9313400

Nelson City Council

Geotechnical Assessment

Tahunanui Slump

Nelson

October 1995

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Nelson City Council

Geotechnical Assessment
Tahunanui Slump, Nelson

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Tahunanui Slump
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1.0 Project Brief

Soils & Foundations were asked by the Nelson City Council (NCC) to review two areas, comprising the Tahunanui Slump and the Grampian Foothills, within 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 . The purpose of our review was to permit management options for the areas to be considered. In this report we consider only the *Tahunanui Slump* (see locality plan - Sheet 1), the area comprising the Grampian Foothills is described separately (Soils & Foundations 1995).

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We have reviewed existing information, both published and unpublished, on the Tahunanui hillside. However, there is a considerable amount of historical information that needs to be assessed. In addition we have examined stereo-pairs of aerial photographs held by DOSLI and Aerial Surveys Ltd. The former photographs comprise 1202/51-53 (1948) and 526 B/507 (1948) at approximate scales of 1:15 800, and 1:6360 respectively. Aerial Surveys photographs, 119594-6, 119598-9 and 113079-81 are respectively dated 5 February 1991 (1:2800) and 25 October 1989 (1:10000).

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, including weak rock underlying steep hillsides, have resulted in significant areas of slope failure. A number of these areas have a relatively long history of extensive, deep seated 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 known 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.

The two largest areas of unstable or potentially unstable developed urban land are:

- the western slopes of the Port Hills above Rocks Road in what is generally known as the Tahunanui Slump (see Site Vicinity map, Sheet 1); and
- the western slopes of the Grampians.

Within these areas requests for further development are likely, including the subdivision of sections and the construction of larger buildings for human occupation such as apartment blocks.

4.0 Tahunanui Slump

4.1 Definition

Between SH6 (Rocks Road/Annesbrook Drive) and Princes Drive on the western face of the Port Hills, the hillside has been involved in a very large complex, and deep seated, slope failure here referred to as the Tahunanui Landslide. The southern part of this landslide is now regarded as inactive, although there are relatively minor failures at periodic intervals. This part of the landslide is not considered further in this report but the northern part shows continuing movement, is relatively well defined and is here referred to as the Tahunanui Slump (see Site Vicinity map). The slump is divided into a number of secondary, active landslides, superimposed on which are a number of more superficial movements.

4.2 Geology

The western side of the Port Hills comprises a sequence of consolidated sandstone-mudstone beds of the Magazine Point Formation which is overlain by clay-bound Port Hills Gravel formation.

The Magazine Point Formation, of mid-Tertiary age, dips southeast at about 65-70° (measured below the horizontal) into the Port Hills. Contact between the Magazine Point Formation and the Port Hills Gravel dips 40° southeast and very approximately coincides with the 50 m contour. The gravel, of late Tertiary age, also dips parallel to this contact.

4.3 Development of the Tahunanui Slump

The Tahunanui Landslide has occurred along a surface or sole plane extending from sea level to the top of the Port Hills. This plane intersects at approximately right angles the contact between the Magazine Point and Port Hills Gravel formations. Movement of the material above the sole plane

has displaced both formations downslope and westward. Erosion by the sea has removed all of the displaced Magazine Point Formation so that within the boundaries of the landslide only Port Hills Gravel remains. The southern part of the landslide has apparently stabilised allowing coastal erosion to cut a seacliff at its toe. The age of the seacliff is not precisely known but is between 2000 years and 6000 years old. Therefore, the southern part of the landslide has been stable for a minimum of several thousand years.

In contrast the northern part of the landslide, the *Tahunanui Slump*, has remained active and the sea has been unable to cut a cliff at its toe. Removal of the toe of the slump continued until the construction of Rocks Road in the 1890s. The Tahunanui Slump shows typical youthful landslide features particularly rapid changes in slope, including reverse topography and well developed head scarps. The headscarp area is a conspicuous feature on which superficial failures are frequent following period of prolonged heavy rain as has occurred in the spring of 1995.

This instability of the hillside above Tahunanui has been recognised for over a hundred years. Significant movements within the Tahunanui Slump were recorded in the 1890s (at the time of construction of Rocks Road), 1929 and 1962. Both the 1929 and 1962 movements followed periods of heavy rain and earthquake ground shaking and there was serious damage to dwellings on the lower part of the slump.

