	CODE OF PRACTICE FOR SUBDIVISION AND DEVELOPMENT
THAMES COROMANDEL DISTRICT COUNCIL	**Section 2** **Earthworks & Land Stability**

CONTENTS

2.1 SCOPE

2.1.1 Requirements for the Geotechnical Reporting / General

2.1.1.1 This Part of the Code sets out the requirements for the geotechnical reporting on proposed building sites and earthworks, and for the carrying out of the earthworks or preparation for foundations, including:

a. The assessment and protection of slope stability
b. The excavation and filling of land to form new contours
c. The suitability of both natural and filled ground for the founding of roads, buildings, services and other works
d. The control of erosion, siltation and dust during and after earthworks.

2.1.1.2 Because of the wide range of soil types, physical conditions and environmental factors applying in different areas it is not possible to specify precise requirements which will be applicable in all situations. The precise geotechnical requirements shall be relevant to the specific site and in accordance with clause 2.1.3 Means of Compliance.

2.1.2 Performance Standards

2.1.2.1 All earthworks are to be carried out in a manner to avoid, remedy or mitigate damage to the natural and physical environment.

2.1.2.2 Modifications to the natural environment resulting from earthworks are to be avoided, remedied or mitigated in order to preserve existing landscape and habitat features as far as practicable.

2.1.2.3 Landform is to be stable.

2.1.2.4 Earthwork is to be carried out, as applicable, in accordance with NZS 4431 “Code of Practice for Earth Fill for Residential Development”.

2.1.3 Means of Compliance

2.1.3.1 This section provides a means of compliance with the Thames Coromandel District Plan.

2.1.3.2 The document is presented with matching commentary where considered appropriate. The commentary is provided at the end of this section to provide an interpretation of Council's standard requirements.

2.1.3.3 An allotment which has specific geotechnical requirements may be approved subject to restrictions which shall be registered on the title to the land by a consent notice or other means if required by the Resource Management Act 1991 (RMA), and recorded in the Council Property Information system as appropriate.

2.1.3.4 All earthworks and land stability investigation and completion reports shall be prepared by a currently Chartered Professional Engineer or Council approved person who is experienced in the practice of geotechnical engineering and registered with IPENZ (Institute of Professional Engineers of New Zealand), and with at least $1,000,000 Professional Indemnity insurance cover.

2.1.3.5 Should the lot numbers on the final survey plan differ from the proposed lot numbers on the plan of proposed subdivision, then amended copies of the report and plans referring to the amended lot numbers and clearly distinguished from the originals by date and reference numbers shall be submitted.

2.1.4 Site Investigation Requirements

a. The objectives of a site investigation are to:
   i. Assess the suitability of a site for its proposed use
   ii. Foresee construction difficulties
   iii. Collect enough information for satisfactory design.

b. A site investigation should address the following factors:
   i. Ownership
   ii. Geology
   iii. Groundwater
   iv. Subsoil conditions, foundation conditions and stability (nature and extent of soils, rocks etc.)
   v. Services
   vi. Access

c. A review of the existing information is essential, and may include:

i. Geological maps and reports
ii. Data from adjacent sites - i.e. previous investigations
iii. Aerial photographs
iv. Performance of related and/or adjacent developments.

d. Geotechnical investigation reports should generally cover, but not necessarily be restricted to, the following:

i. Purpose - to investigate, examine and report on the suitability of a site for its proposed use including an evaluation of slope stability, foundation conditions, earthwork requirements, natural hazards and groundwater.
ii. Soils - Investigate and report on the geology and soil characteristics of the site with regard to foundation and construction conditions.
iii. Foundation Requirements - consider the types of building likely and their load requirements, and evaluate the foundation conditions for each allotment. Consider the type of road and evaluate the foundation at sub grade level.
iv. Effluent Disposal - in areas where sewage disposal is by means of on-site disposal, the report should also comment on the suitability of the site to accept on-site domestic effluent disposal systems and their influence on land stability, including an assessment of soil permeability.
v. Non-Engineered Fills - Identify the existence of previous filling activities on the site and comment on the quality and suitability of such fills for development purposes, with particular regard to settlement and stability.
vi. Slope Stability - Where appropriate, carry out a slope stability appraisal to determine whether the development will provide stable and accessible building sites.
vii. Water Table - The ground water table must be established in terms of MSL (Mean Sea Level) for both winter and summer conditions. In the case of land adjacent to rivers and streams, the ground water table must be established with reference to the average water level of the river or stream in winter.
viii. Natural Hazards - Evaluate the risk from natural hazards, including falling debris, earthquake, flooding, and tsunami.
ix. Liquefaction

