NZGS Specification

NZGS_0200 GROUND INVESTIGATIONS

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NEW ZEALAND GEOTECHNICAL SOCIETY INC

A Collaborating Technical Society of Engineering New Zealand

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NZGS_200.1 Introduction

This specification has been written for use in ground investigations undertaken within New Zealand. It is intended for contracts of any size, with an emphasis on encouraging carefully designed, safely executed, consistently high quality and cost effective work.

The specification is independent of the conditions of contract; it is intended to work in conjunction with NZS3910, other general conditions of contract or purchase order that is appropriate for the scale of project.

The full specification comprises a number of inter-related components that, when used together, provide the best opportunity to achieve a quality ground investigation and a simpler, clearer and more consistent tendering process for all parties.

NZGS_200.1.1 Volume 0 - Commentary

This volume provides general advice regarding the correct application and use of the Specification and the procurement of geotechnical services. It does not form part of the Specification, although the Specification is intended to be read in conjunction with this document.

This document is not a guide to the management or implementation of ground investigations, or the interpretation and development of ground models. For more information on this the reader should consult one of the many text books on the topic. One example is Simons, et al, 2002. The NZGS/MBIE Earthquake Geotechnical Engineering Practice Module 2: ‘geotechnical investigation for earthquake engineering’ provides an excellent introduction with a New Zealand emphasis.

This volume also provides (as appendices) a set of standard templates and guidance which may be useful in improving the consistency of ground investigation practice but do not form part of the specification. This allows the consultants involved to use their own preferred templates where they already exist or where they are more appropriate for the project and site requirements.

NZGS_200.1.2 Volume 1 – Master specification (this document)

The Specification comprises a series of clauses which are intended as minimum requirements. These minimum requirements have been set for the geotechnical investigation techniques which are most commonly used in New Zealand. It is implicit that only the sections relevant to the specific investigation being undertaken are applied to a particular project.

The Specification is fixed in content and scope; project specific requirements, including identification of which sections of the Specification are relevant to that project, are defined in the Project Specific Requirements. This way the Specification can be scaled to suit a range of project sizes.

Associated with the Specification are notes which clarify the intent of the clauses, provide background on why they are worded in a specific manner, or give best-practice advice and/or clarification of general principles where the authors think this is valuable. They do not form part of the Specification or contract.

It should be noted that this document is not intended as a manual for ground investigation. The notes given are for clarity only. There are numerous other references available which provide more detail on the ground investigation process and specific methodologies which should be referred to if additional information is required.

> Notes for guidance are presented in blue boxes similar to this example. They do not form part of the Specification or contract.

NZGS_200.1.3 Volume 2 – Project Specific Requirements

The Project Specific Requirements document is an MS Word format template designed to be completed by the client and geotechnical professional to give details on which aspects of the Specification will apply to the project, and any changes to the standard wording. This template is available from the NZGS website.

NZGS_200.1.4 Volume 3 – Bill of Quantities

An example of Bill of Quantities is provided, together with a preamble which defines payment terms. The bill of quantities is designed to be compatible with the Specification and allow easy management of a ground investigation by defining consistent payment and measurement methods. It is also the preferred tool to clearly define the scope of work to the consultant or contractor. Some parties may choose to use the specification alone with their own alternative method of measurement. This template is available from the NZGS web site.

NZGS_200.2 General

NZGS_200.2.1 Codes of practice

Except where otherwise specified all work shall be carried out in accordance with the relevant New Zealand Standard or guidance document. Where no New Zealand Standard applies, the Geotechnical Professional shall select an appropriate standard or guidance document from the following:

1. International (ISO) Standards
2. ASTM Standards
3. Australian Standards
4. Any other appropriate internationally recognised codes of practice or guidelines.

NZGS_200.2.2 Roles and responsibilities

All parties shall comply with all relevant safety legislation, including the Health and Safety at Work Act 2015 and any subsequent amendments.

The Consultant, Contractor and Laboratory shall be responsible for providing suitably qualified and experienced staff to manage and undertake their components of the proposed work.

The Client (Principal in the NZS3910 terminology) shall:

1. Allow adequate time and budget for the works to be undertaken in a safe and responsible manner.
2. Nominate a Project Manager who will be responsible for ensuring all of the Client's responsibilities and obligations under this contract are met.
3. Immediately notify the Consultant and Contractor should the Project Manager described above change.
4. Be responsible for preparing or procuring the Site Information Pack as defined in Section 2.3.

The consultant shall:

1. Design a Ground Investigation which meets the needs of the project, including design and risk management.
2. Have the responsibilities of a designer in the Health and Safety at Work Act 2015 and must, so far as is reasonably practicable, confirm that the investigation (including selected locations, access routes and equipment) is designed to comply to the Act.
3. Undertake and document a risk assessment for the designed Ground Investigation and highlight to the Client and Contractor all site risks they are aware of, in particular any uncommon or site-specific risks such as geothermal activity.
4. Check that all required health and safety notifications have been completed prior to commencement of physical works.
5. Assess the need for consents and check that all required consents are obtained before works commence.

6 Provide a named Geotechnical Professional for the project.
7 For work on contaminated sites, provide a named Suitably Qualified and Experienced Practitioner (CL-SQEP) in contaminated land.
8 Provide one or more Site Representatives nominated by the Geotechnical Professional and/or CL-SQEP to provide instructions on site.

> On small projects the Site Representative may be the Geotechnical Professional or CL_SQEP.

9 Immediately notify the Client and Contractor in writing should any of the named Professionals, Practitioners or Representatives described above change.
10 Check that the works are carried out in accordance with the Contract, Specification and Bill of Quantities.

The contractor shall:

1 Be in control of health, safety and environmental management of the site, unless the project specific requirements state otherwise, in which case the Contractor shall follow all reasonable instructions given by the person in control of the site.
2 Nominate a Site Manager who will be responsible for ensuring all of the Contractor's responsibilities and obligations under this contract are met on site. The Site Manager shall be based on site during execution of the physical site investigation works.
3 Immediately notify the Client and Consultant should the Site Manager change.
4 Take all practical steps to make the site and working environment safe.
5 Undertake and document a risk assessment for all scheduled work, taking into account the risks highlighted by the Consultant.
6 Provide a method statement covering all aspects of the work and a copy of the risk assessment to the Client and Consultant for comment before commencing physical work.
7 Review and amend the risk assessments and method statements if the methodology or conditions change.
8 Check to the best of their ability that the Consultant and Client have arranged the necessary permits and consents required for undertaking the proposed investigation works prior to starting work.
9 Hold a pre-start/toolbox meeting on site at the start of each day and at each new site before starting any physical work or unloading any equipment. This meeting shall cover as a minimum:
   a. the site hazards and current methods of hazard mitigation
   b. acceptable access routes
   c. no-go areas
   d. requirements for contaminated land
   e. instructions for interactions with the public.
10 Create a record of all pre-start meetings and site inductions and provide the record to the Geotechnical Professional on a weekly basis.

11 Control and induct all visitors to the site, and take all practical steps to make sure that all those working on or visiting the site are aware of (and following) the rules governing site safety and personal protective equipment, are properly supervised and not unnecessarily exposed to hazards.

All Site Staff shall be provided with Personal Protective Equipment by their employer appropriate to the work involved and the classification of the site.

NZGS_200.2.3 Site-specific hazards and constraints

The client shall:

1 Create, or engage a Consultant to create, a Site Information Pack containing site details, access instructions and known or suspected site hazards and constraints including details of the following issues as applicable:

   a. Buried and overhead services (including all available service drawings).
   b. As-built drawings of existing or demolished structures.
   c. Flooding.
   d. Artesian or geothermal conditions.
   e. Contamination.
   f. Unexploded ordnance.
   g. Archaeology.
   h. Ecology, including any protected flora or fauna.
   i. Livestock.
   j. Other parties site usage during the Ground Investigation, and their contact details where known.
   k. Acceptable access routes and property access requirements.
   l. Exclusion zones.
   m. Working hours.
   n. The nature and times of general use of the site by the public.
   o. Noise, dust and/or vibration limitations.
   p. Activities in adjacent properties or sites.
   q. Client or site-specific health and safety requirements.
   r. Any other statutory authority, environmental or social requirements.

2 Provide the Site Information Pack to the Consultant and Contractor before tendering or as part of the invitation to tender.

3 Issue addendums or additions to the Site Information Pack as soon as practicable as new information becomes available.

> Some Clients may choose to provide this information in another format, typically as part of the contract. This is reasonable as long as it contains all the relevant information and is updated if the information changes.

The consultant shall:

1. Review the Site Information Pack
2. Report to the Client and Contractor any errors or omissions identified in the Site Information Pack.

The contractor shall:

1. Review the Site Information Pack
2. Report to the Client and Consultant any errors or omissions identified in the Site Information Pack.

NZGS_200.2.4 Existing utility services

The Client will endeavour to provide in the Site Information Pack all information in their possession about utility services on the site. This information should not be taken as a complete, comprehensive or accurate record and does not in any way relieve the Contractor or Consultant of their obligations described here.

It is the responsibility of the Contractor to identify the presence of, and locations of, all services prior to commencing work on site and arrange any necessary exploratory work, location, protection, isolation, off-setting, temporary diversion, reinstatement or alterations required.

Intrusive investigations shall not commence until the presence or absence of services and utilities has been assessed and an appropriate risk assessment undertaken. Records shall be kept by the Contractor of all activities undertaken for service location. These shall include a Permit to Dig and marked up plans (as described in Volume 0 Appendix B, or the project specific management plan approved by the Client and Geotechnical Professional).

Prior to commencing intrusive work the Contractor shall assess the validity of previous work undertaken to identify and mark services, taking into account the length of time that has passed since the work was undertaken. In case of any doubt this work should be repeated.

> If service location and mark out does not happen immediately before intrusive investigation there is a risk that marks may become obscured, pegs may be moved, or new services may be installed. To reduce this risk the service mark out should happen as close to the time of the investigation as feasible. The amount of time that a service location and mark out will remain valid depends on many factors including the weather and how many people can access the site.

Each intrusive Exploratory Location shall be checked and cleared for buried services prior to starting the test. Where the risk is considered to be medium or higher, or where records are unclear or doubt remains, a pit shall be excavated using non-destructive techniques (such as hand excavation or vacuum excavation) to at least the depth of the deepest likely service to visually check for services at each test location.

> An indication of what is considered medium or high risk is given in Volume 0 risk assessment matrix. This approach is not appropriate in all cases and may be replaced by a project or site-specific variant or an alternative approach to managing the risk.
>
> Non-destructive techniques can vary from site to site and will depend on the ground conditions and the likely services. They should generally not include metal tools with sharp edges unless a risk assessment shows that these are the only appropriate method for the conditions and that the risk of harm to the operator is very low.

For all Intrusive Ground Investigations, except Test Pits and Trenches, the diameter of the inspection pit shall be greater than the largest item of equipment to be inserted into the ground as part of the works.

For Test Pits and Trenches, any suspected services within 5 m of the proposed Exploratory Location shall be physically located by hand excavation or similar non-destructive techniques to visually confirm their position. This step may be omitted (with the prior permission of the Geotechnical Professional) if the risk is low.

NZGS_200.2.5 Social and environmental

No vegetation clearance or soil disturbance shall take place without prior approval from the Client. Any vegetation clearance must be in accordance with the Consent requirements and Local Authority guidelines.

Storage of vehicles, equipment or materials within the dripline of trees is prohibited without the prior approval of the Client. No Exploratory Locations shall be set within the dripline of any trees without the approval of the Client and, where local regulations require, the Local Authority.

The Contractor shall assess the potential for any fluids including drilling muds or sediment to enter the surrounding environment, waterways or stormwater systems and report the results of this assessment with proposed mitigation measures to the Client and Consultant as part of their tender or proposal for the work.

The Contractor shall provide appropriate measures to prevent or minimise sediment generation and silt run off, and comply with all consent requirements and other statutory authority requirements relating to carrying out earthworks.

No discharge of sediment, drilling mud or other fluids to waterways, catch pits or drains will be accepted unless the Contractor can demonstrate to the Geotechnical Professional that they have all the appropriate approvals, including from the Local Authority, Regional Council and asset owner.

All sediment control measures shall be removed by the Contractor once the reinstatement is complete unless otherwise agreed with the land owner.

The Contractor shall consider and make due allowance to mitigate all adverse impacts associated with:

1 Noise.
2 Vibration.
3 Dust.
4 Traffic flow.
5 Disruption to public and businesses.
6 Proximity to receptors of pollution including exhaust fumes.

The Contractor shall keep noise at a level appropriate to the surrounding environment and, where near sensitive receptors, shall minimise the effects of noise by appropriate planning, the careful selection and placement of plant, programming the sequence of operations and use of barriers.

The noise generated from drilling works shall comply with the requirements of NZS 6803; Resource Management Act sections 326, 327 and 328; and the Health and Safety in Employment Regulations clause 11, and any specific requirements set in the prevailing Local Authority bylaws.

> Reference should be made to the NZ Transport Agency State highway construction and maintenance noise and vibration guide.

NZGS_200.2.6 Site access

Only the agreed access routes as defined in the Site Information Pack shall be used.

The Contractor or Consultant shall not access the site prior to receiving the approval of the Client and land owner.

The Contractor shall assess the risk of harm or damage occurring to other site users including livestock and, in consultation with the Client, Consultant and other site users, shall fence or otherwise isolate the site as appropriate.

All barriers breached or disturbed during the work shall be immediately repaired or replaced to at least same standard that existed prior to commencing the physical site works.

Set back limits around works areas should take into account contaminant exposure hazards.

NZGS_200.2.7 Traffic management

The Contractor is responsible for identifying the need for traffic management and applying for the relevant permits to work in the road corridor.

Traffic management shall be provided by the Contractor for all locations as required by the Local Authority, Road Controlling Authority and/or NZ Transport Agency.

NZGS_200.2.8 Working hours

Working hours shall be limited to those specified in the Site Information Pack.

Where the Local Authority, landowner or other stakeholder has specific working time constraints that are more restrictive than those set in the Site Information Pack (eg in setting traffic management timings to minimise disruption) the more restrictive constraints shall take precedence.

The Contractor and Consultant shall monitor the hours worked by their staff, including travel, and implement a fatigue management plan if any person works and travels for more than 12 hours in a day, works for more than six days without a break, or has less than twelve hours rest between shifts including travel.

NZGS_200.2.9 Water supply

It may be necessary for the Contractor to deliver water by truck alone, or by truck to a temporary storage tank. The rate provided by the Contractor shall include the supply of water required to complete the work, and obtaining any permissions required.

Water extraction from watercourses is not permitted unless prior Resource Consent has been granted (where required).

The Contractor shall specify in their methodology the source of the water and provide confirmation of the applicable permissions and consents before work commences.

> Not all water sources are appropriate. For example, sea water is not appropriate in most cases for use to develop an environmental monitoring well. Extracting water from local waterways may be socially or environmentally unacceptable even if the water quality is appropriate for the intended use.

NZGS_200.2.10 Disturbance and inconvenience

The Contractor shall minimise, as far as practicable, nuisance and danger to nearby residents, the public, the environment and businesses.

The Contractor shall make all reasonable efforts to avoid vehicles servicing the site depositing material on public or private thoroughfares. Such material is to be controlled and removed by the Contractor to the satisfaction of the appropriate authorities and the Site Representative. As a minimum, such material should be removed each day prior to leaving the site; the frequency may need to be higher if the road is heavily trafficked or there are any safety concerns.

NZGS_200.2.11 Accidental discovery of possible archaeological sites, koiwi or taonga

> It is an offence under S87 of the Heritage New Zealand Pouhere Taonga Act 2014 to modify or destroy an archaeological site without an authority from Heritage New Zealand Pouhere Taonga (HNZPT) irrespective of whether the works are permitted or a consent has been issued under the Resource Management Act.
>
> Where an archaeological authority has been granted by Heritage New Zealand any material finds within the specified extent of that authority are covered by the conditions of that authority, and this Accidental Discovery Protocol does not apply.
>
> However, in situations where there is no archaeological authority and potential archaeological sites and objects are found, including taonga and koiwi, the following procedure will apply.

Immediately following the discovery of material that could be an archaeological site, koiwi and/or taonga, the Consultant and Contractor shall cease all work within 20 m of any part of the discovery area and immediately advise the Client of the discovery.

The Consultant shall then notify all of the following people of the discovery:

1. The New Zealand Police if any Koiwi are uncovered. This is a requirement of the Coroners Act 1988.
2. The Project Archaeologist, if nominated in the contract documents. If a Project Archaeologist is not nominated in the contract documents, the Client will appoint a qualified archaeologist to ensure all archaeological sites and Taonga Tūturu are dealt with appropriately.
3. The Regional Archaeologist at HNZPT (Heritage New Zealand Pouhere Taonga).
4. Appropriate iwi group(s) or kaitiaki representative.

The Contractor shall secure the discovery area, ensuring the area (and any objects contained within) remains undisturbed and meets health and safety requirements.

The Client, Consultant and Contractor shall work together to identify the next steps in accordance with the Clients' standards or rules. Where such documentation does not exist reference shall be made to the Local Authority guidelines and the NZ Transport Agency Minimum Standard P45 – Accidental Archaeological Discovery Specification.

NZGS_200.2.12 Unforeseeable conditions and obstructions

If unexpected conditions or obstructions are encountered the Contractor shall immediately inform the Site Representative.

> Unexploded ordnance has been found on ground investigations in New Zealand. Although less common than in Europe and the UK, encountering UXO can lead to delays and increased costs,

> especially during ground investigation and groundwork stages, as well as significant health and safety issues. In most cases, these issues can be avoided if a proactive approach is taken comprising UXO risk assessments and if appropriate risk management procedures carried out at the initial stages or during planning. Further advice is available from the UK Association of Geotechnical & Geoenvironmental Specialists at https://www.ags.org.uk/item/guidance-on-the-risk-of-unexploded-ordnance-uxo/

Exploratory Locations terminated early for any reason shall be measured for payment only if they are terminated with the permission of the Site Representative, fully documented and properly reinstated.

NZGS_200.2.13 Reinstatement and damage

The Contractor shall give the Site Representative opportunity to take photographs of each Exploratory Location before works commence.

> It is good practice to take before and after photographs of each Exploratory Location to allow easy re-finding of investigation locations after time has passed and to simplify disputes over land damage caused by the investigation.
>
> These photographs should be named using the same naming convention as the Exploratory Location and shall show the pre-works condition of the site before the Contractor made access with any plant, and after immediate reinstatement activities have been completed. Where possible these photographs shall contain some background context and be taken from sufficient distance to allow easy reorientation during future site visits.

Any damage, or claim by third parties for compensation for damage, shall be reported to the Site Representative.

On completion of the works, the Contractor shall restore the site to its original condition before its occupation unless other reinstatement options are stated in the Project Specific Requirements.

The Contractor shall make good any damage to the satisfaction of the Site Representative.

The Contractor shall not leave any litter, debris, equipment or above ground obstructions with the exception of approved structures such as upstand piezometer or inclinometer covers.

NZGS_200.2.14 Surface materials and reinstatement

NZGS_200.2.14.1 Topsoil

Any topsoil stripped at the site and intended for replacement shall be stockpiled separately from other materials.

Topsoil adjacent to an Exploratory Location which may be damaged by the works shall either be removed and stockpiled, or otherwise protected from damage.

After completion of work at the Exploratory Location the topsoil shall be replaced, levelled, and seeded with vegetation to match the existing. If contaminants are identified within the topsoil the CL-SQEP shall advise whether the existing topsoil may be reinstated or whether it shall be replaced with imported topsoil, and shall define the required remedial and material disposal measures.

NZGS_200.2.14.2 Paved areas

Paved areas (other than paving slabs or blocks) shall be broken out or cored to the minimum extent necessary.

After completion of the work at the Exploratory Location, the paved area shall be reinstated to match the existing unless other reinstatement options are stated in the Project Specific Requirements.

Any settlement of the paved area in the location of the exploratory hole within the defects liability period shall be reinstated by the Contractor at their own cost.

NZGS_200.2.14.3 Paving slabs and blocks

Paving slabs or blocks shall be removed at the site of each Exploratory Location and stored for reuse.

Paving slabs or blocks adjacent to an Exploratory Location which may be damaged by the works shall either be removed and stored for reuse, or otherwise protected from damage.

After completion of the work at the Exploratory Location the paving slabs or blocks shall be re-laid to match the existing unless other reinstatement options are stated in the Project Specific Requirements.

NZGS_200.2.15 Disposal of arisings

> If off-site disposal of arisings is planned, then a review of the risk of contamination should normally be undertaken before work commences to assess the most appropriate repository. A contaminated land management plan may be required if there is a risk of contaminated soil or water.

With the exception of material replaced in the borehole or stored for future reference, the Contractor shall safely dispose of all borehole cuttings, spillage and used drilling fluids offsite at an approved disposal facility.

Contaminated waste materials shall be disposed of at a facility licensed to accept waste of that nature. Unless the Client specifies locations for disposal of arisings, the Contractor shall be responsible for identifying a suitable facility licensed to take waste of the anticipated nature.

NZGS_200.2.16 Equipment and materials

The Contractor is responsible for the provision, purchase and mobilisation of all necessary equipment and material to carry out the works. The Contractor is responsible for ensuring that all material and equipment are suitable for the works being undertaken and capable of achieving the objectives set out in the Contract.

The Contractor is responsible for transportation of equipment to and from site and between Exploratory Locations.

The Contractor is responsible for the maintenance of the equipment in good working order for the duration of the Ground Investigation.

NZGS_200.2.17 Qualifications of field staff

All Field Staff shall attend an induction before commencing any work. The induction shall be managed by the Contractor and shall explain the project specific hazards and mitigation measures.

All Drillers shall hold a current New Zealand or Australian Certificate in Drilling (Level 4 or higher). For works commencing before 2019 this requirement may be waived if the Contractor can demonstrate that the proposed Drillers have an equivalent level of experience.

All Drillers' Assistants shall hold a current New Zealand or Australian Certificate in Drilling (Level 3 or higher), or be enrolled on a course to obtain this qualification. For works commencing before 2019 this requirement may be waived if the Contractor can demonstrate that the proposed Drillers' Assistants have an equivalent level of experience.

All CPT ~~Operators~~ Contractors shall have at least one operator or representative that holds a current CETANZ membership. CPT Contractors shall have demonstrated that they comply with ISO 22476-1:2012 and CETANZ TG6, or otherwise shall have IANZ accreditation for ISO 22476-1. Contractors that have met these requirements are listed on the CETANZ website.

All drill rig and plant operators shall have documented evidence of training on the specific machine they will operate. This should be a Manufactures Operators Competency Certification (MOCC) where available, or training from an experienced operator of the machine where a MOCC is not available.

Prior to commencing work the Contractor shall provide evidence that all drill rig and plant operators have experience of working in the conditions anticipated on the project. Work in any of the following situations will require prior experience in a similar situation. Where this experience is not available the Contractor shall arrange a supervisor with the relevant experience to be present on site at all times.

1. Working over water or within the inter-tidal zone
2. Working on very soft ground
3. Working within the corridor of a high-speed road
4. Working within a railway corridor

5 Working on contaminated sites or landfills
6 Working on slopes over 20 degrees
7 Working on or adjacent to landslides
8 Working in limited access areas or confined spaces
9 Working in close proximity to busy, publically accessible areas

Additional safety requirements are required for working in geothermally active areas. See Project Specific Requirements.

All staff undertaking geotechnical logging, testing or sampling shall be assessed and confirmed as competent by a Geotechnical Professional.

All staff undertaking geoenvironmental logging, testing or sampling shall be assessed and confirmed as competent by CL-SQEP.