Since 1962 the Nelson City Council has progressively installed a new stormwater system on the hillside and taken other measures to ensure that surface stormwater infiltration into the slump is minimised. Information on the stormwater system on the western side of the Port Hills, including the Tahunanui Slump, is recognised by the NCC as inadequate as stated in Condition 800 introduced in 1995.

Although no movement resulting in serious property damage has occurred since 1962, periodic (up to 10 yearly) monitoring surveys by Lands and Survey Department and its successor DOSLI, has shown that all of the Tahunanui Slump is continuing to settle towards Rocks Road. Movement has been documented at varying rates for different sections of the slump. Because of the location of the survey lines, and doubts about the reliability of some of the survey points, monitoring of the slump is possibly not as effective as it might be.

Nevertheless the DOSLI monitoring, documentation of past events (both historical and geological), shows that the failure of the Tahunanui hillside is complex and has occurred over a period of many thousands of years. The failure can be divided into the following:

Order of Magnitude	Description	Comment
1°	Tahunanui Landslide	Southern part is stable and is not considered further in this report.
2°	*Tahunanui Slump*	The active northern part of the Tahunanui landslide and is the subject of this report. The slump, involving an area of 26 ha, extents from sea level to a 75 m high headscarp bounding the crest of the Port Hills.
3°	Subsidiary Slumps	Within the Tahunanui Slump there are up to 6 subsidiary slumps each with well defined headscarps and reverse topography.
4°	Less well defined movements within the subsidiary slumps	Areas of 1-2 ha, particularly on the lower part of the hillside. Not as deepseated as the subsidiary slumps.
5°	Superficial failures	Minor failures up to several metres in depth and typical of what may occur on any hillside.

4.4 Cause of the Tahunanui Slump

Although coastal erosion has played a major role in the continued movement of the Tahunanui Slump it appears unlikely that it was the cause of the wider Tahunanui Landslide. Both the Magazine Point Formation and Port Hills Gravel have a high natural stability. Slopes underlain by these units have been extensively eroded during the development of the seacliffs adjacent to Nelson Haven and the Waimea Inlet and, with the exception of the Tahunanui area, have not failed. In addition at Tahunanui, both formations dip into the hillside so that there are no obvious planes on which a slope failure of this size could occur.

A possible cause of the failure is severe ground shaking resulting from an earthquake centred in the Nelson area many thousands of years ago. The earthquake may have originated on one of the active faults of the Waimea-Flaxmore Fault System that extends northeast through Nelson City.

4.5 Boundaries of the Tahunanui Slump

The boundaries of the slump are shown on the Site Plan (Sheet 2). Because the boundary between the slump and *in situ* material is commonly obscured the position is only approximately shown and to an accuracy no greater than ± 20 metres. The imprecision in locating the boundaries of the slump is not critical in that the area peripheral to it has, for example by surface and groundwater flows, an influence on the slump. Where this peripheral zone to the slump is wide it is shown on the Site Plan - Sheet 2.

5.0 Current Situation

Two factors concerning the Tahunanui Slump are historically recognised:

i) *The slump is extensively built on and is regarded, despite its past history of movements, as a desirable residential area.*

Reasons for this are its northwesterly aspect with spectacular views over Tahunanui Beach and Tasman Bay and, ironically, the varied slump topography that has resulted in areas of gently sloping ground on what otherwise would have been a moderately steep hillside.

ii) *The Tahunanui Slump is still active and has yet to reach stability.*

Although no dramatically obvious movement has occurred since 1962, surveys and other evidence clearly confirm that all of the slump is active, albeit at different rates in different areas. While no damage similar to that of the 1890s, 1929 or 1962 has occurred over the past 33 years such movements cannot be precluded in the future. Indeed, the historical evidence, admittedly over a relatively short time span, indicates that significant movement could be expected approximately every 30 years. However, not too much weight should be placed on this inference as the 1929 and 1962 events may have been partly initiated by ground shaking of water saturated ground.

