IAN LANKSHEAR

TONKIN & TAYLOR LTD
CONSULTING ENGINEERS
REGISTERED SURVEYORS AND TOWN PLANNERS
47 George Street, Auckland 1, New Zealand. P.O. Box 5271
Telephone: 771-865 Telex: NZ 21594 Cable: TONTAY

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STABILITY ASSESSMENT OF COASTAL LAND IN TAURANGA COUNTY

12

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REPORT

1.0 INTRODUCTION

1.1 GENERAL

This report summarises the results of a stability assessment of seven specific areas of coastal margin within Tauranga County, undertaken to identify areas of actual or potential hazard and provide a sound basis for the establishment of guidelines for beach front and cliff top development in these areas. This study has been undertaken at the request of and in association with, the Tauranga County Council.

Following a field inspection of the Tauranga County coastline the Council defined seven specific urban areas as requiring priority for stability assessment. These areas, shown on Drawing 4879 - 1 are Athenree, Tanners Point, Ongare, Omokoroa (East), Omokoroa Station Road, Te Puna West (Snodgrass Road) and Maketu. All these areas encompass either present, or relic, coastline where the coastal margin is mostly cliffed. Awareness of the possible hazard to such areas from sudden landsliding was greatly increased following the dramatic, and widely publicised, landslip at Bramley Drive, Omokoroa, on 9th August, 1979.

Subsequent investigation of the western coastline of Omokoroa (Tonkin and Taylor Report dated February, 1980) revealed that, far from being an isolated incident, similar landslips have occurred over almost the entire western margin of the Omokoroa Peninsula. It appears that such landslides are relatively infrequent in time and perhaps coincide with periods of high intensity rainfall following a prolonged (perhaps six months) wet period.

Contributing factors to the Bramley Drive landslip appear to have been the particular geology of the area and the injection of stormwater and domestic waste water into the ground, thereby altering the groundwater flow regime and contributing to a build up of pore water pressures within the ground. The geological sequence evident on the western margin of Omokoroa does not appear to be evident to the same extent in the other coastal areas examined in this study.

1.2 IDENTIFICATION AND DELINEATION OF AREAS OF HAZARD

The identification of areas of actual or potential hazard due to erosion or landslip (resulting in either regression or backwearing of the coastline) has been undertaken in terms of the First Schedule of the Town and Country Planning Act, 1977. Once such areas are identified the residents, both present and future, can be advised of possible difficulties in various ways. Perhaps the best way of doing this is to formalise the information in the District Scheme, as has already been undertaken for the areas identified on the western coastal margin of the Omokoroa Peninsula. By presenting such information Council is assisting in the avoidance, or reduction, of danger, damage or nuisance caused by, amongst other factors, erosion and landslip in terms of the Second Schedule of the Town and Country Planning Act, 1977.

1.3 SCOPE OF STUDY

The stability assessment was defined at the outset as being essentially an overview to provide a broad evaluation of the relative stability of the areas. In order to achieve the study objectives the following studies were undertaken.

1.3.1 Data Collection, Collation and Review

- Collection of subdivisional plans and base data, aerial photographs, and stormwater and sanitary sewer reticulation plans.
- Collation and review of existing topographical, geological and soils information.
- Examination and comparison of stereoscopically paired vertical aerial photographs.
- Examination and comparison of survey information.

1.3.2 Survey and Reconnaissance

- Field examination of the coastal margin, mapping the geology and soils evident in exposures.
- Field examination of upslope catchment areas (physical and reticulated).
- Measurement of coastal lot boundaries, cliff heights and slope angles.
- Mapping landslips and areas of active coastal erosion.

1.3.3 Assessment and Reporting

- Delineation of areas vulnerable to long term landslip risk
- Delineation of areas possibly subject to instability
- Guidelines for coastal management.

2.0 ENGINEERING GEOLOGY

2.1 GEOLOGY AND SOILS

The strata which comprise the coastal landforms from the ridges and cliff tops to the harbour and ocean below can be subdivided into three discrete units. The oldest unit, generally present below, at and several metres above MHWL, is made up of an assemblage of terrestrial and estuarine sediments and interbedded ashes. These sediments, which constitute the Tauranga Beds, are overlain by a second unit made up of a sequence of weathered rhyolitic ashes, collectively referred to as older ashes. These older ashes are in turn overlain by a sequence of younger, relatively unweathered, rhyolitic ashes.

The sequence is shown in Figure 1

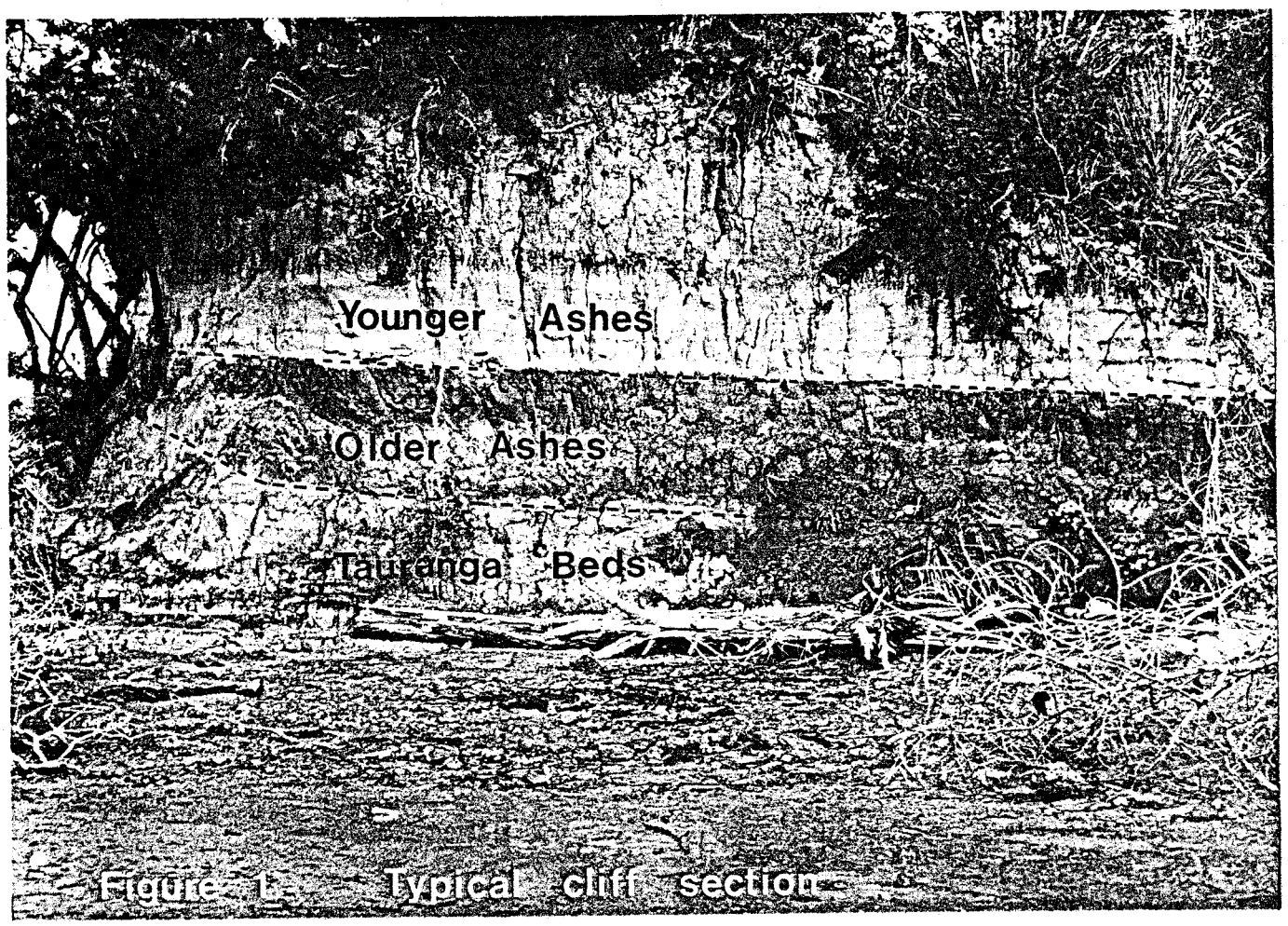


Figure 1: Typical cliff section

Generally apparent at the base of the cliffs and at the coastline, the Tauranga Beds consist of a variety of lithologies, from coarse inorganic sediments (lithified sands, gravels and boulders) to very fine sediments, both inorganic and organic (peat). Because of their largely alluvial origin the Tauranga Beds are typically highly variable over short distances. The coarse sediments (sand, pumice, gravels and boulders) are generally highly resistant to erosion, but fine ash beds and organic materials appear considerably less resistant to erosion.

