Managing Sedimentary Processes in South African Estuaries: A Guide

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Water Research Commission

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Contents

Dedication

This handbook is dedicated to the memory of two people who passed away in 2004: Melchior Menzelele, a previous co-chairman of Tyolomnqa Estuary Management Forum; and Professor Piet Booysen, an active member of EstuaryCare based at the Kariega and Bushmans Estuaries, and the retired Vice-Chancellor of the University of Natal. These gentlemen shared a passion for the estuaries where they lived but, more than that, translated this passion into actions aimed at maintaining and improving the integrity of these systems.

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In the interest of conserving and managing South Africa's critical estuarine resources, the compilers encourage the further dissemination of the contents of this guide. We simply request that the use of information contained in the guide be acknowledged.

Chapter One

1

Purpose

Estuaries are gaining increasing recognition as ecosystems that are important to society. The declaration of the Greater St Lucia Wetland Park (containing both the St Lucia and Kosi estuarine systems) as a World Heritage Site is one example of this recognition. We also recognize that sedimentary processes – the types of sediment that an estuary contains, and how it is moved around in the system and in and out of it – defines fundamentally the character of that system. While sedimentary processes are entirely natural it is apparent that human activities have often fundamentally altered these processes. Taking St Lucia as an example; the draining of the Umfolozi wetlands and their cultivation greatly increased the silt load entering St Lucia's lower reaches and threatened the entire ecosystem. Dredging to remove this silt has also had an impact. The end result is that the largest estuary in South Africa requires continual and expensive management to maintain it for conservation and recreational use.

Sedimentary processes in the Mfolozi/St Lucia system have been significantly affected by human activity (Ricky Taylor)

This booklet is a simple guide aimed at improving our understanding about sediments and sedimentary processes in South African estuaries, and how we might manage these processes. It is aimed at anyone who has an interest in estuaries, and at managers such as municipal or conservation staff who have a direct responsibility for their management. It is particularly designed to assist estuary management forums that have established themselves at many estuaries around the country. Its focus is prevention. Solving sedimentation problems once they have occurred tend to be extremely expensive, highly technical and the solutions often cause impacts themselves.

We recognize that sedimentation is caused mainly by hydrological processes (water movement) so the two processes are intimately linked. However, what local stakeholders

and local managers see are changes in sedimentary processes – sand and mudbanks appearing where there weren't any before; estuarine vegetation covered in silt; the estuary mouth opening less or more often than it did before. So we have decided to engage at the level that we can observe. We explain that preventing many of the sediment problems we observe are grounded in maintaining the natural water flow regimes in estuaries as far as possible. The handbook has been structured into seven chapters which are outlined below:

- Chapter 1 (this Chapter) explains the purpose of the handbook.
- Chapter 2 briefly introduces the topic and explains the sedimentary processes that have resulted in the formation of South African estuaries.
- Chapter 3 briefly introduces the three key themes that make up the handbook's title:
  - Estuaries – what are they and why are they important?
  - Sediment and sedimentary processes – what are they, how do they work, and what is their contribution to how an estuary functions?
  - Management – what is it and why is it important?
- Chapter 4 describes the causes and symptoms of the sedimentary process problems commonly found in South Africa.
- Chapter 5 explains how to prevent problems using a combination of education, individual and group action, and the law as tools.
- Chapter 6 describes some actions that can be used to solve problems once they have occurred.
- Chapter 7 provides specific guidelines on the breaching of estuary mouths.
- Finally we provide details where additional technical and legal information, and advice can be obtained.

This handbook forms part of a set of three publications designed to assist in estuary management. If you are new to estuaries and their management we suggest that you first read "Managing Estuaries in South Africa: an Introduction" (in English, isiZulu or isiXhosa) available from the Institute of Natural Resources (E-mail: inr@ukzn.ac.za, Tel: 033-3460796) and "Managing Estuaries in South Africa: A Step-by-Step Guide" (TT243/04) from the Water Research Commission. This booklet also compliments a technical document "Towards the Management of Marine Sedimentation in South African Estuaries with Special Reference to the Eastern Cape" (WRC Report No.1109/1/03) edited by Eckart Schumann and available from the Water Research Commission (www.wrc.org.za).

Introduction

Sedimentary processes are natural and defining features of South African estuaries. Sand, mud, silt and organic material are transported through estuaries, deposited in estuaries and eroded from estuaries. Deposited sediment forms a critical foundation for an estuary ecosystem and the type of sediment, or combination of types, regularly defines the character of that ecosystem – a sandy lagoon or a muddy mangrove swamp.

The Mtentu Estuary: A typical drowned river valley (DEAT)

Following the last ice-age which ended 13 000 years ago natural processes have fundamentally altered what our estuaries look like. Sea level rose by about 130 m until 5 000 years ago when it reached present levels. As the sea level rose it "drowned" river valleys. In these relatively protected river valleys the rate of water flow slowed and they became areas where sediment from the sea and from catchments was deposited rather than eroded. This natural process has dictated the structure of most of present day South African estuaries.

