WORLEY CONSULTANTS LIMITED

CONSULTING ENGINEERS, SURVEYORS, GEOLOGISTS & PLANNERS

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Our Ref: 8-900-63

Please reply to:
Date: January 1985

S1

D.M. MacKENZIE, SHERIFF PLACE, HAMILTON

REPORT ON LAND STABILITY OF LOTS 1 to 9

OF PROPOSED SUBDIVISION OF PTS LOTS 1 & 6

DP14466 and LOT 1 DPS 19850

D.M. MacKENZIE SUBDIVISION

SHERIFF PLACE, HAMILTON

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D.M. MacKENZIE SUBDIVISION

SHERIFF PLACE, HAMILTON

REPORT ON LAND STABILITY OF LOTS 1 to 9

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DP 14466 AND LOT 1 DPS 19850

1. INTRODUCTION

Worley Consultants Ltd were engaged by Mr D.M. MacKenzie (ref. letter of 23 August 1984) to investigate and report on the land stability of Lots 1 to 9 of this proposed subdivision, with respect to residential development.

The propsed subdivision scheme plan F1381 dated August 1984 as prepared by Thomson and Farrer is reproduced in this report as Figure 1. It shows the location of cross-sections C & D, being slope profiles surveyed by Thomson & Farrer on Lots 7 & 9. These profiles are reproduced on Figures 2 and 3 respectively.

This report presents the findings of the investigations and makes recommendations for the satisfactory development of these Lots.

2. SITE DESCRIPTION

The area of land investigated forms part of a set of terraces formed by the Waikato River down-cutting through sedimentary deposits. Lots 1, 2, 3 and 4 are part of an essentially flat or gently graded terrace area, while the remainder of the lots comprise both parts of the flat terrace area and also of a 10 m high southerly facing slope with an average gradient in the range of 30° to 35°. It is this slope that this report addresses in particular.

3. SCOPE OF INVESTIGATIONS

The field work comprised the drilling of 3 boreholes by hand auger, one each at the top, the middle and the bottom of the slope on Lot 9 and located on cross-section D, as shown on Figure 1. A Scala penetrometer test was carried out adjacent to each borehole and also at positions 4,5 & 6 as shown on Figure 1.

In the office, a study was made of previous investigation data in the area (ref. Worley Report no. 006184 dated February 1983), particularly the data related to cross-section C, located on Lot 7, as shown on Figure 1. Soil parameters from this previous work, plus soil parameters back-analysed from the slope profile of cross-section D were used in stability analyses of the slope.

4. RESULTS

4.1 Subsurface Conditions

The borelogs are presented in Appendix I and the Scala results in Appendix II.

The soils beneath the slope on Lot 9 are predominantly sands, varying in grading from silty through to coarse, with some gravel in places. For the top 1 m to 2.5 m the sands are loose, but below these depths the soils are medium dense to dense. It was considered that the moist nature of the near surface soils on the slope was due in part to the discharge in this area of septic tank effluent from the adjacent residence. Groundwater was encountered only in borehole 3, at a depth of 1.2 m.

4.2 Slope Stability

No evidence of recent instability was observed at or adjacent to the site.

The stability of cross-section C was analysed in the previous investigations (ref. Worley Report No. 006184 dated February 1983), using the Bishop Modified Method. Figure 2 of this present report is reproduced from the previous work and shows the assumed distribution of soils in terms of strength parameters as derived from the investigation data, and also the three trial circular failure arcs analysed (nos. 8,9 & 10). The calculated factors of safety under static loading conditions are 1.46, 1.33 and 1.66 for arc nos. 8,9 & 10 respectively.

The stability of cross-section D has now been analysed on the same basis as for cross-section C. The same distribution of soil strengths as for cross-section C has been used and three trial circular failure arcs analysed are presented on Figure 3. The calcuated factors of safety under static loading conditions are 1.22, 1.44 and 1.65 for arc nos. 11, 12 & 13 respectively.

