

An Investigation into the Port of Durban
Water Quality Management

by

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Preface

This thesis represents original work by the author and where use has been made of work of others it is acknowledged in the text. This work has been undertaken at Portnet Port Authority, Port of Durban, under the supervision of Prof. G. Garland.

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Abstract

The Port of Durban is a resource utilised by a wide range of stakeholders. The water quality of this resource is a prerequisite for sustaining the preferred uses of the bay for future generations. Given the extent of development in the port the abundance of fauna and flora is remarkable.

Based on the current literature available the management of the port uses a combination of international and local standards to manage the water resource. An associated problem however is that the local legislation does not address the heart of the pollution problem - the polluter. This is highlighted in all chapters of this thesis, as the South African water quality guidelines are not legally enforceable, and do not take into account the combined use of resources.

The uncontrolled nutrient loads and pollution present in the port system could ultimately affect the ecosystem health. This is amplified by apparent inability of officials to protect the receiving environment of the Port of Durban. The subsequent condition of water quality in the port compared with the Department of Water Affairs guidelines indicates that there is less than 5% compliance with the target water quality variables.

in comparing the same water quality to international water quality Legislation the compliance percentage increased marginally, however the bacterial contamination and nutrient contamination of the resource is apparent even with more relaxed international comparisons. The noticeable cause was clearly evident when comparing results, indicating extensive unacceptable bacterial and nutrient contamination emanating from stormwater systems from the city of Durban, and highly urbanised river catchments.

Based on the water quality results it is highly recommended that sustainable environmental management practices be implemented to protect and address the water resource. The metropolitan authorities need to investigate the origins of the stormwater pollution and dialogue must ensue between Portnet and the City to reach consensus on receiving water quality objectives with the aim of compiling a water management policy.

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CHAPTER 1

BACKGROUND TO THE STUDY

1.1 Introduction

The Port of Durban is situated in a once natural estuary having a low salinity content with limited intertidal exchange with the sea. The sandbar that was once at the port entrance was dredged out in the early 1900's removing the only natural limiting factor to port growth. Bender (1988) described the importance of Durban to early local residents, traders and colonists who dredged out the sandbar at the entrance to the bay and gained access to the safe haven of the protected estuary (Figure 1). Bigger vessels could then navigate safely into the Port of Durban and this initiated the need for quay anchorage for cargo discharge.

The port has since developed into a well-equipped and modern facility (Figure 2), which is one of the busiest on the African continent (Portnet 1998). The point area developed quickly as a result of easier navigational access and quay walls enabled larger vessels and larger amount of cargo throughput. The Port of Durban was surrounded at close quarters by the fast expanding city of Durban that blossomed due to port activities. The Port of Durban provided an economic lifeline to the hinterland and soon was responsible for development along transport routes. The Port of Durban is a focal point of economic activity and as such is subject to negative environmental impacts (Hay 1993). The once natural estuary with over 200 hectares of mangrove forest has shrunk to accommodate only 15 hectares of natural mangrove forest.

Port development was directly responsible for changing the natural environment, with the City of Durban being responsible for restricting port growth. Day and Morgans (1956) described the port in the 1950's as near pristine with rich fauna and large intertidal and mangrove areas. The transition from pristine conditions to highly altered environmental habitats occurred over a period of 50 years changing the face of the port permanently. The modern port is now on average close to 13 meters below chart datum in most areas and has most of its once natural soft edge transformed into concrete quay walls with cargo handling facilities located on the adjacent land (Figure 2).

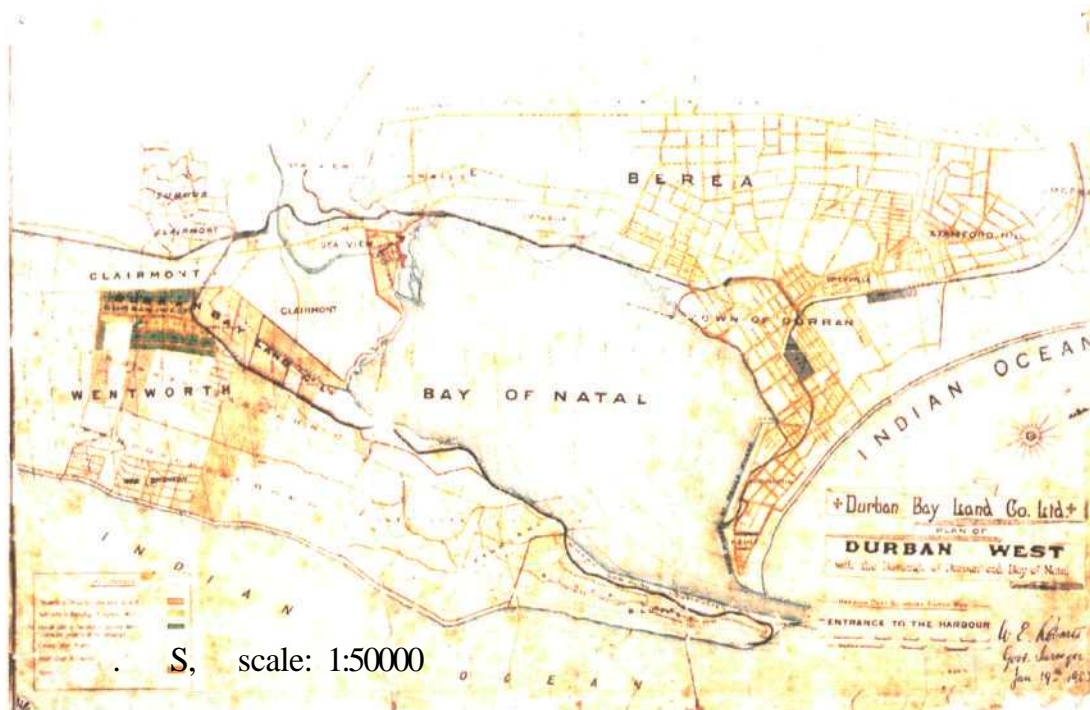


Figure 1: Port of Durban 1903 (Courtesy Port Engineers: Port of Durban)

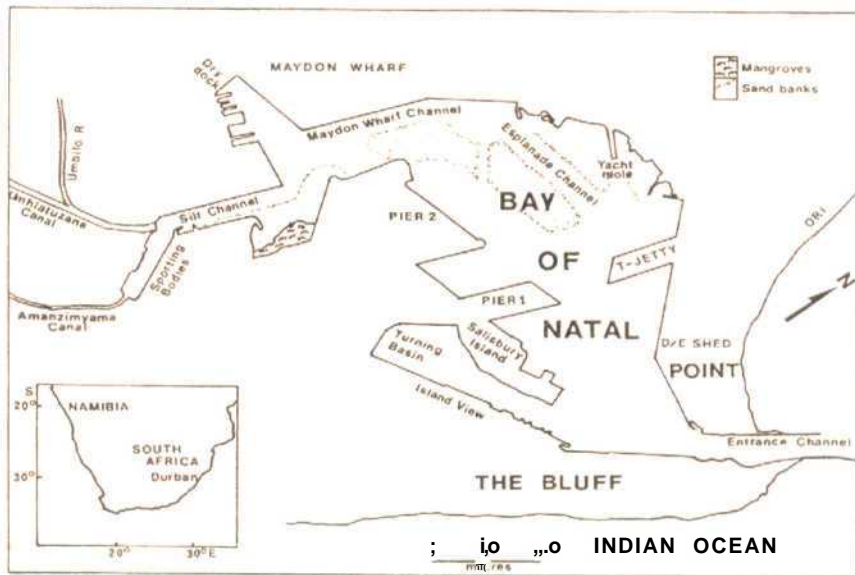


Figure 2: Port of Durban, South Africa (Adapted from Portnet 2000)

The resultant activities regarded the port as a convenient reservoir (Archibald 2000) for their disposal of sewage wastes and wastewater. The consideration for sustainable development and resource conservation was not an issue during the early development of the port. Due to an initial small population the pressure on the resources increased gradually to the point where the water quality of the Port of Durban is now seriously impacted by the activities in the catchments. Monitoring currently reveals how industry, port and urban developments continue to plague the once natural bay, now the busiest port in Southern Africa.

Water quality in the harbour is a complex expression of the combined response and interaction of the physical, chemical and biological components to the pollution impacts derived from the landward (city area) side (Archibald 1999). The port authority as landowner faces the ultimate responsibility both ethically and legally of dealing with the water body under its ownership. The natural capital of the port is an immense asset to protect to ensure the continuation of the economic viability. The port was developed prior to the recognition that the conservation of natural environments was essential to the sustainable functioning of any economic and social system. In balancing conservation with port expansion and activities to achieve sustainable development, a thorough understanding of the functioning of the ecosystem as a whole is required.

The port water quality is constantly under scrutiny, due to the diverse array of port users, and the attitude of the state owned landlord was not always conducive to negotiation. The water quality of ports, harbours, rivers, estuaries and open water bodies has been investigated (Harrison *et al* 2000) in a Department of Water Affairs initiative by attempting to gain insight on the magnitude of the problems. Due to the poor living conditions, the high level of rural populations and the lack of basic amenities of South Africa's population the water of all rivers are contaminated. In order to effectively manage coastal resources, decisions should be made based on sound scientific information and with an agreed and attainable objective for the future state of the coast (Harrison *et al* 2000). Coastal resources are limited and precious and their utilisation is essential for commercial development as well as highly desirable for urban and industrial growth (Berjak *et al* 1995).

1.2 The Study Area

1.2.1 History of the Port of Durban

The Port of Durban has a long history of development, however this development has changed the function and nature of the bay permanently. Prior to the mid 1800's, the bay was a sheltered lagoon comprising tidally exposed sandbanks and deeper channels with extensive mangrove and swamp areas, and two vegetated islands near the centre of the bay (Hay 1993). Development tended to be sporadic as and when new technologies became available they were put into practice. Captain Rogers, who visited the embayment in 1684, said that the harbour opened pretty wide, and was deep enough for small ships (Methven 1924, in Ideas Environmental Consultants 1998). As a result of the strong littoral current running along the coast the drift of sand had formed a sand bar across the entrance to the harbour. From a navigational point of view the sandbar was a nightmare to mariners who had to negotiate ships into the safe confines of the harbour. The bar was a great barrier to the prosperity of Natal. The shallowness of this area had locked vessels out of the bay (Methven 1924). According to the first Harbour Engineer Sir John Milne, the depth over the sand bar was 4 meters at high spring tide and it was 500 feet (approx 170 m) wide), (Figure 3; Bender 1988) suggesting permanent water exchange with the sea.

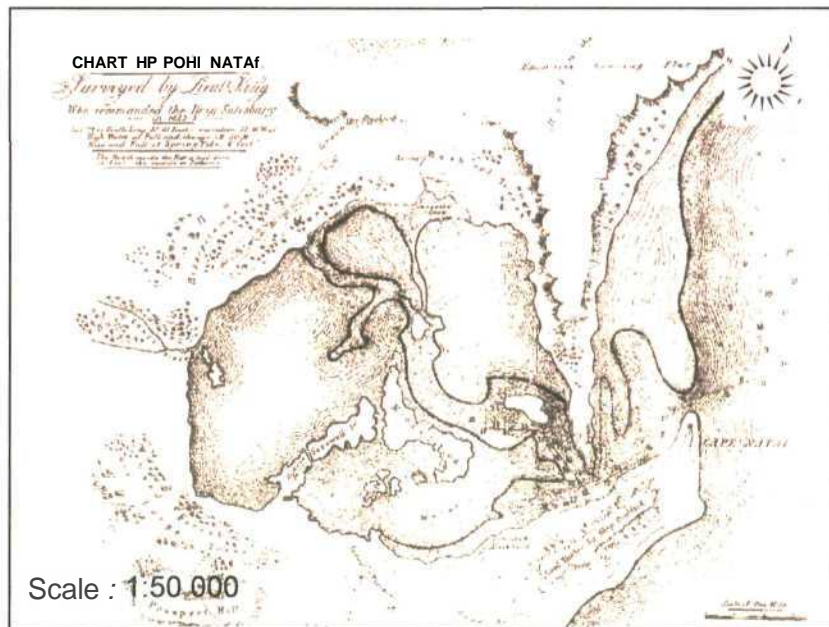


Figure 3: Port of Durban in the early 1800's, after Bender 1988.

There were no landing wharves and once entering the port one had to be carried ashore by hefty Zulus (Bender 1988). Milne proposed a scheme to improve access to the bay in April 1850 (Methven 1924). The proposal recommended the construction of a south pier from the end of the Bluff and a north pier from the end of the point (Ideas Environmental Consultants 1998). The original north pier was completed in 1893 and 1894 saw the completion of the original southern breakwater (Hay 1993). The entry of the Armadale Castle over the sand bar in 1904 marked the port as being open to large vessels (Hay 1993), hence the removal of the sandbar was successful in enticing further vessels to call in Durban.

Subsequent modifications of the bay included the construction of quays, jetties, stone embankments, and the dredging of channels and modification of all sandbanks (Watermeyer *et al* 1996). The harbour was deepened and the entrance was dredged to 11 meters below chart datum in 1938, already having over 4.8 km of hardened wharves and quays. The harbour was further deepened to 12.8 m in 1940 and in the years 1944 to 1945 the southern breakwater was extended by 152.4 m (Watermeyer *et al* 1996). Plate 1 shows the port during the 1950's prior to development of the container terminal and the ship repair jetties.

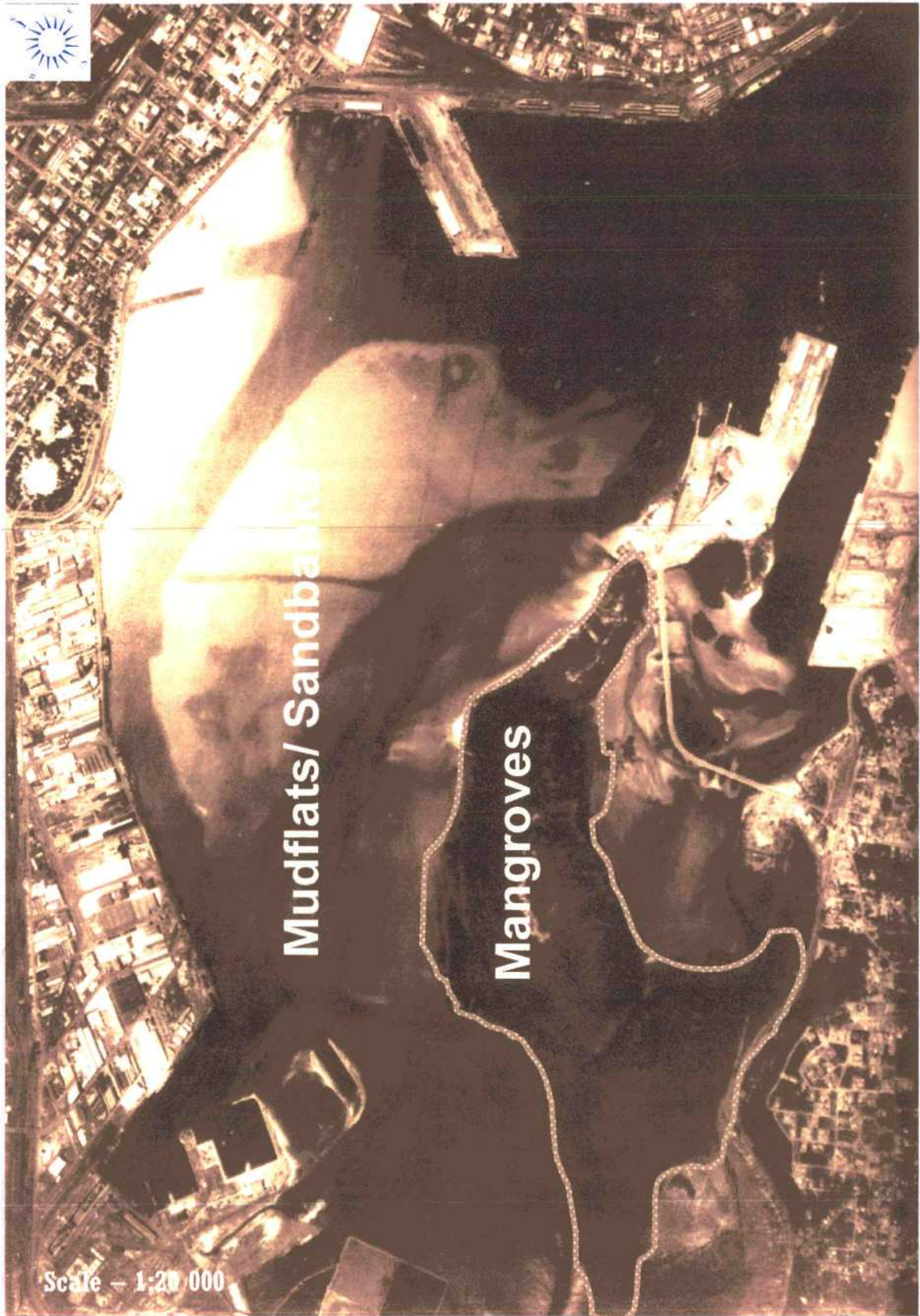


Plate 1: Port of Durban 1956

The modifications to the mouth of the bay would have resulted in changes to the hydrological characteristics of the bay, including increasing tidal amplitude, changing tidal currents and altering the natural channels of the bay (Ideas Environmental Consultants 1998). This would in turn affect the ecology of such an estuarine system. Modifications of the sanctuary area (mangrove forest & intertidal area that was free of development) of the harbour allowed further development, including the pier 1 & 2 developments. The establishment of Salisbury Island and pier 1 had significant impacts on the fauna and flora, (Day & Morgans 1956) noting large-scale differences of fauna and flora populations and spatial spread.

The canalisation of the three incoming rivers began in 1947 (Coombes 1990) and this enabled the lower reaches of the rivers to have a specific entry point into the estuary, and not a gradual entry into the sandbanks. The geography thesis by Coombes (1990) on the Amanzimyama River contamination indicates that the last sections of the river canals were completed as late as 1985. The commissioning of pier 2 for container handling in 1975 marked the most recent of the large-scale modifications to the present port. Little other than dredging for enhancing port performance and the establishment of the silt canal in the upper reaches of the port was undertaken to have a significant change to ecological systems in the port.

1.2.2 Description of the Study Area

The study is limited to the geographical boundaries over which Portnet has jurisdiction in terms of land ownership and local authority status. The Port of Durban is located on the east coast of South Africa (29 53'S, 31 00'E) (Figure 4), and is characterised by having three canalised river inflows. The Amanzimyama, Umhlatuzana and Umbilo canals enter the upper reaches of the Port of Durban into the silt canal (Appendix 1). Durban bay is defined as an embayment (Begg 1978), owing to the fact that it is subject to tidal influences and the salinity is essentially marine in nature. Salinity is fairly uniform, varying from 34,8 to 35,5 parts per million near the canalised river outlets (Guastella *et al* 1994).

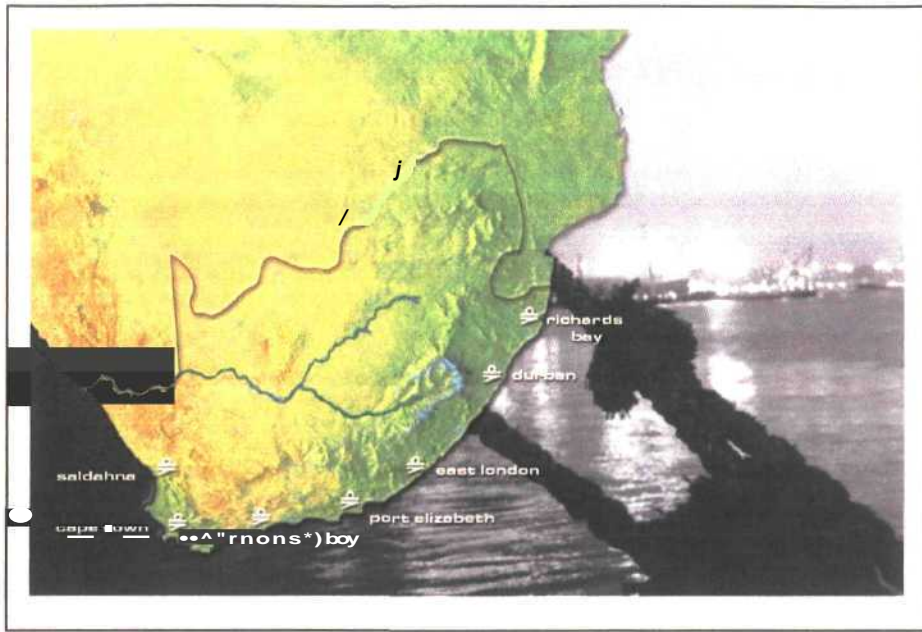


Figure 4: Port of Durban in relation to other ports (Portnet 2000)

The port as described by Begg (1978) is landlocked (except for the entrance), and is essentially an estuary, the largest estuarine system within the Durban metropolitan area. The Port of Durban encompassing the bay (natural component), and the harbour (working component), covers an area of over 1750 hectares in total, shown by the aerial photo in appendix 1.

