

Specification for ground investigation

This document has been produced with the support of, and by representatives of, the following bodies.

Association of British Insurers

Association of Consulting Engineers

Association of Geotechnical Specialists

British Drilling Association

British Geological Survey

British Geotechnical Society

British Property Federation

British Tunnelling Society

Construction Industry Research and Information Association

County Surveyors' Society

Department of the Environment

Department of Transport

Federation of Civil Engineering Contractors

Federation of Piling Specialists

Institution of Civil Engineers

Institution of Structural Engineers

National House-Building Council

Royal Institute of British Architects

Royal Institution of Chartered Surveyors

The Geological Society

Water Services Association

3 Specification for ground investigation

Site Investigation Steering Group

Publications in the Site investigation in construction series:

- 1. Without site investigation ground is a hazard*
- 2. Planning, procurement and quality management*
- 3. Specification for ground investigation*
- 4. Guidelines for the safe investigation by drilling of landfills and contaminated land*

Part 3: *Specification for ground investigation* supersedes and replaces, by common agreement, the Specification for ground investigation published by the Institution of Civil Engineers in 1989.

Published by Thomas Telford Services Ltd, Thomas Telford House, 1 Heron Quay, London E14 4JD

Reprinted 1999. First published 1993.

Reprinted 2001

Reprinted 2002

Reprinted 2005

A catalogue record for this book is available from the British Library.

ISBN 0-7277-1984-X

© Thomas Telford, 1993

Classification

Availability: Unrestricted

Content: Specification based on best current practice

Status: Committee-guided

User: Construction industry firms and individual practitioners

All rights, including translation, reserved. Except for fair copying, no part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of the Publications Manager at the above address

The information contained in this book is intended for use as a general statement and guide only. The publishers cannot accept any liability for any loss or damage which may be suffered by any person as a result of the use in any way of the information contained herein.

Foreword

This Specification includes associated Schedules and a Bill of Quantities and is intended for general application to ground investigation work. It may be used in conjunction with any suitable contractual agreement between the procurer and the ground investigation contractor. The involvement of a geotechnical adviser or geotechnical specialist is essential in the planning, procurement and supervision of ground investigation work.

The requirements for a particular ground investigation are stated in the Schedules. In recognition of the need for flexibility in ground investigation work the Schedules are also used for additions or modifications to the published Specification.

A Bill of Quantities with items corresponding to the Specification is included in this document, together with a Preamble to the Bill which defines payment details. A formal method of measurement and item coverage is not necessary but may be introduced, with an appropriate Bill of Quantities to suit the requirements of a particular procurer. This will inevitably increase the complexity of the documentation, particularly where additions and amendments to the Specification are necessary.

Feedback is important and it is recognised that aspects of the Specification and accompanying documentation will benefit from updating in the future. Users are invited to submit recommendations for revision on copies of the pro forma.

Acknowledgements

The Site Investigation Steering Group wishes to thank all the government departments, learned societies, professional associations and trade organisations for their support of this initiative, to provide guidelines to encourage improved uniform practice in site investigation for the benefit of the construction industry and its clients.

The Steering Group thanks members of the working panels and the secretariat of the Institution of Civil Engineers, who devoted much time and effort to the deliberations on which the documents are based. The Steering Group is also deeply indebted to the many organisations and individuals who provided helpful comments during the consultation period.

Contents

Specification for ground investigation

1	Information	2
2	Definitions	3
3	General requirements	4
4	Boreholes	8
5	Rotary drilling	9
6	Pits and trenches	12
7	Sampling	13
8	In situ testing	15
9	Instrumentation and monitoring	18
10	Daily reports	20
11	Laboratory testing	22
12	Reporting	25

Appendix I. Standpipes and piezometers	27
Appendix II. Gas monitoring standpipe	32
Appendix III. Format of digital data	34
Appendix IV. References	36

Schedules (to be completed)	41
Schedule 1. Information	41
Schedule 2. Exploratory holes	46
Schedule 3. Engineer's facilities	47
Schedule 4. Specification amendments	48
Schedule 5. Specification additions	48

Bill of Quantities for ground investigation	49
Preamble	49
Preamble amendments and additions (to be completed)	51
Works items (to be completed)	
A. General items and provisional services	52
B. Boreholes	53
C. Rotary drilling	54
D. Pits and trenches	56
E. Sampling	58
F. In situ testing	59
G. Instrumentation and monitoring	61
H. Laboratory testing	62
I. Chemical testing for contaminated ground	66
Summary of Bill Quantities	69
Appendix A. Rates for geotechnical and other personnel	70

Addendum (not part of the Contract)	73
Notes for guidance on the Specification for ground investigation	73
Notes on clauses	76
Notes on preparation of the Schedules	81
Notes on the Bill of Quantities and preamble	85
Example Schedules and Bill of Quantities for a small investigation	87
Modification of Schedules for a 'design and investigate' contract	100

1 Information

General 1.1 Information and requirements specific to the particular ground investigation Contract are given in the Schedules which form part of the Specification.

2 Definitions

General	2.1	These definitions are for the purposes of this ground investigation Contract.
Geotechnical and environmental personnel	2.2	Geotechnical and environmental personnel shall be competent to undertake the work required. Categories of personnel who may be required by the Contract are as follows (a) Technician (b) Incorporated Engineer (c) Graduate Engineer/Geologist/Environmental Scientist (d) Graduate Engineer/Geologist/Environmental Scientist with at least 3 years of relevant experience since graduation (e) Chartered Engineer/Geologist/Environmental Scientist with at least 5 years of relevant experience (f) Principal Chartered Engineer/Geologist/Environmental Specialist with at least 10 years of relevant experience.
Topsoil	2.3	The word 'topsoil' shall mean the top layer of material, that contains humus and can also support vegetation.
Soil	2.4	The word 'soil' shall include any natural or artificial material not classified herein as topsoil or hard stratum.
Hard stratum and obstruction	2.5	<ol style="list-style-type: none">1. The words 'hard stratum' and 'obstruction' shall mean natural or artificial material, including rock, which cannot be penetrated except by the use of chiselling techniques, rotary drilling, blasting or powered breaking tools.2. The term 'hard stratum' shall apply during boring, where it is shown that condition (1) and either condition (2) or condition (3) below are fulfilled, provided that the boring rig involved is in good working order and is fully manned.3. Condition (1) Using 150 or 200 mm diameter equipment, boring cannot proceed at a rate greater than 0.5 m/hour through the hard stratum/obstruction being penetrated.4. Condition (2) 100 mm diameter undisturbed sample tubes cannot be driven more than 300 mm.5. Condition (3) A Standard penetration resistance test shows a resistance in excess of 35 blows/75 mm.
Fill	2.6	The word 'fill' shall mean any deposits or construction which have been formed by persons, as distinct from geological agencies.
Exploratory hole	2.7	The words 'exploratory hole' shall mean any hole or in situ test hole formed for the purpose of ground investigation.
Boring	2.8	The term 'boring' shall include percussion boring and auger boring.
Drilling	2.9	The term 'drilling' shall include rotary drilling techniques.
Borehole	2.10	The term 'borehole' shall mean an exploratory hole put down by boring or drilling techniques.

3 General requirements

- British Standards and equivalent** 3.1 The work shall be carried out in accordance with the relevant British Standards (in particular BS 1377 and BS 5930) current on the date of invitation to tender. Any reference in the Contract to a Standard published by the British Standards Institution, or to the specification of another body, shall be construed equally as reference to an equivalent one.
- Work not required** 3.2 Any clauses of this Specification which relate to work or materials not required in the Contract shall be deemed not to apply.
- Statutory undertakers, public authorities and privately owned services** 3.3 The positions of mains, services, drains, sewers and tunnels owned by statutory undertakers, public authorities and private individuals, where shown on Drawing(s), have been based on information extracted from the records of the various bodies and shall be regarded as approximate only. Services to individual properties are likely to exist but are not shown on the Drawings(s). The Contractor shall make his own enquiries of the statutory undertakers and public authorities and satisfy himself as to the exact position of such apparatus and the depth, size and gradient thereof. The Contractor shall also make enquiries as to the presence and location of any privately owned services or land drains. Where the presence of underground services is suspected exploratory holes shall be started by means of a hand-excavated inspection pit.
- Access routes** 3.4 Only the agreed access routes, as defined in the Contract, to and between exploratory positions shall be used.
- Notice of entry** 3.5 In addition to any notices required to be given under the Conditions of Contract, at least one working day's notice shall be given to the owner and/or occupier of the intended time of entry on to the site.
- Care in executing the work** 3.6 All work shall be carried out with the least possible damage to the site and its environs.
- Security of site** 3.7 All barriers breached or otherwise disturbed during the execution of site operations shall be immediately repaired or replaced to the same standard.
- Working hours** 3.8 Working hours shall be restricted to those specified (if any) in Schedule 1.
- Working areas** 3.9
- General* 3.9.1 Operations shall be confined to the minimum area of ground required for the Works. Unless otherwise indicated in Schedule 1, on completion of each exploratory hole all equipment surplus material and rubbish of every kind shall be cleared away and removed from the Site. Avoidable damage to land or property in the vicinity of the exploratory hole and on access routes shall be made good. The whole of the Site and any ancillary works shall be left in a clean and tidy condition.
- Turf and topsoil* 3.9.2 Turf and topsoil shall be stripped at the site of each exploratory hole and stockpiled separately for reuse. Turf and topsoil adjacent to the exploratory hole which may be damaged by the operations shall either be removed and stockpiled as above, or otherwise protected from damage. After completion of the hole the topsoil shall be respread and the turf relayed.
- Paved areas* 3.9.3 1. Paved areas (other than paving slabs) shall be broken out to the minimum extent necessary for each exploratory hole. After completion of the hole the paved area shall be reinstated.

2. Highway reinstatement shall be in accordance with the New Roads and Streetworks Act 1991 and the Specification for the Excavation and Reinstatement of Openings in Highways (HAUC SWP 163) September 1991.

- Paving slabs and blocks* 3.9.4 Paving slabs and blocks shall be removed at the site of each exploratory hole and stored separately for reuse. Paving slabs and blocks which are liable to be damaged by the operations shall either be removed and stored as above or otherwise protected from damage. After completion of the hole the paving slabs and blocks shall relaid.
- Claims for damage** 3.10 Any damage, or claim for compensation for damage by owners or occupiers, shall be reported to the Engineer.
- Engineer's facilities** 3.11 When required in the Contract, accommodation and equipment shall be supplied and maintained for the sole use of the Engineer in accordance with Schedule 3. All accommodation, furnishings, services, equipment and vehicles shall be ready for occupation and use by the Engineer on the date for commencement of the Site Operations, and shall be removed at the end of the Site Operations unless otherwise directed by the Engineer.
- Professional attendance on site** 3.12 When required in the Contract the Contractor shall provide professional attendance of experience as described in Schedule 1 full time on site. The professional attendant shall be approved in writing by the Engineer, and shall be responsible for the technical direction and output of all fieldwork.
- Geotechnical and environmental personnel** 3.13 In addition to the requirements of the Conditions of Contract, and of Clauses 3.12, 4.4.2, 5.3.6, 5.4.2, 6.5 and 7.11 of this Specification, the Engineer may require the services of geotechnical and environmental personnel for advice, assistance and/or the preparation of interpretative reports as defined in Schedule 1. The Contractor shall submit adequate records of time and expenses to the Engineer. If required by the Engineer, details of the qualifications and experience of the personnel shall be supplied.
- Location of exploratory holes** 3.14 Each exploratory hole shall be set out at the location given to the nearest 1 m or to the accuracy (if any) described in Schedule 1. The final position of each hole shall be measured, national grid coordinates determined to the nearest 1 m or accuracy as described in Schedule 1 and the position recorded on a plan as referred to in Clause 12.6.
- Ground elevation of exploratory holes** 3.15 During the period of the site operations, the elevation of the ground at each exploratory hole related to ordnance datum or other datum as described in Schedule 1 shall be established to the nearest 0.05 m.
- Exploratory work** 3.16 The location and depth of each exploratory hole shall be as described in Schedule 2. The Engineer may, after consultation with the Contractor, vary the location and depth of any exploratory hole and the sequence or quantity of in situ testing depending on the actual ground conditions encountered. When the position of an exploratory hole has been varied, the Contractor shall take all necessary measurements and shall inform the Engineer of the revised coordinates and ground elevation or other measurements required to locate the exploratory hole.
- Methods of investigation** 3.17 The Engineer may require investigation to be carried out by all or any of the methods described in the Specification.

Mine workings	3.18	The positions of any known mine workings within the area and at a depth likely to affect the proposed development are shown on the Drawing(s) as far as available records will permit. If evidence of further mining activity is revealed the Contractor shall inform the Engineer immediately.
Hazardous and contaminated ground	3.19	<p>1. The presence and nature of known areas of hazardous or contaminated ground are noted in Schedule 1 as far as available records permit. If evidence of further hazardous or contaminated ground is encountered the Contractor shall inform the Engineer immediately and agree a revised method of working appropriate to the nature and level of contamination encountered. Where contaminated land is present or suspected the Contractor shall take the appropriate Health and Safety precautions as set out in DD175 1988, HSE Guidance Note (HMSO 1991) and British Drilling Association (BDA) Guidance Notes, 1992. The Contractor shall liaise with the Health and Safety Executive with respect to the specific environmental protective measures to be provided. Care shall be taken to avoid contamination egress from the site.</p> <p>2. A method statement indicating the safety procedures to be followed during the investigation of hazardous or contaminated ground shall be provided by the Contractor prior to commencement of the Investigation in the hazardous or contaminated ground.</p>
Anomalous conditions	3.20	Where anomalous or unexpected features are revealed the Contractor shall inform the Engineer immediately.
Surface water control	3.21	Surface water or other water shall be prevented from entering the exploratory hole from ground surface level, except as permitted in Clause 4.2.
Traffic safety and management	3.22	Traffic safety and management measures shall be provided as the progress of the site operations requires. Measures shall be taken in accordance with any statutory requirements, any special requirements in Schedule 1 and recommendations contained in Chapter 8 of the 'Traffic Signs Manual' published by Her Majesty's Stationery Office and any amendments thereto. Where the circumstances of any particular case are not covered by the recommendations or described in the Schedules, proposals for dealing with such situations shall be submitted to the Engineer for approval.
Quality management	3.23	Where required in Schedule 1, all work shall be carried out in accordance with a quality management system established in accordance with BS 5750. Records to indicate compliance with quality management shall be made available to the Engineer on request.
Accreditation of drillers	3.24	<p>1. Unless otherwise required in Schedule 1, all drillers employed on the Contract shall hold a certificate of competence for percussion boring or rotary drilling, as issued by the British Drilling Association Limited under the Ground Investigation Drillers' Accreditation Scheme or an equivalent body in a Member State of the EC.</p> <p>2. Alternatively, non-accredited drillers may be employed, provided each rig is supervised by a person meeting the requirements of Clause 2.2 item (d). This supervision shall be on the basis of one full time qualified engineer or engineering geologist for each rig.</p>
Photographs	3.25	1. Where required in the Contract, colour photographs shall be taken and supplied by the Contractor. Each photograph shall clearly show all necessary details and shall contain a graduated scale which shall be the same

in every photograph of a particular type. A standard colour chart and monochrome step wedge shall also be included in each photograph.

2. A single gloss colour enprint (size 150 mm × 100 mm) copy of each photograph shall be submitted to the Engineer for his approval and retention within 7 working days of the photography. In the event that the photographs are of a quality unacceptable to the Engineer they shall be retaken.

3. On acceptance of the quality of the photograph two complete sets of enprints of all the photographs shall be presented, annotated and submitted in bound volumes together with the photograph negatives with the Factual Report.

4. Particular requirements for photographs of cores and pits and trenches are given in Clauses 5.6 and 6.9.

4 Boreholes

- Method and diameter** 4.1 *1.* The method of advancement and the diameter of a borehole shall be such that the boring can be completed and logged to the scheduled depth, and samples of the specified diameter can be obtained, in situ testing carried out and instrumentation installed as described in the Contract.
- 2.* The following methods may be employed for advancement of a borehole unless otherwise stated in Schedule 1
Percussion boring
Auger boring
Rotary drilling.
- Addition of water to the borehole** 4.2 Water shall not be used to assist the advance of the borehole except in the case of dry granular soils or where approved by the Engineer. Where the borehole penetrates below the water table and disturbance of the soils is likely, a positive hydraulic head shall be maintained in the borehole.
- Hard stratum or obstruction in percussion boring** 4.3 In a borehole where percussion boring is employed and a hard stratum or obstruction is encountered the Contractor shall employ chiselling techniques for a period of up to one hour. Should this not penetrate through the hard stratum or obstruction the Contractor shall inform the Engineer, who may instruct the use of one or more of the following
- (a) continuation of chiselling techniques
- (b) rotary or other approved drilling until the stratum is proved for a sufficient depth; should the hard stratum prove to be a thin layer and further boring be required beneath, the Contractor shall break it out sufficiently to enable boring, in situ testing and sampling to proceed
- (c) abandonment of the borehole.
- Auger boring** 4.4
- Hand auger* 4.4.1 Hand auger boring may be required in suitable self-supporting strata.
- Continuous flight auger boring* 4.4.2 Where continuous flight auger boring is required it shall be carried out under the full time supervision of a person meeting the requirements of Clause 2.2 item (d) who shall produce, as boring proceeds, a record of the material and groundwater encountered.
- Hollow stem flight auger* 4.4.3 Where hollow stem flight auger boring is required the equipment used shall be such as to bore and recover samples as specified in the Contract. Sampling shall be carried out through the hollow stem.
- Rotary, drilling in soils** 4.5 Where rotary drilling is employed the work shall be carried out in accordance with Section 5, Rotary drilling.
- Backfilling** 4.6 The Contractor shall backfill boreholes with arisings in such a manner as to minimise subsequent depression at the ground surface due to settlement of the backfill. In some circumstances special infilling may be required by the Engineer. Unless otherwise instructed the special infilling shall be cement/bentonite grout as specified in Clause 5.5. Where artesian or other water conditions make normal backfilling impracticable, the Contractor shall consult and agree with the Engineer a procedure for sealing the borehole.

5 Rotary drilling

- General** 5.1 Rotary drilling may be required for the recovery of cores or for the advancement of a hole without core recovery.
- Drilling fluid** 5.2 The drilling fluid shall normally be clean water, air or air mist. However, with the agreement of the Engineer drilling muds, additives or foam may be used.
- Rotary drilling with core recovery** 5.3
- Types of equipment* 5.3.1 Unless otherwise stated in Schedule 1 rotary core drilling shall be carried out by a double or triple tube coring system incorporating a removable inner liner. The triple tube system may be effected by use of a double tube barrel with an approved semi-rigid liner.
- Core recovery* 5.3.2 Rotary core drilling shall produce cores of not less than the required diameter (Schedule 1) throughout the core length, and 100% core recovery in any single run should normally be obtained. Core recovery less than 90% in any drill run will not normally be acceptable unless the Engineer is satisfied that more than 90% recovery is impracticable under the prevailing conditions. If in the opinion of the Engineer more than 90% recovery can be achieved, the Contractor, after consultation with the Engineer, shall take measures to improve the core recovery.
- Drill runs* 5.3.3 The first drill run in each hole shall not exceed 1m in length. Subsequent drill runs shall not normally exceed 3m in length and the core barrel shall be removed from the drillhole as often as is required to obtain the best possible core recovery. The Engineer may specify in situ testing between drill runs.
- Removal of cores and labelling of liners* 5.3.4
1. All operations entailed in recovering the cores from the ground after completion of drilling shall be carried out in a manner such as to minimise disturbance to the cores.
 2. Core barrels shall be held horizontally while the innermost liner containing the core is removed without vibration and in a manner to prevent disturbance to the core. The core should be rigidly supported at all times while it is being extruded and during subsequent handling, and the liner containing the core must not be allowed to flex.
 3. Immediately after removing the liner the top and bottom shall be marked in indelible ink. The ends of liners shall be capped and sealed using adhesive tape. Liners shall be cut to the length of the enclosed core.
 4. Where the length of core recovered from any single core run is such that it cannot be accommodated in one channel of the core box, the liner shall be cut to coincide, if possible, with existing fractures. The liner either side of the cut shall be marked 'cut' and the ends capped as above.
 5. Each section of liner shall be marked with the contract title, exploratory hole reference number, date and the depths of the top and bottom of the drill run.
 6. Core obtained without a liner and that from within the core catcher but

not inside the liner shall be wrapped in two layers of plastic cling film and labelled to indicate the depth and exploratory hole reference number.

Core boxes, packing, labelling, storing 5.3.5

1. Core boxes shall be soundly constructed and fitted with stout carrying handles, fastenings and hinged lids. The total weight of the cores and box shall together not exceed 60 kg.