NZGS_200.2.18 Daily site log

The Contractor shall maintain a Daily Site Log with each drill rig or other investigation plant (eg excavator, CPT rig etc).

The Daily Site Log shall be used to record:

1 Contractor's name.
2 Contract number.
3 Client's project number.
4 Project Name.
5 Exploratory Location IDs.
6 Plant type, operator, hours worked.
7 Date of operation and weather conditions.
8 Details of any delay and standing time, giving reasons.
9 All verbal or written instructions.
10 Progress.
11 Results of all testing undertaken.
12 Number and type of all samples taken.
13 Groundwater level measurements.
14 Decontamination undertaken.
15 Consumables used.
16 Time travelled between sites.
17 Copies of all permits, including a Permit to Dig for each Exploratory Location.
18 Any other information relevant to the Geotechnical Professional's assessment of payments.

The Contractor shall submit one copy of their Daily Site Log to the Geotechnical Professional. These records are to be submitted within five working days of the day being reported.

NZGS_200.3 Investigation of contaminated sites

NZGS_200.3.1 References

- NZS 4411:2001. Environmental Standard for Drilling of Soil and Rock.
- AS/NZS 5667. Water Quality – Sampling.
- Ministry for the Environment, Contaminated Land Management Guideline No. 1, Reporting on Contaminated Sites in New Zealand.
- Ministry for the Environment, Contaminated Land Management Guideline No. 2, Hierarchy and Application in New Zealand of Environmental Guideline Values.
- Ministry for the Environment, Contaminated Land Management Guideline No. 5, Site Investigations and Analysis of Soils.

NZGS_200.3.2 Health and safety

The Client and Consultant shall identify known or suspected contamination in the Site Information Pack.

The Contractor shall propose equipment and methodology for use on the site and undertake a site-specific risk assessment to demonstrate that the equipment is appropriate for the risks.

> Certain equipment can introduce unacceptable risks particular to contaminated land. For example, where there is potential for an explosive atmosphere specialist equipment is normally required.

NZGS_200.3.3 Equipment

Soil sampling tools (hand augers, spades, trowels and corers) and other equipment in contact with the ground to be sampled (such as breaker bars) shall comprise clean, unpainted stainless steel.

Monitoring equipment used in groundwater investigations such as water level probes, sample collection pumps and tubing should be selected to minimise the risk that contaminants from the sampling equipment biases samples.

> Equipment for use during contamination investigations should be selected to minimise the risk that the equipment introduces contaminants into the samples, as this provides a potential source of bias during contaminated land investigations, particularly where low levels of analytical detection are required.

All equipment used for contaminated land investigations must be maintained and calibrated in accordance with the manufacturer's specifications and records of calibration should be maintained and available on request.

Field Staff shall implement appropriate decontamination protocols to prevent cross-contamination between sampling points as follows:

1. Loose material shall be washed from the equipment
2. The equipment shall be thoroughly washed using a decontamination agent wash, followed by a potable water rinse and finally a distilled and deionised (DDI) water rinse.
3. If specified by the CL-SQEP in the Project Specific Specification further steam cleaning and/or methanol rinses may be applied prior to final rinsing with DDI water to remove heavy contamination.

The effectiveness of these decontamination protocols shall be checked through the regular use of quality assurance sampling.

NZGS_200.3.4 Methodology

NZGS_200.3.4.1 General

> All contaminated land site investigations should be designed in accordance with the principles outlined in Contaminated Land Management Guideline No. 5, Site Investigations and Analysis of Soils. The site investigation should align with the conceptual site model and with the engineering design if known.
>
> Uncontaminated ground should not be put at risk of becoming contaminated. Suitable procedures to avoid this will be site and contaminant specific, but may include plastic sheeting laid down beneath plant, spoil and core boxes.

Contaminated arisings shall be isolated from uncontaminated ground and water.

Spoil from drill holes may be returned to the drill hole if approved by the CL-SQEP. If the site does not have surface contamination, do not place contaminated or potentially contaminated spoil at the surface. A minimum of 300 mm of clean fill should be placed at the surface.

Any spoil disposed of off-site should be removed to a suitably licensed disposal facility.

NZGS_200.3.4.2 Groundwater investigations

> Where groundwater investigations are undertaken as part of the contaminated land investigations, it is recommended that a minimum of three groundwater wells be installed in positions and screened at depths which align to the conceptual site model.

All groundwater samples shall be collected from groundwater monitoring wells.

> Groundwater analysis can be biased where the monitoring wells are not constructed appropriately. The results of groundwater analysis collected from test pits or directly from boreholes immediately following drilling do not provide a reliable indication of contamination concentrations and should not be used to assess contaminant concentrations.

NZGS_200.4 Logging

NZGS_200.4.1 References

- NZGS, 2005. Field Description of Soil and Rock, Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes', New Zealand Geotechnical Society.
- AS/NZS 1547:2012. On-site domestic wastewater management.
- BS 5930:2015. Code of practice for ground investigations. Only for use on aspects not covered by the NZGS 2005 guide
- ASTM D5434-12. Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock. Only for use on aspects not covered by the NZGS ~~2005~~ guide.

NZGS_200.4.2 Methodology – logging

Where joint geotechnical and contaminated land ground investigations are being completed, Field Staff undertaking logging of core or samples must be sufficiently trained to log both geotechnical and environmental observations. Particular note and record should be made during logging of discolouration, odours or evidence of waste materials such as glass, metal fragments, wood, fibrous materials, rubber and plastic, municipal waste and sheens.

All core and samples shall be logged in accordance with the NZGS ~~(2005)~~ Field Description of Soil and Rock. Where the soakage characteristics of the surficial materials are of consequence to the project the near surface material (depth to be confirmed by Geotechnical Professional) shall also be logged in accordance with AS/NZS 1547 Table B2 and classified according to Table E1. Wherever possible, fill shall be described as a soil in accordance with the NZGS ~~(2005)~~ guidance.

> Fill should be described in full as a geotechnical material (eg gravelly silt), and not simply as fill. It should be identified as fill by putting fill as the geological unit.

The Geotechnical Professional shall arrange full-time supervision of all test pits, and all boreholes where sample recovery is intended.

Logging shall take place on site within one hour of each sample being recovered to the surface.

> Significant changes can occur in a sample once exposed to the atmosphere and as a result of stress reduction. Logging as soon as the sample is recovered allows a significantly better assessment of the in-situ condition. Full-time supervision improves logging quality and allows field staff to take into account changes in drilling conditions that would not otherwise be recorded.
>
> In some circumstances full-time supervision may not be essential. This can be specified in the Project ~~S~~ specific Requirements (Volume 2).

NZGS_200.4.3 Methodology – photographs

Sharp colour photographs shall be taken by the Consultant of:

1. Every Exploratory Location before works commence and after remediation.
2. Every box of core
3. At least one face of each test pit or trench (with a scale eg survey staff/measuring tape) and at least one photo of the arisings from each test pit or trench.
4. Arisings from each hand auger, laid out in depth order.

Each photograph shall be:

1. In JPG format.
2. At least 5 million pixels in resolution.

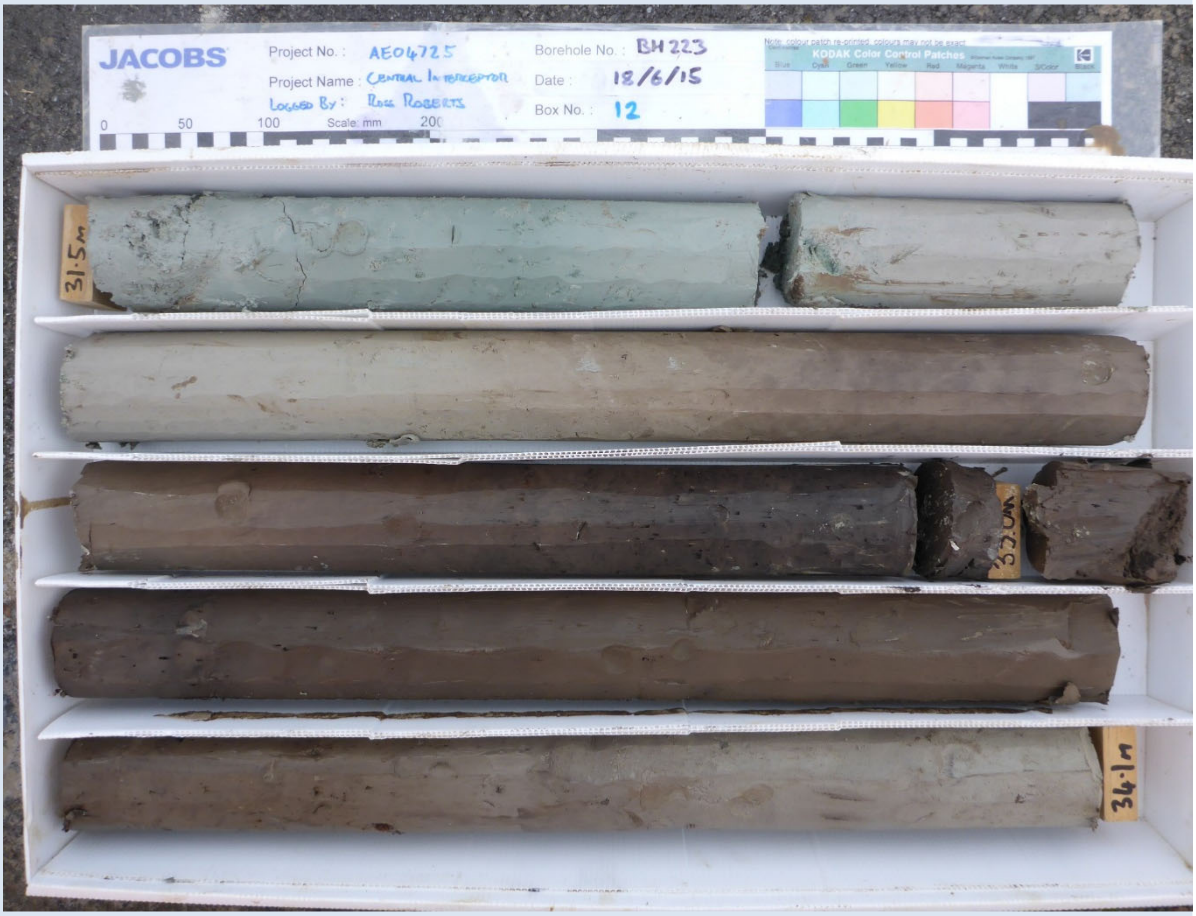
Before and after photographs of each Exploratory Location shall contain sufficient background context to enable easy re-location.

The Consultant shall make sure that the following criteria are met for all photographs of core, samples, or arisings:

1. Photographs are taken in landscape orientation with the shallowest material at the top left.
2. Core boxes are evenly and consistently lit.
3. The focal plane of the camera and the plane of the core box are parallel.
4. The length of each core box in each photograph fills the frame.
5. The camera is placed in the same position with respect to the core box in every photograph.
6. The core is not obscured.
7. The core is in a clean and as undisturbed state as possible (ie before probing, sampling etc, but after placing in the box and cleaning or scraping to remove drill cuttings).
8. The following are provided and clearly legible in the photograph:
   a. A standard colour chart.
   b. A label identifying the project title, Exploratory Location number, date and depth(s).
   c. A graduated scale in millimetres.

> Taking quality core box photographs:
>
> - High contrast images, particularly with sunlight and shadows, result in loss of detail and poor colour rendition. The Consultant should attempt to take all photos in the same lighting conditions, avoiding direct sunlight, to avoid differences in light suggesting a difference in material
> - Photographs should be taken after any drilling-induced smearing is removed and before core wrap is applied. The core should be moist when photographed as the colours will change significantly on drying.

Photographs should be taken before the soil or rock is damaged by testing (except as required to fit in the core box). The example below shows some damage that should not have occurred until after the photograph was taken. Where internal structures are likely to be present the core may be split; photographs should be taken before and after to show the structure.



NZGS_200.4.4 Reporting

All logs shall include the following minimum information:

1. Project name.
2. Client's project number.
3. The name (not initials) of the person responsible for logging the soils encountered.
4. The name (not initials) of the Geotechnical Professional or CL-SQEP who reviewed the logs.
5. The start and finish date of the drilling/excavation.
6. The position of the Exploratory Location (coordinates and reduced level).
7. The horizontal and vertical datum of the coordinates and levels.
8. For New Zealand Transport Agency (NZTA) projects, the State Highway Route Station and Position (SH/RS/RP).

9 For KiwiRail projects the track kilometre location, the horizontal offset from the track centre line, and the vertical offset from the top of rail level.
10 Plant type/size.
11 The soil description of the material encountered, separated into distinct layers with the top and bottom depths of each layer being recorded.
12 Drilling fluids used.
13 Groundwater encountered.
14 The depth at which drilling stopped and the reason why the hole was terminated (eg target depth, hole collapsing, unable to drill further, stopped due to obstruction, etc).
15 In-situ testing and sampling shall be included on the log at the relevant depths. Calibration details of testing equipment including SPT hammers and shear vanes shall be attached to each log.
16 Backfill details (eg backfilled with arisings/backfilled with compacted hardfill, etc).

For logs of Trial Pits or Trenches, in addition to the minimum details for all Exploratory Locations, the following information shall be recorded on each log:

1 Dimensions (length x width x depth) in metres.
2 Orientation of the longest face of the test pit (in degrees from north).
3 Depth to water inflow/outflow and standing water depth.
4 Sketch of pit side wall (or a marked up photograph) showing layer variability.

NZGS_200.5 Hand augering

NZGS_200.5.1 Health and safety

Each Exploratory Location shall be visually checked for overhead hazards, particularly power lines and/or trees.

Tests shall not exceed 5 m in depth unless site-specific health and safety measures are implemented to mitigate the manual handling risk.

Depending on the ground conditions and depth the manual handling of the rods can become hazardous and the amount of squeezing on the head can increase, making extraction of the auger difficult and potentially causing back strains.

NZGS_200.5.2 Methodology

Hand auger holes shall be backfilled on completion, with arisings from the same hole or with sand as defined in the Project Specific Requirements.

NZGS_200.5.3 Reporting

All logs shall include the following minimum information:

1. Project name.
2. Client's project number.
3. The name of the person responsible for logging the soils encountered.
4. The name of the Geotechnical Professional who reviewed the logs.
5. The start and finish date of the drilling/excavation.
6. The position of the Exploratory Location (coordinates and reduced level).
7. The horizontal and vertical datum of the coordinates and levels.
8. For NZTA projects, the State Highway Route Station and Position (SH/RS/RP).
9. Equipment type/size.
10. The soil description of the material encountered, separated into distinct layers with the top and bottom depths of each layer being recorded.
11. Groundwater encountered.
12. The depth at which drilling stopped and the reason why the hole was terminated (eg target depth, hole collapsing, unable to drill further, stopped due to obstruction, etc).
13. In-situ testing and sampling shall be included on the log at the relevant depths.
14. Backfill details (eg backfilled with arisings/backfilled with compacted hardfill, etc).
15. Where a DCP test is undertaken within 1 m of an auger hole, the DCP test results should be included on the hand auger log.

NZGS_200.6 Drilling

NZGS_200.6.1 General

NZGS_200.6.1.1 References

- NZS 4411:2001. Environmental standard for drilling of soil and rock.
- ASTM D2113-06. Practice for diamond core drilling for site investigation.

NZGS_200.6.1.2 Health and safety

The Contractor shall provide the Geotechnical Professional with Safety Data Sheets (as defined by Worksafe New Zealand) for all additives and other potentially hazardous substances proposed to be used on the project, prior to the commencement of any drilling work.

All drill rigs shall be appropriate for the proposed scope and have a current WOF/COF if mounted on a road-going vehicle.

The drill rig must be able to reach the contracted borehole depth within the manufacturer's rating of the machine.

All rotating parts must be guarded, including the drill string when being rotated (except when being rotated to unscrew rods, in which case the rotation should be at the minimum speed possible). This requirement may be disregarded in exceptional circumstances if both the following apply:

1. there is no suitable equipment available; and
2. the Contractor can present suitable alternative mitigations to the satisfaction of the Geotechnical Professional and Client that complies with AS/NZS 4024 and Regulation 11 of the Health and Safety in Employment Regulations 1995.

The drill rig must be free from any oil leaks, excessive noise, dust or smoke.

> For information about noise levels see the Health and Safety in Employment Regulations 1995, Regulation 11.

NZGS_200.6.1.3 Social and environmental

The Contractor shall ensure that all proposed additives are either biodegradable or water soluble and environmentally appropriate.

The Contractor shall arrange for the collection and proper removal and disposal off-site of drilling mud, additives or foam returns.

The Contractor shall excavate re-circulation pits and/or provide re-circulation tanks at the drillhole locations if flush returns cannot be discharged safely, or if instructed by the Site Representative.

Where there is the potential to encounter artesian groundwater, the Contractor shall have a pre-defined methodology to safely control the water and have all the required equipment on site.

NZGS_200.6.1.4 Equipment – general

Drilling rigs and major items of equipment, such as core barrels and field testing equipment, shall have unique identification numbers displayed clearly on them.

Where appropriate, the equipment supplied by the Contractor shall be available for use by the Consultant or Client's Field Staff when required for the duration of the works. The Contractor may refuse to allow their equipment to be used if they do not consider the Field Staff to be suitably trained or capable of using the equipment safely.

Before bringing any rig on-site it should be thoroughly cleaned to remove any soil from previous sites. This requirement may be waived at the discretion of the Geotechnical Professional if the Contractor can demonstrate that there is an insignificant risk of cross contamination of chemical or biological material.

The Contractor shall use only non-mineral based lubricants for drilling equipment joints.

All casing, core barrels and drill rods shall be straight and in good condition, and shall be reasonably clean before use (scale, debris, and other loose materials shall be removed).

Only standard metric lengths of casing and drill rods shall be used.

Short lengths of drill rods shall be available.

Short lengths of casing, not greater than the top-drive stroke length, shall be available to enable casing to be advanced after each core run where necessary.

Manufacturers' details, and the specifications of all core barrels and core bits available for use on the Contract, shall be supplied to the Site Representative if requested.

Sufficient spares shall be available at all times.

NZGS_200.6.1.5 Methodology – general

The methodology shall be in accordance with NZS 4411 and ASTM D2113-06, except as modified in this specification.

The Geotechnical Professional shall determine the diameter and method for each Exploratory Location.

Unless stated otherwise, rotary core drilling shall be used for all boreholes.

The Contractor shall inform the Consultant prior to starting work if they believe that the diameter and method(s) of advance of each drillhole are not appropriate to ensure that:

1. It can be completed to the instructed termination requirements or depth.

2 Samples of the specified type and diameter can be obtained.
3 Specified in-situ tests can be carried out.
4 The proposed standpipes, piezometers or inclinometers can be installed.
5 The maximum amount of core and sample can be recovered.

All depths shall be measured relative to the ground level immediately adjacent to the Exploratory Location.

Groundwater observations are to be made and recorded during drilling by the Contractor. The water level in the borehole shall be measured using a calibrated dipmeter and recorded at the beginning and end of each day/shift, and when sudden changes in water level or water loss/gain are experienced. The Contractor shall supply a dipmeter for the measurement of groundwater levels for the duration of the Contract. The time and date of each reading shall be recorded.

The Contractor shall make every effort to maintain a stable borehole at all times. This may necessitate changing the drilling method and methodology, use of casing or drilling fluid additives and the maintenance of a positive drilling fluid pressure head within the bore.

The condition of the core bit in use shall be carefully monitored and if any damage occurs, such as breaking of teeth, it shall be replaced immediately.

NZGS_200.6.1.6 Methodology – flush and water levels

The flushing medium shall normally be clean water, air or air mist. However, with agreement of the Site Representative, non-toxic drilling muds, additives, or air/foams may be used. Where environmental sampling is being undertaken, any additives must be checked to confirm that they will not compromise environmental samples.

The Contractor shall ensure that soil around the bottom of the drillhole is not unduly disturbed by water entering or leaving the hole, or by stress relief. The removal of water from the casing by a rapid withdrawal of rods and/or closely fitting sampling equipment shall be avoided to maintain hydrostatic head.

The water level inside the casing shall be maintained at a level higher than the natural groundwater level unless agreed otherwise with the Site Representative. The water level shall be measured and recorded regularly by the Contractor, including at the start of each day prior to commencing drilling.

NZGS_200.6.1.7 Borehole reinstatement

Unless stated otherwise, boreholes shall be backfilled on completion with a cement/bentonite grout as specified in Section 13.1.1.

NZGS_200.6.1.8 Reporting

The Contractor shall record the following items per borehole in the Drillers’ Log:

1 Rig type and ID.
2 Method of drilling.

3 Depths drilled and lengths of each drill run.
4 Drilling resistance and rate of penetration for each drill run.
5 Depth to bottom of casing during all stages of drilling.
6 Water levels at start and end of shift.
7 Drillers' stratigraphic observations and depths of changes recorded as a log.

NZGS_200.6.2 Rotary core drilling

NZGS_200.6.2.1 Equipment

The core barrels and all accessories and spare parts shall be as supplied or recommended by the manufacturer. Core barrels shall be triple-tube unless specifically agreed otherwise with the Geotechnical Professional.

Each core barrel shall be provided with the full range of core bit types suitable for the various ground conditions anticipated. Spares for each bit type shall be available for use without causing any delay to drilling operations.

NZGS_200.6.2.2 Methodology – core recovery

The core barrel shall be withdrawn and the core removed as often as may be necessary to secure the maximum possible core recovery.

The core barrel shall be removed from the borehole immediately if blocking of the bit or grinding of the core is apparent.

Core runs shall be limited to a maximum length of 1.5 m in soil or 3 m in rock unless specifically instructed otherwise by the Site Representative.

If total core recovery averaged over any ten metre length is less than 95% in Hard Stratum or 80% in other materials, the Contractor is to immediately inform the Geotechnical Professional. The Contractor and Geotechnical Professional shall consider changes in methodology or equipment to improve recovery. Where the Geotechnical Professional determines that failure to achieve the above core recovery is due to inappropriate drilling methods, an additional exploratory hole may be instructed to be drilled at the Contractor's cost.

> For some projects, more stringent core recovery targets may be required. Where different levels of core recovery are required these will be specified in the Project Specific Requirements.

NZGS_200.6.2.3 Methodology – core extrusion

Core is to be extracted utilising the manufacturers approved methodology and not tipped or manually pushed out.

The Contractor shall take care to avoid inducing fractures or other disturbance in the core and shall make the Site Representative aware of any likely areas of drilling induced fractures within the core recovery immediately after it is extracted.

The extrusion piston shall be maintained in proper working order. Rubber O-rings and a sealing screw in plug shall be maintained in good condition so that no water escapes past the piston during extrusion of the cores. Sufficient spares shall be available on site at all times.

The extruder shall apply a continuous pressure to one end of the core while the barrel is in a horizontal position. Only gentle hammering with a wooden mallet on the side of the core barrel to free wedged pieces is permitted. The Driller shall carefully monitor the pressure applied to avoid firing core from the barrel. The barrel shall be pointed away from any sensitive targets during extrusion.

Where air or foam is to be used as the flushing medium, a water supply with complete by-pass system shall also be available and used for extrusion of cores. Under no circumstances shall air pressure be used for the extrusion of cores.

Cores from triple tube barrels with continuous plastic liners shall be carefully removed from the core barrel by hand. Mechanical extrusion of the core and the core liner is not allowed.

NZGS_200.6.3 Rotary sonic core drilling

NZGS_200.6.3.1 Methodology

Drilling runs are not to exceed 1.5 m length in soil or 3.0 m in rock, and the core barrel shall be withdrawn from the hole and core removed as often as needed to ensure optimal quality and recovery of core.

