TP105	TP + DP	3	568500.58	831825.82	n/a	HV	Hardstanding/asphalt	GEO, ENV

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
TP106	TP + DP	3	568454.06	831650.30	n/a	HV	Hardstanding/asphalt	GEO
TP107	TP + DP	3	567288.97	829219.68	n/a	HV	Hardstanding/asphalt	GEO, ENV
TP108	TP + DP	3	567162.27	829017.48	n/a	HV	Hardstanding/asphalt	GEO, ENV
TP109	TP	3	568541.32	826916.07	n/a	HV	Topsoil	GEO
TP110	TP	3	568544.04	826885.66	n/a	HV	Hardstanding/gravel	GEO
TP111	TP + DP	3	568448.97	826691.10	n/a	HV	Topsoil	GEO, ENV
TP112	TP + DP	3	568250.46	826498.58	n/a	HV	Hardstanding/asphalt	GEO
TP113	TP + DP	3	568110.31	826465.37	n/a	HV	Hardstanding/asphalt	GEO, ENV
TP114	TP + DP	3	568616.18	826501.20	n/a	HV	Topsoil	GEO
TP115	TP + DP	3	568814.09	826535.36	n/a	HV	Topsoil	GEO, ENV
TP116	TP + DP	3	569394.03	826697.44	n/a	HV	Existing railway embankment	GEO
TP117	TP	3	569831.31	826777.02	n/a	HV	Existing railway embankment	GEO
TP118	TP	3	569852.94	826780.86	n/a	HV	Existing railway embankment	GEO
TP119	TP + DP	3	570173.66	826846.58	n/a	HV	Existing railway embankment	GEO, ENV
TP120	TP + DP	3	570476.90	826899.67	n/a	HV	Existing railway embankment	GEO
TP121	TP + DP	3	571276.29	827125.53	n/a	HV	Existing railway embankment	GEO, ENV

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
TP122	TP + DP	3	571499.66	827184.22	n/a	HV	Existing railway embankment	GEO
TP123	TP + DP	3	571672.91	827228.26	n/a	HV	Existing railway embankment	GEO, ENV
TP124	TP + DP	3	572070.98	827303.38	n/a	HV	Topsoil	GEO
TP125	TP + DP	3	572216.21	827326.70	n/a	HV	Topsoil	GEO, ENV
TP126	TP	3	572507.72	827436.00	n/a	HV	Existing railway embankment	GEO
TP127	TP	3	572539.29	827444.38	n/a	HV	Existing railway embankment	GEO
TP128	TP + DP	3	572915.46	827540.34	n/a	HV	Existing railway embankment	GEO, ENV
TP129	TP	3	573390.67	827605.41	n/a	HV	Existing railway embankment	GEO
TP130	TP	3	573402.27	827605.30	n/a	HV	Existing railway embankment	GEO
TP131	TP	3	573697.39	827612.63	n/a	HV	Topsoil	GEO
TP132	TP	3	573707.89	827612.97	n/a	HV	Topsoil	GEO
TP133	TP + DP	3	574536.15	827618.87	n/a	HV	Existing railway embankment	GEO, ENV
TP134	TP + DP	3	574960.65	827622.30	n/a	HV	Existing railway embankment	GEO
TP135	TP + DP	3	575136.88	827595.40	n/a	HV	Topsoil	GEO, ENV
TP136	TP + DP	3	575502.99	827608.12	n/a	HV	Topsoil	GEO

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
TP137	TP + DP	3	576416.37	827663.07	n/a	HV	Topsoil	GEO, ENV
TP138	TP + DP	3	576300.50	827843.94	n/a	HV	Hardstanding/asphalt	GEO
TP139	TP + DP	3	576584.80	827598.95	n/a	HV	Topsoil	GEO, ENV
TP140	TP + DP	3	576724.68	827662.08	n/a	HV	Topsoil	GEO
TP141	TP + DP	3	577231.13	827796.26	n/a	HV	Topsoil	GEO, ENV
TP142	TP + DP	3	577320.19	827898.92	n/a	HV	Topsoil	GEO
WS101	WS	8	575800.39	827521.41	n/a	SPT, GWL	Topsoil	GEO, ENV**
WS102	WS	8	576895.66	827716.54	n/a	SPT	Topsoil	GEO, ENV**
COUNTY LEITRIM								
BH201	CP + RC	30	577924.68	828527.86	n/a	SPT, GWL	Topsoil	GEO, ENV**, GBS
BH202	CP + RC	30	577913.73	828551.80	n/a	SPT	Existing railway embankment	GEO, ENV**, GBS
BH203	CP + RC	30	579544.63	829604.25	n/a	SPT, GWL	Topsoil	GEO, ENV**, GBS
BH204	CP + RC	30	579575.79	829597.16	n/a	SPT	Hardstanding	GEO, ENV**, GBS
BH205	CP + RC	30	580456.19	830905.23	n/a	SPT, GWL	Existing bridge abutment	GEO, ENV**, GBS
BH206	CP + RC	30	580472.68	830936.74	n/a	SPT	Existing bridge abutment	GEO, ENV**, GBS
BH207	CP + RC	30	582102.81	830363.44	n/a	SPT, GWL	Existing railway embankment	GEO, ENV**, GBS
BH208	CP + RC	30	582135.68	830384.53	n/a	SPT	Existing railway embankment	GEO, ENV**, GBS

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
BH209	CP + RC	30	587653.21	836858.48	n/a	SPT, GWL	Topsoil	GEO, ENV**, GBS
BH210	CP + RC	30	587661.94	836869.24	n/a	SPT	Topsoil	GEO, ENV**, GBS
BH211	CP + RC	30	588948.43	839248.33	n/a	SPT, GWL	Topsoil	GEO, ENV**, GBS
BH212	CP + RC	30	589286.99	839286.02	n/a	SPT, GWL	Hardstanding	GEO, ENV**, GBS
BH213	CP + RC	30	589307.85	839288.73	n/a	SPT	Hardstanding	GEO, ENV**, GBS
BH214	CP + RC	30	590801.55	839682.79	n/a	SPT, GWL	Topsoil	GEO, ENV**, GBS
BH215	CP + RC	30	590827.53	839683.43	n/a	SPT	Topsoil	GEO, ENV**, GBS
BH216	CP + RC	30	591633.23	839663.90	n/a	SPT, GWL	Hardstanding	GEO, ENV**, GBS
BH217	CP + RC	30	591641.57	839662.67	n/a	SPT	Topsoil	GEO, ENV**, GBS
BH218	CP + RC	15	592657.09	839488.41	n/a	SPT, GWL	Topsoil	GEO, ENV**
BH219	CP + RC	15	595451.46	838466.71	n/a	SPT	Topsoil	GEO, ENV**
BH220	CP + RC	15	594014.69	838897.49	n/a	SPT	Existing railway embankment	GEO, ENV**
BH221	CP + RC	15	594736.83	838586.77	n/a	SPT, GWL	Existing railway embankment	GEO, ENV**
BH222	CP + RC	30	598725.10	837668.50	n/a	SPT, GWL	Topsoil	GEO, ENV**, GBS
BH223	CP + RC	30	598746.74	837660.28	n/a	SPT	Topsoil	GEO, ENV**, GBS
BH224	CP + RC	15	600391.04	837380.79	n/a	SPT, GWL	Topsoil	GEO, ENV**
BH225	CP + RC	15	600812.67	837466.04	n/a	SPT	Topsoil	GEO, ENV**
BH226	CP + RC	30	601256.39	837371.90	n/a	SPT, GWL	Existing railway embankment	GEO, ENV**, GBS

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
BH227	CP + RC	30	601265.63	837368.59	n/a	SPT	Existing railway embankment	GEO, ENV**, GBS
CPT201	CPTU	20	587313.86	836233.68	n/a	n/a	Topsoil	
CPT202	CPTU	20	587378.94	836306.43	n/a	n/a	Topsoil	
CPT203	CPTU	20	587443.51	836379.83	n/a	n/a	Topsoil	
CPT204	CPTU	20	587494.44	836470.45	n/a	n/a	Topsoil	
CPT205	CPTU	20	587527.22	836566.22	n/a	n/a	Topsoil	
CPT206	CPTU	20	587559.08	836659.58	n/a	n/a	Topsoil	
CPT207	CPTU	20	587642.74	836691.44	n/a	n/a	Topsoil	
CPT208	CPTU	20	587624.01	836778.61	n/a	n/a	Topsoil	
CPT209	CPTU	20	587729.77	836948.90	n/a	n/a	Topsoil	
CPT210	CPTU	20	587789.81	837028.74	n/a	n/a	Topsoil	
CPT211	CPTU	20	587869.28	837128.43	n/a	n/a	Topsoil	
CPT212	CPTU	20	587925.82	837202.46	n/a	n/a	Topsoil	
CPT213	CPTU	20	587971.32	837262.84	n/a	n/a	Topsoil	
CPT214	CPTU	20	588029.00	837344.79	n/a	n/a	Topsoil	
CPT215	CPTU	20	588090.24	837423.43	n/a	n/a	Topsoil	
CPT216	CPTU	20	588216.64	837585.76	n/a	n/a	Topsoil	
CPT217	CPTU	20	588274.98	837660.69	n/a	n/a	Topsoil	
CPT218	CPTU	20	588395.71	837820.32	n/a	n/a	Topsoil	

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
CPT219	CPTU	20	588457.14	837904.45	n/a	n/a	Topsoil	
CPT220	CPTU	20	588490.64	837953.53	n/a	n/a	Topsoil	
DPSH201	DPSH	8	577353.92	827989.13	n/a	n/a	Topsoil	
DPSH202	DPSH	8	579123.79	829213.32	n/a	n/a	Vegetation / Shrubs	
DPSH203	DPSH	8	580480.98	830405.78	n/a	n/a	Hardstanding	
DPSH204	DPSH	8	581252.78	830207.31	n/a	n/a	Topsoil	
DPSH205	DPSH	8	581830.29	830190.17	n/a	n/a	Vegetation / Shrubs	
DPSH206	DPSH	8	582058.69	830335.14	n/a	n/a	Existing railway embankment	
DPSH207	DPSH	8	583025.16	831263.53	n/a	n/a	Vegetation / Shrubs / Existing railway embankment	
DPSH208	DPSH	8	583687.29	832228.27	n/a	n/a	Topsoil	
DPSH209	DPSH	8	584381.29	832744.77	n/a	n/a	Existing railway embankment	
DPSH210	DPSH	8	585440.01	833722.04	n/a	n/a	Existing railway embankment	
DPSH211	DPSH	8	586200.58	834917.53	n/a	n/a	Topsoil	
DPSH212	DPSH	8	586668.78	835362.77	n/a	n/a	Topsoil	
DPSH213	DPSH	8	586805.22	835591.86	n/a	n/a	Topsoil	
DPSH214	DPSH	8	586981.98	835792.22	n/a	n/a	Topsoil	
DPSH215	DPSH	8	588131.34	837476.21	n/a	n/a	Topsoil	

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
DPSH216	DPSH	8	588347.24	837754.40	n/a	n/a	Topsoil	
DPSH217	DPSH	8	588755.85	839258.28	n/a	n/a	Topsoil	
DPSH218	DPSH	8	588815.48	839243.68	n/a	n/a	Topsoil	
DPSH219	DPSH	8	592557.25	839541.28	n/a	n/a	Topsoil	
DPSH220	DPSH	8	589798.46	839736.13	n/a	n/a	Topsoil	
DPSH221	DPSH	8	590640.60	839683.99	n/a	n/a	Existing railway embankment	
DPSH222	DPSH	8	590986.13	839695.42	n/a	n/a	Topsoil	
DPSH223	DPSH	8	591487.36	839679.27	n/a	n/a	Hardstanding	
DPSH224	DPSH	8	592909.91	839293.21	n/a	n/a	Topsoil	
DPSH225	DPSH	8	593497.22	839087.16	n/a	n/a	Existing railway embankment	
DPSH226	DPSH	8	595205.87	838520.56	n/a	n/a	Existing railway embankment / Topsoil	
DPSH227	DPSH	8	596075.13	838319.68	n/a	n/a	Topsoil	
DPSH228	DPSH	8	595368.98	838491.63	n/a	n/a	Existing railway embankment / Topsoil	
DPSH229	DPSH	8	598827.68	837656.73	n/a	n/a	Topsoil	
DPSH230	DPSH	8	599627.40	837745.69	n/a	n/a	Vegetation / Shrubs	
DPSH231	DPSH	8	599658.64	837531.97	n/a	n/a	Topsoil	

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
DPSH232	DPSH	8	600149.49	837406.68	n/a	n/a	Topsoil	
DPSH233	DPSH	8	600609.26	837435.15	n/a	n/a	Topsoil	
DPSH234	DPSH	8	600670.03	837409.46	n/a	n/a	Topsoil	
DPSH235	DPSH	8	600747.01	837377.87	n/a	n/a	Topsoil	
TP201	TP + DP	3	577542.40	828115.52	n/a	HV	Topsoil	GEO, ENV
TP202	TP + DP	3	577685.30	828204.63	n/a	HV	Topsoil	GEO
TP203	TP + DP	3	577853.71	828310.91	n/a	HV	Topsoil	GEO, ENV
TP204	TP	3	577927.97	828527.53	n/a	HV	Vegetation / Shrubs	GEO
TP205	TP	3	577912.68	828547.60	n/a	HV	Existing railway embankment	GEO
TP206	TP + DP	3	578035.95	828712.10	n/a	HV	Existing railway embankment	GEO, ENV
TP207	TP + DP	3	578249.32	828855.05	n/a	HV	Vegetation / Shrubs / Existing railway embankment	GEO
TP208	TP + DP	3	578635.90	828968.90	n/a	HV	Existing railway embankment	GEO, ENV
TP209	TP + DP	3	578813.32	829060.07	n/a	HV	Topsoil / Existing railway embankment	GEO
TP210	TP + DP	3	578990.22	829145.52	n/a	HV	Topsoil	GEO, ENV
TP211	TP + DP	3	579291.46	829369.60	n/a	HV	Vegetation / Shrubs	GEO
TP212	TP + DP	3	579457.91	829524.74	n/a	HV	Vegetation / Shrubs	GEO, ENV

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
TP213	TP	3	579546.21	829604.99	n/a	HV	Vegetation / Shrubs	GEO
TP214	TP	3	579576.50	829596.12	n/a	HV	Hardstanding	GEO
TP215	TP + DP	3	580585.36	830229.55	n/a	HV	Hardstanding	GEO, ENV
TP216	TP + DP	3	580438.27	830669.44	n/a	HV	Hardstanding	GEO, ENV
TP217	TP	3	580454.16	830906.72	n/a	HV	Existing bridge abutment	GEO
TP218	TP	3	580476.50	830932.77	n/a	HV	Existing bridge abutment	GEO
TP219	TP + DP	3	580741.99	830286.82	n/a	HV	Topsoil Existing railway embankment	GEO, ENV
TP220	TP + DP	3	581133.16	830317.64	n/a	HV	Existing railway embankment	GEO
TP221	TP + DP	3	581432.04	830117.63	n/a	HV	Existing railway embankment	GEO, ENV
TP222	TP + DP	3	581627.52	830086.57	n/a	HV	Topsoil	GEO
TP223	TP + DP	3	582010.73	830140.27	n/a	HV	Topsoil	GEO, ENV
TP224	TP + DP	3	581976.69	830282.63	n/a	HV	Vegetation / Shrubs / Existing railway embankment	GEO, ENV
TP225	TP	3	582106.35	830359.57	n/a	HV	Vegetation / Shrubs / Existing railway embankment	GEO
TP226	TP	3	582133.38	830387.82	n/a	HV	Vegetation / Shrubs / Existing railway embankment	GEO

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
TP227	TP + DP	3	582514.33	830723.63	n/a	HV	Existing railway embankment	GEO, ENV
TP228	TP + DP	3	582678.04	830843.48	n/a	HV	Topsoil / Existing railway embankment	GEO
TP229	TP + DP	3	582786.70	831015.20	n/a	HV	Vegetation / Shrubs / Existing railway embankment	GEO, ENV
TP230	TP + DP	3	583154.14	831276.57	n/a	HV	Existing railway embankment	GEO
TP231	TP + DP	3	583514.71	831581.93	n/a	HV	Existing railway embankment	GEO, ENV
TP232	TP + DP	3	583650.22	831928.04	n/a	HV	Topsoil	GEO
TP233	TP + DP	3	583598.15	832159.60	n/a	HV	Topsoil	GEO, ENV
TP234	TP + DP	3	583999.59	832497.03	n/a	HV	Existing railway embankment	GEO
TP235	TP + DP	3	584715.01	832968.91	n/a	HV	Vegetation / Shrubs / Existing railway embankment	GEO, ENV
TP236	TP + DP	3	585145.69	833251.60	n/a	HV	Existing railway embankment	GEO
TP237	TP + DP	3	585586.71	834130.41	n/a	HV	Existing railway embankment	GEO, ENV
TP238	TP + DP	3	585807.02	834610.58	n/a	HV	Topsoil	GEO
TP239	TP + DP	3	586072.81	834778.66	n/a	HV	Topsoil	GEO, ENV
TP240	TP + DP	3	586276.03	834924.77	n/a	HV	Topsoil	GEO

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
TP241	TP + DP	3	586577.86	835194.14	n/a	HV	Vegetation / Shrubs	GEO, ENV
TP242	TP + DP	3	587127.88	835996.60	n/a	HV	Topsoil	GEO
TP243	TP + DP	3	587250.17	836157.69	n/a	HV	Topsoil	GEO, ENV
TP244	TP	3	587654.70	836857.30	n/a	HV	Topsoil	GEO
TP245	TP	3	587662.99	836868.25	n/a	HV	Topsoil	GEO
TP246	TP + DP	3	588133.82	837473.03	n/a	HV	Topsoil	GEO, ENV
TP247	TP + DP	3	588127.87	837479.16	n/a	HV	Topsoil	GEO
TP248	TP + DP	3	588350.77	837753.00	n/a	HV	Topsoil	GEO, ENV
TP249	TP + DP	3	588344.73	837756.63	n/a	HV	Topsoil	GEO
TP250	TP + DP	3	588559.83	839326.04	n/a	HV	Topsoil	GEO, ENV
TP251	TP + DP	3	588634.51	839242.03	n/a	HV	Topsoil	GEO
TP252	TP + DP	3	588710.22	839209.54	n/a	HV	Topsoil	GEO, ENV
TP253	TP + DP	3	588766.17	839186.09	n/a	HV	Topsoil	GEO
TP254	TP + DP	3	588785.26	839220.93	n/a	HV	Topsoil	GEO, ENV
TP255	TP + DP	3	588743.39	839230.98	n/a	HV	Topsoil	GEO
TP256	TP + DP	3	588853.75	839255.48	n/a	HV	Topsoil	GEO, ENV
TP257	TP	3	589285.24	839284.38	n/a	HV	Existing bridge abutment	GEO
TP258	TP	3	589308.40	839286.12	n/a	HV	Existing bridge abutment	GEO

