

DEACONS, LAWYERS
LANDSLIDE ZONING, BALLAR CREEK,
MT ELIZA, VICTORIA

M4164/1-AV
11 July 2000

FILE COPY

Coffey 

M4164/1 - AV RW: RW
11 July 2000

DEACONS, LAWYERS
Level 24
385 Bourke Street
MELBOURNE, VIC., 3000

Attention: Mr Peter Barber

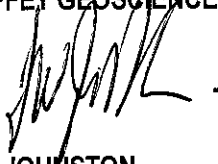
Dear Sir,

RE: **LANDSLIDE ZONING, BALLAR CREEK,
MT ELIZA, VICTORIA**

This letter presents our report on landslide zoning at Ballar Creek, Mt Eliza for use with the Mornington Peninsula Planning Scheme Amendment C17.

If you have any questions related to this report or if we can be of any further assistance, please do not hesitate to contact the undersigned.

For and on behalf of
COFFEY GEOSCIENCES PTY LTD



IAN JOHNSTON

Distribution: Original held by Coffey Geosciences Pty Ltd
 1 copy Coffey Geosciences Pty Ltd Library
 3 copies Deacons, Lawyers
 6 copies Mornington Peninsula Shire Council



16 Church Street Hawthorn
VIC 3122 Australia
PO Box 40 Kew
VIC 3101 Australia
Telephone +61 3 9853 3396
Facsimile +61 3 9853 0189
Email melb@coffey.com.au

TABLE OF CONTENTS

1. INTRODUCTION	1
1.1. Scope	1
1.2. Background	1
1.2.1. Creek Erosion and Recent Construction Works	1
1.2.2. Summary of Previous Landslide Studies	1
2. METHODOLOGY	2
3. STUDY AREA GEOLOGY	2
3.1. Geological Units	2
3.2. Geological Structure	3
3.3. Groundwater	3
4. SLOPE INSTABILITY	3
4.1. Identification of landslides	3
4.2. Landslide mechanisms at Ballar Creek	4
4.3. Past Slope Movements	4
4.4. Future Slope Movements and the Impacts of Placing the Engineered Fill	5
5. LANDSLIDE ZONING	5
5.1. Background	5
5.2. Adopted Landslide Zoning Scheme	5
5.3. Adopted Landslide Zone Categories	6
5.3.1. Zone I Areas	6
5.3.2. Zone II Areas	6
5.3.3. Zone III Areas	6
5.3.4. Zone IV Areas	6
5.4. Limitations of the Landslide Zoning System	7
5.4.1. Missed Landslides	7



5.4.2. Accuracy of Zone Boundaries	7
5.4.3. Existing Cuts and Fills	7
6. DEVELOPMENT CONTROLS	7
6.1. General Principles	7
6.2. Development Controls which Apply to Each Zone	8
6.2.1. Zone I	8
6.2.2. Zone II	8
6.2.3. Zone III and Zone IV	9
6.3. Site Specific Assessments	9
6.4. Some Further Discussion of Development Controls	10
6.4.1. Existing Developments	10
6.4.2. New Cuts and Fills	10
6.4.3. Water Disposal	10
6.4.4. Pipelines/Service Trenches	11
6.4.5. Precedence of Site Specific Studies over this Report	11
7. RECOMMENDATIONS FOR FUTURE WORK	11

REFERENCES

TABLES	1.	Large Landslides in the Study Area
	2.	Definitions of landslide Zone Categories.
FIGURES	1.	Engineering Geological Plan
	2.	Mechanisms of Slope Instability
	3.	Landslide Zone Plan
	4.	Good and Poor Hillside Construction Practices

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL REPORT

APPENDIX	A.	Observations of ground movement and structural distress.
-----------------	----	--





1. INTRODUCTION

1.1. Scope

This report describes the results of a study undertaken by Coffey Geosciences Pty Ltd (Coffey) for landslide zoning at Ballar Creek, Mt Eliza. This study was commissioned by Mr Paul Healy of the Mornington Peninsula Shire Council (MPSC) and follows acceptance of Coffey's proposal dated 23 September 1998 (References 1, 2, 3).

The purpose of this study is to:

- Prepare a landslide zoning map for the land bounded by Glen Shian Lane, Mt Eliza Way, Canadian Bay Road, and the foreshore of Port Philip Bay (see Figure 1). The area immediately adjacent to the foreshore of the bay was not included in this study.
- Prepare general recommendations on action required for development within each zone.

The zones and the development recommendations are to take into consideration the recent construction of the piped section of the creek and associated placement of engineered fill.

1.2. Background

1.2.1. Creek Erosion and Recent Construction Works

The site is a residential area comprising about 150 allotments. The area is about 300 metres wide and extends about 1.4 km from the Mt Eliza shopping centre to Port Philip Bay.

Ballar Creek, which extends along the length of the site, is a small incised stream with a low flow bed-width of only a few metres. The creek drops about 60 metres over its 1.4 km length and has a calculated peak discharge into the Bay of about 5 to 6 m³/sec in a 1 in 5 year storm (Reference 4).

The urbanisation of the catchment of the creek in the last 40 years has increased the peak creek flows which have caused significant bed and bank erosion. The bed of the creek has deepened in one location by about one metre in twenty years (Reference 5). This erosion has in turn exacerbated landsliding problems along the creek. The landsliding has been occurring in a variety of forms, and has impacted upon many properties. The impacts have been substantial enough to require the demolition of one house.

Recent construction work has been carried out to pipe the middle portion of the creek. The work also included the placement of additional engineered fill to minimum thicknesses of between 2.5 m and 4.5 m to provide stabilising berms for the slopes adjacent to the creek. This work was effectively completed at the commencement of this study.

1.2.2. Summary of Previous Landslide Studies

Technical reports on landsliding at Ballar Creek reviewed as part of this study have included:

- A 1977 soils test report prepared by A.S. James Pty Ltd (Reference 6).
- A 1983 report on Ballar Creek landsliding prepared by Golder Associates Pty Ltd for the then Frankston Sewerage Authority (Reference 5).

- A number of technical reports prepared for MMBW or their consultants as part of the initial design for the stormwater management scheme (References 4, 7, 8 and 9).
- A 1998 report on landsliding at Ballar Creek prepared by Coffey as part of the final design for the stormwater management scheme (Reference 10).

2. METHODOLOGY

This study has included:

- Four working days of fieldwork assessing the geological, engineering and geomorphic features of the area. These features were compared with the features noted in previous investigations and with the construction which had taken place. The results of the fieldwork are presented as an engineering geological map of the study area (see Figure 1).
- Reviewing, in the context of the recent earthworks, previous reports on landsliding in the Ballar Creek area and data from a damage audit which was undertaken as part of the construction works.
- Development of a landslide zoning scheme and development controls appropriate to the site conditions.
- Preparation of zone boundary plans.
- Reporting the results of the field and office studies, together with development controls for each zone.

3. STUDY AREA GEOLOGY

3.1. Geological Units

The geology of the study area has been mapped, and reported in some detail in References 8 and 9. Two geological units outcrop in the study area. These are:

Balcombe Clay which is referred to as the Fyansford Formation in some references. This unit outcrops in the base of the former creek bed and comprises a blue grey to grey, slightly micaceous, silty clay to clayey silt of medium to high plasticity. Reported liquid limits of samples collected from this unit vary between 50 and greater than 100. The Balcombe Clay has a consistency which is generally very stiff to hard and is often fissured. The distribution of the Balcombe Clay in the creek prior to the placement of the engineered fill is shown in Drawing No 1 of Reference 8. The distribution closely corresponds to the area of the creek now filled (see Figure 1).

The Balcombe Clay is unconformably overlain by:

Baxter Sandstone which outcrops (albeit poorly) in the upper parts of the creek banks and underlies the remainder of the study area. This unit comprises clayey sands and sandy clays with occasional gravel. It is often iron cemented, occasionally exhibiting rock-like strength. The Baxter Sandstone is commonly overlain by an upper soil horizon about 0.5m to 1m thick. This soil horizon varies from a clayey silt to silty sand to sand depending on the nature of the underlying parent Baxter Sandstone material.





