THE UNIVERSITY OF NEW SOUTH WALES
water research laboratory
Manly Vale N.S.W. Australia

A REVIEW OF PORT HACKING MARINE DELTA MANAGEMENT OPTIONS

by
R.J. Cox, D.N. Foster and R.J.MacIntyre

Technical Report No. 87/06
June 1987

THE UNIVERSITY OF NEW SOUTH WALES

WATER RESEARCH LABORATORY

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D.N. Foster, R.J. MacIntrye and R.J. Cox

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PREFACE

The work reported herein was carried out and is published under the direction of the Director of the Water Research Laboratory, acting on behalf of the client, the Public Works Department, NSW.

Information published in technical reports is available for general release only by permission of the client and the Director.

C.R. DUDGEON
Acting Director

CONTENTS

1. INTRODUCTION

The Public Works Department of NSW (PWD) began in 1980 studies related to the historically ongoing shoaling of Port Hacking. The prime objective of the work was to define the processes contributing to the shoaling problem and determine long term solutions for navigational channel maintenance. Sub objectives included environmental enhancement and improvement of the recreational potential of the waterway. Possible development of the shoaling sand as a marketable resource was also foreseen.

The results of six years of (PWD) investigation were published in 1986 as the "Port Hacking Marine Delta Management Options" report. This report summarises all studies undertaken and puts forward various options for solving the shoaling problem. It recognises the responsibility of the public and Sutherland Shire Council in assisting with the assessment of social and environmental issues and the preparation of a Management Plan.

Unisearch Ltd (utilising the services of coastal engineering and marine biology/zoology expertise available from The University of New South Wales — see Curriculum Vitae at Appendix A) was requested by PWD to undertake a review of the options developed by PWD for overcoming shoaling problems in Port Hacking. This review, presented herein, focusses on the studies completed by PWD and others as input to the Management Options Report with particular regard to technical engineering integrity and ecological aspects.

2. REVIEW SCOPE

As recognised in the Management Options Report, social and environmental issues must be considered in association with engineering and economic issues when assessing the options for long term control of the sand shoaling problem. This review however specifically restricts itself to the engineering and marine biological issues.

All mini reports outlined in Data Sheet 11 of the Management Options Report have been examined and reviewed. In addition lengthy discussions have been held with PWD engineers and technical staff responsible for most of the data collection and interpretation, mathematical modelling of water flow (1-Dimensional and 2-Dimensional models) and sediment transport conceptual modelling.

Preliminary assessment indicated the level of investigation to be extremely thorough and of a high professional standard. This view is further reinforced when it is recognised that work presented in the Management Options Report has been for feasibility assessment of the options only. It is understood that PWD has clear intention to undertake more detailed and comprehensive design work in respect of the preferred option and in fact some of this work is already underway at the PWD Hydraulics Laboratory.

3. THE SHOALING PROBLEM

A wide range of multi-disciplinary studies have contributed to a well considered understanding of the sedimentary processes in Port Hacking. The various studies have complemented, corroborated and checked one another, particularly in respect to the rates of sediment movement and thence the magnitude of the shoaling problem. The landward migration of the marine delta and shoaling problems associated with it are well treated and clearly defined in the reports. The long history of shoaling of the navigation channels goes back to the 1880's when dredging was first required to be carried out. Since then maintenance dredging of the channels has been an ongoing requirement.

To date dredging has effectively been undertaken on a sporadic needs basis. Long term planned dredging programs do not adequately cope with the severe shoaling associated with a single major storm event. Major storms occur irregularly and the wave stirring of sediment can result in significant and unpredictable deposition of large sand shoals within otherwise relatively stable tidal channels. The shoaling so caused is event dominated rather than a regular steady accretion process. Such behaviour is difficult and expensive to deal with as mobilisation of dredging equipment is virtually required upon demand and planned dredge scheduling would be relatively unsuccessful.

With foreseen increases in public leisure time and recreational use of the waterways, the demands for dredging of the navigational channels can be expected to increase in the future at a higher rate than the noted increases of recent times.

Under such conditions the goal of a longer term, more efficient option for controlling the shoaling problem should be applauded.

Disposal of dredge spoil has in the past been sporadic and often, due to equipment and time constraints, ill-placed to the detriment of seagrasses. If dredging were to be continued as a chosen management option, more control on spoil disposal would need to be exercised.