In soils which may be subject to heave the core barrel is to be recovered slowly (<3 m/min velocity) unless agreed otherwise with the Site Representative.

If water is utilised as a preventative measure against excessive heave in the hole, the depths and volumes of injected water must be recorded on the Drillers' Log.

If total core recovery averaged over any ten metre length is less than 95% in Hard Stratum or 80% in other materials the Contractor is to immediately inform the Geotechnical Professional. The Contractor and Geotechnical Professional shall consider changes in methodology or equipment to improve recovery. Where the Geotechnical Professional determines that failure to achieve the above core recovery is due to inappropriate drilling methods, an additional exploratory hole may be instructed to be drilled at the Contractor's cost.

NZGS_200.6.4 Rotary open hole (wash drill)

NZGS_200.6.4.1 Methodology

The equipment, method and rate of drilling shall be such as to recover soil cuttings for logging. The Contractor shall monitor and record drilling resistance, rate of penetration, colour and volumes of flush medium returns. Where changes occur these should immediately be brought to the attention of the Site Representative.

The Contractor shall bag samples at 0.5 m intervals. Each sample shall be:

1. a minimum of 100 grams
2. placed into a clear plastic bag or tub and sealed to be effectively air tight
3. labelled with Exploratory Location ID, depth, date and time.

NZGS_200.6.4.2 Reporting

The Contractor shall report:

1. The depth (relative to adjacent ground level) over which the open hole drilling has been undertaken.
2. The depth (relative to adjacent ground level) of all changes in flush returns colour or volume.
3. The material recovered for each sample.
4. Drilling resistance and rate of penetration every 0.5 m.

NZGS_200.6.5 Percussion drilling

NZGS_200.6.5.1 Equipment

The equipment (eg top drive, down hole, Concentrix) shall be as specified by the Geotechnical Professional.

NZGS_200.6.5.2 Methodology

The equipment, method and rate of drilling shall be such as to recover soil cuttings for logging. The Contractor shall monitor and record drilling resistance, rate of penetration, colour and volumes of flush medium returns. Where changes occur these should immediately be brought to the attention of the Site Representative.

The Contractor shall bag samples at 0.5 m intervals. Each sample shall be:

1. a minimum of 100 grams
2. placed into a clear plastic bag or tub and sealed to be effectively air tight
3. labelled with Exploratory Location ID, depth, date and time.

NZGS_200.6.5.3 Reporting

The Contractor shall report:

1. the depth (relative to adjacent ground level) of all changes in flush returns colour or volume
2. the material recovered for each sample
3. drilling resistance and rate of penetration every 0.5 m.

NZGS_200.6.6 Core orientation

NZGS_200.6.6.1 Equipment

The Contractor and Geotechnical Professional shall agree a specific core orientation tool type suitable for the geological conditions and project requirements. No deviation from the specified tool shall be accepted without prior agreement of the Geotechnical Professional.

NZGS_200.6.6.2 Methodology

The calibration of the tool shall be checked by the drillers and the results reported to the Site Representative prior to commencing drilling each day. The method of calibration shall be agreed with the Geotechnical Professional prior to commencing site work.

Daily calibration checks shall take place with the tool held at the angle of the borehole.

The Contractor shall be suitably experienced in the use of the equipment and take care to limit core disturbance.

The Contractor shall orientate the core, mark either the low side or magnetic north (as agreed with the Geotechnical Professional), and place in core box with the orientation mark facing upwards.

NZGS_200.7 Test pits and trenches

NZGS_200.7.1 Health and safety

No entry shall be made to test pits or trenches greater than 0.5 m deep unless permission is granted by the Site Representative.

When permission is granted to enter the excavation, the individual entering the excavation must check that all of the following apply:

1. No water is flowing into or standing in the excavation.
2. There is no visible evidence of instability or presence of materials considered unlikely to remain stable.
3. Either:
   a. The excavation is not more than 1.2 m deep at the point where the individual will be standing or
   b. The excavation is wider than it is deep.

If any of the above criteria apply, no entry shall be made unless there is a documented risk assessment, and trench support/stability design, approved by the Geotechnical Professional.

Where pits and trenches are required to be left open and unattended for any period the Contractor shall:

1. Undertake a risk assessment to identify the appropriate mitigation measures for each site.
2. Deliver the risk assessment to the Geotechnical Professional and the Client and not start work until the Geotechnical Professional’s written approval is obtained.
3. As a minimum, provide location appropriate fencing together with all necessary lighting and signage. Where practical pits and trenches shall be covered to reduce the risk of falls.

Where there is any danger that a person or item of mobile plant could fall into the pit or trench, measures are to be put in place to allow safe egress.

Excavated materials shall be placed at least 2 m back from the excavation side wall, or further if instructed by the Site Representative.

When working on a slope, wherever possible:

1. The pit shall be orientated up/downslope.
2. The excavator shall be located downslope of the excavation.
3. Excavated materials shall not be placed up slope of the excavation.

The Contractor shall put in place measures to mitigate the risk of working at height for individuals working near or logging the test pits or trenches.

NZGS_200.7.2 Social and environmental

When test pits or trenches are undertaken near to an open waterway or stormwater drain, silt control measures shall be put in place to minimise silt run-off.

NZGS_200.7.3 Methodology

Topsoil, plants and other surface materials shall be excavated carefully and stored separately to allow reinstatement.

The Contractor shall keep pits and trenches free of surface water run-off.

Unless otherwise instructed by the Site Representative, all excavated material shall be placed on a tarpaulin or similar material to minimise damage to the surrounding ground and maintain separation of materials.

Pits and trenches shall be excavated to the specified depth to enable visual examination of the ground.

Unless otherwise instructed by the Site Representative, pits and trenches shall:

1. Have a minimum base area of 1.5 m2 and a minimum width 0.9 m.
2. Be excavated using a toothless bucket. A rock bucket may only be used where a toothless bucket is unable to excavate the material.
3. Be excavated slowly in layers approximately 100 mm thick.

Excavation shall stop if any buried services are observed in the excavation.

Excavation shall stop if the base of the excavation is obscured (eg by fast water inflow) to the extent that any potential buried services could not be observed unless a risk assessment has demonstrated that the likelihood of buried services is negligible.

NZGS_200.7.4 Backfilling and reinstatement

Backfilling of test pits and trenches shall be completed as soon as practicable with material excavated from the pit. Material shall be replaced at approximately the depth it was excavated. The backfill shall be compacted using excavation plant (unless otherwise specified).

Unless otherwise instructed by the Site Representative, all test pit locations shall be reinstated to a condition that is as good as reasonably practicable. The Contractor shall make reasonable efforts to reinstate the test pit to the condition before works commenced.

For test pits located in grassed areas, the excavated material shall be replaced into the excavation. It is expected that this will leave a hummock which will settle over time. The original topsoil shall be replaced last as a top surface, gently compacted, and where requested by the Client, seeded with appropriate plants to match the local environment and protected with straw, coir matting or similar to reduce run-off and sedimentation.

All test pits located within paved or trafficked areas shall be backfilled on completion as detailed below:

Backfill from the base of the test pit to 1.2 m below ground shall be placed in thin layers (no more than 100 mm thick) and compacted with pressure from the excavator bucket or a remotely operated compactor. The material and method to be used is to be agreed with the Client before works commence.

GAP40 from top of the backfill to the underside of the original pavement surface thickness, and compacted to the appropriate standard with a plate compactor or similar, as approved by the Geotechnical Professional.

Pavement materials shall be reinstated to match the existing.

If, after one month, there is visible settlement, then the Contractor shall reinstate the test pit at their own cost, unless they can demonstrate through site records that they correctly followed the Geotechnical Professional’s backfilling requirements.

Where the original surface is neither grass nor a paved/trafficked area, the reinstatement shall be finished to the original condition.

NZGS_200.8 Core handling and sampling for testing

NZGS_200.8.1 References

Geotechnical sampling:

- ASTM D4220-14. Practice for preserving and transporting samples.
- ASTM D1587-08. Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes.
- ASTM D3550-01. Standard Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils.
- NZS 4402. Methods of testing soils for civil engineering purposes. Test 6.5.1, Standard Penetration Test.
- ASTM D1586-11. Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils.
- BS EN.ISO 22475-1:2006. Geotechnical investigation and testing. Sampling methods and groundwater measurements. Technical principles for execution.

Geoenvironmental sampling:

- ASTM D7648-12. Standard Practice for Standard Practice for Active Soil Gas Sampling for Direct Push or Manual-Driven Hand-Sampling Equipment.
- ASTM D6282/D6282M-14. Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations.
- ASTM D6169/D6169M-13. Standard Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations.
- ASTM D4700-15. Standard Guide for Soil Sampling from the Vadose Zone.
- ASTM D6418-09. Standard Practice for Using the Disposable En Core Sampler for Sampling and Storing Soil for Volatile Organic Analysis.
- ASTM D7758-11. Standard Practice for Passive Soil Gas Sampling in the Vadose Zone for Source Identification, Spatial Variability Assessment, Monitoring, and Vapor Intrusion Evaluations.
- ASTM D4547-15. Standard Guide for Sampling Waste and Soils for Volatile Organic Compounds.
- NZS 4402.3.2:1986. Methods of testing soils for civil engineering purposes – Soil chemical tests – Test 3.2 Determination of the total sulphate content.
- AS/NZS 5667.11:1998. Water quality – Sampling. Part 11: Guidance on sampling of groundwaters.
- AS/NZS 5667.12:1999. Water quality – Sampling – Part 12: Guidance on sampling of bottom sediments.
- BS ISO 13196:2013. Soil quality – Screening soils for selected elements by energy-dispersive X-ray fluorescence spectrometry using a handheld or portable instrument.

NZGS_200.8.2 Health and safety

Where, as a result of core size or density, the total weight of the core box is likely to exceed 25 kg the Contractor shall either:

1. Insert polystyrene blocks in one or more of the core run slots to reduce the overall mass of the box to below 25 kg. Such blocks should be clearly labelled ‘spacer’ to distinguish from core loss.
2. Attach a ‘heavy load’ label to the outside of the box (on the top and on the labelled edge).

NZGS_200.8.3 Equipment

The Contractor shall provide all necessary sampling and storage equipment including:

1. Tubes.
2. Sample containers.
3. Plastic wrap to minimise moisture loss and reduce damage.
4. Plastic adhesive tape.
5. Permanent markers.
6. PVC ‘half-rounds’ for storage of selected rock samples for laboratory testing.
7. Bins for disposal of unwanted sample material.
8. Other tools as required to mark samples and core boxes in the field and to store and wrap the core and samples.

All equipment, tubes and containers shall be suitable for long term storage of samples without suffering corrosion and shall be robust enough to withstand the sampling process, outdoor use, transportation and storage for at least five years.

Core boxes shall be of sound construction, able to withstand the weight of the cores and stacking of the boxes, and shall be watertight to protect the cores from rain on site and in transit.

The Site Representative shall have authority to reject any sampling equipment.

NZGS_200.8.4 Methodology

NZGS_200.8.4.1 Numbering and labelling of soil and rock samples

The Contractor shall number and label all samples on site.

Each sample number shall be unique.

The sample number shall comprise the Exploratory Location ID, the sample top depth, the sample bottom depth, and the sample type (eg BH123-12.5-12.9-UN54).

The sample types shall be selected from the following list:

- UNxx (Open drive thin wall sampler, area ratio <10%, xx represents internal diameter in mm)
- UKxx (Open drive thick wall sampler, area ratio >10%, xx represents internal diameter in mm)
- PNxx (Piston drive thin wall sampler, area ratio <10%, xx represents internal diameter in mm)
- PKxx (Piston drive thick wall sampler, area ratio >10%, xx represents internal diameter in mm)
- SPTLS (Standard Penetration Test Liner Sample – Split spoon sampler used in SPT testing)

- SPTUS (Standard Penetration Test Unlined Sample – Split spoon sampler used in SPT testing)
- TNxx (Other tube sample, thin wall, eg window sampler or CPT sampler, area ratio <10%, xx represents internal diameter in mm)
- TKxx (Other tube sample, thick wall, eg window sampler or CPT sampler, area ratio >10%, xx represents internal diameter in mm)
- C (Rotary drilled core)
- D (General small disturbed sample eg from auger drilling, mass <1 kg)
- B (Bulk disturbed sample, mass >1 kg)
- BL (Large bulk sample, mass >20 kg)
- BLK (Block sample)
- W (Water sample)
- ES (Soil sample for environmental testing)
- EW (Water sample for environmental testing)
- G (Gas sample).

Where more than one sample is taken at any one depth using the same method, the samples shall be distinguished with a suffix lower case letter (eg BH123-12.5-12.9-UN54-a).

NZGS_200.8.4.2 Numbering and labelling of core and core boxes

The Contractor shall number and label all core boxes on site. Each box shall be numbered on top and at least one side with:

1. Client's project number.
2. Project name.
3. Exploratory Location ID.
4. Top depth below ground level.
5. Bottom depth below ground level.
6. Box number.
7. Date of coring.

As core is extruded the Contractor shall arrange it in core boxes in sequence, starting with the shallowest core at the top left of the box, and then working left to right. Slats/dividers shall be positioned and secured such that the core is restrained from movement. The Contractor shall take care to avoid inducing fractures or other disturbance in the core.

The Contractor shall securely pack fractured rock. At no time shall the core be loose in the box.

The Contractor shall mark key depths by inserting into the core boxes wood, plastic or polystyrene blocks that fit between the dividing slats. These shall be marked by the Contractor with permanent marker pen in writing that should be large and clear enough to be easily read in a 15 cm wide core photograph. The following features shall be marked in this manner:

1. The start and end of each box (labelled with depth below ground level).
2. The top of each drill run (labelled with depth below ground level).

3 The top of each SPT (labelled with the depth below ground level and the SPT results).
4 Core loss (labelled 'core loss', with the top and bottom depths written on).

The Consultant shall photograph the core boxes once full (see 'logging' for additional requirements).

Once the Consultant has taken core box photographs, the Contractor shall wrap the core to minimise moisture loss and damage. The Contractor shall take care to avoid inducing fractures or other disturbance in the core. The methodology shall be selected by the Geotechnical Professional. The Contractor shall allow for any of the following options:

1 Method 1: Where the core box includes removable dividers the wrap shall be a clear plastic tube which shall be carefully slid over the dividers containing the core, and sealed at each end with tape or similar.
2 Method 2: The core box may be wrapped in cling film with no gaps to form an air tight seal around the outside of the box.
3 Method 3: The individual pieces of core may be wrapped with flat plastic sheeting within the box.

> The methodology selected should take into account the importance of minimising core damage and moisture content changes for the project. In general Methods 1 or 2 are preferred as they are less likely to cause damage to the core.

NZGS_200.8.4.3 Tube samples

The Contractor shall take samples at the depths instructed by the Site Representative.

Tube samples shall be sealed with molten wax poured into both ends of the container immediately after the tube is extruded from the sampler barrel to prevent drying. The wax shall be heated by the minimum amount required to make it pourable to minimise heat disturbance to the sample.

Tubes should be clearly marked showing top of the sample and the sample number.

NZGS_200.8.4.4 Sampling for geoenvironmental testing

Samples shall be collected in accordance with Ministry for the Environment Contaminated Land Management Guideline No. 5.

Composite samples shall only be accepted where agreed in advance with the CL-SQEP and where the following controls are applied in addition to those specified in the most recent version of Contaminated Land Management Guideline No. 5:

1 Subsamples for each composite sample are collected from the same target depth.
2 Composite sampling should not be applied across a site that has multi contaminant sources.

> The use of composite sampling is a helpful way of minimising costs in a site investigation but should be used with caution.

NZGS_200.8.4.5 Quality assurance for geoenvironmental testing

Quality assurance accuracy and precision sampling shall be defined by the CL-SQEP.

> Quality ~~asssurance~~assurance sampling will vary depending on the investigation data quality objectives. Examples of such testing include field duplicate samples (typically 1 sample in 10). Equipment blanks, trip blanks and field blanks are commonly needed at a frequency of 1 per day.

NZGS_200.8.4.6 Transportation, storage and delivery of samples and core

The Contractor shall be responsible for the safe custody of all samples and cores in its possession.

Tube samples shall be stored (and where possible transported) upright, in the orientation they were recovered from the ground.

At the end of each day the Contractor shall move core boxes and samples from the Exploratory Location to a storage area agreed in advance with the Site Representative, in which the samples will be secure, under cover, and protected from sun and rain.

Where the Contractor is providing a core storage facility with shelving, it shall comply with the following requirements:

1. The shelves shall be closely spaced so that no more than 5 core boxes can be stacked on each shelf.
2. No shelves shall be installed above 1.5 m above floor level unless a mechanism is put in place to retrieve core boxes without manual handling.

All samples will be transported to the laboratory with a chain of custody record. This record will include the following information:

1. Client's project number.
2. Project Name.
3. Sample number.
4. Date and time of collection.
5. Analysis requested.
6. Signatures documenting chain of custody.

Samples will be packed with sufficient packing material so that they do not get damaged during transportation.

NZGS_200.8.4.7 Transportation, storage and delivery of geoenvironmental samples

All samples will be transported to the Laboratory with a chain of custody record. This record will include the following information:

1. Client's project number.
2. Project Name.
3. Name of field staff collecting samples.
4. Sample number.
5. Date and time of collection.
6. Number and type of containers.
7. Analysis requested.
8. Detection limits required.
9. Field measurements of sample.
10. Preservatives (if any).
11. Signatures documenting chain of custody.

Samples will be packed into a chilly bin with sufficient packing material so that they do not get damaged during transportation. Samples should be packed into ice to ensure that they are transported in chilled conditions (<4°C) and where possible should be couriered to ensure they arrive at the laboratory on the same day they are sent.

NZGS_200.9 Downhole wireline geophysical testing

The table below gives general guidance on the selection of appropriate techniques for wireline geophysics. It is always recommended that specific specialist guidance be sought when assessing which tools to use.

Geotechnical output / Tool selection	Oriented Structures	Lithology	Density	UCS (Empirical relationship)	Elastic Moduli	Concrete Integrity	Cement Bond Logging	Casing/Screen Integrity	Porosity	Vertical Flow Rates	Water Quality
Acoustic Televiewer (ATV)	Y	*				Y		Y			
Optical Televiewer (OTV)	Y	*				Y		*			
Full Waveform Sonic (FWS)				*	*	*	Y		*		
Density		Y	Y		*				*		
Resistivity		Y				Y					
Natural Gamma		Y									
Calliper	*	*						*			
Flowmeter										Y	
Spontaneous Potential		Y									
Temperature										*	*
Neutron		Y							Y		
Well Video Camera								Y			
Wireline water quality sensors											#

- All geophysical results require calibration.
- Y Appropriate
- * Geotechnical parameters are inferred and need laboratory testing to calibrate.
- # Sensor's selection and measurement range may require specific design for anticipated conditions.

NZGS_200.9.1 General considerations for all downhole geophysics

The Consultant should consider whether the techniques proposed are appropriate for the desired outcome – specifically in terms of method, measured parameters (including range) and resolution. During the planning of the ground investigation the Consultant should consider the requirements for geophysical techniques. Consideration should be given to:

- Drillhole size (minimum internal diameter to fit selected tools).
- Drillhole plunge angle. Recommended shallowest angle for downhole testing is -60°. Shallower angles than this may require use of push rods which may have associated time and complexity costs.

- Type of drilling mud system, and ability to flush holes clean on completion of drilling. Note that bentonite may require chemical methods (dispersants and flocculants) to break down mud cake and ensure clean borehole walls.
- Effect of chemical methods on geotechnical testing.
- Casing plan for boreholes – temporary and permanent. The level of planning required will be dependent on the importance of geophysical data.
- Recovery plan for lost tools. It is illegal to leave tools with radioactive sources in the ground.

It is prudent for the Consultant to allow for:

- Provision and installation time for temporary casing to ensure unexpected ground conditions do not preclude downhole geophysical testing methods.
- Provision of flushing time on completion of borehole drilling to clean the hole prior to geophysics.

Provision of downhole survey to determine risk to geophysical equipment (may be needed depending on downhole methods to be completed and condition of hole during drilling).

NZGS_200.9.1.1 References

- ASTM D5753-05. Standard Guide for Planning and Conducting Borehole Geophysical Logging.

NZGS_200.9.1.2 Health and safety considerations

Some tools use radioactive sources for which special safety requirements apply. Other risks include winches under load and portable power systems.

NZGS_200.9.1.3 Roles and responsibilities

The liability for lost tools shall be discussed and agreed during the procurement process and documented in the Contract.

NZGS_200.9.1.4 Methodology

The methodology shall be in accordance with ASTM D5753-05, except as modified in this specification.

The Contractor responsible for drilling the borehole shall ensure that drill holes:

1. Are flushed as clean as practicable prior to running wireline tools.
2. Have unstable ground, casing depths and groundwater conditions recorded and reported to the geophysical contractor to assist in assessing the risk of tool loss.

A section of borehole should be logged during the course of the investigation more than once (duplicate section) to demonstrate repeatability.

It is recommended that Optical Televiewers should be run together with a calliper tool to correct for variations in hole diameter.

The Geophysics Contractor shall ensure that all tool runs are depth calibrated and matched to a common datum as used on the borehole logs.

NZGS_200.9.1.5 Equipment

The Contractor shall ensure that all tools used have a current calibration certificate undertaken according to manufacturer's specifications.

NZGS_200.9.1.6 Reporting

As a minimum, the Geophysics Contractor shall report:

1. Unique tool identifier (serial number) for each tool run.
2. Tool type, make and model.
3. Depth and time of all tool runs.
4. Reference datum for depth measurements.
5. Exploratory Location ID.

NZGS_200.9.2 Structural orientation

Data is recorded that allows determination of structural geological information. Commonly used to measure azimuth and dip/plunge of geological and geotechnical features (bedding, lithological contacts, rock fabric, faults, folds, joints, shears, etc.).

Wireline tools used may include Acoustic Televiewer, Optical Televiewer, Microresistivity Dipmeter and Calliper.

NZGS_200.9.2.1 Methodology

The Consultant shall provide clear direction for definition of geotechnical defects (a defect library).

For most projects in New Zealand the defect library can be taken directly from the NZGS Guideline for the Description of Soil and Rock.

It is beneficial for the Consultant to provide core photographs and geotechnical logs to assist with assigning defect ‘types’. Geophysical tools cannot see into a defect, so a type cannot be assigned with the same level of confidence one would with physical core.

NZGS_200.9.2.2 Reporting

The Geophysics Contractor shall provide:

1. Continuous logs showing the oriented data.
2. Data in an agreed industry standard format (nominally CWLS .las format).
3. Tabular defect data that may be utilised in a spreadsheet or database by the client (in AGS4 NZ, CSV or Excel format).

The Geophysics Contractors report should include details of calibration for the downhole tools and depth encoders used on the project plus the following minimum information:

1. Acquisition dates and methodology should be included, with reference to any unexpected or adverse borehole conditions.
2. Processing methodology, including any equations used to generate additional logs.
3. Reference datum for azimuthal measurements (magnetic vs true north).
4. Reported datum and projection for coordinate and elevation data.

NZGS_200.9.3 Engineering parameters

> Some engineering parameters may be derived from collected geophysical data (in conjunction with other data sources), including RQD, fracture frequency, elastic moduli, seismic velocities (Vp, Vs).
>
> Wireline tools used may include Acoustic Televiewer, Optical Televiewer, Full Waveform Sonic, Calliper, P and S Wave suspension logger, Natural gamma and bulk density (with radioactive source).
>
> RQD and fracture frequency can be derived from structures identified in structural assessment.
>
> Elastic moduli are assessed through correlation with measured Vp, measured or derived Vs and density (measured by geophysics, lab testing or assumed).

