



EIS 88

AA057087

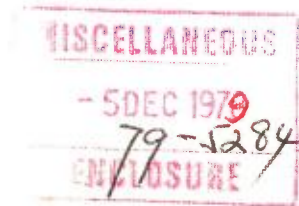
Environmental impact statement : Malabar water pollution
control plant

NSW DEPT PRIMARY INDUSTRIES



AA057087

METROPOLITAN WATER SEWERAGE AND DRAINAGE BOARD
SYDNEY, NEW SOUTH WALES



ENVIRONMENTAL IMPACT STATEMENT

MALABAR

WATER POLLUTION CONTROL PLANT

December 1979

EIS
88



CALDWELL CONNELL ENGINEERS

X
EIS 88

METROPOLITAN WATER SEWERAGE AND DRAINAGE BOARD
SYDNEY, NEW SOUTH WALES

ENVIRONMENTAL IMPACT STATEMENT

MALABAR

WATER POLLUTION CONTROL PLANT

December 1979



CALDWELL CONNELL ENGINEERS

METROPOLITAN WATER SEWERAGE AND DRAINAGE BOARD

THE BOARD

President

E.J. Walder, Esq., C.M.G., B.Ec.

Vice President

N.G. Klamus, B.E., L.S., F.I.E.Aust., M.I.S.Aust.

Members

Ald. G.R. Ibbett

J.S. Kimber, Esq.

Ms.P.J. O'Shane, L.I.B.

Ald. H.G. Percival, O.B.E.

Ald. D.W. Sutherland, B.A., F.C.A., A.C.I.S.

PRINCIPAL OFFICERS

Secretary

S.R. Smith, D.P.A.

Engineer-in-Chief

P.W. Hughes, B.E.

Deputy Engineer-in-Chief (Investigation and Survey)

A.G. Tilley, A.S.T.C.

Deputy Engineer-in-Chief (Construction and Design)

W.I.S. Moyes, B.E., F.I.E.Aust.

Deputy Engineer-in-Chief (Operations and Services)

J.M. Collocott, B.E., B.Sc., F.I.E.Aust.



CALDWELL CONNELL ENGINEERS PTY LTD

ENVIRONMENTAL SCIENCE AND ENGINEERING

60 ALBERT ROAD PO BOX 133 SOUTH MELBOURNE 3205 TELEPHONE 699 5433 TELEX 32071 CABLE BRALCO

3 December 1979

J.W. CONNELL, Chairman
D.H. CALDWELL, Director
M.A. CORNELL, Director
L.B. DUNLAP, Director
J.R. FOSTER, Director
J.W. WILSON, Director

I.V. BEER
J.T. BELLAIR
J.C. COULSON
I.G. WALLIS

The Secretary
Metropolitan Water Sewerage and Drainage Board
P. O. Box A53
Sydney South, N.S.W. 2001

Attention: Mr. M. W. Whyte, Investigating Engineer Sewerage

ENVIRONMENTAL IMPACT STATEMENT FOR MALABAR WATER POLLUTION CONTROL PLANT
(Ref 48/9934)

Dear Sir,

As authorised in your letters of 11 April 1975 and 10 November 1978 we have completed the environmental impact statement for the Malabar Water Pollution Control Plant, and are pleased to submit it herewith.

The Malabar WPCP has provided primary treatment since 1975 and the effluent is discharged through submerged outlets at the cliff face. A significant improvement in conditions at adjacent beaches has been achieved following commissioning of the plant. However, the present treatment and disposal system does not meet all water quality criteria. This impact statement evaluates the various treatment and disposal options available to improve the Malabar system.

As a result of the evaluation, we have concluded that the preferred option is continued operation of the primary plant and construction of a deepwater submarine outfall to discharge primary effluent and digested sludge. This recommendation is based on an assessment of the environmental impacts, cost, and consumption of resources associated with many treatment and disposal options.

In concluding this assignment, we wish to express our appreciation for the cooperation and assistance, which we received from the Board's officers throughout the study.

Yours faithfully,

CALDWELL CONNELL ENGINEERS

D. A. Reinsch
D. A. Reinsch

I. G. Wallis
I. G. Wallis

G. J. Sowards
G. J. Sowards

TABLE OF CONTENTS

SUMMARY AND CONCLUSIONS	i
CHAPTER 1. INTRODUCTION	
1.1 Historical Background	1
1.2 The Board's Sewerage Systems	2
1.3 Objectives of the Environmental Impact Study	3
1.4 Scope of the Study	3
1.5 Acknowledgements	4
CHAPTER 2. MALABAR SEWERAGE SYSTEM	
2.1 Malabar Catchment and Major Sewers	5
2.2 Population and Industrial Growth	5
2.3 Sewage Flows and Loadings	6
Sewage Flows in the Catchment	6
Sewage Flows from Outside the Catchment	8
Sewer System Capacity	8
Waste Loadings	10
CHAPTER 3. MALABAR WATER POLLUTION CONTROL PLANT	
3.1 Design Capacity	11
3.2 Flow Diagram and Design Data	11
3.3 Stage 1 Treatment Processes	11
Effluent Outfalls	16
3.4 Malabar Plant Performance	16
3.5 The Need for Additional Treatment Facilities	18
CHAPTER 4. MALABAR LAND ENVIRONMENT	
4.1 Location	20
4.2 Topography	20
4.3 Geology and Soils	20
4.4 Climate	20
4.5 Vegetation	22
4.6 Surrounding Land Use	22
4.7 Visibility and General Appearance of the Site	23
Operating Plant Areas	23
Site Landscaping	23
CHAPTER 5. RECEIVING WATERS	
5.1 Beneficial Uses of the Ocean and Nearshore Waters	25
Recreational Use	25
Fisheries Production	25
Other Beneficial Uses	26
5.2 Water Quality Criteria	26
Design Criteria	26
Physical Appearance	26
Restricted Substances	27
pH and Dissolved Oxygen	27
Bacteriological	27
Biological	28
5.3 Physical and Physico-Chemical Characteristics of the Receiving Waters	28
Physical Processes	28
Physico-Chemical Factors	29

8.4	Disposal of Sludge to Air by Incineration	67
	Conventional Sludge Incineration	68
	Energy Recovery using Pyrolysis	68
	Impacts of Disposal to Air by Incineration	69
8.5	Comparison of Sludge Disposal Options	69
	Economic Comparison	69
	Resource Recovery	70
	Environmental Comparison	70
8.6	Conclusion	72
 CHAPTER 9. ENVIRONMENTAL SAFEGUARDS AND IMPACTS		
9.1	Selection of Preferred Option	74
9.2	Identification of Environmental Safeguards and Impacts	76
9.3	Impacts of Construction	76
	Construction Impacts on the Land Environment	76
	Construction Impacts on the Marine Environment	78
9.4	Impacts of Operation of the WPCP	78
9.5	Impacts of Effluent Discharge	81
	Physical Appearance	81
	Restricted Substances	81
	Dissolved Oxygen and pH	82
	Microbiological Criteria	83
	Biota	84
9.6	Conclusion	85
 Appendix A References		
Appendix B List of Abbreviations		
		86
		87

LIST OF TABLES

Table 1	Population Projections for the Malabar Sewerage Catchment	5
Table 2	Unit ADWF Factors for the Malabar Sewerage Catchment	7
Table 3	Projected Sewage Flows to the Malabar WPCP	7
Table 4	Malabar WPCP Loadings and Performance	9
Table 5	Malabar WPCP Stage 1 Design Data	14
Table 6	Concentration of Restricted Substances Discharged from the Malabar WPCP	18
Table 7	Criteria for Ocean Discharge of Restricted Substances	27
Table 8	Faecal Coliform Density in the Malabar Effluent Field, Organisms/100 ml	36
Table 9	Preliminary Heavy Metal and Pesticide Data for Malabar and Marley Head	42
Table 10	Summary of Tolerance Levels for Heavy Metals and Pesticide Residues in Foods	43
Table 11	Comparison of Sewage Treatment and Disposal Options for Malabar WPCP Effluent	54
Table 12	Comparison of Effluent Treatment and Disposal Costs for Chemical Treatment (Nearshore) and Primary Treatment (Deepwater)	55
Table 13	Major Constituents of Primary and Digested Sludge	58
Table 14	Heavy Metal Levels in Raw Sewage and Digested Sludge	59
Table 15	Comparisons of Methods for Ocean Disposal of Sludge	61
Table 16	Comparison of Methods for Land Disposal of Sludge	67
Table 17	Indicative Sludge Disposal Costs	71
Table 18	Summary of Environmental Interactions for the Sludge Disposal Options	71
Table 19	Options for Sewage Treatment and Disposal of Effluent and Sludge at Malabar	75
Table 20	Predicted Performance of the Malabar Deepwater Submarine Outfall	82
Table 21	Required Dilutions of Restricted Substances in the Malabar Discharge	83

SUMMARY AND CONCLUSIONS

These pages summarise the results and findings of the environmental impact statement for sewage treatment and disposal from the Malabar Water Pollution Control Plant (WPCP). The Malabar WPCP has provided primary treatment since 1975 and the effluent is discharged through submerged outlets at the cliff face. A significant improvement in conditions at adjacent beaches has been achieved following commissioning of the plant. However, the present treatment and disposal system does not meet all water quality criteria. This impact statement evaluates the various treatment and disposal options available to improve the Malabar system. It is concluded that the preferred option is continued operation of the primary plant and construction of a deepwater submarine outfall to discharge primary effluent and digested sludge.

The summary is divided into nine sections corresponding to the nine chapters of the impact statement.

1. INTRODUCTION

Chapter 1 presents an historical outline of the development of the Malabar sewerage system and describes the objectives and scope of this environmental impact study. Disposal of sewage to the ocean has been practised in the Sydney area for almost 90 years. At the time of construction of Sydney's three major raw sewage ocean outlets at Malabar, North Head and Bondi, the population served was comparatively small. Some contamination of shores and shore waters occurred, but this was generally accepted by the relatively few people who used the beaches for recreational purposes.

However, with increasing use of the beaches, it became evident that the recreational value of some beaches was threatened by pollution of sewage origin. Work on the Bondi WPCP was commenced by the Board in the 1930's to reduce pollution at Bondi Beach. More recently, over the last 15 years or so, a progressive increase in flows combined with a growing public awareness of environmental quality has resulted in conditions which, although earlier considered adequate, are no longer considered acceptable. In response to these trends, the Board has undertaken several major projects including the WPCP at Malabar with the objective of improving the condition of nearby beaches and waters. At this plant primary effluent is discharged to the Pacific Ocean at the cliff face through submerged outlets.

The Board recognises that upgrading and augmentation of the treatment and disposal system may be required. The objectives of this study are to: (1) describe the environmental impacts of the Malabar WPCP; (2) examine the various options available to the Board which may be required to meet water quality criteria, and (3) prepare an Environmental Impact Statement covering the WPCP in accordance with the applicable provisions of the NSW State Pollution Control Commission's Environmental Standard EI-4 "Principles and Procedures for Environmental Impact Assessment in NSW".

2. MALABAR SEWERAGE SYSTEM

Chapter 2 describes the Malabar catchment and major sewers, and presents projections of population, industrial growth and sewage flows and loadings. The Southern and Western Suburbs Ocean Outfall Sewer (SWSOOS) is the largest sewerage system operated by the Board and serves suburbs south and west of Sydney.

Guideline water quality criteria for the design of treatment and disposal systems discharging to the ocean have been described, taking into account the beneficial uses of the receiving waters, together with the requirements of the SPCC Design Criteria for Ocean Discharge. They cover such aspects as physical appearance, restricted substances, pH, dissolved oxygen and bacteriological conditions.

The characteristics of the receiving waters are described based on the results of the intensive oceanographic and biological investigations undertaken during the Board's study of deepwater submarine outfalls offshore from North Head, Bondi and Malabar. Four general types of studies were carried out: (1) physical oceanographic; (2) chemical; (3) biological; and (4) special studies. The principal objective of the physical oceanographic studies was to determine current patterns and density structure during various seasons and under different wind and tidal conditions. Concentrations of a variety of chemical substances in seawater and sediments were determined to characterise the study areas and to support the biological studies. Benthic plant and animal communities were studied to establish baseline conditions in the rocky bottom environment of the North Head area and in the sedimentary bottom environment of the Malabar area. Biological work in other study areas was carried out to determine if bottom communities differed substantially from either of the intensively studied areas. Special investigations included geological surveys of the outfall areas, dye studies to determine diffusion and mixing characteristics of the surface waters, and determinations of die-off rates of faecal coliform organisms.

6. IMPACT OF THE PRESENT DISCHARGE

Chapter 6 discusses the impact of the present Malabar primary effluent discharge on present water quality, beach pollution, marine biota, sediment characteristics, and the level of restricted substances. All are affected to some extent by the present effluent discharge. Water quality in the nearshore area adjacent to the present Malabar outfall is influenced by the discharge of settled sewage and digested sludge. Offshore water quality is influenced to a lesser degree, being largely determined by the direction of movement of the effluent field. It is apparent that water quality criteria for physical appearance and faecal coliform are not met by the present discharge.

Pollution of the swimming beaches along the Sydney coast has been monitored regularly by the Board since 1966. The indicators of pollution monitored in this programme are faecal coliform density in bathing waters, the grease content of beach sand, and a visual assessment of the degree of pollution on most beaches. The data show that Maroubra and Malabar beaches would not meet bacteriological water quality criteria on many occasions and that relatively high grease concentrations are found during summer in sand on these beaches. Since commissioning of the Malabar WPCP, visual pollution by sewage solids has decreased significantly at both Malabar and Maroubra beaches. In addition, Board's records indicate that the amount of contaminated sand required to be removed from the beaches has been substantially reduced.

The overall effects of the discharge on marine biota are a localised increase in biomass and change in community structure as a direct result of the high organic load discharged from the existing outfall. The most noticeable effect is related to the spatial distribution of organisms based on feeding groups. Deposit feeders which gain their food directly from the sediment or from organic layers at its surface tended to dominate in areas with high organic loads. Suspension feeders were less numerous in turbid water, as high sediment loads tend to block their feeding apparatus.

Nearshore Discharge

Chemical primary treatment is a less expensive option than secondary treatment. The effluent from this treatment process is better than primary effluent but not as good as secondary effluent. Thus the possibility of combining chemical primary treatment with a nearshore discharge, i.e. an outfall length somewhere between the present shoreline discharge and an extended deepwater outfall, has been examined.

Chemical treatment using either lime or polyelectrolyte was considered. Lime treatment is not appropriate for Malabar because of the major plant modifications that would be required and excessive chemical costs: capitalised lime costs alone could exceed the total project costs for the deepwater submarine outfall option. Although not as effective as lime treatment, addition of anionic polyelectrolyte would improve suspended solids and BOD removal without most of the problems inherent in adapting the primary treatment facilities for lime addition. Optimal dosages for chemical treatment would need to be determined experimentally but polyelectrolyte and chlorine dosages of 1 mg/l and 10 mg/l, respectively, have been assumed.

The nearshore discharge option has several advantages but is rejected because the effluent field would be likely to be visible during much of the year, the high operating costs, particularly for polyelectrolyte and chlorine, and the difficulty of achieving satisfactory sludge disposal with a nearshore outfall.

Deepwater Submarine Discharge

In 1971 the Board commissioned a comprehensive study of ocean disposal of effluent by deepwater submarine outfalls as an option for meeting receiving water quality criteria. These outfalls are designed to use the physical characteristics of the receiving waters to dilute and disperse wastes so that the marine ecosystem can assimilate the additional load without significant adverse environmental effects.

The preliminary deepwater outfall designs were based on over four years of field investigations of physical, chemical, biological, and geological conditions by the Board's staff and its consultants. It was concluded that it is feasible to construct deepwater submarine outfalls in the waters offshore from Sydney, and that discharge of primary effluent through a deepwater outfall would meet receiving water quality criteria. Biological and chemical conditions in the receiving waters were studied to develop 'baseline' data against which future conditions could be compared to detect any significant environmental changes.

Comparison of Sewage Treatment and Disposal Options

A comparison of all sewage treatment and effluent disposal options demonstrated that the two most favourable options are chemical primary treatment followed by nearshore effluent discharge and primary treatment followed by deepwater effluent discharge. A comparison of these two favourable options established that the latter will meet water quality criteria more comfortably than the former and at a smaller total capitalised cost. However selection of the 'preferred' option will be influenced by the sludge disposal options available. These are discussed in Chapter 8 and the 'preferred' option selected in Chapter 9.

8. SLUDGE DISPOSAL OPTIONS

Chapter 8 discusses the characteristics of sludge, the potential effects of sludge components on the environment, and evaluates options for sludge disposal at the Malabar WPCP in terms of cost, environmental impacts and energy recovery potential.

disadvantage of an incinerator used only for burning sewage sludge is that supplementary energy is required for the combined dewatering-incineration process. The need for supplementary fuel has encouraged the development of combined sludge/refuse incineration. This shows promise of being an attractive alternative to conventional sludge incineration in communities where a source of refuse derived fuel (RDF) can be developed to provide supplementary fuel. At present, however, conventional sludge incineration would be more suitable for the Malabar plant.

Energy Recovery Using Pyrolysis. Research is being undertaken overseas into a process known as pyrolysis in which sludge is reduced to ash whilst hydrocarbons are produced in the form of a combustible gas which can be used as a fuel either directly or after liquefaction. A more promising prospect would appear to be joint energy recovery projects using a combination of municipal refuse and sewage sludge. Further development work is required before pyrolysis can be applied locally, however this process, and other energy recovery processes, are being examined for possible future implementation.

Comparison of Selected Options

An economic comparison of the three sludge disposal options indicates that the capital, operating and total capitalised costs of ocean disposal via deepwater outfall are far less than for any other option, provided the sludge is discharged with primary effluent through the deepwater outfall. Incineration and landfill become competitive in cases where a separate conduit would be required for sludge disposal to deepwater.

The major environmental impacts associated with the landfill option are a consequence of the noise, nuisance and energy impacts associated with heavy truck traffic, and the potential for odour production and contamination of ground and surface waters by leachate.

The major environmental impacts associated with the incineration option are emissions to the atmosphere, the need for supplementary energy and the disposal of heavy metals which are removed from flue gas. However, virtually complete destruction of pesticides and PCB's can be achieved by incineration.

A potentially significant impact associated with ocean disposal is accumulation of material on the seabed. However, an analysis of bottom current data and examination of jump camera photos taken adjacent to existing outfalls showed that digested sludge particles will not accumulate on the seabed. Sludge particles will be dispersed widely throughout the receiving waters, and any particles which may be deposited during weak current conditions will be resuspended within a short time. Because of the wide area of dispersion, the amount of material deposited on a unit area would be hard to detect from natural detrital material. The organic material in digested sludge is a food source for marine organisms.

