Western Cape Government
Environmental Affairs & Development Planning




WESTERN CAPE ESTUARINE MANAGEMENT FRAMEWORK AND IMPLEMENTATION STRATEGY:

Best Practice Activity Guidelines

DOCUMENT DESCRIPTION

Document title and version:

Western Cape Estuarine Management Framework and Implementation Strategy: Best Practice Activity Guidelines v.1 (October 2019)

Project Name:

Western Cape Estuarine Management Framework and Implementation Strategy

Client:

Western Cape Government, Department of Environmental Affairs & Development Planning

Royal HaskoningDHV reference number:

MD1819

Authority reference:

EADP 1/2015

Developed by:

Royal HaskoningDHV/Coastwise Consulting/Ernesta Swanepoel

Acknowledgements:

Western Cape Government Environmental Affairs & Development Planning

Chief Directorate: Environmental Sustainability

Directorate: Biodiversity and Coastal Management

Email: coastal.enquiries@westerncape.gov.za

Date:

October 2019

TABLE OF CONTENTS

1 INTRODUCTION 1
2 WHAT IS THE LITTORAL ACTIVE ZONE? 2
3 COASTAL ZONATION AND DEVELOPMENT MANAGEMENT 4
3.1 NATIONAL ENVIRONMENTAL MANAGEMENT: INTEGRATED COASTAL MANAGEMENT ACT 4
3.2 COASTAL PROTECTION ZONE AND COASTAL MANAGEMENT LINES 5
3.3 REGULATION OF ACTIVITIES FALLING BELOW THE HIGH-WATER MARK 6
3.4 ENVIRONMENTAL IMPACT ASSESSMENTS 7
4 IMPLICATIONS FOR LOCAL GOVERNMENT 9
4.1 GENERAL PRINCIPLES FOR DEVELOPMENT WITHIN THE LAZ 10
5 GUIDELINES FOR MANAGING EROSION AND ACCRETION IN ESTUARIES 11
5.1 PROCESSES OF EROSION AND ACCRETION 11
5.2 HUMAN FACTORS INFLUENCING EROSION AND ACCRETION 13
5.3 GUIDELINES FOR MANAGEMENT OF EROSION AND ACCRETION IN ESTUARIES 15
5.3.1 Land-use planning adjacent to and in the estuarine functional zone 15
5.3.2 Natural patterns of water flow and drainage 16
5.3.3 Estuary mouth manipulation 16
5.3.4 New development 17
5.3.5 Sand mining and dredging 17
5.3.6 Access to river and estuary margins 18
5.3.7 Rehabilitation of degraded areas 19
5.3.8 Agricultural practices 19
6 EROSION PROTECTION & BANK STABILISATION IN ESTUARIES 20
6.1 APPROACHES TO BANK EROSION MANAGEMENT 20
6.2 'SOFT' TECHNIQUES FOR BANK EROSION MANAGEMENT 21
6.2.1 Beach nourishment 22
6.2.2 Vegetation 23
6.2.3 Rip-rap revetment 25
6.2.4 Geotextile 25
6.3 'HARD' TECHNIQUES FOR BANK EROSION MANAGEMENT 27
6.3.1 Seawalls and Bulkheads 27
6.3.2 Post-supported walls 30
6.3.3 Gabions and Concrete Blocks ('retaining walls') 31
6.3.4 Revetments 32
6.4 SUMMARY OF TECHNIQUES 34
7 GUIDELINES FOR MANAGING DUNE ENVIRONMENTS 37
7.1 COASTAL DUNES 37
7.2 APPROACH TO DUNE MANAGEMENT 37
7.3 GUIDELINES FOR HUMAN ACTIVITIES IN DUNE AREAS 38
7.3.1 The use of development set-back lines in land use planning 38
7.3.2 Siting and alignment of buildings, roads and carparks 39
7.3.3 Beach access 40
7.3.4 Dune vegetation 42
7.3.5 Groundwater in dune troughs 43
7.3.6 Mining and excavation on dunes 44

7.3.7 Livestock in dune areas 44
7.4 DUNE REHABILITATION 44
7.4.1 Stabilisation of dunes 44
7.4.2 Planning 45
7.4.3 Reshaping of dunes 45
7.4.4 Dune rebuilding using dune forming materials (CCT, 2017) 46
7.4.5 Re-establishment of dune vegetation 47
7.4.6 Timing of coastal dune re-vegetation 49
7.4.7 Maintenance 50
7.4.8 Protective and other considerations 50
8 GUIDELINES FOR PHYSICAL STRUCTURES BUILT IN THE LITTORAL ACTIVE ZONE 51
8.1 APPROACH TO THE DESIGN AND SITING OF PHYSICAL STRUCTURES 51
8.2 BRIDGES 51
8.3 JETTIES & PIERS 53
8.4 MOORINGS 54
8.5 SLIPWAYS/ LAUNCHING RAMPS 55
8.6 PUBLIC AMENITIES AND SERVICES 57
8.7 STORMWATER STRUCTURES 57
8.8 NON-WATERBORNE SEWAGE DISPOSAL SYSTEMS 58
8.9 ROADS, TRACKS, PARKING AREAS AND ACCESS POINTS 60
8.10 FOOTPATHS/WALKWAYS/ACCESS PATHS (INCLUDING BOARDWALKS) 61
8.11 FENCING 65
8.12 VIEWING DECKS & HIDES 67
8.13 SIGNAGE 68
9 INFORMATION REQUIREMENTS AND EXPERT INVOLVEMENT 70
9.1 INFORMATION REQUIREMENTS 70
9.2 EXPERTISE REQUIRED 71
10 MANAGEMENT RECOMMENDATIONS FOR IMPLEMENTING AND IMPROVING THE GUIDELINES 73
11 REFERENCES 74

TABLE OF FIGURES

Figure 1: Biophysical components of the cycle of erosion and accretion in the coastal zone 12
Figure 2: Entrapment of wind-blown sand using netting, Witsands Beach (Bamford, 2016) 23
Figure 3: Revegetation of eroded habitat (UMA, 2017) 24
Figure 4: Example of soft stabilisation techniques which promote vegetation establishment, including honeycomb meshing (left) and hessian sheeting (right) (SSI, 2011) 24
Figure 5: Example of rip-rap revetment protection (source: shorelinemetrics.com) 25
Figure 6: Sand filled geotextile bags exposed by wave action 27
Figure 7: Summary guide for building new seawalls or modifying existing seawalls (DECC, 2009) 30
Figure 8: Example of a post-supported wall (VIMS, 2019) 31
Figure 9: Gabion protection for a stormwater outlet damaged by wave action 32
Figure 10: Components of a typical rock armour revetment (CIRIA, CUR, CETMEF, 2007) 33
Figure 11: Wave and wind erosion on a road, Goukamma 40
Figure 12: A graphic representation of the three dune vegetation zones (NSW DLWC, 2001) 48
Figure 13: Dune rehabilitation in progress, Stilbaai 49
Figure 14: Disturbed dune vegetation resulting from pedestrian movement 50
Figure 15: Siphofaneni Bridge, Eswatini, with minimal impact on the hydraulic properties of the river (Image: Aurecon) 53
Figure 16: Fixed jetty - Kraalbaai, Langebaan (Photo: Hendrik van den Berg) 54
Figure 17: Struisbaai harbour slipway 56
Figure 18: Seashell-lined footpath is a natural fit, and low railings prevent off-trail damage, but this requires an environmental permit 65
Figure 19: Example of a viewing deck where the surrounding dune has been eroded by wind 67
Figure 20: Interpretive signage provided at a primary access point 69

LIST OF TABLES

Table 1: Summary of the most common human-induced causes of accretion in and around estuaries 13

Table 2: Summary of the most common human induced causes of erosion in and around estuaries 14

Table 3: Advantages and disadvantages of seawalls and bulkheads 28

Table 4: Advantages and disadvantages of revetments 33

Table 5: Comparison of erosion protection and bank stabilisation techniques 35

Table 6: Plant communities found within dune vegetation (Tinley, 1985) 42

Table 7: Considerations during dune reshaping and rebuilding 45

Table 8: Common sand trapping and dune forming materials 47

Table 9: Comparison of different types of pathway surfacing 63

Table 10: Advantages and disadvantages of different types of fencing (Heinecken and Badenhorst, 1999) 66

Table 11: Data requirements for estuarine management 70

ABBREVIATIONS

amsl	Above Mean Sea Level
CML	coastal management line
CPZ	Coastal Protection Zone
DEA&DP	Department of Environmental Affairs and Development Planning
DEFF	Department of Environment, Forestry and Fisheries
DSL	Development Set-Back Line
EA	Environmental Authorisation
EFZ	Estuarine Functional Zone
EIA	Environmental Impact Assessment
EMFIS	Estuarine Management and Implementation Strategy
EWR	Ecological Water Requirements
HWM	high-water mark
IAP	Invasive Alien Plant
ICMA	National Environmental Management: Integrated Coastal Management Act (No. 24 of 2008)
IDP	Integrated Development Plans
LAZ	Littoral Active Zone
MaintMP	maintenance management plan
MEC	Member of the Executive Council
MMP	mouth management plan
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
NEMP	National Estuary Management Protocol
RMA	Responsible Management Authority
SDF	Spatial Development Frameworks

GLOSSARY

accretion	Also referred to as shoaling in estuaries, refers to the accumulation of sediment in water courses and along coastlines deposited through the same natural forces.
beach nourishment	Beach nourishment, or beach replenishment, is the process of replacing sand lost from a sandy shore due to longshore drift or erosion with material from elsewhere through mechanical means, or a combination of mechanical action and natural forces
bulkheads	Similar to seawalls but used along estuary and riverbanks to prevent slumping of the embankment and protect against light to moderate wave action
coastal management line	Means a line determined in accordance with section 25 of the ICMA, in order to protect coastal public property, private property and public safety; to protect the coastal zone; to preserve the aesthetic values of the coastal zone; or for any other reason consistent with the objects of the Act.
coastal processes	As defined by the ICMA means all natural processes continually reshaping the shoreline and near shore seabed and includes: wind action; wave action; currents; tidal action; and river flows.
coastal protection zone	As contemplated in section 16 of the ICMA, a zone established to enable the use of land that is adjacent to coastal public property or that plays a significant role in a coastal ecosystem to be managed, regulated or restricted in order to serve the purpose as intended in section 17 of the ICMA.
coastal public property	Means coastal public property referred to in section 7 of the ICMA. It includes coastal waters, the land below that water, natural islands, the sea shore, and other state land such as Admiralty Reserve. It also includes natural resources found in any of the areas mentioned above.
coastal risk	Risks specifically related to the coastline as informed by events such as coastal erosion, storm surges, sea level rise and storm wave run-up, as well as certain dynamic ecological processes such as active littoral zones (e.g. mobile dune systems).
coastal set-back line	See 'coastal management line' – ICMA terminology changed to 'coastal management line' as per the 2014 amendment.
coastal waters	As defined by the ICMA means the internal waters, territorial waters, exclusive economic zone and continental shelf of the Republic referred to in sections 3, 4, 7 and 8 of the Maritime Zones Act, 1994 (Act No.15 of 1994), respectively; and an estuary;
conservation agriculture	A farming system that promotes maintenance of a permanent soil cover, minimum soil disturbance (i.e. no tillage), and diversification of plant species.
conservancy tank	Any covered tank without an overflow which is used for the reception and temporary retention of sewage and that requires routine emptying at intervals
critical biodiversity areas	Areas demarcated through means of a systematic biodiversity planning process as ecologically sensitive enough to warrant protection from deleterious effects, and as the most efficient manner of preserving ecological functioning of the associated natural environmental system.

ecological reserve	The quantity and quality of water required: • to satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act, 1997 (Act No. 108 of 1997), for people who are now or who will, in the reasonably near future, be relying upon, taking water from, or being supplied from the relevant water resource, and • to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource.
ecological water requirements	Also referred to as Ecological Flow Requirements, quantifies the water regime (quality, quantity and timing) required to ensure the adequate functioning and future persistence of estuaries.
ecosystem services	Humankind benefits in a multitude of ways from ecosystems. These benefits are known as ecosystem services, which include: provisioning services, such as the production of food and water; regulating services, such as the control of climate and disease; supporting services, such as nutrient cycles and crop pollination; and cultural services, such as spiritual and recreational benefits.
erosion	The weathering of rocks, removal of beach or dune sediment as a result of wave action, tidal currents or drainage"
estuarine functional zone	This includes the estuarine open water area, estuarine habitat (sand and mudflats, rock and plant communities) and floodplain area. The 2018 National Biodiversity Assessment has demarcated estuarine functional zones for all estuaries, but these demarcations should be verified on-site whenever high resolution determinations are necessary.
estuary	As defined by the ICMA means a body of surface water — (a) that is permanently or periodically open to the sea; (b) in which a rise and fall of the water level as a result of the tides is measurable at spring tides when the body of surface water is open to the sea; or (c) in respect of which the salinity is higher than fresh water as a result of the influence of the sea, and where there is a salinity gradient between the tidal reach and the mouth of the body of surface water.
gabion	Sand bag or rock-filled wire mesh baskets used in retaining wall construction
geotextile	Permeable textile made of natural or synthetic fibre, used with foundation, soil, rock, earth, or any other geotechnical engineering related material to stabilise structures or act as sediment trap
high-water mark	As defined by the ICMA means the highest line reached by coastal waters, but excluding any line reached as a result of (a) exceptional or abnormal weather or sea conditions; or (b) an estuary being closed to the sea.
jetty	Jetties are considered simpler structures than piers, commonly constructed of wood and/or steel, and largely sacrificial in nature. Jetties may be anchored to the river or estuary bed, or floating from a secured shore-based point
littoral active zone	As defined by the ICMA means any land forming part of, or adjacent to, the seashore that is: unstable and dynamic as a result of natural processes; and characterised by dunes, beaches, sand bars and other landforms composed of unconsolidated sand, pebbles or other such material which is either un-vegetated or only partially vegetated.
mooring	An anchored or freestanding mooring is a stationary device used for attaching a boat, ship, floating structure or other watercraft. This includes mooring buoys, buoyed anchors and pilings that are not part of a formal marina or port.

pier	Piers are considered to be large-scale structures of major capital investment, constructed using massive volumes of concrete and steel, and requiring significant foundations.
pit toilet	A hole in the ground, which may be unlined or lined, with a reinforcing material to contain human excreta; often fitted at the surface with a toilet seat, ventilation pipe and shelter or enclosure.
post-supported walls	A type of bulkhead that comprise treated hardwood posts supporting a facing material, forming a retaining wall.
reno mattress	Flat profile gabion used to line water channels, dissipate flow and prevent erosion from turbulence
revetment	An engineered sloping structure used to absorb wave energy and placed in such a way as to preserve the existing shape and use of the shoreline, while protecting the slope
rip-rap	A term used for naturalised revetment comprising loose rocks placed on a bank slope
sea level rise	A rise in mean sea level as a consequence of global climate change, and driven by the melting of glaciers and ice sheets, the expansion of ocean volume through temperature rise and changes to the amount of water stored on land.
seashore	The area between the Low-Water Mark and the High-Water Mark, except where determined otherwise under section 26 of ICMA.
seawalls	Large structures used along the seashore to resist intense wave action
septic tank	A buried holding tank for the purpose of collection, storage and, to some degree, treatment of sewage
soak away	A soak away, also known as a percolation trench, is an underground soil treatment system, which receives partially treated sewage from the septic tank
Sustainable Urban Drainage Systems (SUDS)	SUDS are an alternative approach to stormwater management that promote more natural drainage of run-off from developed areas and which are also designed to promote ecosystem services ("working with natural processes").

1 INTRODUCTION

Coastlines are highly desirable locations for human settlement due to the socio-economic benefits derived from the diversity of natural resources, distinctive aesthetic appeal and attractiveness for recreational activities. Because of this appeal more and more communities and expanding development are interacting with the coastal zone, placing sensitive, vulnerable, often highly dynamic ecosystems under pressure.

Moreover, a lack of understanding of the complexity of coastal processes operating in the Littoral Active Zone (LAZ), together with poorly planned development and exceedance of ecological carrying capacities, results not only in continuous degradation of the natural environment, but also exposes coastal communities to an ever-increasing level of risk.

The LAZ constitutes the portion of the coastal environment that is unstable and highly dynamic, exhibiting significant change in coastal landforms and features as a result of natural processes, specifically accretion and erosion driven by river flow, waves, tidal action and wind. These processes are intensified during natural disasters but are also being altered by human interference and the impacts of global climate change.

It is against this backdrop that guidelines are required in respect to coping with dynamic coastal processes, specifically erosion and accretion, and key considerations when constructing structures in the LAZ. In the context of the Western Cape Estuarine Management and Implementation Strategy (EMFIS), these guidelines are aimed primarily at the estuarine environment, however, there are areas of overlap with rivers, beaches, and dunes, where oftentimes, the same precautionary principles will apply.

2 WHAT IS THE LITTORAL ACTIVE ZONE?

According to the National Environmental Management: Integrated Coastal Management Act (Act No. 24 of 2008) (ICMA), the LAZ is defined as *"any land forming part of, or adjacent to, the seashore that is -*

a) unstable and dynamic as a result of natural processes; and
b) characterised by dunes, beaches, sand bars and other landforms composed of unconsolidated sand, pebbles or other such material, which is either unvegetated or only partially vegetated."

The above definition does not clearly state the applicability of the LAZ to estuaries. However, the seashore is understood to be the "*area between the low-water mark and the high-water mark (HWM)*", which in turn is the highest line reached by coastal waters, which by definition includes estuaries (but excluding closed estuaries).

An estuary is defined by ICMA as *"a body of surface water -*

a) that is permanently or periodically open to the sea;
b) in which a rise and fall of the water level as a result of the tides is measurable at spring tides when the body of surface water is open to the sea; or
c) in respect of which the salinity is higher than fresh water as a result of the influence of the sea, and where there is a salinity gradient between the tidal reach and the mouth of the body of surface water".

Further to the above, the estuarine functional zone (EFZ) incorporates estuarine open water area, estuarine habitat (such as sand and mudflats, rock and plant communities) and the floodplain area. Essentially, the EFZ encapsulates the most dynamic areas of an estuary that are influenced by long-term estuarine sediment processes, such as deposition and erosion during floods, changes in channel configuration, transport processes governed by wind and changes due to coastal storms (Van Niekerk and Turpie, 2012). The whole EFZ should be considered for the purposes of estuarine management, as estuarine health and functioning depends on the interplay between the terrestrial, freshwater and marine components present in estuaries.

Box 1: Additional definitions from the Integrated Coastal Management Act (No. 24 of 2008)

"seashore", subject to section 26, means the area between the low-water mark and the high-water mark;

"high-water mark" means the highest line reached by coastal waters, but excluding any line reached as a result of—

(a) exceptional or abnormal weather or sea conditions; or
(b) an estuary being closed to the sea.

"coastal waters" means -

a) the internal waters, territorial waters, exclusive economic zone and continental shelf of the Republic referred to in sections 3, 4, 7 and 8 of the Maritime Zones Act, 1994 (Act No.15 of 1994), respectively; and
b) an estuary.

Prior to the 2018 National Biodiversity Assessment (NBA)(SANBI, 2019), the 5 m contour above mean sea level was used in many cases as a proxy for the EFZ, as defined by the 2014 Environmental Impact (EIA) Regulations (as amended in 2017) (GN 324). However, boundaries of the EFZ for all estuaries in South Africa have since been proposed in the 2018 NBA. It is important to note that the LAZ adjacent to an estuary can stretch beyond the 5 m contour, and such areas should therefore be incorporated into the EFZ in site-specific cases (Van Niekerk and Turpie, 2012).

To this end, the LAZ in the context of estuaries includes not only dunes, beaches, and sand bars on the sea front, for example at the mouth of an estuary, but also extends upstream into the estuary when it is open into areas that are subject to tidal fluctuations, and/or the upstream margin of the EFZ.