NZGS_200.9.3.1 Methodology

The Consultant and Geophysics Contractor shall determine and agree:

1. The required outputs during planning of the drill programme (as hole conditions may affect measured data).
2. Any lab testing requirements for geophysical-engineering correlations.

NZGS_200.9.3.2 Reporting

The Geophysics Contractor shall report as a minimum:

1. Method used to derive engineering parameters, including equations used.

2 Any assumptions made in calculating engineering parameters.
3 Any limitations to the data presented or methods used to derive the correlations.

The Geophysics Contractor shall provide:

1 Continuous logs showing the data.
2 Data in an agreed industry standard format (nominally CWLS .las format).
3 Tabular defect data that may be utilised in a spreadsheet or database by the Client (in AGS4 NZ, CSV or Excel format).

NZGS_200.9.4 Geological assessment

> Typically, different geological lithologies display different geophysical properties that may allow them to be identified and their boundaries delineated. Common measurements in New Zealand include natural gamma, in-situ bulk density, electrical resistivity, calliper, sonic velocity, neutron porosity and magnetic susceptibility.

NZGS_200.9.4.1 Reporting

The Contractor shall report as a minimum:

1 Tool serial numbers.

2 Calibration date and method.

3 Reference densities where required (porosity).

The Geophysics Contractor shall provide:

1 Continuous logs showing the data.

2 Data in an agreed industry standard format (nominally CWLS .las format).

3 A pictorial section or other interpretation as defined by the Geotechnical Professional.

NZGS_200.9.5 Groundwater

> Determination of standing groundwater level in drillholes is generally undertaken from distinct (density, natural gamma) or absolute (ATV, FWS) change in geophysical measurements.
>
> Detailed assessment of groundwater using geophysics is relatively unused in New Zealand markets, however, common tools available for use include natural gamma, in-situ bulk density, resistivity, calliper, full-waveform sonic, neutron porosity, flow meters (spinner or heat pulse), temperature, fluid conductivity and water quality (pH, DO).

NZGS_200.9.5.1 Methodology

The Client shall determine the responsibility for consents and adherence to bylaws regarding aquifer penetration when selecting contractors (ie drilling, geophysical and any others).

NZGS_200.9.5.2 Reporting

The Geophysics Contractor shall report as a minimum:

1. Chemical baseline calibration results for any required tools.
2. Matrix or background assumptions for porosity measurements.

NZGS_200.10 Downhole and crosshole seismic testing

NZGS_200.10.1 Downhole seismic

NZGS_200.10.1.1 References

Mandatory standards and codes of practice:

- ASTM D7400-08. Standard Test Methods for Downhole Seismic Testing.

Supporting documentation:

- Redpath, B.B. 2007. Downhole Measurements of Shear- and Compression-Wave Velocities in Boreholes C4993, C4996, C4997, and C4998 at the Waste treatment Plant DOE Hanford Site. www.pnl.gov/main/publications/external/technical_reports/PNNL-16559.pdf

NZGS_200.10.1.2 Health and safety

The source used to generate seismic waves may vary from a sledge hammer or weight drop to explosives. A site-specific safe system of work shall be provided by the Geophysics Contractor for review by the Geotechnical Professional.

> Any use (or storage) of explosives on site will cause the work to be notifiable. See the Health and Safety in Employment Regulations 1995, Section 2 (Interpretation)
>
> For information about noise levels see the Health and Safety in Employment Regulations 1995, clause 11.

NZGS_200.10.1.3 Roles and responsibilities

The Consultant shall:

1. Advise the Geophysics Contractor of their understanding of the site geology so that an appropriate testing resolution may be obtained through thin layers or layers of interest.
2. Define the required resolution for the survey, noting that the resolution is defined primarily by the testing geometry and the seismic source.
3. Provide the Geophysics Contractor with all logged geological data relevant to the site prior to data processing.

The Geophysics Contractor shall:

1. Confirm the appropriate testing geometry with reference to the resolution defined by the Geotechnical Professional.
2. Articulate any constraints or limitations of the testing methodology based on the site conditions and setting (including surrounding sources of noise).

~~NZGS_200.10.1.3~~NZGS_200.10.1.4 Methodology

> Downhole seismic testing is performed either down a cased borehole or by utilising direct push equipment often in association with CPT or DMT testing (SCPT/SDMT).
>
> The Consultant should advise the geophysical contractor of their understanding of the site geology so that appropriate testing resolution may be obtained through thin layers or layers of interest.

The methodology shall be in accordance with ASTM D7400-08, except as modified in this specification.

In the case of a downhole test in a cased borehole, the Consultant shall ensure that boreholes are ~~specified~~ constructed as per the relevant standards and that:

1. Threaded PVC casing is used with no bell joints.
2. The grout installation is undertaken with due care to achieve continuous solid contact between casing and borehole wall.

The Geophysics Contractor shall ensure that as a minimum:

1. The field methodology shall be in accordance with ASTM D7400-08, except as modified in this specification. A range of processing methodologies can be used, as summarised by the references in Section 10.1.1.
2. All appropriate physical measurements of the test setup are recorded. This should include the borehole/direct push sounding to source offset, test depths and a depth reference point. Wherever possible, the orientation of the receiver relative to a reference compass bearing should be tracked or controlled.
3. The source is located an appropriate distance from the borehole or direct push sounding. S-wave sources should be oriented perpendicular to the line connecting the source and the borehole/direct push sounding locations.
4. The energy source is sufficient to produce adequate P-waves and/or S-waves depending on the needs of the survey (depth and/or setting).
5. The downhole seismic receivers in boreholes are sufficiently clamped to the borehole casing when recording shots.
6. The polarisation of S-wave shots are identified and recorded. If possible, at each test depth opposite polarity sources should be used when undertaking S-wave testing.
7. Waveforms are qualitatively assessed in the field for each source shot and poor quality waveforms discarded. Particular care should be taken to assess the first shot at each S-wave test depth and polarisation, as there can be a tendency for the source to slip and affect the waveform.
8. An appropriate number of shots are stacked at each test depth to improve the signal to noise ratio. This should be monitored during testing and the methodology modified accordingly.

9 The test depth spacing is appropriate for the resolution defined by the Consultant.
1 The energy source is sufficient to achieve adequate P-waves and/or S-waves depending on the needs of the survey.
2 Data quality is qualitatively assessed in the field for each strike.
3 Oppositely polarised shear wave shots are appropriately polarised.
4 An appropriate number of stacks are undertaken to improve signal to noise ratio.
5 The downhole seismic receivers are sufficiently clamped to the drillhole wall when recording shear wave strikes.
6 The source is an appropriate distance from the drill hole; or direct push sounding.
7 The vertical sample spacing is appropriate for the resolution defined by the Client.
8 All appropriate physical measurements are made to enable the raypath distance to be calculated during processing. This should include but not be limited to drillhole-source offset, measurement depth and depth reference point.

NZGS_200.10.1.4NZGS_200.10.1.5 Reporting

The Geophysics Contractor shall report as a minimum:

1 Exploratory Location ID.
2 Date and time of survey.
3 Coordinate system and depth datum.
4 Source offset distance
5 Receiver setup (single or dual) and spacing between dual receivers if these are used.
6 Expected waveform voltage polarities for each S-wave source direction.
7 Method(s) used to pick wave arrivals or travel times.
8 Method(s) used to calculate velocities.
9 Waveform plots for each test depth with wave arrival picks or travel times identified.
10 P-wave velocity and/or S-wave velocity plots.
11 Where possible uncertainties in P-wave and/or S-wave velocities at each test depth should be presented. Processing of individual strikes at each test depth with good signal to noise ratios can represent this uncertainty and/or the use of multiple processing methodologies.
4 P-wave and/or S-wave velocities downhole.
5 Appropriate error ranges.

The Geophysics Contractor shall provide:

1 Continuous logs showing the data.
2 Data in an agreed industry standard format (nominally e.g. CWLS .las format).
3 Tabular travel time, P-wave and/or S-wave data that may be utilised in a spreadsheet or database by the Client (in AGS4 NZ, CSV or Excel format).

NZGS_200.10.2 Crosshole seismic

NZGS_200.10.2.1 References

Mandatory standards and codes of practice:

- ASTM D4428/D4428M-14. Standard Test Methods for Crosshole Seismic Testing.

Supporting documentation:

- Cox, A. Stolte, K. Stokoe, and L. Wotherspoon (2019). "A Direct-Push Crosshole (DPCH) Test Method for the In Situ Evaluation of High-Resolution P- and S-Wave Velocities," Geotechnical Testing Journal 42(5): 1101-1132. https://doi.org/10.1520/GTJ20170382.

NZGS_200.10.2.2 Health and safety

The source used may require relatively high currents to initiate the signal. The hazards associated with this current should be addressed by the Geophysics Contractor in their site-specific risk assessment.

NZGS_200.10.2.3 Roles and responsibilities

The Consultant shall:

1 Advise the geophysical contractor of their understanding of the site geology so that appropriate testing resolution may be obtained through thin layers or layers of interest.
2 Define the required resolution for the survey, noting that the resolution is defined primarily by the drillhole spacing and the seismic source.
3 Provide the Contractor with all logged geological data from the drillhole prior to data processing.

The Geophysics Contractor shall

1 Confirm the appropriate testing geometry with reference to the resolution defined by the Consultant.
2 Articulate any constraints or limitations in relation to the testing methodology based on the site conditions and setting.

~~confirm the appropriate drillhole spacing and source with reference to the resolution defined by the Consultant.~~

NZGS_200.10.2.4 Methodology

> Crosshole seismic testing is performed either down a cased borehole or by utilising direct push equipment. It is more common for two boreholes to be used in crosshole testing, in place of the three borehole approach presented in ASTM D4428/D4428M-14.

The methodology shall be in accordance with ASTM D4428/D4428M-14, except as modified in this specification.

The Consultant shall ensure that:

1 bBoreholes are specified as per the relevant standard and that:in Section NZGS_200.10.2.1
2 Threaded PVC casing is used with no bell joints.
3 The grout installation is undertaken with due care to achieve continuous solid contact between casing and borehole wall.

The Geophysics Contractor shall ensure that as a minimum:

1 The field methodology shall be in accordance with that summarised by the references in Section NZGS_200.10.2.1, except as modified in this specification.
2 All appropriate physical measurements of the test setup are recorded. This should include but not be limited to the test depths, distances between source-to-receiver borehole/direct push sounding at each test depth and a depth reference point. Wherever possible, the orientation of the source and receivers relative to a reference compass bearing should be tracked or controlled.
3 The source borehole/direct push sounding is located an appropriate distance from the receiver borehole/direct push sounding to account for any potential refracted wave path effects.
4 The energy source is sufficient to achieve adequate P-wave and/or S-wave quality based on the needs of the survey (depth and/or setting).
5 The seismic source and receivers in boreholes are sufficiently clamped to the borehole casing when recording S-wave shots.
6 The polarisation of S-wave shots are identified and recorded. If possible, at each test depth opposite polarity sources should be used when undertaking S-wave testing.
7 Waveforms are qualitatively assessed in the field for each source shot and poor quality waveforms discarded.
8 An appropriate number of shots are stacked at each test depth to improve the signal to noise ratio. This should be monitored during testing and the methodology modified accordingly.
1 Data quality is qualitatively assessed in the field for each shot.
2 Oppositely polarised ‘shear’ wave shots are appropriately polarised.
3 An appropriate number of stacks are undertaken to improve signal to noise ratio.
4 The downhole seismic geophones/accelerometers are sufficiently clamped to the drillhole wall for shear wave shots.
5 The shot location(s) is/are an appropriate distance from the drill hole.
6 The vertical sample spacing is appropriate for the resolution defined by the Client.

7 All appropriate physical measurements are made to enable the raypath distance to be calculated during processing. This should include but not be limited to drillhole-source offset, measurement depth and depth reference point.

NZGS_200.10.2.5 Reporting

The Geophysics Contractor shall report as a minimum:

1 Exploratory Location ID.
2 Date and time of survey.
3 Coordinate system and depth datums.
4 Source-to-receiver offset distance at each test depth.
5 Expected waveform voltage polarities for each S-wave source direction.
6 Method(s) used to pick wave arrivals or travel times.
7 Method(s) used to calculate velocities.
8 Waveform plots for each test depth with wave arrival picks or travel times identified (waterfall plots).
9 P-wave velocity and/or S-wave velocity plots.
10 Where possible uncertainties in P-wave and/or S-wave velocities at each test depth should be presented. Processing of individual strikes at each test depth with good signal to noise ratios can represent this uncertainty and/or the use of multiple processing methodologies.
4 P-wave and S-wave velocities downhole.
5 Appropriate error ranges.

The Geophysics Contractor shall provide:

1 Continuous logs showing the data.
2 Data in an agreed industry standard format (nominally e.g. CWLS .las format).
3 Tabular source-to-receiver distance, travel time, P-wave and/or S-wave defect data that may be utilised in a spreadsheet or database by the Client (in AGS4 NZ, CSV or Excel format).

NZGS_200.10.3 Directional survey

Tools may include (but are not limited to):

- single/multishot tools (in conjunction with drilling company)
- magnetic survey tools (deviation tool, ATV/OTV)
- gyroscopic survey tool (spinning platter, MEMS, north seeking).

NZGS_200.10.3.1 Methodology

The Client shall advise the Geophysics Contractor of expected hole conditions when planning a borehole survey. Key points to address include:

1. Basic guidance of the anticipated orientation and depth of borehole.
2. Casing type (eg cased or uncased, through rods).
3. Anticipated magnetic interference from magnetic lithology or other sources.

The Geophysics Contractor shall use an appropriate tool based on the survey conditions.

NZGS_200.10.3.2 Reporting

The Geophysics Contractor shall report:

1. Exploratory Location ID.
2. Date and time of survey.
3. Coordinate system and depth datums.
4. Direction datum (magnetic/true north and inclination/declination).
5. Survey data.

NZGS_200.10.4 Other methods

> Due to the site-specific nature of techniques such as borehole magnetometry or crosshole resistivity, it is recommended that a specialist contractor be consulted prior to defining the scope of the investigation.

NZGS_200.11 Surface geophysics

The table below gives general guidance on the selection of appropriate techniques. It is always recommended that specific specialist guidance be sought when assessing which tools to use.

Geotechnical output / Tool selection	Vs30 (Note 4)	Site Subsoil Class /Ground Response Analysis (Note 4)	Rippability and Diggability	Depth to Hard	Bearing (note 5)	Elastic Moduli (Note 5)	Void Identification	Geological Structure	Electrical Grounding Assessment
MASW	Y	Y¥		Y [1]¥	Y	Y*	Y [2]	Y [3]¥	
~~**ReMi**~~	¥	¥		¥		¥		¥	
MAM	Y	Y		Y [1]				Y [3]	
Refraction	Y (Vs)¥	¥	Y	Y	Y (rock)	Y (rock)¥		Y¥	
GPR				Y [1]¥	¥		Y	Y	
ERT				¥	¥		Y	Y [3]	Y
VES	¥	¥		¥		*		Y [3]¥	Y
Reflection	Y (Vs)	Y (Vs)		Y		Y	Y (Vs)	Y	
Microgravity				Y [1]			Y	Y [3]	
HVSR		Y		Y [1]					

- All geophysical results require calibration.
- All surface geophysical techniques require site-specific design of the survey. Site conditions may preclude use of some techniques.
- Y = Generally ~~Appropriate~~appropriate
- Note 1: Depth to hard can be defined but there will be uncertainty associated with this depth due to the use of inversion processes.
- Note 2: Lateral resolution may affect the effectiveness of these methods, with effectiveness also reducing as depth increases.
- Note 3: Geological structure can be defined but there will be uncertainty associated with this structure due to the use of inversion processes
- Note 4: A combination of methods will typically need to be used.
- Note 5: For near surface characterisation only. * ~~Geotechnical parameters are inferred and need laboratory testing to calibrate.~~

> Before procuring a geophysical technique it is recommended to review with a specialist contractor that the method:
>
> - Provides the required range of accuracy.
> - Provides the required depth of investigation.

NZGS_200.11.1 General

NZGS_200.11.1.1 References

- ASTM D6429-99. Standard Guide for Selecting Surface Geophysical Methods.

NZGS_200.11.1.2 Methodology

The methodology shall be in accordance with ASTM D6429-99, except as modified in this specification.

The Consultant shall provide all relevant available geological data to inform data processing.

> Providing geotechnical data to the Contractor allows surface wave ground modelling to be refined during processing and acquisition method to be refined.

NZGS_200.11.2 Surface wave methods

NZGS_200.11.2.1 References

Mandatory standards and codes of practice:

- None

Supporting documentation:

- Foti, S., Hollender, F., Garofalo, F. et al. (2018). "Guidelines for the good practice of surface wave analysis: a product of the InterPACIFIC project". Bulletin of Earthquake Engineering 16: 2367–2420. https://doi.org/10.1007/s10518-017-0206-7

~~NZGS_200.11.2.1~~NZGS_200.11.2.2 Health and safety

A. The source used to generate seismic waves may vary from a sledgehammer or weight drop to explosives. The extent of the array of sensors across the ground surface will vary and should be monitored at all times. A site-specific safe system of work shall be provided by the Geophysics Contractor for review by the Consultant.~~The risks associated with high energy seismic sources (including sledge hammer or weight drops, explosives and noise) shall be addressed by the Geophysics Contractor in their site-specific risk assessment.~~

> Any use (or storage) of explosives on site will cause the work to be notifiable. See the Health and Safety in Employment Regulations 1995, Section 2 (Interpretation)

For information about noise levels see the Health and Safety in Employment Regulations 1995, clause 11.

NZGS_200.11.2.2 The Geophysics Contractor shall be responsible for any notifications. The Geophysics Contractor shall endeavour to isolate the public from seismic lines.

NZGS_200.11.2.3 Social and environmental

Surface wave methods may need to be undertaken at night when interference from human-induced vibrations is at a minimum. Additional measures to manage the noise for sensitive neighbours may be required.

NZGS_200.11.2.4 Roles and responsibilities

The Geotechnical Professional shall:

1. Advise the Geophysics Contractor of their understanding of the site geology so that an appropriate testing resolution may be obtained.
2. Define the required resolution and depth for the survey, noting that these will be controlled by the testing geometry and the source characteristics.
3. Provide the Geophysics Contractor with all available geological data to inform data processing.

The Geophysics Contractor shall:

1. Confirm the appropriate array geometry with reference to the resolution and depth defined by the Geotechnical Professional.
2. Articulate any constraints or limitations of the testing methodology based on the site conditions and setting (including surrounding sources of noise).

Positional control method for source and array location shall be agreed upon between the Geotechnical Professional and the Geophysics Contractor prior to acquisition of data. Accuracy should be appropriate to the requirements of the survey.

NZGS_200.11.2.4NZGS_200.11.2.5 Methodology

Surface wave methods include (1) active source methods, such as Spectral Analysis of Surface Waves (SASW), Multi-channel Analysis of Surface Waves (MASW); and (2) Microtremor Array Measurements (MAM). All equipment used in surface wave methods is located on the ground surface. Active source methods use a linear array of sensors to record vibrations from sources at known locations. MAM can use a linear or 2D array of sensors to record vibrations from surrounding background sources of unknown location.

No standards have been developed for surface wave methods. However, good practice guidance is provided by the references in Section NZGS_200.11.2.1.

The Geophysics Contractor shall ensure that as a minimum:

1. All appropriate measurements of the layout of the test setup are recorded. This should include but not be limited to array location(s), sensor spacing and source offset location(s).
2. The source for active source methods is located an appropriate distance from the array to avoid any near-source effects. Good practice is to make use of multiple source offset locations for each array.
3. The source is sufficient to achieve adequate quality based on the needs of the survey (depth and/or setting).
4. The sensors are well connected to the ground when recording (using tripod bases, spikes or embedment).
5. The record duration for each test meets the requirements for each method and required depth.
6. An appropriate number of shots are stacked at each source location to improve the signal to noise ratio for active source methods. Waveforms should be qualitatively assessed in the field for each source shot and poor-quality waveforms discarded. This should be monitored during testing and the methodology modified accordingly.
7. Notes should be taken throughout data acquisition including data file details, shot locations (if used), array geometry and qualitative observations related to data quality and noise sources.

1 ~~Seismic noise shall be considered and managed by the Geophysics Contractor prior to and during acquisition.~~

~~Positional control method for source and array location shall be agreed upon between the Geotechnical Professional and the Geophysics Contractor prior to acquisition of data. Accuracy should be appropriate to the requirements of the survey.~~

~~Seismic observer's notes should be taken during acquisition and include file number, shot location, spread location and qualitative observations regarding signal to noise ratios.~~

~~NZGS_200.11.2.5~~NZGS_200.11.2.6 Reporting

The Geophysics Contractor shall report as a minimum:

1. Exploratory Location ID~~Location of survey~~.
2. Date and time of survey.

3 Coordinate system and depth datums.
4 Source characteristics/specifications and sensor specifications.
5 Array location(s) and spacing/geometry of sensors.
6 Ground surface conditions and sensor ground coupling method.
7 Duration of the data records used for each test and sampling rate.
8 Source locations (if used), offset distance from end(s) of array(s) and number of shots at each source location.
9 Data processing methodology and software used to develop experimental dispersion data.
10 Inversion methodology and whether other subsurface investigation data has been used to constrain the inversion.
11 Plots of experimental dispersion data and theoretical dispersion data (both on the same axes) for each array location and commentary on the goodness of fit.
12 P-wave velocity and/or S-wave velocity plots for each array location. This could be combined into 2 or 3 dimensional plots. Uncertainties in P-wave and/or S-wave velocities with depth should be presented.
13 Clear indication of the near-surface and maximum depth resolution limits based on the experimental dispersion data and array geometry for each array location.
4 Orientation of survey line from first to last geophone.
514 Location of the end points of each line.

The Geophysics Contractor shall provide:

1 A plan of the array location(s), including sensor and any source locationsA plan of seismic spread locations.
2 Data in an agreed industry standard format (eg miniseed, SEG-2 or SEG-Y format).
3 3. Tabular P-wave and/or S-wave data that may be utilised in a spreadsheet or database by the Client (in AGS4 NZ, CSV or Excel format)Plots of shear wave velocities. This may be presented in 1, 2 or 3 dimensions depending on the survey methodology.
4 Interpretation of shear wave velocity plots.
5 Commentary on data quality and processing method.
63 Commentary on comparison between geophysical shear wave velocity model and ground model.

NZGS_200.11.3 Refraction/reflection

NZGS_200.11.3.1 References

- ASTM D5777-00. Guide for Using the Seismic Refraction Method for Subsurface Investigation.

NZGS_200.11.3.2 Health and safety

The source used to generate seismic waves may vary from a sledgehammer or weight drop to explosives. The extent of the array of sensors across the ground surface will vary and should be monitored at all times. A site-specific safe system of work shall be provided by the Geophysics Contractor for review by the Consultant.

> Any use (or storage) of explosives on site will cause the work to be notifiable. See the Health and Safety in Employment Regulations 1995, Section 2 (Interpretation).
>
> For information about noise levels see the Health and Safety in Employment Regulations 1995, clause 11.

~~The Geophysics Contractor shall endeavour to isolate the public from seismic lines.~~

NZGS_200.11.3.3 Social and environmental

> Seismic methods may need to be undertaken at night when interference from human-induced vibrations is at a minimum. Additional measures to manage the noise for sensitive neighbours may be required.

NZGS_200.11.3.4 Roles and responsibilities

The Geotechnical Professional shall:

4 Advise the Geophysics Contractor of their understanding of the site geology so that an appropriate testing resolution may be obtained.

5 Define the required resolution and depth for the survey, noting that these will be controlled by the testing geometry and the source characteristics.

