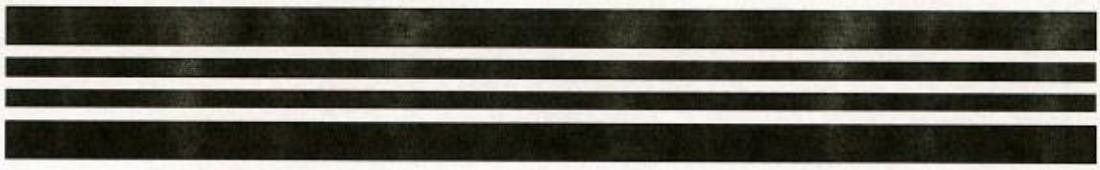

EIS 231

AA052548

Bellinger Keys Estate Pacific Highway Urunga (Shire of Bellingen).

ENVIRONMENTAL IMPACT STATEMENT

PROPOSED CANAL EXCAVATION

BELLINGER KEYS ESTATE

PACIFIC HIGHWAY

URUNGA

(SHIRE OF BELLINGEN)

LOCKETT & MONTGOMERIE PTY. LIMITED

ENGINEERS, PLANNERS & SURVEYORS

COFFS HARBOUR. DECEMBER, 1983

M84/0931

FORM 4

ENVIRONMENTAL PLANNING AND ASSESSMENT ACT, 1979 (SECTION 77 (3)(d).).

ENVIRONMENTAL IMPACT STATEMENT

Am No 8127589

This Statement has been prepared by or on behalf of Gordex Pty. Ltd. being the applicant making the development application referred to below.

The Statement accompanies the development application made in respect of the development described as follows:

Construction of canals, filling of land, reducing level of land and associated subdivision to create approximately 15 additional residental lots.

The development application relates to the land described as follows:

Lot 93 DP263599 Parish of Newry.

The contents of this Statement as required by Clause 34 of the Environmental Planning and Assessment Regulation, 1980, are set forth in the accompanying pages.

Name, Qualifications and Address of person who prepared Environmental Impact Statement:

JOHN NEVE ALLEN LGE;MIE(AUST); LGTCP; MRAIPR.
24 ROBERT GARRETT STREET,
COFFS HARBOUR. NSW. 2450.

Certificate:

I, **JOHN NEVE ALLEN,** of 24 ROBERT GARRETT STREET, COFFS HARBOUR, hereby certify that I have prepared the contents of this Statement in accordance with Clauses 34 and 35 of the Environmental Planning and Assessment Regulation, 1980.

.....

(Signature)

Date: ...7.-9.-83.....

BELLINGER KEYS ESTATE

ENVIRONMENTAL STUDY

PROPOSED CANAL DEVELOPMENT

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ACKNOWLEDGEMENTS

Dr. K. O'Gower	- Preparation of section on Biological Aspects.
Holmes & Holmes	- Report on Site Investigations
Laurie Montgomerie & Pettit	- Preparation of section on Erosion & Siltation.
Laurie Montgomerie & Pettit	- Preparation of section on Hydraulic Analysis
Dr. S. Bowdler	- Preparation of section on Archaeological Aspects

DEFINITIONS:

1. Approved Development:-

   Refers to the Development Approval granted by the Council on 23rd June, 1981.
   for the creation of 137 Lots and all associated facilities

2. Bellinger Keys Estate:-

   Includes all the land indicated by heavy outline in Figure N°2(b)

3. Council:-

   Means the Bellingen Shire Council

4. Development Area:-

   Means the area indicated by hatching on Figure N°1 (b)

5. Study Area:-

   Means the area of the Canal system as indicated on Figure N°3 and adjoining land which may be affected by the construction of the canals.

1. PRECIS OF REPORT

1.1 This Study has been prepared by Lockett & Montgomerie Pty. Limited, Consulting Engineers, Surveyors and Town Planners, on behalf of Gordex Pty. Limited and comprises an Environmental Study of a Proposed Canal Development at Urunga, N.S.W.

The primary objective of the Proposed Development is stated to be:

"To provide a high quality Residential Subdivision consistent with the need to protect and enhance the fragile estuarine environment".

1.2 The Subdividor proposes to achieve this objective by:-

* constructing a canal system to improve the Estuary by expanding the total waterway whilst at the same time maintaining a stable hydrology and ensuring no appreciable changes to flood levels and velocities and providing "waterfront" Lots for the Residential Section of the Development.
* providing fully serviced, flood free Lots, most of which will have access to the Kalang River or the proposed canals.
* by retaining as much as possible of the existing wetlands and mangrove areas.

1.3 The Report establishes:-

* soil types are suitable for the canal sections proposed.

...2/

* the excavated material is suitable for use as fill on the Residential Areas of the Development.
* the 1 in 20 year and 1 in 100 year floods will not be appreciably altered by the Proposed Development.
* the canal outlets lie on essentially stable zones of the river.
* siltation and erosion will not be unreasonable.
* the Proposed Development can be adequately serviced and will not overload the existing services on adjacent land.
* water quality within the canals can be maintained at a satisfactory level.
* there are no aboriginal relics or sites within the Development Area.

...3/

2. Summary

Development is already well advanced on the section of Bellinger Keys Estate which adjoins the Development Area and a number of houses have been constructed thereon.

The Subdividor now proposes to extend development to the northern end of the peninsula.

This will involve the construction of two short canals; the lowering of the peninsular to increase floodway area; the filling of areas for residential development; and a modification of the lot layout approved on 23/6/1981.

Approximately 15 additional residential lots will be created.

The majority of the area to be developed for residential purposes is currently zoned Residential 2 (c). A small section between the two canals is currently zoned Open Space 6 (a) but is the subject of a rezoning proposal currently being processed.

Detailed investigations were carried out into the flooding of the area and it has been determined that no appreciable change will result following the Development. The lowering of the peninsula will adequately compensate for the lost waterway caused by filling but will not cause any undesirable changes to velocities or flow patterns.

...4/

The problems of soil stability, erosion and siltation have all been addressed and it has been determined that the canal section suggested will be stable in the soil strata to be encountered. Because there is a high clay content in the existing soils, it has been recommended that the inter-tidal zone of the canals should be dressed with imported sand.

The investigation into erosion and siltation revealed that siltation of the outlet of the canals could be reduced by shifting their location slightly south. This suggestion has been adopted and the Plans in this Report show the outlet in the recommended location.

Because of the extremely complex nature of the erosion/siltation process, it is not possible to provide accurate, time-related, figures. However, it has been established that the canals are well located so as to minimise any process of siltation or erosion and thus maintenance will be at a minimum level.

The impact of the Proposed Development on the existing roads and services in the area has been considered and it has been established that adequate capacity exists and no conflicts will occur.

Although the construction of the canals will demolish a section of the existing mangrove stand this loss will be balanced by the increased productivity resulting from

...5/

the increased waterway of the Estuary. The total area of mangrove to be removed is very small in comparison with other stands within the Estuary.

There are no sites or relics of aboriginal origin within the Development Area.

The Proposed Development is consistent with the Bellingen Shire Council's objectives for the development of the Urunga Area and will satisfy a real demand for such land. There are no physical, biological or social objections to the Development which cannot be overcome or balanced by beneficial gains.

...6/

3. Introduction

3.1 History of Proposal

The first outline Proposals for the Development of the Bellinger Keys Estate were put forward in mid 1980 and were formally submitted to Council on 20th March, 1981.

The form of that original proposal is set out in Figure 2(a).

Following detailed Site Analysis, the preparation of a Flood Study by Antony Todd & Partners and the ever-necessary Market and Financial Analysis, a refined Proposal was submitted to Bellingen Shire Council and is outlined in Figure 2(b).

Plate N°1 "View over Existing Approved Development"

...7/

That Proposal provided for the creation of 137 Residential Lots; the provision of a central area for recreation, and a small Commercial Centre; but showed the majority of the present Development Area as a Residue Lot.

At that stage the future of the Development Area had not been addressed as any development of it was considered to be undesirable because of the potential impact on major floods.

Investigations commenced early in 1982 into the viability of developing the peninsular area by providing increased floodway area within a canal system.

The construction of a canal/floodway traversing east/west across the peninsular was examined in detail and a comprehensive flood study was carried out. This proposal would have allowed for extensive development of the peninsular with access being gained by the construction of a bridge over the canal. A control barrage would have been constructed at the western end of the canal.

This proposal would have required the filling of appreciable areas of the remaining salt marsh.

After discussions with the State Fisheries Branch of the Department of Agriculture it was decided to eliminate the bridge and barrage and modify development proposals to eliminate any interference with the salt marsh and mangrove areas other

...8/

than that caused by the canals and their outlets.

The layout shown in Figure 3 represents the result of these considerations.

The Flood Report prepared by Antony Todd & Partners in support of the 1981 Development stated:

> "(b) Velocities
>
> All methods of investigation revealed minor increases in flood plain stream velocities in some areas and decreases in other areas adjacent to the Site. The increases in velocity were associated with a reduction in cross sectional width caused by the proposed filling, while decreases in velocity were the result of excavating the high area of the peninsula down to a level of 2.0 metres A.H.D.".

- i.e. it was assumed that the present Development Site would be levelled to a maximum height of 2.00 A.H.D. and thus provide increased waterway for major floods.

Any Proposal to change the finished level of this area would thus require very careful examination and analysis to ensure that flood levels and velocities would not be adversely affected.

This Environmental Study therefore includes a detailed and sophisticated hydraulic analysis of the Proposed Canal

Development and its effects on flood flows over the whole area of influence.

Other detailed investigations have been made into erosion and siltation and soil stabilities along the Canal.

3.2 Existing Approval

The Bellingen Shire Council granted Conditional Approval to the Subdivision and Development of Lots 1 and 2 D.P. 225991, Lot 43 D.P. 539689 and Lot 441 D.P. 566897 on 23rd June, 1981.

A copy of the "Notice of Determination of Application" is set out in Annexure "A" of this Report. Following the re-drafting of the Proposal to comply with the Conditions of that Approval the Plan was finally presented as set out in Figure N° 2 (b). This Plan represents the existing Approval. Figure N° 3 shows the general layout of the present Proposal. Lots 1-92; 112-126 remain essentially unaltered from the original Approval, however, the construction of the closed canal at the rear of Lots 120-126 may have a beneficial effect on them. The remainder of the area to the north will be substantially affected by the proposed Development.

...10/

4. Objectives of Proposed Development

4.1 The major proportion of the Development Site is presently zoned Residential 2(c) under the Bellingen Shire Council's Planning Scheme (I.D.O. N°1). This is the major Residential Zone and is designed primarily to ensure good quality Residential Lots.

4.2 The Development Area is in part, low lying with some of the land being subject to tidal inundation at times of extreme high tides.

The Freehold Title boundary extends to the Mean High Water Mark and forms a peninsula into the Kalang River. It is thus ideally located and structured for canal-type development.

The Bellinger/Kalang River Estuary is one of the major estuaries of the Mid-north Coast and has attracted much attention and Development over recent years as population continues to drift to the North Coast Area. Its major attraction comes from a combination of factors not the least of which is the complex and attractive water system and ease of access thereto.

4.3 The Development of a carefully designed and constructed Canal Subdivision will enhance the area whilst at the same time catering admirably for the strong Regional demand for such land.

...11/

A Report prepared by Dr. A. K. O'Gower and Dr. L. Love in 1981 examined the Biology of the Bellinger Waterway System in detail.

One of the statements made in that Report is as follows:-

".....if urbanisation proposals involve Canal Development, then properly designed Canals will increase the area of this estuary and this will have a beneficial effect on the estuarine ecosystem".

It thus seems probable that a properly designed Canal Subdivision will produce beneficial and acceptable results all round.

The objectives of the Proposed Development may therefore be summarised as follows:-

(a) to provide a high quality Residential Subdivision consistent with the need to protect and enhance the fragile estuarine environment.

(b) to provide floodfree, fully serviced Residential Land without adversely affecting the flood pattern of the estuary or the physical and social attributes of the area.

(c) to give special attention to the development and enhancement of the Bellinger Estuary within the Development Area.

(d) to promote the orderly and economic development of the Site.

...12/

(e) to ensure the provision and development of a generous proportion of land to cater for the recreational needs and public requirements of the area recognising the unique location of the Development Site adjacent to a major waterway.

(f) to create a Canal-type Development consistent with the Government's requirements for the Development of flood-prone lands.

(g) to create a Canal-type Development which requires the minimum of maintenance.

The Development of a Canal Subdivision providing a number of Lots with direct access to the Kalang River and to the Proposed Canals will provide a standard and quality of Residential Land not previously available in the Urunga Area.

The lowering of the undeveloped portion of the peninsula will adequately compensate for the increased area of fill. Restricting the finished level to a minimum of 1.5 metres A.H.D. will ensure that suitable grasses and vegetation can be maintained without problems of salt penetration.

The Flood Study included as Section 13 of this Report establishes that this can be successfully achieved.

The Report prepared by Dr. K. O'Gower and Dr. L. Love in 1981 indicated that the Bellinger/Kalang Estuary will benefit from a properly constructed Canal Estate and thus the Proposed Development may result in an enhancement of the Estuary ecosystem.

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5. Limits of Environmental Impact Study

5.1 Schedule 3 to the Regulations under the Environmental Planning and Assessment Act 1980 classifies as "designated Development"-

"canals, being canals constructed in association with a Subdivision of land by which more than ten (10) Allotments capable of use for Residential purposes are created".

The Proposed Development is, therefore, a "designated Development" and an Environmental Impact Statement must be prepared in accordance with the requirements of Section 77(3)(d) of the Act and Clause 34 of the Regulations.

Accordingly, the Department of Environment and Planning have advised the Director's requirements in relation to the Environmental Impact Statement and a copy of their Letter of Notification is attached as Annexure"B".

5.2 Because an existing Approval applies to a proportion of the Site, it is important that the limits of the present Environmental Study be clearly set.

Accordingly, this Study is based upon the following assumptions:-

(a) The "Designated Development" is the Canal System only. If the Canal were not being considered then it would be possible to proceed with all other aspects of the

...15/

Development without the need for an Environmental Impact Statement but subject only to the Bellingen Shire Council's requirements.

(b) In constructing the Canal, the excavated material will be used to fill some of the Proposed Residential Area.

The two Works together will have a real influence on the flood patterns of the Locality and thus it will be necessary to closely examine the combined effects of the two types of construction on the flood pattern in the Kalang River.

So long as the Flood Study establishes that flood levels and velocities elsewhere will not be appreciably altered, it will not be necessary to further examine the remainder of the area covered by the Development Approval granted by Council on 23rd June, 1981.

(c) The Study need only address itself to changes in erosion and siltation patterns which may be attributable to the Proposed Designated Development and Associated Works.

Existing erosion and siltation patterns which may effect adjoining areas but will not be changed by this Development are outside the limits of this Study and need not be considered.

...16/

(d) In considering transport requirements the Study need only examine changes which may result from the carrying out of the Proposed Designated and Associated Development and is not required to consider existing traffic which may be generated by the Development Approved by Council 23rd June, 1981.

5.3 The Approval granted by the Bellingen Shire Council on 23rd June, 1981 accepts the following changes to the environment:-

(a) The creation of 137 Residential Lots including some 24 Lots backing almost directly onto the Kalang River.

(b) The filling of a substantial proportion of the flood plain.

(c) The satisfactory performance of a shallow floodway in the same general location as the Proposed Canal System.

(d) The generation of a substantial traffic volume from the Estate and the adequacy of a reconstructed intersection of the Pacific Highway with Ranger Street to cater for it.

(e) The suitability of the area for Residential Development.

These acceptable changes will form a background against which the Proposed Designated Development may be considered.

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6. The Existing Environment

6.1 The Development Site comprises a small portion of the Flood Plain of the Kalang River. More particularly, it forms a peninsula into the river and lies directly opposite Newry Island.

Figure N° 1(a) shows the location of the Site in relation to surrounding features.

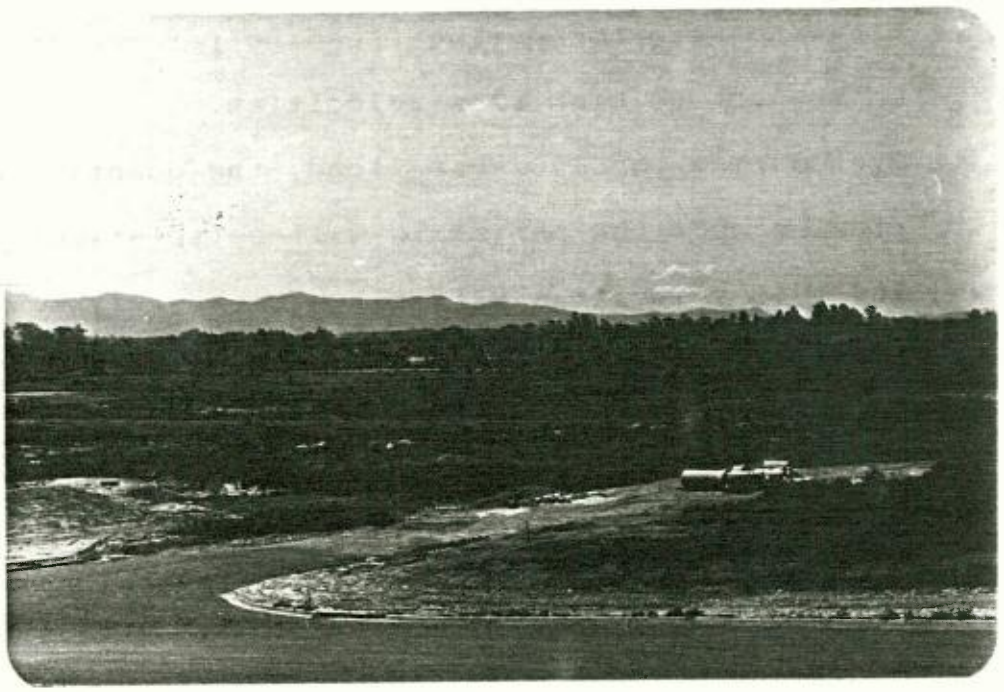

Plate N°2 "View over Development Area"

The Site is well within the tidal limits of the Estuary and as such forms part of an important and fragile ecosystem.

... 18/

6.2 Figure N° 4 (a) shows the basic features of the Development Area and highlights the following main features:

(a) A natural "levee" has developed along the western side of the peninsula and rises to a maximum elevation of approximately 2.60 metres A.H.D. Flooding information published by the Department of Public Works indicates that, during major floods in excess of about a 20 year recurrence interval, this natural levee will be over-topped and thus for those major floods less than this recurrence interval the peninsula will provide only backwater storage during flooding periods and will not be subject to high flow velocities.
Even during the 100 year flood, the quantity of water flowing over the peninsula will be relatively small and thus velocities will likewise be very low.

(b) Areas of low estuarine wetland exist to the north and east of the peninsula. Some of the lower sections of this land are presently subject to inundation during major high tides.

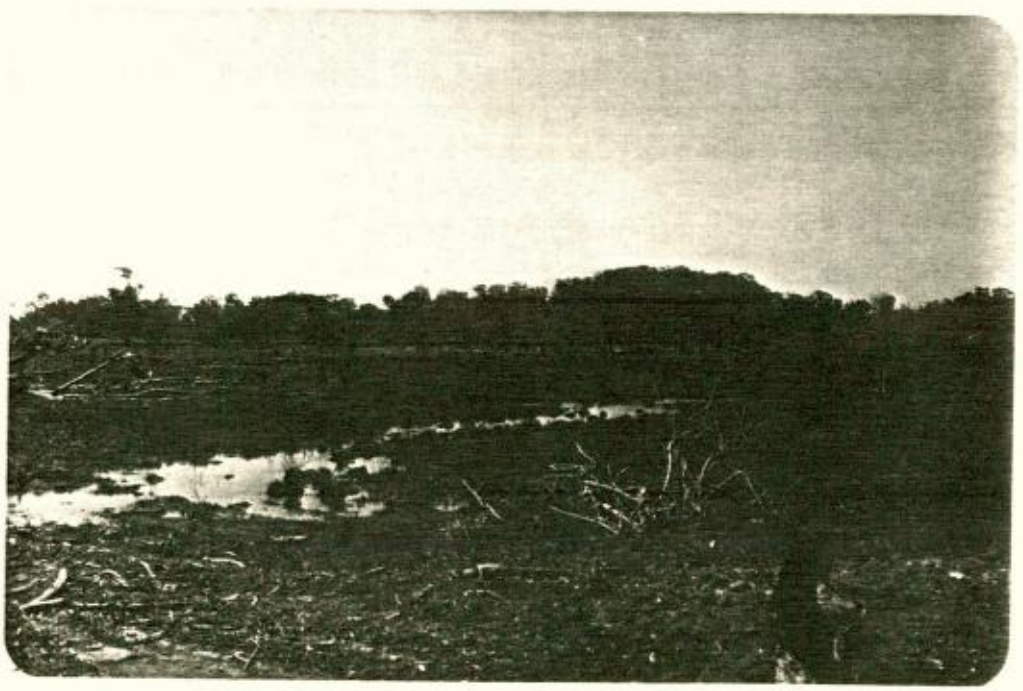

Plate N° 3 "Existing Environment - Salt Marsh - North East Corner of Development Area"

...19/

(c) The major vegetation types have been indicated on Figure N°4(a). The majority of the Site has been used for Agricultural purposes for many years, and is thus comprised of essentially cleared land.

A band of vegetation has been retained around the perimeter of the land to assist in erosion control of the river banks. This vegetation band is comprised mainly of Casuarinas and mangroves.

The Proposed Development would retain most of this band of vegetation.

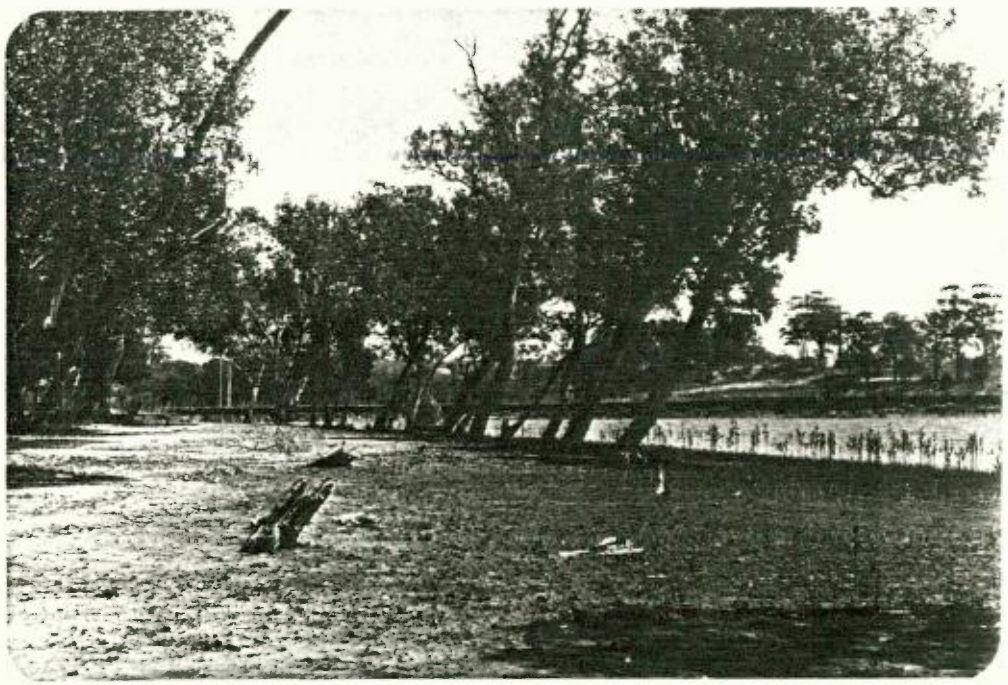

Plate N°4 "Existing Environment - Mangrove Fringe".

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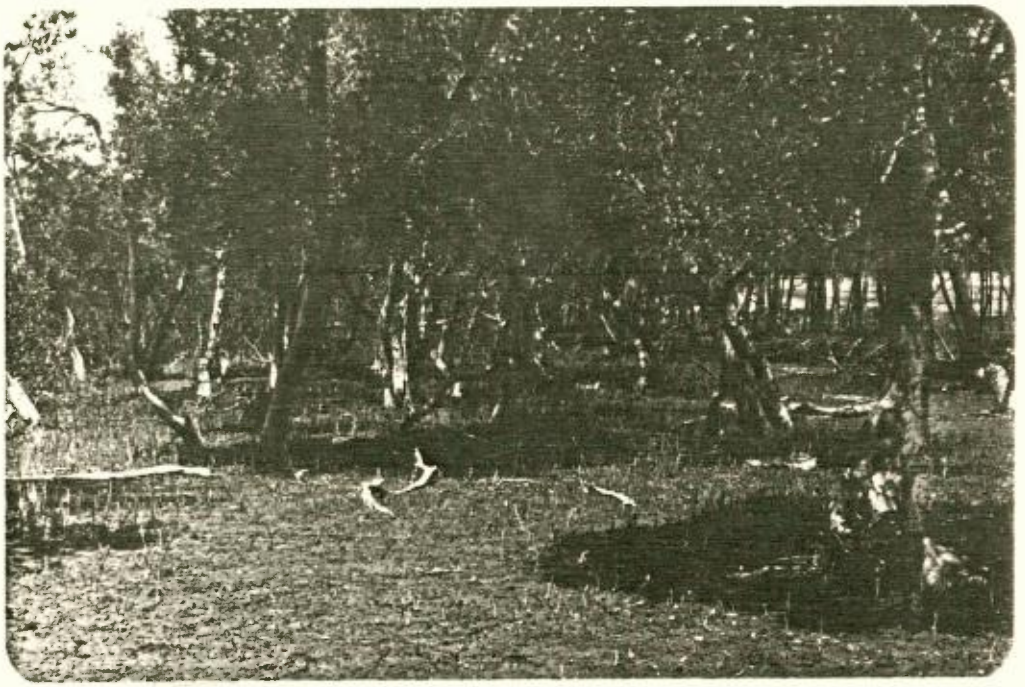
A small area of mangrove swamp exists to the north east of the peninsula, however, its extent is only minor and thus its importance to the overall health of the Estuary is relatively limited.



Plates Nôs. 5 & 6 "Existing Environment" - Mangrove Swamp'

... 21/

The Proposed Development Plan provides for the retention of a large proportion of the mangrove swamp in its natural state.

(d) Spot levels have been indicated on Figure N°4(a)to enable an easy and accurate assessment of the relative levels of different sections of the Development Site.

(e) Figure N°4(a) comprises a transparent overlay for Figure N°4(b) and indicates the inter-relation of the Proposed Development and the various features of the existing environment. This overlay indicates that the majority of the filling will be confined to the higher sections of the peninsula.

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7. Proposed Development

7.1 Introduction

Basically the Development will comprise the construction of two Canals and an associated Residential Subdivision.

The Canals will be excavated to a depth of approximately -2.9 metres A.H.D. (i.e. approximately 2.0m below Indian Spring Low Water) and the excavated material used to fill the Residential Land.

A large proportion of the peninsula will be retained as passive recreational land. This area will include the existing small mangrove swamp and the adjacent estuarine wetlands.

The Proposed Development will not substantially alter the total number of Lots created nor the need for ancilliary facilities when compared to the Approval granted by Council on 23rd June, 1981.

...23/

7.2 The Canals

The two Canals will form the major feature of the Development. Their construction will result in a high standard Residential Development which will be unique for this Area.

The Proposed Construction has been discussed with a number of Government Departments including the Department of Public Works and the State Fisheries. The Canal Section finally adopted is shown in Figure N°5 and is based upon the results of those discussions and the investigations carried out by Geotechnical Consultants, Holmes and Holmes into the stability of the various strata to be encountered during construction.

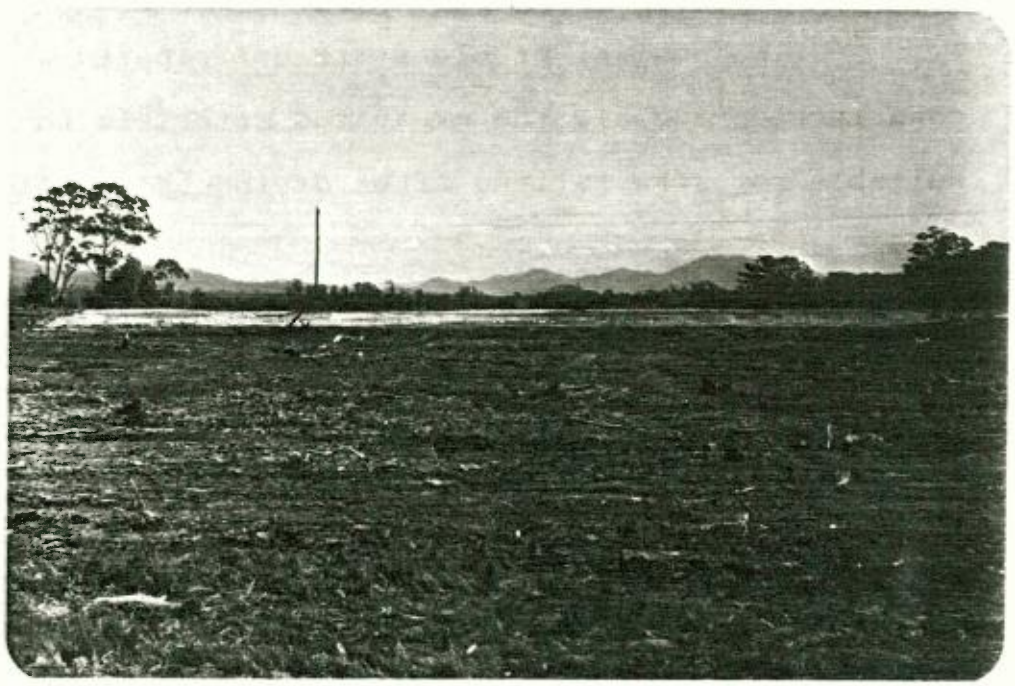

Plate N°7 "Existing Approval - Partly excavated 'Floodway'

Basically the Canal will be excavated to a depth of -2.9 metres A.H.D. with a base width of 20 metres. Side slopes below low-water level will be 1:3.5 and within the tidal zone will be 1:7. From high water level the banks will slope up at 1:4.5 to the finished level of approximately 3.15 metres A.H.D. The excavation will be carried out to the existing bed of the Kalang River with special attention being given to a smooth and hydraulically efficient junction of the two channels.

Tests carried out by Holmes and Holmes indicate that nearly all the excavation will be through silt/clay zones with the only exceptions being a grey sand lens which will lie generally within the tidal zone and a very small section where the canal base will extend down into the "bed-rock" level of weathered grey phyllite.

No unusual problems are anticipated with the construction and all the excavated materials should prove suitable for site filling after drying and compacting.

Much of the tidal zone lies within a layer of silty clay and it may therefore be necessary to import sand to provide an acceptable "beach" zone.

The width of the top of the canals at High Water Level will be a minimum of 50 metres.

In order to ensure that flow conditions after development are as close as possible to existing conditions it is proposed to cut the tip of the peninsula down to a level of approximately 1.5 metres A.H.D.

... 25/

This level has been adopted so as to ensure that no flow will pass over the peninsula under normal conditions but during flood periods the flow in the main stream will be as close as possible to the flood flows under the existing conditions.

7.3 Subdivision Layout and Traffic Flows

The Development Approval granted by Council on 23rd June, 1981 included a crescent road around a central recreation area.

The present Proposal involves the elimination of that crescent road and the re-design of the layout to allow the construction of a canal within what was previously shown as Public Reserve.

This will mean that all traffic from the peninsula will have to travel via Burrawong Parade and Rosedale Drive to gain access to the Highway. This will reduce traffic volumes between Ranger Street and the northern end of Rosedale Drive.

In total, the present proposal will create about 15 additional residential lots.

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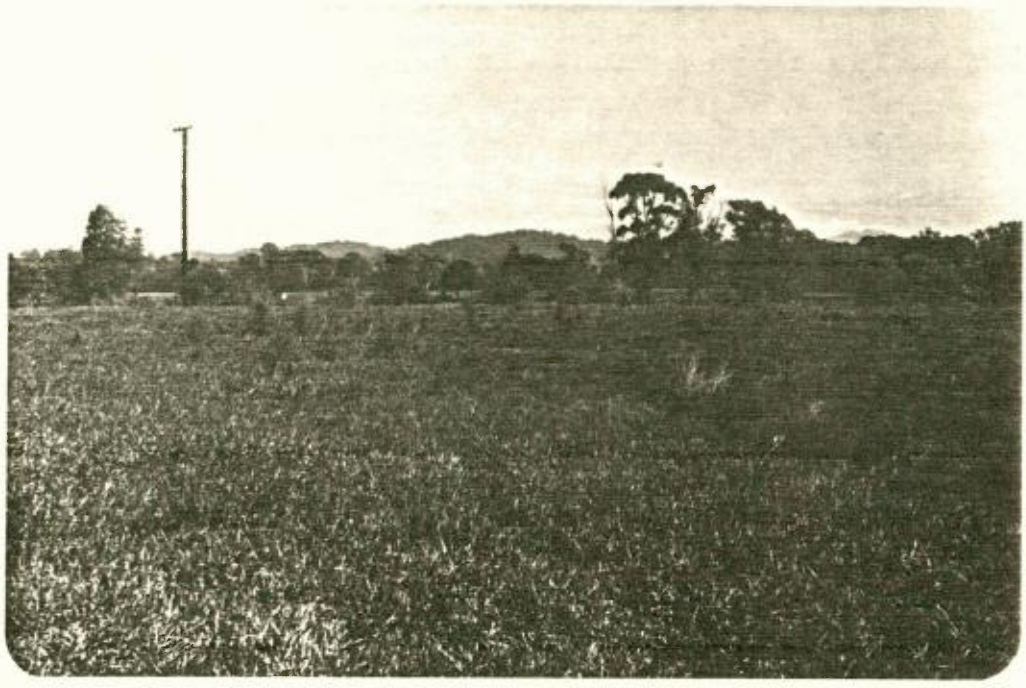

Plate N°8 "Looking North over Proposed Residential Area"

Of the original 137 Lots, 11 were to be developed for medium to high density, catering for an average of about 5 equivalent tenements per Lot. Thus the original Proposal provided for a total of 181 equivalent tenements.

The new Proposal (Total Development) will provide for 152 equivalent tenements - a slight reduction on the original Approval.

The present Development will, therefore, not create an increase in traffic volumes at the Highway Intersection.

Under the existing Approval, Burrawong Parade will be constructed to a width between kerbs of 11 metres.

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This is sufficient for two (2) traffic lanes at 3.0 metres + two (2) parking lanes at 2.50 metres - quite sufficient to carry traffic volumes of approximately three times that expected.

The Proposed Development will, therefore, not create any traffic problems nor will it cause an unacceptable increase in volumes over existing approved roads.

7.4 Recreation Land

The Approved Development provided for the creation of a large central recreation area of some 1.866 Hectares plus a number of smaller reserves giving a total of 2.51 Hectares of Public Recreation Land. As well as this, 2.862 Hectares was shown as Public Reserve to provide for the floodway. This provision is considerably in excess of that normally required by Council.

The Proposed Development provides for the creation of Public Reserves over both the canals (4.3 Hectares in all) and an area of some 3.50 Hectares on the north and eastern sides of the peninsula as well as the minor reserves already provided under the Existing Development. In total this will represent approximately 32.9% of the total area of the whole of Bellinger Keys Estate.

Given the nature of the Development and the orientation of the local population to water recreation the Canals may be considered as adequately providing for the recreational needs of the Community.

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The Proposed Development will, therefore, cater admirably for the recreational needs of the Area.

7.5 Mangrove Areas

Figure N° 4 (a) outlines the limit of the small mangrove area to the north east of the peninsula.

Although this area is attractive, its extent is limited and its real contribution to the health of the Estuary is likewise limited.

Nonetheless the Development has been planned to preserve as much as possible of the mangrove area and the associated wetland.

Although the construction of the Canal will result in the removal of some of the mangroves, the section to be removed is at the southern and narrowest section of the stand as indicated in Plates Nos. 9, 10, and 11 below.

Thus the outlet of the Canal System has been sited to reduce its impact on the mangroves.

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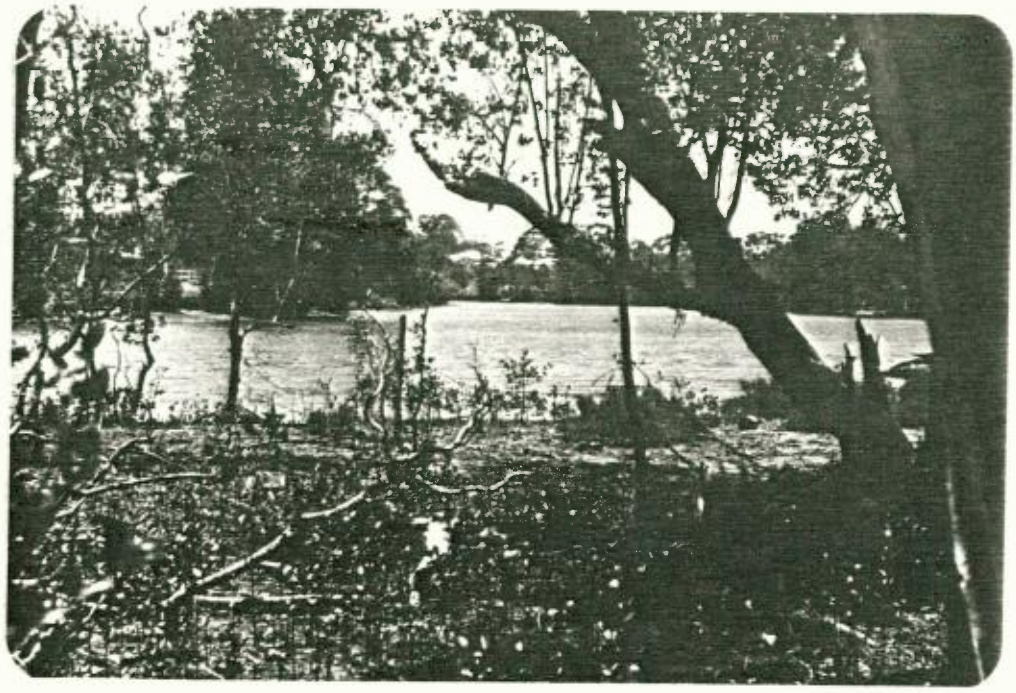

Plate N°9 Existing Environment - View North East from Canal Outlet

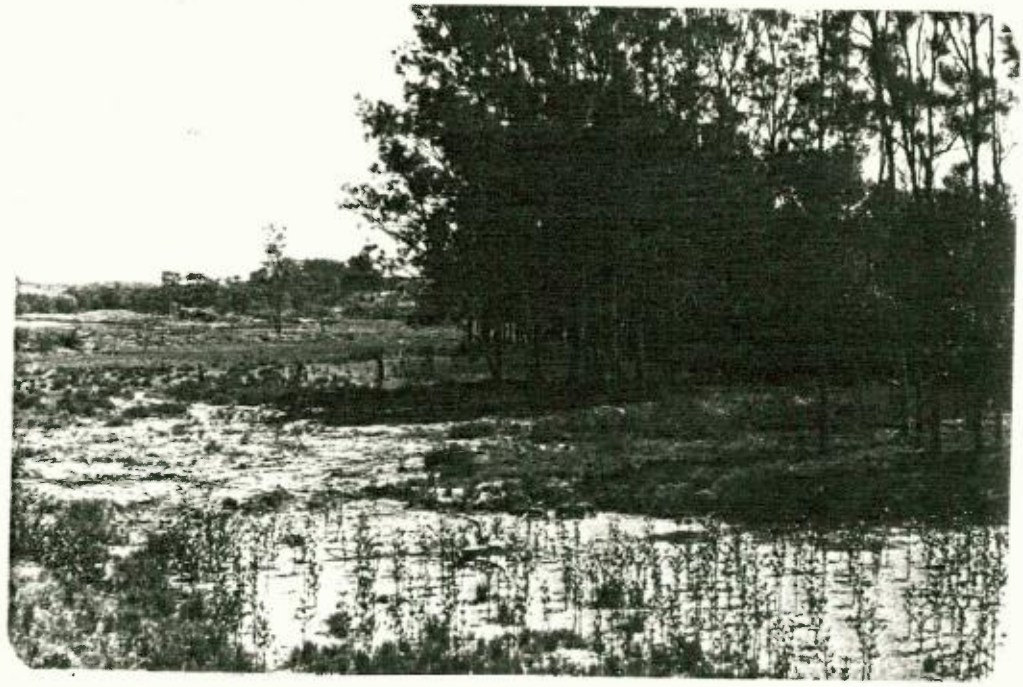

Plate N°10 Existing Environment - View North West from Canal Outlet

...30/

Plate N°11 "Existing Environment - Canal Outlet from end of Rosedale Drive"

...31/

8. Construction Procedure

A detailed construction procedure cannot be prepared until final Engineering Plans and Specifications are available.

In the absence of detailed design information it is proposed that the construction of the Canals and associated Development will involve the following steps:

(a) removal and stockpiling of top soil from area to be excavated or filled

(b) the construction of a bank around the fill area and its segregation into small temporary settling basins of approximately ½ Hectare in area

(c) the removal and stockpiling of "dry" material from the canals

(d) the removal by excavator, dragline or dredging (as necessary) of the "wet" material from the canals, but retaining a bund wall across the outlet

(e) the settlement (with or without settling aids) of the wet material (and, if necessary during extended wet periods, the pumping of clarified liquid to the central flow line of the river under controlled conditions as specified by the State Pollution Control Commission).

(f) the compaction of dried fill and re-spreading of "dry" fill removed at (c) above

(g) the construction of roads and services according to normal procedure

(h) the removal of the bund walls at the ends of the Canals

...32/

9. Alternatives Examined

9.1 Two alternatives to the Development have been considered and these are briefly as follows:-

(a) take no further action, but simply complete the existing Approval and leave the Development Area untouched. This would allow the mangrove and salt marsh areas to remain in their present condition but would leave a large expanse of "Residential" Land undeveloped. If this land were to be rezoned to Recreation, then it would either result in a disproportionately high maintenance cost when compared to the useability of the land or it would receive no maintenance and would thus become over-grown and detract from the surrounding Approved Development.

The Development of the Development Area will increase the viability of the Total Development and thus to take no further action is not an attractive alternative.

(b) retain the floodway as presently Approved but develop the peninsula for Residential purposes.

This alternative would improve the amenity of the Total Development and would greatly improve Public access to the Kalang River, but would present several problems.

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To develop the area for Residential purposes, it would be necessary to fill the land to a flood free level. Without the material from the excavated Canals, it would be necessary to import excessive quantities of fill. This may produce a substantial impact on the environment of that source.

If the floodway were to be retained, it would be difficult to maintain in an attractive condition and may tend to become an area of "no-man's" land.

The original floodway was designed on the assumption that the peninsula area would be levelled to a maximum elevation of 2.0 metres A.H.D.

To fill the Residential Area without excavating the Canal would probably result in increased flood levels in the river.

9.2 Should the Proposed Development not proceed, then the consequences would be:

(a) there would be no increase in the effective water area of the Estuary and thus no increased benefit to the ecosystem

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(b) the existence of an area of "no-man's" land adjacent to the Approved Development would present either continuing maintenance problems or an aesthetic conflict which would detract from the value and amenity of the present Approved Development

(c) the Development Site is presently zoned Residential and should it not be used for that purpose, it will be necessary to provide additional land elsewhere to cater for the continued expansion of the Urunga Area. This would not represent good usage of available resources.

(d) the current situation of poor public access to the Kalang River would remain unaltered

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10. Services

10.1 The adjacent Approved Development has involved the construction of all necessary ancilliary services for a modern Subdivision.

These services were all designed to cater for an anticipated population equivalent to 181 equivalent tenements with proper allowance for the further demands generated by future adjoining developments.

With the modification to the layout and density of the existing Approved Development and the construction of the Works covered by this Report, the population equivalent will be reduced to about 152 equivalent tenements.

10.2 Thus the services of roads, water supply and sewerage as designed for that existing Approval will be quite adequate to service the Residential Lots proposed to be created on the peninsula.

Figure N° 4 (a) shows the location of services and facilities where they terminate at present.

10.3 It will be possible to extend reticulated water to all sections of the Proposed Development with quite adequate residual pressure. Sewerage can be gravitated from all extremities to the existing system and no overloading will result.