2. Cores shall be rigidly and securely packed at the site of drilling and during all subsequent handling and storage the cores shall remain packed unless required for examination or testing. Cores shall be placed in the box, in their liners where used, with the shallowest core to the top left hand corner, the top being considered adjacent to the hinged section. Cores from the core catcher shall also be placed in the core boxes at the correct relative depth.

3. Depth shall be indicated on the core box by durable markers at the beginning and end of each drill run. Rigid core spacers shall be used to indicate missing lengths. The Contract title, exploratory hole reference number and the depth of coring contained in each bore shall be clearly indicated in indelible ink inside, on top and on the right-hand end of the box.

4. Core boxes containing core shall be kept horizontal and moved and handled with care at all times. Cores shall be protected to ensure that their temperature does not fall below 2°C and rise above 45°C. They shall also be protected from direct heat and sunlight. At the end of each day's work, core boxes shall be stored secure from interference and protected from the weather.

Preparation of cores for examination 5.3.6

1. Cores shall be prepared for examination by the removal of sealing materials and splitting of liners in such a way as not to damage the cores. Plastic liners shall be cut lengthwise such that at least half the core circumference is exposed.

2. Prior to examination of the core the Contractor shall photograph the cores as specified in Clause 5.6. The time between commencement of preparation and the examination of the prepared and photographed cores shall be minimised to prevent loss of moisture from the core samples.

3. The cores shall be examined and described on site by a person meeting the requirements of Clause 2.2 item (d) in accordance with BS 5930 and the recommendations of the Engineering Group of the Geological Society Working Party Report 'The logging of rock cores for engineering purposes' (1970).

Retention of core sub-samples 5.3.7

When the examination of the cores has been completed, the Contractor may be required to retain separately specified core sub-samples for possible laboratory testing. The Contractor shall cut the liner and cap and seal the core sub-samples in such a way as to prevent loss of moisture and sample disturbance. They shall be clearly labelled so that the location, depth and origin of the sub-samples can be readily identified. Cores in their liners remaining after the specified sub-samples have been removed shall be end-capped and resealed and replaced in the original core box location. Rigid spacers shall be placed in the spaces in the cores boxes previously occupied by the core sub-samples to prevent movement of adjacent cores and these shall be labelled identically to the core sub-samples that they replace. The core sub-samples shall be retained in separate core boxes clearly marked to indicate the origin of the cores contained within.

- Protection and transportation of cores* 5.3.8 The Contractor shall protect all cores and transport them including loading and unloading
- (a) to the Contractor's premises
 - (b) for a number of selected cores, to the address given in Schedule 1.
- Retention and disposal of cores* 5.3.9 The Contractor shall retain cores for a period of 28 days after submission of the approved final report. After this time the Engineer's written permission should be sought for their disposal. The Contractor shall dispose of all cores other than those delivered to the address in Schedule 1.
- Rotary drilling without core recovery** 5.4
1. Rotary open hole or rotary percussive drilling may be used to advance a hole. The hole diameter shall be as stated in Schedule 1.
 2. When used for the purpose of locating mineral seams, mineworkings, adits, shafts, other cavities or anomalous conditions, drilling shall be under the full-time supervision of a person meeting the requirements of Clause 2.2 item (d). As drilling proceeds a systematic record shall be made of the drilling methods, rate of penetration, loss of flushing medium, the material penetrated and any cavities or broken ground encountered.
- Backfilling** 5.5
1. Except where otherwise specified the Contractor shall backfill rotary drillholes with a cement/bentonite grout. The grout shall consist of equal portions by weight of ordinary Portland cement and bentonite mixed by machine or hand to a uniform colour and consistency before placing, with a moisture content not greater than 250%. The grout shall be introduced at the bottom of the hole by means of a tremie pipe, which shall be raised but kept below the grout surface as the filling proceeds.
 2. Where artesian water conditions or voids make normal grouting impracticable the Contractor shall consult and agree with the Engineer a procedure for sealing the drillhole.
- Photographs** 5.6 In addition to the requirement of Clause 3.25 the Contractor shall photograph cores where required in a fresh condition prior to logging and ensure that the following criteria are fulfilled.
- (a) A graduated scale in centimetres is provided.
 - (b) Labels and markers are clearly legible in the photograph.
 - (c) A clearly legible reference board identifying the project title, exploratory hole number, date and depth of drill runs shall be included in each photograph.
 - (d) Core boxes are evenly and consistently lit.
 - (e) The length of the core box in each photograph fills the frame.
 - (f) The focal plane of the camera and the plane of the core box are parallel.
 - (g) The camera is placed in the same position with respect to the core box in every photograph.

6 Pits and trenches

- Inspection pits** 6.1 Inspection pits for the location of underground services shall be excavated by hand to a depth of 1.2 m unless otherwise indicated in Schedule 1. Hand-operated power tools may be used to assist excavation where necessary. The positions, depths and dimensions of all services encountered shall be measured and recorded in the daily report with other information as required by Clause 10.2.
- Trial pits and trenches** 6.2 Trial pits and trenches shall be excavated by hand to a maximum depth of 1.2 m or by machine to the required depth to enable visual examination and sampling from outside the pit or trench as required. Trial pits or trenches deeper than 1.2 m shall not be entered by personnel.
- Observation pits and trenches** 6.3 Observation pits and trenches shall be excavated by hand or machine, and shall be adequately supported to enable personnel to enter safely and to permit in situ examination, soil sampling and testing as required.
- Pit and trench dimensions** 6.4 Unless otherwise required in Schedule 1
- (a) trial pits and observation pits shall have a minimum base area of 1.5 m².
 - (b) trial trenches and observation trenches shall be 1 m wide.
- Description** 6.5 Trial pits and trenches and observation pits and trenches shall be examined and described by a geotechnical person meeting the requirements of Clause 2.2 item (d) and, if required, photographed. Suspected contaminated ground shall be described by an environmental or geotechnical person, as appropriate, meeting the requirements of Clause 2.2 item (d).
- Groundwater** 6.6 The Contractor shall keep pits and trenches free of surface water run-off. Groundwater shall be controlled by pumping from a sump to permit continuous work insofar as the rate of inflow of groundwater can be controlled by use of a 50 mm outlet diameter pump and the excavation remains stable.
- Backfilling** 6.7 Backfilling of the pits and trenches shall be carried out as soon as practicable with material replaced at similar depth as encountered. The backfilling shall be compacted in such a manner using excavation plant or as specified in Schedule 1 as to minimise any subsequent depression at the ground surface. In open land any surplus shall be heaped proud over the pit site. In paved areas reinstatement shall be to Clause 3.9.3.
- Protection to pits and trenches left open** 6.8 Where pits and trenches are required to be left open for a period the Contractor shall provide fencing together with all necessary lighting and signing. Precautions shall be taken to protect the pits and trenches from the adverse effects of weather during this period.
- Photographs** 6.9 In addition to the requirement of Clause 3.25 photographs shall clearly show details of the ground conditions in the pit and trench with any support in place and shall contain a graduated scale. Arisings shall be photographed where directed by the Engineer. Unless otherwise required in Schedule 1, artificial lighting shall be used where necessary. Photographs will generally be required at the rate of three for every pit or as directed by the Engineer.

7 Sampling

- Small disturbed samples** 7.1 Small disturbed samples shall weigh not less than 0.5 kg. They shall be placed immediately in airtight containers, which they should sensibly fill.
- Bulk disturbed samples** 7.2
1. Bulk disturbed samples shall be representative of the zone from which they have been taken.
 2. Bulk disturbed samples shall weigh not less than 10 kg.
 3. Large bulk disturbed samples shall weigh not less than 30 kg.
- Open tube and piston samples** 7.3
1. Open tube and piston samples shall be taken using the sampling equipment and procedures as described in BS 5930. The diameter shall be 100 mm unless otherwise required in Schedule 1.
 2. Before an open tube or piston sample is taken, the bottom of the hole shall be carefully cleared of loose materials and where a casing is being used the sample shall be taken below the bottom of the casing. Following a break in the work exceeding one hour, the borehole shall be advanced by 250 mm before open tube or piston sampling is resumed.
 3. Where an attempt to take an open tube or piston sample is unsuccessful the hole shall be cleaned out for the full depth to which the sampling tube has penetrated and the recovered soil saved as a bulk disturbed sample. A fresh attempt shall then be made from the level of the base of the unsuccessful attempt. Should this second attempt also prove unsuccessful the Contractor shall agree with the Engineer alternative means of sampling.
 4. The samples shall be sealed immediately to preserve their natural moisture content and in such a manner as to prevent the sealant from entering any voids in the sample.
 5. Soil from the cutting shoe of an open tube shall be retained as an additional small disturbed sample.
- Groundwater samples** 7.4 Groundwater samples shall be taken from each exploratory hole where groundwater is encountered. Where more than one groundwater level is found, each one shall be sampled separately. Where water has been previously added, the hole shall be baled out before sampling so that only groundwater is present. The sample volume shall be not less than 0.25 litre.
- Standard penetration test samples** 7.5 When a standard penetration test (SPT) is carried out the sample from the split barrel sampler shall be retained as a small disturbed sample. Where a sample is not retained in the split barrel or when the cutting shoe is replaced by a solid cone, a bulk disturbed sample shall be taken from the test zone.
- Sampling and testing frequency** 7.6
1. The frequency of sampling and in situ testing is dependent on the ground conditions. Particular requirements are given in Schedule 1. In the absence of particular requirements or instructions from the Engineer the intervals observed shall be as follows.
 2. In boreholes
 - (a) first open tube sample (generally in clay soils) or standard penetration test (SPT) (generally in granular soils) at 0.5 m depth,

		the next at 1.0 m depth, thereafter at 1 m intervals to 5 m depth then at 1.5 m intervals
		(b) small disturbed samples shall be taken of the topsoil, at each change in soil type or consistency and midway between successive open tube samples or SPTs
		(c) bulk disturbed samples shall be taken of each soil type.
	3.	In pits and trenches
	(a)	small disturbed samples shall be taken of the topsoil, at each change in soil type or consistency and between successive bulk disturbed samples
	(b)	bulk disturbed samples shall be taken at 1 m intervals with at least one large bulk disturbed sample of each soil type.
Special sampling	7.7	The Engineer may require special sampling. This work will normally require on-site supervision by a geotechnical person and shall be carried out in accordance with BS 5930 or as described in Schedule 1 of this Specification.
Samples of suspected contaminated ground, groundwater and leachate for chemical analysis	7.8	<p>1. Samples of suspected contaminated ground, groundwater and leachate for chemical analysis shall be taken in accordance with DD175: 1988 and the companion publication (Site Investigation Steering Group, 1993) under the supervision of an environmental and/or geotechnical person meeting the requirements of Clause 2.2 item (d).</p> <p>2. The size and type of sample and container, method of sampling and time limitations for carrying out specific analyses shall be commensurate with the range of analyses to be carried out or as described in Schedule 1.</p>
Gas sampling	7.9	Samples of gas for chromatographic analysis shall be obtained from exploratory holes or standpipes in accordance with DD175 : 1988 and the companion publication (SISG, 1993). The sampling method shall relate to the volume of gas available and the type of laboratory analysis. The sampler receptacle shall be airtight and may include lockable syringes, Teflon-lined bags and gas bombs.
Recording depths of samples	7.10	The depths below ground level at which samples are taken shall be recorded. For open tube and piston samples the depth to the top and bottom of the sample, and the length of sample obtained shall be given. For bulk samples the limits of the sampled zone shall be recorded.
Description of samples	7.11	All samples shall be examined and described by a geotechnical person meeting the requirements of Clause 2.2 item (d) in accordance with BS 5930. Samples of suspected contaminated ground and leachate shall be described by an environmental or geotechnical person meeting the requirements of Clause 2.2 item (d) in accordance with DD 175 : 1988, and descriptions shall include colour and smell with reference to specific inclusions.
Labelling, protection and transportation of samples	7.12	<p>1. Samples shall be clearly labelled in accordance with BS 5930. Samples of fill, groundwater leachate or contaminated ground suspected to be toxic or hazardous shall be tagged with a red label (HMSO, 1984).</p> <p>2. Samples shall be protected to ensure that their temperature does not fall below 2°C or rise above 45°C. They shall also be protected from direct heat and sunlight.</p> <p>3. Samples shall be transported to the Contractor's premises. Where required, selected samples shall be delivered to the address given in Schedule 1.</p>

8 In situ testing

Calibration of measuring instruments 8.1

Where load, displacement or other measuring equipment is used which necessitates regular calibration then this shall be carried out in accordance with the manufacturer's instructions. Evidence of calibrations and copies of calibration charts shall be supplied to the Engineer prior to commencing work and when otherwise requested.

Testing: general 8.2

1. The following information shall be submitted for each test record to be included in the daily report, preliminary log and factual report

- (a) date of test
- (b) project name, exploratory hole number and location
- (c) depth and location of test or depths covered by test, as appropriate, together with reduced levels on preliminary logs and in the factual report
- (d) information on water levels in exploratory hole during testing
- (e) original ground level at test site (not required for daily report)
- (f) soil type and description as identified from the sample.

2. All results shall be reported in SI units.

Tests 8.3

Tests in accordance with BS 1377 8.3.1

The following in situ tests shall be carried out and reported in accordance with BS 1377.

1. In situ density by

- (a) small pouring cylinder method
- (b) large pouring cylinder method
- (c) water replacement method
- (d) core cutter method
- (e) nuclear method.

2. Static cone penetration test (CPT). Capacity to suit scheduled depths unless otherwise stated in Schedule 1.

3. Dynamic probing (DPH or DPSH).

4. Standard penetration test (SPT).

5. Plate loading test.

6. Shallow pad maintained load test.

7. California Bearing Ratio (CBR).

8. Vane shear strength.

9. Apparent resistivity of soil.

10. Redox potential.

Tests in accordance with BS 5930 8.3.2

The following in situ tests shall be carried out and reported in accordance with BS 5930.

1. Constant head permeability test.

2. Variable head permeability test.

3. Packer permeability test.

Geophysical methods of investigation 8.4

1. Geophysical testing shall be carried out as described in Schedule 1. The Contractor shall submit to the Engineer a full description of equipment and procedure for each geophysical method required.

2. The equipment and procedure, and information to be submitted for the following geophysical methods of investigation, shall be as described in BS 5930, BS 7022 and the Geological Society Engineering Group Working Party Report on Engineering Geophysics.

1. Electrical resistivity method.
2. Seismic refraction and reflection method.
3. Magnetic method.
4. Gravity method.
5. Electromagnetic method
 - (a) ground conductivity
 - (b) transient electromagnetic
 - (c) ground probing radar.
6. Borehole geophysical logging.
7. Cross-hole seismic method.

Special in situ testing 8.5 Special in situ testing shall be carried out as described in Schedule 1.

Hand penetrometer and hand vane for shear strength 8.6 1. Hand penetrometer and hand vane tests shall be carried out where required to give a preliminary estimate of undrained shear strength of the soil tested.

2. Hand (or pocket) penetrometer equipment shall be of an approved proprietary make with stainless steel tip of end area 31 mm² with an engraved penetration line 6 mm from the tip. The scale shall be suitably graduated. The procedure for the test shall be in accordance with the manufacturer's instructions. Both unconfined compressive strength and estimated shear strength shall be reported for the soil tested.

3. Hand vane equipment shall be of an approved proprietary make with stainless steel vanes having a length of 19 mm or 33 mm and a length-to-diameter ratio of 2 : 1. The scale shall be suitably graduated. The procedure for test shall be in accordance with BS 5930 and the manufacturer's instructions. Peak shear strength and residual shear strength shall be recorded.

4. The reported shear strengths for the hand penetrometer and hand vane shall be the average of 3 tests in close proximity. Tests giving inconsistent results shall be reported and comments on the relevance of the tests noted.

Self-boring pressuremeter 8.7 The equipment shall be of the Cambridge type (soft ground) self-boring pressuremeter (SBP) unless otherwise stated in Schedule 1. The instruments, calibration, operator, installation, testing procedure, on-site data processing and analysis, information to be submitted, report data processing and analysis and information to be submitted in the report shall be as described by Clarke and Smith (1992) except that reference to Schedule A shall be read as Schedule 1.

9 Instrumentation and monitoring

Groundwater measurement 9.1 records

Encountering groundwater 9.1.1

When groundwater is encountered in exploratory holes, the depth from ground level of the point of entry shall be recorded together with depth of any casing. Exploratory hole operations shall be stopped and the depth from ground level to water level recorded with an approved instrument at 5 minute intervals for a period of 20 minutes. If at the end of the period of 20 minutes the water level is still rising, unless otherwise instructed by the Engineer, this shall be recorded together with the depth to water below ground level and the exploratory hole shall then be continued. If casing is used and this forms a seal against the entry of groundwater, the Contractor shall record the depth of casing at which no further entry or only insignificant infiltration of water occurred. Where applicable, every effort shall be made to seal off each water strike.

Recording groundwater levels 9.1.2

1. Water levels shall be recorded as required by the Contract and at the beginning and end of each shift or other rest periods during the work.

2. On each occasion when groundwater is recorded, the depth of the exploratory hole, the depth of any casing and the time on a 24 hour clock shall also be recorded.

Artesian conditions 9.1.3

Where artesian conditions are encountered, the Contractor shall immediately inform the Engineer and agree a method for dealing with the conditions.

Installation of standpipes 9.2 and piezometers

Standpipes 9.2.1

Standpipes for monitoring groundwater levels and changes in groundwater levels shall be installed in exploratory holes as instructed by the Engineer. They shall be as described in Appendix I of this Specification and all dimensions and depths shall be recorded at the time of installation.

Standpipe piezometers 9.2.2

Standpipe piezometers for monitoring groundwater levels and changes in groundwater levels at a particular depth in exploratory holes shall be installed as instructed by the Engineer. They shall be as described in Appendix I of this Specification and all dimensions and depths shall be recorded.

Piezometers 9.2.3

When required in the Contract the Contractor shall install piezometers of the hydraulic, electrical or pneumatic type described in BS 5930 and Schedule 1.

Installation of gas 9.3 monitoring standpipes

Standpipes for monitoring gas concentration in exploratory holes shall be installed as instructed by the Engineer. They shall be as described in Appendix II of this Specification and all dimensions and depths shall be recorded at the time of installation.

Covers 9.4

The top of each standpipe, the gas monitoring standpipe and piezometer tube shall be protected by a cover of one of the types shown in Appendices I or II of this Specification as appropriate. The type of protective cover shall be agreed with the Engineer.

- Fencing 9.5** When instructed by the Engineer, the Contractor shall install a timber protective fence around the top of a standpipe or piezometer. The fence shall comprise at least three wooden stakes, 75 mm square, preserved in accordance with BS 5589, firmly bedded in the ground, stoutly crossbraced and projecting at least 1.0 m above ground level.
- Readings 9.6**
- Water readings 9.6.1* Daily readings of depths to water in standpipes and piezometers shall be made by the Contractor with an approved instrument during the fieldwork period or as directed by the Engineer.
- Gas readings 9.6.2* Gas measurements using an approved in situ meter shall be made by the Contractor at a range of depths during construction of exploratory holes and in gas monitoring standpipes where the presence of gas is suspected or as directed by the Engineer. The depth to water and barometric pressure shall be measured immediately after each gas measurement.
- Removal of piezometers and standpipes 9.7** Unless otherwise described in the Contract, piezometers, standpipes and protection shall not be removed from the site.
- Other instrumentation and monitoring 9.8** Other instrumentation and monitoring shall be carried out as described in Schedule 1.

10 Daily reports

General 10.1 The Contractor shall prepare for each exploratory hole a daily report which shall be submitted to the Engineer at the beginning of the next working day. Information shall be recorded as work proceeds and shall include the following where relevant.

Information for daily reports 10.2 ✓ means information required;
(✓) means information required if applicable.