During high tide the surface waters cover an area of 892 hectares and during low tide this is reduced to 696 hectares (Portnet 1998), with an average tidal range of 1.8 meters. The axial length from east to west is given as 5.6 km and the north to south width approximately 3 km. About 20% of the water surface area is non - navigable (Watermeyer *et al* 1996). The hardened workable areas are comprised of 57 shipping berths used predominantly for cargo handling. The port is shadowed by the city of Durban, which leads to the hinterland (Ducray 2000).

1.2.3 Port Geology

The rock types of the catchments of the Umbilo and Umhlatuzana rivers include granites and gneisses of the basement complex, sandstones of the Natal Group, Glacial Tillite and Shales of the Dwyka and Ecca Groups, and minor Karoo Dolerite intrusions (Leuci 1998).

Leuci (1998) mentions that the bedrock underlying the Durban Harbour is composed of eastward dipping faulted Karoo sediments of the Dwyka and Ecca groups, overlain by Cretaceous sediments.

1.2.4 Port Catchment

The Umbilo, Umhlatuzana and Amanzimnyama canals are the major inlets to the bay. The three rivers drain both industrial and residential areas, and a smaller portion of water from stormwater systems also enters the port. The Umbilo River is 35 km long and drains a catchment area of 67 km³, whilst the Umhlatuzana River is 50 km long with a drainage catchment area of 113 km³ (Begg 1978). Begg (1978) estimated that the smaller Amanzimnyama River drains mostly an industrial area with a catchment area of 15 km³ (Appendix 2).

1.2.5 Port Ecological Habitats

The port is fortunate to contain diverse mangroves, mudflats and sandbanks that are interconnected and regarded as vital for the continued ecological health of the bay (Watermeyer *et al* 1996). The port system is intertwined with that of the ecological component and thus challenges exist to manage for both uses. A more in depth discussion will describe all habitats in further detail later in the thesis.

1.2.6 Economic Role of the Port of Durban

The Port of Durban is well positioned within the transport chain relative to the larger production and consumption areas of the country, to serve a wide range of freight. The port has developed into an important asset for the South African economy. It has a

strong competitive advantage to support all the strategic thrusts (density, scale & operating efficiency) for the full spectrum of transport modes, namely ocean freight, rail freight and road freight. As a result Durban has developed as the country's premier port for all cargo types with the exception of the large drybulk products. In many instances it serves as a regional hub port (Figure 5), especially on the Southern African seaboard (Ducray 2000).

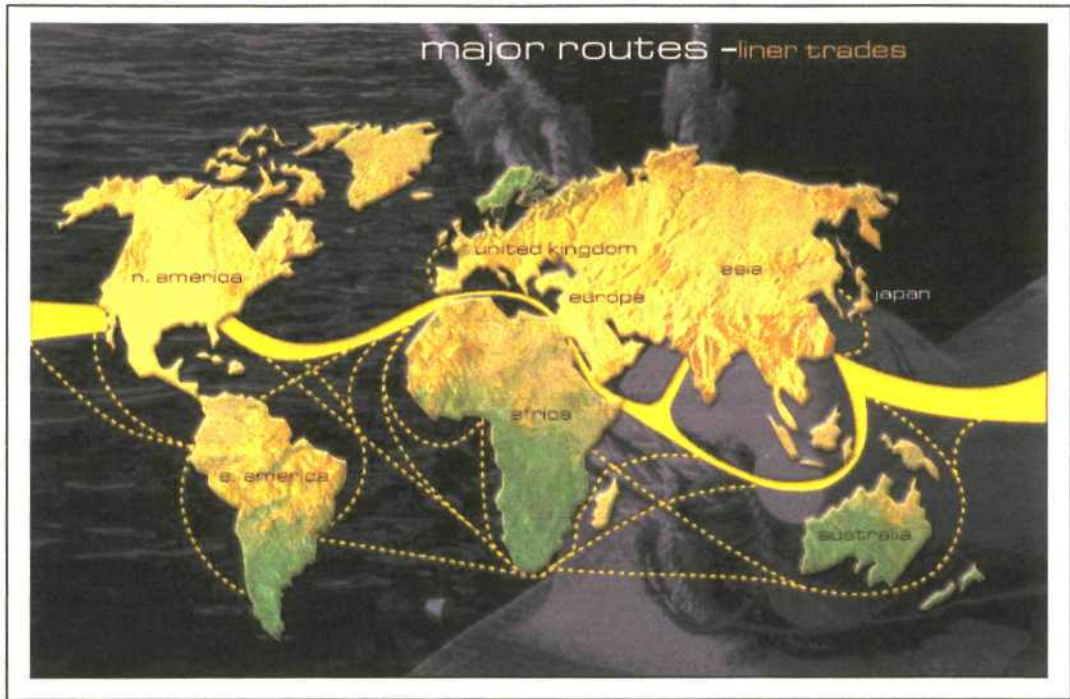


Figure 5: Port of Durban as a hub port: yellow strip indicating major shipping route, yellow lines show minor routes (Portnet 2000).

1.2.7 Ecological Role of the Port

The Port of Durban has significant environmental value due to its estuarine function. South Africa is well endowed with estuaries and in many areas they form part of an important element of the coastal zone ecology, economically and culturally (Harrison *et al* 2000). It stands to reason then that the ecological function is as valuable to the coast as is the economy generated from shipping activities. The open water area and shallower waters provide nursery areas for a large number of fish species, especially those requiring estuarine conditions as part as their life cycle. The mangrove

communities specifically at the Bayhead Natural Heritage Site mangroves contribute to the maintenance of the system.

1.2.8 Use of Environmental Resources of the Bay.

The container handling environmental impact assessment conducted by Common Ground Consulting (1999) attempted to put an economic value to the port resources. The calculation failed due to insufficient data associated with the link Durban has with the east coast fisheries. Economic valuation of a resource measures human preferences for or against changes in the state of environments (O'Riordan 1995). With this in mind it is almost impossible to calculate the value of the resource to a Rand value without considering the value of the resource for ecological purposes and future sustained uses. The sustainable use of resources has long been an issue of debate. It will be difficult to separate the port from the value of the catchment, where the fresh water resource originates, let alone the ecological value of the freshwater inputs sustaining the life of the estuary.

The bay has been extensively used in the past for subsistence fishing. The sustainability of the port to handle both recreational fishermen and subsistence fishermen is in question, yet no threshold for utilisation has been developed due to a lack of scientific data on long term impacts. As science progressed and development altered the face of the port a 30-year gap of scientific data developed. This resulted from the assumption that the port was badly polluted and devoid of life. Studies undertaken by Day & Morgans (Ideas Environmental Consultants 1998), indicated a bay rich in fauna. A study by Guastella *et al* (1994) did reveal that although the bay was now essentially marine in nature but still contained fish species essential to supporting a subsistence fishery in the bay. The bay has a high abundance of sand prawns however to date only 1200 permits have been issued to people by the KwaZulu Natal Wildlife to make use of this resource. This resource is threatened by the poor turbidity in the water quality as a result of poor catchment management.

The bay is extensively visited by birdwatchers, and the presence of migratory birds in the port makes this one of the most rewarding leisure activities in the confines of a working port. Sport and recreation activities however contribute to a high portion of resource use

in the port (Watermeyer *et al* 1996) including yachting, windsurfing, motor boating, canoeing, rowing and chartered boat trips.

1.2.9 Background to the Port of Durban Water Quality.

Portnet has become aware of the impending need to manage the water resource within the port confines. Hay (1993) conducted a study regarding the environmental management including water quality issues as part of the general environmental improvement incentive of Portnet. Authors including Guastella *et al* (1994) highlighted the inadequacies in the fish resource management and this prompted Portnet to hire an Environmental Manager. The ensuing years allowed the port water resource to be extensively studied by the C.S.I.R. and revealed the actual characterisation of the water. The water quality programme conducted in the port has been organised to produce data to address key water quality issues, relating to human health, aesthetics and the ecology of the system.

The water quality programme has been ongoing over a relatively unbroken period for 5 years and has studied bacteriological components, metal concentrations as well as indicators of ecosystem health, namely oxygen, nitrate and salinity. The overall trend has reached a stage where direct associations can be made with the origins of pollutants, notably those associated with the surrounding land use of the port. The challenge to the water quality management is to balance the recreational and industrial uses of the port, whilst managing the port as a sustainable resource. This difficulty is highlighted by Walmsley (1999) who attributes most of the pollution in the port to shipping pollution, however other views Archibald (1998) note that Portnet in total is only responsible for 5% of all pollution. Part of the water quality management is the changing mindset with regards to shipping and pollution.

The water quality results from the C.S.I.R. studies clearly show certain monitored contaminants not being within the Department of Water Affairs limits. This necessitates the need for action for effective pollution control. These uncontrolled nutrient loads present in the system could affect the ecosystem health. There is a direct linkage between improving the present status of the bay and the water quality as a prerequisite for sustaining the preferred uses of the bay for future generations (Archibald 1999). The

sustainable and equitable management should be the primary service or delivery objective.

1.3. The Water Quality Problem

Based on the current literature available the management of the port uses a combination of international and local standards to manage the water resource. An associated problem however is that the legislation does not address the heart of the pollution problem - the polluter. The current Water Quality Guidelines for Coastal and Marine Waters (1996) separate recreational and industrial uses of which the port has both functions in the same area, and this does not include the fact that the marine guidelines do not take into consideration all these uses combined. The lack of a holistic perspective regarding water management has led to a very dispersed and confused system of water management.

The lack of holistic perspective by port management has a direct bearing on the sustainability of the resource. The use of the port water for a myriad of activities suggests the importance of the water body, yet the over exploitation of the natural capital resource should be an important element of study for the port. The sustainable development concept needs to be embraced in the port to ensure environmental justice, up until now it remains a critical flaw and the basis for the current water quality problem in the Port of Durban. Sustainability and sustainable development concepts in this document is considered primarily in terms of continuing to improve human well-being, whilst not undermining the natural resource base on which future generations depend.

1.4 Aims of the Thesis

This study is aimed at highlighting the difficulties associated with the management of large water areas in South Africa, specifically using the Port of Durban as a case study in comparing it to both local and international water quality management standards. Specific requirements are to;

=> Assess the current water quality in the Port of Durban.

- => Compare the water quality guidelines from selected countries to the Water Quality Guidelines for Coastal and Marine Waters (1996).
- => Ascertain whether the water quality is in line with the Water Quality Guidelines for Coastal and Marine Waters (1996).
- => Provide an overview of the water quality management programme of the Port of Durban as administered by Portnet and managed by the CSIR.
- => Suggest improvements to achieve sustained resource management and protection.

1.5 Structure of the Thesis

This thesis highlights the current condition of the port water quality, placing emphasis on improving the environmental management and sustainable use of the resource. The study area is described in detail in chapter 1, with chapter 2 being dedicated to determining the actual meaning of water quality and integrated coastal management to place the water quality of the port into a national context. Legislation and policies of South Africa are discussed in chapter 3 to highlight the varied resource protection tools available to the Environmental Manager. The current land uses of the port and the important economic value is described in chapter 4, having chapter 5 dedicated to characterise the water quality of the port using the water quality data from the past 5 years. Chapter 6 deals with the recommendations required to achieve legal compliance, concluded by chapter 7 summarising the thesis.

CHAPTER 2

COASTAL ZONE MANAGEMENT

2.1 Introduction

The South African coast sustains a myriad of communities and stakeholders, providing a host of different services derived from the natural aesthetic beauty, as well as the usage of the wealth of fauna and flora. The term "coastal management" came into common use with the implementation of the United States Coastal Zone Management Act of 1972. The Act recognised that a sectoral management approach, focusing on individual resources such as fisheries, or activities such as transport, was not working (Chau 1993). The magnitude of users of the South African coast suggests that integrated coastal zone management is necessary to maintain and sustain the resources. Coastal zone management promotes sustainable coastal development by working together to promote human development with ecological integrity (South African Coastal Zone Management Policy Green Paper 2000). The interconnected natural and human components aim to achieve sustainable development practices yet development involves the removal of natural habitat for human benefit. The balance to prevent long lasting impacts on the coast is achieved through a process of improving the quality of life whilst maintaining diverse and productive coastal systems. The term "sustainable development" is aptly described in detail by the Department of Environmental Affairs and Tourism in the Coastal Zone Management Policy (1998), highlighting the meaning as meeting the needs of the present generation without diminishing the prospects for future generations to meet their needs. This is a tall order considering the interrelationships between man and nature and the poor economy of the country forcing food to be sourced increasingly from the coastal zone not meeting the sustainable usage criteria.

The development of a Coastal Zone Policy in South Africa has been driven by the diverse stakeholder requirements along the coast. The policy development process should be undertaken to address a set of perceived problems, largely determined by the stakeholders. The policy should clearly indicate the roles and responsibilities of governmental and non-governmental organisations and clear guidelines using goals and objectives to achieve the end point of sustainable coastal zone management. Policy

should encompass an integration of all stakeholders for a common goal to be achieved. The first goal of policy should be to prioritise specific coastal issues and concerns to provide a mechanism for determining the expected actions of government or global agencies. The driving force for shipping policies is the International Maritime Organisation who produce a set of principles for resource management to reduce the impact shipping has on the coast. One example of this is the move to reduce the possibility of the transfer of alien species in ballast water tanks by following the ballast policy guidelines to circulate ballast at sea prior to berthing in ports. This policy is adopted worldwide as the threat of foreign species has become a high priority in countries with warmer waters prone to possible infestations. The United Nations Law of the Sea Convention in 1992 was a strong global leader in determining guidelines for coastal management. Policies with guidelines are however not legally enforceable yet many countries subscribe out of a need improved management of coasts. This is achieved by policies highlighting principles like integration, duty of care and using the precautionary approach. Funding for implementation of policies should be a high priority for policy implementation as well as establishing a clear legal structure to address specific coastal management issues.

The coastal zone has many definitions including the details of what they contain in the form of physical features. The coastal zone is largely determined as an area influenced by the sea. The coast is a narrow margin on the seashore is the area of transition between land and sea. This is an area of physical and chemical processes including a flow of energy, and a cycle of nutrients. The importance of managing such a dynamic and unique system has increased over time as is the recognition of the strategic importance of coastal areas and ecosystems sustaining a wide range of economic activities (Salomons *et al* 1999). The interpretations of coastal zone often exclude human interference however the combination of the terrestrial and marine environments together with human activities comprises the coastal resource system (Figure 6).

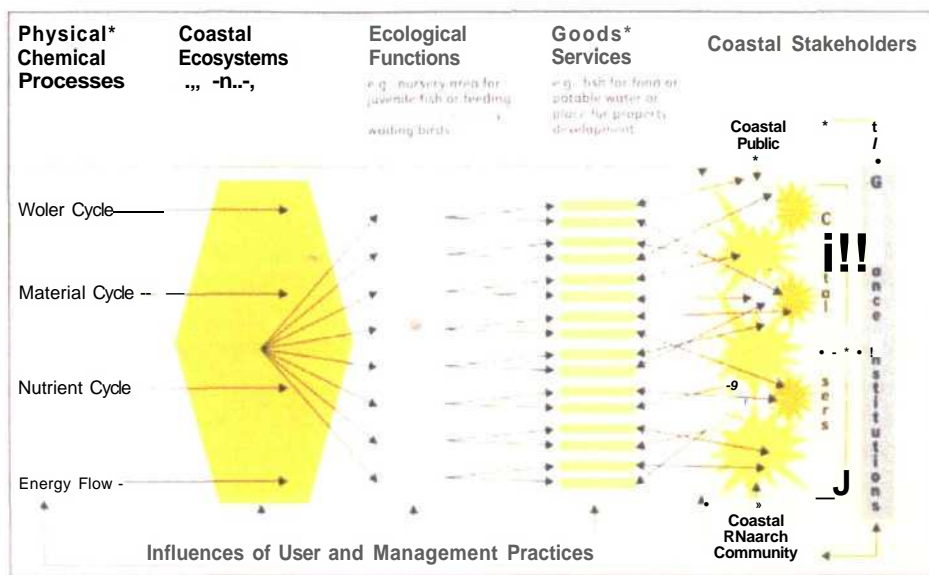


Figure 6: The interrelationship between natural and human components of the coastal system.

The coastal management for sustainable development must take into consideration that economic activities such as port operations have some of the major impacts on the coastal zone. One of the recommendations from the Earth Summit in Rio de Janeiro in June 1992 suggested that the management of coasts should be integrated (Cicin-Sain 1992). The integration of management principles should then be developed into strategies and then implemented to achieve protected coastal resources, a common goal of all South Africans. Integration relates to the linkages among various management actions of programmes and projects are internally consistent with goals and objectives. The underlying philosophy of the Earth Summit also highlighted integration as the key to achieving this success.

Integrate coastal zone management highlights the coexistence of all the elements of the coastal zone. The achievement of even modest levels of sustainable development and integrated development of coastal resource systems requires intersectoral cooperation of plans and an integration of development activities (Salomons *et al* 1999). The integration concept must be informed by knowledge on coastal systems. The

establishment of a coastal zonation scheme, which allocates natural resources for specific uses, is one effective form of functional integration (Chau 1993).

The Brundtland Report and the Agenda 21 programme highlight the integration approach of stakeholders as being key to the management of resources. The coordination of activities would essentially lead to the integrated coastal management. The aim of coastal zone management is to ensure that interventions in the coastal zone consider all possible human and environmental responses before they happen to ensure the best decisions are made. Integrated coastal zone management is an attempt to create a holistic and unified entity at every level from a diverse and disparate environment. The fragmented management of the coastal zone through a process of communication, coordination and harmonisation reaches integration. The attributes of integrated coastal zone management should include a programme over a considerable time period allowing for the establishment of policies for decision-making purposes.

This is particularly relevant when one views the coast as a system with natural components both biotic and abiotic/as well as the socio economic system incorporating the users with the physical and social infrastructure (van der Weide 1993). The general systems approach to integrated coastal zone management recognises the coast as a system as a set of objects or attributes which have a particular structure that act together to perform a specific function (Figure 6). The systems approach to integrated coast zone management recognises the interconnections among coastal systems, actions in one system have a definite impact on another. This approach was adopted in the early 1950's as a means of multiple systems descriptions in a bid to assist scientists to manage the coastal resource appropriately.

2.2 Integrated Port Management

The Ports of South Africa are managed by Transnet and are one of the most important stakeholders responsible for the management of the largest infrastructure essential to the economic functioning of the country. The port development and shipping support facilities are not usually thought of as infrastructure but rather as clients of infrastructure (Clark 1996). The management of the ports must be integrated into the overall coastal zone management, highlighting the need to reduce pollution, improve water quality and reduce potential hazardous installations from impacting on the environment. The history of coastal occupancy and coastal development around the globe shows a pattern of depletion of coastal resources and loss of biodiversity (Clark 1996). This has certainly the case with Durban and Richards Bay will follow suit when their port development framework is implemented, removing large tracts of natural sandbanks and mangrove forests.

The multiple uses of the coastal zone and specifically ports require integrated coastal management to ensure that all parties achieve their goal with the minimum of coastal resource destruction. Because the port is a multiple use zone concentrated in one area apposed to large coastal stretches the approach is somewhat difficult. The port is the recipient of multiple water discharges and needs also to integrate the management with the catchment. The catchment in turn affects the estuary and the biodiversity of the whole coast. Integration of port operations with the larger coastal zone management policy would ensure internal consistency between policies and actions, projects and programmes but also linkages between the process of planning and implementation. The management goal for the port system would be the maintenance of the functional integrity of the coastal resource system, reducing resource conflicts and facilitating the progress of mulit-sectoral development (Chau 1993).

Using a framework like the pressure state impact response approach (discussed in chapter 6) can be simple and flexible enough to assist ports with an effective mechanism for building up socio economic driving forces to achieve integrated coastal zone management with the assistance of all stakeholders (Salomons *et al* 1999). With the threat of continued infrastructure development in sensitive coastal areas, the demand for a strategy for the integrated management of coastal zones is essential. The South

African Coastal Zone Management Policy Green Paper (1998) published by the Department of Environmental Affairs and Tourism (Chapter 3) has highlighted this need and will guide a process forward to achieve managed and protected coastal resources. Harnessing and sustaining the development potential of our coast will require a significant change in thinking about how to plan and manage the coastal development process (Glavovic 2000). To facilitate this change, proactive policy guidance is required from government departments responsible for port management to assist both the public and private sectors to achieve long-term, economically efficient, socially equitable, institutionally viable and ecologically sound coastal development. The process of public participation in environmental impact assessments, strategic environmental impact assessments and integrated environmental management processes aim to achieve sustainable development through a participative and informative process.