However, on the basis of the existing stability of cross-section D, higher soil strength parameters are justified. The steep portion of the slope profile is shown to have a fairly constant gradient of 32.5°, and assuming that this slope has only marginal stability (say, a factor of safety of 1.05) and that the soils have zero cohesion, the "back-analysis" of this slope yields an average soil parameter of angle of internal friction $\emptyset' = 34^{\circ}$. Analysis of arc nos. 11, 12 & 13 using $\emptyset' = 34^{\circ}$ gives the increased factors of safety of 1.47, 1.68 and 1.95 respectively.

For residential developments it is considered that a minimum factor of safety against shear failure of a slope should be 1.5, under static loading conditions. Cross-sections C & D do not meet this criterion, although for cross-section D analysed using the back-analysed parameter, the factor of safety for arc no. 11 is only slightly less than this criterion, while the minimum requirement is exceeded for arc nos 12 & 13. Notwithstanding this, it is clear that some remedial work to the slope is required to achieve adequate stability.

The stability of both cross-sections was re-analysed assuming that the slope face has been re-graded (flattened) to a constant angle of 25° and using soil strength parameters of cohesion C' = 0 kPa and Ø' = 34°. In addition to the static analysis, a pseudo-static seismic analysis was carried out to give an indication of the safety of the slope under earthquake loadings with a horizontal ground acceleration of 0.125g. The factors of safety for the re-graded slope profile are:

Cross-section	Arc No.	Factor of Safety (Static)	Factor of Safety (Seismic)
C	8	2.14	1.52
C	9	2.08	1.45
C	10	2.23	1.59
D	11	1.88	1.34
D	12	1.79	1.30
D	13	1.89	1.36

The usually accepted minimum factor of safety for residential developments is 1.25, under seismic loading conditions.

In addition to the circular failure analyses, planar (wedge) failures through the toe of the re-cut slope were analysed and found to have factors of safety in excess of 1.5.

It is recognised that the circular failure analysis may not have located the trial failure surface with the minimum factor of safety (ie the critical surface). However, we consider that the surfaces chosen for analysis are representative of the types of failure which might occur in this situation, and the margin of safety in adopting the minimum factor of safety of 1.5 is adequate to allow for any unfavourable ground conditions not identified during the investigations. In our opinion, the slope profile re-cut to 25° through the toe of the slope, will have adequate stability for residential development.

5. RECOMMENDATIONS FOR DEVELOPMENT

The following recommendations are made for the satisfactory development of this proposed subdivision, from a land stability standpoint:

5.1 Earthworks

Where the existing slopes on Lots 5,6,7,8, and 9 are steeper than 25°, earthworks shall be undertaken to create a planar slope surface at a maximum angle of 25° to the horizontal, through the toe of the slope. For Lots 5,6,7 and 8, the proximity of an accessway to the toe of the slope dictates that the 25° slope will have to be formed entirely by excavation (probably cut to waste),

although the contour information provided for Lot 8 indicates that the existing slope is approximately 25° at the centre of this lot and therefore only minor excavation would be required at this point. For Lot 9 however, there are no such restrictions at the toe of the slope and in order to maximise the area of flat land on this lot, it would be possible to regrade the slope by both excavation at the head of the slope and filling at the toe of the slope, ie over part of Lot 19 of the adjacent subdivision. Any such filling shall be constructed in accordance with NZS 4431 : 1978, "Code of Practice for Earthfill for Residential Development". For ease of construction and also for maximum benefit to Lot 19, the surface of the filled area shall be no steeper than 18° (1 vertical to 3 horizontal). The foundation for the fill shall be excavated to horizontal benches and a subsoil drain (eg Novaflo or similar surrounded in drainage aggregate) connecting into the stormwater system, shall be provided at the back of at least two of the benches. A diagrammatic cross-section of the earthworks proposed for Lot 9 is shown on Figure 4.

To prevent stormwater runoff from eroding and rilling the regraded slope face, a strong grass cover shall be established as soon as possible. Some damage to the slope face is inevitable while the grass cover is being established and maintenance of any damage should be allowed for in the earthworks contract. The extent of damage could be reduced by constructing a temporary cut-off drain along the top of the batter so that run-off from the sloping ground behind the slope is prevented from running down the slope.