	Borehole	Rotary drilling	Pit and trench	Static and dynamic probing
1. Contract title and site location	✓	✓	✓	✓
2. Contractor's and operator's name	✓	✓	✓	✓
3. British Drilling Association or similar registration number or name of supervising person if not registered	✓	✓		
4. Borehole number	✓	✓	✓	✓
5. Day and date	✓	✓	✓	✓
6. Type and depth of any services or drains encountered	✓	✓	✓	✓
7. Equipment and technique in use	✓	✓	✓	✓
8. Diameter and depth of holes and casing	✓	✓		
9. The depths at which any water was added	✓			
10. Depth of each change of stratum	✓	✓	✓	(✓)
11. Description of each stratum	✓	✓	✓	
12. The types of samples, the depths from which they were taken and length of undisturbed or core sub samples recovered; the method used and the number of blows required to drive open tube samples	✓	(✓)	✓	(✓)
13. The depths and details of all in situ tests	✓	✓	✓	(✓)
14. Depths of hard strata and times o'clock spent on penetration	✓		✓	
15. Records of groundwater	✓	✓	✓	(✓)
16. Installation details of any standpipes, piezometers or other instrumentation	✓	✓	✓	(✓)

	Borehole	Rotary drilling	Pit and trench	Static and dynamic probing
17. Water level readings in previously installed standpipes and piezometers	✓	✓	✓	
18. Details of backfilling and/or infilling	✓	✓	✓	
19. Details of times o'clock spent other than in advancing the borehole, including details and duration of any periods of standing time	✓	✓	✓	✓
20. Inclination and direction relative to grid North of non-vertical drillholes		✓		
21. Type of drilling fluid		✓		
22. Type of core barrel and bit used		✓		
23. Depth of start and finish of each core run		✓		
24. Core diameters and depths of changes in core diameter		✓		
25. Colour and condition of the return drilling fluid and cuttings		✓		
26. The depth and/or extent of any loss of return of drilling fluid		✓		
27. Total core recovery and percentage recovery, with information as to possible location of core losses, if any, for each core run		✓		
28. The dimensions of the pit or trench in plan and orientation relative to grid North			✓	
29. The method of support and comments on stability			✓	
30. Sketches of the strata and any foundations or other feature encountered on each face of the pit or trench as appropriate			✓	
31. Estimate of the quantity of water, if any, pumped from the pit or trench, the type of pump and time spent on pumping			✓	
32. Details of photographs taken			✓	
33. Results of blow count, cone and friction resistance, friction ratio and piezometric pressure as appropriate plotted against depth				✓

Special in situ testing and instrumentation reports 10.3 The information to be recorded and submitted shall be as described in Schedule 1.

11 Laboratory testing

- Schedule of tests 11.1** The Engineer will prepare a schedule of tests, or, if specified in Schedule 1 the Contractor shall prepare a schedule of tests for approval by the Engineer. It may be necessary to specify additional testing after the results of the original tests are available. Unless otherwise agreed, testing schedules will be provided within 5 working days of the receipt of the relevant preliminary records as detailed in Clause 12.1. The Contractor shall inform the Engineer within 5 working days from the receipt of the testing schedule if a sample referred to in the schedule is not available for testing.
- Testing procedures 11.2**
1. All preparation, testing and reporting shall be where applicable in accordance with the relevant British Standards. Where tests are not covered by British Standards they shall be performed in accordance with the procedures in the references or as described in the Schedules.
 2. Calibration of load-displacement or other measuring equipment shall be carried out in accordance with the appropriate British Standards and the manufacturer's recommendations. Evidence of current calibrations shall be supplied to the Engineer when requested.
- Geotechnical testing on contaminated samples 11.2.1* Where geotechnical testing is required on samples of suspected contaminated material, indicative chemical testing shall be carried out and a safe method of working agreed with the Engineer before any such work is started. It should be noted that this may include but is not limited to the safe storage, transportation and handling of all suspect material.
- Soil testing 11.3** Soil testing shall be carried out and reported in accordance with BS 1377 unless otherwise specified.
- Rock testing 11.4** Rock testing shall be carried out and reported in accordance with the following references and as described in Schedule 1.
- Classification 11.4.1*
1. Natural water content — Brown (1981)
 2. Porosity/density — Brown (1981)
 3. Void index — Brown (1981)
 4. Carbonate content — BS 1881: 1971
 5. Petrographic description — Brown (1981)
- Durability 11.4.2*
1. Slake durability index — Brown (1981)
 2. Soundness by solution of magnesium sulphate — BS 812: 1989
- Hardness 11.4.3*
1. Shore sclerometer — Brown (1981)
 2. Schmidt rebound hardness — Brown (1981)
- Aggregates 11.4.4*
1. Aggregate crushing value — BS 812: 1989
 2. Ten percent fines — BS 812: 1989
 3. Aggregate impact value — BS 812: 1989
 4. Aggregate abrasion value — BS 812: 1989
 5. Polished stone value — BS 812: 1975
 6. Aggregate frost heave — BS 812: 1989
- Strength 11.4.5*
1. Uniaxial compressive strength — Brown (1981)
 2. Deformability in uniaxial compression — Brown (1981)

3. Tensile strength — Brown (1981)
Direct tensile strength
Indirect tensile strength by the Brazilian method
4. Undrained triaxial compression without measurement of porewater pressure — Brown (1981)
5. Undrained triaxial compression with measurement of porewater pressure — ASTM: SP 402
6. Direct shear strength — Brown (1981)
7. Swelling pressure — Brown (1981)
Swelling pressure index under conditions of zero volume change.
Swelling strain index for a radially confined specimen with axial surcharge.
Swelling strain developed in an unconfined rock specimen.
8. Point load test — IRSM Commission on Testing Methods (1985).

Geophysical 11.4.6

1. Seismic velocity — Brown (1981)

Chemical testing for contaminated ground 11.5

Chemical testing for contaminated ground shall be carried out and reported in accordance with the following references and as described in Schedule 1.

Primary contaminants in soil 11.5.1

1. Arsenic total – C4
2. Cadmium total – C2
3. Chromium total – C2
4. Hexavalent chromium (undertaken if total chromium content >25 mg/kg dry mass) – C2
5. Lead total – C2
6. Mercury total – C3
7. Selenium total – C4
8. Boron — Water-soluble – C5
9. Copper total – C2
10. Nickel total – C2
11. Zinc total – C2
12. Cyanide total (alkali extraction methods) – C6
13. Cyanide complex – C6
14. Cyanide free – C6
15. Thiocyanate – C6

(Tests 13, 14, and 15 undertaken if total cyanide >25 mg/kg dry mass. Methods shall follow alkali extraction)

16. Phenols total – C7
17. Sulphide – C8
18. Sulphate — total, acid, soluble – C9
19. Sulphate — water soluble, 2 : 1 extract – C9
20. Sulphur free – C10
21. pH value – C9
22. Toluene extractable matter – C11
23. Coal tar/polyaromatic hydrocarbons (undertaken if toluene extractable matter >2000 mg/kg dry mass of soil) – C12
24. Asbestos: Asbestos content determination shall be carried out by visual examination and polarised light microscopy.

Secondary contaminants in soil 11.5.2

1. Antimony total – C13
2. Barium total – C13
3. Beryllium total – C15
4. Vanadium total – C13
5. Cyclohexane extractable matter – C14
6. Freon extractable matter – C15

		7. Mineral oils – C31
		8. Chloride – C9
<i>Contaminants in water</i>	11.5.3	<ol style="list-style-type: none"> 1. Arsenic – C4 2. Cadmium – C2 and C23 3. Chromium – C2 and C24 4. Hexavalent chromium – C2 5. Lead – C2 and C25 6. Mercury – C3 7. Selenium – C4 8. Boron – C5 and C6 9. Copper – C2 and C27 10. Nickel – C2 and C28 11. Zinc – C2 and C29 12. Cyanide total – C6 13. Cyanide complex – C6 14. Cyanide free – C6 15. Thiocyanate – C6 16. Phenols total – C7 17. Sulphide – C8 18. Sulphate – C9 19. Sulphur free – C10 20. pH value – C9 21. Polyaromatic hydrocarbons – C12 22. Antimony – C13 23. Barium – C13 24. Beryllium – C15 25. Vanadium – C13 26. Chloride – C9 27. Ammoniacal nitrogen – C16 28. Nitrate nitrogen – C17 29. Chemical oxygen demand – C18 30. Biochemical oxygen demand – C19 31. Total organic carbon – C20 32. Volatile fatty acids – C21 33. Iron – C22 34. Manganese – C22 35. Calcium – C31 36. Sodium – C31 37. Magnesium – C31 38. Potassium – C21
<i>Constituents of gas samples</i>	11.5.4	<ol style="list-style-type: none"> 1. Carbon dioxide – C30 2. Hydrogen – C30 3. Hydrogen sulphide – C30 4. Methane – C30 5. Nitrogen – C30 6. Oxygen – C30 7. Ethane – C30 8. Propane – C30 9. Carbon monoxide – C30
Laboratory testing on site	11.6	When required in the Contract tests listed under laboratory testing shall be carried out on site.
Special laboratory testing	11.7	Special laboratory testing shall be carried out as described in Schedule 1.

12 Reporting

Preliminary logs 12.1 The Contractor shall prepare a preliminary log of each exploratory hole using an agreed pro forma or as shown in the Schedules. For trial pits a simplified version of the log and elevations showing each face of the pit shall be provided as appropriate. Preliminary logs shall be submitted to the Engineer in duplicate within seven working days of completion of the explorations to which they refer and shall contain the information required for the exploratory hole logs.

Exploratory hole logs 12.2

General 12.2.1

The exploratory hole logs shall be in the same form as the preliminary logs, presented to a suitable vertical scale, and shall include all the information that follows, such information having been updated as necessary in the light of laboratory testing and further examination of samples and cores.

*Information for 12.2.2
exploratory hole logs*

✓ means information required; (✓) means information required if applicable.

	Borehole	Rotary drilling	Pit and trench	Static and dynamic probing
1. All the information set out in Clause 10.2	✓	✓	✓	✓
2. National grid coordinates	✓	✓	✓	✓
3. Ground level related to the datum	✓	✓	✓	✓
4. Elevation of each stratum referred to the datum	✓	✓	✓	(✓)
5. Description of each stratum in accordance with BS 5930 and initials of person who carried out the logging (and responsible Supervisor if under training)	✓	✓	✓	(✓)
6. Details of groundwater observations	✓	✓	✓	(✓)
7. Symbolic legend of strata in accordance with BS 5930	✓	✓	✓	(✓)
8. Solid core recovery as percentage of each core run		✓		
9. Rock Quality Designation RQD (Deere <i>et al.</i> 1967)		✓		

Preliminary laboratory test results 12.3

Laboratory test results shall be submitted to the Engineer in batches at the completion of each week's testing. Legible photocopies of work sheets are acceptable.

Digital data 12.4

Data from the investigation shall be provided in digital form as described in Appendix III.

Form of report 12.5

The report shall be submitted in two sections, the first being the factual report, and the second, if required by the Engineer, the interpretative

report. Both sections of the report shall begin with a cover page showing the name of the Contract and the names of the Employer, Engineer and Contractor. Report pages shall be numbered consecutively.

Contents of factual report 12.6

1. The factual report shall contain the following information
 - (a) a statement from the Engineer on the purpose and rationale of the investigation
 - (b) a description of the work carried out, including reference to specification and standards adopted and any deviations from them
 - (c) exploratory hole logs
 - (d) in situ test records
 - (e) laboratory test results
 - (f) plan with locations of exploratory holes
 - (g) site location plan.
2. The plans shall be to a stated scale and shall include a north point. Additional information shall be provided where required in Schedule 1.

Contents of interpretative report 12.7

1. The interpretative report shall contain the following information
 - (a) the brief agreed with the procurer for the interpretative work
 - (b) reference to the desk study information
 - (c) a written appraisal of the ground and water conditions
 - (d) analyses and recommendations as indicated in Schedule 1.
2. Where required in the Contract the Contractor shall supply the calculations and analyses on which recommendations are based.

Approval of report 12.8

A draft copy of the factual report and the interpretative report shall be submitted to the Engineer for approval before submission of the final report.

Appendix I: Standpipes and piezometers

- Standpipes AI.1**
1. The standpipe shall consist of unplasticised polyvinylchloride (uPVC) or high density polyethylene (HDPE) tubing as specified and not less than 19 mm internal diameter.
 2. The base of the tubing shall be plugged and the lower 1.0 m of tubing perforated by holes not greater than 5 mm in diameter at intervals of approximately 75 mm or an equivalent area of slots not greater than 5 mm width.
 3. The filter shall be pea gravel, or similar material, as approved by the Engineer, 6–10 mm in diameter.
 4. 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 with impermeable materials, approved by the Engineer, to the base of the filter.
 5. The gravel filter shall be placed in the exploratory hole up to the level of the proposed base of the tubing.
 6. The tubing with a centralising device attached within the perforated zone shall be lowered carefully down the exploratory hole to the level of the filter material, and the exploratory hole backfilled to within 1.0 m of ground level with filter gravel or other materials approved by the Engineer. The elevations of the base of the tubing and top and base of the filter shall be recorded.
 7. The top of the tubing shall be covered by a plastic cap or similar, as approved by the Engineer. An air vent shall be provided as indicated on Drawing 1.1.
 8. Arrangements to prevent the ingress of surface water and to protect the top of the tubing shall use a steel water barrel of 75 mm diameter, a 150 mm stopcock cover, or an alternative as agreed with the Engineer. The protective cover shall be set in concrete. Protective fencing, where required, shall be in accordance with Clause 9.5.

- Standpipe piezometers AI.2**
1. The final details of any piezometer installation will be decided by the Engineer and will depend upon the actual subsoil and groundwater conditions found. The installation shall be generally as shown in Drawing 1.2.
 2. The piezometer tip shall consist of a porous ceramic element or other suitable element not less than 150 mm long with a diameter not less than 35 mm, and shall be protected at each end by unplasticised polyvinylchloride (uPCV) fittings. The ceramic shall have a pore diameter of the order of 60 microns and a permeability of the order of 3×10^{-4} m/s.
 3. The uPCV tubing shall be according to BS 3506 Class 6 nominal size 19 mm and shall be supplied and installed in not less than 3 m lengths, except for one shorter length as required to suit the total standpipe dimensions. The tubes shall be jointed together and to the porous element with approved

couplings and glue in such a manner that the joints remain leakproof under the anticipated head of water.

4. Where the depth of the completed exploratory hole is greater than the depth at which the porous element and sand filter are to be installed then the lower part of the exploratory hole shall be grouted.

A grout consisting of cement and bentonite in the proportions of 1 : 1 by weight shall be prepared by thorough mixing with approved equipment and with only sufficient water to form a pumpable mix.

Where the exploratory hole is dry, sufficient grout shall be placed in the hole using a tremie reaching to the bottom of the hole, such that the top of the grout shall just reach its interface with the sand filter. Where there is water in the exploratory hole the top of the grout shall finish 1 m below the proposed grout/filter interface. A similarly proportioned mixture of cement/bentonite shall then be prepared but having just sufficient water to form a cohesive paste. This mix shall be formed into balls of approximately 75 mm diameter and placed in porous canvas bags or other suitable porous bags. The balls shall be placed in the exploratory hole and punned with a suitably shaped punner to form a homogeneous plug to the exploratory hole without significant voids between adjacent bags. The top of this plug shall be at the interface with the sand filter. Compressed bentonite pellets may be used as an alternative to the grout balls where the inflow of water into the piezometer is sufficient for immediate saturation.

5. If water in the exploratory hole becomes contaminated by grout it shall be replaced by clean water, the method being to the approval of the Engineer.

6. The sand filter surround to the porous elements shall be clean and fall wholly between the limits of grading 1200 and 210 microns, and the volume of the sand filter placed shall be recorded.

7. That portion of the sand filter below the porous element shall be placed first, and methods such as tremie pipe shall be used to ensure that no sand adheres to the soil in the sides of an unlined exploratory hole. Where there is water in an exploratory hole the Contractor shall allow sufficient time for all the sand to settle. The final elevation of the top of this sand shall be recorded. The porous element shall be placed in the hole with the vertical axis of the porous element co-incident with the vertical axis of the exploratory hole. The remaining sand filter shall then be added as described above.

8. Further grout balls or compressed bentonite pellets shall be placed on top of this sand filter to form a plug not less than 0.5 m thick. The remainder of the exploratory hole shall be filled with grout to ground level according to the procedure described in Sub-clause 4 above.

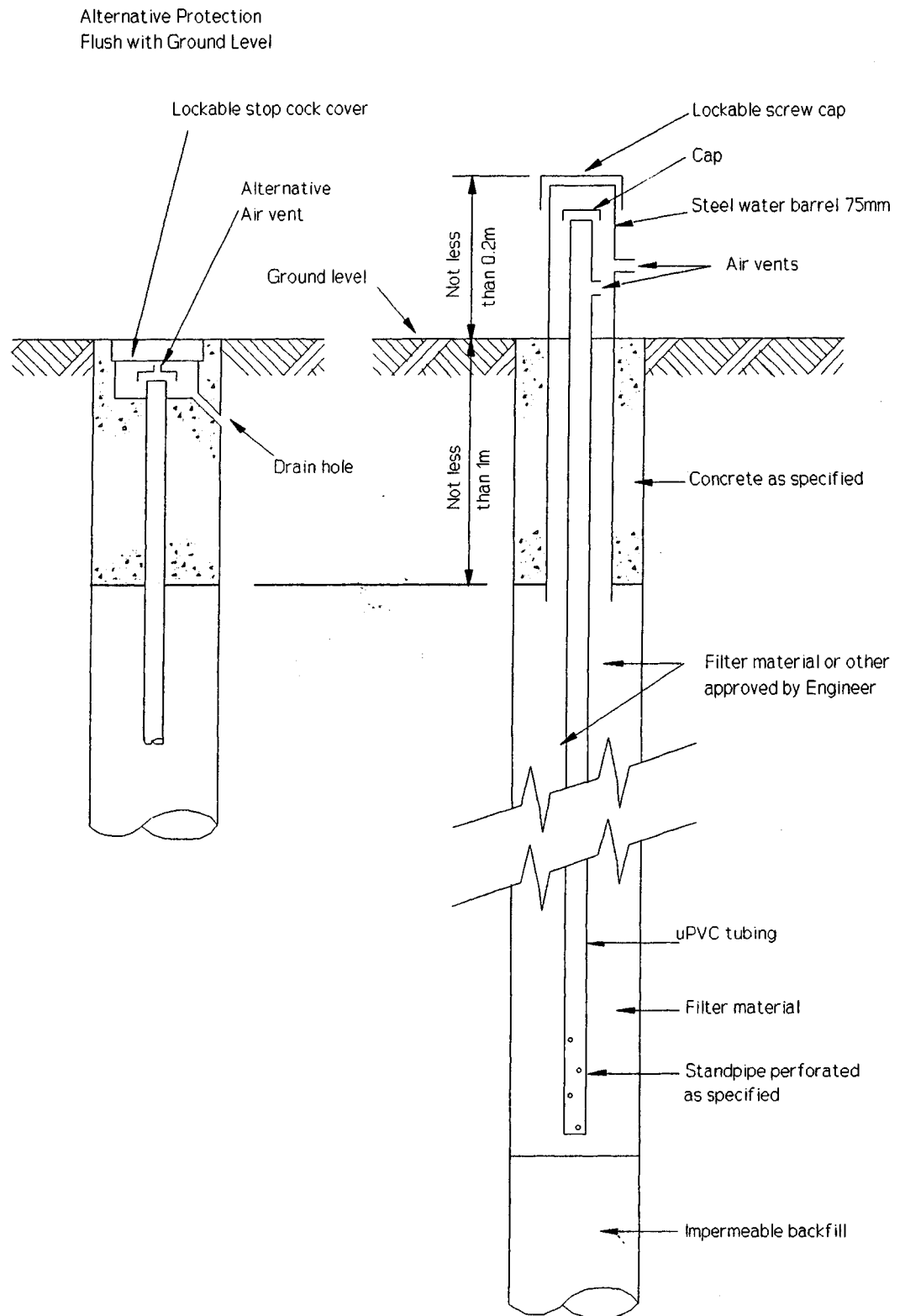
9. The top of the UPVC tubing shall be covered by a plastic cap or similar as approved by the Engineer. An air vent shall be provided as shown on Drawing 1.2.

10. Arrangements to prevent the ingress of surface water and to protect the top of the uPCV tubing shall use a steel water barrel of 75 mm diameter, a 150 mm stopcock cover or an alternative as agreed with the Engineer. The protective cover shall be set in concrete. Protective fencing where required shall be in accordance with Clause 9.5.

