Part 4: Geotechnical Requirements

CONTENTS

Figures

4.1 Referenced Documents

Planning and Policy

- The *Christchurch District Plan* www.ccc.govt.nz/the-council/plans-strategies-policies-and-bylaws/plans/christchurch-district-plan
- Resource Management Act (1991) Section 106
- Building Act (2004) Section 36
- Chartered Professional Engineers Act of New Zealand (2002)
- Christchurch City Council *Water Supply, Wastewater and Stormwater Bylaw* (2014) www.ccc.govt.nz/the-council/plans-strategies-policies-and-bylaws/bylaws/water-supply-wastewater-and-stormwater-bylaw-2014/
- Christchurch *Residential Red Zone Technical Zone Categories* (description and map) www.ccc.govt.nz/consents-and-licences/land-and-zoning/technical-categories-map#10
- Ministry of Business, Innovation and Employment *Repairing and rebuilding houses affected by the Canterbury earthquakes* and updates www.building.govt.nz/building-code-compliance/canterbury-rebuild/repairing-and-rebuilding-houses-affected-by-the-canterbury-earthquakes/
- Ministry of Business, Innovation and Employment *Building in toe slump areas of mass movement in the Port Hills (Class II and Class III)* and FAQs www.building.govt.nz/building-code-compliance/canterbury-rebuild/
- Cubrinovski et al, *Liquefaction Impacts on Pipe Networks. Short Term Recovery Project No. 6,* Natural Hazards Research Platform, December 2011 University of Canterbury
- GNS CR2012-311: Canterbury Earthquakes 2010/11 Port Hills Slope Stability: *Pilot study for assessing life-safety risk from rockfalls (boulder rolls)*
- GNS CR2012-57: Canterbury Earthquakes 2010/11 Port Hills Slope Stability: *Pilot study for assessing life-safety risk from cliff collapse*
- GNS CR2012-124: Port Hills Slope Stability: *Life-safety risk from cliff collapse in the Port Hills*
- GNS Science Stage 1 Report - Mass Movement www.ccc.govt.nz/assets/Documents/Environment/Land/CR2012-317Stage1.pdf

Design

- Christchurch City Council *Waterways, Wetlands and Drainage Guide, Ko Te Anga Whakaora mō Ngā Arawai Rēpo* (WWDG) (2003) www.ccc.govt.nz/environment/water/policy-and-strategy/waterways-wetlands-and-drainage-guide
- Christchurch City Council *Pumping Station O&M Manual Template Draft* www.ccc.govt.nz/consents-and-licences/construction-requirements/infrastructure-design-standards/pumping-station-design-specification
- Christchurch City Council *Water Supply, Treatment, Pumping Station and Reservoir Design Specification* www.ccc.govt.nz/consents-and-licences/construction-requirements/infrastructure-design-standards/watersupply

- NZS 1170 *Structural Design Actions Set*
- NZS 4431:1989 *Code of practice for earthfill for residential purposes*
- NZS 3604:2011 *Timber-framed buildings*
- NZS 4404:2010 *Land development and subdivision infrastructure*
- BS EN 1997 *Eurocode 7 - Geotechnical Design*
- New Zealand Transport Agency *Bridge Manual* www.nzta.govt.nz/resources/bridge-manual/bridge-manual.html
- Canterbury Regional Council *Erosion and sediment control guidelines* 2007 esccanterbury.co.nz/
- Auckland Regional Council Technical Publication 10, *Stormwater treatment devices: design guideline manual* (2003) www.aucklandcity.govt.nz/council/documents/technicalpublications/TP10%20Stormwater%20management%20devices%20design%20guideline%20manual%202003.pdf
- Ministry for the Environment *Hazardous Activities and Industries List (HAIL)* www.mfe.govt.nz/land/risks-contaminated-land/my-land-contaminated/hazardous-activities-and-industries-list-hail
- Ministry for the Environment *Contaminated Land Management Guidelines No. 1 – Reporting on Contaminated Sites in New Zealand* (2011) www.mfe.govt.nz/publications/hazardous/contaminated-land-mgmt-guidelines/index.html
- Ministry of Business, Innovation and Employment *Rockfall: Design considerations for passive protection structures*. www.building.govt.nz/building-code-compliance/b-stability/b1-structure/
- New Zealand Geotechnical Society *Geotechnical Issues in Land Development*, Proceedings of NZ Geotechnical Society Symposium, Hamilton (1996)
- New Zealand Geotechnical Society Geotechnical Earthquake Engineering Practice Module 3 – *Guideline for the identification, assessment and mitigation of liquefaction hazards* www.building.govt.nz/building-code-compliance/b-stability/b1-structure/geotechnical-guidance
- New Zealand Geotechnical Society *Field Description of Soil and Rock (*December 2005) fl-nzgs-media.s3.amazonaws.com/uploads/2016/06/Field-guide-sheet-description-of-soil-and-rock-2005.pdf
- Landcare Research Report LC0203/111 *Soil Conservation Guidelines for the* Port Hills (May 2003)
- Australian Geomechanics Society Practice Note 2007 (and commentary) *Landslide Risk Management*, Australian Geomechanics Volume 42 No 1 (March 2007) www.australiangeomechanics.org
- Engineering NZ Practice Notes & Guidelines www.engineeringnz.org/resources/practice-notes-and-guidelines
- European Organisation for Technical Approvals *ETAG 27 – Falling Rock Protection Kits*
- Transport Research Board. *Landslides: Investigation and Mitigation*, Special Report No. 247 National Academy of Sciences. 1996
- Transport Research Board. *Rockfalls: Characterisation and control*. National academy of sciences, 2013.
- Lambert S, Nicot F. *Rockfall engineering*. Wiley, July 2011
- Volkwein A et al. *Interdisciplinary workshop on rockfall protection*. Switzerland 2008.

- Ministry of Business, Innovation and Employment. Rockfall: Design considerations for passive protection structures. Oct 2016 www.building.govt.nz/assets/Uploads/building-code-compliance/b-stability/b1-structure/rockfall-design-consideration/rockfall-design-passive-protection-structures.pdf

Construction

- Christchurch City Council *Civil Engineering Construction Standard Specifications Parts 1- 7 (CSS)* www.ccc.govt.nz/consents-and-licences/construction-requirements/construction-standard-specifications/download-the-css
- Engineering NZ *Construction Monitoring Services* www.engineeringnz.org/documents/112/Construction_Monitoring_Services.pdf
- Ministry of Business, Innovation and Employment *Part D – Guidelines for the geotechnical investigation and assessment of subdivisions in the Canterbury Region (Dec 2012)* www.building.govt.nz/assets/Uploads/building-code-compliance/canterbury-rebuild/repairing-and-rebuilding-houses/canterbury-guidance-part-d.pdf

Where a conflict exists between any Standard and the specific requirements outlined in the Infrastructure Design Standard (IDS), the IDS takes preference (at the discretion of the Council).

4.1.1 Source documents

This Part of the IDS is based on Part 2 of NZS 4404:2010, by agreement, and with the consent of Standards New Zealand.

4.2 INTRODUCTION

This part of the IDS draws attention to the need for the assessment of land suitability and includes:

- site and ground investigations;
- surface and subsurface drainage and erosion control;
- liquefaction (including lateral spreading);
- contaminated sites;
- foundation stability;
- slope stability (including the design of rockfall protection structures); and
- control of earthworks.

The *District Plan* sets out planning rules, which may include the provision of geotechnical and natural hazards requirements.

Such assessment assures a suitable platform for the construction of buildings, roads and other structures, as well as the minimisation or mitigation of any adverse environmental effects arising from such works. It should also include an early assessment of the site's soils and their potential to provide for on-site stormwater systems (e.g. detention basins, infiltration basins).

This part is not a geotechnical standard but sets out some, though not necessarily all, of the matters to be considered in planning and constructing a land development or geotechnical hazard management project. The Canterbury Earthquake Sequence, which started with the Darfield earthquake in 2010 and continues to date, has increased our scientific and geotechnical understanding of how Christchurch ground conditions react to earthquake shaking. In-depth knowledge has also been gained in understanding how natural hazards pose risks. Apply the knowledge gained to how we use land, through utilising the series of Ministry of Business, Innovation and Employment (MBIE) best practice guidelines.

4.2.1 Relevant standards

NZS 4431 applies to the construction of earthfills for residential development, including residential roading. It does not, however, deal with historic fill that has not been placed in accordance with any Standard. It does not cover natural slopes, banks, batters or reinforced earth rockfall protection barriers.

There is no Standard for earthfill for other than residential developments. Clause 4.8.3 - Compaction standards for fill material sets out the requirements in these situations.

MBIE has published a series of technical guidance documents (Parts A - D) on *Repairing and Rebuilding Houses Affected by the Canterbury Earthquakes*. They have also provided guidance documents on *Building in Port Hills' Toe Slump Areas of Mass Movement (Classes II and III)* and *Rockfall: Design Considerations for Passive Protection Structures*.