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
TP259	TP + DP	3	589450.10	839327.71	n/a	HV	Existing railway embankment	GEO, ENV
TP260	TP + DP	3	589816.18	839757.24	n/a	HV	Topsoil	GEO
TP261	TP + DP	3	590012.03	839762.73	n/a	HV	Topsoil	GEO, ENV
TP262	TP + DP	3	590212.78	839754.49	n/a	HV	Topsoil	GEO
TP263	TP + DP	3	590413.47	839721.56	n/a	HV	Topsoil	GEO, ENV
TP264	TP	3	590801.56	839678.70	n/a	HV	Existing railway embankment	GEO
TP265	TP	3	590828.42	839679.73	n/a	HV	Existing railway embankment	GEO
TP266	TP	3	591632.41	839662.82	n/a	HV	Hardstanding	GEO
TP267	TP	3	591639.01	839665.33	n/a	HV	Topsoil	GEO
TP268	TP + DP	3	592121.80	839678.19	n/a	HV	Topsoil / Existing railway embankment	GEO, ENV
TP269	TP + DP	3	592384.08	839623.06	n/a	HV	Topsoil / Existing railway embankment	GEO
TP270	TP + DP	3	593060.50	839209.83	n/a	HV	Existing railway embankment	GEO, ENV
TP271	TP + DP	3	593759.47	839030.08	n/a	HV	Topsoil / Existing railway embankment	GEO
TP272	TP + DP	3	594319.39	838660.13	n/a	HV	Existing railway embankment	GEO, ENV
TP273	TP + DP	3	594458.10	838759.78	n/a	HV	Topsoil	GEO
TP274	TP + DP	3	594626.65	838693.83	n/a	HV	Topsoil	GEO, ENV

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
TP275	TP + DP	3	595281.89	838509.57	n/a	HV	Existing railway embankment	GEO
TP276	TP + DP	3	595644.84	838430.11	n/a	HV	Vegetation / Shrubs	GEO, ENV
TP277	TP + DP	3	595839.50	838476.94	n/a	HV	Topsoil	GEO
TP278	TP + DP	3	595935.03	838422.75	n/a	HV	Topsoil	GEO, ENV
TP279	TP + DP	3	596748.69	837982.78	n/a	HV	Hardstanding	GEO
TP280	TP + DP	3	598323.65	837673.94	n/a	HV	Hardstanding	GEO, ENV
TP281	TP + DP	3	598546.62	837702.06	n/a	HV	Vegetation / Shrubs	GEO
TP282	TP	3	598726.07	837670.40	n/a	HV	Topsoil / Vegetation / Shrubs	GEO
TP283	TP	3	598745.69	837657.74	n/a	HV	Topsoil / Vegetation / Shrubs	GEO
TP284	TP + DP	3	599332.78	837732.30	n/a	HV	Existing railway embankment / Vegetation / Shrubs	GEO, ENV
TP285	TP + DP	3	599058.44	837628.04	n/a	HV	Existing railway embankment	GEO
TP286	TP + DP	3	599646.27	837679.84	n/a	HV	Topsoil	GEO, ENV
TP287	TP + DP	3	599783.16	837419.08	n/a	HV	Hardstanding/asphalt	GEO
TP288	TP + DP	3	599984.85	837392.92	n/a	HV	Topsoil	GEO, ENV
TP289	TP + DP	3	600098.58	837446.83	n/a	HV	Topsoil	GEO
TP290	TP + DP	3	600286.31	837401.35	n/a	HV	Topsoil	GEO, ENV

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
TP291	TP + DP	3	600521.66	837416.72	n/a	HV	Topsoil	GEO
TP292	TP + DP	3	600853.14	837571.71	n/a	HV	Topsoil	GEO, ENV
TP293	TP	3	601255.59	837370.63	n/a	HV	Existing railway embankment	GEO
TP294	TP	3	601265.03	837367.23	n/a	HV	Existing railway embankment	GEO
WS201	WS	8	577355.14	827990.04	n/a	SPT, GWL	Topsoil	GEO, ENV**
WS202	WS	8	579134.20	829223.02	n/a	SPT	Vegetation / Shrubs	GEO, ENV**
WS203	WS	8	580476.61	830423.13	n/a	SPT, GWL	Hardstanding	GEO, ENV**
WS204	WS	8	581267.97	830197.38	n/a	SPT	Topsoil	GEO, ENV**
WS205	WS	8	581831.14	830181.83	n/a	SPT, GWL	Vegetation / Shrubs	GEO, ENV**
WS206	WS	8	582045.51	830334.10	n/a	SPT	Existing railway embankment	GEO, ENV**
WS207	WS	8	583022.27	831261.71	n/a	SPT, GWL	Vegetation / Shrubs	GEO, ENV**
WS208	WS	8	583701.87	832241.05	n/a	SPT	Topsoil	GEO, ENV**
WS209	WS	8	584368.44	832745.61	n/a	SPT, GWL	Existing railway embankment	GEO, ENV**
WS210	WS	8	585441.30	833724.32	n/a	SPT	Vegetation / Shrubs	GEO, ENV**
WS211	WS	8	586197.58	834925.72	n/a	SPT, GWL	Topsoil	GEO, ENV**
WS212	WS	8	586648.93	835320.77	n/a	SPT	Topsoil	GEO, ENV**
WS213	WS	8	586804.81	835591.26	n/a	SPT, GWL	Topsoil	GEO, ENV**

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
WS214	WS	8	586987.37	835799.32	n/a	SPT	Topsoil	GEO, ENV**
WS215	WS	8	588130.26	837474.81	n/a	SPT, GWL	Topsoil	GEO, ENV**
WS216	WS	8	588346.50	837753.56	n/a	SPT	Topsoil	GEO, ENV**
WS217	WS	8	588776.16	839246.85	n/a	SPT, GWL	Topsoil	GEO, ENV**
WS218	WS	8	588813.55	839271.34	n/a	SPT	Topsoil	GEO, ENV**
WS219	WS	8	592547.87	839545.68	n/a	SPT, GWL	Topsoil	GEO, ENV**
WS220	WS	8	589767.00	839740.90	n/a	SPT	Topsoil	GEO, ENV**
WS221	WS	8	590663.56	839681.64	n/a	SPT, GWL	Existing railway embankment	GEO, ENV**
WS222	WS	8	590973.75	839693.97	n/a	SPT	Topsoil	GEO, ENV**
WS223	WS	8	591494.89	839678.38	n/a	SPT, GWL	Hardstanding	GEO, ENV**
WS224	WS	8	592905.37	839296.48	n/a	SPT	Topsoil	GEO, ENV**
WS225	WS	8	593503.57	839085.16	n/a	SPT, GWL	Existing railway embankment	GEO, ENV**
WS226	WS	8	595194.80	838522.55	n/a	SPT	Existing railway embankment / Topsoil	GEO, ENV**
WS227	WS	8	595355.08	838493.33	n/a	SPT, GWL	Topsoil	GEO, ENV**
WS228	WS	8	596077.27	838325.18	n/a	SPT	Topsoil	GEO, ENV**
WS229	WS	8	598824.23	837658.91	n/a	SPT, GWL	Existing railway embankment / Topsoil	GEO, ENV**

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
WS230	WS	8	599619.23	837747.87	n/a	SPT	Vegetation / Shrubs	GEO, ENV**
WS231	WS	8	599658.07	837542.75	n/a	SPT, GWL	Topsoil	GEO, ENV**
WS232	WS	8	600152.63	837408.08	n/a	SPT	Topsoil	GEO, ENV**
WS233	WS	8	600611.58	837436.43	n/a	SPT, GWL	Topsoil	GEO, ENV**
WS234	WS	8	600670.76	837405.11	n/a	SPT	Topsoil	GEO, ENV**
WS235	WS	8	600752.28	837376.97	n/a	SPT, GWL	Topsoil	GEO, ENV**
COUNTY CAVAN								
BH301	CP + RC	30	601770.98	837215.25	n/a	SPT, GWL	Existing railway embankment	GEO, ENV**, GBS
BH302	CP + RC	30	601796.87	837208.67	n/a	SPT	Existing railway embankment	GEO, ENV**, GBS
BH303	CP + RC	30	602984.14	837038.47	n/a	SPT, GWL	Topsoil	GEO, ENV**, GBS
BH304	CP + RC	30	602986.42	837016.58	n/a	SPT	Topsoil	GEO, ENV**, GBS
BH305	CP + RC	30	603338.38	836936.06	n/a	SPT, GWL	Topsoil	GEO, ENV**, GBS
BH306	CP + RC	30	603338.08	836926.83	n/a	SPT	Hardstanding/asphalt	GEO, ENV**, GBS
BH307	CP + RC	15	604819.12	837261.59	n/a	SPT, GWL	Topsoil	GEO, ENV**
BH308	CP + RC	15	605275.26	837470.68	n/a	SPT	Topsoil	GEO, ENV**
BH309	CP + RC	15	605756.48	837593.46	n/a	SPT, GWL	Topsoil	GEO, ENV**
BH310	CP + RC	30	606108.31	837664.24	n/a	SPT, GWL	Topsoil	GEO, ENV**, GBS
BH311	CP + RC	30	606127.40	837666.83	n/a	SPT	Topsoil	GEO, ENV**, GBS

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
BH312	CP + RC	30	606592.55	837836.34	n/a	SPT, GWL	Topsoil	GEO, ENV**, GBS
BH313	CP + RC	30	606606.03	837842.92	n/a	SPT, GWL	Topsoil	GEO, ENV**, GBS
BH314	CP + RC	30	606771.73	837923.90	n/a	SPT	Topsoil	GEO, ENV**, GBS
BH315	CP + RC	30	606786.42	837931.08	n/a	SPT	Topsoil	GEO, ENV**, GBS
BH316	CP + RC	15	607509.17	838077.06	n/a	SPT, GWL	Topsoil	GEO, ENV**
BH317	CP + RC	15	608125.74	838389.21	n/a	SPT	Hardstanding/asphalt	GEO, ENV**
DPSH301	DPSH	8	602137.70	837128.06	n/a	n/a	Topsoil	
DPSH302	DPSH	8	603371.03	836849.46	n/a	n/a	Topsoil	
DPSH303	DPSH	8	603789.68	836669.98	n/a	n/a	Topsoil	
DPSH304	DPSH	8	604168.06	836705.95	n/a	n/a	Topsoil	
DPSH305	DPSH	8	605047.36	837452.13	n/a	n/a	Topsoil	
DPSH306	DPSH	8	605090.02	837478.45	n/a	n/a	Topsoil	
DPSH307	DPSH	8	605241.25	837477.00	n/a	n/a	Topsoil	
DPSH308	DPSH	8	605569.24	837562.79	n/a	n/a	Topsoil	
DPSH309	DPSH	8	606062.37	837665.30	n/a	n/a	Topsoil	
DPSH310	DPSH	8	606850.49	837962.06	n/a	n/a	Topsoil	
DPSH311	DPSH	8	606956.85	838011.21	n/a	n/a	Topsoil	
DPSH312	DPSH	8	607181.02	838115.12	n/a	n/a	Topsoil	
DPSH313	DPSH	8	607301.11	838132.34	n/a	n/a	Topsoil	

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
TP301	TP	3	601774.57	837214.34	n/a	HV	Existing railway embankment	GEO
TP302	TP	3	601799.36	837208.03	n/a	HV	Existing railway embankment	GEO
TP303	TP + DP	3	602363.45	837084.73	n/a	HV	Topsoil	GEO, ENV
TP304	TP + DP	3	602567.93	837053.16	n/a	HV	Topsoil	GEO
TP305	TP + DP	3	602760.44	837037.16	n/a	HV	Topsoil	GEO, ENV
TP306	TP	3	602981.77	837038.00	n/a	HV	Topsoil	GEO
TP307	TP	3	602989.78	837016.90	n/a	HV	Topsoil	GEO
TP308	TP + DP	3	603091.35	836950.77	n/a	HV	Topsoil	GEO, ENV
TP309	TP	3	603335.82	836936.20	n/a	HV	Topsoil	GEO
TP310	TP	3	603336.15	836926.78	n/a	HV	Hardstanding/asphalt	GEO, ENV
TP311	TP + DP	3	603588.39	836813.34	n/a	HV	Topsoil	GEO
TP312	TP + DP	3	603537.12	836612.43	n/a	HV	Topsoil	GEO, ENV
TP313	TP + DP	3	603651.59	836534.96	n/a	HV	Topsoil	GEO
TP314	TP + DP	3	603972.99	836714.84	n/a	HV	Topsoil	GEO, ENV
TP315	TP + DP	3	604325.15	836737.96	n/a	HV	Topsoil	GEO, ENV
TP316	TP + DP	3	604503.34	836937.29	n/a	HV	Topsoil	GEO
TP317	TP + DP	3	604555.48	837073.19	n/a	HV	Existing railway embankment	GEO, ENV
TP318	TP + DP	3	604681.60	837187.94	n/a	HV	Topsoil	GEO

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
TP319	TP + DP	3	604943.69	837374.05	n/a	HV	Topsoil	GEO, ENV
TP320	TP + DP	3	605075.32	837457.74	n/a	HV	Topsoil	GEO
TP321	TP + DP	3	605432.93	837437.44	n/a	HV	Hardstanding/gravel	GEO, ENV
TP322	TP + DP	3	605568.12	837556.92	n/a	HV	Topsoil	GEO
TP323	TP + DP	3	605568.00	837566.64	n/a	HV	Topsoil	GEO, ENV
TP324	TP	3	606108.46	837662.47	n/a	HV	Topsoil	GEO
TP325	TP	3	606127.53	837665.36	n/a	HV	Topsoil	GEO
TP326	TP + DP	3	606268.34	837696.18	n/a	HV	Topsoil	GEO, ENV
TP327	TP + DP	3	606440.90	837760.78	n/a	HV	Topsoil	GEO, ENV
TP328	TP	3	606592.16	837836.94	n/a	HV	Topsoil	GEO
TP329	TP	3	606605.64	837843.82	n/a	HV	Topsoil	GEO
TP330	TP	3	606772.39	837922.37	n/a	HV	Topsoil	GEO
TP331	TP	3	606787.15	837929.69	n/a	HV	Topsoil	GEO,
TP332	TP + DP	3	607005.18	838033.90	n/a	HV	Topsoil	GEO, ENV
TP333	TP + DP	3	607713.50	838058.88	n/a	HV	Topsoil	GEO
TP334	TP + DP	3	607826.57	838174.14	n/a	HV	Hardstanding/asphalt	GEO, ENV
TP335	TP + DP	3	607992.43	838255.54	n/a	HV	Topsoil	GEO
TP336	TP + DP	3	608197.74	838319.37	n/a	HV	Hardstanding/asphalt	GEO, ENV
TP337	TP + DP	3	608279.55	838466.74	n/a	HV	Hardstanding/asphalt	GEO

Hole Number	Type	Scheduled depth (m)	Easting (ITM)	Northing (ITM)	Approximate ground level (mOD)	In-situ tests and installations *	Existing ground surface type	Remarks
WS301	WS	8	602132.60	837128.79	n/a	SPT	Topsoil	GEO, ENV**
WS302	WS	8	603333.87	836857.12	n/a	SPT, GWL	Topsoil	GEO, ENV**
WS303	WS	8	603790.34	836670.46	n/a	SPT	Topsoil	GEO, ENV**
WS304	WS	8	604170.44	836705.57	n/a	SPT, GWL	Topsoil	GEO, ENV**
WS305	WS	8	605044.82	837450.31	n/a	SPT	Topsoil	GEO, ENV**
WS306	WS	8	605086.57	837477.36	n/a	SPT, GWL	Topsoil	GEO, ENV**
WS307	WS	8	605243.61	837474.82	n/a	SPT	Topsoil	GEO, ENV**
WS308	WS	8	605567.43	837562.25	n/a	SPT, GWL	Topsoil	GEO, ENV**
WS309	WS	8	606062.88	837661.81	n/a	SPT	Topsoil	GEO, ENV**
WS310	WS	8	606851.23	837962.42	n/a	SPT, GWL	Topsoil	GEO, ENV**
WS311	WS	8	606952.66	838009.64	n/a	SPT	Topsoil	GEO, ENV**
WS312	WS	8	607182.57	838115.71	n/a	SPT, GWL	Topsoil	GEO, ENV**
WS313	WS	8	607298.97	838132.44	n/a	SPT	Topsoil	GEO, ENV**

BH = CP to rockhead/refusal with RC follow-on. Min. 5 m inclusion into rock. If rock is not encountered, max. CP+RC depth of 15m or 30m depending on the scheduled depth. Bill of quantities has been prepared assuming switchover from CP to RC occurs at 10m depth at all locations.

CP= CP to rockhead/refusal with max. depth of 10m.

CPTU= CPT with porewater pressure measurement to rockhead/refusal.

TP + DP = TP to a target depth of 3m. Handheld dynamic core penetration test beside TP location to a target depth of 3m.

TP = TP to a target depth of 3m.

WS= Windowless sampling to rockhead/refusal with max. depth of 8m.

DPSH = Super heavy dynamic probing to rockhead/refusal with max. depth of 8m.

* In addition to those required in schedules and annexes.