> 2.3 Water Management of South African Estuaries

Estuaries are part of the South African coastal system contributing to the wealth of fauna and flora by their nature as an important habitat. The role of estuaries in the integrated coastal management is underplayed; they are often the areas with the most economic activity and the most human impacted ecosystems. Therefore water quality management for surface waters is a particularly important issue for management of estuaries along the South African coast as over 50% of South African people live within 100km of the coast (Harrison *et al*/ 2000). As competing demands for existing resources grow the need to consider the cumulative impacts of users increases. Some planning and management methods take a broader approach in considering the system's resources. In essence it is important to determine the end point or achievable goal of sustainable development in waterjgsoucco managornSoi. In order toytullyunderefarvi th° management-of-the resource water quamy needsto be investigated- \vatefquality " monitoring is undertaken for various purposes, including monitoring pollution levels, and maintaining acceptable quality drinking water. According to the Canadian Council of Ministers of the Environment (1999), water quality is managed worldwide using the following terminology and processes:

Guidelines: recommended limits of parameters that will support and maintain a designated water use (given in concentrations).

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Standards: enforceable environmental control laws, set by a level of government, usually to control effluent and emissions.

Objectives: numerical concentrations to support and protect designated uses of water, at a particular location.

Criteria: scientific data used to evaluate and recommend limits and monitoring parameters.

The water quality is managed according to the uses thereof, and commonly centered on aesthetics, agriculture, human consumption, recreation and the protection of aquatic resources (Water Quality Guidelines for Coastal and Marine Waters 1996). This implies a larger management tactic, ecosystem management encompassing all aspects of water quality. Noted in the national biomonitoring programme for South Africa, the Department of Water Affairs interprets water quality concepts to imply that together with the broader ecosystem large picture management; the term water quality is used to describe the physical, chemical, biological and aesthetic properties of water (Harrison *et al* 2000). The monitoring of water, the evaluation of the information derived from monitoring activities and the change of practice arising out of evaluation is a critical process for ensuring sustainability. It is common sense to maintain the productive capacity of ecosystems and to keep management options open for future generations (O'Riordan 1995). Based on this principle development initiatives for the future will need to be radically restructured.

The South African coastline stretches for 2900 km from Walweert-Narmbia in the west and Mozambique in the east. There are 343 estuaries along the coast, two thirds of which are found on the east coast. The major sheltered areas away from wave action are found in estuaries, the vast majority of which are seldom more than a few meters deep and often closed off from the sea by sand bars (Forbes *et al* 1998). Estuaries are an important and unique part of the aquatic environment forming transitional links between rivers and the sea. The salient feature of estuarine ecosystems is the gradient from freshwater to marine conditions (Wooldridge 1995). The salinity gradients being highly dynamic create the conditions for unique biological characteristics associated with estuarine systems. This is further reiterated by Harrison *et al* (2000), confirming the train of thought that in ecology it is a well-known principle that the nature of a biological community in an estuary is largely determined by a multiplicity of factors in its physical

chemical environment. Riverine inflow through the introduction of nutrients and the creation of the mentioned salinity gradients is primarily responsible for the high productivity and diversity of fauna and flora in South African estuaries (Hay 1995). These productive estuarine systems are particularly important habitats for juveniles of numerous marine fish species which utilise these areas as nursery grounds, as they provide shelter from predators and are a rich feeding ground (Forbes *et al* 1998).

Considering estuarine function in the broader ecological context, estuaries are regulated by the bioclimatic zones (Figure 7) in which their catchments occur, the catchment events, their physical configuration (including mouth condition), and conditions at sea (Hay 1995). The Coastal Zone Management Policy Green Paper (1998) highlights the geographical location as a determining factor, due to the east coast being characterised by the warm waters (20 - 25 degrees centigrade) of the Agulhas Current, compared with the Benguela upwelling system (9 - 14 degrees centigrade) of the west coast. Therefore extreme physical variation is considered an intrinsic part of the estuarine dynamic. These agents combine to form an ephemeral environment and in the short term an environment, which is often physically stressed. The habitats of an estuary including shallow infratidal and intertidal mud and sandflats with mangrove areas are erratic in nature, dependant on nutrient inputs to determine their productivity.

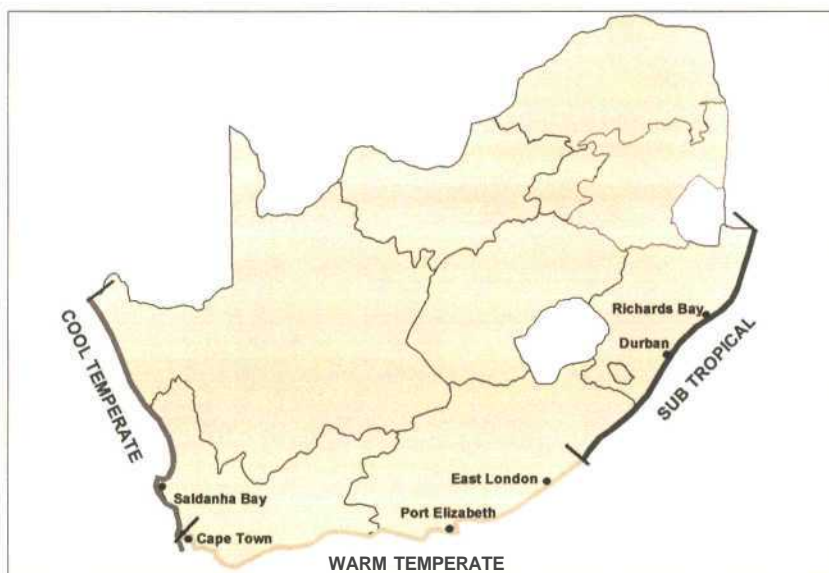


Figure 7: Biogeographical regions along the South African Coast.

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2.4 The Classification of Estuaries

Estuaries are classified according to geomorphological characteristics, together with location, rainfall and temperature to name a few variable characteristics. A geomorphologic estuary is identified so that its condition relative to others may be assessed. This process is a necessary prerequisite so that estuaries of vastly different characteristics are not compared with each other (Harrison *et al* 2000). The National Water Act 36 of 1998 states that an estuary is defined as a partially or fully enclosed water body, which is open to the sea permanently or periodically, within which seawater can be diluted to an extent that is measurable having freshwater drain from land. According to the resource directed measures for protection of water resources for estuarine systems documents produced by Department of Environmental Affairs, there are 260 of the 343 estuaries on the South African coastline matching this description.

According to the estuarine classification system developed by Whitfield (1992), estuaries are classified into 6 groupings namely; an estuarine bay, a permanently open estuary, an estuarine Lake, temporarily open or closed estuary, a modified or canalised estuary and a river mouth.

2.4.1 The Water Quality Variables used in Estuaries.

A water quality constituent is a term used in South African literature (Water Quality Guidelines for Coastal and Marine Waters 1996) to indicate the specific component used to assess water quality, however there are a number of constituents used at once to examine water quality. International literature highlights this aspect by calling the examined constituents variables. By the use of a number of variables water quality indices can be developed, which are generated for different monitoring purposes as mentioned above. The use of indices to condense and summarise large volumes of water quality data has increasingly gained acceptance in the last decade (Harrison *et al* 2000). The work on the water quality on South African estuaries clearly indicates the importance for classification of study areas prior to water quality studies, to enable indices to be developed.

Through these indices the water quality health can be measured, and this generates a pattern used to determine pollution sources. Pollution sources are termed point and non - point sources. Point sources are those associated with outlets, and non-point typically have more than one outlet associated with runoff e.g. agricultural fertilisers (Archibald 1998). Water quality is measured according to substances falling into the broad categories of nutrients, pesticides, heavy metals and substances with hormonal action (Federal German Environmental Ministry 1999). The empirical testing of surface waters has an advantage in creating awareness of water quality; this should be converted into well-informed management actions. The typical combination of water quality variables commonly associated with compiling a suitable set of indices (Table 1) are used to quantify the status of aquatic ecosystems by summarising data on the ecological health status of aquatic communities.

Table 1: Examples of water quality variables (Adapted from the Canadian Council of Ministers of the Environment 1999)

<i>Chemical Variables</i>	<i>Biological Variables</i>	<i>Physical Variables</i>	<i>Heavy Metals</i>
Nitrogen (Nitrates, ammonia)	Bacteria (Faecal oliforms. Total Coliforms)	Colour	Chromium
Phosphorus	Viruses	Temperature	Cadmium
Dissolved oxygen	Parasites	Odour	Lead
pH (Acidity . alkalinity)		Total Dissolved solids	Copper
Pesticides (Herbicides. Insecticides, fungicides)		Suspended solids	
Biochemical Oxygen Demand.		Turbidity	

2.4.2 Water Quality Indicators

The use and selection of water quality indicators to assess the overall condition of the estuarine system is determined by its physical, chemical and biological components. The selection of indicators from a health index is complex, since indicators are defined as characteristics of the environment that provide quantative information on the condition of ecological resources, the magnitude of stress, or the exposure of a biological component to stress (Water Quality Guidelines for Coastal and Marine Waters 1996).

The selection of indicators is dependant on physiographic and biogeographical differences in regions of the South African coast. Certain water quality and ecosystem indicators could also take the form of biological indicators. This specifically can be applied to ecosystems where a species composition of vertebrates or invertebrates can be used as indicators of the overall health of the system (Water Quality Guidelines for Marine and Coastal Waters 1996).

The indicators are selected on their ability to:

- => Represent the overall status of the environment;
- => Permit the detection of trends, through sensitivity to a range of stresses;
- => Be measured and interpreted relatively easy.

The combination of water quality indicators into an index generates an overall picture of the condition of an ecosystem as a whole. The sustainable threshold for the ecosystem can then be determined using indicators. The sustainable thresholds are in most cases exceeded with little chance of a quick recovery. A radical change in management tactics suggested in O'Riordan (1995) could reduce the degradation of estuaries further with the adoption of the think global act local approach.

2.4.3 Water Quality Health Indices used in Estuaries

Aquatic ecosystems health, like human health, cannot be measured directly. Instead, only indicators of health can be measured and in turn, used to assess the health status (Water Quality Guidelines for Coastal and Marine Waters 1996). Water indices do not attempt to explain the reasons for changes in the ecosystem, nor do they account for the complexity of interactions between physical, chemical and biological components (Archibald 1996).

Table 2: A list of biotic and abiotic variables used in an estuarine health index (Harrison 2000).

Abiotic and Biotic Variables	
Hydrology:	
1. Changes in seasonal river inflow patterns	3. Low flow reduction
2. % of natural MAR currently abstracted	4. High flow reduction
Hydrodynamics and mouth condition:	
5. Timing, frequency and duration of closure	7. River mouth stabilisation
6. Tidal flow modification	8. Water level
Water chemistry/quality:	
9. Salinity	
10. Axial and vertical salinity gradients	14. Dissolved oxygen
11. Nitrate and phosphate concentrations	15. pH
12. Suspended solids	16. Temperature
13. Organic and inorganic toxic water quality constituents	17. Faecal coliforms
Physical habitat alteration:	
18. Change in sediment structure and distribution	21. Migration barriers, bridges, weirs, bulkheads, training walls, jetties, marinas
19. Estuary bed and channel modification	
20. Infilling	22. Human disturbance of habitats and biota
Changes in biotic habitats and communities:	
23. Plants - area or biomass of different communities, community composition, diversity	25. Fish - - community composition, diversity, biomass
24. Invertebrates - community composition, diversity, biomass	26. Birds - community composition, diversity, biomass
27. Change in ecosystem complexity	
Alteration of estuary margins and floodplain and catchment area	
28. Amount of floodplain vegetation remaining	30. Degree of human habitation and use
29. Degree of industrial development within floodplain	31. Alteration in catchment area. e.g. plantation forestry

Biotic variables (Table 2) are response variables indicating a change in all or some of the abiotic variables. The inclusion of both biotic and abiotic variables is deemed important, as they are interdependent, however some biotic indicators responses are slow. Therefore biotic indicators would need to be chosen carefully to avoid late or incorrect deductions. The use of specific indicators for the estuarine health of the Port of Durban will be addressed later in the assessment of the current port status.

2.5 Estuarine Water Quality Indices

An Estuarine Water Quality Index (eWQI) is utilised to determine the water quality of estuaries, specifically dealing with indicators in categories that affect aquatic life, have an impact on human health and those indicating a trophic status in a system. The index

is standardised by a set of rating curves, enabling a standard scale. The variables of concern are weighted according to their importance in a particular system, and then a rating system of estuarine health developed accordingly. The use of the eWQI to produce a water quality classification system for South African estuaries has great utility (Harrison *et al* 2000). The development of water quality indices is specialised but the system does not for example consider heavy metals or the effects of pesticides (Harrison *et al* 2000), however it is an ideal tool to obtain regional and national perspectives of water quality.

2.6 Substances of Concern in Estuaries.

Nutrients, pesticides, heavy metals, and substances with hormonal action in varied concentrations are noted as giving rise to problems with water conservation (Canadian Council of Ministers of the Environment 1999). The resultant problems associated with the increase in the above-mentioned substances, are varied having both biological and aesthetic consequences. These include high turbidity, deficient oxygen, fish mortality, restricted use of drinking water and allergic reactions in bathers (Canadian Council of Ministers of the Environment). The problem substances have an effect on the functioning of a system. It follows that in order to manage an aquatic ecosystem these substances would need to be regulated. Legislation and guidelines have been promulgated worldwide to protect environmental degradation of aquatic resources (Salomons *et al* 1999). These substances have largely been ignored in the Port of Durban due to the likelihood of their presence and subsequent cleanup costs associated with their high concentrations.

2.7 General conditions of South African Estuaries

South African estuaries need to be managed in order to protect the ecosystem function and maintain biodiversity. Various studies have been done based on the concern for estuaries all concentrating on the future of estuarine function and management thereof.

A report based on the results from a study commissioned in 1992 by the Department of Environmental Affairs by authors Harrison, Cooper and Ramm (2000) suggest that of the 250 systems tested (systems, as some tested were not estuaries) 41 % were classified as good or very good, 34 % as fair and the remaining 26 % as poor or very poor (Figure 8).

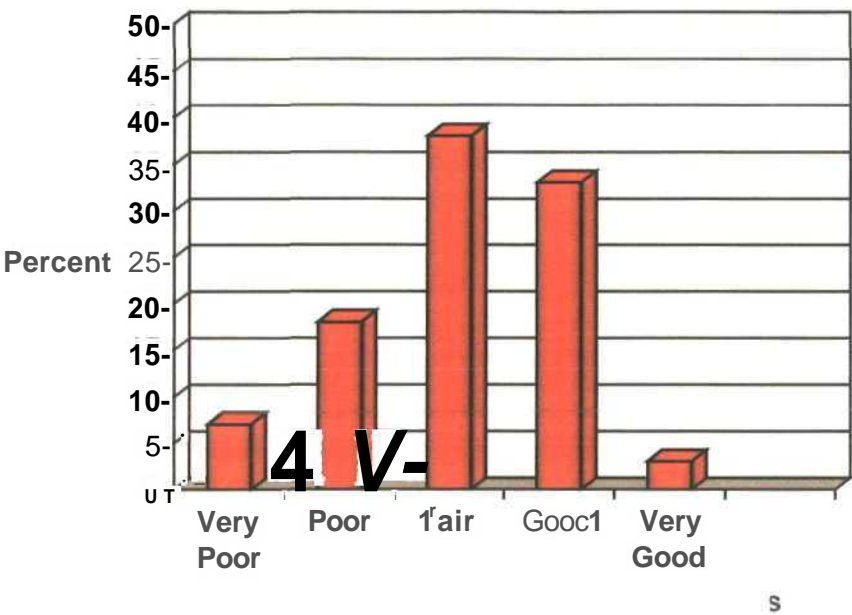


Figure 8: Classification of South African estuaries using the e WQI (Harrison *et al*/2000).

The rating of estuaries was based on the results of all the 250 estuaries sampled using the estuarine water quality index method. In a report for Portnet by Hay (1995), it is mentioned that sound management procedures for estuarine environments should be based on maintenance of the natural processes. This would then improve the overall condition of the system. Begg (1978) suggested that a set of principles be developed for managing estuaries and this would entail the management based on ecosystem functions rather than their physical attributes. This would suggest an approach including catchment management and the regulating of land uses near estuarine environments.

A study conducted by Walmsley (1997), commissioned by the Water Research Commission indicated that the catchment management of estuaries must occur to ensure the maintenance of estuarine function. His report was based on the ecological

function and water quality of the ports of South Africa, however the report was very brief and did not adequately investigate the solutions. The overall condition rating of South African estuaries is subjective, as although a number of estuary types have been studied, there are several in which limited research has been undertaken and their physical processes are poorly understood (Harrison *et al* 2000). This is not desirable in aiming for sustainable development objectives, as without the essential scientific data on ecosystem functioning sustainable management practices are difficult to achieve. For the foreseeable future most coastal nations will remain heavily dependant upon coastal resources to meet the needs of expanding populations and the need to expand and diversify their economies (Salomons *et al* 1999). However coastal planning and management should be undertaken proactively to optimise sustainable development opportunities.

CHAPTER 3

LEGISLATION FOR WATER QUALITY MANAGEMENT

3.1 Introduction

The management of the water resources of South Africa is made possible by a set of water quality guidelines produced by the Department of Water Affairs. These guidelines are split up into different sub sections according to the intended use of water for domestic, recreational, industrial, agricultural and aquatic systems. It must be noted that these documents are guides only and that there are no official South African nutrient standards for estuarine waters (Harrison *et al* 2000). The intended management of coastal resources is then highly reliant on the correct interpretation of field results relative to the standards derived for the other water uses. In some instances it is possible to apply the guidelines depending on whether the estuary is highly industrialised or extensively utilised for recreation. Environmental management must take into account the National Water Act 36 of 1998 to give meaning to the water quality guidelines. The difficulty with the port environments is that the jurisdiction of this act is not clear, and the interpretation of the limits is not adequate for management purposes.

The various legislative requirements for coastal zone management are difficult to interpret (Figure 9). The legislation most applied to manage port environments includes the National Water Act 36 Of 1998, the Water Quality guidelines for Marine and Coastal Waters (1996), developed by the Department of Water Affairs and the Coastal Zone Management Policy (1998) commissioned by the Department of Environmental Affairs and Tourism. The legislation does capture the sustainable development concept adequately but these are not sufficiently interlinked with all tiers of government departments to enable the effective enforcement. The far-reaching aims of South African policies highlight the interpretation of sustainable development on the life sustaining services rendered by the natural environment.

This poses management problems in terms of the correct application of the act. The water resources are classified by a sophisticated system in this act, with it being pertinent to the protection of water resources (Glazewski 2000), this being important to pollution prevention.

The strategic plan of the Department of Water Affairs and Forestry (2000) highlights a plan to regulate the use, flow and control of all water in the republic. One of these strategic objectives includes the formation of catchment management agencies, to empower and capacitate individuals to assist in resource management. This is essential in a port environment where at least 95 % of all pollution is from an external source (Archibald 1997). The sustainable use of water resources in a country where the resource is scarce and unevenly distributed needs to be holistically managed, taking into account the whole water cycle.

3.3 Coastal Zone Management Policy.

The coastal zone policy process has succeeded in drawing attention to long-term consequences of our decisions and actions (Glavovic 2000). The intended aim of the Coastal Zone Management Policy has been to promote sustainable coastal management. Glavovic (2000) notes that this includes planning, decision-making and action on the ground. The policy in essence recognises the varied coastal stakeholders, of various groups. The stakeholders are the coastal users, coastal public, coastal research communities and institutions of coastal governance who are responsible for developing and implementing the policies aimed at governing the behaviour of coastal users and managing coastal resources (Coastal Policy Green Paper 1998). Portnet falls into the category of institutions of local governance as they own and manage the port resources.

Sustainable and integrated coastal management is defined as a continuous and dynamic process that unites government and community, science and management, sectoral and public interests in preparing and implementing an integrated plan for the protection and development of coastal resources (Glavovic 2000). This integration and dynamic interrelationship between natural and human components of the system clearly indicates an understanding of the complexities involved in coastal zone management.

O'Riordan (1995) highlights the self-regulatory public involvement in managing resources. The unfortunate reality facing coastal managers is that the coastal zone management policy is not legally enforceable, yet is an ideal tool for cooperative coastal zone development. This is enforced by the policy principles including social equity, holism, duty of care, cooperative governance, economic development and ecological integrity. This policy has been used for better coastal planning and resource protection, and water being the receiving environment for pollution, requires the protection afforded by this policy. Environmental justice and accessibility and the right to utilise resources is a theme fast emerging as a fault with the coastal zone management policy.

3.4 London Protocol

The London Protocol is an international regulatory convention encapsulating the London Dumping Convention (1972) and the Protocol (1996) dealing with the dumping of land based waste. The waste is classified according to the potential influence it has on marine environments. South Africa is a signatory of the convention and requires that Port authorities apply for a dredging permit from the Department of Sea Fisheries in order to dispose of dredged spoil at sea.

3.5 The Sea Shore Act 21 of 1935

The Sea Shore Act is narrowly conceived and does not regulate activities or impose any type of environmental management system on the coastal area (Glazewski 2000). The coastal zone is a dynamic interface between the land and sea, and uses the high water mark as the boundary for legal administrative purposes. This implies that the high water mark in ports is used as the boundary for this act, but this is not legally enforceable due to the landward boundaries not being clearly defined in the act. Based on the drawing produced in the coastal zone management policy and the adapted version in Glazewski (2000), (Figure 9) the interpretation of the act is ambiguous and as a result cannot be applied in management.