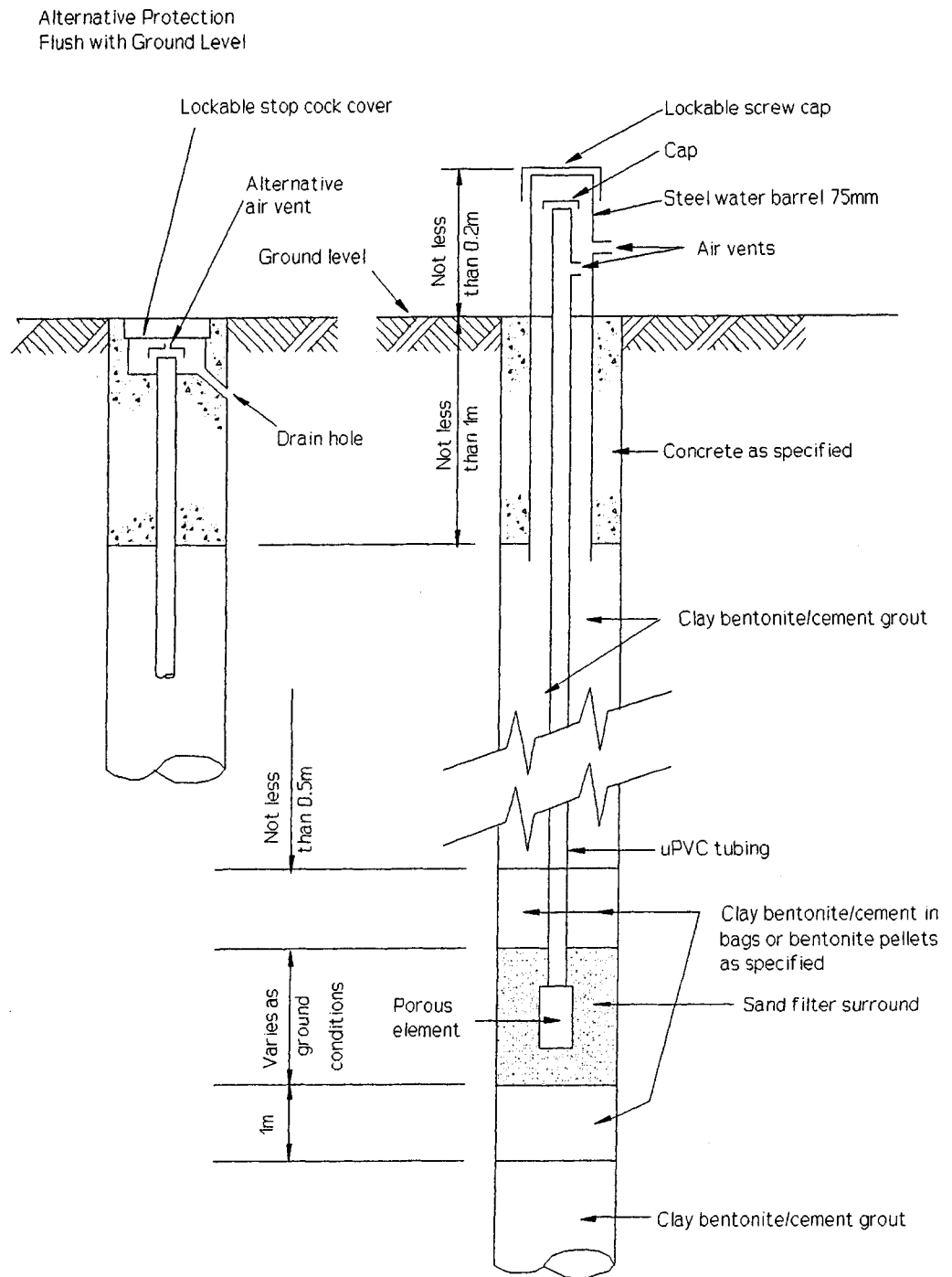
11. The groundwater level shall be recorded immediately before and after installation of the piezometer.

12. Before readings commence the piezometer shall be filled with water and its correct functioning demonstrated to the Engineer. Each piezometer shall be clearly and permanently labelled with a metal stamp or tag giving the exploratory hole number.

Drawing 1.1. Standpipe



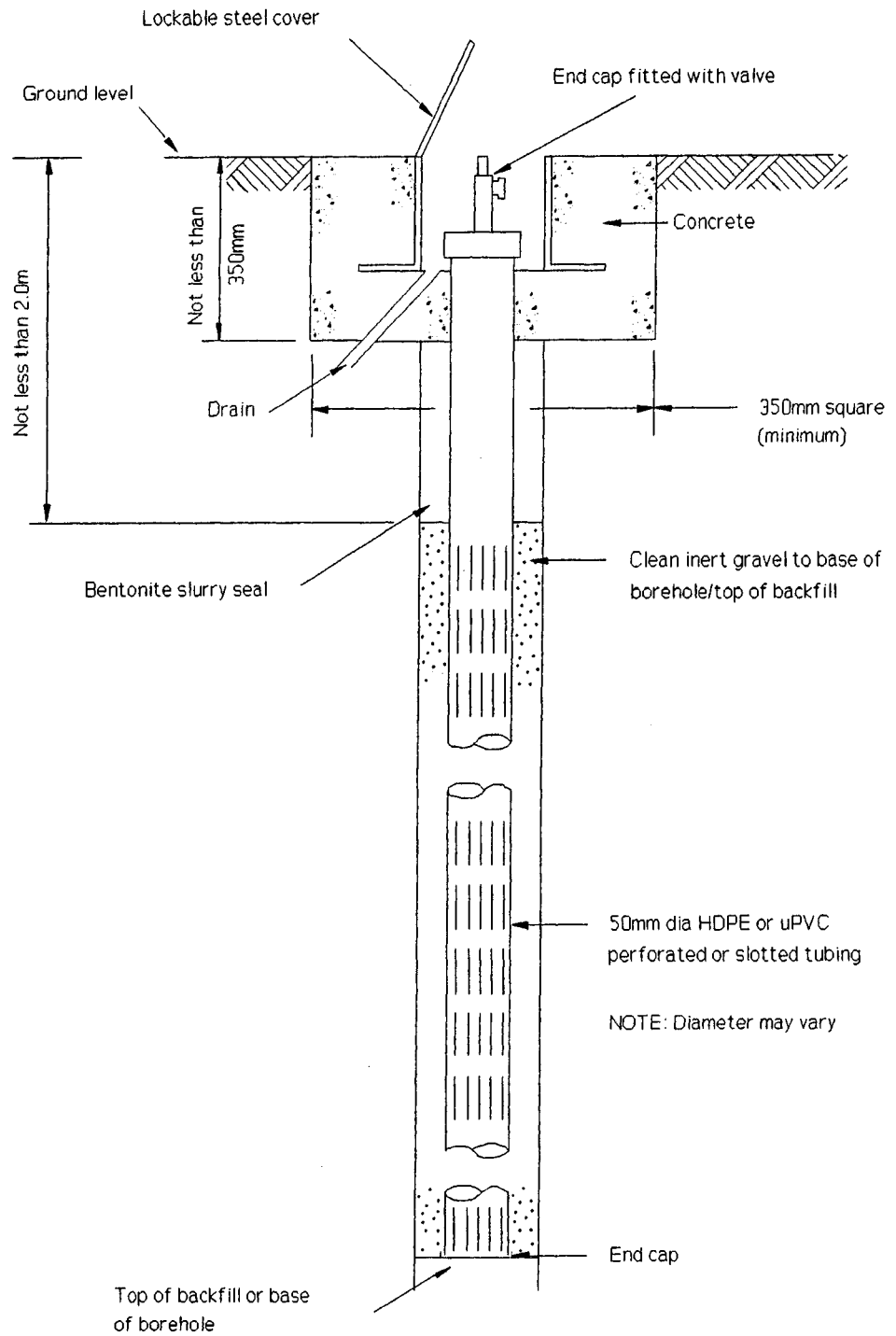
Drawing 1.2. Standpipe piezometer



Appendix II: Gas monitoring standpipe

- Gas monitoring standpipe AII**
1. The standpipe shall consist of unplasticised polyvinylchloride (uPVC) or high-density polyethylene (HDPE) tubing as specified, and shall be not less than 50 mm in diameter.
 2. The base of the tubing shall be plugged and the tubing perforated by holes not greater than 5 mm in diameter at intervals of approximately 75 mm or an equivalent area of slots with not greater than 5 mm width.
 3. The filter shall be clean single-sized gravel, or similar material, as approved by the Engineer, 10–20 mm in diameter.
 4. 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 with materials approved by the Engineer to the base of the filter.
 5. The tubing with centralising devices attached at intervals shall be lowered carefully down the exploratory hole to the level of the filter material, and the exploratory hole backfilled to within 2.0 m of ground level with filter gravel.
 6. The top of the tubing shall be covered by a screwed plastic cap or similar, as approved by the Engineer, and a gas valve shall be provided as indicated on Drawing 2.1.
 7. The upper 2 m of the tubing shall be unperforated and the borehole backfilled by a grout consisting of cement and bentonite in the proportions of 1 : 1 by weight. The grout shall be prepared by thorough mixing with approved equipment and with just sufficient water to form a pumpable mix. A similarly proportioned mixture of cement/bentonite shall then be prepared but having just sufficient water to form a cohesive paste. This mix shall be formed into balls placed in porous canvas bags or other suitable porous bags. These balls shall be placed in the exploratory hole and punned with a suitably shaped punner to form a homogeneous plug to the exploratory hole sensibly without voids between adjacent bags. The base of this plug shall be at the interface with the gravel filter. Compressed bentonite pellets may be used as an alternative to the grout balls and should be partially saturated before adding to the borehole, and further water should be added to the borehole to complete saturation.
 8. Arrangements to prevent the ingress of surface water and to protect the top of the tubing shall use a steel tube, sealed lockable stopcock cover, or other cover as agreed with the Engineer, to appropriate size to facilitate future measurements and sampling procedures, as instructed by the Engineer. The protective cover shall be set in concrete. Protective fencing, where required, shall be in accordance with Clause 9.5.

Drawing 2.1. Gas monitoring standpipe



Appendix III: Digital data

- General AIII.1** 1. Unless otherwise required in Schedule 1, data in digital form shall be provided in accordance with the Association of Geotechnical Specialists (AGS) publication 'Electronic transfer of geotechnical data from ground investigations'.
2. The data in digital form shall be in addition to paper records and the factual report. The reference copy of the data shall be the paper record and factual report as required by the Contract.

- Format AIII.2** 1. The data shall be provided in ASCII format, on 3+ inch double-sided high-density discs or other transmission media as agreed by the Engineer, and formatted to be compatible with MS-DOS Version 3.2 or higher. The files shall not be compressed.
2. The format of the digital data files shall comply with Appendix 1 of the AGS publication. Unless otherwise required in Schedule 1, Key, Common and Additional data fields shall be included from Key, Common and Additional data groups in accordance with Appendices 2 and 3 of the AGS publication to correspond with paper records required by the Contract.
3. Any new, amended or additional groups or fields shall only be created with the Engineer's approval.
4. Prior to the commencement of the investigation the Contractor shall submit to the Engineer a dummy set of data in the required format for the approval of the Engineer.

- Security AIII.3** 1. All disks, or other agreed transmission media, shall be securely labelled and clearly marked with

The title 'AGS Format ASCII Data'
The project identification (PROJ-ID)
The date of issue to the Engineer
The name of the Contractor
The name of the Engineer
The unique issue sequence number.

If more than one disc, or other agreed transmission medium, is required, then each shall be clearly labelled to indicate the order in which the Engineer should read the data. The split of the data into separate files shall be decided by the Contractor. The unique sequence number shall run sequentially from the start of the Contract. Where more than one disc is required for a particular issue of digital data, this fact shall be clearly identified on the labels in that issue.

2. The Contractor shall keep, until the completion of the maintenance period an identical copy of each disc issued and an index detailing:

The heading 'AGS Format ASCII Data'
The title 'Media Index Record'
The project identification (PROJ-ID)
The data of Issue to the Engineer

The name of the Contractor from whom the transmission medium was issued
The name of the Engineer to whom the transmission medium was issued
A general description of the data transferred
The unique issue sequence number.

For each data file, the index shall detail

The file name including the extension, '.AGS'
The date the file was created
The time the file was created
The file size in bytes
A general description of the data contained in each file.

The Contractor shall retain one copy of the index sheet and shall issue to the Engineer a copy of the completed index sheet with the disc(s), or other agreed transmission medium. The Contractor shall maintain the index with details, for each issue of data to the Engineer, or the unique sequence number of the disc.

Preliminary data AIII.4

1. When required in Schedule 1 the Contractor shall issue preliminary digital data to correspond with preliminary paper records.
2. In addition to the labelling given in AIII.3 the preliminary discs shall be labelled 'PRELIM'. All preliminary digital data shall be presented in the same form as the final digital data provided with the factual report.
3. Preliminary digital data shall be updated as necessary (as for paper records) in the light of laboratory testing and the further examination of samples and cores.

Digital data with factual report AIII.5

1. The digital data shall be presented with the draft factual report. The disc(s) or other agreed transmission medium containing data specified in the Contract to be in digital form shall be contained within the covers of the factual report in such a manner that they are secure within the documents but allow ready access.
2. The digital data provided with the factual report shall be complete and a total replacement of any previous preliminary data.
3. The factual report shall clearly indicate where data are included as a paper record but are not included in digital form.
4. In addition to the labelling given in AIII.3 the disc(s) submitted with the final factual report shall be labelled 'FINAL'.

Units of measurement AIII.6

The units of measurement shall be those given in Appendices 2 and 3 of the AGS publication unless other units of measurement for digital data are required by the Contract.

Appendix IV: References

- UK Standards (published by British Standards Institution)**
- BS 812 Testing aggregates (Part 3: 1975, Part 4: 1976 and Parts 110, 111, 112, 113 121 and 124: 1989)
 - BS 1377: 1990 Methods of test for soils for civil engineering purposes (Parts 1–9)
 - BS 1610: 1985, 1990 Materials testing machines and force verification equipment
 - BS 1881 Analysis of hardened concrete (Part 6: 1971)
 - BS 2690 Methods of testing water used in industry
 - BS 3506: 1969 Specifications for unplasticised PVC pipe for industrial uses
 - BS 4019 Rotary core drilling equipment (Part 1: 1974)
 - BS 5589: 1989 Code of practice for preservation of timber
 - BS 5930: 1981 Code of practice for site investigations. The proposed revision of this Standard is being prepared by BSI subcommittee B/526/1.
 - BS 5750 Quality systems
 - BS 7022: 1989 Geophysical logging of boreholes for hydrogeological purposes
- British Standard Code of Practice (Published by BSI)**
- BS 1013: 1965 Earthworks
 - DD 175 1988 Code of practice for the identification of potentially contaminated land and its investigation (draft).
- Transport Research Laboratory publications (Published by TRL, previously TRRL)**
- TRRL Laboratory Report LR 515: Determination of residual shear strength of clay by a modified shear box method (1972)
 - TRRL Supplementary Report SR 829: Specification for the TRRL frost heave test.
- HMSO publications**
- Classification, packaging and labelling of dangerous substances regulations. HMSO, London, 1984.
 - Manual of contract documents for highway works. Volume 1: Specification for highway works, (December 1991): HMSO (MCHW 1)
 - Protection of workers and the general public during the development of contaminated land, HMSO 1991
 - Traffic signs manual, Chapter 8, HMSO 1991
- Note: Latest editions of British Standards shall apply when available unless indicated in Schedule 1.
- Miscellaneous**
- Association of Geotechnical Specialists. *Quality management in geotechnical engineering: a practical approach*. AGS, 1991.

Association of Geotechnical Specialists. *The Electronic Transfer of Geotechnical Data from Ground Investigations*, 1992.

ASTM Special Technical Publications No. 402: 1966 (see Clark and also Neff below)

Bishop A. W. and Henkel D. J. *The measurement of soil properties in the triaxial test*. Second edition, 1962, Edward Arnold.

Bromhead E. N. A simple ring shear apparatus. *Ground Engineering*, Volume 12, No.5, 1979.

Brown E. T. (Editor). *Rock characterisation testing and monitoring*. International Society for Rock Mechanics Suggested Methods. 1981, Pergamon Press.

CIRIA (Weltman A. J. and Head J. M.) Site Investigation Manual, Special publication 25/PSA Civil Engineering Technical Guide 35, 1983.

Clarke B. G. and Smith A. A model specification for radial displacement measuring pressuremeters. *Ground Engineering*, Volume 25, No. 2, March 1992.

Clark G. B. Deformation moduli of rocks. ASTM SP No.402: 1966

Darracott B. W. and McCann D. M. *Planning engineering geophysical surveys*. Geological Society, Ed. B. Hawkins, Engineering Geology Special Publication No. 2.

Deere D. U. et al. Design of surface and near-surface construction in rock. *Proc. 8th US symp. on rock mechanics*. AIME, New York, 1967.

Engineering Group of the Geological Society. The logging of rock cores for engineering purposes. *Quarterly Journal of Engineering Geology*, 1970, 1-25.

Geological Society Engineering Group Working Party Report on Engineering Geophysics. *Quarterly Journal of Engineering Geology*, 21, pp. 207 - 271, 1988.

Head K. H. Manual of soil laboratory testing. Pentech Press, Volume 1, 2nd edition, 1992; Volume 2, 1982; Volume 3, 1986.

Hoek E. and Londe P. The design of surface workings in rock. General Report. *Proceedings of 3rd Congress International Society for Rock Mechanics*. 1974.1 (A).

IRSM Commission on Testing Methods. Suggested method for determining Point Load Strength (revised version). *Int. J Rock Mech. Min. Sci. and Geomech. Abst.*, 22, 51-60 (1985).

Mair R. J. and Wood D. M. *Pressuremeter testing*. CIRIA (1987).

Neff T. L. *Equipment for measuring pore pressure in rock specimens under triaxial load*. ASTM SP No.402 1966.

Site Investigation Steering Group. *Guidelines for the safe investigation by drilling of landfills and contaminated land*. Thomas Telford, London, 1993.

Specification for the excavation and reinstatement of openings in highways, HAUC SWP163, September 1991.

Contaminated ground

C1 Arsenic in potable water by atomic absorption spectrophotometry (semi-automatic method). Methods for the examination of waters and associated materials. HMSO, 1982.

C2 Cadmium, chromium, copper, lead, nickel and zinc in sewage sludge by nitric acid/atomic absorption spectrophotometry. Methods for the examination of waters and associated materials. HMSO, 1981.

C3 Mercury in waters, effluents and sediments. Additional methods for the examination of waters and associated materials. HMSO, 1987.

C4 Selenium and arsenic in sludges, soils and related materials, 1985. A note on the use of hydride generator. Methods for the examination of waters and associated materials. HMSO, 1987.

C5 The analysis of agricultural materials. A manual of analytical methods. Reference Book 427. MAFF, HMSO, 1986.

C6 Standard Methods for the Examination of Water and Waste Water. 17th Edition, 1989, Section 4500. American Public Health Association, American Water Works Association, Water Pollution Control Federation.

C7 Phenols in waters and effluents by gas-liquid chromatography, 4-aminoantipyrine or 3 methyl-2-benzothiazolone Hydrazone. Methods for the examination of waters and associated materials. HMSO, 1981.

C8 Sulphide in waters and effluents, tentative methods. Methods for the examination of waters and associated materials. HMSO, 1983.

C9 Methods of test for soils for civil engineering purposes. BS 1377 Part 3:1990

C10 Wilson D. C. and Stevens C. Problems arising from the redevelopment of gasworks and similar sites. AERE Harwell Report 1981, Department of the Environment.

C11 Characterization of spilled oil samples — purpose sampling, analysis and interpretation. Institute of Petroleum Marine Environment Committee, John Wiley & Sons, 1986, 30–37.

C12 Problems arising from the redevelopment of gasworks and similar site. Annex c. Department of the Environment, HMSO, 1987.

C13 Standard methods for the examination of water and waste water. 17th Edition, Section 3500, HMSO, 1989.

C14 Method based on characterization of spilled oil samples— purpose sampling, analysis and interpretation. Institute of Petroleum Marine Environment Committee, John Wiley & Sons, 1986, 30–37.

C15 Standard methods for the examination of water and waste water. 17th Edition, Section 5520, HMSO, 1989.

C16 Ammonia in waters. Methods for the examination of waters and associated materials. HMSO, 1981.

C17 Oxidised nitrogen in waters. Methods for the examination of waters and associated materials. HMSO, 1981.

C18 Chemical oxygen demand (dichromate value) of polluted and waste water (second editions). Methods for the examination of waters and associated materials. HMSO, 1986.

C19 Biochemical oxygen demand. Methods for the examination of water and associated materials. HMSO, 1981.

C20 Standard methods for the examination of water and wastewater. 17th Edition, Section 5310, HMSO, 1989.

C21 Determination of volatile fatty acids in sewage sludge. Methods for the examination of water and associated materials. HMSO, 1979.

C22 Iron and manganese in potable waters by atomic absorption spectrophotometry. Methods for the examination of water and associated materials. HMSO, 1981.

C23 Cadmium in potable waters by atomic absorption spectrophotometry. Methods for the examination of water and associated materials. HMSO, 1976.

C24 Chromium in raw and potable waters and sewage effluents. Methods for the examination of water and associated materials. HMSO, 1980.

C25 Lead in potable waters by atomic absorption spectrophotometry. Methods for the examination of water and associated materials. HMSO, 1976.

C26 Boron in waters, effluents, sewage and some solids. Methods for the examination of water and associated materials. HMSO, 1980.

C27 Copper in potable waters by atomic absorption spectrophotometry. Methods for the examination of water and associated materials. HMSO, 1981.

C28 Nickel in potable waters. Methods for the examination of water and associated materials. HMSO, 1981.

C29 Zinc in potable waters by atomic absorption spectrophotometry. Methods for the examination of water and associated materials. HMSO, 1980.

C30 The analysis of sludge digester gas. Methods for the examination of waters and associated materials. HMSO, 1979.