4.2.2 Statute and District Plan requirements

Where there is a requirement for an assessment of land stability to meet the provisions of the Resource Management Act and the Building Act, this is the responsibility of the Geoprofessional. The Council relies on that assessment when granting the resource consent. The Geoprofessional determines the methods used and investigations undertaken.

Special requirements apply when the land is subject to erosion, avulsion, alluvium, falling debris, subsidence, inundation or slippage. In such situations, refer to section 106 of the Resource Management Act or section 74 of the Building Act.

Specific Council requirements include:

- No earthworks are permitted for work within Christchurch City unless it complies with the provisions of the *District Plan, clause 6.6 – Waterway body setbacks and clause 9.4 significant trees and other trees*.
- On a subdivision that has been granted resource consent no earthworks can begin prior to final engineering acceptance, unless written permission from the Council is given, detailing conditions that must be adhered to.
- The requirements for areas subject to slope instability are defined in the *District Plan*, which recognises Slope Instability Management Areas for rockfall, cliff collapse and mass movement.

4.3 Quality Assurance Requirements and Records

Provide quality assurance records that comply with the requirements in Part 3: Quality Assurance, during design and throughout construction.

4.3.1 The Geoprofessional

The Geoprofessional must be suitably experienced. Their experience must be to a level to permit an appropriate grade of membership in the relevant professional body. The Geoprofessional may be a suitably experienced civil or geotechnical engineer, engineering or environmental geologist or a hydrologist. Refer to clause 2.7.1 – Investigation and design (General Requirements) for further information.

The Geoprofessional must possess both suitable insurance policies and relevant experience.

4.3.2 Requirement for a Geoprofessional

Engage a Geoprofessional to provide geotechnical, soil contaminant and geohydrological expertise where the following issues exist:

- the lack of, or limitations of, relevant Standards.
- the construction of earthworks associated with any development requires initial planning and design, to ensure that fill, banks, embankments and slopes remain stable and that fill material is placed in such a way that it can support the future loads imposed on it.
- the assessment of ground for building foundations, roads, etc. requires specialist expertise e.g. weak ground may require special design.
- the wide range of soil and rock types, physical conditions and environmental factors existing in different areas make it impossible to lay down precise requirements for land stability assessment or earthworks.
- the preliminary evaluation in clause 4.4 – Preliminary site evaluation raises doubt about the stability, or suitability, of the land for the proposed development.
- other geotechnical hazards are identified.
- the Council requires Geoprofessional expertise to assess the project.

4.3.3 Responsibilities of the Geoprofessional

The Geoprofessional will carry out the following functions:

- Undertake a site assessment and any preliminary site evaluation required, including investigations of sub-surface conditions and identifying geotechnical, natural and environmental hazards affecting the land, before the detailed planning of any development. Consider hazards located outside but which may pose a risk to the site. These matters must be included with the Geotechnical Assessment Report in any assessment of environmental effects (AEE) associated with any consent application;

- Before work commences, be involved in the design or review of the drawings and specifications defining any earthworks, rockfall hazard mitigation or other construction work, and submit a written report to the Council on the foundation recommendations, natural hazard risk and slope stability aspects of the project with the application for engineering acceptance, including any required Producer Statements;
- Determine the earthwork requirements, where no standard for earthworks is applicable to the project, to conform to the IDS and to the subdivision or resource consent conditions (if any) that apply to the proposed development;
- Before work commences, and during construction, determine the extent of further services required (including investigation and geological work);
- Before and during construction, determine the methods and frequency of construction control tests to be carried out, determine the reliability of the testing, and evaluate the significance of the test results and field inspection reports in assessing the quality of the finished work;
- During construction, undertake inspections at intervals consistent with the extent and complexity of the geotechnical issues associated with the project;
- On completion, submit a written report to the Council attesting to the compliance of the earthworks and/or the rockfall hazard mitigation with the specifications and to the suitability of the development for its proposed use. If NZS 4431 is applicable, the reporting requirements of that Standard must be used as a minimum requirement. Otherwise, provide the required Producer Statements as detailed in clause 4.8.4 – Rockfall hazard mitigation construction.

4.3.4 Geotechnical Assessment Report

The Geotechnical Assessment Report is presented with the resource or building consent application. The report shall include, as applicable:

- Details of and the results of site inspections, evaluations and field investigations.
- Documentation of rock and soil types, distribution and properties.
- A liquefaction and lateral spread assessment.
- An assessment of rockfall, cliff collapse and landslide (mass movement) hazards, including those resulting from seismic activity.
- An assessment of the slope stability confirming the location and appropriateness of building sites.
- An assessment of ground bearing capacity.
- Recommendations for measures to avoid, remedy or mitigate any geotechnical hazards on the land subject to the application. These shall be in accordance with the provisions of Section 106 of the Resource Management Act 1991 where they are supporting a resource consent application.

> A statement of professional opinion as set out in Appendix I – Statement of Professional Opinion on the Suitability of Land for Subdivision.

Part D - Guidelines for the geotechnical investigation and assessment of subdivisions in the Canterbury region provide guidance on the extent of the assessment required in areas prone to liquefaction.

4.3.5 Design Report

Detail the key achievement criteria and assumptions in the Design Report, such as the chosen factors of safety, for the geotechnical aspects of the engineering design.

Wherever building sites on natural ground have soil strengths less than 100 kPa, or exhibit other specific characteristics that may require specific foundation design, note them in the report, along with any recommendations for strengthened or piled foundations for residential buildings or other works.

Provide the following design records, as appropriate, to support the Design Report:

> the site inspection and evaluation

> the foundation aspects of the project including proposed mitigation measures

> the consideration of slope stability including displacements, rockfall and/or cliff collapse hazards

> the extent of further Geoprofessional inputs required (including investigation and geological work)

> the methods and frequency of construction control tests to be carried out

> the extent of further construction monitoring by the Geoprofessional to confirm design assumptions

4.3.6 Geotechnical Completion Report

For all developments where a Geoprofessional is engaged, the Geoprofessional must submit a Geotechnical Completion Report, accompanied by a statement of professional opinion as set out in Appendix II – Statement of Professional Opinion on the Suitability of Land for Building Construction. The report must, as applicable:

> Identify any specific design requirements that necessitate the design of the development to deviate from the relevant New Zealand standard.

> Describe the extent of inspection, the results of testing and include all geotechnical reports prepared for the development.

> Indicate the degree of compliance of the development with the design or standards set.

> Include documentation on both the testing of the soils for compaction and for soil strength and type, clearly showing the areas to which the tests relate.

- Include areas where compaction complied with the required Standards, any areas requiring re-testing and areas which did not comply with the Standards.
- Include documentation of rock types, distribution and properties (if rock is present on the site).
- Detail the rockfall protection works undertaken and any ongoing maintenance requirements necessary to protect the site in perpetuity. Note that this may only be completed by an Approved Geoprofessional.

For simple developments where there are no earthworks, the Geotechnical Completion Report will consist of the Geotechnical Assessment Report. For large or more complex developments where there may have been several stages of geotechnical reporting, include all relevant geotechnical information in the Geotechnical Completion Report.

4.3.7 As-Built records

Prepare as-built records and maintenance manuals, which comply with Part 12: As-Builts. Present the as-built records in conjunction with the Geotechnical Completion Report and tabulated results.

4.4 Preliminary Site Evaluation

Consider the total surroundings of the site, without being influenced by details of land tenure, territorial or other boundary considerations.

Locate and review any historic geotechnical investigations or reports (including subsurface investigations) that may help to identify the key geotechnical issues for the site.

In simple cases, a visual appraisal may be sufficient. In other cases, depending on the nature of the project, its locality, the scale of development proposed and individual site characteristics, consider the following matters before preparing a proposal for development.

4.4.1 Existing landforms

Study the general nature and shape of the ground and take particular note of:

- the geological nature and distribution of soils and rock
- existing and proposed surface and subsurface drainage conditions and the likely effects on groundwater and on surface runoff
- the previous history of rockfalls in the area
- the previous history of ground movements in similar soils in the area
- where earthworks are involved, the performance of comparable cuts and fills (if any) in adjacent areas
- air photography and other sources of information that should be reviewed and incorporated into any slope stability assessment

- trees, other significant vegetation and other features to be protected and retained (e.g. natural landforms, ecological protection areas)

4.4.2 Surface and subsurface drainage

Identify the existing natural surface and subsurface drainage pattern of any area, and locate any natural springs or seepage. Wherever any natural surface or subsurface drainage paths may be interfered with or altered by earthworks, assess the wider implications e.g. the impact on springs in nearby waterways. Sealing areas to preserve these drainage paths may be preferable to providing alternative drainage paths. Consider also the stormwater needs of the site and erosion and sedimentation control during development.

4.4.3 Slope stability

When assessing the stability of slopes and earthfills, refer to criteria applicable to land development in New Zealand that is published or recommended by the New Zealand Geotechnical Society, including *Geotechnical Issues in Land Development*.

