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12 December 1995

Ms S M Twigg
Principal Planner
Nelson City Council
P O Box 645
**NELSON**

Dear Sir

**Geotechnical Assessment, Grampians Foothills, Nelson**

We enclose our finalised report which, following our discussions on the 15th November 1995, contains an expanded section 6 and an extended sheet 3B which includes the Bishopdale area.

Please contact the undersigned if you would like to discuss these recommendations in section 6 further or any other aspect of the report.

Yours faithfully
**SOILS & FOUNDATIONS LTD**

per: M R Johnston
MRJ:smh

Encl:report

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SOILS & FOUNDATIONS

# Nelson City Council

# Geotechnical Assessment

# Grampians Foothills
# Nelson

December 1995

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|---|---|
| **Nelson City Council**<br><br>**Grampian Foothills, Nelson** | **Prepared by:**<br>M R Johnston/P C Denton |
| | **Reviewed by:**<br>P C Denton, M R Johnston |
| **Quality Assurance Statement**<br>**Project Manager : M R Johnston** | **Approved for issue by:**<br>Project Manager December 1995<br>P:\9313500\ADMIN\RNJMRB01.DOC |

**Nelson City Council**

# Geotechnical Assessment
# Grampian Foothills, Nelson

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- Site vicinity map - Sheet 1
- Site Plan - Sheets 2B, 3B

**Nelson City Council**
**Grampian Foothills**
**Nelson**

## 1.0 Project Brief

Soils & Foundations were asked by the Nelson City Council (NCC) to review two areas, comprising the Grampian Foothills and Tahunanui Slump, in Nelson City. These areas are within Zone III, the highest of three slope instability hazard zones recognised by the Institute of Geological and Nuclear Sciences (IGNS) in a 1993 report to the Nelson City Council (Johnston *et al.* 1993). The purpose of our review was to provide the geotechnical basis on which management options for the areas could be prepared. In this report we consider only the Grampian Foothills, the area comprising the Tahunanui Slump is described in a separate report (Soils & Foundations 1995b). The Grampian Foothills encompasses the steeper slopes between Brougham Street and Bishopdale.

Details of the NCC brief are contained in a letter from the Principal Policy Planner, S M Twigg, dated 6 September 1995 (Reference File E14-01). Authorisation for the work was documented with NCC purchase order No. 25781 with the same date. Terms of engagement are as per the standard IPENZ agreement.

## 2.0 Scope Of Work

We have briefly reviewed existing information, both published and unpublished, on the Grampian hillside. However, there is probably a significant amount of historical information that should be assessed. We have also examined stereo-pairs of aerial photographs held by DOSLI and Aerial Surveys Ltd. The DOSLI photographs comprise 1202/56-57 and 1203/52-53 dated 14 March 1948 at an approximate scale of 1:15800. The Aerial Surveys photographs are 113069 - 113072, dated 25 October 1989 at an approximate scale of 1:10800.

## 3.0 Slope Instability In Nelson City

Within the boundaries of Nelson City there are a variety of different rock types that underlie slopes ranging from flat to very steep. A combination of factors, but more particularly weak rock on steep hillsides, have resulted in significant areas of slope failure. A number of these areas have a relatively long history of deepseated movement (many thousands of years) and the ground within them has either yet to reach stability and/or has high potential to fail in the future.

The location of these unstable or potentially unstable areas is generally defined although their boundaries, and details as to the hazard they present, may be imprecisely known. For those

areas within the rurally zoned part of the city there is at present little need for further action as any proposal to subdivide in the future could undertake to directly address the question of slope instability. For those areas that have already been built on, in some instances extensively so, then it is appropriate that the future use of this land be reviewed and if necessary its management and/or its planning status amended.

One of the largest areas of unstable or potentially unstable developed urban land is the western slopes of the Grampians. Within this area further development may occur, including the subdivision of existing sections and the construction of larger buildings such as apartment blocks, hostels etc.

## 4.0 Grampian Foothills

### 4.1 Definition

The area comprising the Grampian Foothills consists of moderately gentle to steep slopes on the western face of the Grampians from Brougham Street to Bishopdale (see Site Vicinity map - Sheet 1). This area has a long history of residential development as well as substantial buildings at Nelson College and Braemar Hospital. Only between Motueka and Tukuka streets are buildings absent on the lower slopes. The higher slopes of the Grampians are in trees, including plantations of *Pinus radiata*. The area considered in this report is shown in more detail on the Site Plan - Sheets 2B and 3B.