x. Earthworks Development and Control - discuss earthworks aspects of the site and provide a specification for earthworks control and the installation of services.

xi. Conclusions and Recommendations - set out the findings of the investigation and provide recommendations for:

- Restrictions on use of the land if all or part of the land is unsuitable for some uses.
- Suggested changes to a subdivision layout to achieve better use of the site, and/ or to minimise construction difficulties.
- Control during construction.
- Further investigation where required.
- Regulation and control, or future action necessary to maintain suitability.

2.1.5 Phases of Site Investigation

2.1.5.1 Site investigation for all forms of civil engineering works, and particularly for large scale land development, requires a scheme methodology. The principle is as follows:

a. Preliminary Exploration - A preliminary exploration is necessary to gain an initial appreciation of a site. In the case of land development, this is usually simply a visual appraisal. In some cases a visual appraisal is all that is necessary.

b. Field Investigation - In most land development projects a preliminary exploration will be followed by a specific and detailed field investigation, with in situ and laboratory tests as appropriate. This investigation will yield the basis of the detailed geotechnical appreciation of the site and will provide guidelines for the development of the site, including limitations on that development. Generally, detailed design is likely to be progressing concurrently with reporting.

c. Construction Observation - observation during construction is essential to verify the appreciation obtained from (a) and (b). It is not unusual for the appreciation to be modified as site development proceeds, resulting in further investigation and changes in design and/or constructions concepts.

d. Performance Observation - Performance observation may be necessary where the earthworks design predicts post construction performance which is critical to the ultimate land usage - for example, the monitoring of the settlement of deep fills and fills underlain by highly compressible organic soils.

2.1.5.2 In summary, investigation in one form or another should be continued throughout construction, and may extend beyond the construction phase.

2.1.6 Slope Stability

2.1.6.1 A principal requirement of a site investigation for slope stability is to identify indications of past instability and to determine and recommend mitigating measures to provide an acceptable level of risk against future slope failure.

2.1.6.2 The evaluation of slope stability by the assessment of geological features, measurement of soil strengths and groundwater conditions, and the calculations of theoretical factors of safety needs to consider:-

a. The range of parameters assumed to be applicable, given the present state of stability of a slope
b. Presence of unique geological features such as remnant slick sided joints within hydro thermally altered geological formations
c. Present and future groundwater levels
d. The consequences of limitations on future site development
e. Past history of the site, especially where mining operations have previously occurred
f. High intensity rainfall events.

2.1.6.3 A preliminary appraisal can use site inspection, aerial photo interpretation and available geological and geotechnical records to provide a basis for the conceptual planning of a land development project. Preliminary appraisal should identify:

a. Areas where previous slope failures have been positively identified
b. Areas where it is suspected that slope failures may have occurred many years ago (e.g. historic features)
c. Areas of surface soil creep
d. Springs, swamps, or other areas of either poor drainage or high groundwater conditions.

2.1.6.4 Subsequent specific investigations should provide data on subsurface conditions and establish specific design criteria for such factors as maximum slopes, subsoil drainage, retention or establishment of vegetation, soakage to dispose of domestic effluent etc.