Some natural slopes exist in a state of marginal stability and natural triggers like an earthquake or rainfall event may trigger failure. In addition, relatively minor works such as trenching, excavation for streets or building platforms, removal of scrub and vegetation, or the erection of buildings, can lead to failure. Look for signs of instability, such as cracked or hummocky surfaces, crescent-shaped depressions, crooked fences, trees or power poles leaning uphill or downhill, uneven surfaces, swamps or wet ground in elevated positions, plants such as rushes growing down a slope and water seeping from the ground.

When considering development on or near the Port Hills and Banks Peninsula, refer to GNS Science Stage 1 Report - Mass Movement www.ccc.govt.nz/assets/Documents/Environment/Land/CR2012-317Stage1.pdf when considering developments in the *District Plan* Mass Movement Hazard Management Areas 2 and 3.

Engage a Geoprofessional to assess the slope stability risk for any proposed development and evaluate possible protective structures within Rockfall, Cliff Collapse, Mass Movement and the Remainder of the Port Hills and Banks Peninsula Slope Instability Management Areas.

Incorporate the special requirements that are needed for Port Hill developments in dispersive loess soils. Refer to the *Assessment of slope stability at building sites, WWDG* and *Soil Conservation Guidelines for the Port Hills* for further guidance.

4.4.4 Rockfall and cliff collapse hazards

In some circumstances, a potential hazard from rockfall or cliff collapse may exist on a proposed development site or above an existing structure. In most cases the rockfall source will be beyond the site boundaries, sometimes at a considerable distance. Engage a Geoprofessional to assess the risk for any proposed development and evaluate possible protective structures within the Slope Instability Management Areas as defined in the *District Plan*.

The GNS reports *Pilot study for assessing life-safety risk from rockfalls (boulder rolls)* and *Pilot study for assessing life-safety risk from cliff collapse* contain information on rockfall and cliff

collapse hazards on the Port Hills under seismic conditions. Note that whilst there may be a benefit to using the GNS methodology to compile an Annual Individual Fatality Risk (AIFR) to aid in decision making, this risk metric is not necessarily a requirement of building consents.

An overview of potential mitigation measures for rockfall is included in and refer to MBIE rockfall section 3 Ministry of Business Innovation and Employment. *Rockfall: Design considerations for passive protection structures.*

Adhere closely to *Rockfall: Design Considerations for Passive Protection Structures*.

Provide, as a minimum:

- details of source areas of rockfall or cliff collapse
- a full geological description of potential hazard sources
- an assessment of likely run-out distances and the level of damage that a rockfall or cliff collapse may induce
- an assessment of the likely kinetic energy of boulders at the site
- an assessment of the feasibility and/or suitability of possible mitigation measures

4.4.5 Foundation stability

Study the general topography of the site and its surroundings for indications of areas that have previously been built up; either as a result of natural ground movement or by the deliberate placing of fill material. Unless such fill has been placed and compacted under proper control, long-term differential settlement could occur, causing damage to superimposed structures, roads, services or other structures.

Test those areas of natural ground on planned subdivisions or developments that are not proposed to be filled or excavated, for soil strength and type.

4.4.6 Unsuitable historic fill

Council records may (or may not) indicate that a site has been filled with unsuitable, uncontrolled or contaminated material. Discuss any remediation proposals for such fillings with the Council at an early stage of the investigation.

4.4.7 Contaminated sites

Sites known to be, or subsequently found to be, contaminated as a result of previous activities may require the services of a specialist environmental scientist for a site evaluation. *Hazardous Activities and Industries List (HAIL)* provides further detail.

Ascertain, at an early stage, the extent of any contamination and gain a reasonably accurate picture of any constraints on earthworks, including excavated material disposal. Refer to *Contaminated Land Management Guidelines* for information on reporting requirements.

4.4.8 Local conditions

Consider the range of soil types which exist within Christchurch and Banks Peninsula e.g. expansive soils, volcanic soils, dispersive soils, soft alluvial sediments and compressible soils. Note the presence of loess and loess colluvium as these soils have specific slope instability characteristics. The Council and Canterbury Regional Council (Environment Canterbury) may have information on the soil types of particular areas.

4.4.9 Liquefaction

Liquefaction is the loss of strength of a liquefied soil and can result in any of the following types of damage: ground surface disruption including surface cracking, dislocation, ground distortion and slumping; permanent deformations such as large settlements and lateral spreads; and sand boils. Use the MBIE Module 3 *Guideline for the identification, assessment and mitigation of liquefaction hazards* (https://www.building.govt.nz/building-code-compliance/b-stability/b1-structure/module-3-identify-liquefaction-hazards/) when determining areas at risk of liquefaction.

Appendix IV - Liquefaction Vulnerability Overview Map indicates areas where underground reticulation could be affected by liquefaction. For detailed liquefaction information see Canterbury Maps, "Vulnerability to Liquefaction" (https://apps.canterburymaps.govt.nz/ChristchurchLiquefactionViewer/). The full Tonkin & Taylor report on which the map is based can be downloaded from www.ccc.govt.nz/environment/land/liquefaction.

The "Vulnerability to Liquefaction" map has been prepared using the liquefaction vulnerability categories described in the latest National liquefaction guidance, "Planning and engineering guidance for potentially liquefaction-prone land" (www.building.govt.nz/building-code-compliance/b-stability/b1-structure/planning-engineering-liquefaction-land/).

For the purposes of liquefaction vulnerability mapping, the former MBIE Residential Zone "Technical Categories" have been replaced with the new liquefaction vulnerability categories mapped in Appendix IV and at (https://apps.canterburymaps.govt.nz/ChristchurchLiquefactionViewer/).

The original Technical Categories maps are included under the "Other Maps" tab ("MBIE Technical Categories" layer) at https://apps.canterburymaps.govt.nz/ChristchurchLiquefactionViewer/.

Lateral spread due to liquefaction

When reporting on subdivision developments on land prone to liquefaction, use MBIE Guidance *Part D - Guidelines for the geotechnical investigation and assessment of subdivisions in the Canterbury Region* (www.building.govt.nz/assets/Uploads/building-code-compliance/canterbury-rebuild/repairing-and-rebuilding-houses/canterbury-guidance-part-d.pdf). *Part D* refers to the original Technical Categories.

4.4.10 Peer review

If the risk to the land is assessed as being medium to very high, obtain a peer review of the geotechnical assessment for the proposed development before development. An independent geoprofessional must carry this out. *Peer Review: Reviewing the work of another Engineer* provides guidance on this process. Refer to clause 3.3.2 – Design report (Quality Assurance) for further information.

Consider using the following to aid in the risk assessment:

- Landslide Risk Management (AGS, 2007)
- Pilot study for assessing life-safety risk from rockfalls (boulder rolls)
- Pilot study for assessing life-safety risk from cliff collapse

The Resource Consent Application must make reference to, and give an evaluation of, these matters.

4.5 Ground Investigations

Make sufficient borings, probings or open cuts to:

- classify the soil strata by field and visual methods.
- evaluate the likely extent and variation in depths of the principal soil types.
- establish the natural long-term seasonal groundwater levels.
- characterise the natural ground water environment.

Obtain an indication of the seasonal variation in groundwater levels from a review of historical data held by the Council or Canterbury Regional Council, or by an extended period of monitoring. At least one year's readings may be required wherever groundwater levels are critical, or could have a long-term effect on the development.

4.5.1 Geotechnical data

In addition to the general assessment of the suitability of the site for its intended use (buildings, roads), obtain sufficient geotechnical (rock or soil) test data to characterise the ground data for areas that are intended to:

- form in-situ bases for fills
- yield material for construction of fills
- be exposed as permanent batters

- remain as permanent slopes or cut areas
- be used for stormwater disposal to ground

Special consideration of erosion potential is required wherever excavation and filling is made in Port Hill's loess soils, because of their highly dispersive properties.

The *Part D - Guidelines for the geotechnical investigation and assessment of subdivisions in the Canterbury region* provide guidance on the extent and type of investigation required in land prone to liquefaction.

For consistency in the reporting of soils to the Council, use the *Field Description of Soil and Rock*.

4.5.2 Further investigation

The geotechnical information thus obtained forms the basis for:

- further sampling and testing which may be required on representative soil or rock types
- relating subsequent soil or rock test properties to relevant strata over the site
- assessment of, or calculations for, slope stability
- assessment of, or calculations for, foundations suitable for the finished site
- assessment of, or calculations for, road pavements

Determine the test data that is appropriate for different areas.

4.5.3 Special soil types

Wherever special soil types are known to exist in a locality or are identified, advise on appropriate measures for incorporation of these soils into a development. Where the presence of coal tar contamination has been identified, detail the proposed on-site treatment.