### 4.2 Geology

The Grampians area consists of two contrasting bedrock units, hardrock of the Brook Street Volcanics and consolidated sedimentary rocks of largely Tertiary age (Bruce 1962; Johnston 1979, 1981). The two units are separated by the northeast trending Flaxmore Fault, an active dextral, reverse fault (Johnston *et al.* 1993; Soils & Foundations 1995a). Overlying the bedrock units on the lower slopes are widespread, and locally extensive, superficial deposits.

#### *4.2.1 Brook Street Volcanics*

East of the Flaxmore Fault, and forming the steep upper slopes of the Grampians, are rocks of the Grampian Formation belonging to the Brook Street Volcanics Group of Permian age. The formation consists of hard, well bedded, grey sandstone, siltstone and minor mudstone. Although hard, the formation contains numerous planes of weakness which, in addition to steeply (65° measured below the horizontal) southeast dipping bedding, includes cleavage, joint and fracture planes. Many of these planes are intersecting giving what would otherwise be a formation of hard dense rocks, a certain degree of permeability.

*4.2.2 Consolidated Sedimentary Rocks*

The units west of the Flaxmore Fault include a variety of consolidated, but relatively soft rocks of probable late Cretaceous to early Tertiary age. The rocks range from mudstone to conglomerate and comprise the following formations: Marsden Coal Measures, Bishopdale Formation (a conglomerate) and Braemer Formation (dark coloured siltstone and mudstone). In addition there is a distinctive unnamed, red-stained conglomerate, of probable late Cretaceous age, that outcrops adjacent to the Flaxmore Fault. The bedrock units west of the Flaxmore Fault are considerably affected by faulting and there are numerous crush and shear zones which, along with weathering to a depth of several to many metres below the surface, further weaken the rocks. In addition many of the rocks west of the fault contain swelling clays and which are very abundant along widespread micro fracturing in the red stained conglomerate.

*4.2.3 Superficial Deposits*

The overlying superficial deposits are unconsolidaled and are derived from the bedrock units, on both side of the fault, by slopewash and other alluvial processes, such as fan gravel deposition, and slope failure. The deposits are commonly clay-rich and contain swelling clays, particulary where derived from the red stained conglomerate along the Flaxmore Fault. As the deposits have accumulated over a period of several to many thousands of years, at any one location there is commonly a complex interlayering of materials showing different properties and a range of colours including grey, brown and red.

## 4.3 Slope Failures

The western slopes of the Grampians show widespread, but not uniform, evidence of instability. The instability ranges from relatively small, well defined features to broad areas of slope failure whose boundaries are imprecisely known. The failures are generally poorly documented but the well defined ones are relatively narrow and extend downslope for up to 100 m or more. The thickness of material involved in such failures appears to be up to several metres thick. The broad zones of instability are up to several hundred metres across and probably extend downslope a similar distance. The depth of material involved is not known but it is probably considerably more than in the well defined failures.

Although there are large areas within the western slopes of the Grampians that show no obvious evidence of instability, they may be underlain by weak incompetent materials that when water saturated and/or faces developed on them are oversteepened, have the potential to fail. Much of the water saturation arises from rain falling on the Grampians percolating into the Grampian Formation along bedding, joint and other planes of weakness. This groundwater migrates downwards until its passage is blocked by the low permeability clay rich cretaceous and Tertiary rocks west of the Flaxmore Fault. This low permeability forces the groundwater towards the surface in the vicinity of the Flaxmore Fault. This groundwater

is augmented by rainfull that is concentrated into small gullies in the Grampian Formation and from which water discharges into the superficial deposits, particulary the fan gravel, downslope of the Flaxmore Fault. Within the superficial deposits groundwater tends to become perched above the contact with the underlying sedimentary rocks of Cretaceous and Tertiary age.

Adding to this water saturation is a poorly developed drainage, although in recent years the NCC have installed and/or upgraded the stormwater system. For example above Allan Street the council, acting on geotechnical advice from Tonkin & Taylor (1984, 1985), has taken steps to dewater an area of know instability. In 1995 the NCC has, in introducing condition 800, recognised that the western slopes of the Grampians is served by an inadequate stromwater system.