The sequence of older ashes overlying the Tauranga Beds appear to be seldom preserved due to subsequent erosion and redeposition. Three distinct ashes are generally recognised, being the Pahoia Tuffs, overlain by Kauroa Ash and undifferentiated brown tuff. These ashes are typically highly weathered to clays. Some of these older ashes have been found to be highly sensitive, and much of the landsliding on the western margin of Omokoroa has been attributed to the presence of these older ashes. However, at most coastal sites only one or two metres of older ashes are evident.

In contrast to these fine grained clayey and variously plastic and brittle older ashes (often with well developed paleosols) the younger ashes which generally mantle the entire landscape are comprised of generally coarse friable silts, sands and pumiceous lapilli, with many ashes largely unweathered. These ashes, mostly erupted from the Rotorua District, typically thin to the north east. Textural variations with distance from source are also apparent. Many different younger ashes have been recognised, but the most widespread appear to be Rotoehu Ash and Manganoni lapilli.

2.2 GEOMORPHOLOGY

The present coastal landforms, the surface of which are largely developed in younger ashes, are thus relatively recent. Being so extensive, the mantle of younger ashes has also largely disguised the underlying topography developed in the older ashes and underlying Tauranga Beds. Because of the considerably greater permeability of the younger ash cover, the groundwater flow is probably largely controlled by the paleo-topography, following the old streams and flow paths now infilled. Accordingly, the surface hydrology may bear little relation to the groundwater hydrology.

Without detailed drilling it is difficult to accurately assess the paleo-topography in any area. However, from examination of aerial photographs infilled gully areas are apparent at many locations, and re-excavation and active gully head erosion processes are evident. In some instances therefore erosion and landsliding is occurring where old gullies have been infilled or where prior movement has occurred, as such areas are either natural sites for water to accumulate and water pressures to develop, or are inherently areas of marginal stability.

At the coastal margin, however, the relationship of paleo-topography to erosion or landsliding is less apparent. However, the younger ashes may act as a porous capping, receiving water at a rate greater than that of deep percolation. The prismatic structure in the younger ashes probably further enhances the flow of water down the soil profile. In this way the younger ashes may act as a groundwater reservoir and thus contribute to sudden slope failure. The general incidence of failure surfaces and spring seepage zones below the younger ash sequences support this.

The thickness of older ash sequences apparent at the western margin of the Omokoroa Peninsula are evident to a lesser extent at the eastern margin of Tanners Point. Elsewhere the sequence does not appear well preserved, although very thin highly sensitive ashes are apparent at localised areas of Te Puna and Ongare. However, at these locations other factors indicate that major instability is unlikely to occur due to these sensitive soils.

2.3 COASTAL HAZARD

The association of landsliding and precipitation in the coastal area is clear qualitative evidence that a cause-effect relationship exists. Landslides, however, are seldom attributable to a single cause but rather stem from changes, some gradual others sudden, in the many factors controlling the stability of a sloping mass. An increase in the water content or water pressures within the soil/regolith/geological system is apparently the most common trigger for mass movement in the area. Seismic events may also initiate movement. Other factors which may trigger movement at specific locations include undercutting (by roading or marine erosion) and surcharging (by development), over-steepening and removal of lateral support (coastal erosion). Contributing factors to slope failure, identified both in the recent study and in the Bramley Drive landslip investigation, include:

(i) Static Factors

- Topography - steepness of slope
  - height of cliff
  - paleo-topographic features
- Geology and Soils - weak or sensitive soil or rock
  - variability in subsurface hydraulic conductivity

(ii) Dynamic Factors

- Hydrology - rainfall, stormwater runoff
  - groundwater levels and water pressures
- Removal of vegetation
- Domestic water use and disposal.

The static factors (generally fixed in space and time) can usually be readily identified (with the exception of subsurface features in areas without exposures) especially topography and, in general terms, soils and geology. Dynamic factors (usually variable in space and highly irregular in time) are usually less readily identified and much less readily quantified.

In any area however, the best indication of hazard is often assessed by evidence of prior erosion or instability in the area. For if erosion or lansliding has occurred in the past (especially in an undeveloped area), it is reasonable to assume that such events will occur in the future. For example, if the coastline has had an average rate of regression of 0.1 m/yr over a 100 year surveyed period (with no acceleration apparent) then it appears reasonable to expect the coastline to be approximately 10 m further inland in another 100 years. Such an area can therefore be clearly perceived as an area of hazard and delineated on a map as such.

A problem in accurately assessing the rate of regression of the coastal margin is the general absence of detailed survey information over a long length of time. A further problem is that, especially within the Tauranga Harbour, the coastal margin appears to be regressing due to erosion at the base of the cliffs (slow but continuous) and landsliding at the tops of the cliffs (rapid but infrequent). Where actual erosion or landslip is either not apparent or appears to have been inactive over recent times, an assessment of the potential for erosion or instability is required.

By identifying the static factors (e.g. slope angle, soils and geology) present at a particular location it is possible to broadly identify where erosion or slope failure is likely to occur. The dynamic factors will tend to determine if and when erosion or slope failure occurs.

Of the areas specified for the present study, most are either existing or proposed residential developments which currently rely on ground injection methods for both stormwater and domestic waste water dispoasl. In some areas stormwater runoff from the roadway is also directed either over or into the ground.

Areas which probably developed under full forest cover and a purely climatologically induced groundwater flow regime are thus now generally bare of vegetation and are subject to increased (albeit localised) water levels and pressures. The ground response to these man-induced changes will vary according to topographical, soil and geological conditions, and the exact response is difficult to predict.

However, where particular geological, topographical and soil conditions exist (coincide) which indicate that instability could occur under certain foreseeable conditions then such areas should be identified as areas where more detailed geotechnical investigations are warranted before any development is allowed to proceed.

3.0 COASTAL MANAGEMENT CRITERIA

As a result of our stability assessment, areas of coastal land have been delineated A or B. The areas so delineated are land hazard classifications and indicate that within these areas certain processes or factors occur or could possibly occur which present a hazard to property within these areas.

This does not infer that the edge of such areas can be taken as building line restrictions, as in most instances a setback from the edge of the areas would be appropriate. As well as the hazard to property situated on and above areas vulnerable to landslip, property situated below such areas is similarly at risk should slope failure occur.

This study has specifically examined the stability of the coastal margin, and inland areas not referred to in this report may be subject to erosion or instability.

3.1 AREA 'A' (Vulnerable to Long Term Landslip Risk)

An area delineated on the stability management plans in which processes or factors have been identified which indicate that instability, or erosion, or regression of the coastline is evident or is likely to occur. The landward edge of the area is the expected limit of coastal regression or slope backwearing in approximately 100 years hence (a time based upon the expected useful lifespan of most structures), but in no case is the landward edge of the area less than 6 m from the top of an existing coastal cliff.

This area includes the base, face and top of coastal cliffs where active erosion or landslippage (old and recent) is apparent and land on which instability is evident. Whether the erosion processes are sudden, (e.g. landslip, extensive but infrequent) or gradual, (e.g. marine erosion, less extensive but more frequent) the result is either regression of the coastline or backwearing of the cliff or slope. These processes thus present an identifiable hazard to property within the delineated area.

Conditions which could be applied to this area are that no building or development, including cutting, filling, removal of vegetation, disposal of stormwater or domestic waste water on or into the area delineated, be permitted.

If erosion or instability is evident or likely to occur Council can refuse to issue a building permit within this area under Section 641 of the Local Government Amendment Act 1979 and decline to give scheme plan approval under Section 274 of the Act.

3.2 AREA 'B' (Possibly Subject to Instability)

An area delineated on the stability management plans in which processes or factors appear to be such that instability or erosion is possible. The area does not, however, appear to be directly threatened by regression of the coastline. Because problems could occur, either naturally or induced by development, we consider that any development within areas delineated B only be allowed to proceed in the light of specialist advice.

This area includes land on which prior instability is evident but is now no longer adjacent to the coast, and land which appears to be of marginal stability.

Conditions which could be applied to this area are that building or development, including cutting, filling, removal of vegetation, disposal of stormwater or domestic waste water on or into the area delineated, only be allowed to proceed if supported by, and in accordance with, specialist advice.