Another significant potential impact of ocean disposal of sludge through deepwater submarine outfalls is the accumulation of heavy metals, pesticides and PCB's in sediments and marine life. However, no serious accumulation of these toxic materials had been observed following discharge of raw and partially treated sewage at Malabar for over 60 years. With the deepwater discharges, the possibility of accumulation would be even less as these substances will be distributed over a much wider area than with the existing outlets. Adequate protection of the marine environment at Malabar will continue to be achieved through emphasis on strict source control of contributors of toxic materials to the sewerage system, coupled with an effective monitoring programme.

Physical Appearance. Predictions of performance of the Malabar deepwater submarine outfall showed that the effluent field would be submerged for over 90 per cent of the time in summer. When there are surface fields, the BOD₅, suspended solids, and grease concentrations in the effluent field at the surface would be lower than those attainable with good secondary treatment. In addition, the nearest diffuser ports would be over 2 km from shore. Overseas experience demonstrates that an effluent field with such low constituent concentrations is not obviously visible at such a distance from shore. Therefore, it is concluded that the preferred option would meet the physical appearance criteria.

Restricted Substances. Heavy metals and pesticides are not effectively removed from sewage by conventional treatment processes. The maximum allowable concentrations of such substances at the boundary of the initial dilution zone have been defined by the SPCC and these fix the minimum initial dilution to be achieved. The preferred option will provide more than sufficient initial dilution to meet water quality criteria for restricted substances.

Dissolved Oxygen and pH. Guideline criteria presented in Chapter 5 require that the discharge should not induce a variation in any waters outside the initial dilution zone of more than 0.2 mg/l for dissolved oxygen, or more than 0.1 for pH. The preferred option would meet these criteria comfortably.

Microbiological Criteria. Bacteriological criteria, based on faecal coliform densities in beachwaters, are described in Chapter 5. The criteria require that for any month the geometric mean density should not exceed 200 org/100 ml and that from November to May no more than 10 percent of the samples should have densities exceeding 400 org/100 ml; and, from May to November, no more than 10 percent of the samples should have densities exceeding 2000 org/100 ml. The preferred option would meet microbiological criteria. On the other hand, the data presented in Chapter 6 show that the no change option would not.

Biota. Protection of the marine flora and fauna against adverse effects of waste discharges is another important possible impact. Marine biota may be affected by discharge of restricted substances, suspended particulate matter, oxygen demanding substances and nutrients. On the other hand, marine productivity may be beneficially increased by organic enrichment from the discharge, provided the increased food supply does not exceed the assimilative capacity of the natural systems.

The high dilutions achieved with the deepwater submarine outfalls provide substantial protection to marine biota. The addition of particulate matter in the form of suspended solids would increase natural levels by 1 to 2 mg/l after an initial dilution of 220:1. Transport and subsequent dilution will distribute these particles widely, further ensuring that significant accumulation of particulate matter will not occur.

During periods of the year when the effluent-seawater mixture rises to the surface, as well as when there is a submerged field, the resulting suspended solids concentrations are expected to have a minimal effect on water clarity. Hence, there should be no significant effect on marine flora, especially in the 60 to 70 m deep waters of the mixing zones. Discharge of nutrients should not result in any significantly increased levels of phytoplankton growth in the discharge region.

It is concluded that the deepwater submarine outfall option will not cause any significant adverse effects in the marine environment, providing that potentially toxic materials such as heavy metals and organochlorine pesticides continue to be effectively limited by source control.



MALABAR W.P.C.P. APRIL 1976.



CHAPTER 1

INTRODUCTION

This chapter begins with a historical outline of the development of the Malabar sewerage system. Following this, the Metropolitan Water Sewerage and Drainage Board's sewerage system is presented and the objectives and scope of this environment impact study are described.

1.1 HISTORICAL BACKGROUND

Disposal of sewage to the ocean has been practised in the Sydney area for almost 90 years. The Southern and Western Suburbs Ocean Outfall Sewer (SWSOOS 1) was originally built at the turn of the century to serve areas south and west of Sydney. Initially SWSOOS 1 discharged to a sewer farm adjacent to Botany Bay. The farm was abandoned in 1916 after extension of the sewer to an ocean outfall in its present location at Malabar. The Bondi and Northern Suburbs ocean outlets were completed in 1889 and 1928, respectively.

At the time these ocean outfalls were constructed the population served was comparatively small. Some contamination of shores and shore waters occurred, but this was generally accepted by the relatively few people who used the beaches for recreational purposes. However, with increasing use of the beaches, it became evident that the recreational value of some beaches was threatened by pollution of sewage origin. The Bondi treatment works was commenced by the Board in the 1930's to reduce pollution at Bondi beach. More recently, over the last 15 years or so, a progressive increase in flows combined with a growing public awareness of environmental quality has resulted in conditions which, although earlier considered adequate, are no longer considered acceptable. In response to these trends, the Board has undertaken several major projects including the Water Pollution Control Plant (WPCP) at Malabar.

In 1959 the Board embarked on a programme to treat wastewater from the SWSOOS system and construction of the treatment works was begun near the downstream end of the SWSOOS at the Malabar headland. In November 1964, the Board commissioned the consulting engineering firm of Brown and Caldwell of San Francisco, USA, to review the design of the works. In their report¹, Brown and Caldwell described water quality objectives for the beaches adjacent to the outfall and indicated that primary treatment followed by effluent disposal through a deepwater submarine outfall would meet the objectives. Brown and Caldwell subsequently was engaged to design the Malabar WPCP². Stage 1 of the plant was commissioned in February 1975. Primary effluent is discharged to the Pacific Ocean at the cliff face through submerged outlets.

The Board recognises that the discharge of primary effluent at the cliff face may not meet receiving water quality criteria established by the State Pollution Control Commission (SPCC) of NSW and therefore some augmentation of the treatment and disposal systems may be required.

The deepwater submarine outfall disposal concept is one of various options to be considered by the Board which may be required to meet long range receiving water quality objectives. In 1971 the Board commissioned Caldwell Connell Engineers to study the feasibility and cost of constructing deepwater submarine outfalls³. The study comprised over four years investigation of physical, chemical, and biological conditions at a number of possible deepwater submarine outfall sites offshore from Sydney. Conceptual and

The Board also provides water service to about 3.2 million persons within the metropolitan and adjacent areas. The unsewered population, representing approximately 8 percent of the population served by water, resides in sparsely populated areas which are expensive to sewer, or in built-up areas to which sewer extensions have yet to be constructed.

The Board's sewerage systems consist of separate sanitary sewers; that is, sewers intended for waste flows from domestic, commercial, and industrial sources, but not for storm water flows. However, the earliest sewers in the City of Sydney, now in the Bondi Ocean Outfall System, were constructed as combined sewers for conveyance of both sewage and storm water, but these are gradually being separated in the course of a continuing programme. Although the Board's systems are generally considered to be separate, ingress of some surface water does occur during periods of excessive rainfall.

It should be noted that this situation is not unique to the Sydney area. Almost all major sanitary sewerage systems in the world are faced with problems of a similar nature.

The Malabar system is the largest operated by the Board and serves a population in excess of one million persons. It is described in the next chapter. The Fairfield, Liverpool and Glenfield WPCP's, which can be seen in Fig. 1 near the western boundary of the Malabar catchment, are also relevant to this report because of a proposal for dry weather flow from these plants to be pumped to the Malabar system. This proposal is discussed in the next chapter.

1.3 OBJECTIVES OF THE ENVIRONMENTAL IMPACT STUDY

The responsibility for municipal sewage collection, treatment and disposal includes an obligation to dispose of the effluent and solid residues in a manner which will protect public health, prevent nuisances from occurring at the points of treatment and disposal and, in the case of effluent disposal, maintain receiving water quality consistent with beneficial uses. The objectives of this study are: (1) to describe the environmental impacts of the Malabar WPCP; (2) to examine the various options available to the Board which may be required to meet water quality criteria, and (3) to prepare an Environmental Impact Statement covering the WPCP in accordance with the applicable provisions of the NSW State Pollution Control Commission's Environmental Standard EI-4 "Principles and Procedures for Environmental Impact Assessment in NSW"⁵. Caldwell Connell Engineers was authorised by the Board in its letter of 11 April 1975 to undertake the study and prepare this report.

1.4 SCOPE OF THE STUDY

In developing the scope of the environmental impact study, it was recognised that the Malabar WPCP has been in operation since 1974. This situation clearly commits the Board to the existing treatment plant site and precludes any consideration of alternative sites in the investigation. However, the Board has deliberately retained a range of treatment and disposal options which may be implemented, if required, to meet future effluent and receiving water quality criteria.

The environmental impact investigation concentrated on the long range development of the plants. However, options to overcome any significant problems likely to develop in the short term also were examined. Consideration of options to amplify or divert the major sewers in the Malabar system is beyond the scope of this study. However, in preparing this EIS, the conservative assumption has been made that the Malabar WPCP

CHAPTER 2

MALABAR SEWERAGE SYSTEM

This chapter describes the Malabar catchment and major sewers and presents projections of population, industrial growth and sewage flows and loadings.

2.1 MALABAR CATCHMENT AND MAJOR SEWERS

The Malabar WPCP is the largest water pollution control plant in the metropolitan area of Sydney, and is designed to treat domestic and industrial sewage from the Southern and Western Suburbs Ocean Outfall Sewers (SWSOOS). The sewerage catchment area, with a population of over one million persons, extends over suburbs south and west of Sydney, as shown in Fig. 2, and contains a substantial portion of the industrial areas of the metropolis. About 90 percent of the area tributary to the Malabar WPCP is now developed. This system will ultimately serve an area of 31,000 hectares.

As shown in Fig. 2, three sewers flow into the Malabar WPCP: SWSOOS 1, SWSOOS 2 and the Coogee Diversion Sewer. SWSOOS 1 and 2 serve the area south and west of Sydney. The North Georges River submain (NGRS) is one of the main tributaries of SWSOOS 2 and extends westwards along the north side of the Georges River. The Coogee Diversion Sewer collects sewage from the Randwick area.

2.2 POPULATION AND INDUSTRIAL GROWTH

Population growth and predictions for the Malabar catchment used in this investigation were compiled by the Board for future planning. During dry weather, sewage flows to the Malabar WPCP largely comprise domestic sewage and industrial wastes, and estimates of sewage flows are derived from estimates of population growth and industrial development in the catchment. Industrial flows and loadings are often expressed as being equivalent to the flows and loadings from a specified number of resident persons. Thus, the total contributing population is expressed as the sum of a residential population and an industrial equivalent population (EP).

The Board's population growth prediction for the Malabar area is given in Table 1. The ultimate equivalent population in the catchment is almost 1.8 million, corresponding to maximum or saturation development. The residential population is expected to increase from about 70 percent of the total equivalent population in 1980 to about 74 percent at

Table 1 Population Projections for the Malabar Sewerage Catchment

Population	Year				
	1980	1990	2000	2025	Ultimate
Residential	1 030 000	1 050 000	1 070 000	1 120 000	1 300 000
Industrial	450 000	450 000	450 000	450 000	450 000
Total EP	1 480 000	1 500 000	1 520 000	1 570 000	1 750 000

EP = Equivalent Population

In sewerage system design, the Board utilises factors to relate PDWF and DWWF to ADWF. These factors have been determined from records of sewage flows during dry and wet weather conditions compiled over a number of years. For the Malabar system, the Board has defined that PDWF is 1.4 times ADWF; and that DWWF is 3 times PDWF, or 4.2 times ADWF.

The contribution of domestic sources to ADWF can usually be predicted fairly accurately from records of population served and flows. Unit flow factors adopted by the Board for the Malabar System are shown in Table 2. The unit value for ADWF is expected to increase from 250 litre/EP.day in 1980 to 273 litre/EP.day in 1990 and remain constant thereafter.

Table 2 Unit ADWF Factors for the Malabar Sewerage Catchment

Unit ADWF factor	Year			
	1980	1990	2025	Ultimate
l/EP.d	250	273	273	273

l/EP.d = litres per equivalent population per day.

Using the projected populations shown in Table 1, the unit ADWF factors shown in Table 2 and the fact that DWWF is 4.2 times ADWF, the projected ADWF and DWWF from the Malabar catchment have been calculated and are shown in Table 3.

Table 3 Projected Sewage Flows to the Malabar WPCP

Catchment	Flow in Year Shown (MI/d)				
	1980	1990	2000	2025	Ultimate
ADWF					
Malabar	370	410	415	425	480
Fairfield ^a	70	100	120	130	135
Liverpool ^a	0	80	95	0 ^b	0 ^b
Glenfield ^a					
Total	440	590	630	555 ^b	615 ^b
DWWF					
Malabar	1550	1720	1750	1800	2000

^aTransfer of part of the dry weather raw sewage from Fairfield WPCP to Malabar WPCP has already been effected. Proposals to transfer dry weather effluent from Liverpool and Glenfield WPCP's to Malabar WPCP are only tentative. In wet weather, transfer of flow from outside catchments to Malabar WPCP ceases.

^bAfter the year 2000 all or portion of the dry weather effluent from Liverpool and Glenfield WPCP's may be diverted from Malabar WPCP to other points of discharge.

flows, because the data used did not include unrecorded overflows. However, Fig. 3 indicates that peak flow during severe wet weather exceeds the nominal sewer capacity.

A comparison of the predicted DWWF for the catchment shown in Table 3 and the capacity of the existing sewers indicates that the system requires augmentation to provide for future peak wet weather flows. Because any augmentation schemes will be extensive and costly, the Board has undertaken investigations and comparisons of alternative proposals to determine the most cost effective and environmentally acceptable long range plan.

Two alternatives are currently being considered by the Board: (1) amplification of the existing SWSOOS system; and (2) partial diversion of flow from the southern and western catchments to a new interceptor sewerage system discharging to the ocean south of Sydney. No further expansion of the existing sewer would be required should the interceptor scheme be adopted. However, as noted in Chapter 1, evaluation of options for the interceptor scheme is beyond the scope of this study and it will be assumed for this Environmental Impact Statement that all catchment sewage flows will be conveyed to the Malabar WPCP.

Table 4 Malabar WPCP Loadings and Performance

	Design Criteria Stage 1		Present flows with WPCP Stage 1 treatment facilities ^a		Predictions for year 2025	
Flows, ML/d	250		400		555 ^c	
Average dry weather flow	1 100 ^b		1 100 ^b		1 800	
Design wet weather flow	mg/L	t/d	mg/L	t/d	mg/L	t/d
BOD ₅						
Influent	535	130	310	124	380	210
Effluent, excl. digested sludge	400	100	230	92	290	160
Effluent, incl. digested sludge			255	102	315	170
Suspended Solids						
Influent	520	130	300	120	320	180
Effluent, excl. digested sludge	180	45	160	64	180	100
Effluent, incl. digested sludge			255	102	275	150
Grease						
Influent	130	32	100	40	120	65
Effluent, excl. digested sludge	50	12	60	24	70	40
Effluent, incl. digested sludge			70	29	80	45
Phosphorus-P						
Influent			9	3.6	10	5.6
Effluent			8	3.2	9	5.0
Nitrogen-N						
Influent			35	14	40	22
Effluent			32	13	36	20
Faecal Coliform MPN/100 mL						
Influent			40 × 10 ⁶		40 × 10 ⁶	
Effluent			30 × 10 ⁶		30 × 10 ⁶	
Removal Efficiencies %						
BOD ₅	25		25		25	
Suspended Solids	65		45		45	
Grease	60		40		40	
Phosphorus-P			10		10	
Nitrogen-N			10		10	
Faecal Coliform			25		25	

^aPresent concentrations based on laboratory reports.

^bHydraulic capacity of existing works.

^cFlow includes contributions from Fairfield catchment but not from Liverpool or Glenfield WPCP's.

CHAPTER 3

MALABAR WATER POLLUTION CONTROL PLANT

This chapter describes the design, treatment process and performance of the Malabar water pollution control plant. Construction of the plant began in 1959 and it was completed in 1974 at a cost in excess of \$50 million and commissioned in February 1975.

A particular feature of the Malabar WPCP is that most of the treatment facilities have been constructed below ground in order to minimise the visual impact of the plant. The digesters, the air and water reclamation facilities and the administration, chlorination and incineration buildings are all above-ground structures. The visibility and appearance of the WPCP are discussed in Chapter 4 of this report.

3.1 DESIGN CAPACITY

The design provided for the primary sedimentation treatment units to be built in two stages: Stage 1 with a ADWF capacity of 250 MI/d and a hydraulic capacity of approximately 1100 MI/d. Stage 2 would approximately double the capacity of the plant.

At present, the Malabar WPCP is operating at an ADWF of about 400 MI/d which represents a hydraulic loading 60 percent greater than the value assumed in design. Present wet weather flows use the full hydraulic capacity of the plant.