While the greatest risk is within the rocks west of the Flaxmore Fault and the superficial deposits overlying them, slope failures are also common east of the fault. These latter failures are, however, of a superficial nature and involve a relatively thin layer of topsoil and immediately underlying subsoil and weathered rock of the Grampian Formation. They appear to be more pronounced where ground disturbance, particularly roading, has undercut or loaded slopes and concentrated stormwater discharge. No deepseated failures have been recognised in the Grampian Formation.

## 5.0 Discussion

Because most of the lower western slopes of the Grampians are developed for housing and other purposes, any failure within them has the potential to affect multiple properties. Because of the developed nature of the slopes, remedial action could be difficult to implement as well as being costly.

## 6.0 Recommendations and Conclusions

### 6.1 For immediate consideration

Because of the presence of weak incompetent and frequently water saturated materials underlying moderate to steep slopes, it is recommended that steps be implemented to ensure that this is readily known and that land disturbance within the area shown on the Site Plan, Sheets 2B and 3B, is not undertaken without recognition of the potential risks that may arise. We make the following recommendations:

*6.1.1* The western slopes of the Grampians, as shown on Sheets 2B and 3B, be zoned so that attention is drawn to the relatively high risk of slope failures within it. A

possible name for the area shown on these sheets is in the *Grampians Geotechnical Hazard Zone.*

*6.1.2* Disturbance to the ground in the form of excavations and/or the placement of fill must not be undertaken without prior geotechnical evaluation and council approval.

*Note:* This should not be interpreted to prelude minor landscape development, including minor terracing of sections (see sections 6.1.3, 6.1.4, 6.1.5 and 6.1.6).

*6.1.3* Excavations over 0.6m in height must be carried out under the supervision of a qualified engineer or geologist. Excavations should not be undertaken during or immediately following periods of rainfull or when the ground is highly saturated.

*6.1.4* Excavations over 0.6m height must be drained and retained. All retaining walls and drainage must be installed under the supervision of a qualified engineer.

*6.1.5* Excavations must be retained as soon as possible. Larger excavations may have to be carried out in stages with each stage being retained before commencement of the next stage.

6.1.6 Fill, whether from excavations on site or brought in from elsewhere, must not surcharge unstable or potentially unstable slopes and must be placed under the supervision of a qualified engineer or geologist.

*6.1.7* As much stormwater as possible should be diverted in a controlled manner away from the area in sealed pipes or water tight channels.

*6.1.8* Sewers,water supply pipes and channels should be regulary checked to ensure no leakage from them occurs. A higher than usual rate of regular Council maintenance could be funded by fees generated during consideration of building consent applications.

*6.1.9* We recommend that the Council develop and adopt an outline for implementation of future geotechnical investigation work to be undertaken. This should include a prioritised list of the work required and an appropriate timetable (see section 6.2 below)

## 6.2 Future Work

As discussed above, a finding of our current review of the Grampian Foothills is that insufficient data collection and assessment has been completed to date. It is likely that following an assessment and review of what data is known to exist, further recommendations will be forthcoming. In our opinion further work is critical to the development of an accurate

and complete picture of the Grampian Foothills area and includes the following, listed in relative order of priority:

*6.2.1* Establish a GIS file that records the data that is obtained and to which new data can be added.

*6.2.2* Review of NCC files for reports prepared for any site specific investigation related directly or indirectly to slope instability.

*6.2.3* Review of historic aerial (stereo and non-stereo paired) and ground photographs of the area.

*6.2.6* Where necessary undertake field mapping of current ground features existing in the study area and compilation on an appropriate scaled map.

*6.2.5* Review of existing DOSLI survey data where it exists.

*6.2.4* Compilation of historic ground features, documented by previous investigators, on an appropriate scaled map.

*6.2.7* Others as appropriate.

## References

BRUCE, J G 1962: The geology of the Nelson City area. *Transactions of the Royal Society of New Zealand, Geology* 1(11):157-181

JOHNSTON, M.R. 1979: Geology of the Nelson Urban Area. NZ Department of Scientific and Industrial Research, Wellington

JOHNSTON, M.R. 1981: Sheet 027AC - Dun Mountain, Geological Map of New Zealand, 1:50,000. NZ Department of Scientific and Industrial Research, Wellington.