More recently, over the past hundred years or so, it has been the actions of people that have been superimposed on these natural processes. Land-use practice in catchments, particularly farming, has increased the supply of eroded sediment into some estuaries, while in others freshwater removal for farming, industrial and domestic use has reduced the transport of sediment into others. This same reduction in freshwater flow has allowed marine sediment to encroach further into estuaries than it would normally while in other instances the stabilization of sand dune systems has reduced the amount of marine sediment available to some estuaries. The direct removal of sediment, specifically sand for construction, from the upper reaches of estuaries has fundamentally altered the sediment budget of some urban systems. These impacts have, in some instances, caused the ecological, social and economic value of certain estuaries to decline to the point where they are no longer functional and provide little or no benefit to society.

Open mouth conditions at small intermittently open estuaries, important for their ecological functioning, are normally maintained by river flow. Reduction in river flow because of developments in the catchment has often resulted in a reduction in open mouth conditions, with sometimes serious negative effects on the ecology of these estuaries. The demands for water are almost always increasing, but further water abstractions could cause serious threats to these estuaries.

Chapter Three

3

Estuaries, sediments and management

What are estuaries and why are they important?

An estuary is that part of a river system that meets and interacts with the sea. They are diverse and variable systems including large lakes such as Kosi; the mouths of large river systems such as the Orange; small systems such as Zandvlei in Cape Town, and harbours such as Durban. The mouths of some estuaries such as the Mngazana on the Wild Coast are permanently open to the sea while those of others, such as the Mdloti north of Durban, have mouths that open only temporarily and/or seasonally. Some estuaries are deep with Mkambati exceeding thirty meters in some places while others like St Lucia have an average depth of less than a meter.

Despite their diversity and variability estuaries share certain characteristics that define them:

- Freshwater from a river and saltwater from the sea interacts.
- Tides influence the water level either permanently in the case of open estuaries or occasionally for intermittently open systems.
- Because of protection by land, the water is generally calmer than the adjacent sea.
- Sediment from the sea or from the land, together with nutrients generated in the sea or on land or in the estuary are deposited during normal periods and eroded during floods.

Why are they important? Ecologically an estuary is a system where:

- The high levels of deposited and generated nutrients allow many plants and animals to thrive. Estuaries are recognized as some of the most productive ecosystems on earth.
- The calm and protected environment forms a nursery ground for numerous marine fish and shell-fish species.
- Both plant and animal species are designed to survive floods and drought conditions.

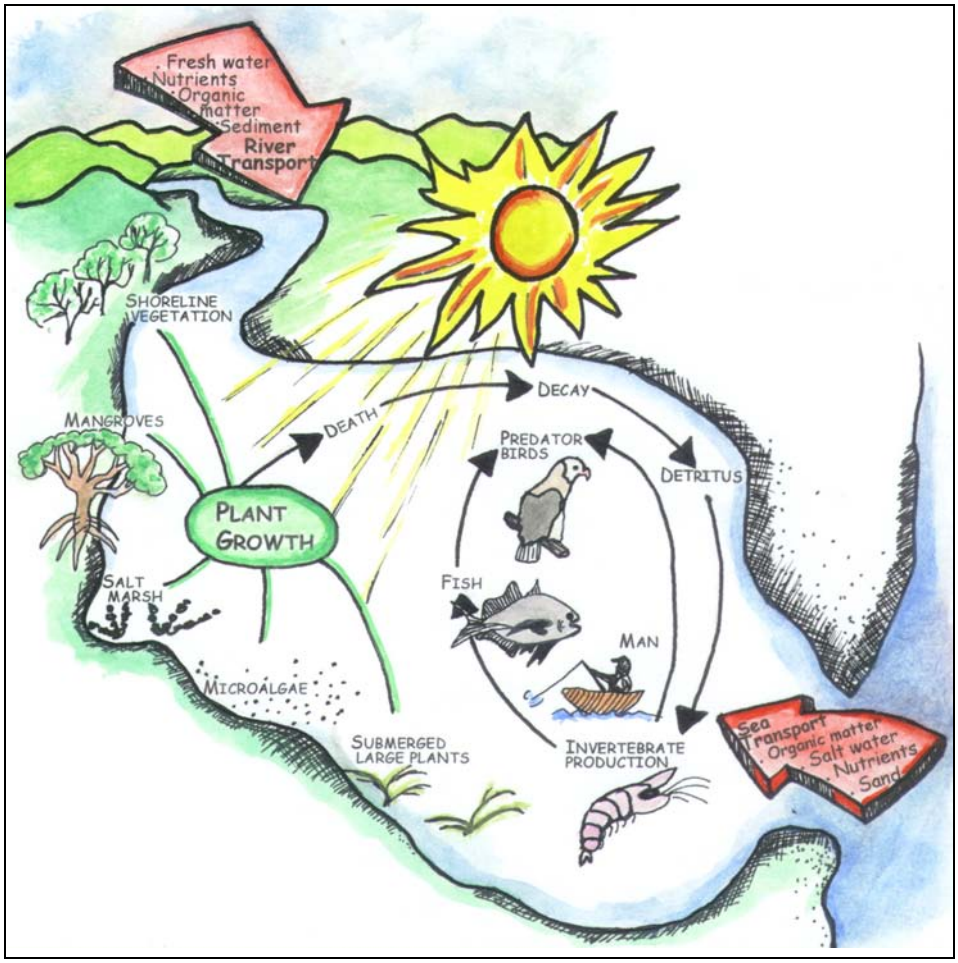
Economically an estuary is an asset or service that:

- Provides food and material for subsistence.
- Supports enterprises based on recreation, tourism, natural resource harvesting and transport.
- Is often of great scenic beauty and the surroundings are therefore highly favoured for development.
- Processes waste and provides protection from floods and storm events.