C31 Gas chromatographic and associated methods for the characterisation of oils, fats, waxes and tars. Methods for the examination of waters and associated materials. HMSO, 1986.

SCHEDULES

Specification The specification shall be the *Specification for ground investigation* published by Thomas Telford Services Ltd in 1993, with information, amendments and additions as described in the Schedules.

- Schedule 1. Information
- Schedule 2. Exploratory holes
- Schedule 3. Engineer's facilities
- Schedule 4. Specification amendments
- Schedule 5. Specification additions

Schedule 1: Information

Name of Contract S1.1 (to be inserted)

Description of site S1.2 (to be inserted)

Main works proposed and purpose of this contract S1.3 (to be inserted)

Scope of investigation S1.4 (to be inserted)

Geology and ground conditions S1.5 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.
(to be inserted)

Schedule of drawing (s) and documents S1.6 (to be inserted)

Particular Contract restrictions S1.7 (to be inserted if any)

(For example: order of work, sections to be completed at a particular time or within a period, reference to particularly difficult access, need for Engineer's approval before backfilling each hole).

Particular general requirements (Section 3) S1.8 (to be inserted if required)

(For example: restricted working hours (Clause 3.8); reinstatement requirements (Clause 3.9); full-time professional attendance required (Clause 3.12); accuracy of setting out (Clause 3.14); requirements for 'special' traffic management (Clause 3.22); if quality management is required (Clause 3.23); if certificated drillers are not required (Clause 3.24).)

Particular borehole requirements (Section 4) S1.9 (to be inserted if required)
(For example: restriction on permitted methods (Clause 4.1); particular use of flight augers (Clauses 4.4.2 and 4.4.3); particular use of rotary drilling (Clause 4.5); special backfilling requirement (Clause 4.6).)

Particular rotary drilling requirements (Section 5) S1.10 (to be inserted if required)
(For example: particular drilling techniques (Clause 5.3.1.); rotary drilling core sizes (Clause 5.3.2); rotary drilling without cores hole size (Clause 5.4); address for delivery of selected cores (Clause 5.3.8); special backfilling requirements (Clause 5.5); particular photographic requirements (Clause 5.6).)

Particular pit and trench requirements (Section 6) S1.11 (to be inserted if required)
(For example: any restrictions on plant (Clauses 6.2 and 6.3); pit and trench alternative dimensions (Clause 6.4); particular photographic requirements (Clauses 6.5 and 6.9).)

Particular sampling requirements (Section 7) S1.12

(to be inserted if required)

(For example: open tube and piston sample diameter if different from Clause 7.3; frequency of sampling (and in situ testing) if different from Clause 7.6; special sampling requirements (Clause 7.7); address for delivery of selected samples (Clause 7.12); requirement for retention and disposal of samples (Clause 7.13).)

Particular in situ testing requirements (Section 8) S1.13

(to be inserted if required)

(For example: capacity of probing equipment (Clause 8.3.1); geophysical investigation requirements (Clause 8.4); special in situ testing requirements (Clause 8.5); requirements for self-boring pressuremeter (Clause 8.7).)

Particular instrumentation and monitoring requirements (Section 9) S1.14

(to be inserted if required)

(For example: installation of piezometers (Clause 9.2.3); type of covers (Clause 9.4); fencing requirements (Clause 9.5); frequency of readings (Clause 9.6); if piezometers and standpipes are to be removed (Clause 9.7); and other instrumentation and monitoring (Clause 9.8).)

Particular daily report requirements (Section 10) S1.15 (to be inserted if required)
(For example: report requirements for special in situ testing (Clause 10.6).)

Particular laboratory testing requirements S1.16 (to be inserted if required)
(For example: if contractor has to schedule tests (Clause 11.1); special laboratory testing requirements (Clause 11.7).)

Particular reporting requirements (Section 12) S1.17 (to be inserted if required)
(For example: requirements of assessment of strata from probing (Clause 12.2.5); if digital data are not required (Clause 12.4); variations in extent of digital data required (AIII.2); requirements for preliminary digital data (AIII.4); requirements for interpretative report (Clause 12.5); additional information required in factual report (Clause 12.6); analysis and recommendations required in interpretative report (Clause 12.7); calculations requirements (Clause 12.7).)

Schedule 2: Exploratory holes

Hole number	Type	Scheduled depth	National grid Reference (provisional)	Approx ground level	Remarks

Schedule 3: Engineer's facilities

Accommodation S3.1 (to be inserted)

Furnishings S3.2 (to be inserted)

Services S3.3 (to be inserted)

Equipment S3.4 (to be inserted)

Transport S3.5 (to be inserted)

Protective clothing S3.6 (to be inserted)
for Engineer

Schedule 4: Specification amendments

The following clauses are amended

Schedule 5: Specification additions

The following clauses are added to the specification

BILL OF QUANTITIES FOR GROUND INVESTIGATION

Preamble

1. In this Bill of Quantities the sub-headings and item descriptions identify the work covered by the respective items. The exact nature and extent of the work to be performed shall be ascertained by reference to the Conditions of Contract, the Specification and the Schedules and Appendices to the Specification, as appropriate. The rates and prices entered in the Bill of Quantities shall be deemed to be the full inclusive value of the work covered by the several items, including the following unless stated otherwise.

- (a) Supervision, labour and all costs in connection therewith.
- (b) The supply of materials, goods, storage, facilities and services, and all costs in connection therewith, including wastage and delivery to site.
- (c) Plant and all costs in connection therewith.
- (d) Fixing, erecting and installing or placing of materials and goods in position.
- (e) All temporary works.
- (f) All general obligations, requirements, liabilities and risks involved in the execution of the investigation as set forth or implied in the documents on which the tender is based.
- (g) Establishment charges, overheads and profit.
- (h) Bringing plant and sampling and in situ testing equipment to the site of each exploratory hole; erecting, dismantling and removing on completion.
- (i) Removal of all equipment and services from site on completion.

2. All items not deleted from section A of the Bill of Quantities (General items and provisional sums) shall be priced and all items in subsequent sections against which quantities are entered shall be priced.

3. Where rates are not priced they shall have £0.00 placed against them.

4. Professional attendance associated with the description of cores and samples and other duties as required by the Contract shall be included in the appropriate rates. When full time professional attendance on site is required in accordance with Clause 3.12 this shall be paid for under item A3 of the Bill of Quantities.

5. The item for photograph shall allow for the standing time of associated plant, and supply of negative, enprints and bound volume.

6. Rates for moving plant and equipment to the site of each exploratory hole shall allow for the formation of access routes, and making—good access routes and working areas on completion as required by the Contract.

7. The rates for moving rotary drilling plant to the site of each hole shall include for setting up over a previously formed borehole.

8. Payment for forming exploratory holes shall be based on

- (a) full thickness of strata investigated and described in accordance with the Specification
- (b) depths measured from ground level
- (c) depth measured from original ground level where an inspection pit has been excavated

- (d) that part of a drillhole below the bottom of a borehole where a drill hole has been ordered to continue from the bottom of a borehole
 - (e) core recovery of at least 90% in any core run, unless the Engineer is satisfied it cannot be achieved
 - (f) volume calculated as measured length \times measured depth \times specified width for trial and observation trenches.
9. Rates for forming exploratory holes shall allow for
- (a) casing installation where necessary, and removal
 - (b) dealing with surface water
 - (c) backfilling with arisings
 - (d) supply of daily report and preliminary log
 - (e) additional site supervision of non-accredited drillers
 - (f) disposal off site of excavated material not required for reuse.
10. Standing time shall be measured as the duration of time for which plant, equipment and personnel are standing on the instruction of the Engineer or in accordance with the Contract. Standing time shall be paid for interruption of the formation of exploratory holes to record groundwater entry in accordance with Clause 9.1.1. The rates for standing time shall allow for
- (a) plant equipment and personnel
 - (b) consequential costs
 - (c) changes in the programme of working
 - (d) recording information and preparing daily report.
11. The rates for hourly provision of pitting and trenching crews and equipment at locations as directed by the Engineer shall allow for compliance with the requirements of the Contract, including preparation of records.
12. The rates for sampling and in situ testing shall allow for the standing time of associated plant. Where in situ testing is paid for on an hourly basis, the time measured shall be the actual time taken to carry out the test in accordance with the Engineer's instruction and/or the Specification but excluding the time taken to erect and dismantle test equipment where this is itemised separately.
13. The rates for installation of instruments shall allow for
- (a) clearing and keeping hole free of unwanted materials
 - (b) all costs associated with equipment, installation, specified seals, surround and backfill materials excluding backfill below the instrument
 - (c) proving correct functioning
 - (d) delays due to installations.
14. The rates for testing shall include for
- (a) the supply of a copy of the preliminary test results to the Engineer
 - (b) the cost of moisture content or density determinations where they form part of the test.
15. The rates for recording of water level or gas measurement shall allow for notices of re-entry to the Engineer, owners or occupiers affected by the location or access route.
16. Appendix A to the Bill of Quantities (Rates for geotechnical and other personnel) shall be priced. The rates given will be used by the Engineer to make an initial estimate of costs where applicable of employing the Contractor's staff in accordance with Clause 3.13 of the Specification.

17. Items for the supply of the master and copies of the interpretative report shall exclude costs covered by Appendix A to the Bill of Quantities.

Units of measurement

18. The following abbreviations shall be used for the units of measurements

Millimetres: mm
Metre: m
Kilometre: km
Square millimetres: mm²
Square metre: m²
Cubic metre: m³
Square metre per day: m²/day
Kilogramme: kg
Tonne: t
Sum: sum
Number: nr
Hour: h
Week: wk
Vehicle week: v.wk
Item: item
Day: day
Specimen day: sp.day

Preamble amendments and additions

The following clauses are amended or added to the Preamble

**Bill of Quantities:
works items**

The following pages constitute the Bill of Quantities.

Number	Item description	Unit	Quantity	Rate	Amount
					£
A	General items and provisional sums				
A1	Offices and stores for the Contractor	sum			
A2	Establish on site all plant, equipment and services	sum			
A4	Establish the location and elevation of the ground at each exploratory hole	sum			
A5	Facilities for the Engineer	sum			
A6	Vehicle (s) for the Engineer	v. wk			
A7	Fuel for vehicle for the Engineer	provisional sum			
A8	Engineer's telephone and facsimile charges	provisional sum			
A9	Deliver selected cores and samples to the specified address	provisional sum			
A10	Special testing and sampling required by Engineer	provisional sum			
A11	Traffic safety and management	sum			
A12	One master copy of the Factual report	sum			
A13	Additional copies of the Factual report	nr			
A14	One master copy of the Interpretative report	sum			
A15	Additional copies of Interpretative report	nr			
A16	Digital data	sum			
A17	Photograph	nr			
Total section A carried to summary					

Number	Item description	Unit	Quantity	Rate	Amount
					£
B	Boreholes				
B1	Move boring plant and equipment to the site of each exploratory hole and set up	nr			
B2	Extra over Item B1 for setting up on a slope of gradient greater than 20%	nr			
B3	Break out surface obstruction where present at exploratory borehole	h			
B4	Advance borehole between existing ground level and 10 m depth	m			
B5	As Item B4 but between 10 m and 20 m depth	m			
B6	As Item B4 but between 20 m and 30 m depth	m			
B7	As Item B4 but between 30 m and 40 m depth	m			
B8	As Item B4 but between 40 m and 50 m depth	m			
B9	Advance borehole through hard stratum or obstruction	h			
B10	Backfill borehole with cement/bentonite grout	m			
B11	Standing time for borehole plant, equipment and crew	h			
B12	Bring hand auger equipment to the position of each exploratory hole	nr			
B13	Bore with hand auger from existing ground level to 2 m depth	m			
B14	As Item B13 but between 2 m and 4 m depth	m			
B15	Standing time for hand auger equipment and crew	h			
Total section B carried to summary					

Number	Item description	Unit	Quantity	Rate	Amount
					£
C	Rotary drilling				
C1	Move rotary drilling plant and equipment to the site of each exploratory drillhole and set up	nr			
C2	Extra over Item C1 for setting up on a slope of gradient greater than 20%	nr			
C3	Extra over Item C1 for setting up drilling plant for inclined drillhole	nr			
C4	Break out surface obstructions where present at exploratory drillhole	h			
	<u>Drilling without cores</u>				
C5	Rotary drill in materials other than hard strata at the specified diameter, from which cores are not required, between existing ground level and 10 m depth	m			
C6	As Item C5 but between 10 m and 20 m depth	m			
C7	As Item C5 but between 20 m and 30 m depth	m			
C8	As Item C5 but between 30 m and 40 m depth	m			
C9	As Item C5 but between 40 m and 50 m depth	m			
C10	Rotary drill in hard strata at the specified diameter, from which cores are not required, between existing ground level and 10 m depth	m			
C11	As Item C10 but between 10 m and 20 m depth	m			
C12	As Item C10 but between 20 m and 30 m depth	m			
C13	As Item C10 but between 30 m and 40 m depth	m			
C14	As Item C10 but between 40 m and 50 m depth	m			
	<u>Drilling to obtain cores</u>				
C15	Rotary drill in materials other than hard strata to obtain cores of the specified diameter between existing ground level and 10 m depth	m			
C16	As Item C15 but between 10 m and 20 m depth	m			
C17	As Item C15 but between 20 m and 30 m depth	m			
C18	As Item C15 but between 30 m and 40 m depth	m			
C19	As Item C15 but between 40 m and 50 m depth	m			
C20	Extra over Items C15 to C19 for use of semi-rigid core liner	m			
C21	Extra over Items C15 to C19 for coring inclined drillhole	m			
C22	Rotary drill in hard strata to obtain cores of the specified diameter between existing ground level and 10 m depth	m			
C23	As Item C21 but between 10 m and 20 m depth	m			
C24	As Item C21 but between 20 m and 30 m depth	m			
C25	As Item C21 but between 30 m and 40 m depth	m			
C26	As Item C21 but between 40 m and 50 m depth	m			
C27	Extra over items C22 to C26 for use of semi-rigid line	m			

Page total, section C, carried forward

Number	Item description	Unit	Quantity	Rate	Amount
					£
D	Pits and trenches				
	<u>Inspection pits</u>				
D1	Excavate inspection pit by hand to 1.2 m depth	nr			
D2	Extra over Item D1 for breaking out surface obstructions	h			
	<u>Trial pits and trenches</u>				
D3	Move equipment to the site of each trial pit or trench	nr			
D4	Excavate trial pit between existing ground level and 3.0 m depth	m			
D5	As Item D4 but between 3.0 m and 4.5 m depth	m			
D6	As Item D4 but between 4.5 m and 6 m depth	m			
D7	Excavate trial trench between existing ground level and 3.0m depth	m ³			
D8	As Item D7 between 3.0 m and 4.5 m depth	m ³			
D9	As Item D7 between 4.5 m and 6 m depth	m ³			
D10	Extra over Items D4, D5, D6, D7, D8 and D9 for breaking out hard strata or surface obstructions	h			
D11	Standing time for excavation plant, equipment and crew for machine dug trial pit or trench	h			
	<u>Observation pits and trenches</u>				
D12	Move equipment to the site of each observation pit or trench	nr			
D13	Excavate observation pit between existing ground level and 3.0 m depth	m			
D14	As Item D13 but between 3.0 m and 4.5 m depth	m			
D15	As Item D13 but between 4.5 m and 6 m depth	m			
D16	Extra over Items D13, D14 and D15 for hand excavation	m			
D17	Excavate observation trench between existing ground level and 3.0 m depth	m ³			
D18	As Item D17 but between 3.0 m and 4.5 m depth	m ³			
D19	As Item D17 but between 4.5 m and 6 m depth	m ³			
D20	Extra over Items D17, D18 and D19 for hand excavations	m ³			
D21	Extra over Items D13, D14, D15, D17 and D18 and D19 for breaking out hard strata or obstructions	h			
D22	Extra over Items D13, D14, D15, D17 and D18 and D19 for breaking out hard strata or obstructions by hand	h			
D23	Standing time for excavation plant, equipment and crew for machine dug observation pit or trench	h			
D24	Standing time for excavation plant, equipment and crew for hand dug observation pit or trench	h			

Page total, section D, carried forward

Number	Item description	Unit	Quantity	Rate	Amount
					£
D	Pits and trenches (continued)				
	<u>Hourly provision of pitting crew and equipment</u>				
D25	Provision of excavation plant equipment and crew for machine dug trial pits or trenches as directed by the Engineer, maximum depth 4.5 m	h			
D26	As above, maximum depth 6.0 m	h			
D27	Provision of excavation plant, equipment and crew for machine-dug observation pit or trench as directed by the Engineer. Maximum depth 4.5 m	h			
D28	As above, maximum depth 6.0 m	h			
D29	Extra over Items D25 to D28 for breaking out hard strata or obstructions	h			
	<u>General</u>				
D30	Bring pump to the position of each exploratory pit or trench	nr			
D31	Pump water from pit or trench	h			
D32	Leave open observation pit or trench	m ² /day			
D33	Leave open trial pit or trench	m ² /day			
			Page total		
			Brough forward page		
Total section D carried to summary					

Number	Item description	Unit	Quantity	Rate	Amount
					£
E	Sampling				
E1	Small disturbed sample	nr			
E2	Bulk disturbed sample	nr			
E3	Large bulk disturbed sample	nr			
E4	Open tube sample	nr			
E5	Piston sample	nr			
E6	Groundwater sample	nr			
E7	Gas sample	nr			
E8	Core sub sample	nr			
Total section E carried to summary					

Number	Item description	Unit	Quantity	Rate	Amount
					£
F	In situ testing				
F1	Standard penetration test in borehole	nr			
F2	Standard penetration test in rotary drillhole	nr			
F3	In situ density testing				
F3.1	Small pouring cylinder method	nr			
F3.2	Large pouring cylinder method	nr			
F3.3	Water replacement method	nr			
F3.4	Core cutter method	nr			
F3.5	Nuclear method	nr			
F4	California Bearing Ratio test	nr			
F5	Vane shear strength test in borehole	nr			
F6	Penetration vane test	nr			
F7	Hand penetrometer test	nr			
F8	Hand vane test	nr			
	<u>Permeability testing</u>				
F9	Set up and dismantle variable head permeability test in borehole	nr			
F10	Set up and dismantle constant head permeability test in borehole	nr			
F11	Carry out permeability test in borehole	h			
F12	Set up and dismantle variable head permeability test in rotary drillhole	nr			
F13	Set up and dismantle constant head permeability test in rotary drillhole	nr			
F14	Carry out permeability test in rotary drillhole	h			
F15	Set up and dismantle packer permeability test	nr			
F16	Carry out packer permeability test	h			
	<u>Probing</u>				
F17	Bring static cone penetration test equipment to the site of each test location	nr			
F18	Carry out static cone penetration test measuring both cone and sleeve resistance from existing ground level to 10 m depth	m			
F19	As Item F18 but between 10 m and 20 m depth	m			
F20	As Item F18 but between 20 m and 30 m depth	m			
F21	As Item F18 but between 30 m and 40 m depth	m			
F22	Extra over Items F18 to F21 for the use of Piezo Cone	m			
F23	Standing time for static cone penetration test equipment and crew	h			
F24	Bring dynamic probing equipment (DPH or DPSH) to the site of each probehole	nr			
Page total, section F, carried forward					

Number	Item description	Unit	Quantity	Rate	Amount
					£
F	In situ testing (continued)				
F25	Carry out probing between existing ground level and 10 m depth	m			
F26	As Item F25 but between 10 m and 20 m depth	m			
F27	Carry out sampling using dynamic probing apparatus between existing ground level and 5 m depth	m			
F28	As Item F27 but between 5 m and 10 m depth	m			
F29	Standing time for dynamic probing test equipment and crew	h			
F30	Bring hand-operated dynamic probing equipment (DPM) to the site of each probehole	nr			
F31	Carry out hand probing between existing ground level and 10 m depth	m			
	<u>Self-boring pressuremeter</u>				
F32	Move self-boring pressuremeter and exploratory equipment to site of each exploratory hole	nr			
F33	Advance exploratory hole to pressuremeter test location between ground level and not exceeding 10 m	m			
F34	Advance exploratory hole to pressuremeter test location between 10 m and not exceeding 20 m	m			
F35	Advance exploratory hole to pressuremeter test location between 20 m and not exceeding 30 m depth	m			
F36	Advance exploratory hole through hard stratum or obstruction	h			
F37	Self-bore to form test pocket between ground level and not exceeding 10 m	m			
F38	Self-bore to form test pocket between 10 m and not exceeding 20 m	m			
F39	Self-bore to form test pocket between 20 m and not exceeding 30 m	m			
F40	Carry out pressuremeter test, provision of data and report, test duration not exceeding 1.5 hours	nr			
F41	Extra over Item F40 for test duration in excess of 1.5 hours	h			
F42	Backfill exploratory hole for pressuremeter with cement/bentonite grout	m			
F43	Standing time for self-boring pressuremeter and exploratory equipment	h			
	<u>Other tests</u>				
F44	Apparent resistivity of soil	nr			
F45	Redox potential	nr			
				Page total	
				Brought forward page	
Total section F carried to summary					