** Geoenvironmental samples to be taken when made ground is encountered.

Abbreviations:

CP - cable percussion borehole	OP - observation pit
CPTU - cone penetration testing with piezocone	HV - hand vane test
CPT - cone penetration testing (without piezocone)	RC - rotary drillhole (with core recovery)
CP+RC - cable percussion starter hole with rotary cored follow-on	RO - rotary drillhole (with no core recovery)
DP - dynamic probing	RZ - response zone
DPSH - super heavy dynamic probing	SD - Resonance (sonic) drilling
G - gas standpipe	SP - standpipe piezometer
GBS – Geobor-S	SPT - standard penetration test
GW - combined gas and groundwater standpipe	ST - slit trench
GWL - groundwater standpipe	TP - trial pit
GS - gas sampling	TT - trial trench
HA - hand auger borehole	WS - window/windowless sampling (dynamic sampling)

Notes

1. Chiselling to be carried out prior to termination of cable percussion drilling on refusal. Contractor to contact Investigation Supervisor after 45 mins of chiselling to seek instruction on how to proceed.
2. GBS – Geobor-S drilling equipment to be used for rotary coring at the boreholes with 30m scheduled depth unless otherwise agreed with the Investigation supervisor.
3. GEO – Geotechnical sampling as defined in S1.12, S5 Annex 2.1 and 2.2. All open tube samples to be thin walled unless agreed with Investigation Supervisor. Rotary core sub-sampling required.
4. ENV – Environmental sampling as defined in S1.12.11 and S5 Annex 9. Where environmental sampling is not specified, samples to be taken only in the event of visual or olfactory evidence of contamination being encountered.
5. SPT – SPT testing in cable percussion holes at 1.5m intervals throughout, SPT testing in rotary holes (only where specified above) between core runs at approx 3m intervals.
6. Response zones for standpipe piezometers to be scheduled by the Investigation Supervisor on receipt of drillers logs. Contractor to give notice prior to termination of hole.
7. HV – Hand vane testing in two sample per trial pit as defined in S1.15.2.

Schedule 3. Investigation Supervisor's Facilities

Not Required

Schedule 4. Specification Amendments

Clause 1.1

Add new paragraph:

"Where there is conflict between the information given in the Schedules and the Specification or standards referred to in the Specification, the requirements of the Schedule shall take precedence".

Clause 3.16.3

Add: "All bituminous and concrete surfaces shall be saw cut prior to breaking as specified in Clause 6.3.3. of the Guidelines for Managing Openings in Public Roads published by the Department of Transport, Tourism and Sport."

Clause 3.16.4

Add: "Paving slabs and blocks shall be laid back in the same position and orientation ensuring that the reinstated surface is level and free from voids."

Clause 3.17

Insert in line 2 after "reported":

"immediately and under no circumstances longer than 24 hours from the receipt of the complaint.".

Clause 3.19

Delete: "The as-built position of each hole shall be determined in relation to Irish National Grid or Irish Transverse Mercator Grid."

Insert: "The as-built position of each hole shall be determined in relation to Irish Transverse Mercator Grid to the nearest 0.5m or to the accuracy (if any) described in Schedule S1.8.18)."

Clause 3.25.2

Delete: "10 million pixels in resolution."

Insert: "12 million pixels in resolution."

Clause 3.26

Add: "Evidence of disposal to the appropriate facilities may be requested by the Investigation Supervisor"

Clause 3.27

Add: new Clause 3.27 Standing Time

"The Investigation Supervisor shall be notified immediately that standing time starts to be incurred. The duration of standing time shall be agreed with the Investigation Supervisor."

Schedule 5. Specification Additions

A number of technical annexes are included as part of this specification under Annex 2 (Specification additions) and are summarised as follows:

- Annex 2 Sampling
  - Annex 2.1 Thin-wall and piston sampling
  - Annex 2.2: Rotary-cored soil sampling
  - Annex 2.3: Dynamic sampling (window/windowless sampling)
- Annex 3 Instrumentation
  - Annex 3.1: Groundwater installations (in addition to Appendix I of the Specification (EI SGI, 2016)
  - Annex 3.2 Ground gas monitoring standpipe (see Appendix II, of the Specification (EI SGI, 2016))
- Annex 5: Cone penetration tests (CPT)
- Annex 9: Ground investigation on potentially contaminated land
- Annex 10: Interpretative reporting
- Annex 12: Digital data
- Annex 13 Geophysics
  - Annex 13.2: Seismic refraction surveying
  - Annex 13.3: Downhole shear wave velocity surveying
  - Annex 13.4: Downhole wireline logging
- Annex 14: Pyrite sampling and testing.
- Annex 15 Designer's risk assessment.
- Annex 16. Masonry Structural Coring
- Annex 17. Structural Slab Inspection Pits
- Annex 18. Pavement Inspection Pits
- Annex 19. Archaeological Works

Annex 1

Bill of Quantities for Ground Investigation

Bill of Quantities

The attached excel spreadsheet constitutes the Bill of Quantities

Appendix A: Rates for Ground Practitioners and other Personnel

See Bill of Quantities.

Appendix B: Long term sample storage

See Bill of Quantities.

Annex 2

Sampling

Annex 2.1 Thin Wall and Piston Sampling

2.1.1 General

Thin-walled sampling and piston sampling shall be carried out in accordance with BS 5930 Section 25.4 and this Annex.

The object of the sampling shall be to obtain Class 1 samples that are as undisturbed as possible.

2.1.2 Sampling equipment

The sampling equipment shall be subject to the advance approval of the Investigation Supervisor.

Sample tubes shall be of a minimum length of 600mm and shall have a minimum internal diameter of 100mm. Tubes shall be made of steel or aluminium. Plastic lining tubes shall not be used in substitution for steel or aluminium sampling tubes. Tubes shall have a sharp cutting edge and provide suitable inside clearance.

The interior of each sample tube shall be smooth, clean and resistant to corrosion. The cutting edge and the ring seals of the sampler (if any) shall be inspected for wear or evidence of any damage and rejected if worn or damaged. The interior face of the tube shall be parallel and the area ratio (as defined in BS 5930) of the tube shall lie in the range 10% to 15%.

Before use, the tube shall be lightly coated inside and out with either petroleum jelly or vegetable oil.

A check shall be made by the Contractor that the various moving parts of the sampler function freely before the sampler is lowered into the borehole.

2.1.3 Supervision

When in use, the sampler (whether piston sampler or thin-wall sampler) shall be under the direct full-time supervision of an experienced technical assistant from the Contractor's staff who is fully experienced in its use ("the Contractor's sampler specialist"). The rig operator may take the role of Contractor's sampler specialist if suitably experienced in the sampling technique involved.

2.1.4 Pushing the sampler

2.1.4.1 General

For piston sampling and for thin-wall sampling, accurate measurements of the depth from which each sample is recovered, the length of sampling stroke and the length of sample recovered shall be made and recorded.

If an obstruction is met, the sampler shall be withdrawn, and another sample taken when the obstruction has been removed. Immediately on completion of the sample stroke, the sampler shall be withdrawn from the ground and the sample tube shall be separated from the sampler.

Precautions shall be taken to ensure that there is no movement of the sample inside the sample tube or other mechanical disturbance. Any distortion or damage of the sampling tube greater than 1mm shall be noted.

2.1.4.2 Pushing the piston sampling

The Contractor shall push the sampler down to the intended sampling level if this is practical.

The sampler shall be advanced a minimum of 300mm below the bottom of the boring before sampling commences. The sampler shall be pressed down smoothly and continuously whilst the piston is firmly secured so that it remains stationary.

The tubes shall be advanced into the soil by hydraulic means in a continual push over a period of between 10 minutes and 30 minutes. The time taken shall be recorded.

The sample tube shall be left in the ground for a further 5 minutes and then withdrawn vertically without any rod rotation. Rod rotation shall not be used to shear the sample base.

A means for measuring the exact penetration of the tube and the maximum thrust achieved shall be provided and used.

2.1.4.3 Pushing the thin-walled sampling

The base of the borehole shall be carefully cleaned out prior to sampling.

The tube shall be advanced into the ground from the base of the borehole by hydraulic means in a continual push. The time taken to advance the tube shall be recorded. The tube shall be progressed beyond the base of the borehole so that the majority of the sample is taken from ground unaffected by drilling induced disturbance. The sample tube shall be left in the ground for 5 minutes and then withdrawn vertically without any rod rotation. Rod rotation shall not be used to shear the sample base.

A means for measuring the exact penetration of the tube and the maximum thrust achieved shall be provided.

2.1.5 Sealing of samples

Careful precautions shall be taken to ensure that there shall be no change in the water content of the sample after it is obtained.

A small amount of melted low melting point wax shall be poured over each end of the sample and a wax sealing disc laid in the wax within 30 minutes of the sample being removed from the ground. When that wax has stiffened, more wax shall be added to complete the seal. Any space between the wax and the ends of the sample tubes shall be packed and secure end caps fitted. The sample shall be clearly labelled with the project name, hole number, sample number and sample depth. The top of the sample shall be clearly labelled.

2.1.6 Written records

The Contractor's sampling specialist shall complete a record sheet for the samples, which shall be submitted with the driller's daily record sheet. At a minimum, the record sheet shall tabulate for each sample:

- Exploratory hole
- Sample number
- Sample type (distinguishing between piston and others)
- Sample depth
- Length of sample stroke
- Length of sample recovered
- Time taken to progress tube
- Maximum thrust
- Depth to base of exploratory hole
- Depth of casing
- Depth to water
- Hand vane result at top of sample (if specified: see Schedule S1.12.4)
- Hand vane result at base of sample (if specified: see Schedule S1.12.4)
- Notes (for example, type of lubricant used, obstructions, sample disturbance, water added, as so forth).

2.1.7 Storage and transportation of samples

Immediately after sealing, each sample tube shall be placed upright in stout wooden boxes suitably divided and provided with resilient packing to prevent movement and damage of the samples during transportation to the laboratory.

The boxes shall be labelled and handled to keep the samples upright until they are removed from the boxes for testing.

Care shall be taken at every stage of transportation and storage to ensure that the boxes containing the samples are protected from jarring, vibration and excessive temperature changes.

Annex 2.2 Rotary Cored Sub Sampling

2.2.1 Aim of the sampling procedure

The aim of the sampling procedure is to obtain high quality rotary core samples of cohesive soils.

The procedures specified in this Annex A2 aim to minimise the changes in water content and suction in the sample caused by the sampling process. Speed is of the essence in achieving this aim: it is essential that the sample be sealed against changes in water content as soon as possible after it has been removed from the ground. It is also essential that the sample is not left down the borehole (and hence in contact with the drilling fluid) for any prolonged period of time.

2.2.2 Drilling

The core shall be of diameter greater than 100mm. The Contractor shall submit with the method statement details of the drilling methods the Contractor will use (such as: use of rigid plastic liners; special flushing mediums) and shall state the maximum total core recovery the Contractor considers possible in the anticipated ground conditions. Before mobilising to site, the Contractor shall submit details of the experienced site personnel the Contractor proposes to use.

2.2.3 Equipment

The following equipment is needed on site to conform to the requirements of this Specification:

- A thermostatically-controlled wax bath capable of maintaining the wax at a temperature of approximately 65°C;
- Low-melting point wax, comprising 50% petrolatum and 50% paraffin wax (or similar approved);
- Heavy-duty cling film to the approval of the Investigation Supervisor;
- Sharp edge trowel,
- Additional short length of plastic liner with caps;
- BH ID, colour board and lighting for photography of each sample; and
- Cutting equipment

2.2.4 Recovering rotary core from the borehole

Each core run from which a sample is to be obtained shall be taken without delay to the site hut as soon as it has been recovered from the borehole. The core shall arrive at the site hut within 1 hour of being removed from the ground.

Whenever the rotary core is being transported from one location to another (such as from the borehole to the site hut, or from outside to inside the hut), it shall at all times be supported by a rigid liner and shall be handled in such a way that the soil is not strained nor subjected to vibrations.

2.2.5 Removing the rotary core from its liner

The liner surrounding the core shall be cut by two counter-rotating saws into two halves along its long axis. The saw cut shall be made in such a way as to cause no visible damage to the core.

If a rotary saw is used, it shall be set up in such a way that it cuts into the liner but not into the core, so that the core is left un-scored by the action of the saw.

If necessary, a sharp knife may be used to complete the separation of the two halves of the liner, provided that due care is taken to avoid cutting into the core.

The liner (still containing the rotary core) shall be placed on a clean, flat working surface, and its top half removed. If necessary, the top half of the liner may be gently tapped in its axial direction, at one end only, in order to facilitate its removal. All drilling fluid on the surface of the rotary core shall be removed by wiping with a dry cloth or absorbent paper towelling.

2.2.6 Selecting and cutting the rotary core sample

Samples of the rotary core shall be taken with the minimum of delay. The Contractor shall notify the Investigation Supervisor at least 24 hours before the cores shall be ready for sub-sampling. The locations of all samples shall be indicated by the Investigation Supervisor on site. The locations selected shall avoid all visible discontinuities in the core caused by drilling disturbance. Natural discontinuities such as sand lenses, joints, and fissures, may also be avoided (at the discretion of the Investigation Supervisor's Representative).

Each sample shall be cut from the rotary core using a cheese-wire or sharp cutting blade. If a sharp blade is used, then, in order to minimise the stresses induced in the sample by the action of cutting into it, the first cut shall be made at whichever end of the sample is nearer to one of the free ends of the core run. The ends of the sample shall be marked 'top' and 'bottom' (as appropriate).

2.2.7 Sealing the core sample against changes in moisture

As part of the method statement submission for the proposed works, the Contractor shall submit to the Investigation Supervisor a method statement for sealing rotary core samples. Two possible procedures are suggested below. Alternative procedures shall not be used without the Investigation Supervisor's prior approval. Each sample shall be photographed prior to sealing

The two suggested procedures (A and B) for sealing rotary core samples are as follows:

Procedure A is as follows:

a. The sample shall be wrapped in plastic (e.g. cling film).

b. The sample shall be dipped, by hand, in a bath of low melting point wax and rotated until it has been entirely covered by wax. It may prove necessary to dip the ends of the sample in wax as a separate action. The wax shall be allowed to cool.

c. When the wax on the surface of the sample is solidified, the sample shall be wrapped tightly in heavy duty cling film. The cling-film shall overlap by at least 30mm onto both ends of the sample. Before wrapping the sample in the cling film.

d. Each end of the sample shall be wrapped tightly in heavy duty cling film. The cling film shall overlap by at least 30mm onto the curved surface of the sample.

e. The sample shall then be dipped for second time in the bath of low melting point wax and rotated until all the cling film (including that at the ends of the sample) has been covered by wax. The wax shall be allowed to cool.

f. When the wax on the surface of the sample has solidified, the sample shall be wrapped in a second layer of cling film and then coated with a second layer of wax, as described above.

g. Finally, the samples shall be wrapped tightly in a third layer heavy duty cling film. The cling film shall cover the curved surface, and both ends of the sample. Any joins in the cling film shall overlap by at least 30mm. Before using the cling film, it shall be dipped into the wax so that it is coated with a thin film of wax.

h. The sample shall be labelled clearly on its outside with the following information: contract number, borehole number, sample number, and depth, and with an arrow pointing to the top of the sample (and marked as such). If a label is attached to the sample, it shall be secured beneath a further layer of tightly wrapped cling film. All markings shall be indelible ink.

Procedure B is as follows:

a. The sample shall be wrapped in plastic (e.g., cling film).

b. The sample shall be rolled carefully, by hand, in a bath of low melting point wax for at least two full revolutions, such that the outside of the sample (except for its ends) becomes completely coated in wax. The depth of wax in the bath shall be no deeper than 25mm

c. When the sample is fully coated with wax, it shall be removed from the bath and placed on a clean, flat surface and the wax allowed to cool. The sample shall be placed on its base on the work surface, with its longitudinal axis vertical.

d. A plastic end-cap with an inside diameter that only slightly exceeds the diameter of the sample shall be half-filled with molten wax.

e. Once the wax on the sample had solidified, the sample shall be placed in an upright position inside the end-cap. The wax in the end-cap shall be allowed to cool.

f. A second plastic end-cap similar to the first shall be half-filled with molten wax.

g. Once the wax in the first end-cap has solidified, the sample shall be turned upside down and the sample shall be placed in an upright position in the second end-cap. The wax in the second end-cap shall be allowed to cool.

h. Any visible gaps between the sample and either of the plastic end-caps shall be fitted with wax. Further coatings of wax shall be applied to the sample in order to smooth off the sharp edges between the end-caps and the sample. Care shall be taken to retain the top and bottom markings on the sample.

i. When all the wax has solidified and cooled, the sample shall be wrapped tightly in two layers of heavy duty cling-film (or similar approved). The cling-film shall overlap by at least 30mm onto both end-caps.

j. The samples shall be labelled clearly on its outside with the following information: contract number, borehole number, sample number and depth, and with an arrow pointing to the top of the sample (and marked as such). If a label is attached to the sample, it shall be secured beneath a further layer of tightly wrapped cling film. All markings shall be indelible ink.

k. Heavy duty adhesive tape shall be wrapped around the bottom edges of both end caps to protect the cling film from damage.

l. The ends caps shall be labelled clearly on their outside surfaces with the following information: contract number, borehole number, sample number and depth, and 'top' and 'bottom' (as appropriate). All markings shall be in indelible ink.

2.2.8 Sample storage on site

When the sample has been sealed as described above, it shall be protected from damage by laying it inside a protective "sleeve" made from split drainpipe, guttering, or rigid liner with caps added. Wax can be place along the liner seem and around the end cap to seal. The liner should be marked with sample details, and the top and bottom of the sample indicated. The sample shall be secured inside its protective sleeve by binding the package with adhesive tape.

The sample shall be stored on site in a temperature-controlled environment that is free of vibrations. The Contractor shall take all reasonable measures to maintain the temperature of the samples between 10 and 12°C. Under no circumstances shall the temperature of the sample be allowed to drop below 5°C.

2.2.9 Removal of core sample from site

When transporting the sample to the laboratory, it shall be handled with great care and shall be protected during the journey from vibration, sudden movement, and excessive changes in temperature or humidity. It shall not be transported in the core boxes. It shall be transported in a separate padded box to minimise jarring, shocks and vibration.

2.2.10 Sample storage in the laboratory

The sample shall be stored in the laboratory in a temperature and humidity-controlled environment that is free of vibrations.

The temperature shall be maintained between 10°C and 12°C, and the relative humidity between 90% and 95%. Under no circumstances shall the temperature of the sample be allowed to drop below 5°C.

