



MAINTENANCE MANAGEMENT PLAN FOR THE
GOUKAMMA ESTUARY MOUTH UNDER SPECIFIC
CONDITIONS

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STATEMENT OF THE PROBLEM

The Goukamma Estuary is a temporarily open/closed estuary in a protected area and which also forms part of a marine protected area. When the mouth closes (about 20 to 30 % of the time) it back floods the surrounding landscape including some low-lying agricultural land and abstraction points. Local farmers from time to time put CapeNature (as responsible management authority of the estuary) under pressure to artificially breach the system to try and prevent the natural back flooding of the surrounding landscape. As this is a protected estuary, the maintenance of natural processes is prioritised and artificial breaching therefore not promoted.

OVERALL OBJECTIVE OF THE LOCAL MOUTH MANAGEMENT PROGRAMME

To manage the estuary mouth as an integral part of the Goukamma Estuary Management Plan that will maintain the healthy functional ecological processes of the estuary. For the Goukamma Estuary this means that its assessment rating should be consistent with an “A” Ecological Category defined as “Largely natural” under the Department of Water and Sanitation’s (DWS) A to F rating system.

DESCRIPTION OF THE GOUKAMMA ESTUARY

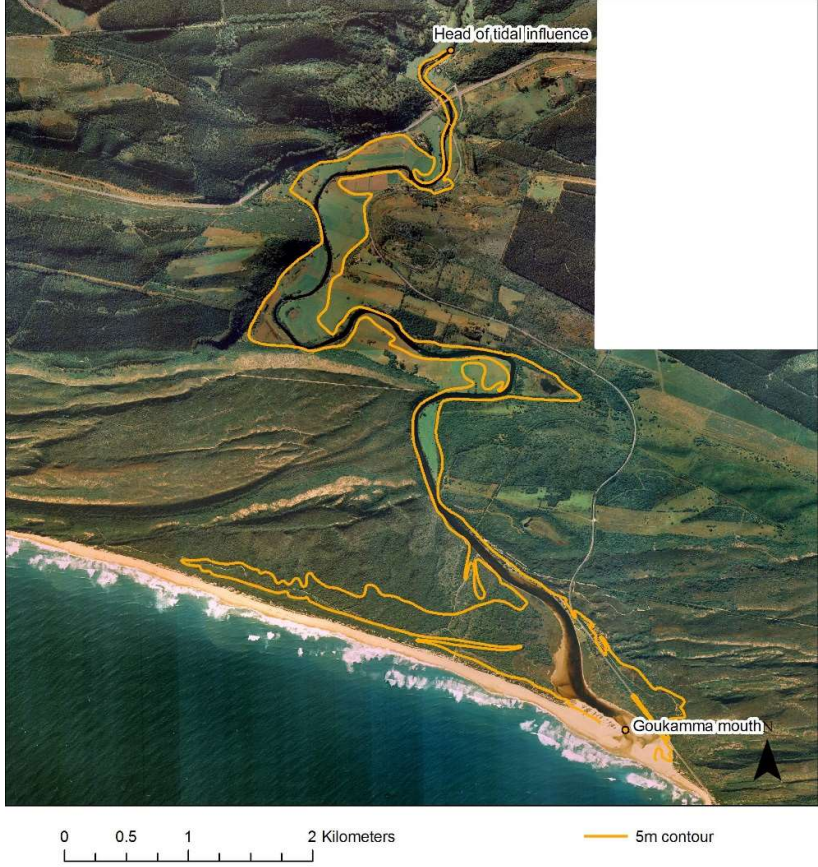
Table 1. Description of the estuary and its importance.

Threat	Discussion
Location	The Goukamma River and its tributaries rise in the Outeniqua Mountains, and flow through plantations, indigenous forest and fynbos in its upper and middle reaches. In the lower reaches the river flows through farms and eventually forms part of the Goukamma Marine Protected. The proposed rezoning of the Goukamma MPA includes an extension of the conserved part of the estuary up until the top of the estuarine

Threat	Discussion
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functional zone. The estuary mouth opens into the ocean to the west of Buffelsbaai. The Goukamma River has a catchment area of 235 km². The geographical boundaries for the study are defined as follows:

- Downstream boundary: Estuary mouth 34° 4'45.93"S; 22°57'14.86"E
- Lateral boundaries: 5 m contour above Mean Sea Level (MSL) as depicted by the Estuary Functional Zone below in orange.