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10.4 The Biological Study carried out by Dr. O'Gower recommends that no stormwater be allowed to discharge into the head of the Canals and thus it will be necessary to extend the existing stormwater line at the rear of Lot 119 north to the Kalang River. All other stormwater can be conveniently discharged to the river and thus no problems are anticipated with the discharge of stormwater once the area is developed.

Care will, however, need to be taken during the construction and early Development phases to prevent or restrict the discharge of sediment into the river.

10.5 The matter of road capacities and traffic volumes has been previously considered and it was established that no problems will be created and there is adequate capacity in the existing road system to accommodate the Total Development.

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11. Social Aspects

11.1 For some years now there has been an evident trend towards above average population increases on the North Coast. The Development Site at Urunga lies within the zone influenced by that rapid population increase and has experienced a marked increase in demand for housing, land and leisure-recreational facilities.

11.2 The marked success of the first stages of Development of the Bellinger Keys Estate provides ample evidence of the shortage of suitable land in the vicinity.

Since the release of the Linen Plan of Subdivision by Council in July 1982, a total of 41 Lots have been contracted for sale. As at 31st May, 1983, thirty seven of these Contracts have been settled. Already building is well advanced on 6 of these Lots.

Consultation with the Local Real Estate Agents has revealed that demand for fully serviced flood free Residential Land, especially where it has close proximity to a Coastal Water Environment, remains strong. This market situation illustrates that a legitimate demand certainly exists. This fact is complemented by the 1976-81 Census figures which reveal an average annual population growth rate in Urunga of approximately 7%.

11.3 The strength of the market in the Urunga area may be attributable to a number of factors, however, a major attraction of the Bellinger Keys Estate may be the availability of sewered land in a waterfront setting.

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Sewered vacant land is scarce in Urunga at present and will probably continue to be so until the Development of the South Urunga Area gets under way in a few years' time. Until then, the Bellinger Keys Estate will provide a very necessary pool of fully serviced and developed land.

11.4 An analysis of sales which have occurred to date within the Estate indicates that approximately 50% are Local Buyers and 50% are Metropolitan Buyers. The majority of the Metropolitan sales were made to persons indicating their intention to retire to the Area. The rapid commencement of building on some Lots supports their stated intention.

The strong market pressure and the proportion of retired people purchasing indicates that the area is proving attractive to people seeking a more relaxed life.

11.5 The age pyramid developed from the 1976 Census (the latest available published figures) indicates a most marked bulge in the age range 50-75 - approximately 33% of the Urunga population falls in this bracket compared to 20.1% for the N.S.W. average. This above average figure is balanced by a below average figure for the age group 15 to 49, and consequently the social needs of the population will vary noticeably from the average.

The need for active competitive sporting facilities will be below average as will the need for shopping facilities aimed at the younger members of the population.

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11.6 It is likely that many people have chosen this area for retirement because of the attraction of the Estuary and consequently there will be a need for relaxed but controlled access to the river and foreshores. Care will need to be taken to ensure that any Development does not detract from the natural attraction of the Estuary and to this end it would seem that a Canal Development provides an acceptable compromise.

Land owners can be provided with ready access to the Estuary without interfering unduly with the natural fringe vegetation but at the same time increasing the area of the Estuary and thus its capacity to support the associated increase in usage.

11.7 For the Census Period 1976-1981, the increase in the Urunga population was a very high average of 7% per annum.

Building figures supplied by the Bellingen Shire Council indicate that the number of new dwellings Approved from 1976 to 1981 was 165 representing an increase of more than 5% per annum.

Over the past 4 years approximately 35 to 40 new dwellings have been constructed each year in Urunga.

11.8 With the rapid consumption of available land within what is a small Community (2,200 people), the need for new Residential Land will shortly become very acute.

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The Proposed Residential extension will aid in overcoming this problem.

11.9 Although some local employment would be provided during the construction of the canal, it is probable that the majority of the work will be carried out by contractors from outside the Area who are experienced in Canal Works.

The major employment benefits to be gained from the Development will be an advantage to the Local Building Industry over the period of construction of new dwellings (estimated at 2-5 years).

With a guaranteed pool of building work in the Area, it is probable that more Building Contractors will be attracted to the Area and provide employment for a younger section of the population. In the longer term, this will assist in creating a more balanced population.

As well as the immediate benefit to the Building Industry, there will be the normal benefit to the supporting trades and commercial businesses resulting in either improved viability of the present business centre or an expansion thereof. In either case, there is a potential for increased secondary employment as a result of the continued growth of the area.

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11.10 The recreational facilities to be provided as part of the Development are all orientated towards the anticipated needs of an older essentially retired population with an affinity for water recreation.

Thus the maximum number of Lots will have access to the Canals (across a protective reserve).

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12. Planning History

Until early 1981 the total area covered by the Bellinger Keys Estate was used only for Agricultural pursuits.

With the gradual development of Urunga out along the Pacific Highway the stage was reached some years ago where Urban Development existed along the south eastern boundary of the area and it became a small Rural Area in danger of isolation from adjoining areas.

Up until 1969, the land was not covered by any formal planning instrument, nor was it proclaimed Residential District.

On 27th February, 1969 the Minister directed the then State Planning Authority to prepare a Planning Scheme for the area of Bellingen Shire Council and this was commenced that year.

Interim Development Order N°1 was proclaimed on 12th September, 1969 as a first step in the preparation of the formal scheme.

That Interim Development Order has since been amended a number of times but, as far as we are able to determine,

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only one amendment has affected the Development Area. Amendment N° 5 which was published in the Government Gazette on 6th December, 1974 zoned some of the eastern portion of the peninsula to Open Space "A" (Recreation).

The zoning boundaries established in 1974 are indicated on Figure N° 4(b). These zoning boundaries were established to conform exactly to a particular subdivision layout and were not necessarily directly related to site or environmental restrictions.

As planning for the development of the estate progressed it became evident that the layout adopted in 1974 could not reasonably be adhered to.

The development as now proposed will require some variation of the zoning boundaries set in 1974.

Once the final lot layout was adopted the Bellingen Shire Council was requested to prepare a new Local Environment Plan to vary the zone boundaries to suit the new layout.

The Bellingen Shire Council passed a resolution under Section 54 of the Environment Planning and Assessment Act 1979 on 17th May, 1983 to prepare a Local Environment Plan on the Development Area. The zonings proposed under that Local Environment Plan are set out on Figure N° 4 (c).

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13. Flooding - Hydraulic Analysis

13.1 Introduction

One of the major concerns with Developments of this type in Coastal Estuaries is that of flooding.

Care must be taken to ensure that the changes to the flood pattern are kept to a minimum and will not alter conditions upstream or downstream of the Site.

Accordingly, the Firm of Laurie, Montgomerie & Pettit Pty. Ltd., were appointed to carry out a detailed Hydraulic Analysis to determine the effect of the Proposed Development on the flood pattern and levels of the Kalang River.

The study was initially carried out for a development proposal which included a canal/floodway with control weir. This proposal involved extensive development of the peninsular area and access was provided by way of a flood free bridge over the canal/floodway.

This development has subsequently proved unacceptable and has now been varied to that outlined in Figure N° 3.

The limits of this development were set as a result of the findings of the hydraulic analysis.

It was originally proposed by the developer that residential development should extend further out onto the

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peninsular however it was found that this would have resulted in unsatisfactory finished levels over the remainder of the peninsular.

A minimum finished level of 1.5 metres A.H.D. was set as providing a satisfactory result and the limits of development adjusted accordingly.

Brief details of the investigations are set out hereunder (the full text of the initial report and the 2 addendums is available for examination).

13.2 Approach

The Proposed Development lies in an area of quite complex flood flow behaviour. The Kalang River is divided into two branches by Newry Island and flood flows are not only split between these branches but a considerable proportion also travels across the Island itself.

Because of the complex hydraulic situation, a sophisticated model is required to reasonably represent prototype conditions. It would be possible to establish a physical hydraulic model of the area, however, this would be extremely costly and time consuming, especially considering the topographical changes to be incorporated. It was therefore decided to use a digital computer model. The model chosen is a quasi-two-dimensional cell-type flood routing model developed by the University of Witwatersrand and commonly known as the Cell Model. This model represents the river

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and flood plain as a series of cells interconnected by weirs or cross-sections, and determines heights and flows throughout the study area at pre-determined time intervals.

Changes in topography can be easily accommodated by altering the data input for particular weirs, cross-sections or cells as required. Figures 6a and 6b show the cell arrangements adopted for this Study.

Although the Cell model is fully capable of modelling unsteady flow, only steady state flow conditions were modelled. Data were inadequate for modelling unsteady conditions, and flood storage changes (which would require unsteady state modelling) were considered to be insignificant within the development. The investigation was therefore concentrated on modelling steady state 20 and 100 year flood flows within the flood plain containing the development.

13.3 Data

Because of the sophistication of the Cell Model it requires a considerable amount of data, both hydrographic and topographic. Fortunately most of the data required for this Study were already available in various Reports and Maps. The prime data sources are described below:

13.3.1 Flood Flows

No directly measured data are available on flows in the lower Kalang River. The only WRC gauge on the

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stream is at Scotchmans, which is too far upstream to be of assistance in this Study.

Flows were therefore generated synthetically using rainfall data from Australian Rainfall and Runoff (AR&R) and the Cordery-Webb Synthetic Unit Hydrograph method.

13.3.2 Flood Heights

Information on flood heights were obtained from a recent Department of Public Works publication which documents the history of flooding on the Bellingen River. It contains two types of information, these being a history of observed flood heights, and a series of flood profiles determined from correlation studies with the Bellinger River at Bellingen.

The observed heights were used to calibrate the Cell Model and an attempt made to reconcile the model results with the flood profiles derived by The Department of Public Works.

13.3.3 Topographical Information

The major source of topographical information was a survey of Newry Island and surrounds provided by Bellingen Shire Council. Additional information in

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the immediate vicinity of Bellinger Keys Estate was provided by Lockett & Montgomerie Pty. Limited. Cross-section data for the river channels were taken mainly from the Department of Public Works' survey of flood mitigation works in 1963. Additional cross-sections were supplied by Lockett & Montgomerie Pty. Limited.

13.4 Setting up and Calibrating the Model

The Department of Public Works' history report is the result of a thorough search of all possible sources of flood information. However, the report contains very little data within the area being modelled. The best documented flood is that of January 1974, for which three heights were available as indicated on Figure 1 (a).

The flood history report indicates that the 1974 flood was a twenty year event on the Bellinger River at Bellingen. This site is on a separate stream, which could be subject to different flooding influences. Nevertheless it is the only site in the valley with sufficient records to enable a satisfactory flood frequency analysis to be carried out. Consequently, it has been assumed that the 1974 flood in the Kalang River was also a 20 year event.

The 20 year flow in the Kalang River was estimated using rainfall data from AR&R. This rainfall was convolved with a synthetic unit hydrograph derived using the Cordery-Webb method and the resultant peak flow found to be 980m^3/s.

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The Cell Model was set up using the topographic data provided and assuming a Manning's 'n' of 0.030 for the river cross-sections. A flow of $980m^3/s$ was input at the upstream end of the model and the height at the Pacific Highway Bridge fixed at 2.3m A.H.D. as observed in 1974. The heights given by the model at the other reference points were:-

Site	Observed Height (m AHD)	Model Position	Model Height (m AHD)
Northern tip Newry Island	2.7	Section 6	2.67
Newry Island (opp.Golden Fleece)	2.6	Cell 23	2.60

The fit is very good and no further adjustments were made to the model parameters.

The model height at the upstream section (2000m upstream of Newry Island) under the above conditions was 3.12m compared to the height for the 20 year flood in the Department of Public Work's flood histroy report of 3.5m at Barnett Ruins (1430m upstream of Newry Island). Thus the modelled height is considerably less than the Department of Public Works' estimate. However, the Department of Public Works' height is based on very limited data and a correlation to the Bellinger River at Bellingen. It is considered that the value given by the Cell Model is more reliable.

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13.5 Investigation of the 100 & 20 Year Flood

The 100 year flood was also derived using AR&R rainfall and the Cordery-Webb Unit Hydrograph method. A peak flow of 1300m^3/s was estimated by this approach compared with the 20 year peak flow of 980m^3/s derived above.

The downstream level was taken as the 100 year flood level at the Pacific Highway as given in the flood history report. Although this level is based on limited data, more information is available at this location than at Barnett Ruins.

The 100 & 20 year floods were examined under pre-development & approved development conditions which were modelled as follows:-

- pre-development - modelled as shown in Figure 6 (a)
- approved development - modelled by isolating Cell 22 to simulate filling, and lowering Weir 23 (see Figure 6 (a)) to a maximum of 2.0m A.H.D.

The post -development conditions were then examined as follows:-

- Extending the development onto the peninsula reduces the flow area of Weir 23 as shown in

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Figure 6 b. To compensate for this, the invert level of Weir 50 has been reduced to allow greater flow across the peninsula. The extent of the proposed development is shown in greater detail in Figure 3.

The 20 and 100 year return period design floods were run for several combinations of shortened Weir 23 and lowered Weir 50, to determine the optimum amount of new land for development without adversely affecting the existing hydraulic regime. In order to adequately model the new proposal, the original Cell 20 was divided up by inserting a new Cross-section 20, and a new Weir 50 was introduced. (See Figure 6b).

The approved development conditions were run with the new cell layout, and this output was used as the basis for comparison with the proposed development.

13.6 **Results**

It was found that a development up to a point 50m upstream of Cross-section 9 would produce marginal changes in the existing hydraulic regime with the peninsula level reduced to 1.5m AHD. The flow patterns and the flood

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levels for the 20 and 100 year return period floods for this proposed development are compared with those of the approved development in Figures 7 and 8. In the critical reach in the vicinity of Cross-sections 20 and 11, the 100 year flow will be increased marginally (less than 2%) while the 20 year flow will drop slightly. The changes in both cases are insignificant.

13.7 Conclusions

Filling to above the 100 year flood level to the extent shown in Figure 9 will not appreciably change the exsiting flood regime, provided any high land on the peninsula to the north of the development is excavated to 1.5m AHD.

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14. Erosion and Siltation Considerations

14.1 Introduction

The Kalang Estuary is, like all estuaries, fundamentally unstable and it is probable that, between major geological upheavals, it is generally tending to silt up. Similarly, any dock or canal excavated off such an estuary will tend to silt up somewhat faster than the natural chamber.

There is currently no satisfactory analytical method for accurately predicting rates of sedimentation in tidal estuaries. Estimates of sedimentation rates based on suspended solids in the water have frequently been found to be unreliable, as these tend to ignore, inter alia, bed load/fluid mud layer movements and the effect of the mobile saline wedge.

This Report will briefly describe likely sediment and erosion problems within the canals and adjacent river system, where necessary, suggesting remedial measures.

14.2 The Site

Figure 1(b) shows the location of the proposed canals. It is proposed that canals will be of 2m depth below Indian Spring Low Water, (local chart datum). The Site is tidal with a mean range of 1.0m

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between M.H.H.W. and M.L.L.W. (the tides exhibit diurnal inequalities at this location) and the high and low tides at the site occur approximately one hour after those at the coast. These areas of river bank surrounding the site which are accreting, eroding or apparently stable are shown in Figure 9. Diagrammetic tidal curves are reproduced in Figure 10.

14.3 General Geological Description

The Site is situated in a Pleistocene estuarine sand deposit. This material is exposed on the river bed adjacent to eroding sections of river bank. The Pleistocene sand is overlain by alluvial deposits of normally consolidated silt and clay, including a deposit apparently containing a bed of marine shells, at the eastern corner of the Site.

14.4 Fresh Water Flow in the Kalang River

The fresh water flow in the river is directly related to the rainfall in the catchment. Water Resources Commission records from the Kooroowi gauging station between April and June 1980 give a peak average daily flow rate of 104m^3/s a minimum flow of 0.04m^3/sec and a dry weather 'average' flow of 0.5m^3/sec. These flows are divided into the north and south channels at Newry Island. The stream flows are clearly very variable. Flood flows can reach 600m^3/sec (Ref.2).

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14.5 Tidal Flows in the Kalang River

The calculated maximum tidal flows in the Kalang were 155m³/sec on the ebb and 225m³/sec on the flood tide for a specific tide (Ref.1). Except during periods of severe flooding the dominant water movement in the river at the Site is due to the tide.

14.6 Salinity at the Site

The river adjacent to the Site is tidal and saline. From measurements taken of the Site by the N.S.W. Public Works Department (see Ref.1);

TABLE 1

'AVERAGE' RIVER STREAM FLOW

	SALINITY	
Depth	High Tide	Low Tide
Water Surface	2.4 percent	1.7p.c.
-5m	2.8 p.c.	2.3p.c.

Salinity in the ocean is normally of the order of 3.5 percent, and the salinity of river water would be of the order of 0.1 percent.

(1.0 percent = 10 parts per thousand)

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The values in Table 1 were obtained during a period of fairly average dry weather stream flow in the Kalang River, i.e. 0.52m³/sec.

The values shown in Table 1 are characteristic of a strongly stratified estuary, the full significance of which will be explained later.

TABLE 2

'LOW' RIVER STREAM FLOW

	SALINITY	
Depth	High Tide	Low Tide
Water Surface	3.3 percent	3.2 p.c.
-5m	3.4 p.c.	3.3 p.c.

The values in Table 2 were obtained during a period of very low stream flow in the Kalang River i.e. 0.06m³/sec.

14.7 Mechanisms of Erosion and Deposition

When fluid passing over a sediment bed reaches a critical velocity, particles are lifted from the bed and entrained in the fluid. The removal of the sediment is erosion or scour. Until the velocity falls to a lower critical level, the entrained sediment will be transported in the stream of the fluid. If the velocity falls below

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the lower critical velocity the sediment will be transported in the stream of the fluid. If the velocity falls below the lower critical velocity the sediment will settle out of the fluid stream and form a deposit at that location, this is deposition, or siltation. (It should be noted that the sediment transporting capacity of a stream varies as the 4th to 6th power of the velocity, thus small increases in velocity are significant).

Of particular significance in this case is the effect of the fresh water/salt water interface, the saline wedge and the adjacent stratified salinity in this estuarine location. Fine sediments suspended in fresh water flocculate when entering salt water, and thus tend to settle out.

14.8 Existing Erosion and Deposition in the Kalang River and Bellinger Estuary

(a) Marine Influences

Beach sediment, mainly sand, travelling generally from south to north under littoral influence, is transported into the mouth of the Kalang and Bellinger Rivers and upstream by tidal flows. The marine sediment forms shoals within the river entrances, but bed sampling carried out by the Public Works Department of N.S.W. suggests that sediments of current marine origin do not reach further upstream on the Kalang River than the Urunga road and railway

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bridges. Whilst marine sediments do not contribute directly to siltation of the Site, the shoaling in the river mouth will tend to reduce the actual tidal flow. It has been recorded by historic observation that the entrance shoals tend to be flushed out during floods and take a considerable time to re-build. The higher maximum water velocities on the flood tide, as compared with the ebb, cause the balance of the marine sediment to be deposited inside the entrance between periods of river flooding. (see Ref.1). The maximum tidal velocities recorded in the river mouth/entrance (0.8m/s) are great enough to erode and transport coarse sand. Between 1890-1905 training walls were constructed to combine the Kalang and Bellinger River outlets in an attempt to provide a navigable entrance.

(b) Fluvial Influences

The area of the Site is bounded by a meander in the southern limb of the bifurcated Kalang River. The Western side of the Site forms the outside of a river bend and is clearly eroding. The bank is undercut and trees and bushes on the bank are falling into the river as their roots are exposed. The exposed material on the river bed is apparently medium grained sand and the eroded strata of the bank appear to be largely clays, silts and organic material. The Northern section of the Site forms the inside of an approximately 180°bend in the river. From the erosion/deposition

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transition zone, located approximately where the power lines cross the river, this inside bank is a zone of deposition - the spiral flow at a bend tends to scour the outsides and deposit sediment on the insides downstream. The deposited fine sediments have been colonised by mangrove seedings and other plants, the roots of which, in turn, encourage the deposition of further sediment causing the bank to further accrete. The Eastern side of the Site, notably at the location of the proposed canal entrance, forms the outside of a river bend, but, while this would be expected to be a transition/erosion area there is a local anomaly there. At this location the main flood and ebb flow can be observed passing close to the opposite bank of the river. The river water adjacent to the site appears clearer and quieter at this location, perhaps aided by the interference to flow caused by dumped machinery, boilers and timber baulks projecting into the river. A number of wild oysters can be seen growing on the timber baulks. The four requirements for spat-fall and subsequent successful growth for wild oysters are generally high salinity, low turbidity, low water velocity and a suitable surface for the spats to be attached to. Wild oysters do not thrive where salinity falls below 1.2% for periods exceeding two weeks. It appears that the bank at the

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proposed canal mouth location has accreted in the past, however the colonising mangrove is now comparatively mature right to the waters's edge and the sediments are well consolidated and firm to walk on. There is no erosion scarp and little sign of recent silt build up around the dumped debris. The bank at this location appears to be partially built up by runoff from the higher ground of the Site, and is apparently, not currently subject to much bank erosion or deposition. Sand has been dredged from a sandbank in a widened part of the northern limb of the Kalang, directly north of the Site, and is apparently, not currently subject to much bank erosion or deposition. This dredging was carried out to obtain the sand rather than improve navigation. The sandbank has not, apparently, significantly re-formed since the dredging was carried out in 1976.

It should be noted that nearly all significant bank erosion occurs during periods of high/flood stream flows.

14.9 The Effects of the Proposed Canal Excavation on the Existing River and Estuary

Carrying out works in water in an area subject to tidal movements may significantly alter the tidal prism

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or cubature. The tidal prism or cubature is the volume of water, of tidal origin, flowing into and out of a tidal chamber on the rising and fall tide. If the tide prism is reduced the volume of water passing through the channel downstream on each tide is reduced and hence the velocity of the flow is also reduced. This will tend to reduce scour and increase siltation over the downstream length of channel. Conversely, if the works increase the tidal prism, the resulting increase in tidal flow will tend to exacerbate erosion downstream of the works.

The proposed canals will increase the area of tidal water in the river and thus will increase the tidal prism, however the increase will not be significant.

Increase in tidal prism due to the canals would be approximately:

$30,000m^3$ (1.0m tide)

The approximate normal tidal prism in the Kalang River, upstream of the Site, is of the order of $2,000,000m^3$ for a similar tide. (Ref.1).

Thus the percentage increase in tidal prism resulting from the works would be less than 1.5%, i.e. insignifant.

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During the construction of the canals the dredging operations, particularly runoff from pumping ashore dredged materials, will tend to cause an increase in local turbidity.

14.10 Maintenance and Stability of the Canals

During normal conditions the maximum water velocity (Um) through a canal entrance will be of the order of 0.023m/s (assuming an approximately sinusoidal tidal movement) (See Figure 10) From:

$$Um = \frac{1}{2} \frac{V}{Ax6.25x3600}$$

$$= \frac{1}{2} \frac{17.7x10^3}{54x6.25x3600}$$

$$= 0.023 m/s$$

This will produce no scouring or self cleaning action due to tidal flows, similarly the tidal flows in and out the canal entrances are unlikely to result in bank erosion. (Fig. 15).

It is probable that both canals will require periodic maintenance dredging to maintain full navigability.

14.11 Siltation in the Canals

As stated in the introduction to this chapter, blind canals with a single connection to a tidal estuary will tend to silt-up. This siltation will be caused by four main

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mechanisms;

(a) Deposition of sediment load suspended in river water due to changes in water velocity.

(b) Deposition of sediments carried into canals by storm water run-off.

(c) Deposition of fine sediments floculated at the fresh water/salt water interface.

(d) Siltation by bed load or 'fluid mud layer' movements.

(a) Deposition of Suspended Load

During every tidal cycle a volume of water equivalent to the tidal prism is effectively exchanged between canal and river. In this particular case the tidal prism represents approximately 50% of the 'high tide' volume of the canal. Thus at each flood tide approximately 50% of the water in the canal will be 'new' river water, complete with 'new' suspended fine sediment load. This load tends to settle out during the tidal cycle and then at the next flood tide a further 'tidal prism' of water and suspended load will enter the canal and further deposition will occur. As there is normally no mechamism to return the settled sediments to the river, the sediment tends to progressively build up in the canal. If the density of the water in the canal and adjacent waterway is identical, tidal movement will be plug-like and the water in the blind end of the canal will tend to remain where it is, hence most deposition will take place in the outer portion of the canal, towards the entrance. In this particular case, the velocity through

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the canal entrance during the falling tide will not be enough to remove any of the settled sediments until the sediment has built up almost to low tide level. This is apparently a fairly predictable mechanism of siltation.

(b) Sediment carried into the Canal by Storm Water Run-off

Considerable siltation can be caused by sediment laden run-off entering the canals. An example of the possible significance of this is given by the appreciable mud bank formed in the river adjacent to the small drainage ditch which outfalls into the river from opposite the north-eastern corner of the Site.

Further, run-off from gardens and fields can raise nutrient levels in the canal water and exacerbate undesirable plant growth.

All run-off, whether piped from street gulleys or water from adjacent gardens, must be, as far as practicable, excluded from the canals.

(c) Deposition of fine Sediments Flocculated at the Fresh water/Salt Water Interface

The dominant physical phenomenon in an estuary is the mixing of saline and fresh water. From Table 1 we have established that under normal flows this is a 'stratified'

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estuary. Figure 11 shows a saline wedge, the interface between fresh and saline water, also called the zone of stratification or mixing. Stratification indicates imperfect mixing of saline and fresh water in the zone.

The saline wedge will move up and down the river with the tide but will generally remain intact. The actual position of the saline wedge in the river, and the form of the wedge, is dictated by the fresh water stream flow, i.e. at high flows the wedge will move downstream, while low flows will find the saline wedge further upstream and the stratification will be less marked. This phenomena is partially illustrated by comparison of Tables 1 and 2.

Fine sediments from the fresh water floculate on entering the salt water and travel no further downstream but form a reservoir of trapped and mobile sediment in the zone of mixing. Thus fine sediments, or mud cannot pass the saline wedge and can only escape from the estuary during periods of very high flood flows when the wedge is swept out to sea. (In a river with an active delta the zone of mixing is mostly established seaward of the river mouth).

Conditions at the nose of the saline wedge are peculiar and difficult to quantify - the sediment load is high and as the stratification tends to be strong, the material is trapped very tightly.

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The particular relevance of the above to siltation in a blind canal is illustrated in Figure 12. Consider Case 1; The tide is low and the canal, like the adjacent river, is full of fresh water. On the flood tide the saline wedge passes the end of the canal as it moves upstream, the stratified saline water is now in contact with fresh water in the canal, causing that fresh water to be 'rolled'out and replaced by salt water loaded with flocculated sediment. This sediment laden salt water then stays in the canal until the saline wedge returns downstream past the canal entrance on the ebb tide, during this period we have ideal quiescent conditions for the flocculated fine sediments to settle. Once settled, these fine sediments very slowly consolidate, forming the characteristic 'soft marine deposit'.

In both Case 2 and Case 3, where the saline wedge does not pass the canal entrance during the tidal cycle the rate of siltation will be many times lower than that occuring in Case 1, inter alia, (in Case 2) the fine sediments will not be flocculated and (in both Cases 2 and 3) only the 'tidal prism' volume of water will be replaced at each tide, not the whole canal volume as in Case 1.

It is most probable that the conditions described above as Case 1 will pertain in the river at the site and proposed canals at least occasionally, probably during periods of high stream flow. For this reason it is not feasible to analytically estimate a rate of siltation with any useful accuracy.

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(d) Siltation by bed load or 'fluid mud layer' movements

Where the canal forms a submerged channel, see Figure 13, this will tend to be filled by any mobile bed load, particularly in areas of deposition, insides of river meanders etc. Whilst any movement of coarse sediments on the river bed may be confined to periods of extreme flooding a fine sediment bed load, in the form of a 'fluid mud layer', may be present.

The movement of the fluid mud layer can be almost undetectable and field work beyond the terms of reference of this report would be required to identify the presence of this form of bed load. Serious siltation from this source can be minimised by siting the canal entrances, where possible, at the points of maximum scour on the river, i.e. the outsides of bends, and away from the deposition areas.

Whilst it is not feasible to realistically estimate a rate of siltation for this site by basic analytical means, a more valuable estimate could be produced by monitoring the siltation rate in a trial excavation at the site of the proposed canal entrance and/or using an artificial silt trap. Similarly, some of the unknown variables mentioned above could be quantified with a small amount of field work sampling and laboratory analysis.

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Methods for reducing siltation in canals.

(a) Relocate the canal entrance to a more favourable position. Figure 14 shows two practical alternatives.

(b) Restrict the entry of sediment carrying water into the canal by the use of nagivation gates, various types of simple lock gate, possibly allowing the flow of 'surface' water into and out of the canal with the tide.

(c) In-situ disturbance dredging methods. Where the rate of siltation proves to be unacceptably high a network of 'hydraulic jet/airlift'nozzles installed in the canal bed can occasionally be used to return the deposited material into suspension on the ebb tide and thus prevent build-up of silt. This method has now been successfully operated in a practical application.

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14.12 Comments on Water Quality in Canals

In blind canals complete exchange of water rarely occurs during the normal tidal cycle. In the absence of other physical mixing mechanisms the tidal movement of water in and out of a blind canal may be plug-like, i.e. the water at the blind end of the canal moves up and down but is not exchanged with water in the main waterway. Thus there is a possibility that water trapped in the blind end of the canal will become increasingly polluted and foetid. In the proposed canals approximately 50% of the high tide volume of water will be exchanged with the main river during a tidal cycle (approximately twice a day) (see Section 11). The shape and section of the proposed canals would probably encourage some circulation, albeit sluggish, of the water in the blind ends. Similarly, everytime the saline wedge passes the end of the canals the water in the canal will tend to be 'rolled out' resulting in a complete change of water between river and canal (see Section 11) which will be beneficial to water quality in the canal, if damaging from the canal siltation point of view. The tidal oscillation of water, which is usually salinity stratified, past the ends of the canals will, to a lesser extent, operate the same mechanism as the saline wedge described above. Similarly, marked temperature stratification in the Kalang River (Ref.1) and diurnal temperature changes will provide a further possible mechanism for water movement in the canals.

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Whilst the above mechanisms may be adequate to preserve the water quality in unpolluted canals they would be unlikely to adequately disperse polluted runoff from road gully pits, (containing animal droppings and motor oils), and gardens, (containing fertilizers and other nutrients). Thus, road gully pit outfalls should not discharge in, or near, the blind ends of the proposed canals and adjacent gardens or paved areas should not be sloped towards the proposed canals. Similarly, every effort should be made to discourage the dumping of rubbish in the proposed canals, particularly at or near the blind ends as none of the water exchange mechanisms mentioned above will remove dumped detritus.

14.13 Conclusions

(a) The proposed canals should not adversely affect the present regime of the Kalang River and Estuary. These works should not result in any significant increases in erosion or siltation in the river downstream of the Site, once constructed.

(b) The particularly complex nature of the estuarine siltation mechanism precludes the use of a simple estimate for the rate of siltation likely to occur in the proposed canals and hence the cost of necessary maintenance. However, a programme of in-situ siltation monitoring and basic field work

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investigations, outside the terms of reference of this report, could provide a better idea of the likely pattern of deposition within the canals.

(c) There is no threat of bank erosion in the blind canals, unless the entrance is re-sited to an eroding river bank - in which case the canal entrance would require appropriate design.

(d) The proposed canals should not adversely affect the ecological balance of the river by causing significant changes in water velocity or turbidity. However, the effects of increased turbidity in the river during the excavation of the canals should be considered.

14.14 Recommendations

(a) The canal openings onto the river should be positioned, as far as possible, away from zones of deposition.

(b) The storm water drainage should not be permitted to outfall into the canals also all gardens or paved areas abutting the canal banks should be graded to drain away from the canal to minimise sediment deposition in the proposed waterways.

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(c) If maintenance dredging is to be used to periodically restore the canal depths, a suitable site for the disposal of dredged material should be identified.

(d) The dumping of refuse in the canals should be strongly discouraged.

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15. Site Investigation

15.1 Introduction

In order to establish the stability of the existing soils and their ability to support the Proposed Development, a series of field tests were carried out.

The following Report was then prepared by Holmes and Holmes:-

15.2 Fieldwork

An excavator was used to dig trial pits adjacent to the existing drainage line, which approximately locates the centreline of the southern most Proposed Canal.

The excavator was able to dig to depths in excess of R.L. -3.0 (A.H.D.) and thus provided a profile of the underlying materials. The logs of the eight pits are shown diagrammatically on the attached sketch.

Most of the material excavated was in a saturated condition, and the holes collapsed within an hour of digging.

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15.3 Laboratory Testing

Four examples of the material encountered were selected as being representative of the sub-strata and were subjected to classification tests. A fifth soil type, the highly weathered phyllite which represents the bedrock was not tested. The phyllite, virtually clay appears about halfway along the canal, and will not be difficult to excavate.

The results of the Laboratory testing are set out in Figures Nos. 17 (a) to 17 (d).

15.4 Canal Profile

Based on the soil types encountered, the canal section set out in Figure N° 5 has been selected to provide a stable shape.

The inter-tidal zone has been flattended because of the silty nature of the material, and it would be advisable to spread sand on this area to provide an acceptable beach zone.

15.5 Excavation and Filling

The earthworks to construct the canal will be a specialist operation, and it is recommended that it be let to Contract. Much of the material excavated will be in a saturated condition and will need to be allowed to drain and dry out before it can be effectively spread and

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compacted onto the fill areas.

In order to reduce pumping costs, it will be necessary to excavate the canal quickly, and in the drier times of the year if possible. Swamp dozers can probably work effectively down to the water table, but excavators and draglines will be needed to reach the final depths.

The filling operation will require the material to be spread and compacted in layers no greater than 150mm in order to achieve an acceptable compaction of 95% of Standard Proctor.

15.6 Filled Lots

Because of the silty nature of much of the fill material and the high water table which will be maintained in flood times, it is our opinion that buildings constructed on the fill should be on raft foundations. Raft foundations designed with stiffening ribs will effectively distribute the load over the whole foundation area and reduce the effects of any minor differential settlements. In this way, foundation pressures will be well below the safe bearing capacity of the soil which is estimated will be 40 KPa to 60 KPa.

Minor buildings such as sheds and garages, could be constructed on edge stiffened ground slabs or strip footings (which should be at least 350mm deep).

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16. Water Quality

16.1 Provided the Canals are constructed to a design which will ensure adequate tidal flushing, and storm and roof water is excluded their water quality will remain high.

16.2 In his Report on the Bellinger Waterway, Dr. O'Gower recommended that the following criteria should be incorporated into any Canal-type Development:

"(i) The Development must be sewered and the effluent cannot be discharged directly into the adjoining Estuary.

(ii) The Development must be adequately flushed by tidal action. Although shallow sills across Canal entrances may not greatly affect the canal habitat, Canal entrances should be as deep as the Canals they serve. Blind ends of Canals should form tidal basins to assist tidal flushing of the Canals.

(iii) State Fisheries indicate Canal depths should not exceed two metres so that sea grasses may become established. However, field studies indicate that depths of three plus metres can support healthy, viable, benthic communities, provided such Canals have sandy substrates and do not act as sinks for urban run-off. Public Works, on the other hand, require a minimum depth of two metres for all Canal Developments. It therefore appears that Canal depths could range from two to three metres without adverse effects on the Canal benthos.

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(iv) A sandy substrate is to be preferred to clay, mud, peat, etc. substrate. While a sandy substrate for the canals depends upon the Development Site, the maintenance of the sandy nature of the substrate depends upon adequate tidal flushing, with minimal urban run-off discharging into the Canals.

(v) Urban stormwater run-off should be discharged into the Canal System at localities where tidal flushing is maximal, i.e. at entrances, and never into the blind ends of Canals. The number of discharge points should be kept to a minimum. If urban run-off is allowed to freely enter blind Canals, the substrate will ultimately become uninhabitable for benthic organisms and such Canals will become biologically barren.

(vi) Canal cross sections should have shallow sloping sides. However, if the littoral edge to the Canals is vertical, sandfly breeding will be greatly reduced or even eliminated.

The above Canal Design Criteria have been evolved from field studies (O'Gower, 1976,1978) in conjunction with State Fisheries (N.S.W.) guidelines."

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16.3 The Proposed Development and Canal Design satisfy all the above criteria except (iv).

If additional sand were imported during construction, it would be possible to establish a sandy bank over the tidal zone and/or to establish a sand layer over the entire canal section.

The construction procedure at present includes the dreding of sand for use as filling.

It would be possible therefore to utilise some of this sand to line the canals and form a stable sandy substrate.

If the dredged sand is unsatisfactory for use on the inter-tidal beach zone, it would be possible to import better quality sand for that purpose.

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17. Biological Aspects

SUMMARY

An examination of the mangroves, benthos and avifauna of the Bellinger Estuary indicated:

1. Urunga Lagoon was the most productive and important area in the Estuary.
2. The large stand of mangroves on the western side of Urunga Island plays an important role in providing organic detritus to the Estuary.
3. The Proposed Canal Development Site supports some sparse, fringing mangroves, but is otherwise virtually devoid of vegetation because of the pre-existing rural development and the current massive and extensive earthworks on the Site.

As the Proposed Site has been so extensively altered from any pristine state, the Proposed Canal Development will have only very minor detrimental biological impact on the "existing" terrestrial biota. The destruction of relatively few fringing mangroves, casuarines and a very few riverside eucalypts for canal entrances will have a very minor detrimental impact on the Bellinger Estuary, because both mangroves and eucalypts are so better represented elsewhere throughout the Estuary.

The creation of canals in a terrestrial environment will be a beneficial extension to the Bellinger Estuary.

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Because the Site is well tidally flushed and because of the design of the canals, the beneficial impact to the Estuary will be small but significant.

Urbanization of the Site will result in both detrimental and beneficial biological impacts. The detrimental garden chemical and petroleum products from urban run-off will be discharged to the Estuary where dilution and metabolism will dissipate its effects to zero. Urban detritus and garden fertilizers will be incorporated beneficially for the estuarine ecosystem. The canal design incorporates urban run-off discharge into well tidally flushed areas, so that detrimental "ageing effects" will not occur.

Finally shrub and tree beautification associated with urbanization will have a small but significantly beneficial impact on the existing urban avifauna.

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17.1 Introduction

As the Bellinger Waterway Study by O'Gower and Love (1981) for the N.S.W. Department of Public Works examined the concepts of canal developments in the Bellinger Estuary, and, as virtually all the data necessary for the biological aspects of an Environmental Impact Study are already in this Study, it will be used extensively to prepare this Impact Study of the Proposed Bellinger Keys Estate on the Bellinger Estuary.

Although the Bellinger Estuary is small, it is reasonably productive and plays an important role in the fisheries of the mid north coast. Because the productivity of the Bellinger Estuary depends heavily on Urunga Lagoon and the Urunga Island Mangroves, any developmental proposals which could affect either of these two important habitats must be carefully examined and any appropriate biological constraints heeded, otherwise the Urunga Estuary could be irreparably damaged.

Before one can assess whether or not any proposed development will affect the estuarine environment, one needs to study that environment in some detail. However, to fully elucidate all the intricacies of an estuarine ecosystem one would need to employ a team of biologists over several years. Consequently in terms of economics of time, effort and budget restricted studies must be made of key aspects of the environment from which overall assessments can be deduced.

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In general terms the estuarine ecosystem can be classified either as benthos (bottom living), nekton (free swimming), plankton (at mercy of tides and currents), or according to trophic level. For example, a typical food web/food pyramid would have the following trophic levels:

First Trophic Level

MANGROVES DETRITUS PHYTOPLANKTON ALGAE

Second Trophic Level

ZOOPLANKTON and

BIVALVES POLYCHAETES CRUSTACEA etc. and

BLACKFISH MULLET GOBI etc.

Third Trophic Level

BREAM WHITING BIRDS etc.

Fourth Trophic Level

FLATHEAD EEL SHARK MULLAWAY BIRDS etc.

Fifth Trophic Level

MAN BIRDS

As more than 70% of the typical estuarine fishes are carnivores feeding mainly on the benthos, or on animals which feed on the benthos, and, as the benthos is immobile, varies little both seasonally and annually (except after catastrophic events) and is readily amenable to replicate sampling and hence to statistical analysis, benthic studies give data which can be used to:

(i) Assess the productivity of an estuary,

(ii) Deduce biological constraints against unwise development and

(iii) Suggest means for maximizing beneficial environmental impacts and for minimizing detrimental environmental

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impacts associated with any planned development in the estuary.

Because the Proposed Bellinger Keys Development will affect the Bellinger Estuary, particularly the benthic environment, the major emphasis in this Impact Study will be focussed on the estuarine benthos. However, as the conversion of a dominantly terrestrial habitat to an aquatic estuarine habitat to form the canals will involve the destruction of a few fringing mangroves, some grass land and a very small portion of marsh a description of the existing terrestrial habitat will be added to the O'Gower (1981) Waterway Study.

17.2 Sampling Analysis

17.2.1 Sampling

To fully describe and assess the estuarine ecosystem of the Urunga Lagoon/Bellinger River/Kalang River area would require the services of a team of Biologists over a period of years. However, as the economics of time, effort and budget restrict the ecological study to a "once only" sample, only those aspects of the estuarine ecosystem can be studied which best exemplify the estuary and are most readily amenable to quantitative sampling.

Because fish are highly mobile and difficult to adequately sample in a "one-off" situation, estimates of estuarine productivity based on fish sampling can be very

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inaccurate. Although algae and seagrasses do form a major source of primary productivity in any estuarine ecosystem, plankton and detritus also play an important role in estuarine productivity. To assess all such sources of food in the estuarine food chain is beyond the scope of a "one-off" sample.

Because the phytoplankton and zooplankton are at the mercy of tides, currents, etc., and may exhibit diurnal depth migrations, a "one-off" study of these organisms may give misleading indications of estuarine productivity. In addition plankton sampling is rather difficult to quantify, because of the problems associated with replicating the sampling method.

As the terrestrial vegetation matter, littoral mangrove vegetative matter, estuarine plankton and seaweeds all finally add to the detritus of the estuarine ecosystem, a study of those animals which utilize the detritus would be a direct measure of the productivity function of this detritus. As the estuarine benthos is dominantly dependent upon detritus it is logical to examine the benthos in detail. In addition the benthos are relatively inactive, their numbers and diversity reflect the productivity of the ecosystem and they are easy to sample quantitatively. While the benthos can vary seasonally and may even have cycles of several years (Stephenson, 1980; Saenger et al., 1980), nevertheless at any given time benthic samplings at different localities will reflect differences in environment at these different localities.

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While benthic sampling best reflects the Bellinger estuarine productivity, other measures can also be taken to reinforce benthic deductions.

It is axiomatic in estuarine studies that mangroves add their productivity to estuarine ecosystems (Goulter and Allaway, 1979; Heald, 1971; Love, 1980; Odum, 1971) and that the mangroves of the estuary should therefore be examined in some detail. While overseas studies on Spartina marshes have also shown them to be extremely important as a source of detritus in estuarine ecosystems (Long and Woodhouse, 1979); Wiegert, 1979), mangroves are the littoral equivalent in Australian estuaries, hence marshland would not be an important source of detritus in the Bellinger Estuary if it occurred to any degree, which it does not. Consequently the mangroves of the Bellinger Estuary were also sampled.

Finally, as birds are the final link in the estuarine food chain, (other than man) and as birds can be readily sampled quantitively, a study was also made of the birds of the Bellinger Estuary.

Having decided that the Bellinger Estuary can best be assessed in terms of its productivity by sampling the mangroves, the benthos and the birds, how can these three facets of the ecosystem be best sampled?

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To draw statistically sound inferences about a community from samples they should be "good samples" and a "good sample" is defined as unbiased, homogeneous and adequate.

In terms of good sampling an unbiased sample is one which has been collected in an unbiased manner and this usually incurs some random process for selecting the sample. A homogeneous sample is one which has been collected in a uniform or homogeneous environment. If the environment is heteregeneous, then different samples should be collected in each of the different parts of the heteregeneous environment, that is, the sampling should be stratified, with each strata having its own sample. If the environment is truly homogeneous then random sampling may be obtained by using a predetermined systematic sampling method, if, however, there is reason to suspect any slight heteregeneity the samples should be randomly selected. Adequacy of sampling refers to the number of samples which need to be collected to give an unbiased estimate of the population mean within a certain probability, provided one already has an estimate of the variance of the sample.