2.2.11 Sub Sampling Records

The time and date of sub sampling shall be recorded for each sub sample taken. This shall be presented in the factual report alongside details of the sampling process used.

Annex 2.3 Dynamic sampling (window / windowless sampling)

2.3.1 General requirements

Dynamic sampling (specifically, window sampling or windowless sampling in accordance with Schedule 2) shall be carried out at the locations specified in Schedule 2. The requirements of Clause 4.6 and this Annex A3 shall apply.

Where underground services and/or hard strata may be present at or near the surface, an inspection pit of sufficient size for locating and avoiding of underground services shall be dug. The materials excavated, and the depth of the inspection pit shall be recorded on the dynamic sampler log.

When working on a slope, a bench may be cut into the slope to facilitate dynamic sampling. The materials excavated, and the depth of the bench shall be recorded on the dynamic sampler log.

The dynamic sampler equipment shall be capable of sampling through the soil strata types listed in Schedule S1.6 to the relevant scheduled hole depths specified in Schedule 2. The Contractor is responsible for selecting and using the appropriate type of dynamic sampler rig (whether hand-held, tracked rig, or other) commensurate with, at a minimum, the specified penetration depth, anticipated ground conditions, and site access.

The dynamic sampler shall produce a continuous (or near continuous) sample for immediate visual examination and photography. Provision shall be made for disturbed sub-samples to be extracted for subsequent laboratory testing.

For window sampling only: the sampling probe shall have a 'window' down one side to allow visual examination and photographing of the soil sample recovered prior to the removal of any disturbed samples required.

For windowless sampling only: the sampling probe shall not include a window. Samples shall be retrieved within a suitably robust plastic liner deployed inside the dynamic sampler.

The system shall utilise a high frequency percussion hammer to drive the sampling probes into the ground, whilst soil passes into the sampling probe. Penetration rates, for each 1m-long run, during driving shall be recorded to provide additional indicative information about driving resistance.

Probes of 1m- and 2m-lengths and various diameters shall be available to address the expected range of ground conditions (refer to Schedule S1.6). Sample tubes of length greater than 2m shall not be used.

In any hole, successive sampler runs may be driven in a sequence of decreasing diameters until the required depth is reached. A plastic casing may be installed to allow the hole to progress through collapsing ground if this is agreed with the Investigation Supervisor in advance.

Care shall be taken to determine whether any collapse of the hole has occurred at depth after recovering of the preceding run. Where collapse has occurred, this shall be recorded.

The subsequent run shall be driven from the top of the collapsed section for a maximum depth equal to the length of the sample tube. On no account will overdriving be permitted.

On reaching the specified termination depth for the hole, the driving hammer shall be removed, and the sampling probe jacked out using hydraulic jacking equipment. Mechanical jacking equipment may be used if agreed with the Investigation Supervisor in advance.

2.3.2 Dynamic sampler photographs

Colour photographs of the retrieved samples from the dynamic sampler shall be taken for each 1m of sampler run. Successive samples may be photographed together, so as to fill a photographic frame, provided each run follows in sequence and can be individually identified by suitable labelling. The camera settings shall be such that the entire sample is in focus. The requirements of Clause 3.25 apply.

For window sampling: the photograph shall be taken at the window side.

For windowless-sampling: the plastic liner shall be split in half longitudinally to allow photography.

Each sample run shall be photographed against a matt grey background and with a clearly legible notice giving the following information:

- Contract title
- Contractor
- Exploratory hole number
- Date
- Depth below ground level of top and bottom of sample
- Scale bar, graduated in decimetres
- Colour chart.

2.3.3 Sub-sampling and testing

Immediately after extraction and photographing, sub-sampling and testing shall be undertaken on the dynamic sampler core.

Unless specified otherwise in Schedule 1, the following testing and sampling shall be undertaken, in the following sequence of priority, on each dynamic sampler core:

- A suite of samples for contamination testing purposes (where container types per suite are as defined in Schedule S1.12.12) shall be taken from each stratum or at 1m centres if the stratum is thicker than 1m;
- A disturbed sample shall be taken from stratum or at 1m centres if the stratum is thicker than 1m;
- A bulk sample shall be taken from each stratum.

2.3.4 Installations and reinstatement

Where installations are required in dynamic sampler holes:

- The requirements for groundwater installations in dynamic sampler holes shall be as specified in Schedule 2 and Annex 2.3;
- The requirements for gas monitoring installations and for combined gas-and-groundwater installations in dynamic sampler holes shall be as specified in Schedule 2 and Annex 9.

Where no installation is required in a dynamic sampler hole, the hole shall be backfilled immediately after its completion. The hole shall be backfilled with bentonite cement grout except that: bentonite pellets may be used if agreed in advance with the Investigation Supervisor; and in coarse-grained (non-cohesive) strata overlying the highest cohesive stratum, arisings from the same non-cohesive strata material may be used as backfill.

Where bentonite pellets are used, they shall have a minimum swelling capacity of 50% of its dry volume and have completed swelling within approximately 30minutes of being hydrated. When adding pellets above the water level in the borehole, at regular (at least every 0.5m) intervals, the contractor shall cease to add pellets and pour clean water over the pellets to cause the bentonite to hydrate. Hydration of the bentonite pellets will be demonstrated once water ceases to drain freely through the bentonite pellets.

All benches and starter pits shall be reinstated. A method statement for reinstatement shall be submitted to the Investigation Supervisor before starting the first dynamic sampler hole.

2.3.5 Records and reporting for dynamic sampling

The Contractor shall provide a daily record (Clause 2.22) for each dynamic sampling hole. A copy of each daily record shall be submitted to the Investigation Supervisor at the beginning of the next working day.

Preliminary logs for dynamic sampler holes shall be prepared and issued in accordance with Clause 16.1 of the Specification.

Logging of dynamic sampler holes shall be carried out by an experienced geotechnical engineer or engineering geologist. Each dynamic sampler log shall include:

- All details marked ✓ and (✓) for 'dynamic probing' specified in Clause 13.2 and Clause 16.2.2 of the Specification and:
- Details of the penetration time for each 1m run
- Length of each dynamic sample run
- Recovery in each dynamic sample run
- Results of any hand penetrometer tests
- Observations on the stability of the hole.

Digital data for dynamic sampler holes shall be supplied in accordance with the requirements of Schedule S1.21, as applicable. Dynamic sampler holes shall be treated as boreholes for the purpose of AGS records.

Annex 3

Instrumentation

Annex 3.1 Closed system piezometers installations

3.1.1 Standpipes and standpipe piezometers

Refer to Appendix I of the Specification (EI SGI, 2016), for general requirements for standpipes and standpipe piezometers. Particular requirements for the installation of standpipes and standpipe piezometers are specified in Section 3.1.4 herein. Particular requirements for the testing and use of standpipes and standpipe piezometers are specified in Section 3.1.5 herein.

3.1.2 Pneumatic piezometers

A pneumatic piezometer shall incorporate a pore water pressure measuring device comprising a porous tip and pressure transducer connected by two small-bore nylon tubes that, during reading, carry nitrogen to a pressure measuring unit.

The pneumatic piezometer tips shall be of the normally closed type and shall have a high air entry porous ceramic tip of pore diameter approximately 1 micron and permeability to water of approximately 2×10E-8 m/s.

The pneumatic piezometer tips shall be connected to the terminal panel with twin nylon 11 tubes enclosed within a polyethylene sheath. The tubes shall be leak-proof and have leak-free connections within the expected range of gas pressures. The lengths of the lines shall be sufficient to allow for the expected movements of the ground. The lines shall be in a continuous length from the piezometer tip to the terminal enclosure. During installation of pneumatic piezometers, care shall be taken not to overstress or otherwise damage pneumatic tubes.

Before installing a pneumatic piezometer, the in-ground system shall be tested by lowering it into a water-filled cased borehole or similar water column not less than 10m deep. The device shall be held at 3 different levels within the water column and pressure readings taken at each level. At any level, if the difference between the readings and the actual water head is greater than 0.1m the piezometer will be rejected and replaced with a device that meets the 0.1m tolerance test.

The pneumatic piezometer shall be connected to suitable terminal units close to the ground surface fitted with quick-release couplings.

Either a Bourdon gauge or digital readout units may be employed. The pressure measurement system shall be accurate to ±0.1m head of water for a range of pressures of 0m head to the pressure head equivalent to full hydrostatic pressure at the scheduled depth of the relevant exploratory hole (as specified in Schedule 2). The readout units shall be portable and have a stout case with all electric components protected in a sealed enclosure.

Digital readout units shall have rechargeable batteries such that they can be used for at least 8 hours between charges and shall incorporate a battery check indicator that allows the state of charge to be monitored. The unit shall be supplied with a battery charger.

A pressure regulator shall be supplied for recharging the unit(s) with nitrogen gas.

Particular requirements for installation of pneumatic piezometers are specified in Section B1.4 herein.

Particular requirements for the testing and use of pneumatic piezometers are specified in Section B1.5 herein.

3.1.3 Vibrating wire (VW) piezometers

A vibrating wire (VW) piezometer shall comprise a pore water pressure measuring device with a porous tip and vibrating wire pressure transducer connected by an electrical cable to a VW readout unit

The vibrating wire piezometers shall be suitable for a range of pressures from 0m head to the pressure head equivalent to full hydrostatic pressure at the scheduled depth of the relevant exploratory hole (as specified in Schedule 2). Devices shall be accurate to ±0.01m.

They shall be fitted with a high air entry porous tip with a pore diameter of approximately 1 micron and permeability to water of approximately 2×10E-8 m/s. All instruments shall be supplied with serial numbers and gauge factors.

The VW piezometer tips shall be connected to the terminal panel with multiple conductor electrical cable suitable for direct burial, compatible with the VW piezometer tip manufacturer's recommendations.

The electrical cables shall be terminated on a switching board within a rigid, lockable waterproof enclosure. During installation, care shall be taken not to overstress or otherwise damage electrical cables. The lengths of the cables shall be sufficient to allow for the expected movements of the ground. Cables should be continuous or have full-strength connections.

Before installing a VW piezometer, the in-ground system shall be tested by lowering it into a water-filled cased borehole or similar water column not less than 10m deep. The device shall be held at 3 different levels within the water column and pressure readings taken at each level. At any level, if the difference between the readings and the actual water head is greater than 0.1m the piezometer will be rejected and replaced with a device that meets the 0.1m tolerance test.

The VW readout unit shall be a portable, waterproof, battery-operated unit giving a direct readout of pore water pressure. It shall be capable of storing gauge factors and storing and subsequently downloading readings to a computer.

VW readout units shall have rechargeable batteries such that they can be used for at least 8 hours between charges and shall incorporate a battery check indicator that allows the state of charge to be monitored. The unit shall be supplied with a battery charger.

Where VW piezometer tips are pushed into the ground (“push-in” VW piezometers), the devices shall be fitted with a conical driving tip and shall have a sleeve above the piezometer tip of minimum length 500mm and minimum diameter equal to the diameter of the piezometer tip. Push-in VW piezometers shall be installed using a hydraulic rig.

Pore water pressure shall be monitored during installation and the rate of penetration controlled to ensure that pore water pressures remain within the allowable limit for the transducer. The rods used for piezometer installation shall be filled with bentonite slurry during installation of the piezometer and a positive head of slurry shall be maintained as the rods are withdrawn. Each push-in VW piezometer shall be installed to within 100mm of the specified depth. The at-surface cabling shall be clearly labelled with the borehole name, instrument type and depth.

Particular requirements for the installation of VW piezometers are specified in Section B1.4 herein. Sections B1.4.1, B1.4.2 and B1.4.3 do not apply to push-in VW piezometers.

Particular requirements for the testing and use of VW piezometers are specified in Section B1.5 herein

3.1.4 Installation of piezometers

3.1.4.1 Formation of hole

Each hole shall remain open until the specified instruments have been installed in accordance with the Specification. Adequate precautions shall be taken including the use of a temporary lining tube if necessary to prevent ingress of soil and water to maintain the hole at its full dimensions.

Where the depth of the hole is greater than the required depth of the instrument, then the lower part of the hole shall be backfilled with cement-bentonite grout or other impermeable materials approved in advance by the Investigation Supervisor.

3.1.4.2 Installation in sand pocket

For the installation of a piezometers in a sand response zone, the piezometer shall be installed within a response zone of filter material of the specified length and depth (the ‘sand pocket’ or ‘sand cell’), with a single piezometer per sand pocket. The sand shall be clean fine aggregate and shall fall wholly within the limits of grading 1200 microns and 210 microns.

The material shall be stored in a waterproof container.

Taken due account of the specified length of the response zone, the sand pocket shall extend not less than 200mm below to 100mm above the piezometer element. That portion of the sand filter below the element shall be placed first. The sand shall either be placed hydraulically by washing into the borehole with clean water through a tremie pipe or deposited directly at the base of the borehole by means of a container that can be opened remotely from the top of the borehole. The volume of sand placed and the final elevation of the top of the sand shall be recorded. The Contractor shall allow sufficient time for the sand to settle if placed under water.

For sand pockets that are not at the base of the borehole, a bentonite seal shall be formed (using bentonite pellets) below the sand pocket to a depth of at least 500mm. If the hole is dry, water shall be added to the hole to ensure the pellets swell to form a seal.

The piezometer tip shall be located at the specified position within the sand pocket using appropriate placing tubes and adapters.

The piezometer tip shall be installed to within 100mm of the specified level. The remaining sand filter shall then be placed as described above. The Contractor shall ensure that the piezometer tips are saturated prior to installation and take all necessary steps to ensure that they remain saturated during installation.

A bentonite seal shall then be formed above the sand pocket to a depth of at least 500mm, adding water if the hole is dry to ensure the pellets swell to form a seal. The remainder of the hole shall be backfilled with grout placed by tremie.

If groundwater was encountered during drilling, then on completion of drilling the borehole shall be flushed with clean water using a tremie pipe lowered to the base of the hole, fitted with an appropriate deflector plate to avoid erosion of material from the base of the hole during flushing. If the water in the borehole becomes contaminated by grout it shall be replaced with clean water.

Throughout the installation of the piezometer(s), the borehole casing shall be withdrawn smoothly and concurrently with installation operations so as to cause the minimum of disturbance.

During piezometer installation, the levels of the piezometer tip, sand filter, bentonite seal and grout, and the length of the piezometer tubing or standpipe used shall be recorded as installation proceeds.

The top of the PVC access tube to standpipe piezometers shall be covered by a plastic end cap with an air vent.

The at-surface tubing or cabling shall be clearly and permanently labelled with the borehole number, instrument number, type and depth.

3.1.4.3 Installation in grout pocket

Where specified, the sand pocket (detailed in Section 3.4.1.2) shall be replaced by a zone of high air entry grout as specified below.

The grout shall comprise bentonite and cement with just sufficient water to form a pumpable mix. It shall have a 7-day unconfined cube strength of between 20N/mm2 and 30N/mm2 unless specified otherwise in Schedule S1.16 or by the Investigation Supervisor. The Contractor shall specify with the method statement the grout mix the Contractor intends to use to achieve this requirement and carry out tests to prove the Contractor's mix before site work commences.

The grout-mixing machine shall be capable of mixing the grout accurately and without segregation according to the mix requirements.

3.1.4.4 Protection of installations

Before the protective cover is in place, instrument access tubes, cabling and head works shall be suitably protected by placing appropriate barriers. Where construction plant is working, the protection shall take the form of concrete manhole rings or similar robust barriers.

Installations that are finished flush with ground level shall be provided with a suitably sized and identified cover. Installations that project above ground level shall be protected with a steel sleeve of minimum height 200mm and cap.

Details of the type of cover required (including requirements for lockable covers) are specified in Schedule S1.16.1 and Schedule 2.

Readout gauges and other equipment that is permanently located on site shall be housed in a secure, robust and weatherproof enclosure. A master key shall be held by the Contractor in addition to any keys provided to the monitoring operatives, for the duration of the monitoring period.

3.1.4.5 Commissioning of piezometers

Each piezometer shall be commissioned as soon as possible on completion of its installation, and always before any works start (including third party works) that are expected to cause pore water pressure changes at the instrument location. The co-ordinates and ground level of the instruments shall have been established before the time of commissioning.

The same measuring equipment used for commissioning shall be used for subsequent monitoring.

To commission a piezometer, 3 sets of 3 readings shall be taken at intervals of 3 hours (i.e. 9 readings in total). The Investigation Supervisor shall be given at least 24 hours' advance notice of the commissioning of each piezometer and shall be invited to observe the commissioning.

If access tubes or cables must be cut down or extended after an installation has been commissioned (for example, to suit subsequent excavation or placing of fill), a reading shall be taken: (i) immediately before cutting or extending the tube or cable; and (ii) immediately after re-establishing the functioning system.

3.1.5 Installation records

The Contractor shall make a complete record of the groundwater instruments installed, including the position and level of each instrument, the identification code for the connections, features used for datum measurements, and the readings during the commissioning period.

One set of records shall be kept on site and be available for inspection during the progress of the Contract.

A copy of the complete records shall be supplied to the Investigation Supervisor within two weeks of completion of the Investigation and a copy shall be included in the final report.

3.1.6 Data collection and reporting

The frequency of readings in groundwater installations are specified in Schedule S1.16.3. The same measuring equipment used for commissioning shall be used for monitoring.

For standpipes and standpipe piezometers, readings shall be taken using a dipmeter. The water level shall be recorded relative to the stop of the standpipe. The level of the top of the standpipe shall be determined at every third set of readings.

For pneumatic piezometers and VW piezometers, readings shall be taken in accordance with the equipment manufacturer's instruction manual and each measurement shall be the average of three readings.

All groundwater monitoring probes and digital readout units shall be calibrated at intervals not exceeding one month.

The instrument readings shall be recorded on approved record sheets and submitted to the Investigation Supervisor by 12.00 noon on the day after the readings were taken. The data shall be provided to the Investigation Supervisor in an agreed format and agreed delivery media, including records from readout units employing a data logger.

The following records shall be made for each set of readings:

- Project name

- Client
- Personnel taking the readings
- Type of instrument
- Location ID and elevation of ground surface and coordinates
- Base depth of installation from log
- Measured depth of hole
- Instrument reference
- Date and time of readings including before and after installation of transducers if installed
- Identification and reference of readout equipment used
- Individual readings, average readings and (as applicable) as specified in Schedule S1.16
- Weather
- Nearby construction activity or earthworks
- Any other pertinent remarks.