Estuary Importance	The estuary is rated as “Average ecological importance” based on its Estuary Importance Score (EIS) of 57 (Van Niekerk et al. 2009). The EIS takes size, the rarity of the estuary type within its biographical zone, habitat, biodiversity and functional importance of the estuary into account.
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Conservation status	The lower reaches of the Goukamma Estuary fall within the Goukamma Marine Protected Area. CapeNature is currently in the process of investigating the possibility of declaring the entire estuary part of the Goukamma Marine Protected Area as part of the development of a regional conservation plan for the cool and warm temperate
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Threat	Discussion
	<p>estuaries. The Goukamma Estuary is also included in the core set of estuaries that needs to be protected to meet biodiversity targets in South Africa (National Estuary Biodiversity Plan (Turpie et al. 2012)). The conservation plan stipulates that 50% of the terrestrial marginal area be included as a no-development area and that the recommended ecological water requirement category be an A.</p>
<p>Important vegetation</p>	<p>The banks of the Goukamma Estuary are steep with limited intertidal area thus restricting the development of estuarine vegetation. At one point in the lower/middle reaches on the west bank, a steep dune forms the estuary bank and on the opposite east bank terrestrial bush/trees occur. Floodplain areas are also absent. The riparian zone is severely disturbed by farming activities below the N2 bridge. Other disturbed areas are evident from bank slumping, eroding banks and the presence of invasive plants e.g. black wattle (<i>Acacia mearnsii</i>) growing in the riparian zone. The dominant vegetation of the Estuary are reeds, <i>Phragmites australis</i>, that occur from approximately 3 to 4 km upstream. Brakgras, <i>Sporobolus virginicus</i>, occur near the mouth region.</p> <p>During low flow conditions, nutrients may be high as a result of agricultural input. Below the N2 bridge there is extensive dairy farming. This could promote the growth of algae particularly during low flow conditions. This represents a change from the reference condition as blackwater estuaries are generally nutrient poor. When the estuary was visited, there were no submerged macrophytes. However past reports have indicated the presence of pipefish which is usually associated with these plants and thus they may have occurred in the estuary in the past. Sediment movement and channel migration in the lower and mouth reaches of the estuary would prevent the establishment of large submerged macrophyte beds. The 1936 and 1942 aerial photographs indicate extensive mobile dune fields on both sides of the mouth. The mouth and lower reaches of the estuary represented an unstable environment which would have reduced the opportunities for macrophyte growth. In addition this may have led to an increased berm height and higher water levels during closed mouth conditions, which would have prevented the establishment of intertidal salt marsh areas.</p>

Threat	Discussion
<p>Important fish nursery</p>	<p>The fish fauna of the Goukamma Estuary was sampled in June 1994 (Harrison et al. 1995), in March 2006 (Ken Hutchings unpublished data) and in February 2008 (Lamberth unpublished data).</p> <p>A total of 33 species have been recorded from the Goukamma Estuary. Of these, estuarine roundherring <i>Gilchristella aestuaria</i> is a category Ia species that spends its entire lifecycle in estuaries; seven species, e.g., barehead goby <i>Caffrogobius nudiceps</i> and Cape silverside <i>Atherina breviceps</i> (Ib) have marine and estuarine breeding populations; eight species, e.g., white steenbras <i>Lithognathus lithognathus</i> and <i>Argyrosomus japonicus</i> have to spend at least their first year of life in estuaries; nine species, e.g., groovy mullet <i>Liza dumerilii</i> (IIb) and harder <i>Liza richardsonii</i> (IIc), have varying degrees of dependence on estuaries and three species are catadromous eels (Va). Overall, there is a high degree of estuarine dependency with 85% of the fish assemblage comprising fish species that are either completely or partially dependent on estuaries. The remaining five species include one marine species blaasop <i>Amblyrhynchotes honckenii</i>, three indigenous freshwater species Cape kurper <i>Sandelia capensis</i>, Cape galaxias <i>Galaxias</i> sp. and Eastern Cape redbfin <i>Pseudobarbus afer</i> and one introduced freshwater species largemouth bass <i>Micropterus salmoides</i>.</p> <p>The high degree of estuarine dependency is typical of temporarily open/closed systems where fish may be required to tolerate frequent or extended periods of mouth closure and the associated variability in salinity. It also suggests that the Goukamma is an important estuarine nursery for fish. Numerically, the fish assemblage is dominated by the opportunistic <i>L. richardsonii</i> (50%) and to a lesser extent <i>G. aestuaria</i> (16%), freshwater mullet <i>Myxus capensis</i> (10%), Cape stumpnose <i>Rhabdosargus holubi</i> (9%) and Knysna sandgoby <i>Psammogobius knysnaensis</i> (6%). Fish abundance or density is typical, but species diversity low, when compared to other blackwater systems.</p> <p>Zostera and other macrophytic growth is sparse and intermittent, probably accounting for the low densities of pipefish <i>Syngnathus temminckii</i> or large fluctuations in the numbers of <i>R. holubi</i> in the estuary. The sandy nature of the estuary sand-loving benthic species such as Cape sole <i>Heteromycterus capensis</i> and <i>P. knysnaensis</i> are well represented. In the absence of macrophytes, the relatively high abundance of the latter</p>

Threat	Discussion
	<p>and other species of goby is probably attributed to their being able to find refuge in the burrows of <i>Callianassa kraussi</i> which occur at high densities in the lower reaches of the system. The distribution of fish along the estuaries length is also typical of a blackwater system with opportunistic species such as <i>L. richardsonii</i> dominant in the lower and middle reaches, a high abundance and diversity of estuarine-dependent species such as <i>L. lithognathus</i> and <i>R. holubi</i> in the middle reaches and species with a preference for lower salinities e.g. <i>Myxus capensis</i> and <i>Mugil cephalus</i> in the upper reaches.</p> <p>With the exception of exploited fish species such as dusky kob <i>Argyrosomus japonicus</i>, which tend to mirror their coast-wide declines, there is likely to have been little change in the fish assemblage of the Goukamma Estuary from reference to the present day.</p>
Important Bird site	<p>A total of 40 waterbird species have been recorded over the past 20 years, but an average of only 12 species was recorded on the estuary during the winter and summer. Thus the diversity of the system is rated average (good for a relatively undisturbed blackwater system). An average of 140 birds were counted in summer and 240 birds in winter. Gulls are the most numerous group of birds, and are found mainly at the mouth of the estuary. The majority of these are found in the lower reaches. Terns venture up the estuary, and Kingfishers, Fish Eagle and Osprey tend to occur throughout. The dominant waders are resident species typical of sandy habitats (e.g. African Black Oystercatcher and White-fronted Plover), grassy areas (Blacksmith Lapwing), and bushy banks (Water Thickknee). There is a lack of suitable intertidal habitat for migrant waders, which are rare on the estuary, although more species have been recorded in the past. The waterfowl are characterized by a regular winter population of Little Grebe, and winter flocks of Yellowbilled Duck. There is a resident population of Fish Eagles, and three species of kingfisher occur on the estuary.</p>
Estuary Condition w.r.t breaching	<p>The Present Ecological Status of the Goukamma Estuary is an A/B on the DWS A - F ecological condition scale. The Goukamma Estuary is negatively impacted on by poor water quality, fishing, structures in the intertidal area and flow reduction (- 15%). A number of these impacts can be reversed with little effort and cost.</p> <p>No artificial breaching is allowed at this system at present.</p>

