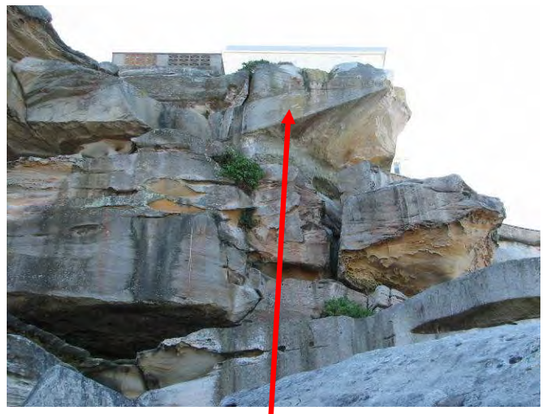

Hastings Parade

Ramsgate Avenue

Brighton Boulevard

No 158 Brighton Boulevard

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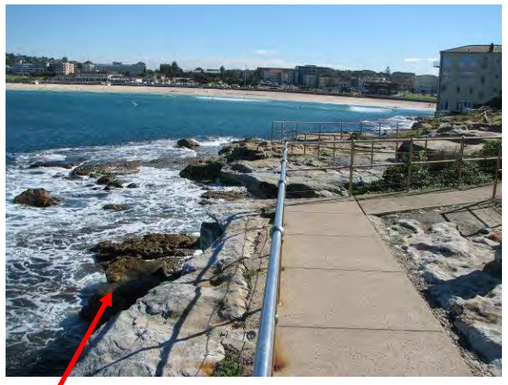
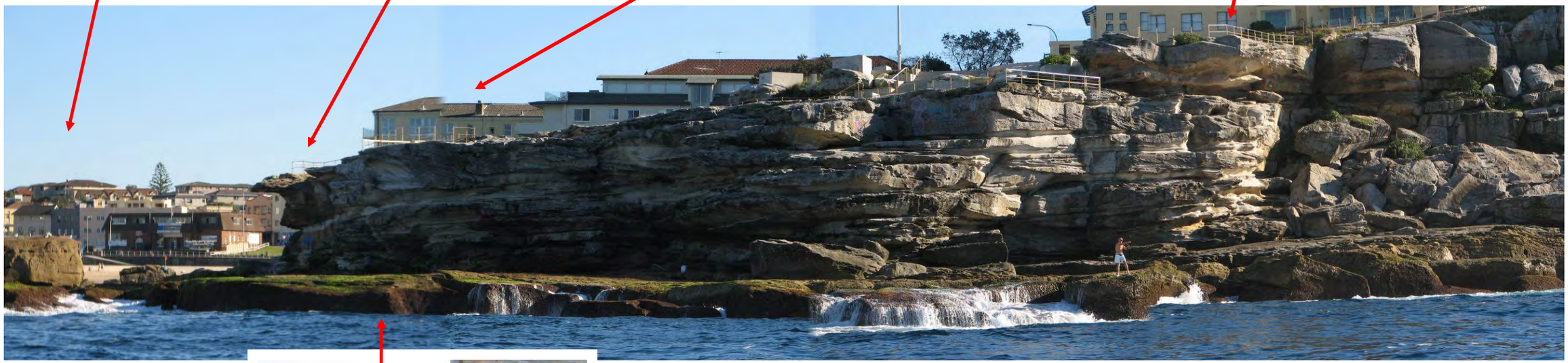




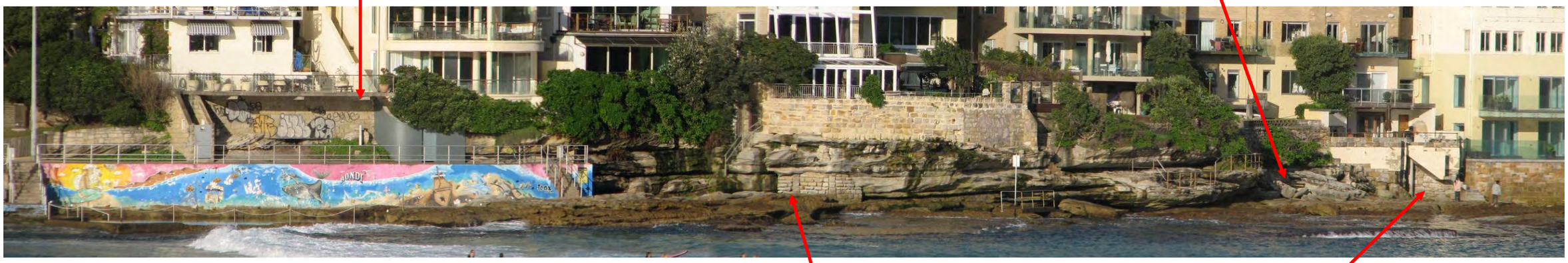
Ben Buckler Headland

To be read in conjunction with text of report.

Ben Buckler Amateur Fish Club

To be read in conjunction with text of report.

North Bondi Rock Pool



Stormwater box culvert

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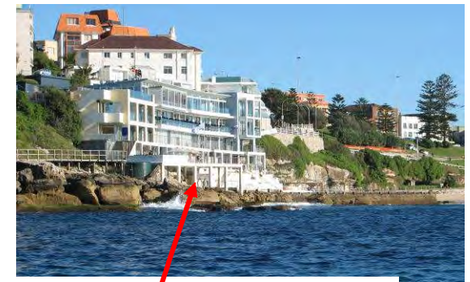
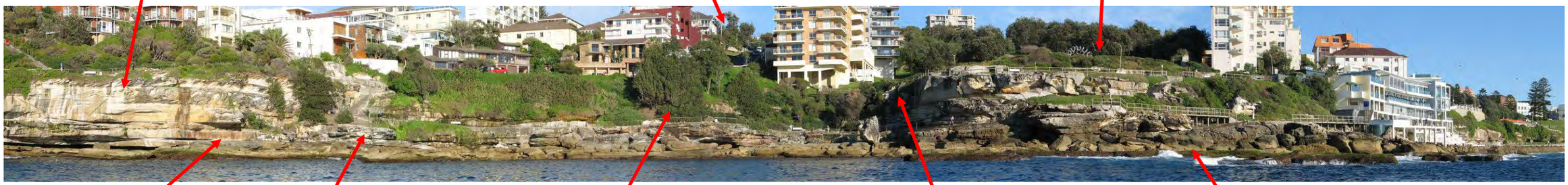
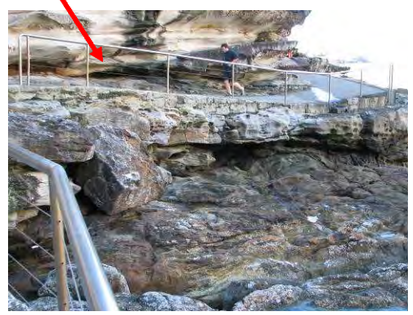


Hunter Park

Bondi Icebergs





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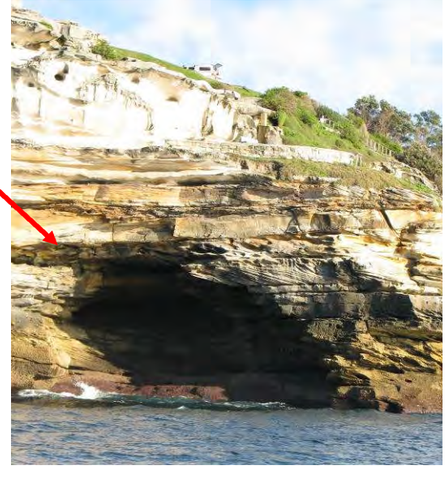
Marks Park



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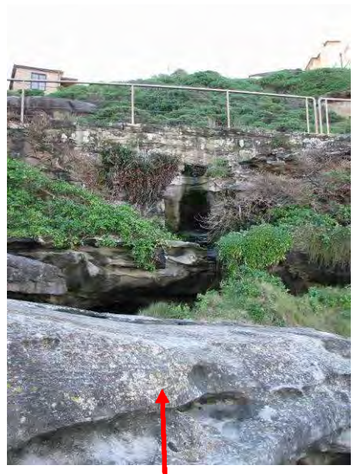
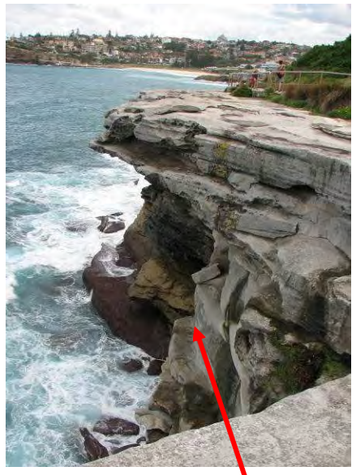
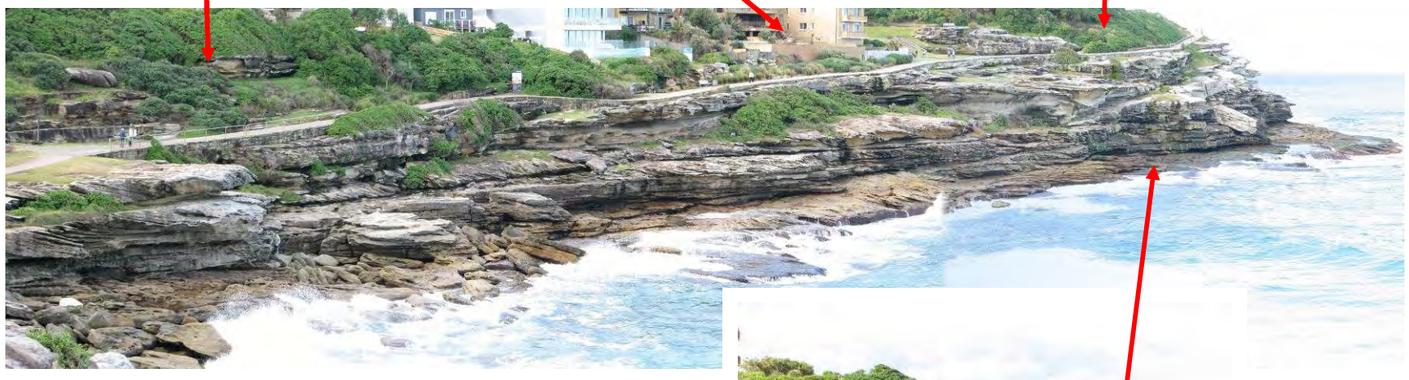
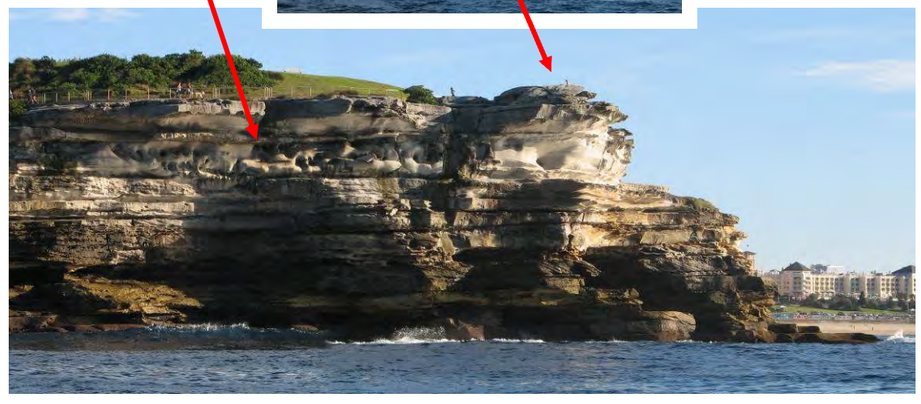






Mackenzies Bay



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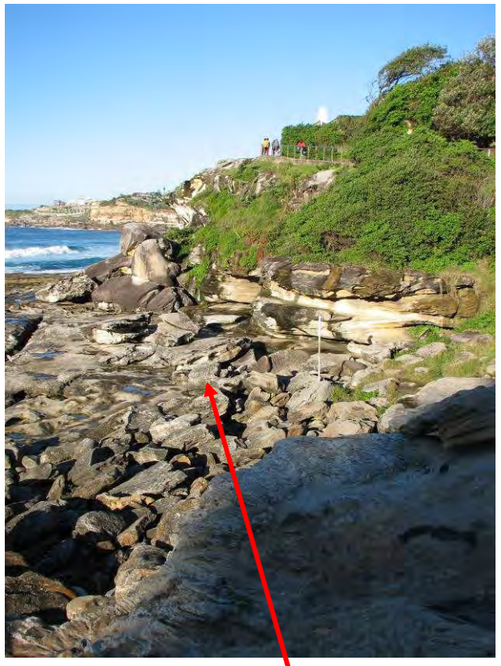

Mackenzies Bay

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Northern side of Tamarama Beach

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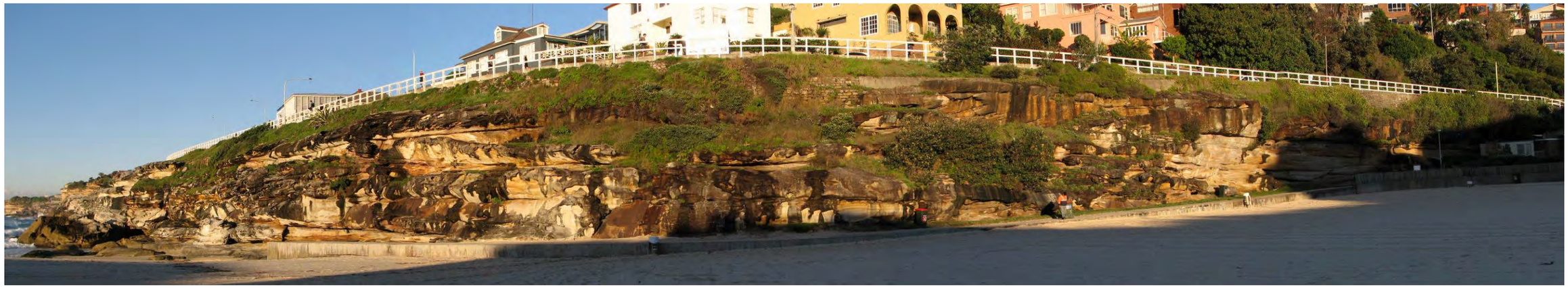

Southern side of Tamarama Beach

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To be read in conjunction with text of report.

Northern side of Bronte Beach

Roof of stormwater box culvert

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Bronte rock baths

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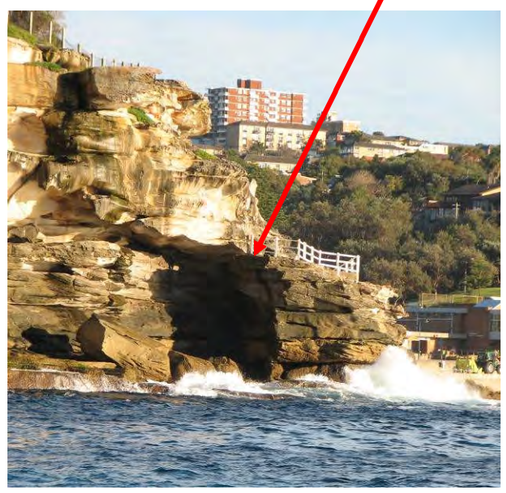
Damaged fence on Calga Place



To be read in conjunction with text of report.

Gully feature

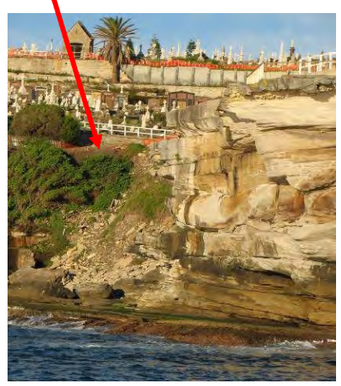
Calga Reserve

To be read in conjunction with text of report.

Ref: 24648ZR Plate 33

Eastern end of Boundary Street

Gully feature



To be read in conjunction with text of report.

24648ZR • PLATE 33

Crest area of gully feature

Waverley Cemetery

Calga Reserve

To be read in conjunction with text of report.

APPENDIX A

LANDSLIDE RISK MANAGEMENT TERMINOLOGY

APPENDIX A
LANDSLIDE RISK MANAGEMENT

Definition of Terms and Landslide Risk

Risk Terminology	Description
Acceptable Risk	A risk for which, for the purposes of life or work, we are prepared to accept as it is with no regard to its management. Society does not generally consider expenditure in further reducing such risks justifiable.
Annual Exceedance Probability (AEP)	The estimated probability that an event of specified magnitude will be exceeded in any year.
Consequence	The outcomes or potential outcomes arising from the occurrence of a landslide expressed qualitatively or quantitatively, in terms of loss, disadvantage or gain, damage, injury or loss of life.
Elements at Risk	The population, buildings and engineering works, economic activities, public services utilities, infrastructure and environmental features in the area potentially affected by landslides.
Frequency	A measure of likelihood expressed as the number of occurrences of an event in a given time. See also 'Likelihood' and 'Probability'.
Hazard	A condition with the potential for causing an undesirable consequence (the landslide). The description of landslide hazard should include the location, volume (or area), classification and velocity of the potential landslides and any resultant detached material, and the likelihood of their occurrence within a given period of time.
Individual Risk to Life	The risk of fatality or injury to any identifiable (named) individual who lives within the zone impacted by the landslide; or who follows a particular pattern of life that might subject him or her to the consequences of the landslide.
Landslide Activity	The stage of development of a landslide; pre failure when the slope is strained throughout but is essentially intact; failure characterised by the formation of a continuous surface of rupture; post failure which includes movement from just after failure to when it essentially stops; and reactivation when the slope slides along one or several pre-existing surfaces of rupture. Reactivation may be occasional (eg. seasonal) or continuous (in which case the slide is 'active').
Landslide Intensity	A set of spatially distributed parameters related to the destructive power of a landslide. The parameters may be described quantitatively or qualitatively and may include maximum movement velocity, total displacement, differential displacement, depth of the moving mass, peak discharge per unit width, or kinetic energy per unit area.
Landslide Risk	The AGS Australian GeoGuide LR7 (AGS, 2007e) should be referred to for an explanation of Landslide Risk.
Landslide Susceptibility	The classification, and volume (or area) of landslides which exist or potentially may occur in an area or may travel or retrogress onto it. Susceptibility may also include a description of the velocity and intensity of the existing or potential landsliding.
Likelihood	Used as a qualitative description of probability or frequency.
Probability	A measure of the degree of certainty. This measure has a value between zero (impossibility) and 1.0 (certainty). It is an estimate of the likelihood of the magnitude of the uncertain quantity, or the likelihood of the occurrence of the uncertain future event. These are two main interpretations: (i) Statistical – frequency or fraction – The outcome of a repetitive experiment of some kind like flipping coins. It includes also the idea of population variability. Such a number is called an 'objective' or relative frequentist probability because it exists in the real world and is in principle measurable by doing the experiment.

Risk Terminology	Description
Probability ***(continued)***	(ii) Subjective probability (degree of belief) – Quantified measure of belief, judgment, or confidence in the likelihood of an outcome, obtained by considering all available information honestly, fairly, and with a minimum of bias. Subjective probability is affected by the state of understanding of a process, judgment regarding an evaluation, or the quality and quantity of information. It may change over time as the state of knowledge changes.
Qualitative Risk Analysis	An analysis which uses word form, descriptive or numeric rating scales to describe the magnitude of potential consequences and the likelihood that those consequences will occur.
Quantitative Risk Analysis	An analysis based on numerical values of the probability, vulnerability and consequences and resulting in a numerical value of the risk.
Risk	A measure of the probability and severity of an adverse effect to health, property or the environment. Risk is often estimated by the product of probability x consequences. However, a more general interpretation of risk involves a comparison of the probability and consequences in a non-product form.
Risk Analysis	The use of available information to estimate the risk to individual, population, property, or the environment, from hazards. Risk analyses generally contain the following steps: scope definition, hazard identification and risk estimation.
Risk Assessment	The process of risk analysis and risk evaluation.
Risk Control or Risk Treatment	The process of decision-making for managing risk and the implementation or enforcement of risk mitigation measures and the re-evaluation of its effectiveness from time to time, using the results of risk assessment as one input.
Risk Estimation	The process used to produce a measure of the level of health, property or environmental risks being analysed. Risk estimation contains the following steps: frequency analysis, consequence analysis and their integration.
Risk Evaluation	The stage at which values and judgments enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental and economic consequences, in order to identify a range of alternatives for managing the risks.
Risk Management	The complete process of risk assessment and risk control (or risk treatment).
Societal Risk	The risk of multiple fatalities or injuries in society as a whole: one where society would have to carry the burden of a landslide causing a number of deaths, injuries, financial, environmental and other losses.
Susceptibility	See 'Landslide Susceptibility'.
Temporal Spatial Probability	The probability that the element at risk is in the area affected by the landsliding, at the time of the landslide.
Tolerable Risk	A risk within a range that society can live with so as to secure certain net benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if possible.
Vulnerability	The degree of loss to a given element or set of elements within the area affected by the landslide hazard. It is expressed on a scale of 0 (no loss) to 1 (total loss). For property, the loss will be the value of the damage relative to the value of the property; for persons, it will be the probability that a particular life (the element at risk) will be lost, given the person(s) is affected by the landslide.

NOTE: Reference should be made to Figure A1 which shows the inter-relationship of many of these terms and the relevant portion of Landslide Risk Management.

Reference should also be made to the paper referenced below for Landslide Terminology and more detailed discussion of the above terminology.

This appendix is an extract from PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT as presented in Australian Geomechanics, Vol 42, No 1, March 2007, which discusses the matter more fully.