3

Socially an estuary is a place:

- Governed and managed by people.
- Where people congregate to live, do business, relax, reflect and recreate.
- Of research and learning.
- Of beauty and symbolism.



Estuaries are complex ecosystems supplying a range of goods and services

In short, estuaries are complex and dynamic ecosystems that supply an array of goods and services to society from which we benefit. In many instances the supply of these goods and services demand that the system be maintained in a condition that resembles as closely as possible its natural state.

3

What are sedimentary processes and why are they important?

Sediment is sand, gravel, mud and/or clay, and organic material in varying combinations. It might occur suspended in the water column moving from freshwater directly through an estuary and into the sea or from the sea to freshwater. It might enter the estuary from the feeding river system or from the sea and be deposited to form the bottom, sides and intertidal area. It might be formed in an estuary, eroded from its place of deposition and move upstream or downstream to be deposited elsewhere or, lastly, it might be blown into or from an estuary by wind. These are all sedimentary processes. Together with other physical and chemical structures and processes such as topography, climate, the chemical composition of the water, currents and tides, sedimentary processes form the foundation for life. In combination with plants (algae, salt marsh plants, reads and mangroves) and animals (zooplankton, benthic invertebrates, prawns, molluscs, fish, birds, reptiles and mammals) they establish the ecosystems that characterize an estuary.

Sediment and sedimentary processes play a fundamental role in dictating what a particular estuarine ecosystem is like. Taking a typical estuary as an example; at its mouth the sediments are conventionally marine comprising mainly large grains of sand with very little in the way of small particles of silt, clay and organic material. Because particles are large they don't stick together (they are not cohesive) and are readily moved about by the strong currents and waves in the mouth area. The mobility of these sediments means that vegetation such as mangroves and sea grasses struggle to take root, and even if they could, there would be little in the way of nutrients to sustain them. Also, the mobility of the sediments and the lack of nutrients present a tough environment for small animal species to live in. As a result of this, what we observe at the mouth is an area of fairly low biological productivity dominated by physical processes.

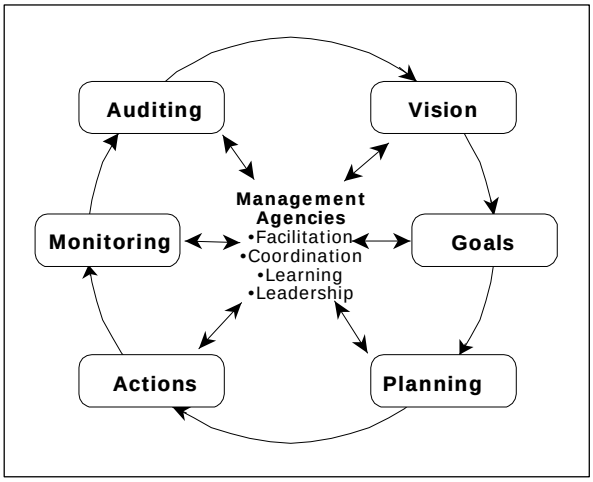
As we move upstream of the mouth and the estuary broadens out the tidal flow decreases and we encounter more mud, silt and organic material mixed in with the sand in the channel areas. These small particles bind the sediment (more cohesive) and, combined with reduced flow rates, the sediment becomes a more stable environment containing large numbers of benthic invertebrates (small animals that live in and on the sediment). As we move from the channel to the sides of the estuary and into the intertidal areas flow rates are further decreased encouraging deposition of fine sediment. It is here that mangroves and salt marsh plants begin to take root. These plants further slow water flow, encourage deposition and also contribute large quantities of organic material through leaf litter. Crabs and other invertebrates feed on this organic material reducing it to a fine paste that combines with mud and silt and creates the soft muddy substrate that is so characteristic of many estuarine systems.

Finally, on reaching the head of the estuary where it narrows, freshwater flow moves the fine sediment in suspension but the larger particles settle out resulting in a fairly course granular sediment on the bottom and sides. With this we again see changes in the ecology of the estuary which is characterized by fewer plants and animals.

Management – what is it and why is it important?

Management is a structured process through which we plan and act. It is illustrated in the diagram below:

- The vision is our overall direction – what we would like the estuary to be like in five or ten year's time. This vision should always take into account what the natural situation was and try and achieve it as closely as possible.
- Our goals or objectives are the things we need to achieve to realize our vision.
- Actions or activities are things we need to do to accomplish our goals or objectives.
- Monitoring and evaluation is our means of checking that we are on the right track.



A Typical Management Process

- Auditing followed by Refinement is how we modify the management components to ensure that our vision is achieved.

A simple sediment process example from the Ohlanga Estuary just north of Durban can illustrate the process above. The inflow from a waste water works at the estuary has caused the mouth to open more often than normal. This negatively affects the ecology as biological production is highest when the mouth is closed and the water level is high. This production is strongly reduced when the mouth is open and the volume of water in the estuary is low. The management process at the Ohlanga Estuary is as follows:

- Vision: The Ohlanga Estuary achieving its desired ecological condition through natural breaching three times a year on average.
- An objective that needs to be met in order to achieve the vision: Reducing the inflow of treated waste water from 1000 cubic meters per day to 300 cubic meters per day. An

action required to meet the objective: Construct a pipeline sufficient to carry 700 cubic meters of water to the adjacent Mdloti catchment:

- Monitoring: Check the frequency of breaching of the mouths of both the Ohlanga and Mdloti estuaries.
- Refinement: Breaching frequency at Mdloti increases from three to five times a year so transfer 400 cubic meters to irrigation scheme in Tongati Catchment.