JOHNSTON, M.R., HULL, A.G. and DOWNES, G.L., 1993: Earthquake, Landslide and Coastal Hazards in Nelson City. Report prepared by the Institute of Geological and Nuclear Sciences Ltd for the Nelson City Council.

SOILS & FOUNDATIONS LTD, 1995a: Redefining fault lines, Nelson City. Unpublished report prepared for the Nelson City Council.

SOILS & FOUNDATIONS LTD, 1995b: Geotechnical assessment, Tahunanui Slump, Nelson. Unpublished report prepared for Nelson City Council October 1995.

TONKIN & TAYLOR LTD, 1994: Nelson Ciy Council, Grampians Reserve, Stability Investigation. Unpublished report prepared for Nelson City Council.

TONKIN & TAYLOR LTD, 1995: Grampians Stability Investigation. Unpublished report prepared for Nelson City Council.

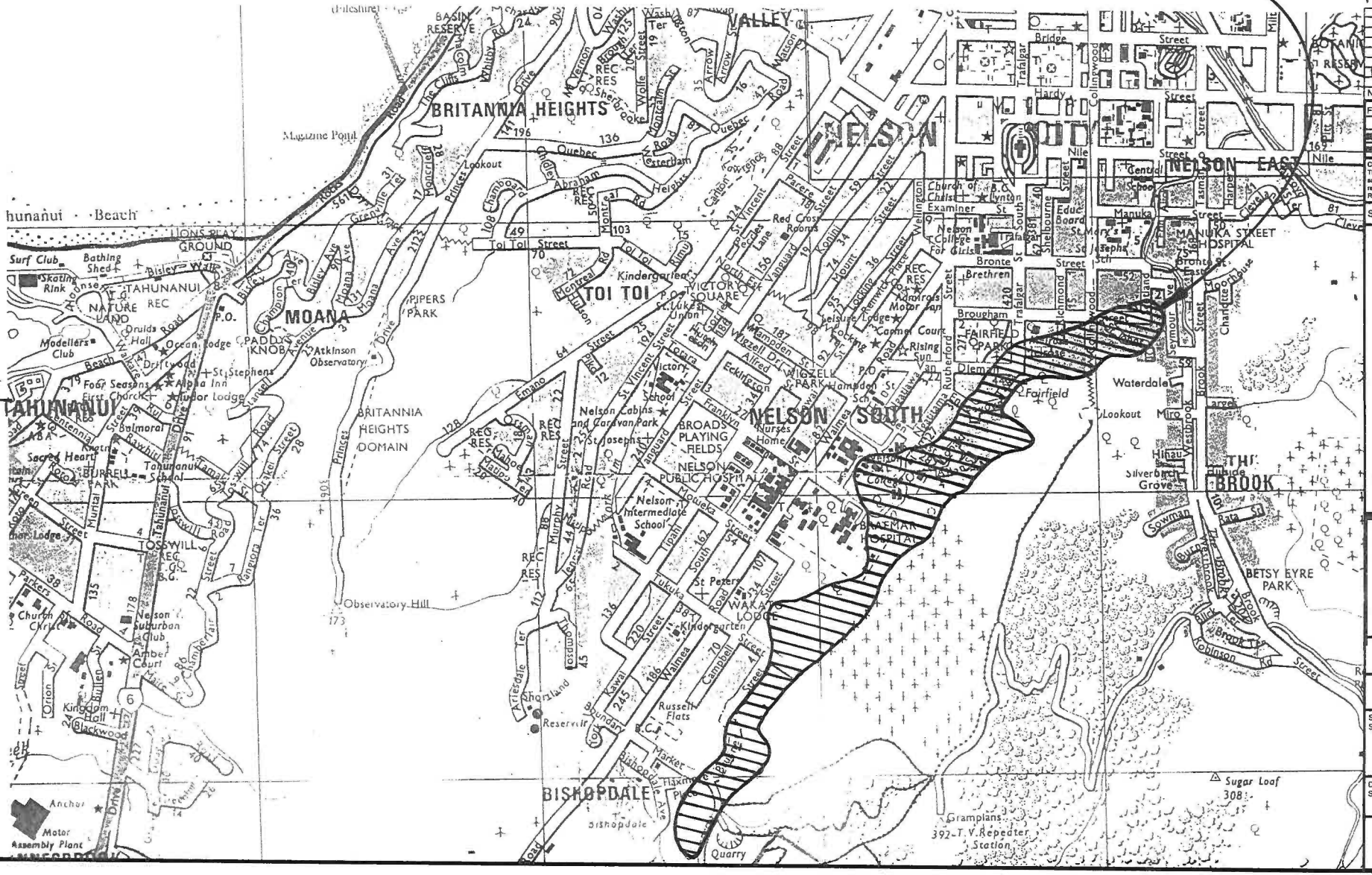
Basemap: DOSLI Infomap 271-20

0 200 400 600 800 1000 metres

0 1km 2km

APPROXIMATE SCALE

# Grampian Foothills Study Area




| No | AMENDMENTS | Date | Initial |
|---|---|---|---|
| A | Updated draft to Conceptual | 12/95 | PB |

| FIELDBOOK | Initials | Date | | Initials | Date |
|---|---|---|---|---|---|
| SURV. | | | DR | | |
| DES. | | | CH | | |
| | | | APP. | | |

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SCALES: 1:20000