2.1.6.5 An acceptable concept for the investigation and assessment of the suitability of land developments in which natural slopes are intended to be left undisturbed provides for the delineation of building limits as follows:

a. A **Building Line Restriction** which represents the closest proximity to a slope for any building development.
b. A zone - defined as the **Specific Design Zone** - extending from the Building Line Restriction to the Building Line Limitation, within which building development requires specific design by a registered engineer experienced in, or with the assistance of an engineer experienced, in soil mechanics (particularly slope stability).
c. A zone - defined as the **Non Specific Design Zone** - delineated by the Building Line Limitation and extending beyond the Specific Design Zone, in which building development can be carried out in accordance with the appropriate standards (e.g. NZS 3604: New Zealand Standard for Timber Frame Buildings) without risk from slope instability or the need for specific design.

2.1.6.6 The determination of the zones should be derived from an assessment of potential risk under varying site conditions. The start of the Non Specific Design zone, defined by the Building Line Limitation, would typically commence 3m to 5m (or possibly more) beyond the Building Line Restriction, and would assume a factor of safety against slope regression of 1.5 or greater. The respective zones are to be defined by a suitable diagram, which can be used to establish relevant ground control points.

2.1.7 Specific Requirements for Cutting/ Filling

2.1.7.1 The engineer/ investigator should, when initially considering a land development project, address at least the following to provide a preliminary assessment of potential difficulties or the need for specialist advice:

2.1.7.2 The present topography and any surface features such as hummocky ground, irregular land forms, rushes, and obvious geological features which might infer past or present instability.

a. Any exposures of soil types, which might indicate potential difficulties for construction, e.g. sand, clay, rock
b. Existing drainage conditions and their relationship to the proposed development.
c. The performance of similar engineering works (cut and fills) in adjacent areas.

2.1.7.3 The proper appreciation of the earthworks concepts for land development will identify:

a. The suitability of the site for the concept, including the appraisal of aerial photos for larger sites and records of previous filling or mine workings.
b. Particular engineering measures that will need to be incorporated in the engineering design.
c. The influence of the earthworks concepts on slope stability, and mitigating design measures.
d. Special measures that might be required for settlement considerations, depending on fill depths etc. (e.g. settlement monitoring, delays on building construction, preloading.)
e. Building platform sites on each section designed to comply with Building Act requirements.
f. A compaction control and quality assurance regime for earthworks.

2.1.7.4 All lots are to be reshaped to slope to the roadside kerb and channel or to the Right of Way serving each lot, or to an approved outfall. The minimum gradient shall be 1 in 500.

2.1.7.5 Reserves are to be shaped to the Council's requirements so that the areas are suitable for mowing and the control of stormwater.

2.1.7.6 All earthworks shall be in accordance with any appropriate standard (and incorporating all amendments) as listed in Appendix C. Where land filling is to be undertaken the areas affected shall be shown on the As Built plans with dimensions relative to the new property boundaries.

2.1.7.7 Any areas of fill or earthworks not certified in accordance with NZS 4431 shall be shown with sufficient dimensions to locate the feature in relation to property boundaries on the As Built plans. The presence of the feature on the site will be registered on the title by way of a consent notice.

2.1.7.8 The developer/ applicant shall take measures to control silt contaminated stormwater at all times during earthworks, roading development and installation of underground services. Details of the control works shall be submitted as part of the engineering plans and specifications.

2.1.8 Quality Assurance and Control

2.1.8.1 The quality control of earthworks is an essential phase of land development, and is aimed at providing for uniform construction in terms of engineering performance. Earthworks should be certified as to how they have been carried out and their suitability for their intended end use. The form of quality control will evolve from the earthworks appreciation and will generally be developed about:

a. Adequate strength.
b. Limited volume change.

2.1.8.2 The engineering performance of soils depends on their condition at the time of compaction and cannot be adequately reflected in a single parameter.

2.1.8.3 Quality control should be undertaken either by, or under the direct supervision of an experienced geotechnical engineer and should involve:

a. Visual inspection
b. Quantitative testing by a Telarc Sai Ltd Registered Organisation.

2.1.9 Settlement

2.1.9.1 For land development works, the pre-development soils investigations should identify areas of risk, such as organic soils, swampy areas, etc. and the likely performance of the foundation under earth fills.