3.2. Geological Structure

The dip on the Balcombe Clay is not known. No reliable in-situ bedding dips were recorded during the course of this study. Reference 8 records a bedding dip of 20° to the west at one location, but suggests it may be of limited reliability. This location may lie within one of the landslides identified during this study. Several relatively reliable bedding dips have been recorded in the Baxter Sandstone within the study area. These dips vary from sub-horizontal to very gentle (approx. 3°) to the west. The contact between the Balcombe Clay and the Baxter Sandstone is regionally known to be an unconformity¹ which dips gently to the west (Reference 11).

References 5 and 8 discuss the presence of a fault or down-warp zone crossing the study area. Reference 8 considers the feature to be a north-south aligned down-warp zone which crosses the creek in the vicinity of the southern end of Glen Shian Crescent. This down-warp zone influences the extent of Balcombe Clay outcrop in the creek, and thereby the extent of landsliding.

3.3. Groundwater

The standing water table measured by Piper (Reference 8) is typically at or close to the water level in the creek, and rises slightly away from the creek.

Several water seepage zones were located during the course of the study (see Figure 1). Some of these seepages lie well above the level of the standing watertable recorded by Piper. It is considered these seepage zones are where perched seasonal water tables exist close to the ground surface.

4. SLOPE INSTABILITY

4.1. Identification of landslides

The recognition, identification and delineation of landslides can be far from simple because of the many complex interactions between the materials and processes which cause them and the signs and indicators available for their detection. Regrettably, nature and man tend to obscure these clues over time to the extent that an experienced and trained eye is usually required to assimilate the generally sparse and apparently random evidence which is available for most landslides.

The methods used to construct a consolidated view of landsliding in a given region include a range of geological, environmental, human and temporal factors. The methods used in this study could be summarised as:

- Geomorphic evidence including irregular landforms, back-tilted slopes, hummocky ground, identifiable landslide scarps and cracks.
- Observable and reported ground movement and cracking, and distress and/or failures of structures such as pipes, buildings and road pavements as summarised in Appendix A.

¹ (An unconformity occurs when there is a time break between the deposition of strata and in this time break erosion and possibly some tilting of the beds occurs.)

- Groundwater seeps and wet ground.
- Vegetation evidence including bent, tilted and/ or dead trees which are commonly associated with slope movements and "water-loving" vegetation including ti-tree, onion weed, tree ferns and sedges.

It is important to note that the presence or otherwise of a landslide is rarely identified by only one of the above features particularly if relatively minor. It is usually a combination of factors which are required for recognition. Particular care must be exercised in the use of observed and reported (and often anecdotal) data such as presented in Appendix A, as there may be many possible reasons for the features recorded.

4.2. Landslide mechanisms at Ballar Creek

Three main mechanisms of slope instability have been identified along Ballar Creek (see Figure 2). These are:

1. Localised slab failures immediately adjacent to the creek. These failures typically involve small volumes of material (say $< 2 \text{ m}^3$).
2. Localised slumping of steep creek bank slopes. These failures typically involve small to moderate volumes of material (say 2 to 50 m^3).
3. Large landslides affecting several lots, the largest of which has a volume in the order of $70,000 \text{ m}^3$.

The localised slab and slumping failures, because of their limited extent, are reasonably simple to identify. Further, because of their localised nature, they generally have little influence on properties and structures more than a few metres from the creek. The large landslides, however, are different in that their influence can extend a considerable distance from the creek. Each of the large landslides has been named for convenience of reference. Table 1 summarises some basic information about the large landslides. The locations of the large landslides are shown in Figures 1 and 3.

4.3. Past Slope Movements

The large landslides are related to areas where the Balcombe Clay outcrops in the creek. The large landslides match the extent of the engineered fill (see Figure 1) and, as previously discussed, the distribution of the fill closely approximates the distribution of Balcombe Clay outcrops in the creek.

The Balcombe Clay is a plastic clay which exhibits considerable strength loss when disturbed. Through a combination of local movements, high water tables, periods of high rainfall and the topography of the area, the Balcombe Clay can become unstable and initiate slope movement. The area between Ballar Creek and Frankston contains many outcrops of Balcombe Clay and there are numerous examples of major slippage on this material.

It is not known when the landslides at Ballar Creek first formed. Worldwide experience is that many large landslides were initiated in the late Pleistocene (some 10,000 or more years ago), when climatic conditions were more severe than the present day, and have been re-activated by modern events. The landslides at Ballar Creek may have formed at this time.

The movements of the large landslides in recent years may be characterised by slow irregular, incremental displacements which, over a period of time, are likely to cause architectural and structural distress to rigid



structures built on the landslides. Structures built over the boundaries of the landslide areas are particularly prone to the development of structural problems. Since the characteristic ground movement is slow, the rate at which buildings develop distress is also slow. Under these circumstances, the risk of personal injury is relatively small although it is conceivable that an extensively damaged building could rapidly deform to bring about some structural collapse and therefore increase the risk of personal injury considerably.

4.4. Future Slope Movements and the Impacts of Placing the Engineered Fill

The engineered fill should generally, and specifically, improve slope stability in the study area.

The placement of the fill can be expected to reduce the occurrence of the localised slab failures along the creek alignment. Depending upon the extent of the fill, it should also help to stabilise the localised slumping failures within the lots. Localised slumping failures could still be expected where local over steepening of the creek banks occurs away from the fill placed in the creek bed.

The engineered fill placed in the creek bed can be expected to have a stabilising effect on the large landslides, although some ongoing movements of the landslides can be expected to occur. The movements are expected to reduce with time. It is not possible to predict how much each large landslide will move, when they will move, and how often they will move with our current state of knowledge of these landslides. The long term effect can only be assessed by on-going monitoring as discussed below in Section 7.

The engineered fill will not prevent instability of loose fill dumped over the top edge of the creek banks.

5. LANDSLIDE ZONING

5.1. Background

The general purpose of landslide zoning is to lessen community risks. Landslide zoning schemes seek to achieve this by identifying zones which have similar landslide risks and for each of these zones defining acceptable development practices. As such, the process acts to:

- Inform residents and relevant statutory bodies on their level of exposure.
- Define appropriate development controls to be applied to lessen the likelihood of inadvertent poor development practice being used in site development.
- Restrict future inadvertent development on marginally stable areas.

Landslide risk zones reflect the nature of the landslide hazard and the land-use of the area. Because there are many different types of landslides and physical environments where they occur, there are no standard methods for landslide zoning. Where landslide zoning schemes are used, they are generally developed to accommodate factors that are specific to the locality.

5.2. Adopted Landslide Zoning Scheme

The adopted system is outlined in Table 2 and is described in the following sections. Four zones have been defined, the boundaries of which are shown in Figure 3. Key features of the scheme are as follows:

- It provides a rational basis with which development can be controlled.



- The scheme uses roman numbers as zone labels thereby avoiding subjective implications through the use of descriptive risk classification zones (eg. low risk, high risk, etc.).
- Development guidelines are provided for each assigned zone so that owners and developers are advised of action required for further development. The guidelines also provide the relevant authorities with details of what should be expected in terms of documentation supporting development.
- The boundaries have been drawn regardless of title boundaries.

5.3. Adopted Landslide Zone Categories

5.3.1. Zone I Areas

These are areas where it is highly unlikely that landslides will occur with conventional residential development. The zone includes areas where:

- natural slope angles are flat to gently inclined (< 5% or 3°); and
- there has been no evidence of natural slope instability.

This zone is the most extensive in the study area and includes the flat to gently sloping ground adjacent to Canadian Bay Road, Mt Eliza Way and Glen Shian Lane.

5.3.2. Zone II Areas

These are areas where it is unlikely that landslides will occur with conventional residential development, but are sensitive to uncontrolled development. The zone includes areas where:

- natural slopes are gentle to moderately inclined; and
- there is no evidence of natural slope instability; and
- may be affected by, or alternatively affect, movement on adjacent Zone III or Zone IV areas.