Please note that the volume of water and the number of breaches used in this example are purely illustrative.

Some useful guidelines for managing sedimentary processes in estuaries:

1. Make sure that what you think is a problem is actually a problem. (It is sometimes difficult to distinguish between natural variation and those induced by human activity.)
2. You cannot manage alone. Gather people around, establish trust, build relationships, obtain commitment and communicate, communicate, communicate.
3. Estuaries and people, and the interactions within and between them, are complex and variable – don't expect the management of these interactions to be simple.
4. Management is a process of learning and doing. Learning without doing gets you nowhere and doing without learning results in mistakes.
5. There is no substitute for good planning.
6. The more you know and understand the better the decisions will be.
7. Know the law, follow it and make it work for you.
8. Prevention is far better (and far cheaper) than a cure.
9. Where possible, treat the cause rather than symptom.
10. If you start out on an expensive process of rehabilitation make sure you have the financial muscle to see it through
11. Be realistic about what you can achieve.
12. Everything takes longer than you think.

Chapter Four

4

Causes and symptoms of problems

There are two general and simple rules.

- If one alters the water flow patterns into and out of an estuary or within the estuary itself one also alters the sedimentary processes.
- Because water flows it transfers or transmits change, so impacts are usually not just localised but spread throughout the system.

For practical purposes the causes of sedimentary process problems in an estuary can be divided into three categories, namely:

- Activities at the mouth or in the sea near the mouth
- Activities in the estuary itself
- Activities in the catchment.

Activities at or near the mouth

Sand dune systems at or near an estuary mouth are often stabilized to facilitate development. This sand is "locked up" and is no longer available to the estuary mouth area. An example of this is at Bushmans Estuary mouth where a desalination plant has been constructed and the dune area stabilized. Experts consider that this has substantially altered the character of the mouth.

The consequences of attempting to stabilize sand at an estuary mouth – Mdloti Estuary (Ken Breetzke)

The erection of breakwaters, piers, groynes and canals at the estuary mouth or in the sea near the mouth all alter water flow and hence how and where sediments are eroded and deposited. The modification of these flows does not only result in a local impact. If, for example, the mouth is permanently fixed with breakwaters on either side, this can alter water flow and sediment dynamics for the entire length of the

estuary. It can change where sediment is deposited and eroded within the system and can alter the nett inflow and outflow of sediments, sometimes reducing it and other times increasing it. The Kowie estuary is an example of where the canalization of the mouth combined with development in the estuary is causing marine sediment to steadily accumulate in the estuary. This in turn affects the ability of boats to navigate in the system. The breaching of an estuary mouth causes impact at the mouth itself and to the entire system (See Chapter 7).

Activities in the estuary

Canalising an estuary, converting soft surfaces and sides to hard surfaces, and constructing piers, bridges and causeways all change estuary water flow dynamics and hence sedimentary processes. As examples:

- A solid pier jutting into an estuary will deflect water flow towards the opposite bank and change the natural channel configuration. Bushmans Estuary (near the public boat launch site) is a good example of this.
- Bridges generally constrict water flow through an estuary. The result is scouring and deepening of the estuarine channel at the bridge's centre and increased deposition both upstream and downstream where the solid on-ramps of the bridge prevent water flow. The build-up of sediment upstream of a bridge can also damage a bridge during flood events. This is a concern on the Umngeni.
- Causeways, particularly those of solid construction which limit water flow can be seen as an extreme example. They can, in effect, throttle water flow and completely alter sediment movement. An example is the causeway near the mouth across the Seekoei Estuary near Jeffries Bay.
- Marina or similar developments convert soft sloping surfaces to hard vertical surfaces which cause significant impacts. A shallow gently sloping intertidal mudflat

Causeways like this one at the Seekoei can completely alter sedimentary processes in estuaries (DEAT)

or sandflat is reclaimed and a steeply sloping wall is constructed at the estuary channel. First, the reclamation "locks up" sediment that was an important part of the estuary sediment budget. Second, the shallows that were lost can no longer act to reduce water velocity and increased velocity in the channel causes additional scour to the sides and bottom of the channel.

- Concrete canals, an extreme example being the Umlaas Canal at Durban. The estuary was rerouted out to sea through a concrete canal. There is no sediment and the system has ceased to function as an estuary.

Activities in the catchment

Dams and weirs act in two ways. First, they reduce the amount of water entering the estuary and change the character of that flow and second, sediment that would normally reach an estuary often settles out in the impoundment. This affects sediment erosion and deposition and, where estuary mouths are intermittently open, they might stay closed for longer. The effects of dams and weirs are particularly severe when there are a number of them in the catchment as they act cumulatively.

Agriculture and forestry also acts in two ways. First, both crop and livestock production cause soil erosion and so increases the sediment load entering estuaries. These sediments are often fine silts which reduce water clarity and smother plant life. Second, crop and timber production uses up significant quantities of water directly and/or through irrigation practices. Particularly during dry periods these activities can significantly reduce the amount of water entering the estuary. This, in turn, affects the sedimentary processes.