Threat	Discussion
Recommended Ecological Condition	The recommended ecological condition for the system is an A (Near natural). A number of initiatives are in progress to address the pressures on the Goukamma Estuary, including this Mouth Management Plan.
Water abstraction	Water is abstracted for agricultural use, as well as for municipal supply to Buffalo Bay town (160 kl/day or 0.1% of the MAR).

MOTIVATION FOR ARTIFICIAL BREACHING

The Goukamma Estuary is a temporary open system that is about 9 km long with a high tide area of 355 000 m² and a volume of 0.6 x 10⁶ m³. The system is narrow with an average width of 30 to 40 m in the upper and middle reaches. The system widens in the lower reaches (~2km from the mouth) to a maximum width of 200 m approximately 0.9 km from the mouth. The depth varies between 1 and 2 m, with some localised deeper areas in the upper and middle reaches. The N2 national road crosses the estuary about 9 km from the mouth, near the limit of tidal variation.

The mouth area of the Goukamma Estuary is dominated by marine sediment. Monthly mouth observations made by CapeNature indicate that the estuary is closed between 20 and 30% of the time. In the past, artificial breaching took place at the request of farmers whose activities on the floodplain were affected by raised water levels. At present, artificial breaching is only carried out in extreme circumstances, e.g. keeping the mouth open to facilitate maintenance of the Buffelsbaai road.

The following restoration measures are recommended to improve the present health of the Goukamma Estuary:

- Reduce the nutrient input from agricultural return flow into the Goukamma Estuary through better land use practices. The source(s) of polluted discharges must be identified and mitigated.
- The relocation of the Buffelsbaai road further inland should be investigated, as it is currently restricting the natural mouth dynamics of the Goukamma Estuary and contributes to the loss of intertidal and subtidal habitats in the system.
- Investigate the overall water resource allocation strategy for the Knysna Municipality, with the objective of reducing abstraction rates or removing the upstream weirs (old and new) to allow for an increase in freshwater inflows, estuarine habitat and allow for migration of estuarine fauna (e.g. fish).

ASSESSMENT OF RISKS, THREATS, OPPORTUNITIES ASSOCIATED WITH MOUTH MANAGEMENT DECISIONS

A summary of the motivations for potential artificial breaching is provided below in Table 2.

Table 2: Summary of artificial breaching motivation

Human wellbeing and safety	Potential Threat	Relevance
	Threat to human life (as a result of high water levels)	No threats to human life
	Threat to immovable property and infrastructure (as a result of high water levels)	No threats to property. Under elevated water levels some riparian abstraction points are back flooded by brackish water.
	Human health impact (e.g. flooding of sewage pump station, septic tanks, chemical storage yards, etc.)	Not a significant consideration.
	Potential loss of agricultural resources (as a result of high water levels)	At high water levels there is some impact on grazing and agricultural land within the estuary functional zone. There is pressure from farmers to prematurely breach the system.
	Potential impact on nearshore environment if breached (e.g. aquaculture facilities)	Not a significant consideration.
	Loss/impaired access (e.g. roads, footpaths, cattle crossings)	Exceptionally high flood levels may impact on the Buffelsbaai access road. Not a significant consideration.
	Human Health	Contact recreation in the form of swimming does occur in this system, but no information is available on water quality being a problem from a human health perspective. However, a recent field visit indicated that the estuary is significantly impacted by cow dung.
	Harmful / Noxious algal blooms	During long closed phases algal blooms can develop in the shallow warm water of the estuary but as the system falls within

Potential Threat	Relevance	
	a Marine Protected Area this is not deemed a significant problem.	
Impact(s) on recreational use (e.g. increase depth / surface area when mouth is closed, reduce fishing).	Boating/canoeing occurs in the system in if water level is deep enough, especially under closed mouth conditions.	
	Impact of artificial breaching	Under open mouth conditions the system can be very shallow, hence the need for canoes.
	Impact of NOT breaching	Closed mouth conditions result in deeper waters, but as only small boats and canoes are encouraged on the system this is not a major issue. At present no motorized vessels are allowed on estuary.
Impact on avifauna abundance, species richness/ community composition	Important bird habitat	The system is important from a bird perspective.
	Impact of artificial breaching	Exposure of intertidal areas is essential for estuarine birds, with the majority of species depending upon these habitats for food, and several more using intertidal areas for roosting.
	Impact of NOT breaching	Fresh water conditions associated with closed mouth conditions favour water birds.
	Occurrence of avian botulism	No information available on this aspect.
Impact on estuarine fish abundance, species richness/ community composition	Important fish nursery	The system is of high importance as a fish nursery. The system has very high densities of juvenile White Steenbras. The fish assemblage is typical of a temporarily open/closed estuary with a high degree of estuarine dependency and species able to withstand prolonged periods of mouth closure.