2.1.9.2 The consolidation settlement and elastic compression of fill are a function of time, albeit of long or short duration, thus in some cases it may be necessary to allow a period of time to elapse from the placement of fill to the commencement of building construction.

2.1.9.3 Consequently, the limits of earth filling and the variations in the depths of fills should be clearly identified on As Built drawings.

2.1.10 Subgrade Design

2.1.10.1 The general principles of earthwork investigation, construction and control as outlined in this section also apply to road subgrades.

2.1.10.2 For subgrades in fill materials, it is usual to attempt to achieve a higher strength fill within the upper 1000mm to sub grade formation level. A minimum CBR (California Bearing Ratio) of 7 must be achieved within the subgrade layer.

2.1.10.3 Two principal methods of pavement design are currently used:

a. CBR method
b. Deflection method.

2.1.10.4 The CBR method is most commonly used and is based on laboratory or in situ tests and is dependent upon approval of the subgrade for uniformity and standard of construction. Proof rolling or in situ tests such as the dynamic cone (Scala) penetrometer may be used to assess uniformity.

2.1.10.5 The deflection method is based on end of service empirical performance criteria and requires the in situ testing of the subgrade by Benkelman beam (or other approved means) prior to placing the metal courses.

2.1.10.6 In general, cut ground may require more treatment for acceptance to road subgrade standards than a controlled earth fill. Undercutting and re-compaction is often a prudent course to follow on cut ground.

2.1.11 Earthworks and Land Stability Completion Report

2.1.11.1 An earthworks and land stability completion report should cover, but not necessarily be restricted to, the following:

a. Purpose - To report on the development after completion of the works, with a view to recording construction information and extending the site investigation report if appropriate, and expressing an opinion on the suitability of all lots within the subdivision for their intended use.

b. Scope - The report should describe all activities from the preliminary site investigation to the completion of the physical works, including earthworks compaction control testing.

c. Requirements - The report should cover, and re-evaluate where necessary, the requirements of the Geotechnical Investigation Report, the requirements of NZS 4431: New Zealand Standards Code of Practice for Earth Fills for Residential Development where appropriate, and any requirements that are set out in the conditions of subdivision consent. Natural hazards and land contamination must be identified for the purposes of the Building Act.

d. Description - The description should include sufficient test results, site inspection data and other information to enable an independent assessment to be made as to the suitability of the development.

2.1.11.2 The emphasis of the report should be on stating what happened during construction, supported by detailed field notes, test results, and construction reports to provide an accurate detailed As Built record.

2.1.12 Peer Review of Soils Report

2.1.12.1 The Engineer reserves the right to call for a peer review of the geotechnical report in cases of serious stability concerns or conflict between the findings of the soils report and previous reports held in the Council's Property Information system. The cost of the peer review shall be met by the developer/ applicant.

2.1.12.2 When the Engineer calls for a peer review of the geotechnical report, the geotechnical engineer or developer/ applicant, as appropriate, shall nominate a geotechnical Chartered Professional Engineer as peer reviewer. Acceptance of the nominated peer reviewer by the Engineer shall be obtained in writing before the peer review commences.

2.1.12.3 The peer review shall examine the appropriateness and completeness of the investigations and analyses applied in the geotechnical report with respect to the site and its environs.

2.1.12.4 The peer reviewer may recommend or request additional investigations and/or analyses to clarify or confirm any concerns, and these shall be addressed by the developer/ applicant's geotechnical engineer in writing to the Engineer and peer reviewer.

2.1.12.5 The peer reviewer shall provide a written report to the Engineer on the matters set out in section 2.2.11.1 and any other matters pertinent to the safe development of the site. The report shall include a conclusion as to the adequacy of the conclusion and recommendations of the geotechnical report, and confirm the suitability of the land for development, subject to the recommendations of the geotechnical report and peer review.

2.1.12.6 The peer review report shall include the current legal description of the site (Lot and Deposited Plan (DP) numbers), clear reference to the report being reviewed, and shall be submitted in duplicate.