The application of these criteria for a good sample to the present Urunga Study poses some problems in that different organisms require different sampling techniques. Thus plants are stationary and are best sampled using standardized transects. Birds, on the other hand, are highly mobile and are sampled using either standardized

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"bird walks" or standardized "bird watchs". Benthic sampling is best done using a replicable standardized grab (Holme and McIntyre, 1971; O'Gower and Wacasey, 1968; Hutchings et al., 1978; Stephenson et al., 1977). and in this Study a self-closing digging sampler (O'Gower and Wacasey loc.cit.) and a modified anchor grab (modified after O'Gower) were used to sample the littoral benthos and the infralittoral benthos respectively.

The number of benthic samples was arbitrarily set at 20. That this number is reasonable can be seen in Table 4, for the mean number of species, applied to the 95% confidence interval formula for the number of samples required to estimate the population mean within specified limits, gave the following:

$n = 4S^2/A.E.^2$, where n is number of samples S^2 is the variance and A.E. is the allowable error

n = 16 for A.E. of 1

n = 4 for A.E. of 2

n = 1.8 for A.E. of 3

However at some sampling stations, where the species richness was obviously low, 10 samples were collected instead of the arbitrary 20 (stations 10, 11, 13, and 20)

The location of 18 sampling stations in the Bellinger Estuary is shown in Figure N°18.

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The terrestrial vegetation was sampled using the nearest neighbour to standardized point method of Cottam and Curtis (1956). That is, a transect was run through the vegetation and the nearest plant in each quarter to predetermined points along the transect, say every ten metres, was identified and its height, girth and distance from the predetermined point were measured. A minimum of ten points per transect were used, giving a minimum of 40 trees for estimates of density, mean girth and mean height. The location of the transects is shown in Figure N°18. Five transects were done through the Urunga Island mangroves and one transect was done through the Tuckers Island mangroves.

Bird sampling was done using standard bird walks during which the observer walked at a standard speed over a distance of approximately one kilometre, taking approximately one hour to cover the distance. All birds observed in a 50 metre strip were recorded. In addition to the standard bird walks bird counts were made along four waterways from a boat travelling at eight knots over approximately five kilometres. All birds observed in a 50 metre strip were recorded.

17.2.2 Analysis

The mangrove stands were sampled by line transects and from the data obtained species frequencies were determined and mean heights and mean girths of the various species encountered were calculated. Tree density was measured after Cottam and Curtis (1956), in which the mean of all distances measured is equal to the square root of the mean area.

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A major question in the analysis of animal communities is whether indices or cluster/ordination dendrograms best describe the communities (Hulvert, 1971; Miedecke and Stephenson, 1977; Pielou, 1969; Southwood, 1966).

Hulvert (1971) questions the use of indices because:

(i) Diversity has too many meanings.

(ii) Some indices are dependent on sample size.

(iii) Some indices are based on empirical distributions, lacking biological meaning.

(iv) Some indices have both mathematical and biological meanings.

This criticism may be met in several ways, including careful definition of the type of diversity used, the selection of an appropriate sample size, the selection of the simplest "diversity index" with both mathematical and biological meaning.

On these grounds"diversity" is defined in the following terms:

1. Species richness or the number of species in the community.
2. Mean density of species per unit area or volume.
3. Index of Diversity of Margalef (1958) and Fisher et al., (1973), which is superior to most other indices (Gage and Tett, 1973; Kempton and Taylor, 1974).

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Communities may also be compared in terms of similarity or dissimilarity using numerical methods of grouping communities. To group communities faunistic records for each community are compared using an appropriate coefficient based on statistics such as correlation coefficients in association analysis (Williams and Lambert, 1960), or empirical coefficients, such as Jaccard (Sokal and Sneath, 1963), Czehanowski (Bray and Curtis, 1957), etc.

With the advent of ready access to large computers some workers construct dendrograms based on Bray-Curtis dissimilarity coefficients etc. (Saenger et al., 1980), but also determine indices for the communities (Saenger et al., loc.cit).

Because of the ease of comprehension, the present study applies statistics in conjunction with diversity indices to describe the benthic communities sampled in the Bellinger Estuary.

If one plots the numbers of species in a series of samples, one derives a hypobolic curve, for, as each new sample is examined, it is more likely that it will contain species already encountered in previous samples. Such hypobolic curves are termed species/area curves and are illustrated in Figures 20 to 22. If one now wishes to analyse the relationships between the numbers of species and the numbers of individuals in a series of samples, it is obvious that beyond the upper asymptote of the species/area curves more samples only add more

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individuals, so "diluting" the species/individuals relationships. Consequently the numbers of samples needed to reach the upper asymptotes have been used to interpolate the numbers of individuals corresponding to the related numbers of species against the number of individuals for each sample in sequence at each sampling station up to the upper asymptote, one would derive a second hyperbolic curve, the species/individuals curve. If one now converts the numbers of individuals to $\log_e$ values, the hyperbolic curves become straight lines and these can then be expressed as regression lines. This has been done with the data for the 17 benthic sampling stations in the Urunga Estuary.

The Margalef Index of Diversity α is calculated from the formula:

$\alpha = S-1/\log_e N$, where S is the number of species and N is the number of individuals.

It is obvious in calculating this Index of Diversity that dilution of the Index by continued sampling (i.e. the disproportionate increase in numbers of individuals vis-a-vis numbers of species with increased sample numbers) will be a problem, therefore the upper asymptote of the species/area curves should again be used to interpolate the numbers of individuals appropriate to the number of species at each sampling station.

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Finally means and standard deviations for both the number of species and the number of individuals have been calculated for each sampling station so they may be used in the normal parametric statistical tests. In addition regressions have been calculated between indices, and mean densities and where appropriate all such regressions have been graphed.

17.3 Description of Existing Environment

While the Bellinger Estuary is typical of small catchments, it has relatively few mangroves, sparse weed beds, few extensive sand flats and a single associated lagoon. Consequently it is to be expected this Estuary will have a low fisheries productivity.

Urunga Estuary has three major components: Urunga Lagoon, Bellinger River and Kalang River plus a minor junction between the two which isolates Urunga Island. Of these components Urunga Lagoon is the most important.

Urunga Lagoon has an area of approximately 46 hectares with an average depth of less than one metre. The tidal range in the Lagoon is about half that in the estuary entrance because of a rock sill across the Lagoon entrance. The shoreline is fringed with mangroves for much of its length and mangroves are extensive along the eastern shore of the Lagoon. Because of nutrients from treated sewage effluent, algae and seaweeds are strikingly abundant in the Lagoon and productivity is high.

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The only other important component of the Bellinger Estuary is the Urunga Island western mangroves. Both the Bellinger and Kalang Rivers support a sparse estuarine biota, for neither have extensive weed beds or mangroves to improve productivity.

The biotic components of the Bellinger Estuary which were studied are: the benthos, seaweeds, mangroves and birds. Examining each of these in turn we find:

17.3.1 Algae

The Bellinger Estuary is depauperate in seaweeds. There are a few Zostera weed beds in the estuary and in Urunga Lagoon, but these are too sparse to be plotted. Similarly Ruppia is too sparse to be plotted especially as this marine plant does not form dense beds. As the Zostera weed beds play such an important role as a habitat for the juveniles of many species of fish etc. such as luderick (Girella tricuspidata), blue groper (Achaerodus gouldii), yellow fin bream (Acanthopagrus australis), tarwhine (Rhabdosargus sarba), leatherjackets (Meuschenia freycineti and M. trachylepis), dusky flathead (Platycephalus fuscus), blue swimmer crabs (Portunus pelagicus), prawns (Penaeus sp.) (Pease et al., 1979), the presence or absence of Zostera largely determines the nekton productivity of any estuary.

In Urunga Lagoon the fertilizing effects of the sewage effluent has given rise to high production of algae, such as Sargassum, Ulva, Colpomenia etc. Zostera and Ruppia, on the

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other hand, are not as extensive as would be expected, although some small pockets of dense Zostera have been observed in association with septic tank effluents. It appears the shallownes and small area of the lagoon and the tidal regime effectively flush away nutrients before eutrophication can be initiated. Gosford Lagoon, on the other hand, is well on its way to eutrophication from septic tank effluent enrichment (Weate and Hutchings, 1977) and indicates the dangers facing Urunga Lagoon.

The estuarine shoreline of the Proposed Bellinger Keys Development supports virtually no algae.

17.3.3 Mangroves

The high productivity of mangroves in estuarine ecosystems has been well documented since Heald's (1971) study in the Florida everglades. Some productivity values can be quoted after Goulter and Allaway (1979) and Love (1980):

Species	Area	Product. (dry ton/Ha./yr.)
Rhizophora apiculata	Thailand	6.7
Rhizophora mangle	Puerto Rico	4.8
Rhizophora mangle	S. Florida	8.8
Avicennia nitida	S. Florida	4.9
Avicennia marina	Roseville	5-8
Avicennia marina	Westport Vic.	2.0
Avicennia marina	Botany BAy	7.8

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The high productivity of mangroves is extensively utilized by the estuarine organisms in areas where tidal flux is low, (Odum 1971) but where tidal range is large, much of the mangrove productivity is exported to the sea, unless it is trapped in a bywater such as a lagoon.

Mangroves also act as a physical harbour to estuarine animals, thus Pease et al. (1979) report the mangroves are nursery areas for luderick, yellow fin bream, flat tail mullet (Liza argentea), sand mullet (Myxus elongatus), sea mullet (Mugil cephalus).

While there may be up to five species of mangroves in some estuaries in the north of the state (Ballina: O'Gower, pers. obs.), in the mid north coast estuaries only two mangrove species occur, namely Avicennia marina var. resinfera and Aegiceras corniculatum. Avicennia usually dominates, but Aegiceras seedlings may be so dense on the water's edge they almost form a hedge. Aegiceras also tends to invade fresher waters than does Avicennia.

In the Bellinger Estuary there are only four localities where mangroves tend towards stands, namely along much of the foreshore of Urunga Lagoon, along the western side of Urunga Island, along the southern side of Tuckers Island and a small islet on the eastern side of Newry Island. Elsewhere the mangroves form a narrow fringe along the river. Avicennia is prevalent up the Kalang River to Station 17, but some five kilometres further upstream only Aegiceras was observed Figure N°19.

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The Urunga Lagocn mangroves were sampled at five sites. At four of the sites the mangroves were the normal multi-stemmed Avicennia but at Site 4 the effluent from the nearby sewage treatment plant added so many nutrients to the mangrove stand, the trees were single stemmed, very tall and of quite small girth. The light intensity within this mangrove stand was depressed by the almost complete canopy cover and was some three factors lower than that in other mangrove stands around the lagoon.

In transect 1 Avicennia was 100% frequent, but a few Aegiceras grew on the leeward side of the stand. Some seedings and saplings were present, but the shoreline was not being prograded and the mangroves formed a fairly narrow band along the shore. The trees were fairly healthy and typically multi-stemmed. The overall density of the mangroves was 29/100sq.m. Mean girth was 29.33 cms. and mean height 3.8m (See Table 3).

Behind the line of mangroves was a fairly extensive sward of rushes (Juncus maritimus var. australiensis and grass (Sporobolus virginicus). Baumea juncea, Zoysia macrantha and Casuarina glauca grew in a narrow band further landward, to be followed by a wet sclerophyll eucalypt forest to the south west and a dune evolved rainforest to the south east.

The mangrove stand sampled by transect 2 was very healthy with multistemmed Avicennia as the dominant species and with Aegiceras forming a shrub like understorey. There were thickets of seedlings and saplings and the density was 16 trees/100sq.m. Mean girth was 15.40 cms. and mean height was

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2.9m., however, some of the Avicennia were very tall, 10 metres high, and strikingly multi-stemmed. The trees formed a dense canopy with a low, ground-level, light intensity.

The mangroves adjacent to the river sampled by transect 3 were dominated almost exclusively by multistemmed Avicennia with only a few Aegiceras. Seedlings and saplings were prominent and these mangroves seemed to be thriving in an almost pure sand substrate. Avicennia density was eight trees per 100 sq. metres, the mean girth was 18.7cm. and the mean height was 4.1m. (See Table 5). Although there was only a restricted marsh behind the mangroves of transects 2 and 3, Sporobolus, Juncus, Baumea, Suaeda australis and occasionally Salicornia quinqueflora and Samolus repens were noted.

The mangroves sampled by transect 4 were adjacent to the septic effluents of the houses on the western side of the lagoon and were dominated by Avicennia, with only a few Aegiceras and many seedlings and saplings. These mangroves were healthy, tall (4.05m) with a girth of 18.68 cms. and the density was eight trees per 100 square metres.

The mangroves adjoining the sewage treatment plant effluent outflow were sampled in transect 4. These mangroves strikingly contrasted with all other mangrove stands examined. The trees were very tall (mean of 12 metres), straight, single stemmed, of small relative girth (25.26 cms) and they formed a complete dense, upper canopy with little light penetration. Few seedlings were present except at the edge of the stand. Avicennia was almost the exclusive tree and the density was 40 trees per 100 square metres. The pneumatophores

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were covered in algae and the nutrient-rich effluent flowed continuously around the trees (See Table 5 for the mangrove transect data).

The mangroves on the western side of Urunga Island are the most extensive in the Bellinger/Kālang Estuary, covering approximately 47 hectares and are equally represented by both Avicennia and Aegiceras, the latter species extending further inland and having the larger trees.

At the northern end of Urunga Island in transect 7 Aegiceras was the dominant species (frequency 69%) and it was short (2.76m.) multistemmed and of small girth (14.2cms.). While the Avicennia was more sparse than the Aegiceras (31% frequency), it was taller (4.5m) and of larger girth (35cms). The overall tree density was 30 per 100 square metres.

Transect 6 at the southern end of Urunga Island passed through an Avicennia dominated stand (96% frequency). The trees were fairly tall (3.17m.) and of fair girth (24.17 cms.). The Aegiceras were, as usual, smaller in height (1.5m.) and girth (15.2 cms). The tree density was 16 trees per 100 square metres. The area was somewhat elevated and supported Sporobolus, Suaeda, Salicornia and weeds.

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Transect 8 through Tuckers Island shows the mangroves at the western end are in danger of extinction from sand burial by siltation. No seedlings were present and the stand was invaded by Lantana, Cassea and various weeds etc. Aegiceras was dominant (80% frequency) and the mean density of trees was 74 per 100 square metres. The mean height and girth of Aegiceras were 6.5 metres and 18.5cms. The mean height and girth of Avicennia were 7.6 metres and 47.13 cms.

The fringing shoreline mangroves on the Proposed Development Site are Avicennia marina. The trees were medium height and moderately large of girth (see Table 5 for mean values) and of low density, being virtually restricted to a fringing strip of up to about 10m wide. Prior to this Study (November, 1982) and subsequent to the Bellinger Waterway Study (O'Gower and Love, 1981), a small area of mangroves (approximately 0.3 ha.) has been destroyed on the eastern Kalang River boundary. However, this small copse only contained a few sparse mangroves, which were noted but not sampled during the 1981 Study.

Table 5 shows all the data for all the mangroves examined in the Bellinger/Kalang Estuary, their distribution is shown in Figure N°19. From these data the following deductions can be drawn:

(i) Tuckers Island mangroves (Aegiceras) were the most dense.

(ii) The sewage effluent mangroves were the tallest.

(iii) The southern Urunga Island mangroves were the thickest.

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(iv) Avicennia was the dominant species.

(v) The height to girth ration of the sewage effluent mangroves showed these trees were very tall and thin relative to the other mangrove stands sampled.

(vi) The fringing mangroves on the Estate were very sparse.

This height to girth ration reflects the nutrient enrichment effect of sewage effluent on mangrove growth and Table 6 shows the mean height to girth ratios for all Avicennia mangroves in the eight sampling sites. It is apparent the "sewage effluent mangroves" have the highest ratio of all, more than twice as great as any other mangroves. The "septic effluen mangrove" height to girth ration was second highest, but only slightly greater than the other ratios.

Applying Student's "t" test to these date gives the "t" values and corresponding probabilities (P values) in comparisons shown in Table 5. It is apparent the "sewage effluent mangrove" height to girth ratio is very significantly higher than that for any of the other mangrove stands examined (P 0.0001). The "septic effluent mangroves" on the other hand did not differ significantly in their height to girth ratio (0.20 P 0.10).

As the "sewage effluent mangroves" are so dense, so tall and so relatively thin and as they are single stemmed and have few seedlings, it is apparent the effluent nutrients have over stimulated growth. Therefore, while this stand must have a high productivity, its future survival may be in doubt, for the trees could "outgrow their strength" and so be prone to wind damage.

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Conclusions from this mangrove study are:

(i) Avicennia marina is the dominant mangrove in the Bellinger Estuary.

(ii) The Urunga Island mangroves are the most extensive in the Estuary.

(iii) The Urunga Lagoon mangroves are possibly the most important in the Estuary because of their productivity input to the Lagoon ecosystem.

(iv) Detrimental siltation effects are clearly shown in the Tuckers Island mangroves.

(v) Nutrients from sewage effluents may overstimulate the mangrove growth.

(vi) Avicennia marina extends up the Kalang River to beyond Newry Island, but Aegiceras corniculatum extends considerably further upstream.

(vii) The fringing Avicennia marina on the Estate are sparse, of medium height but with farily large girths and they are mostly old trees.

17.3.3 Terrestrial Vegetation

Prior to the extensive southern modification of the Estate, the property had obviously been cleared for rural purposes, e.g. grazing. The current earth moving works are further clearing much of the remaining vegetation. It is therefore impossible to describe the pre-existing vegetation and the existing vegetation is restricted to a narrow fringe along the Kalang River boundary.

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In the existing uncleared Estate there is a small copse of dense she-oaks (Casuarina glauca) to the south east. Mangroves (Avicennia marina)line the Kalang River to the east and to the north, while to the west along the Kalang River the fringing trees are remants of a eucalypt forest (Eucalyptus saligna, Eucalyptus robusta, Eucalyptus microcorys, Angophora costata, Acacia floribunda, Acacia mearnsii, Melaleuca ericifolia, Melia azedarach, Leptospermum flavescens and many others).

The existing grassland contains paspalum (Paspalum dilatatum), buffalo (Stenotaphrum secundatum), rat tail grass (Sporobolus elongatus), saw grass (Gahnia sp.), and possibly kikuyu. White clover (Trifolium repens) was also noted.

Weeds were common, e.g. thistle (Cirsium vulgare), milk thistle (Sonchus oleraceus), sorrel (Rumex acetosella), dock (Rumex brownii, Rumex (tispus), blackberry (Rubus fructicosus) herringbone fern (Nephrolepis cordifolia) and various marshes etc. (Juncus maritumus, Scirpus sp., Suaeda australis, Baumea sp.). Lantana (Lantana camara) of course was apparent.

In summary the Estate is currently an earthworks modification of a previously cleared rural paddock with a remnant of a eucalypt forest lining the Kalang River. The remaining vegetation comprises fringing mangroves, a copse of she-oak and weeded grass and marsh.

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17.3.4 Benthos

Accepting the diagrammatic representation of an estuarine ecosystem as shown in Section 2, it is apparent the estuarine benthos best demonstrates the productivity of the estuary. Hence a Study of the benthos of the Bellinger Estuary should indicate those localities which have high productivity. On the other hand it is commonly held the degree of variety of aquatic life or "diversity" is an indication of the quality of the water, natural environmental stress, or alteration of the environment. Thus any marked changes in "species diversity" of a community are often regarded as indicating environmental impacts from pollution, acyclic weather changes, e.g. weather changes such as flooding, or environmental gradients (Boesch, 1972; Dauer and Connor 1980; McNulty, 1970; Westman, 1975).

Typically estuarine ecosystems depend upon seaweeds (Zostera, Halophila, Thalassia, Ruppia, Ulva, etc.) and detritus for their sources of food energy. The detritus originates from dead animals, plankton, sea weeds, Spartina marshes in northern latitudes, mangroves (Avicennia etc.) or from terrestrial sources (Darnell, 1967; Heald, 1971; Keefe, 1972; Jeffries, 1971; Odum 1971; Saenger, et al., e.g. productivity values:

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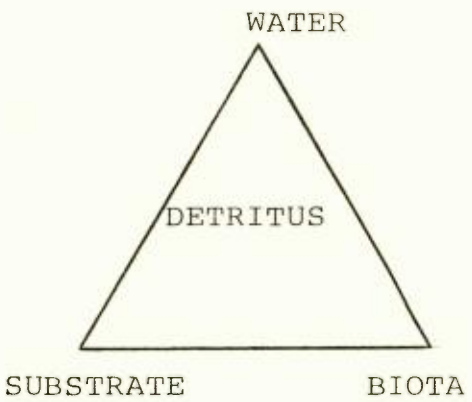
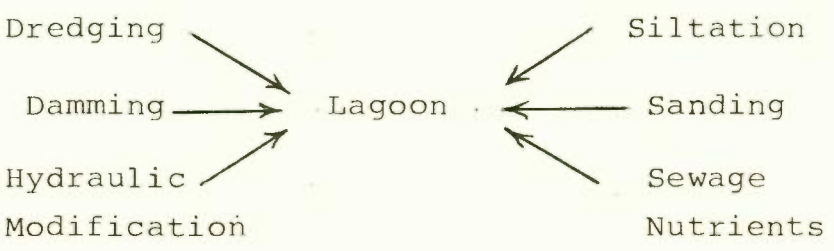
Location	Source	Ann.Prod. (gms/m^2/yr)	Reference
S.E. U.S.A.	Spartina	1000	Wiegert(197
S. Florida	Rhizophora	880	Heald(1 71
Botany Bay	Avicennia	777	Love (1980

Consequently estuarine ecosystems are essentially detritic systems, but with varying dependence upon plankton and seaweeds.

The estuarine ecosystem is the end result of a complex of interactions between biota, substrate, water and food input, hence we may represent this diagramatically thus:



but in all estuaries the influence of man must be considered, and in the case of the Urunga Lagoon these interactions can be represented thus:



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Bearing these interactions in mind we can now examine the Urunga benthos in some detail, but before doing so we should examine the statistical methods used to describe this benthos.

The Index of Diversity (α in Table 3) was calculated from the upper asymptote of the species/area curve (Figures 20 - 22), in which the number of samples needed to reach this asymptote was used to determine the number of species and number of individuals used in the Index calculation. To check the validity of this Index of Diversity regressions were calculated for the cumulative number of species against the natural log of the cumulative number of individuals. These statistics are represented in Table 4 and it is quite apparent the correlation coefficients of all regressions were extremely high, indicating the very close correlation between numbers of species and numbers of individuals. As the Margalef Index of Diversity is based on such a regression analysis, this Index clearly describes the community being sampled.

As the other statistics in Table 3 are based on normal parametric statistics, namely means and variances for densities of species and densities of individuals, these statistics can be further analysed to help sort communities into similar groupings. As an aid in sorting, regressions were calculated for various combinations of density and diversity statistics.

The regressions of the density and diversity statistics in Table 3 gave the following results:

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regression	r	a	b	Significant?
n.sp./$\propto$	0.766	0.144	0.837	YES
$\bar{x}$ sp/$\bar{x}$ ind.	0.518	3.005	3.402	YES
$\bar{x}$ sp/$\propto$	0.615	1.252	0.346	YES
$\bar{x}$ sp./n.sp.	0.863	0.986	2.715	YES
$\bar{x}$ ind./$\propto$	0.216	-	-	NO

where P = 0.05 → r = 0.46 for 19 pairs of observations

P = 0.01 → r = 0.58 for 19 pairs of observations

and these are shown graphically in Figures 23 - 27

As the regression illustrated in Figure 9 has the highest correlation coefficient (r = 0.863), the site groupings in this figure most closely reflect similarities between sites and this figure gives the two following close groupings (with the other sites scattered) viz.

Site	Substrate	Site	Substrate
10	sand	2	mud weed
11	sand	3	sand weed
13	sand	4	sand weed
17	sand	5	sand weed
		6	sand weed
		7	sand weed
		8	mud weed
		9	mud sand
		14S	sand

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That these groupings are reasonable is also shown in the fairly similar groupings in Figures 23,24 and 25. In addition, the substrate of the grouped habitats are also very similar.

If these statistically derived groupings be now examined in terms of locality and substrate we find: The sand substrated sites of the first group are located in bifurcations of streams (See Figure 18). The second group of sites is dominated by the Lagoon sites, and all sites, except 14 sand, have a weed component in their substrate and in general support higher desities of benthic organisms.

Table 3 also clearly demonstrates the benthos of Urunga Lagoon has greater densities of species and of individuals than the benthos in the rest of the estuary, for six of the lagoon sites have greater than median species densities and five of the lagoon sites have greater than median individuals densities.

Converting mean densities of individuals per grab sample into mean densities per square metre we obtain the following values:

Site	Density	Site	Density
1	108	10	133
2	697	11	278
3	1567	12	648
4	617	13	196
5	746	14s	377

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Site	Density	Site	Density
6	1174	14w	1372
7	1252	15	968
8	520	16	577
9	400	17	1225
		18	733

and these will be examined in more detail when the Bellinger Estuary is compared with other estuaries in Section 17.4.

From this benthic Study five generalizations can be drawn about the Bellinger Estuary and the Proposed Development Site:

(i) The Urunga Lagoon is the most productive and important region in the Estuary.

(ii) Provided the existing tidal regime is maintained in the Lagoon, treated effluent has a nutrient value for the benthos.

(iii) The Bellinger sector of the estuary is more productive than the Kalang sector.

(iv) Slower tidal flows are more favourable to the estuarine benthos than the fast tidal flows of the mainstream.

(v) The benthos in the Kalang is reasonably dense, but the diversity is low. The absence of extensive weed beds explains the density and diversity of the benthos.

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17.3.5 Birds

Appendix 2 lists all the birds sighted during this Study and the localities for these sightings are shown in Figure N°18. The occurrences of the different species are shown in Table 8 and the statistics of these occurrences are given in Table 9.

The greatest diversity of birds occurred along the road adjoining the western side of Urunga Lagoon (Table 9). However, as this locality included a very wide range of habitats, mangrove, swamp, dry sclerophyll forest, etc., such a result is not unexpected. But what is unexpected is the very high density on the sewage treatment pond, 141 aquatic birds on an area of approximately 300 sq. metres.

The Urunga Lagoon avifauna was diverse ($\bar{x}\alpha$ = 3.21), dense ($\bar{x}$ ind. = 50.0) and rich (n. sp. = 27). These values were the highest for the whole Bellinger Estuary, apart from the north and south arms of the Kalang around Newry Island where numerous terrestrial birds were sighted (45%). Eighteen of the 27 bird species (67%) observed on the Lagoon, on the other hand, were true estuarine species. The high density and diversity of the Urunga Lagoon avifauna therefore reflects the high productivity of this region of the Bellinger Estuary.

Although earthmoving machinery, road building machinery, trucks, builders etc., etc., constantly move over the Estate bird diversity is quite high. As the Estate virtually lacks any reasonable vegetation, this high diversity

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is of decided interest and while many of the species observed are notably tolerant of man, other species are supposedly shy. Table 9 shows the avifauna of the Estate compares quite favourably with most other study sites on the Bellinger/ Kalang Estuary. This high bird diversity augers well for the development of an extensive avifauna when the urban plantings start to bloom.

17.3.6 Summary

1. The Bellinger Estuary is small.
2. The largest mangrove stand in the estuary borders the western side of Urunga Island, but
3. The Urunga Lagoon mangroves are extensive and form an extremely important part of the estuary productivity.
4. The small area of sand dune rainforest to the east of Urunga Lagoon is unique and should be preserved. This dune forest is presently under threat from a sand extraction operation.
5. The Urunga Lagoon benthos is decidely superior to that elsewhere in the Bellinger Estuary.
6. The benthos living in weed habitats is superior to that living in sand or mud habitats. As much of Urunga Lagoon has a sand/weed substrate, this explains the importance of Urunga Lagoon in this estuarine ecosystem.

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7. The treated sewage effluent flowing into the western end of the Urunga Lagoon is loaded with nutrients. Provided the level of treatment, the level of nutrients and the tidal flushing regime are maintained at present levels, this effluent will continue to be beneficial to the Lagoon ecosystem.

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17.4 Other Estuaries and Canal Developments

Before assessing any impact from possible human activity in the Bellinger Estuary, reference should first be made to what is known of other estuaries so that the relative importance of such an impact can be fully considered in the assessment. To this aim this section of the report will examine the mangroves, benthos and avifauna of a series of estuaries.

17.4.1 Mangroves

There are probably more than the 29 mangrove species listed by Lear and Turner (1977) for Australian estuaries. The estuaries in the Darwin area alone contain 25 mangrove species, while O'Gower (pers.obs.) found 16 species at Weipa in northern Queensland. Above the border at Noosa on the east coast there are seven mangrove species, but this number is reduced to five in N.S.W., namely: Aegiceras corniculatum, Avicennia marina, Bruguiera gymnorhiza, Excoecaria agallocha and Rhizophora stilosa.

In the Bellinger Estuary and along much of the mid north coast there are only two species of mangroves Avicennia and Aegiceras, Although a third species Excoecaria occurs north of Coffs Harbour, while Bruguiera is found on the Clarence River.

Because mangrove stands are so variable even in the one locality it is very difficult to statistically compare

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mangroves from different localities. Consequently only subjective impressions can be given of the relative merits of mangroves from different estuaries, but these subjective assessments must relate to the area of mangroves in the Estuary.

In most respects the Bellinger and Nambucca estuaries are comparable, although it is likely Bellinger has a larger catchment than Nambucca. The area of mangroves in the two estuaries is about the same, but, whereas the Bellinger mangroves are restricted to Urunga Island and Urunga Lagoon, the Nambucca mangroves are scattered along the Nambucca River as far as Macksville and up Warrell Creek to the weir. However, the mangroves of the Nambucca and Bellinger are no match for those of the Tweed, Clarence, Richmond, Hastings, Manning or Hunter Rivers.

17.4.2 Benthos

Again, because of the large variability in the densities of the benthos in any given estuary, inter-estuarine comparisons are statistically difficult, unless one can contrast similar habitats in different estuaries. Similarly, although species richness does give an indication of habitat variability, high or low values for species richness cannot be used as an indicator of estuarine productivity. However, diversity and density in combination can be used as an indicator of productivity.

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Examining first species richness, we find:

Estuary	n.sp.	Reference
Bellinger	56	O'Gower (pres.study)
Nambucca	65	O'Gower (pers. obs.)
Wollomba	40	O'Gower (1978)
Wallis L.	74	Hutchings et.al., (1978)
Noosa, Q.	36	Hegerl & Timmins (1973)
Nerang R.Q.	99	O'Gower (1976)
Moreton BAy, Q.	463	Stephenson et.al., (1978)
Port Philip Bay, V.	246	Poore & Kudenov (1978)
Westernport Bay, V.	571	Coleman et al., (1978)

and now densities per square metre:

Estuary	Av.	Range	Reference
Bellinger	715	108-1567	O'Gower (pres.study)
Nambucca	772	145-2868	O'Gower (pers.obs.)
Wollomba	680	253-1544	O'Gower (1978)
Wallis L.	480	39-1600	Hutchings et al., (1978)
Noosa R.Q.		80-6080	Saenger et al., (1980)
Nerang R. Q.		0-360	Saenger et al., (1980)
Nerang R. Q	328	10-500	O'Gower (1978)
Maroochy R.Q.		40-6240	Saenger et al., (1980)

It is quite apparent that although the benthic diversities of the Bellinger and Nambucca estuaries are factors lower than those in large bays such as Moreton Bay, Port Philip Bay and Westernport Bay they compare favourably with the Wollomba and Noosa estuaries, but not with Wallis Lake

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and Nerang estuaries. However, in terms of benthic density the Bēllinger and Nambucca estuaries compare quite favourably with most of the estuaries for which data is available. The extremely high density range at Maroochy may be the result of pollution enrichment, for samples from a canal development in the Currumbin Estuary on the Gold Coast ranged from zero at areas with extreme urban run-off pollution, to 22,000 per sq.m. in areas of high urban detritus, to more normal values of 270/sq.m. near the mouth of the estuary (O'Gower, 1976).

It can therefore be concluded the Bēllinger Estuary, although small in area and lacking extensive sand flats and weed beds, does support a benthic community which is comparable to equivalent estuaries.

17.4.3 Birds

While species lists tell much of the diversity of the avifauna at a given locality, such lists require extensive seasonal studies. For example the Richmond Valley Naturalists Club (1973) published a guide to the birds of the Richmond Valley and listed 275 species for the area, and O'Gower (pers.obs.) reported 125 species on a 50 hectare ex-dairy farm a kilometre out of town. In both cases the studies were made over several years and the difference in numbers of species at the two localities reflects the ranges of habitats available at each locality.

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"One-off" studies, on the other hand, can vary with season, nevertheless such limited studies can yield valuable data and provided the sampling method is constant, valid comparisons can be made for given habitats.

The following data illustrates these points:

Locality	No. Species	Reference
Richmond R.	275	Richmond R.Nat.Club
Ballina Forest	18	O'Gower (pers.obs.)
Smiths Lake	277	U.N.S.W.
Smiths L. Forest	11	O'Gower (pers.obs.)
Bowraville	125	O'Gower (pers.obs.)
Nambucca Golf Course	55	O'Gower (pers.obs.)
Nambucca River	66	O'Gower (pers. obs.)
Wollomba River	52	O'Gower (pers. obs.)
Urunga River	37	O'Gower (pres.study)
Urunga Lagoon	27	O'Gower (pres.study)
Bellinger Estuary	73	O'Gower (pres.study)
Nambucca Estuary	102	O'Gower (pers.obs.)

Examining the statistical data derived from standard bird walks at a series of localities we find:

Locality	$\bar{x}$ sp.	$\bar{x}$ ind.		n.sp.
Wollomba R.	19.3	58.6	4.42	52
Nambucca R.	20.0	55.4	4.73	66
Urunga L.	13.3	50.0	3.21	27
Urunga Is.	10.8	33.0	2.80	28

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It therefore appears the Bellinger estuarine avifauna has about the same density as the other two estuaries but the diversity is markedly lower. However, as only estuarine birds were observed at Bellinger, whereas at Wollomba and Nambucca terrestrial birds were also counted, it would seem the Bellinger estuarine avifauna is comparable to other estuarine avifaunas. Finally, as Urunga Lagoon is so small relative to the other two estuarine areas covered by bird walks, the Urunga Lagoon avifauna must be considered to be both dense and diverse and it reflects the high productivity of this extension to the Bellinger Estuary.

17.4.4 Canal Developments

Studies by O'Gower (Camp, Scott, Furphy, 1976) for a Gold Coast Region Sewage Disposal, closely examined the Canal Developments of this area to determine the effects of:

(i) treated sewage effluent,

(ii) length of canals relative to tidal flushing

(iii) urban run-off

(iv) age of canals on the estuarine canal benthos.

An Environmental Impact Study for a Canal Development on the Tweed River (O'Gower 1976) also examined

(v) canal substrate effect on the canal benthos in this estuary. While data on the canal benthos in a series of canal developments along the N.S.W. Coast is available from a series of

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Environmental Impact Studies, the above data will suffice to illustrate problems associated with the existing canal developments. From an examination of these problems a set of biological criteria can be derived which can then be applied to the Proposed Bellinger Keys Estate Development.

17.4.4.1 Sewage Effluent

State Fisheries categorically states that sewage effluent cannot be discharged into the estuary adjoining a canal development. While the nutrients from the treated sewage effluent running into Urunga Lagoon clearly improves the biological productivity of this samll estuarine lagoon, the level of nutrients cannot be increased unless the tidal flow of the lagoon is greatly increased (O'gower, and Love, 1981). Irrespective of the benefits to an estuarine ecosystem from a high input of nutrients, inadequate tidal flushing can soon lead to eutrophication with catastrophic effects to the affected body of water, e.g. Sylvania Waters.

17.4.4.2 Length of Canal

The 700 m. blind end canal development in the Tallebudgera Estuary is clearly showing the effects of lack of tidal flushing of accumulated detritus from both natural sources and urban run-off. Thus sampling sites in the canal deeps at the terminal blind end of the canal were

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barren of any benthos. Poor tidal flushing in long narrow canals is detrimental to such an estuarine extension.

17.4.4.3 Urban Run-off

As most of the Gold Coast Canal Developments have urban stormwater outlets into the blind ends of the canal "fingers" in the typical "herringbone" canal developments, the effects of urban run-off on canal benthos is difficult to demonstrate. Nevertheless there is a striking example in the "fingers" of the long Tallebudgera canal in that only one "finger" lacks a terminal stormwater outlet and only this "finger" supported a small patch of Zostera weed bed. All other "fingers" were barren of seagrass.

17.4.4.4 Age of Canals

On the Gold Coast, Miami Keys canals were completed in 1959, Rio Vista Keys in 1964 and Sorrento Keys in 1968. All three systems are herringbone with fairly equivalent tidal regimes. In general terms older canal developments support fewer animals than do younger developments. However, if a canal system is adequately tidally flushed via a channel, via a basin with a narrower entrance, via large areas of open waters, or via a large tidal flux, ageing of such a canal system will not affect its estuarine benthos.

17.4.4.5 Substrate

There is a striking example of the effect of substrate within canals on the Tweed River. The better tidally flushed,

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downstream canal development of Endless Summer has a clay substrate which does not support any benthos in most canal "fingers". On the other hand the poorer tidally flushed, upstream, long, narrow canal of Terranora Waters supports a very healthy seagrass/benthic community and it has a sandy substrate and additionally it lacks a terminal stormwater outlet. It is apparent that a sand substrate is preferred to a clay substrate. With the passage of time no doubt a clay substrate will accumulate some sand from flooding or tidal movement and with the accumulation of detritus such a substrate will eventually develop a healthy estuarine benthos. Notwithstanding a sand substrate is greatly to be preferred to a clay substrate.

17.4.5 Summary

1. While the mangroves of the Bellinger Estuary are inferior to those in the large N.S.W. river estuaries they compare favourably with those of the smaller estuaries, such as the Nambucca.

2. The benthos of the Bellinger Estuary compares favourably in both density and diversity with similar estuarine ecosystems.

3. The avifauna of the Bellinger Estuary is comparable in density and diversity to those in similar estuaries.

4. The productivity of the Bellinger Estuary, based on mangroves, benthos and birds compare favourably with similar sized estuaries.

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5. Studies on canal developments clearly show:

(i) canals should be adequately tidally flushed

(ii) sewage effluent should not be discharged either into the canals or into the adjoining estuary

(iv) provided canals are properly designed for maximal tidal flushing, canal ageing should not affect the canal's estuarine productivity, and

(iv) canal substrates should preferrably be sandy.

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17.5 Biological Constraints for Proposed Development

As the site for the Proposed Bellinger Keys Estate has already been greatly disturbed by earthworks and only supports a few casuarines to the southeast, some fringing mangroves to the east and north along the Kalang River and some riverbank eucalypts etc., along the western Kalang River, there is no point in suggesting any terrestrial constraints, flora or fauna, to this Development. On the other hand, as the destroyed terrestrial environment is to be replaced by a created extension to the Bellinger Estuary in the form of a canal development the following estuarine canal development constraints are proposed:

17.5.1 No sewage effluent to be discharged into either the created canals or into the adjoining estuary. These conditions will be met in the Proposed Development, hence this constraint will be observed.

17.5.2 Adequate tidal flushing is necessary. As the tidal flux for the Estate Site is 1.0m, it exceeds the 0.3m minimum proposed by State Fisheries by several factors. Conseuquently canals will be well flushed by tidal activity. These design criteria will maximize tidal flushing.

17.5.3 Urban run-off will be discharged directly into the Kalang Estuary and not into the head of the

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proposed embayment.

17.5.4 Sand Substrate. While the two metre depth of the canals will expose a clay substrate, above this is a band of approximately 0.5m of clayey sand. The development envisages the placement of this sandy material onto the bed and sides of the canals. Such action will create the desired sandy substrate for the Proposed Canals.

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17.6 Environmental Impacts

The format and presentation of this Biological Impact Study follows the N.S.W. Planning and Environment Commission's Principles and Procedures for Environmental Impact Assessment (as amended, 1980) and incorporates the concept of environmental restraints derived from Queensland's Procedure Manual for Environmental Impact Studies, 1975. In addition Nunn (1977), Scientific Committee on Problems of the Environment, SCOPE 5 and Leopold et al (1971) United States Geological Survey matrix have been referred to.

The Proposed Canal Development will have three types of biological environmental impacts; first those impacts associated with the destruction of the terrestrial habitat of the Site; second those impacts associated with the creation of an extension to the Bellinger Estuary by the formation of the canals; and third those impacts associated with the urbanization of the development. Examining each of these impacts in turn we find:

17.6.1 Terrestrial Impacts

At the time of the site study (November 1982) the approved floodway was already under construction and virtually the whole of the Estate had been cleared, including a small area of sparse mangroves along the eastern Kalang border to the property. When the embayment canal is constructed it will only destroy existing heavily weeded grassland. In addition the two entrances will destroy riverbank vegetation;

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It can therefore be concluded that the destruction of fringing mangroves and casurines will have a low detrimental biological impact of low local or "magnitude" value, and, as these trees do not form part of any valuable stands in the Bellinger Estuary (O'Gower and Love, 1982) the detrimental impact will be of low "importance" or overall importance.

17.6.2 Estaurine Impacts

As the Proposed Canal Development fulfils all of the desirable criteria for estuarine canal extensions, particularly with regard to tidal flushing, this added extension to the Bellinger Estuary will have a high beneficial biological impact to the Estuary in that the canals will provide a healthy habitat for invasion by the benthos, which in turn will attract both fish and wading birds. The "magnitude" value of the impacts will be high but because the area of canals is small relative to the estuary, the "importance" value will be low.

17.6.3 Urbanization Impacts

Urbanization of the Proposed Canal Development will involve both beneficial and detrimental biological impacts

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to the development. Both impacts will be low in both "magnitude" and "importance". The impacts will be urban run-off and beautification.

Urbanization will create urban run-off and this run-off will include detritus, petroleum products and possibly fertilizers and garden chemicals. Provided run-off outlets do not discharge into the blind ends of the embayment where tidal flushing will be least, the run-off products should be tidally flushed and so diluted as to be readily assimilated.

Of the three types of run-off pollutants viz. detritus, petroleum products and garden chemicals/fertilizers, detritus and fertilizers are beneficial to the estuarine ecosystem, provided they are not excessive and provided tidal flushing mixes them well within the estuary. Petroleum products and garden chemicals in general are detrimental to the estuarine ecosystem, but provided they are not excesssive and are well tidally flushed these effects will be minimal. As the amounts of urban run-off will be extremely slight, low values must be given to both the beneficial and detrimental, magnitude and importance impacts.

Urbanization will also bring with it flowering shrubs and trees which will be utilized by the avifauna. While there is a recognised extensive urban avifauna (Trusler, 1980) the ready acceptance of heavy machinery and the presence of man by the avifauna observed on the Proposed Development Site during earthmoving activities, clearly

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indicates much of the avifauna tolerates man and with the evolution of an extensive tree and shrub beautification, much of the urban avifauna wil benefit from urbanization. Consequently urbanisation will have low but significant biological impacts on the avifauna of low "magnitude" and of low "importance".

17.6.4 Summary

1. At the time of inspection the Proposed Development Site had been drastically altered.

2. The Site lacks vegetation except for fringing mangroves and eucalypts. The Destruction of small number of these trees for the canal entrances will have a low detrimental biological impact.

3. The creation of canals will enhance the Bellinger Estuary. As tidal flushing will be more than adequate and as safeguards and desiderata will be met, this Proposed Canal Development will be beneficial to the Bellinger Estuary.

4. Urbanization is associated with possible detrimental urban run-off, but, because this run-off will be discharged into the Estuary and not into canals, the biological impacts will be both beneficial e.g. detritus, fertilizers and detrimental e.g. oil products, garden chemicals. Because of estuarine dilution of the created urban run-off all impacts will be insignificant.

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5. Plantings of flowering shrubs and trees associated with urbanization of the Site will have a low but significant beneficial impact on the avifauna.