3 COASTAL ZONATION AND DEVELOPMENT MANAGEMENT

3.1 National Environmental Management: Integrated Coastal Management Act

The ICMA emanates from the White Paper for Sustainable Coastal Development in South Africa, 2000, and inter alia, establishes a system of integrated coastal and estuarine management. The enactment and subsequent enforcement of this landmark legislation firmly establishes integrated coastal management as the preferred vehicle for the promotion of sustainable coastal development in South Africa. This is promoted through directives in terms of the conservation and maintenance of the natural attributes of the coastal environment concomitant with development that is sustainable as well as socially and economically justifiable. It defines the rights and responsibilities of all coastal stakeholders, including those of organs of State, and gives effect to South Africa's international responsibilities in respect to coastal pollution. The ICMA aims to facilitate the implementation of the principles and guidelines presented by the White Paper and has a number of objectives including:

- The provision of a legal and administrative framework to promote cooperative, coordinated and integrated coastal management;
- The protection of the natural coastal environment as a national heritage;
- The management of coastal resources in the interests of the whole community;
- The promotion of equitable access to the resources and benefits provided by the coast; and
- The fulfilment of South Africa's obligations under international law.

The ICMA requires that activities that are potentially harmful to the coastal zone are considered as part of the NEMA EIA processes. The competent authority needs to consider, amongst others:

- If coastal public property, coastal access land or the coastal protection zone will be affected by the proposed action;
- Estuarine management plans, Coastal Management Programmes, coastal management lines and coastal management objectives;
- The socio-economic impact if that activity or action is authorised or not authorised;
- The likely effect of dynamic coastal processes (such as wave, current and wind action, erosion, accretion, sea-level rise, storm surges and flooding) on the activity; and
- Whether the development of activity is likely to cause irreversible or long-lasting adverse effects on the coastal environment that cannot be properly mitigated; will prejudice the achievement of any coastal management objective; or will not be in the interests of the community as a whole.

3.2 Coastal Protection Zone and Coastal Management Lines

The ICMA defines a default Coastal Protection Zone (CPZ) which, in essence, consists of a continuous strip of land, starting from the HWM and extending 100 m inland in developed urban areas zoned as residential, commercial, or public open space, or 1 000 m inland in areas that remain undeveloped or that are commonly referred to as rural areas. It also includes certain sensitive or at-risk land such as estuaries, littoral active zones and protected areas.

The Provincial Member of the Executive Council (MEC), in consultation with the Local Municipalities, is required to refine and formally adopt the CPZ. A process is currently underway to formally establish a CPZ for the Western Cape Coastline. In accordance with provisional delineation of the CPZ for estuaries, as per draft delineations recommended in the Coastal Set-back / Management Lines for the Eden (DEADP, 2018) and West Coast (DEADP, 2014) District projects, the CPZ is informed by a coastal risks zone approximated by the 10 m Above Mean Sea Level (amsl) contour, either the EFZ or 1:100-year floodline around an estuary, or, in urban areas, the lowest property boundaries still above the HWM.

The ICMA also provides for the establishment of a Coastal Management Line (CML), designed to limit development in ecologically sensitive or vulnerable areas, or an area where dynamic natural processes pose a hazard or risk to humans. In the Western Cape, CMLs are informed by projections of risk emanating from dynamic coastal processes such as sea level rise or erosion, information on ecological or other sensitivities adjacent to the coast, as well as the location and extent of existing development and existing executable development rights. The CML is a continuous line, seawards of which lies:

- Areas of biophysical or social sensitivities such as sensitive coastal vegetation identified as priority conservation areas and formal protected areas,
- those areas that should be left undeveloped, or only be granted appropriately restricted development rights, due to a high risk from dynamic coastal processes, or
- coastal public property.

In respect of the EIA regulatory scheme, an additional line called the Development Set-Back Line (DSL) is differentiated from the CML, as it relates to the 'development set-back' referred to in the EIA regulations[1] rather than the coastal management lines described in the ICMA. Reference to the development set-backs is found in the EIA Listing Notices. In some cases, a DSL is used as spatial reference to include or exclude activities. The EIA regulations indicate that: *"development setback" means a setback line defined or adopted by the competent authority"*. This implies that if such a setback is defined, the setback delineation replaces the default parameters for an activity, as read within the context of that activity. The competent authority in the Western Cape is Department of

[1] The Environmental Impact Assessment Regulations, 2014 (as amended in 2017), published under Government Notice No. 326 in Gazette No. 40772 of 4 April 2017, in terms of sections 24(5) and 44 of the National Environmental Management Act, 1998 (Act No. 107 of 1998)

Environmental Affairs and Development Planning (DEA&DP) or the National Department of Environment, Forestry and Fisheries (DEFF).

The EIA regulations also refer to whether a development is in front or behind the line – for a coastal development set-back this equates to any development seaward of the line being 'in front of', whilst landward of the line being 'behind'.

An important further point to note is that the development set-backs are usually linked to the presence of urban built-up areas. The regulations indicate that "*"urban areas" means areas situated within the urban edge (as defined or adopted by the competent authority), or in instances where no urban edge or boundary has been defined or adopted, it refers to areas situated within the edge of built-up areas*". These exclusion areas create *de facto* islands in the area below the DSL, within which the specifically excluded EIA triggers don't apply.

The Western Cape Government, as designated competent authority, considers the area below/seaward of the adopted urban edge as falling outside of the 'built-up area'. Therefore, any exclusions based on a listed activity taking place within the built-up area would not apply to this strip of coastal land, and the prescriptions for environmental assessments related to the particular activity will apply. For example, the beach in front of seafront houses is not considered 'built-up' and environmental authorisations will be required to execute any listed activities on that beach.

3.3 Regulation of activities falling below the High-Water Mark

As indicated, the HWM is defined in ICMA as the highest line reached by the coastal waters, but does not include any line reached as a result of abnormal weather or sea conditions or in estuaries that are closed to the sea. The position of the HWM is relevant to landowners and other users of coastal public property (which is defined to include an estuary) because the boundaries of the various components of the coastal zone, as defined by the ICMA, are created in relation to the HWM[2]. Due to dynamic natural processes such as erosion and accretion, the position of the HWM is not static or accurate over extended time periods. In light of this natural process, no person may replace the HWM curvilinear boundary with a straight-line boundary in terms of section 34 of the Land Survey Act[3].

Section 15 of ICMA provides that where the HWM shifts landward of a coastal property boundary (as a result of processes such as erosion and sea level rise), the owner of the coastal land bounded by the HWM loses ownership rights of any coastal land that falls below that mark, such that it becomes coastal public property. Simply put, any land submerged by coastal waters forms part of the coastal public property. As such, the 'seaward' boundary of any property that is adjacent to an estuary will be the HWM, regardless of the boundaries indicated on the relevant Surveyor-General diagram, unless the property owner proves that such land was legally alienated before date of effect of the

[2] Section 1 of ICMA

[3] Section 14 of ICMA

Sea-Shore Act, 1935 (Act No. 21 of 1935). Landowners who lose ownership of land will not be entitled to compensation unless the change in position of the HWM was the result of an intentional or negligent act or omission by an organ of state, and it was a reasonably foreseeable outcome (DEA, 2017).

Furthermore, ICMA and the National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998) and its regulations (especially the EIA regulations, 2014[4]) regulate any acts or physical response to erosion or accretion on coastal public property. No person may construct, maintain or extend any structure, or take any other measures to prevent or promote erosion or accretion of the seashore in respect to coastal public property, except in accordance with these statutes. Neither may any person compel or require the State, or other person to take such action, unless the erosion is caused by an intentional act or omission of that organ of state or other person[5].

3.4 Environmental Impact Assessments

Specifically, the erection of structures below the HWM of the sea (including in estuaries) that falls within thresholds listed, needs to obtain Environmental Authorisation (EA) in terms of the EIA regulations prior to commencement. Applications must be made to the applicable competent authority according to the application procedure set out by them. Generally, the competent authority in the Western Cape is DEA&DP, but DEFF will be the competent authority in certain instances, for example, where the applicant is a national department (s24C(2)(d)(i) of NEMA) or where the activity will take place with a national proclaimed protected area (s24C(2)(e) of NEMA)). During the application review process, CapeNature is normally approached for comment.

Some activities that require authorisation, with specific reference to development in and around estuaries, are:

- The development of infrastructure or structures with a physical footprint of 100 square metres or more (Listing Notice 1, Activity 12)
- The development of structures in the coastal public property (Listing Notice 1, Activities 15 and 17; Listing Notice 2, Activities 14 and 26; Listing Notice 3, Activities 14 and 23):
    - fixed or floating jetties and slipways;
    - tidal pools;
    - embankments;
    - rock revetments or stabilising structures including stabilising walls; or
    - where the development footprint is bigger than 50 m^2
- The planting of vegetation or placing of any material on dunes or exposed sand surfaces of more than 10m^2, within the littoral active zone, for the purpose of

[4] Regulations published under Government Notice R982 in Gazette No. 3822 of 4 December 2014, in terms of sections 24(5) and 44 of NEMA, as amended in 2017

[5] Section 15(2) of ICMA

preventing the free movement of sand, erosion or accretion, excluding where (Listing Notice 1, Activity 18) —

  - the planting of vegetation or placement of material relates to restoration and maintenance of indigenous coastal vegetation undertaken in accordance with a maintenance management plan; or
  - such planting of vegetation or placing of material will occur behind a development setback.

- Infilling or depositing of any material of more than 5 cubic metres into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock of more than 5 cubic metres from an estuary (Listing Notice 1, Activities 19 and 19A)
- Clearing of indigenous vegetation, especially large areas and on properties zones for open space functions ((Listing Notice 1, Activity 27; Listing Notice 2, Activity 15; Listing Notice 3, Activity 12)

Note that the trigger thresholds are lowered where sensitive habitat or biodiversity is present.

4 IMPLICATIONS FOR LOCAL GOVERNMENT

DEA&DP, together with CapeNature, play a leading role in coordinated planning, implementation and management of estuaries in the Western Cape. This includes:

- Taking the lead in ensuring coordinated planning, implementation and management of estuaries in the Western Cape;
- Continuing to provide technical support to Responsible Management Authorities (RMAs) and municipalities in developing EMPs;
- Supporting DEFF where regulatory reform is required; and
- Working towards the allocation of adequate funding for estuarine management at national level.

However, local government has an important role to play in the management of estuaries within their municipal boundaries, given that they often have closer involvement with the activities that happen in and around estuaries than other spheres of government. In addition, the National Estuary Management Protocol (NEMP) highlights the fact that it is often the local community that benefits the most from the goods and services provided by estuaries.

Various Local Government functions/roles and responsibilities highlighted in both the Constitution (listed in Part B of Schedules 4 and 5) and the ICMA are believed to find application within estuarine and coastal management. Within the broader context of integrated coastal management, the following are examples of key areas that necessitate the involvement of local government:

- Administration of a wide range of infrastructure within the coastal zone
- Regulation of land-based activities that impact on the coastal zone (e.g. in terms of by-laws)
- Regulation and management of coastal recreation (e.g. in terms of by-laws)
- Estuary management
- Coastal dune management
- Regulation of development in the coastal zone
- Compliance and implementation of all applicable national legislation as it relates to the coast
- Enforcement of coastal legislation
- Integration of coastal management in Integrated Development Plans (IDP) and Spatial Development Frameworks (SDF)
- Developing and preparing planning approval guidelines for development proposals within the coastal zone
- Public Launch Site management and operation

The control or prevention of development around estuaries, as well as management of estuary erosion and sedimentation, at least in part, is therefore also a municipal responsibility.

While Responsible Management Authorities (RMAs) are provided for in the NEMP, and tasked with overall coordination of estuarine management plans (EMPs), the implementation of EMPs includes the implementation of functions attached to all spheres of government, including local government.

4.1 General principles for development within the LAZ

Repairing or reinstating development or structures in the LAZ following damage from coastal processes, oftentimes place significant financial burden on municipalities. It is against this backdrop that development in the LAZ includes not only urban development, the associated infrastructure and desired coastal amenities, but also structures erected to protect such development and coastal communities from risks inherent to the LAZ.

The following general principles, applicable to beaches, dunes and estuaries, are to be used as fundamental decision-making informants, and employed as measures to reduce uncertainty and unanticipated consequences:

- The shoreline must be treated as a dynamic system and sand should be allowed to move freely within and across the different systems of the LAZ without interference
- A development set-back line / coastal management line taking the future effects of climate change into consideration must be determined / implemented and no development should be allowed within the set-back area (especially frontal dune area and on beaches)
- The functioning of each beach, dune and estuarine system must be determined before making any new development or management proposals
- In estuaries, any activity that reduces or restricts tidal action in a normally tidal system, or interferes with the state of the mouth in temporarily open/closed systems, should be discouraged as this interferes with the natural functioning and ecology of the estuary
- Wherever it is permissible in terms of ICMA or duly authorised by the competent authorities, hidden structures or soft solutions such as sand nourishment should be used rather than obvious hard solutions, such as revetments or seawalls/bulkheads, to solve beach erosion problems
- If a storm has drastically altered a beach, it is best to wait for the natural sediment cycle to run its course, as sand will likely be returned to the beach
- Use the best expertise available and relevant to the nature of the project, such as coastal engineer, coastal geomorphologist, and dune rehabilitation specialist, etc. See section 9.
- Interventions must be monitored on a regular basis, and performance measured against set targets for technical, environmental and social outcomes. Any deviation from the defined outcomes must be used to inform an on-going process of refinement and adjustment

5 GUIDELINES FOR MANAGING EROSION AND ACCRETION IN ESTUARIES

5.1 Processes of Erosion and Accretion

Erosion and accretion are natural processes working synergistically that characterise the natural dynamics of the LAZ, a single sediment system, wherein there is a continuous exchange of sediment between beaches, dunes, river mouth/estuaries and the surfzone sandbars (Figure 1). Coastal erosion can be defined as "*the weathering of rocks, removal of beach or dune sediment as a result of wave action, tidal currents or drainage*" (www.coastkzn.co.za). In contrast, accretion (also referred to as shoaling in estuaries) refers to *the accumulation of sediment in water courses and along coastlines deposited through the same natural forces*.

In natural circumstances, any dune, beach or estuary mouth area is in a state of natural dynamic equilibrium, meaning that although short-term cyclical changes, such as erosion and accretion, do take place, the erosion of sand is relatively balanced by the accumulation of sand in the long-term (Tinley, 1985; Heinecken and Badenhorst, 1999). McGwynne *et al.* (1996) refers to the constant exchange of sand within the LAZ as a self-regulating mechanism of coastal protection and preservation. Dunes dissipate storm wave energy and reduce the impact of onshore gale force winds (McGwynne *et al.*, 1996), while also functioning as natural sand reservoirs for the coastline. Sand trapped in the dune system is stored and returned to the beach, thus preventing beach erosion (Heinecken and Badenhorst, 1999) (Figure 1).

In the context of estuarine environments, sedimentation is a continual natural process (Tinley, 1985). Sediment eroded throughout the catchment is deposited within the estuarine system, while Aeolian (wind-blown) and marine sediment is transported into the mouth and lower reaches. The natural removal of sediment occurs as a result of the erosive forces of outflowing river water, as well as the erosive forces associated with tidal ebb and flow currents and wave activity through the mouth (Beck, 2005). Erosive forces are greater during spring tide periods under normal conditions and greatest during extreme weather events, such as floods and marine storm surges (Heinecken and Badenhorst, 1999; Beck, 2005).

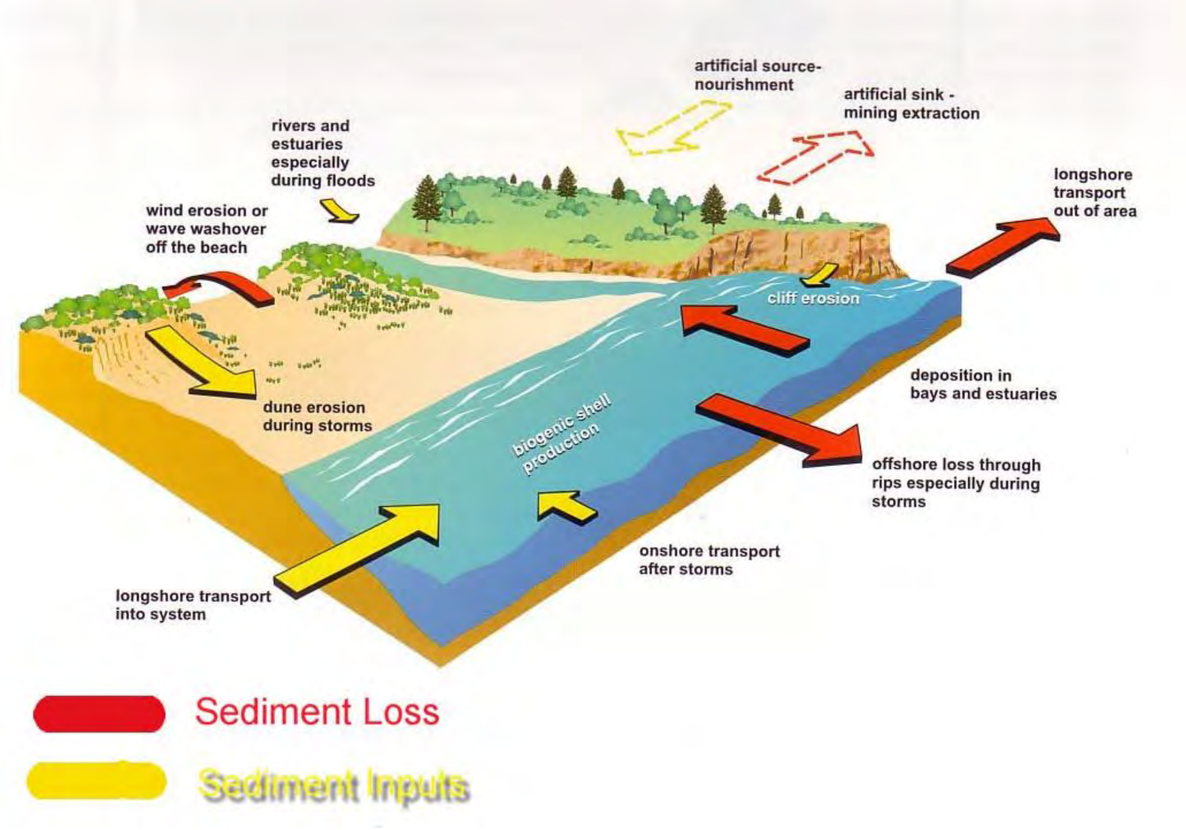

Figure 1: Biophysical components of the cycle of erosion and accretion in the coastal zone[6]

The dynamics of these key coastal processes have been, and continue to be, altered by human impacts, as well as by impacts related to climate change(Bell, R., Green, M., Hume and Gorman, 2000; James and Hermes, 2011). For example, sandwinning in rivers and estuaries removes vital sediment resources that normally build up beaches and dunes along the coast, thus resulting in shoreline erosion (Tinley, 1985); stabilisation of an estuary mouth to prevent the inundation of low-lying development and croplands critically affects the natural functioning of the estuary (Heinecken and Badenhorst, 1999); and stabilisation of dunes to prevent encroachment into urban areas can contribute to severe beach erosion after storm surges, as sand is made unavailable for beach replenishment (McLachlan *et al.*, 1994; Heinecken and Badenhorst, 1999). By disturbing or interfering with the movement of sediment, new erosion and accretion processes start establishing a new equilibrium (Heinecken and Badenhorst, 1999). It is also evident from the above that disturbing the natural processes of one of the components of the LAZ often affects the others because of their complex interconnectivities (McLachlan *et al.*, 1994; McGwynne *et al.*, 1996; Heinecken and Badenhorst, 1999).