This zone is the second largest in the study area and extends along virtually the entire length of both sides of the creek. This zone can be considered as a "buffer zone" between the areas where landsliding is highly unlikely and areas where there is some potential for landsliding.

5.3.3. Zone III Areas

These are areas where the steep banks of the creek provide potential for landslides both with and without development. The zone includes areas where no evidence of landslide movement has been identified to date, or, where the vegetation is thick, it has not been possible to observe any evidence if it were present.

5.3.4. Zone IV Areas

These are areas where there is evidence of past landslide movements and where there is potential for future landslide movements. The large landslides are included in this zone, together with a nominal up-slope buffer area which varies from about 5 to 10m depending on the landslide.

5.4. Limitations of the Landslide Zoning System

5.4.1. Missed Landslides

It is possible that not that every landslide in the study area has been identified. In particular, unidentified landslides may occur in Zone III areas along the steep banks of the creek upstream and downstream of the recently filled area, where existing access is limited and the ground-cover is dense.

5.4.2. Accuracy of Zone Boundaries

The accuracy of the zone boundaries is limited by access onto private land, subsequent ground surface disturbance, as well as the difficulty of observations in densely vegetated areas. Because of these factors, the accuracy of the zone boundaries is assessed no better than ± 10 metres.

The zone boundaries have been drawn regardless of title boundaries. It is recommended that where a zone boundary crosses a title boundary on small sites (eg standard 0.1 Ha house blocks), or where development is proposed within 20 metres of a zone boundary on large sites, the more conservative risk category should be adopted for initial evaluation purposes.

5.4.3. Existing Cuts and Fills

The zoning system is based on natural topographical features and previous slope instability. It does not take into account areas of existing cuts and fills which might locally adversely impact on the zoning. Such features need to be considered during the site specific assessment discussed below.

6. DEVELOPMENT CONTROLS

6.1. General Principles

Five basic principles apply to limit slope instability associated with hillside developments. These are:

1. Appropriate professional advice should be sought before starting work.
2. Where practical, avoid development in potentially unstable areas.
3. The natural landscape should not be changed if it can be avoided; and in particular, the extent of cuts and fills should be minimised.
4. Surface and subsurface water should be controlled and, where possible, all water sources should be removed from the slope.
5. Vegetation should be retained.

A pictorial guide to good and poor hillside development practices is presented as Figure 4. This is not intended to show specific requirements for any zone category, but the general differences between good and poor engineering practice on hillsides. The more critical the zone category, the greater the need to observe good hillside practices. Specific guidelines for each zone are discussed in the following section.

6.2. Development Controls which Apply to Each Zone

The following development controls have been prepared to cover residential developments and similar works. Whilst much of the advice is also applicable to other types of development, some of the advice may not be appropriate. For other types of development, project specific geotechnical advice should be sought and peer reviewed.

6.2.1. Zone I

For development on sites classified as **Zone I**, it is not necessary to obtain site specific slope stability information¹. Good engineering practices are recommended as necessary to control batter stability, run-off and soil erosion. Specific recommendations include:

- Minimising earthworks. Maximum unsupported cut depths and fill thicknesses of 2.0m battered no steeper than 2H:IV are recommended. Steeper and deeper unsupported cuts and fills should be supported with engineered retaining walls.
- Before placement of any filling, the vegetation and topsoil should be pre-stripped, the filling benched into the natural slope and compacted to standards appropriate to its purpose.
- Providing appropriate surface and subsurface drains, and directing water collected by these drainage systems, together with roof run-off, into the stormwater system.

6.2.2. Zone II

Before development in these areas, a site specific zoning assessment will be conducted by an experienced geotechnical practitioner. A general guide to features which need to be considered as part of such an assessment are set out in Section 6.3 below. For **Zone II** sites, the visual assessment may need to be augmented by additional investigation before it can be established with confidence that the site is Zone II or otherwise. The extent of any required geotechnical investigations will be site and project specific.

The site assessment will need to make recommendations which are specific to the site and any proposed development. It is anticipated that the recommendations will include, as a minimum:

- Locating footings in natural ground below any topsoil or zones potentially affected by soil movement.
- Minimising earthworks. Maximum unsupported cut depths of 1.5m, and batters no steeper than 2H:1V are recommended. Maximum unsupported fill thickness of 1.5m, and batters no steeper than 2H:1V are recommended. Steeper and deeper cuts and fills should be supported with engineered retaining walls. These recommendations also apply to driveways as well as outdoor living areas such as barbecue areas, swimming pools and tennis courts.
- Engineered retaining walls should be designed to resist applied soil and water forces, and allow for sloping ground.

¹ It would be normal practice to obtain a soils report under the Building Code of Australia.

- Control surface water run-off. All roof run-off should be collected and directed to the approved point of discharge from the property via pipes or lined surface drains. The approved discharge point from each property should be to the street drainage system or the new pipe-works in the creek. It should not be to the ground surface. The pipes (and lined drains) should be flexible and of adequate size to accommodate storm flows without blocking. Where required energy dissipaters should be used.
- To ensure the recommendations of the site assessment are adopted, the development application plans should be approved by an independent geotechnical expert.
- Site specific details for swimming pool construction where required. As a minimum, the details will need to address the provision for gravity under-drainage of the pool, variable lateral pressures on the walls of the pool, and low permeable surfacing around the pool to limit infiltration of surface water.

6.2.3. Zone III and Zone IV

New residential developments should only be permitted in areas currently zoned III and IV where:

- Detailed investigation can demonstrate the zoning of the site is inappropriate and a lower classification is justified; or
- It can be demonstrated that engineering works can be put in place to ensure the long term slope stability risks are within normally acceptable limits.

Before any work proceeds in these areas, a visual assessment should be conducted by an experienced geotechnical practitioner. The visual assessment may not be sufficient to resolve the slope stability issues, but may be used to establish the scope of geotechnical investigation work which maybe additionally required.

Prior to development in Zoned IV areas, it will be necessary to confirm the placement of the new fill has stopped slope movements on the large landslides or the consequences of slope movements can be satisfactorily accepted by the development. Detailed monitoring of these landslides over a period of many years is likely to be required to assess if movements on the large landslides have ceased.

6.3. Site Specific Assessments

This study provides a broad characterisation of landslide issues in the study area. No attempt has been made to obtain site specific information on individual properties.

The first part of a development process should be to obtain and review site specific information relating to landslide zoning. Depending on the mapped zone category, this may include a site specific assessment, and in some cases, subsequent detailed geotechnical investigations.

A site specific assessment would normally be carried out by an experienced geotechnical consultant at the same time as the site classification for assessment of soil reactivity required by the Building Code of Australia. An assessment would normally include:

- Study of geological and topographic maps, supplemented by the consultant's experience in the area.
- Consideration of data made available by the client about the site, and its surrounding area (including any previous instability, seepage, building distress) and details of the proposed development.

- Appraisal of the site and surrounding areas, including signs of instability and soil creep, soil and rock exposures, seepage, vegetation and existing development which might affect the stability of the area.
- Collection of basic geological and topographic data from the site, to produce a geological model.
- Consideration of possible effects of high rainfall.

The assessment applies to the site at the time of the inspection, and should not be used as justification for future development without an on-site confirmation of its validity at the time. Such an assessment is predominantly deductive and incorporates judgement based upon experience.

Where a site specific assessment indicates doubt as to the stability of a site, geotechnical investigation should be undertaken. A geotechnical investigation may include borehole drilling, test pits, groundwater studies, laboratory testing and engineering analysis. The actual scope of works required by a geotechnical investigation will be site and project dependent.

It is recommended that, because of large variations in the experience and knowledge of "geotechnical practitioners", any site specific assessment be reviewed by a suitably qualified and experienced geotechnical engineer.