Special soil types include, but are not limited to:

- soils with high shrinkage and expansion
- compressible soils
- volcanic soils
- soils subject to liquefaction
- soils prone to dispersion (e.g. loess)
- marine or estuarine soils

Contact the Council for information on hazard rating and on special soil types in the locality additional to those referenced above, if unfamiliar with the area.

4.5.4 Rockfall engineering data

Assess potential rockfall block sizes from mapping of the source area and boulder distribution on the slope. Evaluate block size distribution in relation to the distance from the source to

assess gravity sorting and fragmentation effects. Assess all this information in relation to the block size information in the Council GIS database to arrive at the best estimate for the site-specific boulders.

Rockfall/boulder data is available from the Council on request: email IDS@ccc.govt.nz with 'Request for Port Hills Data' in the subject line. These requests require the Geoprofessional to sign a disclaimer document before data will be released.

Other special requirements for investigations for rockfall engineering may include:

> Basic rock material properties (e.g., uniaxial compressive strength, point load strength, Schmidt hammer rebound value)

> Detailed topographical sections along potential rockfall trajectories

> Assessment of slope characteristics affecting rockfall behaviour (restitution coefficients, roughness, vegetation etc)

> Previous rockfall history in this area e.g. size and distribution of boulders on the slope

4.6 Planning and Design

4.6.1 Suitability of landform

The choice of a suitable landform is dependent on many factors that may be specific to a particular site. Refer to clause 2.5.4 – Balancing landform choices (General Requirements) for these factors.

Avoid unnecessary earthworks, aim to protect original soils and drainage patterns and to minimise disturbance, compaction, earthworks and the importation of topsoil, although earthworks may be justified in the following circumstances:

> to minimise the risk of property damage through ground movement in the form of rockfall, debris slides, slips, subsidence, creep, erosion or settlement.

> to minimise the risk of property damage through flooding, surface water run-off or groundwater modification.

> to lessen tunnel gully erosion within Port Hill developments.

> to develop a more desirable roading pattern with improved accessibility to and within the

Tunnel gully exposed by earthworks

site, and to create a better sense of orientation and identity for the area as a whole.

- to increase the efficiency of overall land use, including the quality of individual sites and amenity areas around buildings, the economics of providing engineering services and the standard of roading and on-site vehicular access.
- to create, where needed, suitably graded areas for playing fields and other community facilities.
- to enhance the general environmental character of the area by softening the landscape or by artificially creating or emphasizing landforms of visual significance, particularly on flat sites or on areas devoid of landscape features.

Note that some Port Hill developments require soil conservation measures such as plantings and revegetation of areas liable to tunnel gully erosion, sheet erosion, slips and existing stream bank/bed erosion. Refer to the *Soil Conservation Guidelines for the Port Hills*, for guidance on erosion prone areas and measures to prevent or control erosion. Refer to clause 10.9.8 - Revegetation, restoration and connection of habitats (Reserves, Streetscape and Open Spaces) for an explanation of revegetation.

4.6.2 Seismic considerations

Consider the seismic effects on earthfills, foundations, major or critical infrastructure, slopes, rockfall sources and liquefiable ground, and take these into account in the design and construction of any development. These effects could include liquefaction, lateral spread, rockfall, cliff collapse and slippage.

Preliminary estimations of importance levels for major infrastructure required by *Structural Design Actions*, from which exceedance probabilities for seismic events are determined, may be obtained from the following documents:

- *Bridge Manual*
- *Sewage Pumping Station Design Specification*
- *Water Supply Wells, Pumping Station and Reservoir Design Specification*.

For liquefaction information see Appendix IV – Canterbury Maps, "Vulnerability to Liquefaction" https://apps.canterburymaps.govt.nz/ChristchurchLiquefactionViewer. Select the liquefaction "Vulnerability Map" tab, which follows the most recent liquefaction guidance. The full Tonkin & Taylor report on which the map is based can be downloaded from www.ccc.govt.nz/environment/land/liquefaction.

The "Vulnerability to Liquefaction" map has been prepared using the liquefaction vulnerability categories described in the latest National liquefaction guidance, "Planning and engineering guidance for potentially liquefaction-prone land" (www.building.govt.nz/building-code-compliance/b-stability/b1-structure/planning-engineering-liquefaction-land/) .

For the purposes of assessing areas where infrastructure could be affected by liquefaction, the former Residential Zone "Technical Categories" have been replaced with the new liquefaction

vulnerability categories mapped in Appendix IV and at https://apps.canterburymaps.govt.nz/ChristchurchLiquefactionViewer.

4.6.3 Peat

Ensure the geotechnical design in peat or organic compressible material areas will achieve the infrastructure design life required by all other parts of the IDS. Preserve the flow of groundwater through the peat at pre-development levels.

Special care is required in any development over peat areas to:

- maintain uninterrupted groundwater flow;
- preserve existing natural groundwater levels to avoid area wide settlement;
- avoid settlement of any surface works or structures;
- ensure the continued operation of infrastructural services and service connections to buildings throughout their design life.

4.6.4 Debris slides

Confirm that any proposed building platform is unlikely to be affected by debris slides. Refer to *WWDG Part B* clause 20.4.5 for further information.

Debris slide in Orton Bradley Park

4.6.5 Reducing waste

When designing the development, consider ways in which waste can be reduced.

- Design to reduce waste during construction e.g. minimise earthworks, reuse excavated material elsewhere.
- Use materials with a high recycled content e.g. recycled concrete subbase. Proposed recycled materials will need approval from the Council to ensure that environmental contamination does not occur.

See the Resource Efficiency in the Building and Related Industries (REBRI) website www.rebri.org.nz for guidelines on incorporating waste reduction in your project.

4.7 Rockfall Hazard Mitigation

All mitigation measures must be designed by a suitably experienced Geoprofessional and will require both building and resource consents. Design of mitigation measures to consider assessment of bounce height and kinetic energy for the likely rock sizes as assessed in clause 4.4.4 – Rockfall and cliff collapse. Calibrate bounce height and kinetic energy with previous rockfall behaviour at the specific site or similar locations.

Rockfall mitigation measures could include any combination of (refer MBIE 2016, *Rockfall: Design considerations for passive protection structures*):

- Avoidance
  - move facility/structure away from hazard
  - build tunnel or viaduct
- Stabilisation
  - remove hazardous material by scaling/drilling/blasting
  - reinforce slope with bolting/shotcrete/buttressing/meshing/cabling/lagging
  - improve drainage
- Protection
  - catch area or bench
  - rigid barrier (earthen bund/berm or structural wall
  - flexible/dynamic barrier (rockfall net fences, etc.)
  - attenuator systems
  - rock Sheds
- Non engineered solutions
  - warning signs
  - monitoring/early warning systems
  - establishment and retention of an effective vegetation barrier (not a suitable short term solution and may be best used in combination with other measures).

Any rockfall protection system shall:

- be accessible for inspection, rock removal and repair without compromising the safety of downhill property or life;
- not be compromised where gates or accessways are provided;
- be and remain effective over their design life.

Ensure the design addresses erosion potential and the impact on any natural surface and subsurface flow.

4.7.1 In-situ anchorage

In-situ anchorage solutions such as grouted steel ground anchors, rock bolts, cables, mesh, nets and drape systems may be used for protective works in rock source areas.

Design above-ground structures and easily replaced components (such as posts and mesh but excluding components such as ground anchors or rock bolts) with a design life of no less than 15 years.

Include the design loads and the manufacturer's testing certificates for the properties of the supplied materials, to support the design life in the design report.

Design anchorage solutions and foundation systems for dynamic rockfall barriers to the following codes of practice:

> *Eurocode 7 - Geotechnical Design*

> Anchor requirements of the *Bridge Manual*

4.7.2 Designer requirements

The designer of the protection system's foundations including ground anchors shall be a suitably qualified Geoprofessional, who shall provide a Producer Statement PS1 - Design, as set out in Appendix V - Producer Statement PS1 – Design.

The design shall be reviewed by a Geoprofessional, who shall provide a Producer Statement PS2a – Design Review, as set out in Appendix VI - Producer Statement PS2a – Design Review.

Design amendments shall also be reviewed by the Geoprofessional, who shall provide a Producer Statement PS2b – Design Review Amendment, as set out in Appendix VII - Producer Statement PS2a – Design Review Amendment.

4.8 Construction

4.8.1 Underrunners and springs

In hill catchments, underrunners are often encountered. Where practicable and considered necessary, intercept these and bring them to the surface, with a free outfall into the stormwater system wherever possible. If possible, locate the source and redirect or eliminate the underrunner.

4.8.2 Control testing

A testing laboratory, or a competent person under the control of the Geoprofessional, must carry out the construction control testing. The testing laboratory must have recognised registration or quality assurance qualifications.

4.8.3 Compaction standards for fill material

The standard of compaction and method of determination is as set out in NZS 4431, except where NZS 4431 is not applicable. For example, reinforced earth embankment barriers, industrial and commercial developments often have specialised requirements for fill materials and compaction. Specify the fill and compaction standards, procedures and methods of determination for the development in these cases. Use NZS 4431 as a basis where appropriate.