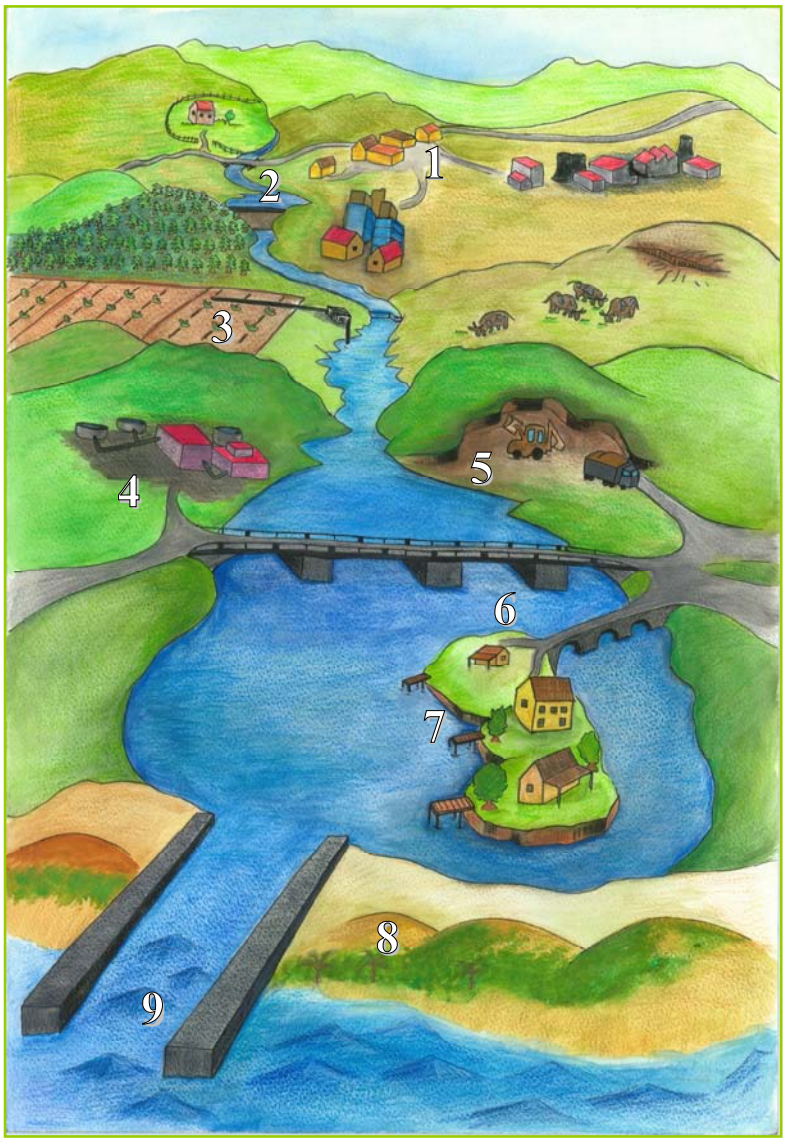
Water Treatment Works have the opposite effect. Treated water is returned to the river and then enters the estuary. This water might have originated in another catchment so one is, in effect, increasing freshwater inflows. Although the level of increase has little impact on erosion it does cause the estuary to breach more often than normal. A good example of this is the Ohlanga Estuary north of Durban.

Roads, homes, factories and similar development have a high proportion of impervious hard surfaces and are all designed to get rid of rainwater as quickly as possible. The result is that after rain more water will flow into the estuary than is normal and during dry periods less water will run into the estuary than is normal. With this change in flow comes a change in sedimentation and deposition. Wet season flooding will cause more erosion than is normal while in the dry season estuary mouths might remain closed longer than normal.

Sand-winning is the process where sand is extracted from river beds usually for concrete and fill used in construction. This might take place immediately upstream of the estuary or in the estuary itself. Apart from the high impact of the extraction, it can fundamentally change the sediment budget and the nature of the sediment available to the estuary. A good example of where this has occurred over a protracted period is the Umngeni River and estuary at Durban. In the 1980's, about 80 000 tons of building sand was being removed annually.

Expert opinion may often be required to quantify the effects of these activities in the catchment.

A summary of activities that affect sedimentary processes



1. Hard surfaces changing the patterns of run-off and with it the patterns of erosion and sedimentation.
2. Dams reducing the supply of sediment and freshwater to an estuary.
3. Agricultural and forestry activities reducing the supply of freshwater and increasing sediment loads through erosion.
4. Water treatment works artificially increasing the supply of freshwater to the estuary (and sometimes reducing water quality).
5. Sand-winning activities altering the sediment budget and causing erosion.
6. Bridges and causeways modifying water flow patterns which in turn changes sedimentary processes.
7. Marina development creating vertical rather than gently sloping banks and reducing the intertidal area.
8. Stabilised dune systems at the mouth.
9. A mouth that is kept open and in a fixed position by training walls.

Preventing problems

In some ways the title of this handbook is a little misleading as prevention does not involve managing sediment and sedimentary processes directly. Rather, the key to preventing problems is managing and influencing how people behave. There are many ways of doing this. They range from "soft" educational and capacity building approaches designed to improve our knowledge and understanding about systems and issues to "hard" legal processes designed to deter people from certain actions.