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Table 3

Density and diversity of the benthos at the 18 sampling stations in the Bellinger/Kalang/Urunga Lagoon estuary

		Density				Diversity	
Station	Substrate	$\bar{x}$ sp.	S.D.	$\bar{x}$ ind.	S.D.	n.sp.	α
1	sand	1.78	1.39	2.44	2.35	10	2.76
2	mud/weed	5.10	1.10	15.70	7.62	15	3.00
3	sand/weed	4.70	1.25	25.30	31.75	18	2.94
4	sand/weed	5.00	1.70	13.90	4.33	16	3.11
5	sand	5.50	1.27	16.80	11.18	13	2.39
6	sand/mud	5.16	1.77	26.44	10.55	16	2.03
7	sand/weed	6.30	1.34	28.20	11.57	17	3.03
8	mud/weed	4.60	1.17	11.70	3.56	16	3.29
9	mud/sand	4.50	1.60	9.40	4.62	16	3.61
10	sand	2.00	0.82	3.00	1.15	4	1.44
11	sand	2.00	1.53	6.25	2.06	6	2.17
12	sand	4.00	2.00	14.60	20.23	11	4.29
13	sand	2.60	0.89	4.40	2.88	3	0.76
14	sand	5.20	1.32	8.50	2.84	17	4.05
14	sand/weed	8.8	1.69	30.90	13.91	23	4.14
15	sand/mud	4.20	1.10	21.80	16.55	13	3.11
16	mud	4.60	1.14	13.00	6.48	10	2.16
17	sand	1.80	0.45	27.60	7.96	5	0.81
18	sand/mud	2.60	0.95	16.50	12.22	11	2.55

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Table 4

Regression analyses of species on $\log_e$ individuals for each benthi sampling station

Station	slope	intercept	"r"	pairs	P
1	0.111	5.857	0.953	7	<0.01
2	0.247	1.245	0.943	7	<0.01
3	0.117	3.437	0.976	8	<0.01
4	0.187	2.171	0.870	9	<0.01
5	0.389	0.103	0.973	9	<0.01
6	0.202	0.876	0.955	7	<0.01
7	0.199	1.995	0.948	7	<0.01
8	0.198	1.705	0.898	8	<0.01
9	0.154	1.954	0.908	6	<0.05
10	0.695	-0.565	0.947	3*	N.S.
11	0.333	0.860	0.914	2*	N.S.
12	0.389	-0.339	0.907	5	<0.05
13	0.491	-0.245	0.986	3*	N.S.
14w	0.130	2.509	0.983	7	<0.01
14s	0.088	2.534	0.946	6	<0.05
15	0.176	1.873	0.951	5	<0.01
16	0.285	1.380	0.977	5	<0.01
17	0.385	3.167	0.934	5	<0.01
18	0.401	1.010	0.949	5	<0.01

(footnote *) Less than five pairs of observations make a regression analysis difficult to interpret. Numbers of pairs for the analyses were interpolated from the upper asymptotes of the species/area curves for each sampling station.

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Table 5

Percent frequency, girths (cms.), heights (m.) and densities of *Aegiceras corniculatum* and *Avicennia marina* in the mangroves of the Bellinger estuary

Transect	Locality	Water	Density/100m^2.	*Avicennia* Frequency	*Avicennia* Girth (cms.) $\bar{x}$	*Avicennia* Girth (cms.) S.D	*Avicennia* Height (m.) $\bar{x}$	*Avicennia* Height (m.) S.D	*Aegiceras* Frequency	*Aegiceras* Girth (cms.) $\bar{x}$	*Aegiceras* Girth (cms.) S.D	*Aegiceras* Height (m.) $\bar{x}$	*Aegiceras* Height (m.) S.D.
1	Urunga L.	clean	29	100	29.33	19.22	3.50	1.49	0				
2	Urunga L.	clean	16	75	15.49	6.55	2.90	1.26	25	7.9	4.67	1.80	2.55
3	Urunga L.	clean	6	100	21.26	14.11	2.79	1.12	0				
4	Urunga L.	septic	8	100	18.68	6.29	4.05	1.33	0				
5	Urunga L.	sewage	40	100	25.26	7.48	12.13	2.13	0				
6	Urunga Is.	clean	16	96	24.17	22.51	3.17	2.15	4	15.2	-	1.50	-
7	Urunga Is.	clean	30	31	35.0	14.20	4.5	1.50	69	14.2	5.18	2.76	1.44
8	Tuckers Is.	clean	74	20	47.13	10.96	7.6	-	80	18.5	7.15	6.50	1.78
9	Estate	clean	8	100	75.60	49.10	4.49	0.86	0				

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Table 6

Ratio of height (dm.) to girth (cm.) of *Avicennia marina* in the seven transects at Bellinger estuary

Transect	Locality	Water Quality	Statistic $\bar{x}$	S.D.
1	Urunga L.	clean	1.50	0.67
2	Urunga L.	clean	1.99	0.65
3	Urunga L.	clean	1.48	0.48
4	Urunga L.	septic effluent	2.23	0.60
5	Urunga L.	sewage effluent	5.10	1.02
6	Urunga Is.	clean	1.45	0.64
7	Urunga Is.	clean	1.57	4.16
8	Tuckers Is.	clean	1.67	0.32
9	Estate	clean	0.77	0.39

Table 7

Student "t" Test values for comparisons in height to girth ratio of *Avicennia marina* between"effluent" and "clean" sites in the Bellinger estuary

Comparisons	d.f.	Statistic "t"	P
Transect 4 v Transect 5	59	11.70	<0.0001
Transect 2 v Transect 5	70	15.40	<0.0001
Transect 7 v Transect 5	79	20.26	<0.0001
Transect 8 v Transect 5	44	6.63	<0.0001
Transect 2 v Transect 4	49	1.31	0.20>P<0.10

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Table 8

Birds sighted at selected areas in the Urunga area

Species	Site 1	2	3	4	5	6	7	8	9
Tern	+						+		
Black cormorant	+				+	+		+	
White ibis	+		+	+	+	+	+	+	
Curlew	+				+		+		
Mangrove heron	+				+	+	+		
White-faced heron	+			+	+	+	+	+	+
Bar-tailed godwit	+				+				
Sooty oyster catcher	+								
Tattler	+				+	+	+		
Crow	+		+		+		+	+	
White egret	+			+	+	+		+	
Black-tail godwit	+				+				
Wimbrel	+						+		+
Brahminy kite	+		+			+			
Pelican	+				+	+			
Little pied cormorant	+		+	+	+				+
Mangrove warbler	+				+	+			+
Magpie lark	+				+	+	+	+	
Spoonbill	+								
Royal spoonbill	+			+	+	+	+		
Dusky wood swallow	+		+			+			
Swamp hen	+								
Ibis								+	+
Rainbow beeater		+	+		+	+		+	+
White-faced honeyeater		+	+						
Lewin honeyeater		+	+		+				+
Swallow		+	+			+	+	+	
East whip bird		+	+						
White-brow scrub wren		+							
Little wattle brid		+	+				+		
Bar-shouldered dove		+	+						+
Flame robin		+							

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Species	Site								
	1	2	3	4	5	6	7	8	9
Variegated wren		+	+						+
Mistletoe bird		+							
Spotted turtle dove			+				+		
Kookaburra			+						
Swamp hen							+		
White-throat tree creeper			+						
Yellow robin			+						
Weebill			+						
Superb wren			+						
Silver eye			+						
Red-brow finch			+						
King quail			+						
Spotted crake			+						
Wagtail			+				+		+
Eastern rosella			+		+				+
Red-backed wren			+						
Black duck			+	+					
Whistling kite			+		+	+			
Black-shoulder kite			+						
Brown tree creeper			+						
Chestnut teal				+					
Wood duck				+					
Moor hen				+					
Coot				+					
White-neck heron				+					
Grass whistle duck				+					
Little egret					+				
Mangrove kingfisher					+		+	+	
Small wimbrel					+				
Little black cormorant					+	+			
Azure kingfisher					+				+
Seagull					+	+			
Black-face cuckoo shrike					+		+	+	
Starling					+		+		
Pied cormorant						+			

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Species	Site								
	1	2	3	4	5	6	7	8	9
Red capped dotterel						+			
Reef heron						+	+	+	
Fig bird							+		
Butcher bird							+		
Magpie							+		+
Brown pidgeon								+	

Site 1 Urunga Lagoon
2 Dune
3 West road
4 Sewage treatment works
5 Urunga Island
6 Tuckers Island
7 North Arm, Kalang River
8 South arm, Kalang River
9 Estate

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Table 9

Numbers of species, numbers of birds and Indices of Diversity for birds sighted at eight localities in the Bellinger estuary

Site		No. species	No. indivs.		n. sp.
Urunga Lagoon		11	40	2.71	
		17	82	3.63	
		12	28	3.30	
	$\bar{x}$	13.3	50.0	3.21	27
	S.D.	3.21	28.35	0.47	
West Road		13	49	3.08	
		18	38	4.67	
		17	59	3.92	
	$\bar{x}$	16.0	48.7	3.89	30
	S.D.	2.65	10.50	0.80	
Sewage Treatment		9	156	1.58	
Works		12	186	2.10	
		6	80	1.14	
	$\bar{x}$	9.0	140.7	1.61	13
	S.D.	3.0	54.64	0.48	
Urunga is.		11	30	2.94	
		9	25	2.49	
		12	31	3.20	
		14	36	3.63	
		10	31	2.62	
		11	34	2.84	
		10	36	2.51	
		9	41	2.15	
	$\bar{x}$	10.75	33.0	2.80	28
	S.D.	1.67	4.84	0.46	
Tuckers Is.		10	30	2.65	
		14	49	3.34	19
Nth. Arm Kalang		22	78	4.82	22
Sth. Arm Kalang		13	54	3.01	13
Estate		18	35	4.78	18

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Appendix 1

Invertebrates sampled in the Bellinger/Kalang/Urunga Lagoon estuary

Crustacea	
Amphipoda	*Eriopisa elongata*
Isopoda	species
Decapoda	*Alpheus audouini*
	Callianassa australiensis
	Exoediceros c.f. *fossor*
	Heloecius cordiformis
	Hymenosomatidae species
	Macrophthalminae species
	Metapenaeus kennetae
	Mictyris longicarpus
	Paguринae species
	Pilumnopeus serratifrons
	Portunus sanguinolentus
	Scylla serrata
	Sesarma erythrodactyla
	Uca vocans
Polychaeta	*Australonereis ehlersi*
	Glycera americana
	Laonome species
	Leitoscoloplos simplex
	Lumbrinereis c.f. *latreilli*
	Marphysa sanguinea
	Nephtys vikingensis
	Notomastus hemipodus
	Notomastus species
	Sigalion species
Nemertea	Pink nemertine
	Beige nemertine
Sipunculoidea	*Phascolosoma nodulifenum*
Mollusca	
Gastropoda	*Austrocochlea obtusa*
	Bedeva hanleyi

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	Bembicium auratum
	Chizacmea flammea
	Glossaulax aulacoglossa
	Littorina scabra
	Ophicardelus ornatus
	Ophicardelus sulcatus
	Pancanassa jonesi
	Pyrazus ebenius
	Salinator solida
	Velacumantus australis
Bivalvia	*Anadara trapezia*
	Eumarkia fumigata
	Florisarka dauphia
	Lasaea australis
	Laternula creccina
	Mysella species
	Neosolen correctus
	Notospisula trigonella
	Saccostrea commercialis
	Tapes species
	Tellina deltoidalis
	Theora fragilis
Tunicata	*Ascidian* species A
	Ascidian species B
	Ascidian species C

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Appendix 2

Birds sighted in the Urunga area

Acanthiza pusilla	Brown thornbill
Aegintha temporalis	Red-browed finch
Anas gibberifrons	Grey teal
Anas superciliosa	Black duck
Anthochaera chrysoptera	Little wattle bird
Ardea novaehollandiae	White-faced heron
Ardea pacifica	White-necked heron
Artamus cyanopterus	Dusky wood swallow
Aythya australis	White-eyed duck
Butorides striatus	Mangrove heron
Calidris canulus	Knot
Charadrius alexandrinus	Red-capped dotterel
Chenonetta jubata	Wood duck
Climacteris picumnus	Brown tree creeper
Coracina novaehollandiae	Black-faced cuckoo shrike
Corvus orru	Crow
Cracticus torquata	Grey butcher bird
Dacelo gigas	Kookaburra
Hirundo neoxena	Swallow
Dendrocygna eytoni	Grass whistle duck
Dicaeum hirundinaceum	Mistletoe bird
Egretta alba	White egret
Egretta garzetta	Little egret
Egretta sacra	Reef heron
Elanus notatus	Black-shouldered kite
Eopsaltria australis	Yellow robin
Excalfactoria chinesis	King quail
Fulica atra	Coot
Gallinula tenebrosa	Dusky moorhen
Geopelia humeralis	Bar-shouldered dove
Gerygone levigaster	Mangrove warbler
Grallina cyanoleuca	Magpie lark
Gymnorhina tibicen	Black-backed magpie
Haematopus fuliginosus	Sooty oystercatcher
Haliastur indus	Brahminy kite
Haliastur sphenurus	Whistling kite

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Halcyone azurea	Azure kingfisher
Hirundo neoxena	Swallow
Larus novaehollandiae	Gull
Limosa lapponica	Bar-tailed godwit
Limosa limosa	Black-tailed godwit
Macropygia amboinensis	Brown pigeon
Malurus cyaneus	Superb blue wren
Malurus lamberti	Varigated wren
Malurus melanocephalus	Red-backed wren
Meliphaga lewinii	Lewin honeyeater
Merops ornatus	Rainbow bee eater
Numenius minutus	Little wimbrel
Numenius phaeopus	Wimbrel
Pelecanus conspicillatus	Pelican
Petroica phoenica	Flame robin
Phalacrocorax carbo	Black cormorant
Phalacrocorax melanoleucos	Little pied cormorant
Phalacrocorax sulcirostris	Little black cormorant
Phalacrocorax varius	Pied cormorant
Phylidonyris niger	White-cheeked honeyeater
Platalea flaviped	Yellow-bill spoonbill
Platalea regia	Royal spoonbill
Platycercus eximius	Eastern rosella
Porphyrio porphrio	Swamp hen
Porzana fluminea	Spotted crake
Psophodes olivaceus	Eastern whipbird
Rhipidura leucophys	Wagtail
Sericornis frontalis	White-browed scrub wren
Sphecotheres vieilloti	Fig bird
Sterna hirundo	Common tern
Streptopelia chinensis	Spotted turtle dove
Sturnus vulgaris	Starling
Threskiornis molucca	White ibis
Threskiornis spinicollis	Straw necked ibis
Vanellus miles	Masked plover
Zosterops lateralis	Silver eye

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18. ARCHAEOLOGICAL ASPECTS

18.1 Introduction

This report describes an archaeological survey of a small area of land on the Kalang River at Urunga, near Coffs Harbour, New South Wales. The site is being developed as a residential development under the name 'Bellinger Keys Estate' by Gordex Pty Ltd. An environmental impact study is being prepared by Lockett and Montgomerie Pty Ltd. The archaeological survey was commissioned by Lockett and Montgomerie to produce a report suitable for inclusion in the environmental study, which would satisfy the requirements of the National Parks and Wildlife Service with respect to Aboriginal sites. The purpose of the survey therefore was to ascertain whether any archaeological or Aboriginal sites existed in the area of development, what the impact of that development would be on any such sites, and what steps should be taken to minimise or mitigate such impact as necessary.

No archaeological sites were found, and hence the development will have no impact with respect to such sites.

18.2 Background

Urunga is located on the north coast of New South Wales, on the mouth of the Kalang and Bellinger Rivers, about 450 km north of Sydney. The climate of the north coast generally may be described as sub-tropical, tempered by a marine effect. Geologically, it lies within the New England fold belt, which is characterised by quite a wide coastal plain dominated by large river systems with wide sandy floodplains and evidence of channel migration (Sullivan 1982: 39). The north coast of New South Wales differs markedly from the south coast, with

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its narrow coastal plain and comparatively fewer, smaller and narrower river valleys. This difference has been shown by Sullivan (1982) to relate to major differences in archaeological sites.

Sullivan (1982) has discussed the general geographical unity of the coastal strip from Port Stephens to Moreton Bay, and archaeological and ethnohistorical research has shown a general corresponding Aboriginal cultural and ecological unity. Such research has been carried out on the north coast of New South Wales since 1961, led by Dr Isabel McBryde (McBryde 1974, 1978).

The focus of this research has largely been on the recording and occasionally excavation of prehistoric archaeological sites. An archaeological site can be defined as any locus of past human behaviour which has left some recognisable physical trace. This can range from a single tree bearing a scar where bark was removed to make a canoe or shield, to a major camp site representing thousands of years of occupation.

Most of the sites on the north coast that have been excavated by archaeologists are either rock shelters or open shell middens. The rock shelter sites contain stratified deposits of daily living debris. They may also be art sites, with engravings in the rock, or paintings in ochre (McBryde 1974). Open midden sites consist of places where Aborigines have camped, and eaten shellfish, whose shells remain to mark the place. Sometimes these have accumulated with other camp site debris to form stable, stratified sites. These can be of considerable size, such as those at Ballina on the Richmond and Stuarts Point on the Macleay. Others may be only small superficial scatters of shell. Archaeologists have

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established guidelines for distinguishing shell middens from other shell accumulations (Gill 1951, Coutts 1966, Bowdler in press).

Archaeological excavations of some north coast middens in conjunction with radiocarbon dating techniques have established that they are up to 6000 years old. No north coast sites of any kind have been satisfactorily shown to be older than this (Bowdler 1977, Coleman 1978). It is now widely known that Aborigines have lived in Australia for over 40,000 years, so it might be wondered as to why the occupation of this region appears to be so recent. In fact, very few sites on the modern Australian coastline are older than 6000 years.

Because of the extensive glaciations during the Pleistocene (or Ice Age) era which lasted from 2 million to 12,000 years ago, much of the world's water was frozen up into glaciers, and sea levels were lower. About 18,000 years ago, sea levels were 100 metres or more lower than they are now, hence in most places the coast was a considerable distance away from its present position. In Australia, the sea reached its present level 6000 years ago (Thom and Chappell 1975). It has been argued that during the Pleistocene, occupation was more tightly concentrated on coasts and inland lakes and rivers, hence coastal sites earlier than 6000 years are now under the sea (Bowdler 1977). Many of the oldest archaeological sites are on inland waterways, such as Lake Mungo.

Besides providing us with information about past occupation dates and patterns, the study of middens may tell us about seasonal movements, diet, and the relationship over time between food and technology, in prehistoric Aboriginal populations (e.g. Bowdler 1976, Coleman 1978, Sullivan 1982).

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The kinds of shellfish species in middens are, obviously, related to the adjacent littoral environment. There are three major kinds of shellfish habitat on the New South Wales coast: open rocky coastal, estuarine, and sandy beach. Some middens are located so as to take advantage of more than one of these, but most are located adjacent to a single such habitat, and this is reflected in the shell species. Sandy beach middens usually only contain pipi shells (Plebidonax deltoides). Estuarine middens usually contain a predominant species which may be oyster (Saccostrea commercialis or Ostrea angasi) or Sydney cockle (Anadara trapezia), together with a lower proportion of other species. An oyster midden will usually also contain cockles and vice versa; the Hercules club whelk (Pyrazus ebeninus) is usually also present in rather smaller numbers. Open rocky coastal middens usually contain a mixture of gastropods found in those habitats and mussels.

Sullivan (1982) has shown that there is an important difference between the north and south coasts, related to their environmental differences. On the south coast, all three kinds of midden are found, but the open rocky coastal type is the most common. On the coast north of Port Stephens some open rocky coastal middens do occur, but by far the most frequent sites are the sandy beach and estuarine type. The latter is usually the more substantial, and also usually contains a greater diversity of archaeological data, such as animal bones and bone and stone artefacts. Such sites may occur on river and lagoon banks anywhere on the coastal plain, but might be expected particularly near mud flats, mangroves and areas with rocky substrates.

Further detailed accounts of the historical and archaeological background to Aboriginal culture on the north coast may be found in McBryde (1974), (1978), Coleman (1982) and Sullivan (1982).

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18.3 Known archaeological sites in the Urunga area

Two archaeological sites near Urunga are on record in the National Parks and Wildlife Service Aboriginal Site Register.

NPWS Site No. 22-4-27 (Coffs Harbour 1:250,000 5018 6252) is described as an open shell midden located on a tidal estuary, but the location is not further pinpointed. It is said to be an extensive midden which is 'now probably destroyed by agriculture'.

NPWS Site No. 22-4-50 (Coffs Harbour 1:250,000 5018 6223) is a possum tree; that is, a tree with scars resulting from footholds cut in the trunk to enable the tree to be climbed (presumably to get possums). It is located somewhat inland, southwest of Hungry Head.

Given the location of the development area it would seem, in the light of all the background information, that if any sites were present, they would be most likely to consist of open estuarine shell middens.

18.4 Archaeological survey of Bellinger Keys Estate development area

The area within which the survey was conducted consists of about six hectares of land which forms a small peninsula on the Kalang River on the southwest side of the township of Urunga. Its position on the Coffs Harbour 1:250,000 topographical map is 501 625. The land is freehold, portion 20, Newry Parish, Raleigh County.

The development area is very low-lying, consisting of river alluvium, with much of it covered with mangrove and paperbark swamp. Mangroves also occur on its riverward fringes, and, in some places, so do casuarinas. At no point is it more than 3 metres higher than water level, and mostly it is between 1 and 2 metres in elevation.

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When the survey was carried out, much of the southern half had already been disturbed by clearing, grading, dumping of fill, and construction. Other disturbances included an open earth drain dug out to the north from a low-lying swampy area in the south central part of the area, and excavation had begun on the approved floodway which will virtually bisect the peninsula from west to east. It was also my impression that mangrove and/or small paperbark trees had been quite extensively cleared from the other low-lying area on the east side of the peninsula which is inundated by very high tides.

I carried out the archaeological survey on 9th November 1982. Since the area was small, an intensive survey was deemed appropriate, in which as much of the ground surface as was visible was inspected, with special attention to the river bank and drain side exposures and so on.

Much of the surrounding river bank area was relatively undisturbed. On the west side, some drain headwaters had been constructed. Detailed inspections of all natural and artificial bank exposures revealed occasional shells, but never anything so concentrated as to suggest a midden. Some pieces of quartz were seen, but none of it appeared artefactual. There was quite a lot of apparently naturally occurring quartz lying around most of the development area.

I inspected all large mangrove trees for scars. There is a very good example of an Aboriginal scarred mangrove tree in the Hastings District Historical Society Museum at Port Macquarie. None were identified here however.

Where the ground surface of the inland part of the area was not disturbed, it was covered with rather dense pasture grass. Here, the ground visibility was not good, but there

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were enough exposures of the earth surface to suggest that no middens of any size were present. The quite well-defined margins of the lowlying areas were carefully inspected, with no result.

On the south side of the east end of the open earth drain, there were piles of shell-bearing sediment. These had apparently been dredged from the drain during its construction, from below the water level. This feature consists of mostly small (less than 3 cm) bivalves, with the occasional cockle, oyster and whelk, all also mostly very small. The matrix is a very fine grey silt, with bits of orange tubular cemented sediment, quite fine grained, most with holes through the middle of the long axis - old mangrove roots? This feature is best interpreted as a natural feature, because of the predominance of small, uneconomical shell species not typical of estuarine middens, and because of a lack of large economic typical species, and lack of artefacts, bones of vertebrate species and charcoal (see photographs).

Isolated find. The only Aboriginal relic found was a single stone artefact in a disturbed context. This is a classic unifacial pebble chopper, in a rather coarse grey-green silcrete, 96 x 77 x 46 cms. It was lying about 10 m east of the river bank of the west side of the peninsula, about 10 m north of the north edge of the excavation of the floodway. It was lying in a bulldozer track, and was clearly not in situ (see photographs). It may have derived from the floodway excavation; on the other hand, I noticed that many fair-sized water-worn pebbles were associated with the imported fill in the southern half of the peninsula, and also with the drain headwaters constructed at intervals along the western bank.

18.5 Sites of significance to Aborigines

This area was traditionally occupied by the Gumbaingerri

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people, and many of their direct descendants still live in the area. Many of their traditional sites have been recorded. One is known from near Urunga, and is NPWS Site No. 22-4-4, the Bat Site at Hungry Head. This is a natural mythological site located southwest of the Hungry Head Lifesavers club house. Most such sites consist of relatively prominent or obvious natural landmarks, and it seems unlikely that one would be present in the development area. In discussion, Mr Ray Kelly (Aboriginal Liaison Officer, National Parks and Wildlife Service) stated that the development had proceeded too far for sites of significance to be identified.

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18.6 RECOMMENDATIONS

1. As no archaeological sites were found, it is recommended that the development should not be constrained on any archaeological grounds.

2. As ground visibility was limited in some places, it is recommended that if any shell deposits consisting largely of oyster or cockle shells be uncovered, or particularly if any human skeletal remains be encountered, during construction, the National Parks and Wildlife Service should be notified immediately.

3. In future, it would be preferable for Aboriginal and archaeological site surveys to be carried out before development has proceeded as far as it had in the present case.

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19. Response from Government Departments

19.1 A draft copy of this Environmental Impact Statement was forwarded to all interested Government Departments and Authorities.

The present proposal - as set out in this study - varies very little from that which was the subject of an earlier study. For some Government bodies the difference between the two proposals was of no consequence and accordingly there has been no change in their comments.

19.2 Public Works Department

The Department have specified a number of things they wish to be addressed in the Study. The major concern centers around the flooding aspects.

The majority of the issues they have raised have been addressed in the body of the report.

The following additional comments are offered:

a) The desireability of examining the effect of the proposed development on the extreme flood is recognised however it is proposed to defer this examination till the detailed design stage when it can be properly addressed with all the ancilliary design details available.

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b) The design of the canal has been addressed in the body of the report and it has been established that the section adopted (Fig. 5) will prove quite satisfactory and stable.

c) Site investigations were carried out by Geotechnical Consultants and have established that the soil types to be encountered will be quite stable for the shape adopted (Sec. 15).

19.3 Land Board Office

The major concern of the Land Board Office relates to the outlet of the canals where it will be necessary to excavate material from the bed of the Kalang River.

It is estimated that it will be necessary to remove approximately 2,500 m^3 of material from below Mean High Water Mark to ensure an adequate and stable entrance to the canals.

This excavation will form part of the construction of the canals and cannot be considered separately.

The construction procedure set out in Section 8 of this report will generally apply but a suction dredge is proposed to be used for dredging within the Kalang River in order to minimise turbidity and comply with the requirements of the State Pollution Control Commission.

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Quantities and procedures can only be specified when the detailed design has been completed.

The Developer is aware of the need to make application to the Land Board for work in the Kalang River and will do so at the appropriate time.

19.4 Soil Conservation Service

The Soil Conservation Service has raised no objection to the proposal.

"Section 19.3.2" referred to in their letter (Annexure "E") relates to a section in the draft statement which dealt with their previous comments.

Their response supports the adoption of sloped sides to the canals as recommended in this report.

19.5 Water Resources Commission

The Commission has raised no objection to the proposal.

19.6 N.S.W. State Fisheries (Department of Agriculture)

Lengthy discussions have been held with officers of the State Fisheries and these have resulted in a number of variations and adjustments to the original proposal.

The proposal as now set out in this report appears to be a very satisfactory compromise and significantly reduces the impact of the proposal on the aquatic and saline areas.

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19.7 State Pollution Control Commission

The Commission's major concern appears to be with the potential for pollution both during construction and after completion.

The construction procedure to be adopted has been briefly outlined in Section 8 and Section 10 deals with the utility services and steps to be taken to reduce or eliminate the potential for pollution from foul and storm sewage.

The pumping of settled liquor as mentioned in Sec 8 will not be necessary under normal conditions. Should extended wet periods render it necessary then the procedure specified would be followed.

Bellingen Shire Council has resolved to proceed with the augmentation of the sewage treatment plant and disposal system.

The remainder of the items raised in their response cannot be resolved until the detail design stage.

19.8 National Parks & Wildlife Service

The Service raises no objections to the proposal.

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19.9 Maritime Services Board

The Maritime Services Board has raised no objection to the proposal.

A number of suggestions have been made which relate to matters which will be dealt with at the construction and operation stages.

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ANNEXURE "A"

Bellingen Shire Council

TELEPHONE: BB 1027
ALL COMMUNICATIONS TO BE ADDRESSED TO THE SHIRE CLERK
P.O. BOX 117
BELLINGEN

Council Chambers,
Bellingen, N.S.W. 2454

IN YOUR REPLY PLEASE QUOTE
ARS:MEH
D/A.992

FORM 7.

Environmental Planning and Assessment Act, 1979.

NOTICE TO APPLICANT OF DETERMINATION OF A DEVELOPMENT APPLICATION

Messrs. Cooper, Blackley & Lockett,
Surveyors,
A/c. Cadea Pty. Ltd.
P.O. Box 981,
COFFS HARBOUR. 2450

being the applicant in respect of development application No. 992

Pursuant to section 92 of the Act notice is hereby given of the determination by the consent authority of the development application abovementioned relating to the land described as follows:-

Subdivision - Lots 1 & 2, DP.225991, Lot 43, DP.539689, Lot 441, DP.566897, Pacific Highway, Urunga.

The development application has been determined by —
~~(a) granting of consent unconditionally~~;
• (b) granting of consent subject to the conditions specified in the notice;
~~(c) refusing the consent~~.

Endorsement of date of consent 23rd June, 1981

NOTES.
(1) To ascertain the date upon which the consent becomes effective refer to section 93 of the Act.
(2) To ascertain the extent to which the consent is liable to lapse refer to section 99 of the Act.
(3) Section 97 of the Act confers on an applicant who is dissatisfied with the determination of a consent authority a right of appeal to the Land and Environment Court exercisable within 12 months after receipt of this notice.

Determination of development application No. 992

The conditions of the consent are set out as follows:—

(1) The submission of a joint venture agreement.

(2) The development of Lots 1, 2, 43 and 441 occur in parallel.

(3) The submission and approval of a subdivision application generally in accordance with the approved Interim Development proposal accompanied by:-
   (a) the subdivision fee fixed by Council at the time of submission of the linen plan. (At present $60).
   (b) the linen plan and six (6) copies.

(4) The submission and approval of full Engineering plans and specifications for, and the construction to the satisfaction of the Shire Engineer of:-
   (1) a Type 3 road junction with the Pacific Highway, such plans and specifications also being submitted to, and approved by the Department of Main Roads
   (2) kerbing and guttering and drainage adjacent to the land
   (3) roadworks to a bitumen seal standard gutter to gutter
   (4) inter-allotment drainage easements and construction within those easements.

   Further to (3) above the following being complied with:-
   (a) entrance road being 12 metres wide between kerbs plus widening associated with the Type 3 entrance/junction
   (b) roads noted as roads 2, 3 and 4 on Council's plan being 11 metres wide between kerbs
   (c) roads noted as roads 5 and 6 on Council's plan being 8 metres wide between kerbs with the cul-de-sac having a minimum radius of 8.5 metres.

(5) All filling works being carried out in strict accordance with Public Works approval and practice with the addition that the base of the floodway be constructed in a manner so as to ensure adequate surface drainage to the River.

(6) The floor level of any residential building being constructed at a level not less than 500 mm above the 1 in 100 year flood level.

(7) The deletion of the Public Reserve and Commercial Zone adjacent to Lots 28-31 and 20-26 and a re-design of this area for residential purposes.

(8) The establishment of a wider Public Reserve access and Commercial Zone in place of proposed Lots 95-98.

(9) The re-location of access to the "Floodway Reserve" to a position standing between Lots 66 and 67.

(10) The construction, at the entrance to the Public Reserve within the development of a hard stand vehicle parking area adequate to house a minimum of 40 vehicles such area to be bitumen sealed, defined by kerb and gutter and signposted.

(11) The submission to, and approval by the Shire Engineer, of plans and specifications providing for the filling and drainage of the Public Reserve, to in (8) and (10) above.

Varied

Determination of development application No 992 - Continued:-

~~the reasons for the imposition of the conditions / the refusal of consent are set out as follows:-~~

(12) The submission and approval of tree planting proposals, including the Public Reserve adjacent to the Pacific Highway, and the carrying out of those approved proposals prior to the release of the linen plan of subdivision.

(13) The construction within the subdivision of water supply services such construction to be in accordance with plans and specifications submitted to and approved by the Shire Engineer such works to tap into Council's water main at a point to be approved by the Shire Engineer.

(14) The lodgement into Council's Trust Fund of a contribution towards the cost of water supply augmentation calculated in respect of 132 allotments at the rate fixed by Council at the time of submission of the linen plan and subdivision application. (At present $85,800).

(15) The construction within the subdivision of sewerage reticulation, pumping stations, rising mains to serve the allotments such construction to be in accordance with plans and specifications approved by the Chief Health Surveyor and the submission of works as executed upon completion of those works.

(16) Plans and specifications referred to in (15) above to provide for the whole of the 2(c) Zone (including land not the subject of this application) and to include all necessary augmentation works required in Pump Station 3 in Hillside Drive. Costs for this phase of the development to be borne in proportion by the beneficiaries.

(17) The lodgement into Council's Trust Fund of a contribution towards the cost of sewer mains, pumping stations and treatment works augmentation calculated in respect of 132 allotments at the rate fixed by Council at the time of submission of the linen plan and subdivision application. (At present $198,000).

(18) The installation of all street name signs in accordance with the standard approved by the Shire Engineer.

(19) The filling of the land to the following heights:-

(a) for residential Lots, a minimum fill height of R.L. 3.05 ~~2.05~~ m AHD (1:100 years flood height), with a minimum surface drainage gradient of 1%.

(b) for roads and public reserves, a minimum fill height of R.L. 2.65 m AHD (1:20 year flood height).

For and on behalf of Bellingen Shire Council

Shire Clerk

Date 23rd June, 1981

ANNEXURE "B"

New South Wales Government

Department of Environment and Planning

Remington Centre
175 Liverpool Street, Sydney 2000
Box 3927 G.P.O. Sydney 2001
DX 15 Sydney
Telephone (02) 266-7587

Contact Ms. L. Dey
Our reference 78/202
Your reference 2104

Mr. G. Lockett,
Lockett and Montgomerie Pty. Ltd.,
Consulting Engineers, Surveyors
and Town Planners.
P.O. Box 981,
COFFS HARBOUR. N.S.W. 2450

Dear Sir,

Proposed Canal Excavation by Lockett and Montgomerie Pty. Ltd. within Lots 17 and 18, D.P. 263166 at Urunga in the Shire of Bellingen.

Thank you for your letter dated 3rd August, 1982, which indicates that you are consulting with the Director with regard to the preparation of an environmental impact statement for the abovementioned proposal.

2. As development consent is necessary for the proposal and it is a designated development within the meaning of Schedule 3 of the Environmental Planning and Assessment Regulation, 1980, it is necessary that an environmental impact statement accompany the development application.

3. The basic requirement is that an environmental impact statement is to be prepared in accordance with Clause 34 of the Environmental Planning and Assessment Regulation, 1980, and that it shall bear a certificate required by Clause 26(1)(b) of the Regulation.

4. With regard to the form and content of the environmental impact statement it is advised that there are legislative requirements for the preservation of relics and Aboriginal places. Where there is a possibility of these being encountered in development the incorporation of an aboriginal archaeological survey as part of an environmental impact statement may be necessary. Where aboriginal archaeological surveys are needed, it is a requirement that they be undertaken by persons who are professionally qualified archaeologists or anthropologists, or who are members of the Association of Consulting Archaeologists. If in doubt on this matter a proponent should consult with the National Parks and Wildlife Service.

5. The Director requires that you should take into account those matters specified in the attachment to this letter. These matters are to be adequately addressed in the environmental impact statement, and should be taken into account in the determination of the proposal.

6. Where matters are likely to come within the scope of legislation relative to air, water and noise control as administered by the State Pollution Control Commission, the view of the Commission should be sought.

.../2

Any requirements of authorities such as the State Pollution Control Commission, Soil Conservation Service, Water Resources Commission should be identified and these requirements taken into account in finalising the EIS. Public Works Department and Department of Fisheries should also be consulted.

The Director has no requirements for the Form of this environmental impact statement. The above matters may be considered in the text in any order that will assist a reader's understanding of the proposal.

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GENERAL COMMENTS RELATING TO THE DIRECTOR'S REQUIREMENTS FOR AN ENVIRONMENTAL IMPACT STATEMENT FOR A PROPOSED CANAL EXCAVATION BY LOCKETT AND MONTGOMERIE PTY. LTD. WITHIN LOTS 17 AND 18, D.P. 263166 AT URUNGA IN THE SHIRE OF BELLINGEN.

A comprehensive environmental impact statement should adequately cover all those matters provided in Clause 34 of the Environmental Planning and Assessment Regulation, 1980. You are advised that the following specific matters, inter alia, should be considered in preparing the environmental impact statement:

Description of the Proposed Works

A concise and complete description of the proposed works, complete with maps and figures, should be provided.

Transport requirements, in relation to rates, types of vehicles and frequency/timing of vehicle movements.

Employment implications, for direct and indirect employment.

Proposed safeguards to mitigate any social and environmental impacts, and an evaluation of their likely effectiveness.

Justification for and Alternative to the Proposal

The proposal should be justified in terms of the need for the works and any other relevant considerations.

Any feasible alternative to the proposal should be concisely identified, with a statement of why the proposed development is preferred. The consequences of not carrying out the proposed extraction should be stated.

Likely Environmental Consequences of the Proposal

Both beneficial and detrimental consequences should be identified. This discussion should include an evaluation of:

- Impact on water quality in the river and any changes in its hydrology.
- Impact on flooding and changes to present river hydraulics.
- Water pollution and possible bank erosion/siltation of the river.
- Estimation of the loss of recreation reserve areas within the subdivision.
- Possible effects on any wetlands downstream or adjacent to the site.

In evaluating the likely environmental consequences, proposed works both on and off the site should be considered, e.g. necessary road works to improve access.

.../2

7. Should you require any further information regarding this matter, please do not hesitate to contact us again.

Yours faithfully,

J. Bo[illegible]ward 9/7/..

Executive Officer
Environment Protection Division.
As Delegate for the Director.

ANNEXURE "C"

New South Wales Government

SW:AB

Public Works Department

COFFS HARBOUR DISTRICT OFFICE

359 High Street,
Coffs Harbour Jetty N.S.W.

Postal Address:
Box 63J P.O.,
Coffs Harbour Jetty 2451

Our reference FM 451 (51)

Your reference 2244

Telex: 66922

Telephone: (066) 52 0411

Contact: Mr. Wyllie

The Manager,
John Allen & Associates Pty. Ltd.,
24 Robert Garrett Street,
COFFS HARBOUR. 2450

26 AUG 1983

Dear Sir,

Proposed Canal Development, Lot 93 Burrawong Parade, Urunga
E.I.S. for Canal Development Bellinger Keys Estate

Reference : Your letter of 30th June 1983.

The revised layout for the proposed development and the assessment detailed in the final draft Environmental Impact Statement (E.I.S.) has been reviewed and the following comments are forwarded for your consideration.

The E.I.S. has discussed and examined the items requested in my letter dated 17th November 1982 (ref. FM 450 min 275). However, it is noted that the proposed tidal barrage, bridge and upstream entrance canal have been deleted from the original concept. Section 3.1 of the statement, History of Proposal, should discuss these changes in concept, as the Department's letter contained in Appendix 'C' specifically refers to the bridge and tidal barrage (item 4 (ii) and (iii)).

The Department reserves the right to make additional comments or impose further requirements, once the E.I.S. has been formally presented by Council.

Yours faithfully,

H.R. COLLEY
District Engineer
Coffs Harbour.

New South Wales Government

ANNEXURE "C"

BW:AM

Public Works Department

COFFS HARBOUR DISTRICT OFFICE

359 High Street,
Coffs Harbour Jetty N.S.W.

Postal Address
Box 63J P.O.,
Coffs Harbour Jetty 2451.

Lockett & Montgomerie Pty. Ltd.,
P.O. Box 981,
COFFS HARBOUR. 2450

Our reference: FM 450 (275)

Your reference 2104

Telex: 66922

Telephone: (066) ~~52 9866~~ 520411

Contact: Mr. Wyllie

17 NOV 1982

Dear Sir,

Proposed Residential Subdivision of Lots 17 & 18,
D.P. 263166, Burrawong Parade, Urunga

In reply to your letter of 27th September 1982, I wish to advise the following :-

1. As the Department is the construction authority under the Rivers and Foreshores Act, 1948, for tidal waters, it is obligated to ensure that the bank stability and hydraulic characteristics of a tidal waterway are not compromised by any construction works. When a canal subdivision is connected to a tidal river or water, the "banks" of the river, under the terms of the River and Foreshores Act, extend to include all the banks of the canal within the subdivision.

2. The issues the Department would like to see addressed in the proposed Environmental Impact Statement are the effects of the proposed development upon the flooding and tidal behaviour of the Kalang River as well as the effects of flooding on the development. As discussed with you on 3rd November 1982, pending the resolution of the possible effects of the proposed development upon flooding of outstanding approved development in the area, the report on "Hydraulic Analysis of Proposed Canal Development" (Sept. 1982) indicates that the proposal is feasible from a flood viewpoint. However, the effects of proposed development on the tidal behaviour (i.e. ventilation of canals and siltation of the Kalang River) is still to be addressed.

3 & 4 The Department's standard conditions have been detailed in Appendix 'F' of the aforementioned letter. However, prior to giving approval to excavate within 40 metres of the Kalang River, the Department would need to receive a report on a detailed hydraulic investigation which should determine and/or detail the :-

i) effects of the development on extreme flooding conditions;
ii) design of the tidal barrage and bridge
iii) bed and abutment protection at the tidal barrage
iv) design of the canals
v) bank stability in the canals.

5. The Department will need to review the items detailed above, before considering concurrence to the proposed development.

Yours faithfully,

H.R. COLLEY
District Engineer
Coffs Harbour.

Cooper, Blackley, Lockett
RECEIVED
18 NOV 1982
Action
Action
File

Lands Office

ANNEXURE "D"

P.O. Box 11,
GRAFTON, N.S.W. 2460

Our reference: GF81 H 1169 JD:HD

Your reference: JNA.JMH 2104

Telephone: 420545

Messrs. Lockett & Montgomerie,
Consulting Engineers,
P.O. Box 981,
COFFS HARBOUR, N.S.W. 2450

Dear Sirs,

PROPOSED REMOVAL OF MATERIAL IN ASSOCIATION WITH LAND SUBDIVISION, BURRAWONG PARADE, URUNGA - GORDEX PTY. LTD.

This office has examined the draft of the E.I.S. prepared for lodgement with Bellingen Shire Council for their consideration under part IV of the E.P.A. Act.

There is no further information considered necessary to be placed with the statement as far as this Department is concerned. However, I do wish to reaffirm the advice given in my letter of 14th October, 1982 which has been included in the statement.

This letter should not be construed as an endorsement of the proposal nor restricts the right of this Department to make further statements or submissions on the proposal when the statement is exhibited.

Copies of the statement should be forwarded to all affected authorities as their conditions will be incorporated in the quarry licence should one be granted.

Yours sincerely,

Officer-in-Charge

ANNEXURE "D"

New South Wales Government

Land Board Office

P.O Box 11
GRAFTON NSW 2460

Messrs Lockett & Montgomerie Pty Ltd.,
PO Box 981,
COFFS HARBOUR 2450

Our reference GF 81 H 1169 AG:MP
Your reference 2104

Telephone 420549

Dear Sir,

PROPOSED RESIDENTIAL SUBDIVISION OF LOTS 17 & 18, D.P. 263166, BURRAWONG PARADE URUNGA. YOUR LETTER OF 27TH SEPTEMBER, 1982.

The only matter in respect of the proposed development which is of interest to this Department is the dredging of any material from the extension of the proposed canal into the Kalang River.

If any material is to be removed from below Mean High Water Mark of the Kalang River then details of the area to be dredged and quantities of material to be removed should be incorporated in the proposed Environmental Impact Statement.

It would also be necessary for your client to make application to this office for permission to remove material from the Kalang River. Any application should be accompanied by the consents of the N.S.W State Fisheries and Department of Public Works.

J.S. Perry
Officer-in-charge

Cooper, Brockett, Lockett
15 OCT 1982
Attention
Action
File

New South Wales Government

ANNEXURE "E"

Soil Conservation Service

P.O Box 582
COFFS HARBOUR 2450

Our reference CH/238B
Your reference 2104

Telephone (066)520512

17th July, 1983

Mr. John Allen
John Allen & Associates Pty. Ltd.,
74 Robert Garrett Street
COFFS HARBOUR. 2450

Dear Sir,

Re Proposed Residential Subdivision
of Lots 17 & 18 Deposited Plan 263166
Burrawong Parade, Urunga.