Since 1962 the amount of water infiltrating into the slump has been reduced although it cannot be completely eliminated. Also the effectiveness of the stormwater system in dewatering the slump has not been determined. It is possible that the amount of water diverted into the stormwater system may not be particularly large in relation to the total volume of groundwater affecting the slump. However, there is probably little doubt that the stormwater system has been effective in drying out the surface of the slump and perhaps reducing the incidence of relatively shallow failures.

It also seems likely that the 1890s, 1929 and 1962 events were relatively shallow failures superimposed on the more slowly moving Tahunanui Slump. In other words it appears unlikely that the ground involved in these movements did not extend down to the sole plane of the slump even though movement, at slow rate, was probably occurring on this plane and on the planes of the subsidiary slumps.

It is also clear that the lower slopes abutting Rocks Road were known to be unstable prior to subdivision. With regard to the upper slopes it is not so obvious whether they were recognised as being the result of active slope movement at the time of subdivision for housing although Professor Patrick Marshall of Otago University, who reported on the hillside in 1939, identified the slump.

6.0 Management of the Tahunanui Slump

6.1 Possible Options

If the Tahunanui Slump was being considered for housing today it is clear that subdivision of its lower part would not have proceeded and it is also very doubtful if the upper slopes would have been subdivided for permanent dwellings. Instead it is possible that parts of the slump may have been utilised in other ways, such as for caravan parks, with large areas being left undeveloped or planted in trees. However, in examining possible options for the future use of the slump it has to be recognised that only in a few areas, notably its lower slopes, has relatively extensive destructive damage occurred. In the remaining areas of the slump there has been relatively slow movement that commonly manifests itself by cracking, settling and/or rotation of the ground surface. While this less dramatic movement has affected some properties, it could probably in many, but certainly not all of these areas, be accommodated by suitably constructed dwellings.

The various options for the future use of the slump we have identified are:

i) return the area to a state approximately that prior to residential development,

ii) allow development to continue with urban infilling by section subdivision and possibly the construction of high occupancy buildings such as apartment blocks and hotels, or

iii) maintain the area approximately as it is today.

These options are discussed below:

6.1.1 Return the area to a non-urban state.

This could be achieved in two ways. One is for the city to purchase the properties as they become available on the market or to zone the area so that rebuilding of existing dwellings would not be permitted. The first could be accomplished in a relatively short period of time but the latter would take a considerable length of time to achieve.

In order to implement this option considerable consultation would be needed, requiring fully documented reasons for such a change in land use. From the relatively limited geotechnical data available it would be difficult to justify this option. The areas where extensive damage have occurred in the 1890s, 1929 and 1962 primarily involve the lower slopes of the Tahunanui Slump and do not appear to have extended down to the sole plane of the slump. There may also have been other factors involved.

In the 1890s the erosion and the construction of Rocks Road had undermined the toe of the slopes that failed. Construction of Rocks Road has now reduced, but not necessarily eliminated, the risk of

future movement of this type. With regard to the 1929 and 1962 movements ground shaking was a further factor although how much this contributed to the movement has not been fully determined.

During construction of Moana Avenue and possible other roading, it appears that large quantities of fill were generated and that some of this fill may have been placed in inappropriate locations resulting in overloading of parts of the lower slopes of the slump, including possibly the areas that failed in 1962. A specific assessment of the contribution unengineered roading fill failure played in past damage on the slump has not yet been fully evaluated or documented. A factor which contributed to the failures in the 1890s, 1929 and 1962 was abnormally high periods of rainfall. Since 1962 drainage and other measures initiated by the council has reduced infiltration and the impact of this has not been quantitatively determined.

Assessment of remedial measures requires monitoring and only a very limited monitoring programme has been in place since 1962, and to a limited degree before this following the installation of trig stations and survey standards. Because the existing monitoring involves some survey points that are inappropriately located and/or whose reliability may be suspect, its effectiveness to document movement not only of the slump as a whole but also within its individual components, needs to be assessed. Until sufficient results from a meaningful monitoring system are obtained, along with an evaluation of the various historical failures is completed, then it would be difficult for the Council to promote the option that the Tahunanui Slump should be cleared of dwellings.