6.4. Some Further Discussion of Development Controls

6.4.1. Existing Developments

The development controls outlined above are directly applicable to new residential developments and works of a similar nature. For existing developments, the guidelines can be used to assess what parts of the development comply or otherwise with the recommended "good practice". Where parts do not comply with the guidelines, geotechnical advice should be sought. The degree of action required will depend on the level of non-compliance with the guidelines and the potential impacts if slope failure occurs.

6.4.2. New Cuts and Fills

Batter slopes of no steeper than 2H: 1V are recommended for all cuts and fills in the study area. These batter slopes are for uncharged permanent slopes in engineering soils and have been recommended because of slope stability as well as erosion and slope maintenance issues.

Steeper cut and fill slopes in soil may be possible in some situations. Steeper slopes may be difficult to vegetate and maintain in the long term and therefore may be prone to erosion and general deterioration. Steeper slopes should only be adopted based on site-specific geotechnical advice.

6.4.3. Water Disposal

Residential development usually results in a significant net increase in the volume of water entering a site and if not controlled adequately, this water can cause stability and erosion problems.

On sloping sites, excess water may act to destabilise the slope if allowed to concentrate on the surface or, more significantly, if it is allowed to enter the ground and build up groundwater pressures. Where stormwater is piped to the street disposal system and where effluent disposal is via mains sewer, the likelihood of

groundwater build-up on a site is substantially reduced.

6.4.4. Pipelines/Service Trenches

Trenches for buried services can adversely influence slope stability by:

- Acting as a point of weakness in the ground along which instability can develop.
- The backfill material acting as a conduit to carry water to unstable areas.
- Disrupting natural groundwater flow paths in the soil.

By the adoption of good hillside construction practices, the adverse impact of underground service construction can be reduced. Some good practices for the construction of buried services on slopes include:

- Selecting a route that avoids obvious problems.
- Using flexible service connections which have some capacity to accommodate ground movements.
- Avoid aligning the service across the slope of the ground.
- Providing trench breakers in combination with subsurface drain outlets to remove water which may accumulate in the trench.

6.4.5. Precedence of Site Specific Studies over this Report

The results of this study can be superseded by site-specific landslide risk studies provided that:

- the site specific information is based upon the principles outlined in this report, and
- has been subject to appropriate, independent technical peer review.

7. RECOMMENDATIONS FOR FUTURE WORK

Monitoring of Zone IV areas needs to be conducted to assess the effectiveness of construction works. The monitoring may need to extend over several decades, and therefore the adopted system needs to be reliable, simple and have redundancy. It is anticipated that system accuracy in the order of $\pm 5\text{mm}$ of total movement per measurement location will be required.

There are a number of possible monitoring schemes and these should be investigated in conjunction with a professional surveyor and an experienced geotechnical practitioner. In order to obtain an on-going assessment of the performance of the monitored areas, the results of the monitoring, together with local rainfall data, would need to be reviewed regularly by an experienced geotechnical practitioner.

For and on behalf of

COFFEY GEOSCIENCES PTY LTD



REFERENCES

1. Mornington Peninsula Shire Council Facsimile dated 2 February 1999. Addressed to Coffey Partners International Pty Ltd.
2. Mornington Peninsula Shire Council Purchase Order No 52658 dated 18 May 1999. Addressed to Coffey Geosciences Pty Ltd.
3. Coffey Proposal Reference MP4080/1-AA dated 23 September 1998. Addressed to Mornington Peninsula Shire Council. Attn. Mr Paul Healy.
4. Fisher Stewart Pty Ltd, Report E950703, D0CSG M/jr/0394202, dated May 1995 re: Ballar Creek, Functional Design Report.
5. Golder Associates Pty Ltd, Report 83612155 dated December 1983 re: Frankston Sewerage Authority, Stability of Ballar Creek.
6. A S James Pty Ltd, Report R28, dated 5 April 1977.
7. Hydrotechnology Pty Ltd, Report CC32780.00.oA/1 dated May 1994 re: Slope Stability Review, Ballar Creek, Mount Eliza.
8. Piper and Associates Pty Ltd, Report 95066, dated February 1995 re: Geotechnical and Geological Investigation for Proposed Piping of Ballar Creek Mount Eliza.
9. Piper and Associates Pty Ltd, Report 95066B, dated 15 April 1995. re: Additional Geotechnical Investigation for Proposed Piping of Ballar Creek, Mount Eliza
10. Coffey Report No M3180/1-AI dated July 1998 re: Geotechnical Investigation, Ballar Creek, Mount Eliza, Victoria, prepared for Gutteridge Haskins & Davey Pty Ltd.
11. Geological Survey Report 1974/3 re: The Geology of the Mornington Peninsula and Western Port.



Table 1: Large Landslides in the Study Area

Landslide Name	Side of Ballar Creek	Area (m x m)	Estimated Volume (m³)	Additional comments
Glen Shian Crescent No 1	NW	250 x 80	70,000	Largest landslide in study area. One house previously demolished on this landslide. Localised failures of the road surface and of services along the road may have been caused by landslide movements. No evidence of movement uphill from Glen Shian Crescent
Glen Shian Crescent No 2	NW	20 x 15	<1,000	Smallest of large landslides, located adjacent to creek. Shows some characteristics of localised slumping landslide mechanism but volume much greater than 50 m ³ .
Penny Lane	NW	280 x 60	50,000	Two houses on this landslide have required substantial remediation.
Canadian Bay Road No 1	SE	220 x 50	35,000	-
Canadian Bay Road No 2	SE	80 x 20	2,500	This landslide is restricted to the steep slopes close to the creek.
Canadian Bay Road No 3	SE	70 x 60	10,000	Evidence for landsliding in this area less pronounced than in other areas.
Canadian Bay Road No 4	SE	40 x 25	3,000	Shows some characteristics of localised slumping landslide mechanism but volume much greater than 50 m ³ .
Canadian Bay Road No 5	SE	190 x 35	20,000	One house on this landslide extensively damaged and has been vacated.



Table 2: Definitions of Landslide Zone Categories

Zone Category	Explanation	Implications for development
I	<p>Flat to gentle natural slopes with no evidence of landsliding.</p> <p>Zone I occurs away from areas of landsliding.</p>	<ul style="list-style-type: none"> • Good engineering practices should be followed. • Slope stability risks after development normally acceptable.
II	<p>Gentle to moderate natural slopes with no evidence of landsliding.</p> <p>These areas may be affected by, or alternatively affect, movement on adjacent Zone III or Zone IV areas.</p> <p>Zone II may occur adjacent to areas of known or potential landsliding.</p>	<ul style="list-style-type: none"> • Site specific assessment. • Good engineering practices suitable for hillside construction should be followed. • Slope stability risks after development normally acceptable.
III	<p>Steep banks of creek where there is potential for landslides.</p>	<ul style="list-style-type: none"> • Site specific assessment, likely followed by geotechnical investigation. • Results of investigation may or may not conclude development can proceed. • Site specific engineering practices suitable for hillside construction will be required, without which slope stability risks may be higher than normally acceptable.
IV	<p>Evidence for past landsliding with potential for future movements.</p>	<ul style="list-style-type: none"> • Site specific assessment followed by geotechnical investigation. • Requires review of monitoring results to confirm slope movements have ceased. Many years of monitoring data may be required. • Results of investigation may or may not conclude development can proceed. • Slope stability risks of development may be higher than normally acceptable.

Information

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of the subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by

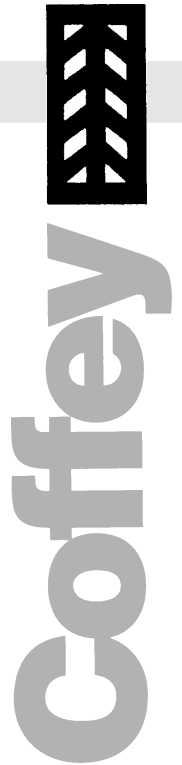
earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.