The revised Environmental Impact Statement for the Proposed canal excavation south of Urunga has been reviewed.

The preliminary construction procedures specified in Section 8 of the Statement meet the requirements of the Soil Conservation Service.

The second paragraph of Section 19.3.2. of the Statement reads that this Service appears to recommend vertical sides to the canal over the tidal zone. This is not the case. My recommendation was that the batters of the canal should be kept at a low angle to ensure stability. This appears in my letter which is Annexure "E" of the Statement.

However the canal section depicted in Figure No. 5 of the Statement meets the requirements of this Service.

Yours faithfully,

(N.T.Sewell)
District Soil Conservationist
Coffs Harbour.

ANNEXURE "E"

SOIL
CONSERVATION
SERVICE
OF N.S.W.

SUB-DISTRICT OFFICE
~~ROOM 5~~ Suite 5 / Level 7
~~HARBOUR HOUSE~~ G.I.O. House
24 47 MOONEE STREET
COFF'S HARBOUR, N.S.W. 2450

P.O. Box 582, Coff's Harbour, N.S.W. 2450
Telephone: ~~4614~~ 52 4444 extn. 12

20th October 1982

In reply quote CH/238
and address "Soil Conservationist"

The Director
Lockett & Montgomerie Pty. Ltd.,
Level 6 G.I.O. House
24 Moonee Street
COFFS HARBOUR. 2450

Lockett
D
27 OCT 1982
File

Dear Sir,

re: Proposed Residential Subdivision
of Lots 17 & 18 D.P. 263166
Burrawong Parade, Urunga
Shire of Bellingen.
Your Ref: 2104

I refer to your letter of 27th September, 1982 and the following comments are submitted in answer to questions raised in that letter.

The Soil Conservation Service has an input into land capability and suitability for various land uses. A Canal Subdivision is one form of land use.

The following recommendations should be included in your Environmental Impact Statement as the Services requirements.

- Topsoil should be stripped and stockpiled from any area to be disturbed and respread later on areas to be revegated.
- The stockpiles should be placed outside hazard areas such as drainage lines. This recommendation includes the material excavated from the proposed canal.
- Provision should be made to effectively accommodate the increased runoff caused by changed soil and surface conditions during and after development.
- Provision should be made to intercept and safely convey runoff to storm drains or natural outlets where it will not erode or flood the land.
- Provision should ba made to complete the drainage system and make it operational as quickly as possible during construction.
- Wherever feasible, natural vegetation should be retained and protected.
- Where necessary, temporary vegetation and/or mulching should be used to protect areas exposed during development.
- Paving of streets should occur as early as possible.
- All disturbed areas which are not to be paved or built upon should be revegetated within 30 days of final land shaping.

Cont...2/

Operations carried out to construct the canal should be conducted in such a way as not to cause erosion of the Kalang River bank. The Kalang River is a prescribed stream under the Water Act. The Water Act requires that, unless the authority of the Catchment Areas Protection Board has been secured, a person shall not -

a) ringbark, cut down, fell, poison or otherwise destroy, or cause to be destroyed; or

b) top, lop, remove or injure, or cause to be injured, any tree within the bed or within 20 metres of the banks of a prescribed river or lake.

The batters of the canal should be kept at a low angle to ensure stability. Canal banks should be protected by stone or other suitable material that will form a permanent retaining wall and prevent soil movement.

Proposed fill areas should be thoroughly compacted in thin layers not exceeding 15cm to finished height, topsoiled and revegetated within 30 days of spreading topsoil.

Yours faithfully,

N.T.Sewell
District Soil Conservationist
Coffs Harbour.

ANNEXURE "F"

New South Wales Government

Water Resources Commission

Ibis House
201/211 Miller Street
Box 952, P.O.,
North Sydney,
N.S.W. 2060
Telegrams: "Aquacomm"
Telex: "Watcom" 21188

Lockett & Montgomerie Pty. Ltd.,
P.O. Box 981,
COFFS HARBOUR. N.S.W. 2450.

Contact Name Mr. M. Lau
Our reference 82/16616

Telephone 922 0121
Extension 737

[illegible] 1982

Dear Sir,

Proposed Residential Subdivision of Lots 17 and 18, D.P. 263166, Burrawong Parade, Urunga Shire of Bellingen

Reference is made to your letter of 27th September 1982, which was forwarded to the Commission's office at Grafton.

It is noted that the proposed subdivision fronts the tidal reach of the Bellingen River. Accordingly, river management and flood aspects for the area are dealt with by the Department of Public Works.

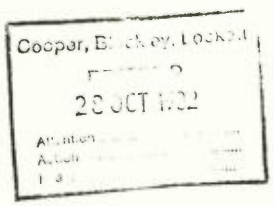
The Commission's interests include groundwater and in this connection it is considered that the proposed development would have little effect on groundwater resources.

Requirements the development might place on community water supplies would be considered by the Department of Public Works and Bellingen Shire Council.

In so far as the water resources aspects under the Commission's administration, there is no objection to the proposed development.

Yours faithfully,

Secretary.



New South Wales Government

Department of Agriculture

Division of State Fisheries

ANNEXURE "H"

McKell Building
Rawson Place
Sydney 2000
P.O. Box K220 Haymarket 2000

Lockett & Montgomerie Pty. Ltd.,
P.O. Box 981,
COFFS HARBOUR. N.S.W. 2450

Lockett & Montgomerie Pty. Limited
8 AUG 1983
Attention .....

Our reference: MJM:SM

Your reference:

Telephone: 237 6564
Extension:

2nd August, 1983.

Re: Proposed residential subdivision of
Lots 17 and 18 deposited plan 263166
Burrawong Parade,
Urunga
Shire of Bellingen

Attention: Mr. J. Allen

Dear Sir,

The first draft of the revised Environmental Impact Statement for the above proposed development has been examined. The following comments relate to our queries re the original EIS (received February 1983).

The matters of sewage effluent disposal and zoning are still apparently under discussion and therefore cannot be commented on at this stage. However, it is reiterated that any increase in effluent disposal to Urunga Lagoon would be unacceptable.

Despite lengthy and detailed criticisms and suggestions provided by State Fisheries (copy enclosed) the biological section of the report has not been revised, thus is still regarded as being inadequate. It is strongly recommended that our previous comments be taken into consideration and the section be rewritten. In pacticular, we require;

a detailed description of the remaining mangrove areas and how they will be affected by this specific development,

the anticipated ecological effects of the "proposed lowering of the peninsula to increase floodway area".

In addition, the question still remains of the mangroves already damaged by apparently unauthorised earthworks. State Fisheries is of the firm opinion that this area, which apparently is not included within the revised proposal, be restored at the cost of the developer. Technical advice regarding the successful restoration of mangrove areas will soon be available from State Fisheries.

State Fisheries is currently developing guidelines for canal estate developments. A copy of the current draft is enclosed for your information - when available a final copy will be forwarded to you.

Yours sincerely,

M.J. Middleton,
for G.H. Knowles,
Director - General.

ANNEXURE "H"

New South Wales Government

New South Wales State Fisheries

Fisheries House,
211 Kent Street,
Sydney N.S.W.

P.O. Box N211,
Grosvenor Street, N.S.W. 2000
Telegrams: Statefish
Address reply to Director

Lockett & Montgomerie Pty. Limited,
Consulting Engineers, Surveyors
and Town Planners,
P.O. Box 981,
COFFS HARBOUR NSW 2450

Our reference 82/2207 TJD:AC

Your reference 2104

Telephone 237 65
Extension 6974

Dear Sirs,

Proposed Residential Subdivision of Lots
17 & 18, D.P. 263166 Burrawong Parade,
Urunga, Shire of Bellingen

I refer to your letter and papers in which you seek certain information associated with the abovementioned project and a subsequent telephone conversation between Mr Lockett of your office and Mr D. Dunstan of this Department.

In answer to the questions raised in your letter, I have provided the following information :-

1. Under the Fisheries and Oyster Farms Act, all proposed canal subdivisions require the approval of this Department.

2. Issues of concern relate to the effects of such developments on the aquatic environment as well as effects on the associated amateur and commercial fishery, including oyster culture.

3. Criteria regarding specifications and safeguards relevant to canal construction are being formulated by the Department. A copy of the current draft is enclosed: it is emphasised these specifications are subject to further revision. Ms M. Middleton (telephone No. 02 237 6500) may be of further assistance in this regard.

4. Approval will be subject to investigation following the submission of the mandatory environmental impact statement.

Furthermore, general conditions 2, 13(a) and 14 laid down by the Department of Public Works in "annexure 'F'" of the provided papers also apply to N.S.W. State Fisheries' requirements.

Yours sincerely,

D D Francois

Donald D. Francois
Director of Fisheries

Encl.

ANNEXURE "H"

DRAFT

GUIDELINES FOR CANAL ESTATE DEVELOPMENTS

Prepared by M.J.Middleton

G.Allan and R.J.Williams

Division of State Fisheries

Department of Agriculture

New South Wales

FOREWORD

Increased public and private awareness of the value of aquatic environments plus the necessity to comply with certain provisions of the Environmental Planning and Assessment Act, 1979, has meant an increase in the number of requests received by State Fisheries for advice on canal estate developments. These estates are generally defined as residential subdivisions incorporating artificial waterways and have been recognised as being potentially damaging to aquatic ecosystems, particularly in estuarine areas. The Minister for Agriculture and Fisheries has a responsibility under the terms of the Fisheries and Oyster Farms Act, 1935, to protect, develop and regulate the fisheries of the State in all tidal and inland waters including all "artificial dams, reservoirs, ponds, canals, channels and waterways"; hence State Fisheries is legitimately concerned with both short and long term effects of canal estate developments.

VALUE OF ESTUARIES AND ESTUARINE WETLANDS

It is widely recognised that estuaries and their associated wetlands are valuable assets of the coastal environment. In particular, they play an important role in providing food and shelter for a wide range of aquatic organisms, including numerous species of commercially important finfish, crustaceans and shellfish. Pollard (1976) estimated that approximately 70% of the commercially important inshore and estuarine fish species in New South Wales are dependent on estuarine ecosystems at some stage of their lifecycle. In addition, the oyster industry in New South Wales, currently valued at $23 million, is conducted in the estuaries.

Estuarine mangroves and seagrass beds have been shown to be nursery habitats for juvenile fish, prawns and crabs as well as being feeding areas for adults. Shallow mud flats and sandy areas are also important feeding grounds. Saltmarshes contribute to primary

productivity and are thought to act as a buffer between sensitive habitats, such as mangroves, and agricultural or urban developments. They are thus important in maintaining the ecological balance of estuaries.

Any decrease in area or damage to these estuarine habitats is likely to detract from their natural productivity.

ESTUARINE PLANNING

State Fisheries recognises that some development of coastal lagoons and estuaries is an inescapable fact. However, if existing attractions and resources are to remain viable, it must be recognised that habitat conservation is the principal requirement for the maintenance of estuaries. Waterway development must occur as part of an overall plan which has been formulated in an environmentally conscious manner. This implies a management philosophy which rejects the common argument that only a small portion of the habitat is being destroyed hence there will be little or no effect on the estuary's remaining natural resources. Of particular importance are possible synergistic effects with existing and future developments.

In New South Wales, many estuaries and wetlands have suffered through indiscriminate or illplanned development. As canal estates will continue to be proposed for coastal areas, State Fisheries strongly recommends these future proposals be restricted to non-sensitive areas. The Rural Land Evaluation Manual (Department of Environment and Planning, 1981) states that Environmental Protection zones "should be applied to areas of environmental significance in order that detrimental development may be excluded and compatible development controlled" (p.9). The Manual subsequently applies the stricture that "Councils should endeavour to apply appropriate protection zoning if the wetland meets any of the following criteria", whereupon fourteen criteria are listed. These criteria relate to the

wetland's size, condition, use by birds and other animals, diversity of vegetation, contribution to fisheries production, scenic quality, whether it has ecological, scientific, educational, geographical or recreational significance or whether it has potential to become a viable wetland with proper management techniques. Environmental Protection zone 7a applies to wetlands which are predominantly freshwater and non-tidal and zone 7b to estuarine wetlands.

Pollution control is the other major problem in estuarine planning. Pollution inputs to canals must be reduced as far as practicable through efficient treatment systems and careful management of runoff.

ENVIRONMENTAL EFFECTS OF CANAL ESTATE DEVELOPMENTS

The construction of canal estates generally occurs adjacent to tidal waterways and involves dredging and subsequent reclamation of low lying land. In most cases, the artificial waterways are connected to the host estuary, thus allowing boat access and water exchange.

Dredging and reclamation affect the estuarine ecosystem in a number of ways. The most obvious is the direct destruction of estuarine habitats. Alterations to tidal prism, velocity of runoff, water quality and circulation and sediment distribution also occur. These effects may be synergistic (i.e. the effect of one impact may increase or enhance that of another) and create a severely stressed and unstable aquatic environment with a depauperate fauna. General reviews of environmental problems which can occur in canal estates have been provided by EPA (1975), Gutteridge, Haskins and Davey (1975), Westman (1975), Adkins and Bowman (1976), Clark (1977), Dwyer and Associates (1978) and Robinson (1982).

However, if canal estates are located in otherwise unproductive areas, designs that are sympathetic to the environment can result in benefits to the aquatic ecosystem. Such design features

would aim to optimise water movement in order to remove pollutants, enhance oxygenation and allow free movement of larvae and other forms to and from the canal as well as providing substrates of suitable slope and material to encourage colonisation by aquatic animals and plants. Ideally, a canal estate waterway would imitate natural estuarine environments and consist of a variety of habitats such as mangroves, seagrass beds and areas of sandy substrate. This would encourage the establishment of diverse animal and plant communities. Diverse systems, as compared to depauperate ones, are less susceptible to undesirable fluctuations in the environment and help maintain high water quality.

In order to prevent further deterioration of estuarine environments in New South Wales and to encourage the development and use of canal designs which may benefit estuarine flora and fauna, State Fisheries has prepared the following guidelines. These guidelines are intended for the use of local councils and developers who are considering canal estate developments.

GUIDELINES FOR CANAL ESTATE DEVELOPMENTS

1. LEGISLATION

1.1 Section 90E-90L of the Fisheries and Oyster Farms Act, 1935, stipulates certain requirements which must be complied with before a work of dredging or reclamation is undertaken. The work must be:-

(a) authorised by the Crown Lands Office

(b) authorised by another public authority (a local government authority such as a council is not a public authority for this purpose), or

(c) be carried out with the consent of the Minister for Agriculture and Fisheries and in accordance with any conditions he may impose.

Where the work falls within categories (a) and (b), the authority is required to notify State Fisheries of its intention to carry out or authorise such work. In all other cases, it is necessary for the person or body to deal directly with State Fisheries in order to obtain the consent of the Minister.

A person not complying with these requirements is liable to prosecution for a breach of the Act.

1.2 Under the provisions of the Fisheries and Oyster Farms Act, 1935, State Fisheries has jurisdiction in respect of fisheries matters over all tidal and inland waters in the State. This provision extends to artificial waterways included in canal and key type developments. Therefore, officers of State Fisheries are required to be given access to such artificial waterways in the discharge of their duties.

1.3 Canal estates which are designed to provide more than ten allotments capable of residential use are classified as "designated developments" under the Environmental Planning and Assessment Act, 1979, and applicants must follow the procedures given therein in making a development application.

1.4 Under the Fisheries and Oyster Farms Act, 1935, administrative responsibilities of leasing oyster growing areas lie with the Division of State Fisheries. Sections 58-90 of the Act deal with various aspects of oysterfarming. Leases can be obtained through State Fisheries by making application for a new lease or by buying an existing lease. When a lease is acquired, it is expected that the lessee (who must observe the covenants and conditions of the lease) will utilise and cultivate the area as an oyster farm.

Under Section 79 of the act, oyster leases may be cancelled if:-

(a) the lessee has not taken adequate (i.e. to the satisfaction of State Fisheries) steps towards cultivation of oysters, or if

(b) the lease is not maintained in a tidy condition.

2. GENERAL

2.1 The applicant should meet claims for compensation by oyster farmers if investigations by officers of State Fisheries establish that operations carried out for the purpose of constructing any part of the development have adversely affected oyster leases due to siltation or any deterioration in water quality.

2.2 Local council must ensure that the owners of the land developed by the applicant abide by environmental safeguards

set out in the appropriate E.I.S. Post-construction monitoring of water quality should be used as an indicator of environmental quality.

2.3 The applicant should submit and publicly display regulations providing for the control and use of the artificial waterway relating to the speed of boats and control of noise and water pollution from boats.

2.4 The public should have access to the host estuary foreshore and to any completed section of the artifical waterway.

2.5 In the planning of the works, it should be ensured that in areas of the site which are not designated for construction work and in areas adjacent to the site, the existing flora and fauna will be retained and maintained in its natural undisturbed state. In particular, this applies to foreshores and saltmarsh, mangrove and seagrass areas.

2.6 The accumulation of organic matter (floating debris, leaves from deciduous trees) in artificial waterways should be minimised. Although organic detritus forms the basis of many estuarine food chains, excessive accumulations may place demands on the dissolved oxygen budget and result in the system becoming anaerobic.

3. CANAL DESIGN AND FLUSHING

3.1 Prior to the commencement of siteworks, State Fisheries will require that the applicant satisfy the Public Works Department that the design and configuration of the artifical waterway will ensure adequate flushing and circulation to disperse any pollutants and maintain satisfactory water quality. "Satisfactory" may be interpreted as being water quality of the same as or higher standard than that of the host estuary.

3.2 The nature of the "in situ" sediment should be determined prior to dredging. In general, sand or sand/silt are acceptable substrates. Clayey soils are less suitable as they are not readily colonized by benthic fauna (i.e. those aquatic animals living in or on the waterway sides and floor). The use of sand as a veneer may be acceptable in areas of clayey soils.

3.3 The location and design of the entrance to the artificial waterway should be such that water exchange between the host estuary and the artificial waterway is maximised.

3.4 The particular plan shape of the artificial waterway should be designed to optimise water circulation (plan shape - the total size and shape of the artificial waterway system relative to the size and location of the entrance/s).

3.5 Strength and direction of winds and tidal flows have considerable influence on water flushing and circulation and should be used to best advantage in artificial waterway design.

3.6 Artificial waterway floors should be uniformly graded towards the entrance and depths should not exceed those of the host estuary in the area of the artificial waterway entrance.

3.7 The maximum depth at M.L.W. should be 2.0 metres to facilitate flushing and to ensure the substrate remains in the euphotic zone and thus allows the growth of the aquatic flora such as seagrasses.

3.8 The beaches and underwater slopes of the artificial waterway should be battered to a slope that is as long and gentle as possible to provide suitable areas for colonization by shallow water fauna and flora, including seagrasses and

mangroves. A slope of 1 in 7 is regarded as being suitable. For the same reason, vertical revetment walls should not be constructed below M.H.W.

3.9 Consideration should be given to planting mangroves for bank stabilisation and to provide a more diverse environment.

3.10 Planning should allow for a buffer zone in the order of 100 m wide to separate developments from sensitive habitats such as mangroves.

3.11 Wherever possible, existing permanent and ephemeral water courses should be retained. However, freshwater inputs to artificial waterways should be avoided where waterways may be susceptible to stratification or where substantial amounts of organic material or sediment may enter.

4. DREDGING AND CONSTRUCTION WORKS

4.1 Any works in relation to excavation, dredging, site filling or building construction should be carried out in such a manner as to prevent material or particulate matter from entering the host estuary. This may entail the provision of settlement ponds. No water should be permitted to flow from the artificial waterway to the natural water body until water quality which is satisfactory (as defined in 3.1) has been achieved.

4.2 The applicant must provide specific details of proposed disposal areas for dredged and excavated material prior to commencement of any excavation or construction work.

5. SEWERAGE AND URBAN RUNOFF

5.1 Residential subdivisions incorporating artificial waterways should be fully sewered, preferably with a connection to a reticulated town sewer system. If this is not possible then secondary treatment followed by ocean discharge is favoured.

In the case of approved package treatment works, treated effluent should only be applied to land that has been demonstrated to have adequate absorption capacity. Septic tank and pit disposal facilities are unacceptable.

5.2 Stormwater from all roads, carparks and other paved surfaces should be drained to retention ponds. Oils and grease are to be trapped by baffles located at the inlet to the ponds, sediments are to be allowed to settle.

5.3 Discharge points for "clean" stormwater should be placed outside artificial waterway systems and at a sufficient distance from the canal entrance to ensure that the effluent is not carried into the system by tidal currents. In general, discharge into deadend canals should be avoided.

5.4 The use of toxic substances such as pesticides and herbicides which may find their way into the artificial waterway via urban runoff should be avoided. The use of nutrient rich substances such as garden fertilisers should be minimised.

6. MARINA AND BOAT HARBOUR FACILITIES

6.1 Any marina or boat harbour facilities should be located as close to the entrance of the artificial waterway system as possible.

6.2 Boat sullage and sewage pump-out facilities should be connected to a reticulated sewerage system and approved facilities provided for disposal of bilge water.

6.3 All fuelling, maintenance or servicing of boats involving use of pollutants (including careening, de-fouling and anti-fouling) should be restricted to a designated boat servicing area designed to prevent contamination of the artificial waterway.

Enquiries should be directed to the Division of State Fisheries, Department of Agriculture, N.S.W., McKell Building, Rawson Place, Sydney, 2000 or P.O. Box K220, Haymarket, 2000.

BIBLIOGRAPHY

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New South Wales Government

State Pollution Control Commission

ANNEXURE "I"

New South Wales
Government Offices
117 Bull Street
Newcastle West 2302
P.O. Box 5268D
Newcastle West 2302

Telephone: (049) 26 9711
Telex: AA 28110

Our reference: 250544A:TT:CK

Your reference:

Mr. John Allen
John Allen & Associates Pty Ltd
24 Robert Garrett Street
COFFS HARBOUR NSW 2450 95

31 AUG 1983

Dear Sir

Environmental Impact Statement
Proposed Canal Excavation
Bellinger Keys Estate - Urunga

Further to your letter of 30 June 1983 and our letter of 28 October 1982 concerning the above development we wish to draw your attention to the following matters.

The canal construction will need to be conducted in a manner so as not to cause contamination of Kalang River. A licence under the Clean Waters Act will therefore not be required. Your statement on page 31 of the E.I.S. concerning discharge of water from the excavation site to the river under controlled condition, is not considered favourably. Water collected in the canal (excavation site) should be retained on site.

We also draw your attention to item 4 of our letter of 28 October 1982.

With respect to the provision of sewerage facilities for the new subdivision it is important to ensure that not only the necessary reticulation system is provided but that adequate sewage treatment facilities are available on completion of the subdivision. We understand that this will require substantial augmentation of Urunga sewage treatment works. We would appreciate your further advice on this matter.

Yours faithfully

B.M. Gibbs
Regional Co-ordinator
for Secretary

ANNEXURE "I"

New South Wales Government

State Pollution Control Commission

G.I.O Building
2 Market Street
Newcastle 2300
P.O. Box 739L, Newcastle 2300

Mr John Allen
Lockett & Montgomerie Pty Limited
PO Box 981
COFFS HARBOUR NSW 2450

Our reference 250544A TT:CK

Your reference

Telephone: 26 1911

28 OCT 1982

Dear Sir

Proposed Residential Subdivision
of Lots 17 & 18 D.P. 263166
Burrawong Parade, Urunga
Shire of Bellingen

Further to your letter of 27 September 1982 and telephone discussion with one of our officers on 21 October 1982 we now confirm comments made to you concerning the above matter.

Our advice in order of the specific questions raised in your letter are as follows.

1. If the canal construction is likely to cause water pollution then the developer or his contractor has specific responsibilities under the Clean Waters Act. The use of swamp dozers and drag lines for dredging purposes can cause significant water pollution and it is imperative that appropriate control measures are taken to avoid siltation and minimise discolouration of natural waters. The Commission has been involved in numerous major canal construction projects and it is our opinion that further discussions are warranted in this canal proposal.

2. The Environmental Impact Statement should include an account and assessment of:-

   (a) the potential for water pollution (sediments and discolouration) of Kalang River, including hydrological data,

   (b) measures to be taken to prevent or abate contamination of the River during the dredging and spoil disposal operations,

   (c) the impact of any expected contamination of the River as a result of the proposed development,

.../2

(d) the proposed canal bank stabilization programme considered necessary,

(e) the proposed sewerage facilities for the new residential subdivision.

3. We have no specific requirement or engineering design standards for canal construction projects.

4. Particular attention should be given to the dredging programme to be adopted. The two ends of the canal should be dredged last. Depending on water levels (due to tide and fresh water flows in Kalang River) it may be necessary to construct two bund walls near the River bank to isolate the canal construction activities from Kalang River. During the final stage when the canal is connected to the River it may be necessary to provide a solid or fabric screen enclosure around the work area to prevent sedimentation of the River. The use of a suction dredge in preference to dragline should be considered.

The proposed canal construction and land reclamation work must be conducted in a manner to comply with the requirements of the Clean Waters legislation. If a discharge of wastewaters arising from any dewatering or dredging activity is likely or if the dredging operation is likely to cause discolouration and sedimentation of Kalang River then a licence under Section 20 of the Clean Waters Act will be required. In addition the construction or installation of any sediment or water pollution control facilities, including any sewage treatment and disposal system, will require the Commission's prior approval under Section 19 of the Clean Waters Act.

5. On the basis of the information presented to us we believe that the proposed development can be conducted in an environmentally acceptable manner.

Should you wish to discuss the above matters or in case of further information please contact the Regional Co-ordinator at our Newcastle office.

Yours faithfully

Thomas Terei
for Secretary

New South Wales Government

National Parks and Wildlife Service

NORTHERN REGION

ANNEXURE "J"

N.S.W. Government Offices
49 Victoria Street
P.O. Box 97
Grafton, N.S.W. 2460

Lockett & Montgomerie,
P.O. Box 981,
[illegible]. N.S.W. 2450

Our reference: NR.81-1 GH.SJB

Your reference

Telephone: 42 0593
STD: 066
Telex: NSWGOGR AA66966

28th July, 1983.

Dear Sir,

Re: Proposed Residential Subdivision of Lots 17 & 18, Deposited Plan 263166 Burrawong Parade, Urunga; Shire of Bellingen.

Reference is made to a copy of the first draft of the revised Environmental Impact Study for the above proposed residential subidivision.

The biological aspects, Section 17, adequately covers the concerns of our original comments. Further revision or comment is not necessary.

Yours faithfully,

G. F. MARTIN,
REGIONAL DIRECTOR,
NORTHERN REGION.
for Director

ANNEXURE "J"

New South Wales Government

National Parks and Wildlife Service

NORTHERN REGION

N.S.W. Government Offices
49 Victoria Street
P.O. Box 97
Grafton, N.S.W. 2460

Our reference: GH:DP

Your reference:

Telephone 42 0593
STD 066
Telex: NSWGOGR AA66966

Locket & Montgomerie Pty Ltd.,
Consulting Engineers,
P.O. Box 981,
COFFS HARBOUR...2450

26th October, 1982.

Dear Sir,

Proposed Residential Subdivision
of Lots 17 and 18 D.P. 263133
Burrawong Parade Urunga
Shire of Bellingen

Reference is made to your letter of the 27th September, 1982 and subsequent telephone conversation regarding the above proposal.

One of the issues that should be addressed in the proposed environmental impact statement are ways of retaining as much as possible of the mangrove saltmarsh, wetland areas of the subdivision. The lower Kalang River environments have been highly modified and the retention of any relatively natural communities especially mangroves is important locally.

Can the area of wetland in the proposal be extended by deleting the bowling green complex for example. From a nature conservation point of view the proposition to make a canal in the green shaded area is better than the earlier decision to fill the low lying ground.

Enclosed is a form letter regarding the necessity for archaeological surveys for development of this kind. Also enclosed is a booklet entitled "For Planners and Developers - Aboriginal Sites in N.S.W.".

The Service would normally involve itself in canal subdivisions where major modification of the natural environment is concerned. Apart from the need for an archaeological survey and a request to retain as much of the natural environment in the area the Service does not wish to become any further involved in the proposal.

Yours faithfully,

G.F. MARTIN,
REGIONAL DIRECTOR,
NORTHERN REGION.

New South Wales Government

National Parks and Wildlife Service
NORTHERN REGION

N.S.W. Government Offices
49 Victoria Street
P.O. Box 97
Grafton, N.S.W. 2460

Our reference:

Your reference: 420593

Telephone: [redacted]
STD: 066
Telex: NSWGOGR AA66966

Re:

The National Parks and Wildlife Service has statutory responsibility for all Aboriginal relics in New South Wales.

(a) No relics have as yet been recorded within the subject area, but this does not mean that none exist there, as no survey for relics has been carried out.

(b) Some relics have previously been recorded within the subject area, and a brief description of their nature and location is attached to this letter. It is probable that there are other unrecorded relics within the area.

(c) Locations of nearest recorded sites are shown on the attached map. One is a midden and the other is a rare "possum tree" showing toe holds cut for climbing after possums or honey. Similar sites may be located in the subject area.

Aboriginal relics occur in all environmental zones, and are sometimes found in areas that have been cleared or otherwise previously disturbed. Your attention is drawn to the enclosed pamphlet "Aboriginal Sites in N.S.W.". Please read it with a view to the types of relics that may exist within your development area (e.g. coastal areas may contain shell middens).

It is an offence against the National Parks and Wildlife Act, 1974 to knowingly destroy, deface or damage a relic or Aboriginal place without the written consent of the Director of the Service. Such an offence may be subject to prosecution and the development will be held up at least until the site has been assessed by a Service archaeologist and reviewed by the Service's Aboriginal Sites Committee. You are also obliged by the Act to notify the Director of the Service of any relics within the subject area that you may know of already, or find in the course of development.

The Service has established procedures for assisting developers to overcome problems associated with these legal restrictions and obligations. The best way to ensure that your project does not disturb Aboriginal relics is to have a survey carried out by a professional archaeologist during the planning stages of the development. You are advised to contact:

The Australian Association of Consulting Archaeologists,
P.O. Box 214, Holme Building,
University of Sydney....N.S.W.....2006

The Association maintains a register of archaeologists who undertake surveys for Aboriginal relics in New South Wales.

...2

A consultant archaeologist will normally also undertake (in co-operation with the Service) any necessary liaison with relevant Aboriginal communities regarding sites of contemporary Aboriginal significance. If sites of this type are threatened by development, Aboriginal communities may become very upset. It is important that they should be adequately consulted at the earliest possible stage of planning. If this does not happen they may not express their concern until a later stage, when a conflict situation may develop.

The consultant archaeologist carries out a survey and prepares a report on any relics and sites found in the subject area. This should include an assessment of their scientific and cultural value, and recommendations for their destruction, salvage or preservation. It is the consultant's responsibility to ensure that the report meets this Service's requirements, for example, the use of standard site recording forms. The report is submitted to the Service's Aboriginal Sites Committee, which considers the recommendations and advises the Director. Where necessary, the Director's consent to destroy relics is issued as a result of this procedure.

If you have further queries about Aboriginal relics and sites within your project area please contact the Regional Archaeologist at this office.

Yours faithfully,

G. F. MARTIN,
REGIONAL DIRECTOR,
NORTHERN REGION.

ANNEXURE "K"

THE MARITIME SERVICES BOARD OF N.S.W.
CIRCULAR QUAY WEST
SYDNEY

Telephone No. 240 2111 (All Hours)
Telex No. AA24944
Telegraphic Address
'Marboard Sydney'
OFFICE HOURS 8.30am — 4.00pm
Address Correspondence to:-
The Secretary
Box 32, G.P.O.
SYDNEY. 2001
Please Quote No. 82/12479
ALC:MTF

11 August 1983

Mr. J.N. Allen,
Lockett & Montgomerie Pty.
Limited,
P.O. Box 981,
COFFS HARBOUR. N.S.W. 2450

Dear Sir,

Proposed Residential Subdivision of Lots 17 & 18
Deposited Plan 263166, Burrawong Parade, Urunga,
Shire of Bellingen.

Referring to your letter of 30 June 1983 (JNA:JMH 2104), it is advised that the Board's previous response can be revised by the deletion of reference to requirements for warning signs and night illumination now that the weir/bridge are excluded from the revised development.

Yours faithfully,

T.C. PAGE,
Secretary.

Lockett & Montgomerie Pty. Limited
12 AUG 1983
Attention
Action

ANNEXURE "K"

THE MARITIME SERVICES BOARD OF N.S.W.

CIRCULAR QUAY WEST,
SYDNEY.

Telephone No. 2-0545 (All Hours)
Telex No. AA24944
Telegraphic Address
'Marboard Sydney'
OFFICE HOURS: 8.30am - 4.00pm
Address Correspondence to:-
The Secretary,
Box 32, G.P.O.,
SYDNEY. 2001
Please Quote No. 82/12479
TP:MTF

Mr. G. Lockett,
Lockett & Montgomerie Pty.
Limited,
P.O. Box 981,
COFFS HARBOUR. N.S.W. 2450

10 January 1983

Dear Mr. Lockett,

Proposed Residential Subdivision of Lots 17 & 18
D.P. 263166, Burrawong Parade, Urunga, Shire of
Bellingen.

I refer to your letter of 27 September 1982 (ref. 2104 GC BL:SJB). It is advised that the Board would not raise objection to the concept of the proposal on the basis of the information contained in your abovementioned correspondence, subject to approval being obtained from all authorities having jurisdiction in the matter.

Notwithstanding that the "navigable waters" of the proposed canals may remain private land, those waters will, whilst they remain open to or used by the public for navigation, be subject navigationally to the legislation administered by this Board and may therefore be invoked to assist in controlling navigation, if required. In this connection the control of speed of vessels and the erection of navigational aids may be necessary in the area which are functions of the Board.

The provisions of the Management of Waters and Waterside Lands Regulations - N.S.W. concerning obstructions to channels etc. will apply, not only during dredging operations, but also when the complex is occupied.

Whilst it is assumed that the proposed development, with the exception of the aspect of access dredging, is to be undertaken wholly within land to be retained in private ownership, a copy of the Board's Standard Conditions for Permissive Occupanices : Oyster Leases Etc. (marked "A") (which are applicable to Crown Land) are enclosed for information as same may be of assistance in this matter. Also enclosed for information is a statement of the Board's Special Conditions in respect of marina premises in Sydney Harbour and its vested areas (marked "B") which sets out details of various requirements which are designed for inclusion in leases granted in respect of marina sites.

The need for warning signs in the vicinity of the weir/bridge and illumination at night should receive consideration once the work has been completed.

Finally, the Board would require evidence of hydraulic studies which ensured that the development did not alter the Kalang River in such a way as to cause extra siltation or scour in the navigational channel, particularly during floods.

Lockett & Montgomerie Pty. Limited
12 JAN 1983
Attention
Action
File 2104

Yours faithfully,

J.E. BRADSTREET
Secretary.

STANDARD CONDITIONS FOR PERMISSIVE OCCUPANCIES : OYSTER LEASES, ETC.

A

(1) The Tenant shall not be exempted from the provisions of the Management of Waters and Waterside Lands Regulations - N.S.W. and shall at all times comply with the requirements of all Acts and Regulations administered by the Maritime Services Board.

(2) The Tenant shall at all times comply with any directions given by the Board or an officer of the Board in regard to painting, lighting or use or alteration of any structure as may from time to time be required in the interests of safe navigation, equitable use of and conservation of waterways and the prevention of pollution.

(3) Area of tenure shall include only that area below high water mark covered by the actual structures.

(4) The sites of any freestanding piles installed for the purpose of mooring a vessel at a jetty/pontoon shall be included in the area of tenure.

RECLAMATIONS

(5) Retaining wall shall be so constructed as to be stable and so that the filling will not escape into the water and to be of such a character as to be vermin proof.

(6) Wall shall be erected to a height of at least 0.9m above the level of local mean high water.

(7) The reclamation site shall conform to all accepted and agreed limit lines of reclamation if applicable.

BATHS

(8) Piles shall be erected to a height of at least 1.0m above the level of local mean high water.

(9) Outer corner piles shall have the bark stripped off 0.6m down from the top and shall be kept painted white. Waling planks, if any, shall be kept painted white.

(10) For a bath consisting of mesh netting supported by buoys/floats, the outer corners shall be marked by yellow buoys having a minimum diameter of 0.3m, a vertical height above the waterline of 0.5m and be so secured as to ensure minimum lateral movement. Intermediary floats shall be yellow or white in colour and float sufficiently high so as to be visible at average wave height.

(11) In the event that the area is to be enclosed by a stone or concrete wall, such wall shall be constructed to a height of at least 0.9m above the level of local mean high water and a diagram of its construction submitted.

PONTOONS

(12) Pontoons shall be so constructed and moored as to withstand the wash of passing vessels, be painted white, be clearly visible above the water level and be moored in such a manner as not to obstruct navigation.

JETTIES

(13) Jetties shall be of substantial construction, have a minimum deck height of 0.75m above local mean high water level with end piles and piles at not more than 15m apart to have a minimum height of 1.0m above local mean high water level. Piles shall be finished at even height, stripped of bark above deck level and painted white. No outlying wires or obstructions shall project outside the extremities of the jetty.

STANDARD CONDITIONS FOR PERMISSIVE OCCUPANCIES : OYSTER LEASES, ETC.

FREESTANDING PILES

(14) Freestanding piles for the mooring of a vessel at a jetty/pontoon shall be erected to a height of at least 1.0m above the level of local mean high water and have the bark stripped off 0.6m down from the top and be painted white and the permissive occupancy number displayed thereon.

SLIPS, RAMPS. ETC.

(15) Slips, ramps and structures of this nature shall be constructed in such a manner as to conform as closely as possible to the bed of the lake, river or waterway.

FUEL INSTALLATIONS AND BOWSERS

(16) The applicant's attention to be drawn to :-

(a) The jurisdiction of the Dangerous Goods Branch, Department of Industrial Relations;

(b) The penalty provided by Section 6 of the Prevention of Oil Pollution of Navigable Waters Act for discharge of oil; and

(c) The obligation of the occupiern under Section 11 of that Act to inform the Board forthwith of the details of any discharge occurring.

STRUCTURES POTENTIALLY HAZARDOUS TO NAVIGATION ON INLAND RIVERS SUBJECT TO FLOODING OF A REGULAR AND/OR LONG LASTING NATURE.

(17) A marker shall be erected and maintained at the outer extremity of the structure :-

(port hand) (a) Such marker shall be can shaped when sighted from any horizontal position and have a base 356mm in diameter and be red in colour.

(starboard hand) (b) Such marker shall be cone shaped when sighted from any horizontal position and have a base 457mm in diameter and be green in colour.

(c) The height of the base of the marker shall be 0.6m above the highest recorded level of flood in the waterway.

DREDGING (General)

(18) All operations shall be carried out in accordance with the Board's Acts and Regulations and any special conditions which may from time to time be required.

(19) Only anchors and mooring arrangements approved by the Board shall be used and plant not working is to be hove clear of navigation or to the bank in restricted areas.

Vessels, plant and pipelines shall carry lights and signals in accordance with the Navigation (Collision) Regulations - N.S.W. Rule 27 (d) (i) and (ii) and any other lights, shapes or signals which may from time to time be required.

No outlying wires, cables or pipes shall be used unless with the approval of the Board.

SPECIAL CONDITIONS
RE NON-FLOATING PLANT (i.e. Conditions 20 and 21)

(20) A navigable channel shall be maintained at all times. Such channel shall be marked in accordance with the I.A.L.A. Maritime Buoyage, System A.

(21) On completion of work in the area, all materials used during the operation shall be removed from the lake, river or waterway.

STANDARD CONDITIONS FOR PERMISSIVE OCCUPANCIES :
OYSTER LEASES, ETC.

DREDGING (General) cont'd.

(22) Any required depth shall be evenly maintained and the bottom left clear of debris, rubbish, potholes, etc. No slope to be steeper than 3 in 1.

(23) No dredging shall be permitted closer than 9m from any shore, jetty structure or navigation mark.

(24) Any licensed structure or occupation and/or apparatus licensed by the Board, if affected by dredging operations, shall be moved, re-aligned temporarily or permanently, re-built or replaced with additional equipment, if required, to the Board's satisfaction and without cost to the licensee.

(25) Dredging shall be carried out so that no loss of depth is caused in adjacent waterways.

(26) No dredged material shall be deposited in any lake, river or waterway.

OYSTER LEASES - RAFT CULTIVATION

(27) The Lessee shall at all times comply with the requirements of all Acts and Regulations administered by the Maritime Services Board of N.S.W.

(28) The Lessee shall at all times comply with any lawful direction given by the Board or an authorised officer of the Board relative to the interests of safe navigation or the conservation of navigable waters.

(29) Rafts shall be properly and securely moored within the leased area and in a manner acceptable to the Board or an authorised officer of the Board.

(30) Rafts shall be fitted with posts at each corner which are of minimum height of 0.75m above the waterline, have an arrangement at or near the top so as to display a flat surface of minimum dimensions of 300mm x 300mm when sighted from any horizontal position and the whole of such posts and such arrangements shall be painted white. Reflectors of engineering quality shall be fitted if required by the Board or an authorised officer of the Board.

(31) No outlying obstructions shall project beyond the extremities of any raft within the leased area.

(32) The leased area shall be cleared of all stakes, posts, equipment and all other structures when not under cultivation or upon the surrender, cancellation, forfeiture or other termination of the lease.

OYSTER LEASES - TRAY, STICK ETC. CULTIVATION

(33) The extremities of the area shall be marked in the interests of safe navigation by posts in accordance with Regulations in terms of the Fisheries and Oyster Farms Act, 1935.

(34) Posts shall also be erected between the corner posts at intervals of not more than 30m. Posts shall be of minimum dimensions of 100mm x 100mm, if of flat surfaces, or 125mm in diameter, and erected to a minimum height of 0.6m above local mean high water level and be stripped of bark and painted white above such level.

(35) Areas of cultivation shall be adjusted from time to time if required by the Board in the interests of safe navigation.

(36) The leased area shall be cleared of all stakes, posts, equipment and all other structures when not under cultivation or upon the surrender, cancellation, forfeiture or other termination of the lease.

SPECIAL CONDITIONS IN RESPECT OF MARINA PREMISES.

The lessee shall not permit, suffer or allow any person to reside permanently on any vessel operated or moored at the premises and casual occupation of such vessel is to be restricted at any time to three consecutive nights.

No noise or disturbance of persons in the neighbourhood shall emanate from the use of the premises or their facilities or from persons on the premises or vessels berthed or moored thereat.

Satisfactory measures shall be taken to prevent pollution of the waters of .... or its foreshores arising out of the use of the premises or from vessels berthed or moored thereat.

The use made of the premises shall be at all times satisfactory to the Board.

The lessee shall observe the requirements of the Health Commission of N.S.W. and comply with any notice issued in respect of the premises.

Toilet facilities and amenities shall be installed by the lessee in a position and to a design acceptable to the Board, such installations to be connected to a sewerage system if/when available.

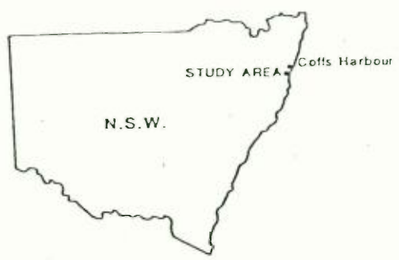
The toilet facilities provided at the marina shall be used by boat owners whilst the craft is berthed at the structure and any toilets installed on the vessel and which discharge directly into the harbour shall not be used whilst the vessel is so berthed.