3.2 FLOW DIAGRAM AND DESIGN DATA

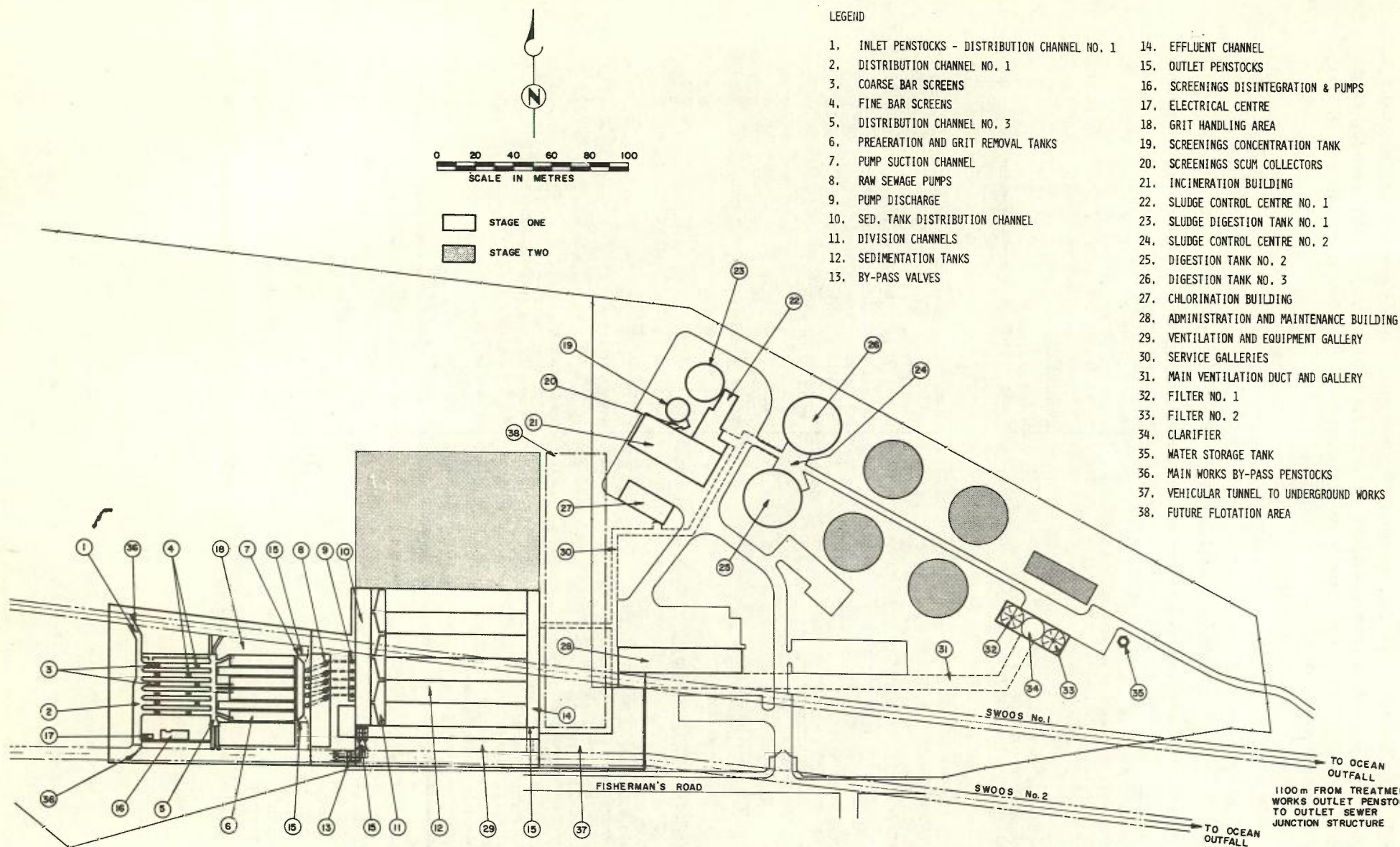
The flow diagram for Malabar WPCP Stage 1 is shown in Fig. 4. The design data for Stage 1 operation are shown in Table 5. Stage 1 development of the plant involved six primary sedimentation tanks, three raw sewage pumps, three digesters and one screenings and scum incinerator. The ultimate screening and preaeration facilities were constructed as part of Stage 1 due to layout requirements. Stage 2 development was planned to involve six additional primary sedimentation tanks, two additional raw sewage pumps, four additional digesters, water and air reclamation facilities and an additional screenings and scum incinerator. The construction of a submarine outfall was planned to follow Stage 1. Air floatation tanks may be provided if further treatment is required to ensure adequate removal of grease, oil and other floatable solids. The plant layout for Stage 1 and ultimate development of the Malabar WPCP is shown in Fig. 5.

3.3 STAGE 1 TREATMENT PROCESSES

The present plant (Stage 1) covers an area of approximately 8 ha of a total site area of approximately 16.2 ha. Information on equipment sizes, capacities and the like are provided in Table 5. Hence only a brief description of the treatment processes is required here. The various process units can be grouped as listed below.

Underground Works. Inlet structures and control centre; screening, preaeration and grit removal; main pumping station, sedimentation; effluent and outfall structure.

Surface Works: Control centre; administration and maintenance blocks; digestion and incineration area, including sludge and gas handling facilities, dewatering equipment for screenings, grit and scum incinerator and boiler houses; chlorination plant; water reclamation and odour control facilities.



Effluent Control Valves and Flow Metering. Settled sewage leaves the sedimentation tanks in submerged effluent collectors and flows to the plant effluent channel. The level in the sedimentation tanks is controlled by butterfly valves located in the outfall conduit. Two sets of effluent control valves are provided, one set being a complete standby for the other. Each set consists of a 750 mm and a 180 mm diameter butterfly valve mounted in parallel. The control valves are located in inverted siphons so that they always operate with both an upstream and downstream positive pressure. Two electrically operated penstocks located at the confluence of the sedimentation effluent channel and the plant effluent channel may be used to by-pass the settled sewage directly to the SWSOOS 2 outfall sewer. These penstocks provide standby back-up for the effluent control valves. The flow is metered upstream of the effluent control valves.

Chlorination. The chlorination plant provides facilities for pre- and post-chlorination of the sewage and for disinfection of reclaimed sewage which is used for various in-plant purposes. Eight evaporator/chlorinator combinations are provided with the necessary chemical feeders and remote ejectors. In addition to odour control, chlorination can be used when necessary to maintain effluent quality.

Sludge Digestion and Disposal. Raw sludge from the sedimentation tanks is pumped through heat exchangers to three sludge digestion tanks. Each tank is provided with circulating sludge pumps, external heat exchangers and gas recirculation facilities. Valves and piping are arranged to allow maximum flexibility in operation, and the tanks can be used as primary, secondary or completely mixed "high-rate" digestion tanks. The digested sludge is screened to remove debris and floatables, the screened sludge discharged to the ocean through SWSOOS 2 and the screenings are incinerated. Sludge gas is collected from the digestion tanks and used as a fuel for boiler and incinerator firing. The Board has an additional digester with gas storage capacity under construction.

Incineration. Screenings, scum, and grit are concentrated, dewatered, and incinerated in the seven-hearth incinerator. The auxiliary fuel burners operate on either fuel oil or sludge gas. Incinerator ash is diluted with reclaimed sewage and discharged to the SWSOOS 2 outfall. A second incinerator will be constructed shortly to provide additional capacity to process solids, including screenings imported to Malabar WPCP from other WPCP's operated by the Board.

Ventilation. Provision of adequate ventilation to ensure removal of all hydrogen sulphide from the underground operating areas was a major design consideration. All key areas of the underground facilities are provided with ^{pressured} powered supply and exhaust ventilation. The ventilation system has a number of exhaust points, the major one being through the two hydrogen sulphide scrubbing filters located in the water and air reclamation plant.

Water and Air Reclamation. A water and air reclamation plant is used to treat sufficient primary effluent for reuse within the plant and to scrub exhaust foul air. Primary effluent is recirculated through two filters. Exhaust air is introduced at the bottom of the filters and the purified air extracted at the top. The reclaimed water is used for various plant uses where high quality water is not required, such as washing-down and flushing.

Service Systems. The plant is provided with various service systems including compressed air, steam cleaning, heat reservoirs, electrical, instrumentation and emergency power systems.

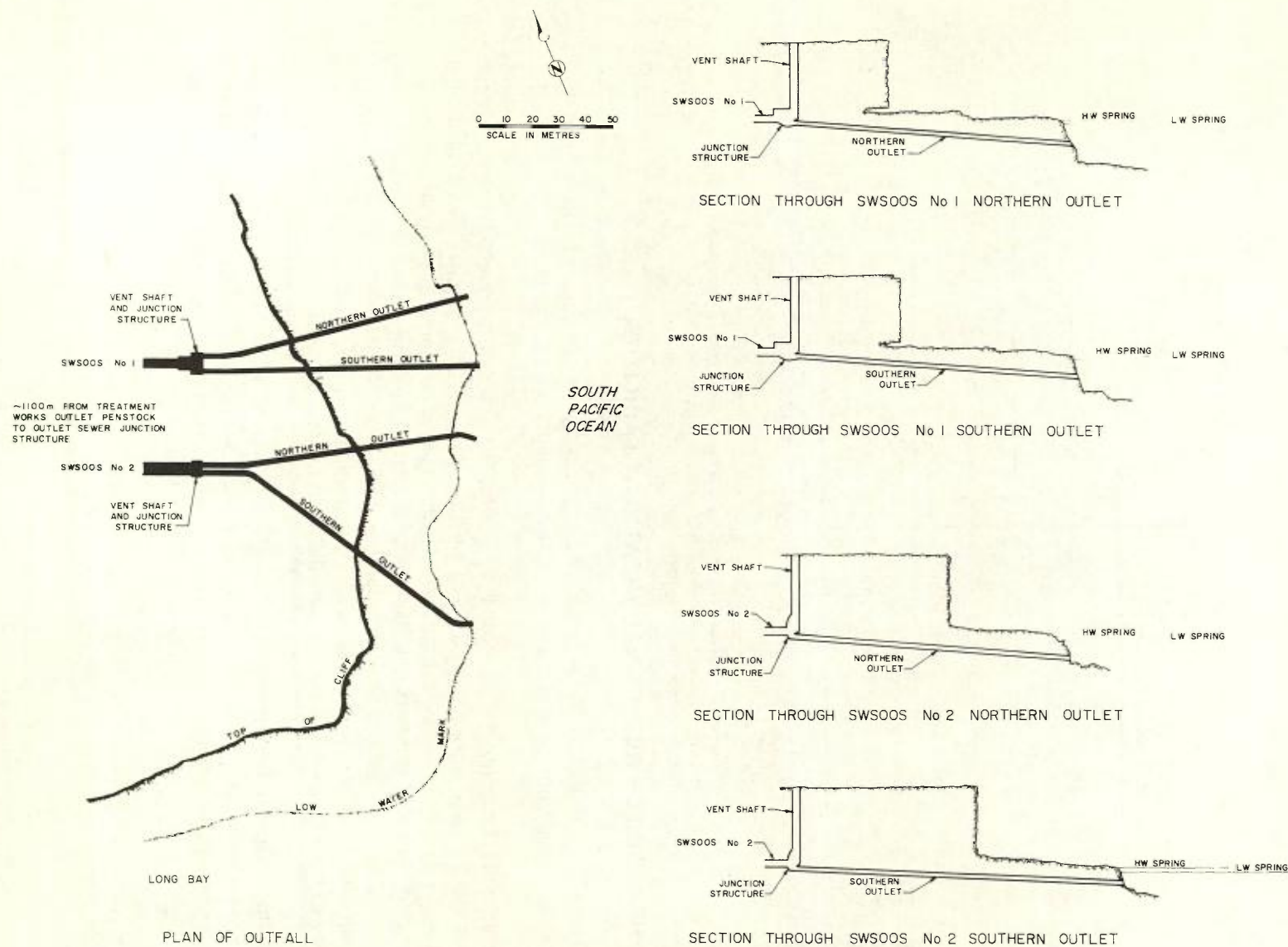


Fig. 6 Plans and Sections of the Existing SWSOOS Outfalls

substantially as the hydraulic loading increases. There is considerable scatter in the results concerning grease removal but floating grease and scum was captured in the tanks with hydraulic loadings much higher than at present. It was also concluded that with sedimentation tanks specifically designed for high hydraulic loading rates, satisfactory floating grease and scum removal would be achieved at even higher hydraulic loadings.

These results indicate that the existing 6 primary sedimentation tanks will be able to capture floating grease and scum under dry weather conditions even with the 43 percent increase in flow predicted up to ultimate conditions (Table 3). Some difficulty is being experienced in removing the captured scum from the tanks under PDWF conditions but this could be overcome by modifying the scum removal system.

In summary, in the short term the scum removal system should be up-graded. The need to provide additional treatment facilities depends on the quality of effluent required, which in turn depends on the effluent discharge option adopted. With this background, various combinations of sewage treatment and effluent outfalls are evaluated in Chapter 7.

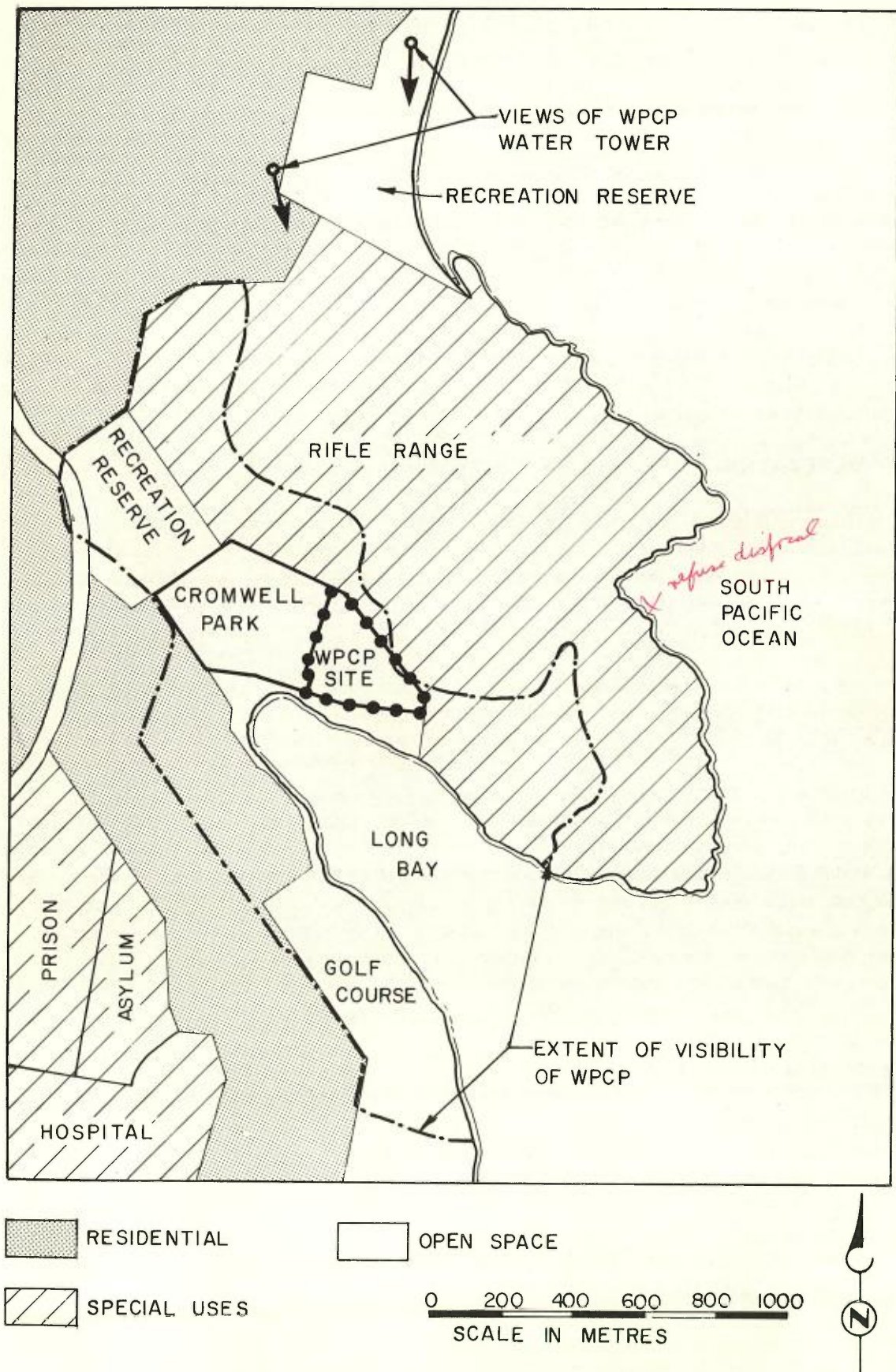


Fig. 7 Land Use Surrounding the Malabar WPCP

residential under the Planning Scheme. This may eventually be developed for residential use by military staff, but development plans have not been prepared. On the northern and western sides of the plant the recreation reserves act as buffers between the plant and the surrounding residential areas. South of the WPCP there are two schools and two major public institutions: Long Bay Prison and Prince Henry Hospital.

4.7 VISIBILITY AND GENERAL APPEARANCE OF SITE

The Malabar WPCP is located in a visual basin that corresponds roughly to the topographic basin surrounding Long Bay. The extent of this area, shown in Fig. 7, indicates that the plant is visible from both residential and recreational areas.

Three residential areas have views across the plant site. The houses on the southern side of Long Bay command clear views of the plant. The plant is also visible from houses facing Anzac Parade about 800 m away, but the recreation reserves lie between them and the site so that the plant only occupies a small part of the field of view. Occupants on the edge of a residential area along Broome Street, about 1 km distant, may also be able to see the plant. This development comprises low rise blocks of flats, and residents on the upper floors should be able to see the plant, although it is not visible from the ground floors. If the vacant land west of the rifle range is developed for flats, those facing east will also have clear views of the plant. The plant is also clearly visible from the clubhouse of Randwick Golf Course, on the opposite side of Long Bay.

The visual impact of the plant depends greatly on the angle from which it is viewed. The tallest structure in the plant is the water tower, which can be seen above the horizon from the hills behind Maroubra Beach, about 3.5 km north of the plant. The rest of the site is visible from most places in the area shown in Fig. 7 but from Malabar Beach and the adjacent reserve only the southern wall of the underground plant area is readily visible. The appearance of the site can be considered in terms of the form of the existing treatment works and the effect of landscaping activity on the site.

Operating Plant Areas. Many parts of the existing plant are buried under a newly created land surface, but some structures are exposed. Except for the water tower and the southern wall of the underground works all structures are of low profile, being either single storey buildings or low concrete structures such as digester rims and covers. The buildings have dark brown textured brick exterior walls, concrete roof facias and flat concrete roofs. The roads are bitumen surfaced and car parks are located in depressions cut into the sandstone, so that parked vehicles are not readily visible from surrounding areas. The structures and roads generally blend well with the surrounding landscape.

Two features of the plant are readily visible from surrounding areas. The first is the 18 m tall water tower, which is built on the highest part of the site and is clearly visible from the surrounding points. The tower has been painted neutral grey and blends with the surroundings. The second visible feature is the southern wall of the underground works, which is 5.5 m high and 180 m long, and constructed of dark brown brick. The wall dominates views from the shores of Long Bay and Malabar Beach, as it occupies up to 120° of the angle of view from these areas.

Site Landscaping. Landscaping operations are not yet complete, and the site is not as attractive as it should finally be. The construction site has been graded with soil material taken from the site. Top soil was not imported, and the ground surface left after grading consisted of sandstone outcrops, broken rock and sand, forming a poor and unstable base for plant growth. Landscape planting on the site has concentrated on the use of native

CHAPTER 5

RECEIVING WATERS

The component of the environment most likely to be affected by the Malabar sewage treatment and disposal operation will be the receiving waters, i.e., the Pacific Ocean in the region offshore from the Sydney coastline. This chapter discusses various aspects of the marine environment in the vicinity of the present outfalls. Beneficial uses of the water body and coastline are defined, then water quality criteria required to maintain these uses are outlined. The physical and physico-chemical processes in the water body are then described, and the biological characteristics of the water body reviewed. The impacts of present and future discharges from the Malabar WPCP on water quality are considered in Chapter 6.

5.1 BENEFICIAL USES OF THE OCEAN AND NEARSHORE WATERS

Beneficial uses were established for the Sydney coastal waters in the report on the Submarine Outfall Studies³, they apply in the vicinity of Malabar outfall. The water quality criteria presented in Section 5.2 are designed to protect these beneficial uses.

Recreational Use

The waters of the Pacific Ocean and the harbours and bays adjacent to the Sydney Metropolitan Area constitute one of the area's most valuable recreational assets. Virtually the entire ocean shoreline from Botany Bay to Broken Bay is used to some extent for recreational purposes. The important uses are pleasure boating, swimming, surfing, skindiving, and fishing. The present growth in recreational use of the shoreline and nearshore waters is expected to continue at a faster rate than the rate of population growth. Impairment of this use would be a serious aesthetic and economic loss to the region.