4. THE OPTIONS

A brief discussion and review on each of the options individually follows — the emphasis being restricted to engineering and technical aspects. Environmental marine biology/zoology aspects are discussed separately in Section 5.

4.1 NO ADJUSTMENT TO THE NATURAL PROCESS

This option is not in fact a "do nothing" option. Rather it would involve continued minimum scale maintenance dredging restricted to the Cronulla - Bundeena ferry route.

Under the now known and continuing landward migration of the marine delta, this option will not even maintain the status quo. In fact, severe deterioration of the estuary will result as entrance shoals move further landward. Severe navigational problems inshore of Burraneer Point can be expected as well as natural atrophy and deterioration in water quality. This option should not be seriously considered and will not be further reviewed.

4.2 MAINTENANCE DREDGING OF THE CHANNELS

As noted in Section 3, sedimentary processes and shoaling of existing navigation channels are significantly affected by single major storm events dominated by wave action. The maintaenance dredging option is not efficient in engineering terms due to the relatively poor chances of success with planned and scheduled dredge operations. Rather, maintenance dredging on demand (at considerable cost) can be expected to become the norm especially as the demand for recreational use of the waterway increases.

No guarantee for open navigable waterways could be given. Closure due to rapid shoaling movements could be expected. Dredge mobilisation to clear such shoals would not be immediate and in certain circumstances could be expected to take several months.

This option requires a commitment to dredging in perpetuity with cost escalation in the future. Continual shoaling problems would occur and no improvement to the recreational use of the area could be realised.

Onshore movement of the middle ground shoal across Simpsons Bay and onto Deeban Spit could be expected. Stabilisation of Deeban Spit to prevent uncontrolled wind blown transport may eventually be necessary in the public interest.

4.3 COMMERCIAL SAND EXTRACTION TO MAINTAIN CHANNELS

This option is identical in engineering terms to 4.2 above. It has all the same problems in respect of likely effectiveness in keeping navigation channels open in circumstances of large shoal migrations after sporadic and unpredictable major storm events.

It cannot be considered commercially viable in light of expressed opposition by Sutherland Shire Council and National Parks to the necessary shore based washing, screening and transport facilities within Port Hacking.

4.4 DEEBAN SPIT TRAINING WALL

The success of this option as proposed is not considered certain by any means. The length of the training wall and the lack of dredging/control of the middle ground shoal are of concern.

Flood dominated tidal transport under superimposed wave action may move significant volumes of shoal sand into and through the improved channel between Burraneer Point and Deeban Spit. The result may be siltation/shoaling problems of equal or more severe magnitude than those already occurring to the entrance to Burraneer Bay.

To guarantee success of this option the main middle ground sand shoals would need to be effectively isolated by either

(i) extension of the training wall seaward to near Hungry Point, or

(ii) dredging of shoal sand with removal or placement on Deeban Spit.

The optimum solution involving a trade off between length of training wall and level of dredging could only be determined by comprehensive and detailed further investigations.

Irrespective of any final optimal training wall option adopted, eventually all sand left undredged on the middle ground shoal will move under wave action onshore to Deeban Spit. If not stabilised, substantially increased volumes of sand would be moved by wind. Also deeper water will then exist offshore and Simpsons Bay, Deeban Spit and the training wall will be exposed to more severe wave action.

4.5 BONNIE VALE TOMBOLO

As this is considered the most appropriate option for longterm solution of the shoaling problem, it will be reviewed in more detail.

The primary objective of this option is to constrict the tidal flow into and out of Port Hacking along the northern side of the estuary and thereby assist in stabilising the tidal channel between Burraneer Point and Hungry Point to provide a stable navigation channel for recreational boating. Additional benefits which may result from the proposal are the formation of a recreational beach to provide a natural extension to the existing Hordems Beach together with the improvement of the marine ecological system within Simpsons Bay.

Whilst detailed engineering and marine biological investigations are needed to refine the proposal, the technical feasibility of the scheme is established.

The tidal prism within Port Hacking is sufficient to provide the tidal power needed to maintain stable navigation channels with the locations of the main tidal streams controlled by the proposed engineering works. The tidal velocity increase from 0.3 to 0.6 m/s within the channel between Hungry Point and the tombolo is considered within normal acceptable limits. Peak velocities of 0.6 m/s cannot be expected to cause any navigational problems. In concurrence with PWD assessment of likely wave steepening, the increase in channel depth is judged to more than

compensate for the increase is velocity. This affect can be readily confirmed in planned phsyical model studies. Current magnitudes and directions inshore of Burraneer Point are unlikely to be altered. The option has negligible impact on tidal ranges and flow volumes.