From a risk perspective, the LAZ is highly malleable and continually changing (McGwynne *et al.*, 1996). Any development within the LAZ is therefore subject to the changeability and impacts of the coastal processes. The consequences of inappropriate development

[6] Image Source: http://www.mrstevennewman.com/geo/Stockton/Biophysical_Interactions/Main.htm

include *inter alia*, damage to coastal amenities (e.g. carparks), resorts, houses and commercial premises, transport infrastructure (e.g. roads and rail) and potential risk to human health and safety (Council for the Environment, 1991). Any strategies aimed at managing the negative impacts of erosion and accretion on coastal developments and communities will need to be maintained and/or reapplied on an ongoing basis.

5.2 Human factors influencing erosion and accretion

In the dynamic LAZ, the processes of erosion and accretion are always active. The relative balance between the two processes is, however, determined by the dominant driving forces at a particular point in time. These drivers can be natural (e.g. seasonal) or due to human interaction (e.g. obstructions to sediment movement). Whereas in an undisturbed system a natural long-term dynamic equilibrium is present, erosion and accretion in estuaries with human presence are closely tied to human disturbance and can be accelerated or impeded. It is consequently necessary to understand how human activities influence erosion and accretion, if we are to manage the root causes of imbalance in estuarine systems that can threaten their overall health and ecological functioning.

Table 1 and Table 2 list the most common human activity-linked causes of accretion (sedimentation) and erosion in and around estuaries. In respect of estuarine management, these are the activities that need to be addressed first, should accretion and erosion become problematic or hazardous.

Table 1: Summary of the most common human-induced causes of accretion in and around estuaries

Poor agricultural practices	Deposition of sediment eroded through aggressive upstream tillage-based cultivation practices (Le Roux and Smith, 2014)
Dam release	Deposition of sediment eroded from the channel and banks of watercourses immediately downstream of dams
Overabstraction of water	Overabstraction of water for potable and agricultural use that reduces the volume and/or the velocity of water reaching the estuary
Artificial breaching of estuary mouths	Inappropriate artificial breaching reduces the flushing efficiency of an estuary. This ultimately leads to increased sediment build-up over time. The system then requires regular and larger flood events to effectively remove sediment naturally.
Verdant growth of marginal vegetation	Accelerated growth of marginal vegetation due to increased nutrients and persistent freshwater conditions leads to entrapment of sediment and rising bed levels
Poorly designed and poorly sited development	Development / fixed structures constructed within highly mobile sand areas (e.g. mobile dune fields, natural sand bypasses, prograding beaches), essentially function as barriers to natural sediment movement and will thus incur sand accretion on the updrift side

Erosion protection/ bank stabilisation	Purpose-built structures to protect areas subject to erosion may exceed the required function of sediment entrapment, or cause secondary accretion, resulting in large scale accretion extending beyond the desired area.

Table 2: Summary of the most common human induced causes of erosion in and around estuaries

Dam release	Instream dams trap sediment, reducing the sand input to the LAZ, and rendering it vulnerable to erosion. In addition, the water released below the dam has excess transport capacity and is termed 'hungry water', as it is devoid of sediment. This results in channel and bank erosion downstream of the dam (Wampler, 2012).
Poor agricultural practices	Aggressive tillage-based cultivation practices, especially on erodible soils during peak rainfall events and on steeper, longer slopes, leads to intensified erosion. The removal of natural vegetation in favour of crop cultivation leaves riverine and estuarine banks exposed, increasing the risk of erosion through river flow or surface runoff (Le Roux and Smith, 2014).
Livestock grazing	Unchecked livestock grazing renders the same impacts as surface water erosion over disturbed areas. Livestock also trample riverine and estuarine banks, often leading to damage and erodible areas.
Deforestation and other land clearing activities	Removal of vegetation, and clearing or reshaping of land for development increases the risk of erosion and removal by surface runoff
Poorly managed stormwater runoff	In the absence of flow attenuation structures, stormwater runoff has the potential to cause significant erosion during storm peaks and low flow conditions. Concentrated stormwater flow creates headcuts in embankments which worsen over time resulting in large-scale bank erosion.
Inappropriate control of Invasive Alien Plant species (IAPs)	Physical removal of IAPs from riparian areas and estuarine banks, without immediate rehabilitation or bank protection in place, leaves the banks exposed, increasing the risk of erosion
Poorly designed and poorly sited development	Inappropriate development in the flood plain or on the riparian or estuarine edge can impede or create a diversion flow, often resulting in concentrated flow or reflected flow elsewhere, thereby intensifying erosion in these areas
Sand mining	Disturbance/ destabilisation of the riparian/ estuarine banks and physical agitation and mobilisation of sediment increases erosion risk in the areas of operation

Boat wake	Boat wake typically generated by recreational speed boats, commercial boats and jetskis results in erosion along the riverine or estuarine shoreline, particularly where vegetation is sparse or absent

5.3 Guidelines for management of erosion and accretion in estuaries

The need to manage erosion and accretion in estuaries typically relates to specific land use and development practices and activities. It is therefore possible to define good management practices that can contribute to a restoration of an appropriate erosion/accretion balance.

5.3.1 Land-use planning adjacent to and in the estuarine functional zone

- The dynamic nature of estuaries and the broader LAZ must be taken into account in land-use planning. This includes planning for the natural meandering and/or migration of the estuary channel and mouth, riparian flooding, tidal surges and sea storm events, as well as the long-term natural processes of erosion and accretion in the coastal zone.
- Where possible, Critical Biodiversity Areas and priority Ecological Support Areas, as well as remaining natural ecosystems, particularly forests, riparian margins and dune systems, should be preserved. These natural units holistically provide protection against extreme events (natural disasters) and associated erosion.
- Any proposed development on a coastline (e.g. breakwaters, piers, jetties, intake infrastructure) has the potential to negatively affect natural processes and patterns of accretion or erosion in an estuary, and must therefore be assessed in detail by a coastal specialist and approved by the mandated authority, with thorough oversight from the RMA for the estuary.
- Unless essential, no new development should be approved to take place in the EFZ or the highly dynamic LAZ.
- Development must take cognisance of any adopted CML and the applicable controls, and/or coastal risk lines where high risk areas are identified. Avoiding development in at-risk or sensitive areas will help to maintain the ecological integrity of the estuarine environment, prevent disruption of the natural coastal processes, maintain the aesthetic quality and ultimately protect coastal development.
- The capacity of the estuary and/or river to accommodate recreational pressure generated by shoreline development should be taken into account in determining the nature and scale of development adjacent to estuaries.
- Beach nourishment projects must not be permitted in close proximity to estuaries, so that the mobilised sediment does not result in deposition at the estuary mouth. Where this not possible, structures such as training walls designed to reduce the effects of accretion, should be investigated.
- Unless unavoidable, there should be a planned process of retreat for developments that have been demolished or are in state of disrepair due to natural hazards or man-

made causes (apart from coastal appropriate development, such as desalination plant, and sacrificial amenities such as lifeguard buildings).

- Disturbance of vegetation in identified natural buffer areas must be kept to a minimum. Clearing of large tracts of natural vegetation in these areas should be prohibited and would likely require specific permitting.
- Major transport routes such as roads, highways and railway lines, as well as other linear infrastructure such as pipelines and powerlines, should avoid estuarine areas. These developments interfere with natural tidal flow and groundwater movement. Roads should be located inland of estuaries, with separate access roads aligned perpendicular to the coast leading to the sea.

5.3.2 Natural patterns of water flow and drainage

- The Ecological Water Requirements (EWR) for a specific river and estuary must be implemented to ensure sustained base-flow to estuaries.
- Where dams are situated in the catchment, releases from dams must be scheduled in accordance with the EWR, coinciding with natural seasonal flow peaks and volumes to reproduce natural scour of accumulated sediment in estuaries.
- All water abstraction must be licensed and monitored according to the EWR for both the river and the estuary.
- The development of any new in-stream or off-stream dams or other impoundment (e.g. weirs) must receive the highest scrutiny and must obtain all relevant environmental authorisations and permits, based on an assessment of the full extent of potential negative impacts. Downstream stakeholders and users, including estuaries, must be accounted for.
- All activities which alter natural water levels and flow patterns within the EFZ and wetlands should be avoided. These include draining of wet areas by excavating ditches or canals, and the building of embankments or levees which interfere with water flow within the floodplain or wetland area.
- IAPs must be controlled in the catchment and the EFZ, as they withdraw significant volumes of water from natural flow patterns, amongst other negative impacts.
- Where existing structures in watercourses and the EFZ, such as jetties, are no longer in use or damaged beyond repair, they should be removed.

5.3.3 Estuary mouth manipulation

- Manipulation of estuary mouths must not become common practice – in most cases mouth management cannot address the causes of estuarine problems. Instead, issues must be addressed at their source.
- Mouth manipulation, dredging or locating a structure which interfere with water flow will artificially alter the water level and flow in an estuary, sometimes with disastrous consequences. It will also have significant short and long-term impacts on the ecology of the estuary. An estuarine expert must be employed to develop a mouth management plan (MMP) and maintenance management plan (MaintMP) before any mouth manipulation is undertaken.

- Artificial breaching must not be permitted without the appropriate environmental permits and in accordance with an approved MMP and MaintMP. The MMP must satisfy the requirements of the relevant authority.

5.3.4 New development

- No new development should be approved to take place in the EFZ or the highly dynamic LAZ, unless consideration of the need and desirability of the development in the context of the coastline and estuarine environment shows that it is essential that the development proceeds.
- If the nature of the development does not require that it be placed within the EFZ, then an alternative location must be sought. Where no location alternatives are possible and the development needs to occur within the EFZ or the broader LAZ, an EIA must be conducted to identify and mitigate impacts, and an EA obtained where necessary. This must take place with thorough oversight from the RMA for the estuary.
- Any newly approved developments within the EFZ or LAZ should be constructed in the most sustainable manner using the appropriate materials, environmental best practice and according to the controls associated with any CMLs.
- The design of bridges over estuaries and wetlands should impart the least amount of resistance to flow and circulation, and not interfere with the natural patterns of erosion and sedimentation.
- Proposed engineering works that alter circulation patterns, such as jetties and piers, should be designed to minimize or prevent both erosion and deposition in estuaries and wetlands. The structural design will therefore be determined by the specific local circumstances. A qualified specialist must be employed to carry out the design and construction of such structures in the LAZ.
- Where structures such as roads and bridges must impinge on wetlands, it is important to minimise the encroachments of abutments or fill areas.
- Where possible, new developments near rivers should be constructed in the dry months to reduce sediment-laden runoff entering the river and subsequently leading to sedimentation in the estuary.
- Existing housing developments in the EFZ should be given landscaping assistance to reduce erosion of sediment into the estuary; this could include the maintaining of a riparian buffer, increasing ground cover and stormwater management.

5.3.5 Sand mining and dredging

- Sand mining is regulated by the Mineral and Petroleum Resources Development Act (Act No. 28 of 2002) administered by the Department of Mineral Resources and Energy.
- Dredging in respect to harbours and marinas is regulated by the National Port Act (Act No. 12 of 2005) administered by the National Ports Authority. It is also an EIA listed activity, and likely to require a Coastal Waters Discharge Permit and Water Use Licence.
- Both sand mining and dredging have significant physical, chemical and biological impacts on rivers and estuaries. Thus, these activities must be regulated for their direct impacts but also impacts on the components of the LAZ. Impacts to be considered include (Coastwatch KZN, no date):

- Macro impacts:
  - Impacts on resources in respect to nursery habitats provided by estuaries;
  - Water quality;
  - Tourism potential and safety factors;
  - Saline intrusion leading to potential contamination of drinking water and/or contamination of water for both agricultural and goods and services purposes;
  - Potential impact of global warming;
  - Exponential increase of erosion and accelerated erosion of banks;
  - Impacts on sedimentation and accelerated deposition of mud; and
  - Compaction of seasonal habitat.
- Micro impacts related specifically to potential changes to the nature of sediment:
  - Stability of sediment and the impact on organisms and on types of organisms (habitat diversity/type);
  - The destabilising and select removal of certain particle sizes; and
  - Increase in fine material in suspension affecting turbidity and affecting light penetration.
- Direct physical impacts:
  - Erosion on banks;
  - Direct habitat destruction;
  - Potential for oil/fuel spills;
  - Creates a path for alien vegetation to take over riparian areas;
  - Destroys riparian vegetation and refuge areas; and
  - Impacts stability as banks become unconsolidated.
- Social impacts:
  - Reduction in free goods and services (Drinking water; Food security; Fishing etc);
  - Reduced tourism potential; and
  - Pollution as a result of dust and noise and no/limited ablution facilities.

- As required by law, and where necessary as best practice, assessment must be undertaken by a qualified coastal specialist to determine the impact of sediment removal and movement on the sediment budget of the local LAZ.

5.3.6 Access to river and estuary margins

- Access to river and estuary margins should be managed in accordance with the ICMA principle of providing reasonable access to the coastal public property, but with the view to preventing trampling and habitat destruction by animals, people, vehicles and watercraft.
- Access must be strictly controlled or closed off in areas that have become degraded or highly eroded. This also applies to beaching and mooring of watercraft.
- Wetlands should be designated as ‘no-go’ areas to all vehicles. Wetlands play a significant role in the entrapment of sediment and removal of contaminants from the water column. Access roads through wetlands and the use of off-road vehicles in wetlands should be prohibited.

- The control and use of vehicles in the coastal area is defined in the 'Outdoor Recreational Vehicle Regulations' (Regulations in terms of The National Environmental Management Act, 1998: Control of Vehicles in the Coastal Zone Government Gazette 22960, 21 December 2001). The regulated area includes the LAZ and an area up to 500 m inland of the HWM where dunes, wetlands, salt marshes, mud flats, salt pans occur.

5.3.7 Rehabilitation of degraded areas

- The riparian margin must be re-established and rehabilitated in degraded areas to reduce excess sediment movement into rivers and estuaries. In areas where vegetation has been cleared, e.g. for easier access and scenic viewsheds, these areas must be rehabilitated. Further detail on rehabilitation actions are provided under the sections *Erosion Protection & Bank Stabilisation in Estuaries* and *Summary of Techniques*.
- Access to the shoreline must be controlled, and formalised into a limited number of access points/areas.
- A detailed assessment must be undertaken by a qualified coastal specialist/engineer before bank stabilisation and erosion protection measures are considered. Erosion protection or bank stabilisation should only be considered in exceptional circumstances where such measures are in the interests of the whole community and therefore the assessment should confirm both the purpose and necessity of the stabilisation measures.

5.3.8 Agricultural practices

- Soil erosion is accelerated by agricultural activities including clearing of vegetation, soil tillage and overgrazing. Agricultural activities that reduce or minimise erosion should therefore be encouraged and actively supported.
- New proposals to develop cultivated areas and proposed expansion of cropland within the EFZ must be prevented.
- There should be a planned process of retreat of existing agricultural practices from the riparian edge with the ultimate goal of full removal from the EFZ. Cleared areas must be rehabilitated with indigenous vegetation in order to reduce bank erosion.
- Current erosion must be controlled with appropriate soil conservation measures or structures, and the application of Conservation Agriculture principles on cultivated areas.
- Areas of severe erosion within the catchment must be prioritised and rehabilitated.
- Grazing should not be permitted in the EFZ, but where existing approved grazing takes place, rotational grazing management systems must be put in place to protect estuarine and riparian vegetation from overgrazing and trampling by livestock as this initiates erosion and collapse of riverine / estuarine banks.
- Where necessary, overgrazed or sensitive areas should be fenced to allow the vegetation to recover.
- Access to the riparian edge should be managed to avoid concentrated erosion hotspots. This may include access restriction using appropriate fencing.

6 EROSION PROTECTION & BANK STABILISATION IN ESTUARIES

Methods for erosion protection and bank stabilisation are described in many sources and reference works. For the purposes of this guideline, extensive use is made of the prescriptions of the Council for the Environment (1991) *and Heinecken & Badenhorst* (1999)*. The work of the original authors is recognised.*

6.1 Approaches to bank erosion management

In many estuaries, active erosion of banks is present and threatening infrastructure or endangering the lives of people and animals. Under such conditions, inaction is seldom feasible and measures are required to address the erosion. Response actions should target not only the site where the erosion is taking place, but also consider possible interventions that can reduce mitigate the drivers of erosion.

River and estuary banks should preferably be left in their natural state and developments set well back behind a development set-back line. However, under certain circumstances where erosion protection may be required it is critical to note that any disturbance to the bank of a natural river or estuary may alter the hydrodynamics of the system, leading to a change in river flow conditions and subsequent channel modifications. Incorrectly designed structures could reflect wave action or stream flow (currents), thereby increasing potential damage to nearby unprotected banks. It is therefore imperative that consultation and detailed investigation precede the planning and implementation of erosion measures to correctly identify the cause of the erosion, and ensure the selection of appropriate and effective bank stabilisation methods in conjunction with erosion mitigation or where management of the erosion itself is not possible.

Preventative policies and land use management must, however, always be used in conjunction with active intervention, in order to assist in the long-term reduction of erosion. Having strict policies in place to avoid inappropriate developments and manage the balance of sediment in estuaries, can potentially reduce a number of erosion problems in future. In this respect, coastal management lines (development set-backs) or a policy of 'no new development' within the EFZ can implemented to limit the role of coastal development in accelerated erosion. Where problematic development exists, a long-term strategy that could be considered is managed retreat; i.e. the removal/relocation of houses/development away from erosion prone areas. Although this technique is expensive and unpopular, particularly in highly urbanised coastal areas, it could be more cost effective than the construction of sea defences in the long run.

Where intervention and erosion protection are deemed necessary by the competent authority(ies), the active intervention measures for a particular scenario are dependent on:

- The physical characteristics of the site;
- The severity of the erosive forces;
- Potential cyclical nature of the erosive forces;
- Potential and nature of extreme events;
- Future climatic conditions and weather patterns;

- The nature of present and future human activities in the area;
- The degree of maintenance that is practical for the particular method.

The emphasis should be on introducing artificial elements in concert with natural processes, rather than in conflict with them, i.e. working with nature. This is the precept that lies behind an environmental or ecological engineering approach. Bergen, Bolton and Fridley (2001) argues that it is crucial for the design of interventions to be consistent with ecological principles:

"Designs produced with regard for, and taking advantage of, the characteristic behaviour of natural systems will be most successful. When we include and mimic natural structures and processes, we treat nature as a partner in design, and not as an obstacle to be overcome and dominated."

Erosion protection measures and bank stabilisation can include hard techniques, soft techniques or a combination of both.

- **'Hard' techniques** are typical engineering solutions used for structures such as revetments (sloped) and retaining walls (vertical).
- **'Soft' techniques** employ the same engineering principles as hard solutions but with a more holistic approach through incorporation of natural environment elements and considerations – linking to the fields of ecological or environmental engineering.

By combining hard and soft techniques, some of the best features of both approaches can be combined, especially if natural processes are enlisted as part of the intervention. A system used to good effect in South Africa is when gabions (hard engineering structures) are buried as 'sleeping' protection beneath a dune (soft engineering), with the dune itself built up through entrapment of naturally wind-blown sand and re-vegetation using indigenous dune plants (enlisting natural processes and structures).

Amongst other benefits, a combined approach could result in:

- Structures that are hidden and therefore aesthetically acceptable
- Structures that are shaped for better 'fit' within the surrounding environment
- Structures made from material (when not hidden) that have a more natural appearance
- The use of natural forces and energy, such as dune rehabilitation techniques used to overcome the effects of windblown sand
- Opportunities for designing structures benefiting both humans and nature

This combined approach usually offer the same protection as would have been provided by a hard solution on its own.