NELSON CITY COUNCIL

GRAMPIAN FOOTHILLS STUDY AREA

Site Vicinity Map

SOILS & FOUNDATIONS

Geotechnical Consulting Engineers Geologists

Status Stamp: CONCEPTUAL

Date Stamp: OCTOBER 1995

| Job No. | Sheet No | Rev |
|---|---|---|
| 9313500/ | 1 | A |

## Notes

1 See Sheet 3 for notes, legend, limitation clause and continuation from joining line

NORTH

0 50 100 150 200 metres

APPROXIMATE SCALE

Crest of Ridge

The Grampians

Seymour Avenue

Scotland Avenue

Cottingwood

Richmond Ave

Broughton Street

Trafalgar Street

Van Diemen Street

Atlas Street

Rokaki St

Ngatitama St

Ngatitawa St

Hampden Street

Emmeline Street

Emmeline Street

Motueka Street

Rutherford Street

Waimea Road

See Sheet 3 for Continuation Joining Line

| No | AMENDMENTS | Date | Initial |
|---|---|---|---|
| B | Updated Draft to Conceptual | 10/95 | KB |
| A | Updated Preliminary Draft Previously released to NCC (25th September 1995) | 10/95 | KB |

| FIELDBOOK | Initials | Date |
|---|---|---|
| SURV. | | |
| DES. | | |

| | Initials | Date |
|---|---|---|
| DR. | KB | 10/95 |
| CH. | PCD | 10/95 |
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SCALES: 1:5000 Approx