We would expect specialist advice to, amongst other matters,

(a) assess the natural stability

(b) assess the impact of building and development

(c) recommend appropriate building and development criteria.

If not satisfied that the land is suitable for building or development Council can refuse to issue a building permit under Section 641 of the Local Government Act 1979. Council can also decline to give scheme plan approval under Section 274 of the Act unless it is satisfied that:

(i) in subdividing the land such action will not be likely to, amongst other things, accelerate, worsen or result in;

  (a) erosion

  (b) subsidence

  (c) slippage

  (d) inundation by the sea

(ii) provision has been made for the protection of the land (whether part of the subdivision or not) from;

  (a) erosion

  (b) subsidence

  (c) slippage

  (d) inundation.

However, protective structures are costly and may cause aesthetic, environmental, engineering and legal problems.

3.3 OTHER AREAS

3.3.1

An undelineated area of a lot encompassing or adjacent to an area delineated A or B.

Within the scope of the study such areas appear relatively stable.

Conditions which could be applied to this area are that building or development may proceed at the discretion of Council. If cutting filling, clearance of vegetation or ground injection of stormwater is contemplated then specialist advice may be required.

3.3.2

An undelineated area or lot remote from an area delineated A or B.

Within the scope of the study such areas appear relatively stable

We consider that no special conditions need be applied to these areas.

3.4 REVIEW

The stability assessment plans should be reassessed at the time of the District Scheme Review in the light of any new events and technical data.

4.0 STABILITY ASSESSMENT OF COASTAL LAND

In this essentially broad brush assessment of the relative stability of the coastal areas, stability analyses have not been undertaken in view of the cost and difficulty in obtaining relevant soil strength parameters, paleo-topographic information, and groundwater and piezmetric data. Accordingly, the following assessments and area delineations are based upon precedent, field evidence and comparative survey data.

4.1 ATHENREE

The section of coastal land examined is a cliffed area of Athenree to the north and east of Pohutukawa Drive, shown on Drawing 4879-2. The site encompasses two terraces, with the land at lower terrace level (typically 10-11 m above MHWL) to the east of Pohutukawa Drive up to the upper terrace to the west of Pohutukawa Drive (about 18 m above MHWL).

Along the section of cliff the height varies from 18 m to the north down to mostly 10 m along the east. The geomorphology is such that the natural surface drainage is away from the cliffs back to the south. From cliff exposures alongside the lower terrace the typical subsurface profile appears to be 1 to 2 m of younger ashes (friable silt) overlying 1 m of older ashes (firm to stiff clay), these ashes overlying moderately cemented sand (Tauranga beds). In the tidal and wave zone the lithology appears moderately resistent to erosion. Also, being situated in a narrow upper harbour estuary the coastline has a high degree of natural protection from waves.

From a field examination of the site there is no evidence of major recent instability along the eastern cliffed section of lower terrace, and comparison of vertical aerial photographs indicates a relatively static shoreline. The extent of weathering and established vegetation are consistent with a static shoreline. Minor undercutting due to wetting and drying, weathering and bio-erosion is evident however, and thus regression of the cliff, albeit very slowly, must be expected. These cliffed coastal areas are therefore delineated A.

Along the north of the lower terrace and east of the upper terrace there is evidence of past instability, and the slopes are presently covered in pasture and scrub vegetation. The instability and erosion has resulted in backwearing of the slopes such that, rather than the slope angles of 50 to 80 degrees typical of the eastern cliffs, the northern slopes are 31 to 36 degrees.

Without more detailed subsurface investigation (which may necessitate drilling) it is difficult to assess whether the increased height of the upper terrace is due to an increased thickness of ashes or Tauranga beds, and whether or not there is any inherent feature in the geological materials or paleo-topography which may indicate the possibility of future instability. These slopes are therefore delineated B.

4.2 TANNERS POINT

The section of coastal land examined is an area of Tanners Point to the east and west of Tanners Point Road, shown on Drawing 4879-3. The site encompasses generally elevated sloping ground which is mostly cliffed at the coastal boundary. The eastern margin is entirely cliffed with the exception of a beach (at the boat ramp) formed at the outlet of the upslope gully area. Apart from the gully slopes which are mostly bare of substantial vegetation due to urban development, the eastern coastline is well vegetated, principally with Pohutukawa. There is evidence of past instability along the entire eastern margin, primarily within the ashes overlying the Tauranga beds, but there is little evidence of recent instability.

The western margin is much less extensively cliffed, with beaches, terraces and estuaries (with adjacent valley slopes) at the coastline. The cliffs on the western margin are typically low in height (less than 5 m) but mostly have sloping land above them. There is no evidence of major recent instability, but an area of developed land near the end of the point may have been formed by major slope failure. The rural land on the western margin is likely to have a paleo-topography more finely incised than is evident by the present topography. This area may therefore be a site of future active erosion processes, especially if the present groundwater flow regime is altered by the injection of domestic waste water and concentrated stormwater (essentially re-excavating the old land surface).

From field evidence and from comparison of vertical aerial photographs the coastline appears relatively static. As at Athenree, a resistant lithology (moderately cemented sand) is present in the tidal/wave zone, overlain by older ashes of various thickness in turn overlain by younger ashes. Tanners Point has, however, only a moderate protection from waves, especially the eastern margin. A well developed tidal stream is also evident adjacent to the eastern margin, which would remove debris fairly rapidly from the base of cliffs. The low cliffs on the western margin appear relatively static, though minor erosion, undercutting and block failure of the sandstone is evident. The cliffed coastal areas are therefore delineated A. The inland areas of land which we consider warrant more detailed examination are delineated B.

4.3 ONGARE

The section of coastal land examined is a cliffed area of Ongare to the east of Ongare Point Road and a relic coastal cliff to the west of The Esplanade, shown on Drawing 4879-4.

From the end of Ongare Road to the northern end of The Esplanade the coastal land ends in vertical cliffs with Tauranga beds evident at the tidal/wave zone. The cliffs are low (generally less than 5 metres), the cliff top well vegetated and the natural resistance of the lithologies (pyroclastic material and ash beds) exposed at the coastline appears generally high, although thin highly sensitive Tauranga beds are evident at the northern end of the cliffs. The cliffs are approximately vertical however, bare of vegetation and fresh material is present at the surface indicating active erosion and removal of material at the base of the cliff. The rate of regression is difficult to estimate without precise survey information but we would expect the rate to be very slow. The cliffs are therefore delineated A.

Behind The Esplanade the land slopes up to a ridge, this area being a relic coastal cliff now protected from marine erosion by the beach in front. Backwearing of this slope has occurred such that the land is now moderately to steeply sloping. These slopes are now largely bare of major vegetation and may be of marginal stability. These areas are therefore delineated B.

4.4 OMOKOROA PENINSULA

The section of coastal land examined is the cliffed coastal margin along the eastern margin of the Omokoroa Peninsula, shown on Drawing 4879-5. We have previously undertaken an investigation of the western and north-eastern coastal margin (Tonkin and Taylor Report 4487/2) and an area of elevated land to the east of Margaret Place (Tonkin and Taylor Report 4487/1).

With the exception of a 100 m section north of the end of Beach Grove, the coastal cliffs are now relic and no longer subject to active coastal erosion processes at the base of the cliffs. The cliffs on the eastern margin do not therefore appear to be actively eroding at the base, although backwearing at the cliff top is apparent.

From cliff exposures and from borehole information the area appears to be comprised of younger ashes overlying older ashes, in turn underlain by sediments (Tauranga beds), these beds being evident in the tidal/wave zone north of Beach Grove. Prior slope failure is evident along most of the eastern margin, although most of these landslips appear to be relatively old (compared to those on the western margin). However, some minor recent slope failures are evident, in particular on slopes where the vegetation has been removed.

The relic coastal cliffed areas, and inland areas which appear to be of marginal stability, are delineated B. North of Beach Grove, where active erosion is evident at the base of the slopes, the area is delineated A. An area of land off Margaret Place, although a relic coastal cliff, is also delineated A as recommended in the light of our detailed investigation.

4.5 OMOKOROA STATION ROAD

The section of coastal land examined is east of Omokoroa Station Road bordering the Te Puna River, shown on Drawing 4879-6. The land to the east of the railway line is cliffed at the coastal margin, the steep slopes being presently well vegetated. The area is situated alongside an estuary and has a high degree of natural protection from waves. From site inspection and from comparison of vertical aerial photographs the shoreline appears relatively static, with little erosion at the shoreline evident. Minor slipping of the cliffs is apparent, especially where major vegetation has been removed. However, these slips appear relatively shallow (2-3 m) and no recent landslips are evident. The steep slopes are therefore delineated A.