6.2 **'Soft' techniques for bank** erosion management

So-called 'soft' stabilisation techniques aim to dissipate wave or water action while still maintaining the natural coastal/estuarine topography and materials. Such techniques include (Prasetya, no date):

- Beach nourishment: creating a wider beach by artificially adding sediment to a beach. To be most effective, this should be used in conjunction with a hard engineering structure such as a headland/groyne.
- Coastal revegetation of muddy coast: this particularly refers to mangroves and other indigenous shrubs found in muddy coastal environments (often permanently open/predominantly open estuaries). It involves replanting of mangrove or saltmarsh species to rehabilitate the EFZ and reduce erosion effects.
- Coastal revegetation of sandy coast: revegetation of this area with indigenous plants is one of the only options that can be used for sandy coasts. This is best done in conjunction with other hard engineering structures.
- Dune reconstruction: the regeneration of dunes via the use of sand fences, mesh matting in conjunction with the replanting of indigenous dune vegetation.

Considerations related to techniques for beach nourishment, revegetation and revetments are listed below. Further detail on dune management is provided in section 7.

6.2.1 Beach nourishment

Beach nourishment, or beach replenishment, is the process of replacing sand lost from a sandy shore due to longshore drift or erosion with material from elsewhere through mechanical means, or a combination of mechanical action and natural forces (National Research Council, 1995). It is employed in instances where a wider beach is preferred for safety (enhancing the natural buffer function), to improve a natural habitat (increase the size of natural areas) or aesthetic and economic reasons (to enhance the recreational amenity value).

The replacement of sand can be accomplished by directly depositing sand in a location where it is required, or by depositing sand above or below the water for the natural dispersive action by wind, wave and currents to distribute across the beach area. The sand can be transported in the form of sludge in a pipeline, or hauled in vehicles.

Considerations that should inform beach nourishment projects include:

- An understanding of the causes of erosion, as critical input into the design of a long-lasting intervention
- The capacity and resources available for maintenance of the nourishment scheme
- The nature of dispersive forces, to determine deposition sites (above or below water, and single or multiple sites) and avoid undesirable outcomes like steep slopes
- The type of replenishment material required (grain size, silt or clay content)
- The sources of replenishment material and the impacts of material sourcing on the environment
- The impacts on the social and natural environments at the replenishment site
- Alternatives such as landward retreat, structural intervention or sand recruitment through entrapment

Beach nourishment undertaken in the form of a series of small additions of sand is likely to have a lower environmental impact than a single major intervention, as that will reduce the large-scale disruption of ecological systems and displacement of biota. Environmental impacts can include (National Research Council, 1995):

- removal of habitat and death of biota in the borrow area
- increased turbidity and sedimentation in both the borrow and nourished areas
- disruption of mobile species that use the beach or borrow area for foraging, nesting, nursing, and breeding
- increases in undesirable species
- changes in wave action and beach morphology (e.g., from dissipative to reflective)
- changes in grain size characteristics
- higher salinity levels in aerosols associated with placement by spraying
- change in community structure and evolutionary trajectories resulting from new conditions in the borrow and nourished areas

Beach nourishment can also be achieved by using natural sand entrapment processes to force the deposition of sediment in particular locations. Entrapment of wind-blown sand is a good example, but obstructive structures such as groynes or headlands will also change sediment transport dynamics and encourage the natural deposition of material.

Figure 2: Entrapment of wind-blown sand using netting, Witsands Beach (Bamford, 2016)

6.2.2 Vegetation

The use of vegetation as stabilisation method is appropriate for low current velocities and small waves. Because of the use of natural materials and processes, it is environmentally acceptable and aesthetically appealing. Generally, management with vegetation is considered a low-cost method, with comparable ease of installation. Eventually it will be self-sustaining/ re-seeding, unless significantly disturbed or damaged.

The following specific considerations apply to the use of vegetation:

- Species appropriate for estuaries and river banks must be used;
- Wide range of grasses can be utilised but generally a mix of species planted at different elevations is required due to variable water levels;
- At least one growing season without disturbance is required for vegetation to become established;
- Additional geo-textile (e.g. hessian sheets, honeycomb meshing) may be required to facilitate establishment;
- There may be varying levels of maintenance and watering required, depending on the designs, species mix, urgency etc.

A coastal vegetation specialist and/or dune rehabilitation specialist must be consulted to provide input to the most appropriate, and locally endemic plant species to be utilised.

Figure 3: Revegetation of eroded habitat (UMA, 2017)

Figure 4: Example of soft stabilisation techniques which promote vegetation establishment, including honeycomb meshing (left) and hessian sheeting (right) (SSI, 2011)

6.2.3 Rip-rap revetment

Rip-rap is a term used for naturalised revetment comprising loose rocks placed on a bank slope. The benefit of rip-rap is that the loose rocks take up deformation in the bank without compromising the protection offered. Like vegetation, it is appropriate for low current velocities and small waves, and is similarly a simple, low cost method, that is easy to install. It is commonly used in the treatment of erosion at the foot of more formal protection works.

The following specific considerations apply to the use of rip-rap:

- Thickness must be at least 1.5 times the average rock size, and is normally taken as twice the average stone size;
- Rock at the foot must be placed in a layer that is 1.5 times as thick as that on the bank;
- The toe must extend beyond the foot of the protection works by at least 1.7- 2 times the estimated scour/ erosion depth;
- Filter under-layer is required to prevent erosion of underlying bed: granular filter (gravel of various sizes or geotextiles);
- Geotextile prevents formation of stagnant, waterlogged conditions.

Figure 5: Example of rip-rap revetment protection (source: shorelinemetrics.com)

6.2.4 Geotextile

Geotextile can be defined as permeable textile used with foundation, soil, rock, earth, or any other geotechnical engineering related material as an integral part of an infrastructure project or structure. The geotextile can be made from natural or synthetic fibres and act as sediment trap or structural element. Natural fibre geotextile is manufactured from coconut ('coir') or sisal fibre ('hessian' or 'jute'), whereas synthetics include a wide variety of plastics (polymers). The textiles are also differentiated according to manufacturing process - either woven, punched or bonded.

Common applications include:

- Layers behind or between other structural elements to act as sediment retardant or materials separator
- Surface cover to prevent water or wind erosion
- As structural elements in the form of sand or silt filled containers as alternatives to rock fill
- Matting in stream channels or swales
- Stabilising feature in foundations, including as lining for gabions or riprap, and backing material for seawalls and bulkheads.

For application in coastal environments as slope stabilisation or erosion control features, natural fibre geotextile is preferable, as exposed synthetic materials will be broken down over time into plastic debris littering the ocean. Synthetic materials can be considered where the geotextiles form part of permanent structures and are not exposed to scour or UV damage.

The application of geotextile must be informed by the required function or functions - i.e. filtration, separation, drainage or protection - as well as the nature of the operational context - type of substrate, hydraulic conditions, mechanical forces, expected lifetime and UV exposure.

When installing geotextile, the following should be adhered to:

- New textile should be inspected for any damage from puncturing or UV exposure
- The application surface should be clear of large or sharp objects that might damage the integrity of the fabric
- Textile must be secured against wind action
- Heavy construction equipment and machinery must avoid traversing the geotextile
- Edges of adjoining textile sheets must overlap and be sewed together if necessary
- Geotextiles must be covered as soon as possible to limit exposure to the elements - guidance is usually provided by the manufacturers

Sand-filled geotextile bags are well suited to applications in non-exposed coastal environments, as they are easily transported, relatively flexible in terms of the type of filling material, and in small volume units, can be used to construct specific geometric shapes. Another advantage of small volume units of geotextile bags is that maintenance and remedial works can be carried out easily by replacing the failed bags (India). Temporary walls constructed of sand/geotextile bags can also be used to protect structures from flooding or provide additional height to existing levee systems when floodwaters reach critical levels. Geotextiles can also be matched to the receiving environment in terms of texture and colour, which reduces visual impact in sensitive locations.

Revegetation on exposed surfaces can be facilitated by the use of natural fibre geotextiles. The textile netting laid on slopes increases soil stability and reduces surface water flow velocities. As these natural fibres degrade (usually within three years), the newly established vegetation would assume the role of erosion control agent, ensuring a smooth transition.

In all applications, the specifications of the material manufacturers should be used to determine the appropriate textile and installation methods. Specifications to consider include (NTCPWC, 2018):

- Adequate weight to sustain the uplift pressure due to hydraulic forces
- High Abrasion Resistance
- Adequate Puncture strength
- High Elongation to absorb the hydraulic energy
- Lower Apparent Opening size to retain even the finer soil particles
- High Permittivity and Transmissivity
- Adequate UV Resistance
- Stable in wider pH range

Figure 6: Sand filled geotextile bags exposed by wave action

6.3 'Hard' techniques for bank erosion management

6.3.1 Seawalls and Bulkheads

Seawalls are large structures used along the seashore to resist intense wave action, while bulkheads are generally used along estuary and riverbanks to prevent slumping of the embankment and protect against light to moderate wave action (USACE, 1995). Essentially, bulkheads are retaining walls that consist of solid vertical walls of concrete, metal, wooden poles, gabion baskets or interlocking brickwork or concrete blocks.

Seawalls and bulkheads are most appropriate where deep water for boating is the primary requirement, and gentle slopes are not necessary. Such protection is expensive in the short-term although cost-effectiveness and sustainability improves over the long term as an appropriately designed structure can withstand damage, thereby reducing maintenance. It must be noted that these structures tend to increase erosion due to reflective waves, and may therefore be inappropriate for sandy shores and fail in the long-term if not properly designed and constructed.

The advantages and disadvantages of seawalls and bulkheads are summarised in Table 3 below.

Table 3: Advantages and disadvantages of seawalls and bulkheads

SEAWALLS	
ADVANTAGES	DISADVANTAGES
• Provides protection both from wave action and stabilises the backshore • Low maintenance cost where successfully installed • Readily lends itself to concrete steps onto beach	• Extremely high initial cost • Subject to full wave forces, often fail from scouring at the flanks and foundation • Not easily repaired • Complex design and construction problems – qualified engineering input is essential • Slope design is important • Subject to catastrophic failure unless positive toe protection is provided
BULKHEADS	
ADVANTAGES	DISADVANTAGES
• Provides positive protection • Maintains shoreline in fixed position • Low maintenance cost where successfully installed • Materials are readily available	• Vertical wall induces severe beach scouring • Adequate toe protection is required • High initial cost • Subject to flanking – bulkhead must be tied back securely • Pile driving requires special skill and heavy construction equipment • Complex engineering design problems • Limits access to the beach

Ecological principles must also be applied to the design and construction of seawalls and bulkheads, given the likelihood that such structures will affect habitat quality in inherently sensitive and important environments. The changes instituted extend to the substrate, surface character and habitat complexity (both macro and micro-habitats). A summary guide for building new seawalls or modifying existing seawalls is provided as Figure 7 (DECC, 2009).

The following specific considerations apply to the design and use of seawalls and bulkheads:

- In the case of seawalls, sloped or curved walls can be used on open stretches to decrease reflective energy;

- Design must ensure that the toe of the structure is well protected, that overtopping is prevented, that weep holes prevent pressure build-up behind the structure and the material used is strong enough to withstand wave action and scouring;
- Because of South Africa's high energy coastline, seawall/bulkhead structures constructed from timber, metal sheeting or interlocking bricks have limited success;
- It is very important to ensure that piling is deep enough and the anchoring is sufficient to maintain stability of the structure during storm events when excessive erosion can take place;
- In exposed beach areas, these types of structures should be designed by suitably qualified specialists;
- The design of seawalls and bulkheads should:
    - Allow maximum dissipation of wave energy
    - Provide adequate toe protection to combat scour, undermining and collapse
    - Minimise adverse effects on the neighbouring coastline especially increased erosion
    - Prevent accelerated erosion and longshore sediment movement
    - Ensure that post-storm recovery is not hampered
    - Minimise adverse effects on beach amenity and aesthetically contribute to the environment
    - Ensure that the structures are resistant against catastrophic failure due to extreme events
    - Tolerate greater erosion at the ends of the structures
    - Ensure that costs are recovered over the longer term
- Protection should always extend well beyond either side of the problem area and be anchored into the bank on the flanks to prevent erosion behind the erosion protection materials.

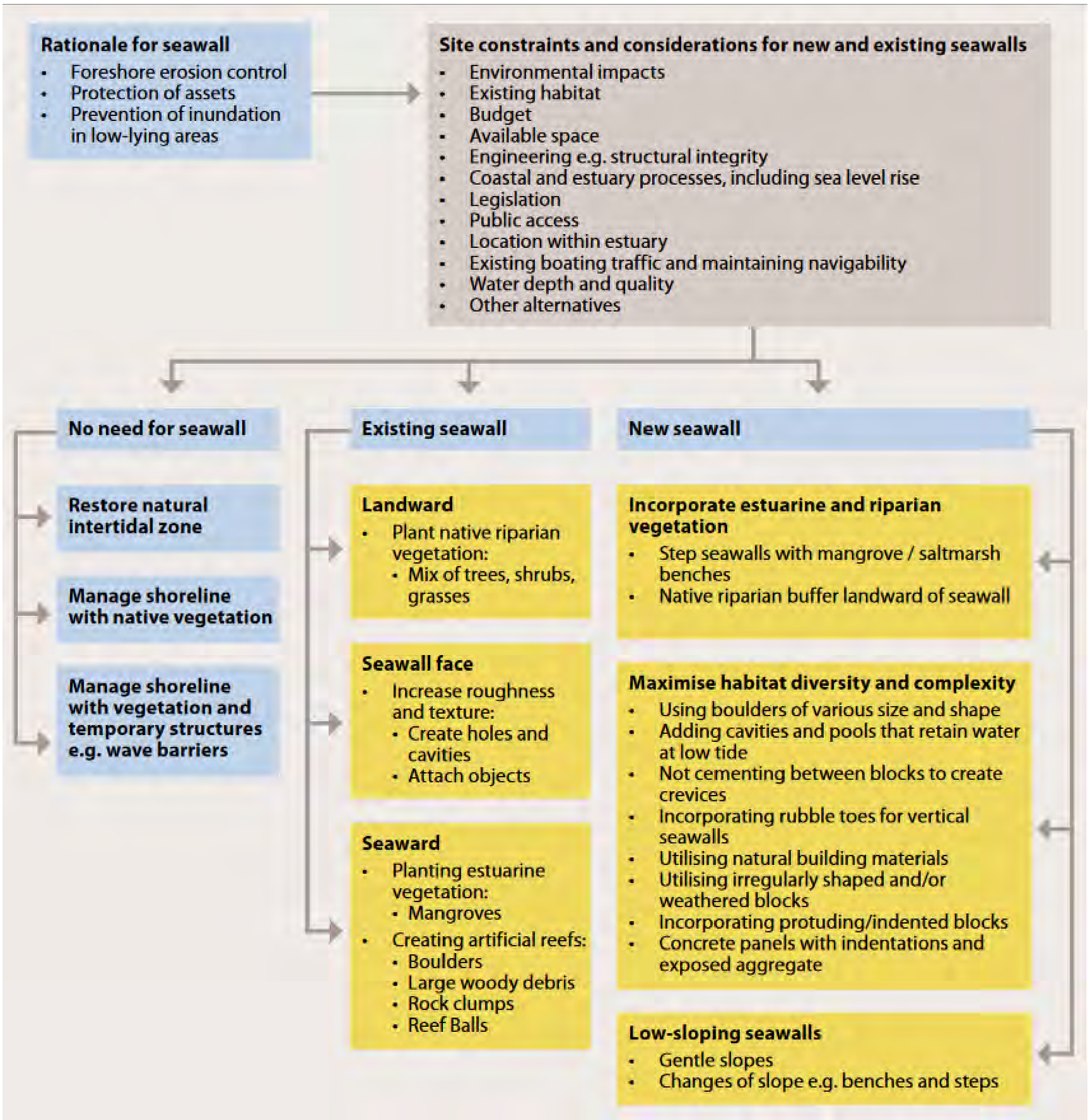

Figure 7: Summary guide for building new seawalls or modifying existing seawalls (DECC, 2009)

6.3.2 Post-supported walls

Post-supported walls are a type of bulkhead that comprise treated hardwood posts supporting a facing material, forming a retaining wall. They are commonly used in marina developments to protect steeply sloping banks and in support of the dredging of channels through wetlands. Post-supported walls are only appropriate for low current velocities and small waves, but represent a simple and economical method, which provides support for vertical banks.

The design of post-supported walls must ensure that posts are driven in to a depth of 2 – 3 times the exposed height above the anticipated scour level. This can be reduced to 1.5- 2 times the exposed height if the posts are tied back to anchors.

Figure 8: Example of a post-supported wall (VIMS, 2019)

6.3.3 Gabions and Concrete Blocks (‘retaining walls’)

Retaining walls are used for steep to near vertical slopes, where wave/current attack is quite severe due to wave action, natural river or stream flows, stormwater outlets, excavation resulting in ‘critical’ steep slopes, and requirements for jetties, walkways, roads, parking areas and building sites. A variety of rocks and styles of interlocking concrete blocks are available, and often can be planted with vegetation to blend with the natural bank and improve the aesthetic appeal.

The use of rock-filled wire mesh baskets (‘gabions’) is also a popular method of bank reinforcement. Gabions are more flexible than rigid interlocking blocks and more accommodating of vegetation establishment, which makes them particularly suitable for application in natural environments. Gabion installation is also labour intensive, which lends itself to employment opportunities for local communities around project sites.

The selection of the type of reinforcement should be informed by the nature of the erosive forces present. Wire mesh baskets are vulnerable to scour and impact damage, especially in saltwater environments where deterioration is accelerated by rust or where structural flex action is possible. Although plastic coated wire mesh is available, it is not recommended for coastal environments due to the plastic litter it produces when the coating fails. All structures are vulnerable to scour around the edges though, and especially prone to rapid progressive failure when erosive forces can exploit any damage or weak areas. Design also needs to take hydraulic action, especially during floods, into consideration.

Retaining wall embankments can be constructed at an angle of up to 70° and heights up to about 5 m. The foot or toe of such protection must, however, be placed on a ‘Reno-mattress’ (i.e. a flat wire basket filled with rock) which must extend out well beyond the expected low water levels. Best practice guidelines, applicable international standards and manufacturer product guides must be adhered to for design and installation guidance.

Figure 9: Gabion protection for a stormwater outlet damaged by wave action

6.3.4 Revetments

Revetments are engineered sloping structures used to absorb wave energy and are placed in such a way as to preserve the existing shape and use of the shoreline, while protecting the slope. The shape of revetments allow for lower cost construction than solid seawalls and bulkheads, as the aim is to dissipate wave energy or reduce flow velocity rather than block water altogether. Rock armoured revetments are the preferred method of protection when rock is readily available at low cost. However, concrete is often cheaper.

The basic structure of a revetment comprises stones or other rough-surfaced materials that are layered on the unprotected slope to reduce wave run-up. Importantly, like seawalls and bulkheads, revetments must be designed in such a way that overtopping does not occur, i.e. the structure must extend above the anticipated high-water level (Figure 10). Filter material must be installed to allow for seepage and adequate toe and flank (side) protection must be provided to prevent erosion. For rubble or rock armoured revetments, progressively larger stones are placed on top of smaller stones. It is the irregular surface of the revetment that makes it effective in dissipating wave energy and minimising reflective waves. In South Africa, however, wave energy can be severe and therefore the selection of material for a revetment must be made carefully.

The advantages and disadvantages of revetments are summarised in Table 4.