NELSON CITY COUNCIL

# GRAMPIAN FOOTHILLS STUDY AREA

## SITE PLAN
(SHEET 1 OF 2)

SOILS & FOUNDATIONS
Geotechnical Consulting Engineers
Geologists

Status Stamp: CONCEPTUAL

Date Stamp: OCTOBER 1995

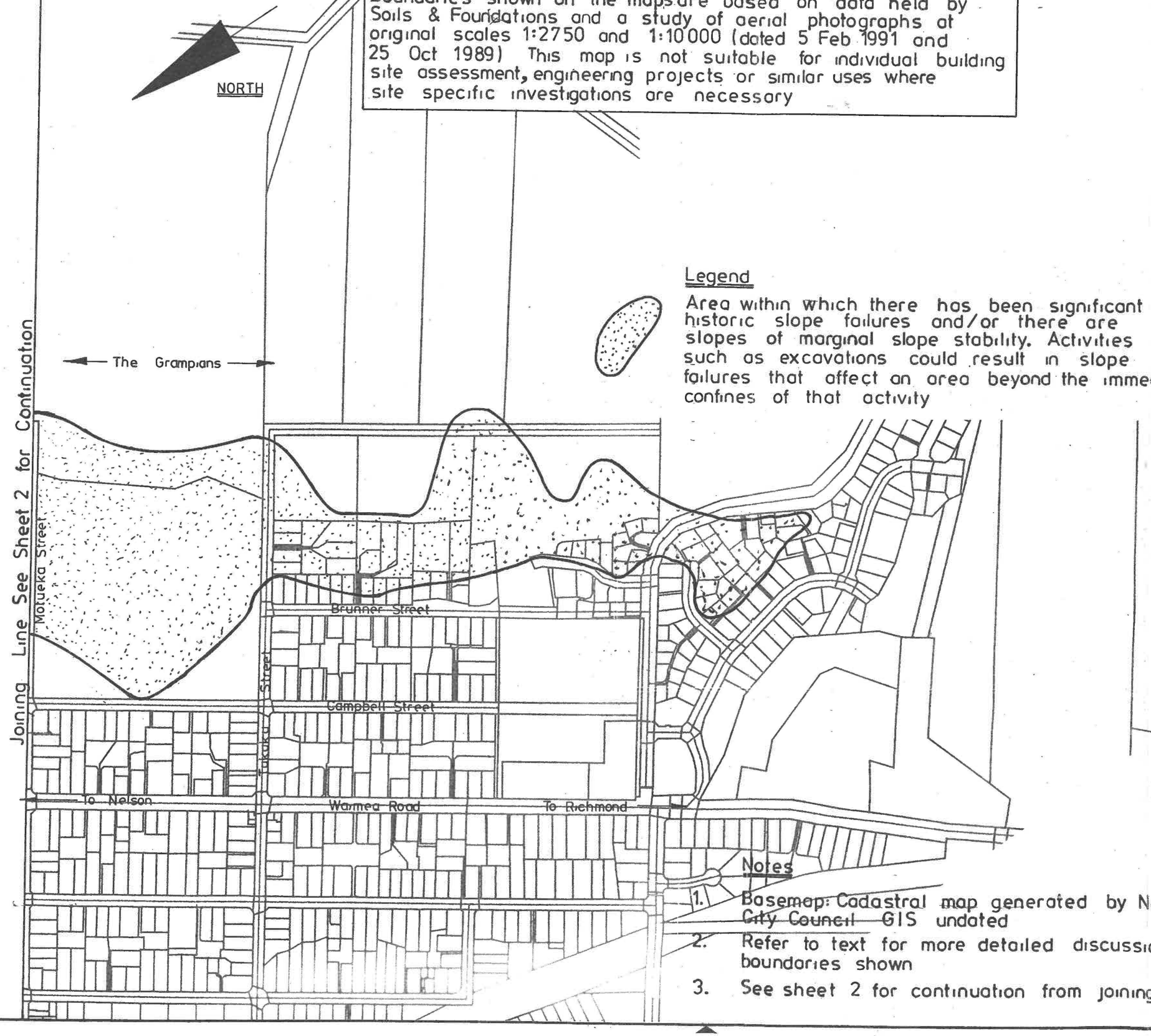
| Job No. | Sheet No. | Rev. |
|---|---|---|
| 93135 00 | / 2 | B |

## Limitations

Boundaries shown on the maps are based on data held by Soils & Foundations and a study of aerial photographs at original scales 1:2750 and 1:10000 (dated 5 Feb 1991 and 25 Oct 1989) This map is not suitable for individual building site assessment, engineering projects or similar uses where site specific investigations are necessary

0 50 100 200 metres

APPROXIMATE SCALE




## Legend

Area within which there has been significant historic slope failures and/or there are slopes of marginal slope stability. Activities such as excavations could result in slope failures that affect an area beyond the immediate confines of that activity

## Notes

1. Basemap: Cadastral map generated by Nelson City Council GIS undated
2. Refer to text for more detailed discussion of boundaries shown
3. See sheet 2 for continuation from joining line

| No | AMENDMENTS | Date | Initial |
|---|---|---|---|
| B | Draft to Conceptual Area Extended & Location of area corrected | 12/95 | KB |
| A | Updated Preliminary Draft Previously released to NCC (25 September 1995) | 10/95 | KB |

| FIELDBOOK | Initials | Date |
|---|---|---|
| SURV. | | |
| DES. | | |

| | Initials | Date |
|---|---|---|
| DR. | KB | 10/95 |
| CH. | PCD | 10/95 |
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SCALES:

# NELSON CITY COUNCIL

# GRAMPIAN FOOTHILLS STUDY AREA

## SITE PLAN (SHEET 2 OF 2)

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Geologists

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Date Stamp: OCTOBER 1995

| Job No. | Sheet No. | Rev. |
|---|---|---|
| 93135 00 | / 3 | B |