The Sea Shore Act although dated, is fundamental to any existing or proposed institutional arrangement for the coast (Glavovic 2000). The policy however further

mentions the need to update the act to align it with the constitution. Port and shipping related activities will need to pay attention to this act to the far-reaching consequences for the environment in the event of a maritime disaster.

3.6 Department of Water Affairs Water Quality Guidelines.

In the executive summary of the Water Quality Guidelines for Coastal and Marine Waters (1996), the steady decline of water quality countrywide was acknowledged. The department has subsequently embarked on a programme to re-evaluate and develop water quality policies (Barnard 1999). The Guidelines for Coastal and Marine Waters (1996) is the current management tool used in the Port of Durban as a guide to the water quality status (Archibald 2001). The use of the guidelines for aquatic, Industrial and recreational values are all combined depending on the variables of concern.

The guidelines should, as far as practically possible, serve as a stand alone source of information and support base for water resource managers to make judgments about the fitness for use of water for different purposes (Water Quality Guidelines for Coastal and Marine Waters 1996). The use of water goes beyond the traditional use of water for domestic, agricultural, recreational or industrial purposes. The execution of controlled activities including waste disposal, no matter how small is also regarded as water resource use (National Water Act 36 of 1998). These guidelines highlight a no effect range for variables indicating a target value. This value is referred to as the target water quality range. This is the range of concentrations or levels at which the presence of a constituent would have no known or anticipated adverse effect on the fitness of water for a particular use or on the protection of ecosystems (Water Quality Guidelines for Coastal and Marine Waters 1996).

The guidelines further highlight the possible consequences in an ecosystem if these values are exceeded. It must be noted however that the impact of a combination of a number of variables over the target water quality range has not been adequately addressed in these documents. Water quality management in South Africa is the responsibility of the Department of Water Affairs and Forestry (Barnard 1999). This places the enforcement and monitoring of the water quality guidelines within their operational duties. The aim of these guidelines is to strive to maintain the quality of

South Africa's water resources such that they remain within the no effect range (Water Quality Guidelines for Coastal and Marine Waters 1996).

Barnard (1999) states however that the water quality guidelines were developed in isolation as water quality issues arose, having not taken into consideration other environmentally degrading activities. Barnard (1999) suggests that the development of the water quality measures was undertaken in a piecemeal manner, resulting in a system that was not coordinated, and not reflecting a holistically conceived unitary structure. The guidelines are used as the primary source of information and decision support, in order to judge the fitness of water for use and for other water quality management purposes (Water Quality Guidelines for Coastal and Marine Waters 1996).

3.7 South African Water Quality Target Values

The South African water quality target values differ depending on the use of water. This allows the manager an opportunity to effectively manage a resource depending on the uses or combination of uses of a water system. Since there are no guidelines for an estuarine system a combination of guideline (Table 3) target values are applied in the Port of Durban water quality management.

Table 3: Department of Water Affairs Water Quality Guidelines as applied in the Port of Durban

Surface Water Quality Variable	Measurements	Water Quality Guideline Used	Target Value
Ammonia Nitrogen	Mg NH/L	Aquatic Guidelines	0-0.03
Nitrate Nitrogen	MgN/L	Aquatic Guidelines	<0,1
Soluble Phosphorus	MgP/L	Aquatic Guidelines	<0.1
Suspended Solids	Mg/L	Agricultural Guidelines	<50
Dissolved Oxygen	Mgo/L	Aquatic Guidelines	6mgO/l
Chloride	Mg cl/L	Domestic	0-100
Faecal Coliforms	Counts per/ 100ml Water	Recreational Guidelines	<2000/100ml

The variable concentration limits (Water Quality Guidelines for Coastal Marine Waters 1996) are achievable, subject to a combination of factors contributing to the minimization of overall pollution loads entering the Port of Durban. The limits are based on norms typically associated with South African conditions, taking into account the

climatologically influences combined with high impact land uses. The limits take into consideration the bacteria influences on public health, indicating a minimum requirement for safe human contact. The sustainable use of the resource is regulated by the limits as determined by the Water Quality Guidelines for Coastal and Marine Waters (1996). The issues pertaining to the actual sustainability threshold are not adequately described in these documents, and should be addressed taking into consideration cumulative impacts and prolonged use of resources.

3.8 Selected International Water Quality Target Values.

International guidelines from selected countries (Australia, Canada & Germany: Table 4) separate their uses according to the domestic, ijgxicuJtttrahaTTcTrecreational uses. There is however little deviation of the target values between these classes as they seem to have a more stringent requirement. These countries have been chosen as a comparison as they range from highly polluted river systems (Germany) to less polluted countries (Australia and Canada). The history of these countries also contributed to their choice as comparison material. Canada has a long history of contaminated sediment problems and as such has promulgated numerous laws to protect their resources. Their high contributions to the International Maritime Organisation for the control of polluting shipping activities makes them an ideal country to use.

Table 4: Selected international water quality legislative requirements

Surface Water Quality Variable	Measurements	Australian Water Quality Target Value	Canadian Water Quality Target Value	Germany Water Quality Target Value	South African Water Quality Target Value
Ammonia Nitrogen	MgNH/L	<0.02	0.013	0.2 - 0.4	0-0.03
Nitrate Nitrogen	MgN/L	<1,10	<0,60	<0,25	<0,1
Soluble Phosphorus	MgP/L	<0.05 (salt water)	N/A	0.04-0.06	<0.1
Suspended Solids	Mg/L	<25	N/A	<39	<50
Dissolved Oxygen	Mgo/L	5	5.5-9.9	2 - 8	6
Faecal Coliforms	Counts per/ 100ml Water	N/A	N/A	Use chlorophyll a as an indicator instead	<2000/100ml

A comparison of the selected international water quality target values indicates that Australia has more stringent requirements than Canada, Germany or South Africa. In reviewing the water guidelines from Canada, Germany and Australia and South Africa, only South Africa used faecal coliforms as an indicator of pathogen and culture species. The International water guidelines recognise the diverse effects pathogens have on the environment but monitor a suite of pathogens. The coliform bacteria are not as important to European countries as they are in South Africa as a result of their more improved sanitation history. The level of pathogens only becomes an issue when it enters European drinking water, typically groundwater not surface water.

South Africa has a history of poverty and poor sanitation and the faecal coliform measurement is an indicator of the lack of sanitation, and the use of the same water resources for both sanitation and drinking. This measure gives an indication of the possibility of other water borne diseases occurring. The Federal German Environmental Ministry (1998) guidelines are aimed at managing their extensive waterways and individual rivers are given different water quality target values. Germany has a history of polluted waterways and the diminished fish stocks in these river systems enable each river system to be managed separately. Australia has a relatively short maritime history yet their marine coral systems have been badly impacted due to the introduction of exotic marine species. Australia has similar warm marine water characteristics as South Africa and is strongly referenced in the Water Quality Guidelines for Coastal and Marine Waters (1996).

3.9 Summary of Water Quality Management

By using a combination of the aquatic, agricultural, domestic, marine and recreational guidelines, the Water Quality Guidelines for Coastal and Marine Waters (1996) are adequate to assess the condition of fresh water resources. The only disadvantage is that there are no separate values for estuarine ecosystems, which would allow for easier interpretation of estuarine results. The Australian national water quality management strategy, the German Environmental Ministry water resource management and the Canadian water quality guideline documents combine fresh and marine water quality in one document for easy reference purposes, whilst the South African guidelines have a separate set of guidelines for marine environments.

The comparison of the South African guidelines with the selected international guidelines indicates that Australia and Canada have so far complied with their guidelines on average, but Germany has a persistent historical pollution problem and has difficulty complying with their guidelines (Federal German Environmental Ministry 1999).

CHAPTER 4

SITUATION ANALYSIS: PORT OF DURBAN

4.1 Introduction

The Port of Durban is now an industrialised working area, however the port is comprised of many natural elements. The Port is a gateway to Southern Africa (Portnet 1998) and is primarily utilised as a port reception facility. South Africa has seven commercial ports on its coastline each of which serves as an important strategic role for the import and export of particular commodities (Walmsley 1997). The study on the Ports of South Africa by Walmsley (1997), showed little information regarding the water quality management. It has been determined by various environmental studies that both land based and marine activities contribute to the degradation of port environments. It is a reality that the Port of Durban is situated on one of the most ecologically sensitive estuarine systems of the east coast (Ducray 2000). It is further recognised that both the range and magnitude of water quality problems experienced at an individual port system usually provide an indication of their environmental condition (Paipai and Brooke 1993).

It follows that a healthy port can be expected to have minimal problems whilst a dirty port will have many. The difficulty associated with this statement is how to quantify dirty and to align the subsequent environmental practices to improve conditions. Due to the nature of port business changing dramatically (Walmsley *et al* 1997) a greater awareness is apparent highlighting the need for a clean port system.

The previous chapters highlighted the requirements for water quality management, what quantifies the healthy estuarine status, as well as the legal aspects of water quality management. The actual condition of the Port of Durban water resource needs to be evaluated taking into consideration the history, the current land uses in the catchment, taking note of how other external pressures are currently influencing the estuarine function. This chapter highlights the current pressures on the resource, and the management practices implemented to assist water quality management. The Port of Durban water quality management programme results will be used in conjunction with the Water Quality Guidelines for Coastal and Marine Waters (1996) to assess the

current status of the port environment. The variables used in this thesis to quantify the water quality status in the Port of Durban will be oxygen, bacteria, nitrates and suspended solids. It must be noted that the contaminants present in the sediment are not considered as part of this study, however their role in release of pollutants into water is noted as a possible contributing factor to poor water quality in the port.

4.2 Description of Port Habitat.

Day and Morgans (1956) identified four main habitats in the Durban Bay. These were hard strata, sands, muds and subtidal areas. The subtidal (shallow tidal areas), sands and muds now are largely referred to as the sandbanks (Figure 10) and within this environment occur the mangrove community. The Port of Durban Bayhead Natural Heritage Site also consists of coastal grasslands, however they are a man made feature (Portnet 2000). Durban's role as an estuary has assumed increasing importance because more than 70% of the 73 estuaries in KwaZulu Natal are seriously degraded (Watermeyer *et al* 1996). This prompted Portnet to conserve the mangroves in the port by proclaiming the habitat a Natural Heritage Site.



Figure 10: Habitats within the Port of Durban. (Adapted from Port of Durban 2000)

The rest of the port is associated with deep waterways between 6 and 13.5 meters in depth below chart datum, and open water also of depths ranging from 0 to 13.5 meters in depth below chart datum. Only 14% of the original tidal mudflats remain, 3% of the mangrove habitat and only 4% of the natural shoreline habitat (Allan 1999).

4.2.1 Biotic Communities of Hard Substrata.

Using the Day & Morgans (1956) study as a guide, the hard substrata are referred to as the embankments, wharves, quay walls, piers and floating structures. Various recent studies (Ideas 1996 and 1998, Hay 1996, Guastella *et al* 1994) have been undertaken to characterise the fauna and flora of the port. The studies all produced species lists but did not conclude with any reference to the overall environmental condition of the port. The hard substrata are inhabited with barnacles, sea anemones and mollusk species (Ideas 1998), with little zonation between littoral, balanoid or infra-tidal zones. This was a change from the Day and Morgans (1956) study. The study undertaken by Ideas on the Port of Durban habitats past and present (1998) also noted that although barnacles were present, all appeared to be dead.

4.2.2 Soft Substrata.

A study of the sand and mud of the port was conducted by the Marine Geosciences Unit of the University of Natal, as well as by Archibald (2000). The associated biota inhabits various sand and mud fractions, with the mud fractions being less than 0.063 mm. The sandbanks support a number of crab species, mostly soldier crab to the north of the mangroves and towards the central sandbank (Watermeyer *et al* 1996). Hay (1992) mentions that coelenterates, amphipods, isopods, polychaetes, annelids and crabs inhabit this substrate. As the portion of mud in the sands increased, so to does the species richness and diversity (Ideas environmental consultants 1998).

4.2.3 Biota of the Mangrove Community.

Avicennia marina (White Mangrove), *Bruguiera gymnorhiza* (Black Mangrove) and *Rhizophora mucronata* (Red Mangrove) are the three tree species present in the mangrove forest (Ward 1996).

The climbing whelk and mangrove whelk are the two most common animals in the forest (Ideas environmental Consultants 1998). Large populations of *Sesarma* and *Uca* crabs are present in the mangroves and associated muddy substrate (Hay 1992).

4.2.4 Fish Communities

A study by the Oceanographic Institute, published by Guestella *et al* (1994) indicated that 89 fish species occur in the port, and are regularly caught by recreational fishermen. Many recreational and subsistence anglers utilise this resource and fish from the quays and accessible shoreline around the perimeter of the bay (Watermeyer *et al* 1996). This is a decline in species compared with the Day & Morgans study in 1956, as their study revealed 186 species. This marks a decline of 97 species in 38 years.

4.2.5 Bird Communities.

The movement of birds in the port is attributed to their habitat preference and associated food requirements. One hundred and seventeen bird species have been recorded in the bay (Allan 1999). Ninety-six of these are regular South African Water bird species and twenty-one are non-breeding vagrant seabirds and waders. Allan (1999) studied the Port of Durban bird life extensively in a study commissioned by Portnet to highlight the impacts on the bird species of the Portnet helicopter service. This study indicated that the abundance of water birds has decreased by over 70% from the period of 1965 to 1999.

The bay in its current state is not a site of global or sub-regional significance, in terms of its water bird populations under the Ramsar Convention and the important bird areas Initiative (Allan 1999). This does not mean however that it must not be conserved.

4.3 Sediment Components in the Bay

The overall makeup of the port sediment is characterised by mud fractions (Figure 11) with an increasing concentration of mud and fine sediment towards the river inflow area of the silt canal. The larger sediment grain size characterises areas nearer the port entrance with associated marine habitats. A predominantly large amount of sediment is

dredged in the vicinity of the Silt Canal and Maydon Wharf areas (Watermeyer *et al* 1996), (Plate 2) reflects the areas tested for sediment particle size (The letters on figure 11 correspond with those on Plate 2).

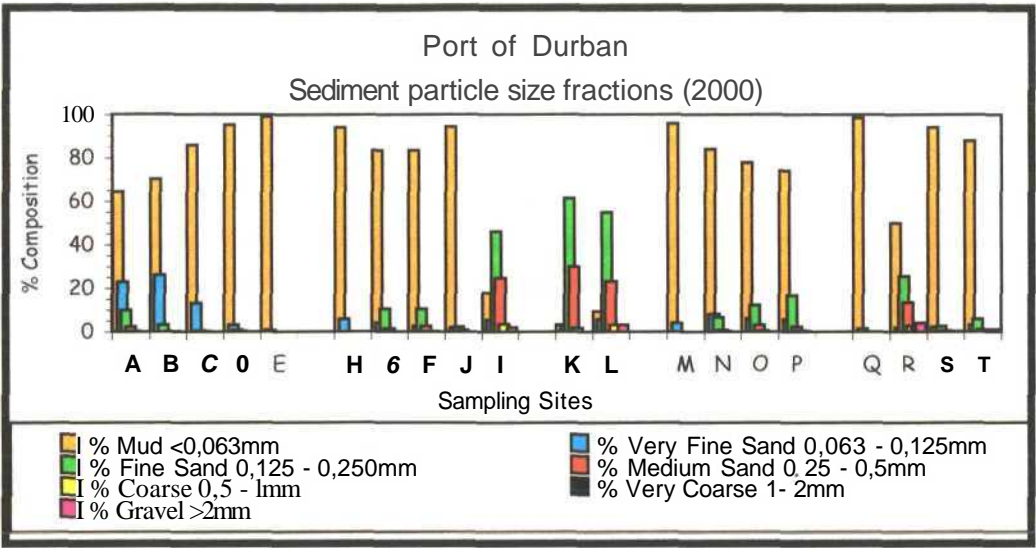


Figure 11: Sediment Particle Size of the Port of Durban (Adapted from the Dredging Report Archibald 2000).



Plate 2: Port of Durban Sediment Testing Areas (Courtesy C.S.I.R.)

4.4 Land use Zones and Economic Value.

The management of the port through a legal context incorporating the environmental legislation and the requirements from the Department of Environmental Affairs is increasingly difficult due to the nature of the current segmented port cargoes (Figure 12) (Ducray 2000). Value adding activities such as warehousing, breakbulk, sorting, manufacturing, and industrial processing are usually strategically located adjacent to ports. This is because a port location usually ensures that transportation costs are minimised and there is the option of moving goods either inland or by sea transport. The main core function of the port is shipping related and the port is the busiest in Africa (Walmsley 1997).

The surrounding land uses include shipping and support functions combining light industry, rail marshaling yards, naval military use, tourism & leisure. The associated land uses provide a road and rail corridor for the port and central business district (Plate 3). The secondary land uses supports ship repair companies, container storage as well as sporting, recreational and protected natural areas complimenting the major shipping land and water use (Plate 4). The container terminal is the largest in the southern hemisphere and handles 65% of the total number of containers passing through South Africa's ports. The terminal is modern by world standards and has been designed and constructed to high standards (Portnet 1998).

The main cargo handling use of the port is spatially varied and this is largely due to infrastructure, creating zones isolated from one another with different characteristics (Plate 5). The Maydon Wharf area handles the multi-purpose and bulk products; these also need to be stored on site. The main physical components of a multi-purpose terminal are open stacking areas for containers and general cargo, covered storage for general cargo requiring protection from the elements, a rail terminal, road vehicle reception area, administration buildings, and staff facilities. The point and pier 1 areas (Plate 5) are dedicated to dry bulk as well as vehicle imports and passenger handling facilities. Pier 2 (Plate 5) handles mainly containerised cargo, and the Bluff Coaling Appliance imports and exports coal (Ducray 2000).