To maintain the amenity of recreational waters, waste disposal should be accomplished without modifying the physical appearance of the water, producing odours or creating a public health hazard. Physical appearance is influenced by water turbidity and colour, the presence of an oil or grease film on the water surface and accumulation of solids. Odour production may result from the discharge of wastes which are not rapidly diluted with seawater. Bacterial contamination may be present without any visual evidence of sewage.

Fisheries Production

The waters of the Pacific Ocean support fish and other marine life, and are fished both commercially and for recreation. Rock fishing is a popular sport; Malabar Head is a particularly popular location, and fishing directly in the effluent field is common. Principal species of game and commercial fish taken in the ocean adjacent to Sydney are mullet, tuna, morwong, flat-head, Australian salmon and schnapper.

The maintenance of suitable conditions for fisheries production depends on a wide range of factors including the availability of food, shelter and adequate levels of dissolved oxygen. Providing that dissolved oxygen concentrations do not fall below approximately 5 mg/l, the discharge of sewage to ocean waters will not harm fisheries and can lead to localised increases in fisheries production due to the input of organic matter and nutrients.

(b) **Restricted Substances.** The maximum concentrations of restricted substances in the effluent-seawater mixture after initial dilution should not exceed those values listed in Table 7. This initial dilution is achieved in a limited area adjacent to the discharge, termed the 'initial dilution zone'.

Table 7 Criteria for Ocean Discharge of Restricted Substances

Substance	Maximum allowable ^a concentration at boundary of initial dilution zone, mg/l
Arsenic	0.1
Cadmium	0.2
Total chromium	0.02
Copper	0.2
Lead	0.1
Mercury	0.001
Nickel	0.1
Silver	0.02
Zinc	0.3
Cyanide	0.2
Phenolic compounds	0.5
Total chlorine residual	1.0
Ammonia (expressed as N)	5.0
Total Identifiable chlorinated hydrocarbons	0.002

^aThe significance of these values relative to effluent concentrations is discussed in Chapter 9.

(c) **pH and Dissolved Oxygen.** The pH value of the effluent should not be less than 6.5 or more than 8.5. The discharge should not induce a variation in the pH of more than 0.1 in any waters outside the initial dilution zone. The discharge should not induce a variation in dissolved oxygen of more than 0.2 mg/l in any waters outside the initial dilution zone.

(d) **Bacteriological.** The SPCC Criteria for bacterial conditions was adopted directly, but was amplified in discussions with SPCC staff, and took the following form: 'Protection of Beaches: For these purposes, "beaches" are defined as the sands in the tidal shoreline and the waters adjoining such shoreline extending out to 100 metres from the mean high water shoreline, or to 3 metres in depth whichever is the furthest point, and, where limited by rocky shoreline, to 50 metres beyond either end of such sands. Beaches, or sections of beaches, commonly used for bathing may be designated by the SPCC as "bathing areas". It is considered that all sandy beaches along the Sydney metropolitan coastline will be designated as bathing areas.

For bathing areas, the geometric mean of the number of faecal coliform bacteria resulting from the operation of the proposed outfall is not to exceed 200 organisms/100 ml for any month. This is to be based on not less than five water samples taken during a 30 day period. Additionally, the number of faecal coliform bacteria are not to exceed 400 organisms/100 ml in more than 10 percent of the samples taken in a designated bathing area during the period 1st November to 1st May. This is to be based on not less than 30 samples taken within this six month period.

*long for offshore are we
talking about*

The predominant direction of water movement in the study region is southerly, tending towards southwesterly during the autumn and winter. Current velocities tend to be highest in summer and lowest in spring, and generally increase as the water moves south from North Head to Malabar.

Stratification. Both temperature and salinity affect density, although offshore from Sydney temperature differences are usually of more importance in causing stratification due to the small variation of salinity with depth. The factors influencing the ocean's temperature include large scale effects such as deep ocean currents and upwelling, and nearshore or local effects such as seasonal heating and cooling. Solar heating at the surface is a major cause of stratified conditions during the summer because of the lower density of the warmer surface layer. Loss of stratification typically occurs in the May — June period when surface cooling causes an increase in surface density, and mixing can occur readily throughout the depth.

Turbulent Diffusion. After the effluent plume has stopped rising, subsequent dilution occurs due to turbulent diffusion. The rate of dilution may be characterised by a diffusion coefficient which is dependent upon local conditions, and was determined by diffusion studies conducted in the study area by release of dye and monitoring its concentration and movement.

Physico-Chemical Factors

Extensive field studies of several physico-chemical parameters were made during the three year period, 1972 to 1974 to define the pre-discharge baseline conditions. This information can then be compared with conditions occurring after commissioning of an outfall, to assess the impact of the outfall on the regional water quality. The four physico-chemical characteristics considered were water clarity, dissolved oxygen (DO), hydrogen ion concentration (pH), and nutrient levels.

Water Clarity. The Secchi disc method was used for water clarity measurements. Clarity is reduced by increased concentrations of suspended solids including plankton and therefore may be affected by waste discharges. In any given location, clarity varies with time over a wide range. Minimum clarity values of 1 m were obtained near the existing outfalls, but in general, the results indicated that sea water in the region is clear and comparable with average coastal conditions. Annual mean values in the range of 10 to 14m were obtained throughout the region offshore from Sydney.

Dissolved Oxygen. Dissolved oxygen (DO) concentrations in coastal waters are influenced by many interrelated physical, chemical and biological factors. Supersaturated conditions near the surface were common during the summer due to photosynthetic activity and wave action. Minimum DO levels were nearly always associated with stratified conditions in the November — March period. When stratified conditions persist over an extended period, the DO in the lower zone is progressively depleted by biological respiration. The occurrence of DO readings of 5.0 mg/l or less was investigated as this represents the minimum desirable DO level in the receiving waters. These occurrences were generally less than one percent of the readings in all areas, with the exception of Malabar where the value was about two percent. No DO readings below 4.0 mg/l were recorded.

Hydrogen Ion Concentration. The hydrogen ion concentration (pH) in the ocean environment tends to be stable, and the ocean's natural buffering capacity prevents any marked shift as a result of local discharges. Consequently, pH is of relatively minor importance in this study other than to establish background values.

solids concentration, as these factors influenced the amount of light reaching the seabed. There was a compensating increase in the population of suspension feeding animals and their associated carnivores with increasing depth and suspended solids concentration.

The effect of depth on the community structure at North Head and Long Reef is by a decrease in the percentage cover of algae with increasing depth as well as a change in the species composition and type of algae present. As the cover of algae decreased with depth the area covered by sponges, polyzoans and coelenterates increased.

Benthic Communities of Soft Bottom Areas. Studies of the biology of sedimentary or soft bottom areas were concentrated in a zone offshore from Malabar, with some additional sampling offshore from North Head. The studies were designed to obtain data on the structure of the benthic community in the soft bottom area and to document seasonal changes in both numbers of individuals and species.

The major groups of animals found in the soft bottom studies at Malabar and North Head included solitary corals, sipunculins, polychaetes, crustaceans, echinoderms, molluscs, ascidians and fish. Over 400 species were collected during the soft bottom studies and considerable differences in the diversity and abundance of organisms collected at adjacent sampling stations were often observed. These changes appeared to be primarily related to the characteristics of the sediments, including particle size distribution and organic content. Of the 215 mollusc species identified, 119 were carnivores, 65 were suspension feeders, 21 were deposit feeders, 9 were ectoparasites and one was a commensal. The deposit feeding component was proportionately larger when both the mud fraction and the organic carbon content of the sediments was high.

Baseline studies of the population dynamics of selected organisms were undertaken to provide information on the stability of biological communities and to form a basis for evaluating the biological effects of changes in the marine environment.

Fish. The fish fauna of the mid-New South Wales coastal waters is recognised as transitional between tropical and temperate water faunas. Because of this, the area supports both tropical and southern fishes. Many of the species found in waters off the coast of South Queensland and New South Wales reach their greatest abundance here. These species, and others which are restricted to the region, represent the characteristic warm temperature fish fauna in the area.

The surveys of fish inhabiting rocky bottom areas were conducted by SCUBA divers at North Head, and soft bottom areas off Malabar were sampled by trawling. A total of 74 species of fish were observed in the rocky bottom areas. Fifty-seven soft bottom species were collected during the trawling studies; the two most abundant species, Crested Flounder and Bellows fish, were found throughout the year, while the occurrence of Nannygai, the third most common fish, was quite irregular.

Seabirds. The seabird fauna along the New South Wales coast is extremely rich and diverse. Fifty five species are known from the area between South Head and Marley Head, and at least another ten are known to inhabit the remainder of the New South Wales coastal region. Particulate matter discharged from the Malabar and North Head outfalls has attracted large numbers of seabirds, primarily Wandering Albatrosses, Northern Giant Petrels, Southern Giant Petrels and Silver Gulls. The introduction of primary treatment at Malabar reduced the discharge of larger particles, thus rendering the effluent less attractive to seabirds.

The die-off rates are usually expressed by a T-90 value, which is the time required for faecal coliform densities to decrease by 90 percent under constant conditions. T-90 values were calculated on an hourly basis from the test results and the result confirmed the existence of a diurnal variation as shown in Fig. 9. It should be noted that the T-90 values shown in Fig. 9 represent the rate of coliform die-off, not the absolute change in density. Thus a T-90 value of 5 hours at 8 am means that the rate of die-off at that hour would, if continued for 5 hours, reduce the faecal coliform density by 90 per cent. In practice, it is not possible for this die-off rate to remain constant for 5 hours: the rate generally changes from hour to hour, as can be seen in Fig. 9. The high T-90 values measured during the early hours of the morning indicate that an allowance must be made for the slow rate of die-off during these periods. Further field studies carried out during 1978 in the existing effluent fields have confirmed that the T-90 values shown in Fig. 9 may be conservatively applied to outfall design.

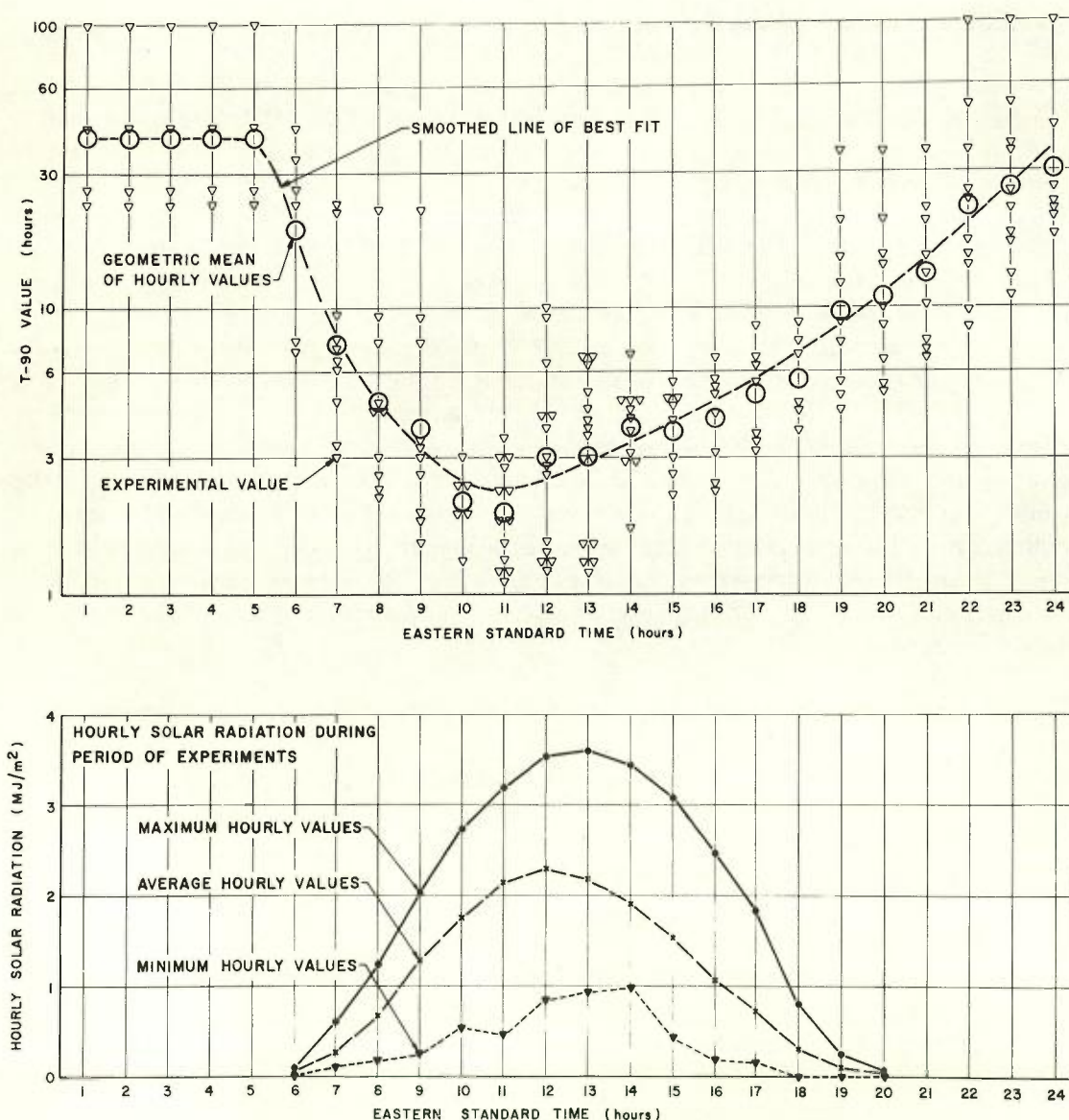


Fig. 9 Summary of Hourly Variation in T-90 Values and Solar Radiation

sampling were not determined, the chloride concentrations of the sewage-seawater mixture provides the only available basis for determining initial dilutions, assuming that the chloride concentration in the effluent is negligible in comparison with seawater. Dilutions at the surface calculated on this basis using averaged values for all runs are shown in Fig. 11. Initial dilution at the surface in the "boil" area adjacent to the discharge point is about 8:1. The dilution approaches 40:1 at a distance of about 1000 m from the discharge point.

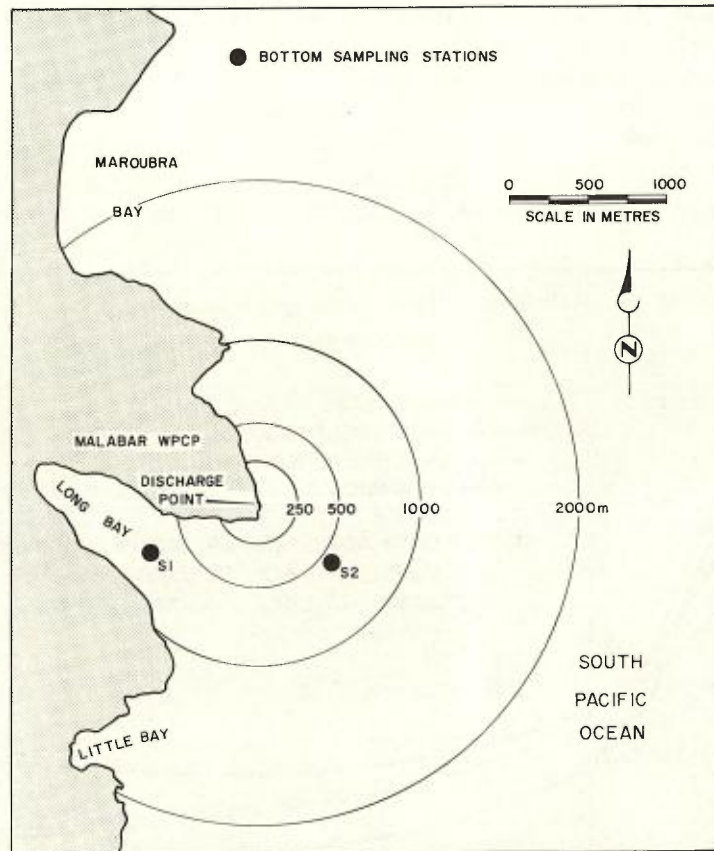


Fig. 10 Distance Contours from the Malabar Discharge Point

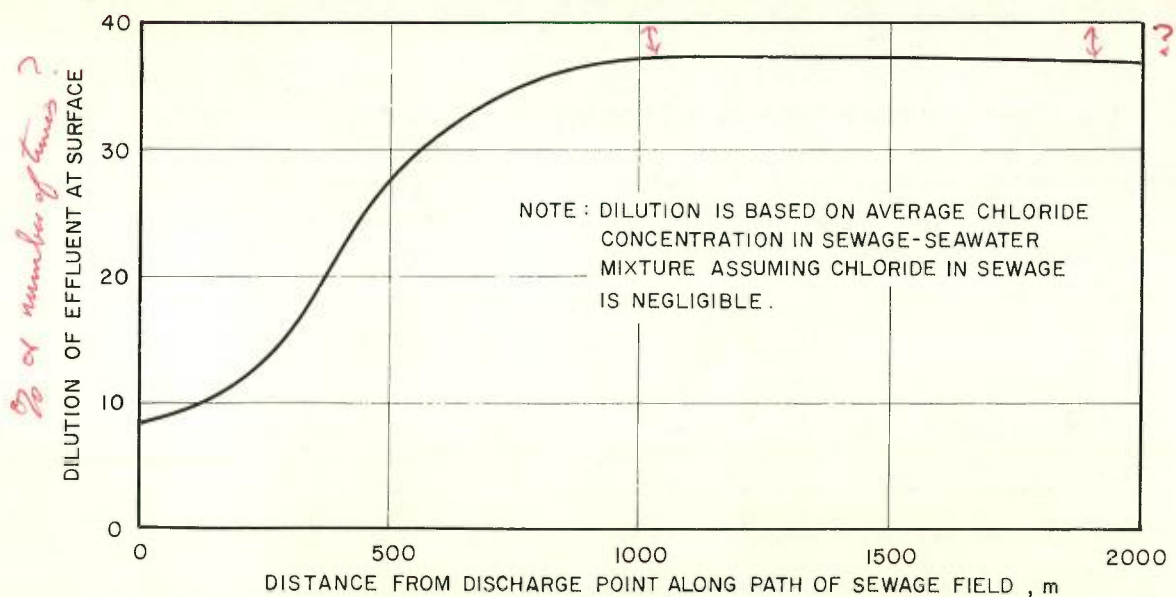


Fig. 11 Dilution in the Malabar Sewage Field based on Chloride Concentration

6.2 BEACH POLLUTION

A potential major impact of effluent discharge in the ocean arises from return of pathogens and floatables to the shoreline and beaches. Such contamination poses both a potential public health risk and an aesthetic nuisance. The degree of contamination is affected by the type of treatment, location of the effluent discharge and oceanographic conditions prevailing in the discharge area.