The present proposal is for the sand tombolo/breakwater to be retained by a relatively short training wall.

Because of the large sand resource available, the construction of the tombolo/breakwater using sand from within the estuary is a cost efficient method of construction. This method, whilst novel, is not new and was used at Saldanha Bay in South Africa for the protection of an iron ore loading facility.

To be successful the alignment of the ocean spending beach of the tombolo must be normal to the average angle of wave attack and the terminal groyne must be of sufficient length to allow for variability around this average. The proposed site is ideal in this regard as it has a very narrow weather window. This is reflected in the alignments of Hordems Beach and the foreshores within Simpsons Bay. These have been used as a guide for the alignment adopted in the preliminiary design.

Physical and/or numerical modelling to optimise the final design and minimise littoral transport along the ocean beach is now in progress. The proposed alignment of the tombolo beaches is unlikely to change significantly. Optimisation of the end groyne alignment and length will also be examined. By maintaining headland control between Hordems Beach and the tombolo, and correct alignment of the tombolo, there is negligible risk of the option creating beach erosion or instability on Hordems Beach.

The Spit in Middle Harbour provides an example of a "natural spending beach breakwater" and the effect of such a "breakwater" on tidal channel control. In principle it has much in common with the present proposal. The tombolo at Palm Beach is also an example of a "natural spending beach breakwater" similar to that proposed. On the NSW coast alone there are more than 20 others.

Provided the alignment of the proposed spending beach breakwater is carefully selected and the end training wall is of sufficient length to inhibit sand loss into the tidal channels, maintenance requirements for the ocean spending beach will be small. The main requirement in the design will be to provide sufficient bulk to satisfy the storm demand. This is the typical sand nourishment problem used for beach protection and a great deal of data have been collected on this aspect over recent years, both within Australia and overseas.

There is no question that tombolos can withstand the most severe of storms without overtopping or any risk of breakthrough. Storms will certainly erode the beach foreshore but the sand will return again during subsequent fair weather. This is the normal pattern of behaviour that takes place on any sandy beach along our coastline.

Data and analyses techniques exist which enable this storm demand to be adequately assessed and this would need to be taken into account in the final design.

The narrow weather window and low wave climate at the tombolo site predicted in wave refraction studies may be misleading. The refraction studies are appropriate for non-breaking wave conditions but have no applicability to storm wave heights or directions inshore of Jibbon Head. Offshore deepwater storm waves of significant height in excess of 6 metres are relatively common. Once this degree of storm activity is reached, refraction techniques can no longer be applied due to occurrence of large scale wave breaking. In such circumstances wave setup will become a dominant term affecting water level and stability of the tombolo. The wave climate at the proposed tombolo does need to be studied in more detail for storm conditions by either physical model and/or direct field measurement. It is understood that the PWD appreciates this problem and is addressing it as part of the detailed design of the tombolo.

In many respects the tombolo location is no different from Balmoral Beach in Middle Harbour which normally is quite calm but is hammered by occasional storms such as those which occurred in 1967, 1969 and 1974.

The alignment and profile of the ocean spending beach will be dictated by ocean wave conditions. These will be the most severe. The protected side on the lee of the tombolo should not, however, be forgotten. Whilst the rate of sand movements will be an order of magnitude smaller they need to be designed in accordance with the local wind, waves and current conditions to which they will be subjected.

Dredging within the estuary for the tombolo option has many bathymetric pattern options, none as yet finalised. The pattern of dredging finally adopted will have little impact on the engineering feasibility or design of the tombolo. Major impacts will be marine biological/environmental. In particular, if Simpsons Bay is left relatively shallow, under the reduced wave climate, seagrass colonisation is highly probable, if not guaranteed. Maintenance of water quality under tidal circulation is ensured for any likely dredging configuration.

The opportunity to provide an additional ferry wharf at Bonnie Vale on the lee of the tombolo is noted. Access in all weather could be virtually guaranteed. This contrasts with the present problems of maintaining the ferry service to Bundeena in bad weather. The tombolo option is the only option addressed that offers this enhancement in ferry service between Cronulla and Bundeena.