4.8.4 Rockfall hazard mitigation construction

The contractor shall verify the construction complies with the manufacturer's requirements and with the design by providing a Completion Certificate complying with Part 3: Quality Assurance, Appendix VIII.

The designer (the Approved Geoprofessional who designed the mitigation) shall review the construction and provide a Producer Statement PS4 – Construction Review, as set out in Appendix VII - Producer Statement PS4 – Construction Review. The minimum construction monitoring requirement shall be *Construction Monitoring Services Level CM4*.

4.9 Erosion, Sediment and Dust Control

4.9.1 Minimisation of effects

Design and construct earthworks to minimise soil erosion and sediment discharge. Where necessary, make permanent provision to control erosion and sediment discharge from the area of the earthworks.

At the planning and design phase, consider the generation of dust during and after the earthworks operation. If necessary, incorporate specific measures to control dust.

Requirements for erosion, sediment and dust control will be set in the resource consent conditions for the project. Refer to these conditions and take into account in the early stages of planning a project. Refer also to the requirements of *CSS: Part 1*.

4.9.2 Site-specific erosion and sediment control plan requirements

For all developments where erosion could result in contaminants in sediments entering the groundwater, surface waters or the Council's stormwater system, provide a site-specific Erosion and Sediment Control Plan (ESCP) to the Council at least four weeks before any works start on site. Note that, even where the Council has accepted an ESCP, the developer remains entirely responsible for all adverse effects associated with the site development.

Develop the ESCP to eliminate or reduce the following issues:

- ecological damage to waterways;
- channel infilling;

- disturbed or uncompacted surfaces and potential sediment yield;
- contaminated runoff;
- sediment discharges from dewatering;
- potential contamination from bituminous materials.

The ESCP must include the following assessment factors:

- a description of the pre-development surface water runoff regime;
- the development area (hectares);
- the catchment area passing through the site (hectares) marked on drawing;
- a plan of the development area, identifying discharge points to waterways or pipelines;
- calculated flow rates, and velocities through from the site (dry weather, two-year flood and typical water levels);
- a site plan showing the proposed earthwork strategy;
- the earthworks engineering drawings;
- a statement on how the exposed soil surface will be minimised;
- a statement (with sketches as appropriate) on how sediment runoff will be trapped and disposed of;
- a statement on potential tracking of soils on and off site by machinery;
- a statement on other contaminants and how they will be controlled;
- a statement on how ground water will be treated and discharged (if required).

The ESCP must comply with the standards:

- as specified by Canterbury Regional Council e.g. *Erosion and sediment control guidelines*;
- *Water Supply, Wastewater and Stormwater Bylaw*;
- *Soil Conservation Guidelines for the Port Hills*,

4.9.3 Protection measures

Take the following protection measures, unless incompatible with Canterbury Regional Council resource consent conditions:

- Construct stabilised construction entrances and detail proposed remedial works to mitigate contaminants moving off site e.g. mud on streets or silt in existing sumps in streets.
- Construct sediment traps and retention ponds where necessary. These should be cleaned out, as required, to ensure that adequate sediment storage is maintained.
- Use temporary barriers, or silt fences using silt control geotextiles, to reduce flow velocities and to trap sediment.

- Leave sections of natural ground unstripped to act as grass (or other vegetation) filters for run-off from adjacent areas.
- Construct temporary drains at the top and toe of steep slopes to intercept surface run-off and to lead drainage away to a stable watercourse or piped stormwater system.
- Slope benches in batter faces back and grade (both longitudinally and transversely), to reduce spillage of stormwater over the batter wherever surface water could cause erosion of batters, or internal instability through infiltration into the soil.
- Prevent surface water from discharging over batter faces by constructing open interceptor drains in permanent materials formed to intercept surface run-off and discharge via stable channels or pipes, preferably into stable watercourses or piped stormwater systems.
- Grade the surfaces of fills and cuts to prevent ponding.
- Shape and compact the upper surface of intermediate fills with rubber-tyred or smooth-wheeled plant when rain is impending or when the site is to be left unattended, to minimise water infiltration.
- Topsoil and grass the completed battered surfaces of fills to reduce run-off velocities.
- Re-topsoil and grass (or hydroseed) all earthwork areas as soon as possible after completion of the earthworks and drainage works.
- Use planting, environmental matting, hydroseeding, drainage channels or similar measures at an early stage in the earthworks construction phase as a permanent control of erosion and sediment discharge.
- To control dust or encourage early vegetation growth, water the site frequently during construction.
- Establish the permanent surface at an early stage of the construction phase.

Possible treatment methods are provided in the *Stormwater treatment devices: design guideline manual*.

Earthworks for developments on hillside land are not to be undertaken between 1 May and 31 August in any year, without the express written permission of the Council. This may be in the form of either conditions of subdivision, building or resource consent.

Ensure a satisfactory grass strike is obtained on all completed earthworks surfaces as soon as practicable. The intention is to provide early vegetative cover, particularly before the onset of winter, to minimise erosion and sedimentation. Suitable irrigation methods may be required to assist grass growth in the summer months.

Prevent water from stormwater systems flowing into a fill or into natural ground near the toe or sides of a fill. Do not construct stormwater or wastewater soakage systems in a fill, which could impair the fill's stability. Take into account the effect of utility services laid within the fill.

APPENDIX I

Statement of Professional Opinion on the Suitability of Land for Subdivision

ISSUED BY: _____

(Geotechnical engineering firm or suitably qualified Geoprofessional)

TO: _____

(Territorial authority)

TO BE SUPPLIED TO: _____

(Owner/Developer)

IN RESPECT OF: _____

(Description of infrastructure/land development)

AT: _____

_____

(Address)

I _____ on behalf of

(Geoprofessional)

_____

(Geotechnical engineering firm)

hereby confirm:

1. I am a suitably qualified and experienced Geoprofessional employed by _____ and the geotechnical firm named above was retained by the owner/developer as the Geoprofessional on the above proposed development.

2. The geotechnical assessment report, dated _____ has been carried out in accordance with the Ministry of Business, Innovation and Employment *Part D - Guidelines for the geotechnical investigation and assessment of subdivisions in the Canterbury region* and the Christchurch City Council *Infrastructure Design Standard – Part 4: Geotechnical Requirements* and includes:

(i) Details of and the results of my/the site investigations.

(ii) A liquefaction and lateral spread assessment.

(iii) An assessment of rockfall and slippage, including hazards resulting from seismic activity.

(iv) An assessment of the slope stability and ground bearing capacity confirming the location and appropriateness of building sites.

(v) Recommendations proposing measures to avoid, remedy or mitigate any potential hazards on the land subject to the application, in accordance with the provisions of Section 106 of the Resource Management Act 1991.

3. In my professional opinion, not to be construed as a guarantee, I consider that Council is justified in granting consent incorporating the following conditions:

(i) _____

(ii) _____

4. This professional opinion is furnished to the territorial authority and the owner/developer for their purposes alone, on the express condition that it will not be relied upon by any other person and does not remove the necessity for the normal inspection of foundation conditions at the time of erection of any building. It is limited to those items referred to in clause 2 only.

5. This statement shall be read in conjunction with the geotechnical report referred to in clause 2 above, and shall not be copied or reproduced except in conjunction with the full geotechnical completion report.

6. Liability under this statement accrues to the geotechnical firm only and no liability shall accrue to the individual completing this statement.

7. The geotechnical engineering firm issuing this statement holds a current policy of professional indemnity insurance of no less than $_____

(Minimum amount of insurance shall be commensurate with the current amounts recommended by ENGINEERING NEW ZEALAND, ACENZ, NZTA, INGENIUM.)

_____ Date:_____

(Signature of engineer, for and on behalf of _____)

Qualifications and experience

_____

_____

This form is to accompany Form 9 – Resource Management Act 1991 (Application for a Resource Consent (Subdivision))

APPENDIX II

Statement of Professional Opinion on the Suitability of Land for Building Construction

ISSUED BY: _____

(Geotechnical engineering firm or suitably qualified engineer)

TO: _____

(Owner/Developer)

TO BE SUPPLIED TO: _____

(Territorial authority)

IN RESPECT OF: _____

(Description of infrastructure/land development)

AT: _____

_____

(Address)

I _____ on behalf of

(Geoprofessional)

_____

(Geotechnical engineering firm)

hereby confirm:

1. 1. I am a suitably qualified and experienced Geoprofessional and was retained by the owner/developer as the Geoprofessional on the above development.

2. The extent of my inspections during construction, and the results of all tests carried

out are as described in my/the geotechnical completion report, dated _____

3. In my professional opinion, not to be construed as a guarantee, I consider that *(delete as appropriate)*:

(a) the earthfills shown on the attached Plan No _____ have been

placed in compliance with the requirements of the_____Council and my/the specification.

(b) the completed works give due regard to land slope and foundation stability considerations.