Plate 4: Port of Durban Other Land Uses



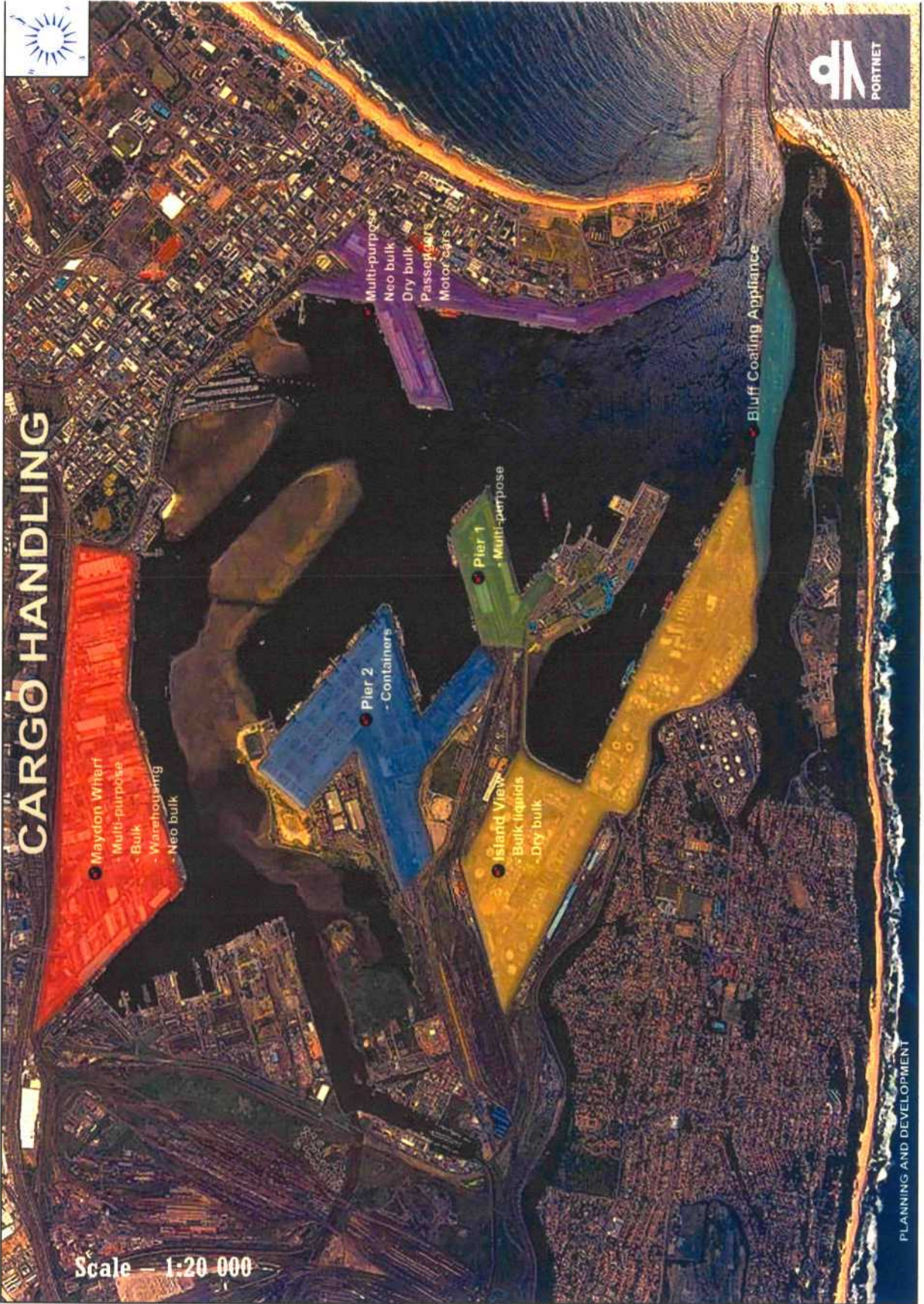


Plate 5: Port of Durban Cargo Handling Areas

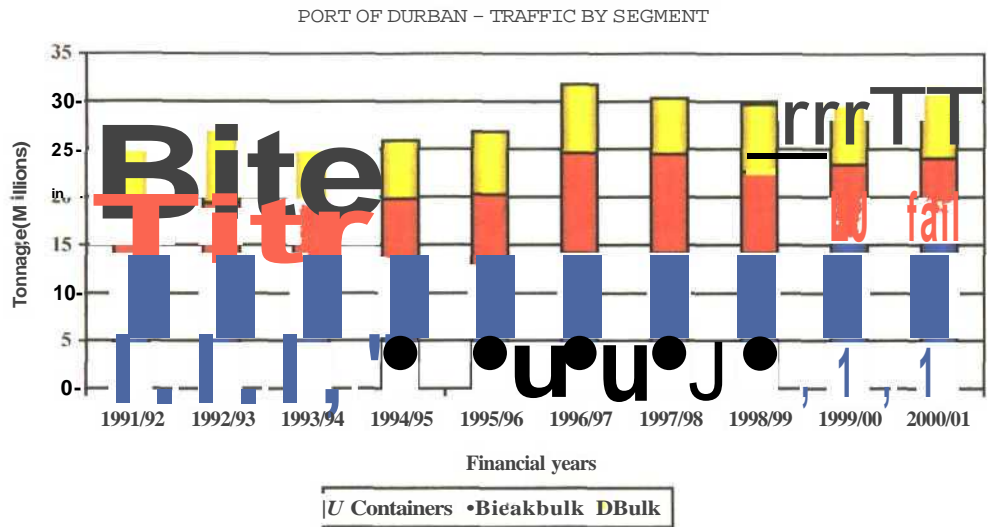


Figure 12: Cargo Volumes handled in the Port of Durban, by segment

The Island View (IV) area of the port, consisting of 156 hectares, is leased primarily to the liquid bulk industry. Principal cargoes handled in this area are crude, petroleum products, chemicals, vegetable oils and acids. There are also dry bulk products such as maize, fertiliser and mineral phosphates handled by Durban Bulk Storage. Bulk liquid cargoes are handled at dedicated terminals, and in most cases at dedicated berths. The bulk liquids are normally categorised as hazardous or non-hazardous commodities and it is normal practice to zone these products at separate locations. The hazardous cargoes include petroleum, chemicals, liquid petroleum gas (LPG), and liquid natural gas (LNG). Non-hazardous products are mainly edible oils (Portnet 1998).

The port is responsible for handling at least 70% of the countries bulk liquids and this makes the port economically essential to the functioning of the country. Due to Durban being the biggest port in South Africa with the busiest terminals and the largest container terminal, the vast economic value of the port reception facility is not often conceptualised or appreciated. The natural water resource providing this economic value is often overlooked yet it provides the backbone for the generation of revenue for the country. The true value of the port can be appreciated without taking the natural component for granted but managing it you can sustain the economic viability of the port.

CHAPTER 5

PORT WATER QUALITY

5.1 Introduction

The current water quality and the average water quality over the last 5 years will be discussed generating a picture of the average ecological picture. The water quality information used is extracted from the 2001 edition of the water quality management programme as raw figures. The data will be interpreted and enhanced indicating areas of concern and possible sources of pollution, using the discussed land uses as a guide. The data as presented in this chapter will be compared to selected international water guidelines. The port is influenced by a number of point and non - point sources of pollution the majority emanating from outside the port confines.

The substantial economic worth of estuaries in terms of commercial fishing, transportation and recreation provides justification for the protection and preservation of these systems. The water quality reporting has taken the form of a glossy document for the last 5 years, paying little attention to implementing any suggestions therein. While comprehensive planning and management of a complex estuarine system is a daunting task, the ongoing drive for resource protection must be the primary goal to ensure the sound ecological management within the sustainable levels. An example would be to divert polluted sewers to be purified prior to entering the bay. As with most solutions the price allocated is often the stumbling block. Sustainable use of water resources is one of the Department of Water Affairs principles and it is no service to the people of South Africa if the resources are permanently negatively affected. Questions related to government resource management would be the result.

5.2 Water Quality Testing in the Port of Durban

The water quality testing in the port is conducted by the C.S.I.R following a programme designed by the Portnet Environmental Department. The programme involves a yearly characterisation using 20 - 24 testing locations including the stormwater, river and open water areas (Plate 6). The current water quality-monitoring programme in Durban bay is

geared to addressing most, if not all of the aspects referred to by Walmsley *et al* (1999) in the Water Research Commission report on port water quality. These aspects included stormwater management, river and pollution management.

The goals of the programme included;

- => Maintaining the oxygen status at a level which will sustain aquatic life in Durban Bay
- => Maintaining acceptable microbial water quality for recreational contact
- => Managing water quality to ensure reduced nutrient loading
- => Controlling and / or reduction of the frequency of algal blooms
- => Prevention of oil spillages entering the aquatic system
- => Reduction flotsam (Floating litter) in the bay
- => Improve conditions in sub-catchments of stormwater drains and rivers.

These goals as outlined in Archibald (1999; 2000; 2001) also have a number of objectives including:

- => Maintaining oxygen concentrations at every open water site within the compliance level in the next 5 years.
- => Increasing the microbial compliance percentage by 25% at each site within the next 5 years.
- => Maintaining or decreasing ambient nutrient concentrations within the next 5 years.
- => Maintaining or decreasing the frequency of algal blooms in the bay.
- => Reduction of the current incidents of oil pollution by 50% over the next 5 years.

The initial background investigations to determine the status of invasive alien species have also been included in the programme. The programme results take the format of a printed document produced once a year with the test results. The programme also incorporates the following principles:

- => Maintenance of ecological balances of the environment.
- => Avoidance of irreversible changes to the environment.
- z> Adoption of the precautionary principle.

The programme is informed by preferences established by public participation exercises and the new water law and Portnet's obligations and commitment (Archibald 2001). The water quality programme also contributes towards maintaining aquatic life, improving aesthetics, prevention of water borne diseases and reducing sediment loads. The outcomes of the programme include informed management decisions, and adaptation of current port practices to minimise water impacts (Walmesly *et al* 1996).

The sites in the port are tested for bacterial contamination and nutrient enrichment using a range of variables (Appendix 3). The water testing is focused on providing comprehensive, accurate and reliable data using water quality parameters to describe the present state of the bay as a benchmark for the 21st Century (Archibald 2001). The river, stormwater and open water testing has been conducted for 5 consecutive years (Portnet 2001). The water is tested monthly on spring low tide obtaining access to sites easily. The water quality programme concentrates on areas most impacted by industry and human intervention. It is notable that a large portion of the programme is dedicated to monitoring the stormwater systems entering the bay; this gives in effect a warning as to the overall open water condition.

The testing of water to obtain a 5-year confidential data set has achieved little in the overall management of the port. At most only 10 out of 5000 employees are aware of the programme as a result of sensitive nature of the results. This confidentiality of information is no longer valid in terms of the National Environmental Management Act 107 of 1998, and the release of a small portion of the results in this document will hopefully generate an interest in the whole catchment management initiative. The environment of the port is on the whole improving, and one can only assume that the reduced visible pollution has had some effect. An example of this can be seen in the improved recruitment of mangrove tree seedlings in the Bayhead Natural Heritage Site. This gives an indication that conditions are conducive for colonisation in other areas, previously not colonised due to pollution or poor water quality.

The surface water variables of the stormwater, open water and river inputs will be compared with the Water Quality Guidelines for Coastal and Marine Waters (1996) and to the Federal German Environmental Ministry (1999), Australian and Canadian Council

of Ministers of the Environment Guidelines (1999) (Chapter 5). The variables used will be oxygen, bacteria, nitrates and suspended solids as depicted graphically in this chapter. These variable concentrations will be shown graphically, and then compared using a tabular format.



Plate 6 : Port of Durban Water Testing Areas

5.2.1 Stormwater Discharges.

A total of 56 stormwater drains discharge urban runoff into the Port of Durban (Guastella *et al* 1994). The urban drainage systems in the area are notorious for delivering unsightly litter into the water (Archibald 1996). The stormwater drains contain a variety of pollutants such as rubber particles, oil, fuel, crane metals, pesticides and street surface litter (Guastella *et al* 1994). The South African Water Quality Guidelines for Coastal and Marine Waters (1996) indicate a level of less than 2000 bacteria per 100ml of water in 95% of the test area (minimum effective dose) is an acceptable limit.

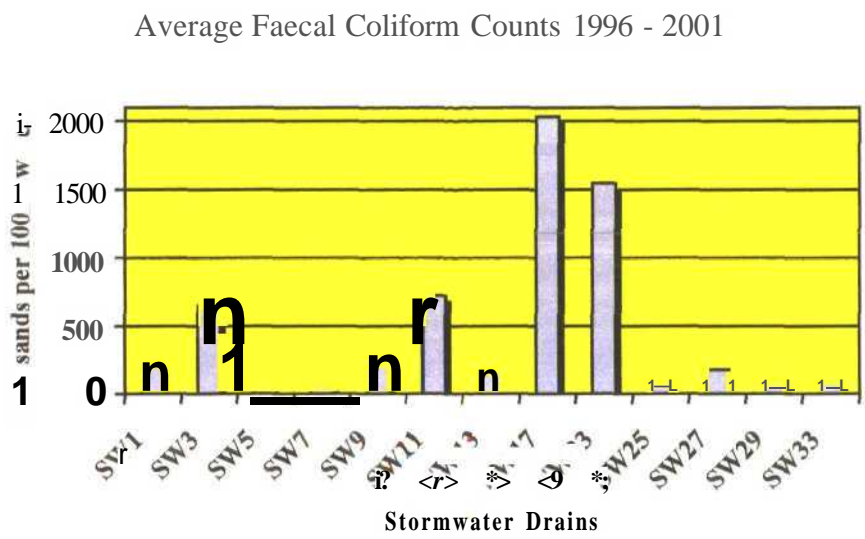


Figure 13: Average faecal coliform counts from the city stormwater drains

Guastella *et al* (1994) states how ruptured sewage systems have occasionally contributed to high faecal pollution in the port. There are 13 stormwater drains currently tested in the port (Figure 13, Table 5), (Plate 6), and they are predominantly those emanating from the city (Archibald 2001). The bacteria counts range between 32350 and 2033986 counts of bacteria for 100ml of water. The highest recorded levels are consistently received from the Milne Road drain (SW17), followed by the Field Street drain SW11 (Archibald 2001)(Plate 7).

The catchment characteristics of the drains vary according to position. Based on the results, the highest recorded levels of contaminants are those emanating from the Victoria Embankment. The Canal Road drain (SW7), (Plate 7) is the largest drain

entering the port and drains Bulwer Road, Greyville racecourse, Musgrave and Warwick Road. The Russell Street drain entering the western part of Victoria Embankment, drains the west end of Smith and West Street, entering via Albert Park with a 7.5 hectare catchment (Archibald 2001). The Field Street drain (S11) flowing from Field Street, draining West and Smith Streets, enters the bay via the Point Yacht Club (Plate 7). This catchment is in the order of 42 hectares in size (Archibald 2001).

Gardner Street drain entering into the Point Yacht Club basin (SW13) (Plate 7) has a catchment size of less than 9 hectares (Archibald 2001). The Aliwal Road drain enters below sand level onto the sandbank and is only evident after storm events but is not tested. The Milne Road drain (Plate 7) exits near the Bat Centre, and contains the highest faecal coliform counts (Figure 13). This drain has a catchment of approximately 208 hectares including commercial, industrial, road, urban and recreational areas (Archibald 2001). Rennie's Corner stormwater drain (SW3)(Plate 8) also shows consistently high levels of bacteria. Its catchment covers an area of 218 hectares including the Natal University, Umbilo urban areas, and King Edward Hospital. King Edward Hospital could be contributing to the high levels of bacteria in this drain, possibly due to outdated sanitation systems. The high level of indicator organisms suggests an increased likelihood and threat for pathogenic organisms (Salmonella, Shingella and Cholera).

The average faecal coliform counts of one drain give little indication of the fluctuations of the coliform levels. The mean, maximum, minimum and standard deviation of the 5-year data set for the stormwater drains (Table 5) shows a varied fluctuation in the coliform levels. It is worth noting that although the high readings of certain drains are consistent the time of the month in respect to recent rainfall has influence on the coliform numbers. Samples taken after rain are a lot lower than those taken before the rain, and the samples taken in winter would be higher due to a lack of water inflow and dilution.

The coliform testing is taken in fresh undiluted water from the port, giving a clear indication as to the numbers entering the port. As most of the samples for the stormwater, river and open water are taken in the same day, a die off gradient is prevalent between the inflow and the open water test sites. This is due to the saline conditions not meeting the optimum requirement for coliform bacteria to thrive.

Table 5: Faecal Coliform Data: City Discharges 1996 - 2001

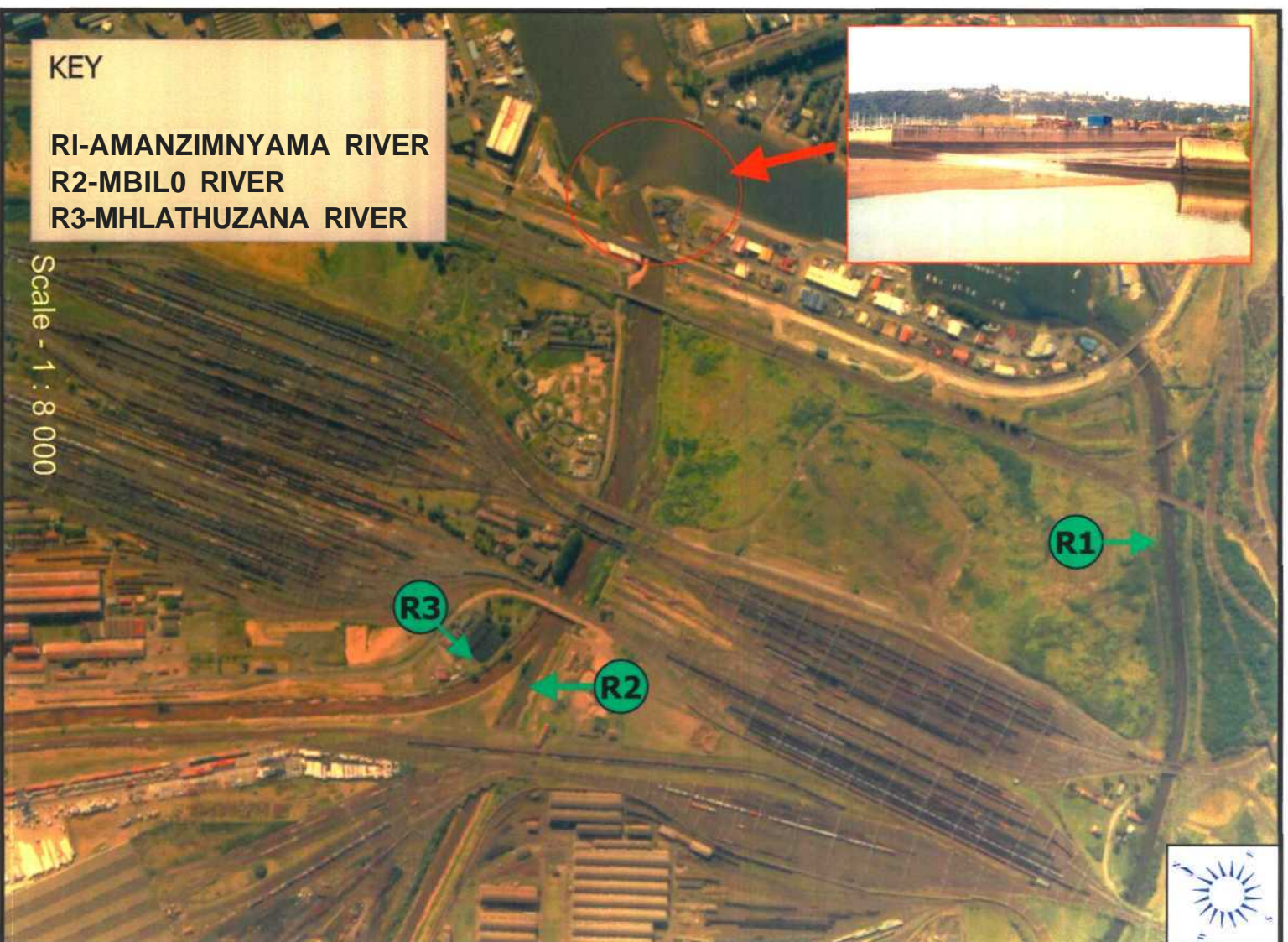
Stormwater	Mean	Maximum	Minimum	Standard Deviation	Observations
SW1	398746	4500000	148	1237132	12
SW3	865135	6900000	310	1745244	28
SW5	32350	57000	6200	20766	3
SW7	67653	600000	115	128551	30
SW9	216277	1510000	880	407510	18
SW11	476601	5350000	390	1138148	31
SW13	171155	1762500	486	372878	30
SW17	2813884	30000000	75	6739882	19
SW23	287479	3295000	200	906960	12
SW25	118030	1900000	124	445721	17
SW27	181686	1070000	260	397304	6
SW29	11903	74000	273	21565	16
SW33	135362	2010000	10	459799	18

The stormwater drains with total observations exceeding 12 are those generating the most concern, due to their location in prime recreational areas. In terms of Portnet's responsibility to the general public is concerned, the risk to human health should have already been publicised and not been retained as confidential information. Stormwater SW33 has had a number of high peaks and yet is prone to a number of lows. It is a fact that the leakages of city sanitation systems contribute to these fluctuations, and predictably the high occurrences of coliform bacteria coincide with rain events and the overflowing city sewer system into the port.

Stormwater SW3 at Rennies corner remains consistently high due to lower salinity in the Congella Turning Basin, and due to the reduced flushing in the area. None of the stormwater drains conform to the Water Quality Guidelines for Coastal and Marine Waters (1996). The stormwater drains are prone to regular flooding due to tidal inundation for 90% of the day. This could lead to a buildup of contamination in the drains exiting during low tide.



Plate 7: Rennie's Corner, Stormwater 3 Catchment



5.2.2 River Discharges.

Chapter 1 of this thesis highlighted the individual river characteristics. The total catchment area of the combined river inflow is in the order 247 km² (Appendix 2), and would produce an annual runoff of 56.34 million cubic meters of water (Walmsley 1997). The catchment includes Durban, Queensburgh, Chatsworth, Pinetown, Kloof, and Hillcrest (Appendix 2). Durban is the recipient of discharges from heavily urbanised catchments, the Umbilo, Amanzimnyama and Mhlatusana rivers, combined with the city centre (Walmsley 1997).

The river discharges into the port (Plate 7; Figure 14) are contaminated with faecal coliforms, and this ranges on average between 12612 and 64528 counts of bacteria per 100ml of water. The highest recorded level during the 5 year period 1996-2001 was 268 000 bacteria per 100ml of water from the Amanzimnyama river (Archibald 2001).

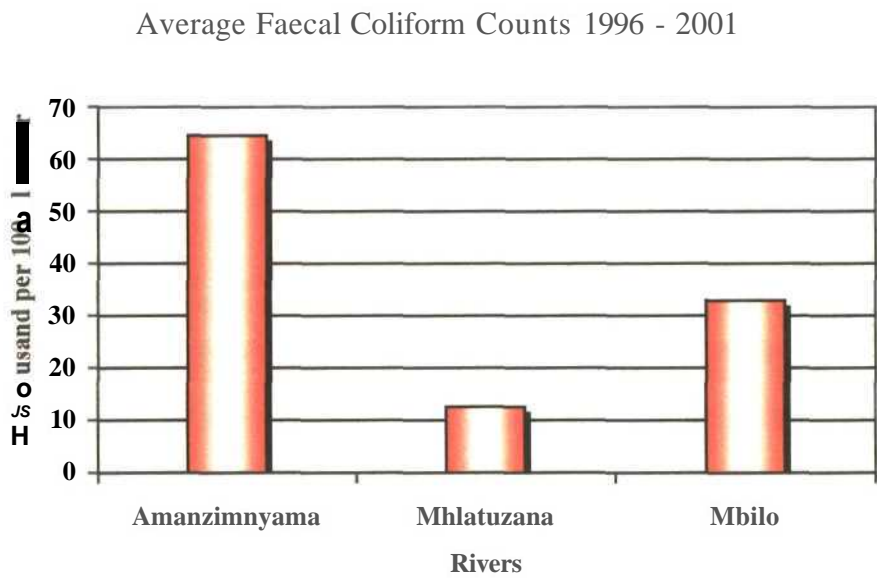


Figure 14: Faecal Coliform counts for river discharges 1996 -2001.