5.2 Household Effluent Disposal

Household effluent shall be disposed of into the sewerage reticulation system provided. Disposal to soakpits or soakage fields is not acceptable. The present means of disposal of septic tank effluent from the existing MacKenzie residence to the east of the proposed subdivision is not acceptable and this residence shall also be connected to the reticulation system to be provided. This shall be undertaken before earthworks on Lot 9 commence.

5.3 Stormwater Disposal

Stormwater from roofs and paved areas from all nine lots on the proposed subdivision as well as the existing MacKenzie residence shall be collected and piped into the reticulation system provided. Disposal into the ground via soakpits or soakage fields is not acceptable.

5.4 Foundation Conditions

In view of loose or soft ground conditions encountered at shallow depths (as indicated by the Scala penetrometer test results), foundations for all buildings to be constructed at this site shall be designed by a Registered Civil Engineer.

6. CONCLUSIONS

Provided that the recommendations outlined in section 5 above are carried out, we consider that the subdivision has adequate long term stability for residential development.

7. LIMITATION

Recommendations and opinions contained in this report are based on data from this present investigation and from the previous investigation undertaken for the adjacent subdivision. In our opinion, the scope of investigation undertaken was sufficient to give subsurface data which are representative of the site and inferences regarding the nature and continuity of ground conditions away from borehole locations are made on this basis.

This report has been prepared for the particular project described in the brief to us and for the use of the Hamilton City Council. We accept no responsibility for the use of any part of this report in other contexts or for other sites, or for any other purpose.

Worley Consultants Limited
Tauranga

APPENDIX 1 : BORELOGS

HAND AUGER LOG

WORLEY CONSULTANTS LTD
PO BOX 524 TAURANGA

CLIENT D.M. MacKenzie — BOREHOLE N° 1 (Top of Slope) — JOB N° 8-900-63

PROJECT Stability Investigation — DATE 12-9-84 — SHEET 1 of 1

LOCATION MacKenzie Subdivision, Sheriff Place, Hamilton — HOLE DEPTH (m) 4

TECHNICIAN C. Nichols

DEPTH (m)	WATER LEVEL	GRAPHIC LOG	VANE SHEAR STRENGTH kPa	SAMPLE N°	SCALA PENETROMETER	SOIL DESCRIPTION
0						Topsoil
0.5						Light brown SILTY fine SAND, moist; soft; slightly plastic - becomes yellowish brown
1.0						
1.5						Greyish brown medium to coarse sand with some fine, rounded gravel, loose to medium dense; moist
2.0						
2.5						
3.0						- light grey fine to medium sand, medium dense; moist
3.5						Greyish brown GRAVELLY SAND, dense; moist

REMARKS

Scala results are number of blows per 300 mm penetration.

GROUND WATER was not encountered /
~~was encountered at a depth of~~

DRILLING METHOD: 50 mm ϕ hand auger.

HAND AUGER LOG

WORLEY CONSULTANTS LTD
PO BOX 524 TAURANGA

CLIENT D.M. MacKenzie BOREHOLE Nº 2 (Mid slope) JOB Nº 8-900-63

PROJECT Stability Investigation MacKenzie Subdivision, Sheriff Place, Hamilton DATE 12-9-84 SHEET 1 of 1

LOCATION HOLE DEPTH (m) 4

TECHNICIAN C. Nichols

DEPTH (m)	WATER LEVEL	GRAPHIC LOG	VANE SHEAR STRENGTH kPa	SAMPLE Nº	SCALA PENETROMETER	SOIL DESCRIPTION
0						Topsoil
						Light brown fine to medium SAND, rare fine gravel; loose; moist
0.5						- light greyish brown
1.0						50 mm laminae orange brown pumiceous medium to coarse SAND
1.5						light greyish brown medium to coarse SAND, loose; moist
2.0						
2.5						
3.0						as above, but becomes medium dense to dense
3.5						

REMARKS

Scala results are number of blows per 300 mm penetration.

GROUND WATER was not encountered

DRILLING METHOD : 50 mm ϕ hand auger.