(c) the original ground not affected by filling is suitable for the erection thereon of buildings designed according to NZS 3604 provided that:

(i) _____

(ii) _____

(d) the filled ground is suitable for the erection thereon of buildings designed according to NZS 3604 provided

that:

(i) _____

(ii) _____

(e)The original ground not affected by filling and the filled ground are suitable for the construction of a development/subdivision and are not subject to erosion, subsidence or slippage provided that:

(i) _____

(ii) _____

NOTE: The sub-clauses in Clause 3 may be deleted or added to as appropriate.

4. This professional opinion is furnished to the territorial authority and the owner/developer for their purposes alone, on the express condition that it will not be relied upon by any other person and does not remove the necessity for the normal inspection of foundation conditions at the time of erection of any building.

5. This statement shall be read in conjunction with my/the geotechnical report referred to in Clause 2 above, and shall not be copied or reproduced except in conjunction with the full geotechnical completion report.

6. Liability under this statement accrues to the geotechnical firm only and no liability shall accrue to the individual completing this statement.

7. The geotechnical engineering firm issuing this statement holds a current policy of professional indemnity insurance of no less than $_____

(Minimum amount of insurance shall be commensurate with the current amounts recommended by ENGINEERING NEW ZEALAND , ACENZ, NZTA, INGENIUM.)

_____ Date:_____

(Signature of engineer)

Qualifications and experience

_____

_____

APPENDIX III

Soil Log

Project:		Project No:	Bore ID:
Client:			
Bore Depth:	Ground Level:	Recorded by:	Date:
Location:	WaterTableDepth:		

Elevation	Depth	Symbol	Material Description Soil Type + Colour + Strength + Moisture + Grading + Organics	Scala Penetrometer (mm/blow) 0 10 20 30 40 50 60 70 80 90 100	Depth
	0.0				0.0
	0.1				0.1
	0.2				0.2
	0.3				0.3
	0.4				0.4
	0.5				0.5
	0.6				0.6
	0.7				0.7
	0.8				0.8
	0.9				0.9
	1.0				1.0
	1.1				1.1
	1.2				1.2
	1.3				1.3
	1.4				1.4
	1.5				1.5
	1.6				1.6
	1.7				1.7
	1.8				1.8
	1.9				1.9
	2.0				2.0
	2.1				2.1
	2.2				2.2
	2.3				2.3
	2.4				2.4
	2.5				2.5
	2.6				2.6
	2.7				2.7
	2.8				2.8
	2.9				2.9
	3.0				3.0

Locality Diagram	Other Comments:

Soil Descriptions

Examples: Sandy GRAVEL, with some clay
Clayey SILT, with trace of peat, light grey, firm, moist

SOIL TYPE

Lesser Fraction		Dominant Fraction			Minor Fraction		
20-50% volume		> 50% volume			12 - 20%	5 - 12%	< 5%
Soil Type Term		Soil Type term		Particle size (mm)	with some	with minor	with trace
		BOULDERS		> 200	boulders		
		COBBLES		60 - 200	cobbles		
Coarse	gravelly	COARSE	GRAVEL	20 - 60	coarse		gravel
Medium	gravelly	MEDIUM	GRAVEL	6 - 20	medium		gravel
Fine	gravelly	FINE	GRAVEL	2 - 6	fine		gravel
Coarse	sandy	COARSE	SAND	0.6 - 2.0	coarse		sand
Medium	sandy	MEDIUM	SAND	0.2 - 0.6	medium		sand
Fine	sandy	FINE	SAND	0.06 - 0.2	fine		sand
Silty		SILT		0.002 - 0.06	silt		
Clayey		CLAY		< 0.002	clay		
Peaty		PEAT		N/A	peat		

COLOUR

Adjective1	*Adjective2*	*Main Colour*
light	pinkish	pink
dark	reddish	red
	yellowish	yellow
	brownish	brown
	olive	olive
	greenish	green
	bluish	blue
	greyish	white
		grey
		black

STRENGTH

Cohesive Soil Consistency

Consistency	*Undrained Shear Strength (kPa)*	*Characteristic*
very soft	< 12	Easily exudes between fingers
soft	12 - 25	Easily moulded by fingers
firm	25 - 50	Can be moulded with fingers with some effort
stiff	50 - 100	Impossible to mould with fingers, but will change shape with heel pressure
very stiff	100 - 200	As for stiff, but considerable heel pressure is required
hard	200 - 500	Brittle, very tough

Non Cohesive Soil Density

Density	*Characteristic*
very loose	Very easy to excavate by hand
loose	Easy to excavate by hand
medium dense	Between loose and dense
dense	Very difficult to excavate by hand
very dense	Particles bound together

MOISTURE

Moisture	*Description*
dry	Cohesive soils usually hard or powdery Granular soils run freely through hands
moist	Some moisture present – usually darkens the colour
wet	Strong squeezing in the hand will drive some water out
saturated	Squeezing will drive water out

SAND/GRAVEL GRADING

well graded
poorly graded

ORGANIC CONTENT

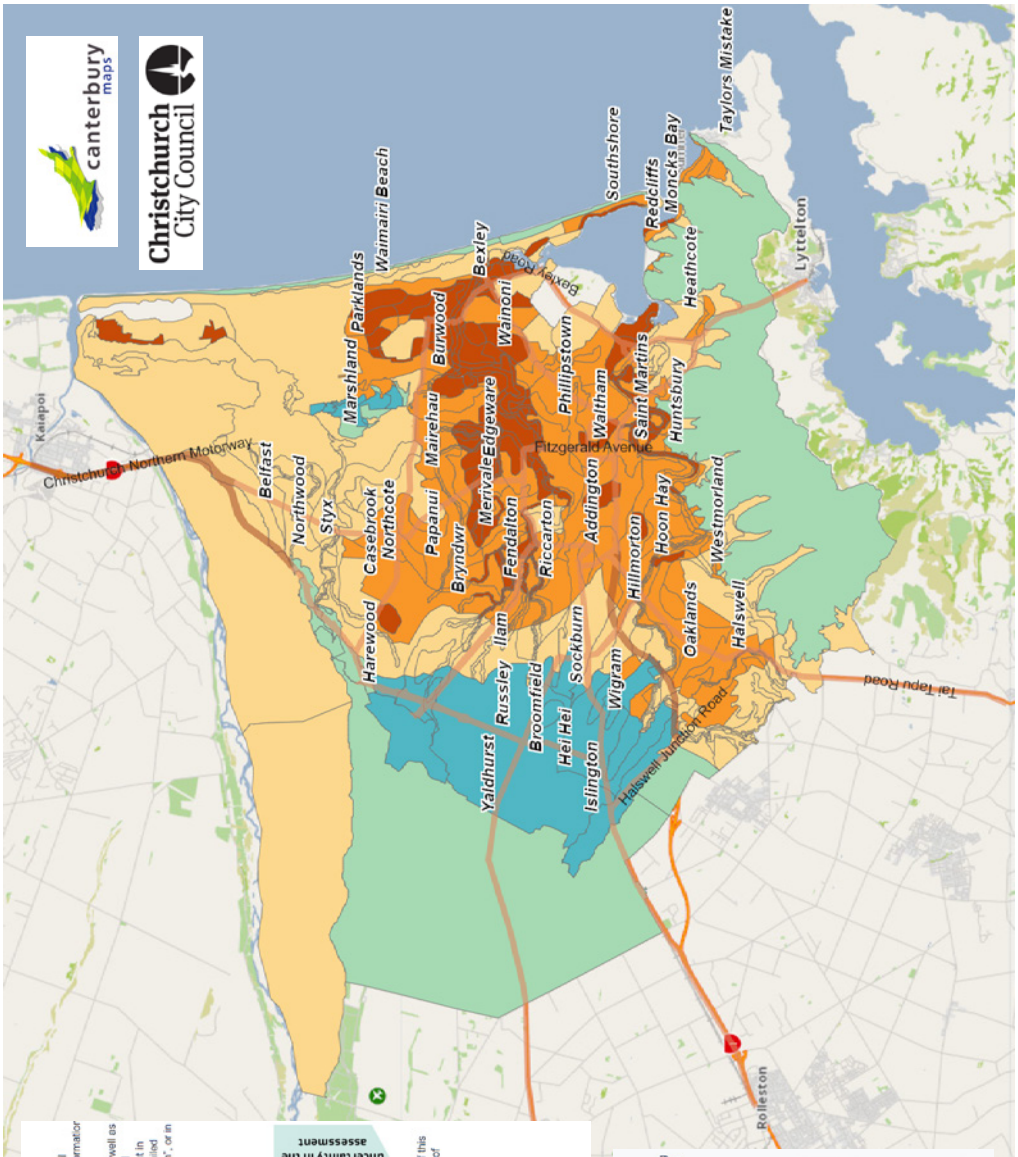
Adjective	*Organic Type*
trace	fibrous
little	wood pieces
some	root fibres
and	vegetation

For full descriptions see: *Field Description of Soil and Rock*, NZ Geotechnical Society, Dec 2005

APPENDIX IV

Liquefaction Vulnerability

Based on the "Vulnerability Map" tab at https://apps.canterburymaps.govt.nz/ChristchurchLiquefactionViewer



Vulnerability to Liquefaction

Christchurch City Council commissioned Tonkin + Taylor to prepare a liquefaction vulnerability map which follows the most recent national liquefaction guidance. This map is shown to the right, and the full report can be downloaded here. You can browse the key sources of information that were used to develop this updated liquefaction map by clicking on the six tabs across the top of the page.