Important information about your **Coffey** Report

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they have incorporated the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

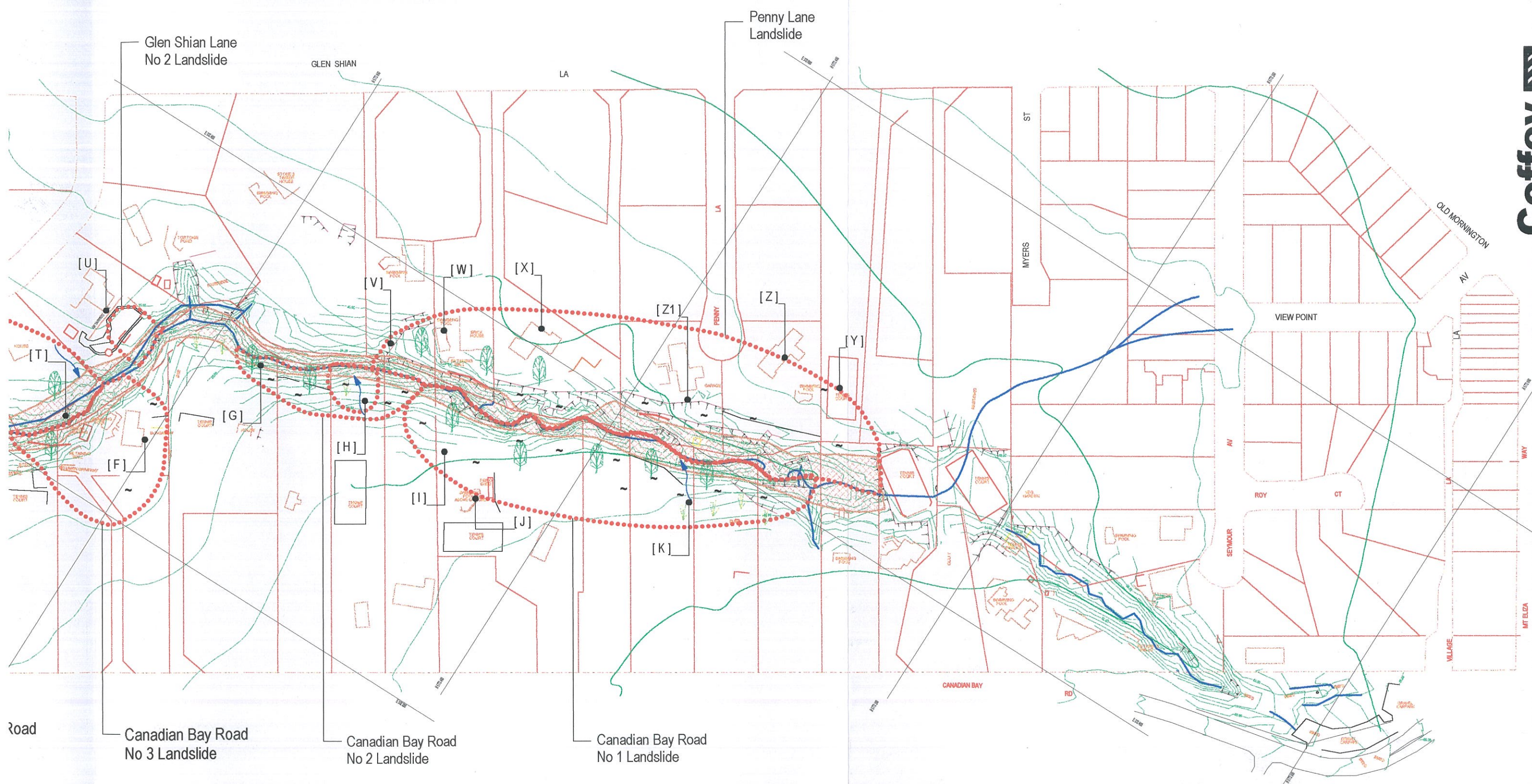
Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design toward construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

** For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical Information in Construction Contracts" published by the Institution of Engineers Australia, National Headquarters, Canberra, 1987.*

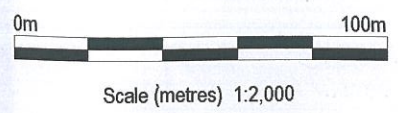




NOTE: Previous exposures of Balcombe Clay in the sides and the base of Ballar Creek have been covered by the Engineered Fill (see discussion in the text of the report).



Coffey Geosciences Pty Ltd ACN 056 335 516 Geotechnical | Resources | Environmental | Technical | Project Management

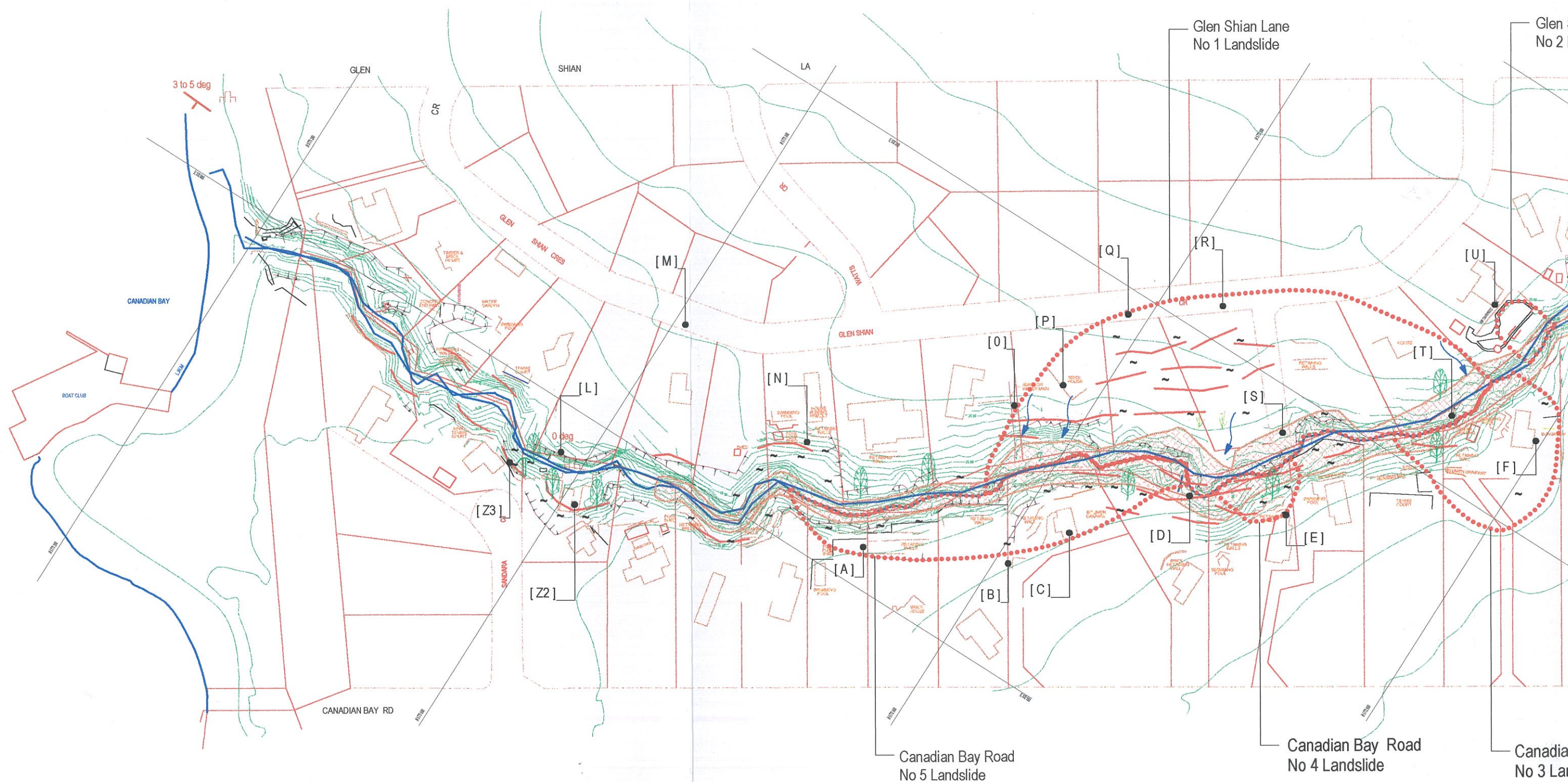


Revision	Description	Drawn	Approved	Date



Drawn	RW
Checked	<i>[Signature]</i>
Date	11 July 2000




MORNINGTON PENINSULA SHIRE COUNCIL
 BALLAR CREEK, MOUNT ELIZA
ENGINEERING GEOLOGY PLAN





FIGURE 1
 Job No.: M4164/1 - AV






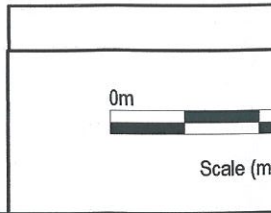
KEY:

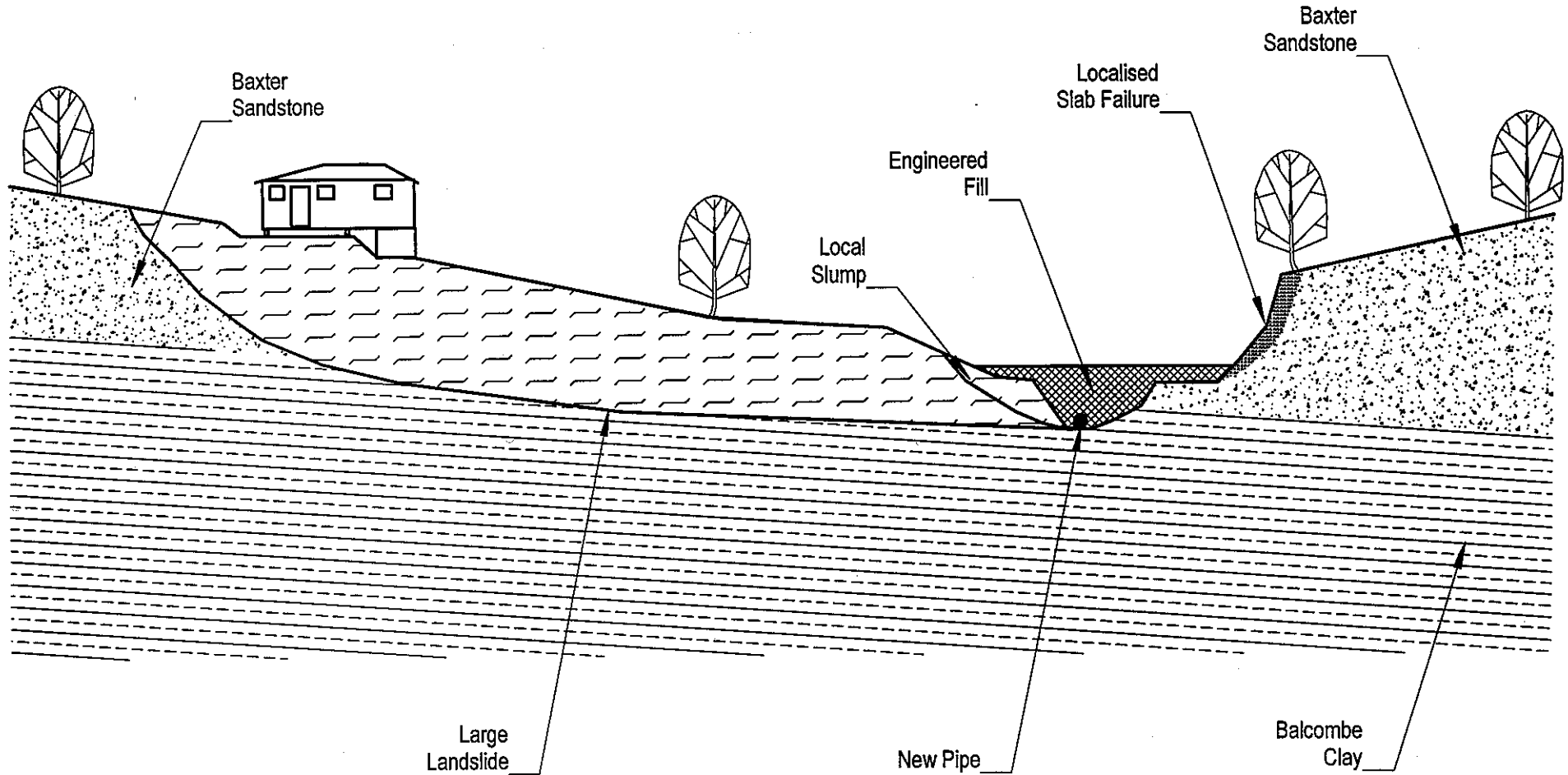
-  **Extent of Mapped Large Landslide**
-  **Approximate Extent of Engineered Fill**

-  **Bent Tree**
-  **Tree Fern**
-  **Sedge**

-  **Air Photo Scar (from Reference 5)**
-  **Dip & Strike of Bedding**
-  **Oucrop**
-  **Water seep**

-  **Sharp break in slope**
-  **Irregular ground**
-  **Observations of ground movement and structural distress. For details see Appendix A of report.**

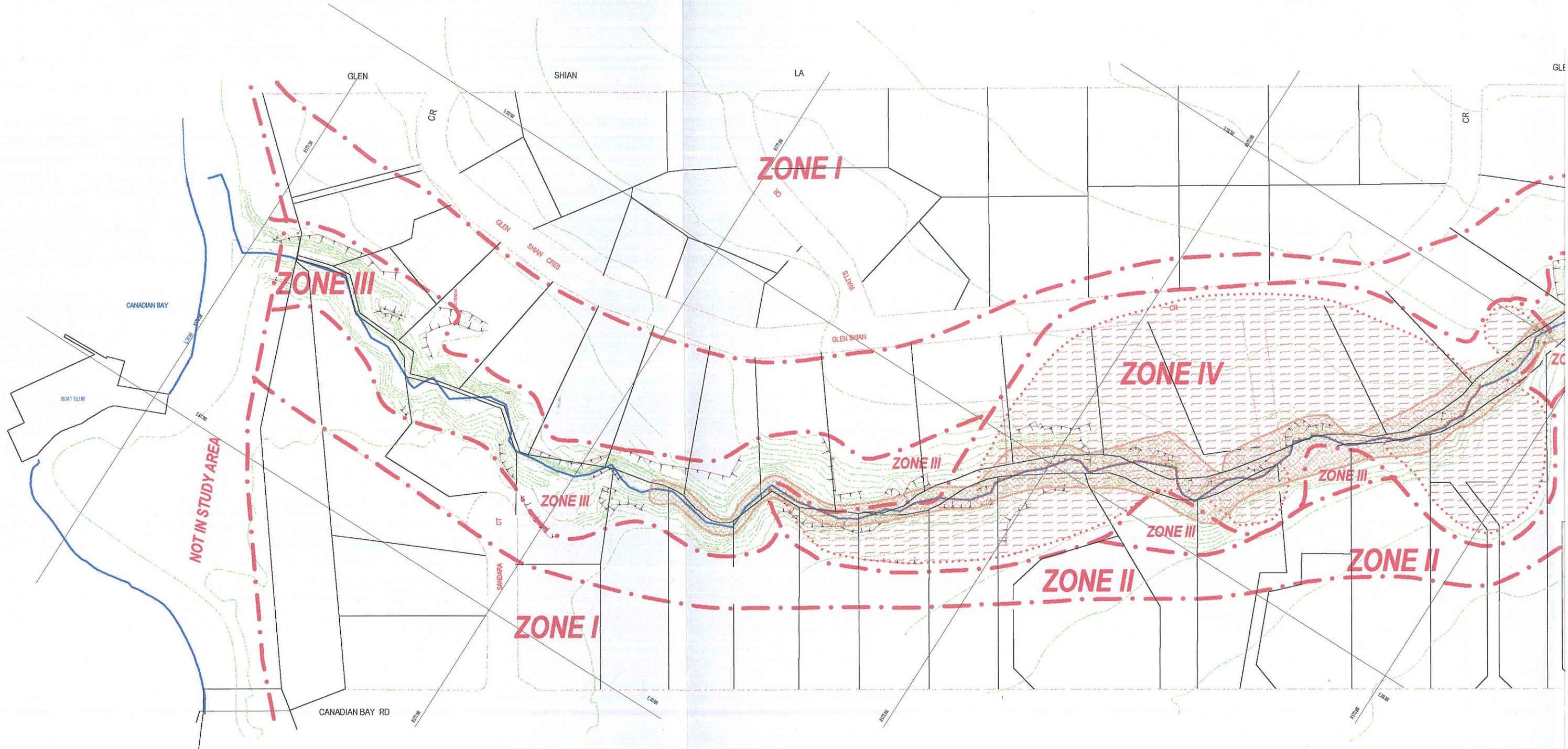




NOTES:

1. This drawing is not to scale.
2. The purpose of this drawing is to show some of the relationships of the types of landslides to geology and topography.