To the south west of the railway line the land encompasses an area of relic coastal margin, with the low lying land west of the railway line now reclaimed. The relic coastal cliff is now protected from active coastal erosion processes. The land is presently in pasture and old slope failures are evident. Accordingly the area is delineated B.

4.6 TE PUNA WEST (Snodgrass Road)

The section of coastline examined incorporates the coastal margin north of Matahiwi Road and east of Wallace and Snodgrass Roads to 40 m south of Park Lane, shown on Drawing 4879-2. Approximately 50% of the coastline is cliffed, with the cliff heights ranging from about 1 to 10 m. From the materials exposed in the cliffs the area is evidently comprised of younger ashes overlying a thin layer of older ashes, with Tauranga beds evident in the tidal/wave zone.

From examination of vertical aerial photographs the section of coastline appears relatively static. Vertical cliffed sections do, however, attest to active erosion and regression, but such regression appears to be either localised or very slow. The section of coastline is exposed to the north east and has, however, only a moderate degree of natural protection from waves. The cliffed coastal areas are therefore delineated A. Where the land at the coastline is gently sloping the coastline appears stable. Recent mangrove infestation of the small bays and inlets is apparent within the estuary, and this may afford greater protection to this coastline in future.

4.7 MAKETU

The section of coastal land examined is the northwestern cliffed area of the Maketu Peninsula, shown on Drawing 4879-8. The cliff ranges in height from 10 m at the southern end to 20 m at the northern end, and is mainly comprised of 3 to 8 metres of younger ashes (mainly Mangaoni Lapilli and Rotoehu Ash) overlying 1 to 2 m of older ashes, overlying terrestrial sediments which extend to, and below, the tidal/wave zone. These terrestrial sediments appear slightly to moderately resistant to erosion.

Bordering the Pacific Ocean the coastline is largely unprotected from waves. From comparison of vertical aerial photographs (1943 to 1978) and survey measurements (1932 to 1981) it is apparent that, contrary to popular belief, this particular section of coastline is essentially static, with little regression of the cliff base or backwearing of the cliff top evident over the past 30-50 years. This conclusion is also supported by long term local knowledge.

In general the cliff top is also the ridge top and thus there is little surface catchment area above the cliffs. On the section of coastline examined minor localised slope failures are evident. Where landsliding has occurred it appears that induced groundwater seepage, together with undercutting or removal of lateral support, has been a contributing factor. Seepage is evident at the younger ashes/older ashes interface and in particular where coarse permeable sands and silts (apparently Lower Rotoehu Ash) overlie considerably less permeable clay (older ashes and paleosols) a feature generally absent south of Rauporoa Road. This seepage appears to have caused erosion and minor slipping, with the result that localised regression has occurred. Continual erosion at the base of the cliffs will probably also inevitably lead to both localised and more general instability in the future.

However, factors appear to be such that we consider major deep seated slope failure is unlikely to occur. Accordingly the cliffed coastal areas are delineated A, with upslope gully areas delineated B.

5.0 GENERAL CONCLUSIONS

The extent and rate of active regression of the coastline apparent on the western margin of Omokoroa is not evident in the other areas of coastline examined in this study. Indeed, the full sequence of older ashes containing highly sensitive soils does not appear to be evident to the same extent elsewhere. However, past instability is evident in many locations, in particular the eastern margin of Omokoroa and the eastern margin of Tanners Point. Less extensive landsliding is evident at Omokoroa Station Road, the western margin of Tanners Point, and Maketu. Athenree and Te Puna West exhibit little evidence of widespread instability with only localised areas of instability apparent. Almost vertical unweathered cliffs faces do, however, attest to active erosion in specific areas.

From examination of vertical aerial photographs, field evidence and comparative survey data it is apparent that the rate of regression of the coastline (MHWL) over all the areas examined is very slow. The reason for this is probably the relative high degree of natural protection of the coastline from waves and the resistant lithologies at the tidal/wave zone (especially at Athenree and Tanners Point).

In contrast to the natural erosion of the base, the cliff tops appear to have regressed by landslides, resulting in both localised and, where numerous, a general backwearing of the cliff. Although many areas adjacent to the coastline appear to have been relatively stable over recent times (past 40 years), more intensive development of these areas may upset the present stability balance, especially if stormwater is injected into ground near the cliff edges or into areas of potential instability, slopes are undercut, or vegetation is removed.

Also, although slow, the marine erosion of the base of cliffs will probably lead to renewed landslip activity in the long term. The areas we consider most vulnerable to landslip activity are steep cliffs greater than 10 m high containing sequences of older ashes and, in particular, highly sensitive soils, where stormwater is concentrated above the slopes. In general terms the greater the thickness of mantle deposits (especially older ashes) the greater the backwearing when landslips occur.

Recommendations for the reduction or avoidance of erosion or landslip in the areas examined are discussed in the following section.

6.0 RECOMMENDATIONS

6.1 DEVELOPMENT CRITERIA

In areas delineated A (vulnerable to long term landslip risk) we recommend that no building or any development, (including cutting, filling, removal of vegetation, stormwater or domestic waste water disposal) be permitted.

In areas delineated B (possibly subject to instability) we recommend that any building or development (including cutting, filling, removal of vegetation, stormwater or domestic waste water disposal) only be allowed to proceed in the light of specialist advice.

In undelineated areas of lots encompassing, or adjacent to, areas delineated A or B we consider that development may proceed without specialist advice provided that Council is satisfied that such development will not adversely affect other areas or lots.

6.2 STORMWATER RETICULATION

In areas delineated A and B containing evidence of past instability which are already developed we consider that stormwater should be properly reticulated and ground injection terminated. Accordingly, as a matter of priority we recommend that the Omokoroa Peninsula be serviced by stormwater reticulation. Other areas where we consider reticulation is warranted include the eastern margin of Tanners Point and the western margin of Maketu north of Rauporoa Road.

Stormwater runoff from roadways and upslope catchment areas is presently reticulated in Athenree, Tanners Point, Omokoroa and Maketu. It is essential that this stormwater is not concentrated onto or over areas delineated A or B, either at the outlet of the reticulated system or any overland flow path when the design capacity of the system is exceeded or the system is inoperable through damage or blockage. Accordingly we recommend that a walkover inspection of all outlets and concentration points be undertaken, preferably during prolonged rainfall, to ensure that the stormwater is discharging at or below MHWL and that the system is clear of blockages and operating satisfactorily. We note in Maketu that the upper Town Point Road stormwater drain presently discharges into the ground west of the end of Rauporoa Road. We recommend that this stormwater be taken all the way down Town Point Road.

6.3 LANDSLIP RECORD

A record of instability problems should be kept for the areas examined by plotting the location on the plans, and recording the date of occurrence and other relevant details, alongside. In this way problems which are essentially site specific, (e.g. due to concentrated stormwater disposal) may be better distinguished from problems affecting a wider area, (e.g. renewal landslip activity along a whole section of coastline due to natural erosion processes).

6.4 MONITORING AND INSPECTION

To record landslips at the coastal margin, and to monitor areas of undercutting which may precede slope failure, we recommend that a walkover inspection at the coastline of areas delineated A be undertaken yearly.

6.5 COASTAL SURVEY

For sections of the coastline where active erosion is evident by bare free fall cliffs we recommend that the cliff top be accurately fixed at various locations. This can either be done by field survey or by photogrammetric techniques from the recent aerial photographs. In this way, if re-surveyed every ten years, quantitative information can be obtained to better assess the rate of cliff regression at particular locations.

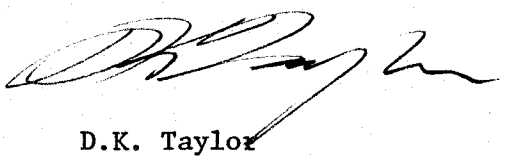
6.6 FURTHER INVESTIGATIONS

From examination of aerial photographs and field evidence during the present study it is apparent that many other coastal areas, and also areas inland from the coastline, have, or could possibly have, problems regarding landslip and erosion. Accordingly we recommend that a very broad brush examination of all remaining residential or proposed residential areas be undertaken to broadly identify areas of actual and potential hazard.