2.1.13 Summary

2.1.13.1 In summary, engineering appraisal and design are required:

a. Prior to detailed planning which usually involves some form of subsurface investigation
b. During the review of and advice on design concepts
c. During construction to ensure the adequacy of the bulk filling and the execution of the earthworks design
d. After construction, to provide certification and/ or define limitations of the works.

2.1.13.2 Geotechnical assessment guidelines are provided in the IPENZ (Auckland Branch) Code of Practice for Urban Land Development Control, and NZS 4404. Refer to Appendix C for a Schedule of Standards. These documents set out the areas in which the rational processes of engineering appraisal and design (site investigation) are necessary, and which require the involvement of a geotechnical (soils) engineer.

2.2 COMMENTARY- EARTHWORK AND LAND STABILITY

2.2.1 General

2.2.1.1 This commentary is to provide further information and guidance to designers. The section numbers cross-reference to the relevant sections of the Code.

2.2.1.2 A rational approach to site investigations for urban land subdivision is given in NZS 4404: New Zealand Standard for Land Development and Subdivision Engineering. Test sites for both scala penetrometer tests and bore holes should be selected as required in NZS3604:2011 clause 3.3.8 (Test sites).

The scala penetrometer tests should be carried out in accordance with the procedure described in NZS4402. Any deviation from the above procedure must be approved by the Council's Planning Manager.

2.2.1.3 In almost all circumstances, it is likely to be prudent for the developer/ applicant or their engineer to at least obtain an initial appraisal by a geotechnical engineer to provide input to the conceptual design.

In many circumstances (e.g. where the size of the development is sufficiently small), a visual appraisal will suffice. In most circumstances, however, some form of investigation will be required.

2.2.2 Phases of Site Investigation

One of the problems which has affected the orderly assessment of the suitability of land for development and building foundations has been a lack of uniformity of understanding between practitioners in their approach to the issues, and between practitioners and Council officers in their interpretation of these approaches.

It is recognised and accepted that no two engineers will approach any one problem in exactly the same way, nor will they reach entirely the same conclusion, or present their data and interpretations in exactly the same way.

A comparative lack of specialised knowledge or experience can act to hinder the rationalisation of these issues, usually at considerable cost to all parties involved, including the practitioner and the Council.

This Means of Compliance document provides a quality-management means of overcoming these issues of communication and understanding, within the framework of a generalised set of expectations.

In terms of a quality-management approach to the satisfaction of engineering criteria, it is necessary for a geotechnical engineer to consider his or her approach to an investigation with respect to:

a. The end use of the site
b. The liability consequences in the event of a wrong appreciation to:

   i. The client and subsequent owners
   ii. The engineer

iii. The Local Authority.

The reality is that the backstop in terms of liability is:

a. The engineer's own professional indemnity insurance
b. The Local Authority's insurance.

A quality management approach then says that the process of site investigation is not complete until the construction aspects of the project are complete.

An incomplete or less than thorough approach to a site investigation is a waste of effort, inconclusive and fraught with risk.

The principles relating to geotechnical investigation for land development/ subdivision purposes are the same, irrespective of whether an intensive urban subdivision or a rural subdivision is being considered. What differs is the extent of the process that needs to be followed. Often the methodology can be abbreviated if site conditions are appropriate. The important element is the provision for hazard assessment and risk mitigation.

2.2.3 Slope Stability

An increase in the slope angle of the land surface and/or a decrease in the shear strength of the slope materials cause most landscapes. However a large number of interrelated factors apply.

Flowing water from rainfall is constantly changing the shape of the earth's surface. The water cuts out a channel and the side slopes of the resulting channel or valley are left over steep and subject to landslip, (i.e. marginally stable).

These side slopes gradually become less steep as the topography matures, and erosion and land slipping become less frequent. Steeper parts of the valley system may, however, remain in a state of only marginal stability and some incident, such as excavation or exceptionally heavy rain, can cause further land slipping to occur.

It follows then that many slopes are potentially unstable in their natural state, and must therefore be considered unsuitable for residential development unless improved by properly designed engineering works.

A primary objective of land development engineering is to provide stable and accessible building sites. These considerations are particularly important in the case of residential land development, which is proceeding more and more into areas of marginal stability avoided in past years.