It is surprising that the average coliform counts from the 3 river inputs are a lot less than those emanating from the city stormwater system (Table 6).

Table 6: Faecal Coliform Data: River Discharges 1996 - 2001

River	Mean	Maximum	Minimum	Standard Deviation	Observations
Amanzimnyama	64528	268000	120	94385	11
Mhlatuzana	12612	35000	23000	8957	11
Mbilo	32962	85000	1860	25464	9

The Amanzimnyama River passes through the heavy industry of Jacobs and Mobeni area with industrial waste being a possible source of pollution. The coliform bacteria on average are high with high maximum levels and very low minimum levels. One explanation of these fluctuations would suggest high pollution actually killing off the bacteria that are present.

The rivers pass through heavily urbanised and populated areas and one would expect the high coliform counts to be present. The Mbilo River passes through Cato Manor, an area with poor sanitation and it still has relatively low counts of bacteria compared to the stormwater systems, even though the freshwater provides the ideal conditions for the bacteria. It is also presumed that the slow moving lower reaches of the rivers with low levels of water exposed to the sunlight also contributes to a rapid die off rate before the port. The Mhlatuzana River shows consistently high conforms, however the numbers of the Mbilo and Mhlatuzana Rivers must be added as the rivers join prior to entering the port. This means on average a coliform count of close to 46000 entering into the one river entry combined with the 64528 bacteria of the Amanzimnyama River and one is presented with badly contaminated fresh water entering the port within one kilometer of one another. This is the very same area where recreational activities are the highest in the port.



Plate 9: Stormwater Monitoring Sites-Victoria Embankment

5.2.3 Open Water Condition

The open water areas are characterised with the testing of a number of variables (Appendix 4). The open water areas cover the bay (Plate 6), which is influenced by freshwater inflows from the stormwater drains and the river inflows (Plates 7&8). Deeper marine dominated sectors are not tested as it is well flushed by regular tidal exchange (Archibald 1997).

The faecal coliform counts over the 5-year testing period (Figure 15; Table 7) at the same sites indicated the lowest level of 778 bacteria per 100ml water, and the highest level on average of 179314 The highest recorded over the 5-year period was 2600000 bacteria, per 100ml of water (Archibald 2001).

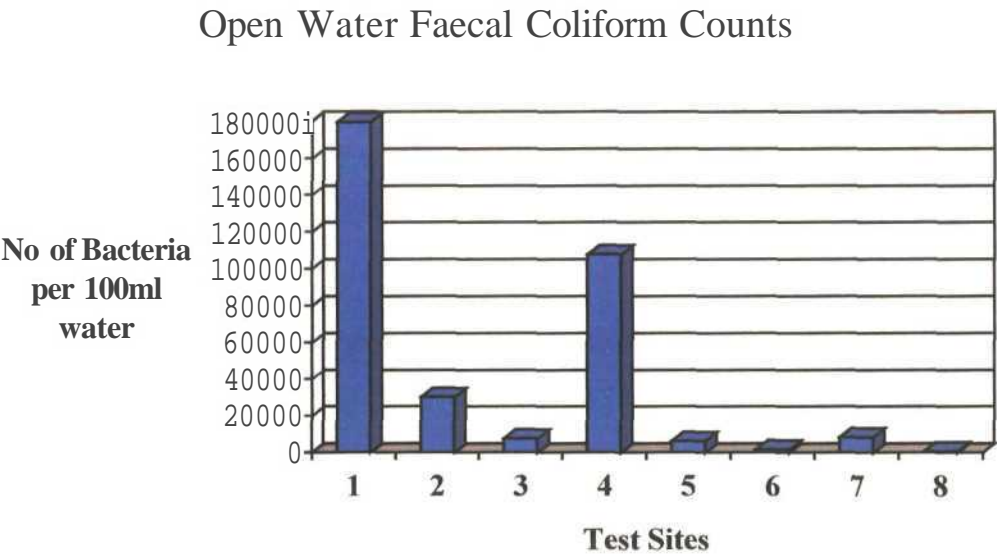


Figure 15: Average open water Faecal Coliform counts 1996 - 2001

The faecal coliform concentrations in the open water in influenced by the inflows of the stormwater and the river inflows. The die off of bacteria in the salt water is evident as lower recorded levels in the seawater are recorded that entering in the rivers or stormwater systems. However this data is prone to the dilution effect, yet there is a definite indication that regular flushing of seawater reduced the levels of bacteria. DBY 1 is located high up in the silt canal and is high due to the concentrations of bacteria entering via the rivers. There is no regular flushing of seawater; the only flushing is with

already polluted fresh water. DBY 2 is also high as this is where the Mbilu and Mhlathuze rivers enter adding higher bacteria numbers to those already present. At this point there is a small amount of flushing due to the effects of the tide. The other high contaminated area is the DBY 4 site opposite the dry dock in the Congella Turning Basin. This is also opposite one of the most contaminated drains that of Rennie's corner. It is surprising that the high bacteria levels are consistent in the salt water yet it highlights the possible high pollution sustaining levels of the stormwater drains. The Congella Turning Basin is also not well flushed and the tidal influence moves little water. As a result oxygen deficiencies occur in this area and fish kills are common. The other common phenomenon in this area is that of an algal bloom, due to the enriched and polluted water.

Table 7: Faecal Coliform Data: Open Water 1996 - 2001

Open Water	Mean	Maximum	Minimum	Standard Deviation	Observations
Dby1	179314	2600000	12	586142	19
Dby2	30112	420000	42	92125	19
Dby3	7696	27100	44	10084	14
Dby4	107752	1740000	38	396949	18
Dby5	6259	40500	40	9591	19
Dby6	1661	12200	10	2994	16
Dby7	8276	80000	21	17498	19
Dby8	778	5800	4	1486	17

The rest of the open water areas are well flushed and this reduced the bacterial accumulation. The sites DBY 6&7 are opposite stormwater drains hence higher levels than DBY8, which is predominantly marine in nature and is well flushed.

The oxygen concentrations at the 8 sampling sites ranged between 5.9 to 6.6 mg/l over the 5-year period of testing (Figure 16). The lowest recorded level was 3.3 and the highest was 12.7. Site DBY3, 6 &8 are not included due to a lack of consistent data.

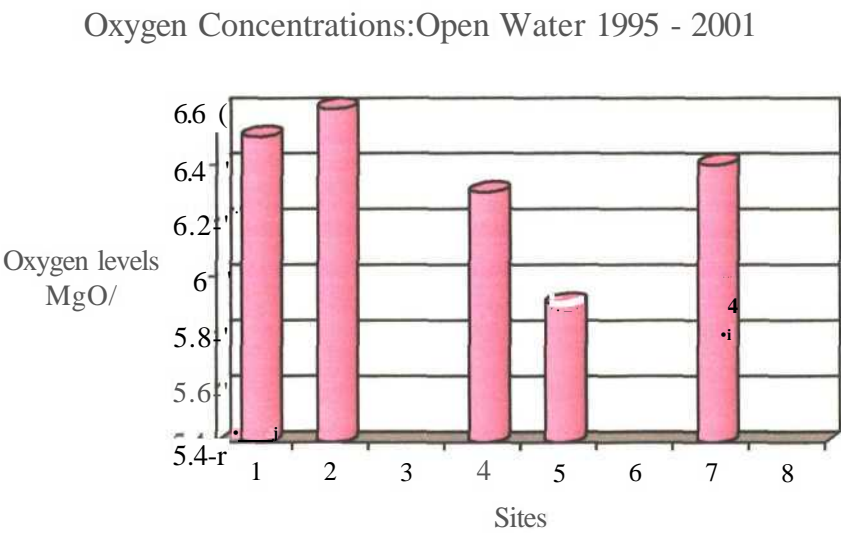


Figure 16: Oxygen concentrations in the open water 1996 - 2001.

The oxygen concentrations over a 5-year period show varied fluctuations (Table 8) and this would be seasonal in nature. Lower oxygen concentrations would typically be a winter phenomenon with low flushing and temperature stratification of the surface waters and the higher oxygen would be a summer occurrence with higher flushing and higher fresh water inflow into the system. Higher oxygen concentrations are present in the upper reaches of the port where river inputs meet the salt water. Towards the dry dock and centre bank open water areas DBY 4& 5 show lower oxygen levels associated with less flushing and poor circulation patterns. The open water site DBY 7 is high in oxygen; it is well flushed and predominantly marine in nature.

Table 8: Oxygen Data: Open water areas 1996 - 2001

Open Water Oxygen	Mean	Maximum	Minimum	Standard Deviation	Observations
Dby1	6.5	12.6	4.0	1.9	18
Dby2	6.6	12.7	3.3	2.0	17
Dby3					
Dby4	6.3	8.0	4.4	1	18
Dby5	5.9	6.9	4.1	0.8	18
Dby6					
Dby7	6.4	8.9	4.9	1	18
Dby8					

As an overall indicator of potential enrichment nitrate concentrations are measured at the open water sites. This also measures the potential for algal blooms as a result of the enrichment. The nitrate concentrations varied between 37 and 184 mg/l (Figure 17) with the highest and lowest levels being 472 and 9 mg/l respectively.

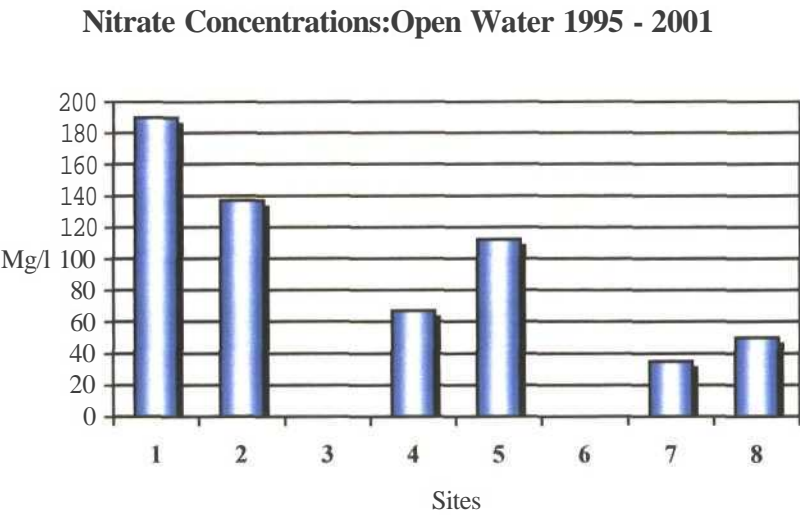


Figure 17: Nitrate Concentrations of open water areas

The nitrate concentrations (Table 9) of DBY 1 and 2 over the 5-year period reflect that a large portion of the inputs to the system is via the rivers. This high nitrate conditions in the rivers would be ideal for the growth of bacteria but again high levels of pollution would reduce this growth. DBY 4 shows a drop in concentration associated with distance from the river, however DBY 5 is quite high. One of the reasons for this is that Maydon Wharf handles bulk fertiliser, of which a large portion of waste enters the port water. This waste is in the form of fertilizer dust, or spilt cargo that is literally swept into the water for disposal purposes. DBY 7&8 show lower levels as would be expected with regular tidal flushing.

Table 9: Nitrate concentrations: Open water 1996 - 2001

Open Water Nitrates	Mean	Maximum	Minimum	Standard Deviation	Observations
Dby1	1847	4722	23	1250	20
Dby2	1399	3500	10	812	20
Dby3					
Dby4	645	3605	10	78819	19
Dby5	1161	3984	83	1110	20
Dby6					
Dby7	503	2270	10	547	20
Dby8	376	1758	9	410	20

The suspended solids for the open water areas tested for the 5-year period range between 29 and 64 mg SS/l on average (Figure 18), with a minimum and maximum of 4 and 240 mg SS/l respectively.

Suspended Solids Concentrations:Open Water

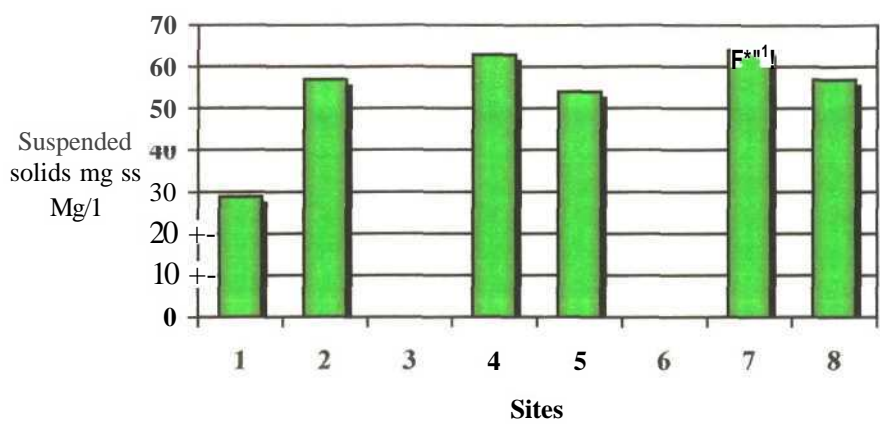


Figure 18: Suspended Solids: Open water.

The suspended solid concentrations in the open water reflect little more than an average time the estuary experiences turbid conditions. Due to the very nature of the bay with over 56 stormwater and 3 river inflows it is logical to assume there would be intermittent turbidity levels. Following rainfall the port can be high in suspended solids for weeks, as a result of the high volumes of silt-laden water from the rivers. The average suspended solids results (Table 9) does suggest a high input from the Mbilu and Mhlatuzana Rivers whilst the input from the Amanzimnyama is lower as it collects runoff from industrial areas, rather than drain a natural catchment. All the rivers are canalised in their lower reaches leaving little riverine vegetation to perform the filtering function. The canal unfortunately slows the river down leaving deposited sediments in the canal. These sediments are then washed into the port during rain.

Other sites DBY 4,5,7 and 8 show higher suspended solids concentrations associated with a buildup prior to flushing. It is presumed that suspended solid concentrations are the highest at low tide and lowest at high tide with the dilution effect of the incoming tide having a marked influence. The readings for suspended solids are taken at low tide. The port water quality is dependant on a number of factors already mentioned, including having Portnet recognise the significance of the resource under their control. Using bacteria, oxygen, nitrates and suspended solids, it is possible to characterise the port water quality and utilise this information at making an informed statement on the actual conditions of the surface water. It is apparent that a large amount of scientific work has

been undertaken in the Port of Durban, yet no large-scale health index has been designed for the port to date.

Table 10: Open water suspended solids 1996 - 2001

Open Water Suspended solids	Mean	Maximum	Minimum	Standard Deviation	Observations
Dby1	48	158	5	45	19
Dby2	65	220	7	60	19
Dby3					
Dby4	67	205	4	62	20
Dby5	60	139	5	47	15
Dby6					
Dby7	70	241	6	64	18
Dby8	67	240	4	65	19

5.3 Comparison of Guidelines

5.3.1 Department of Water Affairs Water Quality Guidelines

The use of the water quality guidelines enables the department to perform a specific role, that of safeguarding the aquatic ecosystems (Water Quality Guidelines for Coastal and Marine Waters 1996). Each aquatic system seems to have thresholds, beyond which it is difficult to recover or regain their functional capacity without mitigation. The comparison of the Port of Durban variable concentrations has indicated that few of the Port of Durban coliform, nitrate and suspended solids meet the guidelines. The oxygen concentrations on average meet the requirements. Management of the resource would have to improve substantially in order for the Water Quality Guidelines for Coastal and Marine Waters (1996) to be met with at least a 50% compliance level.

5.3.2 Selected International Guidelines / Legislation

The levels of coliform bacteria cannot be compared to the selected international guidelines, as they do not consider coliform bacteria to be their indicator species. The available literature suggests that every river and system is treated as a separate entity and treated accordingly. South Africa uses coliform bacteria as an indicator on water health. It indicates the severity and magnitude of bacterial contamination whilst highlighting the possibility that there are more dangerous pathogens present. International use of bacteria as indicators is dependant on what disease they are looking for.

5.3.2.1 Oxygen Concentrations

The oxygen concentrations legislative guidelines all require a high oxygen concentration for aquatic life. The South African guideline of 6 Mg O/L compares well with the Australian (5Mg O/L), Canadian (5.5 - 9.9 Mg O/L) and the German (2-8 Mg O/l) concentration requirements. Based on the international concentrations, the oxygen port concentrations all fall within the range of all three countries requirements for aquatic environments. This indicates to a degree that the port oxygen concentrations meet international requirements.

5.3.2.2 Nitrate Concentrations

Nitrate concentrations as already discussed contribute to the enrichment of an ecosystem. The South African Water Quality Guidelines for Coastal and Marine Waters (1996) Nitrate concentration (<0.5MgN/L) is the same as the Australian legal requirement (<0.5MgN/L) but lower than the Canadian Council of Ministers of the Environment (1999) (<0.6MgN/L) and Federal German Environmental Ministry (<2.5MgN/L) requirements.

The Federal German Environmental Ministry (1998) guidelines do state that their systems are highly enriched due to a long history of pollution. Only 1 port site complies with the Australian Guidelines, 2 sites comply with the Canadian Council of Ministers of the Environment (1999) guidelines but all comply with the Federal German

Environmental Ministry (1998). This provides a subjective picture, but using all the guidelines the Port of Durban is not within the guidelines but is not necessarily in a poor condition.

5.3.2.3 Suspended Solids.

According to the Canadian Council of Ministers of the Environment (1998) there are no suspended solid concentration limits in Canada due to insufficient data available. In comparing the South African Water Quality Guidelines for Agricultural use (1996) (<50 Mg SS/L) to Australia (<25Mg SS/L) and Federal Germany Environmental Ministry (1998) (<39 Mg SS/L), the South African Water Quality Guidelines for Agricultural use (1996) have the lowest requirement. The results of the 5-year water quality programme showing the suspended solids results, indicates none comply with the Australian guidelines and only one site complies with the Federal German Environmental Ministry (1998) guidelines.

This comparison indicates that in terms of selected international legislation, the Port of Durban suspended solid concentrations meet the criteria with at most 17% compliance. This could indicate a catchment management problem (Water Quality Guidelines for Coastal and Marine Waters 1996). The catchment of the port should receive priority conservation commitment.

5.3.2.4 Variables of Concern.

Based on the comparisons undertaken with the South African Water Quality Guidelines for Coastal and Marine Waters (1996) and the Legislation already cited from Australia, Canada and Germany, the coliform bacteria, Nitrate and suspended solid concentrations are all showing indications of exceeding the limits set. The phosphorus levels not investigated in this thesis but mentioned in the Port of Durban Water Quality Report (2001) also exceed the guidelines in most of the sites tested.

This indicates that the water conditions in the port are not in line with the Water Quality Guidelines for Coastal and Marine Waters (1996) Department of Water Affairs Water Quality Guidelines, and do not meet the requirements for effective environmental

management. This has potential consequences for human health, as well as the overall ecosystem function.

5.4 Factors influencing port water Quality.

The results of the stormwater and river data that is already presented show little doubt that the river and stormwater inputs contribute to the worsening water quality situation. The port water quality is influenced by a number of point and non-point pollution sources and the possible origins of these will be discussed later in this chapter.

5.4.1 External Sources of Pollution

The Informal settlements, leaking sewage pipes and industrial land uses have already been mentioned as sources of pollution. It is evident that spillage from industrial operations and from light industry is an on going problem despite the efforts by Durban Metro Water Services to remove as much as possible before it enters the bay (Archibald 2001)(Plate10). The catchment management needs attention to reduce the suspended solid concentrations entering the system (Murray 1987)(Plate11). According to Murray (1987) external sources of pollution include:

- => Industrial effluent discharge into stormwater.
- => Urban Stormwater Discharge
- => Scouring of water from open surface yards.
- => Insufficient monitoring of pollution prevention equipment and oil traps at garages and oil industries.
- => Mismanaged catchments

In most or all cases as listed above legislation is in place for quality control.



Plate 10: Aliwal Stormwater Drain



Plate 11: Pollution from the Port Catchment: April 2000

5.4.2 Internal Port Generated Sources of Pollution

Portnet has over the years been identified for the major contribution to pollution in the Port of Durban (Ackerman 2001). In the Portnet Pollution Contingency Plans: Port of Durban, numerous potential sources of pollution are discussed. According to this document a 5% pollution allocation is attributed to port generated pollution, whilst a value of 95% is given to the external pollution sources (Appendix 4). The pollution contingency plans of the port list sources of pollution as being from:

- => Ship repair jetties
- => Housekeeping and inappropriate waste management.
- => Dry dock operations
- => Floating dock operations
- => Accidents with bunkering services (Fueling Ships).
- => Ship to shore transfer of product (Fertiliser, petroleum, chemicals, maize etc)

5.4.3 Waste Management & Housekeeping.

The Portnet pollution contingency plans indicate that general housekeeping is responsible for the internal port generated pollution. This is amplified by poor waste management practices (Lombard 1998), and the poor integration of Portnet business units. Housekeeping within the Portnet boundary is poorly regulated, with waste stored close to the waters edge with a potential of pollution.