There is a low probability that a change in the alignment of Deeban Spit in response to the altered wave and current climate may occur which could give rise to minor shoaling and navigation problems inshore of Burraneer Point. The rate at which this shoaling possibility might occur would be considerably less than at present. Monitoring of the estuary following the planned works would give early indications of any such problems. The problem, if indicated, could be addressed by the provision of a low level training wall/groyne at the end of Deeban Spit.

4.6 MAJOR COMMERCIAL SAND EXTRACTION

This option to be viable, would require means of effectively transporting sand to a land base some distance away — probably pumping via a pipeline to existing pits at Kurnell.

The option was found to have a significant benefit to cost ratio, however it relies on private commercial extraction which is presently and in the short term future not viable nor economic whilst existing major sand sources at Kurnell remain. In essence, the cost of dredging the sand, transporting it and preparing it for sale exceeds the sale price of existing Kurnell deposits.

In engineering terms, increased wave penetration up the estuary and possible erosion on Deeban Spit are highlighted as possible problems. The necessity for major protection breakwater/groyne works at the end of Deeban Spit are considered likely.

The environmental impacts (good and bad) of this option are more significant than any other.

5. MARINE BIOLOGICAL ASPECTS

5.1 INTRODUCTION

As a remarkably small proportion of the population makes use of the open sea, sheltered water is the single great asset provided by Port Hacking and similar inlets. These inlets are at various stages of suffocation between deep water ocean inlets and infilled flood plains crossed by creeks. Port Hacking has a large marine tidal delta which has penetrated almost half way along its length blocking off the side arms, Jibbon, Bundeena, Gunamatta Bay, Cabbage Tree, Burraneer Bay and South West Arm as it passed.

The high sand body of the marine tidal delta has several important marine biological impacts:

(i) Seagrass beds grow in shallows down to a few metres below the surface, depending on water clarity and available light. They provide both shelter and, indirectly, food for a great range of marine animals. They are particularly important as nurseries for juvenile fishes newly arrived from the sea. In Port Hacking the extent of seagrass cover has fluctuated evidently over the last 57 years at least for reasons more easily guessed than verified. Seagrass beds contain diverse species in high abundance, or biomass, whereas in high-energy areas of mobile sand, where seagrass cannot establish itself, both the diversity of species and their biomass are lower.

(ii) It provides a shallow constricted sill which isolates deep basins in Gunnamatta Bay, Burraneer Bay, the upper basin between Lilli Pilli Point and Grays Point, and South West Arm. The deep water trapped below sill depth is prone to severe quality degredation where urban development supplies excessive nutrient runoff or where flood water caps it off from exchange with the air. South West Arm is a well known text book example in which the bottom water deoxygenates periodically and the fauna is very limited. Lowering sill depth and increasing ventilation leads to greater exchange with ocean water and to water quality more like that of the ocean.

(iii) A special feature of the sand mass is a very deep hole maintained in a jet of tidal circulation between Deeban Spit and Turriel Point known as Ship Rock Marine Reserve. Here is a prolific growth of suspension feeding organisms not normally seen in sluggish water. Similar features might be established elsewhere by directing a tidal jet at a deep rockface.

5.2 THE MANAGEMENT OPTIONS

With a view to making Port Hacking more generally useful to the public the Public Works Department of NSW undertook detailed studies and proposed the set of management options. As all options involve dredging, three points should be stated first and clearly:

(i) Dredging will completely destroy the habitat and biota of the area dredged.

(ii) Dredging will produce a new habitat and biota comparable with those of similar depth, water movement and distance up the estuary.

(iii) In areas dredged, recolonisation by most species can be expected after one year. A few species may, however, take much longer.

In respect of marine biological effect the various management options are considered individually below.

5.2.1 No Adjustment to the Natural Processes

Apart from continual minor dredging to allow shallow draught ferries to travel between Cronulla and Bundeena, no major perturbations are anticipated. The upper Port would suffer reduced navigation amenity due to mobile sand and the hydrological ventilations of the upper basins would diminish with resultant lowering of water quality.

5.2.2 Maintenance Dredging of Channels

While navigation would be maintained and the upper port would be as well ventilated as it is now, the attendant mobile sands would periodically cause obstruction.

5.2.3 Commercial Dredging of Channels

This protracted process has some potential to increase ventilation, but again mobile sand will lead to periodic restriction.

5.2.4 Engineering Works to Stabilise Channels

(a) Deeban Spit Training Wall
While this project is intended to produce stable navigation channels, the area of Simpsons Bay will remain mobile and of high energy and limited fauna and flora. Port ventilation would be increased slightly.