Two measures applied as indices of sewage pollution are the density of faecal coliform organisms in bathing waters and the concentration of grease in beach sand. In the case of waters used for recreational purposes, very little evidence is available relating faecal coliform density to the incidence of water borne disease. A specific faecal coliform limit does not distinguish between safe and hazardous recreational waters but rather is intended as a desirable goal for water quality management. Water quality criteria for faecal coliform organisms were presented in Chapter 5.

The second measure of sewage pollution is the concentration of grease in beach sand, which gives a better indication of aesthetic nuisance than faecal coliform counts. Grease deposits create unpleasant conditions for beach users, and require the Board and foreshore Councils to carry out beach cleaning operations. The preliminary design studies described in the Report on the Submarine Outfall Studies show that faecal coliform density is the critical parameter determining the design of the Malabar outfall; i.e. if beach faecal coliform requirements are attained other requirements will also be met.

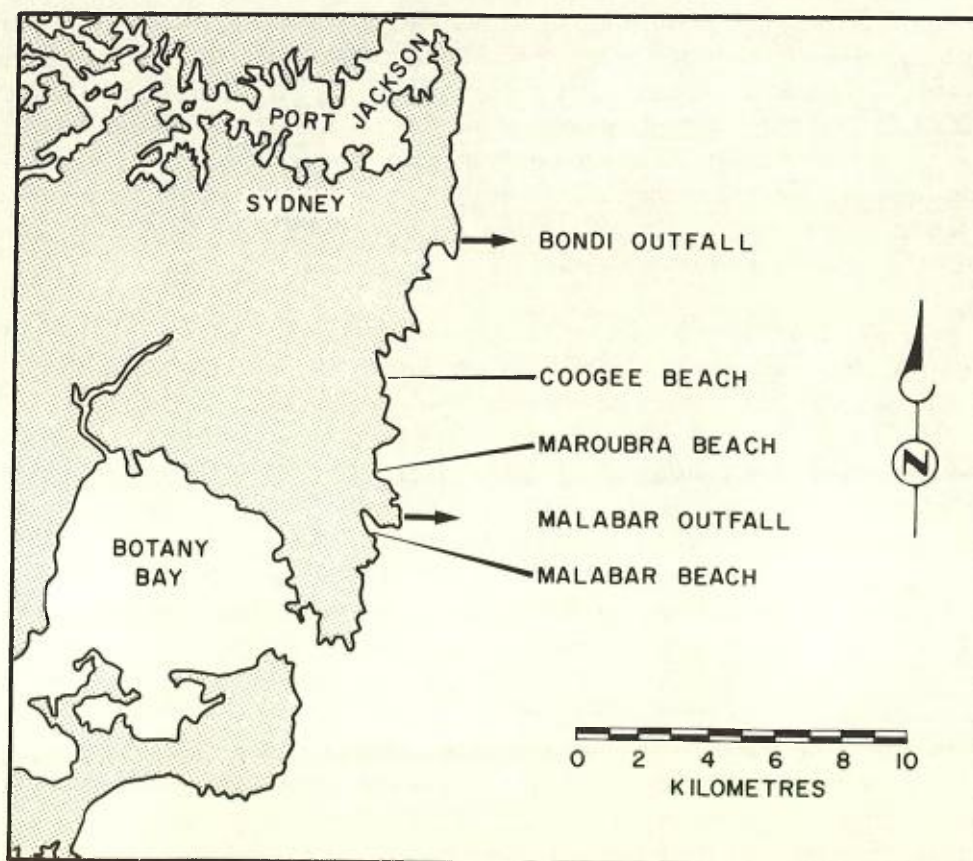


Fig. 13 Location of the Malabar Outfall and Surrounding Beaches

swimming and signs warning of possible contamination by sewage have been placed around the beach by Randwick Council.

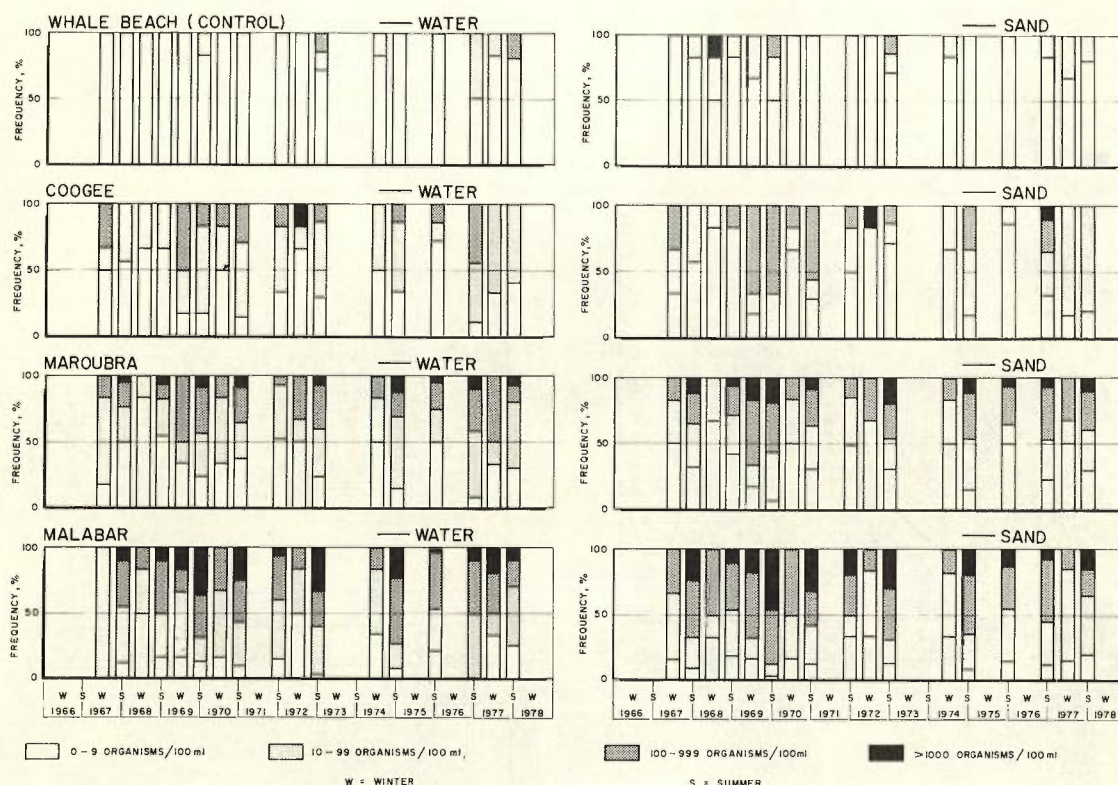


Fig. 14 Faecal Coliform Levels at Beaches near the Malabar Discharge 1967 to 1978

Grease Concentrations. The average and maximum grease concentrations for these beaches are shown in Fig. 15. The difference in grease concentrations with season is the strongest trend in this data, with summer concentrations usually 10 to 100 times greater than those occurring in winter. This also is probably due to the frequent occurrence of onshore sea breezes during the summer months.

By comparing different summer peaks or winter troughs the differences between beaches becomes apparent; the values for Coogee generally are only slightly higher than those for Whale Beach, with higher concentrations at Maroubra and Malabar on most occasions. Commissioning of the Malabar WPCP in 1975 does not appear to have caused any substantial reduction in summer grease levels.

Visual Appearance

Since commissioning of the Malabar WPCP, visual pollution by sewage solids has decreased significantly at both Malabar and Maroubra beaches as indicated by the comments contained in the Beach Pollution Reports. In addition, Board's records indicate that the amount of contaminated sand required to be removed from the beaches has been substantially reduced.

6.3 SEDIMENT CHARACTERISTICS

The organic content of bottom sediments is an index of the availability of food for deposit feeding organisms. In 1974, organic levels in the sediments, expressed in terms of the proportion by weight of volatile solids, were 7.5, 6.2 and 2.2 percent at sampling stations located approximately 2, 2.5 and 3.5 km respectively from the outfall in a generally southwest direction. In 1975, following commissioning of the plant, additional sediment samples were collected by the Board at two sampling stations located closer to the discharge point (Fig. 10). The mean levels of volatile solids for both stations was 1.3 percent. These results suggest that the organic component of sediments in the vicinity of the outfall has decreased following commissioning of the WPCP.

Other observations of bottom conditions tend to support this conclusion. Sediment samples collected prior to the operation of the WPCP in the vicinity of stations S1 and S2 (Fig. 10) identified some areas of anaerobic sediments which occurred during brief periods of very low water velocities. However, evidence of these sludge accumulations was rarely observed, indicating that they were readily dispersed by the prevailing bottom currents. A series of five jump camera surveys of the seabed at stations S1 and S2 between September 1975 and March 1976 failed to detect any sludge deposits.

6.4 MARINE BIOTA

As described in the preceding chapter, studies of the biology of sedimentary or soft bottom areas offshore from Malabar were conducted by the Shelf Benthic Survey Team of the Australian Museum as part of the Submarine Outfall Study³. The study was designed to provide a guide to the likely effects of the construction and operation of the proposed submarine outfall on marine biota; however, some information on the influence of the existing shoreline discharge on the marine environment was also obtained.

The overall effect of the discharge on marine biota appeared to be a localised increase in biomass and change in community structure as a direct result of the high organic load from the existing outfall. The most noticeable effect observed was related to the spatial distribution of organisms based on feeding groups. Deposit feeders which gain their food directly from the sediment or from organic layers at its surface tended to dominate in areas with high sediment loads. Suspension feeders were less numerous in turbid water, as high sediment loads tend to block their feeding apparatus.

Benthic Organisms. An investigation of the distribution of molluscs demonstrated a relationship between feeding groups and sediment characteristics. The proportion of sediment feeders in the mollusc assemblage increased, together with the organic content of the sediments, with decreasing distance from the outfall; the proportion of suspension feeders and carnivores was higher and the organic content of the sediments was lower at sites further from the outfall.

Fish. A trawling study was concentrated along the 70 m depth contour level off Malabar. An otter-type trawl with prawn nets of 20 mm mesh size was towed from a commercial fishing vessel, enabling populations of small bottom-living fish and juveniles to be sampled. A total of 57 species was recorded between September 1972 and January 1974. An analysis of the size distribution of the more abundant species did not show evidence of large recruitment throughout the year, although some size and weight class changes were apparent. These fish probably breed throughout the year, showing no outstanding recruitment for any one month. Gravid females were present in samples for all months except June, September, October and January. Breeding may take place closer

perhaps
east.
see page 37
pp 34, 35

which direction

why this
level &
why concentrated

The reconnaissance study aimed to establish whether a detailed investigation of heavy metal and pesticide levels in marine organisms should be undertaken in the vicinity of the outfall, and was carried out under the direction of Caldwell Connell Engineers by the Australian Museum's Shelf Benthic Survey Unit and the Board's Chemical Sub-Branch. The results of the survey are summarised in Table 9; no level of statistical significance can be assigned to the results as only single samples were analysed. The data indicate that the heavy metal and pesticide levels at Malabar were generally higher than those at Marley Head; however, only two samples exceeded the tolerance levels defined by the National Health and Medical Research Council (Table 10): a blackfish collected at Malabar, which had an elevated mercury level, and a tuna which had an elevated lead level. Subsequently, six additional blackfish collected at Malabar by the New South Wales State Fisheries were all found to be well within the NH&MRC tolerance levels, casting some doubt on the validity of the earlier value. The Malabar outfall is not the only major source of lead to the ocean: aerial fallout and runoff from streets are two other major sources.

Sediment samples at a depth of 25 m adjacent to the existing outfall at Malabar contained elevated levels of heavy metals compared with the corresponding Marley Head values. However, apart from zinc, low concentrations of heavy metals were obtained for the 70 m sampling stations at both Malabar and Marley Head. Studies offshore from California⁹ have shown that these metals may not always exist in the ocean in forms toxic to marine organisms. Elevated DDT and DDE levels were found in the sediment at the Malabar 70 m station. Because of the long residence time of pesticides in sediments, these levels could represent the accumulation of past discharges.

The results are encouraging in that they suggest that no serious environmental problem existed even prior to the full implementation of source control of restricted substances. As stated in Chapter 3 the concentration of these substances has been considerably reduced (by up to 50% in some cases) since the initiation of the Board's trade waste control policy in 1972. The concentration of these substances in biota and sediments in the vicinity of the Malabar outfall should, therefore, also be progressively reduced. As discussed in Section 9.5, an ongoing programme is to be undertaken to monitor restricted substances in marine biota to gauge the effectiveness of control measures and to indicate the need, if any, for further measures.

**Table 10 Summary of Tolerance Levels for Heavy Metals
and Pesticide Residues in Foods**

Substance	Recommended level	Foods
Mercury	0.5 µg/g	fish, molluscs, crustaceans
Cadmium	5.5 µg/g	solid foods
Copper	30.0 µg/g	solid foods
Lead	2.0 µg/g	solid foods
Zinc	40.0 µg/g	solid foods
Aldrin	200 ng/g	meat
DDT + DDE	1,000 ng/g	fish
Dieldrin	200 ng/g	meat
Lindane	1,000 ng/g	fish

Source: National Health and Medical Research Council of Australia.
Reports of the 73rd and 75th sessions, held in 1971 and 1972,
respectively.

CHAPTER 7

SEWAGE TREATMENT AND DISPOSAL OPTIONS

As mentioned earlier, the Malabar sewerage system is the largest in the Board's service area and represents a fixed investment of many hundreds of millions of dollars. Also, the system serves heavily populated metropolitan areas in which sewer construction is difficult and causes unavoidable disturbances to normal activity. It is apparent that significant changes to the basic sewerage systems would entail large capital expenditures. Despite these drawbacks, several options involving diversions or system changes are considered in this EIS since they fall within the general context of long term water and wastewater planning.

In this chapter, the various sewage treatment and effluent disposal options are considered in four broad categories: (1) reduced discharge, (2) shoreline discharge, (3) nearshore discharge, and (4) deepwater submarine discharge. A "no change" option which involves continuation of the present practice of discharging primary effluent at the cliff face is discussed in the shoreline discharge group for comparison purposes only (the "no change" option is not capable of meeting water quality objectives). Options for treatment and disposal of sludge are discussed in Chapter 8. In Chapter 9 the "preferred option" for overall sewage treatment and disposal for the Malabar WPCP is identified and the environmental impacts associated with the "preferred option" are examined.

7.1 REDUCED DISCHARGE

The potential of many parts of Australia for development is limited by the availability of water. Hence reuse of treated sewage deserves careful consideration. The major reuse opportunities in Australia are agricultural or landscape irrigation, stream flow augmentation, groundwater recharge, and industrial cooling and process water. Two options for reduced discharge are effluent reuse within the Sydney region and effluent reuse west of the dividing range. A third option for reduced discharge involves diverting raw or partially treated sewage for treatment and disposal at some other location. These three options are discussed below.

(1) Effluent Reuse within the Sydney Region

Owing to the high rainfall in the Sydney region, particularly on the eastern slopes of the Dividing Range, the need for reconditioned water in the Sydney region is low in comparison with many other areas of Australia. At present reuse in the Sydney area is limited to minor irrigation at the Hawkesbury Agricultural College, in buffer areas of the Board's WPCP's, and irrigation of two golf courses using effluent from relatively small plants operated by the Board.

Water-using industries are generally located too far from the present treatment plants for reuse to be economically viable. Industry requires water for a variety of uses, and the water quality required ranges from low quality washdown water to potable grade and even higher. One of the least demanding of process waters is cooling water, but experience has shown that for cooling purposes a high degree of treatment, including effluent filtration and possible nutrient removal, is often required to prevent slime growth on the cooling equipment. In the case of industries located close to the Malabar WPCP, an alternative source of water supply is available from the Botany sand beds, a traditional low cost source of bore water for Sydney. The cost of reclaiming sewage could far exceed that of using this traditional water supply source.

Summary

Significant reduction in sewage flows tributary to the Malabar WPCP is not a realistic option in the foreseeable future.

7.2 SHORELINE DISCHARGE

The existing Malabar outlets are located 8 m below sea level at the shoreline. This section discusses the potential for improving water quality conditions by increasing the degree of treatment while continuing to discharge effluent through the existing shoreline outfalls. Two degrees of treatment are considered: (1) primary treatment, as at present; and (2) secondary treatment.

(1) Primary Treatment (No Change Option)

As noted, primary treatment represents the "no change" option in which treatment and disposal will continue to be carried out as at present. As discussed in the preceding chapter, the "no change" condition does not meet receiving water quality criteria. The effluent field is clearly visible, and beach pollution surveys provide evidence of bacteriological and grease contamination beyond acceptable limits. Chapter 6 provides further information on the environmental impacts of the present discharge at Malabar.

(2) Biological Secondary Treatment

Various methods of biological secondary treatment could be used including the activated sludge process. Conventional air activated sludge and the more recently developed oxygen activated sludge processes should be capable of providing adequate BOD and suspended solids removal for the existing shoreline outfall. The oxygen process using deep tanks could be advantageous from the standpoint of reducing land area requirements.

Provision of secondary treatment could be accomplished by construction of activated sludge facilities to receive settled sewage from the primary sedimentation stage; or by conversion of the primary treatment units to provide biological treatment of screened sewage. These two systems are discussed below.

Secondary Treatment of Primary Effluent. A flow diagram of a plant providing secondary treatment of primary effluent by the conventional activated sludge process and discharging to the existing shoreline outfalls is shown in Fig. 16. Chlorination of the secondary effluent would be required to meet receiving water quality criteria for faecal coliforms: the criteria for other restricted substances could probably be met considering the removals expected for secondary treatment and observed dilution of effluent at the existing outfalls. However, this dilution would probably not be sufficient to prevent visible surface discolouration. Furthermore, as discussed in Chapter 8, digested sludge could not be discharged with secondary effluent through a shoreline discharge. Sludge would have to be dewatered and incinerated.

The present Malabar WPCP site has insufficient land area to accommodate the usual form of secondary treatment facilities. Adjoining land which might be acquired is at a higher elevation and would require extensive excavation, additional pumping or underground construction. In addition, the site is subject to major constraints on large scale land disturbance due to scenic, recreational, and environmental considerations.

It would be very costly to construct and operate a secondary treatment plant of the size of Malabar. As a guide, the estimated construction cost would be about \$150 million. Operating costs for secondary treatment, including energy consumption for oxygenation,

Chemical Treatment

Although chemicals were commonly used in primary sedimentation tanks to improve performance, particularly in the late 1930's and early 1940's this practice was superseded in most cases by the widespread use of biological secondary treatment. Overall standards of treatment with chemical addition and primary sedimentation are not as effective as activated sludge secondary treatment. Renewed interest in chemical treatment has been stimulated by the need for phosphorus removal, particularly using "high lime" treatment in which the pH is raised to the 10.5 – 11.5 range. Alum, iron salts and polyelectrolytes can also be used in chemical treatment of sewage. If major modifications to the primary treatment facilities were not required, this system would avoid the site difficulties applicable to secondary treatment, and could be more competitive with deepwater submarine outfalls than secondary treatment on the basis of capitalised cost of facilities and operation. A flow diagram of the chemical treatment option is shown in Fig. 17.