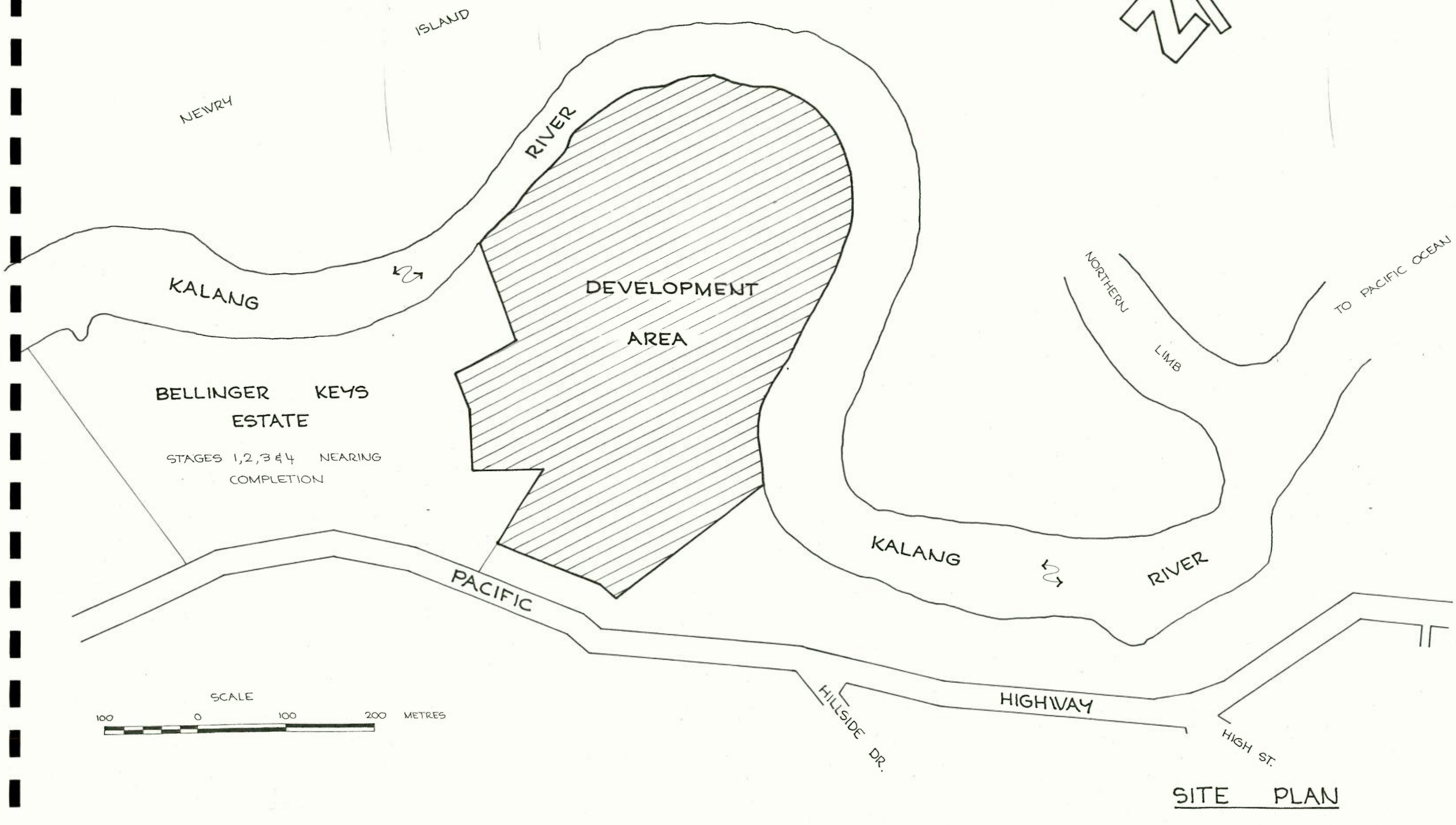
No vessel shall be permitted to moor other than within the area marked mooring area on the plan of lease.

Provide and maintain at the said demised premises and keep readily available for use proper fire extinguishing appliances and the lessee shall not use or permit suffer or allow the same to be used for other than fire extinguishing purposes. Fire extinguishers to be kept charged and in good condition at all times.

The lessee shall provide facilities for pumping out the holding tanks aboard vessels requiring such services, if called upon by the Board so to do.

LOCALITY PLAN




ISLAND
NEVRY
RIVER
KALANG
DEVELOPMENT
AREA
BELLINGER KEYS
ESTATE
STAGES 1,2,3 & 4 NEARING
COMPLETION
PACIFIC
HIGHWAY
HILLSIDE DR.
HIGH ST.
SCALE
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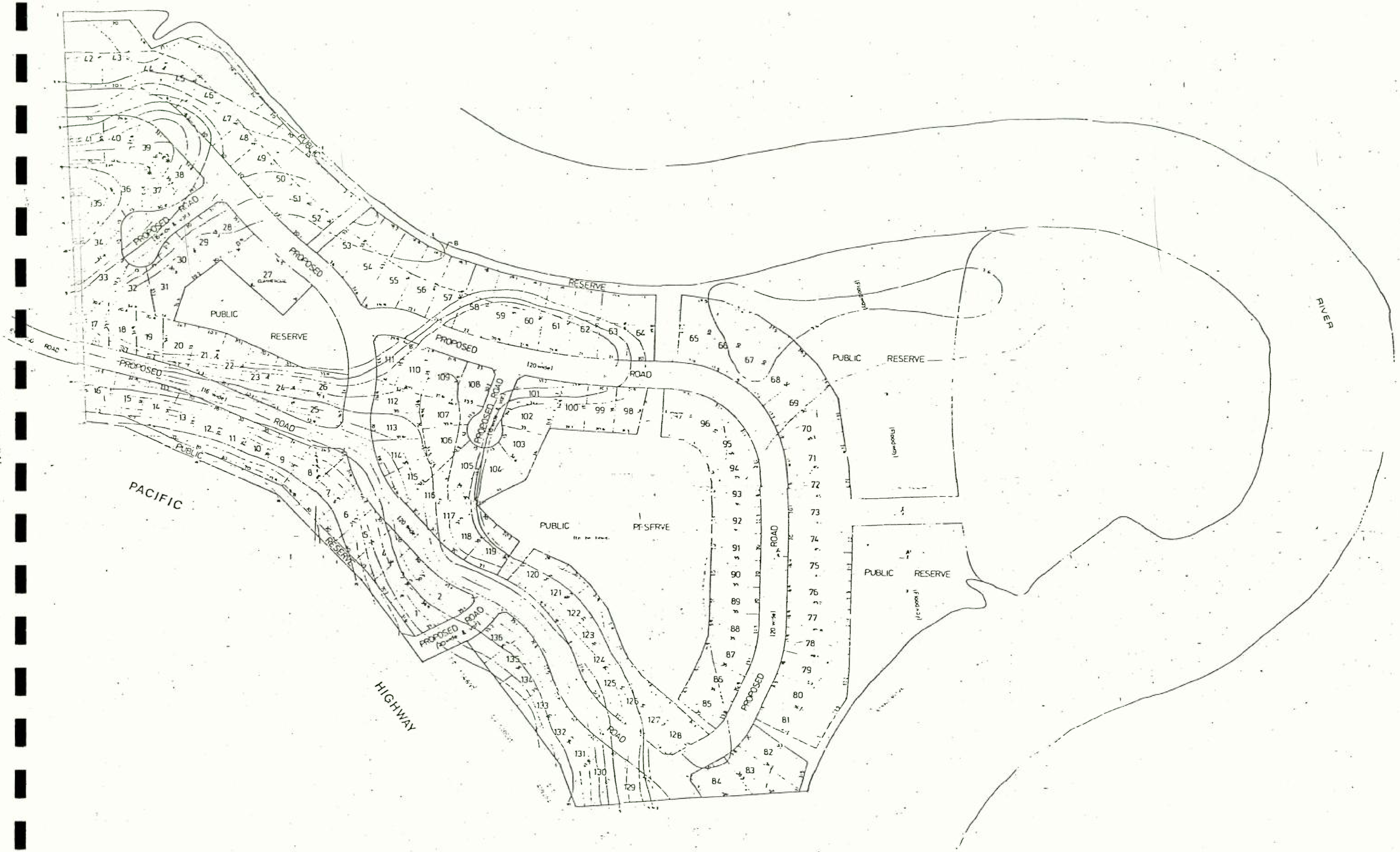
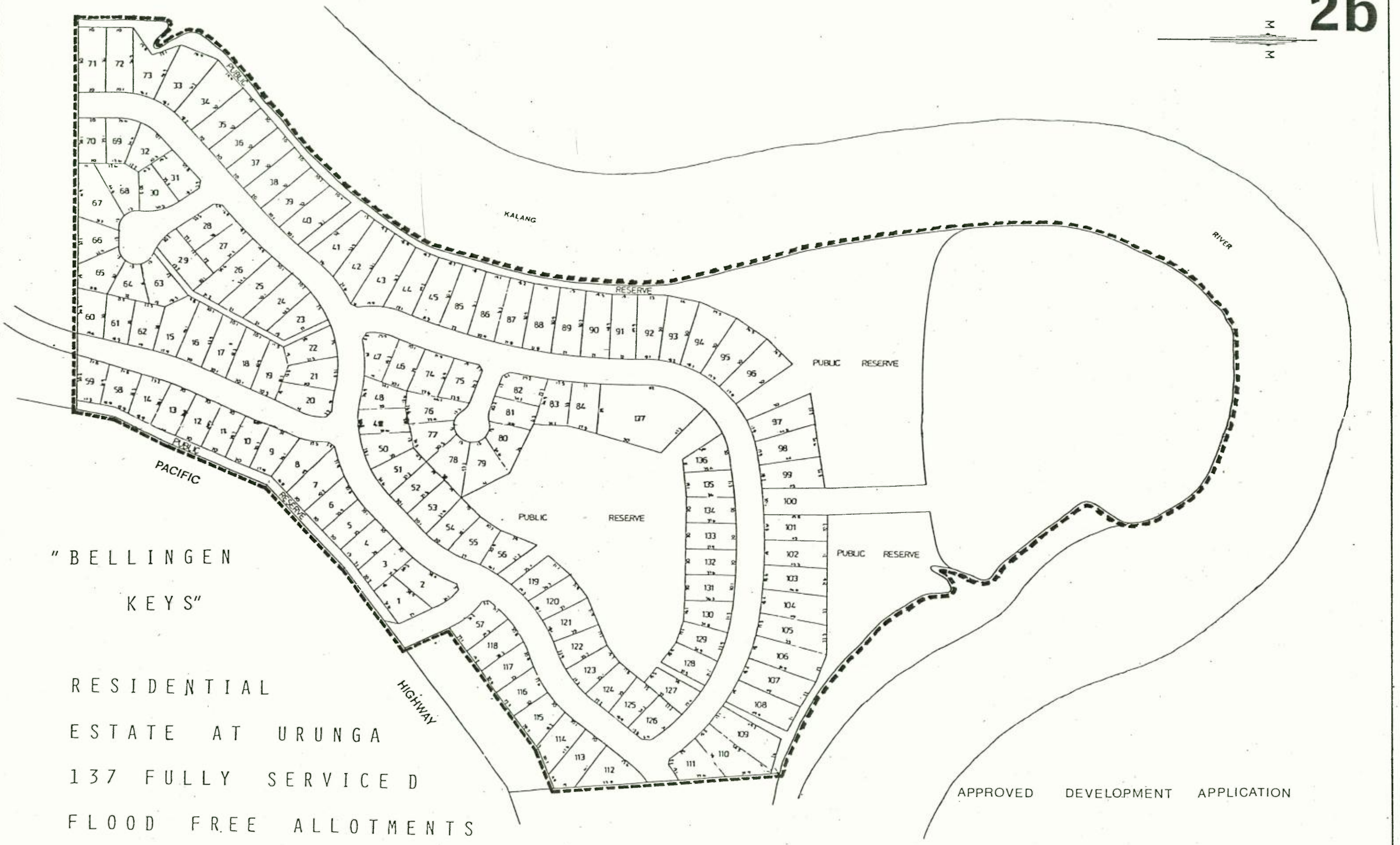
N
NORTHERN
LIMB
TO PACIFIC OCEAN
KALANG
RIVER

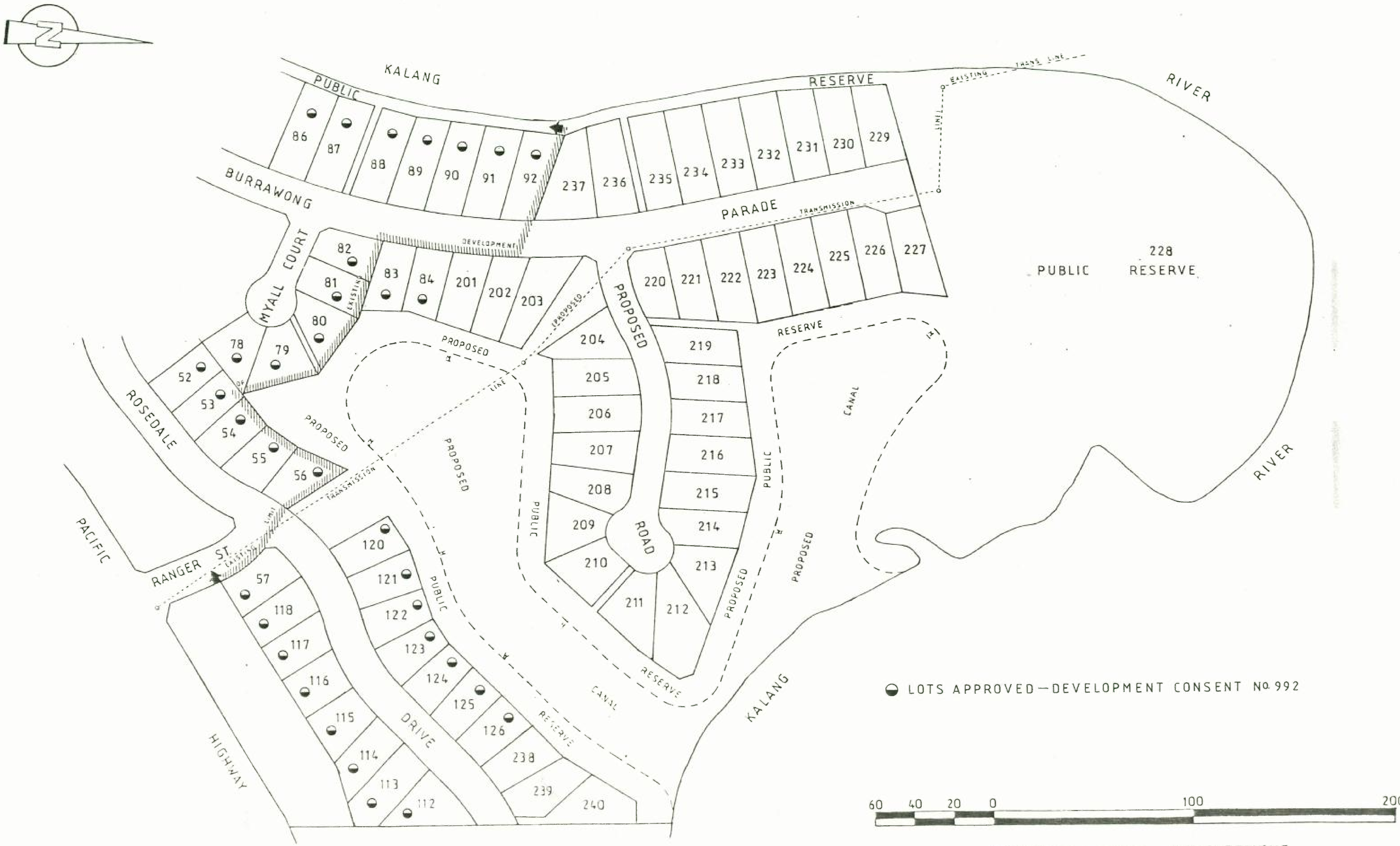
SITE PLAN



ORIGINAL DEVELOPMENT APPLICATION

2b


KALANG
RIVER
PUBLIC RESERVE
PUBLIC RESERVE
PUBLIC RESERVE
PUBLIC RESERVE
PACIFIC HIGHWAY
"BELLINGEN KEYS"
RESIDENTIAL ESTATE AT URUNGA
137 FULLY SERVICED FLOOD FREE ALLOTMENTS
APPROVED DEVELOPMENT APPLICATION



PROPOSED CANAL DEVELOPMENT

KALANG RIVER

(TIDAL)

MEAN HIGH WATER MARK

HEADWALL INV. 1·153 600mm ϕ S'CLASS R.C.P.

150mm ϕ UPV.C. SEWER MAIN

100mm ϕ CLASS 9 uPV.C. WATER MAIN

BURRAWONG PARADE

EXISTING DEVELOPMENT

MYALL COURT

ROSEDALE DRIVE

SEWER PUMPING STN.

LOW LYING SWAMPY AREA

150mm ϕ SEWER

uPVC MAIN

100mm ϕ CLASS 9 uPVC WATER MAIN

HEADWALL INV. 2·207 600mm ϕ 900mm ϕ S'CLASS R.C. PIPES

PACIFIC HIGHWAY

RANGER ST. EXTENT

MOUNTAIN VIEW MOTEL

GENERAL STORE

UAUNGA MOTORS

DWELLING

OPEN DRAIN

EARTH

PASTURES

OPEN

2·65

1·64

1·85

1·50

1·30

1·35

0·70

0·60

AREA COVERED BY EXTREME HIGH TIDES

MANGROVES

1·00

1·80

1·20

2·30

2·40

1·65

1·50

0·75

MANGROVES 0·55

CASUARINAS 1·45

0·70

1·37

0·55

CASUARINAS

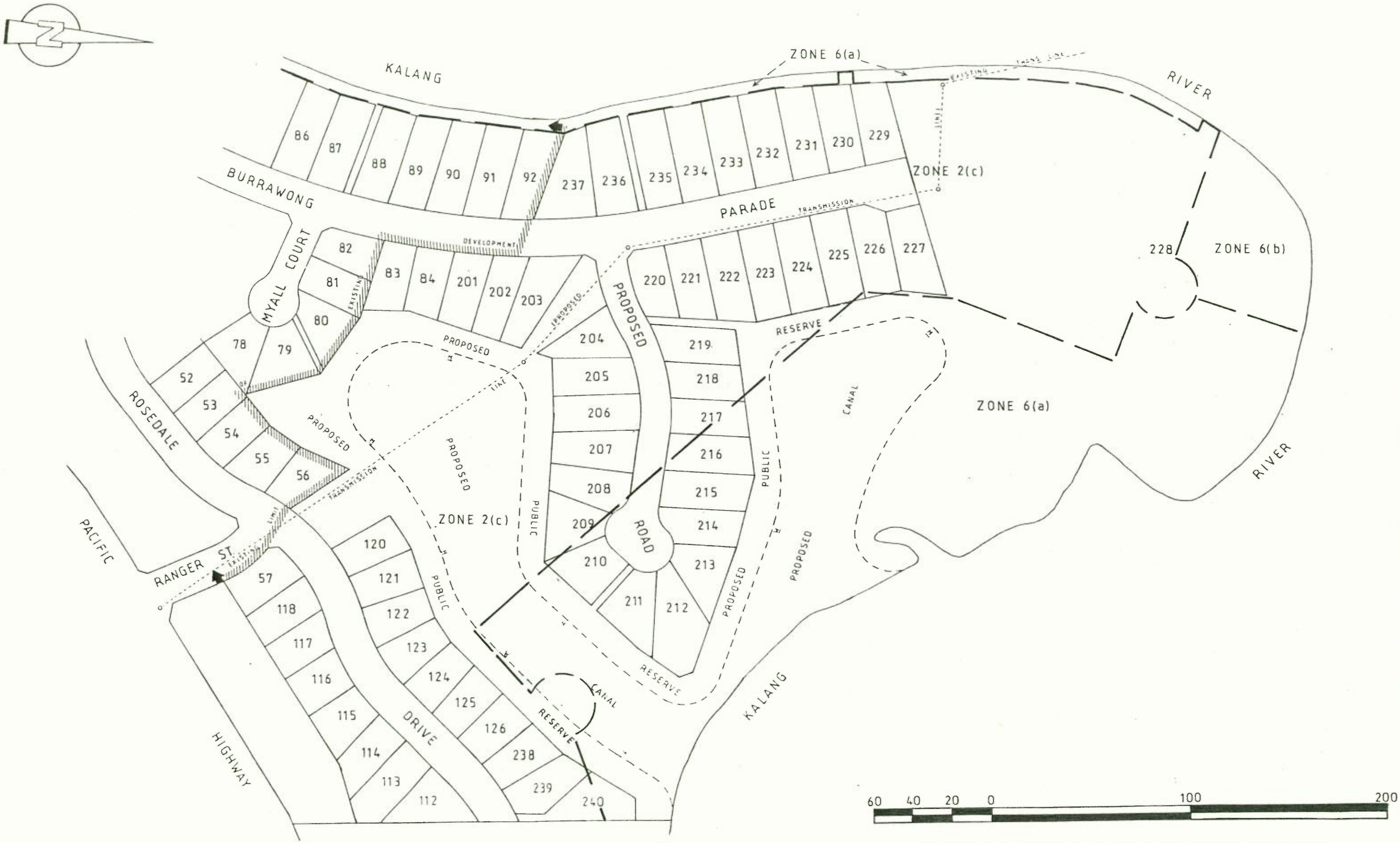
HIGH FLATS

MEAN MANGROVE

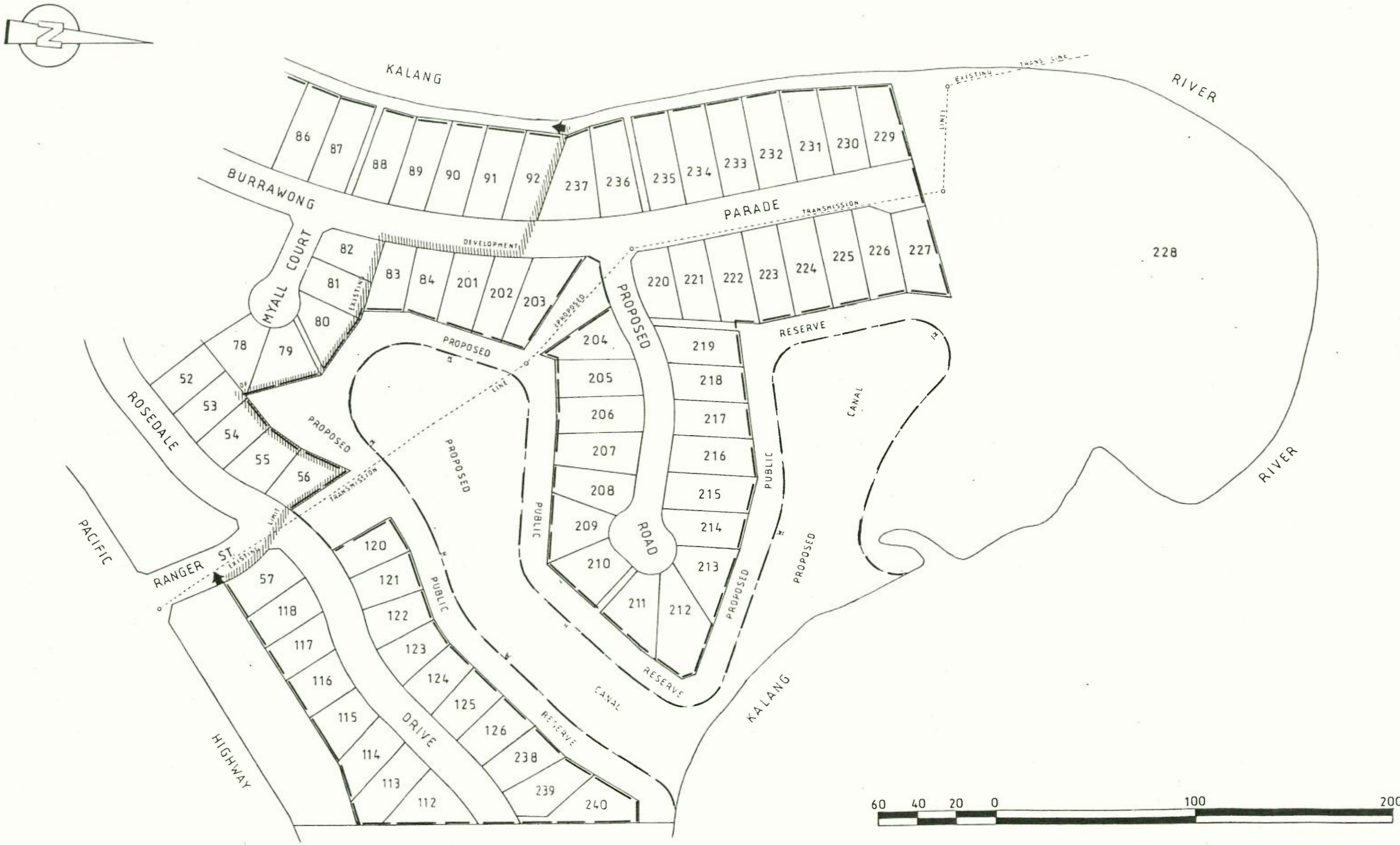
NOTE: INDICATES MEAN HIGH WATER MARK WHICH IS THE PROPERTY BOUNDARY

60 40 20 0 100 200

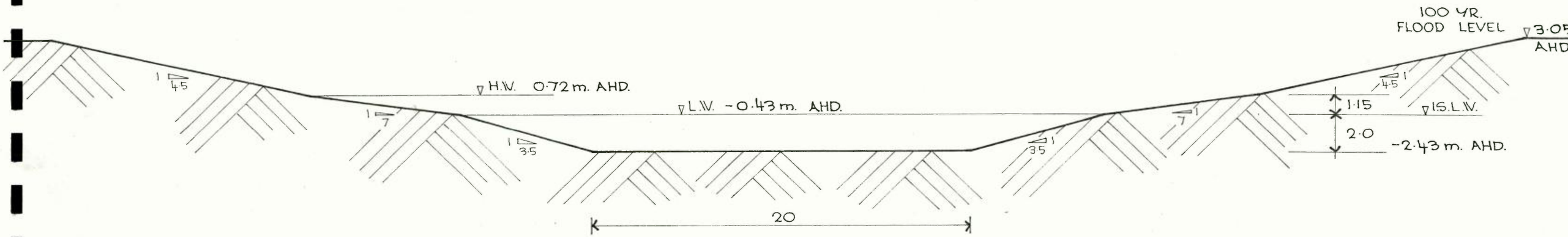
FEATURES OF THE EXISTING ENVIRONMENT



PROPOSED DEVELOPMENT & EXISTING ZONINGS



PROPOSED ZONINGS



TYPICAL CANAL CROSS-SECTION

REDUCTION RATIO 1 : 200

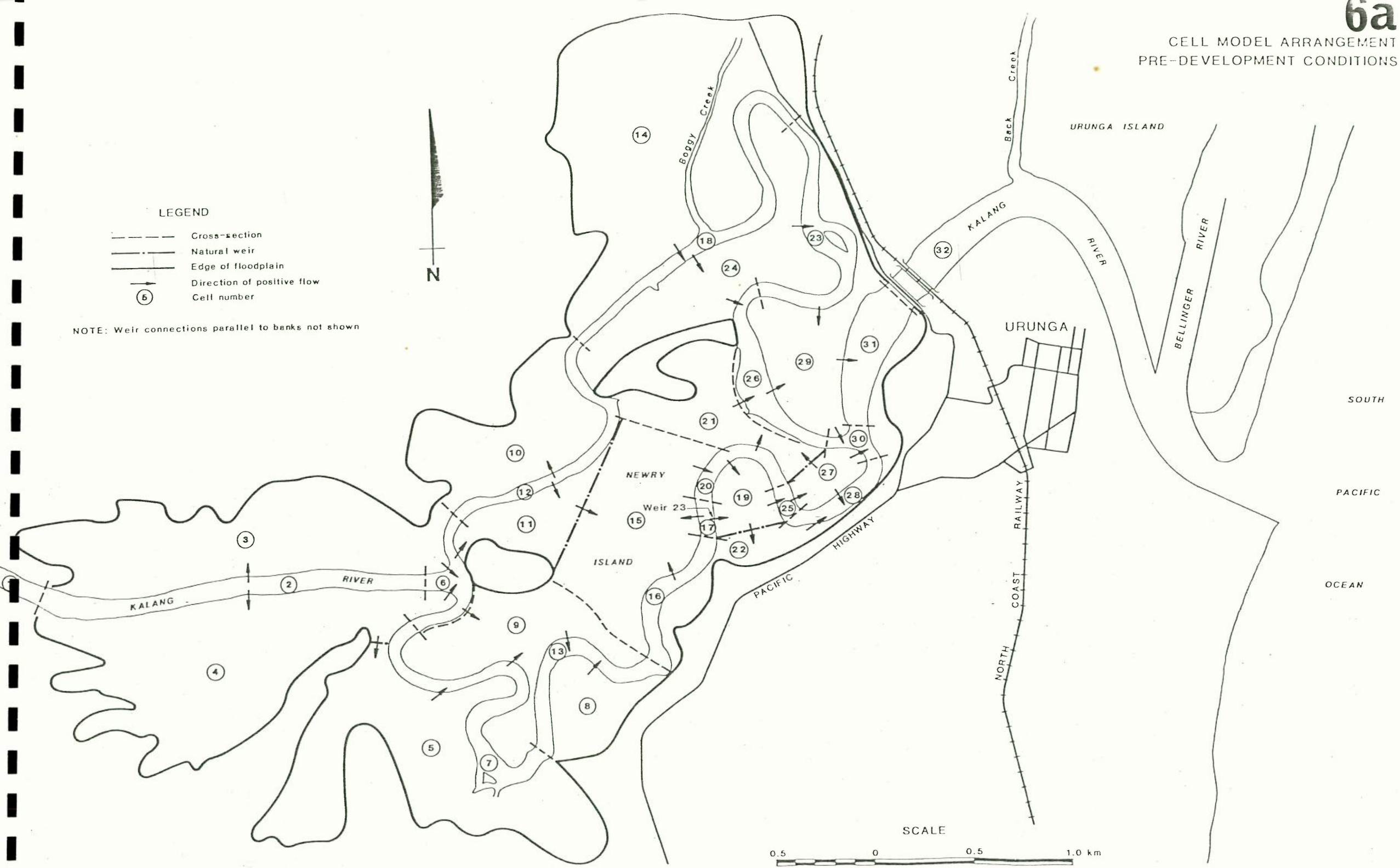
6a

CELL MODEL ARRANGEMENT
PRE-DEVELOPMENT CONDITIONS

LEGEND

- Cross-section
- Natural weir
- Edge of floodplain
- Direction of positive flow
- (5) Cell number

NOTE: Weir connections parallel to banks not shown



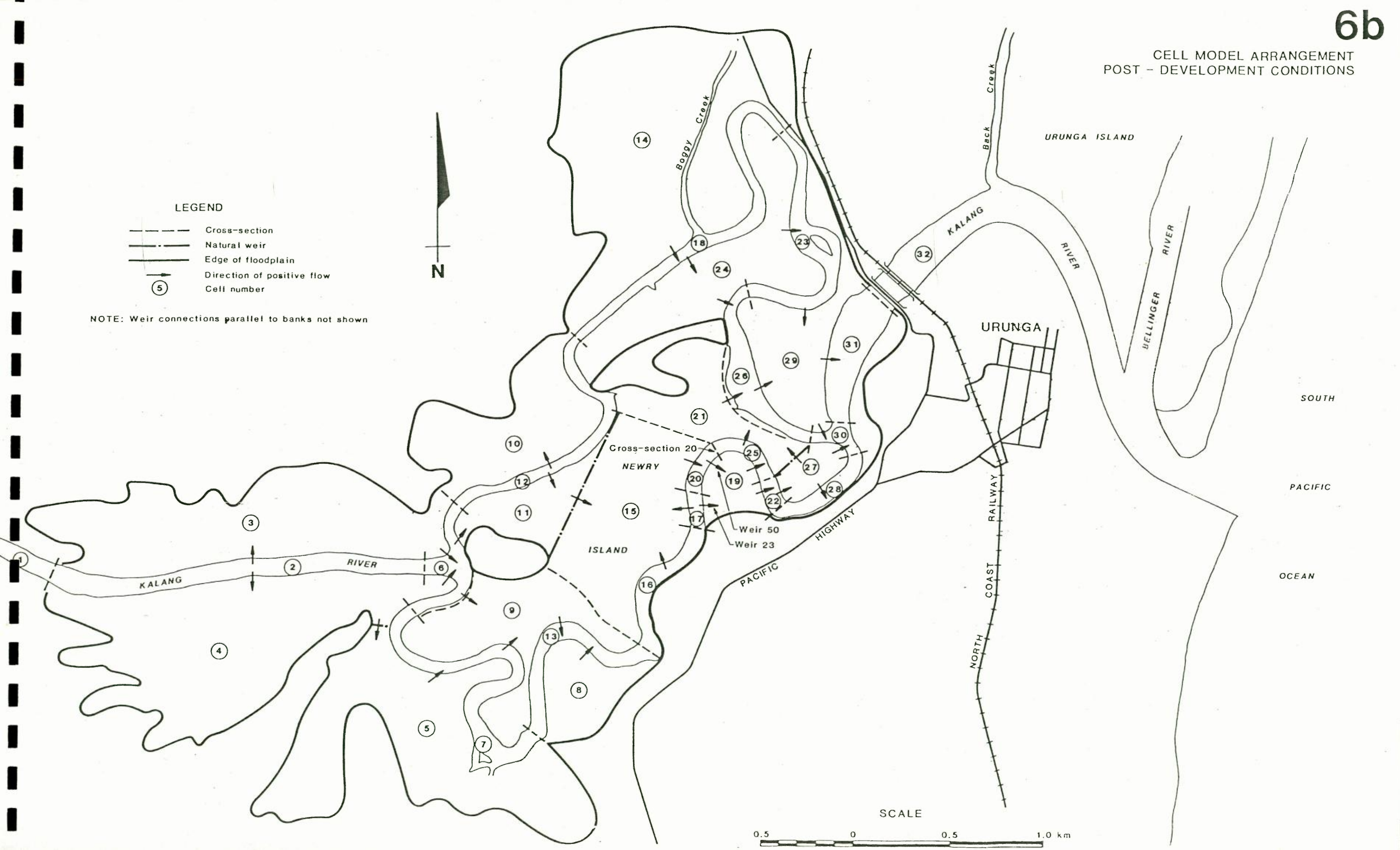
6b

CELL MODEL ARRANGEMENT
POST - DEVELOPMENT CONDITIONS

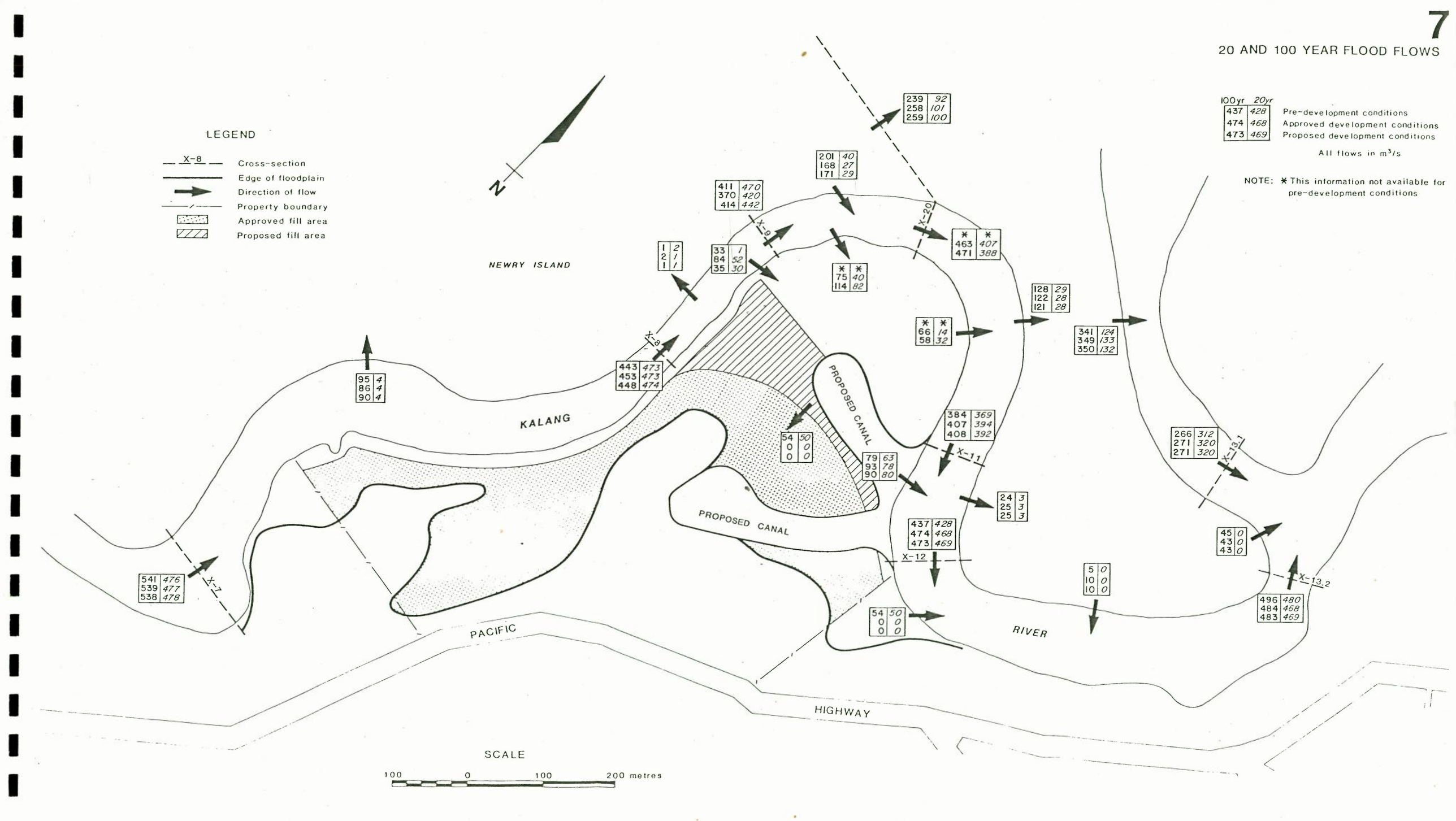
LEGEND

- Cross-section
- Natural weir
- Edge of floodplain
- Direction of positive flow
- (5) Cell number

NOTE: Weir connections parallel to banks not shown



20 AND 100 YEAR FLOOD FLOWS



20 AND 100 YEAR FLOOD HEIGHTS

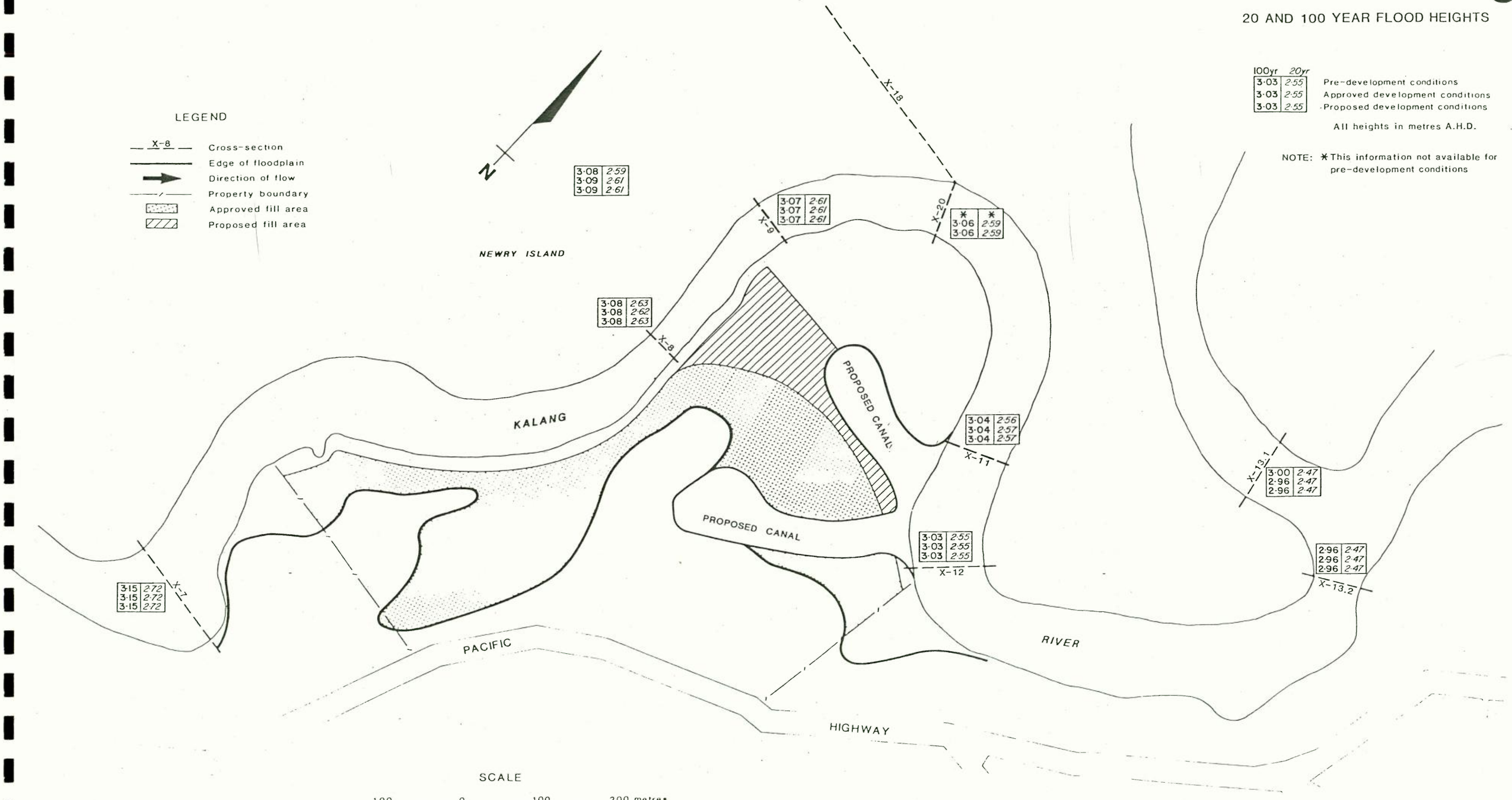
100yr	20yr	
3·03	2·55	Pre-development conditions
3·03	2·55	Approved development conditions
3·03	2·55	Proposed development conditions

All heights in metres A.H.D.