HAND AUGER LOG

WORLEY CONSULTANTS LTD
PO BOX 524 TAURANGA

CLIENT D.M. MacKenzie BOREHOLE N° 3. bott. of slope JOB N° 8-900-63

PROJECT Stability Investigation DATE 12-9-84 SHEET 1 of 1

LOCATION MacKenzie Subdivision, Sheriff Place, ~~Hamilton~~ HOLE DEPTH (m) 1.2

TECHNICIAN C. Nichols

DEPTH (m)	WATER LEVEL	GRAPHIC LOG	VANE SHEAR STRENGTH kPa	SAMPLE N°	SCALA PENETROMETER	SOIL DESCRIPTION
0						Topsoil - silty fine to medium SAND, soft; wet; moderately plastic
0.5						Orange brown medium to coarse pumiceous SAND with some fine pumiceous gravel, loose; wet
1.0	▽					
						End of Bore 1.2 m
1.5						
2.0						
2.5						
3.0						
3.5						

REMARKS

Scala results are number of blows per 300 mm penetration.
No sample recovery was possible blow the water table at 1.2m.

GROUND WATER ~~was xxxx xxxxxxxxxx~~ was encountered at a depth of 1.2 m

DRILLING METHOD : 100mm ϕ hand auger.

APPENDIX 11 : SCALA RESULTS

SCALA PENETROMETER TEST RESULTS

PROJECT TITLE Stability Investigation, MacKenzie Subdivision TECHNICIAN B. Anderson

CLIENT Thomson & Farrer

JOB N° 8-900-63 DATE 12-9-84

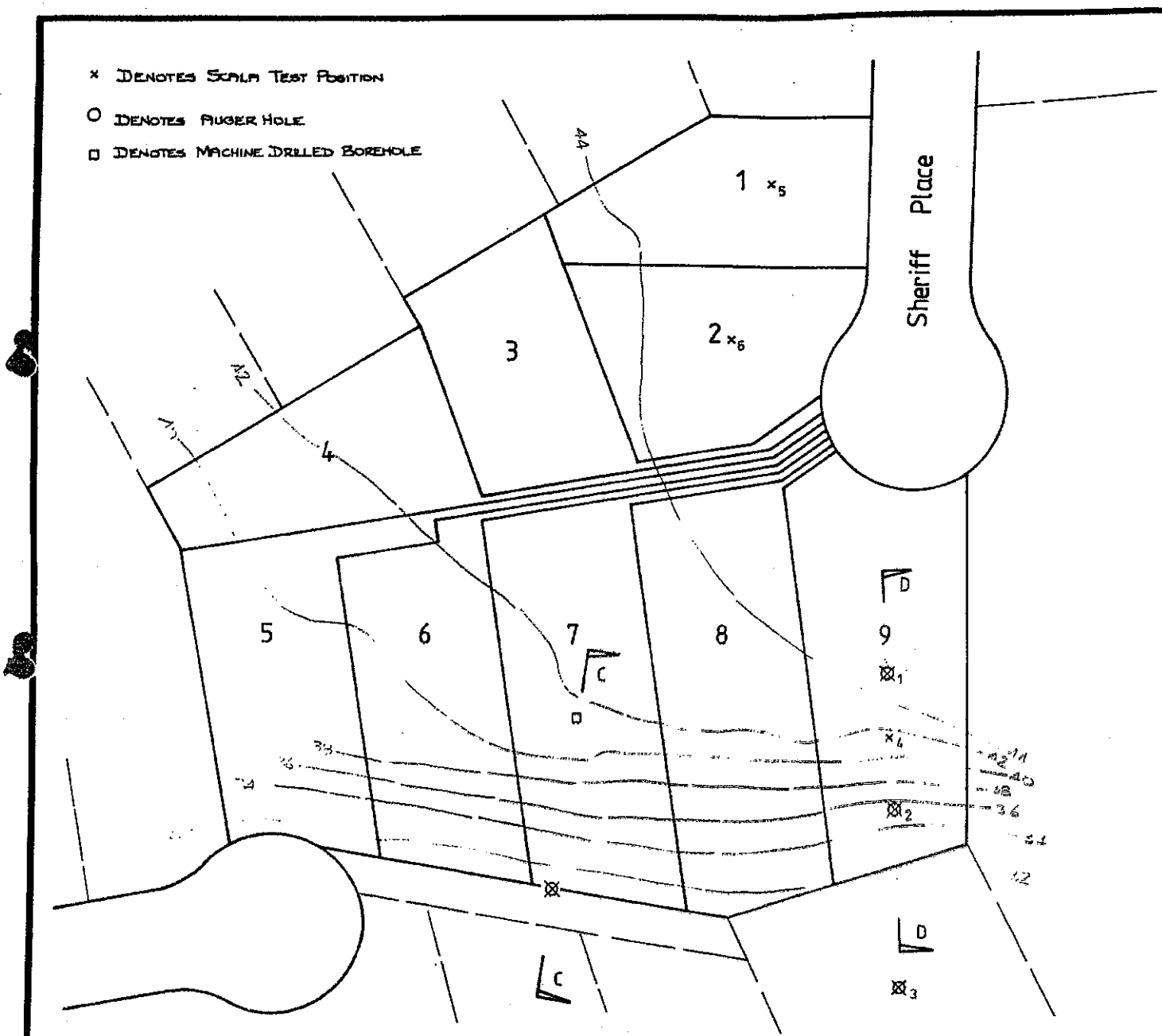
DEPTH (m) \ TEST	1	2	3	4	5	6
0·0 to 0·3	4	3	1	1	7	5
0·3 to 0·6	3	1	3	4	10	6
0·6 to 0·9	1	1	4	5	11	8
0·9 to 1·2	4	1	9	13	17	6
1·2 to 1·5	13	3	7	16	13	13
1·5 to 1·8	10	4	16	22	11	34
1·8 to 2·1	6	4	13	27	25	35
2·1 to 2·4	8	3	14	32	20	41
2·4 to 2·7	8	4	12	38	18	
2·7 to 3·0	12	9	12	52	15	
3·0 to 3·3	18	14	13		13	
3·3 to 3·6	17	17	17		15	
3·6 to 3·9	18	17	26			
3·9 to 4·2	20	13	41			
4·2 to 4·5	15	27	40			
4·5 to 4·8	23	27				
4·8 to 5·1	33	24				
5·1 to 5·4	26					