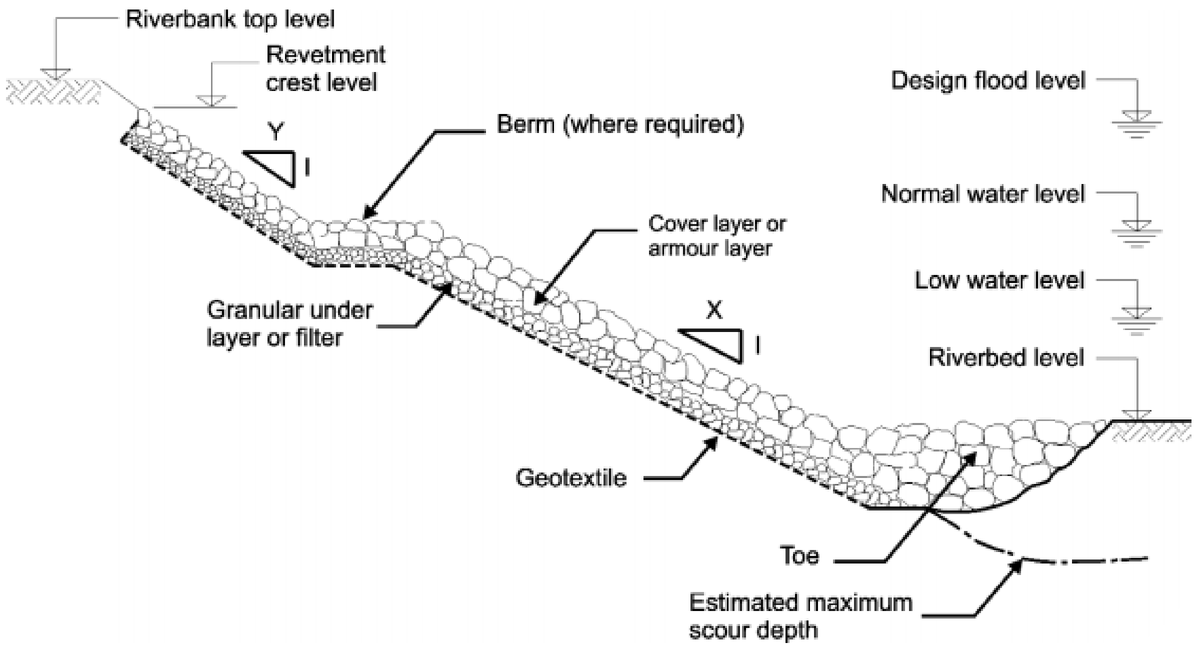

Figure 10: Components of a typical rock armour revetment (CIRIA, CUR, CETMEF, 2007)

Table 4: Advantages and disadvantages of revetments

ADVANTAGES	DISADVANTAGES
• Most effective structure for absorbing wave energy • Flexible – not weakened by slight movement • Natural rough surface reduces runup • Lend itself to stage (terraced) construction • Easily repaired – low maintenance cost • Can be adapted for a variety of locations, using locally available materials	• Heavy equipment required for construction • Subject to flanking and moderate scour • Limits access to the beach or shoreline • Moderately high initial cost • Difficult construction where access is limited

Depending on the landscape setting and the protection requirements, revetments can be designed as flexible structures (or with flexible sections), or as rigid structures. In South African coastal environments, gabions are often used to construct retaining structures or revetments, because they are easy to construct, using smaller stone that can withstand greater forces since they are contained in the wire gabion baskets. When used on open beaches, great care should be taken in providing adequate protection against erosion at the toe of the structure, which will prevent sagging and eventual collapse. When combined with 'soft engineering, the revetment is covered with sand and planted so that it is hidden ('hidden defence') under normal circumstances.

6.4 Summary of techniques

As indicated above, the causes of bank erosion or destabilisation can be related to natural processes such as sea level rise or estuarine channel migration, but in many cases it relates to some human intervention that is destabilising the sediment balance or increasing the erosive action of the water. It is therefore worthwhile to identify the cause of erosion if possible, to ascertain whether an intervention can mitigate the erosive effect. However, active intervention may be required to preserve estuarine or riverine vegetation or protect infrastructure.

A comparative summary of the different types of erosion protection and bank stabilisation, along with indication of when they would be appropriate, are provided below.

Table 5: Comparison of erosion protection and bank stabilisation techniques

Stabilisation technique	Description	Applicability	Typical design	Other considerations
Reinstatement of vegetation	Planting of native species to re-establish riparian or estuarine edge habitat as buffer/impact dissipater, with regular maintenance to ensure plant establishment. Can include removal of exotic or invasive vegetation.	Low to moderate erosive forces, or where banks are degraded but still intact	Planting of estuarine specific vegetation and placing of temporary erosion control materials in horizontally stable layers	Takes time to establish a protective barrier Low cost High ecological benefits
Bank shaping and planting	Flattening the slope of the bank to reduce erosive impact and planting native species to re-establish riparian or estuarine edge habitat. The vegetation will provide buffering against the erosive forces and increase the integrity of the bank.	Where banks are being undercut but erosive action is moderate	Physical shaping of the bank by hand or with excavation machinery followed by planting of estuarine specific vegetation and placing of temporary erosion control materials in horizontally stable layers	Takes time to establish a protective barrier Can be employed in combination with other bank stabilisation methods – e.g. rock protection at or below water level
Reconstruction and vegetative protection of banks	Removal and reconstruction of the bank using geotextile, stone, sand, mesh, rock filled baskets and vegetation as a solid barrier able to resist	Moderate to high erosion	Reconstruction of the bank by hand or with excavation machinery, using a combination of stabilisation materials placed in layers and anchored firmly. This is followed by planting of	Immediate erosion protection Can become self-sustaining

Stabilisation technique	Description	Applicability	Typical design	Other considerations
	erosive forces, to emulate a natural bank.		estuarine specific vegetation and placing of temporary erosion control materials.	Improper design can increase erosion on adjacent sites
Reshaping and armouring	Structural features, especially at the toe of the bank, that provide protection from erosion with little or no re-establishment of habitat or natural erosion buffers	Strong erosive action, high risk to infrastructure or people and insufficient space for reshaping of the bank	Packing and anchoring rocks and stones at the toe of the bank, or providing a riprap surface along part or all of the bank exposed to erosive forces, with sufficient provision for drainage through the layering	High risk of up-and downstream erosion increase High aesthetic impact
Solid retaining wall (seawall)	Hard vertical physical barrier holding back soil material and providing protection against erosion	Strong erosive action, high risk to infrastructure or people and no space for a sloping bank	Building walls, stacking rock filled baskets or driving barriers into the ground as means of separating water and land. Can include stabilisation of soils behind the barrier.	High risk of up-and downstream erosion increase Reflects erosive impacts rather than mitigate them High aesthetic impact Possibility of impact mitigation through provision of micro-habitats

7 GUIDELINES FOR MANAGING DUNE ENVIRONMENTS

7.1 Coastal dunes

Coastal dunes are accumulations of wind-blown sand situated behind beaches, their shape and size determined by the amount and size of sand available, wind direction and strength, embayment topography and beach type (NSW DLWC, 2001). Where associated with estuaries, dunes can occur as part of dynamic estuary mouth environments, as part of the estuary banks or as unconsolidated dune areas (dune fields) adjacent to estuaries.

In addition to their importance as ecosystems, coastal dunes act as natural barriers or buffer areas, protecting landward structures against the impacts of storm events and providing a reservoir of sand that nourishes eroding beaches and feeds nearshore sand bars (O'Connell, 2008). There is thus a balance between erosion during storm events (generally winter) and the slow rebuild or accretion of sand during times of quiet (generally summer) (O'Connell, 2008). An important factor in this cycle is the presence of dune vegetation cover, which reduces wind velocity and encourages the trapping and deposition of wind-blown sand, thereby stabilising the dune(NSW DLWC, 2001).

Coastal dunes, particularly those adjacent to urban areas, are often significantly affected by human activities such as recreational use, uncontrolled vehicular or pedestrian access, housing and infrastructure development, and installation of protective works (such as seawalls), which disrupt the natural processes, leading to dune instability and sand drift (NSW DLWC, 2001). Natural dune recovery is slow, and in some instances completely compromised, necessitating intervention to help manage and maintain existing systems or re-establish degraded systems to replicate historically occurring systems (CCCC, 2007).

Dunes provide several important functions along beaches including being able to replenish sand on beaches that have eroded and providing an important buffer between the sea and the land, often protecting developments near the beach from storms and flooding (Mucina, L. *et al.*, 2006). Fixed sand dunes are also usually areas of high biodiversity, particularly for coastal vegetation, mobile dunes on the other hand have vegetation that is more temporary and has the potential to be removed during a single storm or flood event (Mucina, L. *et al.*, 2006).

7.2 Approach to dune management

As with all sensitive natural systems, the overall objective of dune management should be the maintenance of natural processes that keep the dunes in a functional ecological state. Such a 'functional' state can be defined as:

1. dunes that have enough space for inter-seasonal, inter-annual, and longer, dynamic spatial movement/migration;
2. dunes exhibiting locally representative biodiverse ecological systems with sufficient natural connections to adjacent ecological systems and habitats; and

3. dunes that are in a state of dynamic equilibrium in respect of erosion-accretion cycles

It must always be kept in mind that the formation and constant movement of sand dunes are natural processes and are linked to accretion and erosion processes. The management of dune environments therefore necessarily link to the management of the drivers of erosion and accretion (refer to section 5). It needs to respond to natural forces operating over a long period and constantly working towards achieving a dynamic equilibrium of erosion and accretion.

More active management is required where human activities overlap with the dune environments, and activities impact on dunes or are affected by the dynamic nature of dunes. In these places, it becomes necessary to establish certain guidelines for active intervention in the overlap zones either to prevent human-environment conflict or to mitigate an existing conflict. Such guidelines are provided in section 7.3.

Where human activity is threatened by dune dynamics, or destabilisation of dunes has occurred, intervention might be required to not only manage the human activities, but also rectify or mange the destabilisation over the long term. Guidance on the rehabilitation of dunes is provided in section 7.4.

7.3 Guidelines for human activities in dune areas

The following guidelines draw strongly on the Council for the Environment (1991) *'A Policy for Coastal Zone Management in the Republic of South Africa: Part 2 Guidelines for Coastal Land-Use'. Pretoria: Academica Publishers. The work of the original authors is acknowledged. Other references used includes CCT* (2017)*.*

In addition to the general management actions outlined in section 5.3 related to erosion and accretion in estuaries, the following guidance for managing human activities on coastal dunes in and around estuaries is prescribed. More specific guidance on how to respond to destabilised and problematic dunes is found in the subsequent section on dune rehabilitation.

With respect to management of conflict between dune system dynamics, coastal development and human activities, it is unlikely that any once-off human intervention will result in long-term resolution of the situation. A single intervention will not change or remove the natural processes that give rise to the conflict. Hence, in most cases, intervention will need to be short term, low impact strategies that require long-term maintenance or regular repeats to be effective. Such an approach lends itself to flexible implementation, which can respond to the inherent dynamic nature of dunes, which results in spatial movement, variation in shape and size, as well as periods of instability linked to vegetation dynamics or climatic conditions.

7.3.1 The use of development set-back lines in land use planning

The LAZ is a high-risk area for development, and the zone, which is easily destabilised, is potentially hazardous for development. Development planning must therefore avoid destabilisation of dunes and ensure that developments are kept out of existing and future risk zones. These zones include areas at risk of erosion (also future erosion due to climate change effects) or exposed to wind-blown sand.

The approach to land use planning should preferably avoid all development on the foredune and in the LAZ. If at all possible, development should be set back behind the landward extremity of the LAZ, adjacent areas that may be easily destabilised as well as a vegetated buffer strip that will safeguard the integrity of the LAZ and further reduce risks to the proposed development. The resultant development 'set-back' must be determined during the early planning stages of development.

The early planning stages must furthermore allow for consultation with the provincial authority to ensure that any provincially demarcated Coastal Management Lines (as per section 25 of ICMA) are adhered to.

The required width of the recommended buffer to be demarcated between the LAZ and the development will vary depending on natural characteristics (soil type, wave climate, vegetation type, local topography) and the scale and/or density of the proposed development. The width of this strip may also be informed by progressive long-term erosion or deposition patterns or by episodic events which give rise to periodic beach width fluctuations, such as the 1:50 or 1:100 year storms. Expert advice should be obtained in this regard.

Where development does take place within the LAZ, it should be restricted to back dune areas where there is no danger of destabilising the dune. Development, including camping areas and caravan parks, should integrate with the back dune environment, using natural gaps in vegetation and limiting vegetation clearance to maintenance actions.

7.3.2 Siting and alignment of buildings, roads and carparks

Siting and alignment of buildings, roads and carparks in or adjacent to dune systems must take the overall dune configuration into account. No development should be allowed on the foredune and in the LAZ.

Roads that give access to the dune and beach areas should be aligned perpendicular, and not parallel, to the coast to minimise disturbance to dunes and avoid the creation of a linear barrier. However, roads must not create weak points in the dune cordon through which floodwaters can penetrate into the back dune area.

The nature of the first line of development facing the sea – i.e. whether houses, roads, parking areas etc. would be appropriate - must be determined through consideration of the following principles of:

- securing public access to coastal resources
- respecting existing property ownership
- avoiding conflict between development and coastal processes such as wind-blown sand movement
- protecting sensitive dune environments

- Reducing public (government) liabilities

Figure 11: Wave and wind erosion on a road, Goukamma

7.3.3 Beach access

Although one of the objectives of ICMA is "*…to secure equitable access to the opportunities and benefits of coastal public property…*"; this objective must be balanced with the equally important goal "*…to preserve, protect, extend and enhance the status of coastal public property as being held in trust by the State on behalf of all South Africans, including future generations…*" In this respect, the Western Cape Government has embarked on the development of a Provincial Coastal Access Strategy and Plan, in line with the National Strategy for the Facilitation of Coastal Access in South Africa (2014).

The Provincial Coastal Access Strategy and Plan reflects the situation in the Western Cape with specific reference to concerns, conflicts and opportunities which prevail in the Western Cape.

In principle, therefore, access to beaches on estuary margins should be encouraged. However, access should also be managed to prevent trampling and habitat destruction by animals, people and vehicles. The aim is to maintain natural processes that stabilise any unconsolidated sand and prevent blow-outs[7] or excessive dune migration. At no time, however, may fences be constructed if they limit or restrict public access to the beach.

The following aspects should be implemented where access to beaches is facilitated:

- To restrict trampling of the dunes, access to beaches should be provided at specifically demarcated areas, which are clearly signposted.
- Concrete footings may not be used to secure poles for fences.
- To protect dune vegetation and facilitate access to the beach, paths, boardwalks, board and chain walkways and wooden steps should be provided to link access points (e.g. car parks) to beaches.
    - Board and chain walkways should be placed at the beach end of access paths where frontal dune slopes are between 1:3 and approximately 1:2 (17°–31°).
    - Steps should be used for beach access when the seaward slope of the foredune is greater than 1:2 (26.5°).
    - Elevated boardwalks should be used to traverse sensitive and / or water-logged areas.
    - Boardwalks must be repaired and maintained regularly
    - Existing access routes must be used where possible without the addition of unnecessary infrastructure
    - Unnecessary access routes must be de-commissioned and rehabilitated
    - Boardwalks must be positioned in a manner that does not detract from the aesthetic appeal of the coastal environment
- Vehicle access to the beach over dunes should be strictly controlled according to the '*Regulations pertaining to the Control of Vehicles in the Coastal Zone*' and the associated guidelines for implementation. Generally, only officials performing official duties or persons in possession of a permit (e.g. a physically challenged person, or contractors working on beach sites) are allowed to access beaches with vehicles.
    - Vehicles should not be permitted in dune areas except where officially designated access tracks to the beaches are provided.
    - Vehicle access tracks should be laid over the existing dune surface to avoid the development of blow-outs which occur when tracks are laid in excavations made through the dune.
    - Further detail on vehicle access tracks is provide in section 8.9.
- To prevent damage to critical dune vegetation and to give damaged dunes areas a chance to recover, access to damaged or sensitive dunes (especially the foredune), should be prevented.
    - All sensitive or damaged dune areas must be signposted to alert people to the problem of dune stabilisation and a prohibition on access to certain areas.

---

[7] Blow-outs refer to areas where vegetation is sparse or absent because of the souring action of the wind. Blow-outs often occur as hollows in the dune.

  - Access control in low-usage areas can be combined with rehabilitation measures, such as branches etc. piled in footpaths to arrest erosion and obstruct movement.
  - Fencing can be used to manage human movement in areas used by large numbers of people or where construction is underway.
- Fences should:
  - Be of simple construction, and easy to maintain and remove.
  - Have a low wind resistance so that they will not accumulate wind-blown sand. They should therefore consist of wire strands (and not wooden slats) capable of withstanding corrosion and sand-blasting.
  - Receive regular maintenance.
  - Be removed as soon as they are no longer necessary.

7.3.4 Dune vegetation

Dune vegetation comprises several distinctive plant communities differentiated by their contrasting appearance, growth from and floristic composition. These form a discontinuous or patchy zonation parallel to the shoreline (Tinley, 1985). A summary of the different types of plant communities and their characteristics are provided in Table 6.

Table 6: Plant communities found within dune vegetation (Tinley, 1985)

Type	Description
Strand Plant community	Low creeping grasses and succulent leaved herbs Pioneering species that rapidly colonise mobile sand and responsible for the building up the first embryonic partially stable dunes e.g. Coastal wheat grass, *Thinopyrum distichum*, and creepers, e.g. Dune cabbage, *Arctotheca populifolia*
Shrub community	Behind the stand plant community Less tolerant of highly saline and unstable and severe conditions as for pioneer community An open, short cover of clumped herbaceous plants and shrubs often with an understory of herbs and creepers. Serves as a perch sites for birds which deposit more seeds of shrub species Exceptional species richness, where there is high floristic diversity of fynbos combined with dune species Provides wind and salt protection for backdune plant communities
Scrub – thicket community	Behind shrub community A closed ‘clipped hedge’ canopy – continuously prune-off by salt spray and strong winds, resulting in compact dense growth, with no understory Provides increasing protection and humus for the multiple and single stem dwarf trees which transition into thick/forest community

Type	Description
Thicket/Forest community	Furthest from the sea Oldest mature species of tall woody thicket and trees, with intertwining creeper and climbers, creating a closed canopy Most of the zone is mature thicket with clumps of true forest

Vegetation on coastal dunes binds the sand as well as reduces wind velocity. Unless absolutely unavoidable, dune vegetation should not be removed nor damaged and dunes should not be flattened, reshaped or excavated. Disturbed areas should be graded where necessary and stabilised with indigenous dune vegetation as soon as possible.

Specific circumstances may justify the removal of dune vegetation – usually where alien vegetation is removed to re-establish indigenous vegetation. It also applies where the removal of vegetation is carried out under scientific supervision to restore sediment movement pathways.

As far as practical and acceptable in terms of social impacts, beach cast kelp, otherwise known as kelp 'wrack', must be left to remain in the sandy areas. Kelp is important for the integrity of coastal dunes as it has the ability to trap sand, raise beach profiles and encourages the establishment of pioneer plants, and it also provides a physical barrier for dune systems from storm surges, particularly during the second high tide of a storm surge event. It also provides nutrients for dune vegetation during the decomposition process. Excessive removal of kelp from beaches can consequently have significant implications for the integrity of beach and dune ecology (CCT, 2017).

7.3.5 Groundwater in dune troughs

Groundwater in dune troughs is often close to the surface where it represents a valuable natural resource, controls the movement of surface sand by imparting dampness and may support thriving vegetation communities.

Freshwater aquifers close to the dune surface are sensitive to pollution from human activities. This is an important consideration where dune vegetation should remain in good health for effective management of wind-blown sand, and where coastal development, amenities or activities access freshwater from the dune aquifer. Management actions critical to the protection of dune trough groundwater include:

- Troughs should not be filled or drained, and road or pedestrian crossings should be avoided or if absolutely necessary, elevated above the trough surface.
- French-drains or pit forms of sewage and rubbish disposal should not be used in dune areas. Septic tanks can be considered if a closed /self-contained system is employed.
- Ground water quality should be monitored where human activities pose a threat to water quality.
- Dune areas, in particular the foredune zone, should not be used for the disposal of solid waste.