6.1.2 Allow Additional Developments

In view of the history of the Tahunanui Slump, and that the location and rate of future movements within it cannot as yet be quantified with any degree of certainty, it would be difficult on geotechnical grounds for the Council to justify any decision to allow further subdivision or the construction of buildings such as apartment blocks or hotels (Building Act, Section 36 (2)). Just as for option 6.1.1, for this option to be considered further the council must have greater documentation of the slump and therefore be in a better position than it is now to predict future movement within it.

6.1.3 Maintain the Area at its Existing Residential Status

This option would result in the Tahunanui Slump remaining as a relatively low density residential area, containing approximately 120 dwellings, in which no further subdivisions would normally be allowed and that dwellings would be of a size and construction so as to accommodate as best as possible the geotechnical conditions that exist. Such a policy could allow rebuilding on existing sections, subject to a specific geotechnical assessment of the site and the type of residential building proposed.

While this option could be described as maintaining the status quo this is not correct. For the council still needs to more fully understand the types of movements that have occurred in the past

and to have sufficient information to assess what is likely to occur in the future under various scenarios involving such factors as rainfall and earthquake ground shaking. In this regard it is doubtful if the current information is adequate or that there is in place an appropriate monitoring programme for the slump. The cost of obtaining this information and installing an appropriate monitoring programme is infinitesimal compared to the value of the improvements, such as dwellings, roads, drains etc, currently existing on the slump.

7.0 Conclusions

The Tahunanui Slump is an active feature that has yet to reach stability. It therefore presents a hazard to any structures built on it and there is a possibility that parts of it could be a danger to life. Its status needs to be specifically recognised by the Nelson City Council.

Given the limited, but still significant, information on the active Tahunanui Slump we suggest designation of the area as a "Geotechnical Special Studies Zone" with associated recognition and special planning designations to reflect its unique geohazard standing.

This philosophy has been used successfully in the state of California, USA Alquist-Prioto Studies Zone Act.

8.0 Recommendations

8.1 For Immediate consideration

8.1.1 That the Tahunanui Slump and its principal area (see Site Plan - Sheet 2) be made a special studies zone.

8.2 Future work

As discussed above, a principle finding of this review of the Tahunanui Slump in that insufficient data collection and interpretation has been completed to date. It is likely that following an assessment and interpretation of what data is known to exist, recommendations for further study will be forthcoming. In our opinion further work is critical to the development of an accurate and complete picture of the Tahunanui Slump area and includes the following:

- Review of NCC files of council documented damage following the 1929 and 1962 movements.
- Review of NCC files for reports prepared by others on damage in those events (several of these are listed in the "References" section of this report)

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

- Review of historic aerial (stereo and non-stereo) and ground photographs of the area. A summary of historic photos on file with Aerial Surveys Ltd has been obtained. Others no doubt exist at the Nelson Provincial Museum and elsewhere.

- Additional field reconnaissance mapping of current ground features existing in the study area and compilation on an appropriately scaled map (ie 1:1500).

- Review of existing survey data available from DOSLI and early trig station data where it exists and determine if and how monitoring of the Tahunanui Slump could be improved.

- Pin-pointed review of Nelson Evening Mail and other articles generated immediately following the 1890's, 1929 and 1962 events. This may include review of archival data held at the Nelson Provincial Museum

- Compilation of historic ground features documented by previous investigators on an appropriately scaled map or photograph

- Limited interviews with people remembering the events of 1962

- Determine what parts of the slump were involved in the significant events of the 1890s, 1929 and 1962. This would include both the area and the depth of material involved (ie) whether the events were directly attributable to movement of the whole Tahunanui Slump (2°), a subsidiary slump (3°) or more superficial movement (4°) above the sole plane of the slump or subsidiary slumps.

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

- Others as appropriate.