RESULTS ARE NUMBER OF BLOWS PER 300mm PENETRATION.

× DENOTES SCALA TEST POSITION

○ DENOTES AUGER HOLE

□ DENOTES MACHINE DRILLED BOREHOLE



NOTES

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REVISIONS

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THOMSON & FARRER

MacKENZIE SUBDIV'N

SHERIFF PLACE

HAMILTON

SHEET TITLE

STABILITY INVESTIGATION

SITE PLAN

FIGURE 1

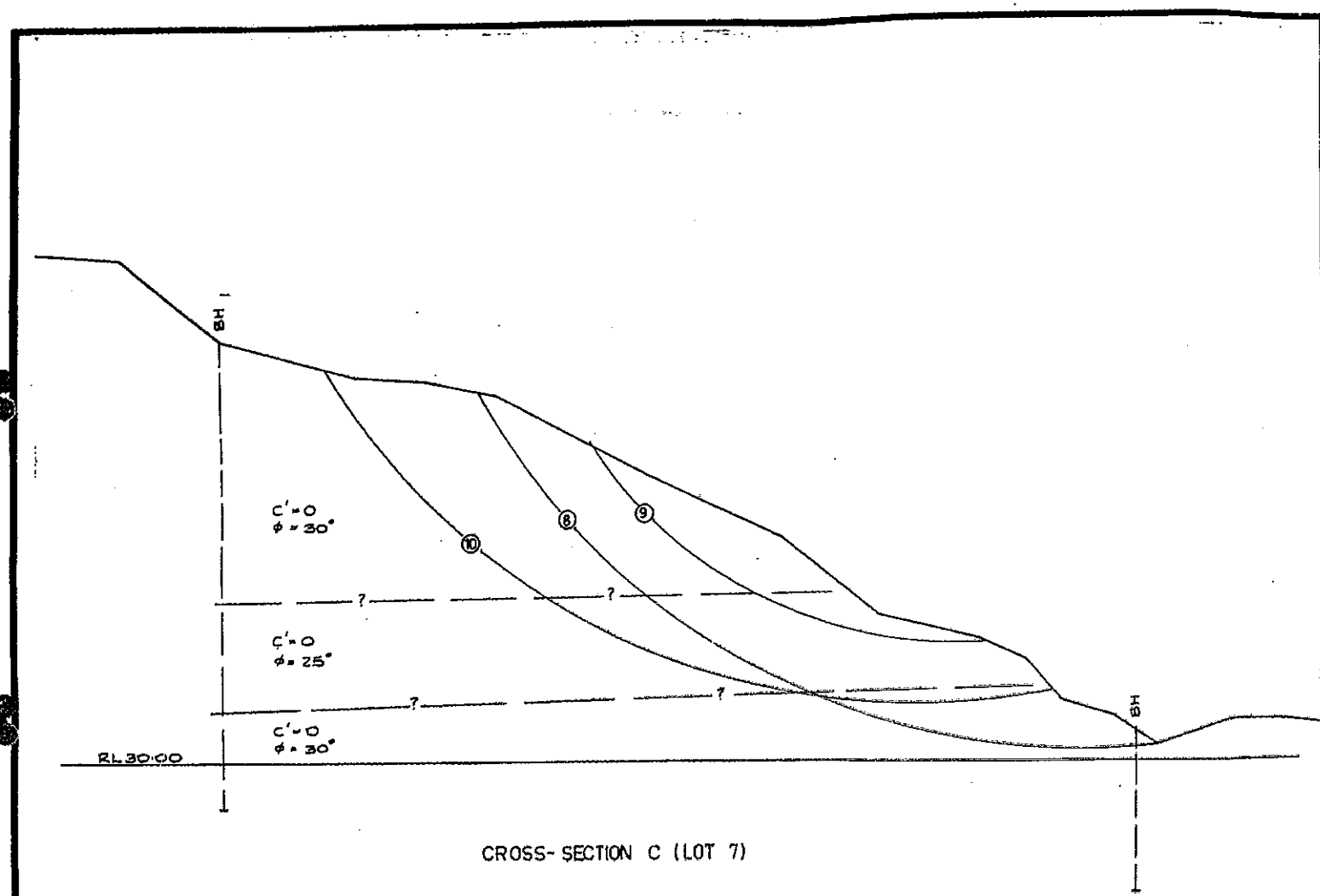
0 10 20 30 40 50 60

ORIGINAL SCALE 1:500

DRAWING NO.

8-900-63 | 1

JOB NO. | SHEET NO. | REV.



CROSS-SECTION C (LOT 7)

⑨ DENOTES TRIAL CIRCULAR FAILURE ARC N°

NOTES

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MacKENZIE SUBDIV'N
SHERIFF PLACE
HAMILTON