6 Provide the Geophysics Contractor with all available geological data to inform data processing.

The Geophysics Contractor shall:

3 Confirm the appropriate array geometry with reference to the resolution and depth defined by the Geotechnical Professional.

4 Articulate any constraints or limitations of the testing methodology based on the site conditions and setting (including surrounding sources of noise).

Positional control method for source and array location shall be agreed upon between the Geotechnical Professional and the Geophysics Contractor prior to acquisition of data. Accuracy should be appropriate to the requirements of the survey.

~~NZGS_200.11.3.4~~NZGS_200.11.3.5 Methodology

The methodology shall be in accordance with ASTM D5777-00, except as modified in this specification.

The Geophysics Contractor shall ensure that as a minimum:

1 All appropriate measurements of the layout of the test setup are recorded. This should include but not be limited to array location(s), sensor spacing and source offset location(s).
2 The source is sufficient to achieve adequate quality based on the needs of the survey (depth and/or setting).
3 The sensors are well connected to the ground when recording (using tripod bases or spikes).
4 The record duration and sampling rate for each test meets the requirements for each method and required depth.
5 An appropriate number of shots are stacked at each source location to improve the signal to noise ratio for active source methods. Waveforms should be qualitatively assessed in the field for each source shot and poor-quality waveforms discarded. This should be monitored during testing and the methodology modified accordingly.
6 Notes should be taken throughout data acquisition including data file details, shot locations (if used), array geometry and qualitative observations related to data quality and noise sources.

~~The Geophysics Contractor shall make allowance for background noise.~~

~~Seismic noise shall be considered and managed by the Geophysics Contractor prior to and during acquisition.~~

~~Positional control method for source and array location shall be defined prior to acquisition of data. Accuracy should be appropriate to the requirements of the survey. Relative elevation data for source and spread locations must be recorded.~~

~~Seismic observer's notes should be taken during acquisition and include file number, shot location, spread location and qualitative observations regarding signal to noise ratios.~~

~~NZGS_200.11.3.5~~NZGS_200.11.3.6 Reporting

The Geophysics Contractor shall report as a minimum:

1 Exploratory Location ID
2 Source characteristics/specifications and sensor specifications.
3 Array location(s) and spacing/geometry of sensors.
4 Ground surface conditions and sensor ground coupling method.
5 Duration of the data records used for each test and sampling rate.
6 Source locations and number of shots at each source location.
7 Data processing methodology and software used.
8 Combined waveform plots across sensor arrays and details of the interpretation of this data.
9 Inversion methodology (if used) and whether other subsurface investigation data has been used to constrain the inversion. Commentary on the goodness of fit of the inversion.

10 For refraction, P-wave velocity and/or S-wave velocity plots versus depth along each array. Where possible uncertainties in these values should be presented.

11 For reflection, two way travel times and/or depth along each array. Where possible uncertainties in these values should be presented.

~~1 Location of survey.~~

~~2 Date and time of survey.~~

~~3 Coordinate system and depth datums.~~

~~4 Orientation of survey line from first to last geophone.~~

~~5 Location of the end points of each line.~~

The Geophysics Contractor shall provide:

1 A plan of the array location(s), including sensor and source locations.

2 Data in an agreed industry standard format (eg miniseed, SEG-2 or SEG-Y format).

3 Plots of outputs along each array. This may be presented in 1, 2 or 3 dimensions depending on the survey methodology.

4 Tabular values of outputs along each array that may be utilised in a spreadsheet or database by the Client (in AGS4 NZ, CSV or Excel format)

~~1 A plan of seismic spread locations.~~

~~2 Data in an agreed industry standard format (eg SEG-2 or SEG-Y format).~~

~~3 Plots of shear wave velocities. This may be presented in 1, 2 or 3 dimensions depending on the survey methodology.~~

~~4 Interpretation of shear wave velocity plots.~~

~~5 Commentary on data quality and processing method.~~

~~6 Commentary on comparison between geophysical shear wave velocity model and ground model.~~

NZGS_200.11.4 Ground penetrating radar (GPR)

NZGS_200.11.4.1 References

- The General User Radio Licence for Ultra Wide Band Devices and their special conditions (Radiocommunications Regulations (General User Radio Licence for Ultra Wide Band Devices) Notice, 19 March 2015).
- EuroGPR good practice guidelines.

NZGS_200.11.4.2 Health and safety

GPR transducers should always be pointed into the media being tested during operation.

NZGS_200.11.4.3 Methodology

Encoder wheels must be calibrated on site, according to the manufacturer's specifications.

GPR transducers shall be calibrated by the Geophysics Contractor according to the manufacturer's specifications.

GPR surveys are often undertaken by recording a grid across the site. The grid shall be positionally controlled using survey techniques appropriate to the required accuracy.

Manually triggered distance markers shall be placed in the data stream to allow rubber banding of data during post processing.

More than 1% of survey lines shall be repeated on site to provide evidence of repeatability.

Appropriate time window and gain curve settings shall be defined by the Geophysics Contractor for the ground conditions experienced on site.

The GPR start pulse must be identified during initial setup and recorded in the GPR data stream.

Except where an air launched transducer is being used GPR transducers shall maintain good ground coupling throughout the survey.

GPR signals shall be sampled at a sufficiently high frequency to avoid aliasing. Appropriate sample frequency is related to the centre frequency of the transducer(s) used during the survey.

Appropriate transducer(s) shall be selected by the Geophysics Contractor based on the required depth and resolution of the survey.

Data shall be processed to improve interpretation. This may include start-time correction, de-clipping, dynamic correction and system noise removal.

NZGS_200.11.4.4 Reporting

The Geophysics Contractor shall report as a minimum:

1. Location of survey.
2. Date and time of survey.
3. Coordinate system and depth datum.
4. Antenna centre frequency.

The Geophysics Contractor shall provide:

1. A plan of GPR survey line locations.
2. Data in an agreed industry standard format (eg SEG-2 or SEG-Y format).
3. Plots of shear wave velocities. This may be presented in 1, 2 or 3 dimensions depending on the survey methodology.
4. Interpretation of GPR sections and timeslices.
5. Commentary on data quality and processing method, including assumed signal velocities for time-depth conversions and the basis for these assumptions.
6. Commentary on comparison between geophysical shear wave velocity model and ground model.

NZGS_200.11.5 Electrical Resistivity Tomography (ERT)/Vertical Electrical Soundings (VES)

NZGS_200.11.5.1 References

- ASTM D6431-99. Standard Guide for Using the Direct Current Resistivity Method for Subsurface Investigation.

NZGS_200.11.5.2 Health and safety

ERT and VES equipment can generate large currents at electrode contacts. The health and safety implications of this must be managed and planned for prior to mobilisation.

> ERT profiles and cables can be very long and represent significant trip hazards.

NZGS_200.11.5.3 Methodology

The methodology shall be in accordance with ASTM D6431-99, except as modified in this specification.

The Geophysics Contractor should undertake forward modelling to assess the suitability of the technique prior to mobilisation. The Consultant should provide the Geophysics Contractor with data to build an appropriate forward model.

ERT/VES arrays shall be of appropriate length to provide sufficient depth of penetration. Depth of penetration required shall be defined by the Geotechnical Professional and array length defined by the Geophysics Contractor.

Resolution of the survey is in part related to electrode spacing. Appropriate electrode spacings shall be selected by the Geophysics Contractor to provide appropriate resolution. This should be informed by the forward modelling.

An appropriate array must be selected by the Geophysics Contractor dependent on the aims of the survey and the information provided by the forward modelling.

The Geophysics Contractor must provide an appropriate means of providing positional control and define its assumed accuracy prior to mobilisation.

The Geophysics Contractor shall assess data quality on site.

Five percent of data acquisition shall be repeated as part of quality control procedures.

NZGS_200.11.5.4 Reporting

The Geophysics Contractor shall report as a minimum:

1 Location of survey.

2 Date and time of survey.
3 Coordinate system and depth datum.
4 Orientation of survey line from first to last geophone.
5 Location of the end points of each line.

The Geophysics Contractor shall provide:

1 A plan of ERT/VES spread locations.
2 Data in an agreed industry standard format (eg SEG-2 or SEG-Y format).
3 Plots of shear inverted resistivities.
4 Interpretation of inverted resistivities sections.
5 Commentary on data quality and processing method.
6 Commentary on comparison between geophysical model and ground model.

NZGS_200.11.6 Horizontal to Vertical Spectra Ratio Method

NZGS_200.11.6.1 Codes of practice

Mandatory standards and codes of practice:

- None

Supporting documentation:

- Molnar, S., Cassidy, J.F., Castellaro., S., et al. (2018). Application of Microtremor Horizontal-to-Vertical Spectral Ratio (MHVSR) Analysis for Site Characterization: State of the Art. Surveys in Geophysics, 39, pp. 613-631. DOI: 10.1007/s10712-018-9464-4.
- SESAME (2004) Guidelines for the implementation of the H/V spectral ratio technique on ambient vibrations: measurements, processing, and interpretation. SESAME European research project.
- Foti, S., Hollender, F., Garofalo, F. et al. (2018). “Guidelines for the good practice of surface wave analysis: a product of the InterPACIFIC project”. Bulletin of Earthquake Engineering 16: 2367–2420. https://doi.org/10.1007/s10518-017-0206-7..

NZGS_200.11.6.2 Health and safety

The sensor on the ground surface should be monitored at all times.

A site-specific safe system of work shall be provided by the Geophysics Contractor for review by the Consultant.

NZGS_200.11.6.3 Roles and responsibilities

The Geotechnical Professional shall:

1 Advise the Geophysics Contractor of their understanding of the site geology so that an appropriate testing methodology can be defined.

2 Provide the Geophysics Contractor with all available geological data to inform data processing.

The Geophysics Contractor shall:

1 Confirm the appropriate testing methodology with reference to the project requirements defined by the Geotechnical Professional.
2 Articulate any constraints or limitations of the testing methodology based on the site conditions and setting (including surrounding sources of noise).

Positional control method for sensor location shall be agreed upon between the Consultant and the Geophysics Contractor prior to acquisition of data. Accuracy should be appropriate to the requirements of the survey.

NZGS 200.11.6.4 Methodology

> The Horizontal-to-Vertical Spectral Ratio (HVSR) method uses single 3-component sensors (geophones or accelerometers) on the ground surface to record vibrations from surrounding background sources of unknown location.
>
> No standards have been developed for the HVSR method. However, good practice guidance is provided by the references in Section 12.3.1.

The Geophysics Contractor shall ensure that as a minimum:

1 The location and orientation of the sensor(s) are recorded.
2 Each sensor is well coupled to the ground when recording (using tripod bases, spikes or embedment).
3 The record duration for each test meets the requirements for constraining the expected site period range.
4 Waveforms are qualitatively assessed in the field.
5 Notes should be taken throughout data acquisition including data file details and qualitative observations related to noise sources.

NZGS 200.11.6.5 Reporting

The Geophysics Contractor shall report as a minimum:

1 Exploratory Location ID.
2 Date and time of survey.
3 Coordinate system and depth datum.
4 Sensor specifications.
5 Sensor location(s).

6 Ground surface conditions and sensor ground connection method.
7 Duration of the data records used for each test and the sampling rate.
8 Data processing methodology and software used.
9 Individual plots of HVSR data for each sensor location including the uncertainties in each HVSR curve.
10 Site period estimates with uncertainties based on a HVSR curve peak shown on the HVSR plots.

The Geophysics Contractor shall provide:

1 A plan of the sensor location(s).
2 Data in an agreed industry standard format (such as miniseed, SEG-2 or SEG-Y).
3 Tabular HVSR curve data that may be utilised in a spreadsheet or database by the Client (in CSV or Excel format).

~~NZGS_200.11.6~~NZGS_200.11.7 Other methods

> Due to the site-specific nature of techniques such as electromagnetic, magnetometry, microgravity and radiometrics, it is recommended that a specialist contractor be consulted prior to defining the scope of the investigation.

NZGS_200.12 In-situ testing

NZGS_200.12.1 Standard penetration testing (SPT)

NZGS_200.12.1.1 References

- ASTM D1586-11. Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils.
- ASTM D4633-10. Standard Test Method for Energy Measurement for Dynamic Penetrometers.
- NZS 4402. Methods of testing soils for civil engineering purposes.

NZGS_200.12.1.2 Health and safety

Safety hammers must be used where possible. These must be closed off from access in accordance with AS/NZS 4024 at all times.

NZGS_200.12.1.3 Equipment

All SPT equipment must have a valid calibration certificate, issued within the last 12 months, defining the energy transfer achieved. A copy of the SPT calibration certificate must be provided to the Geotechnical Professional before work commences and shall also be held on site.

NZGS_200.12.1.4 Methodology

The methodology shall be as per ASTM D1586-11 unless otherwise specified by the Geotechnical Professional.

> The use of the ASTM standard is proposed in favour of the New Zealand equivalent in accordance with the recommendations of the MBIE/NZGS Earthquake Geotechnical Engineering Module 2. There may be project specific reasons to use the New Zealand standard.

NZGS_200.12.1.5 Reporting

The Contractor shall record the following items for each standard penetration test in the Drillers' Log:

1 SPT results (uncorrected).
2 Base heave at the start of each SPT.
3 Water level at the start of each SPT.
4 Reason for termination.
45 The energy efficiency of the SPT hammer used (by provision of a valid calibration certificate).

> Where base heave is a recurring issue the Geotechnical Professional should be contacted to consider adaptations to the test.

NZGS_200.12.2 Cone penetration testing (CPT)

NZGS_200.12.2.1 Codes of practice

Reference standards and codes of practice:

- ~~ASTM D5778-12. Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils.~~
- ISO 22476-1: 2012~~Part 1~~: Electrical cone and piezocone penetration test.
- CETANZ Technical Guideline TG6: Industry Best Practice for Performing Cone Penetration Testing (CPT) in New Zealand

> ISO 2247-1:2012 is based on Application Classes which are dependent on soil type and the accuracy of the test results. TG6 has been developed by the New Zealand CPT industry to provide a best practice guideline on how to undertake the test in accordance with ISO 2247-1:2012. Both the Geotechnical Professional specifying the test and CPT Contractor should be familiar with ISO2247-1, TG6 and the Application Class concept.
>
> Contractors that have been assessed as meeting ISO 2247-1/TG6 or have IANZ accreditation for ISO 2247-1 are listed on the CETANZ website.

NZGS_200.12.2.2 Health and safety

CPT testing can be undertaken using a wide variety of rigs, each presenting their own H&S hazards. The Contractor shall undertake a risk assessment of the equipment that is to be used and demonstrate how the risks can be mitigated. A site specific safety plan will generally be required.

~~NZGS_200.12.2.2~~NZGS_200.12.2.3 Equipment

The Contractor shall supply a thrust machine of suitable push capacity to achieve the required CPT depths in the expected ground conditions. The Contractor shall advise the Geotechnical Professional of the details of the rig to be used prior to works commencing.

The CPT penetrometer shall be an electric piezocone (CPTu). T~~) with t~~he pore pressure filter shall be at the u_2 position, ~~-~~unless an alternative position (ie u_1 or u_3) is specified in the Project Specific Specification.~~and with a friction sleeve of equal end areas.~~ In some cases, a non-piezocone (CPT) penetrometer can be used. If necessary, the Geotechnical Professional shall specify the type, load capacities, degree of accuracy or application class for the penetrometer that is to be used. If none is specified, a piezocone meeting the requirements of Application Class 2 (ISO 22476-1) shall be used. In all cases, the penetrometer shall have a friction sleeve of equal end areas.

For piezocone penetrometers, ~~A~~a suitable porous filter element, such as sintered stainless steel or bronze, or porous PVC or HDPE shall be provided. A slot filter may be used as an alternative if approved by the Geotechnical Professional.

Where a seismic cone penetrometer test (SCPT) is to be undertaken, the seismic testing part of the sounding shall be undertaken in accordance with ~~Section~~ NZGS_200.10.1.

Calibration of the equipment shall be in accordance with ~~the manufacturer's instructions and in accordance~~ with ~~ASTM D5778-12~~ISO 22476-1/TG6. Copies of current calibration certificates shall be supplied to the Geotechnical Professional before work commences and shall also be held on site.

~~NZGS_200.12.2.3~~NZGS_200.12.2.4 Methodology – general

Testing shall be undertaken to the specified depth (target depth) unless refusal (as defined by the Contractor) is reached earlier. Where refusal occurs above the target depth the Site Representative must be immediately informed.

~~NZGS_200.12.2.4~~NZGS_200.12.2.5 Methodology – CPT~~u~~ testing

Tests shall be carried out in accordance with ~~ASTM D5778-12, or~~ ISO 22476-1:2012 and TG6 ~~if applicable~~.

The penetrometer shall be fully cleaned ~~and de-aired~~ prior to starting each sounding.

For piezocone penetrometers, ~~A~~a new porous filter should be provided for each sounding. The cone shall be saturated in a suitable saturation medium such as de-aired silicone oil or glycerine. The method of saturation shall be as per the requirements of TG6.

~~The cone shall be saturated in a suitable saturation medium such as de-aired silicone oil or glycerine.~~ A light silicone grease filled slot filter may ~~also~~ be used if approved by the Geotechnical Professional.

Measurements and/or checks of the penetrometer dimensions shall be taken and a record maintained as per the requirements of TG6.

The penetrometers shall be temperature conditioned in such a way that it is at, or close to, the ground temperature prior to starting a sounding, as per the requirements of TG6.

Zero load readings are to be taken before and after each sounding. ~~Unless otherwise agreed, the maximum allowable zero shift during each individual sounding shall be no more than 1% of the full scale output (FSO) of each of the sensors (50% of the allowance in ASTM D5778-12).~~The zero drift during each sounding and the shift from the baseline calibration readings shall be within the requirements of TG6. A continuous record of zero readings shall be maintained.

~~NZGS_200.12.2.5~~NZGS_200.12.2.6 Methodology – dissipation testing

Dissipation tests (which measure the dissipation of excess pore pressure generated during probing) shall be carried out in accordance with ~~ASTM D5778-12~~ISO 22476-1/TG6 at the depths and locations specified or as instructed by the Site Representative.

The dissipation test shall be performed by stopping penetration of the piezocone at a specified depth. Pore pressure dissipation measurements with time should be taken as soon as possible after stopping penetration.

A pore pressure filter (or slot filter, if applicable) in the u2 position shall be used unless an alternative position (ie u1 or u3) is specified in the Project Specific Specification.

Dissipation tests are to be terminated at T_{50} (time to 50% dissipation of excess pore pressure) or as otherwise instructed by the Site Representative.

The Contractor is to limit any movements/vibrations of the cone and the rig during the test.

> Movement or vibrations will cause changes in the pore pressure, possibly disrupting the test and making interpretation difficult.

Pressure must be kept on the rams during dissipation testing to limit any suction through unloading of the soil around the cone.

NZGS_200.12.2.6NZGS_200.12.2.7 Reporting

Results shall be reported in accordance with the requirements of TG6. These include:including:

1 Test number and location.
12 Cone resistance, sleeve friction, pore water pressure and inclination, plus any other channels recorded such as temperature, shall be reported with respect to depthTarget depth and/or stop criteria and required application class..
3 Details of the rig used.
4 Details of the penetrometer used.
5 Details of the test procedure, including reason for termination and zero readings.
6 A graphical representation of q_c or q_t, f_s and, if applicable, -u_2 with depth.

7 The reason for stoppingDissipation test results, if applicable..
8 Numerical results in excel (or similar), txt file and/or AGS4 format.
2
3 If a ground water level is reported, a note should be provided as to how the ground water level was determined (eg measured or assumed).
49 Cone calibration record.

Any data that has been adjusted or corrected for such things as porewater pressure, sleeve offset, inclination, penetrometer dimensions or rod-breaks are defined as Calculated Parameters. These may be reported but details on what adjustments or corrections should be noted.

5 Interpreted parameters, such as geotechnical soil parameters that have been calculated using theoretical or empirical correlations are considered to be outside the standard. If

these are supplied in reports, a note should be provided stating how the parameters were derived and that they are outside the standard. ~~All other information as per the reporting requirements of ASTM D5779-12 or ISO 22476-1.~~

~~Reports shall be presented electronically in AGS4 NZ format, and may also be supplied as a comma or column delineated text file or as an MS Excel file. Details of any post processing such as smoothing rod changes, cone/sleeve offset correction are to be advised.~~

> ~~It is recommended that the CPT log sheet provided in Volume 0 Appendix D is used to report CPT data.~~

NZGS_200.12.3 Hand shear vane testing

NZGS_200.12.3.1 References

- NZGS, 2001. Guideline for Hand Held Shear Vane Test. New Zealand Geotechnical Society.
- ASTM D2573M-15. Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils.

NZGS_200.12.3.2 Health and safety

Where extension rods are used to test at depth, each testing site shall be visually checked for overhead hazards, particularly power lines and trees.

NZGS_200.12.3.3 Equipment

The vane (comprising a matching set of vane blade and measuring head) shall have a calibration certificate less than 12 months old from an IANZ accredited laboratory.

> Regular calibration of the vane (usually annually and/or to IANZ requirements) is required to account for changes in its spring stiffness, changes in blade dimensions due to wear, and whenever springs and/or blades are damaged and/or replaced. Following calibration, a calibration chart is usually provided giving the Vane Shear Strengths for each of the dial readings. The calibration chart is only applicable to the exact combination of vane head and vane blade.

Extension rods may be added to take readings at greater depths in hand augered or drilled boreholes and test pits. Such rods shall be sufficiently stiff when connected as to transfer the torque to the vane from the ground surface.

NZGS_200.12.3.4 Methodology

The methodology shall be in accordance with the NZGS 2001 Guideline for Hand Held Shear Vane Test, except as modified in this specification.

NZGS_200.12.3.5 Reporting

The following shall be reported:

1. The test method, including whether the vane was pushed into undisturbed in-situ soils or into a confined sample. Where shown on a borehole log these may be abbreviated to:
   a. Vi (Vane in-situ).
   b. Vc (Vane confined, eg by a core barrel or sample tube).
   c. Vb (Vane block sample, taken in a block nominally large enough to be considered as confined).
   d. Vs (Vane spoil, taken in spoil from a block nominally large enough to be considered as confined.)
2. The vane shear strength of the soil, corrected using the calibration certificate; except where:
   a. The vane could not be pushed into the soil to the required depth, the result shall be reported using the abbreviation UTP (unable to penetrate).
   b. The strength is greater than that able to be measured by the vane (ie pointer reaches maximum value on the dial without the soil shearing) the result shall be reported in either of the following two ways eg 195+ kPa or >195 kPa (with the value given being the maximum recordable vane shear strength possible using that vane combination).
3. The remoulded Vane Shear Strength (if carried out), corrected using the calibration certificate.
4. The soil description of the material tested. A general term such as 'fill' may be used where the test is part of earthworks testing.
5. The location of the test site and its Reduced Level (if known) or the depth from a defined surface.
6. The date of test.
7. The name of the person who carried out the test.
8. The serial numbers of the vane head and blade, and the blade diameter (eg 19 mm/25 mm).
9. The uncorrected vane head (dial) reading for each test (peak and remoulded).
10. A copy of the calibration certificate.

NZGS_200.12.4 Large diameter vane testing

> Large diameter vanes are defined for the purposes of this specification as those with blade sizes 35 mm or greater. They are commonly used down boreholes during drilling (mounted to a drill rig) or pushed into the soft ground to depths of tens of metres.

NZGS_200.12.4.1 References

- ASTM D2573M-15. Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils.
- Roberts, 2013. Implausibly low readings with the Geonor Vane investigated and explained. NZ Geomechanics News, Issue 85, June 2013, p102.

NZGS_200.12.4.2 Equipment

The vane (comprising a matching set of vane blade and head) shall have a calibration certificate less than 12 months old from an IANZ accredited laboratory.