7.3.6 Mining and excavation on dunes

Surface mining is an extreme form of dune utilisation which destroys the vegetative cover and the form and content of dunes. It is essential that the utmost care be taken in selecting areas where dune mining may take place as destabilisation will destroy the equilibrium of the ecological system and may take a long time to restore. Mining activities must therefore comply with the following:

- Pristine and unspoilt dune ecosystem areas should not be mined. Rather, areas already modified should be targeted.
- Sand removal and dune mining should be confined to areas where more than one pronounced dune range occurs (i.e. where a prominent foredune and prominent back dunes are present), with exploitation limited to the most landward range.
- The foredune range from the backshore (the beach above the HWM) to first trough at its landward base should be given full protection, that is, no exploitation should be permitted on single dune range sectors.
- Continuing and objective monitoring of primary and secondary impacts must be part of the mining process. The mining company should bear the cost of engaging properly qualified independent experts in undertaking this monitoring, and should be contractually committed to immediately rectify any negative impacts.
- After an excavation or extraction, the surface should be regraded if necessary, and reclaimed with vegetation (either indigenous or non-invasive) and care must be taken not to smother or pollute vleis or other water resources.

7.3.7 Livestock in dune areas

Overgrazing and trampling of dune vegetation by livestock should be prevented as this initiates blow-outs and dune slumping. Consequently, unless a clear management plan has been developed and adequate monitoring is in place to prevent adverse impacts on the integrity of the dune environment, livestock should not be allowed in the LAZ.

Where necessary, overgrazed or sensitive areas should be fenced to protect the dune vegetation.

7.4 Dune rehabilitation

Where dunes have been destabilised, active intervention might be necessary to arrest undesirable erosion or accretion, or to maintain features that provide valuable coastal amenity such as recreational areas or erosion buffers.

Although dune rehabilitation is a complex and context-specific activity influenced by local conditions, the following general considerations can be used as a basis for the compilation of site-specific dune management plans.

7.4.1 Stabilisation of dunes

Unstabilised dunes do not always threaten adjacent development and they usually represent essential natural resources of sand for adjacent beaches. The stabilisation of dunes by vegetation, or other means, should therefore be avoided. Until a study has been undertaken to determine natural patterns of sediment movement in the area concerned, and appropriate environmental approvals/authorisations have been obtained, no dune stabilisation should take place. Expert advice should be obtained.

CapeNature, as the provincial conservation authority, should be consulted prior to the stabilisation of driftsand ('dune fields') areas. Indigenous and non-invasive vegetation should be used if vegetation is to be introduced.

7.4.2 Planning

The first step in successful coastal dune rehabilitation is undertaking the necessary planning. The following should be considered (Badenhorst, 2001):

- The need for dune reshaping or rebuilding, and the most suitable method to implement this;
- The most suitable dune species for the geographic locality and dune zones and the availability of seed or root stock and planting specifications;
- The best time of year for planting;
- The extent of the areas to be replanted and most suitable method of replanting;
- The need to return or replace topsoil;
- The maintenance requirements; and
- The need for fencing or access paths to control movement.

The success of dune rehabilitation is largely dependent on creating a landform that most closely resembles the original layout and shape and encourages the establishment and survival of dune vegetation (NSW DLWC, 2001). Table 7 below sets out some of the factors that need to be considered when reshaping or rebuilding a dune.

Table 7: Considerations during dune reshaping and rebuilding

Factor	Guideline
Method employed	• Large, accessible areas = earthmoving; • Large, inaccessible or sensitive areas = sand trapping; or • Small areas (e.g. blowouts) = sand trapping or brush matting.
Material selection	• Use sand that matches the grain size of the remaining dune sand.
Slope and Shape	• Re-establish the diversity of landform that existed before the disturbance; • Avoid unnatural protruding hummocks or steep-sided undulations; and • Create aerodynamically stable shapes; seaward faces of fore dunes should be flat to slightly convex.
Timing of reconstruction	• Reconstruction programme should coincide with appropriate season for the establishment of primary dune stabilising vegetation.

7.4.3 Reshaping of dunes

Reconstruction of dunes may be necessary when the shape, size or topography has changed significantly and reintroduction of dunes of particular shape, size and location is necessary (CCT, 2017). The dimensions of the reconstructed dunes will depend on those of the remnant dune, the location of the dune in relation to infrastructure and the type and availability of sand to be used for the reconstruction or previous design criteria.

Several methods can be used to reshape dunes depending on the scale of degradation and resources available. These include the use of earthmoving equipment and/or installation of geotextile bags in conjunction with sand trapping techniques, such as wind-nets, hedgerows, spreading of mulch or brush matting, and grass planting (see Table 8). These methods are complementary and usually combined.

Sand to be used can be obtained from a variety of sources, but emphasis must be placed on collecting wind-blown sand that has accumulated in undesirable locations close to the rehabilitation site. Sand may only be used if it is not contaminated with any other debris such as rubble or litter. Sand from other sites with similar grain size and chemical composition may be considered, again provided that such sand is not contaminated. Sand may also be obtained from the beach berm and below the HWM where it is available. This may only be undertaken under the provision that the removal of such sand will not have an impact on the broader beach or dune environment or have any other negative impacts (CCT, 2017), and all necessary permits (e.g. EIA, dredging) are obtained.

7.4.4 Dune rebuilding using dune forming materials (CCT, 2017)

Dune forming fences, wind nets or hedgerows assist with dune rebuilding as they reduce wind velocity and therefore cause sand to be deposited in the vicinity of the fence (Table 8). These materials may be used to:

- build a dune where no dune exists;
- fill gaps or blow-outs in the crest line of existing dunes;
- create a higher or wider dune, making it a more effective barrier to wave run-up, wind and wind-blown sand, and salt spray originating from the beach;
- build a new dune ridge seaward of an existing dune; or
- raise the beach profile

Dune forming fences are mainly used on smaller isolated blowouts which are still surrounded by functional dunes and vegetation; however, they can also be used for larger scale dune formation and at sites where new material cannot be imported. Dune-forming fences may be used in sensitive areas where it is undesirable to use earthmoving equipment or where access is difficult.

Dune-forming materials may also be installed after earthmoving activities have achieved desired dune profile. A benefit of dune forming fences is that public access may be guided by the placement of material. In the event fences are required, natural materials (such as branches obtained from alien invasive removal programmes) may be used in the construction of the fences. This is primarily because this material breaks down over time and does not offer any source of value from a theft perspective. If it is not possible to use natural material or specific results are required in which natural materials cannot achieve, fences from porous materials (such as shade cloth) can be used. Wooden slats laced together as well as hessian may also be used in addition to shade cloth. Other designs may be considered depending on local circumstances and availability of materials. To be most effective, dune forming fences should be positioned at right angles to the prevailing wind.

Table 8: Common sand trapping and dune forming materials

TECHNIQUE	ADVANTAGES	DISADVANTAGES
WIND NETS Use of synthetic woven materials e.g. shade cloth placed perpendicular or angled to main wind direction	• Cost effective, highly successful • Can cover very large areas • Low skilled labour required	• Time and labour intensive • Not suitable on steep areas • Ongoing maintenance required until desired result is achieved • Can become damaged by pedestrians, wildlife and domestic animals/livestock
HEDGEROWS Similar to wind nets – placement of dead plant offcuts or young plants in a dense barrier	• Recycling of plant offcuts (from alien invasive clearing programme) • Building up of vegetation structure • Low skilled labour required • Mimics natural dune formation process	• Plant material must be sourced • Ongoing maintenance required to ensure that young plants succeed
BRUSH MATTING / MULCHING (chips) Covering the sand surface with coastal plant debris / organic material	• Use of low-cost materials straw, branches, stalks, and kelp (beach wrack) • Low skilled labour required • Highly successful • Mimics natural dune formation process	• Donor area and material must be sourced • Applicable to small areas • Machinery may be required to distribute material
GRASS PLANTING Planting of dune grasses on the windward face	• Low skilled labour required • Mimics natural dune formation process • Time and labour intensive initially, and thereafter self-sustaining if well established	• Seedlings must be sourced • Depending on size of area, large labour force may be required • Ongoing maintenance required to ensure that seedlings become established

7.4.5 Re-establishment of dune vegetation

The main objective of dune rehabilitation is to ensure adequate plant cover so that wind cannot erode or mobilise the dune (NSW DLWC, 2001). Therefore, as soon as the desired size, shape and layout of the dune has been achieved, the dune must be stabilised and vegetation re-establishment undertaken.

Where blow-outs occur, these need to be stabilised as soon as possible. This can be done by planting clumps of pioneer dune vegetation suited to the wind-blown sand regime (Barwell, 2014). It may be necessary to make use of temporary dune stabilisers on areas of bare sand to present drift until more permanent vegetation becomes established.

Temporary dune stabilisers include brushes and mulches, liquid sprays, cover crops or geo-textiles, often used in combination (NSW DLWC, 2001).

When selecting dune species for re-vegetation, indigenous species that are native to the particular area being re-vegetated must be used (Badenhorst, 2001). It is also important to consider the dune vegetation zones when selecting species for re-vegetation.

Typically three zones can be identified:

- An unstable incipient foredune of colonising grasses and herbs;
- A semi-stable foredune of shrubs and other ground plants; and
- A stable hind-dune dominated by trees and an understorey of shrubs and ground plants.

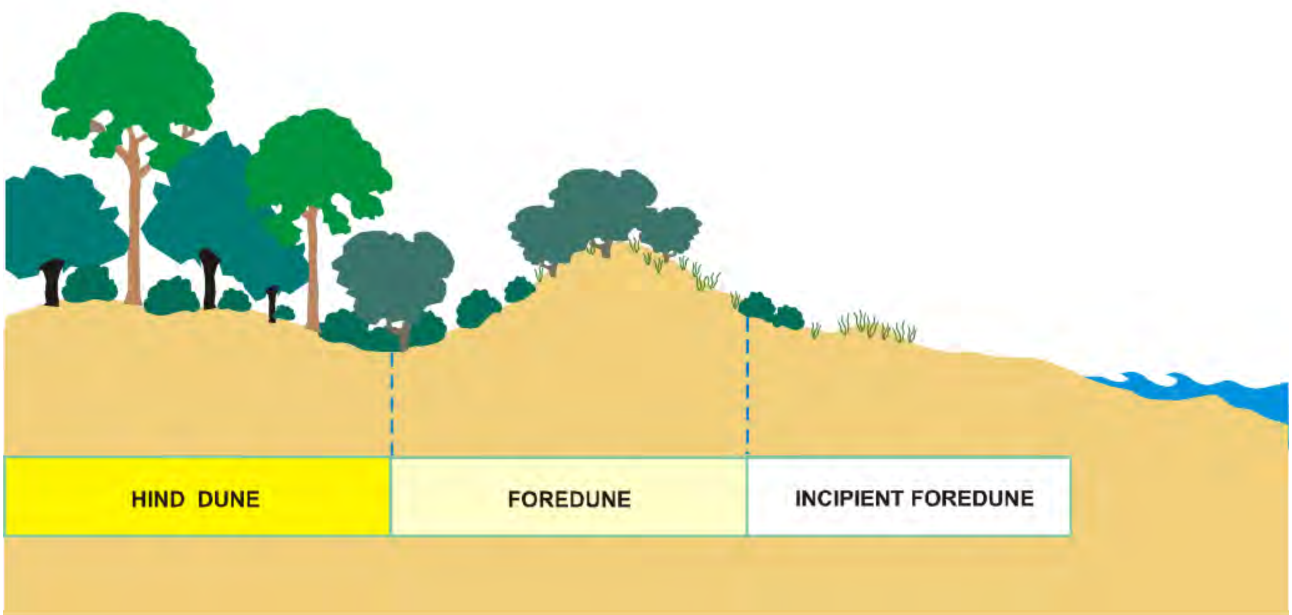

Figure 12: A graphic representation of the three dune vegetation zones (NSW DLWC, 2001)

Under natural conditions, uninterrupted by storm events, the primary species (grasses e.g. coastal wheat grass, *Thinopyrum distichum*, and creepers, e.g. Dune cabbage, *Arctotheca populifolia*) will establish first, followed by shrubs (e.g. Dune gonna, *Passerina rigida* and Brother berry, *Chrysanthemoides monilifera*) and short-lived trees (secondary species, e.g. Bush guarri, *Euclea racemosa* and Cherrywood *Pterocelastrus tricuspidatus*). Lastly, the tertiary species (long-lived trees, e.g. White milkwood, *Sideroxylon inerme*) would establish on the hind dune area (NSW DLWC, 2001). Similarly, artificial dune rehabilitation should try and develop a botanical succession that is similar to what would have occurred in nature (Badenhorst, 2001).

During rehabilitation, dune vegetation can either be re-established using seeds or using plant material. Although more costly, using plant material (cuttings/seedlings) is generally far more successful than using seed. For larger areas it may be most practical to use a combination of these methods. When using seed, it is important to ensure seeds have been treated (e.g. through application of heat or scarification) should they require this to trigger germination. It may also be advisable to scatter untreated seeds along with treated seeds to form part of the seed bank and allow germination in years to come (NSW DLWC, 2001).

Before planting is undertaken a planting guideline should be compiled indicating the number and distribution of each species to be planted/sowed, planting specifications or requirements for each species, including spacing, fertilizer and water requirements.

Figure 13: Dune rehabilitation in progress, Stilbaai

7.4.6 Timing of coastal dune re-vegetation

To ensure success, the timing of management activities should coincide with the appropriate season. In areas with little rainfall and a persistent onshore wind, the following general guideline can be used (Barwell, 2014):

- *Spring* - Spring and early summer represent a time of dune vegetation recovery. The key objective during this time would thus be to cover exposed sandy areas, close off informal pathways and replace or assist recovery of dead or stressed dune vegetation in preparation of the hot, dry summer ahead;
- *Summer* - During summer, the pressure on the dunes increase with an increase in the number of beach goers and an increased risk of fire. The key objective during this time is to protect the dunes from trampling through education, protective structures and irrigation; and
- *Autumn & Winter* -Autumn and winter bring with them storm events that cause erosion and flooding. The key objective during this time is to remove seaward fencing and signage (for replacement in Spring), to pack brushwood in exposed areas to prevent blow-outs and to undertake monitoring.

7.4.7 Maintenance

A crucial and often neglected aspect of successful dune rehabilitation is the maintenance of the area. Maintenance activities may include weeding, watering, fertilising, maintenance of infrastructure (such as walkways, fences and signs) and deterrence of pests. The likely elements and duration of maintenance activities need to be identified in the planning phase of rehabilitation to ensure sufficient time and money is allocated to this phase (NSW DLWC, 2001).

7.4.8 Protective and other considerations

Dune vegetation is prone to being damaged by vehicular or pedestrian traffic. It is thus important to consider access requirements of the area and manage access across the dune accordingly. The layout and type of protective structures used will depend on the level of usage of the area and the dune morphology. Most commonly used protective structures include fences (both landward and seaward of the dune) and beach access ways such as pedestrian board and chain access or raised boardwalks. Other factors to consider are the necessity for parking, provision of seating or lookout decks, informative signage, the provision of a sea view for landward properties and the need for disabled access (NSW DLWC, 2001).

More detail on how coastal access should be managed is provided in section 7.3.3 of this guideline.

Figure 14: Disturbed dune vegetation resulting from pedestrian movement

8 GUIDELINES FOR PHYSICAL STRUCTURES BUILT IN THE LITTORAL ACTIVE ZONE

8.1 Approach to the design and siting of physical structures

Coastal areas are inherently subject to environmental risk due to their dynamic nature. At the same time, infrastructure has the potential to detrimentally affect coastal and ecological processes and systems. For these reasons, infrastructure planned in coastal areas must take the risks and impacts into account, and consider methods and measures that are aimed at mitigating risk that arises from being located in areas that are subject to impacts of tides, waves and wind.

In this section, guidance is provided for specific types or forms of development. It is important to note however, that an approved development or activity will be subject to specific conditions or requirements contained in the Environmental Authorisation.

In all cases, the general objectives for design, construction and decommissioning are:

- The design and construction of the structure must not change natural processes and pylons/supports should interrupt water flow as little as possible
- The structures must be aesthetically compatible with the receiving environment
- The structures may not interfere with legitimate public access to coastal public property
- The structures must accommodate the effects of climate change
- Structures must not facilitate unsustainable impacts on ecological systems or species
- There must be an understanding that if the structure leads to unsustainable impacts, then it must be removed
- Structures may not be left to fall into disrepair – rather, unused structures must be removed

8.2 Bridges

Definition: Bridges are formalised structures which provide a safe crossing for one or more mode of transport and/or human or animal over the track or course of other transport modes, humans, animals, watercourses or water bodies, or sensitive areas and previously inaccessible areas e.g. rocky headlands.

Impacts: changes in flow dynamics, changes in erosion and sedimentation processes and patterns, benthic habitat disturbance, disruption of migration corridors, creation or restoration of movement routes.

In general, selecting the bridge location and structural design is a complex process that requires careful investigation of all factors affect both the bridge and surrounding environment. A careful balance needs to be struck between the economics of the structural system and the environmental and infra-structural requirements affecting selection of the location. Relevant traffic and geometric standards should be met and particular attention paid to aesthetics. Bridge foundations form the most important structural element in the bridge design. They should be designed to accept all loads on the bridge structure should be placed at a level safe enough to avoid erosion problems.

From an environmental perspective, the main issue to be addressed is the functioning of the aquatic ecosystem(s) which a bridge may span. The volume and water flow required to keep these ecosystems ecologically healthy should not be impaired or unduly altered whilst still adhering to the engineering constructions for foundation conditions, sedimentation patterns, approaches and levels.

The following should be carefully considered in bridge construction:

- The erosion, deposition and water exchanges patterns must be fully understood before deciding on the location of and type of bridge to be constructed
- The shape and location of foundations relative to flow patterns – interruption of water flow must be minimised
- Approaches and abutments should be designed to withstand major floods
- The effect of floods, flood levels and the resultant movement of sediments

While the details of bridge design, location and construction are beyond the scope of this guideline, the design of bridges within the LAZ must aim to avoid or minimise the following:

- Size of the footprint and foundations within the water course and floodplain
- Eddying around bridge pillars (piers) or foundations
- Undercutting of structures and foundations
- Causeways intruding into watercourses and floodplains and interfering with flow patterns
- Alteration of flow patterns and impounding of streams
- Increased sediment mobilisation
- Loss of riparian habitat during, and as a result of, bridge construction
- Blocking of riparian wildlife corridors
- Aesthetically insensitive design for perspectives from above and below the bridge
- Pollution of the estuarine environment

It is self-evident that a structural engineer with experience in coastal environments registered with a professional body must be employed to carry out the design and construction of bridge in the LAZ.

Figure 15: Siphofaneni Bridge, Eswatini, with minimal impact on the hydraulic properties of the river (Image: Aurecon)

8.3 Jetties & Piers

Definitions: Piers are considered to be large-scale structures of major capital investment, constructed using massive volumes of concrete and steel, and requiring significant foundations.

Jetties are considered simpler structures than piers, commonly constructed of wood and/or steel, and largely sacrificial in nature. Jetties may be anchored to the river or estuary bed, or floating from a secured shore-based point.