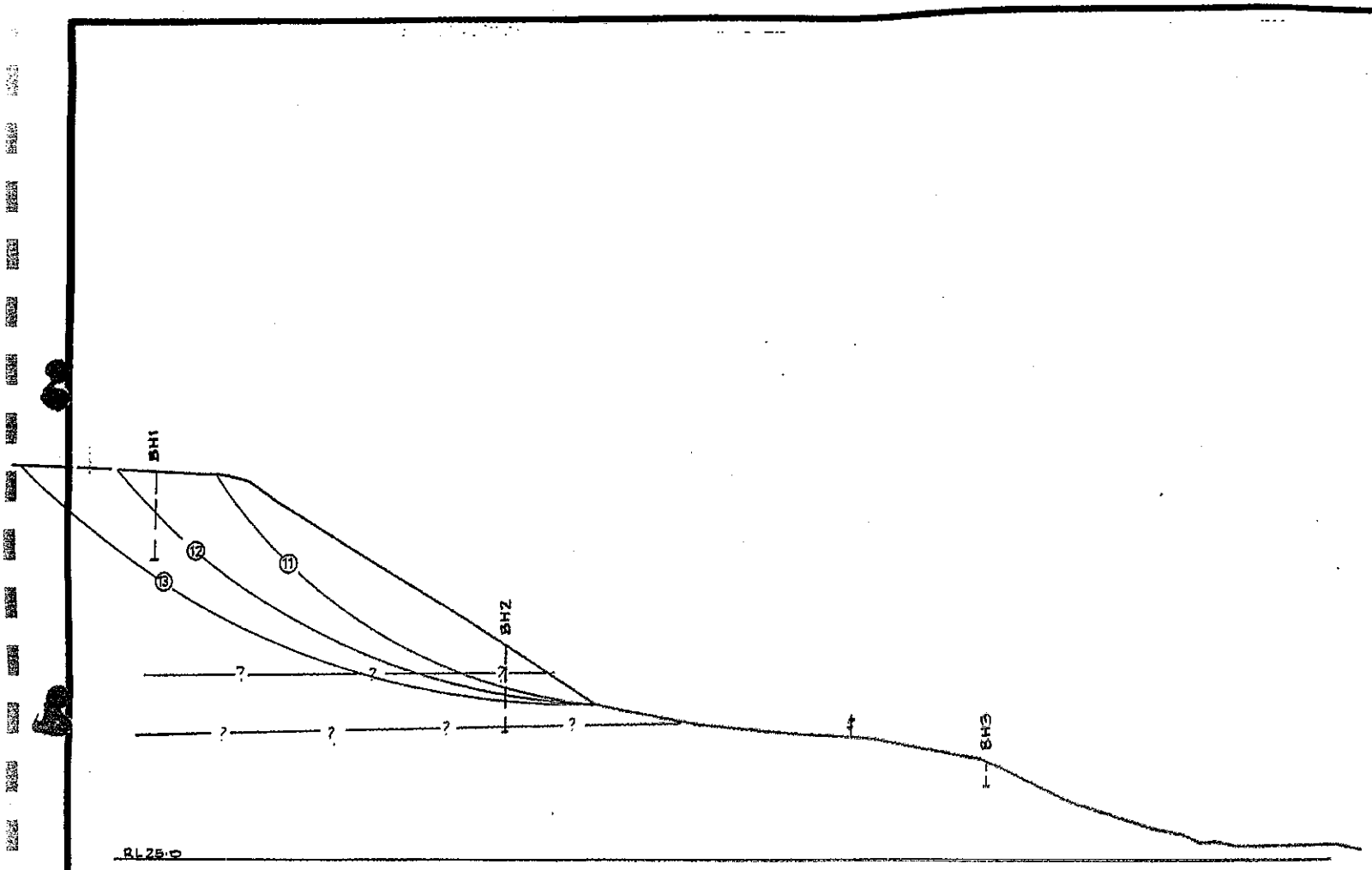
SHEET TITLE
LAND STABILITY
FIGURE 2

0 10 20 30 40 50 60

ORIGINAL SCALE 1:100

DRAWING NO.
8-900-63 (JOB NO.) | 2 (SHEET NO.) | REV.

27/4/98