In the Portnet Waste Management Policy (Lombard 1998) a number of issues are also highlighted as reasons for pollution. Walmsley (1997) also highlighted the same pollution causes:

- Fragmentation of the legislation with different departments of local government and regulatory authorities enforcing varying aspects of waste or pollution legislation.
- Fragmentation of the waste management function over several Portnet departments.
- Lack of clarity with regard to Portnet's authority.

- There are grey areas in the regulations and bylaws as to which are applicable in the Port Authority where very specific national legislation pertains.
- The appropriate authorities (including Portnet) not fulfilling their responsibilities.
- There is no system which ensures that the polluter pays
- There is a risk that those spillages, which are recovered or sold as animal food, could be contaminated.

The waste management is possibly one of the highest contributors to the port water quality problem

5.4.4 Stormwater Management

The systems management within the Portnet jurisdiction are highlighted as a contributing factor in water pollution, be it only 5% of the total pollution. Waste oil is often washed downriver from industry (Plate 12) and this highlights the lack of safeguard measures in place in the port.

5.4.5 Ship Repair Industries

It is with little doubt that the shipbuilding, repair and dock facilities contribute towards decreasing water quality in the port. The use of Tributyl Tin paints (TBT) on ships hulls is still occurring worldwide, bearing in mind that the International Maritime Organisation would like the substance banned due to its polluting qualities.

The ship repair industry is admittedly not a clean operation (Plate 13) however screens and housekeeping could once again prevent excess paint from entering the water. Shot blast is used to clean ships hulls, and it is inert in its pure form. Once used, it is contaminated with paint and is classified by The Department of Water Affairs as a low hazard substance. It therefore stands to reason that this substance entering the port water would affect the overall quality. This is obvious in the oxygen readings taken adjacent to the docks in the port being the lowest on average.

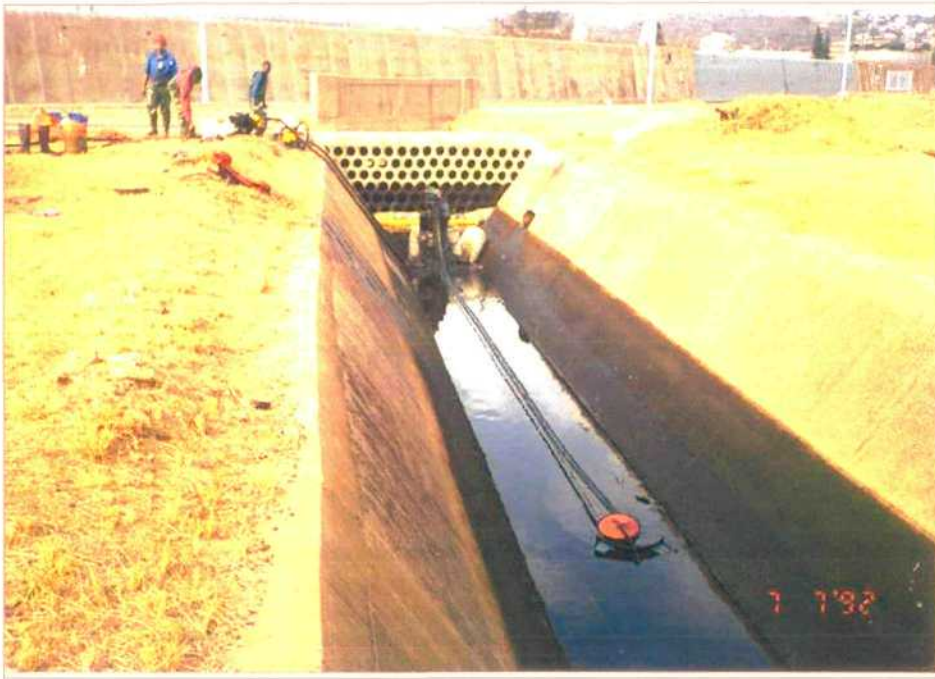


Plate 12 : Oil entering the port via Stormwater Systems



Plate 13: Ship repair in the the Port of Durban.

5.4.6 Port Leaseholders.

Portnet owned land is leased out to other industries within the port confines. The lease agreements signed with Portnet include requirements that all current and future environmental legislation be complied with. Judging from the condition of the leased premises and the poor waste and housekeeping management, it is clear that this is not being addressed. Numerous outfalls from leaseholder properties can be seen adjacent to the waters edge, and this signifies an improper waste disposal method. Leaseholder restaurants within the port confines also have improper sewerage reticulation systems and incorrect capacity pumps, and at high customer levels these overflow into the port, contributing to the bacterial contamination.

5.4.7 Cargo Pollution

Due to the insufficient housekeeping in the port, pollution from cargo does occur. The liquid bulk pollution is not a threat or a concern as it is contained and extracted from the water in the event of an incident (Ackerman 2001). The maize, rice and fertiliser waste is most common. The most threatening is the fertilizer waste, which falls into the water due to poor stevedore handling increasing ammonia-nitrogen levels. The cargo left spilt on the quayside is rarely cleaned up, and is mostly disposed of by sweeping into the water. Scrap metal dust is also considered a pollutant generated during the loading and unloading operations.

5.4.8 Dredging Operations

Although Portnet conducts an extensive dredging operation within the port, the increased turbidity generated as a result is negligible, and of short duration. It is localised and should not be included in the Portnet generated 5% of pollution.

5.5 Summary of Port Water Quality.

The port water quality is impacted on by a variety of internal and external factors. As indicated by the port compliance to the Water Quality Guidelines of Coastal and Marine

Waters (1996), the Port of Durban is not within legal compliance, nor does comparing it to international legislation generate a better picture.

It is evident that the external sources of pollution from catchments contribute to the port degradation however internal port generated pollution has the potential to feature as the most threatening to aquatic life, whilst the external sources of pollution impact on human health aspects. The ability of the resource to continue to receive the highly polluted water and sustain a balanced and productive system is questionable. The higher levels of pollution coupled with the added pressure from population increases in the Durban metropolitan area do little to enhance the ecological functioning of the estuary. The effects of pollution are not well documented and the modern port is not characterised correctly. The use of this resource in a sustainable manner cannot be achieved before the threshold capacities are determined nor can the resource be adequately managed before a baseline condition of health is determined. The shipping industry is growing and should be incorporated into a management system to highlight potential areas of risk.

The port water quality data does indicate that the port is highly polluted but functioning ecologically better than expected. The release of the water quality information to the public and city officials should present the opportunity to obtain firm commitment to implement a programme of continuous improvement. It is however clear that the current catchment management initiatives are not working and this will have an impact on port water quality as well as the coastal system.

CHAPTER 6

RECOMMENDATIONS FOR RESOURCE MANAGEMENT

6.1 Introduction

The environmental management of the Port of Durban should go beyond the biophysical components and seek to integrate the dynamic interaction between development and natural component to encompass a total port initiative, incorporating environmental considerations whilst planning. It is evident from the previous chapters that the Port of Durban is home to a diverse number of fauna and flora species, yet it is managed with a minimum of legislation. An attempt at correcting this has taken the form of the water quality monitoring programme, and various other fauna and flora studies linked to individual environmental impact assessments. The result is fragmented information that serves little function unless combined to produce an environmental management system to operate the users, leaseholders, owners and stakeholders interests in the diverse environment. With this in mind it must be noted that water quality in the port has a number of influences both internal and externally generated, as a result of poor port and town planning.

Integrated catchment management will assist in a coordinated approach to both town planning and port management. A host of fragmented policies exist but have not been compiled into a clear guideline with goals and objectives. The South African coastal zone management policy (Department Environmental Affairs & Tourism 1998) has assisted in making all stakeholders aware of the necessary integration of management to encourage new ideas and solutions to port and city management. The systems approach to integrated management of the coastal zone assists with understanding the coast in sectors, and may contribute towards catchment management objectives. In considering the catchment a number of stakeholders and users could synchronise their efforts by conforming to the policy goals of catchment management agencies to enable rational decisions. What is not clear is the impact on the ecosystem function of the increased pollution loads, what is going to be the final rivet after which gradual degradation will ensue. After interpreting the water quality data and contributing to the overall significance of the meaning of water quality, it must be acknowledged that the

Port of Durban must be near or at pollution saturation point. This chapter will endeavor to suggest a possible approach to address various aspects linked to the worsening water quality problem. Noting a physical lack of strategic management leading to poor resource management prompts the suggestions in this section. Whilst acknowledging the diversity and richness of our coast we seek to maintain an equitable balance of opportunities. We strive for a coast in which there is a balance between material prosperity, social development, spiritual fulfillment and ecological integrity (Glavolic 2000).

6.2 Environmental Management Systems

The Port of Durban has no formal environmental management system in place. The implementation of an environmental management system of which water quality is a part, can lead to cost savings through better management of the organisations operations.

The implementation of a formal environmental management system along the lines of ISO 14000 provides order and consistency for an organisation to address environmental concerns through allocation of resources, assignment of responsibilities and an ongoing evaluation of practices and procedures. For an organisation like Portnet (a parastatal) it would be beneficial to implement the system before official enforcement activities take place. The ISO 14000 series is a set of environmental standards that will serve to promote a common approach to environmental management, enhancement of environmental performance and facilitation of international trade. This system prescribes a minimum performance level of regulatory compliance. The environmental management operates on a cycle (Figure 19) that serves as a continuous performance audit tool.

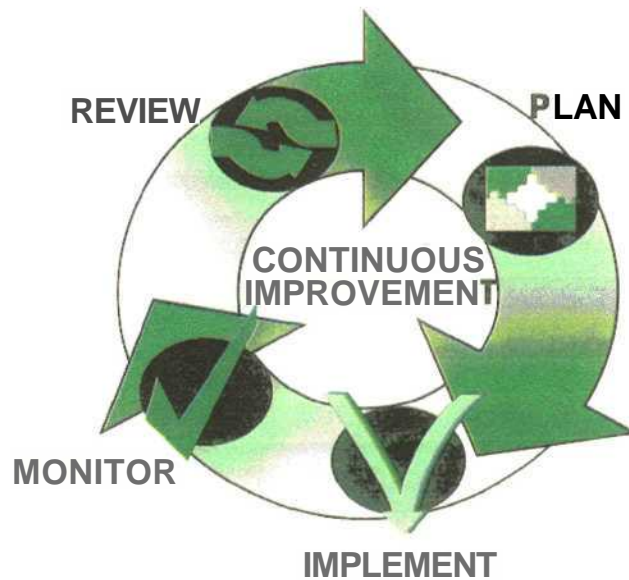


Figure 19: ISO Cycle

The ISO 14000 Environmental Management system will enable the formulation of an Environmental Policy for the port that will:

- => Show commitment to continual improvement and prevention of pollution
- => Commitment to comply with relevant environmental legislation and go beyond any legal requirement.
- => Avail itself to the public sector
- => Should contain achievable statements and targets.

The ISO 14000 series provides guidelines for implementing environmental management, which embodies monitoring of all impacts of the policy and performance of the organisation, which Portnet should utilise. This system will contribute towards the integration of all port disciplines to ensure the resource is managed in order to sustain the business and all stakeholder requirements. The integration of all parties will ensure procedures to all possible impacts, so that the mitigation and management of impacts becomes a reality.

6.3 Legal Compliance

The coastal resources are not receiving the desired management attention they deserve. The non-compliance to the Water Quality Guidelines for Coastal and Marine Waters (1996) in the port raises the risks to human health as well as the sustainable use of the resource. Both Walmsley (1999) and Archibald (2001) point this out as an issue that needs to be addressed. A legal register must be developed, to include current legislation and that which is in white paper format. This will allow an understanding of the complexity of the environmental management problem, to be solved by adequate policing and law enforcement. For Portnet the simple task of including environmental legislation requirements into their leases should be standard practice, with a programme of follow-ups and audits. The metro authorities should be informed of port non-compliance and a programme for compliance must be developed with the port authority, and the Department of Water Affairs and Forestry. Further it must be noted that in a number of aspects the metro, Portnet and Portnet leaseholders do not comply with the Water Act 36 of 1998, nor do they subscribe to the principles as set out in the Department of Environmental Affairs (1998) Coastal Zone Management Policy. This places a higher urgency in at least aligning the port and surrounding stakeholders to ISO 14000, to reduce the possibility of environmental consequences (Lawsuits).

In terms of the Water Act 36 OF 1998 and the Department of Environmental Affairs (1998) Coastal Zone Management Policy, the port stakeholders are not considering the principles of coastal zone management policy (Figure 20).

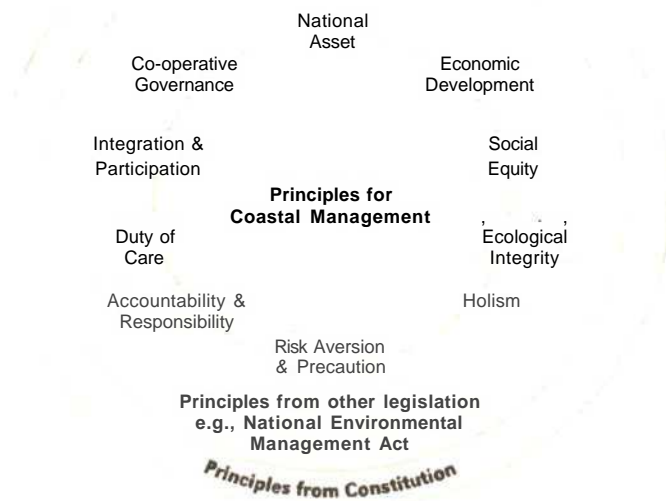


Figure 20: Principles of Coastal Zone Management Policy (Glavovic 2000)

6.4 Policy Formation

In motivating for the alignment of the port to ISO 14000 management practices policy formation would allow for a set of principles, with readily achievable goals and objectives. The metro is currently implementing an environmental policy based on the Agenda 21 principles, very similar in nature to the Coastal Zone Management policy initiatives (Department Environmental Affairs & Tourism 1998). Policy is necessary to provide guidance to all stakeholders. Without a policy there is directionless effort often resulting in a mismatch of management objectives with dire consequences for the resource. Integrated coastal management will assist with developing policy with the goals and objectives aligned to the actual requirements of stakeholders.

The Agenda 21 is a world - wide programme and approach to planning and development, hoping to achieve sustainable development of local (Urban & Informal) communities. It was initiated by the United Nations in 1992 and has been adopted by the South African Government. The Durban metro used this programme locally to assist with sustainable city development, and focuses more of urban strategy planning than pure

environment. This programme could be integrated with ISO 14000 in the port to add value to port and metro environmental management.

6.5 Cooperative Agreements.

Although many water quality problems have been identified for each port, and in many cases these can be related to land based activities, there is no monitoring taking place that allows for interpretation of a cause and effect analysis of long term trends. It stands to reason that the port and metro need to set up a number of agreements and sharing of funds dedicated to improving the combined environmental performance of both. Umgeni Water is another role player of the port as they are responsible for water testing in the port catchments. To obtain this data and get an indication on the sources of pollution is of utmost significance.

6.6 Estuarine Health Index.

The water quality can only be quantified when an estuarine health index is generated. This would enable various influences like oxygen nutrient and bacterial influences to be rated, according to how they impact on a system in proportion. No estuarine health index exists for the Port of Durban, even though there is extensive fauna, flora and water data available. It is suggested that this index be developed urgently so that the impact of pollution on the environment can be adequately interpreted, to ensure the correct environmental management practice is implemented. It is possible for example that by reducing nutrient pollution into the port one presumes that the system would improve. The ecosystem may in fact thrive on the nutrient loads and which be essential to its functioning, however without the estuarine health index the environmental impacts cannot be ascertained. The health index will assist coastal zone management by allowing a comparative set of data to be developed thereby adding to estuarine understanding. The port has a large catchment with a magnitude of users, the lessons learned from this area could be applied elsewhere.

6.7 Integrated Water Quality Management

The current water quality-monitoring programme is adequately addressing the needs of Portnet only, in terms of providing the information on water quality status. The programme lends itself to being part of a larger picture, that of ISO 14000. The programme needs to be integrated with ISO 14000 to embody monitoring of all aspects linked to water quality monitoring. The water quality monitoring programmes lacks the integration of user requirements and cannot be viewed as a complete programme without that aspect. The suggested approach would be to develop a policy with specific goals and objectives to achieve the Water Quality Guidelines for Coastal and Marine Waters (1996) minimum requirements (Table 3) within a 3-year period with detailed procedures on how to achieve this. Port management as custodian of the resource has a responsibility to ensure the resource is managed for adequate future protection.

The current water testing needs to be expanded to include more test locations. This would enable a water quality gradient to be developed, also dependant on external weather factors. This would allow a more precise pinpoint of the sources of pollution. The current testing is undertaken on a monthly basis, it would however be desirable to conduct fortnightly testing instead.

The results from the bacteria testing so far indicate a very polluted port catchment system. The coliform bacteria indicator does then lead to thinking that more ominous pathogens exist in the port water and catchment. More frequent testing at high recreational zones will have to be undertaken to give prior warning in case of a possible disease vector. It is suggested that a signboard be placed near the recreational zones warning bathers and water users of the impending danger and consequences of water contact, which should prompt stakeholder action to clean the port catchment due to human health reasons. Portnet possesses the information that under the National Environmental Act is accessible to all stakeholders, and must be used to their advantage, not to their detriment.

The river catchments are considered to be a contributing factor towards the water quality degradation, especially prominent in the upper reaches of the port. It has already been mentioned that cooperative agreements need to be established with role-players to

reduce river pollution. It is also suggested to form conservancies with companies bordering the rivers or in the rivers catchments, in order to reduce the pollution loads. This could also allow information to be generated on the companies' functions, waste monitoring, waste produced and what chemicals and processes are used on site. This information could be used in time of a pollution spill to narrow down the possible culprits. Conversely fining is not the only possible method for prosecution, the rehabilitation costs and staff awareness training could also form part of mitigation in such cases. Rehabilitation costs usually far exceed fines charged, and accomplished more for environmental management. A catchment management forum should also be established, under the Durban metro initiative, however the port stakeholders should be a major role-player in the forum funded by both Portnet and the Metro. This catchment management forum must have clearly defined roles and responsibilities to ensure delivery on objectives.

River weirs need to be upgraded and re-engineered to stop all litter, all oil and chemicals before it reaches the port. A number of the weirs fall into port property and into metro property, and this causes logistical problems for cleaning. Cleaning is not coordinated and is often not undertaken. Following the floods in April 2000, a large amount of sand was deposited into the river canals and into the port. Prior to the floods a buildup of sand was noted in the canals yet was not removed. A sand winning initiative is suggested, as it would remove the sand from the canal, prevent it from entering the port and be put to use elsewhere.

It is evident that the city has taken steps to prevent litter from entering the stormwater drains. Metal grates have been installed on the close road drains to the port to prevent the litter entering the system, and having it removed instead by street sweepers. This initiative is proactive yet a system needs to be developed at the drain/ port interface to prevent oil, litter and other liquid and solid objects entering the port. Once this is accomplished a large portion of the pollution will be removed before it enters the port system. Due to the high coliform bacteria counts in the port it has been concluded that there is sewage leaks entering the stormwater drains. An integrated water quality monitoring mechanism must be implemented to monitor the outfalls and act as soon as high faecal conforms indicate a leak, in order to reduce the health threat posed to humans.

6.8 Geographic Information Systems

The available information on port water quality now exceeds 5 years worth of data collected. The use of a G.I.S. system would convert all this paper information into digital format, to contribute towards water management. Trends that are not captured adequately on paper are often apparent on a G.I.S. system; it can also be used as an environmental management tool that can pinpoint pollution sources once configured correctly. To capture this data electronically could integrate all databases and ensure appropriate management of the resource. This system could be used to monitor coastal conditions, catchment management and to assist other stakeholders.

6.9 Portnet Waste Management

In light of what has been presented, it is clear that Portnet needs to improve the management of their waste. There is a Portnet waste management policy (Appendix 5) that needs to be implemented as soon as possible. Judging from the date it was approved, it should have at least contributed to the minimisation of waste over the last year and a half. The waste policy needs to be a measurable component of the suggested ISO 14000-management system so that Portnet pollution contributions to the water quality can be reduced. The waste policy needs to be communicated to all leaseholders and an audit system aligned to ISO 14000 needs to be implemented to monitor and manage the waste. Furthermore, new legislation outlining waste management practices will soon require that a database of waste be kept, monitored and managed. As landowner Portnet should manage such a database and collate all the waste data of the port, including the leaseholders information.