(b) Lilli Pilli Groynes
This project, while infilling an area of mobile sand, has the potential to direct a jet of water onto Gogerleys Point which could split the flows into South West Arm and the Upper Port, thereby creating the opportunity for the development of an environment similar to that of Ship Rock.

(c) Bonnie Vale Tombolo
The construction of the sand spit/tombolo will destroy the sand fauna south of Hungry Point, but it will convert Simpsons Bay from an unstable high energy shoal which supports a few worms and whiting to a deeper, quiet, well ventilated water body. Provided the bottom grades up from 4 metres in the channel to the beach on the south side of Simpsons Bay then at some intervening depth a dense seagrass meadow will develop to the great benefit of the estuarine fauna. The channels should stabilise but in doing so it is not considered likely that port ventilation would be greatly increased.

5.2.5 Major Commercial Sand Extraction

Here significant inroads could be made into the occlusion of the port. Large volumes of sand could be removed on a carefully planned basis to give stable deep water and good ventilation

potential grading up through conveniently located productive seagrass meadows. If this option is not adopted now it has the potential of being started at any time in the future.

6. CONCLUSIONS

As stated repeatedly by PWD, the work completed to date is commensurate with a basic understanding of the Port Hacking shoaling problem leading to a feasibility level of assessment of the relative merits of different management options. The ultimate solution will involve the State Government, Sutherland Shire Council and the public.

The work to date demonstrates the feasibility of the tombolo option and clearly ranks it as the preferred option. However, results to hand should not be viewed as final design predictions. This applies to all facets of the feasibility assessment, i.e. engineering, technical, environmental and economic.

The necessity for detailed design for any of the discussed options was recognised and is reportedly progressing, viz: detail design for stability and alignment of the tombolo, specific mathematical modelling of tidal currents and sedimentary shoaling changes and physical modelling of wave penetration.

No deleterious impact/ecologically is foreseen in marine biology/zoology terms. The tombolo will provide a wave protected Simpsons Bay which has the potential of providing a natural environment conducive to the establishment of seagrasses and a marine biological nursery area which at present does not exist. A marine biological study which is needed to optimise this benefit is at present part of the EIS being undertaken.

In conclusion the characteristics of the mouth of Port Hacking are suited to the creation of the tombolo option. It will solve the shoaling problem whilst improving recreational potential use of the waterway. The tombolo is technically feasible and only requires final detail design studies. It does not rely on any preconceived pattern of dredging within Simpsons Bay. The ultimate dredging can be established by the community as a balance between the goals of environmental seagrass and marine biological nursery, ferry routes and recreational use.

APPENDIX A

CURRICULUM VITAE

Assoc. Prof. D.N. Foster
Dr. R.J. MacIntyre
Dr. R.J. Cox

CURRICULUM VITAE

NAME	DOUGLAS NEIL FOSTER
ADDRESS	Rockliffs Road, PO Box 169, SHEFFIELD, Tas. 7306
DATE OF BIRTH	8th December, 1930.
MARITAL STATUS	Married, 2 children.
ACADEMIC RECORD	B.E. Honours, University of Sydney, 1953.

SUMMARY OF CAREER DETAILS

1948 - 1952
Cadet Engineer, Department of Public Works, N.S.W.

1953 - 1955
Engineering Assistant, Department of Public Works, N.S.W.

1955 - 1957
Acting Supervising Engineer, Hydraulics Laboratory, Department of Public Works, N.S.W.

1957 - 1958
Engineer, Launceston Flood Protection Authority, Tasmania.

1958 - 1962
Lecturer, The University of New South Wales.

1962 - 1975
Senior Lecturer, The University of New South Wales.

1973 - 1987
Director, Water Research Laboratory.

1976 - 1987
Associate Professor, The University of New South Wales.

1987
Specialist Consultant, Unisearch Ltd.

INSTITUTE AND COMMITTEE MEMBERSHIP

Member Institution of Engineers, Australia.

Foundation Member of National Committee of Coastal and Ocean Engineering, Institution of Engineers, Australia.

Member N.S.W. State Committee on Coastal and Ocean Engineering, Institution of Engineers, Australia.

Member American Society of Civil Engineers.

Member Coastal Engineering Research Council, A.S.C.E.

Member of Maritime Panel Institution of Engineers, Aust, Sydney Division.