CROSS-SECTION D (LOT 9)

⑫ DENOTES TRIAL CIRCULAR FAILURE ARC Nº

NOTES

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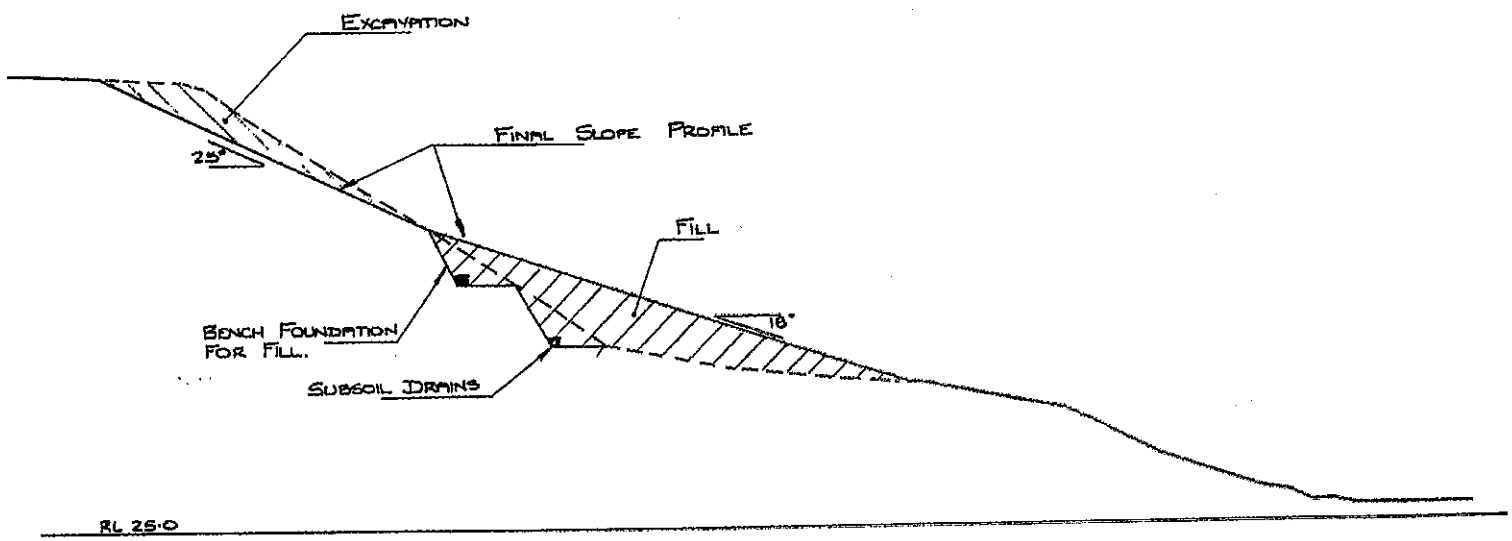
SHERIFF PLACE
HAMILTON