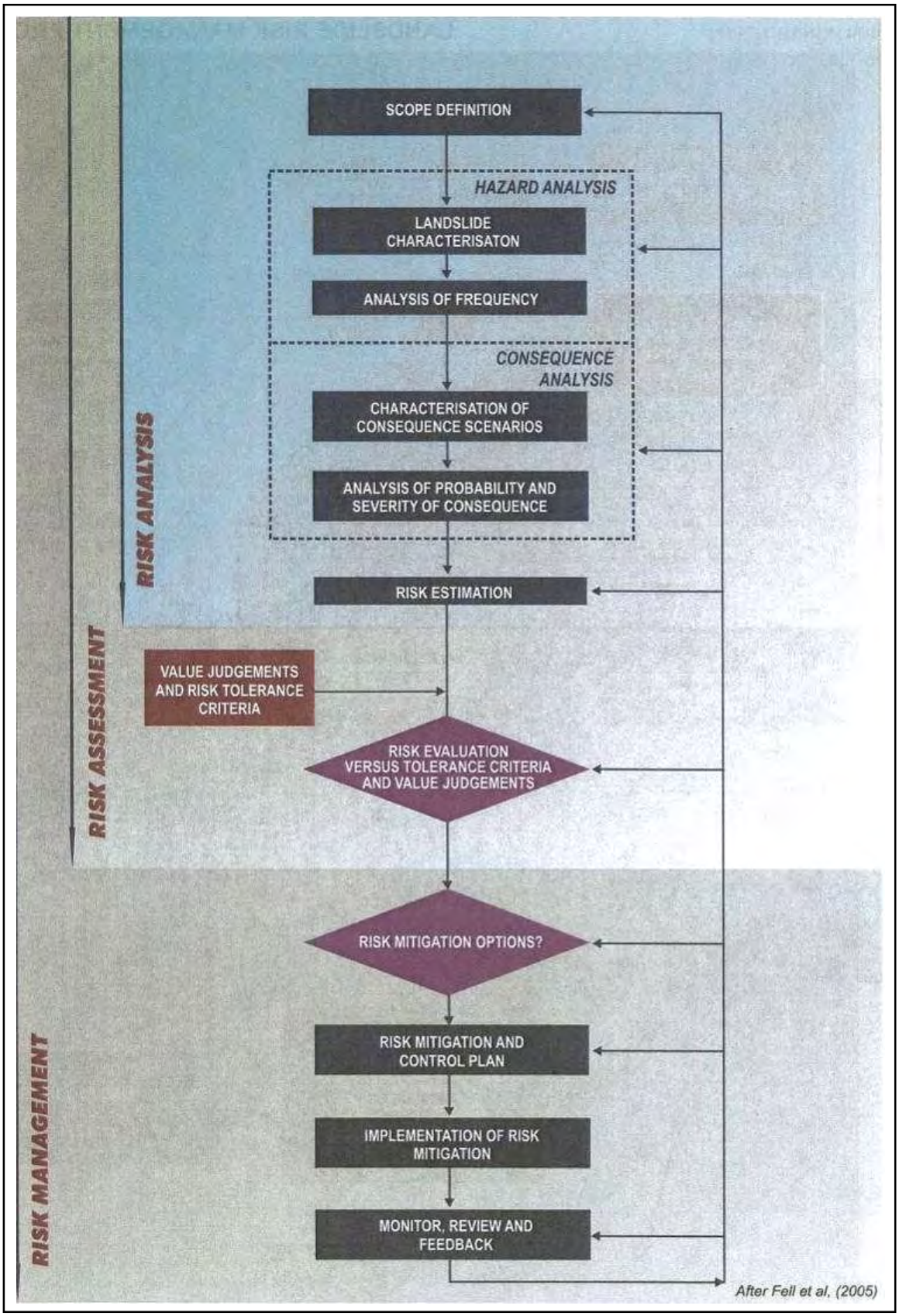


FIGURE A1: Flowchart for Landslide Risk Management.

This figure is an extract from GUIDELINE FOR LANDSLIDE SUSCEPTIBILITY, HAZARD AND RISK ZONING FOR LAND USE PLANNING, as presented in Australian Geomechanics Vol 42, No 1, March 2007, which discusses the matter more fully.

TABLE A1: LANDSLIDE RISK ASSESSMENT
QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa.

Extract from PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT as presented in Australian Geomechanics, Vol 42, No 1, March 2007, which discusses the matter more fully.

TABLE A1: LANDSLIDE RISK ASSESSMENT
QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (continued)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or **L** (5)
B - LIKELY	10^{-2}	VH	VH	H	M	**L**
C - POSSIBLE	10^{-3}	VH	H	M	M	**VL**
D - UNLIKELY	10^{-4}	H	M	**L**	**L**	**VL**
E - RARE	10^{-5}	M	**L**	**L**	**VL**	**VL**
F - BARELY CREDIBLE	10^{-6}	**L**	**VL**	**VL**	**VL**	**VL**

Notes: (5) Cell A5 may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

Extract from PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT as presented in Australian Geomechanics, Vol 42, No 1, March 2007, which discusses the matter more fully.

AUSTRALIAN GEOGUIDE LR2 (LANDSLIDES)

What is a Landslide?

Any movement of a mass of rock, debris, or earth, down a slope, constitutes a "landslide". Landslides take many forms, some of which are illustrated. More information can be obtained from Geoscience Australia, or by visiting its Australian landslide Database at www.ga.gov.au/urban/factsheets/landslide.jsp. Aspects of the impact of landslides on buildings are dealt with in the book "Guideline Document Landslide Hazards" published by the Australian Building Codes Board and referenced in the Building Code of Australia. This document can be purchased over the internet at the Australian Building Codes Board's website www.abcb.gov.au.

Landslides vary in size. They can be small and localised or very large, sometimes extending for kilometres and involving millions of tonnes of soil or rock. It is important to realise that even a 1 cubic metre boulder of soil, or rock, weighs at least 2 tonnes. If it falls, or slides, it is large enough to kill a person, crush a car, or cause serious structural damage to a house. The material in a landslide may travel downhill well beyond the point where the failure first occurred, leaving destruction in its wake. It may also leave an unstable slope in the ground behind it, which has the potential to fall again, causing the landslide to extend (regress) uphill, or expand sideways. For all these reasons, both "potential" and "actual" landslides must be taken very seriously. The present a real threat to life and property and require proper management.

Identification of landslide risk is a complex task and must be undertaken by a geotechnical practitioner (GeoGuide LR1) with specialist experience in slope stability assessment and slope stabilisation.

What Causes a Landslide?

Landslides occur as a result of local geological and groundwater conditions, but can be exacerbated by inappropriate development (GeoGuide LR8), exceptional weather, earthquakes and other factors. Some slopes and cliffs never seem to change, but are actually on the verge of failing. Others, often moderate slopes (Table 1), move continuously, but so slowly that it is not apparent to a casual observer. In both cases, small changes in conditions can trigger a landslide with series consequences. Wetting up of the ground (which may involve a rise in groundwater table) is the single most important cause of landslides (GeoGuide LR5). This is why they often occur during, or soon after, heavy rain. Inappropriate development often results in small scale landslides which are very expensive in human terms because of the proximity of housing and people.

Does a Landslide Affect You?

Any slope, cliff, cutting, or fill embankment may be a hazard which has the potential to impact on people, property, roads and services. Some tell-tale signs that might indicate that a landslide is occurring are listed below:

- Open cracks, or steps, along contours
- Groundwater seepage, or springs
- Bulging in the lower part of the slope
- Hummocky ground
- trees leaning down slope, or with exposed roots
- debris/fallen rocks at the foot of a cliff
- tilted power poles, or fences
- cracked or distorted structures

These indications of instability may be seen on almost any slope and are not necessarily confined to the steeper ones (Table 1). Advice should be sought from a geotechnical practitioner if any of them are observed. Landslides do not respect property boundaries. As mentioned above they can "run-out" from above, "regress" from below, or expand sideways, so a landslide hazard affecting your property may actually exist on someone else's land.

Local councils are usually aware of slope instability problems within their jurisdiction and often have specific development and maintenance requirements. **Your local council is the first place to make enquiries if you are responsible for any sort of development or own or occupy property on or near sloping land or a cliff.**

TABLE 1 – Slope Descriptions

Appearance	Slope Angle	Maximum Gradient	Slope Characteristics
Gentle	0° - 10°	1 on 6	Easy walking.
Moderate	10° - 18°	1 on 3	Walkable. Can drive and manoeuvre a car on driveway.
Steep	18° - 27°	1 on 2	Walkable with effort. Possible to drive straight up or down roughened concrete driveway, but cannot practically manoeuvre a car.
Very Steep	27° - 45°	1 on 1	Can only climb slope by clutching at vegetation, rocks, etc.
Extreme	45° - 64°	1 on 0.5	Need rope access to climb slope.
Cliff	64° - 84°	1 on 0.1	Appears vertical. Can abseil down.
Vertical or Overhang	84° - 90±°	Infinite	Appears to overhang. Abseiler likely to lose contact with the face.

Some typical landslides which could affect residential housing are illustrated below:

Rotational or circular slip failures (Figure 1) - can occur on moderate to very steep soil and weathered rock slopes (Table 1). The sliding surface of the moving mass tends to be deep seated. Tension cracks may open at the top of the slope and bulging may occur at the toe. The ground may move in discrete "steps" separated by long periods without movement. More rapid movement may occur after heavy rain.

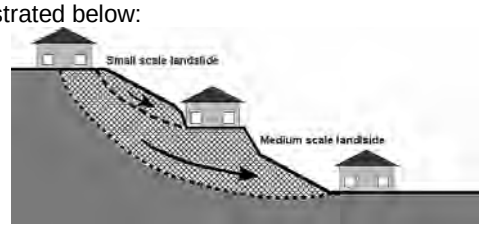


Figure 1

Translational slip failures (Figure 2) - tend to occur on moderate to very steep slopes (Table 1) where soil, or weak rock, overlies stronger strata. The sliding mass is often relatively shallow. It can move, or deform slowly (creep) over long periods of time. Extensive linear cracks and hummocks sometimes form along the contours. The sliding mass may accelerate after heavy rain.

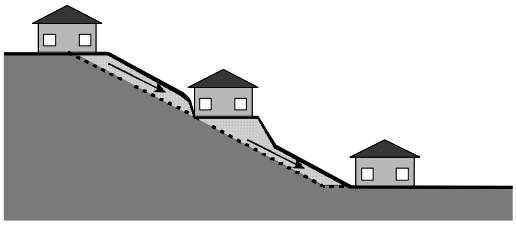


Figure 2

Wedge failures (Figure 3) - normally only occur on extreme slopes, or cliffs (Table 1), where discontinuities in the rock are inclined steeply downwards out of the face.

Rock falls (Figure 3) - tend to occur from cliffs and overhangs (Table 1).

Cliffs may remain, apparently unchanged, for hundreds of years. Collections of boulders at the foot of a cliff may indicate that rock falls are ongoing. Wedge failures and rock falls do not "creep". Familiarity with a particular local situation can instil a false sense of security since failure, when it occurs, is usually sudden and catastrophic.

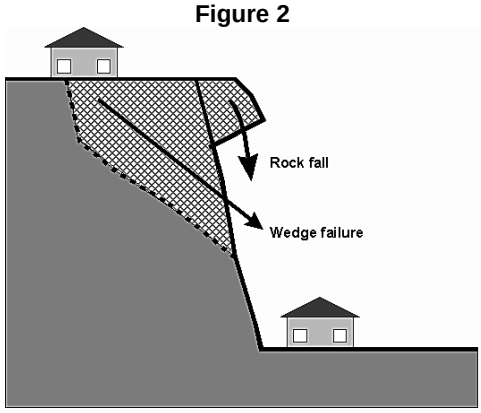


Figure 3

Debris flows and mud slides (Figure 4) - may occur in the foothills of ranges, where erosion has formed valleys which slope down to the plains below. The valley bottoms are often lined with loose eroded material (debris) which can "flow" if it becomes saturated during and after heavy rain. Debris flows are likely to occur with little warning; they travel a long way and often involve large volumes of soil. The consequences can be devastating.

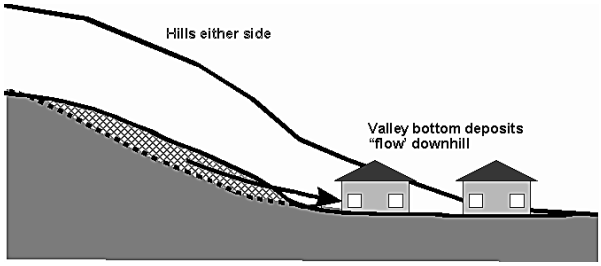


Figure 4

More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR3 - Soil Slopes
- GeoGuide LR4 - Rock Slopes
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR8 - Hillside Construction
- GeoGuide LR9 - Effluent & Surface Water Disposal
- GeoGuide LR10 - Coastal Landslides
- GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.

AUSTRALIAN GEOGUIDE LR7 (LANDSLIDE RISK)

Concept of Risk

Risk is a familiar term, but what does it really mean? It can be defined as *"a measure of the probability and severity of an adverse effect to health, property, or the environment."* This definition may seem a bit complicated. In relation to landslides, geotechnical practitioners (see GeoGuide LR1) are required to assess risk in terms of the likelihood that a particular landslide will occur and the possible consequences. This is called landslide risk assessment. The consequences of a landslide are many and varied, but our concerns normally focus on loss of, or damage to, property and loss of life.

Landslide Risk Assessment

Some local councils in Australia are aware of the potential for landslides within their jurisdiction and have responded by designating specific "landslide hazard zones". Development in these areas is normally covered by special regulations. If you are contemplating building, or buying an existing house, particularly in a hilly area, or near cliffs, then go first for information to your local council. If you have any concern that you could be dealing with a landslide hazard that your local council is not aware of you should seek advice from a geotechnical practitioner.

Landslide risk assessment must be undertaken by a geotechnical practitioner. It may involve visual inspection, geological mapping, geotechnical

investigation and monitoring to identify:

- potential landslides (there may be more than one that could impact on your site);
- the likelihood that they will occur;
- the damage that could result;
- the cost of disruption and repairs; and
- the extent to which lives could be lost.

Risk assessment is a predictive exercise, but since the ground and the processes involved are complex, prediction inevitably lacks precision. If you commission a landslide risk assessment for a particular site you should expect to receive a report prepared in accordance with current professional guidelines and in a form that is acceptable to your local council, or planning authority.

Risk to Property

Table 1 indicates the terms used to describe risk to property. Each risk level depends on an assessment of how likely a landslide is to occur and its consequences in dollar terms. Likelihood is the chance of it happening in any one year, as indicated in Table 2. Consequences are related to the cost of the repairs and perhaps temporary loss of use. These two factors are combined by the geotechnical practitioner to determine the Qualitative Risk.

TABLE 1 – RISK TO PROPERTY

Qualitative Risk		Significance - Geotechnical engineering requirements
Very high	VH	**Unacceptable** without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low. May be too expensive and not practical. Work likely to cost more than the value of the property.
High	H	**Unacceptable** without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable level. Work would cost a substantial sum in relation to the value of the property.
Moderate	M	**May be tolerated** in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as possible.
Low	L	**Usually acceptable** to regulators. Where treatment has been needed to reduce the risk to this level, ongoing maintenance is required.
Very Low	VL	**Acceptable**. Manage by normal slope maintenance procedures.

TABLE 2 – LIKELIHOOD

Likelihood	Annual Probability
Almost Certain	1:10
Likely	1:100
Possible	1:1,000
Unlikely	1:10,000
Rare	1:100,000
Barely credible	1:1,000,000

The terms "unacceptable", "tolerable" etc. in Table 1 indicate how most people react to an assessed risk level. However, some people will always be more prepared, or better able, to tolerate a higher risk level than others. Some local councils and planning authorities stipulate a maximum tolerable risk level. This may be lower than you feel is reasonable for your block but it is, nonetheless, a pre-requisite for development. Reasons for this include the fact that a landslide on your block may pose a risk to neighbours and passers-by and that , should you sell, subsequent owners of the block may be more risk averse than you.

Risk to Life

Most of us have some difficulty grappling with the concept of risk and deciding whether, or not, we are prepared to accept it. However, without doing any sort of analysis, or commissioning a report from an "expert", we all take risks every day. One of them is the risk of being killed in an accident. This is worth thinking about, because it tells us a lot about ourselves and can help to put an assessed risk into a meaningful context. By identifying activities that we either are, or are not, prepared to engage in, we can get some indication of the maximum level of risk that we are prepared to take. This knowledge can help us to decide whether we really are able to accept a particular risk, or to tolerate a particular likelihood of loss, or damage, to our property (Table 2).

In Table 3, data from NSW for the years 1998 to 2002, and other sources, is presented. A risk of 1 in 100,000 means that, in any one year, 1 person is killed for every 100,000 people undertaking that particular activity. The NSW data assumes that the whole population undertakes the activity. That is, we are all at risk of being killed in a fire, or of choking on our food, but it is reasonable to assume that only people who go deep sea fishing run a risk of being killed while doing it.

It can be seen that the risks of dying as a result of falling, using a motor vehicle, or engaging in water-related activities (including bathing) are all greater than 1:100,000 and yet few people actively avoid situations where these risks are present. Some people are averse to flying and yet it represents a lower risk than choking to death on food. The data also indicate that, even when the risk of dying as a consequence of a particular event is very small, it could still happen to any one of us today. If this were not so, there would be no risk at all and clearly that is not the case.

In NSW, the planning authorities consider that 1:1,000,000 is the maximum tolerable risk for domestic housing built near an obvious hazard, such as a chemical factory. Although not specifically considered in the NSW guidelines there is little difference between the hazard presented by a neighbouring factory and a landslide: both have the capacity to destroy life and property and both are always present.

TABLE 3 – RISK TO LIFE

Risk (deaths per participant per year)	**Activity/Event Leading to Death** (NSW data unless noted)
1:1,000	Deep sea fishing (UK)
1:1,000 to 1:10,000	Motor cycling, horse riding , ultra-light flying (Canada)
1:23,000	Motor vehicle use
1:30,000	Fall
1:70,000	Drowning
1:180,000	Fire/burn
1:660,000	Choking on food
1:1,000,000	Scheduled airlines (Canada)
1:2,300,000	Train travel
1:32,000,000	Lightning strike

More information relevant to your particular situation may be found in other AUSTRALIAN GEOGUIDES:

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR8 - Hillside Construction
- GeoGuide LR9 - Effluent & Surface Water Disposal
- GeoGuide LR10 - Coastal Landslides
- GeoGuide LR11 - Record Keeping

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APPENDIX B – Data Acquisition

Documents received from Council:

- Public Works, August 1992. Coastal Storm Water Planning Studies Volume 1 Existing Drainage Systems.
- Public Works, October 1992. Coastal Storm Water Planning Studies Volume 2c City Beach Drainage system Analysis.
- Dames&Moore, August 1990. Catchment Management Study Waverly-Penkivil St Storm Water System.
- Cameron McNamara Consultants, February 1987. Rose Bay Catchment Study.
- Special Environmental Programme, 1991. Rosebay Stormwater Catchment Management Study
- Civic Design, August 2007.Waverly Council Storm Water Drainage System Mapping and Modeling.
- Public Works, October 1990. Municipality of Waverly - Wallis Parade Drainage System Proposal for Augmentation of the Existing Storm Water Drainage System.
- Public Works, May 1988. Bondi Beach Sea Wall / Promenade Stability Report.
- Bruce Thom, Unknown**.** Bondi: a case study in beach resilience.
- Waverley Council, December 2009. Strategic Asset Management Plan 3.
- Parkland Environmental Planners and EDAW Australia, June 2007. Tamarama Plan of Management.

Survey Data

An Airborne Laser (ALS) survey of the LGA was conducted on behalf of Council on 17th and 18th December 2005. Council supplied the 0.5m contour data based on this survey information and the point data. The accuracy of this data is typically considered to be about +/-0.2m. The ALS data points were compared to test points obtained by field survey and gave the following accuracy results:

- Mean difference 0.077m
- Standard Deviation 0.102m
- Standard Error (RMS) 0.101m

Historical Photography

Available historical aerial photography was sourced from the Department of Lands, for the years 1951,1955,1961, 1965, 1970, 1974, 1975, 1976, 1978, 1985, 1986 (Bondi only) and 1993. In additional Council provided aerial photography for the years 2002, 2005 and 2009.

Historical photographs of Bondi, Bronte and Tamarama were provided by Council and also sourced from internet searches.

Council GIS

Council provided data sets from there GIS system including cadastre, land ownership, drainage infrastructure, aerial photography and ALS data.