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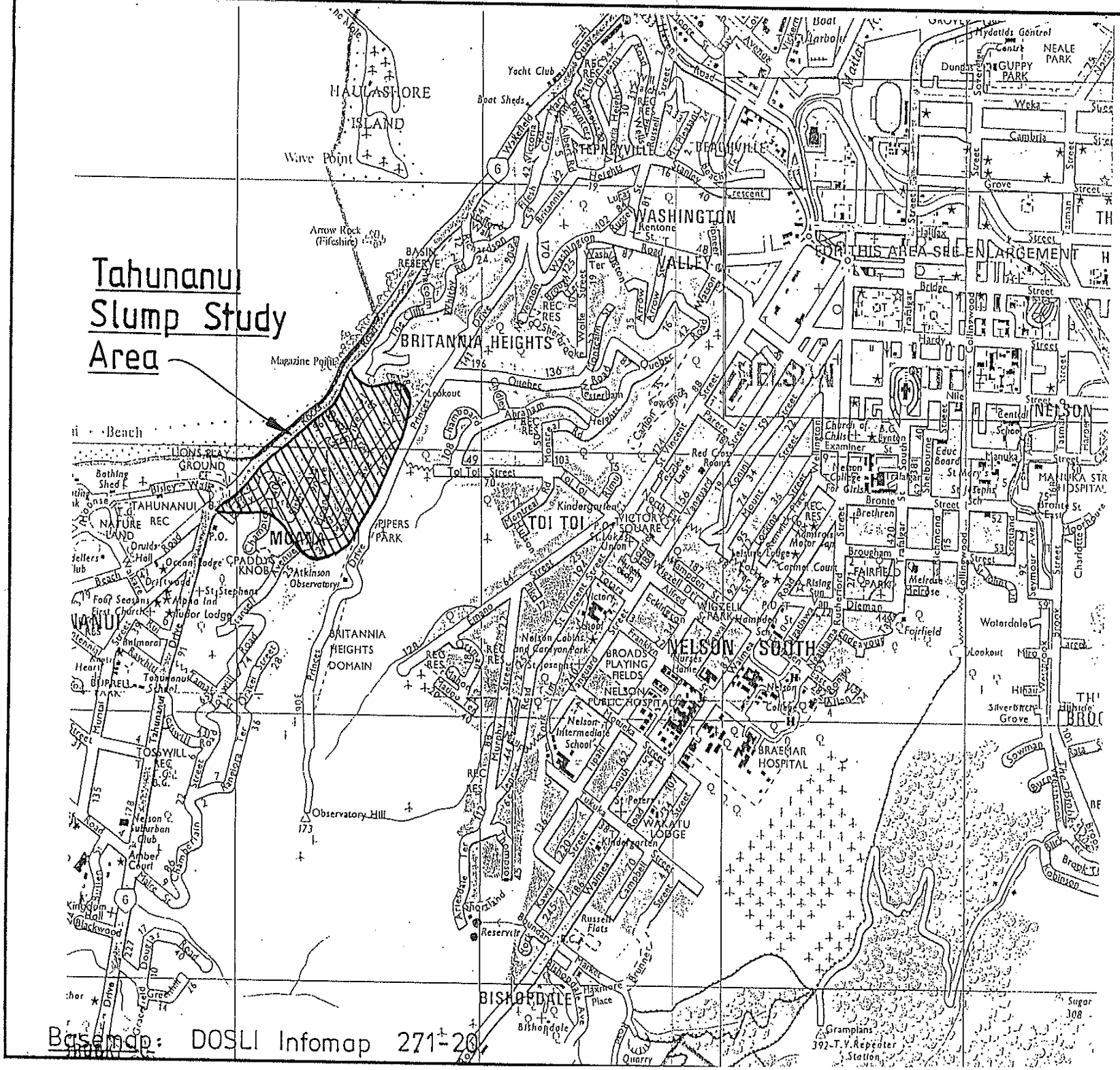