Ecosystem requirements

Potential Threat	Relevance	
	Impact of artificial breaching	Positive impacts are recruitment of larval and juvenile fish and return of adolescents and reproductively active fish to the sea to spawn.
	Impact of NOT breaching	Nursery area not available to juvenile fish.
	Occurrence of fish kills	No information available on this aspect.
Impact on estuarine invertebrate abundance, species richness/ community composition	Impact of artificial breaching	Open mouth linked to higher salinity values and opportunity for euryhaline species to increase in biomass and abundance. An open mouth is also important for the input of larvae into the estuary from the marine environment for recruitment and <i>vice versa</i> .
	Impact of NOT breaching	Closed mouth leads to decrease in species richness (absence of marine-associated species). Associated decrease in salinity would have a negative impact on invertebrates within the lower reaches of the Goukamma River Estuary which are adapted to life in a tidal system.
	Occurrence of invertebrate kills	No information available on this aspect.
Estuarine Macrophytes (plants)	Impact of artificial breaching	The open mouth condition is important as this ensures tidal flushing and introduces saline water maintaining brackish conditions and biodiversity.
	Impact of NOT breaching (i.e. die back of saltmarsh)	Mouth closure occurs for 20-30% of the year. The plants in the estuary i.e. reeds and grasses, are adapted to the water level changes associated with mouth closure.

Potential Threat	Relevance	
		There are no large salt marsh areas with succulent species that would be sensitive to prolonged inundation
Water quality (Thresholds of concern that would compromise estuarine ecosystem or ecosystem services)	Salinity thresholds of concern (high or low) that would compromise ecosystem or ecosystem services	Not applicable.
	Dissolved Oxygen levels	< 4 mg/l
	Ammonia levels	Not applicable.
	Toxic substance in the context of breaching	Not applicable.
	Pollution sources include sewage, septic tanks and agricultural runoff. Water levels should be as high as possible to flush out excessive nutrients (and their sources) during breaching. The ongoing nutrient enrichment is putting the ecology, recreation and eco-tourism at risk.	
Eutrophication	Excessive reed growth	Yes, have been recorded in this system.
	Macrophyte blooms	Yes, have been recorded in this system.
	Harmful algal blooms	During long closed phases algal blooms develop in the shallow warm water. Residents find the decaying matter to be offensive.
Sedimentation	On-going sedimentation	No information on this aspect as no recent bathymetric surveys have been carried out in the estuary, but historical recorders

	Potential Threat	Relevance	
			indicate that the system has become shallower over the past decades.

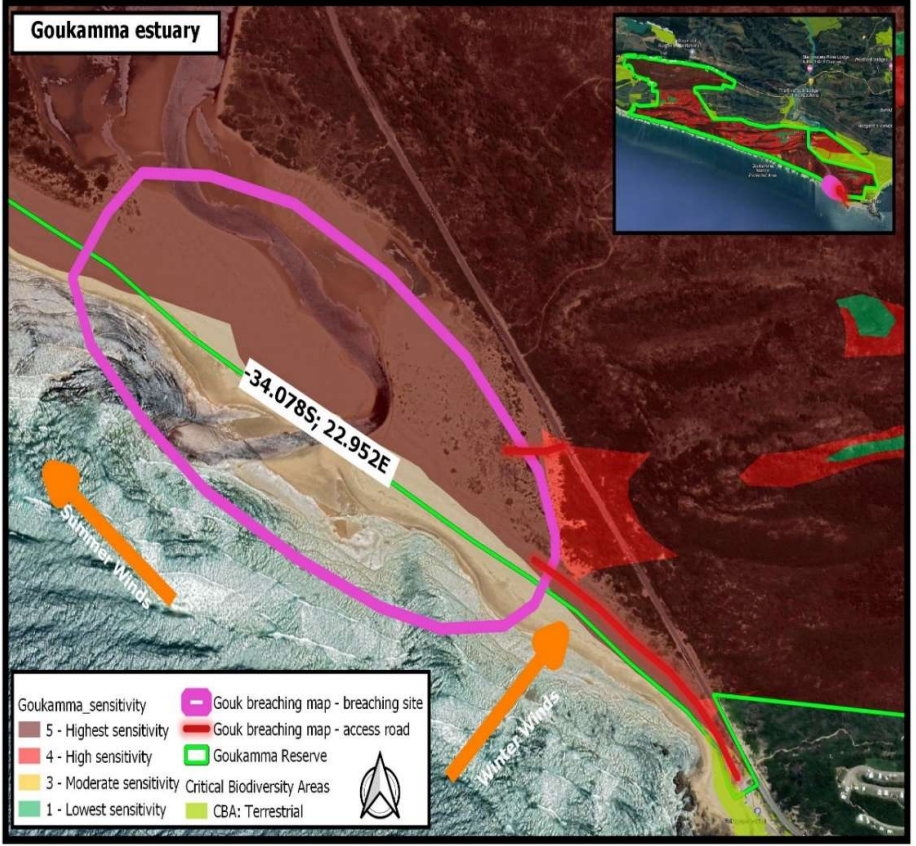
Event Type	Breach Yes/No	Motivation
Back flooding	No (disaster/emergency only)	Water levels must be as high as possible to scour sediment from the system.
Major flood events associated with severe flood damage	Yes	Unfolding natural disaster to be confirmed by local Disaster Management Centre
Poor water quality	No	<p>Low oxygen levels throughout the system will not be considered an emergency (must be verified through regular monitoring and estuarine specialist consultation).</p> <p>Salinity levels are not a consideration because the system is characteristically saline.</p> <p>Artificial breaching will not be considered to flush polluted water out of the estuary - pollution must be fixed as source.</p>
Fish kills	Yes (emergency only)	DFFE to determine the cause of the fish kill. Written findings to be provided to breaching committee.
Hazardous spill	Yes (emergency only)	Breaching will only be considered if hazardous substance holds no risk to the nearshore environment and is registered as a disaster. In the event of an oil spill at sea, the mouth of the Goukamma Estuary can temporarily be closed to prevent oil from entering the system. Spillage of organic waste should be addressed using standard biological control measures.