APPENDIX C – PHOTOGRAMMETRIC AND SURVEY DATA (Bondi)

C1. PWD 1988

C2. NORTH BONDI 1992

C3. SURVEY 1992

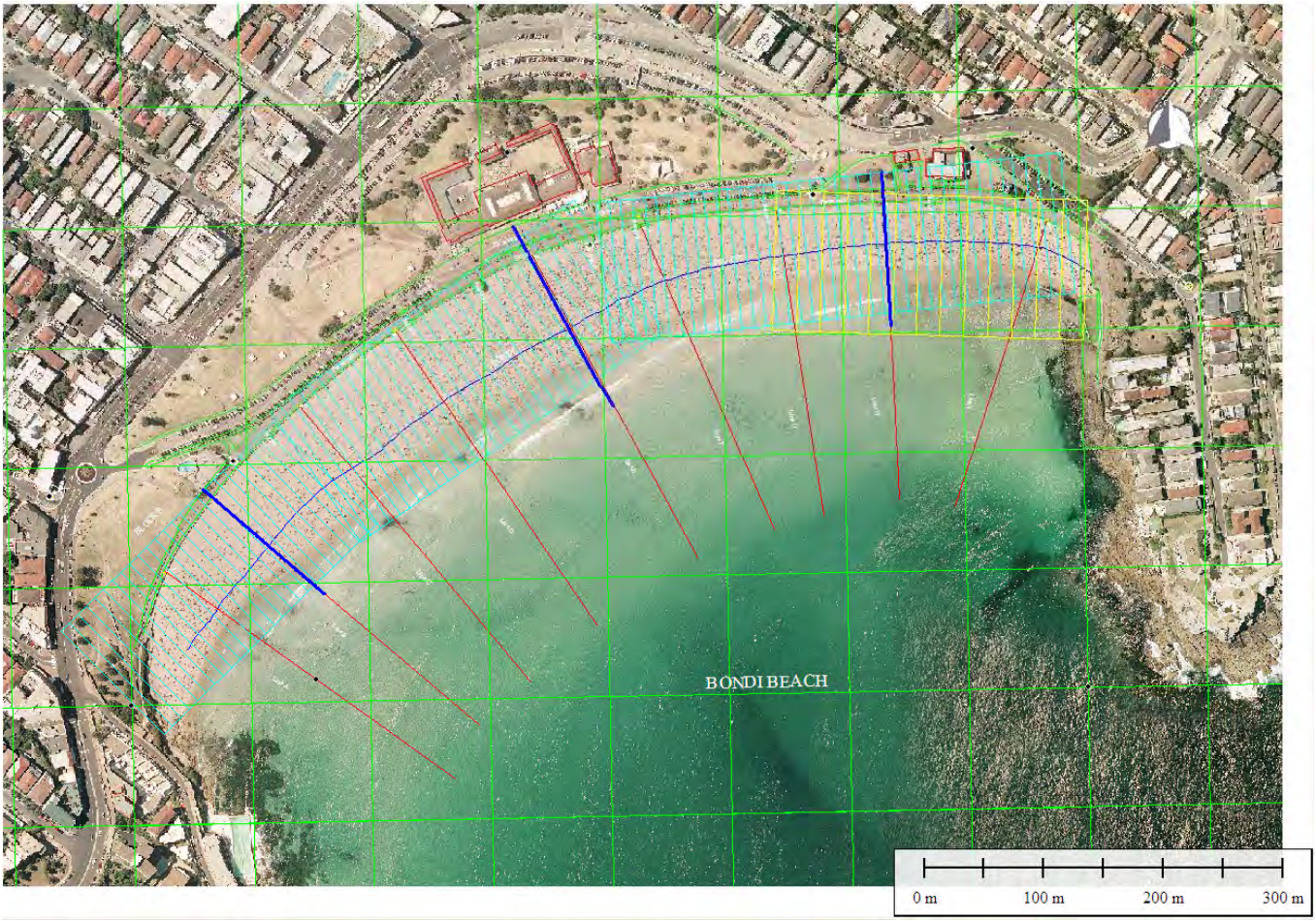
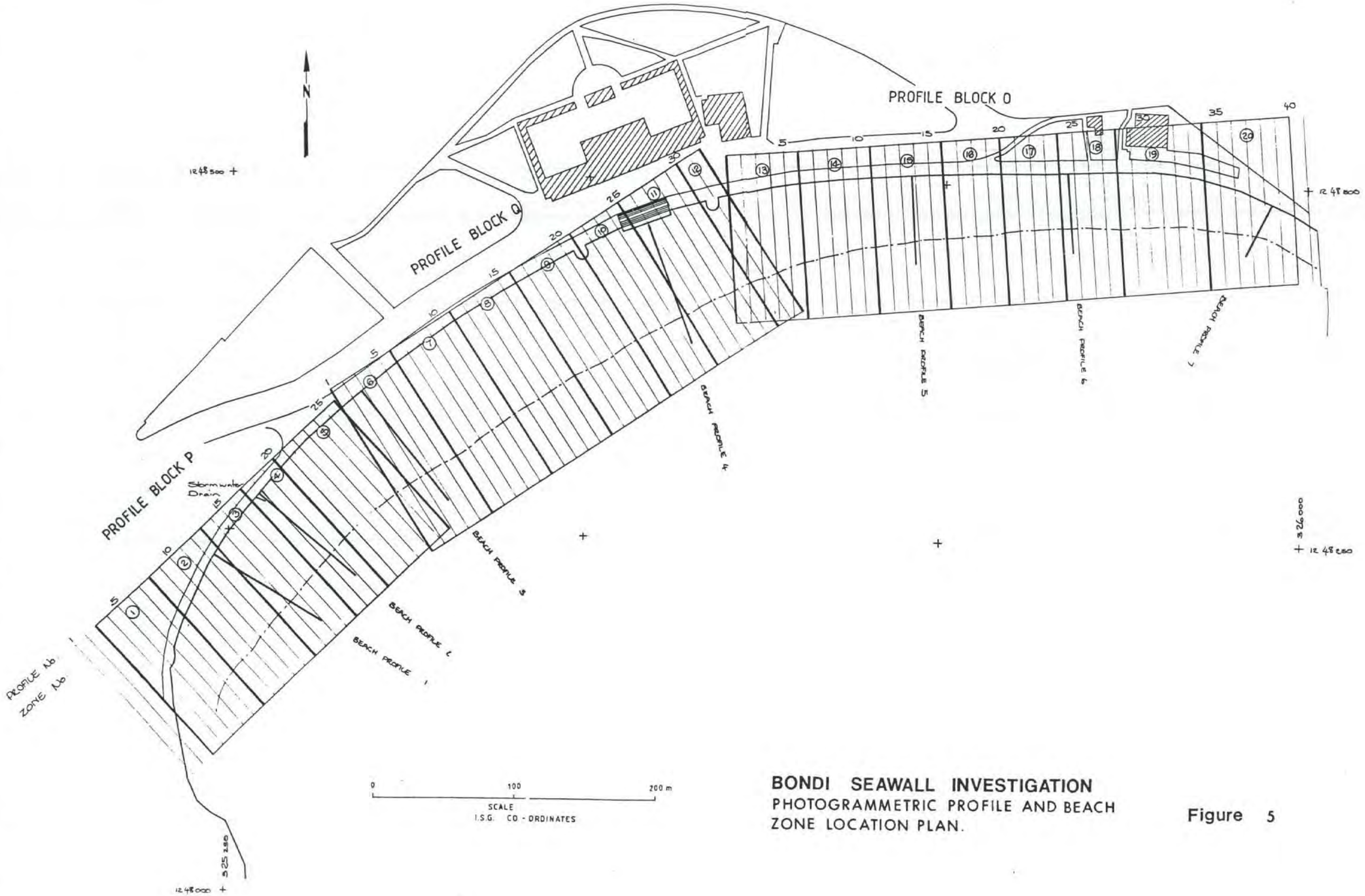


Figure C - Location of Photogrammetric and Survey Data

Legend

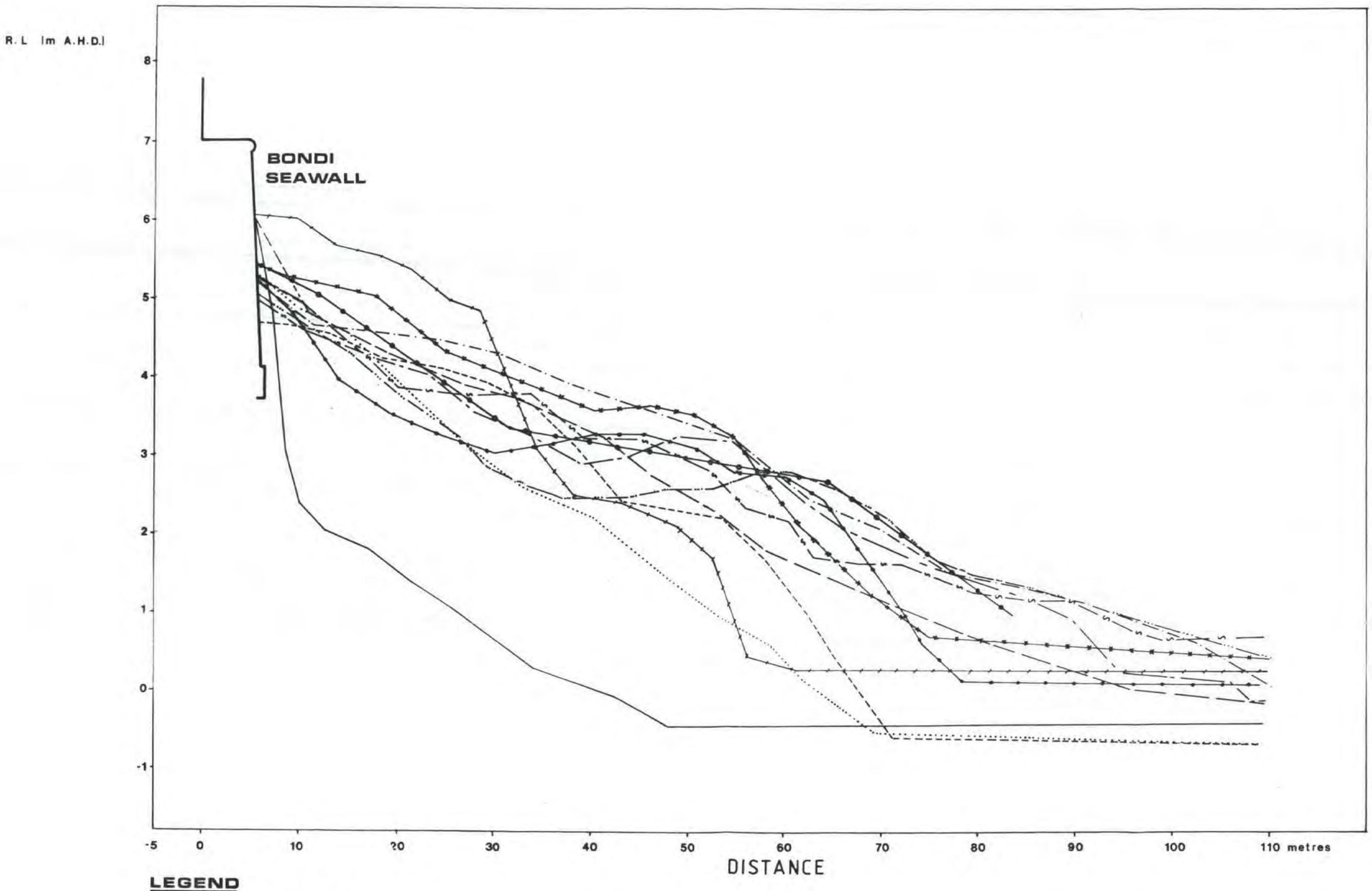
- PWD 1988 Photogrammetric Locations
- North Bondi Photogrammetric Locations
- PWD Land Survey Lines (1992)
- Location of Sections Extracted from ALS data (2005)

C1. PWD 1988



BONDI SEAWALL INVESTIGATION
PHOTOGRAMMETRIC PROFILE AND BEACH ZONE LOCATION PLAN.

Figure 5



LEGEND

- 18·8·1986
- 11·4·1986
- 16·3·1985
- 25·2·1978
- 19·11·1976
- 1·4·1975
- 19·6·1974
- 7·7·1970
- 29·8·1965
- 25·6·1961
- 23·8·1955
- May 1951

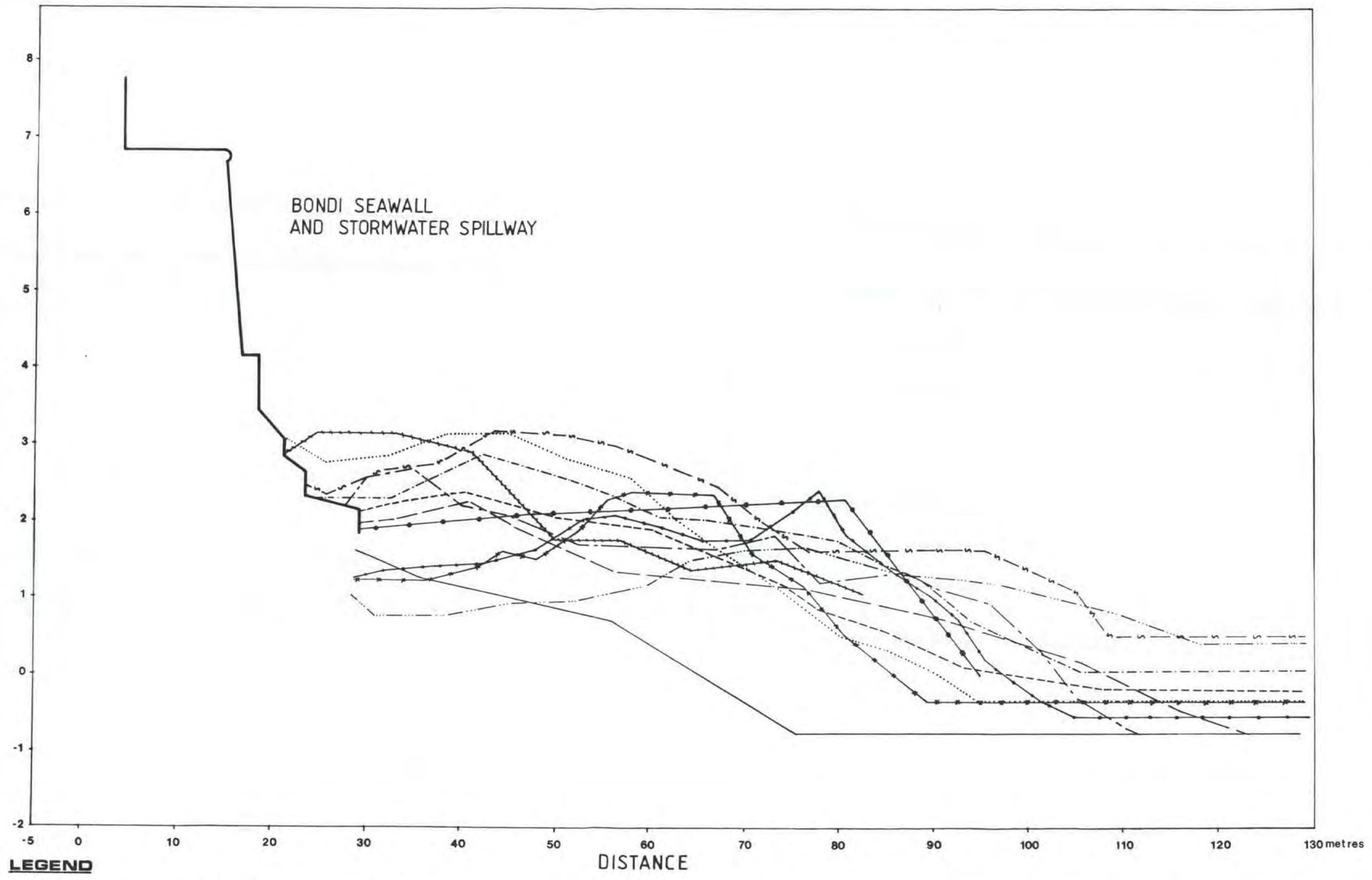
HORIZONTAL SCALE 1 : 400
VERTICAL SCALE 1 : 50

NOTE : Refer to Figure 5 for location of Beach Profile

BONDI SEAWALL INVESTIGATION

BEACH PROFILE 1

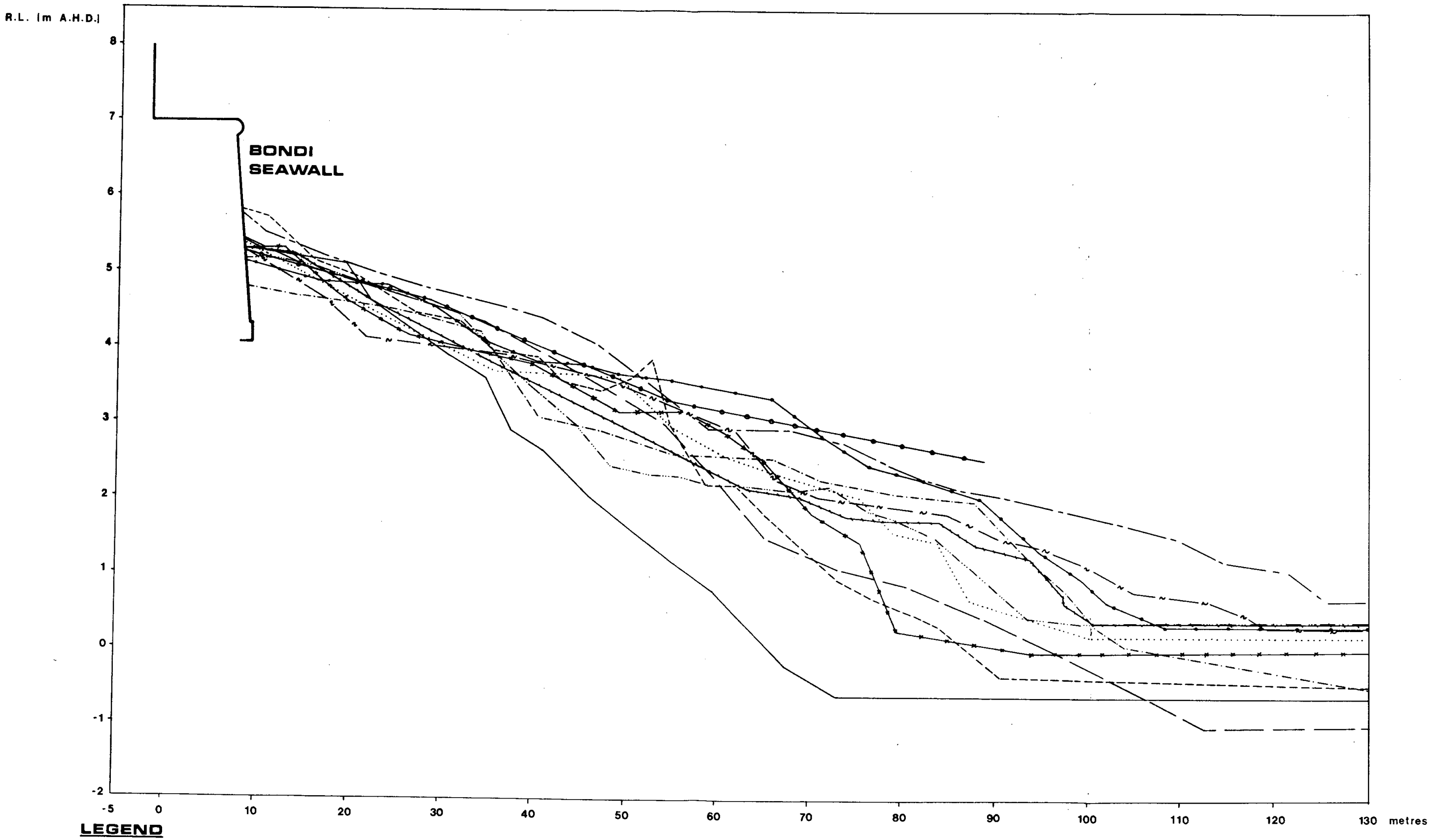
Figure 10



BONDI SEAWALL INVESTIGATION

BEACH PROFILE 2

Figure 11



LEGEND

- 18·8·1986
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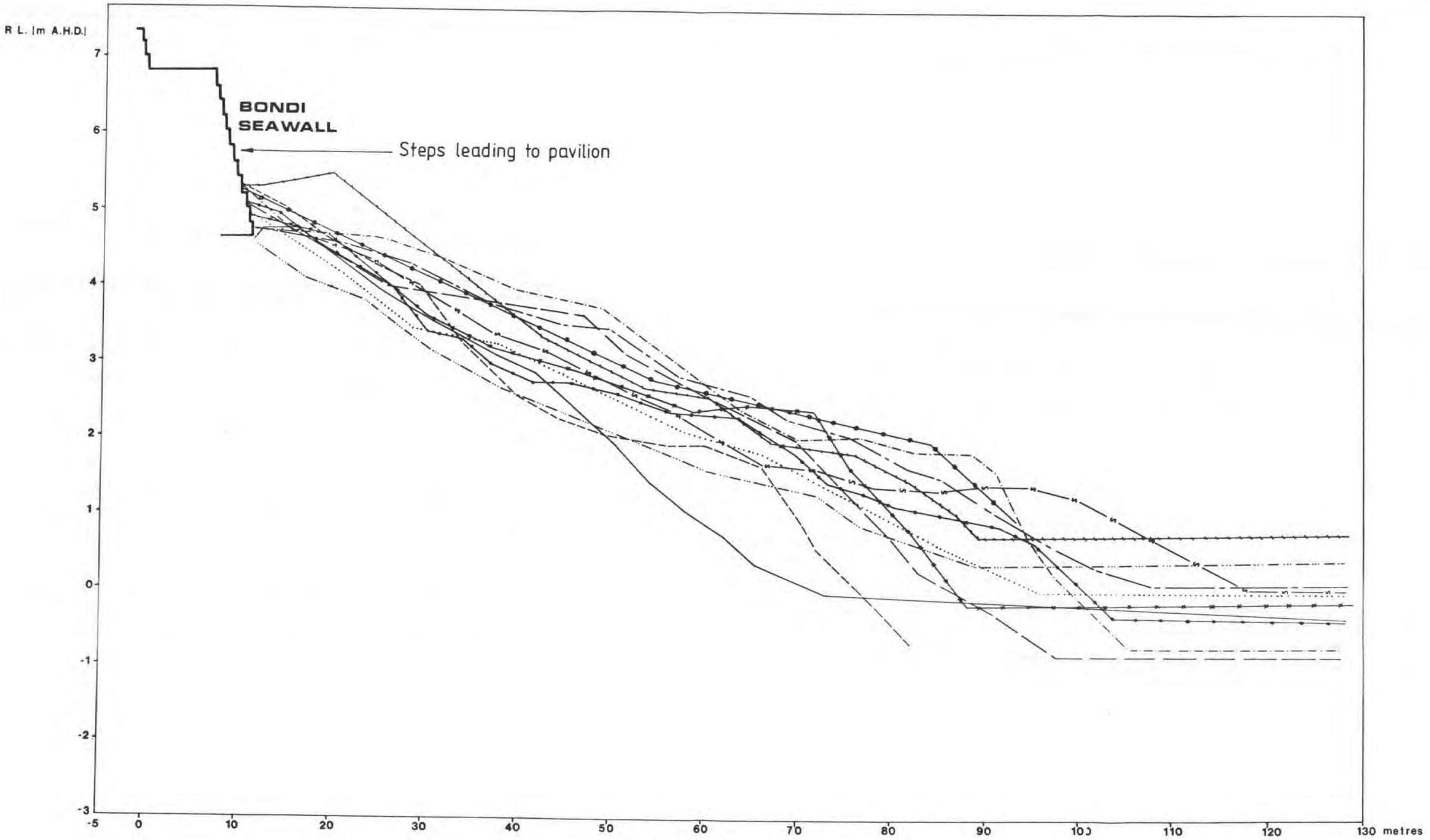
- 19·11·1976
- 1·4·1975
- 19·6·1974
- 7·7·1970
- 29·8·1965
- 25·6·1961
- 23·8·1955
- May 1951

HORIZONTAL SCALE 1 : 400
VERTICAL SCALE 1 : 50

NOTE: Refer to Figure D1 for location of Beach Profile.

BONDI SEAWALL INVESTIGATION
BEACH PROFILE 3.