Sharing knowledge and understanding

The starting point in prevention is improving our own knowledge and understanding of how ecosystems function. Once we understand we are able to share this knowledge with others and in so doing improve their knowledge and understanding. Being able to transfer our understanding to engineers, developers, farmers and municipal officials then allows these individuals and groups to incorporate this understanding into design and into land-use practice.

Stakeholders discussing sedimentation issues at Bushmans Estuary (Margaret McKenzie)

Drawing on the causes and symptoms described in Chapter 4, and drawing on our own knowledge and understanding, here are some of the key messages you would want to transfer to those who might impact on sedimentary processes:

- Maintain the mouth of an estuary and the area surrounding it in as natural state as is possible. Avoid stabilizing natural dune systems, and constructing piers, breakwaters and groynes.
- Only breach the mouth based upon an agreed policy and under the direction of someone appointed to and qualified to carry out the task.

- In the estuary avoid dredging artificial channels and constructing anything in the estuary that might alter current flows.
- When constructing bridges across estuaries ensure that both the bridge pillars and buttresses cause as little alteration of current flows as possible.
- Ensure that infrastructure development and agricultural activity is set back from the estuary edge and that intertidal areas are maintained in their natural state.
- Try to ensure that storm water drains feed into rivers and streams feeding the estuary rather than directly into the estuary itself.
- Upstream in the feeder river, ensure that when dams are built the construction factors in flood releases (from both the bottom and top of the dam wall) and that acceptable levels of water flow will discharge from the dam. Where possible construct dams off the major feeder river on a tributary and the best solution (as seen on the Mngazi River) is to construct the dam entirely away from the river course and only to abstract water from the river when the flow is high enough not to affect essential ecological processes.
- Discourage development close to the river bank and encourage the re-establishment of natural vegetation along the river course (riparian area).
- Encourage farmers to establish effective soil conservation measures on their farms and to be as efficient as possible in irrigation practices.
- Where necessary, waste water treatment works should be able to direct processed water to alternate catchments, especially if the works is on a river feeding an estuary that is only intermittently opening.

Individual and collective action

Estuaries are desirable development sites and, in certain instances, improving knowledge and understanding is not enough. More direct and persuasive action is required. Although individual action (writing to newspapers, lobbying officials etc) can be effective in bringing issues to public and management attention it is usually far more effective to engage as a group. This is where estuary management forums become invaluable. A formally organized group of people with the interest of the estuary at heart can be a very powerful and influential force. Following are some guidelines to assist in direct action:

- Plan your strategy and know what you want to achieve.
- Ensure that you have adequate resources (people and money) to see the strategy through.
- Know who you have to influence and how to influence them.
- Know the law and know it well but only use a formal legal route as a last resort (see below).

- Try and assist with alternate solutions rather than just being negative and preventing the development option.
- Involve someone with technical expertise of the issues in your forum.

The Law

The laws are numerous and complex. Following is a list of key laws and some key points to note:

- The Constitution including the Environmental Bill of Rights ensures that, amongst other things, everyone has the right to an environment that is not harmful to their health or well-being, and to have the environment protected for current and future generations.
- The Policy for Sustainable Coastal Development in South Africa is currently being developed into law. The policy recognizes that estuaries are key coastal resources and that they require active management and conservation to maintain their integrity.
- The Sea Shore Act regulates all activities in the coastal intertidal zone including any activity in an estuary below the high tide mark. However, most of what is covered here is also covered in the Environmental Conservation Act (see below).
- The Environmental Conservation Act requires, through the Environmental Impact Assessment (EIA) Regulations, that an environmental report is required for almost any development in or adjacent to an estuary and permission for development is required from the relevant authority (usually the provincial environmental department). Many activities in the catchment including the cultivation of virgin land, the building of dams and weirs, and the construction of other infrastructure also require an environmental report and permission to be obtained prior to development.
- The National Environmental Management Act contains over-arching environmental legislation. Included in this is the provision that allows members of the public to take legal action in the public interest or in the interest of protecting the environment. This includes taking legal action against government departments to force them to implement laws.
- The Conservation of Agricultural Resources Act requires that, when farming, steps are taken to ensure particularly the conservation of soil and water.
- The Water Act recognizes that an estuary is a water user and that provision needs to be made that an estuary has sufficient freshwater inflow to sustain its ecological functions.
- The Minerals Act requires that mining, quarrying or sand-winning are subject to an environmental report (including rehabilitation measures and dedicated fund to pay for this) prior to commencement and that the activity is permitted by the Department of Minerals and Energy.

- The Municipal Systems Act requires that municipalities establish Integrated Development Plans (IDPs). These plans need to include spatial development frameworks, land-use management systems, and environmental management plans. These all require that potential environmental impacts of development/land-use options are taken into account.
- Common Law is important and, simply stated, prevents people from engaging in activities that impinge on your fundamental rights.

In summary, there are enough laws to ensure that sedimentary processes are maintained intact. The trick is what combination of laws to use and how to use them to realize a particular goal. Remember always that that legal action is expensive and tends to polarize people in opposing camps. This route should only be followed when all other mechanisms have been unsuccessful.

It is important to consult with the responsible government official to determine the legal process and legal constraints if one is contemplating actions that impact on sedimentary processes. If the scale of intervention is considerable (e.g. dredging or marina development) consult an environmental lawyer before engaging the EIA process to make sure you have all bases covered.