NZGS_200.12.4.3 Methodology

The methodology shall be in accordance with ASTM D2573M-15, except as modified in this specification.

NZGS_200.12.4.4 Reporting

The following shall be reported:

1. The test method (including whether the vane was pushed into undisturbed in-situ soils or into a confined sample).
2. The vane shear strength of the soil, corrected using the calibration certificate, except where:
   a. The vane could not be pushed into the soil to the required depth, the result shall be reported using the abbreviation UTP (unable to penetrate).
   b. The strength is greater than that able to be measured by the vane (ie pointer reaches maximum value on the dial without the soil shearing) the result shall be reported in either of the following two ways eg 195+ kPa or >195 kPa (with the value given being the maximum recordable vane shear strength possible using that vane combination).
3. The remoulded Vane Shear Strength (if carried out), corrected using the calibration certificate.
4. The soil description of the material tested. A general term such as ‘fill’ may be used where the test is part of earthworks testing.
5. The location of the test site and its Reduced Level (if known) or the depth from a defined surface.
6. The date of test.
7. The name of the person who carried out the test.
8. The serial numbers of the vane head and blade, and the blade dimensions (diameter and length).
9. The uncorrected vane head (dial) reading for each test (peak and remoulded).
10. A copy of the calibration certificate.

NZGS_200.12.5 Dynamic cone penetration testing (DCP)

> Several different types of DCP equipment have been developed, but in New Zealand the standard DCP test (also referred to as a Scala test) is the one defined in NZS 4402:1988.
>
> Several correlations have been established among the different dynamic probing tests and between them and other tests or geotechnical parameters. In some cases friction along the rods has been eliminated or corrected, but the actual energy transmitted to the probe has not been measured. They cannot therefore be assumed to be generally valid. Care should be taken to

> ensure that the materials being tested are of a similar nature to those for which the correlations were developed and that the purpose for which the correlation was developed is the same as that for which the correlation is being used.

NZGS_200.12.5.1 References

- NZS 4402:1988. Test 6.5.2. Dynamic Cone Penetrometer.
- CETANZ, 2011. TG1 – Scala Dynamic Cone Penetrometer – Cone Calibration.
- ISO 22476-2:2005. Geotechnical investigation and testing – Field testing – Part 2: Dynamic probing.
- Eurocode 7 – Geotechnical design – Part 2: Ground investigation and testing; Section 4.7: Dynamic Probing Tests (DP), March 2007.
- Stockwell, June 1977. NZ Engineering Vol 32 No.6 'Determination of allowable bearing pressure under small structures'.

NZGS_200.12.5.2 Health and safety

> There have been a number of incidents of crushed fingers resulting from the use of Scala Penetrometers. It is essential that these tests are undertaken carefully and slowly by suitably trained individuals.

The equipment shall be manufactured to minimise the risk of entrapment of fingers between the falling weight and the anvil. For the hand held DCP, carry handles may be added to the drop weight, the weight of which must be included in the overall drop weight sizing determination. For mechanical equipment, the falling weight shall be screened to prevent hand access to the hammer or anvil during testing.

Each testing site shall be visually checked for overhead hazards.

Ear protection should be worn when operating or working near to the equipment.

It is recommended that the equipment be fully dismantled before moving to a new testing location. When carrying the equipment, the hammer should be restrained to prevent movement along the slide bar.

NZGS_200.12.5.3 Social and environmental

DCP equipment use can be noisy, potentially restricting its use where work is required outside of normal hours or at certain sites. Where in doubt, inform potentially vulnerable neighbours or other affected parties of intended date and time of use.

NZGS_200.12.5.4 Equipment

For detailed description of the equipment and sizing of the various parts, refer Figure 6.5.2 Dynamic Cone Penetrometer in NZS 4402:1988.

The shoulder width of the cone shall be 3 mm (±1 mm) to allow correlations with Stockwell (1977) and international publications.

NZGS_200.12.5.5 Methodology – to one rod length, maximum 1.5 m long

The methodology shall be in accordance with NZS 4402:1988 Section 6.5.2.4, except as modified by this specification

When raising the hammer, take care that it does not strike the stop with such force as to lift the penetrometer.

Where a pre-drill is required or where the test starts at some depth other than at the ground surface (eg at the base of a test pit), results should be recorded as starting at the relevant depth below ground.

NZGS_200.12.5.6 Methodology – greater than one rod length

> The original test method defined by Scala was intended for use in the upper soil layers only with a view to providing a simplified method for correlating California Bearing Ratio values. Where the DCP test is intended for use for any other purpose or where any test is proposed to continue to depths greater than 1.5m depth, then the DCP test should be completed using the alternative deep testing method.
>
> Factors affecting the penetration resistance of the soil include material type, density and water content. Where the test is not completed per the deep testing method, additional tests for these properties should be undertaken in conjunction with the DCP testing to indicate changes in material type and water content with depth and to allow visual verification of soil characteristics (eg organics, filling, etc.).

Complete DCP test to one rod length depth below ground.

Auger to the base of the DCP test, taking note of changes in material type, density and water content.

Add an extension rod to the DCP equipment and complete test for an additional rod length.

Repeat steps (b) and (c) to target depth.

If the augered hole collapses (eg due to loose material), the DCP may continue without further augering, but the depth of hole collapse must be marked on the log, as this will affect interpretation.

Target depth should be no greater than 5 m below ground.

NZGS_200.12.5.7 Reporting

Reporting requirements are given in NZS 4402:1988 Section 6.5.2.6. The following shall be reported:

1. Clients project number.
2. Project name.
3. Exploratory Location ID.
4. Date of test.
5. Name of the person who completed the test.
6. Reduced level of ground surface at the test site.
7. Results shall be recorded and reported as number of blows per 50 mm penetration.
8. A graphical log should be included showing how the results vary with depth at each test site.

NZGS_200.12.6 Dynamic Probing (DPSH-B)

NZGS_200.12.6.1 References

- ISO 22476-2:2005. Geotechnical investigation and testing – Field testing – Part 2: Dynamic probing.
- Eurocode 7 – Geotechnical design – Part 2: Ground investigation and testing; Section 4.7: Dynamic Probing Tests (DP), March 2007.

NZGS_200.12.6.2 Methodology

The methodology shall be in accordance with ISO 22476-2:2005, except as modified in this specification.

NZGS_200.12.6.3 Reporting

Refer Section 7 of ISO 22476-2:2005.

> In addition to the standard reporting (blows per 200 mm penetration), results may also be presented in other forms eg blows per 100 mm or 300 mm penetration.

NZGS_200.12.7 In-situ density

NZGS_200.12.7.1 References

- NZS 4407:2015. Test 4.1. The Density of Compacted Aggregate – sand replacement method (for use in Aggregates) or NZS 4402:1986 Test 5.1.1 Sand replacement method for the determination of the in-situ density (for use in soils).

- NZS 4407:2015. Test 4.2. The field water content and field dry density of compacted materials – method using a nuclear moisture-density gauge – direct transmission (for use in soils and aggregates).
- NZS 4407:2015. Test 4.3. The field water content and field dry density of compacted materials – method using a nuclear moisture-density gauge – backscatter mode (for use on aggregates).
- NZS 4402:1986. Test 5.1.3. Sampling Tube method for the determination of in-situ density (for use in soils).

NZGS_200.12.7.2 Methodology

The Geotechnical Professional shall specify the test method and the standard to be followed.

> The choice of test will be determined through consideration of suitability of the test in terms of practicality and material type, speed of testing and cost. It is recommended that the Geotechnical Professional considers verification testing using more than one test method.

All testing shall be carried out by an IANZ accredited supplier with the specified method listed on their Scope of Accreditation.

> It is recommended that the Geotechnical Professional consider complimentary testing to be carried out at the same test locations as in-situ density testing, such as shear vane or Scala penetrometer testing.

NZGS_200.12.7.3 Reporting

The following shall be reported:

1. Clients project number.
2. Project name.
3. Exploratory Location ID.
4. Date and time of test.
5. Name of the person who completed the test.
6. Testing location plan and/or surveyed coordinates for each test.
7. Weather conditions (both on the day and in the preceding days).
8. History of the material ie fill/natural.
9. Bulk density.
10. Dry density.
11. Water content (%) of the material.

> Other information that may be requested of the supplier includes air voids as a percentage – this will require either the measurement or an assumption of the solid density of the soil.

NZGS_200.12.8 Plate loading test

NZGS_200.12.8.1 References

- ASTM D1194-94. Standard Test Method for Bearing Capacity of Soil for Static Load and Spread Footings.

NZGS_200.12.8.2 Methodology

> The selection of test areas shall be carried out between the Contractor and the Geotechnical Professional. Care should be taken to choose test points that are representative of the whole construction area. The load tests should be carried out at the elevation of the proposed footings and under the same conditions of the proposed footings.
>
> For normal ground conditions at least three locations shall be tested, with the distance between tests being not less than five times the diameter of the largest plate used in the test.

The methodology shall be in accordance with ASTM D1194-94, except as modified in this specification.

The Geotechnical Professional shall specify the loading platform, the dead load and the reference beam to be used by the Contractor.

The Geotechnical Professional shall specify the plate size, the loading increments and the time interval of the loading cycle.

The tests shall continue until a peak load is reached or until the ratio of load increment to settlement increment reaches a minimum, steady magnitude. If sufficient load is available, the test should be continued until the total settlement reaches at least 10% of the plate diameter, unless a well-defined failure is observed.

All testing shall be carried out by an IANZ accredited supplier with the specified method on their Scope of Accreditation.

NZGS_200.12.8.3 Reporting

The following shall be reported:

1. Clients project number.
2. Project name.
3. Exploratory Location ID.
4. Date and time of test.
5. Name of the person who completed the test.
6. Weather conditions (both on the day and in the preceding days).
7. Air temperature at time of load increments.

8 Any irregularities in the routine procedure.
9 A continuous listing of all time, load and settlement data for each test.

NZGS_200.12.9 California bearing ratio test (in-situ)

NZGS_200.12.9.1 References

- NZS 4402:1986. Test 6.1.3. Determination of the California Bearing Ratio (CBR) – Standard method for in-situ tests.

NZGS_200.12.9.2 Methodology

> The selection of test areas shall be agreed between the Contractor and the Geotechnical Professional. Care should be taken to choose test points that are representative of the whole construction area. This test is appropriate for fine, medium and coarse soils (as specified in NZS 4402). It may be appropriate to carry out laboratory particle size distribution and in-situ density as complimentary parameters.

The methodology shall be in accordance with NZS 4402, except as modified in this specification.

The Geotechnical Professional shall specify the surcharge weight to be used for the tests. This may vary dependant on expected pavement/fill placement.

NZGS_200.12.9.3 Reporting

The following shall be reported:

1 Clients project number.
2 Project name.
3 Exploratory Location ID.
4 Date of test.
5 Name of the person who completed the test.
6 Weather conditions and temperature.
7 Surcharge – diameter and total mass of weights.
8 Water Content % of a sample of material taken from GL to 30 mm below the plunger test location.
9 Penetration rate of the plunger (mm/min).
10 The calculated CBR and the penetration at which it was recorded.
11 History of the material (ie fill or natural, modified or unmodified).

NZGS_200.12.10 Infiltration Test: Double Ring infiltrometer test

NZGS_200.12.10.1 References

- ASTM D3385-03: Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer

NZGS_200.12.10.2 Equipment

The following equipment shall be provided by the Contractor, along with any additional material needed to undertake the necessary works:

1 Infiltrometer rings
2 Driving caps
3 Driving equipment
4 Depth gauge
5 Splash guard
6 Rule or tape
7 Shovels
8 Water
9 Timing device
10 Level
11 Rubber hammer
12 Hand auger.

NZGS_200.12.10.3 Methodology – Calibration

Determine the area of each ring, and the area between rings, before initial use with a technique which will give an overall error of 1% or less.

For each graduated cylinder or graduated Mariotte tube, establish the relationship between the change in elevation of liquid (fluid) level and change in volume of fluid. This relationship shall have an overall error of 1% or less.

NZGS_200.12.10.4 Methodology

> The double-ring infiltrometer method consists of placing and driving two open cylinders, one inside the other into the ground. The cylinders are then partially filled with water and the water maintained at a constant level. The volume of liquid added to the inner ring, to maintain the liquid level constant, is the measure of the volume of liquid that infiltrates the soil. The volume infiltrated is then converted to infiltrated velocity and is usually expressed in millimetres per hour and plotted against elapsed time.
>
> This test method applies to finding the field measurement of infiltration rate of soils. Infiltrations rates have relevance to the following applications: irrigation requirements, drainage and leaching

efficiencies, water spreading and recharge, canal or reservoir leakage, liquid waste disposal, evaluation of potential septic-tank disposal fields, as some examples.

Although the units for infiltration and hydraulic conductivity are the same they are both distinctively different and should not be mixed.

The purpose of the outer ring is to stimulate one dimensional, vertical flow below the inner ring.

The test typically requires an area of 3 m x 3 m accessible by truck.

The methodology shall be in accordance with ASTM D3385-03, except as modified in this specification.

Determine the soil matrix for the test site by classification of soil samples from a nearby/adjacent auger hole in accordance with AS/NZS 1547 Table E1.

Confirm schedule of readings with the Site Representative based on this information.

The appropriate schedule of readings may only be determined through experience. For average soils, record the volume of liquid used at intervals of 15 min for the first hour, 30 min for the second hour, and 60 min during the remainder of a period of at least 6 h, or until after a relatively constant rate is obtained.

For high-permeability materials, readings may be more frequent, while for low-permeability materials, the reading interval may be 24 hours or more. In any event, the volume of liquid used in any one reading interval should not be less than approximately 25 cm3.

The test site should be nearly level, or a level surface should be prepared.

Place the driving cap on the outer ring and the centre it. Place a wooden block on the driving cap. Drive the outer ring into the soil with blows with a heavy hammer on the wooden block to a depth that will prevent the test liquid leaking to the ground surface around the ring, and deeper than the depth the inner ring (a depth of 150 mm is usually adequate). Use medium blows to avoid fracturing the soil strata.

Centre the smaller ring inside the larger ring and drive to a depth that will prevent leakage of the test fluid to the ground surface surrounding the ring, using the same technique as above. A depth of between about 50 and 100 mm is usually adequate.

There are basically three ways to maintain a constant head (liquid level) within the inner ring and annular space between the two rings:

- manually controlling the flow of liquid
- the use of constant-level float valves, or

- the use of a Mariotte tube.

When manually controlling the flow of liquid, a depth gauge is required to assist the investigator visually in maintaining a constant head. Use a depth gauge such as a steel tape or rule for soils having a relatively high permeability; for soils having a relatively low permeability use a hook gauge or simple point gauge.

Install the depth gauges, constant-level valves, or Mariotte tubes, and in such a manner that the reference head will be at least 25 mm and not greater than 150 mm. Select the head on the basis of the permeability of the soil, the higher heads being required for lower permeability soils. Locate the depth gauges near the centre of the centre ring and midway between the two rings. Cover the soil surface within the centre ring and between the two rings with splash guards (150 mm square pieces of burlap or rubber sheet) to prevent erosion of the soil when the initial liquid supply is poured into the rings.

Fill both rings with water to the same desired depth in each ring. Do not record this initial volume of water. Remove the splash guards. Start flow of fluid from the graduated cylinders or Mariotte tubes. As soon as the fluid level becomes constant, determine the fluid depth in the inner ring and in the annular space to the nearest 2 mm using a ruler or tape measure. Record these depths. If the depth between the inner ring and annular space varies more than 5 mm, raise the depth gauge, constant-level float valve, or Mariotte tube having the shallowest depth.

Maintain the liquid level at the selected head in both the inner ring and annular space between rings as near as possible throughout the test to prevent flow of fluid from one ring to the other.

Determine and record the volume of liquid that is added to maintain a constant head in the inner ring and annular space during each timing interval by measuring the change in elevation of liquid level in the appropriate graduated cylinder or Mariotte tube.

Place the driving cap or some other covering over the rings during the intervals between liquid measurements to minimize evaporation.

Upon completion of the test, remove the rings from the soil, assisted by light hammering on the sides with a rubber hammer

NZGS_200.12.10.5 Reporting

All unsuccessful and successful tests shall be reported.

The following shall be reported:

1. Clients project number.
2. Project name.
3. Exploratory Location ID.
4. Date of test.

5 Weather conditions during the test and over the preceding week.
6 Name of the person who completed the test.
7 Methodology used to maintain the constant head.
8 Volume of water and time at each interval.
9 Infiltration rate.

NZGS_200.12.11 Percolation test

NZGS_200.12.11.1 Equipment

The following equipment shall be provided by the Contractor, along with any additional material needed to undertake the necessary works:

1 Timing device
2 Excavating tools
3 Scratching/scarifying tools.

NZGS_200.12.11.2 Methodology

> This test is generally used to test the suitability of soakage devices and on-site sewage treatment systems.

Make an excavation in the soil matrix to be assessed. Dimensions of the test hole shall either be:

1 A square 250 mm x 250 mm hole to depth of at least 300 mm; or
2 A circular hole with a diameter of 300 mm and a depth of at least 300 mm; or
3 A circular hole with a diameter of 100 mm and a depth of at least 600 mm.

Log the soil in accordance with Section 4.

Ensure the removal of all loose material and clays via scratching and scarifying from the sides and bottom of excavation.

If groundwater is encountered the test shall be abandoned.

Fill the test pit with clean water up to the ground level.

Record the depth to water. Unless stated otherwise, the monitoring frequency from the start of the test shall be as follows:

Time from start of test	Time between monitoring readings
0-5 minutes	30 seconds
5-10 minutes	1 minute
10-20 minutes	2 minutes

Time from start of test	Time between monitoring readings
20-60 minutes	5 minutes

The test shall be finished when all the water has percolated out of the hole, or after three hours, whichever comes first.

NZGS_200.12.11.3 Reporting

All unsuccessful and successful tests shall be reported.

The following shall be reported:

1. Clients project number.
2. Project name.
3. Exploratory Location ID.
4. Date of test.
5. Weather conditions during the test and over the preceding week.
6. Name of the person who completed the test.
7. Dimensions of the hole.
8. Soil description.
9. Reason for abandoning or otherwise ending the test.
10. Depth to water and time at each interval.
11. Percolation rate.

NZGS_200.12.12 Constant head permeability test

NZGS_200.12.12.1 References

- AS/NZS 1547:2012. On-site domestic wastewater management.
- BS 5930:2015. Code of practice for ground investigation.
- BS EN ISO 22282-2:2012. Geotechnical investigation and testing. Geohydraulic testing. Water permeability tests in a borehole using open systems.

NZGS_200.12.12.2 Methodology

The methodology shall be as described in AS/NZS 1547:2012 Appendix G.

NZGS_200.12.12.3 Reporting

As a minimum the information specified in AS/NZS 1547:2012 Appendix G Section 7 shall be reported.

NZGS_200.12.13 Variable head permeability test

NZGS_200.12.13.1 References

- BS 5930:2015. Site investigations.
- BS EN ISO 22282-2:2012. Geotechnical investigation and testing. Geohydraulic testing. Water permeability tests in a borehole using open systems.

NZGS_200.12.13.2 Methodology

The methodology shall be in accordance with BS EN ISO 22282-1:2012 and BS 5930:2015, except as modified in this specification.

The Contractor shall provide the Geotechnical Professional with details of proposed methodology.

Unless stated otherwise, the monitoring frequency from the start of the test shall be as follows:

Time from start of test	Time between monitoring readings
0-5 minutes	30 seconds
5-10 minutes	1 minute
10-20 minutes	2 minutes
20-60 minutes	5 minutes

NZGS_200.12.13.3 Reporting

As a minimum, the following data shall be recorded for each hydraulic conductivity test conducted:

1. Clients project number.
2. Project name.
3. Exploratory Location ID.
4. Date and time of test.
5. Name of the person who completed the test.
6. Type of test (rising or falling).
7. Static water level prior to development.
8. Depth of hole prior to testing.
9. Diameter of bore in test section.
10. Depth of casing (if any).
11. Internal radius of casing (if applicable).
12. Height of casing above surrounding ground level.
13. Water level at start of test (time t = 0).
14. Water depth with time.
15. A plot of head vs elapsed time.

NZGS_200.12.14 Packer permeability test

NZGS_200.12.14.1 Codes of practice

Reference standards and codes of practice:

- 1 BS 5930:2015. Site Investigations.
- 2 BS EN ISO 22282-2:2012. Geotechnical investigation and testing. Geohydraulic testing. Water permeability tests in a borehole using open systems.

NZGS_200.12.14.2 Methodology

The methodology shall be in accordance with BS EN ISO 22282-1:2012 and BS 5930:2015, except as modified in this specification.

The Contractor shall be familiar with the operation of these tests and shall provide the Geotechnical Professional with details of their proposed methodology.

Prior to testing, the bore shall be developed for 2 hours. The development may be terminated earlier if the discharge water is clear of drilling mud and cuttings that may be clogging the aquifer.

Water produced by the development shall be discharged in a controlled manner and disposed of so as to cause minimal disturbance to the site. Water shall not be discharged directly onto the ground adjacent to the bore. If discharge water is directed into mud pits, any overflow must be controlled and directed away from the bore.

Tests shall be of a single or double packer type, where the lower section of the hole is isolated by the packer.

Test sections shall typically be between 3 m and 6 m long, with the level at which the packer shall be seated being determined by the Site Representative.

The test shall consist of 5 stages, each of 15 minutes duration, with the maximum pressure being applied in 3 equal increments and reduced by decrements of the same amount.

Accurate pressure and flow measurements shall be taken throughout the test by the Contractor.

Proof of recent calibration of the instruments to be used to measure these quantities shall be provided to the Geotechnical Professional prior to commencement of the first test.

The water level in the section of the bore above the packer shall be monitored during testing to ensure that no leakage occurs. If leakage is detected the test shall be terminated and re-set.

NZGS_200.12.14.3 Reporting

The following data shall be reported for each hydraulic conductivity test conducted:

1 Clients project number.

2 Project name.
3 Exploratory Location ID.
4 Date and time of test.
5 Name of the person who completed the test.
6 Static water level prior to development.
7 Height of pressure gauge above ground level.
8 Depth of hole prior to testing.
9 Length of test section.
10 Packer pressure.
11 Diameter of bore in test section.
12 Internal radius of casing.
13 Water level at start of test (time t = 0).
14 Gauge pressure.
15 Flow rate at regular intervals during each stage of testing.

NZGS_200.12.15 Pumping Tests

NZGS_200.12.15.1 References

- BS 5930:2015. Site investigations.
- BS ISO 14686:2003. Hydrometric determinations – pumping tests for water wells – Considerations and guidelines for design, performance and use.

NZGS_200.12.15.2 Methodology – equipment test

> The equipment test is done to check the pumping equipment, discharge measuring device and water level measuring device is working sufficiently. It is also to determine that all the equipment has met the necessary safety requirements and that all safety devices are fully functional.

For artesian wells the head above the measuring point is to be recorded before pumping or free discharges commences.

The well shall be pumped for a short period of time, to be agreed with the Site Representative, at varying discharge rates. Discharge rates and the drawdown for each discharge rate shall be measured.

> It is important that groundwater levels are measured in the test well and in any observation wells prior to the start of pumping (just before the end of the equipment test). The groundwater levels recorded will give an indication of the range of the water-level depressions that may be expected in the tests to come.

After the equipment test the water level shall be allowed to recover in both the observation wells and abstraction well before any further testing is done. This recovery will occur normally within a few hours, during which time the water levels relative to time for each well shall be recorded.

NZGS_200.12.15.3 Methodology – Stabilisation prior to step or constant drawdown tests

> A monitoring period is prescribed to allow the effect of drilling and bore installation on the groundwater to dissipate. The duration may be amended by the Geotechnical Professional to suit the site conditions.