FIGURE
D 2



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- 25·2·1978
- 19·11·1976
- 1·4·1975
- 19·6·1974
- 7·7·1970
- 29·8·1965
- 25·6·1961
- 23·8·1955
- May 1951

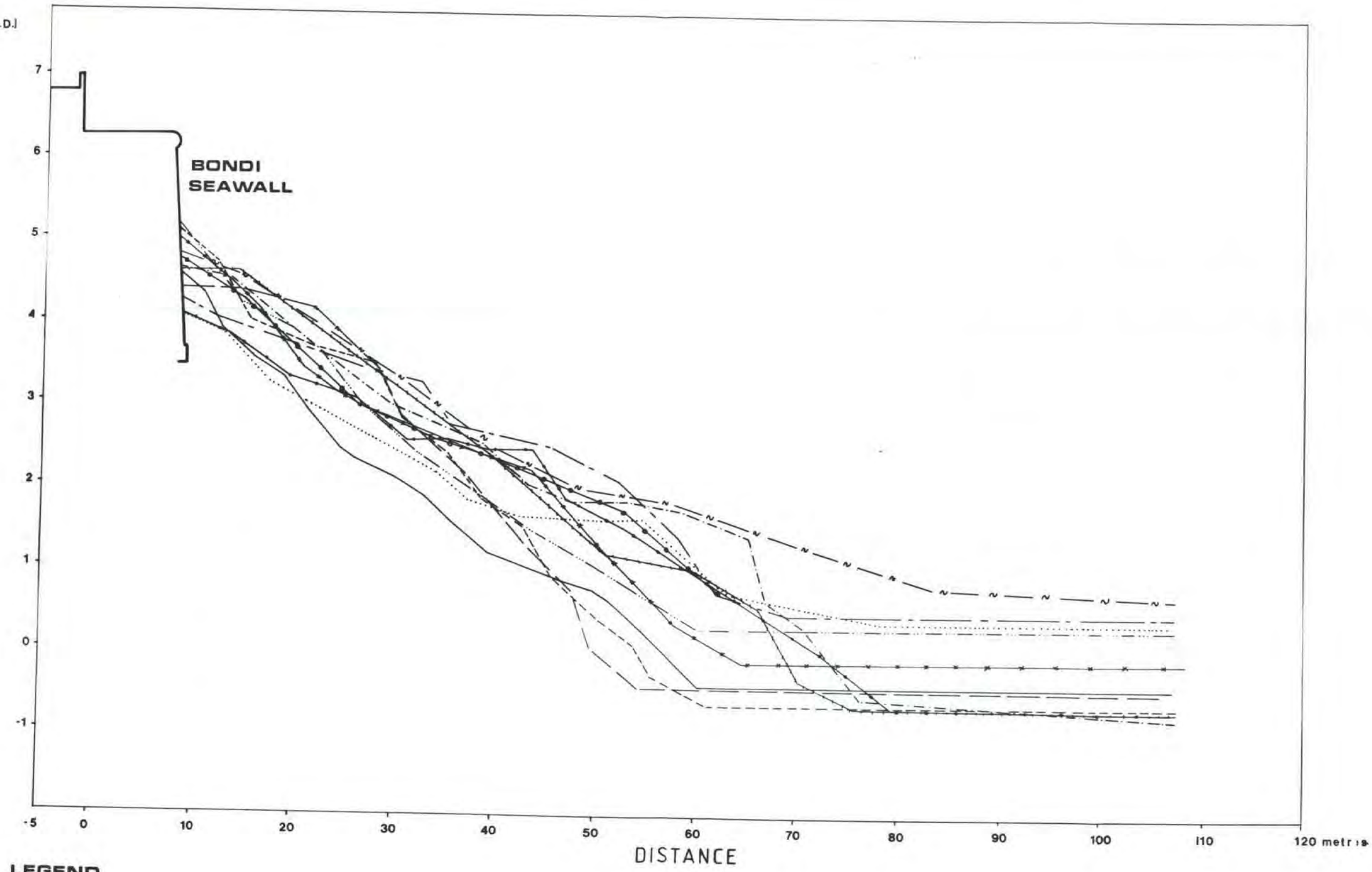
HORIZONTAL SCALE 1 : 400
VERTICAL SCALE 1 : 50

NOTE : Refer to Figure 5 for location of Beach Profile

BONDI SEAWALL INVESTIGATION

BEACH PROFILE 4

Figure 12



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- 19 11 1976
- 1·4·1975
- 19·6·1974
- 7·7·1970
- 29·8·1965
- 25·6·1961
- 23·8·1955
- May 1951

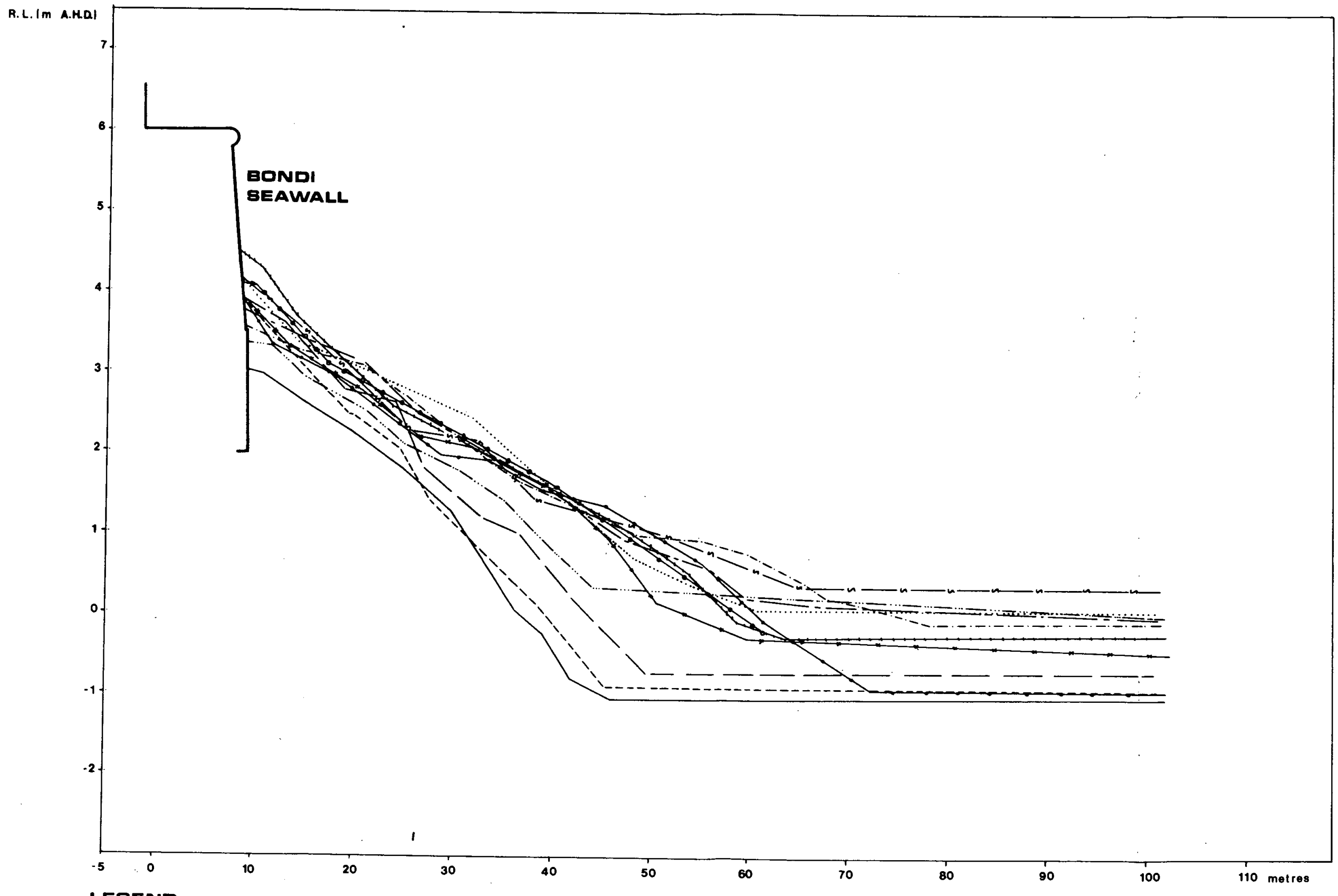
HORIZONTAL SCALE 1 : 400
VERTICAL SCALE 1 : 50

NOTE : Refer to Figure 5 for location of Beach Profile

BONDI SEAWALL INVESTIGATION

BEACH PROFILE 5

Figure 13



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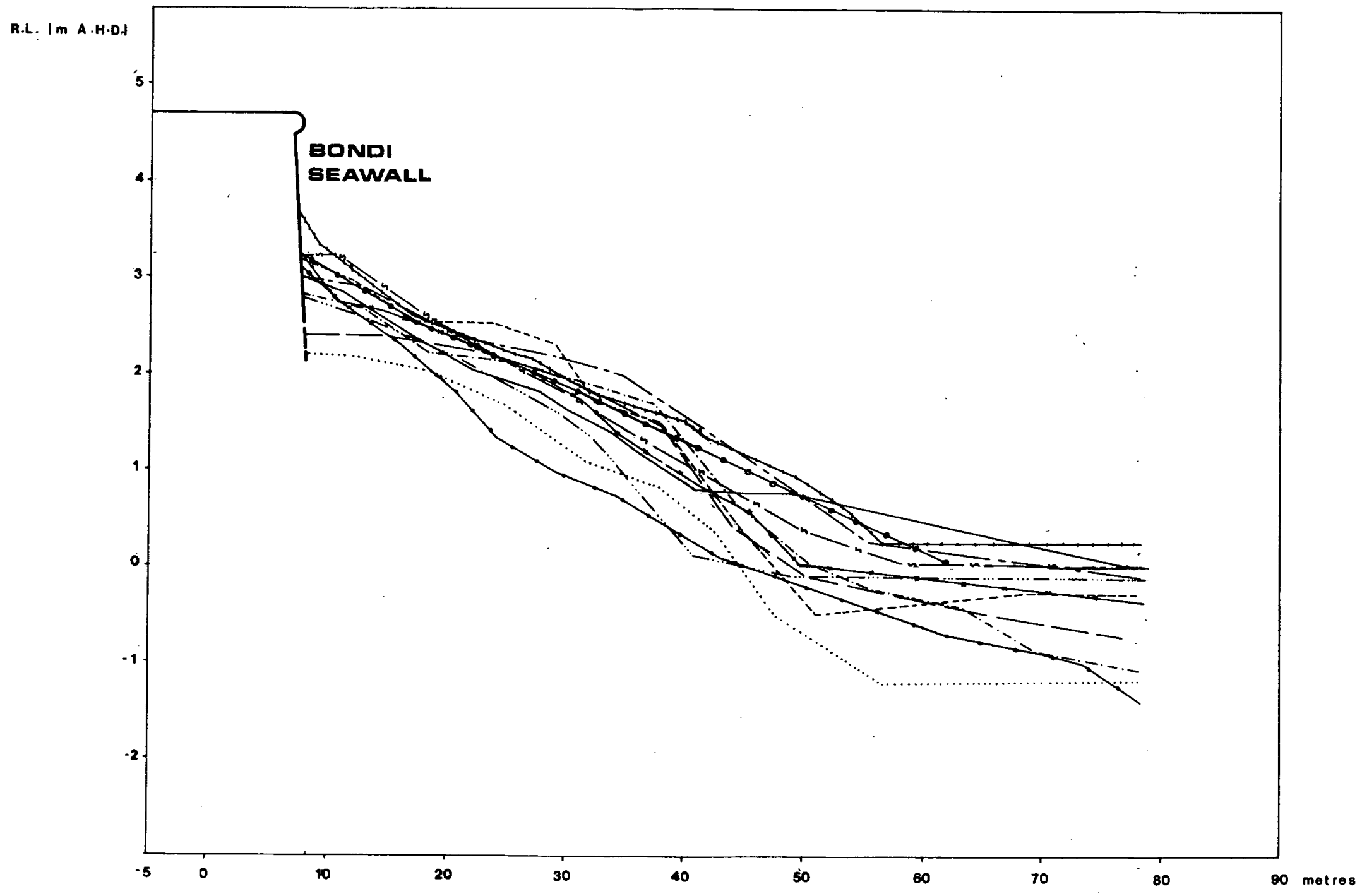
- 7·7·1970
- 29·8·1965
- 25·6·1961
- 23·8·1955
- May 1951

HORIZONTAL SCALE 1 : 400
VERTICAL SCALE 1 : 50

NOTE: Refer to Figure D1 for location of Beach Profile.

BONDI SEAWALL INVESTIGATION
BEACH PROFILE 6

FIGURE
D 3



LEGEND

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- 19·11·1976
- 1·4·1975
- 19·6·1974
- 7·7·1970
- 29·8·1965
- 25·6·1961
- 23·8·1955
- May 1951

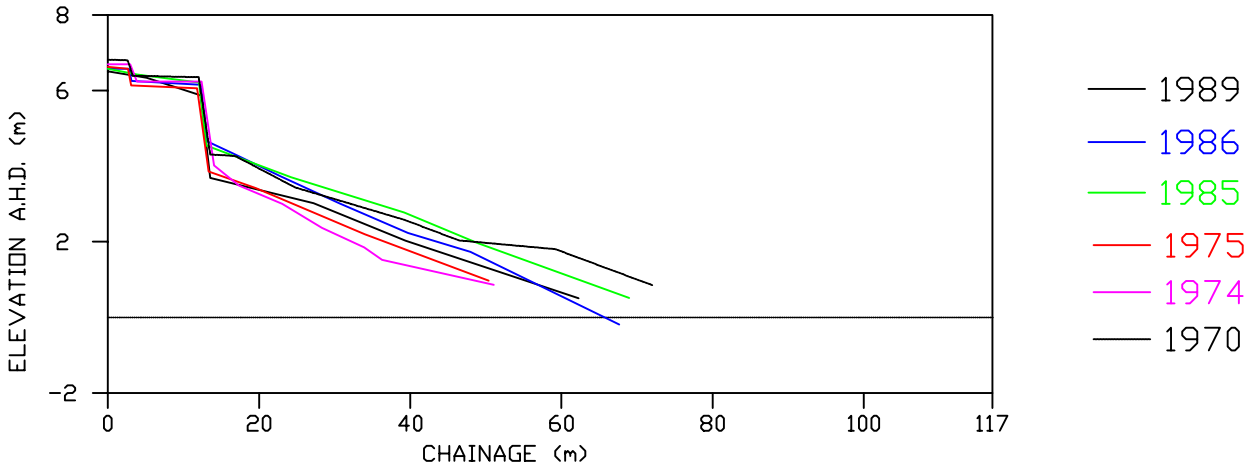
HORIZONTAL SCALE 1:400
VERTICAL SCALE 1:50

NOTE: Refer to Figure D1 for location of Beach Profile.

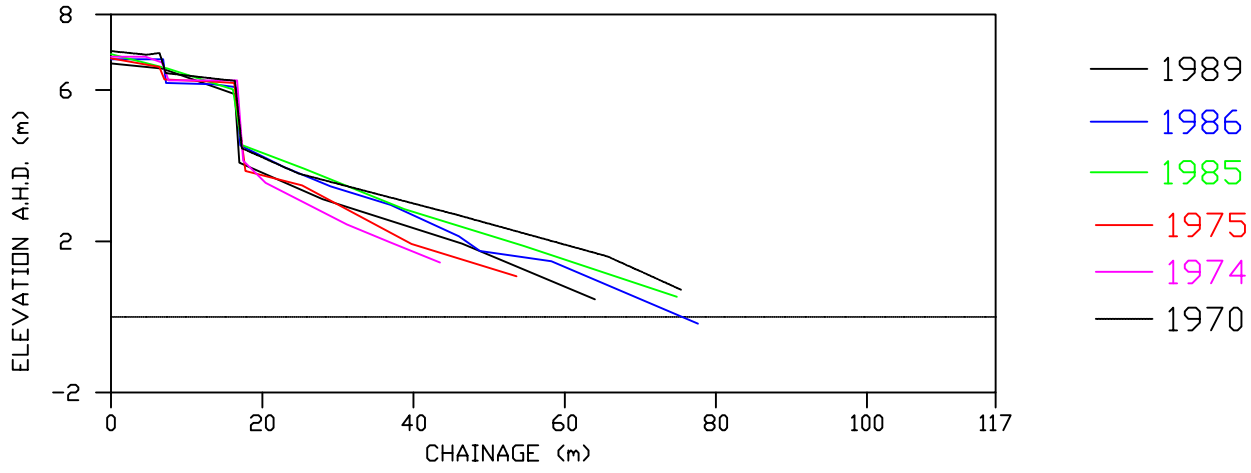
BONDI SEAWALL INVESTIGATION
BEACH PROFILE 7

FIGURE
D4

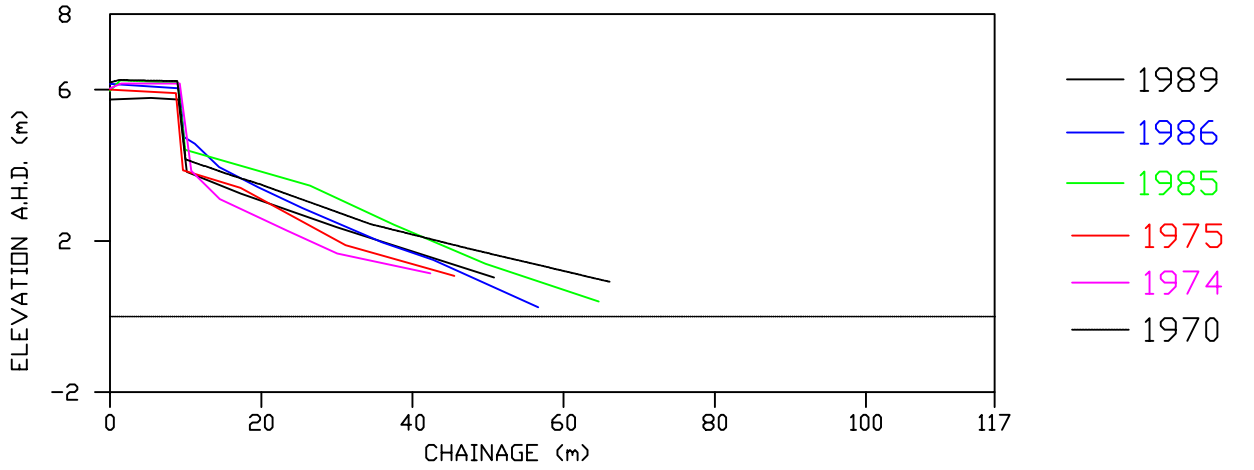
C2. NORTH BONDI 1992



PROFILE 2



PROFILE 1



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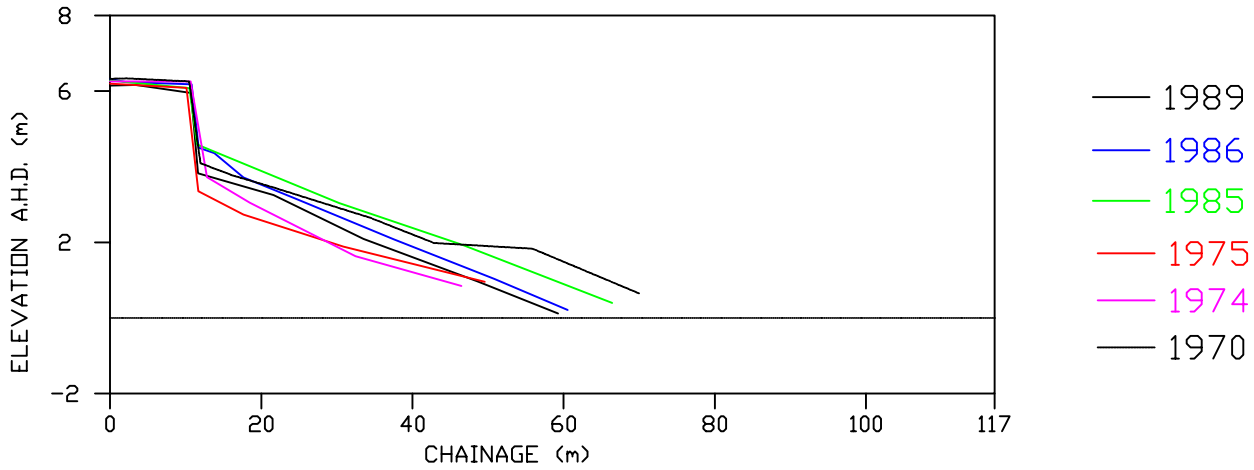
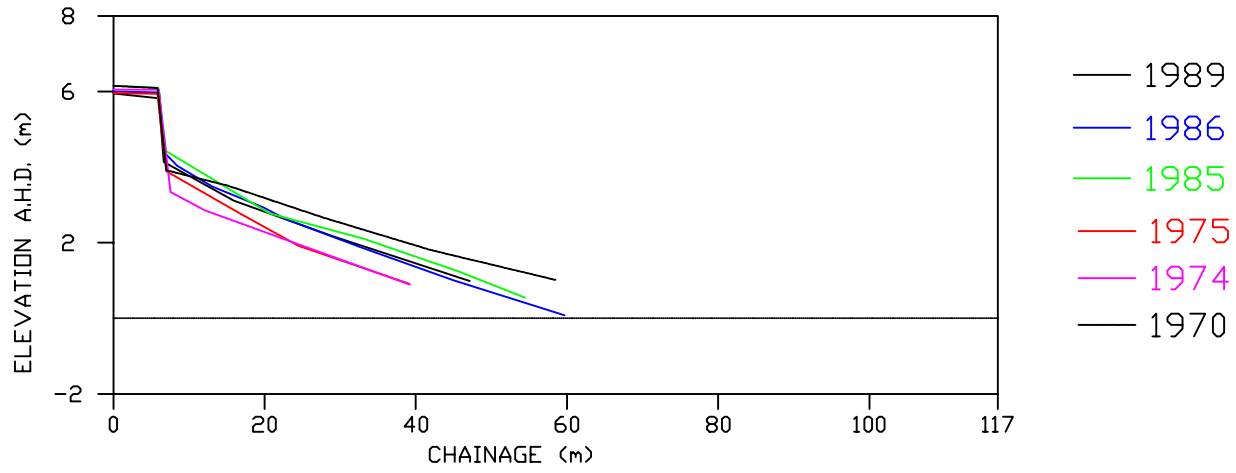
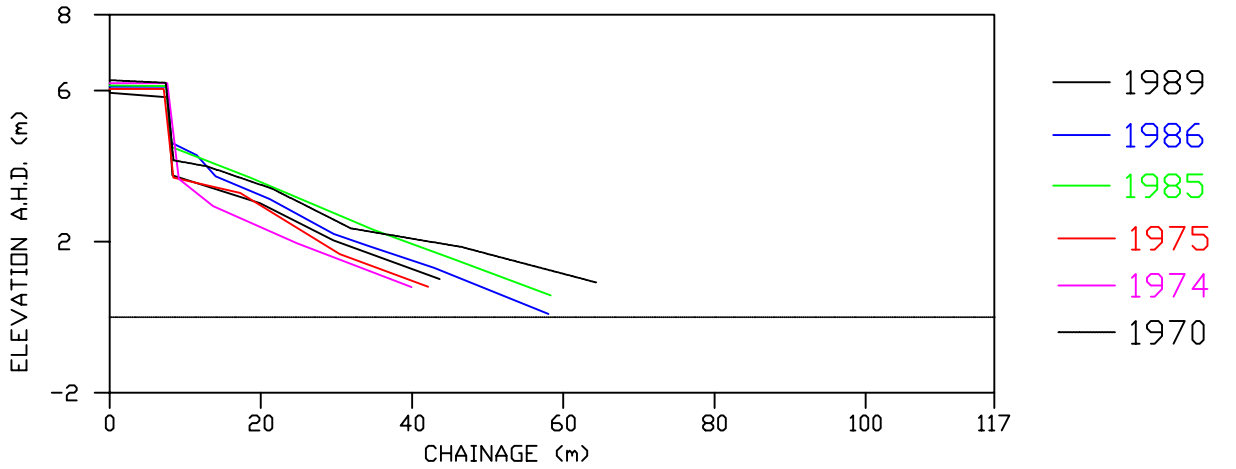