Solving problems

As has been mentioned earlier solving sedimentary process problems are often complex and expensive. This Chapter deals firstly with what not to do when contemplating action and secondly describes very briefly some technical options.

The don'ts

- Do not start any action until you know how the estuary functions and have established whether the problem is because of the dynamics of natural processes or being caused by human activities.
- Do not start any action until you have assessed previous attempts to solve the problem. There are many cases, for example at St Lucia, where well intended management actions either did not work and/or had serious negative side effects because the functioning of the estuary was not properly taken into account.
- Do not build structures (walls etc) to change flow patterns without understanding the consequences of this. The usual scenario is that after a few floods one is left with unsightly broken structures that do not serve any purpose and often contribute further to the problem.
- Do not start any physical work until all the necessary legal steps have been followed and the work is formally authorized.
- When contemplating dredging consult with people at nearby estuaries. They might have a similar problem and you can share the costs of expensive equipment.
- Do not remove sediment without being absolutely clear about what the objective is.

An expensive consequence of poor planning and decision making – the Mdloti Estuary mouth (Ken Breetzke)

- Do not remove sediment without surveying the estuary first. If you don't survey you will not be able to evaluate how successful the removal was.
- Do not remove sediment unless you have a comprehensive plan for where you are going to dispose of this sediment.
- Do not remove sediment until you know what it is going to cost (particularly long term operational costs), who is responsible and who is going to pay these costs.

Some technical options

Technical options are described in some detail in "Towards the Management of Marine Sedimentation in South African Estuaries" edited by EH Schumann and available from the Water Research Commission. This section provides a short summary.

In all instances one needs to either physically move sediment or to influence its deposition and erosion. It is usually only at the mouth where currents are fairly strong that the latter method can be used. At Durban, Richards Bay, Umngeni and Kowie (Port Alfred) single or double "training walls" have been built. These walls act either to deflect away marine sediment that would normally enter the mouth or to maintain a strong erosive water flow through the mouth. These structures should only be contemplated if one wishes to improve navigation through the mouth of the estuary and, given their cost, are unlikely to be of relevance to most South African situations.

The active removal of sediment by mechanical means can be carried out using the following methods:

- Removal by a dredger. This involves excavating the sediment or sucking it up and then placing it in a barge for disposal elsewhere or pumping through a pipe to a disposal site. The size of equipment ranges from dredging ships such as those used at the major harbours to a

A suction dredger operating at St Lucia Estuary (Bruce Mann)

small hand-held suction apparatus such as that used at Club Mykonos. The costs of equipment and ongoing operations range from thousands to millions of rands. This system is the most commonly used in South Africa and is useful for removing sediment over a large area or where ongoing maintenance dredging is required.

- Agitation by dredger: this involves using a variety of methods to get the sediment off the bottom and into suspension in the water column. The sediment is then moved by water currents to another position. This can be used to solve localised problems but is not suitable for large-scale applications.
- Fluidization: similar to agitation, this involves pumping water into the sediment causing it to lift and separate. This fluidized sediment will then move "down-hill". Like agitation it is suitable only to address localised problems.
- Restricting tidal flow: successfully applied at the Green Hole near Leisure Island at Knysna, tidal flaps were attached to the culverts allowing water flow only in one direction. This eroded sediment downstream of the direction of flow. This is only useful in specific circumstances and one should remember that the causeway was the likely cause of the problem in the first place.
- Tidal flushing: This involves erecting what is effectively a temporary barrier in an estuary on the high tide and then collapsing or opening the barrier once the tide has ebbed. The effect is the same as breaching a dam wall and outflow is accelerated. Mathematical modelling indicated that this method was unsuitable for Bushmans estuary but there might be other estuaries where applications could work. To be effective it would need to be applied almost continuously and a well-designed and permanent sluice gate structure would probably be required. Also note that a closed sluice gate would effect boat navigation on the estuary.

The disposal of dredge spoil causes its own environmental problems (Ricky Taylor)

Guidelines on estuary mouth breaching

Many smaller estuaries in South Africa have mouths that only open (breach) intermittently. The breaching of a mouth, whether naturally or as a result of actions by people causes profound changes to the physical processes in the system. Water level is often lowered considerably and the floodplain surrounding the estuary becomes exposed. Salinity (the saltiness of the water) increases from almost fresh to almost that of seawater. Both can have considerable impacts on ecological processes.

Artificial breaching takes place for a number of reasons:

- To prevent the flooding of infrastructure, residences and farmland that occurs on the floodplain of the estuary.
- To prevent prolonged exposure of mangroves to freshwater which will eventually kill them (as occurred at Kosi when the mouth closed for a long period – an entirely natural phenomenon in this case).

Artificial breaching of an estuary mouth (Piet Huizinga)

- To flush away nutrient build-up in the system which causes unpleasant odours and, in extreme cases, the die-off of fish and invertebrate life.
- To flush out sediment that has accumulated during the closed period.
- Through the build-up of freshwater from inter-basin transfers (including from sewerage treatment works).
- Through ignorance. (People do it for fun, not understanding the consequences of their actions).