The step test or constant drawdown test must take place a minimum seven days after drilling of the extraction bore any monitoring bores.

Level loggers set to record hourly shall be installed in the monitoring bores and pumping well.

All the wells shall be monitored for at least seven continuous days before the step or constant drawdown test commences.

NZGS_200.12.15.4 Methodology – Step test

> The purpose of a step test is to establish short-term yield drawdown relationships and thereby enable the ability to define the elements of head loss attributable to laminar flow (Darcian conditions) and additional components of head loss such as those attributable to turbulent flow.
>
> The step test includes pumping the well in a series of steps, each with a different discharge rate. It is advised that at least four different steps are made and that the final discharge rate should approach the maximum yield of the well. If the latter is unattainable then the maximum capacity of the pump should be substituted. It is important to take care as excessive pumping can lead to excessive drawdown which may result in the pump running dry and damage of equipment.

The steps shall be agreed with the Site Representative before the test is commenced.

Individual steps may be taken consecutively or intermittently. When steps are made consecutively the pumping rate is being changed at the end of each step.

The pumping rate shall be increased in equal increments from the first to last step, or decreased in equal decrements from the first to last steps.

When steps are made intermittently, pumping shall be stopped after each step until groundwater levels have fully recovered in the extraction and monitoring wells before commencing the next step.

NZGS_200.12.15.5 Methodology – Constant drawdown test

A pump capable of maintaining a set head in the bore shall be installed at or near the base of the bore. The water shall be left to settle for at least an hour after installation before the pump is started, and the water level in the bore measured with a dip meter immediately before starting pumping.

Water shall be extracted from the bore and disposed of in an approved manner. Obtaining approvals will be the responsibility of the Contractor. The preferred method of disposal is into the local stormwater system.

> The preferred method of disposal is normally into the local stormwater system. Approval for this will be required from the local authority, asset owner and landowner.

Upon commencement of the test pumping exercise, drawdown of the groundwater shall be measured manually using an electronic dip meter at no less than one minute intervals for one hour, then no less than 10 minute intervals until there is no measurable change or until six hours have passed, whichever comes first.

The discharge rate shall be determined either by metering the output of the pump manually by measuring time taken to fill a known volume container with discharged water. The discharge rate shall be monitored no less than daily.

Water samples for laboratory analysis (laboratory analysis is not part of this contract) shall be taken at the start and end of the test pumping to determine detailed water chemistry and evaluation of any changes occurring over the duration of the testing. Samples shall be labelled with the following information:

1. Contract title
2. Location ID (eg drill hole number)
3. Date and time sample taken
4. Position sample taken (eg within drill hole, from outfall)
5. Reason sample taken.

The water level in the bore shall be checked once a day with the dip meter.

Pumping shall continue for a period of seven continuous 24 hour days.

Monitoring of the monitoring boreholes with the level loggers shall continue during the test and for fourteen days beyond the completion of the pumping test at one hour intervals.

NZGS_200.12.15.6 Reporting

Results shall be reported in PDF format, with data also presented in Excel format.

As a minimum, the following should be reported:

1. Photographs of all equipment.
2. Records of all samples taken.
3. Records of all flow rates, dip-meter readings and level logger readings.
4. Calibration certificates for flow rate meters and electronic level loggers.

NZGS_200.12.16 Pressuremeter test

In a pressuremeter test a probe is inserted into the appropriate size borehole and expanded laterally by compressed air or gas. The applied pressures and resulting deformations are measured and enable the strength and deformation characteristics of the tested ground to be assessed.

The earliest and most common probe is the Menard pressuremeter (Menard, 1965). With this instrument, the lateral load is applied by a probe consisting of a water-filled central measuring cell flanked by two guard cells, either gas-filled or water-tilled, depending on the type of instrument.

Readings are taken at the ground surface on pressure and volume gauges which are connected to the central cell by means of a back-pressured annular plastic tube. The pressure tube and probe must be calibrated on site. The function of the guard cells is to ensure a condition of plane strain in the ground in contact with the central cell.

NZGS_200.12.16.1 References

- ASTM D4719-07. Standard Test Methods for Prebored Pressuremeter Testing in Soils (Withdrawn 2016).
- BS EN ISO 22476-4:2012. Geotechnical investigation and testing. Field testing. Ménard pressuremeter test.

NZGS_200.12.16.2 Methodology

The methodology shall be in accordance with BS EN ISO 22476-4:2012 for Menard pressure meter testing and ASTM D4719-07 for other tests, except as modified in this specification.

Pressure and volume calibrations shall be carried out:

1. At the beginning and end of a testing programme.
2. Whenever lengths of connecting tubes are changed.
3. Whenever new sheaths or membranes are installed.
4. Whenever any water line subjected to vacuum or pressure has been suddenly released.
5. Whenever any other factor affecting the calibration has changed.

The hydrostatic pressure due to fluid in the test equipment below the pressure gauge shall be determined prior to each test.

> Pressure calibration is to account for pressure losses which occur because of stiffness of the rubber membrane and slotted steel sheath of the probe.
>
> Volume calibration is to account for volume losses which occur because of expansion of the connecting tubes.

The test pocket must be formed with minimal disturbance of the sidewalls and with the proper diameter for the instrument to be used. The water flush rotary open hole drilling technique shall not be used to form the test pocket.

> The formation of a suitable test pocket is a crucial step in pressuremeter testing as the test data are obtained by radial expansion of the probe of only a few millimetres and even a thin disturbed zone around the pocket will affect the results.

The tests shall be carried out and reported in accordance with a test method that conforms to the requirements for the particular instrument type to be used.

NZGS_200.12.16.3 Reporting

The report shall document the factual results of the investigation. Where it has been agreed that interpretation shall be provided as part of the report it shall be clearly stated which aspects are interpretations and on what basis the interpretation has been made.

The following data shall be reported for each test conducted:

1. Clients project number.
2. Project name.
3. Exploratory Location ID.
4. Date and time of test.
5. Name of the person who completed the test.
6. The instrument used.
7. Testing procedure. This shall be either:
    a. The procedure to obtain a pressuremeter modulus, (EM) and limit pressure, (pLM), that may be used in design procedures formulated for the Ménard pressuremeter.
    b. The procedure to obtain other stiffness and strength parameters.
8. The calibration records.

Where appropriate the applied pressure shall be corrected for membrane stiffness to obtain the true pressure applied to the cylindrical ground contact surface around the probe.

Where a radial displacement type pressuremeter is used the displacement readings shall be converted to cavity strain and, if testing weak rock, corrected for membrane compression and thinning.

Where a volume displacement type pressuremeter is used (eg MPM), the volume reading shall be corrected for system expansion.

For radial displacement probes, the following shall be plotted in addition to the requirements of the individual equipment test standards:

Probe	Ground type	Abscissa	Ordinate
Self-bored, pushed in	All	Cavity strain for each arm	Applied pressure
Pre-bored		Cavity strain for each pair of arms	
Self-bored		Initial cavity strain for each arm	
All		Cavity strain for unload-reload cycle for each arm	
	Clay	Logarithm of cavity strain for each arm	
	Sands	Natural logarithm of current cavity strain for each arm	Natural logarithm of effective applied pressure

For volume displacement probes, the volume change and the rate of volume change shall also be plotted in addition to the requirements of the individual equipment test standards.

NZGS_200.12.17 Flat dilatometer test

The flat dilatometer is 96 mm wide and 15 mm thick steel blade that has in its centre a thin steel membrane of 60 mm diameter. The plate connects to CPT rods and is pushed vertically into the ground using a thrust machine (CPT rig). A cable passes through the rods to connect to a gas cylinder via a control box at the surface. The test involves halting the push at set depth intervals and recorded the pressure required to inflate the membrane against the soil. Two readings are taken;

- one when the membrane ‘lifts off’ the blade (A reading)
- the other when the membrane has expanded into the soil by a distance of 1.1 mm (B reading).

> A third reading can also be taken to record the pressure against the membrane once it has returned flat against the blade (C reading). The flat dilatometer test is abbreviated by DMT.
>
> A seismic module can be attached behind the DMT blade which allows the measurement of shear wave velocity to be obtained in the same sounding. The test is then referred to as SDMT. The seismic part of this test is a type of downhole seismic test that is covered in section 10.1.

NZGS_200.12.17.1 References

- ASTM D6635-01: Standard test method for performing the flat plate dilatometer.

NZGS_200.12.17.2 Equipment

The Contractor shall supply a thrust machine of suitable push capacity to achieve the required sounding depths in the expected ground conditions. The Contractor shall advise the Geotechnical Professional the details of the rig to be used prior to works commencing.

The flat dilatometer apparatus shall be the Marchetti type as specified in ASTM D6635-01. Unless otherwise agreed, the gas to be used shall be compressed dry nitrogen. A suitable gas regulator shall be provided that can supply a maximum gas pressure of not less than 40 bar and no greater than 80 bar.

A suitable membrane thickness shall be selected to suit the expected ground conditions.

> This would generally be 0.25 mm, but 0.30 mm may be more suitable dense sands/gravel and 0.20 mm in soft clays.

NZGS_200.12.17.3 Methodology

A calibration to account for the stiffness of the membrane in air shall be undertaken before and after the sounding. The calibrations should be repeated several times to ensure consistency. The average of the before and after calibration values is used in the subsequent calculations of the raw data. The calibration values should lie within the manufacturer's tolerances.

For newly installed membranes, the membrane should be 'exercised' by inflating to approximately 5 Bar and then deflating repeatedly several times until consistent calibration values are achieved.

The DMT test should be performed at regular depth intervals. A and B readings should be taken every 200 mm, with a C reading every 1 m.

NZGS_200.12.17.4 Reporting

The results shall be reported as specified in ASTM 6635-01.

Unless otherwise specified, the standard report generated by the Marchetti DMT acquisition software is considered adequate for the reporting of the DMT results.

NZGS_200.13 Instrumentation and groundwater monitoring installations

NZGS_200.13.1 General

NZGS_200.13.1.1 Cement/bentonite grout

Cement/bentonite grout shall be designed to produce a 7 day strength approximately 25% of the strength of the adjacent ground.

The liquid grout consistency shall be as thick as possible while remaining liquid enough to be pumped.

In order to keep field procedures simple the emphasis should be on controlling the water-cement ratio. This is accomplished by mixing the cement with the water first. When water and cement are mixed first, the water-cement ratio stays fixed and the strength/modulus of the set grout is more predictable. If bentonite slurry is mixed first, the water-cement ratio cannot be controlled because the addition of cement must stop when the slurry thickens to a consistency that is still pumpable. The mix can be best controlled by hydrating the bentonite before it is added to the water/cement mix.

	Grout for	
	Firm or stiffer soils / rock	Soft soils
Water	2.5	6.6
Portland Cement	1	1
Bentonite	0.3	0.4

Suggested mixes are given in the table above. More detail can be found in Mikkelsen, P.E., 2002. Cement-Bentonite Grout Backfill for Borehole Instruments. Geotechnical Instrumentation News, December 2002, p38–42.

NZGS_200.13.2 Standpipes for groundwater level monitoring

Standpipe installations should be designed to minimise the risk of interference with groundwater flow regimes (long screens can induce vertical flow within an aquifer) and to allow the collection of a sample that meets the requirements of the monitoring objectives. In general, the screen should be the minimum length required to meet the objectives whilst ensuring that mixing and sample dilution within the borehole does not affect the sample results or the interpretation of those results.

> In layered aquifer systems, the response zone should be of an appropriate length to prevent connection between different aquifer layers within the system by adopting standpipe piezometer installation rather than open standpipes.

NZGS_200.13.2.1 Equipment

The perforated section of the standpipe shall be slotted with an open area of 10–15%. Where specified by the Geotechnical Professional this section shall be wrapped with a filter fabric.

> Screen aperture size should be selected to minimise the ingress of fine materials into the borehole and to maximise the hydraulic performance. The required slot size of the screen is determined from the grain size of the filter material. The screen slots should be small enough to prevent 90% of the filter pack material entering. In fine formations it is difficult to construct slot sizes which are sufficiently small to prevent the ingress of fine particles and a geotextile wrap is often used. Where a geotextile wrap is used, consideration should be given to its mesh size and to the material employed due to the potential risk of clogging.

The standpipe tubing shall comprise uPVC, PTFE, HDPE or stainless steel except in zones of high geothermal activity, where stainless steel shall be used.

The filter material shall be clean sand or gravel as defined by the Geotechnical Professional, and inert (free of reactive minerals including iron, carbonates or organic material).

> Where a standpipe is installed into silts or coarser granular soils the filter material must be matched to the aquifer and to the standpipe slot size. An appropriately designed filter pack and screen will prevent or limit the entry of fine material into the casing. Accurate filter design requires a particle size distribution (PSD), preferably from sieve analysis but an estimate of the PSD can be made from visual inspection for the target formation.

Blinding sand shall be fine to medium graded sand (eg pool filter sand with minimum 85% passing 0.6 mm sieve and maximum 15% passing 0.06 mm sieve).

> Blinding sand is placed above the filter material to prevent the grout damaging the filter material.

NZGS_200.13.2.2 Methodology

The installation shall be generally as shown in Volume 0 Appendix C.

The borehole into which the standpipe is installed shall have a diameter more than 60 mm larger than the outside diameter of the standpipe.

Centralisers may be used to ensure that screens are straight and central in the drill hole however care should be taken to ensure that centralisers do not cause bridging of gravel pack. If ballasting is required during installation then clean water should be used.

Where the depth of the hole is greater than the base of the filter material then:

1. The exploratory hole shall be backfilled with impermeable material (cement/bentonite grout or bentonite pellets at the discretion of the Geotechnical Professional) to the base of the filter.
2. Grout shall be placed using a tremie pipe.
3. Sufficient time shall be allowed for the grout to set before continuing with the installation.
4. When the grout has set the remaining depth of hole to the base of the filter shall be filled with bentonite pellets to form the lower seal.

Where the hole is dry and bentonite pellets are used, sufficient clean water for immediate saturation of the pellets shall be added concurrently with the bentonite pellets.

The filter material shall be placed in small quantities to avoid bridging/clogging which could result in voids.

If the filter material is placed in water, after each addition of filter material it shall be allowed to settle and the depth of the upper surface measured before adding the next batch of material.

A minimum 300 mm thick layer of blinding sand shall be placed above and (where appropriate) below the filter.

Bentonite pellets shall be placed above the blinding sand to form an upper seal not less than 0.5 m thick. The remainder of the hole shall be filled with cement/bentonite grout or bentonite pellets to within 0.5 m of ground level unless the Geotechnical Professional specifies otherwise. This is not required for shallow non-artesian standpipes which may be completed by back filling the casing annulus above the gravel pack to within half a metre of the finished ground surface with a suitable free running soil containing no large lumps or stones which could cause bridging.

The top of the standpipe tubing shall be covered with a plastic cap or similar with an air vent to allow free ingress/egress of air.

To prevent surface water ingress and protect the top of the tubing a steel barrel or flush stopcock cover shall be installed. The protective cover shall be set in concrete and incorporate a gravel drainage layer connected to the air space around the top of the tubing. This drainage layer may be omitted for upstands which contain drainage holes near ground level.

Except where installed in roads, the upstand or flush cover shall be surrounded by a minimum 100 mm thick, 0.5 m diameter concrete pad sloped to maximise water drainage away from the well and installed in accordance with NZS4411.

Where installed in roads the finish detail shall be as required by the owner.

The standpipe shall be developed to remove soil fines from around the screens by pump surging or air lifting. Development shall continue until the water is clean and sand-free.

The surface mounting of the standpipe shall be designed to avoid water entering or ponding as these will invalidate the results. The photo below shows an example of poor practice with ponding water.

Nested well sets should be constructed so that there is no opportunity for leakage between aquifers. Where possible, the standpipes should be installed in separate drillholes.

NZGS_200.13.2.3 Reporting

The Contractor shall record the as-built details of the standpipe (preferably using the template provided in Volume 0) including:

1. Clients project number.
2. Project name.
3. Exploratory Location ID.
4. Installation date.
5. Static water level prior to installation.
6. Depth below ground level of all changes in backfill material to 0.05 m accuracy.
7. Depth below ground level of base and slotted section of standpipe to 0.01 m accuracy.
8. Grout mix.

NZGS_200.13.3 Standpipes for contamination monitoring

NZGS_200.13.3.1 General

Standpipes for contamination monitoring shall be constructed as specified for standpipes for groundwater monitoring, with the following modifications and additions.

NZGS_200.13.3.2 Equipment

The perforated section of the standpipe shall be slotted with angled machine cut threads of between 0.5 mm and 1.0 mm.

The piezometer casing and screen shall comprise new and undamaged Class 18, threaded, flush jointed unplasticised uPVC, with 50 mm internal diameter and plug.

Couplings shall comprise new and undamaged Class 18, unplasticised uPVC O-rings or Teflon tape applied to the male thread of casing.

The use of filter socks, glues, cements or adhesive tape is prohibited except where specified by the CL-SQEP.

The filter material shall be clean sand or gravel as defined by the CL-SQEP.

> Filter material is commonly 2 mm washed sand (eg Walton Park 7/14). Where drilling in clay or silt deposits finer sand should be considered to prevent clogging of the well, however consideration of the screen slot size should be made if reducing the grain size of the gravel pack material.
>
> Placement: between 2–10% by volume placed at the base of the drill hole prior to installation of the screen. Gravel pack should then extend 300 mm–600 mm above the top of the well screen. Check placement of gravel pack at the base of the drillhole for dense non-aqueous phase liquids.
>
> As some contamination can impact on the ability of bentonite pellets to swell, bentonite should be added in a slurry form where this is a consideration. All slurries should be placed using a tremie pipe from bottom up to minimise the potential for bridging and to ensure that a good seal is formed.

NZGS_200.13.3.3 Methodology

Casing and screening pipes shall either be:

1. Factory sealed in plastic.
2. Steam cleaned/high pressure washed on site using potable water. In this case a sample of wash water shall be collected for quality assurance purposes.

If any water is added to the hole during installation, a sample of this water shall be collected for quality assurance purposes.

> Screen placement should be designed to measure the presence of light, non-aqueous phase liquid (ie the piezometric surface should be below the top of the screen) and take into account likely groundwater level fluctuations.
>
> Wells should not be screened across aquifers or in such a way that they allow contaminants to move into uncontaminated zones.

NZGS_200.13.4 Vibrating wire piezometers

NZGS_200.13.4.1 References

- ASTM D7764-12. Standard Practice for Pre-Installation Acceptance Testing of Vibrating Wire Piezometers.

NZGS_200.13.4.2 Equipment

The Geotechnical Professional shall specify the appropriate piezometer model for the situation, pressure range, cable length, filter type and readout unit or data logger required.

Where the sand filter installation method has been specified, the filter material shall be clean granular material.

Cement/bentonite grout shall be designed by the Contractor to achieve suitable porosity for the proposed end use.

NZGS_200.13.4.3 Methodology – installation

Cables shall be carefully marked before commencing for positive identification once installed. The tips shall be numbered sequentially from one, commencing with the deepest tip.

The pre-installation acceptance testing methodology shall be in accordance with ASTM D7764-12, except as modified in this specification.

A pre-installation zero check shall be undertaken and the results checked to confirm that current air pressure is being correctly recorded. A series of readings shall be taken until repeatable values are attained.

The piezometer shall be submersed in a bucket of clean water, and the filter removed to allow air to escape from the piezometer, before replacing the filter.

A stiff plastic pipe or stiff tremie pipe should be prepared to be at least as long as the depth to the lowest vibrating wire tip. The piezometer(s) shall be securely attached, filter-end up, to this pipe so that they cannot move during installation.

The depth of the tip from the top of the pipe shall be measured and recorded.

Adequate cable shall be provided for each piezometer to allow the cable to terminate above ground (either at the data logger or extended with a waterproof connector).

Static ground water level in the borehole shall be recorded before and after placing the piezometers in the hole.

The piezometer(s) and support tube shall be placed into the borehole, and any upstand of the support tube above ground level recorded.

A down-hole pressure check shall be undertaken by taking a series of readings until repeatable values are attained. The difference in pressure between the downhole pressure check and the pre-installation zero check shall be checked to ensure it is equal to the head of water above the tip in the borehole.

NZGS_200.13.4.4 Methodology – connection to datalogger

Where multiple vibrating wire tips are attached to a single data logger, the deepest tip will be installed into Channel 1, with subsequent tips installed in numerical order.

NZGS_200.13.4.5 Reporting

The following data shall be recorded for each vibrating wire piezometer:

1. Clients project number.
2. Project name.
3. Exploratory Location ID.
4. Static water level prior to installation.
5. VW serial number.
6. Datalogger channel (where installed into a multi-channel logger).
7. Tip depth as built, to 0.01 m accuracy.
8. Grout installation date and time.
9. Grout mix.
10. VW calibration certificate.
11. Results of pre-installation zero check (‘acceptance test’).
12. Results of downhole pressure check.

NZGS_200.13.5 Inclinometers

NZGS_200.13.5.1 References

- ASTM D6230-13. Standard Test Method of Monitoring Ground Movement Using Probe-Type Inclinometers.
- ASTM D7299-12. Standard Practice for Verifying Performance of a Vertical Inclinometer Probe.

NZGS_200.13.5.2 Equipment

The Geotechnical Professional shall specify the inclinometer diameter required and whether the probe shall be portable or in-place.

Measurements shall be captured using a digital readout unit.

NZGS_200.13.5.3 Methodology – installation

The methodology shall be in accordance with ASTM D6230-13 and ASTM D7299-12, except as modified in this specification.

Prior to installation the Contractor shall clear the borehole of any drilling mud or spoil and report any deviation of the borehole from vertical to the Geotechnical Professional.

The casing shall be installed in the borehole adding casing sections as necessary until the casing reaches the specified depth.

One pair of grooves shall be orientated in the direction of expected movement. The Contractor is to maintain the required orientation of the groove during grouting. Attempts to correct the orientation after grouting are not acceptable and may result in corkscrewing of the casing.

The casing may be weighted from the bottom to counter buoyancy from water and/or grout, until the grout sets. The casing shall not be held from the top as this can result in the casing corkscrewing.

Grout shall be pumped into the borehole through a tremie pipe.

A flush or upstand protective cover shall be installed as directed by the Geotechnical Professional.

The Contractor shall take a set of three initial readings once the grout has set.

NZGS_200.13.5.4 Methodology – Inclinometer reading

Where possible, the same probe and cable should be used for each survey.

The Contractor shall:

1. Check that the wheels turn smoothly and if necessary, clean and lubricate. Check the wheel yoke moves freely. Check for excess play in the wheels and yokes. Check no screws are loose. Check all parts for wear and tear.
2. Check correct orientation readings of the probe by tilting the probe. The readings should be positive when the probe is tilted to the A0 and B0 directions.
3. Keep the probe and cable clean by placing on a protective ground cover close to the inclinometer.
4. Survey the A0 groove first.
5. Lower the probe to the bottom of the casing and allow time for the probe to adjust to the temperature inside the casing.

6 Raise the probe to the starting depth. Wait for the numbers on the readout to stabilise. Record the A and B axis readings.
7 Raise the probe to the next depth. Wait for the numbers to stabilise and record the readings. Repeat until the probe is at the top of the casing.
8 Remove the probe and rotate 180 degrees. Align the upper wheels with the 180 groove and insert into the casing.
9 Lower the probe to the bottom of the casing and repeat the reading process.

NZGS_200.13.5.5 Reporting

The following data shall be recorded for each inclinometer:

1 Clients project number.
2 Project name.
3 Exploratory Location ID.
4 Static water level prior to installation.
5 Probe serial number.
6 Tip depth as built, to 0.01 m accuracy.
7 Grout installation date and time.
8 Grout mix.
9 Reference point for depth control.
10 Initial readings ‘zero readings’ results.