PROFILE 3



PROFILE 6



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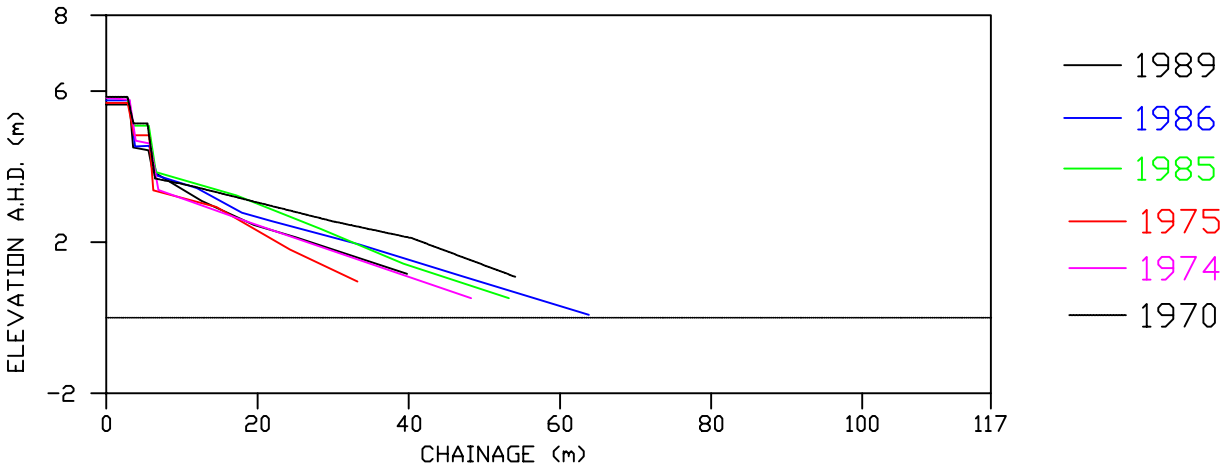

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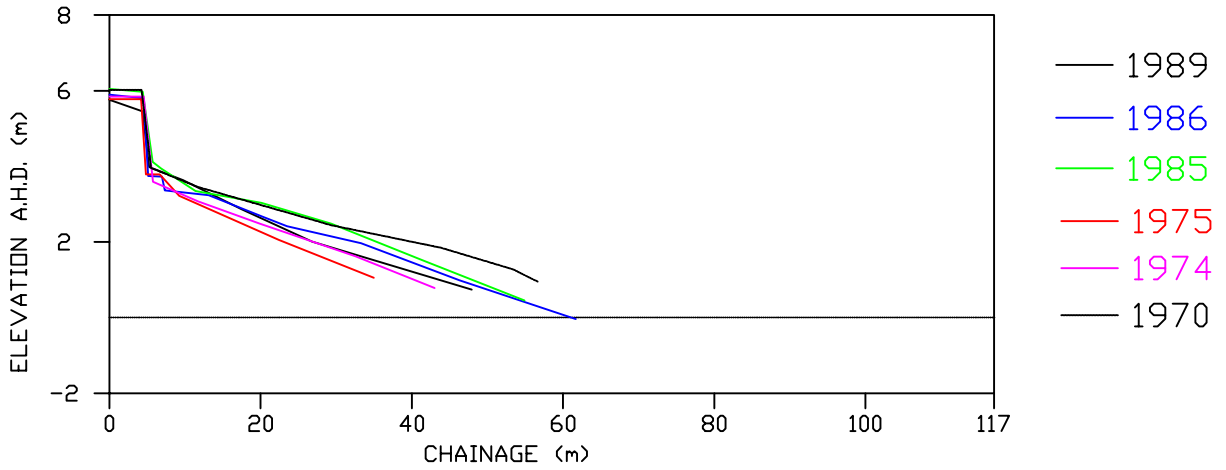
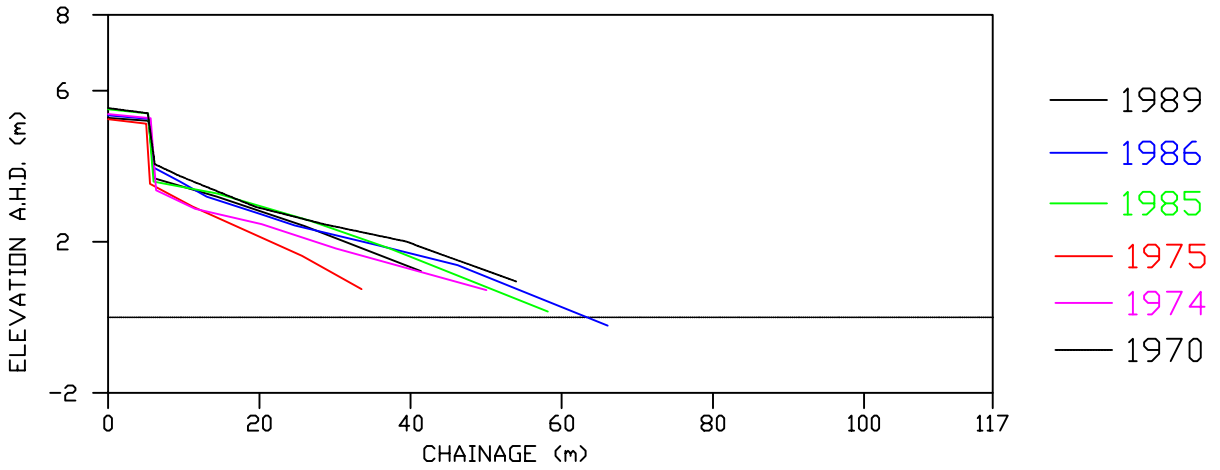


PROFILE 7



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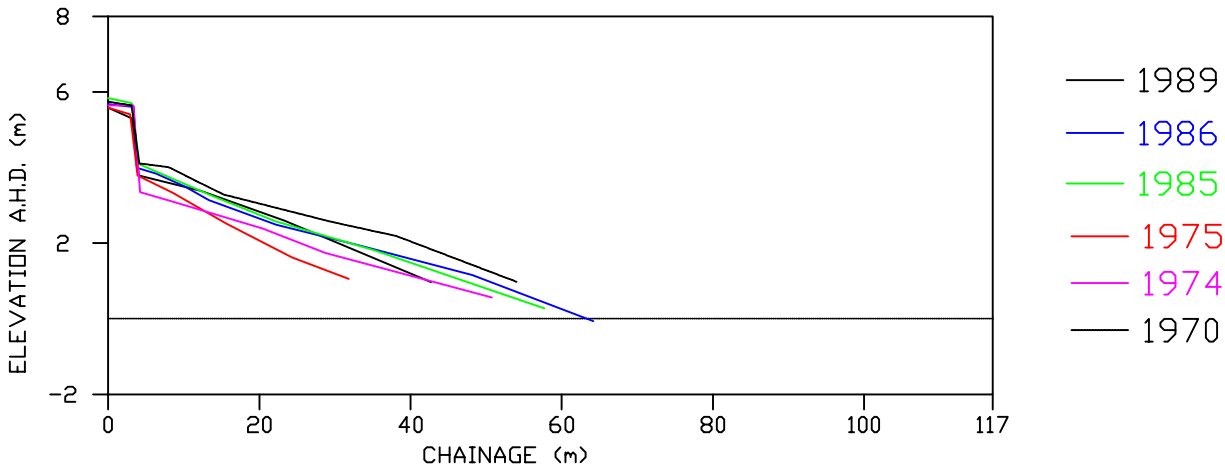

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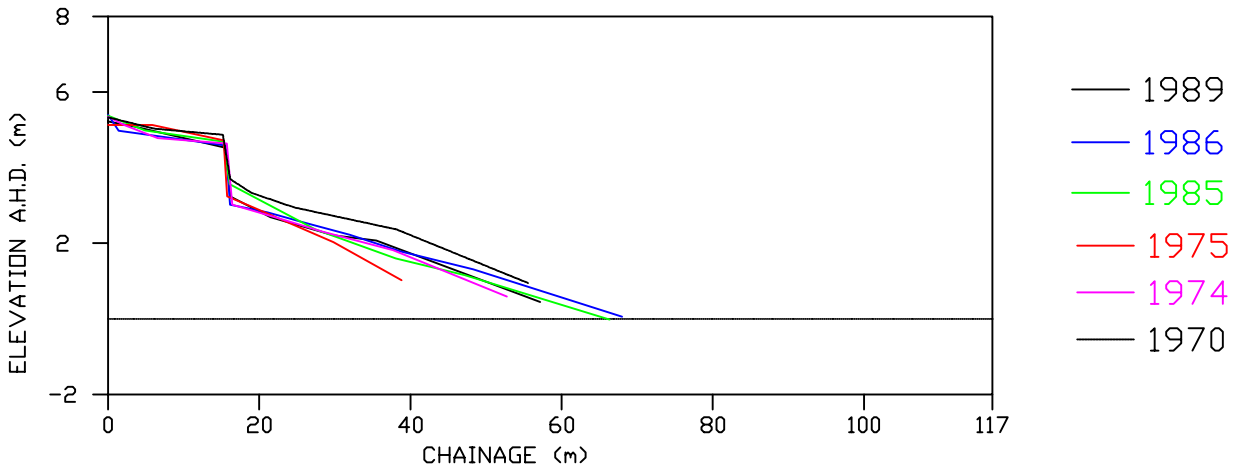
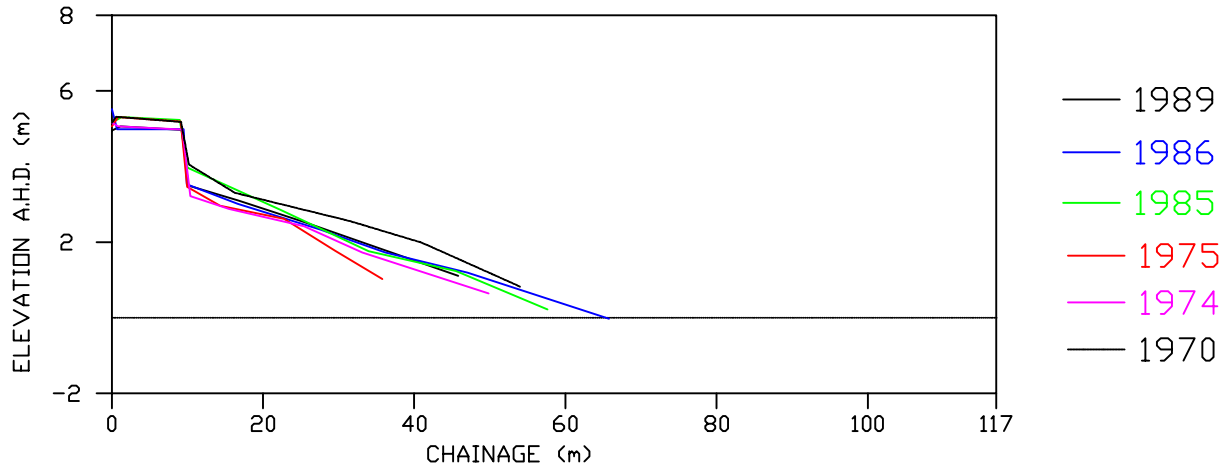


PROFILE 12



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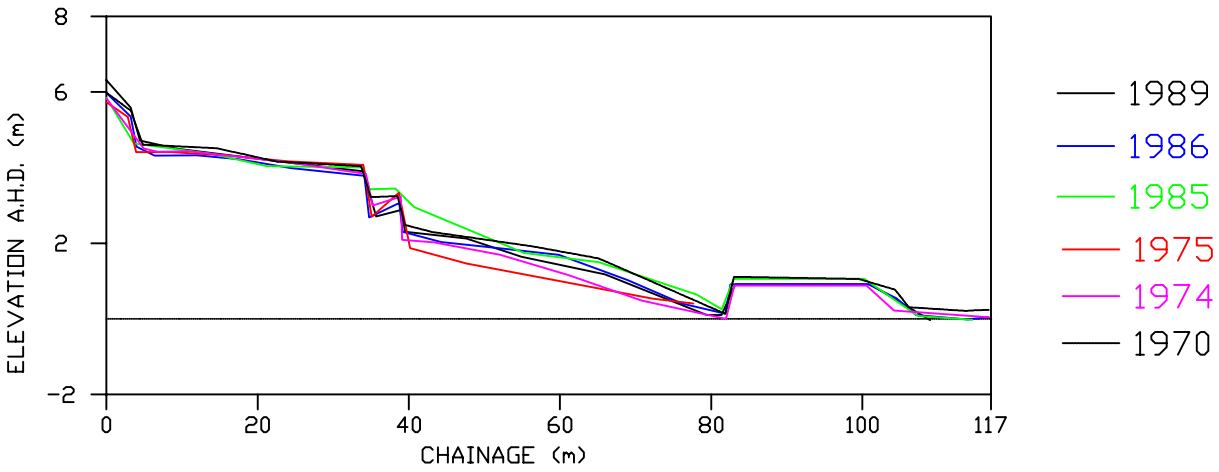

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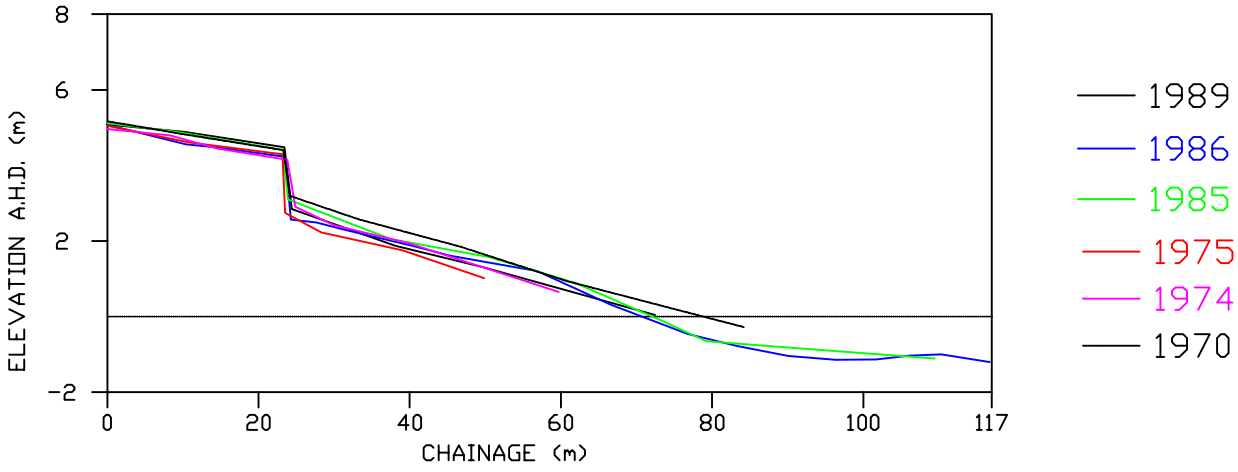
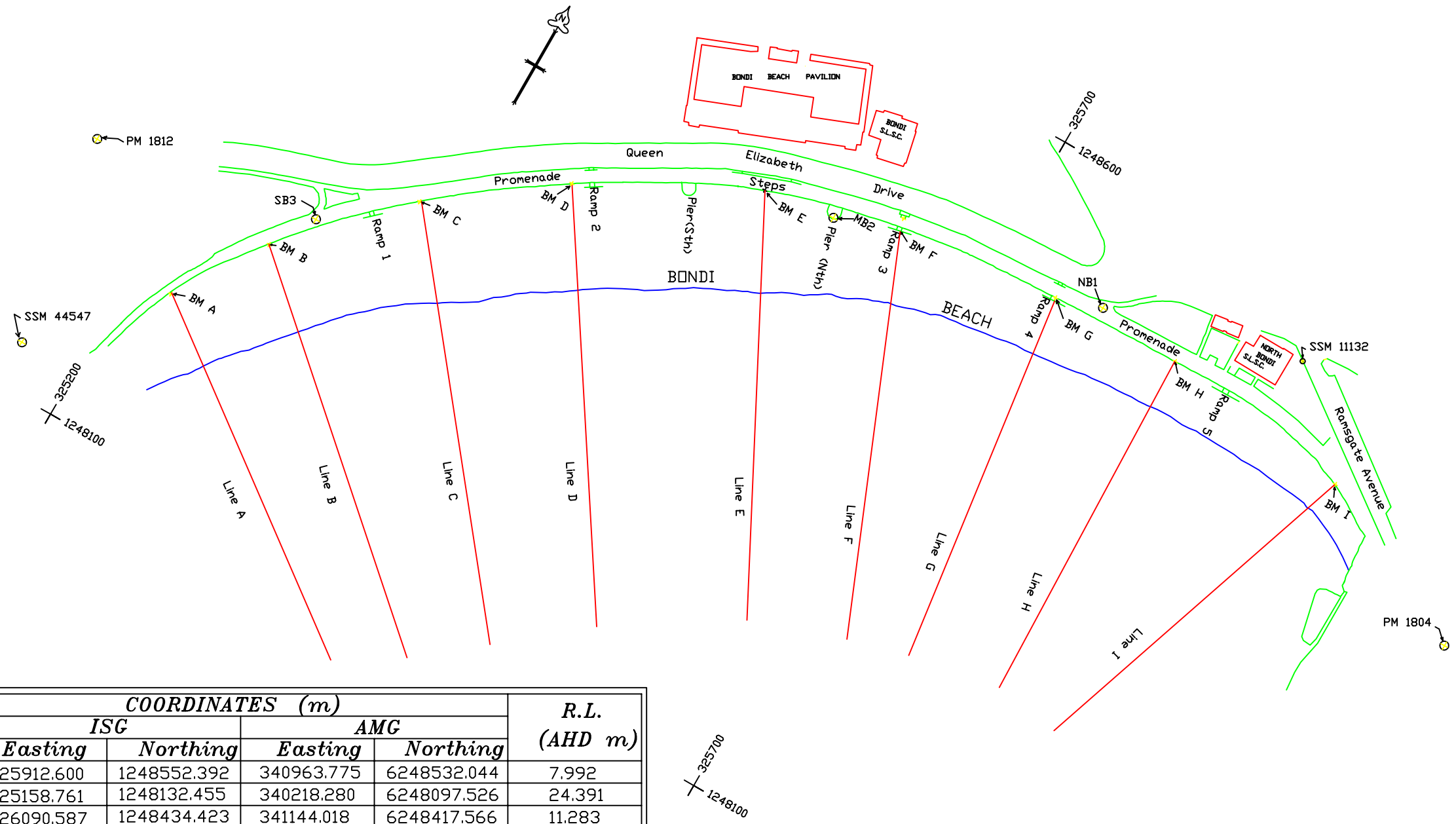


PROFILE 13

C3. SURVEY 1992



MARK	COORDINATES (m)				R.L. (AHD m)
	ISG		AMG		
	Easting	Northing	Easting	Northing	
SSM 1132	325912.600	1248552.392	340963.775	6248532.044	7.992
SSM 44547	325158.761	1248132.455	340218.280	6248097.526	24.391
PM 1804	326090.587	1248434.423	341144.018	6248417.566	11.283
PM 1812	325134.629	1248276.123	340191.357	6248240.692	17.152
NB1	325777.872	1248516.242	340829.781	6248493.279	6.232
MB2	325590.428	1248477.978	340643.124	6248451.375	6.696
SB3	325289.208	1248302.933	340345.379	6248270.505	7.047
BM A	325229.810	1248210.500	340287.794	6248176.937	6.900
BM B	325270.430	1248272.300	340327.202	6248239.514	6.884
BM C	325343.770	1248347.900	340399.054	6248316.524	7.003
BM D	325427.270	1248410.100	340481.324	6248380.336	6.856
BM E	325541.890	1248471.030	340594.732	6248443.484	6.760
BM F	325633.870	1248495.200	340686.221	6248469.439	6.523
BM G	325746.790	1248506.100	340798.904	6248482.534	6.183
BM H	325838.030	1248509.200	340890.063	6248487.410	5.983
BM I	325972.800	1248491.500	341025.147	6248472.337	4.459

PUBLIC WORKS

COAST AND RIVERS BRANCH

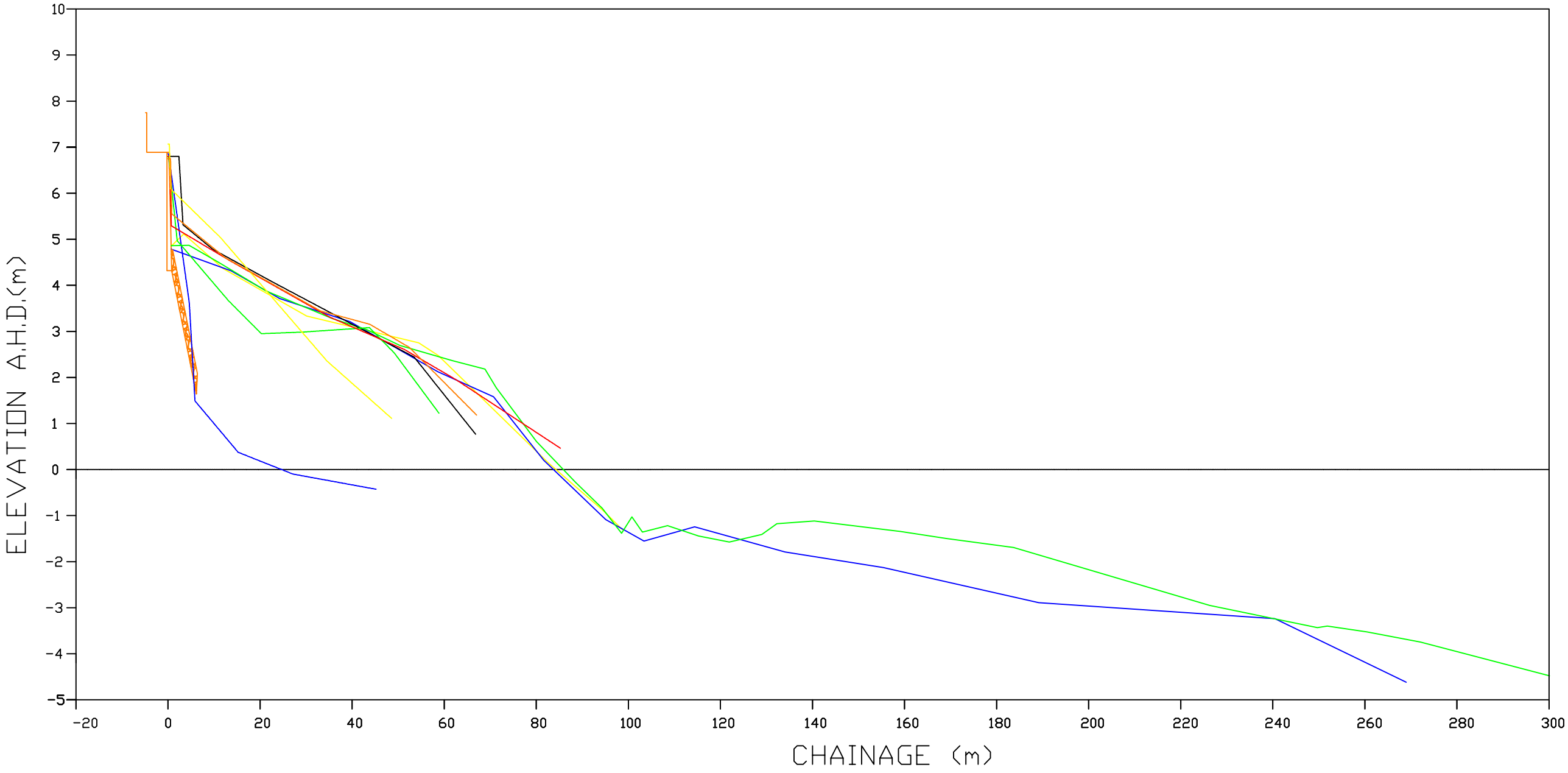
SURVEY CONTROL

BONDI BEACH

DATE: APRIL 1992

DRAWING No.