Not to Scale	Revision	Description	Drawn	Approved	Date	Drawn	RW	MORNINGTON PENINSULA SHIRE COUNCIL BALLAR CREEK, MOUNT ELIZA DIAGRAMATIC SECTION	FIGURE 2
						Checked	<i>[Signature]</i>		
						Date	3/7/00		
								Job No.: M41641 - AU	

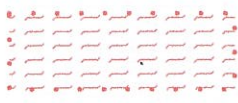


ZONE II

KEY:
Landslide Zone Boundary and Label



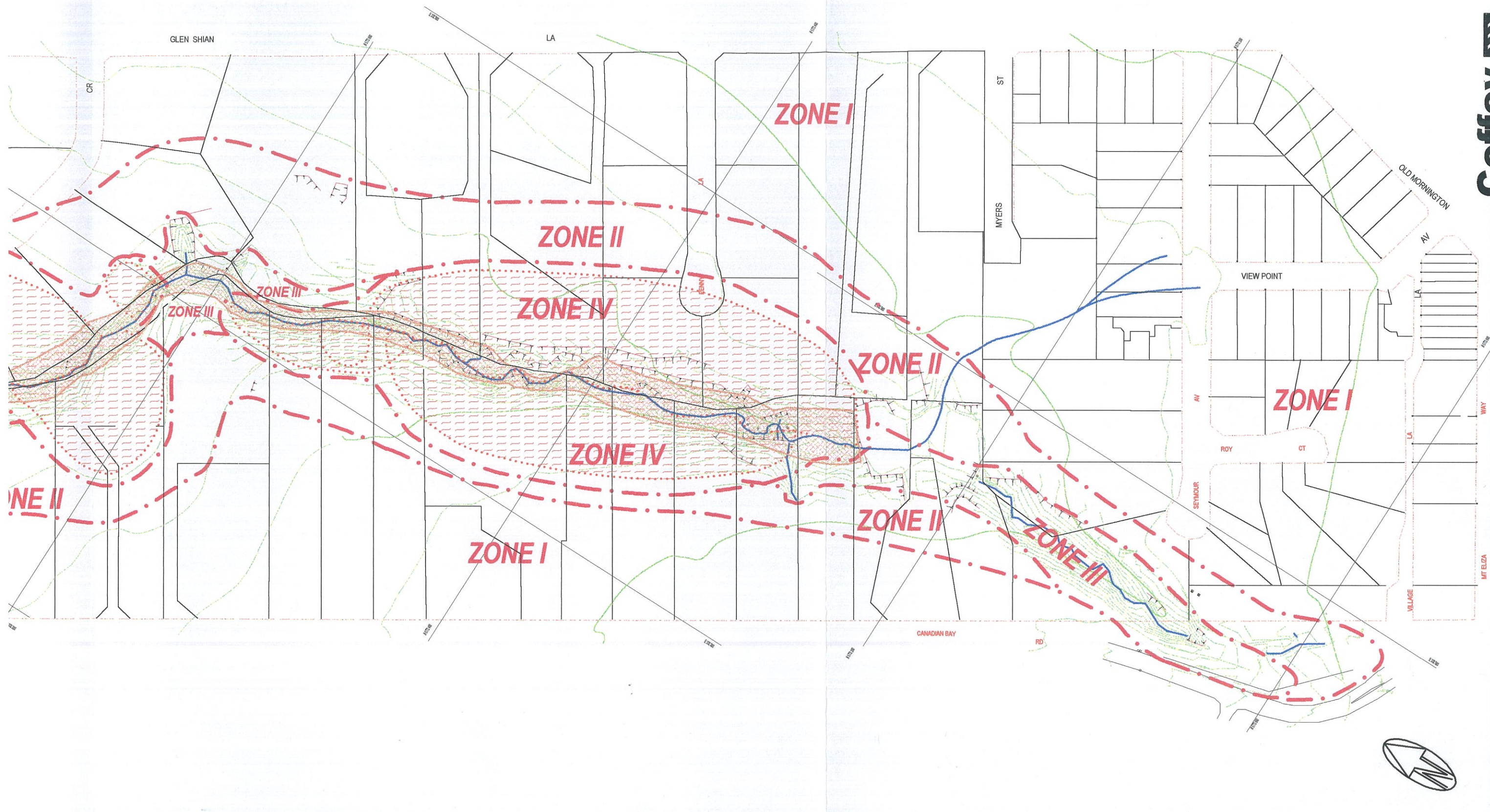
Approximate Extent of Engineered Fill



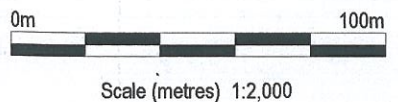
Extent of Mapped Large Landslide



Scale (met)



Coffey Geosciences Pty Ltd ACN 056 335 516 | Geotechnical | Resources | Environmental | Technical | Project Management



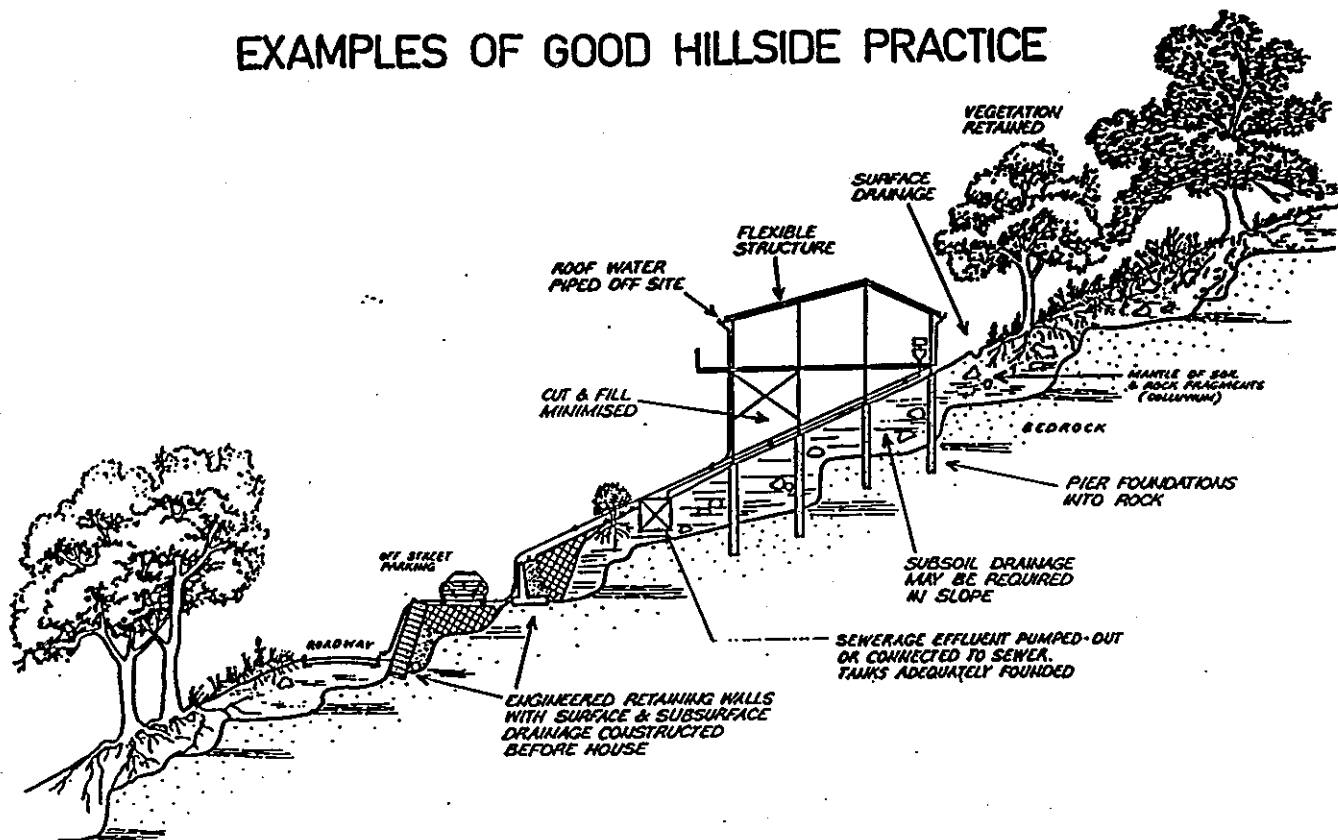
Revision	Description	Drawn	Approved	Date