The map uses the seven categories shown in the table below to describe the vulnerability of the land to liquefaction-induced damage. As well as describing the likelihood and severity of ground damage, the categories also show where there is more or less certainty about the ground conditions. For example, in some areas there is enough information to distinguish between areas of "Medium" and "High" vulnerability. But in other areas where there is less information it might only be possible to conclude that "Liquefaction Damage is Possible". When more detailed information becomes available in future (e.g. new ground investigations), this might show that the actual vulnerability is "Medium" or "High", or in some cases perhaps even "Low".

Increasing precision in the categorisation

Increasing likelihood and severity of ground damage

Decreasing uncertainty in the assessment

LIQUEFACTION CATEGORY IS UNDETERMINED		
LIQUEFACTION DAMAGE IS UNLIKELY	LIQUEFACTION DAMAGE IS POSSIBLE	
Very Low Liquefaction Vulnerability	Low Liquefaction Vulnerability	Medium Liquefaction Vulnerability	High Liquefaction Vulnerability

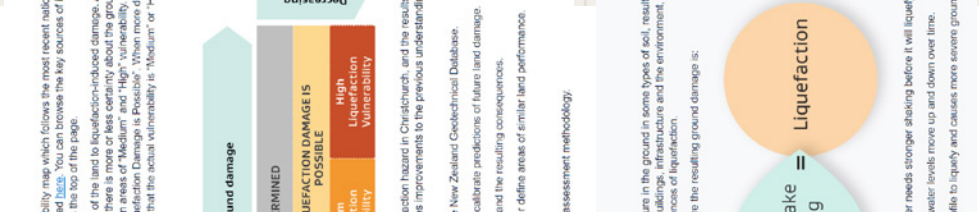
There was already a substantial amount of previous information available about the liquefaction hazard in Christchurch, and the results of this latest assessment broadly align with what was previously known. This updated map makes improvements to the previous understanding of liquefaction vulnerability by:

- Analysing the extensive collection of ground investigation data now available on the New Zealand Geotechnical Database.
- Using observations of land damage caused by the Canterbury earthquakes to help calibrate predictions of future land damage.
- Drawing on improved scientific understanding for analysis of liquefaction triggering and the resulting consequences.
- Using the improved geology and groundwater maps that are now available, to better define areas of similar land performance.
- Providing coverage of the entire Christchurch City territorial land area.
- Using the consistent framework from the new national guidance to standardise the assessment methodology.

About liquefaction

Liquefaction is a natural process where earthquake shaking increases the water pressure in the ground in some types of soil, resulting in temporary loss of soil strength. Liquefaction can cause significant damage to land, buildings, infrastructure and the environment, as well as economic and social disruption. See it here for more details about the consequences of liquefaction.

There are three key factors which influence whether liquefaction occurs and how severe the resulting ground damage is:



- **Soil condition** - Usually only sandy or silty soil can liquefy, and soil that is denser needs stronger shaking before it will liquefy.
- **Groundwater** - Soil can only liquefy if it is below the groundwater table. Groundwater levels move up and down over time.
- **Earthquake shaking** - Stronger earthquake shaking causes more of the soil profile to liquefy and causes more severe ground damage.

APPENDIX V

Producer Statement PS1 – Design

This Producer Statement is for the design of support or protection devices for the rockfall and boulder roll hazards on and near to the Port Hills, Christchurch. It applies to construction consented by the Christchurch City Council under the Building Act 2004 and its amendments.

DESIGNED BY: _____

(Approved Geoprofessional)

ISSUED BY: _____

(Design Firm)

TO: _____

(Purchaser)

OWNERS: _____

(Registered owners shown on the Certificate of Title. Individuals, trusts, Trustees, Company Directors)

Consenting Authority – Christchurch City Council

Appointed Peer Reviewer _____

(Approved Geoprofessional and signatory to a Producer Statement PS2- Peer Review)

Description of Work _____

_____

(Describe the work covered by this Producer Statement in detail)

At _____ (Address)

Lot Number _____ **DP**_____ **C/T Number**_____

Description of Design Services Undertaken _____

_____

Inputs to the Design _____

(Standards and codes used)

_____

(Rockfall Energy used and its derivation/supply)

_____

(other)

Design Life _____ **Expected Service Life** _____

(To take account of the environmental setting)

Name any Proprietary System _____

Test Level for Proprietary System Used _____ **Certificate Number** _____

(Current test level certificate)

The works covered by this Producer Statement are **described** in calculations titled

_____

All details are given on drawings **titled** _____

I _____

(the designer)

being a Chartered Civil Engineer under the Chartered Engineers Act of New Zealand and a Geoprofessional (see note 2) **believe** on reasonable grounds the works designed by me, if constructed according to the details shown on the drawings, in the specification and any other accompanying documents will perform to the design intent as set down by the Christchurch City Council in a consent to construct. The work covered by this Statement will be observed as it is constructed according to:

CM4 ◯ CM5 ◯ Other_____

This statement is endorsed by_____

(Director and/share holder)

of _____

(Design Firm)

and the employer of the Designer.

I/we are member(s) of ACENZ **YES** ◯ **NO** ◯ , hold Professional Indemnity insurance of no less than $5,000,000.00 and accept that liability under this statement accrues to the Design Firm only.

Signed by the Designer _____ (Signature)

_____ (Date)

Signed on behalf of the Design Firm _____ (Signature)

_____ (Date)

Notes And Requirements For Ps1 - Design

1. This Producer Statement shall provide the Christchurch City Council with reasonable grounds to issue a consent for construction of the work without the need for duplicate and independent design checking.

2. PS1 - Design is required from a Geoprofessional, as defined in clause 4.3.1 – The Geoprofessional.

3. The Designer shall have signing authority delegated by the Design Firm. By signing the PS1 – Design the Designer warrants that she/he has:

    a. delegated authority from a Director of the Design Firm to undertake the design and develop the construction details;

    b. a directory role in the gathering of site data, establishing the design inputs overseeing the design process, checking the outputs from design, arranging and signing off internal verification, developing the work specification, overseeing the drawing of details and shall be fully satisfied that the documents accompanying the PS1 – Design are completed and relevant to the stabilisation of rockfall or protection of life and/or property from rockfall or boulder roll.

4. The Designer shall employ a suitably qualified Geoprofessional to independently review the design and to provide a Producer Statement PS2a – Design Review. The costs associated with the design review shall be borne in full by the Design Firm. Issues of disputed design shall be resolved by the Designer and Design Reviewer to enable the PS1 – Design to be signed unconditionally. Council will not accept a PS1 with conditions.

5. The PI Insurance minimum stated on the PS1 shall be current at the time of submission to Christchurch City Council. A certificate of currency shall be appended by the Design firm to the Statement.

6. In the case where a Design Firm ceases to trade within 10 years of the construction of the designed work, the Director(s) shall maintain “run-on” insurance to the full value of $5,000,000 for the balance of time to 10 years from completion of construction.

APPENDIX VI

Producer Statement PS2a – Peer Review

This Producer Statement is for the peer review of the design of the support or protection devices for the rockfall and boulder roll hazards on and near to the Port Hills, Christchurch. It applies to construction consented by the Christchurch City Council under the Building Act 2004 and its amendments.

APPOINTED PEER REVIEWER: _____

(Approved Geoprofessional named on the Producer Statement PS1 - Design)

ISSUED BY: _____

(Peer Reviewer Firm)

TO: _____

(Designer)

OF: _____

(Design Firm)

OWNERS: _____

(Registered owners shown on the Certificate of Title. Individuals, trusts, Trustees, Company Directors)

Consenting Authority – Christchurch City Council

Description of Work _____

_____

(Describe the work covered by this Producer Statement in detail)

At _____ (Address)

Lot Number _____ **DP**_____ **C/T Number**_____

I _____ (Peer Reviewer) have been engaged

by _____ (Design Firm)
to review all of the work included by the design calculations, specification and drawings

Calculations titled _____ dated _____

Specification titled _____ dated _____

Drawings titled _____ dated _____

Drawing numbers _____ Revision numbers _____

I _____

(the Peer Reviewer)

being a suitably qualified Geoprofessional (see note 2) **have** reviewed the design and construction documents supplied by the Designer and agree all matters of difference between the Designer and myself are satisfactorily resolved.