NOTE: * This information not available for pre-development conditions

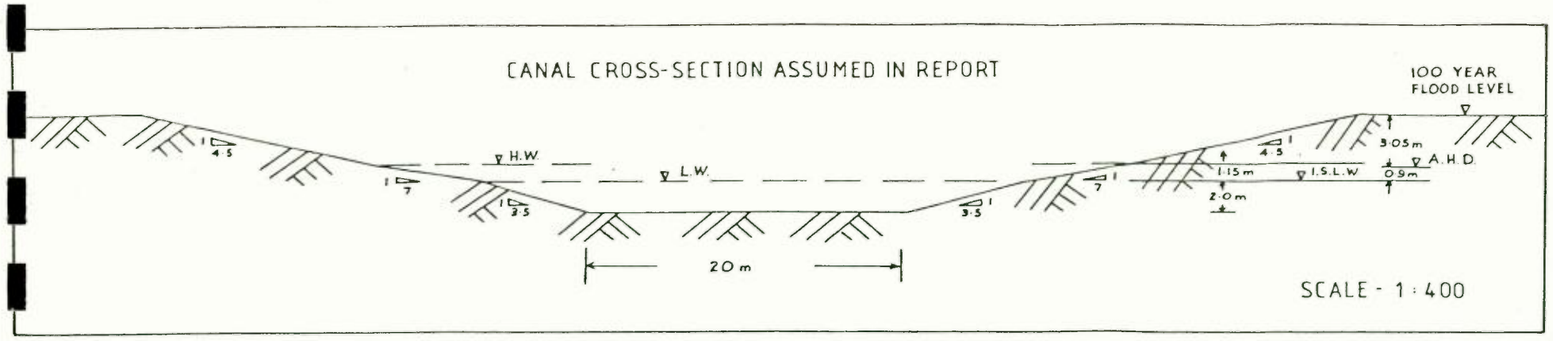
LEGEND

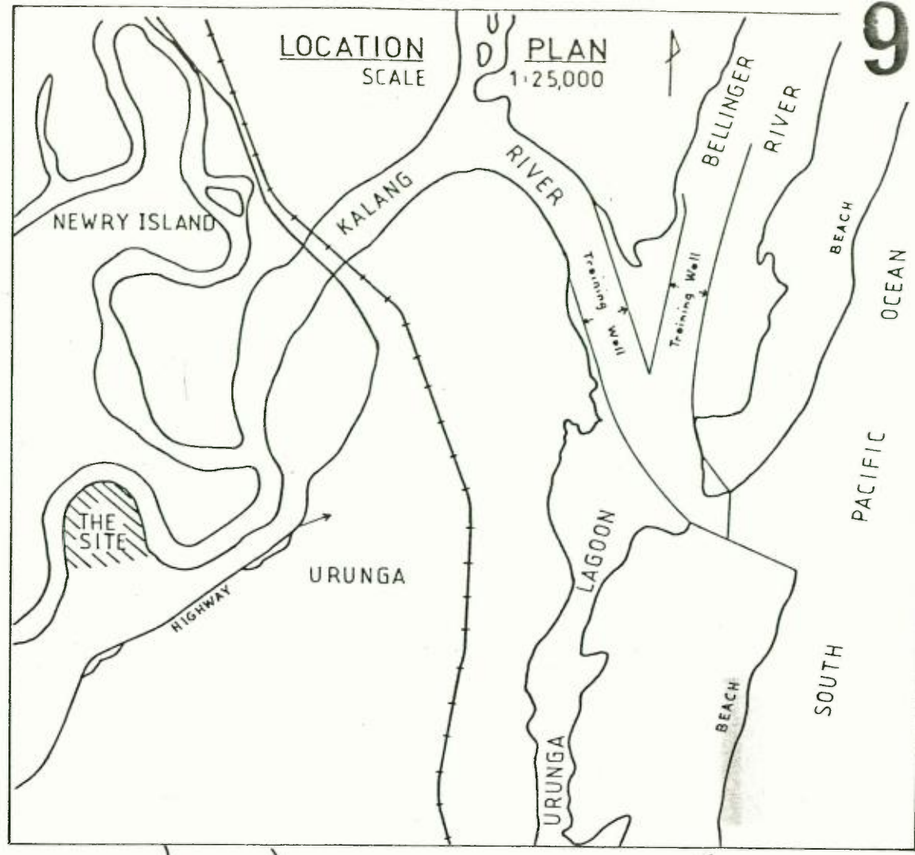
- X-8 — Cross-section
- Edge of floodplain
- Direction of flow
- Property boundary
- Approved fill area
- Proposed fill area

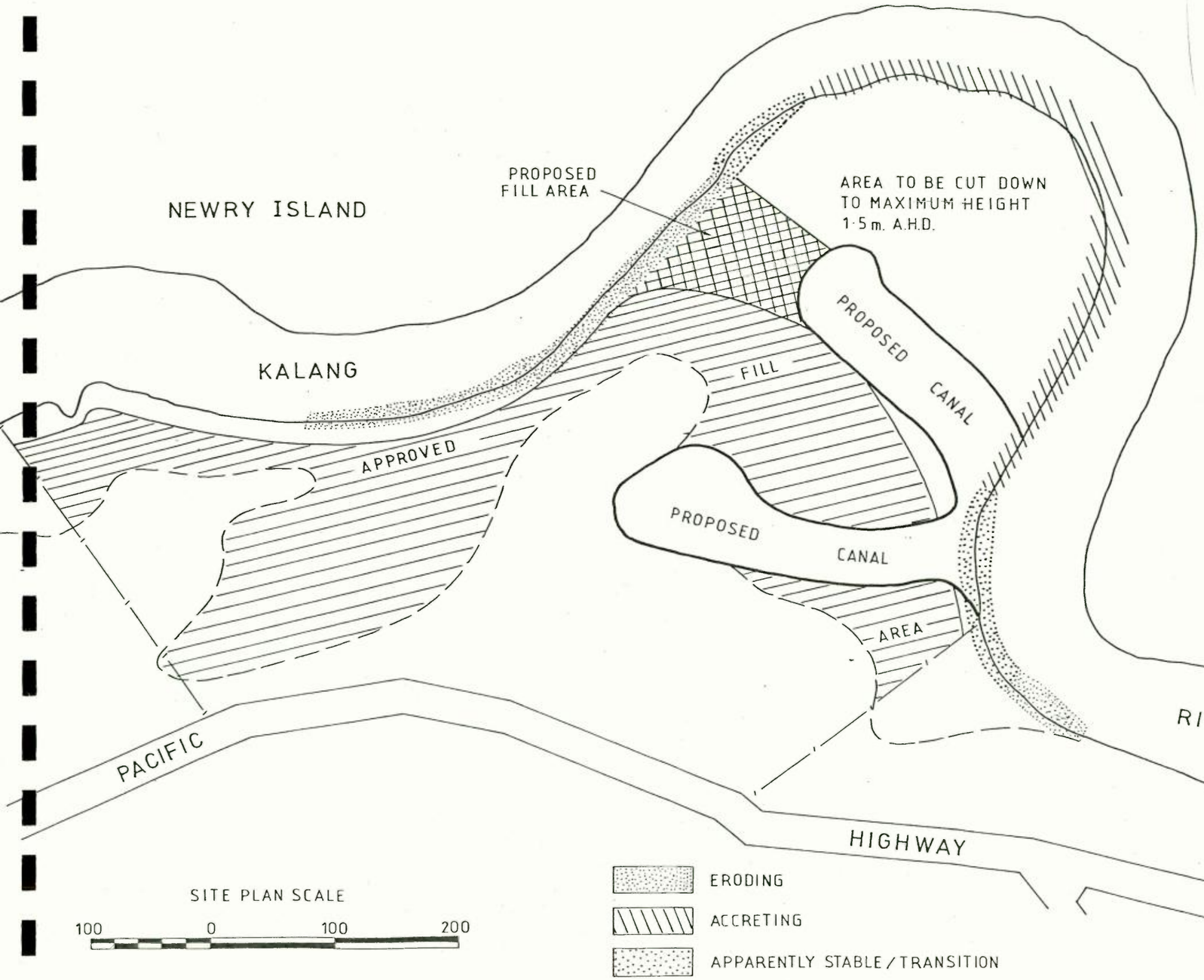


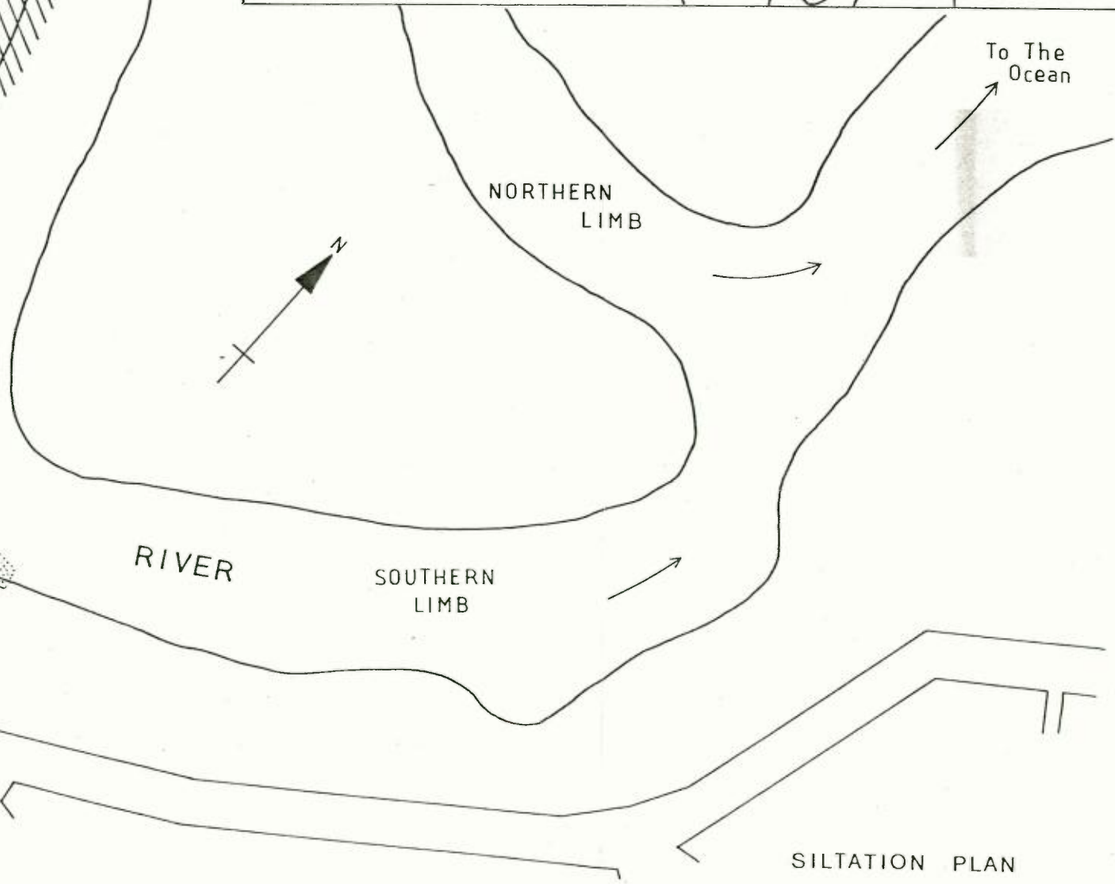
SCALE

100 0 100 200 metres

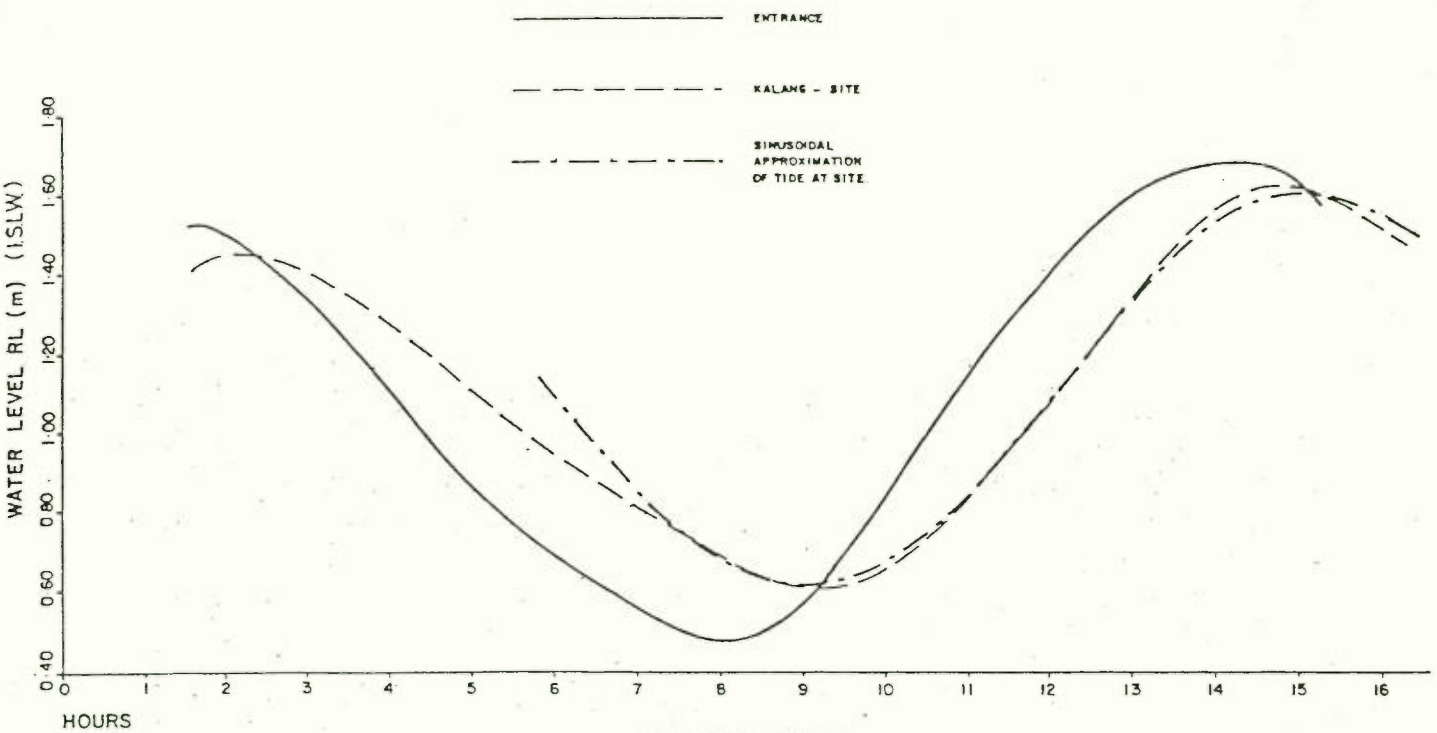

CANAL CROSS-SECTION ASSUMED IN REPORT
100 YEAR FLOOD LEVEL
H.W.
L.W.
I.S.L.W
A.H.D.
3·05m
1·15m
0·9m
2·0m
20m
SCALE - 1:400


LOCATION PLAN
SCALE 1:25,000
NEWRY ISLAND
KALANG RIVER
BELLINGER RIVER
Training Wall
Training Wall
BEACH
OCEAN
PACIFIC
THE SITE
URUNGA
HIGHWAY
LAGOON
URUNGA
BEACH
SOUTH


NEWRY ISLAND
PROPOSED FILL AREA
AREA TO BE CUT DOWN TO MAXIMUM HEIGHT 1·5m. A.H.D.
KALANG
APPROVED
FILL
PROPOSED CANAL
PROPOSED CANAL
AREA
PACIFIC
HIGHWAY
SITE PLAN SCALE
100 0 100 200
ERODING
ACCRETING
APPARENTLY STABLE / TRANSITION


To The Ocean
NORTHERN LIMB
N
RIVER
SOUTHERN LIMB
SILTATION PLAN

TIDAL CURVES

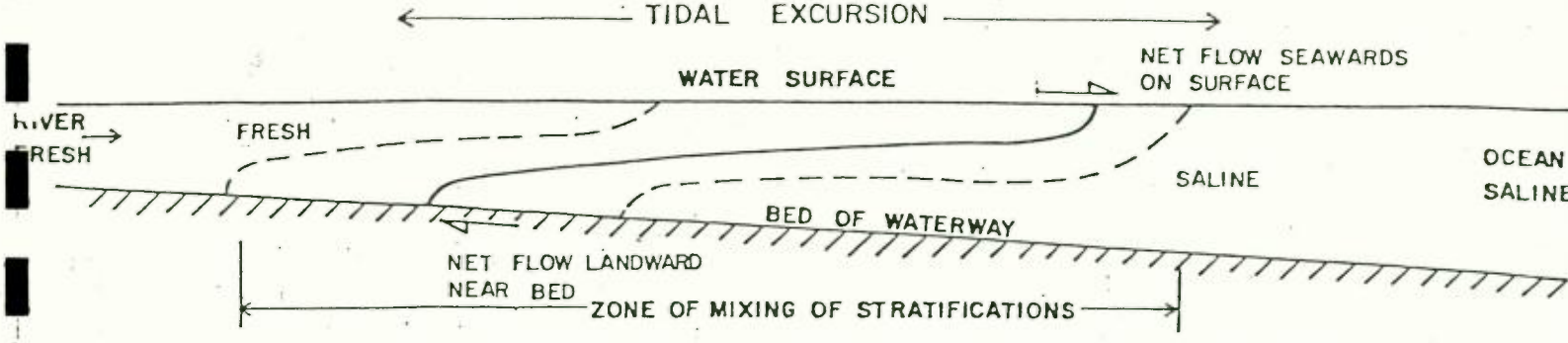


KALANG RIVER
COMPARISON OF WATER LEVELS

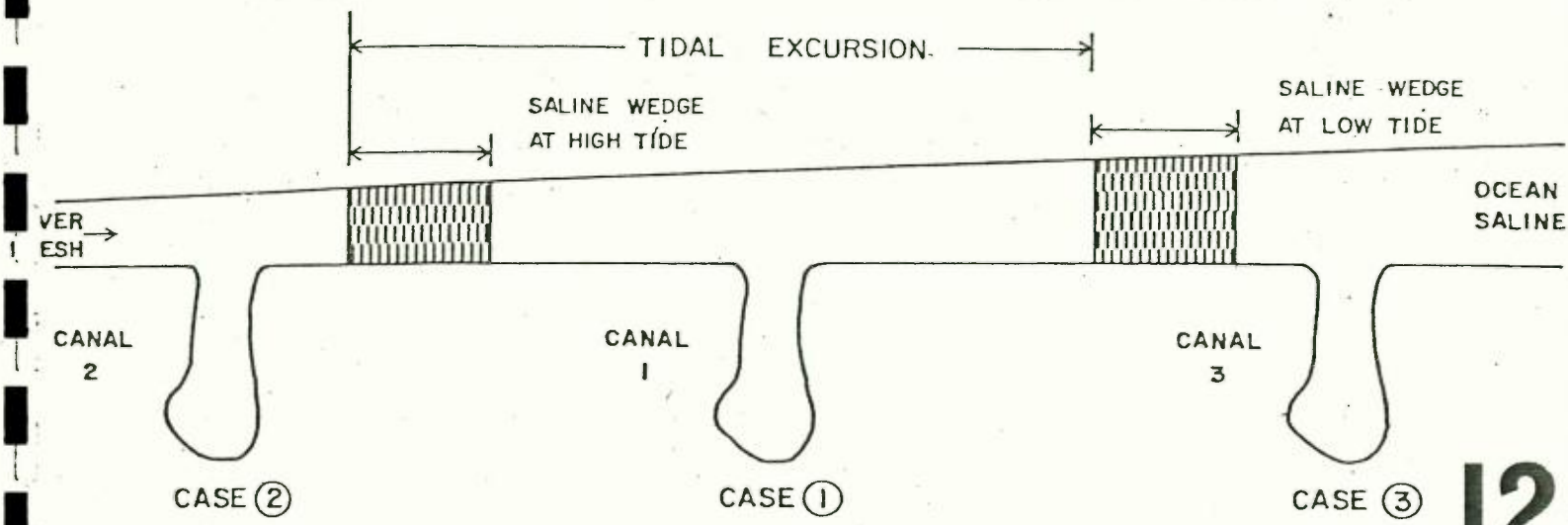
11

SALINE WEDGE — (OR ZONE OF MIXING IN AN ESTUARY)
(A DIAGRAMATIC LONG SECTION)

N.T.S.



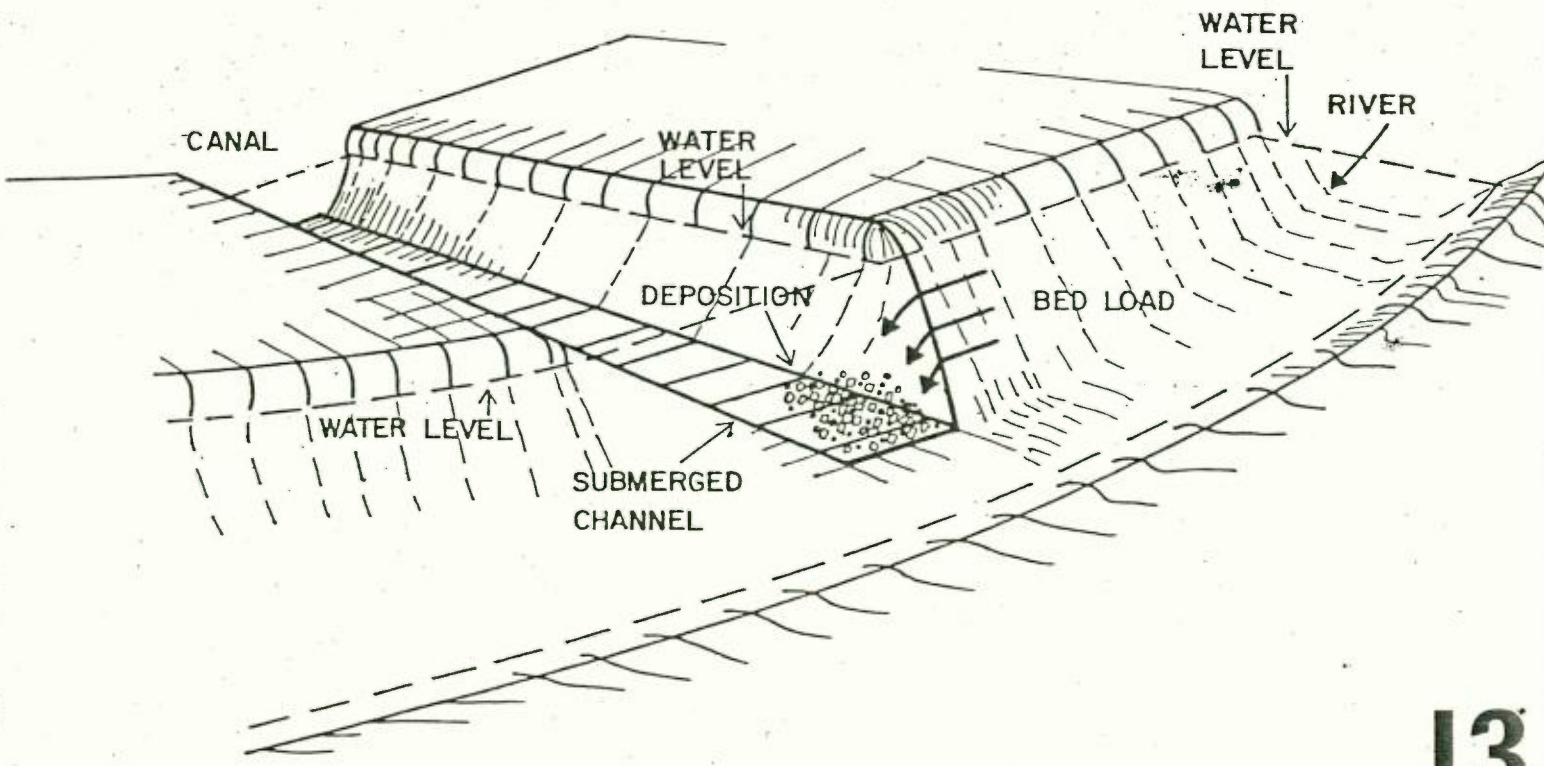
DIAGRAMATIC PLAN SHOWING EFFECTS OF SALINE WEDGE ON CANAL



12

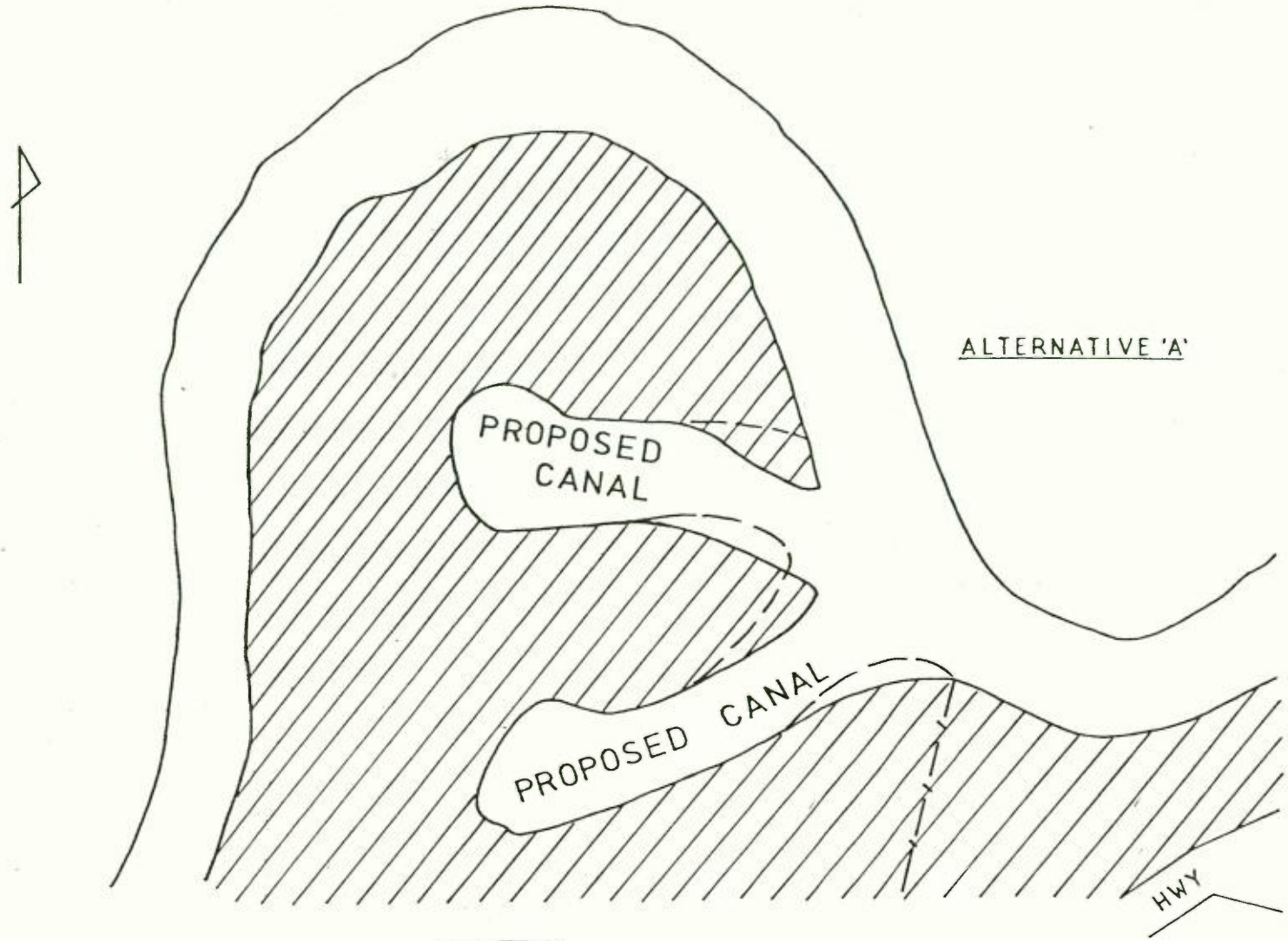
N.T.S.

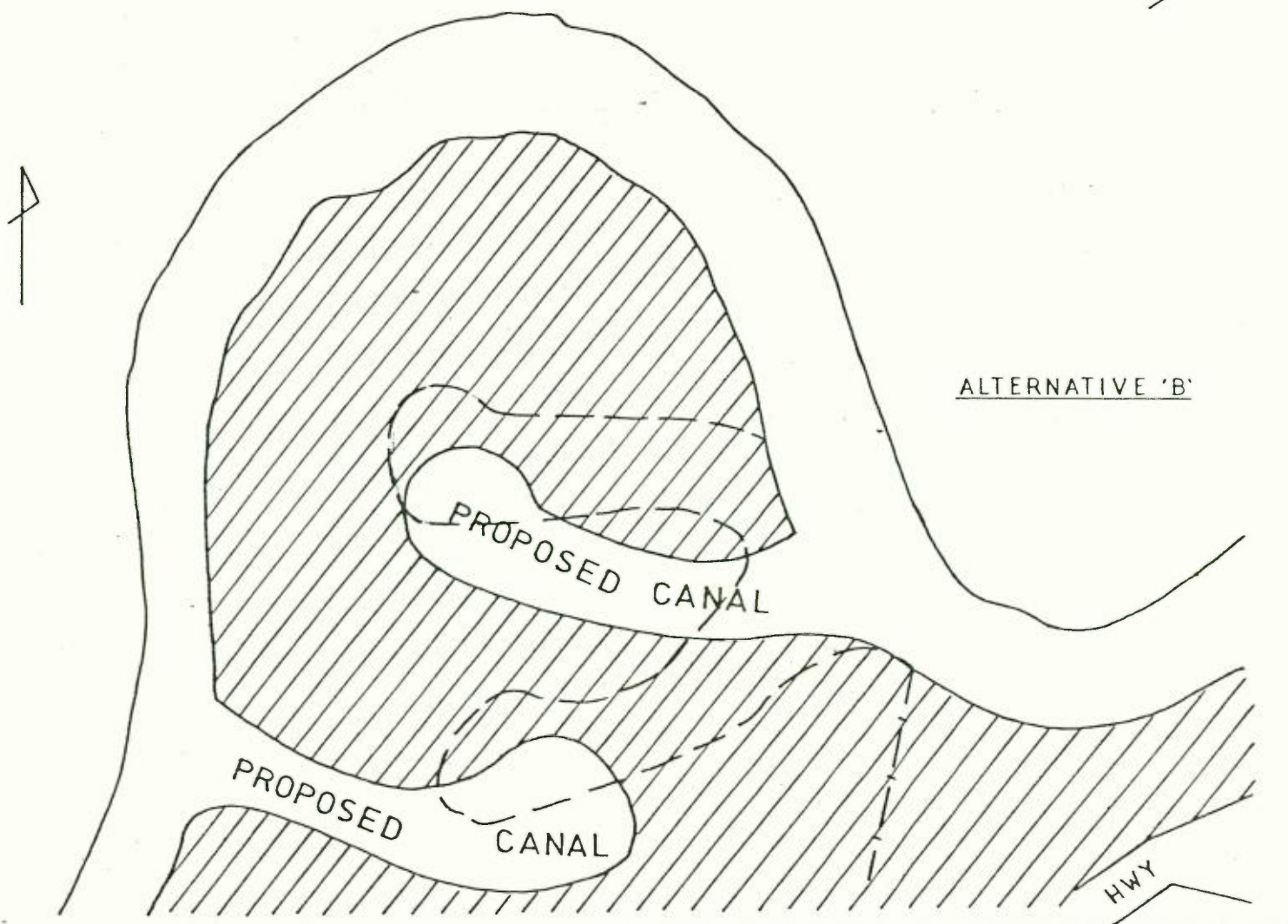
SKETCH OF SUBMERGED CHANNEL
SHOWING EFFECTS OF BED LOAD

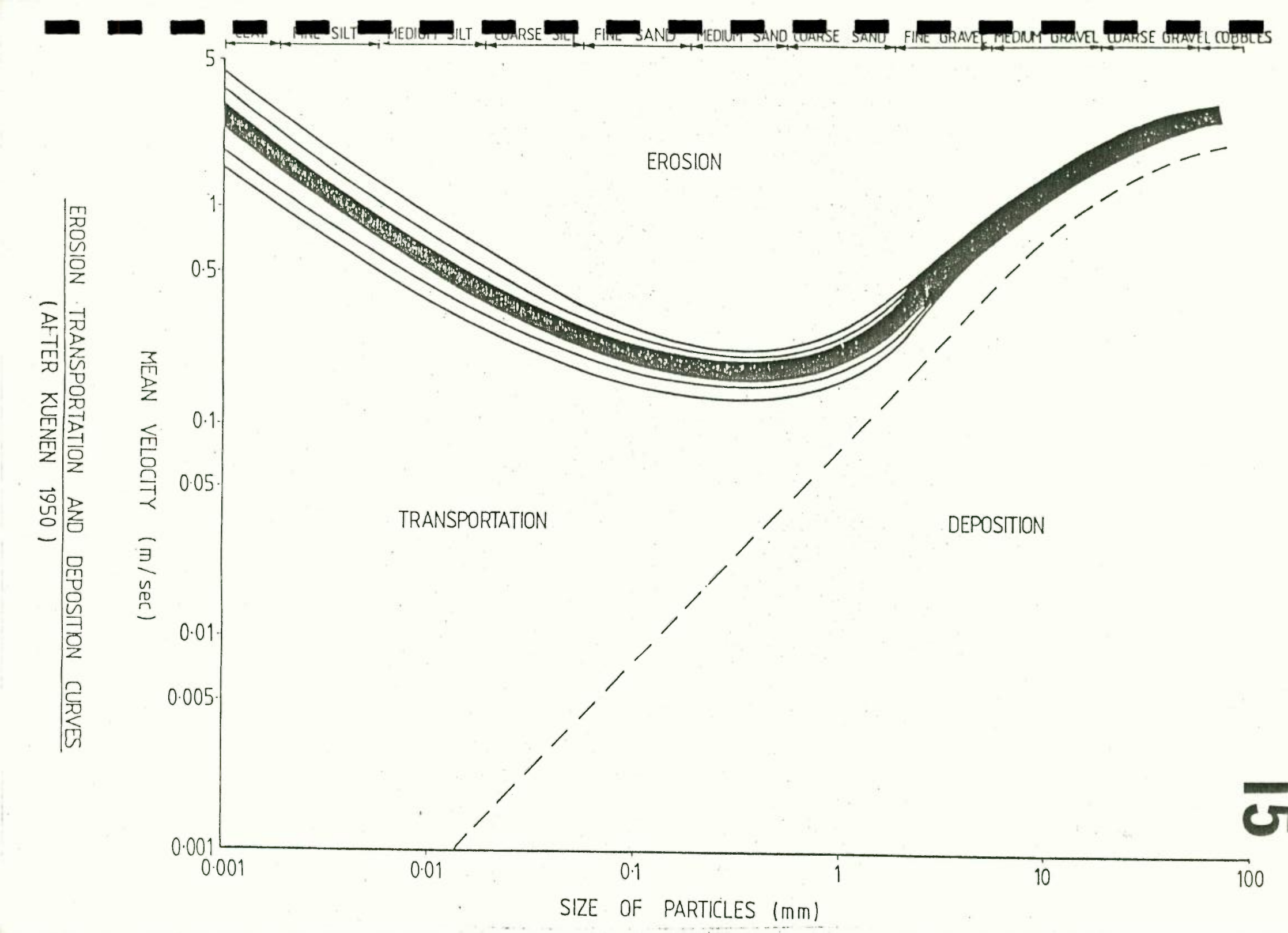


13

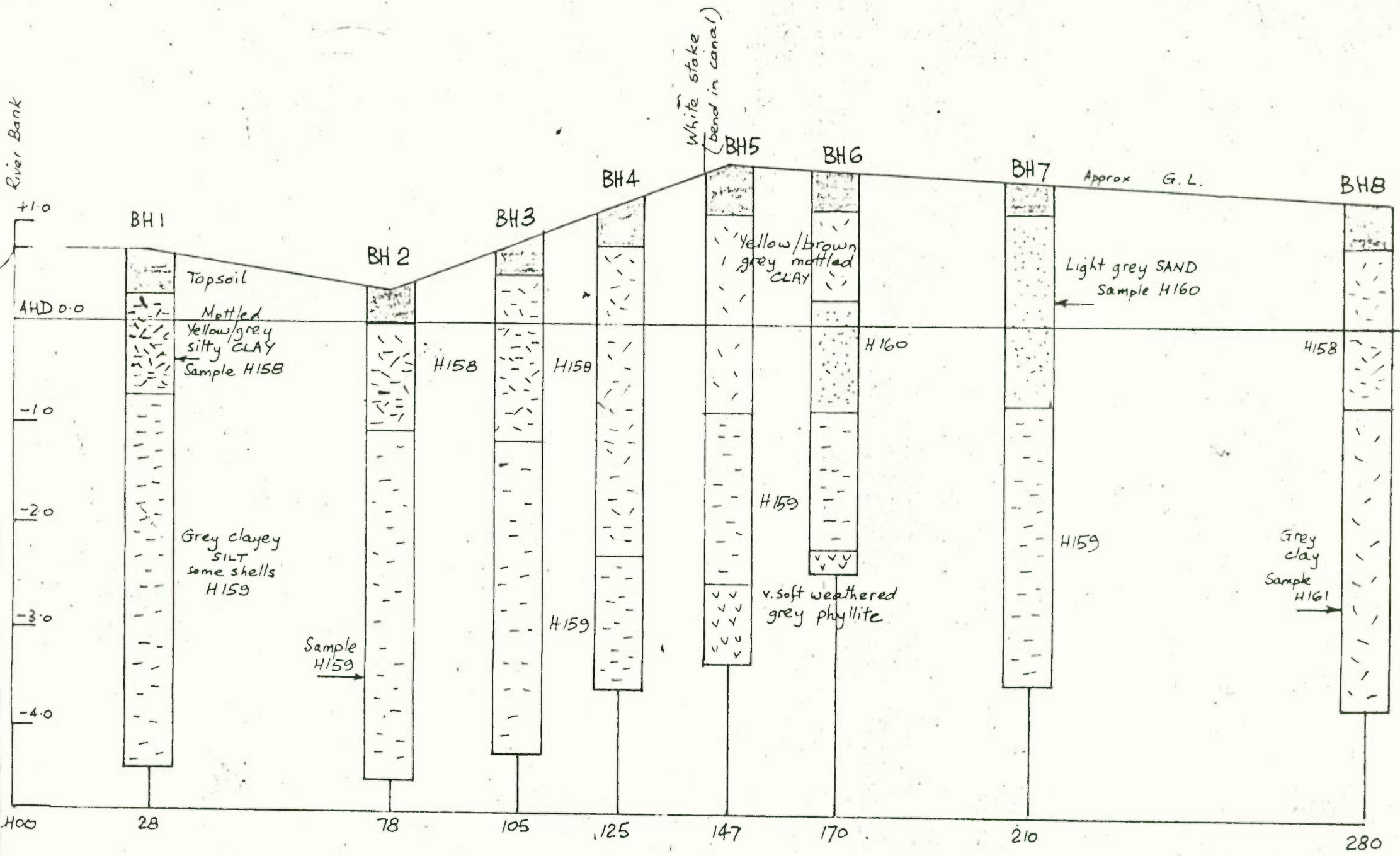
ALTERNATIVE CANAL ENTRANCE LOCATIONS TO AVOID AREAS OF DEPOSITION







EROSION TRANSPORTATION AND DEPOSITION CURVES
(AFTER KUENEN 1950)



Holmes & Holmes
Coffs Harbour

Scales: H 1:1000
V 1:50

BORE LOGS from EXCAVATOR TRIAL PITS

Bellinger Keys Canal Investigation

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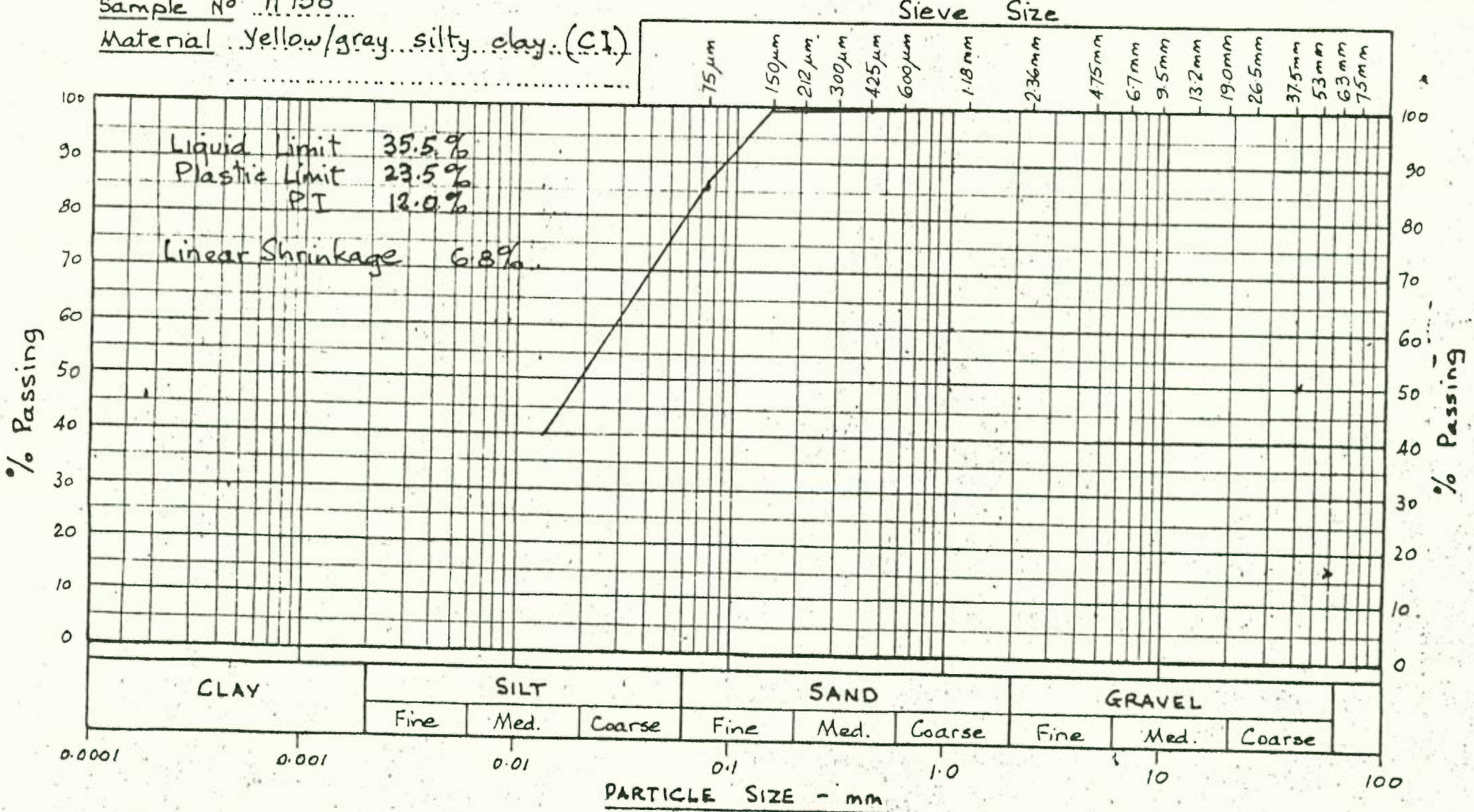
MECHANICAL ANALYSIS

CLIENT N.C.L North Coast Land
PROJECT Bellinger Keys Canal – Urunga

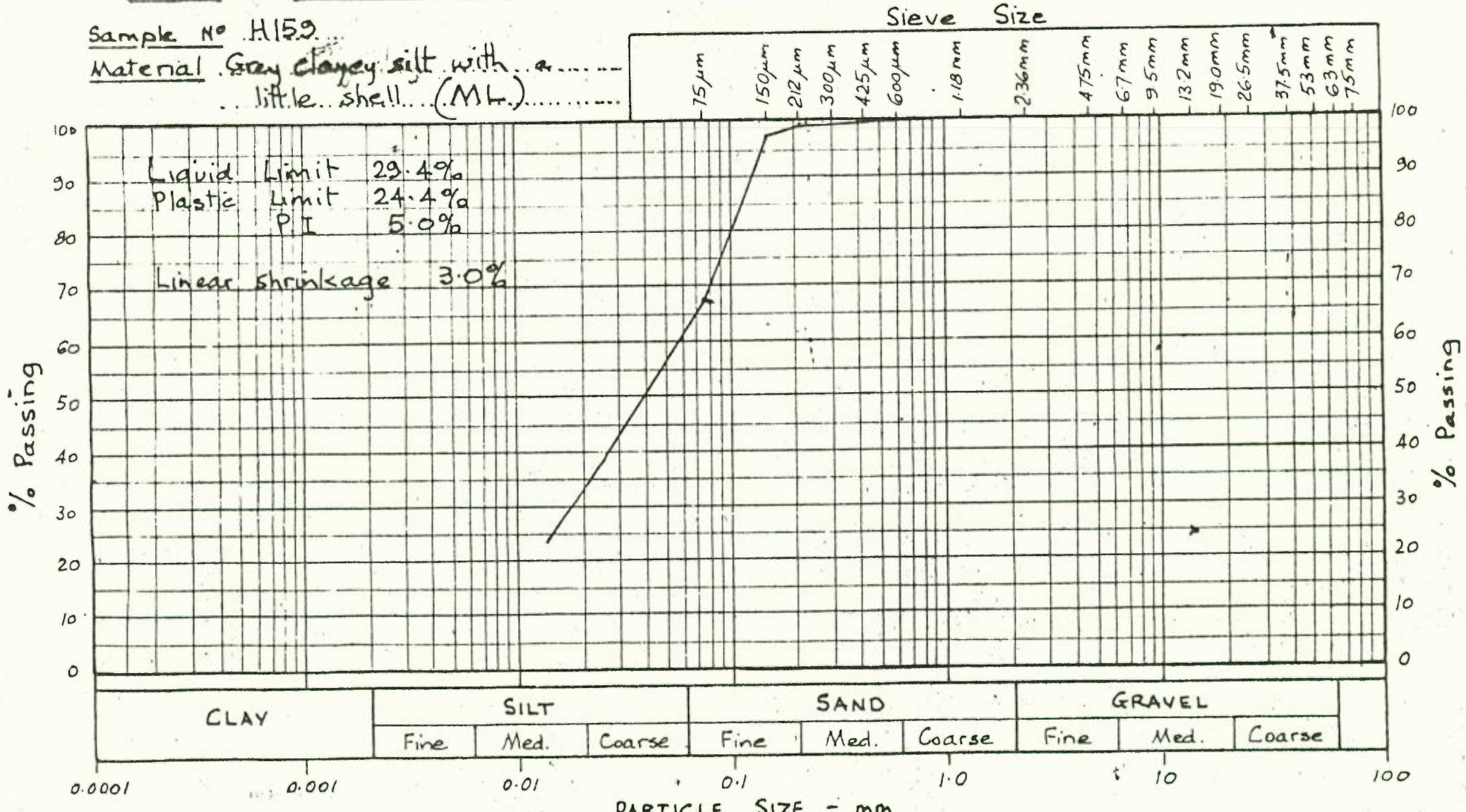
Sample No H 158
Material Yellow/gray silty clay (CI)



MECHANICAL ANALYSIS

CLIENT N.C.L North Coast Land
PROJECT Bellinger Keys Canal – Urunga.