PROFILE A



LEGEND

- 24.01.1990
- 20.02.1990
- 13.03.1992
- 19.03.1992

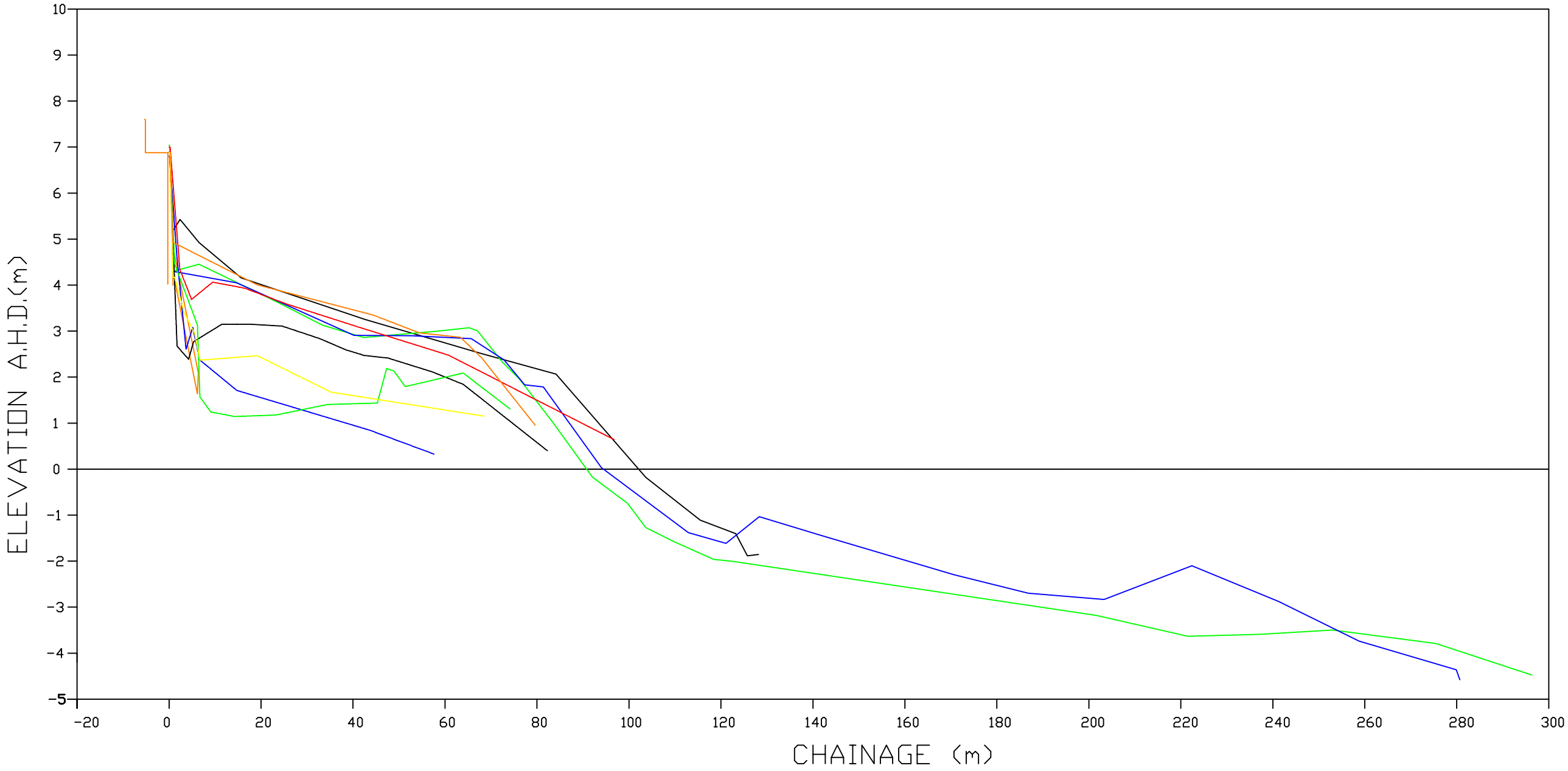
PUBLIC WORKS | COAST AND RIVERS BRANCH

BEACH PROFILES

BONDI BEACH

DATE: MAR 1992 | DRAWING No.

PROFILE B



LEGEND

- 24.01.1990
- 20.02.1990
- 13.03.1992

PUBLIC WORKS

COAST AND RIVERS BRANCH

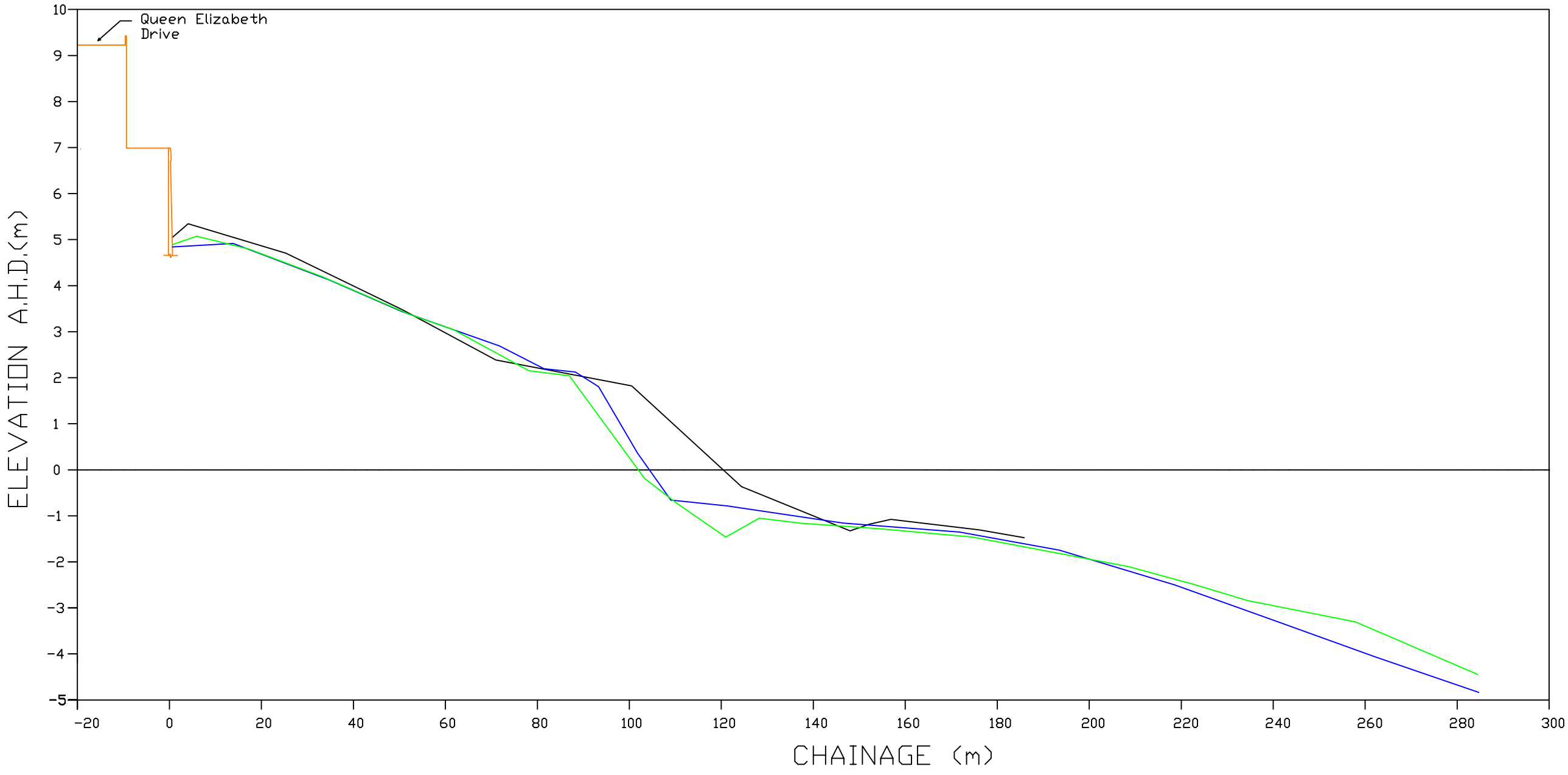
BEACH PROFILES

BONDI BEACH

DATE: MAR 1992

DRAWING No.

PROFILE C



LEGEND

- 24.01.1990
- 20.02.1990
- 13.03.1992

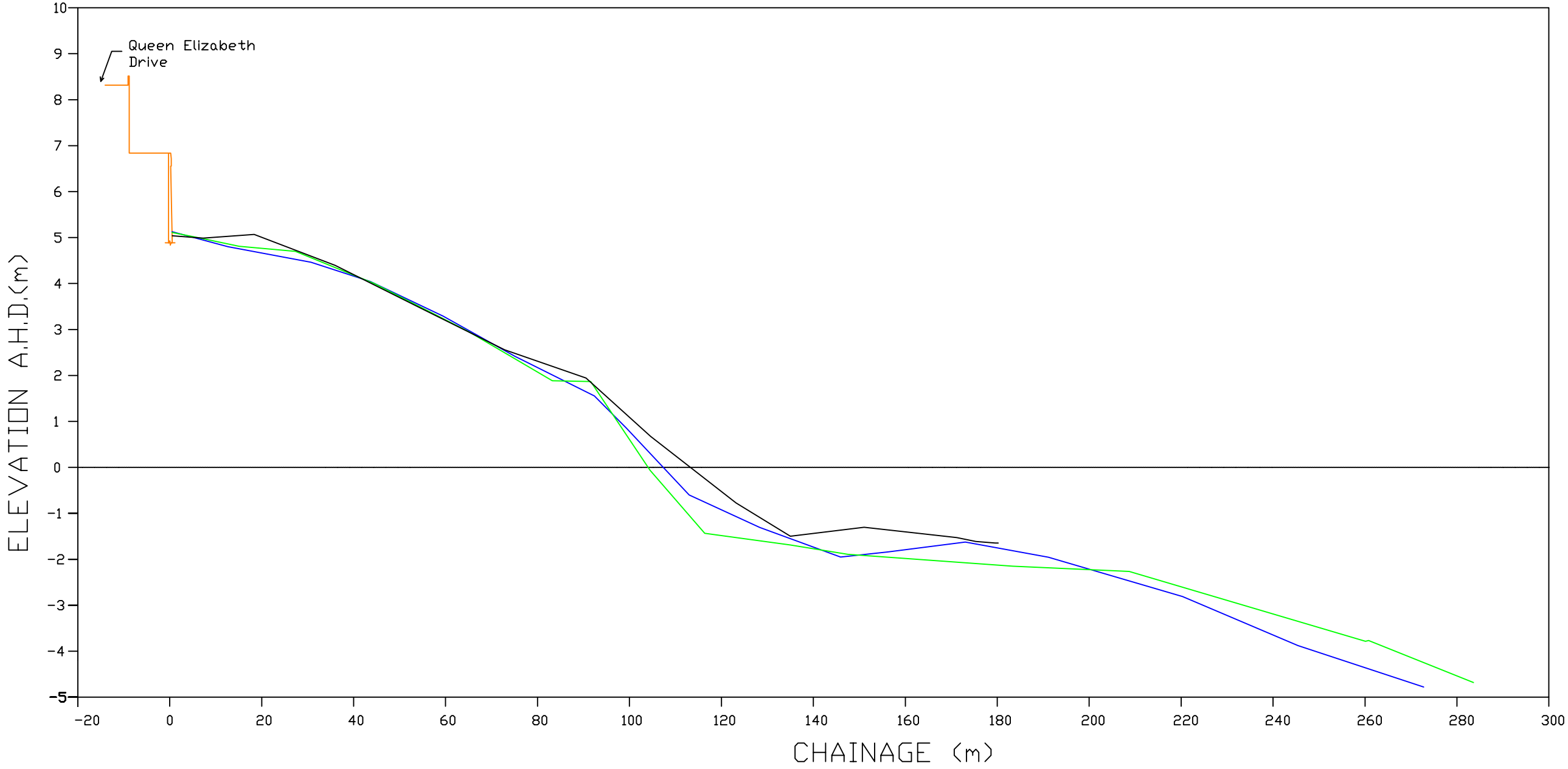
PUBLIC WORKS | COAST AND RIVERS BRANCH

BEACH PROFILES

BONDI BEACH

DATE: MAR 1992 | DRAWING No.

PROFILE D



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- 24.01.1990
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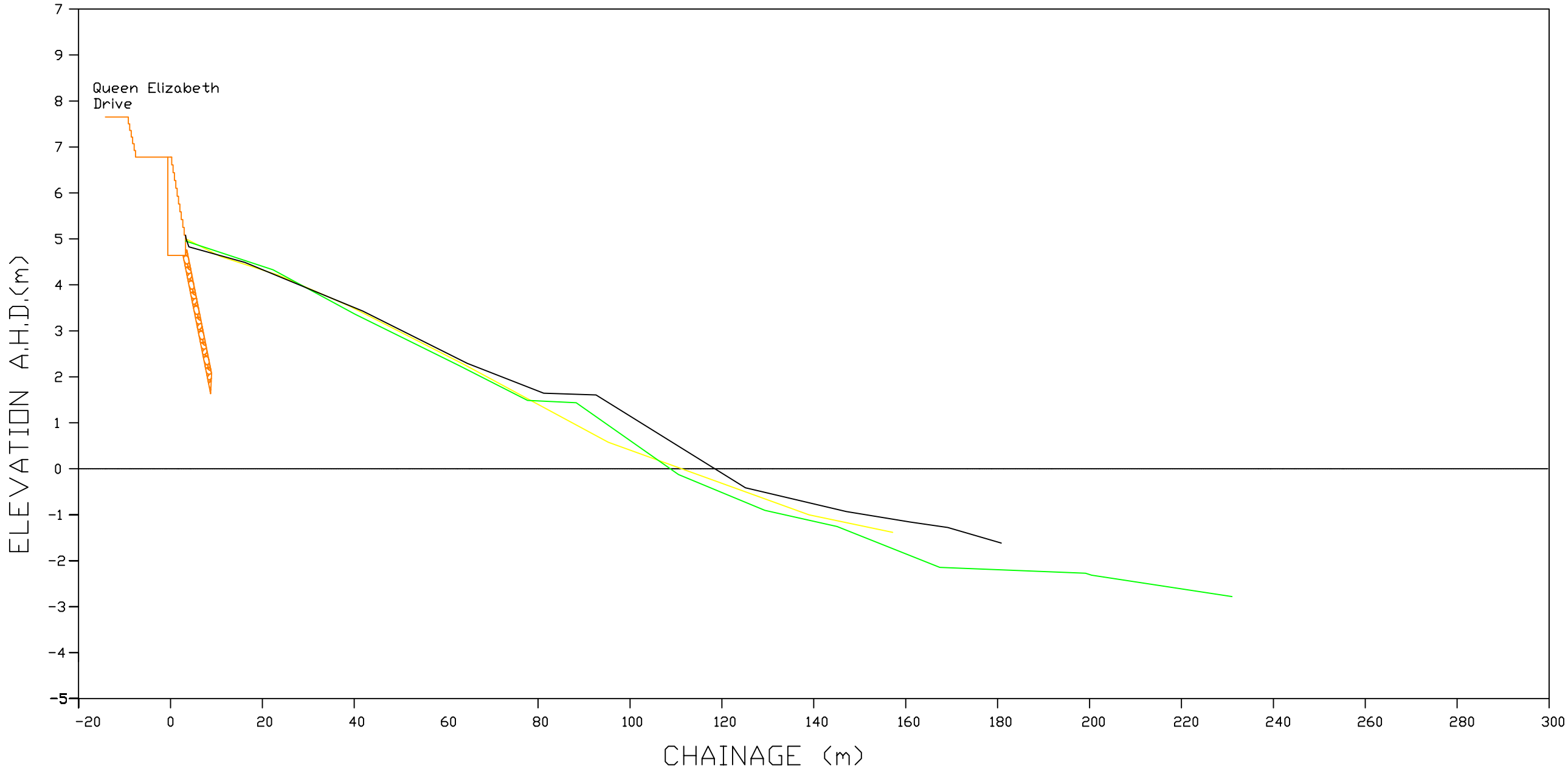
PUBLIC WORKS | COAST AND RIVERS BRANCH

BEACH PROFILES

BONDI BEACH

DATE: MAR 1992 | DRAWING No.

PROFILE E



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PUBLIC WORKS

COAST AND RIVERS BRANCH

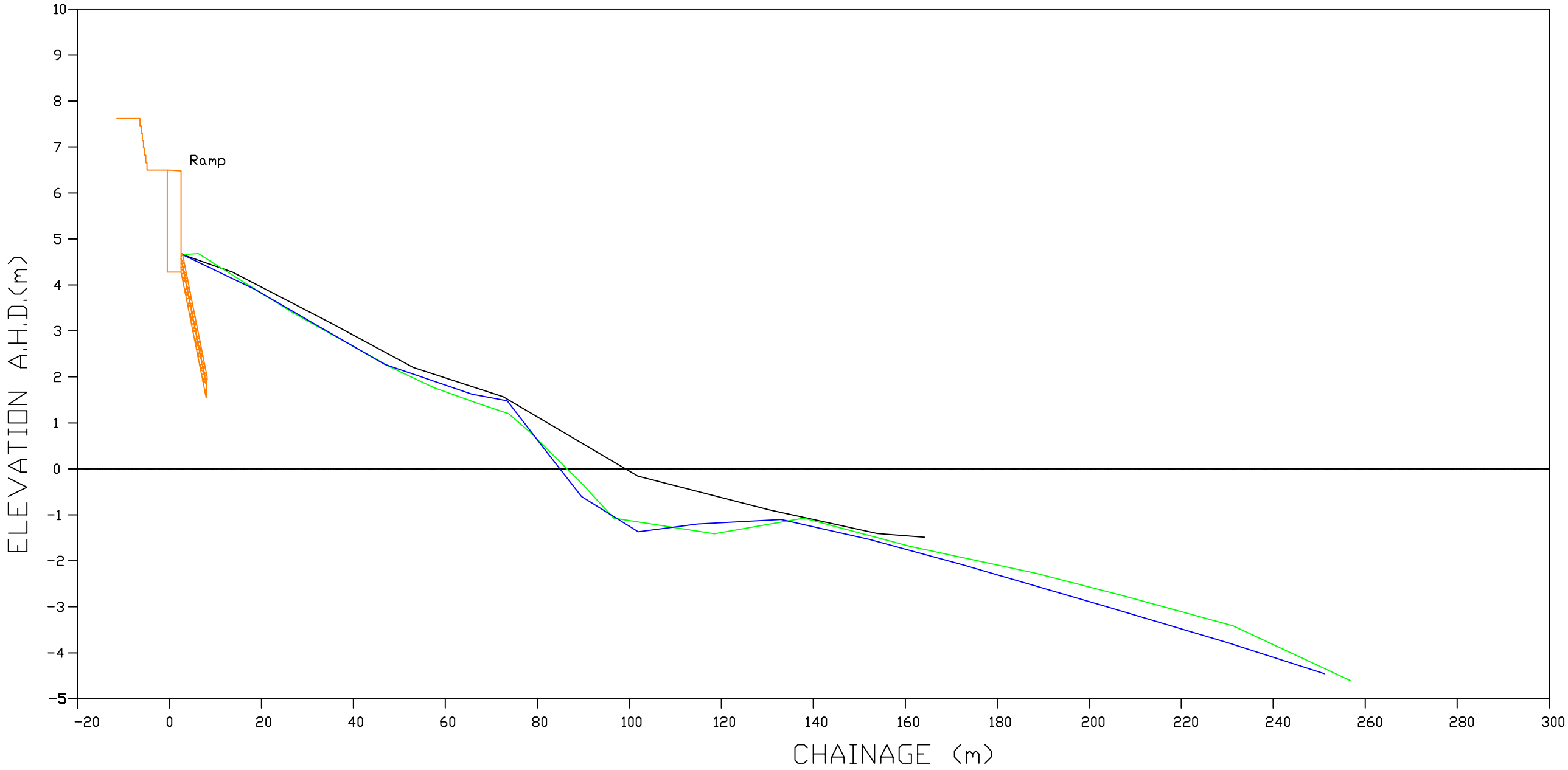
BEACH PROFILES

BONDI BEACH

DATE: MAR 1992

DRAWING No.