INTEGRATED ASSESSMENT

The following breaching specifications need to be met before artificial breaching of the Goukamma Estuary can be considered (Table 3):

Table 3: Goukamma Estuary Breaching Specifications

Breaching considerations	Details		
	Natural levels	Y/N	No
Minimum breaching level (water level should be as high as possible before breaching)	Not a consideration in an emergency.		
Optimum breaching period (if applicable)	Not a consideration in an emergency.		
Neap-spring breaching considerations	Not a consideration in an emergency.		
Timing of breaching	Breach 2 hours before high tide, or just after high tide (to prevent high waves from closing the opening), to maximize the outflow.		
Consider safety of public during breaching	<p>Breaching at the Goukamma Estuary holds little risk to public safety. Nevertheless, care should be taken with the general public to ensure their safety. Cordoning off the works area with the aid of red and white emergency tape will aid in keeping the public out of the area where breaching will take place. Ideally an official or security person must man the area in question.</p> <p>Temporarily close the designated area in circumstances that could pose a danger to human life or property. This must be accompanied by appropriate signage.</p>		

Breaching trench to maximize outflow	Excavate a 2m deep and 4m wide trench before breaching to maximize outflow.
Location of the breaching position.	At the lowest position of the berm, opposite the previous year's channel to assist with the efficient removal of sediment during the breaching.
Propose area of breaching position	 <p>The map displays the Goukamma estuary with various overlays. A pink line indicates the breaching site, and a red line shows the access road. The map is overlaid with sensitivity zones: 5 (Highest sensitivity, brown), 4 (High sensitivity, red), 3 (Moderate sensitivity, yellow), and 1 (Lowest sensitivity, green). It also shows Critical Biodiversity Areas (CBA: Terrestrial, light green) and the Goukamma Reserve (green outline). A coordinate label '34.078S; 22.952E' is present. Arrows indicate 'Summer Winds' and 'Winter Winds'. A legend at the bottom left explains the symbols and colors used on the map.</p>
Estimate amount of sediment to be moved during breaching	Not applicable, as amounts vary significantly between breachings. It therefore cannot be determined in advance.
Disposal of sediment removed during excavation	The sand excavated from the trench should be stored on the banks adjacent to the trench.
Mobilizing machinery and equipment on site during breaching	Equipment and machinery to be utilised in a breaching must be in be in a good state. Oil leaks are not to cause additional pollution.

Care should be taken to ensure that earth moving equipment do not disturb indigenous vegetation of conservation worthiness en route to the excavation site. Bird nesting areas are to be avoided. Where possible existing access roads / tracks should be used. The work area needs to be cordoned off from the public. This is to address any safety issues as well as to prevent people harvesting existing fish in the shallow channel.

Once it has been established that a clear outflow channel has formed and breaching is progressing on its own momentum the earth moving equipment may be removed from the beach.

Implement an appropriate control mechanism, such as erecting comprehensive signage with information of the launching areas and the associated dangers.

Allow DFFE officials access to the designated area for the purpose of assessing and/or monitoring compliance with the conditions contained in the MMP, at all reasonable times.

Be responsible for all costs necessary to comply with these conditions unless otherwise specified

CapeNature retains the management responsibility of the designated area, even though the applicant may grant permission to manage the designated area, on their behalf, to any competent contractor /service provider or Municipal Disaster Management. Ensure that all users adhere to the local authority By-Laws relating to the designated areas at all times.

The legal requirements associated with the use of the designated area must be brought to the attention of all persons that are granted access to the designated area by the applicant (licensee) in terms of the conditions of this license and the applicant shall take measures necessary to bind such persons to these requirements.

Noise & light pollution	Noise on during a breaching should be kept to a minimum and within the relevant noise control by-laws/regulations of the municipality.
Water Quality considerations (Thresholds of Concern)	Salinity: Not a consideration
	Oxygen: < 4 mg/l
	Toxins: Not a consideration
Ecological considerations	Birds: Open mouth conditions per natural conditions.
	Fish: Open mouth conditions per natural conditions.
	Invertebrates: Open mouth conditions per natural conditions.
	Plants: Open mouth conditions per natural conditions.

According to the new Environmental Impact Assessment (EIA) Regulations promulgated on 18 June 2010 in terms of the National Environmental Management Act 1998, the artificial mouth breaching may not commence without an environmental authorisation from the competent authority:

The 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 from:

- I. a watercourse;
- II. the sea;
- III. the seashore;
- IV. the littoral active zone, an estuary or a distance of 100 metres inland of the high-water mark of the sea or an estuary, whichever distance is the greater

but excluding where such infilling, depositing, dredging, excavation, removal or moving

- I. is for maintenance purposes undertaken in accordance with a management plan agreed to by the relevant environmental authority; or
- II. occurs behind the development setback line.