Recognising that artificial breaching does happen and will continue to, the CSIR established a set of broad guidelines that are set out below. Note that local conditions differ and these guidelines should be used as the basis for a specific procedure at each estuary:

1. **The water level in the estuary should be as high as possible and if possible breaching should occur naturally, so that as much sediment as possible will be flushed from the estuary.** The potential of flushing of sediments increases exponentially with the increase of outflow velocities after breaching and the outflow velocities increase with the increase in water levels before breaching. At higher water levels there is also more water in the estuary so that the outflow is sustained for longer. Natural breaching of the mouths of South African estuaries will normally occur at water levels of between 2,5 m and 3,0 m above mean sea level. However, in many places estuary mouths have been breached at too low water levels for a prolonged period. This has caused severe sedimentation in several estuaries.

2. **The mouth of an estuary should be breached in spring or summer and not in autumn or winter.** An estuary fulfils a primary ecological function as a nursery for marine fish. Migration of juvenile fish into estuaries on the South African coast occurs mainly during spring and summer and this migration can normally only take place when the mouth is open. The management policy should therefore be aimed at creating an open mouth condition during this period. A further reason for this timing is that high waves occur more often in winter than in summer along the coast of South Africa. Wave activity is the main reason for mouth closure. High waves, causing turbulence, also contribute to the influx of considerable amounts of marine sediments into the estuary. It is therefore beneficial to keep the mouth closed, if possible, during autumn and winter and to have it open in spring and summer. The third reason is that water quality problems are more likely to develop when the mouth is closed during spring and summer, when the temperatures are higher and when during the holidays the loading of pollutants is increased. Additionally, people generally prefer an open mouth during the summer holiday season.

3. **The mouth of an estuary should ideally be breached three or four days before springtide.** This ensures good additional flushing during the following springtide. This recommendation is important for small estuaries such as the Great Brak, where the mouth sometimes closes at the following neap tide, and less relevant for larger systems such as the Klein Estuary near Hermanus, where the mouth normally stays open for several months after the breaching.

4. **The position where the mouth should be breached depends on local conditions.** Strong controversy often exists about specifically where the mouth of an estuary should be breached, but the best position depends on local conditions and expert advice should

be obtained. Much time is often spent on debating this issue in meetings, but it should always be remembered that recommendations (1) and (2) above are normally far more important.

5. **If possible, not a small trench, but a deeper and wider channel should be excavated before breaching.** A considerable amount of water is generally used to flush a small and narrow trench open to a medium sized trench. A larger initial channel will cause higher immediate flow velocities, causing more sediment to be flushed out to the sea. This guideline is also more relevant at a small estuary such as the Great Brak, where a limited volume of water is available for flushing, than at a large estuary such as that of the Klein River at Hermanus.

A large channel allows for strong flows and the effective flushing of sediment during breaching (Piet Huizinga)

6. **The actual moment of breaching during the tidal cycle is at high tide or as close after high tide as possible, waves permitting.** If it is unlikely that waves will interfere at high tide, then breaching can even be undertaken up to two hours earlier. The high outflow after breaching causes the scouring to last over several hours and sometimes more than a tidal cycle. The maximum outflow normally occurs approximately 4 to 8 hours after a breaching and the flow velocities will be highest when the difference in water levels between the estuary and the sea is greatest. High waves can sometimes interfere with the breaching process at high tide and shortly after high tide. It is therefore important to watch the effects of the waves in front of the mouth position. The mouth can be breached as soon as it is considered that the waves will not interfere in a significant way. Under extraordinary wave conditions that are likely to interfere with the breaching process it may be better to postpone the breaching by a day, if possible.

Books

Allanson, B. R. and Baird, D. (eds.) 1999. Estuaries of South Africa. Cambridge University Press, Cambridge, 340 pp.

Davies, B. and Day, J. 1998. Vanishing Waters. University of Cape Town Press, Cape Town, 487 pp. See Coastal lakes and estuaries p142 - 164.

Day, J. H. (ed.) 1981. Estuarine ecology with particular reference to southern Africa. AA Balkema, Cape Town, 411 pp.

Glazewski, J., 2000. Environmental Law in South Africa. Butterworths, Durban, 903 pp.

Handbooks

Breen, C. M., and McKenzie, M., 2001. Managing estuaries in South Africa: An Introduction. Institute of Natural Resources, Pietermaritzburg. (Also available on the website: www.inr.unp.ac.za/EMHB.)

Hay, D. and McKenzie, M. 2005. Managing Estuaries in South Africa: a step by step guide. WRC Report No. TT 243/04. ISBN No. 1-77005-277-1. Water Research Commission, Pretoria

Technical reports

Boyd, A. J., Barwell, L. and Taljaard, S. 2000. Report on the National Estuaries Workshop. 3 - 5 May 2000, Port Elizabeth, South Africa. Report No 2, Marine and Coastal Management Implementation Workshop. Department of Environmental Affairs and Tourism, Cape Town.

Breen, C. M., Adams, J., Batchelor, A., Cowley, P., Marneweck, G., McGwynne, L., McKenzie, M., Ngulube, P., Paterson, A., Sihlophe, N., Taljaard, S., Turpie, J., Uys, A., van Niekerk, L., and Wood, A., 2004. Towards the Conservation and Sustainable Use of Eastern Cape Estuaries. WRC Report No. TT 237/04. ISBN No. 1-77005-235-6. Water Research Commission, Pretoria.

Department of Environmental Affairs and Tourism 2000. Key Elements of the White Paper for Sustainable Coastal Development in South Africa. Chief Directorate Marine and Coastal Management, Department of Environmental Affairs and Tourism, Cape Town.