7.0 ACKNOWLEDGEMENTS

In undertaking this study we wish to gratefully acknowledge the assistance of the staff of the Tauranga County Council, in particular Mr I.D. McKenzie County Engineer, and Mr B. Smith, Engineering Officer, for their contribution with data collection. We also wish to thank Messrs B.F. Houghton (New Zealand Geological Survey, DSIR) and W.E. Cotching (Soil Bureau, DSIR) for their assistance in the field in describing and identifying the lithologies and soils of the areas.

Finally we extend our thans to the Tauranga County residents of the areas examined for their co-operative attitude in allowing access to the cliffs and beaches and to those residents who willingly provided assistance and information.

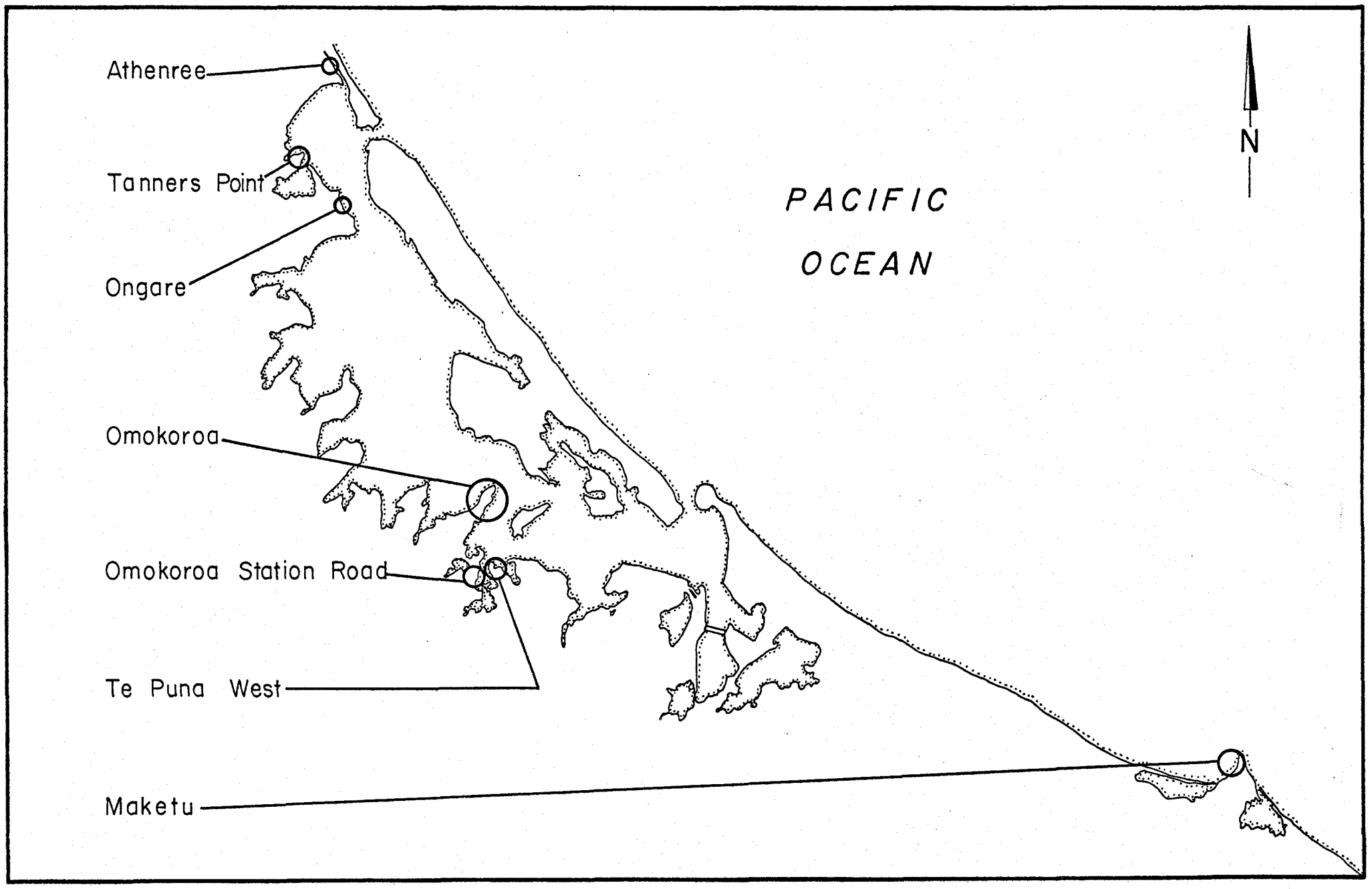


D.K. Taylor

TONKIN & TAYLOR LTD
Consulting Civil Engineers
& Registered Surveyors

Prepared by: N.W. Rogers

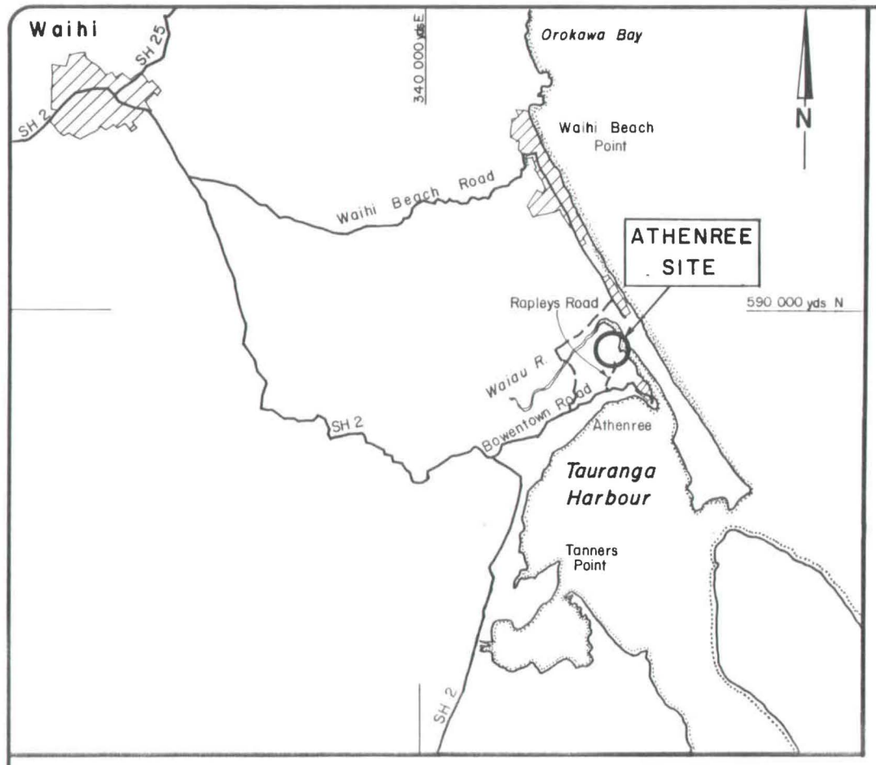
Encl. Drawing 4879-1 to 8



SITES LOCATION PLAN

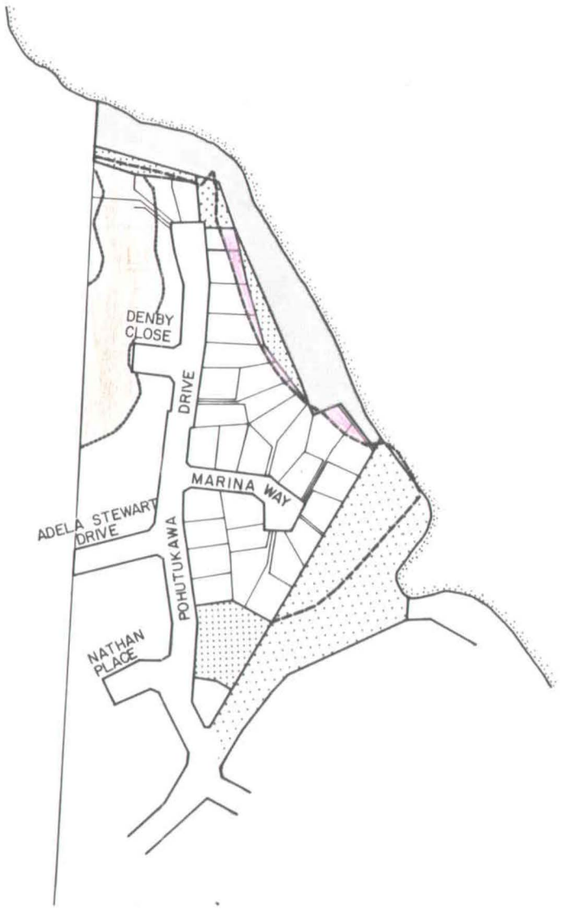
Scale 1: 250 000

4879-1



LOCALITY PLAN

1:63 360



LEGEND

- Esplanade Reserve
- Recreation Reserve
- Road Reserve (not formed)
- Historic Reserve
- A — Vulnerable to long term landslip risk
- B — Possibly subject to instability