Where provision of AGS-format digital data is specified in Schedule S1.21.3 of the Specification, all data from groundwater installations shall be presented in AGS digital format.

Where provision of AGS-format digital data is not required (Schedule S1.21.3), all data from groundwater installations shall be provided in electronic format using non-write protected Microsoft Excel® spreadsheets, in addition to the presentation of the results in the final report.

Annex 5

Cone Penetration Testing (CPT)

Annex 5.1 General

This Annex presents the general requirements for cone penetration testing (CPT). The test procedure shall conform to BS EN ISO 22476-1. All tests shall be carried out with an electrical cone and both cone resistance and sleeve friction shall be reported. In addition, where specified in Schedule 2, pore pressure shall also be measured. The inclination of the cone during penetration shall be measured and reported.

Annex 5.2 Equipment

The Contractor shall provide full details of the proposed thrust machine and other equipment with the method statement. A nominal reaction of 20 tonnes is required, but lower values may be permitted for weak soils.

With reference to BS EN ISO 22476-1 Section 5.2 and Table 2 (reproduced herein as Table A5-1), the Contractor shall indicate the conformance of the proposed equipment to the relevant Application Class.

Electric cones and piezocones shall be of 35.7 mm diameter and cone base area of 1000mm^2 unless stated otherwise in the Schedule S1.13 of the Specification. The cone load sensor shall have a range of up to 100kN.

Where pore pressure measurement is required, the pore pressure sensor shall have a range up to 10MPa. Pore pressure shall be measured behind the cone (the u_2 pressure). The cone area ratio, α, shall be reported and shall be greater than 0.5. The piezocone shall be temperature compensated to account for differentials between ambient air and ground temperatures.

The Contractor shall be solely responsible for any damage to or loss of CPT equipment incurred as a result of undertaking the proposed fieldworks and shall take any appropriate measures to prevent damage and assure high quality and reliable CPT data.

Table A5-1 Application classes (extract from BS EN ISO 22476-1:2012)

Application class	Test type	Measured parameter	Allowable minimum accuracy[a]	Maximum length between measurements	Use	
					Soil[b]	Interpretation / evaluation[c]
1	TE2	Cone resistance	35 kPa or 5 %	20 mm	A	G, H
		Sleeve friction	5 kPa or 10 %			
		Pore pressure	10 kPa or 2 %			
		Inclination	2°			
		Penetration length	0,1 m or 1%			
2	TE1 TE2	Cone resistance	100 kPa or 5 %	20 mm	A	G, H*
		Sleeve friction	15 kPa or 15 %		B	G, H
		Pore pressure[d]	25 kPa or 3 %		C	G, H
		Inclination	2°		D	G, H
		Penetration length	0,1 m or 1 %			
3	TE1 TE2	Cone resistance	200 kPa or 5 %	50 mm	A	G
		Sleeve friction	25 kPa or 15 %		B	G, H*
		Pore pressure[d]	50 kPa or 5 %		C	G, H
		Inclination	5°		D	G, H
		Penetration length	0,2 m or 2 %			
4	TE1	Cone resistance	500 kPa or 5 %	50 mm	A	G*
		Sleeve friction	50 kPa or 20 %		B	G*
		Penetration length	0,2 m or 2 %		C	G*
					D	G*

NOTE For extremely soft soils, even higher demands on the accuracy can be needed.

[a] The allowable minimum accuracy of the measured parameter is the larger value of the two quoted. The relative accuracy applies to the measured value and not the measuring range.

[b] According to ISO 14688-2 [1]:
- A homogeneously bedded soils with very soft to stiff clays and silts (typically $q_c < 3$ MPa)
- B mixed bedded soils with soft to stiff clays (typically $q_c \leq 3$ MPa) and medium dense sands (typically 5 MPa $\leq q_c < 10$ MPa)
- C mixed bedded soils with stiff clays (typically 1,5 MPa $\leq q_c < 3$ MPa) and very dense sands (typically $q_c > 20$ MPa)
- D very stiff to hard clays (typically $q_c \geq 3$ MPa) and very dense coarse soils ($q_c \geq 20$ MPa)

[c]
- G profiling and material identification with low associated uncertainty level
- G* indicative profiling and material identification with high associated uncertainty level
- H interpretation in terms of design with low associated uncertainty level
- H* indicative interpretation in terms of design with high associated uncertainty level

[d] Pore pressure can only be measured if TE2 is used.

Annex 5.3 Non-standardised equipment

Where T-bar, piezoball or other tip elements are to be employed, these elements shall be as specified in Schedule S1.13.2 of the Specification. T-bar or piezoball type testing shall be conducted in accordance with DeJong et al. (2010).

Annex 5.4 Support of CPT rods

Adequate support and restraint shall be provided to the free length of the sounding rods between base of CPT rig and ground level, to prevent buckling or ‘spring’ in the rods under load. This shall include extension guide tubes where the depth to ground is increased by inspection pits or other means.

Details of the measures employed to laterally restrain the sounding rod above ground shall be provided in the Contractor’s Tender.

Where required for the support of sounding rods, any pre-formed hole through obstructions shall be backfilled with loose fine to medium sand to support the CPTs rods.

Annex 5.5 Piezocone filter element preparation

Procedures for preparing the piezocone apparatus shall be as per BS EN ISO 22476-1, except where amended below.

The piezocone apparatus shall have the filter located in the u2 position on the shoulder of the cone.

Only filter element materials of sintered aluminium or stainless steel or porous polypropylene shall be used.

A new filter element shall be fitted for each piezocone sounding.

All filter elements shall be prepared as per Annex D of BS EN ISO 22476-1, with the following amendments:

The use of filters in de-aired distilled water is not permitted.

Use of glycerine is permitted.

Filters shall be heated in glycerine to a temperature of approximately 50°C and subjected to a minimum of 2 no. cycles of de-airing of not less than 2 hours per cycle. The filters and glycerine shall be reheated to 50°C between cycles. Filters shall have been de-aired using this sequence within 4 weeks in advance of their use.

Prepared filter elements shall be stored submerged in de-aired glycerine for not more than 4 weeks prior to use (or shall be subject to a repeat de-airing procedure). Any alternative proposed procedures for de-airing shall be submitted by the Contractor for the acceptance of the Investigation Supervisor at least 7 days in advance of the relevant CPT field work.

All cavities and chambers having connectivity with the pore pressure transducer within the piezocone shall be flooded with de-aired glycerine prior to the fitting of the filter element.

After the piezocone apparatus has been assembled and the calibration checked, the filter element shall be sealed over with a rubber membrane until the penetration testing is commenced.

Annex 5.6 Calibration

The methodology of calibration and a certificate of calibration shall be provided to the Investigation Supervisor for each of the CPT parameters to be measured.

Details of the de-airing of filter elements shall similarly be provided, stating conformance with the requirements of Clause D5 herein.

Piezocones shall be re-zeroed prior to the commencement of each test. The re-zeroing shall be undertaken at an ambient temperature in not more than +/- 10°C of the in-ground temperature. ‘No-load’ values shall be recorded at the end of the test after the piezocone element has been withdrawn from the ground, in order to validate the sensitivity of the apparatus to temperature.

Annex 5.7 Measurements

A daily record shall be maintained for all CPT works. The CPT daily record shall at a minimum include:

- Test location identifier
- Cone number and calibration reference
- Cone preparation start/completion times

- Penetration start and completion times
- Dissipation start and completion times
- Completed test depth and reason for termination (for example: met target, refusal, excessive inclination)
- Depth of inspection pit below ground level and reference level for the CPT test commencement
- Re-zero values for the test parameters at the start/finish of each test
- Water level in each hole immediately after withdrawal of the CPT rods.

The cone penetration test rig shall have the capability to present the response of all required testing parameters in real-time (including end resistance, shaft friction, pore pressure, inclination) such that the operator and Investigation Supervisor can observe the responses during penetration.

Unless specified otherwise, the measurement of cone resistance, sleeve friction and, where required, pore water pressure shall be made at a depth interval of not more than 20mm.

During piezocone testing, the operator shall pay particular attention to the pore pressure response, and look for evidence of any desaturation, lagging, negative pore pressures, or other uncharacteristic behaviour. Such behaviour shall immediately be brought to the attention of the Investigation Supervisor.

Where such behaviour is encountered, and where measurement of excess pore pressure is required and/or where further dissipation testing has been specified at greater depth than the current test depth, the affected test shall be ended, and one of the following mitigation methods shall be implemented:

1. the test location shall be pre-formed to the water table and the penetration test repeated. This shall require guide tubes to extend to the commencement depth in order to provide adequate lateral support to the push rods;
2. the test location shall be pre-formed to the water table, the hole backfilled with fine to medium grained sand, and the penetration test repeated. The test results obtained within the backfill shall be disregarded and a rate of advancement in excess of 20 mm/sec shall be permitted in order to preserve the saturation of the filter element;
3. the test shall be repeated in the existing hole. The test results obtained within the initial repeated depth of testing shall be disregarded. The rate of advancement may be increased at the operator's discretion in excess of 20 mm/sec in order to preserve the saturation of the filter element.

The mitigation method adopted shall be agreed in advance with the Investigation Supervisor.

The holes may be artificially saturated to preserve the saturation of the filter element, at the discretion of the Investigation Supervisor.

Where the provision of preliminary digital data is specified in Schedule S1.21.4 of the Specification, preliminary digital data from cone penetration testing shall be provided to the Investigation Supervisor at the end of each day of CPT operations or as requested by the Investigation Supervisor (in addition to the daily record for CPT operations).

Annex 5.8 Dissipation tests

Where specified in Schedule 2, dissipation tests shall be performed at the specified depths and also at depths selected by the Investigation Supervisor.

For dissipation testing, penetration shall be halted, and pore water pressure and cone resistance shall be recorded at intervals not greater than 5 seconds.

Dissipation tests shall be conducted for a duration sufficient to reach 50% of the initial excess pore water pressure or to a state of equilibrium, or as advised by the Investigation Supervisor.

Annex 5.9 Seismic cone testing

Before the start of seismic cone testing at a location, the cone penetrometer rods shall be rotated such that the axis of a horizontal seismic transducer (receiver) is parallel to the long axis of the shear beam at the ground surface.

Care shall be taken when pushing the cone further into the ground to avoid rotation and inclination of the rods and, hence, of the seismic transducers.

The orientation of and depth to the seismic transducers shall be recorded.

The downhole seismic test methodology shall be in accordance with ASTM D7400-08 unless agreed otherwise with the Investigation Supervisor.

Annex 5.10 Termination criteria

The tests shall be made to the depths specified in Schedule 2 or as advised by the Investigation Supervisor, unless one of the following occurs at a shallower depth:

- The capacity of the thrust machine or reaction is reached, or
- The maximum load range for the sensors is reached, or
- The rod inclination exceeds 15°.

Annex 5.11 Reporting of CPT results

Cone penetration test results shall be reported in accordance with BS EN ISO 22476-1, with the following amendments:

For field reports and test reports, Item (o) of Clause 7.2.1 of BS EN ISO 22476-1 shall additionally include:

'the approximate depth at which the observations were made'

In addition to the records listed in Clause 7.2.3 of BS EN ISO 22476-1, the following additional Item (j) shall be recorded on field reports:

'Date of de-airing filter element preparation (shall be within 4 weeks of use)'

Where pore water pressure is measured, the corrected cone resistance, qt, shall also be given in the test report, where

$$q_t = q_c + u_2(1 - \alpha)$$

where q_c is the uncorrected cone resistance, u_2 is the pore water pressure and α is the cone area ratio.

Where dissipation tests are carried out, the test report shall include plots of pore pressure and cone resistance against time and shall state whether the cone was clamped or not during the test.

For each dissipation test, values of coefficient of consolidation shall be calculated and reported using the Houlsby and Teh (1988) method. The use of other methods may be permitted, subject to the methodology being provided in full and in advance to the Investigation Supervisor.

For seismic cone testing, the reporting shall include source offset distances, receiver depths and measured source-receiver travel times, in addition to the results of the interpretation undertaken in accordance with Clause 8.3.4.

Where provision of AGS-format digital data is specified in Schedule S1.21.3 of the Specification, all AGS-compatible data from cone penetration testing shall be presented in AGS digital format.

Where provision of AGS-format digital data is not required (Schedule S1.21.3), or where certain CPT data types are not compatible with the specified AGS format (see Schedule S1.21.3), the data shall be provided in electronic format using non-write protected Microsoft Excel® spreadsheets, in addition to the presentation of the results in the final report.

Any requirement for interpretation by the Contractor of soil type from CPT results shall be as specified in Schedule S1.13.3 of the Specification.

Annex 5.12 References

Houlsby, G.T. and Teh, C.I. (1988*) Analysis of the piezocone in clay*, Proceedings of the International Symposium on Penetration Testing, Orlando.

DeJong, J. et al. (2010) *Recommended practice for full-flow penetrometer testing and analysis*, ASTM Geotechnical Testing Journal, 33(2), 137–149.

BS EN ISO 22476-1 *Geotechnical investigation and testing. Field testing. Electrical cone and piezocone penetration test* (incorporating corrigendum January 2013), BSI

Annex 6

Permeability

Not required.

Annex 8

Loading Tests

Not required.

Annex 9

Ground Investigation on Potentially Contaminated Land

Annex 9.1 Definitions

Potentially contaminated land: the term 'potentially contaminated land' shall mean that land designated as such in the Specification. This land may contain substances which could give rise to hazards likely to affect human health, the natural environment or the proposed development.

Contamination ground investigation: the term 'contamination ground investigation' shall mean those parts of the Investigation that are undertaken on potentially contaminated land to obtain information on the extent and nature of contamination of the ground and / or groundwater.

Hygiene facility: the term 'hygiene facility' shall mean designated washing and other specific facilities as described in Schedule S1.8.4.

Sampling well: the term 'sampling well' shall mean groundwater sampling standpipes and combined gas and groundwater sampling standpipes from which groundwater samples are taken for the contamination ground investigation.

Annex 9.2 General requirements

9.2.1 Potentially contaminated land

The presence and nature of the known areas of potentially contaminated land are noted in Schedule 1.8.4 and shown on the Drawings as far as available records permit. If evidence of further potentially contaminated land is encountered the Contractor shall cease affected work and inform the Investigation Supervisor immediately. The Contractor shall agree a revised method of working appropriate to the nature and level of hazards encountered, with the Investigation Supervisor and any regulatory authority concerned if necessary.

9.2.2 Working on potentially contaminated land

The Contractor shall take the necessary precautions to control and secure the site operations on potentially contaminated land.

At the end of the working day any exploratory hole not backfilled shall be securely covered and fenced so as to prevent human or animal access.

The Contractor shall dispose of all surplus excavated material in accordance with current waste disposal legislation.

9.2.3 Sample descriptions

All solid samples shall be examined and described in accordance with clause S1.21.2.

Ground from potentially contaminated land shall be described by an environmental or geotechnical person, as appropriate, meeting the requirements of Clause 2.3(c) of the Specification

Solid and liquid samples taken on potentially contaminated land shall be additionally described by an environmental or a geotechnical person meeting the requirements of Clause 2.3(c) of the Specification, and the descriptions shall include colour and smell with reference to specific inclusions.

Annex 9.3 Rotary drilling

On potentially contaminated land, the Contractor shall take all necessary precautions to contain the drilling fluid returns in order to prevent at-surface contamination or contamination of nearby surface water drains or watercourses.

Down hole hammer methods of drilling, using air flush, are not permitted in contaminated soils or made ground. This is due to the generation and mobilisation dust from the contaminated soils / made ground during drilling.

Annex 9.4 Pits and trenches

Trial pits and trenches on potentially contaminated land shall be excavated by machine only.

Observation pits and trenches on potentially contaminated land shall be excavated by machine. All safety precautions as required under Section 9.2.6 of this Annex 9 and those contained in the Preliminary Safety and Health Plan shall be followed before and during personal entry into observation pits and trenches.

Unless specified otherwise, backfill to trial pits and trenches on potentially contaminated land shall comprise the solid arisings which shall be placed at the same depth and location from which they originated.

Any deficit in fill material at a particular level shall be made up with inert material having a coefficient of permeability of less than 1x10E-5 m/sec as placed.

Annex 9.5 In-situ testing for contamination ground investigation

9.5.1 Gas monitoring during boring/drilling

The Contractor shall carry out in-situ measurement of gas concentration during the advancement of the exploratory holes so designated in Schedule 2.

The measurements shall be at 1m intervals over the depth range specified in Schedule 2, or as otherwise directed by the Investigation Supervisor.

The monitoring equipment and the method of testing shall be in accordance with the guidance given in Sections 7, 8, 9 and 10 of CIRIA Report 131.

Gas concentration measurements during the advancement of exploratory holes shall be undertaken by a person experienced in the use of the appropriate specialised equipment.

Concentrations of the following gases shall be measured:

- Methane and flammable gases
- Hydrogen sulphide
- Carbon dioxide
- Oxygen.

The monitoring equipment shall be capable of measuring gas concentrations to the following degrees of accuracy:

Table A9.1 Degree of accuracy of gas concentration monitoring equipment

GAS TYPE	UNITS	DEGREE OF ACCURACY
Flammable gases (including methane)	%LEL	1.0
	%v/v	0.1
Hydrogen sulphide	ppm	0.5
Carbon dioxide	%v/v	0.1
Oxygen	%v/v	0.1

9.5.2 Gas monitoring of dual valve installations

For monitoring of gas concentrations in dual valve installations, the monitoring equipment shall be capable of measuring gas concentrations to the following degrees of accuracy:

Table A9.2 Degree of accuracy of gas concentration monitoring equipment for dual valve installations

GAS TYPE (AND EQUIPMENT)	UNITS	DEGREE OF ACCURACY
Vapour (by PID)	ppm	1.0
Methane (by infrared apparatus)	%v/v	0.1
Hydrogen sulphide	ppm	1.0
Carbon dioxide (by infrared apparatus)	%v/v	0.1
Oxygen	%v/v	0.1

The procedure for measuring gas concentrations and monitoring gas flow and, where specified, for gas sampling from dual valve installations shall be as follows:

1. Measure initial barometric pressure, ambient temperature and differential gas pressure in the standpipe.
2. Take initial gas concentration measurements from each tap valve with PID and then with portable gas monitoring equipment. Record gas and vapour concentrations 5s, 30s and 60s after opening each valve.
3. Circulate gas from top of standpipe through the gas monitoring equipment and back into the standpipe via the tap valve with the suspended sampling tube taking readings at 1-minute intervals until steady values are achieved or a maximum of 10 minutes.
4. If gas sampling is specified, or as instructed by the Investigation Supervisor, take a gas sample for subsequent laboratory analysis via the tap valve with the suspended tube.
5. Take final gas concentration measurements from each tap valve with PID and then portable gas monitoring equipment. Record gas and vapour concentrations 5s, 30s and 60s after opening each valve.
6. Carry out gas flow measurements.
7. Measure atmospheric pressure at the end of the procedure.
8. Gas flow (displacement) measurements shall be taken after the gas concentration measurements as follows:
9. Attach gas flow measuring device to the top valve and take measurements at 1-minute intervals for a period of not less than 10 minutes unless gas flow is exhausted in advance.
10. Gas flow displacement measurements shall be expressed in units of L/hr. The detection limit shall be 0.1 L/hr.