PROFILE F



LEGEND

- 24.01.1990
- 20.02.1990
- 13.03.1992

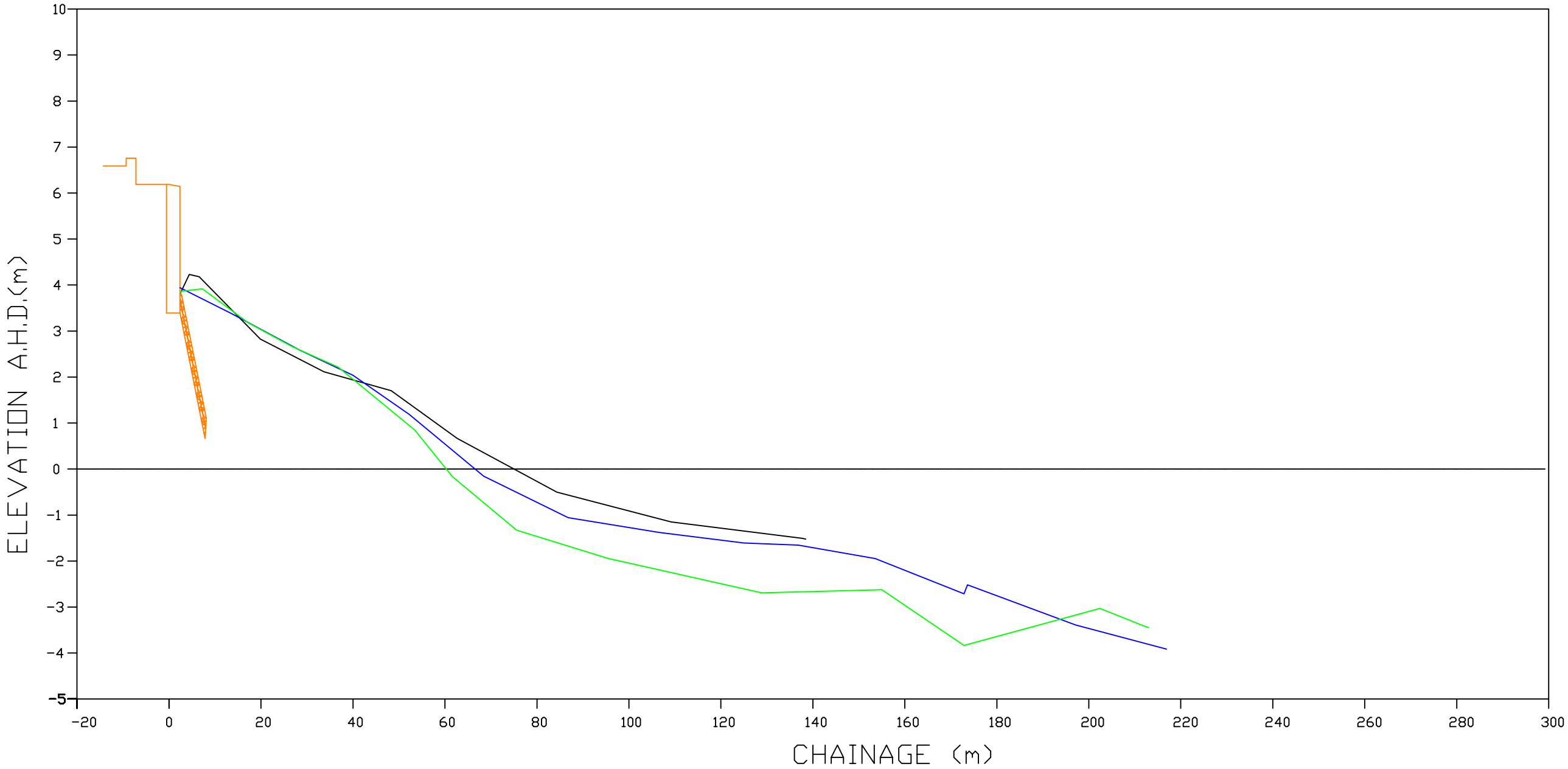
PUBLIC WORKS | COAST AND RIVERS BRANCH

BEACH PROFILES

BONDI BEACH

DATE: MAR 1992 | DRAWING No.

PROFILE G



LEGEND

- 24.01.1990
- 20.02.1990
- 13.03.1992

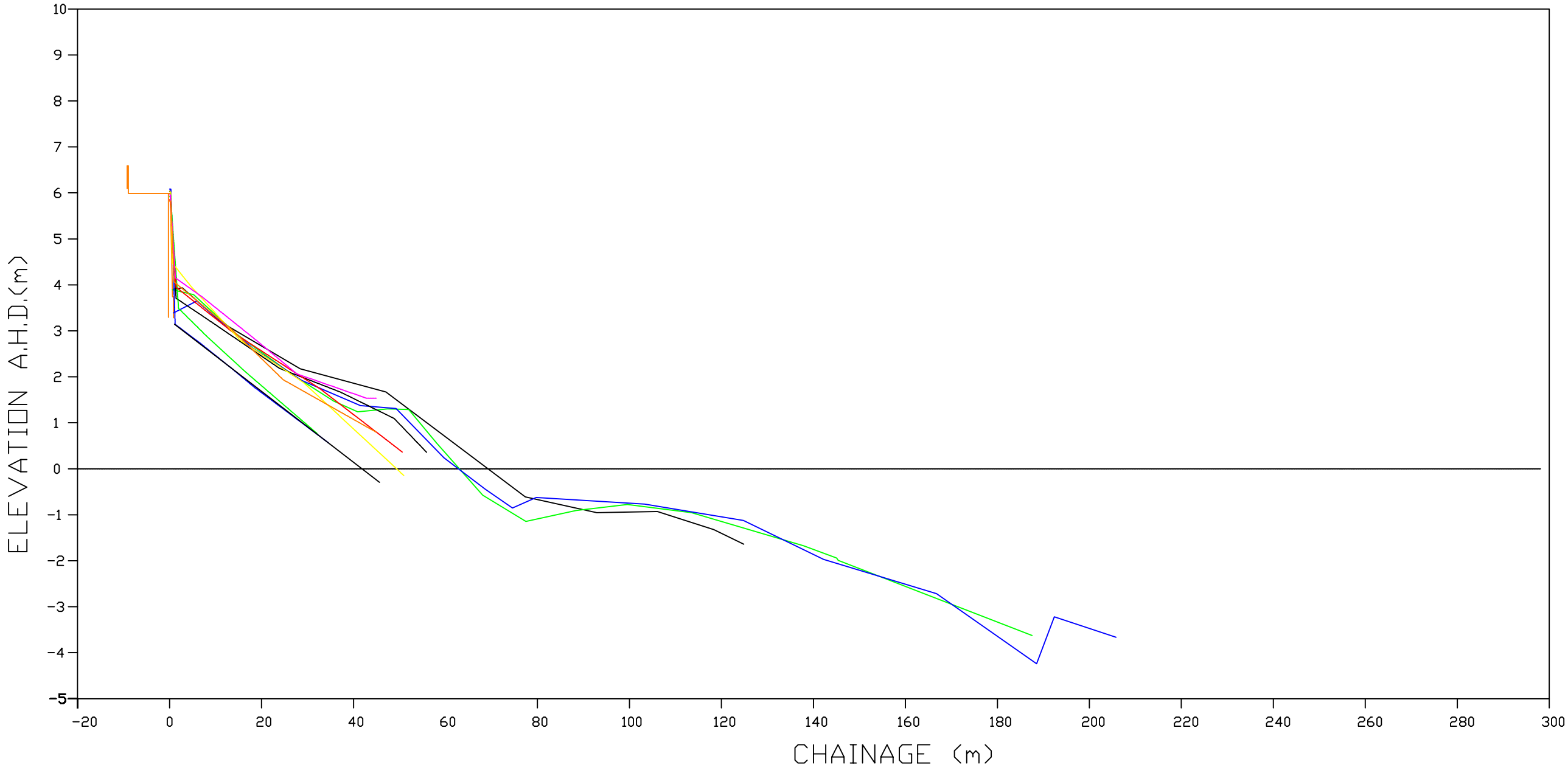
PUBLIC WORKS | COAST AND RIVERS BRANCH

BEACH PROFILES

BONDI BEACH

DATE: MAR 1992 | DRAWING No.

PROFILE H



LEGEND

- 24.01.1990
- 20.02.1990
- 13.03.1992

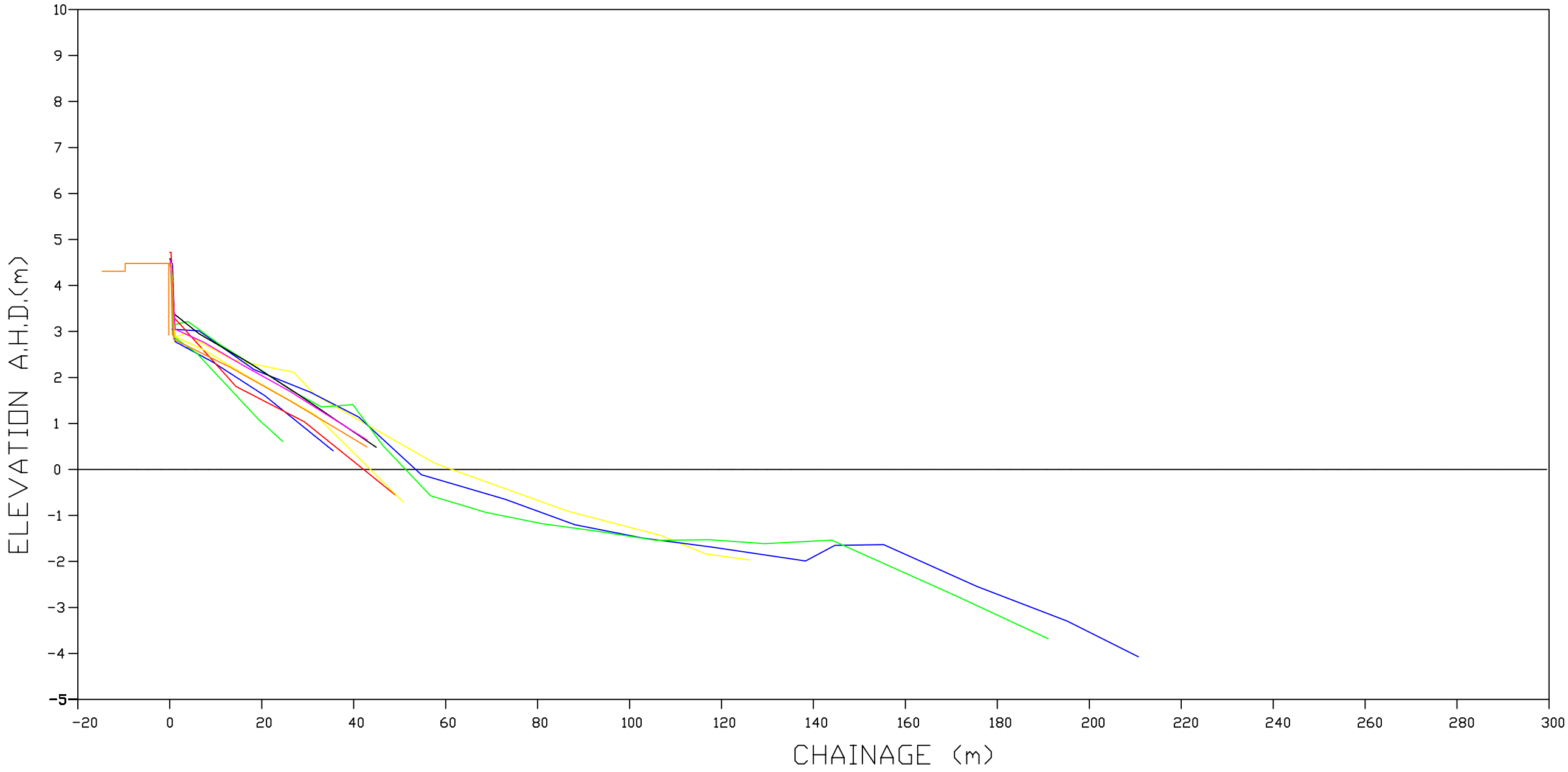
PUBLIC WORKS | COAST AND RIVERS BRANCH

BEACH PROFILES

BONDI BEACH

DATE: MAR 1992 | DRAWING No.

PROFILE I



LEGEND

- 24.01.1990
- 20.02.1990
- 13.03.1992
- 19.03.1992

PUBLIC WORKS

COAST AND RIVERS BRANCH

BEACH PROFILES

BONDI BEACH

DATE: MAR 1992

DRAWING No.

APPENDIX D – Review of Historical Aerial Photographs

Aerial photography is available for the Waverley coastline dating back to 1951. A summary of some of the distinctive features of various dates of photography is set out below on a beach by beach basis.

D.1 Bondi

The seawall and promenade with the grassed areas was constructed at the back of the beach prior to 1951. The SLSC building and the rock pool at the southern end of the beach was also built by this time.

No vegetation or sand dune at the back of the beach was present due to the seawall. The beach is widest in the middle and becomes narrower at both ends with the north eastern end narrower than the south western end. The beach width remained relatively similar in all the aerial photographs except for the 1974 and 1975 aerial photographs where the beach was eroded due to large storms during this time. Breaking waves also caused significant turbulence at the beach in the 1974 and 1975 aerial photographs.

Minor scouring and ponding in the vicinity of the stormwater outlets at the south western end of the beach was observed prior to 1993. By 1993, it is understood that the stormwater outlets has diverted the stormwater to the south west to mitigate further scouring.

Waves, where present, were observed to be generally from south-southeast and perpendicular to the alignment of the beach.

Alternating shoals and gutters perpendicular to the beach was evident in the nearshore zone in most of the aerial photographs from 1951 to present. The size of the shoals and gutters varies between the years. Undulating high water marks were also observed in the aerial photographs from the late 1970s.

D.2 Bronte and Tamarama

The seawalls and promenade with the grassed areas were constructed at the back of the beach prior to 1951. There was no vegetation or sand dunes in front of the seawalls. The buildings and roads were generally similar since 1951.

Bronte and Tamarama beach were eroded and narrow in 1974 and 1975 due to the large storms during this time. Tamarama beach width increased from 1975 to 1993, decreased in 2002 and then increased again in 2009. Bronte beach stayed relatively narrow between 1974 and 1978. The beach width recovered by 1985 and stayed at a similar width.

No gutters or cusps were observed. However, breaking waves at both beaches were observed to be turbulent in some of the aerial photographs, particularly in 1974 and 1975.

D.1 Bondi

1951

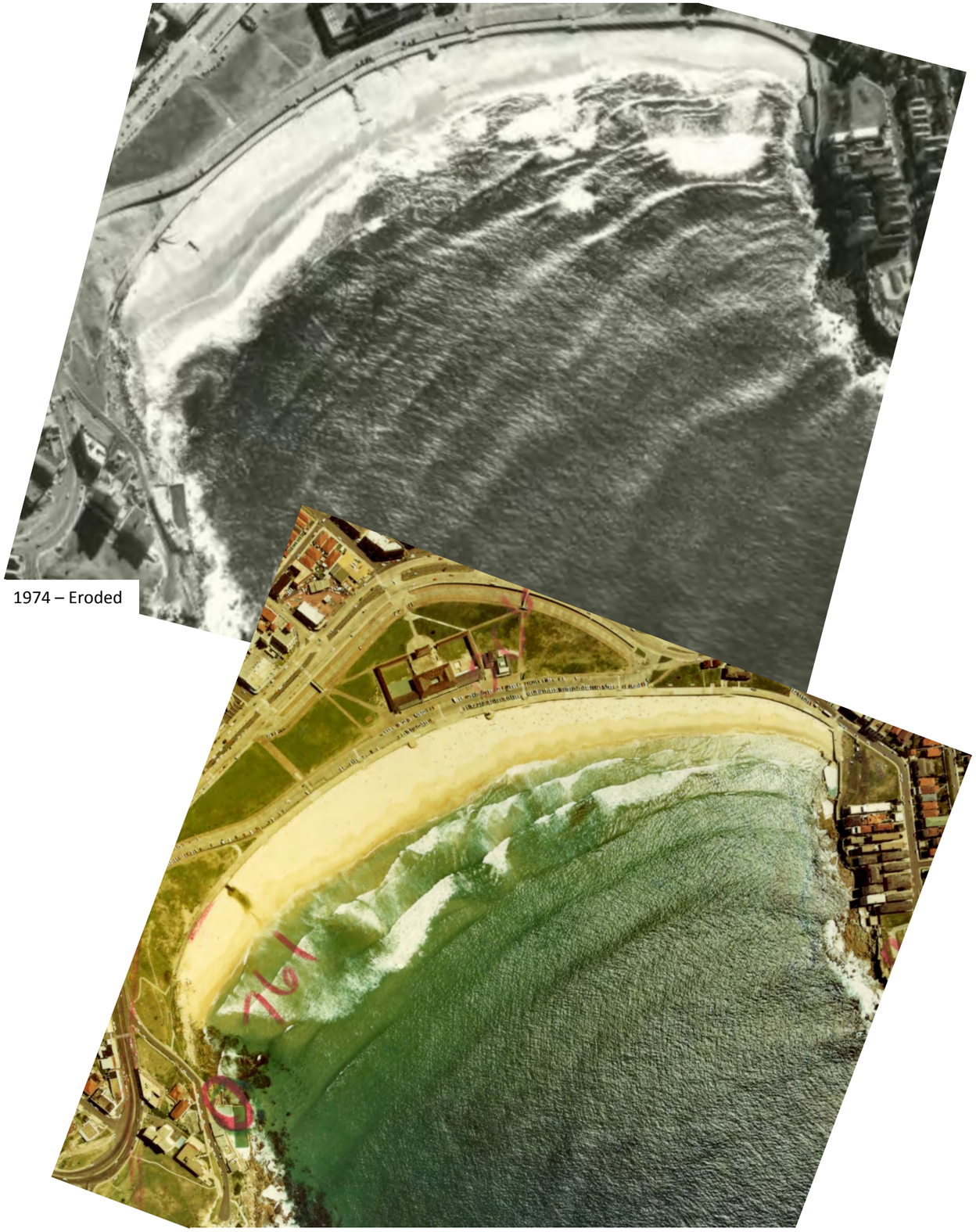
1955

1961

1965

1970

1975 – Eroded



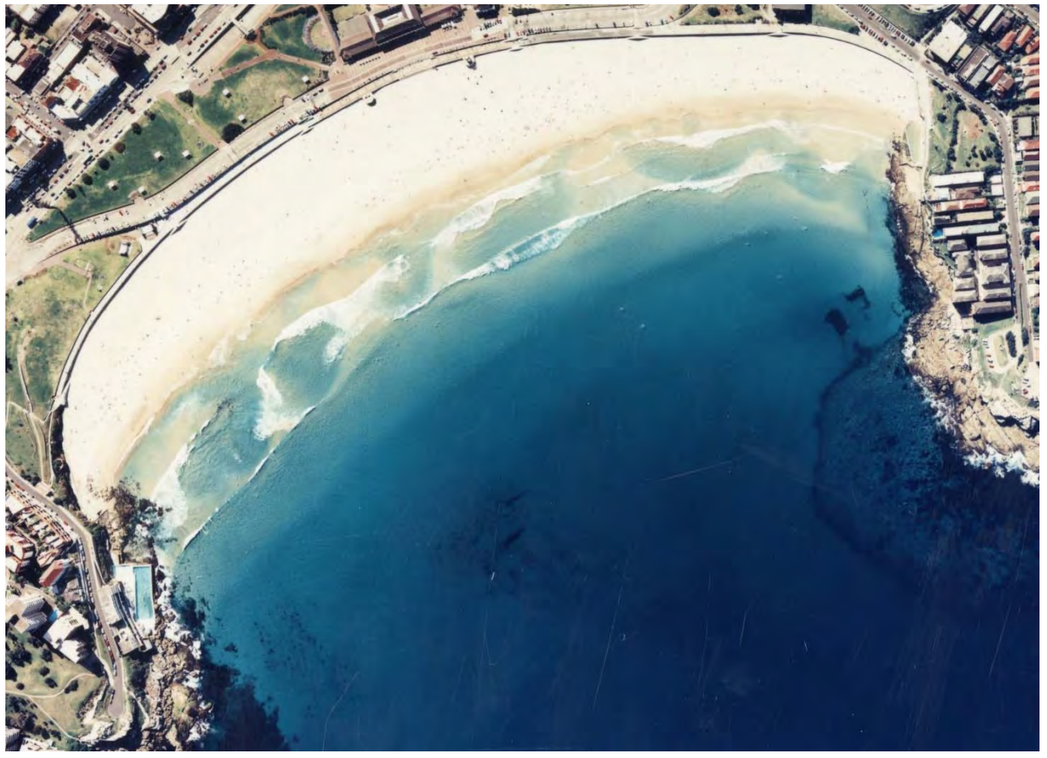
1974 – Eroded

1976

1978

1985

1986 – Eroded



1993

2002

2009

D.2 Bronte and Tamarama

1951

1955

1961

1965

1970

1974 – Eroded

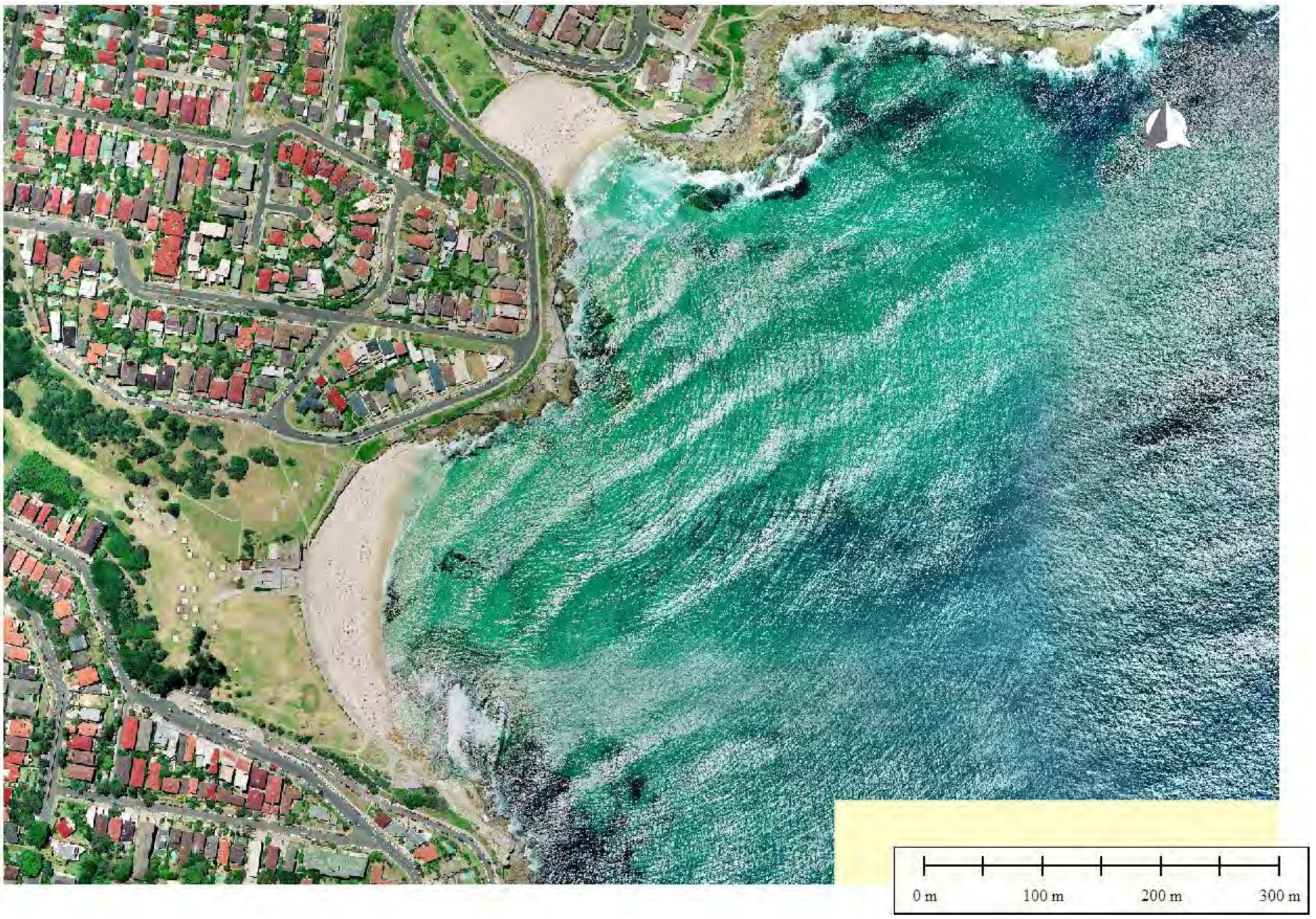
1975 – Erode

1976

1978

1985

1993



2002

2009

APPENDIX E – Photographs of 1974 Storm

PHOTOS TAKEN AT THE SOUTHERN END OF BONDI BEACH
12 NOON THURSDAY . 13th JUNE 1974

Photos by
J. D. AIOSA

PHOTOS TAKEN AT THE SOUTHERN END OF BONDI BEACH

12 NOON - THURSDAY, 13th JUNE 1974.

Photos by J.D. AIOSA

BRONTE BEACH STORM DAMAGE (28·5·74)