Member Management Committee Institution of Marine Science, the University of New South Wales.

Advisory Editor, Coastal Engineering, Elsevier Press.

Member of Advisory Committee for Conferences on Coastal and Port Engineering in Developing Countries.

PROFESSIONAL EXPERIENCE

I have had extensive experience in undertaking water engineering investigations and studies as indicated in the my publication list. Since 1958 I have been in charge of engineering investigations undertaken at the Water Research Laboratory of the University of New South Wales. In my specialist area I have at one time or another acted as a specialist consultant to the following organisations:

GOVERNMENT DEPARTMENTS

Australian Government Department of Transport & Construction
Electricity Commission of N.S.W.
State Electricity Commission of Victoria
Maritime Services Board of N.S.W.
Department of Public Works N.S.W.
Department of Main Roads, Tasmania
Port of Launceston Authority, Tasmania
Department of Harbours and Marine, Queensland
Department of Harbours and Marine, South Australia
Department of Public Works, Western Australia
Metropolitan Water Sewerage & Drainage Board, N.S.W.
National Parks & Wildlife Service, N.S.W.
National Parks & Wildlife Service, Tasmania
Gold Coast Waterways Authority
Queensland Land and Administration

LOCAL GOVERNMENT DEPARTMENTS

Gold Coast City Council	Colo Shire Council
Warringah Shire Council	Blacktown Municipal Council
Randwick Municipal Council	Sutherland Shire Council
Cronulla Shire Council	Launceston City Council
Liverpool Council	Mosman Municipal Council

CONSULTING ENGINEERS

Munro & Johnson
Sinclair Knight & Partners
Posford Pavry
Dwyer & Associates
Macdonald Wagner
Maunsell & Partners
Binnie & Partners
Cardno & Davies
Rohan Kinnaird Hill & Young
Cameron McNamara
Geoff Taylor & Partners
Pitt & Sherry
Blain Bremner & Williams
Gutteridge Haskins & Davey
McIntyre & Associates
Burchill & Partners
Oceanics Australia
Docker Smith Fitzjohn
Crook Michell Peacock Stewart
Longworth & McKenzie
Professional Group Australia

INDUSTRY

Shell Australia
Decca Australia
Australian Hydrographic Services
Comalco
Nabalco
Bocal Australia
Port Jackson Steamship Co.
Padde Valves/Wormald Aust.
Woodside Petroleum
B.H.P.
Penrith Lakes Development Corp.
James Hardie
Secret Harbour
Warman International
Roche Bros
Macdonald Hamilton
John Thompson Australia

PUBLICATIONS

Comprehensive list of numerous publications can be supplied upon request.

CURRICULUM VITAE

NAME R.J. MacINTYRE

BORN 25/12/29 New Zealand

QUALIFICATIONS Master of Science, Canterbury University, New Zealand, 1955.

Doctor of Philosophy, McGill University, Canada, 1960.

MEMBERSHIPS
Australian Marine Science Association
New Zealand Marine Science Association
Royal Society of New Zealand
Australian Society of Fish Biology
Australian & New Zealand Society for the Advancement of Science
Australian Coral Reef Society.

EXPERIENCE

1967 to Date Senior Lecturer, Zoology, University of New South Wales.

Conducts research programmes for various Authorities.

Major studies have included:

- Feasibility study of the culture of mussels around Australia, under Commonwealth Government Grant through Department of Primary Industry.

- Survey of marine borers in Australia-Papua New Guinea for CSIRO Division of Building Research.

- Estuarine ecology studies on cooling water circulation for circulation for several NSW power stations for ELCOM NSW.

- Control of fouling organisms and the effect of heated water on populations of fish, plankton and bottom organisms for existing and proposed power stations.

- Toxicity studies on oil slick dispersants, paper mill effluents and insecticides.

- Assessment of immediate and subsequent damage to oyster farms following oil spills in Botany Bay.

- Mussel-Watch programme assessing base levels of heavy metals in NSW coastal waters.

- Environmental studies on the development of:

  Lake Illawarra, Port Kembla coal loader, Botany Bay Port, Cooks River, Hawkesbury River recreation, Colo River dam, Port Huon pulp mill, Maryvale paper mill,

Brisbane Power Station, Yamba, Tuncurry, Wallis Lake and Tea Gardens housing/marinas, Flood mitigation works in Tweed, Clarence and Bellinger rivers, flushing of sewage-dominated Wyee Creek using ash-dam overflow, gravel and sand extraction from Hawkesbury River, groyne construction off Cronulla.