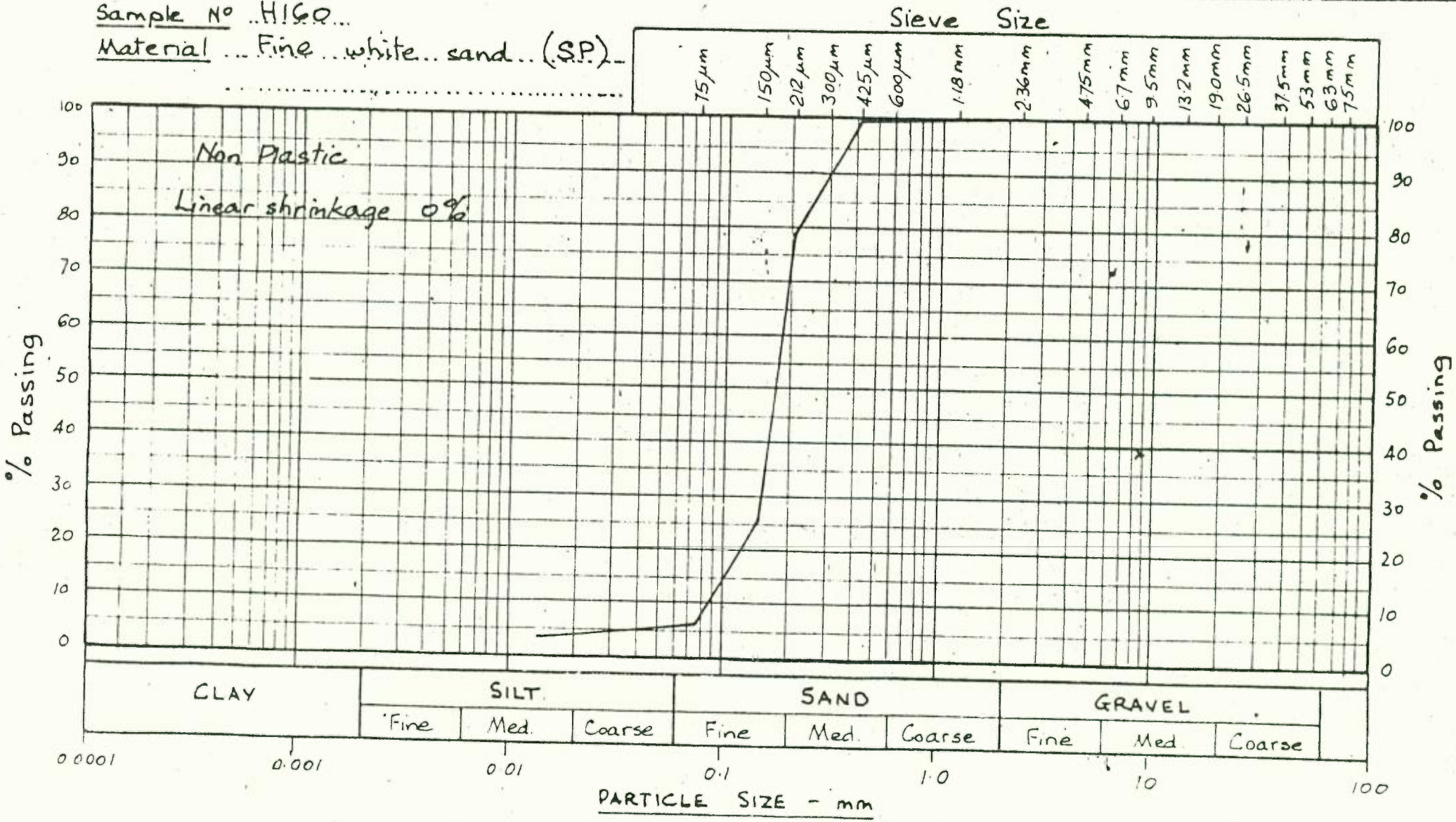
Sample No H159
Material Grey clayey silt with a little shell (ML)



MECHANICAL ANALYSIS

CLIENT N.C.L North Coast Land
PROJECT Bellinger Keys Canal - Urunga

Sample No H160
Material Fine white sand (S.P.)



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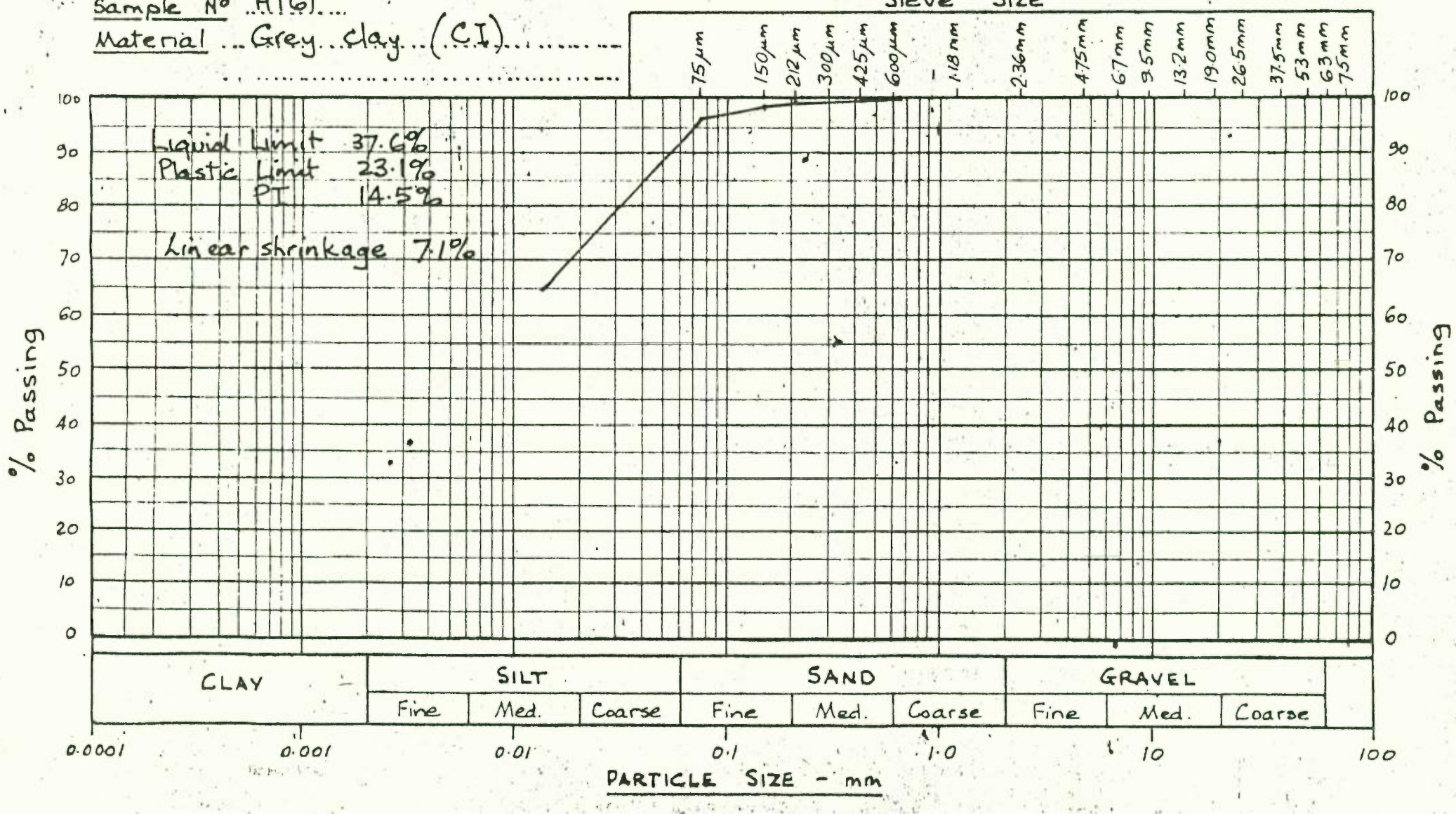
MECHANICAL ANALYSIS

CLIENT N.C.L. North Coast Land
PROJECT Bellinger Keys Canal - Urunga.

Sample No H161
Material Grey clay (CI)



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LOCATION OF BENTHIC SAMPLING STATIONS AND
VEGETATION TRANSECTS IN THE BELLINGER ESTUARY

KEY — BENTHIC SAMPLING STATIONS 1-18
VEGETATION TRANSECTS ①-⑧
DEVELOPMENT AREA

KALANG RIVER
NEWRY ISLAND
PACIFIC HIGHWAY
URUNGA
RAILWAY
NORTH COAST
Urunga Lagoon
KALANG RIVER
Back Creek
URUNGA ISLAND
BELLINGER RIVER
TUCKERS IS.
MYLESTOM
PACIFIC HIGHWAY
BELLINGER RIVER
NORTH COAST RAILWAY
SOUTH PACIFIC OCEAN
SCALE 1:25000

VEGETATION OF THE BELLINGER ESTUARY

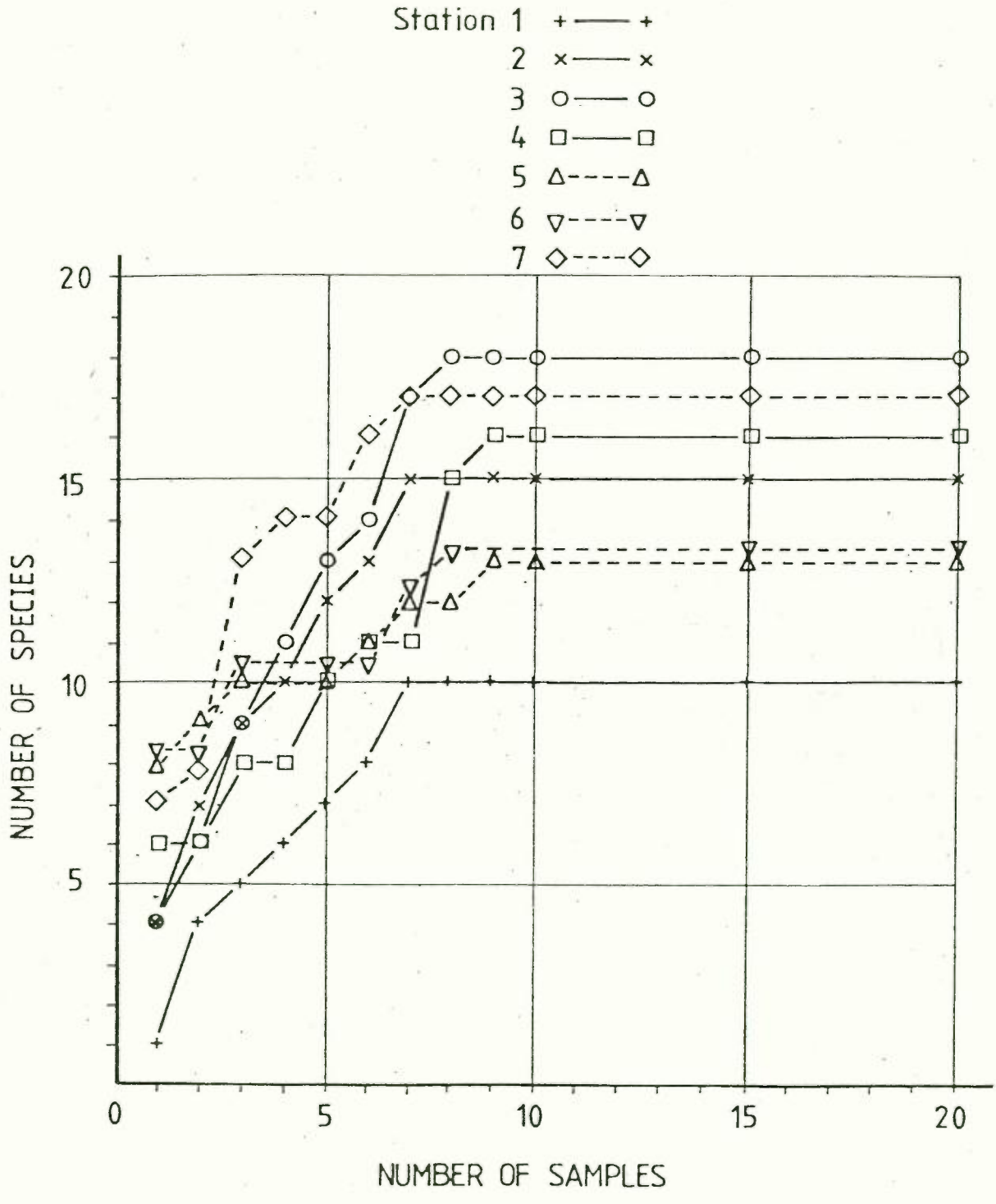
KEY - MANGROVE STANDS
DUNE RAINFOREST
CASUARINES
SCLEROPHYLL
HEATH
SWAIL

SAND EXTRACTION

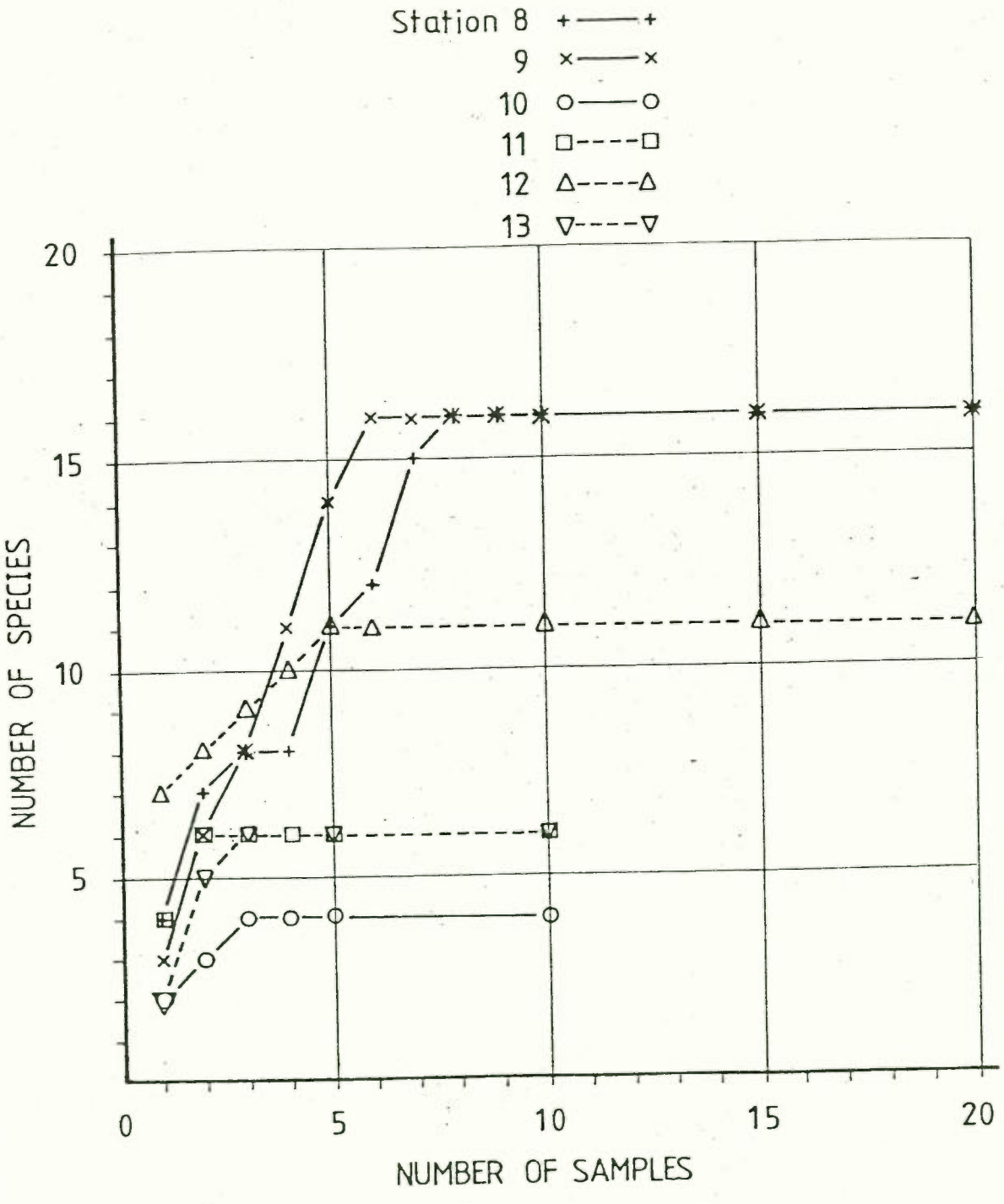
KALANG RIVER
NEWRY ISLAND
PACIFIC HIGHWAY
URUNGA
NORTH COAST RAILWAY
Urunga Lagoon
KALANG RIVER
PACIFIC HIGHWAY
BELLINGER RIVER
Back Creek
URUNGA ISLAND
TUCKERS Is.
BELLINGER RIVER
MYLESTOM
SOUTH PACIFIC OCEAN

SCALE 1:25000

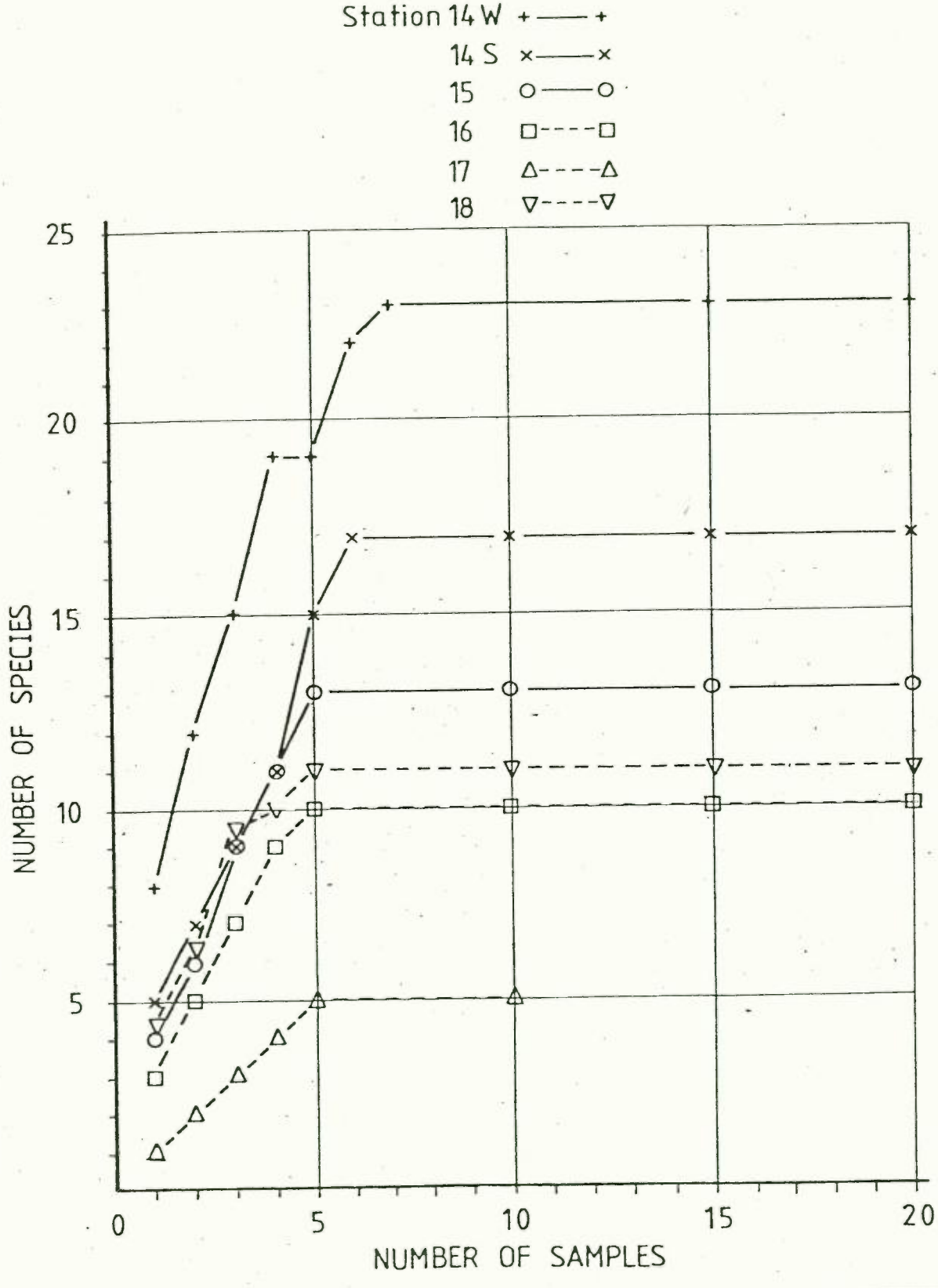
SPECIES/AREA CURVES FOR THE SAMPLING STATIONS IN URUNGA LAGOON (Stations 1 – 7)



SPECIES/AREA CURVES FOR SAMPLING STATIONS 8 – 13 IN THE BELLINGER ESTUARY

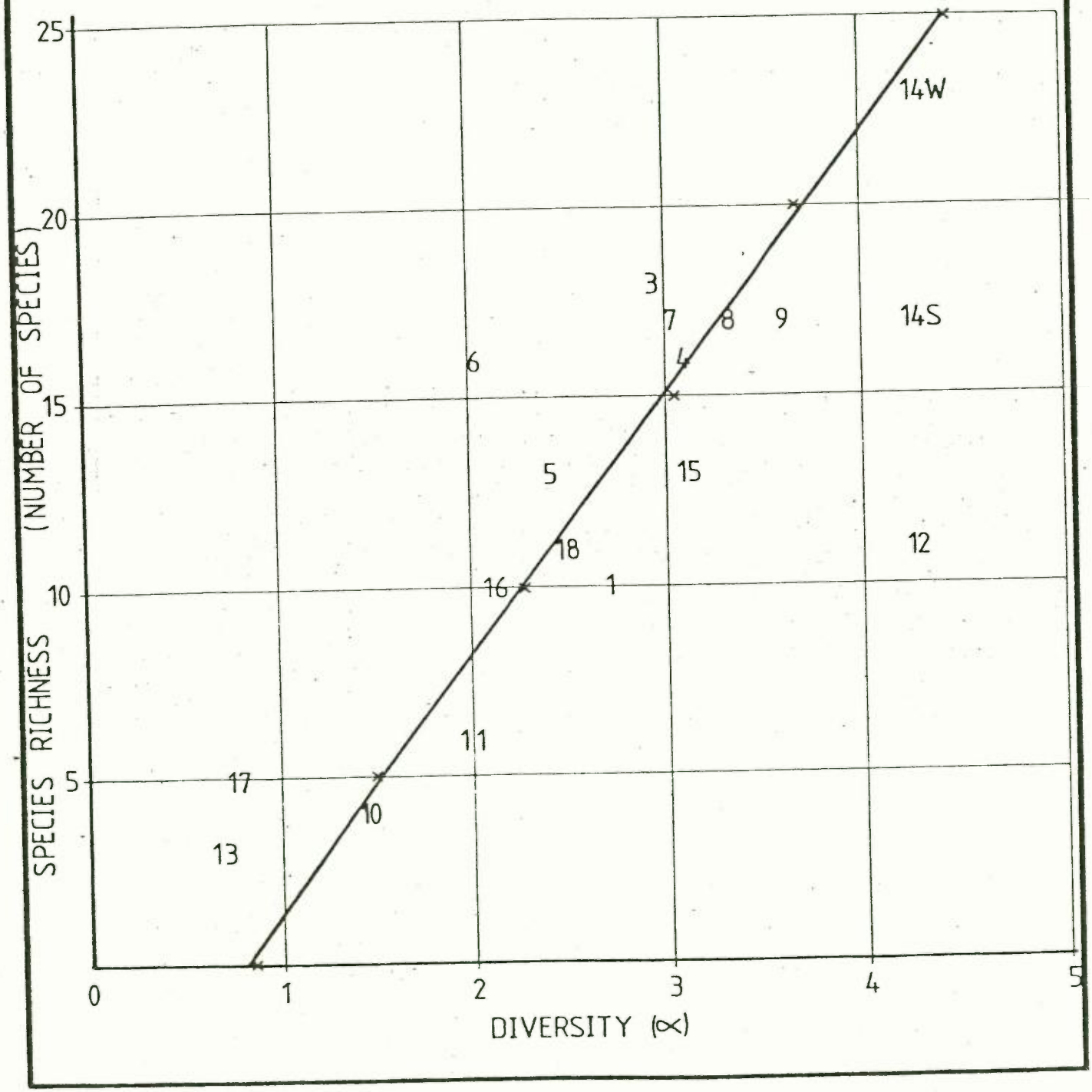


SPECIES/AREA CURVES FOR SAMPLING STATIONS 14-18 IN THE BELLINGER ESTUARY.



REGRESSION OF SPECIES RICHNESS AGAINST INDEX OF DIVERSITY (∝) FOR THE 18 BENTHIC SAMPLING STATIONS IN THE BELLINGER ESTUARY.

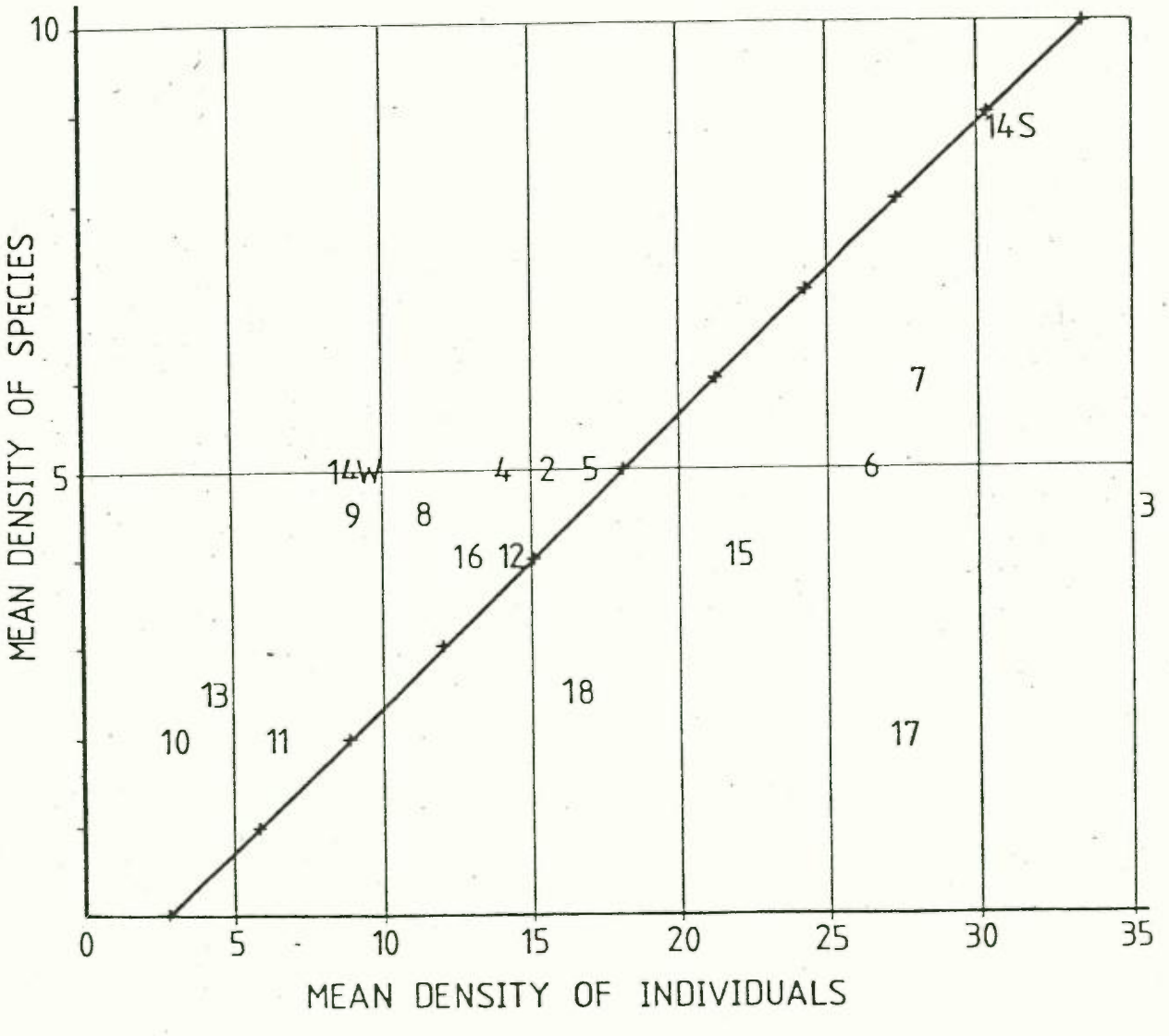
REGRESSION $Y = 0 \cdot 837 + 0 \cdot 144 X$
$(P < 0 \cdot 01)$



REGRESSION OF MEAN DENSITY OF SPECIES AGAINST MEAN DENSITY OF INDIVIDUALS FOR THE 18 BENTHIC SAMPLING STATIONS IN THE BELLINGER ESTUARY.

REGRESSION $Y = 3{\cdot}005 + 3{\cdot}402\,X$

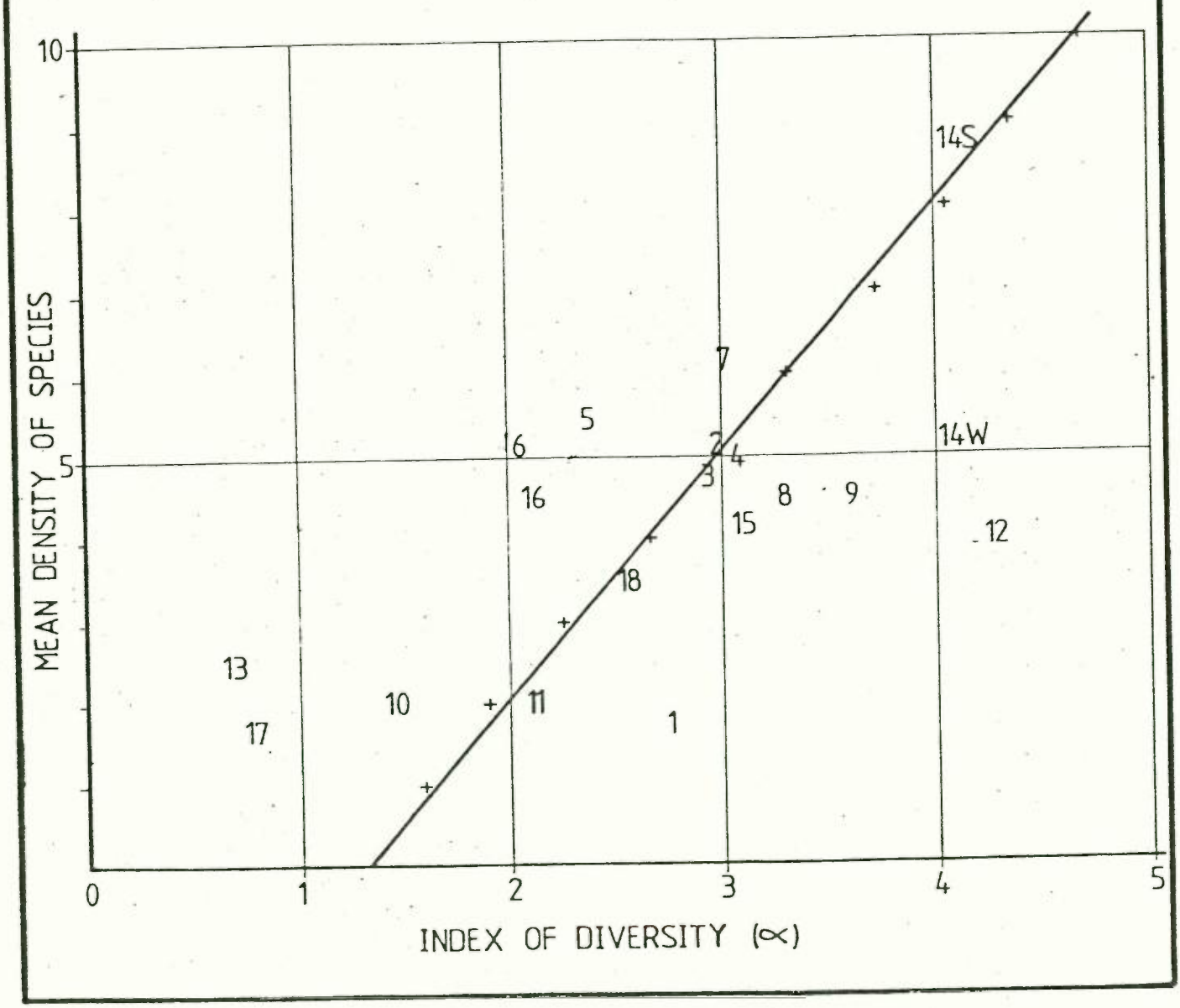
$(0{\cdot}001 > P < 0{\cdot}05)$



REGRESSION OF MEAN DENSITY OF SPECIES AGAINST INDEX OF DIVERSITY (∝) FOR THE 18 BENTHIC SAMPLING STATIONS IN THE BELLINGER ESTUARY.

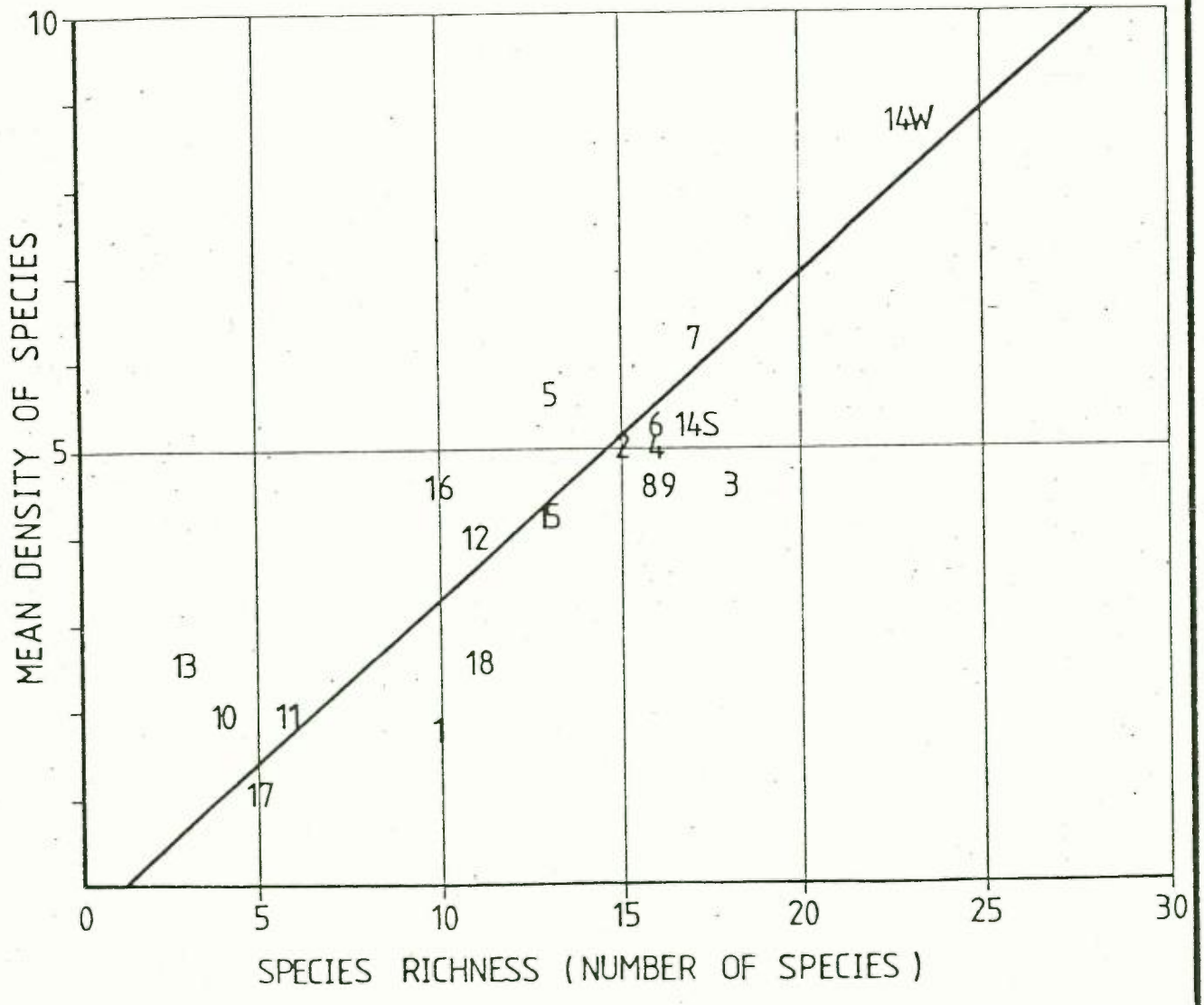
REGRESSION $Y = 1{\cdot}252 + 0{\cdot}346\,X$

$(P < 0{\cdot}001)$



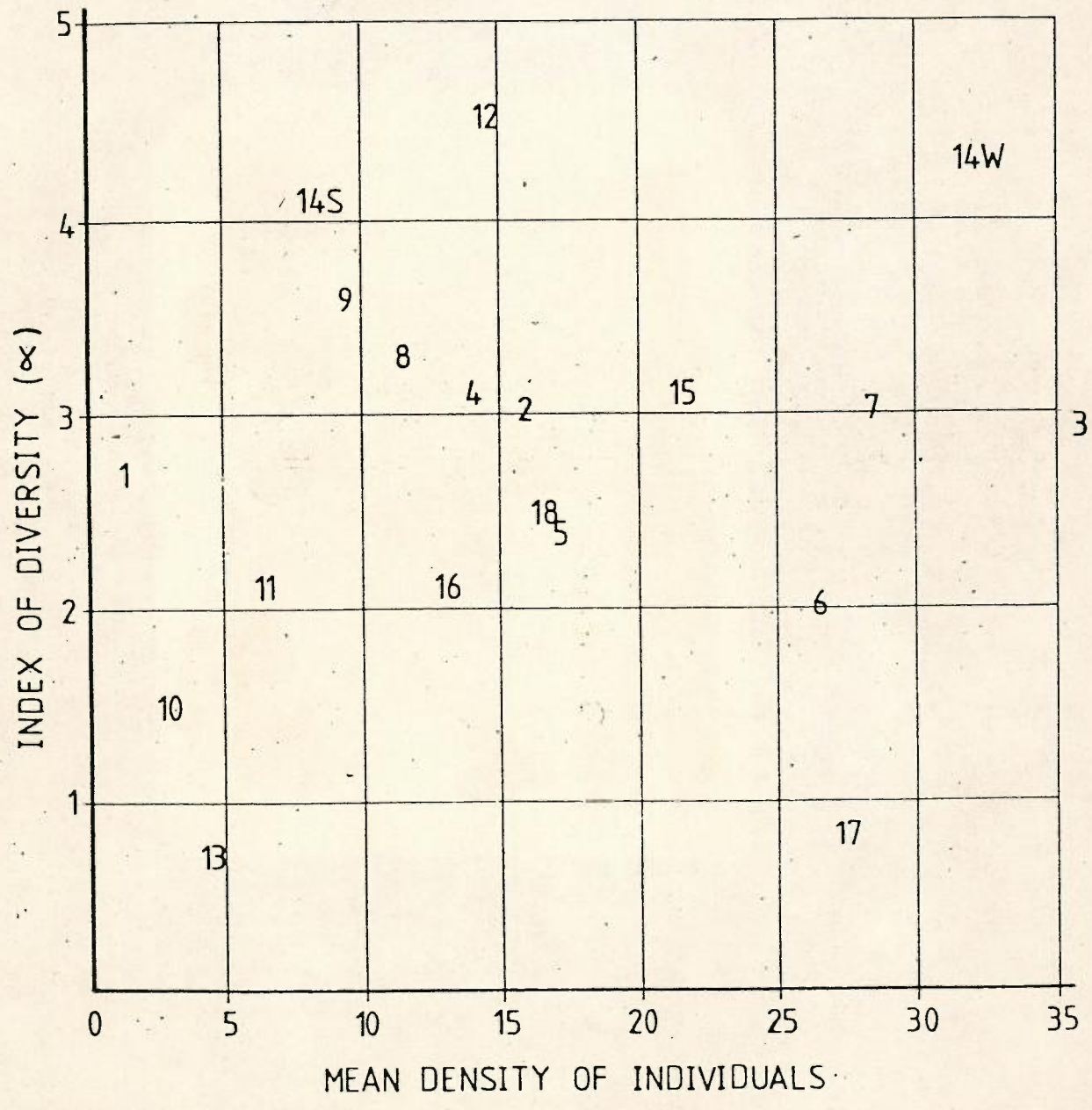
REGRESSION OF SPECIES RICHNESS AGAINST MEAN DENSITY OF SPECIES FOR THE 18 BENTHIC SAMPLING STATIONS IN THE BELLINGER ESTUARY.

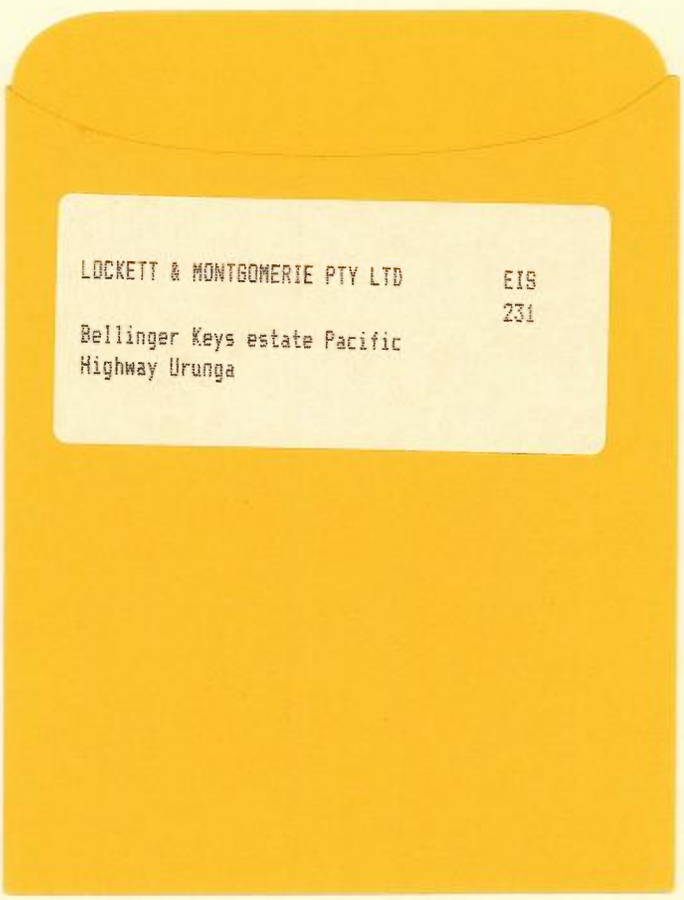
REGRESSION $Y = 0{\cdot}986 + 2{\cdot}715\,X$



PLOT OF MEAN DENSITY OF INDIVIDUALS AGAINST INDEX OF DIVERSITY (α) FOR THE 18 BENTHIC SAMPLING STATIONS IN THE BELLINGER ESTUARY.

($\tau = 0{\cdot}216 : P > 0{\cdot}2$)




LOCKETT & MONTGOMERIE PTY LTD
EIS
231
Bellinger Keys estate Pacific
Highway Urunga

LOCKETT & MONTGOMERIE PTY LTD

EIS
231

Bellinger Keys estate Pacific Highway Urunga

Borrower's name	Date	Ex /

RAECO