PHOTO'S D.V. ABBOTT 27·5·74

BRONTE BEACH STORM DAMAGE (26·5·74)
PHOTO'S D.V. ABBOTT 27·5·74

BRONTE BEACH STORM DAMAGE

BRONTE BEACH STORM DAMAGE (26·5·74)
PHOTOS D.V. ABBOTT 27·5·74

ROCK DEPOSITED IN BRONTE BATHS

26 · 6 · 74

PHOTOS TAKEN M DOBSON

TAMARAMA BEACH

STORM DAMAGE
26·5·74

PHOTO'S TAKEN

D.V. ABBOTT 27·5·74

TAMARAMA BEACH STORM DAMAGE (26·5·74)
PHOTO'S D.V. ABBOTT 27·5·74

TAMARAMA PARK STORM DAMAGE to
RETAINING WALL

TAMARAMA BEACH STORM DAMAGE 26·8·74

PHOTOS TAKEN M DOBSON

BONDI BEACH STORM DAMAGE
PHOTOS TAKEN D.V. ABBOTT 27·5·74

BONDI BEACH STORM DAMAGE 13th JUNE 1974

PHOTOS TAKEN M DOBSON

NTH BONDI BEACH

STORM DAMAGE

26·5·74

PHOTO'S TAKEN

D.V. ABBOTT

27·5·74

BONDI BEACH STORM DAMAGE 13th JUNE 1974
PHOTOS TAKEN M DOBSON

PHOTOS TAKEN AT THE SOUTHERN END OF BONDI BEACH

12 NOON THURSDAY 13th JUNE 1974

PHOTOS BY J.D. ALOSA

APPENDIX F – ABBREVIATIONS AND GLOSSARY

Abbreviations

FoS	Factor of Safety
ARI	Average Recurrence Interval
Council	Waverley Council
PWD	Public Works Department
OEH	Office of Environment and Heritage

Glossary

Accretion	The accumulation of (beach) sediment, deposited by natural fluid flow processes.
Aeolian deposits	Wind-deposited sediments, such as sand dunes.
Alongshore	Parallel to and near the shoreline; same as longshore.
Astronomical tide	The tidal levels and character which would result from gravitational effects, e.g. of the Earth, Sun and Moon, without any atmospheric influences.
Backshore	The upper part of the active beach above the normal reach of the tides (high water), but affected by large waves occurring during a high. The accretion or erosion zone, located landward of ordinary high tide, which is normally wetted only by storm tides.
Bar	An offshore ridge or mound of sand, gravel, or other unconsolidated material which is submerged (at least at high tide), especially at the mouth of a river or estuary, or lying parallel to, and a short distance from, the beach.
Bathymetry	The measurement of depths of water in oceans, seas and lakes; also the information derived from such measurements.
Bay	A recess or inlet in the shore of a sea or lake between two capes or headlands, not as large as a gulf but larger than a cove. See also *bight*, *embayment*.
Beach	The zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation. The seaward limit of a beach – unless otherwise specified – is the mean low water line. A beach includes foreshore and backshore.

Beach crest	The point representing the limit of high tide storm wave run-up.
Beach erosion	The carrying away of beach materials by wave action, tidal currents, littoral currents or wind.
Beach face	The section of the beach normally exposed to the action of wave uprush. The foreshore of the beach.
Beach head	The cliff, dune or sea wall looming the landward limit of the active beach.
Beach nourishment	The process of replenishing a beach by artificial means; e.g., by the deposition of dredged materials, also called beach replenishment or beach feeding.
Beach profile	A cross-section taken perpendicular to a given beach contour; the profile may include the face of a dune or sea wall, extend over the backshore, across the foreshore, and seaward underwater into the nearshore one.
Beach scarp	An almost perpendicular slope along the beach foreshore; an erosional feature due to wave action, it may vary in height from a few centimeters to several meters, depending on wave action and the nature and composition of the beach. See *escarpment*.
	A steep slope produced by wave erosion.
Beach width	The horizontal dimension of the beach measured normal to the shoreline.
Bed	The bottom of a watercourse, or any body of water.
Berm	On a beach: a nearly horizontal plateau on the beach face or backshore, formed by the deposition of beach material by wave action or by means of a mechanical plant as part of a beach recharge scheme.
Berm crest	The seaward limit of the berm, or the minimum depth of a submerged berm; also called berm edge.
Bight	A slight indentation in a coast forming an open bay, usually crescent shaped.
Blowout	A depression on the land surface caused by wind erosion.
Bluff	A high, steep bank or cliff.
Breaker zone	The zone within which waves approaching the coastline commence breaking, typically in water depths of between 5 m and 10 m.
Breaking depth	The still-water depth at the point where the wave breaks.

Breakwater	Offshore structure aligned parallel to the shore, sometimes shore-connected, that provides protection from waves.
Chart datum	The plane or level to which soundings, tidal levels or water depths are referenced, usually low water datum.
Cliff	A high steep face of rock.
Climate change	Refers to any long-term trend in mean sea level, wave height, wind speed, drift rate etc.
Coast	A strip of land of indefinite length and width (may be tens of kilometers) that extends from the seashore inland to the first major change in terrain features.
Coastal currents	Those currents which flow roughly parallel to the shore and constitute a relatively uniform drift in the deeper water adjacent to the surf zone. These currents may be tidal currents, transient, wind-driven currents, or currents associated with the distribution of mass in local waters.
Coastal defence	General term used to encompass both coast protection against erosion and sea defense against flooding.
Coastal Flooding	Catchment-related flooding of coastal areas.
Coastal management	The development of a strategic, long-term and sustainable land use policy, sometimes also called shoreline management.
Coastal plain	The plain composed of horizontal or gently sloping strata of clastic material fronting the coast and generally representing a strip of recently emerged sea bottom that has emerged from the sea in recent geologic times. Also formed by aggradation.
Coastal processes	Collective term covering the action of natural forces on the shoreline, and the nearshore seabed.
Coastal zone	The land-sea-air interface zone around continents and islands extending from the landward edge of a barrier beach or shoreline of coastal bay to the outer extent of the continental shelf.
Coastline	The line where terrestrial processes give way to marine processes, tidal currents, wind waves, etc.
Continental Shelf	The zone bordering a continent extending from the line of permanent immersion to the depth, usually about 100 m to 200 m, where there is a marked or rather steep descent toward the great depths.

Continental slope	The declivity from the offshore border of the continental shelf to oceanic depths. It is characterised by a marked increase in slope.
Datum	Any position or element in relation to which others are determined, as datum point, datum line, datum plane.
Deep water	In regard to waves, where depth is greater than one-half the wave length. Deep-water conditions are said to exist when the surf waves are not affected by conditions on the bottom.
Design storm	Coastal protection structures will often be designed to withstand wave attack by the extreme design storm. The severity of the storm (i.e. return period) is chosen in view of the acceptable level of risk of damage or failure. A design storm consists of a design wave condition, a design water level and a duration.
Design wave	In the design of harbors, harbor works, etc., the type or types of waves selected as having the characteristics against which protection is desired.
Diffraction	The phenomenon occurring when water waves are propagated into a sheltered region formed by a breakwater or similar barrier that interrupts a portion of the otherwise regular train of waves, resulting in the multi-directional spreading of the waves. It results in the transfer of wave energy along the wave crest.
Downdrift	The direction of predominant movement of littoral materials.
Dunes	Accumulations of windblown sand on the backshore, usually in the form of small hills or ridges, stabilised by vegetation or control structures.
Elevation	The distance of a point above a specified surface of constant potential; the distance is measured along the direction of gravity between the point and the surface.
Embayed	Formed into a bay or bays; as an embayed shore.
Embayment	An indentation in a shoreline forming an open bay. The formation of a bay.
Erosion	Wearing away of the land by natural forces. On a beach, the carrying away of beach material by wave action, tidal currents or by deflation. The wearing away of land by the action of natural forces.
Escarpment	A more or less continuous line of cliffs or steep slopes facing in one general direction which are caused by erosion or faulting, also called scarp.

Event	An occurrence meeting specified conditions, e.g. damage, a threshold wave height or a threshold water level.
Fault	A fracture in rock along which there has been an observable amount of displacement. Faults are rarely single planar units; normally they occur as parallel to sub-parallel sets of planes along which movement has taken place to a greater or lesser extent. Such sets are called fault or fracture-zones.
Fetch	The length of unobstructed open sea surface across which the wind can generate waves (generating area).
Foreshore	In general terms, the beach between mean higher high water and mean lower low water.
Gabion	Structures composed of masses of rocks, rubble or masonry held tightly together usually by wire mesh so as to form blocks or walls.
Geomorphology	That branch of physical geography which deals with the form of the Earth, the general configuration of its surface, the distribution of the land, water, etc.
Groyne	A shore-protection structure (built usually to trap littoral drift or retard erosion of the shore). It is narrow in width (measured parallel to the shore) and its length may vary from tens to hundreds of meters (extending from a point landward of the shoreline out into the water). Groynes may be classified as permeable (with openings through them) or impermeable (a solid or nearly solid structure).
Hazard Line	Mapped line representing the estimated extent of beach erosion from an extreme oceanic storm event plus allowance for reduced foundation capacity.
High water (HW)	Maximum height reached by a rising tide. The height may be solely due to the periodic tidal forces or it may have superimposed upon it the effects of prevailing meteorological conditions. Nontechnically, also called the high tide.
Hydrography	The description and study of seas, lakes, rivers and other waters.
Inshore	The region where waves are transformed by interaction with the sea bed. In beach terminology, the zone of variable width extending from the low water line through the breaker zone.
Inshore current	Any current inside the surf zone.
Intertidal	The zone between the high and low water marks.

Lagoon	A shallow body of water, as a pond or lake, which usually has a shallow restricted inlet from the sea.
Leeward	The direction toward which the prevailing wind is blowing; the direction toward which waves are travelling.
Littoral	Of, or pertaining to, a shore, especially a seashore. Living on, or occurring on, the shore.
Littoral currents	A current running parallel to the beach and generally caused by waves striking the shore at an angle.
Littoral drift	The mud, sand, or gravel material moved parallel to the shoreline in the nearshore zone by waves and currents.
Littoral transport	The movement of littoral drift in the littoral zone by waves and currents. Includes movement parallel (long shore drift) and sometimes also perpendicular (cross-shore transport) to the shore.
Longshore	Parallel and close to the coastline.
Longshore drift	Movement of sediments approximately parallel to the coastline.
Longshore transport rate	Rate of transport of sedimentary material parallel to the shore. Usually expressed in cubic meters (yards) per year. Commonly used as synonymous with littoral transport rate.
Low water (LW)	The minimum height reached by each falling tide. Nontechnically, also called low tide.
Mean high water (MHW)	The average elevation of all high waters recorded at a particular point or station over a considerable period of time, usually 19 years. For shorter periods of observation, corrections are applied to eliminate known variations and reduce the result to the equivalent of a mean 19-year value. All high water heights are included in the average where the type of tide is either semidiurnal or mixed. Only the higher high water heights are included in the average where the type of tide is diurnal. So determined, mean high water in the latter case is the same as mean higher high water.
Mean high water springs (MHWS)	The average height of the high water occurring at the time of spring tides.
Mean low water (MLW)	The average height of the low waters over a 19-year period. For shorter periods of observation, corrections are applied to eliminate known variations and reduce the result to the equivalent of a mean 19-year value.

Mean low water springs (MLWS)	The average height of the low waters occurring at the time of the spring tides.
Mean sea level	The average height of the surface of the sea for all stages of the tide over a 19-year period, usually determined from hourly height readings (see *sea level datums*).
Nearshore	In beach terminology an indefinite zone extending seaward from the shoreline well beyond the breaker zone.
Nearshore circulation	The ocean circulation pattern composed of the nearshore currents and the coastal currents.
Nearshore current	The current system caused by wave action in and near the breaker zone, and which consists of four parts: the shoreward mass transport of water; longshore currents; rip currents; and the longshore movement of the expanding heads of rip currents.
Nourishment	The process of replenishing a beach. It may be brought about naturally, by longshore transport, or artificially by the deposition of dredged materials.
Ocean current	A nontidal current constituting a part of the general oceanic circulation.
Oceanography	That science treating of the oceans, their forms, physical features and phenomena.
Offshore	In beach terminology, the comparatively flat zone of variable width, extending from the shoreface to the edge of the continental shelf. It is continually submerged.
Offshore wind	A wind blowing seaward from the land in the coastal area.
Onshore wind	A wind blowing landward from the sea.
Outflanking	erosion behind or around the inner end of a Groyne or bulkhead, usually causing failure of the structure.
Overtopping	Water carried over the top of a coastal defense due to wave run-up or surge action exceeding the crest height.
Photogrammetry	The science of deducing the physical dimensions of objects from measurements on images (usually photographs) of the objects.
Pocket beach	A beach, usually small, between two headlands.

Quaternary	The youngest geologic period; includes the present time. The latest period of time in the stratigraphic column, 0 – 2 million years, represented by local accumulations of glacial (Pleistocene) and post-glacial (Holocene) deposits which continue, without change of fauna, from the top of the Pliocene (Tertiary). The quaternary appears to be an artificial division of time to separate pre-human from post-human sedimentation. As thus defined, the quaternary is increasing in duration as man's ancestry becomes longer.
Recession	A net landward movement of the shoreline over a specified time.
Reef	A ridge of rock or other material lying just below the surface of the sea.
Refraction	The process by which the direction of a wave moving in shallow water at an angle to the bottom contours is changed. The part of the wave moving shoreward in shallower water travels more slowly than that portion in deeper water, causing the wave to turn or bend to become parallel to the contours.
Reno-mattress	A mattress comprising a wire basket, commonly with dimensions 2 m × 6 m × 0.30 m, that is filled with stone cobbles.
Return period	Average period of time between occurrences of a given event.
Revetment	A facing of stone, concrete, etc., to protect an embankment, or shore structure, against erosion by wave action or currents.
Rip current	A strong surface current of short duration flowing seaward from the shore. It usually appears as a visible band of agitated water and is the return movement of water piled up on the shore by incoming waves and wind. A rip current consists of three parts: the feeder current flowing parallel to the shore inside the breakers; the neck, where the feeder currents converge and flow through the breakers in a narrow band or "rip"; and the head, where the current widens and slackens outside the breaker line.
Rips	Agitation of water caused by the meeting of currents or by rapid current setting over an irregular bottom.
Risk analysis	Assessment of the total risk due to all possible environmental inputs and all possible mechanisms.
Run-up	the rush of water up a structure or beach on the breaking of a wave. The amount of run-up is the vertical height above stillwater level that the rush of water reaches.

Sand	An unconsolidated (geologically) mixture of inorganic soil (that may include disintegrated shells and coral) consisting of small but easily distinguishable grains ranging in size from about .062 mm to 2.0 mm.
Sand dune	A dune formed of sand.
Scarp	See *escarpment*.
Scour protection	Protection against erosion of the seabed in front of the toe.
Sea level rise	The long-term trend in mean sea level.
Seawall	A structure separating land and water areas primarily to prevent erosion and other damage by wave action.
Sediment	Loose, fragments of rocks, minerals or organic material which are transported from their source for varying distances and deposited by air, wind, ice and water. Other sediments are precipitated from the overlying water or form chemically, in place. Sediment includes all the unconsolidated materials on the sea floor.
Setback	A required open space, specified in shoreline master programs, measured horizontally upland from an perpendicular to the ordinary high water mark.
Shoal	(noun) A detached area of any material except rock or coral. The depths over it are a danger to surface navigation. Similar continental or insular shelf features of greater depths are usually termed banks. (verb) To become shallow gradually.
Shore	That strip of ground bordering any body of water which is alternately exposed, or covered by tides and/or waves. A shore of unconsolidated material is usually called a beach.
Shoreface	The narrow zone seaward from the low tide shoreline permanently covered by water, over which the beach sands and GRAVELS actively oscillate with changing wave conditions.
Shoreline	The intersection of a specified plane of water with the shore.
Significant wave	A statistical term relating to the one-third highest waves of a given wave group and defined by the average of their heights and periods.
Significant wave height	Average height of the highest one-third of the waves for a stated interval of time.
Spring tide	A tide that occurs at or near the time of new or full moon, and which rises highest and falls lowest from the mean sea level (MSL).

Storm surge	A rise or piling-up of water against shore, produced by strong winds blowing onshore. A storm surge is most severe when it occurs in conjunction with a high tide.
Sub-aerial beach	That part of the beach which is uncovered by water (e.g. at low tide sometimes referred to as drying beach).
Surf zone	The nearshore zone along which the waves become breakers as they approach the shore.
Survey, hydrographic	A survey that has as its principal purpose the determination of geometric and dynamic characteristics of bodies of water.
Survey, photogrammetric	A survey in which monuments are placed at points that have been determined photogrammetrically.
Survey, topographic	A survey which has, for its major purpose, the determination of the configuration (relief) of the surface of the land and the location of natural and artificial objects thereon.
Swell	Waves that have traveled a long distance from their generating area and have been sorted out by travel into long waves of the same approximate period.
Tide	The periodic rising and falling of the water that results from gravitational attraction of the moon and sun acting upon the rotating earth. Although the accompanying horizontal movement of the water resulting from the same cause is also sometimes called the tide, it is preferable to designate the latter as tidal current, reserving the name tide for the vertical movement.
Topography	The form of the features of the actual surface of the Earth in a particular region considered collectively.
Transgression, marine	The invasion of a large area of land by the sea in a relatively short space of time (geologically speaking). Although the observable result of a marine transgression may suggest an almost ‘instantaneous’ process, it is probable that the time taken is in reality to be measured in millions of years. The plane of marine transgression is a plane of unconformity. The reverse of a transgression is a regression.
Undercutting	erosion of material at the foot of a cliff or bank, e.g., a sea cliff, or river bank on the outside of a meander. Ultimately, the overhang collapses, and the process is repeated.
Uprush	The rush of water up the foreshore following the breaking of a wave, also called swash or runup.

Wave	An oscillatory movement in a body of water manifested by an alternate rise and fall of the surface. A disturbance of the surface of a liquid body, as the ocean, in the form of a ridge, swell or hump.
Wave climate	Average condition of the waves at a place, over a period of years, as shown by height, period, direction, etc.
Wave-cut platform	A horizontal bench of rock formed beneath the surf zone as a coast retreats because of wave erosion.
Wave generation	Growth of wave energy by wind.
Wave Height Coefficient	A factor that is applied to the height of a wave offshore in deep water to determine the wave height at a point near the shore. The coefficient combines the effects of wave refraction and wave shoaling and depends upon the offshore wave direction, wave period, nearshore bathymetry, beach slope and water depth.
Wave period	The elapsed time between the passing of sequential wave crests (or troughs).
Wave propagation	The generation of waves, usually by wind, and their transmission through water.
Wave Refraction	A process that affects the transformation of waves in shallow water, resulting in the waves changing their direction of travel and height. Wave refraction is caused by the variation in the water depth towards the shoreline and the degree of change depends on the wave period.
Wave set-up	Elevation of the still-water level due to breaking waves.
Wave Transformation	The passage of a wave from deep water to shallow water, which involves the change in the direction of wave tavel and the wave height.

APPENDIX G – Mapping

Note: All mapping is for current, 2050 and 2100 inclusive, as the same lines apply to all dates.

LOTS WITH IDENTIFIED POTENTIAL CLIFF HAZARD (1 OF 6)

LOTS WITH IDENTIFIED POTENTIAL CLIFF HAZARD (2 OF 6)

LOTS WITH IDENTIFIED POTENTIAL CLIFF HAZARD (3 OF 6)

LOTS WITH IDENTIFIED POTENTIAL CLIFF HAZARD (4 OF 6)

LOTS WITH IDENTIFIED POTENTIAL CLIFF HAZARD (5 OF 6)

LOTS WITH IDENTIFIED POTENTIAL CLIFF HAZARD (6 OF 6)

LOTS WITH IDENTIFIED POTENTIAL OCEAN INUNDATION HAZARD (1 OF 3)

LOTS WITH IDENTIFIED POTENTIAL OCEAN INUNDATION HAZARD (2 OF 3)

LOTS WITH IDENTIFIED POTENTIAL OCEAN INUNDATION HAZARD (3 OF 3)

ZONE OF REDUCED FOUNDATION CAPACITY AT BONDI

ZONE OF REDUCED FOUNDATION CAPACITY AT BRONTE

ZONE OF REDUCED FOUNDATION CAPACITY AT TAMARAMA