An experienced person can recognise previous landslip areas by stereoscope examination of pairs of aerial photographs. This is a fast and economical means for assessing the general slope stability characteristics of a large area.

Visual signs of ground instability include cracked or hummocky surfaces, crescent shaped depressions, crooked fences, leaning trees or power poles, swamps or wet ground in elevated positions, and water seepage.

The filling of gullies and flattening of hill slopes in subdivision development converts the young and potentially unstable slopes found in many parts of New Zealand to a more mature and stable land form. This achieves in a short timeframe what nature would otherwise achieve through landslips and erosion in many thousands of years.

In the situation where the concept of land development is to minimise earthworks and to leave the land in its largely undisturbed natural state, many problems are experienced between the practitioner and local authorities in determining acceptable slope stability criteria, levels of risk and reporting.

Traditionally, if a theoretical factor of safety of 1.5 can be achieved by analysis, then the slope is deemed to be stable. The problem arises in determining the correct parameters to use and the influence of subsurface conditions on the form of analysis, which is consequently dependent on the nature and level of investigation.

Cumulative experience suggests that the proper selection of a theoretical factor of safety for slope stability purposes is dependent upon a proper assessment of the level of risk.

Brand (1982), on analysis and design in residual soils, reports the established practice in Hong Kong (Geotechnical Control Office, 1979) in which the design factor of safety is related to the risk category. The risk category for a particular slope is assessed in terms of the likelihood of loss of life should the slope fail. Typical of high-risk slopes are high cut slopes immediately adjacent to schools and occupied apartment blocks. An example of a low risk slope is one which threatens only a secondary road.

Typical values of acceptable factors of safety in residual soils are given in Table 2.1. The design "standard" for slope safety (i.e. the probability of failure) is (logically) governed largely by the consequences of failure in terms of: loss of life, damage to property, and disruption of communications and services.

Table 2.1: Acceptable Solutions of Safety for Slope in Residual Soils (based on Brand, 1982)

Table 2.1	
Risk Category	**Minimum Factor of Safety for Transient Condition (e.g. 1:10 Year Storm)**
Low	1.2
Significant	1.3
High	1.4

It is noted that factors of safety adopted by engineers in geotechnical design have been developed to cover uncertainties in:

- the geometric accuracy (e.g. of the slope or retaining wall being designed)
- the soils strength (which is likely to vary from point to point even in the same soil "layer")
- the method of analysis adopted (which is usually two dimensional and can have simplifications that may not accurately reflect the actual situation)
- the validity of assumptions made (e.g. depth to groundwater level, depth to rock or hard layer, etc.).

For these reasons, it is customary to adopt a factor of safety value of 1.5 for subdivisions or housing development. This factor of safety does not in every case assure safety from instability or slope movement. Based on references (1 to 3) noted below in Table 2.2, the average risk of failure for different factors of safety adopted is:

Table 2.2	
Factor of Safety	**Risk of Failure Per Annum**
1.1	1:10
1.3	1:50
1.5	1:200
1.7	1:1000

References:

1. Meyerhof, G., Canadian Geotechniques, Vol. 7, No. 4 (11/70)
2. Wu, T.H., et al, ASCE, SM2 (3/70)
3. Sample, R.M., Ground Engineering (9/81)

2.2.4 Quality Assurance and Control

It is recommended that a full quality assurance system be developed to ensure that the end product, e.g. the completed house lot is suitable for its end purpose.

In addition to following guidelines set out in national publications (such as NZS 4431: New Zealand Standard Code of Practice for Earth Fill for Residential Development), it is recommended that progressive testing be carried out to avoid rework and to avoid unsuspected poor quality fill. Refer to Appendix C for the Schedule of Standards.

The fill needs to have sufficient checks (quality assurance procedure) at progressive stages of the works, all with clearly dated and surveyed test points:

a. on completion of clearing and removal of unsuitable soils
b. on completion of compaction of each fill layer until completion of the whole fill.