The reported information shall include

- Location and reference number of installation
- Depth of monitoring
- Weather conditions during monitoring, including ambient air temperature
- Installation details, including response zone
- Depth to groundwater
- Equipment used
- Operator name and responsibility

- Gas concentration measurements
- Gas flow measurements
- Records of gas sampling (if any)
- Atmospheric pressure in units of millibars
- Differential gas pressure measurement in units of mm water gauge. The sensitivity shall be 0.5 mm water gauge.

9.5.3 Gas monitoring of single valve installations

For monitoring of gas concentrations in single valve installations, the monitoring equipment shall be capable of measuring gas concentrations to the following degrees of accuracy:

Table A9.3 Degree of accuracy of gas concentration monitoring equipment for single valve installations

GAS TYPE (AND EQUIPMENT)	UNITS	DEGREE OF ACCURACY
Vapour (by PID)	ppm	1.0
Methane (by infrared apparatus)	%v/v	0.1
Hydrogen sulphide	ppm	1.0
Carbon dioxide (by infrared apparatus)	%v/v	0.1
Oxygen	%v/v	0.1

The procedure for measuring gas concentrations and monitoring gas flow from single-valve installations shall be as follows:

1. Connect PID to gas valve and measure total VOC concentration for a period of 2 minutes. Record VOC concentrations every 15 seconds including maximum, minimum and steady concentrations.
2. Connect Tedlar bag and take vapour sample for laboratory analysis. Record PID concentration at point of sampling.
3. Attach infrared gas monitor and measure gas concentrations for a period of 2 minutes. Record gas concentrations every 15 seconds including maximum, minimum and steady concentrations.
4. Carry out gas flow measurements.
5. Measure atmospheric pressure at the end of the procedure.

The reported information shall include:

- Location and reference number of installation
- Depth of monitoring
- Weather conditions during monitoring, including ambient air temperature
- Installation details, including response zone
- Depth to groundwater
- Equipment used
- Operator name and responsibility
- Gas concentration measurements
- Gas flow measurements

- Records of gas sampling (if any)
- Atmospheric pressure in units of millibars
- Differential gas pressure measurement in units of mm water gauge. The sensitivity shall be 0.5 mm water gauge.

9.5.4 Field tests on groundwater samples

The field tests and measurements specified in the following table shall be undertaken out on groundwater samples obtained for the contamination ground investigation from exploratory holes and from standpipes and piezometers during purging and sampling (Clause 12.3.2).

The date and time of sampling and carrying out the testing shall be recorded and reported.

Table A9.4 Field tests and measurements for groundwater samples

TEST	UNITS	DETECTION LIMIT	DEGREE OF ACCURACY
pH	pH units	0.1	±0.1
Temperature	° C	0.1	±0.1
Dissolved oxygen	mgO_2/l	0.1	±0.1
Electrical conductivity	µS/cm	10	±2.0
Redox potential	mV	±1	±0.1

Annex 9.6 Instrumentation for contamination ground investigation

Details of the specific installation depths for gas and combined gas-groundwater installations shall be instructed by the Investigation Supervisor via the protocol specified for groundwater installations in Schedule S1.16.3.

Requirements for the frequency of monitoring and sampling of gas and groundwater, as applicable, are specified in Schedule S1.17.

9.6.1 Twin valve gas monitoring installations

Installations for monitoring gas concentration, pressure and gas flow velocity shall be installed in exploratory holes as specified in Schedule 2 and as instructed by the Investigation Supervisor. The installations shall be as described herein and on Figure A9.1. As-installed dimensions and depths shall be recorded.

The standpipe shall consist of uPVC tubing (conforming to BS 3506 Class D) or HDPE tubing (conforming to BS EN 12201 type PE 100) and shall be not less than 50mm in diameter.

The base of the tubing shall be capped, and the tubing shall be perforated or slotted to provide an open area of between 10% and 15% or the surface area of the tubing. Holes shall not be greater than 5mm in diameter and slots shall not be greater than 5mm width.

The filter shall be pea gravel, or similar material, as approved by the Investigation Supervisor, 6mm to 10mm in diameter. The pea gravel shall be quartz based and shall have been washed prior to use.

Where the depth of the exploratory hole is greater than the depth to which the filter and tubing are to be installed then the exploratory hole shall be backfilled below the base of the filter with cement/bentonite grout and a 1m plug of cement/bentonite paste in bags, or compressed bentonite pellets, in accordance with Clause 4.5 of the Specification. If compressed bentonite pellets are used as an alternative to grout balls they shall be

partially saturated before being added to the borehole, and further clean water added to the borehole to complete saturation.

The tubing with centralising devices attached at 2m intervals shall be lowered carefully down the exploratory hole to the level of the filter material, and the exploratory hole backfilled with pea gravel to the depth instructed by the Investigation Supervisor.

The top of the tubing shall be covered with a screw threaded plastic cap having two tap valves as indicated on Figure A9.1. One of the two tap valve assemblies shall have a quick fit compression fitting to enable a 5mm internal diameter tube to be suspended on the underside of the tap valve assembly. The tube shall be hung to within 1m of the groundwater level or to the base of the standpipe, whichever is the higher.

The Investigation Supervisor will specify the depth of unperforated tube at the top of the hole. The borehole shall be backfilled by a plug of cement/bentonite paste in bags, or compressed bentonite pellets, in accordance with Clause 4.5 of the Specification. The upper 0.7m shall be concrete. If compressed bentonite pellets are used they shall be partially saturated before being added to the borehole, and further clean water shall be added to the borehole to complete saturation.

Arrangements to prevent the ingress of surface water and to protect the top of the tubing and tap valves shall use a 150mm lockable stop cock cover which shall be set in a sufficiently stiff concrete mix standing slightly proud of the surrounding ground. Each gas standpipe shall be permanently labelled with a metal stamp or tag indicating the exploratory hole number and installation depth (or level). Protective fencing, where required, shall be as specified in Schedule S1.16.2.

The installation of gas installations shall be completed in a single day.

9.6.2 Combined gas and groundwater sampling installation

Installations to allow both gas monitoring and groundwater sampling shall be installed in exploratory holes where indicated in Schedule 2, and as instructed by the Investigation Supervisor. The installations shall be as described herein and on Figure A9.2.

The details of the combined gas and groundwater sampling standpipe shall be as described in Section 9.7.1 of this Annex 9. In addition, unless the installation is to be used for NAPL investigation, the slotted section shall be wrapped is a sewn fabric sleeve or stocking having a pore size of between 100 and 250 microns. The fabric wrapping shall be to the approval of the Investigation Supervisor. The slotted and wrapped section of pipe shall be surrounded by an inert filter material, as described in Section 9.7.1 of this Annex 9.

9.6.3 Discrete-depth groundwater sampling installation

Installations to allow discrete sampling of groundwater within a specific response horizon shall be installed in exploratory holes, where indicated in Schedule 2, and as instructed by the Investigation Supervisor. The installations shall be as described herein and in Figure A9.3.

The installation details for discrete-depth groundwater sampling instruments shall be as specified in Section 9.7.1 of this Annex 9. In addition, an unslotted section of tubing with grout surround shall be formed above the response zone. The response zone shall be provided with well-formed bentonite seals above and below. The construction of the installation shall be such that cross-contamination from potentially contaminated surface strata is prevented.

The depth and length of the response zone shall be instructed by the Investigation Supervisor.

9.6.4 Shallow groundwater sampling installation

Installations to allow discrete sampling of perched or shallow groundwater shall be installed in exploratory holes, where indicated in Schedule 2, and as instructed by the Investigation Supervisor. The installations shall be as described herein and in Figure A9.4.

The installation details of the combined gas and groundwater sampling instruments shall be as described in Section 9.7.1 of this Annex 9. In addition, the slotted section shall be wrapped is a sewn fabric sleeve or

stocking having a pore size of between 100 and 250 microns. The fabric wrapping shall be to the approval of the Investigation Supervisor. The slotted and wrapped section of pipe shall be surrounded by an inert filter material, as described in Section 9.7.1 of this Annex 9. The top of the tubing shall be covered with a screw threaded plastic cap with a single valve. Suspended tubing is not required.