6.10 Integrated Systems and Change Management Approach: Port of Durban

The proposed Portnet environmental management framework (Plate 14) shows the changed approach to include environmental management highlighting the ISO 14000 environmental management system incorporated into an integrated restructured Portnet management system. This system using the steps of planning, implementation of plans and review of plans has the aim of allowing Portnet to obtain ISO 14001 certification,

using this as a tool their water resources will be managed to the optimum benefit of all users and stakeholders. The monitoring of the system would be an ongoing process continuously improving on management. This system would allow for policy review and continuous improvement principles to be incorporated into a performance based remuneration system for port employees. This approach will ensure that environmental visions, goals and objectives are compiled using stakeholders and employees (Portnet Business Units), and are realistically orientated to be attainable. The system will ensure innovation and learning of both the internal and external stakeholders, and the success of the environmental management system will be regularly monitored using audits in accordance with ISO 14001. Since reduced environmental management has an impact on the bottom line of business, it makes sense that this strategic and innovative system should be adopted and implemented across all spheres of Portnet operational activities, with the consequence of improving profitability. Hence the minimum water quality requirement for the port will be to achieve the Water Quality Guidelines for Coastal and Marine Waters (1996) limits within a period of at least 3 years.

O'Riordan (1995) proposes a pressure state impact response system for internal and external use which allows an individual to elicit change by community involvement. The system (Figure 21) starts with the individual at grassroots level with a lifestyle change can contribute to the sustainable use of resources. The use of the pressure state impact response system will assist the policy formulation by determining the actual issues requiring attention. The individual can become active in local action groups to influence community decisions regarding proposed development and land use management through this system. This could be useful in a port perspective due to the nature and magnitude of developments, and how they could affect the communities in a particular way.

Integrated Systems and Change Management
Approach for Port of Durban Environmental
Management

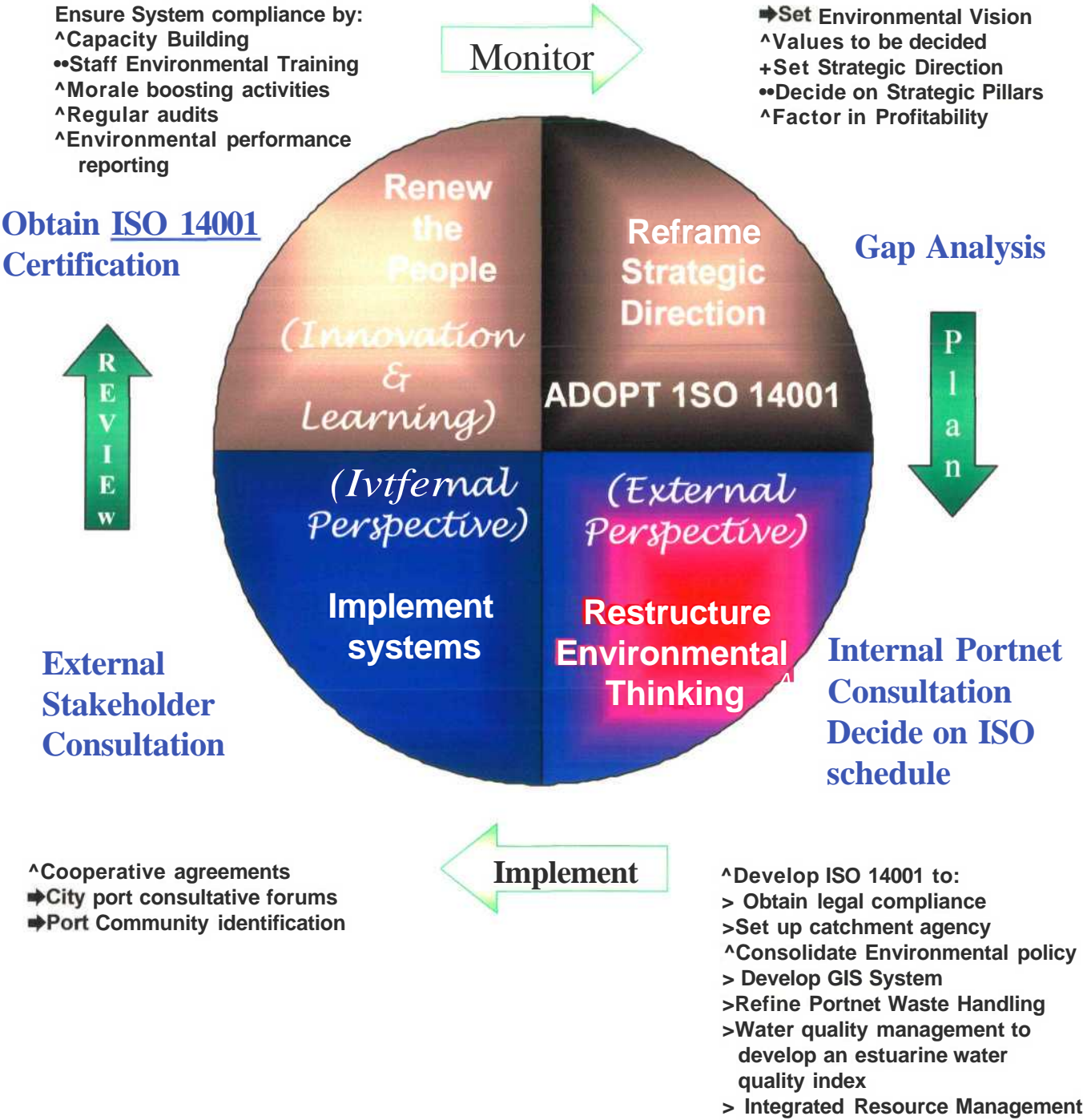


Plate 14 : Integrated systems and change Management: Port of Durban

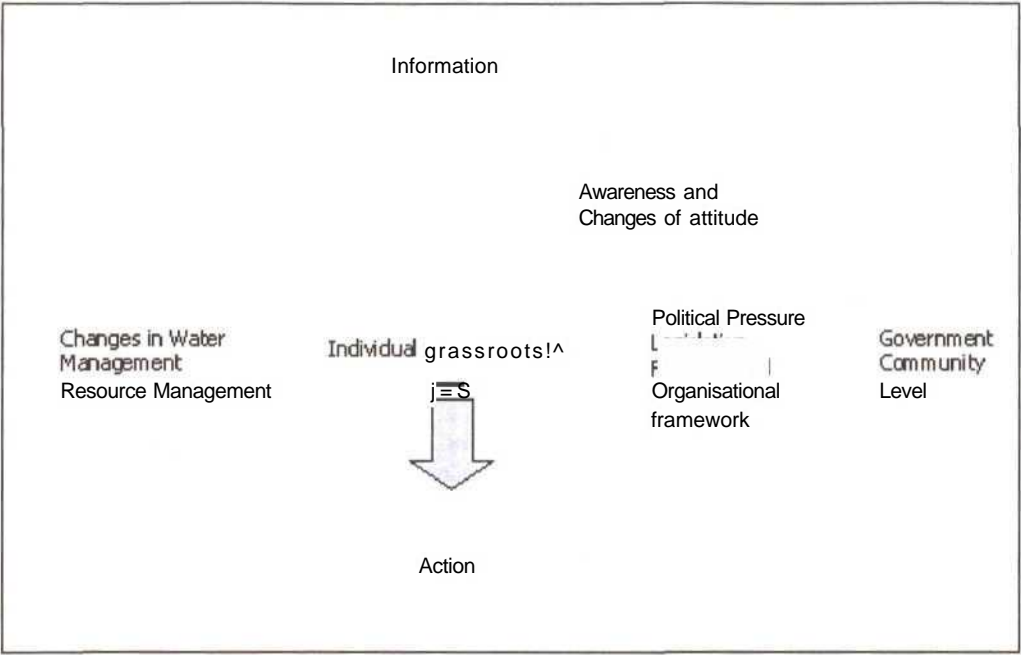


Figure 21: Interplay between the individual and the community towards sustainable ecosystem management (Adapted from O’Riordan 1995).

It is a South African perception that communities do not understand environmental problems. In fact the opposite is true, communities often are aware of the causes and remedies of problems experienced in ecosystems. The local action can be used to generate interest and encourage the aim of sustainable development. This allows for strategic and participatory planning initiatives to provide sustainable pathways. Linkages between different levels of decision making empower community participation to achieve sustainable development. By using individuals and communities, small catchment forums link into the catchment agency to enable sustainable catchment management. Once the catchment agencies are operational funds can be allocated to projects and aspects of sustainable development requiring immediate action. Using the approach suggested by O’Riordan (1995) the active participation of communities will ensure effective ecosystem management. Up to this point participation of communities in port planning has been on a project-by-project basis, and not at an overall management level.

Integrated coastal management can be achieved with assistance of the myriad of environmental legislation available. The National Environmental Management Act 107 of

(1998) has highlighted environmental justice as an area requiring attention. The provision of information to communities and community representatives would allow this aspect to be put into practice. The pressure from the community will generate governmental action and this action should empower the community to take action to begin the change process. The National Water Act 36 of 1996 details the management and use of the water resources that will lead to sustainable resource management. The other mechanisms suggested in this thesis to improve resource management including ISO 14000, would not achieve the same result due to the lack of community involvement and governmental action. At a national level, government has a responsibility to develop an integrated resource management policy, meeting the rational needs of the various users within the limits of available resources both financial and environmental. Responsibilities for water resource management need to decentralise to the lowest appropriate administrative level allowing the contributions of all parties to be maximised. The necessary tools, training and funds must be allocated so that responsibilities can be fulfilled. The role of the public as an authority, regulator, facilitator and moderator should develop an organisational culture in Portnet that is outward looking to facilitate communication with all stakeholders.

The contribution of this integrated approach could be used to facilitate and decide on an appropriate ISO 14000-implementation schedule, and what port policies need revision. The internal stakeholder consultation should then be one of accepting the issues and implementing the ISO system with changes. The implementation of ISO 14000 will allow high staff and stakeholder morale and this is necessary to achieve an integrated approach to port and coastal management. The integration of all port monitoring systems would accomplish a common vision enabling a common goal for all user requirements.

CHAPTER 8

CONCLUSION

Globally, companies are beginning to realise that financial indicators alone no longer communicate opportunities or business risks and that non-financial indicators can now impact on the bottom line, hence the comparison of Port water quality to selected international guidelines. Globalisation and Internet technology are fast exposing businesses to the scrutiny of an ever increasing array of stakeholders, who expect direct environmental accountability. A successful port is an essential part of the economic resources of the national, regional and local communities. The port is expected to conduct all activities in an ecologically sustainable manner with a high standard of performance. This standard will be achieved by adhering to an environmental management system within the integrated coastal management of South Africa. This will ensure the value attached to natural and physical resources are taken into account during business planning.

The Port of Durban does not operate in isolation, with its operations linked to stakeholder, coastal and ecological systems. Stakeholders, in this instance, may include the physical and biophysical environment itself; the human environment including employee impacts and neighbour impacts; and the recognition that Transnet is also an environmental stakeholder. Understanding the interrelationship of coastal systems is poorly developed because of the complexity of the system, and the changes occurring over time. Consequently we need to encourage the cooperation between research disciplines to understand the dynamics of the system and contribute to the knowledge base. As a measure of the Portnet commitment to the environmental management improvement initiative, environmental performance indicators including management, operations and biophysical environment need to be integrated forming a holistic approach to coastal conservation management. Environmentally responsible behaviour is largely dependant upon firstly knowledge and later, experience.

In order to promote sustainable practices eliciting integrated coastal management practices, partnerships will be the key unlocking future opportunities, and this will contribute towards managing port catchments and reducing pollution entering water

systems. Legal compliance is of the highest importance and should be regarded as item one in the environmental management system process formulation of Portnet and Metro authorities. The vision of the coastal zone management policy states that we seek to guide the management of our coast in a way that benefits current and future generations, and honors our obligations and undertakings from local to global levels (Glavovic 2000). This highlights the point that the mismanagement of our resources could have a global implication.

The environment has become synonymous with the way ports of South Africa operate, and handle their environmental protection programmes. The paradigm has been shifted and at an environmental level the Port of Durban should focus and move firmly towards an objective of becoming a world-class port. Following a phased approach in implementing the ISO 14000 environmental management system and following the recommendations outlined in this thesis, the sustainable use of water resources can be achieved. It is essential to understand that the port is not to be managed as a stand-alone function, but to manage the whole resource from the catchment would allow better long term sustained and practical use of the capital resource.

All users of the Port will benefit from the implementation of an overarching resource management system in the Port of Durban. A cleaner healthier Port will promote a progressive and efficient image to an increasing number of visitors, whether on a business visit or as tourists. The demand for and importance of education, training and capacity building in resource management is recognised by all stakeholders and is fundamental to successful implementation of sustainability principles. A structured approach is therefore necessary to acquire appropriate information to manage all these issues. Transnet however is in constant state of change, and this has repercussions on resource management, as long term rational management is not often achieved for long.

This thesis has highlighted the issues contributing to poor management of the port resource and has also highlighted the importance of the concept of integrated coastal zone management. In order to achieve this management objective systems need to be integrated where possible to the benefit of the resource and ultimately the users. The comparison of water quality of the port to the international and local guidelines indicated a port with water quality management problems; most measurements were over the

international and local guidelines. This clearly requires immediate action to prevent irreparable and irreversible changes to the port system. This dissertation has achieved the intended aims by showing clearly faults with the current water quality-monitoring programme used in the port, as well as characterising the current water condition of the port by the comparison of the quality with both local and international standards.

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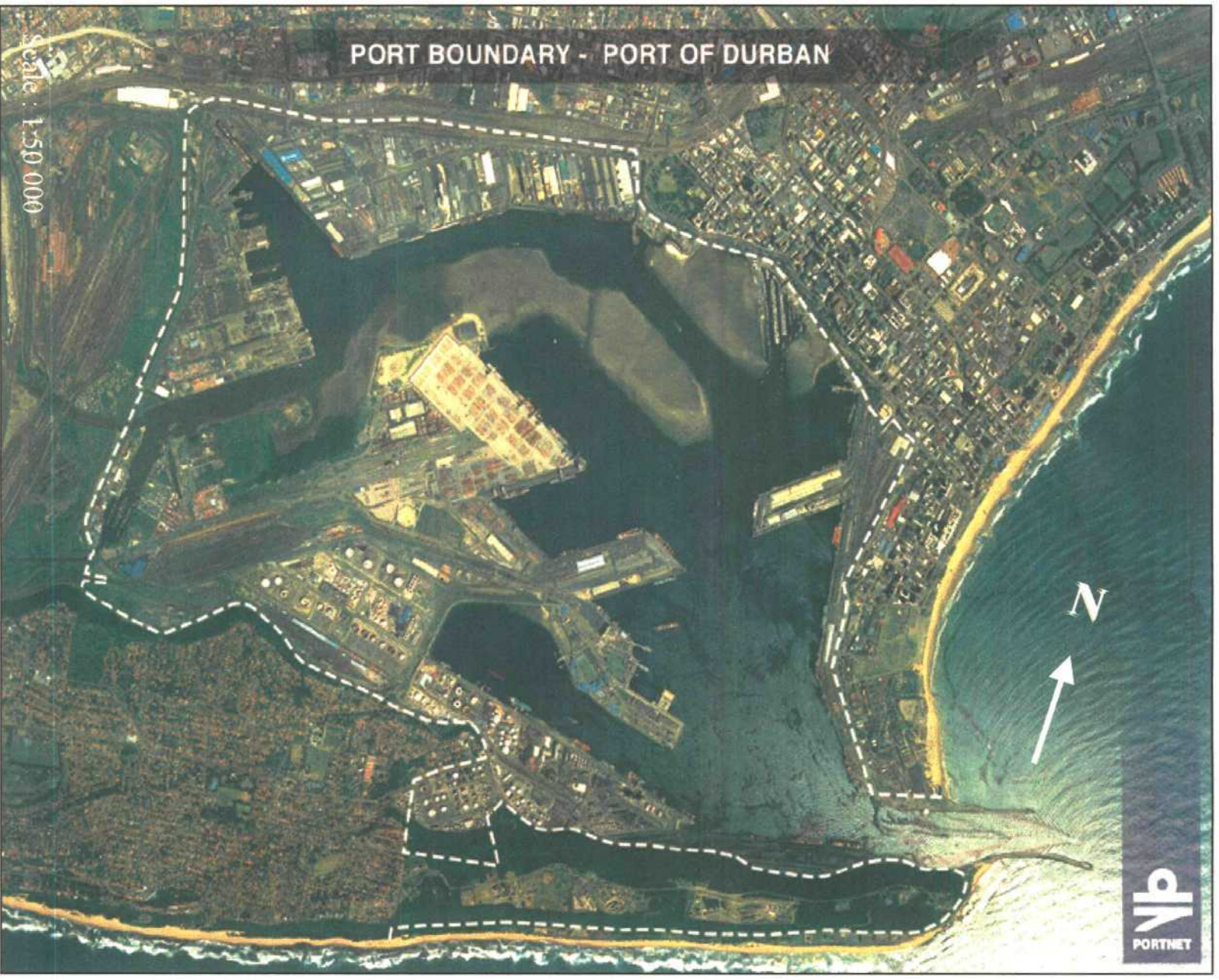
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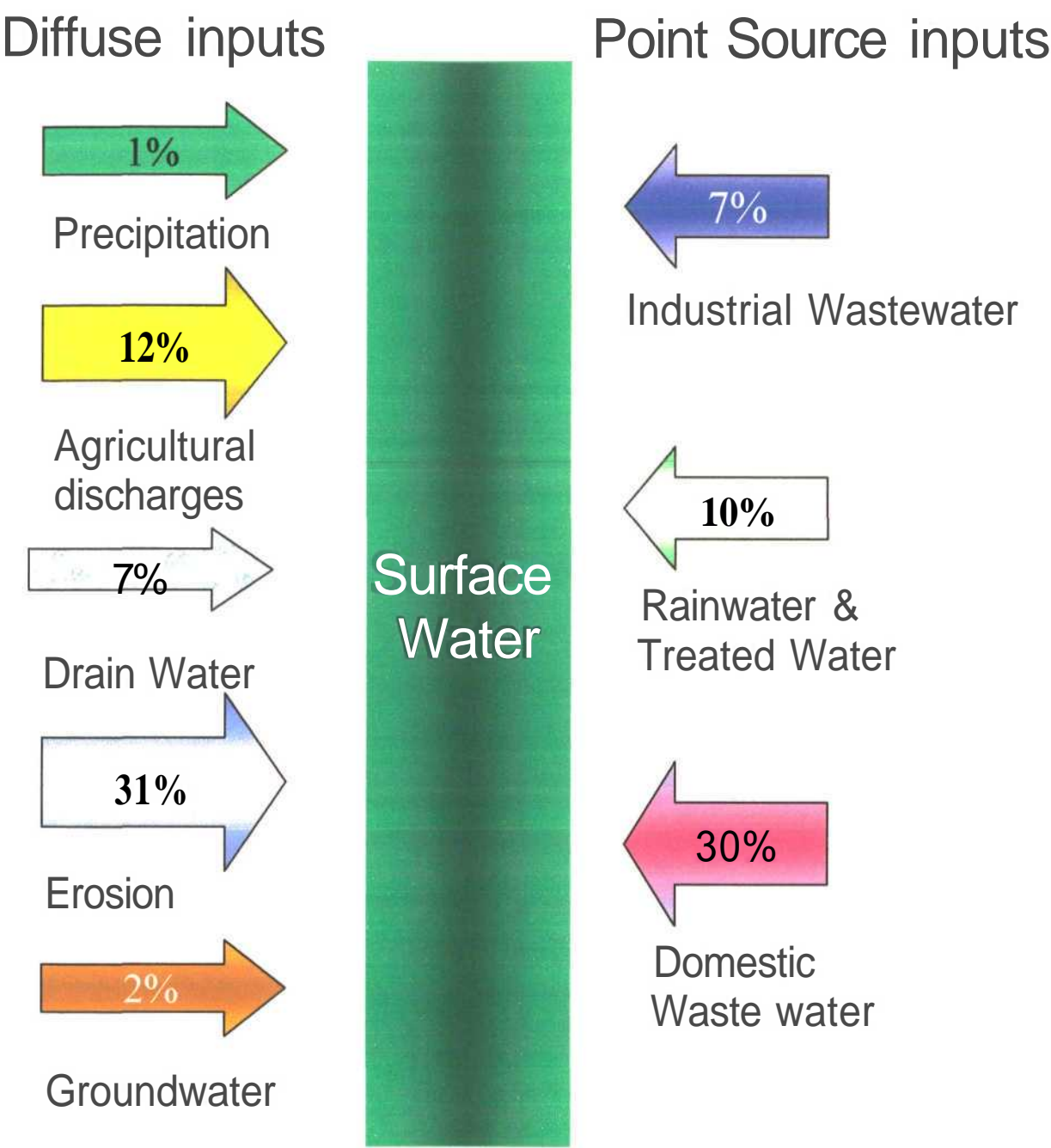
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Appendix 1: Port of Durban in Ground by Size. 99



Appendix 3: Pollution Origins in Surface Waters¹⁰¹



Adapted from Walmsley (1997)