SHEET TITLE
LAND STABILITY
FIGURE 3

0 10 20 30 40 50 60
ORIGINAL SCALE 1:200

DRAWING NO.
8-900-63 | 3
JOB NO. | SHEET NO. | REV.



REGRADED (DIAGRAMMATIC) CROSS SECTION D (LOT 9)

NOTES

NO	DESCRIPTION	DATE	CH'KD

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THOMSON & FARRER
Mac KENZIE SUBDIV'N

SHERIFF PLACE
HAMILTON

SHEET TITLE
LAND STABILITY
FIGURE 4

0 10 20 30 40 50 60

ORIGINAL SCALE 1:200

DRAWING NO.
8-900-63 (JOB NO.) 4 (SHEET NO.) (REV.)

290/S17

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WORLEY CONSULTANTS LIMITED

15 Vialou Street, Hamilton. Telephone (071) 390-170. Telex NZ 63203 GILLMAN. Telefax: (071) 391-182.
Cables TAPENG. PO Box 1317, Hamilton New Zealand.

Please reply to: Mr R.B. Cotter

Our Ref : 50 282 02
RBC:CJW

25 August 1987

The City Engineer,
Hamilton City Council,
Private Bag,
HAMILTON

Dear Sir,

D.M. MacKENZIE SUBDIVISION - LOTS 5,6 & 7 DP 14466
SHERIFF PLACE / MALCOLM STREET, HAMILTON

Further to our report dated January 1985 we advise that we observed the above lots during construction and upon completion. Earthworks on these lots was regrading of the bank to ensure the planar slope surface is at a maximum angle of 25° to the horizontal (refer item 5.1 of our January 1985 Report).

We certify that this requirement has now been met.

Yours faithfully,
WORLEY CONSULTANTS LIMITED

R.B. COTTER

c.c.
Thomson and Farrer
P.O. Box 376
HAMILTON

Mrs Rietema RR

DE/A8E 290/S/17

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Cables TAPENG PO Box 1317, Hamilton New Zealand.

CITY ENGINEERS
27 AUG 1987
HAMILTON

Please reply to Mr R.B. Cotter

Our Ref :50 282 02
RBC:CJW

RECEIVED
27 AUG 1987
CITY

26 August 1987

The City Engineer,
Hamilton City Council,
Private Bag,
HAMILTON

Dear Sir,

D.M. MacKENZIE SUBDIVISION - LOT 5 DPS 19850 -
SHERIFF PLACE, HAMILTON

Further to our report dated January 1985 we advise that we observed earthworks on the above subdivision during the construction phase. We certify that no filling was done on Lot 5 DPS 19850 and therefore a soils report complying with Appendix B of NZS 4404:1981 is not applicable.

Yours faithfully,
WORLEY CONSULTANTS LIMITED

R.B. COTTER

c.c.
Thomson and Farrer,
P.O. Box 376,
HAMILTON (Attn : Mr R. Hewison)

Mr Pietema RR