Impacts: changes in flow dynamics, changes in erosion and sedimentation processes and patterns, benthic habitat disturbance, secondary impacts are related to usage, e.g. pollution caused by fuel spillages from boats, access for fishing

- Jetties, both floating or fixed, and piers can function as sediment stabilising or debris trapping structures, and this must be taken into account in terms of location and design.
- Inappropriately located jetties or piers that are causing increased bank erosion, pose a hazard to water users or fauna or are deleterious to estuarine functioning, should be subject to a process of removal, relocation or redesign that will reduce the environmental impacts
- Local flooding risks and tidal surge must be used by the managing authority to determine the appropriateness of construction types, location and number of jetties and piers

- Jetties may not extend into water deeper than 2m, or into navigable channels
- Jetties and piers must be maintained regularly, and completely removed as soon as the structural components become irreparable (e.g. wooden posts rotting or metal posts rusting through)
- The foundations must be below expected erosion level to resist undermining during storm and flood conditions
- Bank stabilisation must be performed according to the prescriptions under section 6 of this guideline
- The number of private jetties must be restricted as far as reasonably possible
- A qualified specialist must be employed to carry out the design and construction of jetties and piers in the LAZ

Figure 16: Fixed jetty - Kraalbaai, Langebaan (Photo: Hendrik van den Berg)

8.4 Moorings

Definition: An anchored or freestanding mooring is a stationary device used for attaching a boat, ship, floating structure or other watercraft. This includes mooring buoys, buoyed anchors and pilings that are not part of a formal marina or port (N.C. DEQ, 2014).

Impacts: Dependent on design, materials, number of mooring points, but generally damage to estuary/river bed and benthic habitats through scraping/scouring, pollution due to fuel spillages.

- A mooring must be located where there is sufficient access and amenities to service this activity
- Design and materials used should be appropriate to the location:
  - Designs should reflect and complement the character of the area, whether it is rural, urban, near a heritage site or part of a conservation area

  - The impact of artificial light on local amenity and intrinsically dark landscapes or nature conservation areas should be minimised
  - Parking, lockers and other associated infrastructure should be sensitively located to take account of the local character of the site.
  - Mooring points in sensitive areas must be designed to prevent the dragging of lines, chains or ropes across the estuary bed
- As much as possible of the estuary margin must be left in a natural state. Retaining the natural bank edge helps to protect the bank from erosion, provides habitat for birds and fish, and contributes the aesthetics of the estuary.
- If piling is used, it needs to be appropriate to the use type of the mooring, whether that is public, private or commercial, i.e. the load must be taken into account, including tidal and estuary outflow conditions. A piling specialist must be employed in this regard.
- Any length of piled mooring will need to be returned to the bank, meaning the ends are directed into the bank. Returning them to the bank stops water getting behind and causing pockets of erosion.
- Any refurbishment must maintain the existing piling line. Any new mooring will need to ensure there is no adverse impact on channel width as this could affect navigation and reduce channel capacity which could increase flood risk elsewhere.
- The mooring must be maintained and replaced when necessary. Areas of old, rotten, abandoned moorings detract from the sense of place and can become boating hazards.
- The construction of moorings must defer to applicable local Municipal By-laws, e.g. Bitou Municipality River By-law (Provincial Gazette No. 7543).
- Construction of moorings must obtain appropriate authorisation from the relevant envrionmental authority(ies) e.g. in terms of NEMA, the Seashore Act and ICMA.

8.5 Slipways/ launching ramps

Definition: Land-based structures used to facilitate the movement of boats into and out of water.

Impacts: habitat loss, changes in flow dynamics, erosion, secondary impacts are related to boat usage, e.g. fuel spillages

- Public launch sites officially declared under the auspices of the Public Launch Site Regulations, published under ICMA as Government Notice No. R.497 on 27 June 2014, are the preferable entry point for boats into estuaries, as these formalised sites will mitigate environmental degradation and offer public amenities
- Slipways must be supported by sufficient access and amenities, specifically aimed at avoiding environmental impacts such as pollution from oils, fuels and detergents (wash bays) or damage to vegetation through informal staging and parking
- The degree of protection from waves and currents is a critical consideration in the location and design of slipways. Wave heights below 200m are considered good site conditions, wave heights between 400 – 600 mm are considered medium-rated conditions and wave heights between 600 -1000mm are considered poor.

- Slipways should preferably be placed in naturally sheltered or protected areas, with short-wave periods, to reduce the amount of artificial/constructed protection required.
- Wave direction should be parallel to the slope of the slipway.
- The main design points for slipways/launching ramps are as follows:
    - The water depth (at lowest dies) at the end of the ramp should generally be 0.5 to 1.0 m deep.
    - Slope of the ramp should be selected based on the types and sizes of boats likely to be launched. For two-wheel drive vehicles, the ramp slope should be at a gradient of 1:8 above the low water level, and in the order of 1:7 below low water level. Slopes should also allow for manoeuvring of towing vehicles.
    - The width of the ramp depends on the degree of protection from waves or swells. A single lane would typically be 5 m with good protection and 7 m with poor protection. For each additional lane, 4 m can be added for good 5 m for medium, and 6 m for poorly protected areas.
    - The surface of the ramp should have a coarse or rippled finish, particularly in tidal estuarine systems and marine environments, to improve grip where marine growth is prevalent. Marine growth can be cleaned periodically at low-tide using mechanical scrubbers, pressure washers and rotary cleaners, combined as appropriate with environmentally-sensitive solutions.
- Use of slipways must defer to the relevant conditions of the Seashore Act (Act No 21 of 1935), and the site- specific Operational Plan in respect to public launch sites.

Figure 17: Struisbaai harbour slipway

8.6 Public amenities and services

Definition: Ancillary/smaller structures to major development complexes, such as ablutions/ change rooms, life guard facilities, sewer pumpstations, as well as pipelines, water supply, and communication services, etc.

Impacts: Changes in flow dynamics, changes in erosion and sedimentation processes, habitat transformation/loss, impacts relating to maintenance and/or failure, such as solid waste pollution, sewage pollution

- Depending on the purpose of the structure, the CML, coastal risk lines and flood risk lines, as well as requirements for flood protection, must be determined prior to the design and construction of the structure.
- As a general principle, no new development should be placed within high risk zones.
- Where there are no alternatives, correct beach management principles must be followed such that natural processes are interrupted as little as possible. A qualified coastal engineer/expert must be employed in this regard.
- A risk aversion approach/ retreat should be implemented where structures are severely damaged or have been demolished
- The location of structures in the floodplain should be carefully selected. All services should be sited above the 1:50 year flood level, or with the floor level above an agreed level, depending on the acceptable level of inundation.
- Foundations in the floodplain should extend to a depth beyond the maximum anticipated scour level.
- Structures below the water line should be streamlined to facilitate flow of water and sediments.
- Pipelines and service conduits should not be placed in eroding or sediment depositional areas in rivers, estuaries and dune environments. A qualified specialist must be employed to determine the most appropriate site, with least amount of impact, taking natural dynamic processes into account.
- Sewer pipelines and pumpstations must be kept out of floodplains, due to the risk of pollution emanating from leakages. All pumpstations must be designed with the built-in redundancy, to ensure continuous operation.
- Abstraction points must be designed in a manner that avoids bank or riverbed destabilisation, debris entrapment and impoundments that interfere with flow dynamics or faunal movements.

8.7 Stormwater structures

Definition: Discharge points into rivers, floodplains, wetlands and rivers for rainwater run-off from developed areas

Impacts: Changes in flow dynamics, changes in erosion and sedimentation processes, habitat transformation/loss, impacts relating to maintenance and/or failure, such as solid waste pollution, sewage pollution

- The quantity and quality of stormwater must be managed prior to reaching the natural environment. This can include the following management procedures:
    - o De-centralised: *Quantity* - On-site storage and slow release, reduction of impervious surfaces, on-site reuse of stormwater and the use of porous pavements, which will reduce stormwater discharge volumes; *Quality* – good housekeeping landowners, street cleaning, catchment basin maintenance, proper sanitation and waste materials handling.
    - o Centralised: *Quantity* – Sophisticated regulation of flows into sewerage systems, in-system and/or off-system storage and slow release (e.g. storm standby basins), diversion of stormwater flow for other uses, proper maintenance facilities, control of infiltration; *Quality* – treatment of run-off in conventional facilities, diversion of stormwater to crop irrigation or other beneficial uses, treatment of stormwater flow at intermediate locations in sewerage system, regulation and slow release of run-off to receive waters.
- As far as practically possible, Sustainable Urban Drainage Systems (Armitage *et al.*, 2013) must be utilised within the LAZ. This is in line with the ideals of sustainable development and the principles of working with nature.
- Stormwater outlets must be designed and constructed in accordance with general best practice, local municipal by-laws, and to withstand flood events and erosion of magnitudes associated with the effects of projected climate change such as sea level rise and intensified extreme weather events
- Stormwater outlets should be designed with flexible outlets formed by wing (side)-walls and an apron. The wing-wall system should be formed to blend with the environment and should be set well back into the shoreline or river or estuary bank.
- The apron (e.g. a gabion/ Reno mattress) must be placed below the outlet to protect against unnecessary erosion during low flow periods.
- The quality of water discharged into floodplains, rivers or estuaries must be monitored and measures taken to remove pollutants either at source or prior to discharge.

8.8 Non-waterborne sewage disposal systems

Definition: Containment facilities for the storage and disposal of sewage, including pit toilets, septic tanks and soakaways, and conservancy tanks, which are not connected to the municipal waterborne sanitation system

Impacts: Soil and water pollution, including groundwater and stormwater pollution, nutrient loading of water resources and algal blooms, human health risks, erosion as a result of failure or overflow

- The design and management of sewage disposal systems vary greatly between regions and even within a single local authority area (Wright, 1999). Therefore, the construction of any sewage disposal system must adhere to the Municipal bylaws and specifications or regulations, and relevant SABS codes (CSIR, 2003).
- Detailed guidelines for use of septic tanks in the coastal zone are provided by Wright (Wright, 1999). However, within the LAZ, the construction of open or unsealed systems, including septic tanks with soakaways, should not be supported or permitted. Sealed

conservancy tanks and waterborne sanitation systems are deemed the most appropriate.

- The type and design of sewage disposal systems must be strictly guided by land/soil capability and other environmental conditions (such as proximity to surface and ground water resources, potential for flooding, etc.), and may only be constructed according to applicable bylaws.
- Existing open systems and septic tanks must be appropriately closed and converted to conservancy tanks or waterborne sewage, particularly if they are at risk of inundation, e.g. within the floodplain. Existing septic tanks must remain watertight at all times, and well maintained (clearance of sludge, treatment etc.) until conversion.
- No effluent may be discharged to river or estuary without obtaining the appropriate approvals, namely a Water Use License (National Water Act) or a Coastal Waters Discharge Permit (ICMA).
- Property owners utilising a conservancy tank must ensure that the tank is well maintained, easily accessible and emptied regularly, and will be subject to pay municipal tariffs for the clearance of the tank.
- Stormwater must not be connected to any sewage disposal system.
- No industrial, trade or manufacturing waste, refuse or effluent must be discharged into any conservancy tank, except by special arrangement with the relevant Municipality.
- Chemical toilets, used to service construction staff or major public events, must not be considered as a permanent sanitation solution. They must be suitably anchored or secured for the duration of use, frequently emptied and removed entirely as soon as possible (CSIR, 2003).
- When a waterborne sewage system is constructed in the area, all properties must be connected to the sewage and the septic tanks and soakaways and conservancy tanks closed down.

A brief note on waterborne sanitation and sewage reticulation networks:

Water treatment works receiving piped effluent pumped from various low-lying pumpstations, were historically located in close proximity to rivers and estuaries, and the sea for the purpose of discharging of treated effluent.

Because of the environmental risks involved and sensitivities of rivers, estuaries and nearshore marine environments, the construction of new sewage treatment works and pumpstations must not permitted within the LAZ as far as practically possible, in line with environmental best practice. However, such applications must follow due process in terms of NEMA and Environmental Impact Assessments, with the final decision vesting with DEFF together the Department of Water and Sanitation. Further to this, any discharge of effluent must be approved through the various permitting and licensing processes administered by the above-mentioned authorities.

8.9 Roads, tracks, parking areas and access points

Definition: Designated areas for vehicular parking, often associated with vehicular and pedestrian access to coastal features such as including dunes, estuaries and beachfronts.

Impacts: Interruption of natural sediment movement processes, i.e. erosion and sedimentation, habitat transformation/loss, wildlife disturbance, erosion from surface run-off, secondary impacts are linked to usage, e.g. pollution caused by contaminated run off, litter

- Access roads leading to the LAZ must be aligned perpendicular to the coast, rivers or estuary banks, to limit the total encroachment and transformation of the sensitive EFZ.
- It is essential that properly established vehicle access tracks are constructed to prevent damage to dunes and littoral habitats where it is permissible for vehicles to gain access to drive on beaches.
    - Tracks should be laid over the existing dune surface and not through cuttings, to avoid the development of blow outs that can occur when tracks are laid in excavations made through the dune
    - Access tracks should be narrow (no more than 3m wide) and as short as possible and aligned perpendicular to the prevailing wind direction
    - Tracks laid over sand should be surfaced in some way so that they are capable of handling the traffic and are not susceptible to wind erosion.
    - Board and chain or in certain cases rubber matting can be used within and over the frontal dunes
    - Access tracks must be fenced so that vehicles are restricted to a specific route
    - The surfacing of the access track must extend beyond the side edge of the fencing to accommodate crumbling of the edges
    - Vehicle access tracks must be clearly sign posted and only authorised officials or members of the public with appropriate permits are obliged to make use of them
- Parking areas and access roads must never be built on or immediately adjacent to beaches, or in front of or on top of dunes, but rather behind the frontal dune system in areas which are not dynamic and where there will be no interference with the natural processes.
- Where placement of parking areas and access points within the LAZ is unavoidable, correct beach management principles must be followed such that natural processes are interrupted as little as possible.
- At dynamic estuary mouths, parking areas should be located well away from the LAZ and behind any development setback /risk lines.
- Flood events and extreme ocean events (tidal surges, marine storms etc.) as well as the risk of inundation by wind-blown sand must be taken into account when planning the position, layout and construction of parking areas or the adjoining access points.
- Parking areas must be positioned in such a way as to minimise protection structures/measures and maintenance.

- Parking areas and structures which are situated in unfavourable areas that must withstand floods will need to be designed to withstand erosive forces, have foundations below the expected erosion level and must be heavy enough to withstand lifting forces during maximum flow conditions, e.g. concrete and gabions.
- Wherever possible, access points should be constructed on rock foundations, and be designed to withstand anticipated erosion from flood events or otherwise be considered sacrificial, i.e. it can be damaged or washed away and replaced at relatively little cost.
- Access points over dunes or through vegetated areas next to estuaries or wetlands must always take into account the sensitivity of the environment.
- Parking areas that are required to provide access to beaches should always be designed together with beach access paths as outlets through or over the dunes.
- Access to the beach from parking areas should be via properly sited and constructed walkways, especially through or over dunes.
- Poorly sited parking areas will require high-cost protection measures and continuous maintenance.
- Parking areas should be designed in such a way that run-off can drain naturally into the surrounding areas or be allowed to flow onto the sand over a larger area to reduce the flow velocity. Also refer to section 8.7 above that details measures to manage stormwater runoff.
- In cases where it is necessary to concentrate run-off flow, the channels need to be protected, for example, by a gabion structure with a collapsible toe.

8.10 Footpaths/walkways/access paths (including boardwalks)

Definition: Designated pedestrian access routes to coastal features such as dunes, estuaries and beachfronts, etc.

Impacts: Habitat transformation/loss, wildlife disturbance, erosion from surface run-off and wind, secondary impacts are linked to usage, e.g. pollution caused by contaminated run-off, litter

- Coastal access must be provided or managed in accordance with the Western Cape Provincial Coastal Access Strategy and Plan.
- Walkways/board walks should be placed at the beach end of access paths where frontal dune slopes are between 1:3 and approximately 1:2 (18°– 26.5°).
- Slope
    - The slope of a pathway or walkway should not be more than 1:2 (26.5°).
    - Steps should be used for beach access when the seaward slope of the foredune is greater than 1:2 (26.5°).
    - On very steep slopes, the pathway will need to be zig-zigged with a landing and steps at the changes in direction.
    - Where provision is made for disabled persons, the slope should not be me more than 1:12, preferably 1:33, which is more comfortable.

- Boardwalks must be positioned in a manner that does not detract from the aesthetic appeal of the coastal environment
- Access routes and boardwalks must be repaired and maintained regularly, especially where damage creates safety risks or where environmental damage can escalate (e.g. blow-outs).
- Existing access routes must be used where possible without the addition of unnecessary infrastructure
- Unnecessary access routes must be de-commissioned and rehabilitated
- The width of "formal" surfaced access pathway should be at least 1.8m but wider for disabled people. Informal, low intensity pathways through sensitive environments can be narrower.
- In natural heavily vegetated areas, pathways should have vegetation cleared to a minimum width of 1.5m and 2.5m in height.
- Paths and walkways for disabled people will require additional specifications in terms of slope, width, railings, railing heights, the radius of corners, etc. Appropriate organisations for disabled persons should be contacted in this regard.
- Access ways may be fenced on one or both sides to keep pedestrians and vehicles to the pathway, particularly in medium to high-usage areas.
- Where the movement of wildlife may be restricted, the fencing should only consist of horizontal strands or poles at a spacing and height that will allow free movement of animals such as antelope.
- In very sensitive or waterlogged environments (e.g. along an estuary or through wetlands), the pathway should be elevated.
- Pathways should follow natural movement corridors of people as much as possible without compromising the environment.
- In sandy dune environments, pathways must be orientated perpendicular to (away from) the prevailing wind direction so as not to act as a wind tunnel. Where the build-up of sand does occur, it should be returned to its source rather than being removed elsewhere.
- Formal surfacing and erosion control measures required for the pathway will be determined by the anticipated amount of use and type of soil present.
- Proper drainage of the pathway must be provided to prevent unnecessary erosion.
- A railing should be provided along steps, especially on the outer edge of stairways going sideways down steep slopes. The height of the railing should be 85 -90 cm above the land surfaces or leading edge of the steps.
- The type of pathway or surfacing used, must not interfere unduly with the natural processes and if at all possible, should be adaptable and adjustable to allow for natural changes that might take place. Types of surfacing are compared in the following table:

Table 9: Comparison of different types of pathway surfacing

Site characteristics	Type of Pathway	Comments/ Specifications
Natural gentle sloping; low usage area	Existing natural surface (sand, gravel, humus, grass or rock)	1.5 – 2 m width
Level or gentle slope in sandy dune environments	Wood chip surface	75 – 100 mm thick to allow for compaction
Medium usage areas; pedestrian and vehicle access	Gravel, crushed limestone, crushed shell or river gravel	150 mm thick Laid beyond actual traffic width to accommodate crumbling edges Good drainage required, centre should be raised to allow for drainage Should not extend all the way down to the HWM, onto beaches or normally flooded areas
Areas of high usage areas; stable back dune environments; rocky coastlines	Concrete walkways and stairs	Prone to erosion and collapse within the dynamic coastal environment Must be designed by experienced coastal engineer
Dune areas; in wet or seasonally waterlogged areas; steep dune or cliff slopes (slopes 1:2 or more); high intensity pedestrian traffic is expected	Boardwalks or wooden walkways	Raised above ground surface to protect sensitive habitat. Only treated wood or hardwood timber, or 'polywood'[8] should be used, able to withstand the elements and/or water-logged conditions 1.5 – 2 m width using wood of at least 40 m thickness Support poles 100 mm diameter, sunken to a depth of 1.0 m, especially in waterlogged environments. There should be no interference with natural surface or underground water flow patterns

[8] Polywood is the term used for poles and planking made from recycled mixed plastics. It is rot proof, weather resistant and highly suitable for use in the marine environment, particularly in water-logged conditions. It can be used in place of timber for all the various footpath and walkway applications.

Site characteristics	Type of Pathway	Comments/ Specifications
Dune environments	Board and chain	Flexibility allows it to take on the changing shape of the dune when erosion or accretion takes place. Less costly than raised boardwalks Treated planking: 2 m x 125-150 mm x 35 mm, which is fixed at spacings along a pair of hot dipped double galvanised, welded chains with links 6 mm x 10 mm long. Spacing of plank is dependent on slope of dune – the steeper the slope, the greater the spacing. Boards and chain must be regularly lifted so as to lie on top of sand surface. There should be no gap between fencing and edge of pathway to prevent erosion by footfall.