Number	Item description	Unit	Quantity	Rate	Amount
					£
G	Instrumentation and monitoring				
	<u>Standpipes and piezometers</u>				
G1	Backfill exploratory hole with cement/bentonite grout below standpipe or standpipe piezometer	m			
G2	Standpipe	m			
G3	Standpipe piezometer	m			
G4	Gas monitoring standpipe	m			
G5	Protective cover (flush)	nr			
G6	Protective cover (raised)	nr			
G7	Timber fence	nr			
G8	Reading of water level in standpipe, or standpipe piezometer during fieldwork period	nr			
G9	Gas measurement in gas monitoring standpipe during fieldwork period	nr			
Total section G carried to summary					

Number	Item description	Unit	Quantity	Rate	Amount
					£
H	Laboratory testing				
H1	<u>Classification</u>				
H1.1	Moisture content	nr			
H1.2	Liquid limit, plastic limit and plasticity index	nr			
H1.3	Volumetric shrinkage	nr			
H1.4	Linear shrinkage	nr			
H1.5	Density by linear measurement	nr			
H1.6	Density by immersion in water or water displacement	nr			
H1.7	Dry density and saturation moisture content for chalk	nr			
H1.8	Particle density by gas jar or pycnometer	nr			
H1.9	Particle size distribution by wet sieving	nr			
H1.10	Particle size distribution by dry sieving	nr			
H1.11	Sedimentation by pipette	nr			
H1.12	Sedimentation by hydrometer	nr			
H2	<u>Chemical and electrochemical</u>				
H2.1	Organic matter content	nr			
H2.2	Mass loss on ignition	nr			
H2.3	Sulphate content of acid extract from soil	nr			
H2.4	Sulphate content of water extract from soil	nr			
H2.5	Sulphate content of groundwater	nr			
H2.6	Carbonate content by rapid titration	nr			
H2.7	Carbonate content by gravimetric method	nr			
H2.8	Water soluble chloride content	nr			
H2.9	Acid soluble chloride content	nr			
H2.10	Sulphide content	nr			
H2.11	Total dissolved solids	nr			
H2.12	pH value	nr			
H2.13	Resistivity	nr			
H2.14	Redox potential	nr			
H3	<u>Compaction related</u>				
H3.1	Dry density/moisture content relationship using 2.5 kg rammer	nr			
H3.2	Dry density/moisture content relationship using 4.5 kg rammer	nr			
H3.3	Dry density/moisture content relationship using vibrating rammer	nr			
H3.4	Extra over Items H3.1, H3.2 and H3.3 for use of CBR mould	nr			
H3.5	Maximum and minimum dry density for granular soils	nr			

Page total, section H, carried forward

Number	Item description	Unit	Quantity	Rate	Amount
					£
H	Laboratory testing (continued)				
H3.6	Moisture Condition Value at natural moisture content	nr			
H3.7	Moisture Condition Value/moisture content relationship	nr			
H3.8	Chalk crushing value	nr			
H3.9	California Bearing Ratio on recompacted disturbed sample	nr			
H3.10	Extra over Item H3.9 for soaking	day			
H4	<u>Compressibility, permeability, durability</u>	nr			
H4.1	One-dimensional consolidation properties, test period 5 days	nr			
H4.2	Extra over Item H4.1 for test period in excess of 5 days	day			
H4.3	Measurements of swelling pressure, test period 2 days	nr			
H4.4	Measurement of swelling, test period 2 days	nr			
H4.5	Measurement of settlement on saturation, test period 1 day	nr			
H4.6	Extra over Items H4.3 to H4.5 for test period in excess of 2 or 1 day (s)	day			
H4.7	Permeability by constant head method	nr			
H4.8	Dispersibility by pinhole method	nr			
H4.9	Dispersibility by crumb method	nr			
H4.10	Dispersibility by dispersion method	nr			
H4.11	Frost heave of soil	nr			
H5	<u>Consolidation and permeability in hydraulic cells</u>	nr			
H5.1	Consolidation properties of a 76 mm diameter specimen using a hydraulic cell, test period 4 days	nr			
H5.2	As Item H5.1 but using a 100 mm diameter specimen	nr			
H5.3	As Item H5.1 but using a 150 mm diameter specimen	nr			
H5.4	As Item H5.1 but using a 250 mm diameter specimen	nr			
H5.5	Extra over Items H5.1 to H5.4 for test period in excess of 4 days	day			
H5.6	Permeability of a 76 mm diameter specimen in hydraulic consolidation cell, test period 4 days	nr			
H5.7	As Item H5.6 but using a 100 mm diameter specimen	nr			
H5.8	As Item H5.6 but using a 150 mm diameter specimen	nr			
H5.9	As Item H5.6 but using a 250 mm diameter specimen	nr			
H5.10	Extra over Items H5.6 to H5.9 for test period in excess of 4 days	day			
H5.11	Isotropic consolidation properties in a triaxial cell, test period 4 days	nr			
H5.12	Extra over Item H5.11 for test periods in excess of 4 days	day			
H5.13	Permeability in a triaxial cell, test period 4 days	nr			

Page total, section H, carried forward

Number	Item description	Unit	Quantity	Rate	Amount
					£
H	Laboratory testing (continued)				
H5.14	Extra over Item H5.13 for test period in excess of 4 days	day			
H6	<u>Shear strength (total stress)</u>				
H6.1	Shear strength by the laboratory vane method	nr			
H6.2	Shear strength by hand vane	nr			
H6.3	Shear strength by hand penetrometer	nr			
H6.4	Shear strength of a set of three 60 mm × 60 mm square specimens by direct shear, test duration not exceeding 1 day per specimen	nr			
H6.5	Extra over Item H6.4 for test durations in excess of 1 day per specimen	sp.day			
H6.6	Shear strength of a single 300 mm × 300 mm square specimen by direct shear, test duration not exceeding 1 day	nr			
H6.7	Extra over Item H6.6 for test durations in excess of 1 day	day			
H6.8	Residual shear strength of a set of three 60 mm × 60 mm square specimens by direct shear, test duration not exceeding 4 days per specimen	nr			
H6.9	Extra over Item H6.8 for test durations in excess of 4 days per specimen	sp.day			
H6.10	Residual shear strength of a 300 mm square specimen by direct shear, test duration not exceeding 4 days	nr			
H6.11	Extra over Item H6.10 for test duration in excess day of 4 days	day			
H6.12	Residual shear strength using the small ring shear apparatus at three normal pressures, test duration not exceeding 4 days	nr			
H6.13	Extra over Item H6.12 for test duration in excess of 4 days	day			
H6.14	Unconfined compressive strength of 38 mm diameter specimen	nr			
H6.15	Undrained shear strength of a set of three 38 mm diameter specimens in triaxial compression without the measurement of pore pressure	nr			
H6.16	Undrained strength of a single 100 mm diameter specimen in triaxial compression without the measurement of pore pressure	nr			
H6.17	Undrained shear strength of single 100 mm diameter specimen in triaxial compression with multistage loading and without measurement of pore pressure	nr			
H7	<u>Shear strength (effective stress)</u>				
H7.1	Consolidated undrained triaxial compression test with measurement of pore pressure (set of three 38 mm specimens), test duration not exceeding 4 days per specimen	nr			

Page total, section H, carried forward

Number	Item description	Unit	Quantity	Rate	Amount
					£
H	Laboratory testing (continued)				
H7.2	As H7.1 but single-stage or multi-stage test using 100 mm diameter specimen	nr			
H7.3	Consolidated drained triaxial compression test with measurement of volume change (set of three 38 mm specimens), test duration not exceeding 4 days per specimen	nr			
H7.4	As Item H7.3 but single stage or multi stage test using 100 mm diameter specimen, test duration not exceeding 4 days	nr			
H7.5	Extra over Items H7.1 and H7.3 for test duration in excess of 4 days per specimen	sp.day			
H7.6	Extra over Items H7.2 and H7.4 for test duration in excess of 4 days	day			
H8	<u>Rock testing</u>				
H8.1	Natural water content of rock sample	nr			
H8.2	Porosity/density using saturation and calliper techniques	nr			
H8.3	Porosity/density using saturation and buoyancy	nr			
H8.4	Slake durability index	nr			
H8.5	Soundness by magnesium sulphate	nr			
H8.6	Shore scleroscope	nr			
H8.7	Schmidt rebound hardness	nr			
H8.8	Aggregate crushing value	nr			
H8.9	Ten percent fines	nr			
H8.10	Aggregate impact value	nr			
H8.11	Aggregate abrasion value	nr			
H8.12	Polished stone value	nr			
H8.13	Aggregate frost heave	nr			
H8.14	Uniaxial compressive strength	nr			
H8.15	Deformability in uniaxial compression	nr			
H8.16	Indirect tensile strength by Brazilian test	nr			
H8.17	Undrained triaxial compression without measurements of porewater pressure	nr			
H8.18	Undrained triaxial compression with measurement of porewater pressure	nr			
H8.19	Direct shear strength of a single specimen	nr			
H8.20	Swelling pressure test	nr			
H8.21	Determination of point load strength of rock specimen	nr			
			Page total		
			Brought forward page		
			Brought forward page		
			Brought forward page		
Total section H, carried to summary					

Number	Item description	Unit	Quantity	Rate	Amount
					£
I	Chemical testing for contaminated ground				
I1	<u>Soil samples – primary contaminants</u>				
I1.1	Arsenic — total	nr			
I1.2	Cadmium — total	nr			
I1.3	Chromium — total	nr			
I1.4	Chromium — hexavalent	nr			
I1.5	Lead — total	nr			
I1.6	Mercury — total	nr			
I1.7	Selenium — total	nr			
I1.8	Boron — water soluble	nr			
I1.9	Copper — total	nr			
I1.10	Nickel — total	nr			
I1.11	Zinc — total	nr			
I1.12	Cyanide — total	nr			
I1.13	Cyanide — complex	nr			
I1.14	Cyanide — free	nr			
I1.15	Thiocyanate	nr			
I1.16	Phenols — total	nr			
I1.17	Sulphide	nr			
I1.18	Sulphate — total, acid soluble	nr			
I1.19	Sulphate — water soluble, 2: 1 extract	nr			
I1.20	Sulphur — free	nr			
I1.21	ph value	nr			
I1.22	Toluene extractable matter	nr			
I1.23	Coal tar/polyaromatic hydrocarbon	nr			
I1.24	Asbestos	nr			
I2	<u>Soil samples — secondary contaminants</u>				
I2.1	Antimony	nr			
I2.2	Barium	nr			
I2.3	Beryllium	nr			
I2.4	Vanadium	nr			
I2.5	Cyclohexane extractable matter	nr			
I2.6	Freon extractable matter	nr			
I2.7	Mineral oils	nr			
I2.8	Chloride	nr			
I3	<u>Water samples</u>				
I3.1	Arsenic	nr			
I3.2	Cadmium	nr			
Page total, section I, carried forward					

Number	Item description	Unit	Quantity	Rate	Amount
					£
I	Chemical testing for contaminated ground (continued)				
I3.3	Chromium — total	nr			
I3.4	Chromium — hexavalent	nr			
I3.5	Lead total	nr			
I3.6	Mercury total	nr			
I3.7	Selenium total	nr			
I3.8	Boron — water soluble	nr			
I3.9	Copper total	nr			
I3.10	Nickel total	nr			
I3.11	Zinc total	nr			
I3.12	Cyanide — total	nr			
I3.13	Cyanide — complex	nr			
I3.14	Cyanide — free	nr			
I3.15	Thiocyanate	nr			
I3.16	Phenols — total	nr			
I3.17	Sulphide	nr			
I3.18	Sulphate	nr			
I3.19	Sulphur — free	nr			
I3.20	pH value	nr			
I3.21	Polyaromatic hydrocarbons	nr			
I3.22	Antimony	nr			
I3.23	Barium	nr			
I3.24	Beryllium	nr			
I3.25	Vanadium chloride	nr			
I3.26	Chloride	nr			
I3.27	Ammoniacal nitrogen	nr			
I3.28	Nitrate — nitrogen	nr			
I3.29	Chemical oxygen demand	nr			
I3.30	Biochemical oxygen demand	nr			
I3.31	Total organic carbon	nr			
I3.32	Volatile fatty acids	nr			
I3.33	Iron	nr			
I3.34	Manganese	nr			
I3.35	Calcium	nr			
I3.36	Sodium	nr			
I3.37	Magnesium	nr			
I3.38	Potassium	nr			
Page total, section I, carried forward					

Number	Item description	Unit	Quantity	Rate	Amount
					£
I	Chemical testing for contaminated ground				
I4	<u>Gas samples</u>				
I4.1	Carbon dioxide	nr			
I4.2	Hydrogen	nr			
I4.3	Hydrogen sulphide	nr			
I4.4	Methane	nr			
I4.5	Nitrogen	nr			
I4.6	Oxygen	nr			
I4.7	Ethane	nr			
I4.8	Propane	nr			
I4.9	Carbon monoxide	nr			
			Page total		
			Brought forward page		
			Brought forward page		
Total section I carried to summary					

Summary of Bill of Quantities

A. General items and provisional sums	£
B. Boreholes	
C. Rotary drilling	
D. Pits and trenches	
E. Sampling	
F. In situ testing	
G. Instrumentation and monitoring	
H. Laboratory testing	
I. Chemical testing for contaminated ground	
Total tender	

Appendix A. Rates for geotechnical and other personnel

Rates shall be entered for the various grades of staff listed, who will be employed by agreement with the Engineer in the preparation of any interpretative and advisory sections of the report, or employed for advisory work for the Engineer on site on the conduct of the investigation, in accordance with Specification Clause 3.13 and Schedule 1. This excludes the superintendence and technical direction required under the Conditions of Contract and the requirements of Clauses 3.12, 4.4.2, 5.3.6, 5.4.2, 6.5 and 7.11 which must be covered by the rates and prices entered in the main Bill of Quantities (see Clause 1 of the preamble to the Bill of Quantities)

Item	Item description	Unit	Rate
			£
1	Technician	h	
2	Incorporated Engineer	h	
3	Graduate Engineer/Geologist/ Environmental scientist	h	
4	Graduate Engineer/ Geologist/Environmental Specialist with at least 3 years of relevant experience since graduation	h	
5	Chartered Engineer/ Geologist/Environmental Specialist with at least 5 years of relevant experience	h	
6	Principal Chartered Engineer/ Geologist /Environmental Specialist with at least 10 years of relevant experience	h	
	Expenses incurred by staff on site visits or who are resident by agreement with the Engineer		
7	Fare per kilometre from Contractor's premises and return for Items 1, 2 and 3	km*	
8	As above but for Items 4, 5 and 6	km*	
9	All other expenses incurred in conjunction with a site visit where a return journey is made on the same day for Items 1, 2 and 3	visit	
10	As above but for Items 4, 5 and 6	visit	
11	All other expenses incurred in connection with visit where an overnight stay is necessary for Items 1, 2 and 3	night	
12	As above but for Items 4, 5, and 6	night	

*Where considered more appropriate, 'mile' may be used.

Estimate of costs under Appendix A to the Bill of Quantities for preparation of the interpretative report where required in Schedule 1:

£ _____

NOTES FOR GUIDANCE ON THE SPECIFICATION FOR GROUND INVESTIGATION

These Notes for Guidance are for advice on the preparation of a Specification and Bill of Quantities and do not form part of the Contract.

Contents

Introduction	74
Notes on clauses in the Specification for ground investigation	76
Notes on preparation of the Schedules	81
Notes on the Bill of Quantities and preamble	85
Example Schedules and Bill of Quantities for a small investigation	87
Modification of the Schedules for a 'design and investigate' contract	100

Introduction

Use of the Specification for ground investigation

The Specification for ground investigation is intended for general use in ground investigation, for contracts of any size. The emphasis is on encouraging carefully designed good-quality work. An associated bill of quantities is presented with the specification.

The Specification is independent of the Conditions of Contract. However, it has been assumed that the Employer will appoint an Engineer as defined in the Conditions of Contract. If an independent Engineer is not appointed the Employer should nominate an appropriate individual to act as the Engineer who may, for instance, be employed by the Contractor. It has further been assumed that geotechnical specialists will be involved in the work. Geotechnical specialists, appropriately qualified and experienced chartered engineers or chartered geologists, may be from the staff of the Engineer, may be independent specialist consultants or may be employees of the Contractor. This involvement of geotechnical specialists is considered to be essential to the success of a ground investigation.

Where contaminated ground conditions are suspected or encountered the involvement of an environmental specialist is appropriate.

The specification relies heavily on compliance with good practice as set out in BS 5930, *Code of Practice for site investigations*. The reproduction of parts of BS 5930 in the specification, although in some ways preferable to cross-references, has been rejected in favour of keeping the specification as brief as possible. Particular reference should also be made to the CIRIA *Site investigation manual* and to BS 1377, *Methods of test for soils for civil engineering purposes*. Attention is drawn to the increasing use of previously used and contaminated land which will require specific and detailed investigation, particularly with respect to previous history. Special consideration must be given to the risks to which exploratory personnel may be exposed (see the companion publication of the SISG (1993)).

Successful ground investigation work will only be accomplished when the quality of the work, rather than the lowest cost, is recognised as the first priority. Hence attention must be given to initial desk studies, careful planning, the employment of properly equipped and staffed contractors and the supervision of the field and laboratory work by experienced personnel. The following Notes for Guidance are intended to assist with the Contract documentation but for appreciation of the technical aspects of the work geotechnical, and on occasion environmental specialists should be involved.

Geotechnical and environmental personnel provided by the contractors

Geotechnical and environmental specialists provided by the Contractor for interpretative and advisory work will be paid for on a time and expenses basis under the rates for geotechnical personnel (Appendix A of Bill of Quantities) except where such provision is a requirement of the specification. For instance, the cost of specified activities such as the description of samples, cores, pits and trenches, preparation of exploratory hole logs and full time professional attendance on site, where required, should be included in the rates, whereas the provision of additional advice and assistance would be paid for, as an extra, on a time and expenses basis. The cost of preparing any interpretative reports will be paid for under the rates for geotechnical personnel.

Contract documentation

Information and requirements specific to the particular contract are to be inserted in the Schedules. The intention is that all extra information is to be entered in the Schedules so that the remainder of the Specification may be incorporated unchanged or may be simply referenced. Documentation for a particular contract should comprise:

Instructions For Tendering (separate document)

Letter or Form of Agreement (and Appendix)

Conditions of Contract (reference to published Document)

Amendments and additions to Conditions of Contract

Specification for Ground Investigation (reference to published Document)

Schedules

Schedule 1: Information

Schedule 2: Exploratory holes

Schedule 3: Engineer's facilities

Schedule 4: Specification amendments

Schedule 5: Specification additions

Bill of Quantities for ground investigation.

Preamble (reference to published document)

Preamble amendments

Works Items

Summary of Bill Quantities

Appendix A: Rates for geotechnical and other personnel

It should be noted that a formal Method of Measurement and Item Coverage are not required, as the Specification, together with the Preamble to the Bill of Quantities, adequately defines the Bill items for payment. Additional items may be included in the Specification and Bill with the minimum of documentation. However, if required, a formal Method of Measurement and Item Coverage (together with an appropriate Bill of Quantities) may be included with the Contract documentation, but this is likely to result in duplication of statements and increase the complexity of the documentation, particularly when additional items are included.

Notes on clauses in the Specification for ground investigation

Information	NG 1	Information and requirements specific to the particular contract are to be inserted in the Schedules. Work over water or over unstable ground including mineshfts is not dealt with in the specification. This is work of a specialist nature and will require separate documentation.
Definitions	NG 2	Terms defined in the ICE Conditions of Contract for Ground Investigation (1983) are not repeated in this Specification.
Geotechnical and environmental personnel	NG 2.2	In recognition of training requirements a Graduate Engineer /Geologist/Environmental Scientist working under the close supervision of the responsible Engineer/Geologist/Environmental Scientist with at least 3 years of experience would be acceptable for certain activities by agreement with the Engineer.
Hard stratum and obstructions	NG 2.5	The term 'hard stratum' is used in preference to 'rock' as it is more general and more easily defined.
Fill	NG 2.6	The term 'fill' is used in preference to 'made ground' for consistency with Eurocode 7.
Statutory undertakers, public authorities and privately owned services	NG 3.3	Responsibility for locating services rests with the Contractor regardless of any information provided in the Contract to assist in their location. The Contractor should always have the option of commencing an exploratory hole with a hand-dug inspection pit. The Contractor would normally be expected to use cable detection equipment to check on the location of services. The presence of overhead services should be checked by the Contractor.
Access routes	NG 3.4	Access routes should be defined on the Drawing(s) at the time of tender.
Notice of entry	NG 3.5	It is normally the responsibility of the Engineer to arrange access details with the owner/occupier and agree preliminary arrangements for entry.
Care in executing the work	NG 3.6	The Condition of the site prior to the work should be agreed by all parties, using photographs if appropriate. Damage resulting from the work should be recorded by the Engineer and Contractor and made good by the Contractor.
Security of site	NG 3.7	
Working areas	NG 3.9	This clause requires full reinstatement and making good of avoidable damage at the site of the exploratory hole and on access routes. The degree of reinstatement required will vary between projects and hole locations. Alternative requirements may be stated in Schedule 1. For example full reinstatement at the exploratory hole locations may not be required if construction works are to follow immediately. If unavoidable damage to access route (i.e. rutting under normal plant passage) is required to be made good by the Contractor this should be stated in Schedule 1. Compensation to land owners/occupiers for unavoidable damage to crops should be provided by the Employer.
Engineer's facilities	NG 3.11	The requirements of the Engineer's office and facilities required should be listed in Schedule 3 including any motor vehicles for the use of the Engineer.