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NELSON CITY COUNCIL

TAHUNANUI STUDY AREA

Site Vicinity Ma

SOILS & FOUNDATIONS

Geotechnical Consulting Engineers Geologists

Status Stamp: DRAFT

Date Stamp: October 1995

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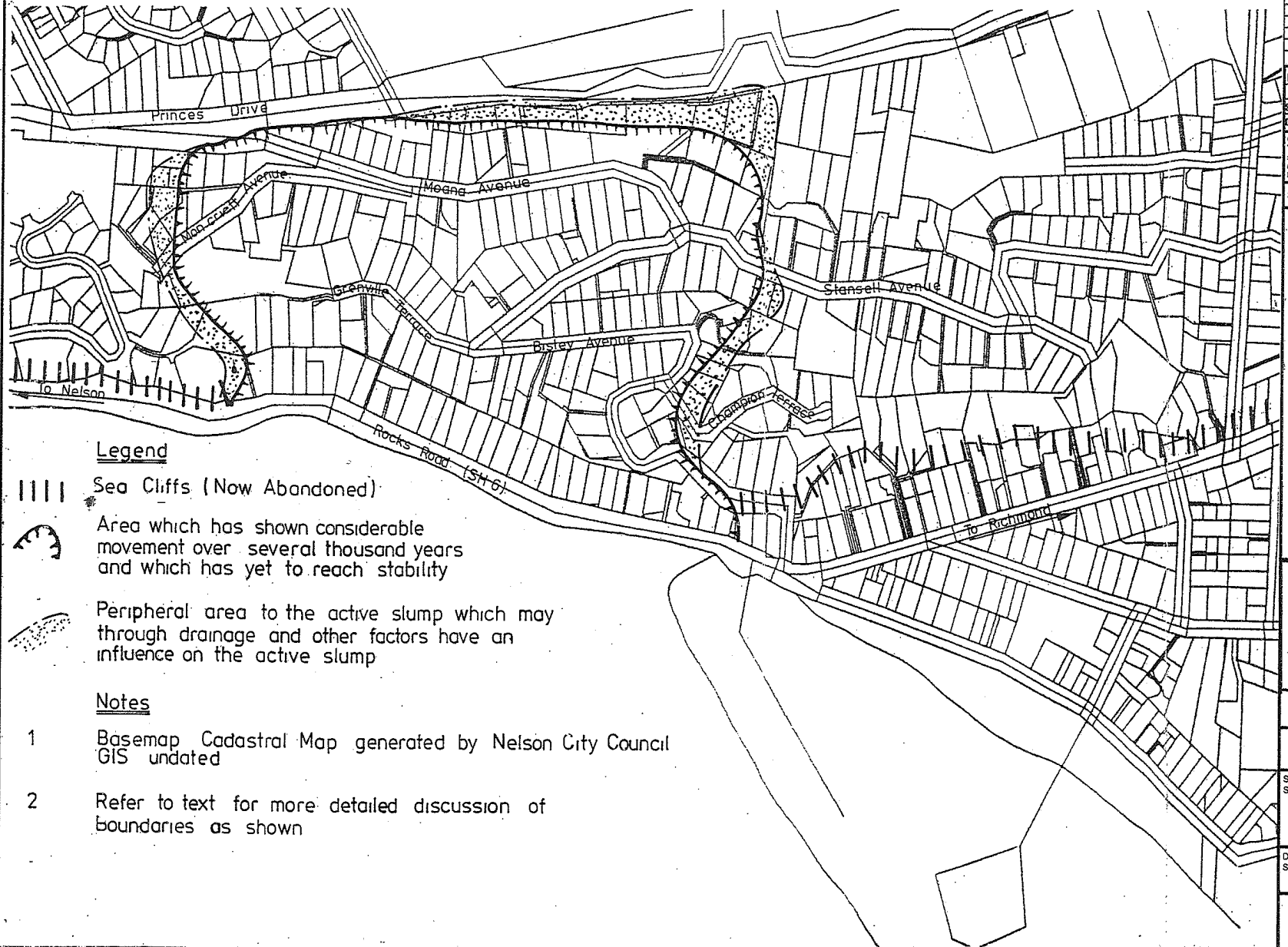
NORTH

Limitations

Boundaries shown on the map 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 October 1989 This map is not suitable for individual building site assessment engineering projects or other similar work where site specific investigations are necessary

0 50 100 200 metres

APPROXIMATE SCALE



Legend

Sea Cliffs (Now Abandoned)

Area which has shown considerable movement over several thousand years and which has yet to reach stability

Peripheral area to the active slump which may through drainage and other factors have an influence on the active slump

Notes

1 Basemap Cadastral Map generated by Nelson City Council GIS undated

2 Refer to text for more detailed discussion of boundaries as shown

No	AMENDMENTS	Date	Initial
A	Updated Preliminary Draft Released to NCC (25 September 1995)	10/95	KB

FIELDBOOK	Initials	Date		Initials	Date
			DR.	KB	10/95
SURV.			CH.	PCD	10/95
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TAHUNANUI SLUMP STUDY AREA

SITE PLAN

SOILS & FOUNDATIONS
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Geologists

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