- In areas that are constantly wet, non-slip surfacing can be applied. This can consist of galvanised netting nailed to the boardwalk, which may be covered with a light coating of bitumen and fine stone chips.
- Particular attention must be paid to anchoring and stability of the uprights where strong tidal currents or flood scour can occur, for example in estuaries.
- For footpaths along rocky shores, namely at the base of a cliff or steep slope:
    - Stability of the slopes must be ascertained;
    - Walkways should not be placed within striking distance of boulders of unstable slopes;
    - Walkways should be situated above normal high spring tide levels;
    - The surface of paths must be roughened in order to give good grip if they are wet; and
    - Adequate drainage must be provided.
- For footpaths along cliffs and steep slopes:
    - Stability of the cliffs or steep slopes must be confirmed before installing any access paths or walkways;
    - There must be proper secure anchoring of any structure, whether raised or on the surface;
    - Very good drainage and erosion control must be installed;
    - Flat landings or viewing areas must be installed at regular intervals to allow for safe passage of users;
    - Safety railings must be provided all along the outer edge of the pathway.

Figure 18: Seashell-lined footpath is a natural fit, and low railings prevent off-trail damage, but this requires an environmental permit

8.11 Fencing

Definition: Barriers of varying materials generally erected to exclude people (including enclosing private property), animals, traffic, or ensure safety.

Impacts: Dependent on design and materials used, generally sediment accumulation, habitat fragmentation, barrier to wildlife migration, changes in flow dynamic

- The type of fencing to be used is dependent on the purpose for which it is erected, such as to exclude people or animals from a particular area, to direct human, animal or vehicular traffic along a particular route, or as a safety barrier in dangerous areas. At no time, however, may fences be constructed if they limit or restrict public access to the beach.
- All fencing must be accompanied by strategically placed informative signage.
- Dynamic coastal processes must be taken into account when deciding upon the positioning of a fence.
- Visible but aesthetically acceptable barrier fencing may be used in all areas of medium to high-intensity use where the surrounding vegetation is sensitive to human impact.
- In areas of medium to low intensity use, visible and low fencing which fits in with the character of the area should be used.
- Fencing for safety purposes must be robust and well-anchored, and aesthetically acceptable.

- Fences along the sea front should be located at least 1.0 m above the normal high spring tide level. This is to allow for storm surges and normal seasonal erosion periods.
- Fences in back dune areas which guide coastal access, should be sited where people naturally tend to walk or gain access but should also take into account dune topography, existing vegetation and developments.
- In areas of low usage and dense dune vegetation, only short sections of fencing will be necessary to direct people and/or close off openings into sensitive areas.
- All posts or uprights and especially the anchor straining posts must be very well anchored so that the fence can be adequately tensioned and that this tension is retained.
- Concrete footings may not be used to secure poles for fences
- All fencing must undergo maintenance an ongoing basis due to the highly corrosive nature of the salt-laden air, and in the event of vandalism and coastal erosion. Fences should be lifted before becoming completely buried and repaired if broken Continuous maintenance reduces the cost of complete renewal and increases the life expectancy of the fencing materials.
- There are numerous types of fencing and combination thereof that can be used within the coastal environment. A few of the main types and their specific features are given in the Table 10 below. Note that this list is not exhaustive.

Table 10: Advantages and disadvantages of different types of fencing (Heinecken and Badenhorst, 1999)

Fence Type	Recommended Location	Advantages	Disadvantages
Fabricated wire mesh (galv. and plastic coated)	Seaward and landward sides and along access tracks on medium to high use beaches where there is no risk of damage.	Different heights afford greater choice and the higher type is a greater deterrent. Strength.	High cost. High maintenance, poor appearance if rusted. Difficult to lift. Not advisable close to the sea. Plastic coating falls off over time, littering the environment.
Plain wire (galv. and plastic coated)	Seaward side and along toe of access tracks on all beaches where wave damage or sand burial is likely. All fencing on low use beaches.	Low cost. Simple to erect. Easy to maintain.	Lesser deterrent capabilities. Subject to rust. Not advisable in close proximity to the sea. Plastic coating falls off over time, littering the environment.
Post and Rail (various types and styles from self-made rough	All fencing on high to medium-use beaches where there is no risk of wave damage or sand	Excellent appearance. Strength, durability. Low maintenance. Can be lifted and	Very high initial cost.

Fence Type	Recommended Location	Advantages	Disadvantages
poles to formal turned poles)	burial. Around surf clubs and public amenities.	replaced after storm erosion damage.	

8.12 Viewing decks & hides

Definition: Elevated structures, often integrated with the surrounding environment, to enjoy the scenic qualities of the area, or in the case of hides, to provide concealed shelter to observe wildlife, such birds, at a closer range.

Impacts: Habitat transformation/loss, wildlife disturbance, erosion from surface run-off and wind, secondary impacts are linked to usage, e.g. pollution caused by contaminated run-off, litter.

- The number and location of existing structures, and thus desirability of additional structures, needs to be assessed with aim of keeping the number of structures within the LAZ to a minimum
- Appropriate size and design for expected capacity and usage (e.g. hides have specific design requirements to enable disturbance-free wildlife/bird viewing)
- Appropriate design to blend in with surrounding environment (must be unobtrusive, not an eyesore)
- Use of naturally high viewpoints is preferred when considering elevated structures
- Safety requirements must be taken into consideration, as well as accessibility and usability for disabled people
- All stipulations applicable to the erection of walkways and access structures are similarly applicable to viewing decks and hides
- All applicable regulatory requirements must be complied with, as these structures are likely to trigger the need for environmental authorisations

Figure 19: Example of a viewing deck where the surrounding dune has been eroded by wind

8.13 Signage

Definition: Signs and information boards which may communicate contextual information for informative or educational purposes, or be directive or regulatory in nature, thereby controlling behaviour or activities in the coastal environment.

Impacts: Aesthetic impacts, wind/water erosion where surface instability is created, litter particularly at educational signage

- Signage must be strategically placed with respect to ease of access, safety and relevance to the information being conveyed
- In sensitive areas, directive signage should be placed at both ends of footpaths or access points
- Interpretative signage should not be obtrusive or detract from the environment in which they are situated
- Regulatory signage should be visible from 30 m for pedestrians, and 50 to 100 m for vehicles
- Signage for restricted areas must be clear and unambiguous, e.g. "No vehicular access beyond this point"
- Signage should clearly demarcate the extent of an amenity to avoid conflict of user groups
- Aesthetically appropriate and the materials used must blend with the surrounding landscape wherever possible
- The supports and signs must be durable and corrosion resistant in order to be able to withstand the elements. There are many new types of plastics, acrylics and non-corrodible materials available, which are suitable for use in the coastal environment
- Bolts and screws should be stainless steel or plated/galvanised
- Specialist advice must be sought when planning and developing, particularly interpretative, signage for a specific area feature or project
- Vandalised or deteriorated signage must be removed and replaced if necessary
- Concrete foundations are not allowed where signage is installed in unconsolidated sand areas

Figure 20: Interpretive signage provided at a primary access point

9 INFORMATION REQUIREMENTS AND EXPERT INVOLVEMENT

The estuarine environment is highly complex and requires careful consideration in planning and decision making. Activities in the LAZ of estuaries are likely to engage with a range of dynamic coastal processes that vary over time and space, and the combination of terrestrial, riparian and marine influences complicates the understanding of complex interactions and the full extent of the impacts of any action or intervention. This results in a high level of uncertainty when dealing with estuarine matters, and difficulty in making informed decisions.

To minimise the inherent uncertainties in estuarine assessments and management, certain critical information sets should be at hand to inform investigations, recommendations and decision-making. This information should also be generated by suitably qualified or experienced specialists who are able to adequately integrate the range of interrelated factors.

9.1 Information requirements

Dataset sets that may be critical to informed decisions and intervention design are listed in Table 11.

Table 11: Data requirements for estuarine management

Aspect	Data type	Possible sources
Water levels	Water level and inflow monitoring through water level and flow recorders	Department of Water and Sanitation (DWS) monitoring Breede-Gouritz Catchment Management Agency (BGCMA) monitoring
Tidal influence	Measurement of upstream tidal variations	Resource Directed Measures (RDM)/EWR studies Municipal monitoring
Salinity profiles	Quarterly measurement of the horizontal and vertical variation in salinity	Regular monitoring
Mouth state	Monthly monitoring of berm state and height, aerial photography	Local authority
Bathymetry	3-yearly bathymetric survey data	RDM/EWR studies/DWS
Flooding	flood records, hydraulic flow models	RDM/EWR studies/DWS
Water quality	Monthly monitoring of water quality parameters: - Dissolved oxygen - Nitrates - Phosphates - Turbidity	RDM/EWR Studies, municipal monitoring DWS monitoring BGCMA monitoring

Aspect	Data type	Possible sources
Land use	Land uses and zoning details	Land cover data, Statistics SA survey data, Municipal information
Vegetation	Quarterly surveys of macroflora and microflora species diversity and dominance, noting spatial extent and biomass, as well as change over time	RDM/EWR Studies
Invertebrates	Seasonal surveys of invertebrate species diversity and dominance, noting spatial extent and abundance, as well as change over time	RDM/EWR Studies
Fish	Bi-annual observations of species diversity, recruitment success, dependencies and behaviour (e.g. spawning, fish kills)	DEFF, CSIR, Water Research Commission (WRC) RDM/EWR Studies
Birds	Seasonal counts (summer/winter)	Animal Demography Unit of the University of Cape Town, local surveys and birder lists RDM/EWR Studies
Recreation activities	Type, number of people, details of equipment or vessels	Monitoring data from local groups or Municipality (Tourism)
Commercial and subsistence activities	Type, number of people, details of equipment or vessels	DEFF records, surveys, self-reporting
Management	Allocation of management action responsibilities to different stakeholders	Estuary Management Plan
Stakeholder engagement	Details of the RMA and stakeholder groups active in the estuary	Local authority
Protected areas	Location of protected areas and conservancies	DEFF, CapeNature, local authorities
Weather	Forecasts	South African Weather Services

9.2 Expertise required

Due to the diverse influences at play in estuaries, it stands to reason that a range of specialists are required to provide expert input whenever assessments are being conducted or decisions are being made about estuaries. The following is a non-exhaustive list of the experts that may be of value to consult when doing assessments or planning activities in estuaries.

- Coastal management expert
- Estuarine scientist / ecologist
- Vegetation specialist / botanist
- Dune rehabilitation specialist

- Ichthyologist
- Avifauna specialist
- Coastal geomorphologist
- Hydrologist
- Water resource management expert
- Structural engineer with experience in coastal environments registered with a professional body
- Environmental Assessment Practitioner (for administration of regulatory processes) registered with a professional body

10 MANAGEMENT RECOMMENDATIONS FOR IMPLEMENTING AND IMPROVING THE GUIDELINES

The guidelines contained in this document are compiled on the basis of high-level stakeholder engagement and desktop review of information pertaining to increased accretion/sedimentation in estuaries. They have consequently not been tested in real-world conditions, as such, except where guidance is taken from existing frameworks and research on managing increasing accretion/sedimentation. It is consequently recommended that these guidelines be tested for appropriateness and completeness in a range of different scenarios throughout the Western Cape. Feedback can then be used to refine the guidelines further for implementation in areas where regulatory control is currently absent, where it requires updating, or where there is need to align controls to a more universal standard in the interest of universal monitoring and enforcement.

Part of the further engagement at specific pilot sites should be direct interaction with local users and residents living near the estuary/river catchment as well as other important and affected parties or entities, such as waste water treatment works that have a known impact on the functioning of the estuaries. There is also value in involving or referring queries to research and academic institutions with specific expertise and scientific knowledge.

The estuarine LAZ is a dynamic, socially important and ecologically critical area. It should therefore be regarded with the respect that matches its resource value, as represented by responsible and sensitive development and activities. The guidance in this document is intended to direct officials, developers, contractors and the general public in respect of good and bad practice as related to human interventions on estuary edges. Adherence to the guidelines will contribute to the long-term health of estuaries, and consequently their value to all who live, work and play in them.

11 REFERENCES

Armitage, N. *et al.* (2013) 'South African Guidelines for Sustainable Drainage Systems. Alternative technology for stormwater management. WRC Report No. TT 558/13'. Pretoria: Water Research Commission.

Badenhorst, P. (2001) 'False Bay Coastal Study: River Mouth Conditions, Dune Rehabilitation and Management Strategies for Zeekoe and Eerste River Mouths'.

Bamford, H. (2016) *R500k a year spent on dump site*. Available at: https://www.iol.co.za/news/south-africa/western-cape/r500k-a-year-spent-on-dump-site-2002283 (Accessed: 24 October 2019).

Barwell, L. (2014) 'Updated Management Plan for the Lappiesbaai Beach and Adjacent Area at Stilbaai'. CSIR Report No CSIR/NRE/ECOS/ER/2014/0003/B.

Beck, J. S. (2005) *Sediment transport dynamics in South African estuaries*. PhD Thesis. University of Stellenbosch.

Bell, R., Green, M., Hume, T. and Gorman, R. (2000) 'What regulates sedimentation in Estuaries?', *Water & Atmosphere*, 8(4), pp. 13–16.

Bergen, S. D., Bolton, S. M. and Fridley, J. L. (2001) 'Design principles for ecological engineering', *Ecological Engineering*, 18(2), pp. 201–210. doi: 10.1016/S0925-8574(01)00078-7.

CCCC (2007) 'Planning Scheme Policies. Policy 15: Management of Coastal Dune Areas. Version 1.1'. Cold Coast City Council.

CCT (2017) 'Maintenance Management Plan: Dunes and Beaches'. Cape Town: City of Cape Town Transport and Urban Design Authority.

CIRIA, CUR, CETMEF (2007) 'The Rock Manual: The use of rock in hydraulic engineering (2nd edition)', in. London: C683, CIRIA.

Coastwatch KZN (no date) *Position Statement: Sandmining in Estuaries*.

Council for the Environment (1991) 'A Policy for Coastal Zone Management in the Republic of South Africa: Part 2 Guidelines for Coastal Land-Use'. Pretoria: Academica Publishers.

CSIR (2003) 'Chaper 10: Sanitation', in *Guidelines for Human Settlement Planning and Design. Volume 2*. Pretoria: Council for Scientific and Industrial Research.

DEA (2017) 'Updated User-Friendly Guide to South Africa's Integrated Coastal Management Act (Revised Edition, 2017)'. Cape Town: Department of Environmental Affairs (DEA). Available at: https://www.environment.gov.za/sites/default/files/reports/updateduserfriendlyguide_SAICMAct.pdf.

DEADP (2014) *Coastal Management (Set-back) Lines for the West Coast District*. Cape Town.

DEADP (2018) *Coastal Management (Set-back) Lines for the Eden District*. Cape Town.

DECC (2009) *Environmentally Friendly Seawalls: A Guide to Improving the Environmental Value of Seawalls and Seawall-lined Foreshores in Estuaries*. Available at: http://snugconingham.files.wordpress.com/2010/08/200907_guideline_envfriendlyseawall.pdf.

Heinecken, T. and Badenhorst, P. (1999) 'Coastal Management in South Africa. A Practical Guide for Coastal Developments and Management. Final Draft. Version 2'. Department of Environmental Affairs and Tourism (DEAT), p. 261.

James, N. and Hermes, J. (2011) *Insights into impacts of climate change on the South African marine and coastal environment*. Pretoria: South African Environmental Observation Network (SAEON).

McGwynne, L. E. *et al.* (1996) 'Sandy Coast Management and Planning Guidelines', in *KwaZulu-Natal Coastal Dunes: Ecological Dynamics, Human Impacts and Guidelines for Planners: A Pilot Study for Sites at Mtunzini and Richards Bay*. Pietermaritzburg: Town and Regional Planning Commission.

McLachlan, A. *et al.* (1994) 'Management Implications of Tampering with Littoral Sand Sources', *Journal of Coastal Research*, pp. 51–59.

Mucina, L. *et al.* (2006) 'Indian Ocean Coastal Belt', in Mucina, L. and Rutherford, M. C. (eds) *The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19:* Pretoria: South African National Biodiversity Institute, pp. 578–579.

N.C. DEQ (2014) 'Section 4: Rules for Specific Types of Projects : Moorings', in *CAMA Handbook for Coastal Development*. North Carollina Department of Environmental Quality. Available at: https://deq.nc.gov/about/divisions/coastal-management/coastal-management-permit-guidance/project-rules/moorings.

National Research Council (1995) *Beach nourishment and dune protection*. Committee on Beach Nourishment and Protection, Marine Board, Commission on Engineering and Natural Systems.

Van Niekerk, L. and Turpie, J. (2012) 'National Biodiversity Assessment 2011: Technical Report. Volume 3: Estuaries Component'. CSIR Report Number CSIR/NRE/ECOS/ER/2011/0045/B. Stellenbosch: Council for Scientific Research.

NSW DLWC (2001) 'Coastal Dune Management: A Manual of Coastal Dune Management and Rehabilitation Techniques'. Newcastle: NSW Department of Land and Water Conservation: Coastal Unit.

NTCPWC (2018) *Draft Guidelines on Geo-synthetics for coastal protection and port works*. Chennai. Available at: http://ntcpwc.iitm.ac.in/download.

O'Connell, J. (2008) *Coastal Dune Protection and Restoration using 'Cape' American Beachgrass and Fencing.*, *Marine Extension Bulletin*. Woods Hole Sea Grant & Cape Cod Cooperative Extension.

Prasetya, G. (no date) 'Thematic paper: The role of coastal forests and trees in protecting against coastal erosion. Chapter 4: Protection from Coastal Erosion'. Available at: http://www.fao.org/docrep/010/ag127e/AG127E09.htm.

Le Roux, J. and Smith, H. (2014) *Soil erosion in South Africa - its nature and distribution*. Available at: https://www.grainsa.co.za/soil-erosion-in-south-africa---its-nature-and-distribution (Accessed: 27 June 2019).

SANBI (2019) *National Biodiversity Assessment 2018: The status of South Africa's ecosystems and biodiversity. Synthesis Report*. Pretoria.

SSI (2011) 'KwaDukuza Municipal Coastal Management Programme'. SSI Engineers and Environmental Consultants. Unpublished report.

Tinley, K. L. (1985) *Coastal Dunes of South Africa. South African National Scientific Programmes Report No 109*. Pretoria.

UMA (2017) *Restore and protect natural shorelines: Use living shoreline techniques*. University of Massachusetts Amherst. Available at: https://climateactiontool.org/content/restore-and-protect-natural-shorelines-use-living-shoreline-techniques (Accessed: 24 October 2019).

USACE (1995) *Engineering and Design: Design of Coastal Revetments, Seawalls, and Bulkheads. Manual No 1110-2-1614*. Washington, DC: Department of the Army, U.S. Army Corps of Engineers.

VIMS (2019) 'Estuarine Beaches of the Bay'. Virginia Institutie of Marine Science. Available at: https://www.vims.edu/research/departments/physical/programs/ssp/beaches/estuarine_beaches/index.php (Accessed: 24 October 2019).

Wampler, P. J. (2012) 'Rivers and Streams — Water and Sediment in Motion', *Nature Education Knowledge*, 3(10), p. 18.

Wright, A. (1999) *Guidelines for the use of Septic Tanks in the South African Coastal Zone. WRC Report No TT 114/99*. Pretoria: Water Research Commission.

Western Cape Government Department of Environmental Affairs and Development Planning
Directorate: Biodiversity and Coastal Management
Leeusig Building, 1 Dorp Street, Cape Town, 8001
Private Bag X9086, Cape Town, 8000
Telephone: 021 483 5126
Website: www.westerncape.gov.za/eadp

Western Cape Government
Environmental Affairs & Development Planning