NZGS_200.14 Surveying of exploratory locations

NZGS_200.14.1 Methodology

One of five standard levels of accuracy shall be specified by the Geotechnical Professional:

1. Full survey by a Chartered Professional Surveyor (X, Y, Z levels surveyed to 50 mm accuracy in the X and Y and 5 mm accuracy in the Z or better)
2. Quality GPS with manufacturer accuracy stated to be ±2m or better (X, Y coordinates surveyed to 2m accuracy or better, Z levels taken from local mapping)
3. Other GPS including pocket or phone GPS (X, Y coordinates surveyed to 10 m accuracy or better, Z levels taken from local mapping)
4. Tape/measure from fixed points on site (X, Y coordinates surveyed to 10 m accuracy or better, Z levels taken from local mapping)
5. Estimate from aerial photography or maps (X, Y coordinates surveyed to 20 m accuracy or better, Z levels taken from local mapping)

Where the Geotechnical Professional has not specified the level of accuracy, Level 2 shall be assumed.

Where specification is to Level 1 standard, all trial pits and trenches shall have each corner surveyed.

Where the Geotechnical Professional has not specified the datums to be used:

1. All coordinates shall be relative to the New Zealand Geodetic Datum 2000 datum.
2. All maps shall be presented in New Zealand Transverse Mercator 2000.
3. All elevations shall be relative to New Zealand Vertical Datum 2009.

Elevations shall be ground level measured immediately adjacent to the Exploratory Location.

All point locations (boreholes, CPTs, hand augers, DCPs etc) shall be recorded as a single point.

Where vibrating wires are installed in such a way that the datalogger is not directly over the borehole and the cable is installed in a trench, then the cable alignment and depth shall be surveyed. A survey point shall be taken at every change of cable direction or depth, with a minimum of one point every 5 m.

NZGS_200.14.2 Reporting

Raw data shall be presented as an Excel format spreadsheet giving Exploratory Location ID, X, Y, Z.

NZGS_200.15 Geotechnical laboratory testing

NZGS_200.15.1 References

- NZS 4402:1986. Methods of testing soils for civil engineering purposes.
- NZS 4407:2015. Methods of sampling and testing Road Aggregate.
- ASTM Standards Volumes 4.08 and 4.09 Soil and Rock.
- BS1377-2:90. Methods of tests for soils for civil engineering purposes.
- NZGS, 2005. Field Description of Soil and Rock.

NZGS_200.15.2 Methodology

The Laboratory must be accredited by IANZ to carry out the requested test methods. Exemptions can be allowed if agreed in advance with the Geotechnical Professional.

The following standards or methods shall be applied to tests on rock:

Test	Default test method/standard	Special requirements and notes
Sample description	NZGS Field Description of Soil and Rock	
Uniaxial Compressive Strength (without strain measurement)	NZS4402 Test 6.3.1	
Uniaxial Compressive Strength (with strain measurement)		
Point Load Index (axial)	ASTM D5731-08	
Point Load Index (diametrical)	ASTM D5731-08	
Bulk density	NZS4402 Test 5.1.3	
Dry density (including porosity and pore volume)	ISRM 1981 Part 2	
Moisture content	NZS4402 Test 2.1	
Slake durability index	ASTM D4644-87 (98)	
Brazilian tensile strength	ASTM D3967-08	
Cherchar (CAI)		
Uniaxial Indirect Tensile Strength (Brazilian)		
Skelerograf/Shore Hardness		
Goodrich Drillability		
Petrographic determination (thin section)		
Sonic veolcity (P and S wave)		
Soil abrasion test		
Three dimensional swelling (1 week monitoring)		

Test	Default test method/standard	Special requirements and notes
Thermal Resistivity (undisturbed 2 points to target dry density)	GEO155	
Triaxial (Hoek Cell)	ASTM D7012	

The following standards shall be applied to tests on soil:

Test	Default test method/standard	Special requirements and notes
Sample description	NZGS Field Description of Soil and Rock	
Water content	NZS4402:1986 Test 2.1	
Atterberg Limits including NWC	ASTM D4318 – 10e1	Although the ASTM method is preferred as it provides correlation with liquefaction data, NZS4402:1986 Test 2.1, 2.2, 2.3, 2.4 may be used in areas not prone to liquefaction
Solid density (Particle density)	NZS4402:1986 Test 2.7.1 or 2.7.2	
Bulk density/Dry density including NWC	NZS4402:1986 Test 5.1.3	
PSD (dry sieve)	NZS4402 Test 2.8.2	
PSD (wet sieve)	NZS4402:1986 Test 2.8.1	
PSD (Wet sieve and pipette/hydrometer)	NZS4402:1986 Test 2.8.3 or 2.8.4	
Organic content	NZS4402:1986 Test 3.1	
ph	NZS4402:1986 Test 3.3.1	
Sulphate	NZS4402:1986 Test 3.2	
Allophane presence	NZS4402:1986 Test 3.4	
Organic content by ignition	NZS4402 Test 3.1.2	
MDD Normal compaction	NZS4402:1986 Test 4.1.1	Lab vane tests in clay
MDD Heavy compaction	NZS4402:1986 Test 4.1.2	Lab vane tests in clay
MDD Vibratory compaction	NZS4402:1986 Test 4.1.3	Lab vane tests in clay
Max/Min/Relative density	NZS4402:1986 Test 4.2	
Dispersion (Emerson Crumb)	AS 1289.3.8.1-2006	
California Bearing Ratio (heavy remoulded, dry)	NZS4402:1986 Test 6.1.1	
California Bearing Ratio (heavy remoulded, soaked)	NZS4402:1986 Test 6.1.1	

Test	Default test method/standard	Special requirements and notes
California Bearing Ratio (heavy remoulded, lime added)	NZS4402:1986 Test 6.1.1	
1D consolidation	NZS4402:1986 Test 7.1	Cv, Mv & e (√ t90 Method, 6 to 7 loading cycles)
Shrink/swell index	AS 1289: Test 7.1.1	
Permeability in constant head cell	BS1377 Part 5 Test 5	Including single pt compaction, NWC
Permeability in triaxial cell	BS1377 Part 6 Test 6	
Lab vane	NZGS Shear Vane Guidelines 2001	
Ring shear	BS 1377-7:1990 part 6	3 stages
Small shear box (undisturbed sample)	BS 1377-7:1990 part 4	3 stages
Small shear box (heavy compacted sample)	NZS4402:1986 Test 4.1.2 and BS 1377-7:1990 part 4	3 stages
Thermal Resistivity	GEO155	4 points
Unconsolidated Undrained triaxial single stage (UU)	NZS4402:1986 Test 6.2	
Unconsolidated Undrained triaxial 3 stage (UU)	NZS4402:1986 Test 6.2	
Consolidated undrained triaxial with pore pressure measurement (CUP)	BS 1377-8:1990 Test 7	
Consolidated drained triaxial with measurement of volume change (CD)	BS 1377-8:1990 Test 8	
Isotropic Consolidation	BS1377 Part 6 Test 5	5 effective consolidation pressures

NZGS_200.15.3 Reporting

All results shall be presented in all of the following formats (where available):

1. The AGS4 NZ data transfer format.
2. PDF.
3. Excel spreadsheet of full test data (not just output results), checked and verified with errors removed.

NZGS_200.16 Geoenvironmental laboratory testing

NZGS_200.16.1 Quality assurance/Quality control

All analysis should be completed by a Laboratory that has an appropriate accreditation for the particular analysis selected.

Laboratories completing analysis of samples should also implement quality assurance testing to provide a record of accuracy or precision. Procedures should be consistent with that required by the test method and records of the quality assurance should be available on request.

NZGS_200.16.2 Methodology

Methodology for analysis should be a recognised test method and the laboratory accredited to carry out this test.

NZGS_200.16.3 Reporting

All results shall be presented in all of the following formats (where available):

1. The AGS4 NZ data transfer format.
2. PDF.
3. Excel spreadsheet.

NZGS_200.17 Factual reporting

NZGS_200.17.1 Quality assurance

All reports shall be reviewed, approved and signed by the Geotechnical Professional.

Each individual bore log shall be reviewed, approved and signed by the Geotechnical Professional, and contain sufficient information that the location, coordinates, grid system, datum, project and date can be identified from the log without reference to the report.

NZGS_200.17.2 Reporting

NZGS_200.17.2.1 Geotechnical factual report

> The factual report should not contain any interpretation of the conducted investigation. Interpretation should reside in the project Geotechnical Interpretative Report which is outside the scope of this Specification. Where interpretation is needed to satisfy the brief, eg in the preparation of geological mapping, the basis of the interpretation shall be clearly identified on the item in question (ie within the report or upon the drawing/map) in order that future uses of the information have a clear understanding of its basis.

The Geotechnical Factual Report shall include the following components:

1. A brief factual description of the purpose and extent of the ground investigation.
2. Site location details.
3. Number and type of Exploratory Locations.
4. Name and contact details of the Contractor(s) undertaking the works.
5. Name(s) of the individuals undertaking logging and of the Geotechnical Professional who reviewed the logs.
6. Date and duration of the work.
7. Prevailing weather conditions and any notable weather conditions prior to investigations being conducted that may impact on the results (eg investigation preceded by snow, snow melt, heavy rainfall or drought.
8. Commentary on how the geographical co-ordinates and level of each Exploratory Location was determined, and the accuracy of this survey.

For each investigation methodology, the report shall provide details of:

1. Equipment used.
2. Testing methodology.
3. Standards adopted.
4. Calibration undertaken.
5. Any deviation from accepted practice or suspected errors and inconsistencies.

For groundwater level monitoring conducted during the investigation period, tabulated measurements referenced to ground level and the elevation of the ground surface together with commentary on installation (eg during drilling, within standpipe, by piezometer etc.).

For any laboratory testing completed, tests undertaken and standards adopted and a summary of results.

The detailed results of the investigation shall be presented in a series of Appendices including:

1. A map (to scale) showing:
   a. Testing locations using symbols (a different symbol being used for each test type)explained in a key.
   b. A north arrow.
   c. A scale bar.
   d. Lot boundaries.
2. A schedule of exploratory holes stating depth achieved below existing ground level, elevation of the ground surface (related to the adopted site datum), location co-ordinates and datum used.
3. Exploratory hole logs (including all data defined in Clause 4.1.4) and associated images (photographs).
4. A key sheet explaining all symbols and acronyms used on the exploratory hole logs.
5. Field observations/mapping with photographs.
6. As-built construction details of all monitoring installations and standpipes.
7. All laboratory testing and analysis results in full.
8. Monitoring undertaken during and immediately after the investigation period.
9. A copy of the Drillers' Log(s).
10. Calibration certificates for field equipment used (including SPT hammer efficiency).

NZGS_200.17.2.2 Contamination factual report

Contaminated land reporting shall be in accordance with Ministry for the Environment MfE Contaminated Land Management Guideline No. 1 Reporting on Contaminated Sites in New Zealand and NZS 4411:2001.

Where exploratory holes are undertaken as part of the contamination assessment, the requirements of Geotechnical Factual Reporting shall be also apply.

NZGS_200.17.2.3 Transferable data format

All new factual information, including field observations, laboratory test results, geotechnical data and geoenvironmental data, shall be reported in the AGS4 NZ data transfer format in addition to other formats required (eg pdf). Ground Investigations meeting all of the following requirements shall be exempt from this requirement, the;

1. maximum depth of the investigation is 5 m or less

2 total number of Exploratory Locations is 15 or fewer
3 client accepts that AGS4 NZ format is not required.

Abbreviation codes shall be as defined in the latest guidance published by the New Zealand Geotechnical Society.

All AGS4 NZ format data shall be checked using AGS4 NZ checking software prior to issue and shall be free of AGS4 NZ Data Format or AGS4 NZ Data Integrity errors. Exceptions may be made for errors in the number of decimal places used, different Unit Types from the suggested type, or items in the ABBR group without descriptions.

AGS4 NZ Format data shall be issued as a single file. However, subject to the agreement of the data receiver, separate files may be permitted in the following cases:

1 Separate field and laboratory data for preliminary issue (if this serves to expedite the issue of data).
2 CPT and other in-situ data as separate files for each test where the data files are large.

The digital data provided with the Factual Report is required to be complete and a total replacement of any previous preliminary data submissions.

The AGS4 NZ data and associated files shall be complete and identical to the data provided in the paper copy of the factual report.

NZGS_200.17.2.4 NZ Geotechnical Data

All factual data (including borehole logs, laboratory test results, and ongoing groundwater monitoring) shall be uploaded to the New Zealand Geotechnical Database by the Consultant.

NZGS_200.18 Appendix A. Abbreviations and definitions

These definitions are for the purposes of this ground investigation specification. Other terms may be defined in the Conditions of Contract.

NZGS_200.18.1 Technical and contractual terms

Term	Definition (the formal or legal meaning of the term)	Commentary (not part of the definition)
AGS4 NZ	New Zealand localisation of the UK 'AGS4' data transfer format.	This data format enables geotechnical and geoenvironmental data to be shared and used across numerous software applications.
Archaeological Site	Any place in New Zealand that either: was associated with human activity that occurred before 1900; or is the site of the wreck of any vessel where that wreck occurred before 1900; and is or may be able through investigation by archaeological methods to provide evidence relating to the history of New Zealand.	In terms of this definition, a site could include an object or material.
Contract	The terms of engagement used for the specific project.	
CPEng	Chartered Professional Engineer.	
Exploratory Location	A specific location defined for one or more method of Intrusive or Non-intrusive Ground Investigation.	
Fill (controlled)	Any deposits which have been formed by persons, as distinct from geological processes, under a designated and controlled scheme of placement and compaction in order to achieve a specified quality of ground.	See also Fill (uncontrolled)
Fill (uncontrolled)	Any deposits which have been formed by human processes, as distinct from geological processes, but without the design and control required for Fill (controlled).	See also Fill (controlled)
GPR	Ground Penetrating Radar.	GPR is commonly used to locate buried services or as a geotechnical investigation tool.

Term	Definition (the formal or legal meaning of the term)	Commentary (not part of the definition)
Ground Investigation	Work undertaken under the guidance of a Geotechnical Professional to examine subsurface materials by indirect or direct methods at a site for a specific engineering project.	See also Site Investigation and Intrusive Ground Investigation.
Hard Rock	Hard Rock is material encountered during drilling or boring where a Standard Penetration Test (SPT) shows a resistance in excess of 35 blows/75 mm penetration. Where SPTs are not undertaken it is defined as material in which boring with normal appropriate tools in good condition cannot proceed at a rate greater than 0.5 m/hour. The stated rate shall be applicable for the boring operation alone and exclude sampling, in-situ testing, equipment and core recovery, and standing time.	See also Soft Rock and Soil. This description is not intended to correlate with NZGS soil and rock descriptions.
Inspection Pit	A hole excavated using non-destructive techniques such as hand or vacuum excavation to locate buried services to attempt to confirm the absence of buried services at exploratory hole locations.	See also Test Pits and Trenches.
Intrusive Ground Investigation	A type of ground investigation which enables direct visual assessment of the subsurface ground conditions and/or the direct in-situ measurement of geotechnical parameters.	Common examples of such types of investigation include boreholes with core recovery, Cone Penetrometer Tests, test pits and 'direct transmission' Nuclear Densometer Tests.
IPENZ	Institution of Professional Engineers New Zealand	
Koiwi	Human skeletal remains.	
m bgl	Metres below the ground level or surface at the time the investigation was carried out.	
m RL	Depth given in terms of the project datum at the time the investigation was carried out.	
MASW	Multichannel Analysis of Surface Waves.	This is a type of geophysical survey which is a surface wave technique.

Term	Definition (the formal or legal meaning of the term)	Commentary (not part of the definition)
Non-intrusive Ground Investigation	A type of ground investigation which enables assessment of the subsurface ground conditions without physically penetrating beneath the ground surface.	Common examples of such types of investigation include geophysical surveys 'back scatter' Nuclear Densometer Tests and Clegg Hammer Tests.
NZS	New Zealand Standard.	
PEngGeol	Professional Engineering Geologist as conferred by IPENZ.	
Permit to Dig	A document giving permission to commence physical works at a specific Exploratory Location recording the steps taken to eliminate, isolate or minimise site risks.	An example Permit to Dig is given in Volume 0. A project, client or site specificsite-specific version should be used as appropriate.
Pre-drill (PD)	Drilling performed through dense or hard stratum to facilitate access to underlying soils.	
Rotary Drilling	The formation of exploratory holes by rotary drilling and auger methods.	
Rotary Sonic Drilling	The formation of exploratory holes using high-frequency mechanical vibration of the casing and/or sampling tools to advance the hole, with optional rotation.	
SASW	Spectral Analysis of Surface Waves	A type surface wave geophysical technique.
SCPT	Seismic Cone Penetration Test.	A type of CPT which has the additional ability to collect data for use in assessment of shear wave velocity.
SDMT	Seismic Dilatometer Test	A type of Flat Plate Dilatometer which has the additional ability to collect data for use in assessment of shear wave velocity.
Site Information Pack	A document prepared and maintained by the Client or their representative detailing site hazards and limitations.	
Site Investigation (SI)	Work undertaken under the guidance of a Geotechnical Professional to characterise the geotechnical and geoenvironmental	SI is typically undertaken in stages to address identify ground conditions and assess the interaction with engineering

Term	Definition (the formal or legal meaning of the term)	Commentary (not part of the definition)
	conditions at a site for a specific engineering project. Site Investigation includes Ground Investigation as well as desk study and walkover surveys.	structures. It may comprise desk studies, site reconnaissance, testing and intrusive investigations. The benefit of additional investigations to reduce geotechnical uncertainty is continually reassessed throughout the SI. See also Ground Investigation.
Soft Rock	Soft Rock is material encountered which has an SPT blow count greater than 50 blows per 300 mm and less than that required for Hard Rock Where SPTs are not undertaken it is defined as material in which boring with normal appropriate tools in good condition cannot proceed at a rate greater than 3 m/hour. The stated rate shall be applicable for the boring operation alone and exclude sampling, in-situ testing, equipment and core recovery, and standing time.	See also Hard Rock and Soil. This description is not intended to correlate with NZGS soil and rock descriptions.
Soil	Any natural or artificial material not classified herein as Topsoil, Hard Rock or Weak Rock.	
Specification	The Specification comprises Volume 1 of the 'Ground Investigation Specification' associated with this document. Volume 0 does not comprise part of the Specification although these definitions shall be used. Volume 2 and 3 form part of the Specification if they are used.	
Surface Water Body	Surface water bodies include rivers, streams, canals, ditches, lakes and ponds (including ephemeral watercourses which may be dry at the time of the investigation).	
Taonga	An object that: Relates to Māori culture, history, or society; and Was (or appears to have been):	

Term	Definition (the formal or legal meaning of the term)	Commentary (not part of the definition)
	Manufactured or modified in New Zealand by Māori; or Brought into New Zealand by Māori; or Used by Māori.	
Taonga Tūturu	An object that meets the definition of Taonga and is more than 50 years old.	Definition summarised from Section 2 of the Protected Objects Act 1975.
Test Pits and Trenches	Excavations to enable the visual examination of the ground conditions and any required sampling from outside the pit or trench without personnel entering into the excavation.	Also referred to as Trial Pits. See also Inspection Pit.
Topsoil	The top layer of material that contains humus and can support vegetation.	

NZGS_200.18.2 Roles and organisations

Term	Definition (the formal or legal meaning of the term)	Commentary (not part of the definition)
Client	The individual or organisation engaging suppliers of ground investigation expertise.	
Consultant	The individual or organisation engaged by the Client to manage and report on the Ground Investigation. In some cases the Consultant may also undertake some or all of the physical work, directly procure a Contractor, or assist the Client to procure a Contractor.	The Consultant has the responsibility of Designer under the Health and Safety at Work Act 2015 for the design of the Ground Investigation.
Contaminated Land Suitably Qualified and Experienced Practitioner (CL-SQEP)	A senior or principal scientist/engineer with a relevant tertiary qualification and at least ten years of experience in the assessment and management of land containing elevated levels of contaminants.	
Contractor	An individual or organisation engaged by the Client, Consultant or another Contractor to undertake some or all of the physical work involved in the Ground Investigation.	

Term	Definition (the formal or legal meaning of the term)	Commentary (not part of the definition)
Driller	The operative in charge of a drill rig.	
Driller's Assistant	The operative assisting, and under the full-time direction of, the Driller.	
Field Staff	Staff engaged in one or more aspects of the site investigation fieldwork, variously charged with marking out, services clearance, traffic control, supervision, logging of the works, etc.	
Geotechnical Professional also referred to as Geo-professional or GP	The authorised representative of the Consultant which is ultimately responsible for design and execution of the geotechnical investigation. A Geotechnical Professional must be the authorising signatory on all geotechnical reports, drawings, producer statements, statements of suitability and/or statements of professional opinion which are submitted to a Local Authority or client. The Geotechnical Professional shall be a suitably qualified and experienced Chartered Professional Engineer (CPEng) with accreditation in the geotechnical practice field as administered by ~~IPENZ~~ Engineering NZ and/or a Professional Engineering Geologist with current registration on the ~~IPENZ~~ Engineering NZ PEngGeol register.	The Geotechnical Professional is likely to be a person with university level qualifications in geotechnical engineering or engineering geology and demonstrable experience in the investigation of sites subject to similar geotechnical hazards over a period of at least 10 years. In this Specification the term Geotechnical Professional always refers to the Consultants' Geotechnical Professional. It is possible that the Client may engage their own Geotechnical Professional to advise them on technical and procurement matters. Where this is the case this person will assist the Client with their obligations and responsibilities, but will not have the authority, obligations and responsibilities of the Geotechnical Professional
Laboratory	An individual or organisation engaged to undertake testing on samples recovered from site.	
NZGS	New Zealand Geotechnical Society	
NZTA	New Zealand Transport Agency (Waka Kotahi)	

Term	Definition (the formal or legal meaning of the term)	Commentary (not part of the definition)
Operator	The operative in charge of an item of field testing apparatus.	Field testing apparatus may comprise CPTs, plate load equipment, geophysical tools etc.
Owner	The person or entity owning the site and/or development in question.	
Project Archaeologist	A qualified archaeologist appointed to oversee the project	Where the project has the potential to affect an archaeological site it is required to obtain an Archaeological Authority from the Heritage New Zealand. The Archaeologist must be approved in writing by the Heritage New Zealand (under s45 of the HNZPTA) before work starts.
Regional Archaeologist	Heritage New Zealand's regional representative	
Site Representative	The Site Representative is the Geotechnical Professional or CL-SQEP's Representative. The Site Representative is the person authorised to issue instructions to the Contractor.	One or more named individuals, nominated in writing by the Geotechnical Professional, with responsibility to see that the technical objectives and quality of the investigations are met. For small projects this role may be undertaken by the Geotechnical Professional.

NZGS_200.18.3 Types of geotechnical reports

Term	Definition (the formal or legal meaning of the term)	Commentary (not part of the definition)
GDCR	Geotechnical Data Compilation Report.	A GDCR is a compilation of pre-existing geotechnical data (typically from multiple Geotechnical Factual Reports).
GFR	Geotechnical Factual Report	The GFR presents the factual data and methodology of a ground investigation without interpretation.
PGAR	Preliminary Geotechnical Appraisal Report.	The PGAR summarises the known geotechnical conditions with potential to impact on a site, normally based on a desk study, site walkover and mapping.

Not all these reports will be required for every project. There are numerous other types of geotechnical reports produced for a variety of other purposes. Where any doubt exists, either refer to the list above or be sure to define what level of interpretation, analysis and/or design is required for any given circumstance.