[Listing Notice 1, Activity Number 18]

Application for a special dispensation to implement the mouth management plan for a period of five years (at which time it will be subject to specialist review) is therefore required from DEA&DP in terms of the need for ecosystem maintenance.

RELEVANT AUTHORITIES

Table 4 lists the key lead authorities involved in artificial breaching at the Goukamma Estuary.

Table 4: Key lead authority involved in artificial breaching

EMP Responsible Management Authority (RMA) (as per the National Estuarine Management Protocol)	CapeNature
Breaching Actions	CapeNature in association with Knysna Municipality (Disaster Management)
Advisory Committee	Goukamma Estuary Advisory Forum
Authorisation (breaching / emergency)	DFFE
Lead authority	Minimum consultation in case of Emergency
CapeNature	✓
Knysna Municipality (Environment Management and Disaster Management sections)	✓
Garden Route District Municipality (Environment Management and Disaster Management sections)	✓
DEA&DP	✓
Department of Forestry Fisheries and Environmental Affairs	✓
Department of Water and Sanitation	✘
SANParks	✘
Research organisation (e.g. CSIR)	✘
Non-Governmental Organisations	✘
<p>The decision to artificially breach will be made by a Breaching sub-committee comprising CapeNature: Eastern Landscape Manager, the Garden Route District Municipality, Knysna Municipality and a representative of the local estuary advisory forum following consultation with estuarine ecological specialists (e.g. a research organisation, DFFE: Inshore Fisheries Research or DFFE: Estuaries Management). Data on water level, berm height, salinity, as well as water quality parameters where feasible, will be collated by CapeNature. These lead authorities are important role players with respect to</p>	

emergency situations and administer their relevant empowering provisions (Disaster Management Act 2002, NEMA 1998, and the Integrated Coastal Management Act 2008).

Once the Breaching sub-committee has decided that an artificial breach must occur, CapeNature in association with the Disaster Risk Management unit of the Knysna Municipality or Garden Route District Municipality will be responsible for overseeing the breaching activities.

Disaster Management	Authority/Organisation	Status
Early warning system	South African Weather Services (weather)	No
	DWS warning system (flow/water levels/dam safety)	No
Disaster Management Plan	Municipality	Yes
Approved Maintenance Management Plan	CapeNature	Yes, in process of update.

Planned mouth breaching procedures

Two types of breachings are generally distinguished, namely (a) Planned artificial breaching undertaken according to an approved MaintMP and (b) Emergency breaching (e.g. to avoid danger of flooding). **In the absence of more detailed information on the mouth behaviour of the Goukamma Estuary only emergency breaching under extremely rare conditions is considered appropriate.**

CapeNature is responsible for the operational aspects of the Goukamma Estuary MMP. They can delegate this function, but ultimately they have oversight. CapeNature is required to co-ordinate the breaching activities, which include:

- Convening emergency breaching meetings;
- Recording the minutes of the meetings;
- Distributing relevant information to the committee members; and
- Sharing the post-breaching incident report;

CapeNature is also responsible for continuous monitoring of the conditions in the estuary when oxygen levels become low (<4 mg/l). Once the emergency breaching criteria is met, the decision to artificially breach will be made by the CapeNature. Note, that an estuary mouth is highly dynamic and unforeseen events may

require special management actions. In such an event, verbal (followed by written) authorisation may be required from the authorising authority (i.e. DFFE).

A flow chart for the undertaking of mouth breaching under emergency conditions is included in Figure 1. Breaching should be undertaken in the swiftest manner possible, and in most cases, CapeNature is responsible for coordination. While breaching should be conducted according to an Estuary Mouth Management Plan some of the general breaching principals may be waived under emergency conditions to ensure an expedient breaching.

Emergency conditions could develop when an estuary mouth is closed and severe rainfall occurs in the catchment causing a large flood. Constant monitoring of the conditions in the catchment is required when emergency conditions develop. Communication between the different role players, i.e. the local municipality and key authorities (DFFE) involved, should take place, if time is available, to monitor the situation. Included in the monitoring are:

- The actual and expected rainfall in the catchment.
- The water level in the estuary and its rate of increase.
- The height and width of the sand berm at the mouth.
- The actual and predicted wave conditions.
- The availability of equipment to breach the mouth on short notice.

While most emergency breaching relate to floods Table 2 lists some additional events that can constitute an emergency at the Goukamma Estuary.