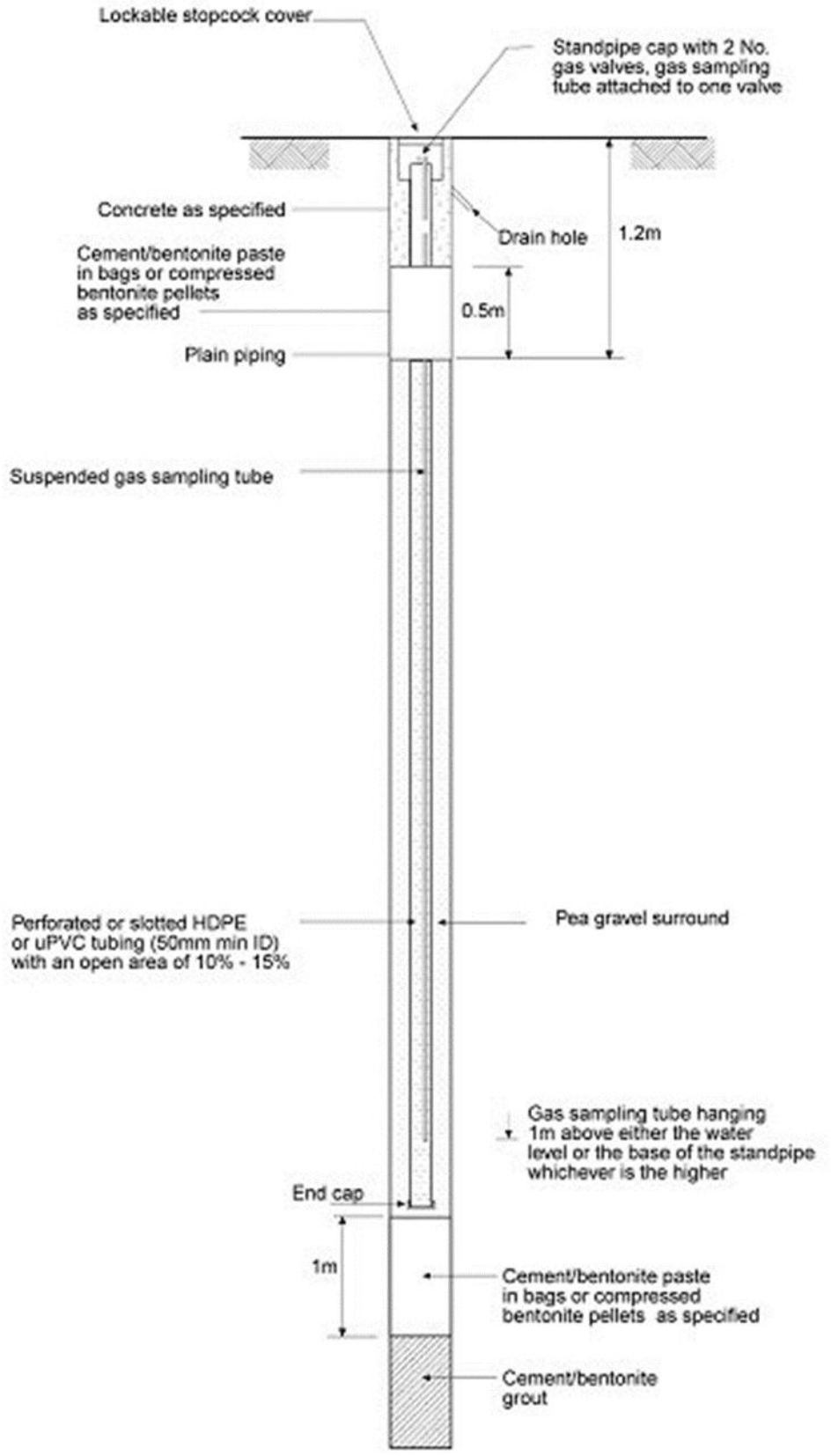

Figure A9.1 Gas monitoring installation detail

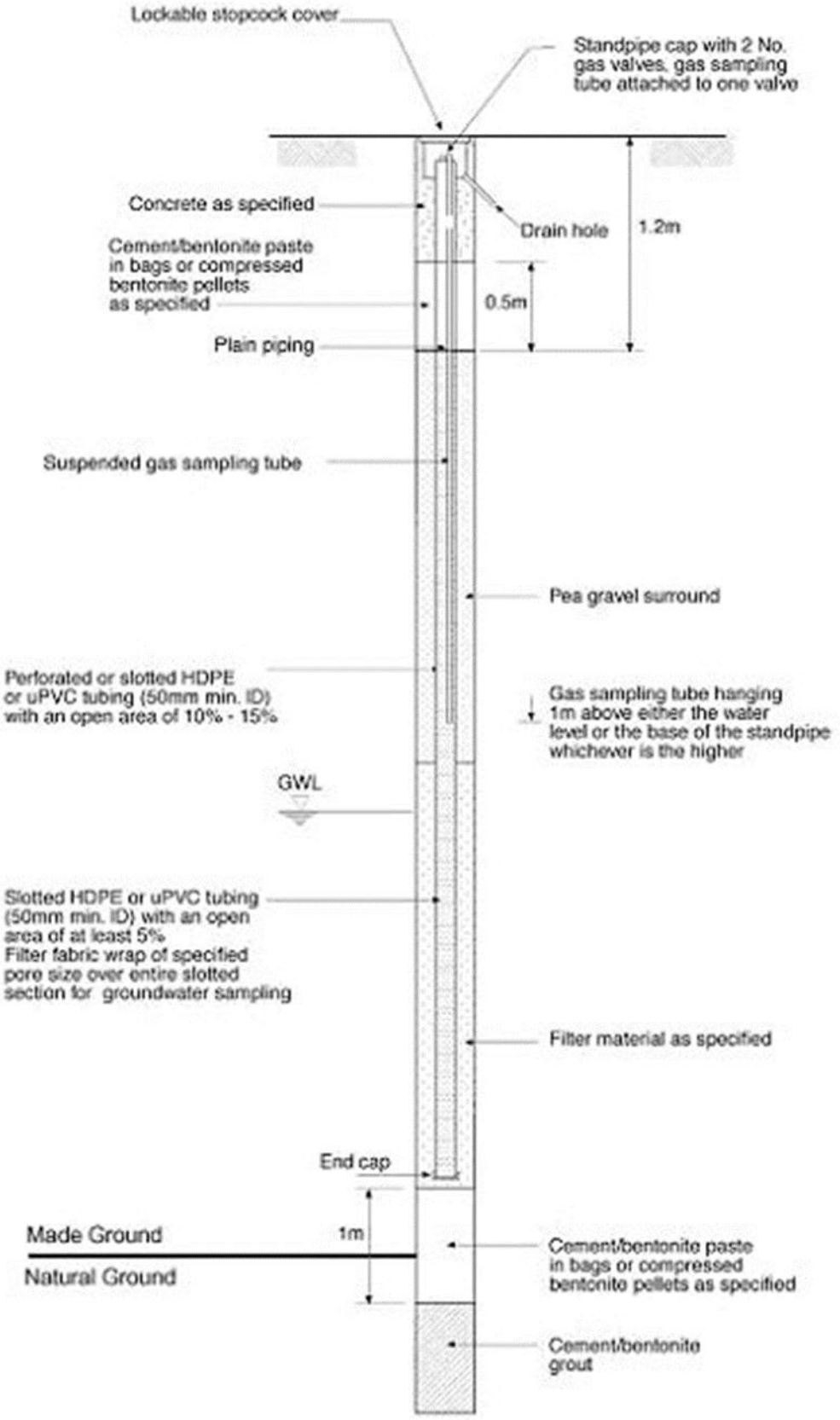

Figure A9.2 Combined gas and groundwater installation detail

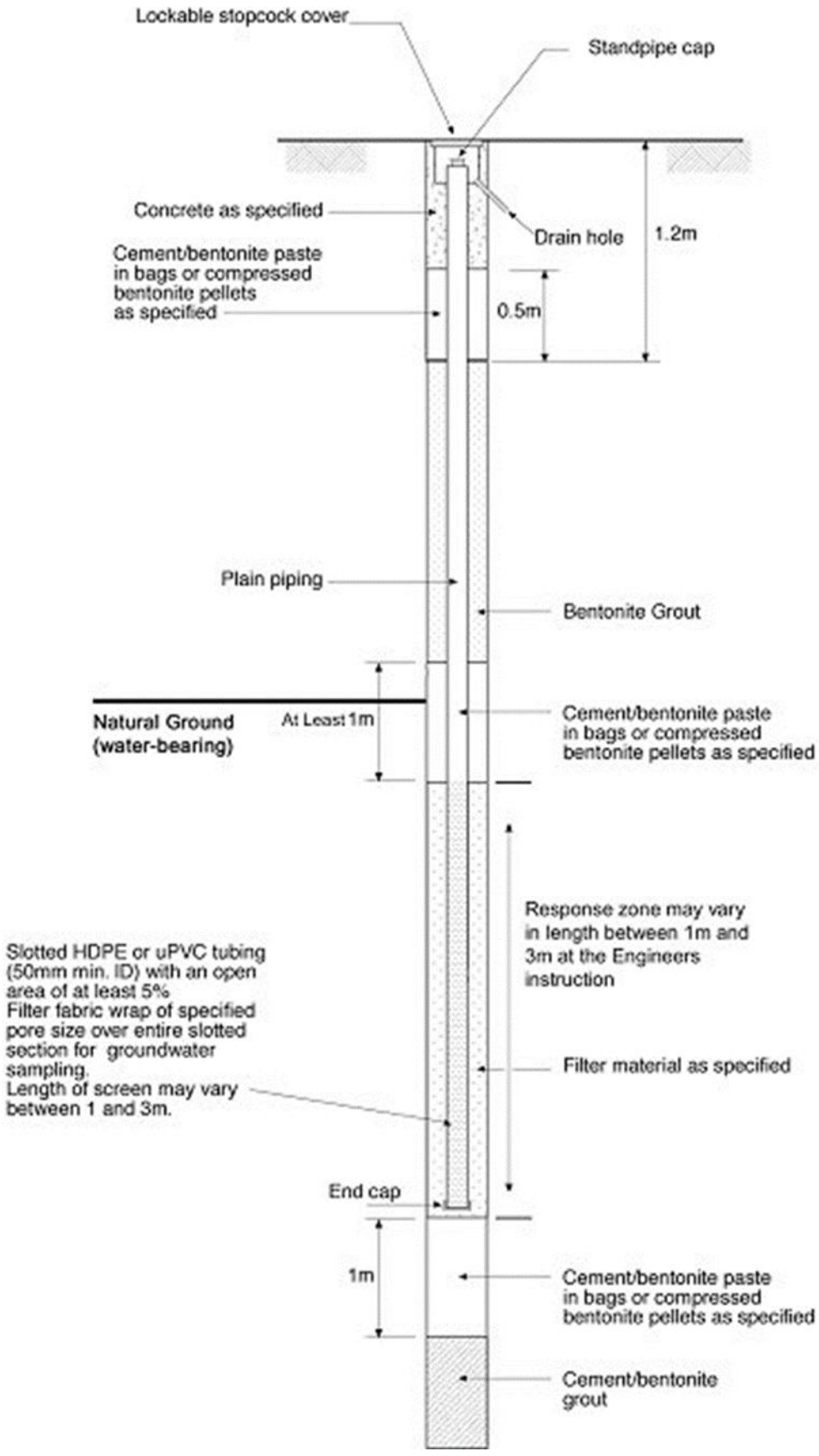

Figure A9.3 Discrete-depth groundwater sampling installation detail

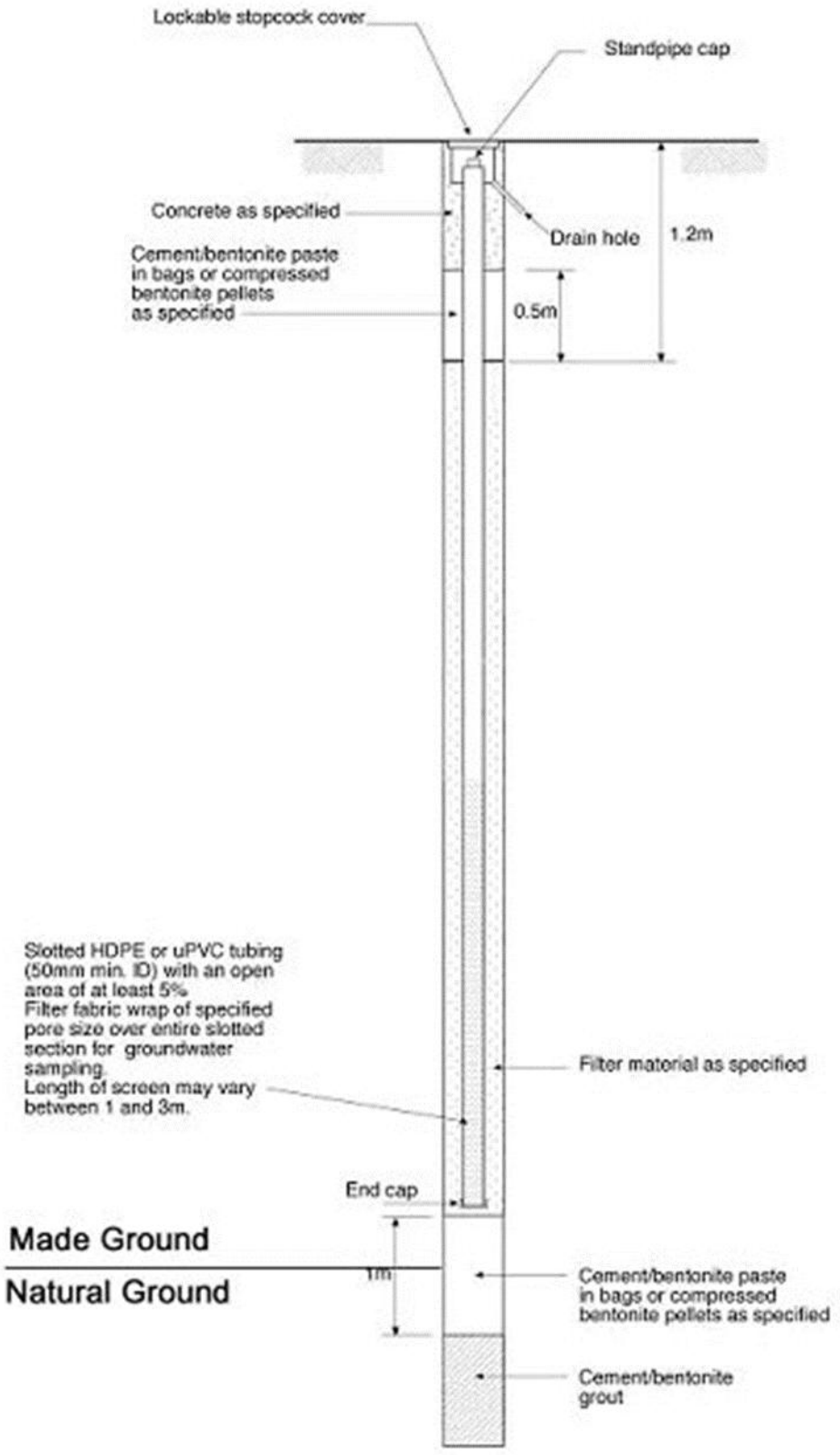

Figure A9.4 Shallow groundwater sampling installation detail

Annex 10

Interpretative Reporting

Not required.

Annex 12

Digital Data

Annex 12.1 Preliminary data

The following requirements apply if the provision of preliminary digital data is specified in Schedule S1.21.4:

- The preliminary digital data shall represent all exploratory holes and shall correspond with the preliminary logs;
- Co-ordinates and levels of exploratory hole locations and test locations shall be included in preliminary data if these have already been surveyed;
- Interpreted geology codes to be included in preliminary logs. (Note: it is recognised that these will be provisional at preliminary data stage and may change subsequently);
- Full referencing of associated files in the relevant fields in the AGS data is not required for preliminary data; and
- Associated files not containing critical data may be omitted from preliminary data.

Annex 12.2 Additional groups, field and codes

In the event that it is found to be necessary to introduce additional groups, fields and codes that are not defined by the specified AGS standard or in this Annex 12 or in Schedule S1.21.3 (including, for example, for specialist testing), the additional groups, fields and codes shall be agreed between the Contractor and the Investigation Supervisor at least 14 days before the scheduled date of issue of the relevant digital data.

Annex 12.3 Use of particular groups and fields

Table J3.1 presents particular field and codes that shall be used in the digital data.

Table J3.1 Usage of particular AGS groups and fields

Group	Field	Requirement
PROJ	PROJ_ID	Contractor's reference for the Investigation
	PROJ_NAME	Shall match the title of the factual report (including name of contract specified in Schedule S1.1)
	PROJ_CLNT	Employer for the Investigation
	PROJ_ENGR	Investigation Supervisor
LOCA*	LOCA_TYPE	Compound codes shall be used as appropriate (e.g. CP+RC). Compound names using IP are not required unless the pit has been fully logged in which case a compound code shall be used.
	LOCA_STAT	Overall status of data for the exploratory hole (preliminary, draft or final)
	LOCA_CLST	If specified in Schedule S1.21.3.
	LOCA_LOCA	If specified in Schedule S1.21.3.

Group	Field	Requirement
GEOL	GEOL_LEG	Use standard abbreviations provided on the AGS website.
	GEOL_GEOL	Use codes specified in Schedule S1.21.3.
	Where unique interpretation of geological stratum is unclear, combinations of relevant strata may be used (e.g. MG/ALV).	
HDPH	-	If an inspection pit has been dug for a routine services or obstructions check, this shall be noted.
ISPT	ISPT	Incremental blows and penetrations shall be provided. Use of other fields that duplicate this data (ISPT_MAIN etc.) is optional. The Contractor may determine the format for ISPT_REP.
WETH	-	Only required if specified in Schedule S1.21.3.
* If the use of AGS3.1 is specified in Schedule S1.21.3, substitute “HOLE” for “LOCA”		

Annex 12.4 Digital data files

Digital data shall usually be submitted in a single file that contains the full data set (preliminary or final). However, in cases where this would lead to an unmanageably large file size, this requirement may be relaxed subject to the prior agreement of the Investigation Supervisor, in which case the digital data submission may be split across multiple files. Where submitted digital data are split between multiple files, data integrity across the files shall be rigorously maintained, for example LOCA group data shall exist for test data and shall not be duplicated across files.

Annex 13

Geophysics

Annex 13.1 Ground Penetrating Radar

13.1.1 Objectives

A Ground Penetrating Radar survey is required to investigate the shallow sub-surface, classify layers and features in terms of possible strata and materials, layer thickness, structural changes, the presence of underground services, pipes and storage tanks within the boundary specified.

13.1.2 General requirements

In advance of any GPR works taking place the Geophysist shall walkover the site in conjunction with the Engineer, to confirm whether site conditions are suitable for GPR and whether any meaningful results will be obtained.

The GPR will be carried out at nominal 1m spacing across the survey area and undertaken at an orthogonal direction (i.e. up/down then at right angles back and across)

13.1.3 Preconstruction submittals

The Contractor shall provide the following information at least 14 days prior to commencement of works:

- Details of the proposed equipment for the Ground Penetrating Radar surveying including the spacing to be implemented during the survey.
- Details of the proposed method of analysis of Ground Penetrating Radar data and software proposed to be used to process the results;
- Examples of the proposed presentation of the survey results;
- The proposed programme for the Ground Penetrating Radar fieldwork and reporting, including the expected rate of progress in fieldwork, data processing and reporting of results;
- The number of sets of equipment and associated crews that the Contractor could mobilise, if required;
- Details of qualifications and experience of the geophysical staff proposed for the geophysical work

13.1.4 Interpretation and reporting

The Contractor shall provide to the Investigation Supervisor draft results within 24 hours of completing each GPR scanline. (Note: the draft results will be used by the Investigation Supervisor to plan whether to instruct any intrusive investigation.)

The presentation of the processed results shall be correlated to any available intrusive site data and shall show details of the structure of the subsurface refractors, and any localised variation within the refractors.

The final reporting for the ground penetration radar surveying shall include:

- Drawing(s) of the survey scanlines undertaken and dimensions stated;
- Description of the methods used, equipment used, field procedure and data processing.

Annex 13.2 Seismic refraction surveying

13.2.1 Objectives

The objective of the seismic refraction surveying is to determine the two-dimensional spatial variation of the velocity of propagation of compressional (P) waves in the superficial deposits and underlying rock to depths not less than 30 m in order to provide the following information:

- P-wave velocity variations in superficial deposits

- Groundwater level
- Level of rock head profile
- Depth and extent of weathered rock
- P-wave variations in the rock (for example due to weathering or faulting).

13.2.2 General requirements

The seismic refraction survey data shall be acquired in accordance with ASTM D5777-00 and shall include multiple shot locations within each spread (to allow two-dimensional data interpretation) as well as end-to-end forward and reverse shot lines. The data shall be analysed using established software capable of two-dimensional processing of seismic refraction data such as Rayfract® or similar approved equivalent.

Unless otherwise instructed by the Investigation Supervisor, the seismic refraction surveying shall be scheduled sufficiently early in the fieldwork programme that the draft results shall be reported before demobilising any relevant site equipment suitable for use in any follow-up exploratory drilling/boring to investigate features identified in the seismic surveying. Using the draft results, the Investigation Supervisor in liaison with Contractor will identify any positions where follow-up intrusive investigations (if any, and if instructed by the Investigation Supervisor) would be undertaken.

The seismic refraction surveying, data analysis and reporting shall be undertaken by qualified geophysical specialists who have prior experience of two-dimensional seismic refraction surveying.

All seismic refraction surveying shall be undertaken when the site is quiet and when no significant works or plant movements are taking place that could adversely affect the quality of the seismic data. The Contractor shall be responsible for co-ordinating the timing of the seismic surveying with other on-site activities including third-party activities.

Seismic refraction surveying shall be conducted as a continuous profile along each of the survey lines at the positions shown in the Drawings. The Contractor shall be responsible for ensuring that the implemented scan lengths are adequate to meet the penetration depth requirement specified in Section L2.1.

The use of signal stacking is permitted, subject to provision of accurately repeatable triggering.

Details of the position of each source and receiver station shall be determined by the Contractor and the plan position and elevation of each source and receiver station shall be measured to an accuracy of ±10mm.

All results shall be reported to the coordinate system and level datum specified in Schedule S1.8.18.

The data processing shall allow for the topography of the site.

The Contractor shall provide a method statement for the seismic refraction survey work including but not limited to:

- Details of equipment to be used;
- Survey geometry (including source and receiver spacings and scan line lengths);
- Method of analysis of field data and details of software to be used derive two-dimensional spatial variation of P-wave propagation velocity in the ground in the vertical plane of each scanline;
- Details of the qualifications and relevant experience of the geophysical staff;
- Programme for field work and reporting.

13.2.3 The following should be extracted and included with the tender documentation to be

13.2.4 Preconstruction submittals

The Contractor shall provide the following information at least 14 days prior to commencement of works:

- Details of the proposed equipment for the seismic refraction surveying, including the seismic source, receivers and seismograph. (Note: if the use of a seismograph having less than 48 channels is proposed, the Contractor shall indicate how the survey requirements would be met.);
- Proposed shot and receiver intervals and scanline lengths to achieve the minimum depth of survey penetration specified in this annex
- Details of the proposed method of analysis of the seismic field data and software proposed to be used to process the results;
- Examples of the proposed presentation of the survey results, including: (i) two-dimensional representation of single scanline; (ii) pseudo three-dimensional representation of multiple parallel or sub-parallel scanlines; and (iii) pseudo three-dimensional representation of an intersecting grid or network of multiple scanlines;
- The proposed programme for the seismic fieldwork and reporting, including the expected rate of progress in fieldwork, data processing and reporting of results;
- The number of sets of equipment and associated crews that the Contractor could mobilise, if required;
- Details of qualifications and experience of the geophysical staff proposed for the geophysical work.

13.2.5 Interpretation and reporting

The Contractor shall provide to the Investigation Supervisor draft results within 24 hours of completing each seismic scanline. (Note: the draft results will be used by the Investigation Supervisor to plan whether to instruct any intrusive investigation.)

If colours are used to represent P-wave velocity values, then the same velocity-colour assignment range shall be used for all the results presented in the final report. All plots and charts shall include full details of the location to which the results apply, expressed in terms of the three-dimensional coordinate system.

The presentation of the processed results shall be correlated to any available intrusive site data and shall show details of the structure of the subsurface refractors, and any localised variation within the refractors.

The results shall include presentation of the P-wave velocity profile down the length of any exploratory hole (if any) that is intersected by a scanline. These charts shall be plotted as P-wave velocity versus elevation. The same vertical axis scale shall be used for all such charts.

The final reporting for the seismic refraction surveying shall include:

- Drawing(s) of the survey scanlines undertaken, with all source and receiver stations shown and dimensions stated;
- Description of the work done, and equipment used;
- For each scan line:
  - Graphical presentation of the two-dimensional distribution of P-wave propagation velocity in the ground in the plane of the survey line; and
  - Copy of said graphical presentation annotated with any inferred subsurface refractors, any interpreted features, and any apparent anomalies within the refractors;
- For all parallel and sub-parallel scanlines, pseudo three-dimensional graphical presentation of the distribution of P-wave propagation velocity in the ground;
- For all intersecting scanlines, pseudo three-dimensional graphical presentation of the distribution of P-wave propagation velocity in the ground for the combined grid/network of planar scans;
- Velocity-depth profiles beneath each exploratory hole (if any) intersected by a scanline (where ‘intersected’ means not more than 3m laterally from a scanline);

- Interpreted possible anomalies (if any) presented on a plan of the site;
- Interpretation of the survey results, with particular focus on the depth and thickness of strata and any in-homogeneity (both laterally spatially and with depth) within the materials investigated.

In addition, the following electronic data shall be provided with the final report for the seismic refraction surveying:

- For each scan line, data in Microsoft Excel® spreadsheets presenting the three-dimensional coordinates of each source and receiver station and the first-arrival travel time between each source-receiver pair.
- The spreadsheet header details shall include project name, survey date, survey line reference code and descriptive column heading and metric units for the data; and
- The raw data file for each shot as downloaded from the seismograph. Each data file shall be profiled with information detailing the shot location, the survey line, location of the geophones and stacking number.

Annex 13.3 Downhole shear wave velocity surveying

13.3.1 Objectives

The objective of the downhole shear wave (S-wave) velocity surveying is to determine the variation with elevation of the velocity of propagation of horizontally-polarised S-waves in specified exploratory holes.

13.3.2 Method

Downhole S-wave velocity surveys shall be carried out at the locations and to the depths specified in Schedule 2.

The downhole S-wave velocity surveying shall be carried out in accordance with the requirements for high quality surveys specified in ASTM D7400-08 Standard test methods for downhole seismic testing.

The depth intervals of the downhole receiver(s) shall be 1.0 metre(s).

13.3.3 Preconstruction submittals

The Contractor shall provide the following information at least 14 days prior to commencement of works:

- Details of the proposed equipment:
- Details of the proposed method of analysis of the data and software proposed to be used to process the results;
- Examples of the proposed presentation of the survey results;
- The proposed programme for the fieldwork and reporting, including the expected rate of progress in fieldwork, data processing and reporting of results;
- The number of sets of equipment and associated crews that the contractor could mobilise, if required;
- Details of qualifications and experience of the geophysical staff proposed for the geophysical work.