Geotechnical and environmental personnel	NG 3.13	The need for the services of geotechnical and environmental personnel to be supplied by the Contractor may be known at the time of tender, in which case the services should be requested, otherwise the initiative lies with the Engineer to request them as required.
Location of exploratory holes	NG 3.14	The use of national grid coordinates and ordnance datum levels are advisable wherever possible to define the exploratory hole location. These will ensure the data remain of value if location plans are misplaced or ground surface levels are subsequently changed by site operations. Where local grid coordinates and datums are used they should, if possible, be related to national grid coordinates and ordnance datum. Bench marks and surveying reference points should be shown on the Contract drawings. If they are not available the Contractor should be informed in Schedule 1.6.
Ground elevation of exploratory holes	NG 3.15	The use of national grid coordinates and ordnance datum levels are advisable wherever possible to define the exploratory hole location. These will ensure the data remain of value if location plans are misplaced or ground surface levels are subsequently changed by site operations. Where local grid coordinates and datums are used they should, if possible, be related to national grid coordinates and ordnance datum. Bench marks and surveying reference points should be shown on the Contract drawings. If they are not available the Contractor should be informed in Schedule 1.6.
Exploratory work	NG 3.16	The nature of ground investigation requires reasonable flexibility from the Contractor. The Engineer and Employer must make provision for possible effects on the Contractor's programme if locations, access routes and quantities of sampling and in situ testing are significantly changed.
Hazardous and contaminated ground	NG 3.19	<p>Safety aspects are paramount and all relevant known information about the site should be listed in Schedule 1 and made available to the Contractor. The category of the site should be stated in accordance with the <i>Guidelines for the safe investigation by drilling of landfills and contaminated land</i> (1993), a companion document. The Contractor's Method Statement should include, among other things</p> <ul style="list-style-type: none"> (a) the proposals for restoration of exploratory holes so that they do not become a hazard to the public or the environment; backfilling with arisings may not be acceptable (b) provision for collection and safe disposal of contaminated soil and liquid arising from exploratory holes (c) procedures to be adopted to protect the environment (e.g. not to place contaminated soil on to unprotected ground) (d) very restricted addition of water (Clause 4.2) because of the danger of spreading contamination (e) procedures to be adopted where routine geotechnical testing is required on suspected contaminated samples.
Traffic safety and management	NG 3.22	Work on or adjacent to public highways and motorways requires utmost care and attention to traffic safety and management. Particular restraints and requirements should be given in Schedule 1.
Quality management	NG 3.23	<p>BS 5750 requires only self-review and self-auditing of a documented quality management system. If an independent third party audit is required the Government has licensed a number of agencies to certify the quality of management systems. Where such Accreditation is required this should be stated in Schedule 1.</p> <p>Requirements for particular laboratory tests to be carried out by a laboratory accredited by NAMAS (or an equivalent in a Member State of the European Community) should be given in Schedule 1. All such tests must comply with NAMAS requirements.</p> <p>The Association of Geotechnical Specialists provides information on quality management in geotechnical engineering (1991).</p>
Accreditation of drillers	NG 3.24	It is intended that all boring and drilling work be undertaken by appropriately accredited drillers. Relaxation of this requirement is only

appropriate where certified drillers are not available to carry out the works in which case drillers must be under the direct supervision on site of an experienced geotechnical person.

Photographs	NG 3.25	Photographs may be requested for any purpose including rock cores, pit and trenches as detailed. Other applications may be to record before and after conditions at exploratory hole locations.
Continuous flight auger boring	NG 4.4.2	A disadvantage with continuous flight auger boring can be the difficulty in identifying the depths of changes in strata unless frequent sampling is carried out through a hollow stem auger. Additional Bill items are required for power auger boring.
Drilling fluid	NG 5.2	Consideration should be given to environmental restraints in selecting a particular drilling fluid.
Rotary drilling with core recovery	NG 5.3	It is recognised that the expertise to select the appropriate equipment to maximise core recovery of the highest quality generally rests with the Contractor although particular methods may be specified in Schedule 1. Unless otherwise indicated in Schedule 1, the Contractor may elect not to use core liner in certain materials where the specification is met without it.
Retention and disposal of cores	NG 5.3.9	It is assumed that long-term storage of rock cores is not generally required as photographic records will suffice.
Inspection pits	NG 6.1	The depth of 1.2 m is the depth below which the Health and Safety Executive requires vertically sided excavations to be supported if they are to be entered by personnel.
Trial pits and trenches	NG 6.2	
Observation pits and trenches	NG 6.3	
Trial pits and trenches	NG 6.2	The differences between trial pits and trenches and observation pits and trenches may be noted from their definitions in Sections 6.2 and 6.3.
Observation pits and trenches	NG 6.3	
Open tube and piston samples	NG 7.3	If cutting shoe samples are not to be retained this should be stated in Schedule 1. Cutting shoe samples would normally be inspected by the personnel responsible for logging. Where piston samples are required the diameter should be stated in Schedule 1.
Sampling and testing frequency	NG 7.6	The frequency of sampling and in situ testing is dependent on the ground conditions and the type of development proposed. For instance shallow foundations would require close or continuous sampling and testing in the upper levels.
Special sampling	NG 7.7	Thin walled (75 mm diameter) or other special samples should be described in Schedule 1 with reference to BS 5930 where possible. Corresponding Bill items will be required.
Retention and disposal of samples	NG 7.13	It should be noted that Clause 20(2) of the ICE Conditions of Contract also refers to retention and disposal of samples.
In situ testing	NG 8.0	The Specification and Bill of Quantities relate generally to in situ testing covered by British Standards and Codes of Practice.

Geophysical methods of investigation	NG 8.4	The requirements for geophysical testing should be listed in Schedule 1, with any additional information to define the work required. Since much of the apparatus is proprietary, the Contractor is required to submit the full description of equipment and procedure for each method. Further guidance is given by Darracott and McCann and the Geological Society (1988).
Special in situ testing	NG 8.5	Where testing is required which is not covered by this specification it should be noted in Schedule 1 and the specification provided based on BS 5930 and BS 1377 where possible.
Hand penetrometer and hand vane for shear strength	NG 8.6 and 11.3.6	It should be noted that the hand vane and hand penetrometer tests are regarded as unreliable and imprecise tests due to a lack of consistency in procedure for the test. The results may be helpful in formulating a controlled test programme.
Self-boring pressuremeter	NG 8.7	Requirements for pressuremeter testing should be detailed in Schedule S1.13 in accordance with Schedule A of the publication by B. G. Clarke and A. Smith (1992).
Standpipes	NG 9.2.1	Simple standpipes should be installed to determine the general water level in the ground.
Standpipe piezometers	NG 9.2.2	Standpipe piezometers should be installed to determine the water pressure within a particular stratum.
Fencing	NG 9.5	Alternative forms of fencing or marker posts may be specified in the Schedules to suit particular landowners' or occupiers' requirements.
Other instrumentation and monitoring	NG 9.8	Where additional instrumentation and monitoring are required this should be listed in Schedule 1 with appropriate Specification Appendices and corresponding Bill items.
Schedule of tests	NG 11.1	If the Contractor is required to prepare the schedules of tests this should be stated in Schedule 1. It must be accepted that laboratory testing quantities cannot be accurately predicted at tender stage before detailed ground conditions are known.
Testing procedures	NG 11.2	References are given in Sections 11.3, 11.4 and 11.5 for laboratory testing. Specifications for laboratory tests not described in British Standards or in the reference list should be inserted in the Schedules.
Testing	NG 11.3, 11.4 and 11.5	If tests include optional methods and a particular test method is required this should be stated in Schedule 1. An environmental specialist should determine appropriate tests on suspected contaminated soil in relation to each specific site.
Primary contaminants in soil	NG 11.5.1	Certain primary contaminant levels will be required before secondary testing is carried out. It should be noted with regard to tests 3 and 4 that hexavalent chromium usually occurs in water-soluble form and is, therefore, leached out of the soil by rain. Hexavalent chromiums are easily reduced to trivalent chromium. This analysis shall only be undertaken if the total chromium content exceeds 25 mg/kg dry mass.
Preliminary logs	NG 12.1	If the Engineer requires a particular style of log to be used an example should be provided with the Schedules.

Digital data (and Appendix III)	NG 12.4	It is assumed that digital output data are required to enable efficient processing, presentation, storage and transfer of data. If such data are not required, this should be stated in Schedule 1. The transfer of data in digital format is a relatively new technology and is still developing at the time of preparation of this document. The details of the required provision of magnetic media containing the data are given in Appendix III. The data required and the format of the data files are provided by the Association of Geotechnical Specialists. Any variations in the extent of digital data and requirements for preliminary digital data should be stated in Schedule 1.
Form of report	NG 12.5	Certain projects may have specific requirements for the format and content of the factual report. For example a particular style of exploratory hole log may be required or long sections may be required to a particular scale and showing particular information. The interpretative report may be required in sections so that particular information may be made available to the construction contractor.
Contents of factual report	NG 12.6	
Content of interpretive report	NG 12.7	Particular requirements for the format and contents of the factual and interpretative reports should be given in Schedule 1.
Approval of report	NG 12.8	It should be noted that certain approval periods may be stated in the appendix to the Agreement given in the ICE Conditions of Contract for Ground Investigation. Where the ICE Conditions are not used, required approval periods should be stated in Schedule 1.
Gas monitoring standpipe	NG Appendix II:	It would be necessary to amend Clause A.2.7 if gas were present and needed to be monitored in the top 2 m of the ground.

Notes on preparation of the Schedules

- General**
1. Information and requirements specific to the particular contract are to be inserted in the Schedules. The intention is that all extra information is to be entered in the Schedules so that the remainder of the specification may be incorporated unchanged or may be simply referenced.
 2. The Schedule may be completed by hand using the published document or retyped for presentation purposes. For consistency Schedule clause numbers should remain unaltered. On retyping, instructions such as '(to be inserted)' and '[examples.....]' may be omitted. If there are no particular requirements in a section it may be left blank or the word 'none' inserted.

Schedule 1: Information

General

1. Items S1.1 to S1.7 must be completed. Other items depend on specific requirements for the particular investigations.
2. Schedule 1 should be used to provide information and particular specification requirements. Schedules 4 and 5 should be used for changes and additions to the actual specification clauses.

Name of Contract NG S1.1 A concise and unique name is required for contract and reporting purposes. The name should include the nearest town if appropriate.

Description of site NG S1.2 The description of the site should include its location (with national grid reference), boundaries, topography and a note concerning current and previous use of the site (if any) with particular reference to contamination.

Mains Works and purpose of contract NG S1.3 A description of the Main Works should be carried out including locations and descriptions of proposed groundworks, earthworks, roads and structures together with type of foundations intended, if known. The text should state whether the investigation is preliminary, main or supplementary.

Scope of investigation NG S1.4 A brief outline is required of the work to be done under the contract, stating the type of exploratory holes (boring, drillings, trial pits, probings, etc.). It should be stated whether sampling and testing (in situ and laboratory) are required, and also what types of report are required (factual, or interpretative with desk study if not already in existence).

Geology and ground conditions NG S1.5 A summarised description is required of the geology and ground conditions expected to exist based on information obtained from maps and memoirs of the British Geological Survey, other readily accessible publications and records and any previous investigations. Difficult ground or groundwater conditions, mine workings, etc. should also be noted. Where hazardous or contaminated ground is known to exist full details must be made available.

Schedule of drawing(s) NG S1.6 The drawing number, title and scale of each contract drawing should be listed; landowners and tenants may be listed where appropriate. Reference should also be made to other relevant documents which may be inspected at the Engineer's Office, e.g. desk study report, previous site investigations, location of underground services, aerial photographs, details of contamination, etc.

<i>Particular contract restrictions</i>	NG SI.7	Particular restrictions may be necessary on access, working times, order of work, etc. and these should be stated. Restrictions may include <ul style="list-style-type: none"> (a) the order of carrying out the work (unnecessary restrictions should not be imposed on the Contractor) (b) section(s) of the investigation which are to be completed at a particular time or within a particular period (c) special requirements for land entry (d) reference to particularly difficult access to exploratory hole location (e) requirement to seek Engineer's approval before commencing each hole and before backfilling each hole.
<i>Particular general requirements (Section 3)</i>	NG SI.8	Any particular general requirements should be stated. When full time Professional Attendance is required on site (Clause 3.12) the level of experience should be stated by reference to Clause 2.2.
<i>Particular boring requirements (Section 4)</i>	NG SI.9	Any particular boring requirements should be stated.
<i>Particular rotary drilling requirements (Section 5)</i>	NG SI.10	Particular rotary drilling requirements should be stated. Rotary drilling core sizes (Clause 5.3.2) will be required and should be selected from standard sizes as recommended in BS 5930.
<i>Particular pits and trenches requirements (Section 6)</i>	NG SI.11	Any particular requirement should be stated.
<i>Particular sampling requirements (Section 7)</i>	NG SI.12	Sampling (and in situ testing) requirements should be stated if different from Clause 7.6. Special sampling requirements should be listed, referring to Schedule 5 (with additional specification appendices) if necessary. Corresponding Bill items are required.
<i>Particular in situ testing requirements (Section 8)</i>	NG SI.13	Geophysical investigation requirements (Clause 8.4) and special in situ testing requirements (Clause 8.5) should be listed referring to Schedule 5 (with additional specification appendices) if necessary. Corresponding Bill items are required.
<i>Particular instrumentation and monitoring requirements (Section 9)</i>	NG SI.14	Particular requirements and details should be given.
<i>Particular daily report requirements (Section 10)</i>	NG SI.15	Particular requirements should be stated relating to special in situ testing.
<i>Particular laboratory testing requirements (Section 11)</i>	NG SI.16	Special laboratory testing requirements should be listed, referring to Schedule 5 (with additional specification appendices) if necessary. Corresponding Bill items are required. Particular tests required to be carried out in a laboratory accredited for those tests by NAMAS, or an equivalent in a Member state of the European Community, should be listed.
<i>Particular reporting requirements (Section 12)</i>	NG SI.17	Particular requirements should be stated, including the requirement for a desk study report if not already in existence and an interpretative report. When an interpretative report is required, adequate details of the proposed scheme should be given together with specific details of the analyses and

recommendations required. Specific details of requirements for factual and interpretative reports and a desk study report if not already in existence may be given in an Additional Specification Appendix included in Schedule 5. If digital data are not required this should be stated. Variations in the extent of digital data required should be stated, along with requirements (and timing) for any preliminary digital data submissions.

Schedule 2: Exploratory holes

<i>Hole number</i> NG S2	This is a unique identification for each hole. If a suffix or prefix is used there should be no space between letters and numbers to assist with digital data, i.e. BH62 TP49A. Trial pit numbers should not repeat the numbers of other exploratory holes.
<i>Type</i> NG S2	Reference to the type of hole should be given if not covered by the hole number.
<i>Scheduled depth</i> NG S2	This is the depth anticipated, but it is subject to variation depending on the ground conditions encountered. Note that under ICE Conditions of Contract the Contractor may vary the depth under certain circumstances.
<i>National grid reference</i> NG S2	A provisional national grid reference should be given where possible, in advance of exploration, for setting out purposes.
<i>Approximate ground level</i> NG S2	The approximate ground level may be determined from Ordnance Survey contour maps prior to final surveying.

Schedule 3: Engineer's office

<i>Accommodation</i> NG S3.1	The accommodation requirements will vary depending on the size and duration of the Contract and the number of the Engineer's staff involved.
<i>Services</i> NG S3.3	The need for steady current electricity may relate to the use of on-site computers. Portable telephones are likely to be necessary on larger sites and where fixed lines are not available. Cleaning of the office should be considered.
<i>Equipment</i> NG S3.4	The Engineer may require equipment such as tapes, penetrometer, hand vane, hand probing equipment, computer hardware and software, etc. Details should be given, and also the period for which it is required. If on-site computer equipment is required the robustness of such equipment in dusty site conditions should be considered.
<i>Transport</i> NG S3.5	<p>If vehicles are required for the Engineer's use the number and type should be specified. The following example clause illustrates factors to be specified.</p> <p>The Contractor shall provide (number) plain-coloured (vehicle type) transport for the exclusive use of the Engineer for any purpose in connection with the site operations. The vehicles shall be delivered and maintained in good roadworthy condition. They shall be licensed and insured for use on the public highway and shall have comprehensive insurance cover for any qualified driver authorised by the Engineer, together with any authorised passengers and the carriage of goods or samples. The Contractor shall provide fuel, oil and maintenance in conformity with the vehicle manufacturer's recommendation and shall clean the vehicles inside and outside as required. A suitable replacement shall be provided for any vehicle out of service for more than 24 hours.</p>

*Protective clothing for
the Engineer* NG S3.6

Essential clothing should be listed, bearing in mind the possibility of working in contaminated ground. If clothing is to be retained by the Engineer this should be stated.

**Schedule 4: Specification
amendments**

General

Clauses which do not apply to the required work are covered by Clause 3.2 and should not be deleted.

Where an applicable clause contains an inappropriate word or phrase this may be amended, for example 'Clause 2.9 Line 3 delete x insert y'. If much of clause is inappropriate the entire clause may be deleted and replaced, i.e. 'Delete Clause 2.9 and insert new clause '...''.

Schedule 5: Specification additions

Where a required activity is not covered by a specification clause an additional clause may be added at the end of the relevant section, or as a sub-clause if a related topic exists, i.e. 'add Clause 3.9.5 Crazy Paving '...''.

Details of special sampling, in situ testing and laboratory testing may be given clause numbers relating to the relevant section. If the addition is extensive or does not relate to an existing section, a new section or an additional Appendix may be added.

Notes on the Bill of Quantities and preamble

- General 1**
1. The Bill of Quantities is presented as a comprehensive list of items which conveniently cross-relate to the Specification items.
 2. It is intended that the numbering of items will remain unaltered. Additional items may be added to correspond with particular specification requirements. If necessary a subsidiary numbering system may be introduced (for example B2.1 Extra over item B1 for setting up over a lagoon – nr).
 3. Work items should have required quantities inserted. Items against which no quantities are entered shall be deemed not to be required. If lump sum items are not required this should be stated against the item in the Bill of Quantities. Provisional sums should be inserted as required to cover items not detailed in the Specification and Bill of Quantities and which are to be charged by the Contractor as agreed with the Engineer.
 4. The use of 'rate only' items is deprecated. Where there is a reasonable probability that an item will be required a realistic assessment of the quantity should be made and entered in the Bill of Quantities. The nature of ground investigation is such that some modifications to the work content may be identified as the investigation proceeds.
 5. It is an option to prepare the Bill of Quantities by hand using the published documents, or to redraft and omit items not required, but preferably retaining the same item numbering system to reduce cross-referencing errors.
 6. For small routine investigations a much simplified Bill of Quantities may be used (see example).
 7. Any apparent conflict between the Bill of Quantities and other contract documentation should be clarified with the Engineer during the tender period.
 8. The preamble supplements the Specification to define general and particular activities to be included in the rates. Additional numbered preambles may be included as necessary.
- General items and provisional sums (Bill A) 2** Item A11 need only be included for stated requirements with particular financial significance to the Contract. Otherwise costs will be deemed to be included in the general rates.
- Boreholes (Bill B) 3** For certain sites it is optional to introduce a rate for moving boring plant and equipment over distances exceeding, say, 500 m to give more flexibility in the Engineer's direction of field operations.
- Rotary drilling (Bill C) 4** Core diameters will be defined in the Schedules. If more than one core diameter is required, the Bill of Quantities must identify this with different items repeated as required for each core size. The separate Bill items for the semi-rigid core liner should always have quantities corresponding to the lengths of rotary drilling to obtain cores, unless the Engineer wishes to restrict the drilling method used.