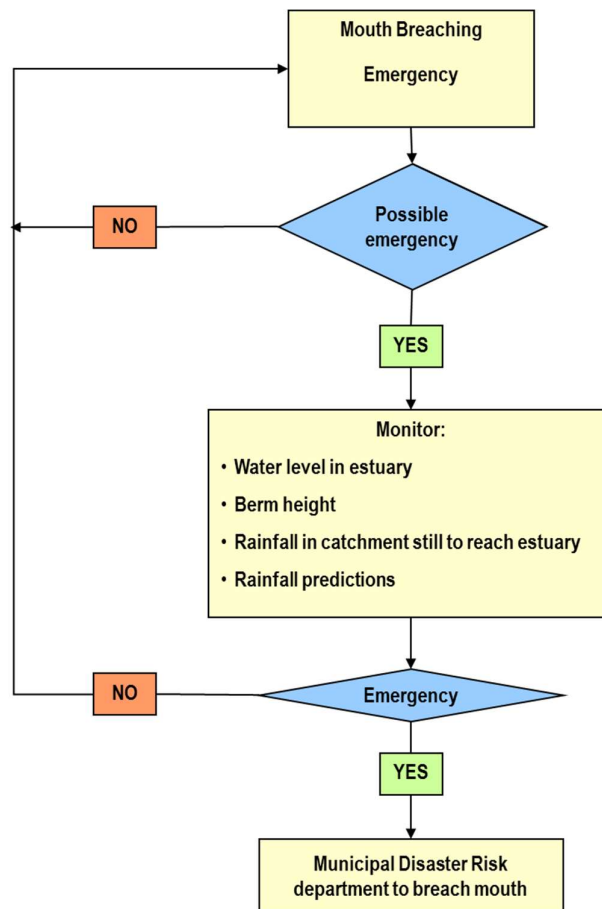


Figure 1: A flow chart illustrating the breaching plan for emergency conditions

Once CapeNature has establish that the relevant criteria have been met and that artificial breach must occur, they shall be responsible for overseeing the following:

- Ensuring the availability of earth moving equipment on day of breaching;
- Establishing the exact location of the breaching channel;
- Verifying that the sand berm at the mouth is high enough above the water line that there is no risk of “fluidization” of berm sediment (i.e. turns to quicksand) and associated risk to operator and equipment;
- Deployment of flags and signage to warn public of risk to safety; and
- Breaching of the estuary mouth.

CapeNature is responsible for the compilation of a Breaching Incident Report to be provided to DFFE within 14 days of the actual breaching (see “Reporting” for more detail on the report).

Emergency

Emergency conditions could develop when an estuary mouth is closed/constricted and severe rainfall occurs in the catchment causing a large flood. Alternatively, they could also develop at the (largely unlikely) event of a break of the dam wall. Constant monitoring of the conditions in the catchment is required when emergency conditions develop. Communication between the different role players, i.e. CapeNature, the local and district municipalities, and key authorities (DFFE) involved, should take place, if time is available, to monitor the situation. Included in the monitoring are:

- The actual and expected rainfall in the catchment.
- The water level in the estuary and its rate of increase.
- The height and width of the sand berm at the mouth.
- The actual and predicted wave conditions.
- The availability of equipment to breach the mouth on short notice.

A flow chart for the procedures to be followed during emergency breaching is provided in Figure 3. Such breachings should be undertaken in the swiftest manner possible. In most cases the Disaster Risk Department of the local municipality will be the responsible authority but for the Goukamma estuary this will most likely be CapeNature. While breaching should be conducted according to an Estuary Mouth Management Plan Mouth and an approved Mouth Maintenance Plan, some of the general breaching principals may be waived under such emergency conditions to ensure an expedient breaching.

While most emergency breaching are usually linked to river floods, Table 2 lists some additional events that can trigger an emergency mouth breaching in the case of the Goukamma Estuary.

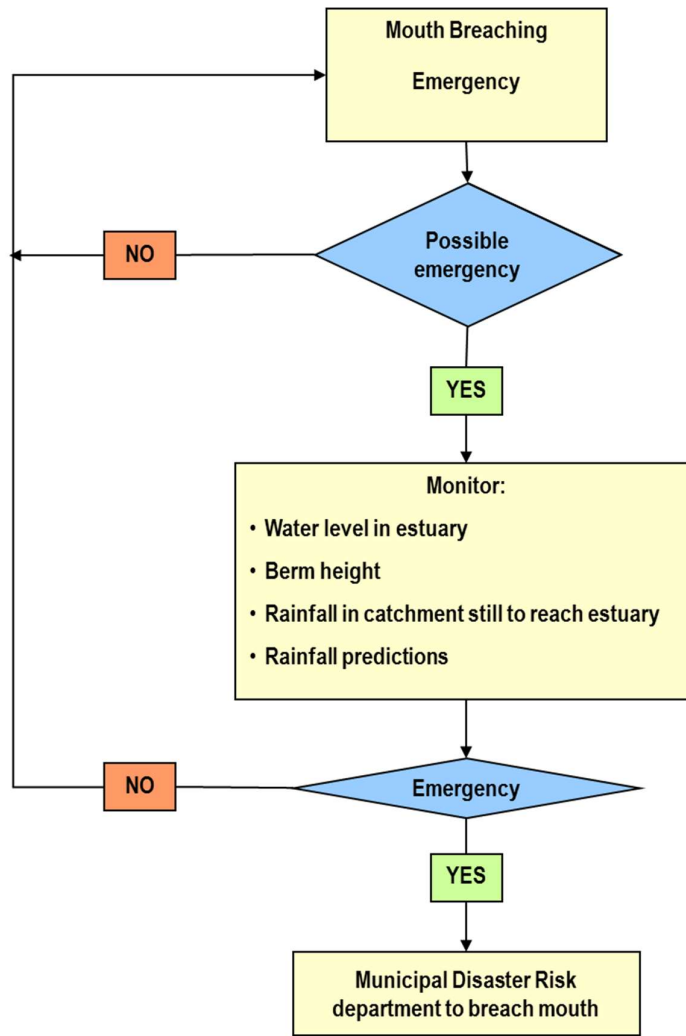


Figure 2: A flow chart of the procedures of an emergency breaching plan

MONITORING PROGRAMME

The following monitoring programme is required to be able to perform artificial breaching in a responsible and effective manner (Table 5):

Table 5: Monitoring programme for Goukamma Estuary relating to artificial breaching