13.3.4 Reporting

The final report for the downhole S-wave velocity surveying shall conform to ASTM D7400-08 and also shall include:

- Description of the work done, and equipment used;
- Description of method(s) of analysis used to determine the reported profiles of S-wave velocity versus elevation.

In addition, the following electronic data shall be provided with the final reporting for the downhole S-wave surveying:

- In Microsoft Excel® spreadsheets, data presenting the three-dimensional coordinates of each source and receiver position and the first-arrival travel time between each source-receiver pair and derived S-wave velocities. The spreadsheet header details shall include project name, survey date, exploratory hole number and descriptive column heading and metric units for the data; and
- The raw data file for each shot as downloaded from the seismograph. Each data file shall be profiled with information detailing the exploratory hole, polarity of S-wave (which can be expressed as blow direction), depth of receiver(s), and stacking number (if any).

Annex 13.4 Downhole wireline logging

13.4.1 Objectives

The objectives of the wireline downhole logging include the following:

- To determine the level of stratigraphic and lithological changes within the logged holes;
- To identify any zones of anomalous properties in the logged holes;
- To inform the determination of rock mass quality by providing data on the extent and nature of discontinuities;
- To provide information on the dip angle and dip direction of strata and discontinuities within the logged holes.

13.4.2 Methods

The Contractor shall propose a suite of one or more suitable wireline logging methods that are compatible with achieving the objectives specified in Section 13.4.1 (Clause 9.1.1). The proposed method(s) shall be compliant with the recommendations in the following:

- ASTM D5753-05 (2010) – Standard Guide for Planning and Conducting Borehole Geophysical Logging
- CIRIA C562 (2002) – Geophysics in Engineering Investigations.

The Contractor shall provide and implement equipment for the undertaking the following suite of wireline of logging techniques:

- neutron-neutron
- natural gamma emission
- gamma-gamma
- high resolution density
- (induction) conductivity
- magnetic susceptibility
- P-S suspension logging
- temperature
- verticality
- three arm calliper
- dipmeter

- acoustic televiewer
- high resolution borehole optical televiewer (with 360-degree view and pixel density of at least 1 pixel per 0.5mm)

13.4.3 Preconstruction submittals

The Contractor shall provide the following information at least 14 days prior to commencement of works:

- Details of the proposed wireline techniques to achieve the objectives specified in Section 13.4.1 and 13.4.2;
- Evidence of suitability of the proposed techniques for the purposes of achieving the specified stated objectives including any appropriate case studies;
- Details of how the wireline logging is to be conducted, including determination of the spatial position of wireline sonde locations and the accuracy with which this information shall be determined, in both plan and elevation, and coordination with drilling work;
- The proposed programme for fieldwork and reporting, including the expected rate of progress in fieldwork and the time required for data processing and presentation;
- Details of qualifications and relevant experience of the geophysical staff proposed for the wireline work.

13.4.4 General requirements

Wireline logging shall be undertaken at the locations and to the depths specified in Schedule 2.

The Contractor shall undertake the wireline logging in a hole within 24 hours of the completion of the drilling/boring of that hole, unless otherwise agreed in advance with the Investigation Supervisor.

All results shall be reported to the coordinate system and level datum specified in Schedule S1.8.18.

All surveying shall be undertaken, and all test data shall be processed by qualified geophysical specialists who have prior experience of the survey technique.

The Contractor shall provide a detailed method statement for the survey work containing the following:

- full details of the equipment that is proposed to be used.
- details of any casing requirements for the boreholes.
- details of how the spatial location of the survey points shall be determined, and the accuracy with which these shall be determined, in both plan and elevation.
- details of the proposed method of analysis of the field data and software used to provide the interpretation of the results.

13.4.5 Interpretation and reporting

The Contractor shall provide preliminary results within 24 hours of completing the suite of wireline logging in a given hole.

The final reporting for the downhole wireline logging at the site shall include:

- Description of the work done, and equipment used;
- Details of all assumptions, corrections, algorithms and methods of interpretation used;
- Graphical presentation of the results of the wireline logging, as profile plots presented to the same vertical scale as the engineering log of the relevant exploratory hole (for example, typically a vertical scale of 1:50 for the engineering log of a rotary drillhole);

- interpreted results from logging within rock including: computed lithology analysis; televiewer interpretation; discontinuity analysis including 360-degree representation and tadpole plot with levels; stereographic projection of data (for each hole) using equatorial equal area stereonet to include dip, strike, frequency and fracture aperture); and a summary stereographic projection for all data.

In addition, the following electronic data shall be provided with the final report for the downhole wireline logging:

- Results in Microsoft Excel® spreadsheets for each wireline logging profile, by level (not depth).

Annex 13.5 2D Resistivity

13.5.1 Objectives

2D Resistivity surveys are required to determine lateral variations in:

- Overburden material,
- Depth to bedrock;
- Bedrock lithology.

The equipment shall be capable of measuring the variation of resistivity of the ground with depth along the specified lines. A multi-electrode cable system shall be used. The equipment shall be easily transportable and suitable for operation over a variety of types of terrain.

13.5.2 General Requirements

This survey method is to make use of the Wenner resistivity array. The 2D resistivity profiling method records a large number of resistivity readings in order to map lateral and vertical changes in material types. This method involves the use of electrodes connected to a resistivity meter using a computer software to control the process of data collection and storage.

13.5.3 Preconstruction submittals

The Contractor shall provide the following information at least 14 days prior to commencement of works:

- Details of the proposed equipment for the 2D resistivity surveying including the proposed electrode spacing to be implemented during the survey to achieve the minimum depth of survey penetration specified in this annex
- Details of the proposed method of analysis of 2D resistivity data and software proposed to be used to process the results;
- Examples of the proposed presentation of the survey results;
- The proposed programme for the 2D resistivity fieldwork and reporting, including the expected rate of progress in fieldwork, data processing and reporting of results;
- The number of sets of equipment and associated crews that the Contractor could mobilise, if required;
- details of qualifications and experience of the geophysical staff proposed for the geophysical work.

13.5.4 Interpretation and reporting

The field readings are to be stored in computer files and inverted using a RES2DINV package or similar (Geotomo software). Up to 5 iterations shall be used on the measured data carried out for each profile to obtain a 2D-depth model of the resistivities.

The inverted 2D resistivity models and interpreted geology are to be displayed on accompanying drawings.

The Contractor shall provide to the Investigation Supervisor draft results within 24 hours of completing each 2D resistivity scanline. (Note: the draft results will be used by the Investigation Supervisor to plan whether to instruct any intrusive investigation.)

The presentation of the processed results shall be correlated to any available intrusive site data and shall show details of the structure of the subsurface refractors, and any localised variation within the refractors.

The final reporting for the 2D resistivity surveying shall include:

- drawing(s) of the survey scanlines undertaken and dimensions stated;
- description of the work done, and equipment used.

Annex 13.6 Multichannel Analysis of Surface Waves (MASW) Profiling

13.6.1 Introduction

The survey shall consist of measurement of refracted seismic waves and the shear wave velocity depth profile using the Multi-Channel Analysis of Surface Waves (MASW) method and calculation of the small strain shear modulus Gmax from the velocities.

13.6.2 Methodology

To produce a stiffness profile of the subsurface using Surface waves the following basic procedure is followed:

- A point source (e.g. a hammer) shall be used to generate vertical ground motions.
- The ground motions shall be measured using low frequency geophones. Geophones shall be placed along a straight line directed toward the source.
- The maximum shot spacing should be 2m and the geophone spacing should be determined by the senior geophysicist on site.
- The geophones must have sufficient length to be introduced into the ground.
- The ground motions shall be recorded using either a conventional seismograph, oscilloscope or spectrum analyser.
- A dispersion curve shall be produced from a spectral analysis of the data. The dispersion curve should show showing the variation of surface wave velocity with wavelength.
- A subsurface profile of the variation of Surface wave and shear wave velocity with depth shall be determined.
- A stiffness-depth profile (shear modulus, G) shall be derived from elastic theory.

13.6.3 Preconstruction submittals

The Contractor shall provide the following information at least 14 days prior to commencement of works:

- Details of the proposed equipment:
- Details of the proposed method of analysis of the data and software proposed to be used to process the results;
- Examples of the proposed presentation of the survey results;
- The proposed programme for the fieldwork and reporting, including the expected rate of progress in fieldwork, data processing and reporting of results;

- The number of sets of equipment and associated crews that the Contractor could mobilise, if required; and
- Details of qualifications and experience of the geophysical staff proposed for the geophysical work.

13.6.4 Data Processing

Preparation of the acquired multi-channel record: this involves converting the data file into the processing format.

Production of a dispersion curve from a spectral analysis of the data showing the variation of Raleigh wave phase velocity with wavelength. Confidence and accuracy of the dispersion curve shall be shown.

A subsurface profile of the variation of shear wave velocity with depth shall be determined.

The shear wave velocities shall be converted into shear modulus values using the formula:

$$G = \frac{V_s^2 \times \rho}{1 \times 10^6}$$

where

G = Shear Modulus (MPa)

Vs = Shear Wave Velocity (m/s)

ρ = Density (kg/m^3)

13.6.5 Processing, Interpretation and Reporting

Processing parameters shall be optimised. Processing shall also take account of the presence and effect of services/underground obstructions encountered.

A preliminary interpretative report of material types and stratigraphy shall be undertaken and issued to the Contractor and Investigation Supervisor no more than two weeks after the completion of fieldwork.

Following review of the draft factual information by the Investigation Supervisor and completion of the intrusive investigation, the remaining information will be provided to the Geophysical Subcontractor for incorporation into their final interpretative report.

The final interpretative report shall incorporate all geophysical results acquired and their interpretation. The final report shall not be issued until the interpretation is calibrated with any other geophysical or intrusive investigations provided by the Investigation Supervisor.

The report shall also include:

- A description of the operational field procedures, the field and post-processing procedures and the methodology and assumptions used for interpretation;
- Survey methodology and location table(s), indicating location on site and coordinates for each profile;
- Summary interpretation table(s) presenting ground layer(s) properties;
- Figures and maps showing interpreted sections;
- Plan view maps showing the locations of the geophysical profiles, overlaying Ordnance Survey or GIS outputs information; and
- Individual scaled plates of the modelled seismic data, with topography shown.

The Interpretative Report will be issued as draft(s) until approved by the Investigation Supervisor. Draft reports are to be provided in one digital version (PDF).

Final report is to be provided in digital version (PDF)

Master copies of all Final drawings are to be provided on USB or by email (one copy with each approved Final report). All drawings shall be provided in digital and PDF format. All maps shall be in model space to ITM.

In addition to the information provided in the report, the Contractor shall provide raw data such as the seismic traces for inspection of such geophones and for such shots as may be requested by the Consultants. Post-acquisition processing of the data to optimise interpretation of the structure/stratigraphy consistent with the stated objectives is required.

Processed data is to be presented on USB in a format to be agreed with the Investigation Supervisor (one copy with each Draft and Final report).

All seismic raw data is to be provided on USB in a SEG-2 (Society of Exploration Geophysics) or SEG-Y standard format (one copy with each Draft and Final report).

Annex 14

Pyrite Sampling and Testing

Annex 14.1 Objectives

In response to damage to a number of housing developments in Ireland which were attributed to pyrite degradation, IS 398-1:2013 – Reactive pyrite in sub-floor hardcore material, Part 1: Testing and categorisation protocol was produced by the National Standards Authority of Ireland (NSAI) Technical committee 58, "Reactive Pyrite".

A revised edition was published in 2017 considering the knowledge and experience gained through the application of IS 398-1:2013 and the evaluation by the NSAI Technical Committee 58, 'Reactive Pyrite' of public comments received.

IS 398-1:2017 Part 1 has been developed for use by those intending to provide testing and categorisation services for buildings suspected of being affected by pyrite, and its purpose it two-fold. It:

- Establishes a comprehensive structured protocol for assessing and determining whether or not a building has been damaged by reactive pyrite or is likely to be in the future, and
- Categorises buildings, in accordance with this standard.

The process for assessing, testing and categorising buildings set out by IS 398-1:2017 is as follows:

- Building Condition Assessment;
- Sampling;
- Testing; and then
- Categorisation of building.

Annex 14.2 Building Condition Assessment

The process begins with a Building Condition Assessment, which includes a desk study and non-invasive internal and external visual inspection carried out by competent person. It establishes whether damage visible in the buildings is indicative of pyrite-induced damage, at the time of inspection. The severity of any such damage is appraised in terms of a Damage Condition Rating, which then in turn, establishes sampling and testing requirements, and re-inspection requirements to establish whether damage is progressing.

Based on the results of the inspection, the damage is evaluated under five damage Element Groups, with an Attribute Value of 1-10 assigned to each element of damage consistent with pyritic heave. The five damage Element Groups are:

- Ground Floor Surface Level
- Fixtures & Fittings
- Walls/Partitions on ground floor
- Ground Floor ceilings
- External

Depending on attribute values and engineering judgement, a Damage Condition Rating is then assigned, see Table A14.1 below.

Table A14.1 Damage condition Rating according to IS 398-1:2017

Evaluation	Damage Level	Damage Condition Rating
Attribute value 2 or less in any combination of Element Groups	None or aesthetic only	0

Evaluation	Damage Level	Damage Condition Rating
Any combination of attribute values not in Damage Condition Rating 0 or 2	Minor	1
Attribute value 6 or more in 3 or more Element Groups or		

Depending on the Engineers report, a re-inspection may be required.

Sampling should be carried out by a competent person in order to obtain representative samples of the sub-floor hardcore material, and to ensure that the samples are preserved and their characteristics substantially unaltered between sampling and testing.

IS 398-1:2017 recommends taking 6 no. overlapping 200mm diameter cores through the concrete floor, in an area where heave is most evident upon discussion with the owner.

A sample should not be taken from the top 50mm or the bottom 50mm of hardcore to avoid cross contamination and should be a minimum 25kg. If there is more than one layer, type or if there is a change in composition, another sample is taken, and all samples should be bagged separately and labelled with the date, depth, location and a unique sample number. For a house with a floor plan of 60m2, a minimum of 2 no. samples should be taken. For buildings with a larger ground floor area, the Engineer/Geologist shall establish the number of additional samples required, based on the total area of the building and its geometry.

Thicknesses of floor slab, insulation, reinforcement etc. shall be measured and photographed and if a sand blinding is present, a 500g sample should be taken.

Annex 14.3 Laboratory Testing

There are 2 no. of test suites in IS 398-1:2017, reduced from 3 in the previous version of the standard IS 398-1:2013, the selection of which is dependent on the Damage Condition Rating and if a cert is required.

Table A14.2 below summarizes the requirements of each Test Suite. The main purpose of the laboratory tests is to identify the presence of reactive pyrite and secondary minerals that may be associated with heave (e.g. gypsum).

Table A14.2 Test Suites according to IS 398-1:2017

Test Suite	Tests
Test Suite 0	Simplified petrographic description Chemical Testing (on unwashed sample)
Chemical Testing (on unwashed sample)	Thin Section petrographic analysis Mineralogical analysis by quantitative X-Ray diffraction (XRD) Water Absorption Particle size distribution (PSD) by sieve analysis (wet sieve method)

Test Suite 0

The pass/fail criteria for Test Suite 0 are shown in Table A14.3 below. Chemical analysis shall be performed on unwashed, crushed and powdered subsamples. Simplified petrographical techniques shall be used to identify rock types. Chemical testing shall include the determination of total sulfur, acid soluble sulfate and water soluble sulfate in accordance with I.S. EN 1744.

Table 14.3 Interpretation of hardcore results for Test Suite 0

Test Parameter	Pass Criteria	Fail Criteria
Acid-soluble sulfate (AS)	N/A	>0.4% SO4
Water-soluble sulfate (WS)	⩽ 750mg/l SO4	1500 mg/l SO4
Total sulfur (TS)	⩽ 0.2% S	>1% S
Proportion of sedimentary mudrock	⩽ 10%	>30%
Evidence of gypsum crystals consistent with pyrite-induced reaction	Rare	Abundant

Test Suite 1

In Test Suite 1, the results of the petrological analysis are evaluated. This involves evaluation of the XRD and petrographic assessments of thin and/or polished sections. The Professional Geologist/Chartered Geotechnical Engineer shall interpret the results on the basis of the susceptibility for expansion of the material.

Upon analysis of all test results on the sample of hardcore, the Professional Geologist classifies the susceptibility of the material to expansion:

- Negligible – Pass
- Low – Potential for future minor damage
- Medium – Potential for future minor or significant damage; or
- Significant – Building has significant existing damage or progressive damage

The hardcore classification is based on the results of the relevant tests undertaken, Test Suite 0 or Test Suite 1 or a combination and possibly with further testing. Annex I IS 398-1:2017, provides guidance on the interpretation of Test Suite results.

Annex 14.4 Categorisation of Building

The building is categorised based on the results of the Building Condition Assessment and the classification of the hardcore material. The building will fall into one of four categories:

- **Category A** - Negligible Risk. Damage Condition Rating of 0 and hardcore which has negligible susceptibility to expansion. Alternatively, the building has a Damage Condition Rating of 1 or 2, and hardcore which has negligible susceptibility to expansion and an alternative probable cause for the damage other than pyritic heave, is likely.
- **Category B** – Low Risk. Damage Condition Rating of 0 or 1 (without progression) consistent with pyritic heave and hardcore which has a low susceptibility to expansion. There is potential for future minor damage from pyritic heave.
- **Category C** – Medium Risk. Damage Condition Rating of 0 or 1 (without progression) consistent with pyritic heave and hardcore which has a medium or significant susceptibility to expansion. Alternatively, the building has Damage Condition Rating of 1 (without progression) consistent with pyritic heave and hardcore with low susceptibility to expansion. There is potential for future minor or significant damage from pyritic heave.
- **Category D** – Significant Pyritic Damage. The building has a Damage Condition Rating of 1 (with progression) or a Damage Condition Rating of 2, consistent with pyritic heave, and hardcore with low to significant susceptibility to expansion.

Annex 15

Designers Risk Assessment

Refer to S1.22 Designers Risk Assessment.

Drawings