GRAPHIC SCALE m5000 0 ·05 ·10 ·15 ·20 ·25 ·30 ·35 km

ORIGINAL SCALE

NOTES

CKD	REVISION	DATE

APPROVED

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TONKIN & TAYLOR

CONSULTING ENGINEERS
REGISTERED SURVEYORS
TOWN PLANNERS

47 George St., Newmarket, Auckland

TITLE

TAURANGA COUNTY COUNCIL

STABILITY ASSESSMENT OF COASTAL LAND ATHENREE

REFERENCES

COUNTY OF TAURANGA

Athenree Community Area, 1:500 series
Approx. Scale 1:2000 - Sheet 1A

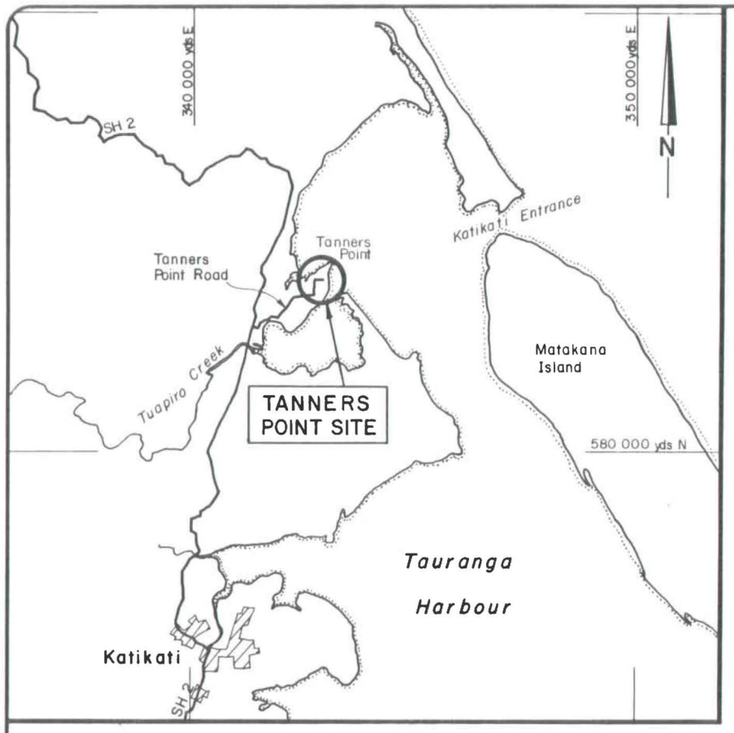
ORIGINAL SCALES

~~1:2500~~
1:5000

metric design

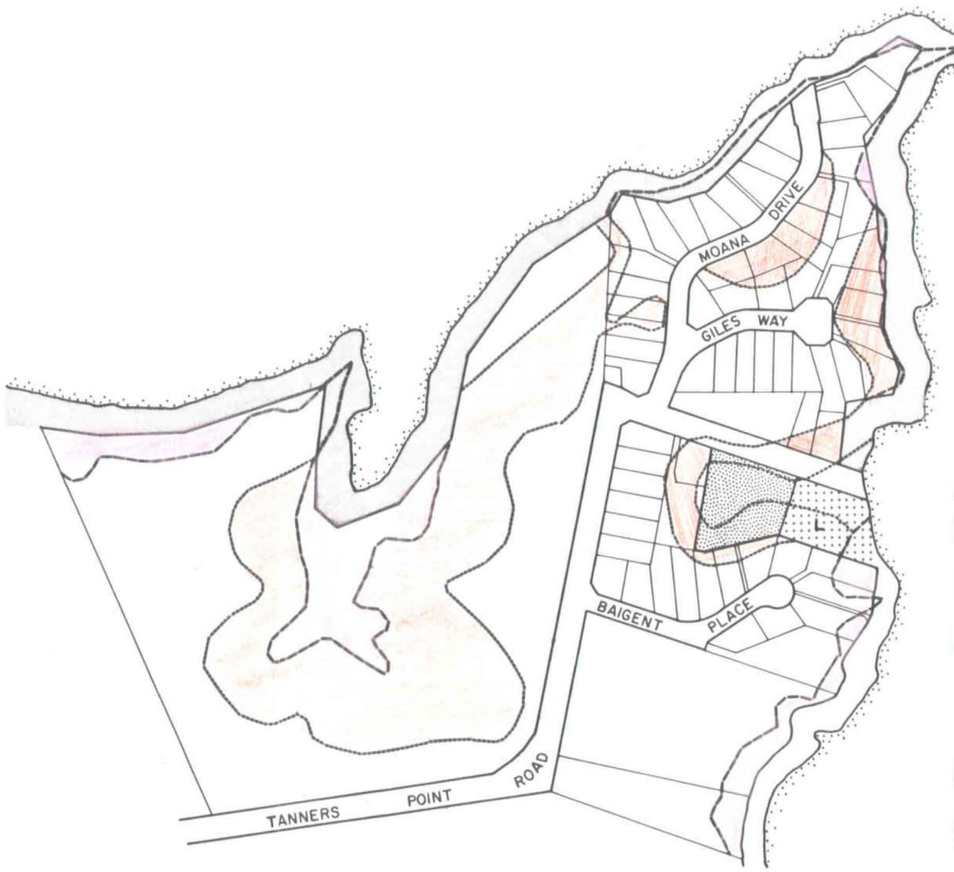
DRAWING No. 4879 - 2

DATE AUG. 1981



LOCALITY PLAN

1 : 63 360



LEGEND

- Esplanade Reserve
- L — Historic Landing Reserve
- Utility Reserve
- A — Vulnerable to long term landslip risk
- B — Possibly subject to instability

GRAPHIC SCALE m 5000 0 05 10 15 20 25 30 35 km

ORIGINAL SCALE

NOTES

CKD	REVISION	DATE

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REGISTERED SURVEYORS
TOWN PLANNERS