- Pits and trenches (Bill D)** 5 Trial pits and trenches and observation pits and trenches may be measured on a linear metre basis (for pits) and a m³ basis (for trenches) or alternatively on a time basis. Normally the Engineer will adopt one of these methods. Quantities shall be entered for only one method for each pit or trench. Measurement on a time basis is often appropriate to permit flexibility for adequate examination, sampling and testing in less certain ground conditions. If two or more pitting crews are required, this should be stated in Schedule 1.
- In situ testing (Bill F)** 6 The items are those most often used. Additional techniques should be added when required and included as additions to the specification.
- Standpipes and Piezometers (Bill G)** 7 When readings of standpipes and piezometers are required to be continued after the fieldwork period, it may be appropriate to measure this work on Appendix A rates.
- Laboratory testing (Bill H)** 8 Items for laboratory testing on soil are listed to correspond with appropriate sections of BS 1377. Where significant quantities of geotechnical testing of contaminated ground are anticipated, consideration may be given to the inclusion of an additional Bill which repeats the relevant geotechnical tests to enable the Contractor to identify better any additional costs involved.

Example Schedules and Bill of Quantities for small investigation

Investigation required In regard to a proposed mixed housing estate, a ground investigation is required for a gently sloping 6 hectare site bordered by mature hedges and containing occasional large trees.

A preliminary desk study indicates that the site is underlain by clay deposits and in one corner there is a former 'clay pit' which is now infilled. The depth of the pit does not exceed 10 metres but the nature of the infill is unknown.

The planned ground investigation is to include 8 trial pits, 3 trial trenches and 2 boreholes, each with a gas monitoring probe.

Schedules required

- Schedule 1. Information
- Schedule 2. Exploratory holes
- Schedule 3. Engineer's facilities
- Schedule 4. Specification amendments
- Schedule 5. Specification additions

Schedule 1: Information

Name of contract	S1.1	<i>Proposed Housing Development, Red House Farm, Western District, Newtown, (short title Red House Farm Housing)</i>
Description of site	S1.2	<i>The site is located at approximate map reference SZ 999 666 to the north of Perimeter Road and east of The Sidings, Western District, Newtown. The site is presently used as pasture and is surrounded by mature hedges with several large oak trees within the hedges and as individual specimens. It slopes gently towards the South at approximately 2°. Access is taken directly from The Sidings by a 3 metre wide gate and agricultural access. It is understood that there are no private or public services within the site.</i>
Main works proposed and purpose of this contract	S1.3	<i>The investigation is the main investigation. The site is to be developed with predominantly detached 3 and 4 bedroom house units but with some blocks of up to 4 'affordable' housing units in both terraces and 'square' units. General ground levels are unlikely to be significantly changed. Roads are to be constructed to adoptable standards and relatively deep drains and sewers are required to meet existing mains outside the site (up to 3.5 metre depth).</i>
Scope of investigation	S1.4	<i>The contract provides for formation of trial pits, trial trenches and cable tool percussion boreholes with associated sampling, in situ testing and laboratory testing. A factual and interpretative report will be required. Previous desk study data in respect of site history and geology will be made available.</i>
Geology and ground conditions	S1.5	<i>The following assessment of the geology and of the site and ground conditions has been inferred from available information. No assurance is given to its accuracy.</i> <i>The site is expected to be underlain by deposits of Upper Lias clay with the 'feather edge' of a cohesive Glacial Till deposit occurring on higher ground to</i>

the north-east of the site. A former clay pit occupies the south-eastern corner of the site but the nature of backfill is unknown. The depth is not expected to exceed 10 metres. However this part of the site may possibly be contaminated (Site Investigation Steering Group site classification – yellow).

Schedule of drawing(s) and documents	S1.6	<p><i>Figure 1: Site Location plan including access routes (1:10,560)</i></p> <p><i>Figure 2: Summary of desk study (1:2,500)</i></p> <p><i>Figures 3 and 4: Ground level survey (1:200)</i></p> <p><i>Figure 5: Proposed layout of development showing sewer/drainage invert levels.</i></p>
Particular contract restrictions	S1.7	<p>(to be inserted if any)</p> <p>(For example: order of work, sections to be completed at a particular time or within a period, reference to particularly difficult access, need for Engineer's approval before backfilling each hole.)</p> <p><i>The contractor shall in general be responsible for determining the locations of exploratory holes to suit the proposed development. However, trial pits 1 and 2 shall be excavated in the positions shown on Figure 5. 3 pits shall be excavated on the alignment of the road at representative locations. Boreholes shall be positioned in the former clay pit and shall not be carried out before completion of the trial trenches.</i></p>
Particular general requirements (Section 3)	S1.8	<p>(to be inserted if required)</p> <p>(For example: restricted working hours (Clause 3.8), reinstatement requirements (Clause 3.9), full time professional attendance required (Clause 3.12), accuracy of setting out (Clause 3.14), if quality management not required (Clause 3.23), if certificated drillers not required (Clause 3.24).)</p> <p><i>Work shall be carried out only during the hours 8.00 to 18.00, Monday to Friday.</i></p> <p><i>Exploratory holes shall be set out to an accuracy of 1 metre and levels may be estimated from the survey drawings provided (Figures 3 and 4).</i></p> <p><i>A quality management system will not be required.</i></p>
Particular borehole requirements (Section 4)	S1.9	<p>(to be inserted if required)</p> <p>(For example: restrictions on permitted methods (Clause 4.1), particular use of flight augers (Clauses 4.4.2 and 4.4.3), particular use of rotary drilling (Clause 4.5), special backfilling requirement (Clause 4.5).)</p>
Particular rotary drilling requirements (Section 5)	S1.10	<p>(to be inserted if required)</p> <p>(For example: particular drilling techniques (Clause 5.3.1), rotary drilling core sizes (Clause 5.3.2), address for delivery of selected cores (Clause 5.3.8), special backfilling requirements (Clause 5.5), particular photographic requirements (Clause 5.6).)</p>
Particular pit and trench requirements (Section 6)	S1.11	<p>(to be inserted if required)</p> <p>(For example: any restrictions on plant (Clauses 6.2 and 6.3), pit and trench alternative dimensions (Clause 6.4), particular photographic requirements (Clauses 6.5 and 6.9).)</p>

Trial pitting equipment shall be capable of excavating to 4.3 m.

Trial trenches shall have a minimum length of 6 m and shall be commenced 3 m inside the expected edge of the former 'clay pit'.

Particular sampling requirements (Section 7) S1.12

(to be inserted if required)

(For example: frequency of sampling (and in situ testing) if different from Clause 7.6, special sampling requirements (Clause 7.7), address for delivery of selected samples (Clause 7.12), requirement for retention and disposal of samples (Clause 7.13).)

In trial pits 1 and 2 small disturbed samples shall be taken at intervals of 0.5 m; in other holes sampling intervals shall be 1 m.

In 3 trial pits in carriageways CBR mould samples shall be taken at depths of 0.5 m below ground level.

In trial trenches bulk samples shall be taken in fill each at 1 m intervals or at change in soil type. Small disturbed samples shall be taken at intervals of 0.5 m in natural ground.

In boreholes in fill, Standard Penetration Tests (SPTs) shall be carried out, alternating with undisturbed 100 mm samples (U100s). SPTs or U100s shall be taken at 1 m intervals.

Particular in situ testing requirements (Section 8) S1.13

(to be inserted if required)

(For example: capacity of probing equipment (Clause 8.3.1), geophysical investigation requirements (Clause 8.4), special in situ testing requirements (Clause 8.5), requirements for self-boring pressuremeter testing (Clause 8.7).)

See above re: SPT.

Assessment of shear strength by hand penetrometer or hand vane is required in trial pits at 1 m intervals.

Particular instrumentation and monitoring requirements (Section 9) S1.14

(to be inserted if required)

(For example: installation of piezometers (Clause 9.2.3), type of covers (Clause 9.4), fencing requirements (Clause 9.5), frequency of readings (Clause 9.6), if piezometers and standpipes are to be removed (Clause 9.7), other instrumentation and monitoring (Clause 9.8).)

Gas monitoring shall be carried out as follows using an approved meter calibrated for oxygen, carbon dioxide, methane and nitrogen.

1. 24 hours after installation

2. 7 days after installation and thereafter 3 further readings at 7 day intervals

3. After this, 2 further readings at 4 week intervals.

'Gresham-Tube' type samples or equivalent approved shall be taken with the agreement of the Engineer in conjunction with items 2 and 3 above.

Groundwater levels shall be recorded when gas monitoring is carried out.

Particular daily report requirements (Section 10) S1.15 (to be inserted if required)
(For example: report requirements for special in situ testing (Clause 10.6).)

Particular laboratory testing requirements (Section 11) S1.16 (to be inserted if required)
(For example: if Contractor has to schedule tests (Clauses 11.1), special laboratory testing requirements (Clause 11.7).)

The Contractor shall prepare a schedule of laboratory tests and submit it to the Engineer for approval.

The Engineer shall agree with the Contractor the extent of laboratory analysis of gas samples required.

Particular reporting requirements (Section 12) S1.17 (to be inserted if required)
(For example: requirements for assessment of strata from probing (Clause 12.2.5), if digital data are not required (Clause 12.4), requirements for interpretative report (Clause 12.5), additional information required in factual report (Clause 12.6), analysis and recommendations required in interpretative report (Clause 12.7), calculations requirements (Clause 12.7).)

Digital data will not be required under this contract.

The interpretative report shall contain the following:

(i) Recommended foundation types, predicted settlements and allowable bearing pressures above natural soils.

(ii) Shrinkage (swell classification of soil types and recommendations for foundation depths and/or mitigating measures in proximity to trees and hedges.

(iii) Determination of the nature and age of the made ground with recommendations for ground improvement techniques and/or piling and/or raft foundations above made ground.

(iv) Comments on trench stability.

(v) Recommendations for concrete composition in respect of sulphate and acid attack.

(vi) Design CBR values for pavement construction.

Not used Schedules 2, 3, 4 and 5.

There are no amendments to the preamble to the Bill of Quantities.

Example Bill of Quantities for a small investigation: works items

The following eight pages comprise an example suitable Bill of Quantities for a small investigation.

Number	Item description	Unit	Quantity	Rate	Amount
					£
A	General items and provisional sums				
A1	Offices and stores for the Contractor	sum			
A2	Establish on site all plant, equipment and services	sum			
A4	Establish the location and elevation of the ground at each exploratory hole	sum			
A10	Special testing and sampling required by Engineer	provisional sum £600			
A12	One master copy of the Factual Report	sum			
A13	Additional copies of the Factual Report	nr	3		
A14	One master copy of the Interpretative Report	sum			
A15	Additional copies of Interpretative Report	nr	3		
Total section A carried to summary					

Number	Item description	Unit	Quantity	Rate	Amount
					£
B	Boreholes				
B1	Move boring plant and equipment to the site of each exploratory hole and set up	nr	2		
B4	Advance borhole between existing ground level and 10 m depth	m	20		
B5	As Item B4 But between 10 m and 20 m depth	m	10		
B9	Advance borehole through hard stratum or obstruction	h	4		
B11	Standing time for boring plant, equipment and crew	h	2		
Total section B carried to summary					

Number	Item description	Unit	Quantity	Rate	Amount
					£
D	Trial pits and trenches				
D3	Move equipment to the site of each trial pit or trench	nr	11		
D4	Excavate trial pit between existing ground level and 3.0 m depth	m	30		
D5	As Item D4 But between 3.0 and 4.5 m depth	m	5		
	Hourly provision of pitting crew and equipment				
D25	Provision of excavation plant, equipment and crew for machine dug trial pits or trenches as directed by the Engineer, max depth 4.5 m	h	4		
Total section D carried to summary					

Number	Item description	Unit	Quantity	Rate	Amount
					£
E	Sampling				
E1	Small disturbed	nr	80		
E2	Bulk disturbed sample	nr	10		
E3	Large bulk disturbed sample	nr	10		
E4	Open tube 100 mm diameter sample	nr	1		
E6	Groundwater sample	nr	4		
E7	Gas sample	nr	6		
E9	CBR Mould sample	nr	3		
Total section E carried to summary					

Number	Item description	Unit	Quantity	Rate	Amount
					£
F	In situ testing				
F1	Standard penetration test in borehole	nr	10		
F7	Hand penetrometer test	nr	26		
F8	Hand vane test	nr	20		
Total section F carried to summary					

Number	Item description	Unit	Quantity	Rate	Amount
					£
G	Instrumentation and monitoring				
	Standpipe and piezometers				
G4	Gas monitoring standpipe	m	20		
G5	Protective cover (flush)	nr	2		
G9	Gas measurement in gas monitoring standpipe during fieldwork period	nr	2		
Total section G carried to summary					

Number	Item description	Unit	Quantity	Rate	Amount
					£
H	Laboratory testing				
H1	Classification				
H1.1	Moisture content	nr	30		
H1.2	Liquid limit, plastic limit and plasticity index	nr	15		
H1.3	Volumetric shrinkage	nr	4		
H1.4	Linear shrinkage	nr	2		
H1.10	Particle size distribution by dry sieving	nr	4		
H1.11	Sedimentation by pipette	nr	4		
H2	Chemical and electrochemical				
H2.1	Organic matter content	nr	4		
H2.3	Sulphate content of acid extract from soil	nr	3		
H2.4	Sulphate content of water extract from soil	nr	3		
H2.5	Sulphate content of groundwater	nr	3		
H2.12	pH value	nr	8		
H3	Compaction related				
H3.9	California Bearing Ratio on recompacted disturbed sample	nr	3		
H6	Shear strength (total stress)				
H6.2	Shear strength by hand vane	nr	5		
H6.3	Shear strength by hand penetrometer	nr	5		
H6.17	Undrained shear strength of a single 100 mm diameter specimen in triaxial compression with multistage loading and without measurement of pore pressure	nr	6		
Total section H carried to summary					

Number	Item description	Unit	Quantity	Rate	Amount
					£
I	Chemical testing for contaminated ground				
I4	Gas analysis				
I4.1	Carbon dioxide	nr	6		
I4.4	Methane	nr	6		
I4.6	Oxygen	nr	6		
Total section I carried to summary					

Summary of Bill of Quantities

	£
A. General items and provisional sums	
B. Boreholes	
C. Rotary drilling	
D. Pits and trenches	Not used
E. Sampling	
F. In situ testing	
G. Instrumentation and monitoring	
H. Laboratory testing	
I. Chemical testing for contaminated ground	
Total tender	

Modification of the Schedules for a 'design and investigate' Contract

The majority of ground investigation contracts are organised by the Employer appointing an Engineer to be responsible for the design and supervision of the work. The procurement of ground investigation services for the smaller project is sometimes effected by the Employer requesting a specialist organisation (Consultant or Contractor) to both design and carry out the investigation as a total package for a quoted sum. This method of procurement is discussed in the companion publication *Planning, procurement and quality management*, together with advice on the appointment of a Geotechnical Adviser and the selection of an appropriate specialist organisation competent to carry out such work.

The following example modification to Schedule 1 (Schedule 1A) is suggested to permit the Employer (advised by a Geotechnical Adviser where appropriate) to state known requirements and list available information. The specialist organisation may then complete the remaining part of Schedule 1 (Schedule 1B) and Schedules 2, 3, 4 and 5 as appropriate, and will assume the responsibility of the Engineer where the term Engineer is referred to in the specification. Schedule 1B, Items S1.8 to S1.17 will include the specialist organisation's proposed modifications to the standard specifications (if any). The term 'requirements' in the original Schedule 1 is taken to mean the specialist organisation's requirements (i.e. proposals) for an effective and adequate ground investigation.

The proposed quantities and prices should be inserted in the Bill of Quantities by the specialist organisation where payment is to be based on the work actually done, and as a basis for variation if a fixed price contract is agreed.

Example Schedules for 'design and investigate' Contract

Specification The specification shall be the *Specification for ground investigation* published by Thomas Telford Services Ltd (1993), with information, amendments and additions as described in the Schedules.

The Specialist Contractor shall assume the responsibilities of the Engineer where the term Engineer is stated in the Specification.

Schedule 1 – Information

Part 1A (completed by Employer)

Part 1B (completed by Specialist Contractor)

Schedule 2 – Exploratory holes (completed by Specialist Contractor)

Schedule 3 – Engineer's facilities (completed by Specialist Contractor)

Schedule 4 – Specification amendments (completed by Specialist Contractor)

Schedule 5 – Specification additions (completed by Specialist Contractor)

Schedule 1A: Information provided by Employer

Name of contract	S1.1	A concise unique name for contract and reporting purposes.
Description of site	S1.2	Location of the site, boundaries, current use and previous use.
Main works proposed and purpose of this Contract	S1.3	Description of main works to be carried out including groundworks, earthworks, roads and structures with types of foundations intended, if known. Statement as to whether investigation is preliminary, main or supplementary.
Scope of investigation	S1.4	List of design parameters, information or recommendations needed; desk study requirements (if not already in existence); any special requirements relating to the investigation, data, factual and interpretative reports and location of existing services, structures or obstructions.
Geology and ground conditions	S1.5	Outline of known geology and ground conditions; i.e. instability, subsidence, flooding. Details of any known contamination.
Schedule of drawings and documents	S1.6	List of drawings and documents provided by the Employer and other relevant drawings and documents which may be inspected at the Employer's office, e.g. desk study report, previous site investigations, location of underground services, photographs, details of contamination, etc.
Particular restrictions and other information	S1.7	Difficult or restricted access, limited working times, special entry requirements, etc. Amount of insurance and limitations of liability (conditions of contract).

Schedule 1B: Contractor's requirements (to be completed by Contractor)

Particular general requirements (Section 3)	S1.8	(to be inserted if required) (For example: restricted working hours (Clause 3.8), reinstatement requirements (Clause 3.9), full time professional attendance required (Clause 3.12), accuracy of setting out (Clause 3.14), requirements for 'special' traffic management (Clause 3.22), if quality management required (Clause 3.23) if certificated drillers not required (Clause 3.24).)
Particular borehole requirements (Section 4)	S1.9	(to be inserted if required) (For example: restrictions on permitted methods (Clause 4.1), particular use of flight augers (Clauses 4.4.2 and 4.4.3), particular use of rotary drilling (Clause 4.5), special backfilling requirement (Clause 4.6).)
Particular rotary drilling requirements (Section 5)	S1.10	(to be inserted if required) (For example: particular drilling techniques (Clause 5.3.1), rotary drilling core sizes (Clause 5.3.2), rotary drilling without cores hole size (Clause 5.4), address for delivery of selected cores (Clause 5.3.8), special backfilling requirements (Clause 5.5), particular photographic requirements (Clause 5.6).)
Particular pit and trench requirements (Section 6)	S1.11	(to be inserted if required) (For example: any restrictions on plant (Clauses 6.2 and 6.3), pit and trench alternative dimensions (Clause 6.4), particular photographic requirements (Clauses 6.5 and 6.9).)
Particular sampling requirements (Section 7)	S1.12	(to be inserted if required) (For example: open tube and piston sample diameter if different from Clause 7.3, frequency of sampling (and in situ testing) if different from Clause 7.6, special sampling requirements (Clause 7.7), address for delivery of selected samples (Clause 7.12), requirement for retention and disposal of samples (Clause 7.13).)
Particular in situ testing requirements (Section 8)	S1.13	(to be inserted if required) (For example: capacity of probing equipment (Clause 8.3.1), geophysical investigation requirements (Clause 8.4), special in situ testing requirements (Clause 8.5), requirements for self boring pressuremeter (Clause 8.7).)
Particular instrumentation and monitoring (Section 9)	S1.14	(to be inserted if required) (For example: installation of requirements piezometers (Clause 9.2.3), type of covers (Clause 9.4), fencing requirements (Clause 9.5), frequency of readings (Clause 9.6), if piezometers and standpipes to be removed (Clause 9.7), other instrumentation and monitoring (Clause 9.8).)
Particular daily report requirements (Section 10)	S1.15	(to be inserted if required) (For example: report requirements for special in situ testing (Clause 10.6).)

Particular laboratory testing (Section 11) S1.16 (to be inserted if required)

(For example: if contractor has to schedule requirements tests (Clause 11.1), special laboratory testing requirements (Clause 11.7).)

Particular reporting requirements (Section 12) S1.17 (to be inserted if required)

(For example: requirements for assessment of strata from probing (Clause 12.2.5), if digital data are not required (Clause 12.4), variations in extent of digital data required (AIII.2) requirements for preliminary digital data (AIII.4), requirements for interpretative report (Clause 12.5), additional information required in factual report (Clause 12.6), analysis and recommendations required in interpretative report (Clause 12.7), calculations requirements (Clause 12.7).)

**To: Site Investigation Steering Group
Specification for ground investigation
1 – 7 Great George Street
London SW1P 3AA**

Specification for ground investigation

Recommendations for revision

Section:

Page:

Clause:

Problem:

Suggested amendment:

From:

Name:

Organisation:

Address:

Signed:

Date:

ICE ref.

Panel review