I believe on reasonable grounds the design work reviewed by me, if constructed according to the details shown on the drawings, in the specification and any other accompanying documents will perform to the design intent determined by the Designer as set down by the Christchurch City Council in the consent to construct.

I have sighted the signed Producer Statement PS1 and confirm that the Statement is complete and correct.

This statement is endorsed by _____

(Director and/share holder)

of _____

(Peer Reviewer Firm)

and the employer of the Peer Reviewer.

I/we are member(s) of ACENZ **YES** ◯ **NO** ◯, hold Professional Indemnity insurance of no less than $5,000,000.00 and accept that liability under this statement accrues to the Design Firm only.

Signed by the Peer Reviewer _____ (Signature)

_____ (Date)

Signed on behalf of the Peer Reviewer Firm _____ (Signature)

_____ (Date)

Notes And Requirements For PS2a – Peer Review

1. This Producer Statement shall provide the Christchurch City Council reasonable grounds to issue consent for construction of the work. It shall be based on an independent review of the design covered by PS1 – Design.

2. PS2a - Peer Review is required from the Peer Reviewer who shall be a Geoprofessional, as defined in clause 4.3.1 – The Geoprofessional.

3. The Peer Reviewer shall be a person and not a Firm and shall have signing authority delegated to him/her from a Director of the Peer Reviewer's Firm to undertake the review and sign the PS2a.

4. The Peer Reviewer is engaged by the Design Firm to undertake a review of the documents representing the design work. Christchurch City Council is not responsible in any part for the commercial arrangements between the Design Firm and the Peer Reviewer.

5. From time to time differences of opinion will arise between the Peer Reviewer and Designer of the work. Both parties are expected to work together to resolve any difference so that the PS1 and PS2 Statements are submitted to Christchurch City Council without conditions.

6. The PI Insurance minimum stated on the PS2a shall be current at the time of submission to Christchurch City Council. A certificate of currency shall be appended by the Design Reviewer Firm to the Statement.

7. In the case where a Peer Reviewer Firm ceases to trade within 10 years of the construction of the designed work, the Director(s) shall maintain "run-on" insurance to the full value of $5,000,000 for the balance of time to 10 years from completion of construction.

APPENDIX VII

Producer Statement PS2b – Peer Review Amendment

This Producer Statement is a variation to PS2a to cover variation to the design content arising out of construction of rockfall support or protection devices for rockfall and boulder roll hazards on and near to the Port Hills, Christchurch. It applies to construction consented by the Christchurch City Council under the Building Act 2004 and its amendments.

APPOINTED PEER REVIEWER: _____

(Approved Geoprofessional named on the Producer Statement PS1 - Design)

ISSUED BY: _____

(Peer Reviewer Firm)

TO: _____

(Designer)

OF: _____

(Design Firm)

OWNERS: _____

(Registered owners shown on the Certificate of Title. Individuals, trusts, Trustees, Company Directors)

Consenting Authority – Christchurch City Council

The amendment to the work _____

_____

(Describe the work covered by this Producer Statement in detail)

At _____ (Address)

Lot Number _____ **DP**_____ **C/T Number**_____

I _____ (Peer Reviewer) have been engaged

by _____ (Design Firm)
to review the work as it is constructed including the design calculations, specification and drawings

VARIATION TO DESIGN CONTENT

- Variation No_____ Description_____Date_____
- Variation No_____ Description_____Date_____
- Variation No_____ Description_____Date_____
- Variation No_____ Description_____Date_____

I _____

(the Peer Reviewer)

being a suitably qualified Geoprofessional (see note 2) have reviewed the amendments to the design reviewed under PS2a and viewed the variations at the place of construction.

I believe on reasonable grounds the amendments to the design work reviewed by me, as constructed, will perform to the design intent determined by the Designer as set down by the Christchurch City Council in the consent to construct.

I have sighted the signed Producer Statement PS1 and PS4 and confirm that the Statements are complete and correct.

This statement is endorsed by _____

(Director and/share holder)

of _____

(Peer Reviewer Firm)

and the employer of the Peer Reviewer.

I/we are member(s) of ACENZ **YES** ◯ **NO** ◯, hold Professional Indemnity insurance of no less than $5,000,000.00 and accept that liability under this statement accrues to the Design Firm only.

Signed by the Peer Reviewer _____ (Signature)

_____ (Date)

Signed on behalf of the Peer Reviewer Firm _____ (Signature)

_____ (Date)

Notes And Requirements For PS2b – Design Review

1. This Producer Statement shall show the Christchurch City Council that variation to the content of the design work which arises out of its construction does not alter the design intent and the basis of the design review. It shall be based on an independent check of the variation to the design covered by the PS2a – Peer Review.

2. PS2b - Peer Review Amendment is required from the Peer Reviewer and signatory to the PS2a, who shall be a Geoprofessional, as defined in clause 4.3.1 – The Geoprofessional.

3. The Peer Amendment Reviewer shall be a person and not a Firm and shall have signing authority delegated to him/her from a Director of the Peer Reviewer's Firm to undertake the review and sign the PS2b.

4. The Peer Amendment Reviewer is engaged by the Design Firm to undertake a review of the documents representing the design work. Christchurch City Council is not responsible in any part for the commercial arrangements between the Design Firm and the Peer Amendment Reviewer.

5. The PI Insurance minimum stated on the PS2b shall be current at the time of submission to Christchurch City Council. A certificate of currency shall be appended by the Design Amendment Reviewer Firm to the Statement.

6. In the case where a Peer Amendment Reviewer Firm ceases to trade within 10 years of the construction of the designed work, the Director(s) shall maintain "run-on" insurance to the full value of $5,000,000 for the balance of time to 10 years from completion of construction.

APPENDIX VIII

Producer Statement PS4 – Construction Review

This Producer Statement is for the construction compliance of design for support or protection devices for the rockfall and boulder roll hazards on and near to the Port Hills, Christchurch. It applies to construction consented by the Christchurch City Council under the Building Act 2004 and its amendments.

ISSUED BY: _____
(Design Firm)

TO: _____
(Purchaser)

OWNERS: _____
(Registered owners shown on the Certificate of Title. Individuals, trusts, Trustees, Company Directors)

Consenting Authority – Christchurch City Council

Description of Work _____

_____
(Describe the work covered by this Producer Statement in detail)

At _____ (Address)

Lot Number _____ **DP**_____ **C/T Number**_____

Designed by _____ (Designer)

Construction observations made by _____

Qualifications of Construction Observer NZCE ◯ REA ◯ TENZ ◯ CPEng ◯ Other ◯

Construction observations to CM4 ◯ CM5 ◯ Other_____
(Categories given by ENGINEERING NEW ZEALAND)

Description of construction observations _____

_____

Authorised variations to design details that are covered by PS1 and PS2a for construction

_____
(attach all documentation to vary content of construction)

Endorsement of variation to vary content of construction by the Design Reviewer Producer Statement PS2b is attached YES ◯ NO ◯
(Include copies of the communication with the Design Reviewer)

I _____ (the designer)

being a Chartered Civil Engineer under the Chartered Engineers Act of New Zealand and a Geoprofessional (see note 2) **have** monitored the construction of the work and **believe** on reasonable grounds the works are constructed according to my design.

I am satisfied that variation to the work as detailed made at time of construction has not altered its expected performance and durability.

I confirm that the conditions of Consent issued by Christchurch City Council are satisfied in full by the construction.

This statement is endorsed by_____

(Director and/share holder)

of_____

(Design Firm)

and the employer of the Designer and Construction Observer.

I/we are member(s) of ACENZ **YES** ◯ **NO** ◯ , hold Professional Indemnity insurance of no less than $5,000,000.00 and accept that liability under this statement accrues to the Design Firm only.

Signed by the Designer _____ (Signature)

_____ (Date)

Signed on behalf of the Design Firm _____ (Signature)

_____ (Date)

Notes And Requirements For PS4 – Construction Review

1. This Producer Statement shall provide the Christchurch City Council with assurance that the work as designed and amended at time of construction has been built according to the documents to which PS1, PS2a and PS2b apply and any conditions of consent to construct.

2. PS4 – Construction Review is required from a suitably qualified Geoprofessional, as defined in clause 4.3.1 – The Geoprofessional.

3. The Designer shall be a person and not a Firm and shall have signing authority delegated to him/her from a Director of the Design Firm to undertake the Construction Review and sign the PS4.

4. The Designer shall establish the frequency for inspections and shall adopt CM4 and CM5 as specified by the consent to construct. The day-to-day inspections of construction can be undertaken by other professional or sub-professional engineers who are under the direct supervision of the Designer.

5. The PI Insurance minimum stated on the PS4 shall be current at the time of submission to Christchurch City Council. A certificate of currency shall be appended by the Design Firm to the Statement.

6. In the case where a Design Firm ceases to trade within 10 years of the construction of the designed work, the Director(s) shall maintain "run-on" insurance to the full value of $5,000,000 for the balance of time to 10 years from completion of construction.