47 George St., Newmarket, Auckland

TITLE

TAURANGA COUNTY COUNCIL

STABILITY ASSESSMENT OF COASTAL LAND TANNERS POINT

REFERENCES

Locality Plan
MURRY-NORTH PARTNERS LTD
TANNERS POINT & ONGARE 18

Main Plan compiled from
County of Tauranga, Plan No 1046/ &
Scale 1:1000 1046/2

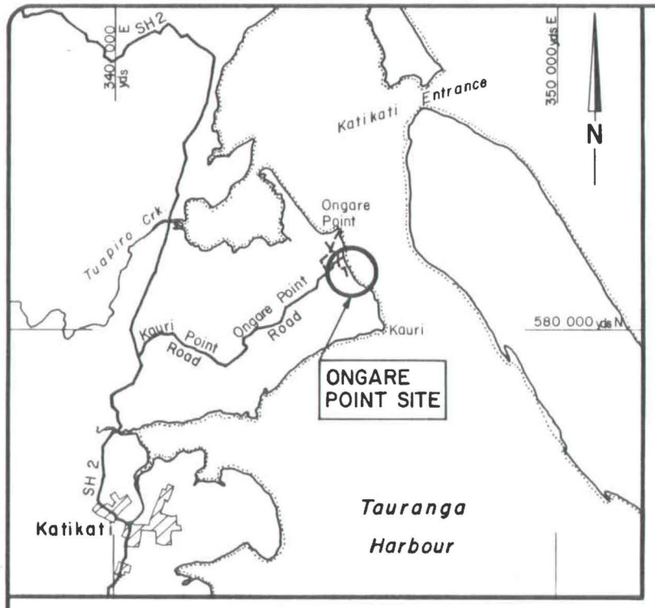
ORIGINAL SCALES

1 : ~~2500~~ 5000

metric design

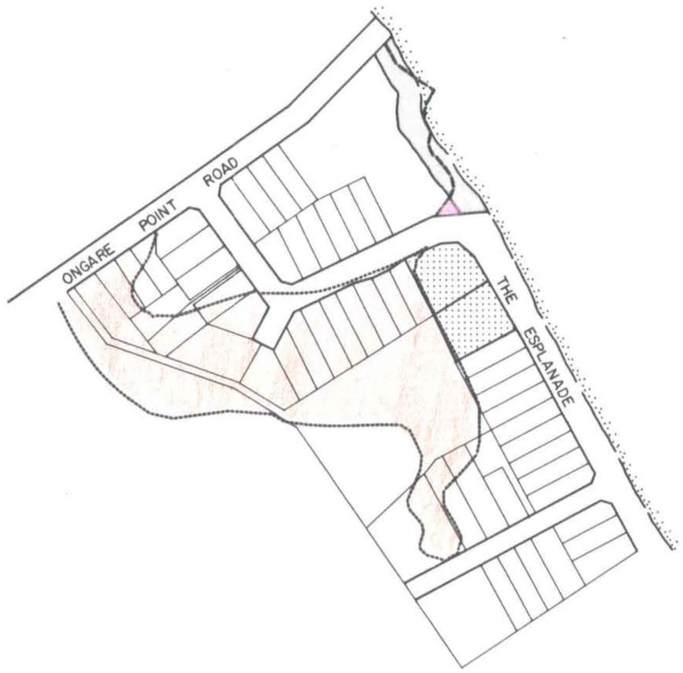
DRAWING No. 4879 -3

DATE AUG. 1981



LOCALITY PLAN

1:63 360



TAURANGA HARBOUR

N

LEGEND

- Esplanade Reserve
- Recreation Reserve
- A — Vulnerable to long term landslip risk
- B — Possibly subject to instability

NOTES

CKD	REVISION	DATE

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REGISTERED SURVEYORS
TOWN PLANNERS

47 George St., Newmarket, Auckland

TITLE

TAURANGA COUNTY COUNCIL

STABILITY ASSESSMENT OF COASTAL LAND ONGARE POINT

REFERENCES

COUNTY OF TAURANGA

Ongare Point Area - Plan No. 1049/1
Original Scale 1:1000

ORIGINAL SCALES

1:~~2500~~ 5000

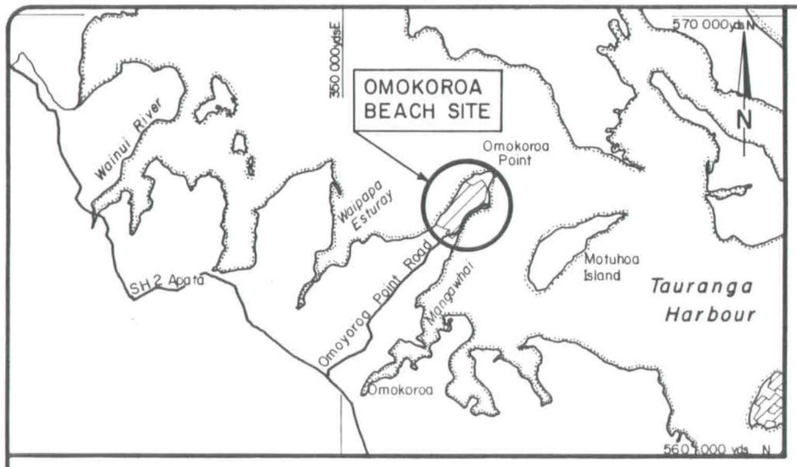
metric design

DRAWING No. 4879– 4

DATE AUG. 1981

GRAPHIC SCALE m5000 0 ·0.5 ·1.0 ·1.5 ·2.0 ·2.5 ·3.0 ·3.5 km

ORIGINAL SCALE



LOCALITY PLAN

1 : 63 360

N

HARBOUR VIEW ROAD

MYRTLE DRIVE

OMOKOROA ROAD

HARBOUR VIEW ROAD

OMOKOROA ROAD

BEACH GROVE

OMOKOROA ROAD

LIMERICK LANE

MARGARET PLACE

TINOPA DRIVE

TAURANGA HARBOUR

LEGEND

- Esplanade Reserve
- Recreation Reserve
- Historic Reserve
- A — Vulnerable to long term landslip risk
- B — Possibly subject to instability

GRAPHIC SCALE m 5000 0 ·05 ·10 ·15 ·20 ·25 ·30 ·35 km

CKD	REVISION	DATE

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CONSULTING ENGINEERS
REGISTERED SURVEYORS
TOWN PLANNERS

47 George St., Newmarket, Auckland.

TITLE

TAURANGA COUNTY COUNCIL

STABILITY ASSESSMENT OF COASTAL LAND OMOKOROA BEACH

REFERENCES
OMOKOROA BEACH - from L&S Block Shts
Southern limit Beach Grove Roadway.
COUNTY OF TAURANGA - Margaret Street
Area - Original Scale 1:7500
MURRAY-NORTH PARTNERS LTD - A 1281
Sht 1 Auckland L — 1 Chain to 1 inch

ORIGINAL SCALES

1 : 2500
5000

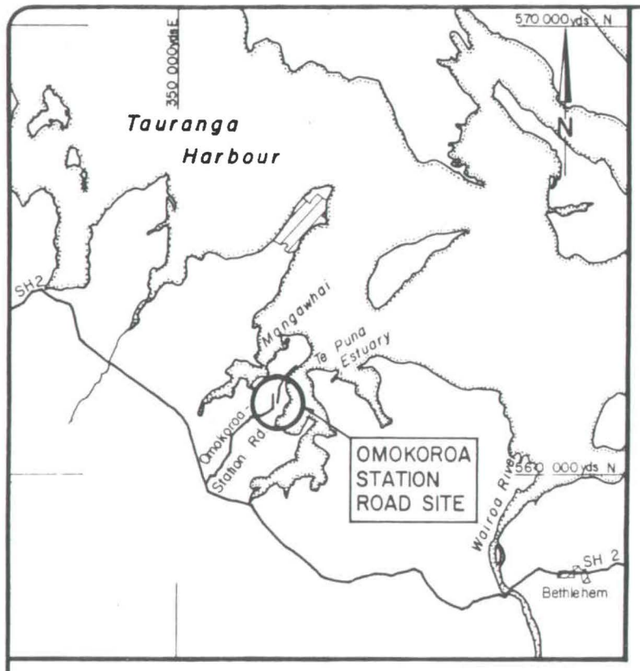
metric design

DRAWING No.

4879 - 5

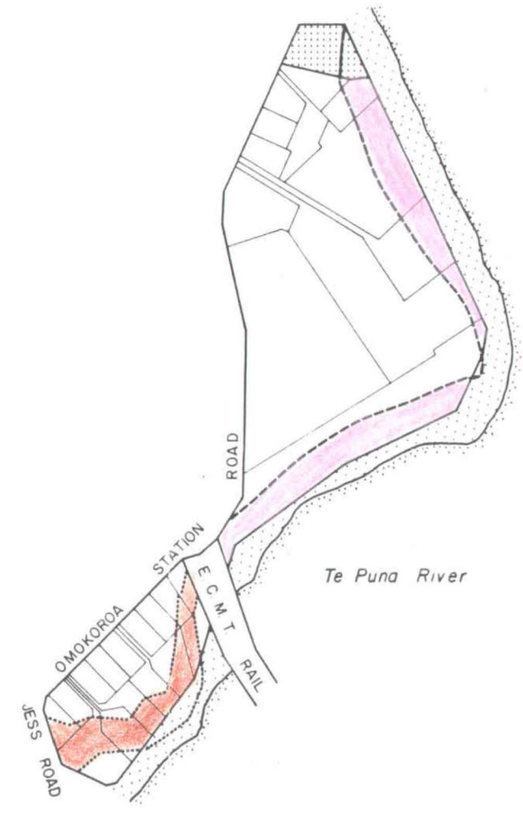
DATE

AUG. 1981



LOCALITY PLAN

1:63 360



N

LEGEND

- Road Reserve
- Recreation Reserve
- A — Vulnerable to long term landslip risk
- B — Possibly subject to instability