- Supervision of sixty research theses on estuarine and coastal ecology, mariculture and fisheries.

1955-1967 CSIRO Division of Fisheries and Oceanography, Cronulla.

- Ecological survey of Lake Macquarie

- Survey of benthos or continental shelf from Brisbane southwards to Perth

- Detailed study of continental shelf off Cronulla

RONALD JOHN COX

DATE OF BIRTH	16 January 1949
QUALIFICATIONS	B.E. (Civil) Hons. 1, 1969 The University of New South Wales
	Ph.D. 1976, The University of New South Wales
POSITIONS	1967 - 1970 Trainee Engineer, Metropolitan Water Sewerage & Drainage Board
	1970 - 1973 Post Graduate, C.S.I.R.O.
	1973 - 1975 Research Engineer, The University of New South Wales / A.W.R.C.
	1976 - Present Engineer/Projects Manager, Water Research Laboratory / Unisearch Ltd.
FIELDS OF RESEARCH AND PROFESSIONAL INTEREST	Coastal and Ocean Engineering, Sediment Transport, Hydrology, Groundwater and Geohydrology, Hydraulic Model Studies (physical, mathematical and numerical), Field Data Collection and Interpretation, Power Station Cooling Water Systems.
PUBLICATIONS	Numerous technical reports and publications in professional journals - can be supplied on request.

RECENT RELEVANT EXPERIENCE

- Wave climate, surge predictions, overtopping estimates and structural stability design and model testing for reclamation protection works, harbours and breakwaters at

  Lennox Head (NSW) - Present
  Darling Harbour (NSW) - 1985-86
  Opera House (NSW) - 1985
  Eden (NSW) - 1984
  Murrays Beach, Jervis Bay (NSW) - 1986
  Hay Point Tug Harbour (Qld) - 1983, 1986
  Townsville Breakwater Inland Resort Casino (Qld) - 1982
  Boondall Olympic Village (Qld) - 1985 to present
  Georges Bay (Tas) - 1983-86
  Currie Harbour (Tas) - 1986 to present
  Avatiu, Raratonga (Cook Islands) - Present

- Studies to investigate and/or monitor the effects of future development proposals and dredging works on flow distributions, sediment and/or effluent movements at

  Brunswick Heads Outfall (NSW) - 1986
  Green Point, Jervis Bay (NSW) - 1986 to present
  Darling Harbour (NSW) - 1985-86
  Sussex Inlet Outfall (NSW) - Present
  Mooloolah River (Qld) - 1978 to present
  Brisbane Airport/Moreton Bay (Qld) - 1980 to present
  Shark Bay (WA) - 1984
  Ok Tedi Mining Project (PNG) - 1983-84

- Major data collection exercises in respect to tidal currents, sediments and water quality at

  Jervis Bay (NSW) - 1986
  Mooloolah River (Qld) - 1978-82
  Darwin (NT) - 1978
  Cairns (Qld) - 1976
  Georges Bay, St Helens (Tas) - 1983
  Tamar Estuary (Tas) - 1984 to present

BIBLIOGRAPHIC DATA SHEET	1. REPORT No. 87/06	2. I.S.B.N. 0/85824/307/5

3. TITLE AND SUBTITLE

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5. AUTHOR (S)

R.J. COX, D.N. FOSTER and R.J. MacINTYRE

6. SPONSORING ORGANISATION

PUBLIC WORKS DEPARTMENT, NEW SOUTH WALES

7. SUPPLEMENTARY NOTES

The work reported was carried out and published under the direction of the Director of the Water Research Laboratory acting on behalf of the client, Public Works Department, New South Wales.

8. ABSTRACT

The Public Works Department of NSW (PWD) began in 1980 studies related to the historically ongoing shoaling of Port Hacking. The prime objective of the work was to define the processes contributing to the shoaling problem and determine long term solutions for navigational channel maintenance. Sub objectives included environmental enhancement and improvement of the recreational potential of the waterway. Possible development of the shoaling sand as a marketable resource was also foreseen.

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10. DESCRIPTORS

Estuaries; Navigable Waters; Sediment Transport; Tidal Currents; Wave Protection; Marine Biology

11. IDENTIFIERS

Port Hacking, NSW; PWD NSW

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