Drawn	RW
Checked	<i>[Signature]</i>
Date	11 July 2000

MORNINGTON PENINSULA SHIRE COUNCIL
BALLAR CREEK, MOUNT ELIZA
LANDSLIDE ZONE PLAN

FIGURE 3
 Job No.: M4164/1 - AV

EXAMPLES OF GOOD HILLSIDE PRACTICE



EXAMPLES OF POOR HILLSIDE PRACTICE

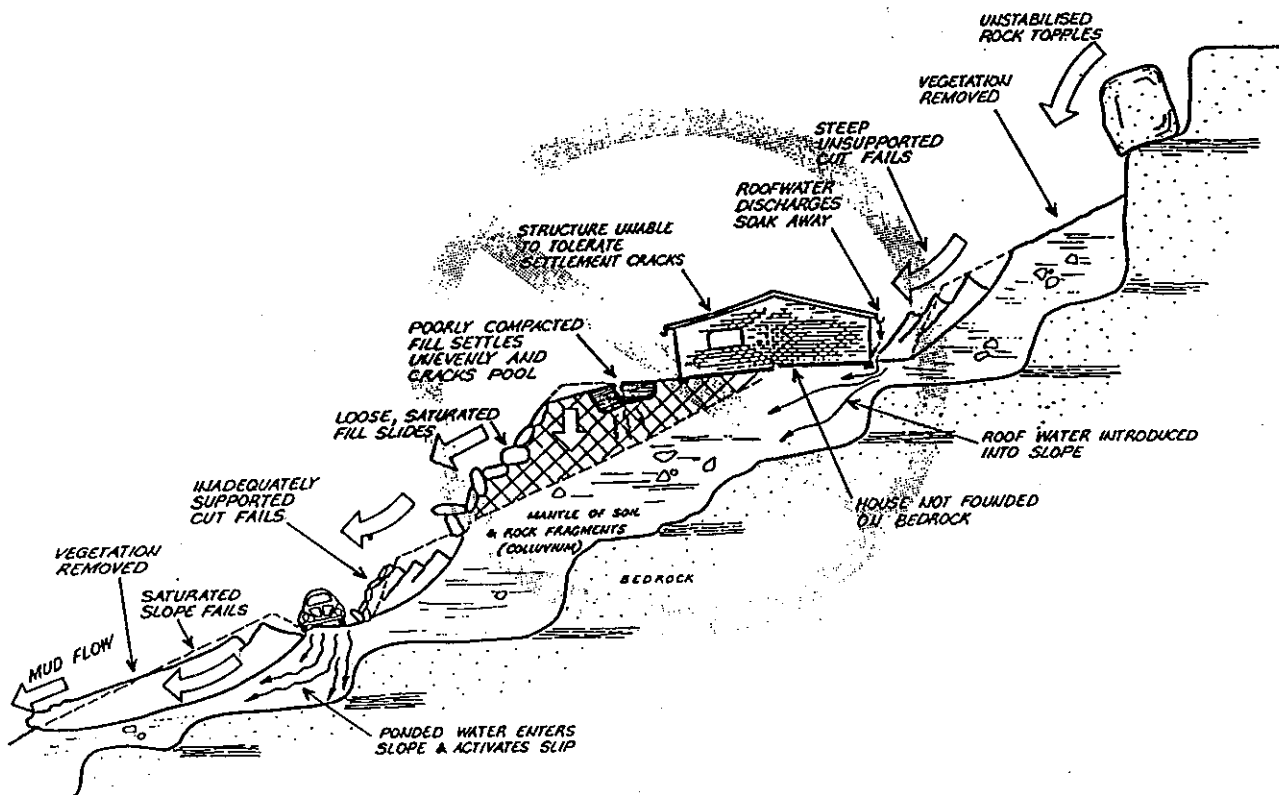


FIGURE 4 Illustrations of Good and Poor Hillside Practice

This figure is an extract from *GEOTECHNICAL RISKS ASSOCIATED WITH HILLSIDE DEVELOPMENT* as presented in *Australian Geomechanics News*, Number 10, December, 1985, which discusses the matter more fully.

M4164/1 - AV
11 July 2000

APPENDIX A:

OBSERVATIONS OF GROUND MOVEMENT AND STRUCTURAL DISTRESS

OBSERVATIONS OF GROUND MOVEMENT AND STRUCTURAL DISTRESS (2 pages)

(Observations made during the course of this study and information from previous studies)

Street	Reference on Figure 1	Observations
Canadian Bay Road	A	Off-set in tennis court
	B	Abandoned cracked water main.
	C	House severely damaged. Obvious landslide scarp with approx. 500 mm displacement extends across property in front of house
	D	Creek bank slippage in late 1983
	E	Crack in house. Irregular slopes downhill.
	F	Crack developed recently in wall.
	G	Creek bank slip
	H	Small landslide on steep bank.
	I	Water pipe breakage. Reported "continual slip movements" in the area.
	J	100 mm cross-fall in swimming pool developed since built in 1990
	K	Spring on steep bank. Irregular slopes & bent trees.
Glen Shian Crescent	L	Local failure of cliff adjacent to creek.
	M	Cracks in road pavement.
	N	Tension cracks in deep, steep (1H: 1V), and loose fill dumped over edge creek bank.
	O	Abandoned damaged water main. Southern end of tennis court lower.
	P	Previous house demolished. Property now substantially landscaped removing physical evidence of past landsliding.
	Q	Cracks in road pavement.
	R	Water main in road keeps breaking.
	S	Inclinometer in easement blocked, possibly sheared.
	T	Slippage near creek.
U	Cracked brick wall	

Observations of ground movement and structural distress (continued)

Street	Reference on Figure1	Observations
Glen Shian Lane	V	Dropped sewer pit
	W	Tilted swimming pool.
	X	Small rotational type slips behind; one of which moved in the winter of 1983. \$80,000 spent in shoring up house
	Y	Off-set in tennis court
Penny Lane	Z	Foundations reinforced with tie-rods to inhibit spreading of footings. Ground movement over 29 years. Warped roof-line, cracks in basalt boulder wall, swimming pool cracked, tilted side to house.
	Z1	Recent landslide behind property. Slightly tilted power pole in street.
Sandara Court	Z2	Cracks in pool house.
	Z3	Thresh-hold cracking in brickwork of house and pavements. Bent trees on steep creek bank.
Seymour Avenue	-	Nothing of significance known