MONITORING ACTIONS	FREQUENCY	LOCAL REQUIREMENT - YES/NO	AGENCY RESPONSIBLE
Weather forecast (projected rainfall and waves)	Period leading up to breaching	Yes	SA Weather Services
Water levels	Continuous	Yes	DWS G4R004 (1979-2016)
River inflow data	Daily	Yes	DWS gauge
Bathymetric surveys	Every 3 years	Yes	CapeNature
Salinity	Monthly (and day before and after, and 5 to 10 days after a breaching)	Yes	CapeNature
<i>In situ</i> water quality measurements (e.g. oxygen)	Monthly	Yes	CapeNature
Berm levels	Monthly (and just before breaching if breaching is planned)	Yes	CapeNature
Photographs	To be arranged between authorities before, during and after breaching	Yes	CapeNature
Observations on estuarine vegetation (e.g. inundation of salt marsh, reeds & sedges, occurrence of algal blooms)	Quarterly (and just before breaching)	Yes	CapeNature

Observations on Invertebrate behavior (e.g. invertebrate kills)	Quarterly (and just before breaching)	Yes	CapeNature
Fish surveys Distribution, abundance, movement and behavior (e.g. recruitment, aggregations, fish kills)	Bi-annually	Yes	DFFE
Co-ordinated Waterbird Counts (CWAC)	Bi-annually	Yes	CapeNature

REPORTING

Following an emergency breaching a Breaching Incidence Report needs to be compiled and provided to DFFE within 14 days of breaching. This report should contain as much as possible information on the breaching motivation for the breaching and the process followed.

In addition to the Breaching Incidence Report, the Managing authority may need to compile an Annual Breaching Report that summarises information on all mouth manipulation activities, ecological responses and consequences to human well-being and safety. The Annual Breaching Report needs to be presented to all Interested and Affected Parties (I&AP) (relevant authorities and civil society) to communicate progress with the implementation of the MMP. Such feedback sessions provide the opportunity for a critical review of current breaching practises and discussions on possible improvements to future MMPs. The Annual Mouth Breaching Report will also serve as a national reporting document.

Breaching Report

Table 1 below summarises the minimum content of post-breaching report in the event the Goukamma Estuary is breached under emergency conditions. The initial incidence report should be compiled within 14 days of breaching, with data gaps (e.g. duration open) addressed after mouth closure.

Table 1: Content of Goukamma Estuary breaching report

ACTIONS	LOCAL REQUIREMENT - YES/NO	AGENCY RESPONSIBLE
<u>Met-ocean information</u> <ul style="list-style-type: none"> • State of the tide (spring-neap/ high-low tide) • Sea conditions (calm/stormy) 	Yes	CapeNature
<u>Estuary Information</u> <ul style="list-style-type: none"> • Water level from DWS (and volume) before breaching • Maximum outflow rate during breaching calculated from water levels and surface area of system • Outflow duration (from water level graph) • Lowest water level achieved after breaching (from water level graph) • Volume of sediment removed during breaching and what was done with the excavated sediment? • Did flooding problems arise before or during the breaching? If so, quantify these problems. • Could measures be taken to prevent such problems in the future? For example by protection of low laying properties. Distinguish between short-term and long-term measures. • Could further problems arise by design of new developments at too low levels? • Were there problems with septic tanks before the breaching? If so quantify Date since last reaching 	Yes	DWS & CapeNature
<u>Location of channel</u>	Yes	CapeNature

ACTIONS	LOCAL REQUIREMENT - YES/NO	AGENCY RESPONSIBLE
<ul style="list-style-type: none"> Align with historical position of channels Reduce channel length Estimated volume of sediment excavated during the breaching 		
Period for which the mouth stayed open	Yes	CapeNature
Bathymetric surveys before breaching events to establish erosion /deposition rates	Yes	CapeNature
Salinity measurement before and after breaching	Yes	CapeNature
Macrophyte conditions	No	
Fish recruitment survey	Yes, in summer after breaching	DFFE
Avifauna counts (CWAC)	Yes	CapeNature
Other		
<u>Assessment record compiled by:</u> Name: Organization: Date: Contact details:		

Feedback on breaching activities

Table 2 below summarises the minimum information required as evidence of breaching feedback reporting. Ideally the breaching report should be provided to the Estuary Advisory Forum and other interested stakeholders / specialists post breaching. The breaching process should be communicated to the forum on an ongoing basis throughout the process to keep stakeholder abreast of all developments and decisions taken. If this is not possible, such report back sessions should be held at least once a year to ensure that the correct breaching procedures are being followed and that additional interventions are not required.

Table 2: Minimum information required on breaching feedback sessions

MONITORING ACTIONS	
Responsible agency /authority	CapeNature
Place & Workshop venue	
Date	
Meeting/committee/workshop participants (attach attendance register)	
Workshop chaired by:	
Key lessons learned that could assist with future breaching	
Material presented at meeting (including copies)	

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- Harrison, T.D., Cooper, J.A.G. & Ramm, A.E.L. 1995. State of South African estuaries – geomorphology, ichthyofauna, water quality and aesthetics. Department of Environmental Affairs and Tourism, State of the Environment Series Report No. 2: 127 pp.
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- van Niekerk L., Taljaard S., Huizinga P., Snow G.C., Adams J.B., Wooldridge T.H., Lamberth S.J. and Turpie J.K. 2009. Reserve Determination studies for selected surface water, groundwater, estuaries and wetlands in the Outeniqua (Groot Brak and other water resources, excluding wetlands) catchment: Ecological Water Requirements Study – Estuarine RDM Report: Goukamma Assessment. Report No. RDM/K10 – K30, K40E/00/CON/0407. Pretoria.