Corrective measures need to be specified and carried out where the target quality is not met.

The final fill control certificate provides a record of work done and tests carried out (quality control record).

Visual inspections should be made:

a. After stripping and prior to filling
b. During the installation of drains
c. Sufficiently often to check that:

- Fill is not placed over soft or organic ground, unless provided for by design
- Seepages and potential seepage areas are provided with drains
- Unsuitable materials are not used as fill
- Compaction operations are systematic and uniform
- Conditions encountered are in keeping with those anticipated from the initial site investigation.

Quantitative testing should be related to the control criteria determined by the soil engineer. They should have a higher frequency (say about 500 to 1000m3 intervals) at the initial stages of earthworks to sort the operations out, with a lesser frequency as the fill progresses and the compaction criteria are being achieved, and when visual appraisal indicates the overall operations are satisfactory.

2.2.5 Settlement

Settlement of soils (consolidation) is a complicated natural phenomenon which is influenced by a number of factors including: the nature and mineralogy of the soil, the soil particle arrangement, whether the soil is undisturbed or remoulded, it's past stress history and the drainage conditions affecting the particular circumstances. Settlement will also occur within earth fills due to the self-weight of the fill.

Because of the variables in the theoretical appreciation of the likely magnitudes of settlement, monitoring of the actual settlement performance of earth fills can often expedite the release of the development.

The absolute magnitude of settlement, except when it is large, is often of lesser concern for most forms of construction than the magnitude of differential settlement and thus angular distortion. It is often overlooked that conventional analytical processes generally imply settlements of the order of approximately 25mm.

It is also often overlooked that seasonal moisture variations, and the associated swelling and shrinking of the soil, will occur with the associated likelihood of seasonal swell/ shrink movements of the order of at least 10mm. These natural effects may cause distortion of building frames, and may cause doors and windows to jam. In many instances, and as more difficult country is developed, earth filling of narrow gullies is occurring with considerable variations in fill thickness over short distances, and thus with the potential for differential settlement.

2.2.6 Subgrade Design

The earthworks and land stability report should address any specific design criteria perceived necessary for subgrade preparation (e.g. stabilisation, re-compaction, geotextile, drainage, etc.).

Not all soils will require the application of the Means of Compliance to the same degree. For example, a site with no obvious risks or identifiable hazards, and which has not been subject to earthworks or other engineering works such as the installation of services, may require a letter from a Council approved person re-affirming the suitability of the site for its intended purpose. This assessment should be reported in letter form to ensure continuity of record for the Quality Assurance audit trail.

2.2.7 Earthworks and Land Stability Completion Report

With most land development projects, the site investigation aspects of a project extend throughout the project and may require considerable flexibility during the construction phase, particularly if complex and varying conditions not anticipated from the formal phases of investigation are encountered.

The processes that have been outlined provide the means of achieving the objectives of sound foundation investigation for subdivision and land development purposes, being:

a. Identifying any constraints on land use;
b. Mitigating any risks;
c. Reducing the potential liability of all parties involved in the processes, including:

- the owner
- the engineer
- the local authority.

These processes define the state of practice for subdivision and land development investigation, which when based largely on a common sense pragmatic approach to hazard identification and risk mitigation in conjunction with a good measure of practical down to earth experience, will ensure:

a. A low risk outcome for all parties involved
b. A product, which is readily understood by most local authority officers and which, through a logical process, should address their concerns
c. As a consequence of (b), a relatively easy progression through the approval processes, which has a net benefit to a client in terms of minimal delays
d. For a well engineered subdivision or land development project, a product which is readily marketed, as a consequence of identified and mitigated risks (with minimum uncertainties).

These processes have the underlying objective of communicating a technical appreciation of a site in a manner which addresses all the relevant issues, and in a manner which can be readily understood by all parties involved, including the lot purchaser/ future home owner.

The process may be subject to variation, depending on specific site circumstances. However, if followed rationally, the outcome should always be the same - a quality managed engineering product based on hazard identification and risk mitigation. The final report can vary from a one page letter through to a sizeable report, depending on the specific site circumstances.