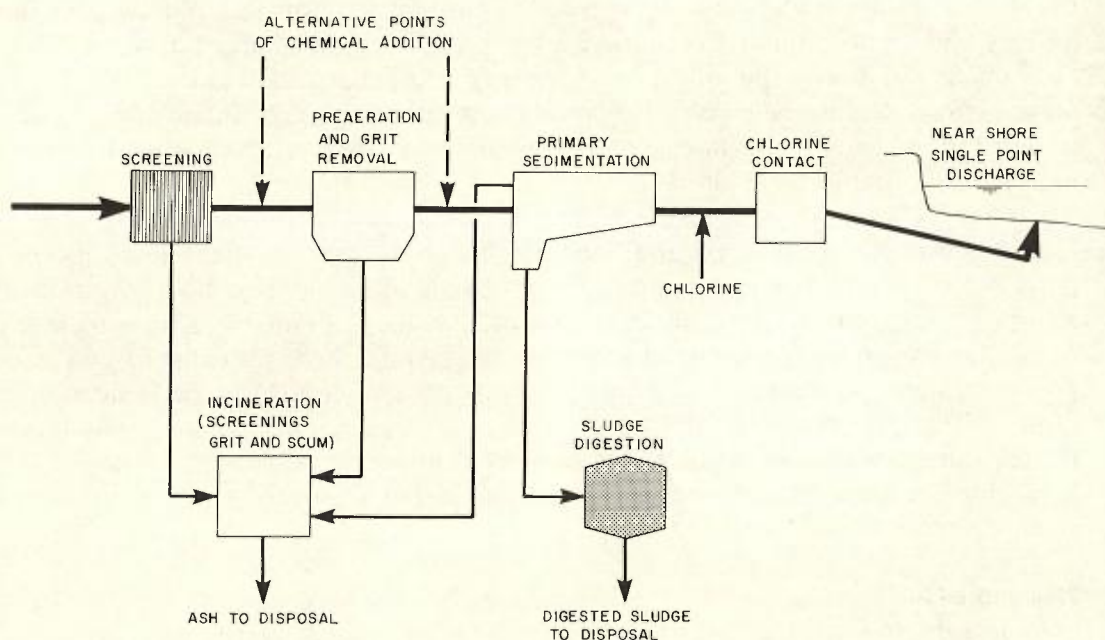


Fig. 17 Flow Diagram of Chemical Treatment Option

Chemical Addition Using Lime. The "high lime" process is most often used where a high degree of phosphorus removal is required, but it also achieves substantial BOD removal and disinfection. To raise the pH to the 11.0 range the lime added must first react with the bicarbonate alkalinity, and in the case of Malabar the required lime dosage (as CaO) would be about 350 mg/l. This represents a lime requirement of about 210 tonnes/day for ADWF in the year 2025. At the cost of about \$60/tonne for lime, chemical cost without lime recovery would be approximately \$13000/day, or over \$4.5 million per year.

The consequence of lime addition to a large primary treatment system which was not specifically designed for this process are far-reaching, with major impacts on solids handling, processing, and disposal systems. Chemical handling, storage, and feeding systems, and pH adjustment provisions following lime treatment are required. The quantity of sludge to be processed is more than doubled, and incineration rather than digestion is the preferred method of stabilising sludge solids because of the high proportion of inert solids. Recovery of lime is generally considered for plants of the size of Malabar. However, as this involves major plant investments in centrifuges, incinerators, and other process equipment, its

viability would require close scrutiny before implementation. Excluding the costs of lime recovery and of sludge treatment and disposal, the capital cost of converting Malabar WPCP to a chemical primary plant is about \$45 million. In this case, because of the major plant modifications that would be required and excessive chemical costs, lime treatment is not considered a feasible option. Capitalised lime costs alone could exceed the total project costs for the deepwater submarine outfall.

Chemical Addition Using Polyelectrolyte. Although not as effective as lime treatment, anionic polyelectrolyte addition can be used to improve suspended solids and BOD removal while avoiding many of the problems inherent in adapting primary treatment facilities for lime addition. Optimal polyelectrolyte dosage must be determined experimentally with the particular sewage involved, but is expected to be of the order of 1 mg/l. Digester capacity must be augmented to accommodate the additional solids, but digester performance is not affected as with lime addition. Effluent disinfection is required, but the improved BOD and suspended solids removal with polyelectrolyte addition renders the settled sewage more amenable to chlorination than is normal settled sewage. Chlorine dosages and contact times to achieve a given bacteriological standard must be determined experimentally, due to the influence of ammonia, suspended solids, dissolved organics, and other factors. A chlorine dosage of 10mg/l and a contact time of 30 minutes at ADWF are assumed to be adequate for faecal coliform reduction to meet receiving water bacteriological requirements after initial dilution.

A schematic profile of the facilities for the chemical treatment option using polyelectrolyte addition and nearshore discharge is shown in Fig. 18. Polyelectrolyte is assumed to be added to the influent pump discharge for rapid mixing, although other points of addition might be considered. Laboratory and possible full-scale experimental work with polyelectrolytes to optimise performance are needed prior to detailed evaluation of this option. This also applies to chlorination since it is necessary to establish optimal dosage and contact times to achieve the necessary level of disinfection. Contact time can be obtained in a chlorine contact tank provided as a part of the treatment plant or in the effluent discharge conduits, access shaft and outfall tunnel.

Nearshore Outfall

The improvement in treatment performance at Malabar WPCP using polyelectrolyte addition cannot be accurately predicted, but would not meet quality criteria if discharged through the existing outlets. For example such an effluent would produce a visible field if discharged near the shore. Thus, it would be necessary to extend the discharge point into deeper nearshore water. If the required dilution can be achieved with a single-point discharge rather than with a multi-point diffuser it may be possible to construct the outfall by a shaft raised from the tunnel to within a short distance of the sea bed as shown in Fig. 18. The rock plug at the top of the raise would be blasted from within the raise, falling to a sump at the bottom of the raise. Good quality rock and absence of appreciable sediment or loose rock on the sea bed are prerequisites for this procedure. The marine work needed to clean up the final excavation and place precast elements or temporary bulkheads to complete the work is of relatively short duration. This should entail significantly less cost and difficulty than the deepwater submarine outfall construction, provided the outlet location is beyond the surf zone and proper care is taken in the design and execution of the outlet details.

At Malabar, the above constraints limit the single point discharge to a location about 500 m offshore as shown in Fig. 18. A location further offshore would encounter deep sediments, and further inshore would encroach into the surf zone. The water depth at this location is approximately 40 m. A dilution approaching 35:1 at the surface could probably

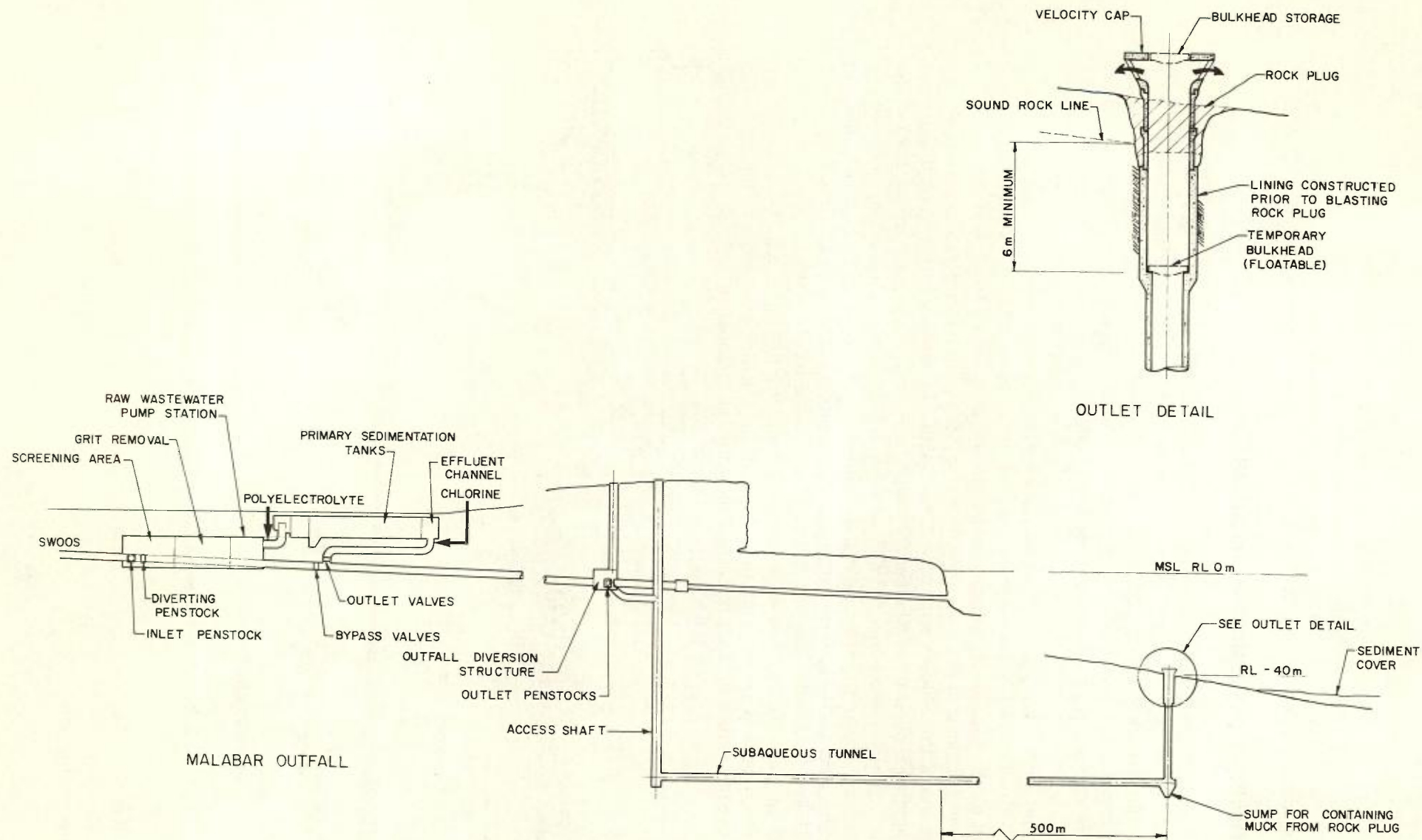


Fig. 18 Schematic Profile of Chemical Treatment Option

be achieved under average conditions for this depth with a single point discharge, assuming an "initial dilution zone" having a radius of 250 m. This dilution would possibly be sufficient to prevent visible surface discoloration. The residence time at ADWF between the sedimentation tank effluent channel and this discharge point would exceed 30 minutes so a separate chlorine contact tank would not be required for adequate disinfection.

7.4 DEEPWATER SUBMARINE DISCHARGE

Ocean disposal of sewage through deepwater submarine outfalls is commonly the method of choice for coastal communities where deepwater is available close to shore. These outfalls are designed to use the physical characteristics of the receiving waters to dilute and disperse wastes so that the marine ecosystem is able to assimilate the additional load without significant adverse environmental effects.

The principle of operation of deepwater submarine outfalls is illustrated schematically in Fig. 19. Effluent is discharge through a series of ports along the diffuser section of the outfall which is generally located normal to the direction of the prevailing currents. The buoyancy of the effluent causes the plume to rise and turbulence associated with the rising plume mixes the effluent with seawater. The density structure of the ocean water in the discharge zone determines whether the diluted effluent will remain submerged or rise to the surface. During the summer months, when normally there is a marked density differential between surface and bottom waters, the effluent field will remain submerged; during the cooler months and following severe storms, when there is little or no density differential, the effluent field will reach the ocean surface. Subsequent dispersion and decay of wastes occurs as the effluent field is transported from the discharge zone by ocean currents. Primary treatment of sewage prior to discharge through submarine outfalls is generally employed to reduce the level of particulate matter and floatables.

but it is warm + fresh?

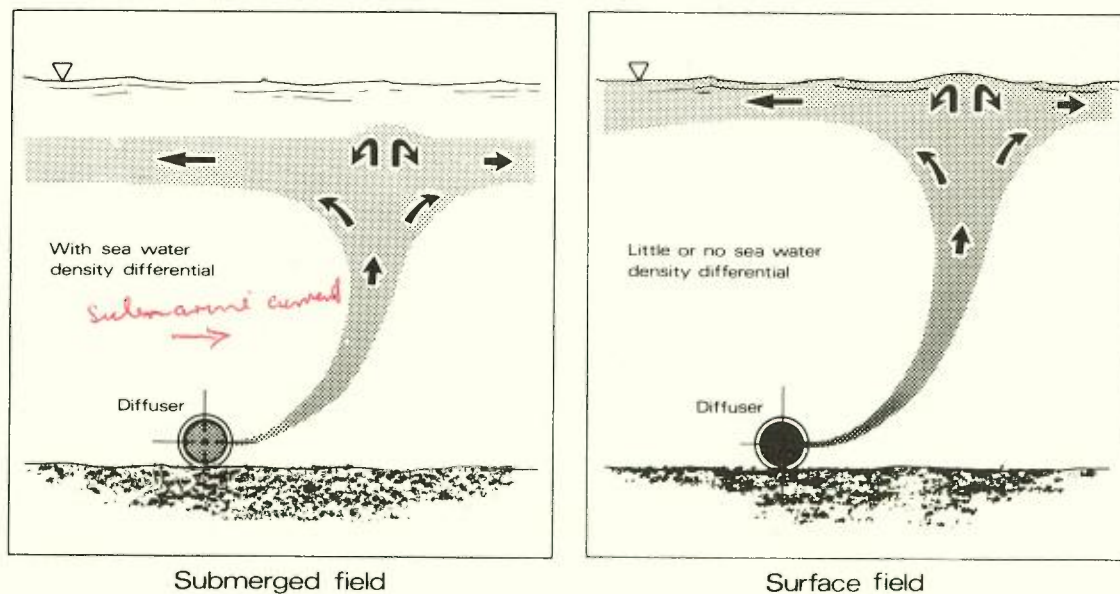


Fig. 19 Schematic Representation of Deepwater Submarine Outfall Operation

The deepwater submarine outfall option was the subject of detailed investigation and preliminary design in the Submarine Outfall Study. A schematic diagram of this option is shown in Fig. 20.

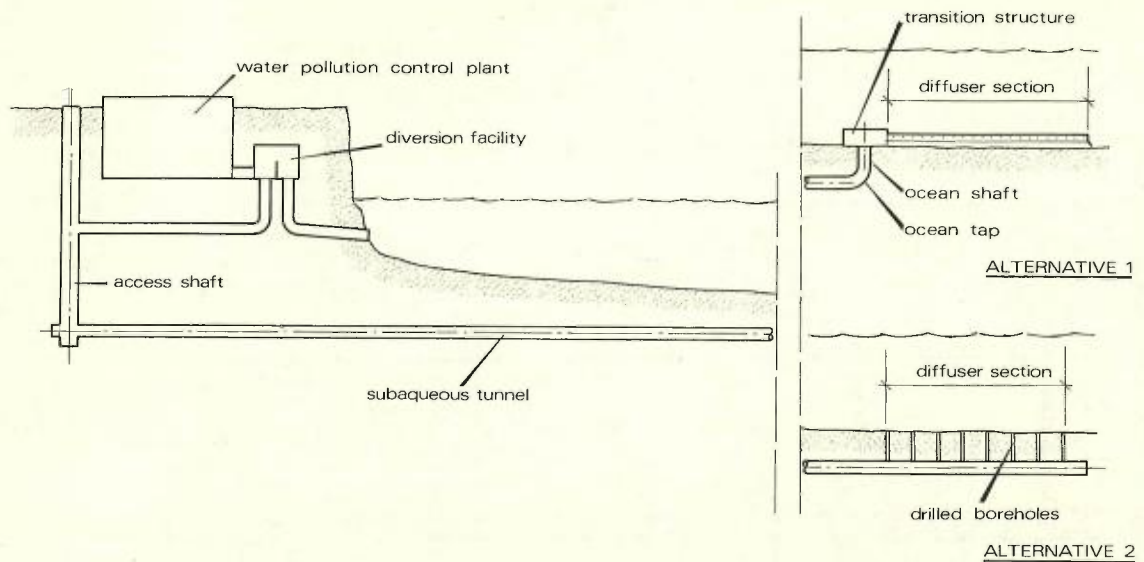


Fig. 20 Schematic Diagram of Deepwater Submarine Outfall Option

As shown in Fig. 20, two alternative deepwater outfall construction methods have been developed. Both involve constructing a tunnel below the ocean floor from the coast to several kilometres offshore. In the first alternative, a vertical ocean shaft would be constructed at the seaward end of the tunnel to connect the tunnel to a diffuser section laid on the seabed. In the second alternative, a longer tunnel would be constructed and a diffuser section created by drilling a series of boreholes to connect the tunnel to the ocean floor. The construction cost, outfall performance and environmental impact are very similar for these two alternatives and therefore it is not necessary to distinguish between them in this EIS.

The preliminary deepwater outfall designs were based on over four years of field investigations of physical, chemical, biological, and geological conditions by the Board's staff and its consultants. It was concluded that it is feasible to construct deepwater submarine outfalls in the waters offshore from Sydney, and that applicable receiving water quality criteria can be met when discharging effluent from primary treatment plants. Total estimated project cost for the Malabar submarine outfall is \$38 million including addition of two sedimentation tanks to cater for ultimate flow.

7.5 COMPARISON OF EFFLUENT TREATMENT AND DISPOSAL OPTIONS

The main characteristics of the options discussed in previous sections of this chapter are summarised in Table 11, which also includes indicative capital, annual operating and total capitalised costs based on ultimate plant capacity. As used herein, "indicative costs" are defined as costs over and above those related to the existing primary treatment plant.

It is apparent from Table 11 that the most economical sewage treatment and effluent disposal option is primary treatment with effluent discharge via a deepwater submarine outfall. As noted previously this option is also capable of meeting water quality objectives

subject to satisfactory arrangements being made for sludge disposal. (In Chapter 8 it will be seen that water quality criteria are still met when digested sludge is discharged with the effluent to deepwater.)

The next most economic option involves nearshore discharge of effluent following chemical treatment by polyelectrolyte. Indicative estimates for capital and annual operation and maintenance costs for these options are compared in Table 12. These costs are based on 1978 construction cost levels, and include the same overhead, risk, profit, contingency and other cost factors as used for developing costs in the Submarine Outfall Report.³ Polyelectrolyte and chlorine dosages were assumed to be 1 mg/l and 10 mg/l, respectively; these values must be established experimentally and could vary significantly from those assumed, with consequent impact on operating costs. No costs are included for disposal of digested sludge.