GRAPHIC SCALE m5000 0 ·05 ·10 ·15 ·20 ·25 ·30 ·35 km

NOTES

CKD	REVISION	DATE

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TOWN PLANNERS

47 George St, Newmarket, Auckland.

TITLE

TAURANGA COUNTY COUNCIL

STABILITY ASSESSMENT OF COASTAL LAND OMOKOROA STATION ROAD

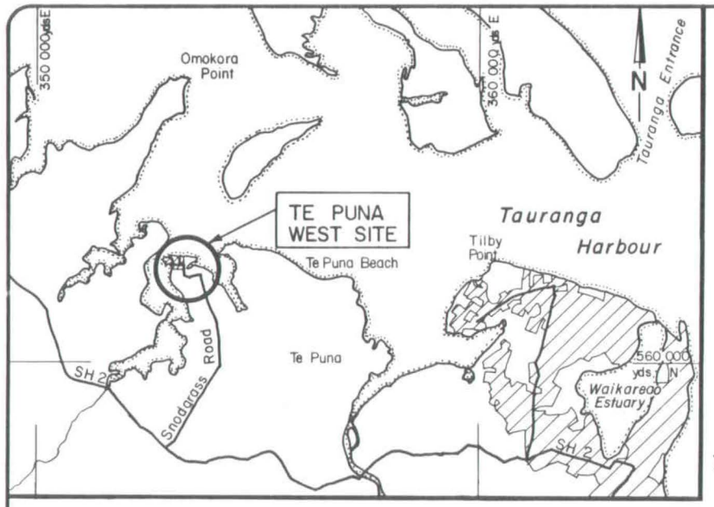
REFERENCES
COUNTY OF TAURANGA
Omokoroa Station Road
Original Scale 1:1000

ORIGINAL SCALES
1:~~2500~~ 5000

metric design

DRAWING No. 4879-6

DATE AUG. 1981



LOCALITY PLAN

1:63 360

TAURANGA HARBOUR

Te Puna River

Waikaraka Estuary

MATAHIWI ROAD

FAIRLIE GROVE

WALLACE ROAD

WALLACE ROAD

SNODGRASS ROAD

LINDOCH AVE.

DRAINAGE EASEMENT

PARK LANE

LEGEND

Esplanade Reserve

A — Vulnerable to long term landslip risk

B — Possibly subject to instability

GRAPHIC SCALE m5000 0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 km

ORIGINAL SCALE

NOTES

CKD	REVISION	DATE

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REGISTERED SURVEYORS
TOWN PLANNERS

47 George St., Newmarket, Auckland.

TITLE

TAURANGA COUNTY COUNCIL

STABILITY ASSESSMENT OF COASTAL LAND TE PUNA WEST

REFERENCES

COUNTY OF TAURANGA

Te Puna West, Scale 1:2500

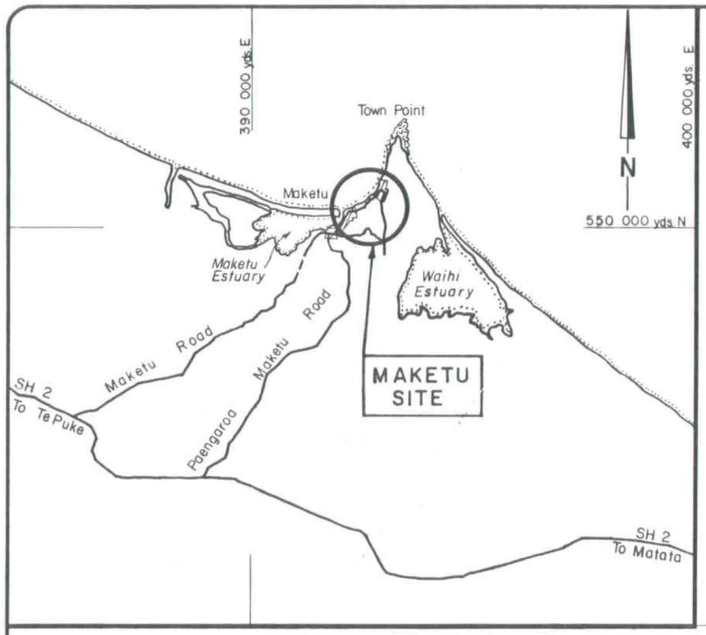
ORIGINAL SCALES

1:2~~500~~ 5000

metric design

DRAWING No. 4879-7

DATE AUG. 1981



LOCALITY PLAN

1 : 63 360

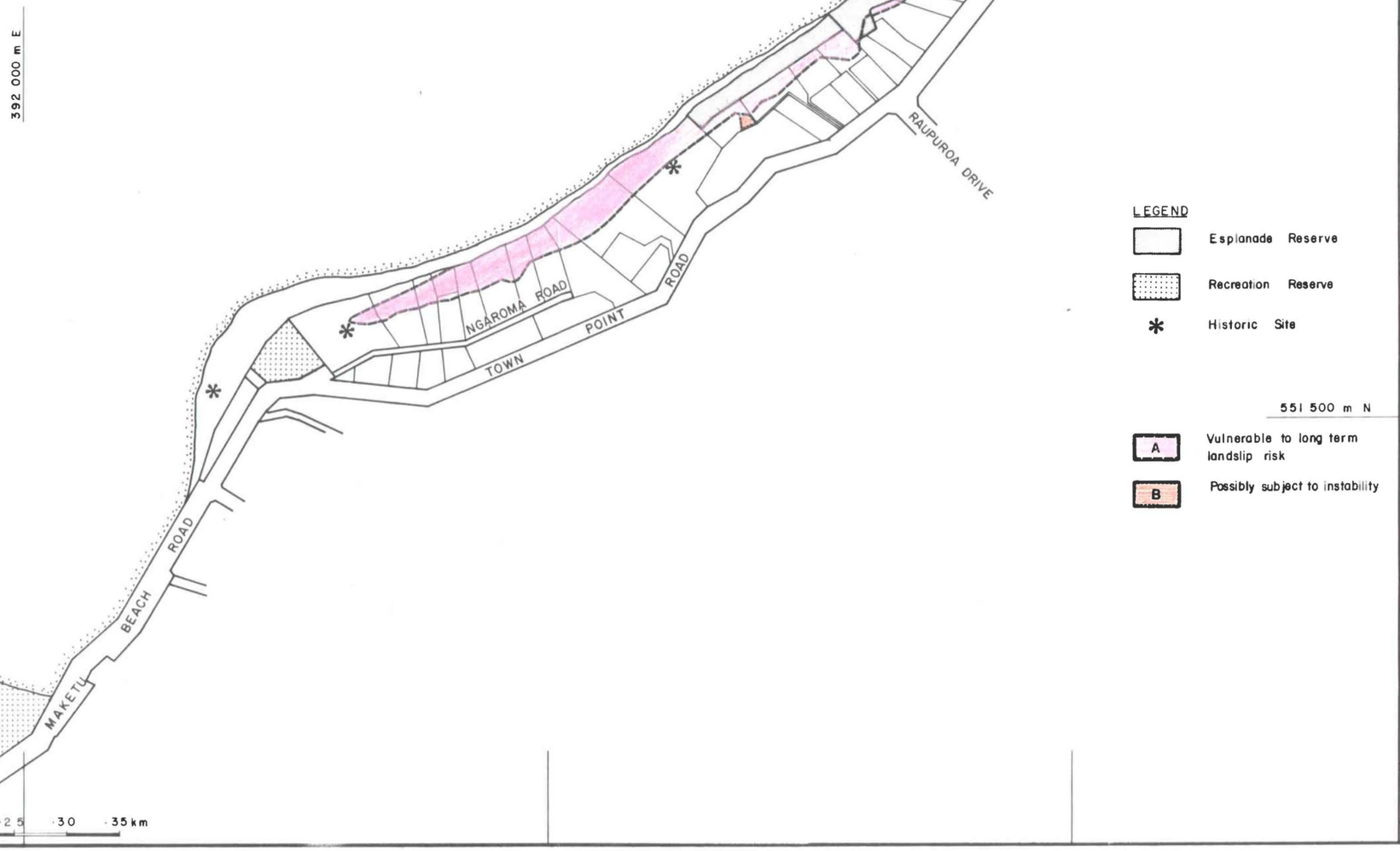
392 500 m E

393 000 m E

N

551 000 m N

551 500 m N



LEGEND

- Esplanade Reserve
- Recreation Reserve
- * Historic Site
- A — Vulnerable to long term landslip risk
- B — Possibly subject to instability

ORIGINAL SCALE

NOTES

CKD	REVISION	DATE

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TOWN PLANNERS

47 George St., Newmarket, Auckland.

TITLE

TAURANGA COUNTY COUNCIL

STABILITY ASSESSMENT OF COASTAL LAND MAKETU

REFERENCES

Locality Plan
MURRY-NORTH PARTNERS LTD.
MAKETU 36

Main Plan compiled from L & S Blk. Shts.

ORIGINAL SCALES

1 : ~~2500~~ 5000

metric design

DRAWING No

4879 -8

DATE

AUG. 1981