Table 12. Comparison of Effluent Treatment and Disposal Costs for Chemical Chemical Treatment (Nearshore) and Primary Treatment (Deepwater)

Item	Indicative 1978 costs ^a (\$ million)	
	Chemical (nearshore)	Primary (deepwater)
Capital Costs		
Additional sedimentation capacity	24	10
Polyelectrolyte and chlorine facilities	6	—
Tunnel and marine work for outfall	8	28
Electrical, services, roads, drainage etc.	7	—
Total capital cost	45	38
Annual Operation and Maintenance Costs		
Additional sedimentation capacity	0.6	0.5
Polyelectrolyte and chlorine facilities	0.1	—
Polyelectrolyte @ \$3.00/kg	0.8	—
Chlorine @ \$400/tonne	0.9	—
Total annual O & M costs	2.4	0.5
Capitalised annual O & M costs, 50 years at 8%	30	7
Total capitalised cost	75	45

^aIndicative costs do not include capital or operating costs attributable to the existing Malabar WPCP or to sludge disposal facilities.

The capitalised annual operation and maintenance costs shown in Table 12 represent the sum of money which is required at the present time to meet the yearly payments of operation and maintenance during the next 50 years. The total capitalised cost represents the sum of the capital cost and the capitalised annual costs.

CHAPTER 8

SLUDGE DISPOSAL OPTIONS

Sludge is the term applied in this report to material which is removed from suspension in the sedimentation tanks of water pollution control plants; the volume of sludge produced generally represents less than one percent of the volume of effluent. This chapter discusses the characteristics of sludge, the potential effects of sludge components on the environment, and evaluates options for sludge disposal at the Malabar WPCP in terms of cost and environmental impacts. A description of the sludge handling facilities at the Malabar WPCP is presented in Chapter 3.

The ultimate disposal of sludge involves the return of waste constituents to the water, air or land. Each of these environmental sectors is dealt with separately in the following discussion. A variety of sludge treatment and disposal methods are available and the most appropriate option for each sector is selected. These three options are then compared in terms of cost, environmental acceptability, and other factors. The detailed environmental impacts of the "preferred" option for disposal of both effluent and sludge are examined in Chapter 9. The opportunity for recovery of energy, either by use of methane gas produced in the digestion process or by conversion of sludge to gaseous and liquid fuels is also considered in this chapter.

The subject of sludge treatment and disposal is receiving intensive study in a number of overseas cities and new developments may arise in the next few years which will affect methods considered herein, or suggest new ones. In particular, the future development of energy recovery methods, including the pyrolysis of sludge and municipal refuse reinforces the importance of retaining the flexibility to adjust or change disposal practices in the future.

Energy conservation is an important consideration in a world faced with dwindling fossil fuel reserves. While N.S.W. has relatively abundant coal deposits, energy recovery from wastes such as sewage sludge and municipal refuse represents a potential contribution to the development of an integrated energy policy for the State.

The present situation regarding possible energy recovery from sludge produced at Malabar W.P.C.P. is outlined in later sections of this Chapter.

8.1 SLUDGE CHARACTERISTICS

In the case of the Malabar WPCP, sludge may be considered under two classifications: (1) primary sludge, which is collected in the primary sedimentation tanks; and (2) digested sludge, consisting of primary sludge which has been treated by anaerobic digestion.

Primary Sludge

The composition of primary sludge depends on a number of factors including the characteristics of the raw wastewater and the performance of the primary sedimentation process. Apart from water, the components of raw and digested sludge may be divided into the following categories: (1) mineral solids, including sand, soil particles and colloidal clay; (2) organic solids, including grease, fat, proteins and cellulose; (3) nutrients, including nitrogen (N), phosphorus (P) and potassium (K); (4) microorganisms, including pathogenic

The concentration of heavy metals in raw sewage and sludge for a number of plants is presented in Table 14. The data on raw sewage illustrate the effect of industrial waste loads on heavy metal concentrations; the concentrations for Malabar, which include significant industrial inputs, are between four and ten times higher than those for the predominantly domestic sewage at North Head. Heavy metal concentrations in digested sludge are also presented in Table 14 for Malabar, the Hyperion plant at Los Angeles, and for London.

Table 14. Heavy Metal Levels in Raw Sewage and Digested Sludge

Metal	Raw sewage, mg/l		Digested sludge, mg/kg dry solids		
	Malabar (mean)	North Head (mean)	Malabar (mean)	33 USA Plants ^a (mean)	London ^b (range)
Chromium	0.7	0.05	790	1100	200-1065
Copper	0.4	0.15	660	1230	505-2500
Lead	0.3	0.07	410	830	n.d. ^c
Zinc	2.0	0.7	1410	2780	2390-5860
Cadmium	0.1	0.01	20	31	30-70
Nickel	0.2	0.05	160	410	150-350
Mercury	0.02	0.003	1.6	6.6	2-150

a. Ref. 10

b. Ref. 11

c. Not determined

Relatively few data are available on a worldwide basis on the concentration of chlorinated hydrocarbon pesticides in raw sewage and sludge. Analyses of raw sewage by the Board indicate that the mean concentration of chlorinated hydrocarbon pesticides plus PCB's at Malabar is approximately 2 µg/l (2 parts per thousand million) while the values for Bondi and North Head are lower by factors of two and four, respectively. PCB's are not manufactured in Sydney and this reduces the possibility of major discharge of these materials to the sewerage system.

Use of Sludge Gas

Sludge digestion is already practised at Malabar W.P.C.P. and could be incorporated in all treatment and disposal options considered below.

As stated in Section 3.3, sludge gas collected from the digestion tanks is at present used as a fuel for boiler and incinerator firing within Malabar W.P.C.P. A considerable quantity of surplus gas is, however, produced at the plant and while there are no economically viable alternative applications within Malabar W.P.C.P. the potential exists for use of this gas by industrial and other users. The most attractive future application is boiler firing in certain industries and major public institutions.

Preliminary discussions have been initiated with potential users of surplus gas and possible local energy recovery developments are being considered as an ongoing programme. Future evaluation would need to take account of such factors as costs involved in transportation of gas, either by pipeline or tanker, from the WPCP site and purification and compression of gas to meet requirements of users. Costs involved in any conversion of existing industrial equipment to enable gas to be used would need to be considered in assessing the viability of particular applications of sludge gas.

Table 15. Comparisons of Methods for Ocean Disposal of Sludge

Factor	Option	
	Outfall	Barging
Capital and operating costs	• lower	higher
Environmental impact	• lower	higher ^a
Public acceptance	• better	poorer ^a
Constraints on implementation	equal	equal
Energy requirements	• lower	higher
Resource recovery potential	equal	equal

^a Due particularly to transporting through populated areas.

Potential Impacts of Ocean Disposal

The environmental impacts of the selected ocean disposal option are discussed below in terms of the potential for sludge deposition and resuspension and the effects of each of the components of sludge.

Potential for Sludge Deposition and Resuspension. One of the principal objectives in the planning for discharge of digested sludge to the ocean is to avoid deposits which may smother bottom dwelling organisms. Velocities in the rising effluent plume and of ocean currents as well as the sizes, densities, and settling velocities of digested sludge particles determine the potential for deposition and resuspension. The potential is considered below from two aspects: (a) by using observed current velocities; and (b) by reference to observations and photographs of the ocean floor.

(a) Currents. Settling velocities ranging from 0.3 mm/sec to 0.0001 mm/sec were determined experimentally for digested sludge from the City of Los Angeles' Hyperion sewage treatment plant¹². The tests covered digested sludge/seawater dilutions up to 1:150 and showed that settling velocities decrease with increasing dilution due to the lower opportunity for flocculation to create larger, faster settling, particles.

By comparison, results of mathematical model simulations of effluent plume rise above a diffuser at a depth of 45 metres show upward velocities from 1700 mm/sec near the diffuser to 260 mm/sec upon reaching the surface. It is clear that digested sludge particles will remain a part of the effluent/seawater mixture until it has stabilised as a surface or submerged field.

For deposition to occur from a surface field, a particle with the faster of the two settling velocities given above, 0.3 mm/sec, would require about 40 hours to settle 45 m from surface to bottom. For a submerged field condition, the time would be less. The lower settling velocity, 0.0001 mm/sec, is one-three thousandth of the higher value, and theoretically a time of 120,000 hours would be required to reach the bottom. In effect, this means that the finer and lighter particles in digested sludge will be dispersed with the effluent/seawater mixture and not settle to the bottom. *- but would on nearby beaches?*

It is apparent, therefore, that many hours would elapse before any particles could reach the bottom and that during this time the digested sludge/effluent/seawater mixture would be dispersed over a large area. Typically, the median current speed in the discharge area is 0.1 m/sec. Thus, during a settling period of 40 hours, the mixture would travel over

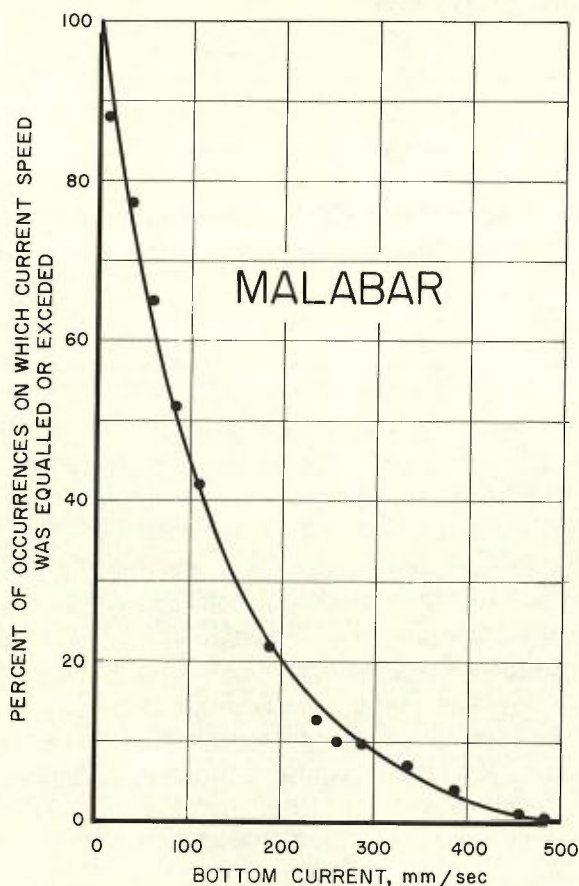


Fig. 21 Cumulative Frequency Distribution of Bottom Currents

(d) Pathogens. While the digestion process reduces the number of many pathogenic organisms, digested sludge may contain viable bacterial, viral and protozoan pathogens along with other non-pathogenic microorganisms. As the density of microbiological indicator organisms in digested sludge is about the same as in primary effluent, ocean disposal of sludge is unlikely to significantly increase microbiological levels in waters which also receive primary effluent.

(e) Toxic Materials. This category includes heavy metals, chlorinated hydrocarbon pesticides and PCB's. These materials are of particular concern because of their toxicity, persistence, and tendency to be concentrated with successive trophic levels in the food web.

Heavy metals and chlorinated hydrocarbon pesticides in raw sewage are not effectively removed from the sewage by conventional primary or secondary treatment. Therefore, the general approach in Australia and overseas has been to limit discharges of toxic materials to sewerage systems by control of major point sources, rather than requiring some form of expensive advanced treatment for the total plant flow. As discussed in Chapter 6, no serious accumulation of these toxic materials has been observed following the long term discharge of raw and partially treated sewage at Malabar and North Head. The wide dispersion of digested sludge discussed earlier will distribute these substances over such a large area that their concentrations at any location will be much lower than in nearshore areas adjacent to the existing Malabar discharge.

application of a sludge could be undertaken on a significant scale in the Sydney area, however, a major experimental programme would be necessary under conditions representative of each proposed site. Health Commission requirements with respect to such matters as the sludge characteristics, permissible crops and management practices, crop use by grazing animals, and monitoring provisions must also be met. For example, to meet specific problems of sludge disposal from the Board's Richmond WPCP, experimental work is being carried out at the Hawkesbury Agricultural College to confirm that sludge application to the ground is satisfactory from a health point of view.

Sites suitable for large scale land application of sludge near a metropolitan area are seldom available except when upgrading of marginal or unused land is possible, and the distances involved are usually greater than for landfill sites. Climatic and seasonal conditions in the Sydney region are relatively unfavourable for land application in comparison with much of Australia, due to the terrain, soil characteristics, and meteorological conditions. Land application could be practised effectively only during the drier period of the year, thus requiring alternate means of disposal or sludge storage facilities for the remainder of the year. Provision must be made to prevent contamination or pollution of ground water, water supplies, or water-courses.

Where conditions permit, application to agricultural land is preferable from a resource reuse standpoint since it makes beneficial use of the sludge constituents. However, there are many obstacles to the implementation of land application on a scale large enough to use all sludge from the Malabar WPCP. These include public health and public acceptance constraints, availability of sufficient suitable land, climatic and soil characteristics and the high cost of transporting and applying sludge. While these obstacles ultimately may be overcome, it is expected that land application will be initially practised using sludge from the Board's inland plants, and hence use of sludge from Malabar WPCP probably could be considered only in the long term.

Disposal to Landfill

Due to the large quantities of sludge from the WPCP, existing landfills or sites within the presently developed boundary of the metropolitan area are unlikely to be suitable for disposal to landfill. Studies conducted by the MWDA identified outlying regional landfill sites for long term disposal of solid wastes and were reported in their Phase II Management Plan¹³. The Lucas Heights site in Sutherland has an estimated capacity by 1985 of 8800 tonnes per week and is the most suitable long term regional landfill site for Malabar WPCP sludge. The transport distances to reach this site by the most direct road route is about 40 km and an investigation of permissible routes and schedules would be necessary to optimise transport costs.

Disposal to landfill may take the form of (a) burying in landfill cells with solid waste, or (b) composting with windrowed pulverised solid waste for later use as landfill cover material or possible marketing as a soil conditioner.

(a) Disposal of Sludge to Landfill

This method involves filling, spreading and compacting dewatered sludge with solid waste in a conventional sanitary landfill in which the waste cells are covered daily with soil cover material. It is basically a stockpiling operation without resource recovery, and tends to restrict potential land uses due to problems of settlement, methane gas generation and other factors. However, this may not be particularly significant where the land can be developed after a period of years for recreational use, for example. Precautions against groundwater contamination, discharge to watercourses, odour, and aesthetic problems are necessary.

Table 16. Comparison of Methods for Land Disposal of Sludge

Factor	Option	
	Agricultural application	Landfill
Capital and operating costs ^a	higher	• lower
Constraints on implementation	poorer	• better ^b
Resource reuse (fertilizer, soil conditioner)	• better	poorer
Effect of rainfall	more	• less
Environmental impact ^c	equal	equal
Public health and acceptance	poorer	• better

^a Includes effects attributable to distance of transport, energy requirements, as well as on-site costs.

^b Particularly affected by availability of sites.

^c Including groundwater and stream pollution potential, impacts of transportation, etc.

(e) **Toxic Materials.** Heavy metals and pesticides will generally remain bound in the sludge. However high concentrations of these materials have been observed in leachate flow from some landfill sites and therefore caution must be exercised.

8.4 DISPOSAL OF SLUDGE TO AIR BY INCINERATION

Advances in incinerator design and gas scrubbing equipment have made sludge incineration a potential sludge disposal option. Incineration of raw sludge is usually preferred, as digested sludge has a lower heat value and is somewhat more difficult to dewater. However, where existing digesters are available, as at Malabar, their continued use may be justified to provide sludge storage and allow alternative means of disposal during incinerator outages. Methane gas produced in the digesters may also be used for supplementary fuel for the incinerator and plant heating requirements.

The need for supplementary fuel for incineration has spurred technological development of both combined sludge/refuse incineration and pyrolysis. These show promise of being attractive alternatives to conventional sludge incineration in communities where a source of refuse derived fuel (RDF) can be developed economically to provide supplementary fuel.

There is considerable interest in the use of RDF in Australia and overseas because it has potential for recovering resources such as metals and glass as well as saving energy. The pyrolysis process also yields gas and liquid fuels as by-products. Unfortunately, under the existing arrangements for handling solid refuse in Australia, RDF is more expensive than use of fossil fuels. Thus the combined processing of sludge and refuse would be viable only when significant reductions in overall process costs can be achieved.

Use of RDF in conjunction with Malabar sludge would, in any case, require feasibility and pilot studies followed by establishment of a suitable solid refuse handling facility. Of the various incineration options available, the use of conventional sludge incinerators involves the least uncertainty and, at this time, less costs and is therefore the incineration option carried forward in this report for comparison purposes.

In view of likely future developments in the field of energy recovery, it is important that present sludge disposal practices remain flexible and do not preclude the future adoption of more appropriate technology.

Impacts of Disposal to Air by Incineration

The impacts of sludge incineration are described below for each of the components of sludge. It should be recognised that some sludge components are non-combustible and others must be removed from the flue gas in order to meet quality standards for discharge to air. Therefore, the impacts of solid and liquid wastes resulting from incineration must also be considered. Further, it should be noted that emission and operational problems have led to closure of a number of incinerators and that supplementary fuel will be required.

(a) Mineral Fraction. The bulk of the mineral fraction is non-combustible and is collected as ash, which is normally disposed of as landfill, or in some cases to the ocean. In either case, the only significant environmental consideration in the disposal of ash involves the likely presence of heavy metals in the residue.

(b) Organic Fraction. The major combustion products of organic matter are carbon dioxide, nitrogen oxides, sulphur dioxide and residual ash. The contribution of these components from well designed and operated sludge incinerators is considered to be insignificant in terms of total emissions in urban areas.

(c) Nutrients. The bulk of the phosphorus present in sludge is recovered in the ash fraction following incineration and this factor should be considered in selecting appropriate techniques for ash disposal. In contrast, the predominant combustion products of nitrogen are various nitrogen oxides; depending on whether the flue gases are purified by wet scrubbing or electrostatic precipitators, the bulk of the nitrogen will finally be discharged in either the scrubber water or to the atmosphere.

(d) Pathogens. Pathogens are destroyed by incineration.

(e) Toxic Materials. Few data are available on the ^{concentration} rate of heavy metals following incineration of sludge. However, most of the potentially toxic metals, with the exception of mercury, will be converted to oxides and appear in the ash or be collected by the scrubber. The high temperatures during incineration decompose mercury compounds to volatile mercuric oxide or metallic mercury; however, in tests conducted by the US EPA, 68 to 96 percent of the volatile mercury was removed from the flue gas by wet scrubbers¹⁷.

Rapid thermal degradation of most pesticides begins at approximately 500°C with near total destruction at 900°C^{18,19}. If some of these materials volatilise before burning, the use of afterburners on incinerators may be required to provide complete destruction.

8.5 COMPARISON OF SLUDGE DISPOSAL OPTIONS

In the preceding sections of this chapter, three sludge disposal options for the Malabar WPCP have been selected for comparative study; (1) ocean disposal through a deepwater submarine outfall, (2) landfill disposal at a MWDA regional landfill site; and (3) conventional sludge incineration at incinerators operated by the Board at each WPCP site. This section makes an economic and environmental comparison of these three options.

Economic Comparison

Estimates of cost for the three sludge disposal options are shown in Table 17. Owing to the wide variation in methods of treatment and disposal involved in the options, the costs

Table 17. Indicative Sludge Disposal Costs

Sludge disposal options	Degree of effluent treatment	Solids production (tonnes dry solids/day)	Capital cost, \$M	Annual operating cost, \$M	Total capitalised cost, \$M	Remarks
Ocean Disposal	Primary	70	— ^a	— ^a	— ^a	Solids production and costs assume sludge digestion provided.
	Secondary	110	36 ^b	0.7 ^b	45 ^b	
	Chemical (Polyelectrolyte)	110	36 ^b	0.7 ^b	45 ^b	
Incineration	Primary	90	14	1.7	35	Assumes existing digestion tanks utilized but no additional digesters provided.
	Secondary	145	18	2.2	45	
	Chemical (Lime)	380	30	6.0	105	
	Chemical (Polyelectrolyte)	145	18	2.2	45	
Landfill	Primary	70	20	1.6	40	Solids production and costs assume sludge digestion provided.
	Secondary	110	32	2.3	60	
	Chemical	110	32	2.3	60	

Notes:

^aAssumes no additional digestion capacity provided; sludge discharge via deepwater effluent outfall.^bIncludes cost of extended sludge outfall.^cTotal capitalised cost determined over 50 year period at 8 per cent per annum.^dCosts and solids production figures assume provision of facilities to cater for ultimate development.^eEstimates are based on December 1978 cost levels.

There is growing recognition in the USA and elsewhere, that each case must be considered individually, and that the limited funds available for pollution control should be spent in ways which provide the maximum protection for the total environment. This approach has been followed in this Environmental Impact Statement for evaluating sludge disposal options for the Malabar WPCP.

For each of the three sludge disposal options, the impact of the various components of sludge on the environment is discussed earlier in this chapter. The impacts are summarised in Table 18.

Table 18. Summary of Environmental Interactions for the Sludge Disposal Options

Option	Marine environment	Ground and surface waters	Air environment	Traffic volume	Energy requirements	Land use
Ocean disposal	•					
Landfill		•		•	•	•
Sludge incineration	• ^a	• ^b	•	•	•	•

^a Assumes discharge of scrubber water wastes.^b Assumes disposal of solid residues by landfill.

(a) **Ocean Disposal.** As discussed in section 8.2, the only significant area of the environment affected by ocean disposal is the marine system. Discharge of digested sludge with the effluent through deepwater submarine outfalls will facilitate the dispersion of particulate matter and the effluent/sludge/seawater mixture will remain submerged for most of the year.

involves a relatively small commitment of resources and does not preclude an alternative sludge disposal method being adopted in the future.

In regard to resource recovery generally, an evaluation programme of possible energy recovery developments on both a local and regional scale can be anticipated.

Selection of the "preferred" option for effluent and sludge disposal is carried out in Chapter 9.

Table 19. Options for Sewage Treatment and Disposal of Effluent and Sludge at Malabar

Option	Indicative 1978 costs			Meets receiving water quality criteria?	Remarks
	Capital \$M	Annual operating costs \$M	Total capitalised cost \$M		
Reuse effluent in catchment Secondary treatment Land disposal of sludge	330	11	470	Not applicable	Low reuse demand. Unit cost is at least 10 times that of Shoalhaven water.
Reuse effluent elsewhere Secondary treatment Land disposal of sludge	530	20	780	Not applicable	Major power requirement for pumping. Not a viable irrigation scheme.
Shoreline discharge Secondary treatment of primary effluent Incineration of sludge	170	7.2	260	Probably satisfactory	Discharge would probably be noticeable. Costs and space requirements create serious constraints.
Shoreline discharge Secondary treatment of screened sewage Incineration of sludge	100	7.2	190	Probably satisfactory	Similar to previous option, except area requirements considerably less.
Nearshore discharge Lime chemical treatment Incineration of sludge	75	11	215	Yes	Chlorination required; major impacts on solids handling, processing and disposal systems
Nearshore discharge Polyelectrolyte treatment Incineration of sludge	63	4.6	120	Yes	Further experimental work required to determine feasibility.
Deepwater outfall discharge Primary treatment Ocean disposal of sludge	38	0.5	45	Yes	Preferred option. Minimal impact on environment.

Notes:

Total capitalised cost determined over 50 year period at 8% per annum.
 Costs do not include capital or operating cost attributable to the existing Malabar WPCP.
 Cost for each option includes provision of facilities to cater for ultimate population.
 Estimates are based on December 1978 levels.
 Costs are derived from Tables 11 and 17.

plant, short-term cement and aggregate storage, air compressors, and a minor amount of storage for concrete lining operations. Where possible, the construction support activities would be sited away from the headland, probably in the present construction depot area.

The proposed access shaft location places the head frame and certain other temporary facilities close to the most elevated point on the Malabar headland, making it visible on the horizon from most directions. The proposed site is located in native heath vegetation, and construction in the head frame area and access road would require removal of some part of this vegetation. However, the disturbed zone surrounding the access shaft can be limited to a small area by restriction of construction operations to those absolutely essential in this area.

Journal. 3m x 2m x 4000 = 24,000 solid = 35,000 broken cum! + shaft + ancillary excavations. ? 3000 to 3500 m long

Disposal of Spoil. Up to 20,000 m³ of spoil could be produced during excavation of tunnels for the submarine outfall. Construction of further treatment facilities could produce a further 20,000 m³ of spoil. Disposal of spoil at suitable landfill sites away from the Malabar area should not cause an adverse environmental impact, but the trucking of spoil from the construction site may pose a considerable nuisance to residents surrounding the plant, and may be prohibitively costly.

Traffic and cost problems associated with the removal of excess spoil from the area suggest that the possibility of spoil disposal at some point on the Malabar headland should be considered. Two modes of disposal are possible; disposal to land on the Anzac Rifle Range, and disposal into the sea at the cliff face. In both cases disposal should be undertaken at a site where the visual impact is minimal and subsequent landscape restoration would be required. Such dumping would presumably require Commonwealth approval. With cliff face spoil disposal, most of the broken rock will enter the sea, and should be dispersed rapidly by wave action. The appearance of the cliff face would also be disturbed at the time of dumping. Disruption to the marine environment would be limited and temporary in nature.

sup 21 Initially the most likely disposal site would be at the cliff face in the small indentation in the Malabar headland to the North of Long Bay. At this point the spoil would only be visible from the ocean or land immediately adjacent. Dumping on the headland would require the construction of a road to the dumping site and some further area of native vegetation would be damaged by this activity.

Site Appearance. The present unobtrusive appearance of the landscaped Malabar WPCP would necessarily be disturbed by further construction work. Tunnelling operations for the outfall construction would also cause a temporary visual impact on the Malabar headland. Located high on the headland, the head frame would be visible on the horizon from many directions.

Traffic. Road access to the WPCP is from Anzac Parade, through Malabar Junction Shopping Centre and via Franklin and Dacre Streets and Fishermans' Road. All are roads through residential and commercial areas and heavy construction traffic may pose noise, disturbance and air pollution impacts. The extent of this impact from plant amplification cannot be assessed until the extent of the works is established but is likely to be less than the impact of Stage 1 construction, for which adequate safeguards were provided. For outfall construction, the traffic impact will be greatest if tunnel spoil is trucked from the Malabar area. Stockpiling may be required with a three shift tunnelling operation to obviate truck movements through suburban areas at night. This aspect should be considered in deciding the method of spoil disposal.

access shafts and tunnels required for the preferred option would not affect the appearance of the completed WPCP site.

Following some public criticism of the visual effects of the waste gas burner flares, the Board relocated the burner system to its present unobtrusive position in the WPCP and additional burners were added. A brick enclosure to match surrounding buildings has also been provided to reduce the visual effect of the flares.

Noise

Very little noise emanates from the WPCP; the few complaints received arose during commissioning of the WPCP, when noise was created by vibration effects in the digester area, safety relief valves and operation of the boilers. These operating problems have been remedied, and the safeguards provided are adequate. There should be no increase in the general noise level due to the "no change" or preferred options.

Odour

As most of the major Malabar treatment facilities are constructed underground, proper ventilation of the operating areas was a major design consideration. Equipment was provided to control odours caused by both the high sulphide content and temperature of the incoming sewage, and moisture released from the treatment processes. A centralised ventilation system was provided with the major exhaust point through the two hydrogen sulphide scrubbing filters shown in Fig. 5. Other exhaust points on the system near and within the plant include stacks on both SWSOOS 1 and 2 at Matraville upstream from the WPCP, a stack on SWSOOS 1 on the Malabar headland, and exhausts at the chlorination electrical centre and the incinerator complex. The volume of exhaust air from all these additional exhaust points is expected to be only about one tenth of the deodorised volume exhausted through the two filters.

Occasional complaints have been received by the Board in relation to odours emanating from their system in the Malabar area. However, these were attributed to malfunctions and breakdowns, especially in the case of the deodorising plant at the Matraville stacks and the loss of a fan house on the Malabar headland in a storm in 1975. The fan house has recently been reconstructed and a programme of works is underway to improve conditions at Matraville. Odour nuisances from unburned digester gas have been eliminated by relocation of the burners to their present position.

The safeguards provided by the Board to minimise odour nuisances are considered to be adequate. Design of the Malabar WPCP allows for inclusion of additional deodorising facilities with further expansion of the plant. Construction of deepwater submarine outfalls would probably require some ventilation of the access shafts to maintain the high standard of the existing ventilation and odour control system.

Air Quality

The SPCC has issued a licence to the Board in accordance with the Clean Air Act, 1961, as amended, which enables the Board to discharge to air the emissions from their fuel burning equipment, including the incinerator flue gases, hot water boilers and steam cleaning boilers. The exhaust gases from the incinerator are monitored for proper combustion and then wet scrubbed so that the temperature of the saturated exhaust gases is normally below 44°C and always less than 80°C. No further air emissions, other than ventilation air, would be required for the preferred option. The existing safeguards are therefore considered to provide adequate protection.

Ash Disposal

Ash from incineration of screenings, grit and scum will continue to be discharged through the existing cliff face outfalls. Operating experience at the existing Malabar WPCP shows that the ash, which is composed principally of silica generally settles and is dispersed by prevailing currents without causing any visible surface field or slick. *towards?*

9.5 IMPACTS OF EFFLUENT DISCHARGE

Ocean disposal of treated sewage effluent is normally the method of choice for coastal cities. Experience has shown that the discharge of effluent and digested sludge may be accomplished without significant adverse effects where ocean conditions are suitable and appropriate outfall structures are provided. Most constituents of sewage are in fact beneficial to marine life, providing that the assimilative capacity of the waters for the additional organic and nutrient load is not exceeded. Potentially toxic components of sewage are mainly of industrial origin and are thus amenable to source control.

Physical Appearance

Physical appearance criteria developed in Chapter 5 require that there should be no obviously visible oil, grease or floatable material, and no nuisance odours or appreciable accumulation of solids, either in the receiving water or on shore. These characteristics are difficult to define quantitatively. Thus the performance of the outfalls in these respects is judged in qualitative terms.

No Change Option. As discussed in Chapter 6, the present quality of the nearshore waters in the vicinity of the Malabar outfall does not meet the criteria for physical appearance. A visible effluent plume extends from the discharge point for several kilometres in a direction which depends on prevailing winds and currents. Surface slicks and accumulations of grease and other floatable material are sometimes observed in the receiving waters and on the shore.

Preferred Option. The deepwater submarine outfall option has been extensively investigated and the predicted performance of the recommended Malabar deepwater diffuser is shown in Table 20. The predictions indicate that the effluent field would be submerged 96 percent of the time in summer. The design is governed by bacteriological criteria, which require relatively large initial dilutions and a long diffuser section in deep water. When there are surface fields, the BOD₅, suspended solids, and grease concentrations in the effluent field at the surface are calculated to be 1.4, 1.2 and 0.3 mg/l, respectively, during peak dry weather flows. As these concentrations are substantially better than those attainable with good secondary treatment, it is concluded that this option is capable of meeting the physical appearance criteria. This is further supported by the fact that the nearest diffuser port would be approximately 2200 m from shore, and movement of the diluted surface field would be towards the shore only a small percentage of the time.

Restricted Substances

The maximum allowable concentrations of restricted substances at the boundary of the initial dilution zone and minimum dilutions required at Malabar to meet guideline criteria are shown in Table 21. The required dilutions are based on the assumption that digested sludge will be discharged with the effluent.

No Change Option. Based on the estimated dilution of 8:1 at the surface for the existing Malabar effluent plume under average conditions, and assuming that the boundary of the initial dilution zone is not more than 250 m from the discharge point, it appears that water quality criteria for total chromium and mercury would be exceeded under average conditions (Table 21).

oxygen, or more than 0.1 for pH. The initial dilutions required to meet these criteria were estimated to be 25:1 for dissolved oxygen and 20:1 for pH³.

Table 21 Required Dilutions of Restricted Substances in the Malabar Discharge

Substance	Maximum allowable concentration ^a mg/l	Effluent concentration ^b mg/l	Minimum required dilution ^b
Arsenic	0.1	0.1	1
Cadmium	0.2	0.1	1
Total Chromium	0.02	0.7	35
Copper	0.2	0.4	2
Lead	0.1	0.3	3
Mercury	0.001	0.020	20
Nickel	0.1	0.2	2
Silver	0.02	0.02	1
Zinc	0.3	2.0	7
Cyanide	0.2	1.0	5
Phenolic compounds	0.5	1.0	2
Total chlorine residual	1.0	0.00	0
Ammonia-N	5.0	28	6
Total identifiable chlorinated hydrocarbons	0.002	0.003	2

^a At boundary of specified initial dilution zone.

^b Mean values assuming digested sludge discharging with plant effluent.

No Change Option. With the present estimated dilution of the rising plume of approximately 8:1 at the surface under average conditions, it appears that dissolved oxygen and pH criteria cannot be met under average conditions.

Preferred Option. The minimum initial dilution of 73:1 provided by this option is well above that required to meet dissolved oxygen and pH guideline criteria.

Microbiological Criteria

Bacteriological criteria, based on faecal coliform densities, are described in Chapter 5. The criteria require that the geometric mean density for any month should not exceed 200 org/100 ml; and, from November to May, no more than 10 per cent of the samples should have values exceeding 400 org/100 ml; and, from May to November, no more than 10 per cent of the samples should have values exceeding 2000 org/100 ml.

Practical methods for routine monitoring of viruses of sewage origin in seawater have yet to be developed. However it is recognised that viruses of faecal or other human origin may present a potential health hazard when contaminating recreational waters. Epidemiological methods have not yet established the risk of transmission of viral disease by marine waters, although outbreaks of infectious hepatitis have been traced to the consumption of shellfish taken from polluted marine waters²¹.

Virus standards in bathing waters have not been established by the SPCC. However, it is clear that the deepwater outfall would provide greater safeguards than the "no change" option.

It is concluded that the deepwater submarine outfall option should not cause any significant adverse effects in the marine environment, providing that the discharge of potentially toxic materials such as heavy metals and organochlorine pesticides continues to be effectively limited by source control.

9.6 CONCLUSION

The foregoing discussion of environmental safeguards and impacts has demonstrated that the preferred option at Malabar — primary treatment with discharge of effluent and digested sludge through a deepwater submarine outfall — would have minimum impacts on the environment.

In the most favourable circumstances, the time between a decision to proceed and completion of the Malabar deepwater submarine outfall is in excess of six years. During this period, interim measures to improve the quality of the effluent discharged to the marine environment should be considered. As discussed in Chapter 5, effluent quality resulting from operation of the plant in its presently overloaded condition can be improved only slightly. Interim measures which could be implemented to improve effluent quality include polyelectrolyte addition and chlorination, similar to that discussed in Chapter 3; however, the necessary facilities would be designed only for interim or short term use. Experimental work would be required to optimise dosages and other parameters. While capital costs associated with temporary chemical treatment would probably be low, operating costs for chemicals alone could exceed one million dollars per annum.

From the standpoints of environmental effects and costs, it is apparent that interim measures would be of limited advantage. Therefore, implementation of the deepwater outfall scheme should be commenced as soon as possible.

APPENDICES

APPENDIX A

REFERENCES

1. Brown and Caldwell, "Design Report, Malabar Sewage Treatment Works"
A Report to the Metropolitan Water, Sewerage and Drainage Board, (1965).
2. Brown and Caldwell, "Northern Suburbs Sewerage Survey, 1966 - 1967"
A Report to the Metropolitan Water, Sewerage and Drainage Board, (1967).
3. Caldwell Connell Engineers, "Report on Submarine Outfall Studies"
A Report to the Metropolitan Water, Sewerage and Drainage Board, (1976).
4. Ninetieth Annual Report for year ended 30th June 1978.
Metropolitan Water, Sewerage and Drainage Board.
5. New South Wales State Pollution Control Commission, "Environmental Standard
EI - 4. Principles and Procedures for Environmental Impact Assessment in New South
Wales" (1974).
6. Hawke, G.S., Hyde, R., Linacre, E.T. and McGrath, C.A.
"Sydney's Winds and Air Pollution". Environment, '75 Conference, Sydney (1975).
7. New South Wales State Pollution Control Commission, "Environmental Design Guide
WP-1, Design Criteria for Ocean Discharge".
8. National Technical Advisory Committee, "Water Quality Criteria". A Report to the
United States Secretary of the Interior, (1968).
9. Southern California Coastal Water Research Project, "The Effects of the Ocean Disposal
of Municipal Waste (1968)".
10. Cohen, J.M. "Trace Metal Removal by Wastewater Treatment"
Technology Transfer, U.S. Environmental Protection Agency, (1977).
11. Royal Commission on Environmental Pollution. Third Report: "Pollution in Some
British Estuaries and Coastal Waters." H.M. Stationery Office, London (1972).
12. Faisst, W.K., "Digested Sewage Sludge: Characterization of a Residual and Modeling
for its Disposal in the Ocean off Southern California". EQL Report No. 13, California
Institute of Technology, (1976).
13. "Sydney Region Solid Waste Management Plan — Phase 11"
Metropolitan Waste Disposal Authority, (1976).
14. "Pulverisation of Solid Waste."
Metropolitan Waste Disposal Authority (1976).
15. "Air Pollution Aspects of Sludge Incineration." U.S. EPA Technology Transfer
Seminar Publication 625/4-75-009, (1975).

METROPOLITAN WATER SEWERAGE AND

EIS

Malabar water pollution control
plant

88

